TOSHIBA
'83
SMALL SIGNAL TRANSISTOR
SEMICONDUCTOR
DATA BOOK

TOSHIBA

SMALL SIGNAL TRANSISTOR

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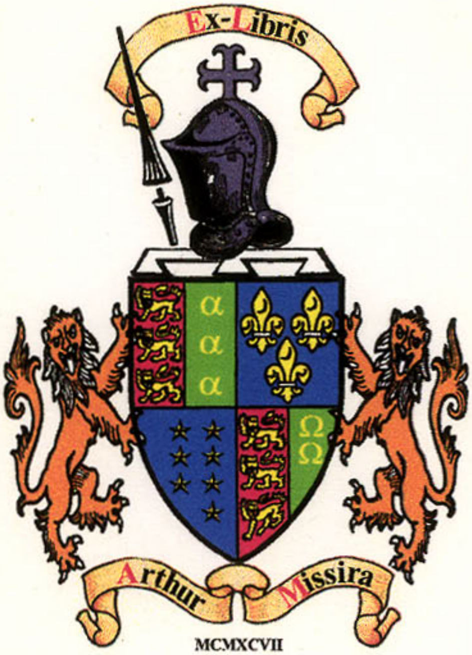
TOSHIBA CORPORATION



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SMALL SIGNAL TRANSISTOR

SEMICONDUCTOR DATA BOOK

INTRODUCTION

We would like to express our heartfelt thanks for your use of TOSHIBA semiconductor devices.

In recent years, the electronics industry has attained rapid technological advancements. Especially, semiconductor products now play a leading role in the electronic industry, expediting the electronization of all kinds of equipments for both industrial and consumer field. This has been a decisive factor in energy saving and rationalization in an age of low economic growth and has contributed greatly to the innovation of industry and to raising living standards.

In particular, transistors with flexible and extensive applications are expected to make greater strides in the future, being applied in a wider range of use as the pivot of active elements.

TOSHIBA intends to devote itself to enriching and developing products in this field and to producing excellent product groups with both high capacity and high reliability.

This volume comprises detailed technical data for small signal trnsistors among our numerous transistor and diode groups. Please use it in combination with the volume on power transistors.

We look forward to ypur continued patronage.

March 1983.

TOSHIBA CORPORATION
SEMICONDUCTOR GROUP
Tsuyoshi Kawanishi
Group Executive

IMPORTANT NOTICE

Toshiba does not assume any responsibility for use of any circuity described; no circuit patent licenses are implied, and Toshiba reserves the right, at any time without notice, to change said circuitry.

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SELECTION GUIDE

Selection Guide

Transistors (Consumer Use)

General-Purpose High Frequency Transistors (Classification Table)

Uses / Frequency (MHz)	Application	Small Signal		Large Signal
		Amplification	Oscillation	
0.55	TV AGC synchronization	2SC1815, 2SA1015, 2SC2458, 2SA1048	2SC1815 2SC2458	
	BC Band Radio	2SC1815, 2SC2458, 2SC380TM, 2SC2669 2SC941TM, 2SC2670	2SC380TM 2SC2669	
1.0	TV Video amplification	2SC1959, 2SC1815, 2SC2458		2SC2229, 2SC2068, 2SC1569, 2SC2482, 2SC2333, 2SC3334, 2SC3335, 2SA1320, 2SA1321, 2SA1322, S1298, S2057/A, S2058/A BF422, BF423, BF457 BF458, BF459, BF469 BF470, BF471, BF472
2.0				
3.0	TV SIF		2SC380TM 2SC2669	
	Short Wave Radio	2SC380TM, 2SC2669, 2SC2995	2SC2995	
10	FM IF	2SC380TM, 2SC2669, 2SC2995		
20	AM, SSB Transceiver	2SC2668, 2SC2669 2SC2995, 2SC1923, 2SC380TM, 3SK59, 3SK73, 3SK101 2SK161 2SK241, 2SK192A	2SC2995 2SC380TM 2SC2669	2SC1678, 2SC2098 2SC1036, 2SC2075

Uses / Frequency (MHz)	Application	Small Signal		Large Signal
		Amplification	Oscillation	
30 50	TV PIF (Europe) TV PIF (USA) Transceiver TV PIF (Japan) FM	2SC3125 2SC2215, 2SC2216, 2SC2717 2SC382TM (1st), 2SC383TM (3rd), 2SC388ATM (3rd), 2SC1923, 2SC2668, 2SC2995 2SK161, 2SK192A 3SK59, 3SK73, 3SK101, 2SK241, 3SK114	2SC1923 2SC2668 2SC2995	
100 200	VHF TV	3SK101, 3SK114 2SC2805, 2SC2806, 2SC3122, 2SC2347, 2SC2348, 2SC3123, 2SC3136, 2SC3172 3SK63	2SC2806 2SC2349 2SC3124	2SC994 2SC1199 2SC1164, 2SC2318, (CATV)
300 500	UHF TV	2SC2498, 2SC2499, 2SC2644, 2SC3098, 2SC3099, 2SC2804, 2SC2805, 2SC3137, 2SC3119, 2SC3120, 2SC3121, 3SK115, 3SK102, 3SK121,	2SC3120 2SC3121 2SC3137 2SC2805 2SC2347	2SC1164, 2SC1199, 2SC2318, 2SC2319 (CATV)
1000		2SC2753, 2SC3011, 2SA1245 2SC2876, 2SC3268, 2SC3301, 2SC3302		
5000				

General Purpose Low Frequency Transistors (Classification Table)

Classification	Collector Dissipation Pc	Silicon Transistor					
		VCEO (VCER)					
		~50V	50V~79V	80V~99V	100V~120V	121V~400V	1000V~
Low Power Low Noise	<500mW	2SC2878 (2SK146 (2SJ73 2SK147 (2SK170 (2SJ74 (2SK147 (2SJ72 2SK270 2SJ90 (TBC547~550 (TBC557~560	2SK30ATM 2SK246 2SK117 2SK118 2SK184 (2SA1015 (2SC1815 2SC732TM (2SC2458 (2SA1048 (TBC546 (TBC556	(2SC2868 (2SA1158	(2SC2240 (2SA970		
Low Power Amplification	0.5~1W	(2SC1959 (2SA562TM (2SC2710 (2SA1150 (TBC327/8 (TBC337/8	(2SC1815 (2SA1015 (2SC2458 (2SA1048		(2SC2240 (2SA970 (2SC2459 (2SA1049		
Medium Power Output	0.51~1W	(2SC2120 (2SA950 2SC2703 (2SC2500 (2SA1160 (2SC2236 (2SA966 (2SC496 (2SA496 (BD135 (BD136	(2SC2655 (2SA1020 (2SC495 (2SA505 2SC2794 (BD137 (BD138	(2SC1627 (2SA817 (2SC1627A (2SA817A (BD139 (BD140	(2SC2235 (2SA965	(2SC2229* (2SA949 2SC2230* 2SC2230A* 2SC2482* (2SC2383* (2SA1013* (2SC2705 (2SA1145	
	1.1~10W (Tc=25°C)	(2SA2877 (2SA1217 (2SC2270 (2SA1120 (2SC1173 (2SA473		(2SA1626 (2SA816 (S1375 (S1376		(2SC2704 (2SA1144 2SC2068* S1377*	

*: TV use (: Complementary pair ※Ask separately

Classification	Collector Dissipation P_C	Silicon Transistor					
		V_{CEO} (V_{CER})					
		~50V	50V~79V	80V~99V	100V~120V	121V~400V	1000V~
High Power Output	11~30W (Tc=25°C)	(BD233 BD234	(2SC2562 2SA1012 (2SC790 2SA490 (2SD880 2SB834 (60V) 2SD1052 2SD1052A (BD235 BD236	(2SD526 2SB596 (BD237 BD238	(2SC2824 2SA1184 (2SC1625 2SA815	2SC1569* 2SC2231* 2SC2231A* 2SC1624 2SA814 2SC2073* 2SA940 2SC2233* 2SC2456* 2SC2242* 2SC2238 2SA968 2SC2238A 2SA968A 2SC2238B 2SA968B 2SC2481* 2SA1021* 2SC2483* 2SA1195*	
	31~60W (Tc=25°C)		(2SB553 2SD553 (2SD754 2SD844	(2SB753 2SD843 S1236 S1237	(2SD525 2SB595 (2SD716 2SB686 ※(2SC3180 2SA1263	2SD1069* 2SD1090* 2SC1617* BU407D* BU326A*	2SD818* 2SD819* 2SD820* 2SD821* 2SD822* 2SD811* 2SD868* 2SD869* 2SD870* 2SD871* 2SD1279* BU205* BU208* BU208A* BUY71* S2818* S2818A*
	61~200W (Tc=25°C)		2SD717 2SD1092* 2SD777* 2SD1294* 2SD1208*	2SD1187	※(2SC3181 2SA1264 (2SD718 2SB688 (2SC2563 2SA1093 (2SD1148 2SB863 ※(2SC3182 2SA1265	(2SD424 2SB554 (2SD845 2SB755 (2SC2564 2SA1094 (2SC2565 2SA1095 (2SC2706 2SA1146 2SC1195* (2SC3182 2SA1265 (2SC3280 2SA1301 ※(2SC3281 2SA1302	2SD1425* 2SD1426* 2SD1427* 2SD1428* 2SD1429* 2SD1430* 2SD1431* 2SD1432* 2SD1433* 2SD1434*

*: TV use (: Complementary pair ※ Ask separately.

Transistors For Audio Equipment

AM/FM Tuner

Package Uses		TO-92	Mini	Super Mini	TO-72	H-SSTM	μ-X	DO-35
FM	RF	2SC1923	2SC2668 2SK161 2SK192A 2SK241	2SC2714 2SK211 2SK210 2SK302	3SK59	3SK73	3SK101 3SK114	
	MIX	2SC1923	2SC2668	2SC2714	3SK59	3SK73	3SK101 3SK114	
	LO	2SC1923	2SC2668 2SC2995	2SC2714 2SC2996				
	IF	2SC380TM	2SC2669	2SC2715				
	AFC							IS2236*
AM	RF	2SC941TM	2SC2670	2SC2716				
	CONV & IF	2SC1815 2SC380TM 2SC941TM	2SC2458 2SC2669 2SC2670 2SC2995	2SC2712 2SC2715 2SC2716 2SC2996				
AM Tuning			ISV100* ISV102* ISV149*					
FM Tuning			ISV101* ISV103* ISV147*					
FM AGC		ISV99*		ISV128*				

*Diode

Low Frequency Small Signal Amplification

Application	Package					
	TO-92		Mini		Super Mini	
General purpose	2SC1815 2SC2868	2SA1015 2SA1158	2SC2458 2SC2459	2SA1048 2SA1049	2SC2712 2SC2713	2SA1162 2SA1163
General purpose (Low Noise)	2SC1815Ⓛ	2SA1015Ⓛ	2SC2458Ⓛ	2SA1048Ⓛ	2SC3323	2SA1311
	2SC732 TM					
E.Q Amp Diff.	2SC2240	2SA970	2SC2459	2SA1049	2SC3324	2SA1312
Main Amp Diff.	2SC2240	2SA970			2SC3324	2SA1312
Low Frequency Amplifier	2SC2120	2SA950	2SC2710	2SA1150	2SC3265	2SA1298
	2SC1959	2SA562TM			2SC2859	2SA1182
Impeadance Converter	2SK246	2SJ103	2SK330	2SJ105	2SK208	2SJ106
	2SK30ATM		2SK118		2SK208	
Low NoiseAudioAmplifier	2SK117		2SK184		2SK209	
Muting	2SC2878		2SC3327		2SC3326	

Structure / Application	Single Type		Dual Type	
	N-ch	P-ch	N-ch	P-ch
E.Q.Amp Diff	2SK170	2SJ74	2SK240	2SJ75
	2SK147 2SK369	2SJ72 2SJ111	2SK146	2SJ73
			2SK270 2SK389	2SJ90 2SJ109
Main Amp Diff			2SK270 2SK389	2SJ109

Power Amplifier

HF Series

Stage / Po	Diff. Amp	Pre. Driver		Driver		Out Put	
		NPN	PNP	NPN	PNP	NPN	PNP
3W	–	–	–	2SC1959	–	2SC2236	2SA966
5W	–	–	–	2SC1959	–	2SC2877	2SA1217
20W	2SA1015	2SC1627	–	2SC1627	2SA817	2SD880	2SD834
25W	2SA1015	2SC1627	–	2SC1627	2SA817	2SD526	2SB596
35W	2SA1015	2SC2705	2SA1145	2SC1627A	2SA817A	2SD716 2SC3180	2SB686 2SA1263
50W	2SA970	2SC2705	2SA1145	2SC2235	2SA965	2SD718 2SC3181	2SB688 2SA1264
70W	2SA970	2SC2705	2SA1145	2SC2824	2SA1184	2SD1148 2SC3182	2SB863 2SA1265
80W	2SA970	2SC2705	2SA1145	2SC2824	2SA1184	2SD845 2SC3280	2SB755 2SA1301
100W	2SA970	2SC2705	2SA1145	2SC2238	2SA968	2SC3281	2SA1302
150W	2SA970	2SC2704	2SA1144	2SC2238	2SA968	2SD845 X 2 2SC3281 X 2	2SB755 X 2 2SA1302 X 2

SHF Series

50W	2SA970	2SC2705	2SA1145	2SC2824	2SA1184	2SC2563	2SA1093
70W	2SA970	2SC2705	2SA1145	2SC2238	2SA968	2SC2706	2SA1146
80W	2SK270	2SC2705	2SA1145	2SC2238	2SA968	2SC2564	2SA1094
100W	2SK270	2SC2704	2SA1144	2SC2238	2SA968	2SC2565	2SA1095
150W	2SK270	2SC2704	2SA1144	2SC2238A	2SA968A	2SC2564 X 2	2SA1094 X 2
200W	2SK270	2SC2704	2SA1144	2SC2238B	2SA968B	2SC2565 X 3	2SA1095 X 3
70W	2SK270	–	–	2SC2704	2SA1144	2SK405**	2SJ115**
120W	2SK270	–	–	2SC2704	2SA1144	2SK405X2**	2SJ115X2**

** : Power MOS FET.

Transistor For TV

Tuner

Uses		TO-92	μ-X	Equivalent to TO-236	1-5G1A	DO-35	1-2G1A	1-2J1A
UHF	RF		3SK102(MOS) 3SK121(GaAs) 3SK115(MOS) 2SC2304	2SC3119				
	MIX		2SC2805 2SC3137	2SC3121 2SC3120				
	OSC	2SC2347	2SC2805 2SC3137	2SC3121 2SC3120				
	Tuning				1SV123*			1SV153*
	AFC				1SV123*	1S2094*		1SV153*
VHF	RF	2SC2348	3SK101(MOS) 3SK114(MOS)	2SC3122				
	MIX	2SC3136	2SC3172 3SK101(MOS) 3SK114(MOS)	2SC3123				
	OSC	2SC2349	2SC2806	2SC3124				
	Tuning				1SV123* 1SV138* 1SV75*			1SV153*
	AFC				1SV123*	1S2094*		1SV153*
	Band SW					1S2186*	1SS155*	

＊ : Diode

Video, Chroma-System

Stage	Color TV			B/W TV			Type
	L	M	S	L	M	S	
Driver	■	■	■				2SA562TM
	■	■	■	■	■	■	2SA1015
				■	■	■	2SC1815
Output	■	■		■			2SC2068/S1298 TBF869/TBF870 TBF871/TBF872
		■	■		■	■	2SC2482
		■	■		■	■	2SC2456 2SA1322/2SC3335
			■			■	2SC2229 2SA1321/2SC3334
	■	■	■				2SC3333/2SA1320 BF422/BF423

Vertical Deflection System

Stage	Color TV			B/W TV			Type
	L	M	S	L	M	S	
Oscillator				■	■	■	2SC1815
				■	■	■	2SA1015
Driver	■	■	■				2SC2229
				■	■	■	2SC1959
Output	■	■					2SC2073／2SA940 S1236／S1237
		■	■	■	■		2SC2481／2SA1021
				■	■		2SD880 ／2SB834
				■	■		2SC1173／2SA473
					■		2SC496 ／2SA496
					■	■	2SC2236／2SA966

L : Large Size Screen
M : Middle Size Screen
S : Small Size Screen

PIF, SIF, AGC, Synchronous Separation, Synchronous Amplifier

PIF			SIF	AGC	Synchronous Separation	Synchronous Amplification
1st	2nd	3rd				
2SC382TM 2SC2215	2SC382TM 2SC2215	2SC383TM 2SC388ATM 2SC2216 2SC2717 2SC3125	2SC380TM 2SC380ATM	2SC1815 2SA1015	2SC1815 2SA1015	2SC1815 2SA1015

Sound Output

Stage	Color TV			B/W TV			Type
	L	M	S	L	M	S	
Output	■	■					2SC2483／2SA1195
	■	■	■				2SC2481/2SA1021
		■	■				2SC2231×2 or2SC2231A×2
		■	■				2SC2230×2 or2SC2230A×2
		■	■				2SC2383/2SA1013
				■	■		2SD880 ／2SB834
				■	■		2SC1173／2SA473
					■	■	2SC2236／2SA966
						■	2SC2120／2SA950

Horizontal Deflection System

Stage	Color TV			B/W TV			Type
	L	M	S	L	M	S	
Oscillator	■	■	■	■	■	■	2SC1815
	■	■	■	■	■	■	2SA1015
Driver	■	■	■				2SC2068, S1377
	■	■	■				2SC2456
	■	■	■				2SC2482
				■	■	■	2SC2229
				■	■	■	2SC1959
Output	■	■		■			2SD822, 2SD1279, 2SD1433
	■	■		■			2SD821, BU208A, 2SD1432, S2000A
	■	■		■			2SD820, BU208, 2SD1431, S2000
		■	■		■	■	2SD819, 2SD1430
		■	■		■	■	2SD818, BU205, 2SD1429, S2056
	■	■		■			2SD871 *, S2818A *, 2SD1428 *, S2055A
	■	■		■			2SD870 *, S2818 *, 2SD1427 *, S2055 *
		■	■		■	■	2SD869 *, 2SD1426 *
		■	■		■	■	2SD868 *, 2SD1425 *
			■	■			2SC1617, BUY71
				■	■		2SD1069 *, BU407D
					■	■	2SC2233

* Built in Damper Diode

Power Supply

Uses		Color TV			B/W TV			Type	Remarks
		L	M	S	L	M	S		
Series Regulator	Error Amplifier	■	■	■				2SC2229, S1854	high+B
					■	■	■	2SC1815	Low+B
					■	■	■	2SA1015	Low+B
	Driver	■	■	■				2SC2229	high+B
					■	■	■	2SC1815	Low+B
					■	■	■	2SA1015	Low+B
	Output	■	■	■				2SD1208, 2SD777	high h_{FE}
			■	■				2SD1092	high h_{FE}
		■	■					2SC1195	
			■	■				2SD1090, 2SD1294	high h_{FE}
					■	■	■	2SD880 or 2SB834	
				■		■	■	2SD1052, 2SD1052A	high h_{FE}
Switching Regulator	Driver	■	■		■	■		2SC2655	
		■	■		■	■		2SC2703	
				■			■	2SC2236	
				■			■	2SC2120	
	Output	■	■		■	■		2SD822, 2SD1279 2SD1434	
			■	■	■	■	■	2SD811, 2SD841, BU326A	
		■						2SC2790, 2SC2790A	High Speed

Package	Type	Application	Maximum Rating		
			V_{CEO}(V)	I_C(mA)	P_C(mW)
TO-92	2SC2498	VHF~UHF Low noise amplifier	20	50	300
	2SC2499		20	30	300
	2SC2753		12	70	300
	2SC2644	VHF~UHF Wide-band amplifier	12	120	500
μ-X	2SC2876	VHF~C band Low noise amplifier	7.5	80	200
Epuivalent to TO-236	2SA1245	VHF~UHF Low noise amplifier	− 8	−30	150
	2SC3098		20	50	150
	2SC3099		20	30	150
	2SC3011	UHF~C band Low noise amplifier	7	30	150
Power Mini	2SC3268	VHF~UHF Low noise amplifier	12	70	800
	2SC3301	VHF~C band Low noise amplifier	7.5	80	800

Package	Type	Application	Electrical Characteristic(TYP)			
			f_T(GHz)	$S21_e^2$	NF(dB)	f(GHz)
TO-92	2SC2498	UHF~UHF Low noise amplifier	3.5	14.5	2.5	0.5
	2SC2499		4.0	15.0	1.7	
	2SC2753		·5.0	10.5	1.7	1.0
	2SC2644		4.0	14.5	2.3	0.5
μ-X	2SC2876	UHF~C band Low noise amplifier	7.0	10.5	2.3	1.0
Epuivalent to TO-236	2SA1245	VHF~UHF Low noise amplifier	4.0	9.5	3.0	
	2SC3088		3.5	14.5	2.5	0.5
	2SC3099		4.0	15.0	1.7	
	2SC3011	UHF~C band Low noise amplifier	6.5	9.0	2.3	1.0
Power Mini	2SC3268	VHF~UHE Low noise amplifier	5.0	9.5	2.0	1.0
	2SC3301	UHF~C band Low noise amplifier	7.0	9.0	2.3	

Chip Device For Hybrid IC (1)

Super Mini Transistor (Equivalent to TO-236)

Type	Application	Electrical Characteristic				Marking	Complementary	Similar Type TO-92 (mini transistor)	Remarks
		V_{CEO} (V)	I_c(mA)	P_c(mW)	T_J(°C)				
2SA1162	Low frequency amplifier	−50	−150	150	125	S	2CC2712	2SA1015 (2SA1048)	–
2SC2712	Low frequency amplifier	50	150	150	125	L	2SA1162	2SC1815 (SC2458)	–
2SA1163	Low frequency high voltage amplifier	−120	−100	150	125	C	2SC2713	2SA970 (2SA1049)	–
2SC2713	Low frequency high voltage amplifier	120	100	150	125	D	2SA1163	2SC2240 (2SC2459)	–
2SC2714	FM RF amplifier	30	20	150	125	Q	–	2SC1923 (2SC2668)	–
2SC2715	AM convertor, FM IF amplifier	30	50	150	125	R	–	2SC380TM (2SC2669)	–
2SC2716	AM RF amplifier	30	100	150	125	F	–	2SA941TM (2SC2670)	–
2SA1182	Low frequency amplifier	−30	−500	150	125	Z	2SC2859	2A562TM	–
2SC2859	Low frequency amplifier	30	500	150	125	W	2SA1182	2SC1959	–
2SC2532	LED driver	40	300	150	125	A	–	2SC982TM	–
2SC2996	FM RF amplifier	30	50	150	125	G	–	(2SC2995)	–
2SA1255	High voltage amplifier	−200	−50	150	125	O	2SC3138	–	–
2SC3138	High voltage amplifier	200	50	150	125	N	2SA1255	–	–
*2SC3011	UHF ∼ C band low noise noise amplifier	7	30	150	125	MA	–	–	f_T=6.5GHz
*2SC3098	VHF ∼ UHF band low noise amplifier	20	50	150	125	MB	–	2SC2498	f_T=3.5GHz
*2SC3099	VHF ∼ UHF band low noise amplifier	20	30	150	125	MC	–	2SC2499	f_T=4GHz
*2SA1245	High speed switching	−8	−30	150	125	MD	–	–	f_T=4GHz
2SC3119	UHF-TV RF amplifier	20	20	150	125	HA	–	–	f_T=900MHz
2SC3120	UHF-TV convertor	15	50	150	125	HB	–	–	f_T=2.4GHz
2SC3121	UHF-TV oscillator	15	50	150	125	HC	–	–	f_T=1.5GHz
2SC3122	VHF-TV RF amplifier	30	20	150	125	HD	–	2SC2348	f_T=400MHz MIN.
2SC3123	VHF-TV convertor	20	50	150	125	HE	–	2SC3136	f_T=900MHz MIN.
2SC3124	VHF-TV oscillator	15	50	150	125	HF	–	2SC2349	f_T=600MHz MIN.
2SC3125	TV PIF amplifier	25	50	150	125	HH	–	2SC388ATM	f_T=350MHz

*Microwave transistor

FET

Type	Application	Electrical characteristic (Ta = 25°C)					Marking	Similiar Type	Remarks
		V_{DSX}** V_{GDO} V_{GRD}* (V)	I_G,I_D* (mA)	P_D(mW)	I_{DSS}(mA)	$\|Y_{fs}\|$(mS)			
2SK208	Low frequency amplifier	−50	10	100	0.3 ~ 6.5	1.2 MIN.	J	2SK30ATM	
2SK209	Low noise low frequency amplifier	−50	10	150	0.6 ~ 14	15	X	2SK117	
2SK210	FM RF amplifier	−18*	10	100	3.0 ~ 24	7 TYP.	Y	2SK192A	
2SK211	FM RF amplifier	−18*	10	100	1.0 ~ 10	9 TYP.	K	2SK161	
2SK302	VHF band amplifier	20**	30*	150	1.5 ~ 14	10 TYP.	T	2SK241	MOS type FET

Diode

Type	Application	Electrical Characteristic (Ta = 25°C)					Marking	Similar Type	
		V_R(V)	I_F(mA)	C_T(PE)	NF(dB)	Rs(Ω)			
ISS154	UHF ~ S band mixer detecter	6	30	0.8	9 MAX.	–	BA	–	
ISV128	VHF ~ UHF band attenuator	50	50	0.25	–	7	BB	ISV99	
ISS181	High Speed Switching	80	100	4.0	–	–	A3	–	Cathode Common
ISS184	High Speed Switching	80	100	4.0	–	–	B3	–	Anode Common
ISS226	High Speed Switching	80	100	4.0	–	–	C3	–	Series Type

Chip Device For Hybrid IC (2)

Power Mini Transistor (Equivalent to SOT-89)

Type	Application	Electrical Characteristic (Ta = 25°C)					Marking	Complementary pair	Similar Type T092MOD (TO-92)	Remarks
		V_{CEO} (V)	I_C (A)	P_C (W)	P_C* (W)	T_J (°C)				
2SA1200	High voltage switching, audio pre-driver	−150	−0.05	0.5	0.8	150	B	2SC2880	2SA949	
2SC2880	High voltage switching, audio pre-driver	150	0.05	0.5	0.8	150	A	2SA1200	2SC2229	
2SA1201	Power amplifier, audio driver	−120	−0.8	0.5	1.0	150	D	2SC2881	2SA965	
2SC2881	Power amplifier, audio driver	120	0.8	0.5	1.0	150	C	2SA1201	2SC2235	
2SA1202	Power amplifier, audio driver	−80	−0.4	0.5	1.0	150	F	2SC2882	2SA817A	
2SC2882	Power amplifier, audio driver	80	0.4	0.5	1.0	150	E	2SA1202	2SC1627A	
2SA1203	Power amplifier	−30	−1.5	0.5	1.0	150	H	2SC2883	2SA966	
2SC2883	Power amplifier	30	1.5	0.5	1.0	150	G	2SA1203	2SC2236	
2SA1204	Power amplifier	−30	−0.8	0.5	1.0	150	R	2SC2884	(2SA950)	
2SC2884	Power amplifier	30	0.8	0.5	1.0	150	P	2SA1204	(2SC2120)	
2SA1213	Power amplifier, switching	−50	−2.0	0.5	1.0	150	N	2SC2873	2SA1020	Low V_{CE}(sat)
2SC2873	Power amplifier, switching	50	2.0	0.5	1.0	150	M	2SA1213	2SC2655	Low V_{CE}(sat)
2SC2982	Strobo flash	10	2.0	0.5	1.0	150	S	–	2SC2500	
2SC3268	RF Low noise amplitcer	10	0.07	0.3	0.8	125	ME	–	(2SC2753)	VHF ~ UHF
2SC3301	RF Low noise amplitcer	7.5	0.08	0.3	0.8	125	MA	–	–	VHF ~C Band

PC *Mounted on 250mm² x 0.8mm Ceramic board

Chip Device For Hybrid IC (3)

Power Mold Transistor

Type	Application	Electrical Characteristic (Ta = 25°C)					Complimentary Pair	Similar Type TO-126,220	Remarks
		V_{CEO} (V)	I_C (A)	P_C (W)	P_C* (W)	T_J (°C)			
2SA1225	Driver Power amplifier	−160	−1.5	1.0	10	150	2SC2983	2SA9688	
2SC2983	Driver Power amplifier	160	1.5	1.0	10	150	2SA1225	2SC2238	
2SA1241	Power amplifier	−50	−2.0	1.0	10	150	2SC3076	**2SA1020	
2SC3076	Power amplifier Strobo flash	50	2.0	1.0	10	150	2SA1241	**2SC2655	
2SA1242	Medium power amplifier	−20	−5.0	1.0	10	150	2SC3072	2SA1120	
2SC3072	Strobo flash Medium power amplifier	20	5.0	1.0	10	150	2SA1242	2SC2270	
2SA1243	Power amplifier	−30	−3.0	1.0	10	150	2SC3073	2SA473	
2SC3073	Power amplifier	30	3.0	1.0	10	150	2SA1243	2SC1173	
2SA1244	Large current switching	−50	−5.0	1.0	20	150	2SC3074	2SA1012	
2SC3074	Large current switching	50	5.0	1.0	20	150	2SA1244	2SC2562	
2SB905	TV vertical deflection output TV Sound output (B class)	−150	−1.5	1.0	10	150	2SD1220	2SA1021	
2SD1220	TV vertical deflection output TV Sound output (B class)	150	1.5	1.0	10	150	2SB905	2SC2481	
2SB906	Low frequency power amplifier	−60	−3.0	1.0	20	150	2SD1221	2SB834	
2SD1221	Low frequency power amplifier	60	3.0	1.0	20	150	2SB906	2SD880	
2SB907	Switching Power amplifier	−40	−3.0	1.0	15	150	2SD1222	2SB677	Darlington
2SD1222	Switching Power amplifier	0	3.0	1.0	15	150	2SB907	2SD687	Darlington
2SB908	Switching Power amplifier	−80	−4.0	1.0	15	150	2SD1223	2SB676	Darlington
2SD1223	Switching Power amplifier	80	4.0	1.0	15	150	2SB908	2SD686	Darlington
2SD1224	Power amplifier	30	1.5	1.0	10	150	–	2SD549	Darlington
2SD1160	Motor control	50 (V_{CES})	2.0	1.0	10	150	–	–	
2SC3075	High voltage power amplifier	400	0.8	1.0	10	150	–	–	

PC* TC = 25°C **TO-92MOD

Transistors (Industrial Use)

Classification Table

Classification			Silicon Transistor (NPN)							
	Ic (Max.)	Pc (Max.)	Basic Product		High Frequency	High Speed	High Voltage	Low Noise	For Governmental Offices	
			Typical Product Description	Classification					NHK Standards	Remarks
Small Power Transistor	~150mA	~400mW	2SC372ⒼTM 2SC2551	2SC372ⒼTM 2SC373ⒼTM 2SC980ⒼTM 2SC980AⒼTM 2SC2551	2SC387AⒼTM	2SC752ⒼTM	2SC780AⒼTM 2SC2551	2SC1000ⒼTM		
	~100mA	~250mW	2SC400 2SC1380	2SC400 2SC979 2SC979A 2SC1380				2SC1380A	2SC587Ⓝ	
	~500mA	~400mW	2SC367ⒼTM 2SC982TM 2SC2550	2SC366ⒼTM 2SC367ⒼTM 2SC982TM 2SC2550		2SC395A			2SC595Ⓝ	
Mendium Power Transistor	100 ~300mA	~750mW	2SC594	2SC507 2SC594			2SC505 2SC506 2SC507		2SC594Ⓝ	
	600 ~800mA	~800mW	2SC108A 2SC503 2SC509ⒼTM	2SC108A 2SC109A 2SC503 2SC504 2SC509ⒼTM		2SC108A 2SC109A	2SC505 2SC506		2SC560Ⓝ	
	~2A	~800mW	2SC510 2SC2655	2SC510 2SC512 2SC2655 2SC3007						
High Power Transistor	1.5~5A	~50W (Tc=25℃)	2SD686 2SD687 2SC522 2SD688 2SD689 2SC2534 2SC2552	2SC522 2SC524 2SD877 2SD686 2SD687 2SD688 2SD689 2SC2562		2SC2534 2SC2552	2SC2534 2SC2552 2SC3148		2SC833Ⓝ 2SC598Ⓝ	
	~7A	~50W (Tc=25℃)	2SC2200 2SC2535 2SC519A 2SD523 2SD633 2SD553	2SC2200 2SC519A 2SC520A 2SC521A 2SD523 2SD633 2SD634 2SD635 2SD553 2SD843		1SC2535 2SC2553	2SC2200 2SC2913 2SC2535 2SC2553 2SD798 2SD799 2SD1088		2SD51Ⓝ 2SD51AⓃ	
	~15A	~100W (Tc=25℃)	2SC1576 2SD524 2SC2790	2SD369 2SC1576 2SD524 2SC2139 2SD867 2SC2555 2SD717 2SD1087 2SD1187		2SC2555 2SC2650 2SC2139 2SC2914 2SC1576 2SD640 1SC2790 2SC2790A 2SC2791 2SC2792 2SC2793			2SD52Ⓝ 2SD52AⓃ 2SD53Ⓝ 2SD53AⓃ	

Classification			Silicon Transistor (NPN)							
	Ic (Max.)	Pc (Max.)	Basic Product		High Frequency	High Speed	High Voltage	Low Noise	For Governmental Offices	
			Typical Product Description	Classification					NHK Standards	Remarks
	15~40A	~300W (Tc=25℃)	2SD552 2SD873 2SD878	2SD552 2SD797 2SD1313 2SD1314 2SD842			2SD641 2SD642 2SD1313 2SD1314		2SD55Ⓝ	
Field Effect Transistor (FET)		Junction	2SK15 2SK112 2SK113 3SK28	2SK11 2SK12 2SK15 2SK48 2SK112 2SK113	3SK28	2SK113 3SK28	2SK112 2SK113	2SK15 2SK48 2SK112 3SK28	2SK12Ⓝ	
		(Dual)	2SK18 2SK72	2SK18 2SK72 2SK18A				2SK18 2SK18A 2SK72	2SK72Ⓝ	
		MOS	3SK38A	3SK38A						
		π-MOS (Power MOS)	2SK324 2SK355 2SK357 2SK386 2SK387 2SK417 2SK419 2SK421	2SK324 2SK325 2SK355 2SK356 2SK357 2SK358		2SK324 2SK355 2SK357 2SK385 2SK387 2SK417 2SK418 2SK420	2SK325 2SK356 2SK358 2SK386 2SK388 2SK419 2SK421			

Classification Table

Classification			Silicon Transistor (PNP)				
	IC (Max.)	PC (Max.)	Basic Product		High Withstand Voltage	Low Noise	NHK Standard
			Typical Product Description	Classification			NHK Standards
Small Power Transistor	~150mA	~400mW	2SA495ⒼTM 2SA1091	2SA495ⒼTM 2SA1091	2SA429ⒼT 2SA1091	2SA493ⒼTM	
	~100mA	~250mW	2SA500	2SA499 2SA500			2SA522Ⓝ 2SA522AⓃ
	~500mA	~300mW	2SA476ⒼTM 2SA1090	2SA476ⒼTM 2SA1090			
Medium Power Transistor	100 ≈300mA	~750W	2SA594	2SA594			
	600 ~800mA	~800mW	2SA503 2SA509ⒼTM	2SA503 2SA504 2SA509ⒼTM			
	~1.5A	~800mW	2SA510 2SA1020	2SA510 2SA512 2SA1020			
High Power Transistor	1.5 ~5A	8 ~30W (Tc=25°C)	2SB676 2SB677 2SB502A 2SB434 2SB678 2SB679	2SB502A 2SB503A 2SB434 2SB435 2SB676 2BB677 2SB678 2SB679 2SA1012	2SA739		
	~7A	~50W (Tc=25°C)	2SA656A 2SB673	2SA656A 2SA657A 2SA658A 2SB673 2SB674 2SB675 2SB553 2SB753	2SA739		
	~15A	~100W (Tc=25°C)					
	15 ~40A	~300W (Tc=25°C)	2SB552 2SB833	2SB552 2SB833			

Notes: 1. 3SK38A is MOS FET and others are Junction FETs.
2. ⒼTM:Green transistor for industrial use (TO-92 epoxy package)
Ⓝ:NHK standards Ⓝ transistor
3. Complimentary transistor
2SC372 TM,2SC367 TM-2SA467 TM,2SC400-2SA500,2SC503F-2SA503F,
2SC510F-2SA510F,2SC595Ⓝ-2SA522Ⓝ,2SC560Ⓝ-2SA560Ⓝ,2SC516Ⓝ-2SA516Ⓝ,
2SC516AⓃ-2SA516AⓃ,2SB502F-2SD102F,2SC519AF-2SC519AF-2SA656AF,2SD552-2SB522
2SC255-2SA1090,2SC2551-2SA1091
F:Family

Selection Table

Application	Frequency Range	Power Range	Silicon Transistor				Remarks
			P N P		N P N		
			$V_{CEO}<40V$	$V_{CEO}>40V$	$V_{CEO}<40V$	$V_{CEO}>40V$	
Low Noise Amplifier	AF (audio frequency)	∼100mW		2SA493ⒼTM	2SK12 2SK12Ⓝ 2SK15 2SK48 2SK72	2SC1000ⒼTM 2SC1380A 2SC18 2SK18A 2SK112	Notes: 1Ⓖ : Green transistor for industiral use. Notes: 2Ⓝ: NHK standardsⓃ transistor Notes: 3. *: for UHF.
Low Frequency Amplifier Oscillation	AF (audio frequency)	∼100mW	2SA500 2SA522	2S495ⒼTM 2SA499 2SA522AⓃ	2SC400Ⓝ 2SC595	2SC372ⒼTM 2SC373ⒼTM 2SC979 2SC979A 2SC980ⒼTM 2SC980AⒼTM	
		100mW ∼300mW	2SA467ⒼTM 2SA500 2SA522Ⓝ	2SA495ⒼTM 2SA499 2SA522AⓃ	2SC367ⒼTM 2SC400	2SC366ⒼTM 2SC505 2SC507 2SK112	
		300mW ∼3W	2SA509ⒼTM	2SA504 2SA503 2SA510 2SA594 2SA1020	2SC509ⒼTM	2SC503 2SC510 2SC507 2SC594 2SC594 2SC504 2SC2655 2SC3007	
	LF (low frequency)	3W∼10W				2SC522	
		10W∼		2SA1012 2SA656A 2SB434Ⓖ 2SB435Ⓖ 2SB502A 2SB503A 2SB552 2SB553 2SB833 2SB753		2SC519A 2SD51Ⓝ 2SD52Ⓝ 2SD53Ⓝ 2SD55Ⓝ 2SD234Ⓖ 2SD235Ⓖ 2SD633 2SD640 2SD641 2SC1576 2SD523 2SD524 2SD552 2SD553 2SD843 2SD842 2SC2562	

Application	Frequency Range	Power Range	Silicon Transistor				Remarks
			P N P		N P N		
			$V_{CEO}<40V$	$V_{CEO}>40V$	$V_{CEO}<40V$	$V_{CEO}>40V$	
High Frequency Amplifier Oscillation	VHF Amplifier Oscillation	~100mW	2SA500 2SA522	2SA495ⒼTM 2SA499 2SA522AⓃ	2SC400 2SC595Ⓝ 3SK28	2SC372ⒼTM 2SC373ⒼTM 2SC979 2SC979A 2SC980ⒼTM 2SC980AⒼTM	
	HF (high frequency)	100mW ~300mW	2SA467ⒼTM 2SA500 2SA522Ⓝ	2SA495ⒼTM 2SA499 2SA522AⓃ 2SA594	2SC367ⒼTM 2SC595Ⓝ	2SC366ⒼTM 2SC507 2SC594 2SC594Ⓝ 2SC383TM 2SC2216 2SK113	
		300mW ~3W		2SA504 2SA503 2SA510 2SA594 2SA1020		2SC503 2SC510 2SC507 2SC594 2SC504 2SC2655	
		3W~		2SA656A 2SA1012	2SC1763 2SC1764 2SC2395 2SC2099 2SC2290 2SC2510	2SC522 2SC519A 2SC2913 2SC914 2SC2790 2SC2552 2SC2553 2SC2555 2SC2650 2SC2652	
VHF Amplifier Oscillation UHF Amplifier Oscillation	VHF UHF	~100mW			3SK28		
		100mW ~300mW	2SA594		2SC387AⒼTM		
		300mW ~3W			2SC998 2SC1001* 2SC1165* 2SC1169 2SC1199* 2SC1765* 2SC1955 2SC2117 2SC2118 2SC2318*		

Application	Frequency Range	Power Range	Silicon Transistor				Remarks
			P N P		N P N		
			$V_{CEO}<40V$	$V_{CEO}>40V$	$V_{CEO}<40V$	$V_{CEO}>40V$	
UHF Amplifier Oscillation	VHF	3W～		2SA598	2SC2101 2SC2102 2SC2103A 2SC2178 2SC2180 2SC2104* 2SC2105* 2SC2106* 2SC2379* 2SC2380* 2SC2381* 2SC2391* 2SC2420 2SC2638 2SC2639 2SC2640 2SC2641* 2SC2642* 2SC2643* 2SC2782 2SC2783*		
HF (high frequency)	UHF						

Selection Table

Application	Frequency Range	Power Range	Silicon Transistor				Remarks
			P N P		N P N		
			$V_{CEO}<40V$	$V_{CEO}>40V$	$V_{CEO}<40V$	$V_{CEO}>40V$	
DC Amplifier Low Level Amp. Chopper	DC	~100mW			2SK12 2SK12Ⓝ 2SK15 2SD38A 2SK48 2SK72	2SK18 2SK18A 2SC1000ⒼTM 2SC1380A 2SK112 2SK113	Notes: 1. 3SK38A is MOS FET and other are Junction FETs. Notes: 2. Ⓖ: Green transistor for industrial use. (ⒼTM transistor is TO-92 package) Notes: 3. Ⓝ: NHK standards Ⓝ transistor.
Logical Circuit Control Circuit	~100kHz	~100mW	2SA500 2SA522Ⓝ	2SA495ⒼTM 2SA429ⒼTM 2SA499 2SA522AⓃ 2SA1090	2SC400 2SC752ⒼTM	2SC372ⒼTM 2SC780AⒼTM 2SC979 2S979A 2SC980ⒼTM 2SC980AⒼTM 2SC2550	
		100mW ~300mW	2SA467ⒼTM 2SA500 2SA522Ⓝ	2SA495ⒼTM 2SA499 2SA522AⓃ 2SA1090 2SA1091	2SC367ⒼTM 2SC400 2SC587Ⓝ 2SC595Ⓝ	2SC366ⒼTM 2SC505 2SC2550 2SC2551	
	100kHz ~1MHz	~100mW	2SA500 2SA522 Ⓝ	2SA495ⒼTM 2SA499 2SA522AⓃ 2SA1090	2SC372ⒼTM 2SC373ⒼTM 2SC400 2SC595Ⓝ	2SC979 2SC979A 2SC980ⒼTM 2SC980AⒼTM 2SC2550	
		100mW ~300mW	2SA467ⒼTM 2SA500 2SA522Ⓝ	2SA495ⒼTM 2SA499 2SA522AⓃ 2SA1090	2SC367ⒼTM 2SC400 2SC595 Ⓝ	2SC366ⒼTM 2SC505 2SC2550	
		300mW ~3W	2SA504	2SA503 2SA510 2SA1020		2SC108A 2SC503 2SC504 2SC507 2SC510 2SC594 2SC594Ⓝ 2SC2655	
	1MHz ~5MHz	~100mW	2SA500 2SA522 Ⓝ	2SA499 2SA522AⓃ	2SC752ⒼTM 2SC400 2SC587Ⓝ 2SC595Ⓝ 2SC372ⒼTMA 2SC373ⒼTMA 2SC395A	2SC979 2SC979A 2SC980ⒼTM 2SC980AⒼTM 2SK112 2SK113	
		100mW ~300mW	2SA467ⒼTM 2SA500 2SA522Ⓝ	2SA499 2SA522AⓃ	2SC395A 2SC400	2SC594 2SC594Ⓝ	
	5MHz ~15MHz	~100mW			2SC752ⒼTM		

Application	Frequency Range	Power Range	Silicon Transistor				Remarks
			P N P		N P N		
			$V_{CEO}<40$V	$V_{CEO}>40$V	$V_{CEO}<40$V	$V_{CEO}>40$V	
Power Supply Regulator DC-DC Converter DC-AC Converter	Control DC-DC Converter Oscillation			2SA1020 2SA1012 2SA510 2SA656A 2SB502A 2SB552 2SB553 2SB753		2SC510 2SC522 2SC519A 2SC833Ⓝ 2SC979 2SC2139 2SC2200 2SC2534 2SC2535 2SC2552 2SC2553 2SC3051 2SC3075 2SD51Ⓝ 2SD52Ⓝ 2SD53Ⓝ 2SD55Ⓝ 2SD523 2SD524 2SD552 2SD553 2SD640 2SD641 2SD797 2SD867 2SD873 2SD878 2SD843 2SC2655 2SC2562 2SC2913 2SC2914 2SD717 2SD1187	
	Amplifier			2SA1020 2SA504 2SA503 2SA510 2SA594		2SC503 2SC504 2SC510 2SC594 2SC594Ⓝ 2SC2655	
	Comparator Detecter		2SA467ⒼTM 2SA500 2SA522Ⓝ	2SA495ⒼTM 2SA499 2SA522AⓃ	2SC367ⒼTM 2SC400	2SC372ⒼTM 2SC373ⒼTM 2SC366ⒼTM 2SC505 2SC594	
High Voltage High Power Switch		~100mW		2SA429ⒼTM 2SA1091		2SC780AⒼTM 2SC2551	
		100mW ~300mW		2SA499 2SA522A		2SC366ⒼTM 2SC505	
		300mW ~3W		2SA503 2SA510		2SC503 2SC507 2SC510	
		3W~10W				2SC522	

Application	Frequency Range	Power Range	Silicon Transistor				Remarks
			P N P		N P N		
			$V_{CEO}<40V$	$V_{CEO}>40V$	$V_{CEO}<40V$	$V_{CEO}>40V$	
High Voltage High Power Switch		~50W		2SA656A 2SA739 2SB434Ⓖ 2SB435Ⓖ 2SB553 2SB834		2SC519A 2SC2200 2SC3148 2SD51Ⓝ 2SD234Ⓖ 2SD235Ⓖ 2SD523 2SD553 2SD633 2SD877 2SD798 2SD799 2SD1088	
		~150W		2SB552		2SC1576 2SC2139 2SD52Ⓝ 2SD53Ⓝ 2SD55Ⓝ 2SD1313 2SD524 2SD552 2SD640 2SD641 2SD797 2SD867 2SD873 2SD878	

Regulator Transistor

System	Type	Maximum Rating *Tc=25°C					Package
		V_{CBO}(V)	V_{CEO}(V)	Ic(A)	*Pc(W)	Tj(°C)	
Switching Regulator	2SC3051	500	400	0.8	10	150	Mold package
	2SC3075			0.8	10		
	2SC2534			2	20		
	2SC2552			2	20		
	2SC2535			5	40		
	2SC2553			5	40		
	2SC2555			8	80		
	2SC2650			10	100		
	2SC2200			7	40		Can package
	2SC2913			7	40		
	2SC2137			7	80		
	2SC2139			10	100		
	2SC2914			10	120		
	2SC2444			30	250		

System	Type	Maximum Rating *Tc=25°C					Package
		V_{CBO}(V)	V_{CEO}(V)	Ic(A)	*Pc(W)	Tj(°C)	
Switching Regulator	2SC3148	900	800	3	40	150	Mold package
	2SC2790/A	850		2	80		Can package
	2SC2791	900		5	100		
	2SC2792	850		2	80		Mold package
	2SC2793	900		5	100		
Series Regulator	2SD880	60	60	3	30	150	Mold package
	2SD1052		50	3	30		
	2SD1052A		50	3	30		
	2SD877	110	80	3	25	175	Can package
	2SD867	130	110	10	100		
	2SD878	100	60	15	115		
	2SD873	160	140	16	150		
	2SD797	100	80	30	200		

Regulator Transistor

Toshiba Supreme Power Transistors

I_C (A)	* V_{CEO} (sus) V_{CEO} (V)	Type		h_{FE}			V_{CE}(sat) MAX(V)			f_T TYP (MHz)	P_C (W) T_C=25°C	Package
		NPN	PNP		V_{CE} (V)	I_C (A)		I_C (A)	I_B (A)			
10	60	2N3713	2N3789	25~90	2	1	1.0	5/4	0.5/0.4	4MIN	150	TO-3
		2N3715	2N3791	50~150	2	1	0.8/1.0	5	0.5	4MIN	150	TO-3
	80	2N3714	2N3790	25~90	2	1	1.0	5/4	0.5/0.4	4MIN	150	TO-3
		2N3716	2N3792	50~150	2	1	0.8/1.0	5	0.5	4MIN	150	TO-3
		TSB3055		20~100	4	4	1.1	4	0.4	8	70	TO-3P
	* 200	2N6249		10~50	3	10	1.5	10	1	2.5MIN	175	TO-3
	* 275	2N6250		8~50	3	10	1.5	10	1.25	2.5MIN	175	TO-3
	* 350	2N6251		6~50	3	10	1.5	10	1.67	2.5MIN	175	TO-3
15	60	2N3055		20~70	4	4	1.1	44	0.4	2.5MIN	115	TO-3
	300	2N6546		12~60	2	5	1.5	10	2	15	175	TO-3
	400	2N6547		12~60	2	5	1.5	10	2	15	175	TO-3
16	140	2N3773		15~60	4	8	1.4	8	0.8	0.2MIN	150	TO-3
20	60	2N3772		15~60	4	10	1.4	10	1	0.2MIN	150	TO-3
	80	2N5303		15~60	2	10	1.0	10	1	2MIN	200	TO-3
	* 75	2N5039		20~100	5	10	2.5	20	5	60MIN	140	TO-3
	* 90	2N5038		20~100	5	12	2.5	20	5	60MIN	140	TO-3
30	40	2N3771		15~60	4	15	2.0	15	1.5	0.2MIN	150	TO-3
	* 40	2N5301	2N4398	15~60	2	15	0.75	10	1	2MIN	200	TO-3
	* 60	2N5302	2N4399	15~60	2	15	0.75	10	1	2MIN	200	TO-3

DC-DC Converter Transistor

LOW V_{CE} (sat) Series

Collector Current I_C (A)	Collector··Emitter Breakdown Voltage V_{CEO} (V)						Collector Power Dissipation * P_C (W)
	20 (V)		50 (V)		80 (V)		
	PNP	NPN	PNP	NPN	PNP	NPN	
12			2SA1328	2SC3345	2SA1329	2SC3346	40
10	2SA1327			2SD717		2SD1187	80
7			2SB754	2SD844			60
			2SB553	2SD553	2SB753	2SD843	40
5			2SA1012	2SC2562			25
	2SA1120	2SC2270					10
2	2SA1300 2SA1160 (V_{CEO}=10V)	2SC3279 2SC2500 (V_{CEO}=10V)	2SA1020	2SC2655	2SA1315	2SC3328	0.9 (Ta=25℃)

* Tc=25℃

Darlington Type Transistor

V_{CEO} Ic	30 V	40 V	60 V	80 V	100 V	150 V	200 V	250 V	300 V	350 V	400 V	450 V	600 V	900 V
0.3 A		2SC982TM※												
1.5 A	2SD549※ 2SD1140※				2SB678* 2SB679※ 2SD688* 2SD689※									
3 A														
4 A				2SB676※ 2SD686※										
6 A								2SD1088※	2SD798※		2SD799※			
7 A			2SB675※ 2SD635※	2SD664* 2SB674※ 2SD634※ 2SD523*	2SB673※ 2SD633※									
10 A											2SD685*			
15 A				2SD524*	2SD1087※						2SD641* 2SD683*	2SD683A* 2SD1314*		
30 A				2SB833* 2SD842*		2SD703*	2SD643* 2SD699*			2SD694* 2SD695*	2SC2444*	2SD644* 2SD645*		
40 A									2SD702*		2SD642*			
50 A										2SD696A*		2SD646A* 2SD547*		
100 A												2SD697A	2SD647A*	2SD1165A*
120 A												2SD548*		
200 A							2SD700* 2SD700Ⓓ*							2SD1166*
300 A												2SD1034A*		
400 A									2SD648A*					
600 A							2SD698A*							

*:Can package
※:Plastic package

☐ Giant transistor is shown in a rectangle.

FET for Commnications Industry (Small Signals)

Type	Application	Structure
2SK11	chopper, switching	N-channel junction type
2SK12	chopper, switching	
2SK15	Low frequency low noise amplifier	
2SK18	Differential amplifier	N-channel junction type (dual)complete separation type
2SK18A	Differential amplifier	
2SK48	Medical equipment	N-channel junction type
2SK72	Differential amplifier	N-channel junction type (dual)complete separation type
2SK112	Low frequency low noise(high gm)	N-channel junction type
2SK113-R	Constant-current, switching	
2SK113-O	Switching, chopper	
2SK113-Y	Analog switch, chopper	
3SK28	Video pre-amplifier	
3SK38A	Chopper circuit	N-channel MOS type (enhancement type)

G-TR Module (Insulated Type)

I_C(A)	$V_{CEO(SUS)}$(V)	Polarity	Structure	Type
±15	450	NPN	Darlington	**MG15G1AL2**
30	450	NPN	Darlington	**MG30G1BL2**
±30×2	450	NPN	Darlington	**MG30G2CL2**
50	450	NPN	Darlington	**MG50G1BL2**
±50×2	450	NPN	Darlington	**MG50G2CL2**
±75×2	500	NPN	Darlington	**MG75H2DL1**
±100	450	NPN	Darlington	**MG100G1AL2**
±100×2	550	NPN	Darlington	**MG100H2DL1**
±200	550	NPN	Darlington	**MG200H1AL1**

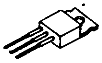
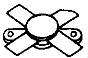
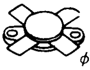
Power MOS FET (π -MOS)

Type	Maximum Rating				Package
	V_{DSX}(V)	V_{GSS}(V)	I_D(A)	P_P(W)	
2SK324	400	±20	10	120	TO-3
2SK325	450	±20	10	120	TO-3
2SK355	150	±20	12	120	TO-3
2SK356	250	±20	12	120	TO-3
2SK357	150	±20	5	40	TO-220AB
2SK358	250	±20	5	40	TO-220AB
2SK385	400	±20	10	120	TO-3P(L)
2SK386	450	±20	10	120	TO-3P(L)
2SK387	150	±20	12	150	TO-3P(L)
2SK388	250	±20	12	150	TO-3P(L)
2SK417	60	±20	10	60	TO-220BS
2SK418	400	±20	2	50	TO-220BS
2SK419	450	±20	2	50	TO-220BS
2SK420	400	±20	5	60	TO-220BS
2SK421	450	±20	5	60	TO-220BS
2SK422	60	±20	0.7	0.9	TO-92MOD
2SK423	100	±20	0.5	0.9	TO-92MOD
2SK405	160	±20	8	100	TO-3P
2SJ115	160	±20	8	100	TO-3P

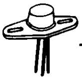
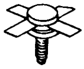
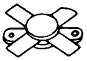
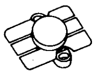
Uni-junction Transistor

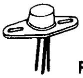
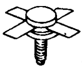
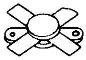
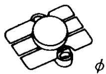
Model	Use	Structure
2SH20	Thyristor gate turn on Timer	SIP emitter planar type
2SH21	Thyristor gate turn on Timer	SIP emitter planer type

RF Power Transistors

	Package Po(W)	 TO-220AB	 ϕ9.5	 ϕ12.7
HF/CB 30MHz	3~3.5	2SC1678 2SC2075		
	10~ 12PEP	2SC2098	2SC2395	
	20PEP		2SC2099	
	40PEP			2SC1763 *
	60PEP			2SC2290
	80PEP			2SC1764 *
	100PEP			2SC2879
	150PEP			2SC2510 *
	200PEP			2SC2652 * *

※ : E−Case
* : $V_{CC}=28V$
* * : $V_{CC}=50V$

	Package Po(W)	 TO-39	 TO-39 Flange	 ϕ9.5	 ϕ9.5	 □6.5	 ϕ12.7
VHF 175MHz	1	2SC994 2SC998※					
	2.5	2SC547	2SC1169※				
	2.8	2SC1955※	2SC2117※				
	5		2SC2118※				
	6			2SC2101		2SC2638	
	15			2SC2102	2SC2178	2SC2639	
	27			2SC2103A	2SC2508		
	32			2SC2420		2SC2640	
	40				2SC2181		
	50						2SC3147
	80						2SC2782

	Package Po(W)	 TO-39	 TO-39 Flange	 ϕ9.5	 ϕ9.5	 □6.5	 ϕ12.7
UHF 470MHz	1	2SC1165 2SC1001					
	2.8		2SC1765				
	3			2SC2104	2SC2391		
	6			2SC2105	2SC2379	2SC2641	
	12			2SC2106	2SC2380	2SC2642	
	25			2SC2173	2SC2381	2SC2643	
	40						2SC2783

RF Power Module

Type	Application	Output Power Po (W)	Frequency Range f (MHz)
S-AV5	10W FM Amateur radio	15	144~148
S-AV6	25W FM Marine radio	28	154~162
S-AV7	25W FM Amateur radio	28	144~148
S-AV8	10W FM/SSB Amateur radio	17	144~148
S-AV9L	5W FM Land Mobile	8	135~155
S-AV9H			150~175
S-AV10L	10W FM Land Mobile	14	135~155
S-AV10H			150~175

Type	Application	Output Power Po (W)	Frequency Range f (MHz)
S-AU3	10W FM Amateur radio	15	430~450
S-AU4	10W FM/SSB Amateur radio	17	430~450
S-AU5L	5W FM Land Mobile	7	400~440
S-AU5M			440~480
S-AU5H			480~512
S-AU6L	10W FM Land Mobile	13	400~440
S-AU6M			440~480
S-AU6H			480~512
S-AU7	10W FM Land Mobile	15	806~825

Condition:V_{CC}, V_{CON}:12.5V, Pi:0.2W

Diodes

Detector & Switching

VR(V) \ IFM(mA)	50~100	300	300~500	750
30	1SS176	1S1555	1S1588 1SS104	
50	1SS177	1S1554 1S2460	1S1586 1S1587	
60		1S1553		
70				1S2095A
80	1SS178		1S1585	
100	1S2091	1S2461	IN4148	
200	1S2092	1S2462		

Type	Use
1S1553 1S1554 1S1555	General Purpose
1N4148 1S1585 1S1586 1S1587 1S1588 1SS176~178	High Speed SW
1S2091 1S2092	High Voltage SW
1S2095A	Hjgh Current SW
1S2460 1S2461 1S2462 1S2463	High Voltage
1SS104	Low Leakage

Zener Diode

List of Zener Diode Products

Vz (V)	250mW Type	500mW Type	1 W Type		5W Type	10W Type
			Epoxy	Metal		
2.0~4.8	02BZ2.2 02BZ2.7 02BZ3.3 02BZ3.9 02BZ4.7	05Z2.0 05Z3.3 05Z2.2 05Z3.6 05Z2.4 05Z3.9 05Z2.7 05Z4.3 05Z3.0 05Z4.7		1S220		1S262
4.8~5.8		05Z5.1 05Z5.6		1S221		1S263
5.8~7.0	(Temperature compensation type) 1SZ57~1SZ59	05Z6.2 05Z6.8	1Z6.2 1Z6.8	1S222		1S264
7.0~8.4		05Z7.5 05Z8.2	1Z7.5 1Z8.2	1S223		1S265
8.4~10		05Z9.1 05Z10	1Z9.1	1S224 1S225		1S266 1S267
10~12		05Z11 05Z12	1Z10 1Z11	1S226 1S227		1S268 1S269
12~14		05Z13	1Z12 1Z13	1S228 1S229		1S270 1S271
14~17		05Z15 05Z16	1Z15 1Z16	1S230~232		1S272~274
17~20		05Z18 05Z20	1Z18 1Z20	1S233~235		1S275~277
20~24		05Z22 05Z24	1Z22 1Z24	1S236 1S237		1S278 1S279
24~29		05Z27	1Z27	1S238 1S239	5Z27	1S280 1S281
29~35		05Z30 05Z33	1Z30 1ZM30 ⁑1Z33	1S240 1S241		1S282 1S283
35~42		05Z36 05Z39	⁑1Z36	1S242 1S243		1S284 1S285
42~50		05Z43 05Z47	1ZM50 ⁑1Z47	1S244~247		1S286~289
50~60		05Z51 05Z56	⁑1Z51	1S248 1S249		1S290 1S291
60~72		05Z62 05Z68	⁑1Z68	1S250 1S251		1S292 1S293
72~86		05Z75 05Z82	⁑1Z75 ⁑1Z82	1S252 1S253		1S294 1S295
86~100		05Z91 05Z100	⁑1Z100	1S254 1S255		1S296 1S297
100~120			⁑1Z110	1S256~258		1S298~300
120~140				1S259 1S260		1S301 1S302
140~170			⁑1Z150	1S261		1S303
170~200			⁑1Z180			
200~400			⁑1Z330 ⁑1Z390			

⁑:New product

05Z Series (500mW)

Type	Zener Voltage						Measurement Current
	X		Y		Z		Iz(mA)
	MIX.	MAX.	MIX.	MAX.	MIX.	MAX.	
05Z2.0	1.88	2.12			2.05	2.24	10
05Z2.2	2.08	2.33			2.20	2.45	10
05Z2.4	2.28	2.55			2.45	2.70	10
05Z2.7	2.50	2.75	2.65	2.95	2.85	3.10	10
05Z3.0	2.80	3.05	2.95	3.25	3.15	3.40	10
05Z3.3	3.10	3.35	3.25	3.55	3.45	3.70	10
05Z3.6	3.40	3.65	3.55	3.85	3.75	4.00	10
05Z3.9	3.70	3.95	3.85	4.20	4.10	4.40	10
05Z4.3	4.00	4.35	4.25	4.60	4.50	4.80	10
05Z4.7	4.40	4.75	4.65	5.00	4.90	5.20	10
05Z5.1	4.80	5.10	4.95	5.25	5.10	5.40	5
05Z5.6	5.30	5.60	5.50	5.80	5.70	6.00	5
05Z6.2	5.80	6.15	6.00	6.35	6.25	6.60	5
05Z6.8	6.40	6.75	6.65	7.00	6.85	7.20	5
05Z7.5	7.10	7.46	7.34	7.70	7.54	7.90	5
05Z8.2	7.70	8.10	7.96	8.40	8.26	8.70	5
05Z9.1	8.60	9.05	8.85	9.30	9.15	9.60	5
05Z10	9.40	9.90	9.75	10.25	10.10	10.60	5
05Z11	10.40	10.95	10.65	11.20	11.05	11.60	5
05Z12	11.40	11.95	11.70	12.25	12.05	12.60	5
05Z13	12.40	13.10	12.90	13.60	13.40	14.10	5
05Z15	13.90	14.65	14.40	15.15	14.85	15.60	5
05Z16	15.40	16.15	15.90	16.65	16.35	17.10	5
05Z18	16.90	17.80	17.55	18.45	18.20	19.10	5
05Z20	18.80	19.80	19.50	20.50	20.20	21.20	5
05Z22	20.80	21.80	21.50	22.50	22.30	23.30	5
05Z24	22.80	24.00	23.50	24.70	24.40	25.60	5
05Z27	25.1	26.5	26.3	27.7	27.5	28.9	5
05Z30	28.0	29.6	29.3	30.8	30.4	32.0	5
05Z33	31.0	32.7	32.2	33.9	33.3	35.0	5
05Z36	34.0	35.7	35.2	36.9	36.3	38.0	5
05Z39	37.0	38.8	38.1	39.9	39.2	41.0	5
05Z43	39.0	42.0	41.0	45.0	44.0	47.0	5
05Z47	43.0	46.0	45.0	49.0	48.0	51.0	5
05Z51	47.0	50.5	49.5	53.5	52.5	56.0	5
05Z56	51.0					62.0	5
05Z62	56.0					68.0	5
05Z68	62.0					75.0	5
05Z75	68.0					82.0	5
05Z82	75.0					91.0	5
05Z91	82.0					100	5
05Z100	91.0					110	5

Bidirectional Zener Diode

Vz Typical Value (V)	1W Type (Resin Mold Type)	Vz Typical Value	1W Type (Resin Mold Type)
17~24		72~140	⁑1ZM100
24~35	⁑1ZM27	140~200	⁑1ZM180
35~72	⁑1ZM47	200~400	⁑1ZM330 ⁑1ZM390

1ZM30 and 1ZM50 are also available.
⁑ :New product

Variable Capacitance Diode

Tuning

Type	Package	V_R (V)	C_T (pF)		C_T (pF)		Application
				V_R(V)		V_R(V)	
1SV100	Mini	15	450~600	1	20~33	9	AM car radio, portable radio
1SV101		15	28~32	3	12~14	9	FM car radio,portable radio
1SV102		30	360~460	2	15~21	25	AM Hi-Fi tuner
1SV103		35	37~42	3	13.2~16.2	25	FM Hi-Fi tuner
1SV147		15	28.5~32.5	3	11.7~13.7	8	FM car radio,portable radio
1SV149		15	435~540	1	14.9~30.0	8	AM car radio,portable radio
1SV75	1-5G1A	28	26~32	3	4.5~6.0	25	VHF TV tuner
1SV123		30	12.04~13.63	3	2.172~2.454	25	VHF, UHF TV tuner
1SV153	1-2J1A	30	14.16~16.25	2	2.11~2.43	25	VHF, UHF TV tuner
1SV138	1-5G1A	30	26~34	2	2.4~3.2	25	CATV tuner

AFC

Type	Package	V_R (V)	C_T (pF)		Application
				V_R(V)	
1S2094	DO-35	18	7~11	4	VHF、UHF TV AFC
1S2236	DO-35	15	7~14	4	FM tuner AFC

PIN Diode

Type	Package	V_R (V)	I_F (mA)	r_S (Ω)	I_F(mA)	f(MHz)	Application
1S2186	DO-35	20	100	1.0Max	10	100	VHF、UHF TV Band SW
1SV99	Equivalent to To-92	50	50	10Max	10	100	Variable ATT、ANT SW、FM AGC
1SV128	Equivalent to TO-236	50	50	7(TYP)	10	100	VHF、UHF Band SW Variable ATT
1SS155	1-2G1A	30	100	0.9Max	2	100	VHF、UHF TV Band SW

Mixer Diode

Type	Structure	Application
1SS154	Si Epi-pl, Schottky barrier	UHF-C band mixing, detection

Miscellaneuous

Type	Application
1S144	Meter protection
1S2093	Trigger diode triode AC switch turn on

Magnetic Electric Transducer (Hall Effect Device)

Type	Structure	Application
THS102A	Ga-As ion impla planar	Magnetic-electric transducer
THS103A	Ga-As ion impla planar	Magnetic-electric transducer

EXPLANATION

Ratings of Transistors

1. Maximum ratings of transistors

The maximum allowable limits of currents, suppliable voltage, and power dissipation are defined as the maximum ratings for each kind of transistor.

The maximum ratings of transistors are one of the most important factors in determining the effective transistor drive and in expecting sufficiently high reliability of transistor circuits over intended periods of operation.

The most typical characteristic inherent to transistors, diodes, and other semiconductors is the temperature dependency of their electrical properties. Maximum ratings for semiconductors are mostly determined based on a thermal variation of electrical properties. For example, should the ambient temperature be increased while supplying constant voltage to a transistor, such an increase of ambient temperature in turn will increase conductivity of the transistor or current flow in the device. Thus, increased power dissipation of the transistor further raises the device temperature and increases the current. This endless circulation of temperature rise and current increase will finally result in thermal runaway and eventual damage to the device.

Transistor maximum ratings constitute those strict limits which must not be exceeded, in any phase, to assure long service life and high reliability of the transistors. Ratings, which are dependent on materials, structure, design, and fabricating conditions of transistors, differ according to the kinds. In principle, maximum ratings are regarded as absolute maximum ratings.

The term "absolute maximum rating" refers to a value that the operating conditions must not exceed at any phases—even momentarily. Should more than one item be determined as having an absolute maximum rating, neither of them should be applied to the transistor simultaneously.

Should an absolute maximum rating be exceeded, the properties of the transistor may not be recovered in certain instances. When designing a transistor circuit, care must be exercised not to exceed any of the absolute maximum ratings, while taking into account fluctuation of the supply voltage, deviation in properties of the electrical components, exceeding the maximum ratings while adjusting the circuits, variations in ambient temperature, and fluctuations of input signals.

Major items for which maximum ratings must be determined included the emitter, base, and collector currents, voltages between electrodes, power dissipation, junction temperature, and storage temperature of transistors. Because of the close correlation among these properties, none of these ratings can be considered independently of each other; the ratings are largely dependent on external connections.

2. Voltage ratings

Transistors are composed of input and output circuits by using one of the electrodes—namely, emitter, base, or collector —as the common terminal. Consequently, voltage ratings for transistors are rated as collector-to-base voltage (V_{CB}), collector-to-emitter voltage (V_{CE}), or emitter-to-base voltage (V_{EB}).

Breakdown voltages which determine voltage ratings are classified into those inherent to individual transistors ($V_{(BR)CBO}$, $V_{(BR)CEO}$, and so on) and those dependent on input circuit conditions ($V_{(BR)CER}$, $V_{(BR)CEX}$, and so on). Generally, the breakdown voltage is a function of the individual characteristics of the circuit and the transistor.

(1) Voltage ratings of collector

Since transistors are normally used in a common base or in a common emitter mode, ratings for collector voltages are most importance to these operation modes.

Fig. 1 reveals a breakdown of collector voltages in various operation modes; the breakdown voltages shown therein may be defined as follows:

$V_{(BR)CBO}$: maximum collector-to-base voltage with the emitter opened

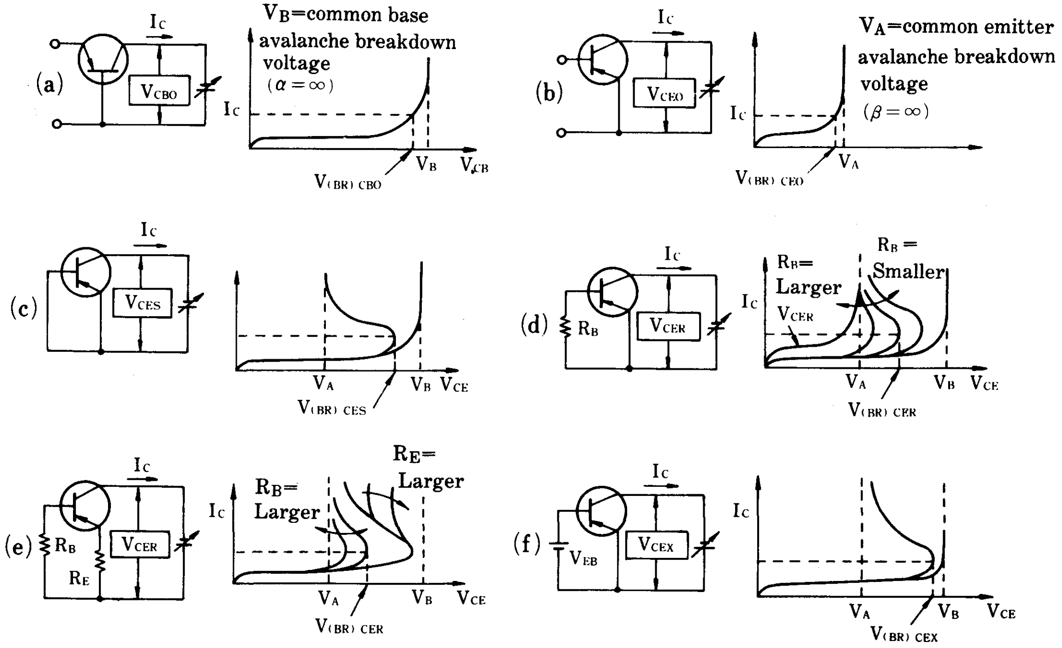


Fig. 1 Maximum collector voltage

$V_{(BR)CEO}$: maximum collector-to-emitter voltage with the base opened

$V_{(BR)CES}$: maximum collector-to-emitter voltage with the emitter and the base short-circuited

$V_{(BR)CER}$: maximum collector-to-emitter voltage with a resistance R between the emitter and the base

$V_{(BR)CEX}$: maximum collector-to-emitter voltage with reverse bias voltage applied between the emitter and the base

When comparing magnitudes of these breakdown voltages, they may be arranged in the following order, although no significant difference is seen between $V_{(BR)CBO}$ and $V_{(BR)CES}$:

$$V_{(BR)CBO} > V_{(BR)CES} > V_{(BR)CEX} > V_{(BR)CER} > V_{(BR)CEO}$$

(a) Maximum collector-to-base voltage with the emitter opened, $V_{(BR)CBO}$

Common base avalanche breakdown voltage—

Maximum collector-to-base voltage with the emitter opened, $V_{(BR)CBO}$ is equivalent to diode characteristics between the collector and the base. When reverse bias voltage is applied between the collector and the base, small leakage current I_{CBO} flows between them. By increasing such bias voltage, the depletion layer is expanded on both the collector and the base sides. After this process is repeated over and over, in which a small amount of carrier accumulates high energy from this accelerated electric field and collides with Ge or Si atoms to finally produce electrons and holes, a so-called avalanche multiplication phenomenon is produced in which a large amount of free carriers are produced, causing large current to flow rapidly.

This avalanche breakdown phenomenon restricts the maximum suppliable voltage applicable to a transistor.

When avalanche multiplication is present, the multiplication factor M of multiplication in junction-type transistors is experimentally represented by

$$M = \frac{1}{1-\left(\frac{V_{CB}}{V_B}\right)^n} \cdots\cdots\cdots\cdots\cdots\cdots\cdots (1)$$

The total current amplification factor α is represented by—

$$\alpha = \alpha_0 \cdot M \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (2)$$

Where,

V_B= true avalanche breakdown voltage

V_{CB}= voltage applied between collector and base

α_0= common base current amplification factor in voltage where no avalanche multiplication occurs

n= Figure determined by the type of transistor; 3—4 for Ge PNP transistors, 4—7 for Ge NPN transistors, 2—4 for Si PNP transistors, and 2—3 for Si NPN transistors.

V_B is determined by a concentration of impurities on the high resistance side; the higher the concentration, the smaller becomes the V_B.

It is this V_B that definitely determines the maximum value of withstand voltage of a transistor. However, in manufacturers' catalogs, maximum ratings for transistors are usually described by using $V_{(BR)CBO}$ to represent a voltage at which the collector current reaches a predetermined value. In general, the stated value $V_{(BR)CBO}$ is smaller than V_B of the transistor.

The thermal coefficient of V_B is positive because it is related to mobility of a carrier. However, the $V_{(BR)CBO}$ may become smaller in the low-current region at high temperatures, because I_{CBO} rises in accordance with the temperature rise.

When constant input current is supplied to the emitter of a common base transistor, the collector current Ic is—

$$I_C = \alpha I_E + M I_{CBO} \cdots\cdots\cdots\cdots\cdots\cdots\cdots (3)$$

(b) Maximum collector voltage in open-base common emitter connection $V_{(BR)CEO}$ —avalanche breakdown voltage in common emitter connection V_A—

Avalanche breakdown of a common emitter transistor occurs at a collector voltage in which the common emitter current amplification factor β becomes infinite. The factor β can be represented as a function of α_0 and expressed as—

$$\beta = \frac{\alpha_0 M}{1-\alpha_0 M} \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (4)$$

The factor β becomes infinite when $\alpha_0 M=1$ or $M=1/\alpha_0$. In other words, as the collector voltage V_{CB} is low, collector current is mostly supplied by the base. But, at a certain collector voltage V_A, which is sufficiently high to create an avalanche phenomenon, the amount of carriers caused by electron multiplication becomes equal to that ($\gamma\beta_0=\alpha_0$) injected from the emitter, due to emitter efficiency γ reaching the depletion layer with the conductivity rate β_0. Base current to support the collector current then becomes unnecessary, or $\beta=\infty$, and avalanche multiplication occurs.

At this point, from $M=1/\alpha_0$ and from equation (1)—

$$\alpha_0 = 1-\left(\frac{V_{CB}}{V_B}\right)^n \cdots\cdots\cdots\cdots\cdots\cdots (5)$$

In developing equation (5) for the collector voltage or the common emitter avalanche breakdown voltage V_A at which $\alpha_0 M=1$—

$$V_A = V_B \sqrt[n]{1-\alpha_0} \cong V_{(BR)CEO} \cdots\cdots (6)$$

For collector voltages smaller than V_A, base current flows forward; the polarity of β is positive. On the other hand, for voltages larger than V_A, base current flows in reverse; the polarity turns to negative.

The relationship between β and the total current amplification factor α is shown in Fig. 2 as a function of the collector voltage.

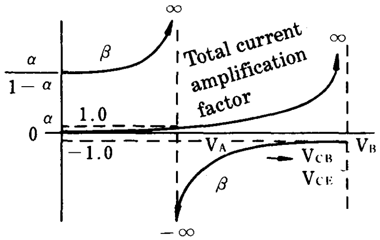


Fig. 2 Current amplification factor and collector voltage

When the input base current is retained constant, collector current I_C of a common emitter transistor is represented by the formula—

$$I_C = \beta I_B + (\beta+1) M I_{CBO} \cdots\cdots\cdots\cdots (7)$$

Temperature dependency of $V_{(BR)CEO}$ is determined by that of V_B, α_0, and I_{CBO} (I_{CEO}); the polarity cannot be defined uniformly.

(c) Common emitter voltage rating as a function of circuit configuration—
$V_{(BR)CER}$, $V_{(BR)CES}$, $V_{(BR)CEX}$

When a transistor is operated with a resistor R_B inserted between the base and the emitter, the total collector leakage current MI_{CBO} flows through the internal base resistance r_b and external resistor R_B. When the emitter junction is forward-biased (or when its voltage becomes larger than the contact voltage Vd), emitter injection occurs; also, breakdown occurs between the collector and the emitter. The voltage $V_{(BR)CER}$ at this moment is represented by the equation—

$$V_{(BR)CER} = V_B{}^n\sqrt{1-\frac{I_{CBO}(R_B+r_b)}{V_d}} \qquad (8)$$

V_{CER} is in reverse proportion to R_B; the breakdown voltage takes the largest value when $R_B=0$. When R_B is zero, voltage is expressed as base-to-emitter short-circuit breakdown voltage, or $V_{(BR)CES}$; (See Fig. 1-c)

When the base is opened (or $R=\infty$), operation of the transistor is controlled by β. All of the leakage current MI_{CBO} flows through the base and forms a collector current equal to $(\beta+1)MI_{CBO}$. Breakdown voltage occurs at a collector-to-emitter voltage where $\beta \rightarrow \infty$. This is the voltage previously defined as V_A (common emitter avalanche breakdown voltage).

Breakdown voltage corresponding to other values of R_B is larger than V_A but smaller than V_B. In other words, after emitter injection starts, total current amplification factor ($=\alpha_0 M$) becomes larger than 1, causing β to change to negative. Figure 2 shows that the negative values of β increase with a reduction of V_{CB}, in the region where V_{CE} is larger than V_A. At the breakdown point, emitter injection occurs and Ic increases suddenly. This increase in Ic reduces collector voltage Vc due to a voltage drop across terminal resistance. A decrease of Vc increases β and Ic.

This effect is accelerated accumulatively, and the transistor represents a negative resistance. Vc approximates V_A where $\beta \rightarrow \infty$.

Figure 3(a) reveals the characteristics of R_B and the breakdown voltage; Fig. 3(b) shows the relationship between $V_{(BR)CER}$ and R_B and that between I_{CER} and R_B. These figures represent the same characteristics.

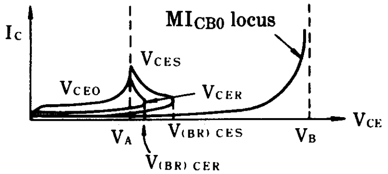


Fig. 3 (a) Characteristics of R_B and breakdown voltage

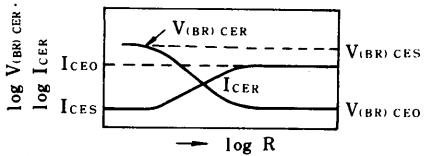


Fig. 3 (b) Characteristics of $V_{(BR)CER}$, I_{CER} and R_B

If R_E is inserted in the emitter side as shown in Fig. 1(e), the negative feedback by R_E increases the avalanche voltage R_A as represented by the equation—

$$V_A' = V_B{}^n\sqrt{1-\frac{\alpha_0 R_B}{R_B+R_E}} \cdots\cdots\cdots\cdots\cdots (9)$$

If the emitter/base is reverse-biased by using V_{EB} as shown in Fig. 1(f), the voltage takes the maximum value when emitter injection occurs, similarly to $V_{(BR)CER}$; it approximates V_A thereafter, displaying negative resistivity characteristics.

The maximum voltage thus obtained, namely V_{CEX}, is obtained by the following formula and is larger than $V_{(BR)CES}$:

$$V_{(BR)CEX} = V_B{}^n\sqrt{1-\frac{I_{CBO}\cdot r_b}{V_d+V_{EB}}} \cdots\cdots (10)$$

(2) Voltage ratings of emitter

Maximum emitter voltage with the collector opened, $V_{(BR)EBO}$, is similar to the above-mentioned $V_{(BR)CBO}$ in terms of essential. However, it is only a few volts in conventional types of transistors because the concentration of impurities is high in the emitter. Unlike the avalanche breakdown previously mentioned, zener breakdown caused by a tunnel effect is produced if breakdown voltage is around 6V or less. Care must be exercised if the base/emitter is reverse-biased at higher voltage; otherwise transistor characteristics will be deteriorated or damaged.

(3) Measuring the voltage ratings

The maximum voltage of a transistor is obtained by measuring the voltage which appears between the specified electrodes when supplying a specified current to specified electrodes under specified conditions. Such measurement is usually effected by regulating the peak current of sinusoidal half-wave to a specified value.

Always refrain from conducting this test by using direct current; otherwise is will thermally breakdown the elements.

3. Current ratings

The current ratings for a transistor include the maximum value of current suppliable in the emitter I_{Emax} forward direction and that which is suppliable in the collector I_{Cmax} reverse direction. Generally speaking, $I_{Cmax} = I_{Emax}$ in most instances. Thus, current ratings are usually determined by duly considering the following items:

(1) Current at which internal power dissipation does not exceed a rated value even though limited collector saturation voltage exists—namely, the current at which junction temperature does not exceed a rated value.

(2) Current at which DC amplification factor h_{FE} is lowered to 1/2~1/3 or less of a peak value—namely for switching purposes, $h_{FE} \cong 10$ for medium-power transistors or $h_{FE} \cong 3$ for large-power transistors.

(3) Current at which internal leads are blown off—The maximum value of the base current I_{Bmax} generally takes the value—$I_{Bmax} \cong 1/2 \sim 1/6 \times I_{Cmax}$.

4. Temperature ratings

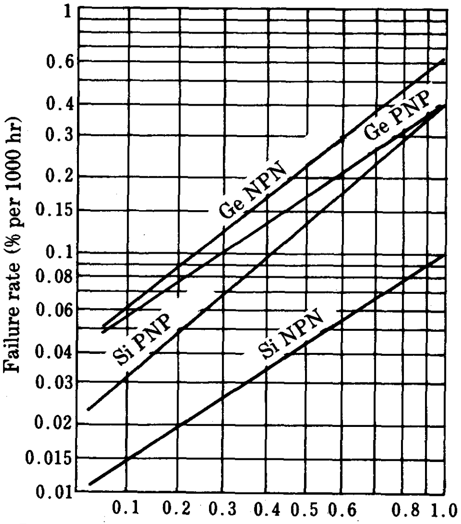
Maximum junction temperature T_{jmax}, specified in accordance with the quality of component materials and their reliability, should be determined by duly considering the characteristics related to reliability (such as deterioration and service life), and not by refering solely to operability.

Generally speaking, transistor deterioration is more accelerated if the junction temperature is higher. The following relationship is found between the average service life Lm (hours) and the junction temperature Tj (°K), with A and B as constants inherent to transistors.

$$\log L_m \fallingdotseq A + \frac{B}{T_j} \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (11)$$

Therefore, the upper limit for allowable junction temperature based on defect ratios and reliability of components is specified for transistors whose long service life must be guaranteed ... 70 ~ 90°C for Ge transistors, 100 ~ 150°C for Si transistors, and 150 ~ 200°C for Si planar transistors whose surface is stabilized.

Storage temperature T_{stg} indicates the temperature range in which a transistor can be stored without causing the transistor to operate. This is also specified according to the quality of component materials and reliability. Fig. 4 reveals the relationship between failure rate and junction temperature of transistors.



Junction temperature Ta regulated by standard temperature To

$$T_a = \frac{T_j - T_o}{T_{j\,max} - T_o}$$

Fig. 4 Relationship between failure rate and junction temperature of transistors (based on MIL-HDBK-217A)

5. Power ratings

Power dissipated in a transistor is converted into thermal energy which in turn causes a temperature rise.

Internal power dissipation of a transistor operating at a certain operating point is represented by the sum of the collector loss $I_C \cdot V_{CB}$ and the emitter loss $I_E \cdot V_{BE}$. Normally, however, it is determined by the collector loss $P_C = I_C V_{CB} \cong I_C V_{CE}$, since the emitter junction is forward-biased—thereby $V_{CB} > V_{BE}$ and $I_C \cong I_E$.

Major parameters limiting maximum power dissipation P_{CMAX} include the maximum allowable junction temperature T_{jmax} and the standard temperature To (ambient temperature Ta or case temperature Tc); it is well known that these parameters are related to each other in the following manner by thermal resistance θ (or R_{th}) —

$$P_{Cmax} = \frac{T_{j\,max} - T_O}{\theta} \quad \cdots\cdots\cdots\cdots\cdots (12)$$

Thermal resistance is a physical value representing the ratio of junction temperature rise per unit-power dissipation—or in other words, a difficulty in exhausting heat. Thus, it is necessary to select a transistor with a large P_{Cmax} to assure large power dissipation. It is very important to rationally design heat radiation in power transistors.

Maximum ratings P_{Cmax} stated in manufacturers' catalogs or other materials generally represent those at normal ambient temperature (Ta = 25°C) or those at Tc = 25°C if use of a radiator is expected. It is possible to obtain thermal resistance between the transistor junction and the environmental temperature, or between junction and case by using former equation (12).

6. Derating

Transistor circuits may be designed by using the maximum ratings of voltage, current, and power (junction temperature) stated in a manufacturer's catalog and by establishing appropriate heat radiating conditions. However, it is a common practice to derate to a considerable extent the operating conditions of high-reliability circuits.

To balance both system reliability and economy, the following derating is recommended:

- Voltage: Voltages at worst operating conditions (including surge voltage) should be 80% or less of maximum rated voltage (especially V_{CEO}).
- Current: Currents at worst operating conditions (including surge current) should be 80% or less of rated value.
- Power: Power dissipation at worst conditions (including surge) should be 50% or less of derated maximum allowable loss at the maximum ambient temperature of equipment.
- Temperature: The operating maximum junction temperature T_{jp} when considering surge and power concentration should be 70—80% or less of the rated maximum junction temperature T_{jmax}.

To calculate the power dissipation of transistors for switching use, the peak values of voltage, current, and power—as well as junction temperature, including surge conditions—must not exceed maximum ratings. However, average power dissipation will sufficiently support system reliability if derating is effected by taking reliability into account.

7. Safe Operating Area (SOA)

The safe operating area represents that area where a transistor retaining high reliability can be used without suffering destruction or deterioration.

Usually, the operating limit of a transistor is determined by its maximum ratings—such as maximum voltage, current, and collector loss. However, when using power transistors in a high-power amplifier or a circuit having an inductive load, deterioration of characteristics or destruction may sometimes result even when they are operated within the maximum ratings. This is caused by secondary breakdown (S/B) of the transistor.

Ever since this phenomenon was first discovered in 1958 by C.G. Tharnton and C.D. Simmons, additional consideration has been required for the concept of SOA, as well as for maximum ratings, when determining the operating limits of a transistor.

It would be very difficult to design high-reliability, economical transistor circuits without properly comprehending the SOA concept as mentioned above.

(1) Secondary breakdown (S/B) phenomenon

As shown in Fig. 5, the secondary breakdown phenomenon further increases current following the primary breakdown. When the current reaches a certain volt-ampere point ($V_{S/B}$, $I_{S/B}$), voltage between the collector and the emitter rapidly drops, descending to a low-impedance area within several microseconds or less, frequently causing destruction of a transistor.

Such a phenomenon may be observed when the base-emitter bias is in a forward or reverse direction, as well as at V_{CEO} or V_{CBO}; If the base bias condition differs, however, the S/B inrush point ($V_{S/B}$, $I_{S/B}$) will vary and align on the locus of the S/B curve shown in Fig. 5. This figure applies to DC. Since the inrush to the S/B possesses an energy dependency, the S/B curve varies in accordance with pulse width of the impressed pulse.

This curve determines an SOA for impressed pulses. Fig. 6 shows the relationship between the pulse width of impressed power and S/B. As the pulse width becomes smaller, the S/B power increases, while the S/B energy decreases. (S/B energy is termed "triggering energy", which implies energy absorbed by a transistor before the energy rushes into the S/B.)

Although various explanations have been given regarding the causes of this S/B, it is generally accepted as an established theory at present that a hot spot is created by a local concentration of current, and causes local thermal runaway. The possible causes for current concentration phenomena are assumed to be a fall of electric potential or instability of laterial temperature distribution in the base area.

Sometimes current will be concentrated when a lack of uniformity of the base width, faulty junction, or unbalanced mounting of the chip on the header material serves as a trigger.

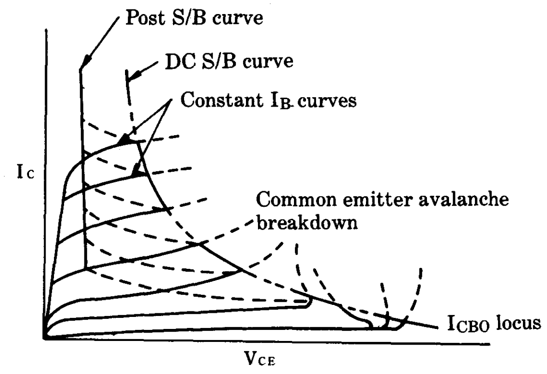


Fig. 5 Collector output characteristics and S/B curve

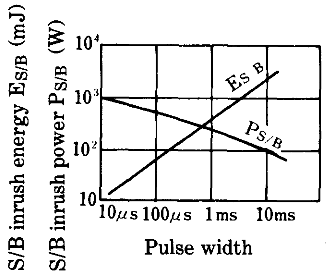


Fig. 6 Relationship between pulse width and $E_{S/B}$, $P_{S/B}$

(2) Forward biased S/B

When forward bias exists between the base and the emitter, a hot spot as a result of local current concentration is created on the emitter periphery.

This is because a fall of electric potential occurs in the base area as a result of the base current immediately flowing laterally below the emitter, and because the emitter periphery is more strongly biased than its center. Therefore, a minority carrier supply to the base is concentrated around the emitter periphery, and the current density rises higher there, as shown in Figs. 7(a) and 7(b).

When this carrier passes through the depletion layer of the collector, it causes a power loss, which leads to local heating, creating a repetition that results in a concentration of current, forming of a hot spot, and S/B.

(Relationship between S/B and transistor characteristics) Current at the inrush point $I_{S/B}$ during the forward bias is closely related to transistor characteristics. When the carrier supplied from the emitter to the base region arrives at the collector junction, it is usually fanned out in a cone-shaped pattern. Therefore, when the transit time of the carrier in the base region becomes longer, the current density becomes lower when it arrives at the collector depletion layer, due to this fan-out effect. And resulting in a hot spot hard to cause. This transit time of the carrier depends on the base width and drift field in the base region. Consequently, $I_{S/B}$ is storongly related to frequency characteristics of a transistor. A negative correlation exists between f_T and $I_{S/B}$ irrespective of the pulse width.

This relationship is shown in Fig. 8 below.

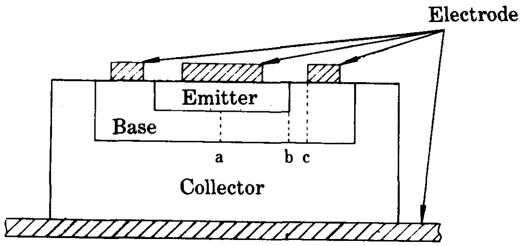


Fig. 7 (a) Planar type transistor

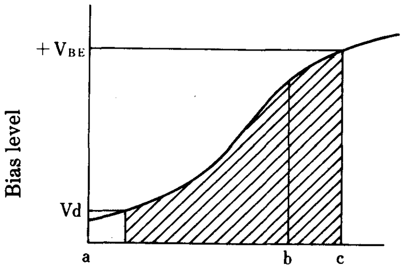
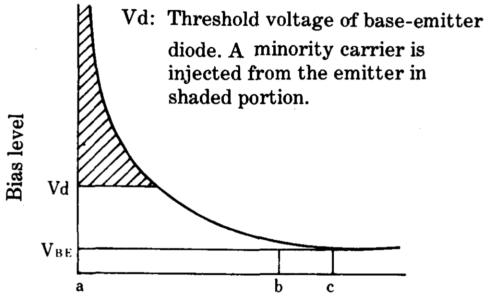
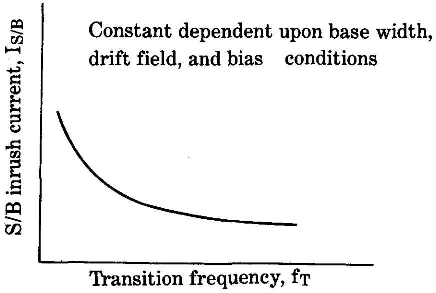


Fig. 7 (b) Emitter voltage (forward bias)



Vd: Threshold voltage of base-emitter diode. A minority carrier is injected from the emitter in shaded portion.

Fig. 7 (c) Emitter voltage (reverse bias)



Constant dependent upon base width, drift field, and bias conditions

Fig. 8 Relationship between $I_{S/B}$ and f_T

(3) Reverse biased S/B

When reverse bias exists between the emitter and the base the direction of a fall of electric potential in the base region becomes contrary to that during forward bias.

Therefore, the carrier supplied from the emitter is concentrated on the center of the emitter. See Fig. 7(c). (The extent of this carrier concentration varies according to the type of transistor. For a ring-shaped emitter, pattern, the carrier concentrates on one point of the emitter center. For a combshaped emitter pattern, it concentrates on one line at the emitter center.)

When reverse bias is higher, the area of concentration at the emitter center becomes smaller. Consequently, triggering energy (energy absorbed by a transistor before it rushes into S/B) during reverse bias becomes far smaller than that during forward bias. The carrier supplied from the emitter, similarly to the case of the forward bias mentioned above, is also fanned out; thus, the base width and the existence of a drift field in the base region are closely correlated with S/B.

Reverse bias S/B occurs mostly in the case of an inductive load. The triggering energy $E_{S/B}$ depends on conditions lying between the base/emitter and the inductance L, as shown in Fig. 9.

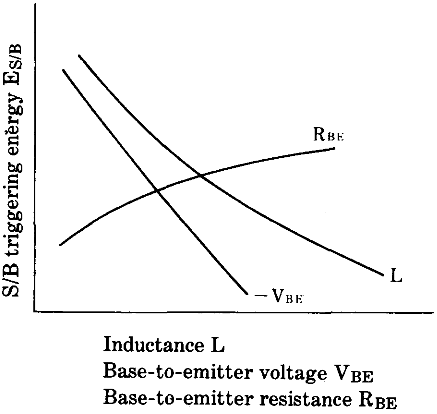


Fig. 9 Dependency of S/B triggering energy $E_{S/B}$ on load inductance and base-to-emitter condition

(4) S/B phenomenon and destruction or deterioration of transistors

Influences of the S/B phenomenon on the electrical characteristics of transistors vary depending on the types of transistors.

If the impressed power is small, or if the power supply is interrupted at the moment S/B occurs, unusual changes may or may not occur in the electrical characteristics, or a transistor may become deteriorated very slowly, even when S/B is caused to occur repeatedly.

Care must be exercised, however, because some transistors are destroyed when they are subjected to S/B just once. Electrical characteristics upon transistor deterioration or destruction due to S/B generally reveal the following aspects: maximum values of V_{EBO}, V_{CBO}, and V_{CEO} usually become lower, or one of them is often short-circuited. Especially, a short circuit between the emitter and the collector indicates a characteristic deterioration of S/B, where a melted spot is formed running from the emitter to the collector. Otherwise, durability against S/B is sometimes reduced even though the electrical characteristics remain unchanged. This is caused by a smaller S/B trigger energy $E_{S/B}$ mentioned above, thereby indicating that the transistor may be easily destructed.

8. Measurement of SOA

Various methods have been proposed for measuring the SOA. Parameters in selecting an appropriate method include circuit configuration, transistor operating conditions, and other factors.

When attempting to directly measure the SOA, in some cases transistors may be deteriorated or destroyed. Thus, for confirming the SOA, it is recommended that the operating conditions of a transistor be measured immediately before the current rushes into the secondary breakdown.

There are three typical methods available for measuring the SOA—

(1) S/B method

(2) Latching method

(3) Transient thermal resistance method

Actual examples of these measuring methods are described subsequently herein.

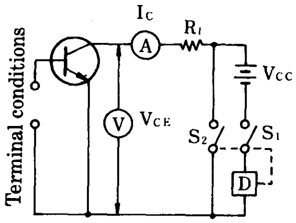
(1) S/B method

This is a methods for actually measuring S/B inrush values by supplying voltage and current between the collector and the base or between the collector and the emitter of a transistor. (See Figs. 10 and 11.)

When applying this methods, a transistor may become deteriorated unless it is mounted in a high-performance protective circuit.

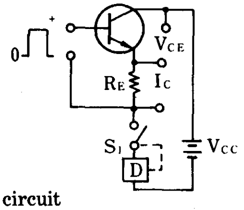
There is another way termed the $T_{S/B}$ method, which is an improved version of the S/B method.

Fig. 12 shows the $T_{S/B}$ method which is a measuring circuit for obtaining a forward-biased SOA when the time of supplied pulse is comparatively long or when using a current similar to DC. A transistor is operated by applying V_{CE} and I_C under a specified temperature (case temperature or ambient temperature) while forward-biasing between the emitter and the base. Measured by this method is the operating time required until I_C fluctuates more than ±10% or exceeds the specified final value. By repeating this measurement to obtain operating time in combinations of I_C and V_{CE}, and by drawing a graph with the operating time as a parameter on the curve of I_C and V_{CE}, the SOA can be obtained.



D: S/B detecting and protective circuit
S1, S2: Switches to be actuated by signals from D

Fig. 10 DC-supplied S/B method.



D: Detecting circuit
S1: Switch to be actuated by the signals from D

Fig. 11 Pulse-supplied S/B method (pulse to be supplied between emitter and base)

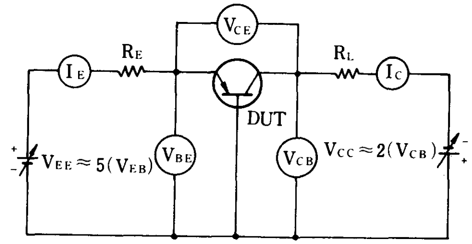


Fig. 12 Forward-biased SOA measuring circuit ($T_{S/B}$ methods)

(2) Latching method

This is a method for measuring the SOA of a transistor by setting it under specified conditions after keeping it in a saturated area under constant current or inductive load conditions.

It is possible to observe oscillation phenomena which occur when the S/B is started by using this method. (Fig. 13)

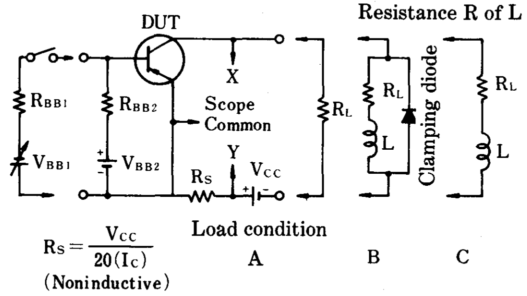
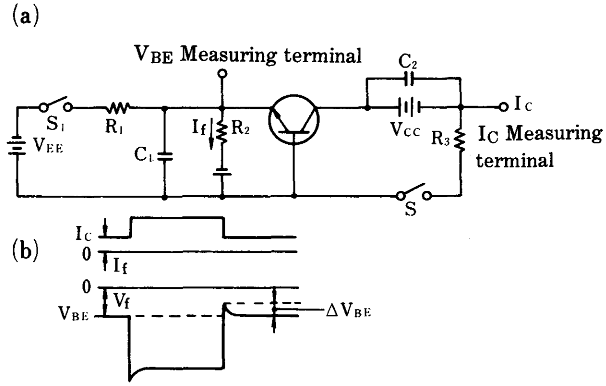


Fig. 13 Reverse-biased SOA measuring circuit (latching method)

(3) Transient thermal resistance method (ΔV_{BE}, ΔV_{CE} method)

Since S/B is regarded as a local temperature rise in the junction of a transistor, the S/B inrush condition can be determined by measuring the junction temperature. Fig. 14 illustrates a typical example. Measure the temperature coefficient of junction forward voltage in advance. The temperature rise in a junction can be obtained by measuring the difference between forward voltage before and after supplying power, transient thermal resistance thus being obtained.



ΔV_{BE}: Temperature drop as a result of power supply suspension

S1, S2: Switches to be actuated depending on conditions of the V_{BE} measuring terminal

Fig. 14 Transient thermal resistance method (ΔV_{BE} method)

This method displays an apparently narrower SOA compared with the two methods mentioned above, and cannot be used to measure reverse-biased SOA.

9. SOA of forward-biased transistors

Fig. 15 and 16 show examples of the SOA of forward-biased transistors.

The SOA implies that the safety operation of a transistor is assured when it is used within the indicated range.

The DC regions of these figures are applied to transistor operations in a DC circuit. A pulse-driven transistor may be used at larger power dissipations as shown in the pulse region of these figures, but safe operation of the transistor is assured only within the given pulse duration.

As shown in Figs. 15 and 16, the lower voltage region shows the thermal resistance limitation while the higher voltage region is limited by S/B. In the thermally limited region, the collector loss Pc is constant and $I=PV^{-1}$; thus, the thermal limitation gradient is -1 when plotted on a logarithmic graph. On the other hand, collector loss in the S/B limited region deviates from the iso-power line of the Pc= constant. The gradient ranges from −1.5 to −4 according to the types of transistors. Note that the relationship of $I_{S/B}=PV^{-N}$ reduces the allowable collector dissipation.

Since the transistor SOA is reduced with a temperature rise, a derating curve shown in Fig. 17 must be used.

When temperature rises, the SOA is far more affected by thermal limitation than by the S/B limitation. Fig. 17 reveals an example of a derating curve for the S/B limitation and the thermal limitation ranges, as a perameter of case temperature. The SOA for transistor 2SA473 shown in Fig. 15 is, at $T_C=100°C$., rendered as narrow as shown by the dashed lines in Fig. 15. This is because the thermally limited and S/B limited regions are derated by 40% and 49% respectively according to the derating curve shown in Fig. 17 (b). For transistor 2SD526 shown in Fig. 16, where V_{CE} is lower and in the thermally limited region, the derating ratio based on thermal limitation must be considered.

Thermal derating ratio in the S/B limited region differs according to the structure of transistors, as shown in Fig. 17. If V_{CE} is high voltage and within the S/B limited region, derating is effected by using the derating curve of the S/B limitation shown in Fig. 17.

Taking as an example transistor 2SD526, illustrated in Fig. 17, the derating ratio d_T is shown as follows for the thermally limited region provided that the case temperature of the transistor Tc=60°C:

$$d_T=\frac{100}{T_{j\,max}-25}(T_{j\,max}-T_C)\% \quad \cdots\cdots (14)$$

By substituting $T_{j\,max}=150°C$, $d_T=72\%$.

Concerning the derating ratio in the S/B limited region ($d_{S/B}$), 2SD526 must be derated by 50% at 150°C because it is a triple diffused mesa transistor; thus, $d_{S/B}=2/5\ (150-Tc)+50\%$. And $d_{S/B}$ at Tc=60°C is 86%.

In conclusion, it is derated by $d_T=72\%$ and $d_{S/B}=86\%$ at Tc=60°C. This is indicated in Fig. 16 by using dashed lines.

10. SOA of reverse-biased transistors

The SOA of reverse-biased transistors cannot be determined so simply as that of forward-biased transistors. However, the SOA in this direction is as important as that in the forward-biased direction because high collector voltage is supplied frequently to a transistor in an inductance-loaded switching circuit, a horizontal deflection output circuit of TV receivers, or a DC-DC converter, while the base-to-emitter voltage is biased in the reverse direction.

In such operations, the worst load conditions are given by an inductive load. The SOA of reverse-biased transistors is ordinarily ob-

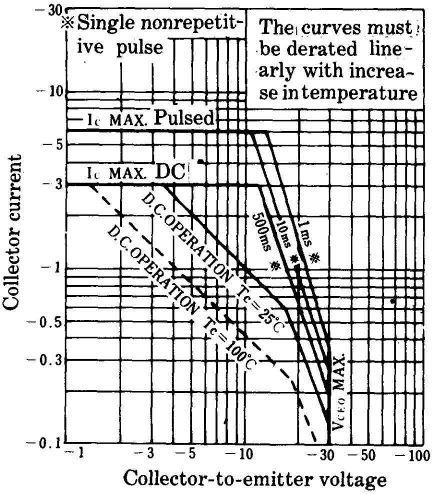


Fig. 15 SOA for 2SA473

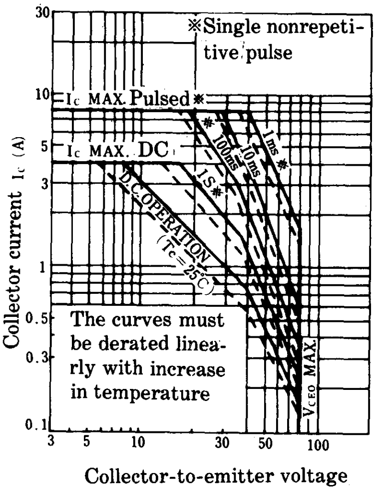
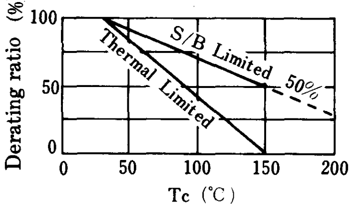


Fig. 16 SOA for 2SD526 and an example of derated SOA at Tc = 60°C

(a) Triple diffused type



(b) Epitaxial type

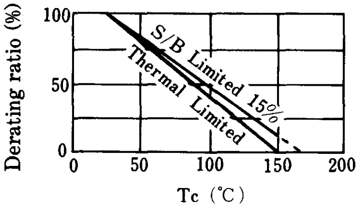


Fig. 17 Thermal derating of the SOA

Note: The above figures shown examples of thermal derating of the SOA for thermally and S/B-limited regions by types of transistor structures.
For a concept of the thermal derating of the SOA, refer to this section on "The SOA of forward-biased transistors."

tained by using the load condition C of the measuring circuit shown in Fig. 13. Fig. 18 (a) illustrates Ic-L curves of a transistor under specified reverse-bias conditions.

Figs. 18 (b) and 18 (c) show the derating of Ic when V_{BB2} and R_{BB2} are changed. It is possible to obtain the SOA for simple L-loaded circuits directly by using the curves shown in Fig. 18. For complicated circuits, however, the effective L must be obtained before utilizing the curves of Fig. 18.

However, plotting a typical SOA for a reverse-biased transistor as shown in Fig. 18 is quite difficult. It is also hard to obtain an effective L accurately from an actual load circuit for users. At Toshiba, the SOA is determined by selecting an adequate Ic, L, R_{BB2}, V_{BB2}, and other data for specific transistor applications and by regarding as defective those transistors whose load characteristics are outside the region shown in Fig. 19 and which display oscillation or partial flickering on the load line.

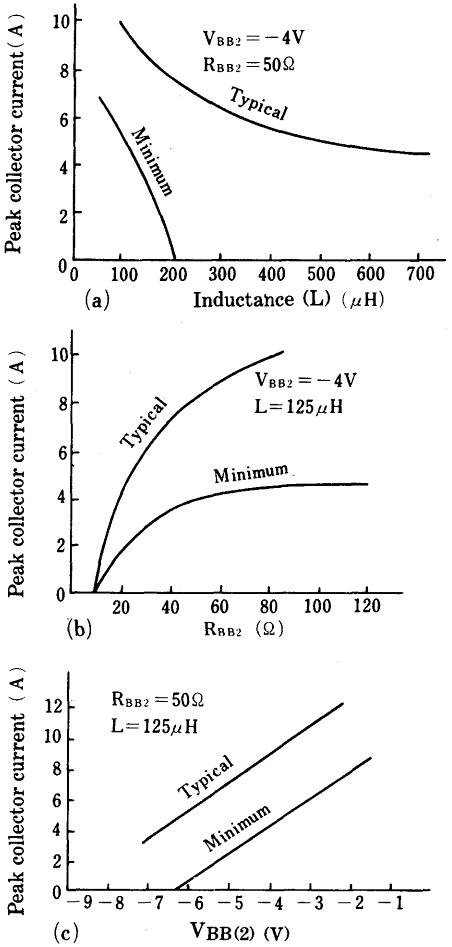
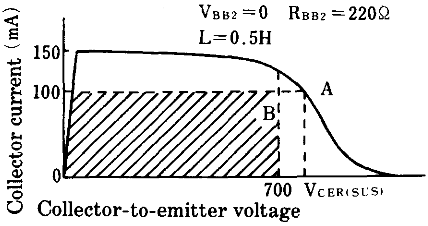


Fig. 18 Examples of SOA for reverse-biased transistors



Measurement is taken at the point (A) above where collector current drops to 100 mA when supplying 150 mA of collector peak current.

Fig. 19 Example of SOA for reverse-biased transistors

Identification System (Transistors, Accessories, and Radiator Holders)

1. Transistors

Example: 2SC 780 A G
1st 2nd 3rd 4th groups

1st group: Represents the types of transistors as shown in the following Table:

1st group	Types of transistors
2SA	PNP transistor, fundamentally high-frequency use
2SB	PNP transistor, fundamentally low-frequency use
2SC	NPN transistor, fundamentally high-frequency use
2SD	NPN transistor, fundamentally low-frequency use
2SH	Uni-junction transistor
2SJ	P-channel field effect transistor
2SK	N-channel field effect transistor

2nd group: Figure starting from 11 (EIAJ number)

3rd group: Suffix denoting modifications in alphabetical order

4th group: Suffix denoting special applications

4th group	Types of special applications
G :	Green transistors for communications and industry applications
D :	Products specially approved by NTT (Nipon Telegraph and Telephone Public Corp.)
N :	Products specially approved by NHK (Japan Broadcasting Corp.)

2. RF Power Amplifier Modules

Example: S – A U 5 L

L: One or two alphabets representing subdivision of frequency

5: Serial No. represents types of modules

U: Symbols representing operating frequency ranges H: HF range, V: VHF range, U: UHF range

A: Represents an amplifier

S: Represents semiconductors

3. GaAs hall sensor

Example: THS 102 A

A: Suffix denoting modifications in alphabetical order.

102: Numerals starting from 101 represent product division

THS: Represents Toshiba Hall Sensor

4. Giant transistor modules

Example: MG 50 G 2 C L 1

- 1 — Serial No.
- L — Symbols representing polarity and structure (L: NPN Darlington; K: NPN Triple Darlington; M: N-ch MOS FET)
- C — Symbols representing circuit structure (Table 1)
- 2 — Numeral showing the number of G-TR
- G — Symbols representing breakdown voltage (Table 2)
- 50 — Collector current (A)
- MG — Symbol representing G-TR module

Table 1

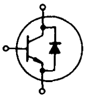
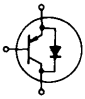
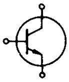
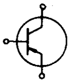
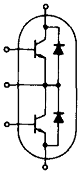
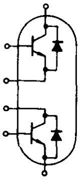
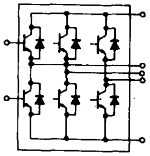
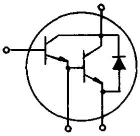
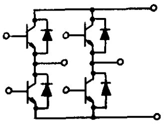
	Circuit structure
A	(1)  (2) 
B	(1)  (2) 
C	(1) 
D	(1) 
E	
Z	Others
F	
G	

Table 2

Characters	Max. voltage range (V)	Characters	Max. voltage range (V)
Z	25 or more to less than 50	J	600 or more to less than 700
A	50 ″~100 ″	K	700 ″~ 800 ″
B	100 ″~150 ″	L	800 ″~ 900 ″
C	150 ″~200 ″	M	900 ″~1000 ″
D	200 ″~300 ″	N	1000 ″~1100 ″
F	300 ″~400 ″	P	1100 ″~1200 ″
G	400 ″~500 ″	Q	1200 ″~1300 ″
H	500 ″~600 ″		

5. Accessories and radiator holder

Example : AC 23 A
1st, 2nd, 3rd groups
1st group: AC represents accessory
2nd group: Serial number
3rd group: Suffix denoting modifications

Example 2: RH - 16 A
1st, 2nd, 3rd groups
1st group: RH represents radiator holder
2nd group: Serial number
3rd group: Suffix denoting modifications

Thermal Stability and Radiation Design of Transistor Circuit

One of the characteristics of semiconductor products such as transistor and diode is that the electrical characteristic is very susceptible to temperature. Therefore, in circuit design, it is necessary to give consideration to operating temperature and a temperature rise caused by self-dissipation.

For instance, in case the ambient temperature rises in a condition that certain voltage is applied to a transistor, the conductivity of the element is raised and current increases, and thereby the transistor consumes more power and junction temperature rises, thus the current being further increased. This vicious circle leads to a phenomenon that will cause the transistor to be destructed in the end.

Therefore, a design considering changes of operating point caused by changes of temperature is required.

1. Temperature Characteristic of Transistor

(1) Thermal stability

Performance stability factor S is definied by the following expression.

$$S = \frac{\partial I_C}{\partial I_{CBO}} \cdots\cdots\cdots\cdots (1)$$

That is, this shows a change of collector current I_C when a change was produced in collector cutoff current I_{CBO} by temperature. Among transistor parameters, those that depend most on temperature are leakage current I_{CBO} (I_{CEO}) and base-emitter voltage V_{BE}. These are expressed as function of temperature as follows.

$$I_{CBO(Tx)} = I_{CBO(To)}\, e^{K(Tx-To)} \cdots\cdots\cdots\cdots (2)$$

$$I_E = I_{CBO}\, e^{qV_{BE}/KT} \cdots\cdots\cdots\cdots (3)$$

where

To: Reference temperature

Tx: Temperature to be found

K: Temperature coefficient: generally 0.07~0.08/°C when material is silicon

q: Electric charge

k: Boltzmann's constant

T: Absolute temperature

Suppose that the dissipation applied to the junction is Pc and that a variation of ΔPc was produced in this dissipation by some cause. There appears a temperature change of $\Delta Pc\theta_{ja}$ in the junction. (θ_{ja}: thermal resistance from the junction to the open air, which will be described in the following chapter) Consequently, changes are produced in I_{CBO} and V_{BE}. These changes ΔI_{CBO} and ΔV_{BE} cause changes of $S \cdot I_{CBO}$ and $g_m \cdot \Delta V_{BE}$ to collector current.

(The g_m of the transistor is defined by $g_m = \partial I_C / \partial V_{BE}$)

If the variation of the dissipation caused by this change is larger than ΔPc, the temperature will continuously rise. Therefore, this needs to be made small. That is,

$$\Delta P_C \geqq V_C (S \Delta I_{CBO} + g_m \Delta V_{BE}) \cdots\cdots (4)$$

where, Vc: Collector supplied voltage.

Under the above condition, it is considered that stability can be obtained.

Expression (4) is transformed as follows:

$$V_C \cdot S \cdot \frac{\Delta I_{CBO}}{\Delta P_C} + V_C \cdot g_m \cdot \frac{\Delta V_{BE}}{\Delta P_C} \leqq 1 \cdots (5)$$

As $\Delta T = \Delta Pc \cdot \theta_{ja}$ can be considered, expression (2) is differentiated by Pc.

$$\frac{\Delta I_{CBO}}{\Delta P_C} = \frac{\Delta I_{CBO}}{\Delta T} \cdot \frac{\Delta T}{\Delta P_C}$$

$$= K \cdot \theta_{ja} \cdot I_{CBO(To)} \cdot e^{K(Tx-To+Pc \cdot \theta ja)} \cdots\cdots (6)$$

Then, obtain the temperature characteristic of V_{BE} by making emitter current I_E constant in expression (3).

$$\frac{\Delta V_{BE}}{\Delta T} \fallingdotseq \frac{KkT}{q} \fallingdotseq -2.0 \times 10^{-3} V/^\circ C \cdots (7)$$

Note:
Generally, −1.8 mV/°C—−2.2 mV/°C can be obtained according to the bias condition of the transistor, but the above −2 mV/°C is usually used as a typical practical value. In Darlington transistor, temperature coefficient becomes twofold, and −4.0—−4.5 mV/°C is used as a typical value, depending on operating conditions.

Consequently,

$$\frac{\Delta V_{BE}}{\Delta P_C} = \frac{\Delta V_{BE}}{\Delta T}\cdot\frac{\Delta T}{\Delta P_C} \doteqdot -2.0\times10^{-3}\times\theta_{ja} \quad \cdots\cdots (8)$$

Expressions (6) and (8) are substituted for expression (5).

$$V_C\cdot S\cdot K\cdot\theta_{ja}\cdot I_{CBO(T_O)}\cdot e^{K(T_X-T_O+P_C\cdot\theta_{ja})} - 2.0\times10^{-3}\cdot\theta_{ja}\cdot V_C\cdot g_m \leqq 1 \quad \cdots\cdots(9)$$

where,

$$T_X - T_O + P_C\cdot\theta_{ja} \leqq T_{j\,max} - T_O$$

That is, if expression (9) is satisfied, the circuit is considered to be stable. However, expression (9) is too complicated for practical use. If a change of Ic to the change of V_{BE} is included in the definition of S, the second term in expression (9) can be omitted for practical use. That is, espression (9) is simplified as follows:

$$V_C\cdot K\cdot\theta_{ja}\cdot S\cdot I_{CBO(T_O)}e^{K(T_X-T_O+P_C\cdot\theta_{ja})} \leqq 1 \quad \cdots\cdots (10)$$

where, $T_X - T_O + P_C\cdot\theta_{ja} \leqq T_{j\,max} - T_O$

Here, critical voltage V_{crit} is defined as follows.

$$V_{crit} = \frac{1}{K\cdot\theta_{ja}\cdot S\cdot I_{CBO(T_O)}} \quad \cdots\cdots (11)$$

Expression (11) is substituted for expression (10);

$$\frac{V_C}{V_{crit}}\, e^{K(T_X-T_O+P_C\cdot\theta_{ja})} \leqq 1 \quad \cdots\cdots (12)$$

By transforming the above and making k=0.08, reference temperature (ambient temperature) To=25°C,

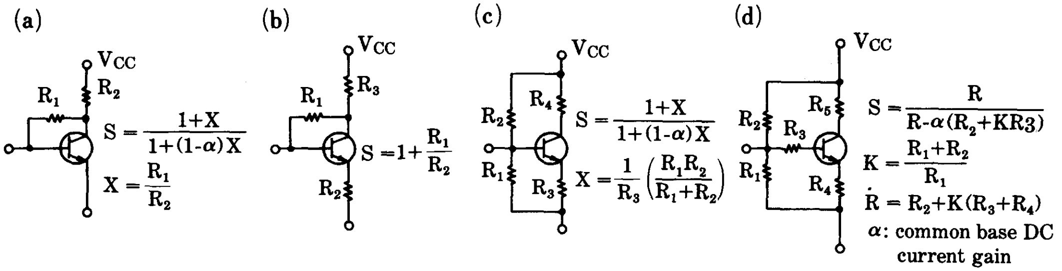
$$P_C\cdot\theta_{ja} + T - 25 \leqq 29\log\frac{V_C}{V_{crit}} \quad \cdots\cdots (13)$$

Consequently, expressions (11) and (13) are expressions giving stability conditions of the circuit.

(2) Stability coefficient of bias circuit

As the stability coefficient of the circuit is described and calculated in various literatures on bias circuit design, only a few examples are mentioned below.

Fig. 1 shows what becomes of the stability coefficient of each bias circuit. (a), (b) and (c) show general bias circuits, and (d) shows a case where direct current resistance of an input transformer can not be ignored.



In general, the smaller the stability coefficient is, the better. However, with a small coefficient, the direct current dissipation of the circuit increases, thereby lowering the efficiency.

If the stability coefficient is made small in the bias circuit in output stage, this dissipation is made large, resulting in poor economy.

Therefore, the bias circuit in output stage generally adopts the method of improving thermal stability by a temperature compensating device.

If the temperature compensating device is used, it is possible to optionally select the stability. As the temperature compensating device, thermistor and varister are commonly used.

For the use of them, refer to the catalog for each device. In case thermal stability is completely compensated by the temperature compensating device, it is enough for the transistor to take only the maximum rating of collector power dissipation into consideration.

2. Radiation Design

(1) Maximum allowable power dissipation and radiation equivalent circuit

The maximum allowable power dissipation (P_{Cmax}) of a transistor, if the thermal stability of the bias circuit described in the previous item is designed to be stable enough, can be given by expression (14), according to the ambient (open air) temperature (Ta) where the transistor is used, its maximum junction temperature (T_{jmax}) and the total thermal resistance (θ_{ja} or Rth) from junction to ambient (open air) depending on the radiating conditions to be described.

$$P_{Cmax} = \frac{T_{j\,max} - T_a}{\theta_{ja}} \text{ (W)} \cdots\cdots\cdots\cdots\cdots \text{(14)}$$

$$\left(P_{C\,max} = \frac{T_{j\,max} - T_C}{\theta_i}\right)$$

For the path conducting the heat generated in the transistor junction to the outside, thermal movement is supposed to be equal to current, and an electric circuit is substituted for convenience's sake. Consequently, it is expressed by thermal resistance and thermal capacitance. In thermally stationary state, it can be shown by the radiation equivalent circuit in Fig. 2.

θi: Internal thermal resistance (from junction to case)

θb: External thermal resistance (from case to ambient)

θs: Thermal resistance of insulating plate

θc: Thermal resistance of contact (in contact with radiating plate)

θf: Thermal resistance of heat sink (to the open air)

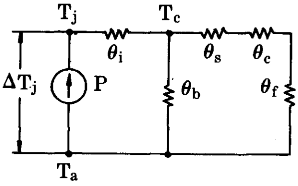


Fig. 2 Radiation Equivalent Circuit

The total thermal resistance θ_{ja} to the open air, viewed from the junction, is given by expression (15) from the radiation equivalent circuit illustrated in Fig. 2.

$$\theta_{ja} = \theta_i + \frac{\theta_b(\theta_s + \theta_c + \theta_f)}{\theta_b + \theta_s + \theta_c + \theta_f} \cdots\cdots\cdots\cdots\cdots \text{(15)}$$

As transistors with middle or lower output generally use no heat sink, θ_{ja} will be:

$$\theta_{ja} = \theta_i + \theta_b \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \text{(16)}$$

Though there appears maximum allowable power dissipation of Ta=25°C in catalogs for transistors with middle or lower output, the value given by the following expression with the θ_{ja} given by expression (16) and $T_{j\,max.}$ is available.

$$P_{C\,max(Ta=25\,°C)} = \frac{T_{j\,max} - 25}{\theta_{ja}} \cdots\cdots\cdots\cdots\cdots \text{(17)}$$

The thermal resistance θ_b from the case to the open air depends on the material and con-

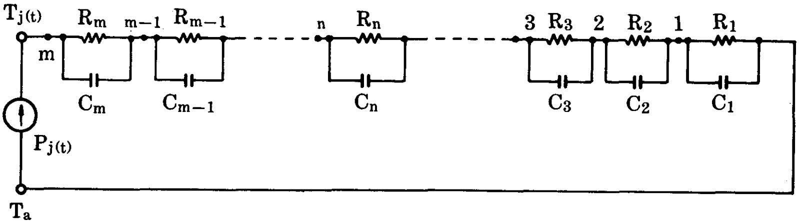


Fig. 3

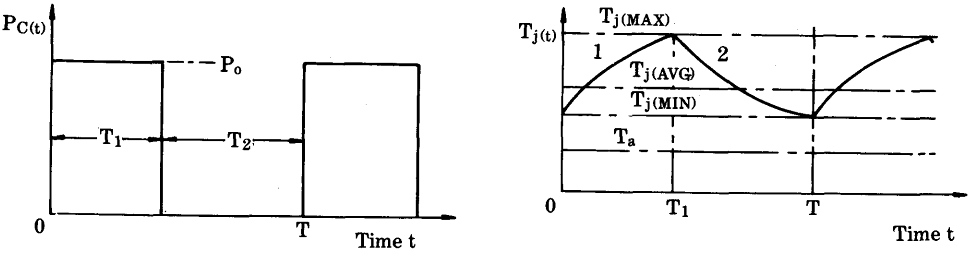


Fig. 4

figuration of the case, but it is a considerably large value as compared with θ_i, θ_c, θ_s and θ_f. Therefore, expression (15) is simplified and the following expression can be used in practice.

$$\theta_{ja} = \theta_i + \theta_c + \theta_s + \theta_f \cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (18)$$

In dealing with direct current dissipation, it is possible to realize a radiation design satisfying the maximum rating by finding expression (18).

In using transistors in a pulse circuit, etc., great care must be taken so that the peak value of T_j must not exceed T_{jmax}.

(2) Pulse response of junction temperature

In general, the thermal impedance of a transistor is given by such a distributed constant circuit as shown in Fig. 3.

When the pulse dissipation $P_j(t)$ shown in Fig. 4 is applied to the circuit shown in Fig. 3, a temperature change $T_j(t)$ that appears in the mth CR parallel circuit is given by the following expression.

(1) In the region of $P_j(t) = Po$;

$$T_{j(t)} \sum_{n-1}^{m} \{(P_o R_n) - T_{n(min)}\} \times \{1 - \exp(-t/C_n R_n)\} + T_{n(min)} \cdots\cdots\cdots \quad (19)$$

(2) In the region of $P_j(t) = 0$;

$$T_{j(t)} \sum_{n-1}^{m} T_{n(max)} \exp(-t/C_n R_n) \cdots\cdots\cdots \quad (20)$$

By supposing n=4 for common transistors, it is possible to approximate to the actual value. However, in case the values of C and R are not clear, it is hard to calculate the value of T_j.

Therefore, in general, T_{jpeak} is estimated by using the transient thermal resistance shown below.

Fig. 5 shows the characteristic of 2SC3236 as an typical example of transient thermal resistance characteristic.

When single nonrepetitive rectangular pulse (pulse width T_1, peak value P_0) is applied, the transient thermal resistance $r_{th}(T_1)$ to pulse width T_1 is obtained and T_{jpeak} is given by the following.

$$T_{j\,peak} = r_{th}(T_1) \cdot P_o + T_a \cdots\cdots\cdots\cdots\cdots \quad (21)$$

When continuous pulses of cycle T are applied, the T_{jpeak} is given by the following expression in thermally stable state.

$$T_{j\,peak} = P_o \left[\frac{T_1}{T} \theta_{ja} + \left(1 - \frac{T_1}{T}\right) \cdot r_{th}(T + T_1) - r_{th}(T) + r_{th}(T_1) \right] + T_a \cdots\cdots \quad (22)$$

The above expression (22) can be applied only in a region where current concentration is not caused by the so-called secondary breakdown.

In the radiation design of pulse circuit, great care must be taken so that the T_{jpeak} in expression (22) may not exceed the T_{jmax} of the transistor.

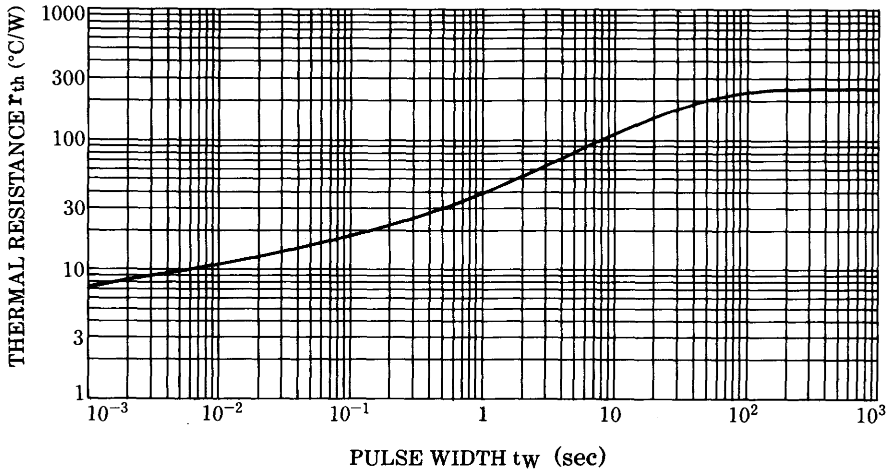
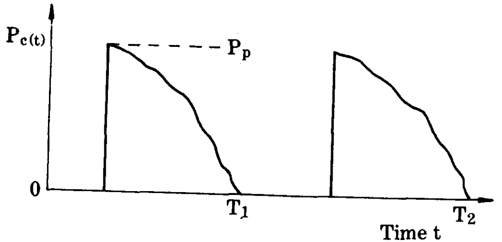
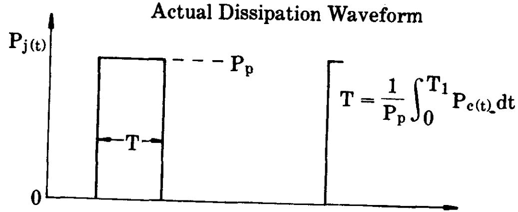


Fig. 5 TRANSIENT THERMAL RESISTANCE CHARACTERISTIC (2SC372)

In the above analysis, the rectangular wave is discussed, but in adapting transistors to equipment in practice, $P_j(t)$ may not be a rectangular wave.



Actual Dissipation Waveform



Approximate Waveform

Fig. 6

In such case, by approximating a dissipation waveform to a rectangular waveform, T_{jpeak} can be calculated by expression (22).

3. Thermal Resistance

The thermal resistance in the radiation equivalent circuit shown in Fig. 2 is explained as follows.

(1) Junction-case thermal resistance (internal thermal resistance) θi

The internal thermal resistance θi from transistor junction to case is directly determined by transistor structure, material, mounting methods of the transistor chip to its case and case filler. Therefore, it is the thermal resistance peculiar to individual transistor.

For measuring this value in practice, it is necessary to keep the temperature of the transistor case constant to make a forcedly cooled state.

In case the transistor operates by cooling the case temperature to constant Tc=25°C, the maximum dissipation allowable to the transistor is given by:

$$P_{C\,max} = \frac{T_{j\,max} - T_C}{\theta_i}\ (W)$$

$$= \frac{T_{j\,max} - 25}{\theta_i}\ (W) \cdots\cdots (23)$$

Though there appears Tc=25°C or maximum allowable collector power dissipation in using an infinite heat sink in catalogs for large-output transistors, it is determined by the internal resistance of the transistor, as clarified in expression (14).

4. Radiation Design Considering Reliability

The fundamental conception and calculation for thermal stability and radiation in transistor circuit design have already described.

Now, it is necessary to consider the conception about reliability. Particularly, for communication equipment and equipment using numerous parts per unit, derating is required in consideration of reliability.

Generally, the degradation of a transistor has the relation of exponential function with junction temperature. An one-figure (tenfold) improvement of reliability is expected by derating of 40−50°C with difference among individual kinds of transistor. In case high reliability is needed, it is necessary to keep junction temperature (temperature rise by applied voltage + ambient temperature) as low as possible.

A sudden change of junction temperature is caused by switching on and off of equipment, and its repetition gives rise to thermal fatigue of the electrode junction within the transistor. As a result, a long life may not be expected.

In order to avoid this, sufficient derating is required for junction temperature and its change.

Precautions on Utilizing Transistors

It is necessary to carefully handle semiconductor products when operating them, especially when carrying or mounting them. The following refers to notes on handling transistors.

1. Mounting on a heat sink

Power transistors sometimes require heat sinks depending on the source voltage, current load conditions, and ambient temperature. In such a case, the following attentions must be paid so that the heat sink effect is maximized and the transistors are subjected to minimum stress.

(1) Coating with silicon grease

Coat the silicon grease between the transistor and the heat sink to optimize thermal resistance between them. Coat the silicon grease thinly and uniformly.

It is recommended for using a nonvolatile silicon compound. (Should a volatile compound be used, the grease may be cracked in the long run, thus degrading the heat sink effect.)

In some cases where silicon grease is applied to plastic package-type transistors, the base oil contained in the silicon grease may be separated and permeate in the transistor interior, extremely shortening transistor life time. Be careful when selecting the type of silicon grease.

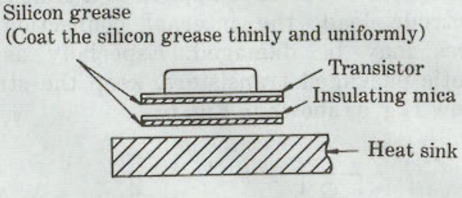


Fig. 1 Coating the silicon grease

Silicon Grease YG6260, produced by Toshiba Silicon Co., is recommended for this purpose. Its base oil is seldom separated, so that it does not affect the transistor life time.

This notice is not applicable to metal-sealed transistors.

(2) Mounting accessories for tightening screws and nuts

It is recommended following the mounting procedures shown in Fig. 2 (TO-3, Toshiba 2-21D1A), Fig. 3 (TO-66, Toshiba 2-13A1A) and Fig. 4 (TO-220 AB, Toshiba 2-10A1A), so that transistors are electrically insulated from the heat sink and thus increase the heat sink effect.

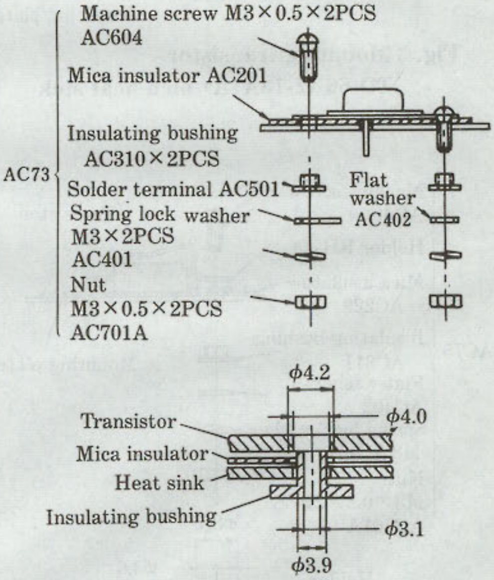


Fig. 2 Mounting transistor TO-3 (2-21D1A) on a heat sink

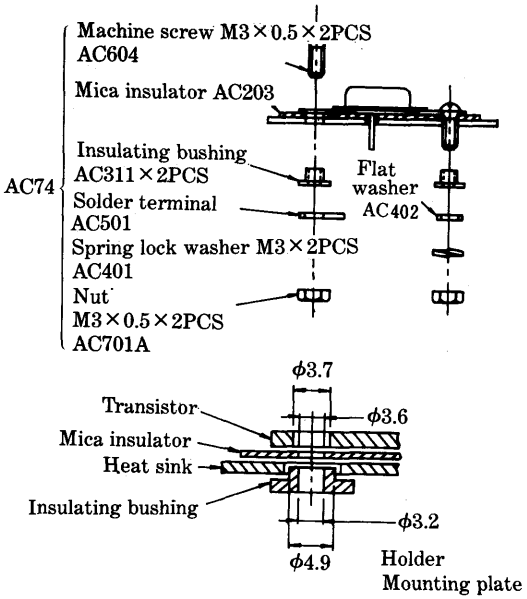


Fig. 3 Mounting transistor TO-66 (2-13A1A) on a heat sink

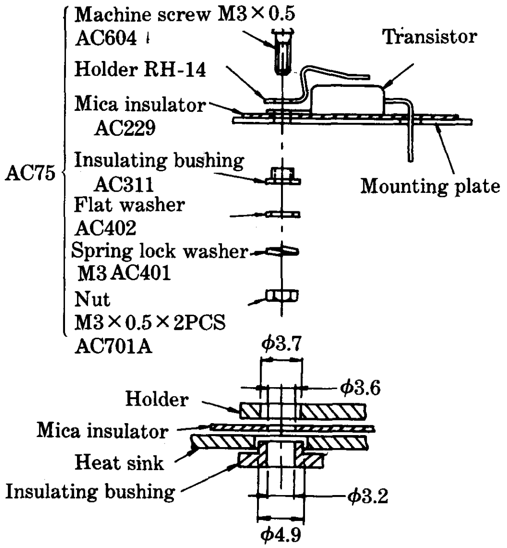


Fig. 4 Mounting transistor TO-220AB (2-10A1A) on a heat sink

(3) Screw tightening torque

Should a screw be tightened with excessive tightening torque, it may be wrenched off or the transistor system may be strained or damaged.

Fig. 5 illustrates relations between screw tightening torque and thermal resistance. Should a certain value of torque be exceeded, thermal resistance becomes saturated.

It is recommended to force below following the tightening torque so that optimum thermal resistance is assured and the transistor is freed from stress, mentioned below (Table 1).

Table 1 Recommended screw tightening torque

Outline		Screw tightening torque (MAX.)
JEDEC	Toshiba product No.	
TO-3	2-21D1A	8kg·cm
TO-66	2-13A1A	6kg·cm
TO-220AB	2-10A1A	6kg·cm
TO-126	2-8F2A	4kg·cm
—	2-16B1A	8kg·cm
—	2-34A1A	8kg·cm

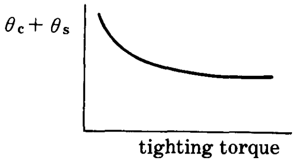


Fig. 5 Relations between screw tightening torque and thermal Resistance

When using a pneumatic screwdriver, it is necessary to control the tightening torque so that its maximum value falls within that listed in Table. 1

(4) Stress on transistor electrode leads

If excessive stress is applied to a transistor electrode lead, the internal connection of wires may be damaged. Especially as to plastic-packaged transistors, keep the stress below 1kg, as shown in Fig. 6.

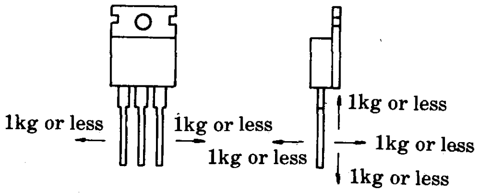
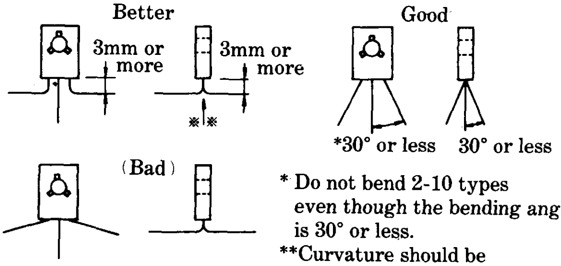


Fig. 6 Stress to electrode leads

(5) Lead Bending

Lead bendings are shown in Fig. 7 if they are require.



* Do not bend 2-10 types even though the bending angle is 30° or less.

**Curvature should be 1mm or more when bending the leads.

Fig. 7 Lead bending (common to 2-8F1A and 2-10A1A)

2. Electrostatic breakdown

Each transistor has its own maximum rating. The circuits are designed so that excessive voltage and current will not be applied. However, transistors are sometimes damaged before they are actually mounted on circuit boards. This is often resulted by overvoltage breakdown before mounting transistors. It is caused by static electricity produced by a charged human body or packing materials.

For instance, clothes made of chemical fiber which are worn daily are particularly charged with static electricity. Everyone experiences a static electricity "crackling" sound when they take off a coat on a fine and dry day. These values are known from experiments to be from around several kV to tens of kV as listed in Table 2.

Table 2 Voltage electrified by clothing friction (kV)

Static electricity in the human body immediately after removing a work uniform after strongly rubbing against one's underclothing.
(Ambient conditions: 25°C, 25% RH, Unit: kV)

Underclothing Work uniform	Cotton	Wool	Acryl	Polyester	Nylon	Vinylon + cotton
Cotton 100%	1.2	0.9	12	15	1.5	1.8
Vinylon/cotton (55%/45%)	0.6	4.5	12	12	4.8	0.3
Polyester/rayon (65%/35%)	4.2	8.4	19	17	4.8	1.2
Polyester/cotton (65%/35%)	14	15	12	7.5	15	14

It has been confirmed that such static electricity leads a transistor to overvoltage breakdown, when applying it to the transistor through its electrode. Although this voltage differs substantially depending on ambient conditions, such voltage will sometimes cause an unexpected breakdown in MOS FETs or high-frequency transistors which are rather easily affected by excessive voltage.

Therefore, take care of handling such transistors as follows.

(1) When storing transistors, it is recommended short-circuiting between electrodes with conductive materials, or to pack the entire transistor with aluminum foil or similar material.

Avoid storing or transporting transistors in nylon or plastic containers which are easily charged static electricity.

(2) When handling transistors, it is necessary to safely discharge static electricity in the ambient environment; for example, by grounding easily charged things on a desk or a human body. (Note)

Note: To ensure human safety, be sure to ground an employee's body through a resistance of 10MΩ or so, rather than directly grounding.

(3) As far as possible avoid using work uniforms of chemical fiber, nylon gloves, and similar fiber.

(4) When mounting transistors for a printed circuit board (PCB), the board often constitutes a high-impedance circuit if it is without being additionally processed.

Since it sometimes happens to apply overvoltage on transistors, it is recommended short-circuiting the electrodes of a PCB with each other in the same manner as when storing transistors.

(5) Although this is not caused by static electricity, when soldering transistors, be careful as to leakage from the soldering iron. It is necessary to protect the transistor from suppling voltage to the solder. It is advisable to ground the tip of the soldering iron through substantially low resistance.

3. Soldering

(1) Soldering temperature

When soldering a transistor onto a printed circuit board, 6/3 solder is usually used. When using this type of solder, it is expected that temperature of the soldering bath (such as flow solder) is about 240—260°C and that of the soldering iron is, 300°C or more.

Maximum rating for storing temperature of a transistor is usually from −55° to +125°C or from −65° to +175°C. It is preferable to solder transistors in as short a time and at as low temperature as possible.

Generally it is necessary to maintain a soldering temperature, 260°C and to shorten the soldering time to less than 10 seconds, except for specially designed transistors.

Even when considering use of a soldering iron, it is necessary to maintain 350°C and 3 seconds or less. It is also recommended that when using a soldering iron, pincettes or pinchers be employed to let heat escape from the transistor main body.

(2) Soldering procedures

As mentioned above, it is necessary that heat being transferred to a transistor be minimized when soldering it.

It is necessary to separate the transistor main body from a printed circuit board or to form its leads in such a manner as to lighten the stress from being applied to the main body, as shown in fig. 8 below.

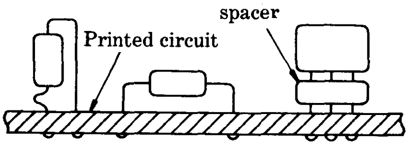


Fig. 8 Example of soldering method

(3) Cleaning method

To remove flux, cleaning is often conducted after soldering transistors to printed circuit boards. This cleaning often involves a cleaning agent for removing flux or an ultrasonic wave cleaning method. Since the outline and markings of semiconductor devices are very delicate, it is necessary to carefully select such solvents. It is recommended using freon-type solvents such as Freon TE and Dai-Freon Solvent S3-E.

When using an ultrasonic wave cleaning method, stress applied to a transistor differs substantially depending on the cleaning bath size, vibrator output, and resonance among devices. Therefore, it is recommended avoiding the use of an ultrasonic wave cleaning method for hollow transistors. However, if use of that method is unavoidable, it is necessary to position the main body of transistors in location not directly exposed to a vibrator and to reduce cleaning time to less than 30 seconds, so that no stress is applied to the main body of transistors.

Reliability of semiconductors

1. Quality assurance program

The quality and reliability of semiconductor elements are closely related and important to our daily lives as well as to industrial equipment.

In this section is explained the quality assurance program as shown in Fig. 1 and Table 1, including the ATS (Approval Test System) in which severe approval tests are defined for each stage of processes from planning through mass production when developing a new item, as well as the maintenance service after delivery of semiconductors.

(1) Development stage

The quality and reliability of semiconductor products are highly dependent upon the designing of element structures. In this stage, the designing, production technology, applied technology, and quality assurance departments and sections cooperate in deliberating on basic design, production processes, and quality and reliability, as well as market research.

Some examples of specific jobs in this stage include setting reliability goals, research on past data, checking design criteria, and establishing estimating methods and criteria considering application. After clearly solving these problems, the development and trial production are started.

In the development and trial production process, both electrical properties and reliability goals are checked and confirmed as to whether or not they have reached the levels initially established.

In this stage, production technology, especially processes peculiar to each product is estimated and confirmed. After quality and reliability are confirmed, a subsequent trial run for mass production is initiated.

In the trial run stage for mass production, are priority is given to the stability of production process estimates.

In this stage, it is important to check whether reliability confirmed in the development and trial run stage are constantly maintained in a stabilized condition. The ability of production processes is confirmed and priority items are established to realize ideal process control, thus paving the way for subsequent mass production.

(2) Mass production stage

To maintain quality and reliability in the development stage for mass-produced items and to continue stable production with least variations, it is essential that the production process be stabilized, that quality control be thoroughly effected, and that the quality of parts and materials be stabilized.

Toshiba has established QCS (Quality Control Standards) with top priority on in-process quality control, based on the basic policy that "the production process plays the main role in assuring quality and reliability." The check points in process control assimilated in the development stage are strictly and closely followed.

For example, control items, sampling methods, equipment to be used, and supervisors, as well as persons to be contacted if any problems occur, are established for each process so that any abnormalities can be detected at an earlier stage, necessary actions can be taken promptly, and required data can be fed back correctly.

It is quite important to control the quality of component parts and materials. By standardizing individual specifications and quality control procedures, stringent quality control results.

Since semiconductor products and devices have made surprising progress over recent years, they have contributed to laborsaving, automation, and an improvement in quality and reliability. The facilities and instruments for quality control processes constitute important factors in quality control. Therefore, these factors are regularly controlled and calibrated in accordance with Toshiba's standards as well as national agencies.

In addition, the ZD (Zero defects) movement, small-group activities such as QC circles, and training and education programs as conducted to improve employees' workmanship and morale.

Fig. 1 Quality Assurance Process

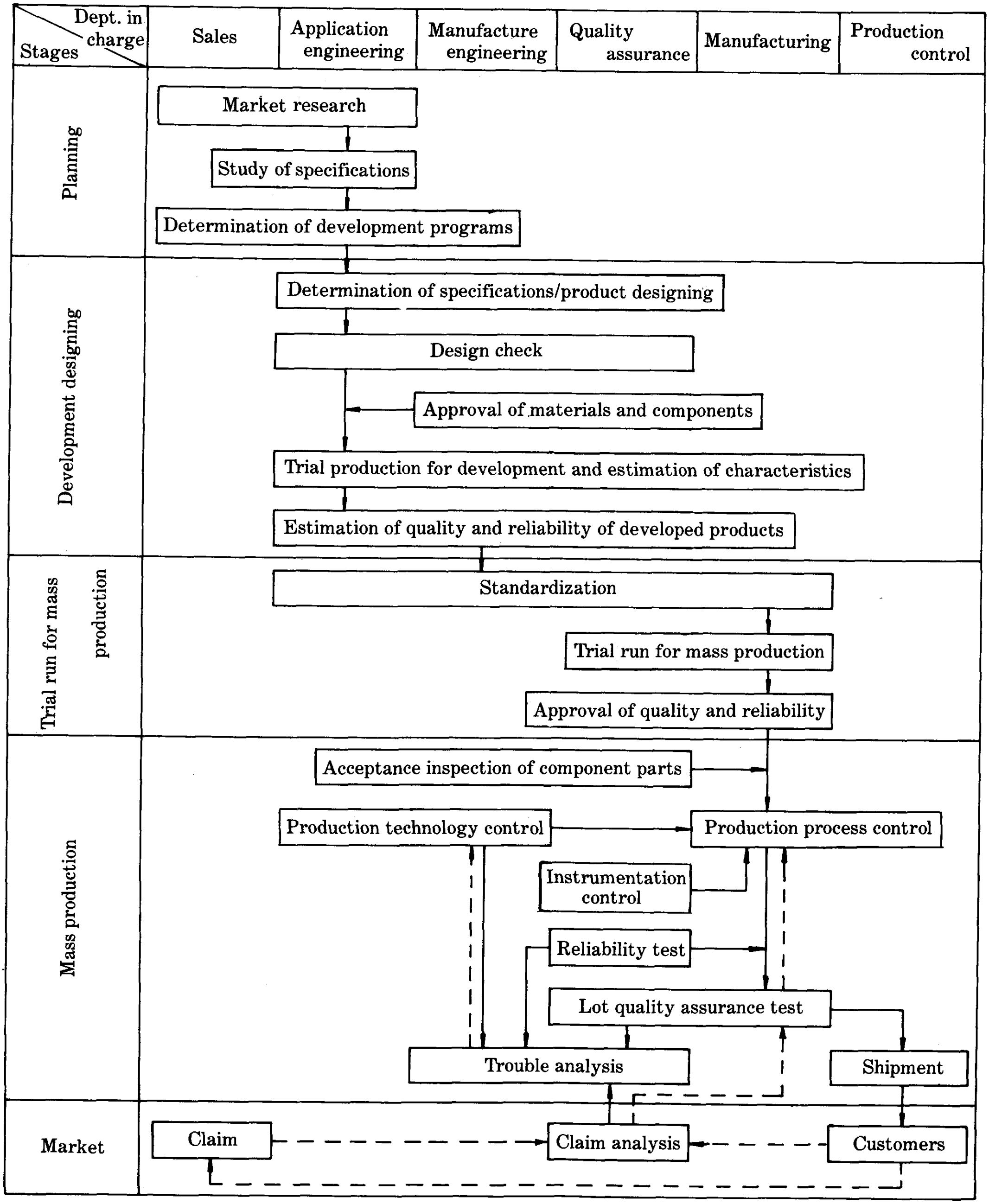


Table 1 Control system for product development

Development steps		Approval Test System (ATS)	Departments participating
Research and designing	Research, study, and establishment of quality and reliability goals so that products to be developed fulfill the expected functions	Design check	Development designing, application engineering, and quality assurance depts.
Trial run for development	Establishing production processes by duly considering economic merits and mass production capability, and by establishing quality and reliability	Estimation and approval of designs, DAT (Design Approval Test)	Application engineering, manufacturing engineering, fabrication group, and quality assurance depts.
Trial run for mass production	Establishing quality and reliability levels and process stabilizing/quality controlling methods	Estimation and approval of quality and reliability levels QAT (Quality Approval Test)	Production technology, quality assurance, production, and production control depts.
Mass production	Establishment of all controlling systems to manufacture standard products	DAT or QAT is conducted in accordance with the importance of any changes in components, materials, processes, and so on.	Production technology, quality assurance, production, and production control depts

(3) Quality assurance of delivered goods

The quality of products to be delivered is assured under the above-mentioned quality control, such as intermediate inspections and tests at each stage of processing and lot quality assurance tests (electrical properties, external appearance, structure, and service life).

Reliability check tests are regularly conducted to supervise quality and reliability levels. Results and data obtained from these inspections and tests are effectively utilized and filed for improving designing and production processes, as well as for estimating quality in the market.

The above-mentioned flow of products is shown in Fig. 2 quality assurance and confirmation flow chart.

The quality assurance criteria of Toshiba Corporation are based on the LTPD method which is in accordance with MIL-S-1900.

Quality assurance levels of the criteria are as listed in Table 2.

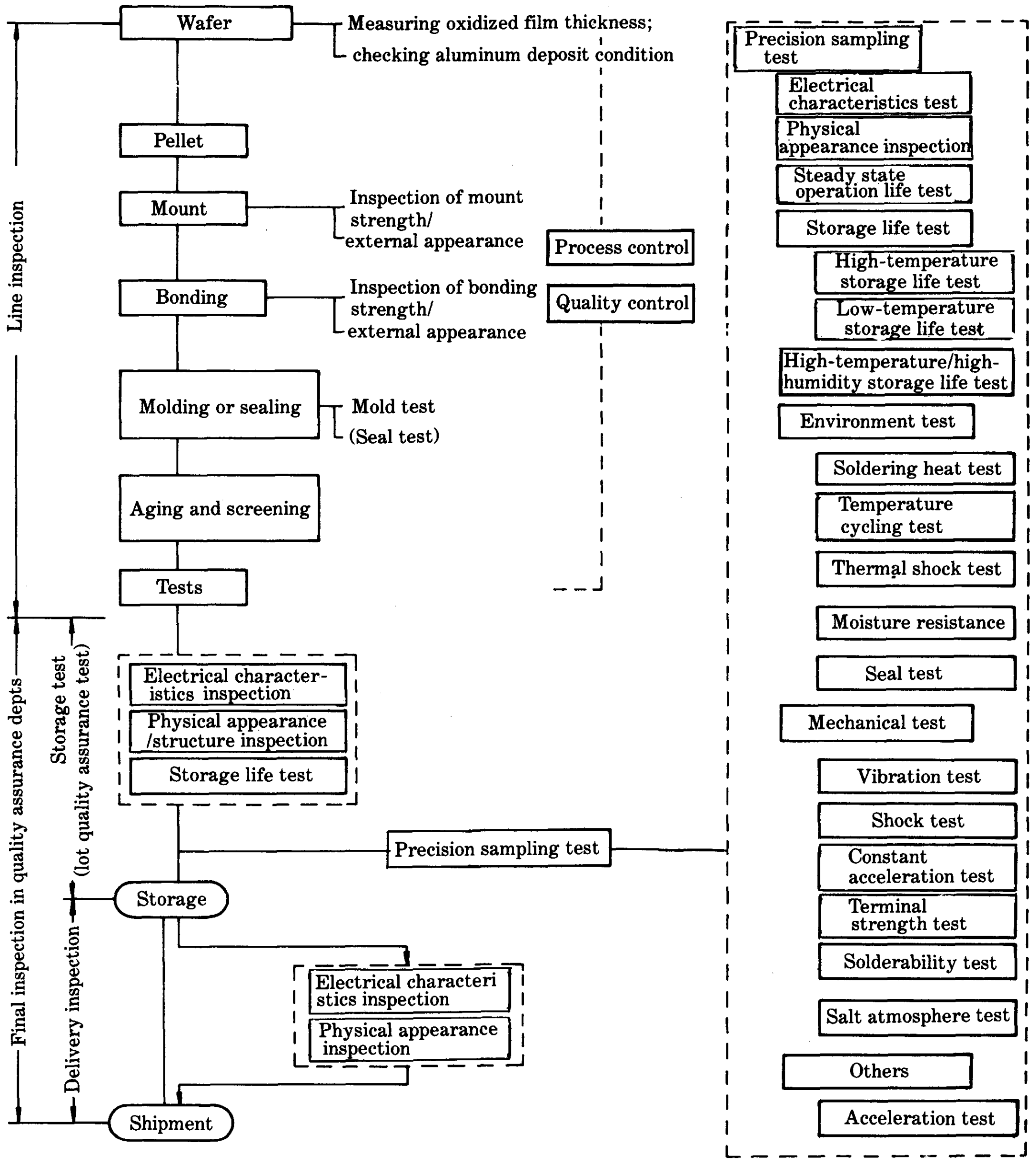
Table 2 Lot quality assurance level (LTPD method)

	Quality	Communications industry use	Household use
External appearance/ structure/ electrical properties	Catastrophic defects	1.5%	5%
	Major defects	5%	10%
	Minor defects	10%	25%

(4) Service activities after shipment

Market information related to quality and

Fig. 2 Quality assurance and confirmation flow chart



reliability of products already shipped is very important for quality control purposes as well as for sales activities. Especially, any information in which the history and conditions of trouble occurrence are clarified is effective as a direct guideline for improving the quality and reliability of such products.

A variety of information obtained through contacts with customers is processed and computed to serve for studying the causes of trouble and for determining preventive measures, thus contributing to quality improvement.

2. Concept and scale of reliability

The quality that makes an element highly reliable is, that when it is used as a part of equipment, it "offers objective functions under stable conditions without failure for a specified duration of time", such an element should be easily compatible in electrical properties when replaced if necessary.

To quantitatively represent reliability, the degree of reliability or the ratio of failure is used to express it as a function of distribution in which time is used as one of the parameters. Therefore, the exponential distribution or the Wieble distribution is often used for semiconductor products.

Fig. 3 illustrates failures observed in ordinary electronic parts and semiconductors with time as a parameter; it has been recognized that this curve shows a certain trend.

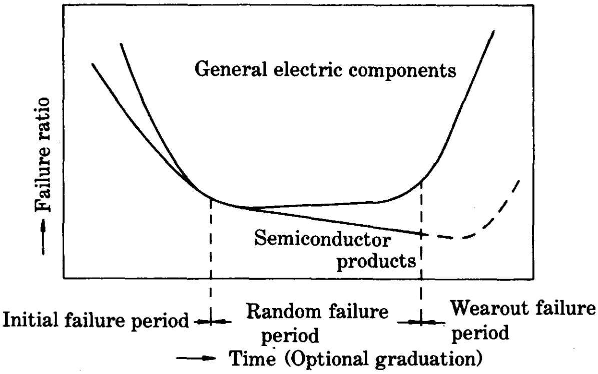


Fig. 3 Variation of failure rate regarding elapsed time

This trend is divided into three periods:

- Initial
- Random failure period
- Wearout failure period

Failure of semiconductor products is characteristic of a gradual reduction in the failure ratio during the random failure period; it is important to minimize the failure ratio in this period because failure occurs at random.

To represent the reliability of semiconductor products, an approximation is conducted by using various types of distribution functions. When assuming an exponential distribution, the most basic distribution pattern in life distribution of electronic components, the reliability function R(t) can be expressed by the equation—

$R(t)=\exp(-\lambda t)$

The instantaneous failure ratio $\lambda(t)$ and average life μ are expressed as—

$\lambda(t)=\lambda$ (constant irrespective of time lapse)

$\mu=1/\lambda$

$\mu=1/\mu=\mathrm{MTTF}$.

Generally, the failure ratio of semiconductor products is expressed by %/1,000 hours through assuming that time (t)=1,000 hours. Since failure is rare and the failure ratio is small judging from the field data and estimated failure ratio, $1/10^4$ times this value—namely 10^{-4}(%/1,000 hours)$=10^{-9}$(failures/hour)—is used under the unit of 1 Fit.

3. Reliability factors

The reliability of transistors should be handled not only for the transistors themselves, but by also taking operational stress and environmental stress into consideration. They are so closely related to each other that the following explanation will help users to utilize them with higher reliability.

(1) Operating conditions

Voltage and current supplied to transistors and the operating conditions surrounding equipment are important factors which affect transistor reliability. The operating points should be determined by selecting and appropriate element for an objective circuit and by designing an appropriate circuit.

It is known that the transistor failure ratio is substantially affected by temperature, and as the temperature rises, the ratio is increased. However, small-signal transistors handle such low voltage and current that no special consideration need be given to temperature, except for those circuits with special operation.

Instead of considering the influence of temperature, attention should be paid to the application of surge voltage and deviation in characteristcs caused by external influences or induction. By lowering the limit values for allowable fluctuations in characteristics, to widen the difference between theoretical and actual operation limits when designing a circuit, it is possible to substantially increase the service life of a transistor, and hence, that of the equipment. On the other hand, power transistors which handle comparatively large voltage and current have large dissipations as a result of a far larger volume of current compared with voltage.

This power dissipation causes a transistor to heat up, adversely affecting both its characteristics and its reliability. Such heat should be efficiently discharged. Refer to the explanation in the previous section for details of heat discharge.

It is recommended that derating be applied to the voltage, current, and temperature specified by maximum ratings, so that transistors may be employed with high reliability. Since derating is determined as a compromise between reliability and economic values, it is rather difficult to consistently specify the degree of derating. The degrees mentioned below are those generally recommended:

Voltage: 70—80% or less for maximum rating
Current: 50% or less for maximum rating
Power: 50% or less for maximum rating

Regarding the degrees of derating, certain government agencies in Japan have established their own standards for operation and designing, and have limited the application ranges. Such a movement constitutes one of the basic activities for improving transistor reliability.

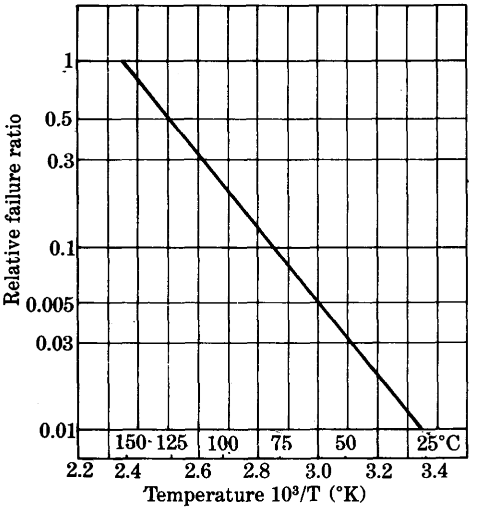


Fig. 4 Derating curve for silicon transistors

Fig. 4 shows an example of relations between the temperature and the failure ratio by using a Toshiba silicon transistor. It is evident from that figure that the failure ratio is substantially affected by the operating temperature and that higher reliability can be expected by effecting derating.

(2) Variations in transistor quality

The automatization of production processes and the improvement and progress of production technology have been outstanding. The quality and reliability of transistors have continued to be improved year after year thanks to such development, and by positively adopting newly developed technology.

It has probably been stated that there are no variations in quality thanks to the use of modern controlling methods and the full automation of processes. However, transistors and other semiconductor products are extremely small in shape, structure, and size, and are based on microtechnology for conducting their high-precision control, reinforced by physical and chemical technology. Therefore, even the slightest deviation exercises a large influence upon a transistor's characteristics. It is rather difficult to maintain various types of characteristics uniform, even by making full use of today's latest technology.

(3) Resistance against environmental factors

The housings of semiconductor products are classified into the plastic resin-sealed type and the airtight-sealed type using metal. The plastic resin-sealed type, less expensive and possible to mass produce, recently has been employed in the majority of cases, covering application ranges from small signal to large power transistors.

This trend is backed by the facts that resins with high mechanical strength and excellent electrical insulation and resistance against environmental factors have been developed and employed, and that the reliability of this type has been greatly enhanced thanks to progress in molding techniques and surface treatment know-how.

The plastic resin-sealed type up to now has reached the level of the airtight-sealed type except concerning special environments, although transistors are subjected to many environments in the markets. Since the plastic resin-sealed type is not airtight, humidity infiltrates the transistor interior through the resin. It is recommended employing the airtight-sealed type if the equipment or system is intended for use under a. high-humidity environment or when high reliability is required.

Be careful not to directly expose semiconductor products to dust, harmful gases, salty (sea) air, radioactive rays, or similar environments; otherwise, they will suffer from unstable characteirstics or rust in the lead wires.

4. Precautions of handling

(1) Mounting on printed circuit boards

When mounting a transistor on a printed circuit, it is assumed that lead wires will be processed or reformed due to space limitation or relations with other components. Even if no such special processing or reforming is conducted, exercise care on the following points:

(a) Make the spaces of lead wire inserting holes on the printed circuit board the same as those of lead wires on a transistor.

(b) Even if the spaces are not the same, do not pull the lead wires or push heavily against the transistor element.

For TO-220AB-type transistors, do not apply stress in the direction of the lead wire thicker side.

(c) Use a spacer for form a lead maintain space between a transistor and a printed circuit board, rather than closely contacting them with each other.

(d) When forming a lead prior to mounting onto a board:

- Bend the lead at a point 3 mm or more apart from the body. (Lead root)
- Bend one lead wire after securing the other lead wire (near the main body).
- Keep space between the transistor main body and a fixing jig.
- When bending the lead along the jig, be careful not to damage it with an adge of the jig.
- Follow other precautions described in respective standards.

(e) When mounting a transistor onto a heat sink:

- Use the specified accessory.
- Drill threaded holes on the heat sink as per specifications and keep the surface free drom burrs and undulations.
- Use Toshiba's recommended silicon grease.
- Tighten the screws within the specified torque.
- Never apply a pneumatic screwdriver to a transistor main body.

(f) Do not bend or stretch the lead wires repeatedly.

When pulling in the axial direction, apply 500g or 1 kg power, depending on the shapes of lead wires.

(2) Soldering

When soldering a transistor to a printed circuit board, the soldering temperature is usually so high that it adversely affects the transistor. Normally, tests are conducted at a soldering temperature of 260°C for 10 seconds or 350°C for 3 seconds. Be sure to complete soldering procedures under these conditions of temperature and time.

Be careful to select a type of flux that will neither corrode the lead wires nor affect the electrical characteristics of a transistor.

The basic precautions for soldering procedures are as follows:

(a) Complete soldering procedures in a time as short as possible.

(b) Do not apply stress to a transistor after soldering by correcting or modifying its location or direction.

(c) For a transistor employing a heat sink, mount it on the heat sink first; then solder this unit to a printed circuit board after confirming that it is fully secured.

(d) Do not directly solder the heat-radiating portion of a transistor to a printed circuit board.

(e) In flow solder jobs, transistors are apt to float on the solder due to solder surface tension. When adjusting the locations of transistors, be careful not to apply excessive stress to the roots of the transistor lead wires.

(f) When using a soldering iron, select those which have less leakage, and be sure to ground the soldering iron.

(3) Cleaning a circuit board

After soldering, circuit boards must be cleaned to remove flux. Observe the following precautions while cleaning them.

(a) The below-mentioned solvents are recommended for cleaning purposes:

- Freon TE, TF
- Di-Freon Solvent S3-E

(b) Do not rub the indication marks with a brush or one's fingers when cleaning or while a cleaning agent is applied to the markings.

(c) There areultrasonic wave cleaning methods which offer a high cleaning effect within a short time. Since these methods involve a complicated combination of factors such as the cleaning bath size, ultrasonic wave vibrator output, and printed circuit board mounting method, there is fear that the service life of airtight seal-type transistors may be extremely shortened. Therefore, as far as possible avoid using the ultrasonic wave cleaning method. This concern is not applicable to plastic-type transistors, although below-mentioned basic requirements should be followed:

- Basic requirements of ultrasonic wave cleaning method

Frequency:	27–29 kHz
Output:	300W or less (about 0.3W/cm^2 or less)
Recommended solvents:	Refer to details above
Cleaning time:	30 seconds or less

Conduct ultrasonic wave cleaning with both the printed circuit board and the transistors floating in the solvent, so that neither product comes in direct contact with the ultrasonic wave vibrator.

It is recommended adopting steam cleaning or jet stream cleaning methods which exert less influence on transistors than dose ultrasonic wave cleaning; it is assummed that various types of transistors are mounted on a printed circuit board.

(4) Static electricity

The maximum ratings designated for transistors denote those values which should not be exceeded even an instant, as described in the previous section; this is applicable commonly to semiconductor products.

It is probable, however, that static electricity or surge voltage that exceed such values may be applied to transistors directly or indirectly while handling or operating them.

Especially, static electricity sometimes reaches several kV or tens of kV. Should this high voltage be discharged through the electrodes of transistors, high-frequency transistors and MOS-FET transistors which are less resistive to such high voltage in structure, they may be deteriorated or break down. Since protective devices to be mounted on the transistors themselves are restricted for the purpose of assuring electrical characteristics, pay special attention to handling procedures and to separate protective circuits.

Such wires as I/O signal wires and control wires connected to a printed circuit are often connected with other types of electronic components, and they are often very long. Should noise or surge voltage caused by induction be added to these I/O signal wires and control wires, transistors may sometime deteriorate or break down. Take advance protective measures such as inserting protective circuits.

5. Failure mode and failure mechanism

Types of failure are classified into open circuits, short circuits, and deterioration.

(1) Open failure

Factors causing open failure are

(a) Structural flaws related to or caused by bonding

(b) Those caused by electrochemical reaction such as electromigration and local cell formation

(c) Application of stress exceeding that guaranteed by the standards

It is also possible that bonding wires and aluminum wires may be fused off as a result of a combination of the above three factors.

(2) Short failure

Principal factors causing short are

(a) Excessive stress caused by overvoltage and overcurrent

(b) Short failure caused by an extreme example of degradation

(c) Electrochemical reaction

(3) Degradation

From the viewpoint of electrical characteristics, degradation denotes a reduction of withstand voltage lower than the specified value, an abnormal increase in current, and a drift of characteristic values.

Since transistors are produced based on

physical and chemical technology, it is assumed that thermodynamic changes on the surface or in the interior of a transistor caused by voltage, current, temperature, or humidity will result in changes in its physical and chemical properties. As such changes increase gradually, the specified values will be finally exceeded.

The principal factors for deterioration are supposedly—

(a) Structural flaws
(b) Designing problems
(c) Operating problems

Table 3 Lists the relations between failure modes caused by these factors and failure mechanisms.

Table 3 Relationship between failure modes and failure mechanisms

Failure mode	Failure mechanisms / Failure factors	Structural items				Seal		Interior					Surge		
		Structural flaws	Contact and connecting portions	Correlation between components	Thermal fatigue	Defective housing	Sealing	Junction imperfection	Surface channel	Entrapped foreign gas ions	Ionic conduction	Corrosion	Overcurrent	Overvoltage	Static electricity
Open circuit	Open lead (fused)												○		
	Open lead (mechanical)	○			○										
	Abnormal bonding.	○	○	○	○							○			
Short circuit	Junction short circuit				○			○					○	○	○
	Arcing													○	○
	Pellet crack	○		○	○										
	Infiltrated foreign matter	○				○									
	Contact between leads	○	○	○		○									
Degradation	Atmosphere						○		○	○	○	○			
	Smears				○				○	○	○	○			
	Influence of surface oxidized film				○				○		○	○			
	Junction interior				○			○							○
	Arcing													○	○
	Pellet cracks	○		○	○										
Others	Defective external lead wires	○	○			○									
	Housing surface leak	○				○									
	Rust					○									

6. Reliability test

Reliability tests are conducted either for maintaining and confirming reliability assurance levels or for comprehending the design margins and limit levels for using such data when renewing a design.

The reliability test methods and conditions differ according to respective objectives. Normally, an accelerated life test and an environment test are conducted based on maximum ratings by simulating stresses to which transistors will be subjected in actual operation.

Since some tests posses destructive characteristics, it is important to establish reproducible, generally applicable test methods and conditions.

Standard test methods applicable to semiconductor products include JIS, EIAJ, MIL, and IEC standards. Some typical standards among them are described hereunder; the contents of reliability tests are listed in Table 3.

- Japanese Industrial Standards (JIS)

JIS C5003	General test procedure of failure ratio for electronic components
JIS C5700	General rules for reliability assured electronic components
JIS C7021	Environmental testing methods and endurance testing methods for discrete semiconductor devices
JIS C7030	Testing methods for transistors
JIS C7032	General rules for transistors
JIS C7210	General rules for reliability assured discrete semiconductor devices

- Electronic Industries Association of Japan (EIAJ) Standards

EIAJ SD-121	Environmental and mechanical test methods for discrete semiconductor devices
EIAJ SD-71	Transistor test methods
EIAJ SD-31	Field-effect transistor test methods

- U.S. Military Standards (MIL)

MIL-STD-202	Test methods for electronic and electrical components parts
MIL-STD-750	Test methods for semiconductor devices
MIL-S-19500	Semiconductor devices, general specifications for

Table 4 Types and Contents of Reliability Tests

Clasification	Types	Description	Applicable standards
Initial performance test	Initial characteristics test	Items of electrical characteristics specified as ratings by respective standards are tested to confirm they fall within requirements of the standards.	
	Appearance, dimensions, and structure tests	Tests are conducted to confirm that materials, polarity, structure, external shapes, dimensions, marking, and external appearance of a transistor are in normal condition or within the allowable limits specified.	
Operation life test	Steady state operation life test:	Durability of a transistor is judged by applying electrical stress (voltage and current) and thermal stress (including temperature rise caused by load) to that transistor over a long period. This test is normally conducted by continuously applying voltage, current, or power at 25±5°C.	EIAJ SD-121 B-4 JIS C7021 B-4 MIL-STD-750B: 1026
	Intermittent operation life test:	Electrical and mechanical durability of a transistor is judged by intermittently feeding power to that transistor and by raising/lowering temperature in accordance with ON/OFF conditions. This test is normally conducted at 25±5°C under separately specified electrical and time conditions (such as power feeding cycle and interrupting cycle.)	EIAJ SD-121 B-6 JIS C7021 B-6 MIL-STD-750B: 1036
Storage life test	High-temperature storage life test:	Durability of a transistor is judged by storing the transistor at high temperature. Normally, the test temperature is the maximum rated storage temperature (Tstg Max).	EIAJ SD-121 B-9 JIS C7021 B-10 MIL-STD-750B: 1031
	Low-temperature storage life test:	Durability of a transistor is judged by storing the transistor at low temperature. Normally, the test temperature is the minimum rated storage temperature (Tstg Min).	EIAJ SD-121 B-9 JIS C7021 B-12
	High-temperature/high-humidity storage life test:	Durability of a transistor is judged under operation and storage at high relative humidity over a long period. Normally, the test conditions are 60°C and 90%RH.	EIAJ SD-121 B-10 JIS C7021 B-11 MIL-STD-202E: 103B

Clasifi-cation	Types	Description	Applicable standards
Environment test	Soldering heat test:	Heat resistance of a transistor is determined against heat to which it is subjected while soldering. Normally, the test conditions are 206±5°C for 10 seconds.	EIAJ SD-121 A-1 JIS C7021 A-1 MIL-STD-750B: 2031
	Temperature cycling test:	Thermal resistance of a transistor is determined by exposing it to high and low temperatures. Normally, the test is conducted for 5 cycles of minimum and maximum storage temperatures.	EIAJ SD-121 A-4 JIS C7021 A-4 MIL-STD-750B: 1051
	Moisture resistance test (temperature/humidity cycling test):	Durability of a transistor is determined by exposing it to high humidity under low and high temperature cycles. Normally, the test conditions are Ta=25°C – 65°C to −10°C and RH=90 – 98%. The test is conducted for ten cycles, with one cycle continued for 24 hours.	EIAJ SD-121 A-5 JIS C7021 A-5 MIL-STD-750B: 1021
	Seal test:	Air tightness of the seal is determined. Tiny gas leakages are detected by using tracer gas, large leakages by air bubbles.	EIAJ SD-121 A-6 JIS C7021 A-6 MIL-STD-750B: 1071
Mechanical test	Solderability test:	Ease in soldering lead wires is determined. Normally, the test is conducted at 230±5°C for 5 seconds.	EIAJ SD-121 A-2 JIS C7021 A-2 MIL-STD-750B: 2026
	Vibration test:	Durability against vibration during transportation or operation is determined. Normally, changes in vibration frequency (100 –2000 Hz) are applied.	EIAJ SD-121 A-10 JIS C7021 A-10 MIL-STD-202E: 2046, 2056
	Shock test:	Structural and mechanical durability is judged. The test is conducted by applying 1500G three times each in four directions.	EIAJ SD-121 A-7 JIS C7021 A-7 MIL-STD-750B: 2016
	Constant acceleration test:	Durability against constant acceleration is determined. The test is normally conducted by applying 20,000G for 1 min. in six directions.	EIAJ SD-121 A-9 JIS C7021 A-9 MIL-STD-750B: 2006

Clasification	Types	Description	Applicable standards
Mechanical test	Drop test:	Structural and mechanical durability is judged. Normally, a test piece is dropped three times from the height of 75cm onto a maple board.	EIAJ SD-121 A-8 JIS C7021 A-8
	Lead strength test:	Lead strength is determined as to whether or not leads are strong enough to endure force to be applied while mounting, wiring, or operating. Normally, lead wires are bent three times by 90° through applying a 250g weight.	EIAJ SD-121 A-8 JIS C7021 A-8 MIL-STD-750B: 2036
	Salt atmosphere test:	Corrosion resistance of a transistor is determined. Normally, the test is conducted at 35°C room temperature by spraying with 5% salt solution for 24 hours. The test is conducted for ten cycles, with one cycle continued for 24 hours.	EIAJ SD-121 A-2 JIS C7021 A-2 MIL-STD-750B: 1046
Acceleration test	Acceleration test:	Generally, life tests consume a long time; at present, especially, the time when the reliability of transistors has been enhanced substantially, life tests require an extremely long time and many samples. Therefore, a forced deterioration test is conducted by increasing stresses exceeding the rated values. The types of forced deterioration factors which should be used such a this test differ substantially depending on the mechanism to cause failures. It is important, therefore, to select forced deterioration factors suitable for the mechanism to be inspected. Additionally, it is necessary to fully comprehend the relations with normal life tests.	

7. Reliability data

Tables 5 and 7 display the results of reliability tests as a typical example of tests conducted in accordance with the above-mentioned test methods, by using a plastic resin sealed-type, small-signal transistor.

Typical criteria for judging failures in these tests are listed in Tables 6 and 8.

Variations by time of various characteristic parameters in operation tests are often analyzed in detail as one of the most basic procedures for estimating transistor reliability. Variations by time of such parameters in life tests conducted as to Tables 5 and 7 are shown in Figs. 5 and 6 as typical examples.

It is evident from these data that initial characteristics are maintained over long hours despite the fact that these tests were conducted based on test conditions using maximum ratings.

It is presumed, therefore, that high reliability can be expected under actual operating conditions of equipment or a device.

Table 5 Results of reliability tests using plastic resin sealed-type small-signal transistor 2SC1815

	Test item	Applicable standards (JIS C7021)	Test conditions	Sample size	Failures	Remarks*
Life test	Steady state operation	B−4	Vc=25V, Pc=300mW Ta=25°C, 1000Hrs	230	0	0.4
	High-temperature storage	B−10	Ta=125°C, 1000Hrs	210	0	
	High-temperature/ High-humidity storage	B−11	Ta=60°C, RH=90% 1000Hrs	230	0	
Environmental test	Soldering heat	A-1	260°C, 10 sec., 1 time (up to 1.5mm from lead root)	170	0	
	Temperature heat	A-4	−55°C~25°C~125°C~25°C 20 cycles	530	0	
	Thermal shock	A-3	100°C~0°C, 10 cycles	190	0	
	Moisture resistance	A-5	Ta=~65°C, RH=90~98% 10 cycles	190	0	
Mechanical tests	Vibration	A-10	100~2000Hz 20G 3 directions x four times each	60	0	
	Shock	A-7	1500G, 0.5ms 4 directions x 3 times each	60	0	
	Constant acceleration	A-9	20000G, 6 directions x 1 min.	60	0	
	Lead strength	A-11	250g, 90° bending x 3 times	90	0	
	Drop	A-8	75cm, maple board	90	0	
	Solderability	A-2	230°C, 5 seconds (using specified flux)	90	0	

*Failure ratio = %/1,000 hrs, 60% confidence level

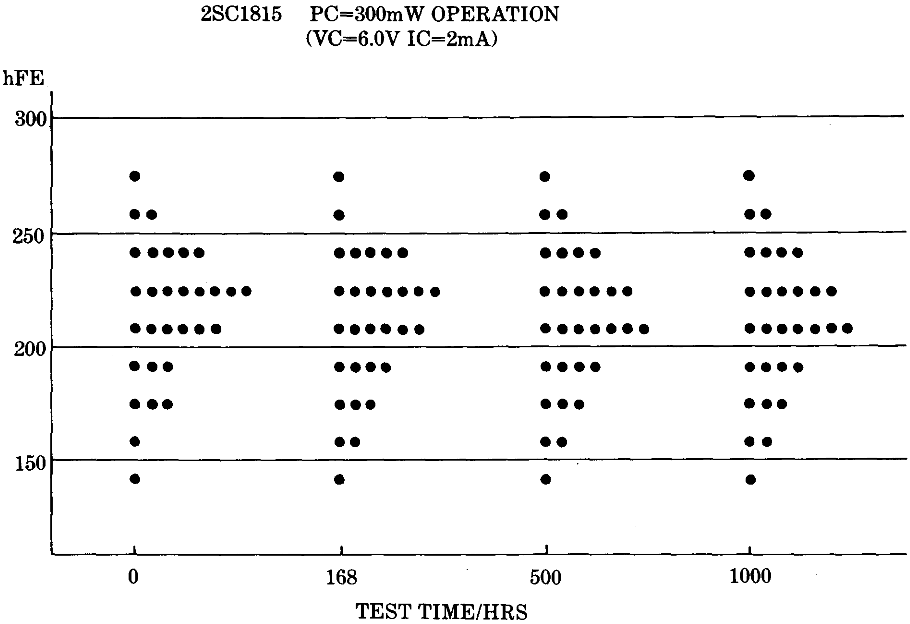


Fig. 5 Typical example of results of steady state operation life test of plastic resin sealed-type 2SC1815

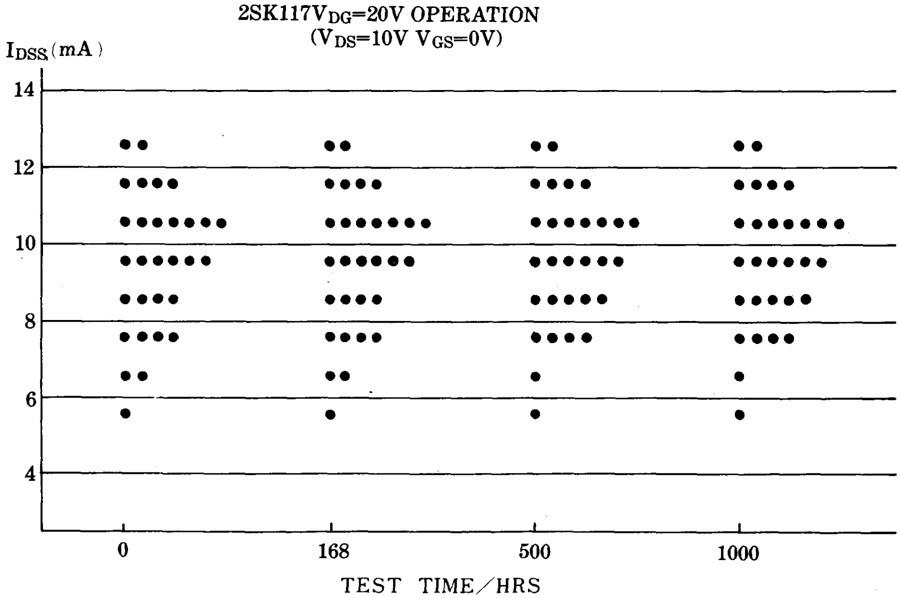


Fig. 6 Typical example of results of steady state operation life test of plastic resin sealed-type 2SK117

Table 6 Criteria on failures for 2SC1815

Items of characteristics	Symbols	Measuring conditions (Ta=25°C)	Criteria*	Remarks
Collector cutoff current	I_{CBO}	V_{CB}=60Vm I_E=0	USLx2	0.2μA Max
Emitter cutoff current	I_{EBO}	V_{EB}=5V, I_C=0	USLx2	0.2μA Max
Static forward current transfer ratio	h_{FE}	V_{CE}=6V, I_C=2mA	USLx1.2 LSLx0.8	56~480

*USL: Upper specification limit, LSL: Lower specification limit

Table 7 Extracted results of reliability tests using plastic resin sealed-type FET transistor 2SK117

	Test item	Applicable standards (JIS C7021)	Test conditions	Sample size	failures	Remarks*
Life test	Steady state operation	B−5	V_{DS}=20V Ta=25°C, 1000Hrs	190	0	0.5
	High-temperature storage	B−10	Ta=125°C, 1000Hrs	190	0	
	High-temperature/ High-humidity storage	B−11	Ta=60°C, RH=90% 1000Hrs	190	0	

*Failure ratio = %/1,000 hrs, 60% confidence level

Table 8 Criteria on failures for 2SK117

Items of characteristics	Symbols	Measuring conditions (Ta=25°C)	Criteria*	Remarks
Gate leak current	I_{GSS}	V_{GS}=−30V, V_{DS}=0	USLx2	−2.0nA Max
Gate drain voltage with source short-circuited to drain	V_{GDS}	V_{DS}=0, I_G=~100μA	LSLx0.9	−45V Min
Drain current	I_{DSS}	V_{DS}=10V, V_{GS}=0	USLx1.2 LSLx0.8	0.48~16.8mA

*USL: Upper specification limit, LSL: Lower specification limit

Characteristics of Transistor

Equivalent parameters of a transistor include the device parameters which closely respond to the internal operating mechanism of a transistor and the circuit parameters which are indicated as a matrix obtained from regarding a transistor as a terminal circuit network.

These parameters are also divided into small-signal equivalent circuits (analog circuits) and large-signal equivalent circuits (digital circuits), in accordance with the extent of signals (amplitude) to be handled.

Equivalent circuits have been developed very much. It is necessary for circuit designers to select an optimal one by paying attention to the application ranges and operating limits of respective equivalent circuits. Table 1 lists equivalent circuits presently employed. Among others, small-signal eqivalent circuits are hereafter described, since they are generally used.

Table 1 List of transistor equivalent circuits

- Transistor equivalent circuits
  - Small-signal equivalent circuits (general linear circuits such as amplification, oscillation, modulation, and demodulation)
    - Device parameters
      - Early's T-type equivalent circuits (common base circuit)
      - Giacoletto's π-type equivalent circuit (emitter and collector common circuit)
    - Circuits parameters
      - Matrices showing the relation among the input and the output by voltage and current
        - a,b matrices;
        - g,h matrices (low frequency);
        - y,z matrices (high frequency)
      - Matrix showing the relation among the input and the output by power
        - s matrices (superhigh frequency) (transmittance coefficient, reflection coefficient indication)
  - Large-signal equivalent circuit—device parameter (nonlinear circuit such as pulse, digital, and switching circuits)
    - Current control model by Evers-Moll;
    - Charge control model by Beaufoy-Sparkes;
    - Density control model by Linvill;
    - other nonlinear models

1. Device parameter

(1) Early's T-type equivalent circuit

(Bipolar transistor)

Figure 1 shows Early's T-type equivalent circuit.

r_e: Emitter resistance,

This is represented by the following equation, since it is forward-biased resistance with emitter-to-base junction:

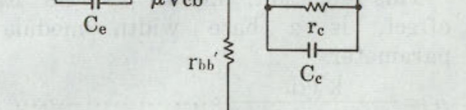


Fig. 1 Early's T-type equivalent circuit

$$r_e = \frac{kT}{qI_E}(\Omega) \cdots\cdots\cdots \quad (1)$$

where,

k: Boltzman's constant $(1.38 \times 10^{-26} J/°K)$

T: Absolute temperature (°K)

q: Electric charge of electron $(1.60 \times 10^{-19} C)$

I_E: Emitter current (A)

Equation (1) is changed as follows at normal temperature (300°K) if the emitter current is represented by mA:

$$r_e = \frac{26}{I_E(mA)}(\Omega) \cdots\cdots\cdots \quad (2)$$

C_e: Emitter capacitance $(C_{Te} + C_{De})$

This is represented as a sum of the depletion layer capacitance and the diffusion capacitance. Normally since the depletion layer capacitance in an emitter-to-base junction is far smaller than the diffusion capacitance, it can be ignored.

The depletion layer capacitance C_{Te} and the diffusion capacitance C_{De} are represented as—

$$C_{Te} = A_e \sqrt{\frac{\frac{1}{2}\varepsilon q n_N}{\phi_0 - V_{b'e}}}(F) \cdots\cdots\cdots \quad (3)$$

where,

Ae: Emitter junction area (m^2)

ϵ: permittivity

n_N: Majority carrier density (m^{-3}) on high specific resistance side (NPN in this case)

ϕ_0: Contact potential difference (potential fault when balanced) (V)

$V_{b'e}$: Potential applied to both ends of base to emitter junction (1)

$$C_{De} = \frac{qI_E W^2}{2kTD}(F) \cdots\cdots\cdots \quad (4)$$

where,

W: Base width (m)

D: Diffusion coefficient of minority carrier in base area (m^2/sec)

μ: Voltage feedback ratio (Early constant)

This constant, known as the Early effect, is a base width modulation parameter,

$$\mu = \frac{kTd_c}{3qW(\phi_0 - V_{b'c})} \cdots\cdots\cdots \quad (5)$$

where,

d_c: Width of collector depletion layer (m)

r_c: Collector resistance

This is a kind of base width modulation parameter, represented as follows:

$$r_c = \frac{1}{I_E\left(\frac{\partial \alpha}{\partial V_{b'c}}\right)}(\Omega) \cdots\cdots\cdots \quad (6)$$

The value of r_c is usually 1— 2 MΩ or so.

C_c: Collector capacitance

Similarly to emitter capacitance, this is shown as the sum of depletion layer capacitance and diffusion capacitance of the collector-to-base junction. However, since the diffusion capacitance of the collector-to-base junction is far smaller than the depletion layer capacitance, it can be ignored. The depletion layer capacitance is represented as

$$C_{Tc} = A_C \sqrt[3]{\frac{\frac{\varepsilon^2 qa}{12}}{\phi_0 - V_{b'e}}}(F) \cdots\cdots\cdots \quad (7)$$

where,

A_c: Collector junction area (m^2)

a: Impurity concentration gradient (m^{-4})

$V_{b'c}$: Potential applied to both ends of base to collector junction (V)

Usually the value of Cc is 1—10pF.

α: DC forward current transfer ratio

This is the only parameter among Early's T-type parameters that depends on frequency, represented by the equation

$$\alpha = \frac{\alpha_0}{1 + j\omega C_e r_e} \qquad f\alpha = \frac{1}{2\pi C_e r_e}$$

therefore,

$$\alpha = \frac{\alpha_0}{1 + j\frac{f}{f\alpha}} \cdots\cdots\cdots \quad (8)$$

where,

α_0: Value of α at low frequency

$f\alpha$: α-interrupting frequency (frequency at which α is reduced by 3db less than α_0)

Fig. 2 shows the frequency locus of α. When actually measuring α, the difference between theoretical and measured values is increased as the frequency approaches $f\alpha$. This is because Early's equivalent circuit is based on the primary approximation of physical phenomena.

To correct it, Thomas-Moll introduced excess phase m and offered the equation

$$\alpha = \frac{\alpha_0}{1+j\frac{f}{f\alpha}} e^{-jm\frac{f}{f\alpha}} \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (9)$$

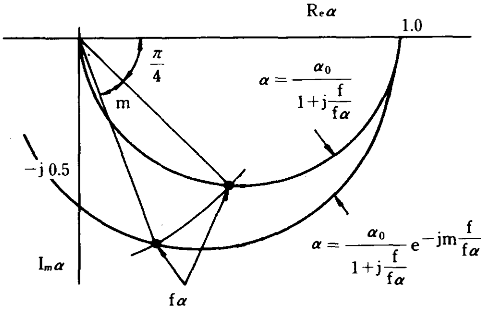


Fig. 2 Frequency locus of α

The above equation agrees well with measured values in frequencies less than f_α.

DC Current gain (β) at common emitter is represented as follows:

$$\beta = \frac{\alpha}{1-\alpha} = \frac{\alpha_0}{(1-\alpha_0)+j\frac{f}{f\alpha}}$$

The β-interrupting frequency f_β is defined as the frequency at which the absolute value of β becomes $\beta_0/\sqrt{2}$, similarly to $f\alpha$, f_β is represented as—

$$f_\beta = \frac{\alpha_0}{\beta_0} f\alpha$$

therefore,

$$\beta = \frac{\beta_0}{1+j\frac{f}{f_\beta}} \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (10)$$

$r_{bb'}$: Base diffusion resistance

This is resistance from the center of base area to the external base terminal which actually contributes to transistor action and is determined according to shape and dimensions of the transistor and base specific resistance.

$$r_{bb'} \fallingdotseq \frac{q_B}{8\pi W}(\Omega) \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (11)$$

where,

q_B: Specific resistance of base area (Ω·m)

(2) Giacoletto's π-type equivalent circuit (bipolar transistor)

Fig. 3 shows the π-type equivalent circuit. This equivalent circuit is in itself the same as Early's T-type equivalent circuit mentioned above. The only difference from Early's T-type eqivalent circuit is that each parameter has—in principle— no frequency response.

Since the physical meaning of each parameter is easy to understand, this circuit is popularly employed. When actually employed for circuit calculation, it will prove convenient if the basic style shown in Fig. 3 is slightly simplified by considering frequency range.

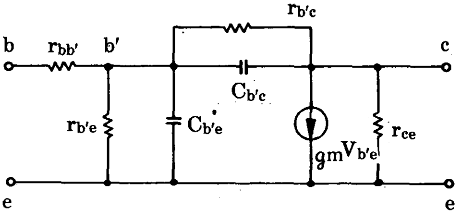


Fig. 3 π-type equivalent circuit

Paramaters of the T-type equivalent circuit and those of the π-type have the correlation shown in Table 2.

Table 2 Relationship between paramaters of T-type and π-type equivalent circuits

π-type equivalent circuit paramaters	T-type equivalent circuit paramaters
$C_{b'e}$	C_e
$r_{b'e}$	$\frac{r_e}{1-\alpha_0}$
$C_{b'c}$	C_c
$\frac{1}{r_{b'c}}$	$\frac{1}{r_c}-\frac{\mu(1-\alpha_0)}{r_e}$
r_{ce}	$\frac{r_e}{\mu}$
g_m	$\frac{\alpha_0}{r_e}$
r_{bb}	$r_{bb'}$

(3) FET equivalent circuit

Similarly to bipolar transistors, FET can be indicated by using an equivalent circuit. Fig. 4 is a schematic diagram of the equivalent circuit by relating to its structure.

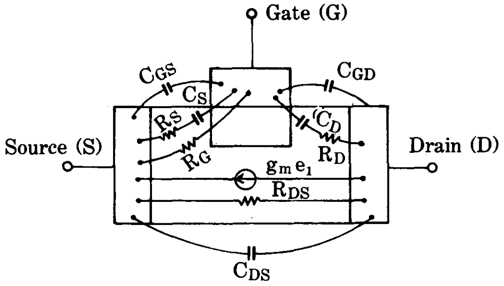


Fig. 4 equivalent circuit in relation to structure of an FET

This diagram is rewritten into an equivalent circuit in Fig. 5(a), and further rewritten into a practical, simplified equivalent circuit in Fig. 5(b).

C_{GD}, C_{GS} and C_{DS} shown here are parasitic capacitances. Since their values are relatively small, it is possible to ignore them unless this circuit is used in VHF regions.

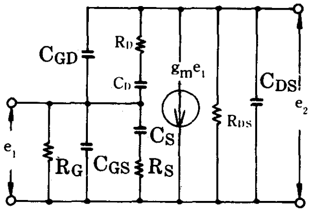
However, when using transistors whose capacitances between electrodes are large, such as a power FET and a high-gm FET in low-frequency regions, these capacitances must be considered fully.

For FET to be used in chopper circuits, it is necessary to keep the difference between C_{DG} and C_{GS} small to prevent spikes.

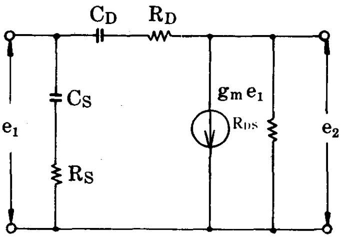
This equivalent circuit shows the characteristic of an FET very well, because it is related to the structure of an FET and it is shown by using basic parameters not depending on frequency.

As shown in the simplified equivalent circuit, for example, it is understood that DC input resistance (which is infinity) can be practically ignored and that C_D (internal feedback capacitance) is an unstable factor at high frequency.

At low frequency, it is possible to ignore capacitance; input resistance is infinity, while output resistance=R_{DS}. This is almost the equivalent circuit of a vacuum tube.



(a) Equivalent circuit



(b) Simplified equivalent circuit

Fig. 5 Equivalent circuit

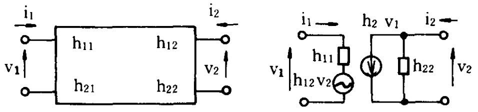
2. Circuit parameters

This is a method used to describe a transistor by regarding it as a four-terminal circuit network and by using the electrical characteristics of terminals irrespective of the physical characteristics of the transistor.

(1) Matrices showing the relation among the input and the output by voltage and current.

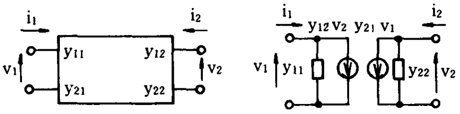
Those matrices have the six types shown in Table 1 (a, b, g, h, y, and z matrices). Among others, both"h"and"y"matrices are used comparatively often.

Fig. 6 and 7show the definitions of"h"and"y" matrices. Classification between the common emitter and the common base is shown by using suffixes e or b after i, r, f, or o.



$$\begin{bmatrix} v_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} i_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} h_i & h_r \\ h_f & h_o \end{bmatrix} \begin{bmatrix} i_1 \\ v_2 \end{bmatrix}$$

Fig. 6 Circuit network by using "h" matrix



$$\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} y_i & y_r \\ y_f & y_o \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

Fig. 7 Circuit network by using "y" matrix

The physical meanings of each parameter in Figs. 6 and 7 are as follows:

h_i: input impedance
h_r: voltage feedback ratio
h_f: current gain
h_o: output admittance
y_i: input admittance
y_r: reverse transfer admittance
y_f: forward transfer admittance
y_o: output admittance

The h matrix are often used for the low-frequency regions, and y matrix for the high-frequency regions.

(2) Matrix showing the relation among the input and the output by power

Such phenomena as the reflection and transfer of waves in microwave circuits (such as waveguides and cavity resonators) are usually indicated by a "s" matrix (scattering matrix).

As the frequency limits for semiconductor products expand, the "s" matrix is occasionally used as a circuit paramater.

The definition of the "s" matrix is shown in Fig. 8; the physical meanings of each parameter are as follows:

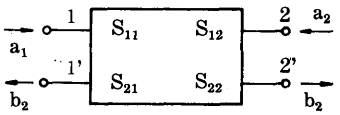
s_{11} : input reflection coefficient
s_{12} : reverse transfer coefficient

Table 3 Conversion of parameters

	[H]	[Y]	[S]
[H]	$\begin{matrix} h_i & h_r \\ h_f & h_o \end{matrix}$	$\begin{matrix} \frac{1}{y_i} & -\frac{y_r}{y_i} \\ \frac{y_f}{y_i} & \frac{y_i y_o - y_r y_f y_f}{y_i} \end{matrix}$	$\begin{matrix} \frac{(1+s_o)(1+s_i)-s_r s_f}{(1-s_i)(1+s_o)+s_r s_f} & \frac{2s_r}{(1-s_i)(1+s_o)+s_r s_f} \\ \frac{-2s_f}{(1-s_i)(1+s_o)+s_r s_f} & \frac{(1-s_i)(1-s_o)-s_r s_f}{(1-s_i)(1+s_o)+s_r s_f} \end{matrix}$
[Y]	$\begin{matrix} \frac{1}{h_i} & -\frac{h_r}{h_i} \\ \frac{h_f}{h_i} & \frac{h_i h_o - h_r h_f}{h_i} \end{matrix}$	$\begin{matrix} y_i & y_r \\ y_f & y_o \end{matrix}$	$\begin{matrix} \frac{(1+s_o)(1-s_i)+s_r s_f}{(1+s_i)(1+s_o)-s_r s_f} & \frac{-2s_r}{(1+s_i)(1+s_o)-s_r s_f} \\ \frac{-2s_f}{(1+s_i)(1+s_o)-s_r s_f} & \frac{(1+s_i)(1-s_o)+s_r s_f}{(1+s_i)(1+s_o)-s_r s_f} \end{matrix}$
[S]	$\begin{matrix} \frac{(h_i-1)(h_o+1)-h_r h_f}{(h_i+1)(h_o+1)-h_r h_f} & \frac{2h_r}{(h_i+1)(h_o+1)-h_r h_f} \\ \frac{-2h_f}{(h_i+1)(h_o+1)-h_r h_f} & \frac{(1+h_i)(1-h_o)+h_r h_f}{(h_i+1)(h_o+1)-h_r h_f} \end{matrix}$	$\begin{matrix} \frac{(1-y_i)(1+y_o)+y_r y_f}{(1+y_i)(1+y_o)-y_r y_f} & \frac{-2y_r}{(1+y_i)(1+y_o)-y_r y_f} \\ \frac{-2y_f}{(1+y_i)(1+y_o)-y_r y_f} & \frac{(1+y_i)(1-y_o)+y_r y_f}{(1+y_i)(1+y_o)-y_r y_f} \end{matrix}$	$\begin{matrix} s_i & s_r \\ s_f & s_o \end{matrix}$

s_{21} : forward transfer coefficient
s_{22} : output reflection coefficient

Suffix b or e is used to indicate the common base or the common emitter in the same manner as y parameters and h parameters.



$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} s_{11} & s_{12} \\ s_{21} & s_{22} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} s_i & s_r \\ s_f & s_o \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$

Fig. 8 Circuit network by using "s" matrix

Table 4 Conversion formulas for "h" parameters

		Converted"h"parameters		
		Common base	Common emitter	Common collector
Known "h" parameters	Common base		$\begin{matrix} \frac{h_{ib}}{1+h_{fb}} & \frac{\Delta h_b - h_{rb}}{1+h_{fb}} \\ \frac{-h_{fb}}{1+h_{fb}} & \frac{h_{ob}}{1+h_{fb}} \end{matrix}$	$\begin{matrix} \frac{h_{ib}}{1+h_{fb}} & 1 \\ \frac{-1}{1+h_{fb}} & \frac{h_{ob}}{1+h_{fb}} \end{matrix}$
	Common emitter	$\begin{matrix} \frac{h_{ie}}{1+h_{fe}} & \frac{\Delta h_e - h_{re}}{1+h_{fe}} \\ \frac{-1}{1+h_{fe}} & \frac{h_{oe}}{1+h_{fe}} \end{matrix}$		$\begin{matrix} h_{ie} & 1-h_{re} \\ -(1+h_{fe}) & h_{oe} \end{matrix}$
	Common collector	$\begin{matrix} \frac{-h_{ic}}{h_{fc}} & \frac{-\Delta h_c}{h_{fc}} - 1 \\ \frac{-(1+h_{fc})}{h_{fc}} & \frac{h_{oc}}{h_{fc}} \end{matrix}$	$\begin{matrix} h_{ic} & 1-h_{rc} \\ -(1+h_{fc}) & h_{oc} \end{matrix}$	

$\Delta h_e = h_{ie} \cdot h_{oe} - h_{re} \cdot h_{fe}$, $\Delta h_b = h_{ib} \cdot h_{ob} - h_{rb} \cdot hh_{fb}$, $\Delta h_c = h_{ic} \cdot h_{oc} - h_{rc} \cdot h_{fc}$

Table 5 Conversion formulas for "y" parameters

		Converted"y"parameters		
		Common base	Common emitter	Common collector
Known "y" parameters			$\begin{matrix} \Sigma y_b & -(y_{rb}+y_{ob}) \\ -(y_{fb}+y_{ob}) & y_{ob} \end{matrix}$	$\begin{matrix} \Sigma y_b & -(y_{ib}+y_{ob}) \\ -(y_{ib}+y_{rb}) & y_{ib} \end{matrix}$
		$\begin{matrix} \Sigma y_e & -(y_{re}+y_{oe}) \\ -(y_{fe}+y_{oe}) & y_{oe} \end{matrix}$		$\begin{matrix} y_{ie} & -(y_{ie}+y_{re}) \\ -(y_{ie}+y_{oe}) & \Sigma y_e \end{matrix}$
		$\begin{matrix} y_{oc} & -(y_{fc}+y_{oc}) \\ -(y_{rc}+y_{oc}) & \Sigma y_c \end{matrix}$	$\begin{matrix} y_{ic} & -(y_{ic}+y_{rc}) \\ -(y_{ic}+y_{fc}) & \Sigma y_c \end{matrix}$	

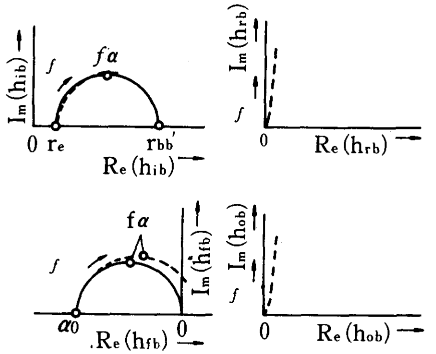
$\Sigma y_e = y_{ie} + y_{re} + y_{fe} + y_{oe}$
$\Sigma y_b = y_{ib} + y_{rb} + y_{fb} + y_{ob}$
$\Sigma y_c = y_{ic} + y_{rc} + y_{fc} + y_{oc}$

Table 6 "h" parameters converted by Early's T-type device parameters

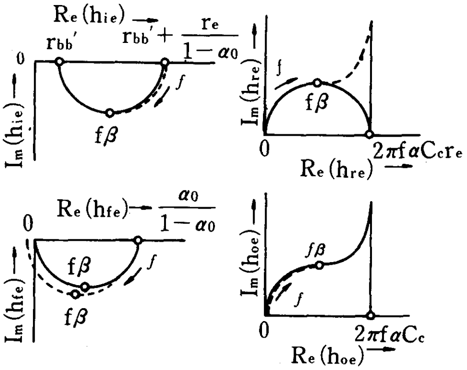
	Common base		Common emitter
h_{ib}	$\dfrac{r_e+r_{bb}'\left[(1-\alpha_0)+j\dfrac{f}{f\alpha}\right]}{1+j(f/f\alpha)}$	h_{ie}	$r_{bb}'+\dfrac{r_e}{(1-\alpha_0)+j(f/f\alpha)}$
h_{rb}	$j2\pi fC_c r_{bb}'$	h_{re}	$2\pi f\alpha C_c r_e\dfrac{j\dfrac{f}{f\alpha}}{(1-\alpha_0)+j(f/f\alpha)}$
h_{fb}	$\dfrac{-\alpha_0}{1+j(f/f\alpha)}$	h_{fe}	$\dfrac{\alpha_0}{(1-\alpha_0)+j(f/f\alpha)}$
h_{ob}	$j2\pi fC_c$	h_{oe}	$2\pi f\alpha C_c\dfrac{j\dfrac{f}{f\alpha}(1+j\dfrac{f}{f\alpha})}{(1-\alpha_0)+j(f/f\alpha)}$

Table 7 "y" parameters converted by Early's T-type device parameters

	Common base		Common emitter
y_{ib}	$\dfrac{1+j\dfrac{f}{f\alpha}}{r_e+jr_{bb}'\dfrac{f}{f\alpha}}$	y_{ie}	$\dfrac{(1-\alpha_0)+j\dfrac{f}{f\alpha}}{r_e+jr_{bb}'\dfrac{f}{f\alpha}}$
y_{rb}	$-2\pi f\alpha C_c\dfrac{j\dfrac{f}{f\alpha}\left(1+j\dfrac{f}{f\alpha}\right)}{\dfrac{r_e}{r_{bb}'}+j\dfrac{f}{f\alpha}}$	y_{re}	$-2\pi f\alpha C_c\dfrac{r_e}{r_{bb}'}\dfrac{j\dfrac{f}{f\alpha}}{\dfrac{r_e}{r_{bb}'}+j\dfrac{f}{f\alpha}}$
y_{fb}	$-\dfrac{\alpha_0}{r_e+jr_{bb}'\dfrac{f}{f\alpha}}$	y_{fe}	$\dfrac{\alpha_0}{r_e+jr_{bb}'\dfrac{f}{f\alpha}}$
y_{ob}	$2\pi f\alpha C_c\dfrac{j\dfrac{f}{f\alpha}\left(1+\dfrac{r_e}{r_{bb}'}+j\dfrac{f}{f\alpha}\right)}{\dfrac{r_e}{r_{bb}'}+j\dfrac{f}{f\alpha}}$	y_{oe}	y_{ob}

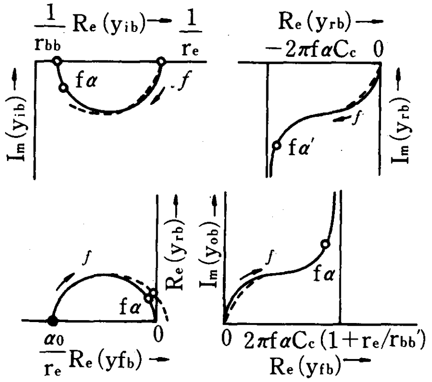


(1) Common base

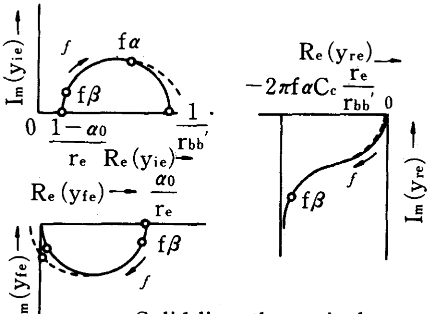


(2) Common emitter

Fig. 9 Frequency locus of "h" parameters



(1) Common base



Solid line: theoretical curves
Hyphenated line: measured curves

(2) Common emitter

Fig. 10 Frequency locus of "y" parameters

Please refer to Tables 3, 4, and 5 for the correlation and conversion of common base and common emitter among circuit parameters. Fig. 9 and 10 shows the frequency locuses of "h" and "y" parameters obtained from Tables 6 and 7.

The above-mentioned parameters vary according to the operating points and temperature; thus, circuit designers should effect designing by comprehending the rough trends of such variations.

3. Low-frequency, low-noise amplifier circuit

(1) Design for low-noise amplifiers

It is necessary to carefully select the types and operating methods of transistors to be used when designing low-noise amplifiers. Voltage, current, and signal source impedance conditions to be operated should be fully checked and operate the transistors within the best noise characteristic range.

This section describes the concept of noise characteristics, the most suitable transistor conditions, and relations between the amplifier S/N ratio and the noise figure of transistors, so that circuits can be designed by fully utilizing the charactristics of low-noise transistors.

(2) Noise characteristics of transistors

The noise figures (NF) of transistors are represented by the equation

$$\mathrm{NF} = 10 \log \left(\frac{\mathrm{Esi}}{\mathrm{Eni}} \Big/ \frac{\mathrm{Eso}}{\mathrm{Eno}} \right)^2 \qquad \mathrm{(dB)}$$

$$= 20 \log\left(\frac{\text{Esi}}{\sqrt{4\text{kTRgB}}} \Big/ \frac{\text{Eso}}{\text{Eno}}\right) \text{ (dB)} \quad \cdots\cdots (13)$$

Esi: input signal voltage
Eni: input noise voltage
Eso: output signal voltage
Eno: output noise voltage
k: Boltzmann's constant (1.38×10^{-23}J/°K) $4kT = 1.63 \times 10^{-20}$J
T: absolute temperature (°K)
Rg: signal source resistance
B: noise bandwidth
or Eni = 4kTRgB

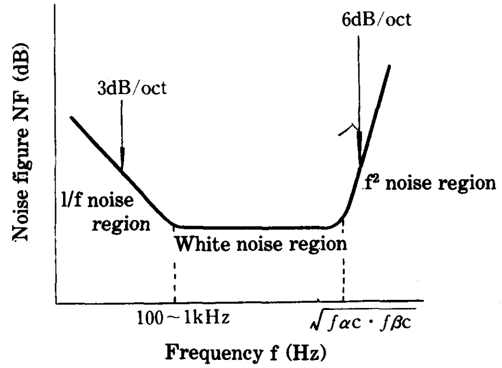


Fig. 11

Table 8

Items \ Types	1/f noise region	White noise region	f² noise region
Discription	Noise increasing in reverse proportion to frequency f	Constant noise irrespective of frequency	Noise increasing by 6 dB/oct in proportion to frequency f
Causes	Surface fluctuation	Thermal noise caused by base spreading resistance $r_{bb'}$	Fluctualtion by current separation
Suitability for audio application	○	○	×
Equalizer amplifier	◎	○	×

The relations between NF and the frequency is shown in the above figure. Noise characteristics are divided into ① 1/f noise region, ② white noise region, and ③ f² noise region, according to the frequency.

$$e_N = \sqrt{4kTR_NB}$$

$$i_N = \sqrt{2qI_bB}$$

Assuming that there is an ideal transistor possessing no noise sources, the abovementioned noise figure (NF) can be represented as

$$NF = 10 \log\left(\frac{4kTRg + e_N^2 + i_N^2Rg^2 + 2\gamma e_N \cdot i_N}{4kTRg}\right) \text{ (dB)} \quad \cdots\cdots (14)$$

where, B=1 Hz, and γ:=correlated coefficient of e_N and i_N

This equation shows the relations between NF and e_N and i_N

It is evident from equation (14) that noise figure NF is dependent upon collector current Ic and signal source impedance Rg. Assuming that the total noise voltage=e_{NT},

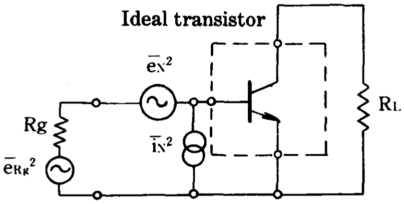


Fig. 12

Transistors can be identified by using the following voltage noise source e_N and current noise source i_N

$$\bar{e}_{NT}^2 = 4kTRg + \bar{e}_N^2 + \bar{i}_N^2Rg^2 + 2\gamma e_N \cdot i_N \quad \cdots\cdots (15)$$

Therefore, there is the following relationship between e_{NT} and signal source impedance Rg.

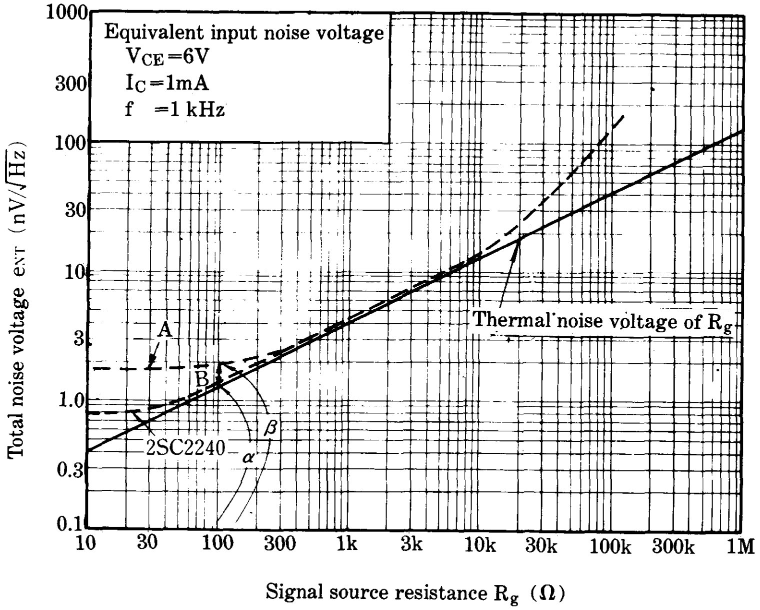
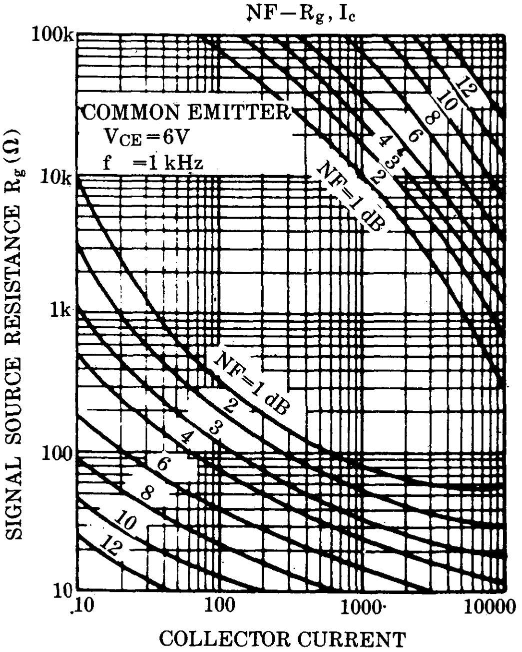
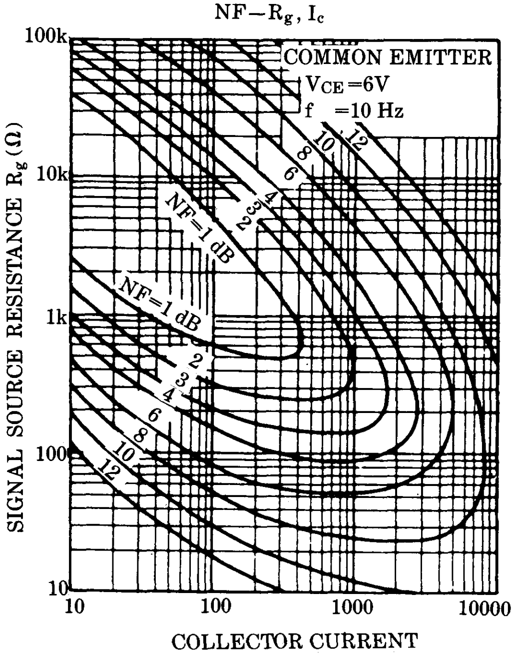


Fig. 13





(2SC2240) **Fig. 14**

Fig. 15

When referring to the curve A in the figure of e_{NT}-Rg, NF can be represented by the difference B between the curve and the thermal noise voltageof Rg.

$NF=20\ (\log\beta-\log\alpha)$ corresponds to B in the above figure.

As is evident from equation (15), voltage noise plays the main role in those regions where signal source impedance Rg is small, while current noise plays the main role in those regions where Rg is large.

The figure termed an NF map, shown Fig. 14, Fig. 15, is obtained by adding the dependability of collector current to the graph of e_{NT}-Rg.

In this figure, contour lines of the NF are used to determine optimum operating conditions.

By referring to this NF map, the collector current Ic at which NFs at f=1 kHz and f=10 Hz are minimized is obtained by using the signal source impedance of a circuit to be used. When designing low-noise amplifiers, it is necessary to consider the conditions of circuits before and after them.

By referring to the foregoing description of NF, amplifier noise is explained in the next section.

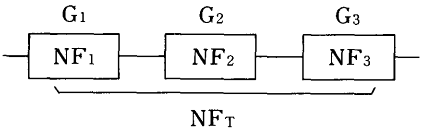


Fig. 16 NF of multistage amplifiers

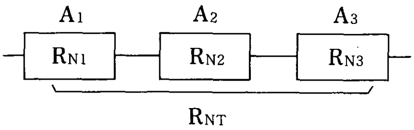


Fig. 17 Multistage amplifiers represented by using equivalent noise resistance

(3) Noise of amplifiers

The signal-to-noise ratio (S/N ratio) is an important factor in designing an amplifier.

$$S/N = 20\log\frac{\text{rated output voltage}}{\text{output noise voltage}}\ (\text{dB}) \quad \cdots\cdots (16)$$

From equation (13) for NF, equation (16) is connected with NF as follows:

$$\begin{aligned} S/N &= 20\log\frac{Eso}{Eno} \\ &= 10\log\frac{Eso^2}{Eno^2} \\ &= 10\log\left(\frac{Esi^2}{Eni^2}\cdot 10^{-\frac{NF}{10}}\right) \\ &= 10\log\frac{Esi^2}{4kTRgB}-NF\quad(\text{dB}) \end{aligned} \quad \cdots\cdots (17)$$

$$\boxed{\text{S/N ratio (dB) of amplifier}}=\boxed{\text{S/N ratio (dB) of Input-side}}-\boxed{\text{NF (dB) of Amplifier}}$$

(3-1) Noise figure of multistage amplifiers

The NF of the multistage amplifier shown in Fig. 16 is expressed as—

$$NF_T = NF_1+\frac{NF_2-1}{G_1}+\frac{NF_3-1}{G_1\cdot G_2}\cdots \quad (18)$$

NF_T: total noise figure
NF1: first-stage noise figure
NF2: second-stage noise figure
NF3: third-stage noise figure
G1: first-stage power gain
G2: second-stage power gain
G3: third-stage power gain

When using equivalent noise resistance R_N, the R_{NT} is expressed as—

$$R_{NT}=R_{N1}+\frac{R_{N2}}{A_1}+\frac{R_{N3}}{(A_1A_2)^2}\ \cdots\cdots\cdots \quad (19)$$

R_{NT}: total equivalent input noise resistance
R_{N1}: first-stage equivalent noise resistance
R_{N2}: second-stage equivalent noise resistance
R_{N3}: third-stage equivalent noise resistance
A_1: first-stage voltage gain
A_2: second-stage voltage gain

If the first-stage voltage gain G_1 is sufficiently large, the total noise figure NF_T is obtained as follows from equations (18):

$$NF_T \doteqdot NF_1 \cdots\cdots\cdots\cdots (20)$$

Therefore, NF_T is determined by the NF of the transistor to be used at the first stage.

(3-2) Obtaining the noise figure of a circuit (NF_T) by using the NF of transistors

The NFs of transistors shown in catalogs are generally based on measurements at spot frequencies (such as 1 kHz, 100 Hz, and 10 Hz). They are not applicable without adjustment to such wide-bandwidth amplifiers as equalizer amplifiers in which low-frequency outputs are boosted.

Therefore, conversion is necessary by using the following method:

Since the f^2 noise region is related to high frequency, both the 1/f noise region and the white noise region are concerned with low-frequency amplification (see Fig. 11).

Assuming:

$\overline{e_g}^2$: mean square voltage of thermal noise produced by signal source resistance R_g

$\overline{e_w}^2$: mean square voltage of white noise

$\overline{e_{1/f}}^2$: mean square voltage of 1/f noise

and from the definition of a noise figure;

$$\text{NF (for white noise region)} = \frac{\overline{e_g}^2+\overline{e_w}^2}{\overline{e_g}^2}$$

$$= NF_{(1kHz)} \cdots\cdots\cdots\cdots (21)$$

$NF_{(1kHz)}$ = NF at 1 kHz spot frequency

When obtaining $\overline{e_w}^2$ from equation (21):

$$\overline{e_w}^2 = (NF_{(1kHz)}-1)\,\overline{e_g}^2 \cdots\cdots\cdots\cdots (22)$$

Assuming the noise figure at f=10 Hz to be $NF_{(10\,kHz)}$:

$$NF_{(10Hz)} = \frac{\overline{e_g}^2+\overline{e_w}^2+\overline{e_{1/f}}^2{}_{(10Hz)}}{\overline{e_g}^2} \cdots\cdots (23)$$

From equation (23),

$$\overline{e_{1/f}}^2{}_{(10Hz)} = (NF_{(10Hz)}-NF_{(1kHz)})\,\overline{e_g}^2 \cdots (24)$$

Since 1/f noise varies at the rate of 3 dB/oct with frequency, $\overline{e_{1/f}}^2$ at normal frequency is

$$\overline{e_{1/f}}^2 = (NF_{(10Hz)}-NF_{(1kHz)})\cdot\overline{e_g}^2\cdot\frac{10}{f}$$

$$\cdots\cdots\cdots\cdots (25)$$

From equations (22) and (25), the total noise figure NF_T of an amplifier, whose frequency response and bandwidth are as shown in Fig. 18(a), (b), and (c), can be obtained from the equations

(a) Flat amplifier

$$NF_T = \frac{\int_{f1}^{f2}(\overline{e_g}^2+\overline{e_w}^2+\overline{e_{1/f}}^2)\,df}{\int_{f1}^{f2}\overline{e_g}^2 df}$$

$$= NF_{(1kHz)} + \frac{10(NF_{(10Hz)}-NF_{(1kHz)})\,\ell n\frac{f_2}{f_1}}{f_2-f_1}$$

$$\cdots\cdots\cdots\cdots (26)$$

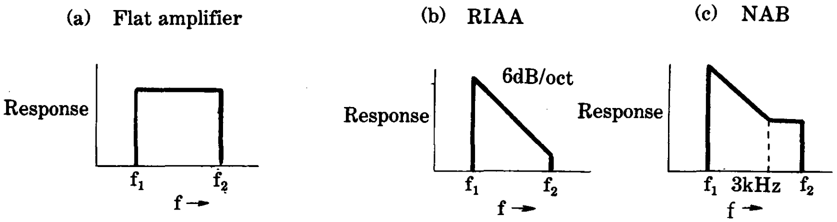

(a) Flat amplifier (b) RIAA (c) NAB

Fig. 18 Frequency response of wide-bandwidth amplifiers

(b) Equalizer amplifier (RIAA)

$$\mathrm{NF_T} = \frac{\int_{f1}^{f2} (\bar{e}_g^2 + \bar{e}_w^2 + \bar{e}_{1/f}^2)\,(\frac{f_2}{f})^2 df}{\int_{f1}^{f2} \bar{e}_g^2\,(\frac{f_2}{f})^2 df} \fallingdotseq \mathrm{NF_{(1kHz)}} + \frac{5(\mathrm{NF_{(10Hz)}} - \mathrm{NF_{(1kHz)}})}{f_1} \quad \cdots\cdots\cdots\cdots\cdots\cdots \text{(27)}$$

(c) Equalizer amplifier (NAB)

$$\mathrm{NF_T} = \frac{\left\{\int_{f1}^{3kHz} (\bar{e}_g^2 + \bar{e}_w^2 + \bar{e}_{1/f}^2)\,(\frac{3kHz}{f})^2\ df + \int_{3kHz}^{f2} (\bar{e}_g^2 + \bar{e}_w^2 + \bar{e}_{1/f}^2)\,df\right\}}{\left\{\int_{f1}^{3kHz} \bar{e}_g^2\,(\frac{3kHz}{f})^2\ df + \int_{3kHz}^{f2} \bar{e}_g^2 df\right\}}$$

$$\fallingdotseq \mathrm{NF_{(1kHz)}} + \frac{5(\mathrm{NF_{(10Hz)}} - \mathrm{NF_{(1kHz)}})}{f_1} + \frac{f_1}{(3kHz)^2}(f_2 - 3kHz)\,\mathrm{NF_{(1kHz)}} \quad \cdots\cdots\cdots\cdots\cdots\cdots \text{(28)}$$

Fig. 19 shows an example of actual values calculated by using these equations. This figure shows how much the NF (1/f noise) at 10 Hz of a first-stage transistor influences a circuit in which the low-frequency region is boosted.

by substituting the wide-bandwidth noise figure $\mathrm{NF_T}$ thus obtained with that in equation (17), the S/N ratio can be calculated.

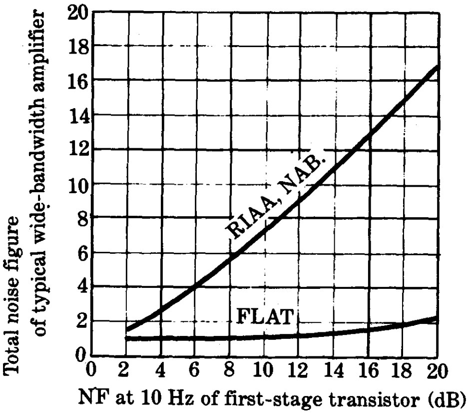


Fig. 19 Total noise figure of a typical wide-bandwidth amplifier

(4) Example of calculation of amplifier S/N ratio

By using the above-mentioned method, the S/N ratio of an amplifier using low-noise transistor 2SC2240 as the first-stage is calculated as

- Example of an amplifier

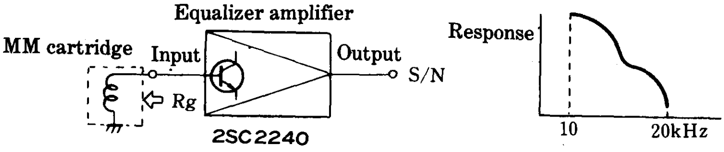


Fig. 20 Amplifier and typical frequency response

Signal source resistance (R_g):	2.2 kΩ at 1 kHz
Bandwidth (B):	10 ~ 20 kHz ≒ 20 kHz
Minimum input signal level (Esi):	2 mV
First-stage transistor:	low-noise transistor 2SC2240
Frequency response:	RIAA

Assuming that $I_c=100\mu A$ at $R_g=2.2k\Omega$ from the NF map of 2SC2240 above,

$$NF\ (1kHz) = 1.0\,dB$$

$$NF\ (10Hz) = 1.0\,dB$$

and from Fig. 19 and equation (17), (27)

$$S/N\ (dB) = 10\log\left\{\frac{(Esi)^2}{4kTRgB}\right\} - 1.0\ (dB)$$

$$= 10\log\left\{\frac{(2\times10^{-3})^2}{1.63\times10^{-20}\times2.2\times10^3\times20\times10^3}\right\}$$

$$-1.0$$

$$\fallingdotseq 67.5\ (dB) - 1.0\ (dB)$$

$$= 66.5\ (dB)$$

Thus, the S/N ratio of an amplifier in which 2SC2240 is used as the first-stage transistor is 66.5 (dB). However, IHF-A curve is not considered in this instance.

Bibliography:

1) WILLIAM A. RHEINFELDER: DESIGN OF LOW NOISE TRANSISTOR INPUT CIRCUITS, LONDON ILIFFE BOOKS LTD. (1964)

2) J. WATSON: SEMICONDUCTOR CIRCUIT DESIGN, ADAM HILGER LTD. (1970)

4. Switching characteristics

This section refers to switching characteristics of a bipolar transistor. Should a pulse be supplied to the base in the circuit shown in Fig. 21, the waveforms of the base current and collector current are as shown in Fig. 22. Delay times of output waveforms to input waveforms, tr, tstg, and tf, in Fig. 22 represent switching times of the transistor. The terms tr, tstg, and tf represent rise time, storage time, and fall time respectively. Equations related to the switching characteristics of diffused base NPN transistors are generally expressed as

$$t_d \cong \frac{2}{I_{B1}}\Big\{C_{TE}V_{BE}{}^{1/2}{}_{(OFF)} + C_{TC}\left[(V_{CC}{}^{1/2}+V_{BE(OFF)})^{1/2} - V_{CC}{}^{1/2}\right]\Big\} \quad \cdots\cdots (29)$$

$$t_r = \tau_R h_{FE}\ \mathrm{In}\left[\frac{h_{FE}I_{B1}}{h_{FE}I_{B1}-0.9\,I_C}\right] \quad \cdots\cdots (30)$$

$$t_{stg} = \tau_S \mathrm{In}\left[\frac{h_{FE}(I_{B1}-I_{B2})}{I_C-h_{FE}I_{B2}}\right] \quad \cdots\cdots (31)$$

$$t_f = \tau_F h_{FE}\mathrm{In}\left[\frac{I_C-h_{FE}I_{B2}}{0.1\,I_C-h_{FE}I_{B2}}\right] \quad \cdots\cdots (32)$$

$$\tau_R \approx \tau_F \approx \frac{1}{2\pi f_T} + 1.7R_LC_{TC} \quad \cdots\cdots (33)$$

$$\tau_S \approx \frac{0.6}{2\pi f_b} + \frac{\tau_{nc}}{2} \quad \cdots\cdots (34)$$

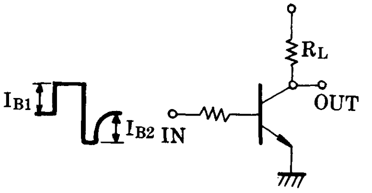


Fig. 21 Switching time measuring circuit

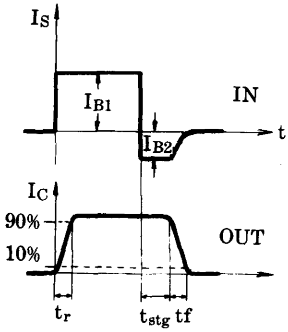


Fig. 22 Definition of switching waveform and switching time

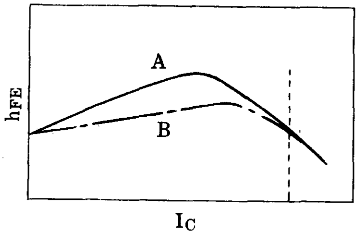


Fig. 23 I_C dependency of h_{FE}

where,

C_{TE} : emitter transition capacitance measured at $|V_{BE(OFF)} - \phi_0| = 1V$

ϕ_0 : contact potential difference at base-to-emitter junction

$V_{BE(OFF)}$: base-emitter voltage when transistor is off

C_{TC} : collector transition capacitance measured at V_{cc} $V_{BE(OFF)} << V_{cc}$

V_{cc} : collector supply voltage

h_{FE} : DC current gain at end of saturation region

f_T : transition frequency

f_b : base cutoff frequency

τ_{nc} : life time of minority carrier in collector layer

Consequently, it is possible to reduce td by reducing the emitter transition capacitance from equation (29) and tr by using the high driving circuit at high $h_{FE'}$ and by increasing f_T from equation (30). tf can be reduced by lowering the switching current ratio (I_c/I_{B2}), though it will be elongated if h_{FE} is increased, in accordance with equation (32). It is evident from equation (31) that tstg is related to the recombination of minority carriers, and that life time of minority carriers in the base and collector regions are important factors. h_{FE} and tstg are in proportion to each other; therefore, it is acknowledged that very difficult technology is required to collectively speed up tr, tf, and tstg.

It is clear that equations from (30) to (32) are dependent upon h_{FE}. Though h_{FE} should be preferably kept small to lower the switching time, it must be large to reduce the drive energy when using a transistor. Thus, h_{FE} must be kept within a practical range.

When further research is conducted to improve this tradeoff as much as possible, the following method is found. Fig. 23 shows a collector current dependency of h_{FE}. Normally, there is a peak similar to A in Fig. 23. The peak of h_{FE} is often located on the low-current side from the operating point shown by a hyphenated line in that figure. h_{FE} at the operating point is fairly lower than that at the peak. When measuring the switching time at the operating point in the figure, it can be noticed that the switching time (especially t_{stg}) depends on h_{FE} at the peak more strongly than on that at the operating point.

By using this method, it is possible to lower the peak of h_{FE} without lowering h_{FE} at the operating point, by moving the peak of h_{FE} to a larger-current side (or the operating point side) as illustrated by line B. In other words, the problem is solved by making h_{FE} flat. To flatten h_{FE} coincides with the objective of the EPR structure in which the emitter is divided into minute portions (multi-emitter) to increase the effective area.

Then, research is conducted concerning equations (33) and (34) which are the logarithmic outer terms of equations (30) to (32). They include f_T and fb, the parameters representing frequency response of a transistor. Conventionally, increasing the base width and depth was unavoidable to increase the breakdown voltage and safe operating area, frequency response thus being sacrificed.

Since transition frequency f_T ($f_T < f_b$) amounts to some MHz, the first term of equation (33) and (34) is assumed to be 10^{-6} or 10^{-7}s. This means that by adopting an EPR structure based on high-frequency technology of power transistors, the frequency response can be improved by one digit or so. The second term of equation (33), a time constant based on collector transition capacitance and load resistance, is normally as small as 10^{-7} to 10^{-8}s. On the other hand, the second term of the equation (34) is as large as 10^{-6}s, the first and the second term thus being almost similar conventionally. As previously mentioned, this can be improved in a manner such as the first term being ignored with reference to the second term.

τnc in the second term can be controlled by introducing heavy metals called "life time killers" to the collector layer. By allowing the first term to be ignored, this controllability is much enhanced.

As already mentioned, switching time can be reduced by improving the large current characteristics of h_{FE} (termed "improving h_{FE} linearity") and by increasing the high-frequency response. This is realized by using the EPR structure in which a multi-emitter is used. For this reason, the EPR structure has been widely employed in switching transistors.

GPL structure employed in switching transistor

This section describes new transistors using a GPL structure, including an EPR structure.

Fig. 24 shows the FPR structure; Fig. 25 illustrates a section of the base-to-collector junction ends of this structure. The hyphenated lines in the figure illustrate base-to-collector junction is reverse-biased. It can be noticed that the depletion layer is narrower near the surface, and not bent in strict accordance with the junction line. This is caused by action of the positive charge contained in the thermally oxidized film (SiO_2), a protective film for the surface. Therefore, the electric field applied to the junction is increased near the surface, breakdown thus being evident there (applicable only to NPN transistors)

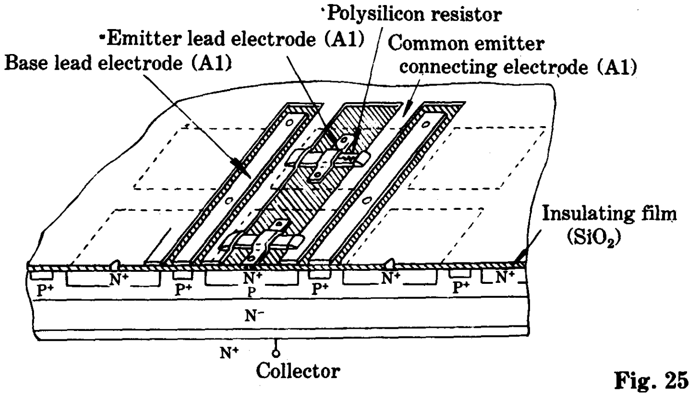


Fig. 24 EPR structure

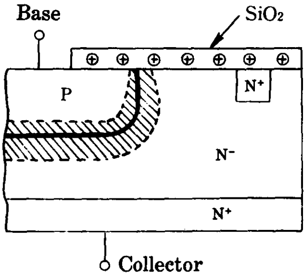


Fig. 25 Section of base-to-colector junction ends of EPR structure

In an ideal junction condition, breakdown voltage of the junction is determined by a concentration of impurities contained in the junction. It is known that even if the concentration of impurities is designed to assure high breakdown voltage, the objective is not achieved near the surface, as mentioned above.

To improve this condition, a new GPL structure is employed. Fig. 26 shows a schematic sectional view of the GPL structure. This structure is obtained by peeling off a thin layer of the Si surface near the junction, forming a glass film there almost flush with the surrounding surface, and introducing negative charges into the glass film. This expands the depletion layer near the surface to reduce the electric field, which in turn cause breakdown to occur in the inside junction, thus obtaining a higher breakdown voltage.

Fig. 27 shows a GPL structure actually employed in power transistors (V_{CEO}=800V) for switching regulators. The only difference between this and that in Fig. 26 is that a floating junction termed a "guard ring" is mounted outside the base junction. The reason is as follows: In Fig. 26, the curved portion of the inside junction (shown by the arrow) has a high electric field and determines the breakdown here. In Fig. 27, the same role is played by the curved portion of the guard ring whose voltage share is low, thus increasing the breakdwon voltage. By further mounting a double or a triple guard ring, breakdown voltage approaches the theoretical value. Then it is possible to obtain a withstand voltage exceeding 2,000V without difficulty.

The reason for adopting glass for the protective film is that it is possible to easily introduce a stable, controllable charge into the glass film and it is also possible to produce a film thick enough to prevent the internal electric field from leaking outside. The glass film is formed by using an electrophoretic method that selectively causes glass powder to adhere onto the chip and by burning at a high temperature.

Conventionally, high breakdown voltage was obtained by using a mesa structure, but the existence of mesa grooves rendered photoengraving of fine patterns rather difficult.

On the other hand, the GPL structure is feature of the realization of high breakdown voltage while using a planar structure to make a photoengraving of fine patterns as easy as those on IC's. As previously mentioned, the GPL structure is based on the technology of realizing higher breakdown voltage than that achieved by using an EPR structure in which fine patterns of a multi-emitter are used to produce high frequency and high output.

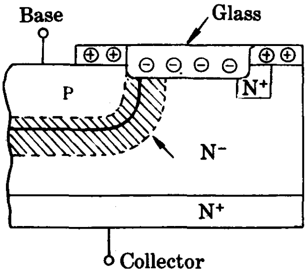


Fig. 26 Sectional view of base-to-collector junction end of basic GPL

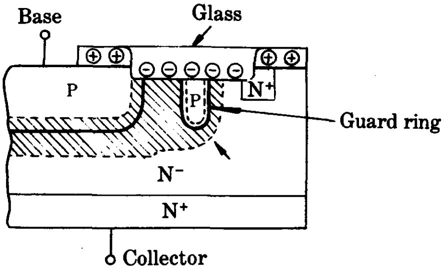


Fig. 27 Sectional view of base-to-collector junction end of GPL

Characteristics of Field Effect Transister (FET)

1. Basis of FETs

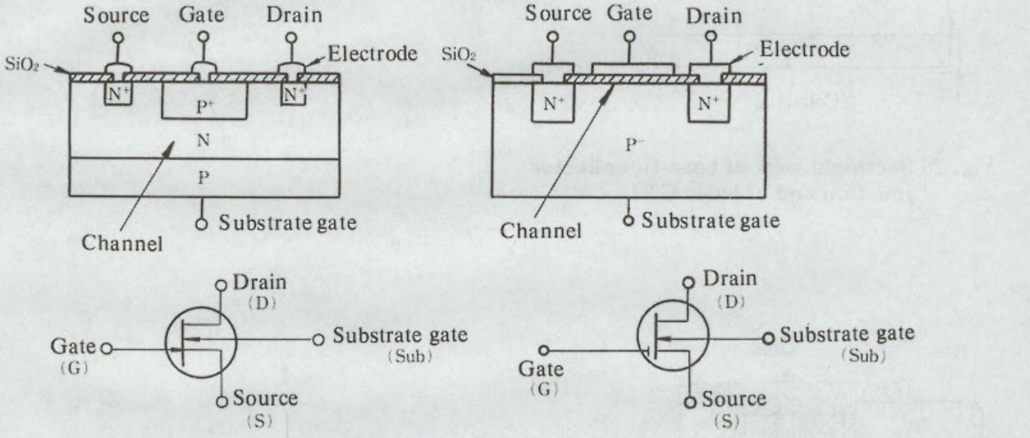
Field effect transistors (abbreviated to FETs) differ totally from normal bipolar transistors in their principle of operation. While a bipolar transistor is a current-controlled type, an FET is a voltage-controlled type in which an electric field controls the current.

The operation principle of an FET is similar to that of space-charge-controlled vacuum tubes; the requirements are similar to those of 5-pole vacuum tubes, except for some power FETs.

The merits of FET characteristics are:

(1) Input impedance is extremely high.
(2) Noise is least in high signal source resistance.
(3) The storage effect of minority carriers is eliminated.
(4) Cross modulation and inter modulation characteristics are excellent.

Based on these advantages, FETs are widely employed in such applications as amplifiers requiring high input impedance and high-frequency.



* Substrate gate is usually connected to the source.

(a) Junction FET

* Substrate gate is usually connected to the source.

(b) MOS FET

Fig. 1 Structure and symbols for FET

(1) Types and structures of FETs

FETs can be classified into the following two types according to the gate:

FET { Junction FET (junction gate)
MOS FET (insulated gate)

Fig. 1 shows the structures of both types.

A junction FET is one whose gate-to-channel portion is composed of a PN junction; an FET whose gate-to-channel portion is composed of **M**etal, **O**xide, and a **S**emiconductor is termed a MOS FET. FETs are also classified into P-channel and N-channel types according to the type (P or N) of the semiconductor layer through which drain current flows.

The structural drawings shown in Fig. 1 are all N-channel type.

Both junction and MOS types have their merits and disadvangtages. Since a MOS FET is insulated through the gate from its own structural features, it is much more easily broken by static electricity. Unless suitable protective measures are taken, extreme care must be exercised when handling a MOS FET.

However, almost all MOS FETs incorporate a protective diode at the gate to prevent such breakage, and it is very rare that they are broken when handled in a normal manner.

On the contrary, junction FETs are not damaged if they are handled normally, thus permitting them to be handled in the same manner as bipolar transistors without producing inconvenience.

Almost all MOS FETs are used for high-frequency circuits and chopper circuits. This is because, compared with the junction type, the MOS type is superior in cross modulation and inter modulation characteristics, and that when used in a chopper circuit, there is less spike and switching speed is higher.

When using FETs for a high-frequency circuit, it is necessary to reduce the internal feedback capacitance as low as possible so that stable gain is obtainable. Once FETs were employed by adopting a cascode connection for this purpose.

In recent years, this problem was solved by producing a cascode FET which two FETs are cascode-connected in the interior as well as dual-gate MOS FETs.

Fig. 2 illustrates the structure and a drawing of an equivalent connection of a cascode FET. A cascode FET has two junction gates — the one near the drain connected to the substarate gate; thereby two FETs — namely a common source FET and a common gate FET — are produced.

This structure causes feedback from the drain to be grounded as alternate current, producing an FET with small reverse transfer capacitance.

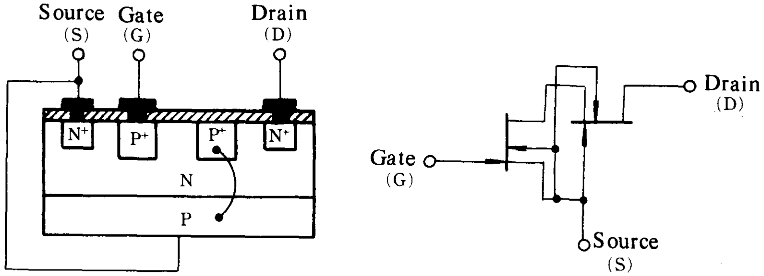


Fig. 2 Structure and equivalent connection drawing of cascode FET

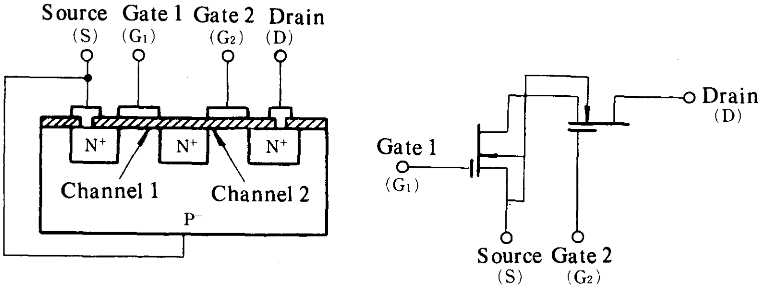
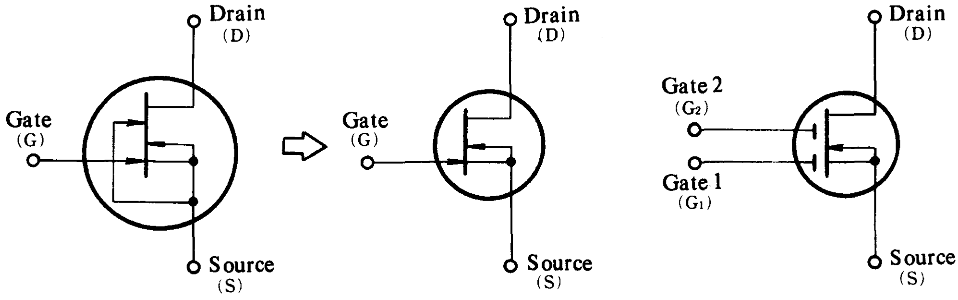


Fig. 3 Structure and equivalent connection drawing of dual-gate MOS FET

Fig. 3 shows the structure and equivalent connection drawing of a dual-gate MOS FET. As far as the operating principle is concerned, this FET is identical with a cascode FET. In the dual-gate MOS FET, gete 2 is lead out to be grounded for AC and to be supplied with positive bias voltage for DC, when the FET is used for an high-frequency amplifier circuit. It is possible to use gate 2 as an injection terminal when using for mixing circuit.

The symbols used for junction cascode FET and dual-gate MOS FET are shown in Fig. 4. In addition to above, a power FET and a GaAs FET are avilable as other versions of FETs.



(a) Junction cascode FET (b) Dual-gate MOS FET

Fig. 4 Symbols used for junction cascode FET and dual-gate MOS FET

(2) Static characteristics of FET

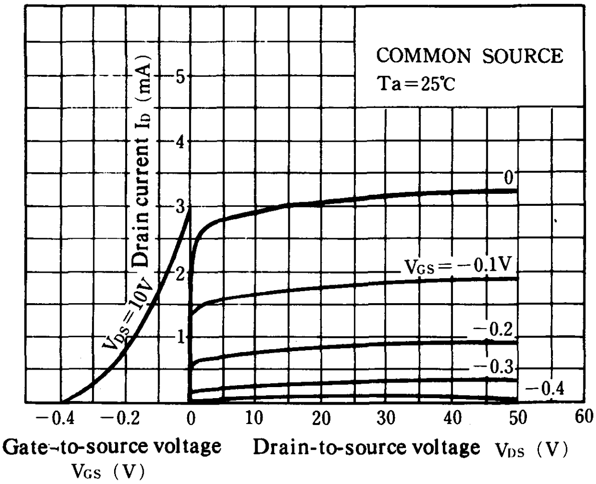


Fig. 5 Static characteristics of 2SK117

Fig. 5 reveals the V_{DS}—I_D characteristics and the V_{GS}—I_D characteristics of junction FET 2SK117.

As is evident from this figure, because it is an N channel, the 2SK117 possesses similar characteristics as a vacuum tube. In other words, the collector current in a normal bipolar transistor is controlled by using the base current, while the drain current in a FET is controlled by gate voltage.

Generally, there are three types of V_{GS}—I_D characteristics, as shown in Fig. 6. The junctioon type shows a depression-type characteristic, while the MOS type shows an enhancement type or an enhancement + depression type as an intermediate pattern.

It is possible to positively bias V_{GS} in the MOS type; positive biasing, however, should not be applied to the junction type because it causes the gate-to-channel current.

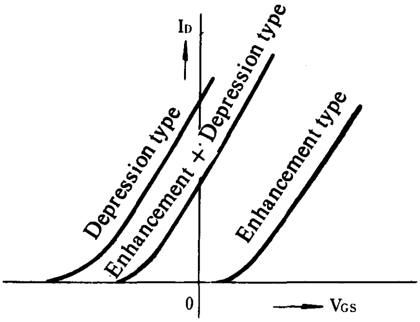


Fig. 6 V_{GS}—I_D characteristics

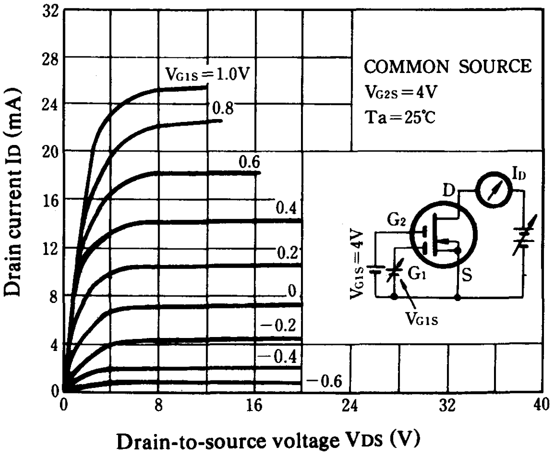


Fig. 7 V_{DS}—I_D characteristic of 3SK59

Fig. 7 shows the static characteristics of dual-gate MOS FET 3SK59.

This is a typical example of the enhancement + depression type.

(3) Basic parameters

$V_{GS(OFF)}$: gate-to-source cutoff voltage

Denotes the value of V_{GS} when the depletion layers are expanded from both sides of the gate electrode to contact each other. The measuring point is the value of V_{GS} at the point where drain current I_D nearly reaches zero (for junction FET).

In principle, $V_{GS(OFF)}$ equals to $V_{DS}-I_D$ when $V_{GS}=0$.

I_{DSS}: drain saturation current

Denotes the value of I_D when G−S is short-circuited, or when $V_{GS}=0$ while sufficient V_{DS} is supplied.

I_{GSS}: gate leakage current

Denotes reverse-flow current at the gate junction when D−S is short-circuited; offers a guideline for DC input impedance of an FET.

Similarly to I_{CBO} of transistors, this value is termperature-sensitive.

BV_{GDS}: gate-drain breakdown voltage

A value of voltage at which current is rapidly increased when reverse-biasing G−D while short-circuiting D−S.

$|Y_{fs}|$: Forward transfer admittance

Defined by the equation $|Y_{fs}| = \dfrac{\triangle I_{DS}}{\triangle V_{GS}}$ serves as a guideline for amplification.

C_{iss}: input capacitance (common source)

Denotes the capacitance between G and S when short-circuiting D and S with AC.

C_{rss}: reverse transfer capacitance (common source)

Denotes the capacitance between G and D when short-circuiting D and S with AC.

This is an important parameter of FETs for high-frequency circuits, Input capacitance for amplifier circuits is expressed by —

$$C_{in} = C_{iss} + \frac{g_{fs}}{g_{os} + g_L} \cdot C_{rss}$$

g_{os}: output conductance,
g_{fs}: forward transfer conductance,
g_L: load conductance

The second term of the above equation is subjected to the Miller effect. If Crss is large, input capacitance is increased by the Miller effect, bias dependency of g_{fs} also affects the input capacitance.

At the same time, the stability coefficient represented by the equations —

$$S = \frac{2 \quad g_{is} \cdot g_{os}}{1 + \cos(\phi_{rs} + \phi_{fs}) \, |y_{rs}| \, |y_{fs}|}$$

is reduced if C_{rss} is large.

where, g_{is} = input conductance
ϕ_{rs} = reverse transfer admittance phase angle
ϕ_{fs} = forward transfer admittance phase angle

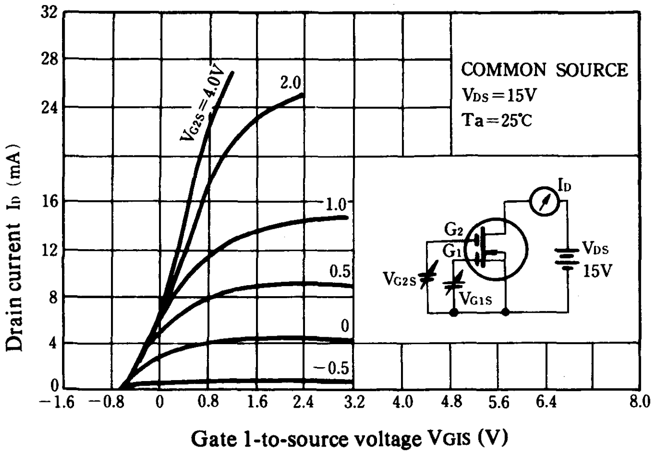


Fig. 8 $V_{G1S}-I_D$ characteristics of 3SK59

$|Y_{rs}|$ = reverse transfer admittance
$|Y_{fs}|$ = forward transfer admittance

I_{GSX}: gate excess current

In junction FETs, gate reverse current depending on voltage between D and S flows even when using the FETs with the drain-to-source voltage falling within the rated value. This current lowers input impedance and causes low-frequency noise.

2. Reading and utilizing the catalogs

(1) FETs for high-frequency circuits

(a) Various parameters and their characteristics at high frequency

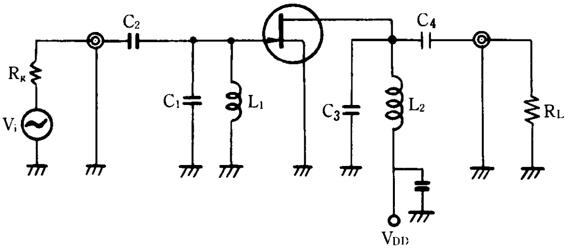


Fig. 9 Example of high-frequency amplifier circuit using FETs

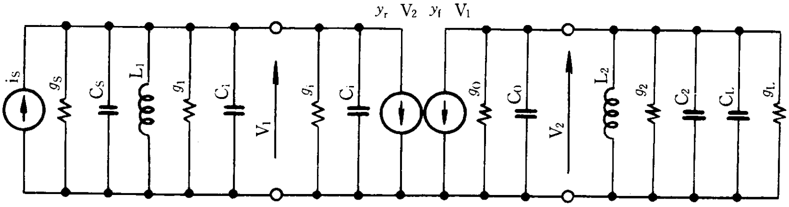


Fig. 10 Equivalent circuit for high-frequency amplifier circuit using FETs

Fig. 9 is an example of a high-frequency amplifier circuit using FETs; Fig. 10 shows its equivalent circuit. The parameters used in this equivalent circuit are:

i_s = signal constant current source
g_s, C_s = signal source conductance, capacitance
L_1, L_2 = I/O tuning inductance
g_1, g_2 = I/O output coil loss conductance
g_L, C_L = load conductance, capacitance
C_1, C_2 = I/O external additional capacitance
g_i, C_i = input conductance, capacitance
g_o, C_o = output conductance, capacitance

In this respect, signal source conductance gs is an important parameter in affecting the noise characteristics of an amplifier circuit. In Fig. 9, R_s is obtained by using the formula —

$$R_S = \frac{1}{R_g \omega^2 C_2^2} + R_g$$

Next, various parameters employed in a high-frequency amplifier circuit are explained by using the above-mentioned parameters.

$G_{P(MAX)}$: maximum available power gain

Abbreviated to MAG, this is gain obtained only when input and output are fully matched with a certain direction of a device.

$$G_{P(Max)} = \frac{|y_f|^2}{4 g_i \, g_O}$$

G_P: power gain

Expressed by the equation —

$$G_P = \frac{4 \, |y_f|^2 g_S \, g_L}{(g_S + g_i)^2 (g_O + g_L)^2}$$

this takes the maximum value when $g_s = g_i$ and $g_L = g_o$; namely, when input and output are fully matched with each other.

s: stability coefficient of a device

Expressed by the equation —

$$s = \frac{2}{1+\cos(\phi_r+\phi_f)} \cdot \frac{g_i g_o}{|y_r||y_f|}$$

this is stable irrespective of input circuits if $s > 1$. Although there is a possibility of oscillation if $s \leqq 1$.

S: stability coefficient of a circuit

$$S = \frac{2}{1+\cos(\phi_r+\phi_f)} \cdot \frac{G_i G_o}{|y_r||y_f|}$$

$$\begin{cases} G_i = g_S + g_1 + g_i \\ G_o = g_o + g_2 + g_L \end{cases}$$

The relationship between this S and the stability coefficient of a device (s) is shown by the formula —

$$S = \frac{G_i \cdot G_o}{g_i \cdot g_o} \cdot s = \left(1 + \frac{g_S\ g_1}{g_i}\right)$$

$$\left(1 + \frac{g_L + g_2}{g_o}\right) \cdot s$$

$$S \geqq s$$

By selecting larger values for g_S, g_L or g_1, g_2, the stability of a circuit is increased. When input and output are matched with each other, even if loss conductance (g_1, g_2) of a coil is zero;

$$\begin{cases} G_i = g_S + g_i = 2g_i \\ G_o = g_o + g_L = 2g_o \end{cases}$$

Namely, obtaining $S \geqq 4s$, it is possible to ensure circuit stability four times more stable than that of a device.

Power gain G_P in which this stability S is considered is shown as —

$$G_P = \frac{1}{S} \cdot \frac{2}{1+\cos(\phi_r+\phi_f)} \cdot \frac{|y_f|}{|y_r|}$$

$$G_P = \frac{4}{S} \cdot \frac{2}{1+\cos(\phi_r+\phi_f)} \cdot \frac{g_i g_o}{|y_r||y_f|}$$

$$\cdot \frac{|y_f|^2}{4g_i g_o} = \frac{4s}{4} \cdot G_{P(Max)}$$

Since it is defined that generally the value of S should be 4 or better, and assuming here that $S \geqq 4$,

$$G_P \leqq sG_{P(MAX)}$$

Therefore, stability gain when $s \geqq 1$ is a product of MAG and the stability coefficient of an device (s).

NF: noise figure

Noises in FETs at high frequency are mostly thermal noise, shot noise, and induction gate noise.

This noise figure NF is represented by the equation —

$$NF = 10\log\left\{1 + \frac{g_i}{g_S} + \frac{R_n}{g_S}(g_S + g_i)^2\right\}$$

where, R_n = equivalent noise resistance

Noise source conductance $(g_s)_{OPT}$ of minimum NF can be obtained as follows:

$$\frac{d}{dg_S} NF(g_S) = 0$$

$$(g_S)_{OPT} = \sqrt{g_i\left(g_i + \frac{1}{R_n}\right)} \qquad (> g_i)$$

This relation of $(g_s)_{OPT} > g_i$ shows that so-called NF matching (with NF = minimum) does not coincide with G_P matching.

In other words, when matching is effected in the input side, $g_s = g_i$, and

$$NF = 10\log(2 + 4R_n g_i)$$

Even if noise of a device is zero ($R_n = 0$),

$$NF = 10\log 2 \fallingdotseq 3\text{dB}$$

Thus, it is impossible to lower the NF below 3 dB.

Therefore, $g_s > g_i$ is required to lower the NF below 3 dB. This denotes that G_P is not well matched.

AGC characteristics

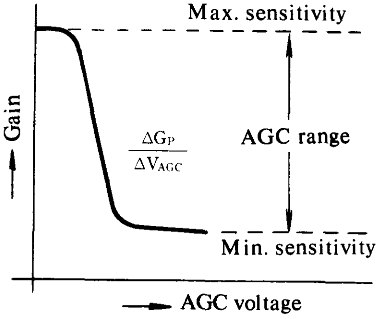


Fig. 11 AGC characteristics diagram

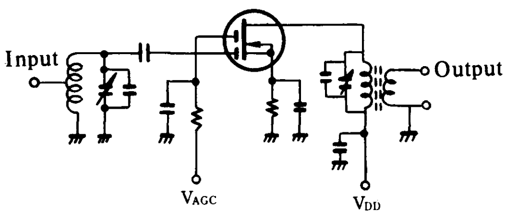


Fig. 12 Applying AGC voltage

In FETs, no drain current flows if the gate-to-source is reversely biased, whereby forward transfer admittance $|Y_{fs}|$ and power gain G_p are lowered.

AGC characteristics are represented by the AGC range, AGC sensitivity, and response changes by AGC.

Since the AGC range is in proportion to y_f/y_r, it is more advantageous when applied to devices with smaller reverse transfer capacitance C_{rss}.

AGC sensitivity is defined as changes in gain in relation to AGC voltage. Therefore, this characteristic is caused by transfer characteristics of a device, and the sensitivity is larger if the cutoff is sharper.

In other words, it is determined according to the size of $V_{GS(OFF)}$.

Changes in response depending on AGC are caused by the fact that input/output admittance possesses a dependency upon bias voltage and current.

AGC characteristics are as shown in the technical data for each item. However, it is necessary to consider influences of the Miller effect.

Input admittance y_{in} in actual mounting condition is

$$y_{in} = y_i + y_r \left(\frac{-y_f}{y_o + y_L} \right)$$

If matching is synchronized at the output side, $y_o + y_L = g_o + g_L$. Susceptance of y_{in} is expressed as

$$b_{in} = b_i + \frac{g_f b_r - g_r b_f}{g_o + g_L}$$

When converting b_{in} into capacitnce, the following formula is established within the frequency range of $g_r = 0$.

$$C_{in} = C_i + \frac{g_f}{g_o + g_L} \cdot C_r$$

This formula indicates that input capacitance includes the Miller effect component in addition to C_i in the definition of the y parameter.

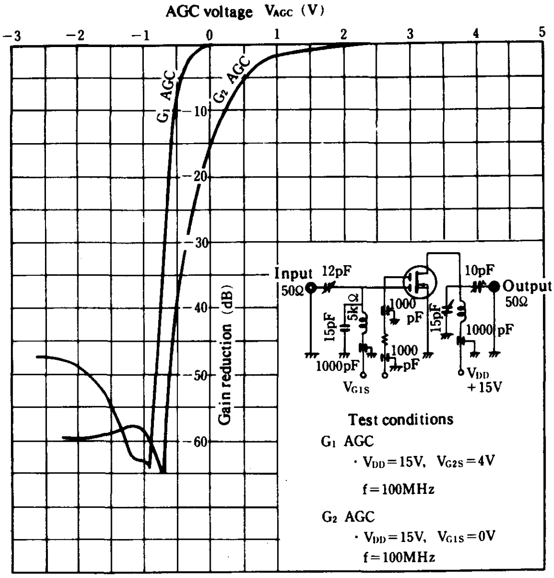


Fig. 13 AGC characteristics (3SK59)

Fig. 13 shows the AGC characteristics of an FET 3SK59.

Cross modulation and inter modulation characteristics

The term cross modulation denotes a phenomenon that modulated waves of an interfering signal are mixed in the desired signal as a result of nonlinearity of the transfer characteristics of active device, when two electric waves with different frequencies are applied to an amplifier circuit or mixing circuit.

Cross modulation is determined by the scale of a third-order coefficient or third-order harmonic waves when developing input voltage with output current through Tayler's formula.

In mixing circuits, there is another type of cross modulation which is caused by local frequency fluctuation, unlike amplifier circuits.

The features of cross modulation are as follows:

○ Not related to the input level of a desired signal.
○ Not related to frequencies of desired and interfering signals.
○ In proportion to the square of input of an interfering signal.
○ In proportion to the degree of modulation in an interfering signal.

Now, assuming the two signals of input voltage e_i — the desired one e_1 and the interfering one e_2 — are applied to an FET whose transfer characteristic is represented by the following formula of an output current i_d:

$$i_d = a_0 + a_1 e_i + a_2 e_i^2 + a_3 e_i^3 + \cdots\cdots\cdots$$

where,

$$e_1 = E_1 \cos \omega_1 t$$

$$e_2 = E_2 (1 + m_2 \cos n_2 t) \cos \omega_2 t$$

m_2 = degree of modulation in interfering signal

n_2 = modulation angle frequency of interfering signal

Then, i_d is developed by using $e_i = e_1 + e_2$. Since only frequency ω_1 near the desired frequency is taken out by a tuning circuit among a variety of frequency components produced by the output, it is sufficient in considering the output current to use the single component of $\cos \omega_1 t$.

$$i_d = a_1 E_1 \left(1 + 3 \frac{a_3}{a_1} \cdot m_2 E_2^2 \cos n_2 t\right) \cos \omega_1 t$$

Namely, this means that the desired signal which should be free from modulation has been modulated by the interfering signal to the degree of modulation:

$$m_k = 3 \frac{a_3}{a_1} \cdot m_2 E_2^2$$

On the other hand, the desired signal thus modulated is expressed by the equation —

$$i_d = a_1 E_1 (1 + m_1 \cos n_1 t) \cos \omega_1 t$$

where, n_1 = modulation angle frequency
m_1 = degree of modulation

Therefore, the cross modulation figure is

$$K_C = \frac{3 a_3 m_2 E_2^2}{a_1 m_1}$$

From the above equation,

$$E_2 = \sqrt{\frac{a_1 m_1}{3 a_3 m_2} K_C}$$

Cross modulation means a variation of modulated wave of desired signal. Once they are cross-modulated, they cannot be removed in subsequent stages because they cannot be differentiated from original modulation waves.

Fig. 14 reveals the cross modulation characteristics of the 3SK59.

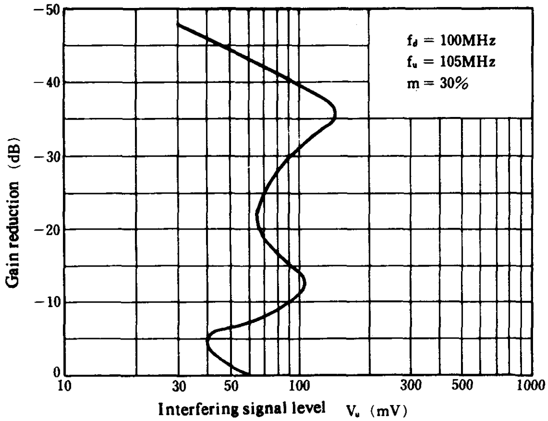


Fig. 14 Cross modulation characteristics (3SK59)

Inter modulation is produced due to the nonlinearity of an amplifier device when more than one interfering signal adjoining a desired signal is mixed with the desired signal.

Supposing, for example, that the frequency of a desired station is 100 MHz and the frequencies of adjacent stations are 400 kHz apart from each other, with the most adjacent station being 100.4 MHz and the next one 100.8 MHz.

These frequencies are applied to an amplifier device because they cannot be removed due to the bandwidth of the high-frequency selective circuit being ±1 MHz or more. In this instance, the same frequency as that of the desired station is produced from the adjacent and the next adjacent stations (f_1 and f_2, respectively); $2f_1 - f_2 = (2 \times 100.4) - 100.8 = 100.0$ MHz.

Therefore, the desired station is in a radio interference status as a result of signals produced between the adjacent and the next adjacent stations.

To prevent such a condition, it is necessary to employ an amplifier device with a wide dynamic range and excellent linearity, or to maintain the gain of a circuit at a value not more than that required.

Inter modulation also occurs in a mixing circuit.

In this instance, intermediate frequency is created by the secondary harmonic wave of beat between the frequency of the adjacent station and local oscillator frequency, and by the beat between the frequency of the next adjacent station and the local oscillator frequency.

Assuming, as above, that the signal of the desired station f_i = 100.0 MHz, that of the adjacent station f_1 = 100.4 MHz, and that of the next adjacent staqtion f_2 = 100.8 MHz.

Assuming that the local oscillator frequency (f_L) is higher than the input signals,

$$f_L = 100.0 + 10.7 = 110.7 \text{ MHz}$$

The beat between the local oscillator frequency (f_L) and the signal of the adjacent station (f_1) is

$$f_{1if} = 110.7 - 100.4 = 10.3 \text{ MHz},$$

with the secondary harmonic wave being 20.6 MHz.

On the other hand, the beat between the local oscillator frequency (f_L) and the signal of the next adjacent station (f_2) is

$$f_{2if} = 110.7 - 100.8 = 9.9 \text{ MHz},$$

with the beat between the secondary harmonic wave and f_{2if} being

$$f_{3if} = 20.6 - 9.9 = 10.7 \text{ MHz}.$$

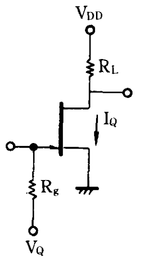
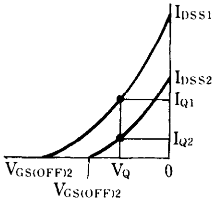
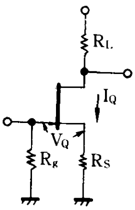
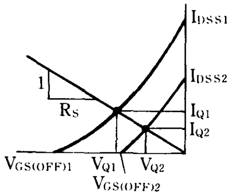
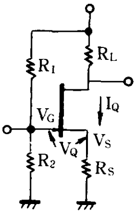
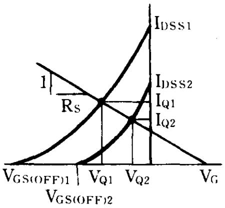
As seen above, radio interference is created because the intermediate frequency of 10.7 MHz is produced by the adjacent station signal (f_1) and the next adjacent station signal (f_2).

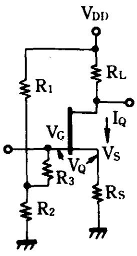
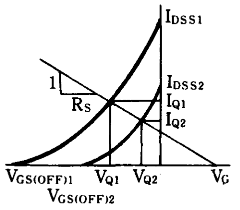
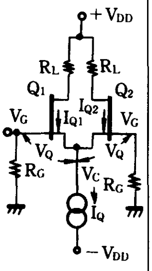
(2) FETs for low-frequency circuits

(a) Bias circuits for FETs

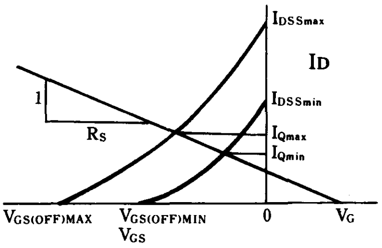
When using FETs for an amplifying circuit, it is necessary to design bias circuits suitable for applications.

When designing bias circuits, for example, by using transistors, attention is paid only to the variation in h_{FE}, since the voltage (V_{BE}) applied to the base-to-emitter circuit is definitely 0.6 or 0.7V regardless of the type of transistor. On the other hand, when using an FET, it is important to refer to the technical data — especially, forward transfer admittance $|Y_{fs}|$ and the correlation between the gate-source cut-off voltage ($V_{GS(OFF)}$) and the drain current (I_{DSS}) — because there are a lot of difference according to the type of FET.

Bias Circuits	Circuit composition	Variation viewed from transfer characteristics	Design formula	Features
Fixed bias		Variation viewed from transfer characteristics 	$V_Q = V_{GS(OFF)}\left(1-\sqrt{\frac{I_Q}{I_{DSS}}}\right)$	1) Quiescent points can be freely selected. 2) Power source is utilized with high efficiency because the source voltage = 0. 3) Variation in (I_{DSS}) is that of I_Q as it is. 4) Used when applying AGC to a high-frequency circuit.
Self-bias (1)			$V_Q = V_{GS(OFF)}\left(1-\sqrt{\frac{I_Q}{I_{DSS}}}\right)$ $R_S = \frac{-V_{GS(OFF)}}{I_Q}\left(1-\sqrt{\frac{I_Q}{I_{DSS}}}\right)$	1) Most popular in FET bias circuits and of simplified circuit composition. 2) Variation in I_Q can be suppressed by R_S. 3) Designing is not so freely effected because R_S is determined by I_Q. 4) To suppress the variation in I_Q, R_S must be increased, and I_D decreased, thereby not being suitable to circuit requirements.
Self-bias (2)			$V_Q = \frac{R_2}{R_1+R_2}V_{DD} - I_QR_S$ $R_S = \frac{R_2}{R_1+R_2}V_{DD}$ $-\frac{V_{GS(OFF)}}{I_Q}\left(1-\sqrt{\frac{I_Q}{I_{DSS}}}\right)$	1) Designing can be effected freely, because a value of R_S can be selected irrespective of I_Q. 2) Input impedance is decreased to R_1/R_2. 3) The efficiency of power utilization is decreased because source voltage is considerably high. It is difficult to take a dynamic range in a circuit with low voltage.

Self-bias (3)			$V_Q = \frac{R_2}{R_1+R_2} V_{DD} - I_Q R_S$ $R_S = \frac{R_2}{R_1+R_2} V_{DD} \cdot$ $- \frac{V_{GS(OFF)}}{I_Q}\left(1-\sqrt{\frac{I_Q}{I_{DSS}}}\right)$	1) Designing can be effected freely, since a value of Rs can be selected irrespective of IQ. 2) Input impedance can be increased more than in the self-bias item (2) above. R3 + R1 // R2 3) The efficiency of power utilization is decreased because source voltage is considerably high. It is difficult to take a dynamic range in a circuit with low voltage.
Differential circuit			$I_{Q1} = I_{DSS1} - \lvert Y_{fs}\rvert_1 V_Q$ $I_{Q\,2} = I_{DSS2} - \lvert Y_{fs}\rvert_2 V_Q$ $I_Q = (I_{DSS1} + I_{DSS2})$ $- V_Q(\lvert Y_{fs}\rvert_1 + \lvert Y_{fs}\rvert_2)$ $I_{Q1} - I_{Q2} = (I_{DSS1} - I_{DSS2})$ $- V_Q(\lvert Y_{fs}\rvert_1 - \lvert Y_{fs}\rvert_2)$	1) Most suitable for the first stage of a DC amplifier. 2) The FETs, Q1, Q2 used in this circuit must have good pair characteristics. (IDSS, VGS pair)

Designing bias circuits by considering the variation of FETs



Supposing the upper and lower limits of IDSS and VGS(OFF), as well as the allowable range of operating current, are determined:

$$R_S = -\left[\frac{V_{GS(OFF)MAX.}\left(1-\sqrt{\frac{I_{Qmax}}{I_{DSSmax}}}\right) - V_{GS(OFF)MIN.}\left(1-\sqrt{\frac{I_{Q\,min}}{I_{DSSmin}}}\right)}{I_{Qmax} - I_{Qmin}}\right]$$

$$V_G = \frac{V_{GS(OFF)MIN.} \cdot I_{Qmin}\left(1-\sqrt{\frac{I_{Q\,min}}{I_{DSSmin}}}\right) - V_{GS(OFF)MAX.} \cdot I_{Q\,min}\left(1-\sqrt{\frac{I_{Q\,max}}{I_{DSSmax}}}\right)}{I_{Qmax} - I_{Qmin}}$$

Fig. 15 Types and characteristics of bias circuits

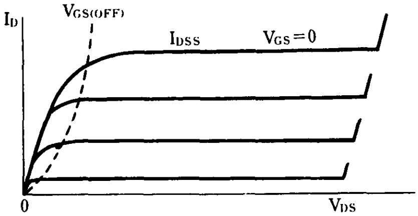
Voltage range applicable between drain and source

For transistor amplifying circuits, the range of voltage applied between the collector and the emitter V_{CE} is designed based on the minimum = $V_{CE(SAT)}$ and the maximum = $V_{CEO} \times 0.8$. For FETs, Table 1 is used as the standard, as mentioned in the section on High-frequency Circuits.

Table 1 Reference values of voltage applicable between drain and source of FETs (Junction FET)

	V_{DSmin}	V_{DSmax}	COMMENT
FET	$V_{DS} > V_{GS(OFF)}$ (Note 1)	$V_{DS} < V_{DS}$ when $I_{GSX} = 1nA$ (Note 2)	See Note 1 See Note 2
Bipolar Transistor (comparison purpose only)	$V_{CE} > V_{CE(sat)}$	$V_{CE} < V_{CEO} \times 0.8$	

Note 1: The voltage at the point of the knee of the saturation characteristics corresponds to the gate-source cut-off voltage $V_{GS(OFF)}$.



Static characteristics of FET

Note 2: When using FETs for a first-stage amlifying circuit, the value of $V_{DS(MAX)}$ may be based on gate-drain breakdown voltage $V_{GDO(S)} \times 0.8$, in the case of MOS FETs. However, this is not applicable to junction FETs, especially the N-channel type. It is necessary to consider gate excess current.

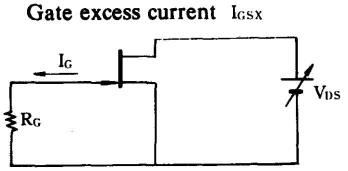


Fig. 16 I_{GSX} measuring circuit

When increasing voltage applied between drain and source in Fig. 16, the gate excess current I_{GSX} starts increasing at a certain voltage, as shown in Fig. 17.

As the higher electric field near the drain is applied electron-hole pairs appear (or minority carriers are increased in this case) at the near-pinchoff region in the channel; thus, a current corresponding to the sum of I_{GSX} and the gate cut-off current (I_{GSS}) flows into the gate. This increase of I_{GSX} causes such phenomena as reduced input impedance, increased noise current, and deepened gate potential. Thus, $V_{DS(MAX)}$ should be determined according to the I_{GSX} — V_{DS} dependency of an FET.

$V_{DS(MAX)}$ should be determined in accordance with the V_{DS} dependency; for example, that 5 nA or less is required as the value of I_{GSX} not affecting tape heads and cartridges. This value is determined according to the chip design of an FET, and therefore, there are almost no variations among the same types. Figs. 18 (a), (b), and (c) show data on the I_{GSX} — V_{DS} dependency of low-frequency, low-noise FETs; Table 2 shows the reference values of voltage applicable between drain and source.

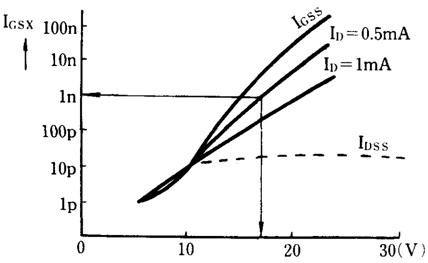


Fig. 17 I_{GSX}-V_{DS} Junction FET

Table 2 Reference values of voltage applicable between drain and source of FETs (according to I_{GSX}—V_{DS} dependency)

V_{DS}	2SK30ATM	2SK112	2SK117	2SK147	2SK170	2SK246	COMMENT
Minimum value (V)	1.0	0.4	0.4	0.3	0.4	1.0	I_D=1mA
Maximum value (V)	25	20	20	20	15	25	I_D=1mA $I_{GSX} \leqq 5nA$
Maximum value (V)	20	17	17	17	13	17	I_D=1mA $I_{GSX} \leqq 1nA$

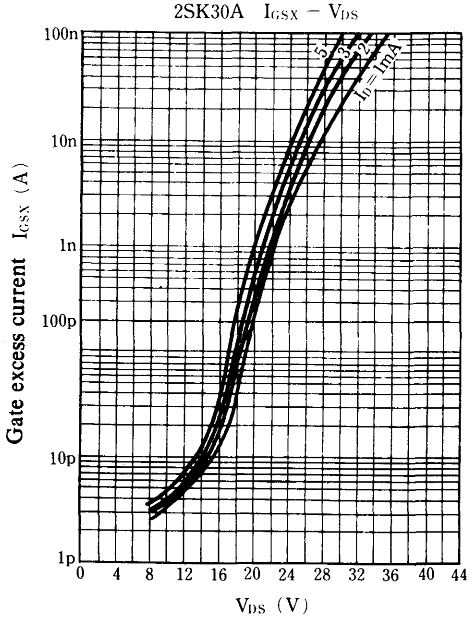


Fig. 18 (a) **2SK30A I_{GSX}—V_{DS}**

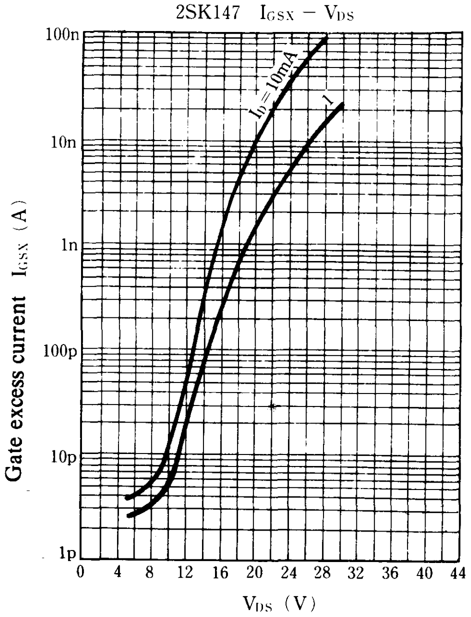


Fig. 18 (b) **2SK147 I_{GSX}—V_{DS}**

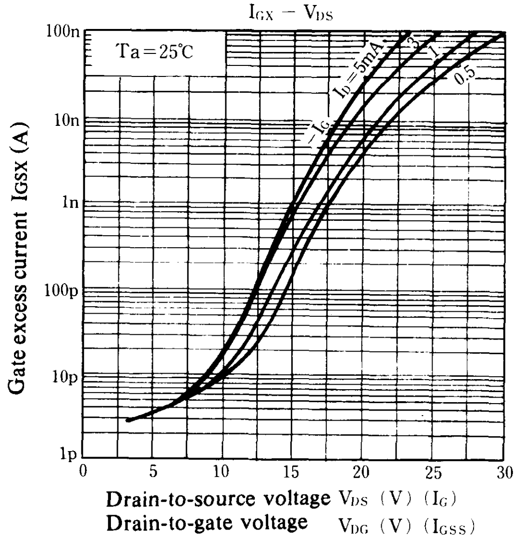


Fig. 18 (c) 2SK112, 2SK117 I_{GSX}—V_{DS}

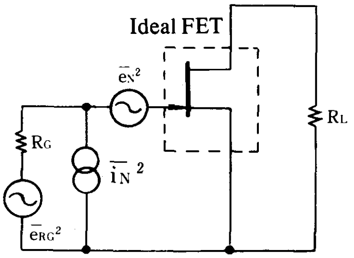


Fig. 19 Noise Source of FETs

(b) Principal parameters and their characteristics for low-frequenc circuits

Since no current flows through a gate, FETs can be freely used for designing ICL (Input Condenser-Less) circuits. Concerning forward transfer admittance $|Y_{fs}|$ and noises in low signal source impedance which were conventionally inferior to bipolar transistors, low-frequency, low-noise FETs such as 2SK117, 2SK147, and 2SK170 have been developed to reach the level of transistors, thereby replacing such transistors in the application of first-stages in amplifying circuits.

Characteristics of FETs

Similarly to ordinary transistors, the noise of FETs — the result of thermal noise, shot noise, and flicker noise — is represented by a noise figure.

The noise of FETs can be expressed by using the two independent factors of voltage noise source e_N and current noise source i_N, in the same manner as that of bipolar transistors.

Both $\bar{e}_N$ and i_N are represented by the equations —

$$\bar{e}_N = \sqrt{4kTR_NB}$$

$$R_N \cong \frac{0.67}{|Y_{fs}|}$$

$$\bar{i}_N = \sqrt{2qI_GB} = \sqrt{\frac{4kTB}{R_P}}$$

where, k = Boltzmann's constant

$4kT = 1.63 \times 10^{-20}$J

T = absolute temperature (°K)

B = bandwidth (Hz)

R_N = equivalent noise resistance

$q = 1.602 \times 10^{19}$ (coulomb)

Rp = gate-to-source input impedance (real)

$|Y_{fs}|$ = forward transfer admittance

When using the foregoing equation to express the noise figure (NF):

$$F = 1 + \frac{\bar{e}_N^2 + \bar{i}_N^2 R_G^2}{4kTR_GB}$$

$$\therefore NF = 10\log_{10}\left(1 + \frac{\bar{e}_N^2 + \bar{i}_N^2 R_G^2}{4kTR_GB}\right) \text{ (dB)}$$

It may be deduced the foregoing equation that noise voltage of FETs (e_N) is determined by forward transfer admittance, and that an FET with a higher forward transfer admittance $|Y_{fs}|$ has a lower noise. Concerning noise current of FETs. i_N, the gate current is 1 nA or less because input impedance of FETs is very high; noise caused by current $i_N R_G$ as small as 1.8 nV/$\sqrt{Hz}$ at R_G = 100 kΩ, so that it can be neglected. Fig. 20 offers a comparison between noise characteristics of FETs and those of bipolar transistors.

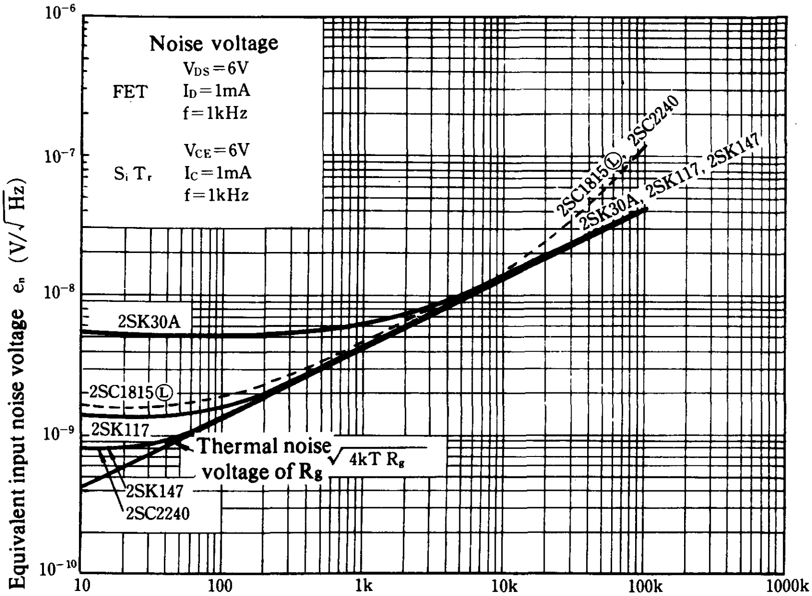


Fig. 20 Equivalent input noise voltage

It is evident from observing Fig. 20 that low-noise FETs such as 2SK117 and 2SK147 are superior to low-noise bipolar transistors 2SC1815 Ⓛ and 2SC2240 in the high signal source resistance region (R_g > 10 kΩ), and that 2SK117 is comparable to 2SC1815 Ⓛ — and 2SK147 to 2SC2240 — in the low signal source resistance region (R_g > 100 Ω). When considering the impedance of tape heads and MM cartridges, FETs are superior for first-stages of amplifiers.

ON resistance $R_{DS(ON)}$ and OFF resistance $R_{DS(OFF)}$

FETs have higher OFF resistance than bipolar transistors due to lower cut-off current; they require no drive current such as base current for bipolar transistors because the gate control of FET is the voltage drive type. Thanks to these advantages, FETs are used for switching, chopper, and sample-hold circuits.

In this respect, problems exist in $R_{DS(ON)}$ and $R_{DS(OFF)}$. Fig. 21 shows the static characteristics of 2SK113 in the low voltage region. ON resistance $R_{DS(ON)}$, the gradient in the I_D — V_{DS} curve when gate-to-source voltage V_{GS} is constant, is defined as —

$$R_{DS(ON)} = \Delta V_{DS}/\Delta I_D \,|V_{GS} = \text{constant}$$

The smaller this value, the nearer to the actual value of transfer is attained. On the other hand, OFF resistance $R_{DS(OFF)}$ is shown as value at pinch-off, although it is set as follows if under normal switch-off condition:

$$\overset{*}{V}_{GS(OFF)} = V_{GS(OFF)} + \alpha$$

In this case, lower cut-off current is preferable.

The values of $V_{GS(OFF)}$ normally described in manufacturers' catalogs denote values measured under the condition of $I_D = 50$ nA $\sim 1\ \mu$A. Thus, it is necessary to select a value $1 \sim 2$V lower than the $V_{GS(OFF)}$ values shown in catalogs for switching applications.

Technical data for switching FETs usually denotes the optimal voltage of $V_{GS(OFF)}$ and $I_{D(OFF)}$ similarly to those for 2SK113.

For detailed designing methods of digital and analog switches, refer to the application circuits included at the end of this manual.

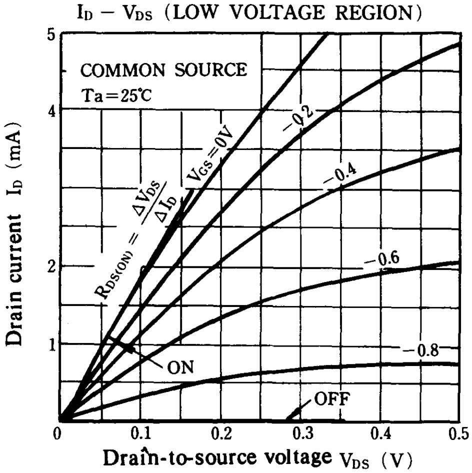


Fig. 21 Static characteristics of 2SK113

(c) Thermal characteristics of FETs

Similarly to bipolar transistors, since FETs are sensitive to temperature, fluctuation in parameters in accordance with changes in environmental conditions must be duly considered when designing and operating them. Thorough consideration is required, especially as to FETs for industrial use.

This section describes the thermal characteristics of FET principal parameters.

Those parameters which are affected by temperature are as follows:

Cut-off current : $I_{GSS}, I_{GSX}, I_{D(OFF)}$

Drain current : I_{DSS}, I_D

Gate-to-source cut-off voltage : $V_{GS(OFF)}$

Forward transfer admittance : $|Y_{fs}|$

ON resistance : $R_{DS(ON)}$

Gate cut-off current, I_{GSS}

Temperature dependency of I_{GSS} of junction FETs shows changes similar to I_{CO} of transistors. When obtaining I_{GSS} at room temperature under the same voltage conditions, I_{GSS} at a certain temperature is expressed as —

$$I_{GSS(Tx)} = I_{GSS(To)} \exp K(Tx - To) \cdots\cdots\cdots\cdots \quad (1)$$

where, $I_{GSS(Tx)}$: I_{GSS} at temperature Tx°C
$I_{GSS(To)}$: I_{GSS} at reference temperature To°C
k: temperature coefficient (function of energy gap of semiconductor)

Fig. 22 shows the temperature dependency of cut-off current of 2SK113. Those values which are normally described in technical data indicate reference values which differ among devices.

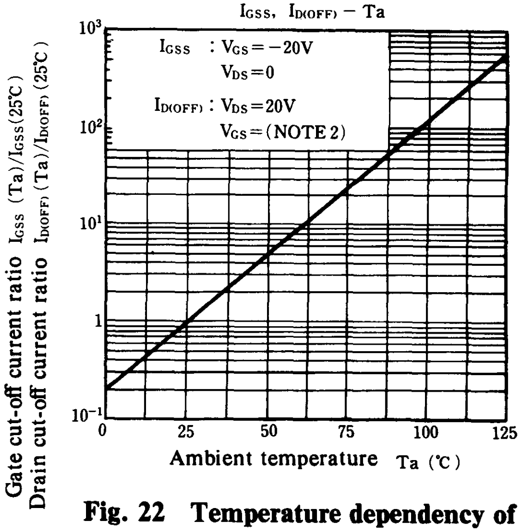


Fig. 22 Temperature dependency of cut-off current of 2SK113

The temperature coefficient K mentioned above is generally determined as —

Silicon K = 0.07
Germanium K = 0.10

Similarly to equation (1) above, the temperature coefficient is based on stable operation of a device. However, silicon — for example — includes variations such as K = 0.05 0.08 due to measuring voltage conditions; thus, K is substantially affected by the value of initial leakage, as shwon in Fig. 23.

In other words, even if the ratio between room temperature leakages of any two stable devices of the same process in 2:1, the ratios of respective leakage are not always 2:1 at a temperature change of ΔTa.

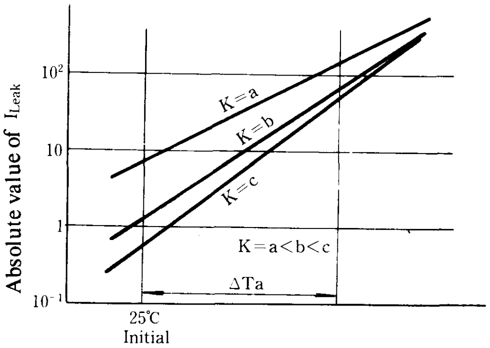


Fig. 23

Drain current: I_D

The changes of drain current I_D with temperature are caused by two types of temperature dependency —

1) Carrier mobility in channel: μ

and

2) Contact potential in PN junction: ϕ.

Since these temperature change factors are contrary to each other, there is the point where drain current I_D is freed from the influence of temperature, as shown in Figs. 24 and 25. Now, let us discuss how the operating points should be established.

As previously mentioned, since the temperature dependency of I_D is derived from two parameters, μ and ϕ, it is possible to assume that —

$$I_D = I_D(\mu, \phi)$$

differentiating this by temperature T, the equation obtained is —

$$\frac{\partial I_D}{\partial T} = \frac{\partial I_D}{\partial \mu} \cdot \frac{\partial \mu}{\partial T} + \frac{\partial I_D}{\partial \phi} \cdot \frac{\partial \phi}{\partial T} \cdots\cdots\cdots\cdots (2)$$

Because $\partial I_D / \partial \phi = -|Y_{fs}|$,
the temperature coefficient α of I_D is shown as —

$$\alpha = \frac{1}{I_D} \frac{\partial I_D}{\partial T} = \frac{1}{\mu} \cdot \frac{\partial \mu}{\partial T} - \frac{|Y_{fs}|}{I_D} \frac{\partial \phi}{\partial T} \cdots\cdots (3)$$

When substituting the following equation into the equation (3) —

$$I_D = I_{DSS} \left(1 - \frac{V_{GS}}{V_{GS(OFF)}}\right)^2$$

$$|Y_{fs}| = \frac{\partial I_D}{\partial V_{GS}} = -\frac{2 I_{DSS}}{V_{GS(OFF)}} \left(1 - \frac{V_{GS}}{V_{GS(OFF)}}\right)$$

$$\alpha = \frac{1}{\mu} \frac{\partial \mu}{\partial T} + \frac{2}{V_{GS(OFF)} - V_{GS}} \cdot \frac{\partial \phi}{\partial T} \cdots\cdots (4)$$

Temperature dependency of mobility μ is generally expressed as —

$$\mu = \mu_0 \left(\frac{T}{T_0}\right)^{-n}$$

where, μ_0 = mobility at $T = T_0$

$$n = \begin{cases} 1.5 \text{ (electron } \cdots\cdots\cdots\text{ N channel)} \\ 2.3 \text{ (hole } \cdots\cdots\cdots\cdots\text{ P channel)} \end{cases}$$

Therefore,

$$\frac{1}{\mu} \cdot \frac{\partial \mu}{\partial T} = -\frac{n}{T} = \begin{cases} -\frac{1.5}{300} = -0.5(\%/{}^\circ K) \cdot\cdot \text{N channel} \\ -\frac{2.3}{300} = -0.77(\%/{}^\circ K) \cdot\cdot \text{P channel} \end{cases}$$

$$\cdots\cdots\cdots\cdots\cdots (5)$$

On the other hand, the temperature, dependency of contact potential ϕ is shown in the same manner as the temperature coefficient of V_{BE} normally being $-2mV/{}^\circ K$,

$$\frac{\partial \phi}{\partial T} = -2 \ (mV/{}^\circ K) \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (6)$$

By substituting equations (5) and (6) into equation (4),

$$\alpha = \begin{cases} -0.5 - \dfrac{0.4}{V_{GS(OFF)} - V_{GS}} (\%/°\mathrm{K}) \cdots \text{N channel} \\ -0.77 - \dfrac{0.4}{V_{GS(OFF)} - V_{GS}} (\%/°\mathrm{K}) \cdots \text{P channel} \end{cases} \quad \cdots\cdots (7)$$

Therefore,

$$\begin{aligned} V_{GS(OFF)} - V_{GS} &= -0.8\mathrm{V} \quad \cdots\cdots\cdots\cdots \text{N channel} \\ V_{GS(OFF)} - V_{GS} &= -0.52\mathrm{V} \quad \cdots\cdots\cdots\cdots \text{P channel} \end{aligned} \quad \cdots\cdots (8)$$

It is possible to reduce the temperature coefficient α to zero by setting the operating points of those values as shown in equation (8), above.

Fig. 26 shows the measured values of 2SK30A; it indicates that they agee well with equation (3).

However, the foregoing explanation does not consider fluctuations in the temperature coefficients of μ and ϕ. Table 3 lists the reference values of bias voltages at which the temperature coefficients of principal FETs are reduced to zero.

Table 3

Type name	$V_p - V_{GS}$	
2SK15	−0.68V	Take account of ±10% as design margin
2SK30A	−0.80V	
2SK112	−0.75V	
2SK113	−0.60V	
2SK117	−0.75V	

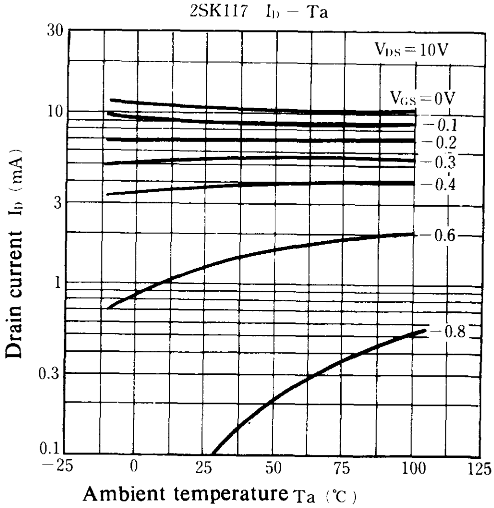


Fig. 24 I_D—Ta Characteristic

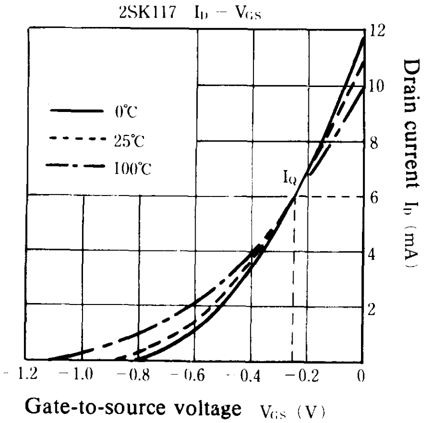


Fig. 25 $I_D - V_{GS}$ characteristic

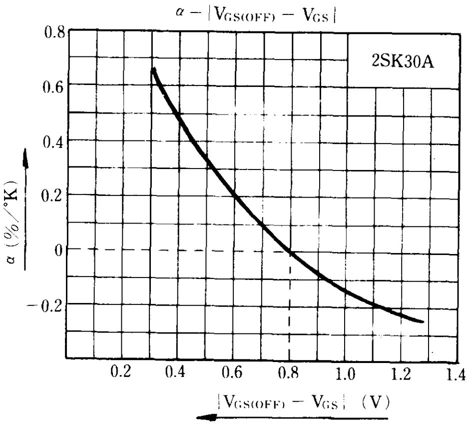


Fig. 26 $\alpha - |V_{GS(OFF)} - V_{GS}|$ characteristic

Others

The following is a brief description on temperature dependency of the gate-to-source cut-off voltage $V_{GS(OFF)}$, forward transfer admittance $|Y_{fs}|$, and drain-to-source ON resistance $R_{DS(ON)}$.

$V_{GS(OFF)}$, related to the contact potentials of PN junction (ϕ), is generally expressed as —

$$V_{GS(OFF)} = V_{Pi} - \phi$$

where, V_{pi} = gate-to-channel potential
Since V_{pi} is not temperature-dependent,

$$\frac{V_{GS(OFF)}}{dT} = -\frac{d\phi}{dT} \fallingdotseq 2\ (\mathrm{mV}/°\mathrm{K})$$

Therefore, it constitutes an adverse sign when compared with the temperature dependency of ϕ as mentioned above.

The temperature dependency of forward transfer admittance $|Y_{fs}|$ is expressed by the following equation, when the temperature coefficient of $|Y_{fs}| = \beta$, similarly to that of I_D:

$$\beta = \frac{1}{|Y_{fs}|}\frac{|Y_{fs}|}{dT} = \frac{1}{|Y_{fs}|}\frac{\partial|Y_{fs}|}{\partial\mu}\frac{\partial\mu}{\partial T} - \frac{1}{|Y_{fs}|}\frac{\partial|Y_{fs}|}{\partial\phi}\frac{\partial\phi}{\partial T}$$

$$= \frac{1}{\mu}\frac{\partial\mu}{\partial T} - \frac{1}{|Y_{fs}|}\frac{\partial|Y_{fs}|}{\partial\phi}\frac{\partial\phi}{\partial T}$$

Thus, it is determined by $(1/|Y_{fs}|)(\partial|Y_{fs}|/\partial\phi)$. Similarly to α, β also takes a negative coefficient in the region of a large I_D. However, when I_D becomes smaller, it turns to a positive coefficient. Fig. 27 shows the temperature dependency of $|Y_{fs}|$ of 2SK30A.

Finally, Fig. 28 shows the temperature dependency of $R_{DS(ON)}$ [$(r_{DS(ON)})$] of 2SK113.

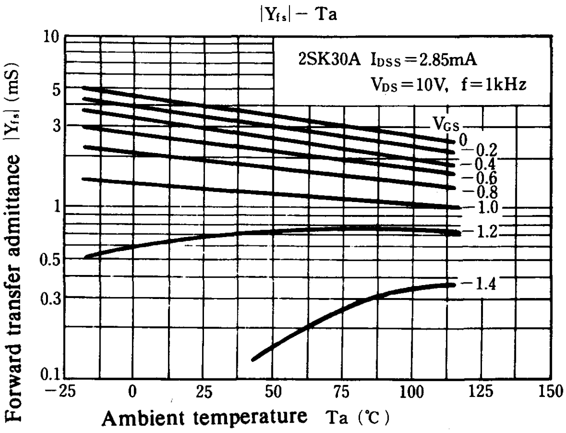


Fig. 27 $|Y_{fs}|$ — Ta of 2SK30A

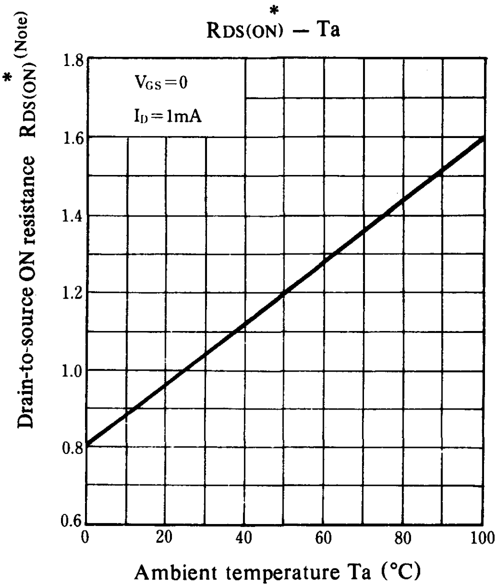


Fig. 28 $R_{DS(ON)}$*— Ta of 2SK113

Note: However this value of $R_{DS(ON)}$* is standardized concerning the value at Ta = 25°C.

Hall Sensor

1. General

The Hall sensor (element) is a magnetoelectric transducer which has attracted popular attention in recent years as a position sensor or a electronic switch in application ranges such as small DC (brushless) motors, automotive use, and instrumentation equipment.

And it enables conversion from mechanical to electronic switching and from brushed to brushless motor, and the production of noiseless high-performance units, so it is expected to be applied over a very wide application range in both consumer and industrial fields in near future.

The materials and features of commerciallized Hall Sensor at present are shown as follows.

And the material of Toshiba Hall Sensor is GaAs.

Table 1

Type of Hall Sensors	Characteristics of elements
GaAs Hall sensor	(1) Temperature coefficient of V_H is very small with constant current operation (wide bandgap; 1.43 eV). (2) Temperature coefficient of V_{HO} is small with constant voltage operation. (3) Linearity of V_H to magnetic flux is excellent. (4) Input resistance is not changed by current or magnetic flux.
InAs Hall sensor	(1) Temperature coefficient of V_H is small with constant current operation. Other characteristics are situated between those of GaAs and InSb sensors.
InSb Hall sensor	(1) High output is possible (electron mobility μn is very high: 75,000cm^2/sec). (2) V_H varies less against temperature changes with constant voltage operation (however, inferior to GaAs sensors). (3) V_H varies greatly against temperture changes with constant current operation. $\frac{V_H\,(T=50°C)}{V_H\,(T=25°C)} = 1/3 \sim 1/2$ V_H shows lapsed changes due to self-heating. (4) V_H becomes saturated near B = 1kG. (5) Input resistance varies depending on current and is internally modulated by a magnetic field.

As may be observed from the above remarks, it may be stated that InSb Hall sensors are suitable for digital application and GaAs Hall sensors for analog use.

As a matter of reference, Toshiba Hall sensors — high output voltage — are applicable for both digital and analog fields.

2. Hall effect

When applying a current I_C to a thin semiconductor element and applying a magnetic flux B in the vertical direction to it, voltage V_H is generated in a direction vertical to both the current and the magnetic flux. This phenomenon is the so-called Hall effect discovered by E. H. Hall in 1879.

The voltage V_H thus occuring, termed "Hall output voltage," is defined as —

$$V_H = \frac{R_H}{d} \cdot I_C \cdot B \cdot f_H \left(\frac{\ell}{W} \cdot \theta\right) \cdots\cdots\cdots\cdots (1)$$

f_H in this equation is a design factor, substantially dependent upon the element design (ℓ/W) and the magnetic field. The larger both ℓ/W and B become, the nearer f_H is unity.

Assuming that

$$K_H = \frac{R_H}{d} f_H \left(\frac{\ell}{W} \cdot \theta\right)$$

$$V_H = K_H \cdot I_C \cdot B \cdots\cdots\cdots\cdots\cdots (2)$$

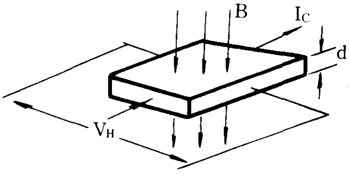
Therefore, V_H is represented by the product of control current I_C and magnetic flux B.

K_H is termed product sensitivity, a constant to be determined according to the characteristics of the semi-conductor elements to be used.

Assuming that $K^* = \frac{K_H}{Rd}$ equation (2) is changed as follows:

$$V_H = K^* Rd \cdot I_C \cdot B \cdots\cdots\cdots\cdots\cdots (3)$$

where, Rd is internal resistance of the element and K* is specific sensitivity. The larger this value, the more excellent the output characteristics of the element.



R_H: Hall coefficient
d: element thickness
θ: Hall angle
I_C: control current
B: magnetic flux density
f_H: design factor

Fig. 1

3. Hall sensor driving methods

Hall sensor driving methods are constant-current and constant-voltage driving.

(1) Constant-current driving

In the case of constant-current driving, it is possible to get the Hall output voltage in proportion to the internal resistance of the element from equation (3). The temperature characteristics of the Hall output voltage are quite excellent for GaAs Hall sensors. (V_{HT} = −0.06%/°C, maximum). This is because the band gap of the actual GaAs is so large (E_g = 1.43 eV) that the GaAs Hall sensors are highly stable thermally.

(2) Constant-voltage driving

In the case of constant-voltage driving of a Hall sensor, V_H is shown as follows from equation (3):

$$V_H = K^* \cdot V_C \cdot B \;\Big|\; (Rd \cdot I_C = V_C \text{ [constant]})$$

The Hall output voltage is not related to internal resistance Rd of an element; thus, obtained is almost constant Hall output voltage. The deviation of specific sensitivity K* is nearly ±10%. When setting V_C' it is necessary to set the control current I_C (= V_C/Rd) against the minimum Rd, so that must not exceed over the maximum rating of I_C.

The temperature characteristics of Hall output voltage are one digit larger than those of the constant-current driving method because V_{HT}(constant-voltage drive) is approximately −0.3%/°C. This is because the temperature characteristics of Hall output voltage depend on those of electron mobility in the case of constant-voltage driving, while they depend on those of carrier concentration n (= $n_0 \exp(E_g/2KT)$) in the case of constant current driving.

4. Positioning accuracy of Hall sensors

(1) THS102A (H-Type)

The positioning accuracy of this Hall sensors is ±0.15mm in both the X and the Y axes, assuming that the center of the Hall sensor is represented by the intersection point of the two diagonal lines A and B shown in Fig. 2.

(2) THS103A (SIP-Type)

The positioning accuracy of this type is shown in Fig. 3.

(3) A Hall sensor is mounted on the fourth terminal for the H-type or on the second terminal for the SIP-type; the operating layer is about 0.3mm above the terminal surface. (See Fig. 4)

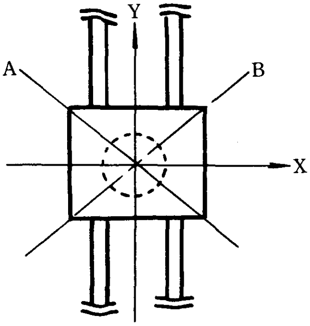


Fig. 2

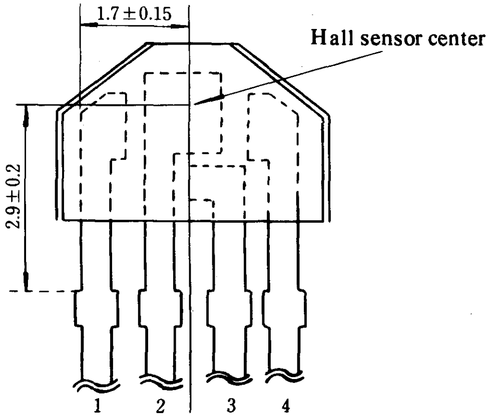


Fig. 3

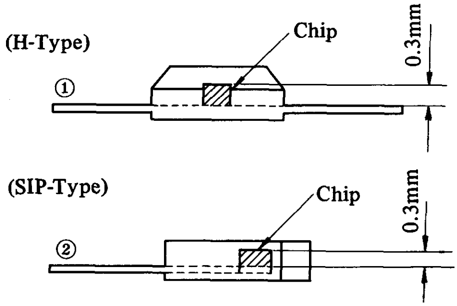


Fig. 4

5. Typical application examples

This section describes the use of a Hall sensor when using it for position sensing of rotors in a brushless motor.

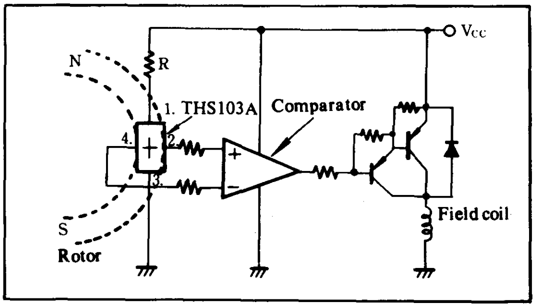


Fig. 5 Application circuit

Conditions:

1 The Hall sensor to be used in THS103A.
2 Flux linkage applied to the Hall sensor is the sinusoidal wave type; its peak value Bm is 0.8 KG.
3 Comparator offset voltage $V_{IO} = \pm 2$ mV.
4 Comparator output is the open collector type.
5 $V_{CC} = 12.0$ V.

Since the rated value of control current I_C of THS103A is 10 mA maximum, the value of series resistance R must be a value that satisfies $I_C \max. \geqq V_{CC}/(R + Rd\min.)$.

The range of internal resistance Rd of THS103A is 450 ~ 900Ω; R ≧ 750 Ω. Therefore, R = 910 Ω is selected in this case.

Since the Hall output voltage $V_H = K_H \cdot I_C \cdot B = K^* \cdot Rd \cdot I_C \cdot B$,

$$V_H = K^* \cdot Rd\min. \cdot I_C . Bm \sin\theta$$

for the minimum Rd, and

$$V_H = K^* \cdot Rd\max. \cdot I_C \cdot Bm \sin\theta$$

for the maximum Rd.

However, actual voltage evidenced at the output terminal of a Hall sensor is that to which residual voltage V_{HO} is added.

$$V_H = K^* \cdot Rd \cdot I_C \cdot Bm \sin\theta \pm V_{HO}$$

This residual voltage V_{HO} as well as the offset voltage of comparator V_{IO} are the major factors affecting turnoff timing of the field coil drive transistor — namely, the electric angle allowance.

Specific sensitivity K* takes the following value in accordance with the relation between Hall output voltage V_H and element resistance Rd of THS103A. Since Rd and V_H have the linear relation, V_H is minimum when Rd is minimum (only under the constant-current condition).

Therefore, from the specifications of THS103A —

$K^*\text{min.} = 50(\text{mV})/[5(\text{mA}) \times 450(\Omega) \times 1(\text{KG})] = 22.2 \times 10^{-3}(1/\text{KG})$

$K^*\text{max.} = 120(\text{mV})/[5(\text{mA}) \times 900(\Omega) \times 1(\text{KG})] = 26.7 \times 10^{-3}(1/\text{KG})$

The Hall output voltage of THS103A is —

$V_H\text{min.} = K^*\text{min.} \cdot \text{Rd min.} \cdot \text{Ic} \cdot \text{Bm} \sin\theta \pm V_{HO}$
$= 22.2 \times 10^{-3} \times 450 \times 8.8 \times 0.8 \sin\theta \pm V_{HO}$
$= 70.3 \sin\theta \pm V_{HO}(\text{mV})$

$V_H\text{max.} = K^*\text{max.} \cdot \text{Rd max.} \cdot \text{Ic} \cdot \text{Bm} \sin\theta \pm V_{HO}$
$= 26.7 \times 10^{-3} \times 900 \times 6.6 \times 0.8 \sin\theta \pm V_{HO}$
$= 126.9 \sin\theta \pm V_{HO}(\text{mV})$

Figs. 6 and 7 below show the waveforms of flux linkage, Hall output voltage, and comparator output voltage.

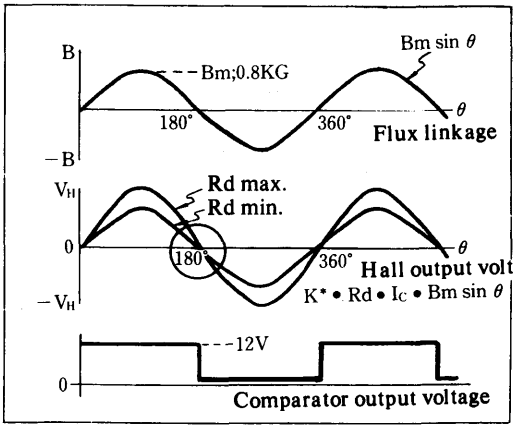


Fig. 6

Enlarged view of the encircled portion of Hall output voltage in the figure on the left

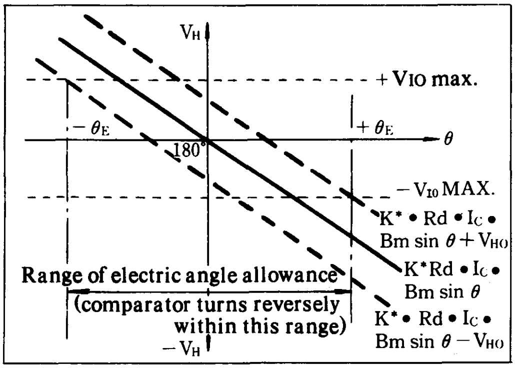


Fig. 7

The calculation of electric angle allowance is —

When Rd is maximum:

Since residual voltage V_{HO} is in linear proportion to control current Ic, the maximum value of V_{HO} (namely, V_{HO} max.) is —

$V_{HO}\text{max.} = V_H\text{max.} \cdot (V_{HO}/V_H)\text{max.} \cdot$ [Ic (actually supplied)/Ic (V_{HO}/V_H measured)]
$= 120(\text{mV}) \times 10(\%) \times 6.6(\text{mA})/5(\text{mA}) = 15.8(\text{mV})$

Assuming the comparator output is reversed when the Hall output voltage V_H exceeds the offset voltage of the comparator.

$-V_{IO}\text{max.} = K^*\text{max.} \cdot \text{Rdmax.} \cdot \text{Ic} \cdot \text{Bm} \sin(180° \pm \theta_E) + V_{HO}\text{max.}$

$-2(\text{mV}) = 126.9 \sin(180° \pm \theta_E) + 15.8(\text{mV})$

$\therefore \theta_E = 8.06°$

When Rd = minimum:

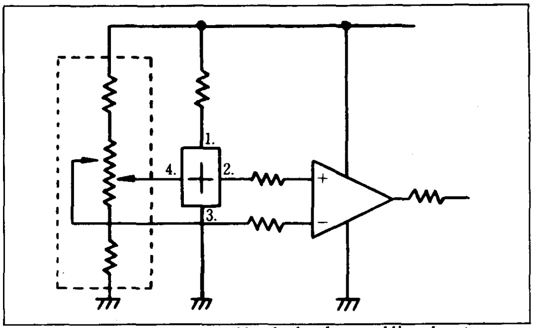
In the same manner as above,

$V_{HO}\text{max.} = V_H\text{min.} \cdot (V_{HO}/V_H)\text{max.} \cdot$ [Ic (actually supplied)/Ic (V_{HO}/V_H measured)] $= 8.8$ (mV)

$-V_{IO}\text{max.} = K^*\text{min.} \cdot \text{Rd min.} \cdot \text{Bm} \sin(180° + \theta_E) + V_{HO}\text{max.}$
$-2(\text{mV}) = 70.3 \sin(180° + \theta_E) + 8.8$
$\therefore \theta_E = 8.84°$

Therefore, if it is necessary to reduce the above-mentioned θ_E due to performance requirements of a motor, also it is necessary to increase the peak value of flux linkage or to suppress V_{HO} of a Hall element and offset voltage of the comparator.

Fig. 8 is a typical example of a V_{HO} compensating circuit for a Hall sensor.



The portion surrounded by the hyphenated line denotes the V_{HO} compensating circuit

Fig. 8

It is possible to reduce θ_E to zero by using the V_{HO} compensating circuit of a Hall sensor.

With reference to the residual voltage ratio of a Hall sensor (V_{HO}/V_H), it is possible to suppress θ_E by selecting the optimum offset voltage of a comparator.

In the actual design stage, consideration must be taken to variations of source voltage, variations of relevant constants to be caused by changes in ambient temperature, and positioning accuracy.

6. Precautions on handling

The enclosure of a Toshiba Hall sensor is designed very compactly in size to facilitate mounting onto small-scaled equipment. Pay heed to the following points when actually mounting these sensors.

Stress on electrode leads

Be careful not to supply 500g or more force to the leads.

Bending electrode leads

1) Prior to bending electrode leads, secure the lead side in position so that excessive force is not applied between molded resin parts and the lead wires.
2) Bend the leads at a point lmm or more apart from their roots (molded end).
3) Do not repeat bending and stretching the leads.
4) Avoid bending the leads on their thicker side.

Mounting on a circuit board

1) When using an adhesive agent to severe an element, select an agent which will not adversely affect the element.
2) When soldering a Hall sensor on a circuit board, it is recommended using rosin flux with low corrosiveness and high insulating capability.
   Due care must be exercised as to SIP-package Hall sensors, since the distance between leads is small.
3) Solder the lead wires at 260°C or less for 10 seconds or less.

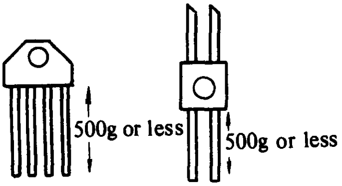


Fig. 9

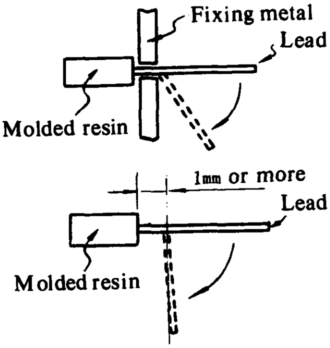


Fig. 10

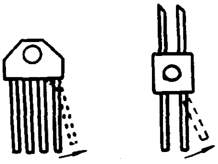


Fig. 11

PCT (Perfect Crystal device Technology)

1. Progress made in transistor technology up to now is the result of transition from germanium to silicon from the standpoint of materials and to substantial improvement in packaging thanks to surface stabilizing technology and the adoption of resins from the standpoint of manufacturing.

Especially, advance in surface stabilizing technology has substantially contributed to the progress of transistor technology; resin seals would not have been realized without this advance. Surface stabilizing technology is often referred to by the term ''passivation''. Research and development activities are still being conducted on seeking a more complete level of surface stabilization.

Toshiba has obtained a variety of patents related to surface stabilizing technology. In 1969, we succeeded in completing PCT, the acronym for Perfect Crystal (device) Technology. Since then, this technology has been applied to semiconductors and has been commercialized.

PCT denotes technology employed to manufacture semiconductor products (a) by using perfect-crystal wafers without defects such as dislocation, (b) by not allowing the occurrence of defects in the manufacturing processes such as epitaxial growth, diffusion, and oxidization, and (c) by maintaining the original perfect-crystal condition.

2. Transistors in which PCT is applied offer the following merits:

1 Low-frequency noises are minimized because there are no distortions in crystal.

2 In conventional diffusion technology, dislocation or other defects will develop at base areas while conducting emitter diffusion, and an emitter dip effect which thrusts out the base area interferes with high-frequency performance. However, PCT has improved this point to enhance high-frequency performance.

3 Thanks to freedom from crystal defects, longer life time is ensured, while linearity and saturation voltage are improved.

3. Transistors to which PCT is applied are identified in the respective specifications by the following indication:

Example: Silicon NPN epitaxial transistor (PCT process)

Precautions for Handling Hybrid Application Devices

Hybrid application devices are small package and are assembled in a different method as compared with conventional TO-92, TO-92MOD, TO-126, and TO-220. This section describes general precautions for handling and other points on which users should take care.

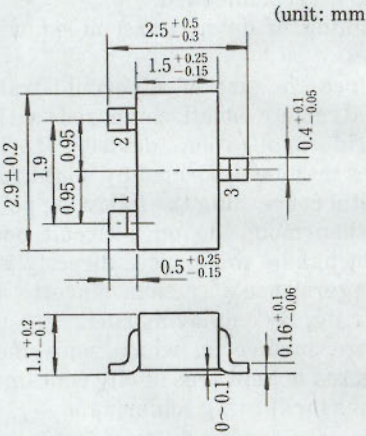
For further details, refer to the respective technical data.

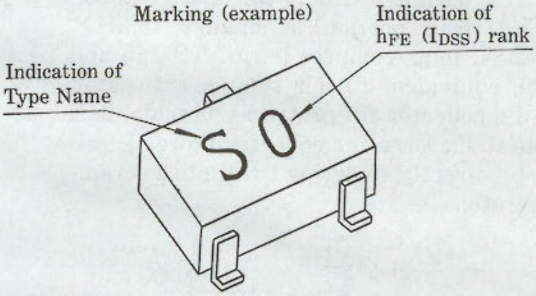
1. Hybrid application devices

Hybrid application devices are divided into the following three groups:

(1) Supermini-transistor (equivalent to TO-236)

Supermini-transistors are housed equivalents to TO-236 (SOT-23). Outline is shown in Fig. 1.





Electrode connection

Items	1	2	3
Transistor	Emitter	Base	Collector
2SK208/209	Drain	Source	Gate
2SK210/211	Gate	Drain	Source

Fig. 1 Outline of supermini-transistor

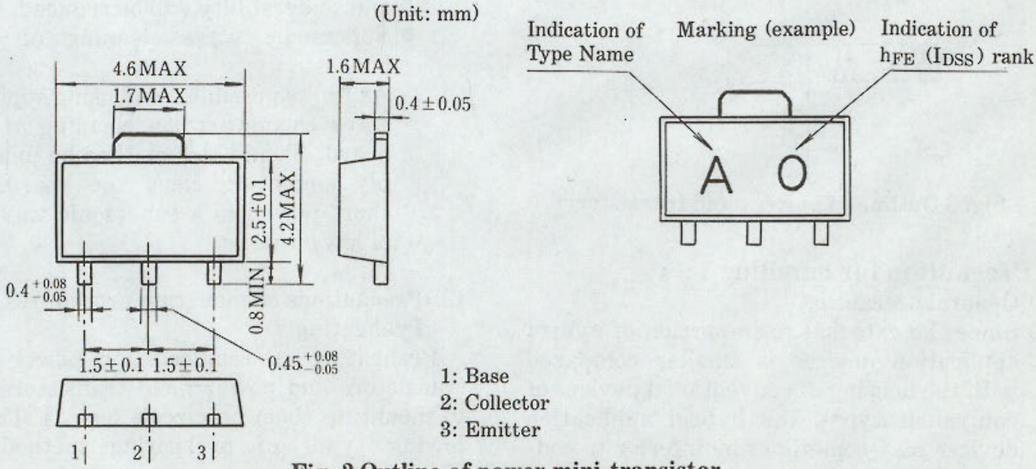


Fig. 2 Outline of power mini-transistor (equivalent to SOT-89)

(2) Power mini-transistor (equivalent to SOT-89)

Fig. 2 is outline of the power mini-transistor. The resin portion is small (2.5H × 4.5L × 1.5T, mm). Since the collector fin protrudes outside, it can be directly soldered to a ceramic substrate, making it possible to increase the collector Power Dissipation. This type of transistor is a flat package type in which the emitter, collector, and base leads are flush on the same surface to facilitate mounting on a ceramic substrate. Fig. 2 also shows a example of marking.

(3) Power mold transistor

Fig. 3 is outline of the power mold transistor. The resin portion is smaller (5.5H × 6.5L × 2.3T, mm) compared with TO-126 and TO-220, equivalent to this type of transistor. Since the collector fin protrudes outside, it is possible to increase the collector Power Dissipation by directly soldering the fin to a ceramic substrate.

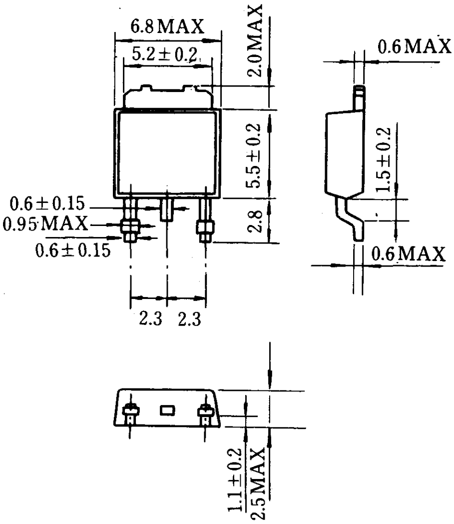


Fig. 3 Outline of power mold transistor

2. Precaution for handling

(1) General precaution

(a) Since the external resin portion of hybrid application devices is smaller compared with the housing of conventional devices of equivalent types, the hybrid application devices may sometimes be inferior to conventional types in humidity experiment. Therefore, it is necessary to coat the surface and surrounding units of such hybrid devices with resin or similar materials when using them under high-temperature, high-humidity conditions.

(b) Removing flux after soldering

After soldering a hybrid application device to a circuit board, flux which may have adhered while soldering or during the preflux treatment process must be removed. Should flux remain, rinsing is necessary because the flux component or compounds may cause a problem of lead wires corrosion. Do not attempt to remove inorganic flux by rinsing, because it can scarcely be rinsed off. Use of olefin cleaners such as Freon TE or Di-Freon Solvent S3-E is recommended.

(c) Handling of devices assembled with lead wires

Since the size of supermini-transistors is extremely small compared with other hybrid application devices, their lead wires may be deformed by slight force. Be careful concerning the following points.

- When mounting on a circuit board, do not handle the devices directly with the fingers; use a vacuum pincette or similar jig. By employing such a jig, the lead wire surface on which soldering is effected is kept free of oily contamination, thus facilitating soldering.
- Do not impart a force of 500g or more to the resin portion and lead wires while cleaning a circuit board; otherwise, lead wires may be deformed or disconnected and solderability will be reduced.
- Supersonic wave cleaning of circuit boards

  As far as possible avoid using supersonic wave cleaning when cleaning a circuit board. Should this method be unavoidably employed, clean the board for a short period in a supersonic wave bath of low output.

(2) Precautions on mounting procedures

Preheating

Preheating is required for power mini-transistors and power mold transistors prior to mounting them on circuit boards. The following types of preheating methods are available:

- Method of using a heater

Heat an device at 100~150°C/2 minutes by using an infrared heater or a heating panel (with built-in heater). Be careful to raise the temperature as slowly as possible; the semiconductor pellets may be damaged if the temperature rise is abrupt.

- Lamp heat radiating method

  This method utilizes a parabolic infrared lamp. Avoid an abrupt temperature rise, the same as in the mehtod above, by regulating the lamp focus and the power distance applied.

- Other method

  In addition to the foregoing are hot-air methods and others. If using these methods, preheat an element at 100~150°C for 2 minutes or similar conditions basically.

(3) Precautions on soldering process

(a) Allowable soldering time and temperature

The relation between allowable soldering time and temperature is as follows. Establish soldering conditions within these specifications.

- Supermini-transistors

  Soldering temperature... 260°C... 20 sec. or less (only one application allowed)

- Power mini-transistors and power mold transistor

  Soldering temperature... 250°C... 20 sec. or less (one each for preheating and soldering)

(b) Solder to be used

Be sure to use solder whose fusing point is as low as possible. The solder generally used is 6/3 or 6/4 solder with a fusing point of about 190°C. General soldering conditions include 220~240°C temperature and 3~5 seconds time.

When using creamy solder for printing by the metal mask method, use a newly mixed one as far as possible; be careful to avoid uneven printing or deformation. The recommended printing thickness of this solder printing is 200μm or more to improve lead wires solderability.

(c) Using a soldering iron

When using a soldering iron to mount an device on a circuit board, the device is often subjected to mislocation or package damage. Thus, it is recommended using a soldering iron only for experiments or repair. When using it, be careful about the following points:

- Temperature of soldering iron tip (for bonding): 250°C, 3 sec. or less
- Diameter of soldering iron tip: ϕ1 mm or less
- Do not allow the tip to contact the resin portions.

(d) Relationship between time and temperature for soldering and preheating

Figs. 4 and 5 show the relation between temperature and time for preheating and soldering in device mounting procedures such as the solder dip method.

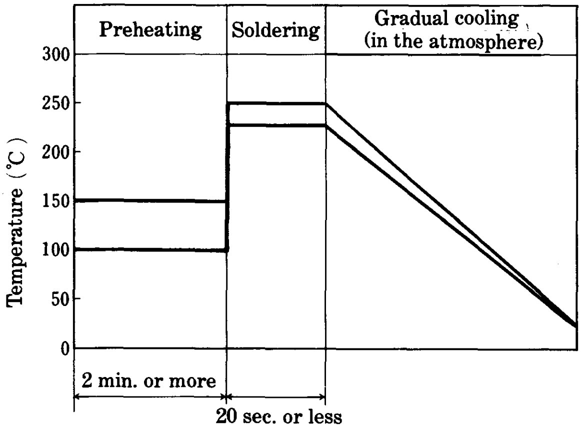


Fig. 4 Solder dip method

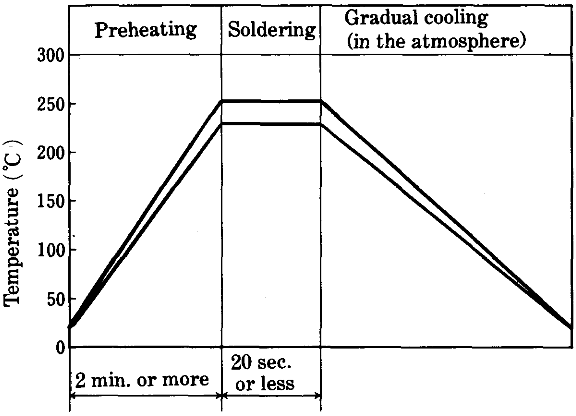


Fig. 5 Reflow soldering method (furnace soldering method)

(4) Precautions on allowable power dissipation (steady-state conditions)

The values of allowable power dissipation differ between an individual transistor and a transistor mounted on a circuit board. Changes in allowable power dissipation are described hereunder for typical models classified by their housing.

(a) Soupermini-transistor

Allowable power dissipation of supermini-transistors is 100~200 mW when they are used separately.

When mounted on a ceramic board, dissipation will be increased as shown in Fig. 4, in accordance with board sizes. The transistors used for this figure were 2SA1162/2SC2712.

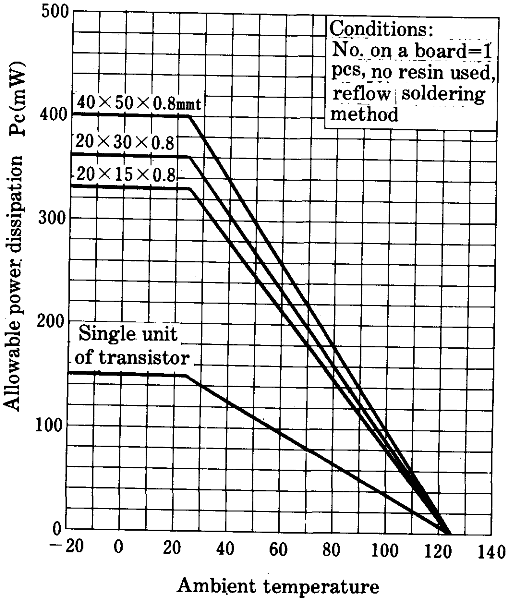


Fig. 6 **Pc (max) — Ta characteristics of 2SA1162 and 2SC2712 mounted on an alumina ceramic substrate.**

(b) Power mini-transistor

Being a small-sized housing, a power mini-transistor has an allowable power dissipation of 500 mW when used separately. When mounted on a board, however, it has an allowable power dissipation of a high 1.0W~2.0W because thermal diffusion from the collector fin to the board is increased. Therefore, it is possible to effect circuit designing similar to TO-92MOD (800~900 mW) and TO-126 (1.0~1.2W)

Fig. 5 illustrates examples of allowable power dissipation for the 2SC2873 and 2SA1213 mounted on a board.

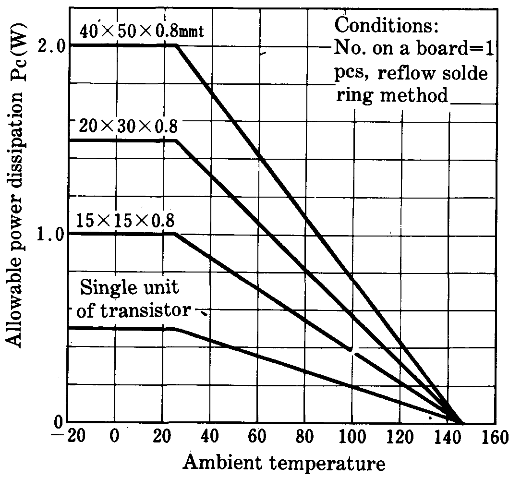


Fig. 7 **Pc (max) — Ta characteristics of 2SC2873 and 2SA1213 mounted on an alumina ceramic substrate**

(c) Power mold-transistor

Allowable power dissipation for the straight type is Pc=1W; however, that for the LB type is increased when mounted on a board through a collector fin. When soldering a power mold transistor to an alumina ceramic substrate, Pc(1) (1000mm^2) and Pc(2) (2500mm^2) are increased to 2W and 3W respectively. Fig. 8 shows the relation between the allowable power dissipation Pc and the ambient temperature Ta by using transistors 2SC3074 and 2SC1244.

(5) Precautions on allowable power dissipation (transient conditions)

When using a device for stroboscopic flash and motor driving circuits, the circuit design requires allowable power dissipation applicable to a short time in addition to allowable power dissipation under saturated conditions. Several types can be applied to such applications among Toshiba power mini-transistors and power mold-transistors. The relation between allowable power dissipation and pulse width under transient conditions for typical models for various packages is shown below:

(a) Power mini-transistor
Shown in Fig. 9.

(b) Power mold transistor
When using power mold transistors, it is also possible to take larger values of allowable power dissipation in a transient condition than in a saturated one. By using 2SC3074 and 2SA1244, the allowable power dissipation shown in Fig. 10 can be taken.

Be careful on the following points in this respect:

- Collector Power Dissipation Pc is a value within an area with restricted thermal resistance.
- The curve shown in he Figure is based on a single nonrepetitive pulse.

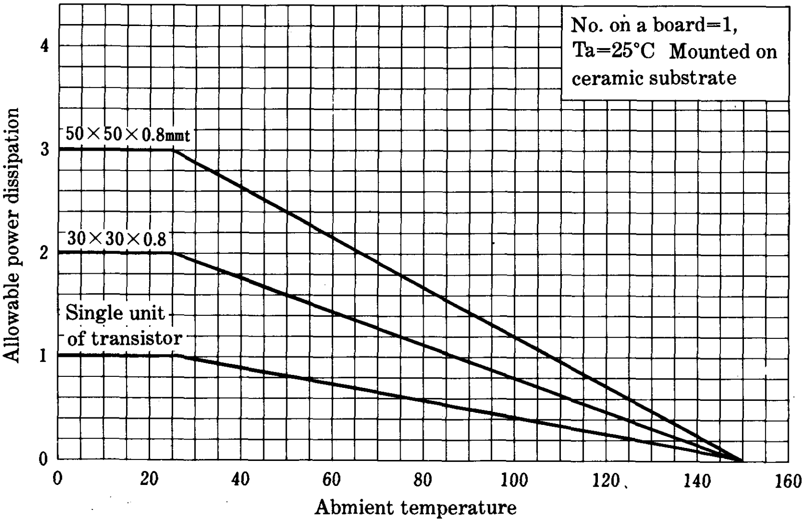


Fig. 8 Pc (max) — Ta characteristics of 2SC3074 and 2SA1244 mounted on an alumina ceramic substrate

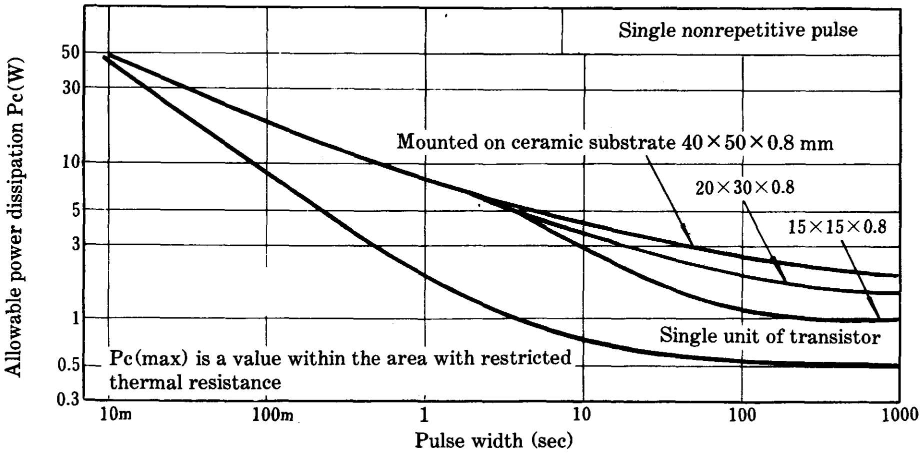


Fig. 9, Allowable power dissipation of 2SC2873 and 2SA1213 under transient conditions

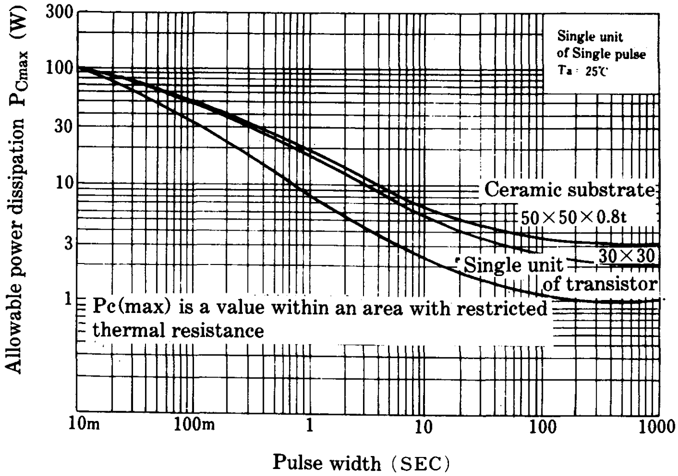


Fig. 10 Allowable power dissipation Pc—pulse width (2SC3074 and 2SA1244)

(6) Minimum pad size

(a) Supermini-transistor

Fig. 11 illustrates lead wire mounting locations and the minimum size of pads in supermini-transistors. Since the allowable power dissipation is substantially affected by the collector conducting pad area, it is advantageous to adopt a pad with as wide an area as possible, if the heat sink is taken into consideration.

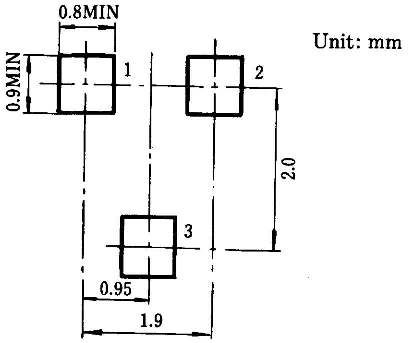


Fig. 11 Minimum size of mounting pad size for supermini-trasistors

(b) Power mini-transistor

Fig. 12 shows the lead wire mounting locations and the minimum size of pads in power mini-transistors. Since the allowable power dissipation is substantially affected by the collector connecting pad area, it is advantageous to adopt a pad with as wide an area as possible.

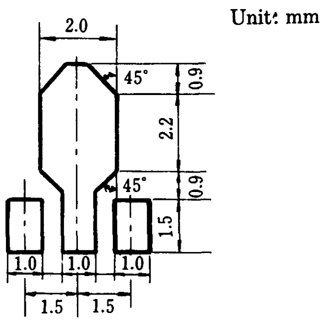


Fig. 12 Minimum pad size for power mini-transistors

(c) Power mold transistor

The thermal radiation of power mold transistors is effected mainly through a collector fin. If the area of conductor pattern connected to this portion is further increased, the allowable power dissipation is also increased. Thus, must be increase the conductor pattern size at the collector as much as possible. Shown in Fig. 13.

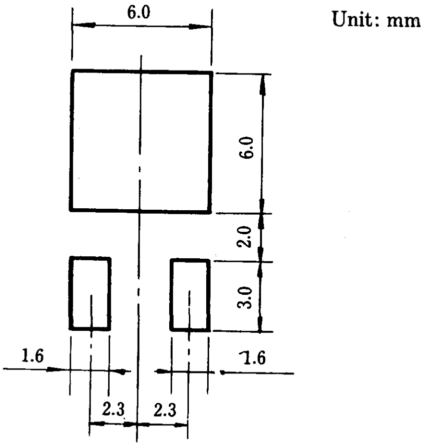


Fig. 13 Minimum pad size for Power-mold-transistor

Hybrid application devices, Group (1)

Supermini-Transistors (equivalent to TO-236)

*Transistor for microwave

Type Name	Application	Electrical characteristics (Ta=25°C)				Mark ing	Comple-mentary Pair	Type Name similar to TO-92	Remarks (mini-transistor)
		V_{CEO} (V)	I_C (mA)	P_C (mW)	T_j (°C)				
2SA1162	General Purpose	−50	150	150	125	S	2SC2712	2SA1015	2SA1048
2SC2712	General Purpose	50	150	150	125	L	2SA1162	2SC1815	2SC2458
2SA1163	High Voltage Amp.	−120	−100	150	125	C	2SC2713	2SA 970	2SA1049
2SC2713	High Voltage Amp.	120	100	150	125	D	2SA1163	2SC2240	2SC2459
2SC2714	FM RF.	30	20	100	125	Q	—	2SC1923	2SC2668
2SC2715	AM CONV.	30	50	150	125	R	—	2SC380TM	2SC2669
2SC2716	AM RF.	30	100	150	125	F	—	2SC941TM	2SC2670
2SA1182	General Purpose	−30	−500	150	125	Z	2SC2859	2SA562TM	—
2SC2859	General Purpose	30	500	150	125	W	2SA1182	2SC1959	—
2SC2532	LED driver	40	300	150	125	AN	—	2SC 982	—
2SC2996	FM RF.	30	50	150	125	G	—	—	2SC2995
2SA1255	High-Voltage Amp.	−200	−50	150	125	O	2SC3138	—	—
2SC3138	High-Voltage Amp.	200	50	150	125	N	2SA1255	—	—
*2SC3011	UHF, C-Band RF	7	30	150	125	MA	—	—	f_T=6.5GHz
*2SC3098	VHF, UHF RF.	20	50	150	125	MB	—	2SC2498	f_T=3.5GHz
*2SC3099	VHF, UHF RF.	20	30	150	125	MC	—	2SC2499	f_T=4GHz
*2SA1245	High-speed switching	−8	−30	150	125	MD	—	—	f_T=4GHz
2SC3119	UHF RF.	20	20	150	125	HA	—	—	f_T=900MHz
2SC3121	UHF OSC.	15	50	150	125	HC	—	—	f_T=1.3GHz
2SC3122	UHF RF.	30	20	150	125	HD	—	2SC2348	f_T=400MHz MIN.
2SC3123	VHF MIX.	20	50	150	125	HE	—	2SC3136	f_T=900MHz MIN.
2SC3124	VHF OSC.	15	50	150	125	HF	—	2SC2349	f_T=600MHz MIN.
2SC3125	PIF Stage	25	50	150	125	HH	—	2SC388ATM	f_T=350MHz

FETs

Type Name	Applications	V_{DSX}** V_{GDO} V_{GDS} *(V)	Electrical characteristics (Ta=25°C)				Mark-ing	Similar Type Name	Remarks
			I_C, I_D * (mA)	P_D (mW)	I_{DSS} (mA)	Yfs (ms)			
2SK208	General Purpose	−50	10	100	0.3~6.5	1.2MIN	J	2SK30ATM	
2SK209	General Purpose	−50	10	150	0.4~14	15	X	2SK117	
2SK210	FM RF, MIX.	−18*	10	100	3.0~24	7Typ.	Y	2SK192A	
2SK211	FM RF, MIX.	−18*	10	100	1.0~10	9Typ.	K	2SK241	
2SK302	FM RF, MIX.	20**	30*	150	1.5~14	10Typ.	T	2SK241	MOS FET

Diodes

Type Name	Applications	Electrical characteristics (Ta=25°C)					Marking	Similar Type Name	Remarks
		V_R (V)	I_P (mA)	C_T (PF)	NF(bB)	Rs(Ω)			
ISS154	UHF, S Band MIX.	6	30	0.8	9 MAX.	—	BA	—	
ISV128	VHF, UHF Attenator	50	50	0.25	—	7	BB	ISV99	

Hybrid application devices, Group (2)

Power mini-transistor (equivalent to SOT-89)

Pc; Mounted on ceramic substrate (250mm² × 0.8t)

Type Name	Application	Electrical characteristics (Ta=25°C)					Marking	Complementary Pair	Similar Type Name (TO-92MOD)	Remarks
		V_{CEO} (V)	I_C (A)	P_C (W)	P_C* (W)	T_j (°C)				
2SA1200	High-voltage switching	−150	−0.05	0.5	0.8	150	B	2SC2880	2SA949	
2SC2880	High-voltage switching	150	0.05	0.5	0.8	150	A	2SA1200	2SC2229	
2SA1201	Audio Driver Amp.	−120	−0.8	0.5	1.0	150	D	2SC2881	2SA965	
2SC2881	Audio Driver Amp.	120	0.8	0.5	1.0	150	C	2SA1201	2SC2235	
2SA1202	Audio Driver Amp.	− 80	−0.4	0.5	1.0	150	F	2SC2882	2SA817A	
2SC2882	Audio Driver Amp.	80	0.4	0.5	1.0	150	E	2SA1202	2SC1627A	
2SA1203	Power Switching	− 30	−1.5	0.5	1.0	150	H	2SC2883	2SA966	
2SC2883	Power Switching	30	1.5	0.5	1.0	150	G	2SA1203	2SC2236	
2SA1204	Power Switching	−30	−0.8	0.5	1.0	150	R	2SC2884	2SA950	
2SC2884	Power Switching	30	0.8	0.5	1.0	150	P	2SA1204	2SC2120	
2SA1213	Power Amp., power switching	−50	−2.0	0.5	1.0	150	N	2SC2873	2SA1020	Low $V_{CE(sat)}$
2SC2873	Power Amp., power switching	50	2.0	0.5	1.0	150	M	2SA1213	2SC2655	Low $V_{CE(sat)}$
2SC2982	Stroboscopic flash	10	2.0	0.5	1.0	150	S	—	2SC2500	Low $V_{CE(sat)}$
2SA1314	Stroboscopic flash	− 10	−2.0	0.5	1.0	150	T	—	2SA1160	Low $V_{CE(sat)}$
2SC3268	VHF～UHF RF	12	0.07	0.5	0.8	150	UA	—	—	
2SC3301	VHF～UHF RF	7.5	0.08	0.5	0.8	150	UB	—	—	

Hybrid application devices, Group (3)

Power mold-transistor

P_C*: @T_C=25°C **TO−92 MOD

Type Name	Application	Electrical characteristics (Ta=25°C)					Complementary Pair	Similar Type Name (TO-126, 220)	Remarks
		V_{CEO} (V)	I_C (A)	P_C (W)	P_C* (W)	T_j (°C)			
2SA1225	Audio Driver Amp.	−160	−1.5	1.0	10	150	2SC2983	2SA968	
2SC2983	Audio Driver Amp.	160	1.5	1.0	10	150	2SA1225	2SC2238	
2SA1241	Power Amp.	− 50	−2.0	1.0	10	150	2SC3076	2SA1020	
2SC3076	Power Amp.	50	2.0	1.0	10	150	2SA1241	2SC2655	
2SA1242	Stroboscopic flash	− 20	−5.0	1.0	10	150	2SC3072 Refer to h_{FE} classification	2SA1120	
2SC3072	Stroboscopic flash	20	5.0	1.0	10	150	2SA1242 Refer to h_{FE} classification	2SC2270	
2SA1243	Power Amp.	− 30	−3.0	1.0	10	150	2SC3073	2SA473	
2SC3073	Power Amp.	30	3.0	1.0	10	150	2SA1243	2SC1173	
2SA1244	High-current switching	− 50	−5.0	1.0	20	150	2SC3074	2SA1012	
2SC3074	High-current switching	50	5.0	1.0	20	150	2SA1244	2SC2562	
2SB 905	TV vertical output	−150	−1.5	1.0	10	150	2SD1220	2SA1021	
2SD1220	TV vertical output	150	1.5	1.0	10	150	2SB 905	2SC2481	
2SB 906	Power Amp.	− 60	−3.0	1.0	20	150	2SD1221	2SB834	
2SD1221	Power Amp.	60	3.0	1.0	20	150	2SB 906	2SD880	
2SB 907	Power Switching	− 40	−3.0	1.0	15	150	2SD1222	2SB677	Darlington Type
2SD1222	Power Switching	40	3.0	1.0	15	150	2SB 907	2SD687	Darlington Type
2SB 908	Power Switching	− 80	−4.0	1.0	15	150	2SD1223	2SB676	Darlington Type
2SD1223	Power Switching	80	4.0	4.0	15	150	2SB 908	2SD686	Darlington Type
2SD1224	Power Amp.	30	1.5	1.0	10	150	—	2SD549	Darlington Type
2SD1160	Motor control	50**	2.0	1.0	10	150	—	—	
2SC3075	High-voltage power Amp.	400	0.8	1.0	10	150	—	—	
2SC3303	High-current switching	80	5.0	1.0	20	150	—	2SC3258	
2SC3233	High-voltage switching	400	2.0	1.0	10	150	—	2SC2552	

**: V_{CES}

Standard Taping and Various Packaging Suitable for Automatization

Standard taping and various packaging suitable for automatization

Procedures for mounting elements on circuit boards for electronic equipment are becoming more and more automated and laborsaving. Accordingly, packaging styles of transistors suitable for automatic mounting machines are required. To cope with such trends, Toshiba has staqndardized a variety of packages, thereby meeting user demands.

1. Standard taping for TO-92/ mini-transistor

(1) Identification method

Suffixes given to the model name of the transistor indicate the packaging styles.

Example:

2SC1815	GR	TPE 1
↑	↑	↑ ↑
Type Name	Classification	Indication of taping specifications

(2) List of standard taping styles

Taping styles of the TO-92/mini-transistor are classified as shown in Table 1 according to the package and packaging methods:

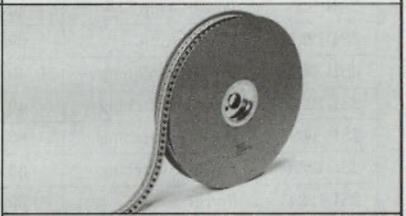
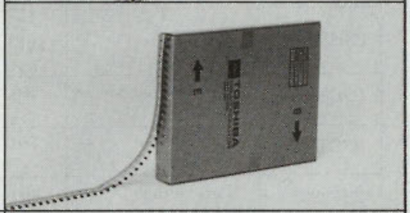
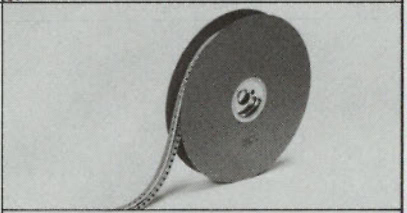
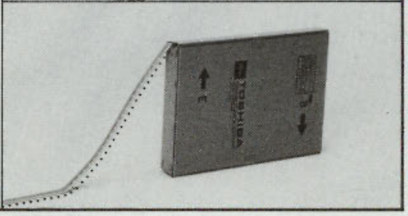
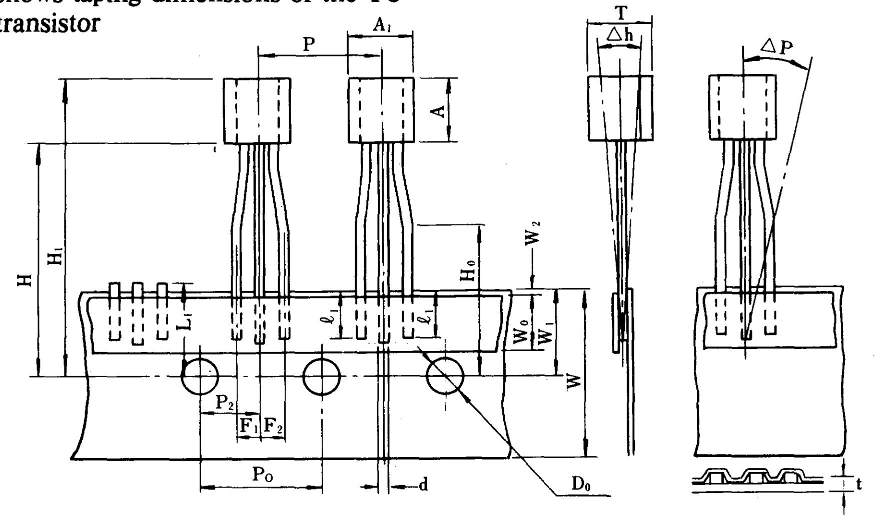
Indication of taping specifications	Package	Outlined specifications	Quantity per package	External view
TPE1	TO-92 (2-5F)	Reel (emitter first)	2000 pcs	
TPER1		Reel (base first)		
TPE2		AMMO PACK (FAN FOLD BOX)		
TPE3	MINI (2-4E)	Reel (emitter first)	2500 pcs	
TPER3		Reel (base first)		
TPE4		AMMO PACK (FAN FOLD BOX)		

Table 1 Taping specifications for TO-92/ mini transistor

(3) Taping specifications

Fig. 1 shows taping dimensions of the TO-92/mini transistor



Unit: mm

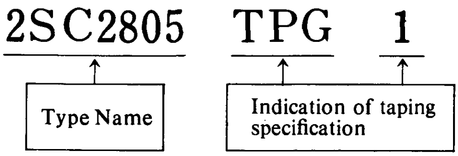
Item	Symbol	Dimension		Remarks
		TO-92	MINI	
Component Width	A1	6.0 MAX	4.5 MAX	
Component Height	A	9.0 MAX	3.5 MAX	
Component Thickness	T	6.0 MAX	2.6 MAX	
Lead wire Diam. (square)	d	0.45□ TYP	0.4□ TYP	
Lead Retention	ℓ1	3.5 MIN	3.0 MIN	
Component Center Pitch	P	12.7 ± 1.0		
Feed Hole Pitch	Po	12.7 ± 0.3		Accumullated pitch allowance is ±1mm for every 20 pitches.
Feed Hole Dislocation	P2	6.35 ±0.4		
Center Lead Spacing	F1,2	2.5 $^{+0.45}_{-0.15}$		
Deflection (1)	Δ h	0 ± 2.0		
Tape Width	W	18.0 $^{+1.0}_{-0.5}$		
Retention Tape Width	Wo	6.0 ± 0.3		
Feed Hole Location	W1	9.0 ± 0.5		
Adhesive Tape Border	W2	0.5 MAX		
Feed Hole to Bottom of Component	H	20 MAX	20 $^{+0.75}_{-0.5}$	
Height of Sealing Plane	Ho	16.0 ± 0.5		
Feed Hole to Top of Component	H1	32.25 MAX		
Feed Hole Diameter	Do	4.0 ± 0.2		
Tape Thickness (Total)	t	0.6 ± 0.2		
Lead Length after Component Removal	L1	11.0 MAX		
Deflection (2)	ΔP	0 ± 1.0		

2. Standard taping for microwave transistors

(1) Identification method

Suffixes applied to the model indentification of the transistors indicate the packaging styles.

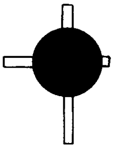
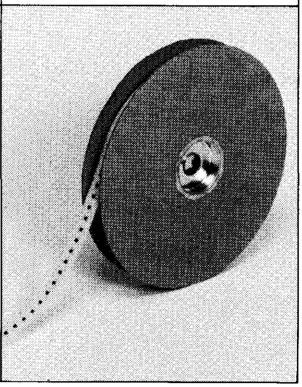
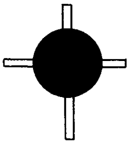
Example:



(2) List of standard taping styles

Taping styles of a microwave transistor are calssified as listed in Table 2 according to the external housings.

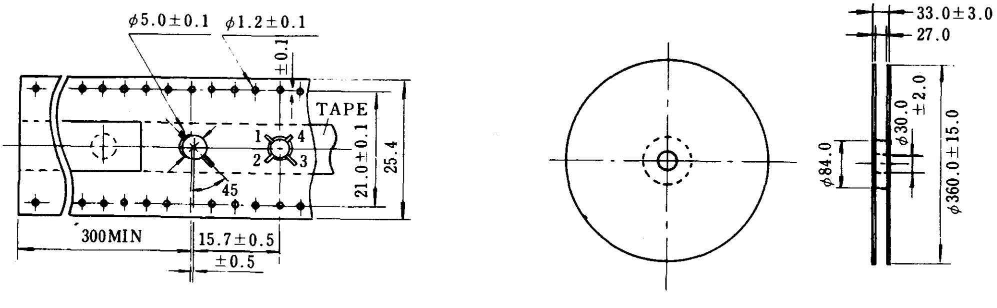
Table 2 List of microwave transistor standard taping styles

Indication of taping specifications	Package	Outlined specifications	Quantity per package	External view
TPG1	 3 leads	Reel	3000pcs	
TPG2	 4 leads			

(3) Taping specifications

Fig.2 shows the external dimensions and taping dimensions for microwave transistors.

Unit: mm


Taping dimensions

Reel dimensions

1 reel = 3000 pieces

Lead-forming dimensions (for 4 leads)

Lead-forming dimensions (for 3 leads)

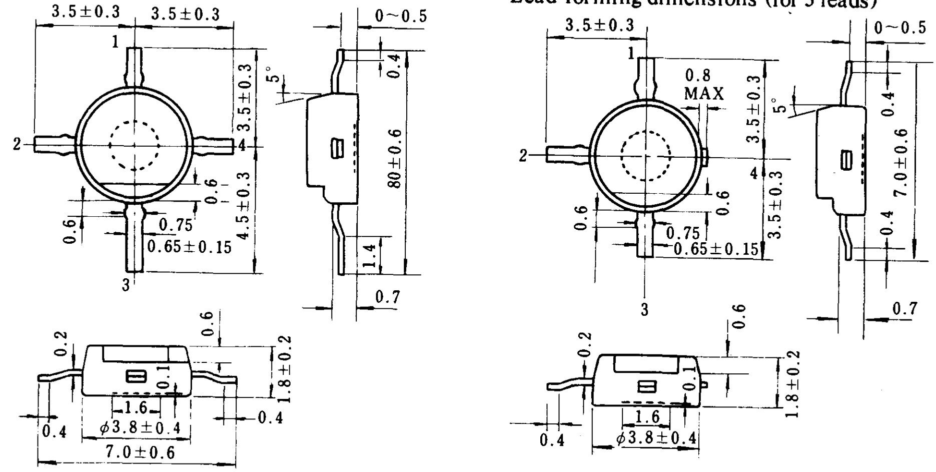


Fig. 2 Taping/external dimensions of microwave transistors

3. Packaging styles of supermini-transistors

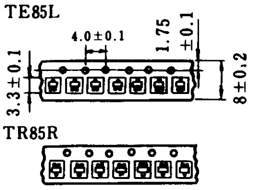
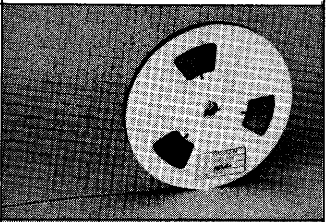
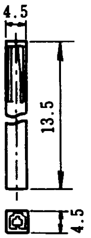
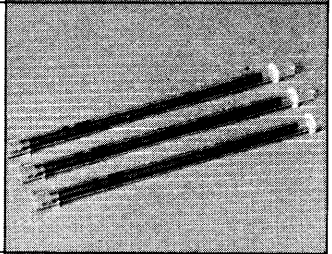
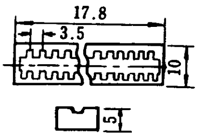
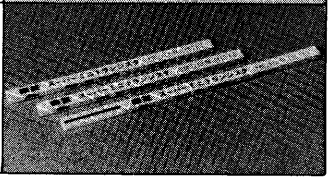
The standard packaging styles of supermini-transistors include (1) taping, (2) stick magazine, and (3) horizontal magazine with respective features:

- Taping: Transistors can be continuously mounted on boards by using a one by one automounting machine.
- Stick magazine: Transistors can be continuously mounted on boards by using a multi-shot automounting machine.
- Horzontal magazine: A variety of automounting machines can be freely designed. Mounting efficiency is enhanced because products are kept in order even during manual mounting.

(1) List of packaging styles

Table 3 presents an outline of respective packaging styles for supermini-transistors.

Table 3 List of packing styles for supermini-transistors

Classification	Quantity	Dimensions (Unit: mm)	External view
Taping	3000 pcs./reel		
Stick magazine	100pcs./magazine		
Horizontal magazine	50 pcs./magazine		

4. Lead-forming specifications for the TO-92/mini-transistor

Figs. 3 (a), (b), and (c) show lead-forming specifications of TO-92/mini-transistors.

Package No. 2-5F106

Package No. 2-5F108

(Unit: mm)

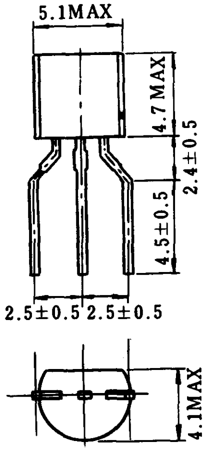


Fig. 3 (a) Forming dimensions of TO-92 package transistor

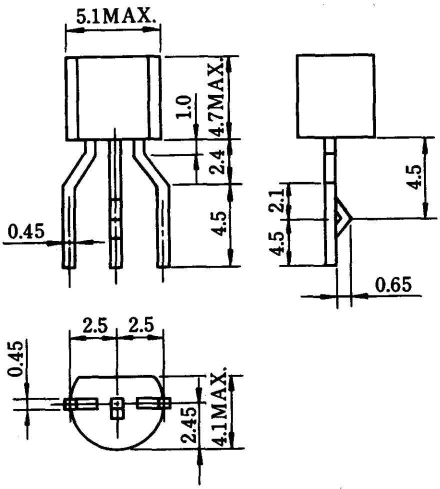
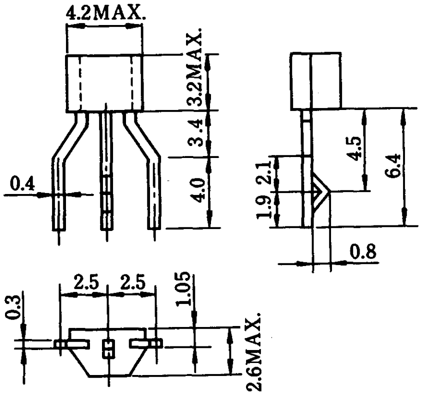


Fig. 3 (b) Forming dimensions of mini-transistor

Package No. 2-4F101



Snap forming: center load only

Fig. 3 (c) Forming demensions of mini-transistor

Letter Symbol and Graphical Symbol

1. Letter symbol

Table 1 General

Symbol	Description
NF	noise figure
P	allowable power dissipation
R_{th}	thermal resistance
$R_{th\ j-c}$	thermal resistance, (junction to case)
$R_{th\ j-s}$	thermal resistance, (junction to stud)
$R_{th\ j-a}$	thermal resistance, (junction to ambient)
$R_{th-(f-a)}$	thermal resistance, (heat sink to ambient)
$R_{th-(s-f)}$	thermal resistance, (stud to heat sink)
r_{th}	transient thermal resistance
T_a	ambient temperature
T_c	case temperature
T_j	junction temperature
T_{stg}	storage temperature
t_d	delay time
t_f	fall time
t_r	rise time
t_{rr}	reverse recovery time (diode)
t_{stg}	storage time
t_{on}	turn-on time
t_{off}	turn-off time

Table 2 Transistor

Symbol	Description
$V_{(BR)CBO}$	collector-base breakdown voltage, emitter open
$V_{(BR)CEO}$	collector-emitter breakdown voltage, base open
$V_{(BR)CER}$	collector-emitter breakdown voltage, with specified resistance between base and emitter
$V_{(BR)CES}$	collector-emitter breakdown voltage, with base short-circuited to emitter
$V_{(BR)CEX}$	collector-emitter breakdown voltage, with specified circuit between base and emitter
$V_{(BR)EBO}$	emitter-base breakdown voltage, collector open
b_{fb}	forward transfer susceptance, common base
b_{fe}	forward transfer susceptance, common emitter
b_{ib}	input susceptance, common base
b_{ie}	input susceptance, common emitter
b_{ob}	output susceptance, common base
b_{oe}	output susceptance, common emitter
C_{ob}	output capacitance, common base
C_{oe}	output capacitance, common emitter
C_{ib}	input capacitance, common base
C_{ie}	input capacitance, common emitter
$C_c r_{bb'}$	$C_c \times r_{bb'}$ (collector-to-base time constant)
C_{re}	reverse transfer capacitance
$f_{\alpha b}$	small-signal, short-circuit forward current transfer ratio cutoff frequency, common base
f_T	transistion frequency (common emitter gain band-width product)
G_c	conversion power gain
G_{pe}	power gain, common emitter
G_{ve}	voltage gain, common emitter
g_{fb}	forward transfer conductance, common base
g_{fe}	forward transfer conductance, common emitter
g_{ib}	input conductance, common base
g_{ie}	input conductance, common emitter
g_{ob}	output conductance, common base
g_{oe}	output conductance, common emitter
g_{rb}	reverse transfer conductance, common base
g_{re}	reverse transfer conductance, common emitter
h_{fb}	small-signal, short-circuit, forward current transfer ratio, common base
h_{fe}	small-signal, current gain, common emitter
h_{FE}	DC current gain, common emitter
h_{ib}	small-signal, short-circuit input impedance, common base
h_{ie}	small-signal, short-circuit input impedance, common emitter
$Re(h_{ie})$	real part of small-signal, short-circuit input impedance, common emitter
$Im(h_{ie})$	imaginary part of small-signal, short-circuit input impedance, common emitter
h_{oe}	small-signal, open-circuit output admittance, common emitter
h_{ob}	small-signal, open-circuit output admittance, common base
h_{rb}	small-signal, open circuit reverse voltage transfer ratio, common base
h_{re}	small-signal, open circuit reverse voltage transfer ratio, common emitter
I_B	base current
I_C	collector current
I_E	emitter current
I_{CBO}	collector cutoff current, emitter open
I_{CBV}	collector cutoff current, with specified reverse voltage between base and emitter
I_{CEO}	collector cutoff current, base open
I_{CEX}	collector cutoff current, with specified circuit between base and emitter
I_{EBO}	emitter cutoff current, collector open
KF	overall harmonic distortion
P_o	output power
P_i	input power
P_c	collector power dissipation
Q_s	stored charge
$r_{bb'}$	base spreading resistance
R_E	external emitter resistance
R_G	signal source resistance
R_i	input resistance
R_L	load resistance

R_o	output resistance
UMAPG	maximum available power gain
V_{BE}	base-emitter voltage
$V_{BE(sat)}$	base-emitter saturation voltage
V_{CB}	collector-base voltage
V_{CBO}	collector-base voltage, emitter open
V_{CBV}	collector-base voltage, with specified voltage between base and emitter
V_{CE}	collector-emitter voltage
V_{CEO}	collector-emitter voltage, base open
V_{CER}	collector-emitter voltage, with specified resistance between base and emitter
V_{CES}	collector-emitter voltage, with base short-circuited to emitter
V_{CEV}	collector-emitter voltage, with base specified voltage between base and emitter
V_{CEX}	collector-emitter voltage, with specified circuit between base and emitter
$V_{CE(sat)}$	collector-emitter saturation voltage
$V_{CE(sus)}$	collector-emitter sustaining voltage
V_{EBO}	emitter-base voltage, collector open
V_i	input voltage
V_N	noise voltage
V_R	reverse voltage
V_{osc}	oscillating output voltage
y_{fb}	forward transfer admittance, common base
y_{fe}	forward transfer admittance, common emitter
y_{rb}	reverse transfer admittance, common base
y_{re}	reverse transfer admittance, common emitter
θ_{fb}	phase angle of forward transfer admittance, common base
θ_{fe}	phase angle of forward transfer admittance, common emitter
θ_{rb}	phase angle of reverse transfer admittance, common base
θ_{re}	phase angle of reverse transfer admittance, common emitter

Table 3 Unijunction transistor

Symbol	Description
I_B	base current
$I_{B2(Mod)}$	modulated interbase current
I_E	emitter current
I_{EB20}	emitter reverse current, base 1 open
I_{EM}	peak emitter current
I_P	peak point emitter current
I_V	valley point emitter current
V_{B2B1}	base 2-base 1 voltage
V_{B1E0}	base 1-emitter voltage, with base 2 open
V_{B2E0}	base 2-emitter voltage, with base 1 open
V_{EB1}	emitter-base 1 voltage
$V_{EB1(sat)}$	emitter-base 1 forward saturation voltage, with specified voltage between bases 1 and 2
V_V	valley point emitter voltage
V_P	peak point emitter voltage
R_{BBO}	base 1-base 2 resistance, with emitter open instrinsic standoff ratio

Table 4 Field Effect Transistor (FET)

Symbol	Description
SOA	safe operating area
C_{G1D}	gate 1-drain capacitance
C_{G2D}	gate 2-drain capacitance
C_{is}	input capacitance, common source
C_{os}	output capacitance, common source
C_{rs}	reverse transfer capacitance, common source
C_{iss}	small-signal, short-circuit input capacitance, common source
C_{oss}	small-signal, short-circuit output capacitance, common source
C_{rss}	small-signal, short-circuit reverse transfer capacitance, common source
f_{opr}	operated frequency
G_{ps}	power gain, common source
GR	gain reduction
g_{iss}	input conductance, common source
g_{oss}	output conductance, common source
I_D	drain current
I_{DR}	drain reverse current (refer to measuring conditions)
$I_{D(OFF)}$	drain cutoff current
I_{DSS}	drain current, with gate short-circuited to source
I_{DSX}	drain-source current with specified circuit between gate and source
I_G	gate current
I_{GSS}	gate-source cutoff current, with source short-circuited to drain
I_{GSX}	gate excess current
NF	noise figure
P_D	drain power dissipation
$R_{DS(ON)}$	drain-source ON resistance, DC
$R_{DS(OFF)}$	drain-source OFF resistance, DC
$r_{DS(ON)}$	drain-source ON resistance, AC
$r_{ds(ON)}$	drain-source ON resistance, internal equivalent
r_G	gate resistance, internal equivalent
T_{ch}	channel temperature
T_j	junction temperature
T_{stg}	storage temperature range
$t_{d(on)}$	turn-on delay time
t_r	rise time
t_{on}	turn-on time
$t_{d(off)}$	turn-off delay time
t_f	fall time
t_{off}	turn-off time
$V_{DS(ON)}$	drain-source ON voltage
V_{DSX}	drain-source voltage with specified circuit between gate and source
V_{DSF}	drain-source forward transfer voltage
V_{DSS}	drain-source voltage, with gate short-circuited to source
V_{emf}	drain-source thermal electromotive force
V_{GS}	gate-source voltage
$V_{GS(OFF)}$	gate-source cutoff voltage
V_{GSS}	gate-source voltage, with drain short-circuited to source
V_{GDS}	gate-drain voltage, with source short-circuited to drain

$V_{(BR)DSS}$	drain-source breakdown voltage
$V_{(BR)GDS}$	gate-drain breakdown voltage
V_N	noise voltage
$V_{N(p-p)}$	peak-peak noise voltage
$V_{N(AV)}$	average noise voltage
V_{th}	gate-source threshold voltage
$\lvert Y_{fs} \rvert$	forward transfer admittance
y_{fs}	forward transfer admittance, common source
y_{is}	input admittance, common source
y_{rs}	reverse transfer admittance, common source
y_{os}	output admittance, common source

2. Graphical symbol

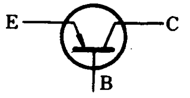
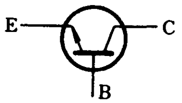
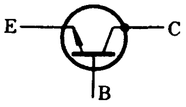
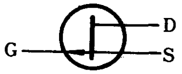
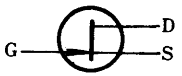
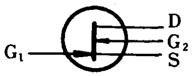
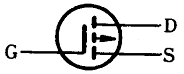
- Letters and numbers shown on the drawings of graphical symbols listed below are given only for explanation purposes and do not comprise a part of relevent symbols.

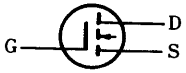
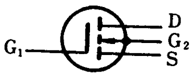
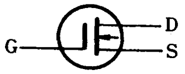
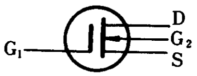
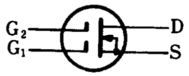
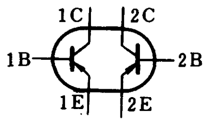
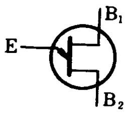
  The letters used here denote the following

E: emitter
C: collector
B: base
D: drain
G: gate
S: source

- The following envelope symbols may be omitted if no confusion will arise or if none of the elements in a device is connected to an envelope.

Envelope Symbols

Description	Graphical symbol
PNP transistor	
NPN transistor	
NPN transistor (collector to case connected)	
P-channel junction type field effect transistor	
N-channel junction type field effect transistor	
N-channel junction type field effect transistor (gate taken out of a substrate)	
P-channel MOS enhancement type field effect transistor	

Description	Graphical symbol
N-channel MOS enhancement type field effect transistor	
N-channel MOS enhancement type field effect transistor (gate taken out of a substrate and connected to case)	
N-channel MOS depletion type field effect transistor	
N-channel MOS depletion type field effect transistor (gate taken out of a substrate)	
Dual-gate N-channel MOS depletion type field effect transistor (substrate internally connected to source)	
Twin transistor	
High-speed switching N-type base uni-junction transistor	

TECHNICAL DATA

2SA series

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

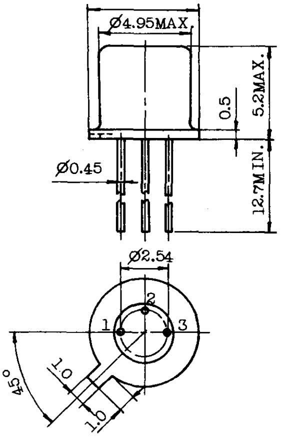
2SA499
2SA500

HIGH FREQUENCY AMPLIFIER APPLICATIONS.

HIGH SPEED SWITCHING APPLICATIONS.

INDUSTRIAL APPLICATIONS

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR(CASE)

JEDEC	TO − 18
EIAJ	TC − 7, TB − 8C
TOSHIBA	2 − 5A1B

Weight : 0.31g

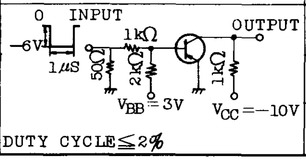
FEATURES:

- High Breakdown Voltage : V_{CBO}=−50V (Min.) (2SA499)
  : V_{CBO}=−30V (Min.) (2SA500)
- High Transition Frequency : f_T=250MHz (Typ.)
- Fast Switching Speed : t_{on}=25ns (Typ.)
- Complementary to 2SC400 and 2SC979.

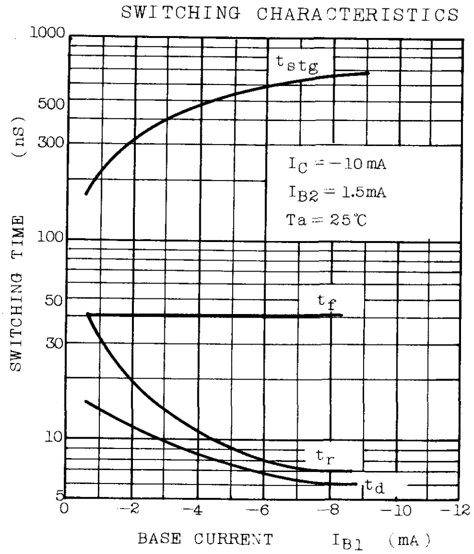
MAXIMUM RATINGS (Ta=25°C)

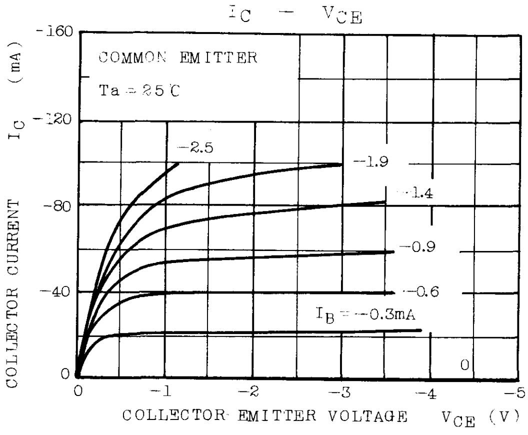
CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Voltage	2SA499	V_{CBO}	-50	V
	2SA500		-30	
Collector-Emitter Voltage	2SA499	V_{CEO}	-40	V
	2SA500		-20	
Emitter-Base Voltage		V_{EBO}	-5	V
Collector Current		I_C	-100	mA
Base Current		I_B	-20	mA
Collector Power Dissipation		P_C	250	mW
Junction Temperature		T_j	175	°C
Storage Temperature Range		T_{stg}	-65∿175	°C

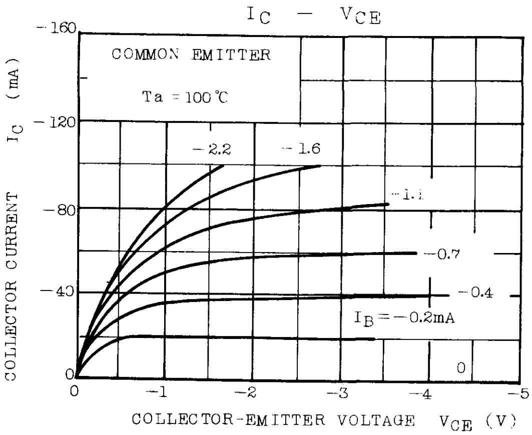
ELECTRICAL CHARACTERISTICS (Ta=25°C)

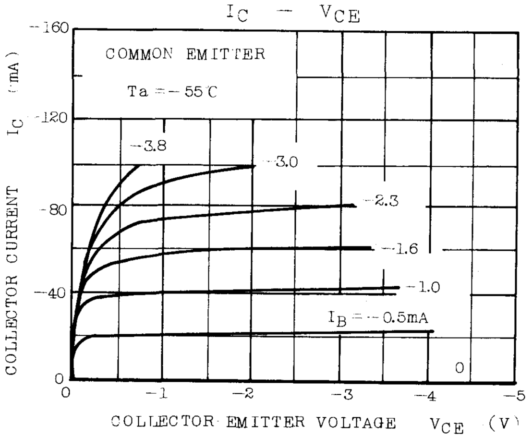
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cuf-off Current		I_{CBO}	V_{CB}=−15V, I_E=0	-	-	-0.5	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=−5V, I_C=0	-	-	-1.0	μA
DC Current Gain		h_{FE} (Note)	V_{CE}=−1V, I_C=−10mA	60	-	200	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=−10mA, I_B=−1mA	-	-0.1	-0.4	V
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=−10mA, I_B=−1mA	-	-0.8	-1.0	V
Transition Frequency		f_T	V_{CE}=−10V, I_C=−10mA	100	250	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=−10V, I_E=0, f=1MHz	-	5	7	pF
Base Intrinsic Resistance		$r_{bb'}$	V_{CB}=−6V, I_E=1mA, f=30MHz	-	30	70	Ω
Switching Time	Turn-on Time	t_{on}		-	25	-	ns
	Storage Time	t_{stg}		-	400	-	
	Fall Time	t_f		-	40	-	

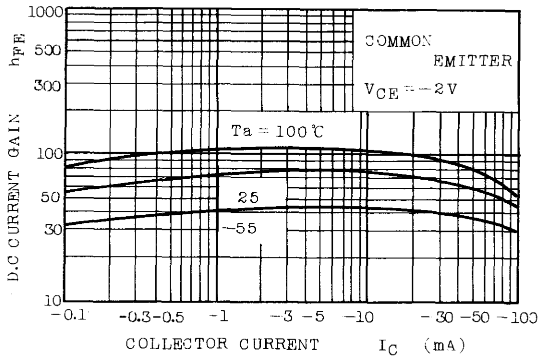
Note : h_{FE} Classification O : 60∿120, Y : 100∿200

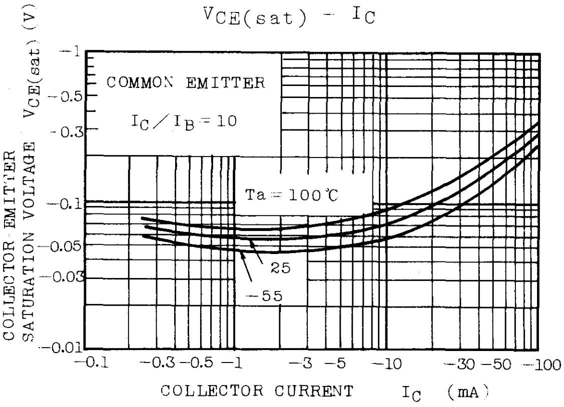

SWITCHING CHARACTERISTICS
SWITCHING TIME (nS)
1000
500
300
100
50
30
10
5
t_{stg}
t_f
t_r
t_d
$I_C = -10$ mA
$I_{B2} = 1.5$mA
Ta = 25℃
0
−2
−4
−6
−8
−10
−12
BASE CURRENT I_{B1} (mA)

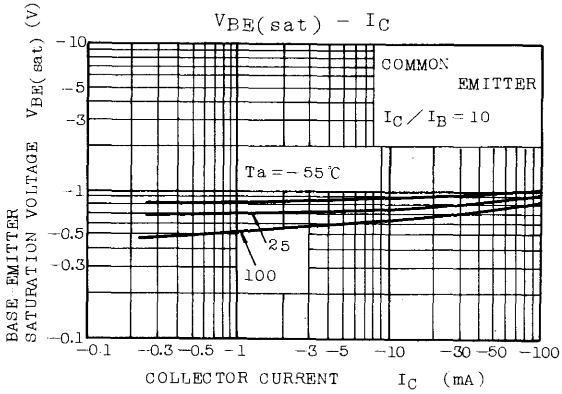

I_C — V_{CE}
COMMON EMITTER
Ta = 25℃
COLLECTOR CURRENT I_C (mA)
−160
−120
−80
−40
0
−2.5
−1.9
−1.4
−0.9
−0.6
$I_B = -0.3$mA
0
0
−1
−2
−3
−4
−5
COLLECTOR EMITTER VOLTAGE V_{CE} (V)

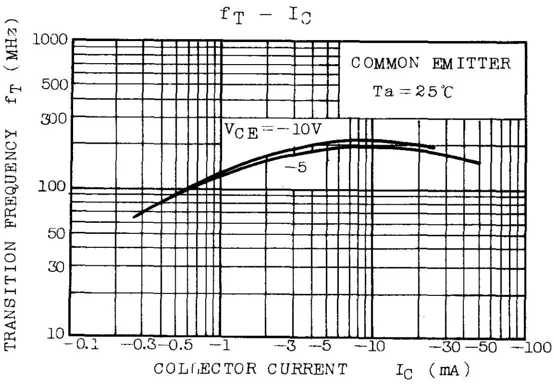

I_C — V_{CE}
COMMON EMITTER
Ta = 100℃
COLLECTOR CURRENT I_C (mA)
−160
−120
−80
−40
0
−2.2
−1.6
−1.1
−0.7
−0.4
$I_B = -0.2$mA
0
0
−1
−2
−3
−4
−5
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)

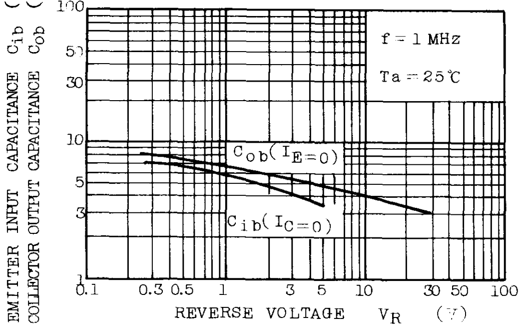

I_C — V_{CE}
COMMON EMITTER
Ta = −55℃
COLLECTOR CURRENT I_C (mA)
−160
−120
−80
−40
0
−3.8
−3.0
−2.3
−1.6
−1.0
$I_B = -0.5$mA
0
0
−1
−2
−3
−4
−5
COLLECTOR EMITTER VOLTAGE V_{CE} (V)

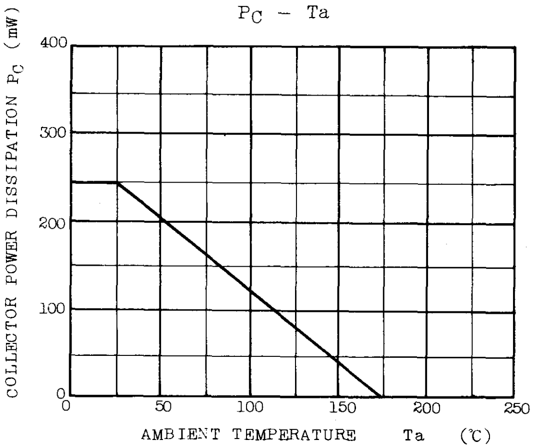

h_{FE} − I_C


$V_{CE(sat)}$ − I_C


$V_{BE(sat)}$ − I_C


f_T − I_C


C_{ib},C_{ob} − V_R


P_C − Ta

2SA562TM

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

AUDIO FREQUENCY LOW POWER AMPLIFIER APPLICATIONS.

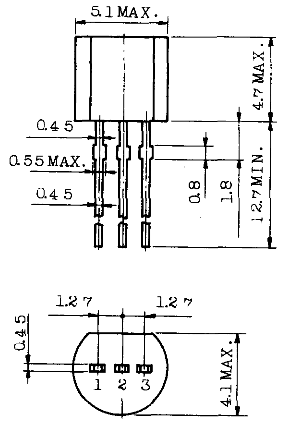
DRIVER STAGE AMPLIFIER APPLICATIONS.

SWITCHING APPLICATIONS.

FEATURES:

- Excellent h_{FE} Linearity.
  $h_{FE}(2)=25$(Min.) at $V_{CE}=-6V$, $I_C=-400mA$
- 1 Watt Amplifier Application.
- Complementary to 2SC1959.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight :0.21g

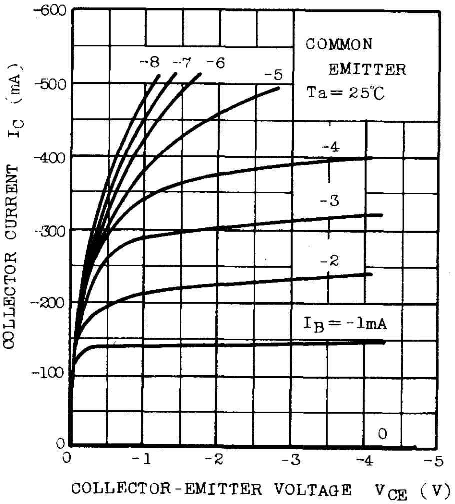
MAXIMUM RATINGS ($Ta=25^{\circ}C$)

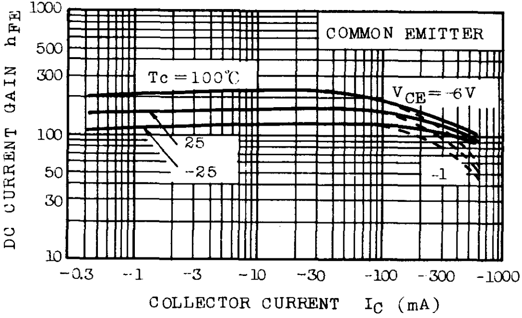
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-35	V
Collector-Emitter Voltage	V_{CEO}	-30	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-500	mA
Base Current	I_B	-100	mA
Collector Power Dissipation	P_C	500	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

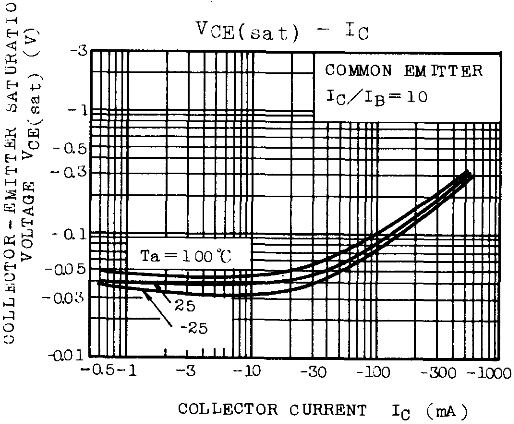
ELECTRICAL CHARACTERISTICS ($Ta=25^{\circ}C$)

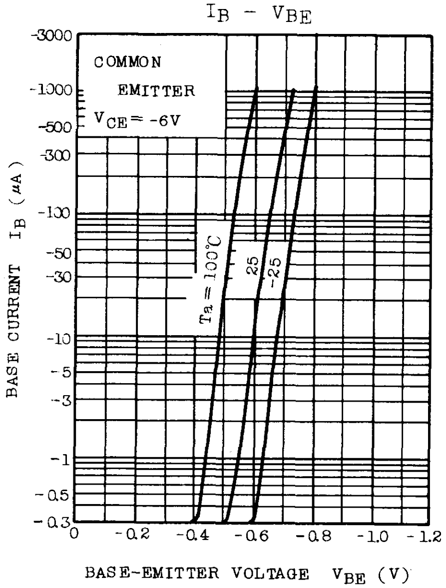
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	$V_{CB}=-35V$, $I_E=0$	-	-	-0.1	μA
Emitter Cut-off Current	I_{EBO}	$V_{EB}=-5V$, $I_C=0$	-	-	-0.1	μA
DC Current Gain	$h_{FE}(1)$ (Note)	$V_{CE}=-1V$, $I_C=-100mA$	70	-	240	
	$h_{FE}(2)$ (Note)	$V_{CE}=-6V$, $I_C=-400mA$	25	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C=-100mA$, $I_B=-10mA$	-	-0.1	-0.25	V
Base-Emitter Voltage	V_{BE}	$V_{CE}=-1V$, $I_C=-100mA$	-	-0.8	-1.0	V
Transition Frequency	f_T	$V_{CE}=-6V$, $I_C=-20mA$	-	200	-	MHz
Collector Output Capacitance	C_{ob}	$V_{CB}=-6V$, $I_E=0$, $f=1MHz$	-	13	-	pF

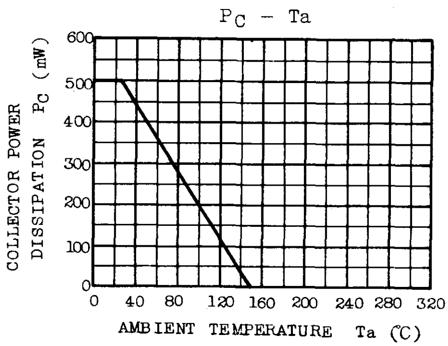
Note :			
$h_{FE}(1)$	Classification	O:70~140,	Y:120~240
$h_{FE}(2)$	"	O:25Min.,	Y:40Min.


I_C - V_{CE}


h_{FE} - I_C


$V_{CE(sat)}$ - I_C


I_B - V_{BE}


P_C - Ta

2SA817

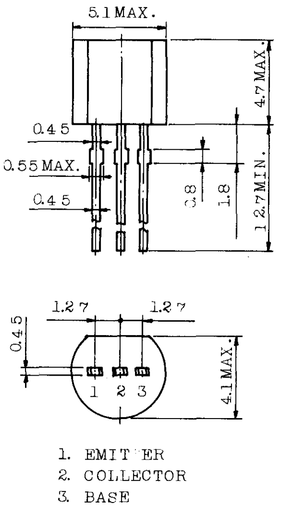
SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

AUDIO FREQUENCY AMPLIFIER APPLICATIONS.

FEATURES:

- Complementary to 2SC1627.
- Suitable for driver of 20~25 watts audio amplifier.

Unit in mm



JEDEC	TO−92
EIAJ	SC−43
TOSHIBA	2−5F1P

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

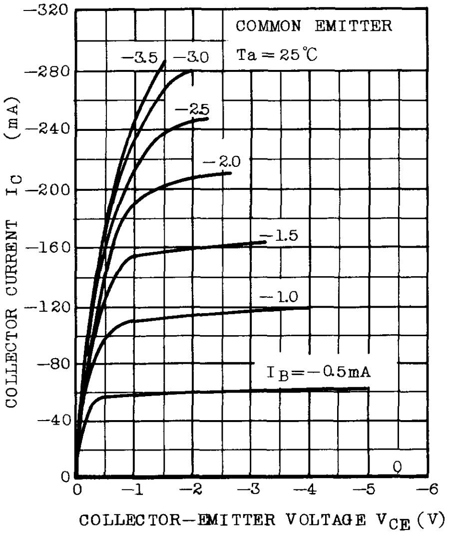
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-80	V
Collector-Emitter Voltage	V_{CEO}	-80	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-300	mA
Emitter Current	I_E	300	mA
Collector Power Dissipation	P_C	600	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

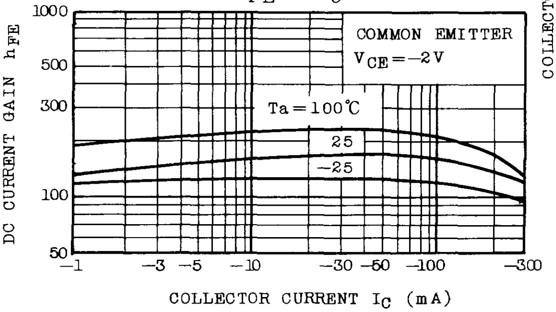
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-50V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-5mA, I_B=0	-80	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=-2V, I_C=-50mA	70	-	240	
	$h_{FE(2)}$	V_{CE}=-2V, I_C=-200mA	40	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-200mA, I_B=-20mA	-	-	-0.4	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-2V, I_C=-5mA	-0.55	-	-0.8	V
Transition Frequency	f_T	V_{CE}=-10V, I_C=-10mA	70	100	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	14	-	pF

Note: $h_{FE(1)}$ Classification, O:70~140, Y:120~240

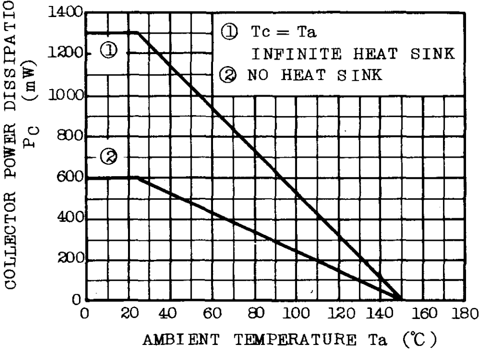
I_C - V_{CE}



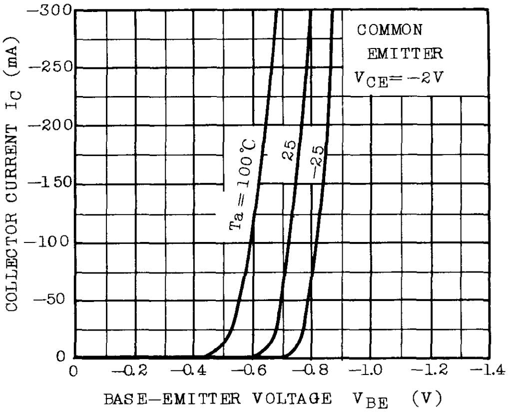
h_{FE} - I_C



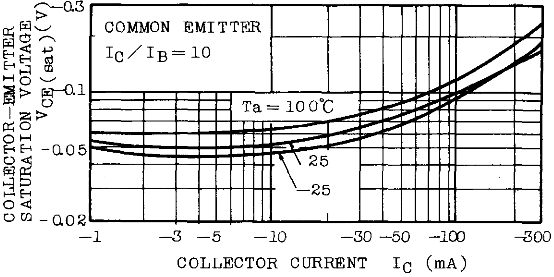
P_C - Ta



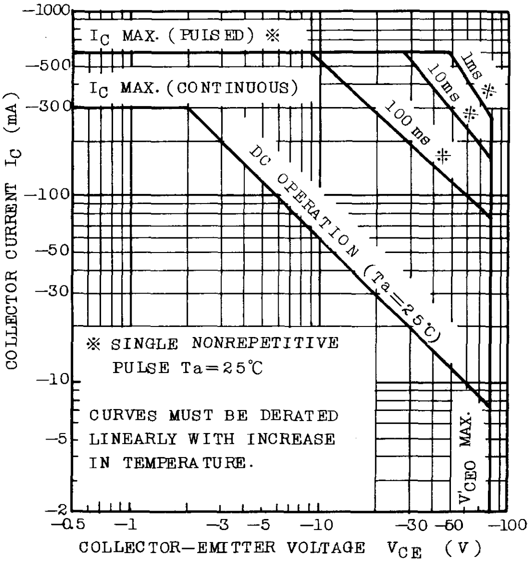
I_C - V_{BE}



$V_{CE(sat)}$ - I_C



SAFE OPERATING AREA



2SA817A

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

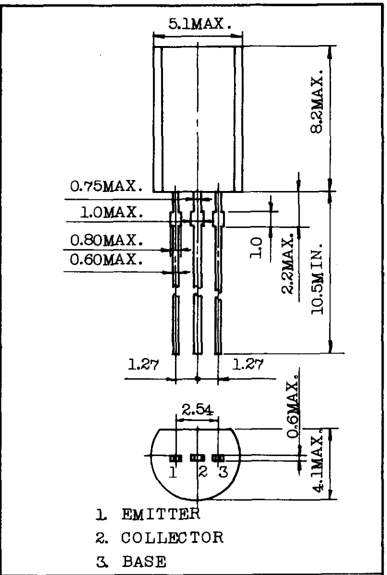
DRIVER STAGE AMPLIFIER APPLICATIONS.

VOLTAGE AMPLIFIER APPLICATIONS.

FEATURES:

- Complementary to 2SC1627A.
- Driver Stage Application of 30 to 35 Watts Amplifiers.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO − 92MOD
EIAJ	−
TOSHIBA	2 − 5J1A

Weight : 0.36g

MAXIMUM RATINGS (Ta=25°C)

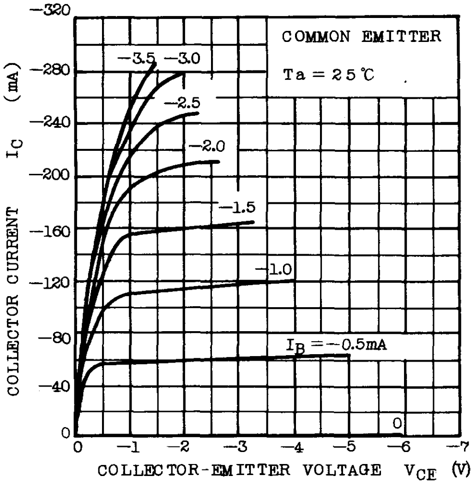
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-80	V
Collector-Emitter Voltage	V_{CEO}	-80	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-400	mA
Emitter Current	I_E	400	mA
Collector Power Dissipation	P_C	800	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55∿150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

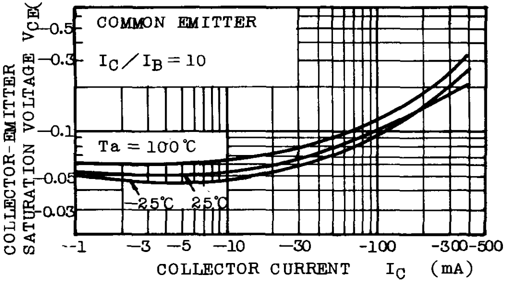
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-50V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-5mA, I_B=0	-80	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=-2V, I_C=-50mA	70	-	240	
	$h_{FE(2)}$	V_{CE}=-2V, I_C=-200mA	40	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-200mA, I_B=-20mA	-	-	-0.4	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-2V, I_C=-5mA	-0.55	-	-0.8	V
Transition Frequency	f_T	V_{CE}=-10V, I_C=-10mA	-	100	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	14	-	pF

Note : $h_{FE(1)}$ Classification O : 70∿140, Y : 120∿240

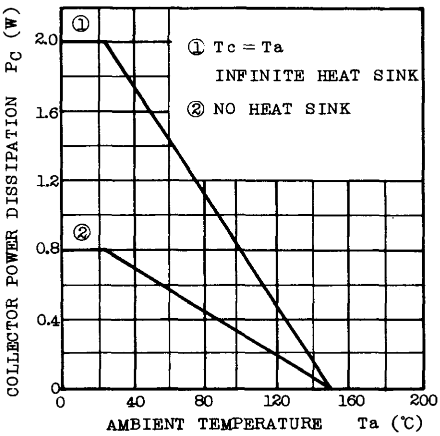
$I_C - V_{CE}$



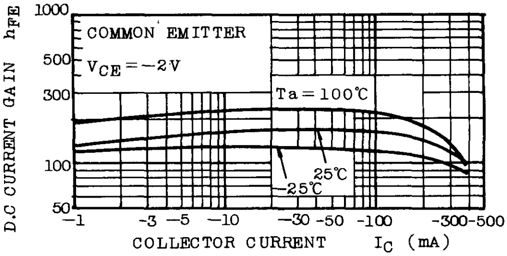
$V_{CE(sat)} - I_C$



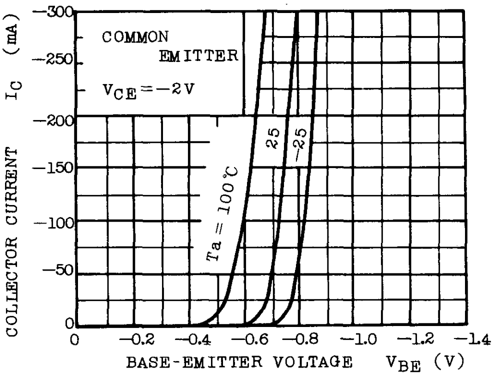
$P_C - Ta$



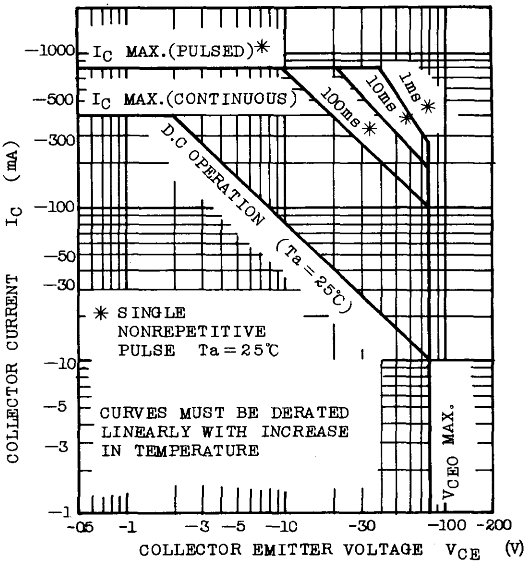
$h_{FE} - I_C$



$I_C - V_{BE}$



SAFE OPERATING AREA



2SA949

SILICON PNP TRIPLE DIFFUSED TYPE (PCT PROCESS)

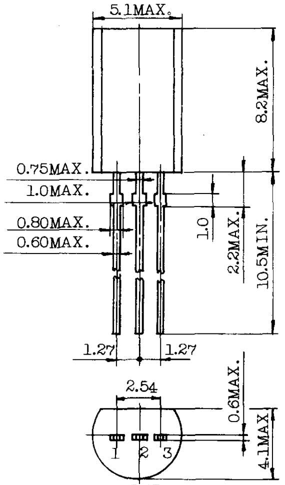
DRIVER STAGE AUDIO AMPLIFIER APPLICATIONS.

HIGH VOLTAGE SWITCHING APPLICATIONS.

FEATURES:

- High Breakdown Voltage : V_{CEO}=-150V
- Low Output Capacitance : C_{ob}=5.0pF (Max.)
- High Transition Frequency : f_T=120MHz (Typ.)

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO — 92MOD
EIAJ	—
TOSHIBA	2 — 5J1A

Weight : 0.36g

MAXIMUM RATINGS (Ta=25°C)

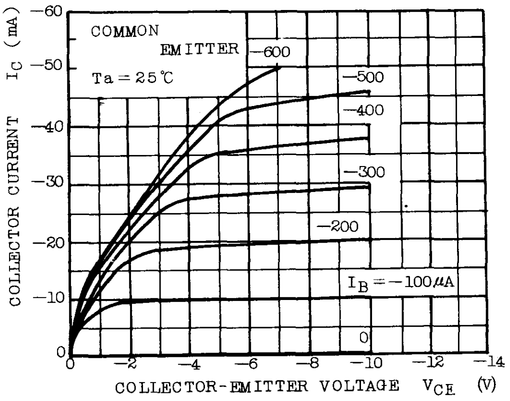
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-150	V
Collector-Emitter Voltage	V_{CEO}	-150	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-50	mA
Emitter Current	I_E	50	mA
Collector Power Dissipation	P_C	800	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	Tstg	-55∿150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

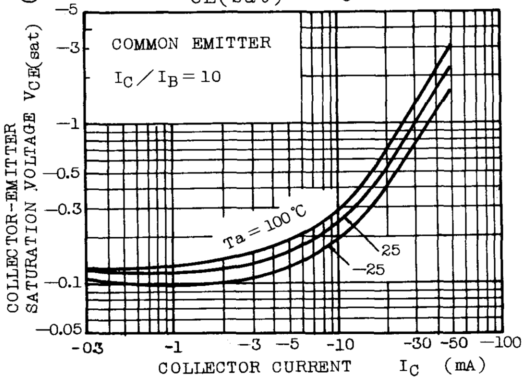
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-150V, I_E=0	-	-	-0.1	μA
Emitter Cuf-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=-5V, I_C=-10mA	70	-	240	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-10mA, I_B=-1mA	-	-	-0.8	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-5V, I_C=-30mA	-	-	-0.9	V
Transition Frequency	f_T	V_{CE}=-30V, I_C=-10mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	4.0	5.0	pF

Note : h_{FE} Classification O : 70∿140, Y : 120∿240

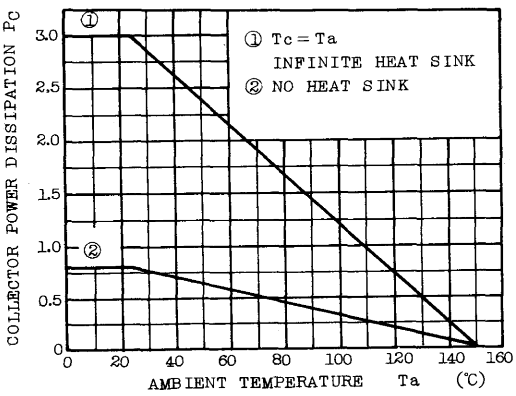
$I_C - V_{CE}$



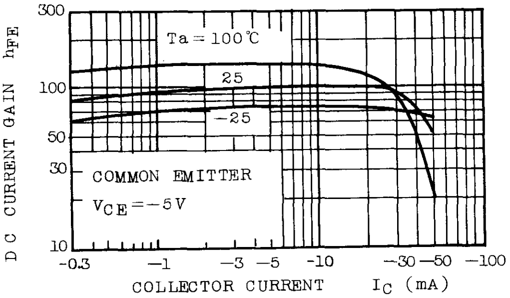
$V_{CE(sat)} - I_C$



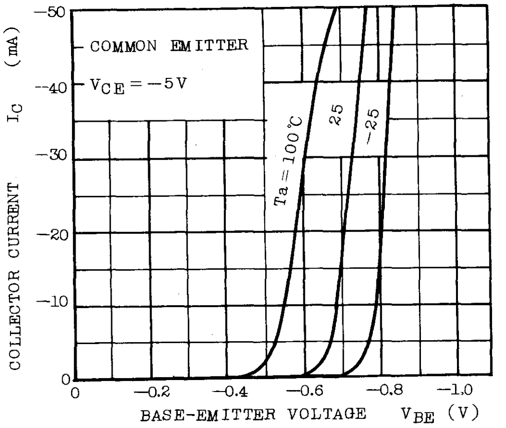
$P_C - Ta$



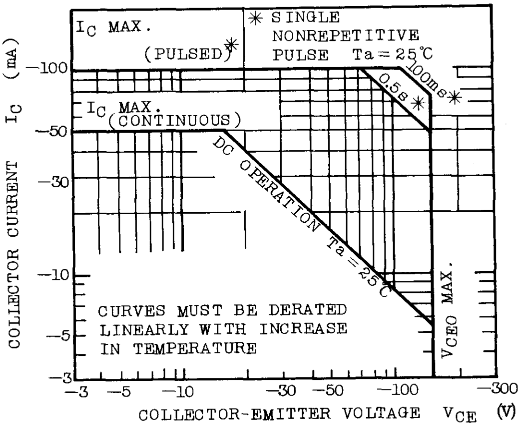
$h_{FE} - I_C$



$I_C - V_{BE}$



SAFE OPERATING AREA



2SA950

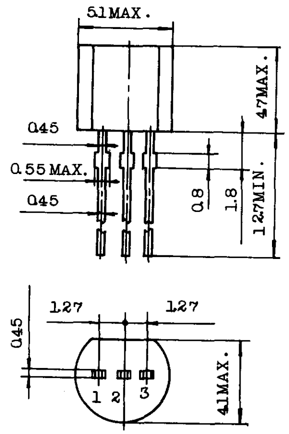
SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

AUDIO POWER AMPLIFIER APPLICATIONS.

FEATURES:

- High h_{FE} : h_{FE}=100∿320
- 1W Output Applications.
- Complementary to 2SC2120.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

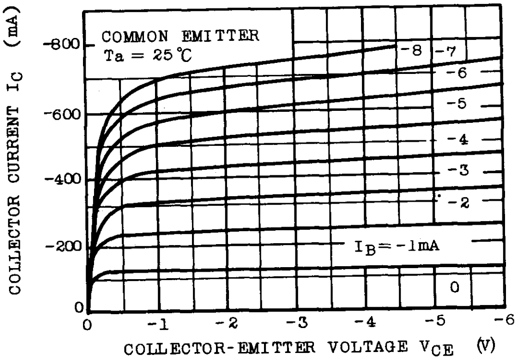
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-35	V
Collector-Emitter Voltage	V_{CEO}	-30	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-800	mA
Emitter Current	I_E	800	mA
Collector Power Dissipation	P_C	600	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55∿150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

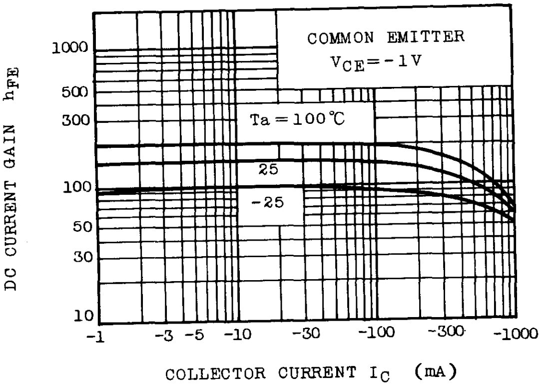
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-35V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-10mA, I_B=0	-30	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=-1V, I_C=-100mA	100	-	320	
	$h_{FE(2)}$	V_{CE}=-1V, I_C=-700mA	35	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-500mA, I_B=-20mA	-	-	-0.7	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-1V, I_C=-10mA	-0.5	-	-0.8	V
Transition Frequency	f_T	V_{CE}=-5V, I_C=-10mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, f=1MHz	-	19	-	pF

Note : $h_{FE(1)}$ Classification O : 100∿200, Y : 160∿320

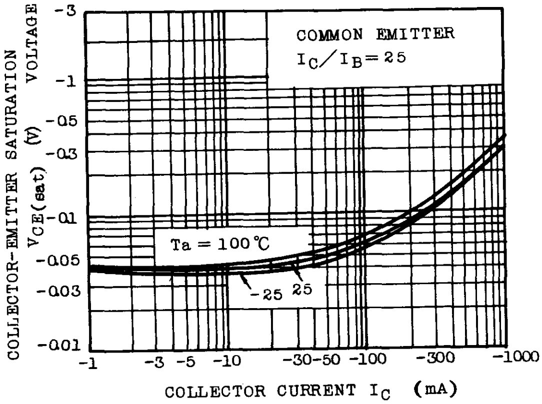
I_C - V_{CE}



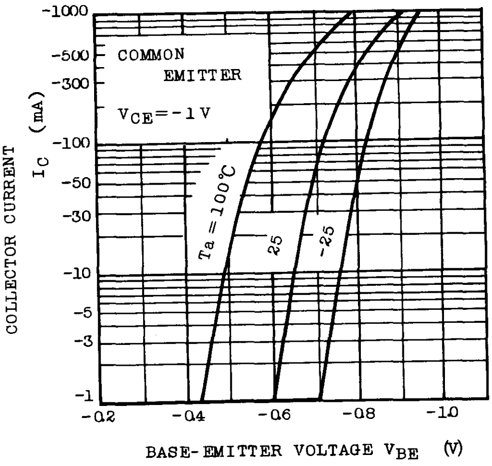
h_{FE} - I_C



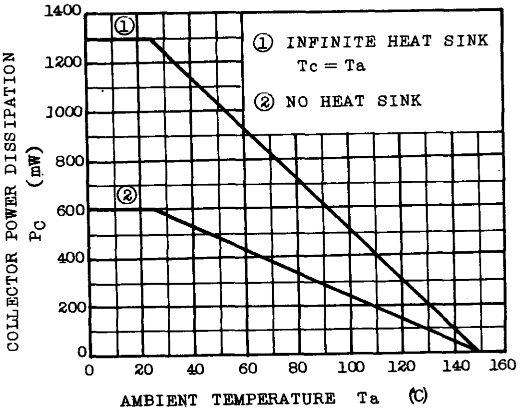
$V_{CE(sat)}$ - I_C



I_C - V_{BE}



P_C - Ta



2SA965

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

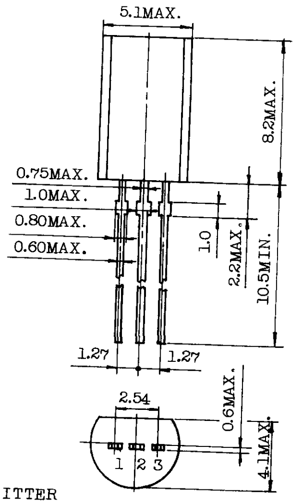
POWER AMPLIFIER APPLICATIONS.

DRIVER STAGE AMPLIFIER APPLICATIONS.

FEATURES:

- Complementary to 2SC2235.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO — 92MOD
EIAJ	—
TOSHIBA	2 — 5J1A

Weight : 0.36g

MAXIMUM RATINGS (Ta=25°C)

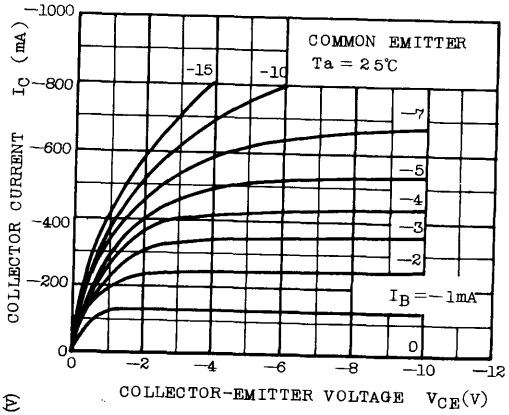
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-120	V
Collector-Emitter Voltage	V_{CEO}	-120	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-800	mA
Emitter Current	I_E	800	mA
Collector Power Dissipation	P_C	900	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55∿150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

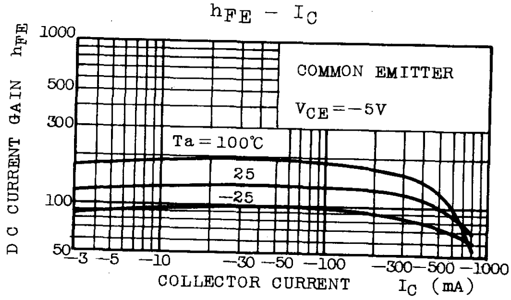
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-120V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-10mA, I_B=0	-120	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=-1mA, I_C=0	-5	-	-	V
DC Current Gain	h_{FE} (Note)	V_{CE}=-5V, I_C=-100mA	80	-	240	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-500mA, I_B=-50mA	-	-	-1.0	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-5V, I_C=-500mA	-	-	-1.0	V
Transition Frequency	f_T	V_{CE}=-5V, I_C=-100mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	-	40	pF

Note : h_{FE} Classification O : 80∿160, Y : 120∿240

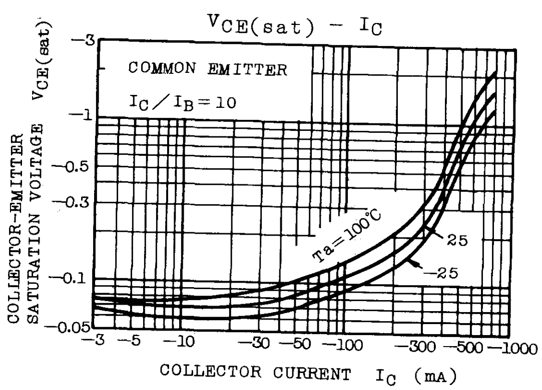
$I_C - V_{CE}$



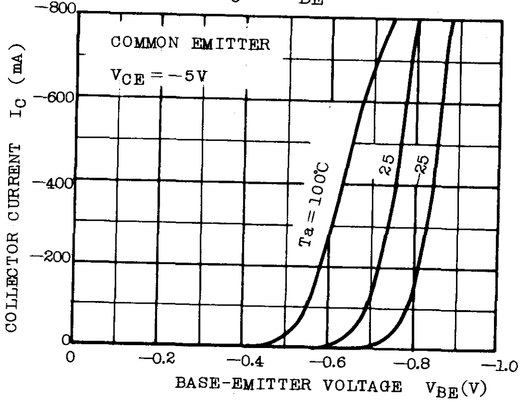
$h_{FE} - I_C$



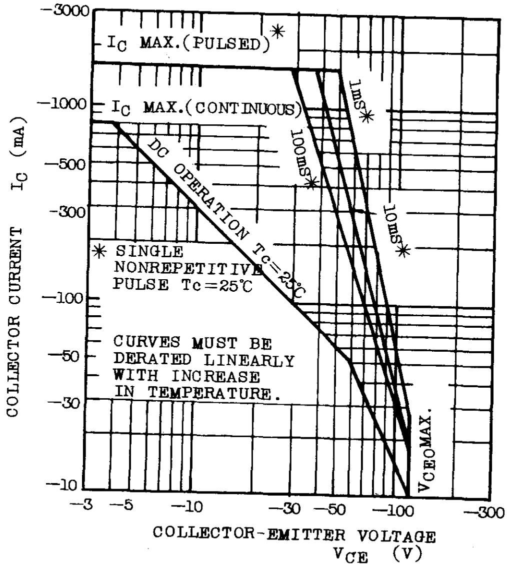
$V_{CE(sat)} - I_C$



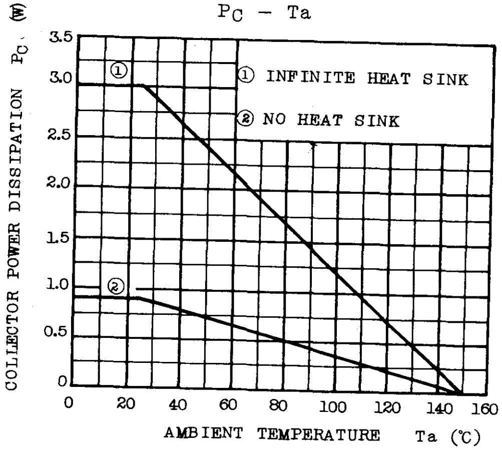
$I_C - V_{BE}$



SAFE OPERATING AREA



$P_C - Ta$



2SA966

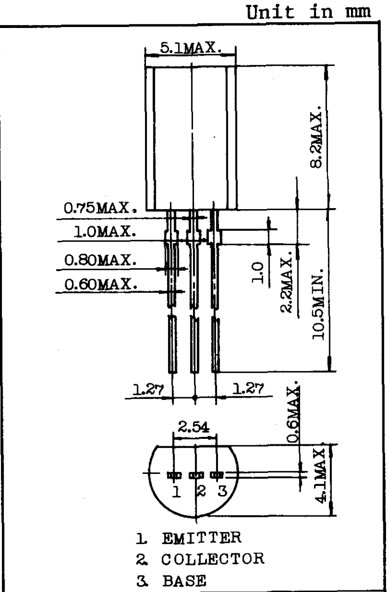
SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

AUDIO POWER AMPLIFIER APPLICATIONS.

FEATURES:

- Complementary to 2SC2236 and 3Watts Output Applications.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO – 92MOD
EIAJ	—
TOSHIBA	2 – 5J1A

Weight : 0.36g

MAXIMUM RATINGS (Ta=25°C)

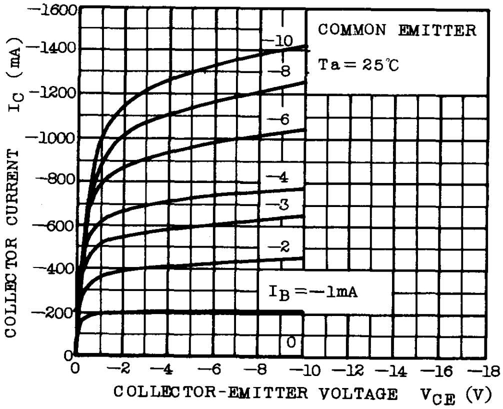
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-30	V
Collector-Emitter Voltage	V_{CEO}	-30	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-1.5	A
Emitter Current	I_E	1.5	A
Collector Power Dissipation	P_C	900	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55∿150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

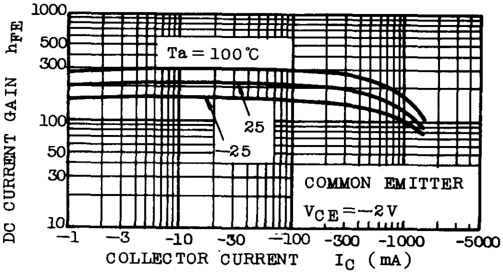
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-30V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-10mA, I_B=0	-30	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=-1mA, I_C=0	-5	-	-	V
DC Current Gain	h_{FE} (Note)	V_{CE}=-2V, I_C=-500mA	100	-	320	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-1.5A, I_B=-0.03A	-	-	-2.0	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-2V, I_C=-500mA	-	-	-1.0	V
Transition Frequency	f_T	V_{CE}=-2V, I_C=-500mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	-	30	pF

Note : h_{FE} Classification O : 100∿200, Y : 160∿320

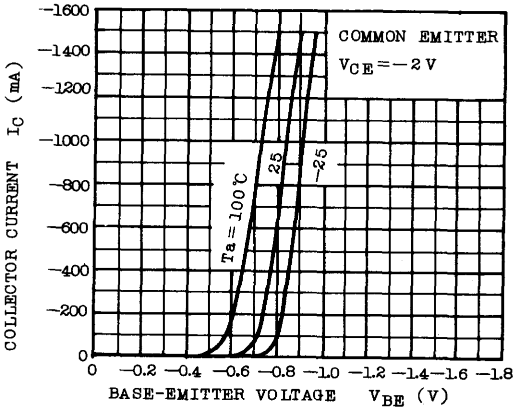
IC – VCE



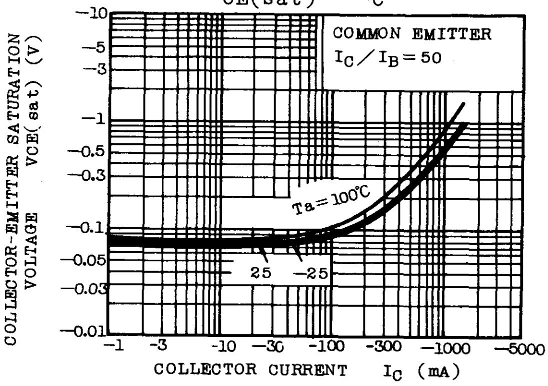
hFE – IC



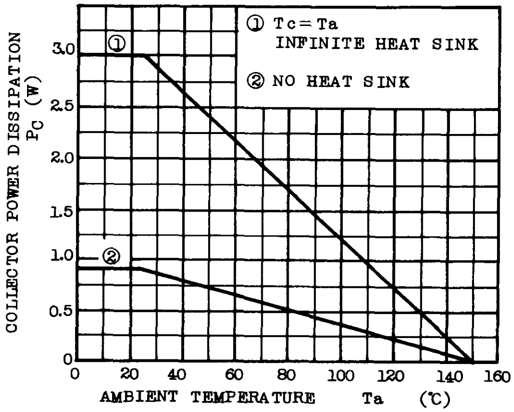
IC – VBE



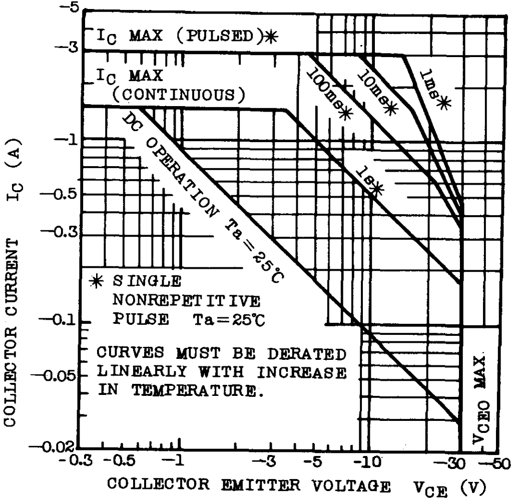
VCE(sat) – IC



PC – Ta



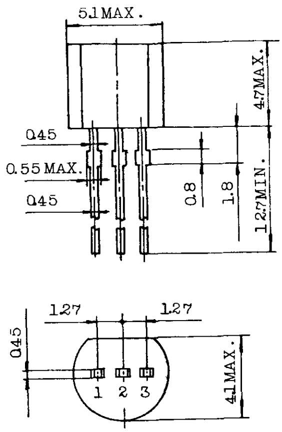
SAFE OPERATING AREA



2SA970

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

LOW NOISE AUDIO AMPLIFIER APPLICATIONS.

FEATURES:

- Low Noise
  : NF=3dB(Typ.) $R_g=100\Omega$, $V_{CE}=-6V$, $I_C=-100\mu A$, f=1kHz
  : NF=0.5dB(Typ.) $R_g=1k\Omega$, $V_{CE}=-6V$, $I_C=-100\mu A$, f=1kHz
- High DC Current Gain : $h_{FE}=200\sim700$
- High Breakdown Voltage : $V_{CEO}=-120V$
- Low Pulse Noise. Low 1/f Noise

MAXIMUM RATINGS (Ta=25°C)

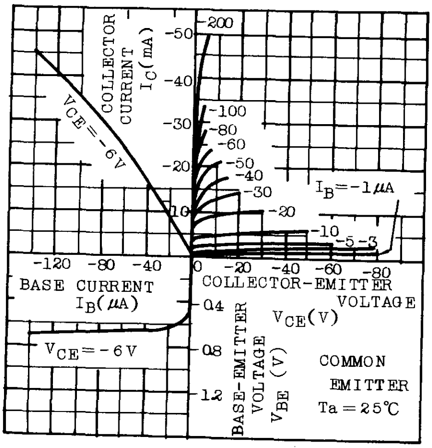
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-120	V
Collector-Emitter Voltage	V_{CEO}	-120	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-100	mA
Emitter Current	I_E	100	mA
Collector Power Dissipation	P_C	300	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

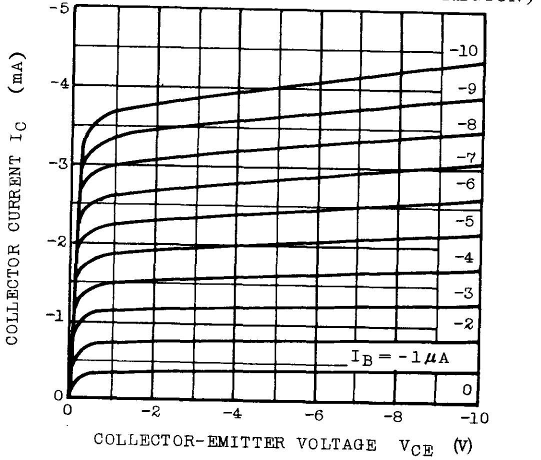
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	$V_{CB}=-120V$, $I_E=0$	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	$V_{EB}=-5V$, $I_C=0$	-	-	-100	nA
Collector-Emitter Breakdown Voltage	V_{CEO}	$I_C=-1mA$, $I_B=0$	-120	-	-	V
DC Current Gain	h_{FE} (Note)	$V_{CE}=-6V$, $I_C=-2mA$	200	-	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C=-10mA$, $I_B=-1mA$	-	-	-0.3	V
Base-Emitter Voltage	V_{BE}	$V_{CE}=-6V$, $I_C=-2mA$	-	-0.65	-	V
Transition Frequency	f_T	$V_{CE}=-6V$, $I_C=-1mA$	-	100	-	MHz
Collector Output Capacitance	C_{ob}	$V_{CB}=-10V$, $I_E=0$, f=1MHz	-	4.0	-	pF
Noise Figure	NF	$V_{CE}=-6V$, $I_C=-100\mu A$ f=10Hz, $R_g=10k\Omega$	-	-	6	dB
		$V_{CE}=-6V$, $I_C=-100\mu A$ f =1kHz, $R_g=10k\Omega$	-	-	2	
		$V_{CE}=-6V$, $I_C=-100\mu A$ f=1kHz, $R_g=100\Omega$	-	3	-	

Note : h_{FE} Classification GR : 200∿400, BL : 350∿700

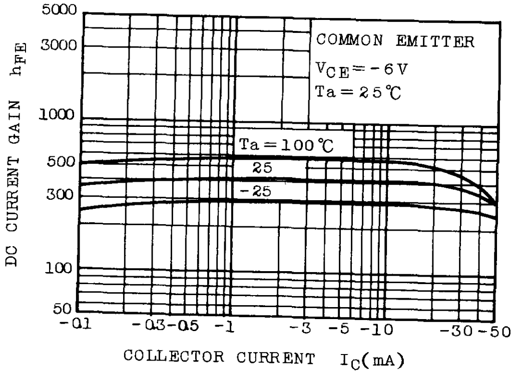
STATIC CHARACTERISTICS



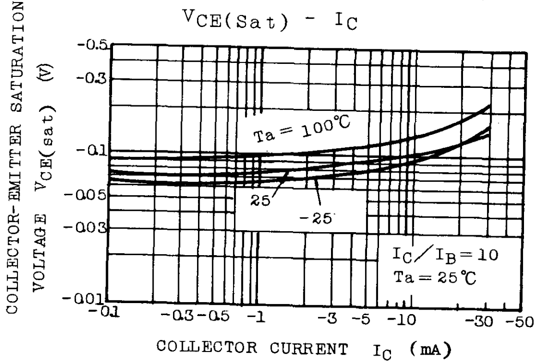
I_C - V_{CE}
(LOW CURRENT AND LOW VOLTAGE REGION)



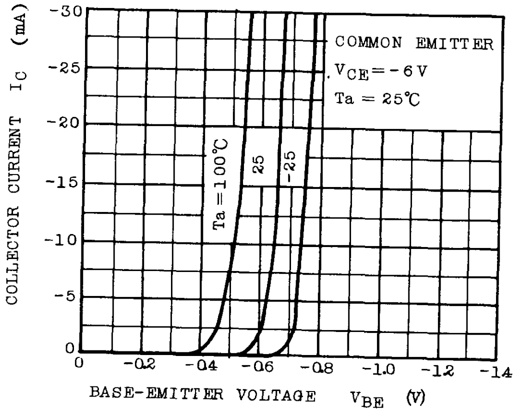
h_{FE} - I_C



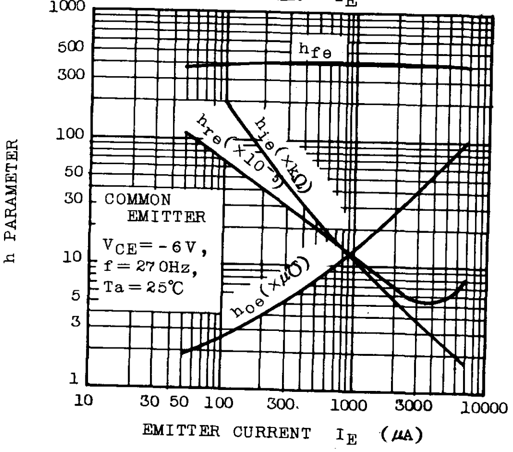
$V_{CE(Sat)}$ - I_C



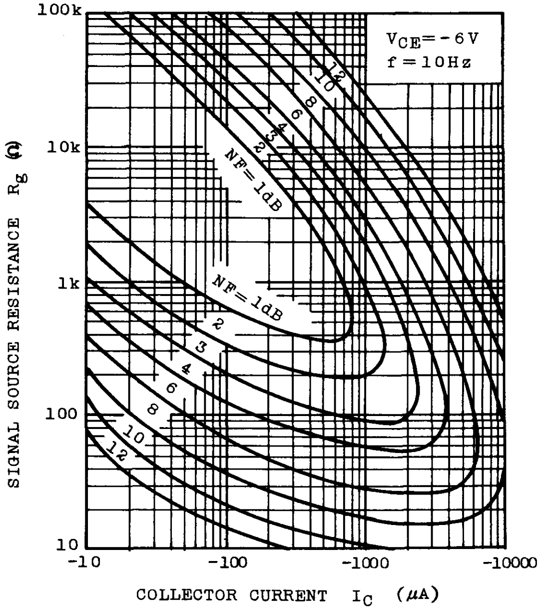
I_C - V_{BE}



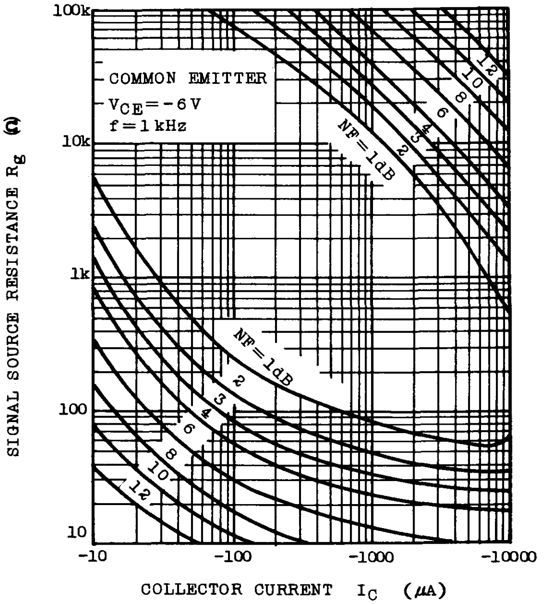
h PARAMETER - I_E



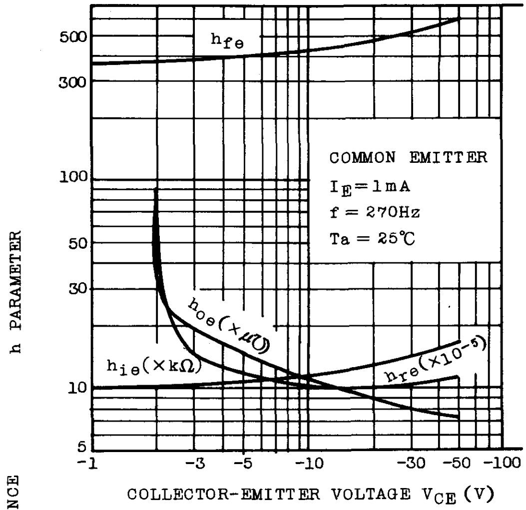
NF - R_g, I_C



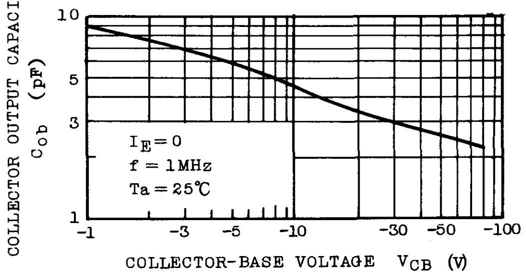
NF - R_g, I_C



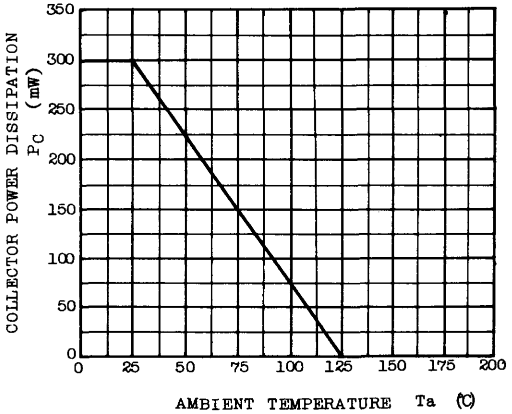
h PARAMETER - V_{CE}



C_{ob} - V_{CB}



P_C - Ta



SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

2SA1013

COLOR TV VERT. DEFLECTION OUTPUT APPLICATIONS.

COLOR TV CLASS B SOUND OUTPUT APPLICATIONS.

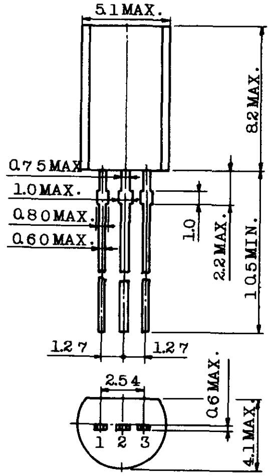
FEATURES:

- High Voltage : $V_{CEO} = -160V$
- Large Continuous Collector Current Capability.
- Recommended for Vert. Deflection Output & Sound Output Applications for Line Operated TV.
- Complementary to 2SC2383.

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-160	V
Collector-Emitter Voltage	V_{CEO}	-160	V
Emitter-Base Voltage	V_{EBO}	-6	V
Collector Current	I_C	-1	A
Base Current	I_B	-0.5	A
Collector Power Dissipation	P_C	900	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92MOD
EIAJ	—
TOSHIBA	2-5J1A

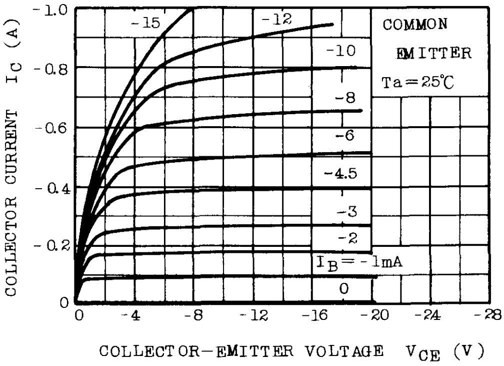
Weight : 0.36g

ELECTRICAL CHARACTERISTICS (Ta=25°C)

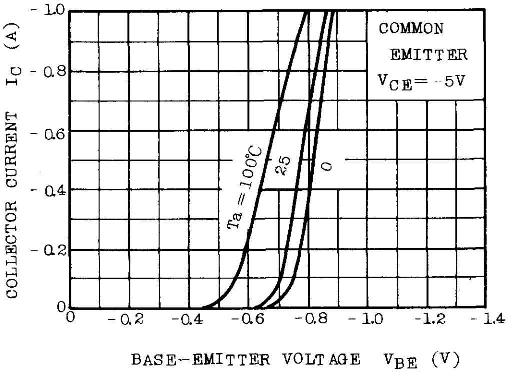
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-150V, I_E=0	-	-	-1.0	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-6V, I_C=0	-	-	-1.0	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-10mA, I_B=0	-160	-	-	V
DC Current Gain	h_{FE} (Note)	V_{CE}=-5V, I_C=-200mA	60	-	320	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-500mA, I_B=-50mA	-	-	-1.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-5V, I_C=-5mA	-0.45	-	-0.75	V
Transition Frequency	f_T	V_{CE}=-5V, I_C=-200mA	15	50	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	-	35	pF

Note: h_{FE} Classification R:60~120 O:100~200 Y:160~320

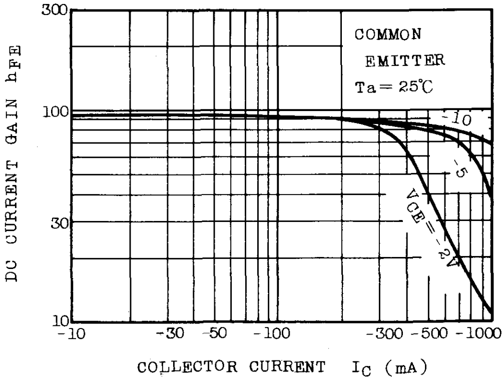
$I_C - V_{CE}$



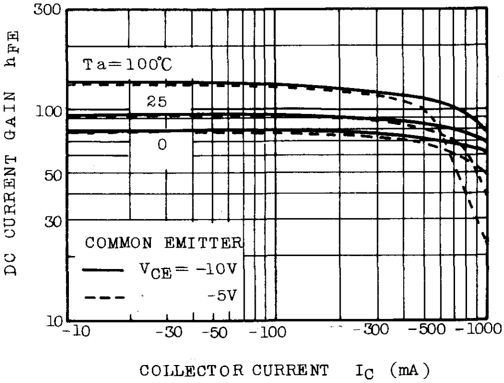
$I_C - V_{BE}$



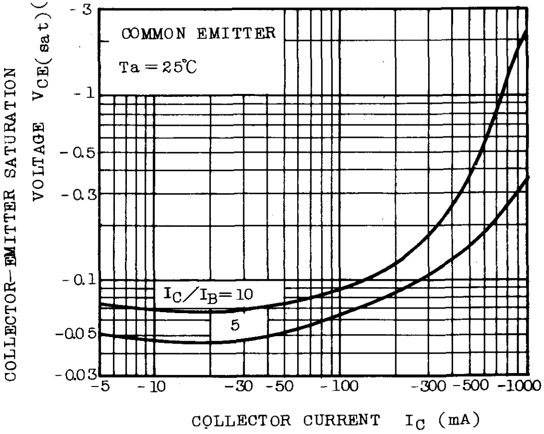
$h_{FE} - I_C$



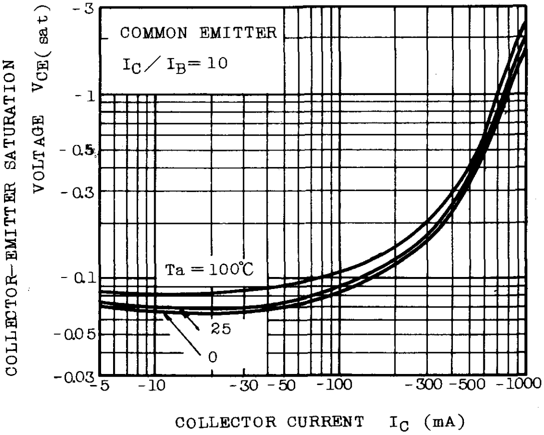
$h_{FE} - I_C$

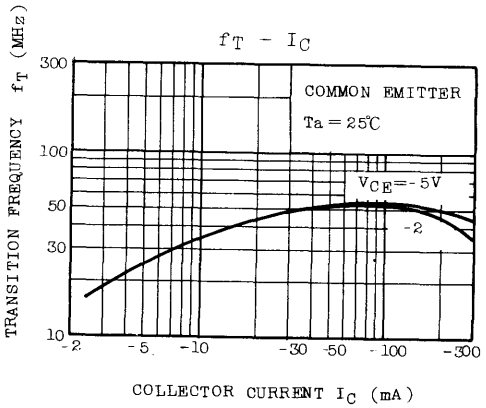


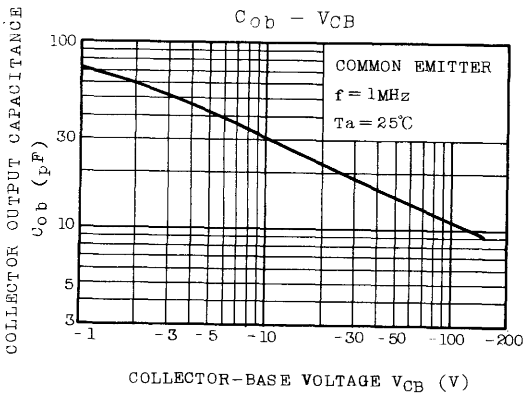
$V_{CE(sat)} - I_C$

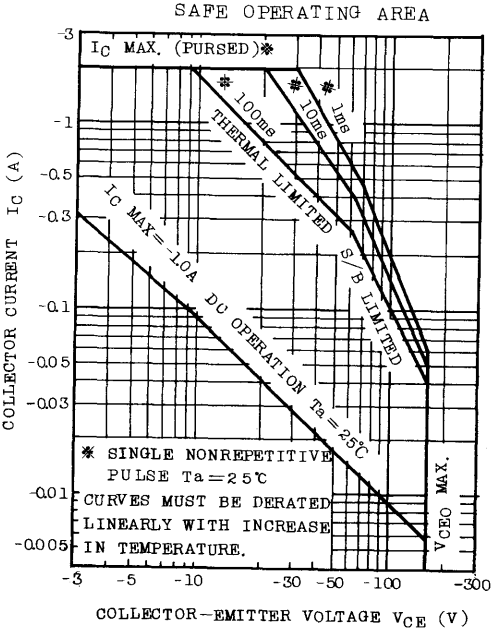


$V_{CE(sat)} - I_C$




fT - IC
TRANSITION FREQUENCY fT (MHz)
300
100
50
30
10
COMMON EMITTER
Ta = 25℃
VCE = -5V
-2
-2
-5
-10
-30
-50
-100
-300
COLLECTOR CURRENT IC (mA)


Cob - VCB
COLLECTOR OUTPUT CAPACITANCE Cob (pF)
100
30
10
5
3
COMMON EMITTER
f = 1MHz
Ta = 25℃
-1
-3
-5
-10
-30
-50
-100
-200
COLLECTOR-BASE VOLTAGE VCB (V)

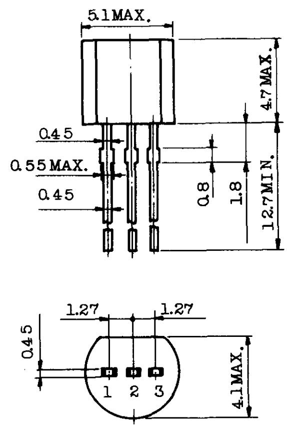

SAFE OPERATING AREA
COLLECTOR CURRENT IC (A)
-3
-1
-0.5
-0.3
-0.1
-0.05
-0.03
-0.01
-0.005
IC MAX. (PURSED)✱
✱ 100ms
✱ 10ms
✱ 1ms
THERMAL LIMITED
S/B LIMITED
IC MAX = -1.0A DC OPERATION Ta = 25℃
VCEO MAX.
✱ SINGLE NONREPETITIVE PULSE Ta = 25℃
CURVES MUST BE DERATED LINEARLY WITH INCREASE IN TEMPERATURE.
-3
-5
-10
-30
-50
-100
-300
COLLECTOR-EMITTER VOLTAGE VCE (V)

2SA1015

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

AUDIO FREQUENCY GENERAL PURPOSE AMPLIFIER APPLICATIONS.
DRIVER STAGE AMPLIFIER APPLICATIONS.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

FEATURES:

- High Voltage and High Current.
  V_{CEO}=-50V(Min.), I_C=-150mA(Max.)
- Excellent h_{FE} Linearity
  : $h_{FE}(2)$=80 (Typ.) at V_{CE}=-6V, I_C=-150mA
  : $h_{FE}(I_C$=0.1mA$)/h_{FE}(I_C$=2mA$)$=0.95(Typ.)
- Low Noise : NF=1dB(Typ.) at f=1kHz
- Complementary to 2SC1815.

MAXIMUM RATINGS (Ta=25°C)

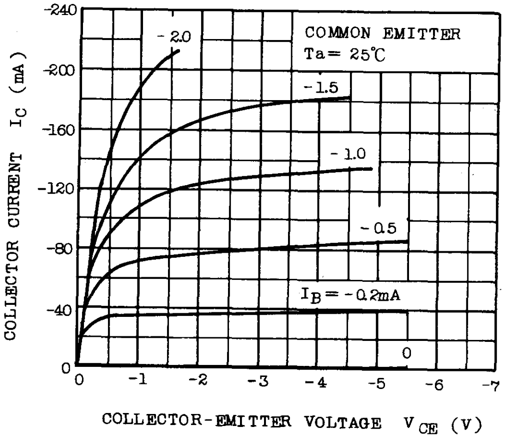
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-50	V
Collector-Emitter Voltage	V_{CEO}	-50	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-150	mA
Base Current	I_B	-50	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

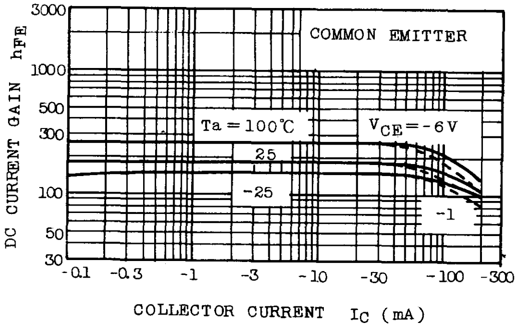
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-50V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
DC Current Gain	$h_{FE}(1)$ (Note)	V_{CE}=-6V, I_C=-2mA	70	-	400	
	$h_{FE}(2)$	V_{CE}=-6V, I_C=-150mA	25	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-100mA, I_B=-10mA	-	-0.1	-0.3	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=-100mA, I_B=-10mA	-	-	-1.1	V
Transition Frequency	f_T	V_{CE}=-10V, I_E=1mA	80	-	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	4	7	pF
Base Intrinsic Resistance	$r_{bb'}$	V_{CB}=-10V, I_E=1mA f=30MHz	-	30	-	Ω
Noise Figure	NF	V_{CE}=-6V, I_C=-0.1mA R_g=10kΩ, f=1kHz	-	1.0	10	dB

Note : $h_{FE}(1)$ Classification O : 70~140, Y : 120~240, GR : 200~400

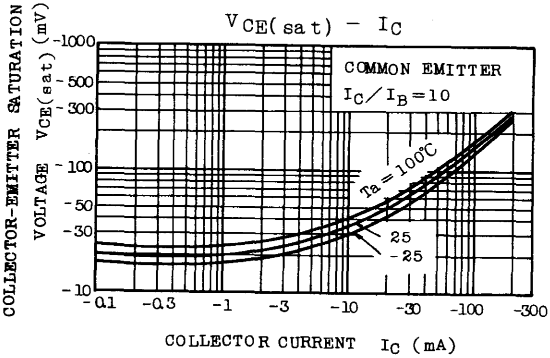
$I_C - V_{CE}$



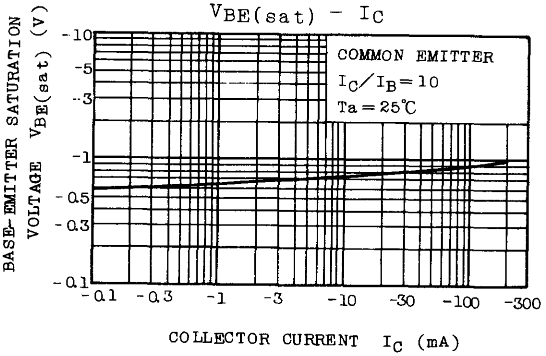
$h_{FE} - I_C$



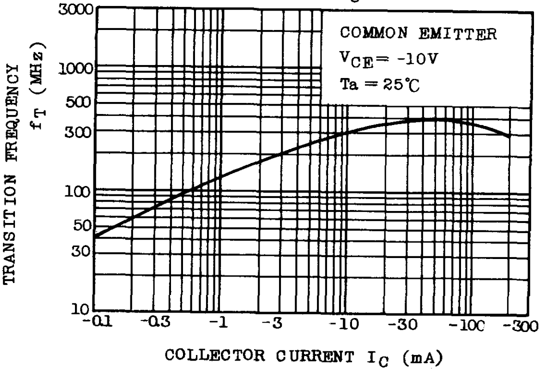
$V_{CE(sat)} - I_C$



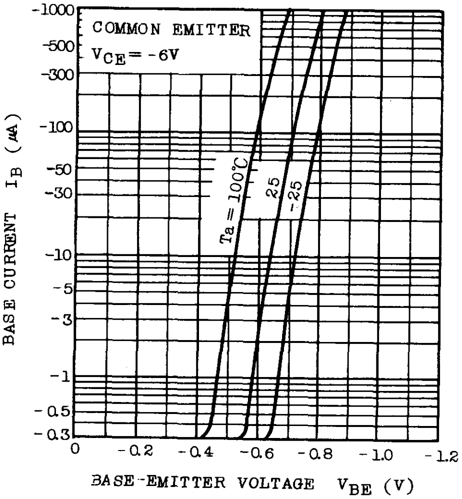
$V_{BE(sat)} - I_C$

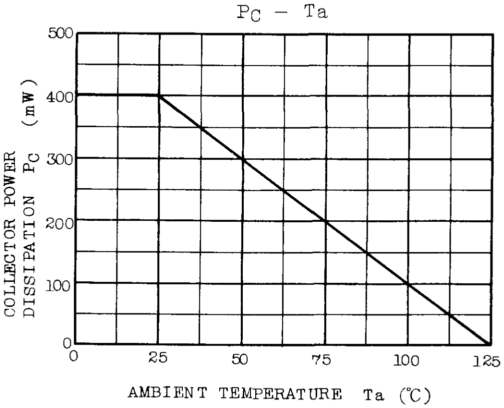


$f_T - I_C$



$I_B - V_{BE}$



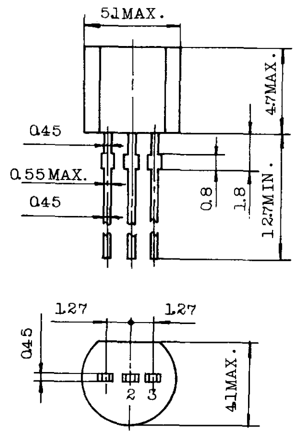

P_C − Ta
COLLECTOR POWER DISSIPATION P_C (mW)
500
400
300
200
100
0
0
25
50
75
100
125
AMBIENT TEMPERATURE Ta (℃)

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

2SA1015Ⓛ

AUDIO FREQUENCY AMPLIFIER APPLICATIONS.
LOW NOISE AMPLIFIER APPLICATIONS.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TC-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

FEATURES:

- High Voltage and High Current.
  : V_{CEO}=-50V (Min.), I_C=-150mA (Max.)
- Excellent h_{FE} Linearity
  : $h_{FE(2)}$=80 (Typ.) at V_{CE}=-6V, I_C=-150mA
  : $h_{FE}(I_C$=0.1mA)/$h_{FE}(I_C$=2mA)=0.95 (Typ.)
- Low Noise : NF=0.2dB (Typ.) (f=1kHz)
- **Complementary** to 2SC1815 Ⓛ

MAXIMUM RATINGS (Ta=25°C)

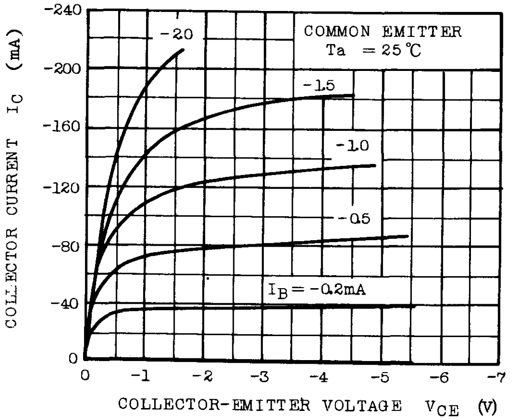
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-50	V
Collector-Emitter Voltage	V_{CEO}	-50	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-150	mA
Emitter Current	I_E	150	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

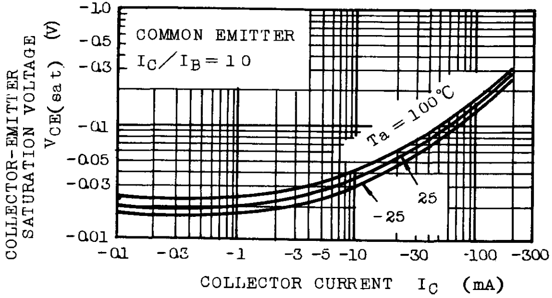
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-50V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=-6V, I_C=-2mA	70	-	400	
	$h_{FE(2)}$	V_{CE}=-6V, I_C=-150mA	25	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-100mA, I_B=-10mA	-	-0.1	-0.3	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=-100mA, I_B=-10mA	-	-	-1.1	V
Transition Frequency	f_T	V_{CE}=-10V, I_E=1mA	80	-	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	4	7	pF
Base Intrinsic Resistance	$r_{bb'}$	V_{CB}=-10V, I_E=1mA f=30MHz	-	30	-	Ω
Noise Figure	NF(1)	V_{CE}=-6V, I_C=-0.1mA, f=100Hz, R_g=10kΩ	-	0.5	6	dB
	NF(2)	V_{CE}=-6V, I_C=-0.1mA, f=1KHz R_g=10kΩ	-	0.2	3	

Note : $h_{FE(1)}$ Classification O : 70∿140, Y : 120∿240, GR : 200∿400

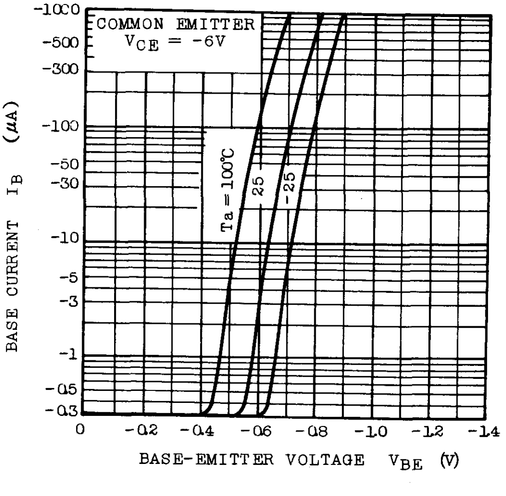
$I_C - V_{CE}$



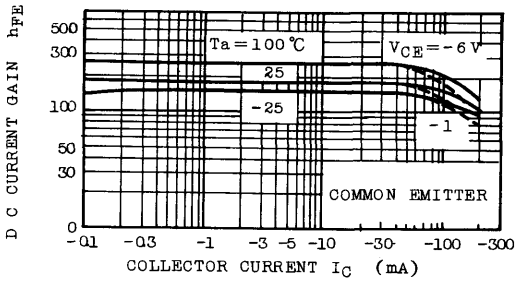
$V_{CE(sat)} - I_C$



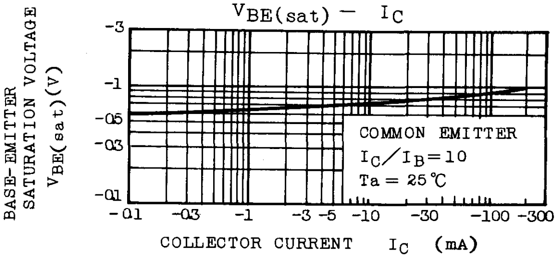
$I_B - V_{BE}$



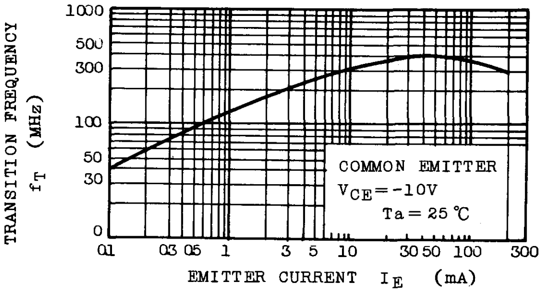
$h_{FE} - I_C$



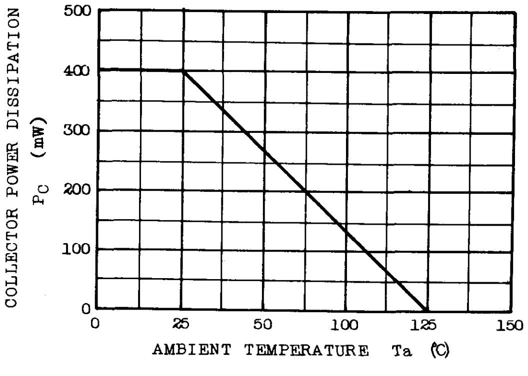
$V_{BE(sat)} - I_C$



$f_T - I_E$



$P_C - Ta$



SILICON PNP EPITAXIAL TYPE (PCT PROCESS) (INDUSTRIAL APPLICATIONS)

2SA1020

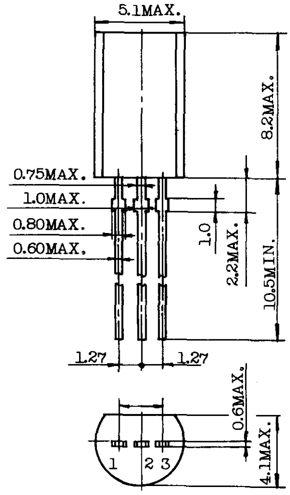
POWER AMPLIFIER APPLICATIONS.

POWER SWITCHING APPLICATIONS.

FEATURES:

- Low Collector Saturation Voltage
  : $V_{CE(sat)}=-0.5V$ (Max.) ($I_C=-1A$)
- High Speed Switching Time : $t_{stg}=1.0\mu s$ (Typ.)
- Complementary to 2SC2655.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

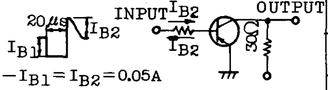
JEDEC	TO－92MOD
EIAJ	―
TOSHIBA	2－5J1A

Weight : 0.36g

MAXIMUM RATINGS (Ta=25°C)

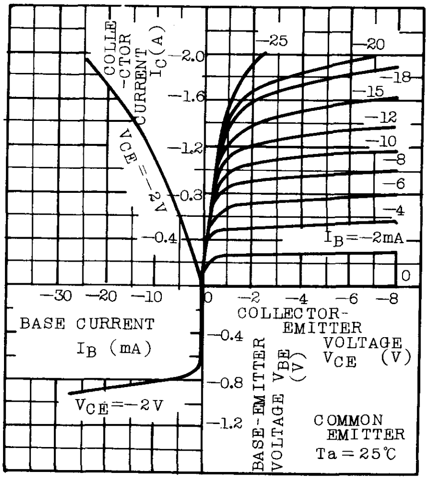
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-50	V
Collector-Emitter Voltage	V_{CEO}	-50	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-2	A
Collector Power Dissipation	P_C	900	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55∿150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

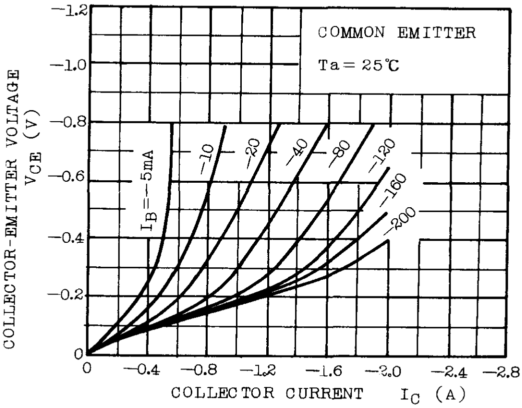
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	$V_{CB}=-50V,\ I_E=0$	-	-	-1.0	μA
Emitter Cut-off Current		I_{EBO}	$V_{EB}=-5V,\ I_C=0$	-	-	-1.0	μA
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	$I_C=-10mA,\ I_B=0$	-50	-	-	V
DC Current Gain		$h_{FE(1)}$	$V_{CE}=-2V, I_C=-0.5A$ (Note)	70	-	240	
		$h_{FE(2)}$	$V_{CE}=-2V,\ I_C=-1.5A$	40	-	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	$I_C=-1A,\ I_B=-0.05A$	-	-	-0.5	V
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	$I_C=-1A,\ I_B=-0.05A$	-	-	-1.2	V
Transition Frequency		f_T	$V_{CE}=-2V,\ I_C=-0.5A$	-	100	-	MHz
Collector Output Capacitance		C_{ob}	$V_{CB}=-10V, I_E=0, f=1MHz$	-	40	-	pF
Switching Time	Turn-on Time	t_{on}		-	0.1	-	μs
	Storage Time	t_{stg}	$-I_{B1}=I_{B2}=0.05A$	-	1.0	-	
	Fall Time	t_f	DUTY CYCLE≦1% $V_{CC}=-30V$	-	0.1	-	

Note : $h_{FE(1)}$ Classification O : 70∿140, Y : 120∿240

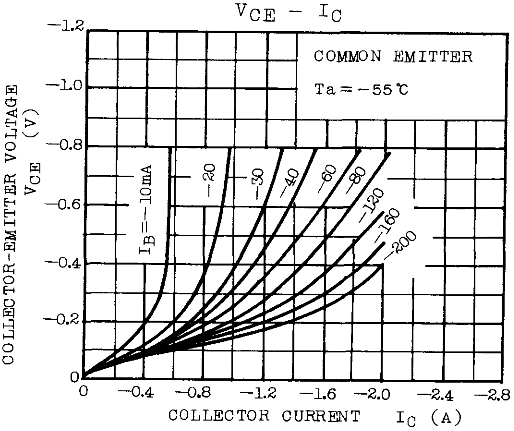
STATIC CHARACTERISTICS



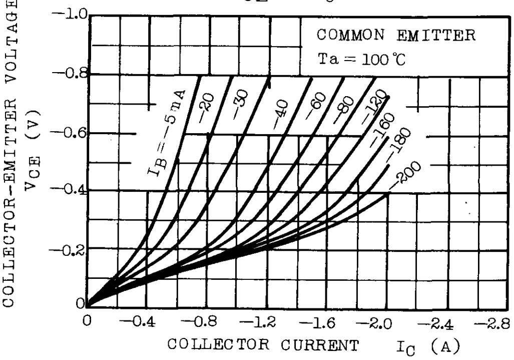
$V_{CE} - I_C$



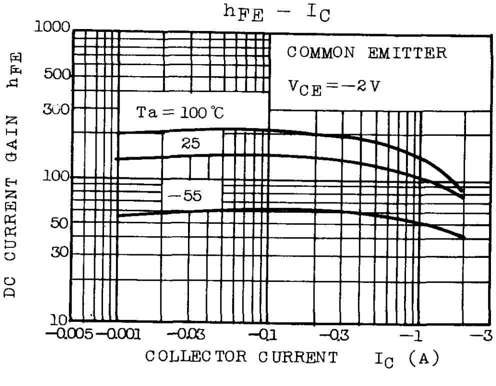
$V_{CE} - I_C$



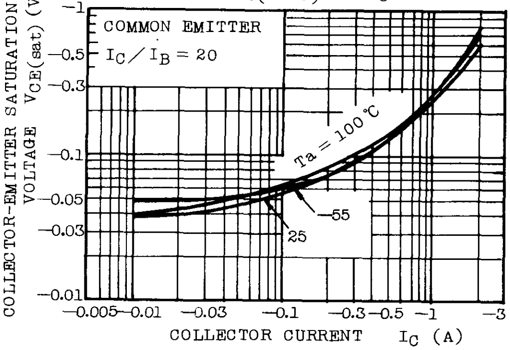
$V_{CE} - I_C$



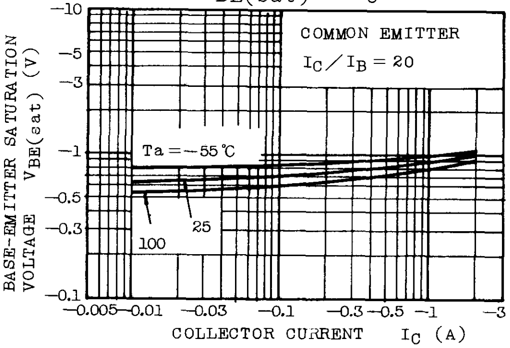
$h_{FE} - I_C$



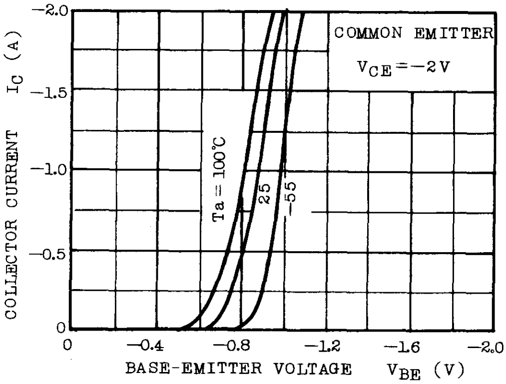
$V_{CE(sat)} - I_C$



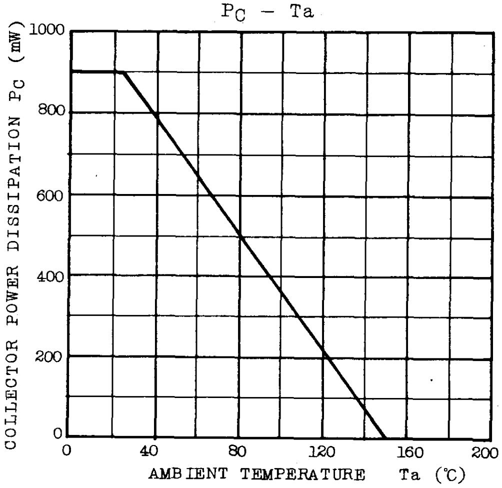
$V_{BE(sat)} - I_C$



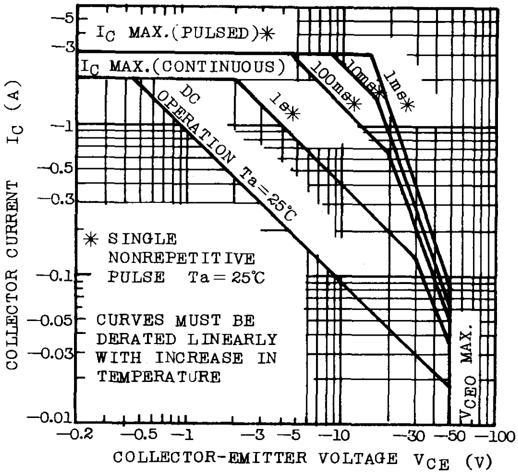
$I_C - V_{BE}$



$P_C - Ta$



SAFE OPERATING AREA



2SA1048

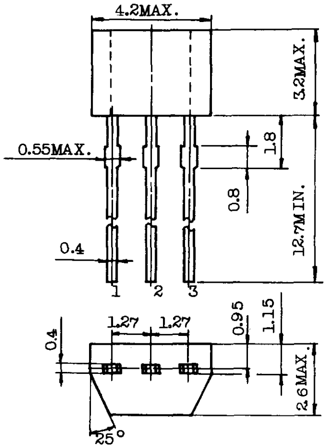
SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

AUDIO FREQUENCY AMPLIFIER APPLICATIONS.

FEATURES:

- Small Package.
- High Voltage : V_{CEO}=-50V (Min.)
- High h_{FE} : h_{FE}=70∿400
- Excellent h_{FE} Linearity
  : h_{FE}(0.1mA)/h_{FE}(2mA)=0.95 (Typ.)
- Low Noise : NF=1dB (Typ.), 10dB (Max.)
- Complementary to 2SC2458.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	—
EIAJ	—
TOSHIBA	2 — 4E1A

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

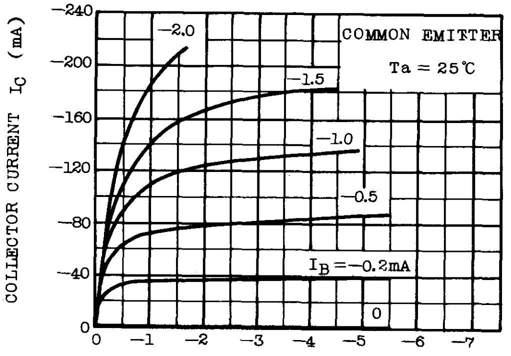
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-50	V
Collector-Emitter Voltage	V_{CEO}	-50	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-150	mA
Emitter Current	I_E	150	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

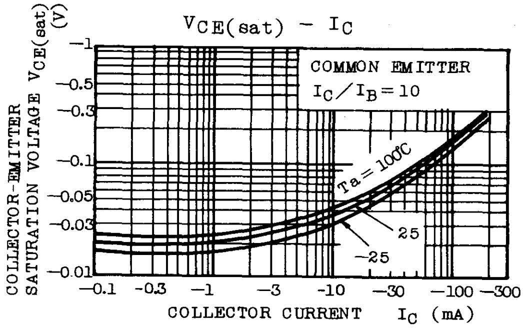
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-50V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=-6V, I_C=-2mA	70	-	400	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-100mA, I_B=-10mA	-	-0.1	-0.3	V
Transition Frequency	f_T	V_{CE}=-10V, I_C=-1mA	80	-	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	4	7	pF
Noise Figure	NF	V_{CE}=-6V, I_C=-0.1mA f=1kHz, R_g=10kΩ	-	1.0	10	dB

Note : h_{FE} Classification O : 70∿140, Y : 120∿240, GR : 200∿400

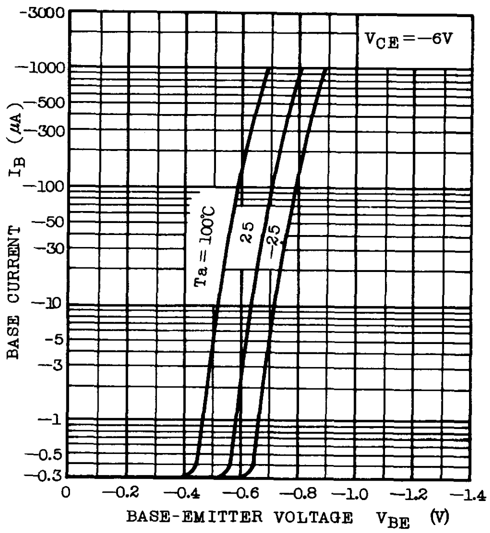
I_C − V_{CE}



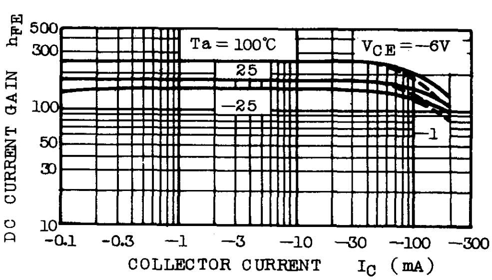
$V_{CE(sat)}$ − I_C



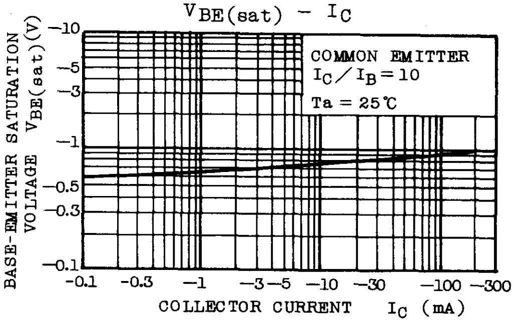
I_B − V_{BE}



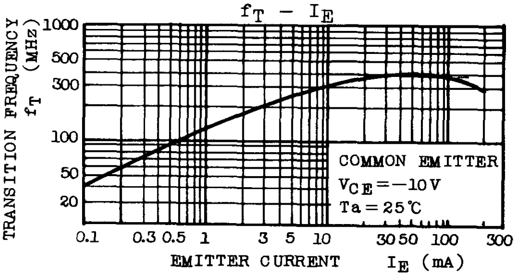
h_{FE} − I_C



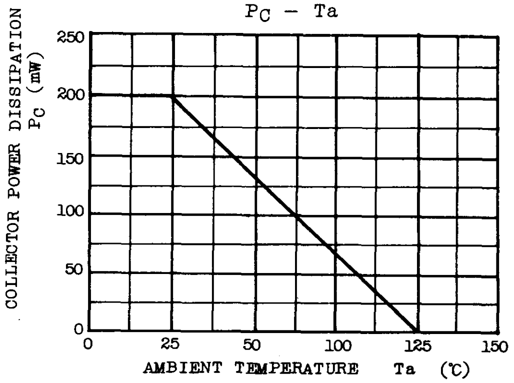
$V_{BE(sat)}$ − I_C



f_T − I_E



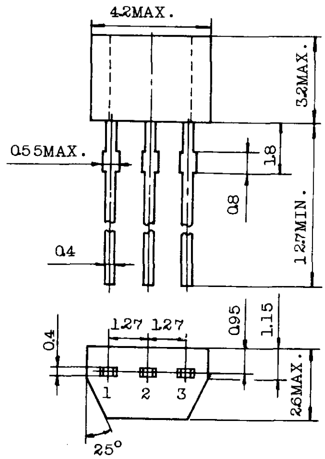
P_C − Ta



2SA1048Ⓛ

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	–
EIAJ	–
TOSHIBA	2-4E1A

Weight : 0.13g

AUDIO FREQUENCY AMPLIFIER APPLICATIONS.

LOW NOISE AUDIO FREQUENCY APPLICATIONS.

FEATURES:

- Small Package
- High Voltage : V_{CEO}=-50V (Min.)
- High h_{FE} : h_{FE}=70∿400
- Excellent h_{FE} Linearity
  : h_{FE}(0.1mA)/h_{FE}(2mA)=0.95 (Typ.)
- Low Noise : NF=0.2dB (Typ.), 3dB (Max.)
- Complementary to 2SC2458Ⓛ

MAXIMUM RATINGS (Ta=25°C)

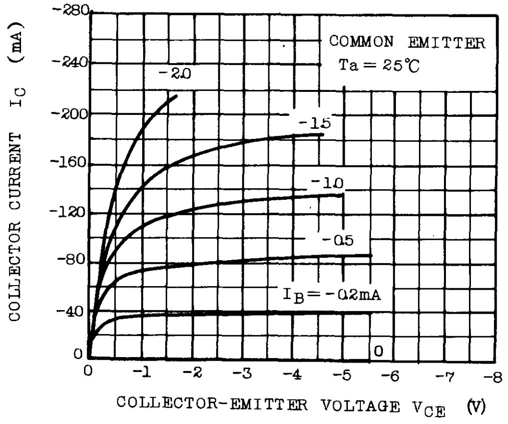
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-50	V
Collector-Emitter Voltage	V_{CEO}	-50	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-150	mA
Emitter Current	I_E	150	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

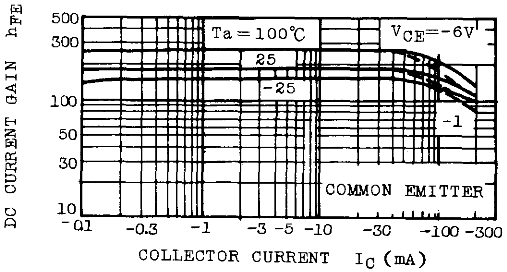
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-50V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=-6V, I_C=-2mA	70	-	400	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-100mA, I_B=-10mA	-	-0.1	-0.3	V
Transition Frequency	f_T	V_{CE}=-10V, I_C=-1mA	80	-	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	4	7	pF
Noise Figure	NF(1)	V_{CE}=-6V, I_C=-0.1mA f=100Hz, R_g=10kΩ	-	0.5	6	dB
	NF(2)	V_{CE}=-6V, I_C=-0.1mA f=1kHz, R_g=10kΩ	-	0.2	3	

Note : h_{FE} Classification O : 70∿140, Y : 120∿240, GR; 200∿400

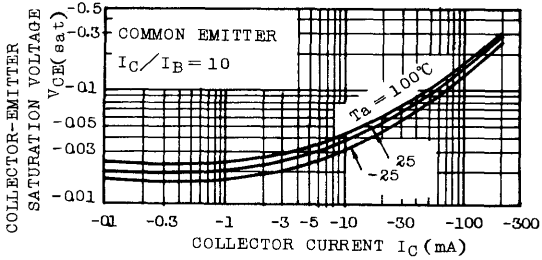
I_C - V_{CE}



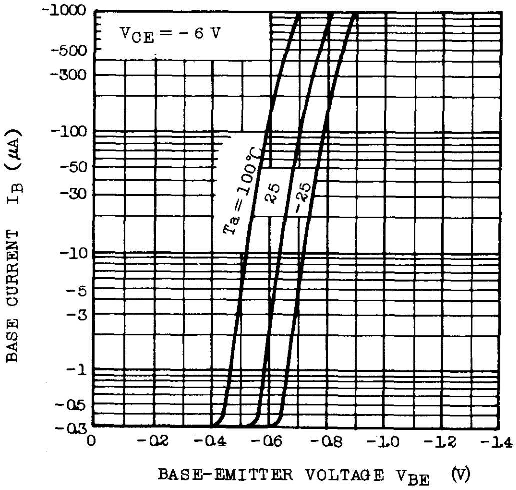
h_{FE} - I_C



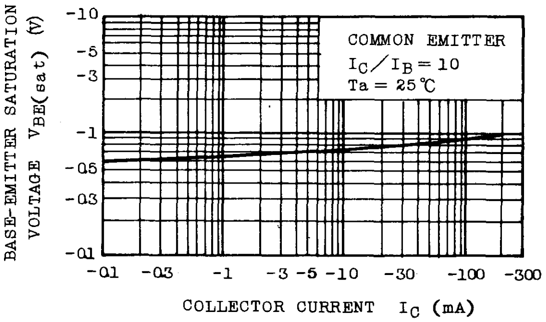
$V_{CE(sat)}$ - I_C



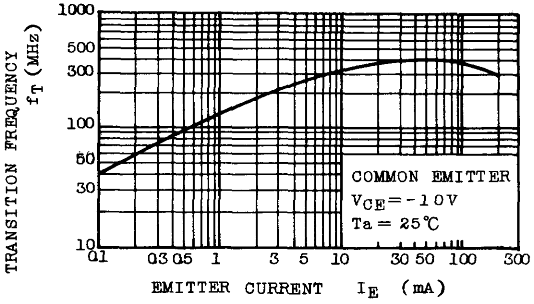
I_B - V_{BE}



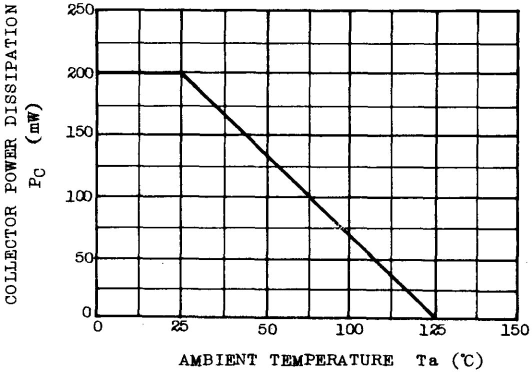
$V_{BE(sat)}$ - I_C



f_T - I_E



P_C - Ta



2SA1049

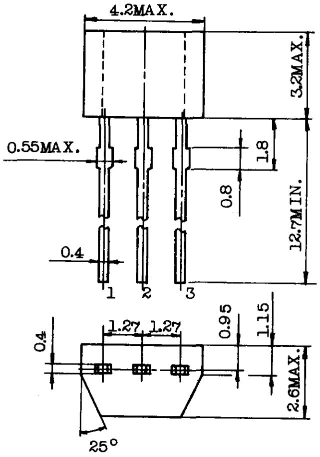
SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

AUDIO FREQUENCY AMPLIFIER APPLICATIONS.

FEATURES:

- Small Package.
- High Voltage : V_{CEO}=-120V (Min.)
- High h_{FE}: h_{FE}=200∿700
- Excellent h_{FE} Linearity
  : h_{FE}(0.1mA)/h_{FE}(2mA)=0.95 (Typ.)
- Low Noise : NF=1dB (Typ.), 10dB (Max.)
- Complementary to 2SC2459.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	—
EIAJ	—
TOSHIBA	2 — 4E1A

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

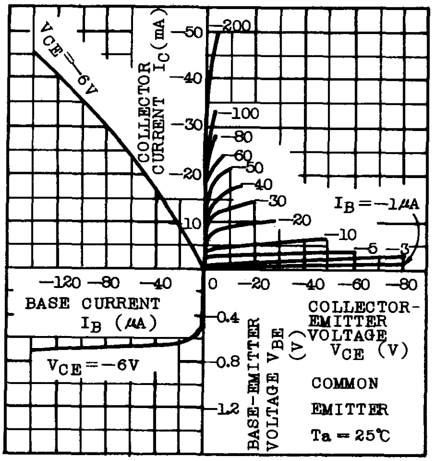
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-120	V
Collector-Emitter Voltage	V_{CEO}	-120	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-100	mA
Emitter Current	I_E	100	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

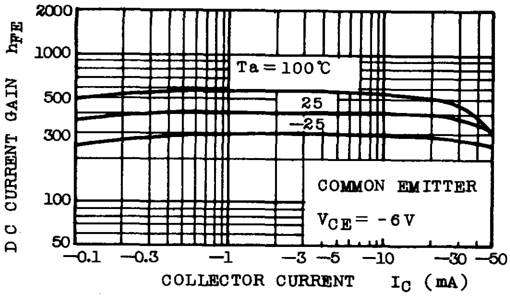
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-120V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=-6V, I_C=-2mA	200	-	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-10mA, I_B=-1mA	-	-	-0.3	V
Transition Frequency	f_T	V_{CE}=-6V, I_C=-1mA	-	100	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	4	-	pF
Noise Figure	NF	V_{CE}=-6V, I_C=-0.1mA f=1kHz, R_g=10kΩ	-	1.0	10	dB

Note : h_{FE} Classification GR : 200∿400, BL : 350∿700

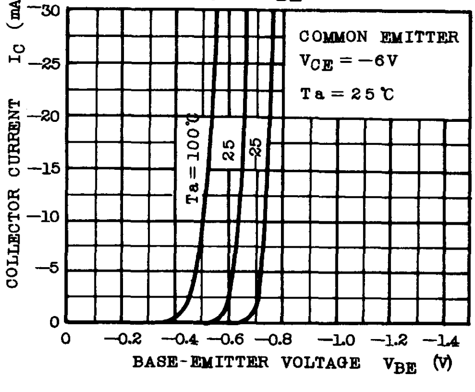
STATIC CHARACTERISTICS



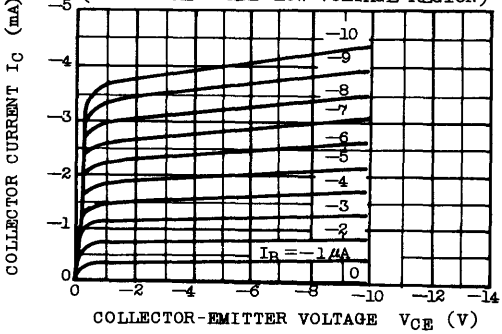
h_{FE} − I_C



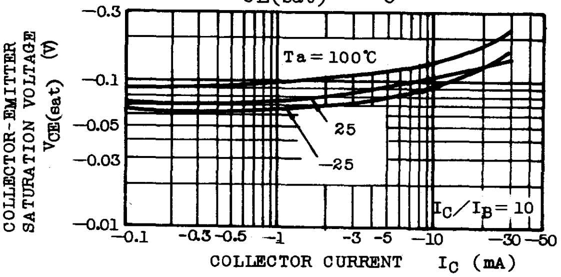
I_C − V_{BE}



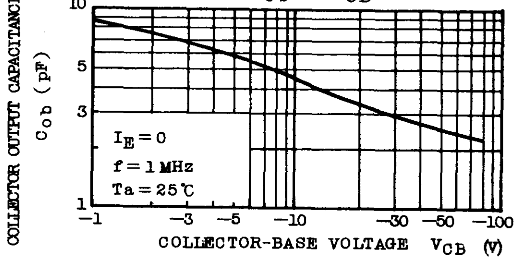
I_C − V_{CE}
(LOW CURRENT AND LOW VOLTAGE REGION)



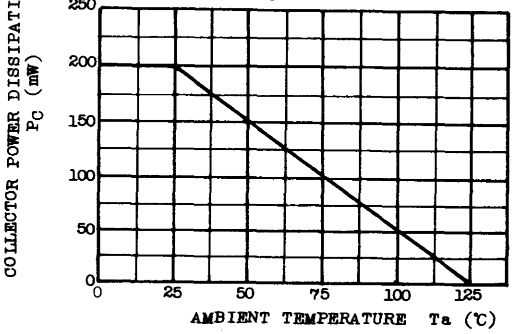
$V_{CE(sat)}$ − I_C



C_{ob} − V_{CB}



P_C − Ta



2SA1090

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)
(INDUSTRIAL APPLICATIONS)

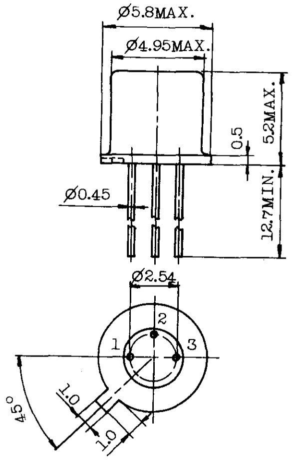
HIGH FREQUENCY AMPLIFIER APPLICATIONS.

HIGH SPEED SWITCHING APPLICATIONS.

FEATURES:

- High Breakdown Voltage
  : V_{CEO}=-50V (Min.), V_{EBO}=-8V (Min.)
- High Gain and Excellent h_{FE} Linearity
  : h_{FE}=70 ~ 400 at V_{CE}=-1V, I_C=-10mA
- Complementary to 2SC2550.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR (CASE)

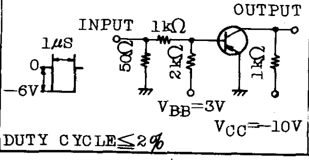
JEDEC	TO — 18
EIAJ	TC — 7, TB — 8C
TOSHIBA	2 — 5A1B

Weight : 0.31g

MAXIMUM RATINGS (Ta=25°C)

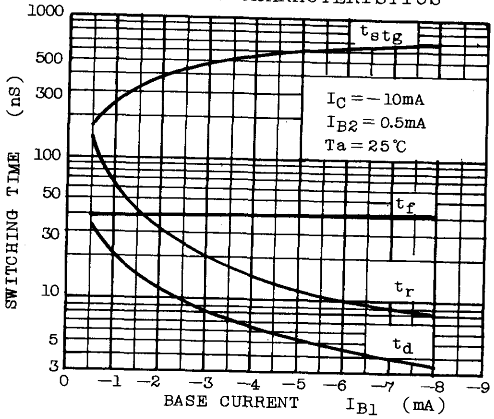
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-60	V
Collector-Emitter Voltage	V_{CEO}	-50	V
Emitter-Base Voltage	V_{EBO}	-8	V
Collector Current	I_C	-200	mA
Base Current	I_B	-50	mA
Collector Power Dissipation	P_C	300	mW
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_{stg}	-65∿175	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

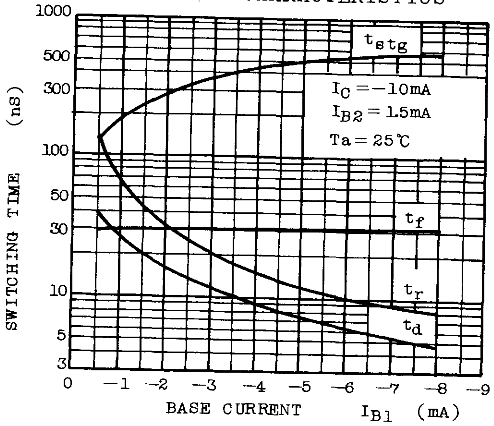
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=-60V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
DC Current Gain		$h_{FE(1)}$ (Note)	V_{CE}=-1V, I_C=-10mA	70	-	400	
		$h_{FE(2)}$	V_{CE}=-1V, I_C=-100mA	10	-	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=-100mA, I_B=-10mA	-	0.1	-0.3	V
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=-100mA, I_B=-10mA	-	-	-1.1	V
Transition Frequency		f_T	V_{CE}=-10V, I_C=-10mA	150	250	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	4.0	7.0	pF
Base Intrinsic Resistance		$r_{bb'}$	V_{CB}=-10V, I_E=10mA, f=30MHz	-	30	-	Ω
Switching Time	Turn-on Time	t_{on}		-	30	-	ns
	Storage Time	t_{stg}		-	400	-	
	Fall Time	t_f		-	30	-	

Note : $h_{FE(1)}$ Classification O : 70∿140, Y : 120∿240, GR : 200∿400

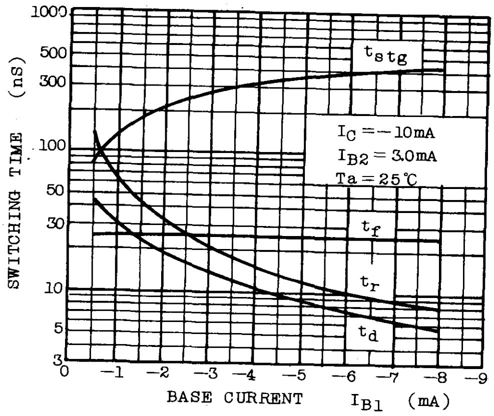
SWITCHING CHARACTERISTICS



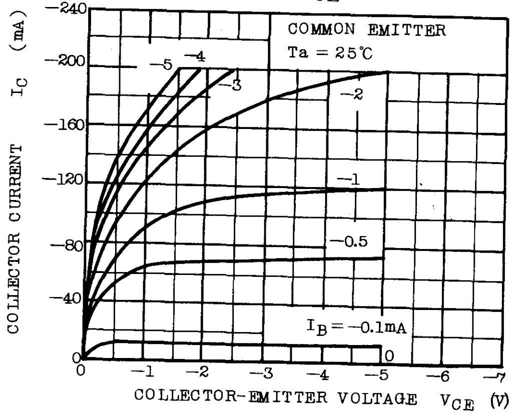
SWITCHING CHARACTERISTICS



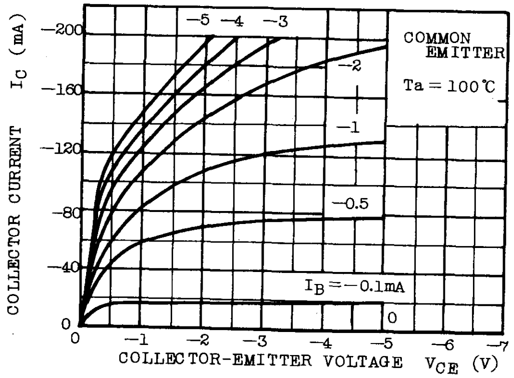
SWITCHING CHARACTERISTICS



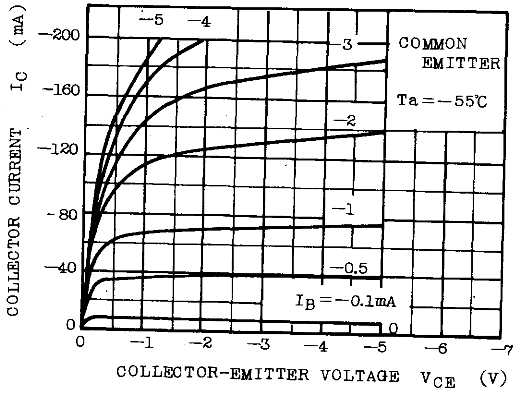
I_C − V_{CE}

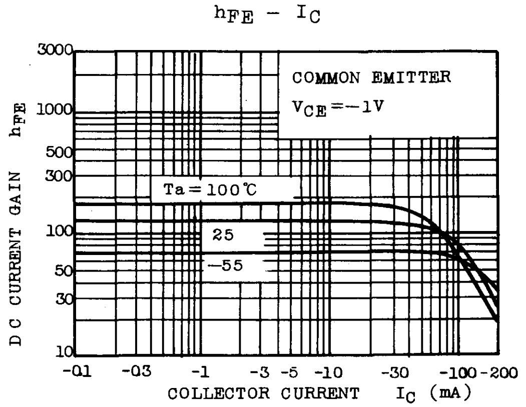


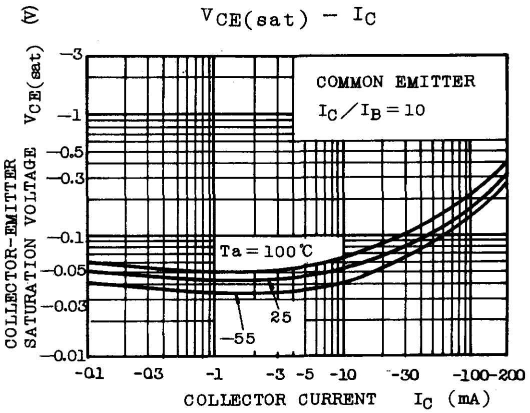
I_C − V_{CE}

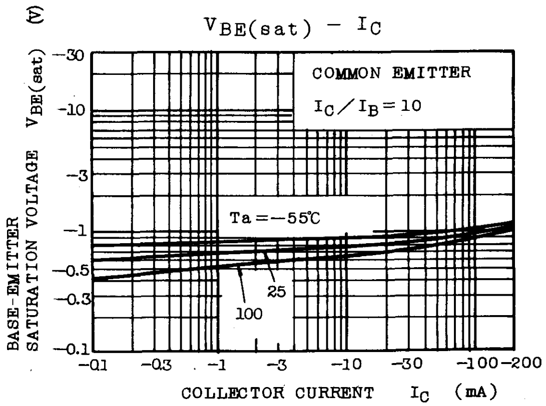


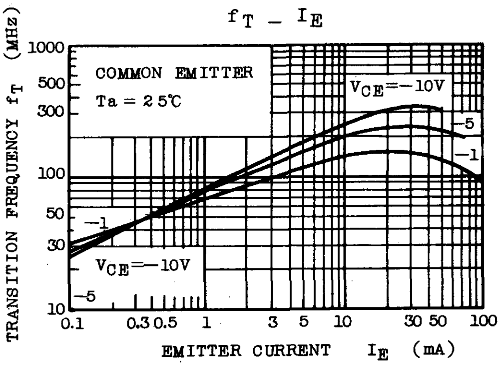
I_C − V_{CE}

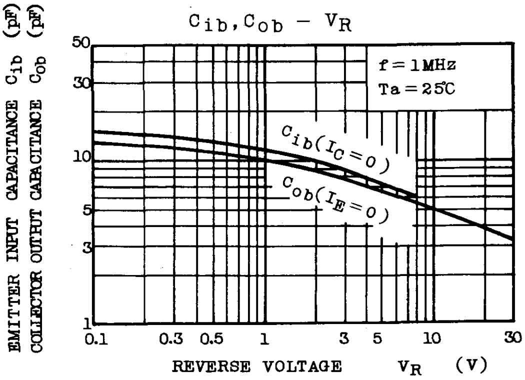


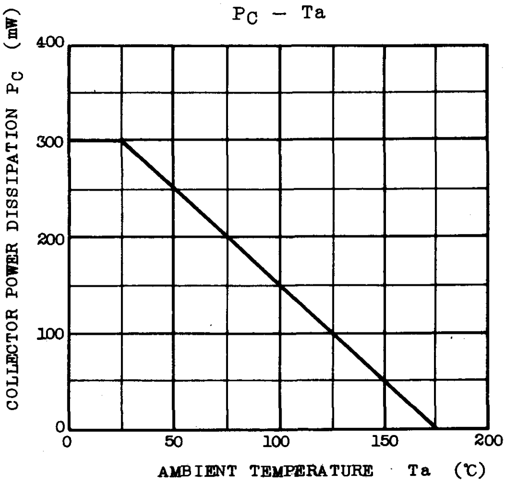

h_{FE} – I_C


$V_{CE(sat)}$ – I_C


$V_{BE(sat)}$ – I_C


f_T – I_E


C_{ib}, C_{ob} – V_R


P_C – Ta

SILICON PNP TRIPLE DIFFUSED TYPE (PCT PROCESS)
(INDUSTRIAL APPLICATIONS)

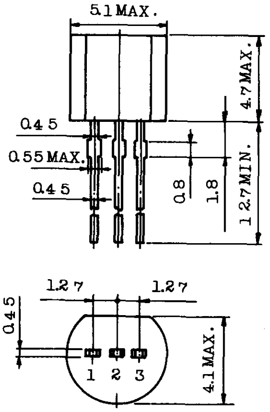
2SA1091

HIGH VOLTAGE CONTROL APPLICATIONS.
PLASMA DISPLAY, NIXIE TUBE DRIVER APPLICATIONS.
CATHODE RAY TUBE BRIGHTNESS CONTROL
APPLICATIONS.

FEATURES:

- High Voltage : V_{CBO}=-300V, V_{CEO}=-300V
- Low Saturation Voltage : $V_{CE(sat)}$=-0.5V(Max.)
- Small Collector Output Capacitance : C_{ob}=6pF(Typ.)
- Complementary to 2SC2551

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

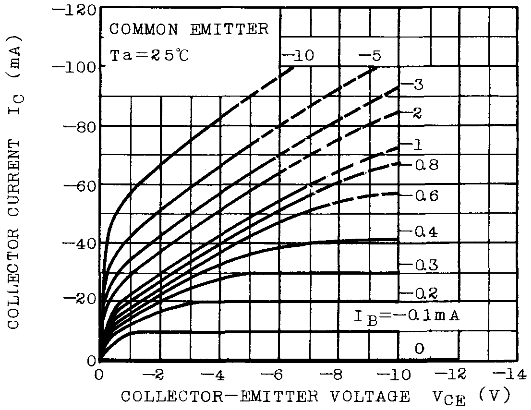
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-300	V
Collector-Emitter Voltage	V_{CEO}	-300	V
Emitter-Base Voltage	V_{EBO}	-8	V
Collector Current	I_C	-100	mA
Base Current	I_B	-20	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

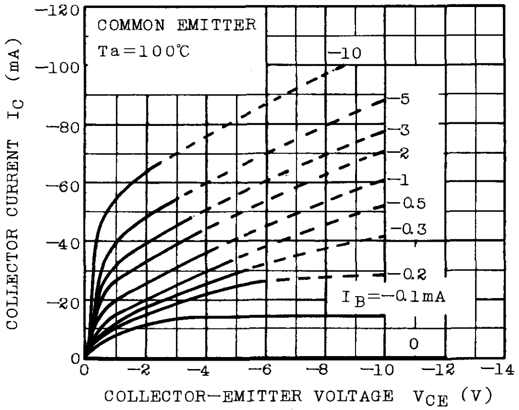
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-300V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-8V, I_C=0	-	-	-0.1	μA
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C=-0.1mA, I_E=0	-300	-	-	V
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-1mA, I_B=0	-300	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=-10V, I_C=-20mA	30	-	150	
	$h_{FE(2)}$	V_{CE}=-10V, I_C=-1mA	20	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-20mA, I_B=-2mA	-	-	-0.5	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=-20mA, I_B=-2mA	-	-	-1.2	V
Transition Frequency	f_T	V_{CE}=-10V, I_C=-20mA	40	60	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-20V, I_E=0, f=1MHz	-	6	8	pF

Note: $h_{FE(1)}$ Classification R:30~90 O:50~150

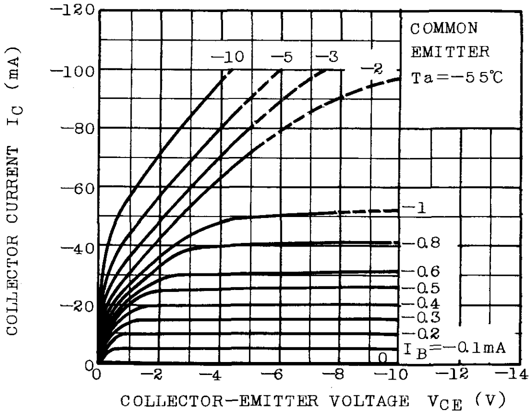
I_C - V_{CE}



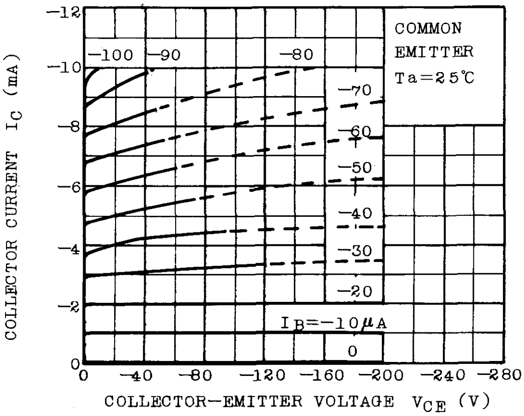
I_C - V_{CE}



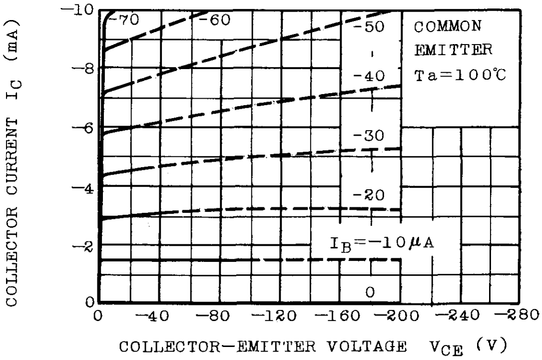
I_C - V_{CE}



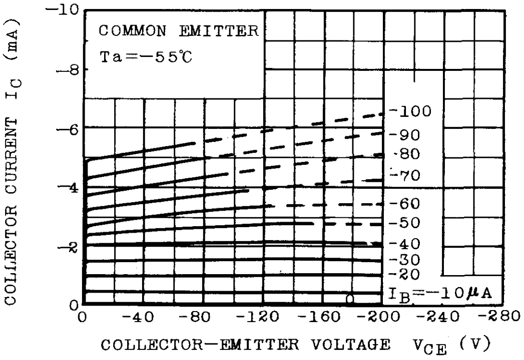
I_C - V_{CE}



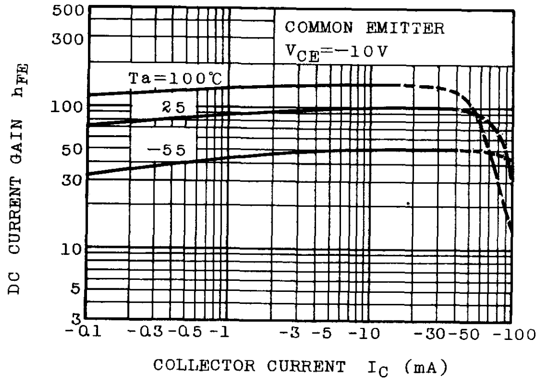
I_C - V_{CE}



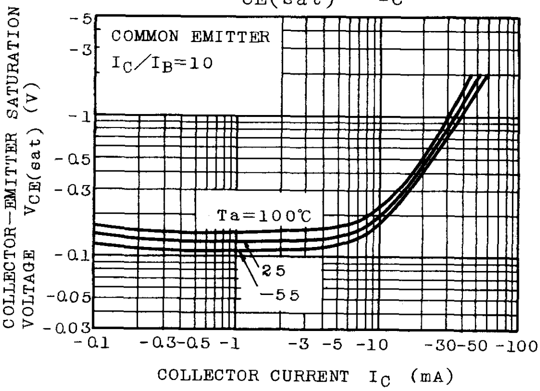
I_C - V_{CE}



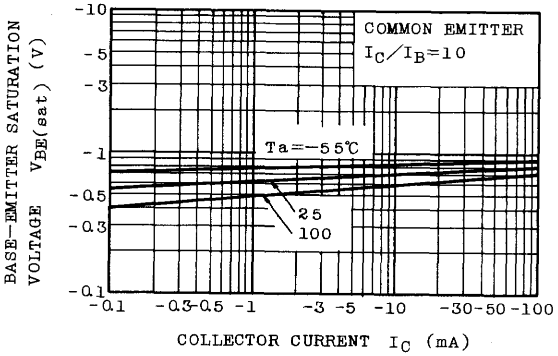
$h_{FE} - I_C$



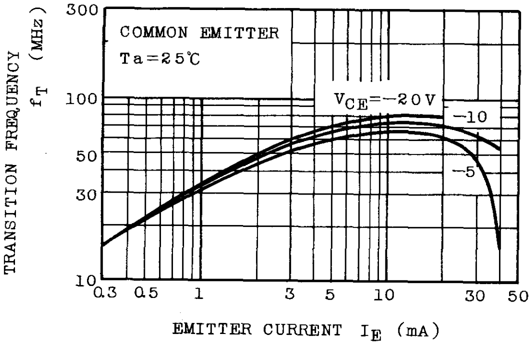
$V_{CE(sat)} - I_C$



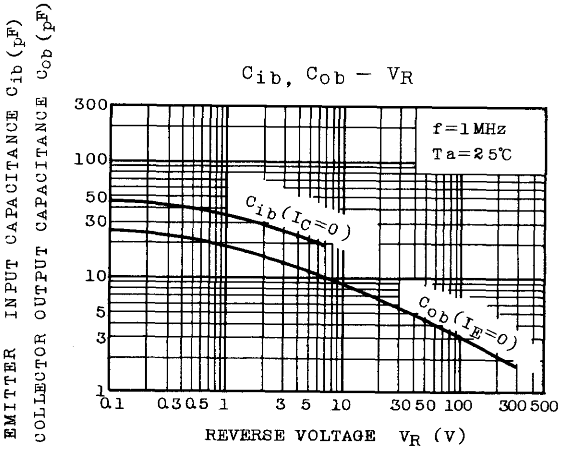
$V_{BE(sat)} - I_C$



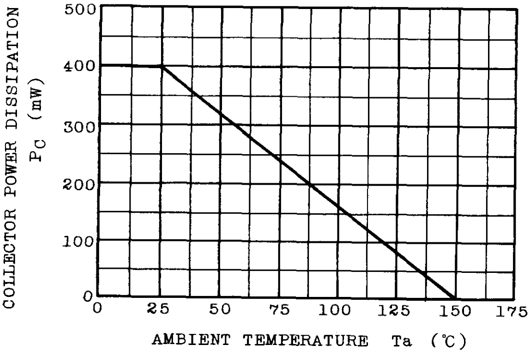
$f_T - I_E$



$C_{ib}, C_{ob} - V_R$



$P_C - Ta$



2SA1145

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

AUDIO FREQUENCY AMPLIFIER APPLICATIONS.

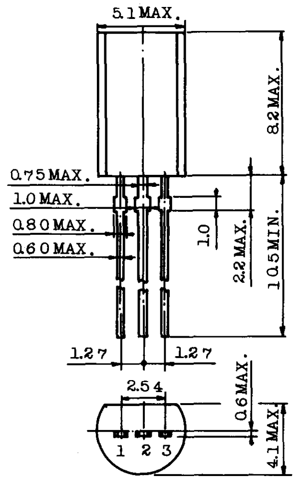
FEATURES:

- Complementary to 2SC2705.
- Small Collector Output Capacitance : C_{ob}=2.5pF(Typ.)
- High Transition Frequency : f_T=200MHz(Typ.)

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-150	V
Collector-Emitter Voltage	V_{CEO}	-150	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-50	mA
Base Current	I_B	-5	mA
Collector Power Dissipation	P_C	800	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92MOD
EIAJ	—
TOSHIBA	2-5J1A

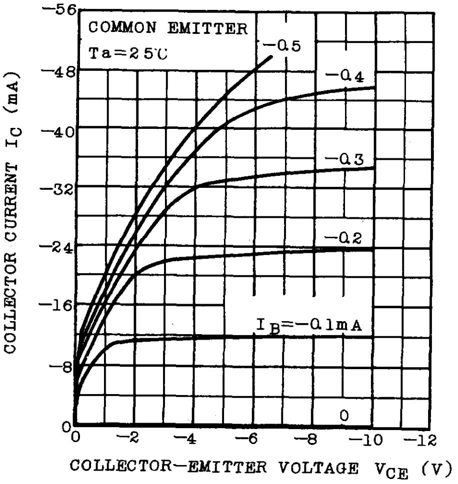
Weight:0.36g

ELECTRICAL CHARACTERISTICS (Ta=25°C)

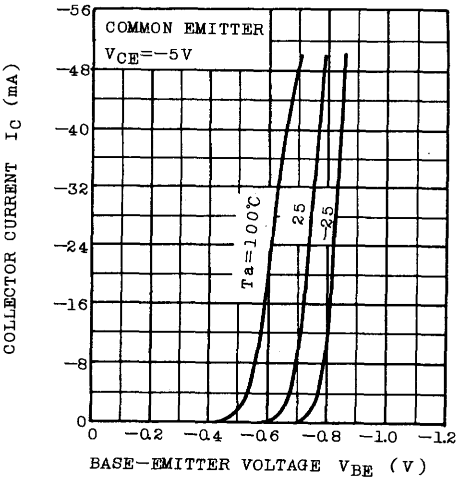
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-150V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-1mA, I_B=0	-150	-	-	V
DC Current Gain	h_{FE} (Note)	V_{CE}=-5V, I_C=-10mA	80	-	240	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-10mA, I_B=-1mA	-	-	-1.0	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-5V, I_C=-10mA	-	-	-0.8	V
Transition Frequency	f_T	V_{CE}=-10V, I_C=-10mA	-	200	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	2.5	-	pF

Note: h_{FE} Classification O:80~160, Y:120~240

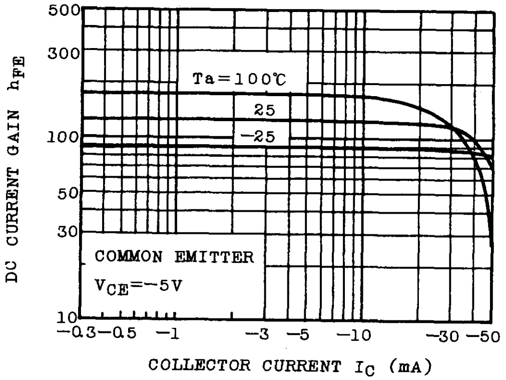
$I_C - V_{CE}$



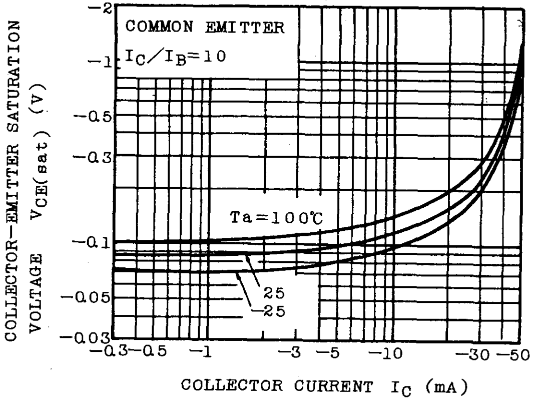
$I_C - V_{BE}$



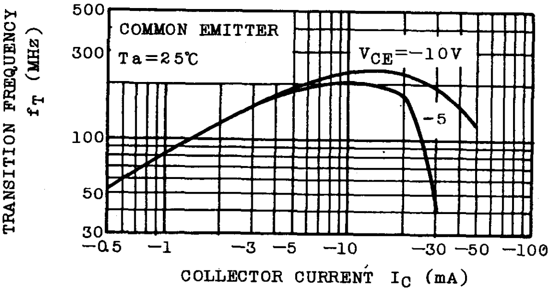
$h_{FE} - I_C$



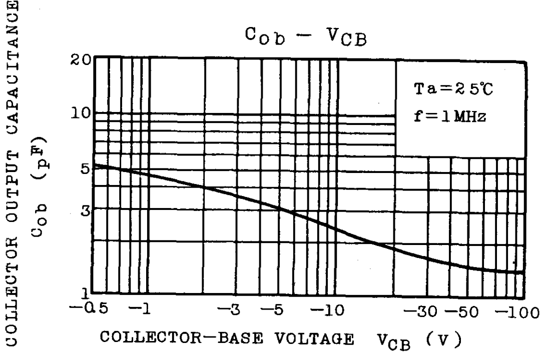
$V_{CE(sat)} - I_C$

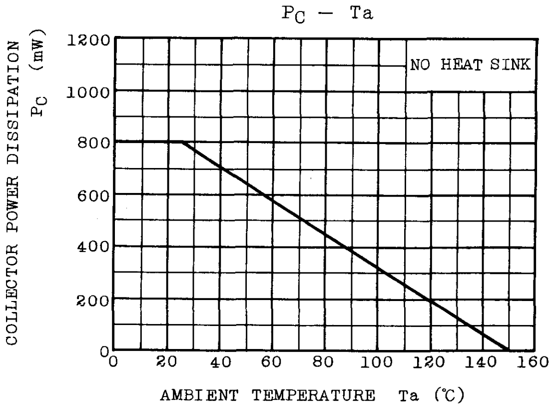


$f_T - I_C$



$C_{ob} - V_{CB}$




P_C — Ta
COLLECTOR POWER DISSIPATION P_C (mW)
1200
1000
800
600
400
200
0
NO HEAT SINK
0
20
40
60
80
100
120
140
160
AMBIENT TEMPERATURE Ta (℃)

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

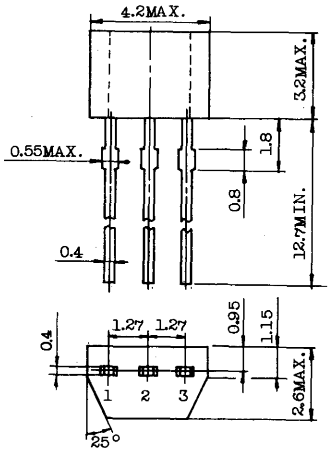
2SA1150

LOW FREQUENCY AMPLIFIER APPLICATIONS.

FEATURES:

- High h_{FE} : h_{FE}=100∿320
- Complementary to 2SC2710.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	—
EIAJ	—
TOSHIBA	2 — 4E1A

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

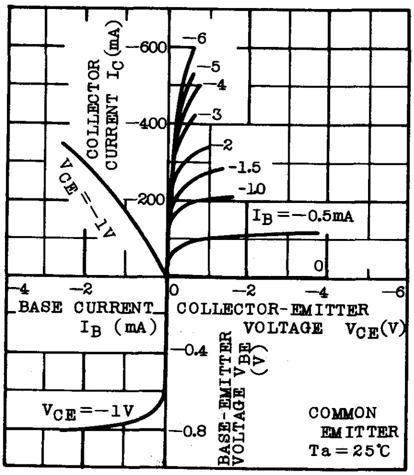
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-35	V
Collector-Emitter Voltage	V_{CEO}	-30	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-800	mA
Emitter Current	I_E	800	mA
Collector Power Dissipation	P_C	300	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

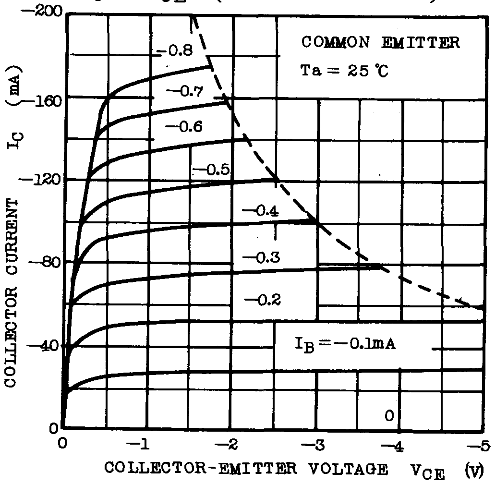
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-30V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-10mA, I_B=0	-30	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=-1V, I_C=-100mA	100	-	320	
	$h_{FE(2)}$	V_{CE}=-1V, I_C=-700mA	35	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-500mA, I_B=-20mA	-	-	-0.7	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-1V, I_C=-10mA	-0.5	-	-0.8	V
Transition Frequency	f_T	V_{CE}=-5V, I_C=-10mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	19	-	pF

Note : $h_{FE(1)}$ Classification O : 100∿200, Y : 160∿320

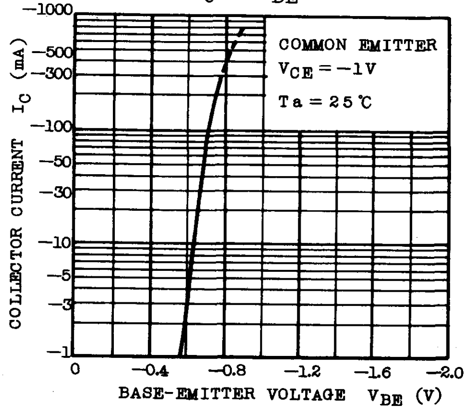
STATIC CHARACTERISTICS



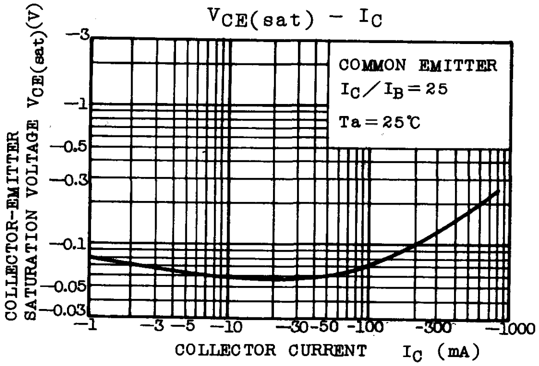
I_C − V_{CE} (LOW VOLTAGE REGION)



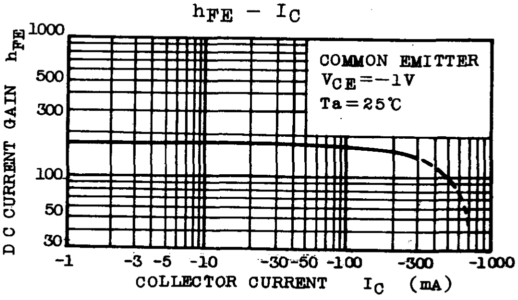
I_C − V_{BE}



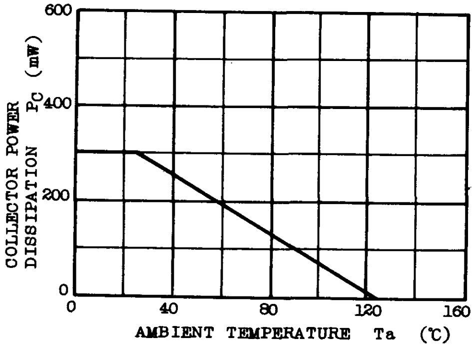
$V_{CE(sat)}$ − I_C



h_{FE} − I_C



P_C − Ta



SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

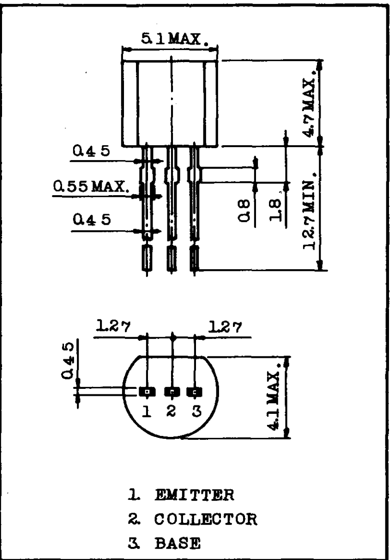
2SA1158

AUDIO FREQUENCY AMPLIFIER APPLICATIONS.
DRIVER STAGE AMPLIFIER APPLICATIONS.

FEATURES:

- High Breakdwon Voltage : V_{CEO}=-80V
- Low Noise Figure : NF=1dB(Typ.), 10dB(Max.)
- Excellent h_{FE} Linearity :
  h_{FE}(0.1mA)/h_{FE}(2mA)=0.90(Typ.)
- Complementary to 2SC2868.

Unit in mm



JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

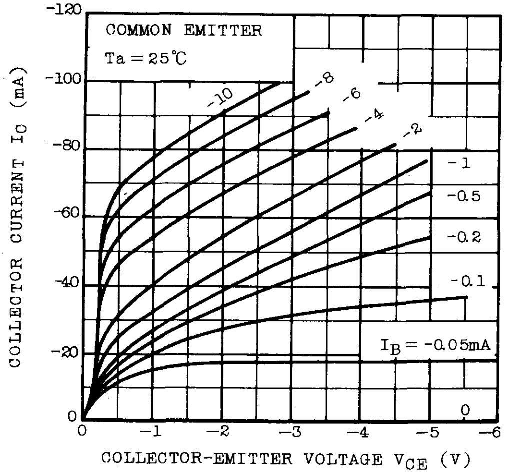
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-80	V
Collector-Emitter Voltage	V_{CEO}	-80	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-100	mA
Base Current	I_B	-50	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55～125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

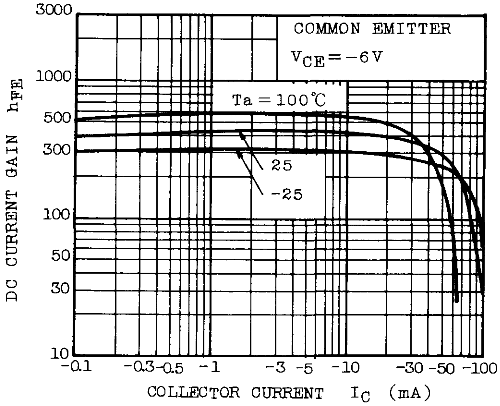
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-80V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-100	nA
DC Current Gain	h_{FE}	V_{CE}=-6V, I_C=-2mA	120	-	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-10mA, I_B=-1mA	-	-	-0.3	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=-10mA, I_B=-1mA	-	-	-1.0	V
Transition Frequency	f_T	V_{CE}=-10V, I_E=2mA	80	-	-	MHz
Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	3.0	7.0	pF
Noise Figure	NF	V_{CB}=-6V, I_C=-0.1mA R_g=10kΩ, f=1kHz	-	1.0	10	dB

Note : h_{FE} Classification Y:120～240 GR:200～400 BL:350～700

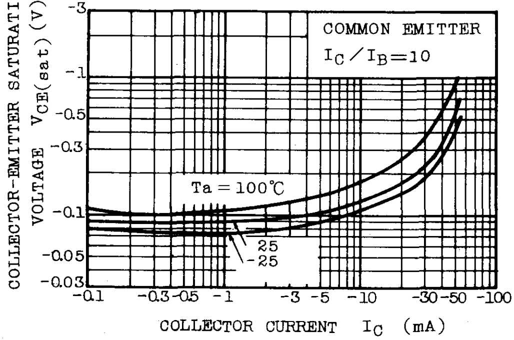
I_C — V_{CE}



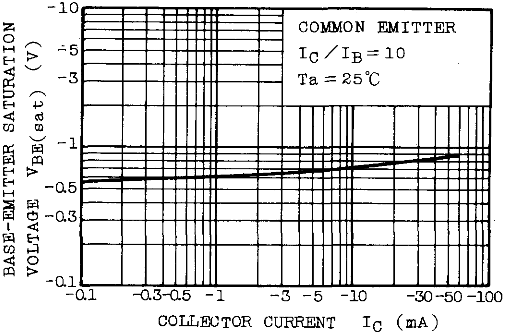
h_{FE} — I_C



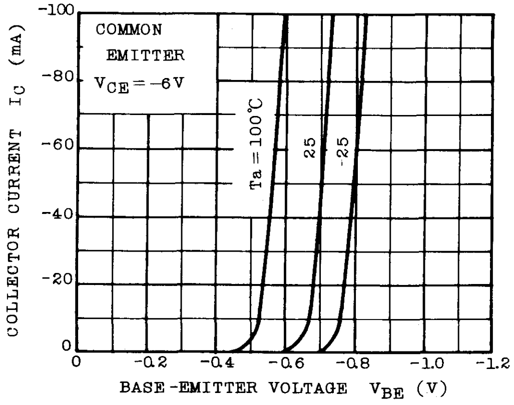
$V_{CE(sat)}$ — I_C



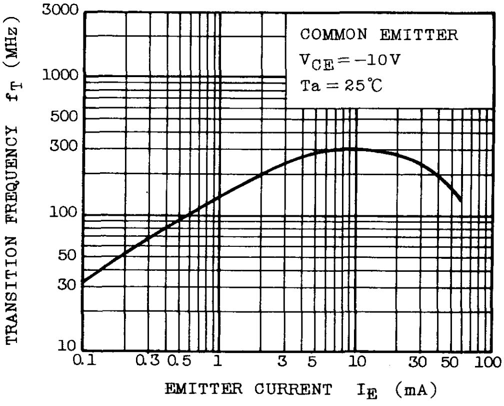
$V_{BE(sat)}$ — I_C

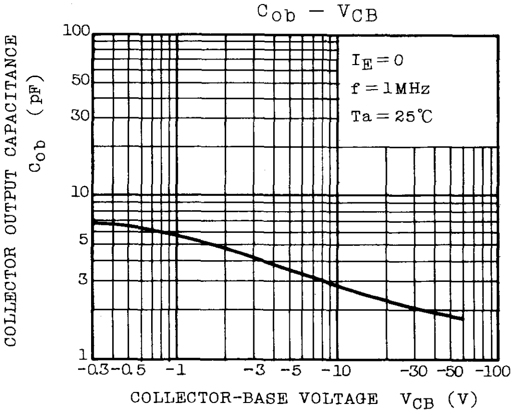


I_C — V_{BE}

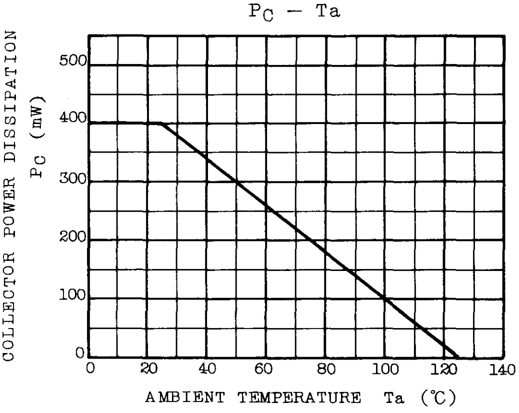


f_T — I_E





Cob — VCB
COLLECTOR OUTPUT CAPACITANCE Cob (pF)
100
50
30
10
5
3
1
IE = 0
f = 1MHz
Ta = 25℃
-0.3
-0.5
-1
-3
-5
-10
-30
-50
-100
COLLECTOR-BASE VOLTAGE VCB (V)



PC — Ta
COLLECTOR POWER DISSIPATION PC (mW)
500
400
300
200
100
0
0
20
40
60
80
100
120
140
AMBIENT TEMPERATURE Ta (℃)

2SA1160

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

STROBO FLASH APPLICATIONS.

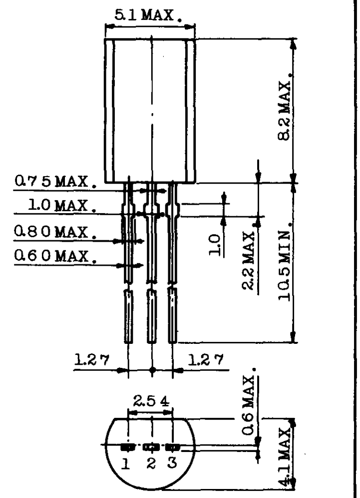
MEDIUM POWER AMPLIFIER APPLICATIONS.

FEATURES:

. High DC Current Gain and Excellent h_{FE} Linearity
  : $h_{FE(1)}$=140～600 (V_{CE}=-1V, I_C=-0.5A)
  : $h_{FE(2)}$=60(Min.), 120(Typ.) (V_{CE}=-1V, I_C=-4A)

. Low Saturation Voltage
  : $V_{CE(sat)}$=-0.5V(Max.) (I_C=-2A, I_B=-50mA)

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92MOD
EIAJ	—
TOSHIBA	2-5J1A

Weight : 0.36g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Voltage		V_{CBO}	-20	V
Collector-Emitter Voltage		V_{CES}	-20	V
		V_{CEO}	-10	
Emitter-Base Voltage		V_{EBO}	-6	V
Collector Current	DC	I_C	-2	A
	Pulse (Note 1)	I_{CP}	-4	
Base Current		I_B	-2	A
Collector Power Dissipation		P_C	900	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_{stg}	-55～150	°C

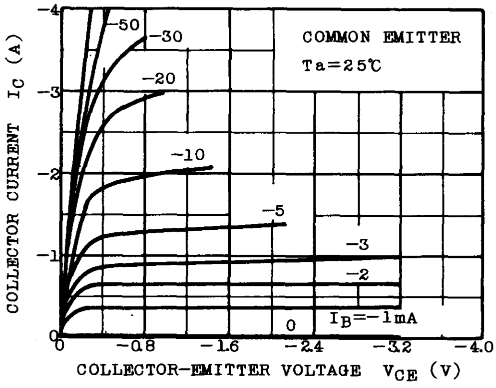
Note 1 : Pulse Width=10ms(Max.), Duty Cycle=30%(Max.)

ELECTRICAL CHARACTERISTICS (Ta=25°C)

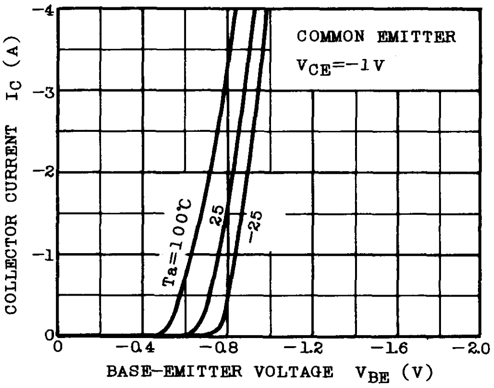
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-20V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-6V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-10mA, I_B=0	-10	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=-1mA, I_C=0	-6	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note 2)	V_{CE}=-1V, I_C=-0.5A	140	-	600	
	$h_{FE(2)}$	V_{CE}=-1V, I_C=-4A	60	120	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-2A, I_B=-50mA	-	-0.20	-0.50	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-1V, I_C=-2A	-	-0.83	-1.5	V
Transition Frequency	f_T	V_{CE}=-1V, I_C=-0.5A	-	140	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	50	-	pF

Note 2 : $h_{FE(1)}$ Classification A : 140～280, B : 200～400, C : 300～600

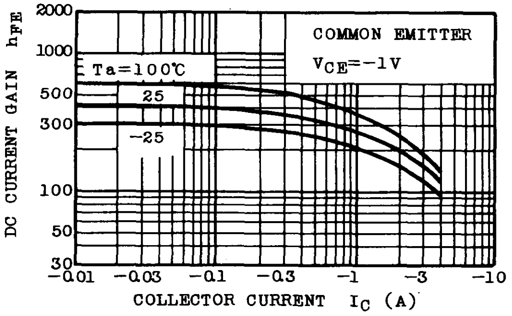
I_C — V_{CE}



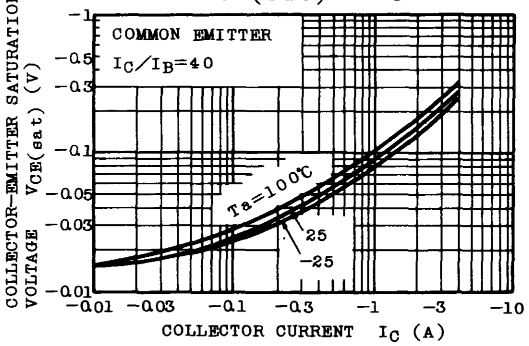
I_C — V_{BE}



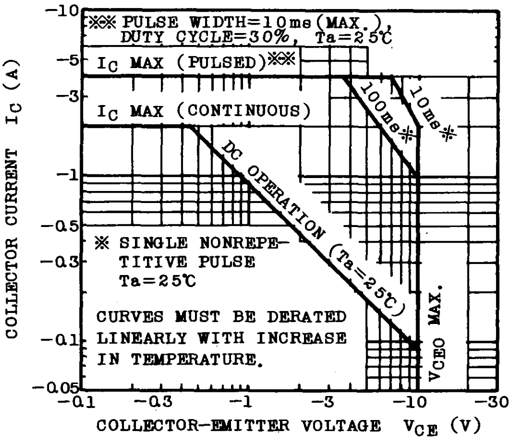
h_{FE} — I_C



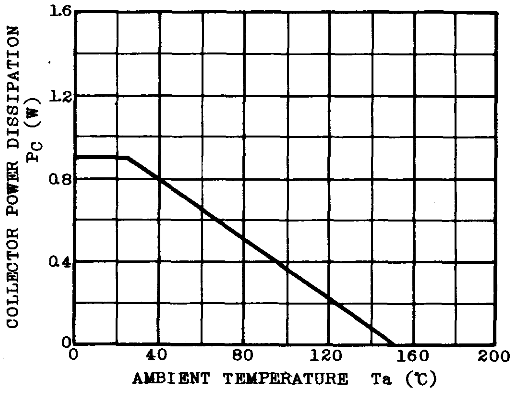
$V_{CE(sat)}$ — I_C



SAFE OPERATING AREA



P_C — Ta



2SA1162

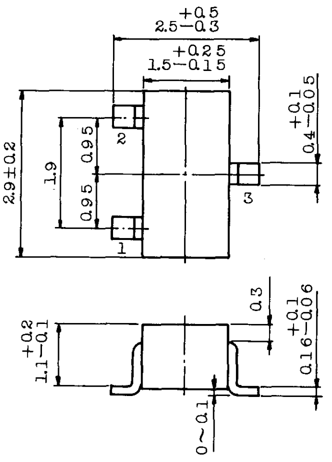
SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

AUDIO FREQUENCY GENERAL PURPOSE AMPLIFIER APPLICATIONS.

FEATURES:

- High Voltage and High Current
  : V_{CEO}=-50V, I_C=-150mA(Max.)
- Excellent h_{FE} Linearity
  : h_{FE}(0.1mA)/h_{FE}(2mA)=0.95(Typ.)
- High h_{FE}: h_{FE}=70 ~ 400
- Low Noise: NF=1dB(Typ.), 10dB(Max.)
- Complementary to 2SC2712
- Small Package

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	–
EIAJ	SC-59
TOSHIBA	2-3F1A

Weight: 0.012g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-50	V
Collector-Emitter Voltage	V_{CEO}	-50	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-150	mA
Base Current	I_B	-30	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

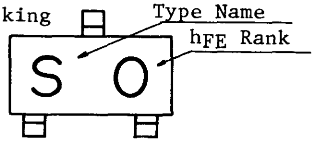
ELECTRICAL CHARACTERISTICS (Ta=25°C)

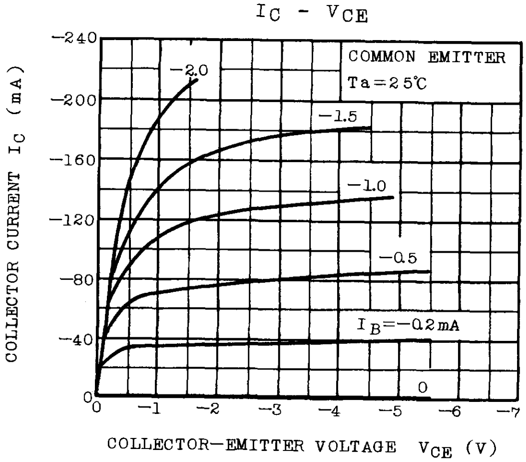
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-50V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=-6V, I_C=-2mA	70	-	400	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-100mA, I_B=-10mA	-	-0.1	-0.3	V
Transition Frequency	f_T	V_{CE}=-10V, I_C=-1mA	80	-	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	4	7	pF
Noise Figure	NF	V_{CE}=-6V, I_C=-0.1mA f=1kHz, R_g=10kΩ	-	1.0	10	dB

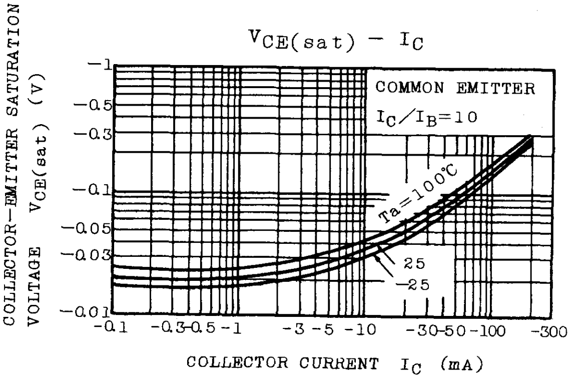
Note : h_{FE} Classification

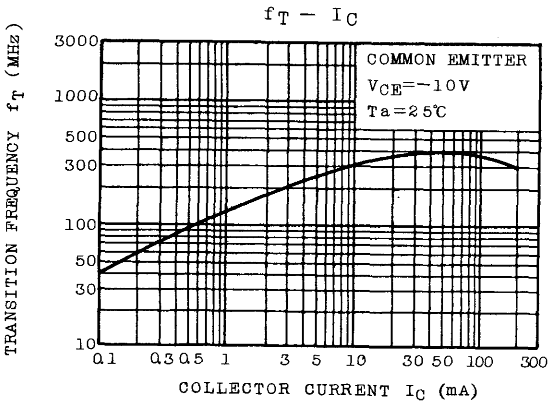
O:70~140, Y:120~240, GR(G) : 200~400

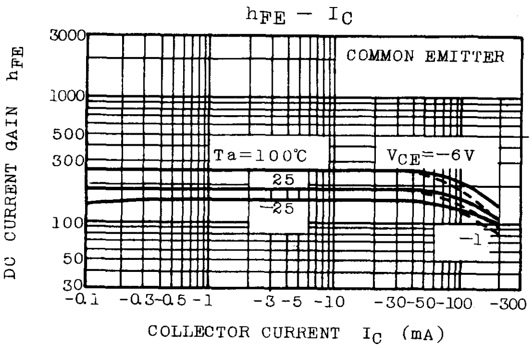
Marking

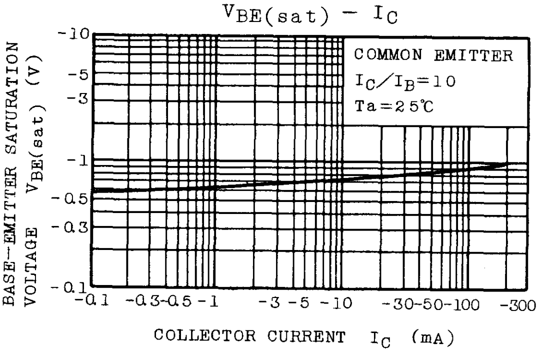


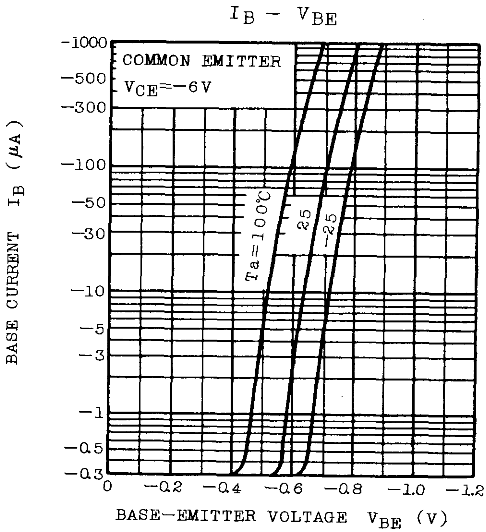

I_C - V_{CE}
COMMON EMITTER
Ta=25℃
−2.0
−1.5
−1.0
−0.5
I_B=−0.2mA
0
−240
−200
−160
−120
−80
−40
0
0
−1
−2
−3
−4
−5
−6
−7
COLLECTOR CURRENT I_C (mA)
COLLECTOR−EMITTER VOLTAGE V_{CE} (V)

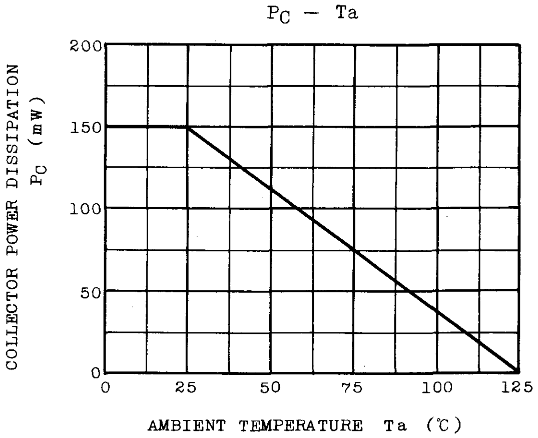

$V_{CE(sat)}$ − I_C
COMMON EMITTER
I_C/I_B=10
Ta=100℃
25
−25
−1
−0.5
−0.3
−0.1
−0.05
−0.03
−0.01
−0.1
−0.3
−0.5
−1
−3
−5
−10
−30
−50
−100
−300
COLLECTOR−EMITTER SATURATION VOLTAGE $V_{CE(sat)}$ (V)
COLLECTOR CURRENT I_C (mA)


f_T − I_C
COMMON EMITTER
V_{CE}=−10V
Ta=25℃
3000
1000
500
300
100
50
30
10
0.1
0.3
0.5
1
3
5
10
30
50
100
300
TRANSITION FREQUENCY f_T (MHz)
COLLECTOR CURRENT I_C (mA)


h_{FE} − I_C
COMMON EMITTER
Ta=100℃
25
−25
V_{CE}=−6V
−1
3000
1000
500
300
100
50
30
−0.1
−0.3
−0.5
−1
−3
−5
−10
−30
−50
−100
−300
DC CURRENT GAIN h_{FE}
COLLECTOR CURRENT I_C (mA)

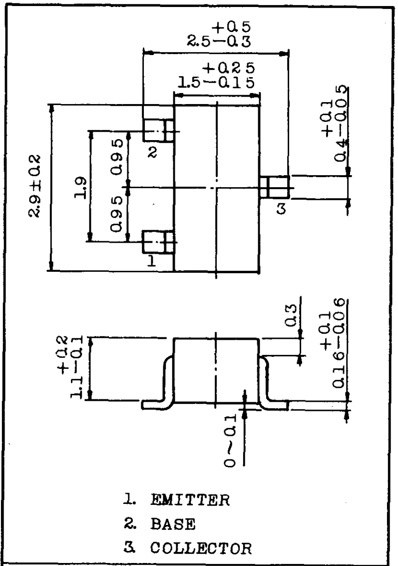

$V_{BE(sat)}$ − I_C
COMMON EMITTER
I_C/I_B=10
Ta=25℃
−10
−5
−3
−1
−0.5
−0.3
−0.1
−0.1
−0.3
−0.5
−1
−3
−5
−10
−30
−50
−100
−300
BASE−EMITTER SATURATION VOLTAGE $V_{BE(sat)}$ (V)
COLLECTOR CURRENT I_C (mA)


I_B − V_{BE}
COMMON EMITTER
V_{CE}=−6V
Ta=100℃
25
−25
−1000
−500
−300
−100
−50
−30
−10
−5
−3
−1
−0.5
−0.3
0
−0.2
−0.4
−0.6
−0.8
−1.0
−1.2
BASE CURRENT I_B (μA)
BASE−EMITTER VOLTAGE V_{BE} (V)


P_C — Ta
COLLECTOR POWER DISSIPATION P_C (mW)
200
150
100
50
0
0
25
50
75
100
125
AMBIENT TEMPERATURE Ta (℃)

AUDIO FREQUENCY GENERAL PURPOSE AMPLIFIER APPLICATIONS.

Unit in mm



JEDEC	−
EIAJ	SC−59
TOSHIBA	2−3F1A

Weight: 0.012g

FEATURES:

- High Voltage: V_{CEO}=-120V
- Excellent h_{FE} Linearity
  : h_{FE}(0.1mA)/h_{FE}(2mA)=0.95(Typ.)
- High h_{FE}: h_{FE}=200 ~ 700
- Low Noise: NF=1dB(Typ.), 10dB(Max.)
- Complementary to 2SC2713
- Small Package

MAXIMUM RATINGS (Ta=25°C)

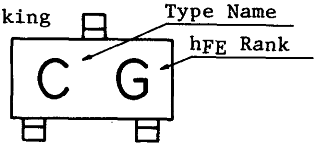
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-120	V
Collector-Emitter Voltage	V_{CEO}	-120	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-100	mA
Base Current	I_B	-20	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

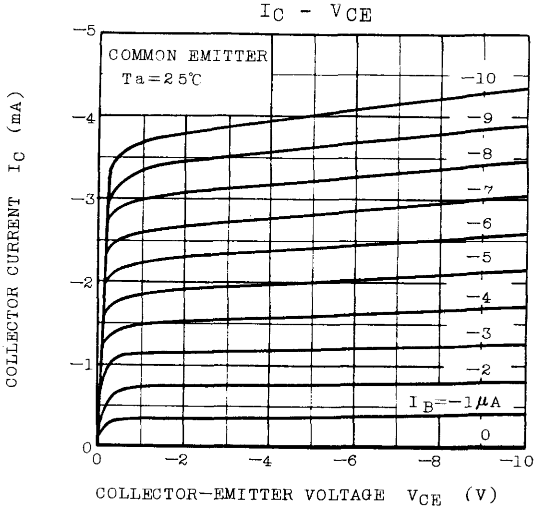
ELECTRICAL CHARACTERISTICS (Ta=25°C)

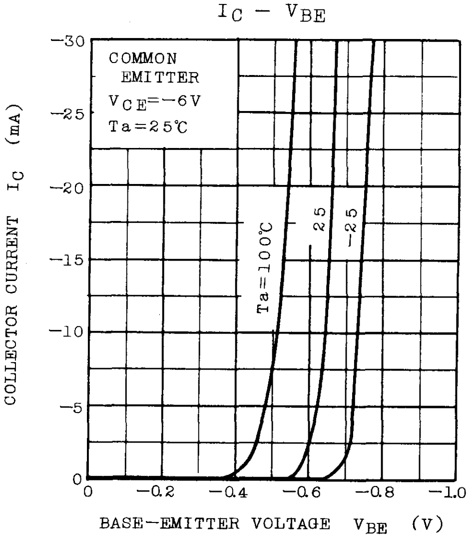
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-120V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=-6V, I_C=-2mA	200	-	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-10mA, I_B=-1mA	-	-	-0.3	V
Transition Frequency	f_T	V_{CE}=-6V, I_C=-1mA	-	100	-	MHz
Collector Output Capacitance	Cob	V_{CB}=-10V, I_E=0, f=1MHz	-	4	-	pF
Noise Figure	NF	V_{CE}=-6V, I_C=-0.1mA f=1kHz, R_g=10kΩ	-	1.0	10	dB

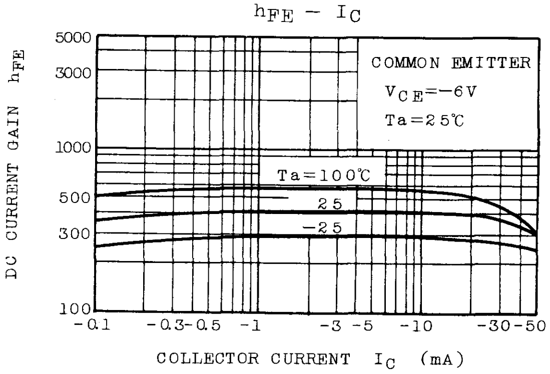
Note : h_{FE} Classification
GR(G) : 200 ~ 400, BL(L) : 350 ~ 700

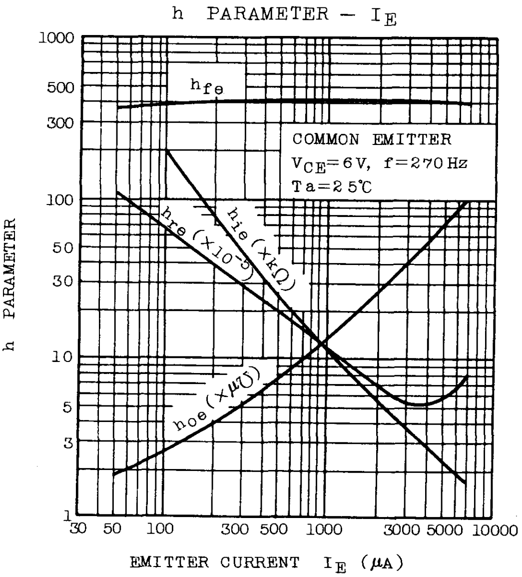
Marking

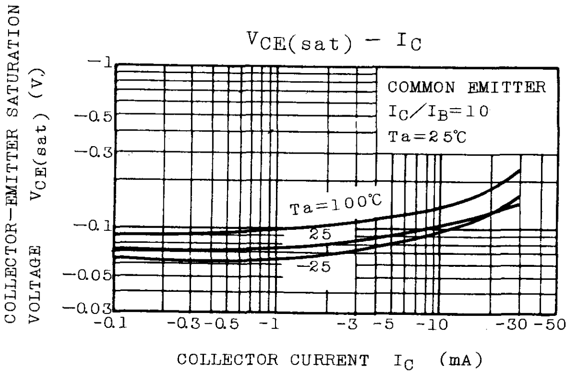



I_C – V_{CE}
COMMON EMITTER
Ta=25℃
I_B=−1μA
0
−2
−3
−4
−5
−6
−7
−8
−9
−10
−5
−4
−3
−2
−1
0
0
−2
−4
−6
−8
−10
COLLECTOR CURRENT I_C (mA)
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)

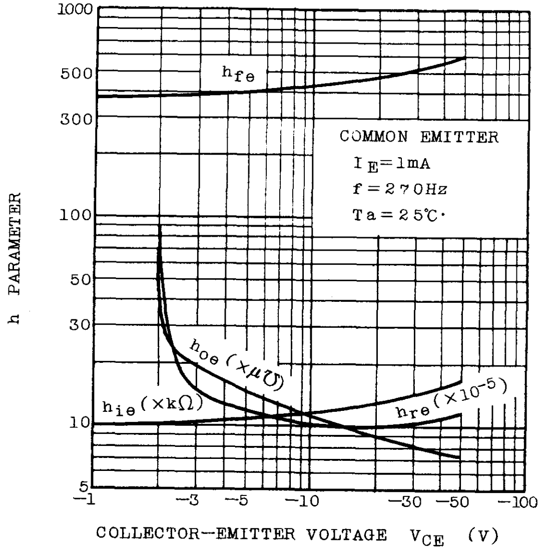

I_C – V_{BE}
COMMON EMITTER
V_{CE}=−6V
Ta=25℃
Ta=100℃
25
−25
−30
−25
−20
−15
−10
−5
0
0
−0.2
−0.4
−0.6
−0.8
−1.0
COLLECTOR CURRENT I_C (mA)
BASE-EMITTER VOLTAGE V_{BE} (V)


h_{FE} – I_C
COMMON EMITTER
V_{CE}=−6V
Ta=25℃
Ta=100℃
25
−25
5000
3000
1000
500
300
100
-0.1
-0.3
-0.5
-1
-3
-5
-10
-30
-50
DC CURRENT GAIN h_{FE}
COLLECTOR CURRENT I_C (mA)

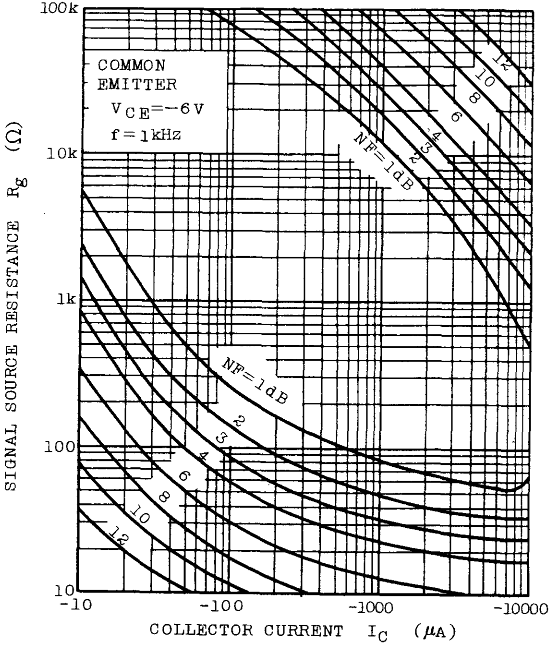

h PARAMETER – I_E
COMMON EMITTER
V_{CE}=6V, f=270Hz
Ta=25℃
h_{fe}
h_{re} (×10^{-5})
h_{ie} (×kΩ)
h_{oe} (×μ℧)
1000
500
300
100
50
30
10
5
3
1
30
50
100
300
500
1000
3000
5000
10000
h PARAMETER
EMITTER CURRENT I_E (μA)


$V_{CE(sat)}$ – I_C
COMMON EMITTER
I_C/I_B=10
Ta=25℃
Ta=100℃
25
−25
−1
−0.5
−0.3
−0.1
−0.05
−0.03
-0.1
-0.3
-0.5
-1
-3
-5
-10
-30
-50
COLLECTOR-EMITTER SATURATION VOLTAGE $V_{CE(sat)}$ (V)
COLLECTOR CURRENT I_C (mA)

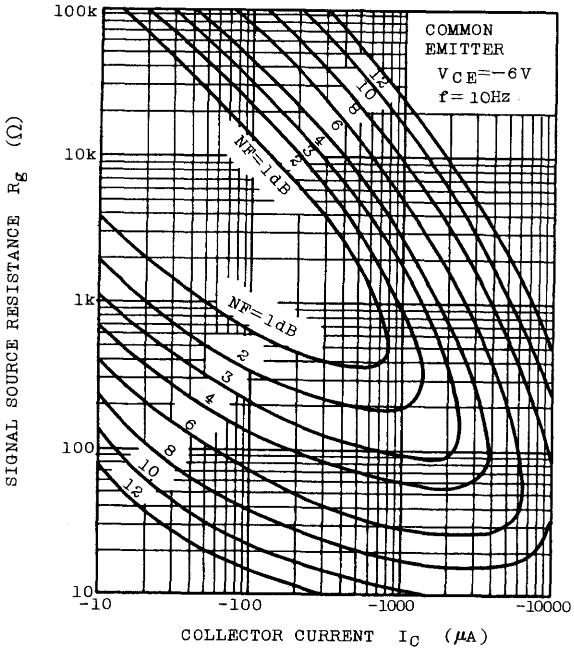
h PARAMETER — V_{CE}



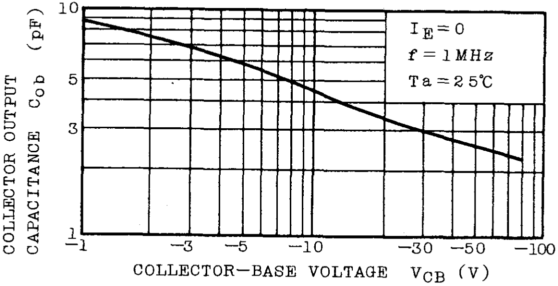
NF — R_g, I_C



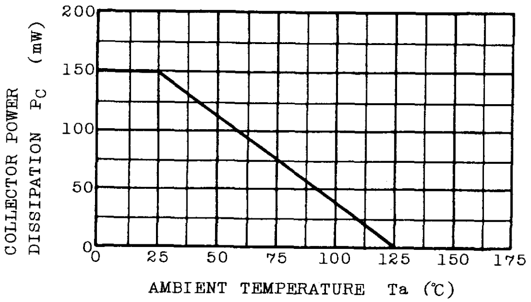
NF — R_g, I_C



C_{ob} — V_{CB}



P_C — Ta



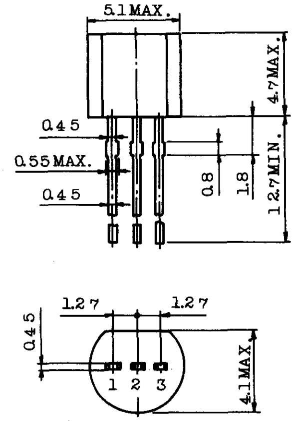
2SA1164

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

HIGH FREQUENCY AMPLIFIER APPLICATIONS.
LOW FREQUENCY AMPLIFIER APPLICATIONS.
HIGH SPEED SWITCHING APPLICATIONS.

- High Transition Frequency : f_T=400MHz(Typ.)
- Low $V_{CE(sat)}$: $V_{CE(sat)}$=0.5V(Max.)
- Small Collector Output Capacitance : C_{ob}=4pF(Max.)
- High Speed Switching.
- Designed for Complementary Use with 2SC2754.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

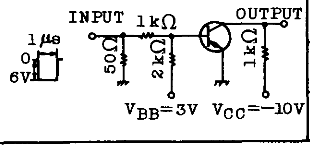
JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

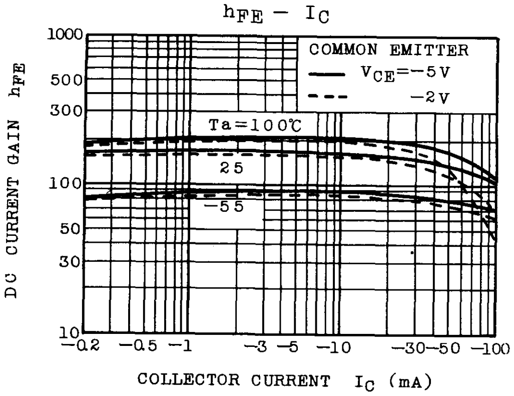
MAXIMUM RATINGS (Ta=25°C)

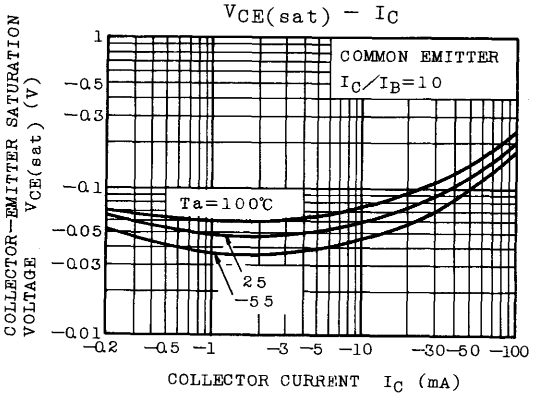
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-35	V
Collector-Emitter Voltage	V_{CEO}	-30	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-100	mA
Base Current	I_B	-50	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

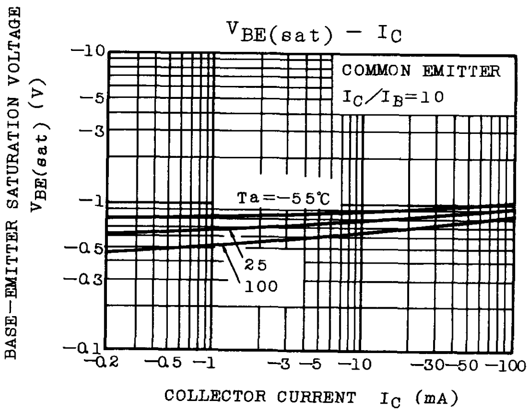
ELECTRICAL CHARACTERISTICS (Ta=25°C)

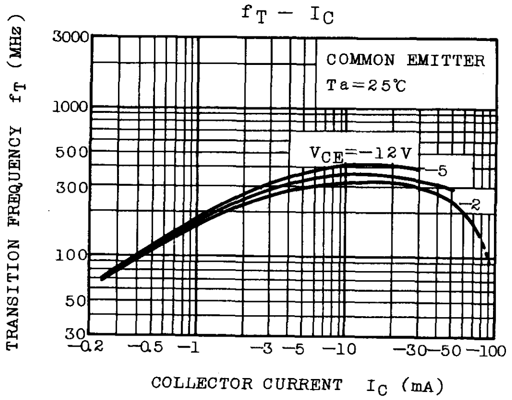
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=-35V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
DC Current Gain		h_{FE} (Note)	V_{CE}=-12V, I_C=-2mA	70	-	400	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=-10mA, I_B=-1mA	-	-	-0.5	V
Base-Emitter Voltage		V_{BE}	V_{CE}=-12V, I_C=-2mA	-0.5	-	-0.8	V
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=-10mA, I_B=-1mA	-	-	-1.0	V
Transition Frequency		f_T	V_{CE}=-12V, I_C=-10mA	100	400	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	2.5	4	pF
Switching Time	Turn-on Time	t_{on}		-	30	-	ns
	Storage Time	t_{stg}		-	250	-	
	Fall Time	t_f		-	70	-	

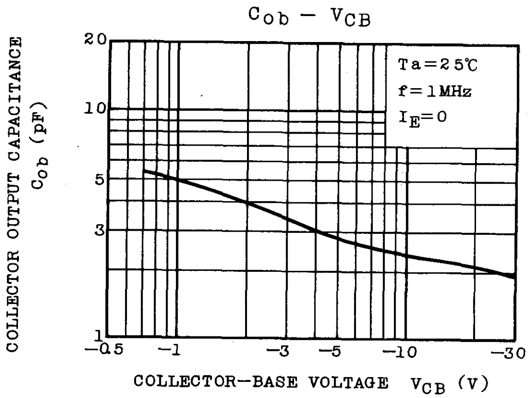
Note: h_{FE} Classification O : 70~140, Y : 120~240, GR : 200~400

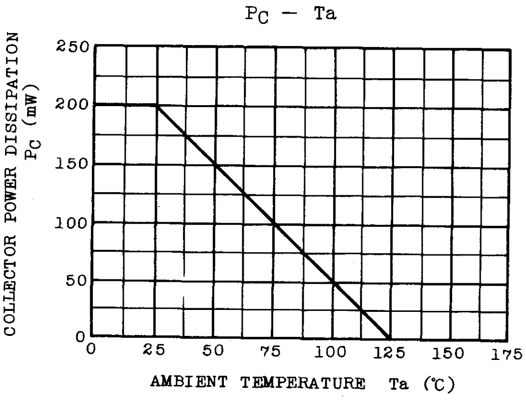

hFE — IC
COMMON EMITTER
VCE=−5V
−2V
Ta=100℃
25
−55
DC CURRENT GAIN hFE
1000
500
300
100
50
30
10
−0.2
−0.5
−1
−3
−5
−10
−30
−50
−100
COLLECTOR CURRENT IC (mA)


VCE(sat) — IC
COMMON EMITTER
IC/IB=10
Ta=100℃
25
−55
COLLECTOR−EMITTER SATURATION VOLTAGE VCE(sat) (V)
1
−0.5
−0.3
−0.1
−0.05
−0.03
−0.01
−0.2
−0.5
−1
−3
−5
−10
−30
−50
−100
COLLECTOR CURRENT IC (mA)


VBE(sat) — IC
COMMON EMITTER
IC/IB=10
Ta=−55℃
25
100
BASE−EMITTER SATURATION VOLTAGE VBE(sat) (V)
−10
−5
−3
−1
−0.5
−0.3
−0.1
−0.2
−0.5
−1
−3
−5
−10
−30
−50
−100
COLLECTOR CURRENT IC (mA)


fT — IC
COMMON EMITTER
Ta=25℃
VCE=−12V
−5
−2
TRANSITION FREQUENCY fT (MHz)
3000
1000
500
300
100
50
30
−0.2
−0.5
−1
−3
−5
−10
−30
−50
−100
COLLECTOR CURRENT IC (mA)


Cob — VCB
Ta=25℃
f=1MHz
IE=0
COLLECTOR OUTPUT CAPACITANCE Cob (pF)
20
10
5
3
1
−0.5
−1
−3
−5
−10
−30
COLLECTOR−BASE VOLTAGE VCB (V)


PC — Ta
COLLECTOR POWER DISSIPATION PC (mW)
250
200
150
100
50
0
0
25
50
75
100
125
150
175
AMBIENT TEMPERATURE Ta (℃)

2SA1182

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

AUDIO FREQUENCY LOW POWER AMPLIFIER APPLICATIONS

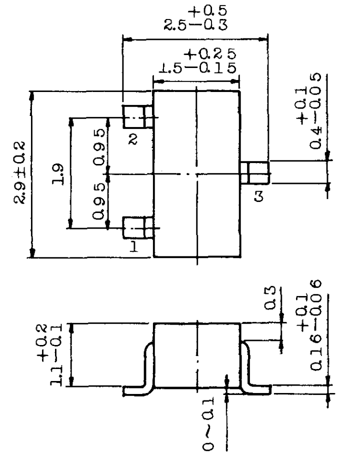
DRIVER STAGE AMPLIFIER APPLICATIONS

SWITCHING APPLICATIONS

FEATURES:

- Excellent h_{FE} Linearity: $h_{FE(2)}=25$(Min.) at $V_{CE}=-6V$ $I_C=-400mA$
- Complementary to 2SC2859.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO−236
EIAJ	—
TOSHIBA	2−3F1A

Weight : 0.012g

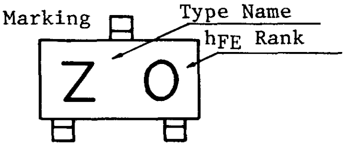
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-35	V
Collector-Emitter Voltage	V_{CEO}	-30	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-500	mA
Base Current	I_B	-50	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

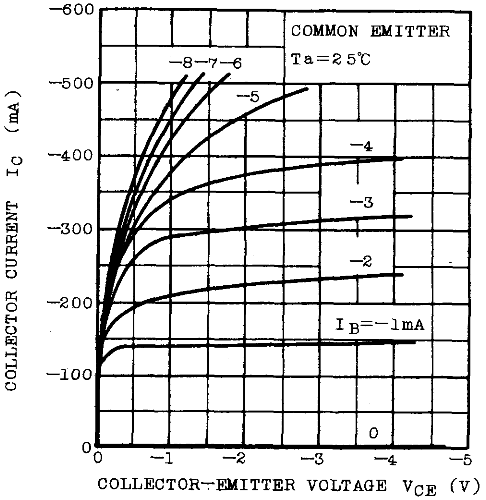
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	$V_{CB}=-35V$, $I_E=0$	-	-	-0.1	μA
Emitter Cut-off Current	I_{EBO}	$V_{EB}=-5V$, $I_C=0$	-	-	-0.1	μA
DC Current Gain (Note)	$h_{FE(1)}$	$V_{CE}=-1V$, $I_C=-100mA$	70	-	240	
	$h_{FE(2)}$	$V_{CE}=-6V$, $I_C=-400mA$	25	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C=-100mA$, $I_B=-10mA$	-	-0.1	-0.25	V
Base-Emitter Voltage	V_{BE}	$V_{CE}=-1V$, $I_C=-100mA$	-	-0.8	-1.0	V
Transition Frequency	f_T	$V_{CE}=-6V$, $I_C=-20mA$	-	200	-	MHz
Collector Output Capacitance	C_{ob}	$V_{CB}=-6V$, $I_E=0$, f=1MHz	-	13	-	pF

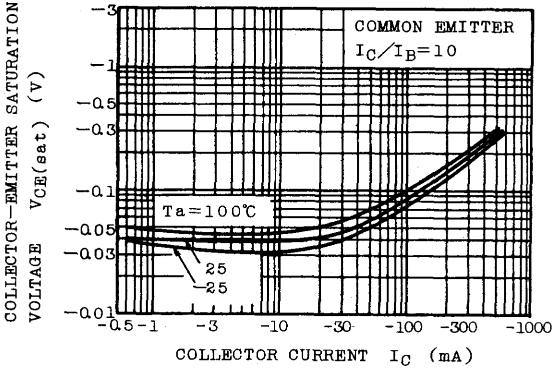
(Note): $h_{FE}(1)$ Classification O:70~140, Y:120~240
$h_{FE}(2)$ Classification O:25Min. Y:40Min.



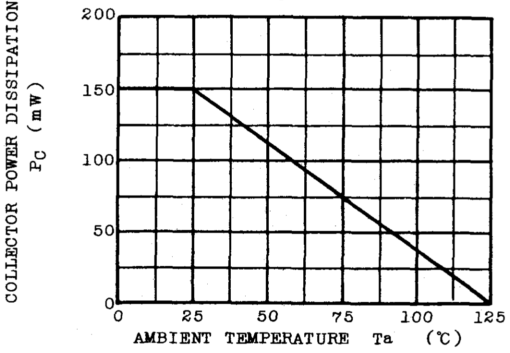
$I_C - V_{CE}$ (LOW VOLTAGE REGION)



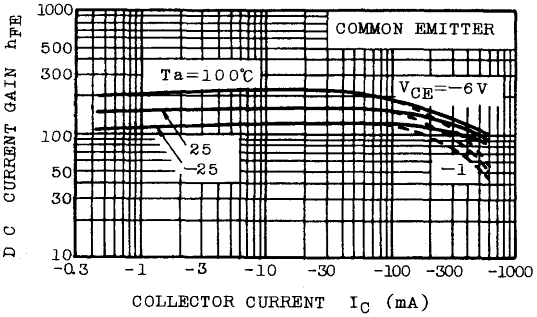
$V_{CE(sat)} - I_C$



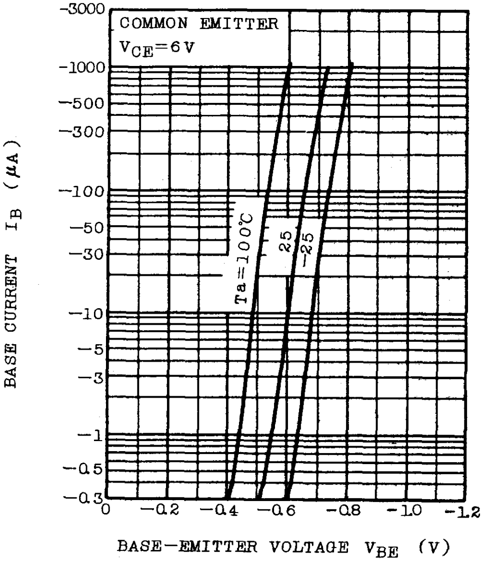
$P_C - Ta$



$h_{FE} - I_C$



$I_B - V_{BE}$



2SA1200

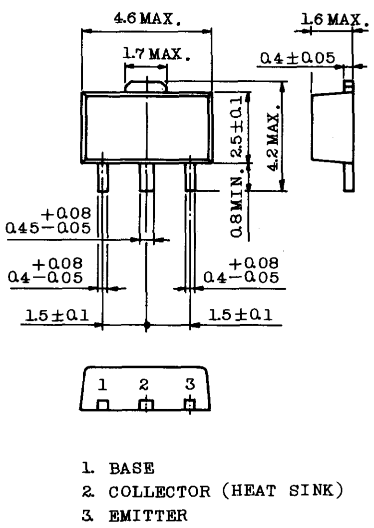
SILICON PNP EPITAXIAL DIFFUSED TYPE (PCT PROCESS)

HIGH VOLTAGE SWITCHING APPLICATIONS.

FEATURES:

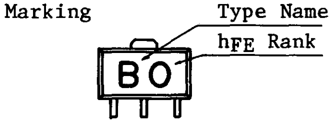
- High Voltage : V_{CEO}=-150V
- High Transition Frequency : f_T=120MHz
- P_C=1 ~ 2W (Mounted on Ceramic Substrate)
- Small Flat Package
- Complementary to 2SC2880

Unit in mm



JEDEC	–
EIAJ	–
TOSHIBA	2-5K1A

Weight : 0.052g



MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-150	V
Collector-Emitter Voltage	V_{CEO}	-150	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-50	mA
Base Current	I_B	-10	mA
Collector Power Dissipation	P_C	500	mW
Collector Power Dissipation	P_C※	800	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55 ~ 150	°C

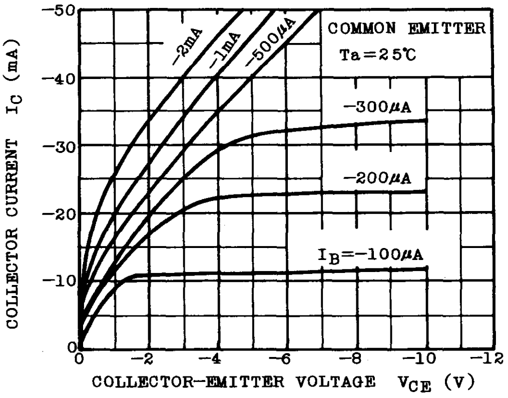
P_C※ : 2SA1200 mounted on ceramic substrate (250mm^2 × 0.8t)

ELECTRICAL CHARACTERISTICS (Ta=25°C)

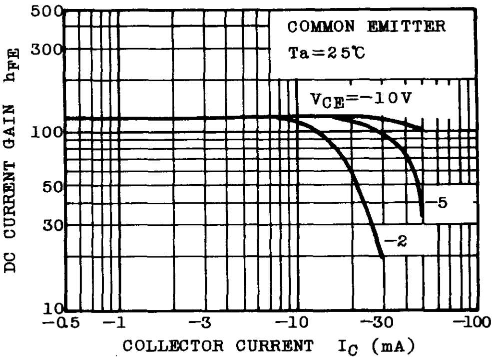
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-150V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=-5V, I_C=-10mA	70	-	240	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-10mA, I_B=-1mA	-	-	-0.8	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-5V, I_C=-30mA	-	-	-0.9	V
Transition Frequency	f_T	V_{CE}=-30V, I_C=-10mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CE}=-10V, I_E=0, f=1MHz	-	4.0	5.0	pF

Note : h_{FE} Classification O : 70 ~ 140, Y : 120 ~ 240

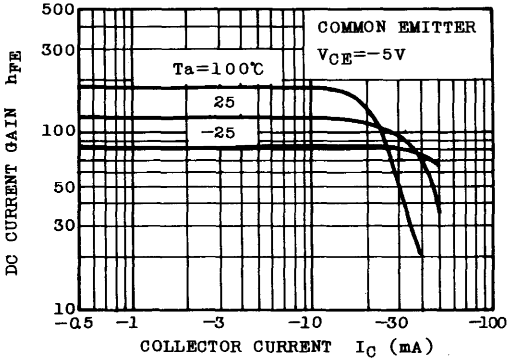
$I_C - V_{CE}$



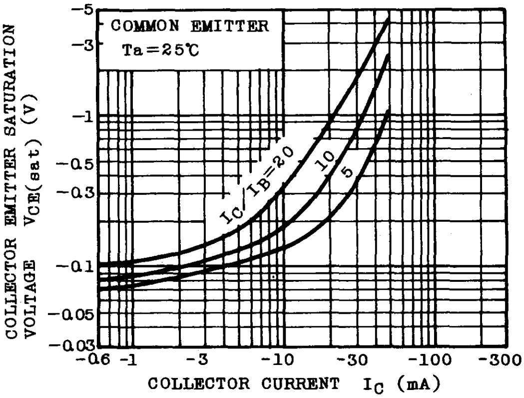
$h_{FE} - I_C$



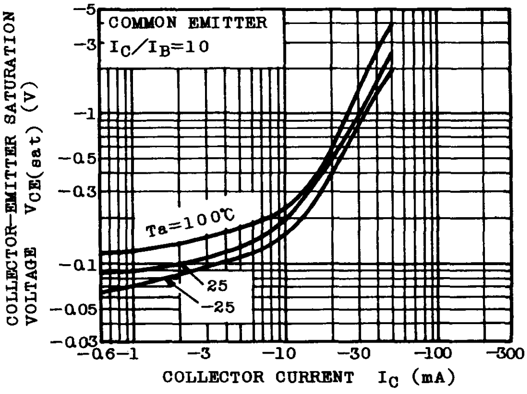
$h_{FE} - I_C$



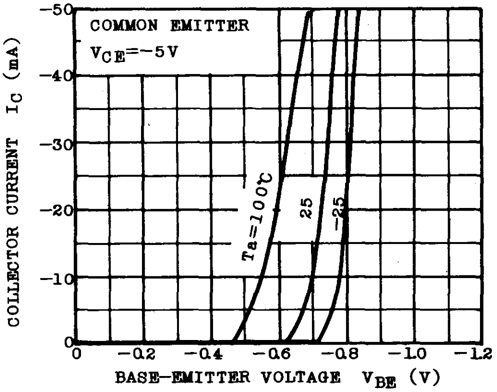
$V_{CE(sat)} - I_C$



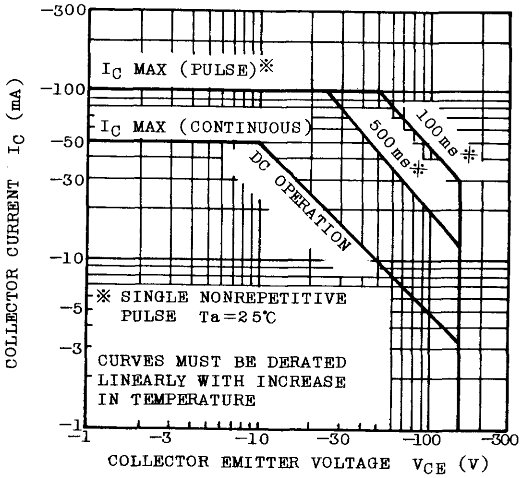
$V_{CE(sat)} - I_C$



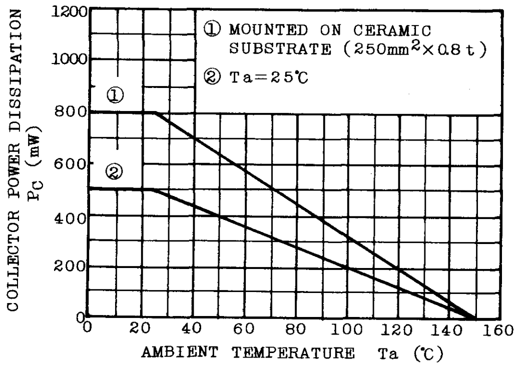
$I_C - V_{BE}$



SAFE OPERATING AREA



P_C − Ta



SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

2SA1201

POWER AMPLIFIER APPLICATIONS.

FEATURES:

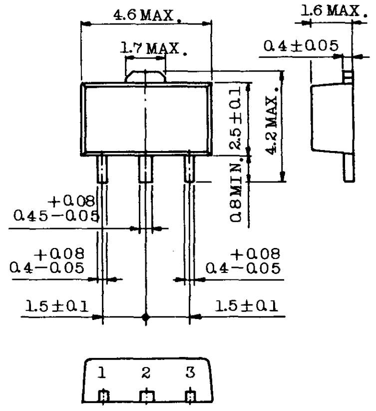
- High Voltage : V_{CEO}=-120V
- High Transition Frequency : f_T=120MHz
- P_C=1 ~ 2W (Mounted on Ceramic Substrate)
- Small Flat Package
- Complementary to 2SC2881

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-120	V
Collector-Emitter Voltage	V_{CEO}	-120	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-800	mA
Base Current	I_B	-160	mA
Collector Power Dissipation	P_C	500	mW
Collector Power Dissipation	P_C※	1000	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55 ~ 150	°C

P_C※ : 2SA1201 mounted on ceramic substrate ($250mm^2 \times 0.8t$)

Unit in mm

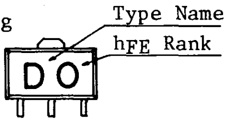


1. BASE
2. COLLECTOR (HEAT SINK)
3. EMITTER

JEDEC	–
EIAJ	–
TOSHIBA	2-5K1A

Weight : 0.052g

Marking

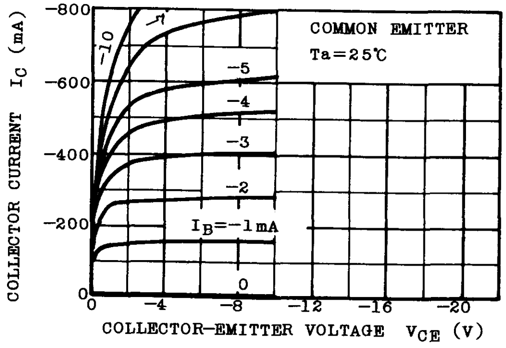


ELECTRICAL CHARACTERISTICS (Ta=25°C)

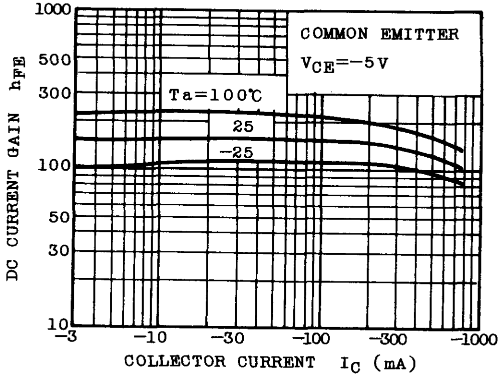
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-120V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-10mA, I_B=0	-120	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=-1mA, I_C=0	-5	-	-	V
DC Current Gain	h_{FE} (Note)	V_{CE}=-5V, I_C=-100mA	80	-	240	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-500mA, I_B=-50mA	-	-	-1.0	V
Base Emitter Voltage	V_{BE}	V_{CE}=-5V, I_C=-500mA	-	-	-1.0	V
Transition Frequency	f_T	V_{CE}=-5V, I_C=-100mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	-	30	pF

Note : h_{FE} Classification O : 80 ~ 160, Y : 120 ~ 240

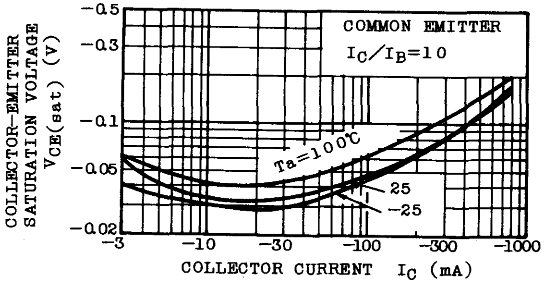
I_C — V_{CE}



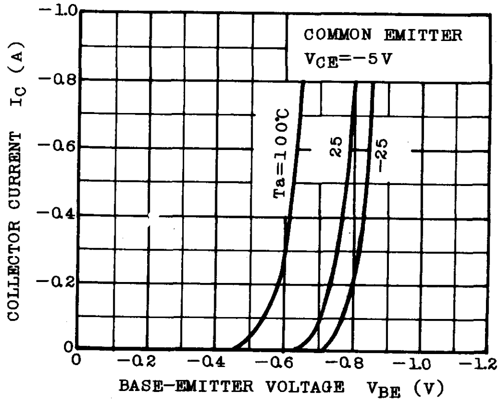
h_{FE} — I_C



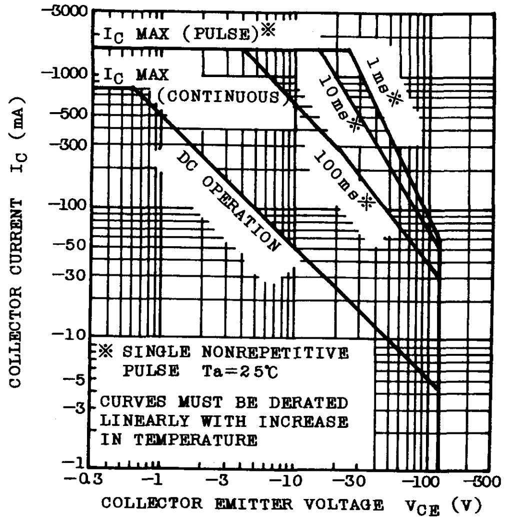
$V_{CE(sat)}$ — I_C



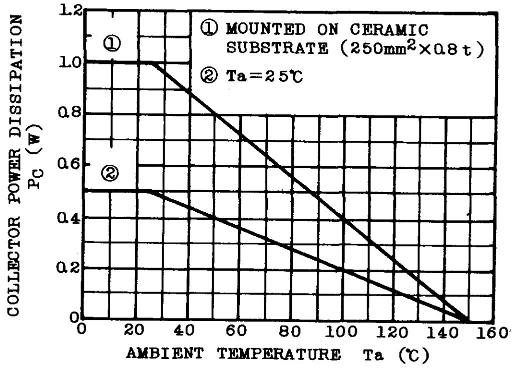
I_C — V_{BE}



SAFE OPERATING AREA



P_C — Ta



SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

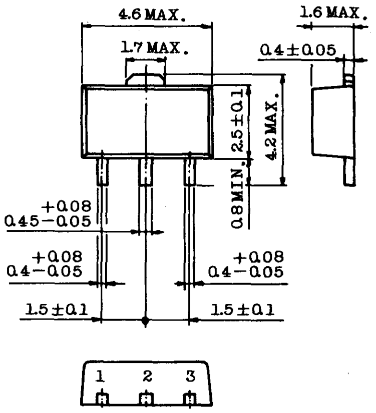
2SA1202

POWER AMPLIFIER APPLICATIONS.
VOLTAGE AMPLIFIER APPLICATIONS.

FEATURES:

- Suitable for driver of 30～35 Watts Audio Amplifier
- P_C=1～2W (Mounted on Ceramic Substrate)
- Small Flat Package
- Complementary to 2SC2882

Unit in mm

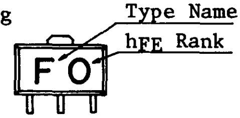


1. BASE
2. COLLECTOR (HEAT SINK)
3. EMITTER

JEDEC	−
EIAJ	−
TOSHIBA	2−5K1A

Weight : 0.052g

Marking



MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-80	V
Collector-Emitter Voltage	V_{CEO}	-80	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-400	mA
Base Current	I_B	-80	mA
Collector Power Dissipation	P_C	500	mW
Collector Power Dissipation	P_C※	1000	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55～150	°C

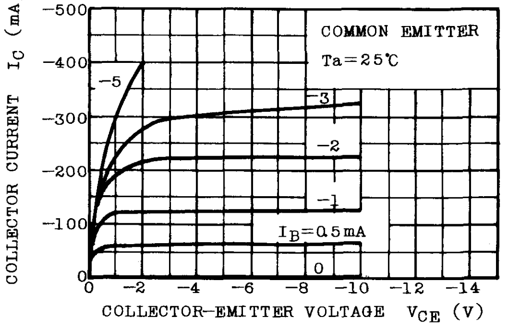
P_C※: 2SA1202 mounted on ceramic substrate ($250mm^2 \times 0.8t$)

ELECTRICAL CHARACTERISTICS (Ta=25°C)

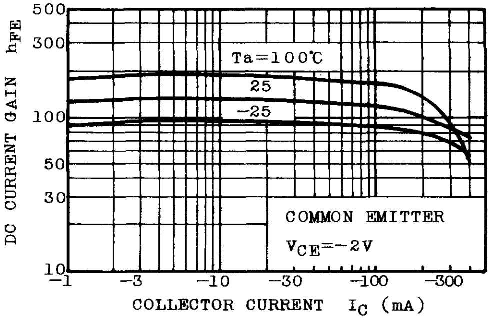
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-80V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-10mA, I_B=0	-80	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=-2V, I_C=-50mA	70	-	240	
	$h_{FE(2)}$	V_{CE}=-2V, I_C=-200mA	40	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-200mA, I_B=-20mA	-	-	-0.4	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-2V, I_C=-5mA	0.55	-	-0.8	V
Transition Frequency	f_T	V_{CE}=-10V, I_C=-10mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	14	-	pF

Note : h_{FE} Classification O : 70～140, Y : 120～240

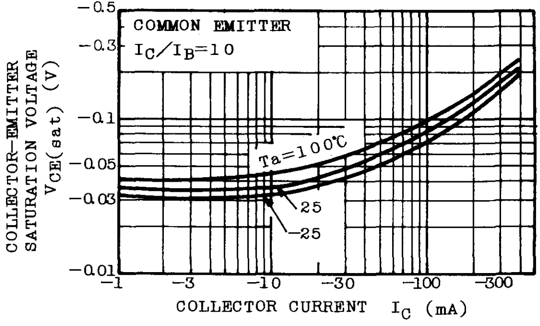
I_C — V_{CE}



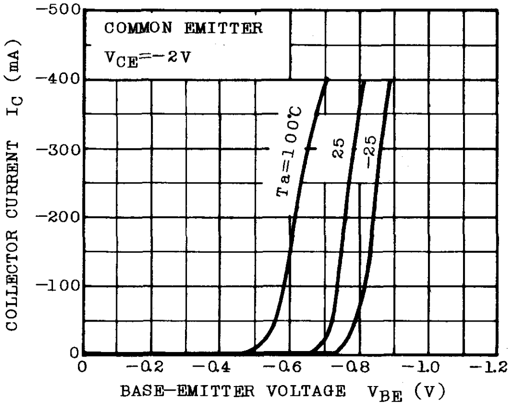
h_{FE} — I_C



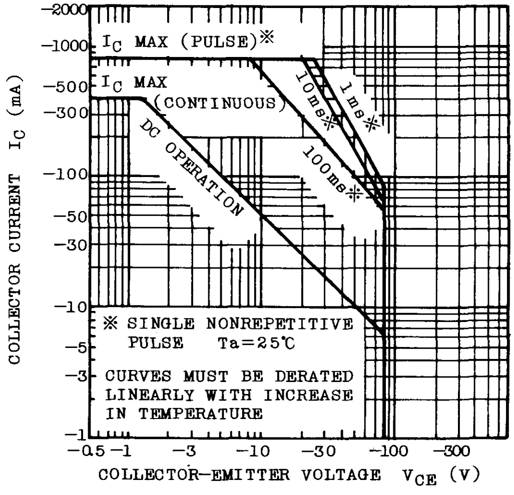
$V_{CE(sat)}$ — I_C



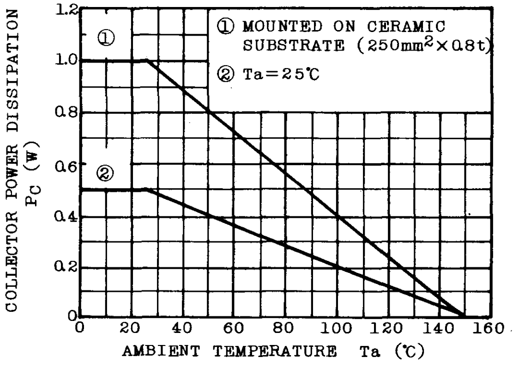
I_C — V_{BE}



SAFE OPERATING AREA



P_C — Ta



SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

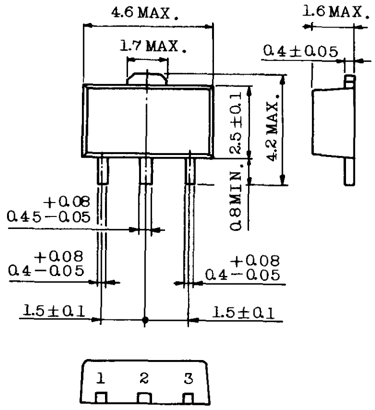
2SA1203

AUDIO FREQUENCY AMPLIFIER APPLICATIONS.

FEATURES:

- Suitable for Output Stage of 3 Watts Amplifier
- P_C=1 ~ 2W (Mounted on Ceramic Substrate)
- Small Flat Package
- Complementary to 2SC2883

Unit in mm

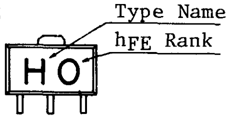


1. BASE
2. COLLECTOR (HEAT SINK)
3. EMITTER

JEDEC	—
EIAJ	—
TOSHIBA	2−5K1A

Weight : 0.052g

Marking



MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-30	V
Collector-Emitter Voltage	V_{CEO}	-30	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-1.5	A
Base Current	I_B	-0.3	A
Collector Power Dissipation	P_C	500	mW
Collector Power Dissipation	P_C※	1000	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55 ~ 150	°C

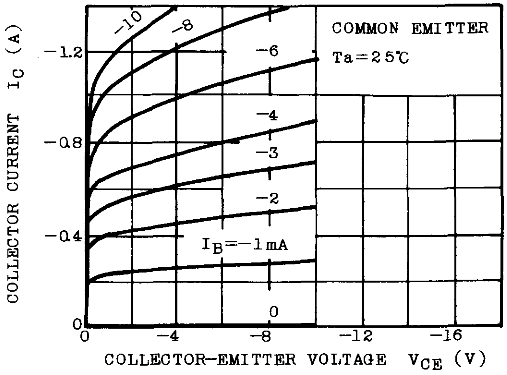
P_C※ : 2SA1203 mounted on ceramic substrate (250mm^2 × 0.8t)

ELECTRICAL CHARACTERISTICS (Ta=25°C)

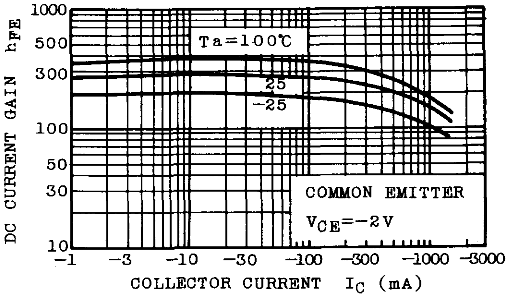
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-30V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-10mA, I_B=0	-30	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=-1mA, I_C=0	-5	-	-	V
DC Current Gain	h_{FE} (Note)	V_{CE}=-2V, I_C=-500mA	100	-	320	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-1.5A, I_B=-0.03A	-	-	-2.0	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-2V, I_C=-500mA	-	-	-1.0	V
Transition Frequency	f_T	V_{CE}=-2V, I_C=-500mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	-	50	pF

Note : h_{FE} Classification O : 100 ~ 200, Y : 160 ~ 320

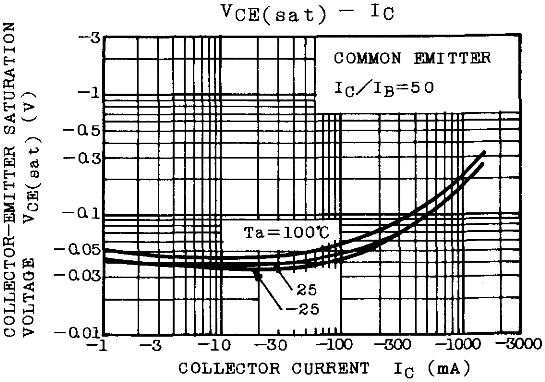
$I_C - V_{CE}$



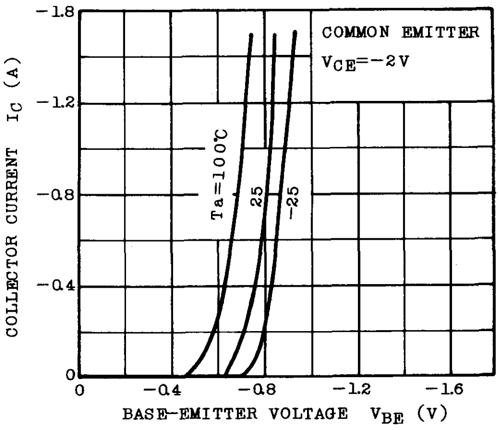
$h_{FE} - I_C$



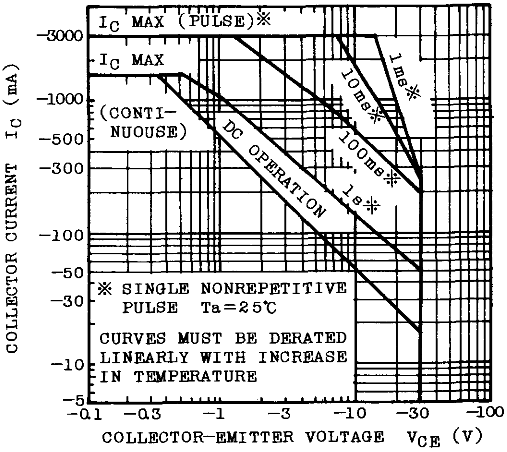
$V_{CE(sat)} - I_C$



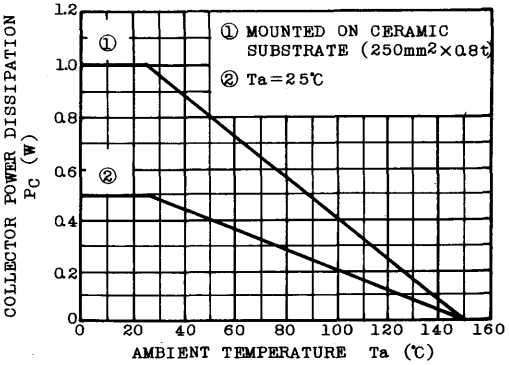
$I_C - V_{BE}$



SAFE OPERATING AREA



$P_C - Ta$

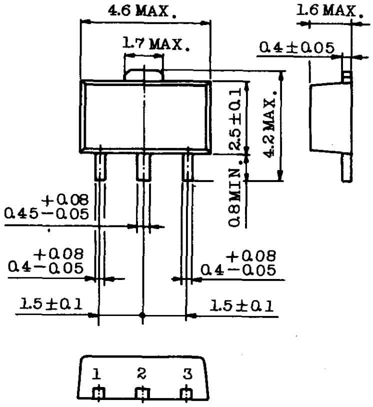


SILICON PNP EPITAXIAL TYPE (PCT) PROCESS

2SA1204

AUDIO FREQUENCY AMPLIFIER APPLICATIONS.

Unit in mm

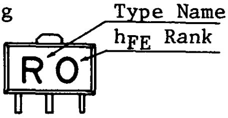


1. BASE
2. COLLECTOR (HEAT SINK)
3. EMITTER

JEDEC	–
EIAJ	–
TOSHIBA	2-5K1A

Weight : 0.052g

Marking



FEATURES:

- High DC Current Gain : h_{FE}=100～320
- Suitable for Output Stage of 1 Watts Amplifier
- P_C=1～2W (Mounted on Ceramic Substrate)
- Small Flat Package
- Complementary to 2SC2884

MAXIMUM RATINGS (Ta=25°C)

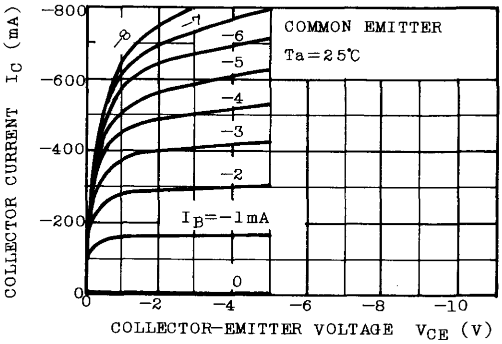
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-35	V
Collector-Emitter Voltage	V_{CEO}	-30	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-800	mA
Base Current	I_B	-160	mA
Collector Power Dissipation	P_C	500	mW
Collector Power Dissipation	P_C※	1000	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55～150	°C

P_C※ : 2SA1204 mounted on ceramic substrate ($250mm^2 \times 0.8t$)

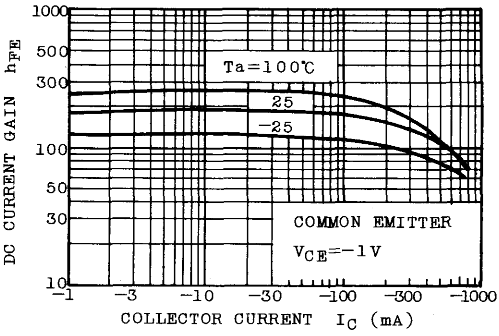
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-35V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-10mA, I_B=0	-30	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=-1V, I_C=-100mA	100	-	320	
	$h_{FE(2)}$	V_{CE}=-1V, I_C=-700mA	35	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-500mA, I_B=-20mA	-	-	-0.7	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-1V, I_C=-10mA	-0.5	-	-0.8	V
Transition Frequency	f_T	V_{CE}=-5V, I_C=10mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	19	-	pF

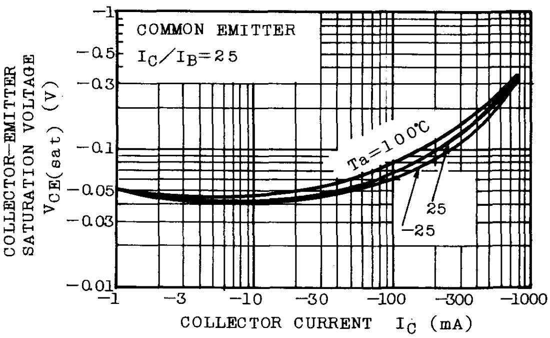
Note: $h_{FE(1)}$ Classification. O : 100～200, Y : 160～320



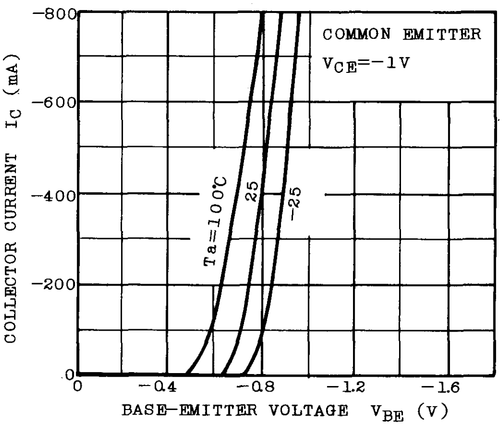
$I_C - V_{CE}$



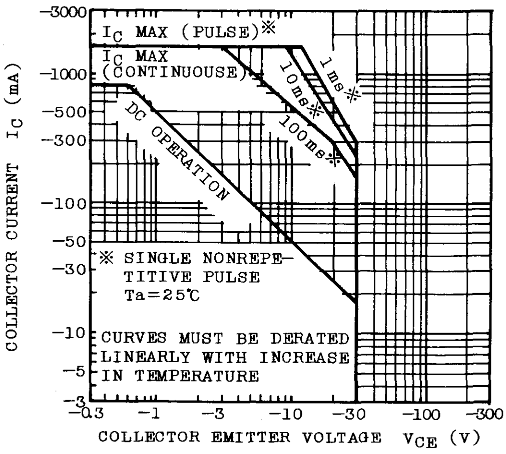
$h_{FE} - I_C$



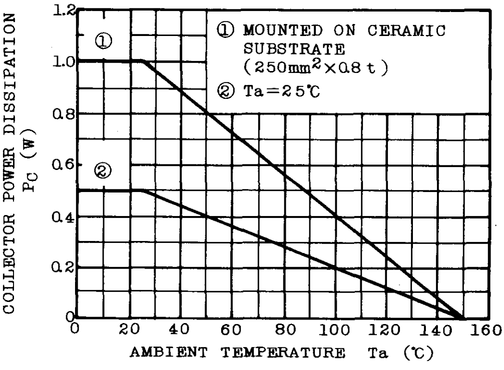
$V_{CE(sat)} - I_C$



$I_C - V_{BE}$



SAFE OPERATING AREA



$P_C - Ta$

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

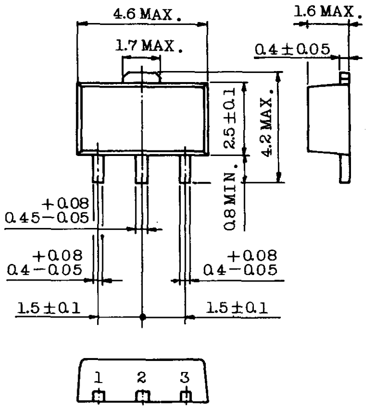
2SA1213

POWER AMPLIFIER APPLICATIONS.
POWER SWITCHING APPLICATIONS.

FEATURES:

- Low Saturation Voltage
  : $V_{CE(sat)}=-0.5V$(Max.) ($I_C=-1A$)
- High Speed Switching Time : $t_{stg}=1.0\mu s$(Typ.)
- $P_C=1\sim 2W$ (Mounted on Ceramic Substrate)
- Small Flat Package
- Complementary to 2SC2873

Unit in mm



1. BASE
2. COLLECTOR (HEAT SINK)
3. EMITTER

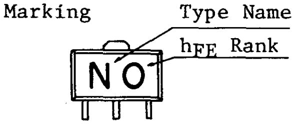
JEDEC	–
EIAJ	–
TOSHIBA	2–5K1A

Weight : 0.052g

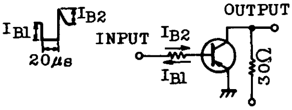
MAXIMUM RATINGS ($Ta=25^{\circ}C$)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-50	V
Collector-Emitter Voltage	V_{CEO}	-50	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-2	A
Base Current	I_B	-0.4	A
Collector Power Dissipation	P_C	500	mW
Collector Power Dissipation	P_C※	1000	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55～150	°C

P_C※ : 2SA1213 mounted on ceramic substrate ($250mm^2 \times 0.8t$)

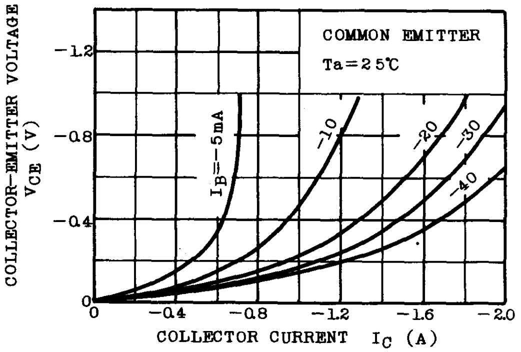


ELECTRICAL CHARACTERISTICS (Ta=25°C)

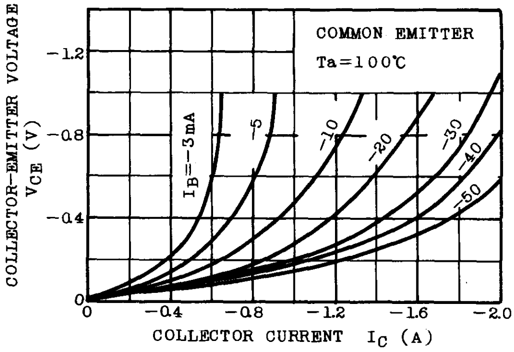
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=-50V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	I_C=-10mA, I_B=0	-50	-	-	V
DC Current Gain		$h_{FE}(1)$ (Note 2)	V_{CE}=-2V, I_C=-0.5A (Note 1)	70	-	240	
		$h_{FE}(2)$	V_{CE}=-2V, I_C=-2.0A (Note 1)	20	-	-	
Collector-Emitter Saturation Voltage		$V_{CE}(sat)$	I_C=-1A, I_B=-0.05A (Note 1)	-	-	-0.5	V
Base-Emitter Saturation Voltage		$V_{BE}(sat)$	I_C=-1A, I_B=-0.05A (Note 1)	-	-	-1.2	V
Transition Frequency		f_T	V_{CE}=-2V, I_C=-0.5A	-	120	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	40	-	pF
Switching Time	Turn-on Time	t_{on}	 $-I_{B1}=I_{B2}$=0.05A V_{CC}=-30V DUTY CYCLE≦1%	-	0.1	-	μs
	Storage Time	t_{stg}		-	1.0	-	
	Fall Time	t_f		-	0.1	-	

Note 1 : Pulse width≦300μs, Duty Cycle≦2%

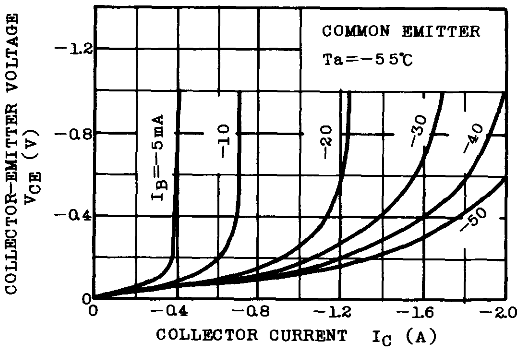
2 : $h_{FE}(1)$ Classification O : 70~140, Y : 120~240



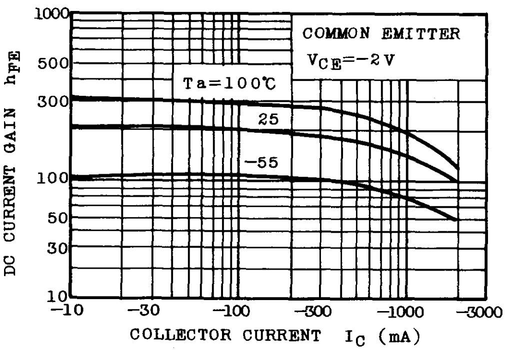
V_{CE} — I_C



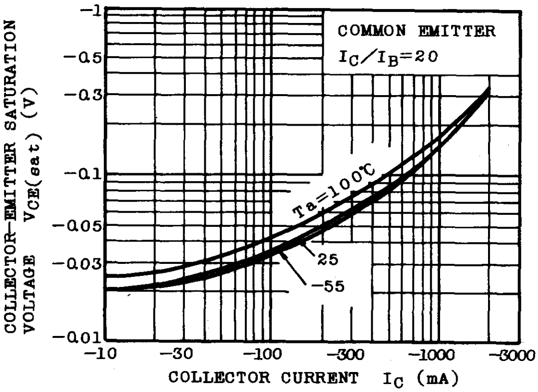
V_{CE} — I_C



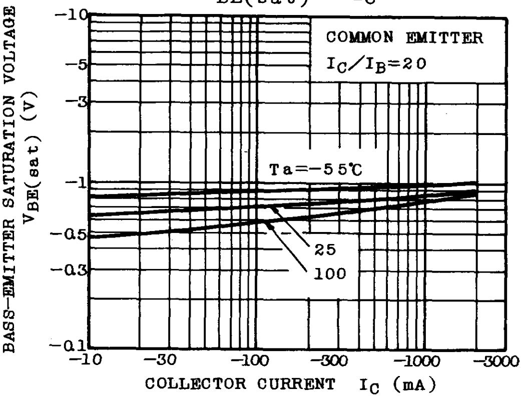
V_{CE} — I_C



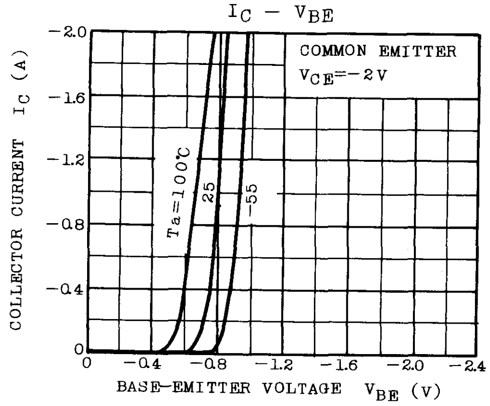
h_{FE} — I_C

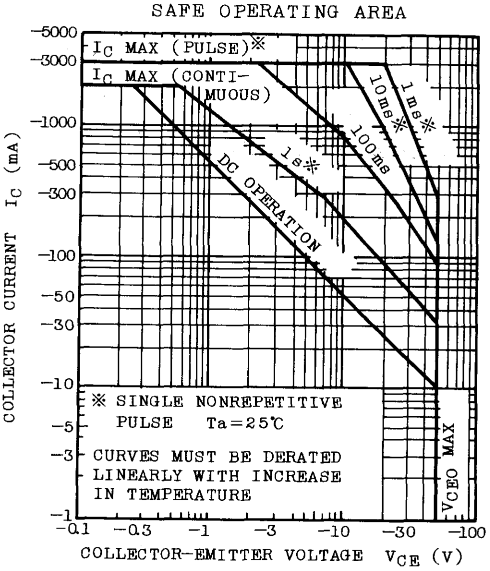


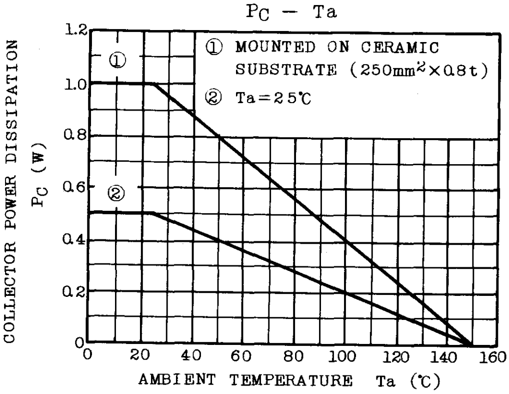
$V_{CE(sat)}$ — I_C



$V_{BE(sat)}$ — I_C


I_C – V_{BE}
COMMON EMITTER
V_{CE}=−2V
Ta=100℃
25
−55
COLLECTOR CURRENT I_C (A)
−2.0
−1.6
−1.2
−0.8
−0.4
0
0
−0.4
−0.8
−1.2
−1.6
−2.0
−2.4
BASE-EMITTER VOLTAGE V_{BE} (V)


SAFE OPERATING AREA
I_C MAX (PULSE)※
I_C MAX (CONTI-MUOUS)
10ms※
1ms※
100ms
1s※
DC OPERATION
V_{CEO} MAX
※ SINGLE NONREPETITIVE PULSE Ta=25℃
CURVES MUST BE DERATED LINEARLY WITH INCREASE IN TEMPERATURE
COLLECTOR CURRENT I_C (mA)
−5000
−3000
−1000
−500
−300
−100
−50
−30
−10
−5
−3
−1
−0.1
−0.3
−1
−3
−10
−30
−100
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)

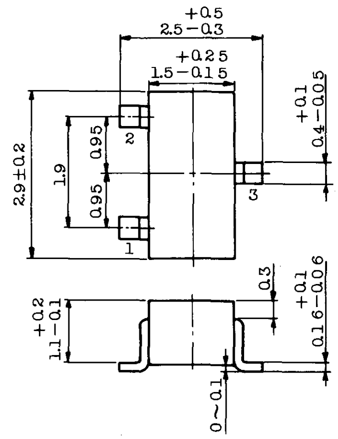

P_C – Ta
① MOUNTED ON CERAMIC SUBSTRATE (250mm²×0.8t)
② Ta=25℃
①
②
COLLECTOR POWER DISSIPATION P_C (W)
1.2
1.0
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
120
140
160
AMBIENT TEMPERATURE Ta (℃)

SILICON PNP EPITAXIAL PLANAR TYPE

2SA1245

HIGH FREQUENCY AMPLIFIER AND SWITCHING APPLICATIONS.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	−
EIAJ	SC−59
TOSHIBA	2−3F1A

Weight : 0.012g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-15	V
Collector-Emitter Voltage	V_{CEO}	-8	V
Emitter-Base Voltage	V_{EBO}	-2	V
Collector Current	I_C	-30	mA
Emitter Current	I_E	30	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

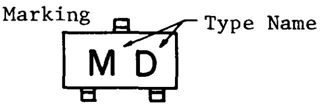
MICROWAVE CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Transition Frequency	f_T	V_{CE}=-5V, I_C=-10mA	-	4	-	GHz
Insertion Gain	$\lvert S_{21e}\rvert^2(1)$	V_{CE}=-5V, I_C=-10mA, f=500MHz	-	14	-	dB
	$\lvert S_{21e}\rvert^2(2)$	V_{CE}=-5V, I_C=-10mA, f=1GHz	-	9.5	-	dB
Noise Figure	NF(1)	V_{CE}=-5V, I_C=-3mA, f=500MHz	-	2.5	-	dB
	NF(2)	V_{CE}=-5V, I_C=-3mA, f=1GHz	-	3.0	-	dB

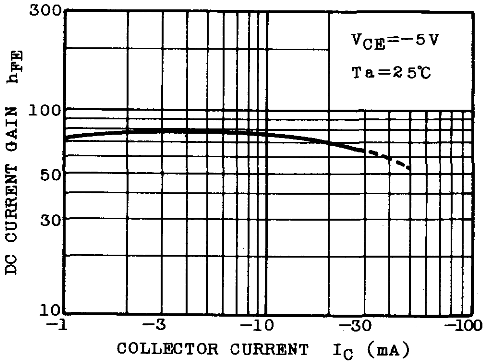
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-5V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-1V, I_C=0	-	-	-0.1	μA
DC Current Gain	h_{FE}	V_{CE}=-5V, I_C=-10mA	20	-	-	
Output Capacitance	C_{ob}	V_{CB}=-5V, I_E=0, f=1MHz	-	0.75	-	pF
Reverse Transfer Capacitance	C_{re}	(Note)	-	0.60	-	pF

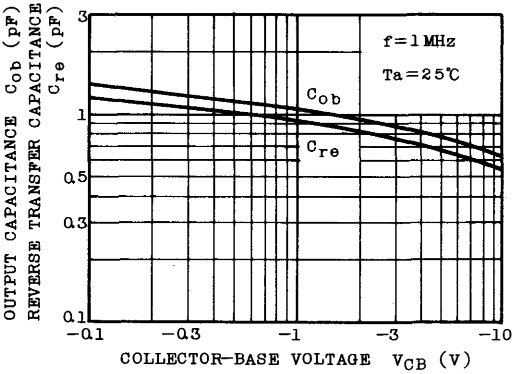
Note : Cre is measured by 3 terminal method with Capacitance Bridge.



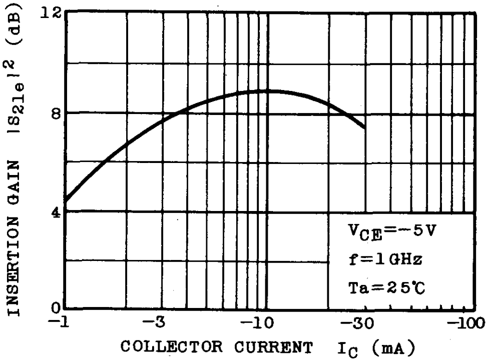
h_{FE} — I_C



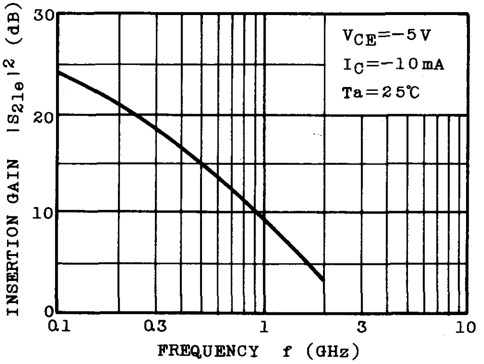
C_{ob}, C_{re} — V_{CB}



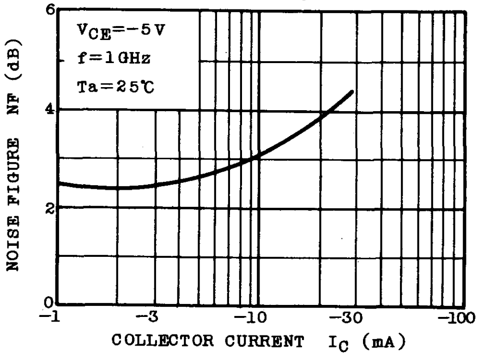
$|S_{21e}|^2$ — I_C



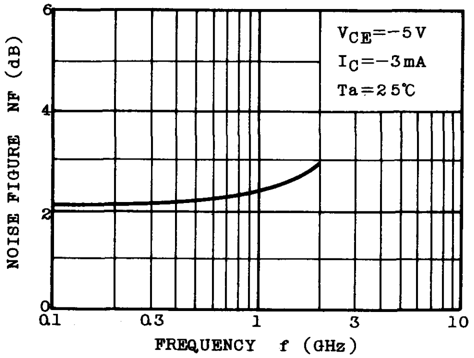
$|S_{21e}|^2$ — f



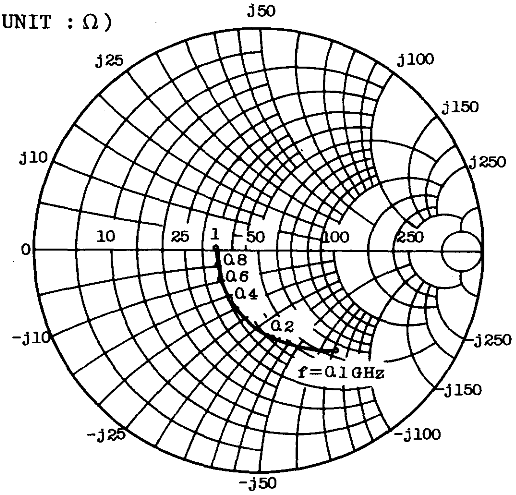
NF — I_C



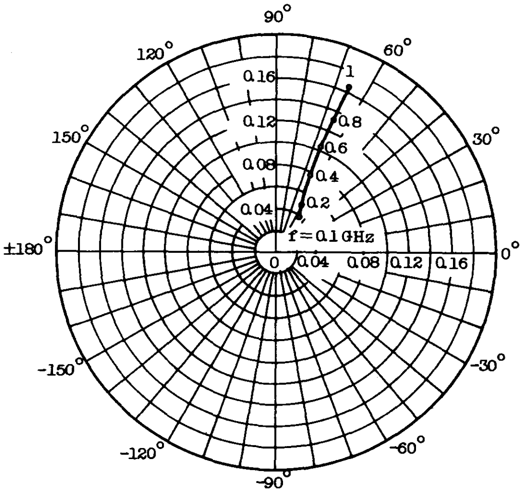
NF — f



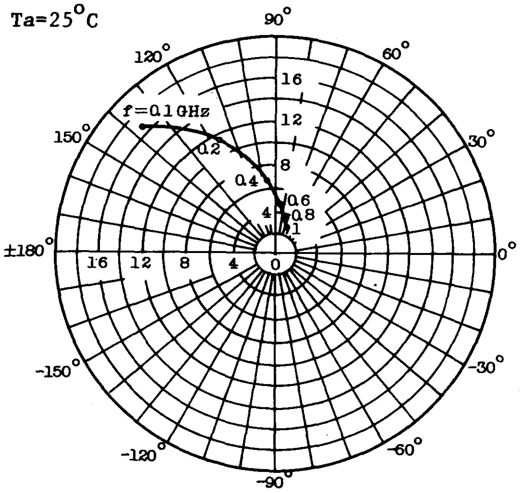
S_{11e}
V_{CE}=-5V
I_C=-10mA
Ta=25°C
(UNIT : Ω)



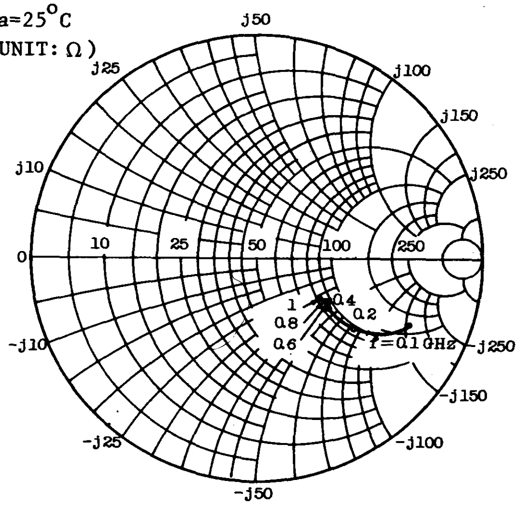
S_{12e}
V_{CE}=-5V
I_C=-10mA
Ta=25°C



S_{21e}
V_{CE}=-5V
I_C=-10mA
Ta=25°C



S_{22e}
V_{CE}=-5V
I_C=-10mA
Ta=25°C
(UNIT: Ω)



2SA1255

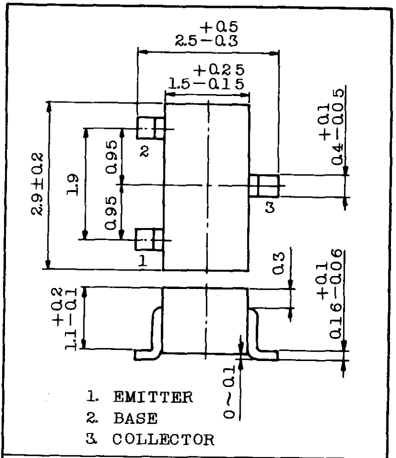
SILICON PNP TRIPLE DIFFUSED (PCT PROCESS)

HIGH VOLTAGE SWITCHING APPLICATIONS.

FEATURES:

- High Voltage : V_{CEO}=-200V
- Small Flat Package
- Complementary to 2SC3138

Unit in mm

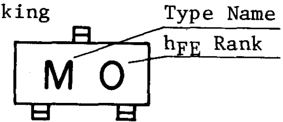


1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	−
EIAJ	−
TOSHIBA	2−3F1A

Weight : 0.012g

Marking



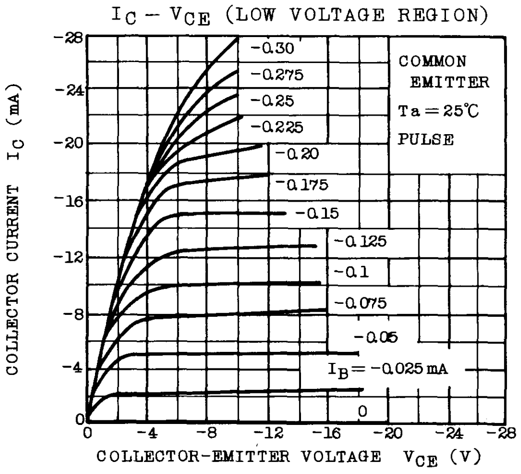
MAXIMUM RATINGS (Ta=25°C)

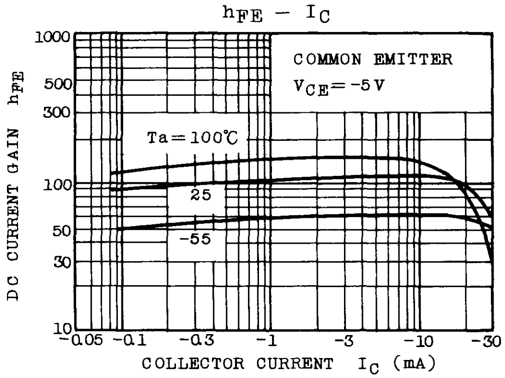
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-200	V
Collector-Emitter Voltage	V_{CEO}	-200	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-50	mA
Base Current	I_B	-20	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	Tstg	-55~125	°C

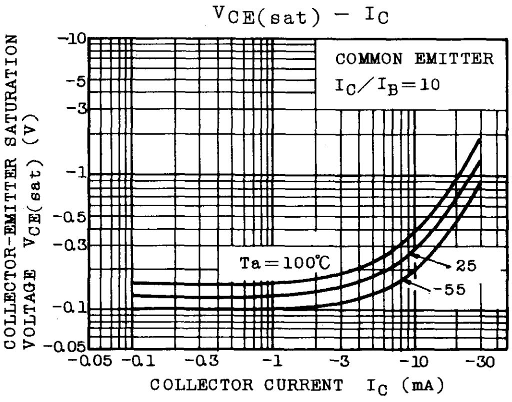
ELECTRICAL CHARACTERISTICS (Ta=25°C)

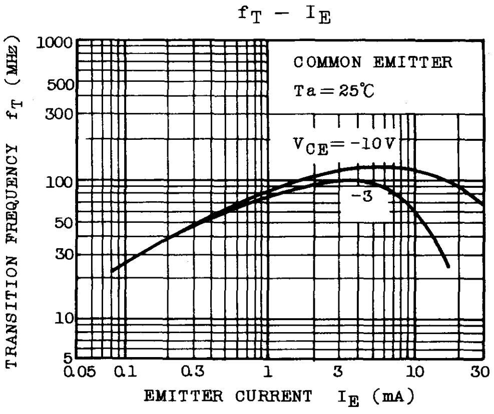
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=-200V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=5V, I_C=0	-	-	-0.1	μA
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$	I_C=-0.1mA, I_E=0	-200	-	-	V
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	I_C=-1mA, I_B=0	-200	-	-	V
DC Current Gain		h_{FE} (Note)	V_{CE}=-3V, I_C=-1mA	70	-	240	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=-10mA, I_B=-1mA	-	-0.2	-1	V
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=-10mA, I_B=-1mA	-	-0.75	-1.5	V
Transition Frequency		f_T	V_{CE}=-10V, I_C=-2mA	50	100	-	MHz
Collector Output Capacitance		Cob	V_{CB}=-10V, I_E=0, f=1MHz	-	3	7	pF
Switching Time	Turn-on Time	ton	V_{CC}=-50V, PULSE WIDTH=5μs	-	0.3	-	μs
	Storage Time	tstg	I_C=-6mA, DUTY CYCLE≦2%	-	2	-	μs
	Fall Time	tf	$-I_{B1}=I_{B2}$=0.5mA	-	0.4	-	μs

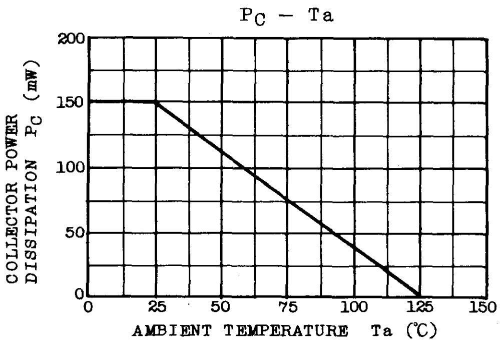
Note : h_{FE} Classification O : 70~140, Y : 120~240


IC – VCE (LOW VOLTAGE REGION)
COMMON EMITTER
Ta = 25℃
PULSE
−0.30
−0.275
−0.25
−0.225
−0.20
−0.175
−0.15
−0.125
−0.1
−0.075
−0.05
IB = −0.025 mA
0
COLLECTOR CURRENT IC (mA)
−28
−24
−20
−16
−12
−8
−4
0
COLLECTOR-EMITTER VOLTAGE VCE (V)
0
−4
−8
−12
−16
−20
−24
−28


hFE – IC
COMMON EMITTER
VCE = −5 V
Ta = 100℃
25
−55
DC CURRENT GAIN hFE
1000
500
300
100
50
30
10
COLLECTOR CURRENT IC (mA)
−0.05
−0.1
−0.3
−1
−3
−10
−30


VCE(sat) – IC
COMMON EMITTER
IC/IB = 10
Ta = 100℃
25
−55
COLLECTOR-EMITTER SATURATION VOLTAGE VCE(sat) (V)
−10
−5
−3
−1
−0.5
−0.3
−0.1
−0.05
COLLECTOR CURRENT IC (mA)
−0.05
−0.1
−0.3
−1
−3
−10
−30


fT – IE
COMMON EMITTER
Ta = 25℃
VCE = −10 V
−3
TRANSITION FREQUENCY fT (MHz)
1000
500
300
100
50
30
10
5
EMITTER CURRENT IE (mA)
0.05
0.1
0.3
1
3
10
30


PC – Ta
COLLECTOR POWER DISSIPATION PC (mW)
200
150
100
50
0
AMBIENT TEMPERATURE Ta (℃)
0
25
50
75
100
125
150

2SA1298

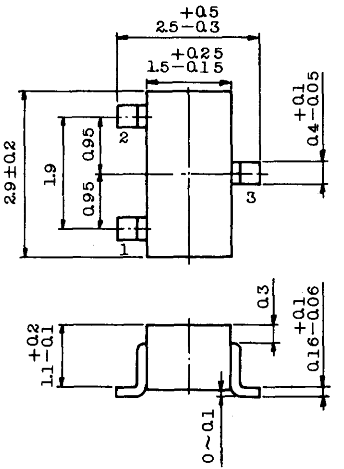
SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

LOW FREQUENCY POWER AMPLIFIER APPLICATION.
POWER SWITCHING APPLICATIONS.

FEATURES:

- High DC Current Gain : h_{FE}=100 ~ 320
- Low Saturation Voltage
  : $V_{CE(sat)}$=-0.4V(Max.) (I_C=-500mA, I_B=-20mA)
- Suitable for Driver Stage of Small Motor
- Complementary to 2SC3265
- Small Package

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	−
EIAJ	SC−59
TOSHIBA	2−3F1A

Weight : 0.012g

MAXIMUM RATINGS (Ta=25°C)

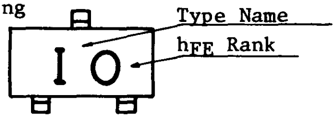
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-35	V
Collector-Emitter Voltage	V_{CEO}	-25	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-800	mA
Base Current	I_B	-160	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55 ~ 150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

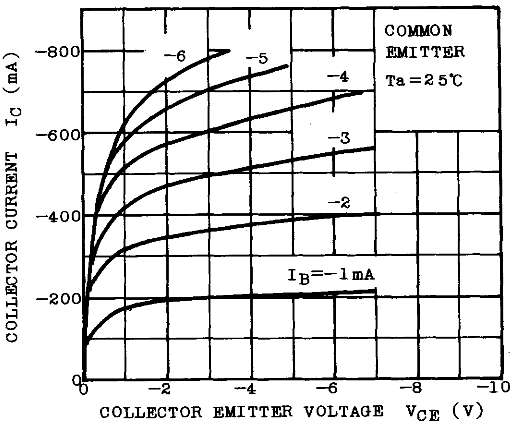
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-30V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-10mA, I_B=0	-25	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=-1mA, I_C=0	-5	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=-1V, I_C=-100mA	100	-	320	
	$h_{FE(2)}$	V_{CE}=-1V, I_C=-800mA	40	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-500mA, I_B=-20mA	-	-	-0.4	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-1V, I_C=-10mA	-0.5	-	-0.8	V
Transition Frequency	f_T	V_{CE}=-5V, I_C=-10mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	13	-	pF

Note : $h_{FE(1)}$ Classification O : 100 ~ 200,
Y : 160 ~ 320

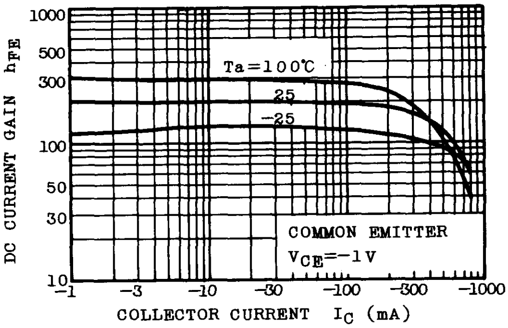
Marking



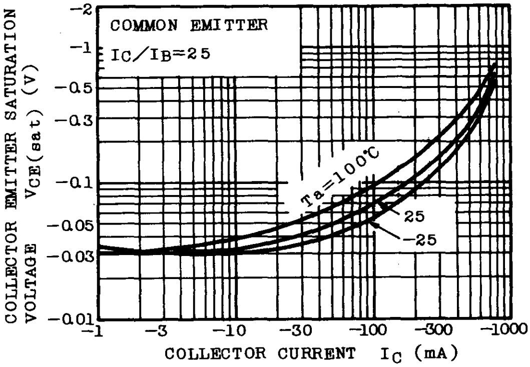
$I_C - V_{CE}$



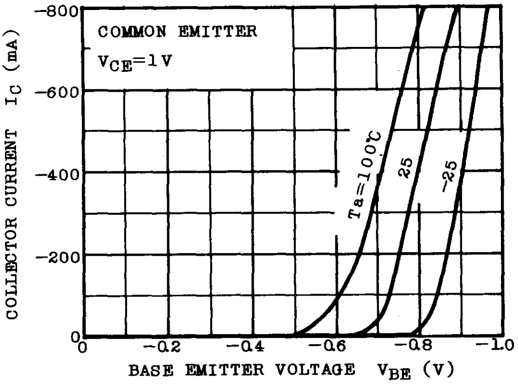
$h_{FE} - I_C$



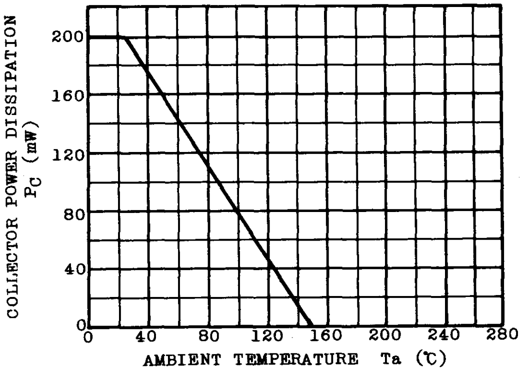
$V_{CE(sat)} - I_C$



$I_C - V_{BE}$



$P_C - Ta$



2SA1300

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

STROBO FLASH APPLICATIONS.

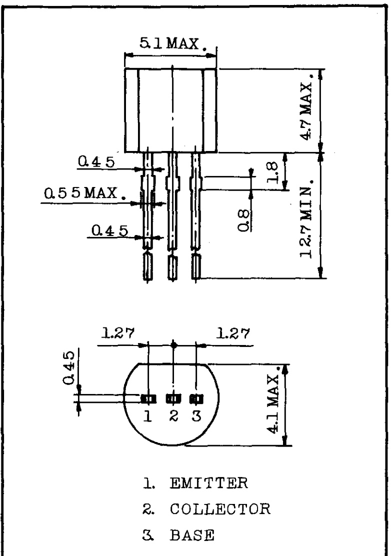
MEDIUM POWER AMPLIFIER APPLICATIONS.

FEATURES:

. High DC Current Gain and Excellent h_{FE} Linearity
  : $h_{FE(1)}$=140~600 (V_{CE}=-1V, I_C=-0.5A)
  : $h_{FE(2)}$=60(Min.), 120(Typ.) (V_{CE}=-1V, I_C=-4A)

. Low Saturation Voltage
  : $V_{CE(sat)}$=-0.5V(Max.) (I_C=-2A, I_B=-50mA)

Unit in mm



JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Voltage		V_{CBO}	-20	V
Collector-Emitter Voltage		V_{CES}	-20	V
		V_{CEO}	-10	
Emitter-Base Voltage		V_{EBO}	-6	V
Collector Current	DC	I_C	-2	A
	Pulsed (Note 1)	I_{CP}	-5	
Base Current		I_B	-2	A
Collector Power Dissipation		P_C	750	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_{stg}	-55~150	°C

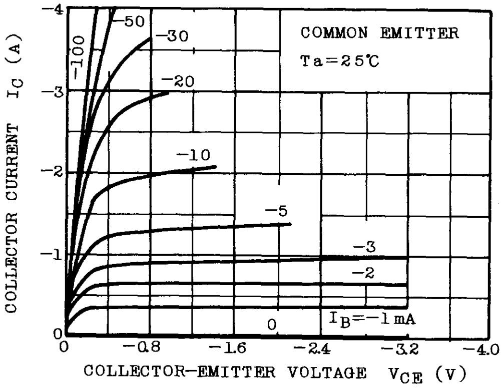
Note 1 : Pulse Width=10ms(Max.), Duty Cycle=30%(Max.)

ELECTRICAL CHARACTERISTICS (Ta=25°C)

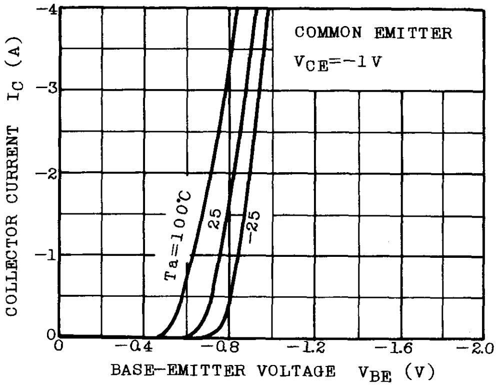
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-20V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-6V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-10mA, I_B=0	-10	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=-1mA, I_C=0	-6	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note 2)	V_{CE}=-1V, I_C=-0.5A	140	-	600	
	$h_{FE(2)}$	V_{CE}=-1V, I_C=-4A	60	120	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-2A, I_B=-50mA	-	-0.20	-0.50	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-1V, I_C=-2A	-	-0.83	-1.5	V
Transition Frequency	f_T	V_{CE}=-1V, I_C=-0.5A	-	140	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	50	-	pF

Note 2 : $h_{FE(1)}$ Classification Y : 140~280, GR : 200~400, BL : 300~600

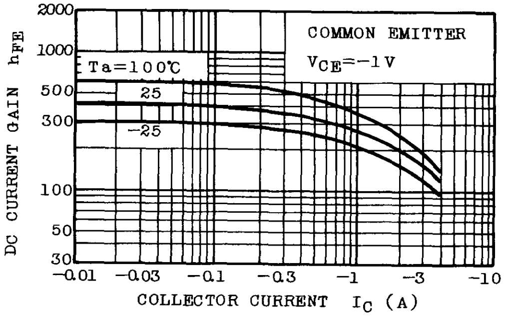
I_C — V_{CE}



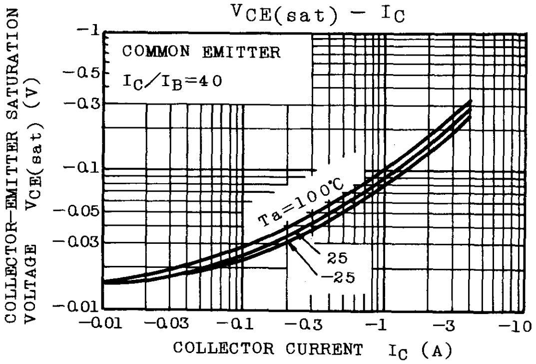
I_C — V_{BE}



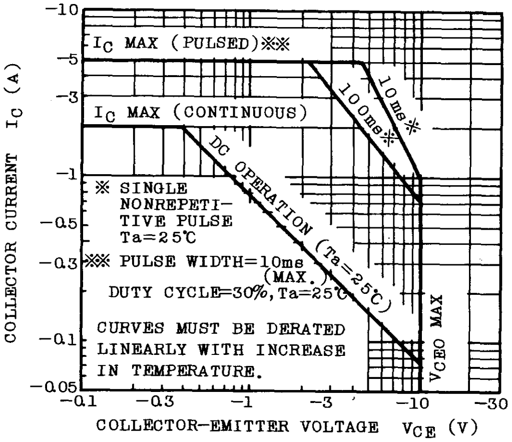
h_{FE} — I_C



$V_{CE(sat)}$ — I_C



SAFE OPERATING AREA

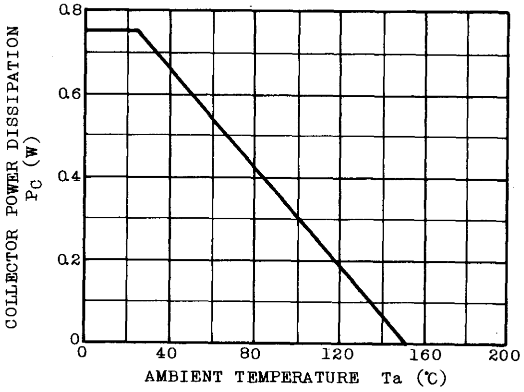


※ SINGLE NONREPETITIVE PULSE
Ta=25℃

※※ PULSE WIDTH=10ms (MAX.)
DUTY CYCLE=30%, Ta=25℃

CURVES MUST BE DERATED LINEARLY WITH INCREASE IN TEMPERATURE.

P_C — Ta



2SA1312

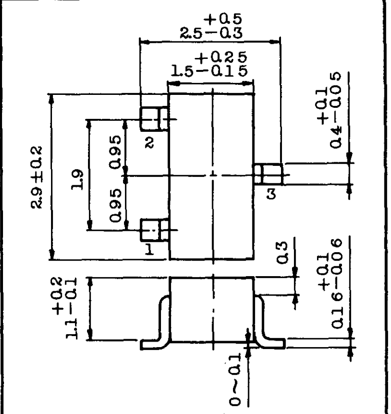
SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

AUDIO FREQUENCY LOW NOISE AMPLIFIER APPLICATIONS.

FEATURES:

- High Voltage : V_{CEO}=-120V
- Excellent h_{FE} Linearity
  : h_{FE}(0.1mA)/h_{FE}(2mA)=0.95(Typ.)
- High h_{FE} : h_{FE}=200~700
- Low Noise : NF=0.2dB(Typ.), 3dB(Max.) at f=1kHz
- Complementary to 2SC3324
- Small Package

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

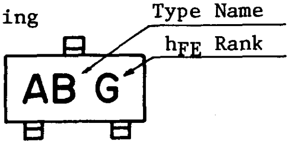
JEDEC	–
EIAJ	SC-59
TOSHIBA	2-3F1A

Weight : 0.012g

MAXIMUM RATINGS (T_a=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-120	V
Collector-Emitter Voltage	V_{CEO}	-120	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-100	mA
Base Current	I_B	-20	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

Marking

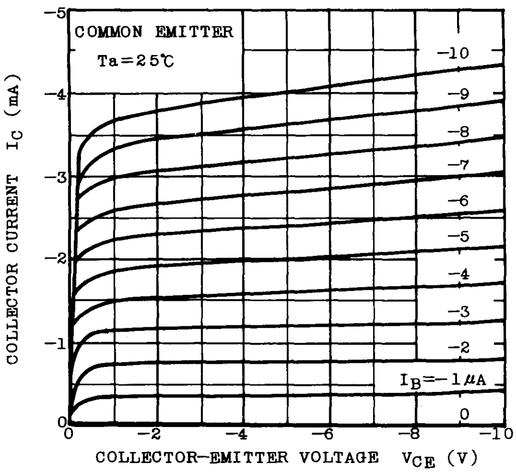


ELECTRICAL CHARACTERISTICS (T_a=25°C)

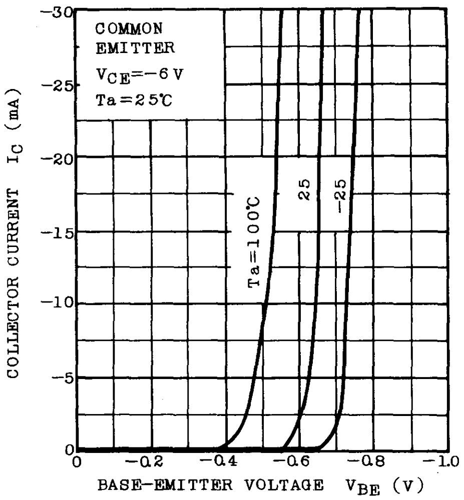
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-120V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=-6V, I_C=-2mA	200	-	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-10mA, I_B=-1mA	-	-	-0.3	V
Transition Frequency	f_T	V_{CE}=-6V, I_C=-1mA	-	100	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	4	-	pF
Noise Figure	NF(1)	V_{CE}=-6V, I_C=-0.1mA f=100Hz, R_g=10kΩ	-	0.5	6	dB
	NF(2)	V_{CE}=-6V, I_C=-0.1mA f=1kHz, R_g=10kΩ	-	0.2	3	dB

Note : h_{FE} Classification GR(G) : 200~400, BL(L) : 350~700

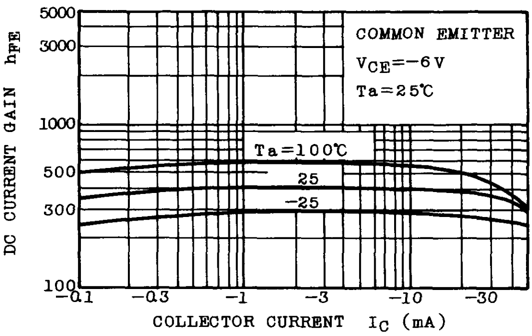
I_C — V_{CE}



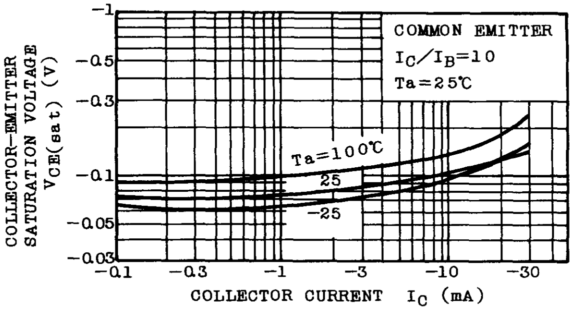
I_C — V_{BE}



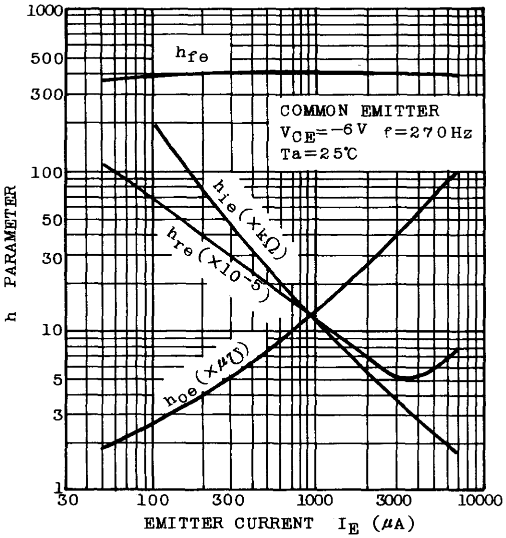
h_{FE} — I_C



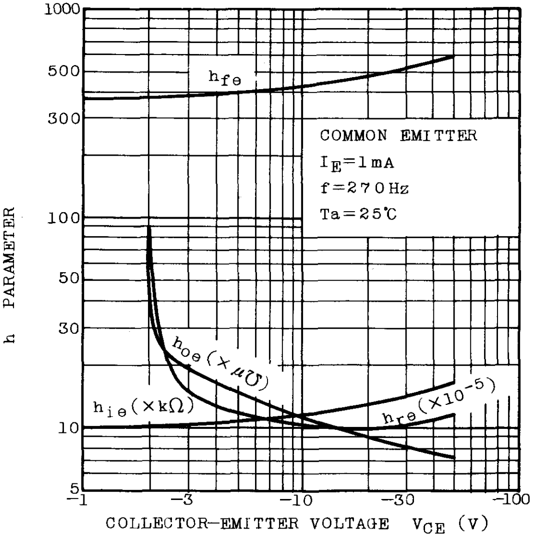
$V_{CE(sat)}$ — I_C



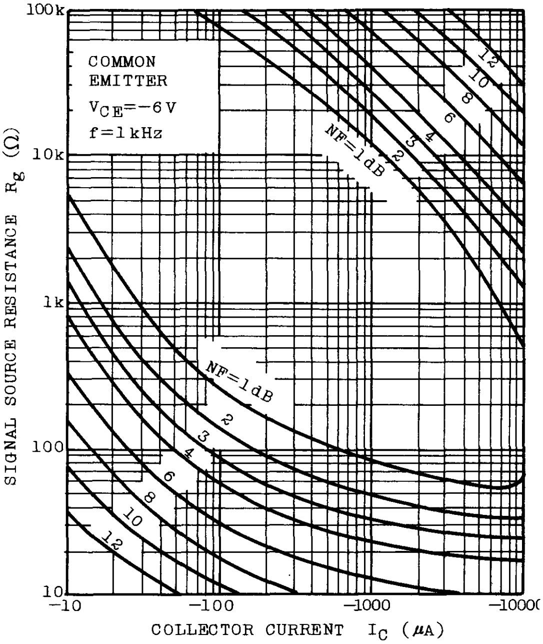
h PARAMETER — I_E



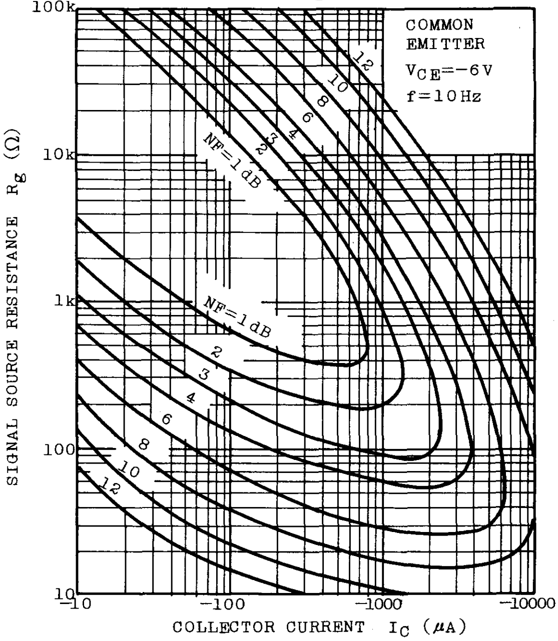
h PARAMETER – V_{CE}



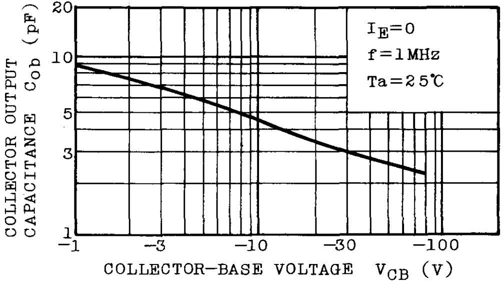
NF – R_g, I_C



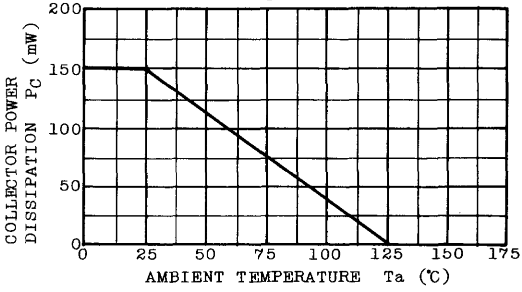
NF – R_g, I_C



C_{ob} – V_{CB}



P_C – Ta



SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

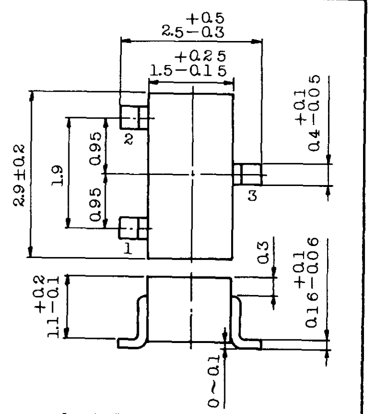
2SA1313

AUDIO FREQUENCY LOW POWER AMPLIFIER APPLICATIONS.
DRIVER STAGE AMPLIFIER APPLICATIONS.
SWITCHING APPLICATIONS.

FEATURES:

- Excellent h_{FE} Linearity : $h_{FE(2)}$=25(Min.)
  at V_{CE}=-6V, I_C=-400mA
- High Voltage : V_{CEO}=-50V (Min.)
- Complementary to 2SC3325
- Small Package

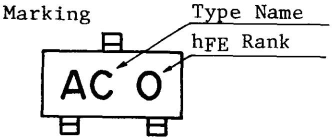
Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	–
EIAJ	SC-59
TOSHIBA	2-3F1A

Weight : 0.012g



MAXIMUM RATINGS (Ta=25°C)

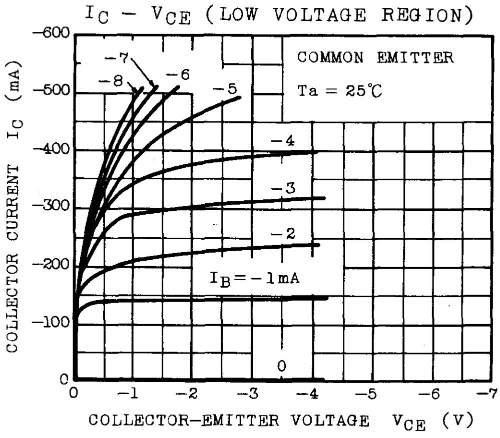
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-50	V
Collector-Emitter Voltage	V_{CEO}	-50	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-500	mA
Base Current	I_B	-50	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55～150	°C

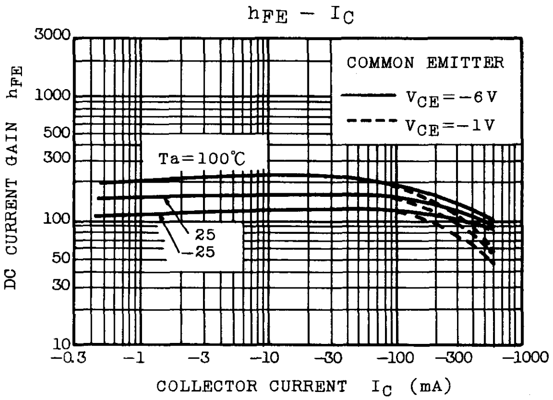
ELECTRICAL CHARACTERISTICS (Ta=25°C)

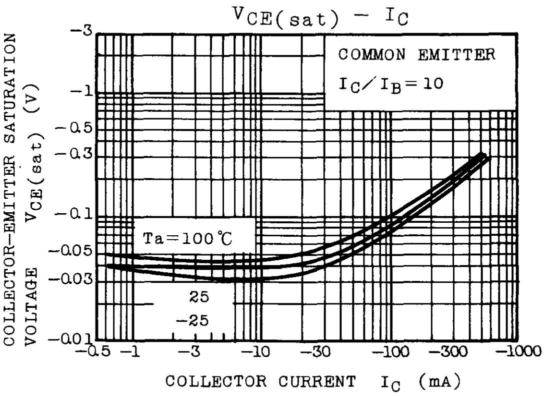
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-35V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=-1V, I_C=-100mA	70	-	240	
	$h_{FE(2)}$ (Note)	V_{CE}=-6V, I_C=-400mA	25	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-100mA, I_B=-10mA	-	-0.1	-0.25	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-1V, I_C=-100mA	-	-0.8	-1.0	V
Transition Frequency	f_T	V_{CE}=-6V, I_C=-20mA	-	200	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-6V, I_E=0, f=1MHz	-	13	-	pF

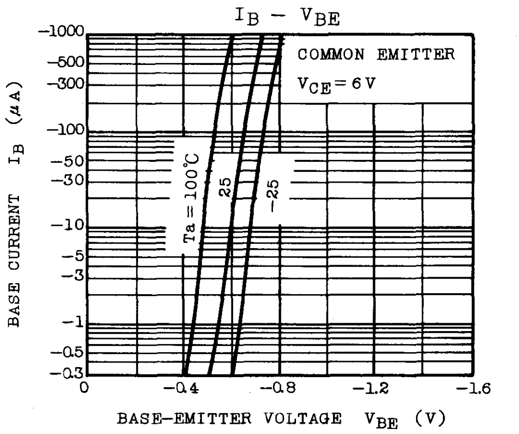
Note : $h_{FE(1)}$ Classification O : 70～140, Y : 120～240
$h_{FE(2)}$ Classification O : 25Min. Y : 40Min.

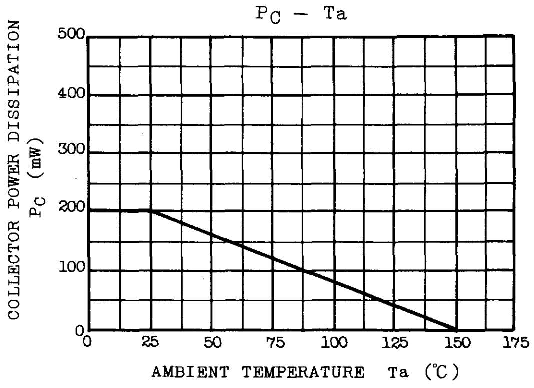
2SA1313


I_C − V_{CE} (LOW VOLTAGE REGION)
COMMON EMITTER
Ta = 25℃
−7
−8
−6
−5
−4
−3
−2
I_B = −1mA
0
COLLECTOR CURRENT I_C (mA)
−600
−500
−400
−300
−200
−100
0
0
−1
−2
−3
−4
−5
−6
−7
COLLECTOR−EMITTER VOLTAGE V_{CE} (V)


h_{FE} − I_C
COMMON EMITTER
V_{CE} = −6 V
V_{CE} = −1 V
Ta = 100℃
25
−25
DC CURRENT GAIN h_{FE}
3000
1000
500
300
100
50
30
10
−0.3
−1
−3
−10
−30
−100
−300
−1000
COLLECTOR CURRENT I_C (mA)


$V_{CE(sat)}$ − I_C
COMMON EMITTER
I_C/I_B = 10
Ta = 100℃
25
−25
COLLECTOR−EMITTER SATURATION VOLTAGE $V_{CE(sat)}$ (V)
−3
−1
−0.5
−0.3
−0.1
−0.05
−0.03
−0.01
−0.5
−1
−3
−10
−30
−100
−300
−1000
COLLECTOR CURRENT I_C (mA)


I_B − V_{BE}
COMMON EMITTER
V_{CE} = 6 V
Ta = 100℃
25
−25
BASE CURRENT I_B (μA)
−1000
−500
−300
−100
−50
−30
−10
−5
−3
−1
−0.5
−0.3
0
−0.4
−0.8
−1.2
−1.6
BASE−EMITTER VOLTAGE V_{BE} (V)

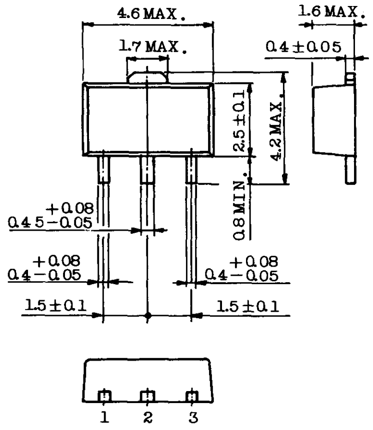

P_C − Ta
COLLECTOR POWER DISSIPATION P_C (mW)
500
400
300
200
100
0
0
25
50
75
100
125
150
175
AMBIENT TEMPERATURE Ta (℃)

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

2SA1314

STROBO FLASH APPLICATIONS.
AUDIO POWER APPLICATIONS.

Unit in mm

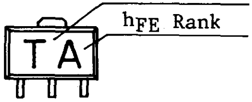


1. BASE
2. COLLECTOR(HEAT SINK)
3. EMITTER

JEDEC	―
EIAJ	―
TOSHIBA	2-5K1A

Weight : 0.052g

Marking



FEATURES:

- High DC Current Gain and Excellent Linearity
  - : $h_{FE}(1)=140 \sim 600$ ($V_{CE}=-1V$, $I_C=-0.5A$)
  - : $h_{FE}(2)=60$ (Min.), 120 (Typ.), ($V_{CE}=-1V$, $I_C=-4A$)
- Low Saturation Voltage
  - : $V_{CE(sat)}=-0.5V$(Max.) ($I_C=-2A$, $I_B=-50mA$)
- Small Package

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Voltage		V_{CBO}	-30	V
Collector-Emitter Voltage		V_{CES}	-30	V
		V_{CEO}	-10	V
Emitter-Base Voltage		V_{EBO}	-6	V
Collector Current	DC	I_C	-2	A
	Pulse (Note 1)	I_{CP}	-4	A
Base Current	DC	I_B	-0.4	A
	Pulse	I_{BP}	-0.8	A
Collector Power Dissipation		P_C	500	mW
		P_C※	1000	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_{stg}	-55 ~ 150	°C

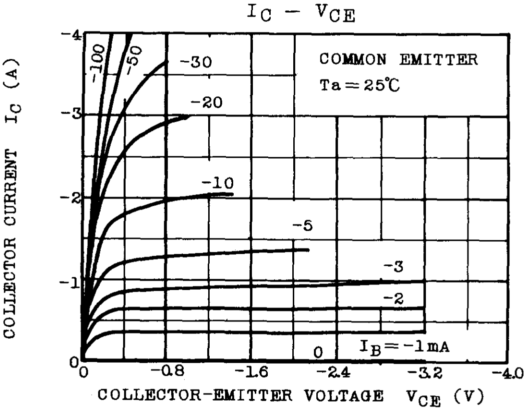
Note 1 Pulse Test : Pulse Width=10ms(Max.), Duty Cycle=30%(Max.)

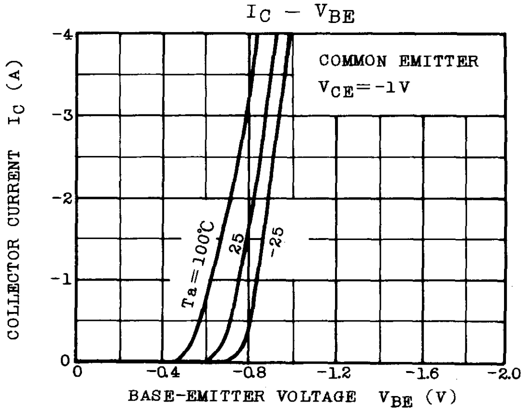
P_C※ : 2SA1314 mounted on Ceramic Substrate ($250mm^2 \times 0.8mmt$)

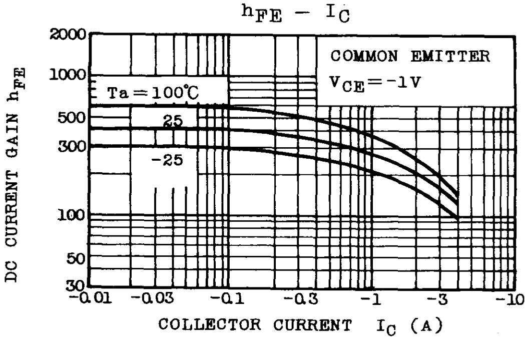
ELECTRICAL CHARACTERISTICS (Ta=25°C)

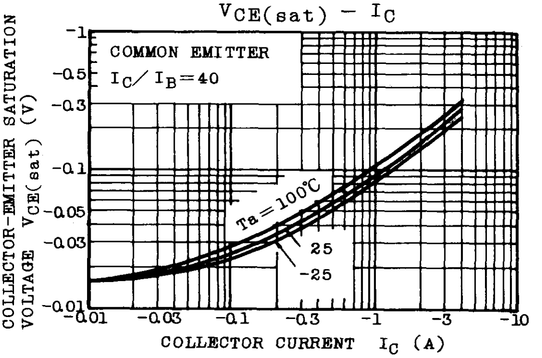
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-30V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-6V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-10mA, I_B=0	-10	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=1mA, I_C=0	-6	-	-	V
DC Current Gain (Note 2)	$h_{FE(1)}$	V_{CE}=-1V, I_C=-0.5A	140	-	600	
	$h_{FE(2)}$	V_{CE}=-1V, I_C=-4A	60	120	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-2A, I_B=-50mA	-	-0.2	-0.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-1V, I_C=-2A	-	-0.86	-1.5	V
Transisiton Frequency	f_T	V_{CE}=-1V, I_C=-0.5A	-	140	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	50	-	pF

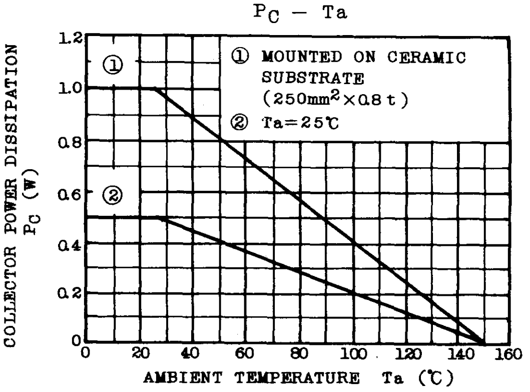
Note 2 : $h_{FE(1)}$ Classification A : 140～280, B : 200～400, C : 300～600

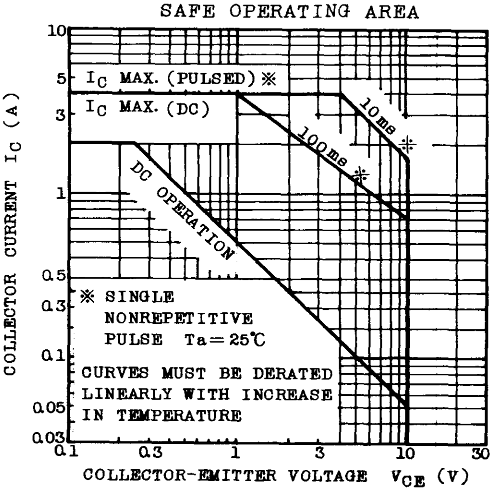

IC − VCE
COMMON EMITTER
Ta=25℃
COLLECTOR CURRENT IC (A)
COLLECTOR-EMITTER VOLTAGE VCE (V)
-100
-50
-30
-20
-10
-5
-3
-2
IB=-1mA
0
-4
-3
-2
-1
0
-0.8
-1.6
-2.4
-3.2
-4.0


IC − VBE
COMMON EMITTER
VCE=-1V
COLLECTOR CURRENT IC (A)
BASE-EMITTER VOLTAGE VBE (V)
Ta=100℃
25
-25
-4
-3
-2
-1
0
-0.4
-0.8
-1.2
-1.6
-2.0


hFE − IC
COMMON EMITTER
VCE=-1V
DC CURRENT GAIN hFE
COLLECTOR CURRENT IC (A)
Ta=100℃
25
-25
2000
1000
500
300
100
50
30
-0.01
-0.03
-0.1
-0.3
-1
-3
-10


VCE(sat) − IC
COMMON EMITTER
IC/IB=40
COLLECTOR-EMITTER SATURATION VOLTAGE VCE(sat) (V)
COLLECTOR CURRENT IC (A)
Ta=100℃
25
-25
-1
-0.5
-0.3
-0.1
-0.05
-0.03
-0.01
-0.01
-0.03
-0.1
-0.3
-1
-3
-10


PC − Ta
① MOUNTED ON CERAMIC SUBSTRATE (250mm2×0.8t)
② Ta=25℃
①
②
COLLECTOR POWER DISSIPATION PC (W)
AMBIENT TEMPERATURE Ta (℃)
1.2
1.0
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
120
140
160


SAFE OPERATING AREA
IC MAX. (PULSED)※
IC MAX. (DC)
10ms※
100ms※
DC OPERATION
※ SINGLE NONREPETITIVE PULSE Ta=25℃
CURVES MUST BE DERATED LINEARLY WITH INCREASE IN TEMPERATURE
COLLECTOR CURRENT IC (A)
COLLECTOR-EMITTER VOLTAGE VCE (V)
10
5
3
1
0.5
0.3
0.1
0.05
0.03
0.1
0.3
1
3
10
30

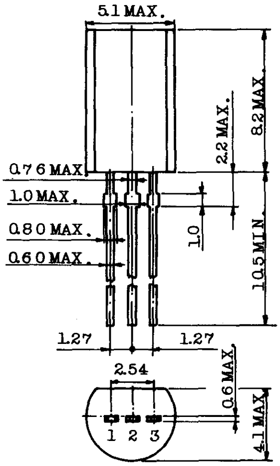
2SA1315

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)
(INDUSTRIAL APPLICATIONS)

POWER AMPLIFIER APPLICATIONS.
POWER SWITCHING APPLICATIONS.

FEATURES:
- Low Collector Saturation Voltage
  : $V_{CE(sat)}$=-0.5V(Max.) (I_C=-1A)
- High Speed Switching Time : t_{stg}=1.0μs(Typ.)
- Complementary to 2SC3328

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

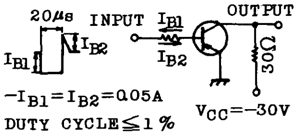
JEDEC	TO-92MOD
EIAJ	–
TOSHIBA	2-5J1A

Weight : 0.36g

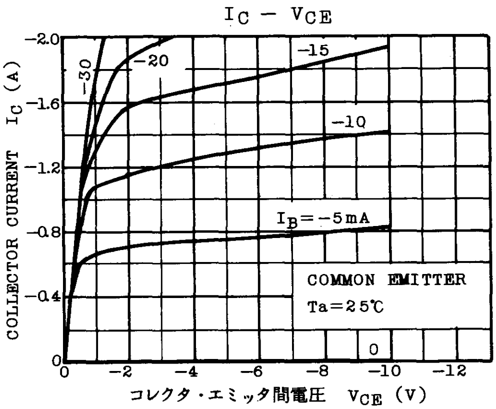
MAXIMUM RATINGS (T_a=25°C)

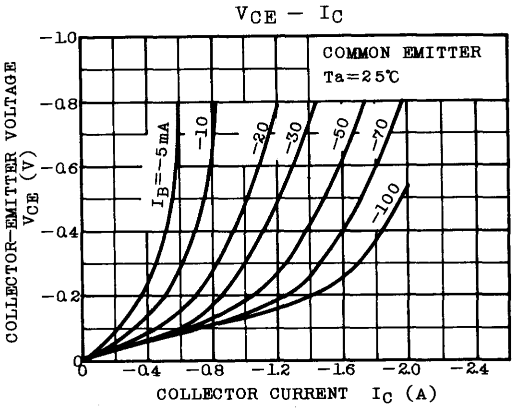
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-80	V
Collector-Emitter Voltage	V_{CEO}	-80	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-2	A
Base Current	I_B	-1	A
Collector Power Dissipation	P_C	900	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

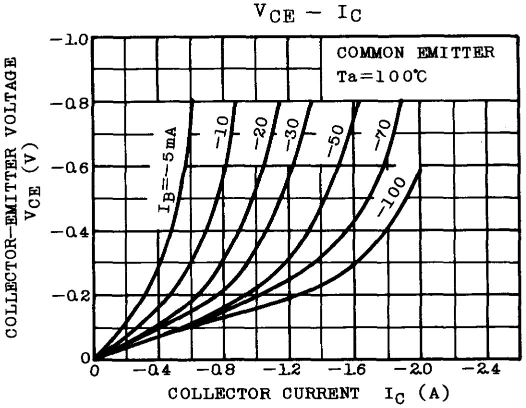
ELECTRICAL CHARACTERISTICS (T_a=25°C)

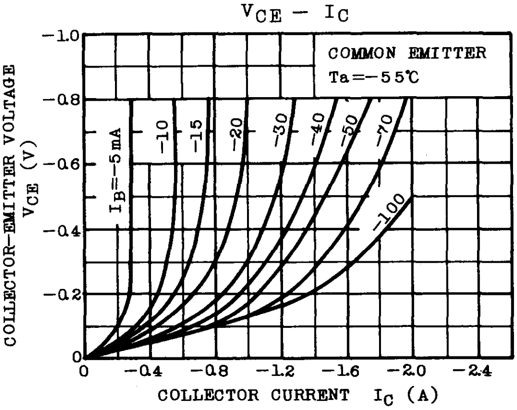
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=-80V, I_E=0	-	-	-1.0	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-1.0	μA
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	I_C=-10mA, I_B=0	-80	-	-	V
DC Current Gain		$h_{FE(1)}$ (Note)	V_{CE}=-2V, I_C=-0.5A	70	-	240	
		$h_{FE(2)}$	V_{CE}=-2V, I_C=-1.5A	40	-	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=-1A, I_B=-0.05A	-	-0.2	-0.5	V
Base-Emiiter Saturation Voltage		$V_{BE(sat)}$	I_C=-1A, I_B=-0.05A	-	-0.9	-1.2	V
Transition Frequency		f_T	V_{CE}=-2V, I_C=-0.5A	-	80	-	MHz
Collector Output Capacitance		Cob	V_{CB}=-10V, I_E=0, f=1MHz	-	45	-	pF
Switching Time	Turn-on Time	t_{on}		-	0.2	-	μs
	Storage Time	t_{stg}		-	1.0	-	
	Fall Time	t_f		-	0.2	-	

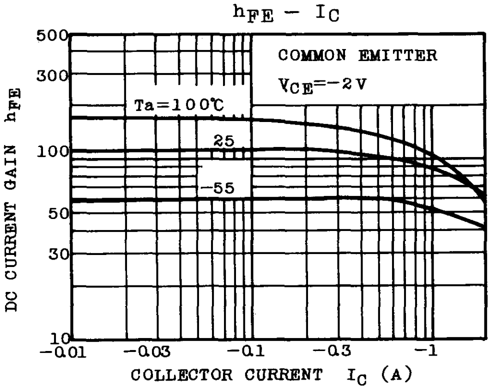
Note : $h_{FE(1)}$ Classification O : 70~140, Y : 120~240

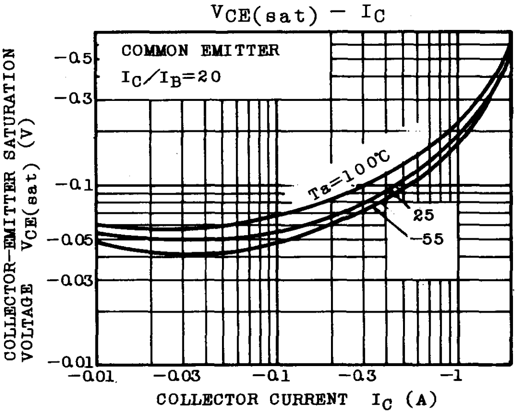

I_C — V_{CE}
COLLECTOR CURRENT I_C (A)
-2.0
-1.6
-1.2
-0.8
-0.4
0
-30
-20
-15
-10
I_B=-5mA
COMMON EMITTER
Ta=25℃
0
0
-2
-4
-6
-8
-10
-12
コレクタ・エミッタ間電圧 V_{CE} (V)


V_{CE} — I_C
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)
-1.0
-0.8
-0.6
-0.4
-0.2
0
COMMON EMITTER
Ta=25℃
I_B=-5mA
-10
-20
-30
-50
-70
-100
0
-0.4
-0.8
-1.2
-1.6
-2.0
-2.4
COLLECTOR CURRENT I_C (A)

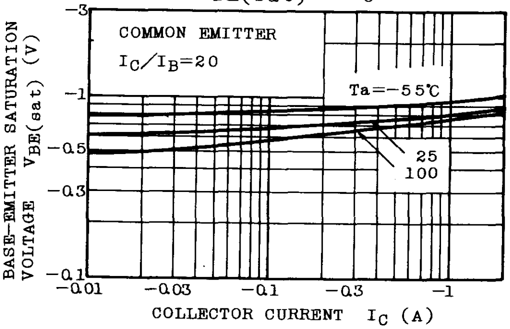

V_{CE} — I_C
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)
-1.0
-0.8
-0.6
-0.4
-0.2
0
COMMON EMITTER
Ta=100℃
I_B=-5mA
-10
-20
-30
-50
-70
-100
0
-0.4
-0.8
-1.2
-1.6
-2.0
-2.4
COLLECTOR CURRENT I_C (A)


V_{CE} — I_C
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)
-1.0
-0.8
-0.6
-0.4
-0.2
0
COMMON EMITTER
Ta=-55℃
I_B=-5mA
-10
-15
-20
-30
-40
-50
-70
-100
0
-0.4
-0.8
-1.2
-1.6
-2.0
-2.4
COLLECTOR CURRENT I_C (A)

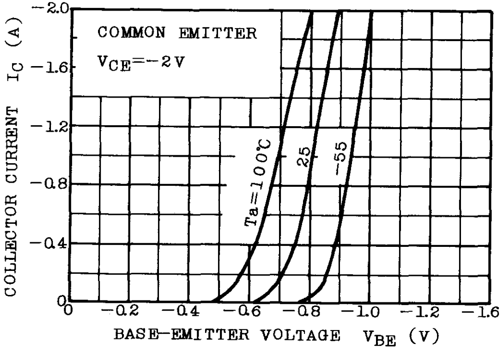

h_{FE} — I_C
DC CURRENT GAIN h_{FE}
500
300
100
50
30
10
COMMON EMITTER
V_{CE}=-2V
Ta=100℃
25
-55
-0.01
-0.03
-0.1
-0.3
-1
COLLECTOR CURRENT I_C (A)


$V_{CE(sat)}$ — I_C
COLLECTOR-EMITTER SATURATION VOLTAGE $V_{CE(sat)}$ (V)
-0.5
-0.3
-0.1
-0.05
-0.03
-0.01
COMMON EMITTER
I_C/I_B=20
Ta=100℃
25
-55
-0.01
-0.03
-0.1
-0.3
-1
COLLECTOR CURRENT I_C (A)

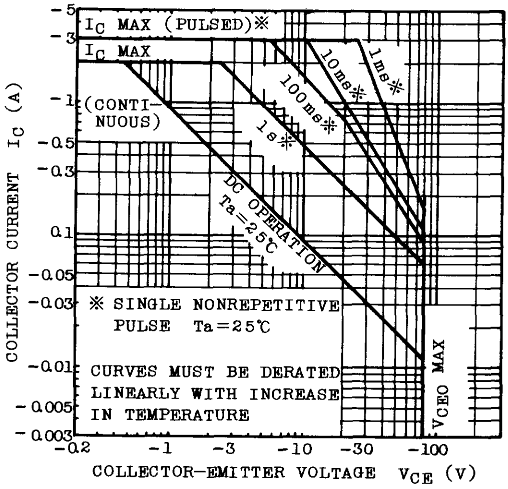
$V_{BE(sat)}$ – I_C



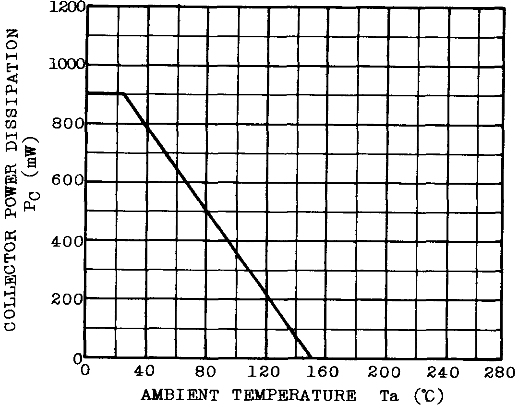
I_C – V_{BE}



SAFE OPERATING AREA



P_C – Ta



SILICON PNP EPITAXIAL TYPE

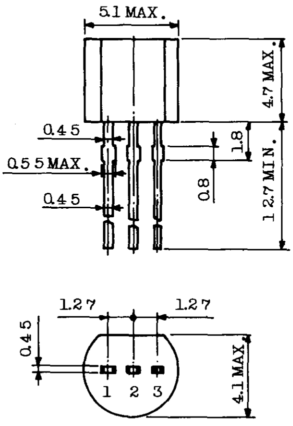
2SA1316

FOR LOW NOISE AUDIO AMPLIFIER APPLICATIONS AND RECOMMENDED FOR THE FIRST STAGES OF MC HEAD AMPLIFIERS.

FEATURES:

. Very Low Noise in the Region of Low Signal Source Impedance
  Equivalent Input Noise Voltage : E_n=0.6nV/$\sqrt{Hz}$ (Typ.)
. Low Pulse Noise· Low 1/f Noise
. Low Base Spreading Resistance : $r_{bb'}$=2.0Ω (Typ.)
. Complementary to 2SC3329

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

MAXIMUM RATINGS (T_a=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-80	V
Collector-Emitter Voltage	V_{CEO}	-80	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-100	mA
Base Current	I_B	-20	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

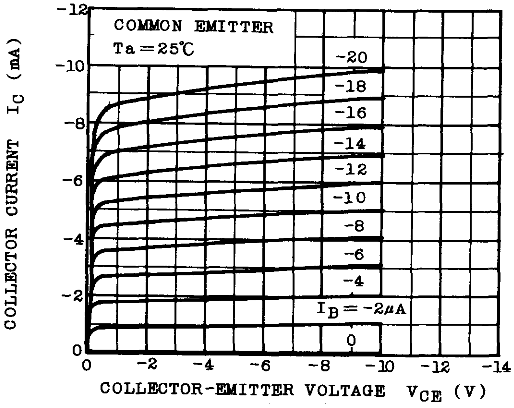
ELECTRICAL CHARACTERISTICS (T_a=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-80V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-1mA	-80	-	-	V
DC Current Gain	h_{FE} (Note)	V_{CE}=-6V, I_C=-2mA	200	-	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-10mA, I_B=-1mA	-	-	-0.1	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-6V, I_C=-2mA	-	0.6	-	V
Base Spreading Resistance	$r_{bb'}$	V_{CE}=-6V,I_C=-1mA,f=100MHz	-	2.0	-	Ω
Transition Frequency	f_T	V_{CE}=-6V,I_E=1mA,f=100MHz	-	50	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	6.2	-	pF
Noise Figure	NF	V_{CE}=-6V, I_C=-0.1mA f=10Hz, R_g=10kΩ	-	1	6	dB
		V_{CE}=-6V, I_C=-0.1mA f=1kHz, R_g=10kΩ	-	0.5	2	
		V_{CE}=-6V, I_C=-0.1mA f=1kHz, R_g=100Ω	-	2.5	-	

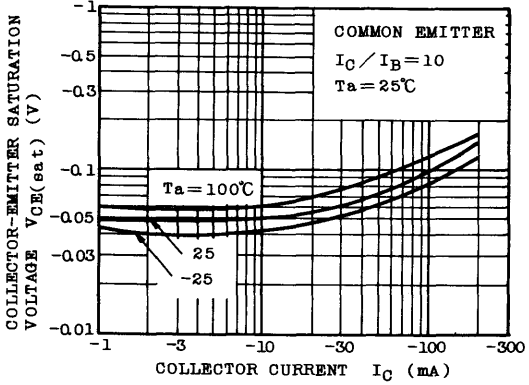
Note : h_{FE} Classification GR : 200~400, BL : 350~700

2SA1316

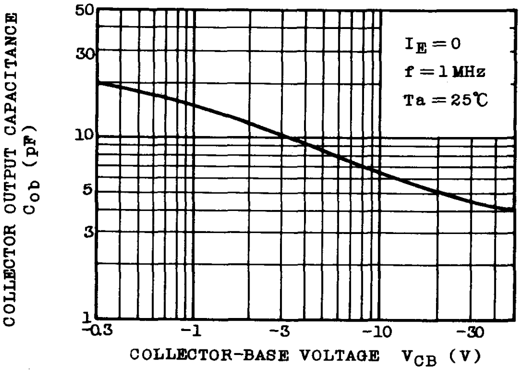
$I_C - V_{CE}$



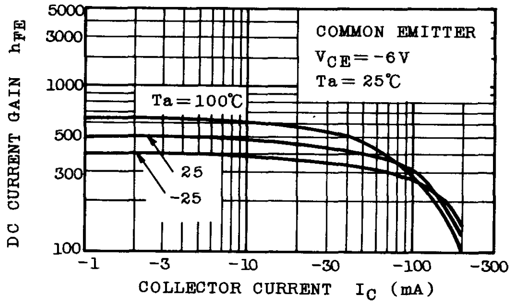
$V_{CE(sat)} - I_C$



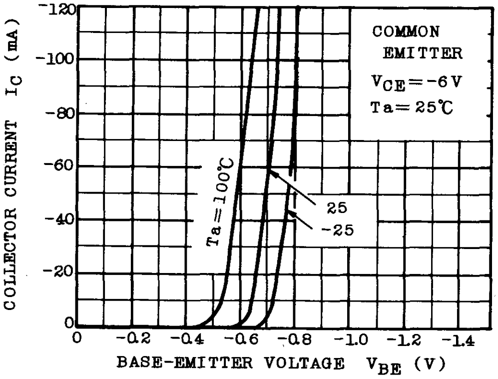
$C_{ob} - V_{CB}$



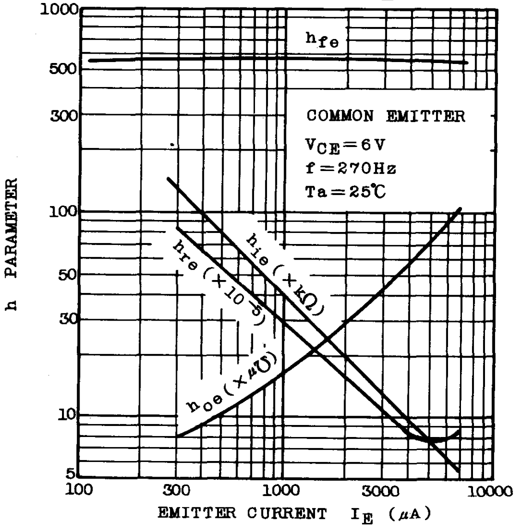
$h_{FE} - I_C$

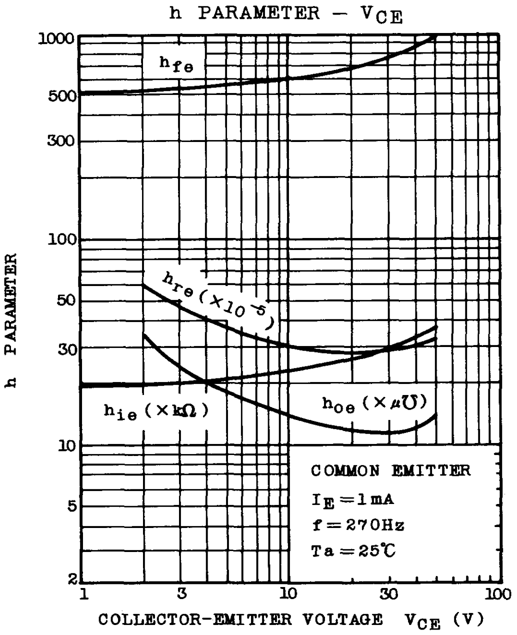


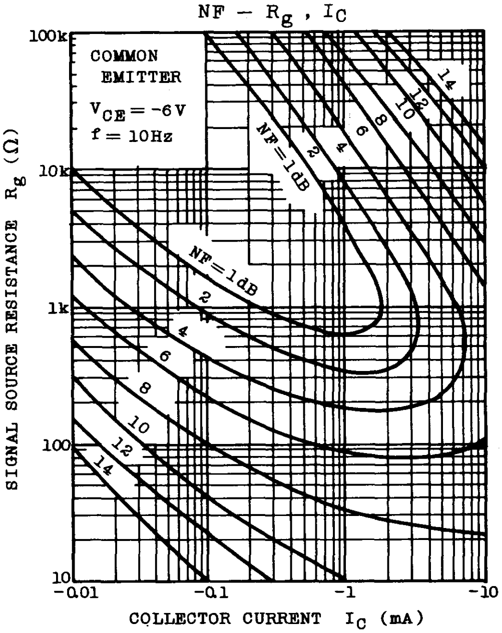
$V_{BE} - I_C$

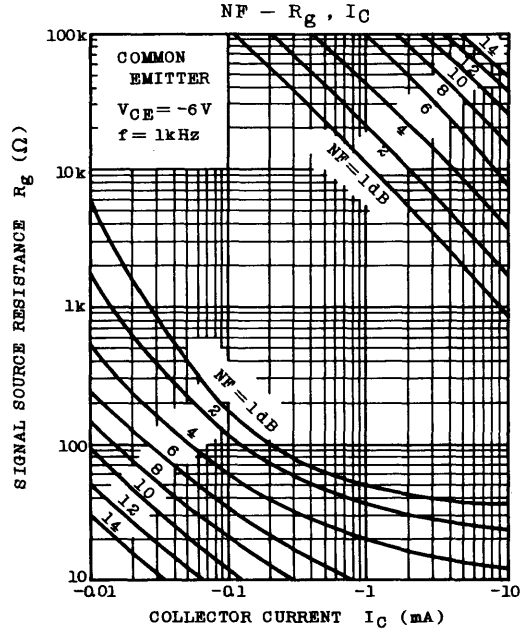


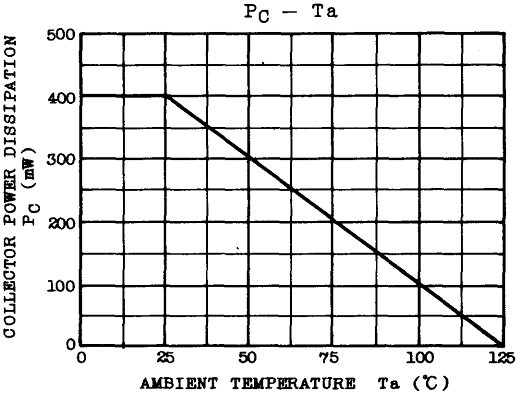
h PARAMETER $- I_E$




h PARAMETER — V_{CE}
h PARAMETER
h_{fe}
h_{re} ($\times 10^{-5}$)
h_{ie} ($\times$kΩ)
h_{oe} ($\times\mu$℧)
COMMON EMITTER
I_E = 1 mA
f = 270Hz
Ta = 25℃
1000
500
300
100
50
30
10
5
2
1
3
10
30
100
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)


NF — R_g , I_C
COMMON EMITTER
V_{CE} = −6 V
f = 10Hz
NF = 1dB
2
4
6
8
10
12
14
SIGNAL SOURCE RESISTANCE R_g (Ω)
100k
10k
1k
100
10
−0.01
−0.1
−1
−10
COLLECTOR CURRENT I_C (mA)


NF — R_g , I_C
COMMON EMITTER
V_{CE} = −6 V
f = 1kHz
NF = 1dB
2
4
6
8
10
12
14
SIGNAL SOURCE RESISTANCE R_g (Ω)
100k
10k
1k
100
10
−0.01
−0.1
−1
−10
COLLECTOR CURRENT I_C (mA)


P_C — Ta
COLLECTOR POWER DISSIPATION P_C (mW)
500
400
300
200
100
0
0
25
50
75
100
125
AMBIENT TEMPERATURE Ta (℃)

2SA1320

SILICON PNP TRIPLE DIFFUSED TYPE (PCT PROCESS)

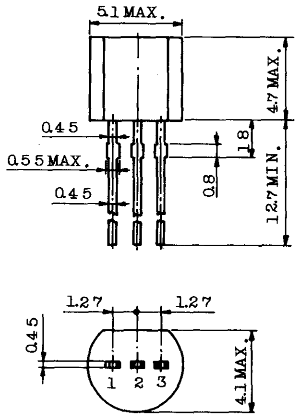
HIGH VOLTAGE SWITCHING APPLICATIONS.

COLOR TV CHROMA OUTPUT APPLICATIONS.

FEATURES:

- High Voltage : V_{CEO}=-250V
- Low C_{re} : 1.8pF(Max.)
- Complementary to 2SC3333

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

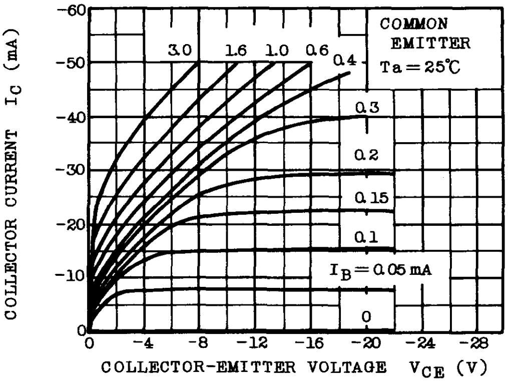
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Voltage		V_{CBO}	-250	V
Collector-Emitter Voltage		V_{CEO}	-250	V
Emitter-Base Voltage		V_{EBO}	-5	V
Collector Current	DC	I_C	-50	mA
	Peak	I_{CP}	-100	
Base Current		I_B	-20	mA
Collector Power Dissipation		P_C	0.6	W
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_{stg}	-55~150	°C

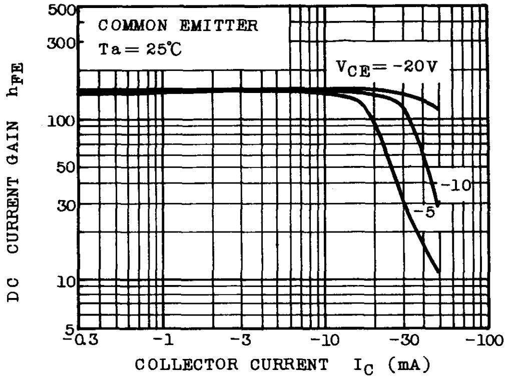
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-200V, I_E=0	-	-	-1.0	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-1.0	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-1mA, I_B=0	-250	-	-	V
DC Current Gain	h_{FE}	V_{CE}=-20V, I_C=-25mA	50	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-10mA, I_B=-1mA	-	-	-1.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-20V, I_C=-25mA	-	-0.75	-	V
Transition Frequency	f_T	V_{CE}=-10V, I_C=-10mA	60	80	-	MHz
Reverse Transfer Capacitance	C_{re}	V_{CB}=-30V, I_E=0, f=1MHz	-	-	1.8	pF

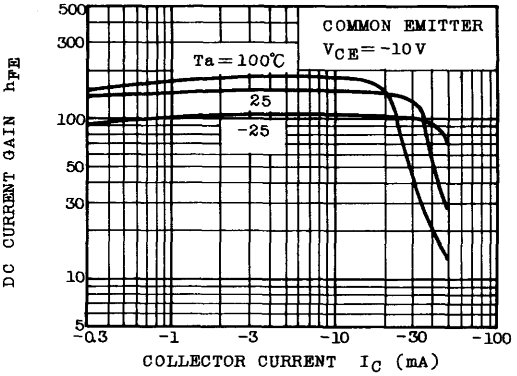
I_C – V_{CE} (LOW VOLTAGE REGION)



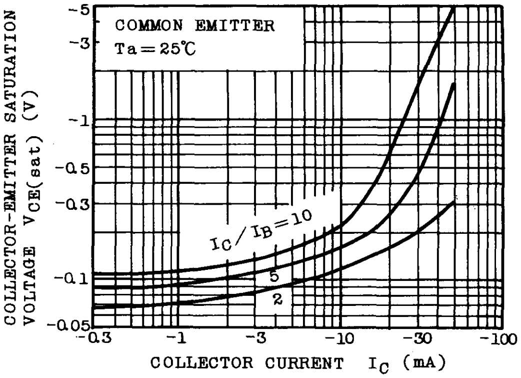
h_{FE} – I_C



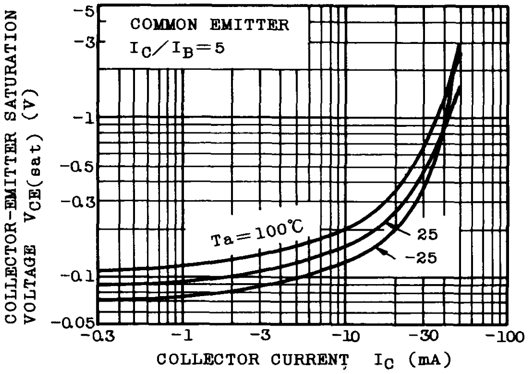
h_{FE} – I_C



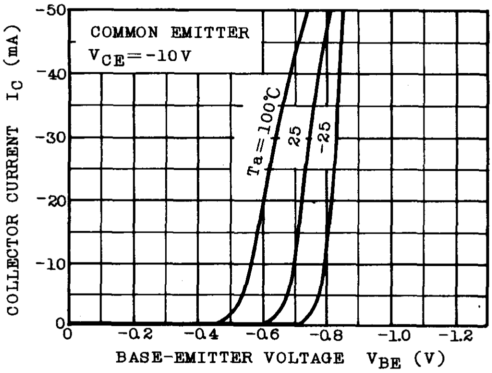
$V_{CE(sat)}$ – I_C

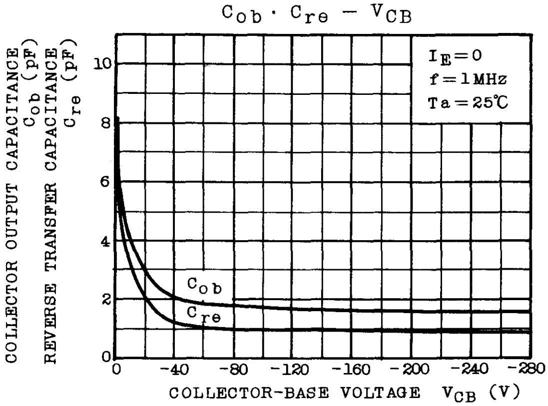


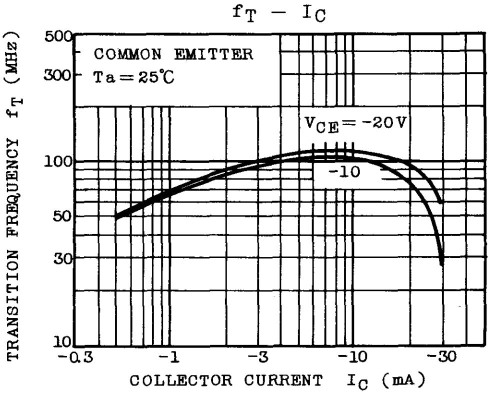
$V_{CE(sat)}$ – I_C

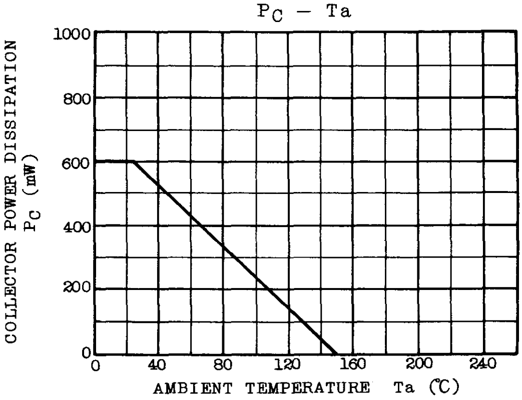


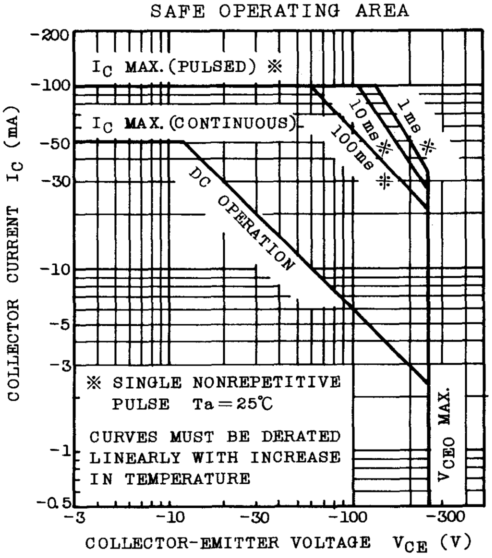
I_C – V_{BE}




$C_{ob} \cdot C_{re} - V_{CB}$
$I_E = 0$
$f = 1MHz$
$Ta = 25℃$
C_{ob}
C_{re}
COLLECTOR OUTPUT CAPACITANCE C_{ob} (pF)
REVERSE TRANSFER CAPACITANCE C_{re} (pF)
0
2
4
6
8
10
0
-40
-80
-120
-160
-200
-240
-280
COLLECTOR-BASE VOLTAGE V_{CB} (V)


$f_T - I_C$
COMMON EMITTER
$Ta = 25℃$
$V_{CE} = -20V$
-10
TRANSITION FREQUENCY f_T (MHz)
10
30
50
100
300
500
-0.3
-1
-3
-10
-30
COLLECTOR CURRENT I_C (mA)


$P_C - Ta$
COLLECTOR POWER DISSIPATION P_C (mW)
0
200
400
600
800
1000
0
40
80
120
160
200
240
AMBIENT TEMPERATURE Ta (℃)


SAFE OPERATING AREA
I_C MAX. (PULSED) ※
I_C MAX. (CONTINUOUS)
10ms ※
100ms ※
1ms ※
DC OPERATION
V_{CEO} MAX.
※ SINGLE NONREPETITIVE PULSE $Ta = 25℃$
CURVES MUST BE DERATED LINEARLY WITH INCREASE IN TEMPERATURE
COLLECTOR CURRENT I_C (mA)
-200
-100
-50
-30
-10
-5
-3
-1
-0.5
-3
-10
-30
-100
-300
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)

SILICON PNP TRIPLE DIFFUSED TYPE (PCT PROCESS)

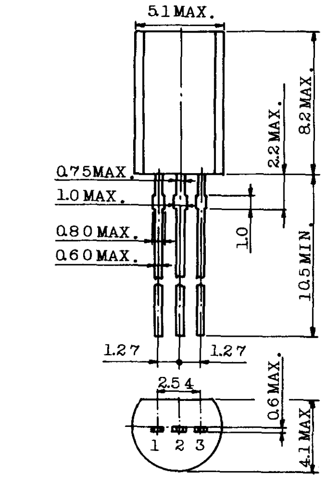
2SA1321

HIGH VOLTAGE SWITCHING APPLICATIONS.
COLOR TV CHROMA OUTPUT APPLICATIONS.

FEATURES:

- High Voltage : V_{CEO}=-250V
- Low C_{re} : 1.8pF(Max.)
- Complementary to 2SC3334

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92MOD
EIAJ	–
TOSHIBA	2-5J1A

Weight : 0.36g

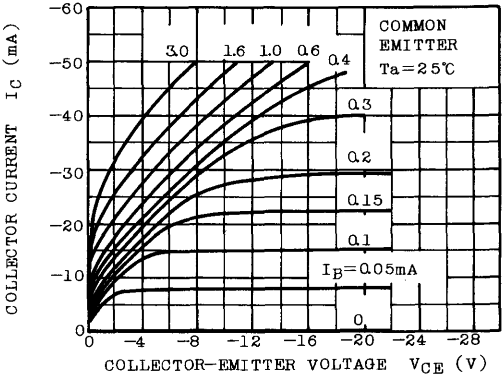
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Voltage		V_{CBO}	-250	V
Collector-Emitter Voltage		V_{CEO}	-250	V
Emitter-Base Voltage		V_{EBO}	-5	V
Collector Current	DC	I_C	-50	mA
	Peak	I_{CP}	-100	
Base Current		I_B	-20	mA
Collector Power Dissipation		P_C	0.9	W
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_{stg}	-55~150	°C

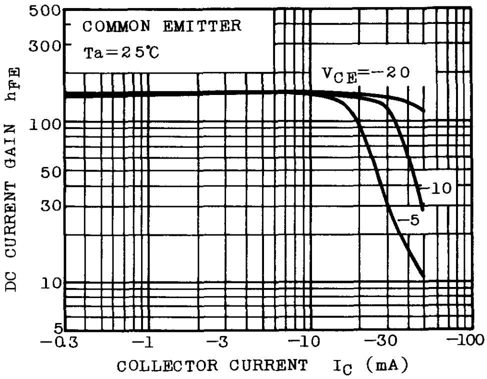
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-200V, I_E=0	-	-	-1.0	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-1.0	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-1mA, I_B=0	-250	-	-	V
DC Current Gain	h_{FE}	V_{CE}=-20V, I_C=-25mA	50	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-10mA, I_B=-1mA	-	-	-1.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-20V, I_C=-25mA	-	-0.75	-	V
Transition Frequency	f_T	V_{CE}=-10V, I_C=-10mA	60	80	-	MHz
Reverse Transfer Capacitance	C_{re}	V_{CB}=-30V, I_E=0, f=1MHz	-	-	1.8	pF

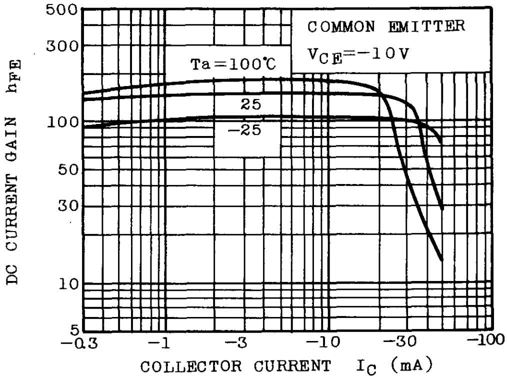
IC− VCE (LOW VOLTAGE REGION)



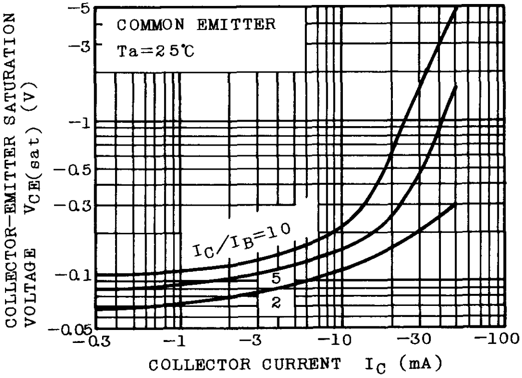
hFE − IC



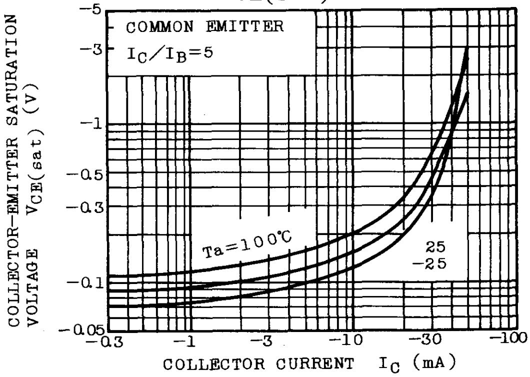
hFE − IC



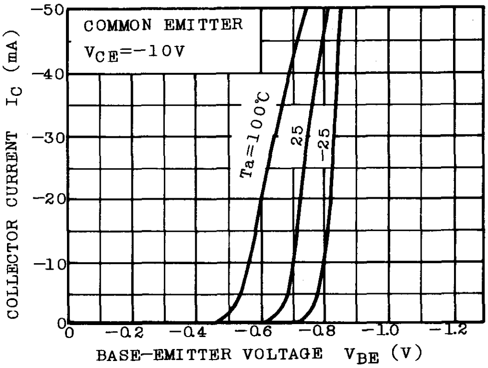
VCE(sat) − IC

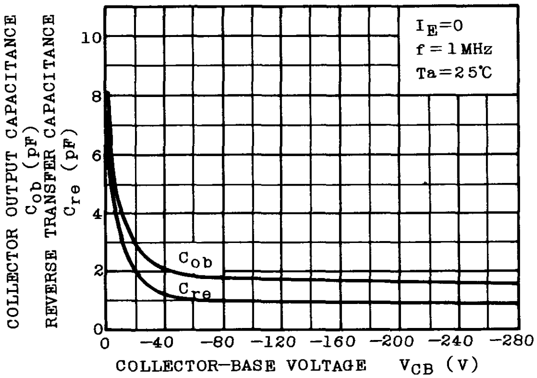


VCE(sat) − IC

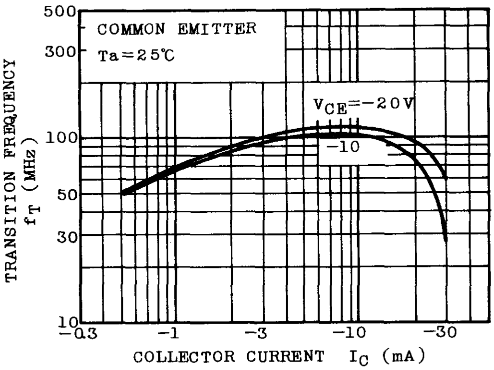


IC − VBE

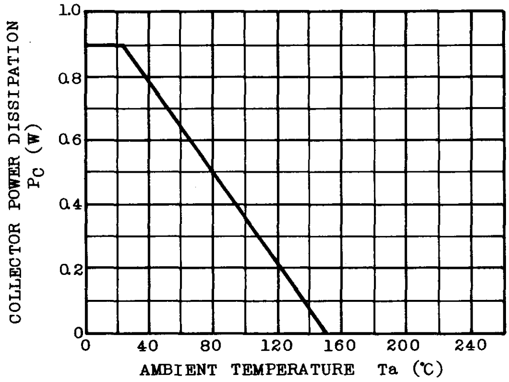




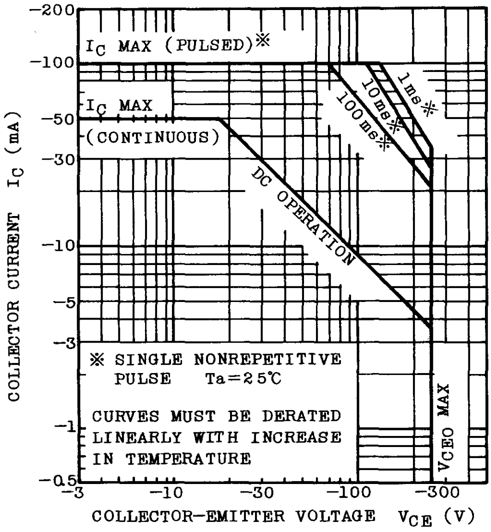
C_{ob}, C_{re} — V_{CB}



f_T — I_C



P_C — Ta



SAFE OPERATING AREA

2SC series

SILICON NPN EPITAXIAL PLANAR TYPE (PCT PROCESS)

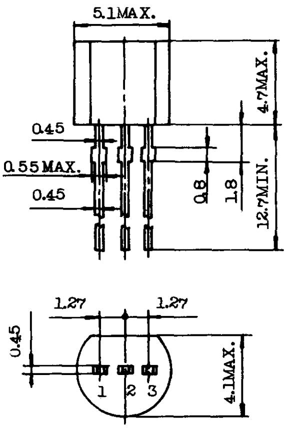
2SC380TM

HIGH FREQUENCY AMPLIFIER APPLICATIONS.

FEATURES:

- High Power Gain : G_{pe}=29dB(Typ.) (f=10.7MHz)
- Recommended for FM IF, OSC Stage and AM CONV. IF Stage.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO – 92
EIAJ	SC – 43
TOSHIBA	2 – 5F1B

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	35	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	50	mA
Emitter Current	I_E	-50	mA
Collector Power Dissipation	P_C	300	mW
Junction Temperature	T_j	125	°C
Strage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=35V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=4V, I_C=0	-	-	1.0	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=12V, I_C=2mA	40	-	240	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	0.4	V
Base-Emitter Voltage	V_{BE}	I_C=10mA, I_B=1mA	-	-	1.0	V
Transition Frequency	f_T	V_{CE}=10V, I_C=1mA	100	-	400	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	1.4	2.0	3.2	pF
Collector-Base Time Constant	$C_c \cdot rbb'$	V_{CE}=10V, I_E=-1mA, f=30MHz	10	-	50	ps
Power Gain	G_{pe}	V_{CC}=6V, I_E=-1mA, f=10.7MHz, (Fig.)	27	29	33	dB

Note : h_{FE} classification R : 40∿80, O : 70∿140, Y : 120∿240

y PARAMETERS (Typ.)

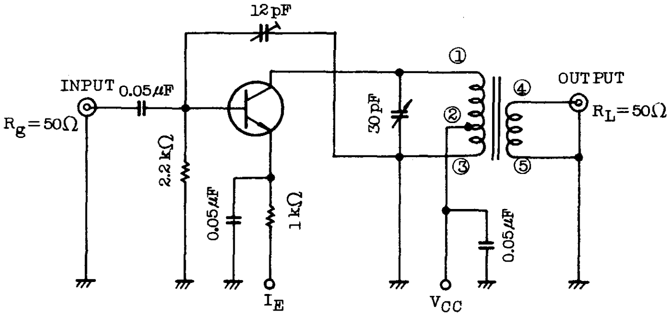
(1) (COMMON EMITTER f=455kHz, Ta=25°C)

CHARACTERISTIC	SYMBOL	2SC380TM-R	2SC380TM-O	2SC380TM-Y	UNIT
Collector-Emitter Voltage	V_{CE}	6	6	6	V
Emitter Current	I_E	-1	-1	-1	mA
Input Conductance	g_{ie}	0.58	0.41	0.26	mS
Input Capacitance	C_{ie}	53	46	38	pF
Output Conductance	g_{oe}	1.9	2.7	4.8	μS
Output Capacitance	C_{oe}	2.6	2.8	3.6	pF
Forward Transfer Admittance	$\|y_{fe}\|$	38	38	38	mS
Phase Angle of Forward Transfer Admittance	θ_{fe}	-0.79	-0.83	-0.92	°
Reverse Transfer Admittance	$\|y_{re}\|$	5.7	5.7	6.2	μS
Phase Angle of Reverse Transfer Admittance	θ_{re}	-90	-90	-90	°

(2) (COMMON EMITTER f=10.7MHz, Ta=25°C)

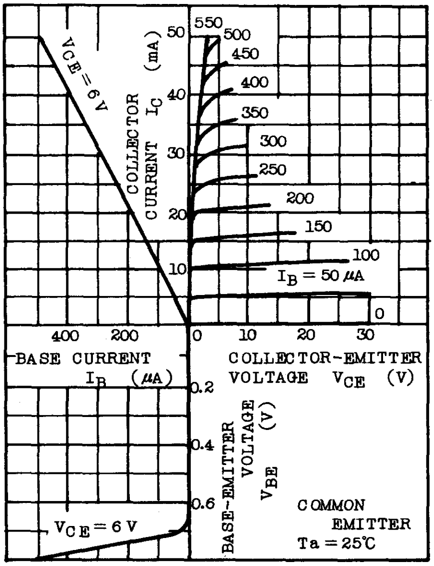
CHARACTERISTIC	SYMBOL	2SC380TM-R	2SC380TM-O	2SC380TM-Y	UNIT
Collector Emitter Voltage	V_{CE}	6	6	6	V
Emitter Current	I_E	-1	-1	-1	mA
Input Conductance	g_{ie}	1.04	0.85	0.65	mS
Input Capacitance	C_{ie}	49	43	36	pF
Output Conductance	g_{oe}	10	15	28	μS
Output Capacitance	C_{oe}	2.7	2.9	3.6	pF
Forward Transfer Admittance	$\|y_{fe}\|$	37	37	37	mS
Phase Angle of Forward Transfer Admittance	θ_{fe}	-9.6	-10.4	-11.5	°
Reverse Transfer Admittance	$\|y_{re}\|$	120	120	140	μS
Phase Angle of Reverse Transfer Admittance	θ_{re}	-90	-90	-90	°

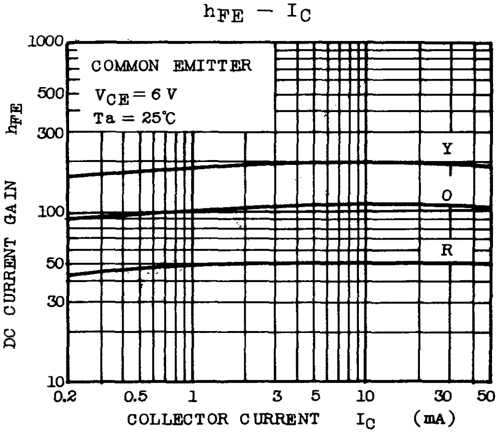
Fig. G_{pe} TEST CIRCUIT

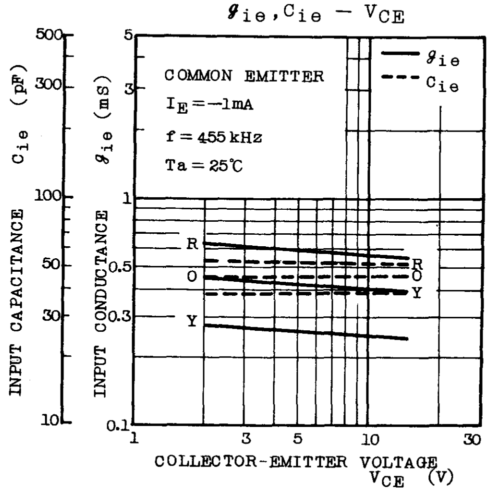


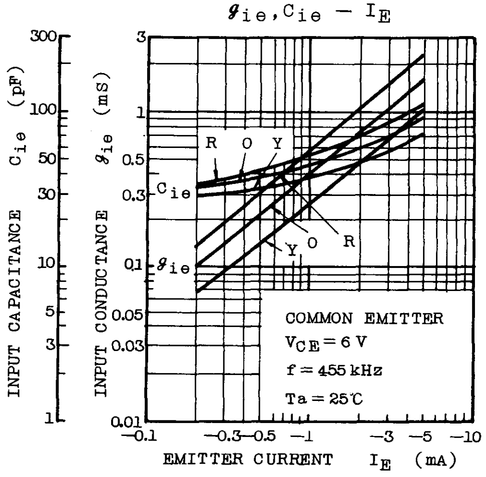
T : ①–② 0.1mmØ UEW 20T
②–③ 0.1mmØ UEW 8T
④–⑤ 0.1mmØ UEW 2T

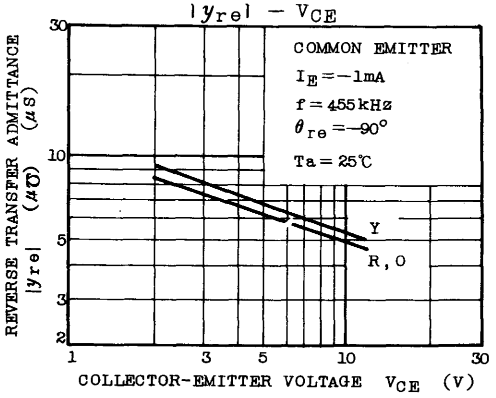
STATIC CHARACTERISTICS

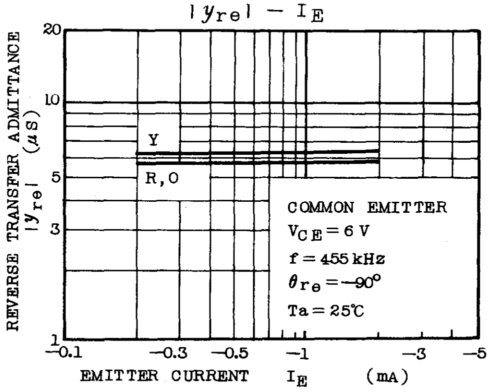


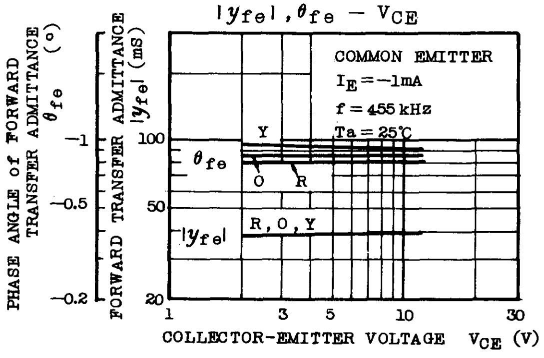


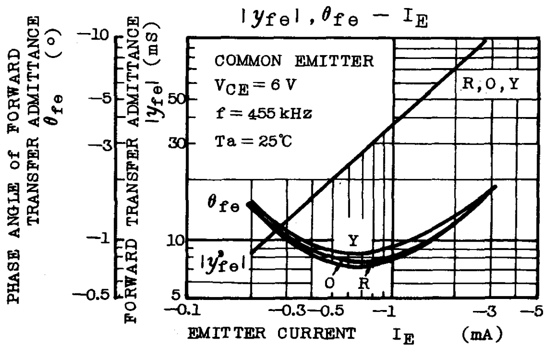

g_{ie}, C_{ie} — V_{CE}
COMMON EMITTER
$I_E = -1mA$
f = 455 kHz
Ta = 25℃
g_{ie}
C_{ie}
R
O
Y
INPUT CAPACITANCE C_{ie} (pF)
INPUT CONDUCTANCE g_{ie} (mS)
500
300
100
50
30
10
5
3
1
0.5
0.3
0.1
1
3
5
10
30
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)

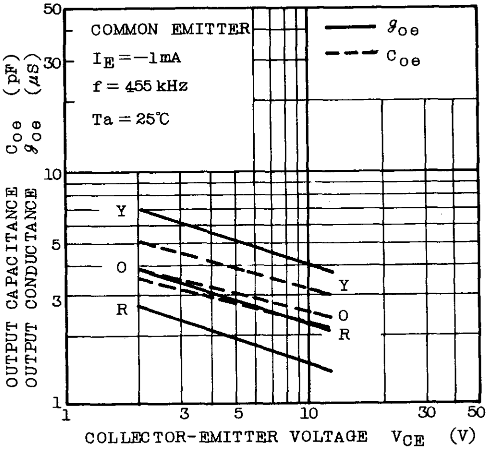

g_{ie}, C_{ie} — I_E
COMMON EMITTER
$V_{CE} = 6$ V
f = 455 kHz
Ta = 25℃
R O Y
C_{ie}
g_{ie}
Y O R
INPUT CAPACITANCE C_{ie} (pF)
INPUT CONDUCTANCE g_{ie} (mS)
300
100
50
30
10
5
3
1
3
1
0.5
0.3
0.1
0.05
0.03
0.01
−0.1
−0.3
−0.5
−1
−3
−5
−10
EMITTER CURRENT I_E (mA)

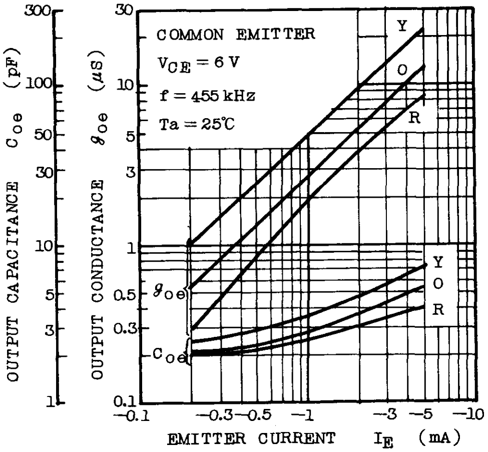

$|y_{re}|$ — V_{CE}
COMMON EMITTER
$I_E = -1mA$
f = 455 kHz
$\theta_{re} = -90°$
Ta = 25℃
Y
R, O
REVERSE TRANSFER ADMITTANCE $|y_{re}|$ (μ℧) (μS)
30
10
5
3
2
1
3
5
10
30
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)

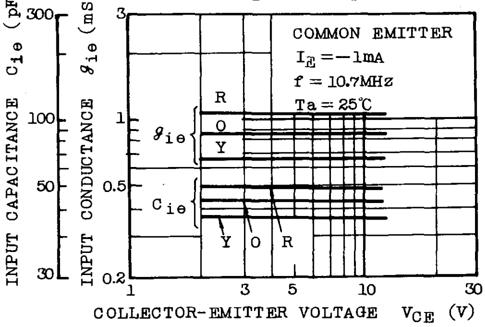

$|y_{re}|$ — I_E
Y
R, O
COMMON EMITTER
$V_{CE} = 6$ V
f = 455 kHz
$\theta_{re} = -90°$
Ta = 25℃
REVERSE TRANSFER ADMITTANCE $|y_{re}|$ (μS)
20
10
5
3
1
−0.1
−0.3
−0.5
−1
−3
−5
EMITTER CURRENT I_E (mA)

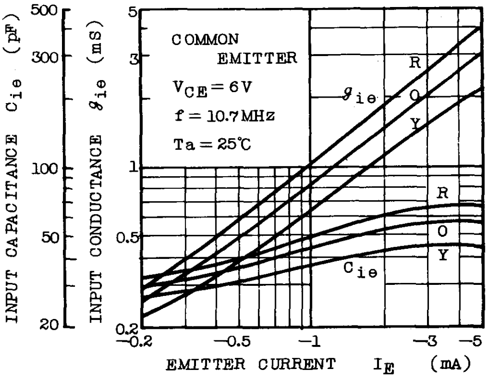

$|y_{fe}|, \theta_{fe}$ — V_{CE}
COMMON EMITTER
$I_E = -1mA$
f = 455 kHz
Ta = 25℃
Y
θ_{fe}
O
R
$|y_{fe}|$
R, O, Y
PHASE ANGLE of FORWARD TRANSFER ADMITTANCE θ_{fe} (°)
FORWARD TRANSFER ADMITTANCE $|y_{fe}|$ (mS)
−1
−0.5
−0.2
100
50
20
1
3
5
10
30
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)

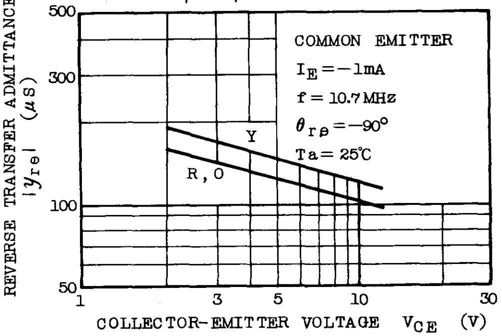

$|y_{fe}|, \theta_{fe}$ — I_E
COMMON EMITTER
$V_{CE} = 6$ V
f = 455 kHz
Ta = 25℃
R, O, Y
θ_{fe}
$|y_{fe}|$
Y
O
R
PHASE ANGLE of FORWARD TRANSFER ADMITTANCE θ_{fe} (°)
FORWARD TRANSFER ADMITTANCE $|y_{fe}|$ (mS)
−10
−5
−3
−1
−0.5
50
30
10
5
−0.1
−0.3
−0.5
−1
−3
−5
EMITTER CURRENT I_E (mA)

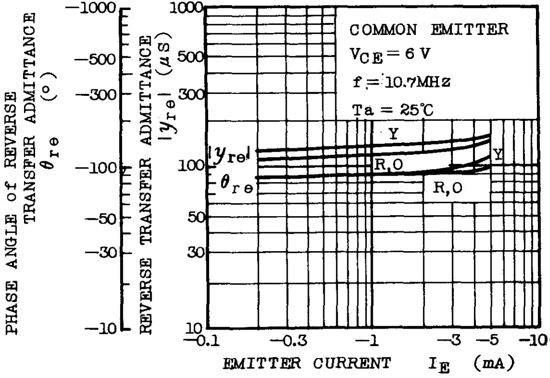

$g_{oe}, C_{oe} - V_{CE}$


$g_{oe}, C_{oe} - I_E$

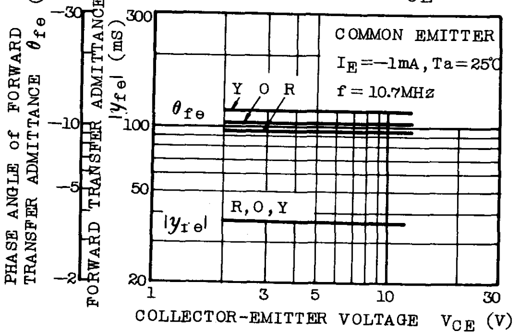

$g_{ie}, C_{ie} - V_{CE}$


$g_{ie}, C_{ie} - I_E$

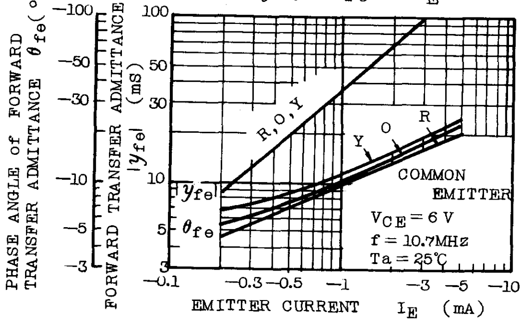

$|y_{re}| - I_E$


$|y_{re}|, \theta_{re} - V_{CE}$

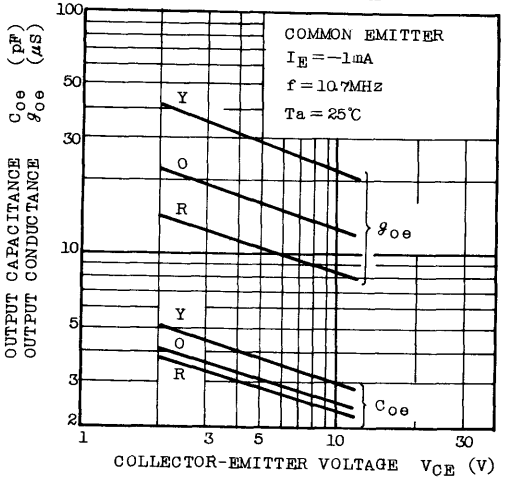
$|y_{fe}|, \theta_{fe} - V_{CE}$



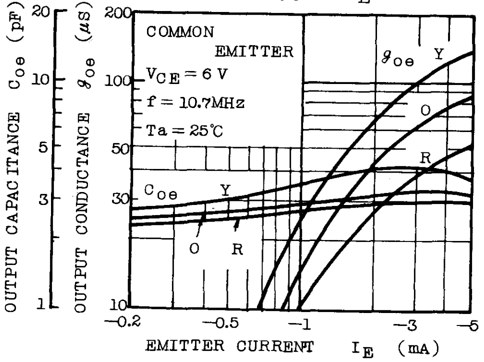
$|y_{fe}|, \theta_{fe} - I_E$



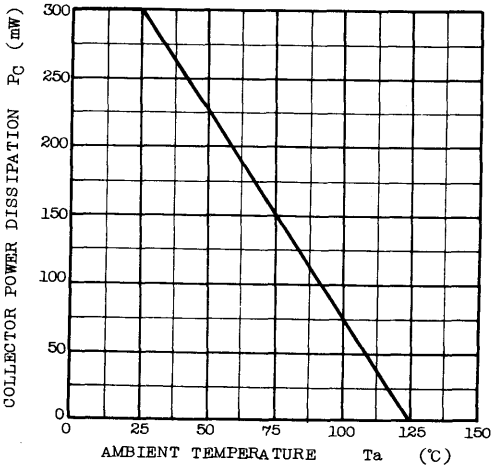
$g_{oe}, C_{oe} - V_{CE}$



$g_{oe}, C_{oe} - I_E$



$P_C - Ta$



SILICON NPN EPITAXIAL PLANAR TYPE

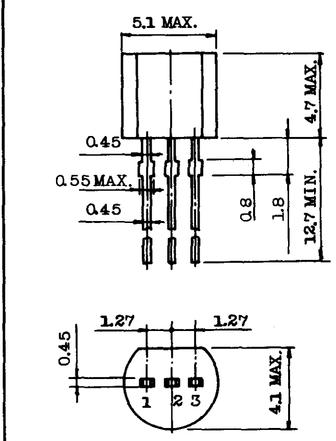
2SC382TM

TV 1ST, 2ND PICTURE IF AMPLIFIER APPLICATIONS.

FEATURES:

- High Gain : G_{pe}=35dB(Typ.) (f=45MHz)
- Excellent Forward AGC Characteristic.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	40	V
Collector-Emitter Voltage	V_{CEO}	40	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	50	mA
Emitter Current	I_E	-50	mA
Collector Power Dissipation	P_C	250	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

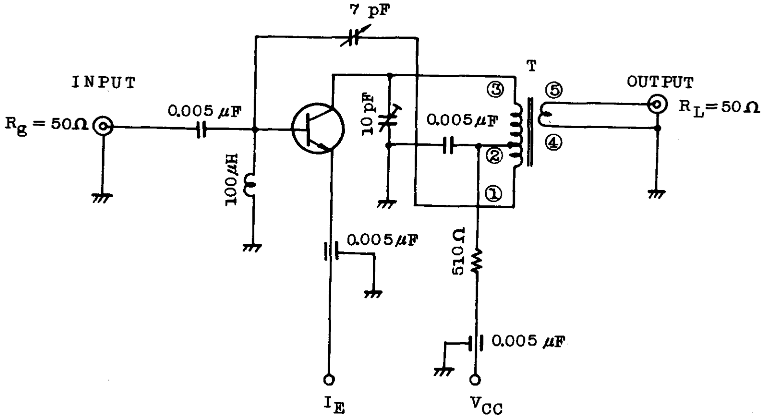
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=40V, I_E=0	-	-	0.1	µA
Emitter Cut-off Current	I_{EBO}	V_{EB}=3V, I_E=0	-	-	0.1	µA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=3mA, I_B=0	40	-	-	V
DC Current Gain	h_{FE}	V_{CE}=10V, I_C=4mA	30	-	-	
Transition Frequency	f_T	V_{CE}=10V, I_C=4mA	400	-	-	MHz
Collector-Base Time Constant	Cc.rbb'	V_{CB}=10V, I_m=-1mA, f=30MHz	-	-	30	ps
Reverse Transfer Capacitance	C_{re}	V_{CB}=10V, I_E=0 f=1MHz	-	-	1.2	pF
Power Gain (Fig.1)	G_{pe}	V_{CC}=12V, I_C=4mA, f=45MHz	32	35	40	dB
AGC Current (Note 1,2)	I_{AGC}	V_{CC}=12V, f=45MHz	7.2	-	10.8	mA

Note 1: Measured by circuit shown in Fig.1, when power gain is reduced to 30dB compared with that of I_C at 4mA.

Note 2: I_{AGC} Classification BL: 7.2∿8.8, V: 8.2∿10.1, W: 8.9∿10.8

Fig. 1 G_{pe} AND I_{AGC} CHARACTERISTICS TEST CIRCUITS (f=45 MHz)



COIL DATA

0.20 mmØ Cu WIRE

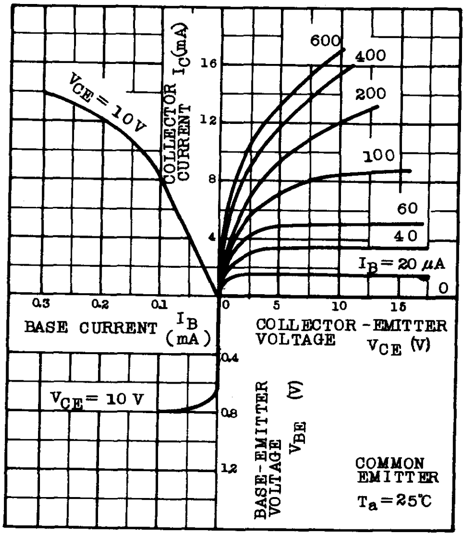
L=12µH WITH M-5 CORE

T: ①-② 3.0 T

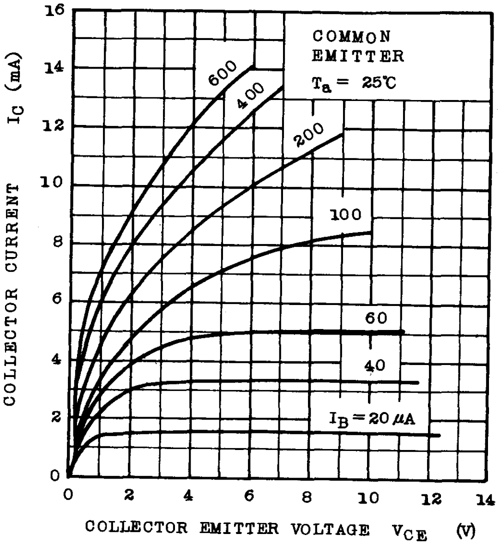
②-③ 8.0 T

④-⑤ 1.0 T

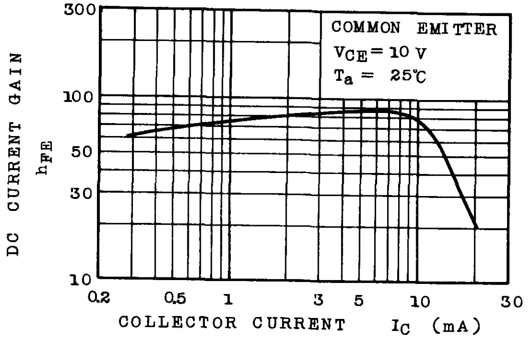
STATIC CHARACTERISTICS



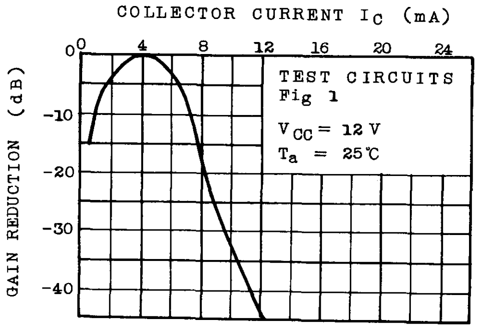
I_C − V_{CE}



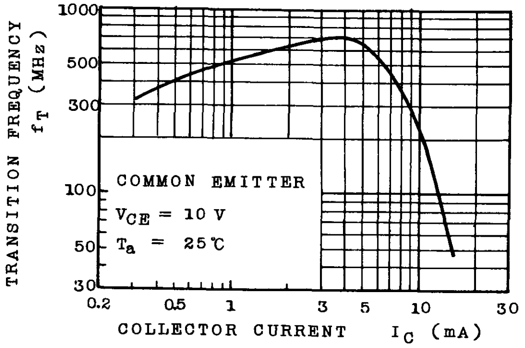
h_{FE} — I_C



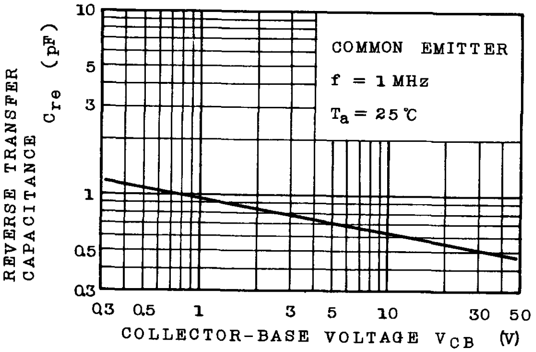
AGC CHARACTERISTICS



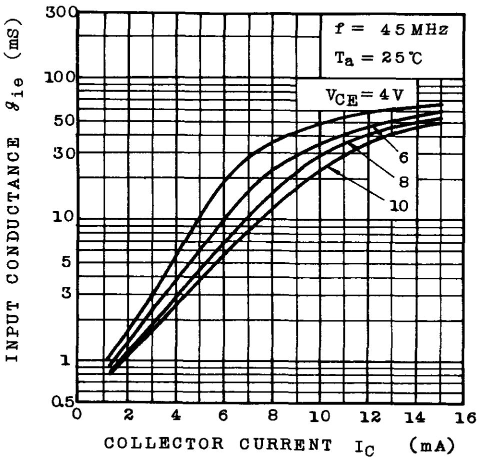
f_T — I_C



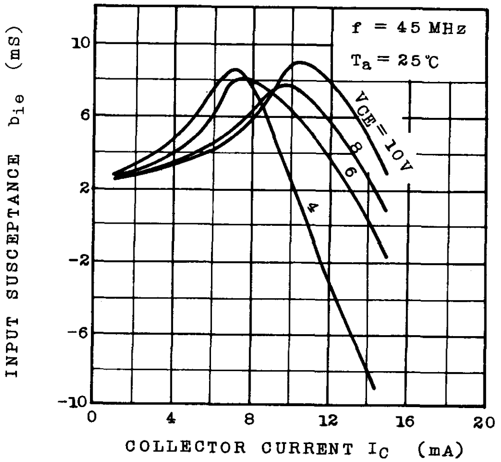
C_{re} — V_{CB}

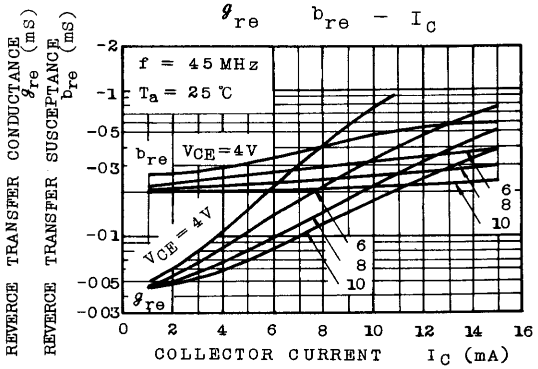


g_{ie} — I_C

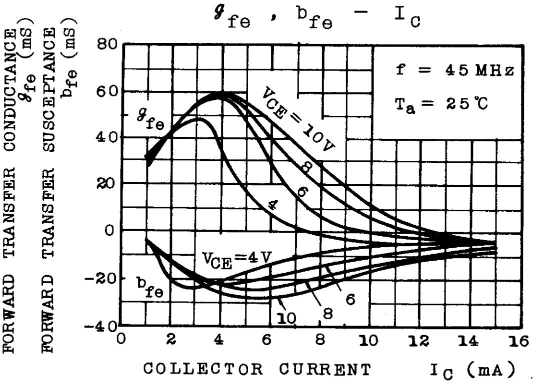


b_{ie} — I_C

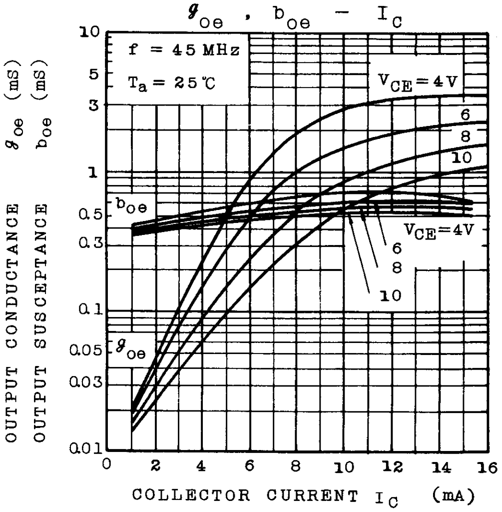




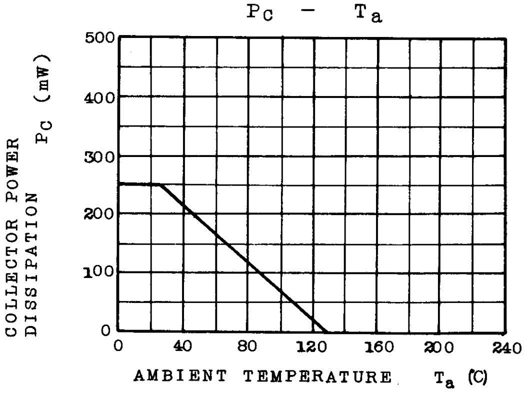
g_{re} b_{re} – I_C



g_{fe} , b_{fe} – I_C



g_{oe} , b_{oe} – I_C



P_C – T_a

SILICON NPN EPITAXIAL PLANAR TYPE

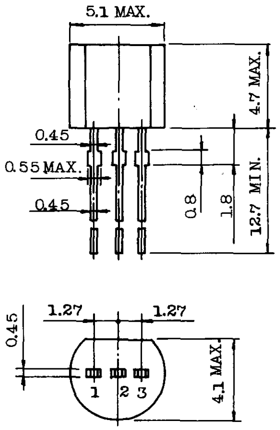
2SC383TM
2SC388ATM

TV FINAL PICTURE IF AMPLIFIER APPLICATIONS.

FEATURES:

- High Gain: G_{pe}=33dB(Typ.) (f=45MHz)
- Good Linearity of h_{FE}.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

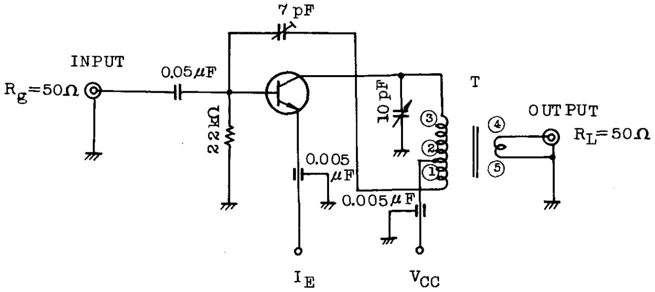
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector Base Voltage	2SC383TM	V_{CBO}	50	V
	2SC388ATM		30	
Collector Emitter Voltage	2SC383TM	V_{CEO}	45	V
	2SC388ATM		25	
Emitter-Base Voltage		V_{EBO}	4	V
Collector Current		I_C	50	mA
Emitter Current		I_E	-50	mA
Collector Power Dissipation		P_C	300	mW
Junction Temperature		T_j	125	°C
Storage Temperature Range		T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

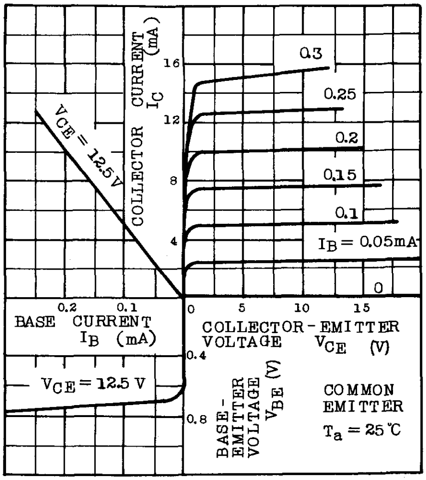
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	2SC383TM	I_{CBO}	V_{CB}=50V, I_E=0	–	–	0.1	μA
	2SC388ATM		V_{CB}=30V, I_E=0				
Emitter Cut-off Current		I_{EBO}	V_{EB}=3V, I_C=0	–	–	0.1	
Collector-Emitter Breakdown Voltage	2SC383TM	$V_{(BR)CEO}$	I_C=10mA, I_B=0	45	–	–	V
	2SC388ATM			25	–	–	
DC Current Gain	2SC383TM	h_{FE}	V_{CE}=12.5V, I_C=12.5mA	20	–	100	
	2SC388ATM			20	–	200	
Saturation Voltage	Collector-Emitter	$V_{CE(sat)}$	I_C=15mA, I_B=1.5mA	–	–	0.2	V
	Base-Emitter	$V_{BE(sat)}$		–	–	1.5	
Collector Output Capacitance		C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	0.8	–	2.0	pF
Collector-Base Time Constant		$C_c \cdot r_{bb'}$	V_{CB}=10V, I_E=-1mA, f=30MHz	–	–	25	ps
Transition Frequency		f_T	V_{CE}=12.5V, I_C=12.5mA	300	–	–	MHz
Power Gain (Fig. 1)	2SC383TM	G_{pe}	V_{CC}=12.5V, I_E=-12.5mA f=45MHz	29	–	36	dB
	2SC388ATM			28	–	36	

Fig. 1 45MHz G_{pe} TEST CIRCUIT

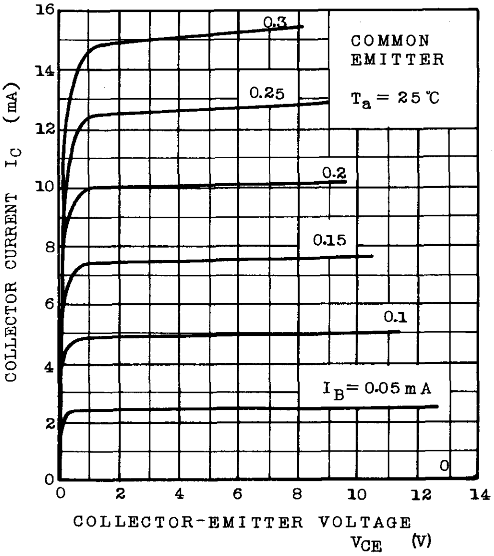


COIL DATA
0.20 mmØ Cu WIRE
L=12μH WITH M-5 CORE
T : ①-② 3.0 T
②-③ 8.0 T
④-⑤ 1.0 T

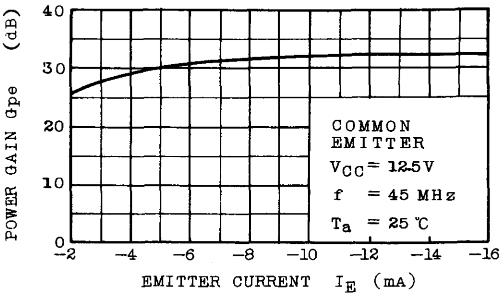
STATIC CHARACTERISTICS



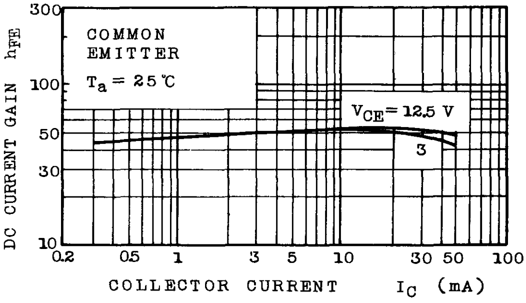
I_C – V_{CE}



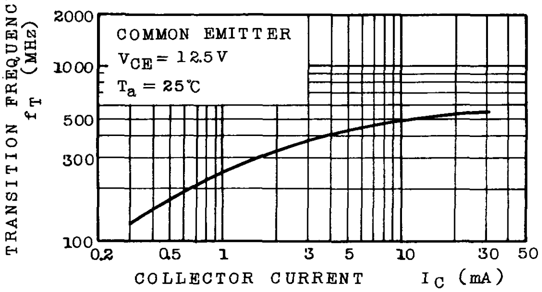
G_{pe} – I_E (See Fig 1)



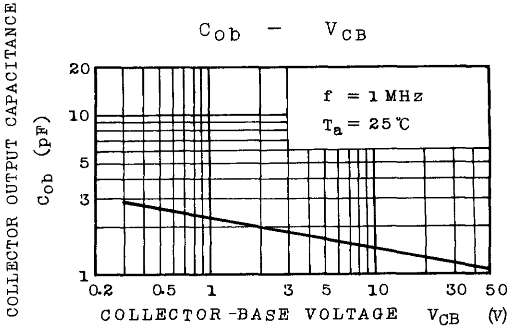
h_{FE} – I_C



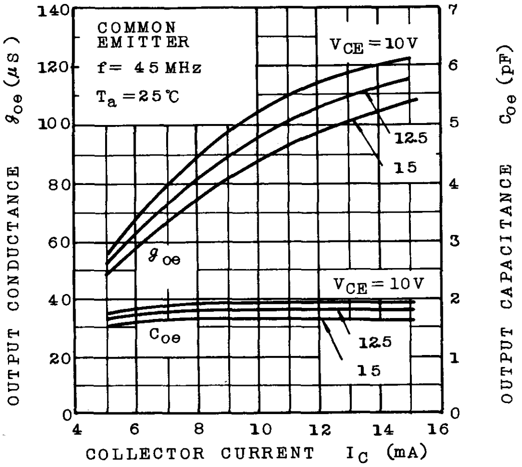
f_T − I_C



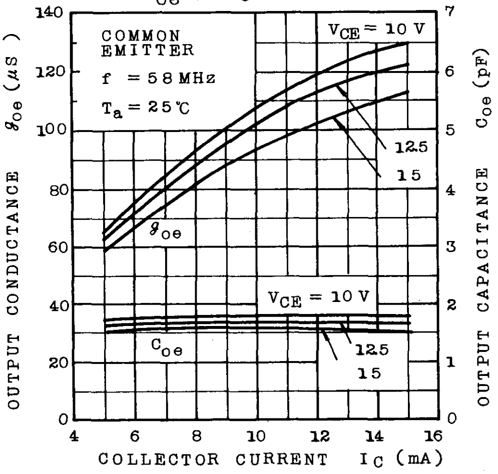
C_{ob} − V_{CB}



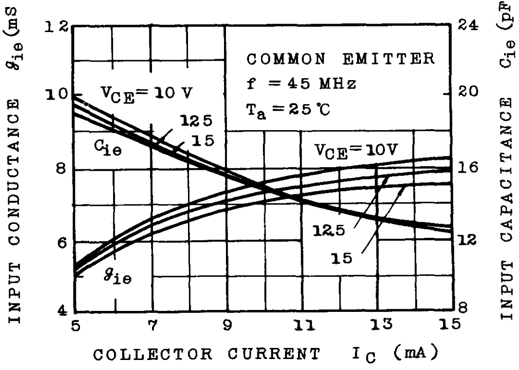
g_{oe}, C_{oe} − I_C



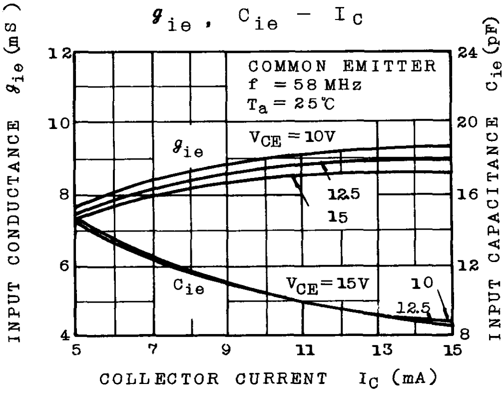
g_{oe}, C_{oe} − I_C

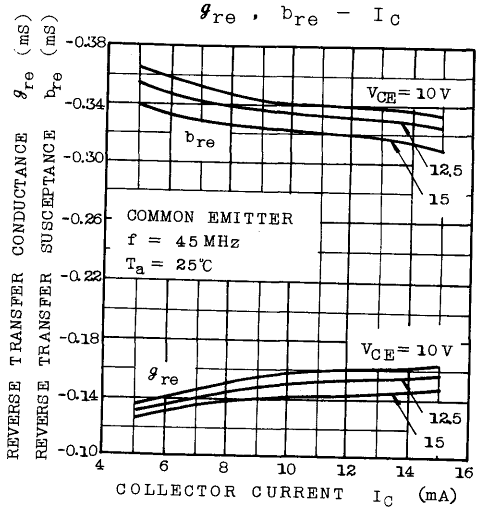


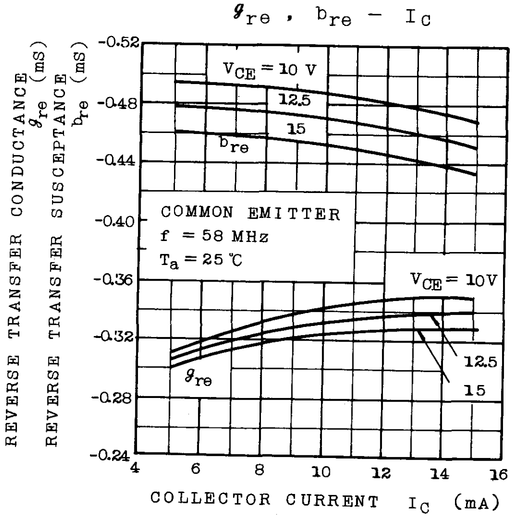
g_{ie}, C_{ie} − I_C

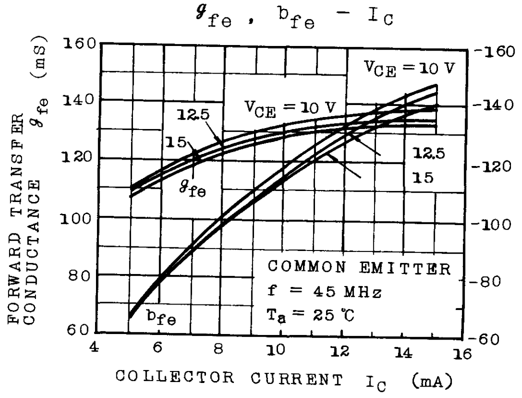


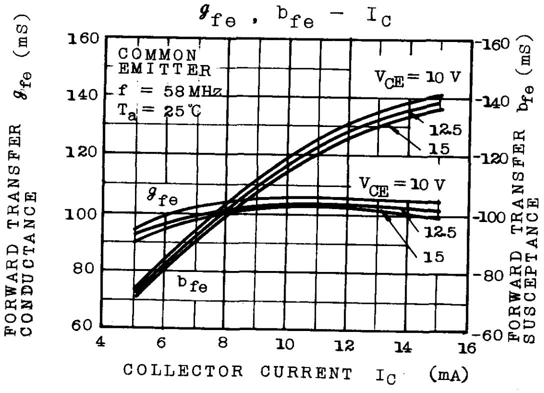
g_{ie}, C_{ie} − I_C

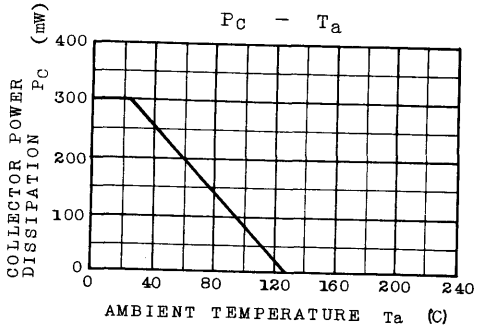



g_{re} , b_{re} – I_C
REVERSE TRANSFER CONDUCTANCE g_{re} (mS)
REVERSE TRANSFER SUSCEPTANCE b_{re} (mS)
-0.38
-0.34
-0.30
-0.26
-0.22
-0.18
-0.14
-0.10
V_{CE} = 10 V
b_{re}
12.5
15
COMMON EMITTER
f = 45 MHz
T_a = 25℃
V_{CE} = 10 V
g_{re}
12.5
15
4
6
8
10
12
14
16
COLLECTOR CURRENT I_C (mA)


g_{re} , b_{re} – I_C
REVERSE TRANSFER CONDUCTANCE g_{re} (mS)
REVERSE TRANSFER SUSCEPTANCE b_{re} (mS)
-0.52
-0.48
-0.44
-0.40
-0.36
-0.32
-0.28
-0.24
V_{CE} = 10 V
12.5
15
b_{re}
COMMON EMITTER
f = 58 MHz
T_a = 25 ℃
V_{CE} = 10V
g_{re}
12.5
15
4
6
8
10
12
14
16
COLLECTOR CURRENT I_C (mA)


g_{fe} , b_{fe} – I_C
FORWARD TRANSFER CONDUCTANCE g_{fe} (mS)
FORWARD TRANSFER SUSCEPTANCE b_{fe} (mS)
160
140
120
100
80
60
-160
-140
-120
-100
-80
-60
V_{CE} = 10 V
12.5
V_{CE} = 10 V
15
g_{fe}
12.5
15
COMMON EMITTER
f = 45 MHz
T_a = 25 ℃
b_{fe}
4
6
8
10
12
14
16
COLLECTOR CURRENT I_C (mA)


g_{fe} , b_{fe} – I_C
FORWARD TRANSFER CONDUCTANCE g_{fe} (mS)
FORWARD TRANSFER SUSCEPTANCE b_{fe} (mS)
160
140
120
100
80
60
-160
-140
-120
-100
-80
-60
COMMON EMITTER
f = 58 MHz
T_a = 25 ℃
V_{CE} = 10 V
12.5
15
V_{CE} = 10 V
g_{fe}
12.5
15
b_{fe}
4
6
8
10
12
14
16
COLLECTOR CURRENT I_C (mA)


P_C – T_a
COLLECTOR POWER DISSIPATION P_C (mW)
400
300
200
100
0
0
40
80
120
160
200
240
AMBIENT TEMPERATURE Ta (C)

SILICON NPN EPITAXIAL PLANAR TYPE (INDUSTRIAL APPLICATIONS)

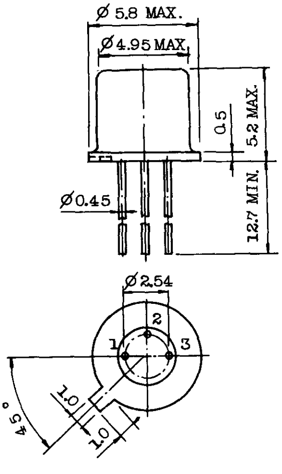
2SC395A

ULTRA HIGH SPEED SWITCHING APPLICATIONS.
COMPUTER, COUNTER APPLICATIONS.

FEATURES:

- High Transition Frequency : f_T=200MHz(Min.)
- Low Saturation Voltage
  : $V_{CE(sat)}$=0.25V(Max.) at I_C=10mA, I_B=1mA
- High Switching Speed : t_{stg}=25ns(Typ.)

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR (CASE)

JEDEC	TO-18
EIAJ	TC-7, TB-8C
TOSHIBA	2-5A1B

Weight : 0.31g

MAXIMUM RATINGS (Ta=25°C)

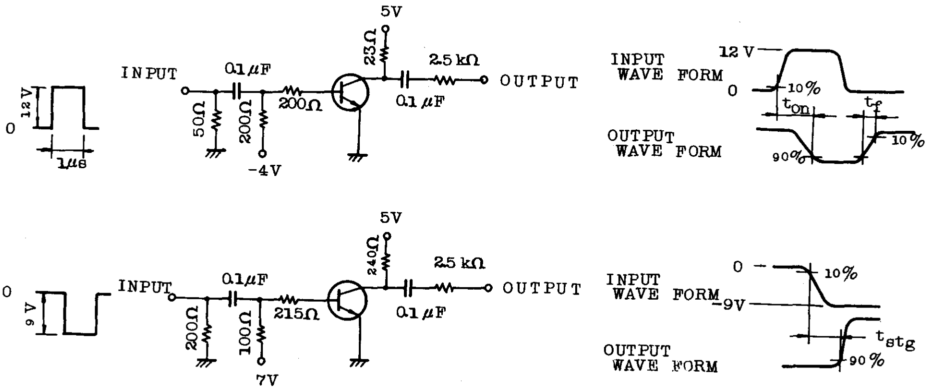
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	20	V
Collector-Emitter Voltage	V_{CEO}	12	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	500	mA
Base Current	I_B	100	mA
Collector Power Dissipation	P_C	300	mW
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_{stg}	-65∿175	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

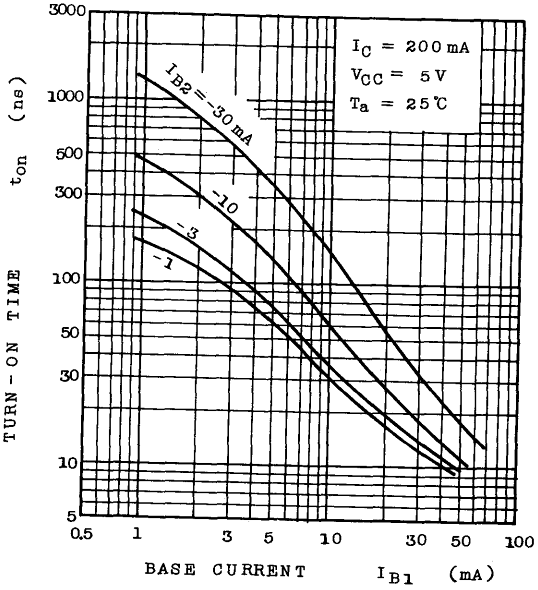
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CE}=20V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=5V, I_C=0	-	-	1.0	μA
DC Current Gain		$h_{FE}(1)$ (Note)	V_{CE}=1V, I_C=10mA	60	-	200	
		$h_{FE}(2)$	V_{CE}=5V, I_C=500mA	10	-	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$ (1)	I_C=10mA, I_B=1mA	-	-	0.25	V
		$V_{CE(sat)}$ (2)	I_C=200mA, I_B=20mA	-	-	0.7	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=10mA, I_B=1mA	-	-	0.8	V
Transition Frequency		f_T	V_{CE}=10V, I_C=10mA	200	400	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	4	6	pF
Switching Time	Turn-on Time	t_{on}	Fig.	-	20	40	ns
	Storage Time	t_{stg}		-	25	50	
	Fall Time	t_f		-	15	30	

Note: $h_{FE}(1)$ Classification 0: 60∿120, Y: 100∿200

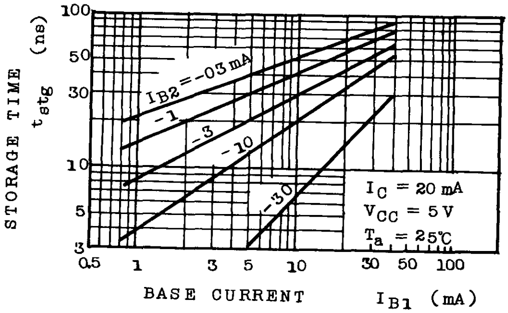
Fig. SWITCHING TIME TEST CIRCUIT



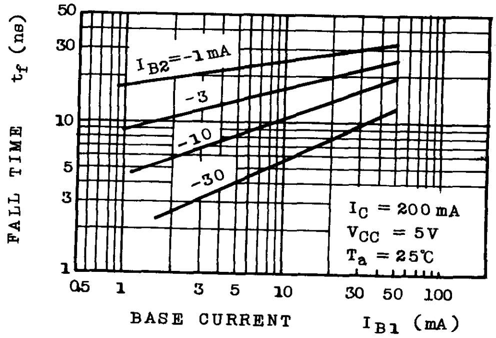
SWITCHING CHARACTERISTICS

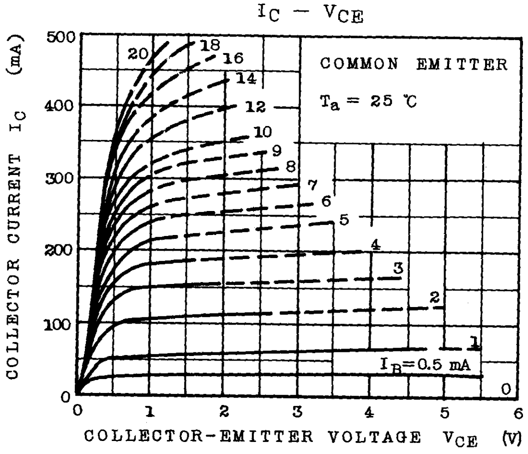


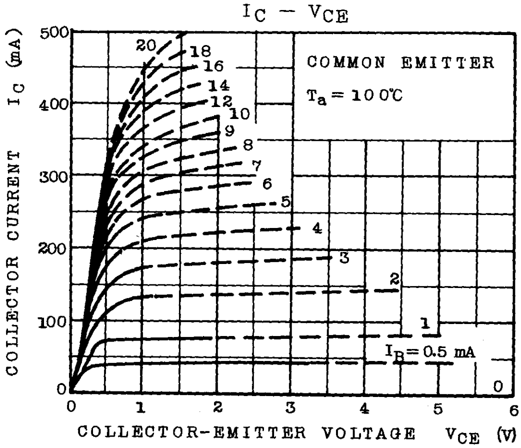
SWITCHING CHARACTERISTICS

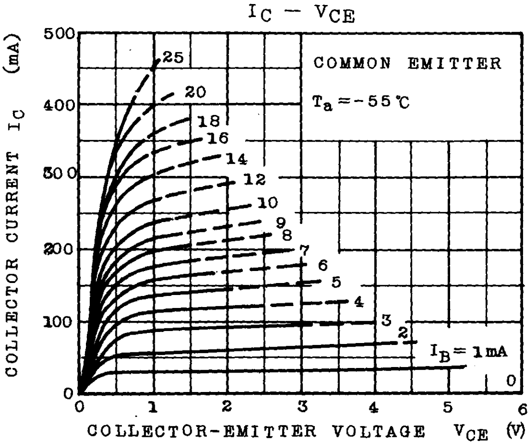


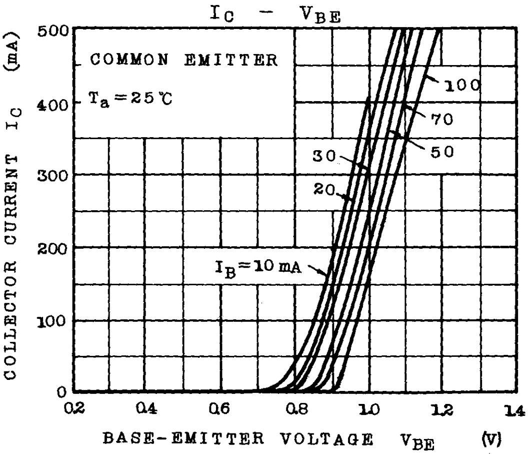
SWITCHING CHARACTERISTICS

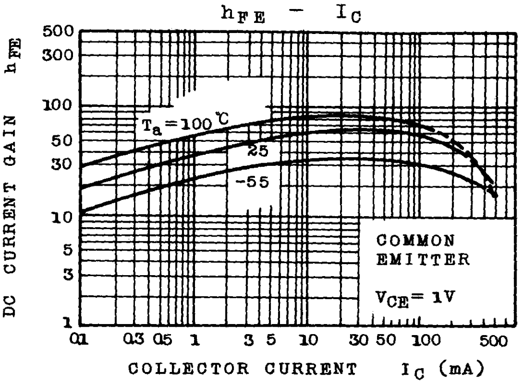


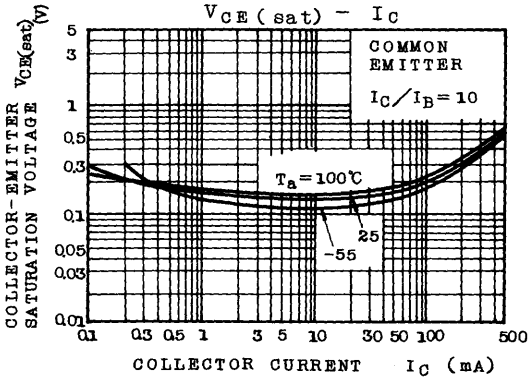

$I_C - V_{CE}$
COMMON EMITTER
$T_a = 25$ ℃
20
18
16
14
12
10
9
8
7
6
5
4
3
2
1
$I_B = 0.5$ mA
0
COLLECTOR CURRENT I_C (mA)
0
100
200
300
400
500
0 1 2 3 4 5 6
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)

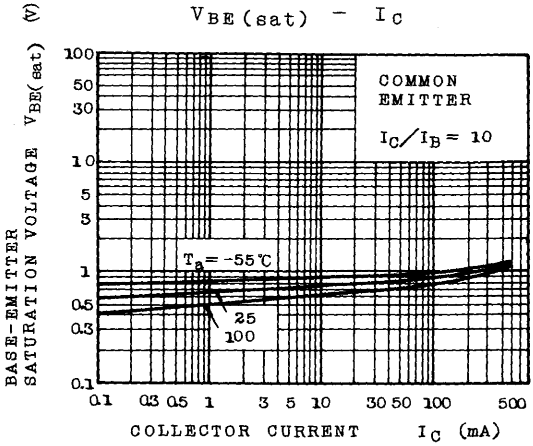

$I_C - V_{CE}$
COMMON EMITTER
$T_a = 100$ ℃
20
18
16
14
12
10
9
8
7
6
5
4
3
2
1
$I_B = 0.5$ mA
0
COLLECTOR CURRENT I_C (mA)
0
100
200
300
400
500
0 1 2 3 4 5 6
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)

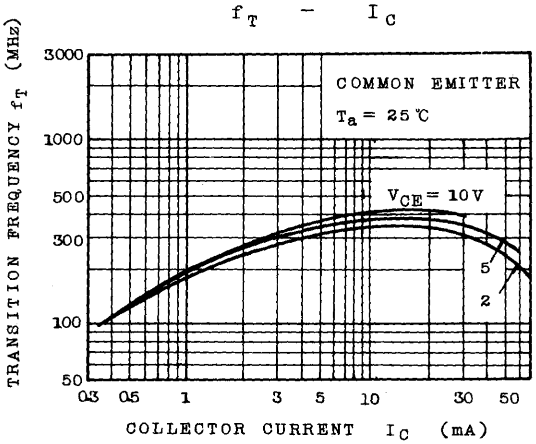

$I_C - V_{CE}$
COMMON EMITTER
$T_a = -55$ ℃
25
20
18
16
14
12
10
9
8
7
6
5
4
3
2
$I_B = 1$ mA
0
COLLECTOR CURRENT I_C (mA)
0
100
200
300
400
500
0 1 2 3 4 5 6
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)

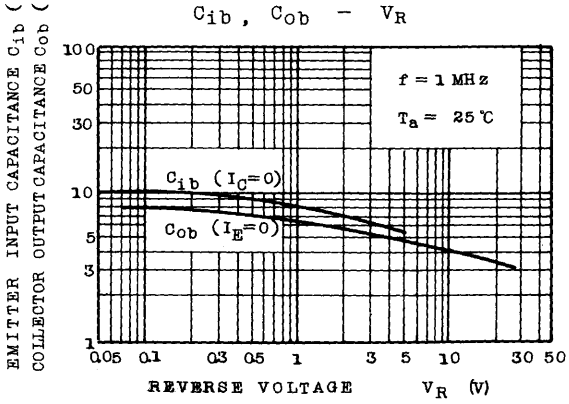

$I_C - V_{BE}$
COMMON EMITTER
$T_a = 25$ ℃
100
70
50
30
20
$I_B = 10$ mA
COLLECTOR CURRENT I_C (mA)
0
100
200
300
400
500
0.2 0.4 0.6 0.8 1.0 1.2 1.4
BASE-EMITTER VOLTAGE V_{BE} (V)

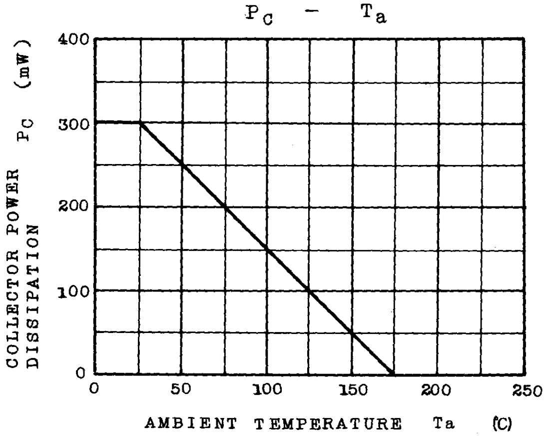

$h_{FE} - I_C$
$T_a = 100$ ℃
25
-55
COMMON EMITTER
$V_{CE} = 1$V
DC CURRENT GAIN h_{FE}
1
3
5
10
30
50
100
300
500
0.1 0.3 0.5 1 3 5 10 30 50 100 500
COLLECTOR CURRENT I_C (mA)


$V_{CE(sat)} - I_C$
COMMON EMITTER
$I_C / I_B = 10$
$T_a = 100$ ℃
25
-55
COLLECTOR-EMITTER SATURATION VOLTAGE $V_{CE(sat)}$ (V)
0.01
0.03
0.05
0.1
0.3
0.5
1
3
5
0.1 0.3 0.5 1 3 5 10 30 50 100 500
COLLECTOR CURRENT I_C (mA)


$V_{BE(sat)} - I_C$


$f_T - I_C$


$C_{ib}, C_{ob} - V_R$


$P_C - T_a$

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)
(INDUSTRIAL APPLICATIONS)

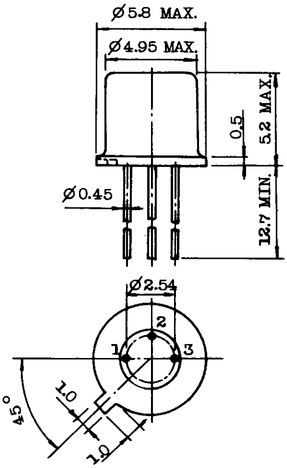
2SC400

HIGH FREQUENCY AMPLIFIER APPLICATIONS.
HIGH SPEED SWITCHING APPLICATIONS.

FEATURES:

- High Transition Frequency : f_T=300MHz (Typ.)
- Low Collector Output Capacitance : C_{ob}=4pF (Typ.)
- Low Saturation Voltage
  : $V_{CE(sat)}$=0.15V (Typ.) at I_C=10mA, I_B=1mA
- High Switching Speed : t_{stg}=300ns (Typ.)
- Complementary to 2SA500.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR (CASE)

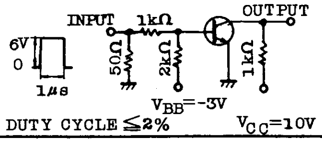
JEDEC	TO-18
EIAJ	TC-7, TB-8C
TOSHIBA	2-5A1B

Weight : 0.31g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	20	V
Emitter Base Voltage	V_{EBO}	5	V
Collector Current	I_C	100	mA
Base Current	I_B	20	mA
Collect Power Dissipation	P_C	250	mW
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_{stg}	-65∿175	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

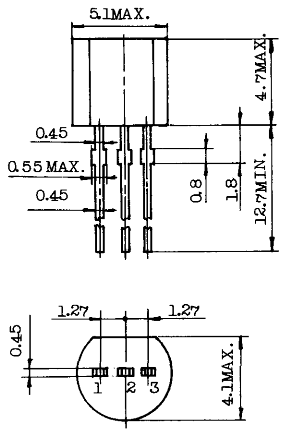
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=15V, I_E=0	-	-	0.5	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=5V, I_C=0	-	-	1.0	μA
DC Current Gain		h_{FE} (Note)	V_{CE}=1V, I_C=10mA	60	-	350	
Saturation Voltage	Collector-Emitter	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	0.15	0.4	V
	Base-Emitter	$V_{BE(sat)}$		-	0.8	0.95	
Transition Frequency		f_T	V_{CE}=10V, I_C=10mA	100	300	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	4	6	pF
Base Intrinsic Resistance		$r_{bb'}$	V_{CB}=6V, I_E=-1mA, f=30MHz	-	40	150	Ω
Input Impedance		h_{ie}	V_{CE}=10V, I_E=-10mA f=270Hz	-	0.3	-	kΩ
Voltage Feedback Ratio		h_{re}		-	2	-	X10^{-4}
Small-Signal Current Gain		h_{fe}		-	80	-	
Collector Output Admittance		h_{oe}		-	150	-	μ℧
Switching Time	Turn-on Time	t_{on}		-	25	-	ns
	Storage Time	t_{stg}		-	300	-	ns
	Fall Time	t_f		-	30	-	ns

Note : h_{FE} Classification O : 60 ∿ 120, Y : 100 ∿ 200, GR : 170 ∿ 350

2SC732TM

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO — 92
EIAJ	SC — 43
TOSHIBA	2 — 5F1B

Weight : 0.21g

LOW NOISE AUDIO AMPLIFIER APPLICATIONS.

FEATURES:

- High Breakdown Voltage : V_{CEO}=50V
- Excellent h_{FE} Linearity
  : $h_{FE}(I_C=0.1mA)/h_{FE}(I_C=2mA)=0.95$ (Typ.)
- Low Noise
  : NF(1)=0.5dB Typ. (f=100Hz)
  : NF(2)=0.2dB Typ. (f=1kHz)

MAXIMUM RATINGS (Ta=25°C)

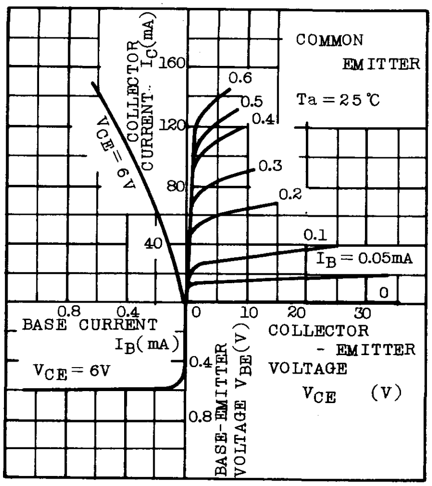
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	60	V
Collector-Emitter Voltage	V_{CEO}	50	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	150	mA
Emitter Current	I_E	-150	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=60V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=6V, I_C=2mA	200	-	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	0.3	V
Base-Emitter Voltage	V_{BE}	V_{CE}=6V, I_C=2mA	-	0.65	-	V
Transition Frequency	f_T	V_{CE}=6V, I_C=1mA	-	150	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	2.0	-	pF
Noise Figure	NF(1)	V_{CE}=6V, I_C=0.1mA f=100Hz, R_g=10kΩ	-	0.5	6	dB
Noise Figure	NF(2)	V_{CE}=6V, I_C=0.1mA f=1kHz, R_g=10kΩ	-	0.2	3	dB

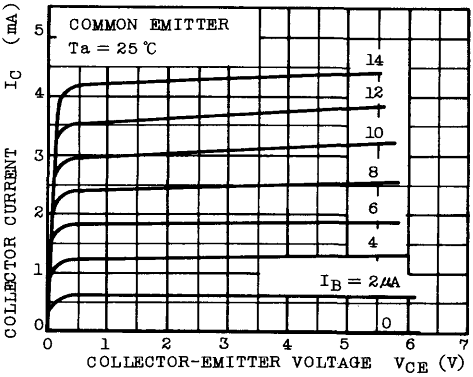
Note : h_{FE} Classification GR : 200∿400, BL : 350∿700

STATIC CHARACTERISTICS

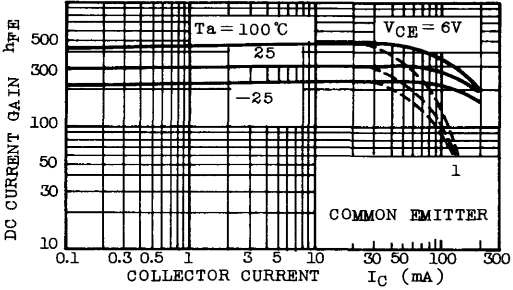


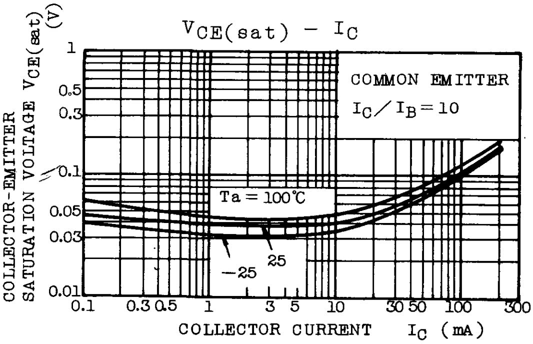
I_C − V_{CE}

(LOW CURRENT AND LOW VOLTAGE REGION)

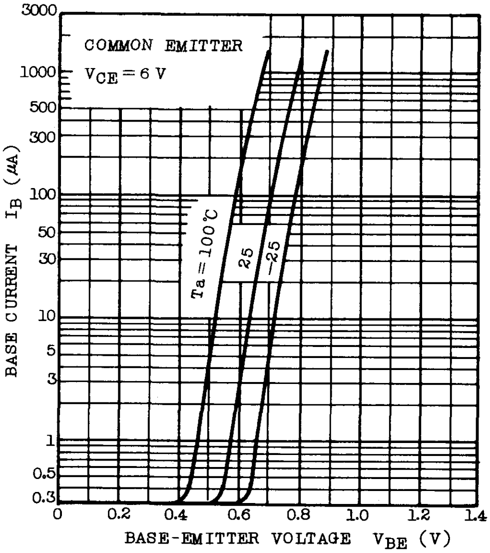


h_{FE} − I_C

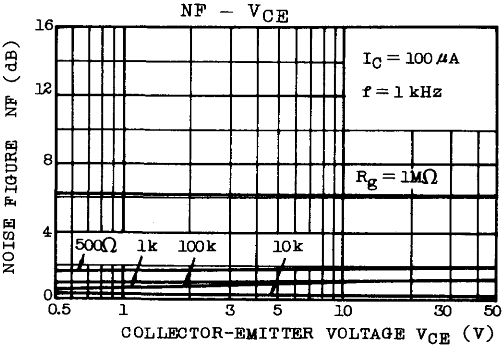




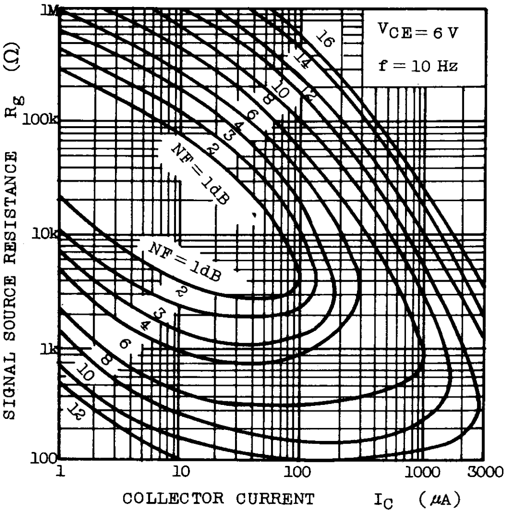
I_B − V_{BE}



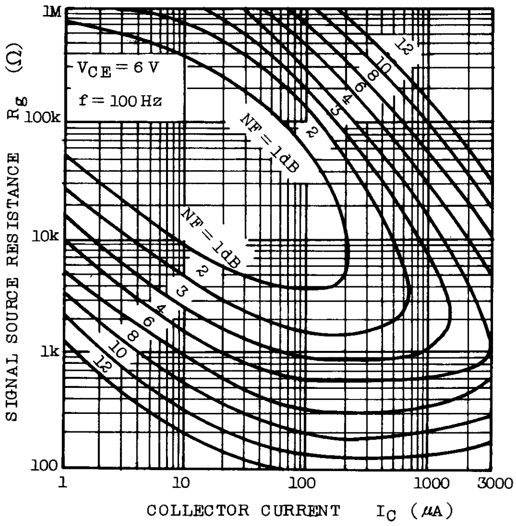
NF − V_{CE}



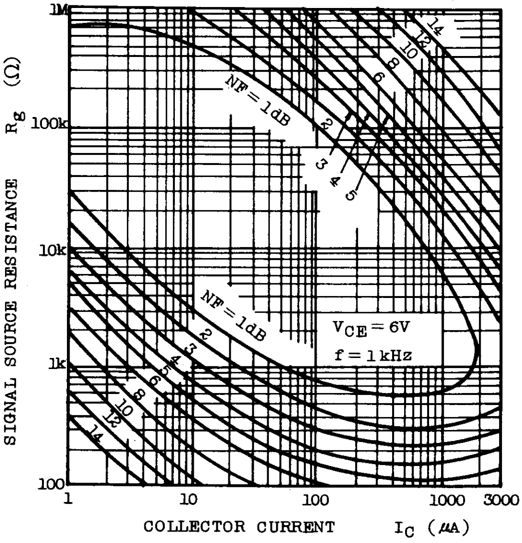
NF — R_g, I_C



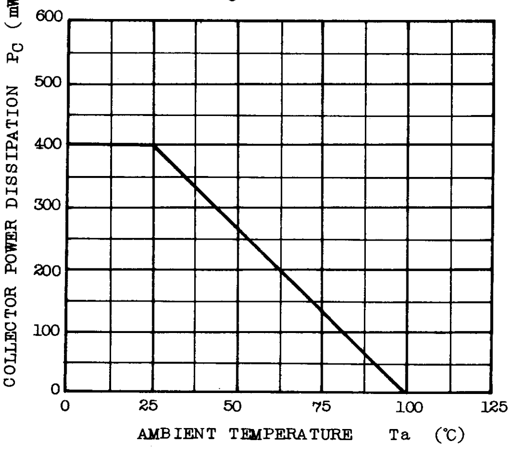
NF — R_g, I_C



NF — R_g, I_C



P_C — Ta



SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

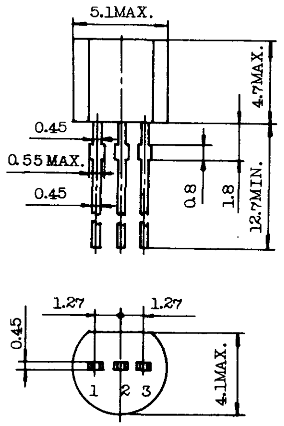
2SC941TM

HIGH FREQUENCY AMPLIFIER APPLICATIONS.
AM HIGH FREQUENCY AMPLIFIER APPLICATIONS.
AM FREQUENCY CONVERTER APPLICATIONS.

FEATURES:

- Low Noise Figure : NF=3.5dB (Max.) (f=1MHz)

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO — 92
EIAJ	SC — 43
TOSHIBA	2 — 5 F 1 B

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	35	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	100	mA
Emitter Current	I_E	-100	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

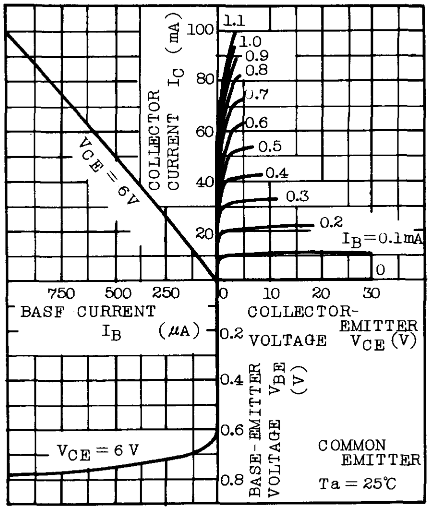
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=20V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=2V, I_C=0	-	-	1.0	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=12V, I_C=2mA	40	-	240	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	0.4	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=10mA, I_B=1mA	-	-	1.0	V
Transition Frequency	f_T	V_{CE}=10V, I_C=2mA	80	120	-	MHz
Reverse Transfer Capacitance	C_{re}	V_{CB}=10V, I_E=0, f=1MHz	-	2.2	3.0	pF
Collector-Base Time Constant	$C_c \cdot r_{bb'}$	V_{CE}=10V, I_E=-1mA, f=30MHz	-	30	50	ps
Noise Figure	NF	V_{CE}=10V, I_E=-1mA f=1MHz, R_g=50Ω	-	2.0	3.5	dB

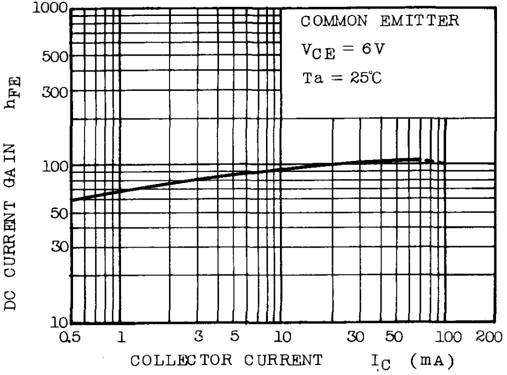
Note: h_{FE} classification R : 40∿80, O : 70∿140, Y : 120∿240 y PARAMETERS (Typ.) (COMMON EMITTER V_{CE}=6V, I_E=-1mA, f=1MHz)

CHARACTERISTIC	SYMBOL	2SC941-R	2SC941-O	2SC941-Y	UNIT
Input Conductance	g_{ie}	0.5	0.35	0.22	mS
Input Capacitance	C_{ie}	50	48	46	pF
Output Conductance	g_{oe}	4	5	6.5	μS
Output Capacitance	C_{oe}	3.7	3.4	3.2	pF
Forward Transfer Admittance	$\|y_{fe}\|$	36	36	36	mS
Phase Angle of Forward Transfer Admittance	θ_{fe}	-1.6	-1.6	-1.6	°
Reverse Transfer Admittance	$\|y_{re}\|$	14	14	14	μS
Phase Angle of Reverse Transfer Admittance	θ_{re}	-90	-90	-90	°

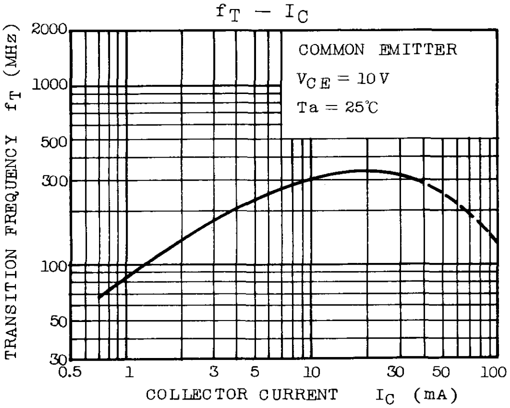
STATIC CHARACTERISTICS



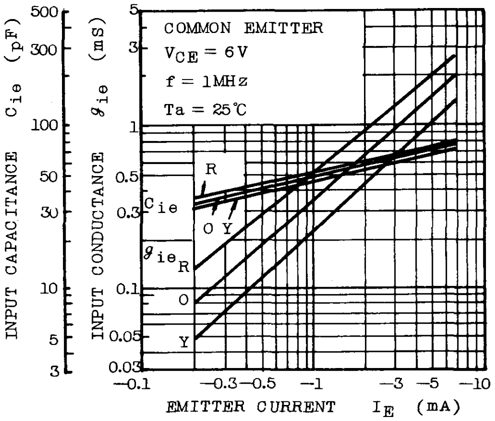
h_{FE} — I_C



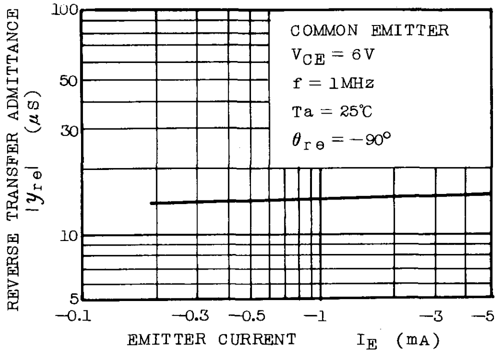
f_T — I_C

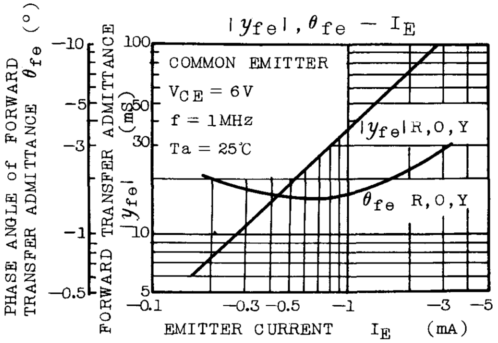


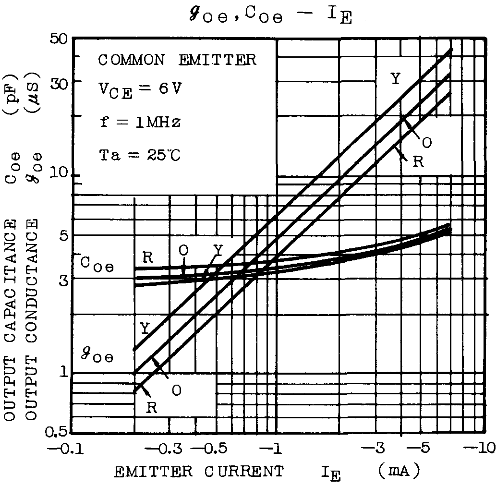
g_{ie}, C_{ie} — I_E

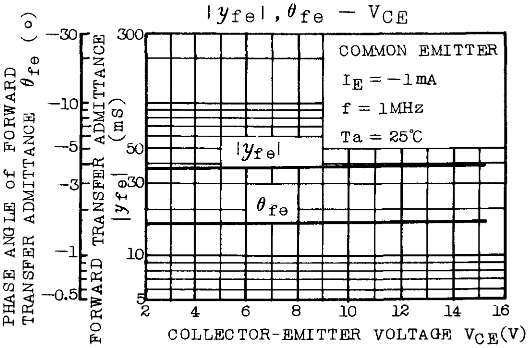


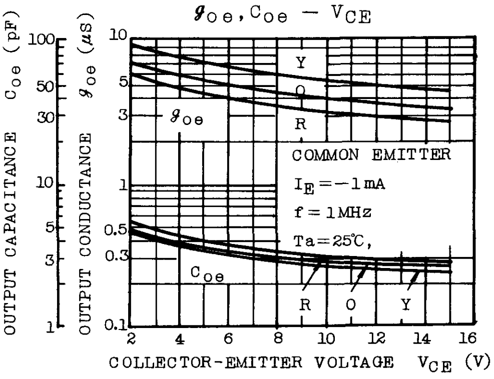
$|y_{re}|$ — I_E

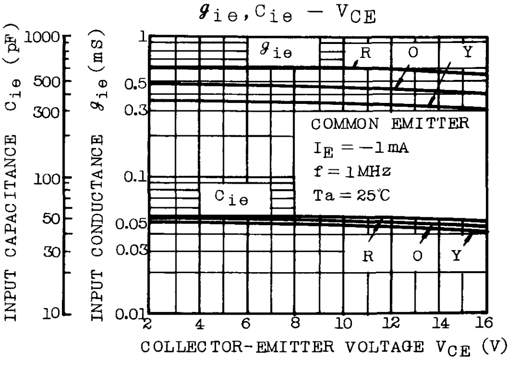


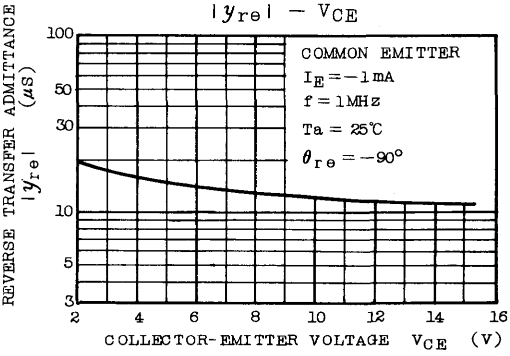

|yfe|, θfe — IE
COMMON EMITTER
VCE = 6V
f = 1MHz
Ta = 25℃
|yfe| R, O, Y
θfe R, O, Y
PHASE ANGLE of FORWARD TRANSFER ADMITTANCE θfe (°)
−10
−5
−3
−1
−0.5
FORWARD TRANSFER ADMITTANCE |yfe| (mS)
100
50
30
10
5
−0.1
−0.3
−0.5
−1
−3
−5
EMITTER CURRENT IE (mA)


goe, Coe — IE
COMMON EMITTER
VCE = 6V
f = 1MHz
Ta = 25℃
Y
O
R
Coe
R
O
Y
goe
Y
O
R
OUTPUT CAPACITANCE Coe (pF)
OUTPUT CONDUCTANCE goe (μS)
50
30
10
5
3
1
0.5
−0.1
−0.3
−0.5
−1
−3
−5
−10
EMITTER CURRENT IE (mA)


|yfe|, θfe — VCE
COMMON EMITTER
IE = −1mA
f = 1MHz
Ta = 25℃
|yfe|
θfe
PHASE ANGLE of FORWARD TRANSFER ADMITTANCE θfe (°)
−30
−10
−5
−3
−1
−0.5
FORWARD TRANSFER ADMITTANCE |yfe| (mS)
300
50
30
10
5
2
4
6
8
10
12
14
16
COLLECTOR-EMITTER VOLTAGE VCE(V)


goe, Coe — VCE
Y
O
R
goe
COMMON EMITTER
IE = −1mA
f = 1MHz
Ta = 25℃,
Coe
R
O
Y
OUTPUT CAPACITANCE Coe (pF)
100
50
30
10
5
3
1
OUTPUT CONDUCTANCE goe (μS)
10
5
3
1
0.5
0.3
0.1
2
4
6
8
10
12
14
16
COLLECTOR-EMITTER VOLTAGE VCE (V)


gie, Cie — VCE
gie
R
O
Y
COMMON EMITTER
IE = −1mA
f = 1MHz
Ta = 25℃
Cie
R
O
Y
INPUT CAPACITANCE Cie (pF)
1000
500
300
100
50
30
10
INPUT CONDUCTANCE gie (mS)
1
0.5
0.3
0.1
0.05
0.03
0.01
2
4
6
8
10
12
14
16
COLLECTOR-EMITTER VOLTAGE VCE (V)


|yre| — VCE
COMMON EMITTER
IE = −1mA
f = 1MHz
Ta = 25℃
θre = −90°
REVERSE TRANSFER ADMITTANCE |yre| (μS)
100
50
30
10
5
3
2
4
6
8
10
12
14
16
COLLECTOR-EMITTER VOLTAGE VCE (V)

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)
(INDUSTRIAL APPLICATIONS)

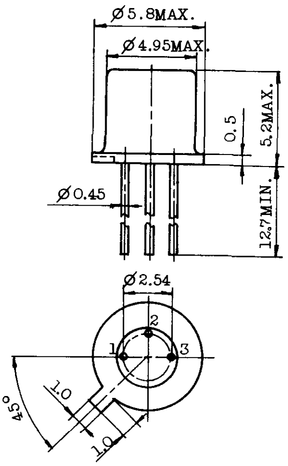
2SC979
2SC979A

HIGH FREQUENCY AMPLIFIER APPLICATIONS.
HIGH SPEED SWITCHING APPLIATIONS.

FEATURES:

- High Breakdown Voltage : V_{CEO}=70V(2SC979A).
- Low Saturation Voltage
  : $V_{CE(sat)}$=0.05V (Typ.) at I_C=10mA, I_B=1mA
- High Transition Frequency
  : f_T=250MHz (Typ.) at V_{CE}=10V, I_C=10mA
- Low Output Capacitance : C_{ob}=3pF (Typ.)
- Complementary to 2SA499.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR(CASE)

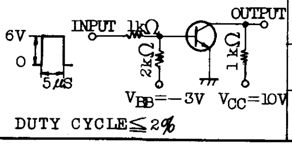
JEDED	TO—18
EIAJ	TC—7, TB—8C
TOSHIBA	2—5A1B

Weight : 0.31g

MAXIMUM RATINGS (Ta=25°C)

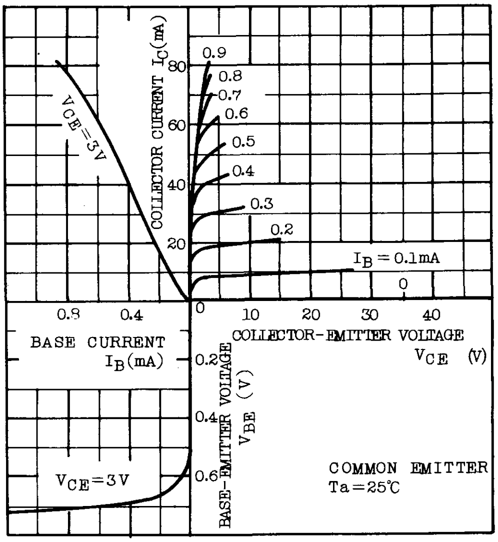
CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Voltage	2SC979	V_{CBO}	70	V
	2SC979A		100	
Collector-Emitter Voltage	2SC979	V_{CEO}	50	V
	2SC979A		70	
Emitter-Base Voltage		V_{EBO}	5	V
Collector Current		I_C	100	mA
Base Current		I_B	20	mA
Collector Power Dissipation		P_C	300	mW
Junction Temperature		T_j	175	°C
Storage Temperature Range		T_{stg}	-65∿175	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

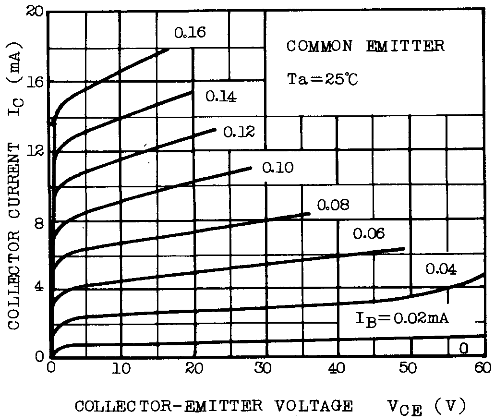
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	2SC979	I_{CBO}	V_{CB}=70V, I_E=0	-	-	1.0	μA
	2SC979A		V_{CB}=100V, I_E=0	-	-	1.0	
Emitter Cut-off Current		I_{EBO}	V_{EB}=5V, I_C=0	-	-	1.0	μA
DC Current Gain	2SC979	h_{FE} (Note)	V_{CE}=1V, I_C=10mA	70	-	240	
	2SC979A			70	-	140	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	0.05	0.3	V
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=10mA, I_B=1mA	-	0.75	1.0	V
Transition Frequency		f_T	V_{CE}=10V, I_C=10mA	150	250	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	3	5	pF
Switching Time	Turn-on Time	t_{on}	 DUTY CYCLE≦2%	-	25	-	ns
	Storage Time	t_{stg}		-	400	-	
	Fall Time	t_f		-	30	-	

Note : h_{FE} Classification O : 70∿140, Y : 120∿240

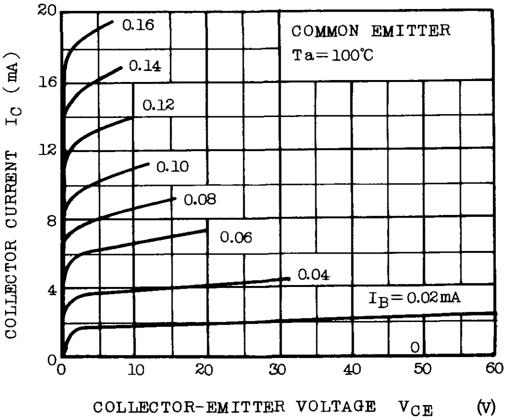
STATIC CHARACTERISTICS



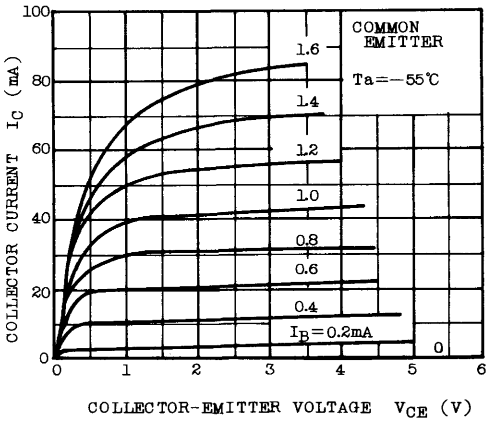
I_C-V_{CE}(LOW CURRENT REGION)



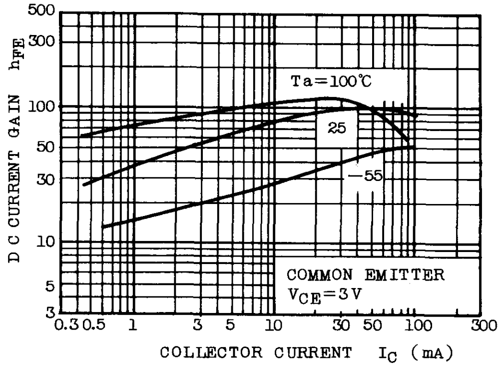
I_C-V_{CE}(LOW CURRENT REGION)



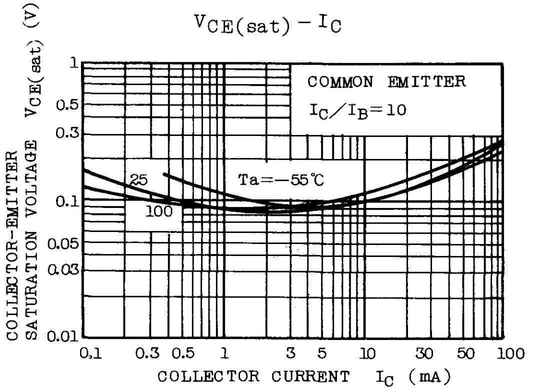
I_C-V_{CE}(LOW VOLTAGE REGION)



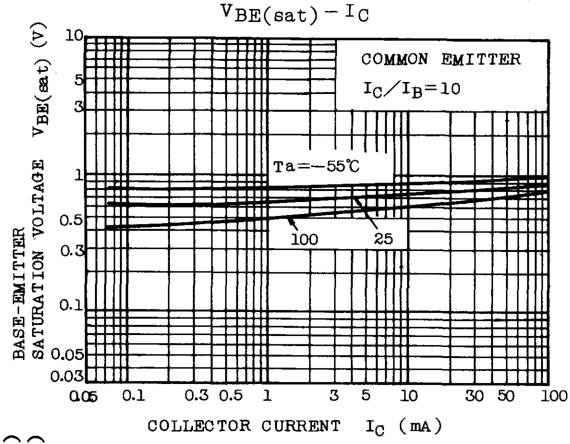
$h_{FE} - I_C$



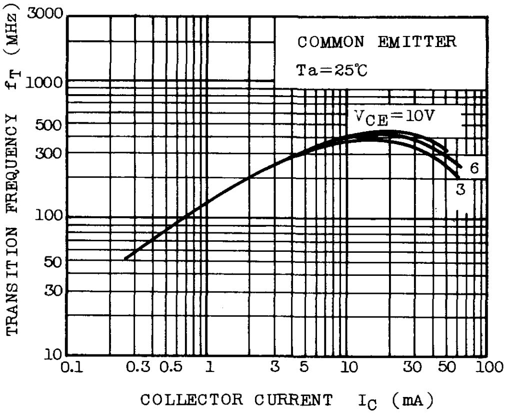
$V_{CE(sat)} - I_C$



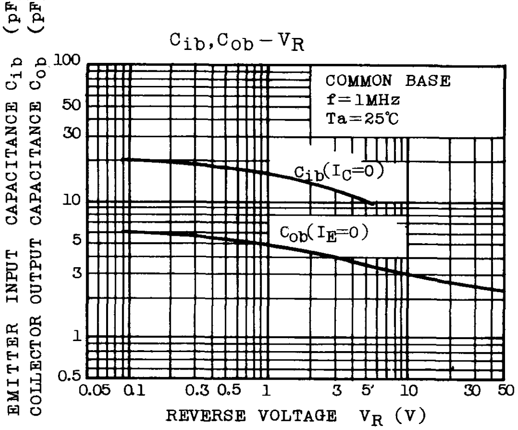
$V_{BE(sat)} - I_C$



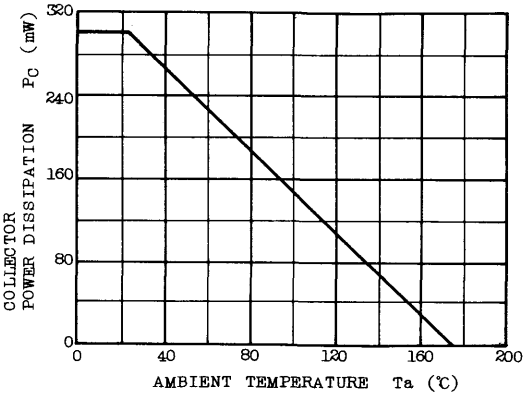
$f_T - I_C$



$C_{ib}, C_{ob} - V_R$



$P_C - Ta$



2SC982TM

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)
(INDUSTRIAL APPLICATIONS)

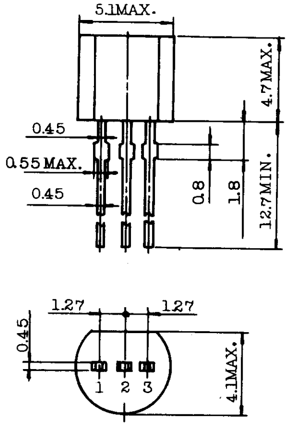
PRINTER DRIVE, CORE DRIVE AND LED DRIVE APPLICATIONS.

LOW FREQUENCY AMPLIFIER APPLICATIONS.

FEATURES:

- High DC Current Gain
  : $h_{FE(1)}$=5000 (Min.) (I_C=10mA)
  : $h_{FE(2)}$=10000 (Min.) (I_C=100mA)

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

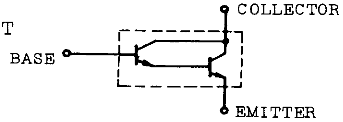
Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	40	V
Collector-Emitter Voltage	V_{CEO}	40	V
Emitter-Base Voltage	V_{EBO}	10	V
Continuous Collector Current	$I_{C(DC)}$	300	mA
Peak Collector Current	I_{CP} (Note)	500	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

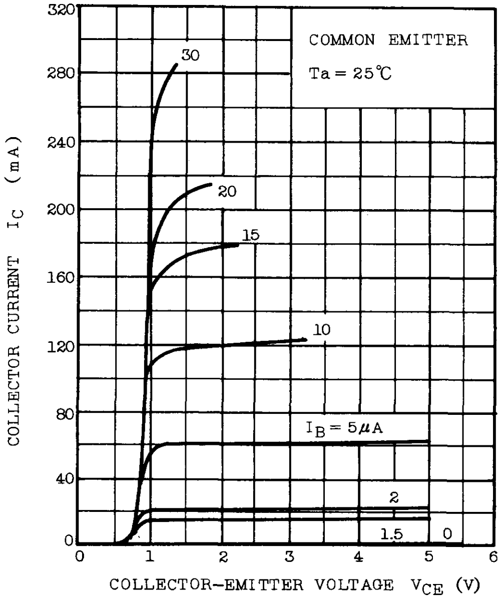
Note : Pulee width≦10ms duty cycle≦10%

EQUIVALENT CIRCUIT

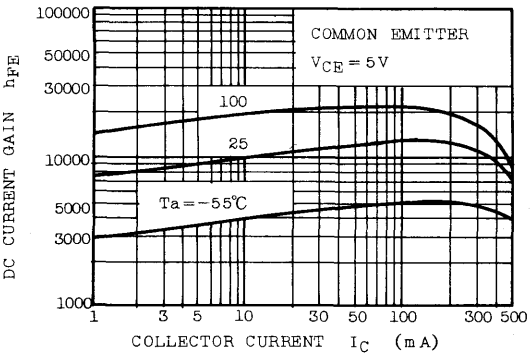


ELECTRICAL CHARACTERISTICS (Ta=25°C)

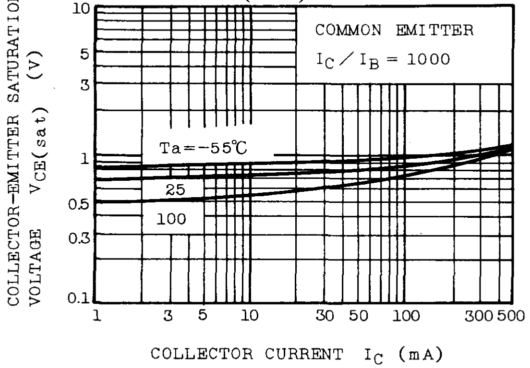
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=40V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=8V, I_C=0	-	-	0.1	μA
DC Current Gain	$h_{FE(1)}$	V_{CE}=5V, I_C=10mA	5000	-	-	
	$h_{FE(2)}$	V_{CE}=2V, I_C=100mA	10000	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=300mA, I_B=0.3mA	-	0.9	1.3	V
Base-Emitter Voltage	V_{BE}	V_{CE}=2V, I_C=100mA	-	1.25	1.6	V



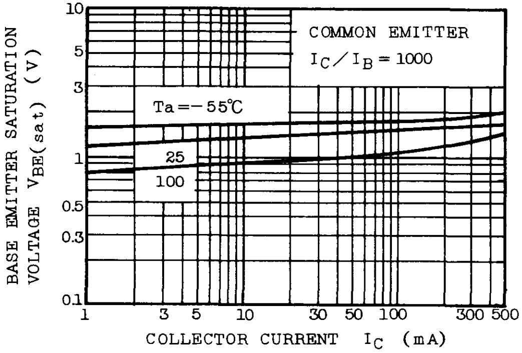
$I_C - V_{CE}$



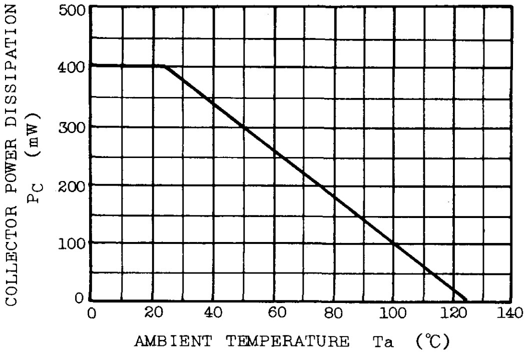
$h_{FE} - I_C$



$V_{CE(sat)} - I_C$



$V_{BE(sat)} - I_C$



$P_C - Ta$

2SC1380
2SC1380A

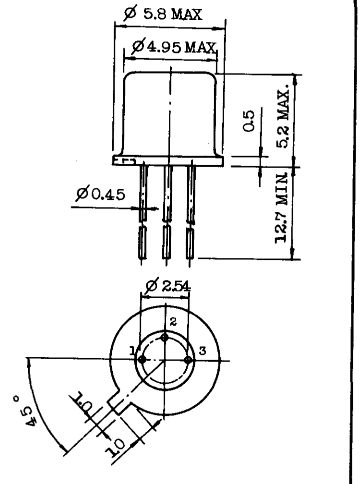
SILICON NPN EPITAXIAL TYPE (PCT PROCESS)
(INDUSTRIAL APPLICATIONS)

HIGH FREQUENCY AMPLIFIER APPLICATIONS.
LOW NOISE AUDIO AMPLIFIER APPLICATIONS. (2SC1380A)

FEATURES:

- High Breakdown Voltage : V_{CEO}=50V
- High DC Current Gain : h_{FE}=200∿700
- Low Noise Figure : NF=2dB(Max.)(2SC1380A)
  at R_g=10kΩ, f=100Hz

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR (CASE)

JEDEC	TO-18
EIAJ	TC-7, TB-8C
TOSHIBA	2-5A1B

Weight : 0.31g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	55	V
Collector-Emitter Voltage	V_{CEO}	50	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	100	mA
Base Current	I_B	20	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55∿150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=18V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain		h_{FE} (Note)	V_{CE}=6V, I_C=2mA	200	-	700	
Transition Frequency		f_T	V_{CE}=6V, I_C=1mA	-	80	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=6V, I_E=0, f=1MHz	-	6	10	pF
Noise Figure	2SC1380A Only	NF(1)	V_{CE}=6V, I_C=0.1mA f=10Hz, R_g=10kΩ	-	-	10	dB
		NF(2)	V_{CE}=6V, I_C=0.1mA f=100Hz, R_g=10kΩ	-	-	2	

Note: h_{FE} Classification GR: 200∿400, BL: 350∿700

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

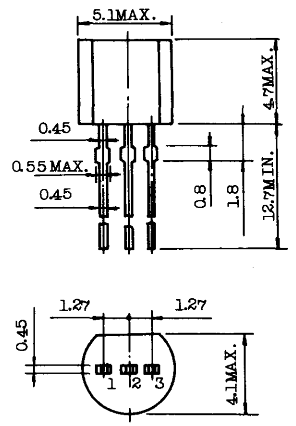
2SC1627

DRIVER STAGE AMPLIFIER APPLICATIONS.
VOLTAGE AMPLIFIER APPLICATIONS.

FEATURES :

- Complementary to 2SA817.
- Driver Stage Application of 20 to 25 Watts Amplifiers.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO — 92
EIAJ	SC — 43
TOSHIBA	2 — 5F1B

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

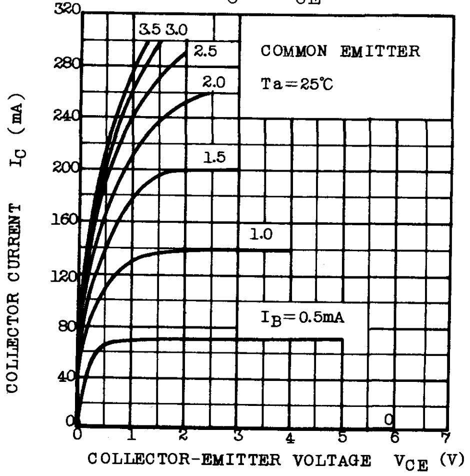
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	80	V
Collector-Emitter Voltage	V_{CEO}	80	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	300	mA
Emitter Current	I_E	-300	mA
Collector Power Dissipation	P_C	600	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55∿150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

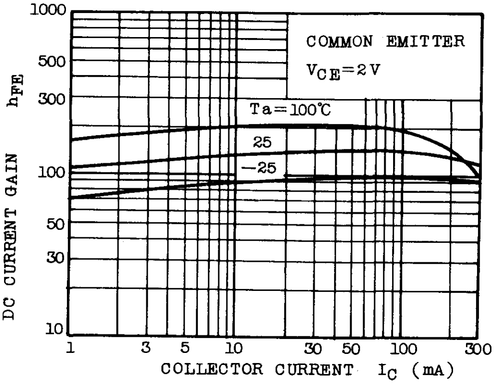
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=50V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA
Collector-Emitter Saturation Voltage	$V_{(BR)CEO}$	I_C=5mA, I_B=0	80	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=2V, I_C=50mA	70	-	240	
	$h_{FE(2)}$	V_{CE}=2V, I_C=200mA	40	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=200mA, I_B=10mA	-	-	0.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=2V, I_C=5mA	0.55	-	0.8	V
Transition Frequency	f_T	V_{CE}=10V, I_C=10mA	-	100	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f≈1MHz	-	10	-	pF

Note : $h_{FE(1)}$ Classification 0 : 70∿140, Y : 120∿240

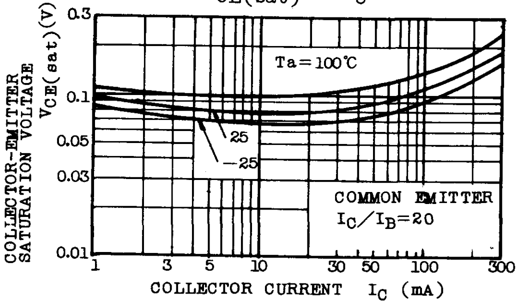
$I_C - V_{CE}$



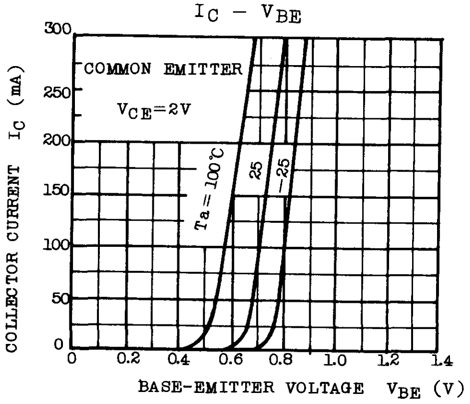
$h_{FE} - I_C$



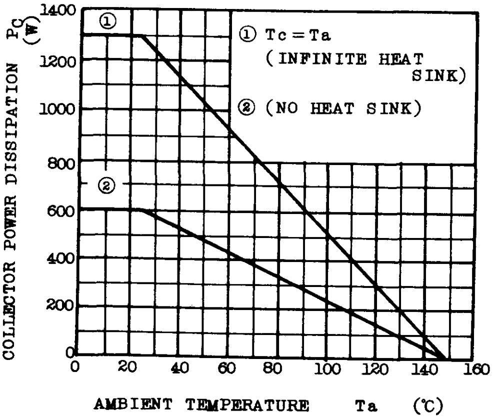
$V_{CE(sat)} - I_C$



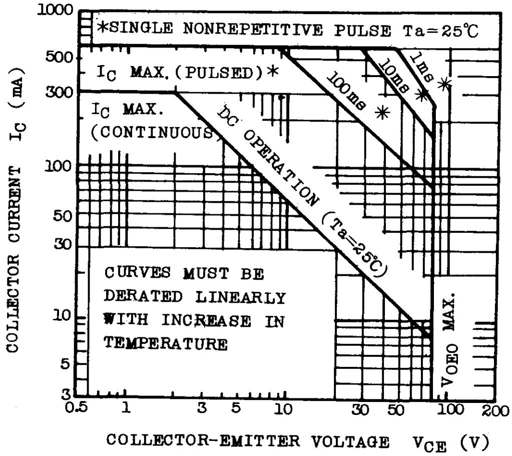
$I_C - V_{BE}$



$P_C - Ta$



SAFE OPERATING AREA



SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

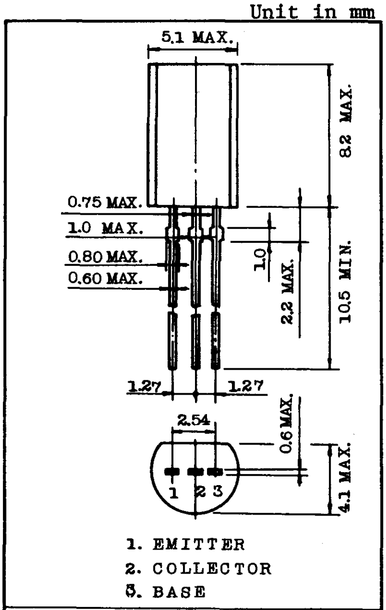
2SC1627A

DRIVER STAGE AMPLIFIER APPLICATIONS.
VOLTAGE AMPLIFIER APPLICATIONS.

FEATURES:

- Complementary to 2SA817A.
- Driver Stage Application of 30 to 35 Watts Amplifiers.

Unit in mm



JEDEC	TO-92MOD
EIAJ	—
TOSHIBA	2-5J1A

Weight : 0.36g

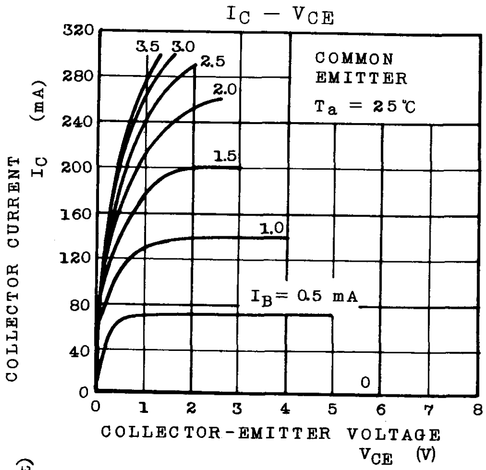
MAXIMUM RATINGS (Ta=25°C)

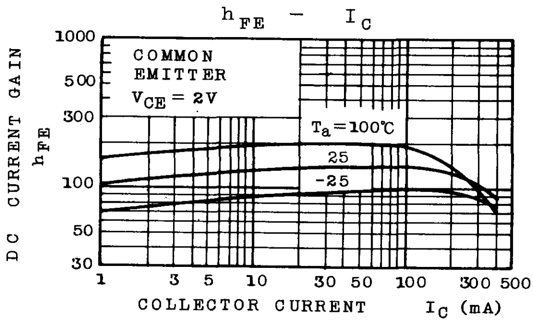
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	80	V
Collector-Emitter Voltage	V_{CEO}	80	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	400	mA
Emitter Current	I_E	-400	mA
Collector Power Dissipation	P_C	800	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55∿150	°C

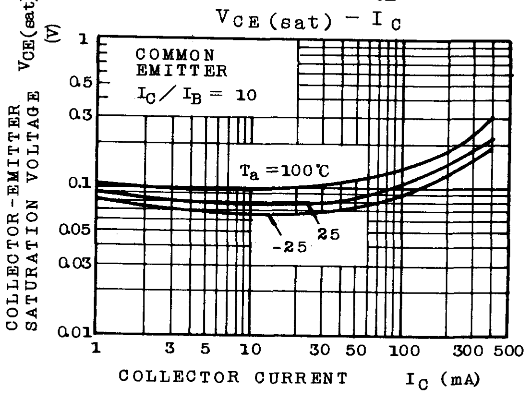
ELECTRICAL CHARACTERISTICS (Ta=25°C)

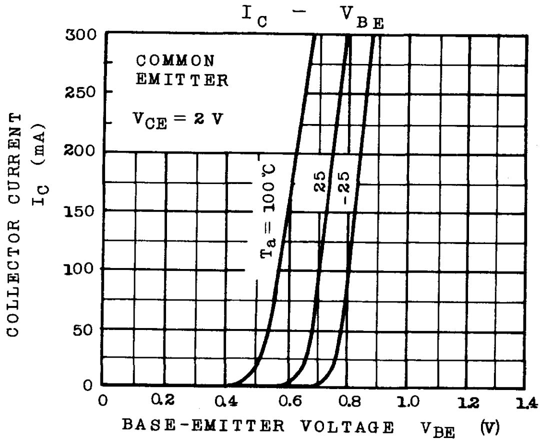
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=50V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=5mA, I_B=0	80	-	-	V
DC Current Gain	$h_{FE}(1)$ (Note)	V_{CE}=2V, I_C=50mA	70	-	240	
	$h_{FE}(2)$	V_{CE}=2V, I_C=200mA	40	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=200mA, I_B=20mA	-	-	0.4	V
Base-Emitter Voltage	V_{BE}	V_{CE}=2V, I_C=5mA	0.55	-	0.8	V
Transition Frequency	f_T	V_{CE}=10V, I_C=10mA	-	100	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, f = 1 MHz	-	10	-	pF

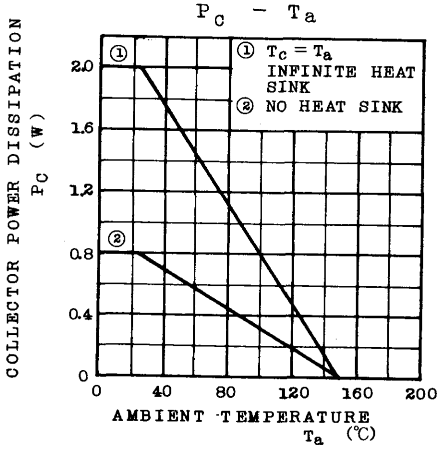
Note : $h_{FE(1)}$ Classification 0 : 70∿140, Y : 120∿240

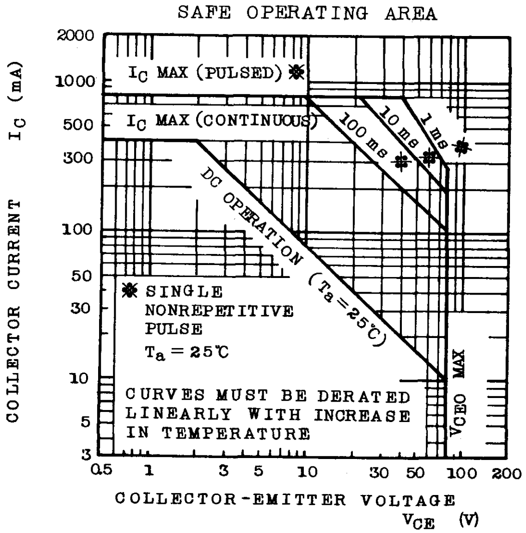

I_C — V_{CE}
COMMON EMITTER
T_a = 25℃
3.5
3.0
2.5
2.0
1.5
1.0
I_B= 0.5 mA
0
COLLECTOR CURRENT I_C (mA)
320
280
240
200
160
120
80
40
0
0
1
2
3
4
5
6
7
8
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)


h_{FE} — I_C
COMMON EMITTER
V_{CE} = 2V
T_a=100℃
25
-25
DC CURRENT GAIN h_{FE}
1000
500
300
100
50
30
1
3
5
10
30
50
100
300
500
COLLECTOR CURRENT I_C (mA)


V_{CE} (sat) — I_C
COMMON EMITTER
I_C / I_B = 10
T_a =100℃
25
-25
COLLECTOR-EMITTER SATURATION VOLTAGE V_{CE}(sat) (V)
1
0.5
0.3
0.1
0.05
0.03
0.01
1
3
5
10
30
50
100
300
500
COLLECTOR CURRENT I_C (mA)


I_C — V_{BE}
COMMON EMITTER
V_{CE} = 2 V
T_a = 100℃
25
-25
COLLECTOR CURRENT I_C (mA)
300
250
200
150
100
50
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
BASE-EMITTER VOLTAGE V_{BE} (V)


P_C — T_a
① T_c = T_a INFINITE HEAT SINK
② NO HEAT SINK
①
②
COLLECTOR POWER DISSIPATION P_C (W)
2.0
1.6
1.2
0.8
0.4
0
0
40
80
120
160
200
AMBIENT TEMPERATURE T_a (℃)

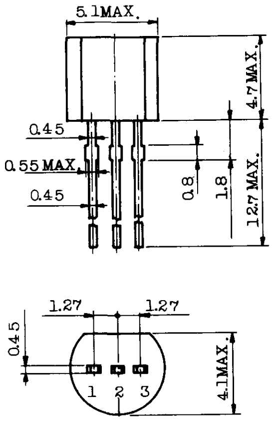

SAFE OPERATING AREA
I_C MAX (PULSED) ✱
I_C MAX (CONTINUOUS)
100 ms ✱
10 ms ✱
1 ms ✱
DC OPERATION (T_a = 25℃)
✱ SINGLE NONREPETITIVE PULSE T_a = 25℃
CURVES MUST BE DERATED LINEARLY WITH INCREASE IN TEMPERATURE
V_{CEO} MAX
COLLECTOR CURRENT I_C (mA)
2000
1000
500
300
100
50
30
10
5
3
0.5
1
3
5
10
30
50
100
200
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

2SC1815

AUDIO FREQUENCY GENERAL PURPOSE AMPLIFIER APPLICATIONS.
DRIVER STAGE AMPLIFIER APPLICATIONS.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

FEATURES:
- High Voltage and High Current
  : V_{CEO}=50V(Min.) I_C=150mA(Max.)
- Excellent h_{FE} Linearity
  : $h_{FE}(2)$=100(Typ.) at V_{CE}=6V, I_C=150mA
  : $h_{FE}(I_C=0.1mA)/h_{FE}(I_C=2mA)$=0.95(Typ.)
- Low Noise : NF=1db(Typ.) at f=1kHz
- complementary to 2SA1015 (O,Y,GR class)

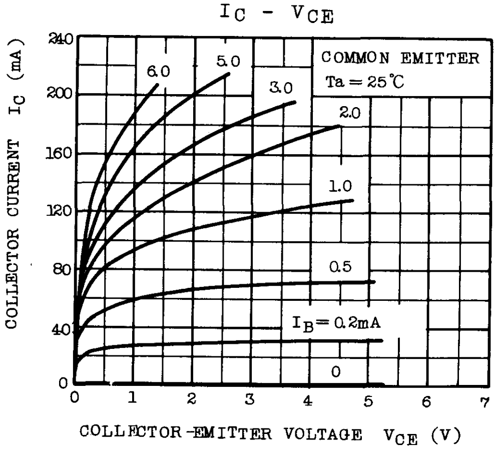
MAXIMUM RATINGS (Ta=25°C)

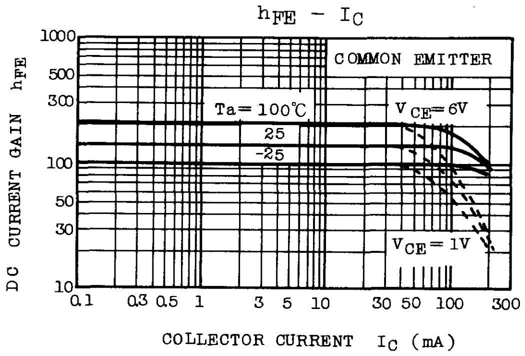
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	60	V
Collector-Emitter Voltage	V_{CEO}	50	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	150	mA
Base Current	I_B	50	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

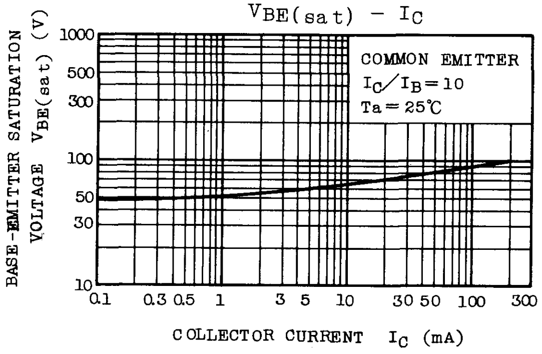
ELECTRICAL CHARACTERISTICS (Ta=25°C)

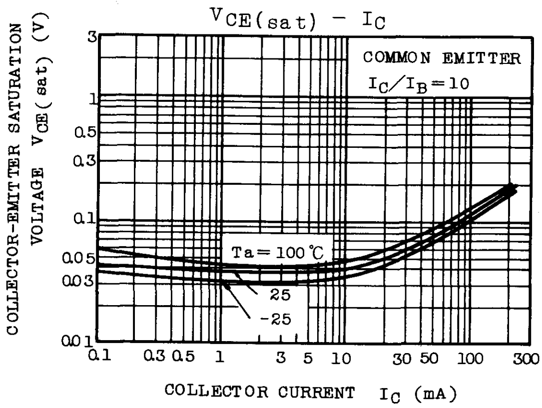
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=60V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain	$h_{FE}(1)$ (Note)	V_{CE}=6V, I_C=2mA	70	-	700	
	$h_{FE}(2)$	V_{CE}=6V, I_C=150mA	25	100	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=100mA, I_B=10mA	-	0.1	0.25	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=100mA, I_B=10mA	-	-	1.0	V
Transition Frequency	f_T	V_{CE}=10V, I_E=1mA	80	-	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	2.0	3.5	pF
Base Intrinsic Resistance	$r_{bb'}$	V_{CB}=10V, I_C=1mA, f=30MHz	-	50	-	Ω
Noise Figure	NF	V_{CE}=6V, I_C=0.1mA, R_g=10kΩ, f=1kHz	-	1.0	10	dB

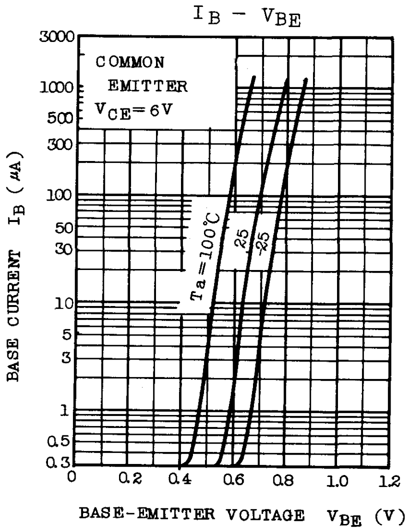
Note : h_{FE} Classification O:70~140 Y:120~240 GR:200~400 BL:350~700

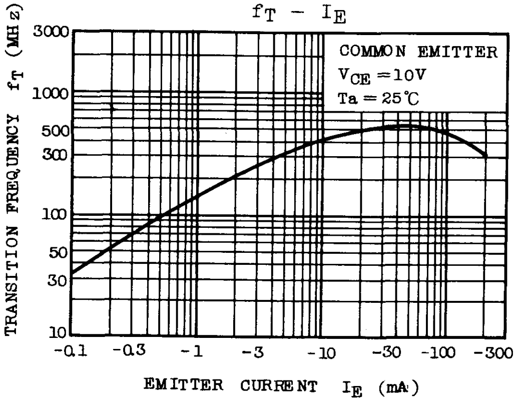

I_C - V_{CE}
COMMON EMITTER
Ta = 25℃
6.0
5.0
3.0
2.0
1.0
0.5
I_B = 0.2mA
0
COLLECTOR CURRENT I_C (mA)
240
200
160
120
80
40
0
0
1
2
3
4
5
6
7
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)


h_{FE} - I_C
COMMON EMITTER
Ta = 100℃
25
-25
V_{CE} = 6V
V_{CE} = 1V
DC CURRENT GAIN h_{FE}
1000
500
300
100
50
30
10
0.1
0.3
0.5
1
3
5
10
30
50
100
300
COLLECTOR CURRENT I_C (mA)

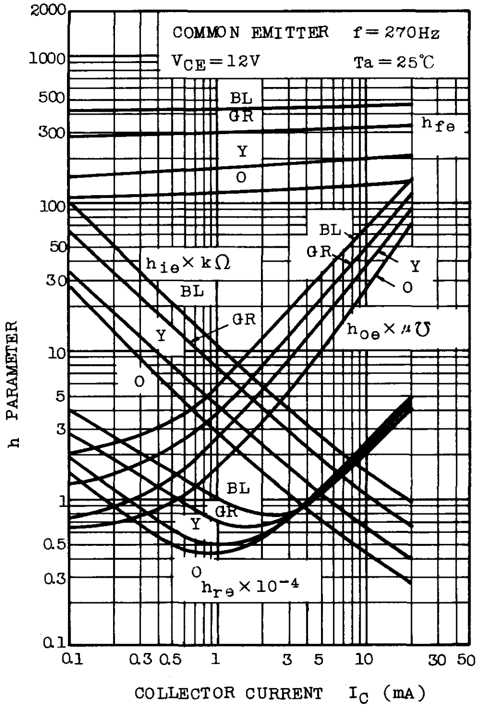

$V_{BE(sat)}$ - I_C
COMMON EMITTER
I_C/I_B = 10
Ta = 25℃
BASE-EMITTER SATURATION VOLTAGE $V_{BE(sat)}$ (V)
1000
500
300
100
50
30
10
0.1
0.3
0.5
1
3
5
10
30
50
100
300
COLLECTOR CURRENT I_C (mA)


$V_{CE(sat)}$ - I_C
COMMON EMITTER
I_C/I_B = 10
Ta = 100℃
25
-25
COLLECTOR-EMITTER SATURATION VOLTAGE $V_{CE(sat)}$ (V)
3
1
0.5
0.3
0.1
0.05
0.03
0.01
0.1
0.3
0.5
1
3
5
10
30
50
100
300
COLLECTOR CURRENT I_C (mA)

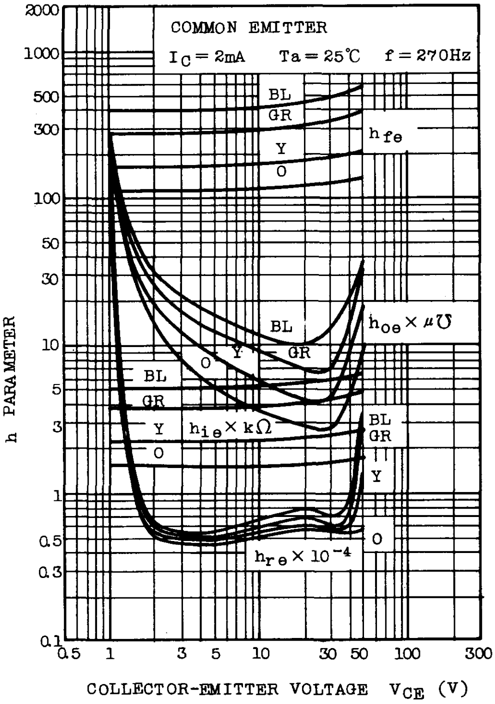

I_B - V_{BE}
COMMON EMITTER
V_{CE} = 6V
Ta = 100℃
25
-25
BASE CURRENT I_B (μA)
3000
1000
500
300
100
50
30
10
5
3
1
0.5
0.3
0
0.2
0.4
0.6
0.8
1.0
1.2
BASE-EMITTER VOLTAGE V_{BE} (V)


f_T - I_E
COMMON EMITTER
V_{CE} = 10V
Ta = 25℃
TRANSITION FREQUENCY f_T (MHz)
3000
1000
500
300
100
50
30
10
-0.1
-0.3
-1
-3
-10
-30
-100
-300
EMITTER CURRENT I_E (mA)

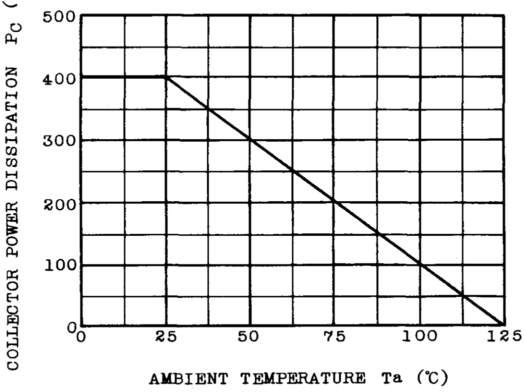
h PARAMETER – I_C



h PARAMETER – V_{CE}



P_C – Ta



2SC1815 Ⓛ

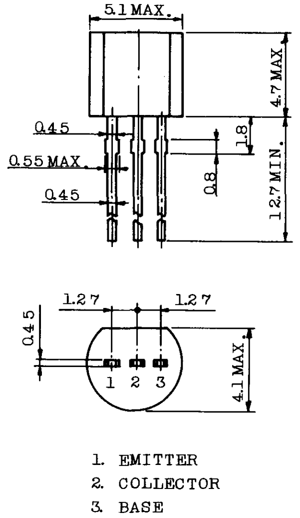
SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

AUDIO FREQUENCY VOLTAGE AMPLIFIER APPLICATIONS.
LOW NOISE AMPLIFIER APPLICATIONS.

FEATURES:

- High Breakdown Voltage, High Current Capability
  : V_{CEO}=50V(Min.), I_C=150mA(Max.)
- Excellent Linearity of h_{FE}
  : $h_{FE}(2)$=100(Typ.) at V_{CE}=6V, I_C=150mA
  : $h_{FE}(I_C=0.1mA)/h_{FE}(I_C=2mA)$=0.95(Typ.)
- Low Noise : NF=0.2dB(Typ.)(f=1kHz).
- Complementary to 2SA1015Ⓛ. (O,Y,GR class).

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	60	V
Collector-Emitter Voltage	V_{CEO}	50	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	150	mA
Emitter Current	I_E	-150	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

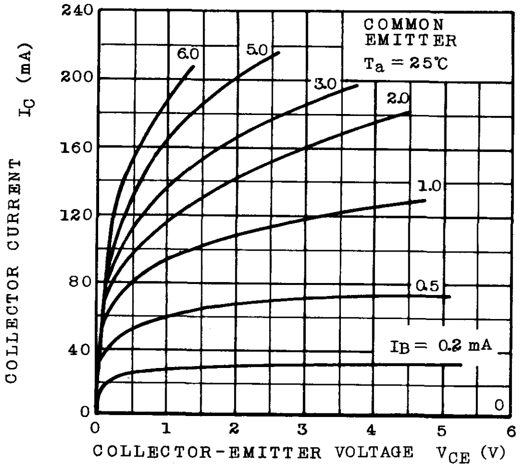
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=60V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain		$h_{FE}(1)$ (Note)	V_{CE}=6V, I_C=2mA	70	-	700	
		$h_{FE}(2)$	V_{CE}=6V, I_C=150mA	25	100	-	
Saturation Voltage	Collector-Emitter	$V_{CE}(sat)$	I_C=100mA, I_B=10mA	-	0.1	0.25	V
	Base-Emitter	$V_{BE}(sat)$	I_C=100mA, I_B=10mA	-	-	1.0	
Transition Frequency		f_T	V_{CE}=10V, I_C=1mA	80	-	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	2.0	3.0	pF
Base Intrinsic Resistance		$r_{bb'}$	V_{CB}=10V, I_E=-1mA, f=30MHz	-	50	-	Ω
Noise Figure		NF(1)	V_{CE}=6V, I_C=0.1mA R_g=10kΩ, f=100Hz	-	0.5	6	dB
		NF(2)	V_{CE}=6V, I_C=0.1mA R_g=10kΩ, f=1kHz	-	0.2	3	

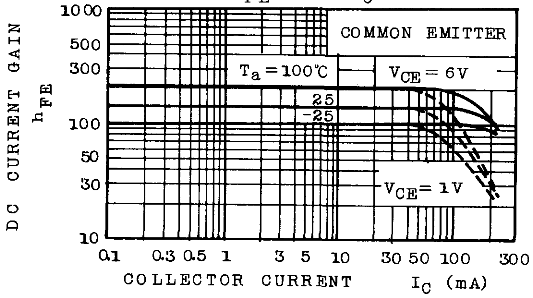
Note : $h_{FE}(1)$ Classification O:70~140, Y:120~240, GR:200~400 BL:350~700

2SC1815Ⓛ

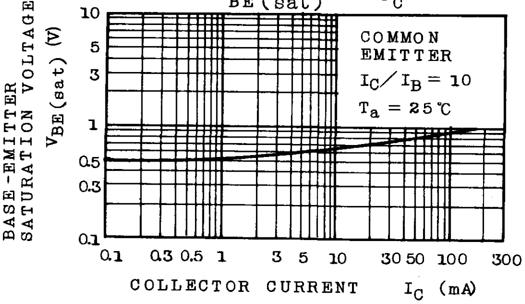
I_C — V_{CE}



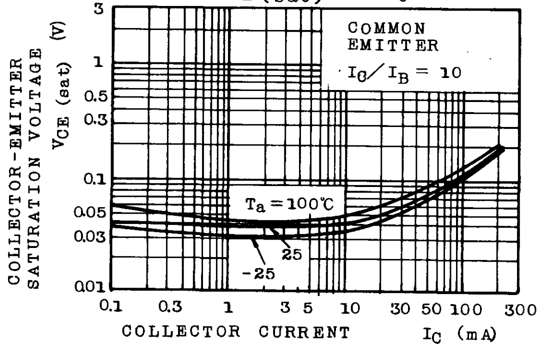
h_{FE} — I_C



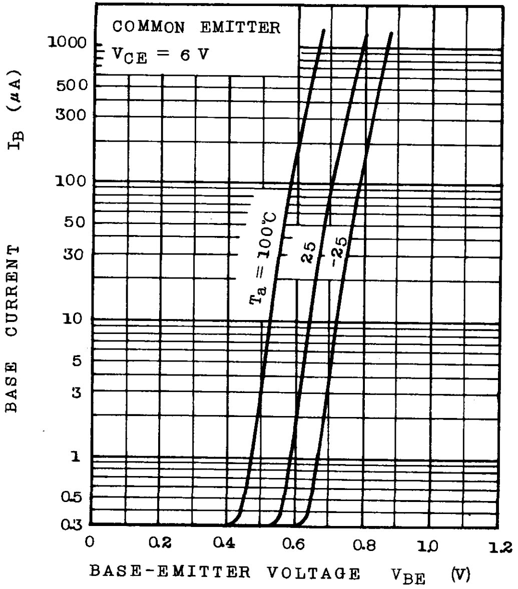
$V_{BE(sat)}$ — I_C



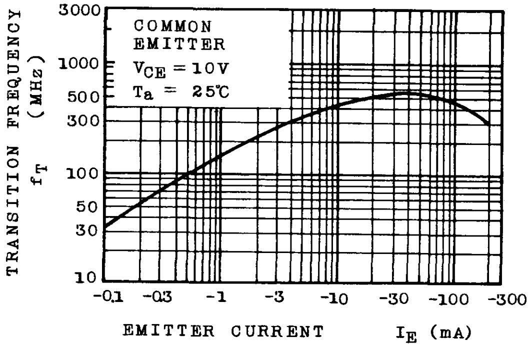
$V_{CE(sat)}$ — I_C



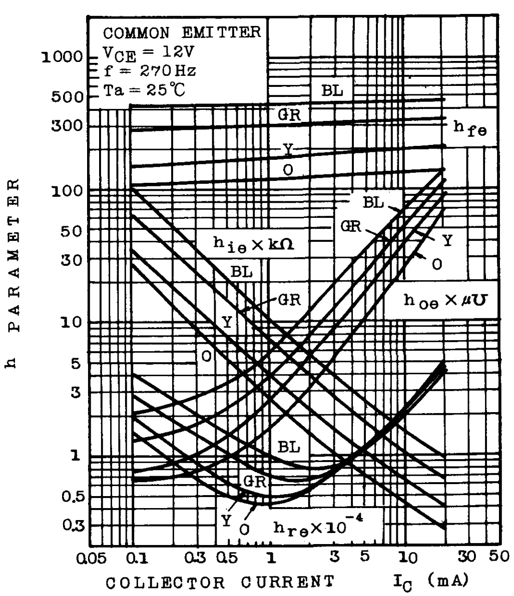
I_B — V_{BE}



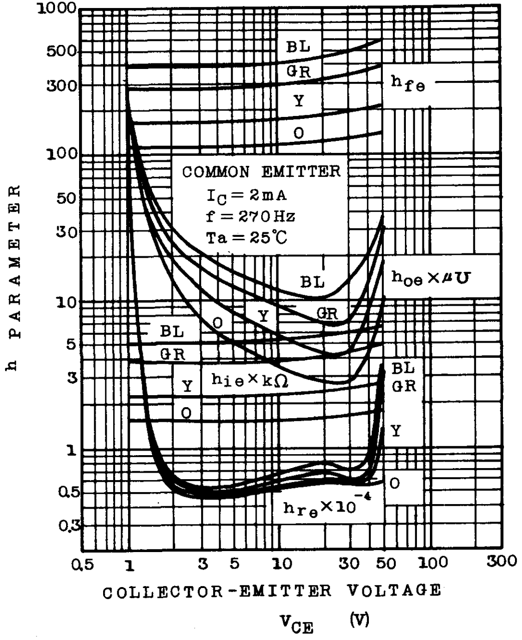
f_T — I_E



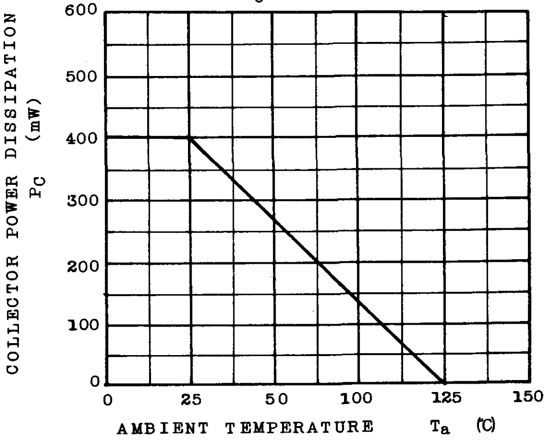
h PARAMETER − I_C



h PARAMETER − V_{CE}



P_C − T_a



SILICON NPN EPITAXIAL PLANAR TYPE (PCT PROCESS)

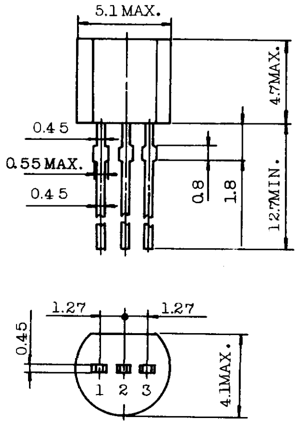
2SC1923

HIGH FREQUENCY AMPLIFIER APPLICATIONS.
FM, RF, MIX, IF AMPLIFIER APPLICATIONS.

FEATURES:

- Small Reverse Transfer Capacitance
  : C_{re}=0.7pF (Typ.)
- Low Noise Figure : NF=2.5dB (Typ.) (f=100MHz)

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

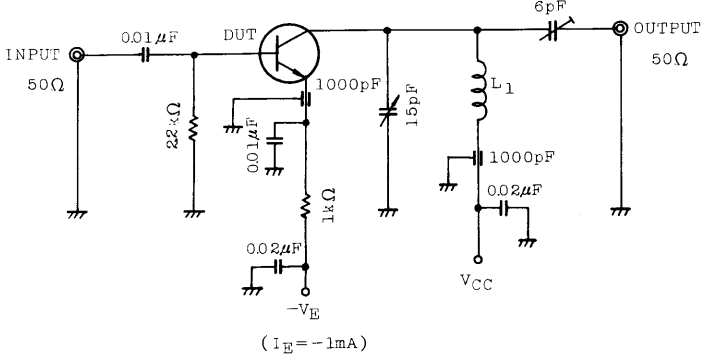
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	40	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	20	mA
Emitter Current	I_E	-20	mA
Collector Power Dissipation	P_C	100	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	Tstg	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=18V, I_E=0	-	-	0.5	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=4V, I_C=0	-	-	0.5	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=6V, I_C=1mA	40	-	200	
Reverse Transfer Capacitance	C_{re}	V_{CE}=6V, f=1MHz	-	0.70	-	pF
Transition Frequency	f_T	V_{CE}=6V, I_C=1mA	-	550	-	MHz
Collector-Base Time Constant	$C_c \cdot r_{bb'}$	V_{CE}=6V, I_E=-1mA, f=30MHz	-	-	30	ps
Noise Figure	NF	V_{CE}=6V, I_E=-1mA f=100MHz, Fig.	-	2.5	4.0*	dB
Power Gain	G_{pe}		15	18	-	

Note : h_{FE} Classificaiton R : 40∿80, O : 70∿140, Y : 100∿200 (* NF=5.0dB Max.)

Fig. NF, Gpe TEST CIRCUIT



L_1 : 0.8mmø SILVER PLATED COPPER WIRE, 4T, 10ID, 8 LENGTH

y PARAMETER (Typ.)

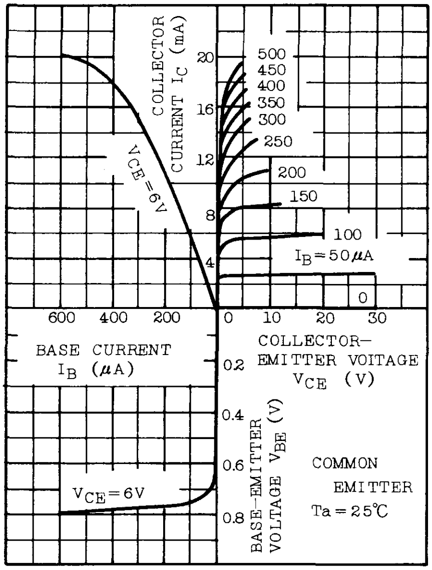
(1) COMMON EMITTER (V_{CE}=6V, I_E=−1mA, f=100MHz)

CHARACTERISTIC	SYMBOL	TYP.	UNIT
Input Conductance	g_{ie}	2.9	mS
Input Capacitance	C_{ie}	10.2	pF
Reverse Transfer Admittance	$\lvert y_{re} \rvert$	0.33	μS
Phase Angle of Reverse Transfer Admittance	θ_{re}	-90	°
Forward Transfer Admittance	$\lvert y_{fe} \rvert$	40	mS
Phase Angle of Forward Transfer Admittance	θ_{fe}	-20	°
Output Conductance	g_{oe}	45	μS
Output Capacitance	C_{oe}	1.1	pF

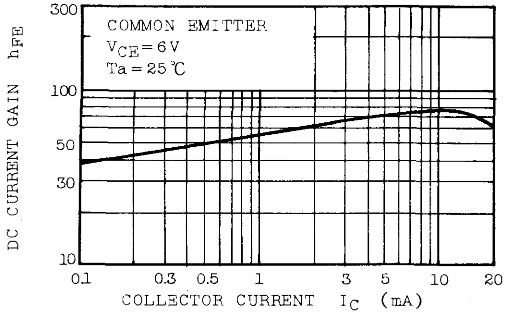
(2) COMMON BASE (V_{CE}=6V, I_E=−1mA, f=100MHz)

CHARACTERISTIC	SYMBOL	TYP.	UNIT
Input Conductance	g_{ib}	34	mS
Input Capacitance	C_{ib}	-10	pF
Reverse Transfer Admittance	$\lvert y_{rb} \rvert$	0.27	μS
Phase Angle of Reverse Transfer Admittance	θ_{rb}	-105	°
Forward Transfer Admittance	$\lvert y_{fb} \rvert$	34	mS
Phase Angle of Forward Transfer Admittance	θ_{fb}	165	°
Output Conductance	g_{ob}	45	μS
Output Capacitance	C_{ob}	1.1	pF

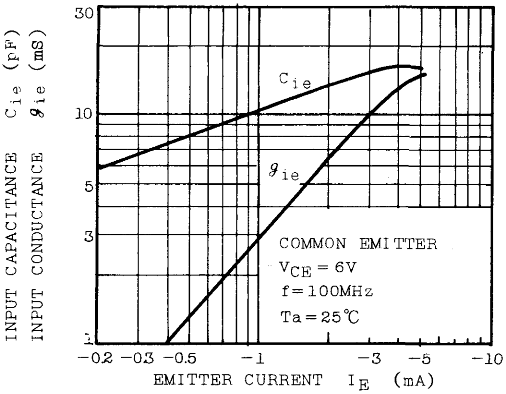
STATIC CHARACTERISTICS



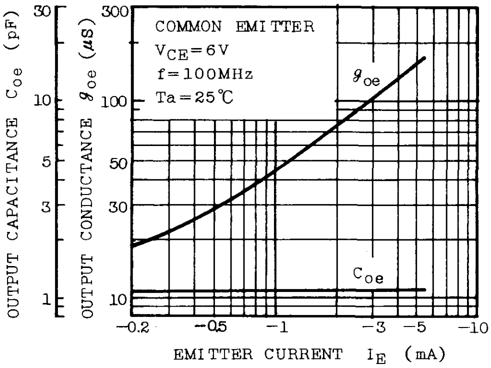
h_{FE} — I_C



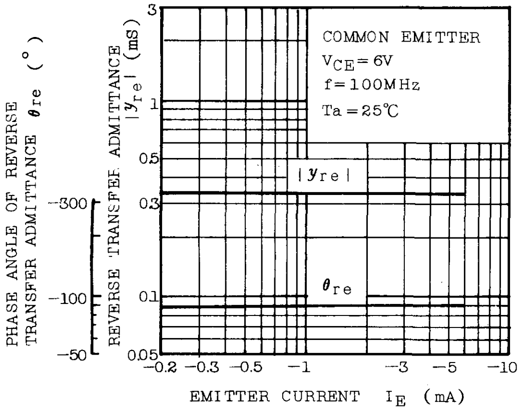
C_{ie}, g_{ie} — I_E

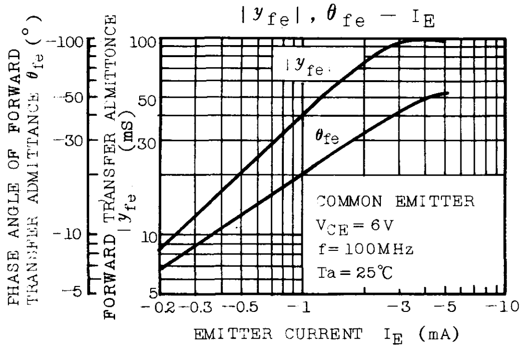


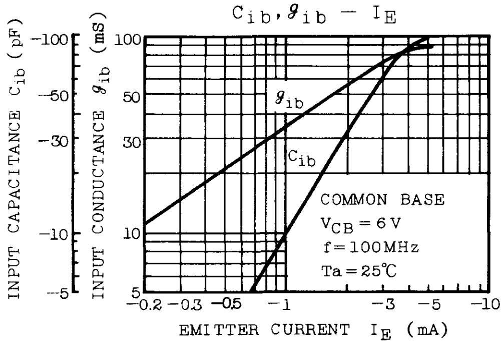
C_{oe}, g_{oe} — I_E

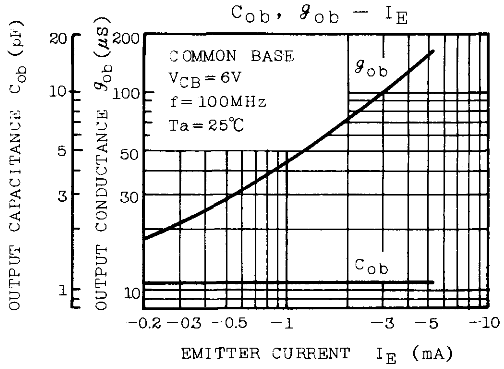


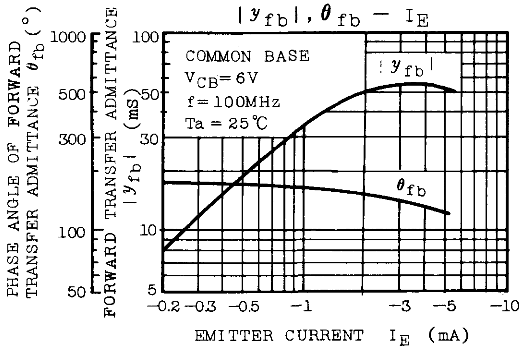
$|y_{re}|$, θ_{re} — I_E

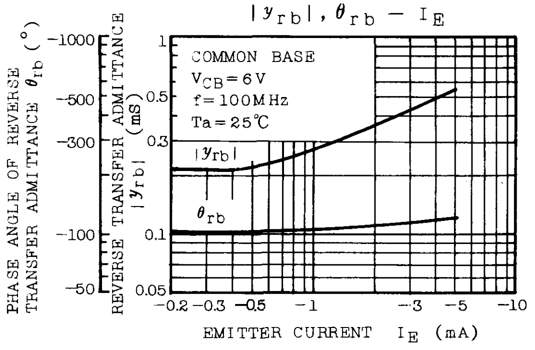


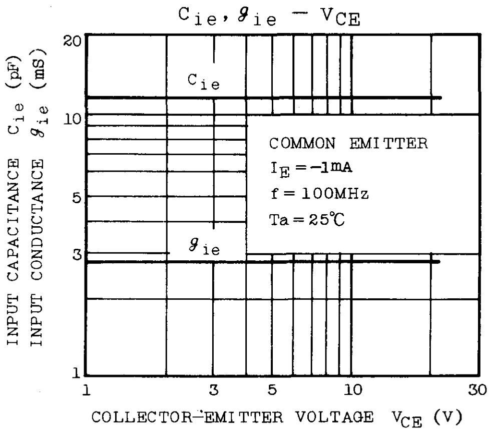

$|y_{fe}|, \theta_{fe} - I_E$
PHASE ANGLE OF FORWARD TRANSFER ADMITTANCE θ_{fe} (°)
FORWARD TRANSFER ADMITTONCE $|y_{fe}|$ (mS)
−100
−50
−30
−10
−5
100
50
30
10
5
$|y_{fe}|$
θ_{fe}
COMMON EMITTER
V_{CE} = 6 V
f = 100MHz
Ta = 25℃
−0.2
−0.3
−0.5
−1
−3
−5
−10
EMITTER CURRENT I_E (mA)


$C_{ib}, g_{ib} - I_E$
INPUT CAPACITANCE C_{ib} (pF)
INPUT CONDUCTANCE g_{ib} (mS)
−100
−50
−30
−10
−5
100
50
30
10
5
g_{ib}
C_{ib}
COMMON BASE
V_{CB} = 6 V
f = 100MHz
Ta = 25℃
−0.2
−0.3
−0.5
−1
−3
−5
−10
EMITTER CURRENT I_E (mA)

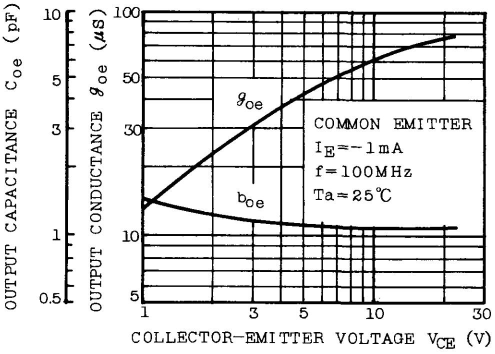

$C_{ob}, g_{ob} - I_E$
OUTPUT CAPACITANCE C_{ob} (pF)
OUTPUT CONDUCTANCE g_{ob} (μS)
20
10
5
3
1
200
100
50
30
10
COMMON BASE
V_{CB} = 6V
f = 100MHz
Ta = 25℃
g_{ob}
C_{ob}
−0.2
−0.3
−0.5
−1
−3
−5
−10
EMITTER CURRENT I_E (mA)


$|y_{fb}|, \theta_{fb} - I_E$
PHASE ANGLE OF FORWARD TRANSFER ADMITTANCE θ_{fb} (°)
FORWARD TRANSFER ADMITTANCE $|y_{fb}|$ (mS)
1000
500
300
100
50
100
50
30
10
5
COMMON BASE
V_{CB} = 6V
f = 100MHz
Ta = 25℃
$|y_{fb}|$
θ_{fb}
−0.2
−0.3
−0.5
−1
−3
−5
−10
EMITTER CURRENT I_E (mA)

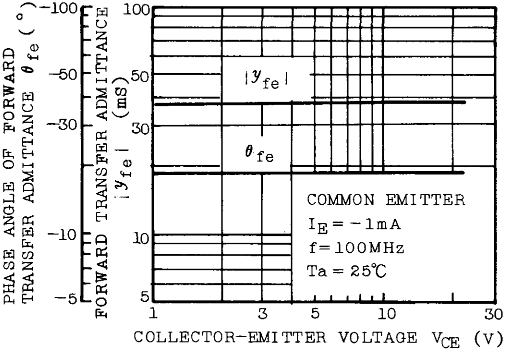

$|y_{rb}|, \theta_{rb} - I_E$
PHASE ANGLE OF REVERSE TRANSFER ADMITTANCE θ_{rb} (°)
REVERSE TRANSFER ADMITTANCE $|y_{rb}|$ (mS)
−1000
−500
−300
−100
−50
1
0.5
0.3
0.1
0.05
COMMON BASE
V_{CB} = 6V
f = 100MHz
Ta = 25℃
$|y_{rb}|$
θ_{rb}
−0.2
−0.3
−0.5
−1
−3
−5
−10
EMITTER CURRENT I_E (mA)


$C_{ie}, g_{ie} - V_{CE}$
INPUT CAPACITANCE C_{ie} (pF)
INPUT CONDUCTANCE g_{ie} (mS)
20
10
5
3
1
C_{ie}
g_{ie}
COMMON EMITTER
I_E = −1mA
f = 100MHz
Ta = 25℃
1
3
5
10
30
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)

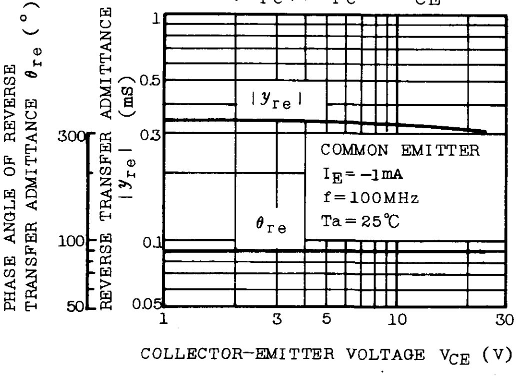
C_{oe}, g_{oe} — V_{CE}



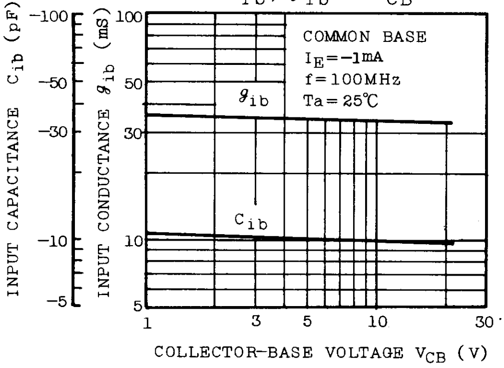
$|y_{fe}|$, θ_{fe} — V_{CE}



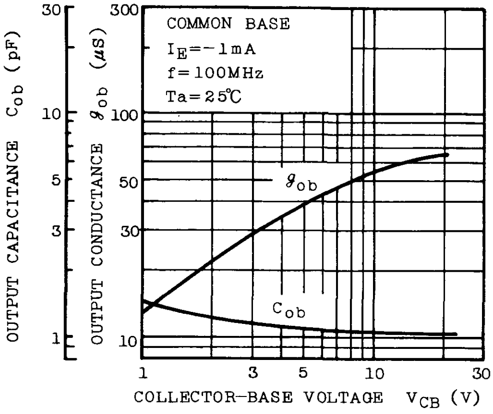
$|y_{re}|$, θ_{re} — V_{CE}



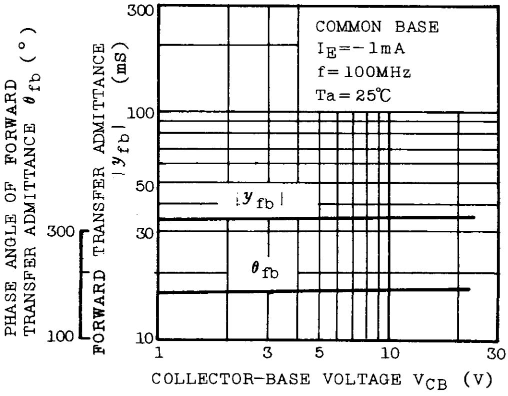
C_{ib}, g_{ib} — V_{CB}



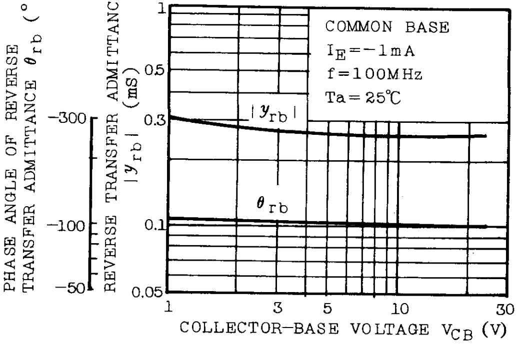
C_{ob}, g_{ob} — V_{CB}



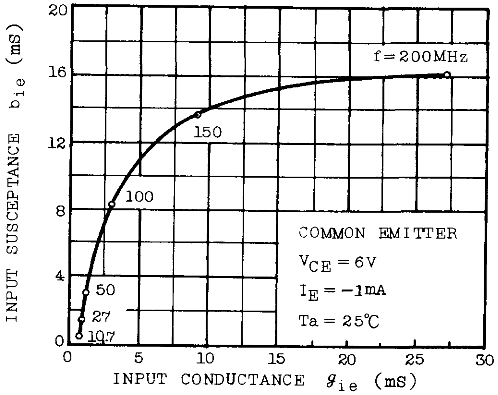
$|y_{fb}|$, θ_{fb} — V_{CB}



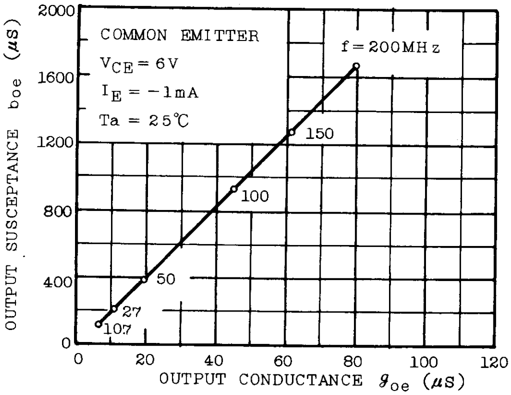
$|y_{rb}|, \theta_{rb}$ — V_{CB}



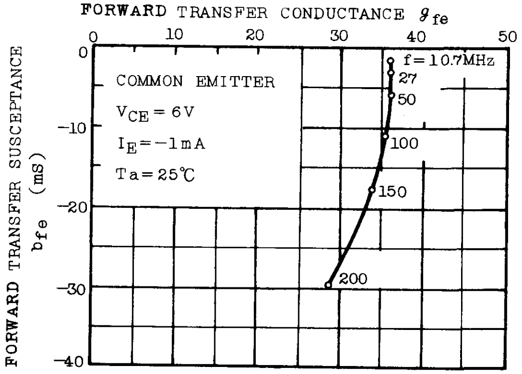
y_{ie} — f



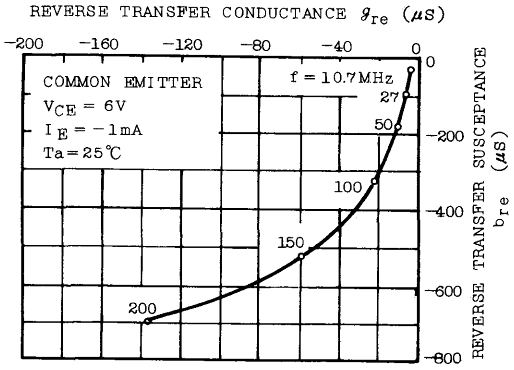
y_{oe} — f



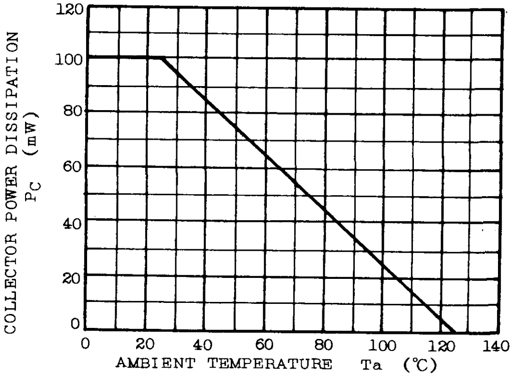
y_{fe} — f



y_{re} — f



P_C — Ta



SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

2SC1959

AUDIO FREQUENCY LOW POWER AMPLIFIER APPLICATIONS.

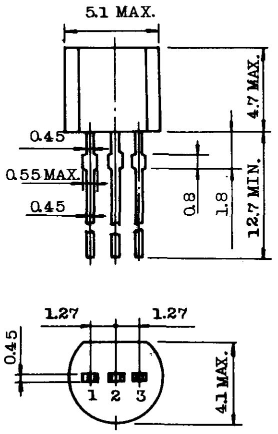
DRIVER STAGE AMPLIFIER APPLICATIONS.

SWITCHING APPLICATIONS.

FEATURES:

- Excellent h_{FE} linearity
  : $h_{FE(2)}$=25Min. : V_{CE}=6V, I_C=400mA
- 1 Watt Amplifier Applications.
- Complementary to 2SA562TM.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	35	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	500	mA
Emitter Current	I_E	-500	mA
Collector Power Dissipation	P_C	500	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55∿150	°C

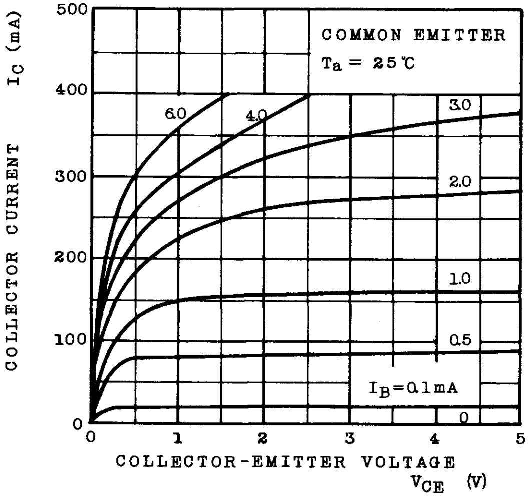
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=35V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=1V, I_C=100mA	70	-	240	
	$h_{FE(2)}$ (Note)	V_{CE}=6V, I_C=400mA	25	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=100mA, I_B=10mA	-	0.1	0.25	V
Base-Emitter Voltage	V_{BE}	V_{CE}=1V, I_C=100mA	-	0.8	1.0	V
Transition Frequency	f_T	V_{CE}=6V, I_C=20mA	-	300	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=6V, I_E=0, f=1 MHz	-	7	-	pF

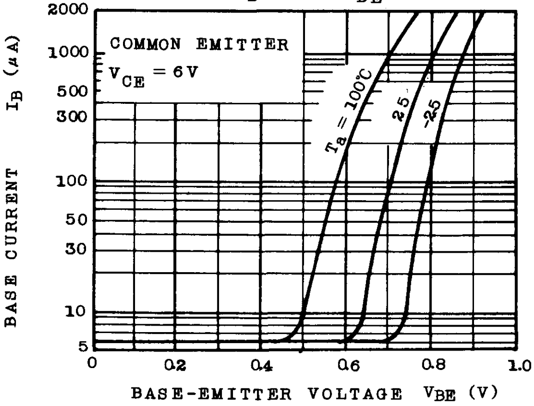
Note : $h_{FE(1)}$ Classification O : 70∿140, Y : 120∿240

$h_{FE(2)}$ Classification O : 25(MIN.), Y : 40(MIN.)

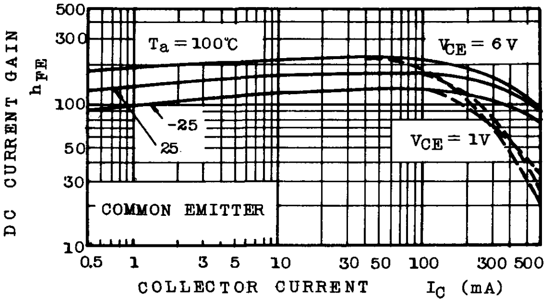
I_C – V_{CE}



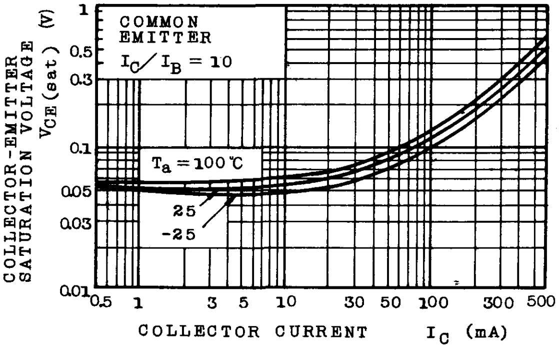
I_B – V_{BE}



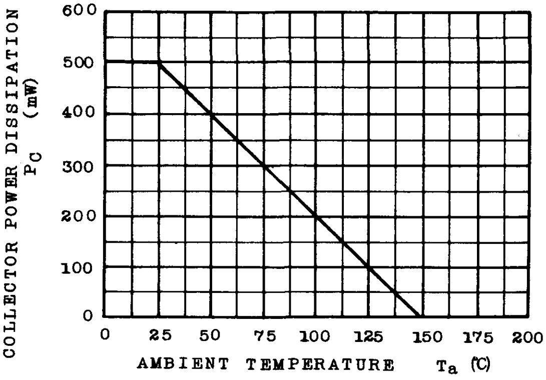
h_{FE} – I_C



$V_{CE(sat)}$ – I_C



P_C – Ta



SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

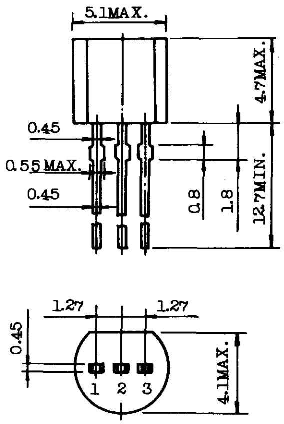
2SC2120

Unit in mm

AUDIO POWER AMPLIFIER APPLCIATIONS.

FEATURES:

- High h_{FE} : h_{FE}=100 ∿ 320
- 1 Watts Amplifier Applications.
- Complementary to 2SA950.



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO — 92
EIAJ	SC — 43
TOSHIBA	2 — 5F1B

Weight : 0.21g

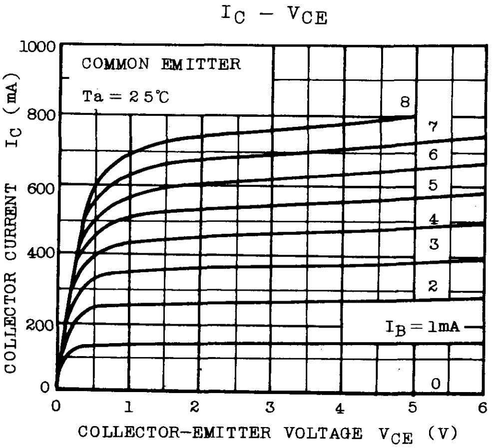
MAXIMUM RATINGS (Ta=25°C)

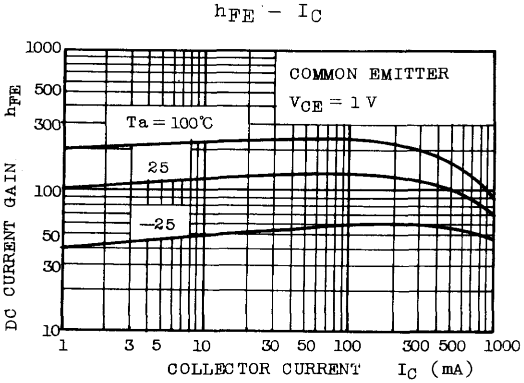
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	35	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	800	mA
Emitter Current	I_E	-800	mA
Collector Power Dissipation	P_C	600	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55 ∿ 150	°C

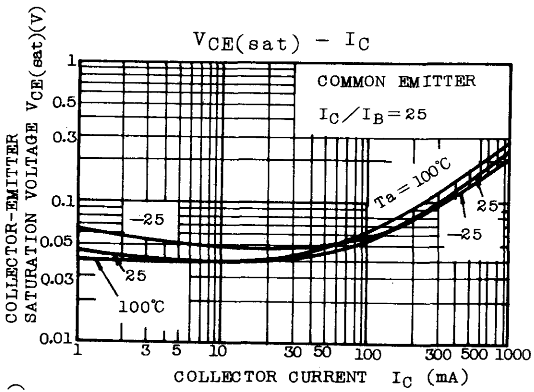
ELECTRICAL CHARACTERISTICS (Ta=25°C)

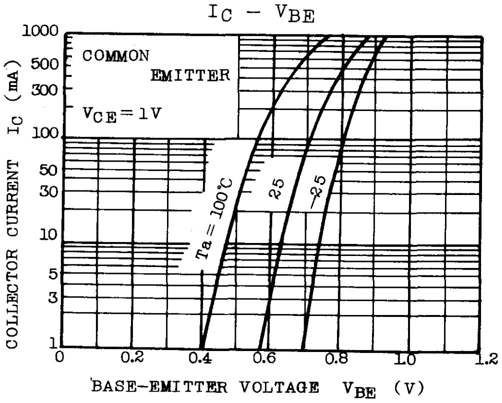
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=35V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=10mA	30	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=1V, I_C=100mA	100	-	320	
	$h_{FE(2)}$	V_{CE}=1V, I_C=700mA	35	-		
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=500mA, I_B=20mA	-	-	0.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=1V, I_C=10mA	0.5	-	0.8	V
Transition Frequency	f_T	V_{CE}=5V, I_C=10mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, f=1MHz, I_E=0	-	13	-	pF

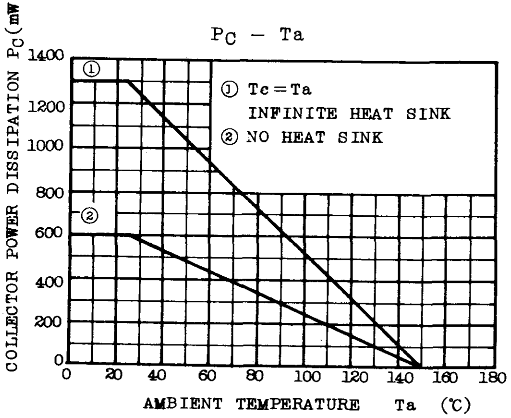
Note : $h_{FE(1)}$ Classification O : 100∿200, Y : 160∿320


$I_C - V_{CE}$


$h_{FE} - I_C$


$V_{CE(sat)} - I_C$


$I_C - V_{BE}$


$P_C - Ta$

SILICON NPN PLANAR TYPE

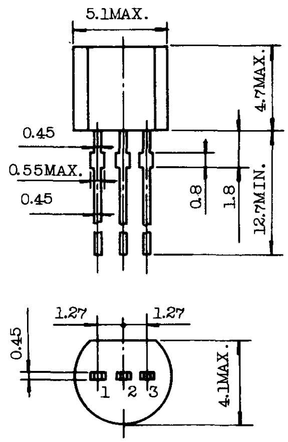
2SC2215

TV 1ST, 2ND PICTURE IF AMPLIFIER APPLICATIONS.

FEATURES:

- High Gain : G_{pe}=35dB (Typ.) (f=45MHz)
- Excellent Forward AGC Characteristics.

Unit in mm



1. BASE
2. EMITTER
3. COLLECTOR

JEDEC	TO — 92
EIAJ	SC — 43
TOSHIBA	2 — 5F1E

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	40	V
Collector-Emitter Voltage	V_{CEO}	40	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	50	mA
Emitter Current	I_E	-50	mA
Collector Power Dissipation	P_C	250	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

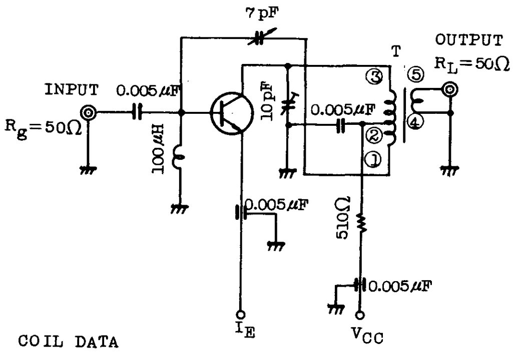
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=40V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=3V, I_C=0	-	-	0.1	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=3mA, I_B=0	40	-	-	V
DC Current Gain	h_{FE}	V_{CE}=10V, I_C=4mA	30	-	-	
Transition Frequency	f_T	V_{CE}=10V, I_C=4mA	400	-	-	MHz
Collector-Base Time Constant	$C_c \cdot r_{bb'}$	V_{CB}=10V, I_E=-1mA, f=30MHz	-	-	30	ps
Reverse Transfer Capacitance	C_{re}	V_{CB}=10V, I_E=0, f=1MHz	-	-	1.2	pF
Power Gain (Fig. 1)	G_{pe}	V_{CC}=12V, I_C=4mA, f=45MHz	32	-	40	dB
AGC Current (Note 1,2)	I_{AGC}	V_{CC}=12V, f=45MHz	7.2	-	10.8	mA

Note 1 : I_{AGC} Classification BL : 7.2∿8.8, V : 8.2∿10.1, W : 8.9∿10.8

Note 2 : Measured by circuit shown in Fig 1, when power gain is reduced 30dB compared with that of I_C at 4mA.

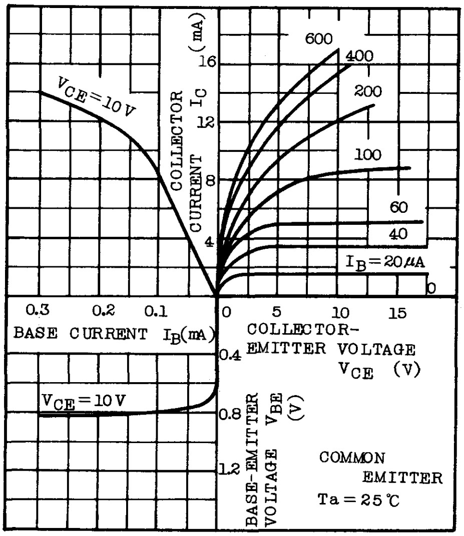
Fig.1 G_{pe} AND I_{AGC} CHARACTERISTICS

TEST CIRCUIT (f=45MHz)

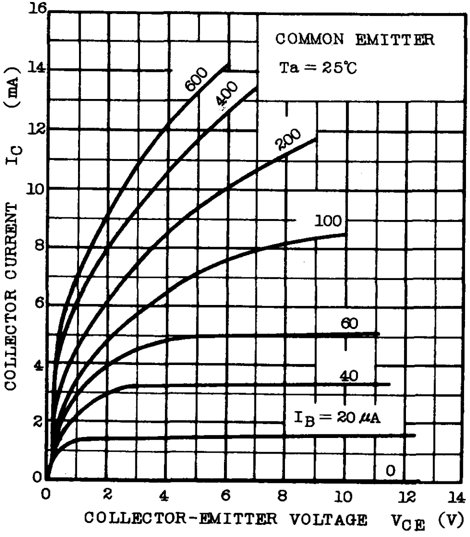


COIL DATA
0.2mmø Cu WIRE
L=1.2μH WITH M-5 CORE
T : ①–② 3.0T
②–③ 8.0T
④–⑤ 1.0T

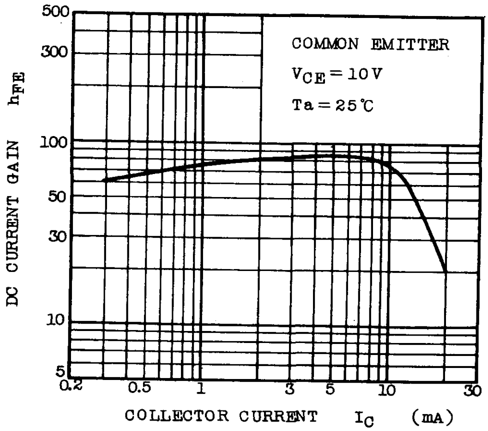
STATIC CHARACTERISTICS

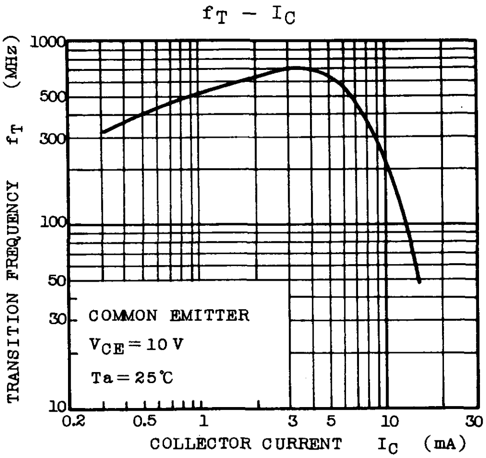


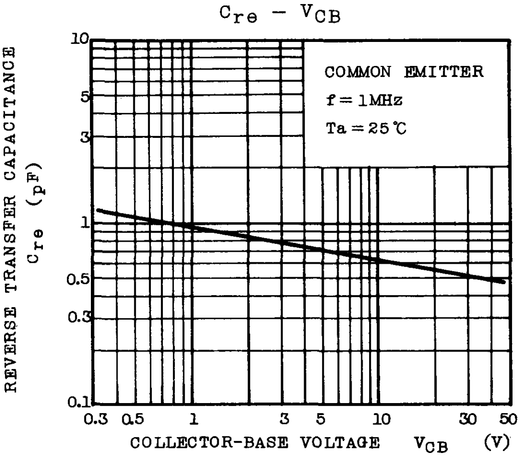
I_C – V_{CE}

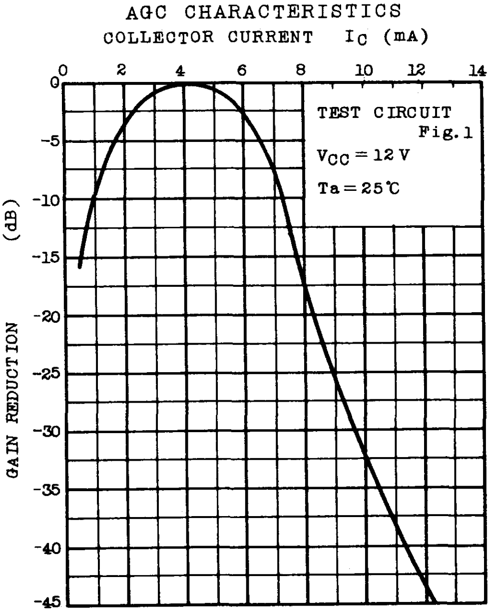


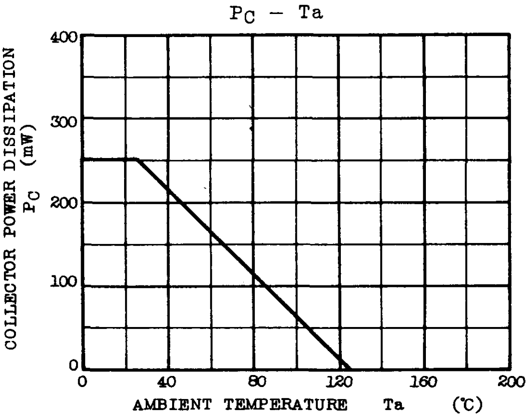
h_{FE} – I_C




fT – IC
TRANSITION FREQUENCY fT (MHz)
1000
500
300
100
50
30
10
0.2
0.5
1
3
5
10
30
COLLECTOR CURRENT IC (mA)
COMMON EMITTER
VCE = 10 V
Ta = 25℃


Cre – VCB
REVERSE TRANSFER CAPACITANCE Cre (pF)
10
5
3
1
0.5
0.3
0.1
0.3
0.5
1
3
5
10
30
50
COLLECTOR-BASE VOLTAGE VCB (V)
COMMON EMITTER
f = 1MHz
Ta = 25℃


AGC CHARACTERISTICS
COLLECTOR CURRENT IC (mA)
0
2
4
6
8
10
12
14
GAIN REDUCTION (dB)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
TEST CIRCUIT Fig.1
VCC = 12 V
Ta = 25℃


PC – Ta
COLLECTOR POWER DISSIPATION PC (mW)
400
300
200
100
0
0
40
80
120
160
200
AMBIENT TEMPERATURE Ta (℃)

2SC2216
2SC2717

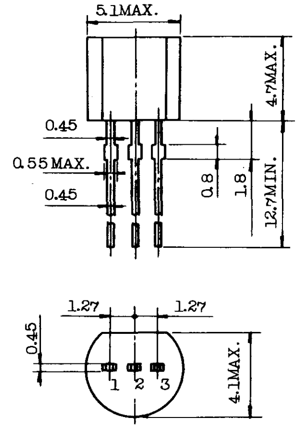
SILICON NPN EPITAXIAL PLANAR TYPE

TV FINAL PICTURE IF AMPLIFIER APPLICATIONS.

FEATURES:

- High Gain : G_{pe}=33dB (Typ.)(f=45MHz)
- Good Linearity of h_{FE}.

Unit in mm



1. BASE
2. EMITTER
3. COLLECTOR

JEDEC	TO — 92
EIAJ	SC — 43
TOSHIBA	2 — 5F1E

Weight : 0.21g

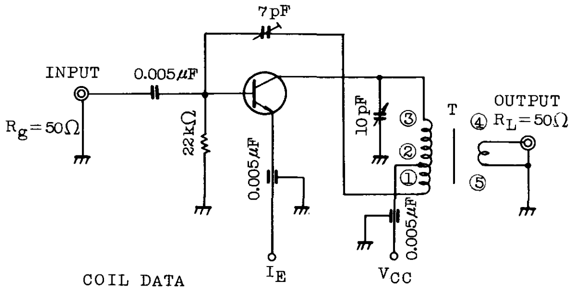
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Voltage	2SC2216	V_{CBO}	50	V
	2SC2717		30	
Collector-Emitter Voltage	2SC2216	V_{CEO}	45	V
	2SC2717		25	
Emitter-Base Voltage		V_{EBO}	4	V
Collector Current		I_C	50	mA
Emitter Current		I_E	-50	mA
Collector Power Dissipation		P_C	300	mW
Junction Temperature		T_j	125	°C
Storage Temperature Range		T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

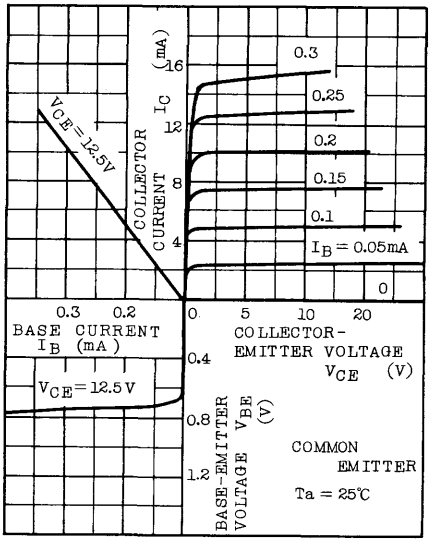
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	2SC2216	I_{CBO}	V_{CB}=50V, I_E=0	-	-	0.1	μA
	2SC2717		V_{CB}=30V, I_E=0				
Emitter Cut-off Current		I_{EBO}	V_{EB}=3V, I_C=0	-	-	0.1	μA
Collector-Emitter Breakdown Voltage	2SC2216	$V_{(BR)CEO}$	I_C=10mA, I_B=0	45	-	-	V
	2SC2717			25	-	-	
DC Current Gain	2SC2216	h_{FE}	V_{CE}=12.5V, I_C=12.5mA	40	-	140	
	2SC2717			40	-	240	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=15mA, I_B=1.5mA	-	-	0.2	V
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=15mA, I_B=1.5mA	-	-	1.5	V
Collector Output Capacitance		C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	0.8	-	2.0	pF
Collector-Base Time Constant		$C_c \cdot r_{bb'}$	V_{CB}=10V, I_E=-1mA, f=30MHz	-	-	25	ps
Transition Frequency		f_T	V_{CE}=12.5V, I_C=12.5mA	300	-	-	MHz
Power Gain (Fig.)	2SC2216	G_{pe}	V_{CC}=12.5V, I_E=-12.5mA, f=45MHz	29	-	36	dB
	2SC2717			28	-	36	

Fig. 45MHz G_{pe} TEST CIRCUIT

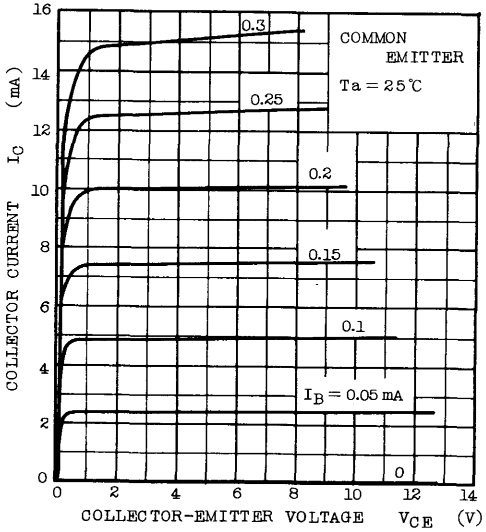


COIL DATA
0.20mmØ Cu WIRE
L=1.2μH WITH M-5 CORE
T : ①—② 3.0T
②—③ 8.0T
④—⑤ 1.0T

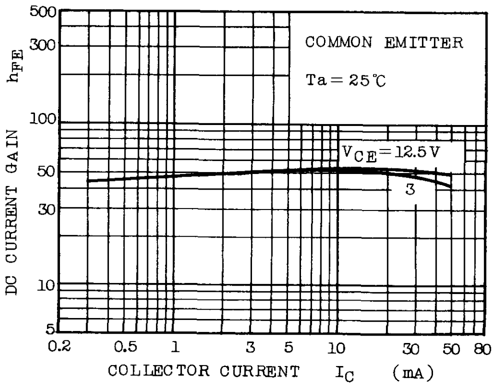
STATIC CHARACTERISTICS



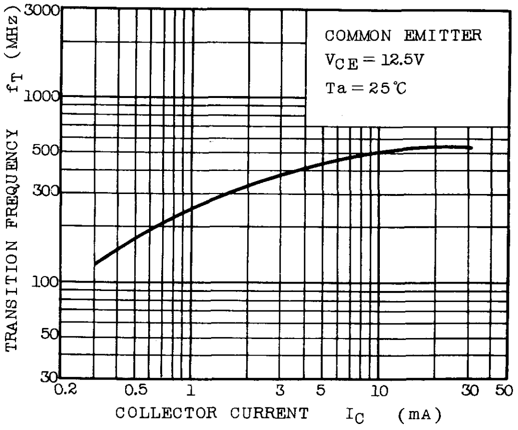
$I_C - V_{CE}$



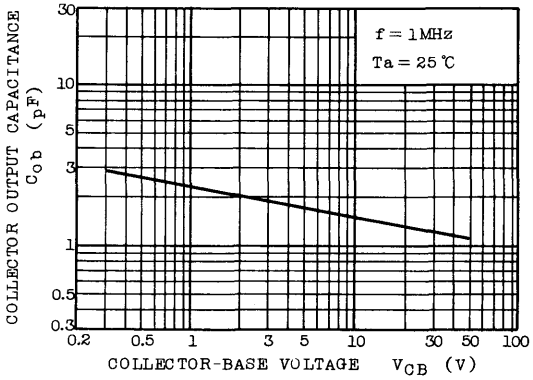
$h_{FE} - I_C$



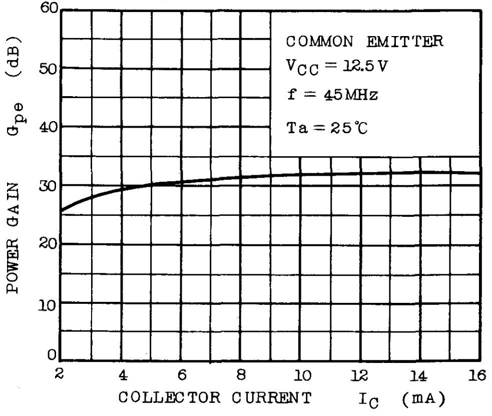
$f_T - I_C$



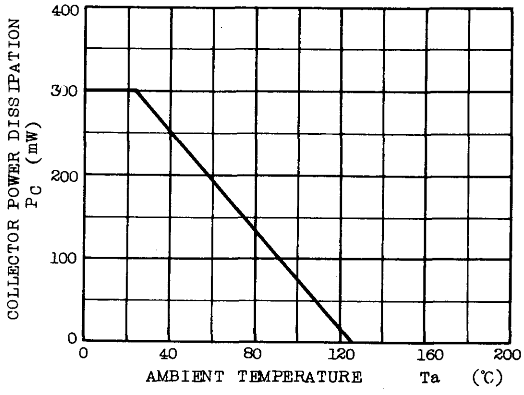
$C_{ob} - V_{CB}$



$G_{pe} - I_C$ (See Fig.)



P_C - Ta



SILICON NPN TRIPLE DIFFUSED TYPE

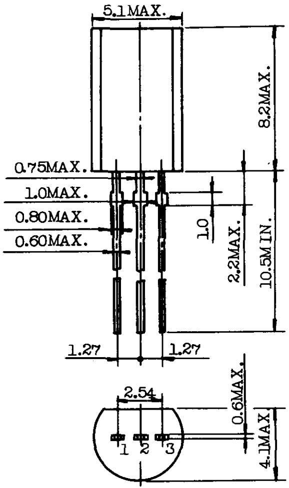
2SC2229

BLACK AND WHITE TV VIDEO OUTPUT APPLICATIONS.
HIGH VOLTAGE SWITCHING APPLICATIONS.
DRIVER STAGE AUDIO AMPLIFIER APPLICATIONS.

FEATURES :

- High Breakdown Voltage : V_{CEO}=150V (Min.)
- Low Output Capacitance : C_{ob}=5.0pF (Max.)
- High Transition Frequency: f_T=120MHz (Typ.)

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO－92MOD
EIAJ	－
TOSHIBA	2－5J1A

Weight : 0.36g

MAXIMUM RATINGS (Ta=25°C)

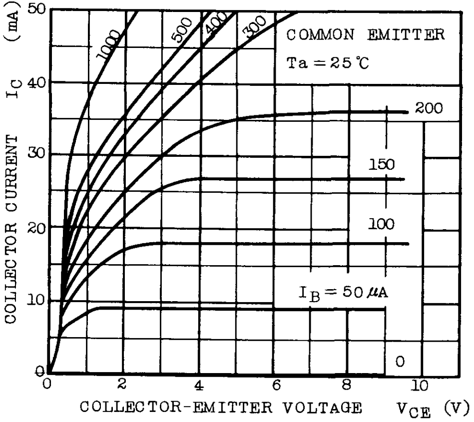
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	200	V
Collector-Emitter Voltage	V_{CEO}	150	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	50	mA
Emitter Current	I_E	-50	mA
Collector Power Dissipation	P_C	800	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55∿150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

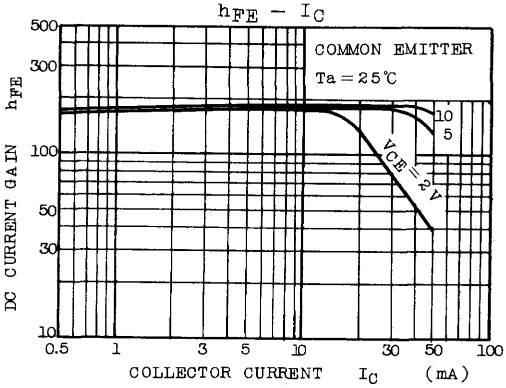
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=200V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=5V, I_C=10mA	70	-	240	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	0.5	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=10mA, I_B=1mA	-	-	1	V
Transition Frequency	f_T	V_{CE}=30V, I_C=10mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	3.5	5	pF

Note: h_{FE} Classification O : 70∿140, Y : 120∿240

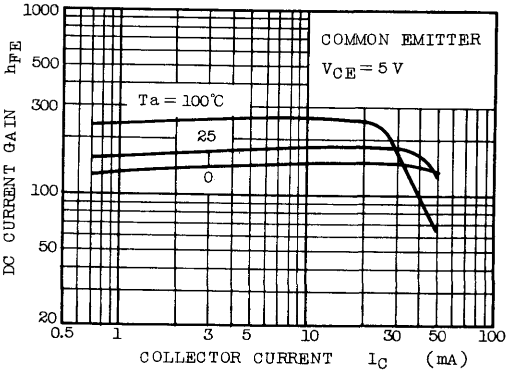
$I_C - V_{CE}$



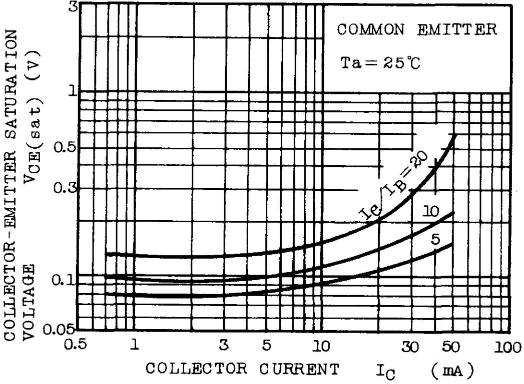
$h_{FE} - I_C$



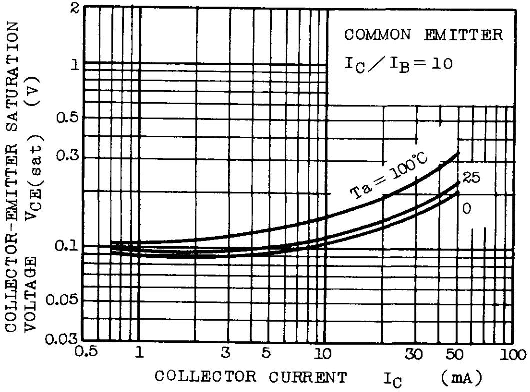
$h_{FE} - I_C$



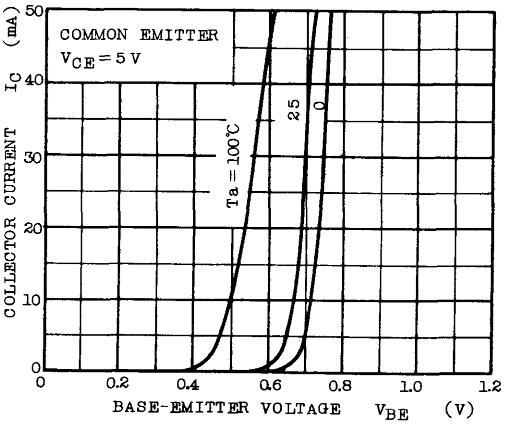
$V_{CE(sat)} - I_C$



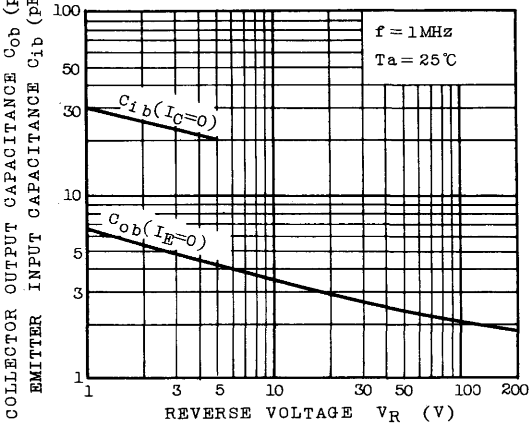
$V_{CE(sat)} - I_C$



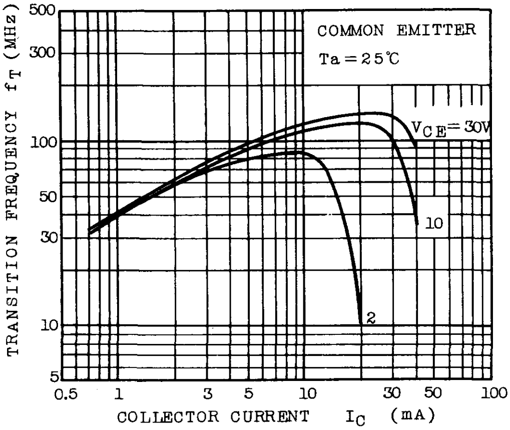
$I_C - V_{BE}$



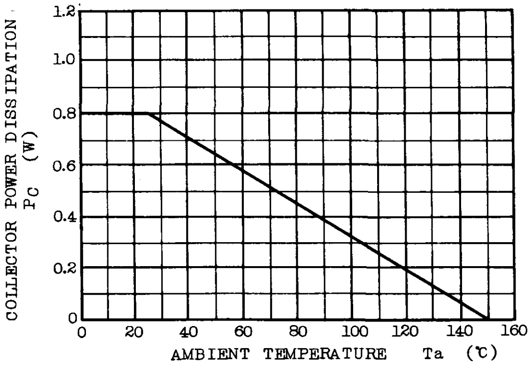
$C_{ib}, C_{ob} - V_R$



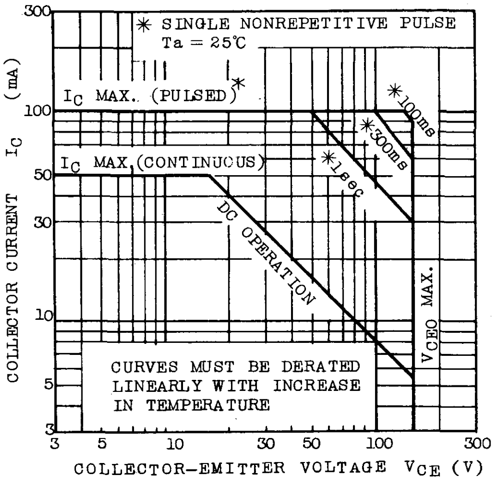
$f_T - I_C$



$P_C - Ta$



SAFE OPERATING AREA



2SC2230
2SC2230A

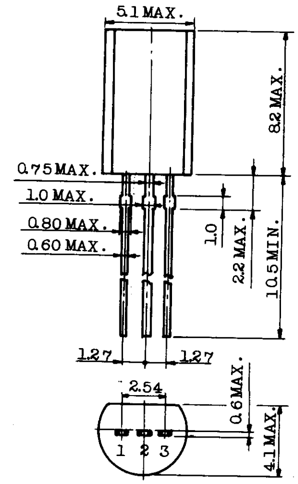
SILICON NPN TRIPLE DIFFUSED TYPE (PCT RPOCESS)

HIGH VOLTAGE GENERAL AMPLIFIER APPLICATIONS.
COLOR TV CLASS B SOUND OUTPUT APPLICATIONS.

FEATURES:

- High Voltage : V_{CEO}=180V (2SC2230A)
- High DC Current Gain.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO−92MOD
EIAJ	−
TOSHIBA	2−5J1A

Weight :0.36g

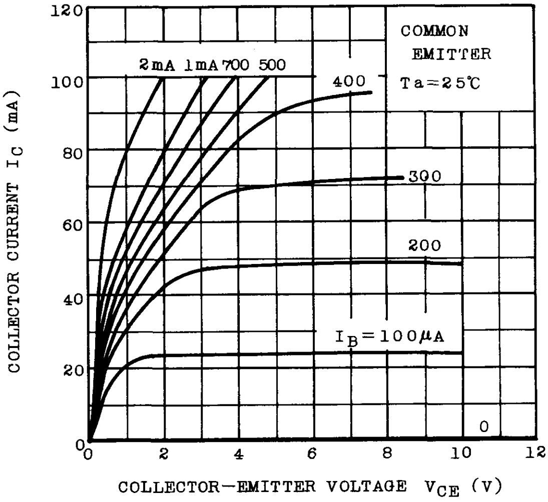
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Voltage		V_{CBO}	200	V
Collector-Emitter Voltage	2SC2230	V_{CEO}	160	V
	2SC2230A		180	
Emitter-Base Voltage		V_{EBO}	5	V
Collector Current		I_C	100	mA
Base Current		I_B	50	mA
Collector Power Dissipation		P_C	800	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_{stg}	-55~150	°C

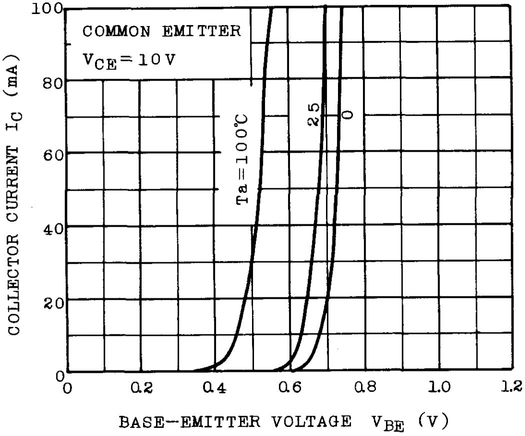
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=200V, I_E=0	−	−	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	−	−	0.1	μA
DC Current Gain	$h_{FE}(1)$ (Note)	V_{CE}=10V, I_C=10mA	120	−	400	
	$h_{FE}(2)$	V_{CE}=10V, I_C=50mA	80	−	−	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=50mA, I_B=5mA	−	−	0.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=10V, I_C=1mA	0.50	0.60	0.70	V
Transition Frequency	f_T	V_{CE}=10V, I_C=10mA	50	−	−	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	−	−	7.0	pF

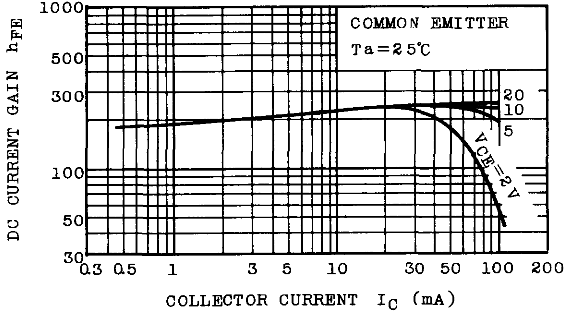
Note: $h_{FE}(1)$ Classification Y:120~240, GR:200~400



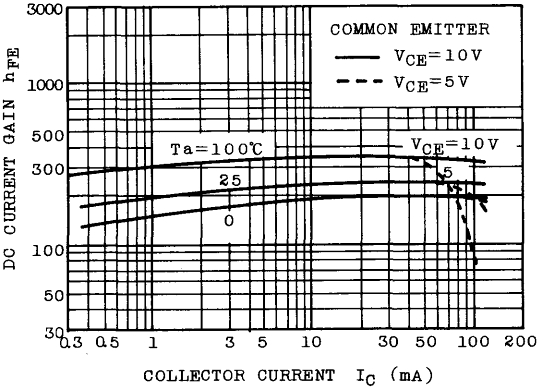
$I_C - V_{CE}$



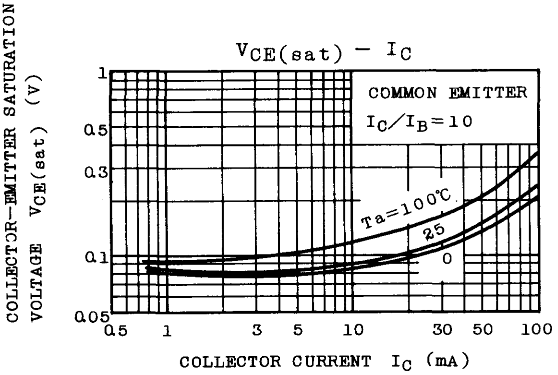
$I_C - V_{BE}$



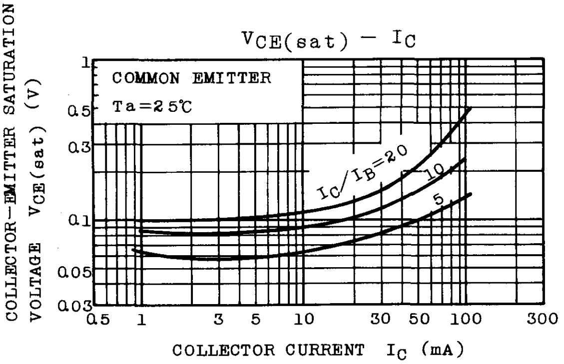
$h_{FE} - I_C$



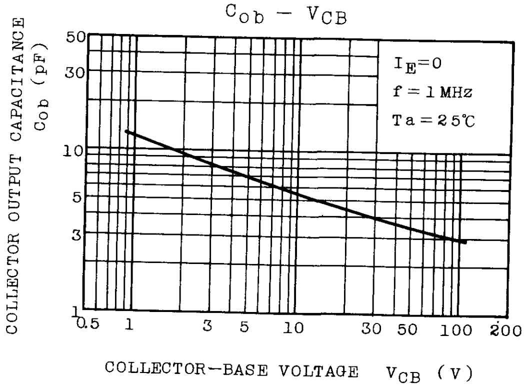
$h_{FE} - I_C$

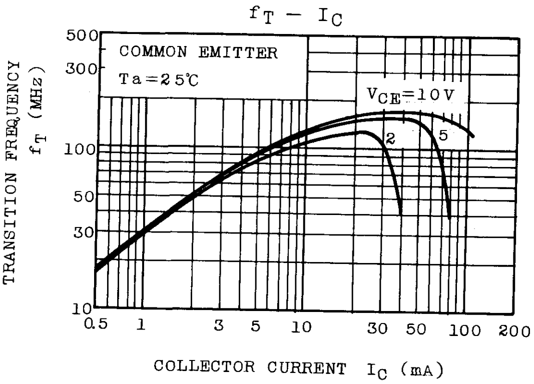


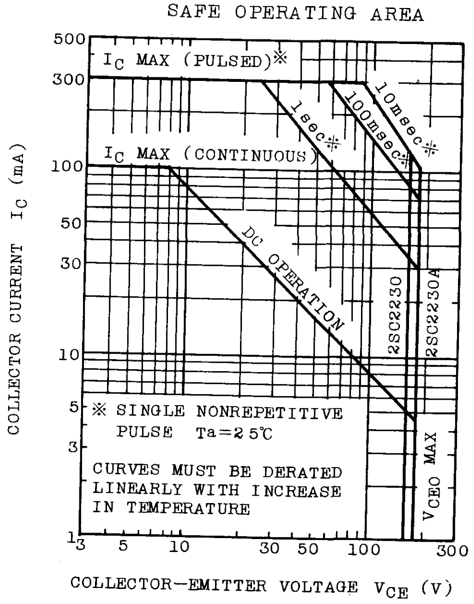
$V_{CE(sat)} - I_C$



$V_{CE(sat)} - I_C$


C_{ob} − V_{CB}
I_E=0
f = 1 MHz
Ta = 25℃
COLLECTOR OUTPUT CAPACITANCE C_{ob} (pF)
50
30
10
5
3
1
0.5
1
3
5
10
30
50
100
200
COLLECTOR−BASE VOLTAGE V_{CB} (V)


f_T − I_C
COMMON EMITTER
Ta=25℃
V_{CE}=10V
2
5
TRANSITION FREQUENCY f_T (MHz)
500
300
100
50
30
10
0.5
1
3
5
10
30
50
100
200
COLLECTOR CURRENT I_C (mA)


SAFE OPERATING AREA
I_C MAX (PULSED)※
I_C MAX (CONTINUOUS)
1sec※
100msec※
10msec※
DC OPERATION
2SC2230
2SC2230A
V_{CEO} MAX
※ SINGLE NONREPETITIVE PULSE Ta=25℃
CURVES MUST BE DERATED LINEARLY WITH INCREASE IN TEMPERATURE
COLLECTOR CURRENT I_C (mA)
500
300
100
50
30
10
5
3
1
3
5
10
30
50
100
300
COLLECTOR−EMITTER VOLTAGE V_{CE} (V)

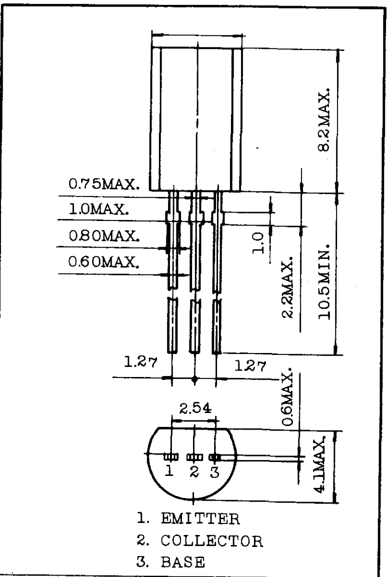
2SC2235

AUDIO POWER AMPLIFIER APPLICATIONS.
DRIVER STAGE AMPLIFIER APPLICATIONS.

FEATURES:

- Complementary to 2SA965.

Unit in mm



JEDEC	TO-92MOD
EIAJ	—
TOSHIBA	2-5J1A

Weight : 0.36g

MAXIMUM RATINGS (Ta=25°C)

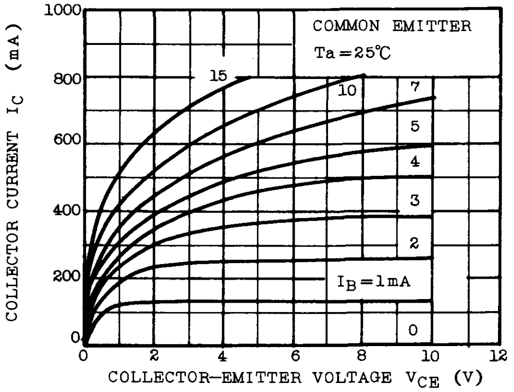
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	120	V
Collector-Emitter Voltage	V_{CEO}	120	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	800	mA
Emitter Current	I_E	-800	mA
Collector Power Dissipation	P_C	900	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55∿150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

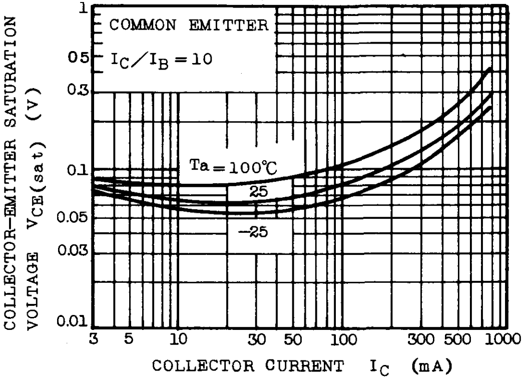
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=120V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=10mA, I_B=0	120	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=1mA, I_C=0	5	-	-	V
DC Current Gain	h_{FE} (Note)	V_{CE}=5V, I_C=100mA	80	-	240	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=500mA, I_B=50mA	-	-	1.0	V
Base-Emitter Voltage	V_{BE}	V_{CE}=5V, I_C=500mA	-	-	1.0	V
Transition Frequency	f_T	V_{CE}=5V, I_C=100mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	-	30	pF

Note : h_{FE} Classification O : 80∿160, Y : 120∿240

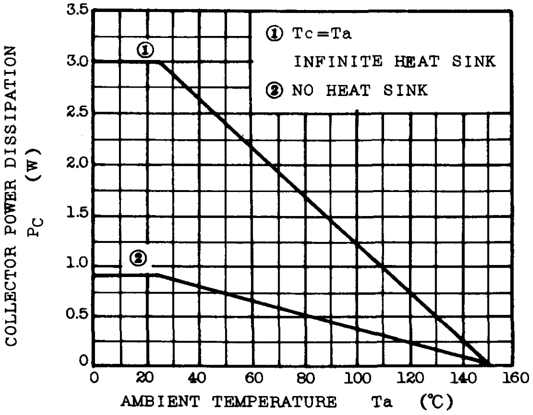
I_C – V_{CE}



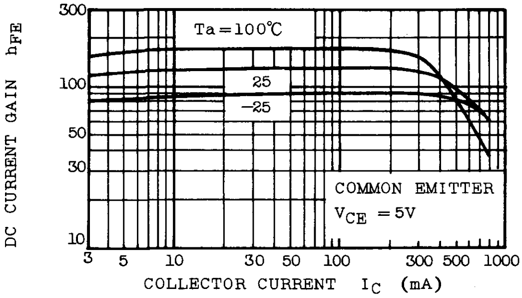
$V_{CE(sat)}$ – I_C



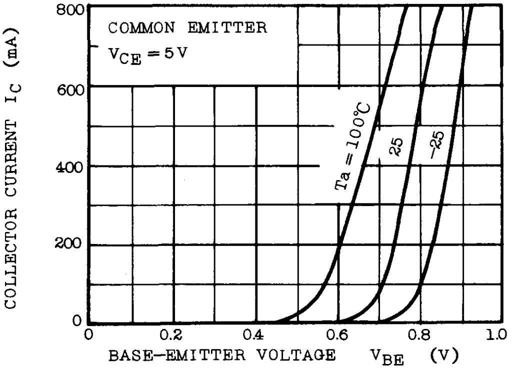
P_C – Ta



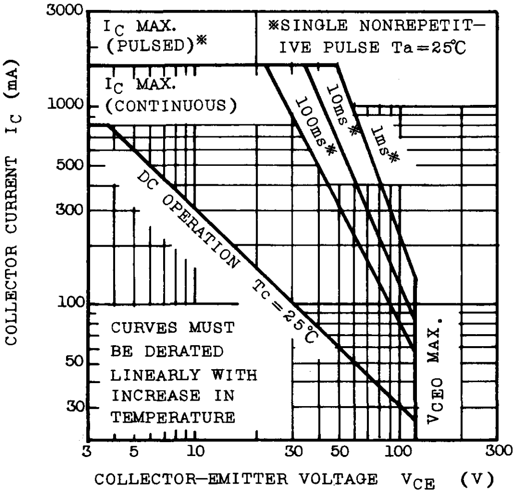
h_{FE} – I_C



I_C – V_{BE}



SAFE OPERATING AREA



SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

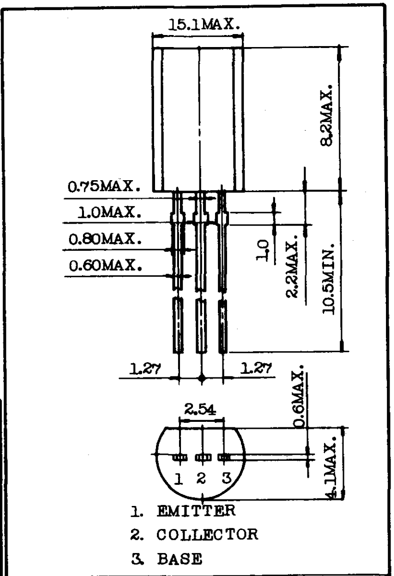
2SC2236

AUDIO POWER AMPLIFIER APPLICATIONS.

FEATURES:

- Complementary to 2SA966 and 3 Watts Output Applications.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO — 92MOD
EIAJ	—
TOSHIBA	2 — 5J1A

Weight : 0.36g

MAXIMUM RATINGS (Ta=25°C)

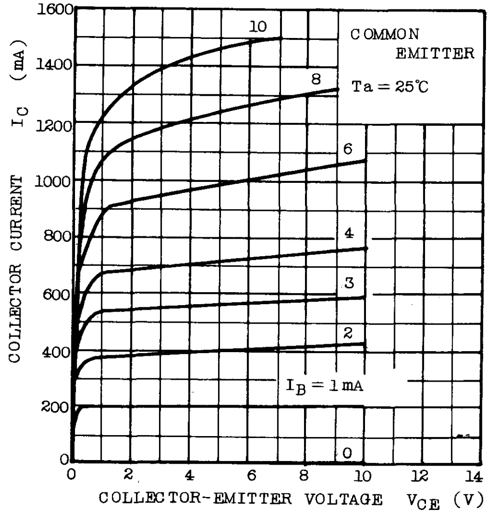
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	1.5	A
Emitter Current	I_E	-1.5	A
Collector Power Dissipation	P_C	900	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55∿150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

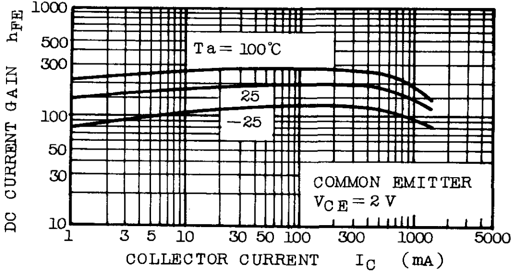
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=30V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=10mA, I_B=0	30	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=1mA, I_C=0	5	-	-	V
DC Current Gain	h_{FE} (Note)	V_{CE}=2V, I_C=500mA	100	-	320	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=1.5A, I_B=0.03A	-	-	2.0	V
Base-Emitter Voltage	V_{BE}	V_{CE}=2V, I_C=500mA	-	-	1.0	V
Transition Frequency	f_T	V_{CE}=2V, I_C=500mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	-	30	pF

Note : h_{FE} Classification O : 100∿200, Y : 160∿320

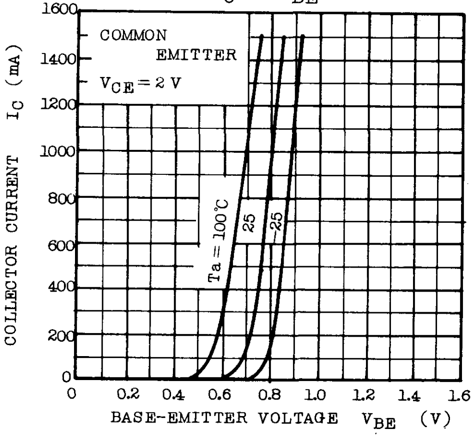
I_C — V_{CE}



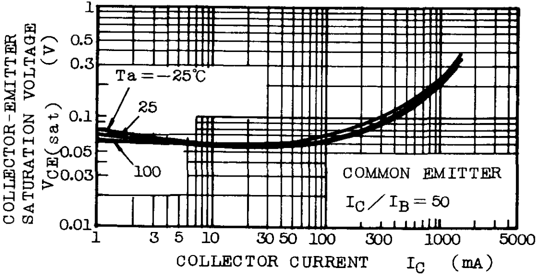
h_{FE} — I_C



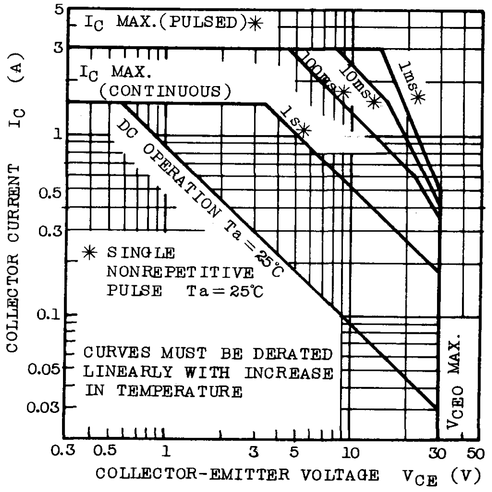
I_C — V_{BE}



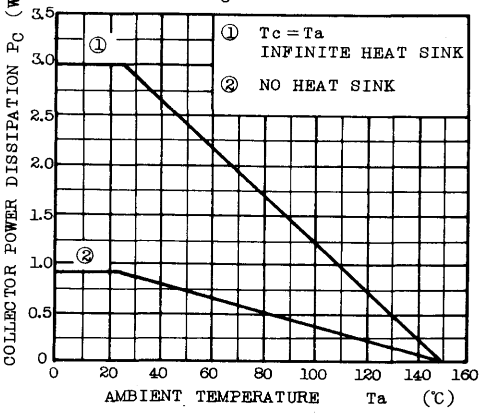
$V_{CE(sat)}$ — I_C



SAFE OPERATING AREA



P_C — Ta



SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

2SC2240

LOW NOISE AUDIO AMPLIFIER APPLICATIONS.

FEATURES:

The 2SC2240 is a transistor for low frequency and low noise applications. This device is designed to lower noise figure in the region of low signal source impedance, and to lower the pulse noise. This is recommended for the first stages of Equalizer amplifiers.

Low Noise

: NF=4dB (Typ.), R_g=100Ω, V_{CE}=6V, I_C=100μA, f=1kHz

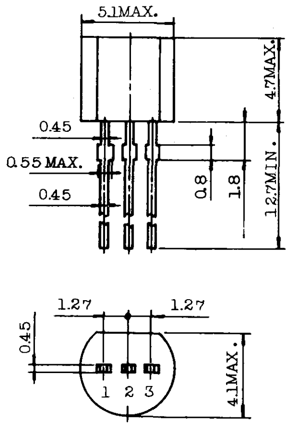
: NF=0.5dB (Typ.), R_g=1kΩ, V_{CE}=6V, I_C=100μA, f=1kHz

Low Pulse Noise : Low 1/f Noise

High DC Current Gain : h_{FE}=200∿700

High Breakdown Voltage : V_{CEO}=120V

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

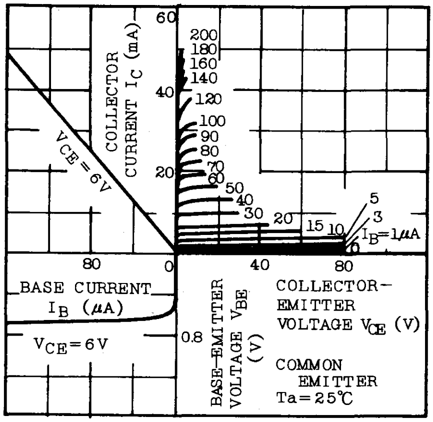
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	120	V
Collector-Emitter Voltage	V_{CEO}	120	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	100	mA
Emitter Current	I_E	-100	mA
Collector Power Dissipation	P_C	300	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	Tstg	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

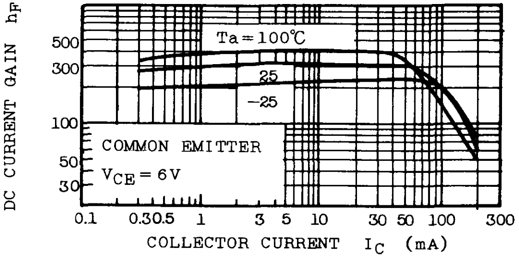
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=120V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	120	-	-	V
DC Current Gain	h_{FE} (Note)	V_{CE}=6V, I_C=2mA	200	-	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	0.3	V
Base-Emitter Voltage	V_{BE}	V_{CE}=6V, I_C=2mA	-	0.65	-	V
Transition Frequency	f_T	V_{CE}=6V, I_C=1mA	-	100	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	3.0	-	pF
Noise Figure	NF	V_{CE}=6V, I_C=100μA, f=10Hz, R_g=10kΩ	-	-	6	dB
		V_{CE}=6V, I_C=100μA f=1kHz, R_g=10kΩ	-	-	2	
		V_{CE}=6V, I_C=100μA f=1kHz, R_g=100Ω	-	4	-	

Note : h_{FE} Classification GR : 200∿400, BL : 350∿700

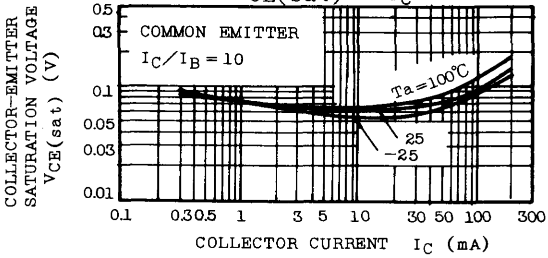
STATIC CHARACTERISTICS



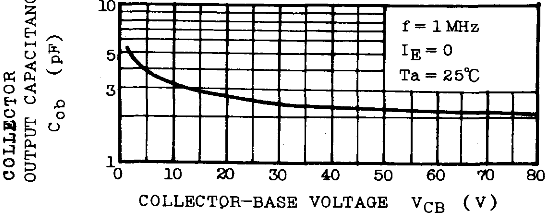
hFE — IC



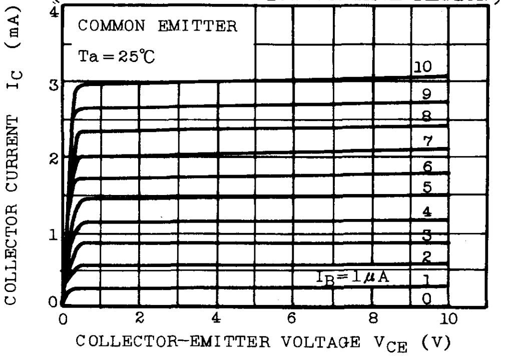
VCE(sat) — IC



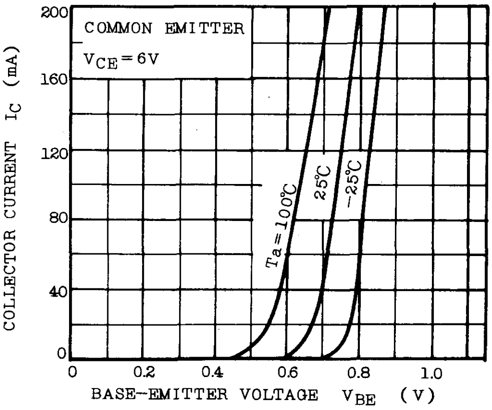
Cob — VCB



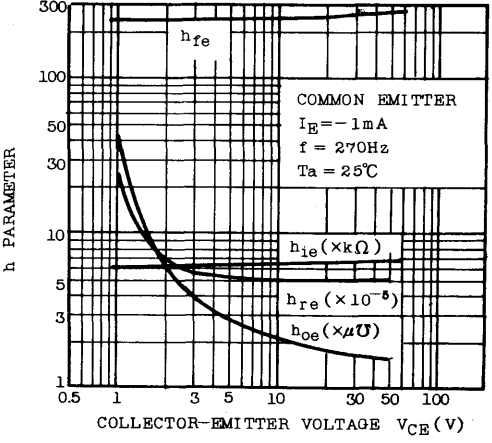
IC - VCE
(LOW CURRENT AND LOW VOLTAGE REGION)



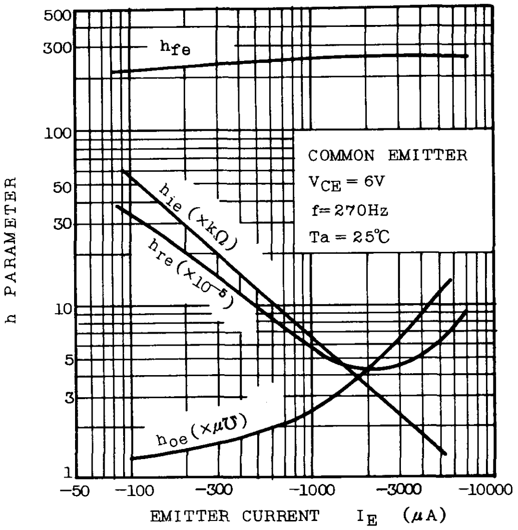
IC — VBE



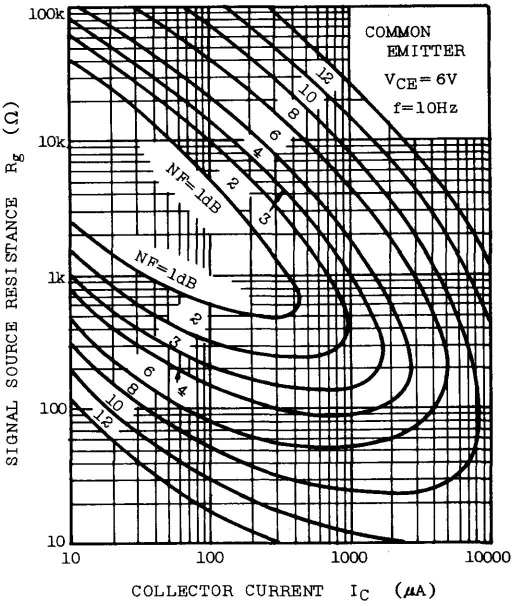
h PARAMETER — VCE



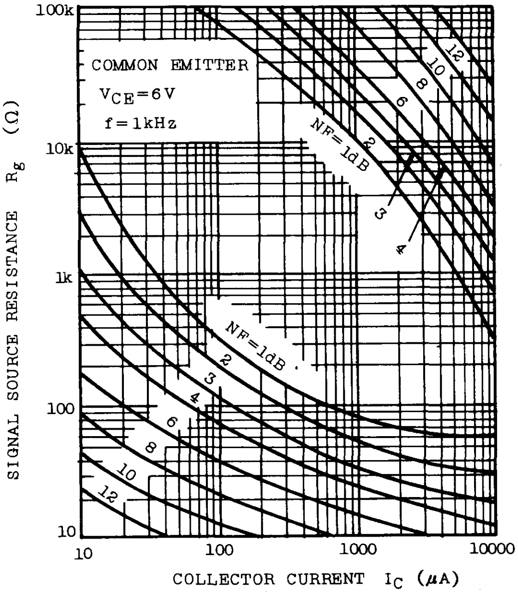
h PARAMETER — I_E



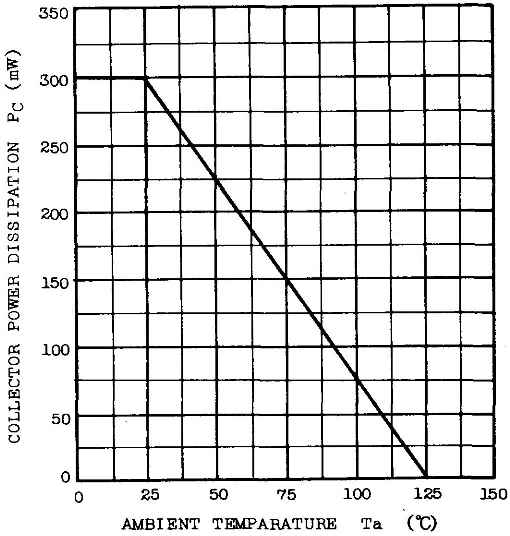
NF — R_g, I_C



NF — R_g, I_C



P_C — Ta



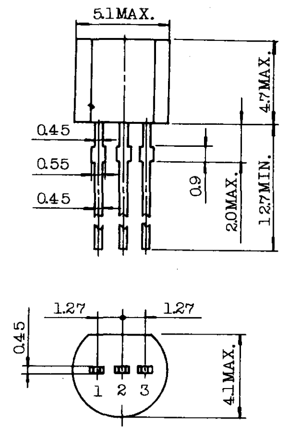
2SC2347

SILICON NPN EPITAXIAL PLANAR TYPE

TV UHF OSCILLATOR APPLICATIONS.

TV VHF MIXER APPLICATIONS.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

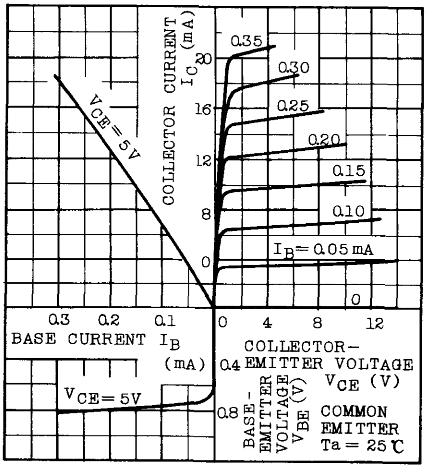
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	15	V
Emitter-Base Voltage	V_{EBO}	3	V
Collector Current	I_C	50	mA
Emitter Current	I_E	-50	mA
Collector Power Dissipation	P_C	250	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	Tstg	-55∿125	°C

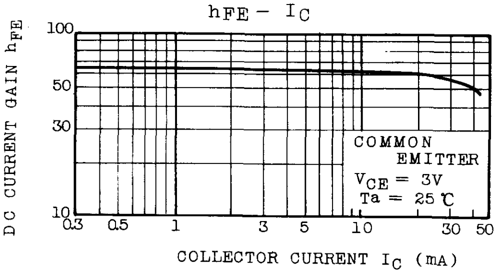
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=15V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=3V, I_C=0	-	-	1.0	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	15	-	-	V
DC Current Gain	h_{FE}	V_{CE}=3V, I_C=8mA	20	-	-	
Transition Frequency	f_T	V_{CE}=10V, I_C=8mA	650	-	-	MHz
Collector Output Capacitance	Cob	V_{CB}=10V, I_E=0, f=1MHz	-	1.2	1.5	pF
Collector-Base Time Constant	$C_c \cdot r_{bb'}$	V_{CB}=10V, I_C=8mA, f=30MHz	-	-	12	ps

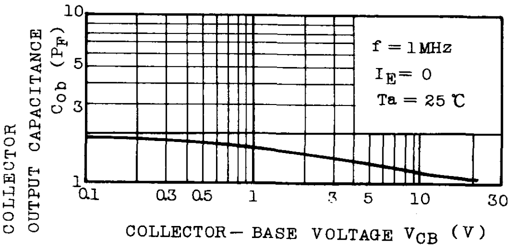
STATIC CHARACTERISTICS



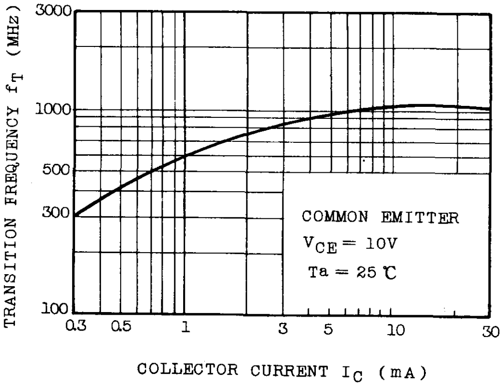
h_{FE} − I_C



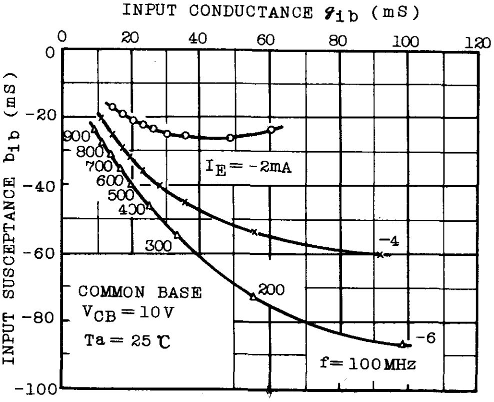
C_{ob} − V_{CB}



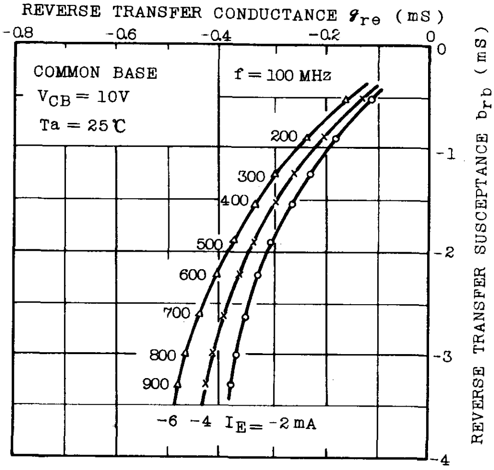
f_T − I_C

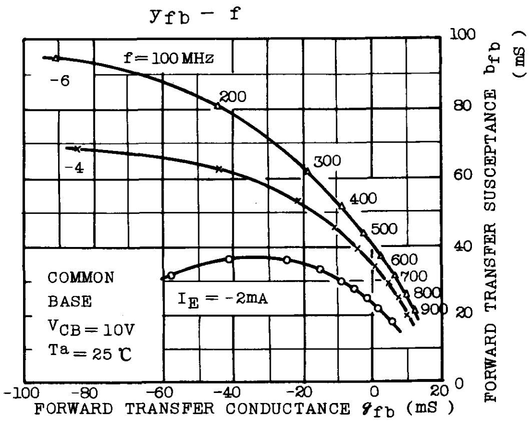


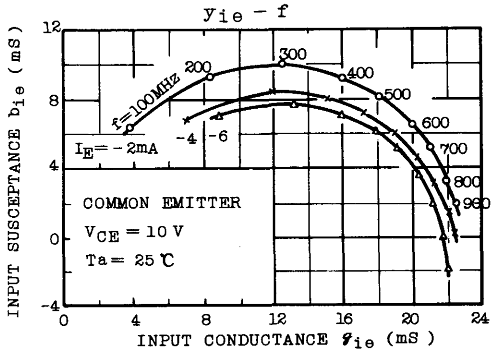
y_{ib} − f

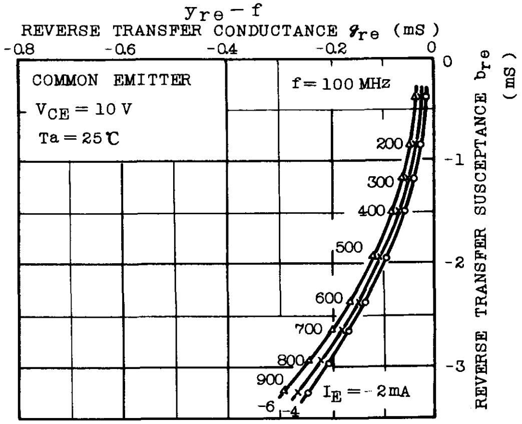


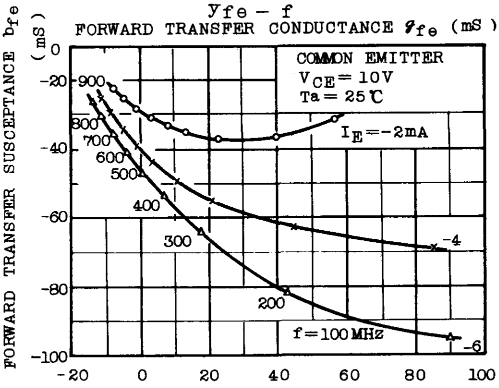
y_{rb} − f

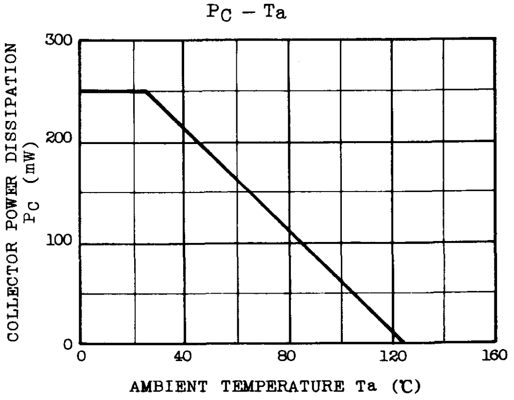


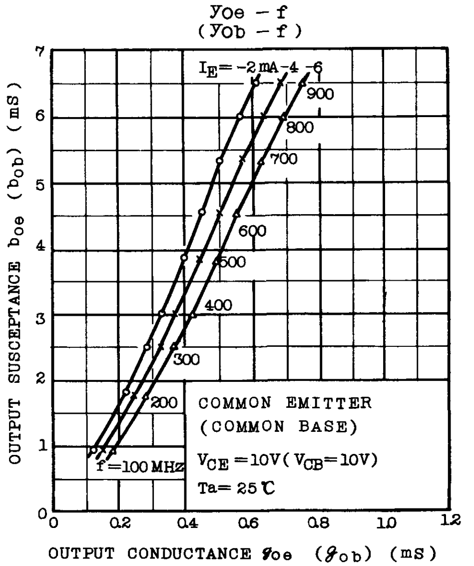

yfb – f
f=100 MHz
-6
200
-4
300
400
500
600
700
800
900
COMMON
BASE
VCB=10V
Ta=25 ℃
IE = -2mA
-100
-80
-60
-40
-20
0
20
FORWARD TRANSFER CONDUCTANCE gfb (mS)
100
80
60
40
20
0
FORWARD TRANSFER SUSCEPTANCE bfb (mS)


yie – f
f=100MHz
200
300
400
500
600
700
800
900
-4
-6
IE= -2mA
COMMON EMITTER
VCE = 10 V
Ta= 25 ℃
12
8
4
0
-4
0
4
8
12
16
20
24
INPUT CONDUCTANCE gie (mS)
INPUT SUSCEPTANCE bie (mS)


yre – f
REVERSE TRANSFER CONDUCTANCE gre (mS)
-0.8
-0.6
-0.4
-0.2
0
COMMON EMITTER
VCE = 10 V
Ta = 25 ℃
f= 100 MHz
200
300
400
500
600
700
800
900
-6
-4
IE = -2mA
0
-1
-2
-3
REVERSE TRANSFER SUSCEPTANCE bre (mS)


yfe – f
FORWARD TRANSFER CONDUCTANCE gfe (mS)
COMMON EMITTER
VCE= 10V
Ta= 25 ℃
IE=-2mA
900
800
700
600
500
400
300
200
-4
f=100MHz
-6
0
-20
-40
-60
-80
-100
-20
0
20
40
60
80
100
FORWARD TRANSFER SUSCEPTANCE bfe (mS)


PC – Ta
300
200
100
0
0
40
80
120
160
COLLECTOR POWER DISSIPATION PC (mW)
AMBIENT TEMPERATURE Ta (℃)


yoe – f
(yob – f)
IE= -2 mA -4 -6
900
800
700
600
500
400
300
200
f=100 MHz
COMMON EMITTER
(COMMON BASE)
VCE =10V(VCB=10V)
Ta= 25 ℃
7
6
5
4
3
2
1
0
0
0.2
0.4
0.6
0.8
1.0
1.2
OUTPUT SUSCEPTANCE boe (bob) (mS)
OUTPUT CONDUCTANCE goe (gob) (mS)

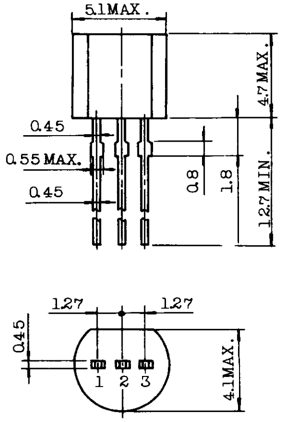
2SC2348

TV VHF RF AMPLIFIER APPLICATIONS.

FEATURES:

- High Gain : G_{pe}=24dB (Typ.)(f=200MHz)
- Low Noise : NF=2.3dB (Typ.)(f=200MHz)
- Excellent Forward AGC Characteristics.

Unit in mm



1. BASE
2. EMITTER
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1E

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

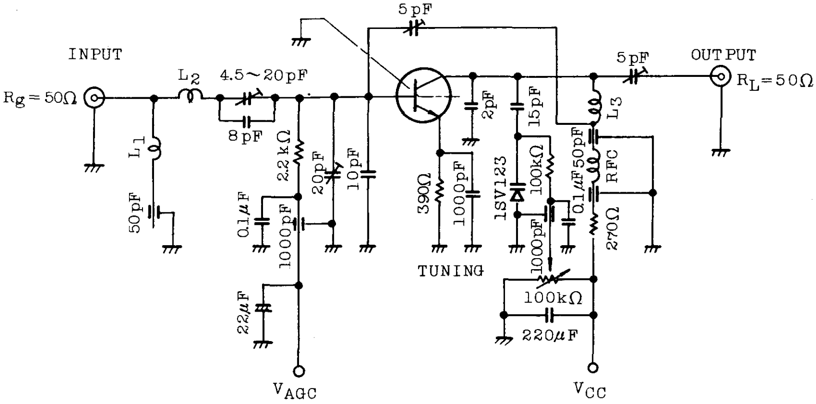
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	2	V
Collector Current	I_C	20	mA
Emitter Current	I_E	-20	mA
Collector Power Dissipation	P_C	250	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=25V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=2V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	30	-	-	V
DC Current Gain	h_{FE}	V_{CE}=10V, I_C=2mA	20	-	200	
Reverse Transfer Capacitance	C_{re}	V_{CB}=10V, I_E=0, f=1MHz	-	0.3	0.4	pF
Transition Frequency	f_T	V_{CE}=10V, I_C=2mA	400	650	-	MHz
Power Gain	Gpe	V_{CE}=12V, V_{AGC}=1.4V f=200MHz	20	24	28	dB
Noise Figure	NF		-	2.3	3.2	dB
AGC Voltage (Note)	V_{AGC}	V_{CC}=12V, GR=30dB, f=200MHz	3.6	4.4	5.1	V

Note : V_{AGC} : V_{AGC} measured by test circuit shown in Fig. 1 when power gain is reduced to 30dB compared that of V_{AGC} at 1.4V.

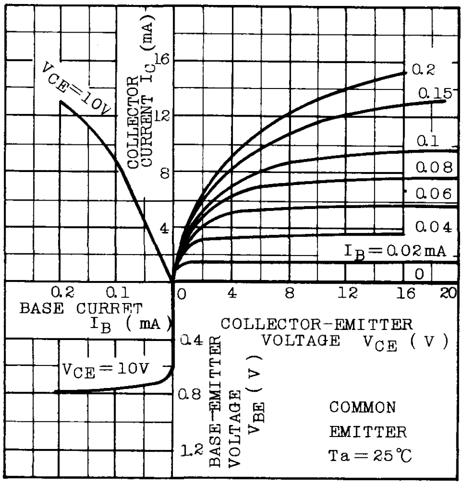
Fig.1 200MHz Gpe , NF & V_{AGC} TEST CIRCUIT



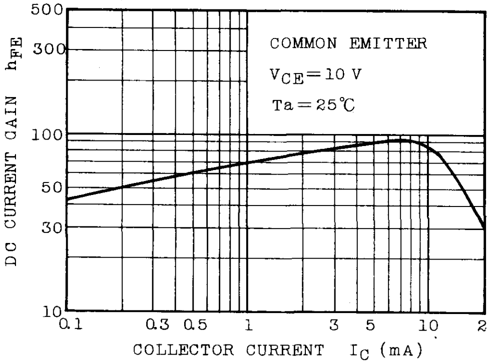
L1 , L2 : SILVER PLATED COPPER WIRE , 10T , 10mmID

L3 : SILVER PLATED COPPER WIRE , 20T , 10mmID

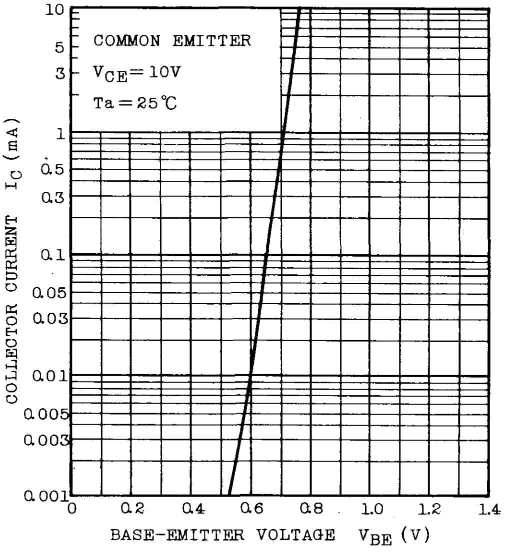
STATIC CHARACTERISTICS



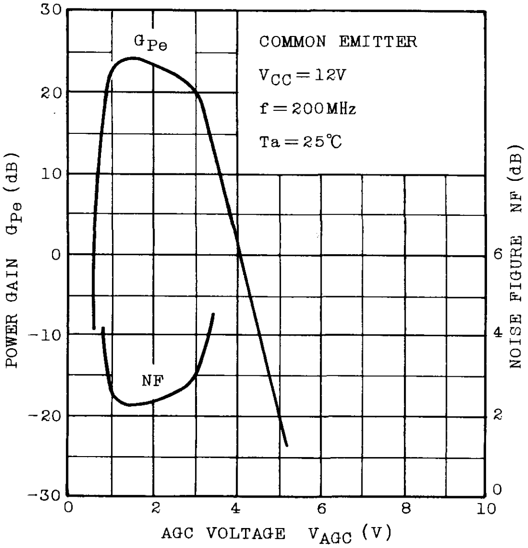
h_{FE} - I_C

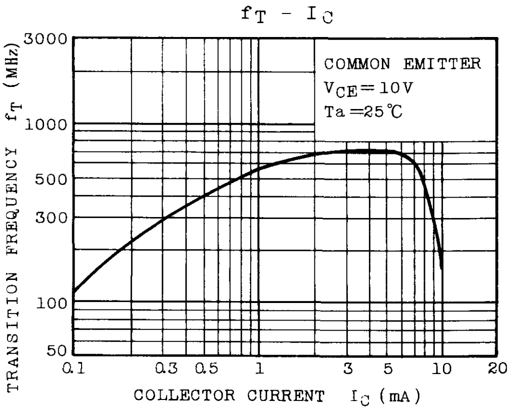


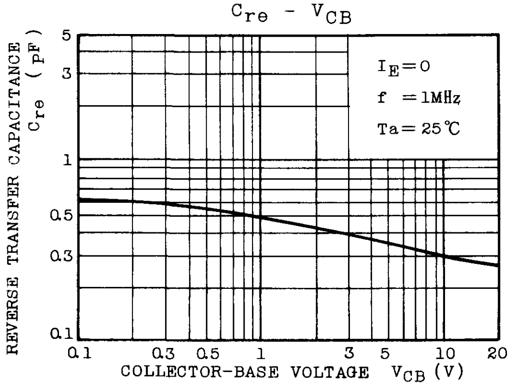
I_C - V_{BE}

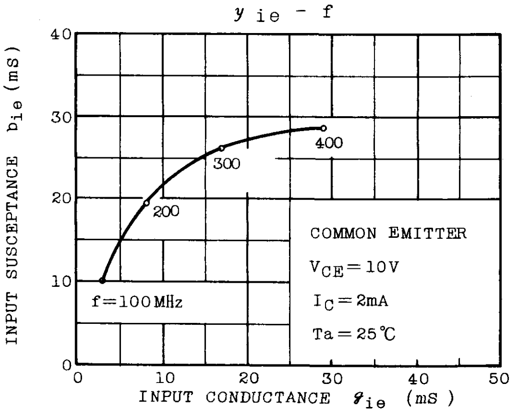


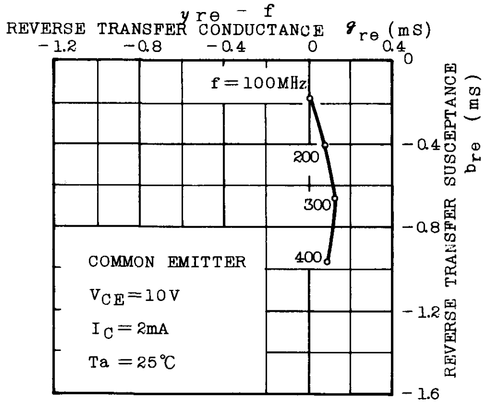
G_{Pe}, NF - V_{AGC}

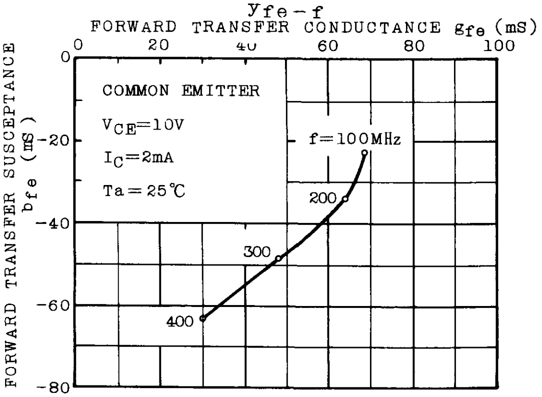


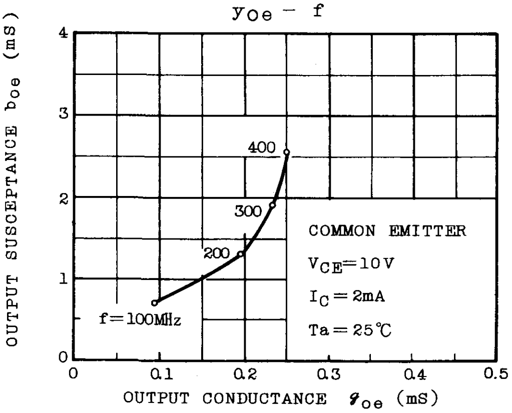

f_T - I_C
COMMON EMITTER
V_{CE} = 10V
Ta = 25℃
TRANSITION FREQUENCY f_T (MHz)
3000
1000
500
300
100
50
0.1
0.3
0.5
1
3
5
10
20
COLLECTOR CURRENT I_C (mA)


C_{re} - V_{CB}
I_E = 0
f = 1MHz
Ta = 25℃
REVERSE TRANSFER CAPACITANCE C_{re} (pF)
5
3
1
0.5
0.3
0.1
0.1
0.3
0.5
1
3
5
10
20
COLLECTOR-BASE VOLTAGE V_{CB} (V)

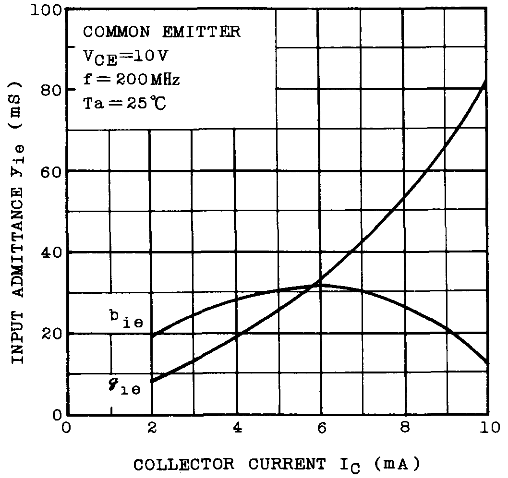

y_{ie} - f
INPUT SUSCEPTANCE b_{ie} (mS)
40
30
20
10
0
0
10
20
30
40
50
INPUT CONDUCTANCE g_{ie} (mS)
f=100MHz
200
300
400
COMMON EMITTER
V_{CE} = 10V
I_C = 2mA
Ta = 25℃


y_{re} - f
REVERSE TRANSFER CONDUCTANCE g_{re} (mS)
-1.2
-0.8
-0.4
0
0.4
0
-0.4
-0.8
-1.2
-1.6
REVERSE TRANSFER SUSCEPTANCE b_{re} (mS)
f = 100MHz
200
300
400
COMMON EMITTER
V_{CE} = 10V
I_C = 2mA
Ta = 25℃

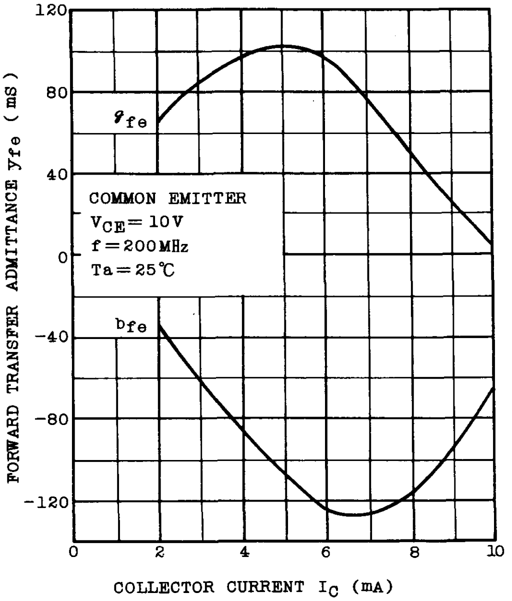

y_{fe} - f
FORWARD TRANSFER CONDUCTANCE g_{fe} (mS)
0
20
40
60
80
100
FORWARD TRANSFER SUSCEPTANCE b_{fe} (mS)
0
-20
-40
-60
-80
COMMON EMITTER
V_{CE} = 10V
I_C = 2mA
Ta = 25℃
f = 100MHz
200
300
400


y_{oe} - f
OUTPUT SUSCEPTANCE b_{oe} (mS)
4
3
2
1
0
0
0.1
0.2
0.3
0.4
0.5
OUTPUT CONDUCTANCE g_{oe} (mS)
400
300
200
f = 100MHz
COMMON EMITTER
V_{CE} = 10V
I_C = 2mA
Ta = 25℃

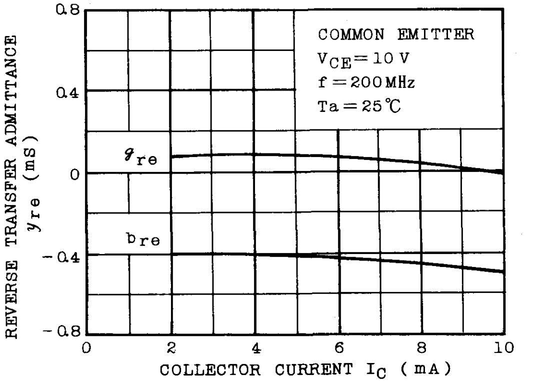
y_{ie} – I_C



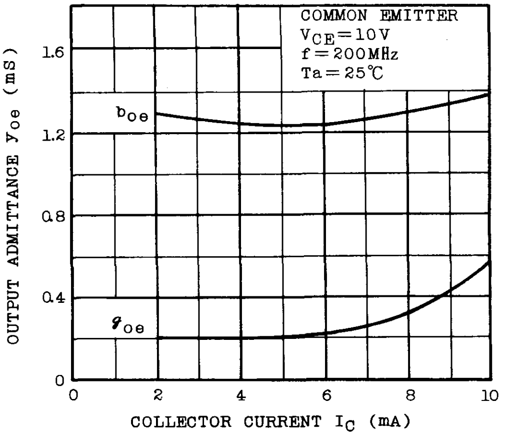
y_{fe} – I_C



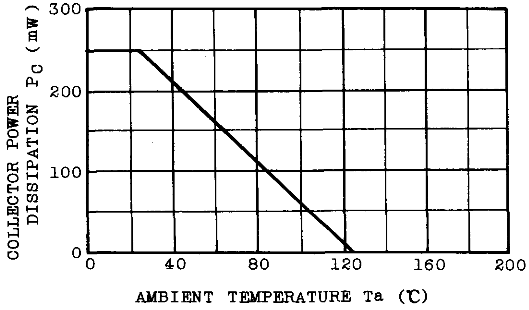
y_{re} – I_C



y_{oe} – I_C



P_C – Ta

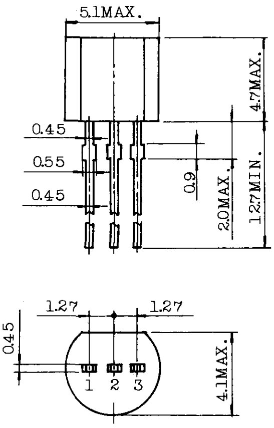


2SC2349

SILICON NPN EPITAXIAL PLANAR TYPE

TV VHF OSCILLATOR APPLICATIONS.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SO-43
TOSHIBA	2-5F1B

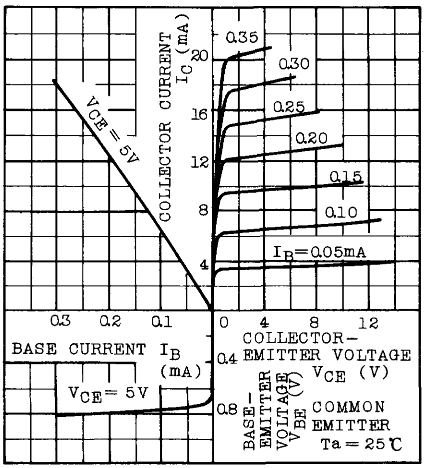
Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

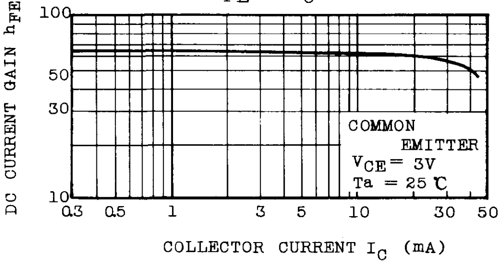
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	15	V
Emitter-Base Voltage	V_{EBO}	3	V
Collector Current	I_C	50	mA
Emitter Current	I_E	-50	mA
Collector Power Dissipation	P_C	250	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

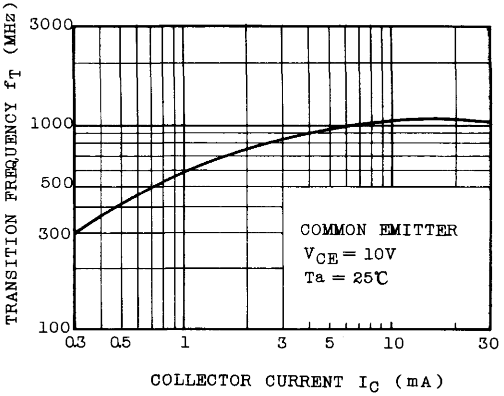
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=15V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=3V, I_C=0	-	-	1.0	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	15	-	-	V
DC Current Gain	h_{FE}	V_{CE}=3V, I_C=8mA	20	-	-	
Transition Frequency	f_T	V_{CE}=10V, I_C=8mA	600	-	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	1.2	1.5	pF
Collector-Base Time Constant	$C_c \cdot r_{bb'}$	V_{CB}=10V, I_C=8mA, f=30MHz	-	-	20	ps



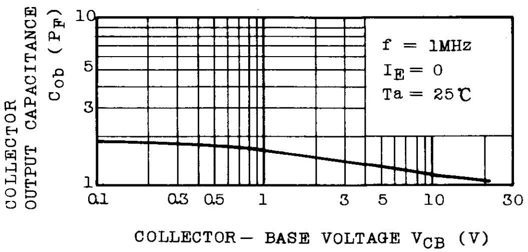
STATIC CHARACTERISTICS



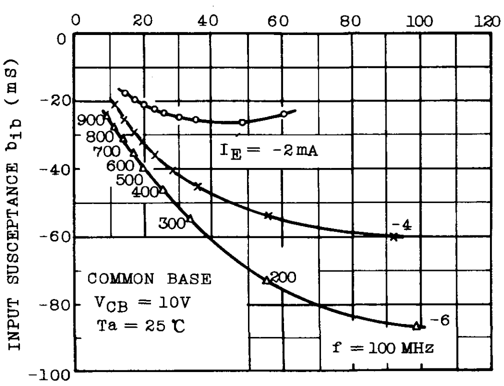
$h_{FE} - I_C$



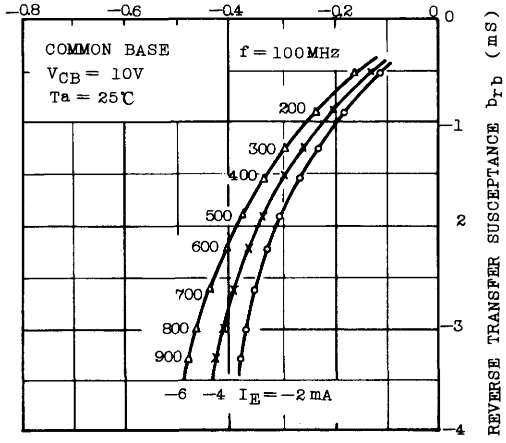
$f_T - I_C$



$C_{ob} - V_{CB}$

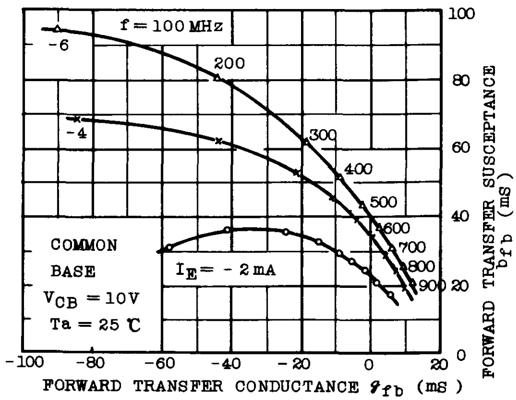


$y_{ib} - f$

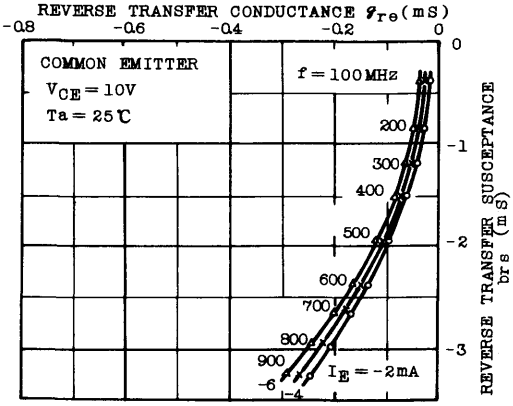


$y_{rb} - f$

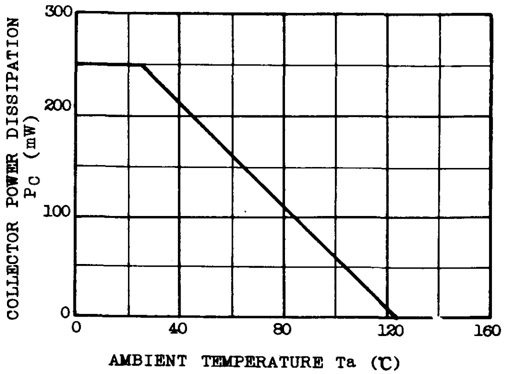
$y_{fb} - f$



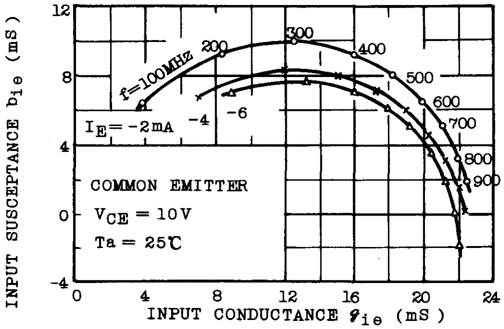
$y_{re} - f$



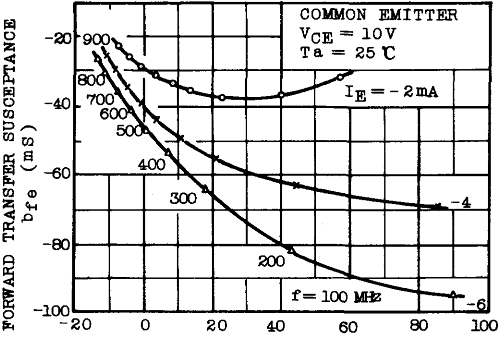
$P_C - Ta$



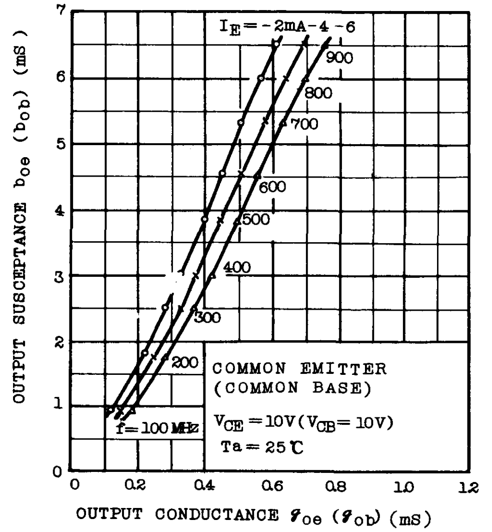
$y_{ie} - f$



$y_{fe} - f$



$y_{oe} - f$
($y_{ob} - f$)



SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

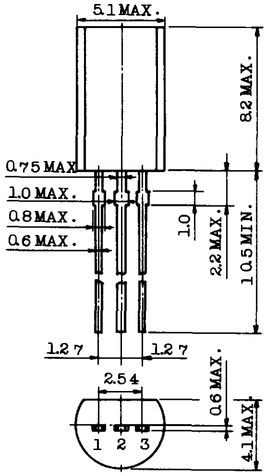
2SC2383

COLOR TV VERT. DEFLECTION OUTPUT APPLICATIONS.
COLOR TV CLASS B SOUND OUTPUT APPLICATIONS.

FEATURES:

- High Voltage : $V_{CEO} = 160V$
- Large Continuous Collector Current Capability.
- Recommended for Vert. Deflection Output & Sound Output Applications for Line Operated TV.
- Complementary to 2SA1013

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO−92MOD
EIAJ	—
TOSHIBA	2−5J1A

Weight : 0.36g

MAXIMUM RATINGS (Ta=25°C)

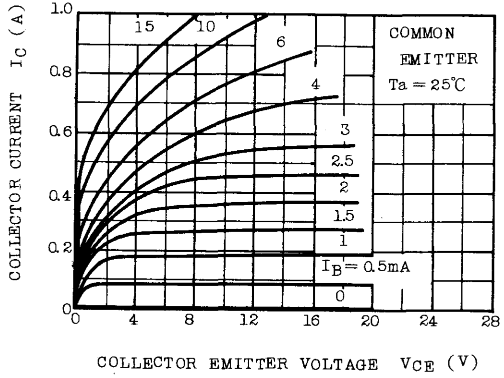
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	160	V
Collector-Emitter Voltage	V_{CEO}	160	V
Emitter-Base Voltage	V_{EBO}	6	V
Collector Current	I_C	1	A
Base Current	I_B	0.5	A
Collector Power Dissipation	P_C	900	mW
Junction Temper ture	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

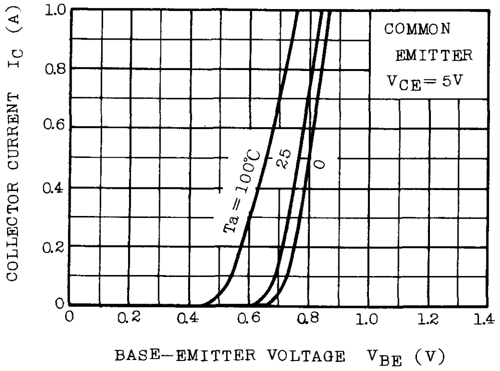
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=150V, I_E=0	-	-	1.0	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=6V, I_C=0	-	-	1.0	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=10mA, I_B=0	160	-	-	V
DC Current Gain	h_{FE}(Note)	V_{CE}=5V, I_C=200mA	60	-	320	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=500mA, I_B=50mA	-	-	1.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=5V, I_C=5mA	0.45	-	0.75	V
Transition Frequency	f_T	V_{CE}=5V, I_C=200mA	20	100	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	-	20	pF

Note : h_{FE} Classification R:60~120 O:100~200 Y:160~320

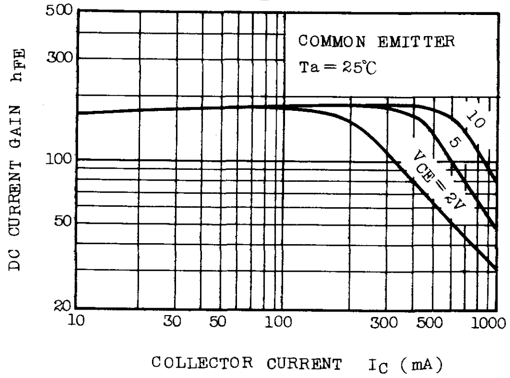
I_C - V_{CE}



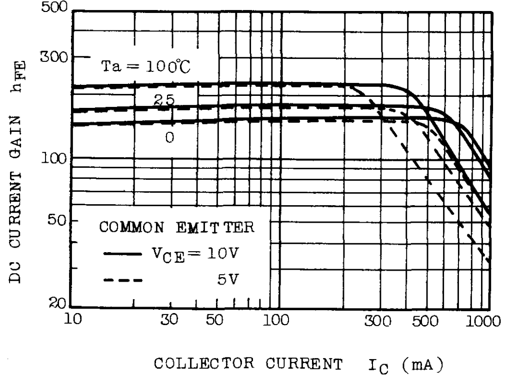
I_C - V_{BE}



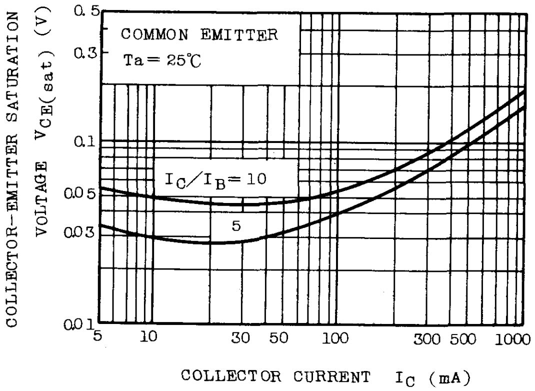
h_{FE} - I_C



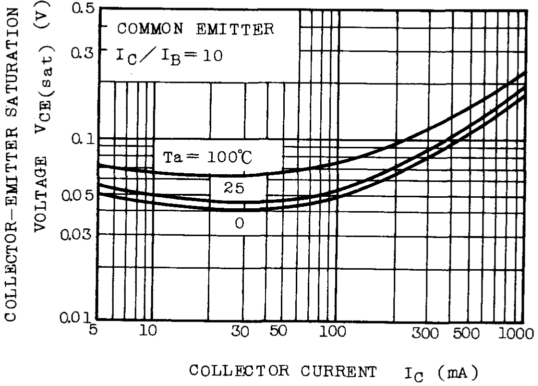
h_{FE} - I_C

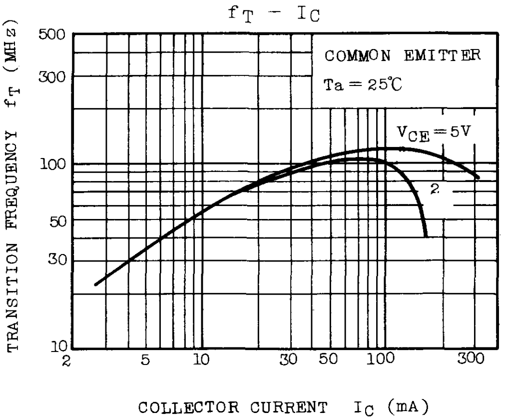


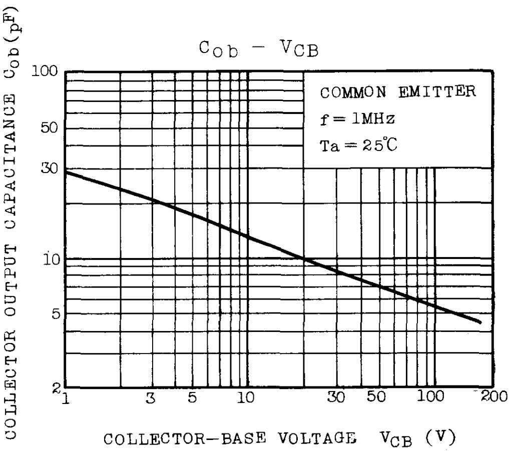
$V_{CE(sat)}$ - I_C

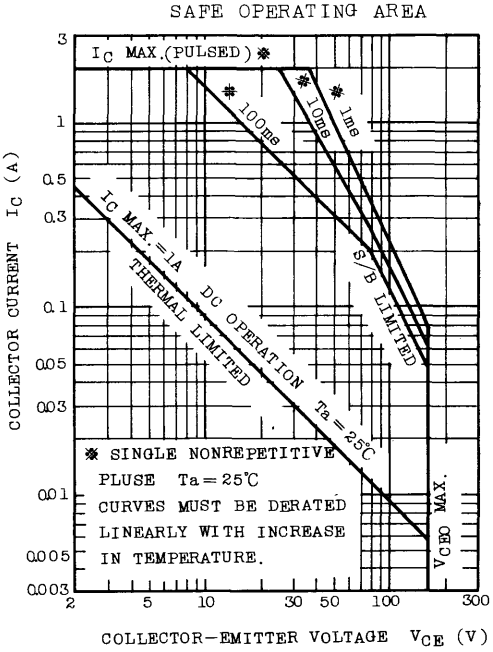


$V_{CE(sat)}$ - I_C




f_T – I_C
COMMON EMITTER
Ta = 25℃
V_{CE} = 5V
2
TRANSITION FREQUENCY f_T (MHz)
500
300
100
50
30
10
2
5
10
30
50
100
300
COLLECTOR CURRENT I_C (mA)


C_{ob} – V_{CB}
COMMON EMITTER
f = 1MHz
Ta = 25℃
COLLECTOR OUTPUT CAPACITANCE C_{ob} (pF)
100
50
30
10
5
2
1
3
5
10
30
50
100
200
COLLECTOR-BASE VOLTAGE V_{CB} (V)


SAFE OPERATING AREA
I_C MAX.(PULSED) ※
※ 100ms
※ 10ms
※ 1ms
I_C MAX.=1A
DC OPERATION
THERMAL LIMITED
Ta = 25℃
S/B LIMITED
V_{CEO} MAX.
※ SINGLE NONREPETITIVE
PLUSE Ta = 25℃
CURVES MUST BE DERATED
LINEARLY WITH INCREASE
IN TEMPERATURE.
COLLECTOR CURRENT I_C (A)
3
1
0.5
0.3
0.1
0.05
0.03
0.01
0.005
0.003
2
5
10
30
50
100
300
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)

2SC2458

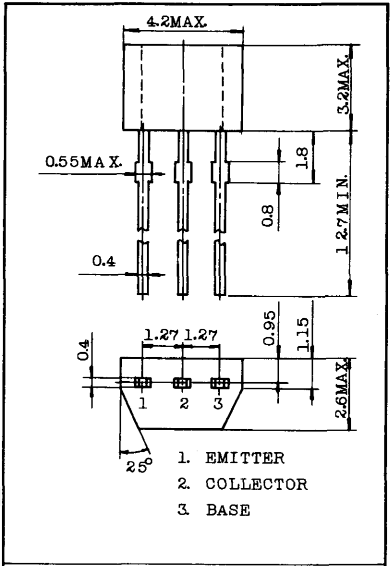
SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

AUDIO AMPLIFIER APPLICATIONS.

FEATURES:

- High Current Capability : I_C=150mA (Max.)
- High DC Current Gain : h_{FE}=70∿700
- Excellent h_{FE} Linearity
  : $h_{FE(0.1mA)}/h_{FE(2mA)}$=0.95 (Typ.)
- Low Noise : NF=1dB (Typ.), 10dB (Max.)
- Complementary to 2SA1048.
- Small Package.

Unit in mm



JEDEC	-
EIAJ	-
TOSHIBA	2-4E1A

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

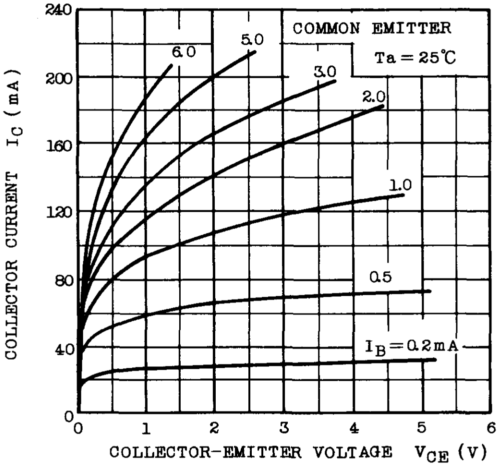
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	50	V
Collector-Emitter Voltage	V_{CEO}	50	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	150	mA
Emitter Current	I_E	-150	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

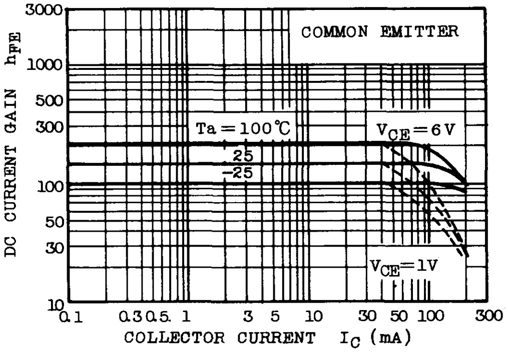
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=50V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=6V, I_C=2mA	70	-	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=100mA, I_B=10mA	-	0.1	0.25	V
Transition Frequency	f_T	V_{CE}=10V, I_C=1mA	80	-	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	2.0	3.5	pF
Noise Figure	NF	V_{CE}=6V, I_C=0.1mA f=1kHz, R_g=10kΩ	-	1.0	10	dB

Note : h_{FE} Classification O : 70∿140, Y : 120∿240, GR : 200∿400, BL : 350∿700

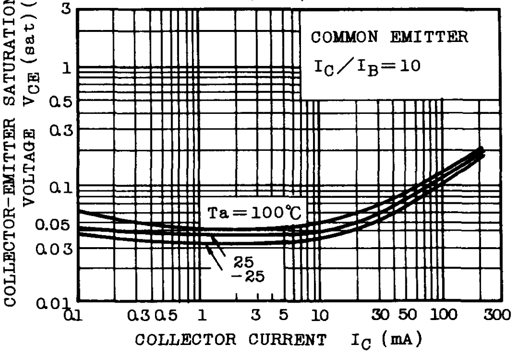
I_C - V_{CE}



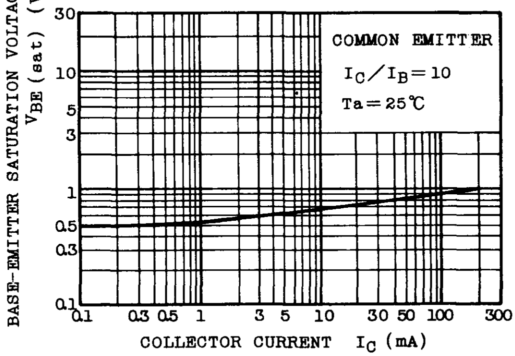
h_{FE} - I_C



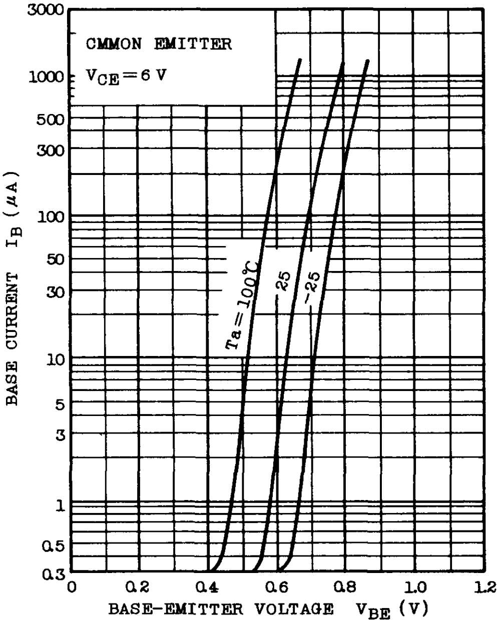
V_{CE} (sat) - I_C

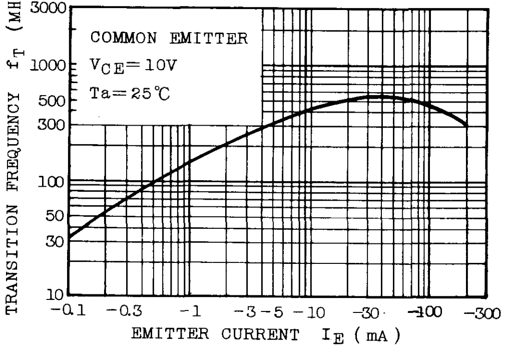


V_{BE} (sat) - I_C

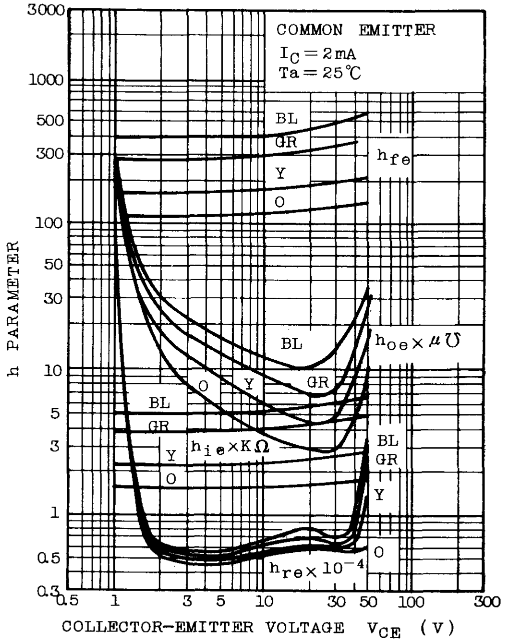


I_B - V_{BE}

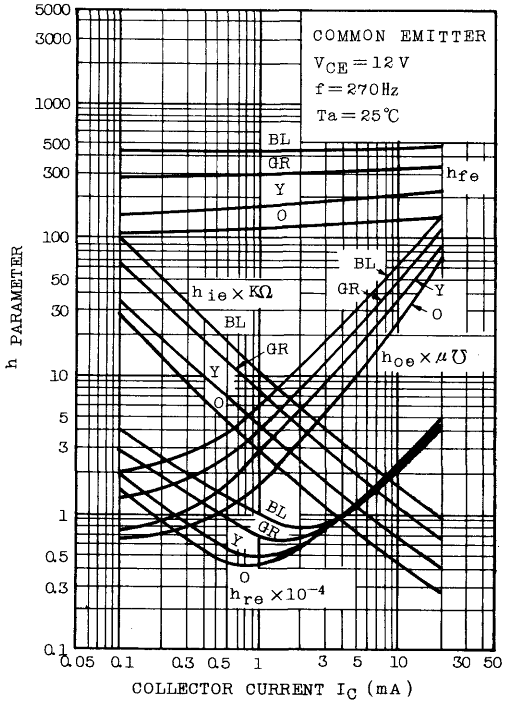




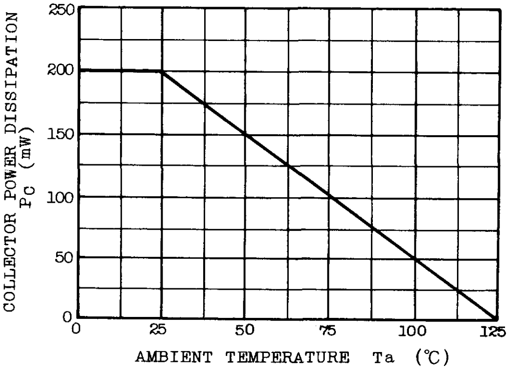
f_T - I_E



h PARAMETER - V_{CE}



h PARAMETER - I_C



P_C - T_a

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

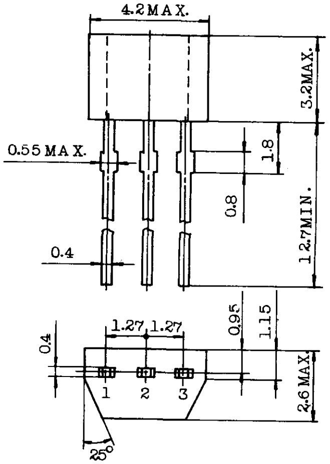
2SC2458Ⓛ

AUDIO AMPLIFIER APPLICATIONS.
LOW NOISE AUDIO AMPLIFIER APPLICATIONS.

FEATURES:

- High Current Capability : I_C=150mA (Max.)
- High DC Current Gain : h_{FE}=70∿700
- Excellent h_{FE} Linearity
  : $h_{FE(0.1mA)}/h_{FE(2mA)}$=0.95 (Typ.)
- Low Noise : NF=0.2dB (Typ.), 3dB (Max.)
- Complementary to 2SA1048 Ⓛ.
- Small Package.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	―
EIAJ	―
TOSHIBA	2-4E1A

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

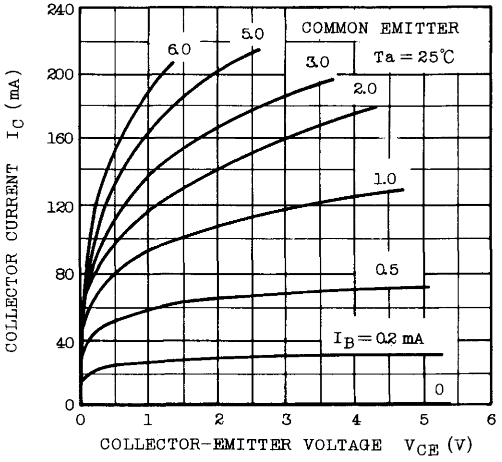
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	50	V
Collector-Emitter Voltage	V_{CEO}	50	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	150	mA
Emitter Current	I_E	-150	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	Tstg	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

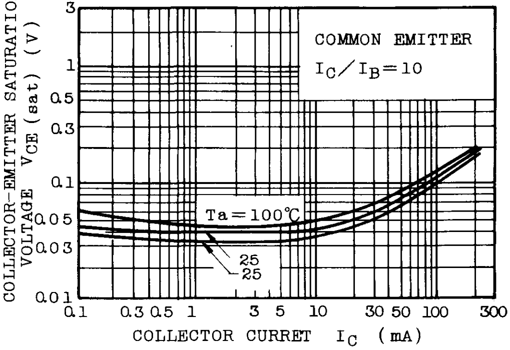
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=50V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=6V, I_C=2mA	70	-	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=100mA, I_B=10mA	-	0.1	0.25	V
Transition Frequency	f_T	V_{CE}=10V, I_C=1mA	80	-	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	2.0	3.5	pF
Noise Figure	NF (1)	V_{CE}=6V, I_C=0.1mA f=100Hz, R_g=10kΩ	-	0.5	6	dB
	NF (2)	V_{CE}=6V, I_C=0.1mA f=1kHz, R_g=10kΩ	-	0.2	3	

Note : h_{FE} Classification O : 70∿140, Y : 120∿240, GR: 200∿400, BL : 350∿700

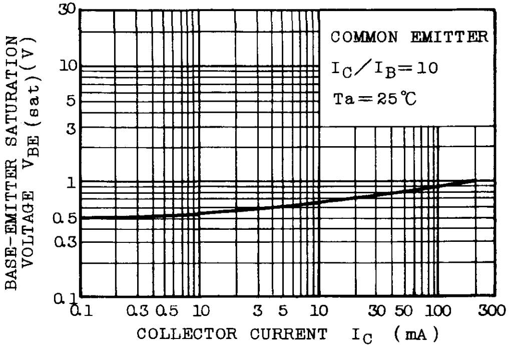
I_C - V_{CE}



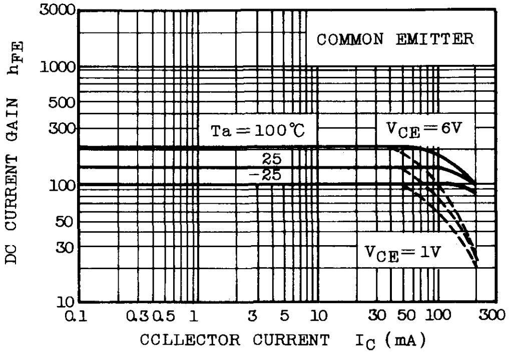
$V_{CE(sat)}$ - I_C



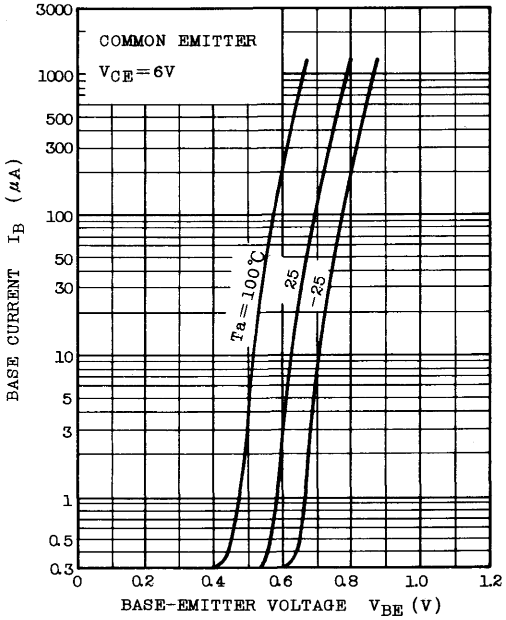
$V_{BE(sat)}$ - I_C

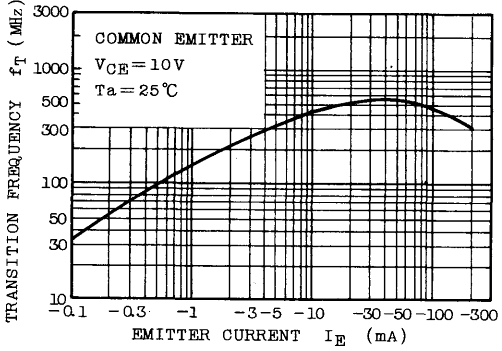


h_{FE} - I_C

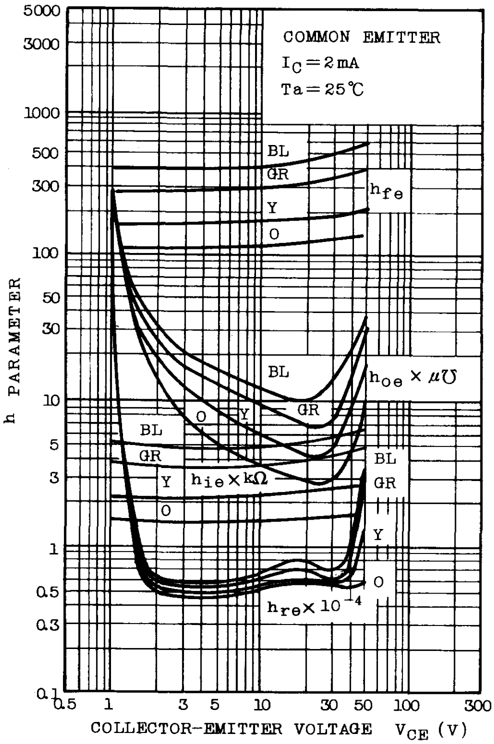


I_B - V_{BE}

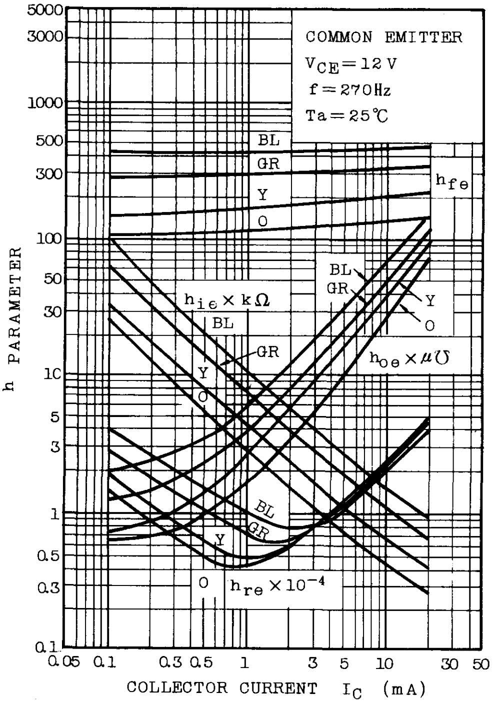




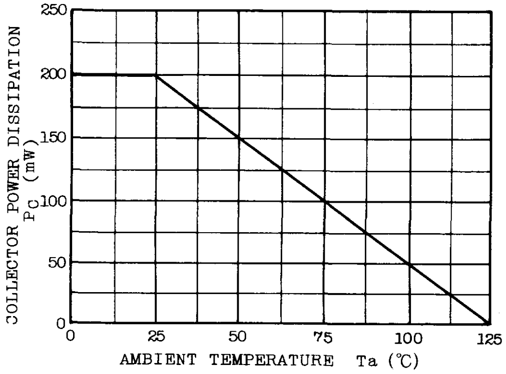
f_T - I_E



h PARAMETER - V_{CE}



h PARAMETER - I_C



P_C - T_a

2SC2459

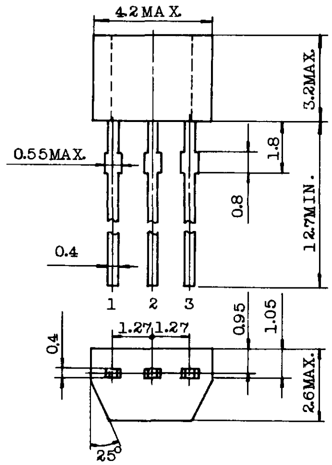
SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

AUDIO AMPLIFIER APPLICATIONS.

FEATURES:

- High Breakdown Voltage : V_{CEO}=120V (Min.)
- High DC Current Gain : h_{FE}=200∿700
- Excellent h_{FE} Linearity
  : $h_{FE}(0.1mA)/h_{FE}(2mA)$=0.95 (Typ.)
- Low Noise : NF=1dB (Typ.), 10dB (Max.)
- Complementary to 2SA1049.
- Small Package.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	-
EIAJ	-
TOSHIBA	2-4E1A

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

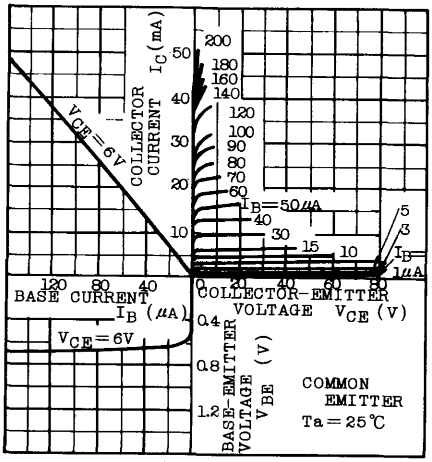
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	120	V
Collector-Emitter Voltage	V_{CEO}	120	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	100	mA
Emitter Current	I_E	-100	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	Tstg	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

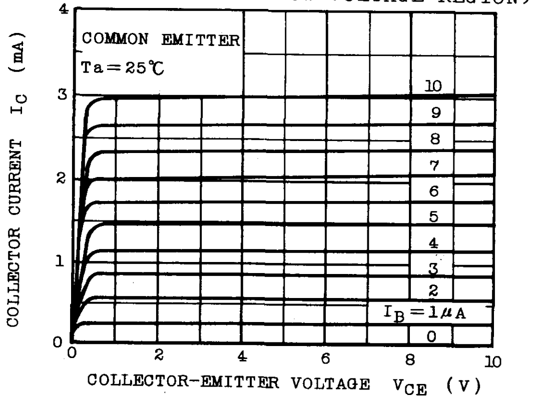
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=120V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=6V, I_C=2mA	200	-	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	0.3	V
Transition Frequency	f_T	V_{CE}=6V, I_C=1mA	-	100	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	3.0	-	pF
Noise Figure	NF	V_{CE}=6V, I_C=0.1mA f=1kHz, R_g=10kΩ	-	1.0	10	dB

Note : h_{FE} classification GR : 200∿400, BL : 350∿700

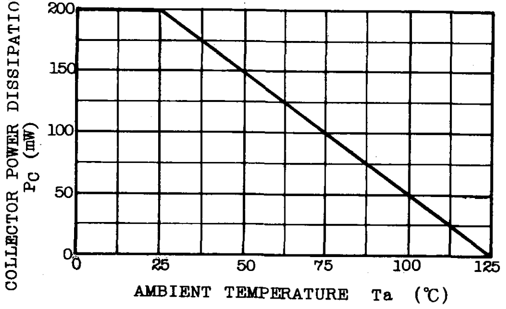
STATIC CHARACTERISTICS



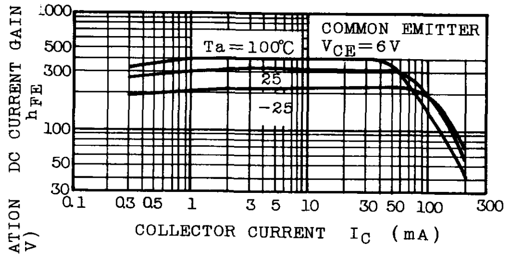
I_C - V_{CE}
(LOW CURRENT AND LOW VOLTAGE REGION)



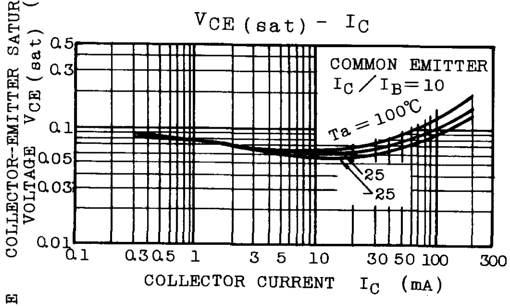
P_C - T_a



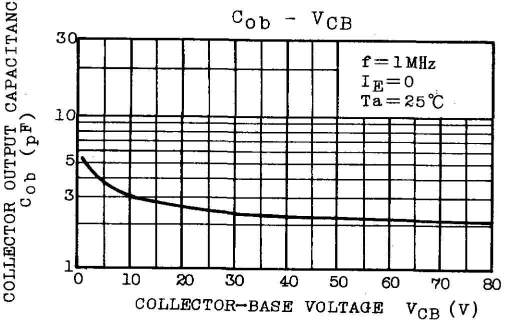
h_{FE} - I_C



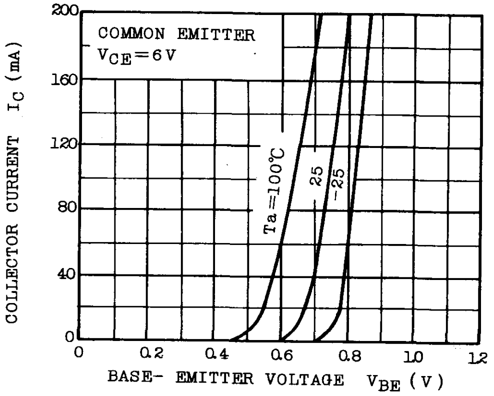
V_{CE} (sat) - I_C



C_{ob} - V_{CB}



I_C - V_{BE}



2SC2482

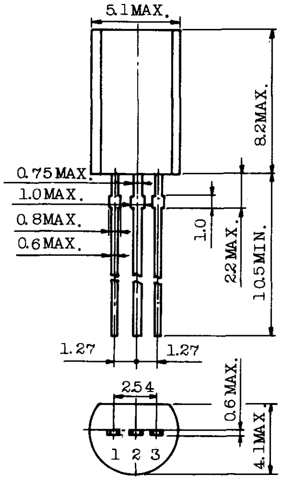
SILICON NPN TRIPLE DIFFUSED TYPE (PCT PROCESS)

HIGH VOLTAGE SWITCHING AND AMPLIFIER APPLICATIONS.
COLOR TV HORIZ. DRIVER APPLICATIONS.
COLOR TV CHROMA OUTPUT APPLICATIONS.

FEATURES:

- High Voltage : $V_{(BR)CEO}$=300V
- Small Collector Output Capacitance
  : C_{ob}=3.0pF (Typ.)

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO−92MOD
EIAJ	—
TOSHIBA	2−5J1A

Weight: 0.36g

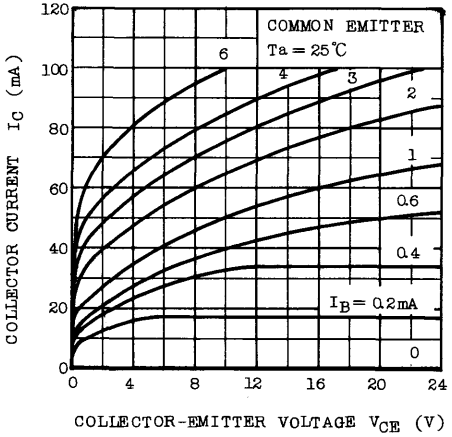
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	300	V
Collector-Emitter Voltage	V_{CEO}	300	V
Emitter-Base Voltage	V_{EBO}	7	V
Collector Current	I_C	100	mA
Base Current	I_B	50	mA
Collector Power Dissipation	P_C	900	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

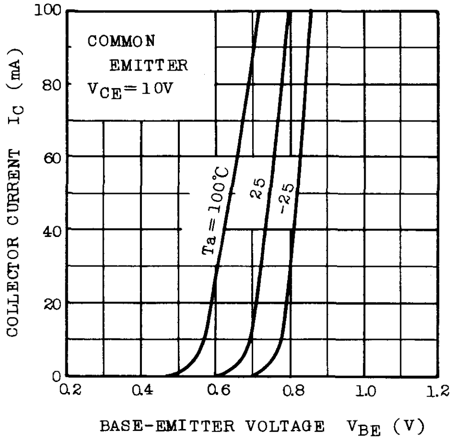
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=240V, I_E=0	−	−	1.0	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=7V, I_C=0	−	−	1.0	μA
DC Current Gain	$h_{FE}(1)$	V_{CE}=10V, I_C=4mA	20	−	−	−
	$h_{FE}(2)$	V_{CE}=10V, I_C=20mA	30	−	150	−
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	−	−	1.0	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=10mA, I_B=1mA	−	−	1.0	V
Transition Frequency	f_T	V_{CE}=10V, I_C=20mA	50	−	−	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=20V, I_E=0, f=1MHz	−	3.0	−	pF

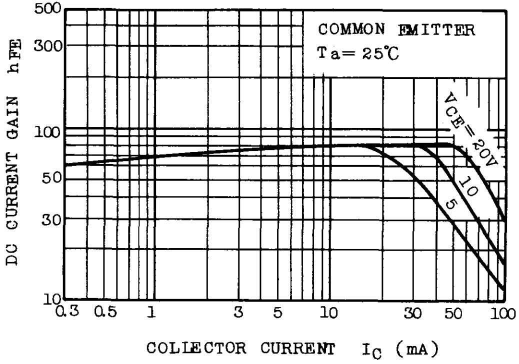
I_C - V_{CE}



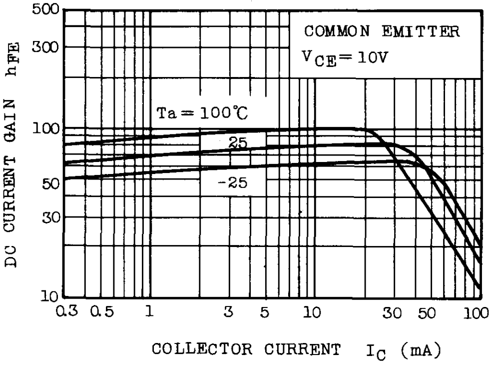
I_C - V_{BE}



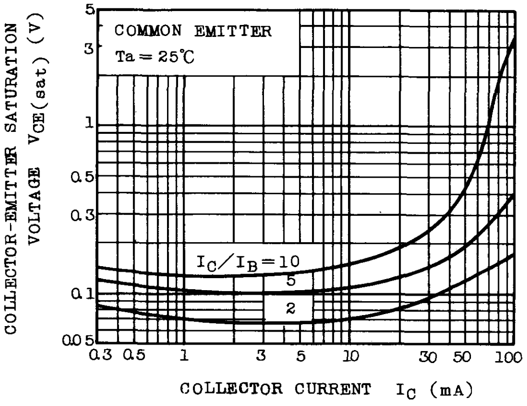
h_{FE} - I_C



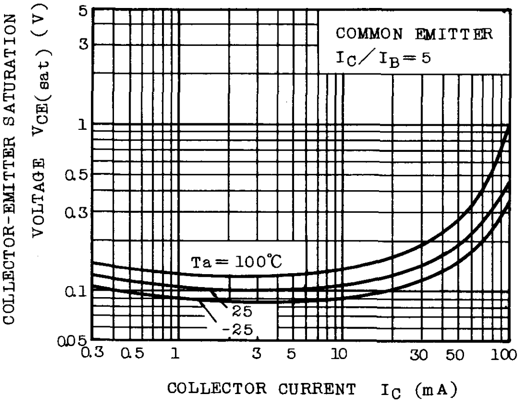
h_{FE} - I_C



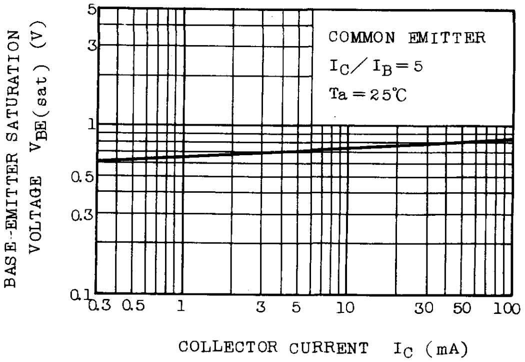
$V_{CE(sat)}$ - I_C



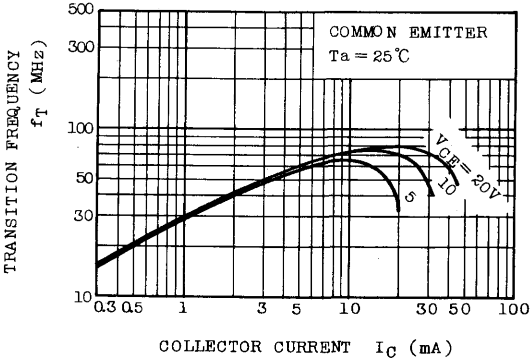
$V_{CE(sat)}$ - I_C



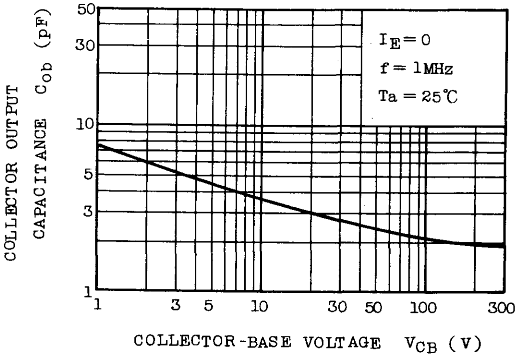
$V_{BE(sat)} - I_C$



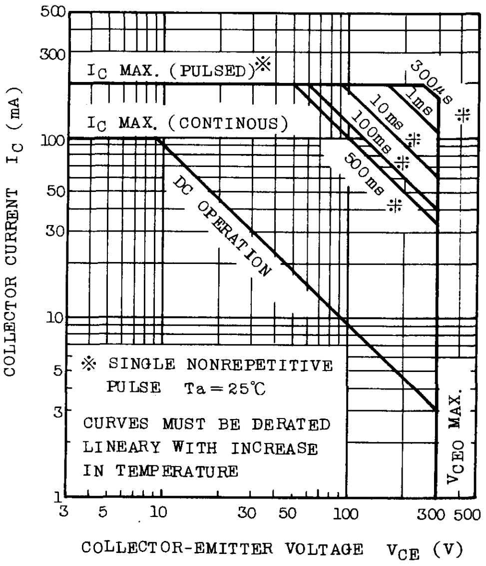
$f_T - I_C$



$C_{ob} - V_{CB}$



SAFE OPERATING AREA

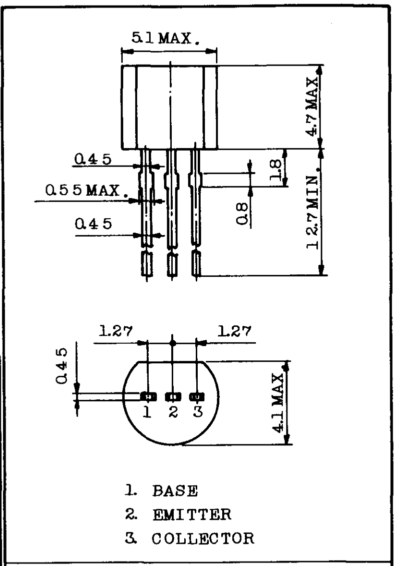


SILICON NPN EPITAXIAL PLANAR TYPE

2SC2498

VHF ~ UHF BAND LOW NOISE AMPLIFIER APPLICATIONS.

Unit in mm



1. BASE
2. EMITTER
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1E

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	20	V
Emitter-Base Voltage	V_{EBO}	3	V
Collector Current	I_C	50	mA
Collector Power Dissipation	P_C	300	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~ 125	°C

MICROWAVE CHARACTERISTICS (Ta=25°C)

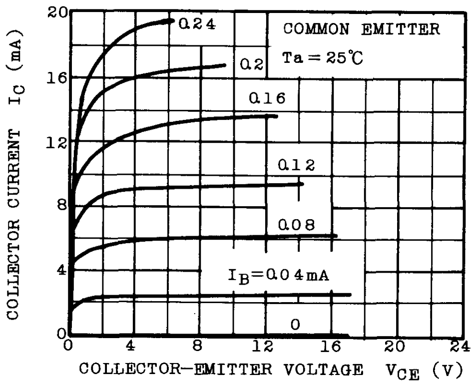
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Transition Frequency	f_T	V_{CE}=10V, I_C=10mA	-	3.5	-	GHz
Insertion Gain	$\|S_{21e}\|^2$(1)	V_{CE}=10V, I_C=10mA, f=500MHz	-	14.5	-	dB
	$\|S_{21e}\|^2$(2)	V_{CE}=10V, I_C=10mA, f=1GHz	-	9	-	dB
Noise Figure	NF(1)	V_{CE}=10V, I_C=5mA, f=500MHz	-	2.5	-	dB
	NF(2)	V_{CE}=10V, I_C=5mA, f=1GHz	-	4	-	dB

ELECTRICAL CHARACTERISTICS (Ta=25°C)

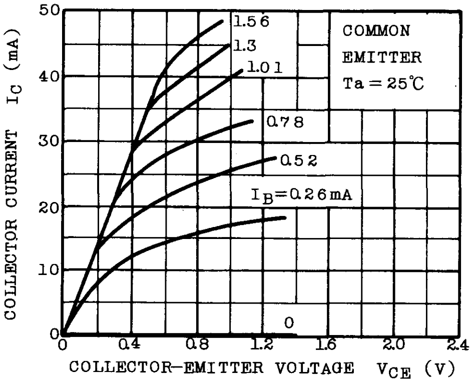
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=10V, I_E=0	-	-	1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=1V, I_C=0	-	-	1	μA
DC Current Gain	h_{FE}	V_{CE}=10V, I_C=10mA	30	80	300	
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	1.15	-	pF
Reverse Transfer Capacitance	C_{re}	(Note)	-	0.75	-	pF

Note : Cre is measured by 3 terminal method with Capacitance Bridge.

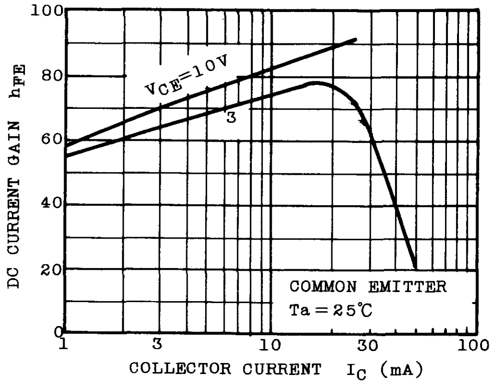
$I_C - V_{CE}$



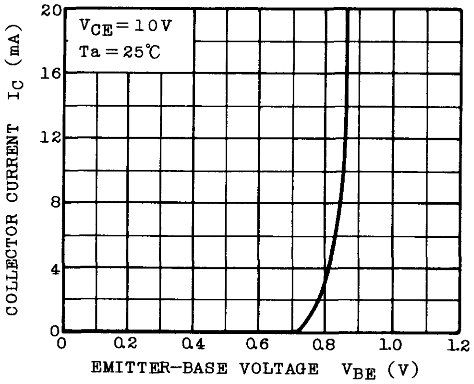
$I_C - V_{CE}$



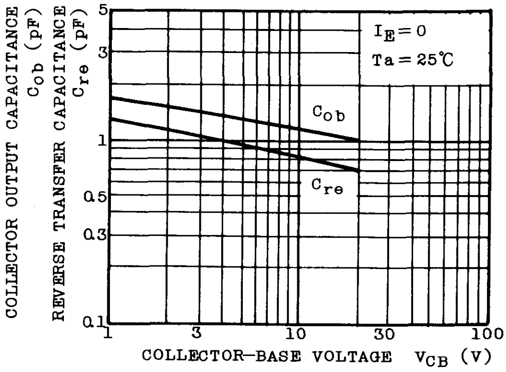
$h_{FE} - I_C$



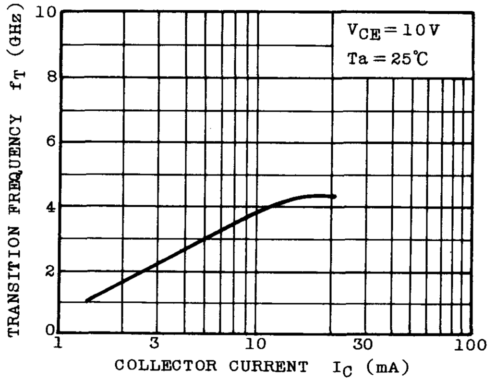
$I_C - V_{BE}$



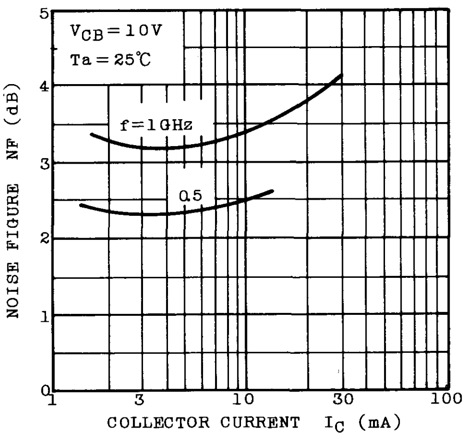
C_{ob}, $C_{re} - V_{CB}$



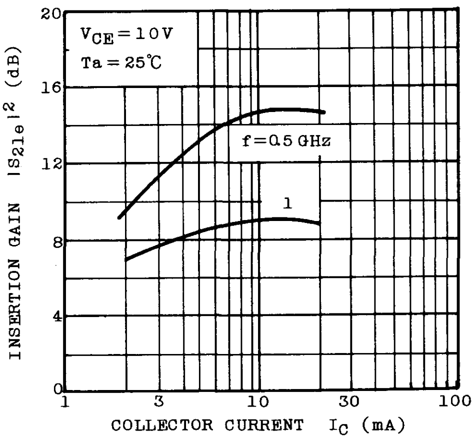
$f_T - I_C$



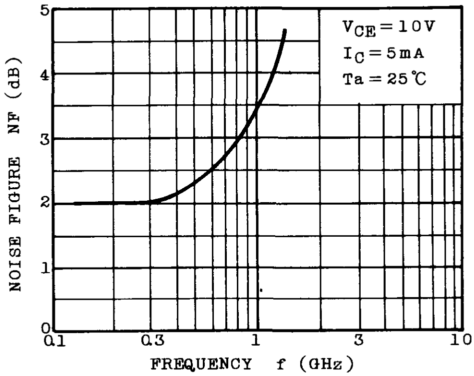
NF — I_C



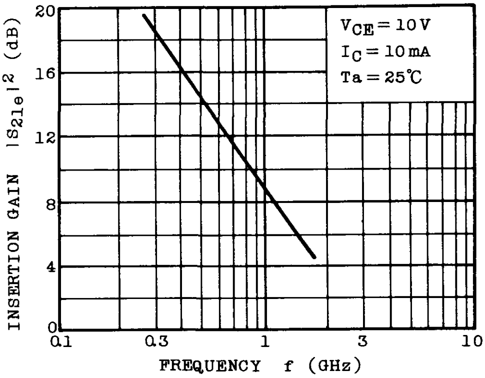
$|S_{21e}|^2$ — I_C



NF — f

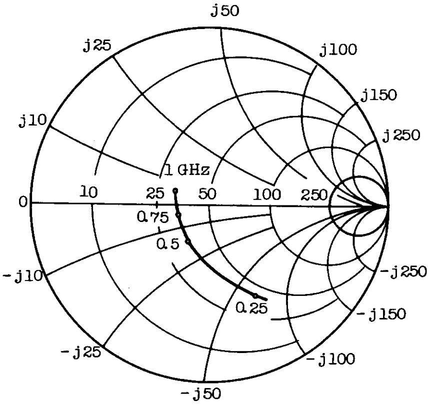


$|S_{21e}|^2$ — f

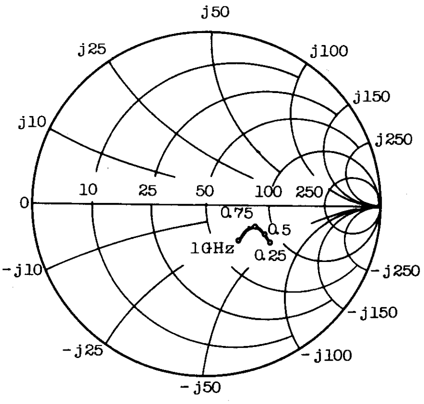


COMMON EMITTER SMALL SIGNAL S-PARAMETERS OF 2SC2498.

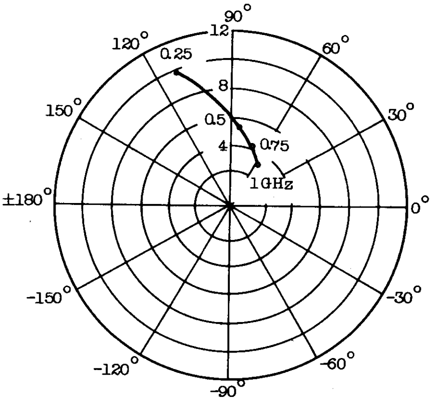
V_{CE}=10V, I_C=10mA



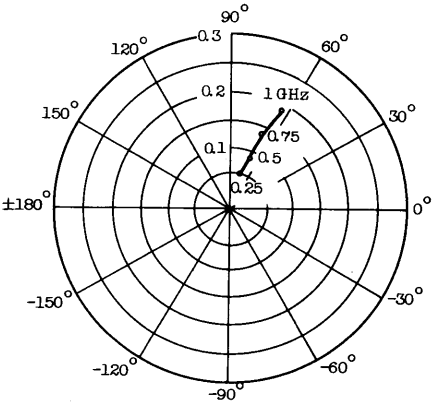
S_{11e} (UNIT : Ω)



S_{22e} (UNIT : Ω)



S_{21e}



S_{12e}

SILICON NPN EPITAXIAL PLANAR TYPE

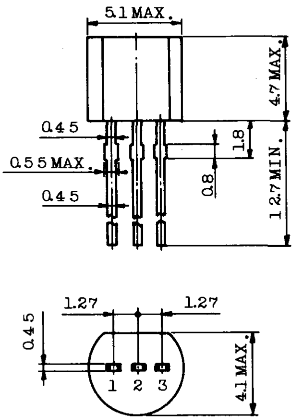
2SC2499

VHF ~ UHF BAND LOW NOISE AMPLIFIER APPLICATIONS.

FEATURES:

- Low Noise Figure
- NF=1.7dB, $|S_{21e}|^2$=15dB (f=500MHz)
- NF=2.5dB, $|S_{21e}|^2$=9.5dB (f=1000MHz)

Unit in mm



1. BASE
2. EMITTER
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1E

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	20	V
Collector-Emitter Voltage	V_{CEO}	20	V
Emitter-Base Voltage	V_{EBO}	3.0	V
Collector Current	I_C	30	mA
Emitter Current	I_E	-30	mA
Collector Power Dissipation	P_C	300	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~ 125	°C

MICROWAVE CHARACTERISTICS (Ta=25°C)

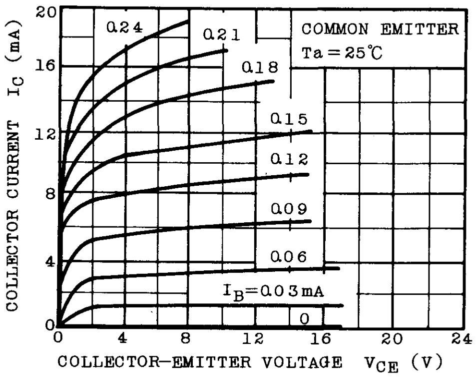
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Transition Frequency	f_T	V_{CE}=10V, I_C=10mA	-	4.0	-	GHz
Insertion Gain	$\|S_{21e}\|^2(1)$	V_{CE}=10V, I_C=10mA, f=500MHz	-	15.0	-	dB
	$\|S_{21e}\|^2(2)$	V_{CE}=10V, I_C=10mA, f=1000MHz	-	9.5	-	dB
Noise Figure	NF (1)	V_{CE}=10V, I_C=3mA, f=500MHz	-	1.7	-	dB
	NF (2)	V_{CE}=10V, I_C=3mA, f=1000MHz	-	2.5	-	dB

ELECTRICAL CHARACTERISTICS (Ta=25°C)

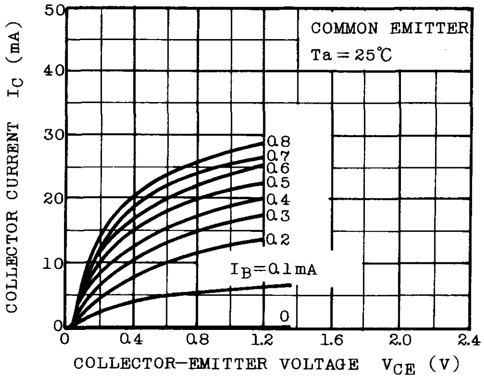
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=10V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=1.0V, I_C=0	-	-	1.0	μA
DC Current Gain	h_{FE}	V_{CE}=10V, I_C=5mA	30	-	-	
Collector Output Capacitance	Cob	V_{CB}=10V, I_E=0, f=1MHz	-	0.9	-	pF
Reverse Transfer Capacitance	Cre	(Note)	-	0.6	-	pF

Note : Cre is measured by 3 terminal method with Capacitance Bridge.

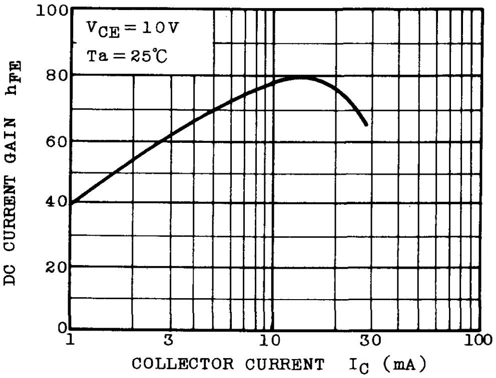
$I_C - V_{CE}$



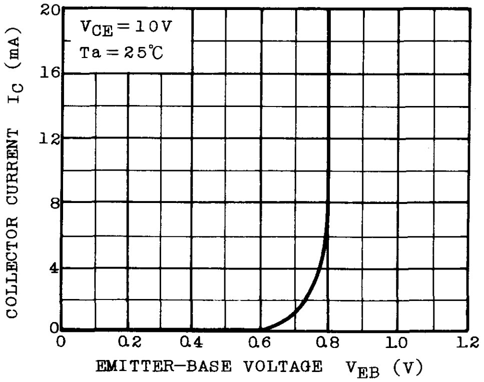
$I_C - V_{CE}$



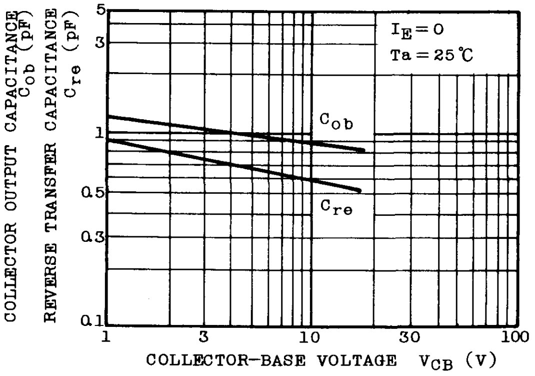
$h_{FE} - I_C$



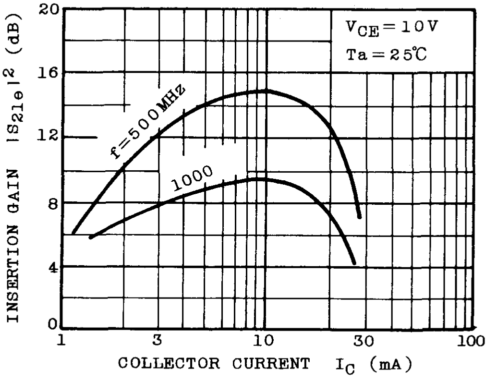
$I_C - V_{EB}$

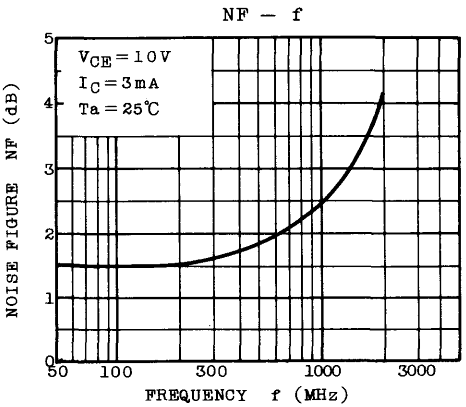


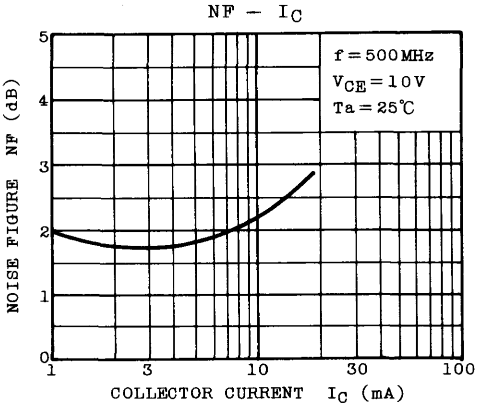
$C_{ob}, C_{re} - V_{CB}$

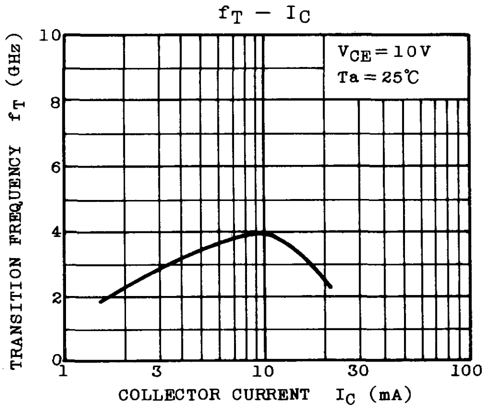


$|S_{21e}|^2 - I_C$



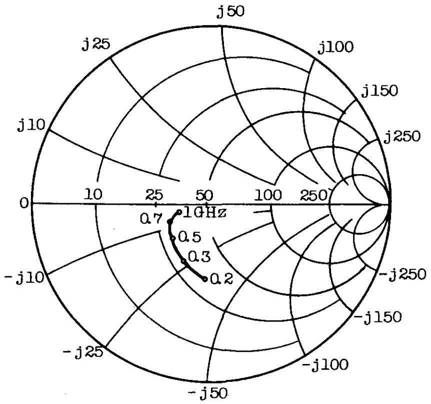

NF — f
$V_{CE}=10V$
$I_C=3mA$
Ta = 25℃
NOISE FIGURE NF (dB)
0
1
2
3
4
5
50
100
300
1000
3000
FREQUENCY f (MHz)


NF — I_C
f = 500MHz
$V_{CE}=10V$
Ta = 25℃
NOISE FIGURE NF (dB)
0
1
2
3
4
5
1
3
10
30
100
COLLECTOR CURRENT I_C (mA)

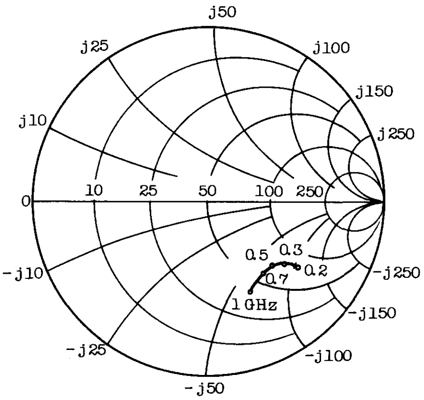

f_T — I_C
$V_{CE}=10V$
Ta = 25℃
TRANSITION FREQUENCY f_T (GHz)
0
2
4
6
8
10
1
3
10
30
100
COLLECTOR CURRENT I_C (mA)

COMMON EMITTER SMALL SIGNAL S-PARAMETERS OF 2SC2499.

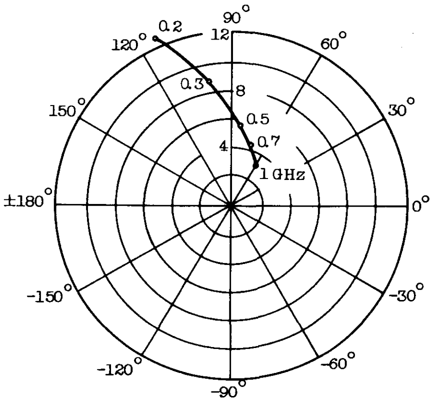
V_{CE}=10V, I_C=10mA



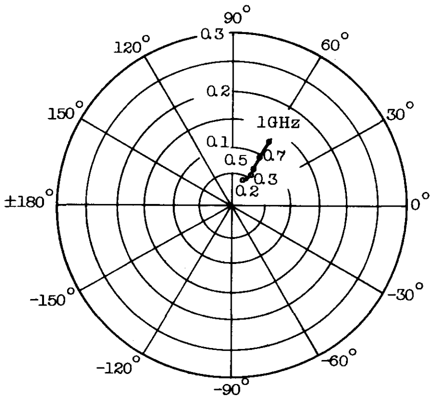
S_{11e} (UNIT : Ω)



S_{22e} (UNIT : Ω)



S_{21e}



S_{12e}

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

2SC2500

STROBO FLASH APPLICATIONS.

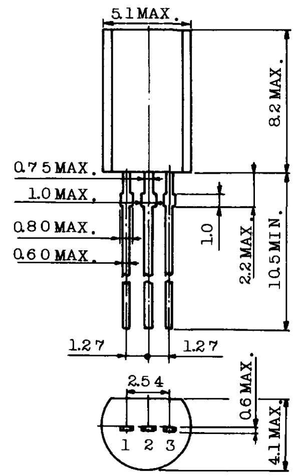
MEDIUM POWER AMPLIFIER APPLICATIONS.

FEATURES:

. High DC Current Gain and Excellent h_{FE} Linearity
    : $h_{FE}(1)$=140~600 (V_{CE}=1V, I_C=0.5A)
    : $h_{FE}(2)$=70(Min.), 200(Typ.) (V_{CE}=1V, I_C=2A)

. Low Saturation Voltage
    : $V_{CE(sat)}$=0.5V(Max.) (I_C=2A, I_B=50mA)

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92MOD
EIAJ	—
TOSHIBA	2-5J1A

Weight : 0.36g

MAXIMUM RATINGS (T_a=25°C)

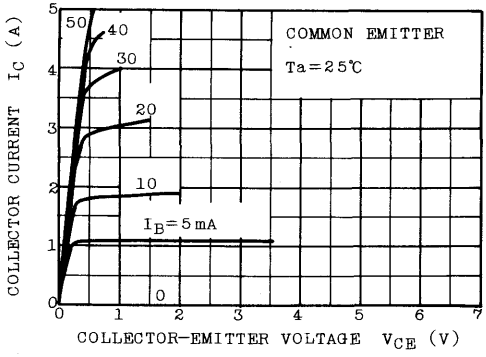
CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Voltage		V_{CBO}	30	V
Collector-Emitter Voltage		V_{CES}	30	V
		V_{CEO}	10	
Emitter-Base Voltage		V_{EBO}	6	V
Collector Current	DC	I_C	2	A
	Pulse (Note 1)	I_{CP}	5	
Base Current		I_B	2	A
Collector Power Dissipation		P_C	900	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_{stg}	-55~150	°C

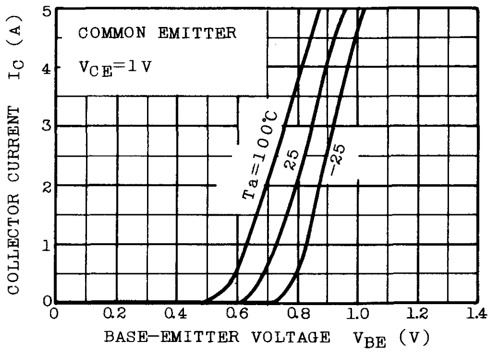
Note 1 : Pulse Width≦10ms, Duty Cycle≦30%

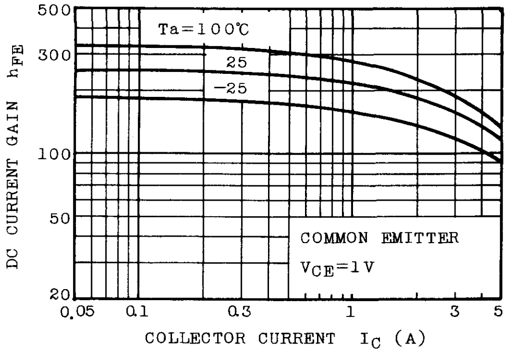
ELECTRICAL CHARACTERISTICS (T_a=25°C)

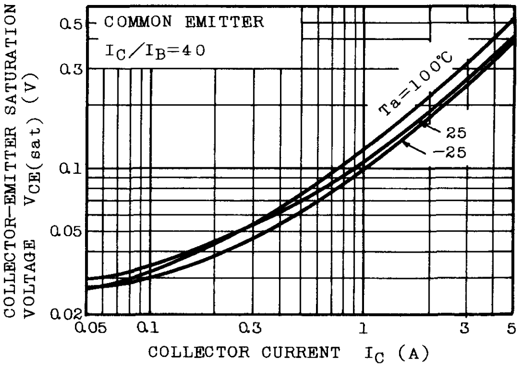
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=30V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=6V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=10mA, I_B=0	10	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=1mA, I_C=0	6	-	-	V
DC Current Gain	$h_{FE}(1)$ (note 2)	V_{CE}=1V, I_C=0.5A	140	-	600	
	$h_{FE}(2)$	V_{CE}=1V, I_C=2A	70	200	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=2A, I_B=50mA	-	0.2	0.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=1V, I_C=2A	-	0.86	1.5	V
Transition Frequency	f_T	V_{CE}=1V, I_C=0.5A	-	150	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	27	-	pF

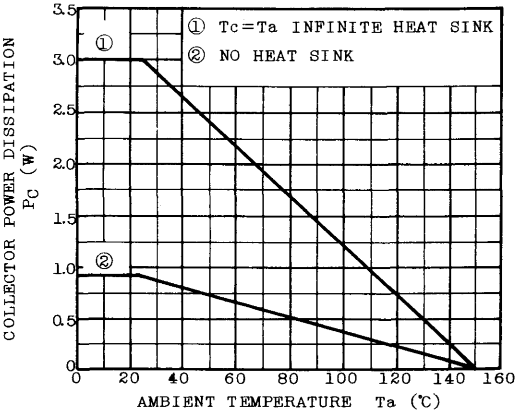
Note 2 : $h_{FE}(1)$ Classification A : 140~240, B : 200~330, C : 300~450,
D : 420~600

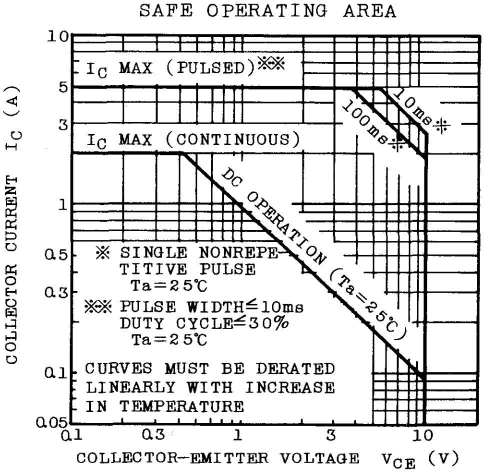

I_C — V_{CE}


I_C — V_{BE}


h_{FE} — I_C


$V_{CE(sat)}$ — I_C


P_C — Ta


SAFE OPERATING AREA

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

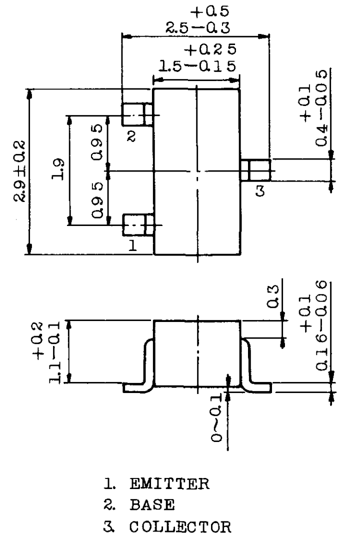
2SC2532

AUDIO FREQUENCY AMPLIFIER APPLICATIONS.
DRIVER STAGE FOR LED LAMP APPLICATIONS.
TEMPERATURE COMPENSATION APPLICATIONS.

FEATURES:

- High h_{FE} : $h_{FE}(1)=5000$(Min.) ($I_C=10mA$)
  $h_{FE}(2)=10000$(Min.) ($I_C=100mA$)

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO−236
EIAJ	—
TOSHIBA	2−3F1A

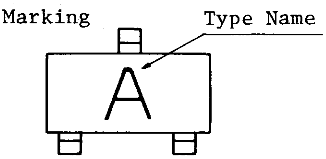
Weight : 0.012g

MAXIMUM RATINGS (Ta=25°C)

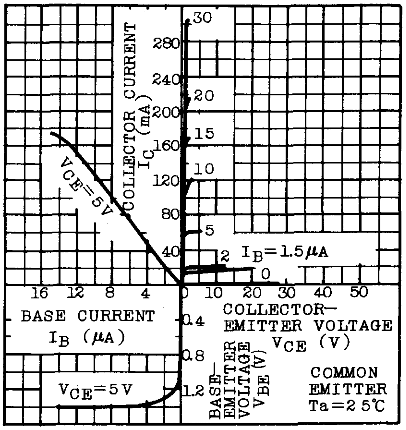
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	40	V
Collector-Emitter Voltage	V_{CEO}	40	V
Emitter-Base Voltage	V_{EBO}	10	V
Collector Current	I_C	300	mA
Emitter Current	I_E	-300	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	Tstg	-55 ~ 125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

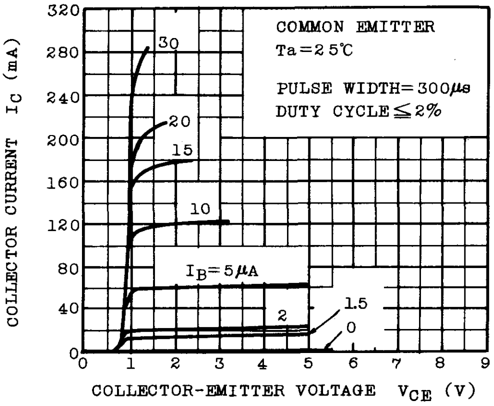
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	$V_{CB}=40V$, $I_E=0$	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	$V_{EB}=8V$, $I_C=0$	-	-	0.1	μA
DC Current Gain	$h_{FE(1)}$	$V_{CE}=5V$, $I_C=10mA$	5000	-	-	
	$h_{FE(2)}$	$V_{CE}=2V$, $I_C=100mA$	1000	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C=300mA$, $I_B=0.3mA$	-	0.9	1.5	V
Base-Emitter Voltage	V_{BE}	$V_{CE}=2V$, $I_C=100mA$	-	1.25	1.6	V



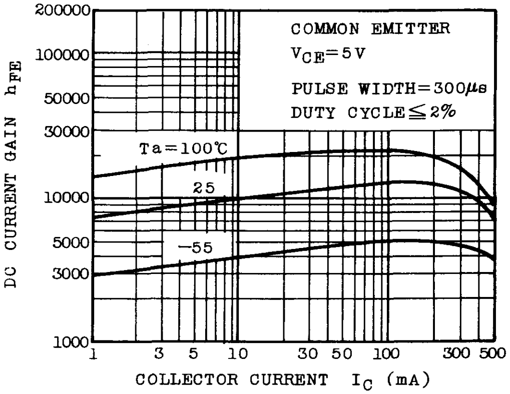
STATIC CHARACTERISTICS



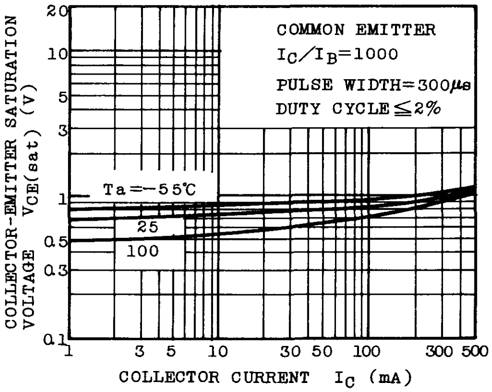
$I_C - V_{CE}$ (LOW VOLTAGE REGION)



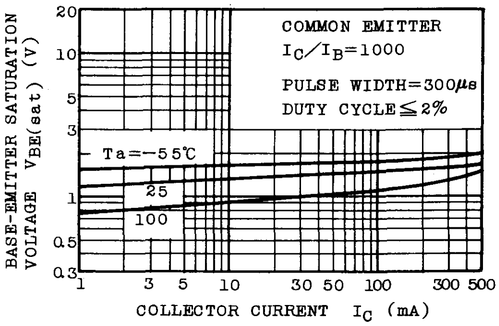
$h_{FE} - I_C$



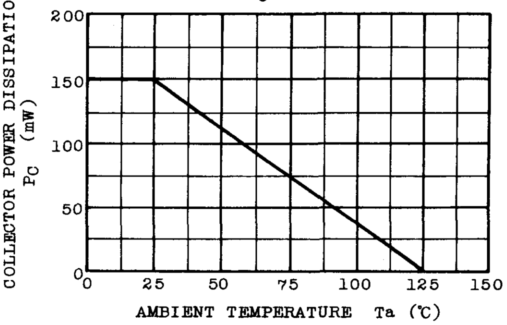
$V_{CE(sat)} - I_C$



$V_{BE(sat)} - I_C$



$P_C - Ta$



SILICON NPN EPITAXIAL TYPE (PCT PROCESS)
(INDUSTRIAL APPLICATIONS)

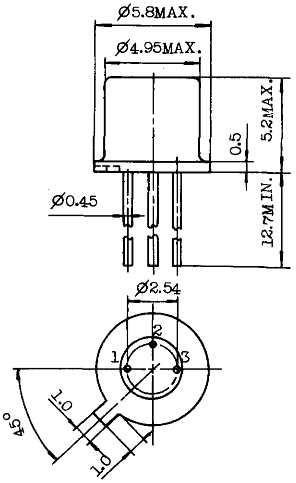
2SC2550

HIGH FREQUENCY AMPLIFIER APPLICATIONS.
HIGH SPEED SWITCHING APPLICATIONS.

FEATURES:

- High Breakdown Voltage : V_{CEO}=50V, V_{EBO}=8V
- High Gain and Excellent h_{FE} Linearity
  h_{FE}=70∿400 at V_{CE}=1V, I_C=10mA
- Complementary to 2SA1090.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR (CASE)

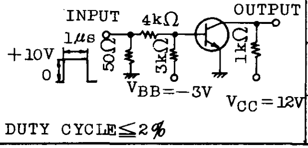
JEDEC	TO — 18
EIAJ	TC — 7, TB — 8C
TOSHIBA	2 — 5A1B

Weight : 0.31g

MAXIMUM RATINGS (Ta=25°C)

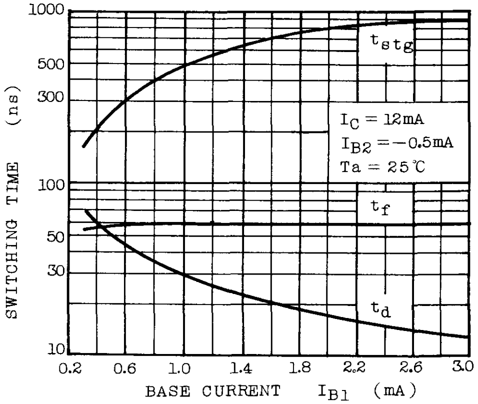
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	60	V
Collector-Emitter Voltage	V_{CEO}	50	V
Emitter-Base Voltage	V_{EBO}	8	V
Collector Current	I_C	200	mA
Base Current	I_B	50	mA
Collector Power Dissipation	P_C	300	mW
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_{stg}	-65∿175	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

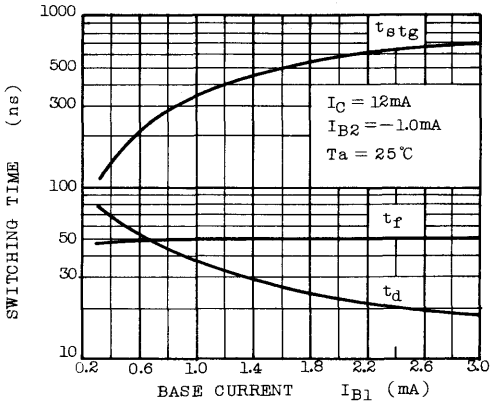
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=60V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain		$h_{FE(1)}$ (Note)	V_{CE}=1V, I_C=10mA	70	-	400	
		$h_{FE(2)}$	V_{CE}=1v, I_C=100mA	20	-	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=200mA, I_B=20mA	-	0.3	0.5	V
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=200mA, I_B=20mA	-	-	1.2	V
Transition Frequency		f_T	V_{CE}=10V, I_C=10mA	150	250	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	3.0	4.0	pF
Base Intrinsic Resistance		$r_{bb'}$	V_{CB}=10V, I_E=-10mA, f=30MHz	-	30	-	Ω
Switching Time	Turn-on Time	t_{on}		-	100	-	ns
	Storage Time	t_{stg}		-	400	-	
	Fall Time	t_f		-	50	-	

Note : $h_{FE(1)}$ Classification O : 70∿140, Y : 120∿240, GR : 200∿400

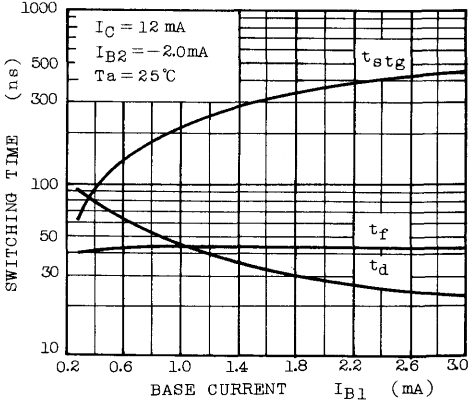
SWITCHING CHARACTERISTICS



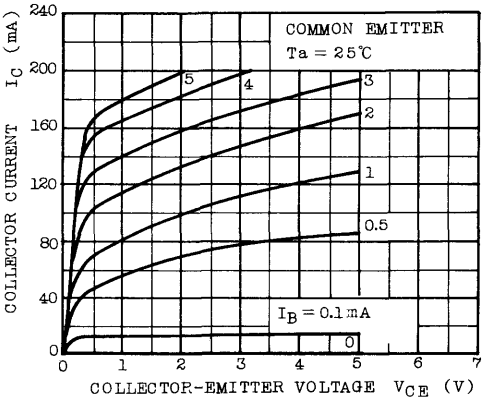
SWITCHING CHARACTERISTICS



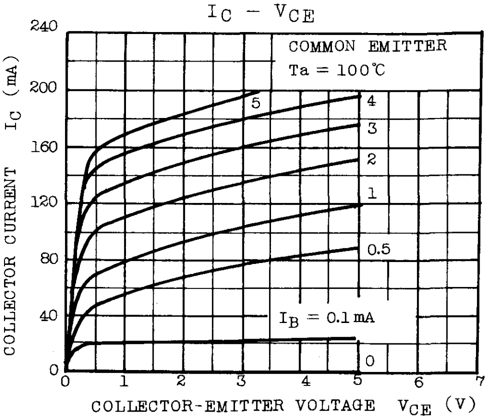
SWITCHING CHARACTERISTICS



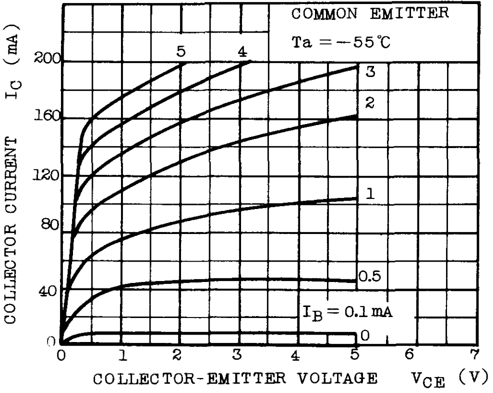
I_C − V_{CE}

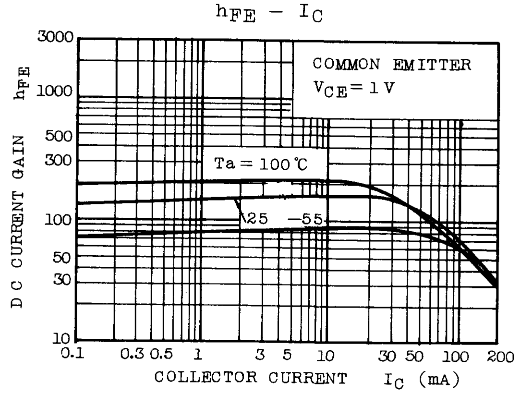


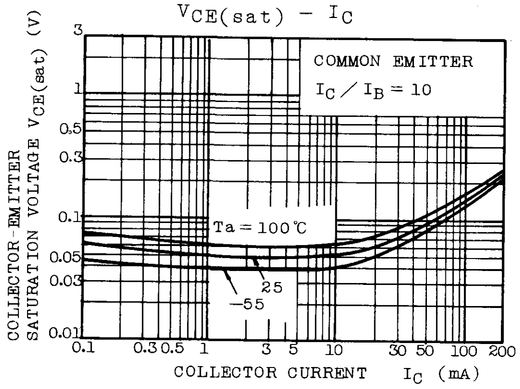
I_C − V_{CE}

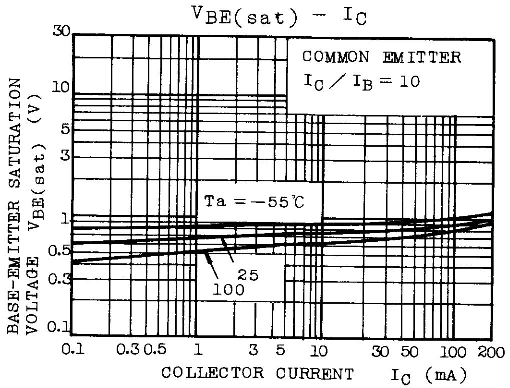


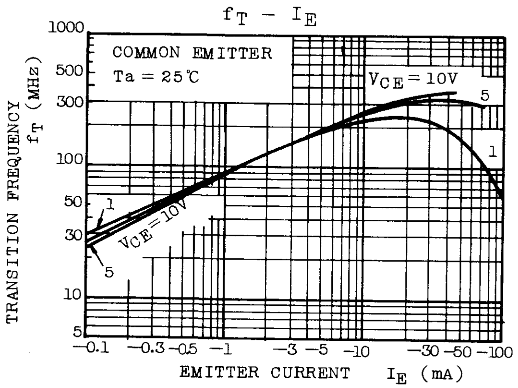
I_C − V_{CE}

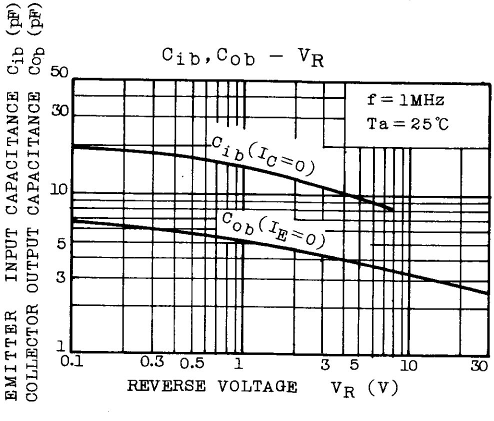


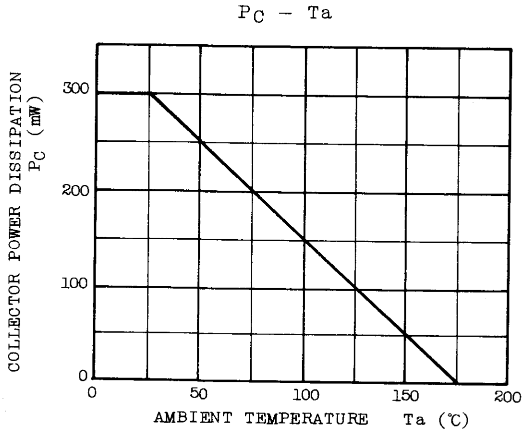

$h_{FE} - I_C$


$V_{CE(sat)} - I_C$


$V_{BE(sat)} - I_C$


$f_T - I_E$


$C_{ib}, C_{ob} - V_R$


$P_C - Ta$

2SC2551

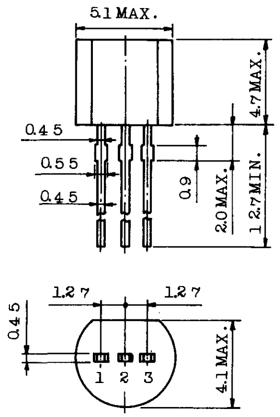
SILICON NPN TRIPLE DIFFUSED TYPE (PCT PROCESS) (INDUSTRIAL APPLICATIONS)

HIGH VOLTAGE CONTROL APPLICATIONS.
PLASMA DISPLAY, NIXIE TUBE DRIVER APPLICATIONS.
CATHODE RAY TUBE BRIGHTNESS CONTROL APPLICATIONS.

FEATURES:

- High Voltage : V_{CBO}=300V, V_{CEO}=300V
- Low Saturation Voltage : $V_{CE(sat)}$=0.5V(Max.)
- Small Collector Output Capacitance : C_{ob}=3pF(Typ.)
- Complementary to 2SA1091.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

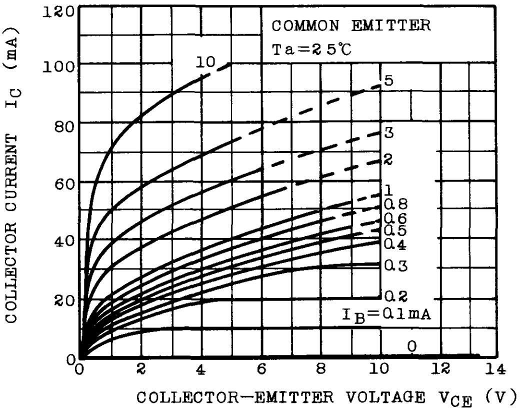
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	300	V
Collector-Emitter Voltage	V_{CEO}	300	V
Emitter-Base Voltage	V_{EBO}	6	V
Collector Current	I_C	100	mA
Base Current	I_B	20	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

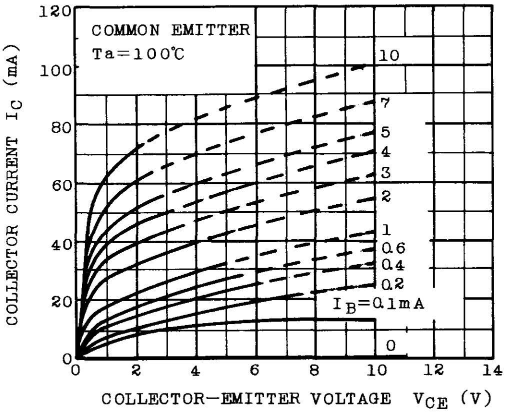
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=300V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=6V, I_C=0	-	-	0.1	μA
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C=0.1mA, I_E=0	300	-	-	V
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	300	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=10V, I_C=20mA	30	-	150	
	$h_{FE(2)}$	V_{CE}=10V, I_C=1mA	20	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=20mA, I_B=2mA	-	-	0.5	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=20mA, I_B=2mA	-	-	1.2	V
Transition Frequency	f_T	V_{CE}=10V, I_C=20mA	50	80	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=20V, I_E=0, f=1MHz	-	3	4	pF

Note: $h_{FE(1)}$ Classification R:30~90 O:50~150

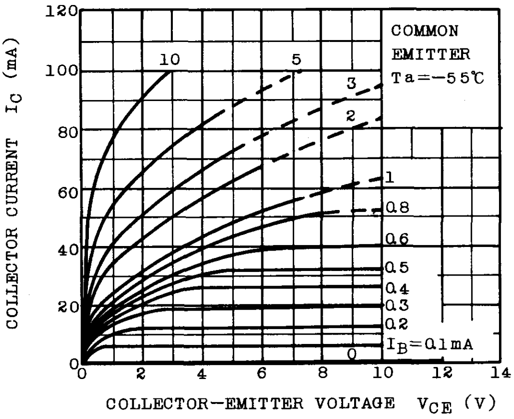
$I_C - V_{CE}$



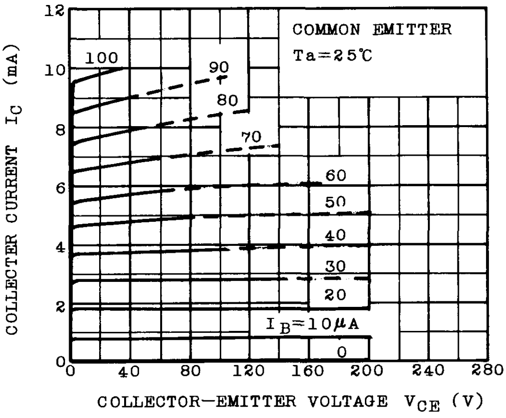
$I_C - V_{CE}$



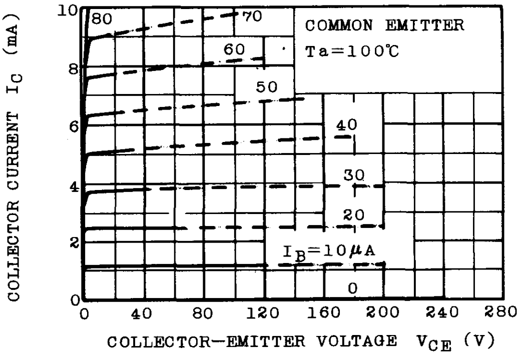
$I_C - V_{CE}$



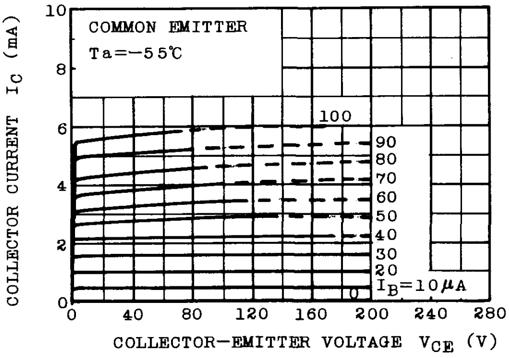
$I_C - V_{CE}$



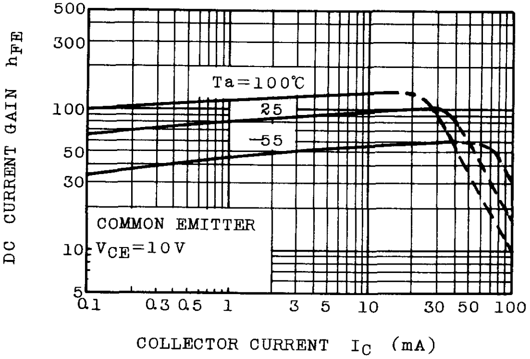
$I_C - V_{CE}$



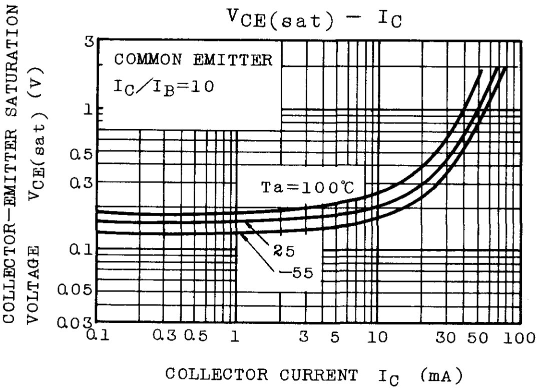
$I_C - V_{CE}$



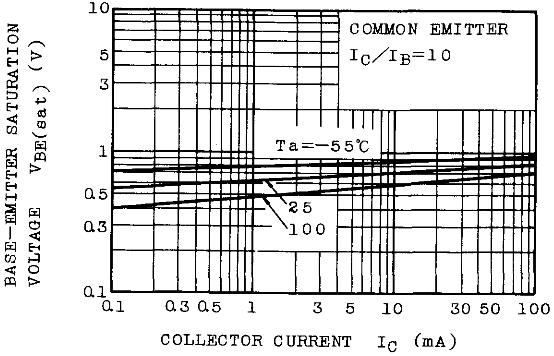
h_{FE} — I_C



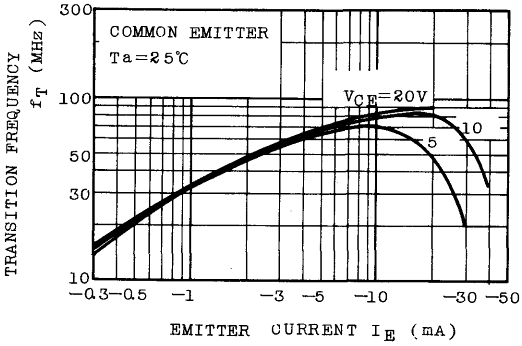
$V_{CE(sat)}$ — I_C



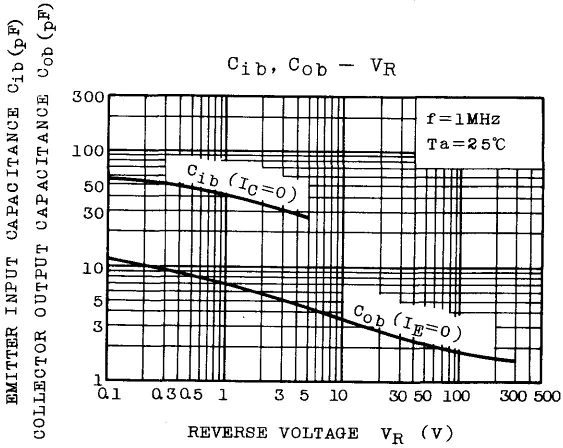
$V_{BE(sat)}$ — I_C



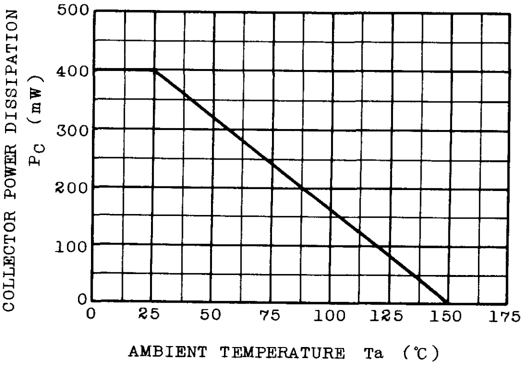
f_T — I_E



C_{ib}, C_{ob} — V_R



P_C — Ta



SILICON NPN EPITAXIAL PLANAR TYPE

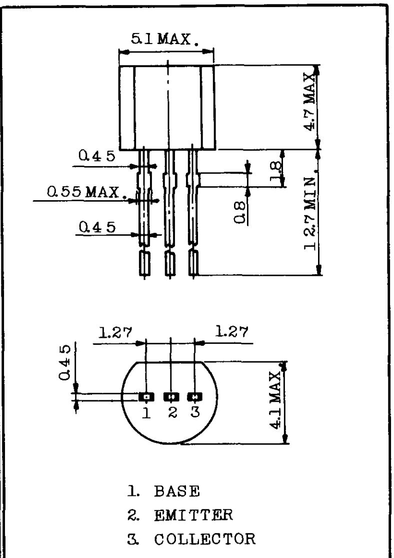
2SC2644

VHF ~ UHF BAND WIDEBAND AMPLIFIER APPLICATIONS.

FEATURES:

- High Gain
- Low IMD
- f_T=4GHz (Typ.)

Unit in mm



JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1E

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	25	V
Collector-Emitter Voltage	V_{CEO}	12	V
Emitter-Base Voltage	V_{EBO}	3.0	V
Collector Current	I_C	120	mA
Emitter Current	I_E	-120	mA
Collector Power Dissipation	P_C	0.5	W
Junction Temperature	T_j	125	°C
Storage Temperature Range	Tstg	-55 ~ 125	°C

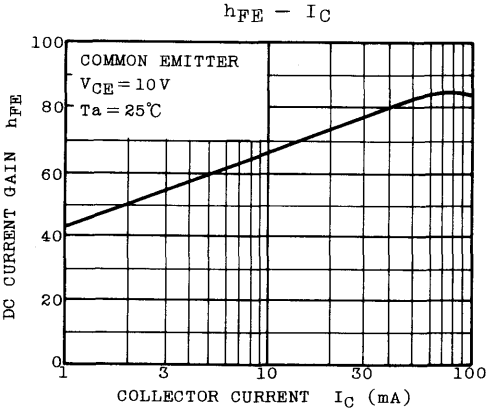
MICROWAVE CHARACTERISTICS (Ta=25°C)

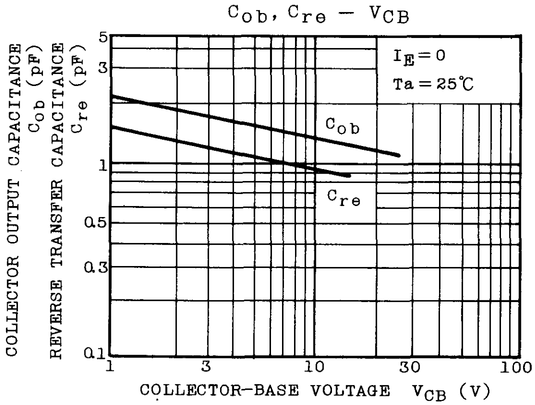
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Transition Frequency	f_T	V_{CE}=10V, I_C=30mA	-	4.0	-	GHz
Insertion Gain	$S_{21e}{}^{2}$(1)	V_{CE}=10V, I_C=30mA, f=0.5GHz	-	14.0	-	dB
	$S_{21e}{}^{2}$(2)	V_{CE}=10V, I_C=30mA, f=1GHz	-	8.5	-	dB
Noise Figure	NF (1)	V_{CE}=10V, I_C=10mA, f=0.5GHz	-	2.3	-	dB
	NF (2)	V_{CE}=10V, I_C=10mA, f=1GHz	-	3.0	-	dB

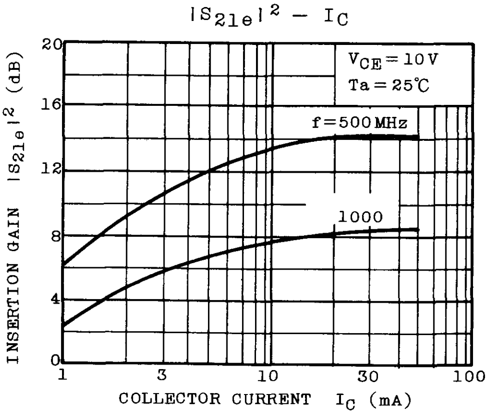
ELECTRICAL CHARACTERISTICS (Ta=25°C)

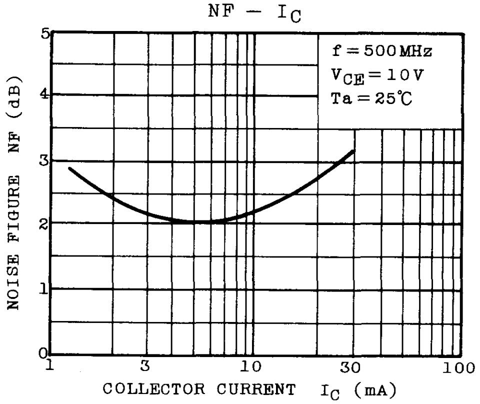
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=10V, I_E=0	-	-	1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=1.0V, I_C=0	-	-	10	μA
DC Current Gain	h_{FE}	V_{CE}=5V, I_C=50mA	20	50	-	
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	1.6	-	pF
Reverse Transfer Capacitance	C_{re}	(Note)	-	1.1	-	pF

Note : Cre is measured by 3 terminal method with Capacitance Bridge.


hFE — IC
COMMON EMITTER
VCE = 10 V
Ta = 25℃
DC CURRENT GAIN hFE
100
80
60
40
20
0
1
3
10
30
100
COLLECTOR CURRENT IC (mA)

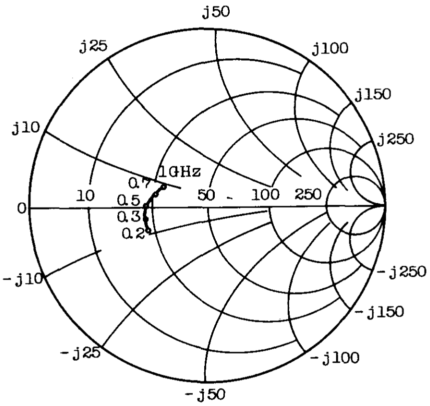

Cob, Cre — VCB
IE = 0
Ta = 25℃
Cob
Cre
COLLECTOR OUTPUT CAPACITANCE Cob (pF)
REVERSE TRANSFER CAPACITANCE Cre (pF)
5
3
1
0.5
0.3
0.1
1
3
10
30
100
COLLECTOR-BASE VOLTAGE VCB (V)


|S21e|² — IC
VCE = 10 V
Ta = 25℃
f = 500 MHz
1000
INSERTION GAIN |S21e|² (dB)
20
16
12
8
4
0
1
3
10
30
100
COLLECTOR CURRENT IC (mA)

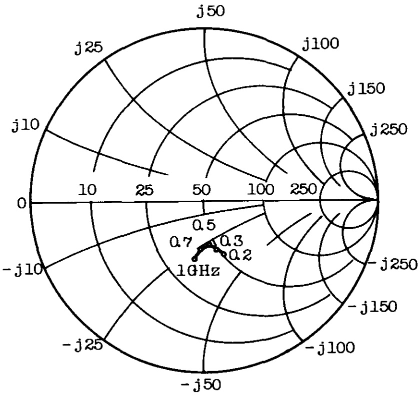

NF — IC
f = 500 MHz
VCE = 10 V
Ta = 25℃
NOISE FIGURE NF (dB)
5
4
3
2
1
0
1
3
10
30
100
COLLECTOR CURRENT IC (mA)

COMMON EMITTER SMALL SIGNAL S-PARAMETERS OF 2SC2644.

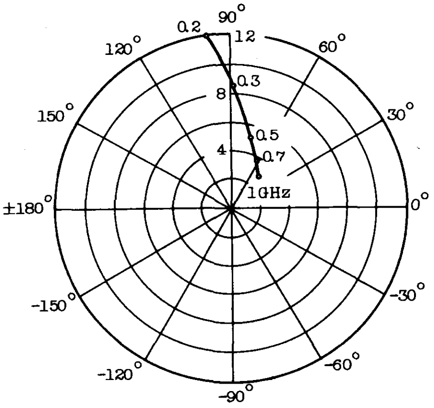
V_{CE}=10V, I_C=30mA



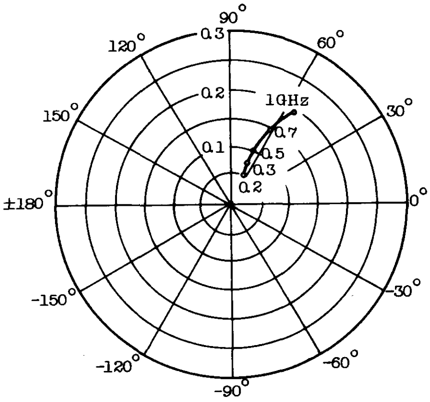
S_{11e} (UNIT : Ω)



S_{22e} (UNIT : Ω)



S_{21e}



S_{12e}

2SC2655

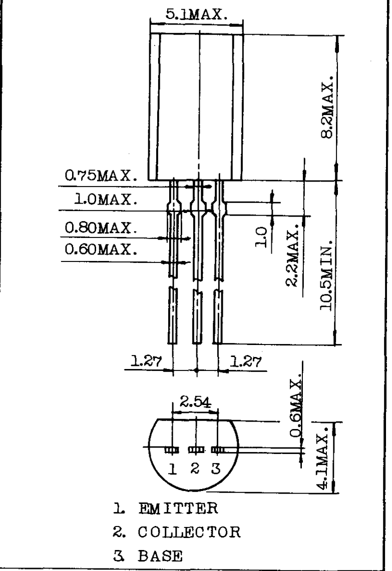
SILICON NPN EPITAXIAL TYPE (PCT PROCESS)
(INDUSTRIAL APPLICATIONS)

POWER AMPLIFIER APPLICATIONS.
POWER SWITCHING APPLICATIONS.

FEATURES:

- Low Saturation Voltage
  : $V_{CE(sat)}$=0.5V (Max.) (I_C=1A)
- High Speed Switching Time : t_{stg}=1.0μs (Typ.)
- Complementary to 2SA1020.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

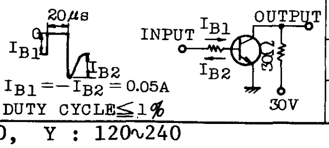
JEDEC	TO − 92MOD
EIAJ	−
TOSHIBA	2 − 5J1A

Weight : 0.36g

MAXIMUM RATINGS (Ta=25°C)

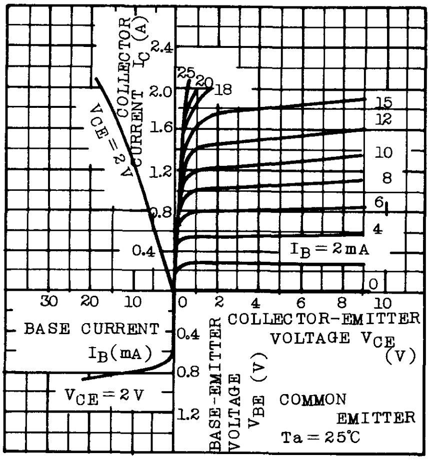
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	50	V
Collector-Emitter Voltage	V_{CEO}	50	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	2	A
Collector Power Dissipation	P_C	900	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55∿150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

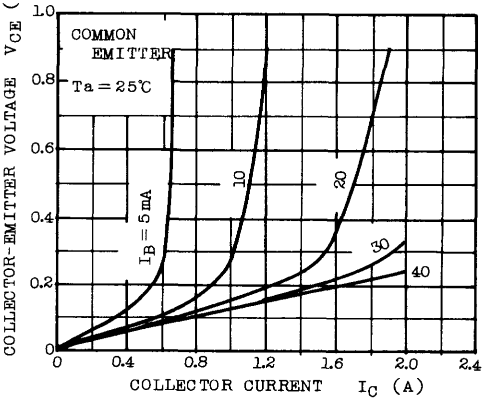
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=50V, I_E=0	-	-	1.0	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=5V, I_C=0	-	-	1.0	μA
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	I_C=10mA, I_B=0	50	-	-	V
DC Current Gain		$h_{FE(1)}$ (Note)	V_{CE}=2V, I_C=0.5A	70	-	240	
		$h_{FE(2)}$	V_{CE}=2V, I_C=1.5A	40	-	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=1A, I_B=0.05A	-	-	0.5	V
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=1A, I_B=0.05A	-	-	1.2	V
Transition Frequency		f_T	V_{CE}=2V, I_C=0.5A	-	100	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	30	-	pF
Switching Time	Turn-on Time	t_{on}	 $I_{B1}=-I_{B2}=0.05A$ DUTY CYCLE≦1%	-	0.1	-	μs
	Storage Time	t_{stg}		-	1.0	-	
	Fall Time	t_f		-	0.1	-	

Note : $h_{FE(1)}$ Classification O : 70∿140, Y : 120∿240

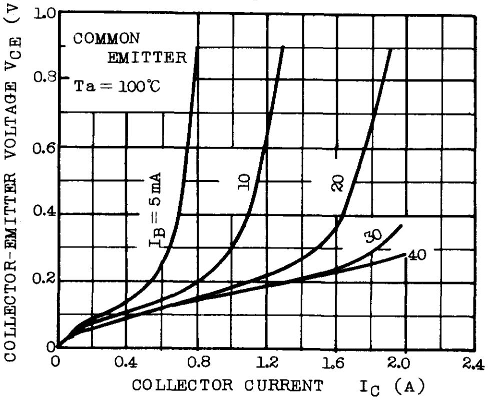
STATIC CHARACTERISTICS



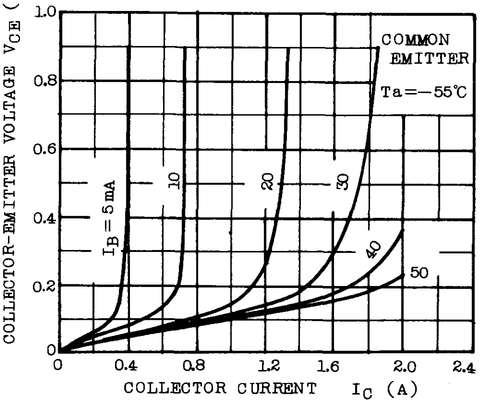
$V_{CE} - I_C$



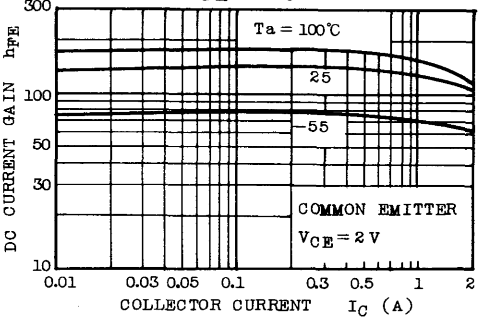
$V_{CE} - I_C$



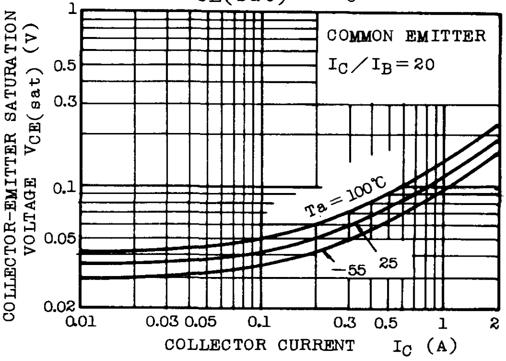
$V_{CE} - I_C$

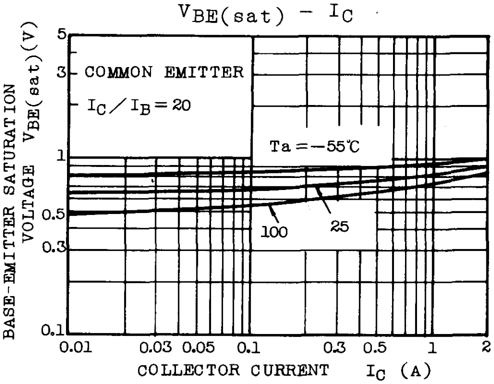


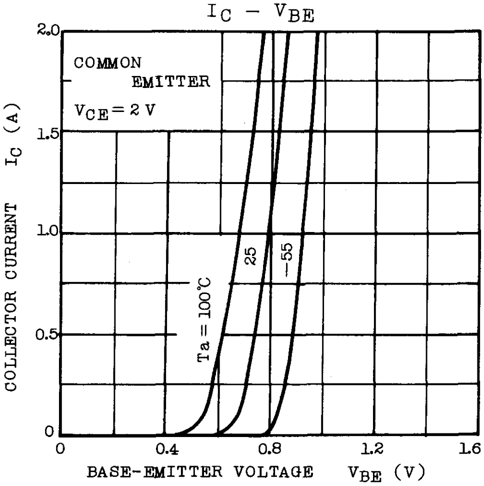
$h_{FE} - I_C$

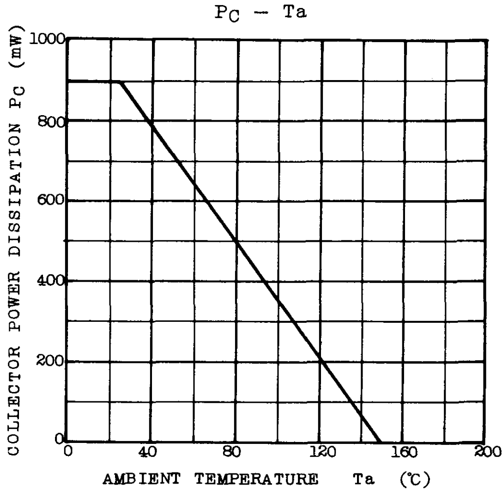


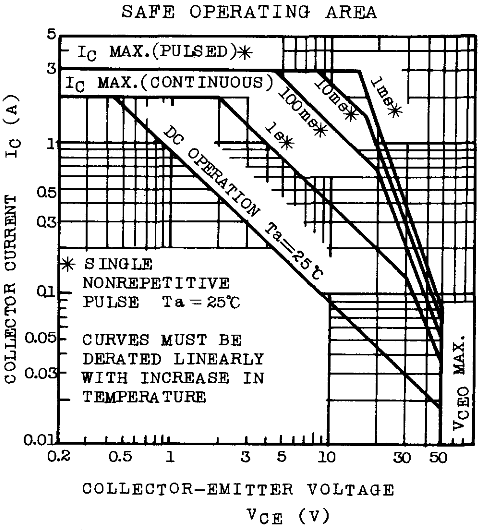
$V_{CE(sat)} - I_C$




$V_{BE(sat)} - I_C$
COMMON EMITTER
$I_C/I_B=20$
Ta = −55℃
100
25
BASE-EMITTER SATURATION VOLTAGE $V_{BE(sat)}$ (V)
5
3
1
0.5
0.3
0.1
0.01
0.03
0.05
0.1
0.3
0.5
1
2
COLLECTOR CURRENT I_C (A)


$I_C - V_{BE}$
COMMON EMITTER
$V_{CE}=2$ V
Ta = 100℃
25
−55
COLLECTOR CURRENT I_C (A)
2.0
1.5
1.0
0.5
0
0
0.4
0.8
1.2
1.6
BASE-EMITTER VOLTAGE V_{BE} (V)


P_C − Ta
COLLECTOR POWER DISSIPATION P_C (mW)
1000
800
600
400
200
0
0
40
80
120
160
200
AMBIENT TEMPERATURE Ta (℃)


SAFE OPERATING AREA
I_C MAX.(PULSED)✳
I_C MAX.(CONTINUOUS)
1ms✳
10ms✳
100ms✳
1s✳
DC OPERATION Ta = 25℃
✳ SINGLE NONREPETITIVE PULSE Ta = 25℃
CURVES MUST BE DERATED LINEARLY WITH INCREASE IN TEMPERATURE
V_{CEO} MAX.
COLLECTOR CURRENT I_C (A)
5
3
1
0.5
0.3
0.1
0.05
0.03
0.01
0.2
0.5
1
3
5
10
30
50
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)

SILICON NPN EPITAXIAL PLANAR TYPE (PCT PROCESS)

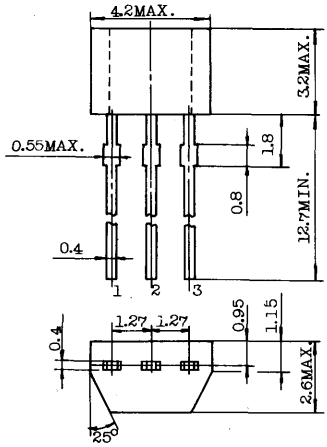
2SC2668

HIGH FREQUENCY AMPLIFIER APPLICATIONS.
FM, RF,MIX, IF AMPLIFIER APPLICATIONS.

FEATURES:

- Small Reverse Transfer Capacitance
  : C_{re}=0.70pF (Typ.)
- Low Noise Figure : NF=2.5dB (Typ.)

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	—
EIAJ	—
TOSHIBA	2 — 4 E 1 A

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

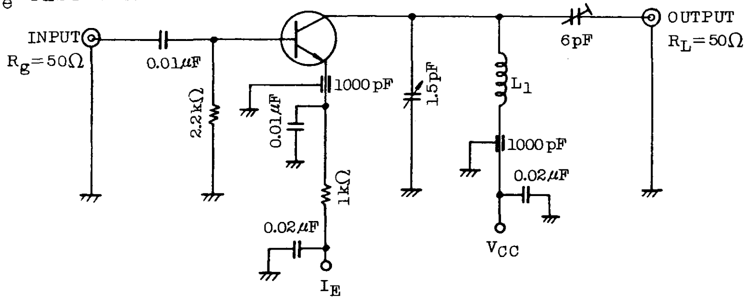
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	40	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	20	mA
Emitter Current	I_E	-20	mA
Collector Power Dissipation	P_C	100	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=40V, I_E=0	—	—	0.5	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=4V, I_C=0	-	-	0.5	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=6V, I_C=1mA	40	-	200	
Reverse Transfer Capacitance	C_{re}	V_{CE}=6V, f=1MHz	-	0.70	-	pF
Transition Frequency	f_T	V_{CE}=6V, I_C=1mA	-	550	-	MHz
Collector-Base Time Constant	$C_c.r_{bb'}$	V_{CE}=6V, I_E=-1mA, f=30MHz	-	-	20	ps
Noise Figure	NF	V_{CC}=6V, I_E=-1mA f=100MHz (Fig.)	-	2.5	5.0	dB
Power Gain	G_{pe}		-	18	-	dB

Note : h_{FE} Classification R : 40~80, O : 70~140, Y : 100~200

Fig. NF, G_{pe} TEST CIRCUIT



L_1 : 0.8mmØ SILVER PLATED COPPER WIRE, 4Turns.
10mm ID, 8mm Length.

y PARAMETER (Typ.)

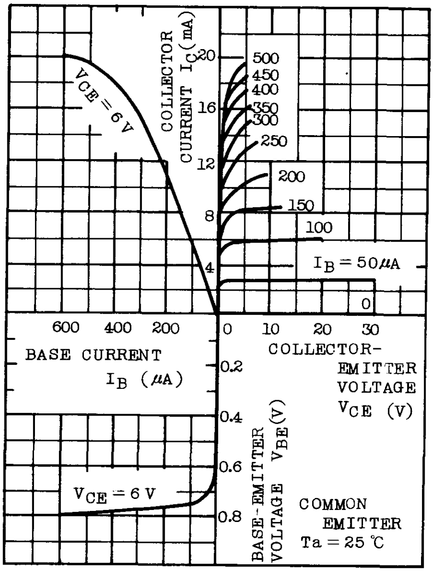
(1) COMMON EMITTER (V_{CE}=6V, I_E=-1mA, f=100MHz)

CHARACTERISTIC	SYMBOL	TYP.	UNIT
Input Conductance	g_{ie}	2.9	mS
Input Capacitance	C_{ie}	10.2	pF
Reverse Transfer Admittance	$\lvert y_{re}\rvert$	0.33	mS
Phase Angle of Reverse Transfer Admittance	θ_{re}	-90	°
Forward Transfer Admittance	$\lvert y_{fe}\rvert$	40	mS
Phase Angle of Forward Transfer Admittance	θ_{fe}	-20	°
Output Conductance	g_{oe}	45	μS
Output Capacitance	C_{oe}	1.1	pF

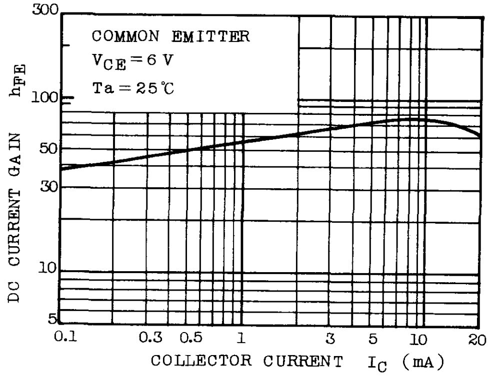
(2) COMMON BASE (V_{CE}=6V, I_E=-1mA, f=100MHz)

CHARACTERISTIC	SYMBOL	TYP.	UNIT
Input Conductance	g_{ib}	34	mS
Input Capacitance	C_{ib}	-10	pF
Reverse Transfer Admittance	$\lvert y_{rb}\rvert$	0.27	mS
Phase Angle of Reverse Transfer Admittance	θ_{rb}	-105	°
Forward Transfer Admittance	$\lvert y_{fb}\rvert$	34	mS
Phase Angle of Forward Transfer Admittance	θ_{fb}	165	°
Output Conductance	g_{ob}	45	μS
Output Capacitance	C_{ob}	1.1	pF

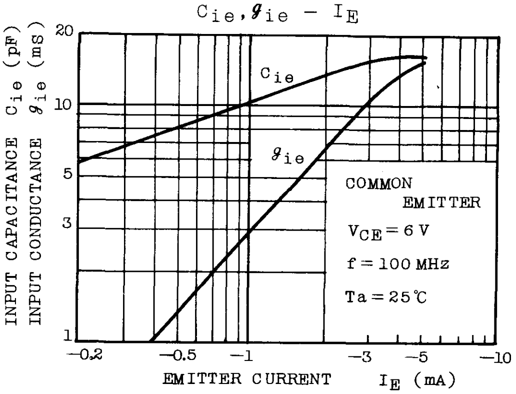
STATIC CHARACTERISTICS



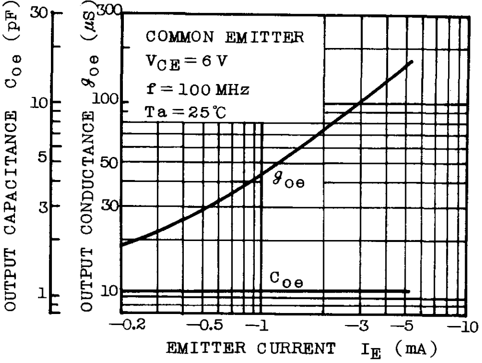
h_{FE} – I_C



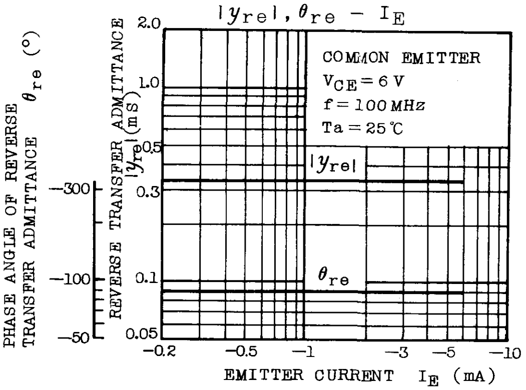
C_{ie}, g_{ie} – I_E

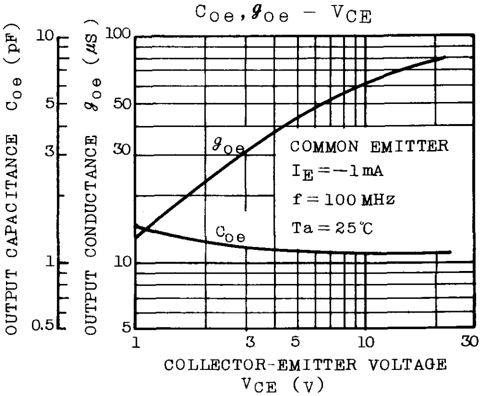


C_{oe}, g_{oe} – I_E

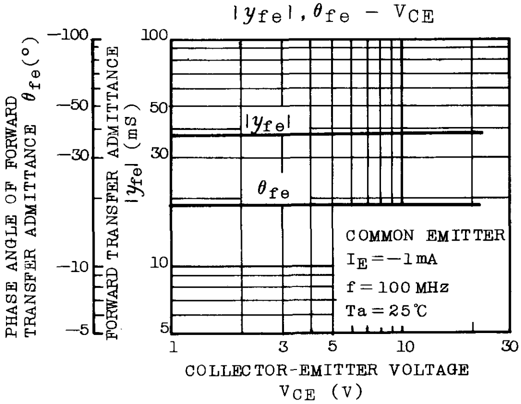


$|y_{re}|, \theta_{re}$ – I_E

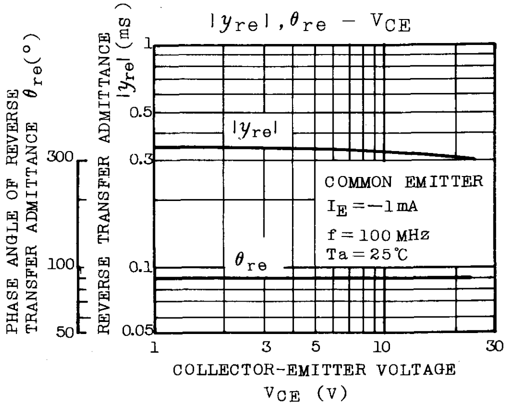




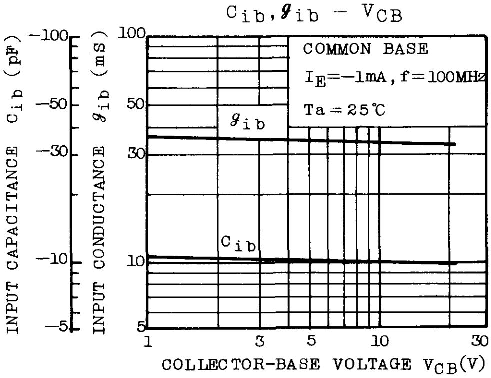
C_{oe}, g_{oe} – V_{CE}
OUTPUT CAPACITANCE C_{oe} (pF)
OUTPUT CONDUCTANCE g_{oe} (μS)
10
5
3
1
0.5
100
50
30
10
5
g_{oe}
C_{oe}
COMMON EMITTER
$I_E = -1$ mA
f = 100 MHz
Ta = 25℃
1
3
5
10
30
COLLECTOR-EMITTER VOLTAGE
V_{CE} (V)



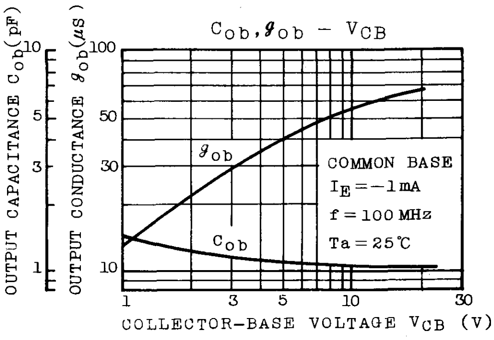
$|y_{fe}|, \theta_{fe}$ – V_{CE}
PHASE ANGLE OF FORWARD TRANSFER ADMITTANCE θ_{fe}(°)
FORWARD TRANSFER ADMITTANCE $|y_{fe}|$ (mS)
−100
−50
−30
−10
−5
100
50
30
10
5
$|y_{fe}|$
θ_{fe}
COMMON EMITTER
$I_E = -1$ mA
f = 100 MHz
Ta = 25℃
1
3
5
10
30
COLLECTOR-EMITTER VOLTAGE
V_{CE} (V)



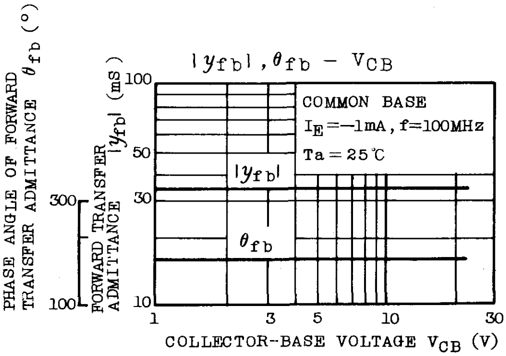
$|y_{re}|, \theta_{re}$ – V_{CE}
PHASE ANGLE OF REVERSE TRANSFER ADMITTANCE θ_{re}(°)
REVERSE TRANSFER ADMITTANCE $|y_{re}|$ (mS)
300
100
50
1
0.5
0.3
0.1
0.05
$|y_{re}|$
θ_{re}
COMMON EMITTER
$I_E = -1$ mA
f = 100 MHz
Ta = 25℃
1
3
5
10
30
COLLECTOR-EMITTER VOLTAGE
V_{CE} (V)



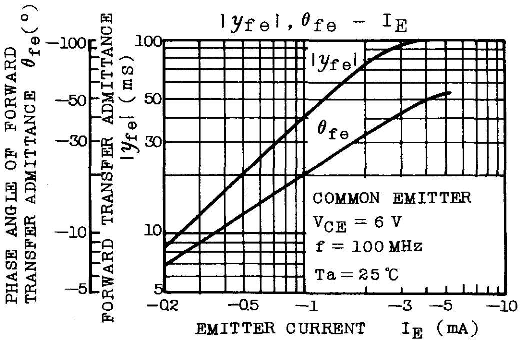
C_{ib}, g_{ib} – V_{CB}
INPUT CAPACITANCE C_{ib} (pF)
INPUT CONDUCTANCE g_{ib} (mS)
−100
−50
−30
−10
−5
100
50
30
10
5
COMMON BASE
$I_E = -1$mA, f = 100MHz
Ta = 25℃
g_{ib}
C_{ib}
1
3
5
10
30
COLLECTOR-BASE VOLTAGE V_{CB}(V)

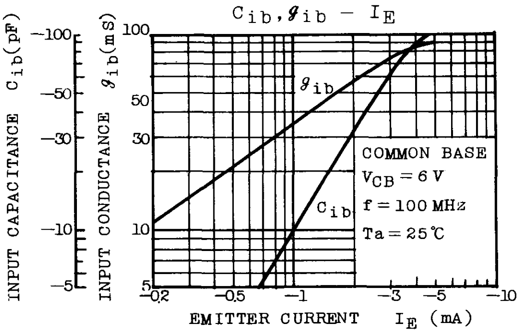


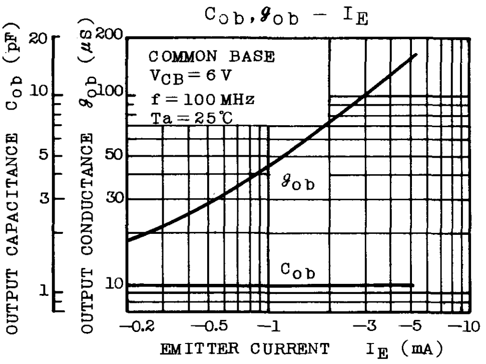
C_{ob}, g_{ob} – V_{CB}
OUTPUT CAPACITANCE C_{ob}(pF)
OUTPUT CONDUCTANCE g_{ob}(μS)
10
5
3
1
100
50
30
10
g_{ob}
C_{ob}
COMMON BASE
$I_E = -1$ mA
f = 100 MHz
Ta = 25℃
1
3
5
10
30
COLLECTOR-BASE VOLTAGE V_{CB} (V)

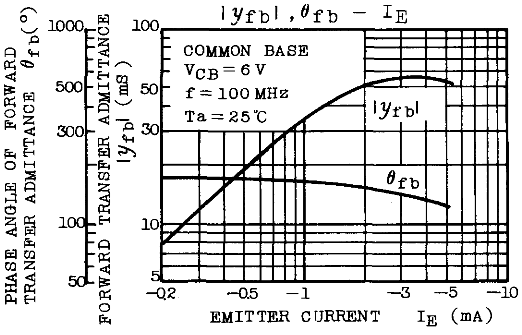


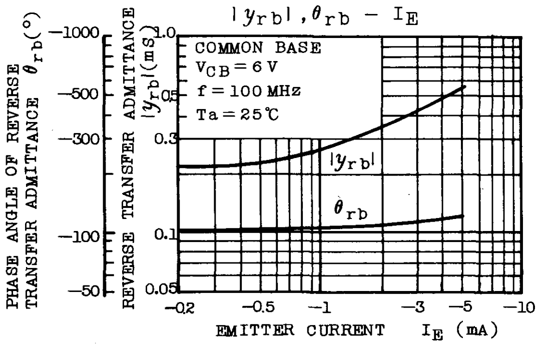
$|y_{fb}|, \theta_{fb}$ – V_{CB}
PHASE ANGLE OF FORWARD TRANSFER ADMITTANCE θ_{fb} (°)
FORWARD TRANSFER ADMITTANCE $|y_{fb}|$ (mS)
300
100
100
50
30
10
COMMON BASE
$I_E = -1$mA, f=100MHz
Ta = 25℃
$|y_{fb}|$
θ_{fb}
1
3
5
10
30
COLLECTOR-BASE VOLTAGE V_{CB} (V)

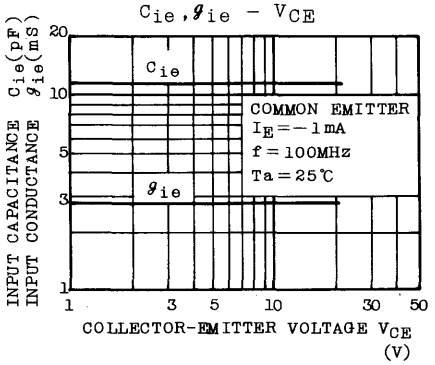

|yfe|, θfe – IE
PHASE ANGLE OF FORWARD TRANSFER ADMITTANCE θfe(°)
FORWARD TRANSFER ADMITTANCE |yfe| (mS)
–100
–50
–30
–10
–5
100
50
30
10
5
|yfe|
θfe
COMMON EMITTER
VCE = 6 V
f = 100 MHz
Ta = 25 ℃
–0.2
–0.5
–1
–3
–5
–10
EMITTER CURRENT IE (mA)


Cib, gib – IE
INPUT CAPACITANCE Cib (pF)
INPUT CONDUCTANCE gib (mS)
–100
–50
–30
–10
–5
100
50
30
10
5
gib
Cib
COMMON BASE
VCB = 6 V
f = 100 MHz
Ta = 25 ℃
–0.2
–0.5
–1
–3
–5
–10
EMITTER CURRENT IE (mA)

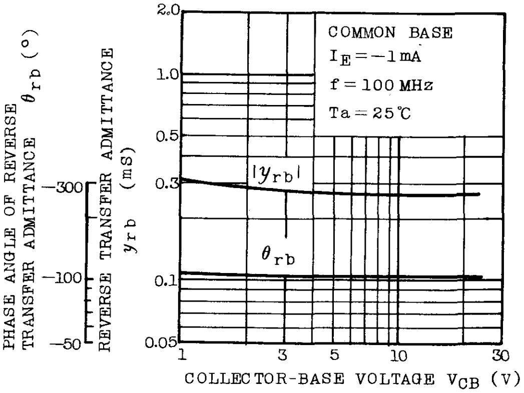

Cob, gob – IE
OUTPUT CAPACITANCE Cob (pF)
OUTPUT CONDUCTANCE gob (μS)
20
10
5
3
1
200
100
50
30
10
COMMON BASE
VCB = 6 V
f = 100 MHz
Ta = 25 ℃
gob
Cob
–0.2
–0.5
–1
–3
–5
–10
EMITTER CURRENT IE (mA)


|yfb|, θfb – IE
PHASE ANGLE OF FORWARD TRANSFER ADMITTANCE θfb(°)
FORWARD TRANSFER ADMITTANCE |yfb| (mS)
1000
500
300
100
50
100
50
30
10
5
COMMON BASE
VCB = 6 V
f = 100 MHz
Ta = 25 ℃
|yfb|
θfb
–0.2
–0.5
–1
–3
–5
–10
EMITTER CURRENT IE (mA)

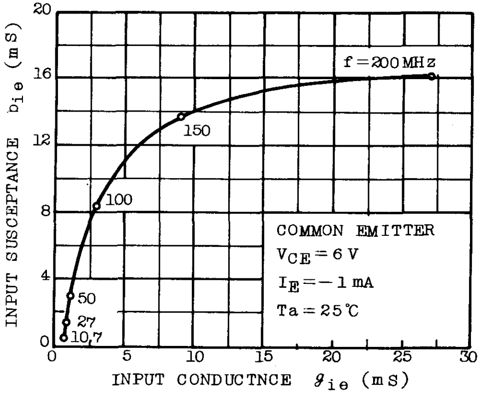

|yrb|, θrb – IE
PHASE ANGLE OF REVERSE TRANSFER ADMITTANCE θrb(°)
REVERSE TRANSFER ADMITTANCE |yrb| (mS)
–1000
–500
–300
–100
–50
1.0
0.5
0.3
0.1
0.05
COMMON BASE
VCB = 6 V
f = 100 MHz
Ta = 25 ℃
|yrb|
θrb
–0.2
–0.5
–1
–3
–5
–10
EMITTER CURRENT IE (mA)


Cie, gie – VCE
INPUT CAPACITANCE Cie (pF)
INPUT CONDUCTANCE gie (mS)
20
10
5
3
1
Cie
gie
COMMON EMITTER
IE = –1 mA
f = 100MHz
Ta = 25 ℃
1
3
5
10
30
50
COLLECTOR-EMITTER VOLTAGE VCE (V)

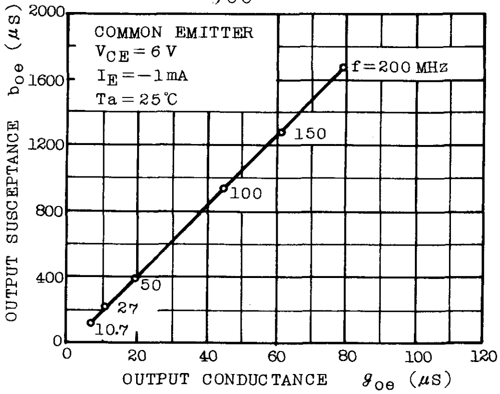
$|y_{rb}|, \theta_{rb} - V_{CB}$



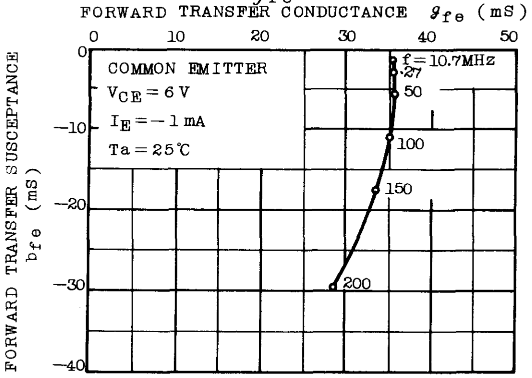
$y_{ie} - f$



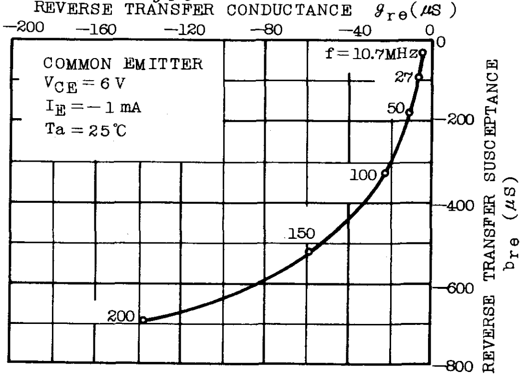
$y_{oe} - f$



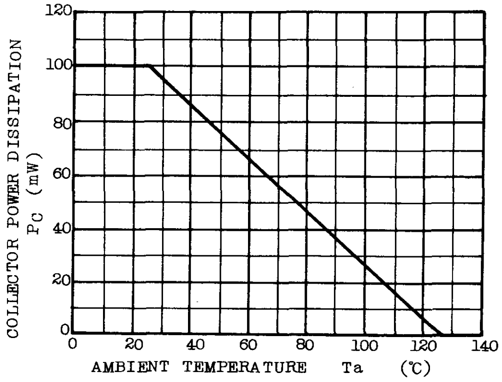
$y_{fe} - f$



$y_{re} - f$



$P_C - Ta$



SILICON NPN EPITAXIAL PLANAR TYPE (PCT PROCESS)

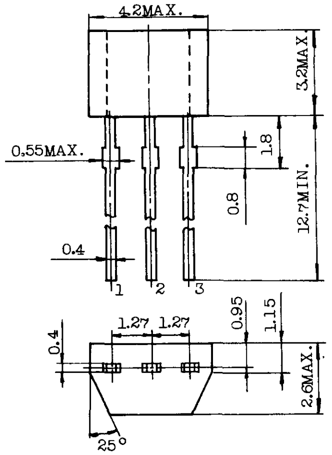
2SC2669

HIGH FREQUENCY AMPLIFIER APPLICATIONS.

FEATURES:

- High Power Gain : G_{pe}=30dB (Typ.) (f=10.7MHz)
- Recommended for FM IF, OSC Stage and AM CONV, IF Stage.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	—
EIAJ	—
TOSHIBA	2 —4 E 1 A

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

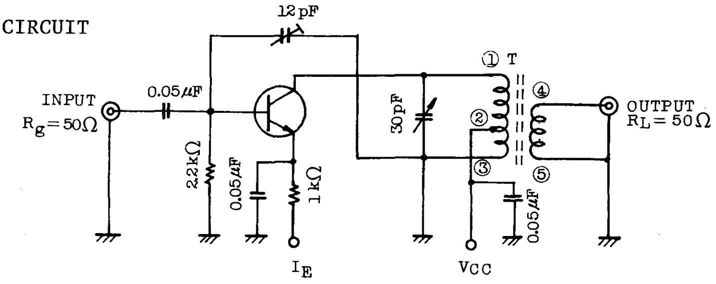
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	35	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	50	mA
Emitter Current	I_E	-50	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=35V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=4V, I_C=0	-	-	1.0	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=12V, I_C=2mA	40	-	240	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	0.4	V
Base-Emitter Voltage	V_{BE}	I_C=10mA, I_B=1mA	-	-	1.0	V
Transition Frequency	f_T	V_{CE}=10V, I_C=1mA	100	-	-	MHz
Collector Output Capacitance	Cob	V_{CB}=10V, I_E=0, f=1MHz	-	2.0	3.2	pF
Collector-Base Time Constant	$C_c \cdot r_{bb'}$	V_{CE}=10V, I_E=-1mA, f=30MHz	-	-	50	ps
Power Gain	G_{pe}	V_{CC}=6V, I_E=-1mA f=10.7MHz (Fig.)	27	30	33	dB

Note : h_{FE} Classification R : 40∿80, O : 70∿140, Y : 120∿240

Fig. G_{pe} TEST CIRCUIT



T : ①—② 0.1mmØ UEW 20T
②—③ 0.1mmØ UEW 8T
④—⑤ 0.1mmØ UEW 2T

Y PARAMETERS (Typ.)

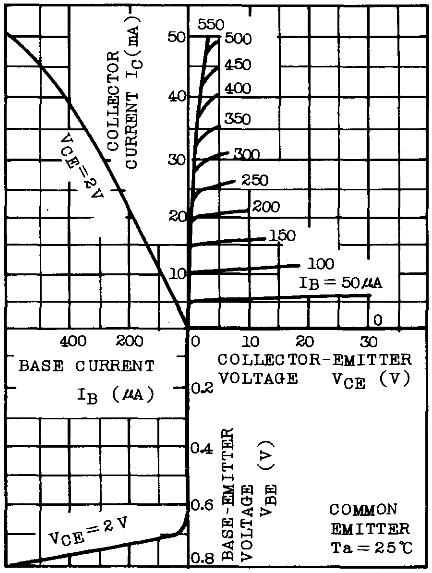
(1) (COMMON EMITTER f = 455 kHz, Ta = 25°C)

CHARACTERISTIC	SYMBOL	2SC2669-R	2SC2669-0	2SC2669-Y	UNIT
Collector-Emitter Voltage	V_{CE}	6	6	6	V
Emitter Current	I_E	-1	-1	-1	mA
Input Conductance	g_{ie}	0.58	0.41	0.26	mS
Input Capacitance	C_{ie}	53	46	38	pF
Output Conductance	g_{oe}	1.9	2.7	4.8	μS
Output Capacitance	C_{oe}	2.6	2.8	3.6	pE
Forward Transfer Admittance	$\|y_{fe}\|$	38	38	38	mS
Phase Angle of Forward Transfer Admittance	θ_{fe}	-0.79	-0.83	-0.92	°
Reverse Transfer Admittance	$\|y_{re}\|$	5.7	5.7	6.2	μS
Phase Angle of Reverse Transfer Admittance	θ_{re}	-90	-90	-90	°

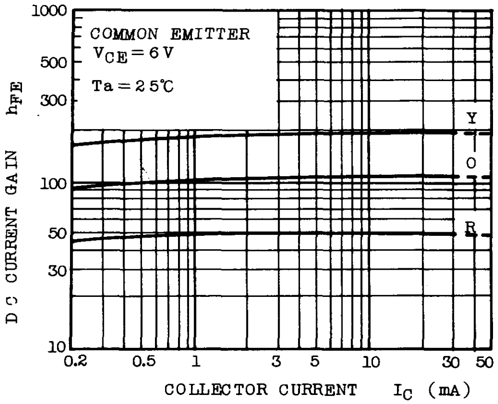
(2) (COMMON EMITTER f = 10.7 MHz, Ta = 25°C)

CHARACTERISTIC	SYMBOL	2SC2669-R	2SC2669-0	2SC2669-Y	UNIT
Collector-Emitter Voltage	V_{CE}	6	6	6	V
Emitter Current	I_E	-1	-1	-1	mA
Input Conductance	g_{ie}	1.04	0.85	0.65	mS
Input Capacitance	C_{ie}	49	43	36	pF
Output Conductance	g_{oe}	10	15	28	μS
Output Capacitance	C_{oe}	2.7	2.9	3.6	pF
Forward Transfer Admittance	$\|y_{fe}\|$	37	37	37	mS
Phase Angle of Forward Transfer Admittance	θ_{fe}	-9.6	-10.4	-11.5	°
Reverse Transfer Admittance	$\|y_{re}\|$	120	120	140	μS
Phase Angle of Reverse Transfer Admittance	θ_{re}	-90	-90	-90	°

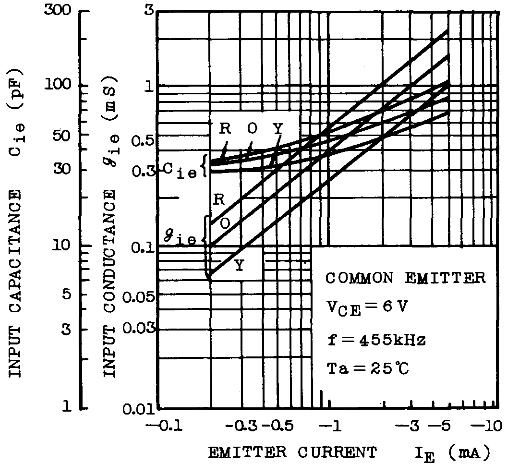
STATIC CHARACTERISTICS



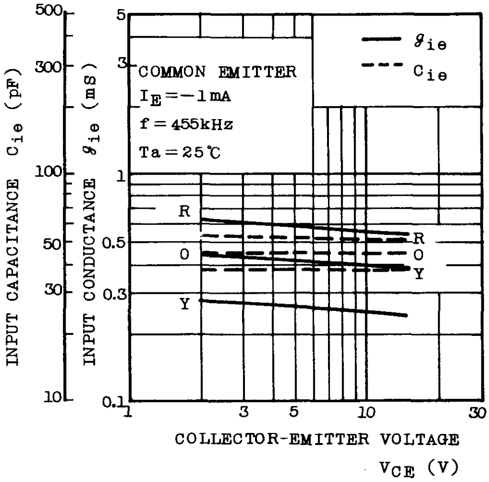
$h_{FE} - I_C$

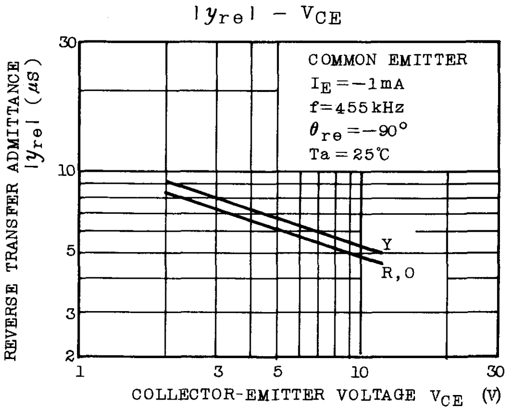


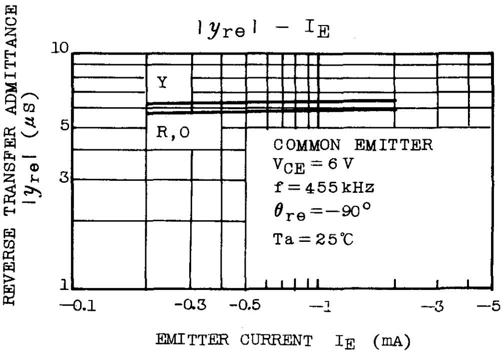
$g_{ie}, C_{ie} - I_E$

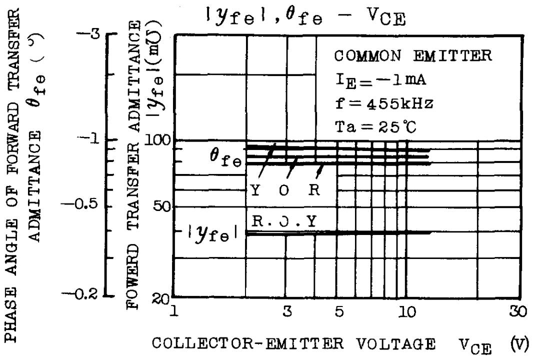


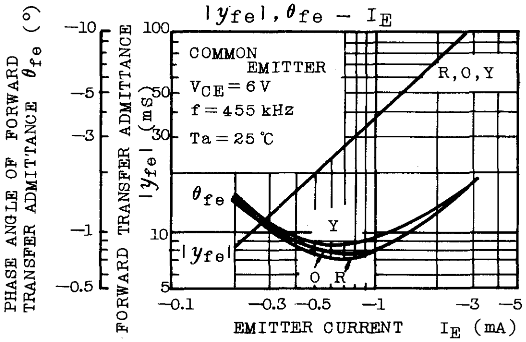
$g_{ie}, C_{ie} - V_{CE}$

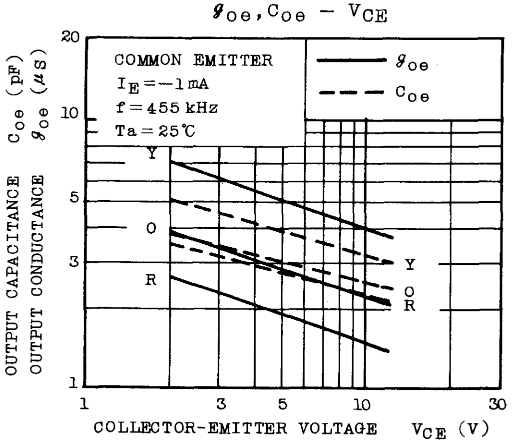


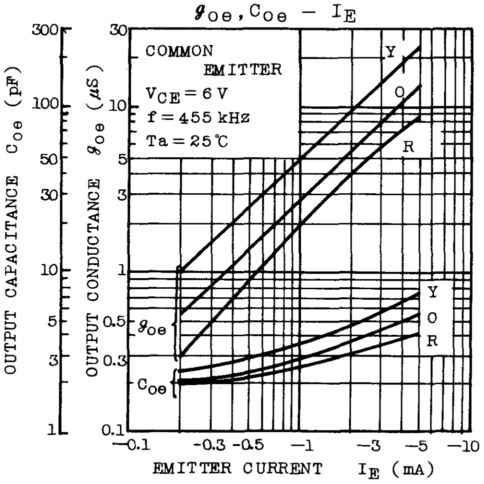

|yre| – VCE
REVERSE TRANSFER ADMITTANCE |yre| (μS)
COMMON EMITTER
IE = −1 mA
f = 455 kHz
θre = −90°
Ta = 25℃
Y
R, O
30
10
5
3
2
1
3
5
10
30
COLLECTOR-EMITTER VOLTAGE VCE (V)


|yre| – IE
REVERSE TRANSFER ADMITTANCE |yre| (μS)
Y
R, O
COMMON EMITTER
VCE = 6 V
f = 455 kHz
θre = −90°
Ta = 25℃
10
5
3
1
−0.1
−0.3
−0.5
−1
−3
−5
EMITTER CURRENT IE (mA)

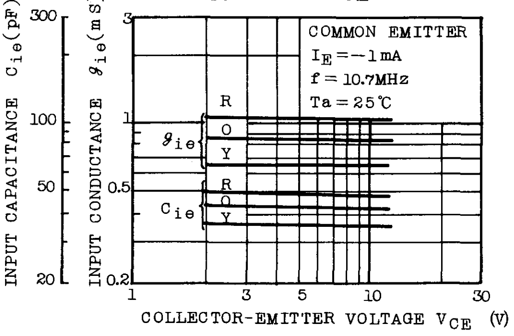

|yfe|, θfe – VCE
PHASE ANGLE OF FORWARD TRANSFER ADMITTANCE θfe (°)
FOWERD TRANSFER ADMITTANCE |yfe| (m℧)
COMMON EMITTER
IE = −1 mA
f = 455 kHz
Ta = 25℃
θfe
Y O R
|yfe|
R. O. Y
−3
−1
−0.5
−0.2
100
50
20
1
3
5
10
30
COLLECTOR-EMITTER VOLTAGE VCE (V)


|yfe|, θfe – IE
PHASE ANGLE OF FORWARD TRANSFER ADMITTANCE θfe (°)
FORWARD TRANSFER ADMITTANCE |yfe| (mS)
COMMON EMITTER
VCE = 6 V
f = 455 kHz
Ta = 25 ℃
R, O, Y
θfe
Y
|yfe|
O R
−10
−5
−3
−1
−0.5
100
50
30
10
5
−0.1
−0.3
−0.5
−1
−3
−5
EMITTER CURRENT IE (mA)

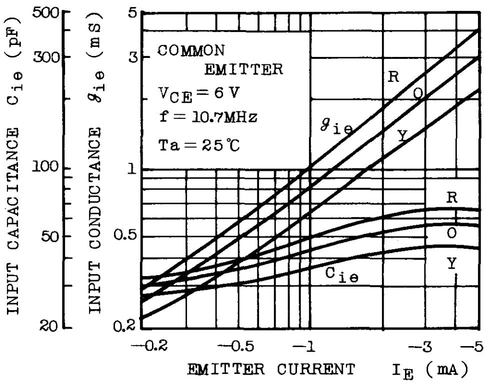

goe, Coe – VCE
OUTPUT CAPACITANCE Coe (pF)
OUTPUT CONDUCTANCE goe (μS)
COMMON EMITTER
IE = −1 mA
f = 455 kHz
Ta = 25℃
goe
Coe
Y
O
R
Y
O
R
20
10
5
3
1
1
3
5
10
30
COLLECTOR-EMITTER VOLTAGE VCE (V)


goe, Coe – IE
OUTPUT CAPACITANCE Coe (pF)
OUTPUT CONDUCTANCE goe (μS)
COMMON EMITTER
VCE = 6 V
f = 455 kHz
Ta = 25℃
Y
O
R
goe
Coe
Y
O
R
300
100
50
30
10
5
3
1
30
10
5
3
1
0.5
0.3
0.1
−0.1
−0.3
−0.5
−1
−3
−5
−10
EMITTER CURRENT IE (mA)

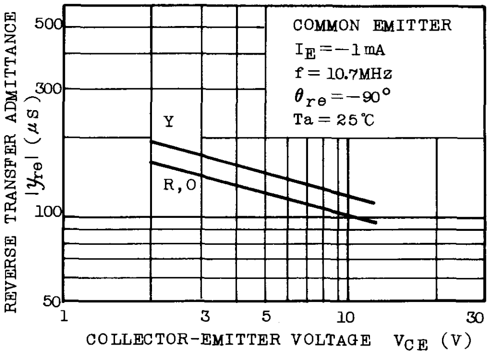
$g_{ie}, C_{ie} - V_{CE}$



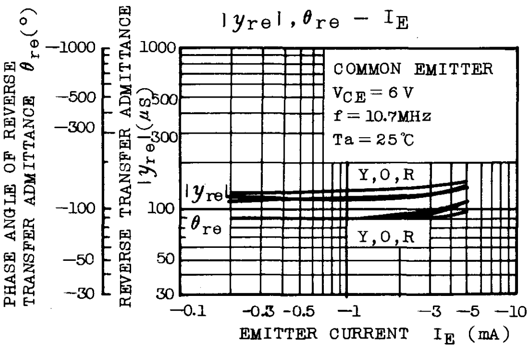
$g_{ie}, C_{ie} - I_E$



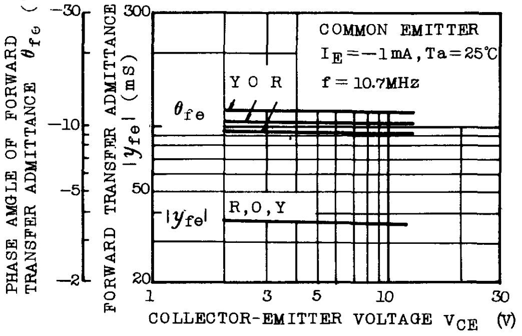
$|y_{re}| - V_{CE}$



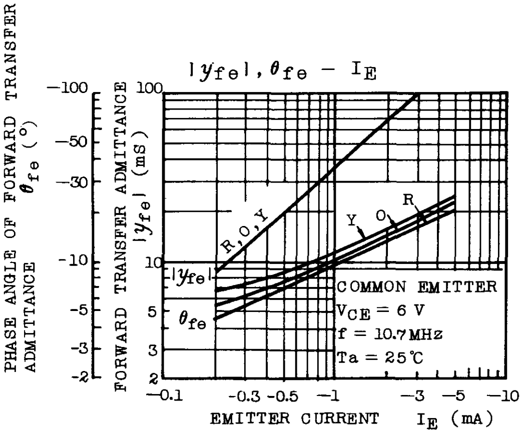
$|y_{re}|, \theta_{re} - I_E$

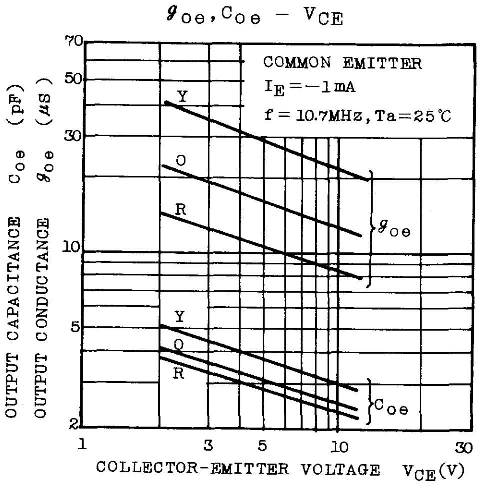


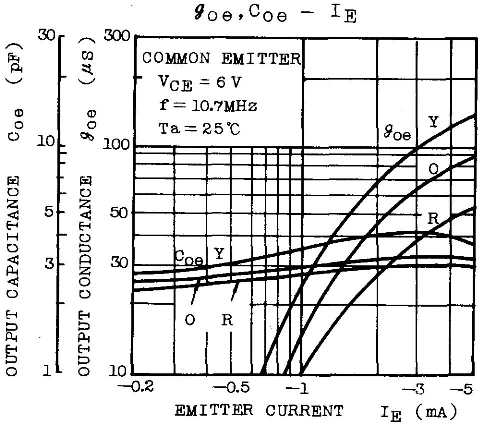
$|y_{fe}|, \theta_{fe} - V_{CE}$

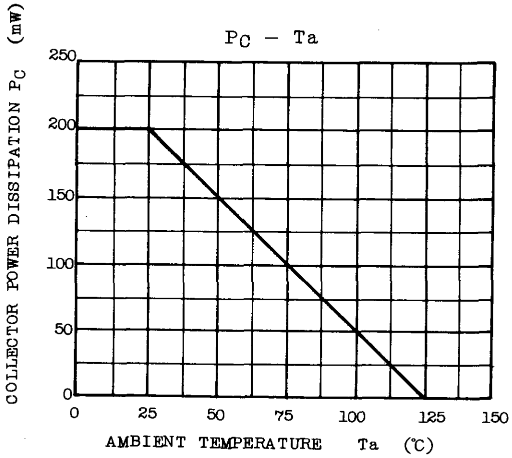


$|y_{fe}|, \theta_{fe} - I_E$




g_{oe}, C_{oe} – V_{CE}
COMMON EMITTER
$I_E = -1$ mA
f = 10.7MHz, Ta = 25℃
Y
O
R
g_{oe}
Y
O
R
C_{oe}
OUTPUT CAPACITANCE C_{oe} (pF)
OUTPUT CONDUCTANCE g_{oe} (μS)
70
50
30
10
5
2
1
3
5
10
30
COLLECTOR-EMITTER VOLTAGE V_{CE}(V)


g_{oe}, C_{oe} – I_E
COMMON EMITTER
$V_{CE} = 6$ V
f = 10.7MHz
Ta = 25℃
g_{oe}
Y
O
R
C_{oe}
Y
O
R
OUTPUT CAPACITANCE C_{oe} (pF)
OUTPUT CONDUCTANCE g_{oe} (μS)
30
10
5
3
1
300
100
50
30
10
−0.2
−0.5
−1
−3
−5
EMITTER CURRENT I_E (mA)


P_C – Ta
COLLECTOR POWER DISSIPATION P_C (mW)
250
200
150
100
50
0
0
25
50
75
100
125
150
AMBIENT TEMPERATURE Ta (℃)

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

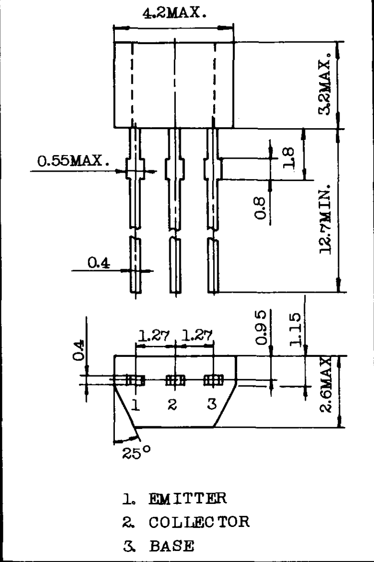
2SC2670

HIGH FREQUENCY AMPLIFIER APPLICATIONS.
AM HIGH FREQUENCY AMPLIFIER APPLICATIONS.
AM FREQUENCY CONVERTER APPLICATIONS.

FEATURES:

- Low Noise Figure : NF=3.5dB (Max.) (f=1MHz)

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	—
EIAJ	—
TOSHIBA	2 — 4E1A

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	35	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	100	mA
Emitter Current	I_E	-100	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	Tstg	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

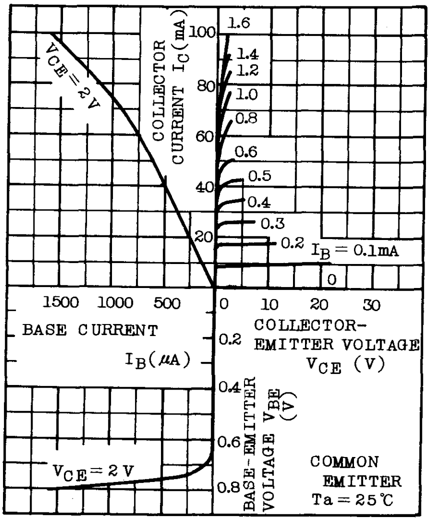
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=35V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=4V, I_C=0	-	-	1.0	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=12V, I_C≑2mA	40	-	240	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	0.4	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=10mA, I_B=1mA	-	-	1.0	V
Transition Frequency	f_T	V_{CE}=10V, I_C=2mA	80	-	-	MHz
Reverse Transfer Capacitance	C_{re}	V_{CE}=10V, f=1MHz	-	2.2	3.0	pF
Collector-Base Time Constant	$C_c \cdot r_{bb'}$	V_{CE}=10V, I_E=-1mA, f=30MHz	-	-	50	ps
Noise Figure	NF	V_{CE}=10V, I_E=-1mA f=1MHz, R_g=50Ω	-	2.0	3.5	dB

Note : h_{FE} Classification R : 40∿80, O : 70∿140, Y : 120∿240

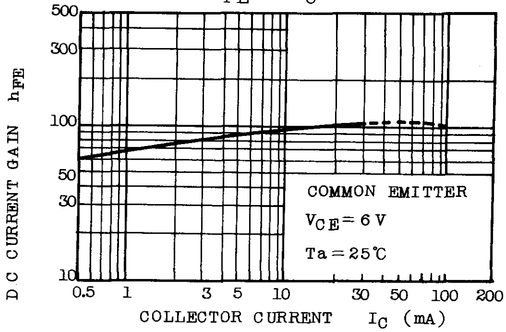
Y PARAMETERS (Typ.)
(COMMON EMITTER V_{CE}=6V, I_E=-1mA, f=1MHz)

CHARACTERISTIC	SYMBOL	2SC2670-R	2SC2670-O	2SC2670-Y	UNIT
Input Conductance	g_{ie}	0.5	0.35	0.22	mS
Input Capacitance	C_{ie}	50	48	46	pF
Output Conductance	g_{oe}	4	5	6.5	μS
Output Capacitance	C_{oe}	3.7	3.4	3.2	pF
Forward Transfer Admittance	y_{fe}	36	36	36	mS
Phase Angle of Foward Transfer Admittance	θ_{fe}	-1.6	-1.6	-1.6	°
Reverse Transfer Admittance	y_{re}	14	14	14	μS
Phase Angle of Reverse Transfer Admittance	θ_{re}	-90	-90	-90	°

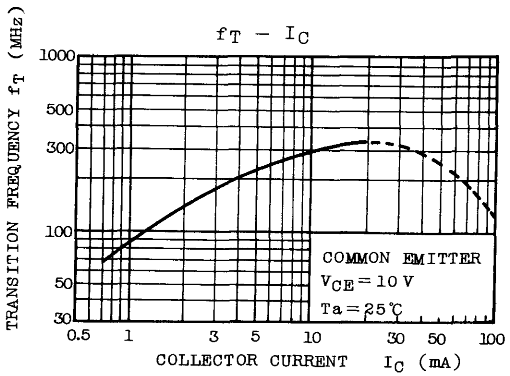
STATIC CHARACTERISTICS



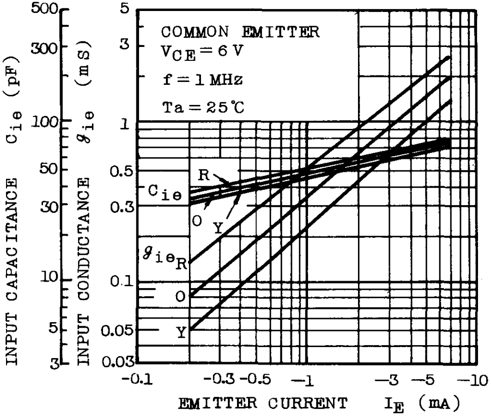
h_{FE} − I_C



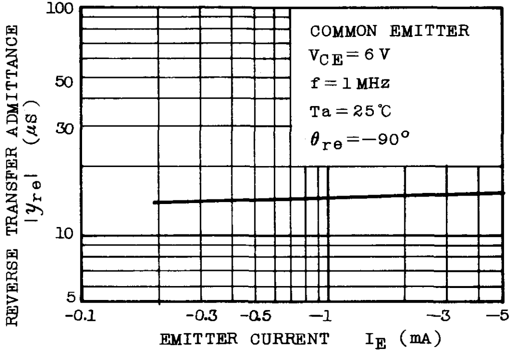
f_T − I_C



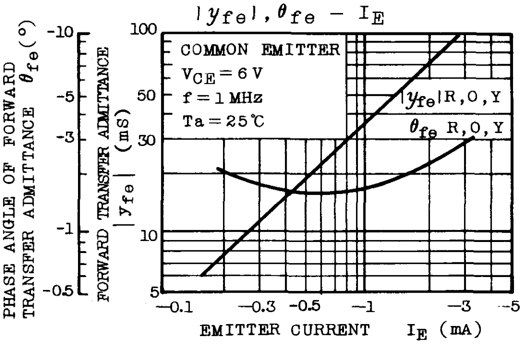
g_{ie}, C_{ie} – I_E



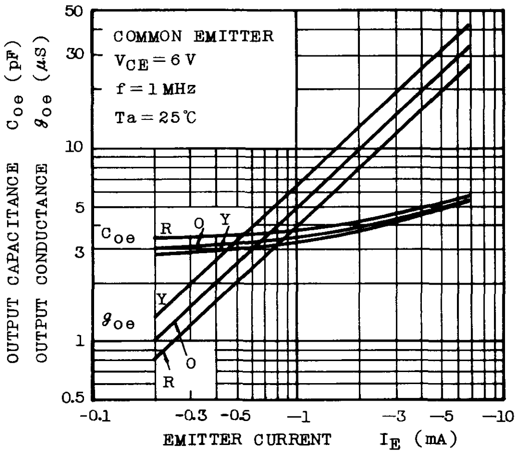
$|y_{re}|$ – I_E



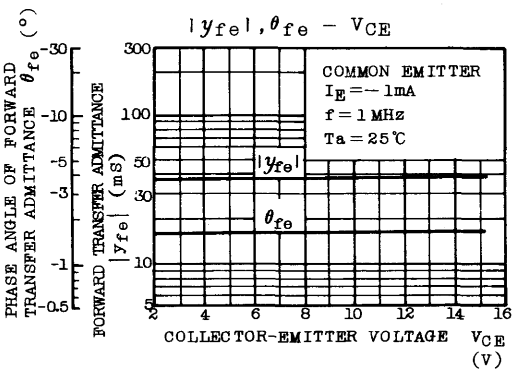
$|y_{fe}|$, θ_{fe} – I_E



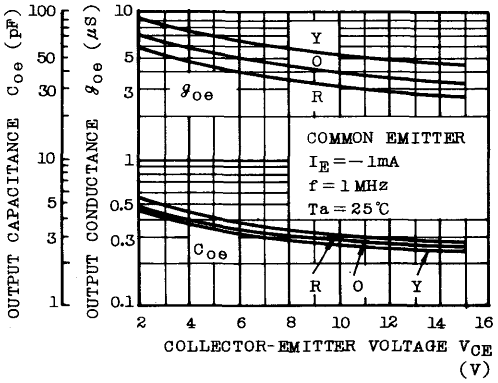
g_{oe}, C_{oe} – I_E

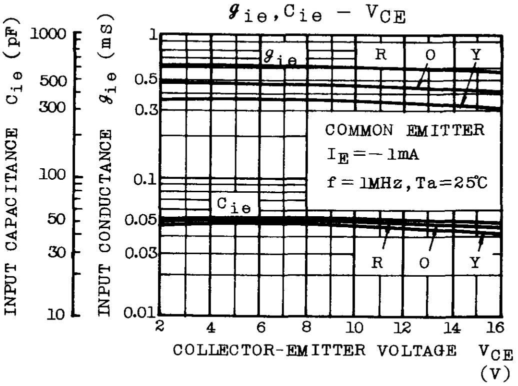


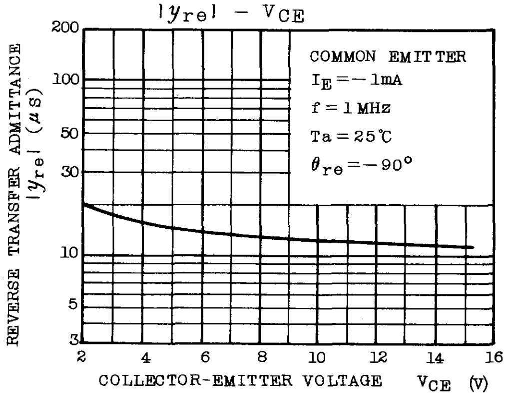
$|y_{fe}|$, θ_{fe} – V_{CE}

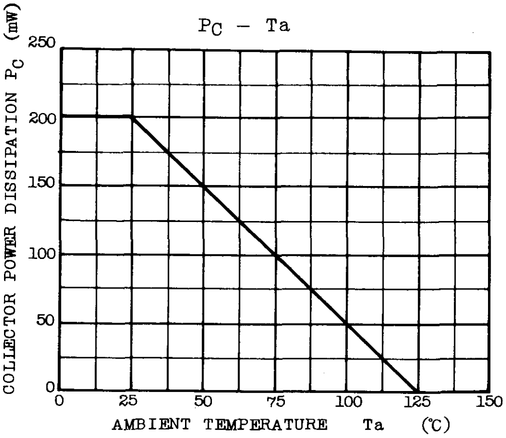


g_{oe}, C_{oe} – V_{CE}




g_{ie}, C_{ie} – V_{CE}
INPUT CAPACITANCE C_{ie} (pF)
INPUT CONDUCTANCE g_{ie} (mS)
1000
500
300
100
50
30
10
1
0.5
0.3
0.1
0.05
0.03
0.01
g_{ie}
R
O
Y
C_{ie}
R
O
Y
COMMON EMITTER
$I_E = -1mA$
f = 1MHz, Ta = 25℃
2
4
6
8
10
12
14
16
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)


$|y_{re}|$ – V_{CE}
REVERSE TRANSFER ADMITTANCE $|y_{re}|$ (μS)
200
100
50
30
10
5
3
COMMON EMITTER
$I_E = -1mA$
f = 1 MHz
Ta = 25℃
$\theta_{re} = -90°$
2
4
6
8
10
12
14
16
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)


P_C – Ta
COLLECTOR POWER DISSIPATION P_C (mW)
250
200
150
100
50
0
0
25
50
75
100
125
150
AMBIENT TEMPERATURE Ta (℃)

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

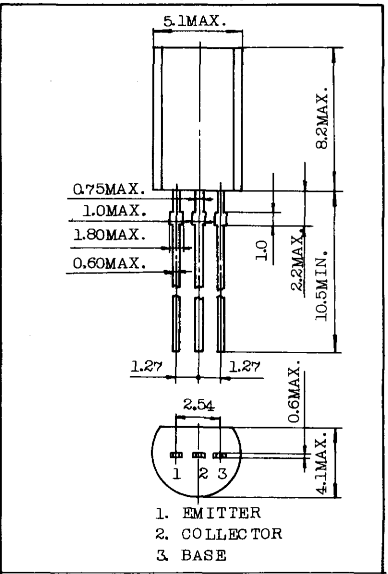
2SC2703

AUDIO POWER AMPLIFIER APPLICATIONS.

FEATURES:

High DC Current Gain : h_{FE}=100∿320

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO − 92MOD
EIAJ	−
TOSHIBA	2 − 5J1A

Weight : 0.36g

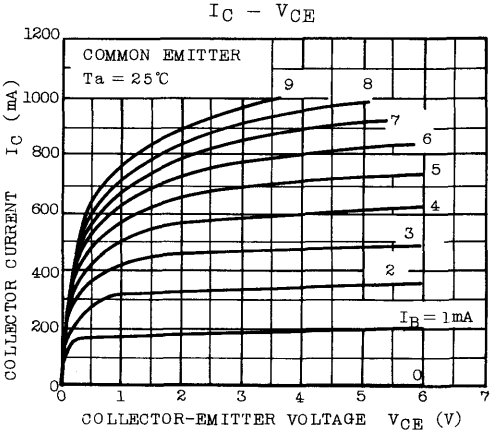
MAXIMUM RATINGS (Ta=25°C)

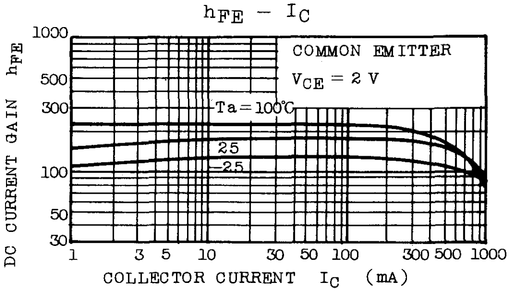
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	1	A
Emitter Current	I_E	-1	A
Collector Power Dissipation	P_C	900	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55∿150	°C

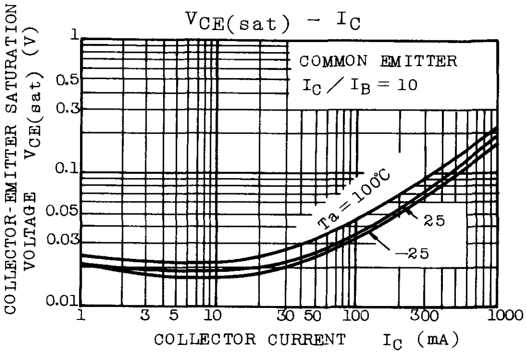
ELECTRICAL CHARACTERISTICS (Ta=25°C)

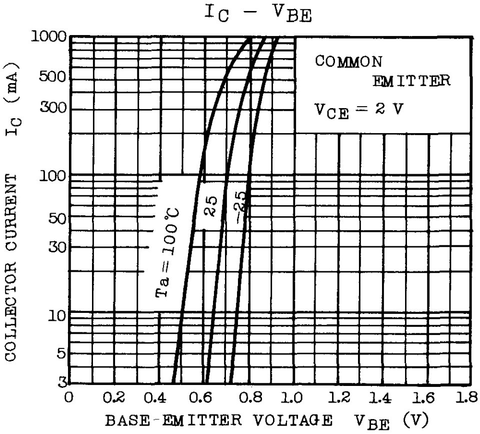
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=30V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=10mA	30	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=2V, I_C=100mA	100	-	320	
	$h_{FE(2)}$	V_{CE}=2V, I_C=800mA	40	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=800mA, I_B=80mA	-	-	0.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=2V, I_C=800mA	-	0.9	1.5	V
Transition Frequency	f_T	V_{CE}=2V, I_C=100mA	-	150	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	13	-	pF

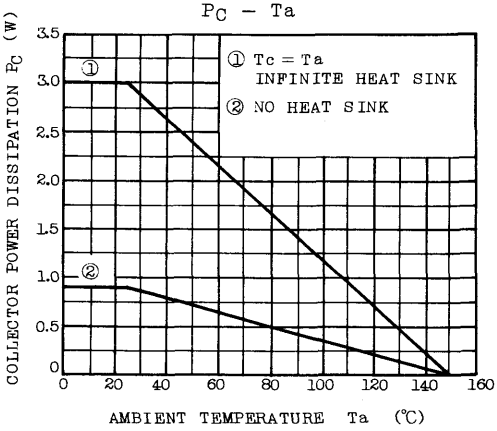
Note : h_{FE} Classification O : 100∿200, Y : 160∿320

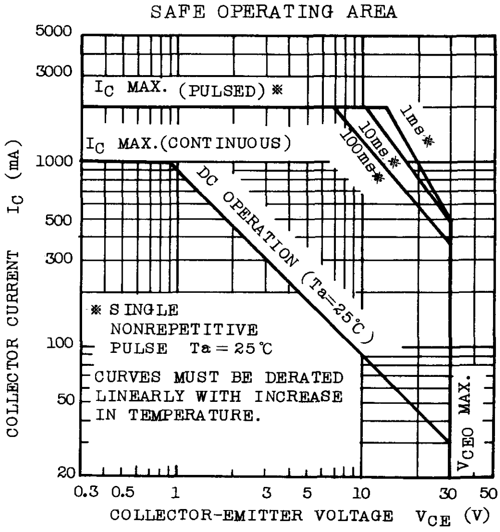

IC – VCE
COMMON EMITTER
Ta = 25℃
IB = 1mA
2
3
4
5
6
7
8
9
0
COLLECTOR CURRENT IC (mA)
1200
1000
800
600
400
200
0
0
1
2
3
4
5
6
7
COLLECTOR-EMITTER VOLTAGE VCE (V)


hFE – IC
COMMON EMITTER
VCE = 2 V
Ta = 100℃
25
−25
DC CURRENT GAIN hFE
1000
500
300
100
50
30
1
3
5
10
30
50
100
300
500
1000
COLLECTOR CURRENT IC (mA)


VCE(sat) – IC
COMMON EMITTER
IC / IB = 10
Ta = 100℃
25
−25
COLLECTOR-EMITTER SATURATION VOLTAGE VCE(sat) (V)
1
0.5
0.3
0.1
0.05
0.03
0.01
1
3
5
10
30
50
100
300
1000
COLLECTOR CURRENT IC (mA)


IC – VBE
COMMON EMITTER
VCE = 2 V
Ta = 100℃
25
−25
COLLECTOR CURRENT IC (mA)
1000
500
300
100
50
30
10
5
3
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
BASE-EMITTER VOLTAGE VBE (V)


PC – Ta
① Tc = Ta
INFINITE HEAT SINK
② NO HEAT SINK
①
②
COLLECTOR POWER DISSIPATION PC (W)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
0
20
40
60
80
100
120
140
160
AMBIENT TEMPERATURE Ta (℃)


SAFE OPERATING AREA
IC MAX. (PULSED) ※
IC MAX. (CONTINUOUS)
1ms ※
10ms ※
100ms ※
DC OPERATION (Ta = 25℃)
※ SINGLE
NONREPETITIVE
PULSE Ta = 25℃
CURVES MUST BE DERATED
LINEARLY WITH INCREASE
IN TEMPERATURE.
VCEO MAX.
COLLECTOR CURRENT IC (mA)
5000
3000
1000
500
300
100
50
20
0.3
0.5
1
3
5
10
30
50
COLLECTOR-EMITTER VOLTAGE VCE (V)

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

2SC2705

AUDIO FREQUENCY AMPLIFIER APPLICATIONS.

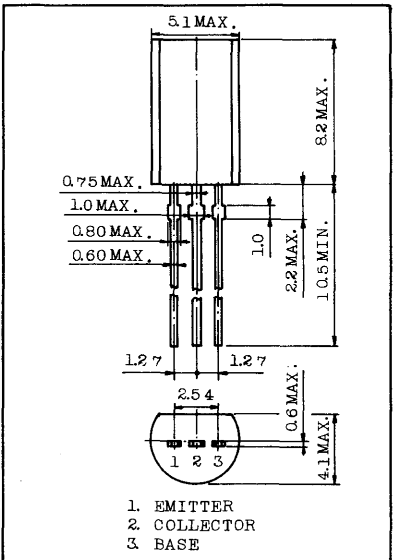
FEATURE:

- Complementary to 2SA1145.
- Small Collector Output Capacitance : C_{ob}=1.8pF(Typ.)
- High Transition Frequency : f_T=200MHz(Typ.)

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	150	V
Collector-Emitter Voltage	V_{CEO}	150	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	50	mA
Base Current	I_B	5	mA
Collector Power Dissipation	P_C	800	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	155~150	°C

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

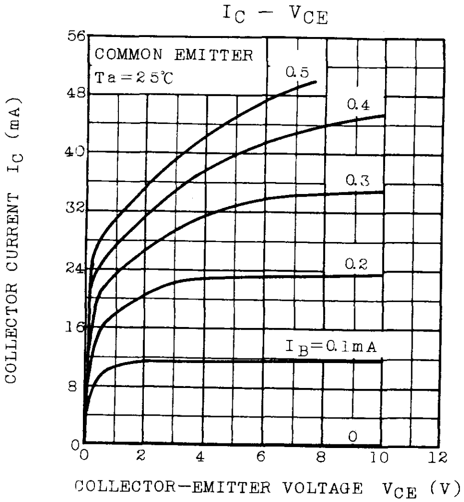
JEDEC	TO−92MOD
EIAJ	−
TOSHIBA	2−5J1A

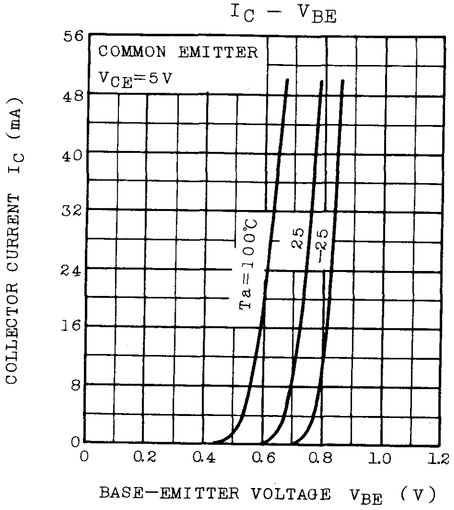
Weight : 0.36g

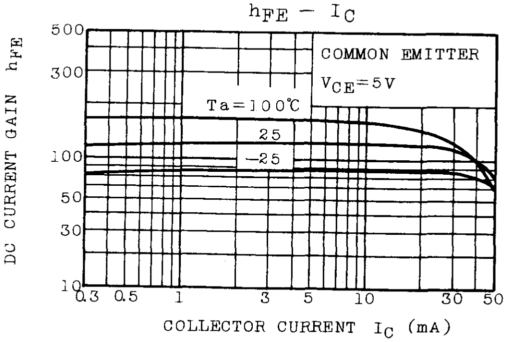
ELECTRICAL CHARACTERISTICS (Ta=25°C)

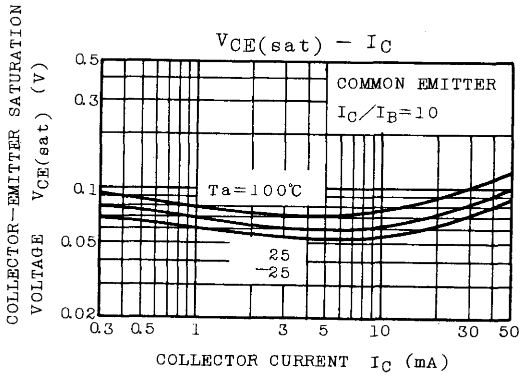
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=150V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	150	-	-	V
DC Current Gain	h_{FE} (Note)	V_{CE}=5V, I_C=10mA	80	-	240	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	1.0	V
Base-Emitter Voltage	V_{BE}	V_{CE}=5V, I_C=10mA	-	-	0.8	V
Transition Frequency	f_T	V_{CE}=10V, I_C=10mA	-	200	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	1.8	-	pF

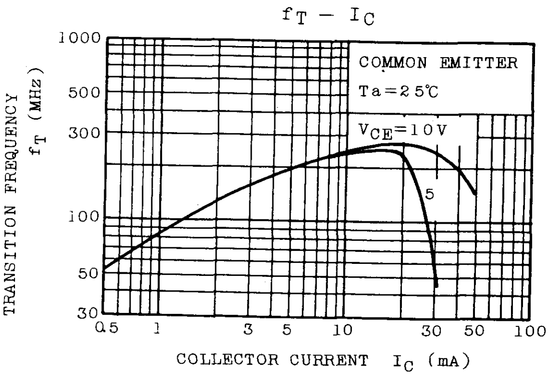
Note: h_{FE} Classification. O:80~160, Y:120~240

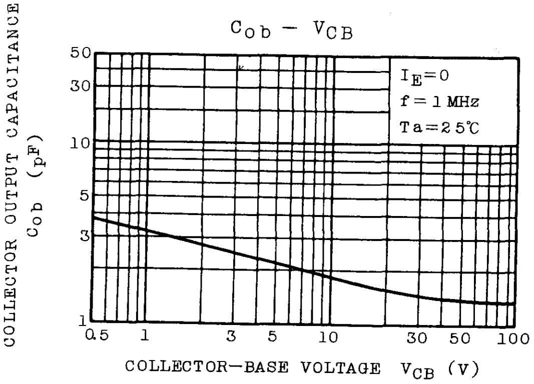

IC — VCE
COMMON EMITTER
Ta=25℃
0.5
0.4
0.3
0.2
IB=0.1mA
0
56
48
40
32
24
16
8
0
0
2
4
6
8
10
12
COLLECTOR CURRENT IC (mA)
COLLECTOR−EMITTER VOLTAGE VCE (V)

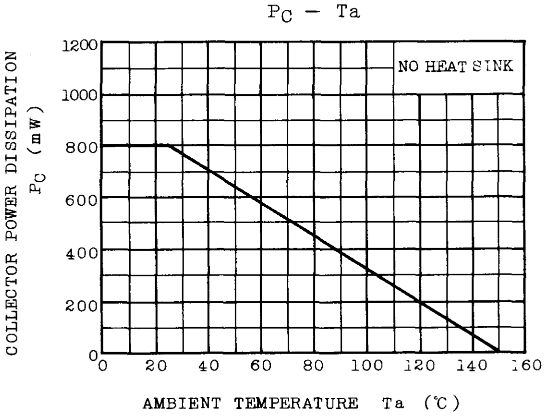

IC — VBE
COMMON EMITTER
VCE=5V
Ta=100℃
25
−25
56
48
40
32
24
16
8
0
0
0.2
0.4
0.6
0.8
1.0
1.2
COLLECTOR CURRENT IC (mA)
BASE−EMITTER VOLTAGE VBE (V)


hFE — IC
COMMON EMITTER
VCE=5V
Ta=100℃
25
−25
500
300
100
50
30
10
0.3
0.5
1
3
5
10
30
50
DC CURRENT GAIN hFE
COLLECTOR CURRENT IC (mA)


VCE(sat) — IC
COMMON EMITTER
IC/IB=10
Ta=100℃
25
−25
0.5
0.3
0.1
0.05
0.02
0.3
0.5
1
3
5
10
30
50
COLLECTOR−EMITTER SATURATION VOLTAGE VCE(sat) (V)
COLLECTOR CURRENT IC (mA)


fT — IC
COMMON EMITTER
Ta=25℃
VCE=10V
5
1000
500
300
100
50
30
0.5
1
3
5
10
30
50
100
TRANSITION FREQUENCY fT (MHz)
COLLECTOR CURRENT IC (mA)


Cob — VCB
IE=0
f=1MHz
Ta=25℃
50
30
10
5
3
1
0.5
1
3
5
10
30
50
100
COLLECTOR OUTPUT CAPACITANCE Cob (pF)
COLLECTOR−BASE VOLTAGE VCB (V)


PC − Ta
COLLECTOR POWER DISSIPATION PC (mW)
1200
1000
800
600
400
200
0
NO HEAT SINK
0
20
40
60
80
100
120
140
160
AMBIENT TEMPERATURE Ta (℃)

2SC2710

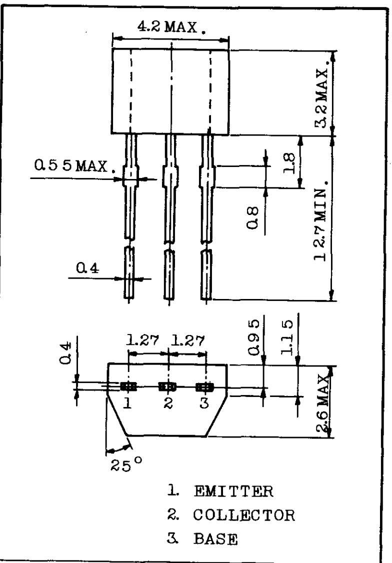
SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

FOR AUDIO AMPLIFIER APPLICATIONS.

FEATURES:

- High DC Current Gain : h_{FE}=100~320
- Complementary to 2SA1150

Unit in mm



JEDEC	–
EIAJ	–
TOSHIBA	2–4E1A

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

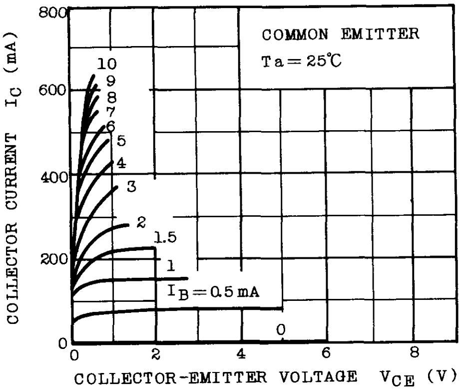
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	35	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	800	mA
Base Current	I_B	160	mA
Collector Power Dissipation	P_C	300	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

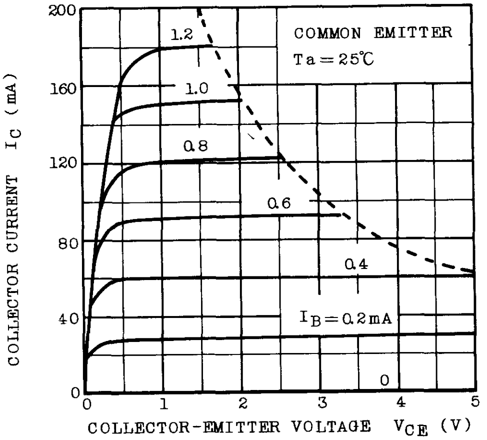
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=30V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=10mA	30	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=1V, I_C=100mA	100	-	320	
	$h_{FE(2)}$	V_{CE}=1V, I_C=700mA	35	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=500mA, I_B=20mA	-	-	0.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=1V, I_C=10mA	0.5	-	0.8	V
Transition Frequency	f_T	V_{CE}=5V, I_C=10mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, f=1MHz	-	13	-	pF

Note : $h_{FE(1)}$ Classification O : 100~200, Y : 160~320

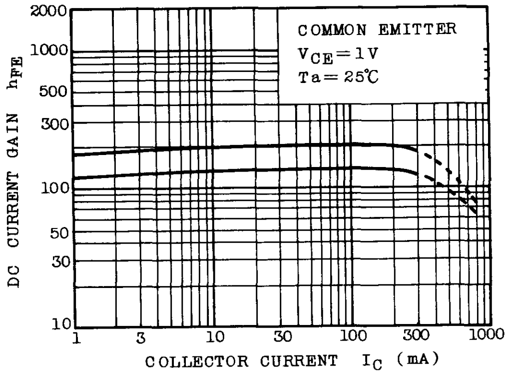
I_C − V_{CE}



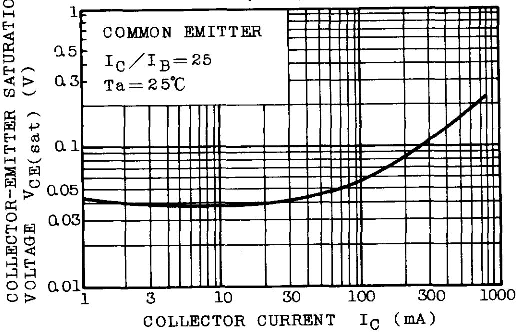
I_C − V_{CE} (LOW VOLTAGE REGION)



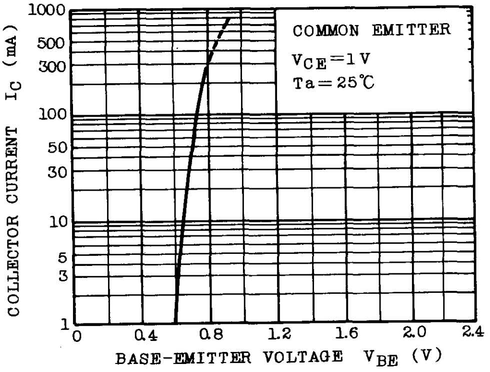
h_{FE} − I_C



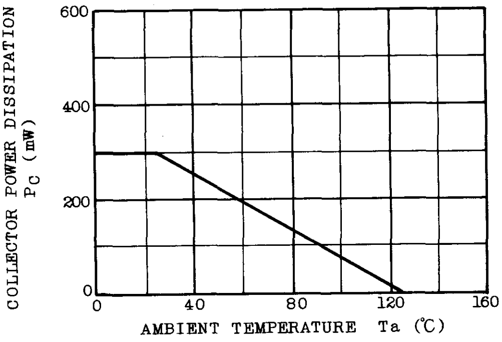
$V_{CE(sat)}$ − I_C



I_C − V_{BE}



P_C − Ta

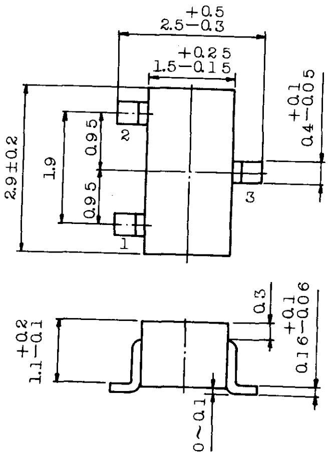


2SC2712

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

AUDIO FREQUENCY GENERAL PURPOSE AMPLIFIER APPLICATIONS.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	−
EIAJ	SC−59
TOSHIBA	2−3F1A

Weight : 0.012g

FEATURES:

- High Voltage and High Current
  : $V_{CEO}=50V$ $I_C=150mA$ (Max.)
- Excellent h_{FE} Linearity
  : $h_{FE}(0.1mA)/h_{FE}(2mA)=0.95$ (Typ.)
- High h_{FE} : $h_{FE}=70 \sim 700$
- Low Noise : NF=1dB (Typ.), 10dB (Max.)
- Complementary to 2SA1162
- Small Package

MAXIMUM RATINGS ($Ta=25°C$)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	60	V
Collector-Emitter Voltage	V_{CEO}	50	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	150	mA
Base Current	I_B	30	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	−55 ~ 125	°C

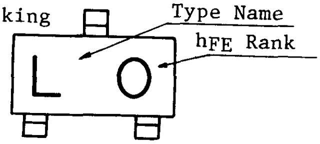
ELECTRICAL CHARACTERISTICS ($Ta=25°C$)

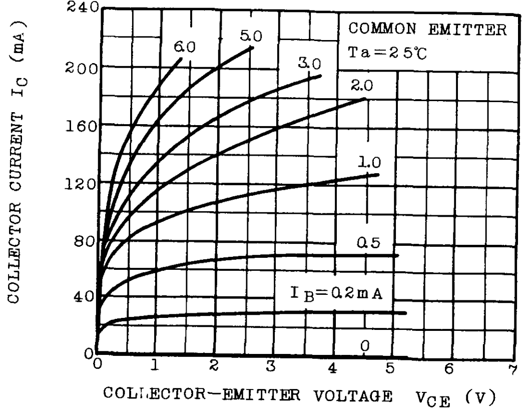
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	$V_{CB}=60V$, $I_E=0$	−	−	0.1	μA
Emitter Cut-off Current	I_{EBO}	$V_{EB}=5V$, $I_C=0$	−	−	0.1	μA
DC Current Gain (Note)	h_{FE}	$V_{CE}=6V$, $I_C=2mA$	70	−	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C=100mA$, $I_B=10mA$	−	0.1	0.25	V
Transition Frequency	f_T	$V_{CE}=10V$, $I_C=1mA$	80	−	−	MHz
Collector Output Capacitance	C_{ob}	$V_{CB}=10V$, $I_E=0$, f=1MHz	−	2.0	3.5	pF
Noise Figure	NF	$V_{CE}=6V$, $I_C=0.1mA$ f=1kHz, $R_g=10kΩ$	−	1.0	10	dB

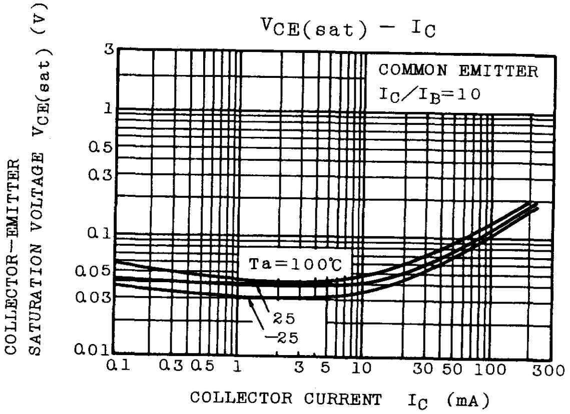
Note : h_{FE} Classification

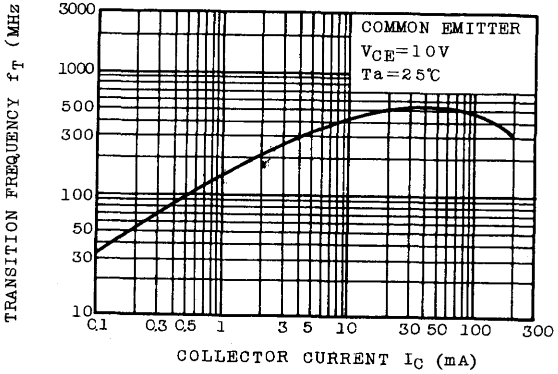
O:70~140, Y:120~240, GR(G):200~400, BL(L):350~700

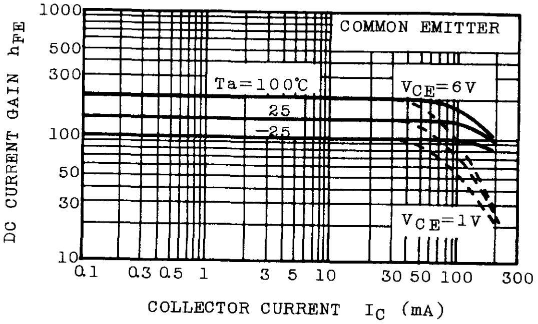
Marking

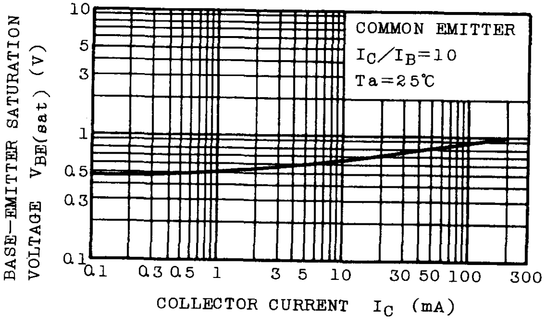


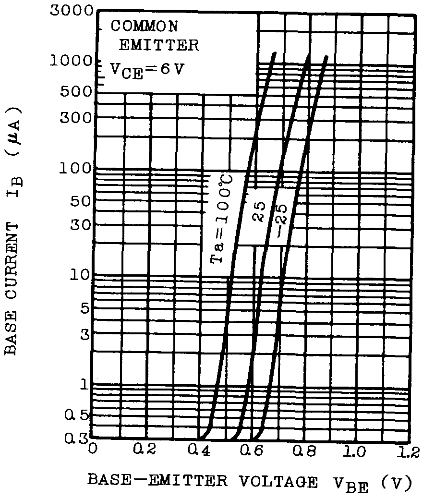

I_C - V_{CE}

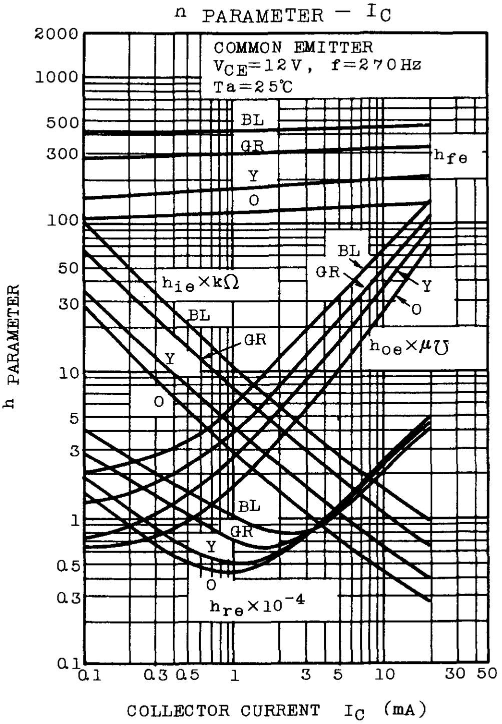

$V_{CE(sat)}$ – I_C

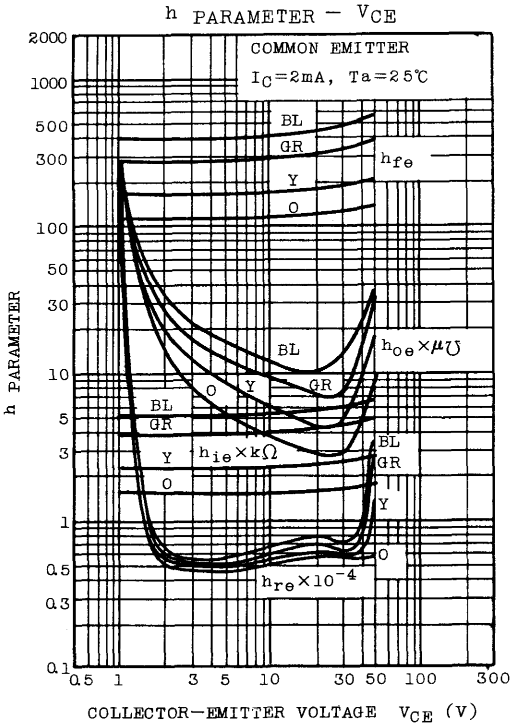

f_T – I_C

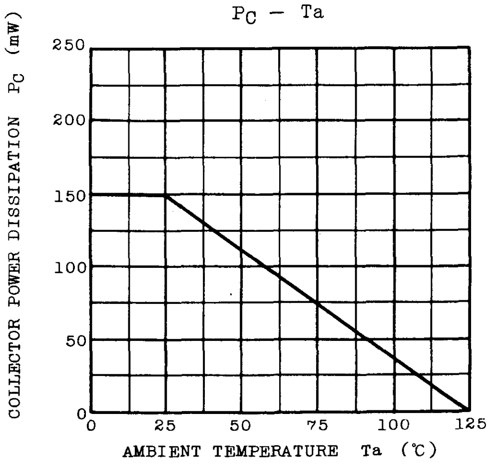

h_{FE} – I_C


$V_{BE(sat)}$ – I_C


I_B – V_{BE}


h PARAMETER — I_C
COMMON EMITTER
V_{CE}=12V, f=270Hz
Ta=25℃
2000
1000
500
300
100
50
30
10
5
3
1
0.5
0.3
0.1
h PARAMETER
BL
GR
Y
O
h_{fe}
h_{ie}×kΩ
BL
GR
Y
O
BL
GR
Y
O
h_{oe}×μ℧
BL
GR
Y
O
h_{re}×10^{-4}
0.1
0.3
0.5
1
3
5
10
30
50
COLLECTOR CURRENT I_C (mA)


h PARAMETER — V_{CE}
COMMON EMITTER
I_C=2mA, Ta=25℃
2000
1000
500
300
100
50
30
10
5
3
1
0.5
0.3
0.1
h PARAMETER
BL
GR
Y
O
h_{fe}
BL
O
Y
GR
h_{oe}×μ℧
BL
GR
Y
O
h_{ie}×kΩ
BL
GR
Y
O
h_{re}×10^{-4}
0.5
1
3
5
10
30
50
100
300
COLLECTOR—EMITTER VOLTAGE V_{CE} (V)

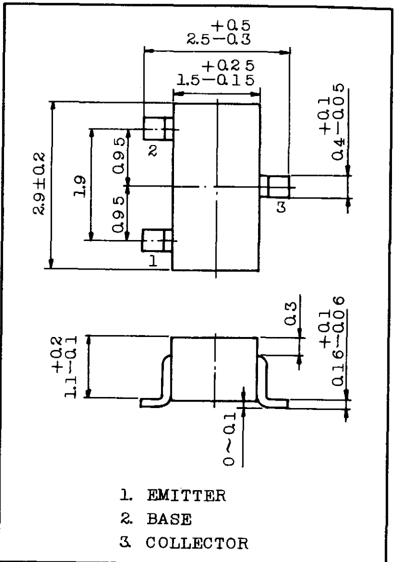

P_C — Ta
COLLECTOR POWER DISSIPATION P_C (mW)
250
200
150
100
50
0
0
25
50
75
100
125
AMBIENT TEMPERATURE Ta (℃)

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

2SC2713

AUDIO FREQUENCY GENERAL PURPOSE AMPLIFIER APPLICATIONS.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	—
EIAJ	SC−59
TOSHIBA	2−3F1A

Weight : 0.012g

FEATURES:

- High Voltage : V_{CEO}=120V
- Excellent h_{FE} Linearity
  : h_{FE}(0.1mA)/h_{FE}(2mA)=0.95(Typ.)
- High h_{FE} : h_{FE}=200 ~ 700
- Low Noise : NF=1dB(Typ.), 10dB(Max.)
- Complementary to 2SA1163.
- Small Package.

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	120	V
Collector-Emitter Voltage	V_{CEO}	120	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	100	mA
Base Current	I_B	20	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

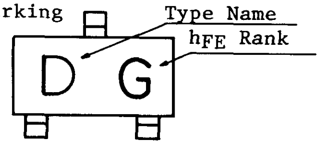
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=120V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain (Note)	h_{FE}	V_{CE}=6V, I_C=2mA	200	-	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	0.3	V
Transition Frequency	f_T	V_{CE}=6V, I_C=1mA	-	100	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	4	-	pF
Noise Figure	NF	V_{CE}=6V, I_C=0.1mA f=1kHz, R_g=10kΩ	-	1.0	10	dB

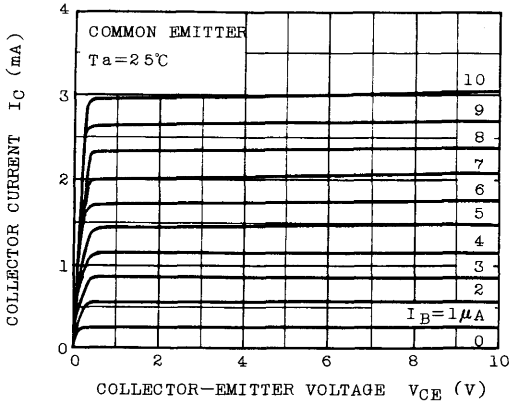
Note : h_{FE} Classification

GR(G) : 200 ~ 400, BL(L) : 350 ~ 700

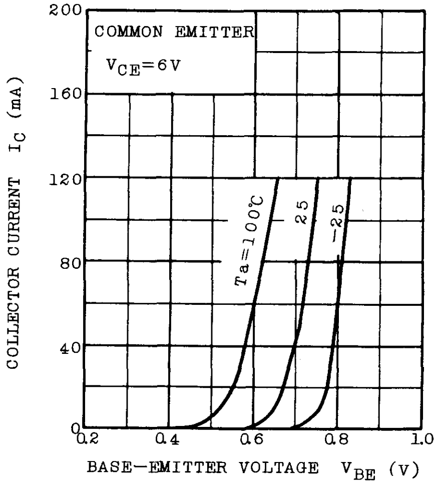
Marking



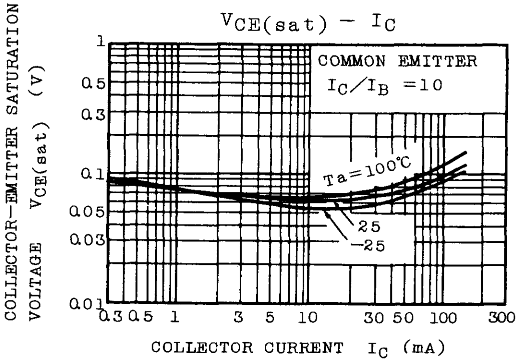
I_C - V_{CE}



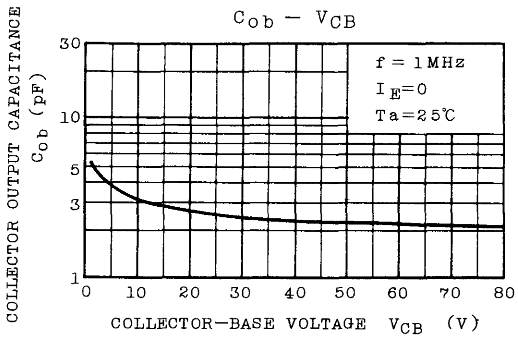
I_C — V_{BE}



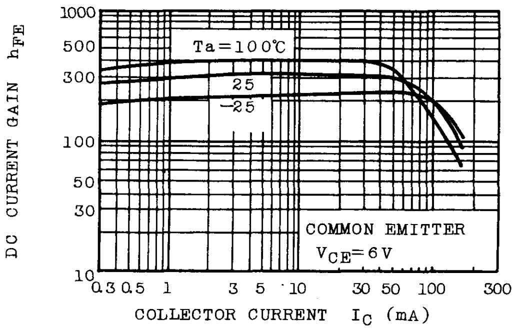
$V_{CE(sat)}$ — I_C



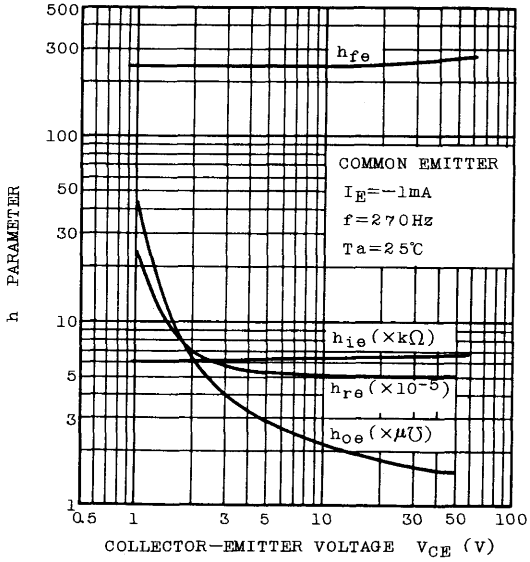
C_{ob} — V_{CB}

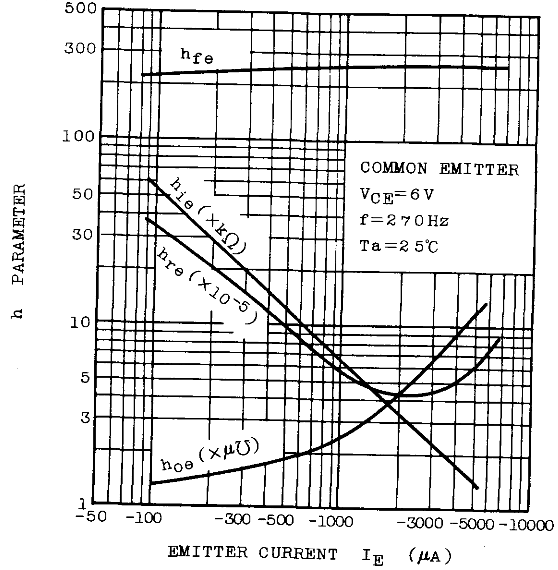


h_{FE} — I_C

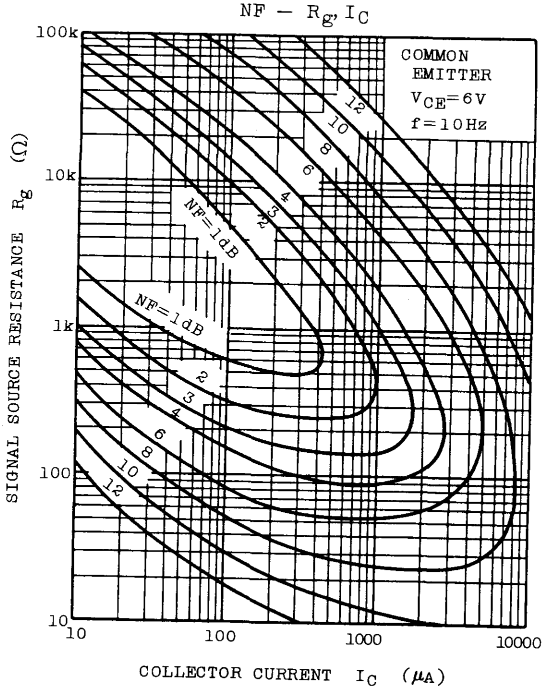


h PARAMETER — V_{CE}

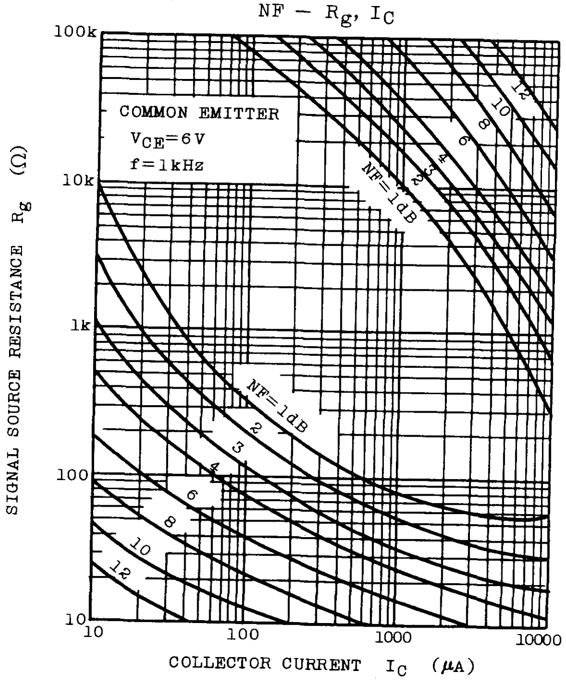




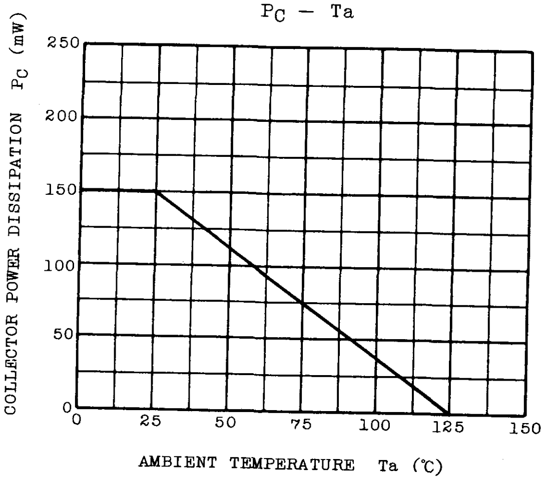
h PARAMETER — I_E



NF — R_g, I_C



NF — R_g, I_C



P_C — Ta

2SC2714

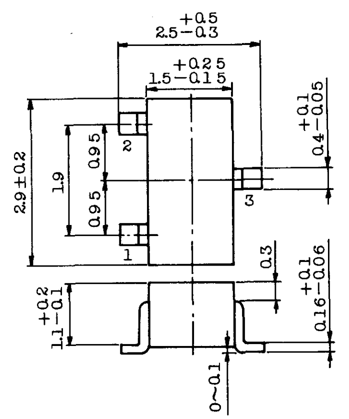
SILICON NPN EPITAXIAL PLANAR TYPE (PCT PROCESS)

HIGH FREQUENCY AMPLIFIER APPLICATIONS.
FM, RF, MIX, IF AMPLIFIER APPLICATIONS.

FEATURES:

- Small Reverse Transfer Capacitance : C_{re}=0.7pF (Typ.)
- Low Noise Figure : NF=2.5dB (Typ.) (f=100MHz)

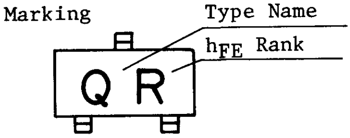
Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	—
EIAJ	SC−59
TOSHIBA	2−3F1A

Weight : 0.012g



MAXIMUM RATINGS (Ta=25°C)

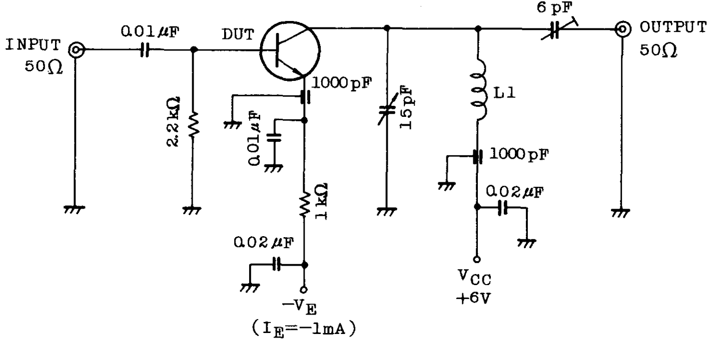
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	40	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	20	mA
Emitter Current	I_E	-20	mA
Collector Power Dissipation	P_C	100	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=18V, I_E=0	-	-	0.5	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=4V, I_C=0	-	-	0.5	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=6V, I_C=1mA	40	-	200	
Reverse Transfer Capacitance	C_{re}	V_{CE}=6V, f=1MHz	-	0.70	-	pF
Transition Frequency	f_T	V_{CE}=6V, I_C=1mA	-	550	-	MHz
Collector-Base Time Constant	$C_c \cdot r_{bb'}$	V_{CE}=6V, I_E=-1mA, f=30MHz	-	-	30	ps
Noise Figure	NF	V_{CE}=6V, I_E=-1mA f=100MHz, Fig.	-	2.5	5.0	dB
Power Gain	G_{pe}		15	18	-	dB

Note : h_{FE} Classification R : 40~80, O : 70~140, Y : 100~200

Fig. NF, G_{pe} TEST CIRCUIT



L1 : 0.8mmϕ SILVER PLATED COPPER WIRE, 4T, 10ID, 8 LENGTH

y PARAMETER (Typ.)

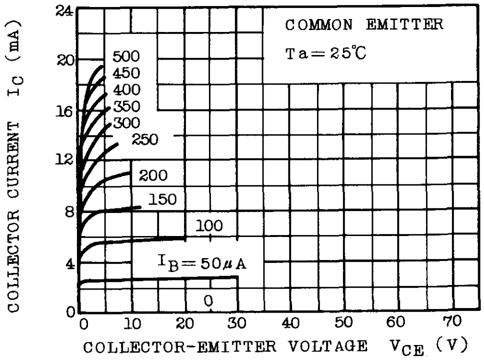
(1) COMMON EMITTER (V_{CE}=6V, I_E=-1mA, f=100MHz)

CHARACTERISTIC	SYMBOL	TYP.	UNIT
Input Conductance	g_{ie}	2.9	mS
Input Capacitance	C_{ie}	10.2	pF
Reverse Transfer Admittance	$\lvert y_{re} \rvert$	0.33	mS
Phase Angle of Reverse Transfer Admittance	θ_{re}	-90	°
Forward Transfer Admittance	$\lvert y_{fe} \rvert$	40	mS
Phase Angle of Forward Transfer Admittance	θ_{fe}	-20	°
Output Conductance	g_{oe}	45	μS
Output Capacitance	C_{oe}	1.1	pF

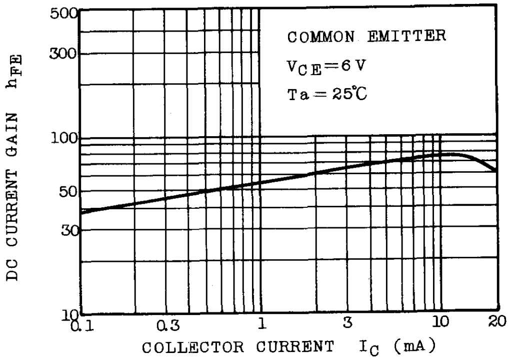
(2) COMMON BASE (V_{CE}=6V, I_E=-1mA, f=100MHz)

CHARACTERISTIC	SYMBOL	TYP.	UNIT
Input Conductance	g_{ib}	34	mS
Input Capacitance	C_{ib}	-10	pF
Reverse Transfer Admittance	$\lvert y_{rb} \rvert$	0.27	mS
Phase Angle of Reverse Transfer Admittance	θ_{rb}	-105	°
Forward Transfer Admittance	$\lvert y_{fb} \rvert$	34	mS
Phase Angle of Forward Transfer Admittance	θ_{fb}	165	°
Output Conductance	g_{ob}	45	μS
Output Capacitance	C_{ob}	1.1	pF

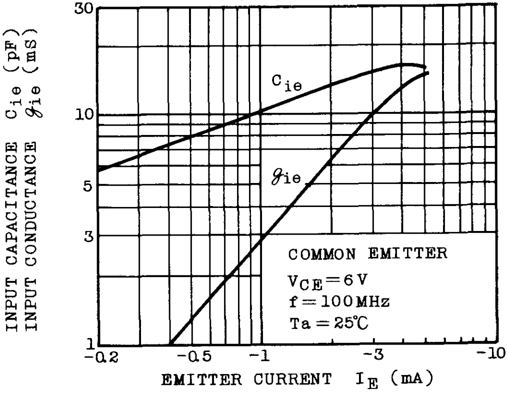
$I_C - V_{CE}$



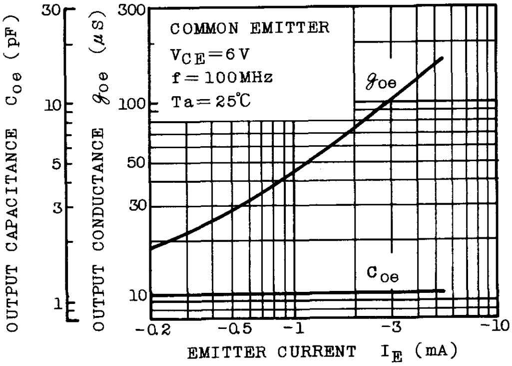
$h_{FE} - I_C$



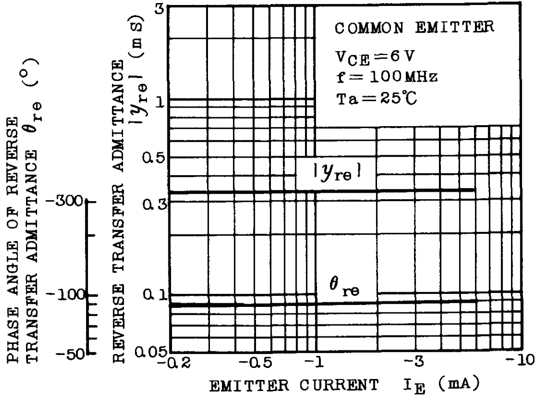
C_{ie}, $g_{ie} - I_E$



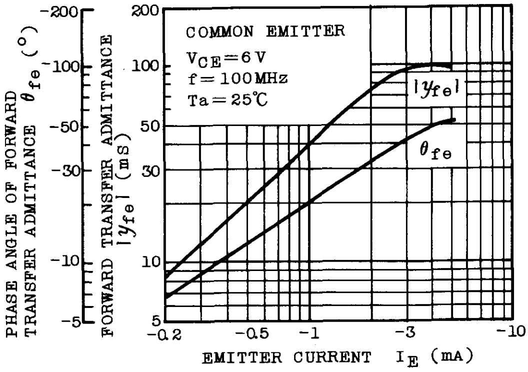
C_{oe}, $g_{oe} - I_E$



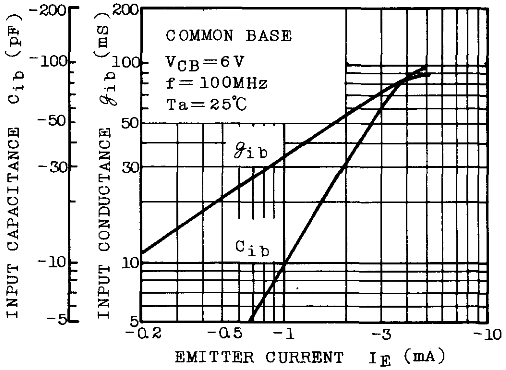
$|y_{re}|$, $\theta_{re} - I_E$



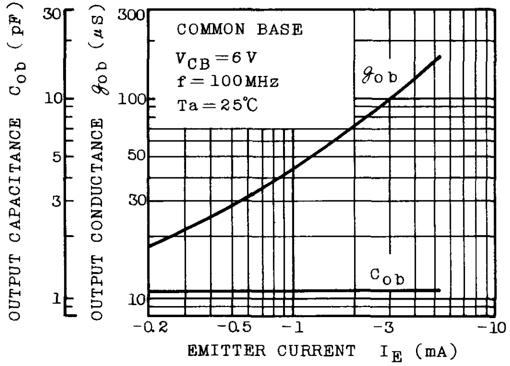
$|y_{fe}|$, $\theta_{fe} - I_E$



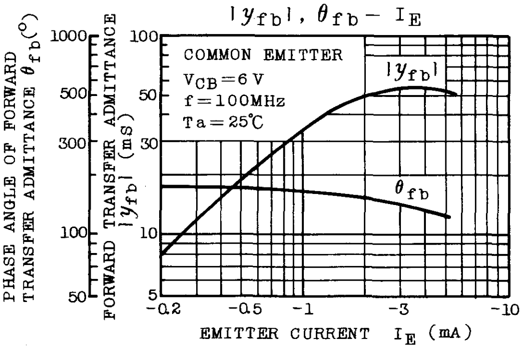
$C_{ib}, g_{ib} - I_E$



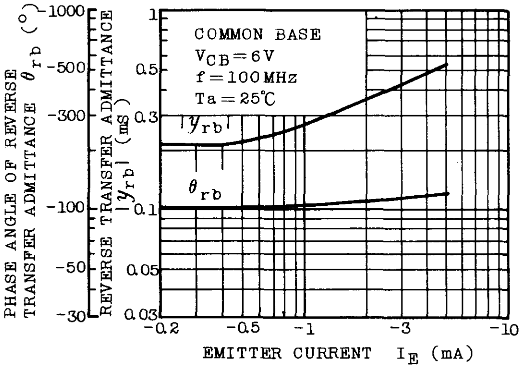
$C_{ob}, g_{ob} - I_E$



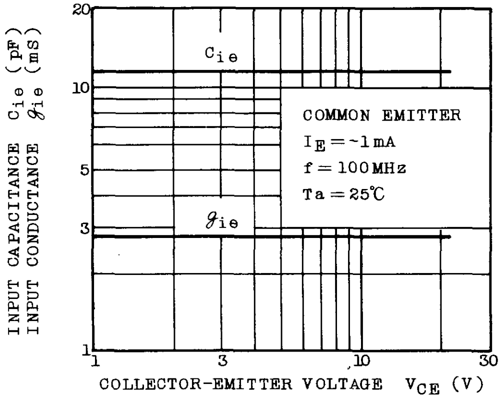
$|y_{fb}|, \theta_{fb} - I_E$



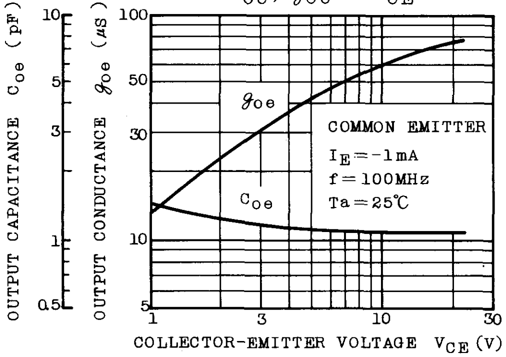
$|y_{rb}|, \theta_{rb} - I_E$

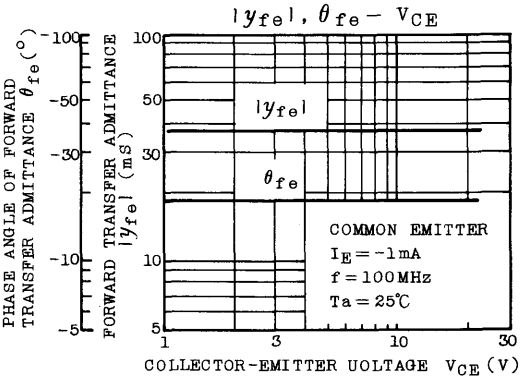


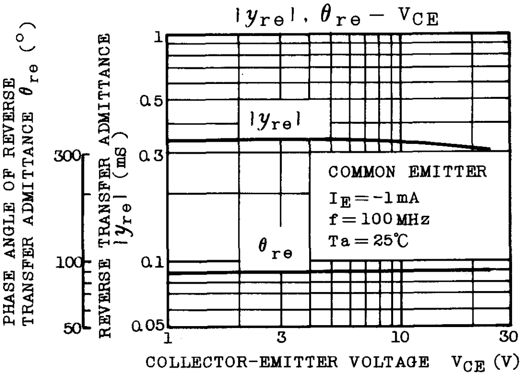
$C_{ie}, g_{ie} - V_{CE}$

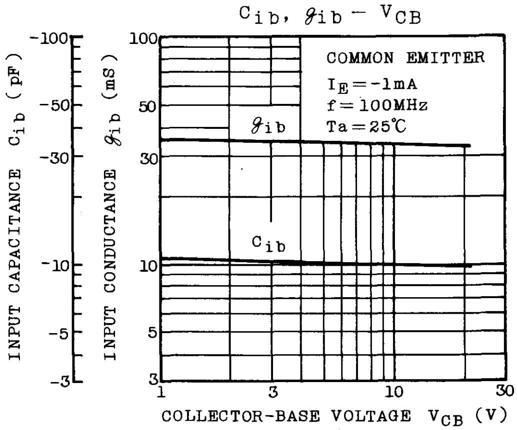


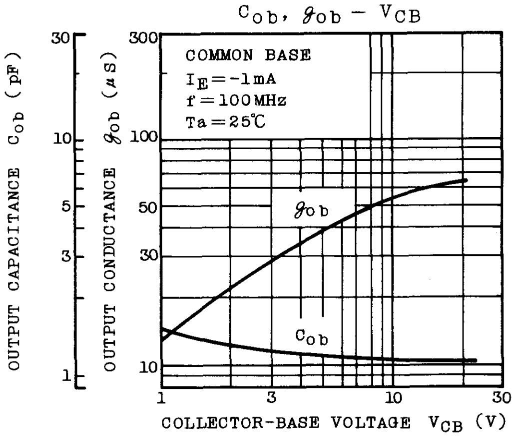
$C_{oe}, g_{oe} - V_{CE}$

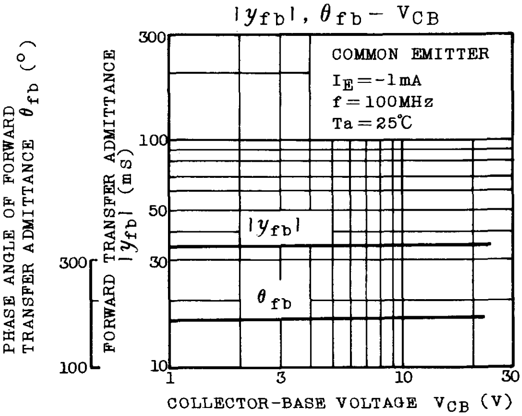


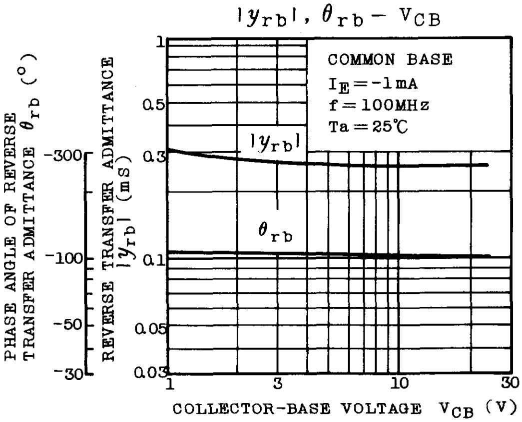

$|y_{fe}|, \theta_{fe} - V_{CE}$

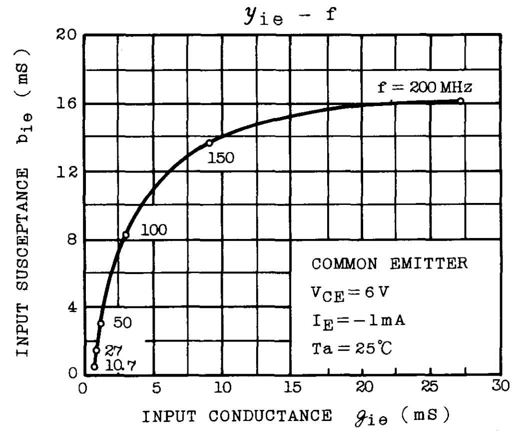

$|y_{re}|, \theta_{re} - V_{CE}$

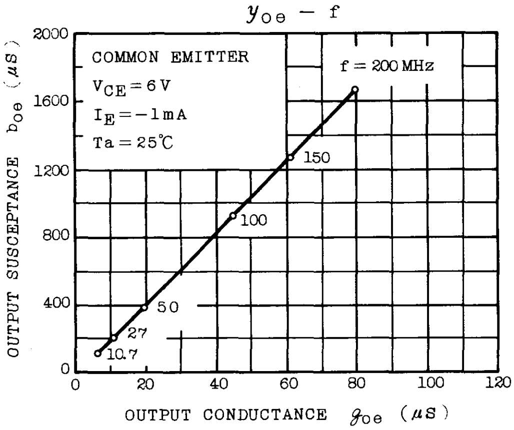

$C_{ib}, g_{ib} - V_{CB}$

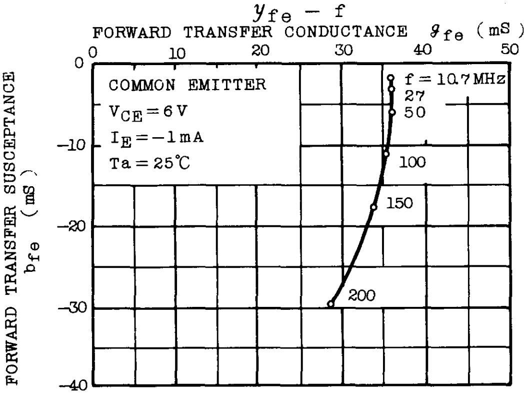

$C_{ob}, g_{ob} - V_{CB}$

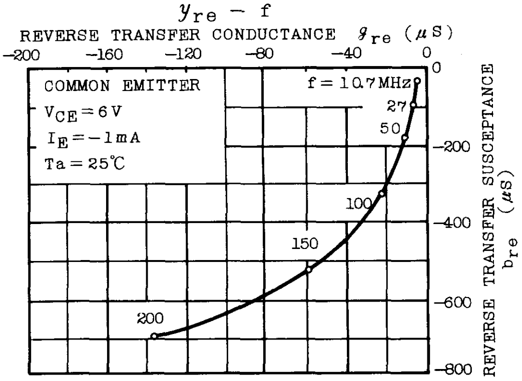

$|y_{fb}|, \theta_{fb} - V_{CB}$

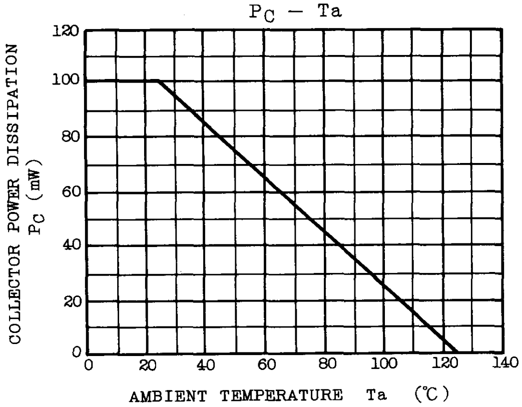

$|y_{rb}|, \theta_{rb} - V_{CB}$


y_{ie} – f
INPUT SUSCEPTANCE b_{ie} (mS)
INPUT CONDUCTANCE g_{ie} (mS)
20
16
12
8
4
0
0
5
10
15
20
25
30
f = 200 MHz
150
100
50
27
10.7
COMMON EMITTER
V_{CE} = 6 V
I_E = −1 mA
Ta = 25℃


y_{oe} – f
OUTPUT SUSCEPTANCE b_{oe} (μS)
OUTPUT CONDUCTANCE g_{oe} (μS)
2000
1600
1200
800
400
0
0
20
40
60
80
100
120
COMMON EMITTER
V_{CE} = 6 V
I_E = −1 mA
Ta = 25℃
f = 200 MHz
150
100
50
27
10.7


y_{fe} – f
FORWARD TRANSFER CONDUCTANCE g_{fe} (mS)
FORWARD TRANSFER SUSCEPTANCE b_{fe} (mS)
0
10
20
30
40
50
0
−10
−20
−30
−40
COMMON EMITTER
V_{CE} = 6 V
I_E = −1 mA
Ta = 25℃
f = 10.7 MHz
27
50
100
150
200


y_{re} – f
REVERSE TRANSFER CONDUCTANCE g_{re} (μS)
REVERSE TRANSFER SUSCEPTANCE b_{re} (μS)
−200
−160
−120
−80
−40
0
0
−200
−400
−600
−800
COMMON EMITTER
V_{CE} = 6 V
I_E = −1 mA
Ta = 25℃
f = 10.7 MHz
27
50
100
150
200


P_C – Ta
COLLECTOR POWER DISSIPATION P_C (mW)
AMBIENT TEMPERATURE Ta (℃)
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140

2SC2715

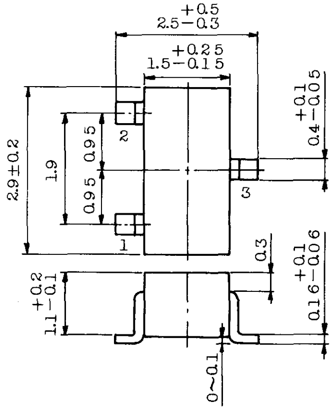
SILICON NPN EPITAXIAL PLANAR TYPE (PCT PROCESS)

HIGH FREQUENCY AMPLIFIER APPLICATIONS.

Unit in mm

FEATURES:

- High Power Gain : G_{pe}=29dB(Typ.) (f=10.7MHz)
- Recommended for FM IF, OSC Stage and AM CONV. IF Stage.

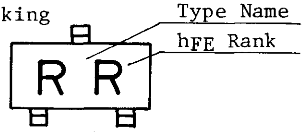


1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	—
EIAJ	SC−59
TOSHIBA	2−3F1A

Weight : 0.012g

Marking



MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	35	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	50	mA
Emitter Current	I_E	-50	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=35V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=4V, I_C=0	-	-	1.0	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=12V, I_C=2mA	40	-	240	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	0.4	V
Base-Emitter Voltage	V_{BE}	I_C=10mA, I_B=1mA	-	-	1.0	V
Transition Frequency	f_T	V_{CE}=10V, I_C=1mA	100	-	400	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	1.4	2.0	3.2	pF
Collector-Base Time Constant	$C_c \cdot r_{bb'}$	V_{CE}=10V, I_E=-1mA, f=30MHz	10	-	50	pS
Power Gain	G_{pe}	V_{CC}=6V, I_E=-1mA, f=10.7MHz (Fig.)	27	29	33	dB

Note : h_{FE} Classification R : 40~80, O : 70~140, Y : 120~240

y PARAMETERS (Typ.)

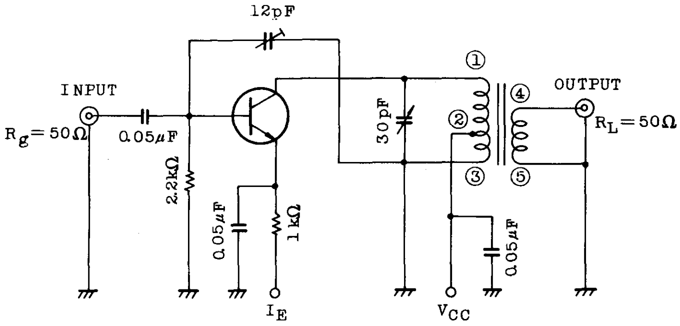
(1) (COMMON EMITTER f=455kHz, Ta=25°C)

CHARACTERISTIC	SYMBOL	2SC2715-R	2SC2715-O	2SC2715-Y	UNIT
Collector-Emitter Voltage	V_{CE}	6	6	6	V
Emitter Current	I_E	-1	-1	-1	mA
Input Conductance	g_{ie}	0.58	0.41	0.26	mS
Input Capacitance	C_{ie}	53	46	38	pF
Output Conductance	g_{oe}	1.9	2.7	4.8	μS
Output Capacitance	C_{oe}	2.6	2.8	3.6	pF
Forward Transfer Admittance	$\|y_{fe}\|$	38	38	38	mS
Phase Angle of Forward Transfer Admittance	θ_{fe}	-0.79	-0.83	-0.92	°
Reverse Transfer Admittance	$\|y_{re}\|$	5.7	5.7	6.2	μS
Phase Angle of Reverse Transfer Admittance	θ_{re}	-90	-90	-90	°

(2) (COMMON EMITTER f=10.7MHz, Ta=25°C)

CHARACTERISTIC	SYMBOL	2SC2715-R	2SC2715-O	2SC2715-Y	UNIT
Collector Emitter Voltage	V_{CE}	6	6	6	V
Emitter Current	I_E	-1	-1	-1	mA
Input Conductance	g_{ie}	1.04	0.85	0.65	mS
Input Capacitance	C_{ie}	49	43	36	pF
Output Conductance	g_{oe}	10	15	28	μS
Output Capacitance	C_{oe}	2.7	2.9	3.6	pF
Forward Transfer Admittance	$\|y_{fe}\|$	37	37	37	mS
Phase Angle of Forward Transfer Admittance	θ_{fe}	-9.6	-10.4	-11.5	°
Reverse Transfer Admittance	$\|y_{re}\|$	120	120	140	μS
Phase Angle of Reverse Transfer Admittance	θ_{re}	-90	-90	-90	°

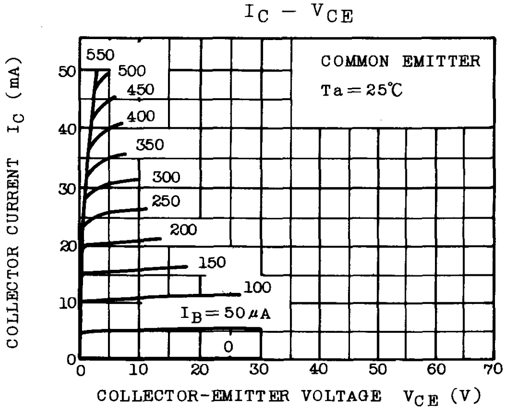
Fig. G_{pe} TEST CIRCUIT

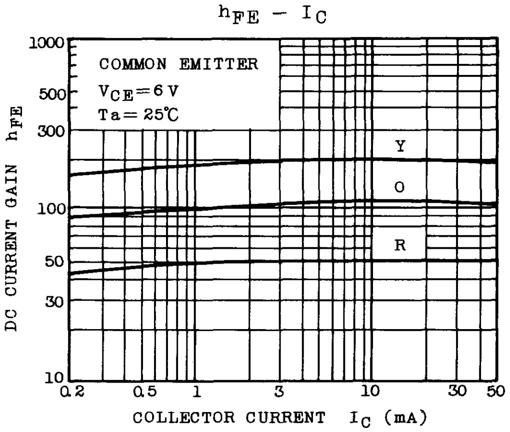


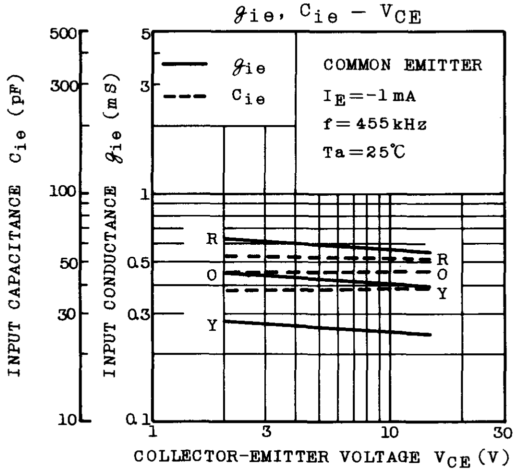
T : ①－② 0.1mmØ UEW 20T

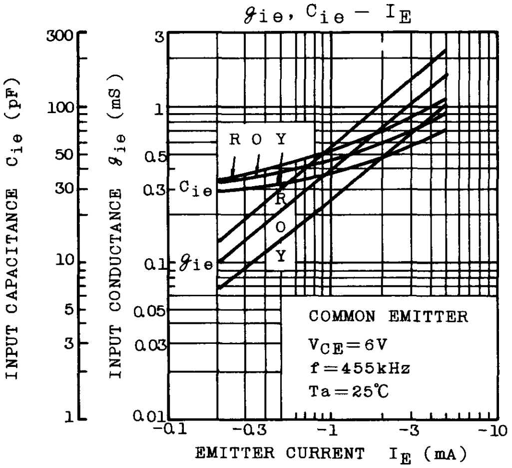
②－③ 0.1mmØ UEW 8T

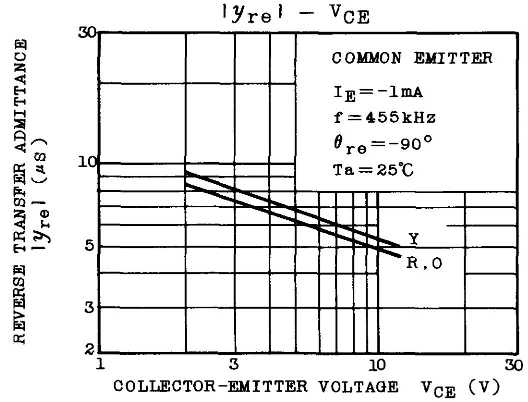
④－⑤ 0.1mmØ UEW 2T

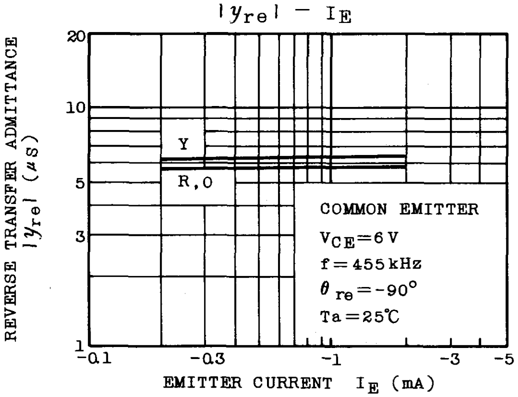


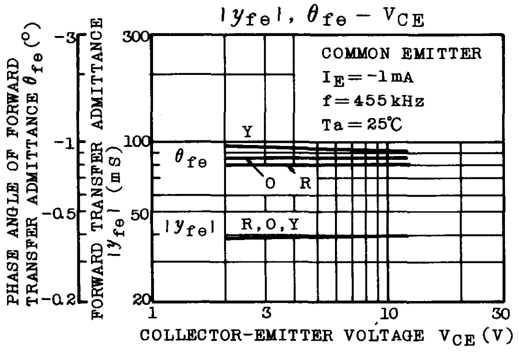


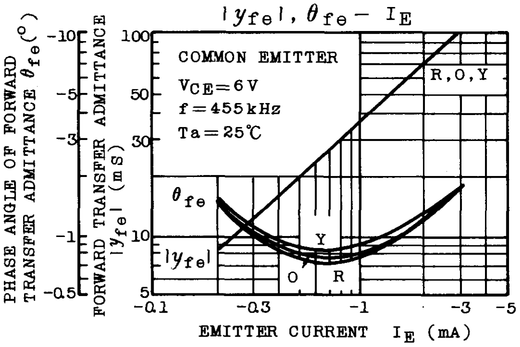

gie, Cie – VCE
gie
Cie
COMMON EMITTER
IE=-1 mA
f=455kHz
Ta=25℃
R
O
Y
R
O
Y
INPUT CAPACITANCE Cie (pF)
500
300
100
50
30
10
INPUT CONDUCTANCE gie (mS)
5
3
1
0.5
0.3
0.1
1
3
10
30
COLLECTOR-EMITTER VOLTAGE VCE (V)


gie, Cie – IE
R O Y
Cie
R
O
Y
gie
COMMON EMITTER
VCE=6V
f=455kHz
Ta=25℃
INPUT CAPACITANCE Cie (pF)
300
100
50
30
10
5
3
1
INPUT CONDUCTANCE gie (mS)
3
1
0.5
0.3
0.1
0.05
0.03
0.01
-0.1
-0.3
-1
-3
-10
EMITTER CURRENT IE (mA)

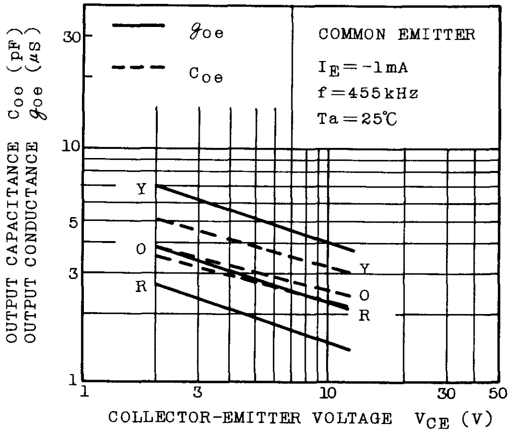

|yre| – VCE
COMMON EMITTER
IE=-1mA
f=455kHz
θre=-90°
Ta=25℃
Y
R,O
REVERSE TRANSFER ADMITTANCE |yre| (μS)
30
10
5
3
2
1
3
10
30
COLLECTOR-EMITTER VOLTAGE VCE (V)


|yre| – IE
Y
R,O
COMMON EMITTER
VCE=6V
f=455kHz
θre=-90°
Ta=25℃
REVERSE TRANSFER ADMITTANCE |yre| (μS)
20
10
5
3
1
-0.1
-0.3
-1
-3
-5
EMITTER CURRENT IE (mA)

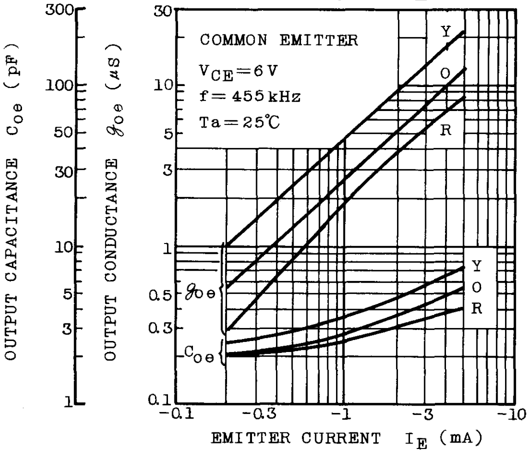

|yfe|, θfe – VCE
COMMON EMITTER
IE=-1mA
f=455kHz
Ta=25℃
Y
θfe
O
R
|yfe|
R,O,Y
PHASE ANGLE OF FORWARD TRANSFER ADMITTANCE θfe (°)
-3
-1
-0.5
-0.2
FORWARD TRANSFER ADMITTANCE |yfe| (mS)
300
100
50
20
1
3
10
30
COLLECTOR-EMITTER VOLTAGE VCE (V)


|yfe|, θfe – IE
COMMON EMITTER
VCE=6V
f=455kHz
Ta=25℃
R,O,Y
θfe
|yfe|
Y
O
R
PHASE ANGLE OF FORWARD TRANSFER ADMITTANCE θfe (°)
-10
-5
-3
-1
-0.5
FORWARD TRANSFER ADMITTANCE |yfe| (mS)
100
50
30
10
5
-0.1
-0.3
-1
-3
-5
EMITTER CURRENT IE (mA)

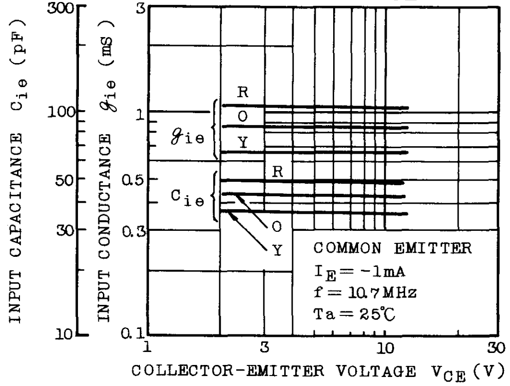
g_{oe}, C_{oe} – V_{CE}



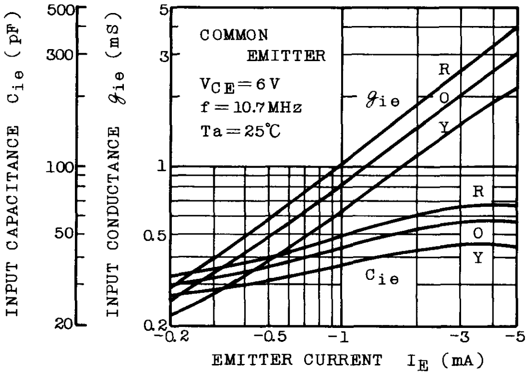
g_{oe}, C_{oe} – I_E



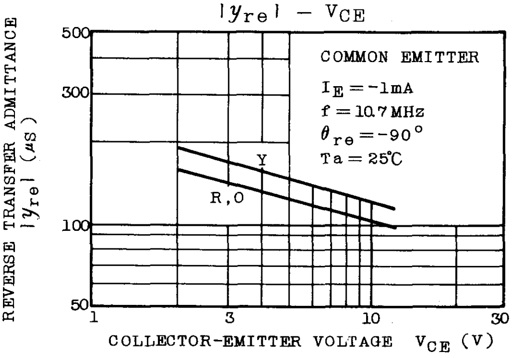
g_{ie}, C_{ie} – V_{CE}



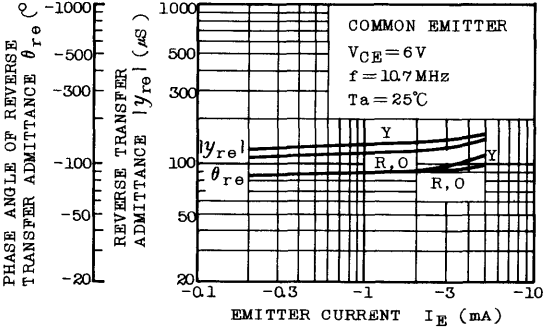
g_{ie}, C_{ie} – I_E



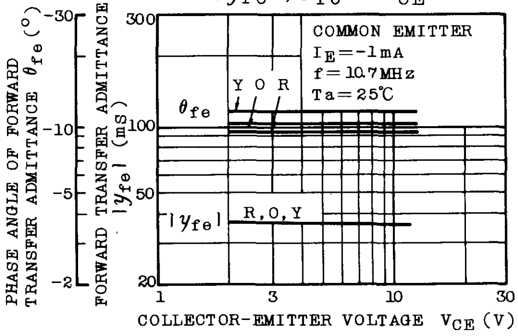
$|y_{re}|$ – V_{CE}



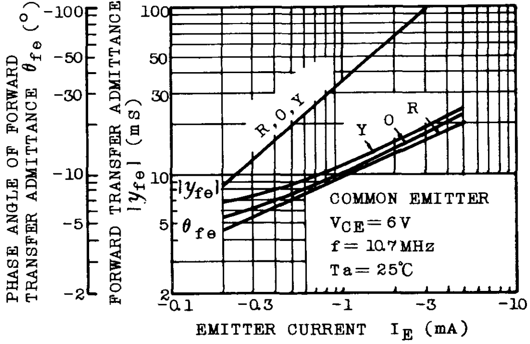
$|y_{re}|$, θ_{re} – I_E



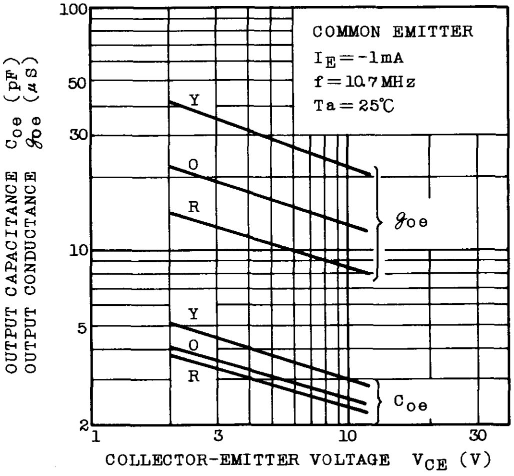
$|y_{fe}|, \theta_{fe} - V_{CE}$



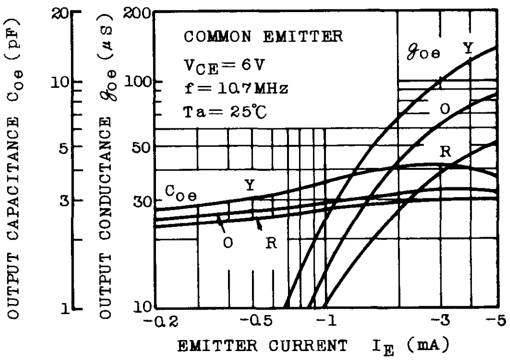
$|y_{fe}|, \theta_{fe} - I_E$



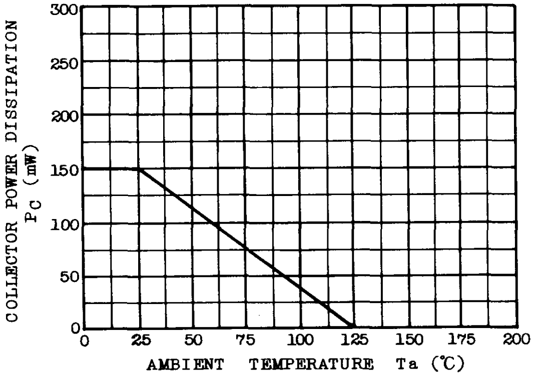
$g_{oe}, C_{oe} - V_{CE}$



$g_{oe}, C_{oe} - I_E$



$P_C - Ta$



2SC2716

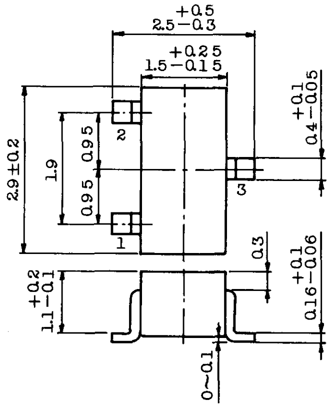
SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

HIGH FREQUENCY AMPLIFIER APPLICATIONS.
AM HIGH FREQUENCY AMPLIFIER APPLICATIONS.
AM FREQUENCY CONVERTER APPLICATIONS.

FEATURES:

- Low Noise Figure : NF=3.5dB(Max.) (f=1MHz)

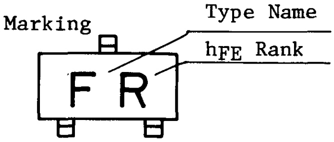
Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	−
EIAJ	SC−59
TOSHIBA	2−3F1A

Weight : 0.012g



MAXIMUM RATINGS ($T_a=25^\circ C$)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	35	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	100	mA
Emitter Current	I_E	-100	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	Tstg	-55~125	°C

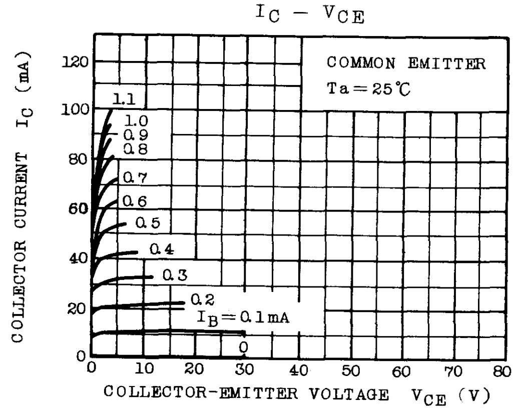
ELECTRICAL CHARACTERISTICS ($T_a=25^\circ C$)

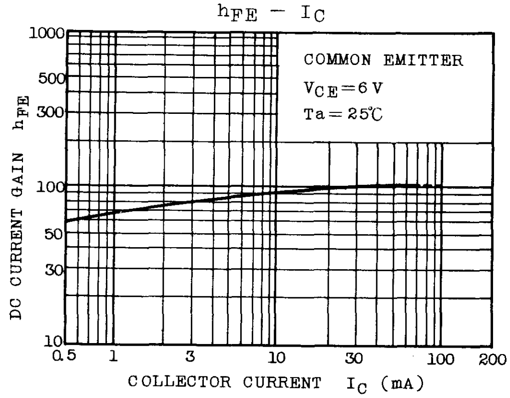
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=20V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=2V, I_C=0	-	-	1.0	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=12V, I_C=2mA	40	-	240	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	0.4	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=10mA, I_B=1mA	-	-	1.0	V
Transition Frequency	f_T	V_{CE}=10V, I_C=2mA	80	120	-	MHz
Reverse Transfer Capacitance	Cre	V_{CB}=10V, I_E=0, f=1MHz	-	2.2	3.0	pF
Collector-Base Time Constant	Cc·rbb'	V_{CE}=10V, I_E=-1mA, f=30MHz	-	30	50	ps
Noise Figure	NF	V_{CE}=10V, I_E=-1mA f=1MHz, R_g=50Ω	-	2.0	3.5	dB

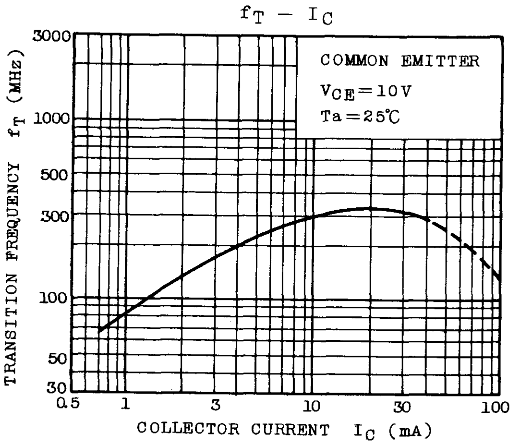
Note : h_{FE} Classification R : 40~80, O : 70~140, Y : 120~240

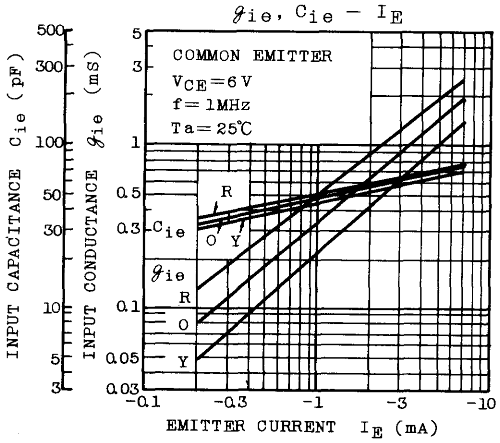
y PARAMETERS (Typ.) (COMMON EMITTER $V_{CE}=6V$, $I_E=-1mA$, f=1MHz)

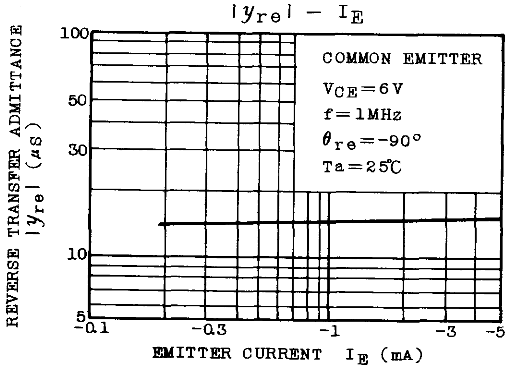
CHARACTERISTIC	SYMBOL	2SC2716-R	2SC2716-O	2SC2716-Y	UNIT
Input Conductance	g_{ie}	0.5	0.35	0.22	mS
Input Capacitance	C_{ie}	50	48	46	pF
Output Conductance	g_{oe}	4	5	6.5	μS
Output Capacitance	C_{oe}	3.7	3.4	3.2	pF
Forward Transfer Admittance	$\|y_{fe}\|$	36	36	36	mS
Phase Angle of Forward Transfer Admittance	θ_{fe}	-1.6	-1.6	-1.6	°
Reverse Transfer Admittance	$\|y_{re}\|$	14	14	14	μS
Phase Angle of Reverse Transfer Admittance	θ_{re}	-90	-90	-90	°

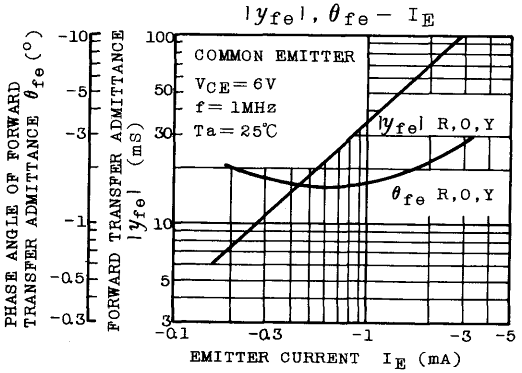

$I_C - V_{CE}$


$h_{FE} - I_C$

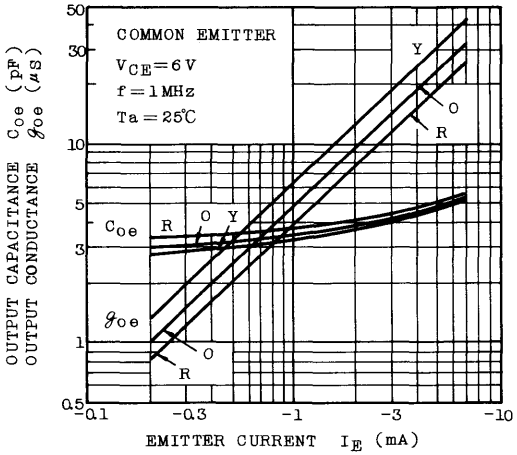

$f_T - I_C$


$g_{ie}, C_{ie} - I_E$

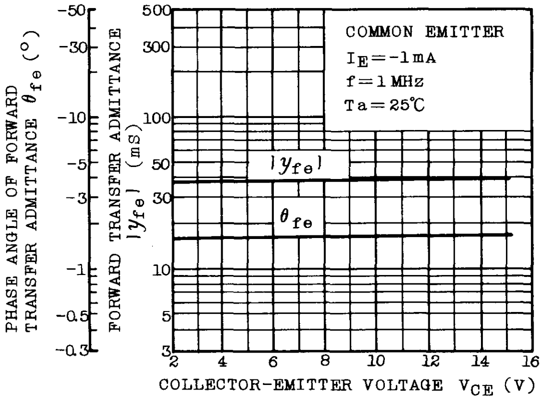

$|y_{re}| - I_E$


$|y_{fe}|, \theta_{fe} - I_E$

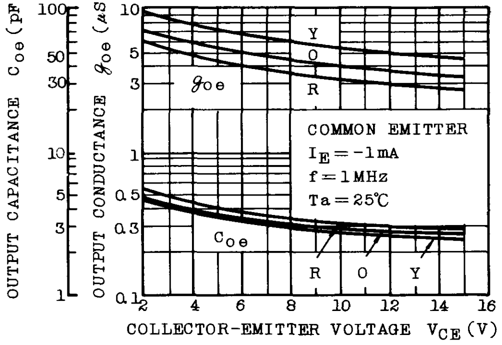
g_{oe}, C_{oe} – I_E



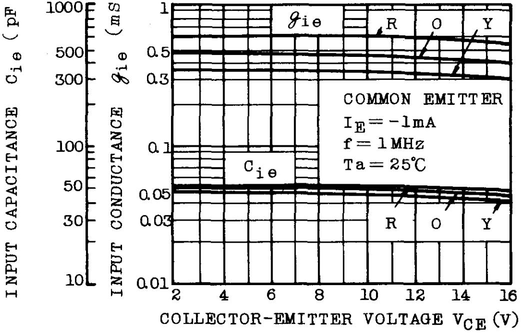
$|y_{fe}|$, θ_{fe} – V_{CE}



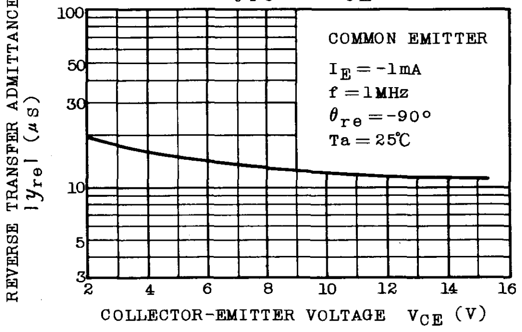
g_{oe}, C_{oe} – V_{CE}



g_{ie}, C_{ie} – V_{CE}



$|y_{re}|$ – V_{CE}



2SC2753

SILICON NPN EPITAXIAL PLANAR TYPE

VHF ~ UHF BAND LOW NOISE AMPLIFIER APPLICATIONS.

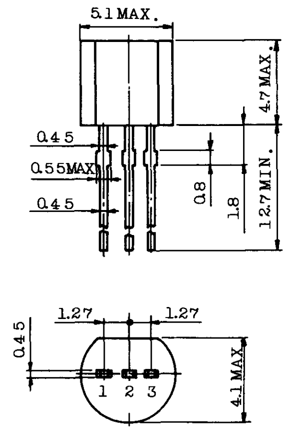
FEATURES:

. Low Noise Figure, High Gain

. NF=1.5dB, $|S_{21e}|^2$=16dB (f=500MHz) (Typ.)

. NF=1.7dB, $|S_{21e}|^2$=10.5dB(f=1000MHz)(Typ.)

Unit in mm



1. BASE
2. EMITTER
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1E

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	17	V
Collector-Emitter Voltage	V_{CEO}	12	V
Emitter-Base Voltage	V_{EBO}	3	V
Collector Current	I_C	70	mA
Emitter Current	I_E	-70	mA
Collector Power Dissipation	P_C	300	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55 ~150	°C

MICROWAVE CHARACTERISTICS (Ta=25°C)

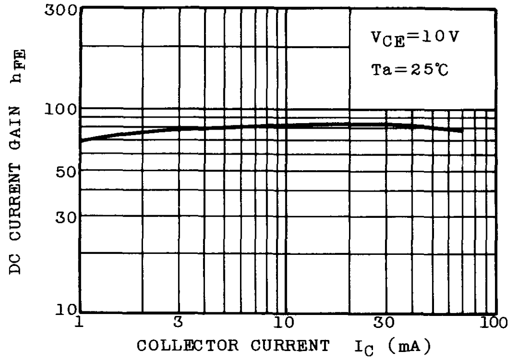
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Transition Frequency	f_T	V_{CE}=10V, I_C=20mA	-	5	-	GHz
Insertion Gain	$\|S_{21e}\|^2(1)$	V_{CE}=10V, I_C=20mA, f=500MHz	-	16	-	dB
	$\|S_{21e}\|^2(2)$	V_{CE}=10V, I_C=20mA, f=1000MHz	-	10.5	-	dB
Noise Figure	NF(1)	V_{CE}=10V, I_C=5mA, f=500MHz	-	1.5	-	dB
	NF(2)	V_{CE}=10V, I_C=5mA, f=1000MHz	-	1.7	-	dB

ELECTRICAL CHARACTERISTICS (Ta=25°C)

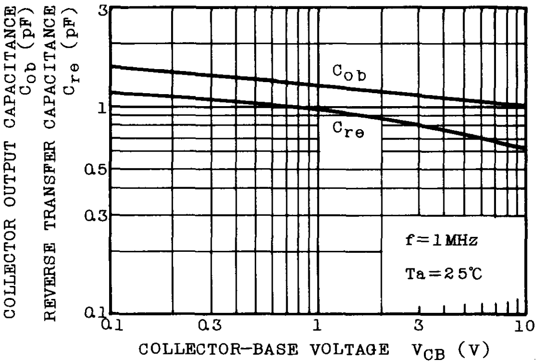
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=10V, I_E=0	-	-	1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=1V, I_E=0	-	-	1	μA
DC Current Gain	h_{FE}	V_{CE}=10V, I_C=20mA	30	-	180	
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	1.1	-	pF
Reverse Transfer Capacitance	C_{re}	(Note)	-	0.65	-	pF

Note : Cre is measured by 3-terminal method with Capacitance Bridge.

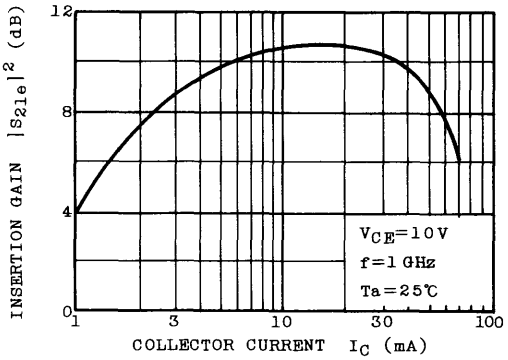
$h_{FE} - I_C$



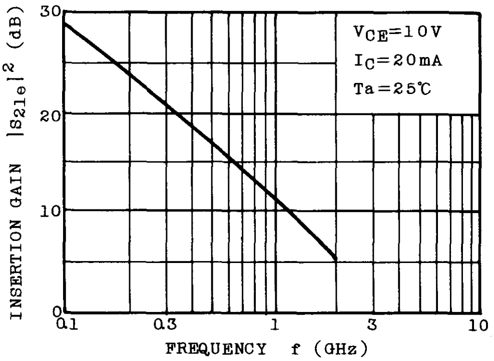
$C_{ob}, C_{re} - V_{CB}$



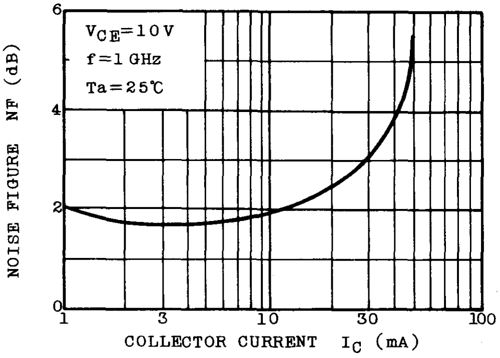
$|S_{21e}|^2 - I_C$



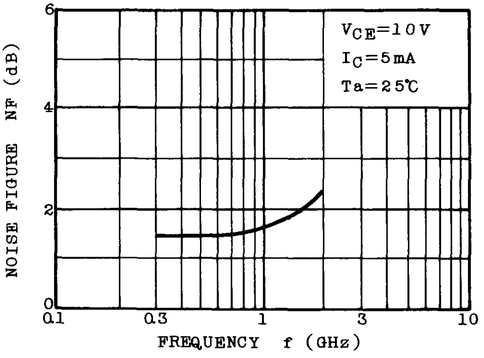
$|S_{21e}|^2 - f$



NF — I_C

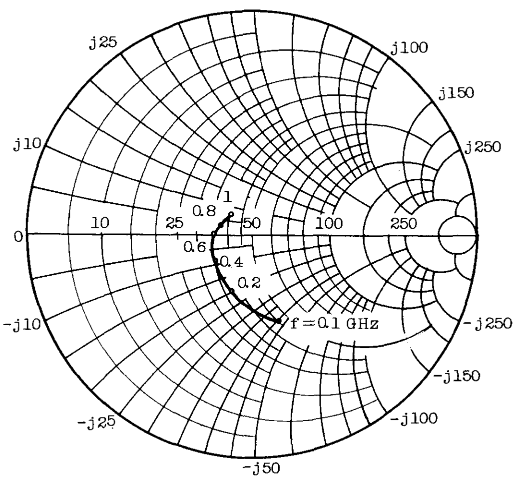


NF — f

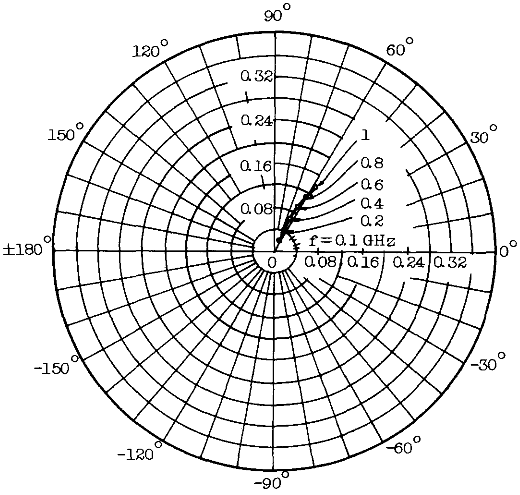


S_{11e}
V_{CE}=10V
I_C=20mA
Ta=25°C

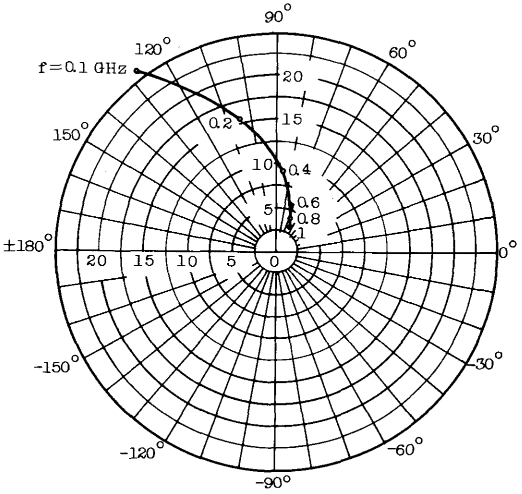
(UNIT:Ω)



S_{12e}
V_{CE}=10V
I_C=20mA
Ta=25°C

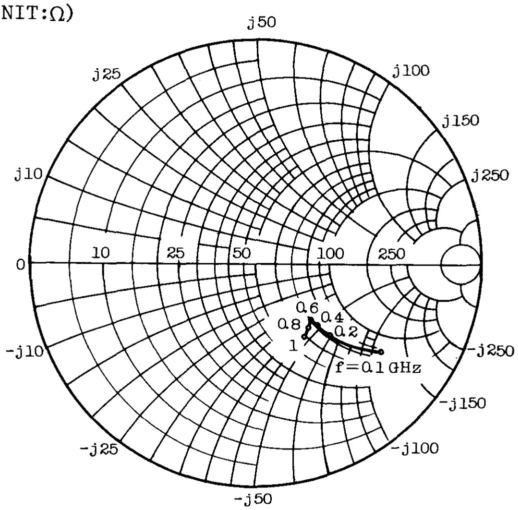


S_{21e}
V_{CE}=10V
I_C=20mA
Ta=25°C



S_{22e}
V_{CE}=10V
I_C=20mA
Ta=25°C

(UNIT:Ω)



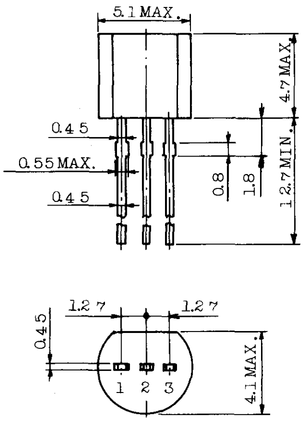
SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

2SC2754

HIGH FREQUENCY AMPLIFIER APPLICATIONS.
LOW FREQUENCY AMPLIFIER APPLICATIONS.
HIGH SPEED SWITCHING APPLICATIONS.

- High Transition Frequency : f_T=400MHz(Typ.)
- Low $V_{CE(sat)}$: $V_{CE(sat)}$=0.5V(Max.)
- Small Collector Output Capacitance : C_{ob}=3.5pF(Max.)
- High Speed Switching.
- Designed for Complementary Use with 2SA1164.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

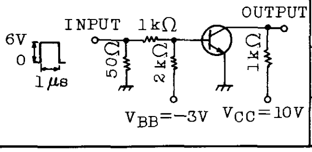
JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

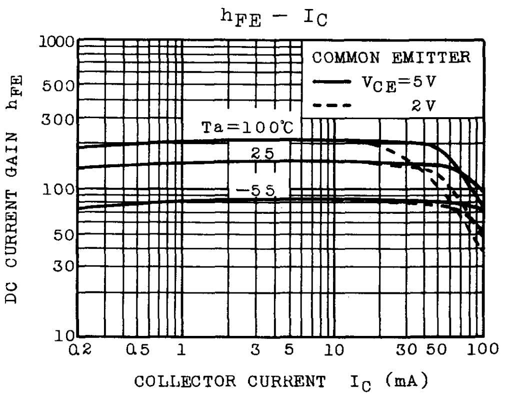
MAXIMUM RATINGS (Ta=25°C)

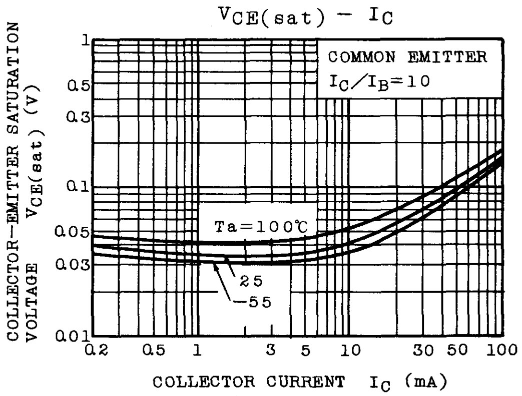
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	35	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	100	mA
Base Current	I_B	50	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~ 125	°C

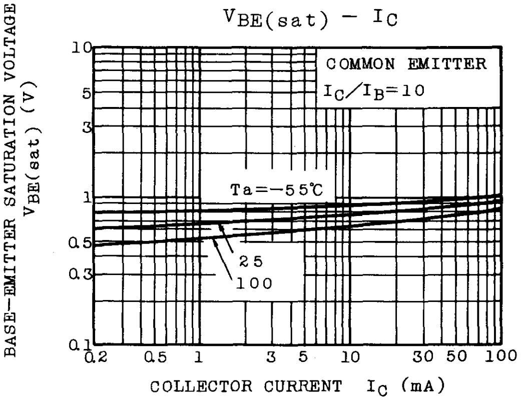
ELECTRICAL CHARACTERISTICS (Ta=25°C)

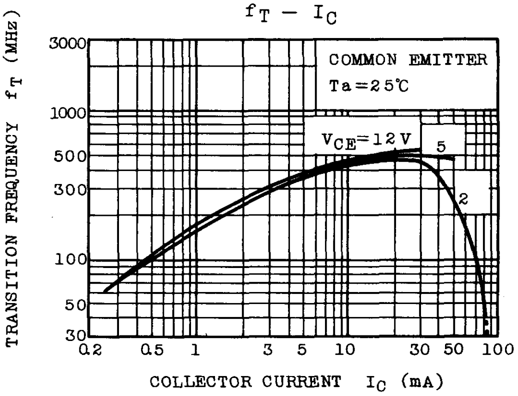
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=35V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain		h_{FE} (Note)	V_{CE}=12V, I_C=2mA	70	-	400	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	0.5	V
Base-Emitter Voltage		V_{BE}	V_{CE}=12V, I_C=2mA	0.5	-	0.8	V
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=10mA, I_B=1mA	-	-	1.0	V
Transition Frequency		f_T	V_{CE}=12V, I_C=10mA	100	400	-	MHz
Collector Output Capacitance		Cob	V_{CB}=10V, I_E=0, f=1MHz	-	2	3.5	pF
Switching Time	Turn-on Time	t_{on}		-	30	-	ns
	Storage Time	t_{stg}		-	400	-	
	Fall Time	t_f		-	70	-	

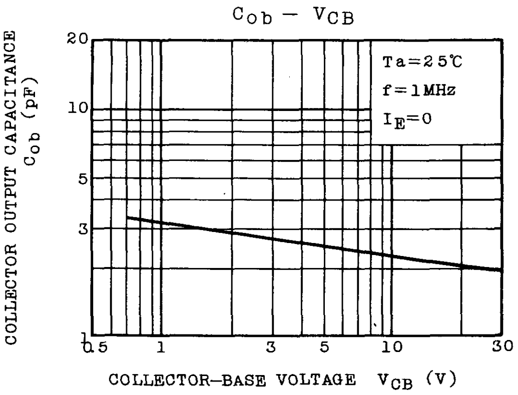
Note: h_{FE} Classification O : 70~140, Y : 120~240, GR : 200~400

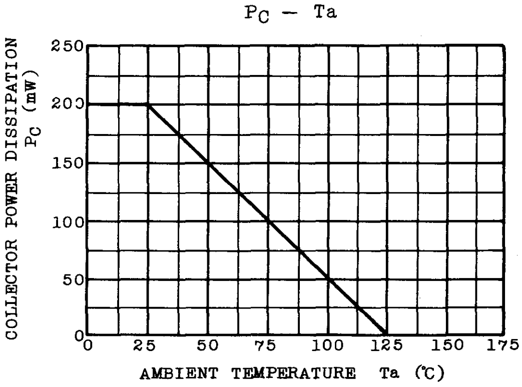

$h_{FE} - I_C$


$V_{CE(sat)} - I_C$


$V_{BE(sat)} - I_C$


$f_T - I_C$


$C_{ob} - V_{CB}$

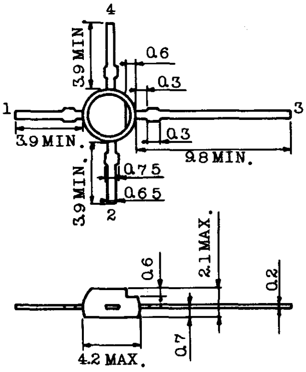

$P_C - Ta$

SILICON NPN PLANAR TYPE

2SC2804

UHF TV TUNER RF AMPLIFIER APPLICATIONS.

Unit in mm



1. EMITTER
2, 4. BASE
3. COLLECTOR

JEDEC	—
EIAJ	—
TOSHIBA	2−4F1B

Weight : 0.08g

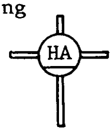
FEATURES:

- Low Noise Figure : NF=3.5dB(Typ.), f=800MHz
- High Power Gain : G_{pb}=16dB(Typ.), f=800MHz
- Excellent Forward AGC Characteristics

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	25	V
Collector-Emitter Voltage	V_{CEO}	20	V
Emitter-Base Voltage	V_{EBO}	3	V
Base Current	I_B	10	mA
Collector Current	I_C	20	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	Tstg	-55～125	°C

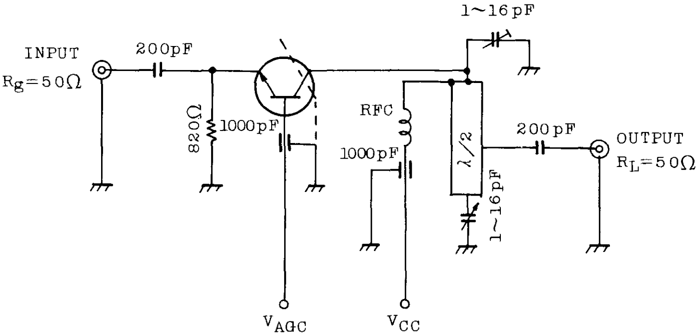
Marking



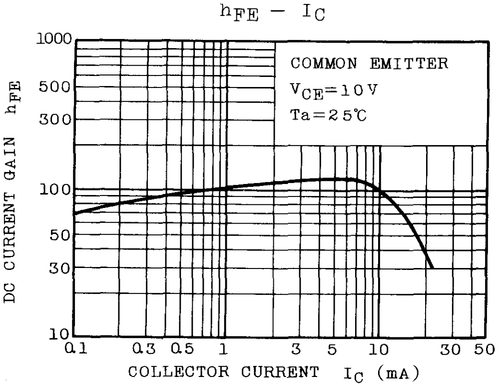
ELECTRICAL CHARACTERISTICS (Ta=25°C)

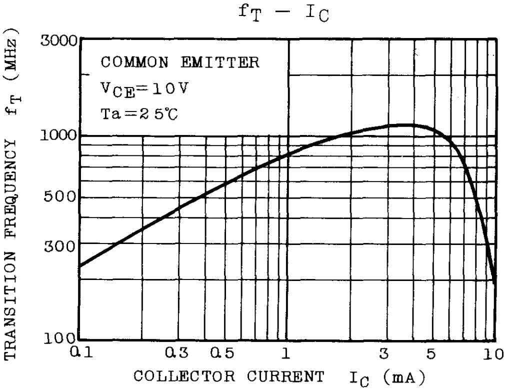
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=10V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=2V, I_C=0	-	-	1	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	20	-	-	V
DC Current Gain	h_{FE}	V_{CE}=10V, I_C=2mA	25	100	-	
Transition Frequency	f_T	V_{CE}=10V, I_C=2mA	600	900	-	MHz
Reverse Transfer Capacitance	C_{rb}	V_{CE}=10V, I_B=0, f=1MHz	-	0.25	0.45	pF
Power Gain	G_{pb}	V_{CC}=12V, V_{AGC}=3.0V	10	16	-	dB
Noise Figure	NF	f=800MHz (Fig. 1)	-	3.5	5.5	dB
AGC Voltage	V_{AGC}	V_{CC}=12V, G.R.=-20dB f=800MHz (Fig. 1)	4.75	6.0	7.25	V

Fig. 1 : 800MHz G_{pb}, NF, AND V_{AGC} TEST CIRCUIT

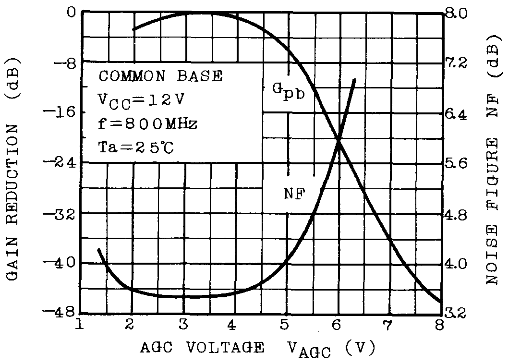


Note : V_{AGC} measured by the test circuit shown in Fig.1, when the power gain is reduced to 20dB compared with G_{pb} shown above Table.

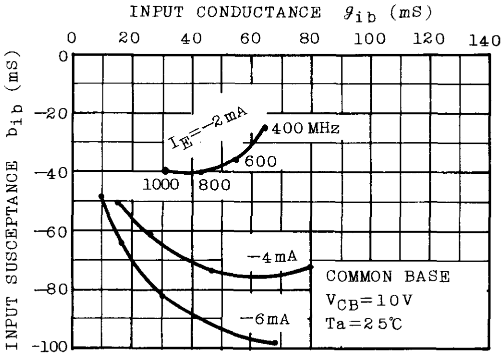




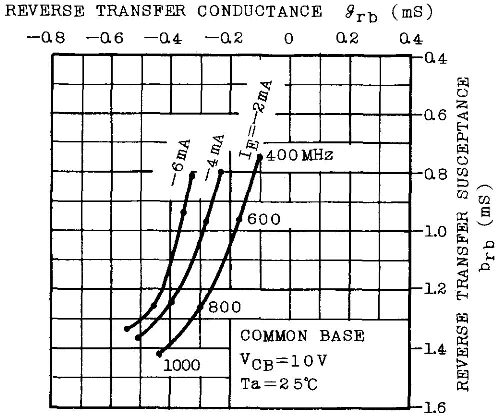
G_{pb}, NF — V_{AGC}



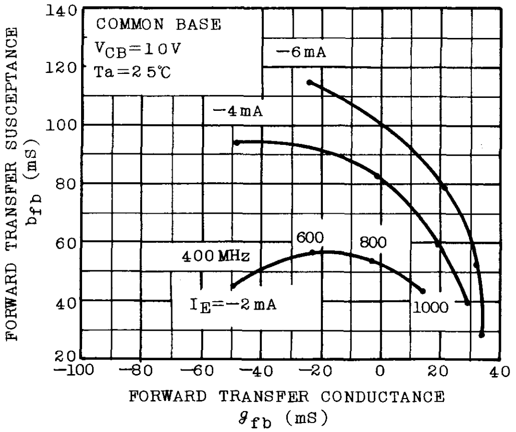
y_{ib} — f



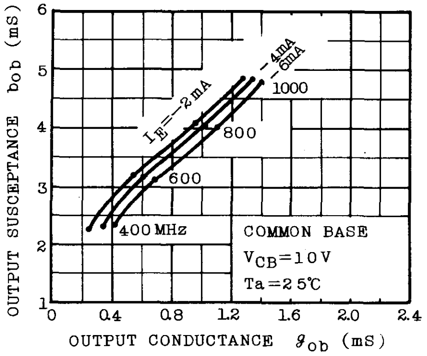
y_{rb} — f



y_{fb} — f



y_{ob} — f



2SC2805

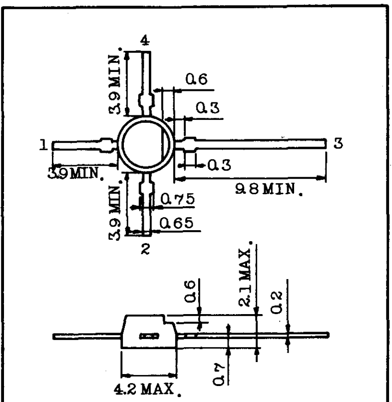
SILICON NPN EPITAXIAL PLANAR TYPE

TV TUNER, UHF OSCILLATOR APPLICATIONS.(COMMON BASE)
TV TUNER, UHF CONVERTER APPLICATIONS.(COMMON BASE)

FEATURES:

. High Transition Frequency : f_T=1500MHz (Typ.)
. Excellent Linearity

Unit in mm



1. BASE
2. COLLECTOR
3. EMITTER
4. NC.

JEDEC	—
EIAJ	—
TOSHIBA	2-4F1D

Weight : 0.08g

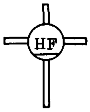
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	15	V
Emitter-Base Voltage	V_{EBO}	3	V
Base Current	I_B	25	mA
Collector Current	I_C	50	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

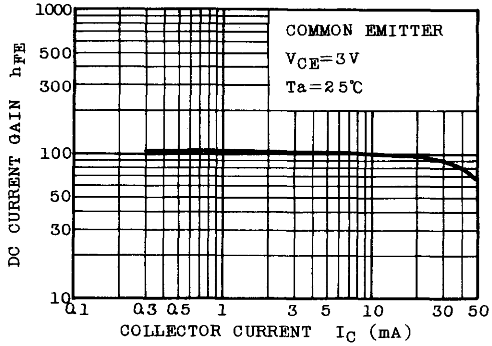
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=15V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=3V, I_C=0	-	-	1.0	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	15	-	-	V
DC Current Gain	h_{FE}	V_{CE}=3V, I_C=8mA	60	150	320	
Transition Frequency	f_T	V_{CE}=10V, I_C=8mA	1100	1500	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	0.9	1.3	pF
Collector-Base Time Constant	$C_c \cdot r_{bb'}$	V_{CB}=10V, I_C=8mA, f=30MHz	-	7	12	ps

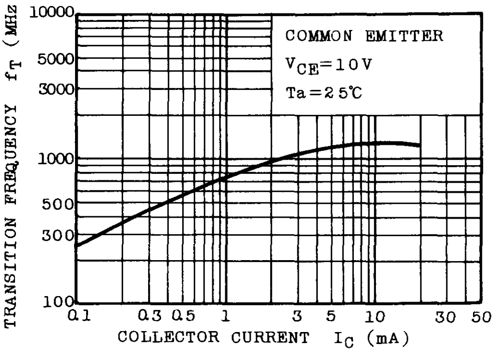
Marking



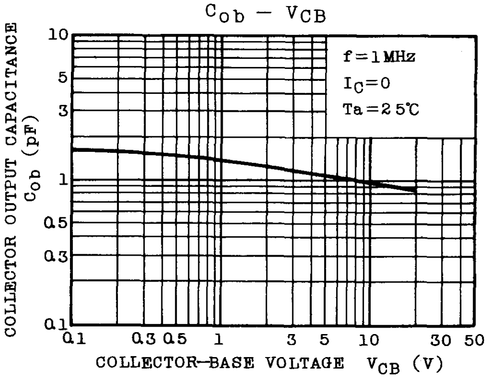
$h_{FE} - I_C$



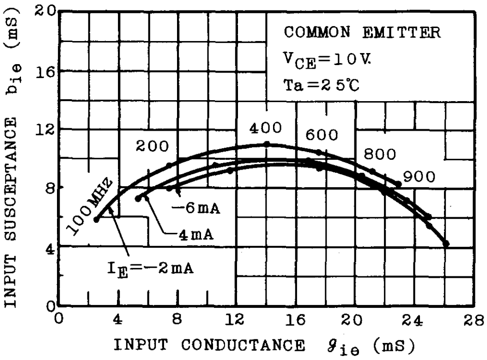
$f_T - I_C$



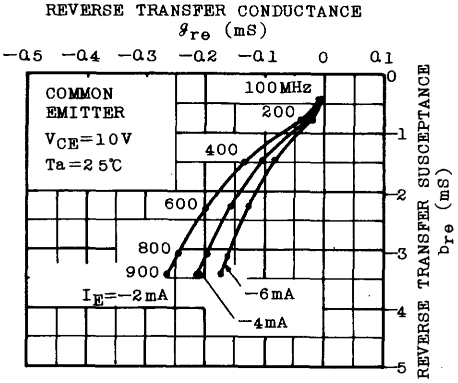
$C_{ob} - V_{CB}$



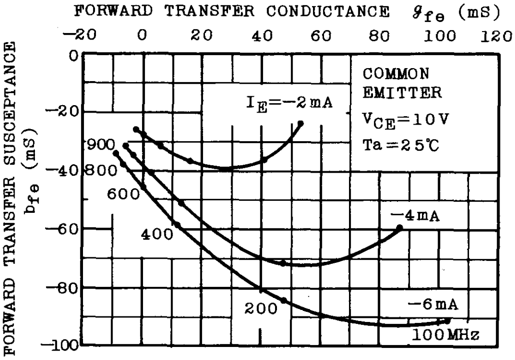
$y_{ie} - f$



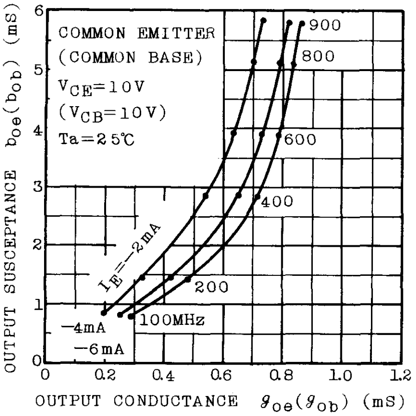
$y_{re} - f$



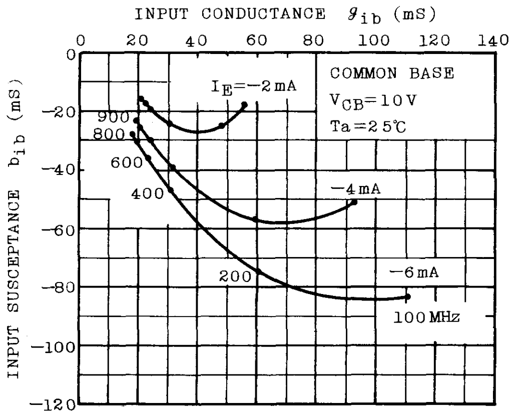
$y_{fe} - f$



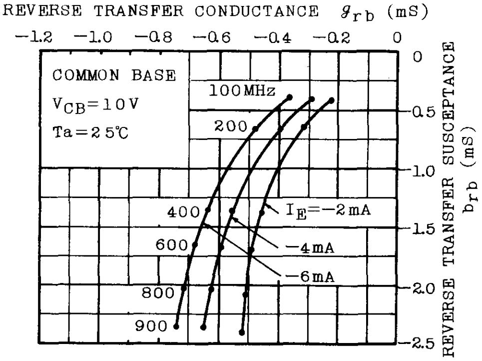
y_{oe} − f
(y_{ob} − f)



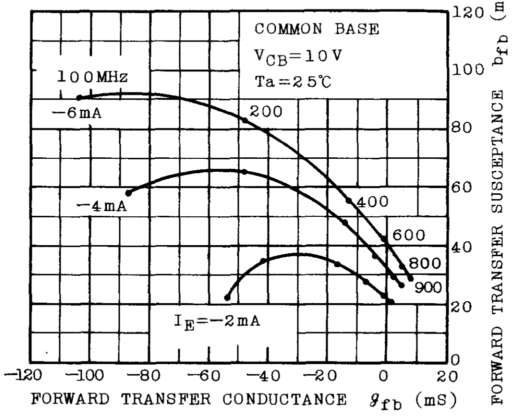
y_{ib} − f



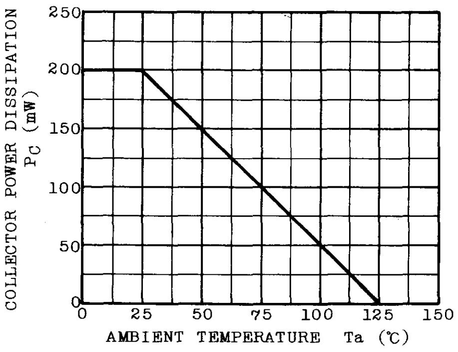
y_{rb} − f



y_{fb} − f



P_C − Ta



SILICON NPN EPITAXIAL PLANAR TYPE

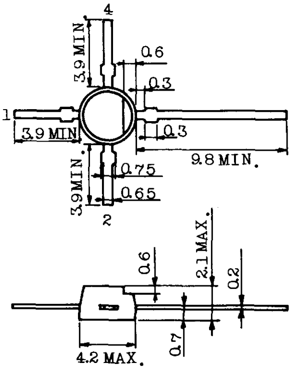
2SC2806

TV TUNER, VHF OSCILLATOR APPLICATIONS.
TV TUNER, VHF MIXER APPLICATIONS.

FEATURES:

- Excellent Linearity

Unit in mm



1. BASE
2. COLLECTOR
3. EMITTER
4. NC.

JEDEC	—
EIAJ	—
TOSHIBA	2-4F1D

Weight : 0.08g

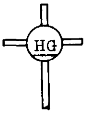
MAXIMUM RATINGS ($T_a=25^{\circ}C$)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	15	V
Emitter-Base Voltage	V_{EBO}	3	V
Base Current	I_B	25	mA
Collector Current	I_C	50	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

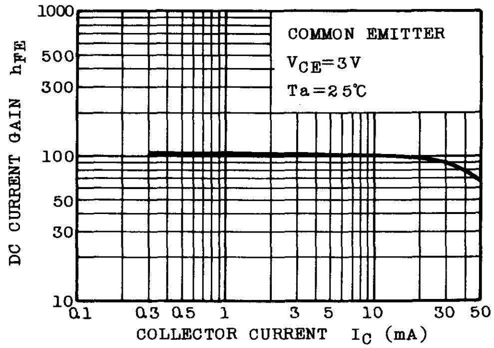
ELECTRICAL CHARACTERISTICS ($T_a=25^{\circ}C$)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	$V_{CB}=15V,\ I_E=0$	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	$V_{EB}=3V,\ I_C=0$	-	-	1.0	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	$I_C=1mA,\ I_B=0$	15	-	-	V
DC Current Gain	h_{FE}	$V_{CE}=3V,\ I_C=8mA$	40	100	200	
Transition Frequency	f_T	$V_{CE}=10V,\ I_C=8mA$	600	1100	-	MHz
Collector Output Capacitance	C_{ob}	$V_{CB}=10V,\ I_E=0,\ f=1MHz$	-	0.9	1.3	pF
Collector-Base Time Constant	$C_c \cdot r_{bb'}$	$V_{CB}=10V,\ I_C=8mA,\ f=30MHz$	-	7	20	ps

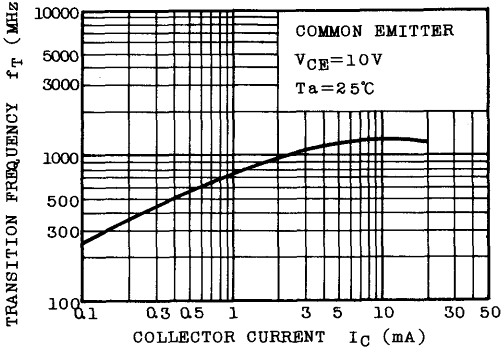
Marking



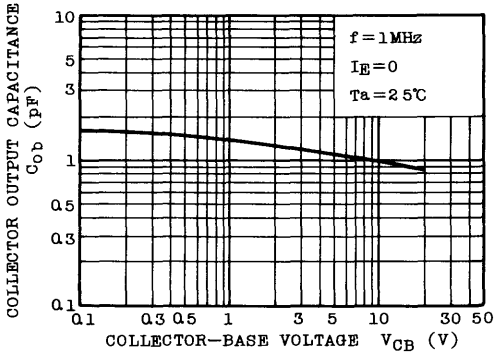
h_{FE} — I_C



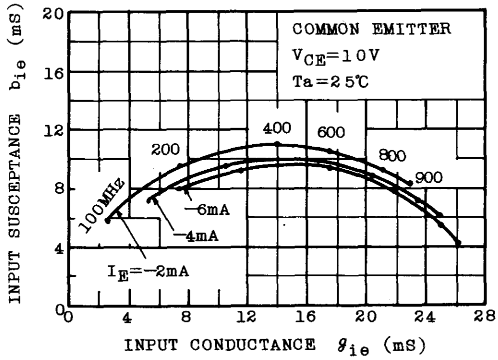
f_T — I_C



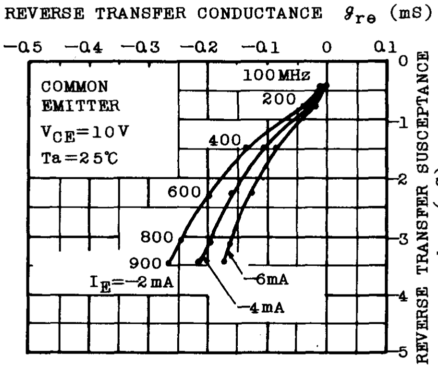
C_{ob} — V_{CB}



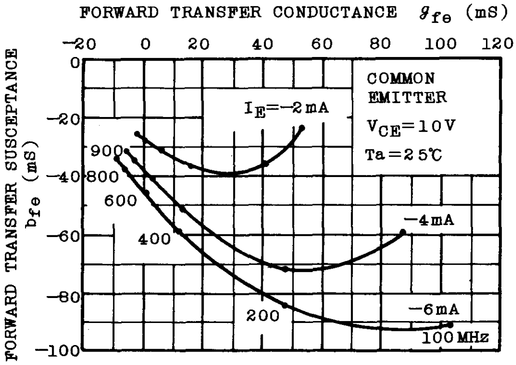
y_{ie} — f

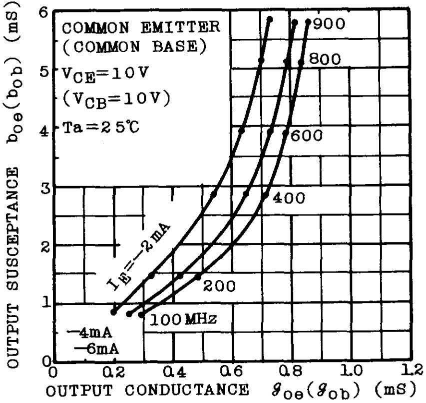


y_{re} — f



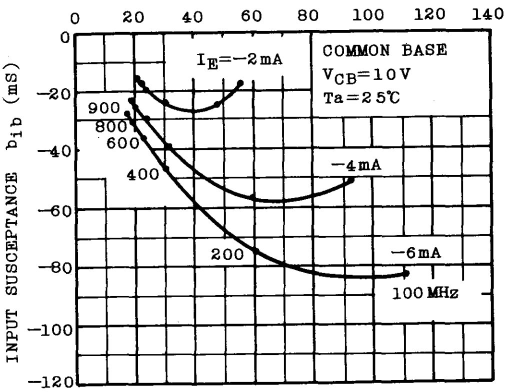
y_{fe} — f



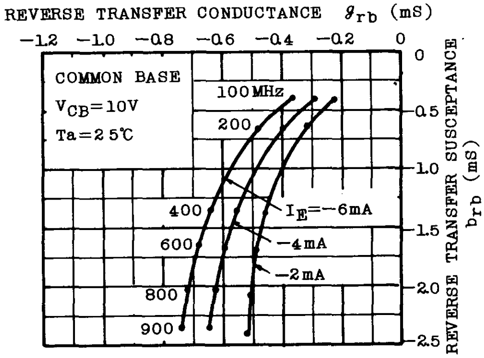


y_{oe} – f

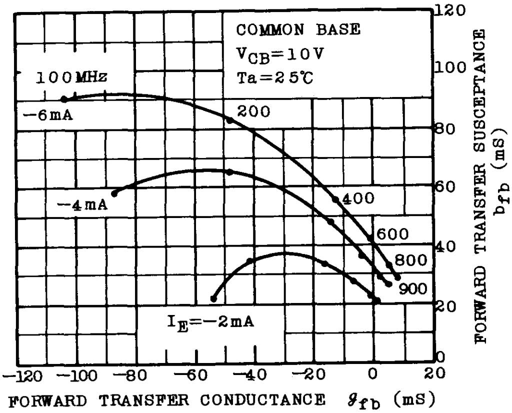
(y_{ob} – f)



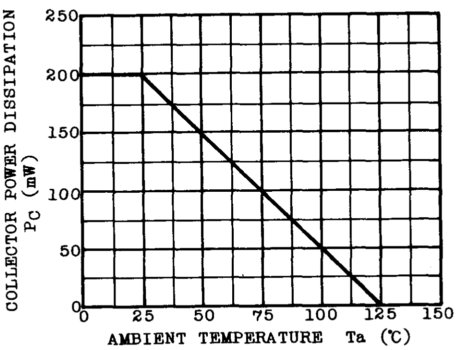
y_{ib} – f



y_{rb} – f



y_{fb} – f



P_C – Ta

2SC2859

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

AUDIO FREQUENCY LOW POWER AMPLIFIER APPLICATIONS

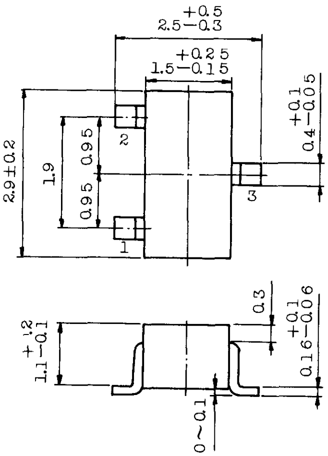
DRIVER STAGE AMPLIFIER APPLICATIONS

SWITCHING APPLICATIONS

FEATURES:

- Excellent h_{FE} Linearity: $h_{FE(2)}$=25(Min.) at V_{CE}=6V, I_C=400mA
- Complementary to 2SA1182.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO−236
EIAJ	−
TOSHIBA	2−3F1A

Weight : 0.012g

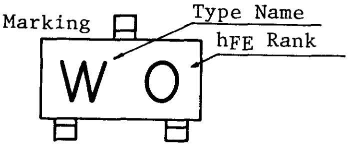
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	35	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	500	mA
Base Current	I_B	50	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

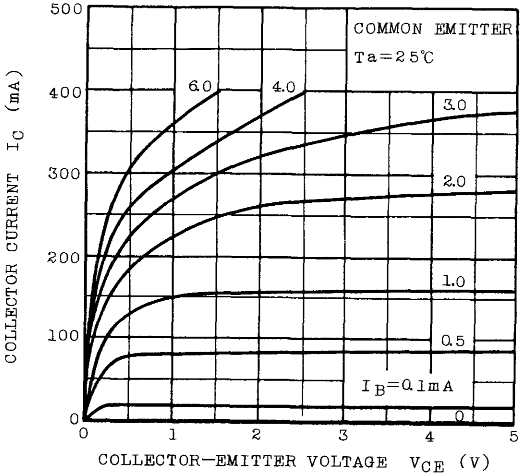
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=35V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain (Note)	$h_{FE(1)}$	V_{CE}=1V, I_C=100mA	70	-	240	
	$h_{FE(2)}$	V_{CE}=6V, I_C=400mA	25	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=100mA, I_B=10mA	-	0.1	0.25	V
Base-Emitter Voltage	V_{BE}	V_{CE}=1V, I_C=100mA	-	0.8	1.0	V
Transition Frequency	f_T	V_{CE}=6V, I_C=20mA	-	300	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=6V, I_E=0, f=1MHz	-	7	-	pF

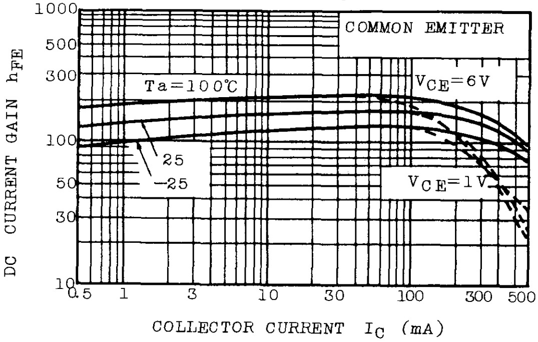
(Note): $h_{FE(1)}$ Classification O:70~140, Y:120~240
$h_{FE(2)}$ Classification O:25Min. Y:40Min.



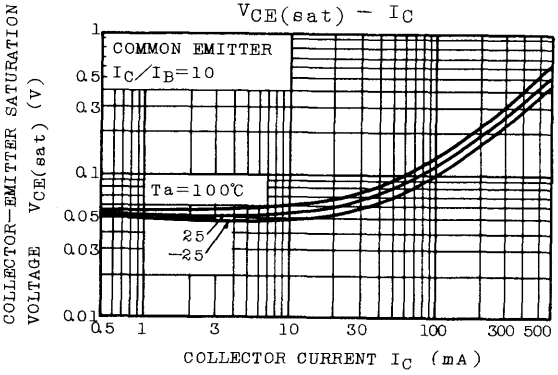
$I_C - V_{CE}$ (LOW VOLTAGE REGION)



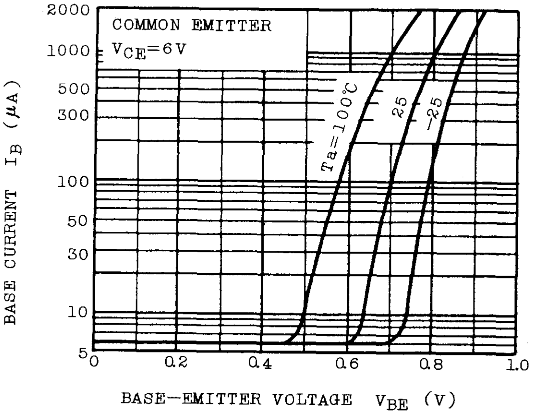
$h_{FE} - I_C$



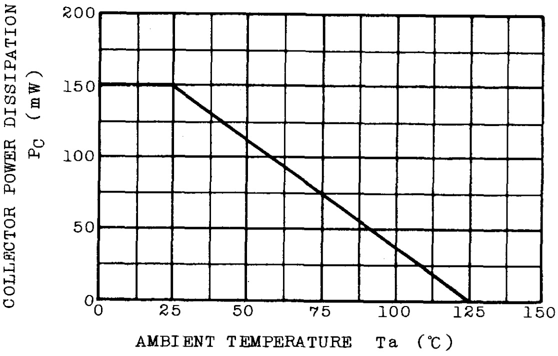
$V_{CE(sat)} - I_C$



$I_B - V_{BE}$



$P_C - Ta$



2SC2868

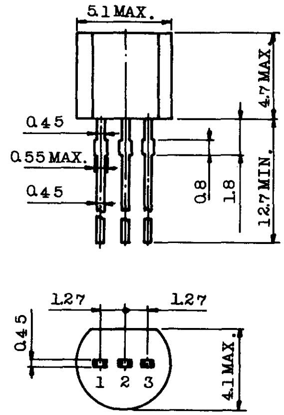
SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

AUDIO FREQUENCY AMPLIFIER APPLICATIONS.
DRIVER STAGE AMPLIFIER APPLICATIONS.

FEATURES:

- High Breakdown Voltage : V_{CEO}=80V
- Low Noise Figure : NF=1dB(Typ.), 10dB(Max.)
- Excellent h_{FE} Linearity: h_{FE}(0.1mA)/h_{FE}(2mA)=0.90(Typ.)
- Complementary to 2SA1158.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

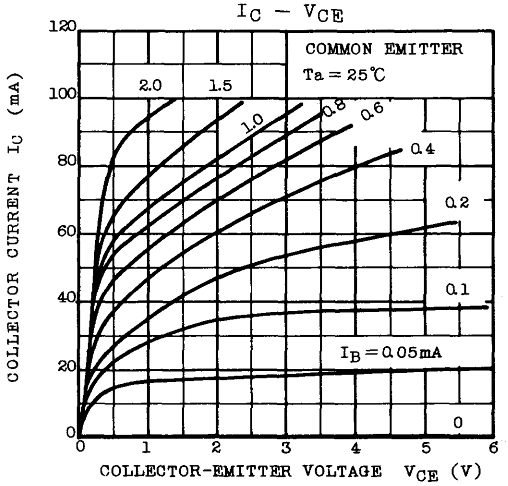
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	80	V
Collector-Emitter Voltage	V_{CEO}	80	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	100	mA
Base Current	I_B	50	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

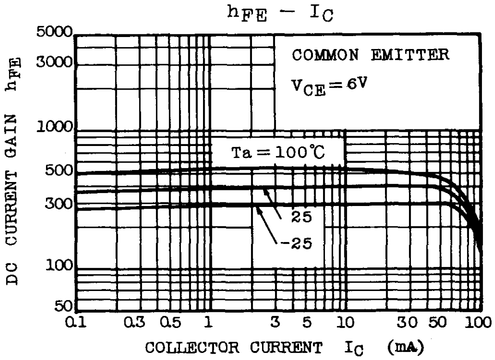
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=80V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA
DC Current Gain	h_{FE}	V_{CE}=6V, I_C=2mA	120	-	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	0.3	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=10mA, I_B=1mA	-	-	1.0	V
Transition Frequency	f_T	V_{CE}=10V, I_E=-2mA	80	-	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	2.5	3.5	pF
Noise Figure	NF	V_{CE}=6V, I_C=0.1mA R_g=10kΩ, f=1kHz	-	1.0	10	dB

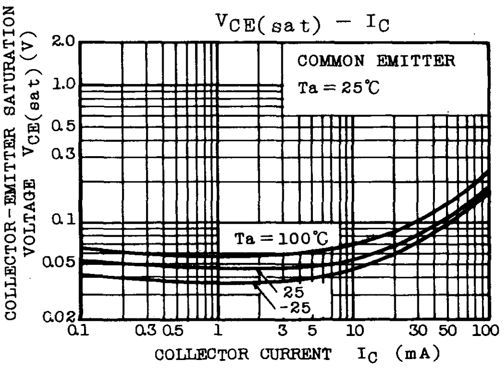
Note : h_{FE} Classification Y:120~240 GR:200~400 BL:350~700



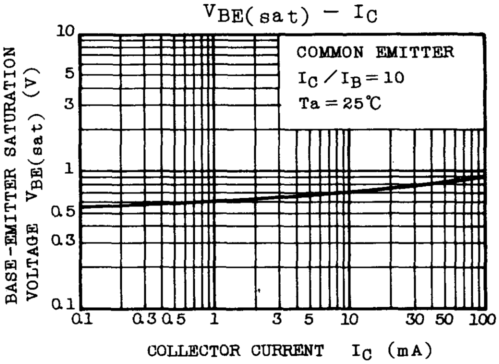
I_C — V_{CE}



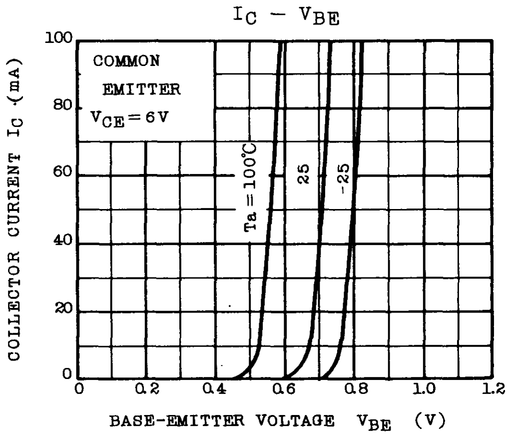
h_{FE} — I_C



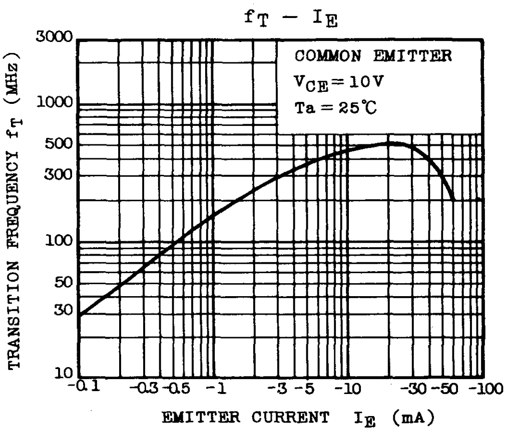
$V_{CE(sat)}$ — I_C



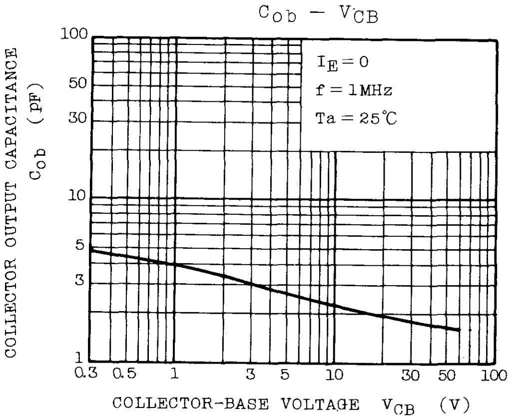
$V_{BE(sat)}$ — I_C

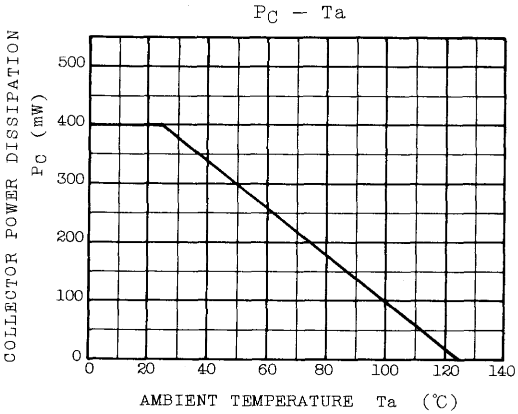


I_C — V_{BE}



f_T — I_E


Cob − VCB
IE = 0
f = 1MHz
Ta = 25℃
COLLECTOR OUTPUT CAPACITANCE Cob (pF)
100
50
30
10
5
3
1
0.3
0.5
1
3
5
10
30
50
100
COLLECTOR-BASE VOLTAGE VCB (V)


PC − Ta
COLLECTOR POWER DISSIPATION PC (mW)
500
400
300
200
100
0
0
20
40
60
80
100
120
140
AMBIENT TEMPERATURE Ta (℃)

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

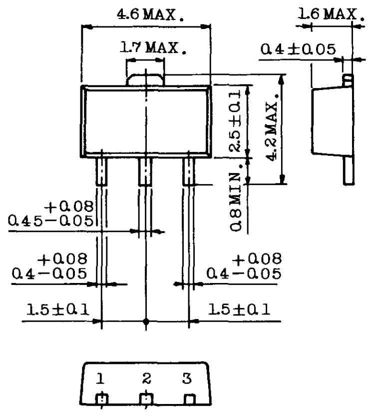
2SC2873

POWER AMPLIFIER APPLICATIONS.
POWER SWITCHING APPLICATIONS.

FEATURES:

- Low Saturation Voltage
  : $V_{CE(sat)}=0.5V(Max.)$ $(I_C=1A)$
- High Speed Switching Time : $t_{stg}=1.0\mu s$(Typ.)
- $P_C=1\sim2W$ (Mounted on Ceramic Substrate)
- Small Flat Package
- Complementary to 2SA1213

Unit in mm



1. BASE
2. COLLECTOR (HEAT SINK)
3. EMITTER

JEDEC	–
EIAJ	–
TOSHIBA	2–5K1A

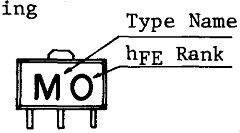
Weight : 0.052g

MAXIMUM RATINGS (Ta=25°C)

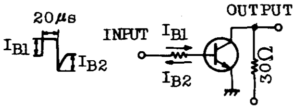
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	50	V
Collector-Emitter Voltage	V_{CEO}	50	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	2	A
Base Current	I_B	0.4	A
Collector Power Dissipation	P_C	500	mW
Collector Power Dissipation	P_C※	1000	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

P_C※: 2SC2873 mounted on ceramic substrate ($250mm^2 \times 0.8t$)

Marking



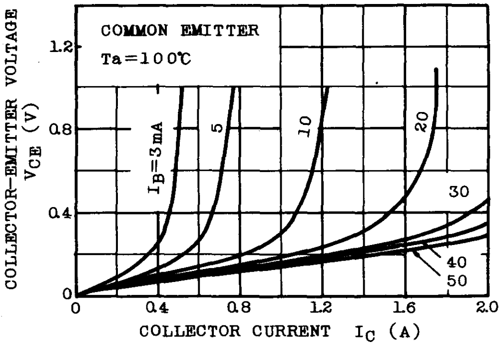
ELECTRICAL CHARACTERISTICS ($T_a=25^{\circ}C$)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	$V_{CB}=50V$, $I_E=0$	-	-	0.1	μA
Emitter Cut-off Current		I_{EBO}	$V_{EB}=5V$, $I_C=0$	-	-	0.1	μA
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	$I_C=10mA$, $I_E=0$	50	-	-	V
DC Current Gain		$h_{FE(1)}$ (Note 2)	$V_{CE}=2V$, $I_C=0.5A$ (Note 1)	70	-	240	
		$h_{FE(2)}$	$V_{CE}=2V$, $I_C=2.0A$ (Note 1)	20	-	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	$I_C=1A$, $I_B=0.05A$ (Note 1)	-	-	0.5	V
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	$I_C=1A$, $I_B=0.05A$ (Note 1)	-	-	1.2	V
Transition Frequency		f_T	$V_{CE}=2V$, $I_C=0.5A$	-	120	-	MHz
Collector Output Capacitance		C_{ob}	$V_{CB}=10V$, $I_E=0$, $f=1MHz$	-	30	-	pF
Switching Time	Turn-on Time	t_{on}	 $I_{B1}=-I_{B2}=0.05A$ DUTY CYCLE≦1%	-	0.1	-	μs
	Storage Time	t_{stg}		-	1.0	-	
	Fall Time	t_f		-	0.1	-	

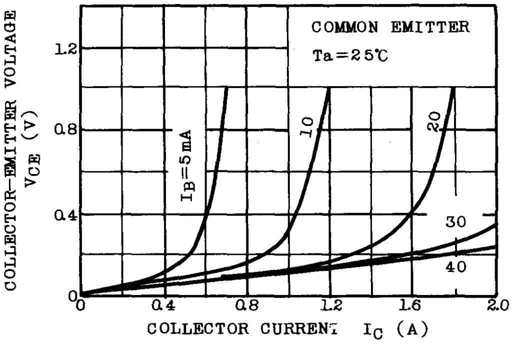
Note 1 : Pulse width≦300μs, Duty Cycle≦1%

2 : h_{FE} Classification O : 70～140, Y : 120～240

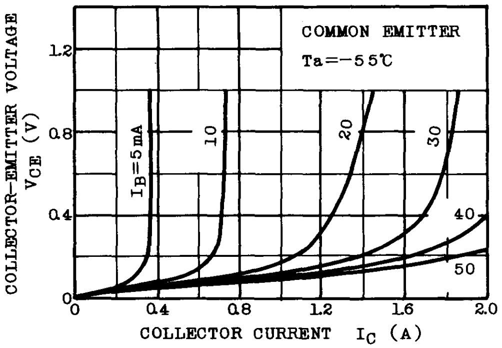
V_{CE} – I_C



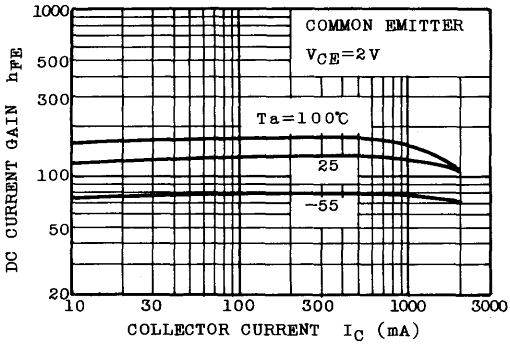
V_{CE} – I_C



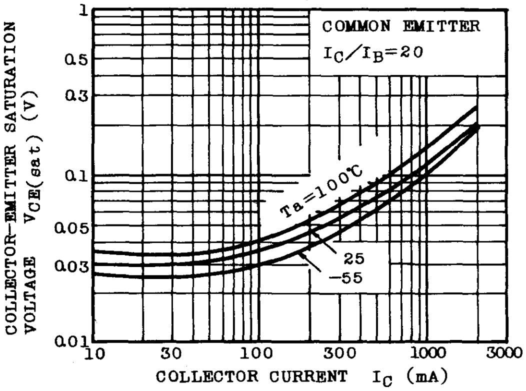
V_{CE} – I_C



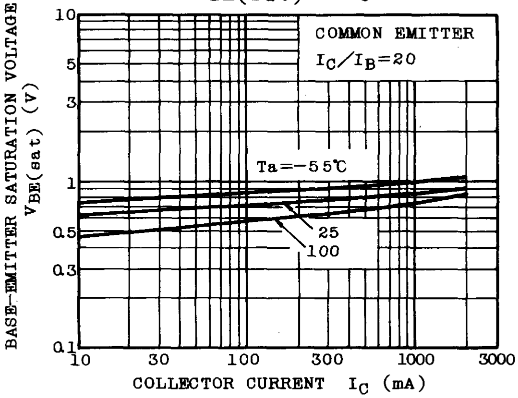
h_{FE} – I_C

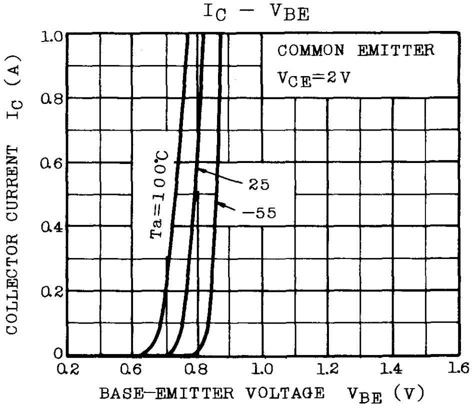


$V_{CE(sat)}$ – I_C

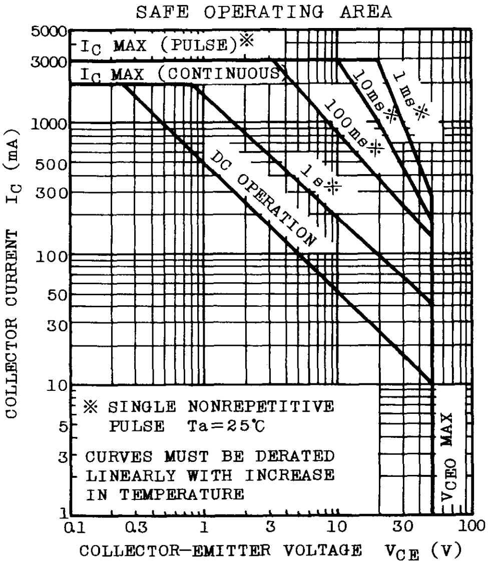


$V_{BE(sat)}$ – I_C

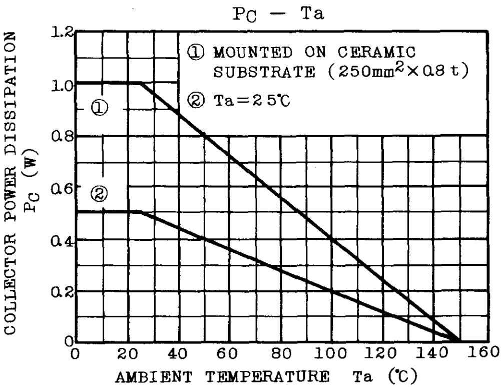




I_C — V_{BE}
COMMON EMITTER
V_{CE}=2V
Ta=100℃
25
−55
COLLECTOR CURRENT I_C (A)
1.0
0.8
0.6
0.4
0.2
0
0.2
0.6
0.8
1.0
1.2
1.4
1.6
BASE−EMITTER VOLTAGE V_{BE} (V)



SAFE OPERATING AREA
I_C MAX (PULSE)※
I_C MAX (CONTINUOUS)
10ms※
1ms※
100ms※
1s※
DC OPERATION
※ SINGLE NONREPETITIVE PULSE Ta=25℃
CURVES MUST BE DERATED LINEARLY WITH INCREASE IN TEMPERATURE
V_{CEO} MAX
COLLECTOR CURRENT I_C (mA)
5000
3000
1000
500
300
100
50
30
10
5
3
1
0.1
0.3
1
3
10
30
100
COLLECTOR−EMITTER VOLTAGE V_{CE} (V)



P_C — Ta
① MOUNTED ON CERAMIC SUBSTRATE (250mm^2×0.8t)
② Ta=25℃
①
②
COLLECTOR POWER DISSIPATION P_C (W)
1.2
1.0
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
120
140
160
AMBIENT TEMPERATURE Ta (℃)

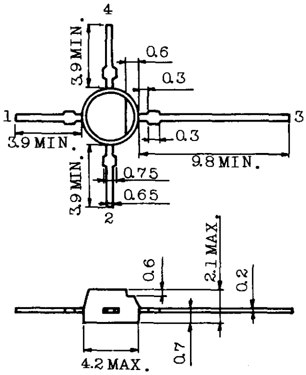
2SC2876

UHF~C BAND LOW NOISE AMPLIFIER APPLICATIONS.
HIGH SPEED SWITCHING APPLICATIONS.

FEATURES:

- High Gain : $|S_{21e}|^2$=10.5dB (Typ.), f=1GHz
- Low Noise Figure : NF=2.3dB (Typ.), f=1GHz
- High f_T : f_T=7.0GHz (Typ.)
- Low $V_{CE(sat)}$: $V_{CE(sat)}$=0.13V (Typ.)

Unit in mm



1. BASE
2. EMITTER
3. COLLECTOR
4. EMITTER

JEDEC	—
EIAJ	—
TOSHIBA	2-4F1C

Marking : MA
Weight : 0.08g

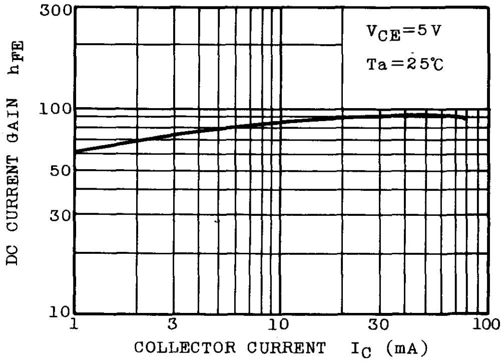
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	15	V
Collector-Emitter Voltage	V_{CEO}	7.5	V
Emitter-Base Voltage	V_{EBO}	3	V
Base Current	I_B	40	mA
Collector Current	I_C	80	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

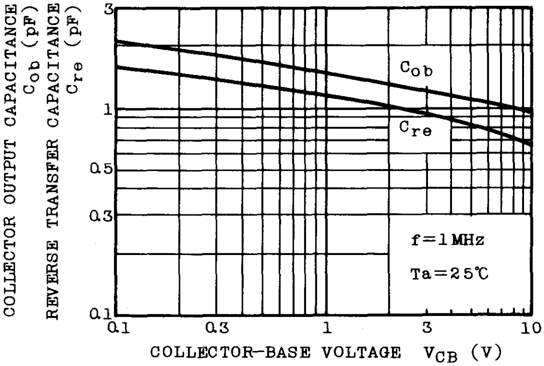
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=10V, I_E=0	-	-	0.1	µA
Emitter Cut-off Current	I_{EBO}	V_{EB}=1V, I_C=0	-	-	1.0	µA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=5mA, I_B=0	7.5	-	-	V
DC Current Gain	h_{FE}	V_{CE}=3V, I_C=50mA	30	-	200	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=30mA, I_B=3mA	-	0.13	-	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$		-	0.87	-	V
Collector Output Capacitance	C_{ob}	V_{CB}=5V, I_E=0, f=1MHz	-	1.25	1.6	pF
Reverse Transfer Capacitance	C_{re}		-	0.86	-	pF
Input Capacitance	C_{ib}	V_{EB}=05V, I_C=0, f=1MHz	-	2.5	-	pF
Transition Frequency	f_T	V_{CE}=5V, I_C=30mA	-	7.0	-	GHz
Insertion Gain	$\|S_{21e}\|^2$	V_{CE}=5V, I_C=30mA, f=1GHz	-	10.5	-	dB
Noise Figure	NF	V_{CE}=5V, I_C=10mA, f=1GHz	-	2.3	-	dB

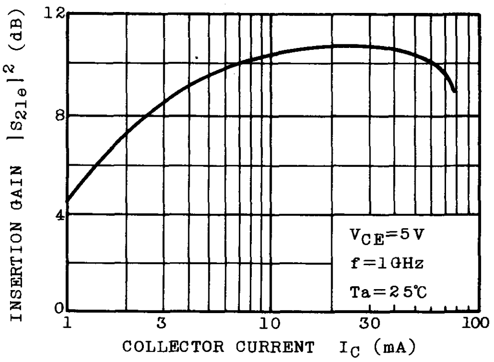
$h_{FE} - I_C$



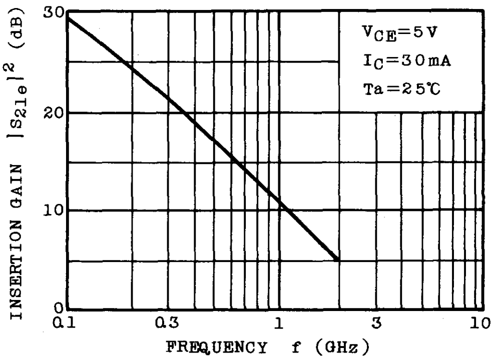
$C_{ob}, C_{re} - V_{CB}$



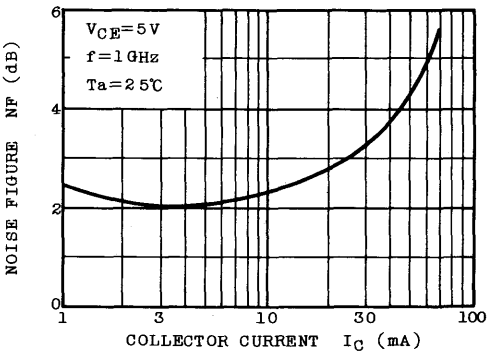
$|S_{21e}|^2 - I_C$



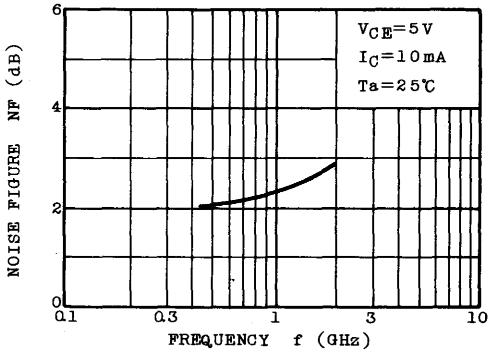
$|S_{21e}|^2 - f$



$NF - I_C$

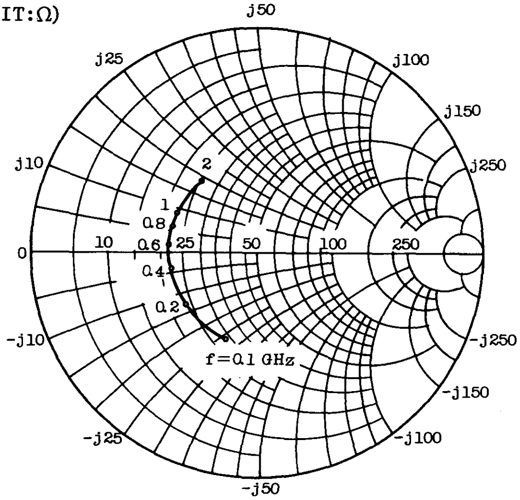


$NF - f$

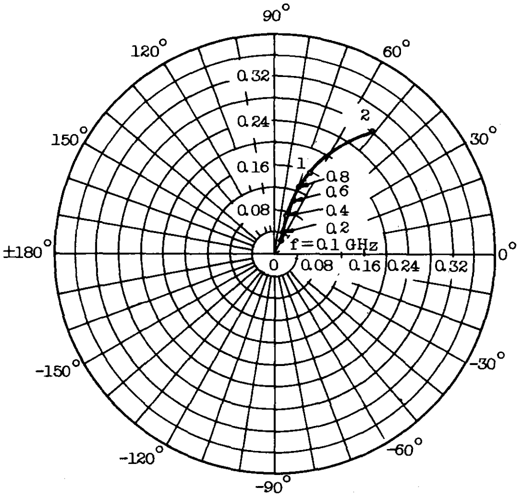


S_{11e}
V_{CE}=5V
I_C=30mA
Ta=25°C

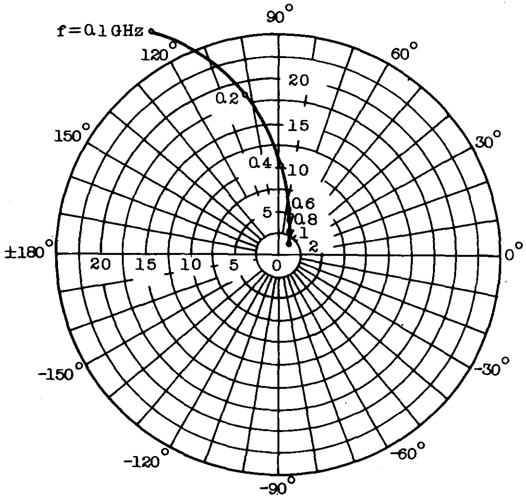
(UNIT:Ω)



S_{12e}
V_{CE}=5V
I_C=30mA
Ta=25°C

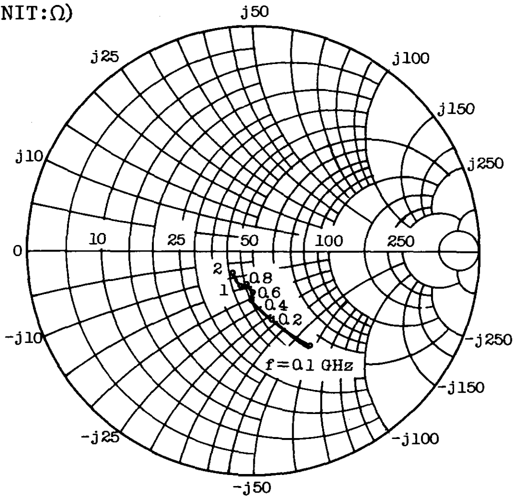


S_{21e}
V_{CE}=5V
I_C=30mA
Ta=25°C



S_{22e}
V_{CE}=5V
I_C=30mA
Ta=25°C

(UNIT:Ω)



2SC2878

SILICON NPN EPITAXIAL TYPE

FOR MUTING AND SWITCHING APPLICATIONS

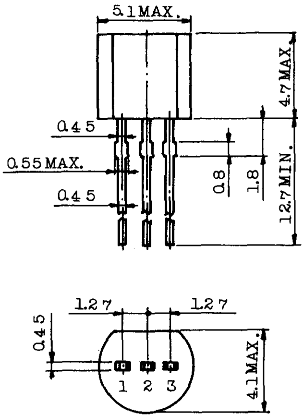
FEATURES:

- High Emitter-Base Voltage : V_{EBO}=25V (Min.)
- High Reverse h_{FE}
  - : Reverse h_{FE}=150(Typ.)(V_{CE}=-2V, I_C=-2mA)
- Low On Resistance : R_{ON}=1Ω (Typ.)(I_B=5mA)

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	50	V
Collector-Emitter Voltage	V_{CEO}	20	V
Emitter-Base Voltage	V_{EBO}	25	V
Collector Current	I_C	300	mA
Base Current	I_B	60	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~125	°C

Unit in mm

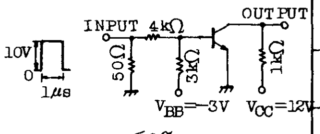


1. EMITTER
2. COLLECTOR
3. BASE

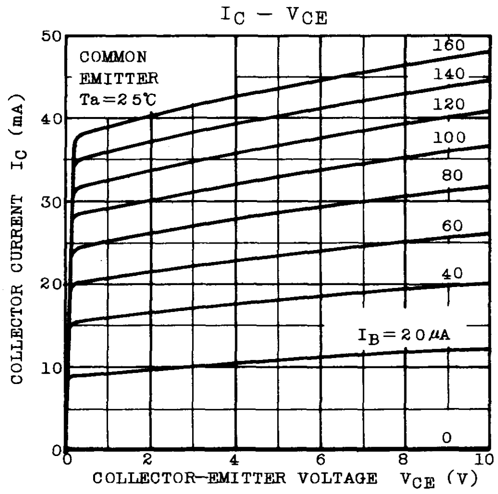
JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

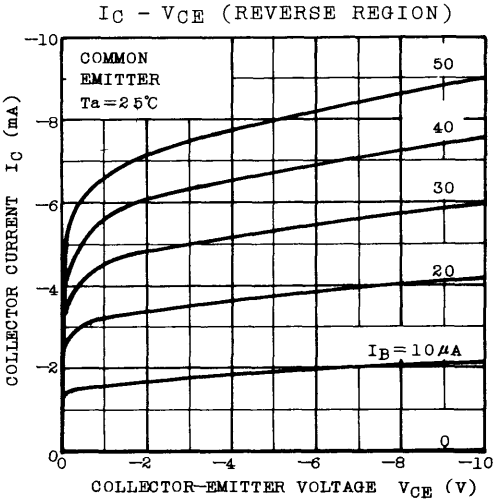
Weight : 0.21g

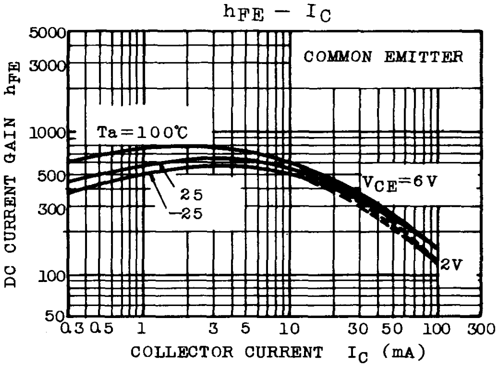
ELECTRICAL CHARACTERISTICS (Ta=25°C)

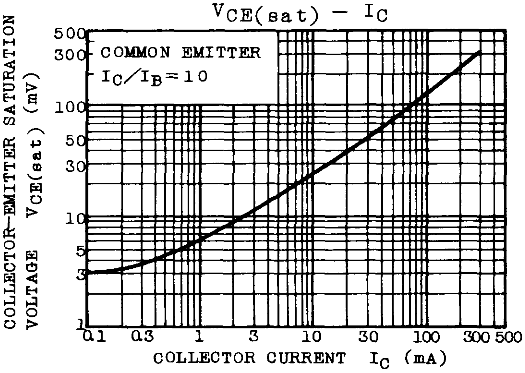
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=50V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=25V, I_C=0	-	-	0.1	μA
DC Current Gain		h_{FE} (Note)	V_{CE}=2V, I_C=4mA	200	-	1200	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=30mA, I_B=3mA	-	0.042	0.3	V
Base-Emitter Voltage		V_{BE}	V_{CE}=2V, I_C=4mA	-	0.61	-	V
Transition Frequency		f_T	V_{CE}=6V, I_C=4mA	-	30	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	4.8	7	pF
Switching Time	Turn-on Time	t_{on}	 DUTY CYCLE≦2%	-	160	-	ns
	Storage Time	t_{stg}		-	500	-	
	Fall Time	t_f		-	130	-	

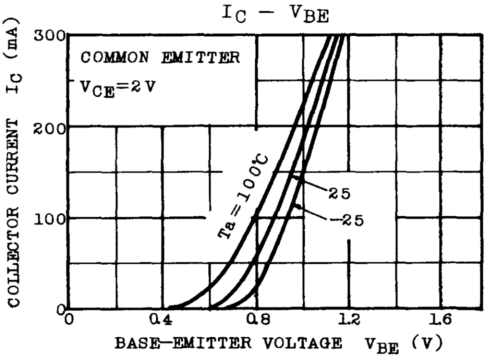
Note : h_{FE} Classification A : 200~700, B : 350~1200

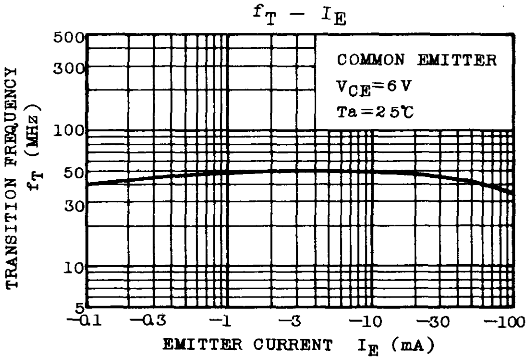

IC − VCE
COMMON EMITTER
Ta=25℃
160
140
120
100
80
60
40
IB=20μA
0
COLLECTOR CURRENT IC (mA)
0
10
20
30
40
50
0
2
4
6
8
10
COLLECTOR-EMITTER VOLTAGE VCE (V)

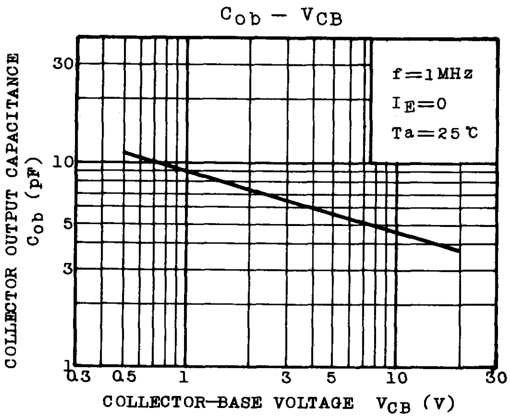

IC − VCE (REVERSE REGION)
COMMON EMITTER
Ta=25℃
50
40
30
20
IB=10μA
0
COLLECTOR CURRENT IC (mA)
0
−2
−4
−6
−8
−10
0
−2
−4
−6
−8
−10
COLLECTOR-EMITTER VOLTAGE VCE (V)

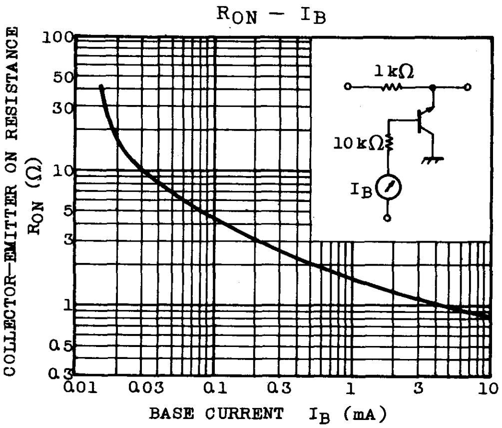

hFE − IC
COMMON EMITTER
Ta=100℃
25
−25
VCE=6V
2V
DC CURRENT GAIN hFE
50
100
300
500
1000
3000
5000
0.3
0.5
1
3
5
10
30
50
100
300
COLLECTOR CURRENT IC (mA)

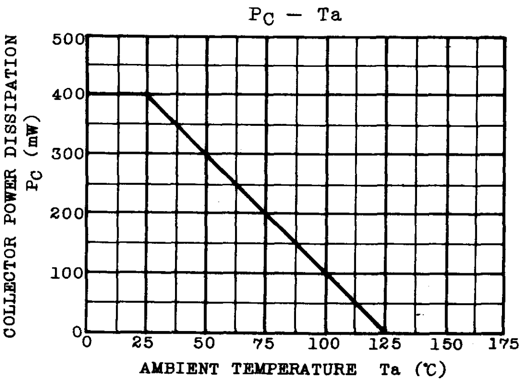

VCE(sat) − IC
COMMON EMITTER
IC/IB=10
COLLECTOR-EMITTER SATURATION VOLTAGE VCE(sat) (mV)
1
3
5
10
30
50
100
300
500
0.1
0.3
1
3
10
30
100
300
500
COLLECTOR CURRENT IC (mA)


IC − VBE
COMMON EMITTER
VCE=2V
Ta=100℃
25
−25
COLLECTOR CURRENT IC (mA)
0
100
200
300
0
0.4
0.8
1.2
1.6
BASE-EMITTER VOLTAGE VBE (V)


fT − IE
COMMON EMITTER
VCE=6V
Ta=25℃
TRANSITION FREQUENCY fT (MHz)
5
10
30
50
100
300
500
−0.1
−0.3
−1
−3
−10
−30
−100
EMITTER CURRENT IE (mA)


Cob — VCB


RON — IB


PC — Ta

SILICON NPN TRIPLE DIFFUSED TYPE (PCT PROCESS)

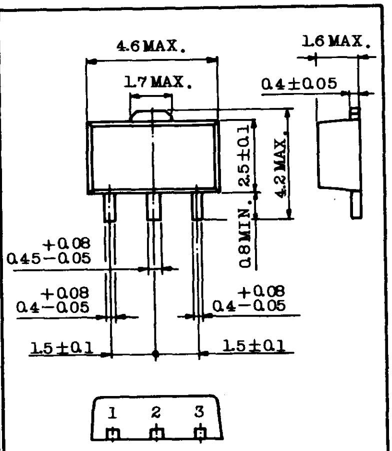
2SC2880

HIGH VOLTAGE SWITCHING APPLICATIONS.

FEATURES:

- High Voltage : V_{CEO}=150V
- High Transition Frequency : f_T=120MHz
- P_C=1 ~ 2W (Mounted on Ceramic Substrate)
- Small Flat Package
- Complementary to 2SA1200

Unit in mm

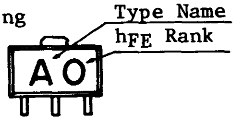


1. BASE
2. COLLECTOR (HEAT SINK)
3. EMITTER

JEDEC	−
EIAJ	−
TOSHIBA	2-5K1A

Weight : 0.052g

Marking



MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	200	V
Collector-Emitter Voltage	V_{CEO}	150	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	50	mA
Base Current	I_B	10	mA
Collector Power Dissipation	P_C	500	mW
Collector Power Dissipation	P_C※	800	mW
Junction Temperature	T_j	150	°C
Storage Temperature	T_{stg}	-55 ~ 150	°C

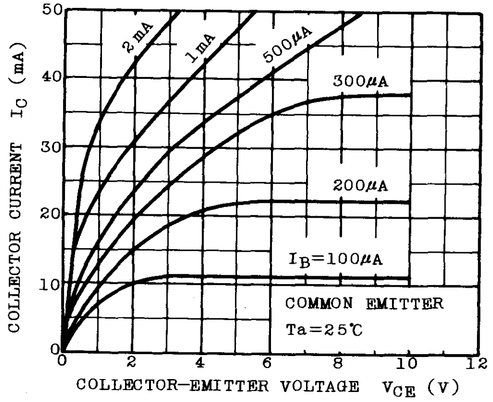
P_C※ : 2SC2880 mounted on ceramic substrate (250mm² × 0.8t)

ELECTRICAL CHARACTERISTICS (Ta=25°C)

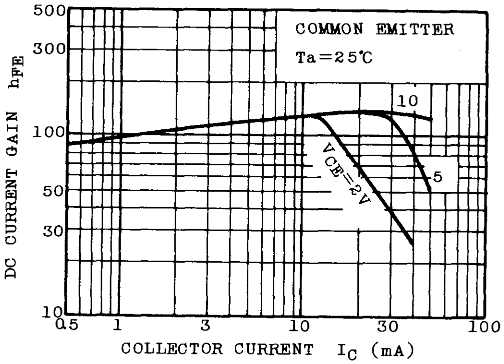
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=200V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=5V, I_C=10mA	70	-	240	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	0.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=5V, I_C=30mA	-	-	1	V
Transition Frequency	f_T	V_{CE}=30V, I_C=10mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	3.5	5.0	pF

Note : $h_{FE(1)}$, h_{FE} Classification O : 70 ~ 140, Y : 120 ~ 240

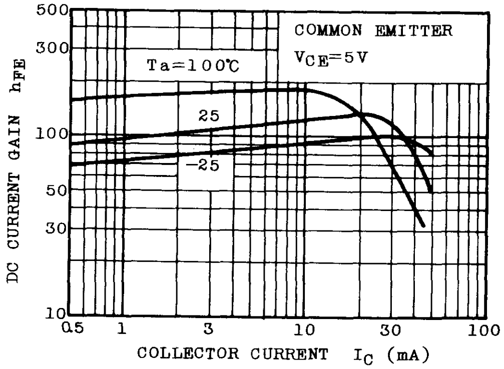
I_C — V_{CE}



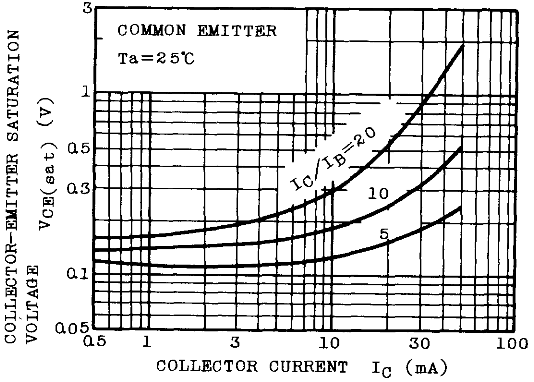
h_{FE} — I_C



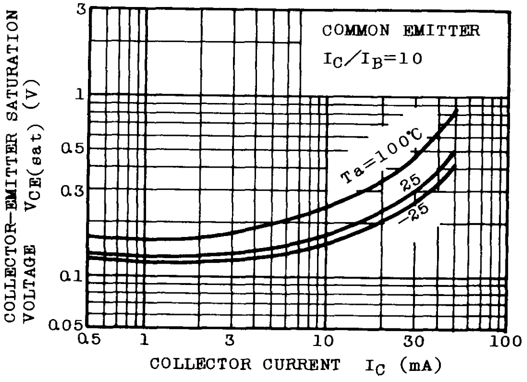
h_{FE} — I_C



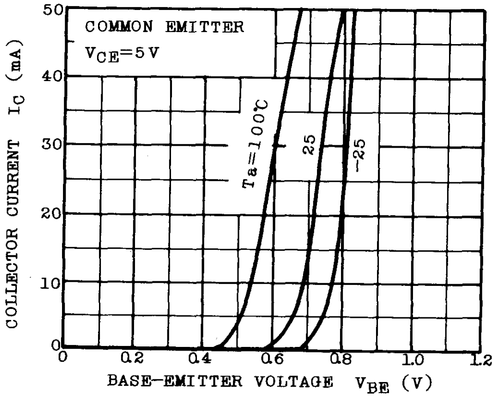
$V_{CE(sat)}$ — I_C



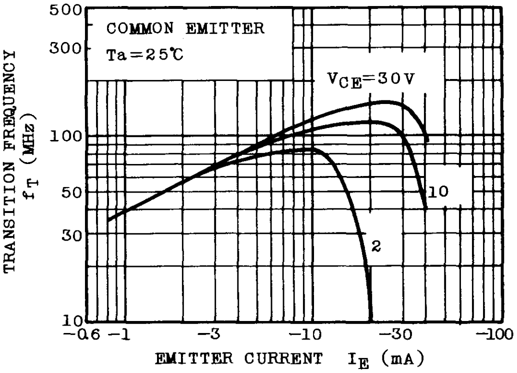
$V_{CE(sat)}$ — I_C



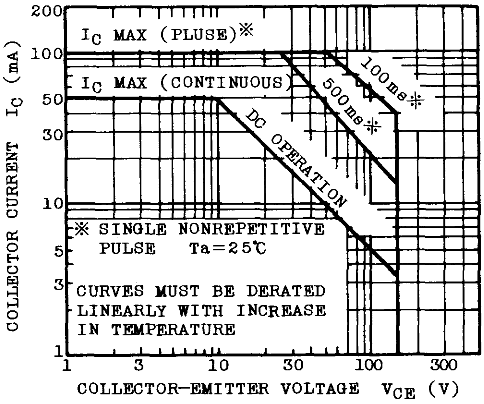
I_C — V_{BE}



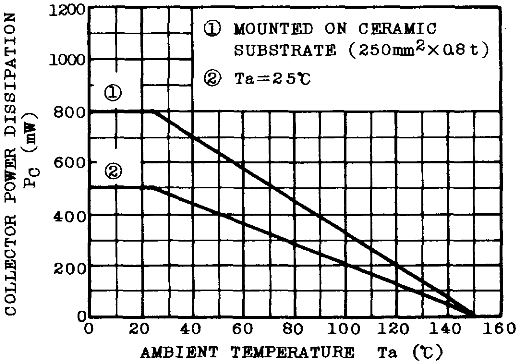
$f_T - I_E$



SAFE OPERATING AREA



$P_C - Ta$

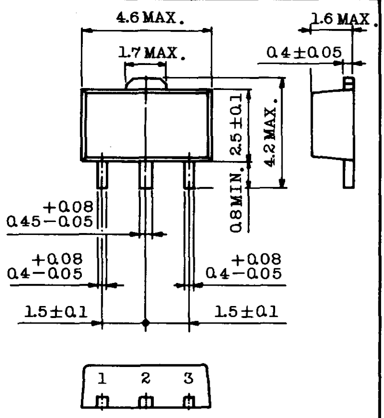


2SC2881

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

POWER AMPLIFIER APPLICATIONS.

Unit in mm



1. BASE
2. COLLECTOR (HEAT SINK)
3. EMITTER

JEDEC	−
EIAJ	−
TOSHIBA	2−5K1A

Weight : 0.052g

FEATURES:

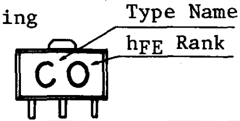
- High Voltage : V_{CEO}=120V
- High Transition Frequency : f_T=120MHz
- P_C=1～2W (Mounted on Ceramic Substrate)
- Small Flat Package
- Complementary to 2SA1201

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	120	V
Collector-Emitter Voltage	V_{CEO}	120	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	800	mA
Base Current	I_B	160	mA
Collector Power Dissipation	P_C	500	mW
Collector Power Dissipation	P_C※	1000	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55～150	°C

P_C※ : 2SC2881 mounted on ceramic substrate ($250mm^2 \times 0.8t$)

Marking

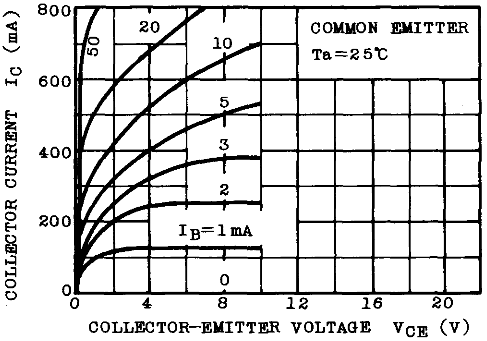


ELECTRICAL CHARACTERISTICS (Ta=25°C)

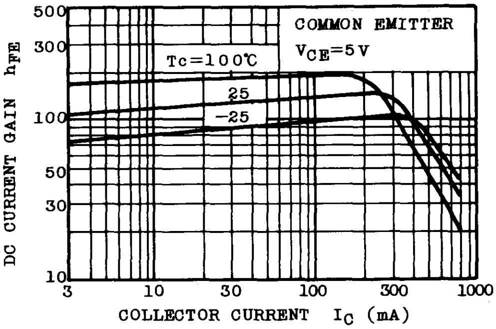
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=120V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=10mA, I_B=0	120	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=1mA, I_C=0	5	-	-	V
DC Current Gain	h_{FE} (Note)	V_{CE}=5V, I_C=100mA	80	-	240	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=500mA, I_B=50mA	-	-	1.0	V
Base-Emitter Voltage	V_{BE}	V_{CE}=5V, I_C=500mA	-	-	1.0	V
Transition Frequency	f_T	V_{CE}=5V, I_C=100mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	-	30	pF

Note : h_{FE} Classification O : 80～160, Y : 120～240

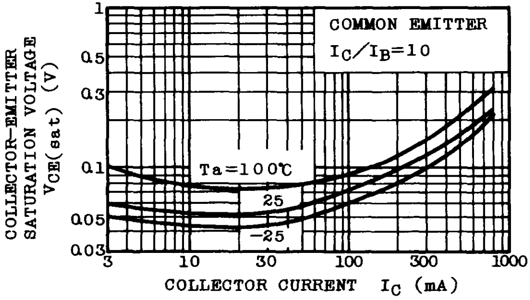
I_C — V_{CE}



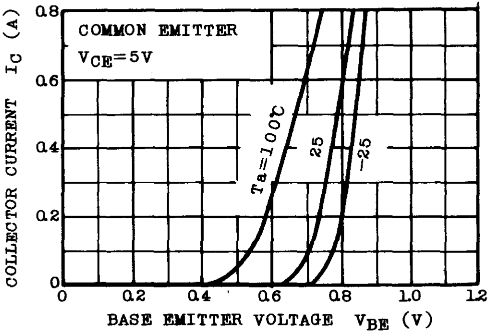
h_{FE} — I_C



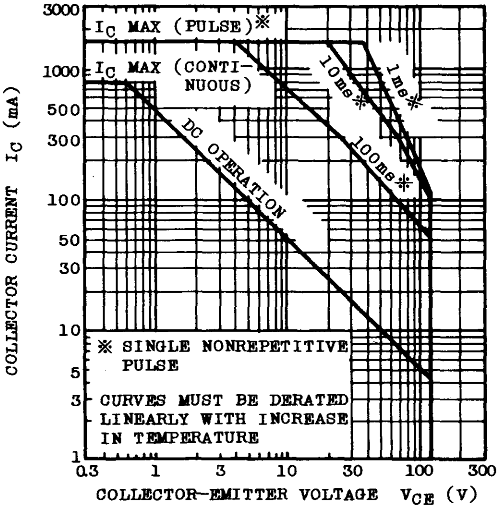
$V_{CE(sat)}$ — I_C



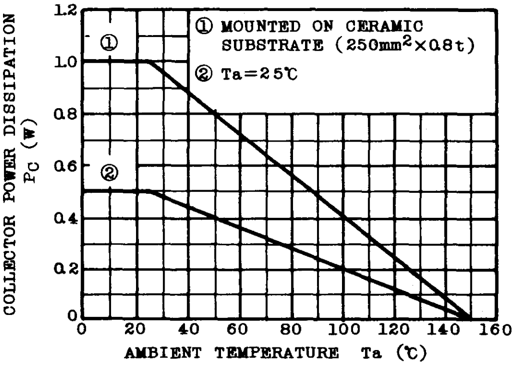
I_C — V_{BE}



SAFE OPERATING AREA



P_C — Ta



2SC2882

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

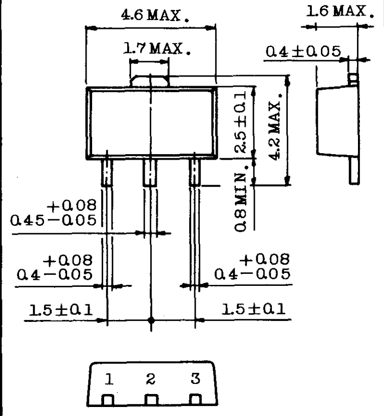
POWER AMPLIFIER APPLICATIONS.

VOLTAGE AMPLIFIER APPLICATIONS.

FEATURES:

- Suitable for Driver of 30 ~ 35 Watts Audio Amplifier
- P_C=1 ~ 2W (Mounted on Ceramic Substrate)
- Small Flat Package
- Complementary to 2SA1202

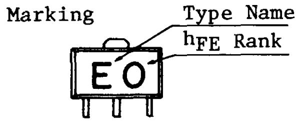
Unit in mm



1. BASE
2. COLLECTOR (HEAT SINK)
3. EMITTER

JEDEC	−
EIAJ	−
TOSHIBA	2−5K1A

Weight : 0.052g



MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	80	V
Collector-Emitter Voltage	V_{CEO}	80	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	400	mA
Base Current	I_B	80	mA
Collector Power Dissipation	P_C	500	mW
Collector Power Dissipation	P_C※	1000	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	−55 ~ 150	°C

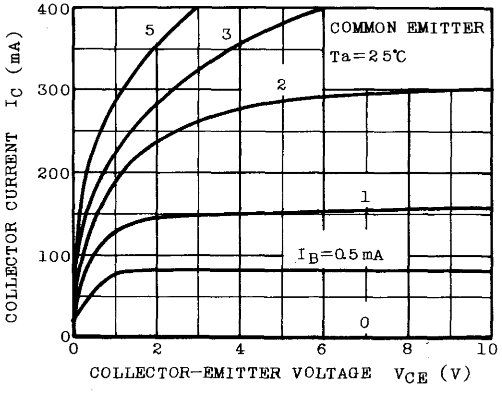
P_C※: 2SC2882 mounted on ceramic substrate (250mm^2 × 0.8t)

ELECTRICAL CHARACTERISTICS (Ta=25°C)

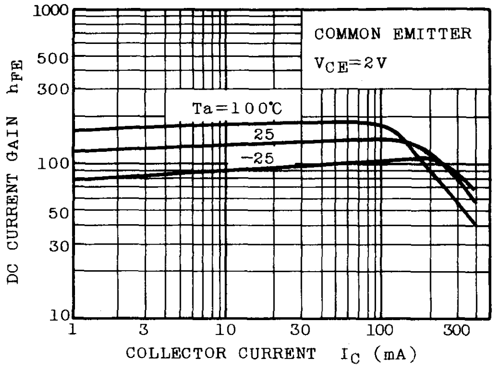
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=80V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=10mA, I_B=0	80	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=2V, I_C=50mA	70	-	240	
	$h_{FE(2)}$	V_{CE}=2V, I_C=200mA	40	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=200mA, I_B=20mA	-	-	0.4	V
Base-Emitter Voltage	V_{BE}	V_{BE}=2V, I_C=5mA	0.55	-	0.8	V
Transition Frequency	f_T	V_{CE}=10V, I_C=10mA	-	100	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	10	-	pF

Note : h_{FE} Classification O : 70 ~ 140, Y : 120 ~ 240

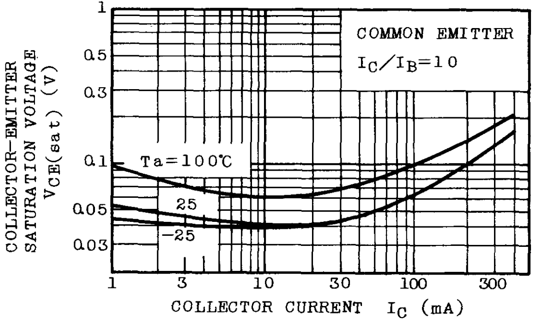
$I_C - V_{CE}$



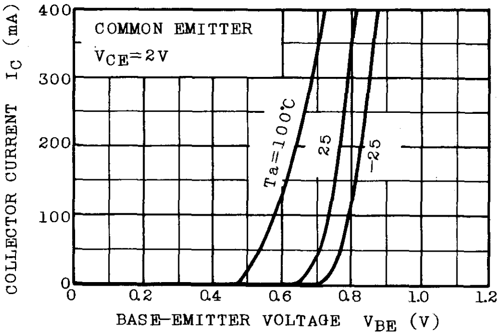
$h_{FE} - I_C$



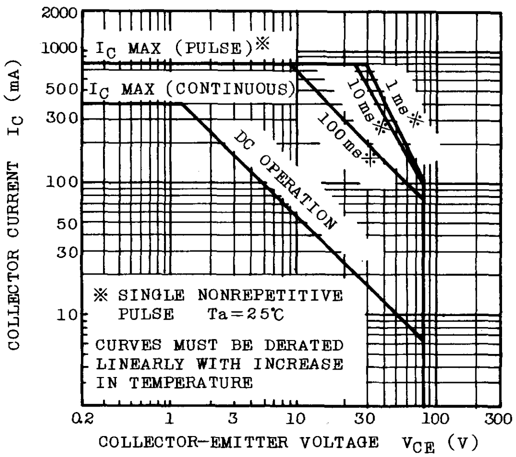
$V_{CE(sat)} - I_C$



$I_C - V_{BE}$



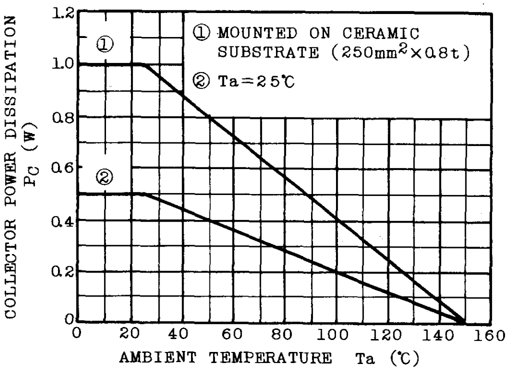
SAFE OPERATING AREA



※ SINGLE NONREPETITIVE PULSE Ta=25℃

CURVES MUST BE DERATED LINEARLY WITH INCREASE IN TEMPERATURE

$P_C - Ta$



① MOUNTED ON CERAMIC SUBSTRATE (250mm^2×0.8t)

② Ta=25℃

2SC2883

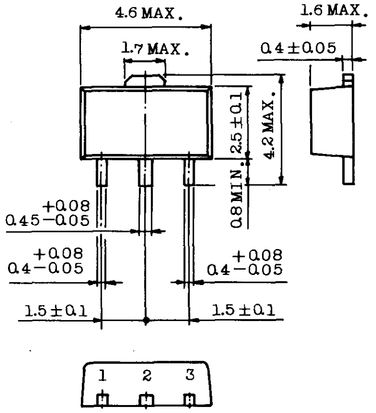
SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

AUDIO FREQUENCY AMPLIFIER APPLICATIONS.

FEATURES:

- Suitable for Output Stage of 3 Watts Amplifier
- P_C=1 ~ 2W (Mounted on Ceramic Substrate)
- Small Flat Package
- Complementary to 2SA1203

Unit in mm

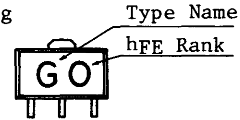


1. BASE
2. COLLECTOR (HEAT SINK)
3. EMITTER

JEDEC	–
EIAJ	–
TOSHIBA	2−5K1A

Weight : 0.052g

Marking



MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	1.5	A
Base Current	I_B	0.3	A
Collector Power Dissipation	P_C	500	mW
Collector Power Dissipation	P_C※	1000	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55 ~ 150	°C

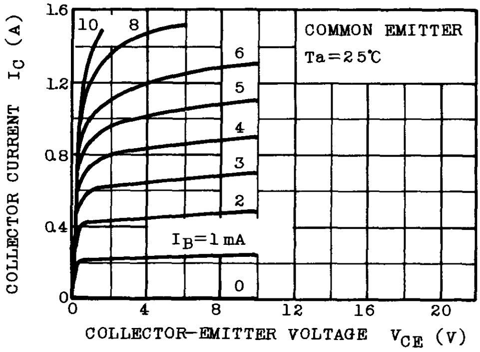
P_C※ : 2SC2883 mounted on ceramic substrate (250mm^2 × 0.8t)

ELECTRICAL CHARACTERISTICS (Ta=25°C)

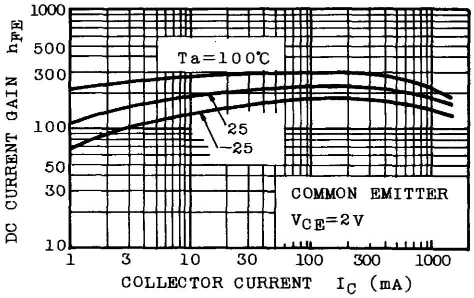
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=30V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=10mA, I_B=0	30	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=1mA, I_C=0	5	-	-	V
DC Current Gain	h_{FE} (Note)	V_{CE}=2V, I_C=500mA	100	-	320	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=1.5A, I_B=0.03A	-	-	2.0	V
Base-Emitter Voltage	V_{BE}	V_{CE}=2V, I_C=500mA	-	-	1.0	V
Transition Frequency	f_T	V_{CE}=2V, I_C=500mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	-	40	pF

Note : h_{FE} Classification O : 100 ~ 200, Y : 160 ~ 320

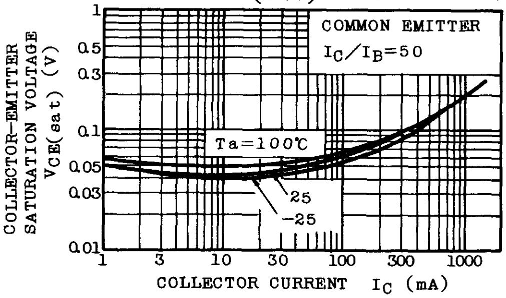
$I_C - V_{CE}$



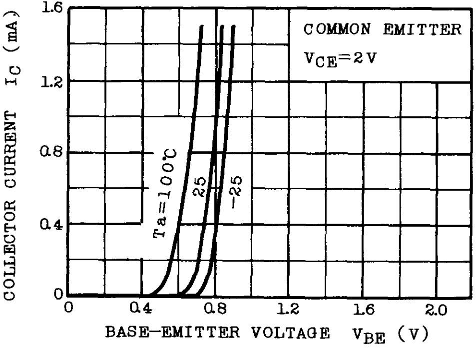
$h_{FE} - I_C$



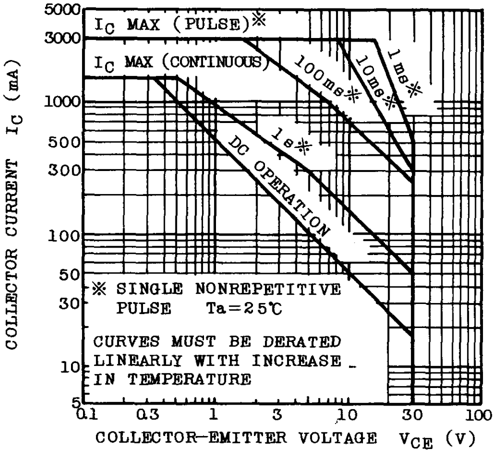
$V_{CE(sat)} - I_C$



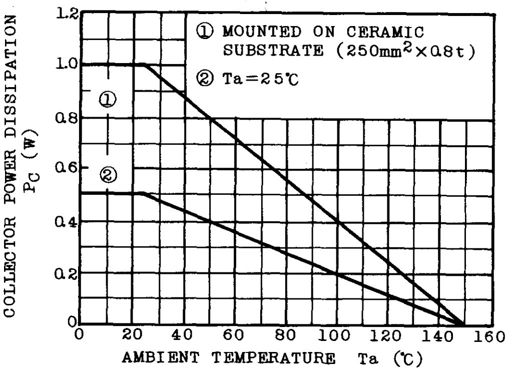
$I_C - V_{BE}$



SAFE OPERATING AREA



$P_C - Ta$



2SC2884

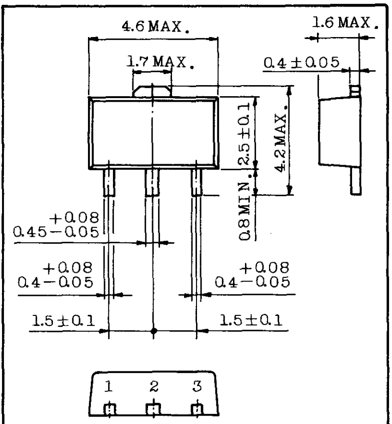
SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

AUDIO FREQUENCY AMPLIFIER APPLICATIONS.

FEATURES:

- High DC Current Gain : h_{FE}=100 ~ 320
- Suitable for Output Stage of 1 Watts Amplifier
- P_C=1 ~ 2W (Mounted on Ceramic Substrate)
- Small Flat Package
- Complementary to 2SA1204

Unit in mm

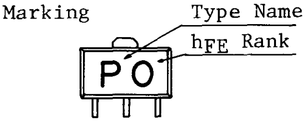


1. BASE
2. COLLECTOR (HEAT SINK)
3. EMITTER

JEDEC	−
EIAJ	−
TOSHIBA	2−5K1A

Weight : 0.052g

Marking



MAXIMUM RATINGS (Ta=25°C)

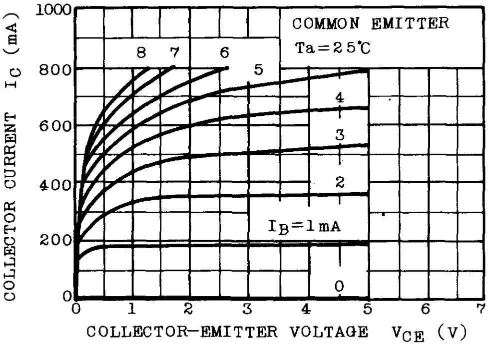
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	35	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	800	mA
Base Current	I_B	160	mA
Collector Power Dissipation	P_C	500	mW
Collector Power Dissipation	P_C※	1000	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55 ~ 150	°C

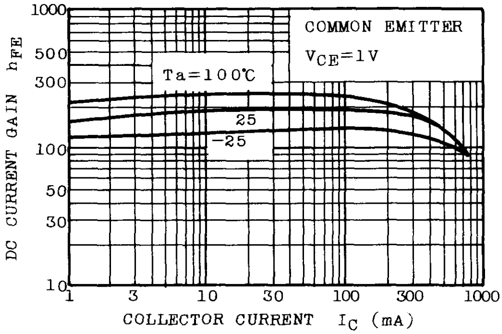
P_C※ : 2SC2884 mounted on ceramic substrate ($250mm^2 \times 0.8t$)

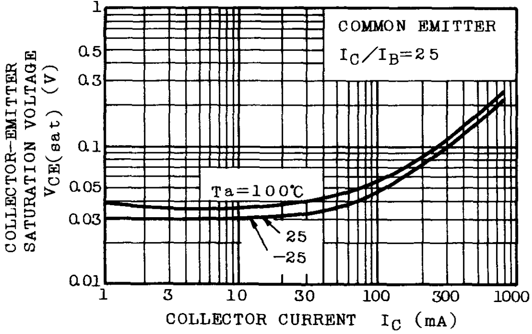
ELECTRICAL CHARACTERISTICS (Ta=25°C)

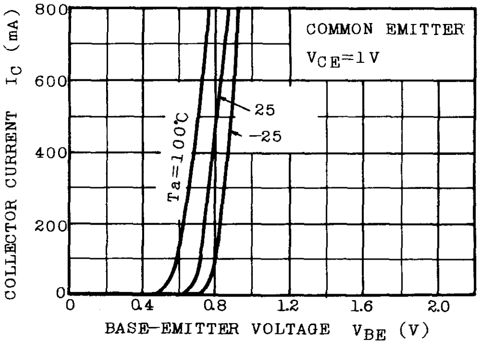
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=35V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=10mA, I_B=0	30	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=1V, I_C=100mA	100	-	320	
	$h_{FE(2)}$	V_{CE}=1V, I_C=700mA	35	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=500mA, I_B=20mA	-	-	0.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=1V, I_C=10mA	0.5	-	0.8	V
Transition Frequency	f_T	V_{CE}=5V, I_C=10mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	13	-	pF

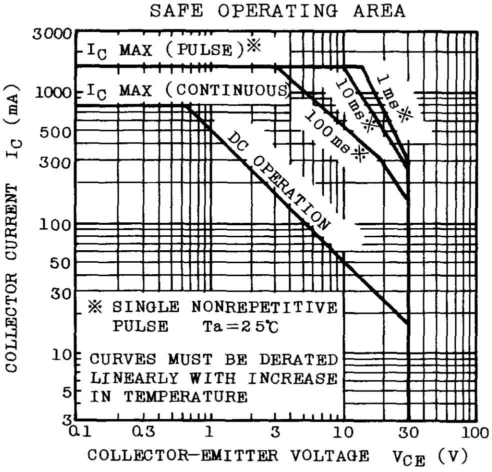
Note : h_{FE} Classification O : 100 ~ 200, Y : 160 ~ 320

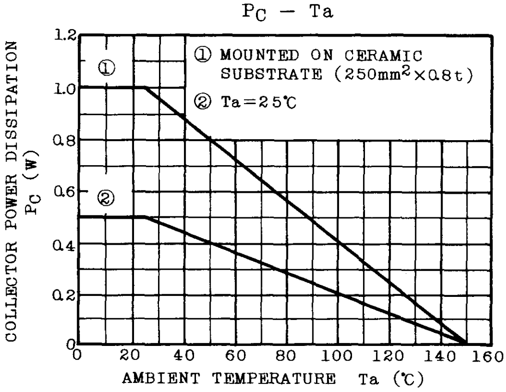

$I_C - V_{CE}$


$h_{FE} - I_C$


$V_{CE(sat)} - I_C$


$I_C - V_{BE}$


SAFE OPERATING AREA


$P_C - Ta$

2SC2982

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

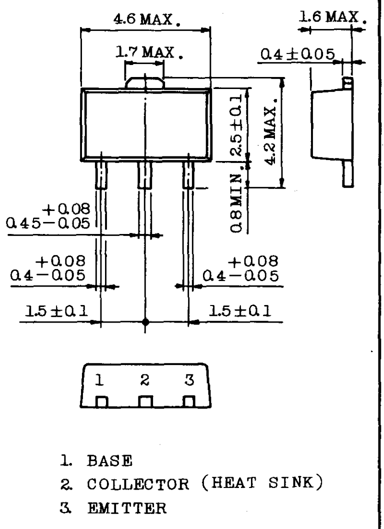
STROBO FLASH APPLICATIONS.

MEDIUM POWER AMPLIFIER APPLICATIONS.

FEATURES:

- High DC Current Gain and Excellent h_{FE} Linearity
  - : $h_{FE(1)}=140\sim600$ ($V_{CE}=1V$, $I_C=0.5A$)
  - : $h_{FE(2)}=70$ (Min.), 140 (Typ.) ($V_{CE}=1V$, $I_C=2A$)
- Low Saturation Voltage
  - : $V_{CE(sat)}=0.5V$ (Max.) ($I_C=2A$, $I_B=50mA$)
- Small Flat Package
- $P_C=1\sim2W$ (Mounted on Ceramic Substrate)

Unit in mm



1. BASE
2. COLLECTOR (HEAT SINK)
3. EMITTER

JEDEC	–
EIAJ	–
TOSHIBA	2-5K1A

Weight : 0.052g

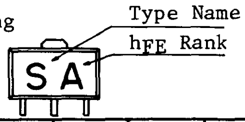
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Voltage		V_{CBO}	30	V
Collector-Emitter Voltage		V_{CES}	30	V
		V_{CEO}	10	
Emitter-Base Voltage		V_{EBO}	6	V
Collector Current	DC	I_C	2	A
	Pulse (Note 1)	I_{CP}	4	
Base Current	DC	I_B	0.4	A
	Pulse (Note 1)	I_{BP}	0.8	
Collector Power Dissipation		P_C	500	mW
Collector Power Dissipation		P_C※	1000	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_{stg}	$-55\sim150$	°C

Note 1 : Pulse Width≦10ms, Duty Cycle≦30%

P_C※ : 2SC2982 mounted on ceramic substrate ($250mm^2\times0.8t$)

Marking

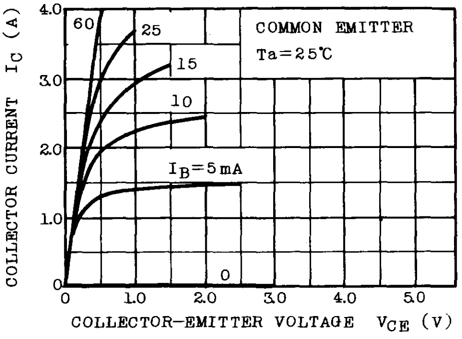


ELECTRICAL CHARACTERISTICS (Ta=25°C)

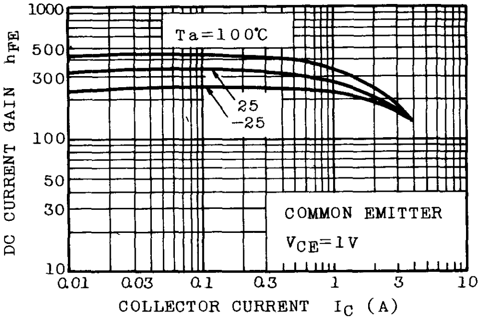
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	$V_{CB}=30V$, $I_E=0$	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	$V_{EB}=6V$, $I_C=0$	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	$I_C=10mA$, $I_B=0$	10	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	$I_E=1mA$, $I_C=0$	6	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note 2)	$V_{CE}=1V$, $I_C=0.5A$	140	-	600	
	$h_{FE(2)}$	$V_{CE}=1V$, $I_C=2A$	70	140	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C=2A$, $I_B=50mA$	-	0.2	0.5	V
Base-Emitter Voltage	V_{BE}	$V_{CE}=1V$, $I_C=2A$	-	0.86	1.5	V
Transition Frequency	f_T	$V_{CE}=1V$, $I_C=0.5A$	-	150	-	MHz
Collector Output Capacitance	C_{ob}	$V_{CB}=10V$, $I_E=0$, f=1MHz	-	27	-	pF

Note 2 : $h_{FE(1)}$ Classification A:140～240, B:200～330, C:300～450, D:420～600

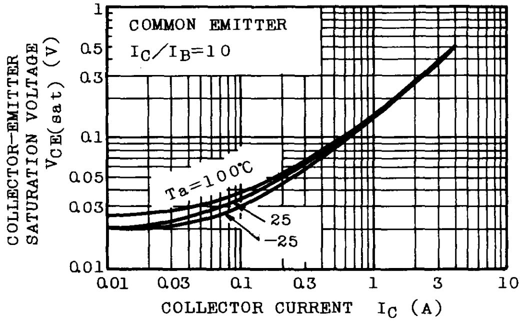
$I_C - V_{CE}$



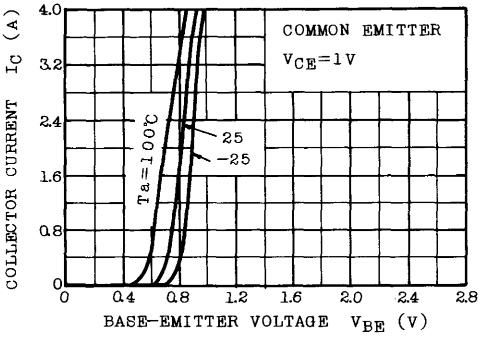
$h_{FE} - I_C$



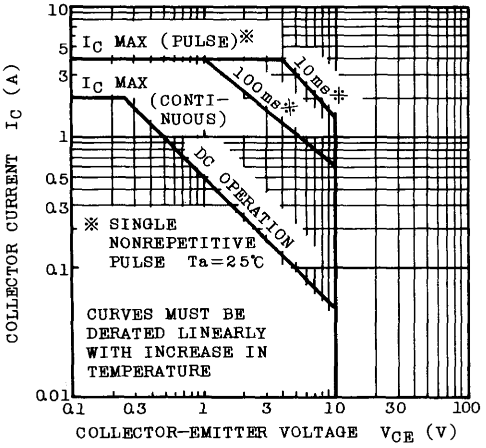
$V_{CE(sat)} - I_C$



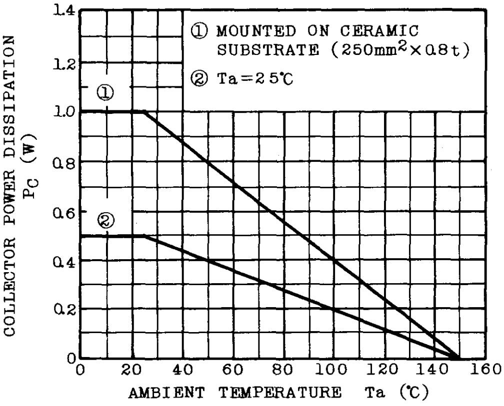
$I_C - V_{BE}$



SAFE OPERATING AREA



$P_C - Ta$



2SC2986

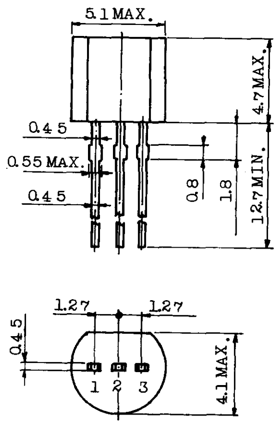
SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

FM/AM, RF, MIX, OSC, IF
HIGH FREQUENCY AMPLIFIER APPLICATIONS.

FEATURES:

- High Stability Oscillation Voltage On FM Local Oscillator.
- Recommend FM/AM RF, MIX, OSC, and IF.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

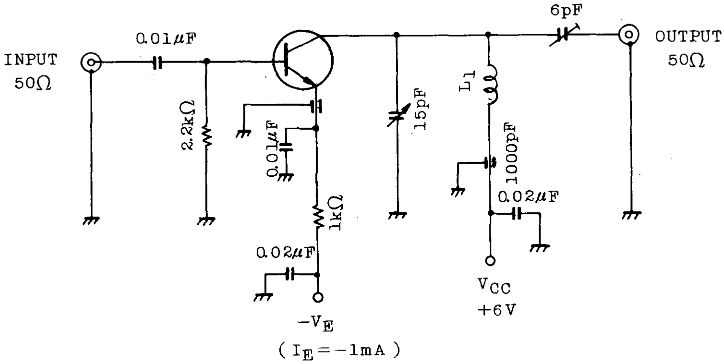
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	40	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	50	mA
Emitter Current	I_E	-50	mA
Collector Power Dissipation	P_C	300	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=40V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=4V, I_C=0	-	-	0.5	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=6V, I_C=1mA	40	-	240	
Reverse Transfer Capacitance	C_{re}	V_{CE}=6V, f=1MHz	-	0.9	1.3	pF
Transition Frequency	f_T	V_{CE}=6V, I_E=-1mA	150	350	-	MHz
Collector-Base Time Constant	$C_c.r_{bb'}$	V_{CE}=6V, I_E=-1mA, f=30MHz	-	15	30	ps
Noise Figure	NF	V_{CC}=6V, I_E=-1mA f=100MHz (Fig.1)	-	4.0	-	dB
Power Gain	G_{pe}		-	15	-	
Oscillation Output Voltage	V_{OSC}	V_{CC}=6V, f=100MHz (Fig.2)	-	150	-	mV

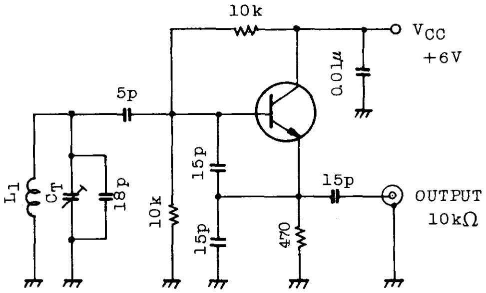
Note : h_{FE} Classification R:40~80 O:70~140 Y:120~240

Fig. 1 NF, G_{pe} TEST CIRCUIT



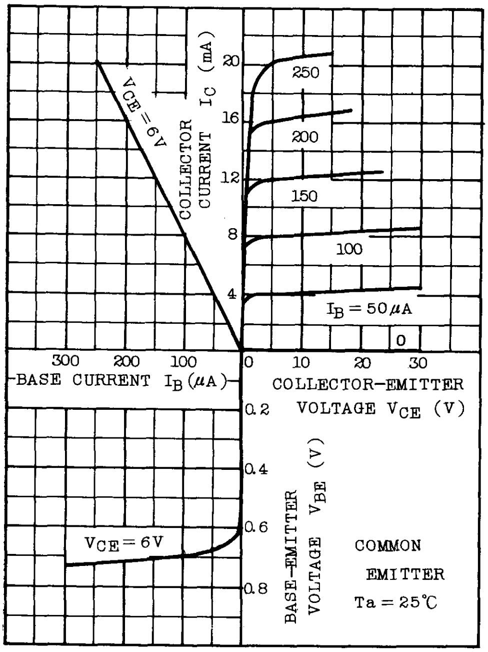
L_1 : 0.8mmϕ SILVER PLATED COPPER WIRE, 4T, 10ID, 8 LENGTH

Fig. 2 V_{OSC} TEST CIRCUIT

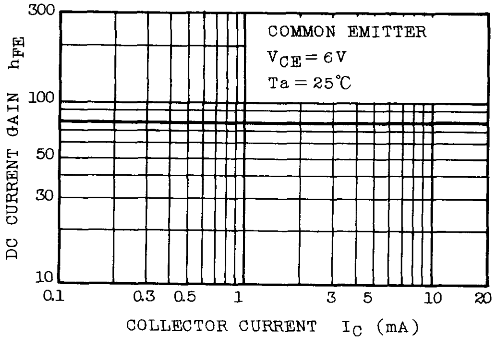


L_1 : 0.8mmϕ SILVER PLATED COPPER WIRE,4T, 10ID, 8 LENGTH

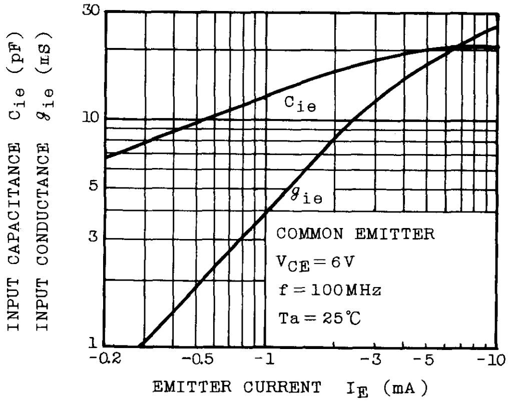
STATIC CHARACTERISTICS



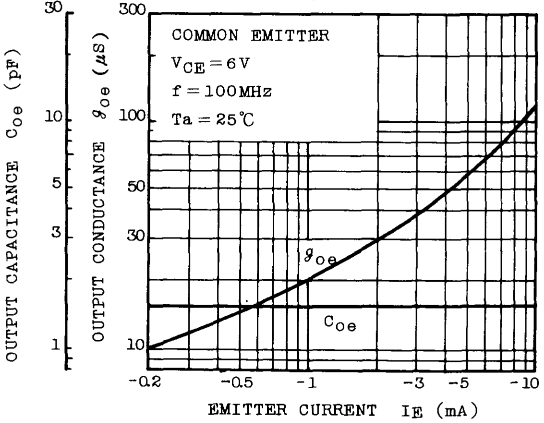
h_{FE} — I_C



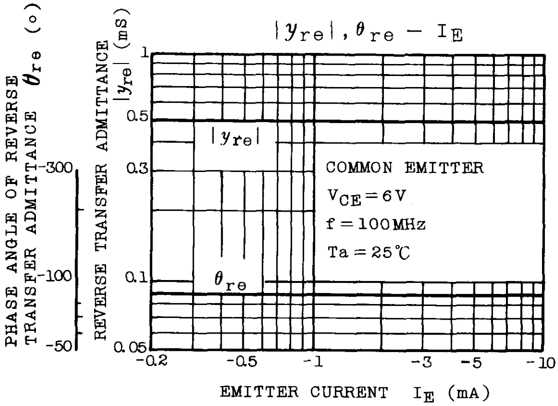
C_{ie}, g_{ie} — I_E

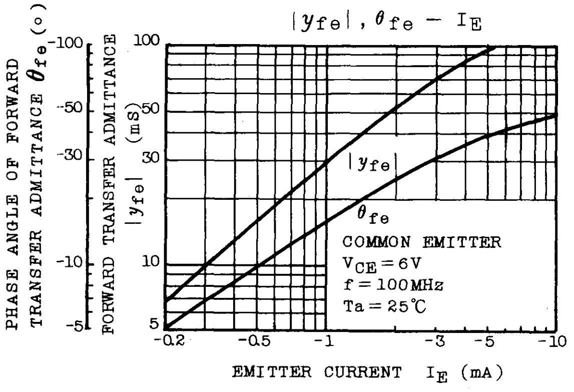


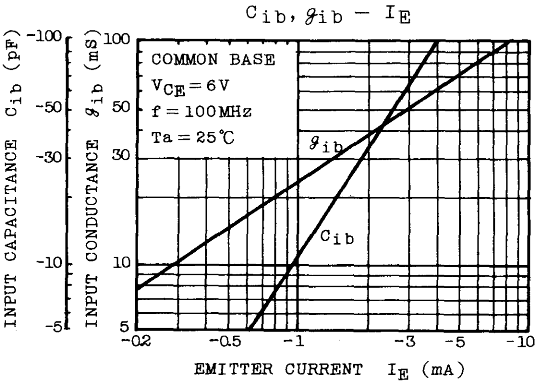
C_{oe}, g_{oe} — I_E

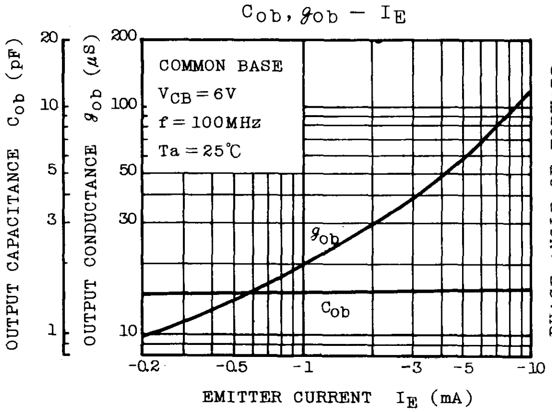


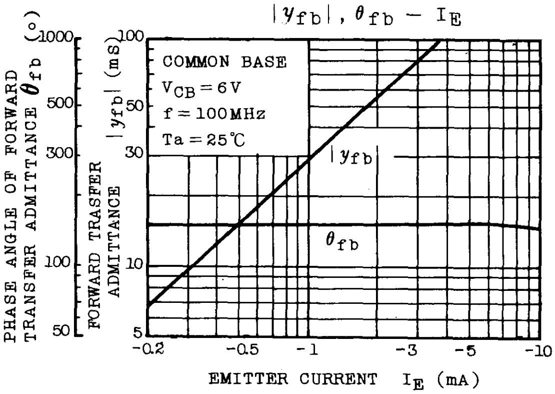
$|y_{re}|$, θ_{re} — I_E

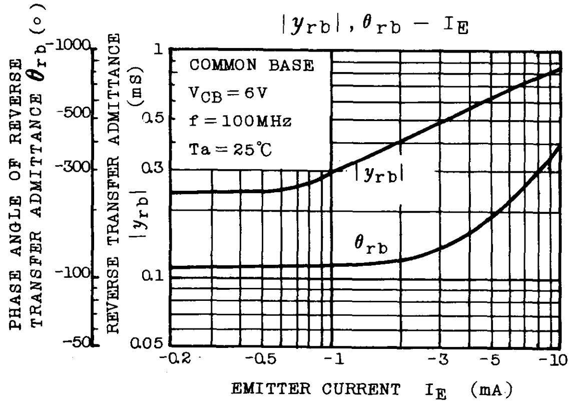


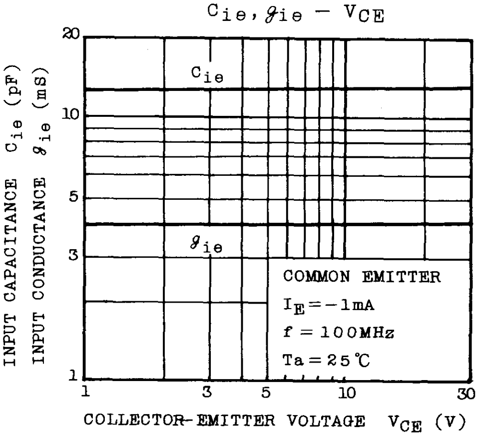

$|y_{fe}|, \theta_{fe} - I_E$
PHASE ANGLE OF FORWARD TRANSFER ADMITTANCE θ_{fe} (°)
-100
-50
-30
-10
-5
FORWARD TRANSFER ADMITTANCE $|y_{fe}|$ (mS)
100
50
30
10
5
$|y_{fe}|$
θ_{fe}
COMMON EMITTER
$V_{CE}=6V$
f = 100MHz
Ta = 25℃
-0.2
-0.5
-1
-3
-5
-10
EMITTER CURRENT I_E (mA)


$C_{ib}, g_{ib} - I_E$
INPUT CAPACITANCE C_{ib} (pF)
-100
-50
-30
-10
-5
INPUT CONDUCTANCE g_{ib} (mS)
100
50
30
10
5
COMMON BASE
$V_{CB}=6V$
f = 100MHz
Ta = 25℃
g_{ib}
C_{ib}
-0.2
-0.5
-1
-3
-5
-10
EMITTER CURRENT I_E (mA)

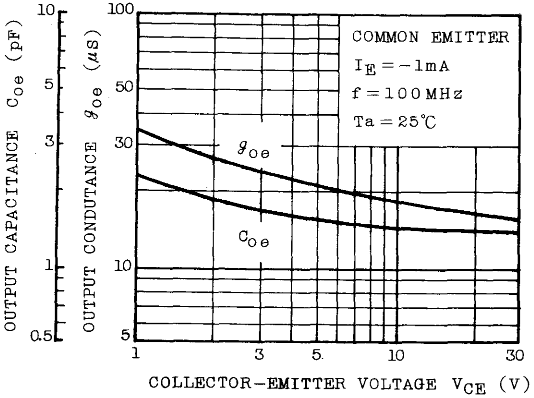

$C_{ob}, g_{ob} - I_E$
OUTPUT CAPACITANCE C_{ob} (pF)
20
10
5
3
1
OUTPUT CONDUCTANCE g_{ob} (μS)
200
100
50
30
10
COMMON BASE
$V_{CB}=6V$
f = 100MHz
Ta = 25℃
g_{ob}
C_{ob}
-0.2
-0.5
-1
-3
-5
-10
EMITTER CURRENT I_E (mA)


$|y_{fb}|, \theta_{fb} - I_E$
PHASE ANGLE OF FORWARD TRANSFER ADMITTANCE θ_{fb} (°)
1000
500
300
100
50
FORWARD TRASFER ADMITTANCE $|y_{fb}|$ (mS)
100
50
30
10
5
COMMON BASE
$V_{CB}=6V$
f = 100MHz
Ta = 25℃
$|y_{fb}|$
θ_{fb}
-0.2
-0.5
-1
-3
-5
-10
EMITTER CURRENT I_E (mA)

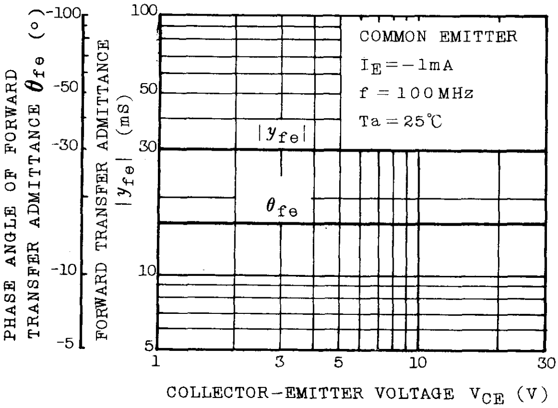

$|y_{rb}|, \theta_{rb} - I_E$
PHASE ANGLE OF REVERSE TRANSFER ADMITTANCE θ_{rb} (°)
-1000
-500
-300
-100
-50
REVERSE TRANSFER ADMITTANCE $|y_{rb}|$ (mS)
1
0.5
0.3
0.1
0.05
COMMON BASE
$V_{CB}=6V$
f = 100MHz
Ta = 25℃
$|y_{rb}|$
θ_{rb}
-0.2
-0.5
-1
-3
-5
-10
EMITTER CURRENT I_E (mA)


$C_{ie}, g_{ie} - V_{CE}$
INPUT CAPACITANCE C_{ie} (pF)
INPUT CONDUCTANCE g_{ie} (mS)
20
10
5
3
1
C_{ie}
g_{ie}
COMMON EMITTER
$I_E=-1mA$
f = 100MHz
Ta = 25℃
1
3
5
10
30
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)

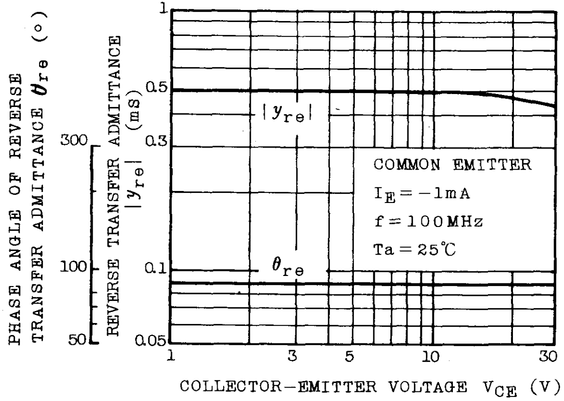
C_{oe}, g_{oe} − V_{CE}



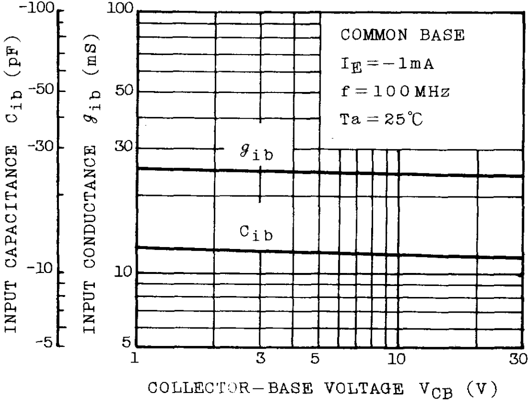
$|y_{fe}|$, θ_{fe} − V_{CE}



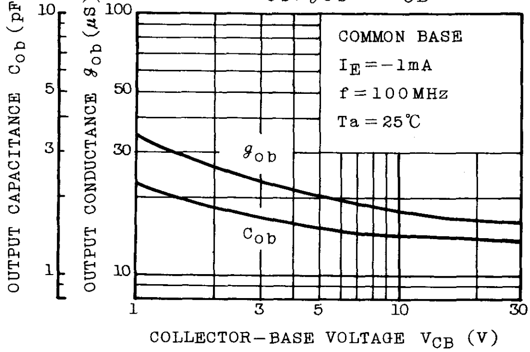
$|y_{re}|$, θ_{re} − V_{CE}



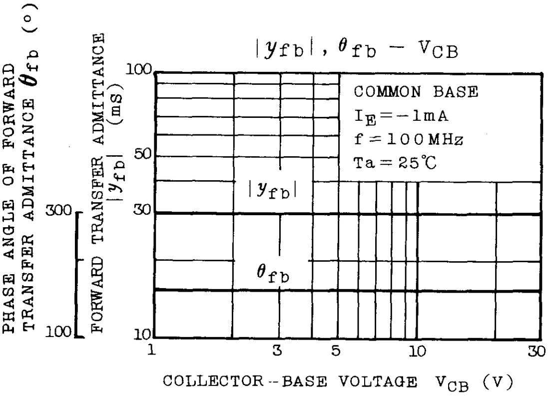
C_{ib}, g_{ib} − V_{CB}

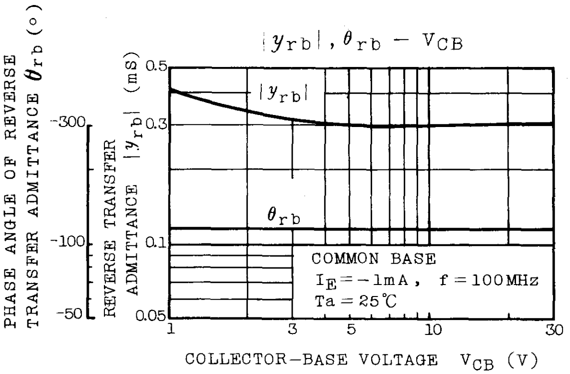


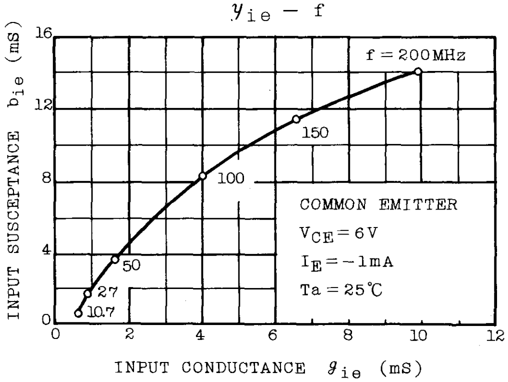
C_{ob}, g_{ob} − V_{CB}

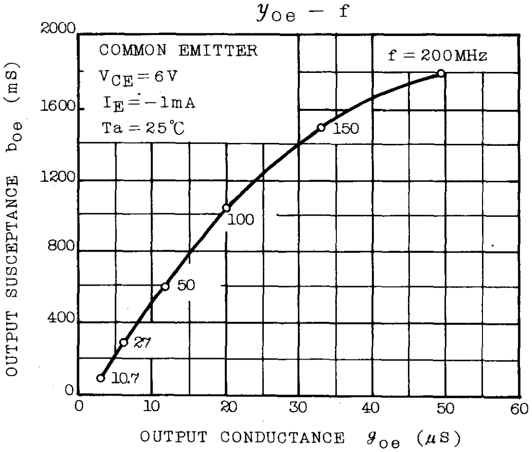


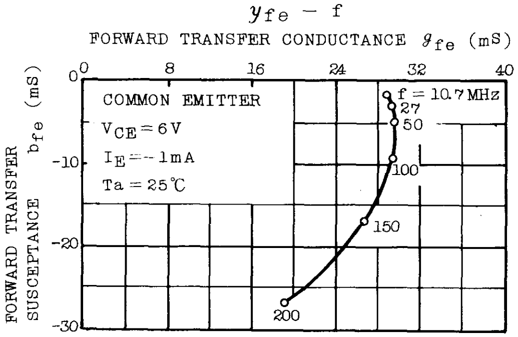
$|y_{fb}|$, θ_{fb} − V_{CB}

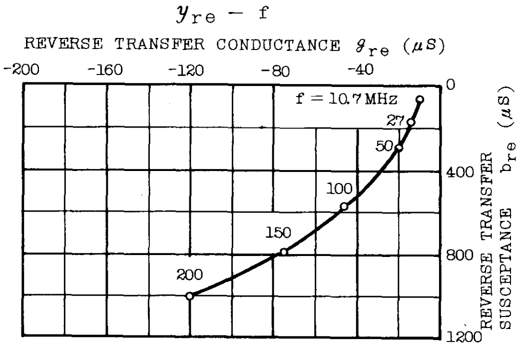


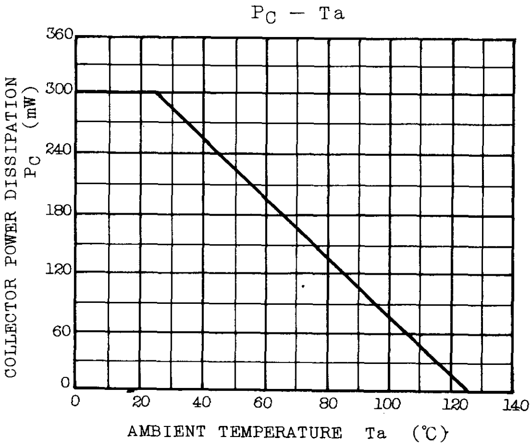

$|y_{rb}|, \theta_{rb} - V_{CB}$


$y_{ie} - f$


$y_{oe} - f$


$y_{fe} - f$


$y_{re} - f$


$P_C - Ta$

2SC2995

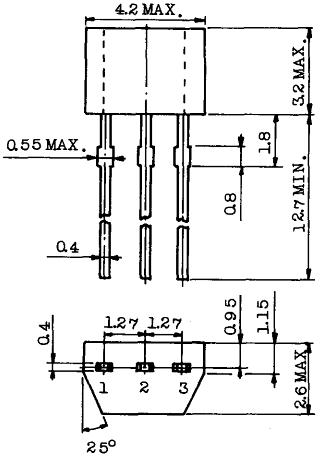
SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

FM/AM RF, MIX, OSC, IF
HIGH FREQUENCY AMPLIFIER APPLICATIONS.

FEATURES:

- High Stability Oscillation Voltage On FM Local Oscillator.
- Recommend FM/AM RF, MIX, OSC and IF.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	–
EIAJ	–
TOSHIBA	2–4E1A

Weight : 0.13g

MAXIMUM RATINGS (Ta=25 °C)

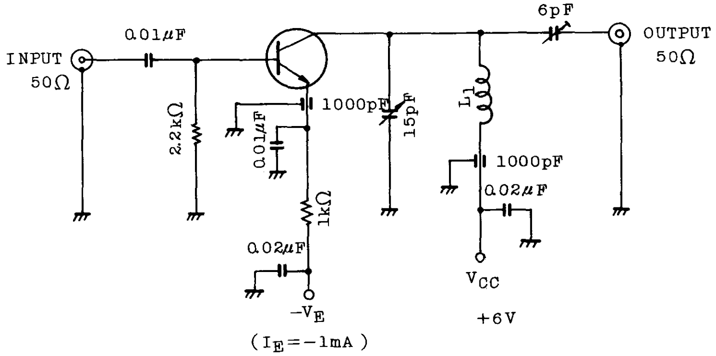
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	40	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	50	mA
Emitter Current	I_E	-50	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55～125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=40V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=4V, I_C=0	-	-	0.5	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=6V, I_C=1mA	40	-	240	
Reverse Transfer Capacitance	C_{re}	V_{CE}=6V, f=1MHz	-	0.9	1.3	pF
Transition Frequency	f_T	V_{CE}=6V, I_E=-1mA	150	350	-	MHz
Collector-Base Time Constant	$C_c.r_{bb'}$	V_{CE}=6V, I_E=-1mA, f=30MHz	-	15	30	ps
Noise Figure	NF	V_{CC}=6V, I_E=-1mA f=100MHz (Fig.1)	-	4.0	-	dB
Power Gain	G_{pe}		-	15	-	
Oscillation Output Voltage	V_{OSC}	V_{CC}=6V, f=100MHz (Fig.2)	-	150	-	mV

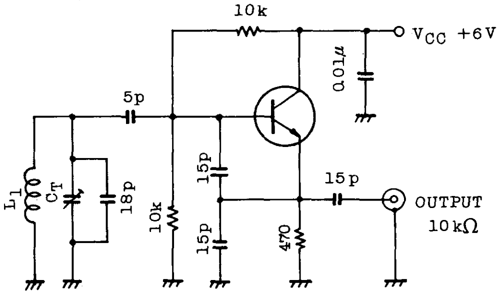
Note : h_{FE} Classification R:40~80 O:70~140 Y:120~240

Fig. 1 NF, G_{pe} TEST CIRCUIT



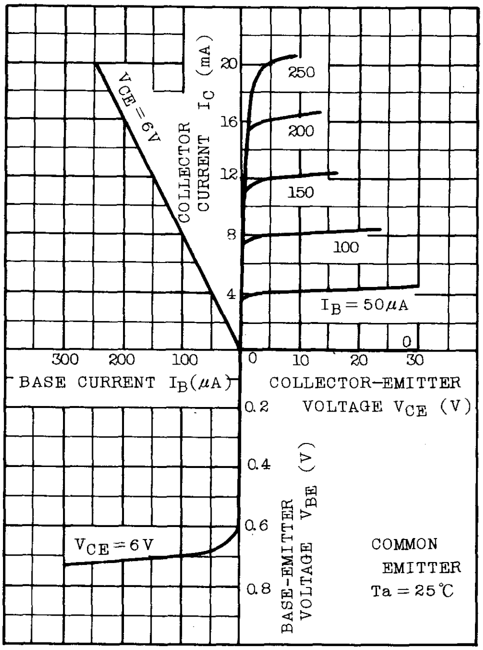
L_1 : 0.8mmϕ SILVER PLATED COPPER WIRE, 4T, 10ID, 8 LENGTH

Fig. 2 V_{OSC} TEST CIRCUIT

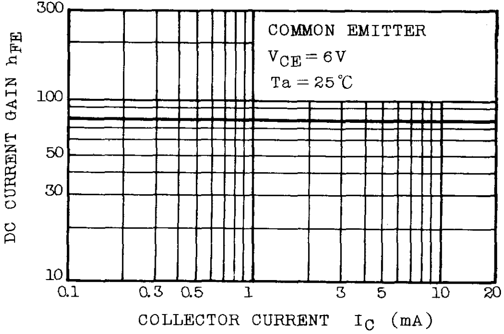


L_1 : 0.8mmϕ SILVER PLATED COPPER WIRE, 4T, 10ID, 8 LENGTH

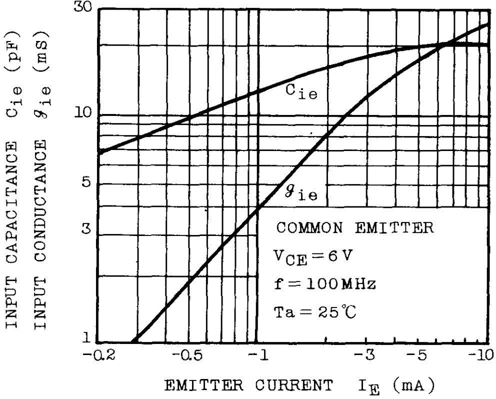
STATIC CHARACTERISTICS



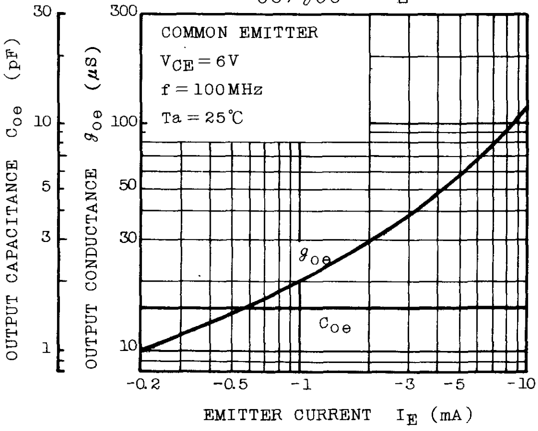
h_{FE} − I_C



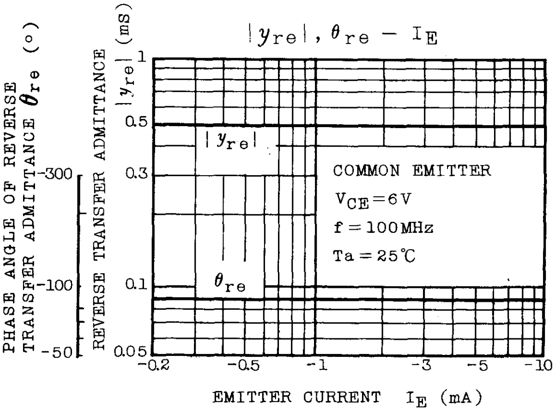
C_{ie}, g_{ie} − I_E

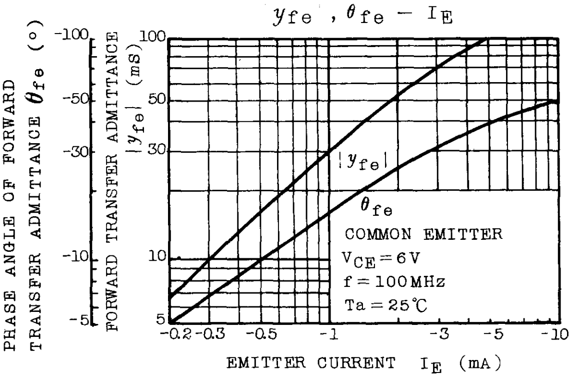


C_{oe}, g_{oe} − I_E

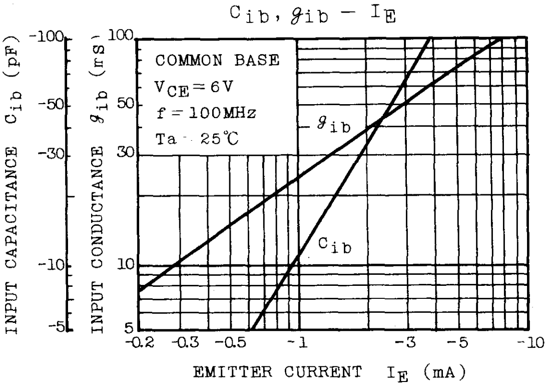


$|y_{re}|$, θ_{re} − I_E

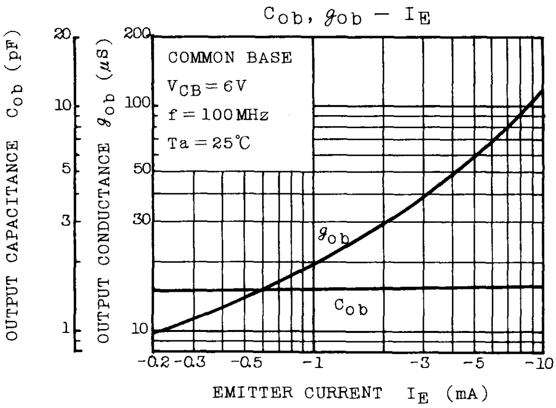




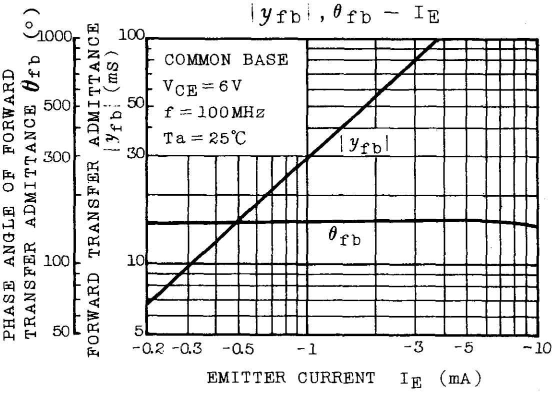
y_{fe} , θ_{fe} — I_E



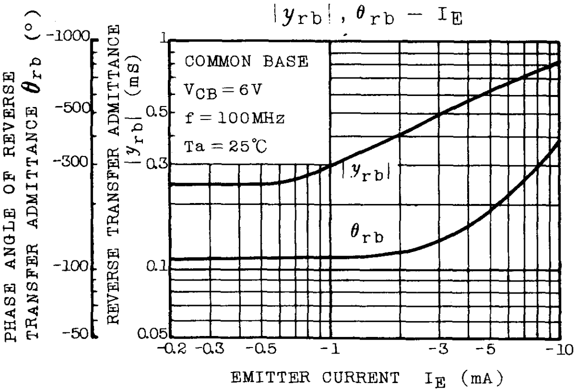
C_{ib}, g_{ib} — I_E



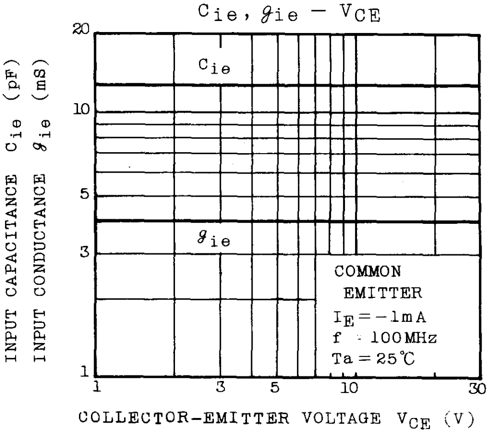
C_{ob}, g_{ob} — I_E



|y_{fb}|, θ_{fb} — I_E

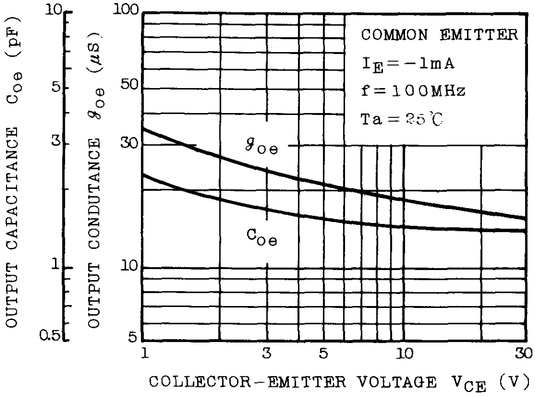


|y_{rb}|, θ_{rb} — I_E

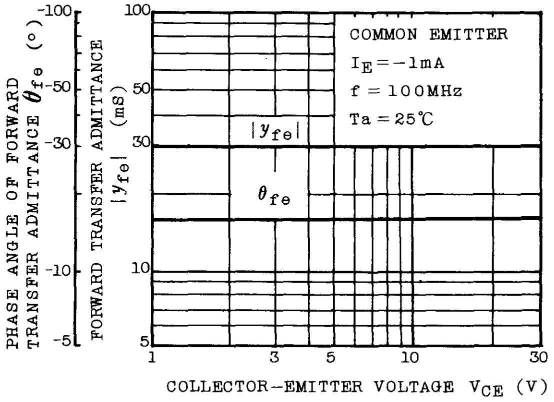


C_{ie}, g_{ie} — V_{CE}

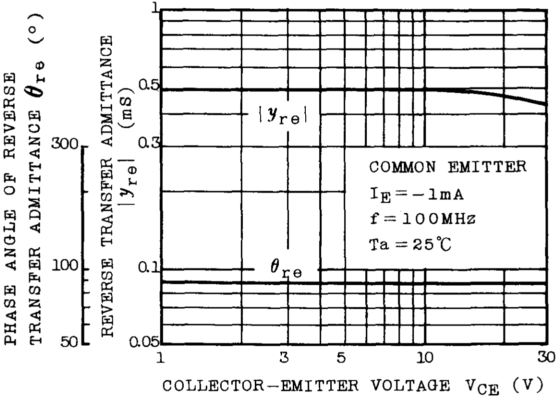
C_{oe}, g_{oe} — V_{CE}



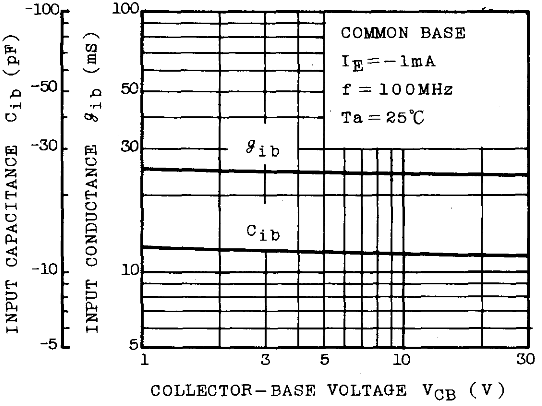
$|y_{fe}|$, θ_{fe} — V_{CE}



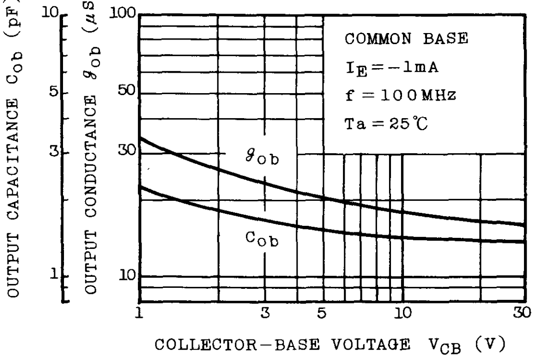
$|y_{re}|$, θ_{re} — V_{CE}



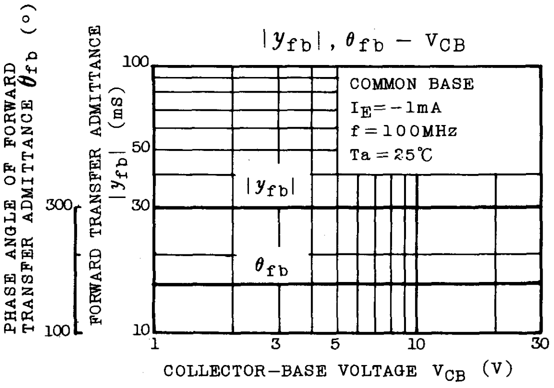
C_{ib}, g_{ib} — V_{CB}

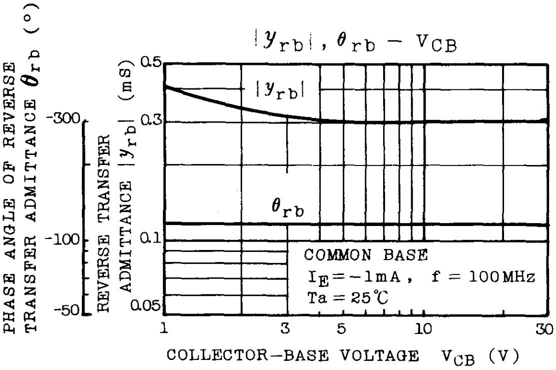


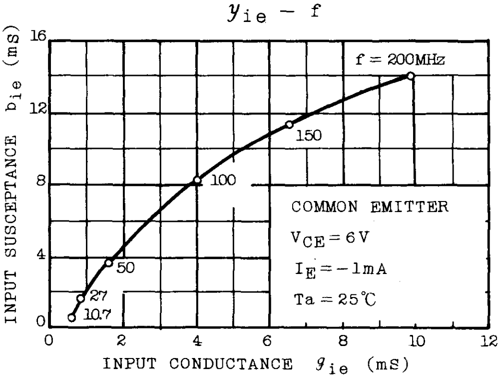
C_{ob}, g_{ob} — V_{CB}

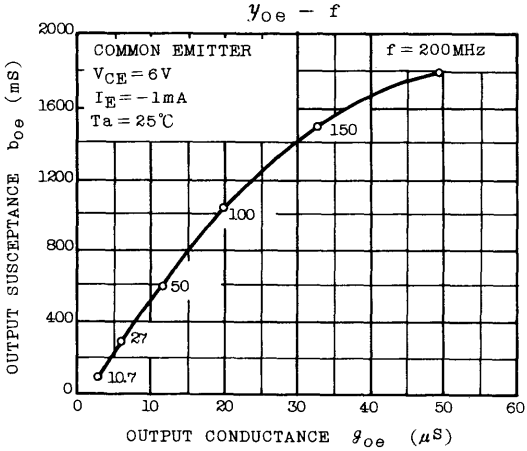


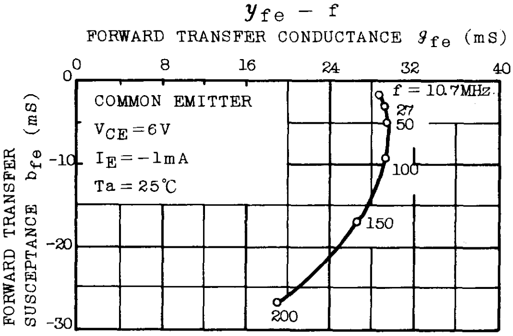
$|y_{fb}|$, θ_{fb} — V_{CB}

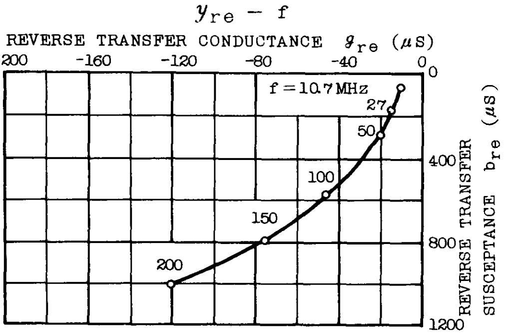


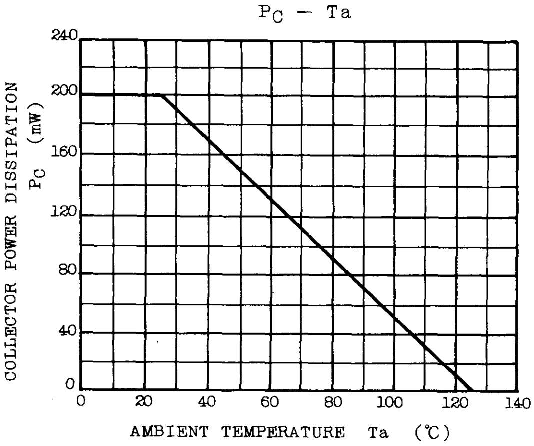

$|y_{rb}|, \theta_{rb} - V_{CB}$


$y_{ie} - f$


$y_{oe} - f$


$y_{fe} - f$


$y_{re} - f$


$P_C - Ta$

2SC2996

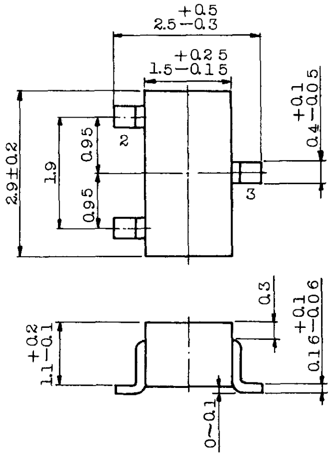
SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

FM/AM, RF, MIX, OSC, IF
HIGH FREQUENCY AMPLIFIER APPLICATIONS.

FEATURES:

- High Stability Oscillation Voltage On FM Local Oscillator.
- Recommend FM/AM RF, MIX, OSC, and IF.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	—
EIAJ	SC—59
TOSHIBA	2—3F1A

Weight : 0.012g

MAXIMUM RATINGS (Ta=25°C)

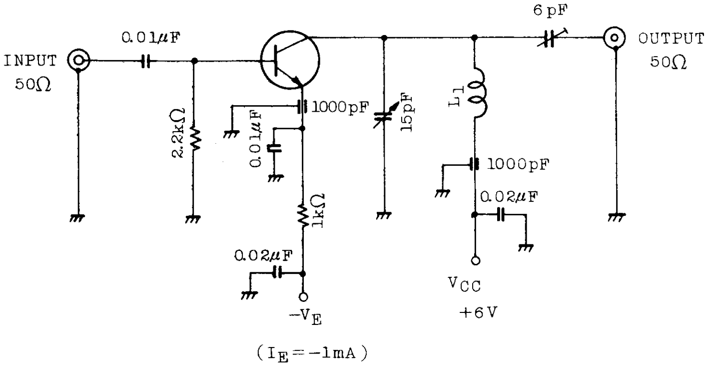
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	40	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	50	mA
Emitter Current	I_E	-50	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=40V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=4V, I_C=0	-	-	0.5	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=6V, I_C=1mA	40	-	240	
Reverse Transfer Capacitance	C_{re}	V_{CE}=6V, f=1MHz	-	0.9	1.3	pF
Transition Frequency	f_T	V_{CE}=6V, I_E=-1mA	150	350	-	MHz
Collector-Base Time Constant	$C_c.r_{bb'}$	V_{CE}=6V, I_E=-1mA, f=30MHz	-	15	30	ps
Noise Figure	NF	V_{CC}=6V, I_E=-1mA, f=100MHz (Fig.1)	-	4.0	-	dB
Power Gain	G_{pe}		-	15	-	
Oscillation Output Voltage	V_{OSC}	V_{CC}=6V, f=100MHz (Fig.2)	-	150	-	mV

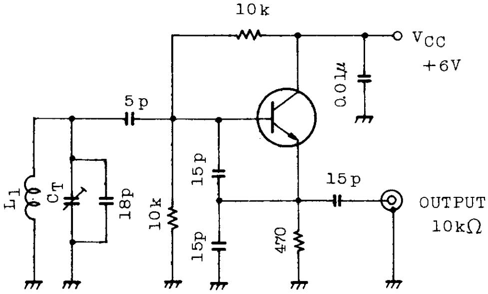
Note : h_{FE} Classification R:40~80 O:70~140 Y:120~240

Fig. 1 NF, G_{pe} TEST CIRCUIT



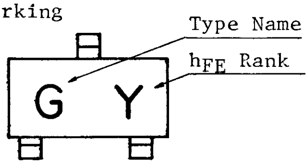
L_1 : 0.8mmφ SILVER PLATED COPPER WIRE, 4T, 10ID, 8 LENGTH

Fig. 2 VOSC TEST CIRCUIT

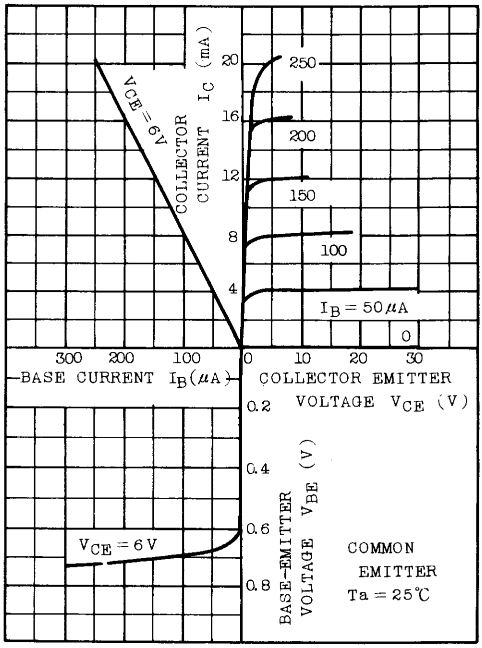


L_1 : 0.8mmφ SILVER PLATED COPPER WIRE, 4T, 10ID, 8 LENGTH

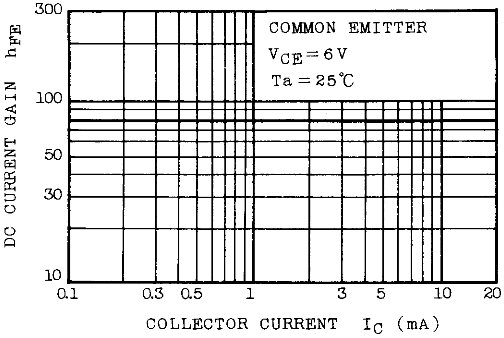
Marking



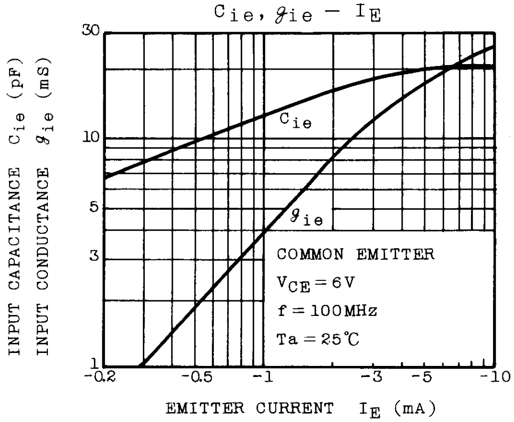
STATIC CHARACTERISTICS



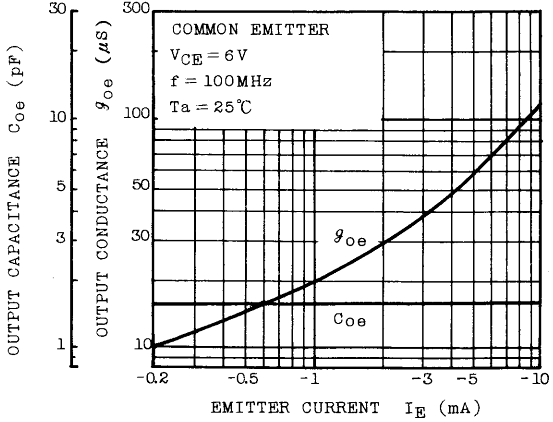
$h_{FE} - I_C$



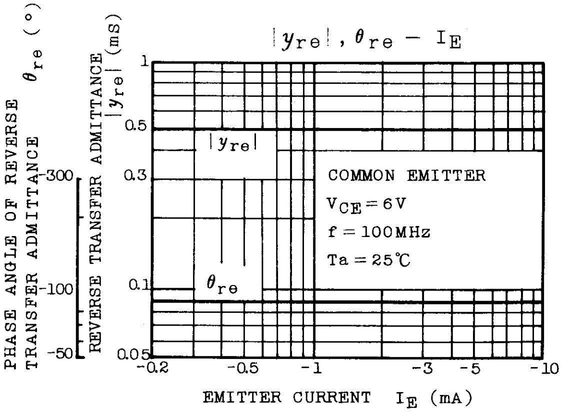
$C_{ie}, g_{ie} - I_E$



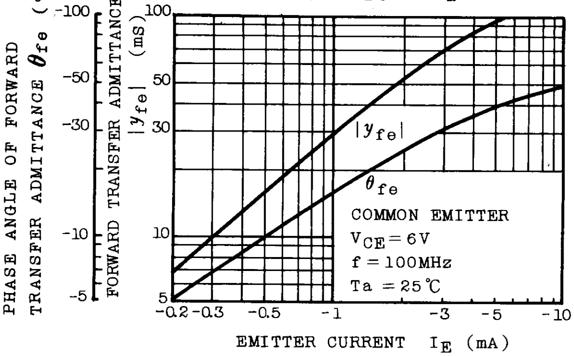
$C_{oe}, g_{oe} - I_E$



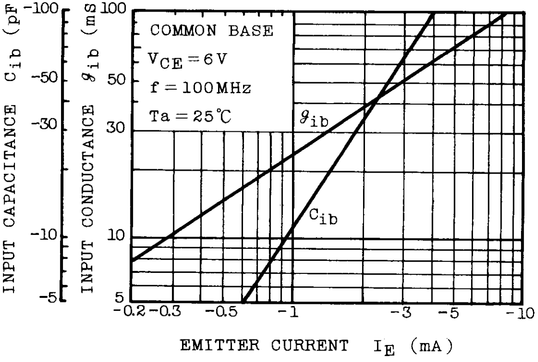
$|y_{re}|, \theta_{re} - I_E$



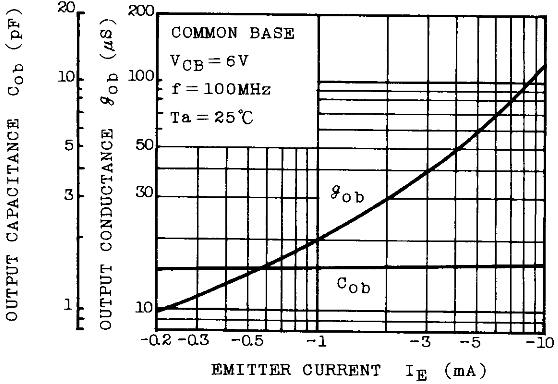
$|y_{fe}|$, θ_{fe} — I_E



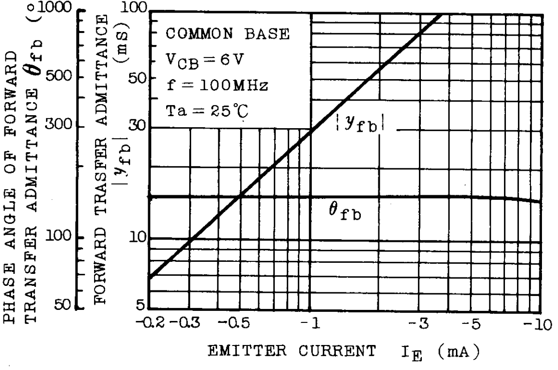
C_{ib}, g_{ib} — I_E



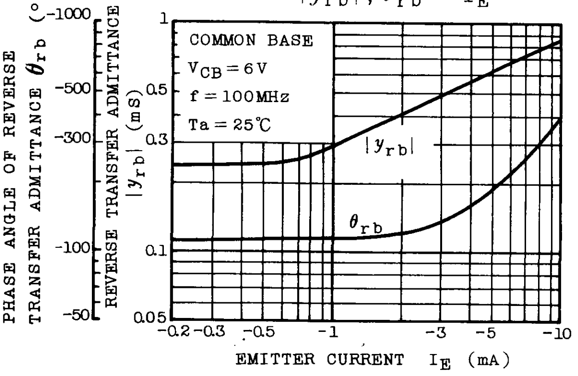
C_{ob}, g_{ob} — I_E



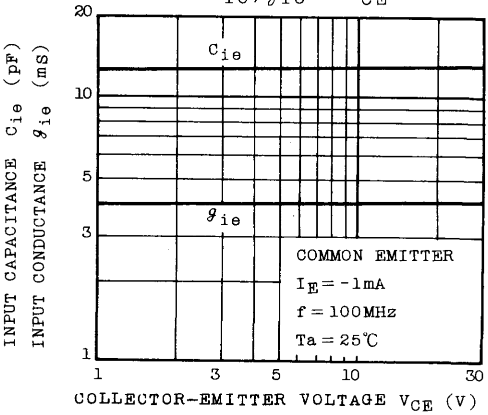
$|y_{fb}|$, θ_{fb} — I_E

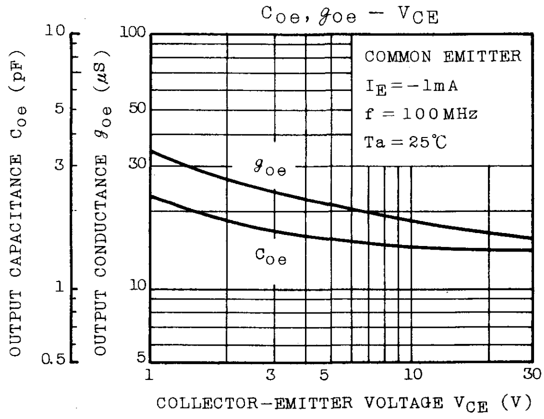


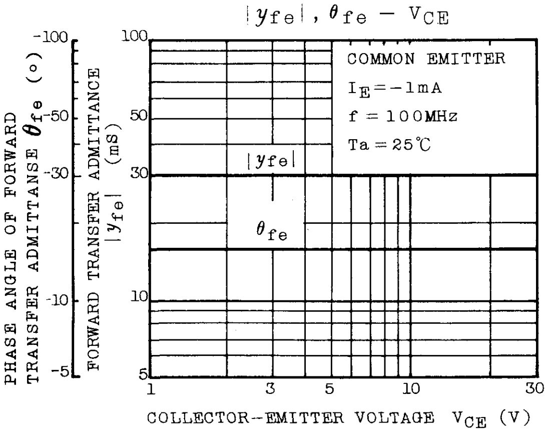
$|y_{rb}|$, θ_{rb} — I_E

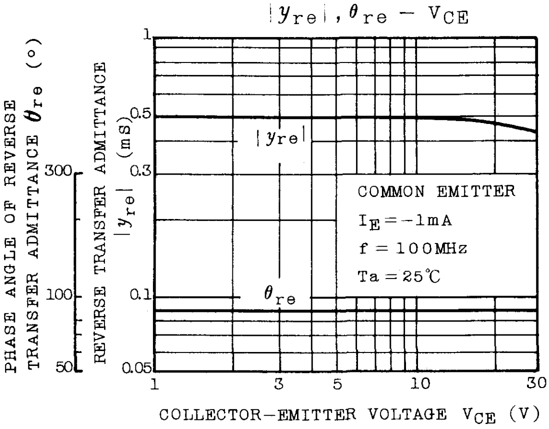


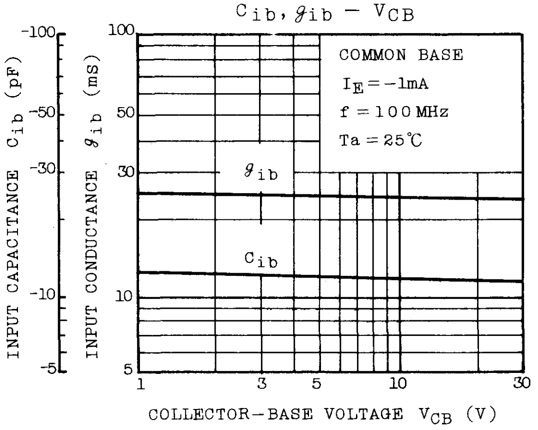
C_{ie}, g_{ie} — V_{CE}

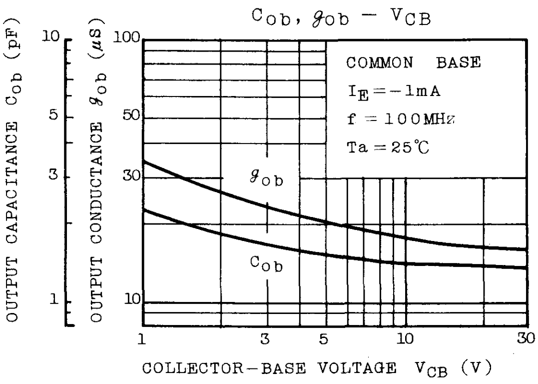


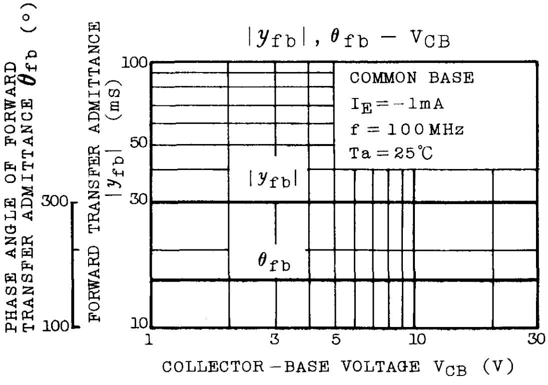

Coe, goe — VCE
COMMON EMITTER
IE=−1mA
f = 100MHz
Ta = 25℃
goe
Coe
OUTPUT CAPACITANCE Coe (pF)
OUTPUT CONDUCTANCE goe (μS)
10
5
3
1
0.5
100
50
30
10
5
1
3
5
10
30
COLLECTOR−EMITTER VOLTAGE VCE (V)


|yfe|, θfe — VCE
COMMON EMITTER
IE=−1mA
f = 100MHz
Ta = 25℃
|yfe|
θfe
PHASE ANGLE OF FORWARD TRANSFER ADMITTANSE θfe (°)
FORWARD TRANSFER ADMITTANCE |yfe| (mS)
−100
−50
−30
−10
−5
100
50
30
10
5
1
3
5
10
30
COLLECTOR−EMITTER VOLTAGE VCE (V)

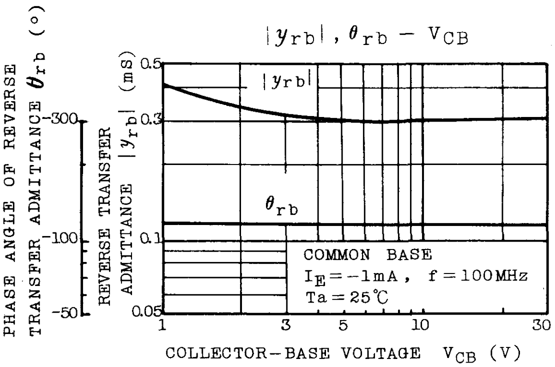

|yre|, θre — VCE
COMMON EMITTER
IE=−1mA
f = 100MHz
Ta = 25℃
|yre|
θre
PHASE ANGLE OF REVERSE TRANSFER ADMITTANCE θre (°)
REVERSE TRANSFER ADMITTANCE |yre| (mS)
300
100
50
1
0.5
0.3
0.1
0.05
1
3
5
10
30
COLLECTOR−EMITTER VOLTAGE VCE (V)


Cib, gib — VCB
COMMON BASE
IE=−1mA
f = 100MHz
Ta = 25℃
gib
Cib
INPUT CAPACITANCE Cib (pF)
INPUT CONDUCTANCE gib (mS)
−100
−50
−30
−10
−5
100
50
30
10
5
1
3
5
10
30
COLLECTOR−BASE VOLTAGE VCB (V)

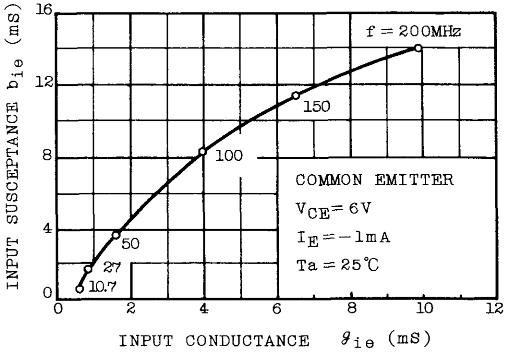

Cob, gob — VCB
COMMON BASE
IE=−1mA
f = 100MHz
Ta = 25℃
gob
Cob
OUTPUT CAPACITANCE Cob (pF)
OUTPUT CONDUCTANCE gob (μS)
10
5
3
1
100
50
30
10
1
3
5
10
30
COLLECTOR−BASE VOLTAGE VCB (V)


|yfb|, θfb — VCB
COMMON BASE
IE=−1mA
f = 100MHz
Ta = 25℃
|yfb|
θfb
PHASE ANGLE OF FORWARD TRANSFER ADMITTANCE θfb (°)
FORWARD TRANSFER ADMITTANCE |yfb| (mS)
300
100
100
50
30
10
1
3
5
10
30
COLLECTOR−BASE VOLTAGE VCB (V)

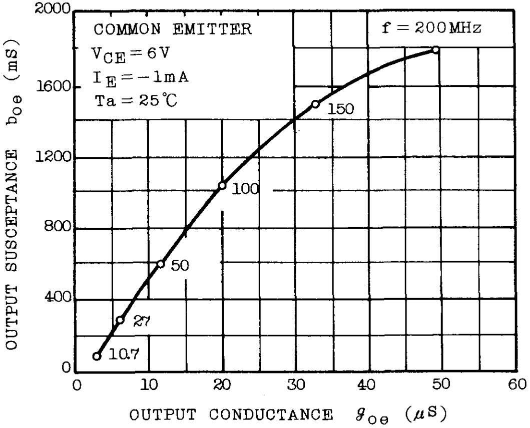
$|y_{rb}|, \theta_{rb} - V_{CB}$



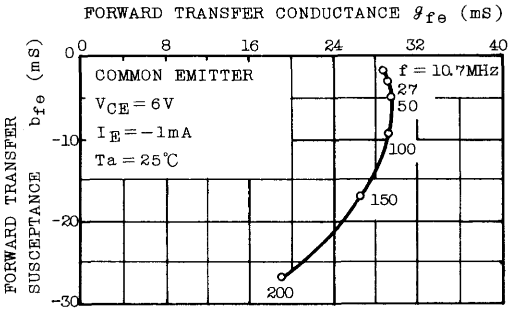
$y_{ie} - f$



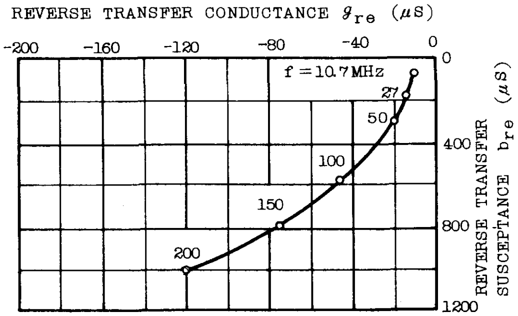
$y_{oe} - f$



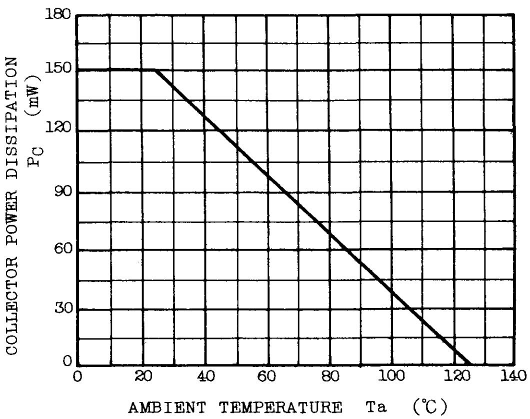
$y_{fe} - f$



$y_{re} - f$



$P_C - Ta$

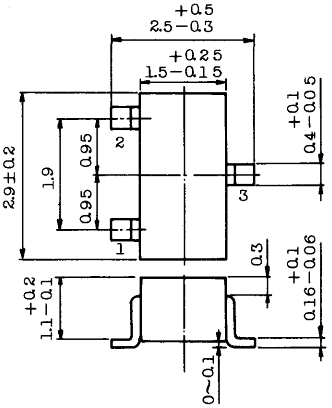


2SC3011

SILICON NPN EPTAXIAL PLANAR TYPE

UHF~C BAND LOW NOISE AMPLIFIER APPLICATIONS.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	−
EIAJ	SC−59
TOSHIBA	2−3F1A

Weight : 0.012g

FEATURES:

- High Gain : $|S_{21e}|^2$=12dB (Typ.)
- Low Noise Figure : NF=2.3dB (Typ.), f=1GHz
- High f_T : f_T=6.5GHz (Typ.)

MAXIMUM RATINGS ($Ta=25^{\circ}C$)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	20	V
Collector-Emitter Voltage	V_{CEO}	7	V
Emitter-Base Voltage	V_{EBO}	3	V
Base Current	I_B	10	mA
Collector Current	I_C	30	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	−55~125	°C

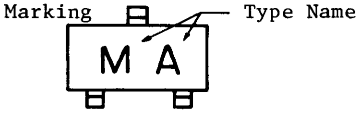
MICROWAVE CHARACTERISTICS ($Ta=25^{\circ}C$)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Transition Frequency	f_T	V_{CE}=5V, I_C=10mA	−	6.5	−	GHz
Insertion Gain	$\|S_{21e}\|^2$	V_{CE}=5V, I_C=10mA, f=1GHz	−	12	−	dB
Noise Figure	NF	V_{CE}=5V, I_C=5mA, f=1GHz	−	2.3	−	dB

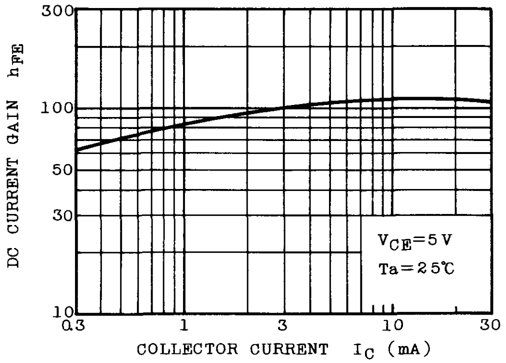
ELECTRICAL CHARACTERISTICS ($Ta=25^{\circ}C$)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=10V, I_E=0	−	−	1.0	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=1V, I_C=0	−	−	1.0	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=0.5mA, I_B=0	7	−	−	V
DC Current Gain	h_{FE}	V_{CE}=5V, I_C=10mA	30	120	−	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	−	0.1	−	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$		−	0.87	−	V
Collector Output Capacitance	C_{ob}	V_{CB}=5V, I_E=0, f=1MHz	−	0.7	0.9	pF
Reverse Transfer Capacitance	C_{re}	(Note)	−	0.5	−	pF
Input Capacitance	C_{ib}	V_{EB}=0, I_C=0, f=1MHz	−	0.8	−	pF

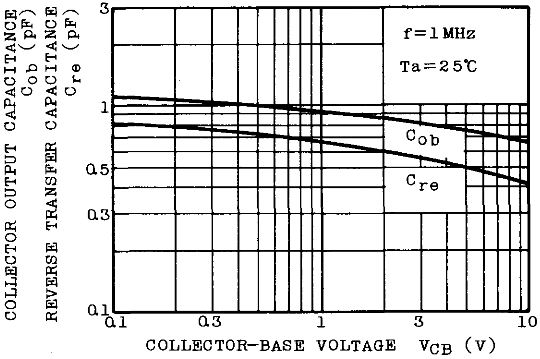
Note : Cre is measured by 3-terminal method with Capacitance Bridge.



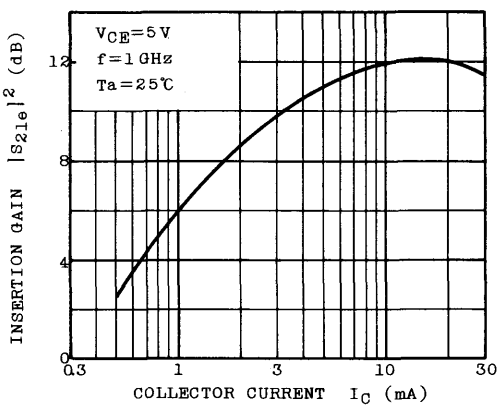
$h_{FE} - I_C$



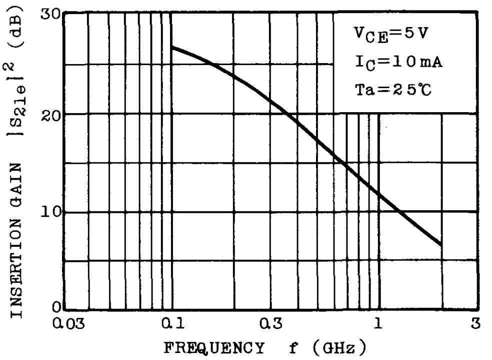
$C_{ob}, C_{re} - V_{CB}$



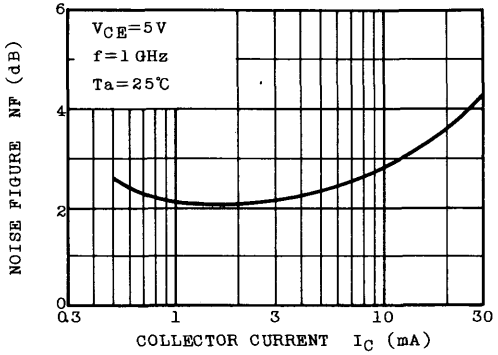
$|S_{21e}|^2 - I_C$



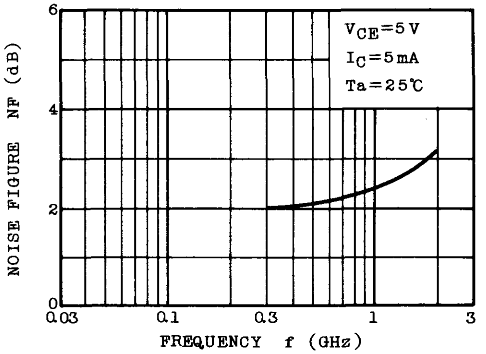
$|S_{21e}|^2 - f$



NF — I_C

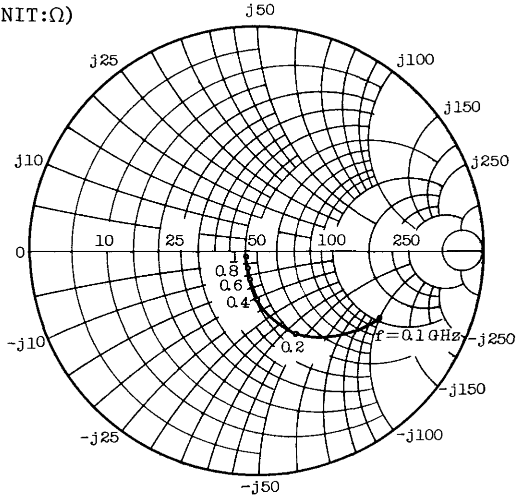


NF — f

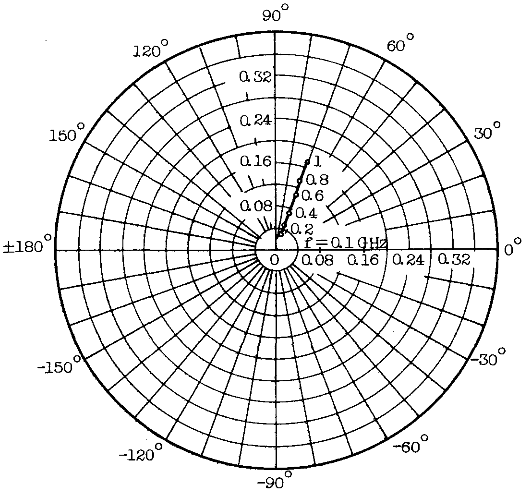


S_{11e}
V_{CE}=5V
I_C=10mA
Ta=25°C

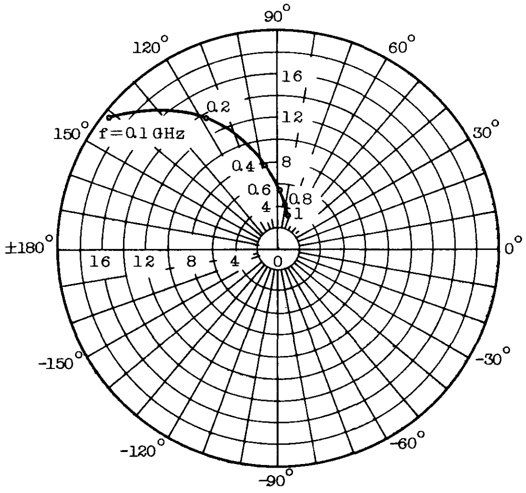
(UNIT:Ω)



S_{12e}
V_{CE}=5V
I_C=10mA
Ta=25°C

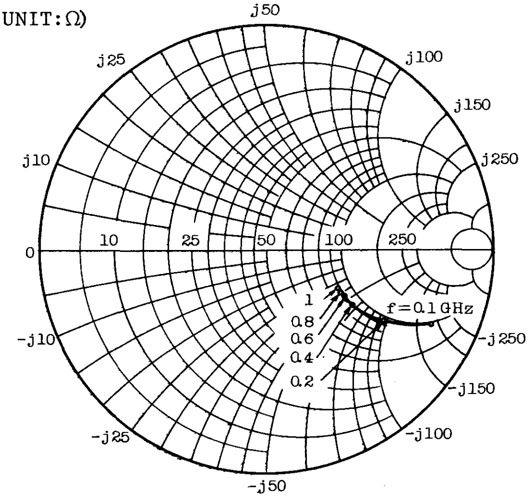


S_{21e}
V_{CE}=5V
I_C=10mA
Ta=25°C



S_{22e}
V_{CE}=5V
I_C=10mA
Ta=25°C

(UNIT:Ω)



SILICON NPN EPITAXIAL PLANAR TYPE

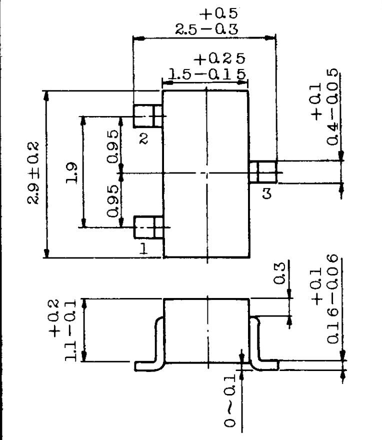
2SC3098

VHF ~ UHF BAND LOW NOISE AMPLIFIER APPLICATIONS.

FEATURES:

- Low Noise Figure.
- NF=2.5dB, $|S_{21e}|^2$=14.5dB (f=500MHz)
- NF=3.0dB, $|S_{21e}|^2$=9.0dB (f=1000MHz)

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	−
EIAJ	SC−59
TOSHIBA	2−3F1A

Weight : 0.012g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	20	V
Emitter-Base Voltage	V_{EBO}	3	V
Collector Current	I_C	50	mA
Emitter Current	I_E	-50	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~ 125	°C

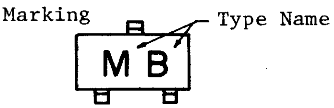
MICROWAVE CHARACTERISTICS (Ta=25°C)

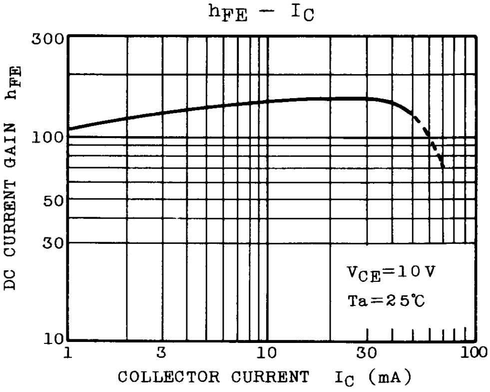
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Transition Frequency	f_T	V_{CE}=10V, I_C=10mA	-	3.5	-	GHz
Insertion Gain	$\|S_{21e}\|^2(1)$	V_{CE}=10V, I_C=10mA, f=500MHz	-	14.5	-	dB
	$\|S_{21e}\|^2(2)$	V_{CE}=10V, I_C=10mA, f=1GHz	-	9	-	dB
Noise Figure	NF(1)	V_{CE}=10V, I_C=5mA, f=500MHz	-	2.5	-	dB
	NF(2)	V_{CE}=10V, I_C=5mA, f=1GHz	-	3	-	dB

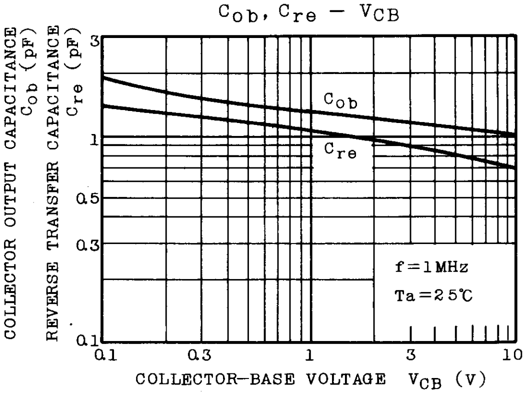
ELECTRICAL CHARACTERISTICS (Ta=25°C)

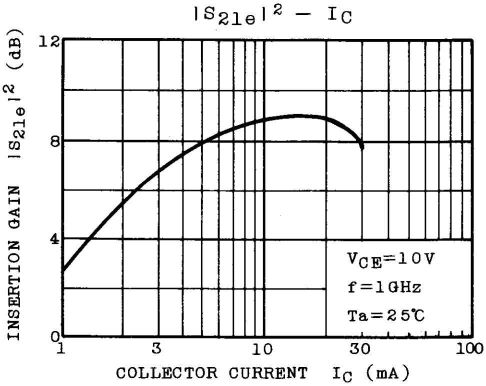
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=10V, I_E=0	-	-	1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=1V, I_C=0	-	-	1	μA
DC Current Gain	h_{FE}	V_{CE}=10V, I_C=10mA	30	80	300	
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	1.15	-	pF
Reverse Transfer Capacitance	C_{re}	(Note)	-	0.75	-	pF

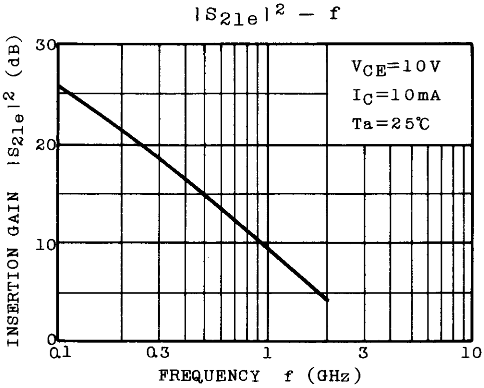
Note : Cre is measured by 3 terminal method with Capacitance Bridge.

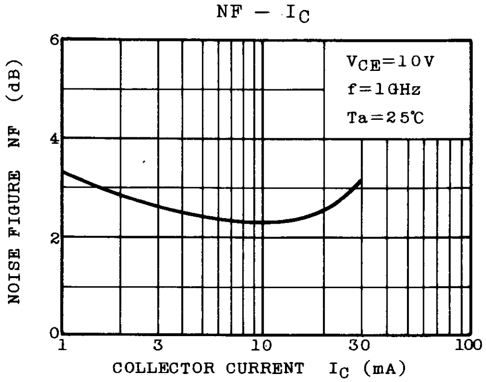


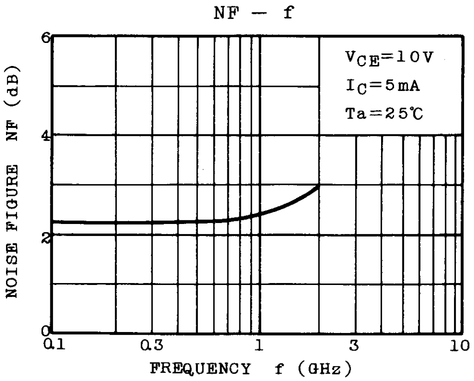

h_{FE} — I_C
DC CURRENT GAIN h_{FE}
300
100
50
30
10
1
3
10
30
100
COLLECTOR CURRENT I_C (mA)
V_{CE}=10V
Ta=25℃


C_{ob}, C_{re} — V_{CB}
COLLECTOR OUTPUT CAPACITANCE C_{ob} (pF)
REVERSE TRANSFER CAPACITANCE C_{re} (pF)
3
1
0.5
0.3
0.1
0.1
0.3
1
3
10
COLLECTOR-BASE VOLTAGE V_{CB} (V)
C_{ob}
C_{re}
f=1MHz
Ta=25℃

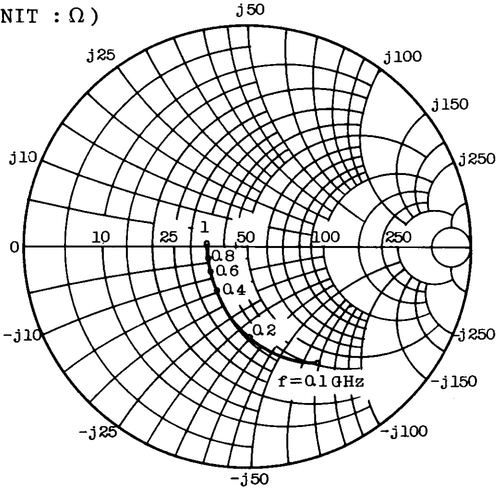

$|S_{21e}|^2$ — I_C
INSERTION GAIN $|S_{21e}|^2$ (dB)
12
8
4
0
1
3
10
30
100
COLLECTOR CURRENT I_C (mA)
V_{CE}=10V
f=1GHz
Ta=25℃


$|S_{21e}|^2$ — f
INSERTION GAIN $|S_{21e}|^2$ (dB)
30
20
10
0
0.1
0.3
1
3
10
FREQUENCY f (GHz)
V_{CE}=10V
I_C=10mA
Ta=25℃

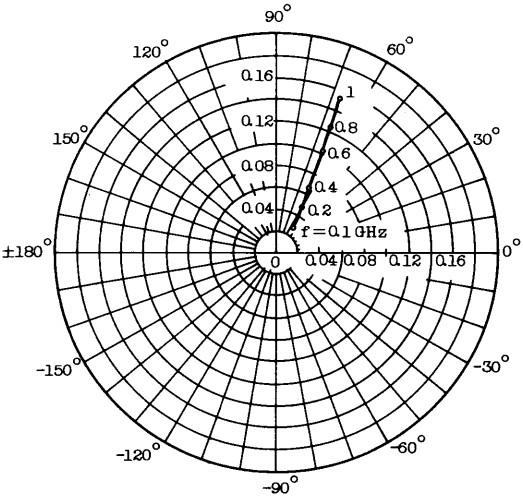

NF — I_C
NOISE FIGURE NF (dB)
6
4
2
0
1
3
10
30
100
COLLECTOR CURRENT I_C (mA)
V_{CE}=10V
f=1GHz
Ta=25℃


NF — f
NOISE FIGURE NF (dB)
6
4
2
0
0.1
0.3
1
3
10
FREQUENCY f (GHz)
V_{CE}=10V
I_C=5mA
Ta=25℃

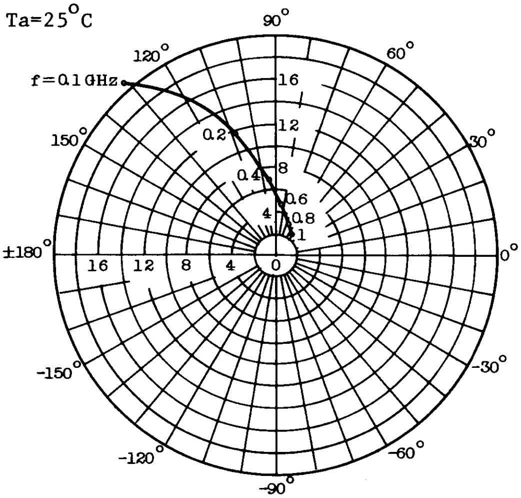
S_{11e}
V_{CE}=10V
I_C=10mA
Ta=25°C
(UNIT : Ω)



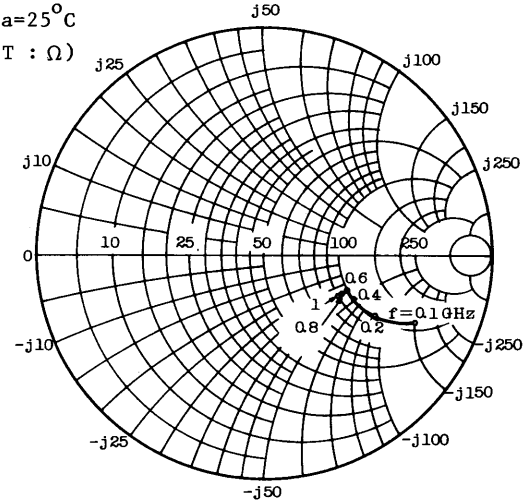
S_{12e}
V_{CE}=10V
I_C=10mA
Ta=25°C



S_{21e}
V_{CE}=10V
I_C=10mA
Ta=25°C



S_{22e}
V_{CE}=10V
I_C=10mA
Ta=25°C
(UNIT : Ω)



2SC3099

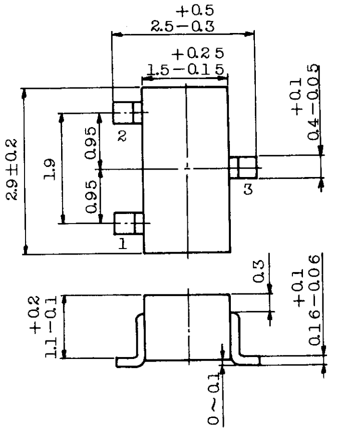
SILICON NPN EPITAXIAL PLANAR TYPE

VHF ~ UHF BAND LOW NOISE AMPLIFIER APPLICATIONS.

FEATURES:

- Low Noise Figure.
- NF=1.7dB, $|S_{21e}|^2$=15dB (f=500MHz)
- NF=2.5dB, $|S_{21e}|^2$=9.5dB (f=1000MHz)

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	−
EIAJ	SC−59
TOSHIBA	2−3F1A

Weignt : 0.012g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	20	V
Collector-Emitter Voltage	V_{CEO}	20	V
Emitter-Base Voltage	V_{EBO}	3	V
Collector Current	I_C	30	mA
Emitter Current	I_E	-30	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

MICROWAVE CHARACTERISTICS (Ta=25°C)

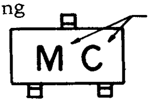
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Transition Frequency	f_T	V_{CE}=10V, I_C=10mA	-	4.0	-	GHz
Insertion Gain	$\|S_{21e}\|^2(1)$	V_{CE}=10V, I_C=10mA, f=500MHz	-	15.0	-	dB
	$\|S_{21e}\|^2(2)$	V_{CE}=10V, I_C=10mA, f=1000MHz	-	9.5	-	dB
Noise Figure	NF(1)	V_{CE}=10V, I_C=3mA, f=500MHz	-	1.7	-	dB
	NF(2)	V_{CE}=10V, I_C=3mA, f=1000MHz	-	2.5	-	dB

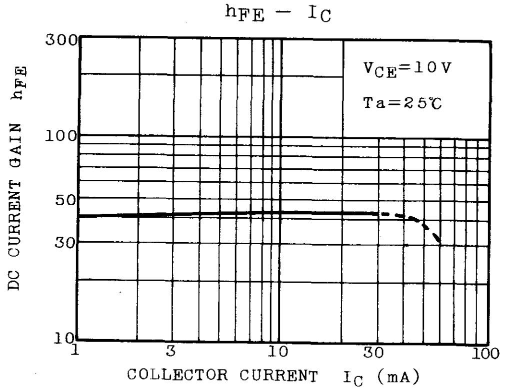
ELECTRICAL CHARACTERISTICS (Ta=25°C)

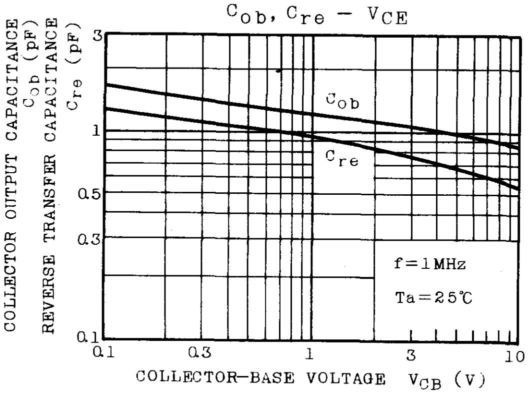
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=10V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=1V, I_C=0	-	-	1.0	μA
DC Current Gain	h_{FE}	V_{CE}=10V, I_C=5mA	30	-	250	
Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	0.9	-	pF
Reverse Transfer Capacitance	C_{re}	(Note)	-	0.6	-	pF

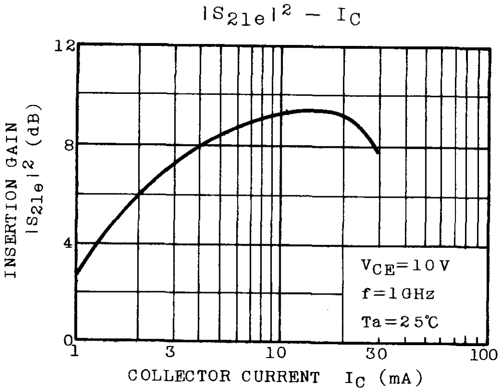
Note : Cre is measured by 3 terminal method with Capacitance Bridge.

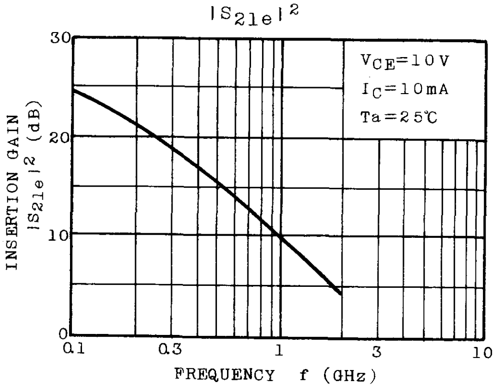
Marking

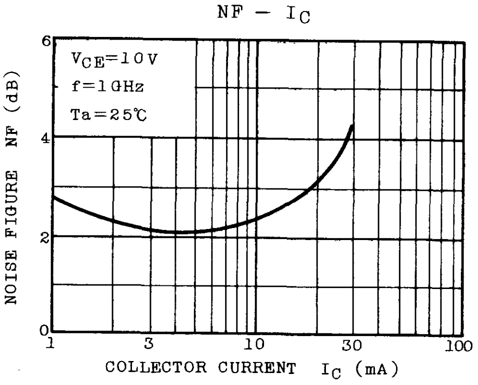


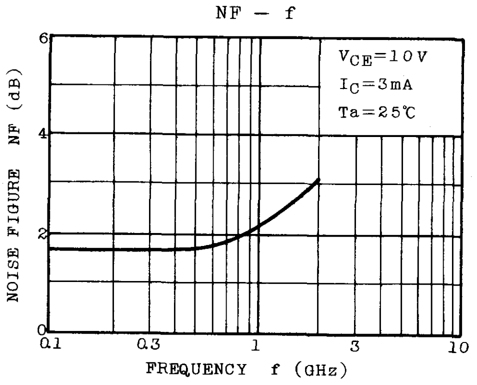

hFE — IC
DC CURRENT GAIN hFE
VCE=10V
Ta=25℃
300
100
50
30
10
1
3
10
30
100
COLLECTOR CURRENT IC (mA)


Cob, Cre — VCE
COLLECTOR OUTPUT CAPACITANCE Cob (pF)
REVERSE TRANSFER CAPACITANCE Cre (pF)
Cob
Cre
f=1MHz
Ta=25℃
3
1
0.5
0.3
0.1
0.1
0.3
1
3
10
COLLECTOR—BASE VOLTAGE VCB (V)

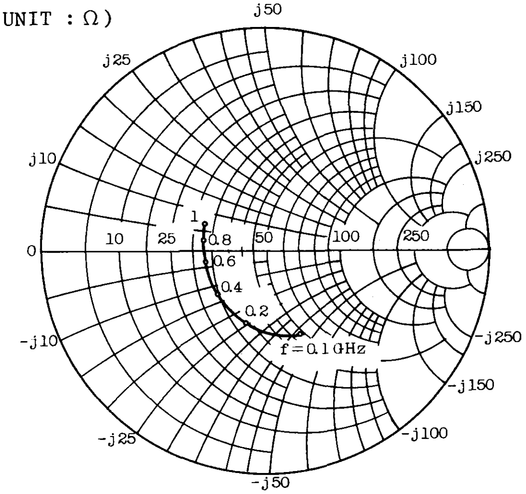

|S21e|2 — IC
INSERTION GAIN |S21e|2 (dB)
VCE=10V
f=1GHz
Ta=25℃
12
8
4
0
1
3
10
30
100
COLLECTOR CURRENT IC (mA)


|S21e|2
INSERTION GAIN |S21e|2 (dB)
VCE=10V
IC=10mA
Ta=25℃
30
20
10
0
0.1
0.3
1
3
10
FREQUENCY f (GHz)

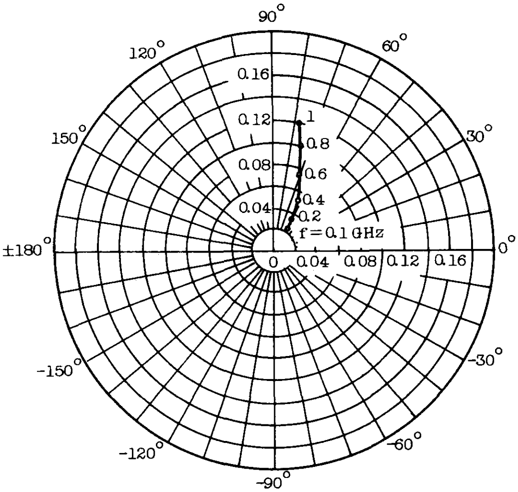

NF — IC
NOISE FIGURE NF (dB)
VCE=10V
f=1GHz
Ta=25℃
6
4
2
0
1
3
10
30
100
COLLECTOR CURRENT IC (mA)


NF — f
NOISE FIGURE NF (dB)
VCE=10V
IC=3mA
Ta=25℃
6
4
2
0
0.1
0.3
1
3
10
FREQUENCY f (GHz)

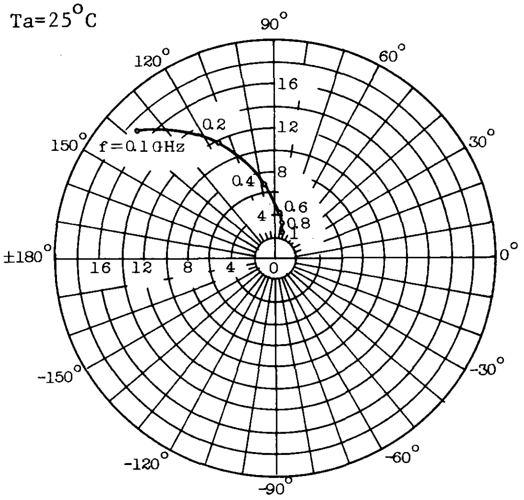
S_{11e}
V_{CE}=10V
I_C=10mA
Ta=25°C
(UNIT : Ω)



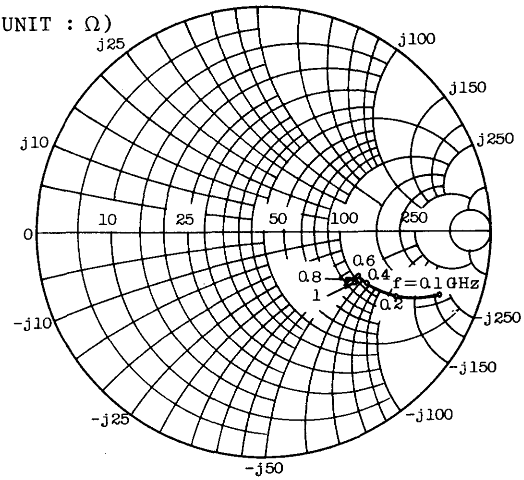
S_{12e}
V_{CE}=10V
I_C=10mA
Ta=25°C



S_{21e}
V_{CE}=10V
I_C=10mA
Ta=25°C



S_{22e}
V_{CE}=10V
I_C=10mA
Ta=25°C
(UNIT : Ω)



SILICON NPN EPITAXIAL TYPE

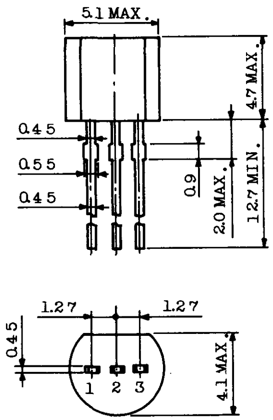
2SC3112

FOR AUDIO AMPLIFIER AND SWITCHING APPLICATIONS.

FEATURES:

- High DC Current Gain : h_{FE}=600 ~ 3600
- High Breakdown Voltage : V_{CEO}=50V
- High Collector Current : I_C=150mA (Max.)

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

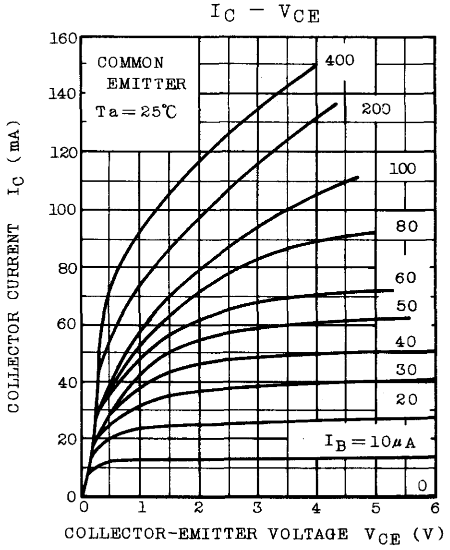
MAXIMUM RATINGS ($Ta=25^{\circ}C$)

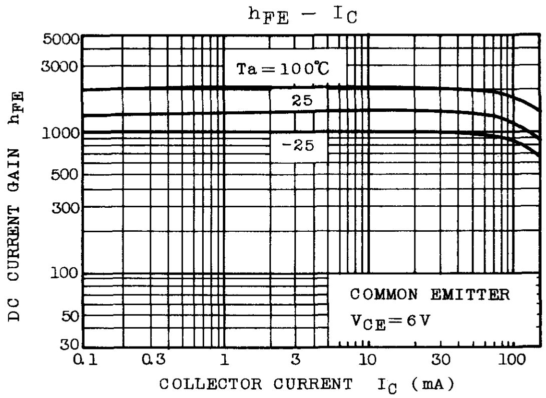
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	50	V
Collector-Emitter Voltage	V_{CEO}	50	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	150	mA
Base Current	I_B	30	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~ 125	°C

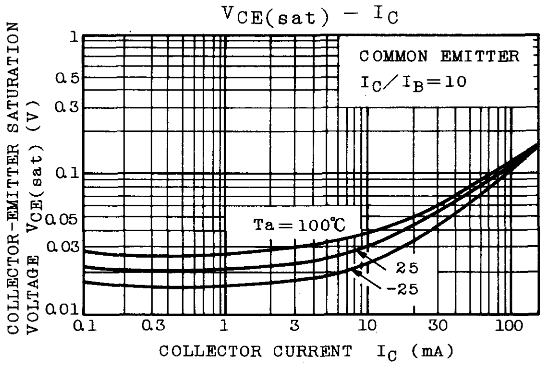
ELECTRICAL CHARACTERISTICS ($Ta=25^{\circ}C$)

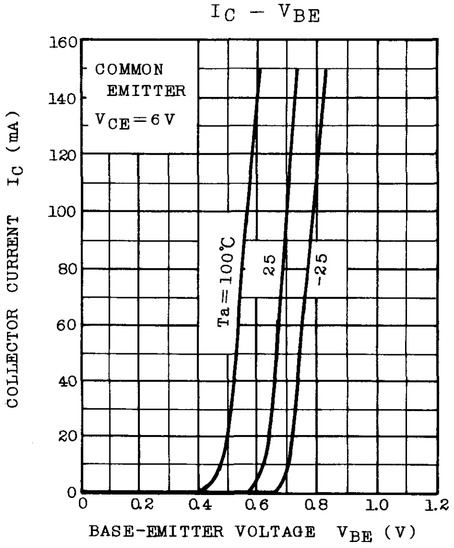
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CE}=50V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=6V, I_C=2mA	600	-	3600	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=100mA, I_B=10mA	-	0.12	0.25	V
Transition Frequency	f_T	V_{CE}=10V, I_C=10mA	100	250	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	3.5	-	pF
Noise Figure	NF(1)	V_{CE}=6V, I_C=0.1mA f=100Hz, R_g=10kΩ	-	0.5	-	dB
	NF(2)	V_{CE}=6V, I_C=0.1mA f=1kHz, R_g=10kΩ	-	0.3	-	dB

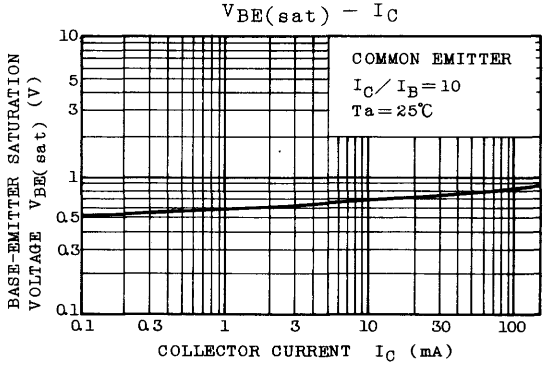
Note : h_{FE} Classification A : 600 ~ 1800, B : 1200 ~ 3600

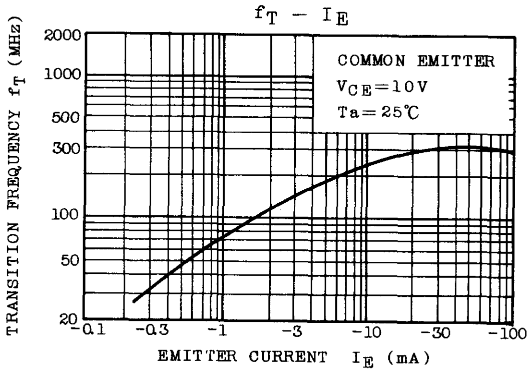

IC − VCE
COMMON EMITTER
Ta=25℃
COLLECTOR CURRENT IC (mA)
COLLECTOR-EMITTER VOLTAGE VCE (V)
IB=10μA
400
200
100
80
60
50
40
30
20
0
0
20
40
60
80
100
120
140
160
0
1
2
3
4
5
6

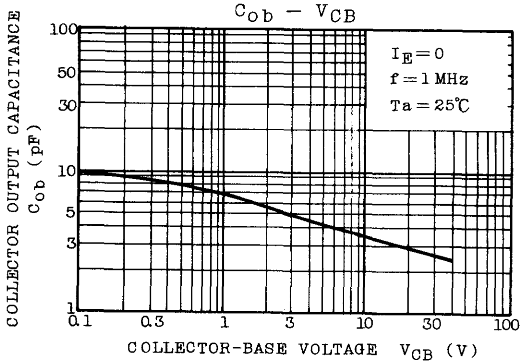

hFE − IC
Ta=100℃
25
-25
COMMON EMITTER
VCE=6V
DC CURRENT GAIN hFE
COLLECTOR CURRENT IC (mA)
5000
3000
1000
500
300
100
50
30
0.1
0.3
1
3
10
30
100

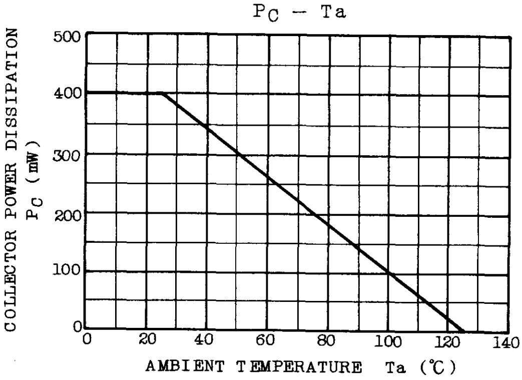

VCE(sat) − IC
COMMON EMITTER
IC/IB=10
Ta=100℃
25
-25
COLLECTOR-EMITTER SATURATION VOLTAGE VCE(sat) (V)
COLLECTOR CURRENT IC (mA)
1
0.5
0.3
0.1
0.05
0.03
0.01
0.1
0.3
1
3
10
30
100


IC − VBE
COMMON EMITTER
VCE=6V
Ta=100℃
25
-25
COLLECTOR CURRENT IC (mA)
BASE-EMITTER VOLTAGE VBE (V)
0
20
40
60
80
100
120
140
160
0
0.2
0.4
0.6
0.8
1.0
1.2


VBE(sat) − IC
COMMON EMITTER
IC/IB=10
Ta=25℃
BASE-EMITTER SATURATION VOLTAGE VBE(sat) (V)
COLLECTOR CURRENT IC (mA)
10
5
3
1
0.5
0.3
0.1
0.1
0.3
1
3
10
30
100


f_T – I_E
COMMON EMITTER
V_{CE}=10V
Ta=25℃
TRANSITION FREQUENCY f_T (MHz)
2000
1000
500
300
100
50
20
−0.1
−0.3
−1
−3
−10
−30
−100
EMITTER CURRENT I_E (mA)


C_{ob} – V_{CB}
I_E=0
f=1MHz
Ta=25℃
COLLECTOR OUTPUT CAPACITANCE C_{ob} (pF)
100
50
30
10
5
3
1
0.1
0.3
1
3
10
30
100
COLLECTOR-BASE VOLTAGE V_{CB} (V)

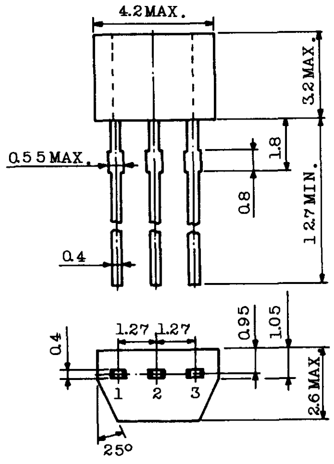

P_C – Ta
COLLECTOR POWER DISSIPATION P_C (mW)
500
400
300
200
100
0
0
20
40
60
80
100
120
140
AMBIENT TEMPERATURE Ta (℃)

2SC3113

SILICON NPN EPITAXIAL TYPE

FOR AUDIO AMPLIFIER AND SWITCHING APPLICATIONS.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	—
EIAJ	—
TOSHIBA	2-4E1A

Weight : 0.13g

FEATURES:

- High DC Current Gain : h_{FE}=600～3600
- High Breakdown Voltage : V_{CEO}=50V
- High Collector Current : I_C=150mA (Max.)
- Small Package

MAXIMUM RATINGS (Ta=25°C)

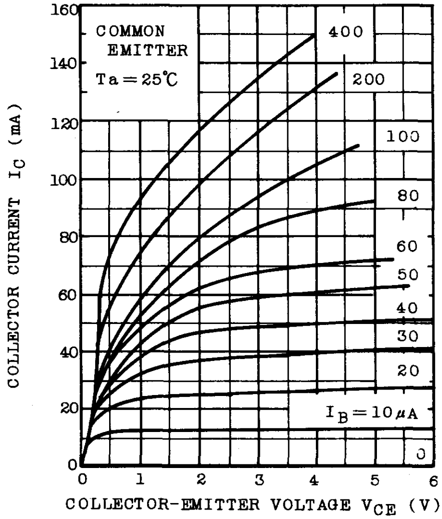
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	50	V
Collector-Emitter Voltage	V_{CEO}	50	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	150	mA
Base Current	I_B	30	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55～125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

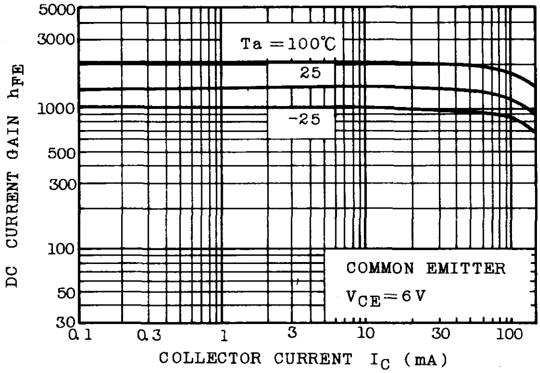
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CE}=50V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=6V, I_C=2mA	600	-	3600	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=100mA, I_B=10mA	-	0.12	0.25	V
Transition Frequency	f_T	V_{CE}=10V, I_C=10mA	100	250	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	3.5	-	pF
Noise Figure	NF(1)	V_{CE}=6V, I_C=0.1mA f=100Hz, R_g=10kΩ	-	0.5	-	dB
	NF(2)	V_{CE}=6V, I_C=0.1mA f=1kHz, R_g=10kΩ	-	0.3	-	dB

Note : h_{FE} Classification A : 600～1800, B : 1200～3600

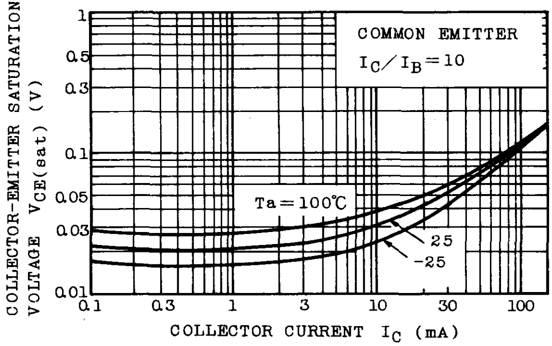
$I_C - V_{CE}$



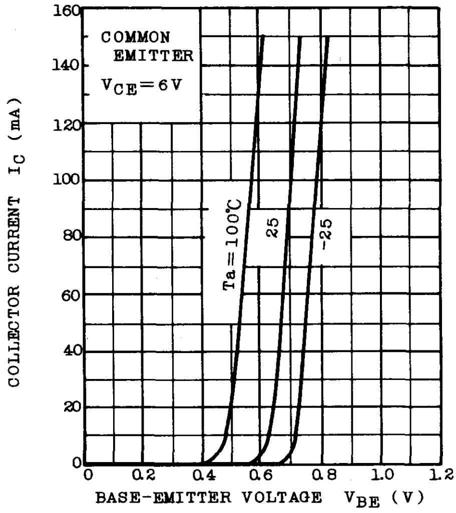
$h_{FE} - I_C$



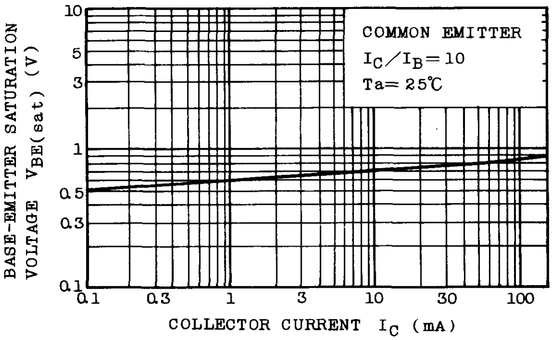
$V_{CE(sat)} - I_C$

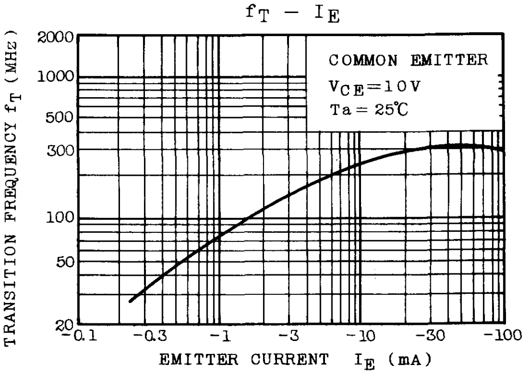


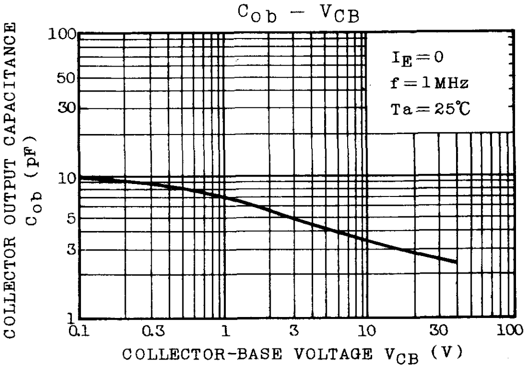
$I_C - V_{BE}$

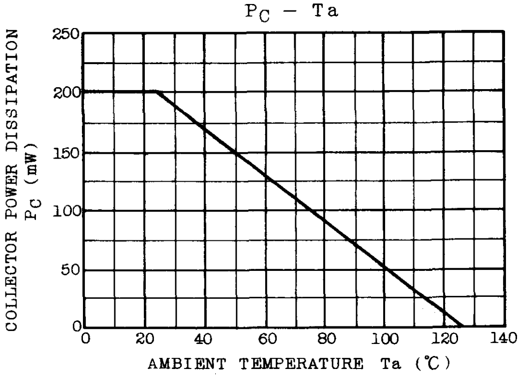


$V_{BE(sat)} - I_C$




f_T — I_E
COMMON EMITTER
V_{CE}=10V
Ta=25℃
TRANSITION FREQUENCY f_T (MHz)
2000
1000
500
300
100
50
20
−0.1
−0.3
−1
−3
−10
−30
−100
EMITTER CURRENT I_E (mA)


C_{ob} — V_{CB}
I_E=0
f=1MHz
Ta=25℃
COLLECTOR OUTPUT CAPACITANCE C_{ob} (pF)
100
50
30
10
5
3
1
0.1
0.3
1
3
10
30
100
COLLECTOR-BASE VOLTAGE V_{CB} (V)


P_C — Ta
COLLECTOR POWER DISSIPATION P_C (mW)
250
200
150
100
50
0
0
20
40
60
80
100
120
140
AMBIENT TEMPERATURE Ta (℃)

SILICON NPN EPITAXIAL TYPE

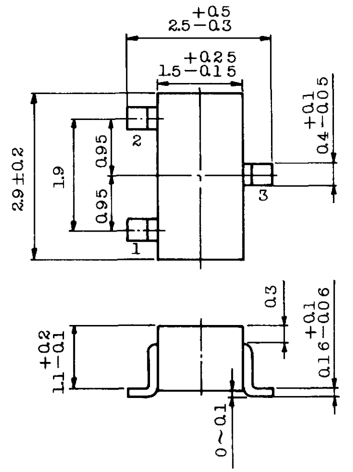
2SC3119

UHF TV TUNER RF AMPLIFIER APPLICATIONS.

FEATURES:

. Excellent Forward AGC Characteristics.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	—
EIAJ	SC-59
TOSHIBA	2-3F1A

Weight : 0.012g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	25	V
Collector-Emitter Voltage	V_{CEO}	20	V
Emitter-Base Voltage	V_{EBO}	3	V
Collector Current	I_C	20	mA
Base Current	I_B	10	mA
Collector Power Dissipation	P_C	150	mW
Jinction Temperature	T_j	125	°C
Storage Temperature Range	Tstg	-55 ~ 125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=10V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=2V, I_C=0	-	-	1	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	20	-	-	V
DC Current Gain	h_{FE}	V_{CE}=10V, I_C=2mA	25	100	-	-
Transition Frequency	f_T	V_{CE}=10V, I_C=2mA	600	900	-	MHz
Reverse Transfer Capacitance	C_{rb}	V_{CE}=10V, I_B=0, f=1MHz	-	0.38	0.55	pF
Power Gain	G_{pb}	V_{CC}=12V, V_{AGC}=3.0V f=800MHz	9	12	-	dB
Noise Figure	NF		-	4.0	6.0	dB
AGC Voltage	V_{AGC}	V_{CC}=12V, GR=-20dB f=800MHz	5.75	7.0	8.25	V

Marking

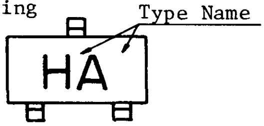
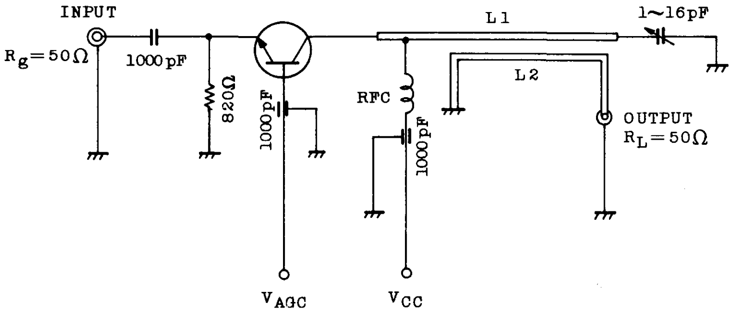
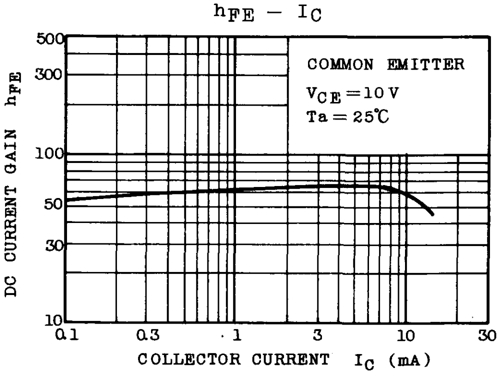


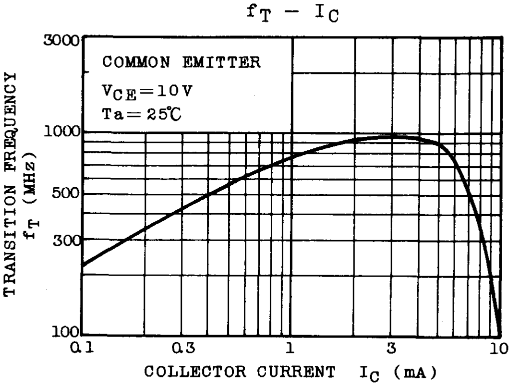
Fig. 1 800MHz G_{pb}, NF TEST CIRCUIT



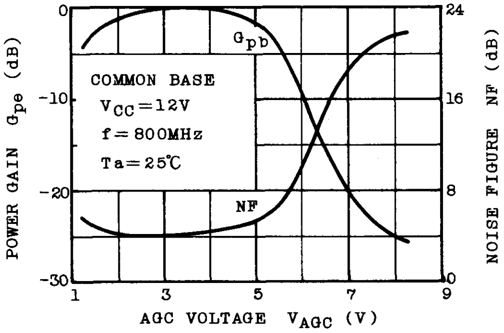
L1, L2 : ∅1.0mm SILVER PLATED COPPER WIRE

Note : V_{AGC} measured by the test circuit shown in Fig.1, when the power gain is reduced to 20dB compared with G_{pb} shown above Table.

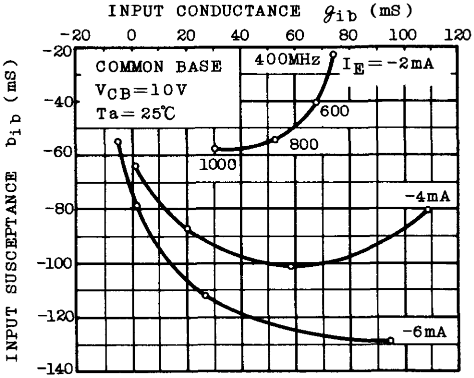




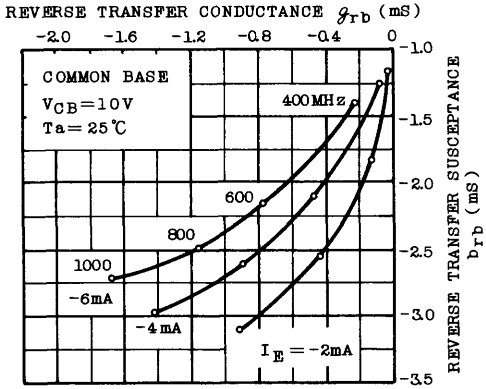
G_{pb}, NF – V_{AGC}



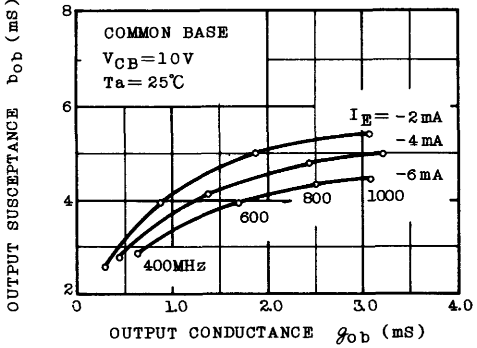
y_{ib} – f



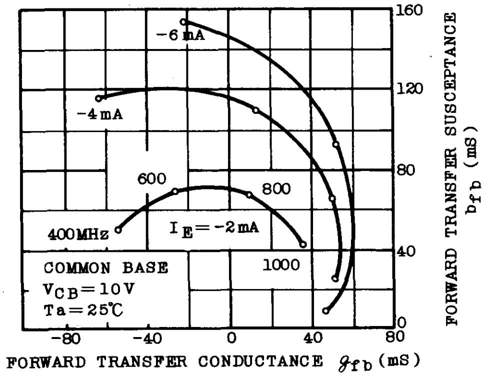
y_{rb} – f



y_{ob} – f



y_{fb} – f



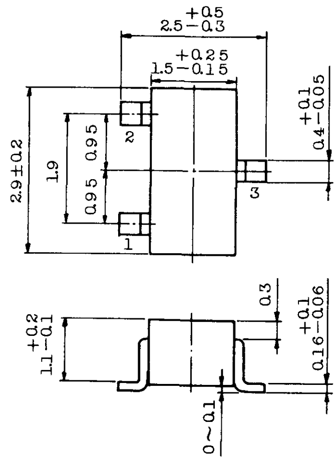
2SC3120

SILICON NPN EPITAXIAL PLANAR TYPE

TV TUNER, UHF MIXER APPLICATIONS.

VHF ~ UHF BAND RF AMPLIFIER APPLICATIONS.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	—
EIAJ	—
TOSHIBA	2-3F1A

Weight : 0.012g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	15	V
Emitter-Base Voltage	V_{EBO}	3	V
Collector Current	I_C	50	mA
Base Current	I_B	25	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	Tstg	-55 ~ 125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=30V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=2V, I_C=0	-	-	1.0	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	15	-	-	V
DC Current Gain	h_{FE}	V_{CE}=10V, I_C=5mA	40	100	200	
Reverse Transfer Capacitance	Cre	V_{CB}=10V, I_E=0, f=1MHz	-	0.6	0.9	pF
Transition Frequency	f_T	V_{CE}=10V, I_C=2mA	1500	2400	-	MHz
Conversion Gain	G_{ce}	V_{CC}=10V, I_C=2mA, f=800MHz, f_L=830MHz(0dBm) (Fig.1)	12	17	-	dB
Noise Figure	NF		-	8	-	dB

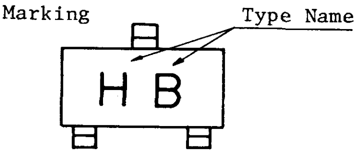
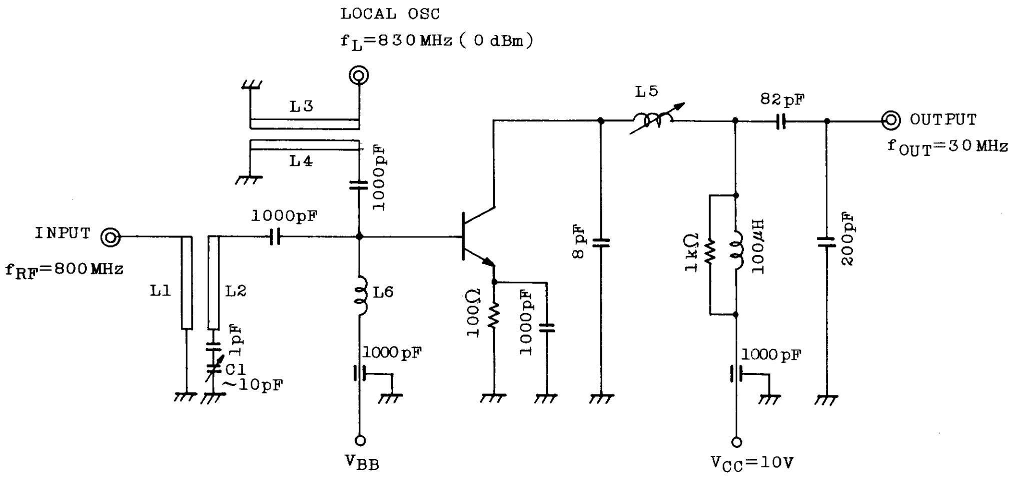


Fig. 1 800MHz G_{ce}, NF TEST CIRCUIT



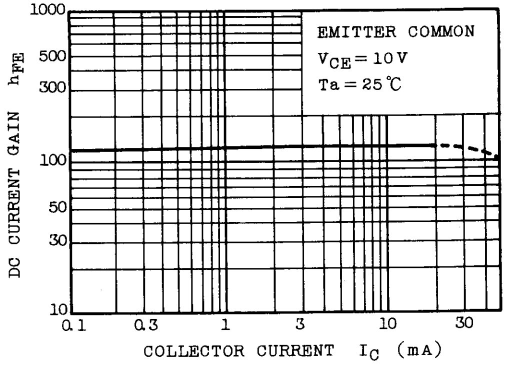
L1 ~ L4 : ϕ0.8mm SILVER PLATED COPPER WIRE

L5 : AIR COIL SCN-5948 ① - ③ TOKO OR EQUIVALENT

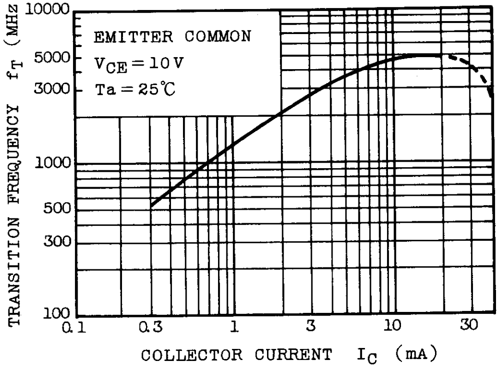
L6 : ϕ0.2mm COPPER WIRE 10T 5mm ID

C1 : AIR TRIMMER TTA23A100 MURATA MFC. Co., LTD. OR EQUIVALENT

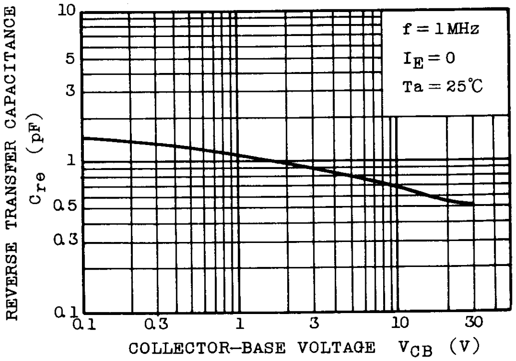
h_{FE} — I_C



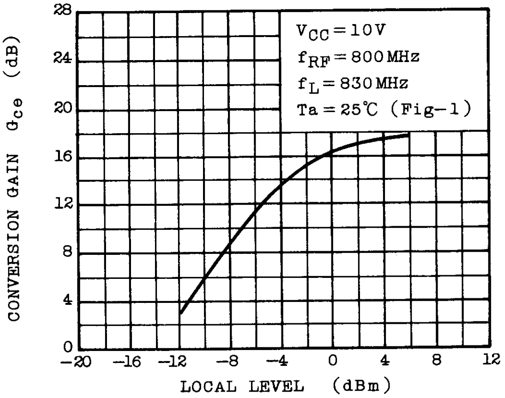
f_T — I_C



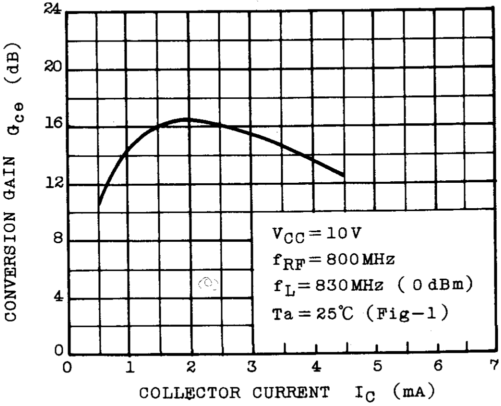
C_{re} — V_{CB}



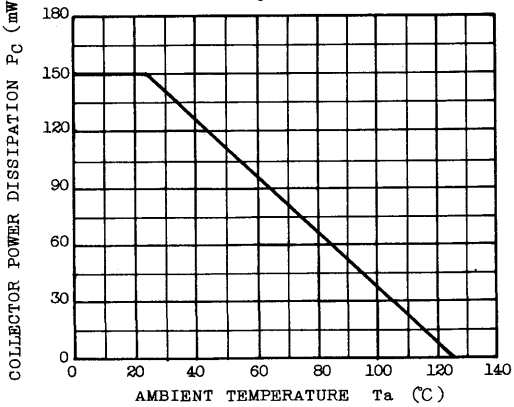
G_{ce} — LOCAL LEVEL



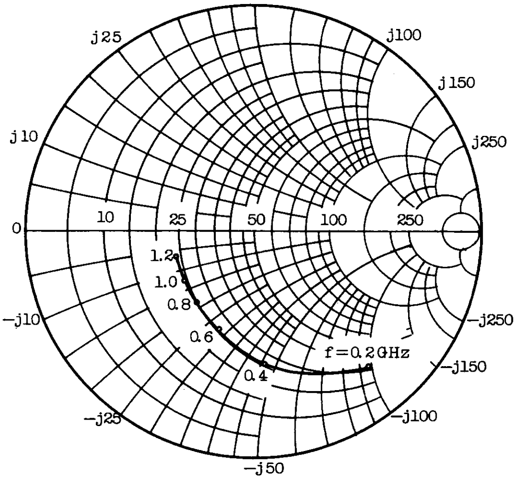
G_{ce} — I_C



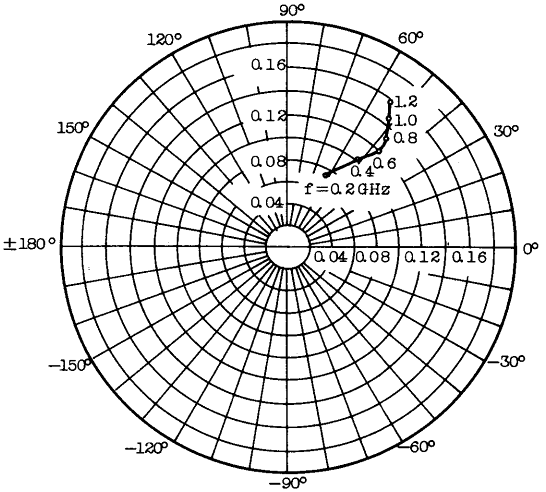
P_C — Ta



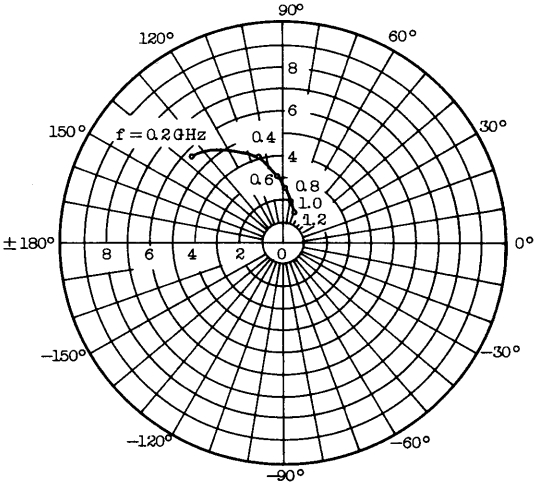
S_{11e}
$V_{CE} = 10V$
$I_C = 2\,mA$
Ta = 25℃
(UNIT : Ω)



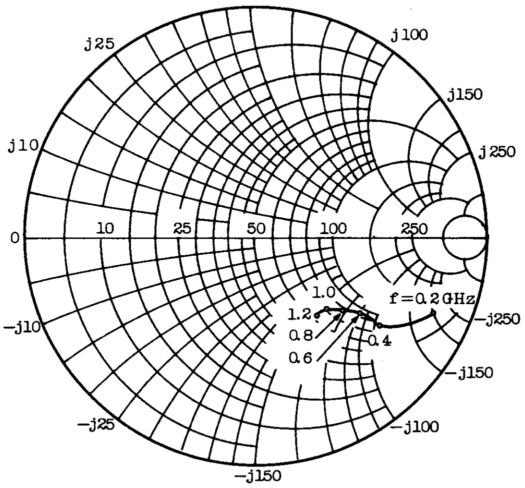
S_{12e}
$V_{CE} = 10V$
$I_C = 2\,mA$
Ta = 25℃



S_{21e}
$V_{CE} = 10V$
$I_C = 2\,mA$
Ta = 25℃



S_{22e}
$V_{CE} = 10V$
$I_C = 2\,mA$
Ta = 25℃
(UNIT : Ω)



2SC3121

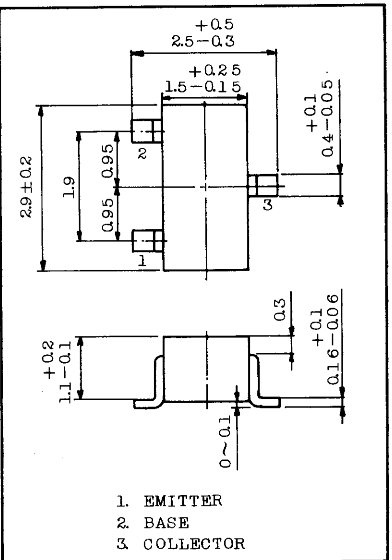
SILICON NPN EPITAXIAL PLANAR TYPE

TV TUNER, UHF OSCILLATOR APPLICATIONS.(COMMON BASE)
TV TUNER, UHF CONVERTER APPLICATIONS.(COMMON BASE)

FEATURES:

- High Transition Frequency : f_T=1500MHz (Typ.)
- Excellent Linearity

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	–
EIAJ	SC-59
TOSHIBA	2-3F1A

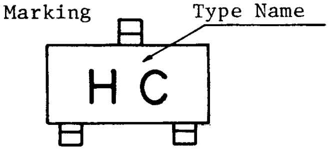
Weight : 0.012g

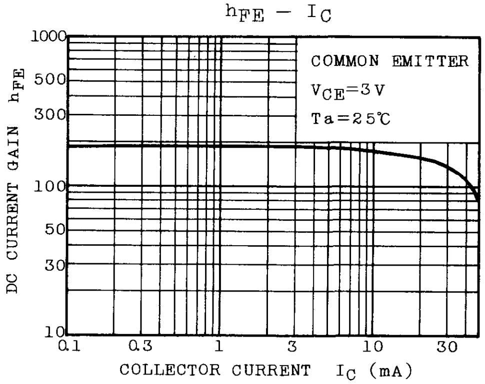
MAXIMUM RATINGS (T_a=25°C)

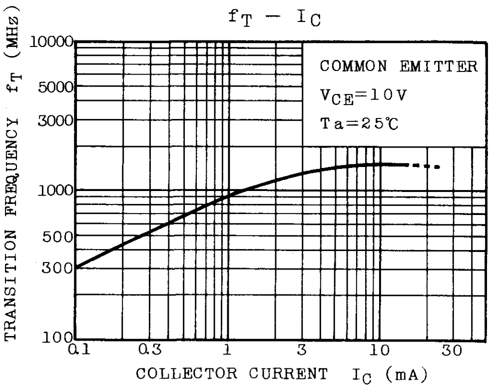
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	15	V
Emitter-Base Voltage	V_{EBO}	3	V
Base Current	I_B	25	mA
Collector Current	I_C	50	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

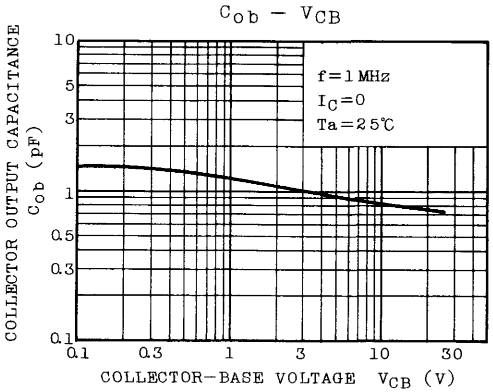
ELECTRICAL CHARACTERISTICS (T_a=25°C)

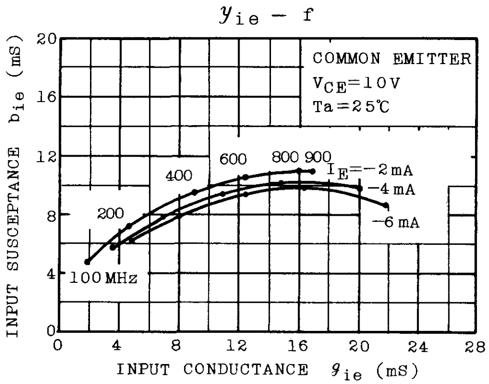
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=15V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=3V, I_C=0	-	-	1.0	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	15	-	-	V
DC Current Gain	h_{FE}	V_{CE}=3V, I_C=8mA	60	150	320	
Transition Frequency	f_T	V_{CE}=10V, I_C=8mA	1100	1500	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	0.9	1.3	pF
Collector-Base Time Constant	$C_c \cdot r_{bb'}$	V_{CB}=10V, I_C=8mA, f=30MHz	-	7	12	pS

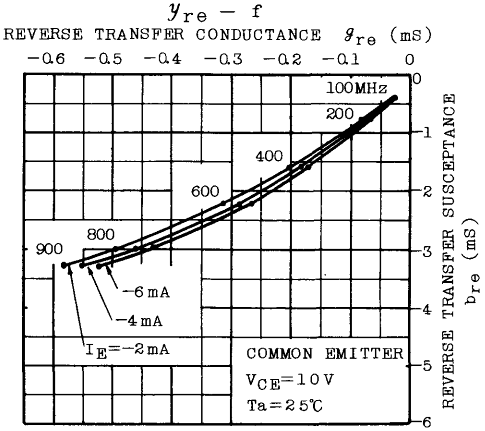


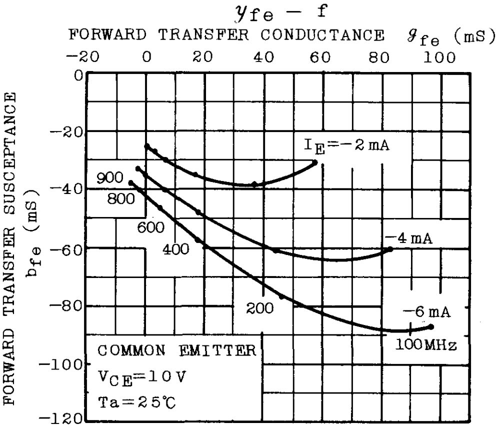

$h_{FE} - I_C$


$f_T - I_C$

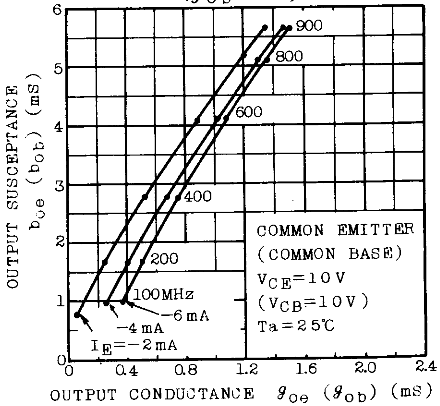

$C_{ob} - V_{CB}$


$y_{ie} - f$

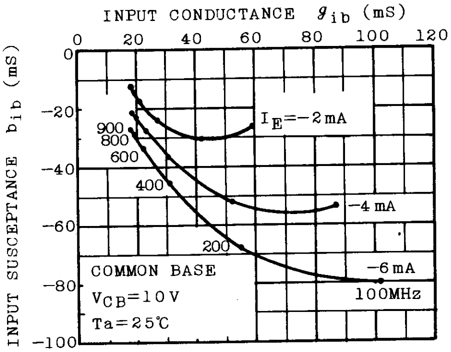

$y_{re} - f$


$y_{fe} - f$

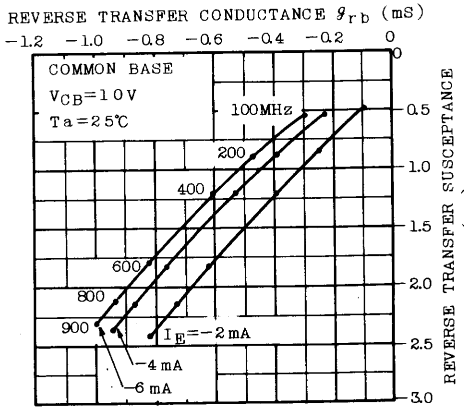
y_{oe} – f
(y_{ob} – f)



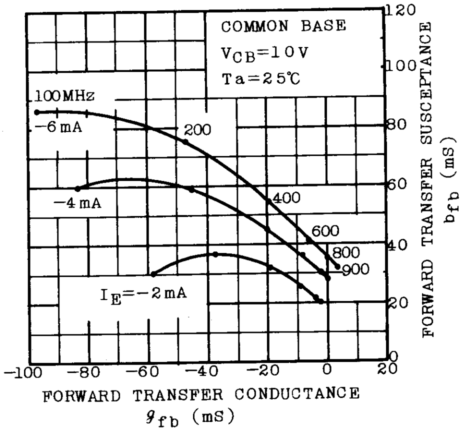
y_{ib} – f



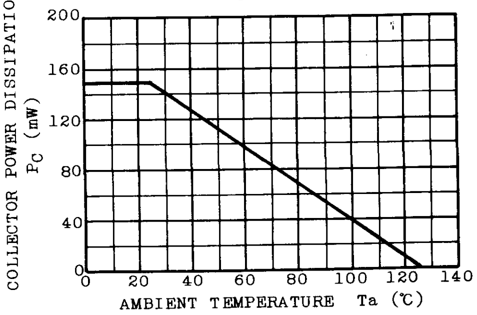
y_{rb} – f



y_{fb} – f



P_C – Ta



SILICON NPN PLANAR TYPE

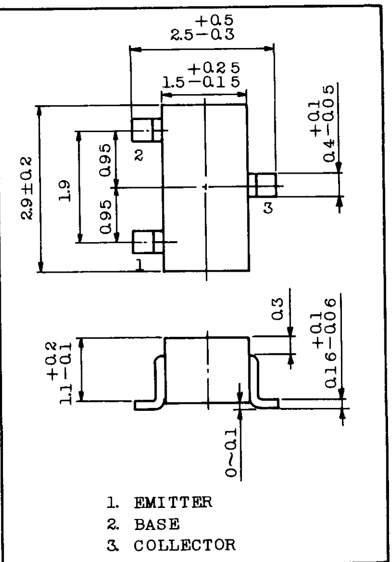
2SC3122

TV VHF RF AMPLIFIER APPLICATIONS.

FEATURES:

- High Gain : G_{pe}=24dB (Typ.) (f=200MHz)
- Low Noise : NF=2.0dB (Typ.) (f=200MHz)
- Excellent Forward AGC Characteristics.

Unit in mm



JEDEC	―
EIAJ	SC−59
TOSHIBA	2−3F1A

Weight : 0.012g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	3	V
Collector Current	I_C	20	mA
Base Current	I_B	10	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=25V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=2V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	30	-	-	V
DC Current Gain	h_{FE}	V_{CE}=10V, I_C=2mA	60	150	300	
Reverse Transfer Capacitance	C_{re}	V_{CB}=10V, I_E=0, f=1MHz	-	0.3	0.45	pF
Transition Frequency	f_T	V_{CE}=10V, I_C=2mA	400	650	-	MHz
Power Gain	G_{pe}	V_{CE}=12V, V_{AGC}=1.4V f=200MHz	20	24	28	dB
Noise Figure	NF		-	2.0	3.2	dB
AGC Voltage (Note)	V_{AGC}	V_{CC}=12V, GR=30dB, f=200MHz	3.6	4.4	5.1	V

Note : V_{AGC} measured by test circuit shown in Fig. 1 when power gain is reduced to 30dB compared that of V_{AGC} at 1.4V.

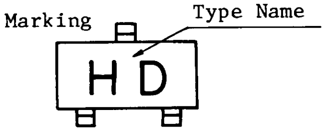
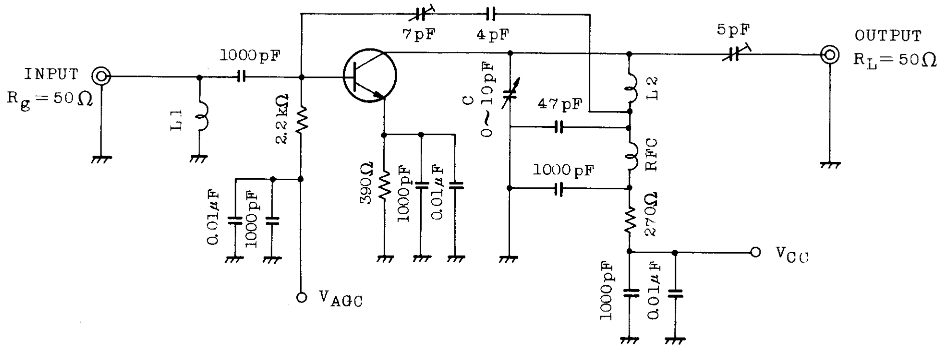


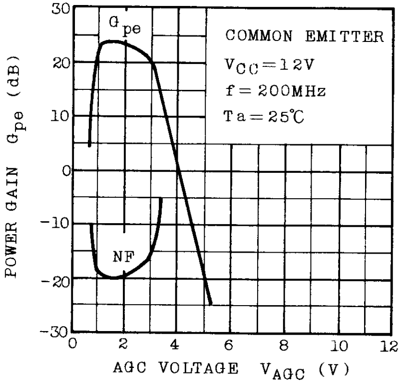
Fig. 1 200MHz G_{pe}, NF TEST CIRCUIT



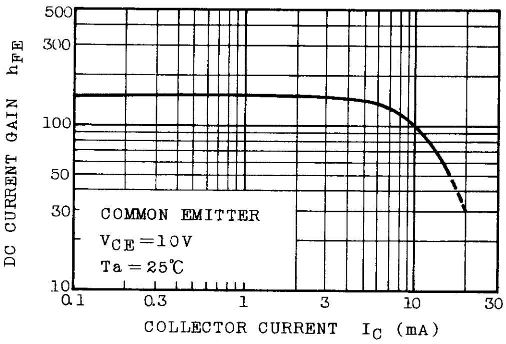
L1 : RF Coil M-15T (TOKO Inc.) or EQUIVALENT

L2 : RF Coil M-25T (TOKO Inc.) or EQUIVALENT

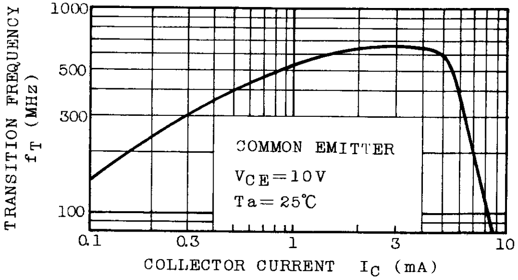
G_{pe}, NF — V_{AGC}



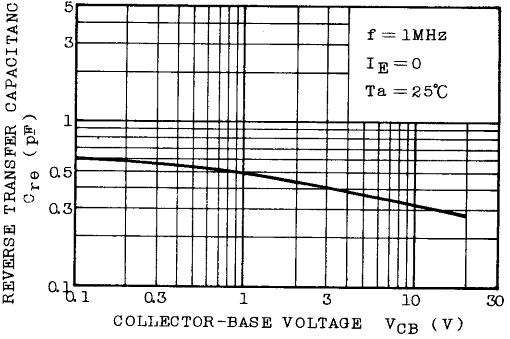
h_{FE} — I_C

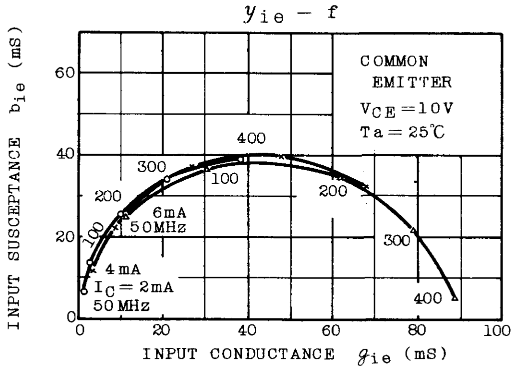


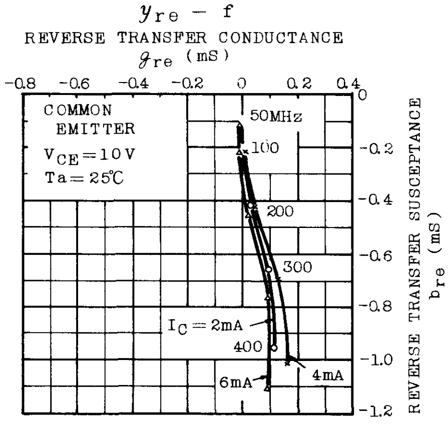
f_T — I_C

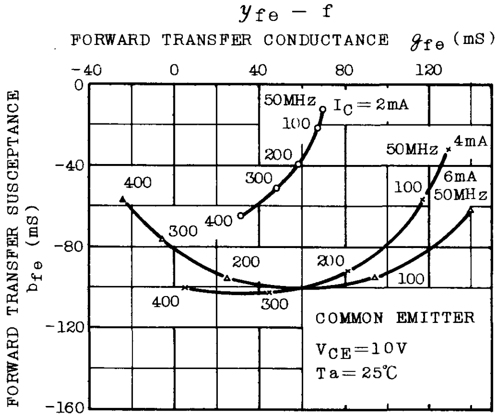


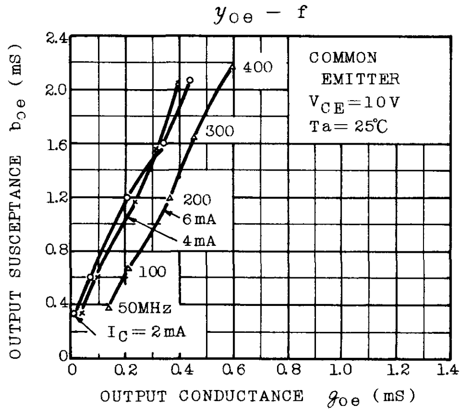
C_{re} — V_{CB}

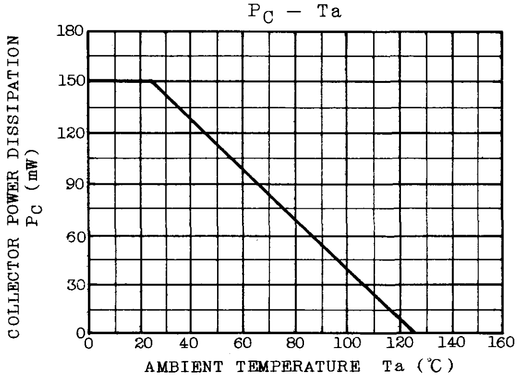



y_{ie} – f
COMMON EMITTER
V_{CE}=10V
Ta=25℃
INPUT SUSCEPTANCE b_{ie} (mS)
INPUT CONDUCTANCE g_{ie} (mS)
0
20
40
60
80
100
400
300
100
200
200
6mA
50MHz
100
300
4mA
I_C=2mA
50MHz
400


y_{re} – f
REVERSE TRANSFER CONDUCTANCE
g_{re} (mS)
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
−0.2
−0.4
−0.6
−0.8
−1.0
−1.2
REVERSE TRANSFER SUSCEPTANCE b_{re} (mS)
COMMON EMITTER
V_{CE}=10V
Ta=25℃
50MHz
100
200
300
I_C=2mA
400
6mA
4mA


y_{fe} – f
FORWARD TRANSFER CONDUCTANCE g_{fe} (mS)
−40
0
40
80
120
0
−40
−80
−120
−160
FORWARD TRANSFER SUSCEPTANCE b_{fe} (mS)
50MHz
I_C=2mA
100
200
300
400
50MHz
4mA
6mA
50MHz
100
400
300
200
200
100
400
300
COMMON EMITTER
V_{CE}=10V
Ta=25℃


y_{oe} – f
OUTPUT SUSCEPTANCE b_{oe} (mS)
OUTPUT CONDUCTANCE g_{oe} (mS)
2.4
2.0
1.6
1.2
0.8
0.4
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
400
300
200
6mA
4mA
100
50MHz
I_C=2mA
COMMON EMITTER
V_{CE}=10V
Ta=25℃

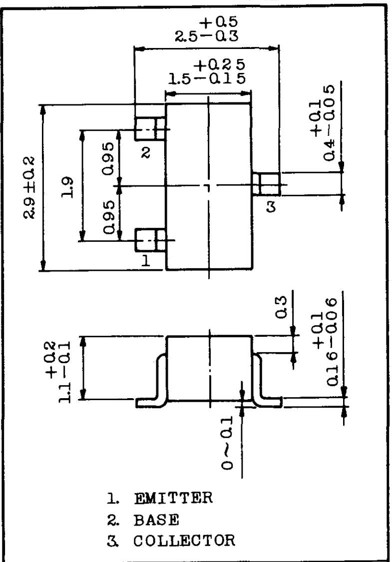

P_C – Ta
COLLECTOR POWER DISSIPATION P_C (mW)
180
150
120
90
60
30
0
0
20
40
60
80
100
120
140
160
AMBIENT TEMPERATURE Ta (℃)

2SC3123

SILICON NPN EPITAXIAL PLANAR TYPE

TV VHF MIXER APPLICATIONS.

Unit in mm



JEDEC	−
EIAJ	SC−59
TOSHIBA	2−3F1A

Weight : 0.012g

FEATURES:

- High Conversion Gain : G_{ce}=23dB (Typ.)
- Low Reverse Transfer Capacitance : C_{re}=0.4pF (Typ.)

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	20	V
Emitter-Base Voltage	V_{EBO}	3	V
Collector Current	I_C	50	mA
Base Current	I_B	25	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=25V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=3V, I_C=0	-	-	1000	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	20	-	-	V
DC Current Gain	h_{FE}	V_{CE}=10V, I_C=5mA	40	150	300	
Reverse Transfer Capacitance	C_{re}	V_{CB}=10V, I_E=0, f=1MHz	-	0.4	0.5	pF
Transition Frequency	f_T	V_{CE}=10V, I_C=5mA	900	1400	-	MHz
Conversion Gain	G_{ce}	V_{CC}=12V, f=200MHz f_L=260MHz	20	23	-	dB
Noise Figure	NF		-	3.8	5.5	dB

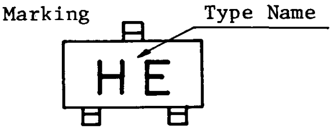
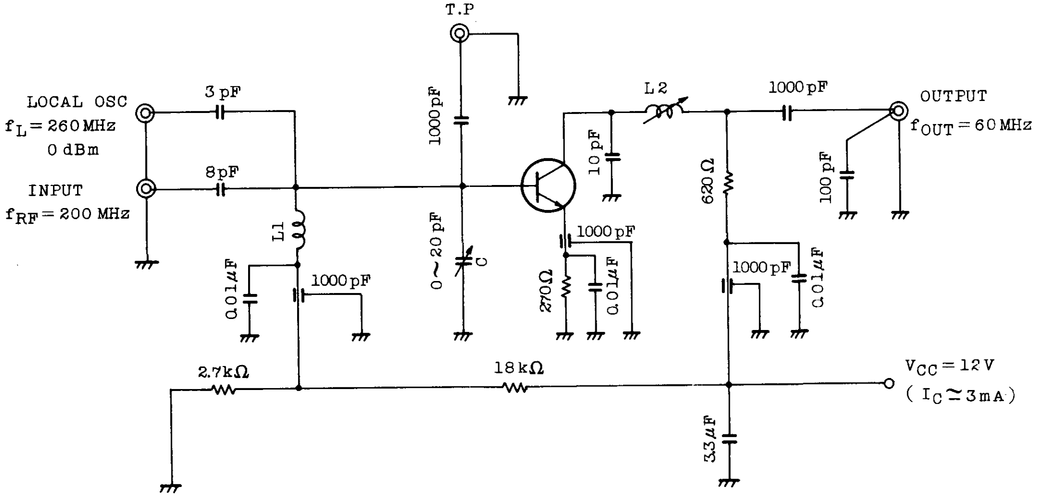


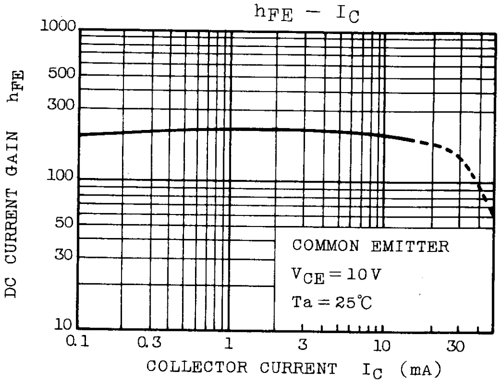
Fig. 1 200MHz G_{ce}, NF TEST CIRCUIT

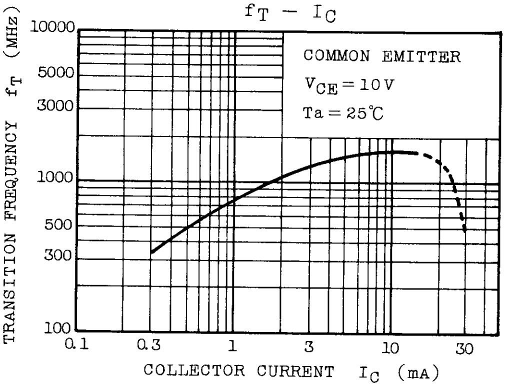


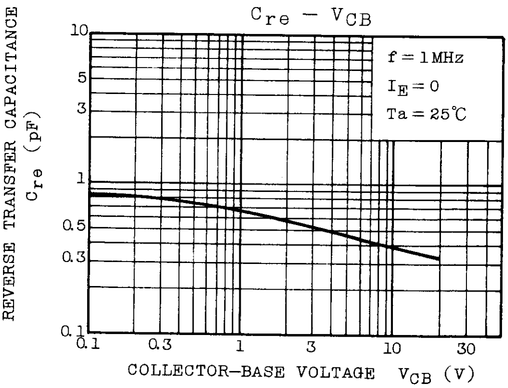
L1 : 0.8mmϕ SILVER PLATED COPPER WIRE, 1.5T 5mm ID

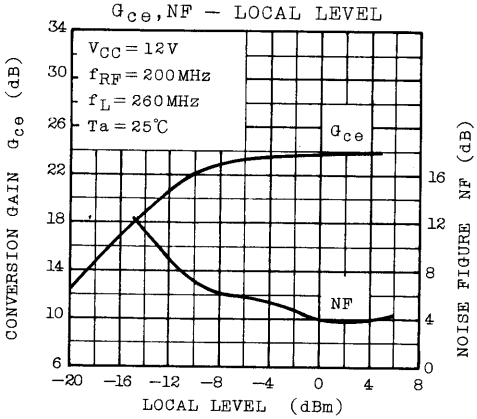
L2 : COIL WITH CORE SCN-5962A ① - ③ (TOKO INC.)OR EQUIVALENT

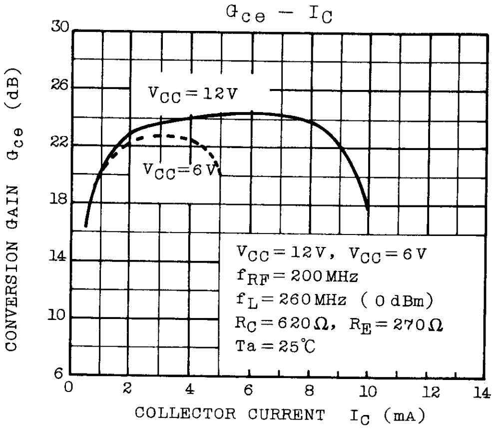
C : AIR TRIMMER TTA25A200A (MURATA MFG. Co., LTD.) OR EQUIVALENT


h_{FE} – I_C

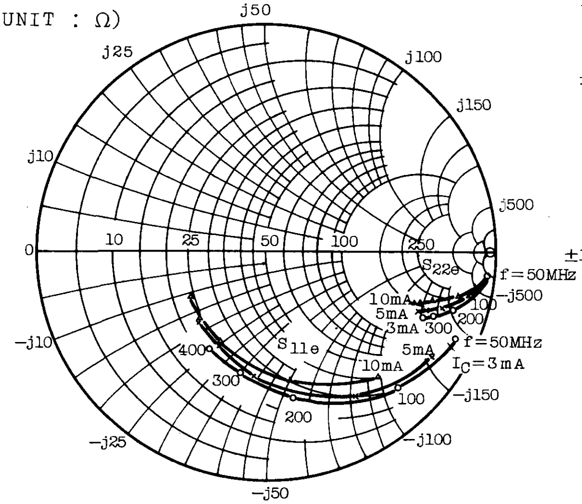

f_T – I_C


C_{re} – V_{CB}

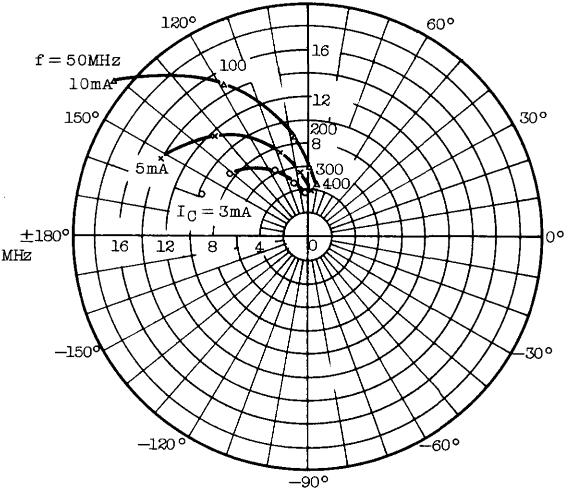

G_{ce}, NF – LOCAL LEVEL


G_{ce} – I_C

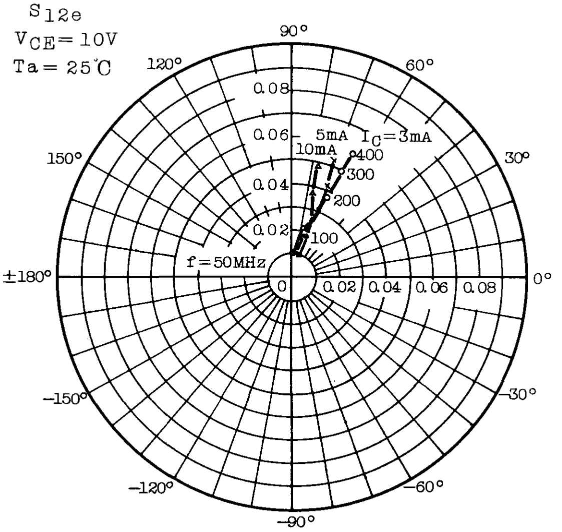
S_{11e}, S_{22e}
V_{CE} = 10V
Ta = 25°C
(UNIT : Ω)

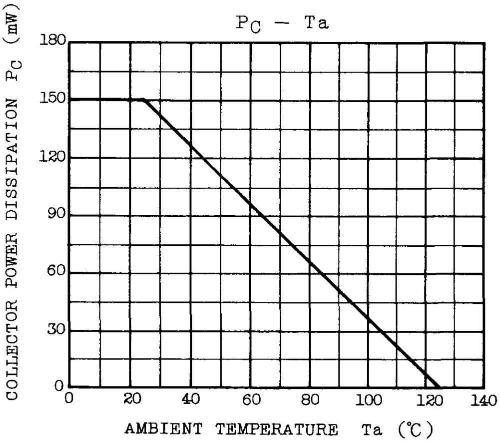


S_{21e}
V_{CE} = 10V
Ta = 25°C



S_{12e}
V_{CE} = 10V
Ta = 25°C



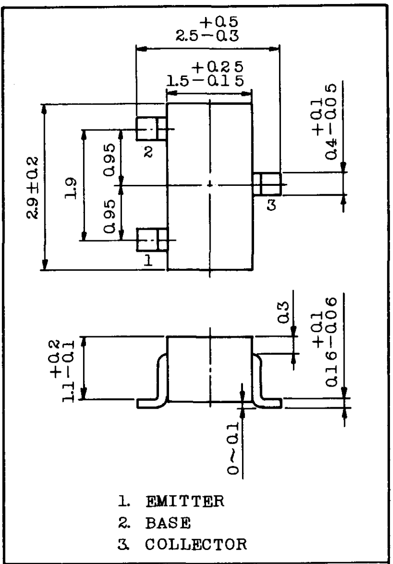


2SC3124

SILICON NPN EPITAXIAL PLANAR TYPE

TV TUNER, VHF OSCILLATOR APPLICATIONS.

Unit in mm



JEDEC	−
EIAJ	SC−59
TOSHIBA	2−3F1A

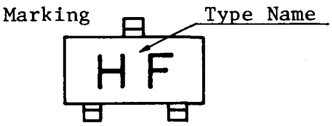
Weight : 0.012g

MAXIMUM RATINGS (Ta=25°C)

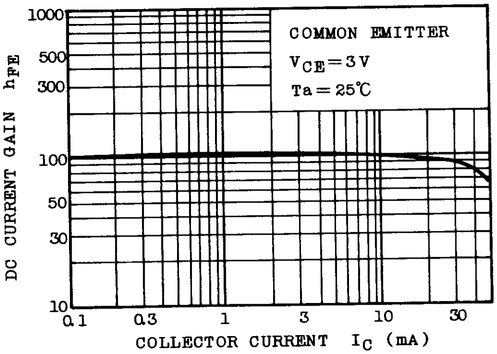
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	15	V
Emitter-Base Voltage	V_{EBO}	3	V
Collector Current	I_C	50	mA
Base Current	I_B	25	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

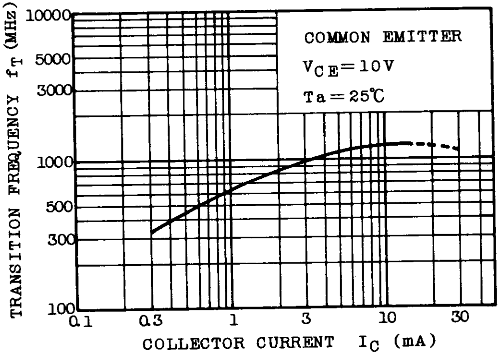
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=15V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=3V, I_C=0	-	-	1.0	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	15	-	-	V
DC Current Gain	h_{FE}	V_{CE}=3V, I_C=8mA	40	100	200	-
Transition Frequency	f_T	V_{CE}=10V, I_C=8mA	650	1100	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	0.9	1.3	pF
Collector-Base Time Constant	$C_c \cdot r_{bb'}$	V_{CB}=10V, I_C=8mA f=30MHz	-	7	12	Ps

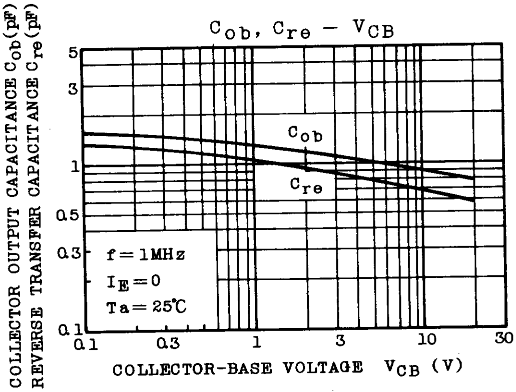


h_{FE} — I_C

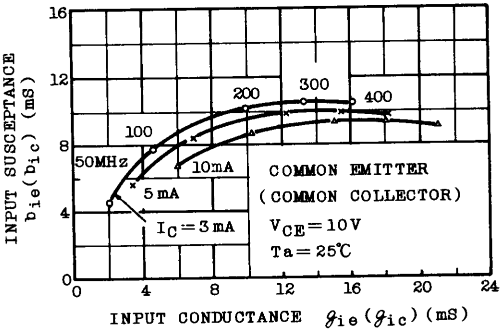


f_T — I_C

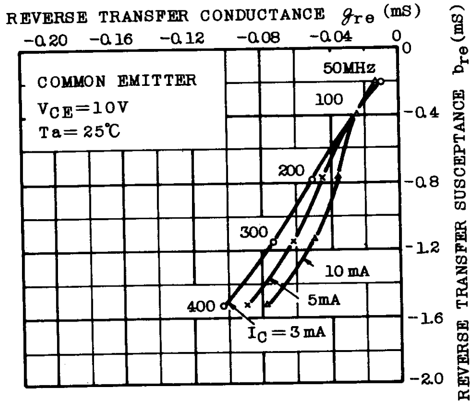




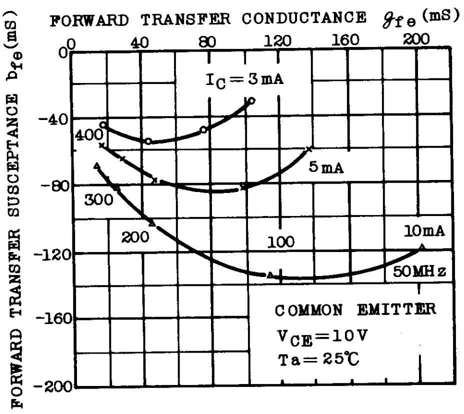
y_{ie} — f
(y_{ic} — f)

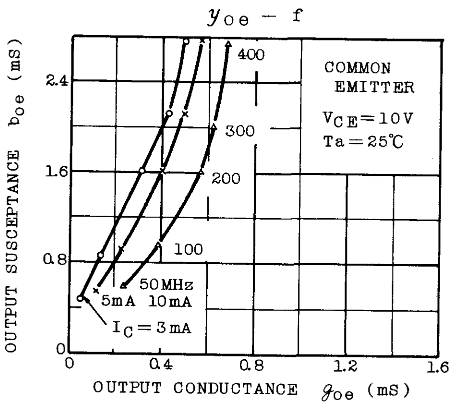


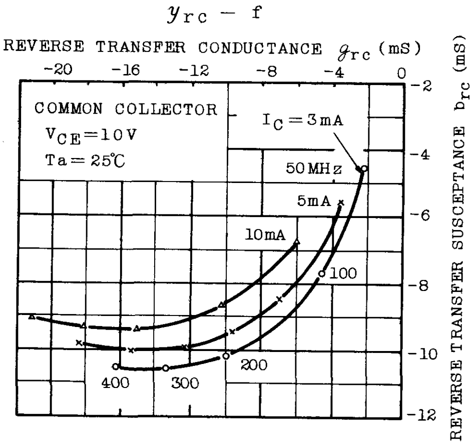
y_{re} — f

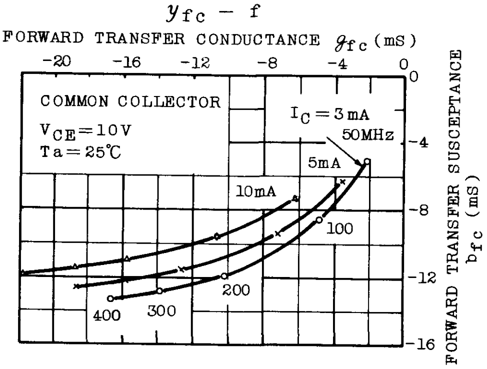


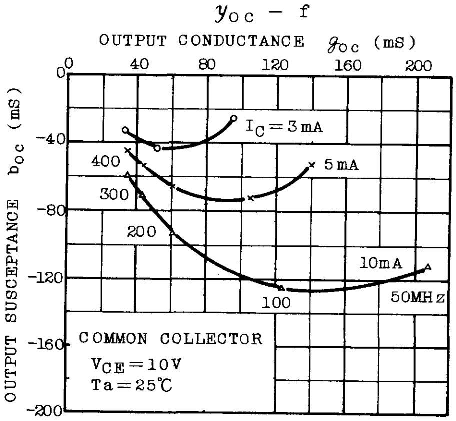
y_{fe} — f

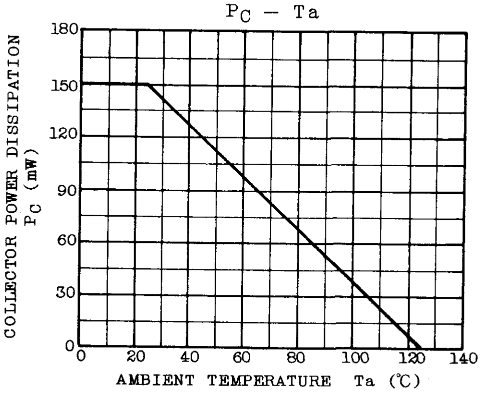



yoe — f
COMMON EMITTER
VCE=10V
Ta=25℃
OUTPUT SUSCEPTANCE boe (mS)
OUTPUT CONDUCTANCE goe (mS)
0
0.8
1.6
2.4
0
0.4
0.8
1.2
1.6
400
300
200
100
50MHz
5mA
10mA
IC=3mA


yrc — f
REVERSE TRANSFER CONDUCTANCE grc (mS)
REVERSE TRANSFER SUSCEPTANCE brc (mS)
-20
-16
-12
-8
-4
0
-2
-4
-6
-8
-10
-12
COMMON COLLECTOR
VCE=10V
Ta=25℃
IC=3mA
50MHz
5mA
10mA
100
200
300
400


yfc — f
FORWARD TRANSFER CONDUCTANCE gfc (mS)
FORWARD TRANSFER SUSCEPTANCE bfc (mS)
-20
-16
-12
-8
-4
0
0
-4
-8
-12
-16
COMMON COLLECTOR
VCE=10V
Ta=25℃
IC=3mA
50MHz
5mA
10mA
100
200
300
400


yoc — f
OUTPUT CONDUCTANCE goc (mS)
OUTPUT SUSCEPTANCE boc (mS)
0
40
80
120
160
200
0
-40
-80
-120
-160
-200
IC=3mA
5mA
10mA
400
300
200
100
50MHz
COMMON COLLECTOR
VCE=10V
Ta=25℃


PC — Ta
COLLECTOR POWER DISSIPATION PC (mW)
AMBIENT TEMPERATURE Ta (℃)
0
30
60
90
120
150
180
0
20
40
60
80
100
120
140

SILICON NPN EPITAXIAL PLANAR TYPE

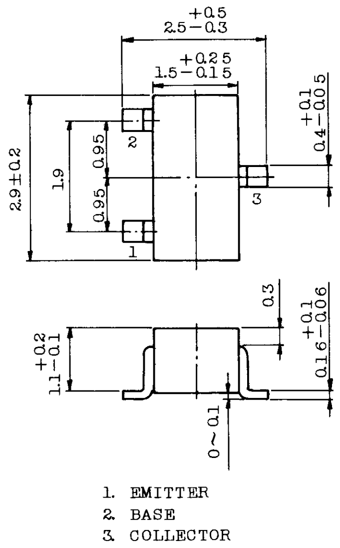
2SC3125

TV FINAL PICTURE IF AMPLIFIER APPLICATIONS.

FEATURES:

. Good Linearity of f_T

Unit in mm



JEDEC	―
EIAJ	SC-59
TOSHIBA	2-3F1A

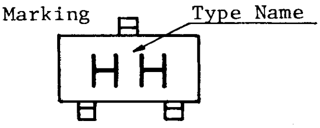
Weight : 0.012g

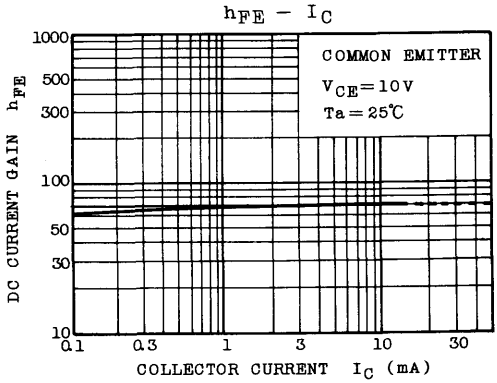
MAXIMUM RATINGS (Ta=25°C)

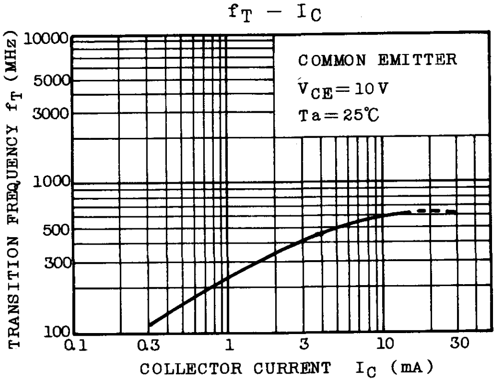
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	25	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	50	mA
Base Current	I_B	25	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~125	°C

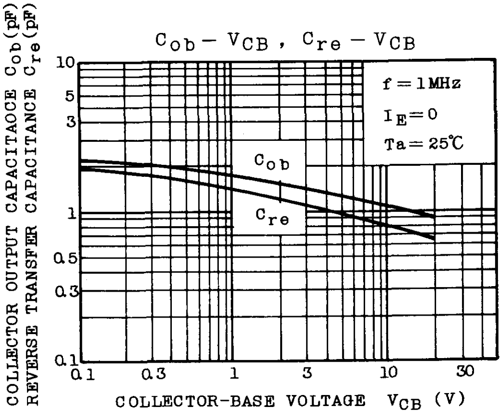
ELECTRICAL CHARACTERISTICS (Ta=25°C)

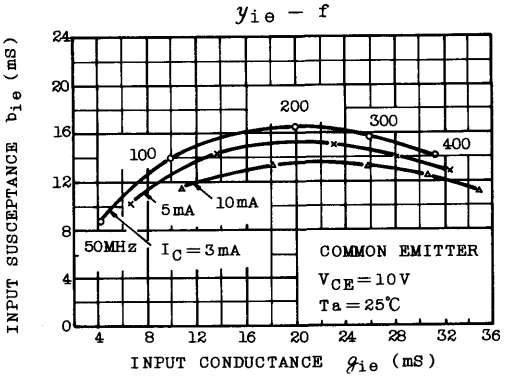
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=30V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=3V, I_C=0	-	-	0.1	μA
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	I_C=10mA, I_B=0	25	-	-	V
DC Current Gain		h_{FE}	V_{CE}=10V, I_C=10mA	20	70	200	
Saturation Voltage	Collector-Emitter	$V_{CE(sat)}$	I_C=15mA, I_B=1.5mA	-	-	0.2	V
	Base-Emitter	$V_{BE(sat)}$		-	-	1.5	
Collector Output Capacitance		C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	1.1	1.6	pF
Collector-Base Time Constant		$C_c \cdot r_{bb'}$	V_{CB}=10V, I_C=1mA, f=30MHz	-	-	25	ps
Transition Frequency		f_T	V_{CE}=10V, I_C=10mA	250	600	-	MHz

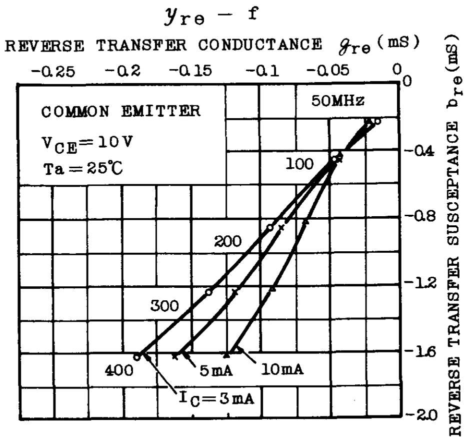


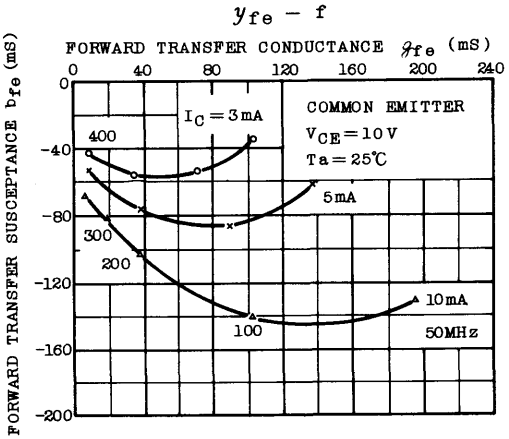

$h_{FE} - I_C$

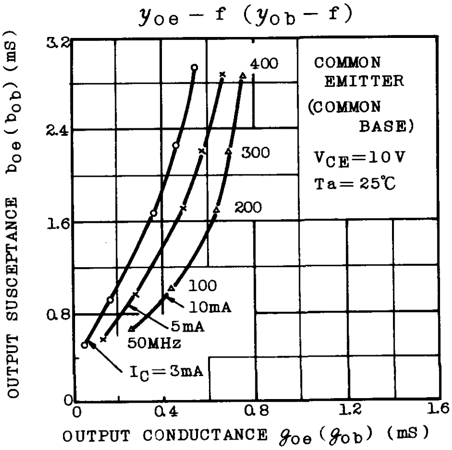

$f_T - I_C$

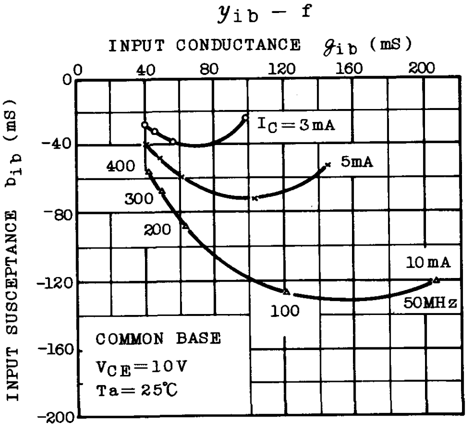

$C_{ob} - V_{CB}$, $C_{re} - V_{CB}$

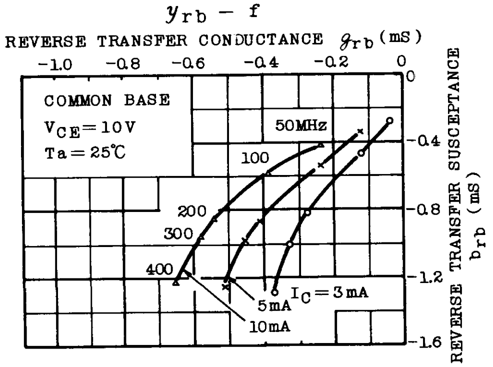

$y_{ie} - f$

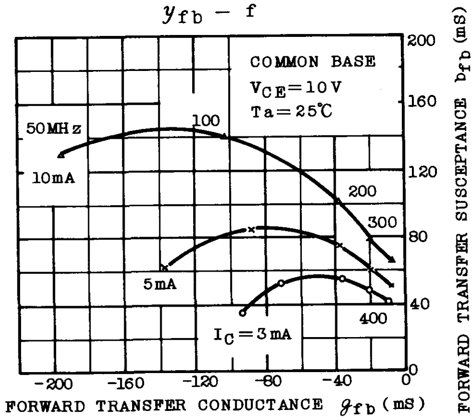

$y_{re} - f$

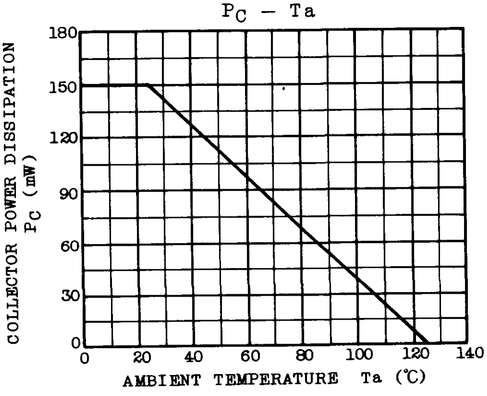

$y_{fe} - f$


y_{oe} – f (y_{ob} – f)
OUTPUT SUSCEPTANCE b_{oe} (b_{ob}) (mS)
OUTPUT CONDUCTANCE g_{oe} (g_{ob}) (mS)
COMMON EMITTER (COMMON BASE)
V_{CE}=10V
Ta=25℃
400
300
200
100
10mA
5mA
50MHz
I_C=3mA
0
0.8
1.6
2.4
3.2
0
0.4
0.8
1.2
1.6


y_{ib} – f
INPUT CONDUCTANCE g_{ib} (mS)
INPUT SUSCEPTANCE b_{ib} (mS)
0
40
80
120
160
200
-40
-80
-120
-160
-200
I_C=3mA
5mA
10mA
400
300
200
100
50MHz
COMMON BASE
V_{CE}=10V
Ta=25℃


y_{rb} – f
REVERSE TRANSFER CONDUCTANCE g_{rb} (mS)
REVERSE TRANSFER SUSCEPTANCE b_{rb} (mS)
-1.0
-0.8
-0.6
-0.4
-0.2
0
-0.4
-0.8
-1.2
-1.6
COMMON BASE
V_{CE}=10V
Ta=25℃
50MHz
100
200
300
400
5mA
10mA
I_C=3mA


y_{fb} – f
FORWARD TRANSFER CONDUCTANCE g_{fb} (mS)
FORWARD TRANSFER SUSCEPTANCE b_{fb} (mS)
COMMON BASE
V_{CE}=10V
Ta=25℃
50MHz
10mA
100
200
300
400
5mA
I_C=3mA
-200
-160
-120
-80
-40
0
40
80
120
160
200

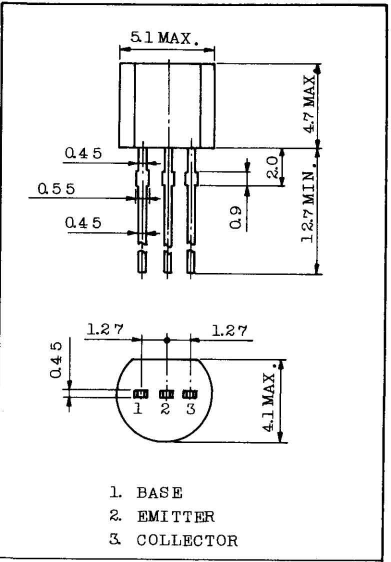

P_C – Ta
COLLECTOR POWER DISSIPATION P_C (mW)
AMBIENT TEMPERATURE Ta (℃)
0
30
60
90
120
150
180
0
20
40
60
80
100
120
140

2SC3136

SILICON NPN EPITAXIAL PLANAR TYPE

TV VHF MIXER APPLICATIONS.

Unit in mm



1. BASE
2. EMITTER
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1E

Weight : 0.21g

FEATURES:

- High Conversion Gain : G_{ce}=23dB (Typ.)
- Low Reverse Transfer Capacitance : C_{re}=0.4pF (Typ.)

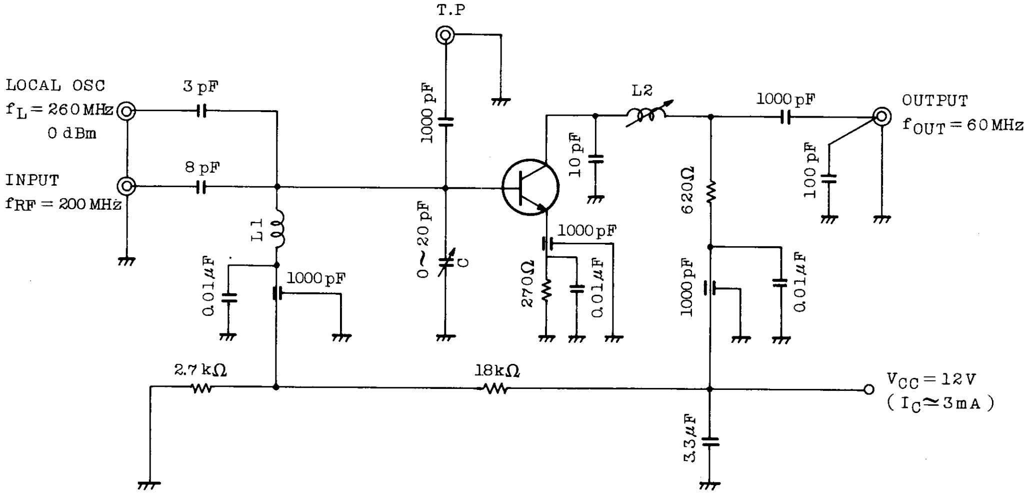
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	20	V
Emitter-Base Voltage	V_{EBO}	3	V
Collector Current	I_C	50	mA
Base Current	I_B	25	mA
Collector Power Dissipation	P_C	250	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=25V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=3V, I_C=0	-	-	1000	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	20	-	-	V
DC Current Gain	h_{FE}	V_{CE}=10V, I_C=5mA	40	150	300	
Reverse Transfer Capacitance	C_{re}	V_{CB}=10V, I_E=0, f=1MHz	-	0.4	0.5	pF
Transition Frequency	f_T	V_{CE}=10V, I_C=5mA	900	1400	-	MHz
Conversion Gain	G_{ce}	V_{CC}=12V, f=200MHz f_L=260MHz	20	23	-	dB
Noise Figure	NF		-	3.8	5.5	dB

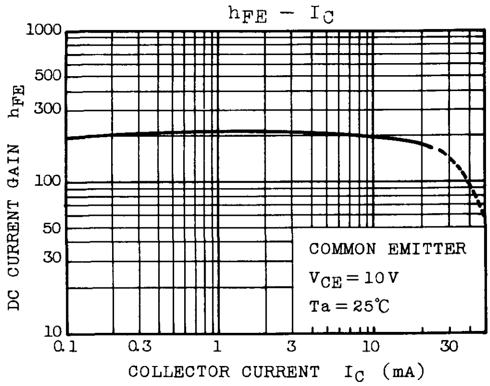
Fig. 1 200MHz G_{ce}, NF TEST CIRCUIT

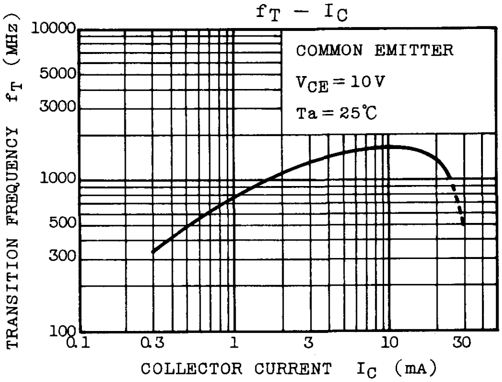


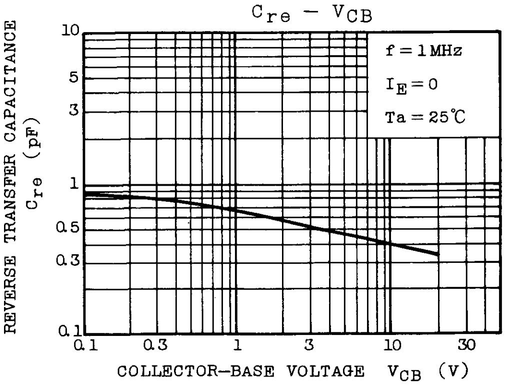
L1 : 0.8mmϕ SILVER PLATED COPPER WIRE, 1.5T, 5mm ID

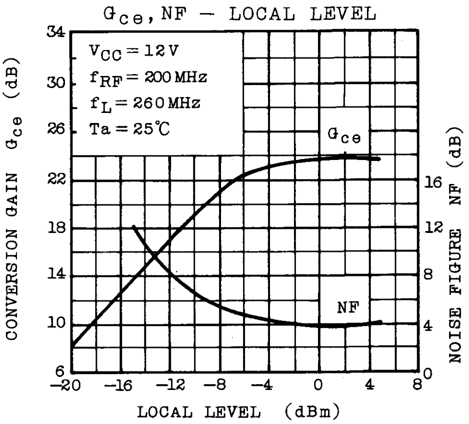
L2 : COIL WITH CORE SCN-5962A ① - ③ (TOKO INC.) OR EQUIVALENT

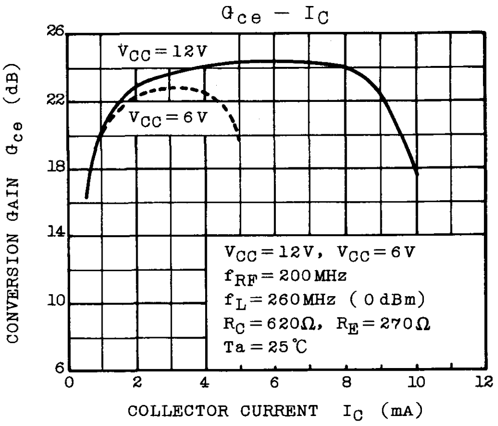
C : AIR TRIMMER TTA25A200A (MURATA MFG. Co., LTD.) OR EQUIVALENT

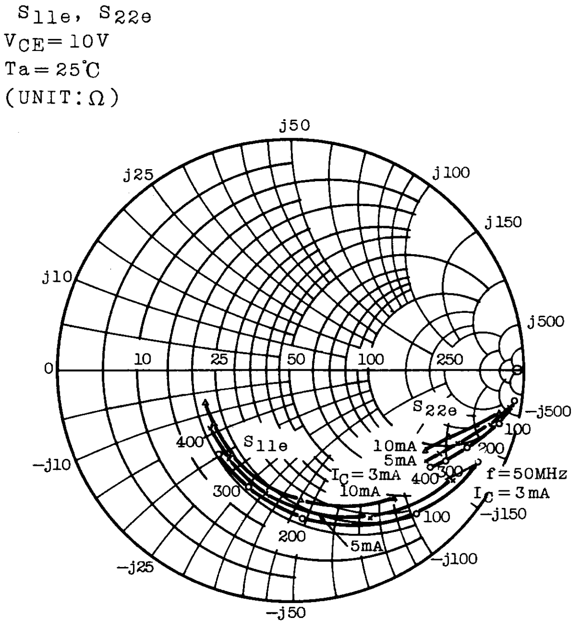

hFE — IC
DC CURRENT GAIN hFE
1000
500
300
100
50
30
10
COMMON EMITTER
VCE = 10 V
Ta = 25℃
0.1
0.3
1
3
10
30
COLLECTOR CURRENT IC (mA)

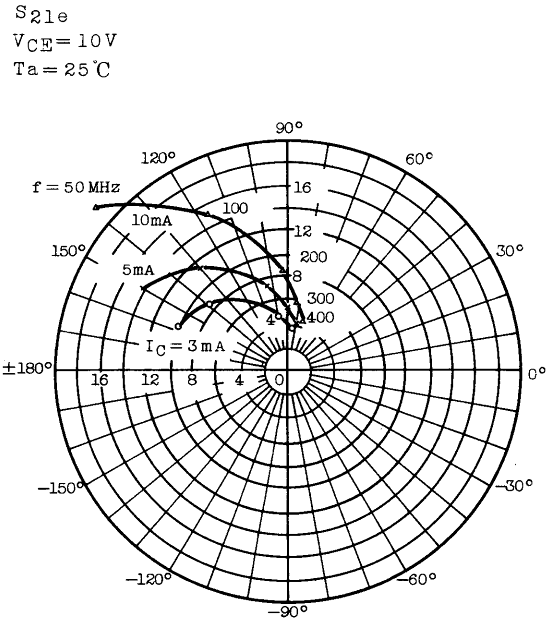

fT — IC
TRANSITION FREQUENCY fT (MHz)
10000
5000
3000
1000
500
300
100
COMMON EMITTER
VCE = 10 V
Ta = 25℃
0.1
0.3
1
3
10
30
COLLECTOR CURRENT IC (mA)

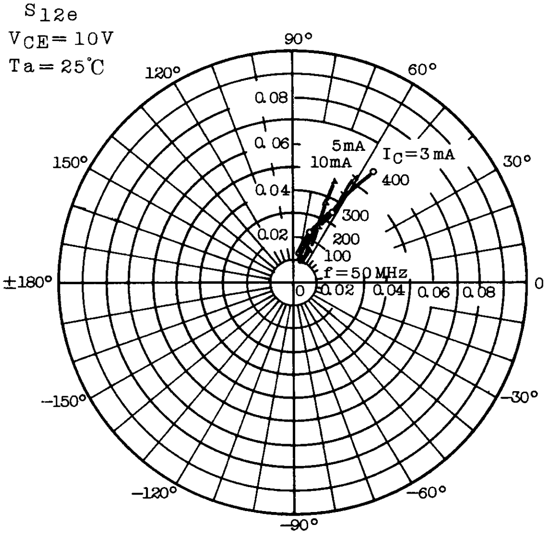

Cre — VCB
REVERSE TRANSFER CAPACITANCE Cre (pF)
10
5
3
1
0.5
0.3
0.1
f = 1 MHz
IE = 0
Ta = 25℃
0.1
0.3
1
3
10
30
COLLECTOR-BASE VOLTAGE VCB (V)

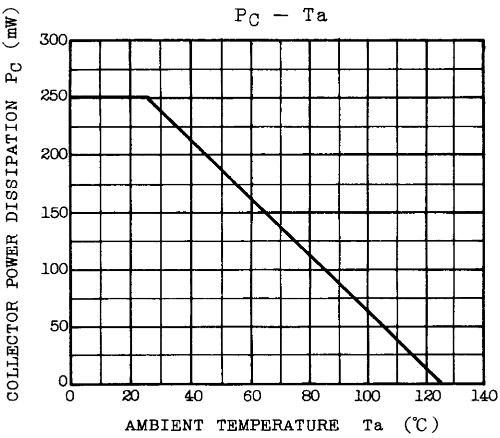

Gce, NF — LOCAL LEVEL
CONVERSION GAIN Gce (dB)
34
30
26
22
18
14
10
6
VCC = 12 V
fRF = 200 MHz
fL = 260 MHz
Ta = 25℃
Gce
NF
NOISE FIGURE NF (dB)
16
12
8
4
0
−20
−16
−12
−8
−4
0
4
8
LOCAL LEVEL (dBm)


Gce — IC
CONVERSION GAIN Gce (dB)
26
22
18
14
10
6
VCC = 12 V
VCC = 6 V
VCC = 12 V, VCC = 6 V
fRF = 200 MHz
fL = 260 MHz (0 dBm)
RC = 620Ω, RE = 270Ω
Ta = 25℃
0
2
4
6
8
10
12
COLLECTOR CURRENT IC (mA)


S_{11e}, S_{22e}
V_{CE} = 10V
Ta = 25°C
(UNIT: Ω)
j50
j25
j100
j150
j10
j500
0
10
25
50
100
250
S_{22e}
−j500
100
10mA
5mA
200
S_{11e}
400
300
400
I_C = 3mA
f = 50MHz
−j10
300
10mA
I_C = 3mA
100
−j150
200
5mA
−j100
−j25
−j50


S_{21e}
V_{CE} = 10V
Ta = 25°C
90°
120°
60°
f = 50 MHz
100
16
10mA
12
150°
200
30°
5mA
8
300
4
400
I_C = 3 mA
±180°
16
12
8
4
0
0°
−150°
−30°
−120°
−60°
−90°


S_{12e}
V_{CE} = 10V
Ta = 25°C
90°
120°
60°
0.08
0.06
5mA
10mA
I_C = 3 mA
150°
400
30°
0.04
300
0.02
200
100
f = 50 MHz
±180°
0
0.02
0.04
0.06
0.08
0°
−150°
−30°
−120°
−60°
−90°

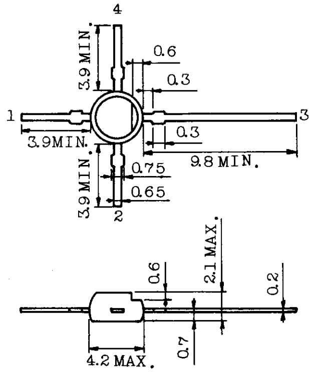

P_C − Ta
COLLECTOR POWER DISSIPATION P_C (mW)
300
250
200
150
100
50
0
0
20
40
60
80
100
120
140
AMBIENT TEMPERATURE Ta (°C)

2SC3137

SILICON NPN EPITAXIAL PLANAR TYPE

TV TUNER, UHF MIXER APPLICATIONS.
VHF ~ UHF BAND RF AMPLIFIER APPLICATIONS.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR
4. BASE

JEDEC	—
EIAJ	—
TOSHIBA	2-4F1B

Weight : 0.08g

MAXIMUM RATINGS ($T_a=25^{\circ}C$)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	15	V
Emitter-Base Voltage	V_{EBO}	3	V
Collector Current	I_C	50	mA
Base Current	I_B	25	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~ 125	°C

ELECTRICAL CHARACTERISTICS ($T_a=25^{\circ}C$)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	$V_{CB}=30V,\ I_E=0$	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	$V_{EB}=2V,\ I_C=0$	-	-	1.0	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	$I_C=1mA,\ I_B=0$	15	-	-	V
DC Current Gain	h_{FE}	$V_{CE}=10V,\ I_C=5mA$	40	100	200	-
Reverse Transfer Capacitance	C_{re}	$V_{CB}=10V,\ I_E=0,\ f=1MHz$	-	0.65	0.9	pF
Transition Frequency	f_T	$V_{CE}=10V,\ I_C=2mA$	1500	2400	-	MHz
Conversion Gain	G_{ce}	$V_{CC}=10V,\ I_C=2mA,$ f=800MHz, $f_L=830MHz(0dBm)$ (Fig.1)	12	17	-	dB
Noise Figure	NF		-	8	-	dB

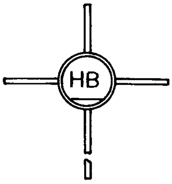
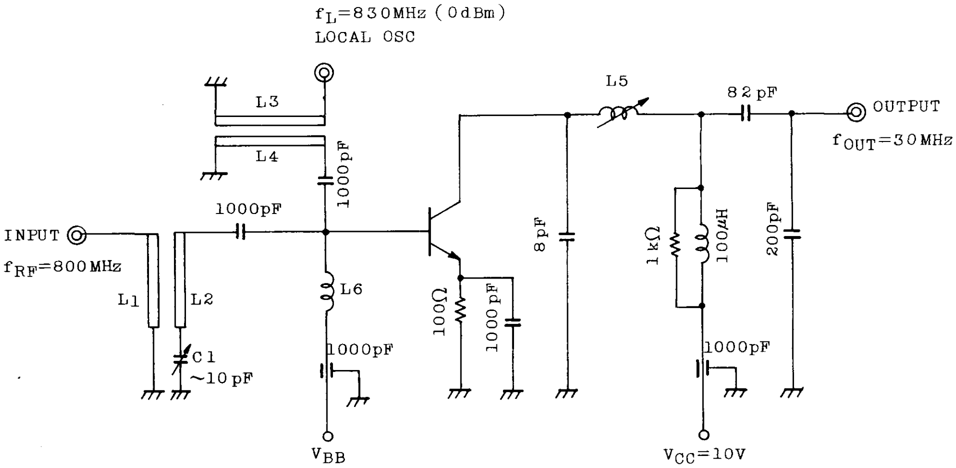


Fig. 1 800MHz G_{ce}, NF TEST CIRCUIT



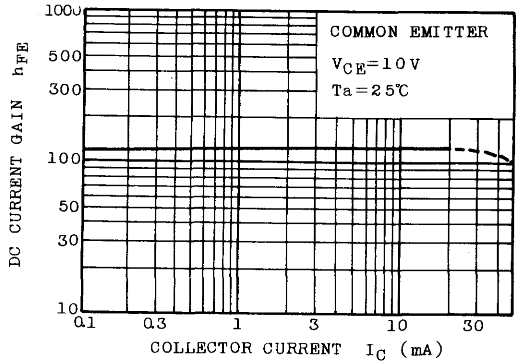
L1～L4 : ϕ0.8mm SILVER PLATED COPPER WIRE

L5 : AIR COIL SCN-5948 ① - ③ TOKO OR EQUIVALENT

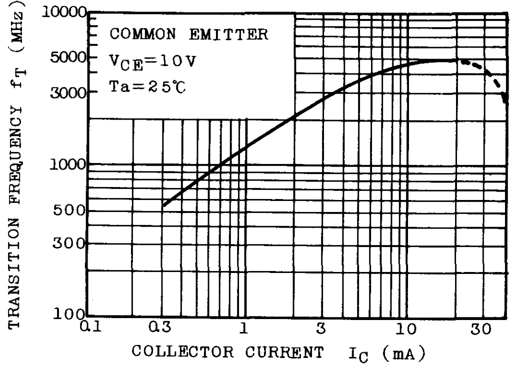
L6 : ϕ0.2mm COPPER WIRE 10T 5mm ID

C1 : AIR TRIMMER TTA23A100 MURATA MFC. CO., LTD. OR EQUIVALENT

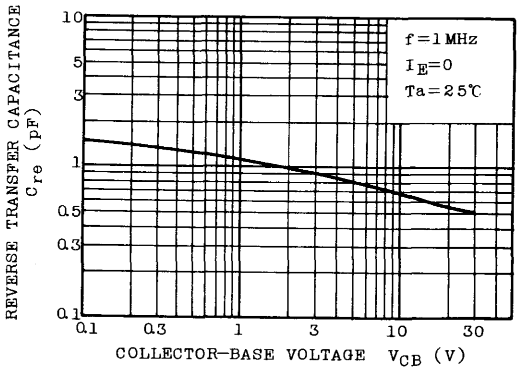
h_{FE} — I_C



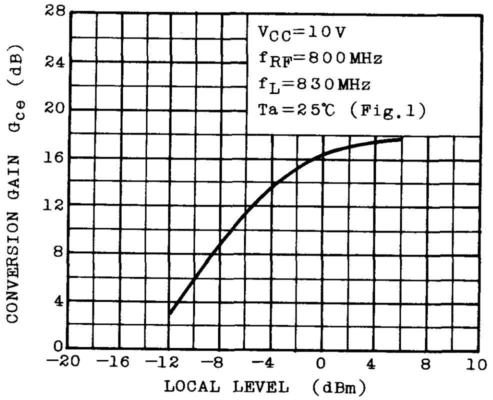
f_T — I_C



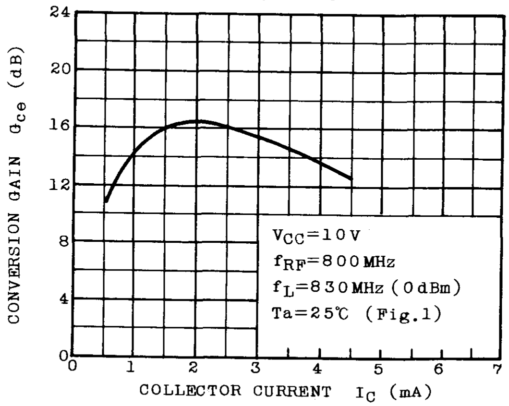
C_{re} — V_{CB}



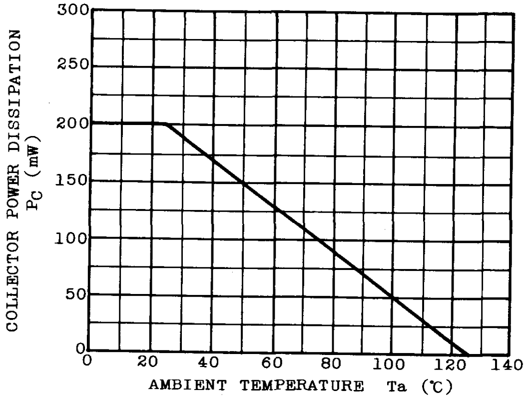
G_{ce} — LOCAL LEVEL



G_{ce} — I_C



P_C — Ta



SILICON NPN TRIPLE DIFFUSED TYPE (PCT PROCESS)

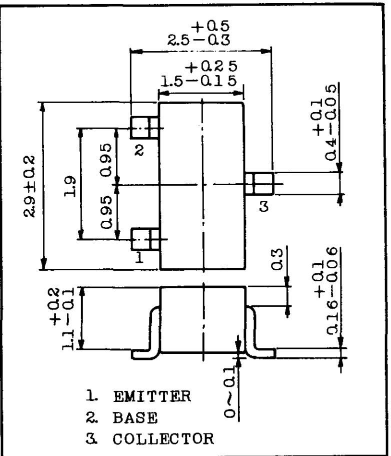
2SC3138

HIGH VOLTAGE SWITCHING APPLICATIONS.

FEATURES:

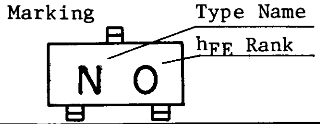
- High Voltage : V_{CEO}=200V
- Small Flat Package
- Complementary to 2SA1255

Unit in mm



JEDEC	―
EIAJ	―
TOSHIBA	2-3F1A

Weight : 0.012g



MAXIMUM RATINGS ($T_a=25^{\circ}C$)

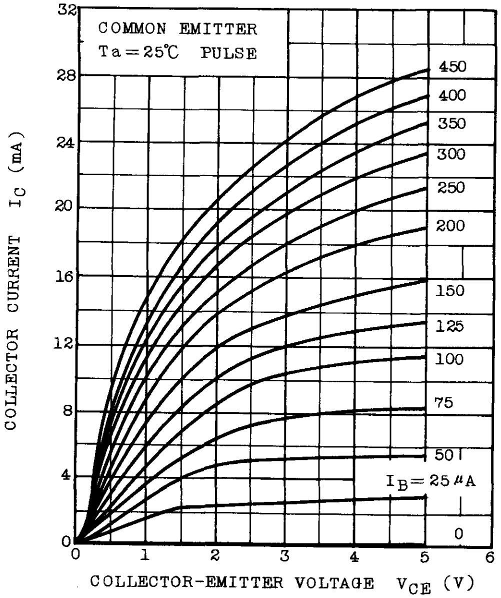
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	200	V
Collector-Emitter Voltage	V_{CEO}	200	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	50	mA
Base Current	I_B	20	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS ($T_a=25^{\circ}C$)

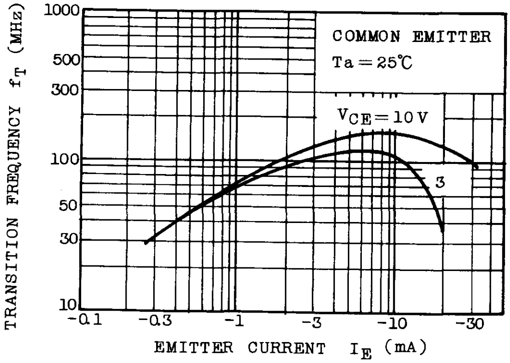
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=200V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=5V, I_C=0	-	-	-0.1	μA
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$	I_C=0.1mA, I_E=0	200	-	-	V
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	I_C=1mA, I_B=0	200	-	-	V
DC Current Gain		h_{FE} (Note)	V_{CE}=3V, I_C=1mA	70	-	240	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	0.1	0.5	V
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=10mA, I_B=1mA	-	0.75	1.5	V
Transition Frequency		f_T	V_{CE}=10V, I_C=2mA	50	100	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	2	4	pF
Switching Time	Turn on Time	t_{on}	V_{CC}=50V, PULSE WIDTH=5μs I_C=6mA, DUTY CYCLE≦2% $I_{B1}=-I_{B2}$=-0.5mA	-	0.3	-	μs
	Storage Time	t_{stg}		-	2	-	μs
	Fall Time	t_f		-	0.4	-	μs

Note : h_{FE} Classification O : 70~140, Y : 120~240

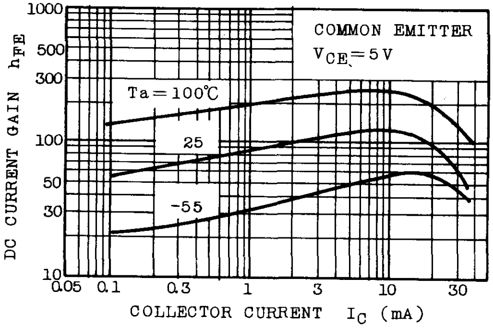
$I_C - V_{CE}$



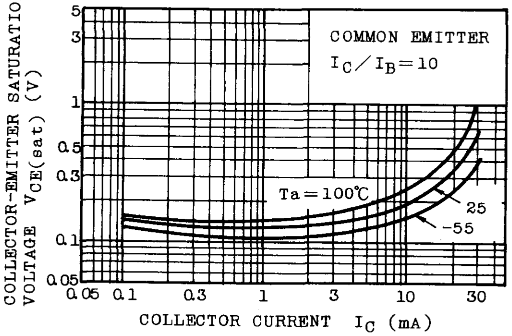
$f_T - I_E$



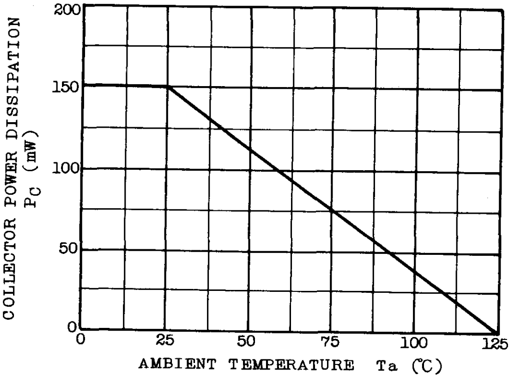
$h_{FE} - I_C$



$V_{CE(sat)} - I_C$



$P_C - Ta$

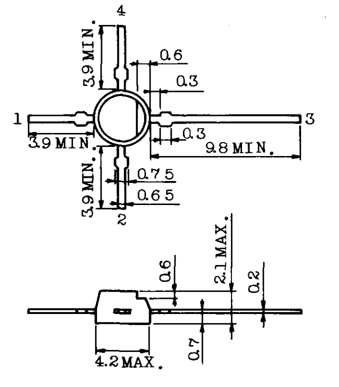


SILICON NPN EPITAXIAL PLANAR TYPE

2SC3172

TV VHF MIXER APPLICATIONS.

Unit in mm



1. BASE
2. EMITTER
3. COLLECTOR
4. EMITTER

JEDEC	—
EIAJ	—
TOSHIBA	2-4F1D

Weight : 0.08g

FEATURES:

- High Conversion Gain : G_{ce}=26dB (Typ.)
- Low Reverse Transfer Capacitance : C_{re}=0.4pF (Typ.)

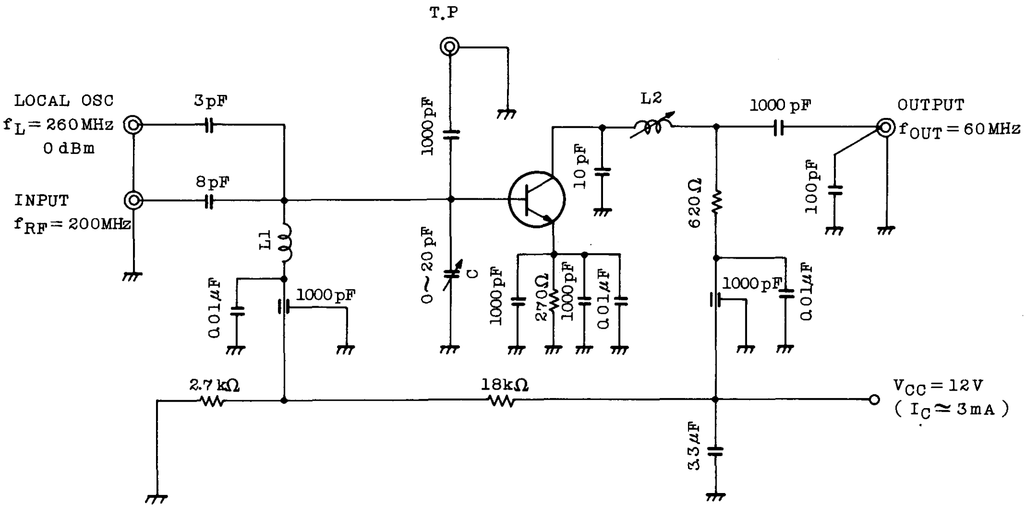
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	20	V
Emitter-Base Voltage	V_{EBO}	3	V
Collector Current	I_C	50	mA
Base Current	I_B	25	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=25V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=3V, I_C=0	-	-	1000	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	20	-	-	V
DC Current Gain	h_{FE}	V_{CE}=10V, I_C=5mA	40	150	300	
Reverse Transfer Capacitance	C_{re}	V_{CB}=10V, I_E=0, f=1MHz	-	0.4	0.5	pF
Transition Frequency	f_T	V_{CE}=10V, I_C=5mA	900	1400	-	MHz
Conversion Gain	G_{ce}	V_{CC}=12V, f=200MHz f_L=260MHz	23	26	-	dB
Noise Figure	NF		-	3.8	5.5	dB

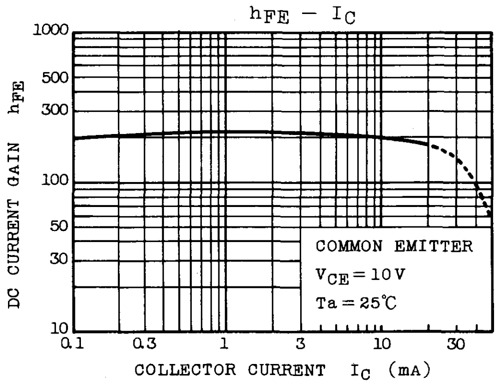
Fig. 1 200MHz G_{ce}, NF TEST CIRCUIT

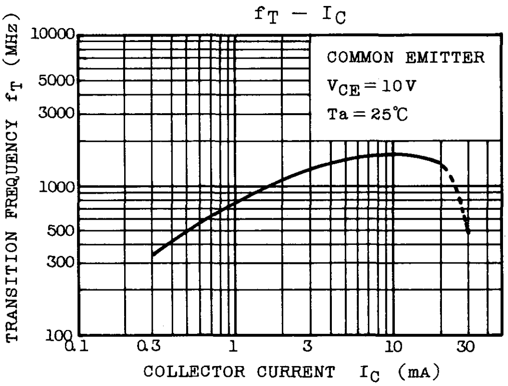


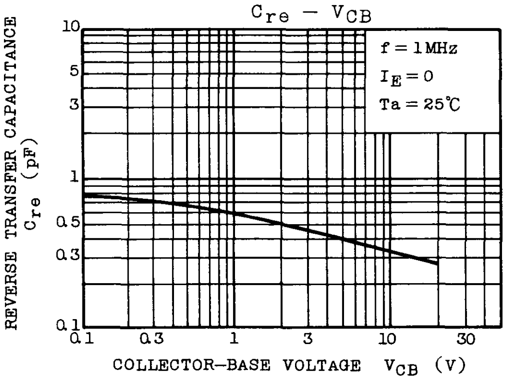
L1 : 0.8mmϕ SILVER PLATED COPPER WIRE, 1.5T, 5mm ID

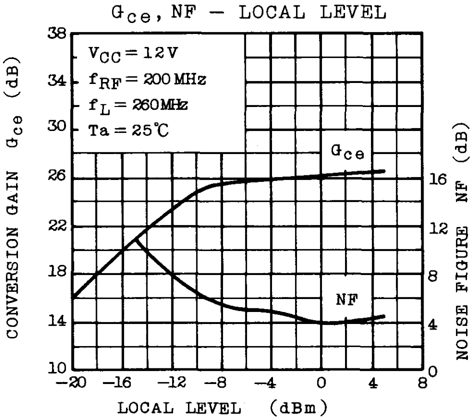
L2 : COIL WITH CORE SCN-5962A ① - ③ (TOKO INC.) OR EQUIVALENT

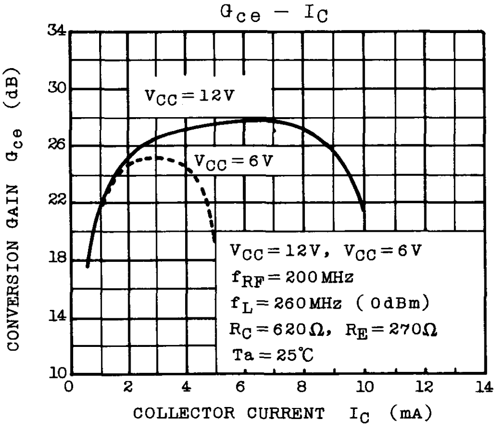
C : AIR TRIMMER TTA25A200A(MURATA MFG. Co., LTD.) OR EQUIVALENT


hFE — IC
DC CURRENT GAIN hFE
1000
500
300
100
50
30
10
0.1
0.3
1
3
10
30
COLLECTOR CURRENT IC (mA)
COMMON EMITTER
VCE = 10 V
Ta = 25℃

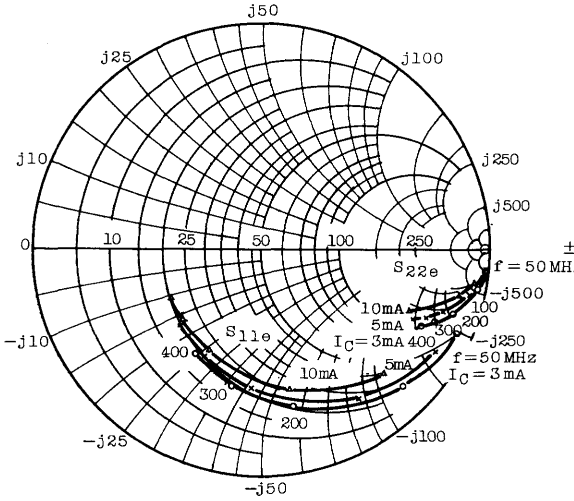

fT — IC
TRANSITION FREQUENCY fT (MHz)
10000
5000
3000
1000
500
300
100
0.1
0.3
1
3
10
30
COLLECTOR CURRENT IC (mA)
COMMON EMITTER
VCE = 10 V
Ta = 25℃


Cre — VCB
REVERSE TRANSFER CAPACITANCE Cre (pF)
10
5
3
1
0.5
0.3
0.1
0.1
0.3
1
3
10
30
COLLECTOR-BASE VOLTAGE VCB (V)
f = 1 MHz
IE = 0
Ta = 25℃

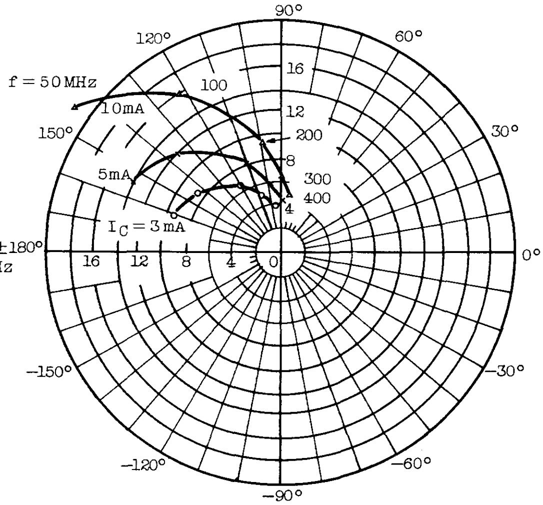

Gce, NF — LOCAL LEVEL
CONVERSION GAIN Gce (dB)
38
34
30
26
22
18
14
10
NOISE FIGURE NF (dB)
16
12
8
4
0
−20
−16
−12
−8
−4
0
4
8
LOCAL LEVEL (dBm)
VCC = 12 V
fRF = 200 MHz
fL = 260 MHz
Ta = 25℃
Gce
NF


Gce — IC
CONVERSION GAIN Gce (dB)
34
30
26
22
18
14
10
0
2
4
6
8
10
12
14
COLLECTOR CURRENT IC (mA)
VCC = 12 V
VCC = 6 V
VCC = 12 V, VCC = 6 V
fRF = 200 MHz
fL = 260 MHz (0 dBm)
RC = 620 Ω, RE = 270 Ω
Ta = 25℃

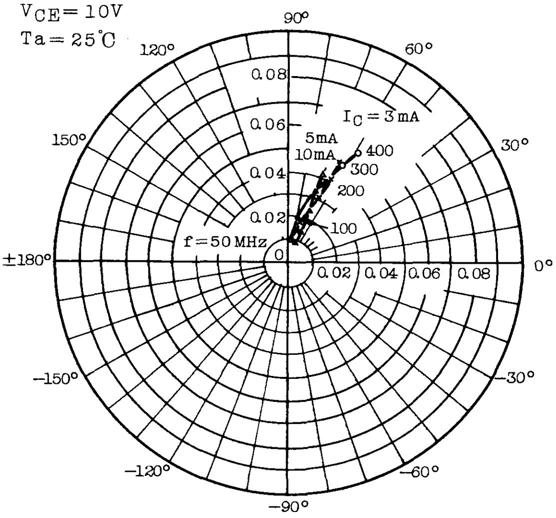
S_{11e}, S_{22e}
$V_{CE}=10V$
$Ta=25°C$
(UNIT : Ω)

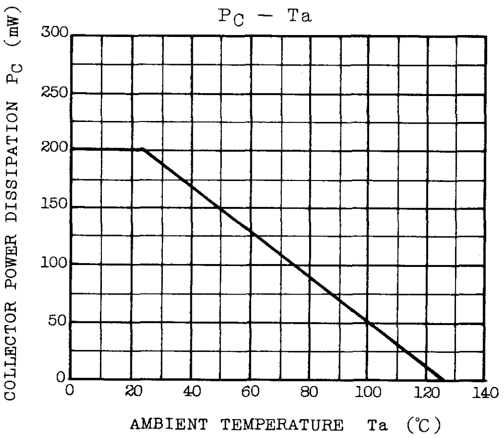


S_{21e}
$V_{CE}=10V$
$Ta=25°C$



S_{12e}
$V_{CE}=10V$
$Ta=25°C$





SILICON NPN EPITAXIAL TYPE (PCT PROCESS)
(INDUSTRIAL APPLICATIONS)

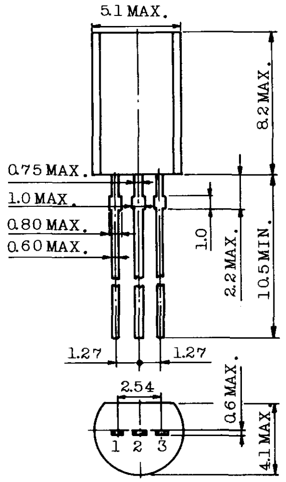
2SC3225

SWITCHING APPLICATIONS.
SOLENOID DRIVE APPLICATIONS.

FEATURES:

- High DC Current Gain : h_{FE}=500(Min.)(I_C=400mA)
- Low Saturation Voltage : $V_{CE(sat)}$=0.5V(Max.)(I_C=300mA)

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

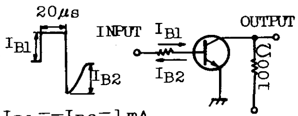
JEDEC	TO−92MOD
EIAJ	−
TOSHIBA	2−5J1A

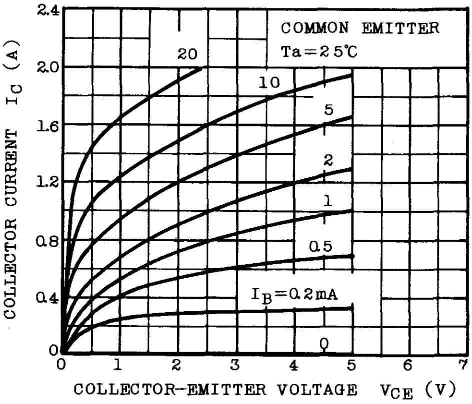
Weight : 0.36g

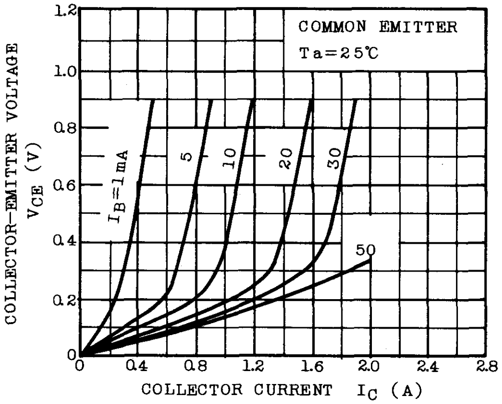
MAXIMUM RATINGS (Ta=25°C)

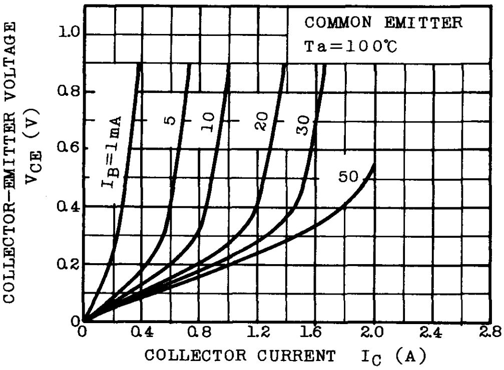
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	40	V
Collector-Emitter Voltage	V_{CEO}	40	V
Emitter-Base Voltage	V_{EBO}	7	V
Collector Current	I_C	2	A
Base Current	I_B	0.5	A
Collector Power Dissipation	P_C	900	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	−55~150	°C

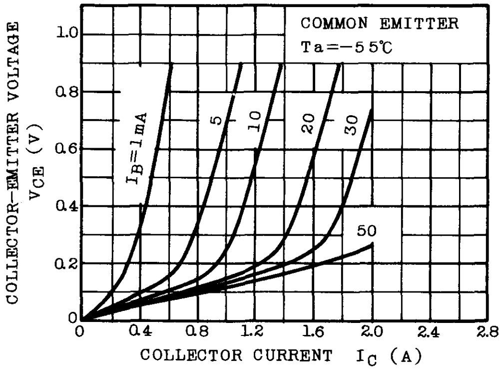
ELECTRICAL CHARACTERISTICS (Ta=25°C)

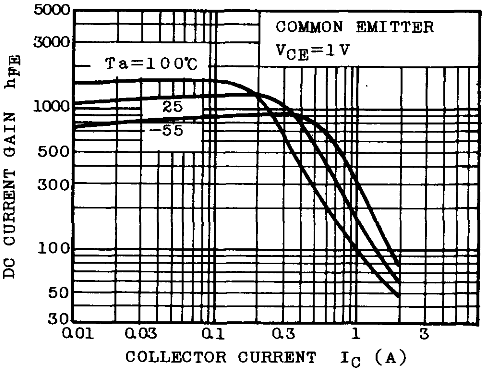
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=40V, I_E=0	−	−	10	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=7V, I_C=0	−	−	1	μA
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	I_C=10mA, I_B=0	40	−	−	V
DC Current Gain		h_{FE}	V_{CE}=1V, I_C=400mA	500	−	−	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=300mA, I_B=1mA	−	0.3	0.5	V
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=300mA, I_B=1mA	−	−	1.1	V
Transition Frequency		f_T	V_{CE}=2V, I_C=100mA	−	220	−	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	−	20	−	pF
Switching Time	Turn-On Time	t_{on}	 I_{B1}=−I_{B2}=1mA DUTY CYCLE≦1% V_{CC}=30V	−	1.0	−	μs
	Storage Time	t_{stg}		−	3.0	−	
	Fall Time	t_f		−	1.2	−	

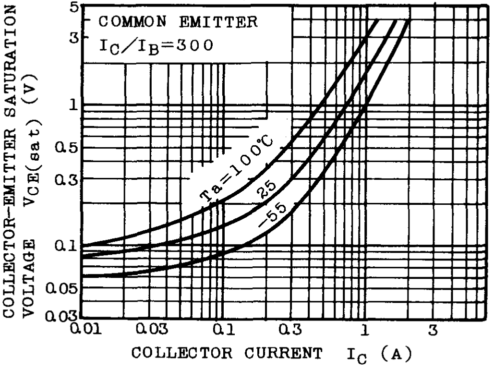

I$_C$ − V$_{CE}$


V$_{CE}$ − I$_C$

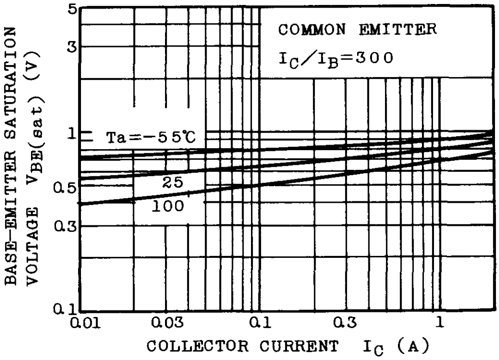

V$_{CE}$ − I$_C$


V$_{CE}$ − I$_C$

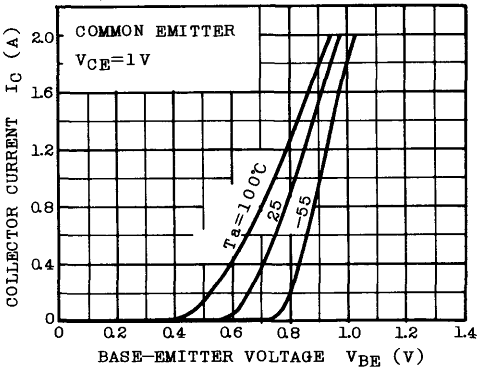

h$_{FE}$ − I$_C$


V$_{CE(sat)}$ − I$_C$

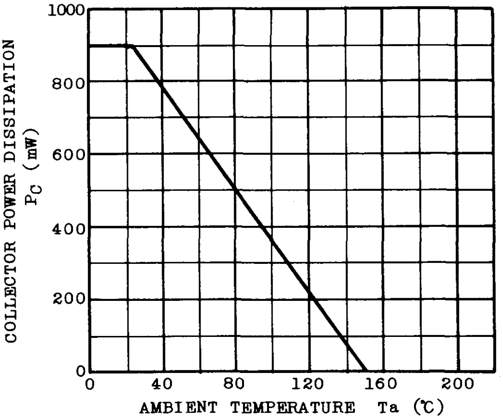
$V_{BE(sat)}$ — I_C



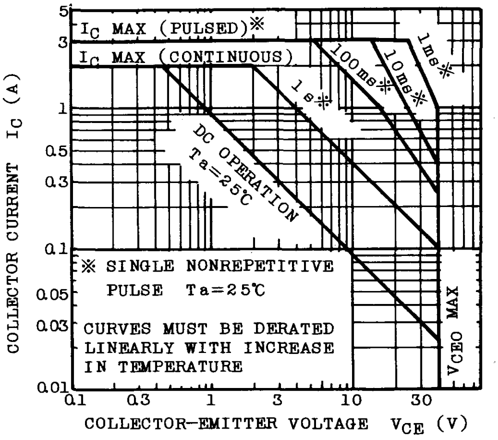
I_C — V_{BE}



P_C — Ta



SAFE OPERATING AREA



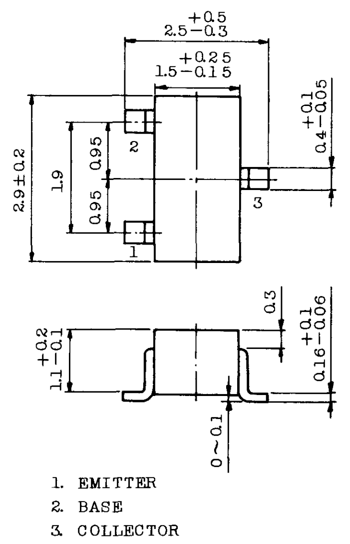
2SC3265

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

LOW FREQUENCY POWER AMPLIFIER APPLICATION.
POWER SWITCHING APPLICATIONS.

FEATURES:
- High DC Current Gain : h_{FE}=100 ~ 320
- Low Saturation Voltage
  : $V_{CE(sat)}$=0.4V (Max.) (I_C=500mA, I_B=20mA)
- Suitable for Driver Stage of Small Motor
- Complementary to 2SA1298
- Small Package

Unit in mm



JEDEC	−
EIAJ	SC−59
TOSHIBA	2−3F1A

Weight : 0.012g

MAXIMUM RATINGS (Ta=25°C)

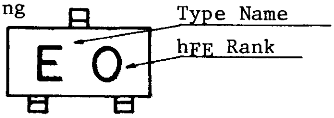
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	35	V
Collector-Emitter Voltage	V_{CEO}	25	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	800	mA
Base Current	I_B	160	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55 ~ 150	°C

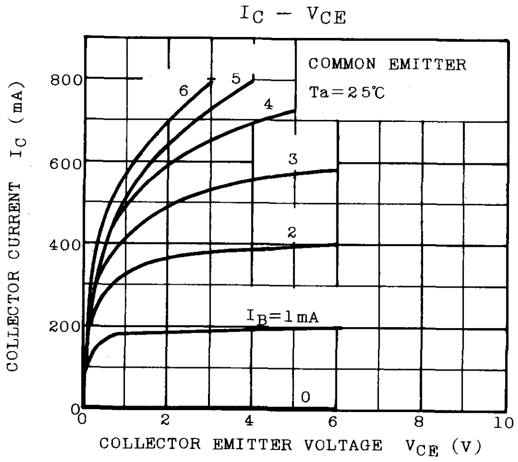
ELECTRICAL CHARACTERISTICS (Ta=25°C)

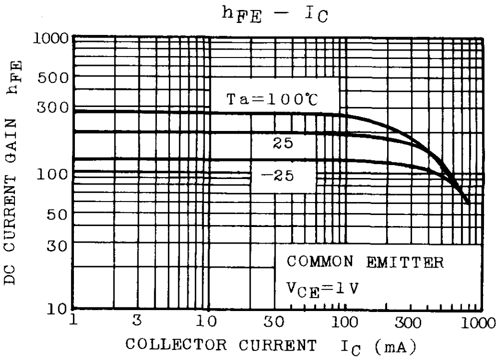
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=30V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=10mA, I_B=0	25	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=1mA, I_C=0	5	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=1V, I_C=100mA	100	-	320	
	$h_{FE(2)}$	V_{CE}=1V, I_C=800mA	40	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=500mA, I_B=20mA	-	-	0.4	V
Base-Emitter Voltage	V_{BE}	V_{CE}=1V, I_C=10mA	0.5	-	0.8	V
Transition Frequency	f_T	V_{CE}=5V, I_C=10mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	13	-	pF

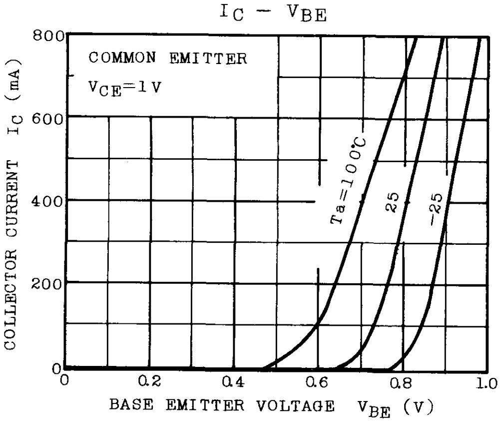
Note : $h_{FE(1)}$ Classification O : 100 ~ 200,
Y : 160 ~ 320

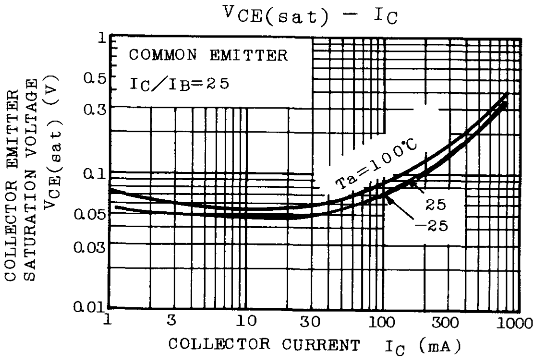
Marking

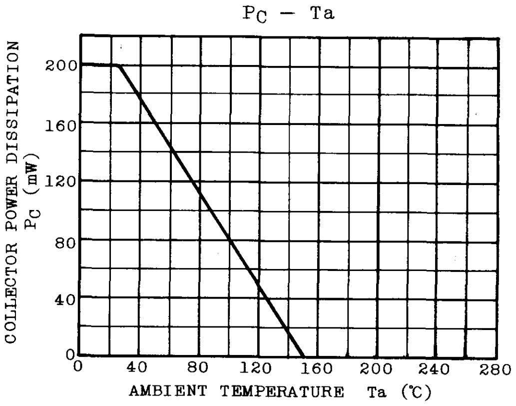



I_C − V_{CE}
COMMON EMITTER
Ta=25℃
6
5
4
3
2
I_B=1mA
0
800
600
400
200
0
COLLECTOR CURRENT I_C (mA)
0
2
4
6
8
10
COLLECTOR EMITTER VOLTAGE V_{CE} (V)


h_{FE} − I_C
Ta=100℃
25
−25
COMMON EMITTER
V_{CE}=1V
1000
500
300
100
50
30
10
DC CURRENT GAIN h_{FE}
1
3
10
30
100
300
1000
COLLECTOR CURRENT I_C (mA)


I_C − V_{BE}
COMMON EMITTER
V_{CE}=1V
Ta=100℃
25
−25
800
600
400
200
0
COLLECTOR CURRENT I_C (mA)
0
0.2
0.4
0.6
0.8
1.0
BASE EMITTER VOLTAGE V_{BE} (V)


$V_{CE(sat)}$ − I_C
COMMON EMITTER
I_C/I_B=25
Ta=100℃
25
−25
1
0.5
0.3
0.1
0.05
0.03
0.01
COLLECTOR EMITTER SATURATION VOLTAGE $V_{CE(sat)}$ (V)
1
3
10
30
100
300
1000
COLLECTOR CURRENT I_C (mA)


P_C − Ta
200
160
120
80
40
0
COLLECTOR POWER DISSIPATION P_C (mW)
0
40
80
120
160
200
240
280
AMBIENT TEMPERATURE Ta (℃)

2SC3268

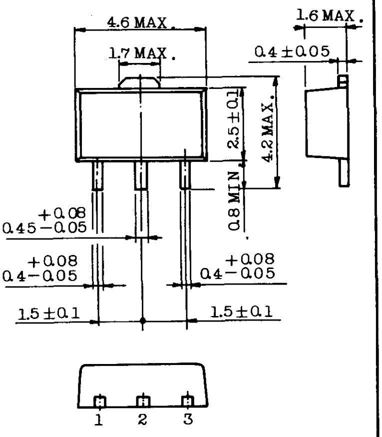
SILICON NPN EPITAXIAL PLANAR TYPE

VHF ~ UHF BAND LOW NOISE AMPLIFIER APPLICATIONS.

Unit in mm

FEATURES:

- NF=1.7dB, $|S_{21e}|^2$=15.0dB (f=500MHz)
- NF=2dB, $|S_{21e}|^2$=9.5dB (f=1000MHz)



1. BASE
2. COLLECTOR (HEAT SINK)
3. EMITTER

JEDEC	–
EIAJ	–
TOSHIBA	2-5K1A

Marking : ME
Weight : 0.052g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	17	V
Collector-Emitter Voltage	V_{CEO}	12	V
Emitter-Base Voltage	V_{EBO}	3	V
Base Current	I_B	30	mA
Collector Current	I_C	70	mA
Collector Power Dissipation	P_C	300	mW
Collector Power Dissipation	P_C ※	800	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~ 125	°C

P_C※ : When mounted ceramic substrate of 250mm^2 × 0.8mmt

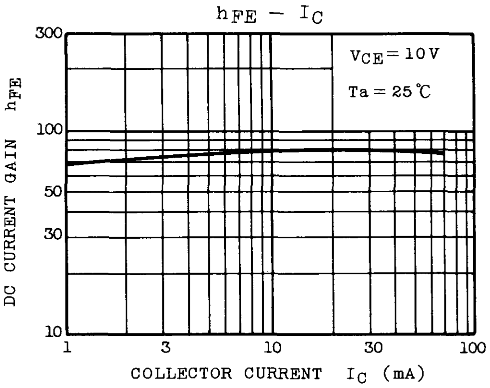
MICROWAVE CHARACTERISTICS (Ta=25°C)

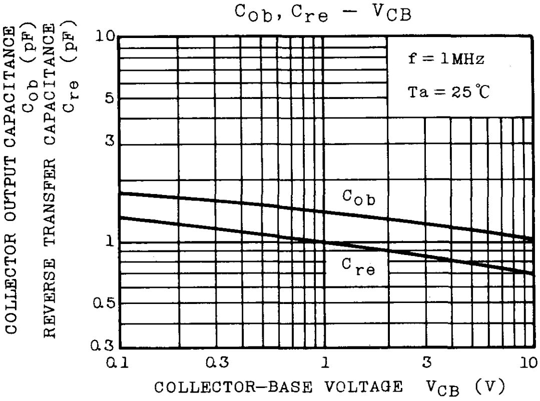
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Transition Frequency	f_T	V_{CE}=10V, I_C=20mA	-	5	-	GHz
Insertion Gain	$\lvert S_{21e}\rvert^2$(1)	V_{CE}=10V, I_C=20mA, f=500MHz	-	15.0	-	dB
	$\lvert S_{21e}\rvert^2$(2)	V_{CE}=10V, I_C=20mA, f=1GHz	-	9.5	-	dB
Noise Figure	NF(1)	V_{CE}=10V, I_C=5mA, f=500MHz	-	1.7	-	dB
	NF(2)	V_{CE}=10V, I_C=5mA, f=1GHz	-	2.0	-	dB

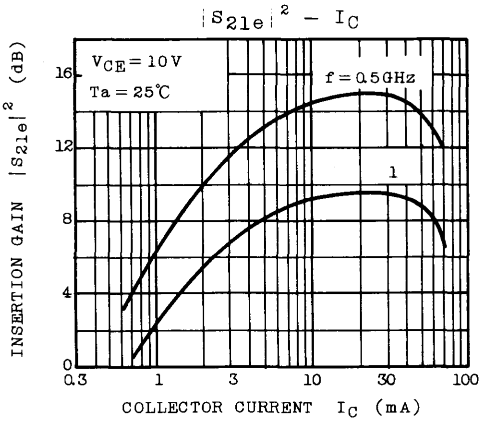
ELECTRICAL CHARACTERISTICS (Ta=25°C)

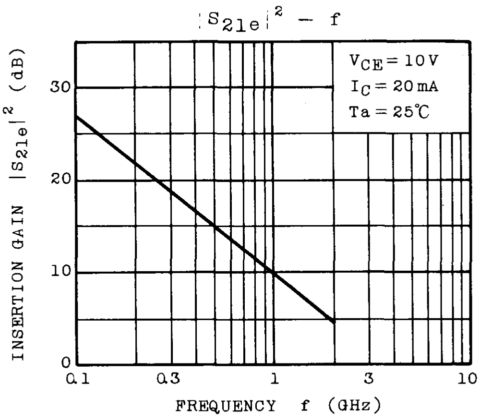
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=10V, I_E=0	-	-	1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=1V, I_C=0	-	-	1	μA
DC Current Gain	h_{FE}	V_{CE}=10V, I_C=20mA	25	-	-	
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	1.05	-	pF
Reverse Transfer Capacitance	C_{re}	(Note)	-	0.7	-	pF

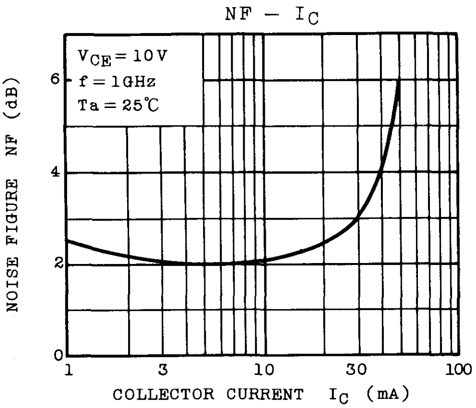
Note : Cre is measured by 3 terminal method with Capacitance Bridge.

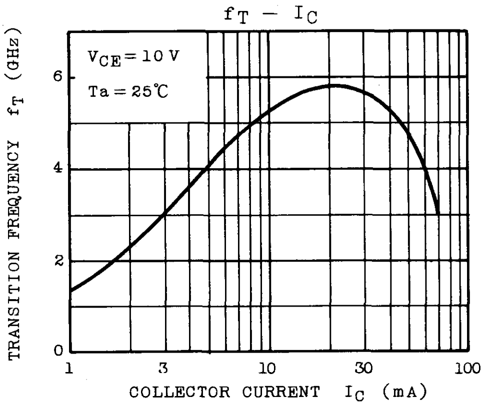

hFE — IC
VCE = 10 V
Ta = 25 ℃
300
100
50
30
10
DC CURRENT GAIN hFE
1
3
10
30
100
COLLECTOR CURRENT IC (mA)

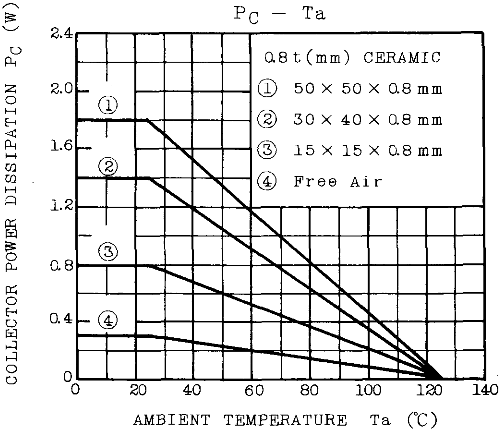

Cob, Cre — VCB
f = 1 MHz
Ta = 25 ℃
Cob
Cre
10
5
3
1
0.5
0.3
COLLECTOR OUTPUT CAPACITANCE Cob (pF)
REVERSE TRANSFER CAPACITANCE Cre (pF)
0.1
0.3
1
3
10
COLLECTOR–BASE VOLTAGE VCB (V)

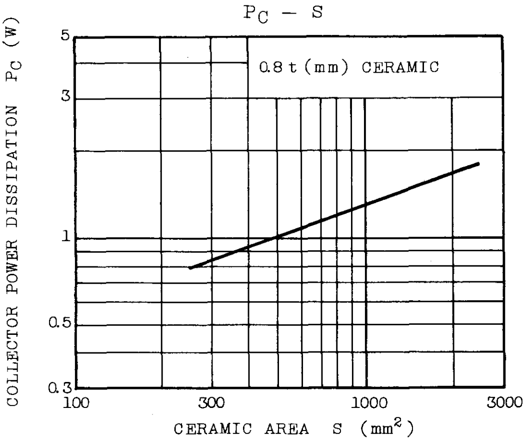

|S21e|² — IC
VCE = 10 V
Ta = 25 ℃
f = 0.5 GHz
1
16
12
8
4
0
INSERTION GAIN |S21e|² (dB)
0.3
1
3
10
30
100
COLLECTOR CURRENT IC (mA)

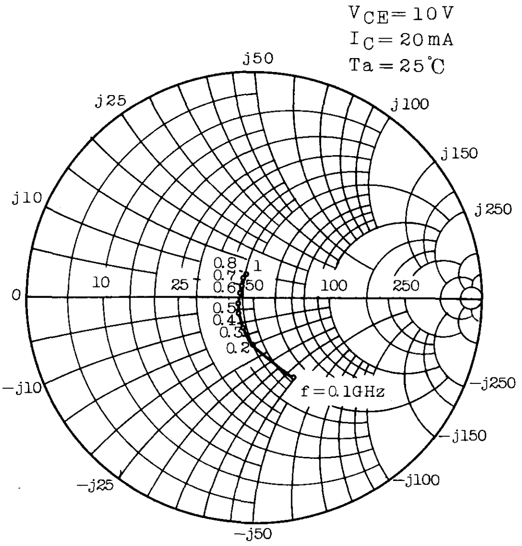

|S21e|² — f
VCE = 10 V
IC = 20 mA
Ta = 25 ℃
30
20
10
0
INSERTION GAIN |S21e|² (dB)
0.1
0.3
1
3
10
FREQUENCY f (GHz)


NF — IC
VCE = 10 V
f = 1 GHz
Ta = 25 ℃
6
4
2
0
NOISE FIGURE NF (dB)
1
3
10
30
100
COLLECTOR CURRENT IC (mA)

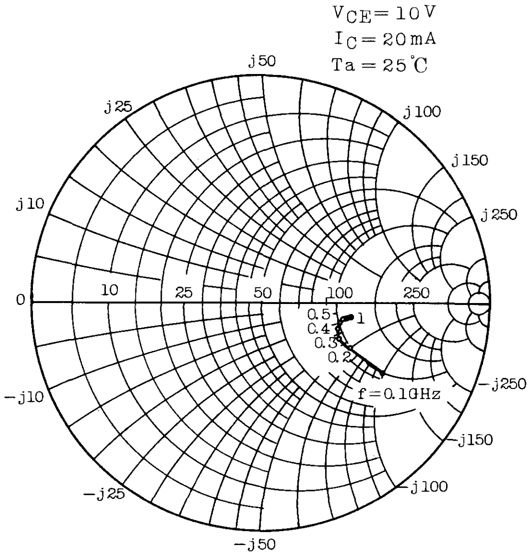

fT — IC
VCE = 10 V
Ta = 25 ℃
6
4
2
0
TRANSITION FREQUENCY fT (GHz)
1
3
10
30
100
COLLECTOR CURRENT IC (mA)


P_C – Ta
COLLECTOR POWER DISSIPATION P_C (W)
2.4
2.0
1.6
1.2
0.8
0.4
0
0
20
40
60
80
100
120
140
AMBIENT TEMPERATURE Ta (℃)
0.8 t (mm) CERAMIC
① 50 × 50 × 0.8 mm
② 30 × 40 × 0.8 mm
③ 15 × 15 × 0.8 mm
④ Free Air
①
②
③
④

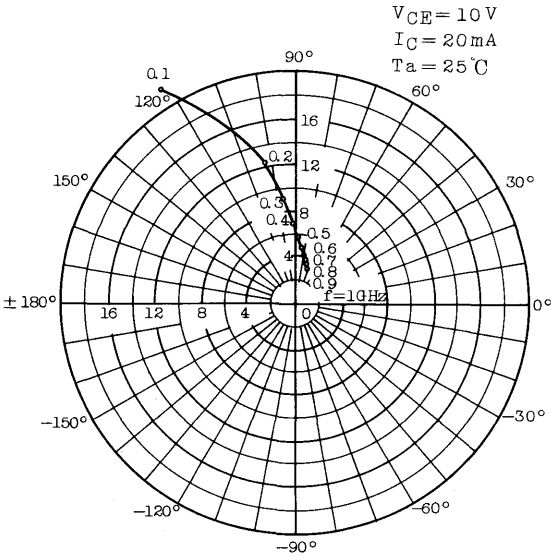

P_C – S
COLLECTOR POWER DISSIPATION P_C (W)
5
3
1
0.5
0.3
100
300
1000
3000
CERAMIC AREA S (mm^2)
0.8 t (mm) CERAMIC



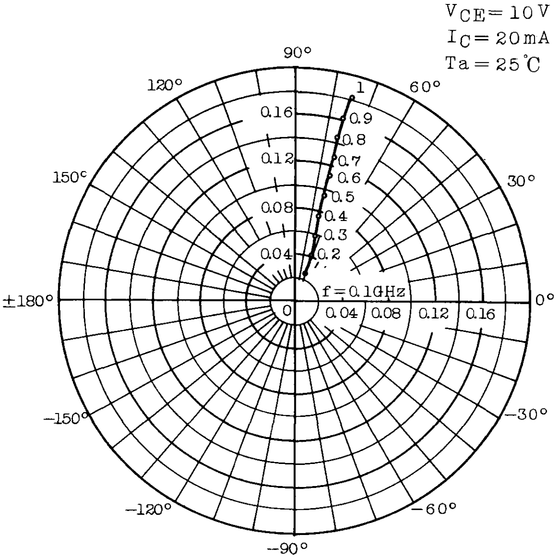
S_{11e}
(UNIT : Ω)



S_{22e}
(UNIT : Ω)



S_{21e}



S_{12e}

2SC3279

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

STROBO FLASH APPLICATIONS.

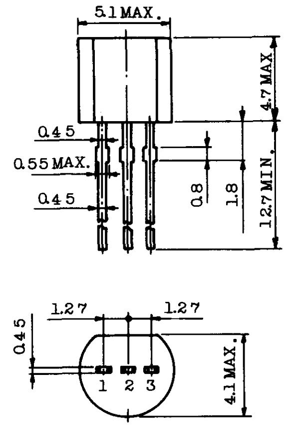
MEDIUM POWER AMPLIFIER APPLICATIONS.

FEATURES:

. High DC Current Gain and Excellent h_{FE} Linearity
  : $h_{FE(1)}$=140～600 (V_{CE}=1V, I_C=0.5A)
  : $h_{FE(2)}$=70(Min.), 200(Typ.) (V_{CE}=1V, I_C=2A)

. Low Saturation Voltage
  : $V_{CE(sat)}$=0.5V(Max.) (I_C=2A, I_B=50mA)

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Voltage		V_{CBO}	30	V
Collector-Emitter Voltage		V_{CES}	30	V
		V_{CEO}	10	
Emitter-Base Voltage		V_{EBO}	6	V
Collector Current	DC	I_C	2	A
	Pulsed(Note 1)	I_{CP}	5	
Base Current		I_B	2	A
Collector Power Dissipation		P_C	750	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_{stg}	-55～150	°C

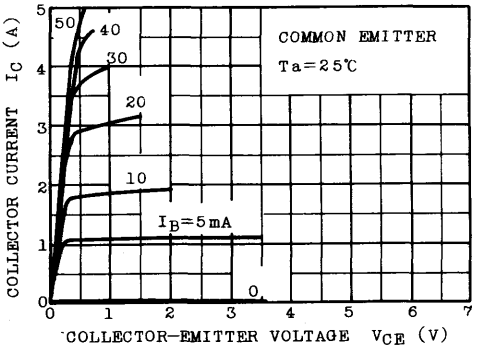
Note 1 : Pulse Width=10ms(Max.), Duty Cycle=30%(Max.).

ELECTRICAL CHARACTERISTICS (Ta=25°C)

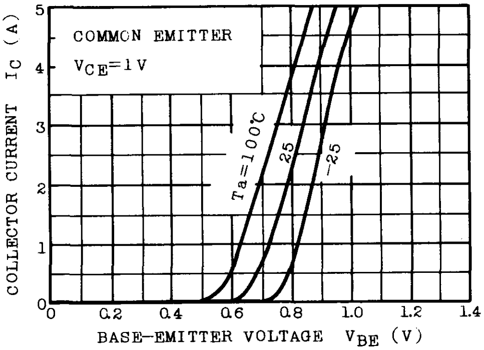
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=30V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=6V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	V_{CEO}	I_C=10mA, I_B=0	10	-	-	V
Emitter-Base Breakdown Voltage	V_{EBO}	I_E=1mA, I_C=0	6	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note 2)	V_{CE}=1V, I_C=0.5A	140	-	600	
	$h_{FE(2)}$	V_{CE}=1V, I_C=2A	70	200	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=2A, I_B=50mA	-	0.2	0.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=1V, I_C=2A	-	0.86	1.5	V
Transition Frequency	f_T	V_{CE}=1V, I_C=0.5A	-	150	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	27	-	pF

Note 2 : $h_{FE(1)}$ Classification L : 140~240, M : 200~330, N : 300~450, P : 420~600

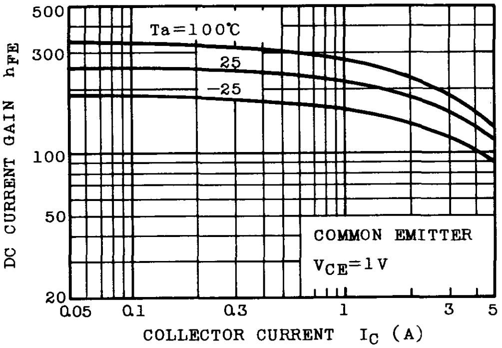
I_C – V_{CE}



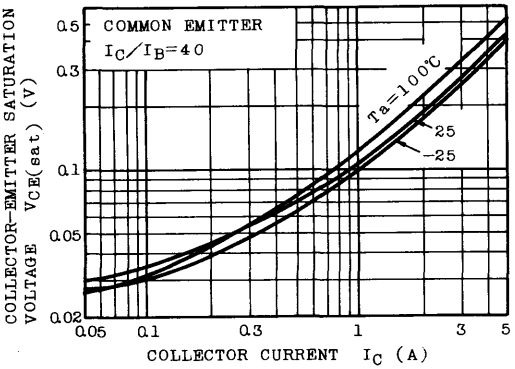
I_C – V_{BE}



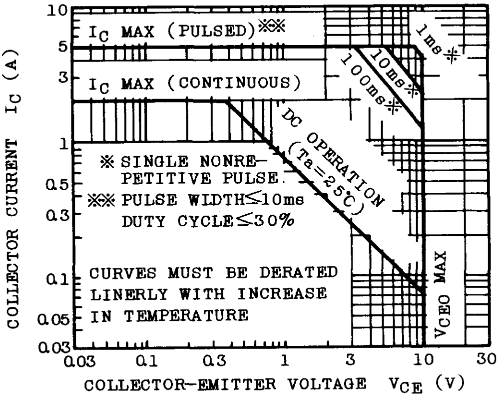
h_{FE} – I_C



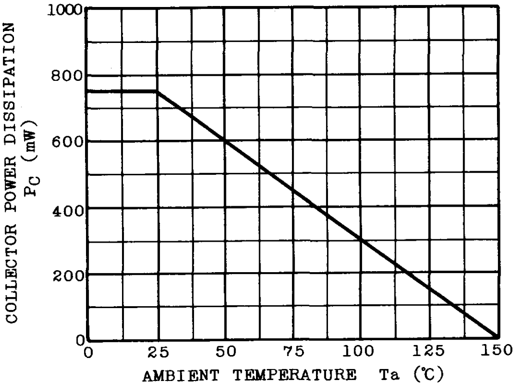
$V_{CE(sat)}$ – I_C



SAFE OPERATING AREA



P_C – Ta



2SC3295

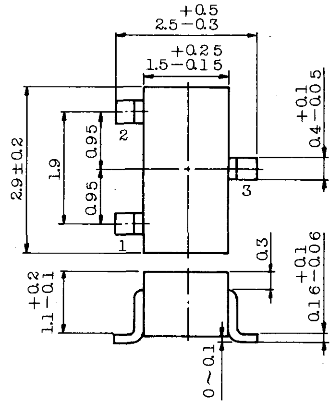
SILICON NPN EPITAXIAL TYPE

AUDIO FREQUENCY AMPLIFIER APPLICATIONS.
SWITCHING APPLICATIONS.

FEATURES:

- High h_{FE} : h_{FE}=600～3600
- High Voltage : V_{CEO}=50V
- High Collector Current : I_C=150mA (Max.)
- Small Package

Unit in mm

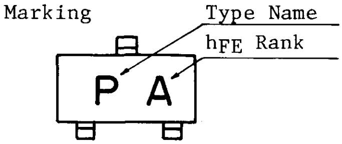


1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	—
EIAJ	SC−59
TOSHIBA	2−3F1A

Weight : 0.012g

Marking



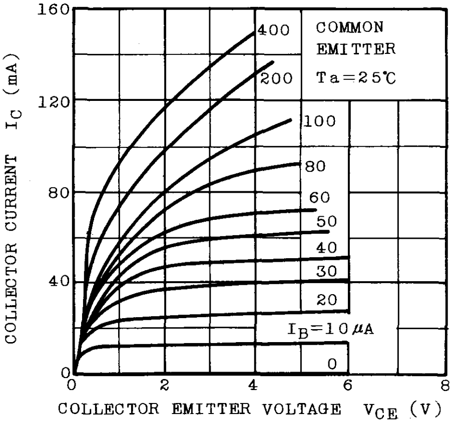
MAXIMUM RATINGS (Ta=25°C)

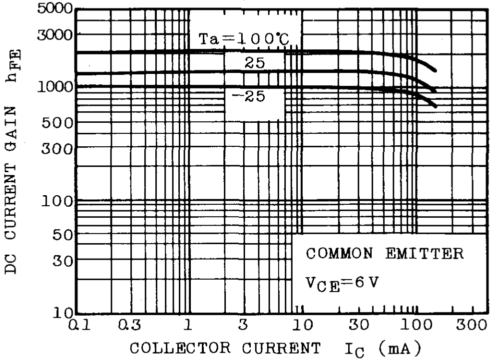
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	60	V
Collector-Emitter Voltage	V_{CEO}	50	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	150	mA
Base Current	I_B	30	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55～125	°C

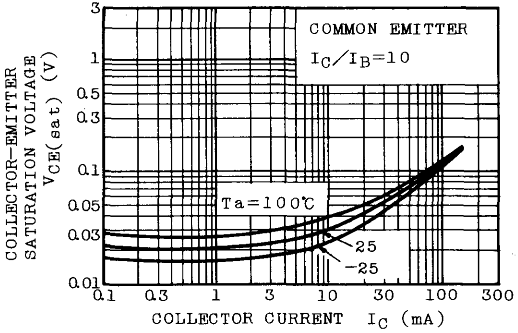
ELECTRICAL CHARACTERISTICS (Ta=25°C)

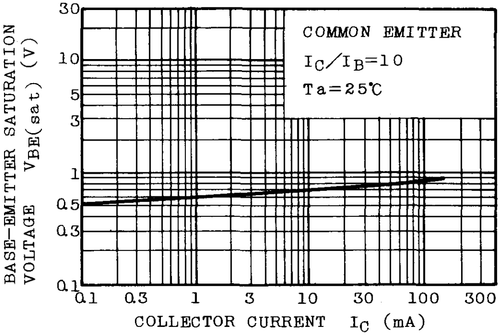
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CE}=50V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=6V, I_C=2mA	600	-	3600	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=100mA, I_B=10mA	-	0.12	0.25	V
Transition Frequency	f_T	V_{CE}=10V, I_C=10mA	100	250	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	3.5	-	pF
Noise Figure	NF(1)	V_{CE}=6V, I_C=0.1mA f=100Hz, R_g=10kΩ	-	0.5	-	dB
	NF(2)	V_{CE}=6V, I_C=0.1mA f=1kHz, R_g=10kΩ	-	0.3	-	dB

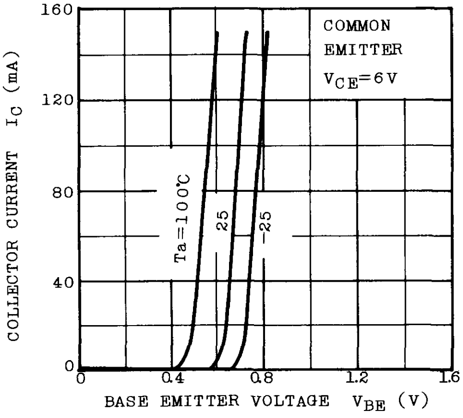
Note : h_{FE} Classification A : 600～1800, B : 1200～3600

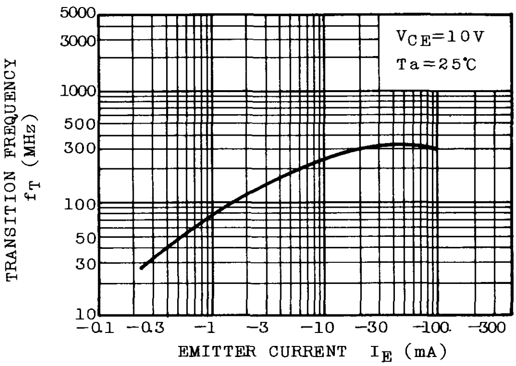

$I_C - V_{CE}$

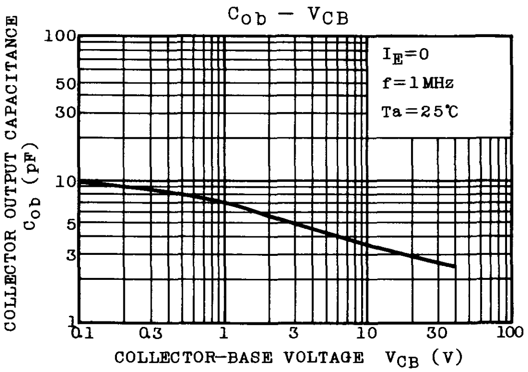

$h_{FE} - I_C$

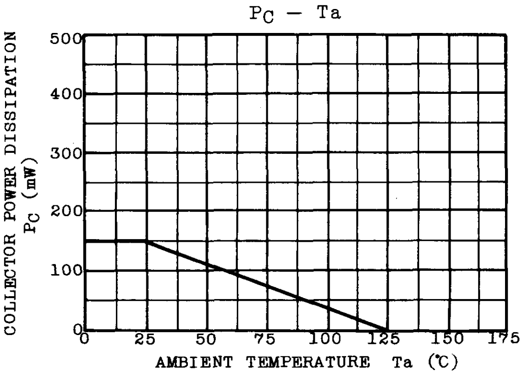

$V_{CE(sat)} - I_C$


$V_{BE(sat)} - I_C$


$I_C - V_{BE}$


$f_T - I_E$


C_{ob} — V_{CB}
I_E=0
f=1 MHz
Ta=25℃
COLLECTOR OUTPUT CAPACITANCE C_{ob} (pF)
100
50
30
10
5
3
1
0.1
0.3
1
3
10
30
100
COLLECTOR-BASE VOLTAGE V_{CB} (V)


P_C — Ta
COLLECTOR POWER DISSIPATION P_C (mW)
500
400
300
200
100
0
0
25
50
75
100
125
150
175
AMBIENT TEMPERATURE Ta (℃)

SILICON NPN EPITAXIAL PLANAR TYPE

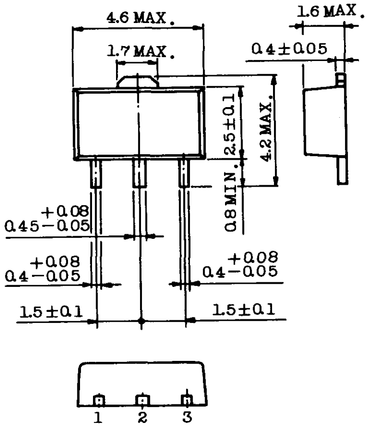
2SC3301

VHF ~ UHF BAND LOW NOISE AMPLIFIER APPLICATIONS.

FEATURES:

- NF=1.7dB, $|S_{21e}|^2$=14.5dB (f=500MHz)
- NF=2.3dB, $|S_{21e}|^2$=9dB (f=1000MHz)

Unit in mm



1. BASE
2. COLLECTOR (HEAT SINK)
3. EMITTER

JEDEC	—
EIAJ	—
TOSHIBA	2-5K1A

Marking : MA
Weight : 0.052g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	15	V
Collector-Emitter Voltage	V_{CEO}	7.5	V
Emitter-Base Voltage	V_{EBO}	3	V
Base Current	I_B	40	mA
Collector Current	I_C	80	mA
Collector Power Dissipation	P_C	300	mW
Collector Power Dissipation	P_C ※	800	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~ 125	°C

P_C ※: When mounted cermic substrate of 250mm² × 0.8t

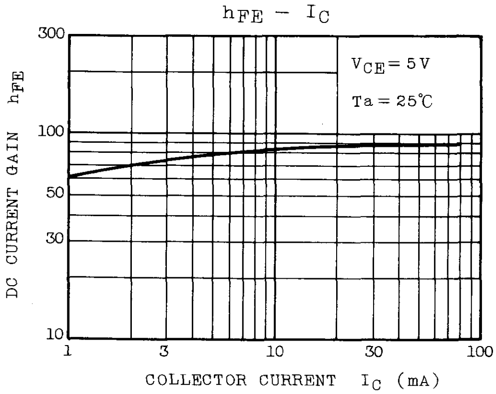
MICROWAVE CHARACTERISTICS (Ta=25°C)

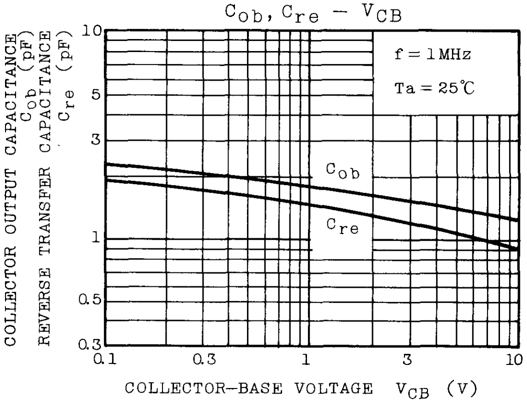
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Transition Frequency	f_T	V_{CE}=5V, I_C=30mA	-	7	-	GHz
Insertion Gain	$|S_{21e}|^2$(1)	V_{CE}=5V, I_C=30mA, f=500MHz	-	14.5	-	dB
	$|S_{21e}|^2$(2)	V_{CE}=5V, I_C=30mA, f=1GHz	-	9	-	dB
Noise Figure	NF(1)	V_{CE}=5V, I_C=10mA, f=500MHz	-	1.7	-	dB
	NF(2)	V_{CE}=5V, I_C=10mA, f=1GHz	-	2.3	-	dB

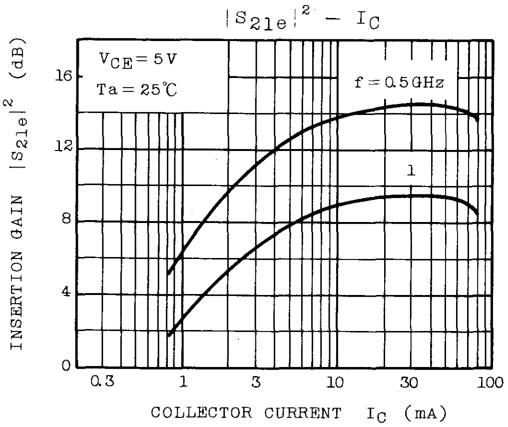
ELECTRICAL CHARACTERISTICS (Ta=25°C)

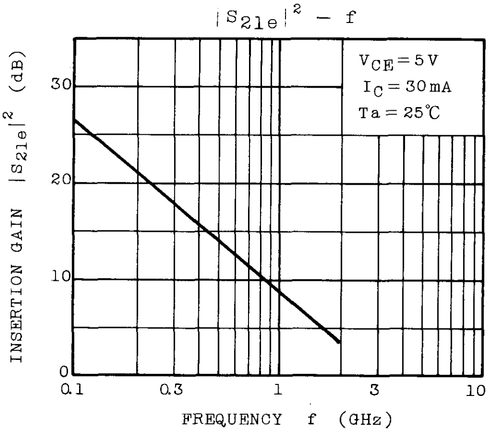
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=10V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=1V, I_C=0	-	-	1	μA
DC Current Gain	h_{FE}	V_{CE}=3V, I_C=50mA	30	-	200	
Collector Output Capacitance	C_{ob}	V_{CB}=5V, I_E=0, f=1MHz	-	1.45	-	pF
Reverse Transfer Capacitance	C_{re}	(Note)	-	1.1	-	pF

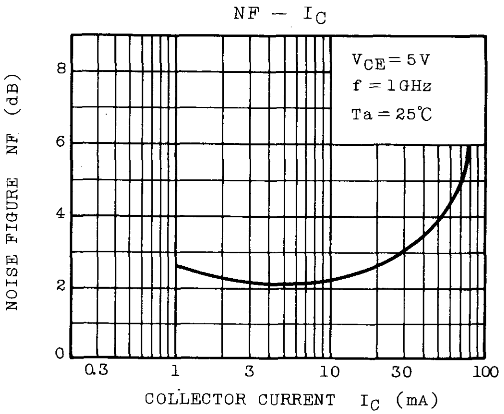
Note : Cre is measured by 3 terminal method with Capacitance Bridge.

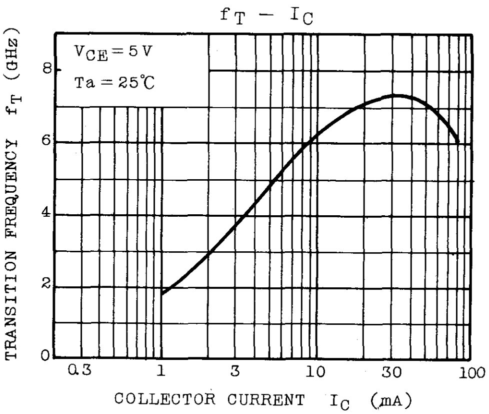

hFE — IC
VCE = 5 V
Ta = 25℃
DC CURRENT GAIN hFE
300
100
50
30
10
1
3
10
30
100
COLLECTOR CURRENT IC (mA)

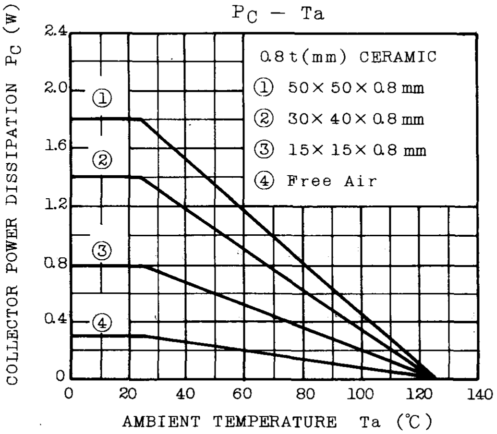

Cob, Cre — VCB
f = 1 MHz
Ta = 25℃
Cob
Cre
COLLECTOR OUTPUT CAPACITANCE Cob (pF)
REVERSE TRANSFER CAPACITANCE Cre (pF)
10
5
3
1
0.5
0.3
0.1
0.3
1
3
10
COLLECTOR–BASE VOLTAGE VCB (V)

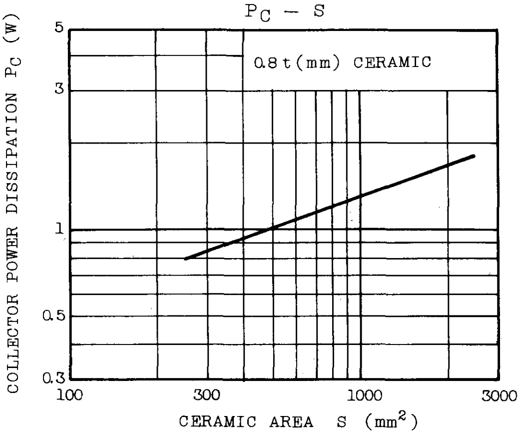

|S21e|² — IC
VCE = 5 V
Ta = 25℃
f = 0.5 GHz
1
INSERTION GAIN |S21e|² (dB)
16
12
8
4
0
0.3
1
3
10
30
100
COLLECTOR CURRENT IC (mA)

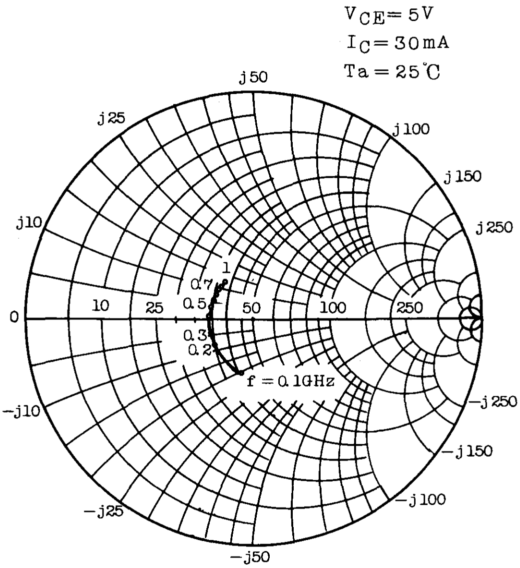

|S21e|² — f
VCE = 5 V
IC = 30 mA
Ta = 25℃
INSERTION GAIN |S21e|² (dB)
30
20
10
0
0.1
0.3
1
3
10
FREQUENCY f (GHz)


NF — IC
VCE = 5 V
f = 1 GHz
Ta = 25℃
NOISE FIGURE NF (dB)
8
6
4
2
0
0.3
1
3
10
30
100
COLLECTOR CURRENT IC (mA)

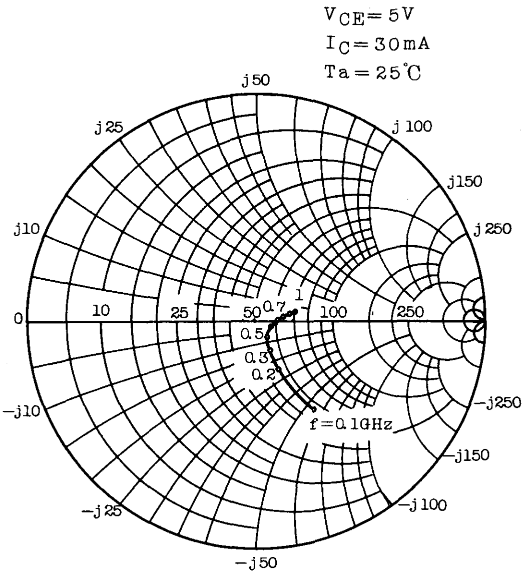

fT — IC
VCE = 5 V
Ta = 25℃
TRANSITION FREQUENCY fT (GHz)
8
6
4
2
0
0.3
1
3
10
30
100
COLLECTOR CURRENT IC (mA)


P_C — Ta
COLLECTOR POWER DISSIPATION P_C (W)
AMBIENT TEMPERATURE Ta (℃)
0.8t(mm) CERAMIC
① 50×50×0.8 mm
② 30×40×0.8 mm
③ 15×15×0.8 mm
④ Free Air
2.4
2.0
1.6
1.2
0.8
0.4
0
0
20
40
60
80
100
120
140

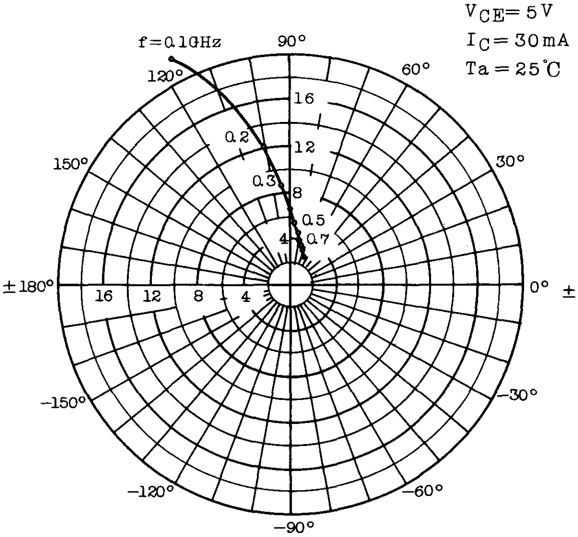

P_C — S
COLLECTOR POWER DISSIPATION P_C (W)
CERAMIC AREA S (mm^2)
0.8t(mm) CERAMIC
5
3
1
0.5
0.3
100
300
1000
3000


$V_{CE}=5V$
$I_C=30mA$
$Ta=25^\circ C$

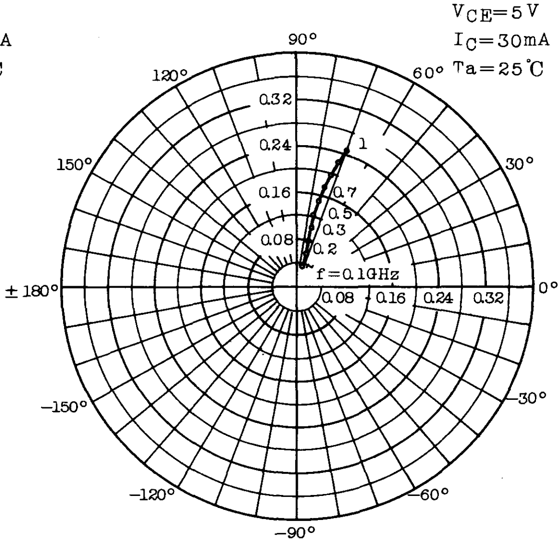
S_{11e}
(UNIT : Ω)


$V_{CE}=5V$
$I_C=30mA$
$Ta=25^\circ C$

S_{22e}
(UNIT : Ω)


$V_{CE}=5V$
$I_C=30mA$
$Ta=25^\circ C$

S_{21e}


$V_{CE}=5V$
$I_C=30mA$
$Ta=25^\circ C$

S_{12e}

SILICON NPN EPITAXIAL PLANAR TYPE

2SC3302

VHF ~ UHF BAND LOW NOISE AMPLIFIER APPLICATIONS.

FEATURES:

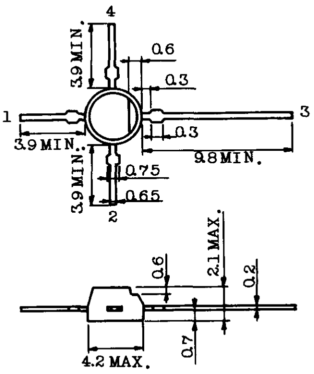
. NF=1.5dB, $|S_{21e}|^2$=16.5dB (f=500MHz)

. NF=1.7dB, $|S_{21e}|^2$=11dB (f=1000MHz)

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	17	V
Collector-Emitter Voltage	V_{CEO}	12	V
Emitter-Base Voltage	V_{EBO}	3	V
Base Current	I_B	30	mA
Collector Current	I_C	70	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~ 125	°C

Unit in mm



1. BASE
2. EMITTER
3. COLLECTOR
4. EMITTER

JEDEC	—
EIAJ	—
TOSHIBA	2-4F1C

Marking : ME
Weight : 0.08g

MICROWAVE CHARACTERISTICS (Ta=25°C)

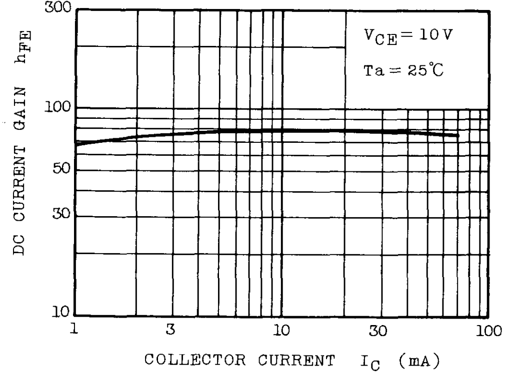
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Transition Frequency	f_T	V_{CE}=10V, I_C=20mA	-	5	-	GHz
Insertion Gain	$|S_{21e}|^2(1)$	V_{CE}=10V, I_C=20mA, f=500MHz	-	16.5	-	dB
	$|S_{21e}|^2(2)$	V_{CE}=10V, I_C=20mA, f=1GHz	-	11	-	dB
Noise Figure	NF(1)	V_{CE}=10V, I_C=5mA, f=500MHz	-	1.5	-	dB
	NF(2)	V_{CE}=10V, I_C=5mA, f=1GHz	-	1.7	-	dB

ELECTRICAL CHARACTERISTICS (Ta=25°C)

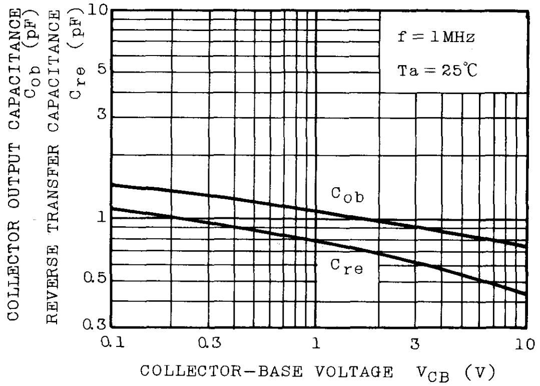
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=10V, I_E=0	-	-	1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=1V, I_C=0	-	-	1	μA
DC Current Gain	h_{FE}	V_{CE}=10V, I_C=20mA	25	-	-	
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	0.8	-	pF
Reverse Transfer Capacitance	C_{re}	(Note)	-	0.45	-	pF

Note : Cre is measured by 3 terminal method with Capacitance Bridge.

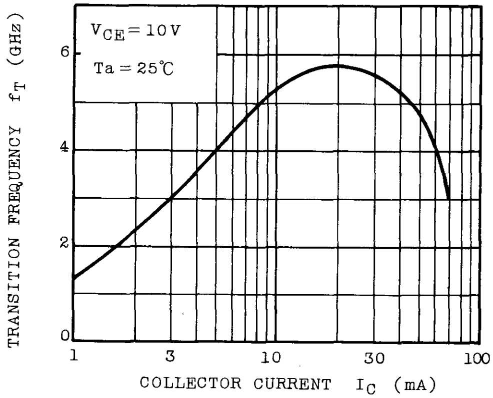
h_{FE} − I_C



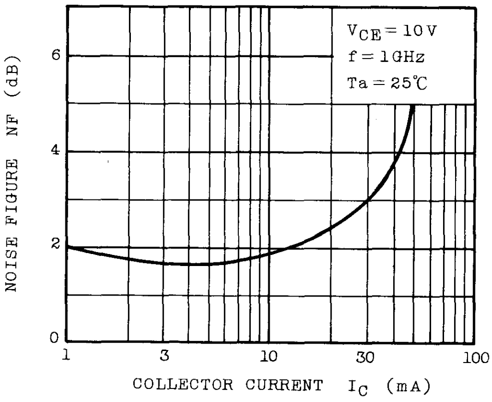
C_{ob}, C_{re} − V_{CB}



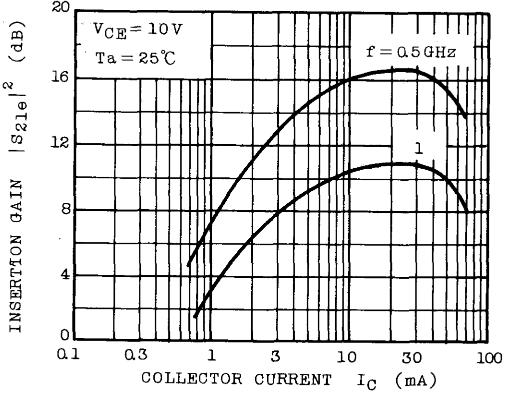
f_T − I_C



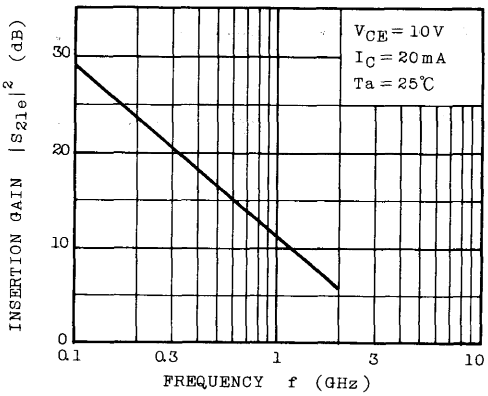
NF − I_C

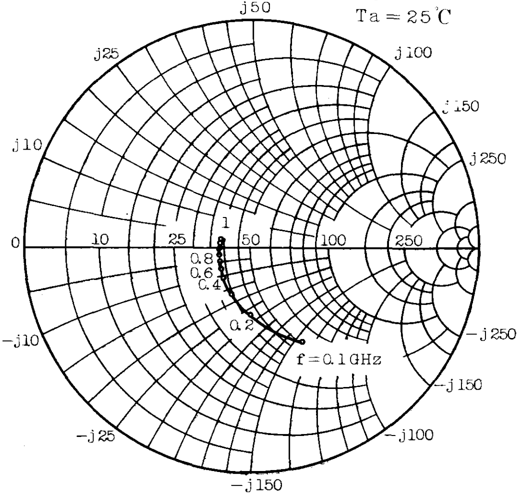


$|S_{21e}|^2$ − I_C



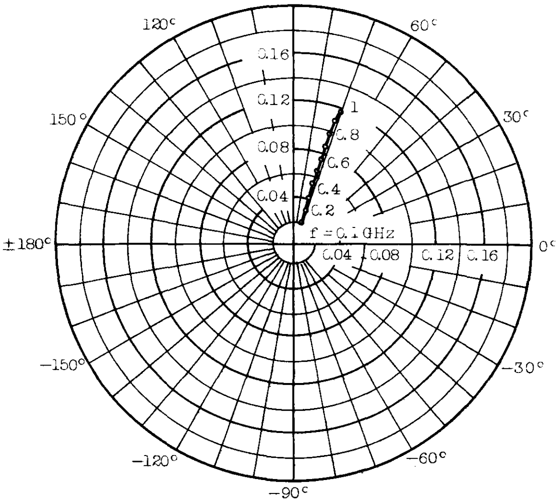
$|S_{21e}|^2$ − f





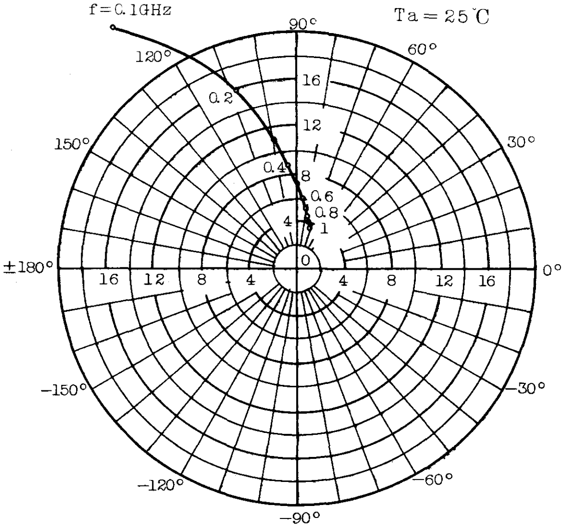
V_{CE}= 10 V
I_C= 20 mA
Ta = 25 ℃

S_{11e}
(UNIT : Ω)



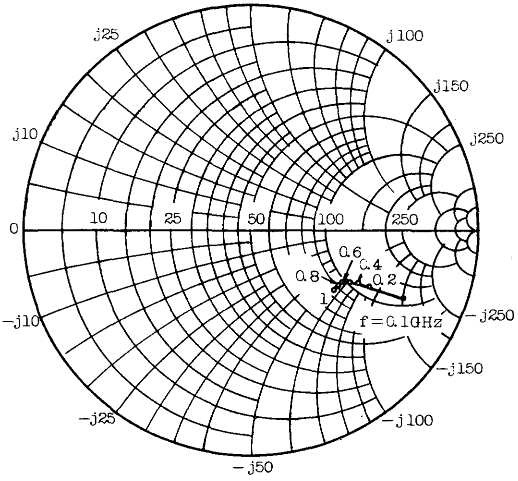
V_{CE}= 10 V
I_C= 20 mA
Ta = 25 ℃

S_{12e}



V_{CE}= 10 V
I_C= 20 mA
Ta = 25 ℃

S_{21e}



V_{CE}= 10 V
I_C= 20 mA
Ta = 25 ℃

S_{22e}
(UNIT : Ω)

2SC3324

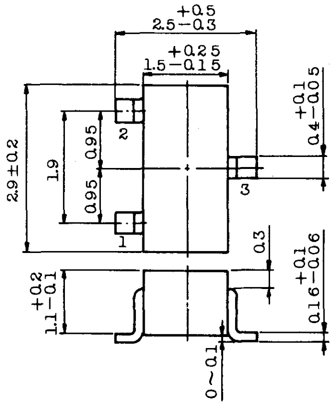
SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

AUDIO FREQUENCY LOW NOISE AMPLIFIER APPLICATIONS.

FEATURES:

- High Voltage : V_{CEO}=120V
- Excellent h_{FE} Linearity
  : h_{FE}(0.1mA)/h_{FE}(2mA)=0.95(Typ.)
- High h_{FE} : h_{FE}=200～700
- Low Noise : NF=0.2dB(Typ.), 3dB(Max.) at f=1kHz
- Complementary to 2SA1312
- Small Package

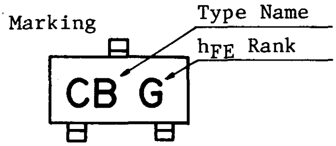
Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	−
EIAJ	SC−59
TOSHIBA	2−3F1A

Weight : 0.012g



MAXIMUM RATINGS (Ta=25°C)

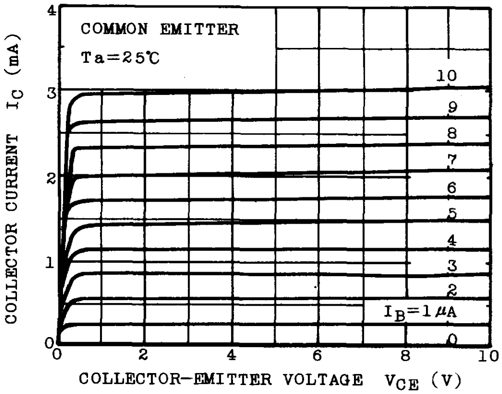
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	120	V
Collector-Emitter Voltage	V_{CEO}	120	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	100	mA
Base Current	I_B	20	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55～125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

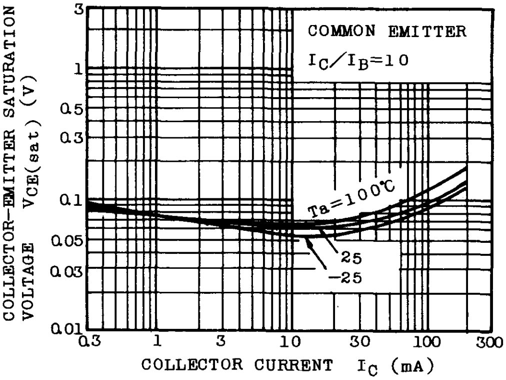
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=120V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=6V, I_C=2mA	200	-	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	0.3	V
Transition Frequency	f_T	V_{CE}=6V, I_C=1mA	-	100	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	4	-	pF
Noise Figure	NF(1)	V_{CE}=6V, I_C=0.1mA f=100Hz, R_g=10kΩ	-	0.5	6	dB
	NF(2)	V_{CE}=6V, I_C=0.1mA f=1kHz, R_g=10kΩ	-	0.2	3	dB

Note : h_{FE} Classification GR(G) : 200～400, BL(L) : 350～700

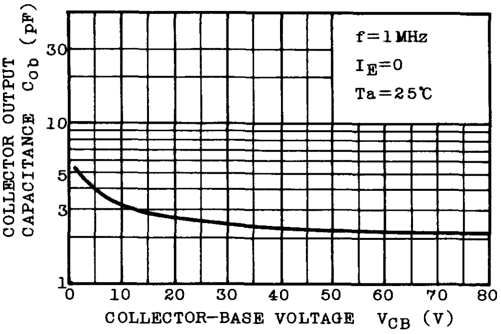
I_C — V_{CE}



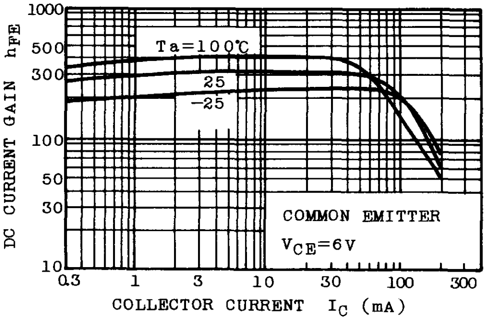
$V_{CE(sat)}$ — I_C



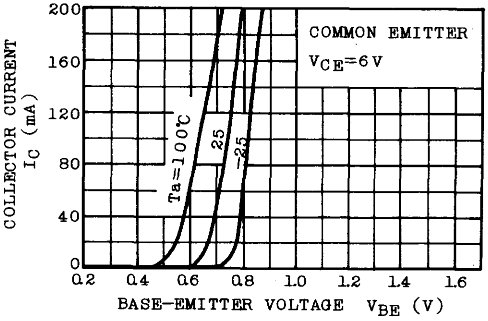
C_{ob} — V_{CB}



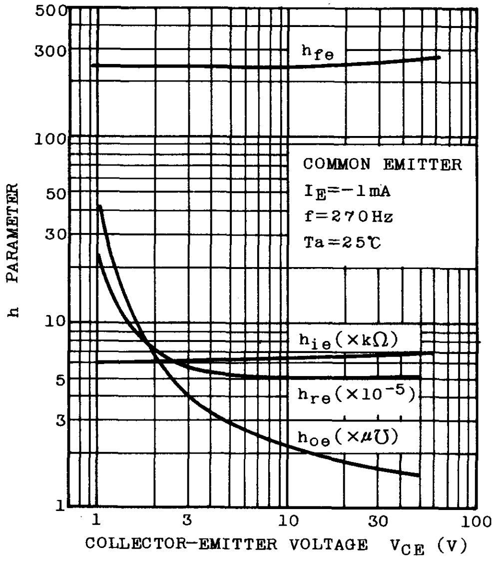
h_{FE} — I_C

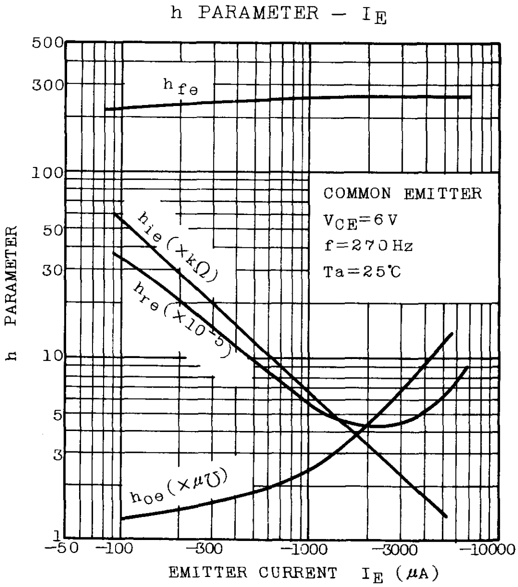


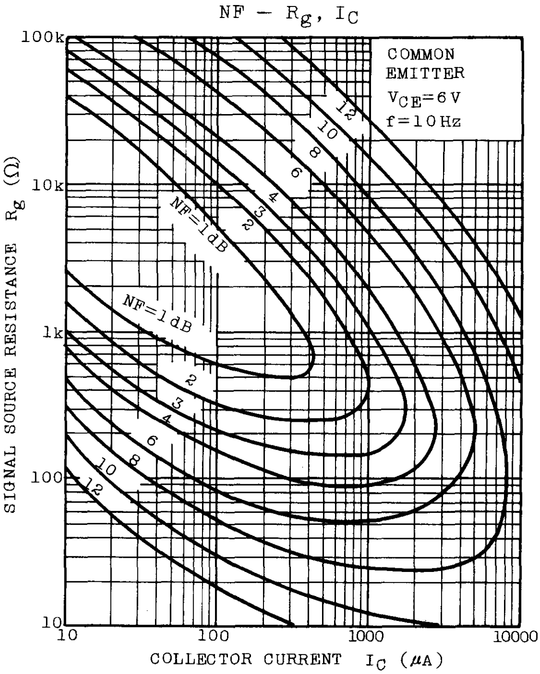
I_C — V_{BE}

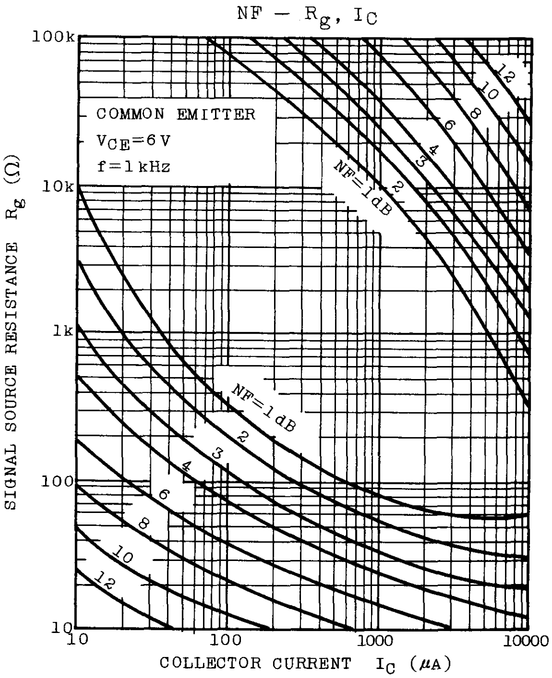


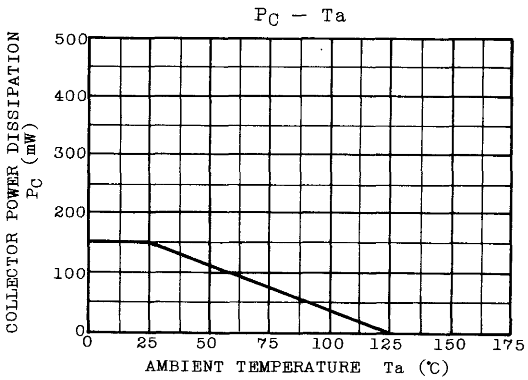
h PARAMETER — V_{CE}




h PARAMETER — I_E


NF — R_g, I_C


NF — R_g, I_C


P_C — Ta

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

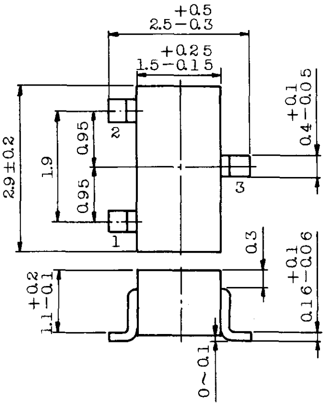
2SC3325

AUDIO FREQUENCY LOW POWER AMPLIFIER APPLICATIONS.
DRIVER STAGE AMPLIFIER APPLICATIONS.
SWITCHING APPLICATIONS.

FEATURES:

- Excellent h_{FE} Linearity : $h_{FE(2)}=25$(Min.) at $V_{CE}=6V$, $I_C=400mA$
- High Voltage : $V_{CEO}=50V$ (Min.)
- Complementary to 2SA1313
- Small Package

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

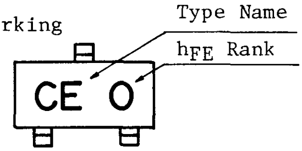
JEDEC	
EIAJ	SC−59
TOSHIBA	2−3F1A

Weight : 0.012g

MAXIMUM RATINGS ($T_a=25^\circ C$)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	50	V
Collector-Emitter Voltage	V_{CEO}	50	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	500	mA
Base Current	I_B	50	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

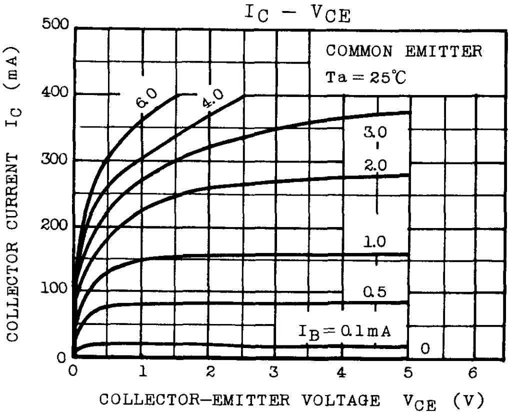
Marking

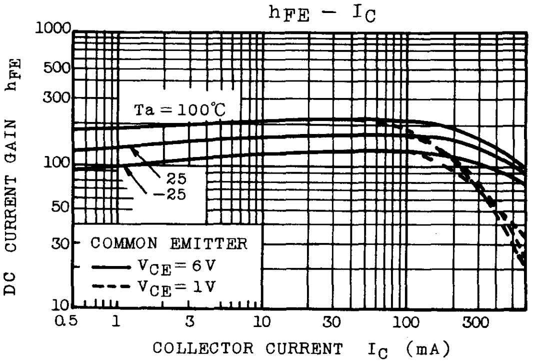


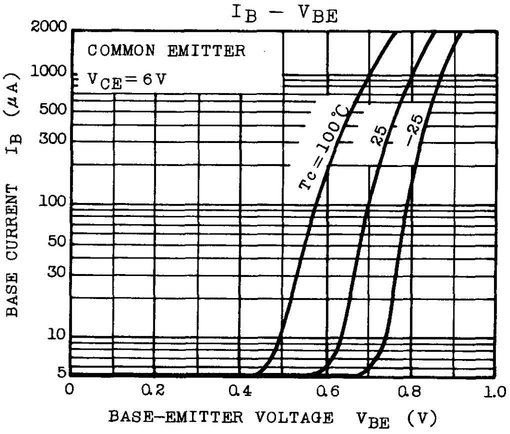
ELECTRICAL CHARACTERISTICS ($T_a=25^\circ C$)

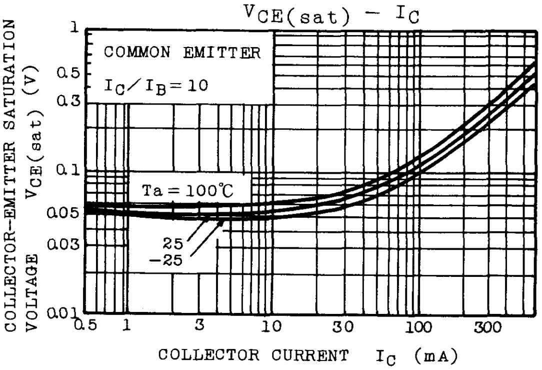
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	$V_{CB}=50V$, $I_E=0$	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	$V_{EB}=5V$, $I_C=0$	-	-	0.1	μA
DC Current Gain	$h_{FE(1)}$ (Note)	$V_{CE}=1V$, $I_C=100mA$	70	-	240	
	$h_{FE(2)}$ (Note)	$V_{CE}=6V$, $I_C=400mA$	25	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C=100mA$, $I_B=10mA$	-	0.1	0.25	V
Base-Emitter Voltage	V_{BE}	$V_{CE}=1V$, $I_C=100mA$	-	0.8	1.0	V
Transition Frequency	f_T	$V_{CE}=6V$, $I_C=20mA$	-	300	-	MHz
Collector Output Capacitance	C_{ob}	$V_{CB}=6V$, $I_E=0$, f=1MHz	-	7	-	pF

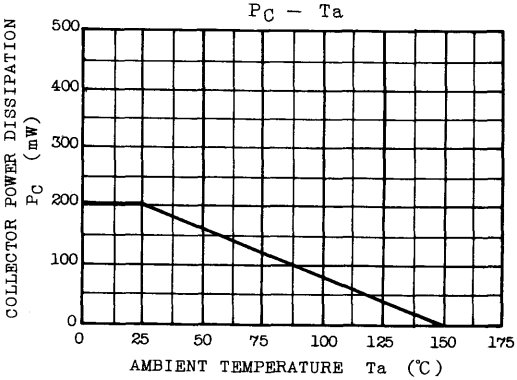
Note : $h_{FE(1)}$ Classification O : 70~140, Y : 120~240
$h_{FE(2)}$ Classification O : 25Min. Y : 40Min.


I_C − V_{CE}
COMMON EMITTER
Ta = 25℃
6.0
4.0
3.0
2.0
1.0
0.5
I_B = 0.1 mA
0
COLLECTOR CURRENT I_C (mA)
500
400
300
200
100
0
1
2
3
4
5
6
COLLECTOR−EMITTER VOLTAGE V_{CE} (V)


h_{FE} − I_C
DC CURRENT GAIN h_{FE}
1000
500
300
100
50
30
10
Ta = 100℃
25
−25
COMMON EMITTER
V_{CE} = 6 V
V_{CE} = 1 V
0.5
1
3
10
30
100
300
COLLECTOR CURRENT I_C (mA)


I_B − V_{BE}
COMMON EMITTER
V_{CE} = 6 V
BASE CURRENT I_B (μA)
2000
1000
500
300
100
50
30
10
5
Tc = 100℃
25
−25
0
0.2
0.4
0.6
0.8
1.0
BASE−EMITTER VOLTAGE V_{BE} (V)


$V_{CE(sat)}$ − I_C
COLLECTOR−EMITTER SATURATION VOLTAGE $V_{CE(sat)}$ (V)
COMMON EMITTER
I_C/I_B = 10
Ta = 100℃
25
−25
1
0.5
0.3
0.1
0.05
0.03
0.01
0.5
1
3
10
30
100
300
COLLECTOR CURRENT I_C (mA)

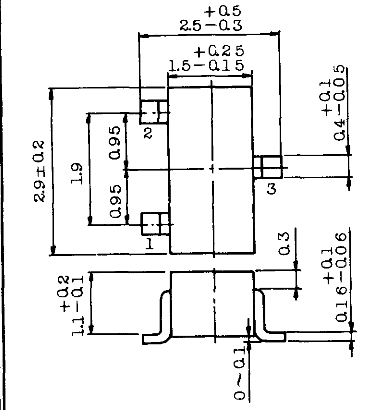

P_C − Ta
COLLECTOR POWER DISSIPATION P_C (mW)
500
400
300
200
100
0
0
25
50
75
100
125
150
175
AMBIENT TEMPERATURE Ta (℃)

SILICON NPN EPITAXIAL TYPE

2SC3326

FOR MUTING AND SWITCHING APPLICATIONS.

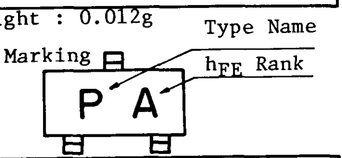
Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	–
EIAJ	SC-59
TOSHIBA	2-3F1A

Weight : 0.012g



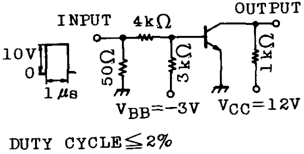
FEATURES:

- High Emitter-Base Voltage : V_{EBO}=25V(Min.)
- High Reverse h_{FE}
  : Reverse h_{FE}=150(Typ.) (V_{CE}=-2V, I_C=-2mA)
- Low on Resistance : R_{ON}=1Ω (Typ.) (I_B=5mA)
- High DC Current Gain : h_{FE}=200 ~ 1200
- Small Package

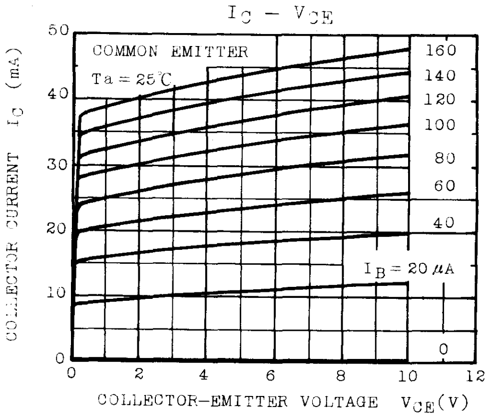
MAXIMUM RATINGS (Ta=25°C)

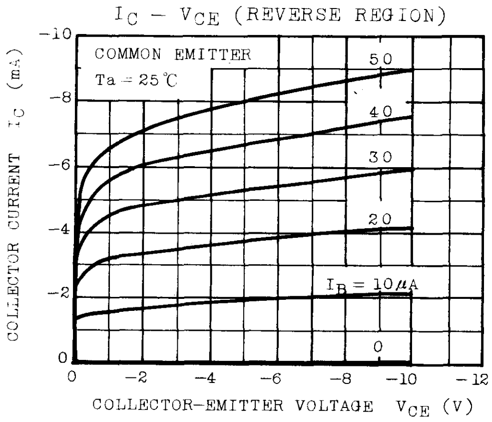
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	50	V
Collector-Emitter Voltage	V_{CEO}	20	V
Emitter-Base Voltage	V_{EBO}	25	V
Collector Current	I_C	300	mA
Base Current	I_B	60	mA
Collector Power Dissipation	P_C	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~ 125	°C

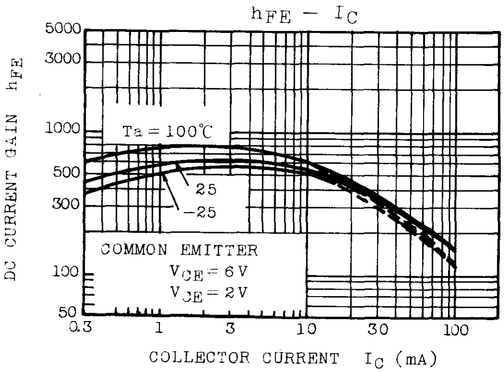
ELECTRICAL CHARACTERISTICS (Ta=25°C)

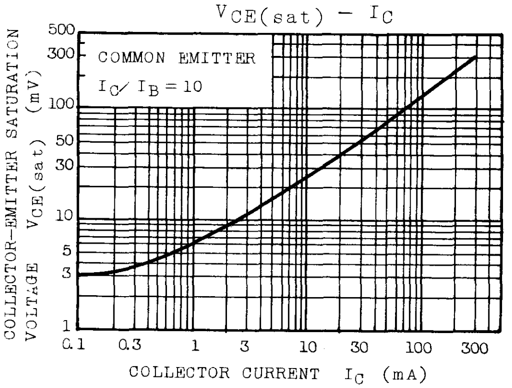
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=50V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=25V, I_C=0	-	-	0.1	μA
DC Current Gain		h_{FE} (Note)	V_{CE}=2V, I_C=4mA	200	-	1200	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=30mA, I_B=3mA	-	0.042	0.3	V
Base-Emitter Voltage		V_{BE}	V_{CE}=2V, I_C=4mA	-	0.61	-	V
Transition Frequency		f_T	V_{CE}=6V, I_C=4mA	-	30	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	4.8	7	pF
Switching Time	Turn-on Time	t_{on}	 DUTY CYCLE≦2%	-	160	-	ns
	Storage Time	t_{stg}		-	500	-	
	Fall Time	t_f		-	130	-	

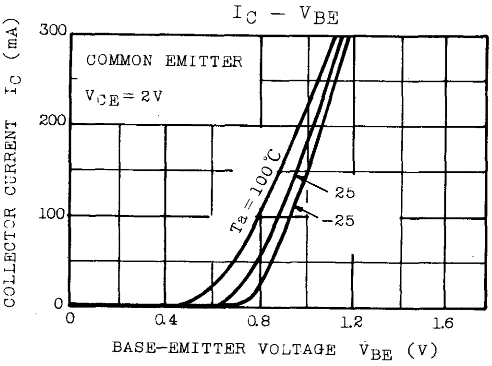
Note : h_{FE} Classification A : 200 ~ 700, B : 350 ~ 1200

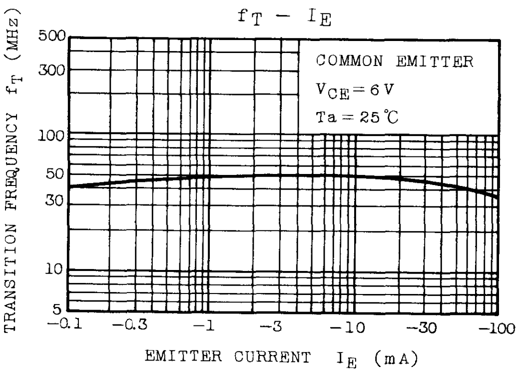

IC − VCE

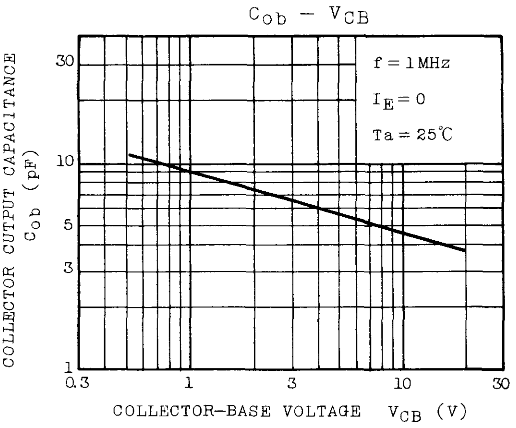

IC − VCE (REVERSE REGION)

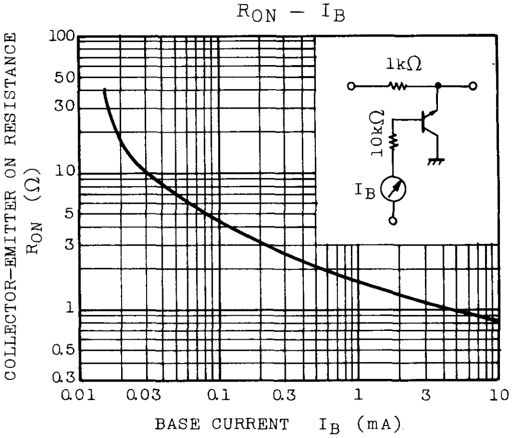

hFE − IC

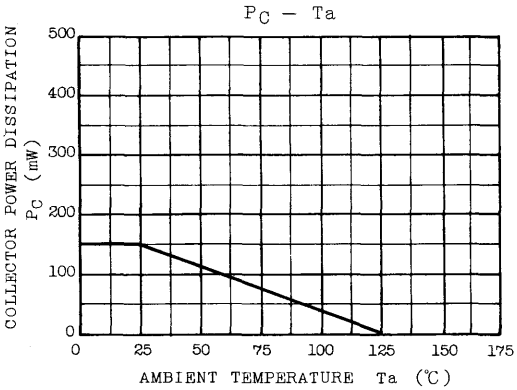

VCE(sat) − IC


IC − VBE


fT − IE


C_{ob} – V_{CB}
f = 1 MHz
I_E = 0
Ta = 25℃
COLLECTOR OUTPUT CAPACITANCE C_{ob} (pF)
30
10
5
3
1
0.3
1
3
10
30
COLLECTOR–BASE VOLTAGE V_{CB} (V)


R_{ON} – I_B
1kΩ
10kΩ
I_B
COLLECTOR–EMITTER ON RESISTANCE R_{ON} (Ω)
100
50
30
10
5
3
1
0.5
0.3
0.01
0.03
0.1
0.3
1
3
10
BASE CURRENT I_B (mA)

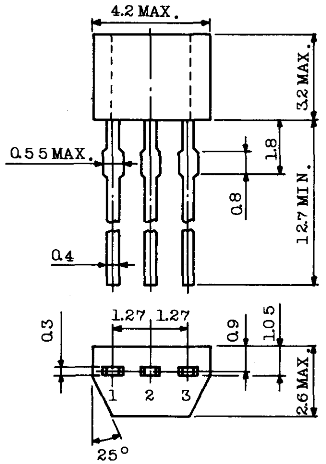

P_C – Ta
COLLECTOR POWER DISSIPATION P_C (mW)
500
400
300
200
100
0
0
25
50
75
100
125
150
175
AMBIENT TEMPERATURE Ta (℃)

2SC3327

SILICON NPN EPITAXIAL TYPE

FOR MUTING AND SWITCHING APPLICATIONS.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	–
EIAJ	–
TOSHIBA	2–4E1A

Weight : 0.13g

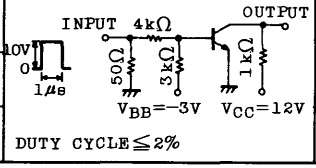
FEATURES:

- High Emitter-Base Voltage : V_{EBO}=25V (Min.)
- High Reverse h_{FE}
  - : Reverse h_{FE}=150(Typ.) (V_{CE}=-2V, I_C=-4mA)
- Low On Resistance : R_{ON}=1Ω (Typ.) (I_B=5mA)
- Small Package

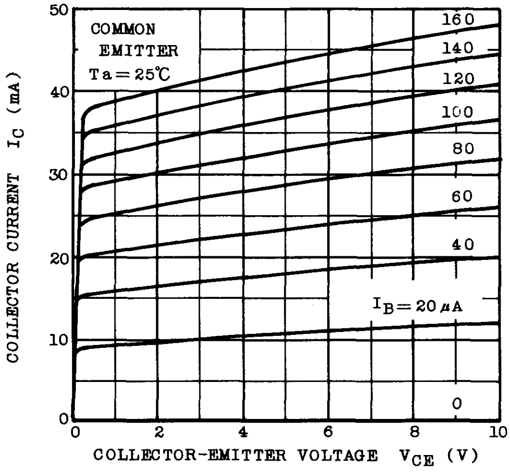
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	50	V
Collector-Emitter Voltage	V_{CEO}	20	V
Emitter-Base Voltage	V_{EBO}	25	V
Collector Current	I_C	300	mA
Base Current	I_B	60	mA
Collector Power Dissipation	P_C	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

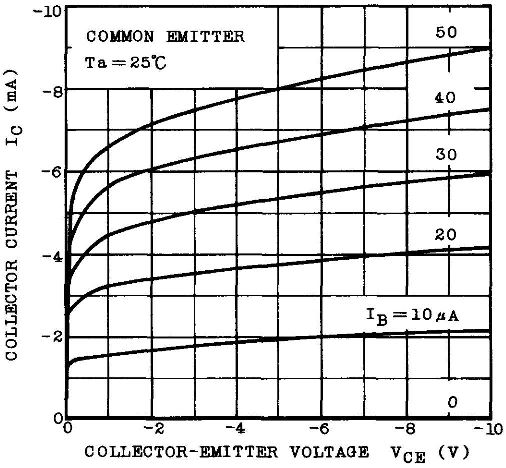
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=50V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=25V, I_C=0	-	-	0.1	μA
DC Current Gain		h_{FE} (Note)	V_{CE}=2V, I_C=4mA	200	-	1200	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=30mA, I_B=3mA	-	0.042	0.1	V
Base-Emitter Voltage		V_{BE}	V_{CE}=2V, I_C=4mA	-	0.61	-	V
Transition Frequency		f_T	V_{CE}=6V, I_C=4mA	-	30	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	4.8	7	pF
Switching Time	Turn-on Time	t_{on}		-	160	-	ns
	Storage Time	t_{stg}		-	500	-	
	Fall Time	t_f		-	130	-	

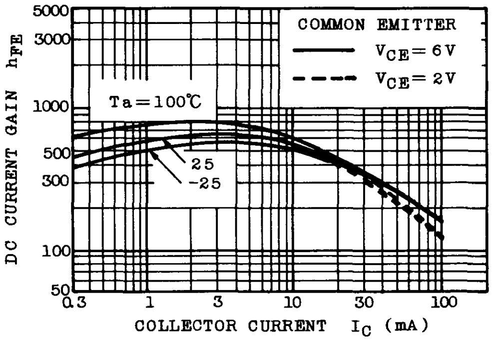
Note : h_{FE} Classification A : 200~700, B : 350~1200



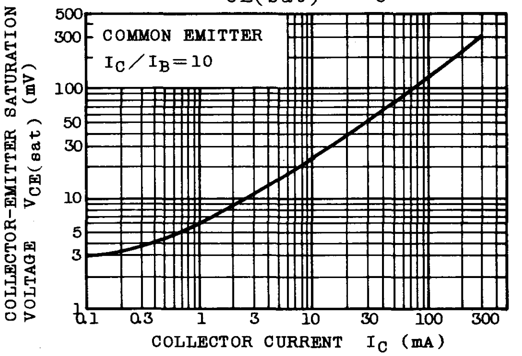
$I_C - V_{CE}$



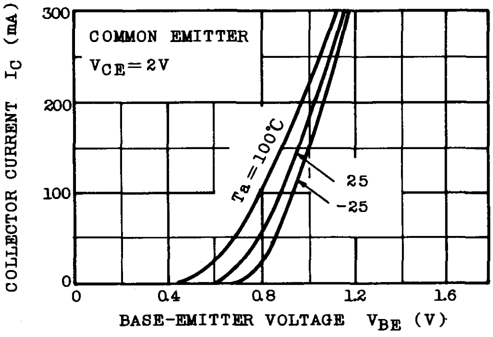
$I_C - V_{CE}$ (REVERSE REGION)



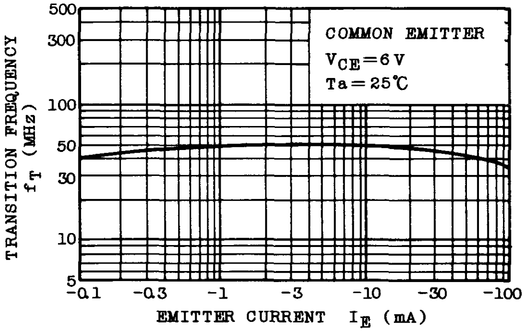
$h_{FE} - I_C$



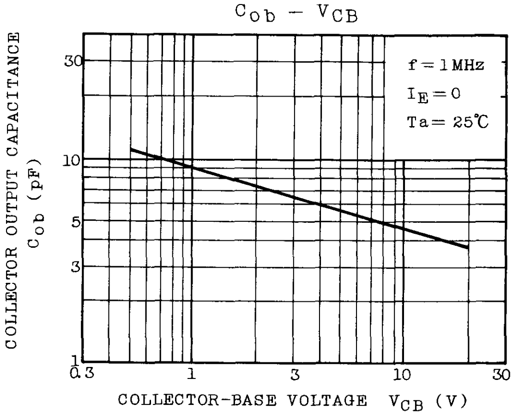
$V_{CE(sat)} - I_C$

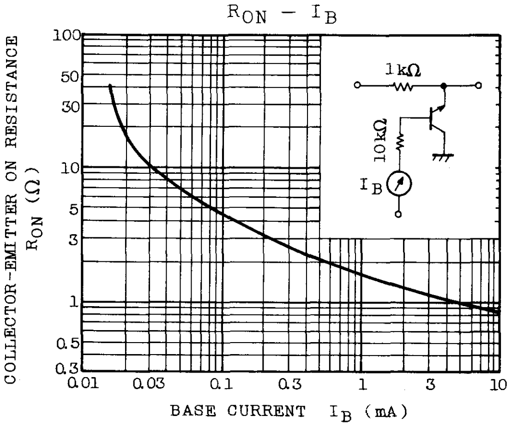


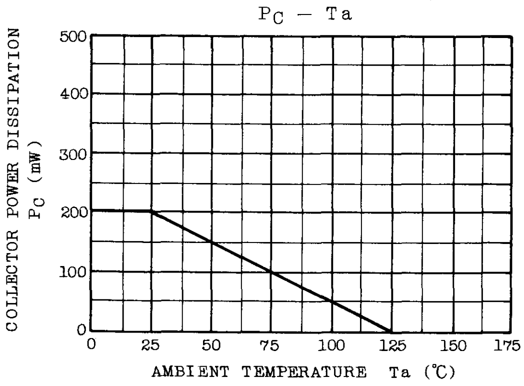
$I_C - V_{BE}$



$f_T - I_E$


Cob — VCB
COLLECTOR OUTPUT CAPACITANCE Cob (pF)
30
10
5
3
1
f = 1MHz
IE = 0
Ta = 25℃
0.3
1
3
10
30
COLLECTOR-BASE VOLTAGE VCB (V)


RON — IB
COLLECTOR-EMITTER ON RESISTANCE RON (Ω)
100
50
30
10
5
3
1
0.5
0.3
1kΩ
10kΩ
IB
0.01
0.03
0.1
0.3
1
3
10
BASE CURRENT IB (mA)


PC — Ta
COLLECTOR POWER DISSIPATION PC (mW)
500
400
300
200
100
0
0
25
50
75
100
125
150
175
AMBIENT TEMPERATURE Ta (℃)

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)
(INDUSTRIAL APPLICATIONS)

2SC3328

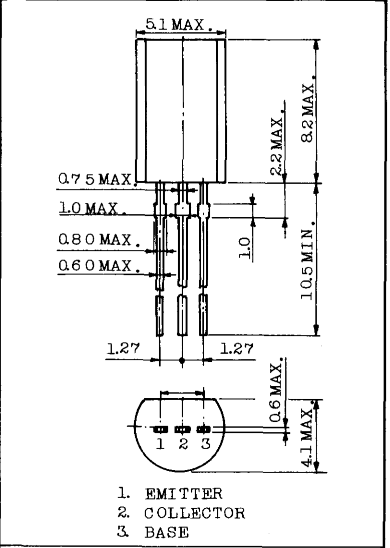
POWER AMPLIFIER APPLICATIONS.

POWER SWITCHING APPLICATIONS.

FEATURES:

- Low Saturation Voltage
  : $V_{CE(sat)}$=0.5V(Max.) (I_C=1A)
- High Speed Switching Time : t_{stg}=1.0μs(Typ.)
- Complementary to 2SA1315

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

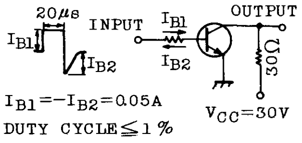
JEDEC	TO−92MOD
EIAJ	−
TOSHIBA	2−5J1A

Weight : 0.36g

MAXIMUM RATINGS (T_a=25°C)

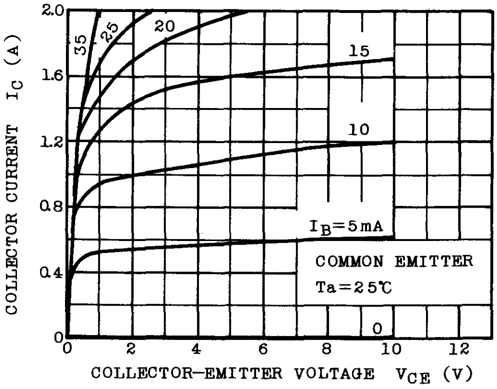
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	80	V
Collector-Emitter Voltage	V_{CEO}	80	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	2	A
Base Current	I_B	1	A
Collector Power Dissipation	P_C	900	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

ELECTRICAL CHARACTERISTICS (T_a=25°C)

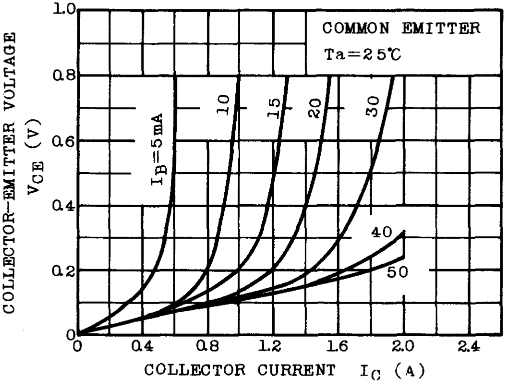
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=80V, I_E=0	-	-	1.0	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=5V, I_C=0	-	-	1.0	μA
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	I_C=10mA, I_B=0	80	-	-	V
DC Current Gain		$h_{FE(1)}$ (Note)	V_{CE}=2V, I_C=0.5A	70	-	240	
		$h_{FE(2)}$	V_{CE}=2V, I_C=1.5A	40	-	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=1A, I_B=0.05A	-	0.15	0.5	V
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=1A, I_B=0.05A	-	0.9	1.2	V
Transition Frequency		f_T	V_{CE}=2V, I_C=0.5A	-	100	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	30	-	pF
Switching Time	Turn-on Time	t_{on}		-	0.2	-	μs
	Storage Time	t_{stg}		-	1.0	-	
	Fall Time	t_f		-	0.2	-	

Note : $h_{FE(1)}$ Classification O : 70~140, Y : 120~240

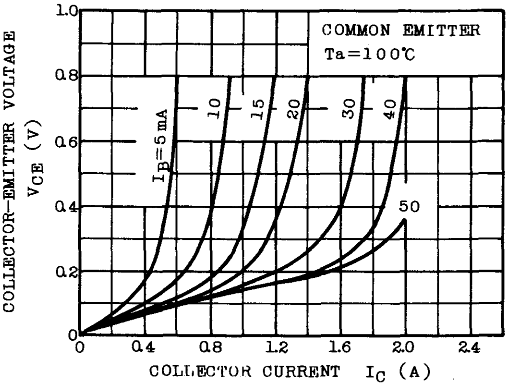
I_C — V_{CE}



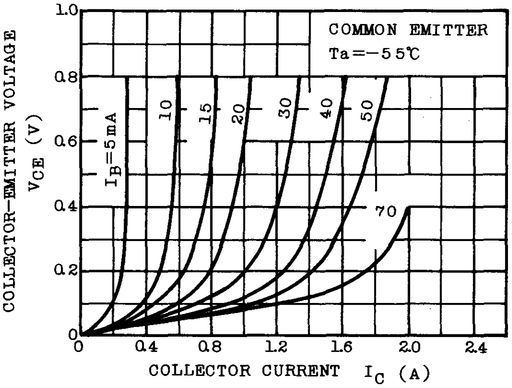
V_{CE} — I_C



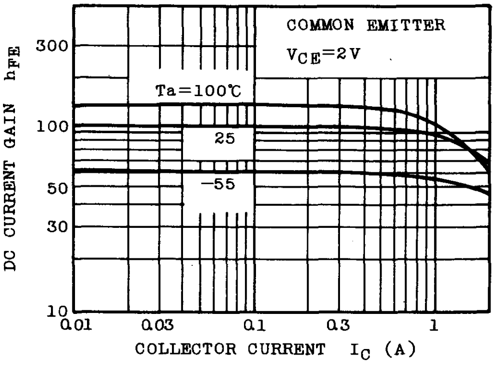
V_{CE} — I_C



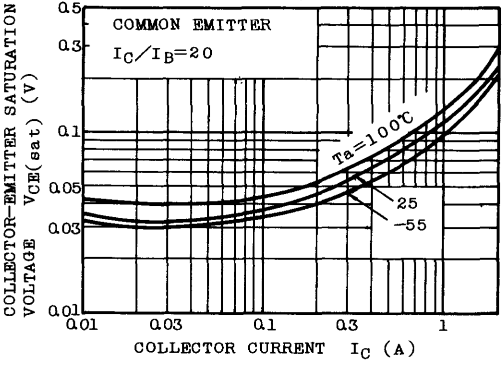
V_{CE} — I_C



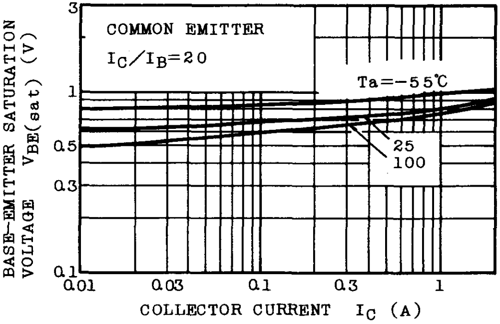
h_{FE} — I_C



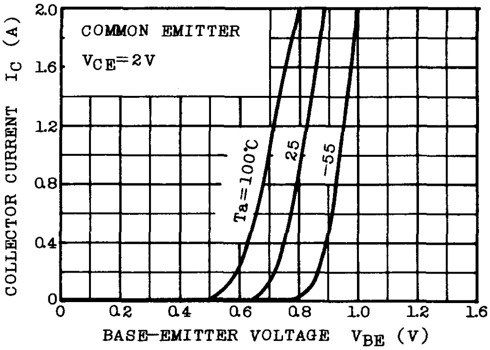
$V_{CE(sat)}$ — I_C



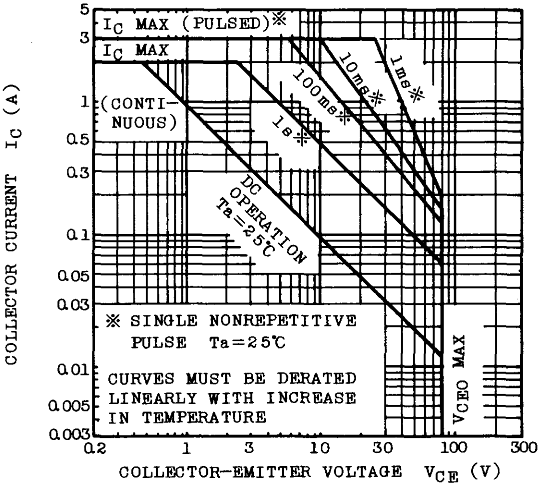
$V_{BE(sat)}$ — I_C



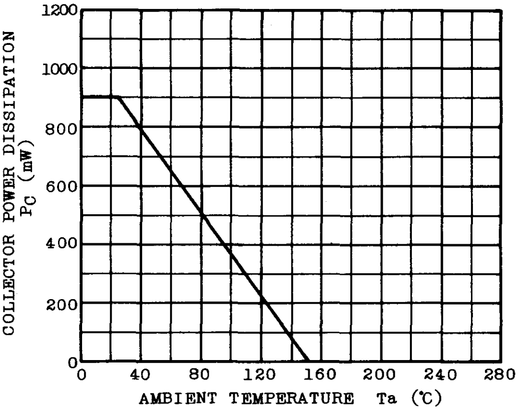
I_C — V_{BE}



SAFE OPERATING AREA



P_C — Ta

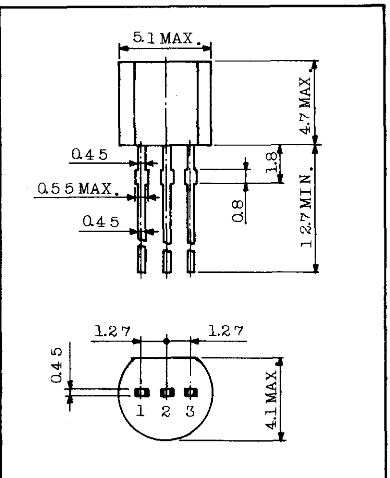


2SC3329

SILICON NPN EPITAXIAL TYPE

FOR LOW NOISE AUDIO AMPLIFIER APPLICATIONS AND RECOMMENDED FOR THE FIRST STAGES OF MC HEAD AMPLIFIERS.

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

Weight : 0.21g

FEATURES:

- Very Low Noise in the Region of Low Signal Source Impedance
  Equivalent Input Noise Voltage : $E_n=0.6nV/\sqrt{Hz}$ (Typ.)
- Low Pulse Noise. Low 1/f Noise
- Low Base Spreading Resistance : $r_{bb'}=2.0\Omega$ (Typ.)
- Complementary to 2SA1316

MAXIMUM RATINGS ($Ta=25^{\circ}C$)

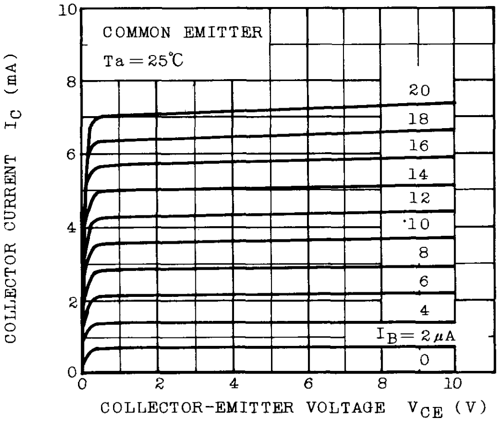
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	80	V
Collector-Emitter Voltage	V_{CEO}	80	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	100	mA
Base Current	I_B	20	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	Tstg	-55~125	°C

ELECTRICAL CHARACTERISTICS ($Ta=25^{\circ}C$)

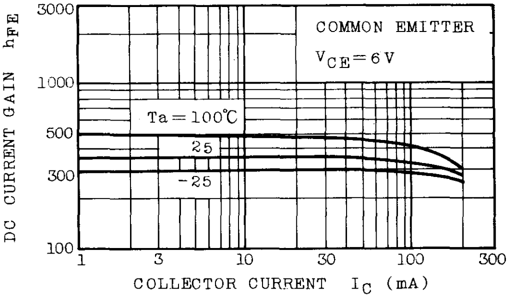
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	$V_{CB}=80V$, $I_E=0$	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	$V_{EB}=5V$, $I_C=0$	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	$I_C=1mA$	80	-	-	V
DC Current Gain	h_{FE} (Note)	$V_{CE}=6V$, $I_C=2mA$	200	-	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C=10mA$, $I_B=10mA$	-	-	0.1	V
Base-Emitter Voltage	V_{BE}	$V_{CE}=6V$, $I_C=2mA$	-	0.6	-	V
Base Spreading Resistance	$r_{bb'}$	$V_{CE}=6V$, $I_C=1mA$, f=100MHz	-	2.0	-	Ω
Transition Frequency	f_T	$V_{CE}=6V$, $I_E=-1mA$, f=100MHz	-	42	-	MHz
Collector Output Capacitance	C_{ob}	$V_{CB}=10V$, $I_E=0$, f=1MHz	-	6.2	-	pF
Noise Figure	NF	$V_{CE}=6V$, $I_C=0.1mA$, f=10Hz, $R_g=10k\Omega$	-	2	6	dB
		$V_{CE}=6V$, $I_C=0.1mA$, f=1kHz, $R_g=10k\Omega$	-	1	2	
		$V_{CE}=6V$, $I_C=0.1mA$, f=1kHz, $R_g=100\Omega$	-	2.5	-	

Note : h_{FE} Classification GR : 200~400, BL : 350~700

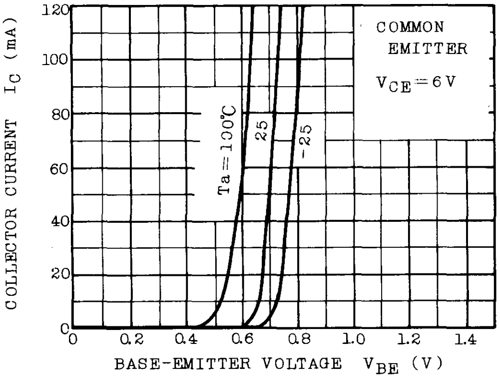
I_C – V_{CE}



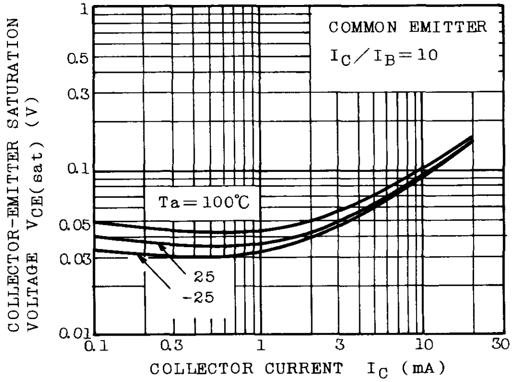
h_{FE} – I_C



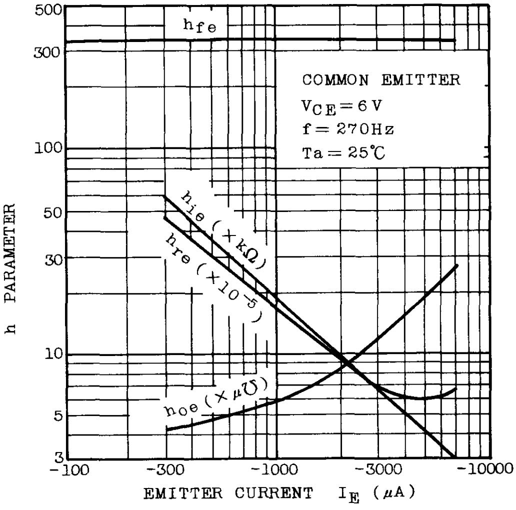
V_{BE} – I_C



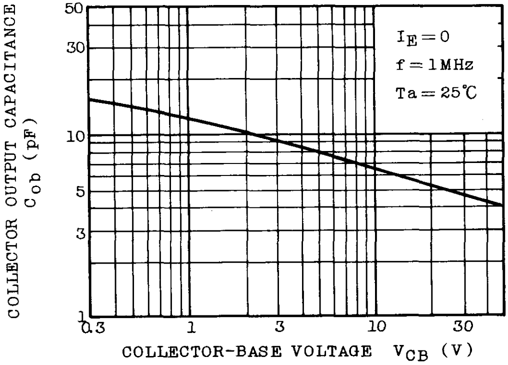
$V_{CE(sat)}$ – I_C

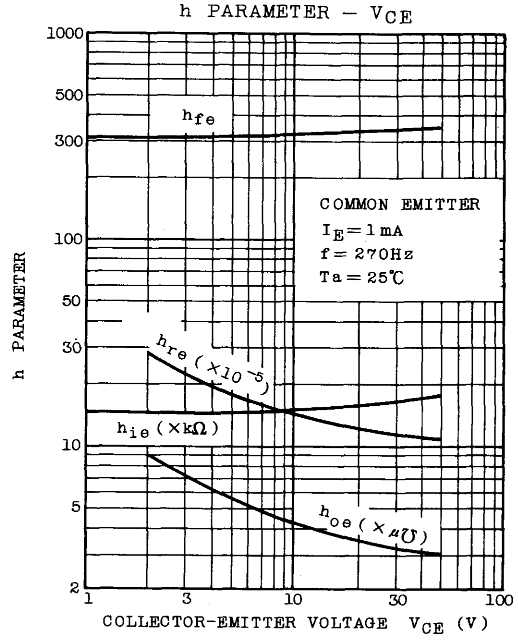


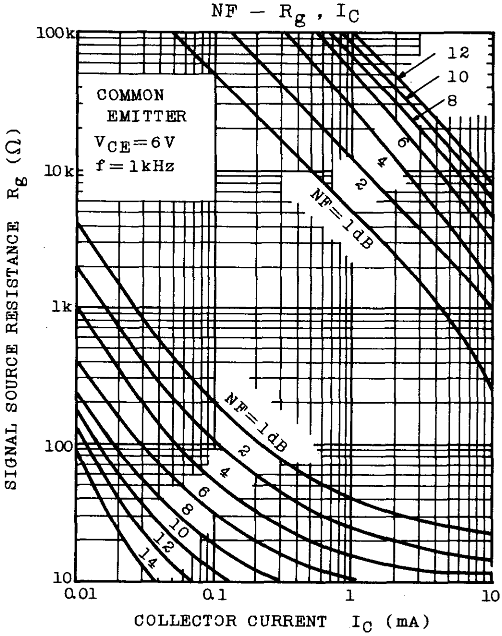
h PARAMETER – I_E

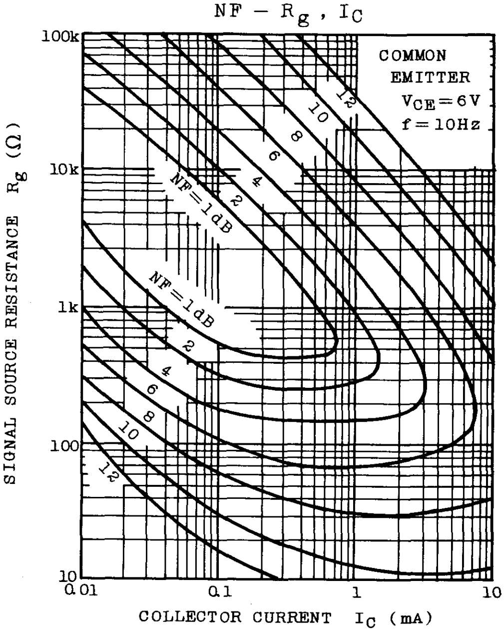


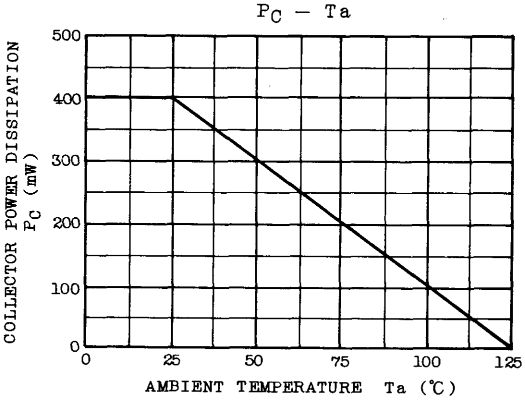
C_{ob} – V_{CB}




h PARAMETER − V_CE
COMMON EMITTER
I_E = 1 mA
f = 270Hz
Ta = 25℃
h_fe
h_re (×10^-5)
h_ie (×kΩ)
h_oe (×μ℧)
h PARAMETER
COLLECTOR-EMITTER VOLTAGE V_CE (V)
1000
500
300
100
50
30
10
5
2
1
3
10
30
100


NF − R_g , I_C
COMMON EMITTER
V_CE = 6 V
f = 1 kHz
12
10
8
6
4
2
NF = 1dB
NF = 1dB
2
4
6
8
10
12
14
SIGNAL SOURCE RESISTANCE R_g (Ω)
COLLECTOR CURRENT I_C (mA)
100k
10k
1k
100
10
0.01
0.1
1
10


NF − R_g , I_C
COMMON EMITTER
V_CE = 6 V
f = 10Hz
12
10
8
6
4
2
NF = 1dB
NF = 1dB
2
4
6
8
10
12
SIGNAL SOURCE RESISTANCE R_g (Ω)
COLLECTOR CURRENT I_C (mA)
100k
10k
1k
100
10
0.01
0.1
1
10


P_C − Ta
COLLECTOR POWER DISSIPATION P_C (mW)
AMBIENT TEMPERATURE Ta (℃)
500
400
300
200
100
0
0
25
50
75
100
125

SILICON NPN TRIPLE DIFFUSED TYPE (PCT PROCESS)

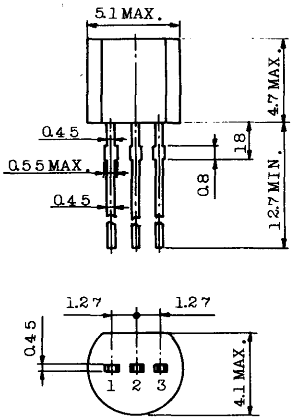
2SC3333

HIGH VOLTAGE SWITCHING APPLICATIONS
COLOR TV CHROMA OUTPUT APPLICATIONS.

FEATURES:

- High Voltage : V_{CEO}=250V
- Low C_{re} : 1.8pF(Max.)
- Complementary to 2SA1320

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1B

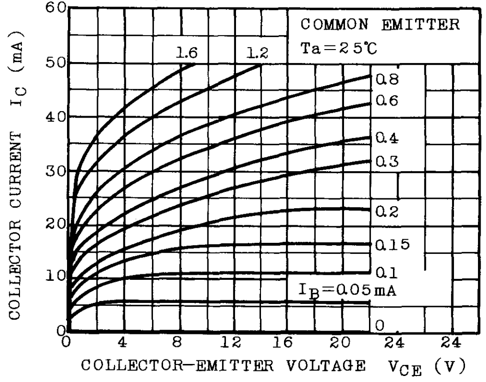
Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

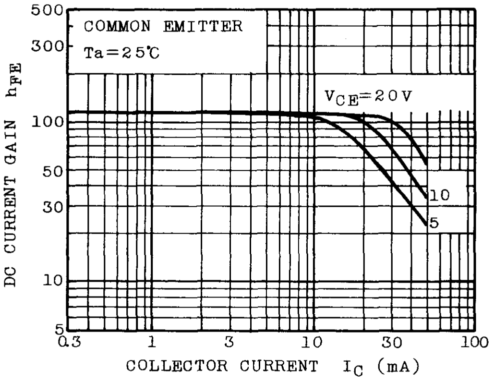
CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Voltage		V_{CBO}	250	V
Collector-Emitter Voltage		V_{CEO}	250	V
Emitter-Base Voltage		V_{EBO}	5	V
Collector Current	DC	I_C	50	mA
	Peak	I_{CP}	100	
Base Current		I_B	20	mA
Collector Power Dissipation		P_C	0.6	W
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_{stg}	-55~150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

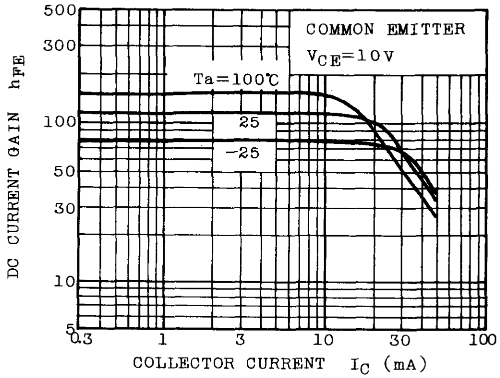
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=200V, I_E=0	-	-	1.0	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	1.0	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	250	-	-	V
DC Current Gain	h_{FE}	V_{CE}=20V, I_C=25mA	50	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	1.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=20V, I_C=25mA	-	0.75	-	V
Transition Frequency	f_T	V_{CE}=10V, I_C=10mA	60	100	-	MHz
Reverse Transfer Capacitance	C_{re}	V_{CB}=30V, I_E=0, f=1MHz	-	-	1.8	pF



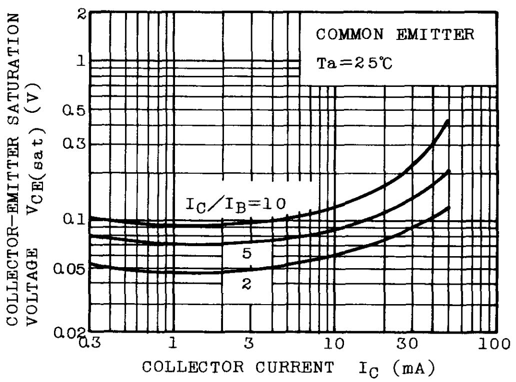
$I_C - V_{CE}$ (LOW VOLTAGE REGION)



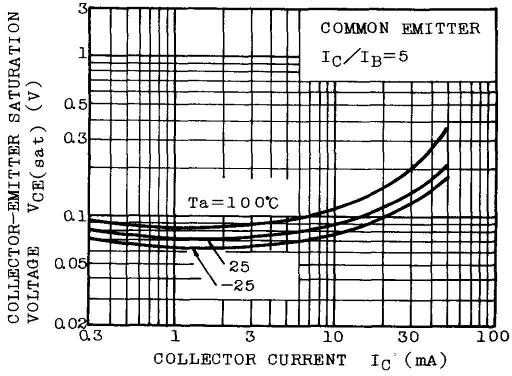
$h_{FE} - I_C$



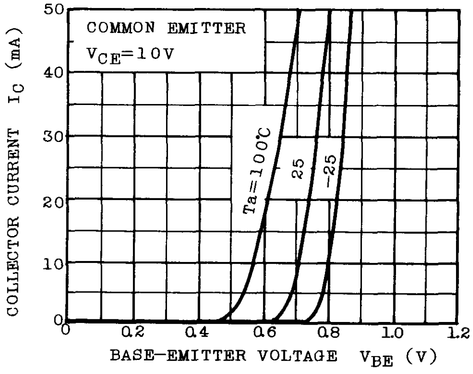
$h_{FE} - I_C$



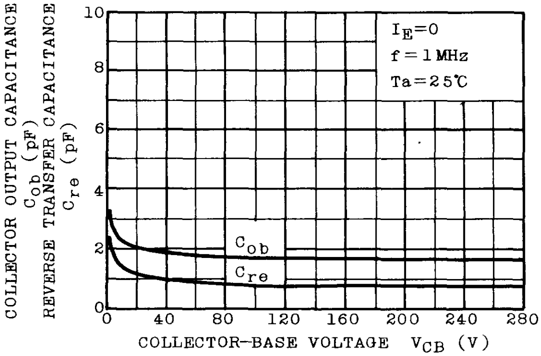
$V_{CE(sat)} - I_C$



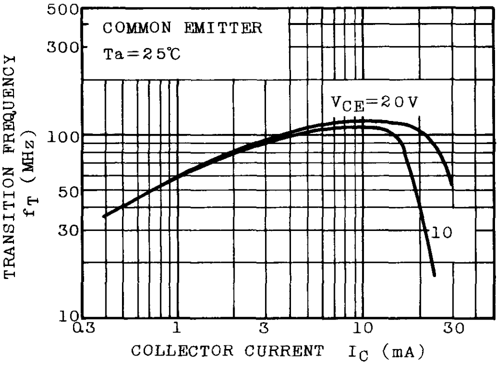
$V_{CE(sat)} - I_C$



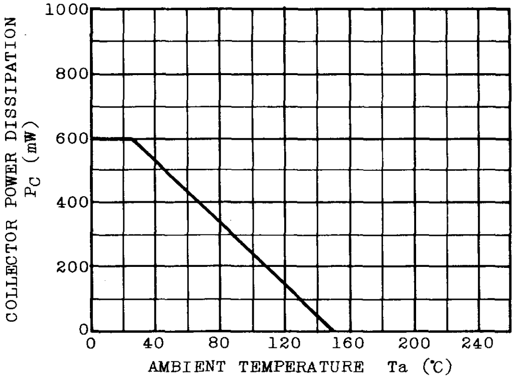
$I_C - V_{BE}$



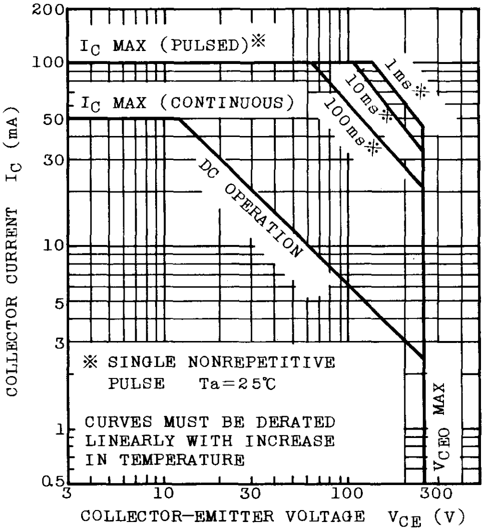
$C_{ob}, C_{re} - V_{CB}$



$f_T - I_C$



$P_C - Ta$



SAFE OPERATING AREA

2SC3334

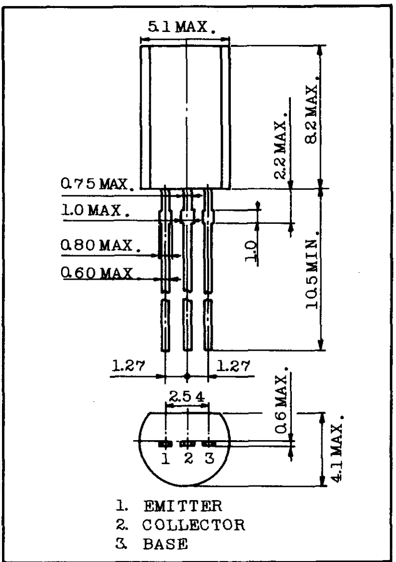
SILICON NPN TRIPLE DIFFUSED TYPE (PCT PROCESS)

HIGH VOLTAGE SWITCHING APPLICATIONS.
COLOR TV CHROMA OUTPUT APPLICATIONS.

FEATURES:

- High Voltage : V_{CEO}=250V
- Low C_{re} : 1.8pF(Max.)
- Complementary to 2SA1321

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92MOD
EIAJ	–
TOSHIBA	2-5J1A

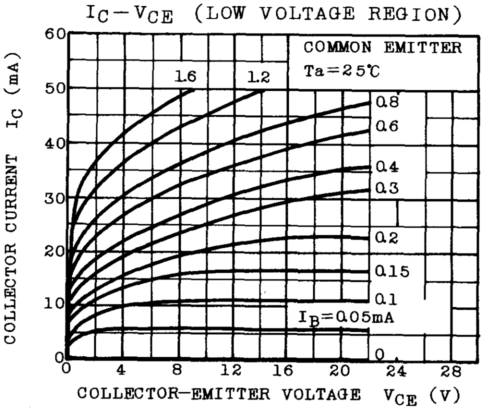
Weight : 0.36g

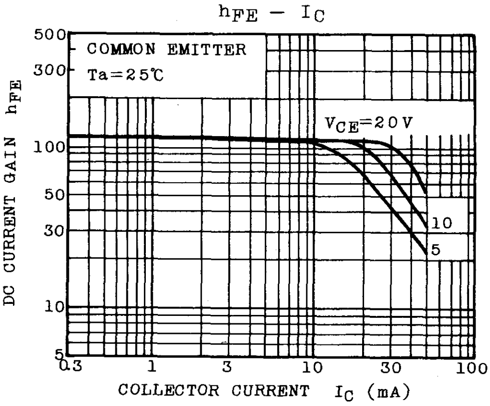
MAXIMUM RATINGS (Ta=25°C)

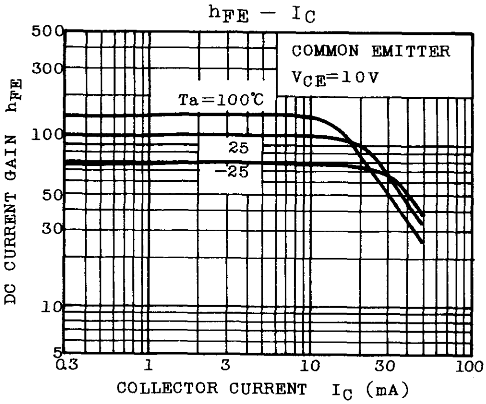
CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Voltage		V_{CBO}	250	V
Collector-Emitter Voltage		V_{CEO}	250	V
Emitter-Base Voltage		V_{EBO}	5	V
Collector Current	DC	I_C	50	mA
	Peak	I_{CP}	100	
Base Current		I_B	20	mA
Collector Power Dissipation		P_C	0.9	W
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_{stg}	-55~150	°C

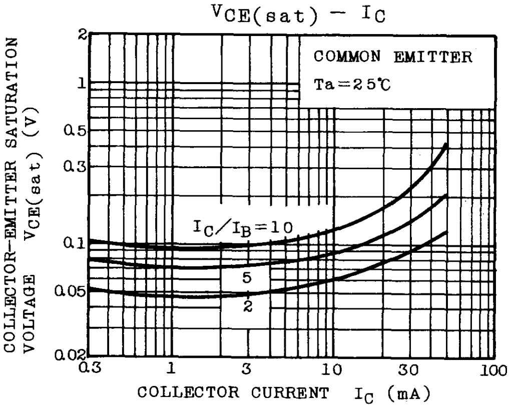
ELECTRICAL CHARACTERISTICS (Ta=25°C)

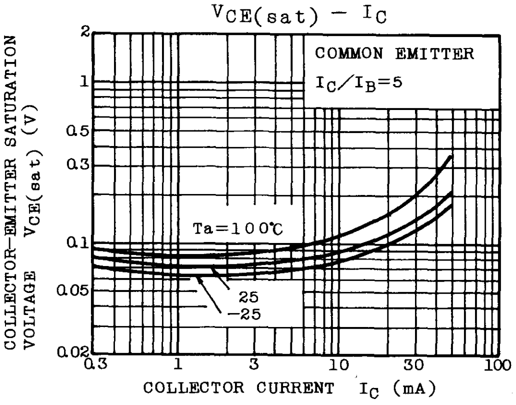
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=200V, I_E=0	-	-	1.0	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	1.0	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	250	-	-	V
DC Current Gain	h_{FE}	V_{CE}=20V, I_C=25mA	50	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	1.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=20V, I_C=25mA	-	0.75	-	V
Transition Frequency	f_T	V_{CE}=10V, I_C=10mA	60	100	-	MHz
Reverse Transfer Capacitance	C_{re}	V_{CB}=30V, I_E=0, f=1MHz	-	-	1.8	pF

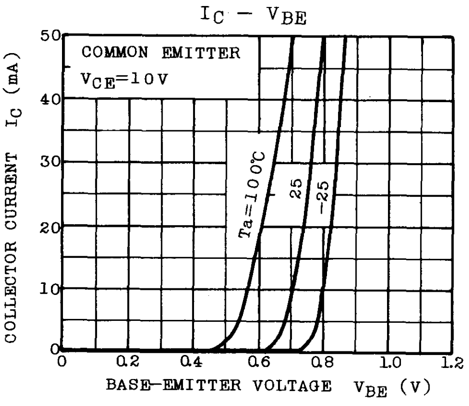

IC − VCE (LOW VOLTAGE REGION)
COMMON EMITTER
Ta=25℃
COLLECTOR CURRENT IC (mA)
COLLECTOR-EMITTER VOLTAGE VCE (V)
1.6
1.2
0.8
0.6
0.4
0.3
0.2
0.15
0.1
IB=0.05mA
0
0
10
20
30
40
50
60
4
8
12
16
20
24
28

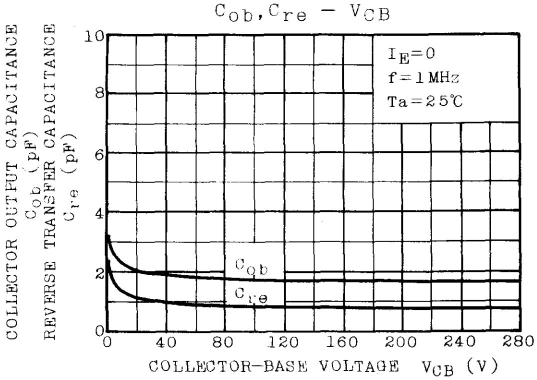

hFE − IC
COMMON EMITTER
Ta=25℃
VCE=20V
10
5
DC CURRENT GAIN hFE
COLLECTOR CURRENT IC (mA)
500
300
100
50
30
10
5
0.3
1
3
10
30
100

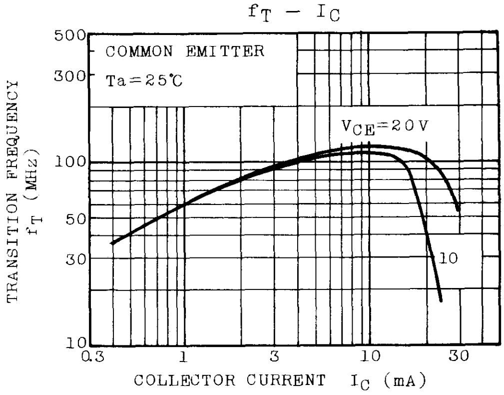

hFE − IC
COMMON EMITTER
VCE=10V
Ta=100℃
25
−25
DC CURRENT GAIN hFE
COLLECTOR CURRENT IC (mA)
500
300
100
50
30
10
5
0.3
1
3
10
30
100

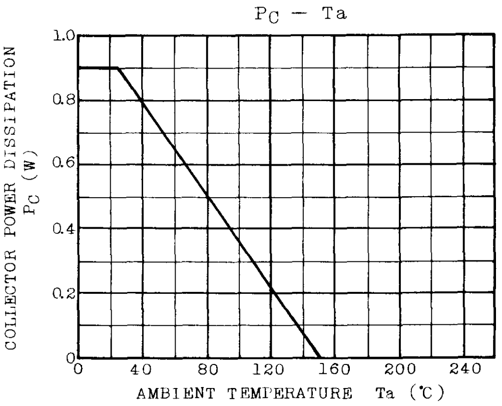

VCE(sat) − IC
COMMON EMITTER
Ta=25℃
IC/IB=10
5
2
COLLECTOR-EMITTER SATURATION VOLTAGE VCE(sat) (V)
COLLECTOR CURRENT IC (mA)
2
1
0.5
0.3
0.1
0.05
0.02
0.3
1
3
10
30
100

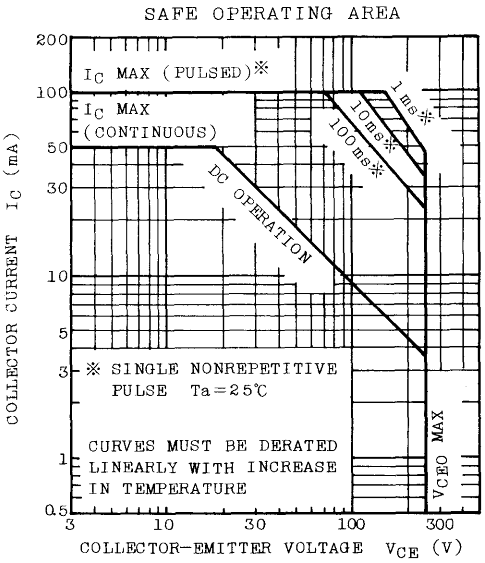

VCE(sat) − IC
COMMON EMITTER
IC/IB=5
Ta=100℃
25
−25
COLLECTOR-EMITTER SATURATION VOLTAGE VCE(sat) (V)
COLLECTOR CURRENT IC (mA)
2
1
0.5
0.3
0.1
0.05
0.02
0.3
1
3
10
30
100


IC − VBE
COMMON EMITTER
VCE=10V
Ta=100℃
25
−25
COLLECTOR CURRENT IC (mA)
BASE-EMITTER VOLTAGE VBE (V)
50
40
30
20
10
0
0
0.2
0.4
0.6
0.8
1.0
1.2


C_{ob}, C_{re} — V_{CB}
I_E=0
f=1 MHz
Ta=25℃
C_{ob}
C_{re}
COLLECTOR OUTPUT CAPACITANCE C_{ob} (pF)
REVERSE TRANSFER CAPACITANCE C_{re} (pF)
0
2
4
6
8
10
0
40
80
120
160
200
240
280
COLLECTOR-BASE VOLTAGE V_{CB} (V)


f_T — I_C
COMMON EMITTER
Ta=25℃
V_{CE}=20 V
10
TRANSITION FRECUENCY f_T (MHz)
10
30
50
100
300
500
0.3
1
3
10
30
COLLECTOR CURRENT I_C (mA)


P_C — Ta
COLLECTOR POWER DISSIPATION P_C (W)
0
0.2
0.4
0.6
0.8
1.0
0
40
80
120
160
200
240
AMBIENT TEMPERATURE Ta (℃)


SAFE OPERATING AREA
I_C MAX (PULSED)※
I_C MAX (CONTINUOUS)
1ms※
10ms※
100ms※
DC OPERATION
※ SINGLE NONREPETITIVE PULSE Ta=25℃
CURVES MUST BE DERATED LINEARLY WITH INCREASE IN TEMPERATURE
VCEO MAX
COLLECTOR CURRENT I_C (mA)
0.5
1
3
5
10
30
50
100
200
3
10
30
100
300
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)

2SD
series

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)
(DARLINGTON POWER)
(INDUSTRIAL APPLICATIONS)

2SD1140

MICRO MOTOR DRIVE, HAMMER DRIVE APPLICATIONS.

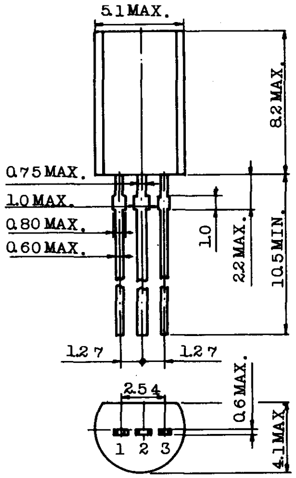
SWITCHING APPLICATIONS.

POWER AMPLIFIER APPLICATIONS.

FEATURES:

- High DC Current Gain : h_{FE}=4000(Min.)
  (V_{CE}=2V, I_C=150mA)
- Low Saturation Voltage : $V_{CE(sat)}$=1.5V (Max.)
  (I_C=1A, I_B=1mA)

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

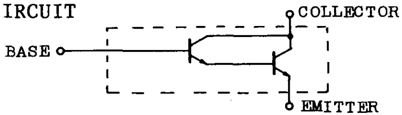
JEDEC	TO−92MOD
EIAJ	−
TOSHIBA	2−5J1A

Weight : 0.36g

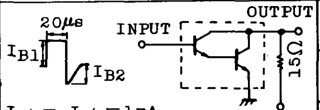
MAXIMUM RATINGS (Ta=25°C)

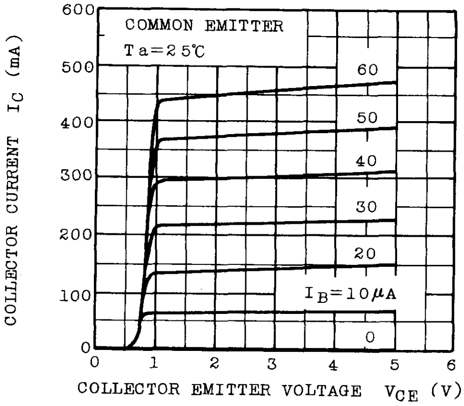
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	10	V
Continuous Collector Current	I_C	1.5	A
Continuous Base Current	I_B	50	mA
Collector Power Dissipation	P_C	900	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	Tstg	-55~150	°C

EQUIVALENT CIRCUIT

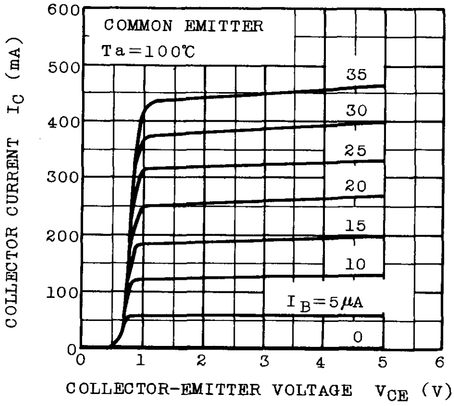


ELECTRICAL CHARACTERISTICS (Ta=25°C)

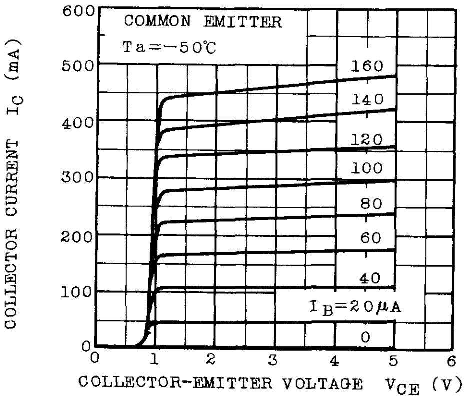
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=30V, I_E=0	−	−	10	μA
Emitter Cut-off Current		I_{EBO}	V_{EB}=10V, I_C=0	−	−	10	μA
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	I_C=10mA, I_B=0	30	−	−	V
DC Current Gain		h_{FE}	V_{CE}=2V, I_C=150mA	4000	−	−	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=1A, I_B=1mA	−	−	1.5	V
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=1A, I_B=1mA	−	−	2.2	V
Switching Time	Turn-on Time	t_{on}	 $I_{B(1)}=-I_{B(2)}$=1mA I_C=1A, P_W=20μs, Du≦1%	−	0.20	−	μs
	Storage Time	tstg		−	0.6	−	μs
	Fall Time	tf		−	0.3	−	μs



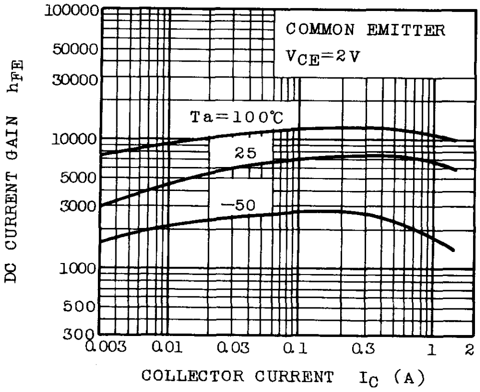
$I_C - V_{CE}$



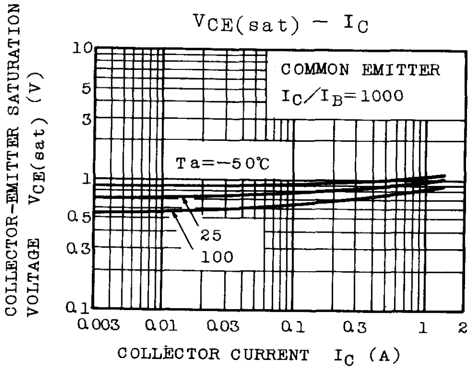
$I_C - V_{CE}$



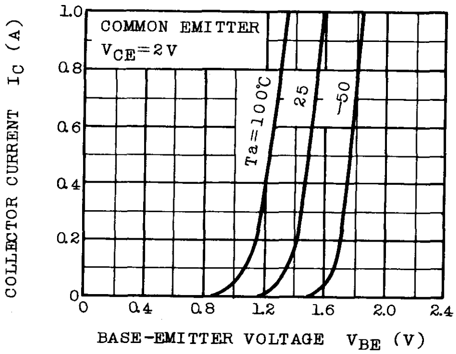
$I_C - V_{CE}$



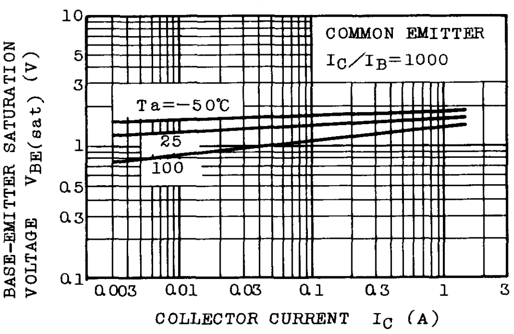
$h_{FE} - I_C$



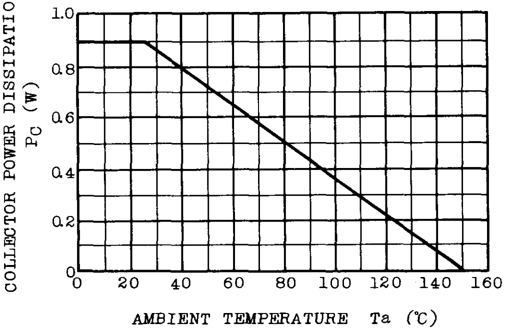
$V_{CE(sat)} - I_C$



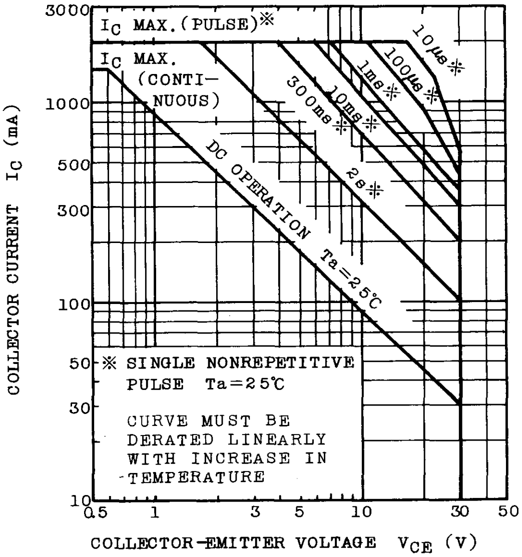
$I_C - V_{BE}$



$V_{BE(sat)} - I_C$



$P_C - Ta$



SAFE OPERATING AREA

2SH

series

SILICON P EMITTER PLANAR TYPE
(INDUSTRIAL APPLICATIONS)

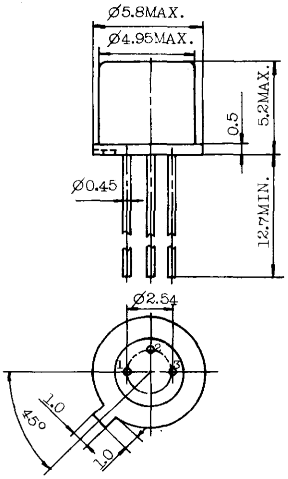
2SH20
2SH21

RELAXATION OSCILLATOR, SCR TRIGGER AND TIMER APPLICATIONS.

FEATURES:

- High Oscillation Output Voltage
  : V_{OB1}=3V (Min.)
- Low Emitter Reverse Current
  : I_{EC}=0.1μA (Max.)
- Wide Oscillation Area : Ip=3.5μA (Max.)(2SH20)
  Iv=6mA (Min.)

Unit in mm



1. BASE 1
2. EMITTER
3. BASE 2 (CASE)

JEDEC	TO — 18
EIAJ	TC — 7, TB — 8C
TOSHIBA	2 — 5A1A

Weight : 1.13g

MAXIMUM RATINGS (Ta=25°C)

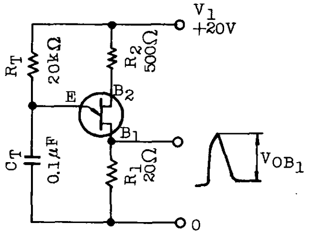
CHARACTERISTICS	SYMBOL	RATING	UNIT
Base 2 - Base 1 Voltage	V_{B2B10}	55	V
Base 1 - Emitter Voltage	V_{B1EO}	60	V
Base 2 - Emitter Voltage	V_{B2EO}	60	V
Peak Emitter Current	$I_{E(peak)}$	1	A
Emitter Current	I_E	50	mA
Allowable Power Dissipation	P	250	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	Tstg	-65∿150	°C

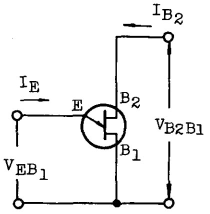
ELECTRICAL CHARACTERISTICS (Ta=25°C)

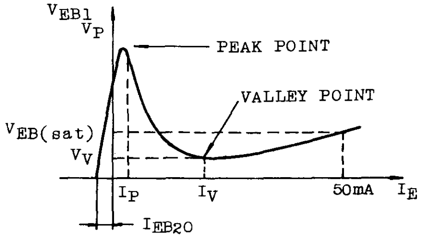
CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Emitter-Base 2 Reverse Current		I_{EB20}	V_{EB2}=-60V, I_{B1}=0	-	-	-0.1	μA
Base 1 - Base 2 Resistance		R_{BBO}	V_{B2B1}=3V, I_E=0	4	-	12	kΩ
Intrinsic Stand-off Ratio		η(Note)	V_{B2B1}=20V	0.70	-	0.85	
Emitter - Base 1 Forward Saturation Voltage		$V_{EB1(sat)}$	V_{B2B1}=10V, I_E=50mA	-	-	4	V
Peak Point Emitter Current	2SH20	Ip	V_{B2B1}=20V	-	-	3.5	μA
	2SH21			-	-	4	
Valley Point Emitter Current	2SH20	Iv	V_{B2B1}=20V	6	-	-	mA
	2SH21			4	-	-	
Valley Point Emitter Voltage		Vv	V_{B2B1}=20V	-	-	4	V
Oscillation Output Voltage		V_{OB1}	Fig.	3	-	-	V

Note: η Classification Y : 0.70∿0.80, GR : 0.75∿0.85

Fig. V_{OB1} TEST CIRCUIT





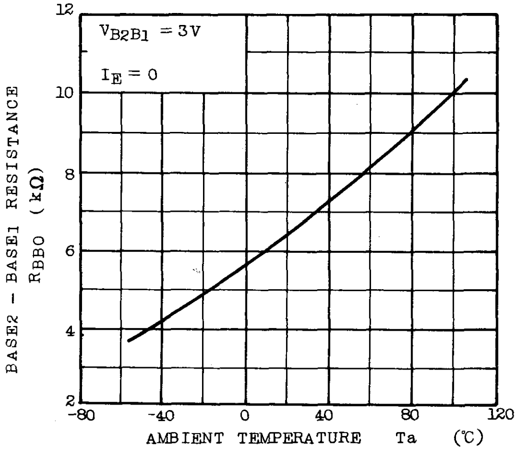


$V_P = \eta V_{B_2B_1} + V_D$

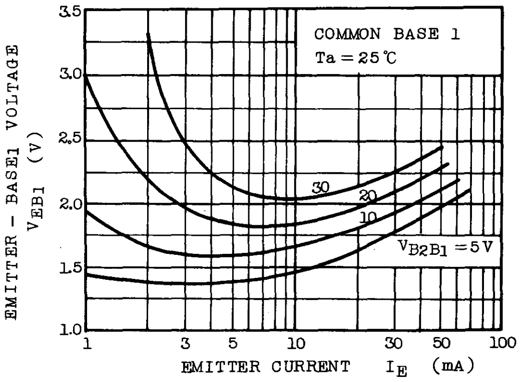
Where V_D : Contact potential of diode between emitter and base is about 0.7V at 25℃.

Approval Oscillation Frequency f = 5 kHz (MAX.)

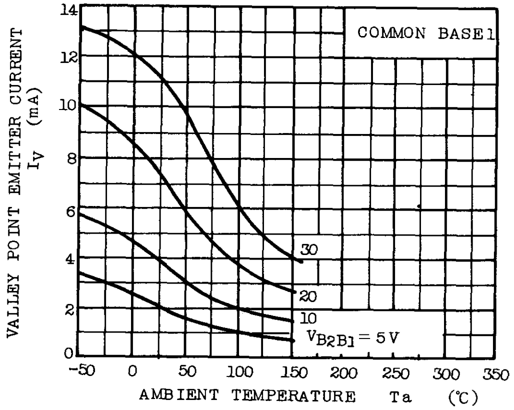
R_{BBO} – Ta



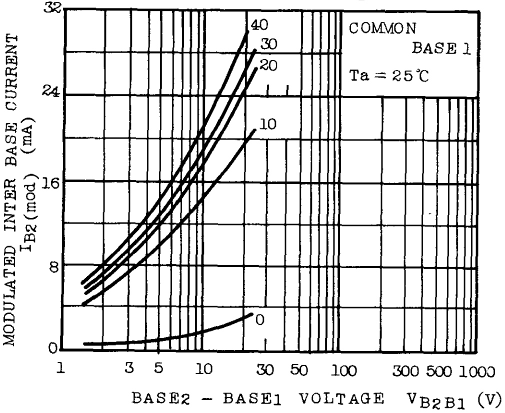
V_{EB_1} – I_E



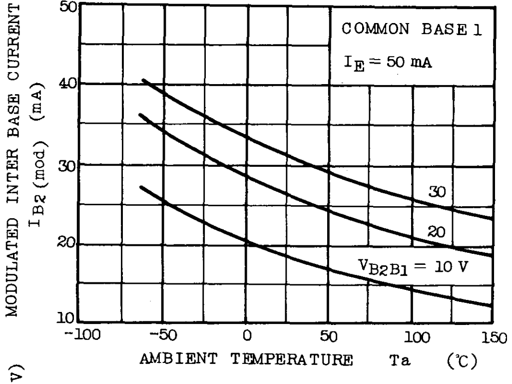
I_V − Ta



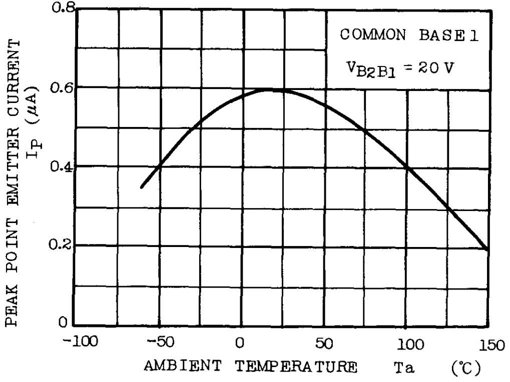
I_{B2}(mod) − V_{B2B1}



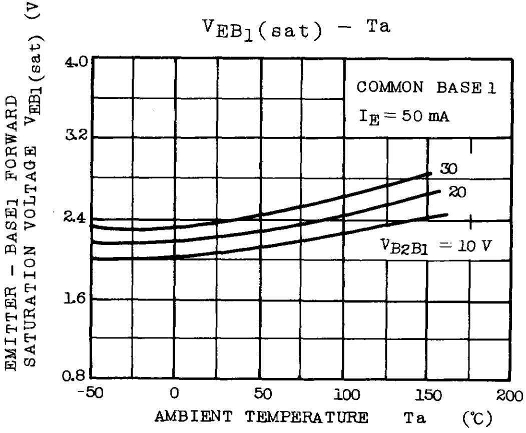
I_{B2}(mod) − Ta



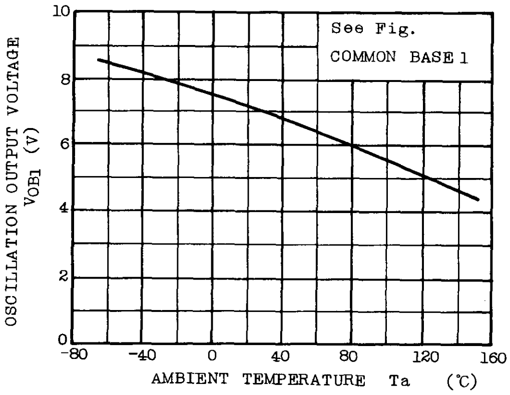
I_P − Ta



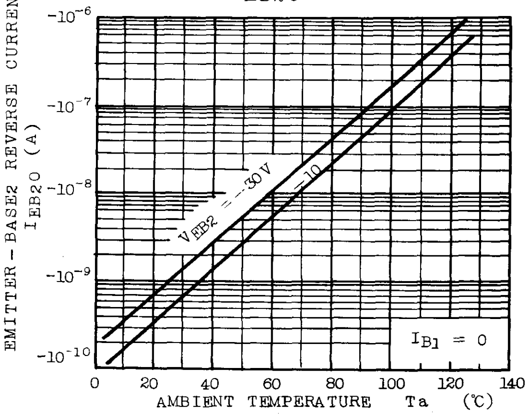
V_{EB1}(sat) − Ta



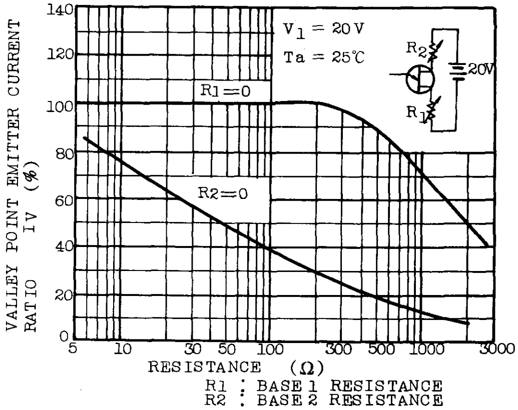
V_{OB1} − Ta



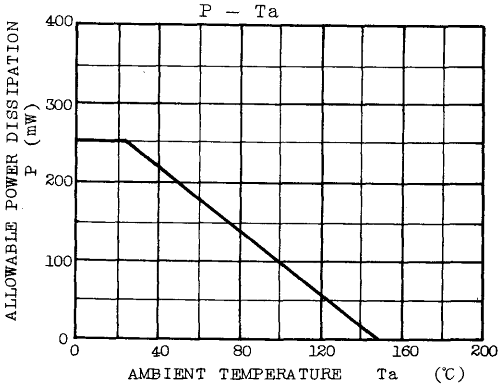
I_{EB20} - Ta



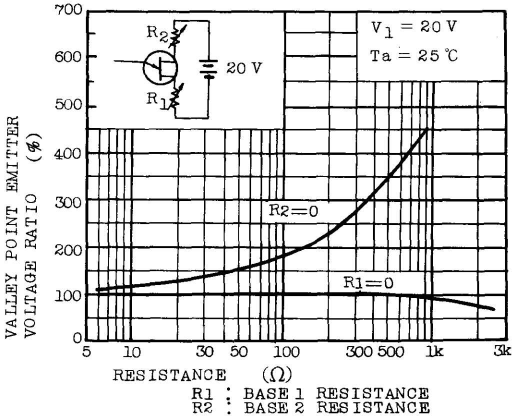
I_V - R1, R2



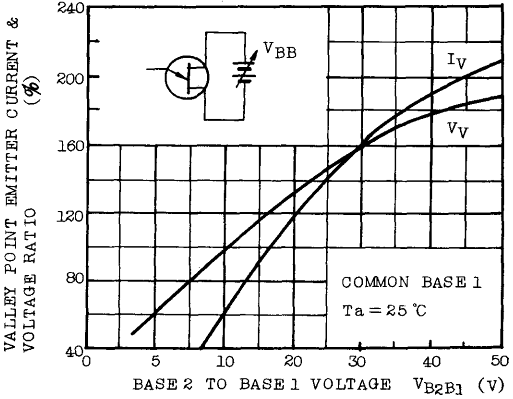
P - Ta



V_V - R1, R2



I_V, V_V - V_{B2B1}



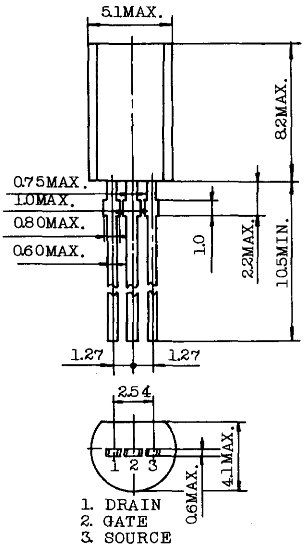
2SJ series

SILICON P CHANNEL JUNCTION TYPE

2SJ72

LOW NOISE AUDIO AMPLIFIER APPLICATIONS.

Unit in mm



JEDEC	TO−92MOD
EIAJ	−
TOSHIBA	2−5J1B

Weight : 0.36g

FEATURES:

- Recommended for first stages of EQ Amplifiers and M.C. Head Amplifiers.
- High $|y_{fs}|$
  : $|y_{fs}|$=40mS(Typ.)(V_{DS}=-10V, V_{GS}=0, I_{DSS}=-5mA)
- Low Noise : NF=1.0dB (Typ.)
  (V_{DS}=-10V, I_D=-5mA, f=1kHz, R_g=100Ω)
- High Input Impedance
  : I_{GSS}=1nA (Max.) (V_{GS}=25V)
- High Drain Power Dissipation : P_D=600mW
- Complementary to 2SK147

MAXIMUM RATINGS (Ta=25°C)

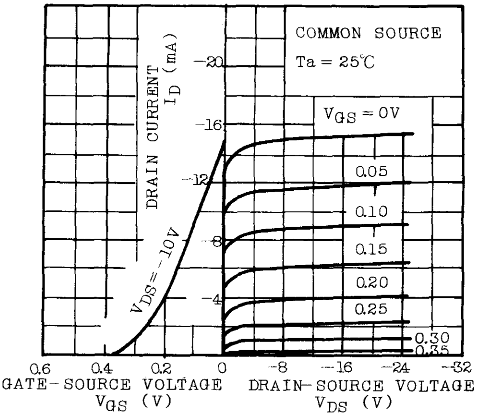
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	25	V
Gate Current	I_G	-10	mA
Drain Power Dissipation	P_D	600	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

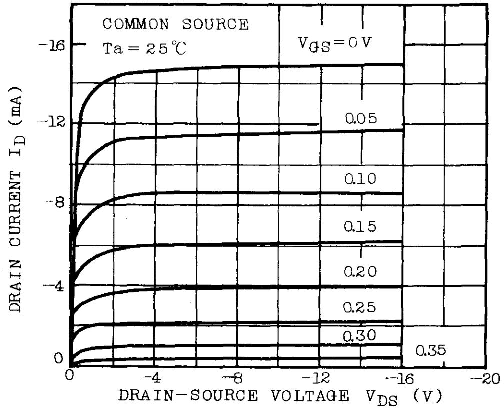
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=25V, V_{DS}=0	-	-	1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=100μA	25	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=-10V, V_{GS}=0	-5.0	-	-30	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=-10V, I_D=-0.1μA	0.3	-	2.0	V
For-ard Transfer Admittance	$\|y_{fs}\|$	V_{DS}=-10V, V_{GS}=0, f=1kHz(TYP:I_{DSS}=-5mA)	30	40	-	mS
Input Capacitance	C_{iss}	V_{DS}=-10V, V_{GS}=0, f=1MHz	-	185	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=-10V, I_D=0, f=1MHz	-	55	-	pF
Noise Figure	NF(1)	V_{DS}=-10V, R_g=100Ω I_D=-5mA, f=100Hz	-	5	10	dB
	NF(2)	V_{DS}=-10V, R_g=100Ω I_D=-5mA, f=1kHz	-	1	2	

Note : I_{DSS} Classification GR : -5.0∿-10.0, BL : -8.0∿-16.0, V : -14.0∿-30.0

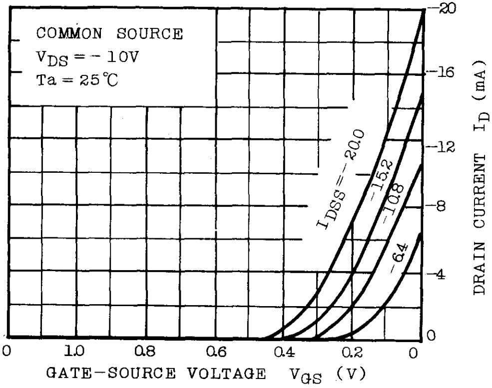
STATIC CHARACTERISTICS



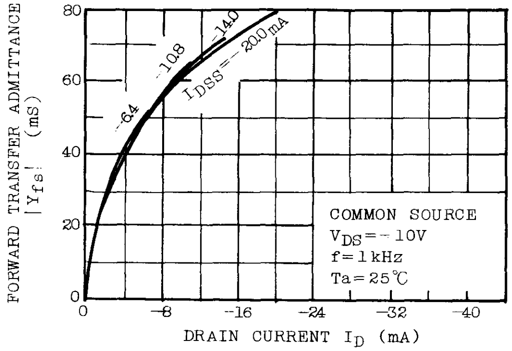
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



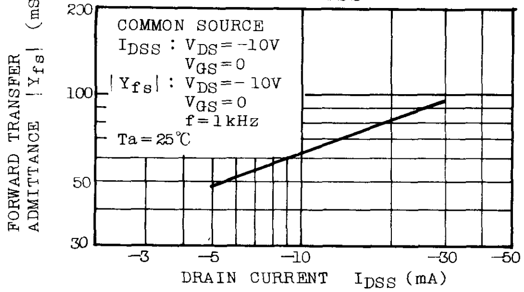
$I_D - V_{GS}$



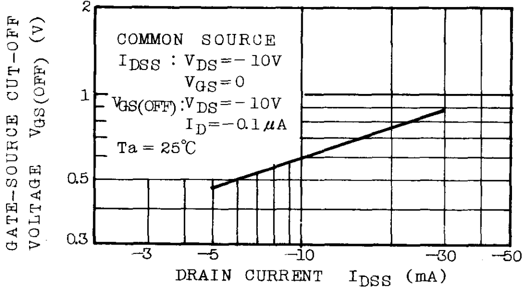
$|Y_{fs}| - I_D$



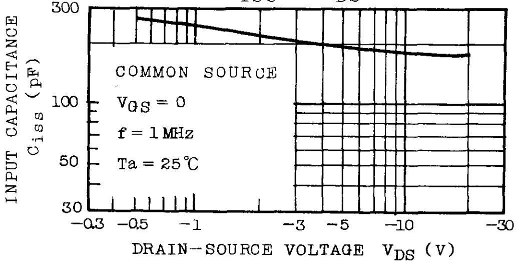
$|Y_{fs}| - I_{DSS}$

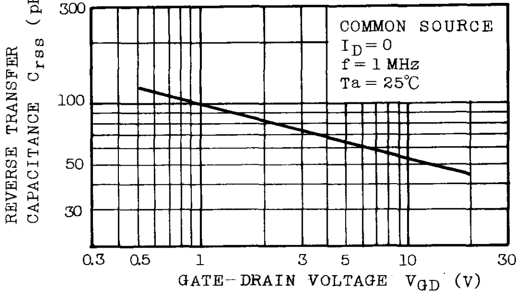


$V_{GS(OFF)} - I_{DSS}$

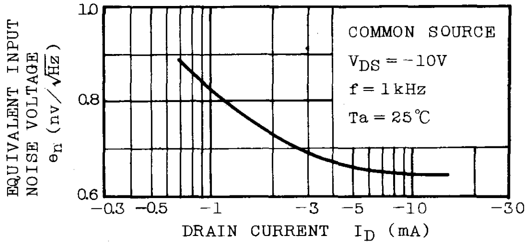


$C_{iss} - V_{DS}$

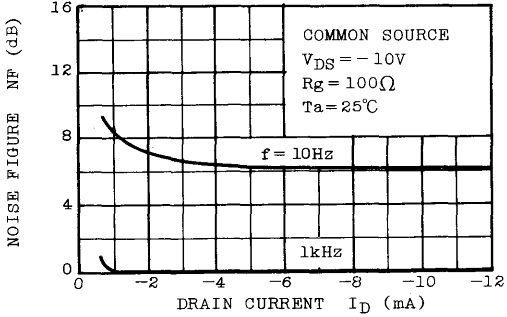




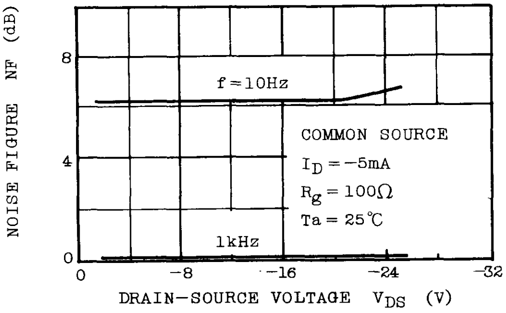
C_{rss} — V_{GD}



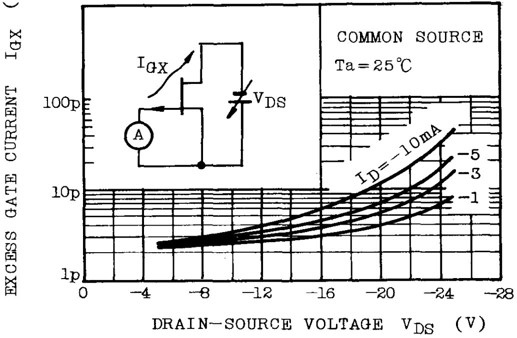
e_n — I_D



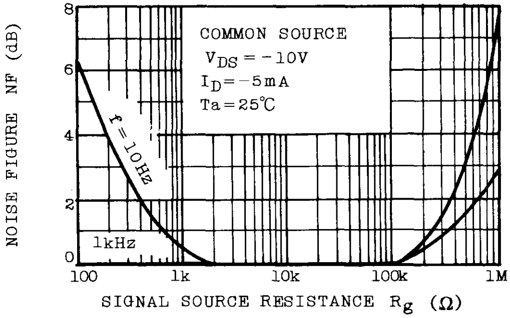
NF — I_D



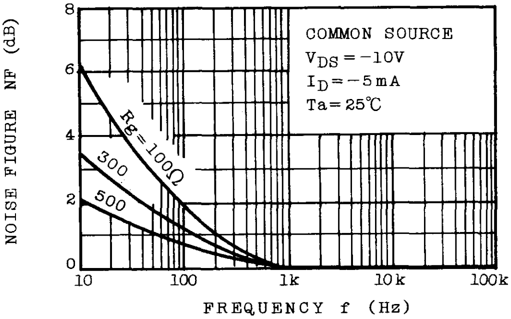
NF — V_{DS}



I_{GX} — V_{DS}



NF — R_g



NF — f

2SJ73

SILICON P CHANNEL JUNCTION TYPE

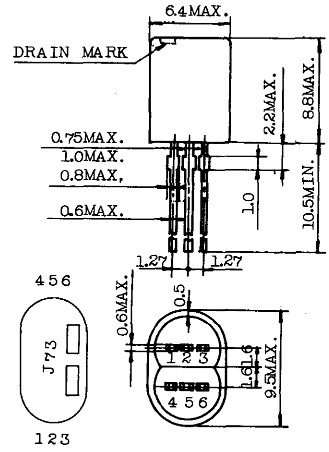
LOW NOISE AUDIO AMPLIFIER APPLICATIONS.

DIFFERENTIAL AMPLIFIER APPLICATIONS.

FEATURES:

- Recommended for first stages of EQ Amplifiers and M.C. Head Amplifiers.
- High $|y_{fs}|$: $|y_{fs}|$=40mS(Typ.)
  (V_{DS}=-10V, V_{GS}=0, I_{DSS}=-5mA)
- Excellent Pair Characteristics
  : $|V_{GS1}-V_{GS2}|$=20mV (Max.)
  (V_{DS}=-10V, I_D=-5mA)
- Low Noise : NF=1.0dB (Typ.)
  (V_{DS}=-10V, I_D=-5mA, f=1kHz, R_g=100Ω)
- High Input Impedance : I_{GSS}=1nA (Max.)
  (V_{GS}=25V)
- Complementary to 2SK146

Unit in mm



1. SOURCE 1
2. GATE 1
3. DRAIN 1
4. DRAIN 2
5. GATE 2
6. SOURCE 2

JEDEC	—
EIAJ	—
TOSHIBA	2 — 6E1B

Weight : 1.1g

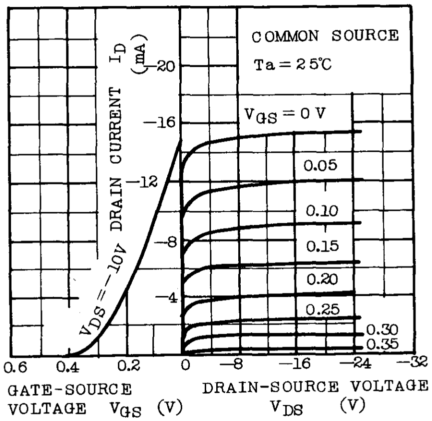
MAXIMUM RATINGS (Ta=25°C)

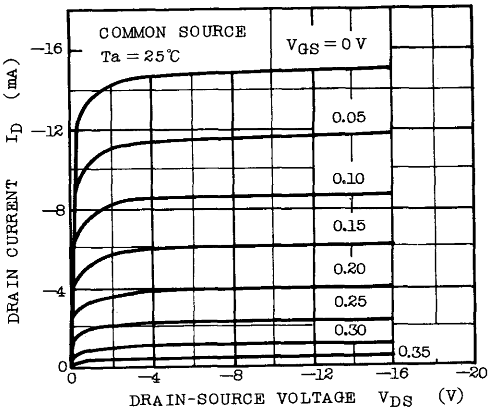
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	25	V
Gate Current	I_G	-10	mA
Drain Power Dissipation	P_D	600×2	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

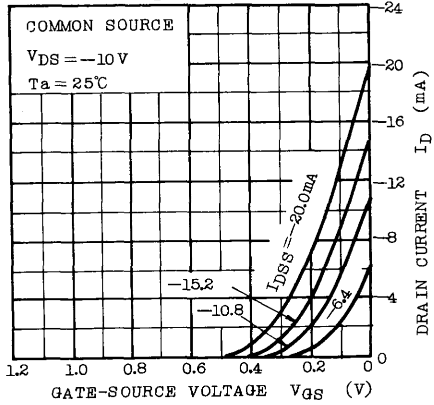
ELECTRICAL CHARACTERISTICS (Ta=25°C)

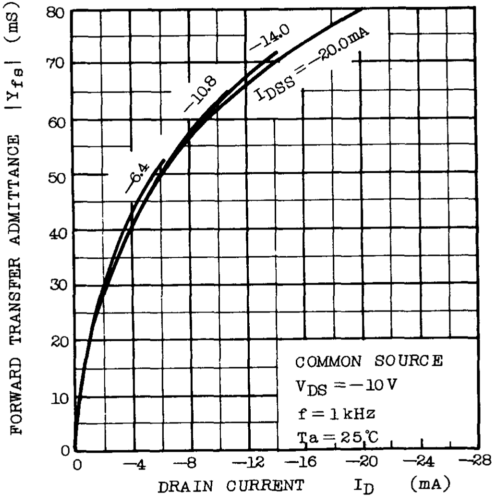
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=25V, V_{DS}=0	-	-	1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=100μA	25	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=-10V, V_{GS}=0	-5.0	-	-30	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=-10V, I_D=-0.1μA	0.3	-	2.0	V
Forward Transfer Admittance	$\|y_{fs}\|$	V_{DS}=-10V, V_{GS}=0, f=1kHz	25	40	-	mS
Differential Gate-Source Voltage	$\|V_{GS1}-V_{GS2}\|$	V_{DS}=-10V, I_D=-5mA	-	-	20	mV
Input Capacitance	C_{iss}	V_{DS}=-10V, V_{GS}=0, f=1MHz	-	185	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=-10V, I_D=0, f=1MHz	-	55	-	pF
Noise Figure	NF(1)	V_{DS}=-10V, I_D=-5mA R_g=100Ω, f=100Hz	-	5	10	dB
	NF(2)	V_{DS}=-10V, I_D=-5mA R_g=100Ω, f=1kHz	-	1	2	

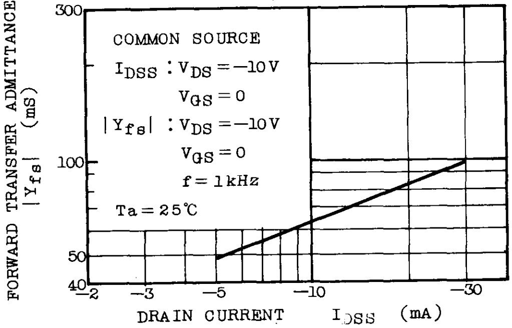
Note: I_{DSS} Classification GR : -5.0∿-10, BL : -8.0∿-16, V : -14∿-30

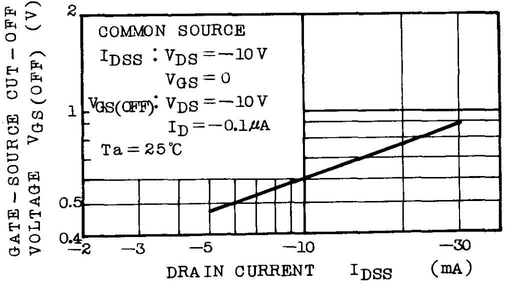

STATIC CHARACTERISTIC


$I_D - V_{DS}$ (LOW VOLTAGE REGION)

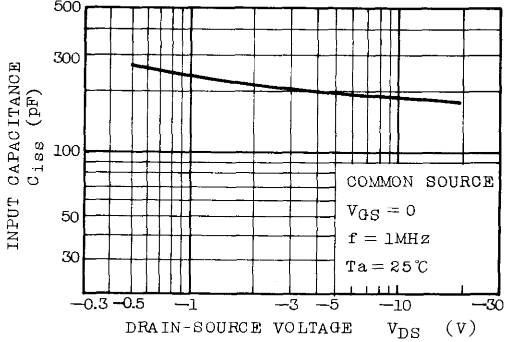

$I_D - V_{GS}$


$|Y_{fs}| - I_D$

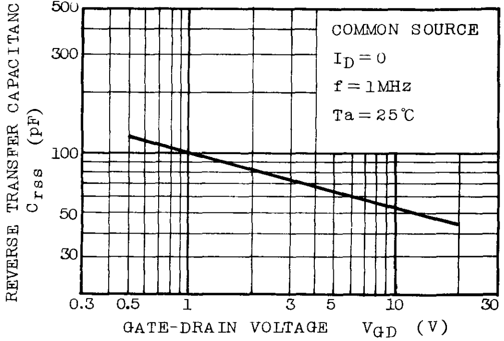

$|Y_{fs}| - I_{DDS}$


$V_{GS(OFF)} - I_{DSS}$

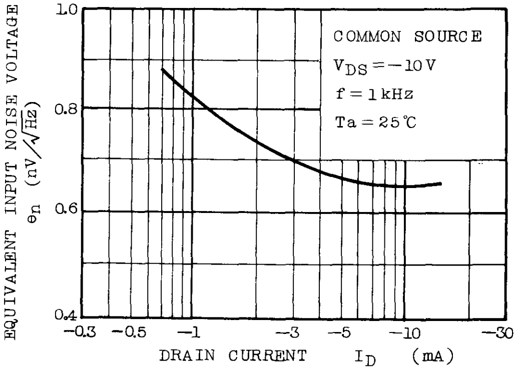
C_{iss} — V_{DS}



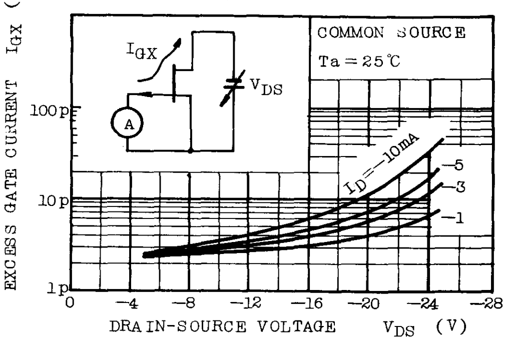
C_{rss} — V_{GD}



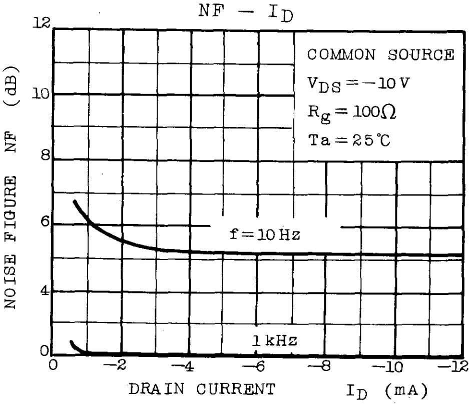
e_n — I_D



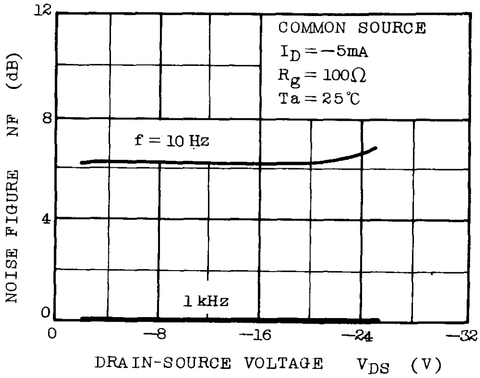
I_{GX} — V_{DS}



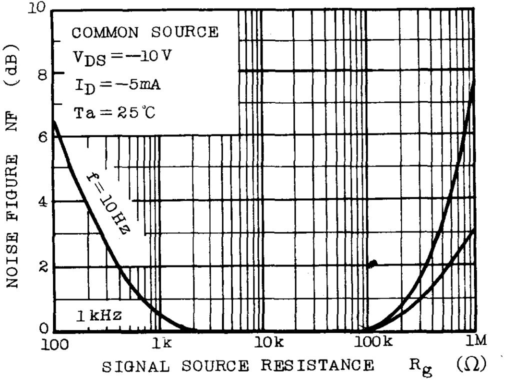
NF — I_D



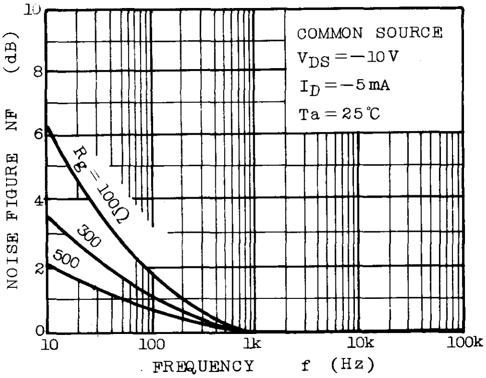
NF — V_{DS}



NF — R_g


COMMON SOURCE
V_{DS} = −10 V
I_D = −5mA
Ta = 25℃
f = 10Hz
1 kHz
NOISE FIGURE NF (dB)
10
8
6
4
2
0
100
1k
10k
100k
1M
SIGNAL SOURCE RESISTANCE R_g (Ω)

NF — f


COMMON SOURCE
V_{DS} = −10 V
I_D = −5 mA
Ta = 25℃
R_g = 100Ω
300
500
NOISE FIGURE NF (dB)
10
8
6
4
2
0
10
100
1k
10k
100k
FREQUENCY f (Hz)

2SJ74

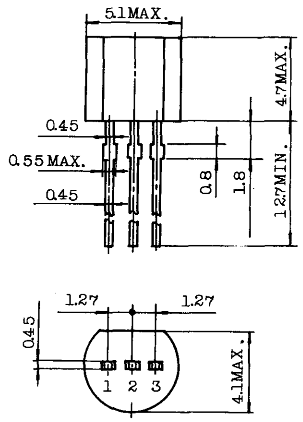
SILICON P CHANNEL JUNCTION TYPE

LOW NOISE AUDIO AMPLIFIER APPLICATIONS.

FEATURES:

- Recommended for first stages of EQ Amplifiers and M.C. Head Amplifiers.
- High $|y_{fs}|$
  : $|y_{fs}|$=22mS(Typ.)(V_{DS}=-10V, V_{GS}=0, I_{DSS}=-3mA)
- Low Noise : en=0.95nV/$\sqrt{Hz}$ (Typ.)
  (V_{DS}=-10V, I_D=-1mA, f=1kHz)
- High Input Impedance : I_{GSS}=1.0nA (Max.)(V_{GS}=25V)
- Complementary to 2SK170

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1D

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

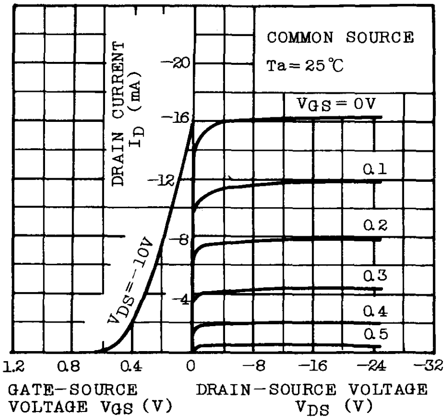
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	25	V
Gate Current	I_G	-10	mA
Drain Power Dissipation	P_D	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

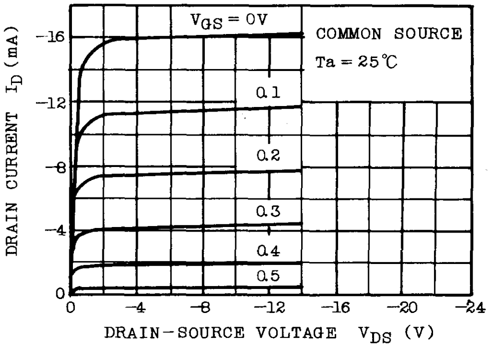
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=25V, V_{DS}=0	-	-	1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=100μA	25	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=-10V, V_{GS}=0	-1	-	-20	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=-10V, I_D=-0.1μA	0.15	-	2.0	V
Forward Transfer Admittance	$\|y_{fs}\|$	V_{DS}=-10V, V_{GS}=0, f=1kHz	8	22	-	mS
Input Capacitance	C_{iss}	V_{DS}=-10V, V_{GS}=0, f=1MHz	-	105	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=-10V, I_D=0, f=1MHz	-	32	-	pF
Noise Figure	NF(1)	V_{DS}=-10V, I_D=-1mA, R_g=1kΩ, f=10Hz	-	1.0	10	dB
	NG(2)	V_{DS}=-10V, I_D=-1mA, R_g=1kΩ, f=1kHz	-	0.5	2	

Note : I_{DSS} Classification Y : -1.0∿-3.0, GR : -2.6∿-6.5
BL : -6.0~-12, V : -10~-20

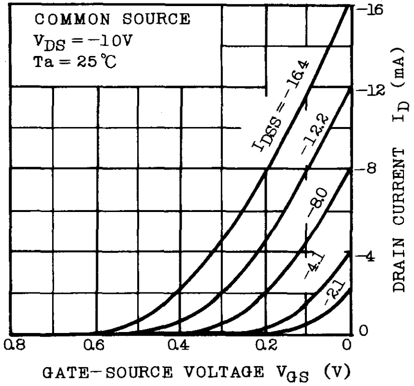
STATIC CHARACTERISTICS



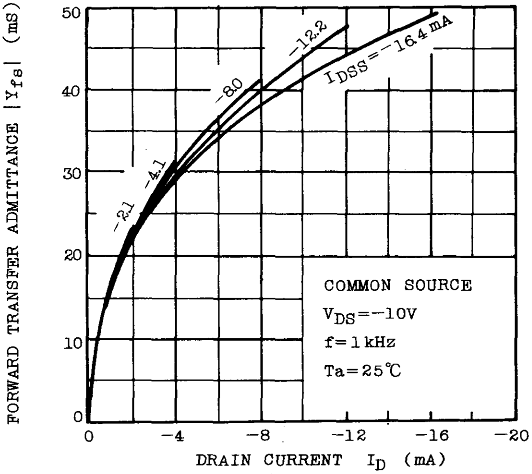
I_D − V_{DS} (LOW VOLTAGE REGION)



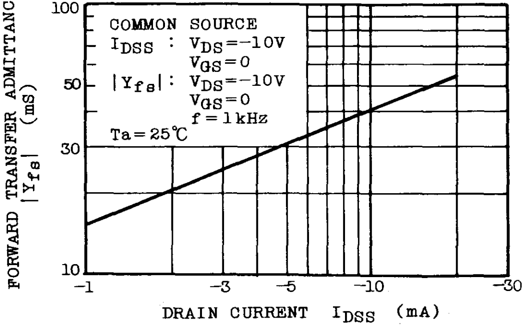
I_D − V_{GS}



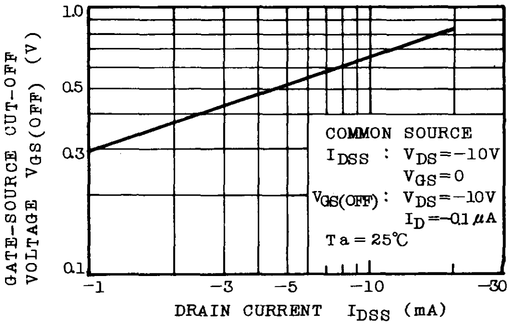
$|Y_{fs}|$ − I_D



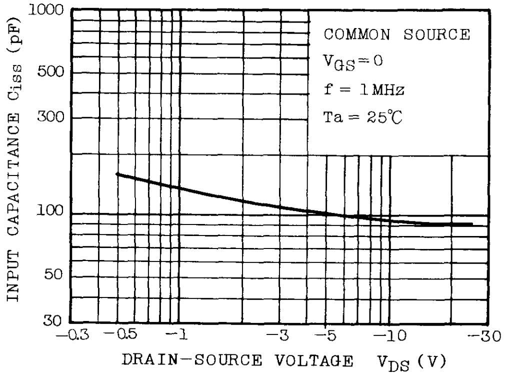
$|Y_{fs}|$ − I_{DSS}



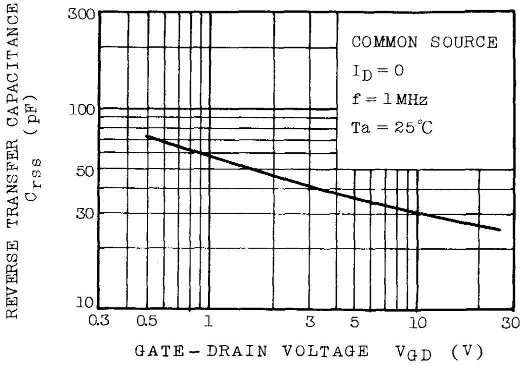
$V_{GS(OFF)}$ − I_{DSS}



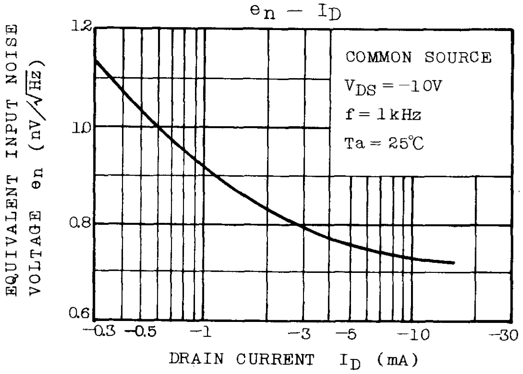
C_{iss} — V_{DS}



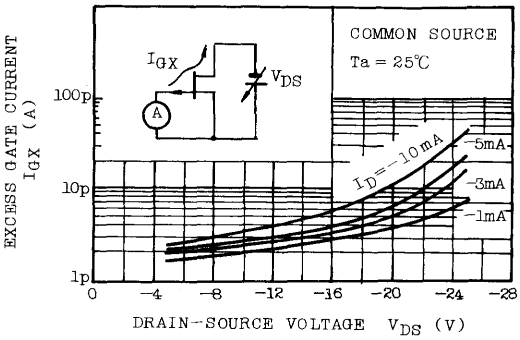
C_{rss} — V_{GD}



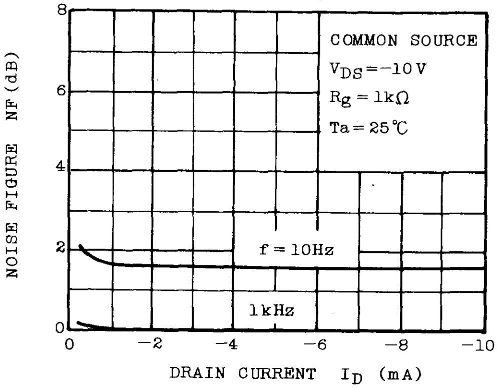
e_n — I_D



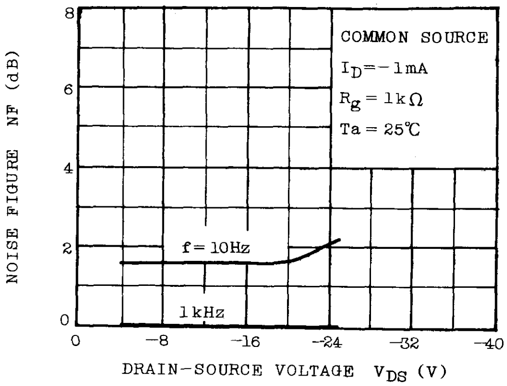
I_{GX} — V_{DS}

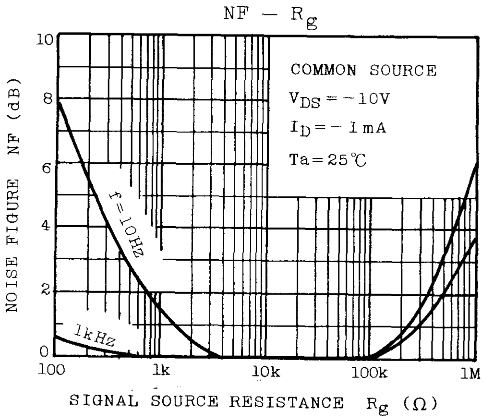


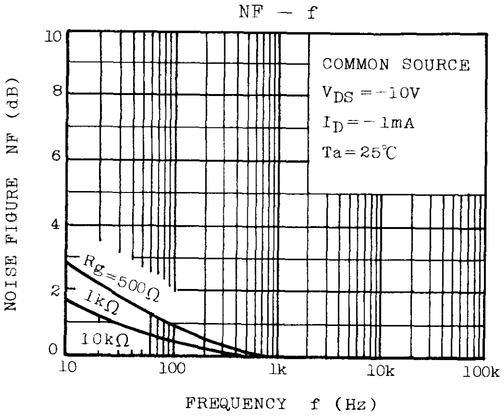
NF — I_D



NF — V_{DS}




NF — Rg
COMMON SOURCE
VDS = −10V
ID = −1mA
Ta = 25℃
f = 10Hz
1kHz
NOISE FIGURE NF (dB)
0
2
4
6
8
10
100
1k
10k
100k
1M
SIGNAL SOURCE RESISTANCE Rg (Ω)


NF — f
COMMON SOURCE
VDS = −10V
ID = −1mA
Ta = 25℃
Rg = 500Ω
1kΩ
10kΩ
NOISE FIGURE NF (dB)
0
2
4
6
8
10
10
100
1k
10k
100k
FREQUENCY f (Hz)

2SJ75

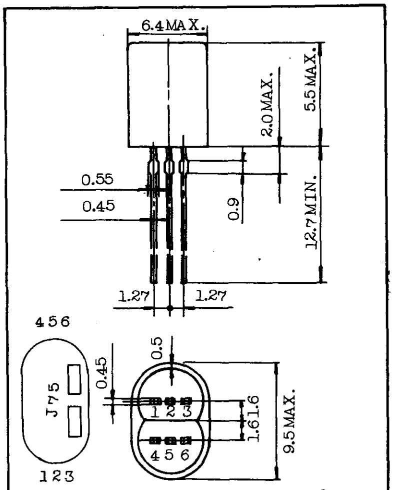
SILICON P CHANNEL JUNCTION TYPE

LOW NOISE AUDIO AMPLIFIER APPLICATIONS.
DIFFERENTIAL AMPLIFIER APPLICATIONS.

FEATURES:

- Recommended for first stages of EQ Amplifiers.
- High $|y_{fs}|$: $|y_{fs}|$=22mS(Typ.)
- Excellent Pair Characteristics
  : $|V_{GS1} - V_{GS2}|$ = 20mV (Max.)
  (V_{DS}=-10V, I_D=-1mA)
- Low Noise : e_n = 0.95nV/$\sqrt{Hz}$ (Typ.)
  (V_{DS} = -10V, I_D = -1mA, f = 1kHz)
- High Input Impedance : I_{GSS} = 1nA (Max.)
  (V_{GS}=25V)
- Complementary to 2SK240

Unit : mm



1. SOURCE 1
2. GATE 1
3. DRAIN 1
4. DRAIN 2
5. GATE 2
6. SOURCE 2

JEDEC	—
EIAJ	—
TOSHIBA	2 — 6F1B

Weight : 0.72g

MAXIMUM RATINGS (Ta=25°C)

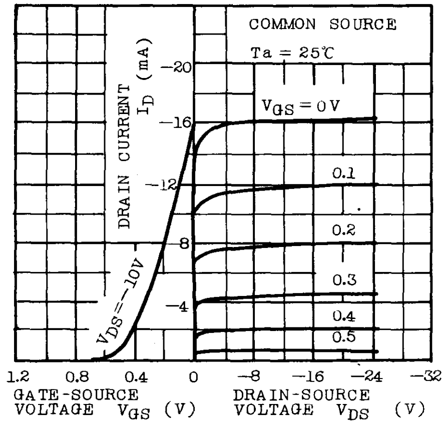
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	25	V
Gate Current	I_G	-10	mA
Drain Power Dissipation	P_D	400 × 2	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

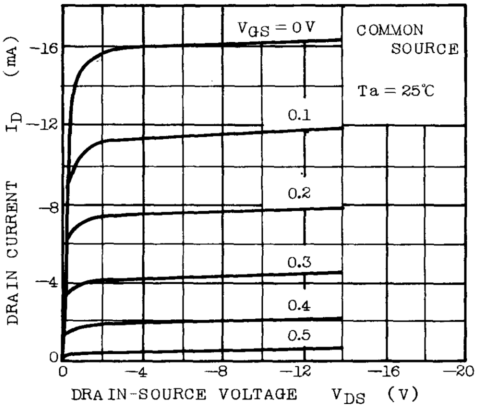
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=25V, V_{DS}=0	-	-	1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=100μA	25	-	-	V
Drain Current	I_{DSS}(Note)	V_{DS}=-10V, V_{GS}=0	-2.6	-	-20	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=-10V, I_D=-0.1μA	0.15	-	2.0	V
Forward Transfer Admittance	$\lvert y_{fs}\rvert$	V_{DS}=-10V, V_{GS}=0, f=1kHz	15	22	-	mS
Differential Gate-Source Voltage	$\lvert V_{GS1}-V_{GS2}\rvert$	V_{DS}=-10V, I_D=-1mA	-	-	20	mV
Input Capacitance	C_{iss}	V_{DS}=-10V, V_{GS}=0, f=1MHz	-	105	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=-10V, I_D=0, f=1MHz	-	32	-	pF
Noise Figure	NF(1)	V_{DS}=-10V, I_D=-1mA, Rg=1kΩ, f=10Hz	-	1.0	10	dB
	NF(2)	V_{DS}=-10V, I_D=-1mA, Rg=1kΩ, f=1kHz	-	0.5	2	

Note : I_{DSS} Classification GR : -2.6∿-6.5, BL : -60∿-12. V : -10∿-20

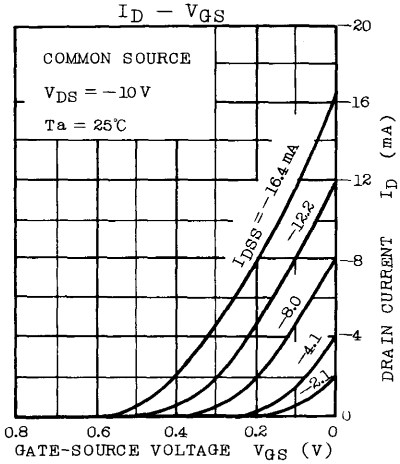
STATIC CHARACTERISTIC



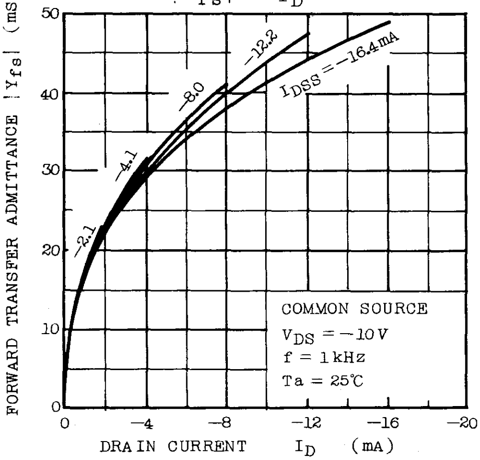
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



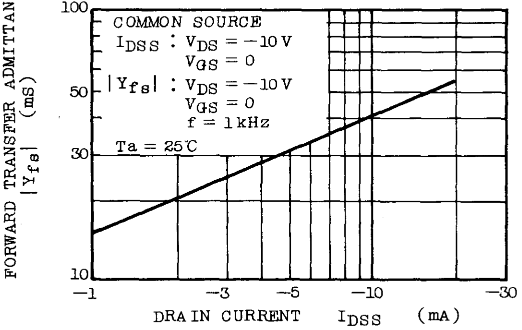
$I_D - V_{GS}$



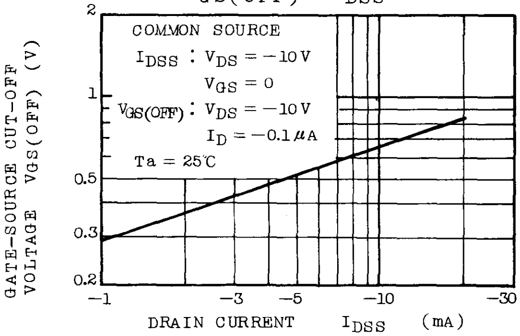
$|Y_{fs}| - I_D$



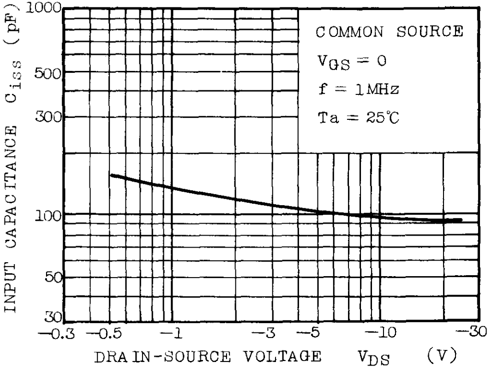
$|Y_{fs}| - I_{DSS}$



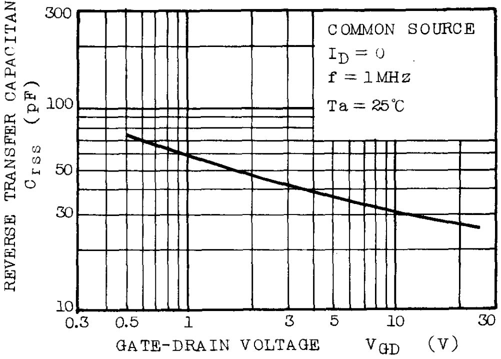
$V_{GS(OFF)} - I_{DSS}$



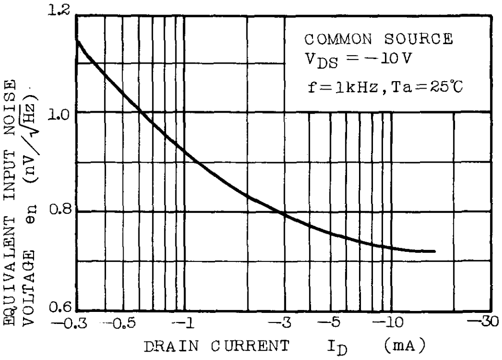
C_{iss} — V_{DS}



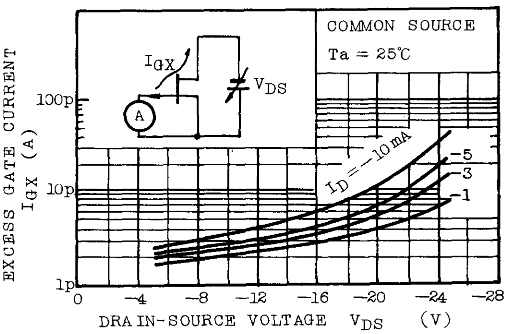
C_{rss} — V_{GD}



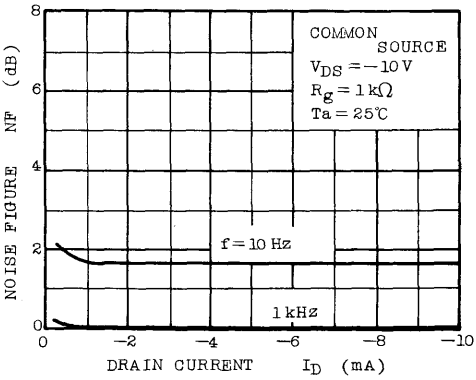
en — I_D



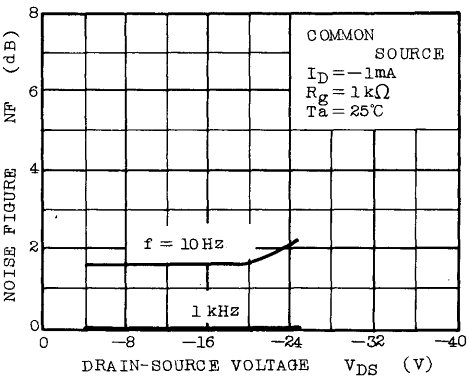
I_{GX} — V_{DS}



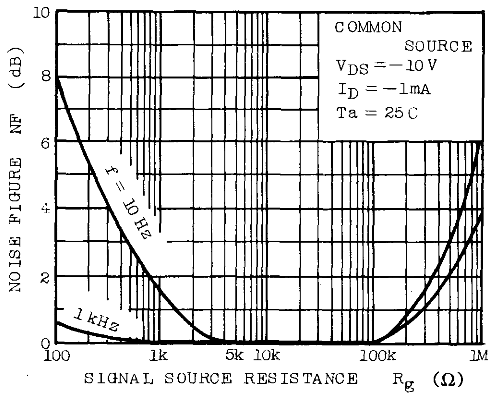
NF — I_D



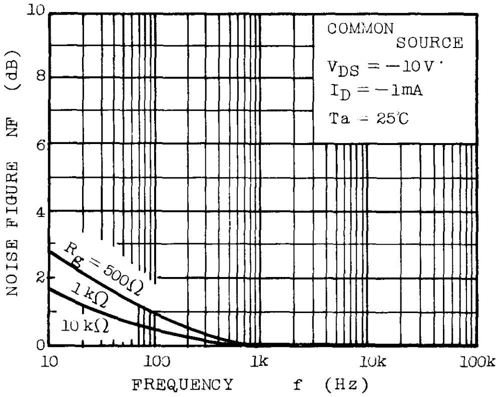
NF — V_{DS}



NF — R_g


COMMON SOURCE
V_{DS} = −10 V
I_D = −1mA
Ta = 25 C
f = 10 Hz
1 kHz
NOISE FIGURE NF (dB)
10
8
6
4
2
0
100
1k
5k
10k
100k
1M
SIGNAL SOURCE RESISTANCE R_g (Ω)

NF — f


COMMON SOURCE
V_{DS} = −10 V
I_D = −1mA
Ta = 25°C
R_g = 500Ω
1 kΩ
10 kΩ
NOISE FIGURE NF (dB)
10
8
6
4
2
0
10
100
1k
10k
100k
FREQUENCY f (Hz)

2SJ90

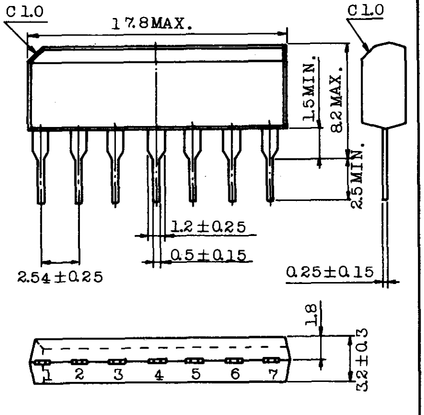
SILICON MONOLITHIC P CHANNEL JUNCTION TYPE

LOW NOISE AUDIO AMPLIFIER APPLICATIONS.
DIFFERENTIAL AMPLIFIER APPLICATIONS.

FEATURES:

- 1 Chip Dual Type.
- High $|Y_{fs}|$: $|Y_{fs}|$=22ms(Typ.)
  (V_{DS}=-10V, V_{GS}=0, f=1kHz, I_{DSS}=-3mA)
- Good Pair Characteristics :
  $|V_{GS1}-V_{GS2}|$=30mV(Max.)(V_{DS}=-10V, I_D=-1mA)
- Very Low Noise : NF=0.5dB(Typ.)
  (V_{DS}=-10V, I_D=-1mA, R_g=1kΩ, f=1kHz)
- Very High Input Impedance : I_{GSS}=10nA(Max.)
  (V_{GS}=30V, V_{DS}=0)

Unit in mm



1. DRAIN 1
2. GATE 1
3. SOURCE 1
4. SUBSTRATE
5. SOURCE 2
6. GATE 2
7. DRAIN 2

JEDEC	—
TOSHIBA	2−18A1A

Weight: 0.7g

MAXIMUM RATINGS (Ta=25°C)

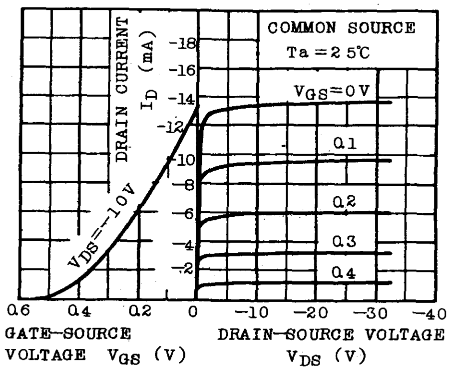
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	30	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	200	mW/UNIT
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~ 125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

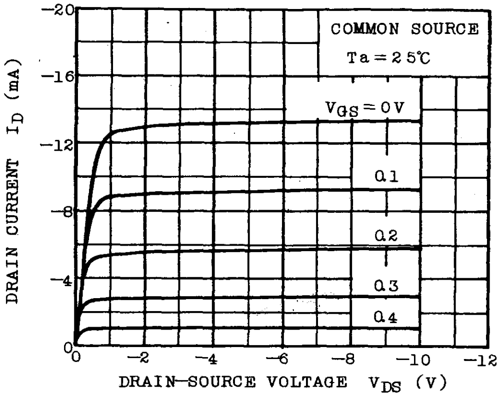
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=30V, V_{DS}=0	-	-	10	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=100μA	30	-	-	V
Drain Current	I_{DSS}(Note)	V_{DS}=-10V, V_{GS}=0	-1.0	-	-20	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=-10V, I_D=-0.1μA	0.2	-	2.0	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=-10V, V_{GS}=0, f=1kHz I_{DSS}=-3mA	8	22	-	ms
Forward Transfer Admittance Ratio	$\|Y_{fs(S)}\|$ / $\|Y_{fs(L)}\|$	V_{DS}=-10V, V_{GS}=0, f=1kHz	0.9	-	-	-
Differential Gate-Source Voltage	$\|V_{GS1}-V_{GS2}\|$	V_{DS}=-10V, I_D=-1mA	-	-	30	mV
Input Capacitance	C_{iss}	V_{DS}=-10V, V_{GS}=0, f=1MHz	-	95	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=-10V, I_D=0, f=1MHz	-	29	-	pF
Noise Figure	NF(1)	V_{DS}=-10V, R_g=1kΩ, I_D=-1mA, f=10Hz	-	-	11	dB
	NF(2)	V_{DS}=-10V, R_g=1kΩ, I_D=-1mA, f=1kHz	-	-	2	dB

Note : I_{DSS} Classification Y : -1.0 ~ -3.0mA, GR : -2.6 ~ -6.5mA,
BL : -6 ~ -12mA, V : -10 ~ -20mA

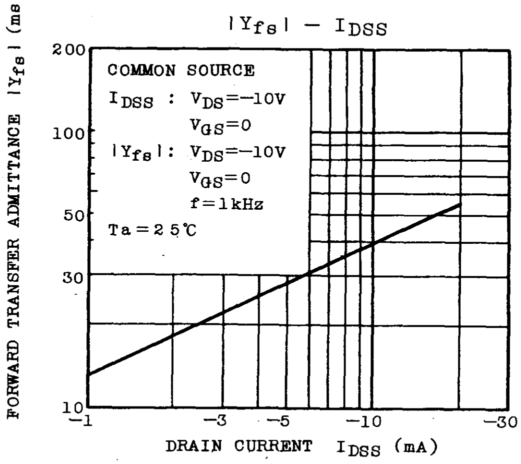
STATIC CHARACTERISTICS



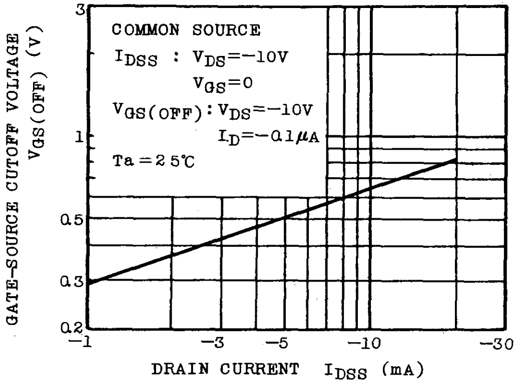
I_D – V_{DS} (LOW VOLTAGE REGION)



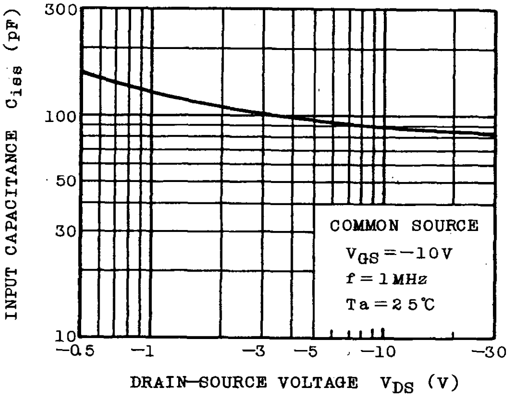
$|Y_{fs}|$ – I_{DSS}



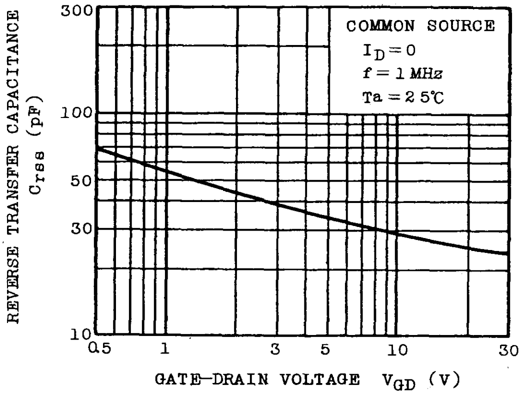
$V_{GS(OFF)}$ – I_{DSS}

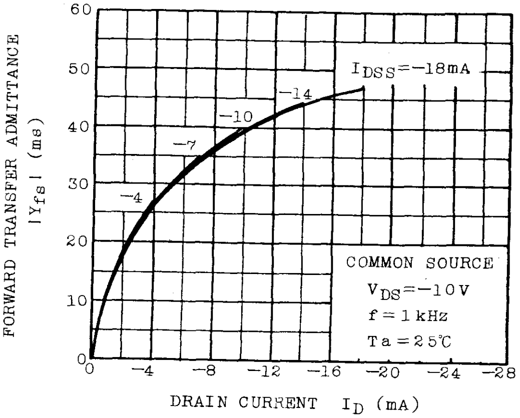


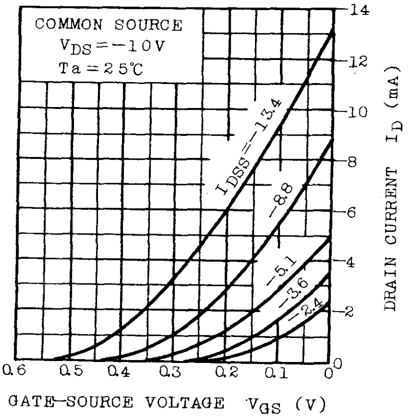
C_{iss} – V_{DS}

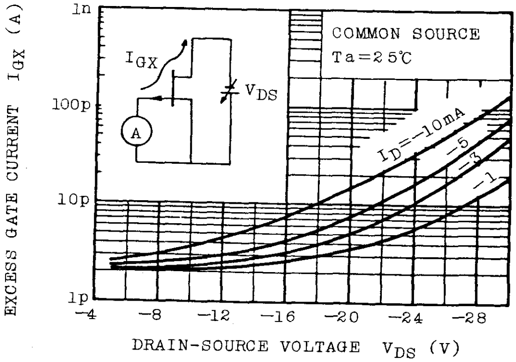


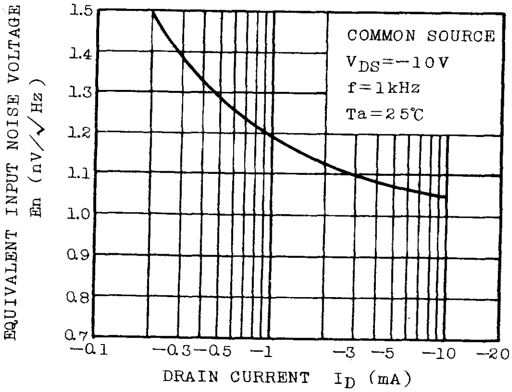
C_{rss} – V_{GD}

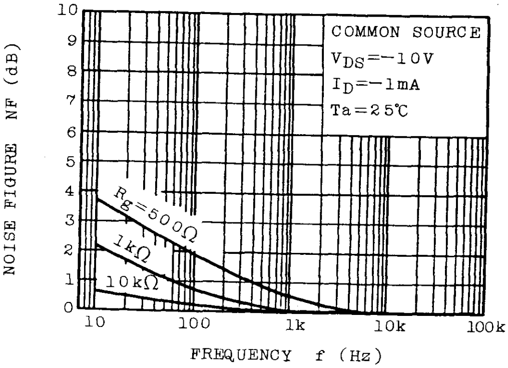


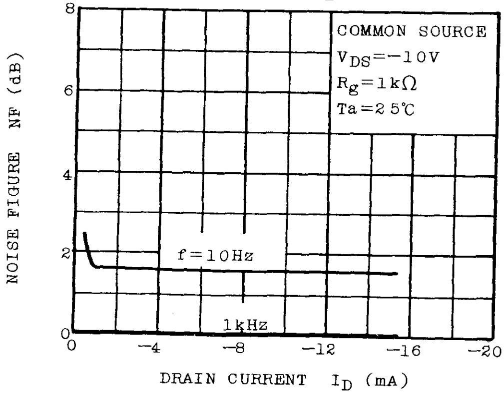

|Yfs| − ID

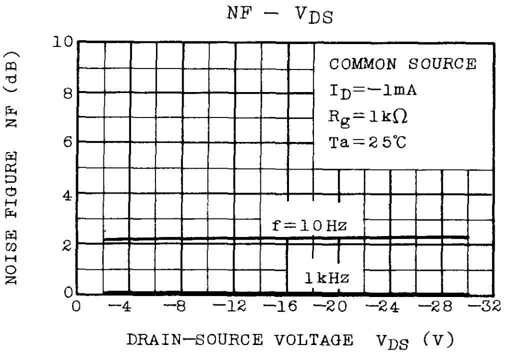

ID − VGS

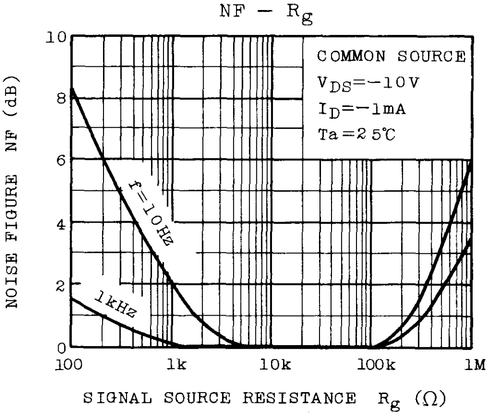

IGX − VDS


En − ID


NF − f


NF − ID


NF – V_{DS}
COMMON SOURCE
I_D=−1mA
R_g=1kΩ
Ta=25℃
f=10Hz
1kHz
NOISE FIGURE NF (dB)
10
8
6
4
2
0
0
−4
−8
−12
−16
−20
−24
−28
−32
DRAIN–SOURCE VOLTAGE V_{DS} (V)


NF – R_g
COMMON SOURCE
V_{DS}=−10V
I_D=−1mA
Ta=25℃
f=10Hz
1kHz
NOISE FIGURE NF (dB)
10
8
6
4
2
0
100
1k
10k
100k
1M
SIGNAL SOURCE RESISTANCE R_g (Ω)

2SJ103

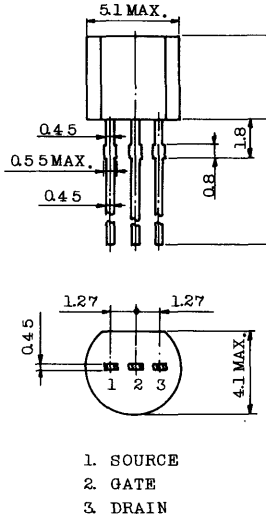
SILICON P CHANNEL JUNCTION TYPE

FOR AUDIO AMPLIFIER, ANALOG SWITCH, CONSTANT CURRENT AND IMPEDANCE CONVERTER APPLICATIONS.

FEATURES:

- High Breakdown Voltage : V_{GDS}=50V
- High Input Impedance : I_{GSS}=1.0nA (Max.) (V_{GS}=30V)
- Low $R_{DS(ON)}$: $R_{DS(ON)}$=270Ω (Typ.) (I_{DSS}=-5mA)
- Complementary to 2SK246

Unit in mm



JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1C

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

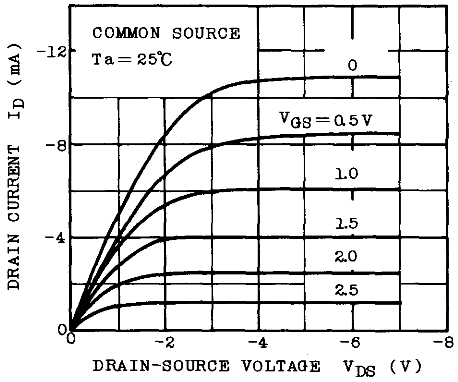
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	50	V
Gate Current	I_G	-10	mA
Drain Power Dissipation	P_D	300	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55～125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

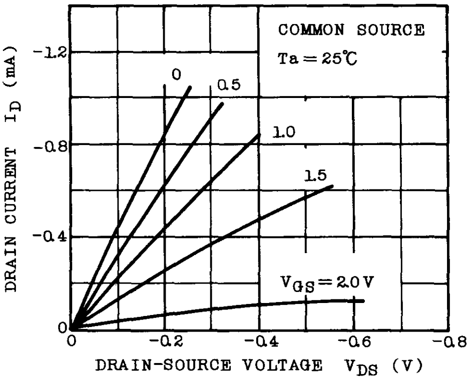
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=30V, V_{DS}=0	-	-	1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=100μA	50	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=-10V, V_{GS}=0	-1.2	-	-14	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=-10V, I_D=-0.1μA	0.3	-	6.0	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=-10V, V_{GS}=0, f=1kHz	1.0	4.0	-	mS
Drain-Source ON Resistance	$R_{DS(ON)}$	V_{DS}=-10mV, V_{GS}=0, I_{DSS}=-5mA	-	270	-	Ω
Input Capacitance	C_{iss}	V_{DS}=-10V, V_{GS}=0, f=1MHz	-	18	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=-10V, I_D=0, f=1MHz	-	3.6	-	pF

Note : I_{DSS} Classification Y : -1.2～-3.0mA, GR : -2.6～-6.5mA, BL : -6～-14mA

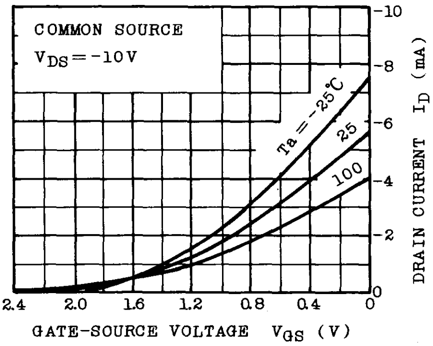
$I_D - V_{DS}$



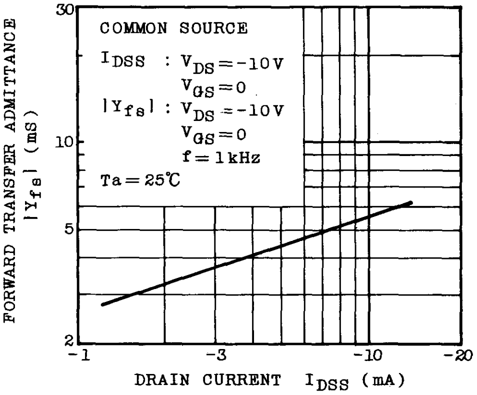
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



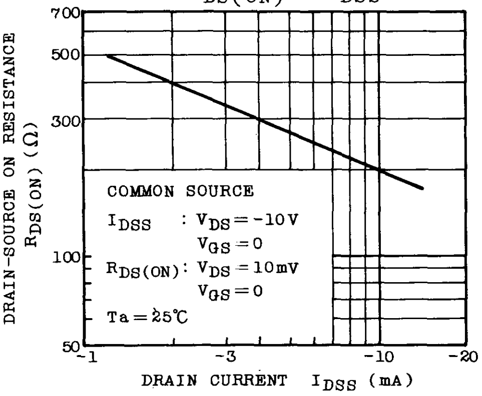
$I_D - V_{GS}$



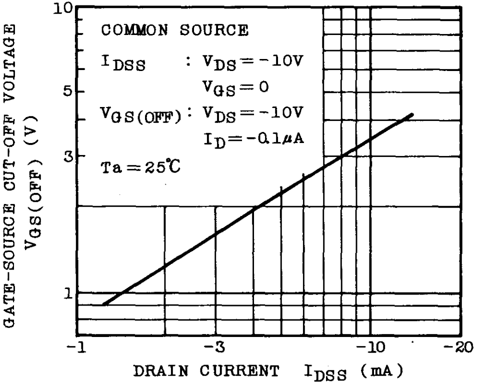
$|Y_{fs}| - I_{DSS}$

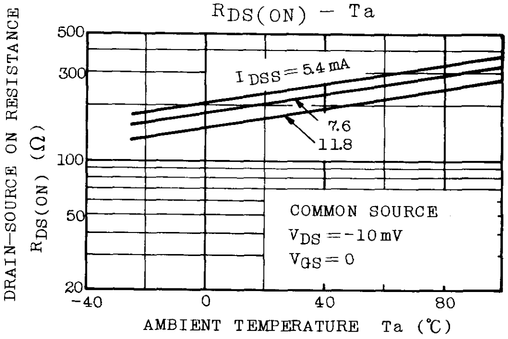


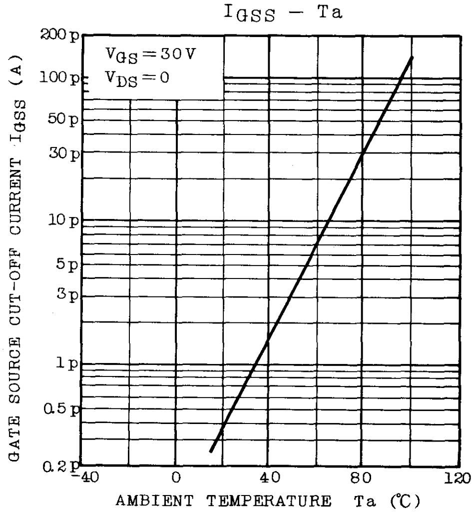
$R_{DS(ON)} - I_{DSS}$

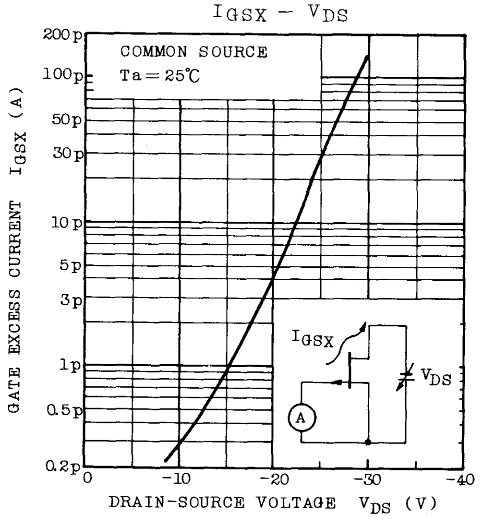


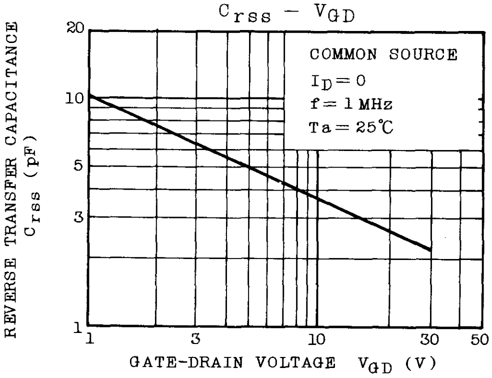
$V_{GS(OFF)} - I_{DSS}$

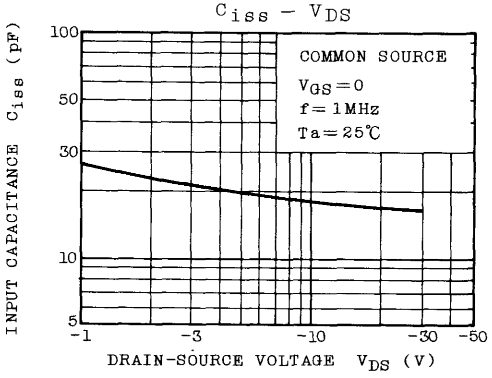


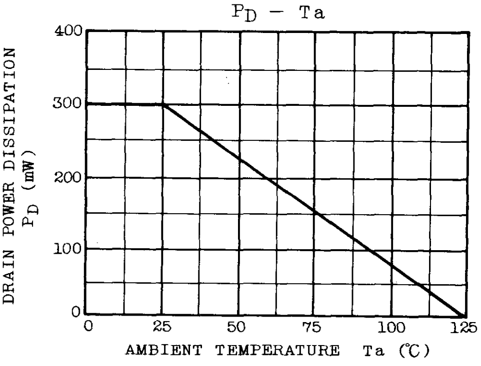

RDS(ON) – Ta
DRAIN-SOURCE ON RESISTANCE RDS(ON) (Ω)
500
300
100
50
20
I DSS = 5.4 mA
7.6
11.8
COMMON SOURCE
VDS = -10 mV
VGS = 0
-40
0
40
80
AMBIENT TEMPERATURE Ta (℃)


IGSS – Ta
GATE SOURCE CUT-OFF CURRENT IGSS (A)
VGS = 30 V
VDS = 0
200 p
100 p
50 p
30 p
10 p
5 p
3 p
1 p
0.5 p
0.2 p
-40
0
40
80
120
AMBIENT TEMPERATURE Ta (℃)


IGSX – VDS
GATE EXCESS CURRENT IGSX (A)
COMMON SOURCE
Ta = 25℃
200 p
100 p
50 p
30 p
10 p
5 p
3 p
1 p
0.5 p
0.2 p
IGSX
VDS
A
0
-10
-20
-30
-40
DRAIN-SOURCE VOLTAGE VDS (V)


Crss – VGD
REVERSE TRANSFER CAPACITANCE Crss (pF)
COMMON SOURCE
ID = 0
f = 1 MHz
Ta = 25℃
20
10
5
3
1
1
3
10
30
50
GATE-DRAIN VOLTAGE VGD (V)


Ciss – VDS
INPUT CAPACITANCE Ciss (pF)
COMMON SOURCE
VGS = 0
f = 1 MHz
Ta = 25℃
100
50
30
10
5
-1
-3
-10
-30
-50
DRAIN-SOURCE VOLTAGE VDS (V)


PD – Ta
DRAIN POWER DISSIPATION PD (mW)
400
300
200
100
0
0
25
50
75
100
125
AMBIENT TEMPERATURE Ta (℃)

SILICON P CHANNEL JUNCTION TYPE

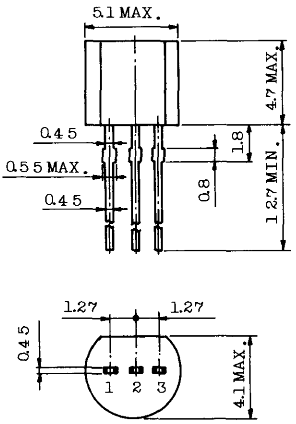
2SJ104

FOR AUDIO AMPLIFIER, ANALOG SWITCH, CONSTANT CURRENT AND IMPEDANCE CONVERTER APPLICATIONS.

FEATURES:

- High Input Impedance
  - : I_{GSS}=1.0nA (Max.) (V_{GS}=25V)
- Low $R_{DS(ON)}$=40Ω (Typ.) (I_{DSS}=-5mA)
- Complementary to 2SK364

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1D

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	25	V
Gate Current	I_G	-10	mA
Drain Power Dissipation	P_D	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55～125	°C

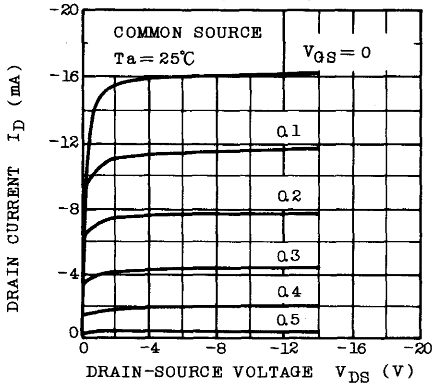
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=25V, V_{DS}=0	-	-	1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=100μA	25	-	-	V
Drain Current	I_{DSS} (Note 1)	V_{DS}=-10V, V_{GS}=0	-2.5	-	-20	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=-10V, I_D=-0.1μA	0.2	-	2.0	V
Forward Transfer Admittance	$\lvert Y_{fs} \rvert$	V_{DS}=-10V, V_{GS}=0 f=1kHz (Note 2)	12	30	-	mS
Input Capacitance	C_{iss}	V_{DS}=-10V, V_{GS}=0, f=1MHz	-	105	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=-10V, I_D=0, f=1MHz	-	32	-	pF
Drain-Source ON Resistance	$R_{DS(ON)}$	V_{DS}=-10mV, V_{GS}=0 (Note 2)	-	40	-	Ω

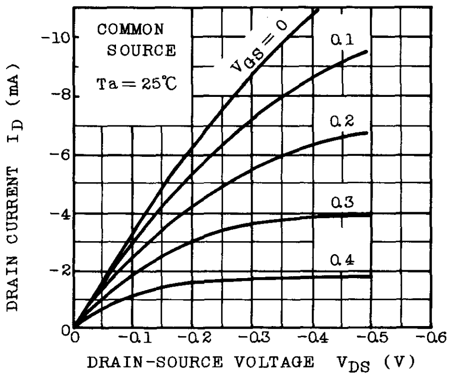
Note 1 : I_{DSS} Classification GR : -2.6～-6.5, BL : -6～-21, V : -10～-20

2 : Concition of the typical value I_{DSS}=-5mA

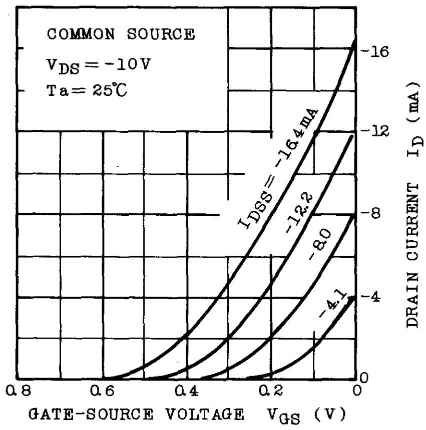
$I_D - V_{DS}$



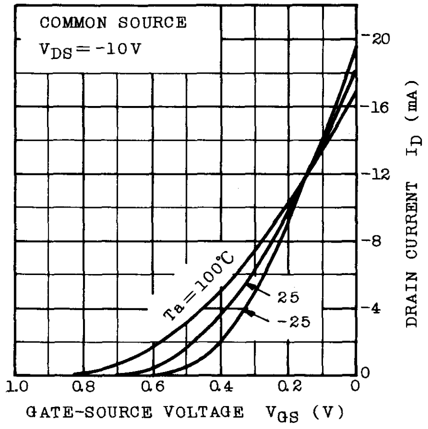
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



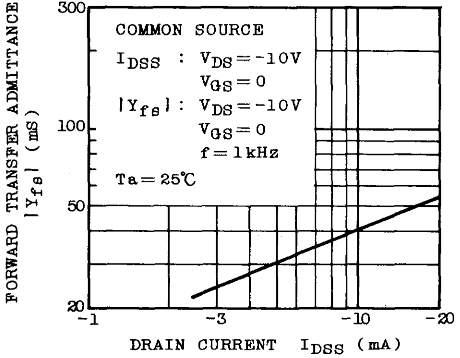
$I_D - V_{GS}$



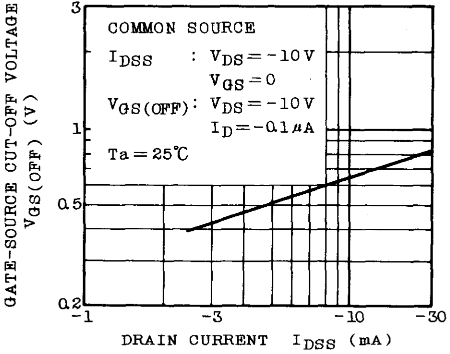
$I_D - V_{GS}$ (TEMPERATURE DEPENDENCY)

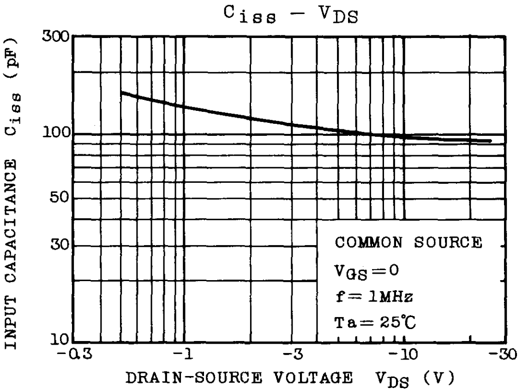


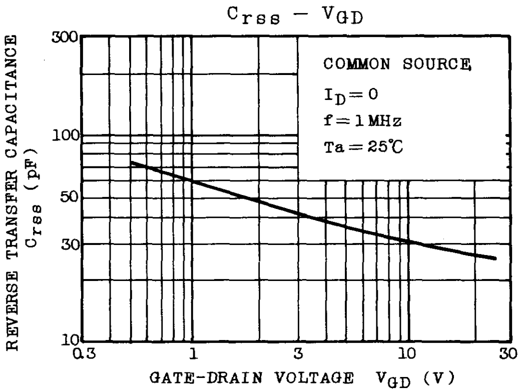
$|Y_{fs}| - I_{DSS}$

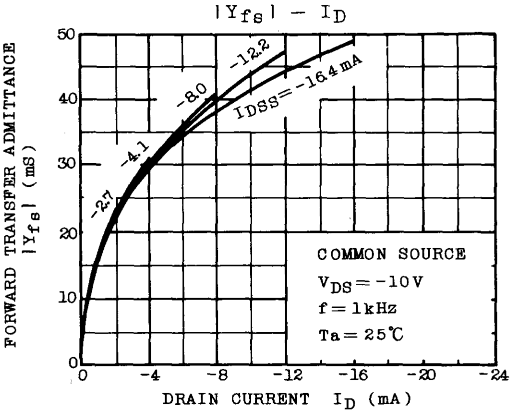


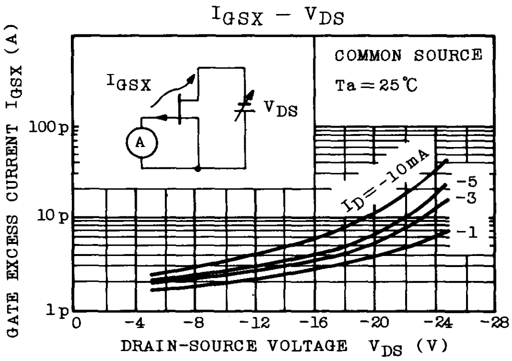
$V_{GS(OFF)} - I_{DSS}$

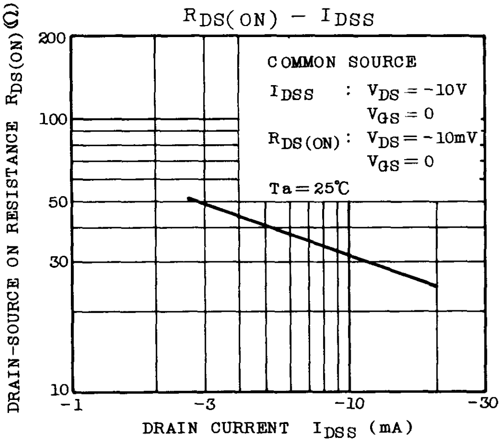


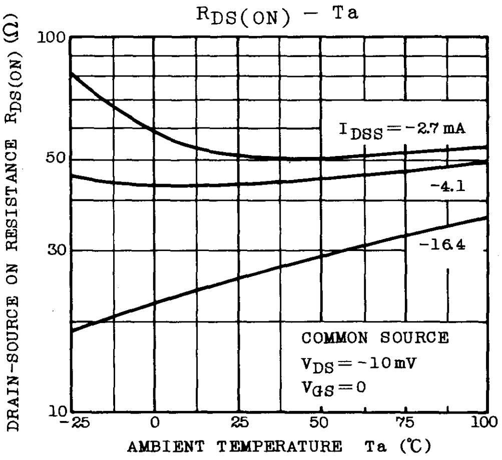

Ciss – VDS
INPUT CAPACITANCE Ciss (pF)
300
100
50
30
10
-0.3
-1
-3
-10
-30
DRAIN-SOURCE VOLTAGE VDS (V)
COMMON SOURCE
VGS = 0
f = 1MHz
Ta = 25°C

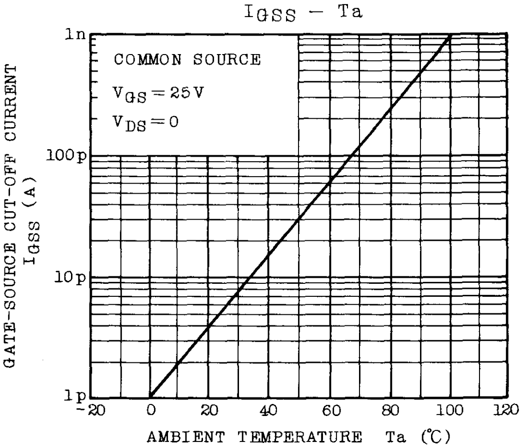

Crss – VGD
REVERSE TRANSFER CAPACITANCE Crss (pF)
300
100
50
30
10
0.3
1
3
10
30
GATE-DRAIN VOLTAGE VGD (V)
COMMON SOURCE
ID = 0
f = 1MHz
Ta = 25°C

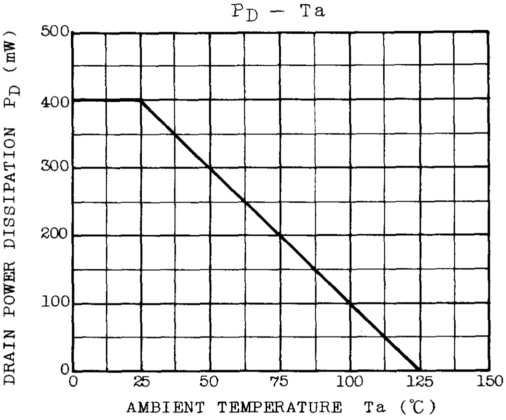

|Yfs| – ID
FORWARD TRANSFER ADMITTANCE |Yfs| (mS)
50
40
30
20
10
0
0
-4
-8
-12
-16
-20
-24
DRAIN CURRENT ID (mA)
-2.7
-4.1
-8.0
-12.2
IDSS = -16.4mA
COMMON SOURCE
VDS = -10V
f = 1kHz
Ta = 25°C


IGSX – VDS
GATE EXCESS CURRENT IGSX (A)
100p
10p
1p
0
-4
-8
-12
-16
-20
-24
-28
DRAIN-SOURCE VOLTAGE VDS (V)
IGSX
VDS
A
COMMON SOURCE
Ta = 25°C
ID = -10mA
-5
-3
-1


RDS(ON) – IDSS
DRAIN-SOURCE ON RESISTANCE RDS(ON) (Ω)
200
100
50
30
10
-1
-3
-10
-30
DRAIN CURRENT IDSS (mA)
COMMON SOURCE
IDSS : VDS = -10V
VGS = 0
RDS(ON) : VDS = -10mV
VGS = 0
Ta = 25°C


RDS(ON) – Ta
DRAIN-SOURCE ON RESISTANCE RDS(ON) (Ω)
100
50
30
10
-25
0
25
50
75
100
AMBIENT TEMPERATURE Ta (°C)
IDSS = -2.7mA
-4.1
-16.4
COMMON SOURCE
VDS = -10mV
VGS = 0


I_{GSS} − Ta
COMMON SOURCE
V_{GS} = 25V
V_{DS} = 0
GATE-SOURCE CUT-OFF CURRENT I_{GSS} (A)
1n
100p
10p
1p
−20
0
20
40
60
80
100
120
AMBIENT TEMPERATURE Ta (℃)


P_D − Ta
DRAIN POWER DISSIPATION P_D (mW)
500
400
300
200
100
0
0
25
50
75
100
125
150
AMBIENT TEMPERATURE Ta (℃)

SILICON P CHANNEL JUNCTION TYPE

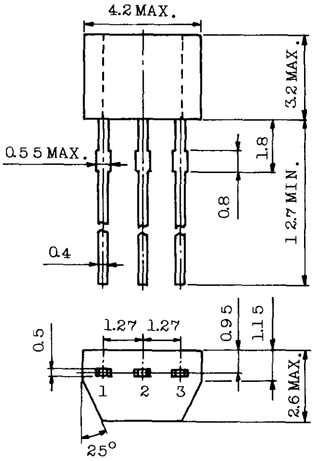
2SJ105

FOR AUDIO AMPLIFIER, ANALOG SWITCH, CONSTANT CURRENT AND IMPEDANCE CONVERTER APPLICATIONS.

FEATURES:

- High Breakdown Voltage : V_{GDS}=50V
- High Input Impedance : I_{GSS}=1.0nA (Max.)(V_{GS}=30V)
- Low $R_{DS(ON)}$: $R_{DS(ON)}$=270Ω(Typ.) (I_{DSS}=-5mA)
- Complementary to 2SK330
- Small Package

Unit in mm



1. SOURCE
2. GATE
3. DRAIN

JEDEC	—
EIAJ	—
TOSHIBA	2−4E1B

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

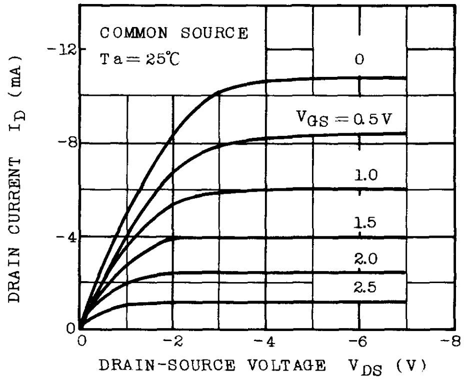
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	50	V
Gate Current	I_G	-10	mA
Drain Power Dissipation	P_D	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

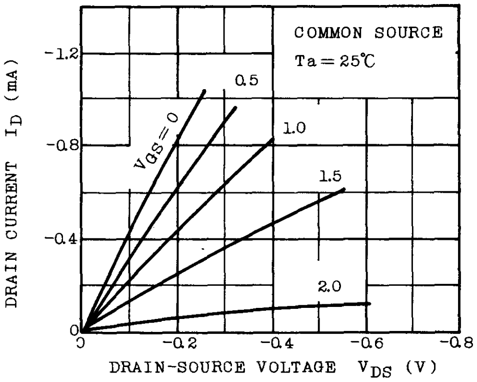
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=30V, V_{DS}=0	-	-	1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=100μA	50	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=-10V, V_{GS}=0	-1.2	-	-14	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=-10V, I_D=-0.1μA	0.3	-	6.0	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=-10V, V_{GS}=0, f=1kHz	1.0	4.0	-	mS
Drain-Source ON Resistance	$R_{DS(ON)}$	V_{DS}=-10mV, V_{GS}=0 I_{DSS}=-5mA	-	270	-	Ω
Input Capacitance	C_{iss}	V_{DS}=-10V, V_{GS}=0, f=1MHz	-	18	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=-10V, I_D=0, f=1MHz	-	3.6	-	pF

Note : I_{DSS} Classification Y : -1.2~-3.0mA, GR : -2.6~-6.5mA, BL : -6~-14mA

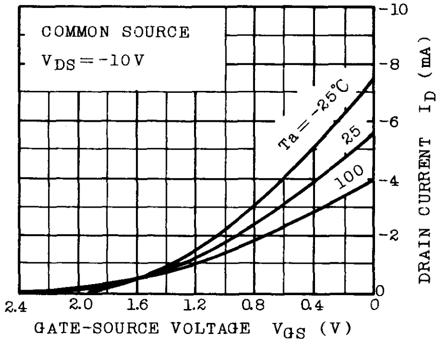
$I_D - V_{DS}$



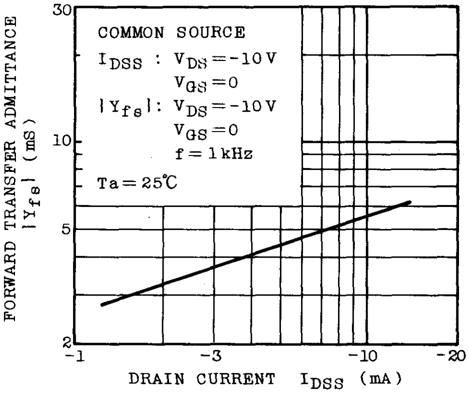
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



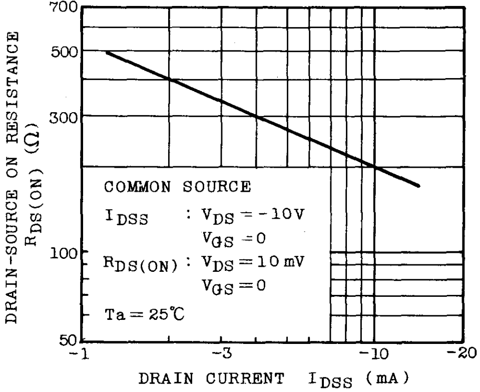
$I_D - V_{GS}$



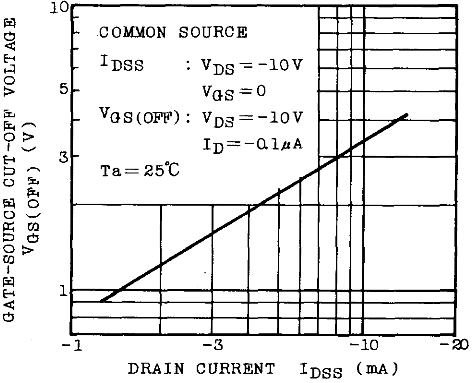
$|Y_{fs}| - I_{DSS}$



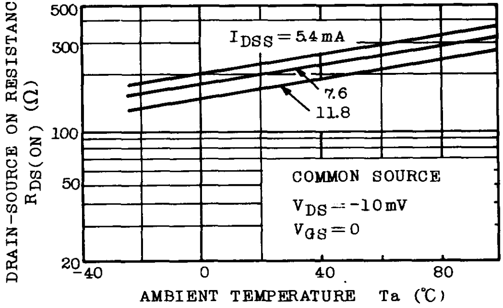
$R_{DS(ON)} - I_{DSS}$



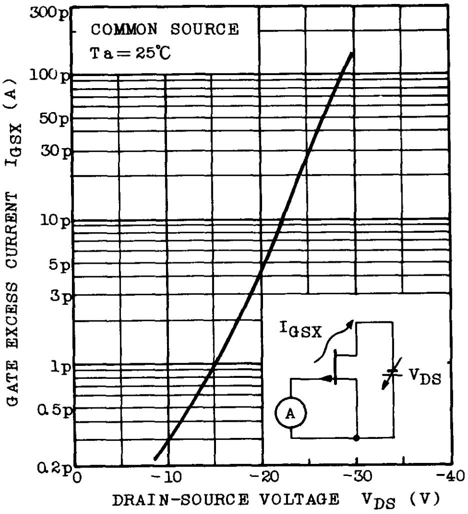
$V_{GS(OFF)} - I_{DSS}$



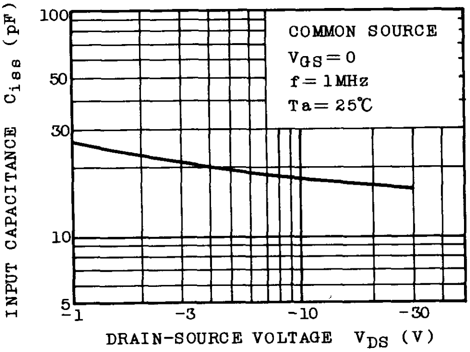
$R_{DS(ON)}$ – Ta



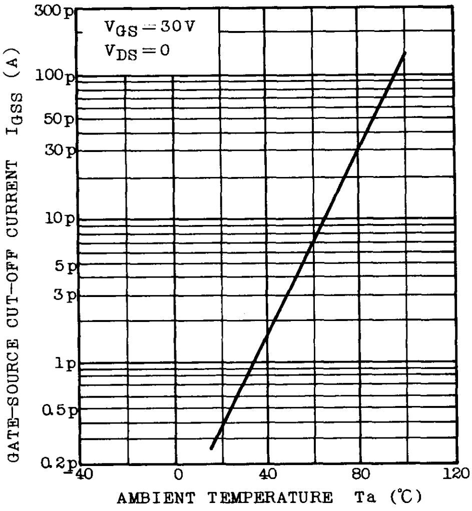
I_{GSX} – V_{DS}



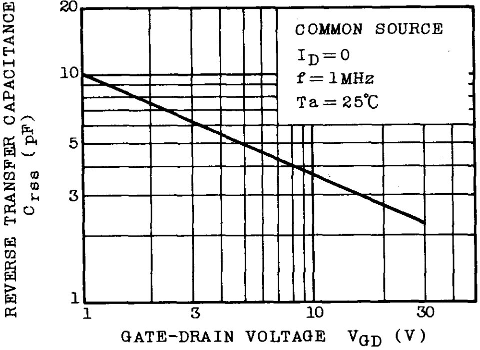
C_{iss} – V_{DS}



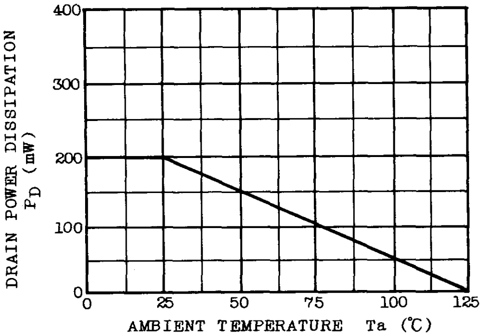
I_{GSS} – Ta



C_{rss} – V_{GD}



P_D – Ta

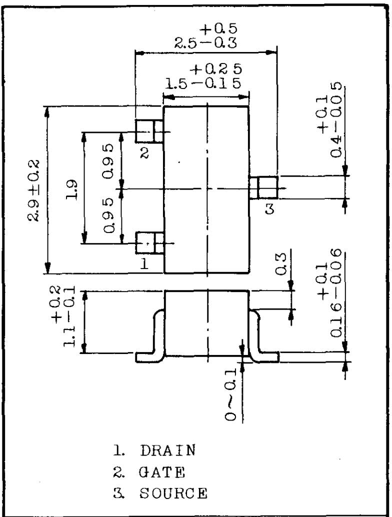


2SJ106

SILICON P CHANNEL JUNCTION TYPE

AUDIO FREQUENCY AMPLIFIER APPLICATIONS.
ANALOG SWITCH APPLICATIONS.
CONSTANT CURRENT APPLICATIONS.
IMPEDANCE CONVERTER APPLICATIONS.

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

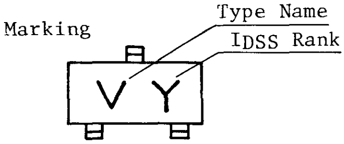
JEDEC	—
EIAJ	SC−59
TOSHIBA	2−3F1B

Weight : 0.012g

FEATURES:

- High Breakdown Voltage : V_{GDS}=50V (Min.)
- High Input Impedance : I_{GSS}=1.0nA (Max.) (V_{GS}=30V)
- Low $R_{DS(ON)}$: $R_{DS(ON)}$=270Ω (Typ.) (I_{DSS}=−5mA)
- Small Package

Marking



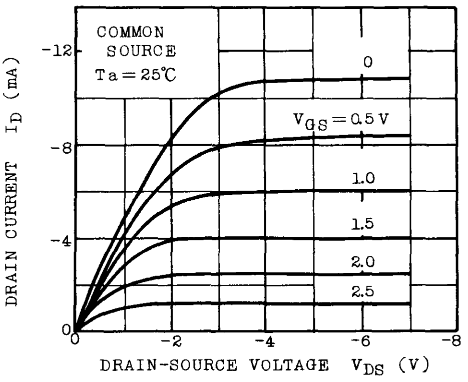
MAXIMUM RATINGS (Ta=25°C)

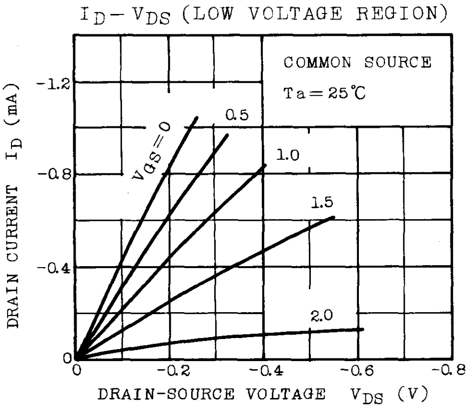
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	50	V
Gate Current	I_G	-10	mA
Drain Power Dissipation	P_D	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~ 125	°C

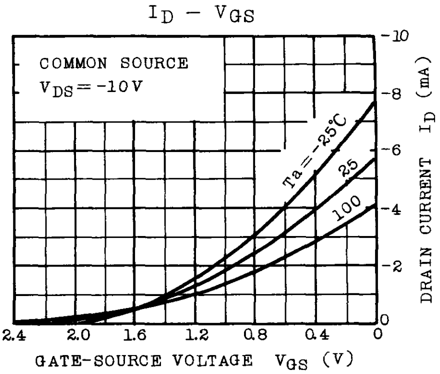
ELECTRICAL CHARACTERISTICS (Ta=25°C)

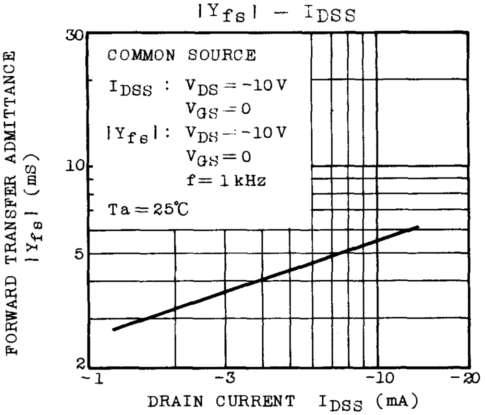
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=30V, V_{DS}=0	-	-	1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=100 A	50	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=-10V, V_{GS}=0	-1.2	-	-14	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=-10V, I_D=-0.1 A	0.3	-	6.0	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=-10V, V_{GS}=0, f=1kHz	1.0	4.0	-	mS
Drain-Source On Resistance	$R_{DS(ON)}$	V_{DS}=-10mA, V_{GS}=0 I_{DSS}=-5mA	-	270	-	Ω
Input Capacitance	C_{iss}	V_{DS}=-10V, V_{GS}=0, f=1MHz	-	18	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=-10V, I_D=0, f=1MHz	-	3.6	-	pF

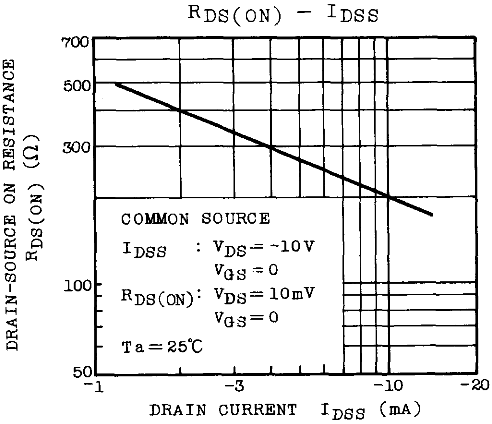
Note : I_{DSS} Classification Y : -1.2 ~ 3.0mA, GR(G) : -2.6 ~ -6.5mA, BL(L) : -6 ~ 14mA

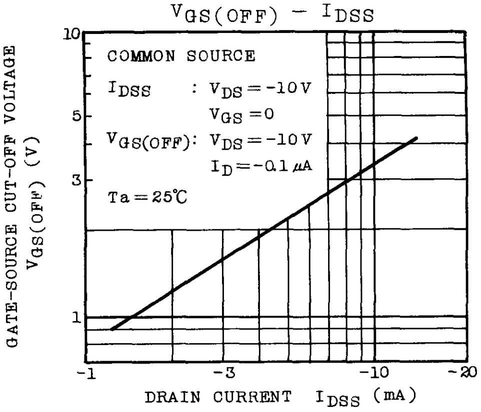

$I_D - V_{DS}$

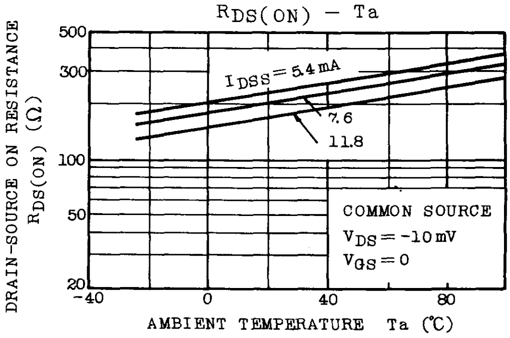

$I_D - V_{DS}$ (LOW VOLTAGE REGION)

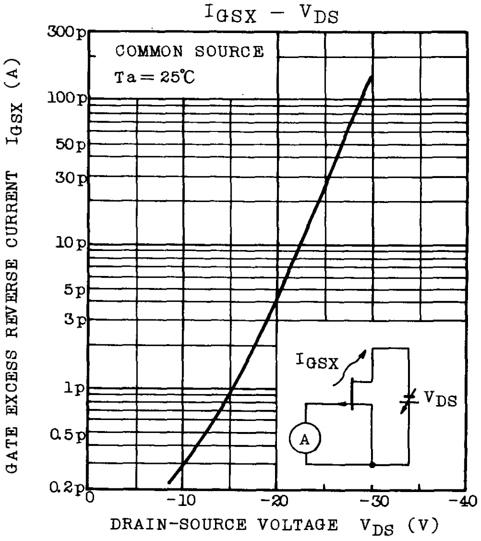

$I_D - V_{GS}$

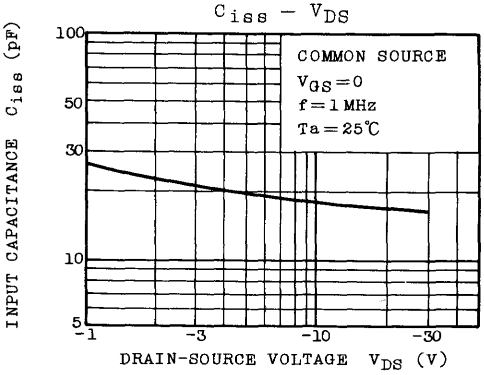

$|Y_{fs}| - I_{DSS}$

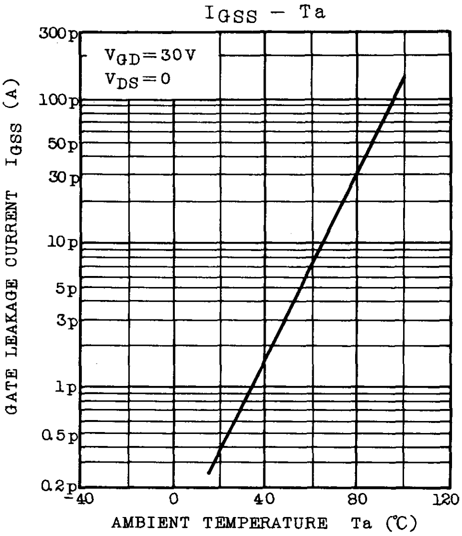

$R_{DS(ON)} - I_{DSS}$

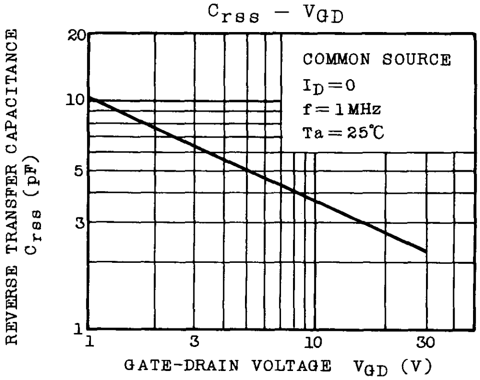

$V_{GS(OFF)} - I_{DSS}$

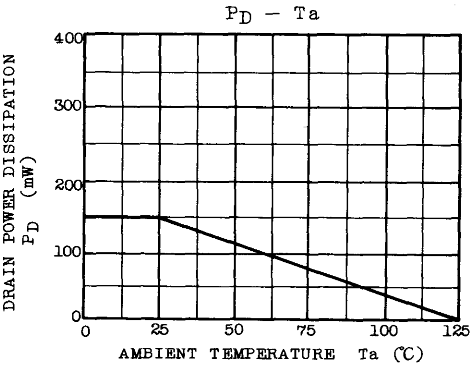

$R_{DS(ON)}$ — Ta


I_{GSX} — V_{DS}


C_{iss} — V_{DS}


I_{GSS} — Ta


C_{rss} — V_{GD}


P_D — Ta

SILICON P CHANNEL JUNCTION TYPE

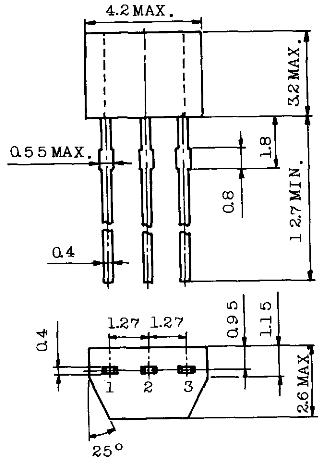
2SJ107

FOR AUDIO AMPLIFIER, ANALOG SWITCH, CONSTANT CURRENT AND IMPEDANCE CONVERTER APPLICATIONS.

FEATURES:

- High Input Impedance : I_{GSS}=1.0nA (Max.) (V_{GS}=25V)
- Low $R_{DS(ON)}$: $R_{DS(ON)}$=40Ω (Typ.)
- Small Package
- Complementary to 2SK366

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

JEDEC	–
EIAJ	–
TOSHIBA	2–4E1C

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

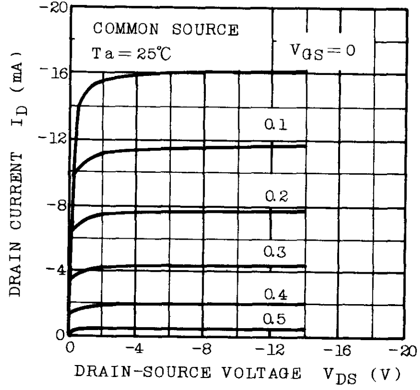
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	25	V
Gate Current	I_G	-10	mA
Drain Power Dissipation	P_D	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55～125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

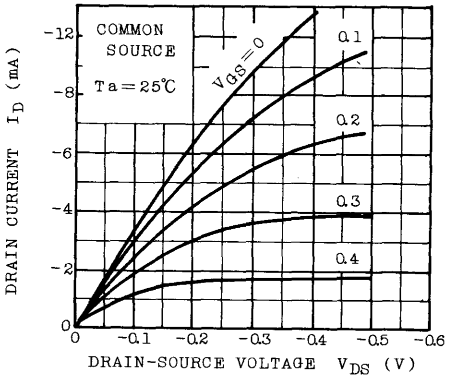
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=25V, V_{DS}=0	-	-	1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=100μA	25	-	-	V
Drain Current	I_{DSS} (Note 1)	V_{DS}=-10V, V_{GS}=0	-2.6	-	-20	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=-10V, I_D=-0.1μA	0.2	-	2.0	V
Forward Transfer Admittance	$\lvert Y_{fs}\rvert$	V_{DS}=-10V, V_{GS}=0 f=1kHz (Note 2)	12	30	-	mS
Input Capacitance	C_{iss}	V_{DS}=-10V, V_{GS}=0, f=1MHz	-	105	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=-10V, I_D=0, f=1MHz	-	32	-	pF
Drain-Source ON Resistance	$R_{DS(ON)}$	V_{DS}=-10mV, V_{GS}=0 (Note 2)	-	40	-	Ω

Note 1 : I_{DSS} Classification GR : -2.6～6.5, BL : -6～-12, V : -10～-20

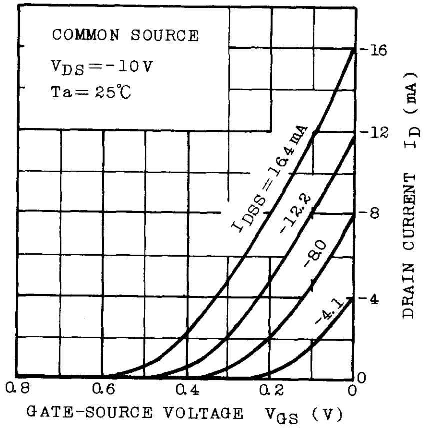
2 : Condition of the typical value I_{DSS}=-5mA



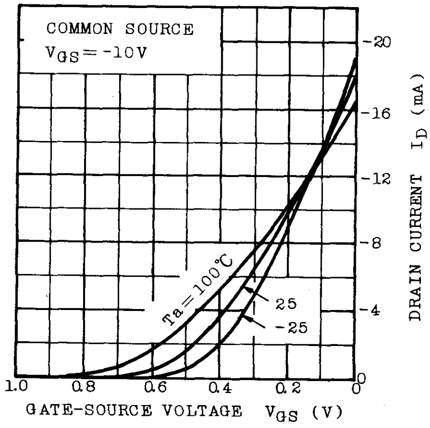
I_D – V_{DS}



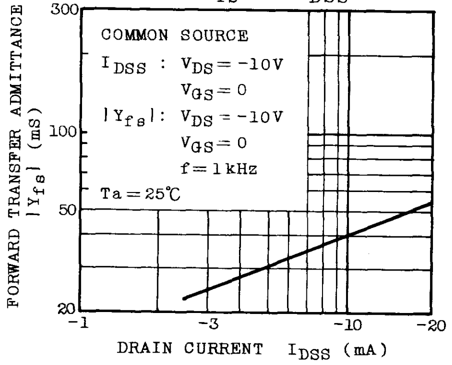
I_D – V_{DS} (LOW VOLTAGE REGION)



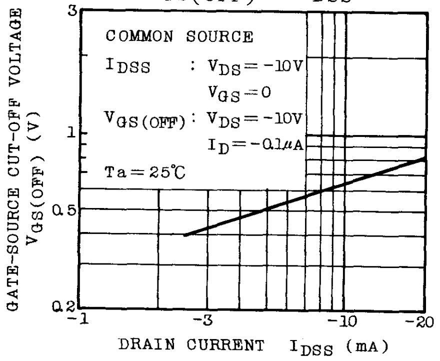
I_D – V_{GS}



I_D – V_{GS} (TEMPERATURE DEPENDENCY)

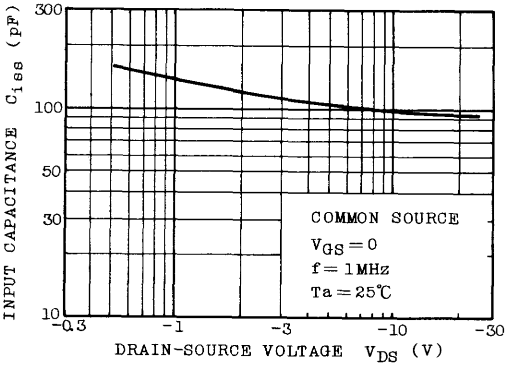


$|Y_{fs}|$ – I_{DSS}

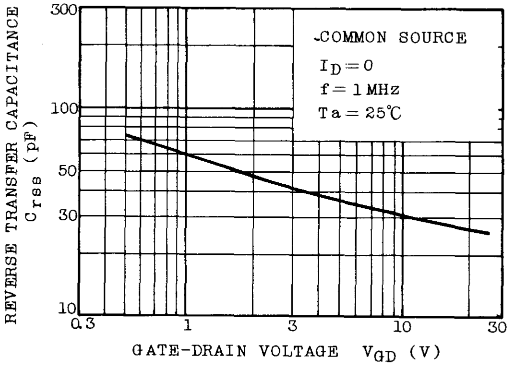


$V_{GS(OFF)}$ – I_{DSS}

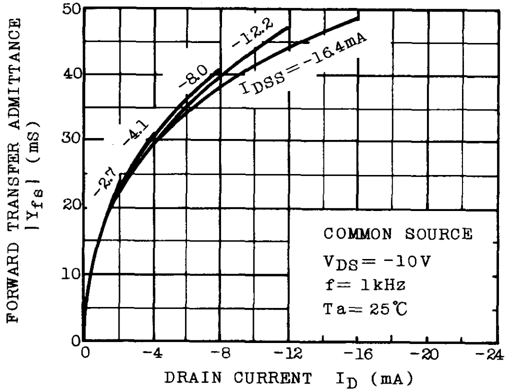
$C_{iss} - V_{DS}$



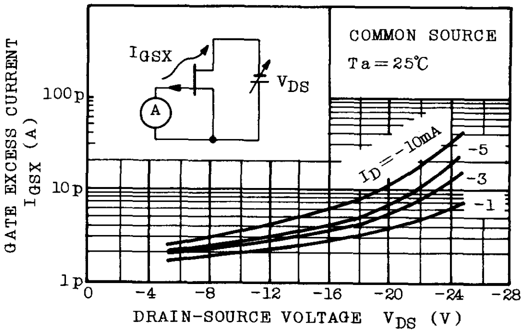
$C_{rss} - V_{GD}$



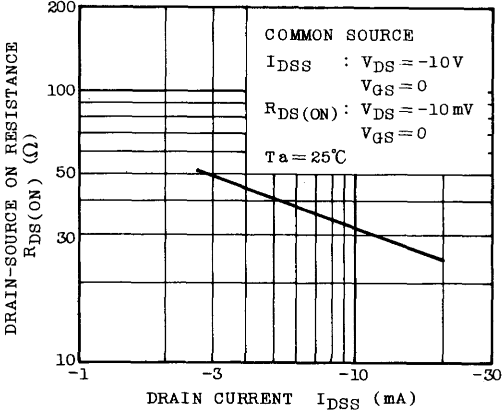
$|Y_{fs}| - I_D$



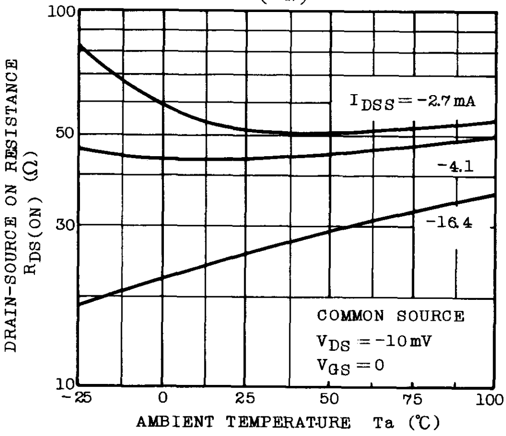
$I_{GSX} - V_{DS}$

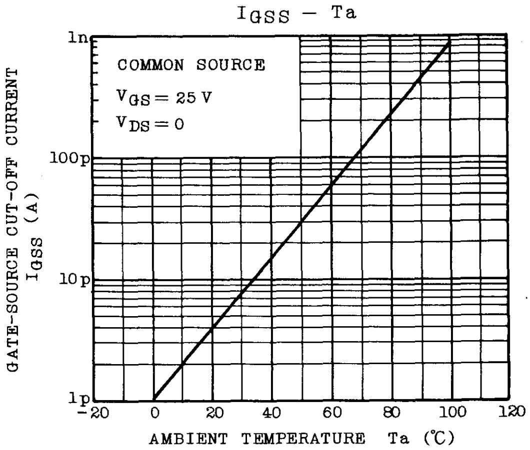


$R_{DS(ON)} - I_{DSS}$

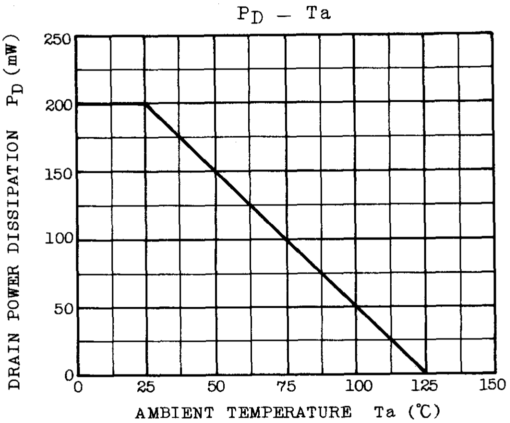


$R_{DS(ON)} - Ta$





I_{GSS} – Ta
COMMON SOURCE
$V_{GS} = 25$ V
$V_{DS} = 0$
GATE-SOURCE CUT-OFF CURRENT I_{GSS} (A)
1n
100p
10p
1p
−20
0
20
40
60
80
100
120
AMBIENT TEMPERATURE Ta (℃)



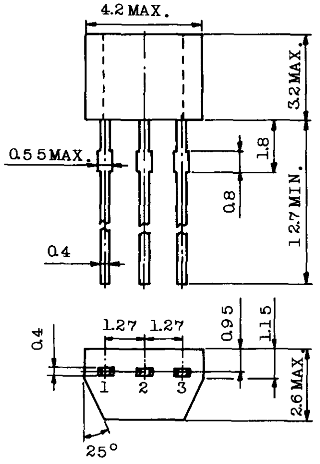
P_D – Ta
DRAIN POWER DISSIPATION P_D (mW)
250
200
150
100
50
0
0
25
50
75
100
125
150
AMBIENT TEMPERATURE Ta (℃)

SILICON P CHANNEL JUNCTION TYPE

2SJ108

LOW NOISE AUDIO AMPLIFIER APPLICATIONS.

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

JEDEC	―
EIAJ	―
TOSHIBA	2-4E1C

Weight : 0.13g

FEATURES:

- Recommended for First Stages of EQ Amplifiers and MC Head Amplifiers.
- High $|Y_{fs}|$
  : $|Y_{fs}|$ =22mS(Typ.) (V_{DS}=-10V, V_{GS}=0, I_{DSS}=-3mA)
- Low Noise : e_n=0.95nV/$\sqrt{Hz}$ (Typ.)
  (V_{DS}=-10V, I_D=-1mA, f=1kHz)
- High Input Impedance : I_{GSS}=1.0nA(Max.) (V_{DG}=-25V)
- Complementary to 2SK370
- Small Package

MAXIMUM RATINGS (Ta=25°C)

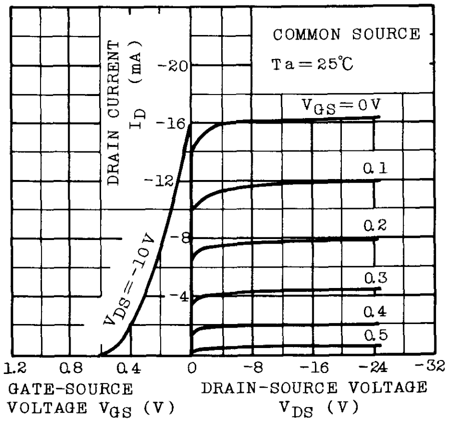
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	25	V
Gate Current	I_G	-10	mA
Drain Power Dissipation	P_D	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

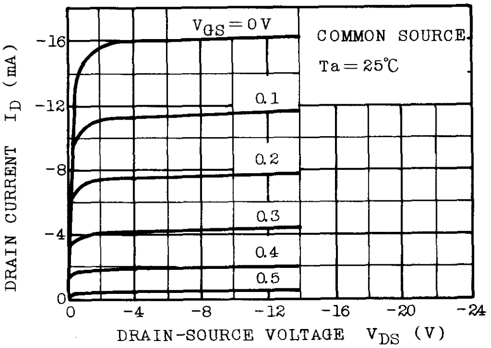
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=25V, V_{DS}=0	-	-	1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=100μA	25	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=-10V, V_{GS}=0	-1	-	-20	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=-10V, I_D=-0.1μA	0.15	-	2.0	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=-10V, V_{GS}=0, f=1kHz	8	22	-	mS
Input Capacitance	C_{iss}	V_{DS}=-10V, V_{GS}=0, f=1MHz	-	105	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DS}=-10V, I_D=0, f=1MHz	-	32	-	pF
Noise Figure	NF(1)	V_{DS}=-10V, I_D=-1mA R_g=1kΩ , f=10Hz	-	1.0	10	dB
	NF(2)	V_{DS}=-10V, I_D=-1mA R_g=1kΩ , f=1kHz	-	0.5	2	

Note : I_{DSS} Classification Y : -1.0~-3.0, GR : -2.6~-6.5
BL : -60~-12, V : -10~-20

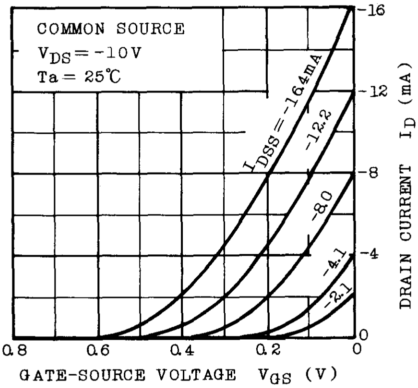
STATIC CHARACTERISTICS



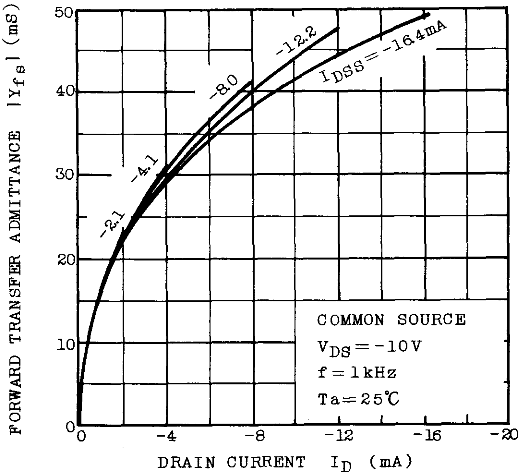
I_D – V_{DS} (LOW VOLTAGE REGION)



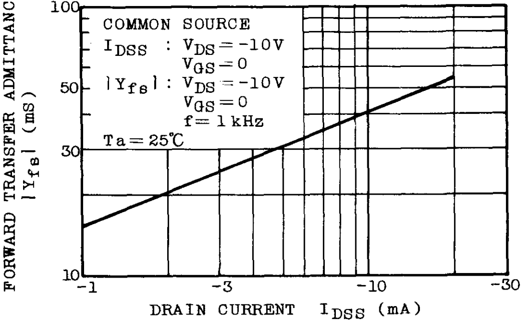
I_D – V_{GS}



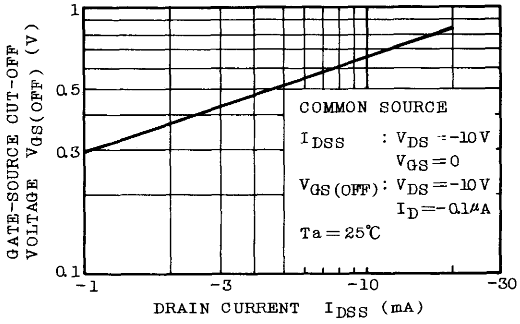
$|Y_{fs}|$ – I_D

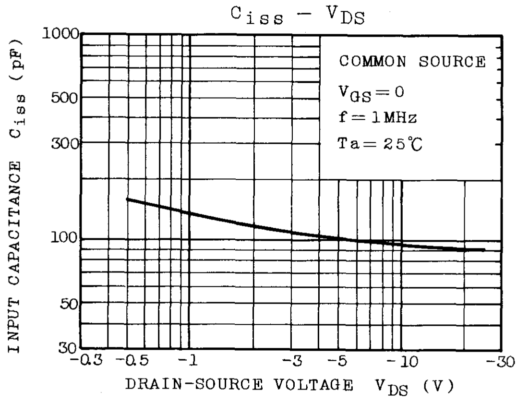


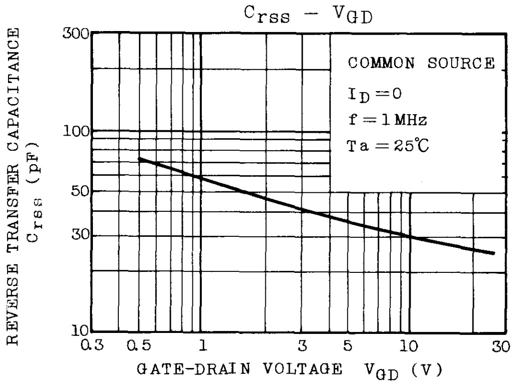
$|Y_{fs}|$ – I_{DSS}

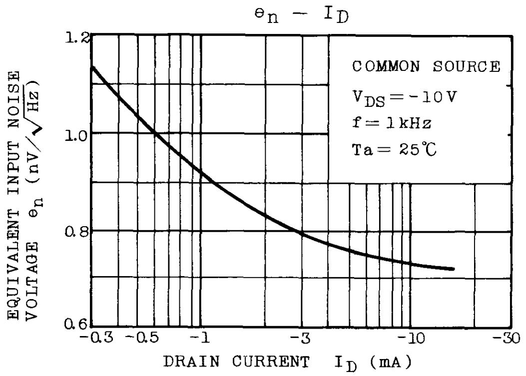


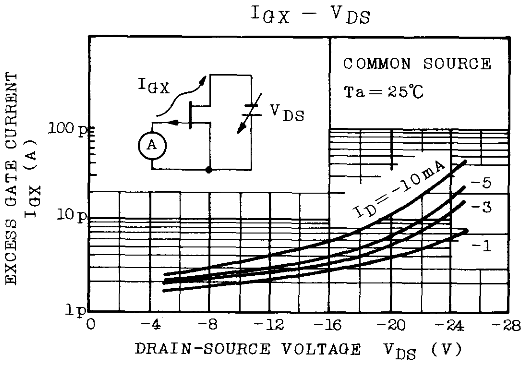
$V_{GS(OFF)}$ – I_{DSS}

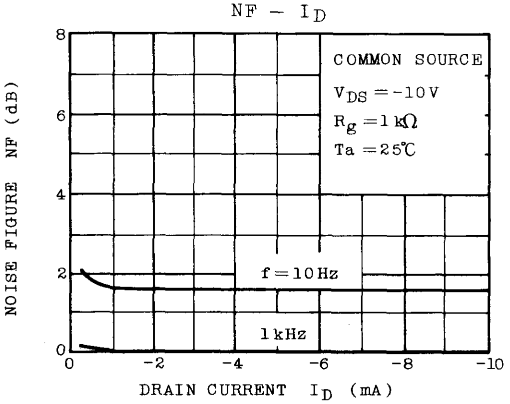


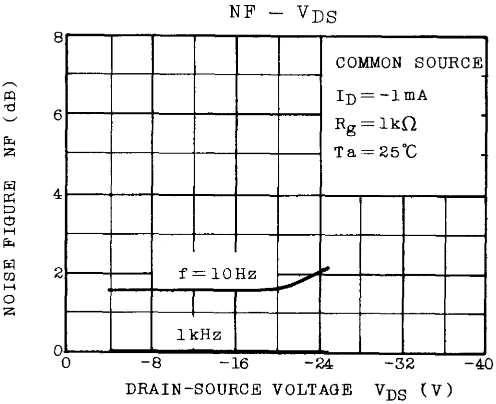

Ciss – VDS
INPUT CAPACITANCE Ciss (pF)
1000
500
300
100
50
30
COMMON SOURCE
VGS = 0
f = 1 MHz
Ta = 25℃
-0.3
-0.5
-1
-3
-5
-10
-30
DRAIN-SOURCE VOLTAGE VDS (V)

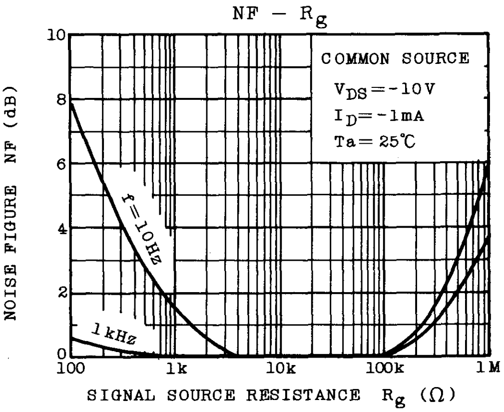

Crss – VGD
REVERSE TRANSFER CAPACITANCE Crss (pF)
300
100
50
30
10
COMMON SOURCE
ID = 0
f = 1 MHz
Ta = 25℃
0.3
0.5
1
3
5
10
30
GATE-DRAIN VOLTAGE VGD (V)

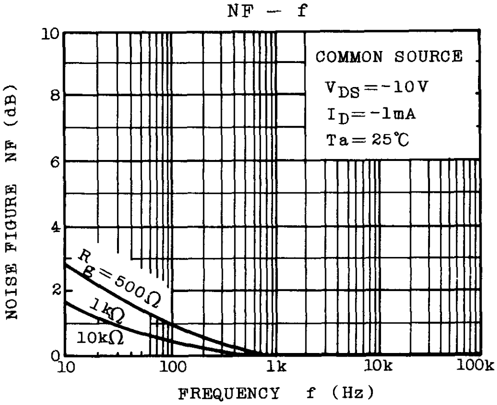

en – ID
EQUIVALENT INPUT NOISE VOLTAGE en (nV/√Hz)
1.2
1.0
0.8
0.6
COMMON SOURCE
VDS = -10 V
f = 1 kHz
Ta = 25℃
-0.3
-0.5
-1
-3
-10
-30
DRAIN CURRENT ID (mA)


IGX – VDS
EXCESS GATE CURRENT IGX (A)
100 p
10 p
1 p
IGX
VDS
A
COMMON SOURCE
Ta = 25℃
ID = -10 mA
-5
-3
-1
0
-4
-8
-12
-16
-20
-24
-28
DRAIN-SOURCE VOLTAGE VDS (V)


NF – ID
NOISE FIGURE NF (dB)
8
6
4
2
0
COMMON SOURCE
VDS = -10 V
Rg = 1 kΩ
Ta = 25℃
f = 10 Hz
1 kHz
0
-2
-4
-6
-8
-10
DRAIN CURRENT ID (mA)


NF – VDS
NOISE FIGURE NF (dB)
8
6
4
2
0
COMMON SOURCE
ID = -1 mA
Rg = 1 kΩ
Ta = 25℃
f = 10 Hz
1 kHz
0
-8
-16
-24
-32
-40
DRAIN-SOURCE VOLTAGE VDS (V)


NF − R_g
COMMON SOURCE
V_{DS}=−10V
I_D=−1mA
Ta=25℃
f=10Hz
1kHz
NOISE FIGURE NF (dB)
0
2
4
6
8
10
100
1k
10k
100k
1M
SIGNAL SOURCE RESISTANCE R_g (Ω)


NF − f
COMMON SOURCE
V_{DS}=−10V
I_D=−1mA
Ta=25℃
R_g=500Ω
1kΩ
10kΩ
NOISE FIGURE NF (dB)
0
2
4
6
8
10
10
100
1k
10k
100k
FREQUENCY f (Hz)

SILICON MONOLITHIC P CHANNEL JUNCTION TYPE

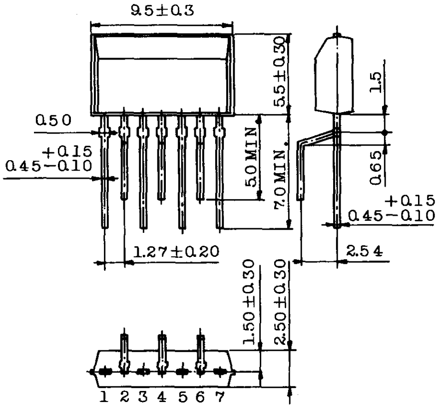
2SJ109

LOW NOISE AUDIO AMPLIFIER APPLICATIONS.
DIFFERENTIAL AMPLIFIER APPLICATIONS.

FEATURES:

- 1 Chip Dual Type.
- High $|Y_{fs}|$: $|Y_{fs}|$=22mS(Typ.)
  (V_{DS}=-10V, V_{GS}=0, f=1kHz, I_{DSS}=-3mA)
- Good Pair Characteristics
  : $|V_{GS1}-V_{GS2}|$=20mV(Max.) (V_{DS}=-10V, I_D=-1mA)
- Very Low Noise : NF=0.5dB(Typ.)
  (V_{DS}=-10V, I_D=-1mA, R_g=1kΩ, f=1kHz)
- Very High Input Impedance : I_{GSS}=1.0nA(Max.)
  (V_{GS}=30V, V_{DS}=0)
- Complementary to 2SK389

Unit in mm



1. DRAIN 1
2. GATE 1
3. SOURCE 1
4. SUBSTRATE
5. SOURCE 2
6. GATE 2
7. DRAIN 2

JEDEC	—
EIAJ	—
TOSHIBA	2-10M1A

Weight : 0.37g

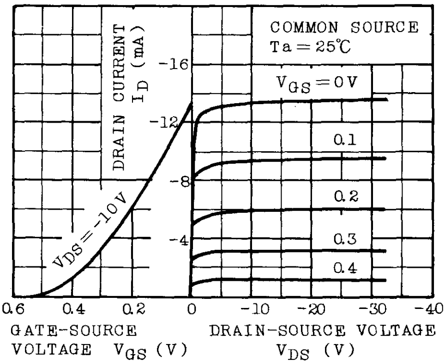
MAXIMUM RATINGS (Ta=25°C)

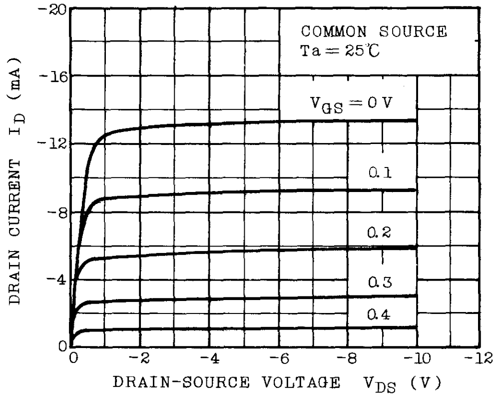
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	30	V
Gate Current	I_G	-10	mA
Drain Power Dissipation	P_D	200	mW/UNIT
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55～125	°C

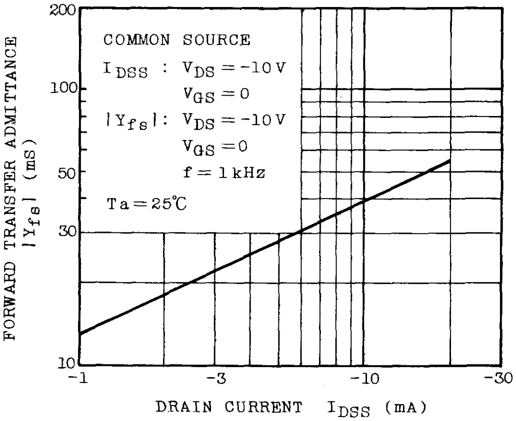
ELECTRICAL CHARACTERISTICS (Ta=25°C)

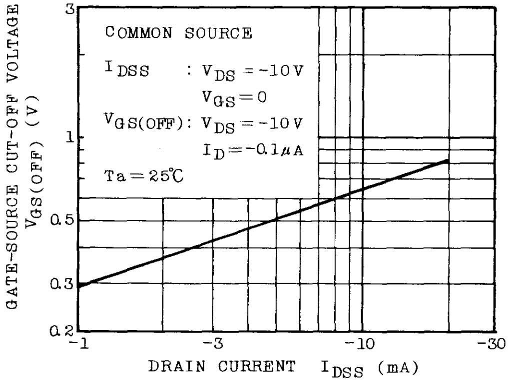
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=30V, V_{DS}=0	-	-	1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=100μA	30	-	-	V
Drain Current	I_{DSS}(Note)	V_{DS}=-10V, V_{GS}=0	-2.6	-	-20	mA
Drain Current Ratio	$I_{DSS(S)}$/ $I_{DSS(L)}$	V_{DS}=-10V, V_{GS}=0	0.9	-	-	-
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=-10V, I_D=-0.1μA	0.2	-	2.0	V
Forward Transfer Admittance	$\lvert Y_{fs}\rvert$	V_{DS}==10V, V_{GS}=0, f=1kHz, I_{DSS}=-3mA	8	22	-	mS
Forward Transfer Admittance Ratio	$\lvert Y_{fs(S)}\rvert$/ $\lvert Y_{fs(L)}\rvert$	V_{DS}=-10V, V_{GS}=0, f=1kHz	0.9	-	-	-
Differential Gate-Source Voltage	$\lvert V_{GS1}-V_{GS2}\rvert$	V_{DS}=-10V, I_D=-1mA	-	-	20	mV
Input Capacitance	C_{iss}	V_{DS}=-10V, V_{GS}=0, f=1MHz	-	95	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=-10V, I_D=0, f=1MHz	-	29	-	pF
Noise Figure	NF(1)	V_{DS}=-10V, R_g=1kΩ, I_D=-1mA, f=10Hz	-	1.5	11	dB
	NF(2)	V_{DS}=-10V, R_g=1kΩ, I_D=-1mA, f=1kHz	-	0.5	2	

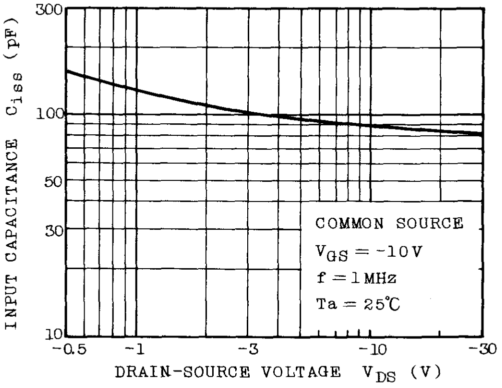
Note : I_{DSS} Classification GR : -2.6～-6.5mA, BL : -6～-12mA, V : -10～-20mA

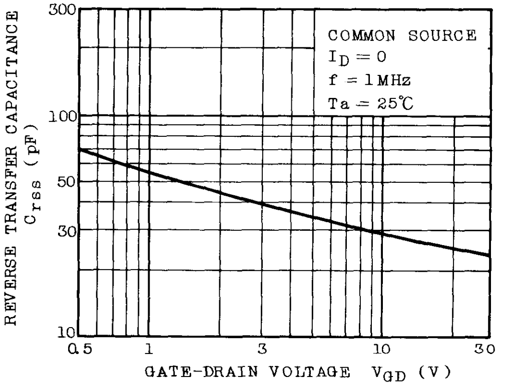

STATIC CHARACTERISTICS

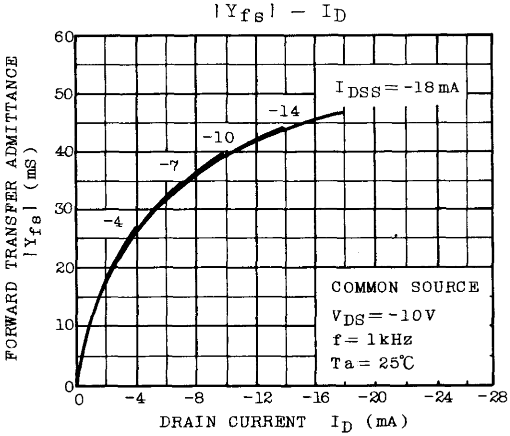

I_D — V_{DS} (LOW VOLTAGE REGION)

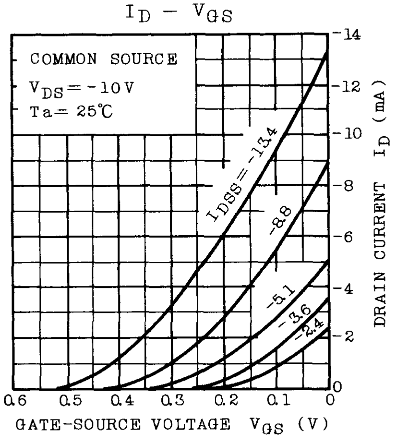

$|Y_{fs}|$ — I_{DSS}

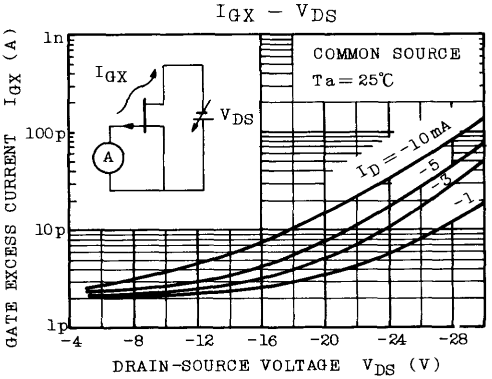

$V_{GS(OFF)}$ — I_{DSS}

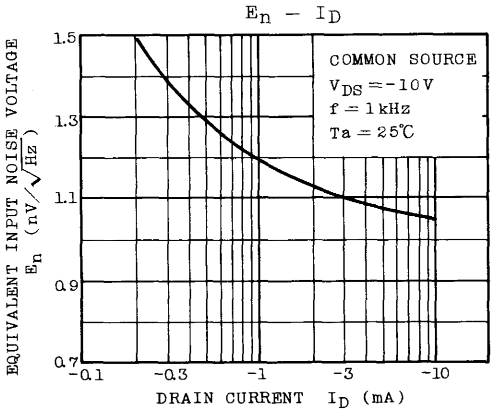

C_{iss} — V_{DS}

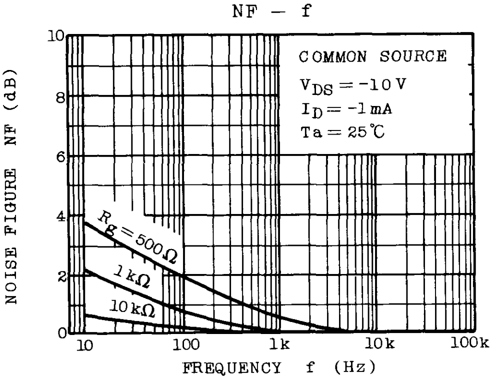

C_{rss} — V_{GD}

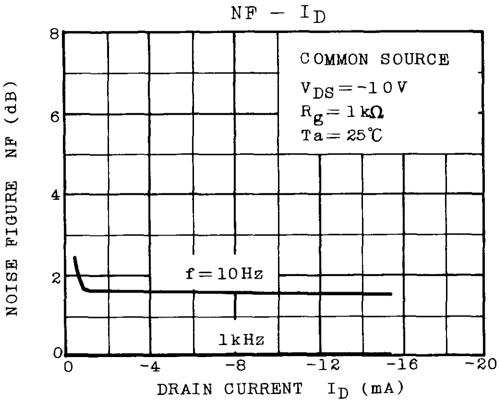

|Yfs| — ID
FORWARD TRANSFER ADMITTANCE |Yfs| (mS)
60
50
40
30
20
10
0
IDSS = -18 mA
-14
-10
-7
-4
COMMON SOURCE
VDS = -10 V
f = 1 kHz
Ta = 25℃
0
-4
-8
-12
-16
-20
-24
-28
DRAIN CURRENT ID (mA)

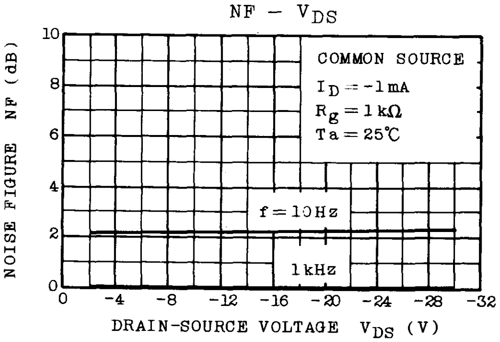

ID — VGS
COMMON SOURCE
VDS = -10 V
Ta = 25℃
IDSS = -13.4
-8.8
-5.1
-3.6
-2.4
-14
-12
-10
-8
-6
-4
-2
0
DRAIN CURRENT ID (mA)
0.6
0.5
0.4
0.3
0.2
0.1
0
GATE-SOURCE VOLTAGE VGS (V)

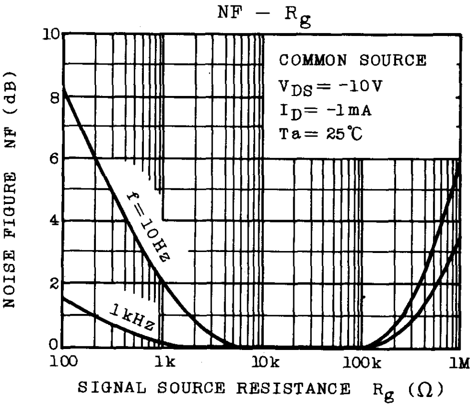

IGX — VDS
GATE EXCESS CURRENT IGX (A)
1n
100p
10p
1p
IGX
A
VDS
COMMON SOURCE
Ta = 25℃
ID = -10 mA
-5
-3
-1
-4
-8
-12
-16
-20
-24
-28
DRAIN-SOURCE VOLTAGE VDS (V)


En — ID
EQUIVALENT INPUT NOISE VOLTAGE En (nV/√Hz)
1.5
1.3
1.1
0.9
0.7
COMMON SOURCE
VDS = -10 V
f = 1 kHz
Ta = 25℃
-0.1
-0.3
-1
-3
-10
DRAIN CURRENT ID (mA)


NF — f
NOISE FIGURE NF (dB)
10
8
6
4
2
0
COMMON SOURCE
VDS = -10 V
ID = -1 mA
Ta = 25℃
Rg = 500 Ω
1 kΩ
10 kΩ
10
100
1k
10k
100k
FREQUENCY f (Hz)


NF — ID
NOISE FIGURE NF (dB)
8
6
4
2
0
COMMON SOURCE
VDS = -10 V
Rg = 1 kΩ
Ta = 25℃
f = 10 Hz
1 kHz
0
-4
-8
-12
-16
-20
DRAIN CURRENT ID (mA)


NF − V_DS
COMMON SOURCE
I_D = −1 mA
R_g = 1 kΩ
Ta = 25℃
f = 10Hz
1kHz
NOISE FIGURE NF (dB)
0
2
4
6
8
10
0
−4
−8
−12
−16
−20
−24
−28
−32
DRAIN-SOURCE VOLTAGE V_DS (V)


NF − R_g
COMMON SOURCE
V_DS = −10V
I_D = −1mA
Ta = 25℃
f = 10Hz
1kHz
NOISE FIGURE NF (dB)
0
2
4
6
8
10
100
1k
10k
100k
1M
SIGNAL SOURCE RESISTANCE R_g (Ω)

SILICON P CHANNEL JUNCTION TYPE

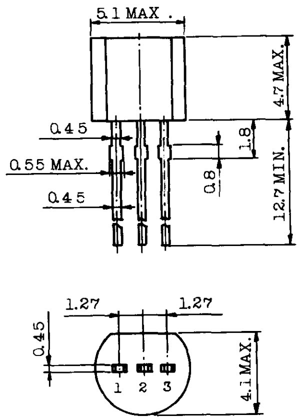
2SJ111

FOR LOW NOISE AUDIO AMPLIFIER APPLICATIONS.

FEATURES:

- Recommended for First Stages of EQ Amplifier and MC Head Amplifiers.
- High $|Y_{fs}|$
  : $|Y_{fs}|$=40mS(Typ.) (V_{DS}=-10V, V_{GS}=0, I_{DSS}=-5mA)
- Low Noise : NF=1.0dB(Typ.)
  (V_{DS}=-10V, I_D=-5mA, f=1kHz, R_g=100Ω)
- High Input Impedance : I_{GSS}=1nA(Max.) (V_{DG}=-25V)
- Complementary to 2SK369

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

JEDEC	TO-92MOD
EIAJ	—
TOSHIBA	2-5F1D

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

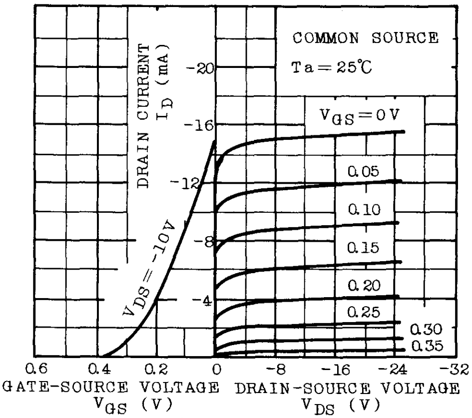
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	25	V
Gate Current	I_G	-10	mA
Drain Power Dissipation	P_D	400	mW
Junction Temperature	Tj	125	°C
Storage Temperature Range	Tstg	-55～125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

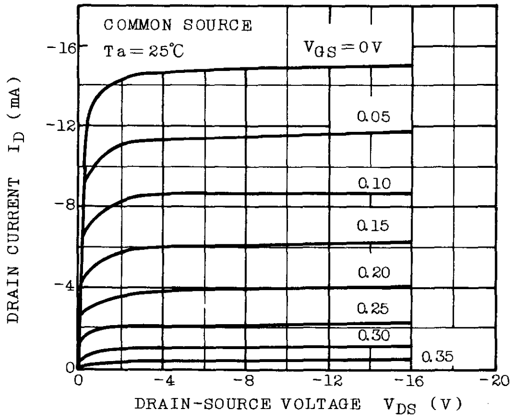
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=25V, V_{DS}=0	-	-	1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=100μA	25	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=-10V, V_{GS}=0	-5.0	-	-30	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=-10V, I_D=-0.1μA	0.3	-	2.0	V
Forward Transfer Adimttance	$\|Y_{fs}\|$	V_{DS}=-10V, V_{GS}=0, f=1kHz (TYP:I_{DSS}=-5mA)	30	40	-	mS
Input Capacitance	C_{iss}	V_{DS}=-10V, V_{GS}=0, f=1MHz	-	185	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=-10V, I_D=0, f=1MHz	-	55	-	pF
Noise Figure	NF(1)	V_{DS}=-10V, R_g=100Ω I_D=-5mA, f=100Hz	-	5	10	dB
	NF(2)	V_{DS}=-10V, R_g=100Ω I_D=-5mA, f=1kHz	-	1	2	

Note : I_{DSS} Classification GR : -5.0～-10.0, BL : -8.0～-16.0, V : -14.0～-30.0

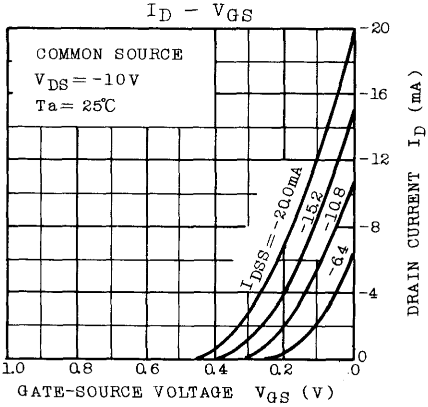
STATIC CHARACTERISTICS



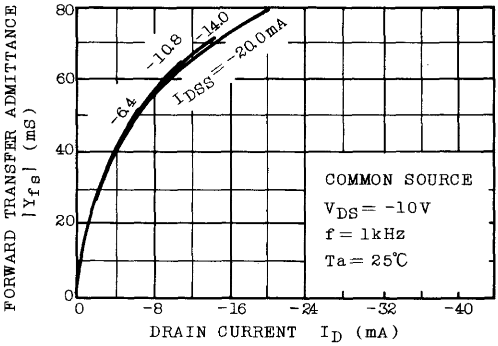
I_D – V_{DS} (LOW VOLTAGE REGION)



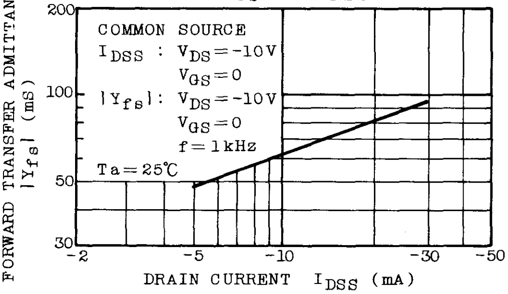
I_D – V_{GS}



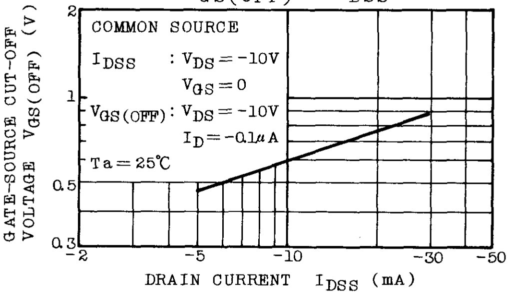
|Y_{fs}| – I_D



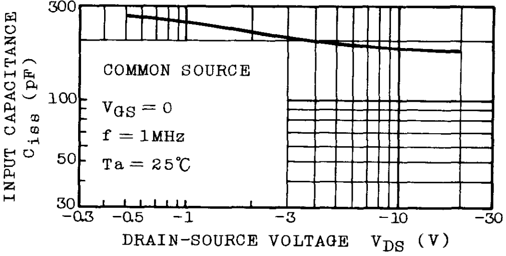
|Y_{fs}| – I_{DSS}



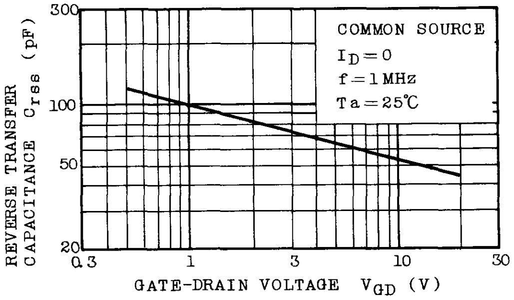
$V_{GS(OFF)}$ – I_{DSS}



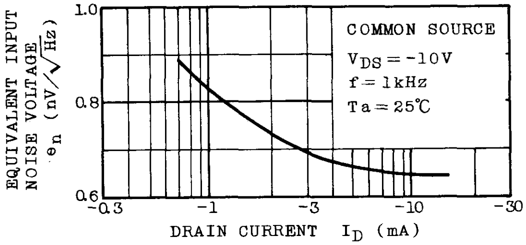
C_{iss} – V_{DS}



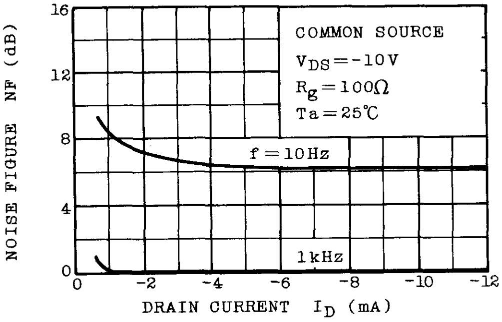
C_{rss} — V_{GD}



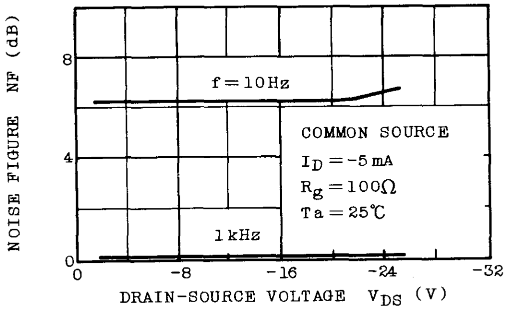
e_n — I_D



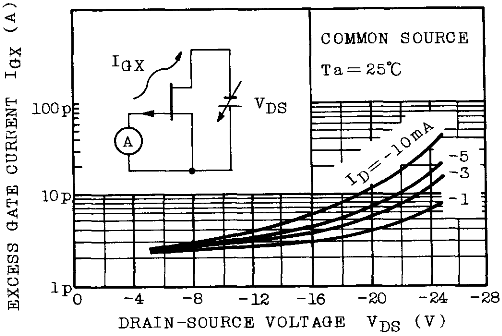
NF — I_D



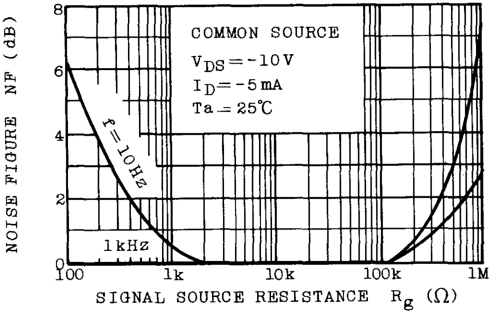
NF — V_{DS}



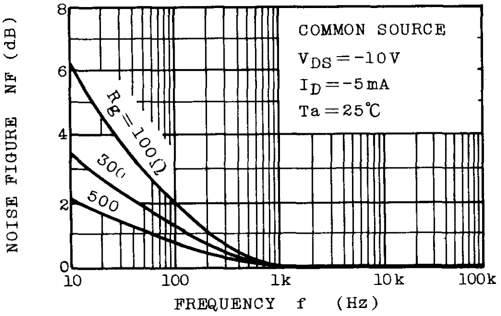
I_{GX} — V_{DS}



NF — R_g



NF — f



2SK
series

SILICON N CHANNEL JUNCTION TYPE (INDUSTRIAL APPLICATIONS)

2SK11
2SK12
2SK15

LOW FREQUENCY AMPLIFIER, HIGH INPUT IMPEDANCE CIRCUIT, CHOPPER AMPLIFIER, DIFFERENTIAL AMPLIFIER AND SWITCHING CIRCUIT APPLICATIONS.

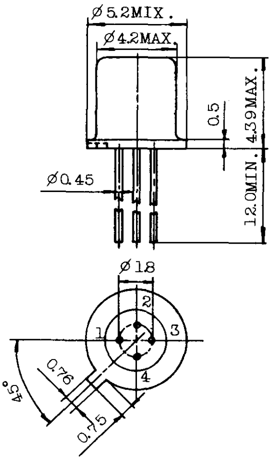
LOW NOISE AMPLIFIER APPLICATIONS (2SK15).

FEATURES:

- Low Gate Leakage Current
  - : I_{GSS}=-1.0nA (Max.) (2SK11)
  - : I_{GSS}=-0.1nA (Max.) (2SK12, 2SK15)
- High Gain
  - : $|y_{fs}|$=700 ∿ 3200 μS (2SK11)
  - : $|y_{fs}|$=800 ∿ 3200 μS (2SK12, 2SK15)
- Low Noise
  - : NF=3dB (Max.) at f=1kHz, R_g=1MΩ (2SK12)
  - : NF=3dB (Max.) at f=1kHz, R_g=10kΩ (2SK15)
  - : NF=10dB (Max.) at f=120Hz, R_g=10kΩ (2SK15)

Well Matched Pairs are Available. (Refer to page 3)

Unit in mm



1. SOURCE
2. GATE
3. DRAIN
4. SHIELD

JEDEC	TO-17
EIAJ	TC-4, TB-6C
TOSHIBA	2-4A1A

Weight : 0.30g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-20	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	100	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-65 ∿ 150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	2SK11	I_{GSS}	V_{GS}=-10V, V_{DS}=0	-	-	-1.0	nA
	2SK12 2SK15			-	-	-0.1	
Gate-Drain Breakdown Voltage		$V_{(BR)GDS}$	V_{DS}=0, I_G=0.1mA	-20	-	-	V
Drain Current	(Note 1) 2SK11	I_{DSS}	V_{DS}=10V, V_{GS}=0	0.3	-	6.5	mA
	(Note 2) 2SK12 (Note 3) 2SK15			0.45	-	5.0	
Gate-Source Cutoff Voltage	(Note 1) 2SK11	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.5	-	-6.0	V
	(Note 2) 2SK12			-0.65	-	-4.5	
	(Note 3) 2SK15			-0.65	-	-5.0	
Forward Transfer Admittance	(Note 1) 2SK11	$\|y_{fs}\|$	V_{GS}=-10V, V_{DS}=0, f=1kHz	700	-	3200	μS
	(Note 2) 2SK12 (Note 3) 2SK15			800	-	3200	
Gate Capacitance		C_G	V_{GS}=-10V, V_{DS}=0, f=1MHz	-	3.0	5.0	pF
Noise Voltage	2SK12	V_N	V_{DS}=10V, I_D=0.45mA Rg=1MΩ, Δf=10Hz ∿ 10kHz	-	-	16	μV
	2SK15	V_N(P-P)	V_{DS}=5V, I_D=0.45mA, Rg=10kΩ, Δf=5Hz ∿ 50Hz	-	-	4	
Noise Figure	2SK12	NF	V_{DS}=10V, I_D=0.45mA, Rg=1MΩ, f=1kHz	-	-	3	dB
	2SK15	NF(1)	V_{DS}=10V, I_D=0.45mA, R_g=10kΩ, f=1kHz	-	-	3	
		NF(2)	V_{DS}=10V, I_D=0.45mA R_g=10kΩ, f=120Hz	-	-	10	

: According to the value of I_{DSS}, $V_{GS(OFF)}$ and $|y_{fs}|$, the 2SK11 is classified as follows.

CLASSIFICATION	SYMBOL	I_{DSS} (mA)		$V_{GS(OFF)}$ (V)		$\|y_{fs}\|$ (μS)	
		MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
2SK11-R	R	0.3	1.0	-0.5	-2.0	700	2300
2SK11-0	0	0.8	2.5	-0.8	-3.5	1000	3000
2SK11-Y	Y	2.0	6.5	-1.4	-6.0	1300	3200

Note 2 : According to the value of I_{DSS}, $V_{GS(OFF)}$ and $|y_{fs}|$, the 2SK12 is classified as follows.

CLASSIFICATION	SYMBOL	I_{DSS} (mA)		$V_{GS(OFF)}$ (V)		$\|y_{fs}\|$ (μS)	
		MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
2SK12-R	R	0.45	0.9	-0.65	-1.6	800	1900
2SK12-O	O	0.8	1.6	-0.9	-2.2	1000	2300
2SK12-Y	Y	1.4	2.8	-1.2	-3.0	1300	3000
2SK12-GR	GR	2.5	5.0	-1.7	-4.5	1600	3200

Note 3 : According to the value of I_{DSS}, $V_{GS(OFF)}$ and $|y_{fs}|$, the 2SK15 is classified as follows.

CLASSIFICATION	SYMBOL	I_{DSS} (mA)		$V_{GS(OFF)}$ (V)		$\|y_{fs}\|$ (μS)	
		MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
2SK15-R	R	0.45	0.9	-0.65	-1.8	800	1900
2SK15-O	O	0.8	1.6	-0.9	-2.5	1000	2300
2SK15-Y	Y	1.4	2.8	-1.3	-3.5	1300	3000
2SK15-GR	GR	2.6	5.0	-1.8	-5.0	1600	3200

STANDARD MATCHED PAIR FETS

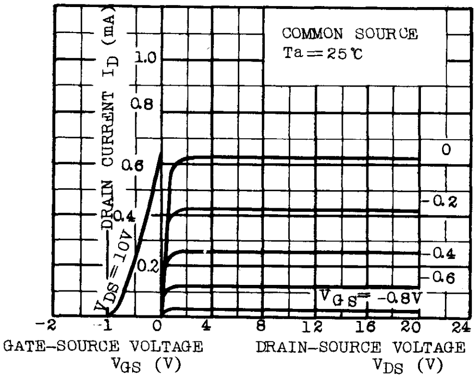
2SK12-R Ⓟ	2SK15-R Ⓟ
2SK12-O Ⓟ	2SK15-O Ⓟ
2SK12-Y Ⓟ	2SK15-Y Ⓟ
2SK12-GR Ⓟ	2SK15-GR Ⓟ

MATCHED PAIR CHARACTERISTICS (Ta=25°C)

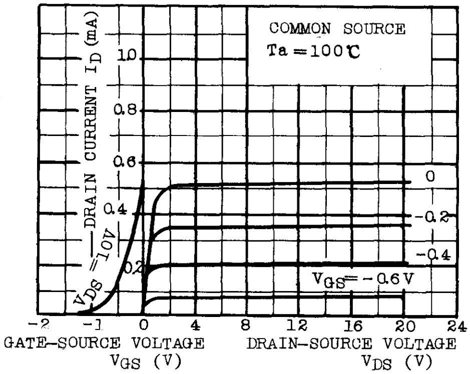
CHARACTERISTIC	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Differential Drain Current	ΔI_{DSS}	V_{DS}=10V, V_{GS}=0	-	-	10	%
Gate-Source Voltage Differential Drift	ΔV_{GS}	V_{DG}=10V, I_D=0.3mA	-	-	20	mV

Other Characteristics are same as 2SK12, 2SK15.

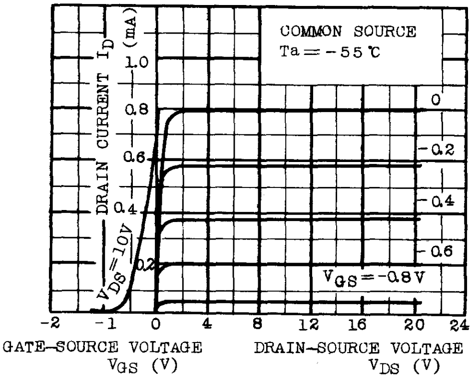
2SK11-R, 2SK12-R, 2SK15-R
STATIC CHARACTERISTICS



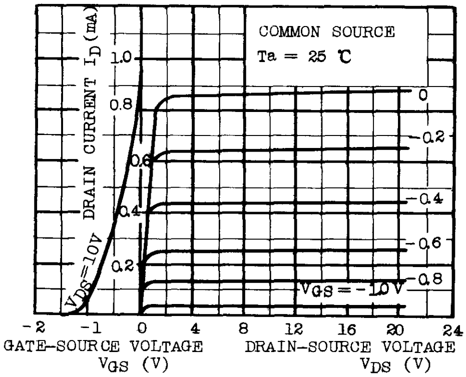
2SK11-R, 2SK12-R, 2SK15-R
STATIC CHARACTERISTICS



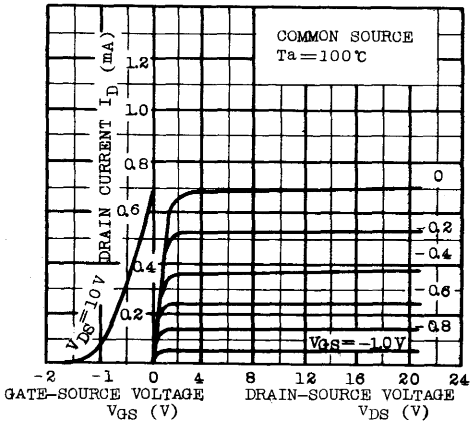
2SK11-R, 2SK12-R, 2SK15-R
STATIC CHARACTERISTICS



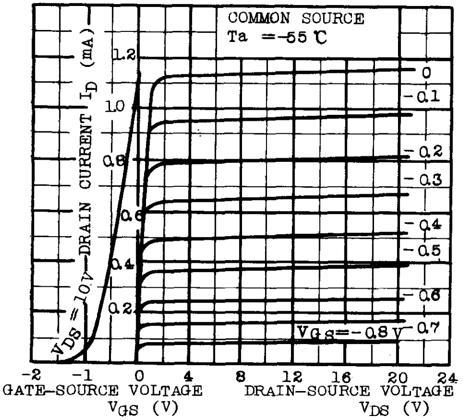
2SK11-O, 2SK12-O, 2SK15-O
STATIC CHARACTERISTICS



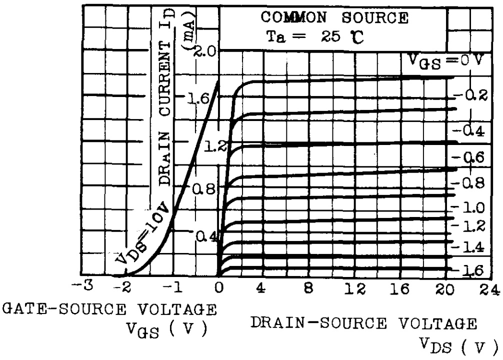
2SK11-O, 2SK12-O, 2SK15-O
STATIC CHARACTERISTICS



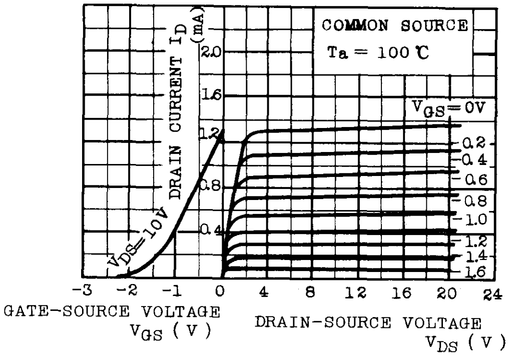
2SK11-O, 2SK12-O, 2SK15-O
STATIC CHARACTERISTICS



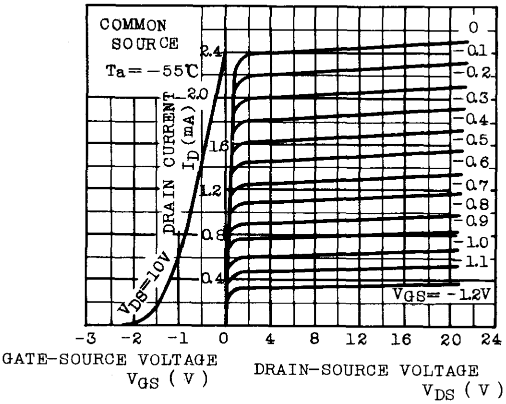
2SK11-O, 2SK12-Y, 2SK15-Y
STATIC CHARACTERISTICS



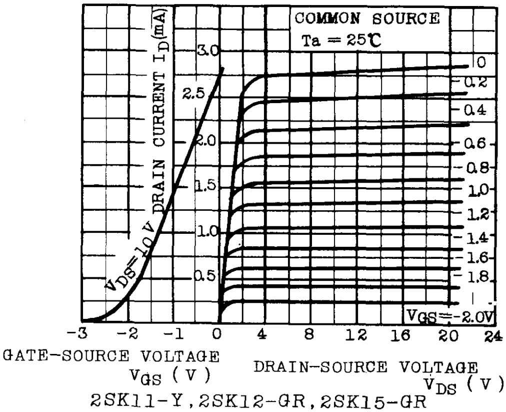
2SK11-O, 2SK12-Y, 2SK15-Y
STATIC CHARACTERISTICS



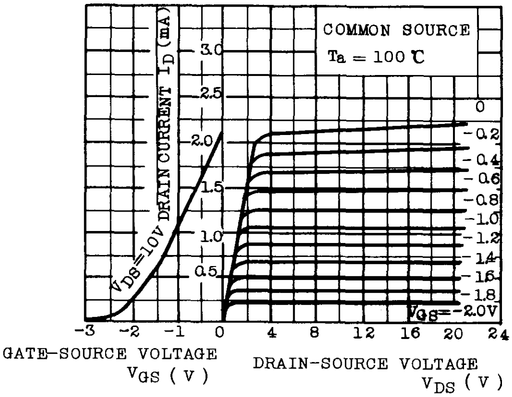
2SK11-O, 2SK12-Y, 2SK15-Y
STATIC CHARACTERISTICS



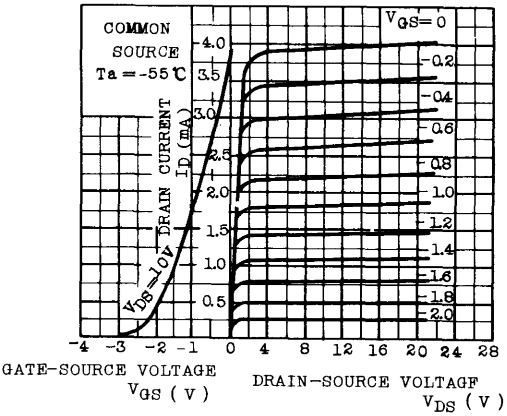
2SK11-Y, 2SK12-GR, 2SK15-GR
STATIC CHARACTERISTICS



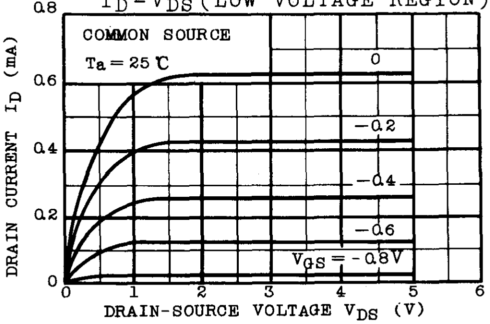
2SK11-Y, 2SK-12GR, 2SK15-GR
STATIC CHARACTERISTICS



2SK11-Y, 2SK12-GR, 2SK15-GR
STATIC CHARACTERISTICS



2SK11-R, 2SK12-R, 2SK15-R
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



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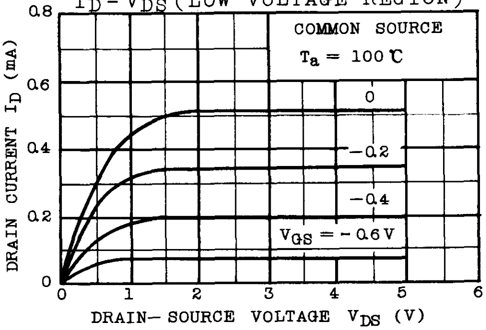

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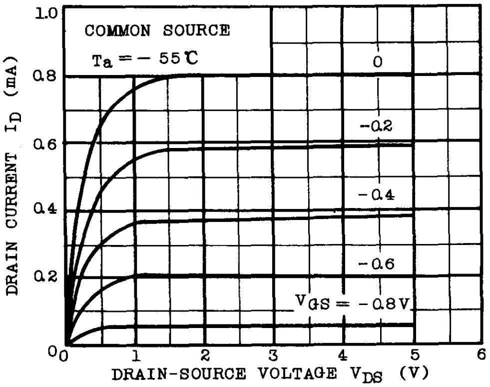
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



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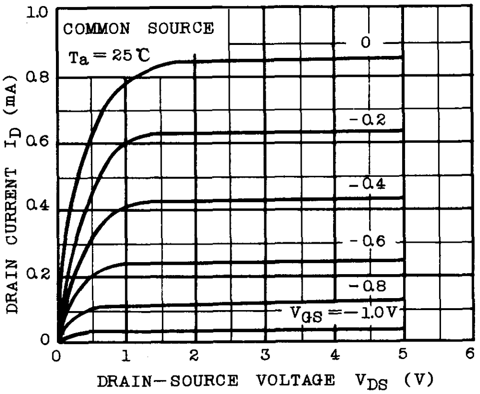
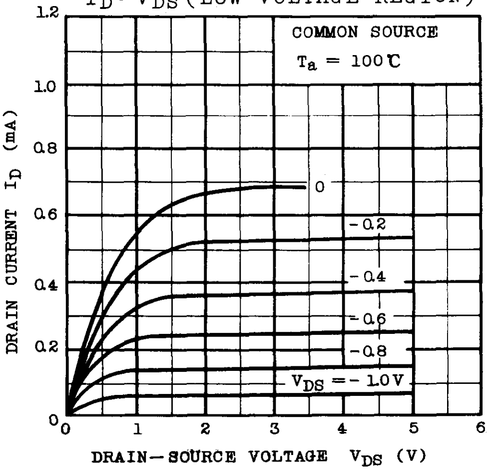


2SK11-O, 2SK12-O, 2SK15-O
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



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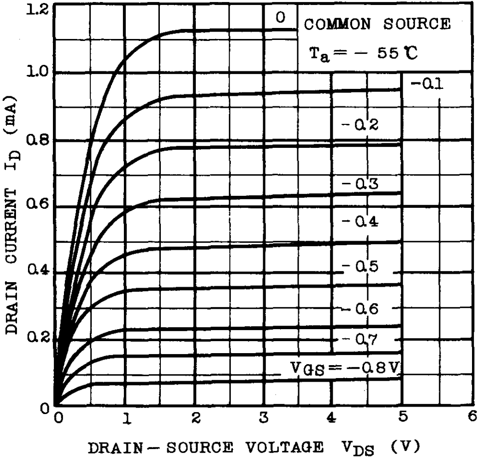
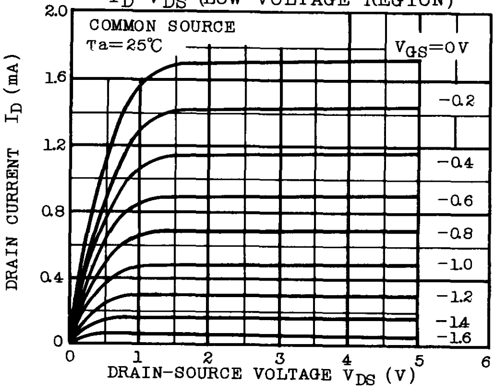
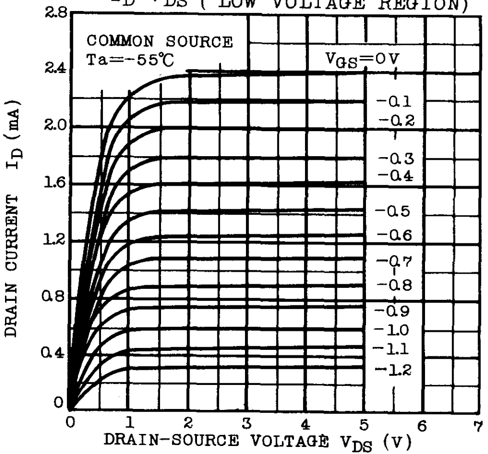
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



2SK11-O, 2SK12-Y, 2SK15-Y
I_D-V_{DS} (LOW VOLTAGE REGION)



2SK11-O, 2SK12-Y, 2SK15-Y
I_D-V_{DS} (LOW VOLTAGE REGION)



2SK11-Y, 2SK12-GR, 2SK15-GR
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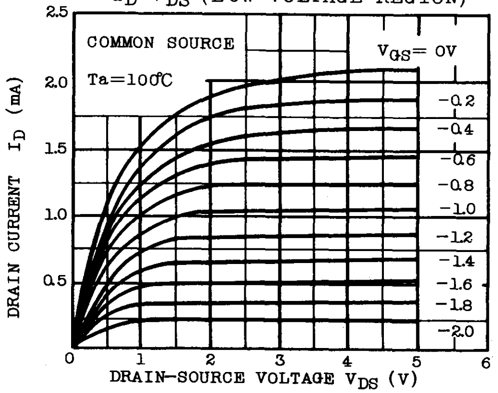
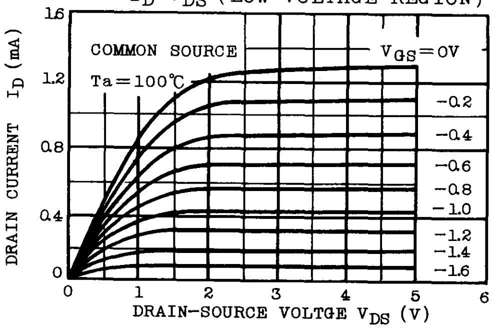
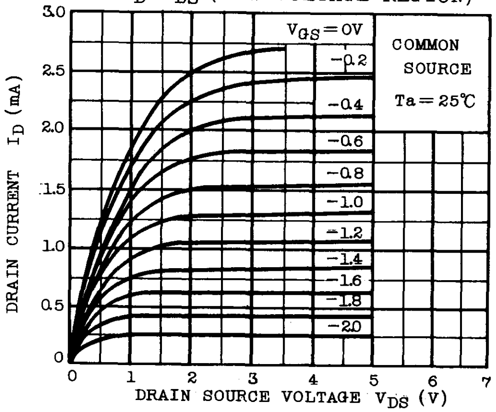


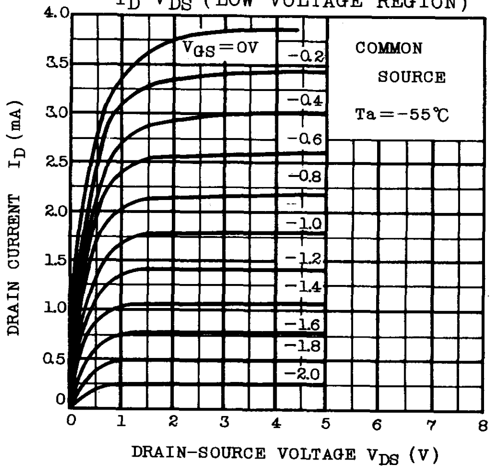
2SK11-O, 2SK12-Y, 2SK15-Y
I_D-V_{DS} (LOW VOLTAGE REGION)



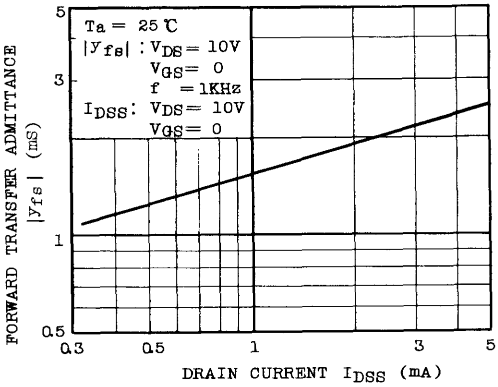
2SK11-Y, 2SK12-GR, 2SK15-GR
I_D-V_{DS} (LOW VOLTAGE REGION)



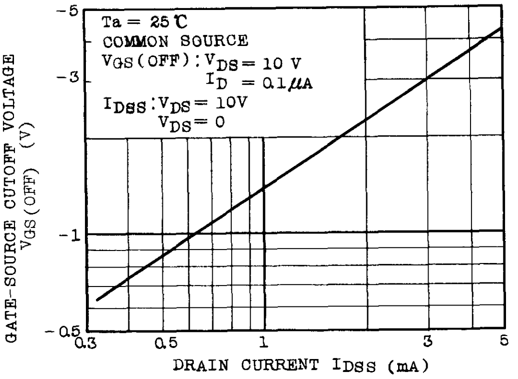
2SK11-Y, 2SK12-GR, 2SK15-GR
I_D-V_{DS} (LOW VOLTAGE REGION)



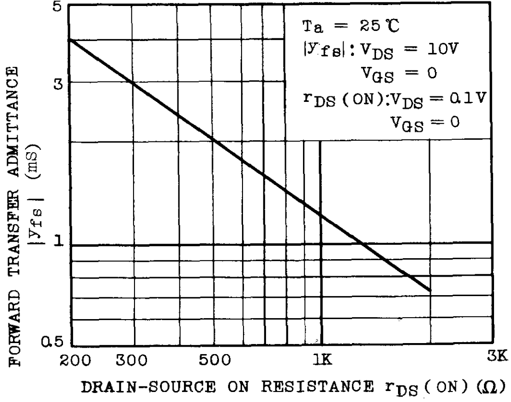
$|y_{fs}|$ – I_{DSS}



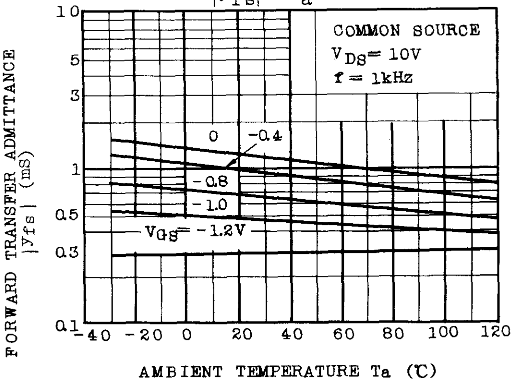
V_{GS} (OFF) – I_{DSS}



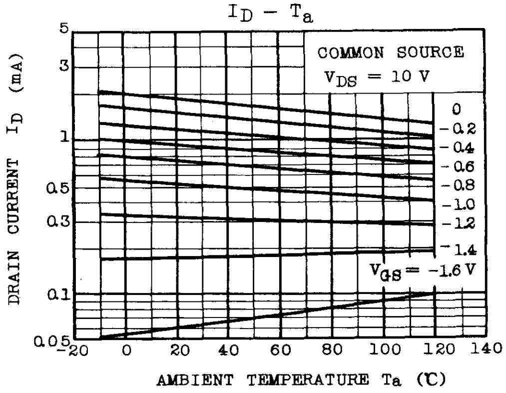
$|y_{fs}|$ – r_{DS} (ON)



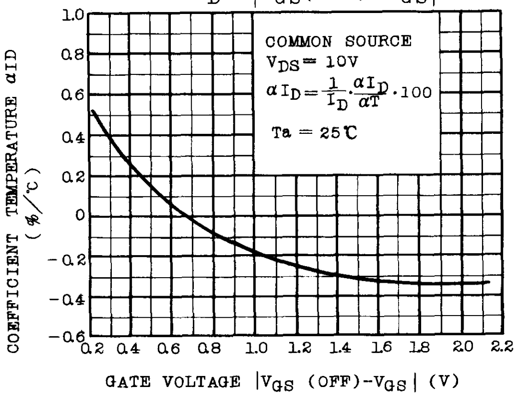
$|y_{fs}|$ – T_a

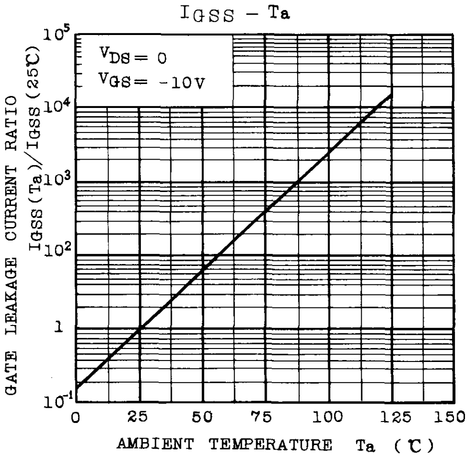


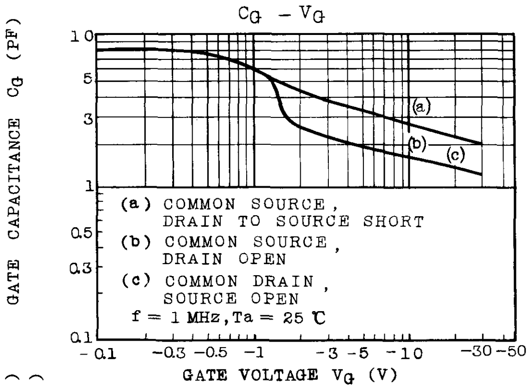
I_D – T_a

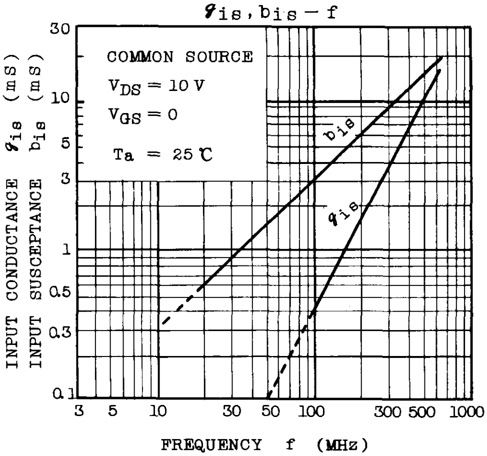


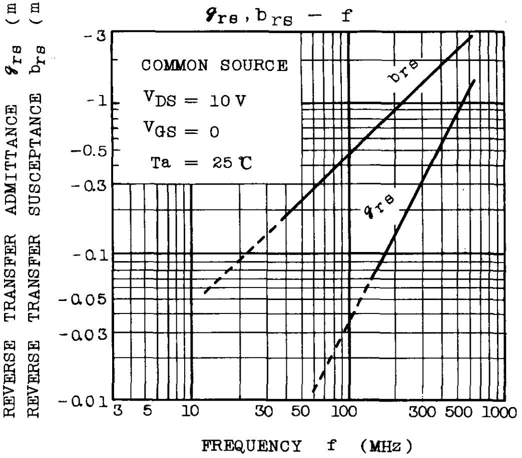
αI_D – $|V_{GS}(OFF) - V_{GS}|$

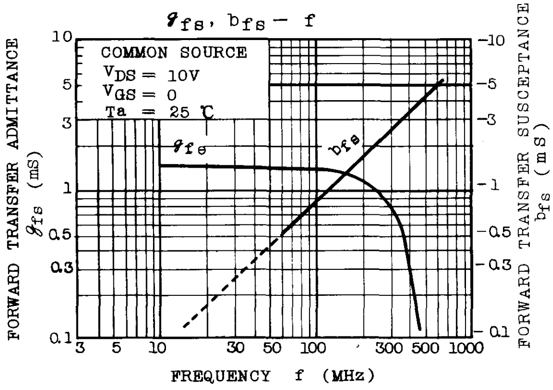


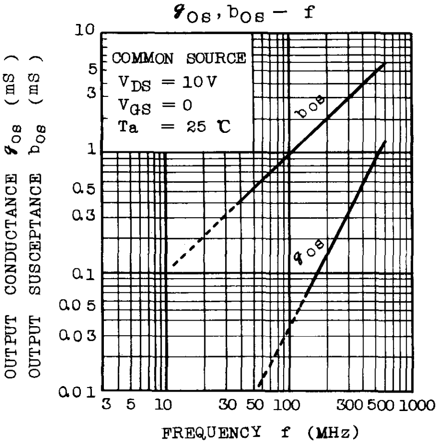

I_{GSS} – Ta


C_G – V_G

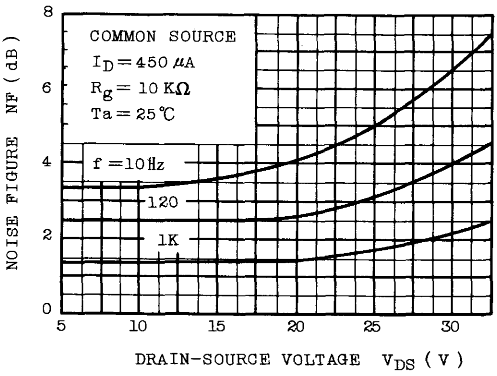

g_{is}, b_{is} – f


g_{rs}, b_{rs} – f

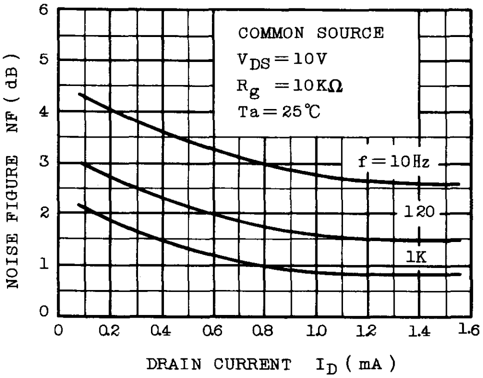

g_{fs}, b_{fs} – f


g_{os}, b_{os} – f

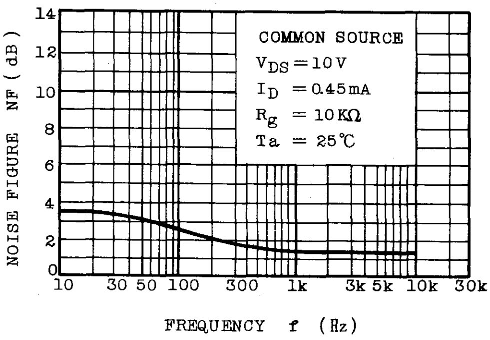
2SK15 NF - V_{DS}



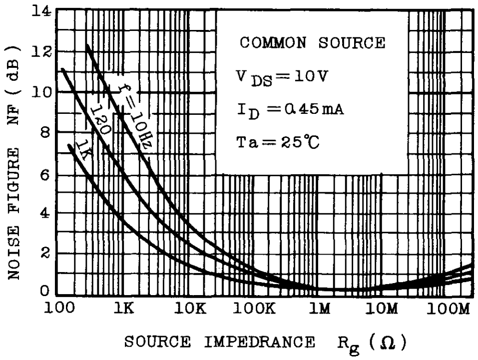
2SK15 NF - I_D



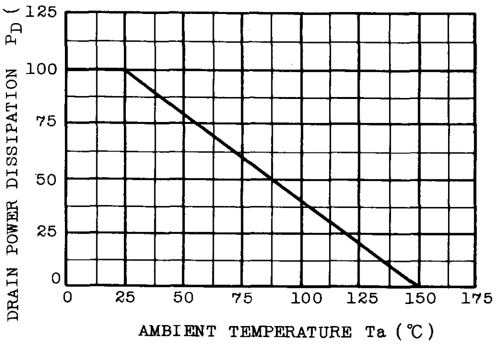
2SK15 NF - f



2SK15 NF - R_g



P_D - Ta



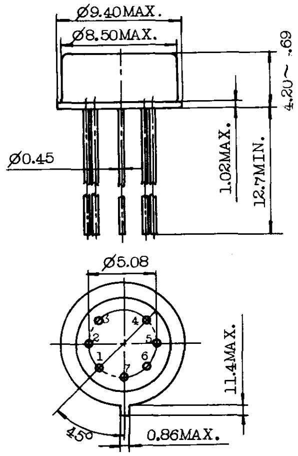
SILICON N CHANNEL JUNCTION DUAL TYPE (COMPLETELY SEPARATED TYPE)

2SK18
2SK18A

DIFFERENTIAL AMPLIFIER APPLICATIONS.

FEATURES:

- Low Offset : $V_{GS1}-V_{GS2}$ =10mV (Max.)
- Good Tracking
  : $\Delta|V_{GS1}-V_{GS2}|/\Delta Ta=20\mu V/°C$ (Max.). (2SK18A)
- High Input Impedance : I_G=-100pA (Max.)
  at V_{DS}=10V, I_D=400μA.
- Similar Characteristics as 2SK15.



1. SOURCE (1)
2. GATE (1)
3. DRAIN (1)
4. DRAIN (2)
5. GATE (2)
6. SOURCE (2)
7. CASE

JEDEC	—
EIAJ	—
TOSHIBA	2 — 9C1A

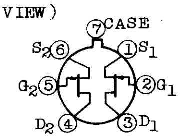
Weight : 0.90g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-40	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	200	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-65~150	°C

PIN CONNECTION

(BOTTOM VIEW)



2SK18
2SK18A

ELECTRICAL CHARACTERISTICS ($Ta=25°C$)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current		I_G	$V_{DS}=10V$, $I_D=400\mu A$	-	-	-0.1	nA
Gate-Drain Breakdown Voltage		$V_{(BR)GDS}$	$V_{DS}=0$, $I_G=-0.1mA$	-40	-	-	V
Drain Current		I_{DSS} (Note)	$V_{DS}=10V$, $V_{GS}=0$	0.45	-	2.8	mA
Gate-Source Cut-off Voltage		$V_{GS(OFF)}$(Note)	$V_{DS}=10V$, $I_D=0.1\mu A$	-0.65	-	-3.5	V
Forward Transfer Admittance		$\lvert y_{fs}\rvert$ (Note)	$V_{DS}=10V$, $V_{GS}=0$, f=1kHz	800	-	3000	μS
Input Capacitance		Ciss	$V_{GD}=0$, f=1MHz	-	4.5	6.0	pF
Reverse Transfer Capacitance		Crss	$V_{DS}=0$, $V_{GD}=-10V$, f=1MHz	-	2.0	2.5	pF
Drain Current Ratio		$I_{DSS(small)}/I_{DDSS(large)}$	$V_{DD}=10V$, $V_{GS}=0$	0.9	-	1.0	
Forward Transfer Admittance Ratio		$\lvert y_{fs}\rvert$ (S) $\lvert y_{fs}\rvert$ (L)	$V_{DS}=10V$, $V_{GS}=0$, f=1kHz	0.9	-	1.0	
Differential Gate-Source Voltage		$\lvert V_{GS1}-V_{GS2}\rvert$	$V_{DG}=10V$, $I_D=400\mu A$	-	-	10	mV
			$V_{DG}=10V$, $I_D=200\mu A$	-	-	10	mV
			$V_{DG}=10V$, $I_D=50\mu A$	-	-	10	mV
Gate-Source Voltage Differential Drift	2SK18	$\Delta\lvert V_{GS1}-V_{GS2}\rvert / \Delta Ta$	$V_{DS}=10V$, $I_D=200\mu A$ $Ta=0 \sim 60°C$	-	-	100	μV/°C
	2SK18A			-	-	20	

Note : According to the value of I_{DSS1}, $V_{GS(OFF)1}$, $V_{GS(OFF)1}$, and $|y_{fs}|_1$, the 2SK18 series are classified as follows.

CLASSIFICATIONS	I_{DSS1} (mA)		$V_{GS(OFF)1}$ (V)		$\lvert y_{fs}\rvert_1$ (μS)	
	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
2SK18-R, 2SK18A-R	0.45	0.90	-0.65	-1.8	800	1900
2SK18-O, 2SK18A-O	0.80	1.60	-0.90	-2.5	1000	2300
2SK18-Y, 2SK18A-Y	1.40	2.80	-1.40	-3.5	1300	3000

SILICON N CHANNEL JUNCTION TYPE

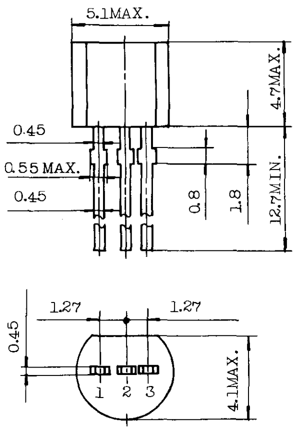
2SK30ATM

LOW NOISE PRE-AMPLIFIER, TONE CONTROL AMPLIFIER AND DC-AC HIGH INPUT IMPEDANCE AMPLIFIER CIRCUIT APPLICATIONS.

FEATURES:

- High Breakdown Voltage : V_{GDS}=-50V
- High Input Impedance : I_{GSS}=-1nA (Max.) (V_{GS}=-30V)
- Low Noise : NF=0.5dB (Typ.)(Rg=100kΩ) (f=120Hz)

Unit in mm



1. SOURCE
2. GATE
3. DRAIN

JEDEC	TO — 92
EIAJ	SC — 43
TOSHIBA	2 — 5F1C

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

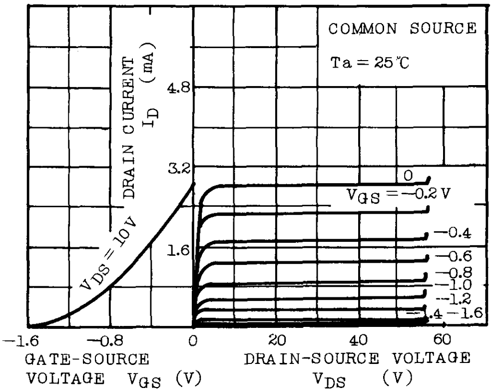
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-50	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	100	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

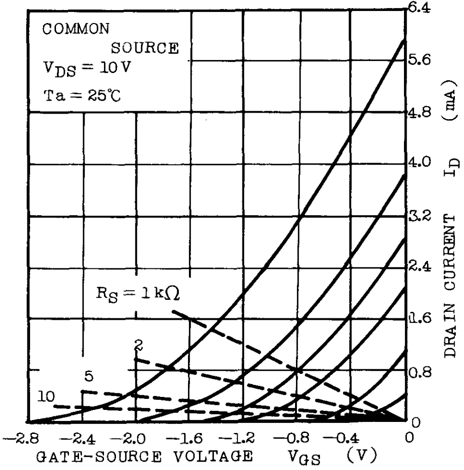
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-50	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=10V, V_{GS}=0	0.3	-	6.5	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.4	-	-5.0	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz	1.2	-	-	mS
Input Capacitance	C_{iss}	V_{GS}=0, V_{DS}=0, f=1MHz	-	8.2	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{GD}=-10V, V_{DS}=0, f=1MHz	-	2.6	-	pF
Noise Figure	NF	V_{DS}=15V, V_{GS}=0, R_g=100kΩ, f=120Hz	-	0.5	5.0	dB

Note : I_{DSS} Classification R : 0.30∿0.75, O : 0.60∿1.40, Y : 1.20~3.00, GR: 2.60∿6.50

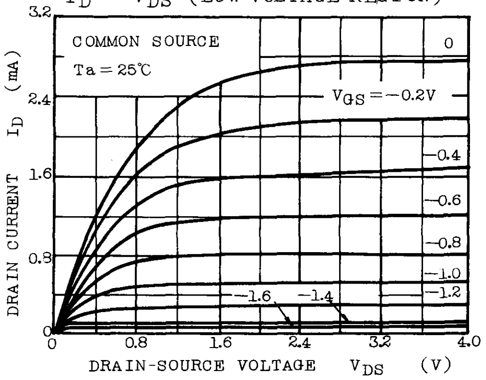
STATIC CHARACTERISTICS



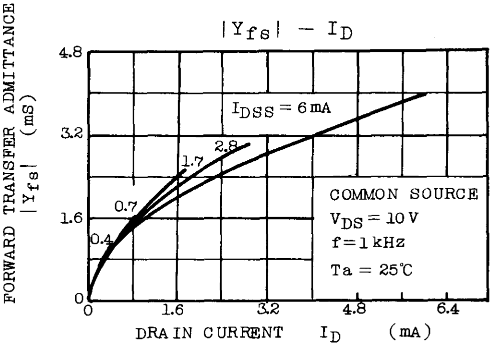
$I_D - V_{GS}$



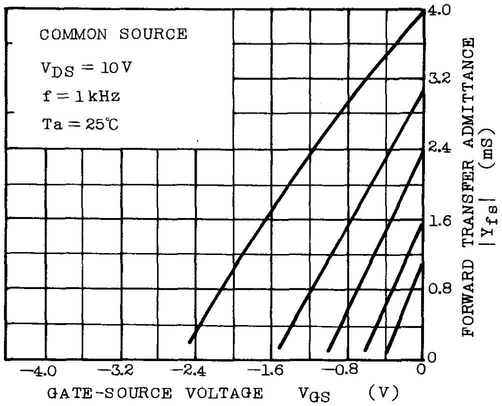
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



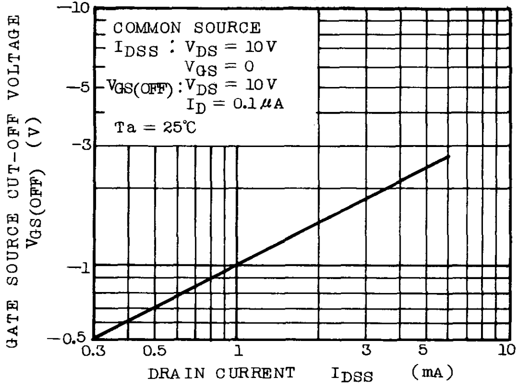
$|Y_{fs}| - I_D$



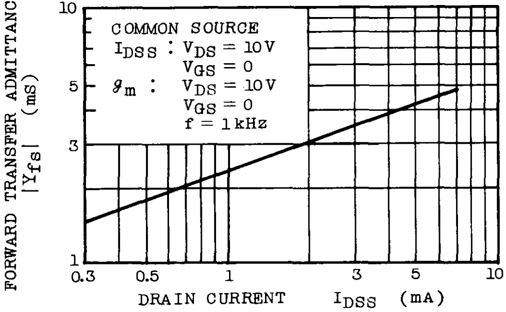
$|Y_{fs}| - V_{GS}$



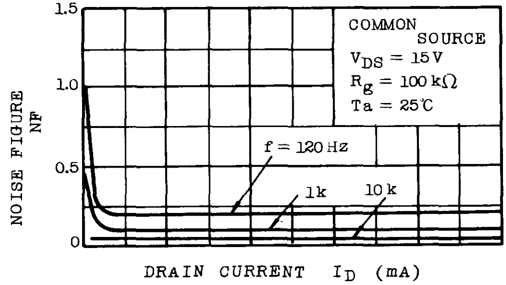
$V_{GS(OFF)} - I_{DSS}$



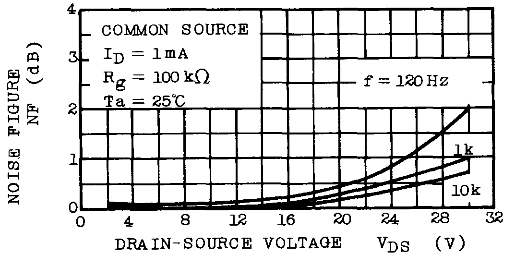
$|Y_{fs}| - I_{DSS}$



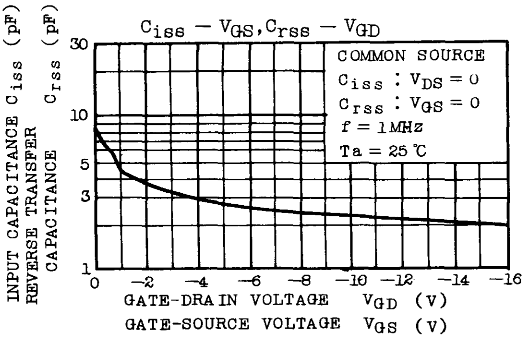
NF — I_D



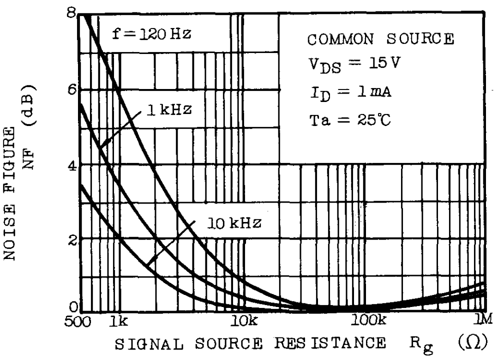
NF — V_{DS}



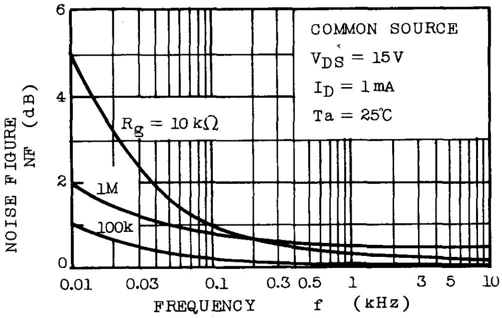
$C_{iss} - V_{GS}, C_{rss} - V_{GD}$



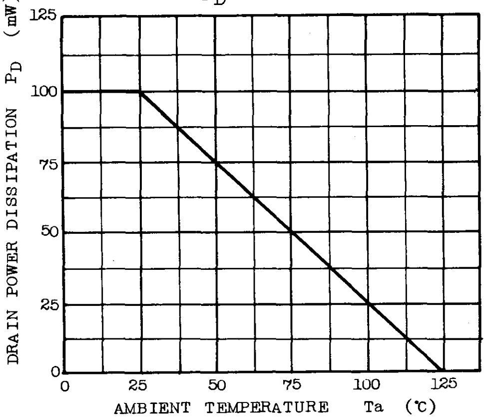
NF — R_g



NF — f



P_D — Ta



2SK48

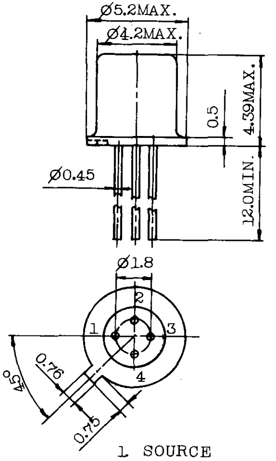
SILICON N CHANNEL JUNCTION TYPE
(INDUSTRIAL APPLICATIONS)

MEDICAL ELECTRONIC EQUIPMENT APPLICATIONS.

FEATURES:

- Ultra Low Noise
  - : NF=0.5dB (Typ.) at R_g=100kΩ, f=120Hz
  - : V_{Np-p}=1.7μV (Typ.) at R_g=10kΩ, f=5∿50Hz
- High Gain: $|Y_{fs}|$ =1.0∿5.0mS
- High Input Impedance
  - : I_{GSS}=-0.1nA (Max.) at V_{GS}=-10V.

Unit in mm



1. SOURCE
2. GATE
3. DRAIN
4. SHIELD (CASE)

JEDEC	TO − 17
EIAJ	TC − 4, TB − 6C
TOSHIBA	2 − 4A1A

Weight : 0.30g

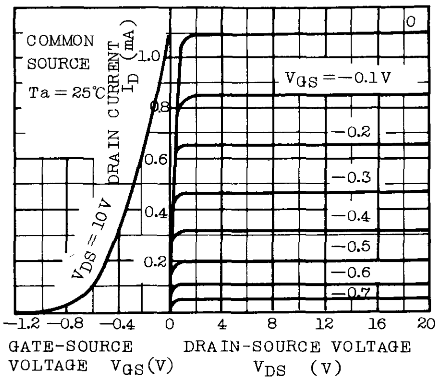
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-20	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	100	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-65∿150	°C

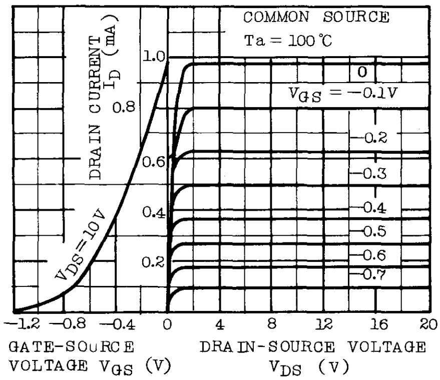
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-10V, V_{DS}=0	-	-	-0.1	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-0.1mA	-20	-	-	V
Drain Current	I_{DSS}	V_{DS}=10V, V_{GS}=0	0.3	-	3.0	mA
Gate Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.35	-	-2.3	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz	1.0	-	5.0	mS
Gate Capacitance	C_G	V_{GS}=-10V, V_{DS}=0, f=1kHz	-	5.0	8.0	pF
Noise Voltage (peak to peak)	$V_{N(p-p)}$	V_{DS}=5V, I_D=450μA, R_g=10kΩ, Δf=5∿50Hz	-	1.7	4.0	μV
Noise Figure	NF	V_{DS}=10V, I_D=450μA, R_g=100kΩ, f=120Hz	-	0.5	5.0	dB

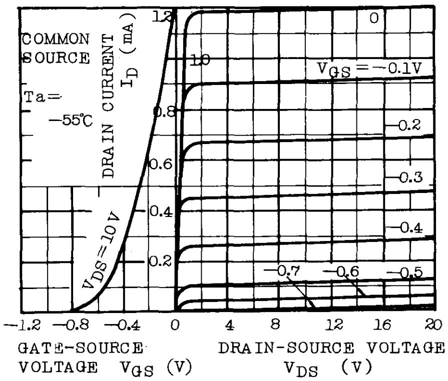
STATIC CHARACTERISTICS



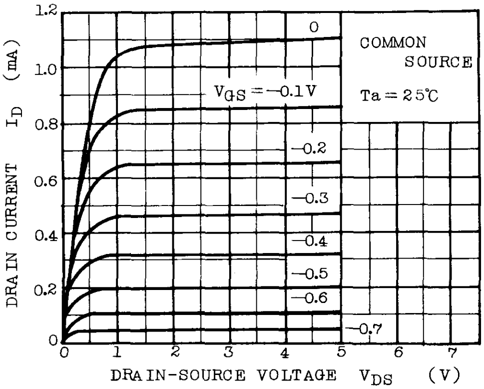
STATIC CHARACTERISTICS



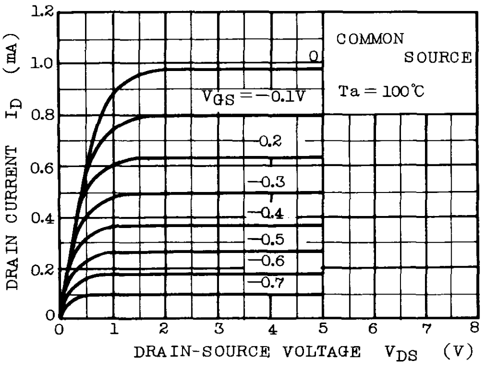
STATIC CHARACTERISTICS



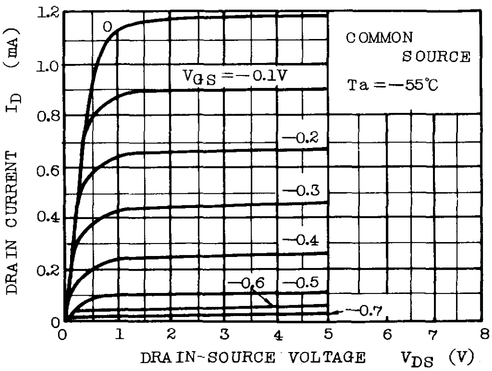
I_D – V_{DS} (LOW VOLTAGE REGION)

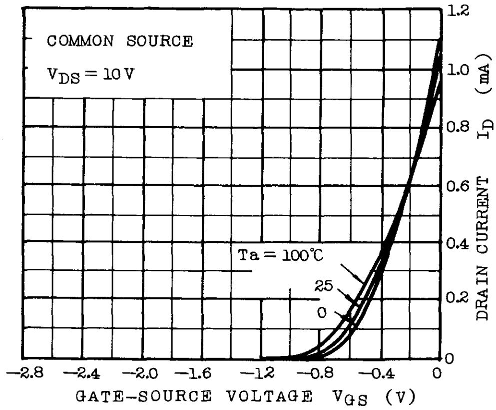


I_D – V_{DS} (LOW VOLTAGE REGION)

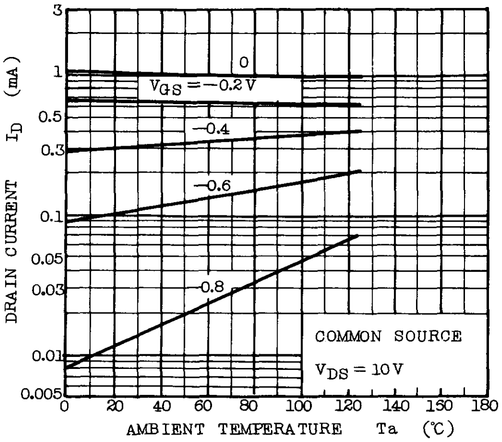


I_D – V_{DS} (LOW VOLTAGE REGION)

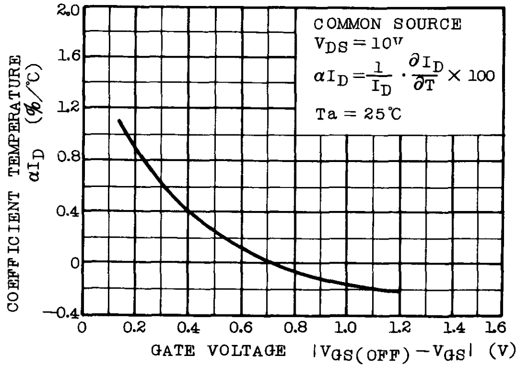




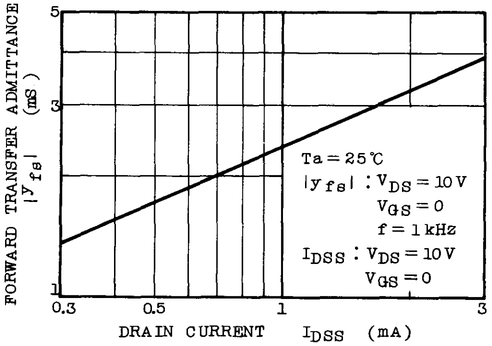
$I_D - V_{GS}$



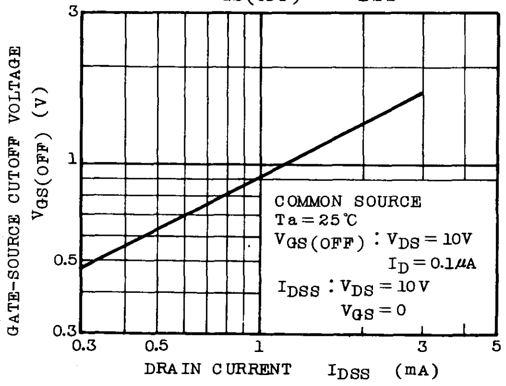
$I_D - Ta$



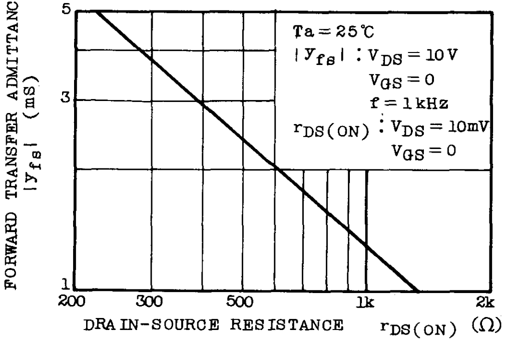
$\alpha I_D - |V_{GS(OFF)} - V_{GS}|$



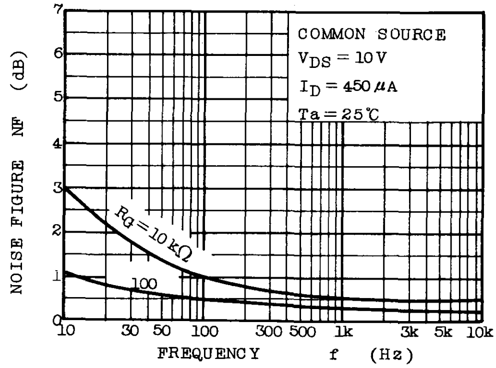
$|y_{fs}| - I_{DSS}$

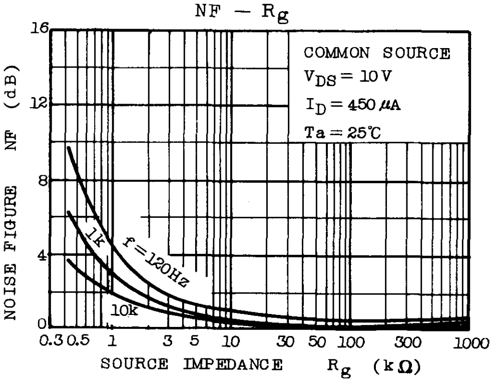


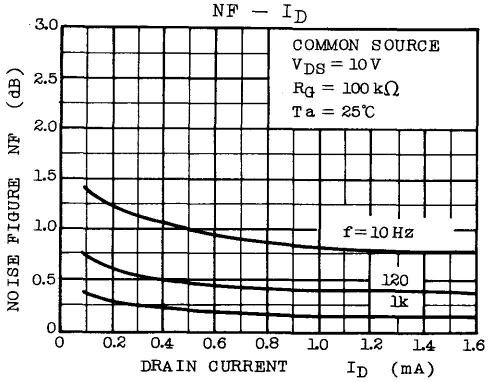
$V_{GS(OFF)} - I_{DSS}$

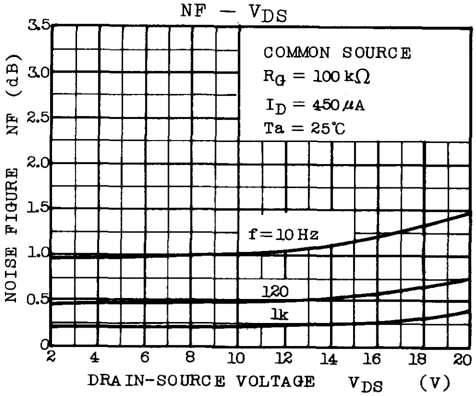


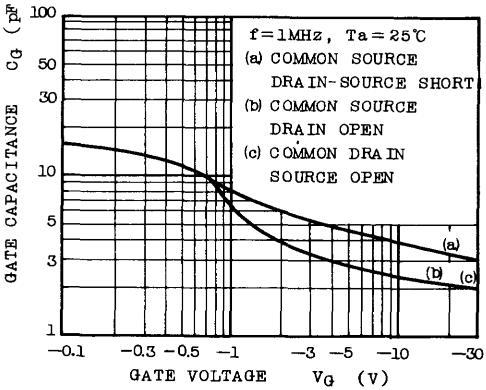
$|y_{fs}| - r_{DS(ON)}$

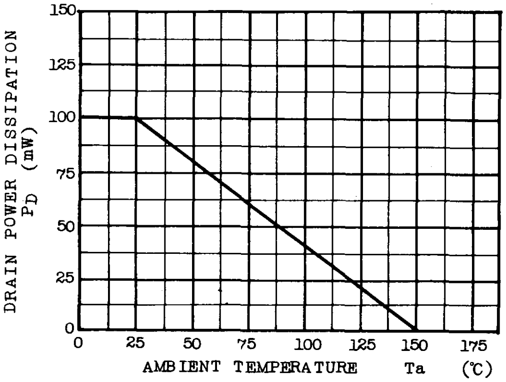

NF — f


NF — Rg


NF — ID


NF — VDS


CG — VG


PD — Ta

2SK72

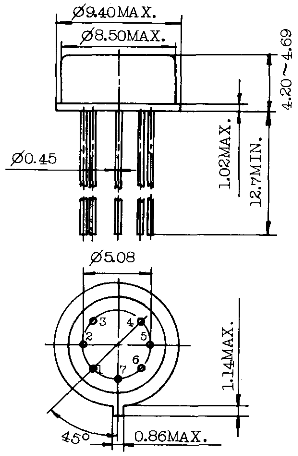
SILICON N CHANNEL JUNCTION DUAL TYPE
(COMPLETELY SEPARATED TYPE)

DIFFERENTIAL AMPLIFIER APPLICATIONS.

FEATURES:

- Ultra Low Noise:
  - NF=0.5dB (Typ.) at R_g=100kΩ, f=120Hz
  - $V_{N(p-p)}$=1.7μV (Typ.) at R_g=10kΩ, Δf=5∿50Hz
- High Gain : $|y_{fs}|$=1.5∿6.5mS
- Low Offset : $|V_{GS1}-V_{GS2}|$=10mV (Max.)
- Good Tracking: $\Delta|V_{GS1}-V_{GS2}|/\Delta Ta$=30μV/°C (Typ.)
- High Input Resistance: I_G=-100pA (Max.) at V_{DS}=10V, I_D=400μA
- Similar characteristics as 2SK48.

Unit in mm



1. SOURCE (1)
2. DRAIN (1)
3. GATE (1)
4. SOURCE (2)
5. DRAIN (2)
6. GATE (2)
7. CASE

JEDEC	—
EIAJ	—
TOSHIBA	2 — 9C1B

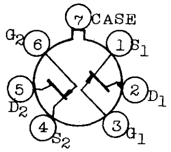
Weight : 0.90g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Gate-Drain Voltage		V_{GDS}	-20	V
Gate 1 - Gate 2 Voltage		V_{G1G2}	±80	V
Gate Current		I_G	10	mA
Drain Power Dissipation	(One Side)	P_{D1}	150	mW
	(Total)	P_{D2}	200	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_{stg}	-65 ∿ 150	°C

PIN CONNECTION

(BOTTOM VIEW)



ELECTRICAL CHARACTERISTICS ($Ta=25°C$)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_G	$V_{DS}=10V$, $I_D=400\mu A$	-	-	-0.1	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	$V_{DS}=0$, $I_G=-0.1mA$	-20	-	-	V
Drain Current	I_{DSS} (Note)	$V_{DS}=10V$, $V_{GS}=0$	0.6	-	6.5	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$(Note)	$V_{DS}=10V$, $I_D=0.1\mu A$	-0.5	-	-3.3	V
Forward Transfer Admittance	$\lvert y_{fs}\rvert$ (Note)	$V_{DS}=10V$, $V_{GS}=0$, f=1kHz	1500	-	6500	μS
Gate Capacitance	C_G	$V_{GS}=-10V$, $V_{DS}=0$, f=1MHz	-	-	9.0	pF
Noise Voltage (peak-peak)	$V_{N(p-p)}$	$V_{DS}=5V$, $I_D=450\mu A$, $R_g=10k\Omega$, f=5 ∿ 50Hz	-	1.7	4.0	μV
Noise Figure	NF	$V_{DS}=10V$, $I_D=450\mu A$, $R_g=100k\Omega$, f=120Hz	-	0.5	5.0	dB
Drain Current Ratio	$I_{DSS(S)}$ / $I_{DSS(L)}$	$V_{DS}=10V$, $V_{GS}=0$	0.9	-	1.0	
Forward Transfer Admittance Ratio	$\lvert y_{fs}\rvert(S)$ / $\lvert y_{fs}\rvert(L)$	$V_{DS}=10V$, $V_{GS}=0$, f=1kHz	0.9	-	1.0	
Differential Gate-Source Voltage	$\lvert V_{GS1}-V_{GS2}\rvert$	$V_{DG}=10V$, $I_D=400\mu A$	-	-	10	mV
		$V_{DG}=10V$, $I_D=200\mu A$	-	-	10	mV
		$V_{DG}=10V$, $I_D=50\mu A$	-	-	10	mV
Gate-Source Voltage Differential Drift	$\frac{\Delta\lvert V_{GS1}-V_{GS2}\rvert}{\Delta Ta}$	$V_{DG}=10V$, $I_D=200\mu A$, Ta=0 ∿ 60°C	-	30	-	μV/°C

Note: According to the value of I_{DSS1}, $V_{GS(OFF)1}$ and $\lvert y_{fs}\rvert_1$, the 2SK72 is classified as follows.

CLASSIFICATION	I_{DSS} 1 (mA)		$V_{GS(OFF)}$1 (V)		$\lvert y_{fs}\rvert$1 (μS)	
	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
2SK72-O	0.60	1.4	-0.50	-1.40	1500	3700
2SK72-Y	1.20	3.0	-0.70	-2.3	2000	5000
2SK72-GR	2.60	6.5	-1.0	-3.3	2600	6500

2SK112

SILICON N CHANNEL JUNCTION TYPE
(INDUSTRIAL APPLICATIONS)

FOR LOW NOISE AMPLIFIER, DC-AC HIGH INPUT IMPEDANCE CIRCUIT, CHOPPER AND SWITCHING CIRCUIT APPLICATIONS.

FEATURES:

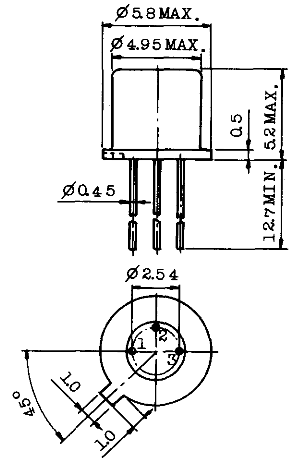
. Ultra Low Noise, as well Low Source Impedance
  : NF=10dB(Max.) (f=10Hz, R_g=1kΩ)
  : NF= 2dB(Max.) (f=1kHz, R_g=1kΩ)

. High Forward Transfer Admittance
  : $|Y_{fs}|$ = 7~34mS

. Low Gate-Source Cutoff Voltage
  : $V_{GS(OFF)}$=-0.75V(Max.) (2SK112-R)
  : $V_{GS(OFF)}$=-1.20V(Max.) (2SK112-O)

. High Breakdown Voltage: $V_{(BR)GDS}$=-50V

Unit in mm



1. SOURCE
2. DRAIN
3. GATE (CASE)

JEDEC	TO-18
EIAJ	TC-7, TB-8C
TOSHIBA	2-5A1C

Weight : 0.31g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-50	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	250	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-65 ~ 150	°C

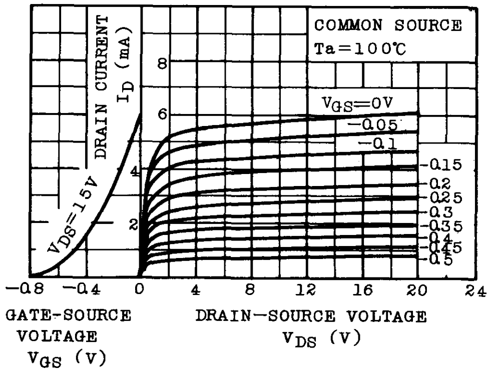
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONCITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-0.1	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-1μA	-50	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=15V, V_{GS}=0	1.2	-	9.0	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$ (Note)	V_{DS}=15V, I_D=0.1μA	-0.25	-	-1.2	V
Forward Transfer Admittance	$\lvert Y_{fs}\rvert$ (Note)	V_{DS}=15V, V_{GS}=0, f=1kHz	7	-	34	mS
Input Capacitance	C_{iss}	V_{DS}=15V, V_{GS}=0, f=1MHz	-	12	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DS}=15V, V_{GS}=0, f=1MHz	-	3	-	pF
Noise Figure	NF(1)	V_{DS}=15V, I_D=1mA, R_g=1kΩ, f=10Hz	-	5	10	dB
	NF(2)	V_{DS}=15V, I_D=1mA, R_g=1kΩ, f=1kHz	-	1	2	

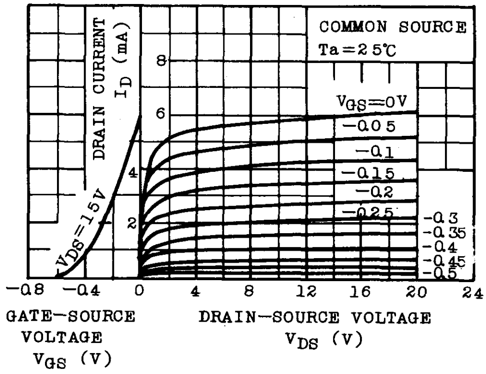
Note : I_{DSS}, $V_{GS(OFF)}$ and $|Y_{fs}|$ classification.

I_{DSS}(mA)→ R:1.2 ~ 3.6 O:3.0 ~ 9.0
$V_{GS(OFF)}$ (V)→R:-0.25 ~ -0.75 O:-0.4 ~ -1.2
Yfs (ms)→R: 7 ~ 21 O: 10 ~ 34

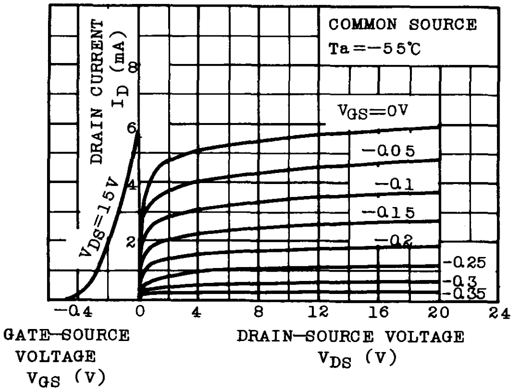
STATIC CHARACTERISTICS



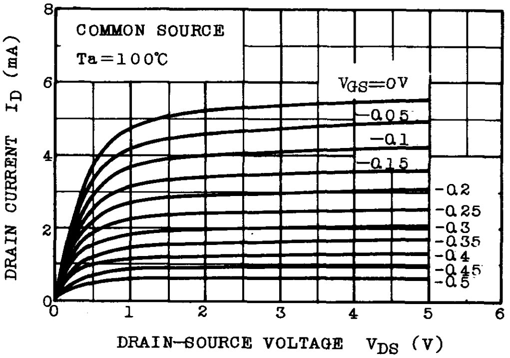
STATIC CHARACTERISTICS



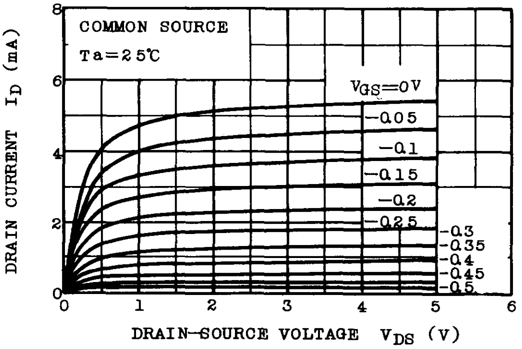
STATIC CHARACTERISTICS



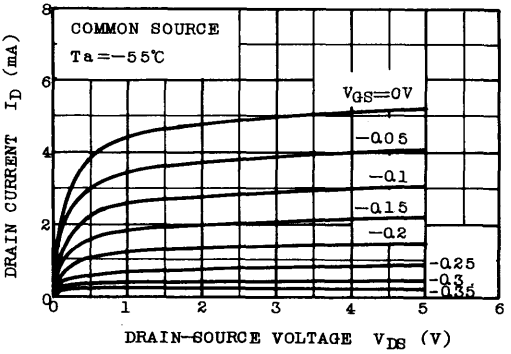
I_D − V_{DS} (LOW VOLTAGE REGION)



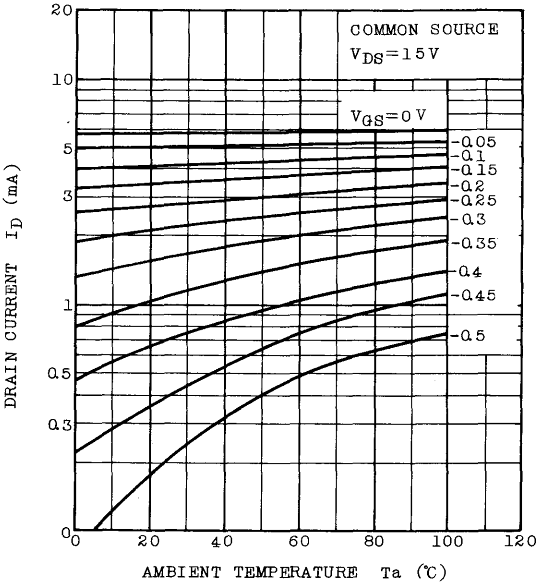
I_D − V_{DS} (LOW VOLTAGE REGION)



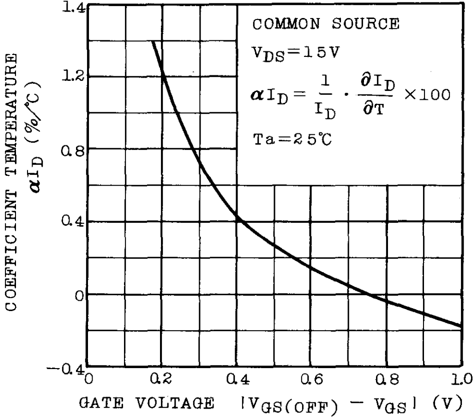
I_D − V_{DS} (LOW VOLTAGE REGION)



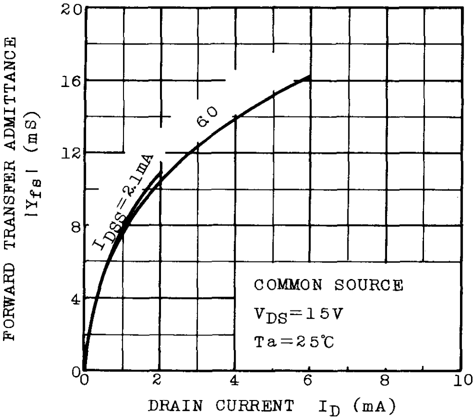
I_D — Ta



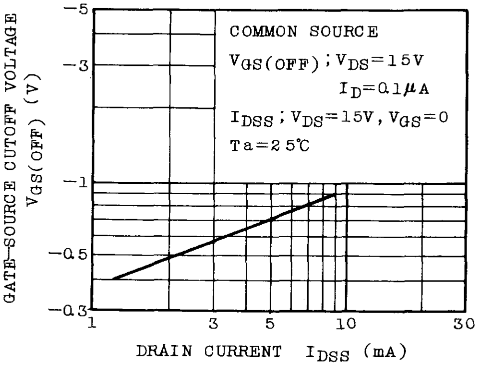
αI_D — $|V_{GS(OFF)} - V_{GS}|$



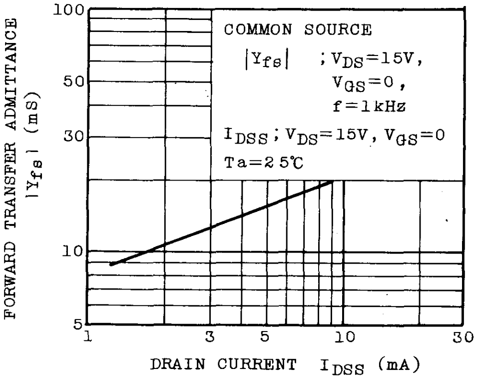
$|Y_{fs}|$ — I_D



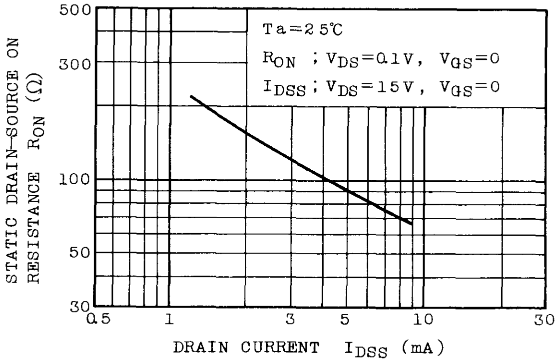
$V_{GS(OFF)}$ — I_{DSS}



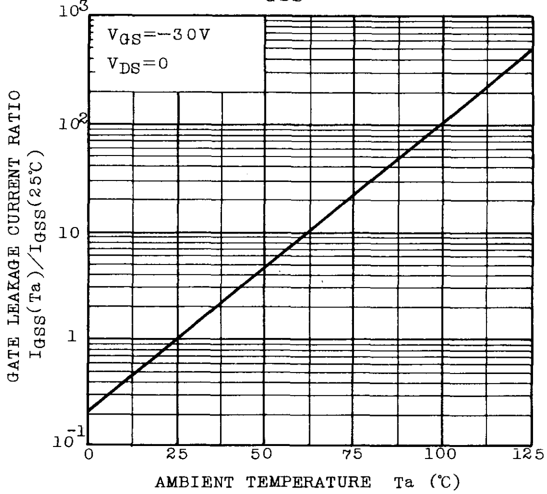
$|Y_{fs}|$ — I_{DSS}



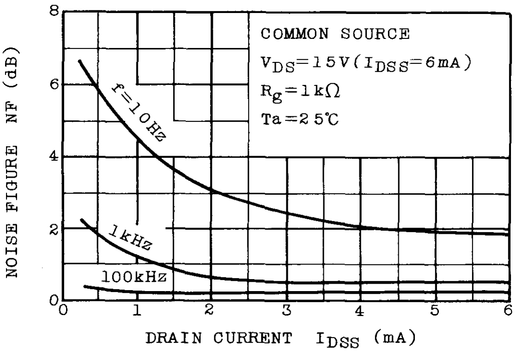
R_{ON} — I_{DSS}



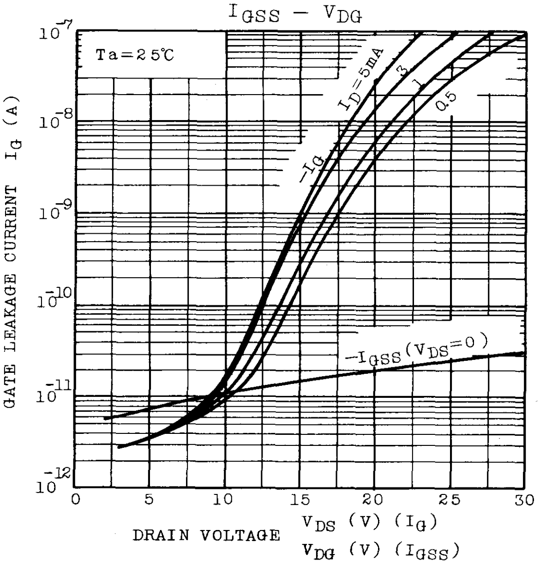
I_{GSS} — Ta



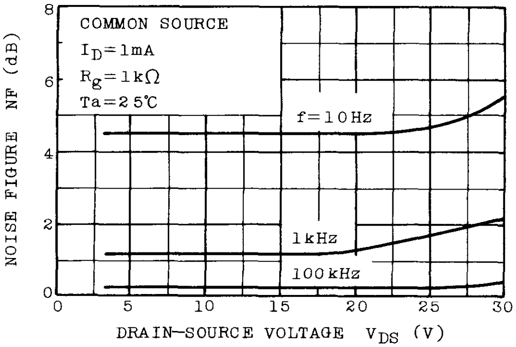
NF — I_D



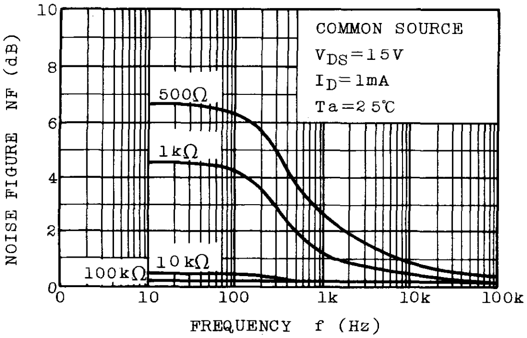
I_{GSS} — V_{DG}

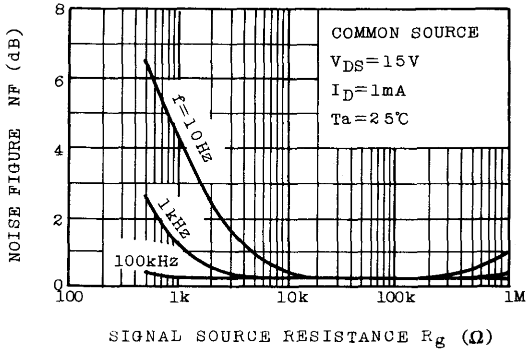


NF — V_{DS}

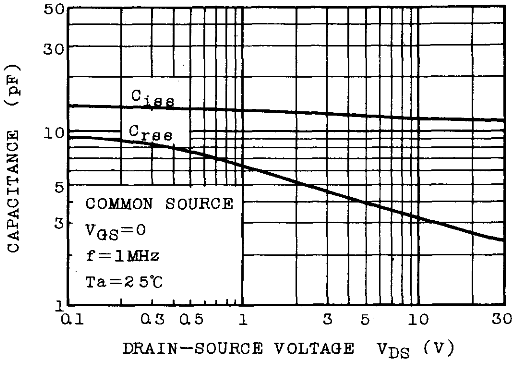


NF — f

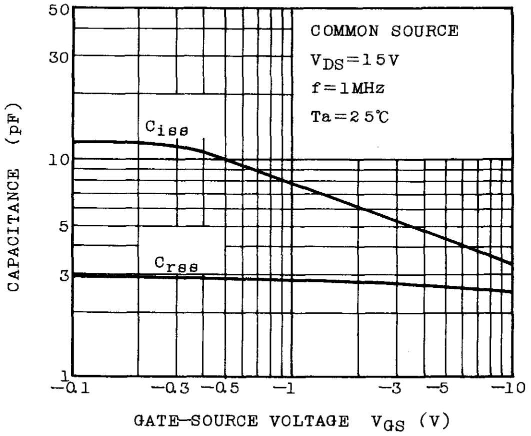




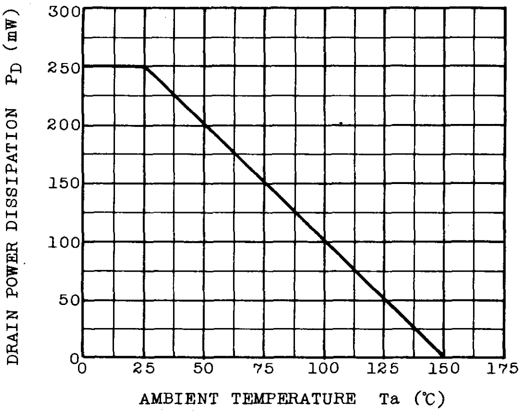
NF – R_g



C_{iss}, C_{rss} – V_{DS}



C_{iss}, C_{rss} – V_{GS}



P_D – Ta

SILICON N CHANNEL JUNCTION TYPE
(INDUSTRIAL APPLICATIONS)

2SK113

FOR ANALOG SWITCH, CHOPPER AMPLIFIER AND SWITCHING CIRCUIT APPLICATIONS.

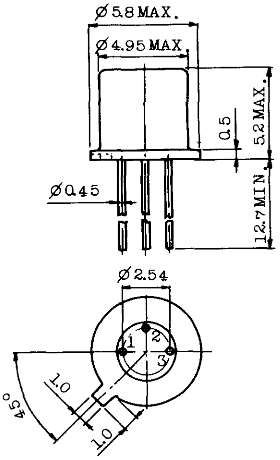
FEATURES:

. High Breakdown Voltage : $V_{(BR)GDS}$=-50V

. Low ON Resistance : $r_{DS(ON)}$=30Ω(Max.) (2SK113-Y)

. Low Leakage : $I_{D(OFF)}$=100pA(Max.) (V_{DS}=20V)

Unit in mm



1. SOURCE
2. DRAIN
3. GATE (CASE)

JEDEC	TO-18
EIAJ	TC-7, TB-8C
TOSHIBA	2-5A1C

Weight : 0.31g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-50	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	250	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-65 ~ 150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-20V, V_{DS}=0	-	-	-0.1	nA
Drain Cutoff Current	$I_{D(OFF)}$	V_{DS}=20V, V_{GS}=(Note 3)	-	-	0.1	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-1μA	-50	-	-	V
Drain Current	I_{DSS} (Note 1)	V_{DS}=20V, V_{GS}=0, (Note 2)	5	-	150	mA
Gate-Source Cutoff Voltage	$V_{GS(OFF)}$	V_{DS}=20V, I_D=0.1μA, (Note 2)	-0.3	-	-10	V
Drain-Source ON Voltage	$V_{DS(ON)}$	V_{GS}=0, I_D=(Note4), (Note2)	-	-	0.4	V
Static Drain-Source ON Resistance	$r_{DS(ON)}$	V_{GS}=0, I_D=1mA, (Note 2)	-	-	100	Ω
Drain-Source ON Resistance	$r_{ds(on)}$	V_{GS}=0, I_D=0, f=1kHz (Note 2)	-	-	100	Ω
Input Capacitance	C_{iss}	V_{DS}=20V, V_{GS}=0, f=1MHz	-	10	14	pF
Reverse Transfer Capacitance	C_{rss}	V_{DS}=0, V_{GS}=(Note 3), f=1MHz	-	3	5	pF

Note 1 : Pulse Test : Pulse Width≦100μs, Duty Cycle≦0.1%

Note 2:

According to the value of I_{DSS}, $V_{GS(OFF)}$, $V_{DS(ON)}$, $r_{DS(ON)}$ and $r_{ds(on)}$, the 2SK113 is classified as follows.

CLASSIFICATION	SYMBOL	I_{DSS} (mA)		$V_{GS(OFF)}$ (V)		$V_{DS(ON)}$ (V)	$r_{DS(ON)}$ (Ω)	$r_{ds(on)}$ (Ω)
		MIN.	MAX.	MIN.	MAX.	MAX.	MAX.	MAX.
2SK113-R	R	5	30	-0.3	-3	0.4	100	100
2SK113-O	O	25	75	-1.2	-5	0.4	60	60
2SK113-Y	Y	50	150	-2.5	-10	0.4	30	30

Note 3:

According to the classification, the 2SK113 is supplied voltage as follows.

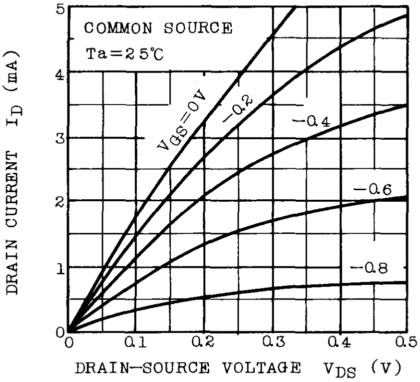
CLASSIFICATION	SYMBOL	V_{GS}(V)
2SK113-R	R	-5
2SK113-O	O	-7
2SK113-Y	Y	-12

Note 4:

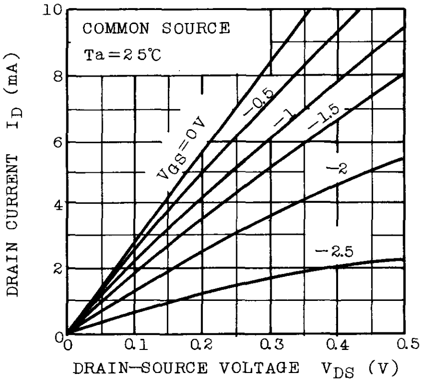
According to the classification, the 2SK113 is supplied drain current I_D as follows.

CLASSIFICATION	SYMBOL	I_D (mA)
2SK113-R	R	3
2SK113-O	O	6
2SK113-Y	Y	12

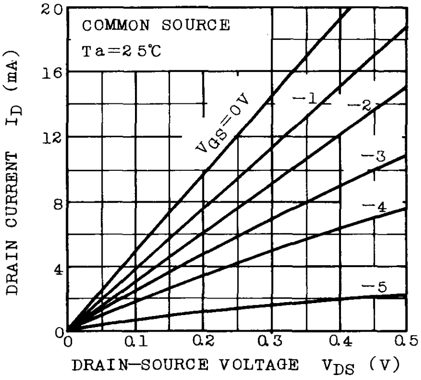
2SK113-R I_D - V_{DS}



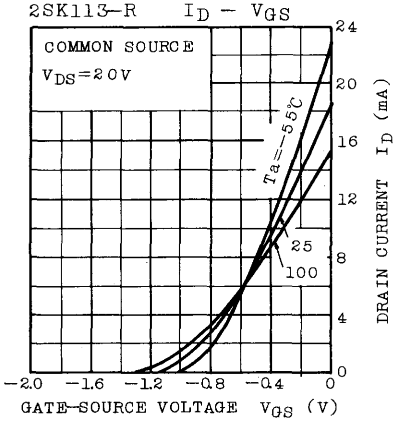
2SK113-O I_D - V_{DS}



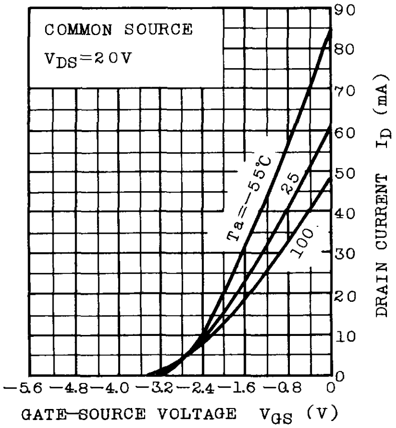
2SK113-Y I_D - V_{DS}



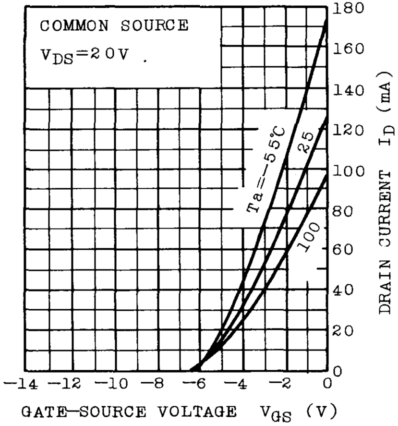
2SK113-R I_D — V_{GS}

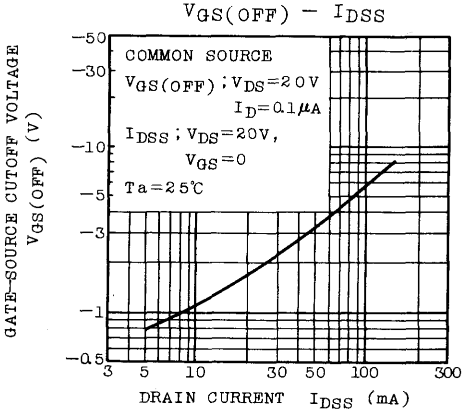


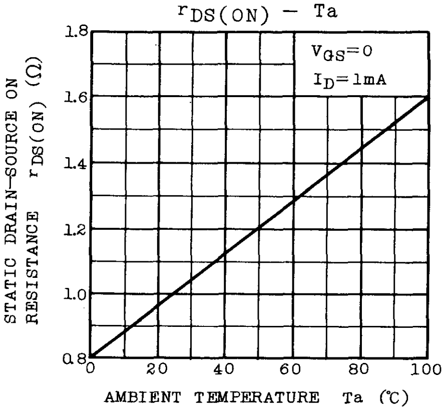
2SK113-O I_D — V_{GS}

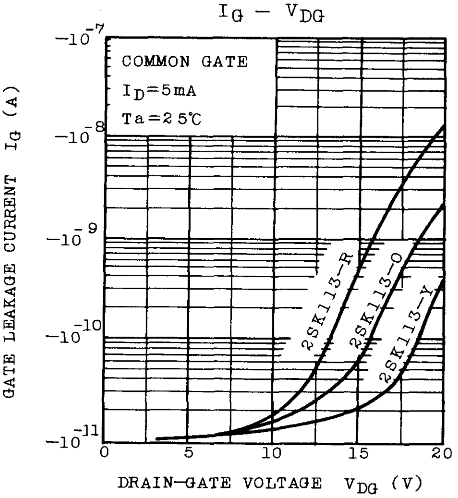


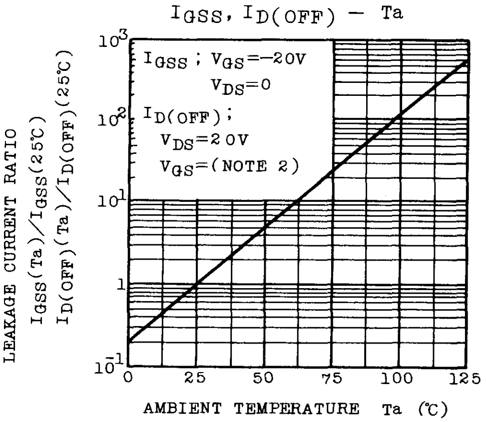
2SK113-Y I_D — V_{GS}

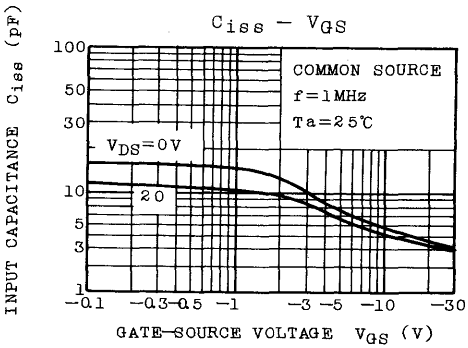


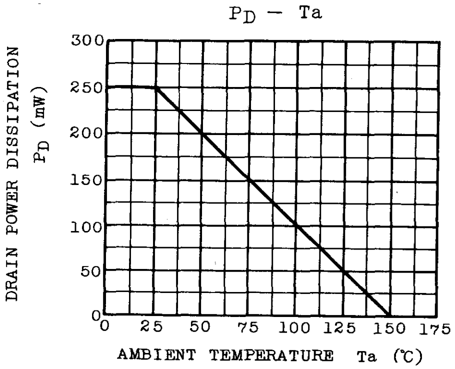

VGS(OFF) – IDSS
COMMON SOURCE
VGS(OFF) ; VDS=20V
ID=0.1μA
IDSS ; VDS=20V,
VGS=0
Ta=25℃
GATE–SOURCE CUTOFF VOLTAGE VGS(OFF) (V)
–50
–30
–10
–5
–3
–1
–0.5
3
5
10
30
50
100
300
DRAIN CURRENT IDSS (mA)


rDS(ON) – Ta
VGS=0
ID=1mA
STATIC DRAIN–SOURCE ON RESISTANCE rDS(ON) (Ω)
1.8
1.6
1.4
1.2
1.0
0.8
0
20
40
60
80
100
AMBIENT TEMPERATURE Ta (℃)


IG – VDG
COMMON GATE
ID=5mA
Ta=25℃
2SK113–R
2SK113–O
2SK113–Y
GATE LEAKAGE CURRENT IG (A)
–10⁻⁷
–10⁻⁸
–10⁻⁹
–10⁻¹⁰
–10⁻¹¹
0
5
10
15
20
DRAIN–GATE VOLTAGE VDG (V)


IGSS, ID(OFF) – Ta
IGSS ; VGS=–20V
VDS=0
ID(OFF) ;
VDS=20V
VGS=(NOTE 2)
LEAKAGE CURRENT RATIO
IGSS(Ta)/IGSS(25℃)
ID(OFF)(Ta)/ID(OFF)(25℃)
10³
10²
10¹
1
10⁻¹
0
25
50
75
100
125
AMBIENT TEMPERATURE Ta (℃)


Ciss – VGS
COMMON SOURCE
f=1MHz
Ta=25℃
VDS=0V
20
INPUT CAPACITANCE Ciss (pF)
100
50
30
10
5
3
1
–0.1
–0.3
–0.5
–1
–3
–5
–10
–30
GATE–SOURCE VOLTAGE VGS (V)


PD – Ta
DRAIN POWER DISSIPATION PD (mW)
300
250
200
150
100
50
0
0
25
50
75
100
125
150
175
AMBIENT TEMPERATURE Ta (℃)

SILICON N CHANNEL JUNCTION TYPE

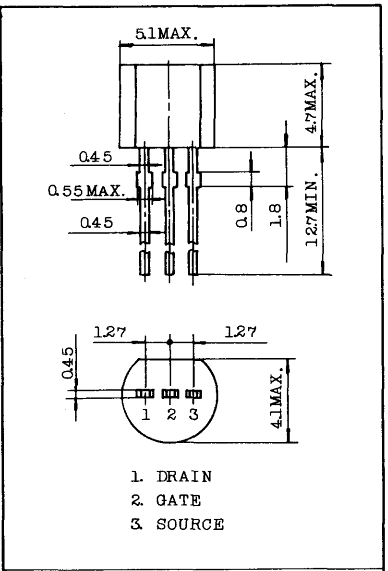
2SK117

LOW NOISE AUDIO AMPLIFIER APPLICATIONS.

FEATURES:

- High $|y_{fs}|$: $|y_{fs}|$=15mS (Typ.)
  (V_{DS}=10V, V_{GS}=0)
- High Breakdown Voltage : V_{CDS}=-50V
- Low Noise : NF=1.0 dB (Typ.)
  (V_{DS}=10V, I_D=0.5mA, f=1kHz, R_g=1kΩ)
- High Input Impedance : I_{GSS}=-1nA (Max.)(V_{GS}=-30V)

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1D

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

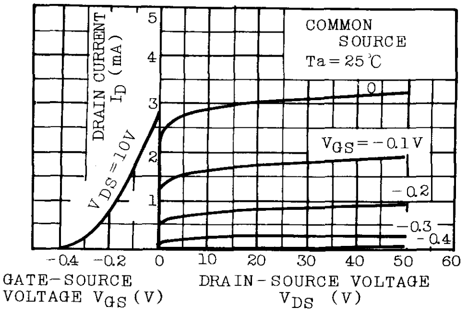
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-50	V
Gate-Current	I_G	10	mA
Drain Power Dissipation	P_D	300	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ∿ 125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

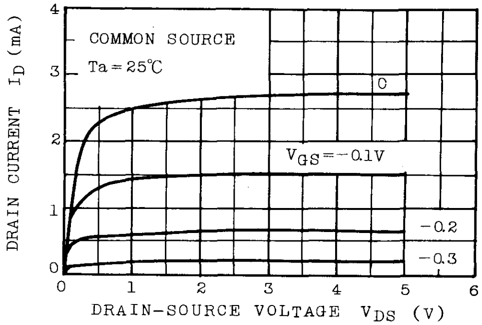
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-50	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=10V, V_{GS}=0	0.6	-	14	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.2	-	-1.5	V
Forward Transfer Admittance	$\|y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz	4.0	15	-	mS
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	13	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=10V, I_D=0, f=1MHz	-	3	-	pF
Noise Figure	NF(1)	V_{DS}=10V, R_g=1kΩ I_D=0.5mA, f=10Hz	-	5	10	dB
	NF(2)	V_{DS}=10V, R_g=1kΩ I_D=0.5mA, f=1kHz	-	1	2	

Note : I_{DSS} Classification O: 0.6 ∿ 1.4, Y : 1.2 ∿ 3.0
GR: 2.6 ∿ 6.5, BL: 6.0 ∿ 14.0

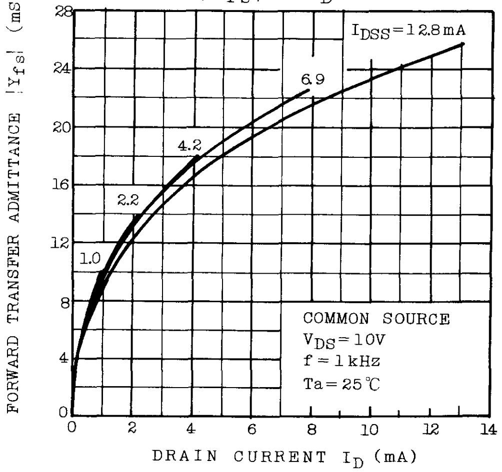
STATIC CHARACTERISTICS



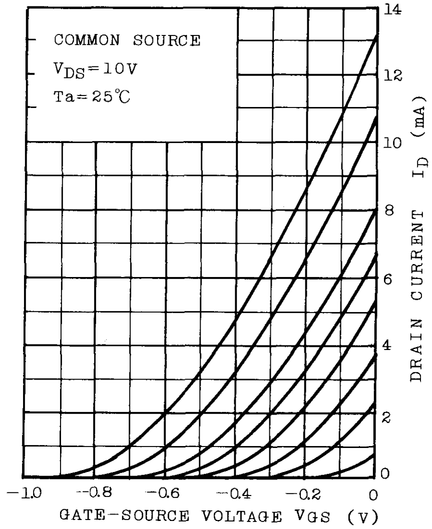
I_D − V_{DS} (LOW VOLTAGE REGION)



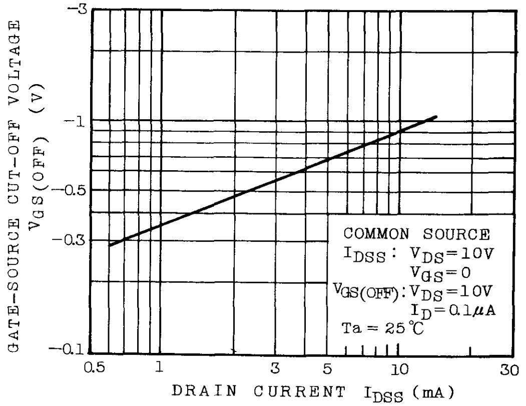
|Y_{fs}| − I_D



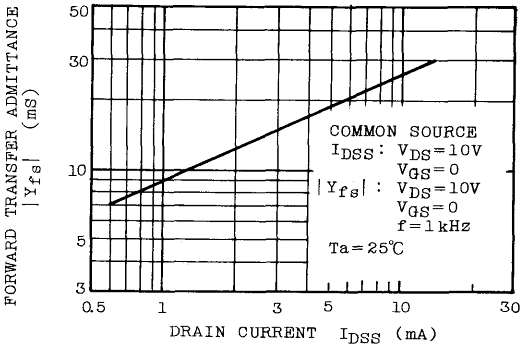
I_D − V_{GS}



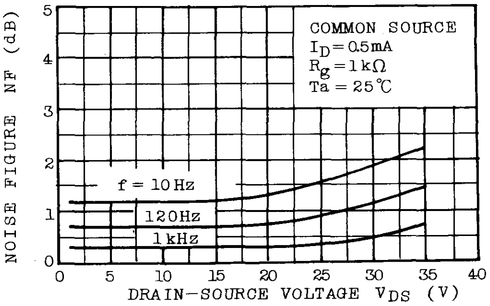
$V_{GS(OFF)}$ − I_{DSS}



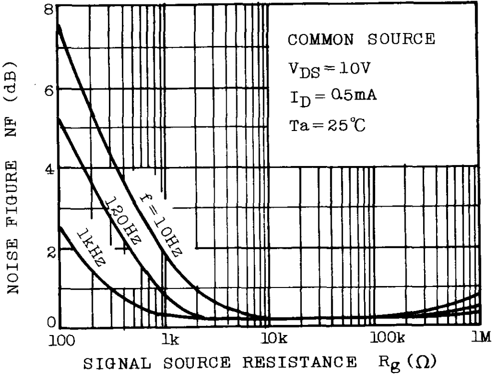
|Y_{fs}| − I_{DSS}



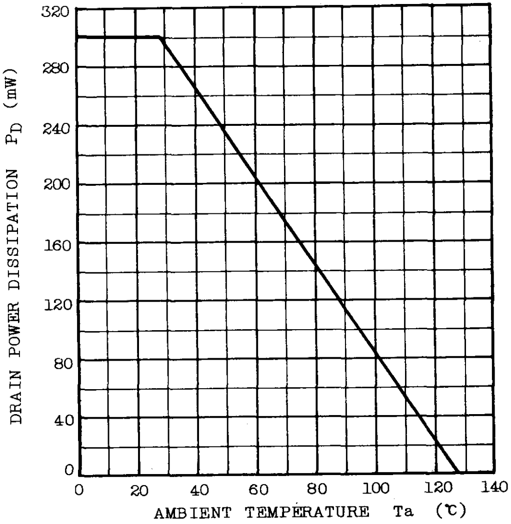
NF — V_{DS}



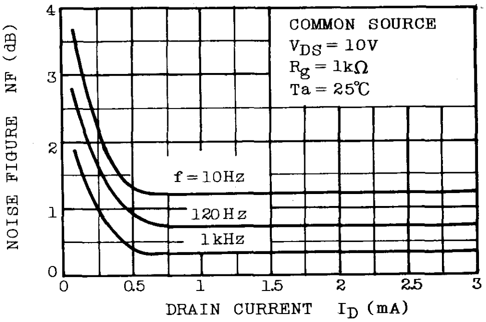
NF — R_g



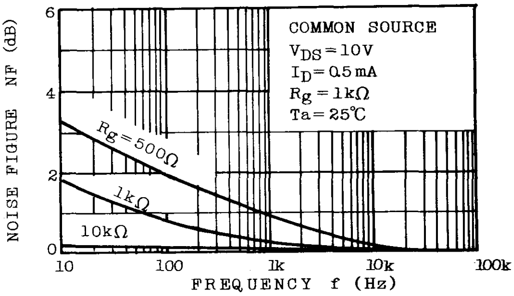
P_D — Ta



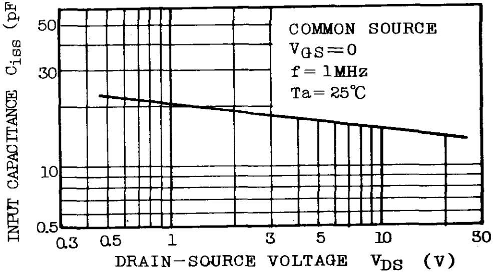
NF — I_D



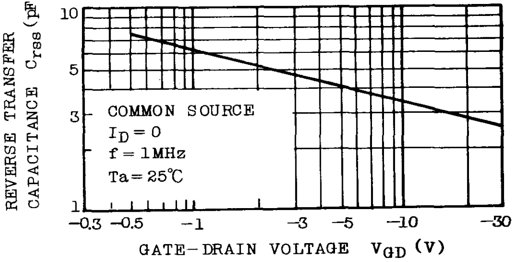
NF — f



C_{iss} — V_{DS}



C_{rss} — V_{GD}



2SK118

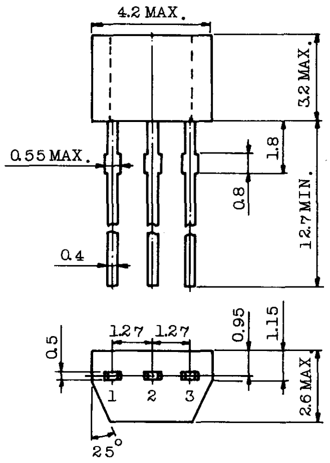
SILICON N CHANNEL JUNCTION TYPE

GENERAL PURPOSE AND IMPEDANCE CONVERTER AND CONDENSER MICROPHONE APPLICATIONS.

FEATURES:

- High Breakdown Voltage : V_{GDS}=-50V
- High Input Impedance : I_{GSS}=-1nA(Max.) (V_{GS}=-30V)
- Low Noise : NF=0.5dB(Typ.) (R_g=100kΩ) (f=120Hz)
- Small Package.

Unit in mm



1. SOURCE
2. GATE
3. DRAIN

JEDEC	—
EIAJ	—
TOSHIBA	2—4E1B

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

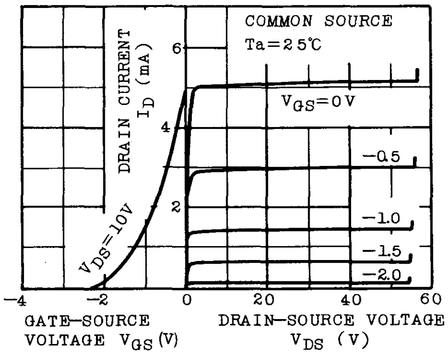
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-50	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	100	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

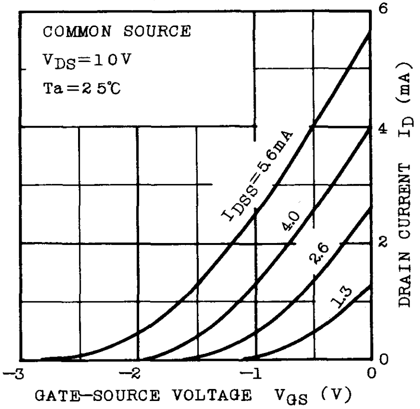
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-50	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=10V, V_{GS}=0	0.3	-	6.5	mA
Pinch-off Voltage	V_P	V_{DS}=10V, I_D=0.1μA	-0.4	-	-5.0	V
Forward Transfer Admittance	$\lvert Y_{fs} \rvert$	V_{DS}=10V, V_{GS}=0, f=1kHz	1.2	-	-	mS
Input Capacitance	C_{iss}	V_{GS}=0, V_{DS}=10V, f=1MHz	-	8.2	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{GD}=-10V, I_D=0, f=1MHz	-	2.6	-	pF
Noise Figure	NF	V_{DS}=15V, V_{GS}=0, R_g=100kΩ, f=120Hz	-	0.5	5.0	dB

Note: I_{DSS} Classification R : 0.30 ~ 0.75, O : 0.60 ~1.40, Y : 1.20 ~3.00, GR : 2.60 ~6.50

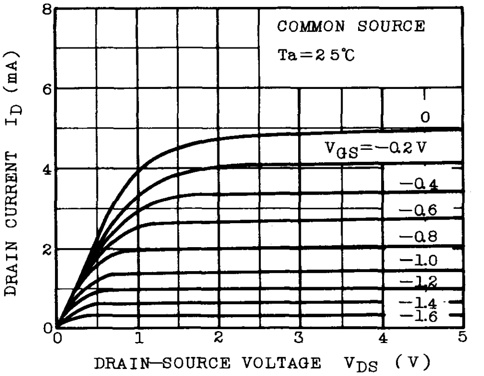
STATIC CHARACTERISTICS



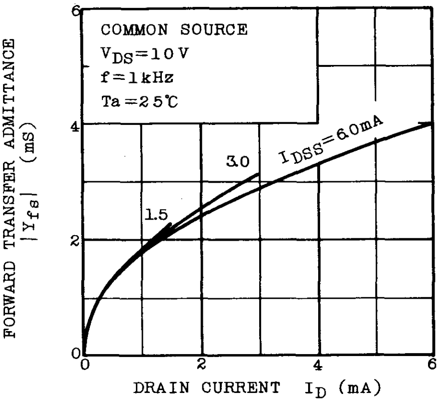
$I_D - V_{GS}$



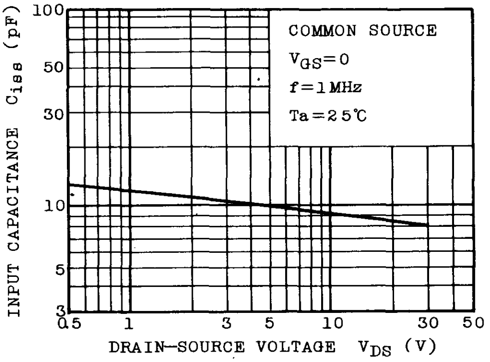
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



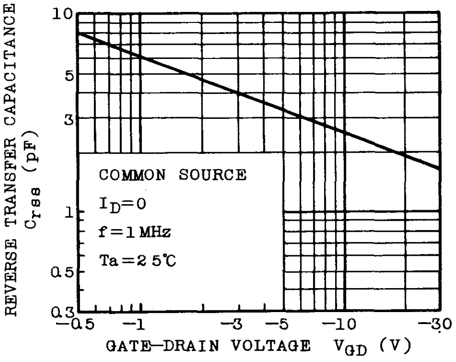
$|Y_{fs}| - I_D$



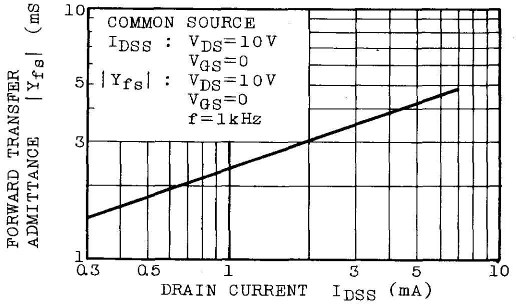
$C_{iss} - V_{DS}$



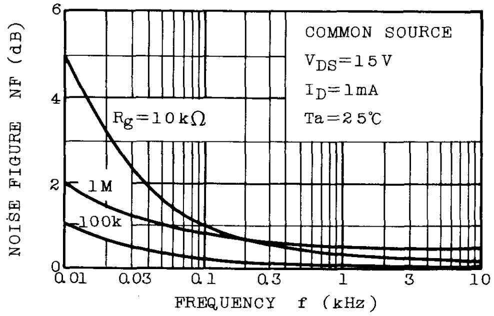
$C_{rss} - V_{GD}$



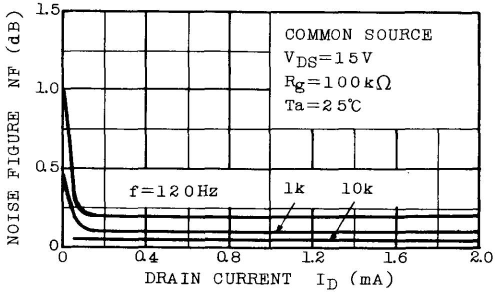
$|Y_{fs}| - I_{DSS}$



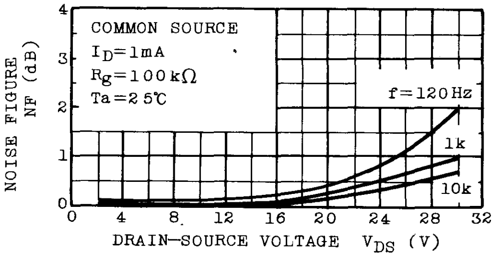
$NF - f$



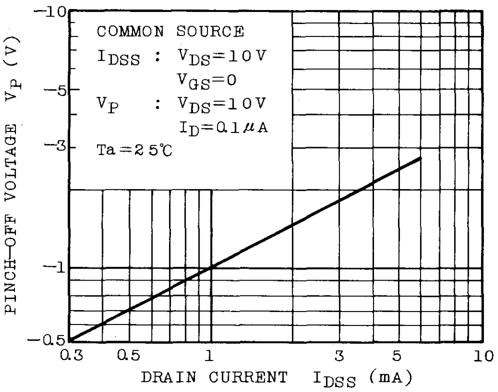
$NF - I_D$



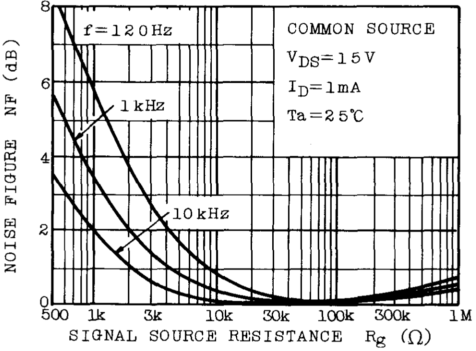
$NF - V_{DS}$



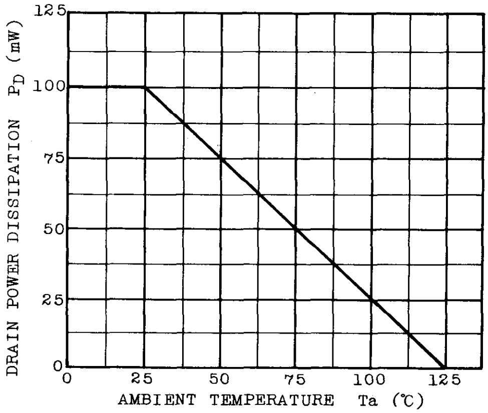
$V_P - I_{DSS}$



$NF - R_g$



$P_D - Ta$



SILICON N CHANNEL JUNCTION TYPE

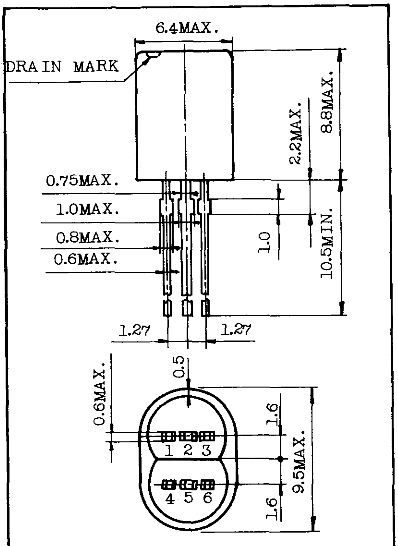
2SK146

LOW NOISE AUDIO AMPLIFIER APPLICATIONS.
DIFFERENTIAL AMPLIFIER APPLICATIONS.

FEATURES:

- High $|y_{fs}|$
  : $|y_{fs}|$=40mS(Typ.) (V_{DS}=10V, V_{GS}=0, I_{DSS}=5mA)
- Excellent Pair Characteristics
  : $|V_{GS1}-V_{GS2}|$ = 20mV (Max.) (V_{DS}=10V, I_D=5mA)
- High Breakdown Voltage : V_{GDS}=-40V
- Low Noise : NF=1.0dB (Typ.)
  (V_{DS}=10V, I_D=5mA, R_g=100Ω, f=1kHz)
- High Input Impedance : I_{GSS}=-1nA(Max.) (V_{GS}=-30V)
- High Drain Power Dissipation : P_D=600mW × 2

Unit in mm



1. DRAIN 1
2. GATE 1
3. SOURCE 1
4. DRAIN 2
5. GATE 2
6. SOURCE 2

JEDEC	—
EIAJ	—
TOSHIBA	2 — 6E1A

Weight : 1.08g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-40	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	600x2	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

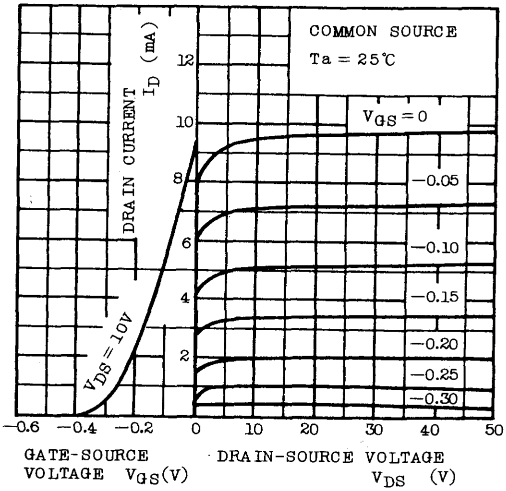
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-40	-	-	V
Drain Current	I_{DSS} (Note1)	V_{DS}=10V, V_{GS}=0	5.0	-	30	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.3	-	-1.2	V
Forward Transfer Admittance	$\|y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz, I_{DSS}=5mA	30	40	-	mS
Differential Gate-Source Voltag	$V_{GS1}-V_{GS2}$	V_{DS}=10V, I_D=5mA	-	-	20	mV
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0,f=1MHz	-	75	-	pF
Reserve Transfer Capacitance	C_{rss}	V_{DG}=10V, I_D=0, f=1MHz	-	15	-	pF
Noise Figure (Note 2)	NF(1)	V_{DS}=10V, R_g=100Ω I_D=5mA, f=100Hz	-	5	10	dB
	NF(2)	V_{DS}=10V, R_g=100Ω I_D=5mA, f=1kHz	-	1	2	

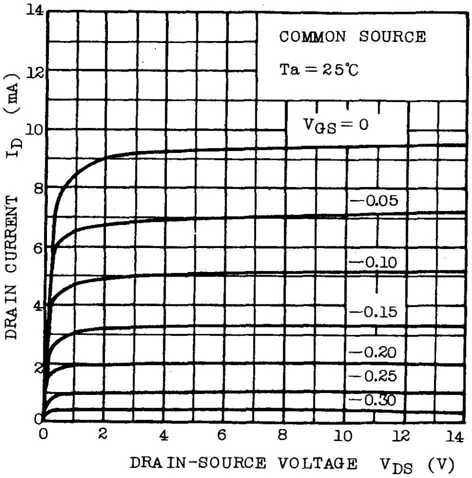
Note 1 : I_{DSS} Classification GR : 5.0∿10, BL : 8.0∿16, V : 14.0∿30

2 : When low noise audio amplifier, recommended V_{DS} up to 15V.

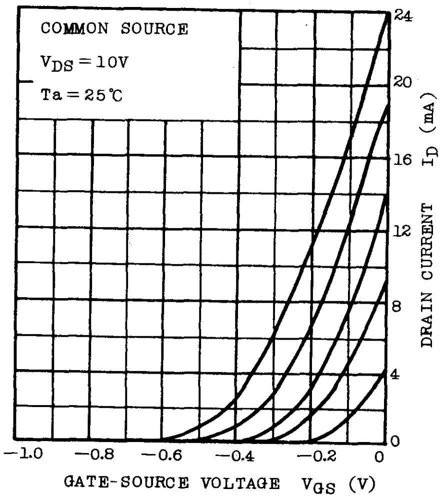
STATIC CHARACTERISTICS



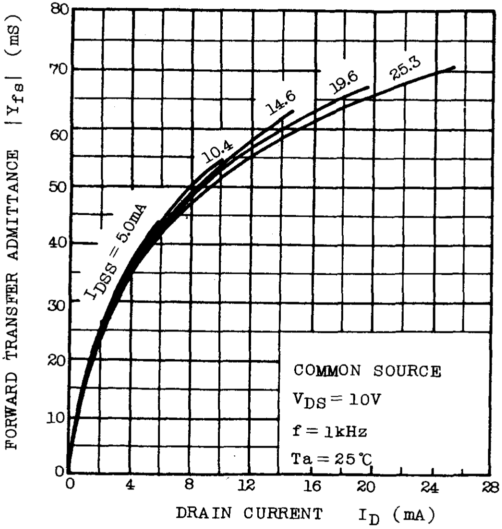
I_D − V_{DS} (LOW VOLTAGE REGION)



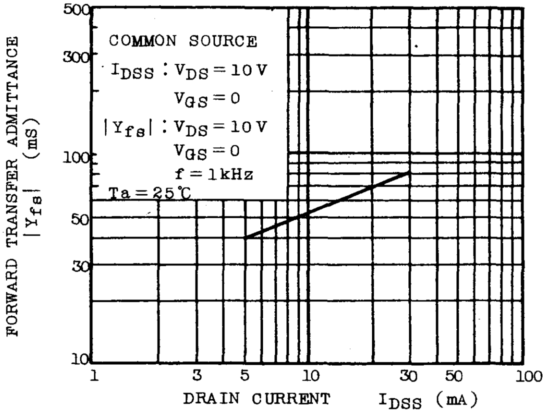
I_D − V_{GS}



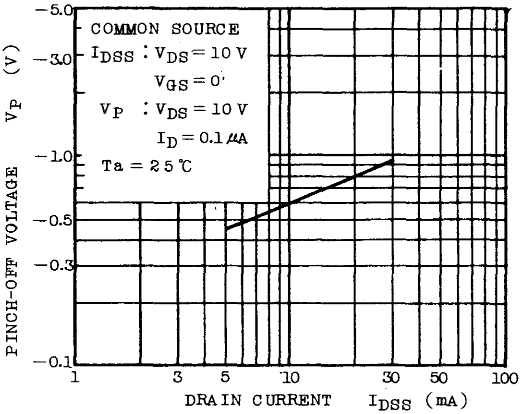
$|Y_{fs}|$ − I_D



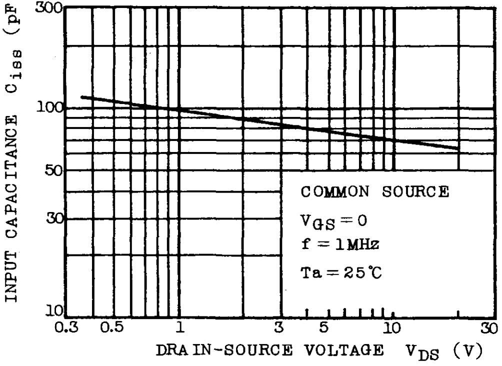
|Yfs| – IDSS



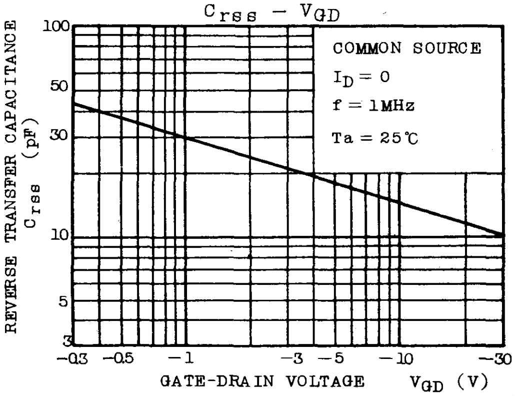
VP – IDSS



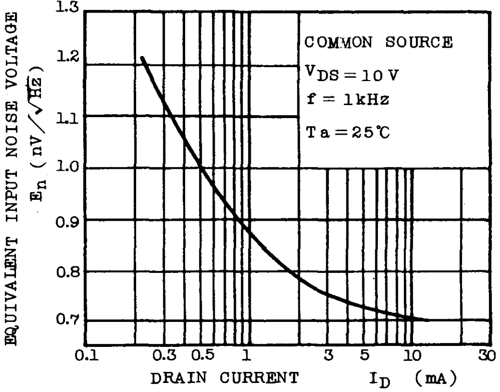
Ciss – VDS



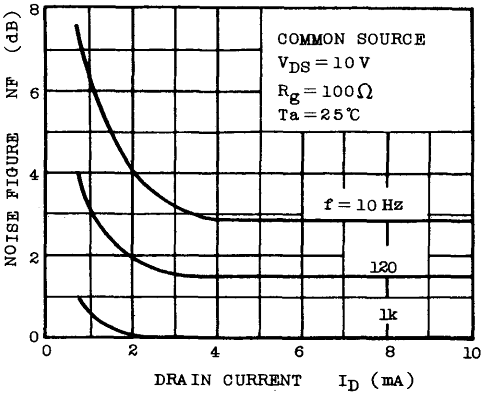
Crss – VGD



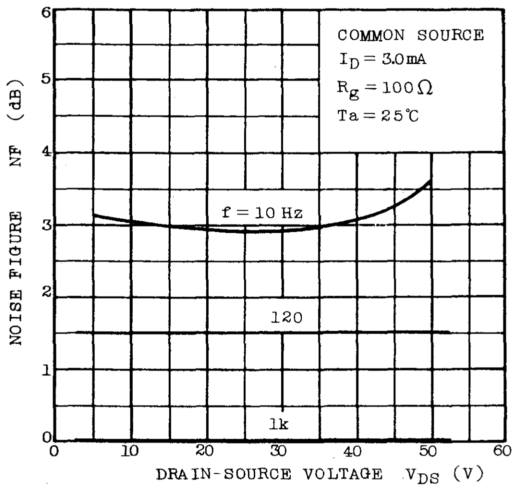
En – ID



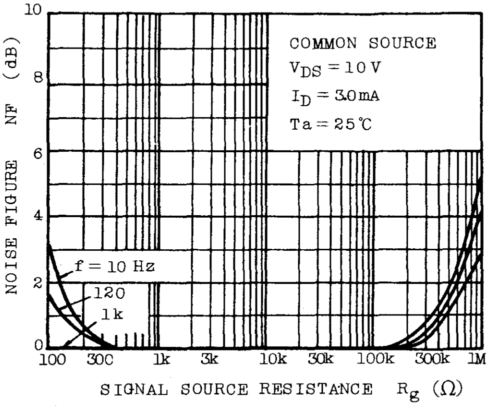
NF – ID



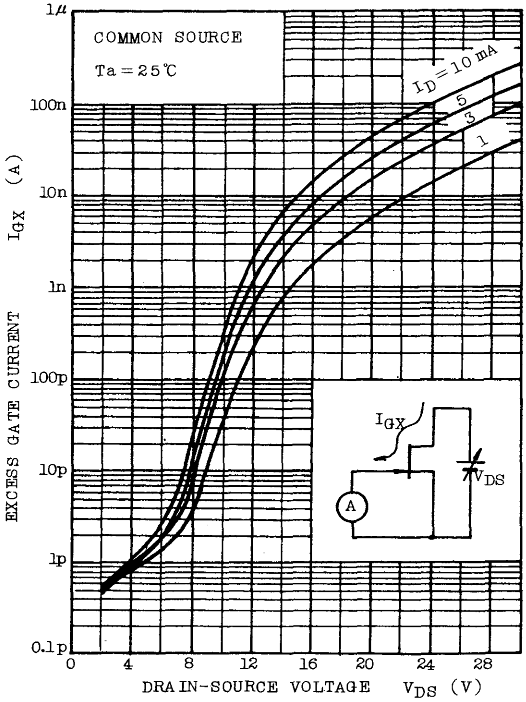
NF – V_{DS}



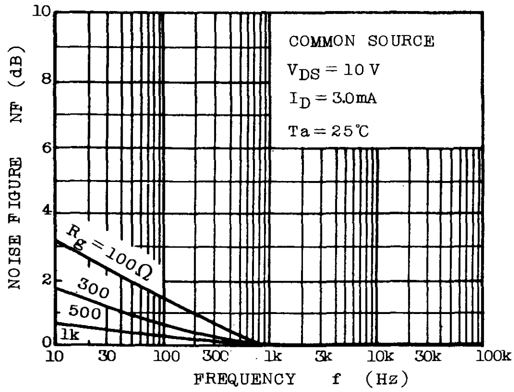
NF – R_g



I_{GX} – V_{DS}



NF – f



SILICON N CHANNEL JUNCTION TYPE

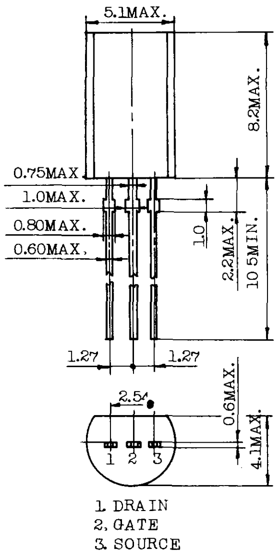
2SK147

LOW NOISE AUDIO AMPLIFIER APPLICATIONS.

FEATURES:

- High $|y_{fs}|$
  : $|y_{fs}|$=40mS(Typ.) (V_{DS}=10V, V_{GS}=0, I_{DSS}=5mA)
- High Breakdown Voltage : V_{GDS}=-40V
- Low Noise : NF=1.0dB (Typ.)
  (V_{DS}=10V, I_D=5mA, f=1kHz, R=100Ω)
- High Input Impedance
  : I_{GSS}=-1nA (Max.) (V_{GS}=-30V)
- High Drain Power Dissipation : P_D=600mW
- Complementary to 2SJ72.

Unit in mm



JEDEC	TO — 92MOD
EIAJ	—
TOSHIBA	2 — 5J1B

Weight : 0.36g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-40	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	600	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∼125	°C

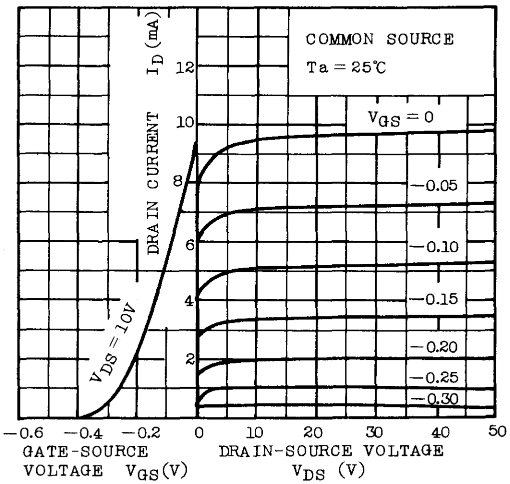
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-40	-	-	V
Drain Current	I_{DSS} (Note 1)	V_{DS}=10V, V_{GS}=0	5.0	-	30	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.3	-	-1.2	V
Forward Transfer Admittance	$\|y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz, (Typ.: I_{DSS}=5mA)	30	40	-	mS
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	75	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=10V, I_D=0, f=1MHz	-	15	-	pF
Noise Figure (Note 2)	NF(1)	V_{DS}=10V, R_g=100Ω I_D=5mA, f=100Hz	-	5	10	dB
	NF(2)	V_{DS}=10V, R_g=100Ω I_D=5mA, f=1kHz	-	1	2	dB

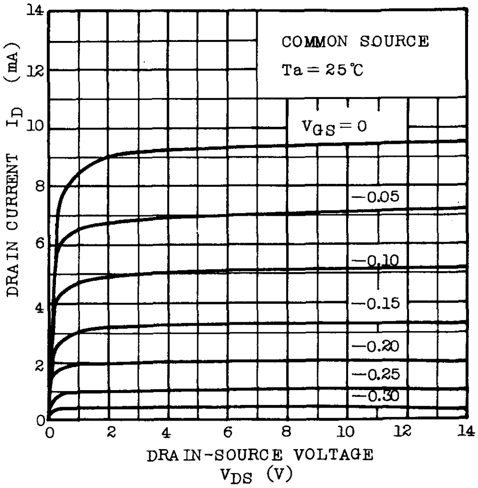
Note 1 : I_{DSS} Classification GR : 5.0∼10.0, BL : 8.0∼16.0, V : 14.0∼30.0

2 : When low noise audio amplifier, recommended V_{DS} up to 15V.

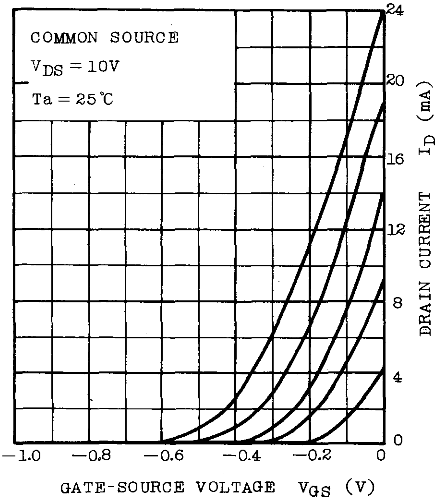
STATIC CHARACTERISTICS



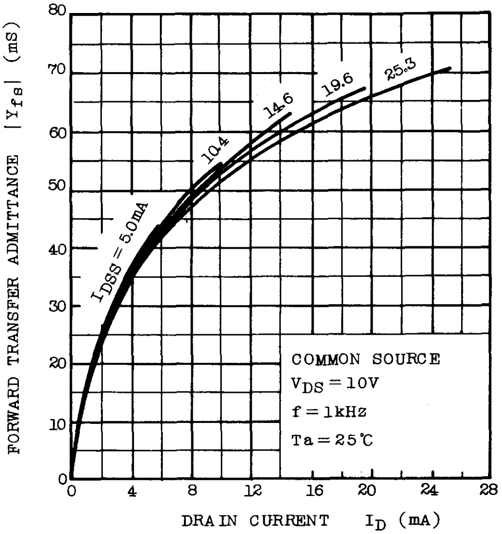
I_D − V_{DS} (LOW VOLTAGE REGION)



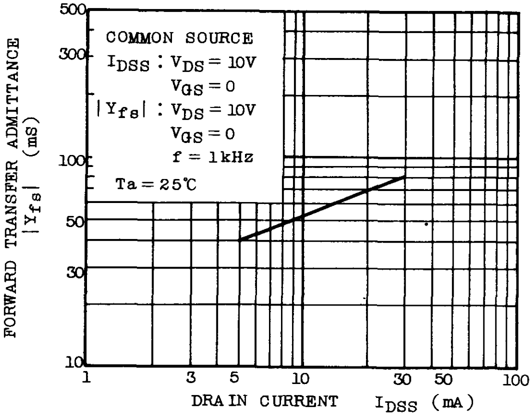
I_D − V_{GS}



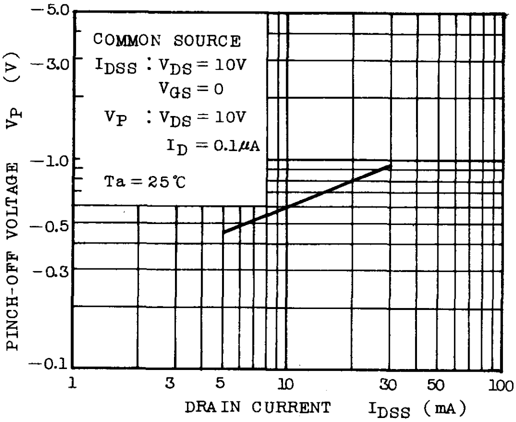
|Y_{fs}| − I_D



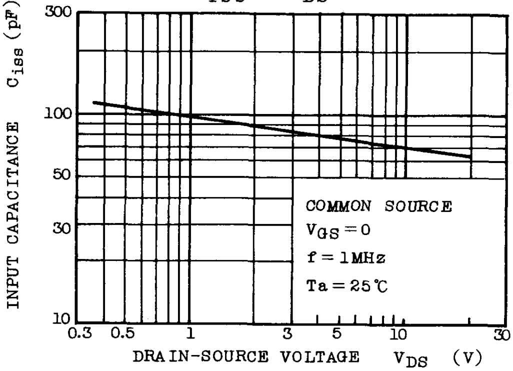
$|Y_{fs}| - I_{DSS}$



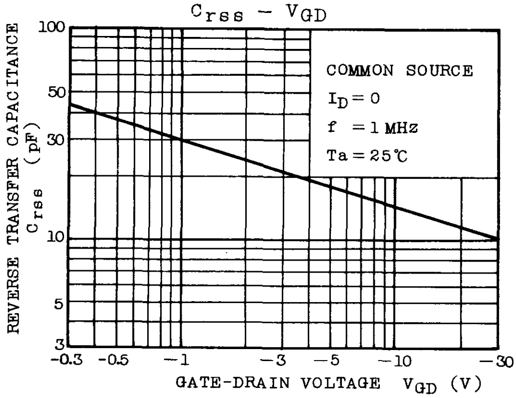
$V_P - I_{DSS}$



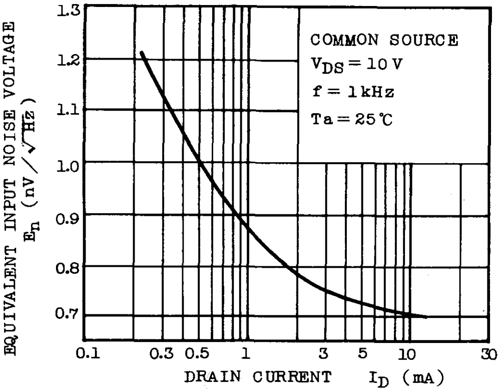
$C_{iss} - V_{DS}$



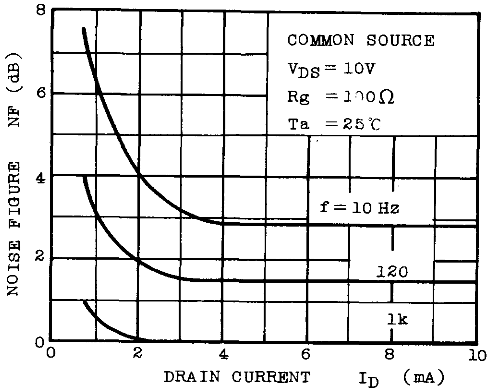
$C_{rss} - V_{GD}$



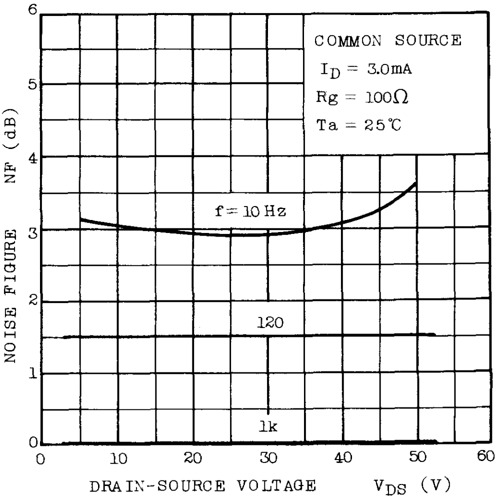
$E_n - I_D$



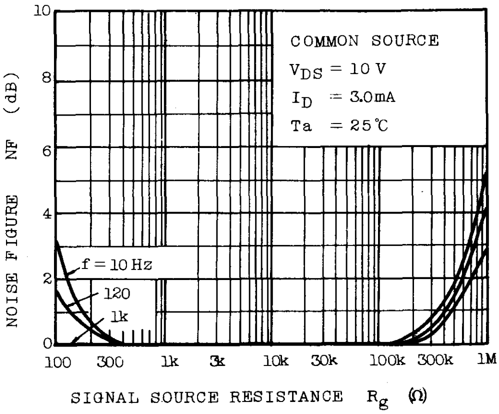
$NF - I_D$



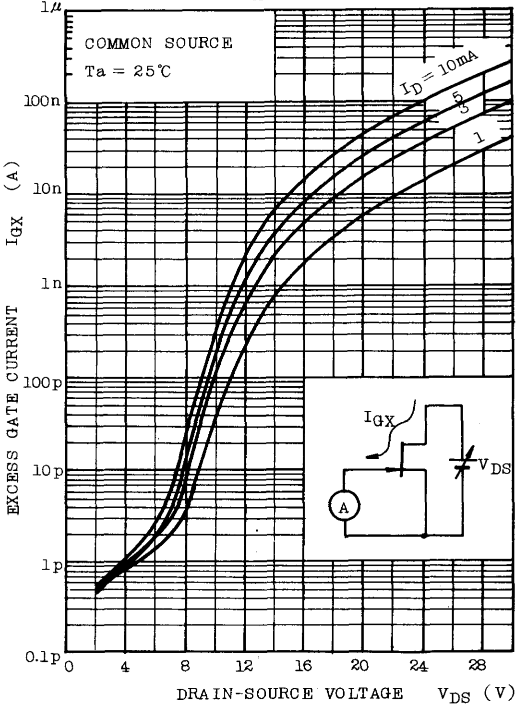
NF – V_{DS}



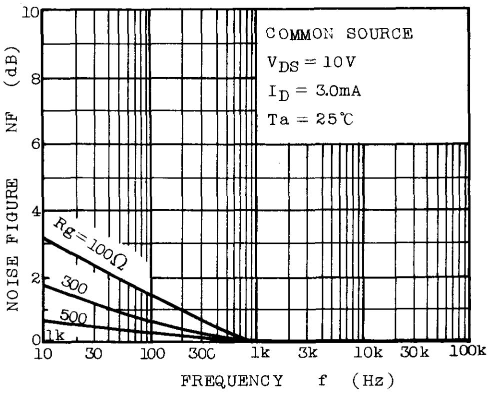
NF – R_g



I_{GX} – V_{DS}



NF – f



SILICON N CHANNEL JUNCTION TYPE

2SK161

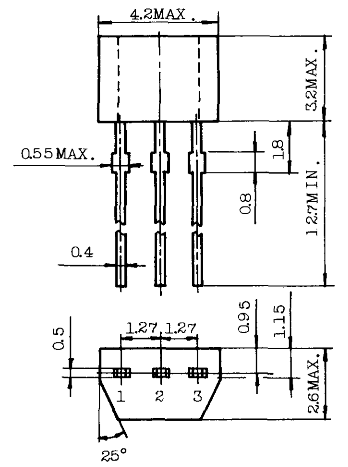
FM TUNER APPLICATIONS.

VHF BAND AMPLIFIER APPLICATIONS.

FEATURES:

- Low Noise Figure : NF=2.5dB (Typ.)(f=100MHz)
- High Forward Transfer Admittance : $|y_{fs}|$ =9mS (Typ.)
- Extremely Low Reverse Transfer Capacitance : C_{rss}=0.1pF (Typ.)

Unit in mm



1. DRAIN.
2. SOURSE
3. GATE

JEDEC	—
EIAJ	—
TOSHIBA	2-4E1D

Weight: 0.13g

MAXIMUM RATINGS (Ta=25°C)

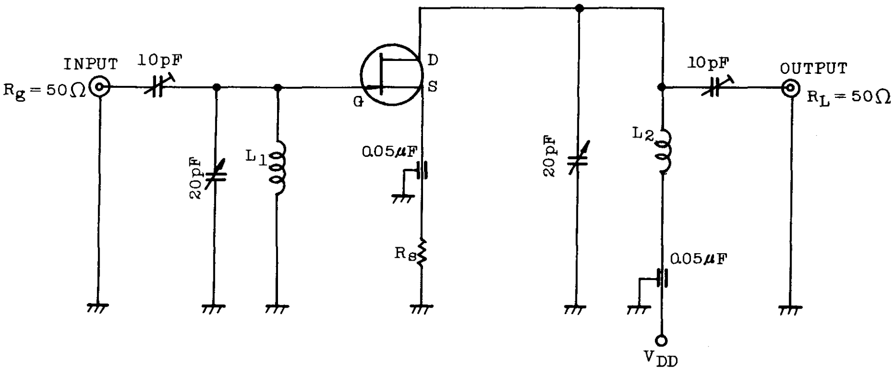
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDO}	-18	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-0.5V, V_{DS}=0	-	-	-10	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDO}$	I_G=-100μA	-18	-	-	V
Drain Current	I_{DSS} (Note)	V_{GS}=0, V_{DS}=10V	1.0	-	10	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=1μA	-0.4	-	-4.0	V
Foward Transfer Admittance	$\lvert y_{fs}\rvert$	V_{GS}=0, V_{DS}=10V, f=1kHz	-	9	-	mS
Reverse Transfer Capacitance	C_{rss}	V_{GD}=-10V, f=1MHz	-	0.10	0.15	pF
Power Gain	G_{PS}	V_{DD}=10V, f=100MHz (Fig.)	-	18	-	dB
Noise Figure	NF	V_{DD}=10V, f=100MHz (Fig.)	-	2.5	3.5	dB

Note: I_{DSS} Classification O : 1.0∿3.0, Y : 2.5∿6.0, GR : 5.0∿10.0

Fig. : 100MHz G_{PS} , NF TEST CIRCUIT



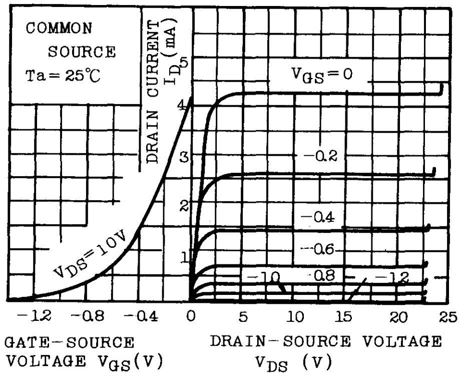
L_1 : 0.8 mm∅ Ag PLATED Cu WIRE, 3 TURNS, 10mm ID, 10mm LENGTH.

L_2 : 0.8 mm∅ Ag PLATED Cu WIRE, 3.5 TURNS, 10mm ID, 10mm LENGTH.

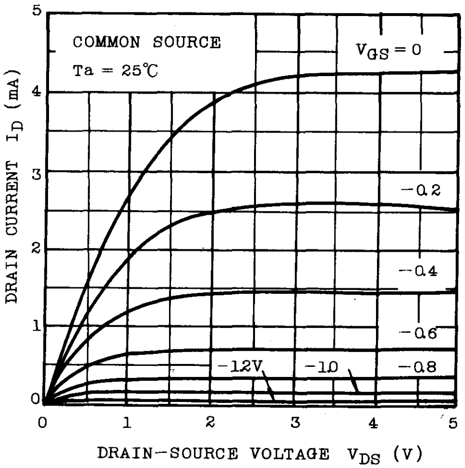
2SK161 is measured at each group by changing R_S.

GROUP	R_S (Ω)
2SK161−O	0
2SK161−Y	18Ω±5%
2SK161−GR	100Ω±5%

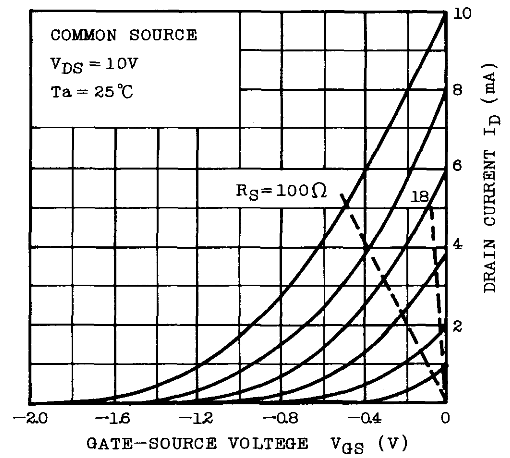
STATIC CHARACTERISTICS



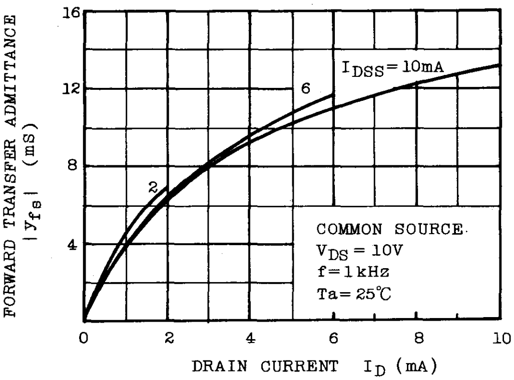
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



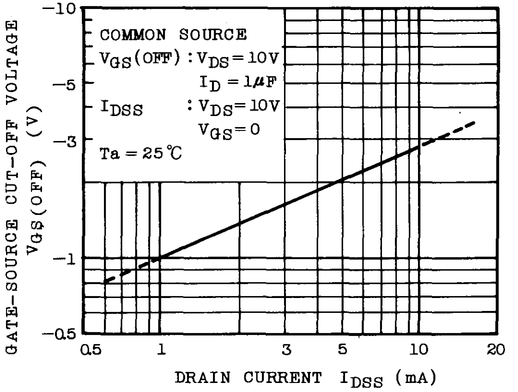
$I_D - V_{GS}$



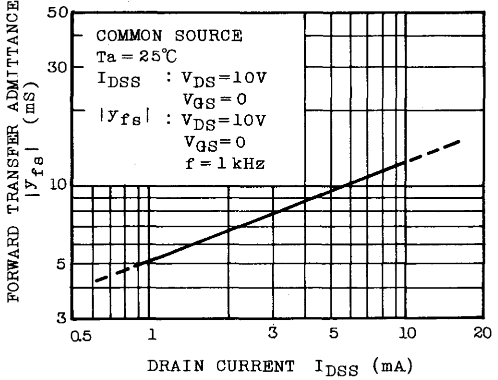
$|y_{fs}| - I_D$



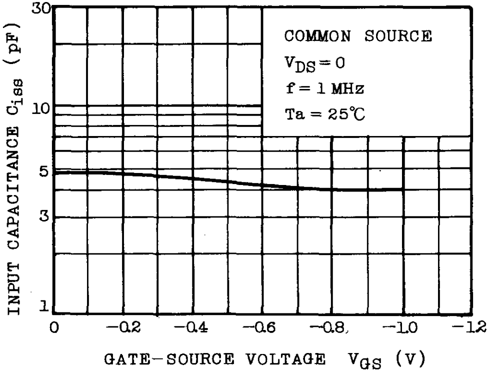
$V_{GS(OFF)} - I_{DSS}$



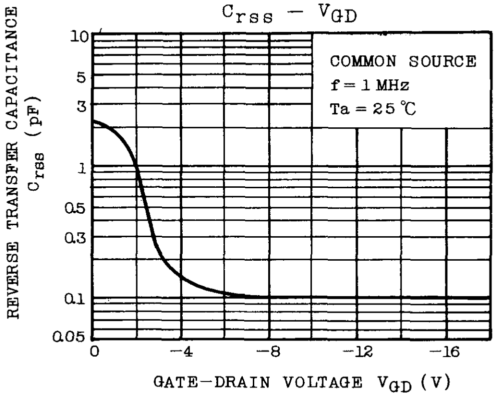
$|y_{fs}| - I_{DSS}$

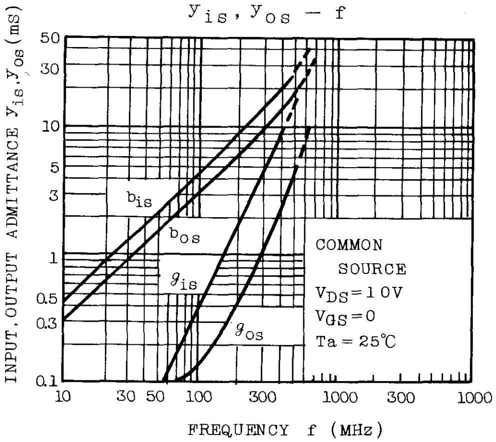


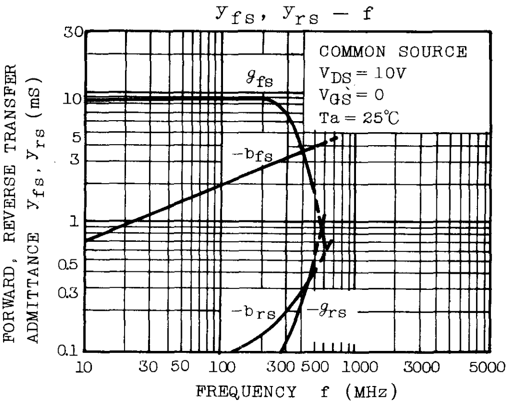
$C_{iss} - V_{GS}$

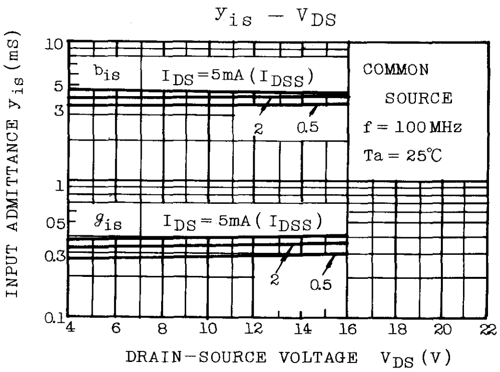


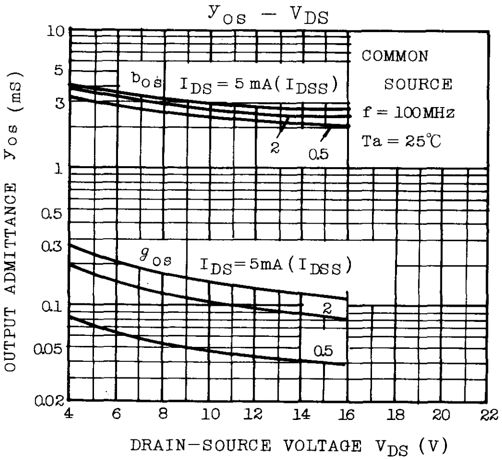
$C_{rss} - V_{GD}$

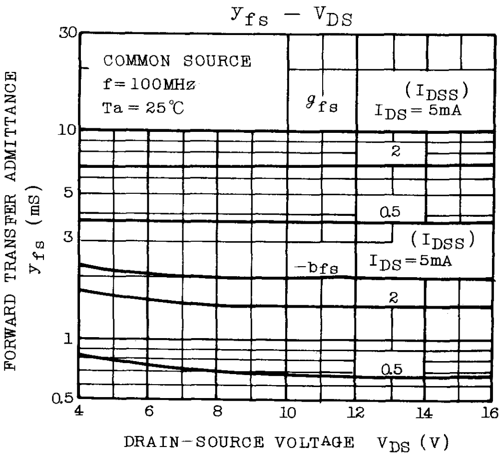


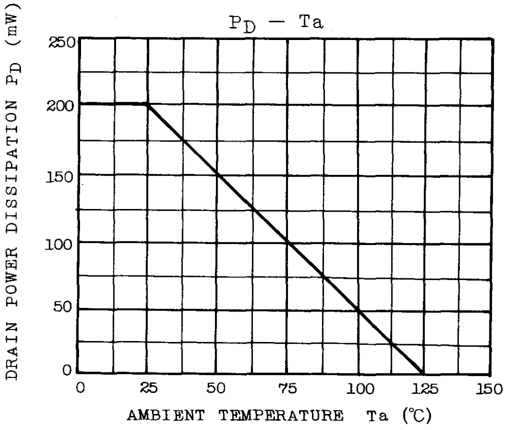

yis , yos − f
INPUT, OUTPUT ADMITTANCE yis, yos (mS)
50
30
10
5
3
1
0.5
0.3
0.1
bis
bos
gis
gos
COMMON
SOURCE
VDS = 1 0V
VGS = 0
Ta = 25℃
10
30
50
100
300
1000
300
1000
FREQUENCY f (MHz)


yfs , yrs − f
FORWARD, REVERSE TRANSFER ADMITTANCE yfs , yrs (mS)
30
10
5
3
1
0.5
0.3
0.1
COMMON SOURCE
VDS = 10V
VGS = 0
Ta = 25℃
gfs
−bfs
−brs
−grs
10
30
50
100
300
500
1000
3000
5000
FREQUENCY f (MHz)


yis − VDS
INPUT ADMITTANCE yis (mS)
10
5
3
1
0.5
0.3
0.1
bis
IDS = 5mA (IDSS)
2
0.5
gis
IDS = 5mA (IDSS)
2
0.5
COMMON
SOURCE
f = 100MHz
Ta = 25℃
4
6
8
10
12
14
16
18
20
22
DRAIN−SOURCE VOLTAGE VDS (V)


yos − VDS
OUTPUT ADMITTANCE yos (mS)
10
5
3
1
0.5
0.3
0.1
0.05
0.02
bos
IDS = 5 mA (IDSS)
2
0.5
gos
IDS = 5mA (IDSS)
2
0.5
COMMON
SOURCE
f = 100MHz
Ta = 25℃
4
6
8
10
12
14
16
18
20
22
DRAIN−SOURCE VOLTAGE VDS (V)


yfs − VDS
FORWARD TRANSFER ADMITTANCE yfs (mS)
30
10
5
3
1
0.5
COMMON SOURCE
f = 100MHz
Ta = 25℃
gfs
(IDSS)
IDS = 5mA
2
0.5
−bfs
(IDSS)
IDS = 5mA
2
0.5
4
6
8
10
12
14
16
DRAIN−SOURCE VOLTAGE VDS (V)

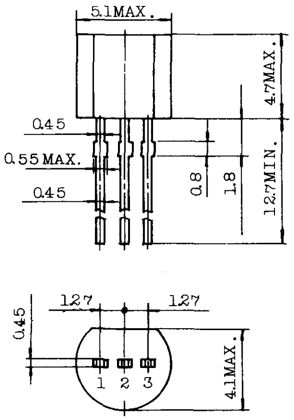

PD − Ta
DRAIN POWER DISSIPATION PD (mW)
250
200
150
100
50
0
0
25
50
75
100
125
150
AMBIENT TEMPERATURE Ta (℃)

SILICON N CHANNEL JUNCTION TYPE

2SK170

LOW NOISE AUDIO AMPLIFIER APPLICATIONS.

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

JEDEC	TC−92
EIAJ	SC−43
TOSHIBA	2−5F1D

Weight : 0.21g

FEATURES:

- Recommended for first stages of EQ and M.C. Head Amplifiers.
- High $|Y_{fs}|$
  : $|Y_{fs}|$=22mS(Typ.) (V_{DS}=10V, V_{GS}=0, I_{DSS}=3mA)
- High Breakdown Voltage : V_{GDS}=-40V
- Low Noise : e_n=0.95nV/$\sqrt{Hz}$ (Typ.)
  (V_{DS}=10V, I_D=1mA, f=1kHz)
- High Input Impedance : I_{GSS}=-1nA (Max.) (V_{GS}=-30V)

- Complementary to 2SJ74

MAXIMUM RATINGS (Ta=25°C)

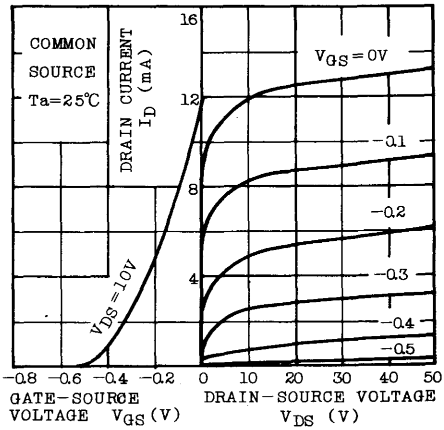
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-40	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

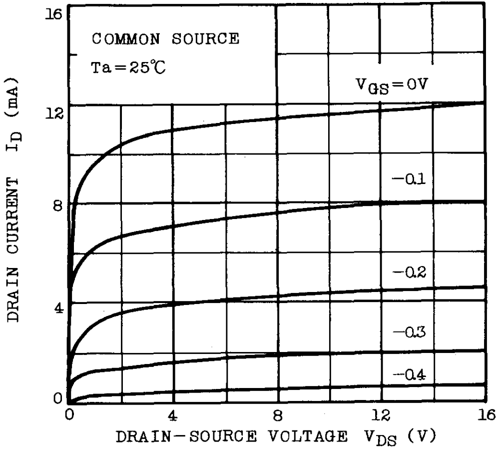
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-40	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=10V, V_{GS}=0	1	-	20	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.2	-	-1.5	V
Forward Transfer Admittance	$|Y_{fs}|$	V_{DS}=10V, V_{GS}=0, f=1kHz	-	22	-	mS
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	30	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=10V, I_D=0, f=1MHz	-	6	-	pF
Noise Figure	NF(1)	V_{DS}=10V, I_D=1.0mA, Rg=1kΩ, f=10Hz	-	1.0	10	dB
	NF(2)	V_{DS}=10V, I_D=1.0mA, Rg=1kΩ, f=1kHz	-	0.5	2	

Note : I_{DSS} Classification Y : 1.0∿3.0, GR : 2.6∿6.5, BL : 6.0∿12, V : 10∿20

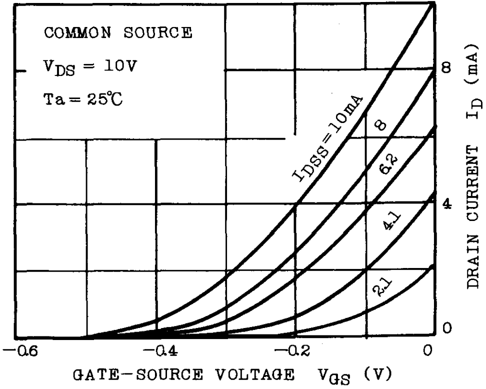
STATIC CHARACTERISTICS



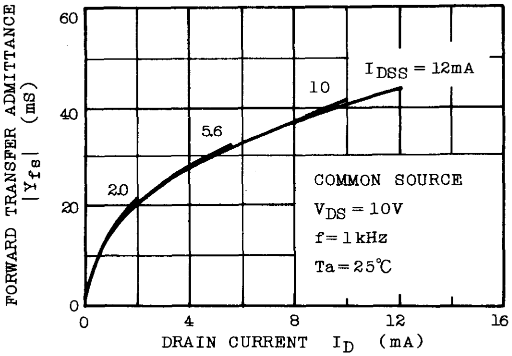
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



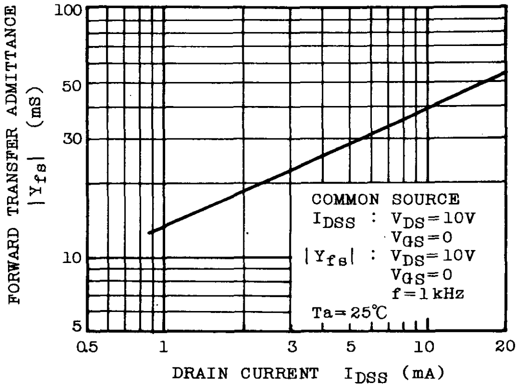
$I_D - V_{GS}$



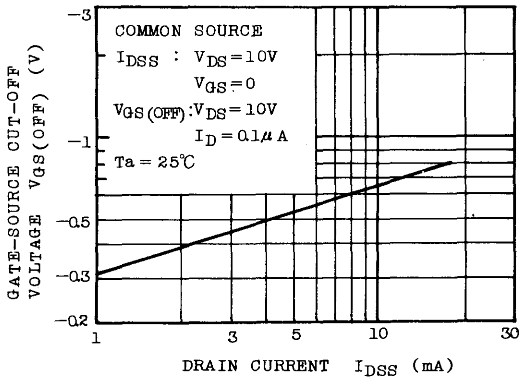
$|Y_{fs}| - I_D$

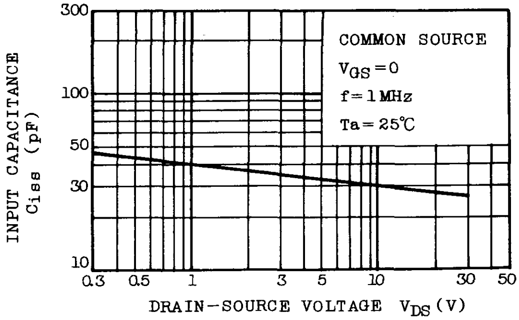


$|Y_{fs}| - I_{DSS}$

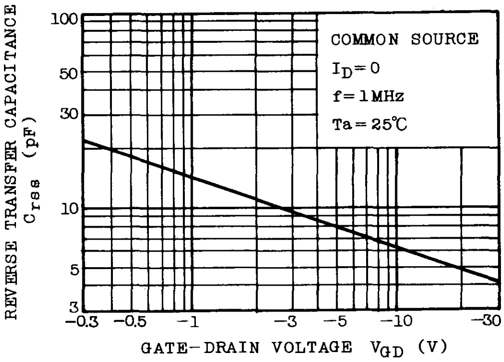


$V_{GS(OFF)} - I_{DSS}$

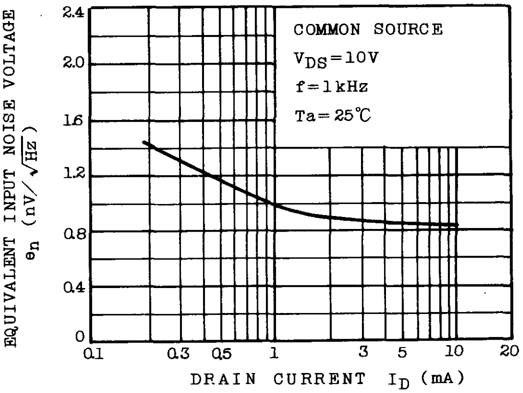




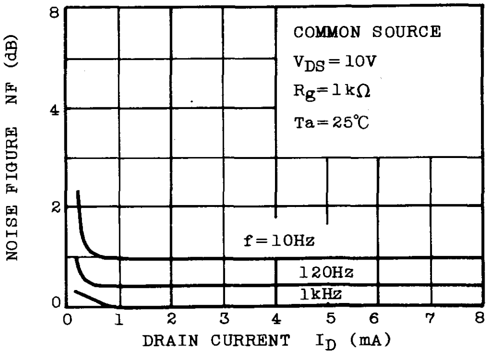
C_{iss} — V_{DS}



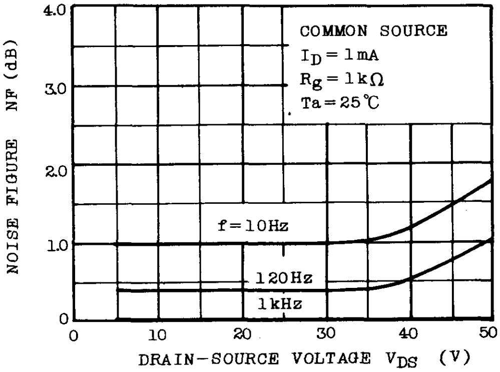
C_{rss} — V_{GD}



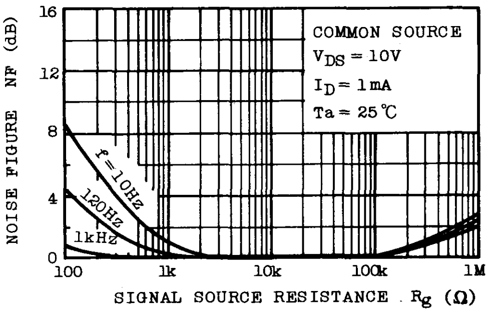
e_n — I_D



NF — I_D

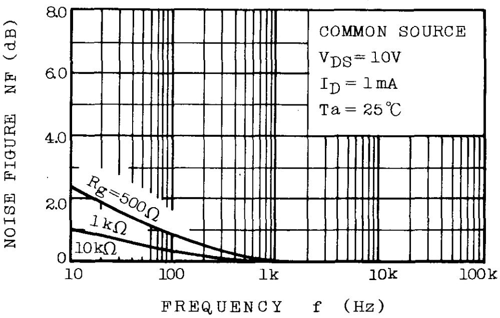


NF — V_{DS}

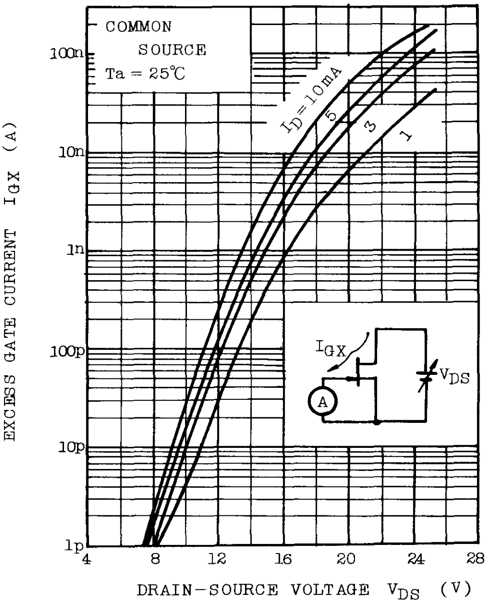


NF — R_g

NF — f


COMMON SOURCE
V_{DS}= 10V
I_D = 1 mA
Ta = 25℃
Rg=500Ω
1kΩ
10kΩ
NOISE FIGURE NF (dB)
8.0
6.0
4.0
2.0
0
10
100
1k
10k
100k
FREQUENCY f (Hz)

I_{GX} — V_{DS}


COMMON SOURCE
Ta = 25℃
I_D = 10 mA
5
3
1
I_{GX}
V_{DS}
A
EXCESS GATE CURRENT I_{GX} (A)
100n
10n
1n
100p
10p
1p
4
8
12
16
20
24
28
DRAIN-SOURCE VOLTAGE V_{DS} (V)

SILICON N CHANNEL JUNCTION TYPE

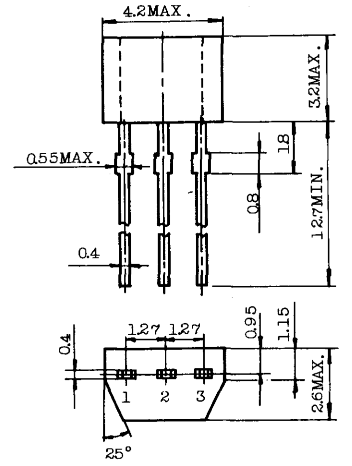
2SK184

LOW NOISE AUDIO AMPLIFIER APPLICATIONS

FEATURES:

- High $|y_{fs}|$: $|y_{fs}|$=15mS(Typ.) (V_{DS}=10V, V_{GS}=0)
- High Breakdown Voltage : V_{GDS}=-50V
- Low Noise : NF=1.0dB (Typ.)
  (V_{DS}=10V, I_D=0.5mA, f=1kHz, Rg=1kΩ)
- High Input Impedance.
  : I_{GSS}=-1nA (Max.)(V_{GS}=-30V)
- Small Package.

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

JEDEC	—
EIAJ	—
TOSHIBA	2-4E1C

Weight : 0.13 g

MAXIMUM RATINGS (Ta=25°C)

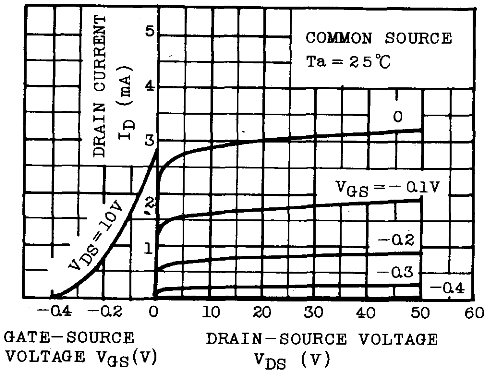
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-50	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

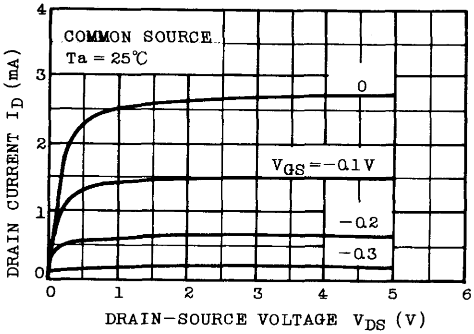
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	V(BR)GDS	V_{DS}=0, I_G=-100μA	-50	-	-	V
Drain Current	I_{DSS} (Note)	V_D=10V, V_{GS}=0	0.6	-	14.0	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.2	-	-1.5	V
Forward Transfer Admittance	$\|y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz	4.0	15	-	mS
Input Capacitance	Ciss	V_{DS}=10V, V_{GS}=0, f=1MHz	-	13	-	pF
Reverse Transfer Capacitance	Crss	V_{DG}=10V, I_D=0, f=1MHz	-	3	-	pF
Noise Figure	NF(1)	V_{DS}=10V, R_g=1kΩ, I_D=0.5mA, f=10Hz	-	5	10	dB
	NG(2)	V_{DS}=10V, Rg=1kΩ, I_D=0.5mA, f=1kHz	-	1	2	

Note: I_{DSS} Classification O : 0.5∿1.4, Y : 1.2∿3.0,
GR : 2.6∿6.5, BL : 6.0∿14.0

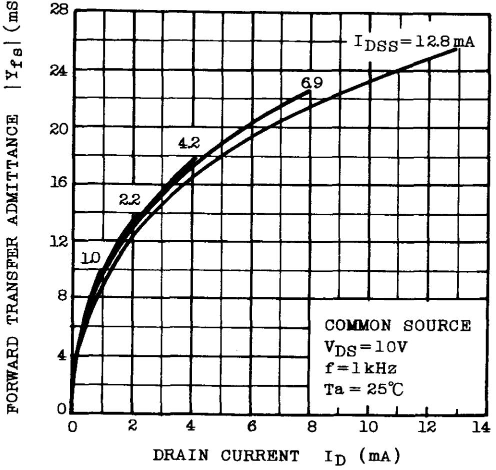
STATIC CHARACTERISTICS



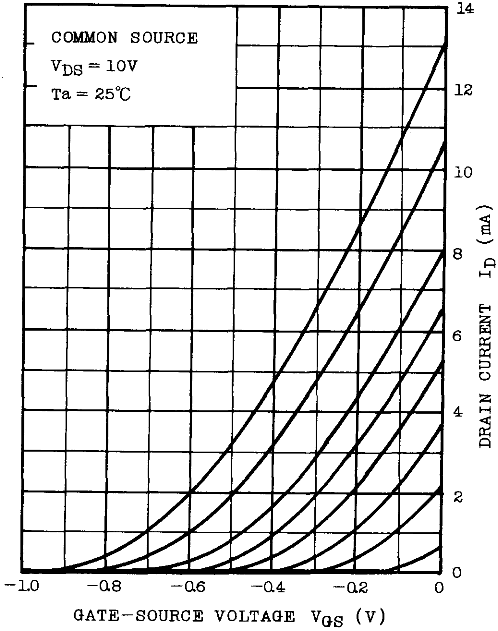
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



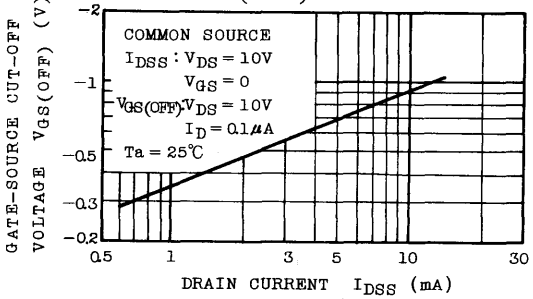
$|Y_{fs}| - I_D$



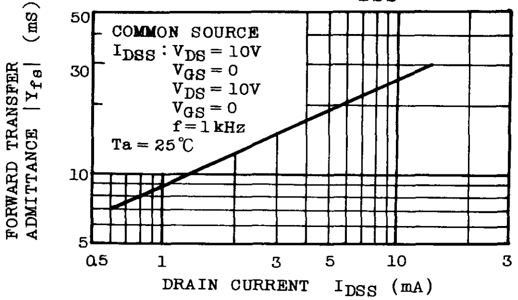
$I_D - V_{GS}$

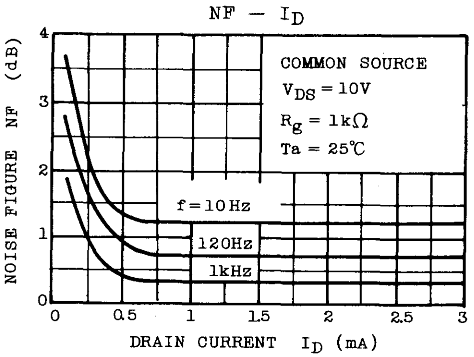


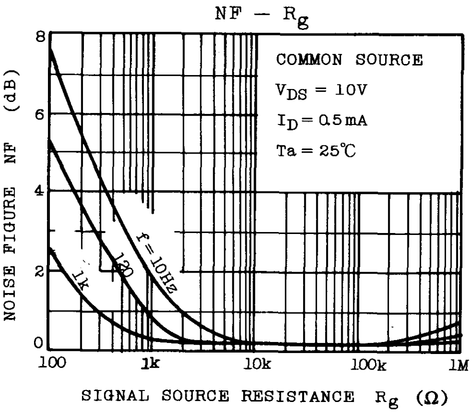
$V_{GS(OFF)} - I_{DSS}$

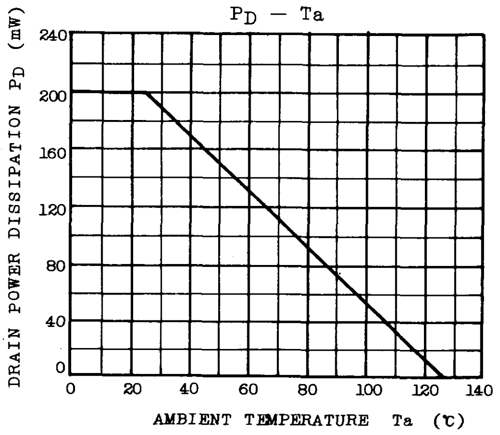


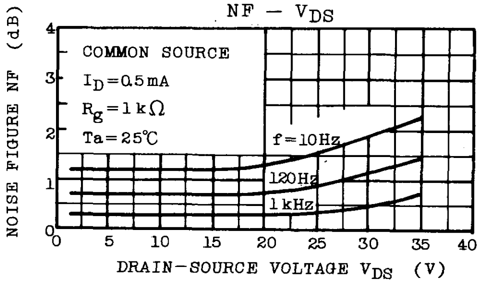
$|Y_{fs}| - I_{DSS}$

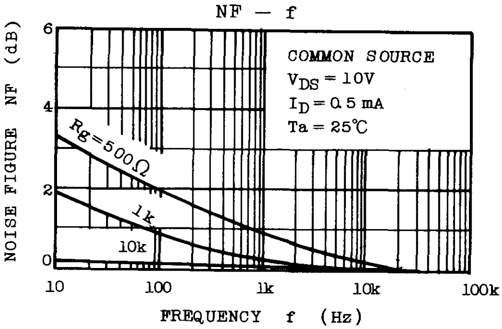


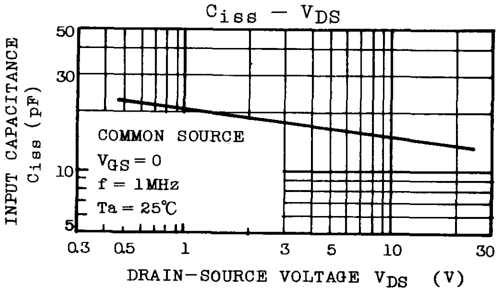

NF — I_D

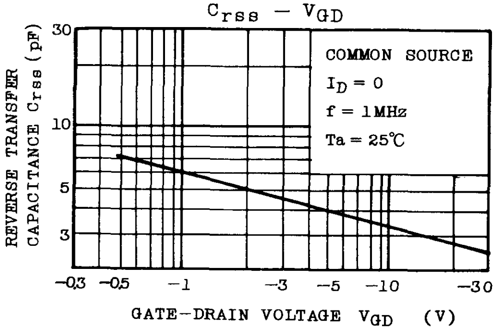

NF — R_g


P_D — Ta


NF — V_{DS}


NF — f


C_{iss} — V_{DS}


C_{rss} — V_{GD}

2SK192A

SILICON N CHANNEL JUNCTION TYPE

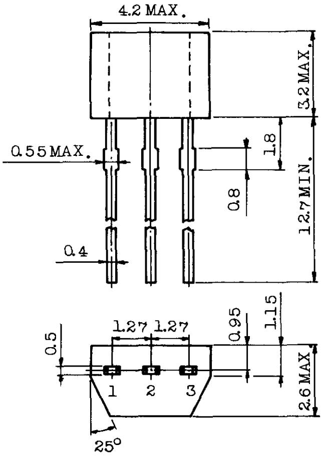
FM TUNER APPLICATIONS.

VHF BAND AMPLIFIER APPLICATIONS.

FEATURES:

- High Power Gain : G_{PS}=24dB(Typ.) (f=100MHz)
- Low Noise Figure : NF=1.8dB(Typ.) (f=100MHz)
- High Forward Transfer Admittance : $|y_{fs}|$=7mS(Typ.) (f=1kHz)

Unit in mm



JEDEC	—
EIAJ	—
TOSHIBA	2—4E1D

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

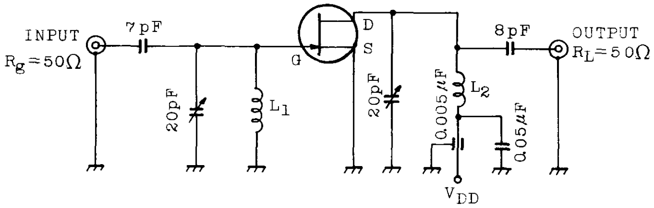
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDO}	-18	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55～125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-1.0V, V_{DS}=0	-	-	-10	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDO}$	I_G=-100μA	-18	-	-	V
Drain Current	I_{DSS} (Note)	V_{GS}=0, V_{DS}=10V	3	-	24	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=1μA	-1.2	-3	-	V
Forward Transfer Admittance	$\|y_{fs}\|$	V_{GS}=0, V_{DS}=10V, f=1kHz	-	7	-	mS
Reverse Transfer Capacitance	C_{rss}	V_{GD}=-10V, f=1MHz	-	-	0.65	pF
Power Gain	G_{PS}	V_{DD}=10V,f=100MHz (Fig.)	-	24	-	dB
Noise Figure	NF	V_{DD}=10V,f=100MHz (Fig.)	-	1.8	3.5	dB

Note : I_{DSS} Classification Y : 3.0～7.0, GR : 6.0～14.0, BL : 12.0～24.0

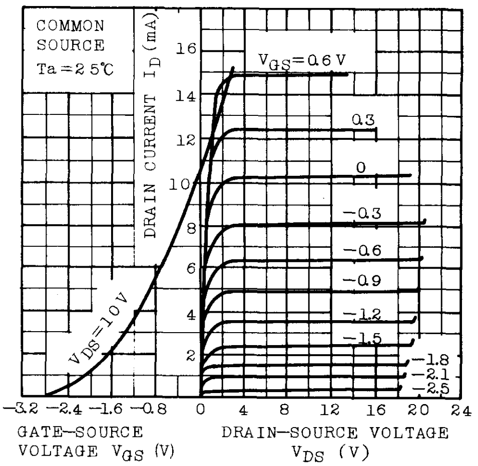
Fig. 100MHz G_{ps}, NF TEST CIRCUIT



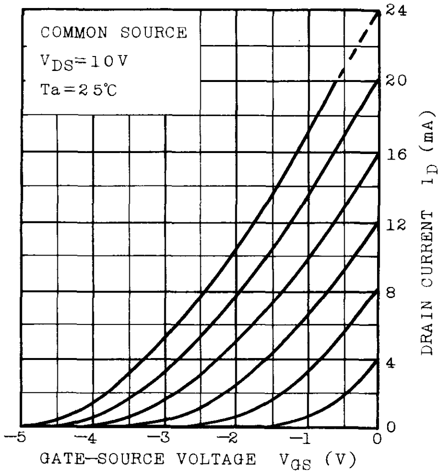
L_1: 0.8mmϕ Ag PLATED Cu WIRE 3 TURNS, 10mm ID, 10mm LENGTH

L_2: 0.8mmϕ Ag PLATED Cu WIRE 3.5 TURNS, 10mm ID, 10mm LENGTH

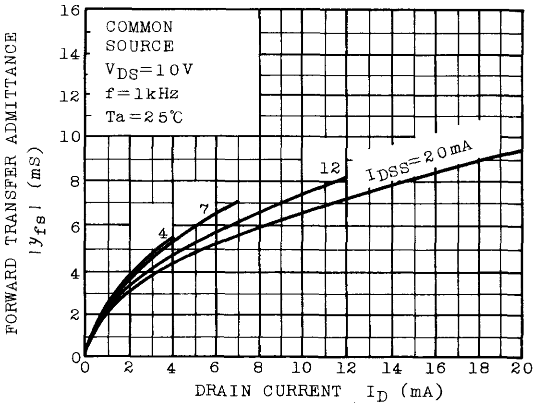
STATIC CHARACTERISTICS



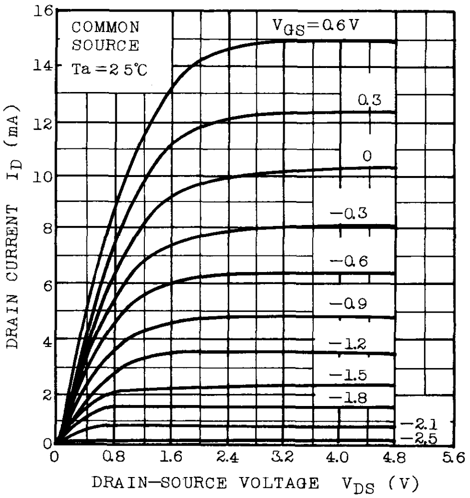
$I_D - V_{GS}$



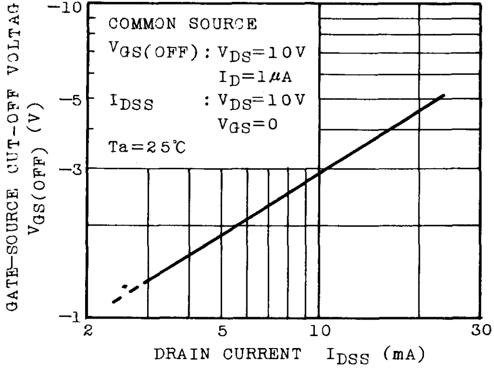
$y_{fs} - I_D$



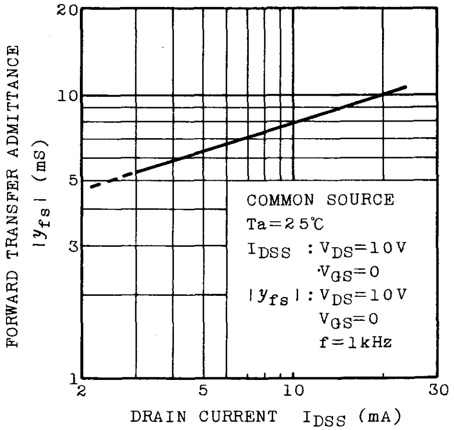
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



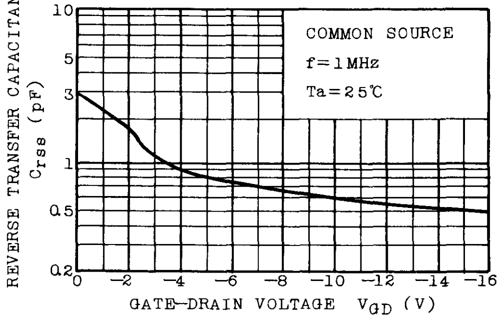
$V_{GS(OFF)}$ – I_{DSS}



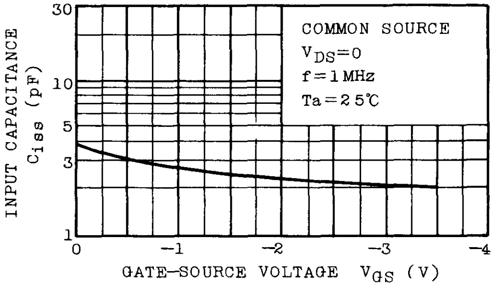
y_{fs} – I_{DSS}



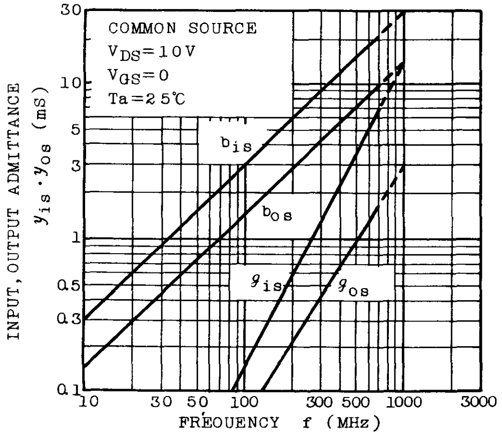
C_{rss} – V_{GD}



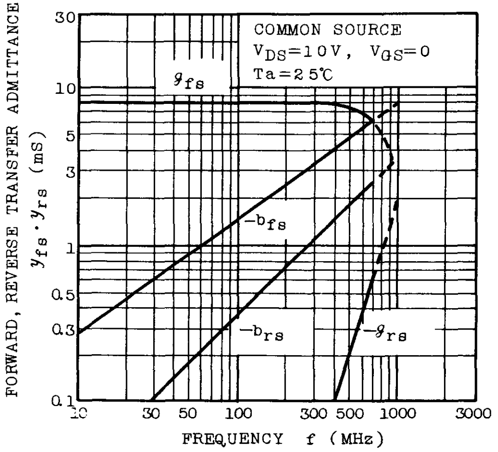
C_{iss} – V_{GS}

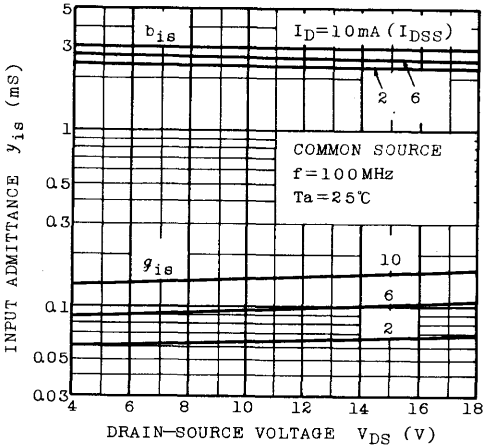


y_{is}, y_{os} – f

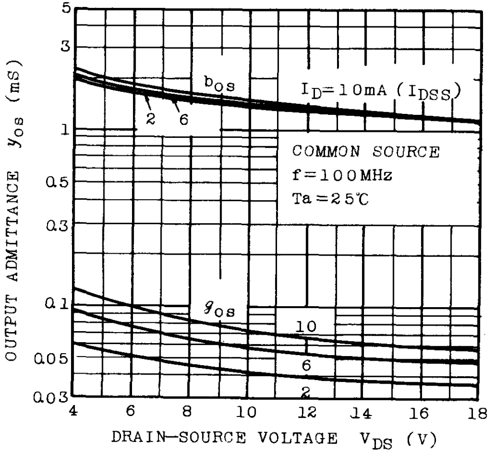


y_{fs}, y_{rs} – f

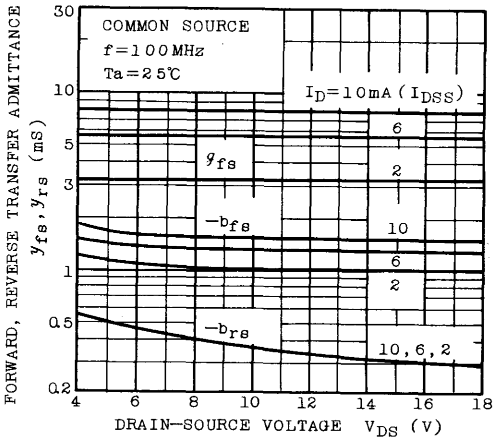




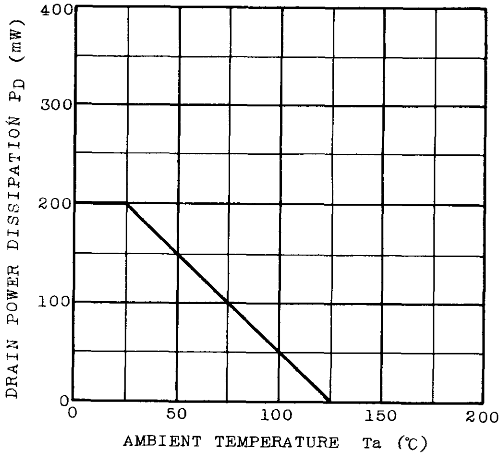
$y_{is} - V_{DS}$



$y_{os} - V_{DS}$



y_{fs}, $y_{rs} - V_{DS}$



$P_D - Ta$

2SK208

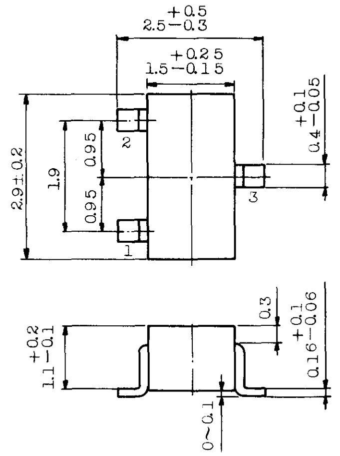
SILICON N CHANNEL JUNCTION TYPE

GENERAL PURPOSE AND IMPEDANCE CONVERTER AND CONDENSER MICROPHONE APPLICATIONS.

FEATURES:

- High Breakdown Voltage : V_{GDS}=-50V
- High Input Impedance : I_{GSS}=-1.0nA (Max.)
  (V_{GS}=-30V)
- Low Noise : NF=0.5dB(Typ.) (R_g=100kΩ, f=120Hz)
- Small Package.

Unit in mm



1. DRAIN
2. SOURCE
3. GATE

JEDEC	—
EIAJ	SC-59
TOSHIBA	2-3F1B

Weight : 0.012g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-50	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	100	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~125	°C

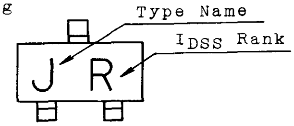
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-50	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=10V, V_{GS}=0	0.3	-	6.5	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.4	-	-5.0	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz	1.2	-	-	mS
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	8.2	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{GD}=-10V, I_D=0, f=1MHz	-	2.6	-	pF
Noise Figure	NF	V_{DS}=15V, V_{GS}=0, R_g=100kΩ, f=120Hz	-	0.5		dB

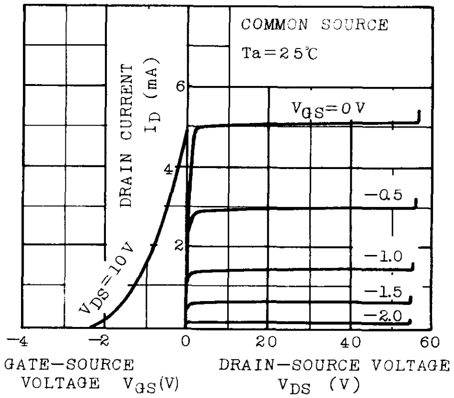
Note: I_{DSS} Classification

R : 0.30∿0.75, O : 0.60∿1.40
Y : 1.2∿3.0, G : 2.6∿6.5

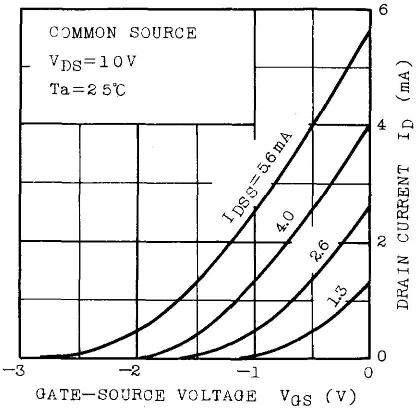
Marking



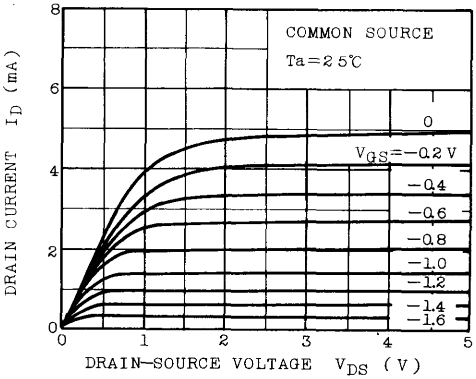
STATIC CHARACTERISTICS



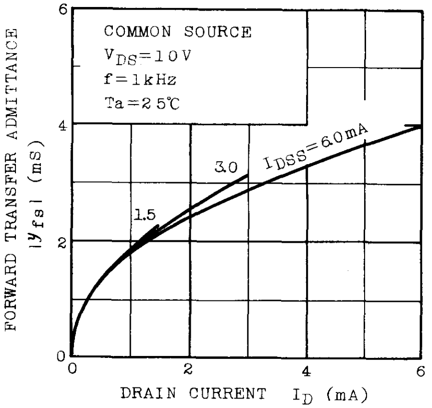
I_D − V_{GS}



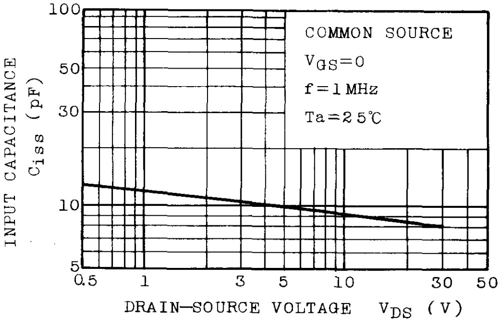
I_D − V_{DS} (LOW VOLTAGE REGION)



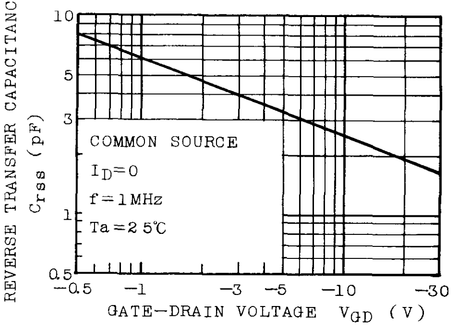
y_{fs} − I_D



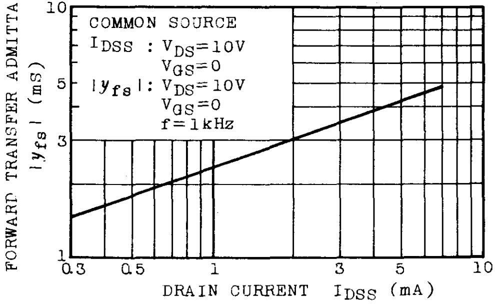
C_{iss} − V_{DS}



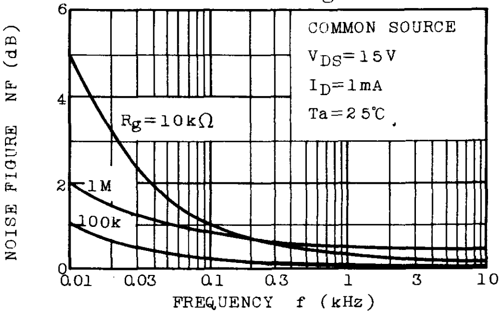
C_{rss} − V_{GD}



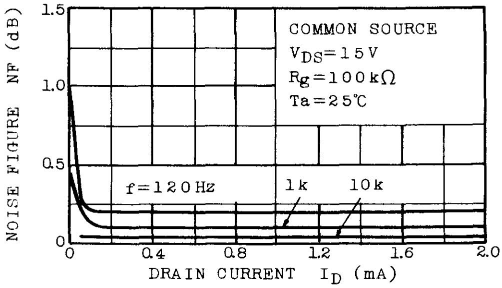
$|y_{fs}|$ – I_{DSS}



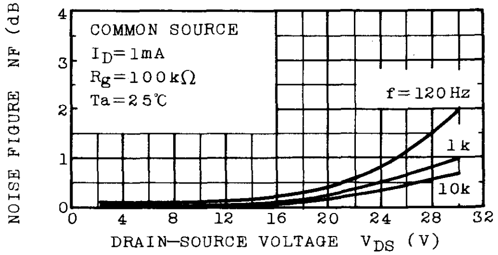
NF – R_g



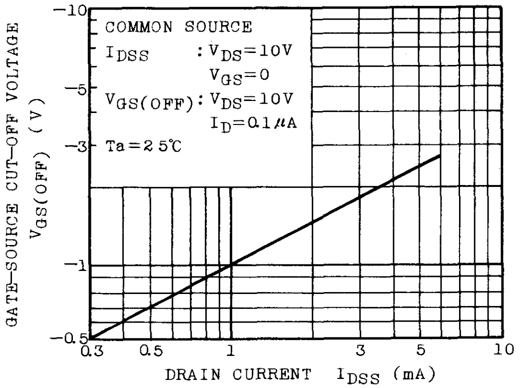
NF – I_D



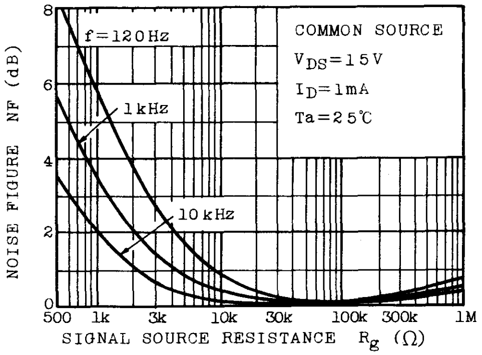
NF – V_{DS}



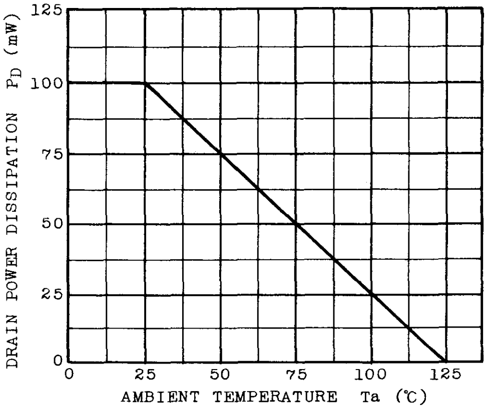
$V_{GS(OFF)}$ – I_{DSS}



NF – R_g



P_D – Ta



SILICON N CHANNEL JUNCTION TYPE

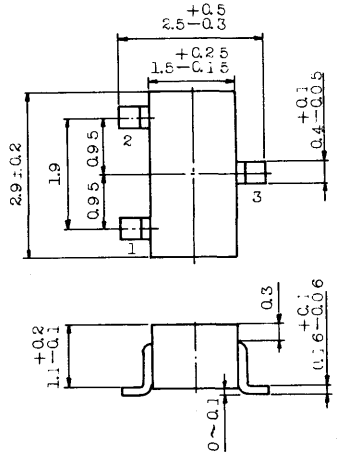
2SK209

AUDIO FREQUENCY LOW NOISE AMPLIFIER APPLICATIONS.

FEATURES:

- High $|Y_{fs}|$:
  $|Y_{fs}|$=15ms(Typ.) at V_{DS}=10V, V_{GS}=0
- High Breakdown Voltage : V_{GDS}=-50V
- Low Noise : NF=1.0dB(Typ.)
  at V_{DS}=10V, I_D=0.5mA, f=1kHz, R_g=1kΩ
- High Input Impedance : I_{GSS}=-1nA(Max.)
  at V_{GS}=-30V
- Small Package

Unit in mm



1. DRAIN
2. SOURCE
3. GATE

JEDEC	
EIAJ	SC−59
TOSHIBA	2−3F1B

Weight : 0.012g

MUXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-50	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

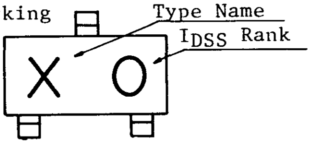
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-50	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=10V, V_{GS}=0	0.6	-	14.0	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.2	-	-1.5	V
Forward Transfer Admittance	$\vert Y_{fs}\vert$	V_{DS}=10V, V_{GS}=0, f=1kHz	4.0	15	-	ms
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	13	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=10V, I_D=0, f=1MHz	-	3	-	pF
Noise Figure	NF(1)	V_{DS}=10V, R_g=1kΩ I_D=0.5mA, f=10Hz	-	5	-	dB
Noise Figure	NF(2)	V_{DS}=10V, R_g=1kΩ I_D=0.5mA, f=1kHz	-	1	-	dB

Note : I_{DSS} Classification

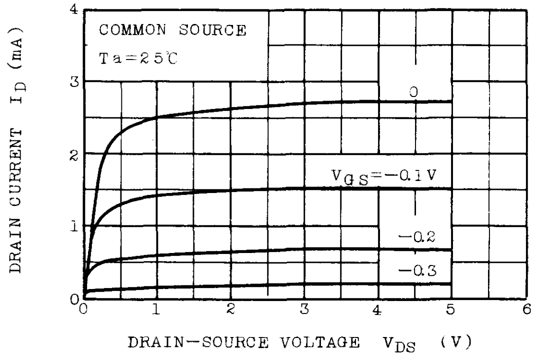
O:0.6~1.4mA, Y:1.2~3.0mA,

GR(G):2.6~6.5mA, BL(L):6.0~14mA

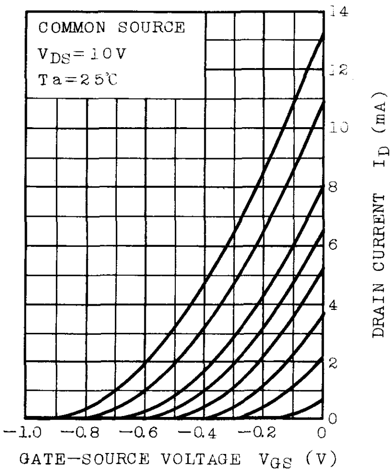
Marking



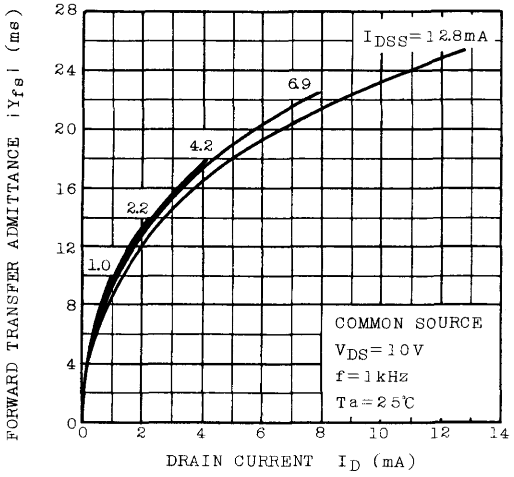
I_D – V_{DS}



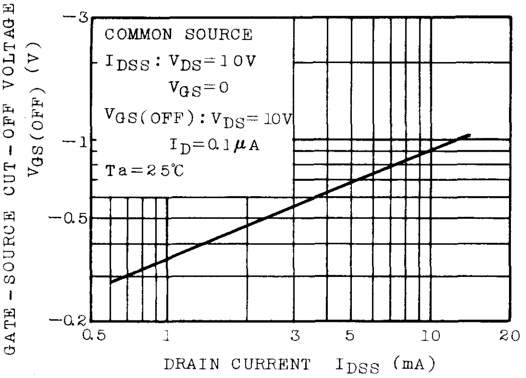
I_D – V_{GS}



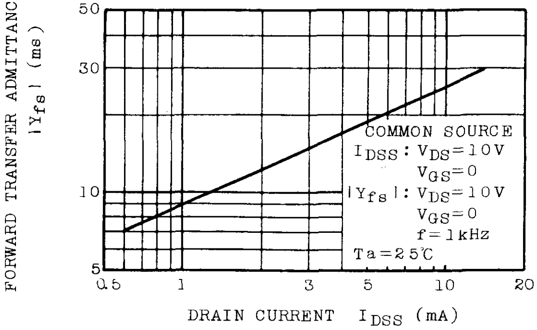
$|Y_{fs}|$ – I_D



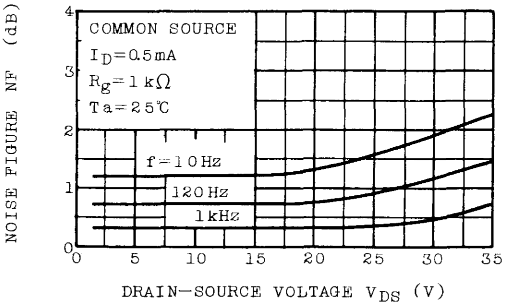
$V_{GS(OFF)}$ – I_{DSS}



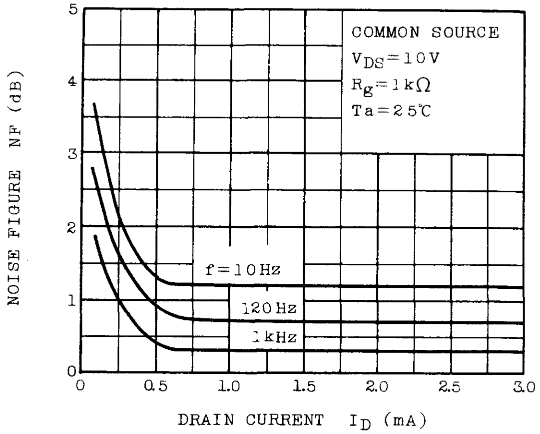
$|Y_{fs}|$ – I_{DSS}



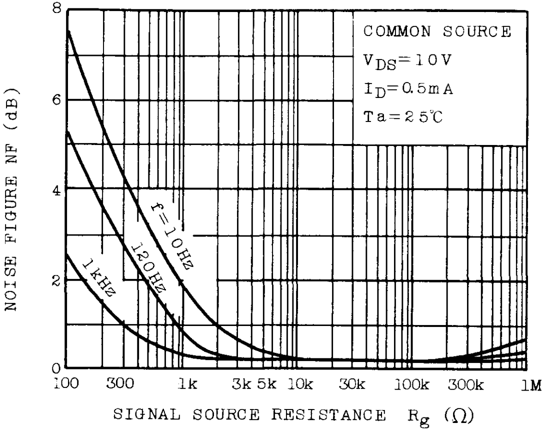
NF – V_{DS}



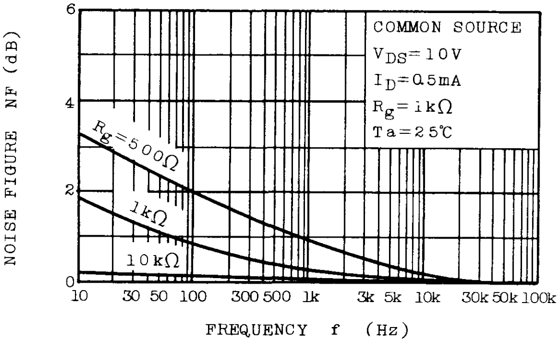
NF − I_D



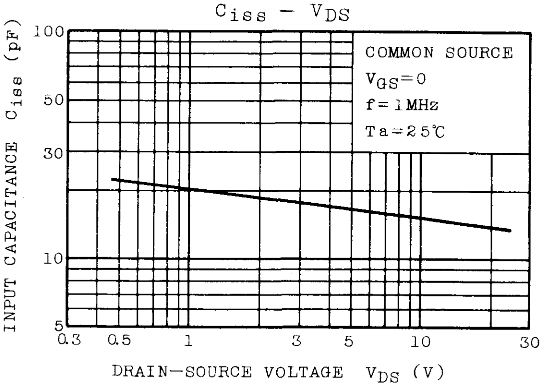
NF − R_g



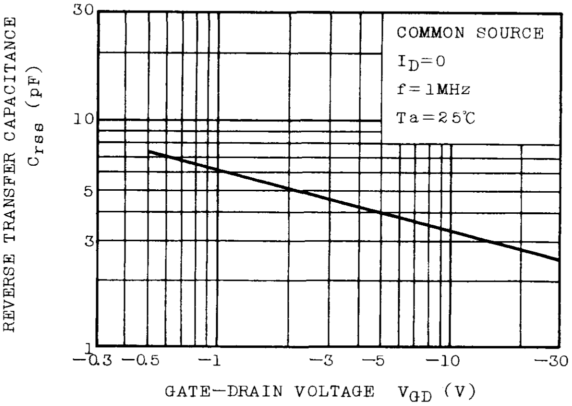
NF − f



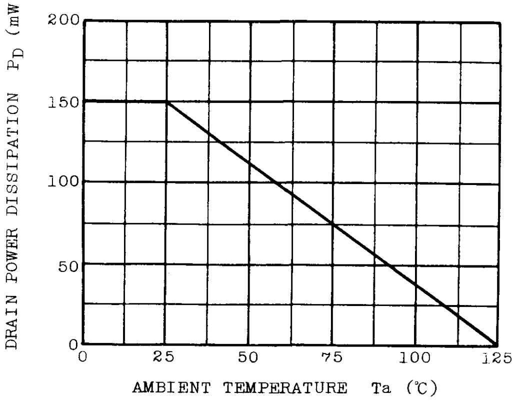
C_{iss} − V_{DS}



C_{rss} − V_{GD}



P_D − Ta



2SK210

SILICON N CHANNEL JUNCTION TYPE

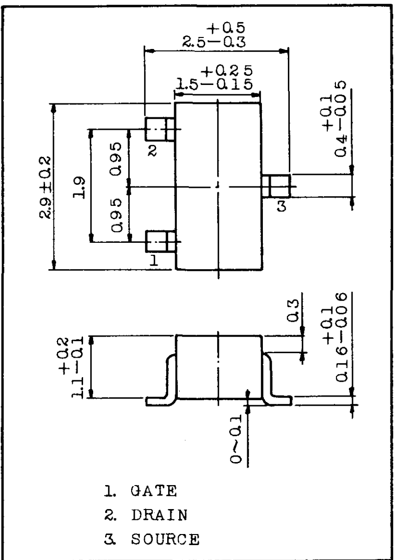
FM TUNER APPLICATIONS.

VHF BAND AMPLIFIER APPLICATIONS.

FEATURES:

- High Power Gain : G_{PS}=24dB(Typ.) (f=100MHz)
- Low Noise Figure : NF=1.8dB(Typ.) (f=100MHz)
- High Forward Transfer Admitance : $|y_{fs}|$=7mS(Typ.) (f=1kHz)

Unit in mm



JEDEC	—
EIAJ	SC−59
TOSHIBA	2−3F1C

Weight : 0.012g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDO}	-18	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	100	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~ 125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-1.0V, V_{DS}=0	-	-	-10	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDO}$	I_G=-100μA	-18	-	-	V
Drain Current	I_{DSS} (Note)	V_{GS}=0, V_{DS}=10V	3	-	24	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=1μA	-1.2	-3	-	V
Forward Transfer Admittance	$\|y_{fs}\|$	V_{GS}=0, V_{DS}=10V, f=1kHz	-	7	-	mS
Reverse Transfer Capacitance	C_{rss}	V_{GD}=-10V, f=1MHz	-	-	0.65	pF
Power Gain	G_{PS}	V_{DD}=10V, f=100MHz (Fig.)	-	24	-	dB
Noise Figure	NF	V_{DD}=10V, f=100MHz (Fig.)	-	1.8	3.5	dB

Note : I_{DSS} Classification Y : 3.0 ~ 7.0, GR(R) : 6.0 ~ 14.0, BL(L) : 12.0 ~ 24.0

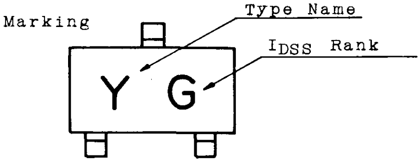
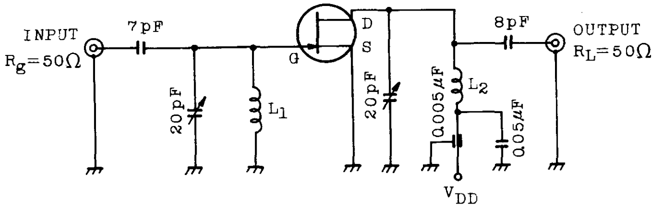


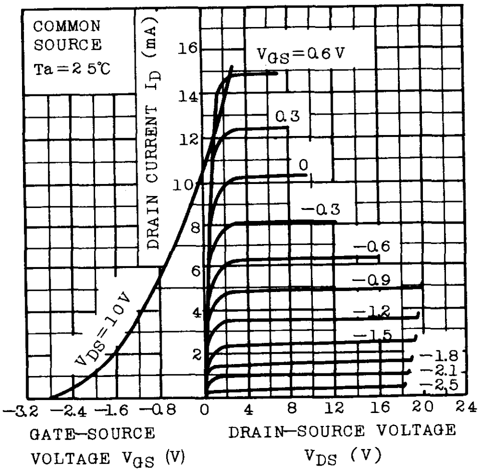
Fig. 100MHz G_{ps} NF TEST CIRCUIT



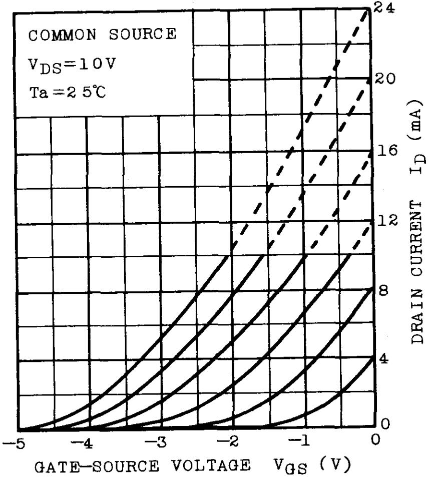
L_1 : 0.8mmϕ Ag PLATED Cu WIRE 3 TURNS, 10mm ID, 10mm LENGTH

L_2 : 0.8mmϕ Ag PLATED Cu WIRE 3.5 TURNS, 10mm ID, 10mm LENGTH

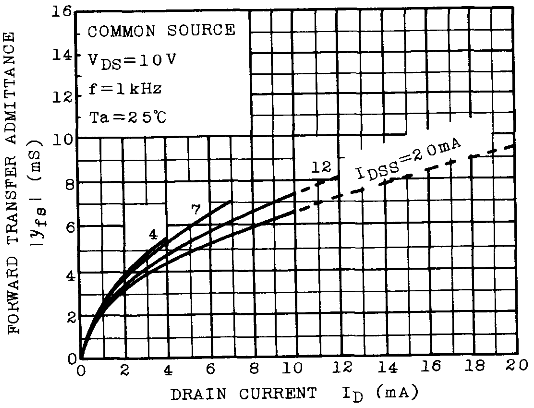
STATIC CHARACTERISTICS



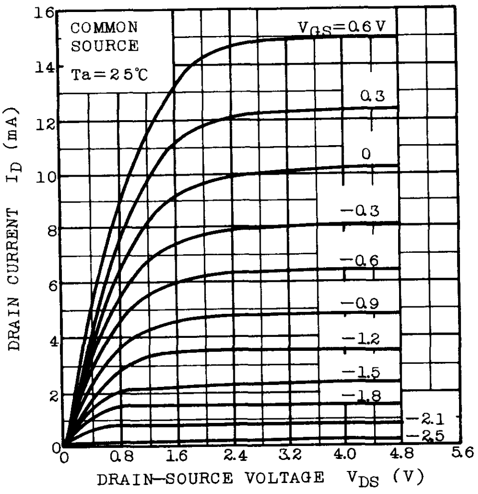
I_D − V_{GS}



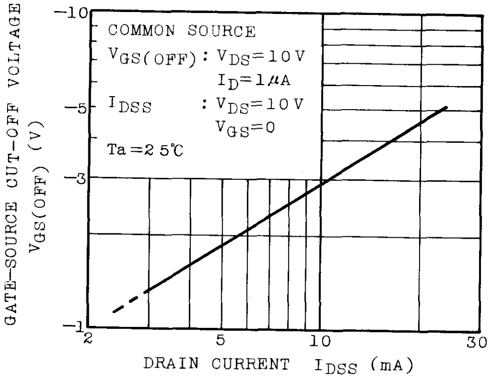
y_{fs} − I_D



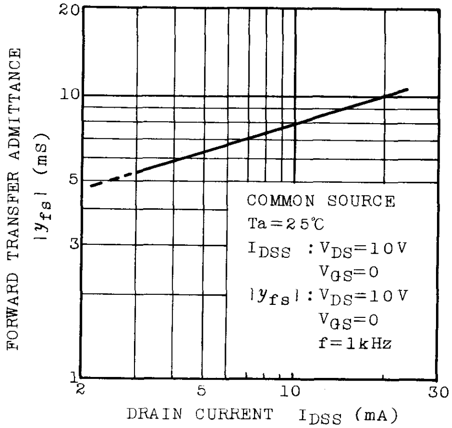
I_D−V_{DS} (LOW VOLTAGE REGION)



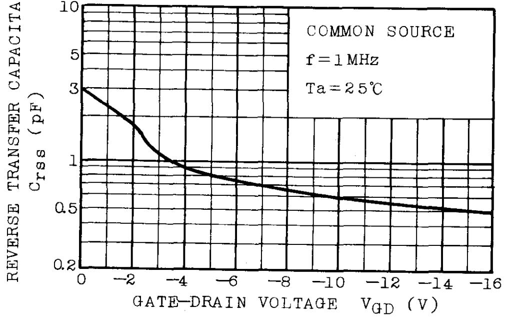
$V_{GS(OFF)} - I_{DSS}$



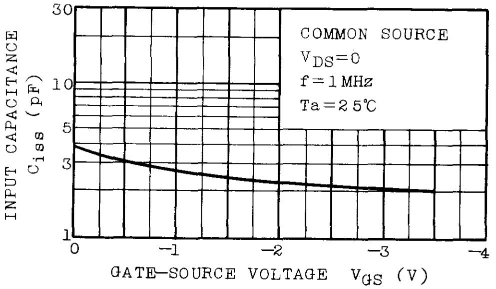
$y_{fs} - I_{DSS}$



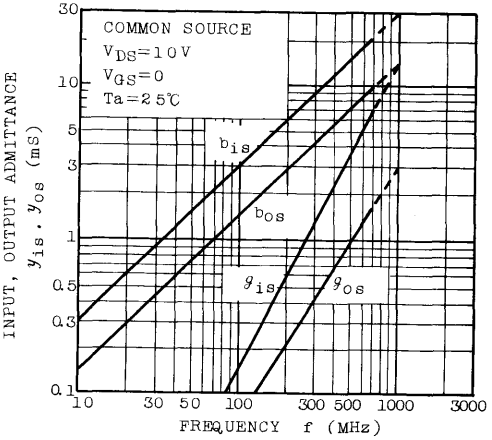
$C_{rss} - V_{GD}$



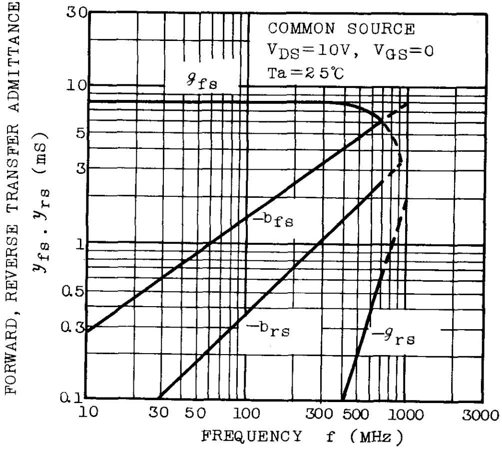
$C_{iss} - V_{GS}$



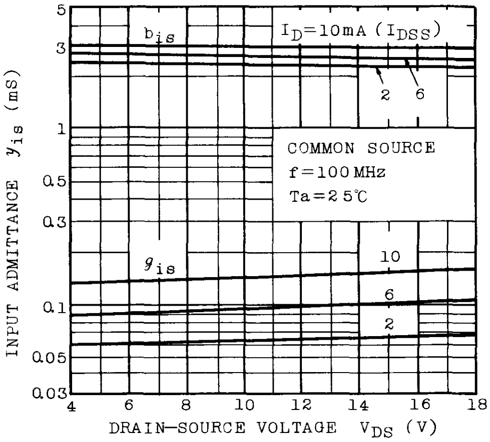
$y_{is}, y_{os} - f$



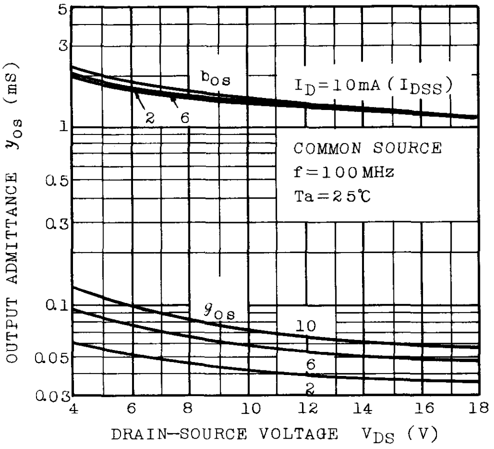
$y_{fs}, y_{rs} - f$



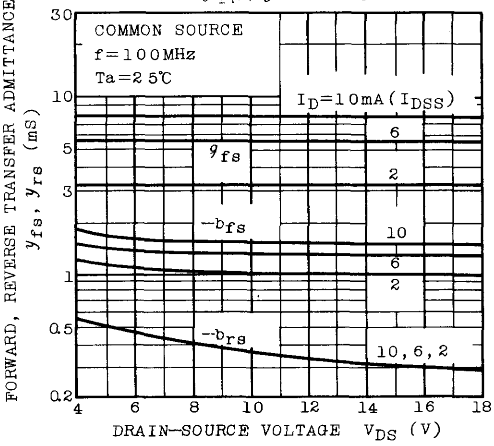
y_{is} – V_{DS}



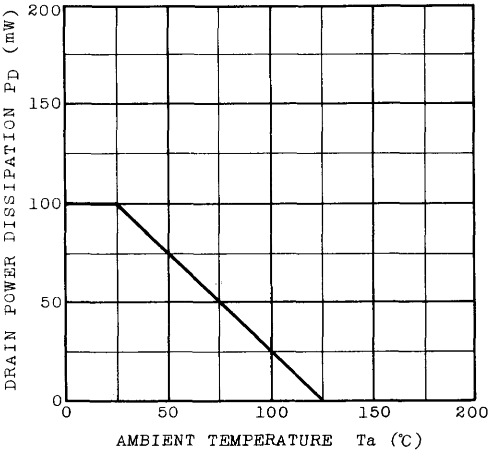
y_{os} – V_{DS}



y_{fs}, y_{rs} – V_{DS}



P_D – Ta



2SK211

SILICON N CHANNEL JUNCTION TYPE

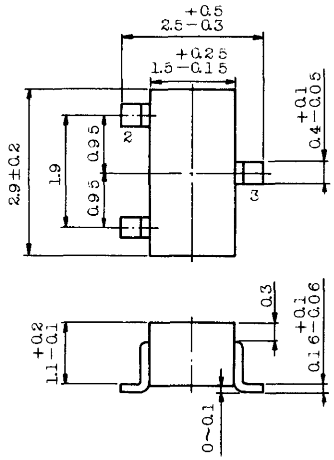
FM TUNER APPLICATIONS.

VHF BAND AMPLIFIER APPLICATIONS.

FEATURES:

- Low Noise Figure : NF=2.5dB(Typ.) (f=100MHz)
- High Forward Transfer Admittance : $|Y_{fs}|$ =9mS(Typ.)
- Extremely Low Reverse Transfer Capacitance : C_{rss}=0.1pF(Typ.)

Unit in mm



1. GATE
2. DRAIN
3. SOURCE

JEDEC	—
EIAJ	SC−59
TOSHIBA	2−3F1C

Weight : 0.012g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDO}	-18	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-0.5V, V_{DS}=0	-	-	-10	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDO}$	I_G=-100μA	-18	-	-	V
Drain Current	I_{DSS} (Note)	V_{GS}=0, V_{DS}=10V	1.0	-	10	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=1μA	-0.4	-	-4.0	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{GS}=0, V_{DS}=10V, f=1kHz	-	9	-	mS
Reverse Transfer Capacitance	C_{rss}	V_{GD}=-10V, f=1MHz	-	0.10	0.15	pF
Power Gain	G_{PS}	V_{DD}=10V, f=100MHz (Fig.)	-	18	-	dB
Noise Figure	NF	V_{DD}=10V, f=100MHz (Fig.)	-	2.5	3.5	dB

Note : I_{DSS} Classification O : 1.0~3.0, Y : 2.5~6.0, GR(G) : 5.0~10.0

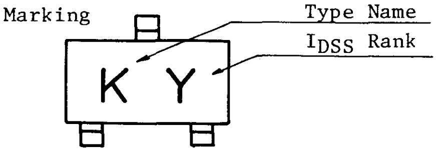
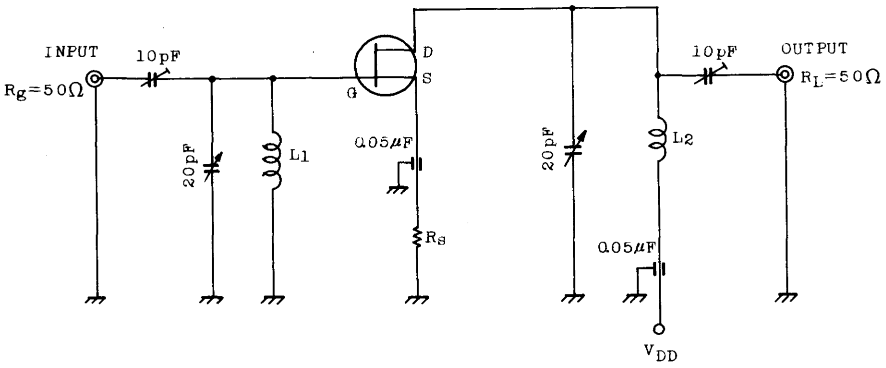


Fig. : 100MHz G_{PS}, NF TEST CIRCUIT



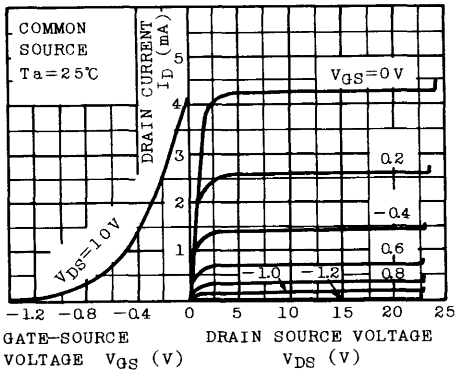
L1 : 0.8mmϕ Ag PLATED Cu WIRE, 3 TURNS, 10mm ID, 10mm LENGTH.

L2 : 0.8mmϕ Ag PLATED Cu WIRE, 3.5 TURNS, 10mm ID, 10mm LENGTH.

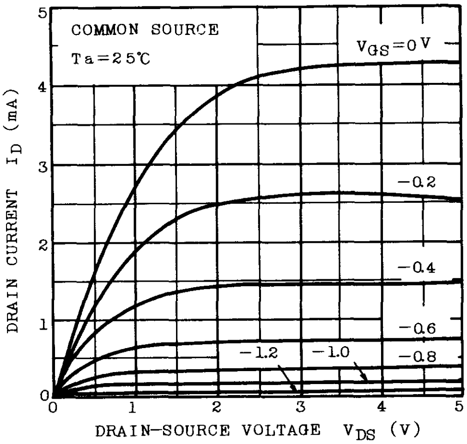
2SK211 is measured at each group by changing R_S.

GROUP	R_S (Ω)
2SK211-O	0
2SK211-Y	18Ω ±5%
2SK211-GR	100Ω ±5%

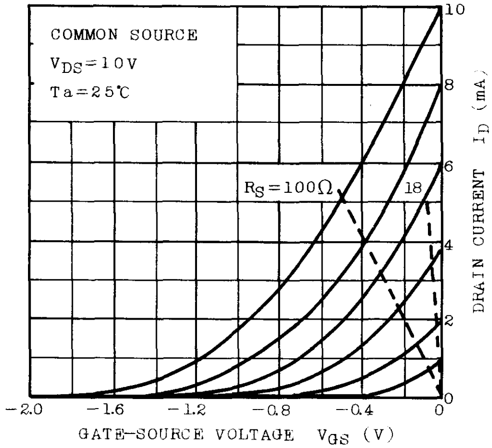
STATIC CHARACTERISTICS



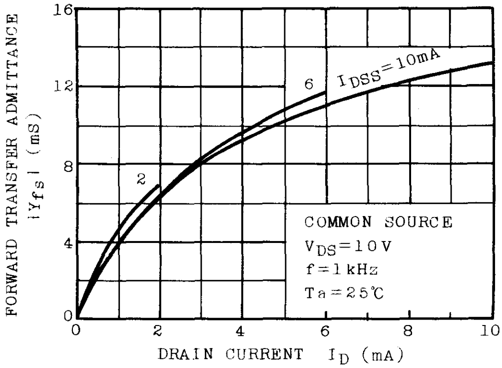
I_D − V_{DS} (LOW VOLTAGE REGION)



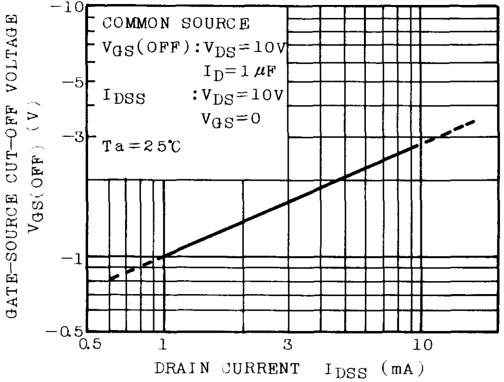
$I_D - V_{GS}$



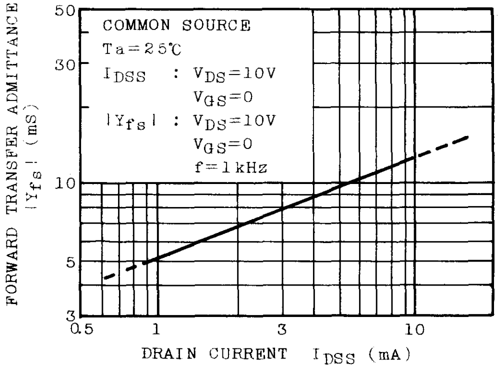
$|Y_{fs}| - I_D$



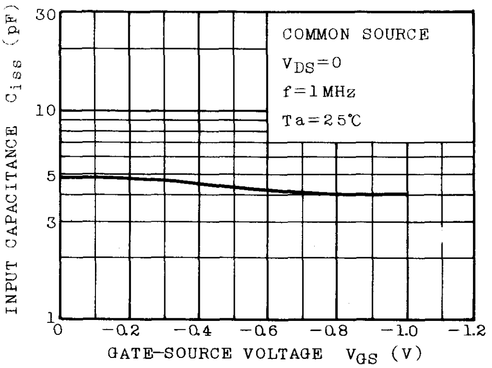
$V_{GS(OFF)} - I_{DSS}$



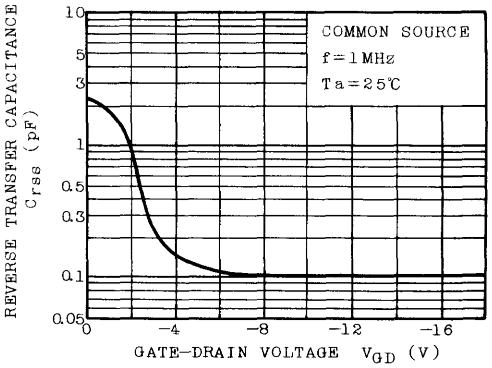
$|Y_{fs}| - I_{DSS}$



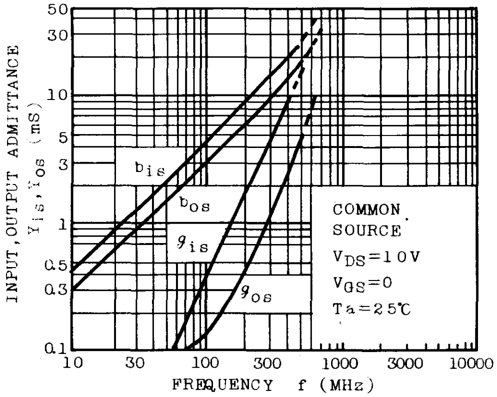
$C_{iss} - V_{GS}$



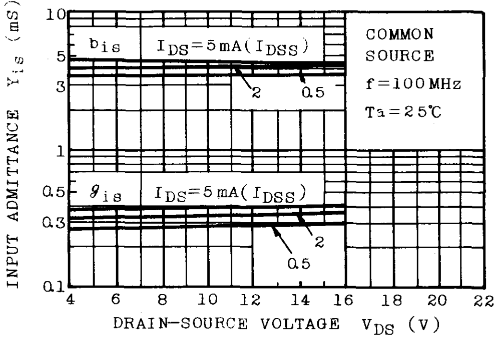
$C_{rss} - V_{GD}$



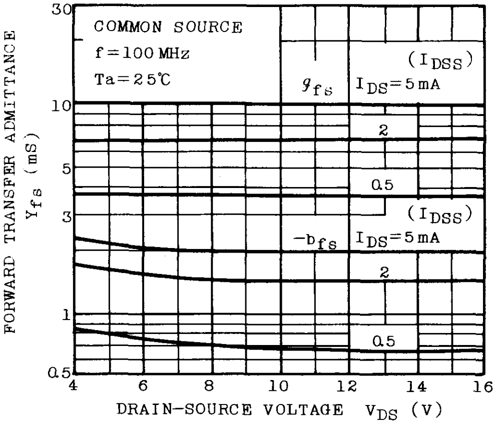
Y_{is}, Y_{os} — f



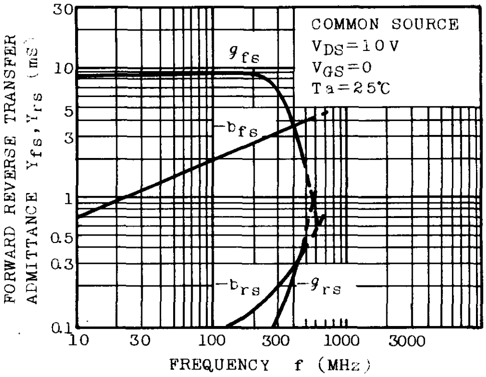
Y_{is} — V_{DS}



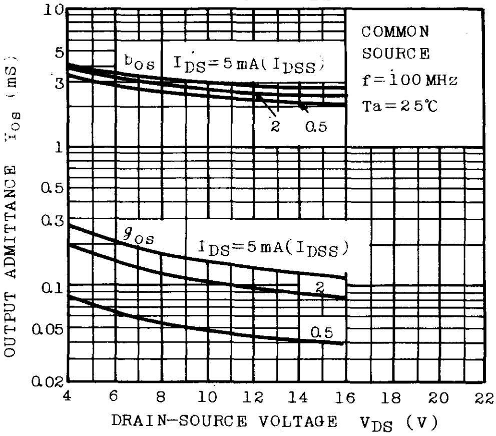
Y_{fs} — V_{DS}



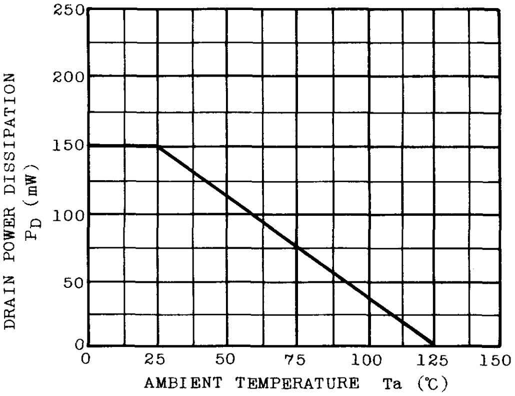
Y_{fs}, Y_{rs} — f



Y_{os} — V_{DS}



P_D — Ta



2SK240

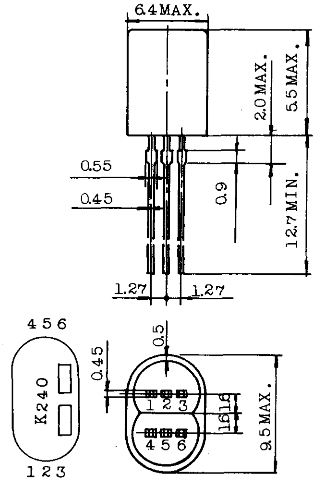
SILICON N CHANNEL JUNCTION TYPE

LOW NOISE AUDIO AMPLIFIER APPLICATIONS.
DIFFERENTIAL AMPLIFIER APPLICATIONS.

FEATURES:

- Recommended for first stages of EQ Amplifiers.
- High $|y_{fs}|$: $|y_{fs}|$=22mS(Typ.)
  (V_{DS}=10V, V_{GS}=0, I_{DSS}=3mA)
- Excellent Pair Characteristics
  : $|V_{GS1}-V_{GS2}|$= 20mV (Max.)
  (V_{DS}=10V, I_D=1mA)
- High Breakdown Voltage : V_{GDS}=-40V (Min.)
- Low Noise : e_n=0.95nV/$\sqrt{Hz}$ (Typ.)
  (V_{DS}=10V, I_D=1mA, f=1kHz)
- High Input Impedance : I_{GSS}=-1nA(Max.) (V_{GS}=-30V)
- Complementary to 2SJ75.

Unit: mm



1. DRAIN 1
2. GATE 1
3. SOURCE 1
4. DRAIN 2
5. GATE 2
6. SOURCE 2

JEDEC	–
EIAJ	–
TOSHIBA	2－6F1A

Weight: 0.72 g

MAXIMUM RATINGS (Ta=25°C)

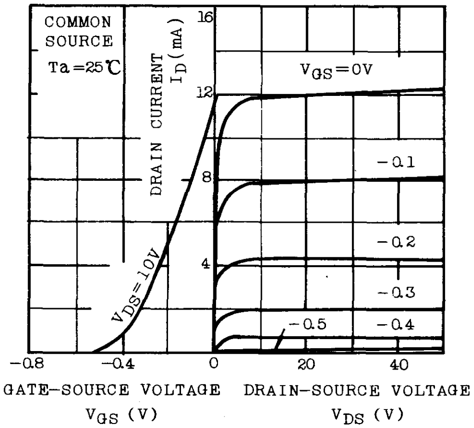
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-40	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	400×2	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	Tstg	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

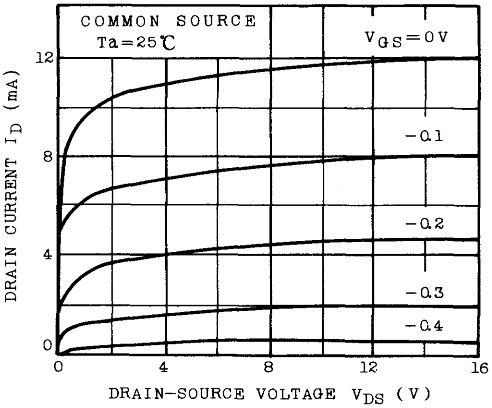
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	–	–	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-40	–	–	V
Drain Current	I_{DSS}(Note)	V_{DS}=10V, V_{GS}=0	2.6	–	20	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.2	–	-1.5	V
Forward Transfer Admittance	$\|y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz	15	22	–	mS
Differential Gate-Source Voltage	$\|V_{GS1}-V_{GS2}\|$	V_{DS}=10V, I_D=1mA	–	–	20	mV
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	–	30	–	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=10V, I =0, f=1MHz	–	6	–	pF
Noise Figure	NF(1)	V_{DS}=10V, I_D=1.0mA, R_g=1kΩ, f=10Hz	–	1.0	10	dB
	NF(2)	V_{DS}=10V, I_D=1.0mA, R_g=1kΩ, f=1kHz	–	0.5	2	

Note: I_{DSS} Classification GR : 2.6∿6.5, BL : 6.0∿12, V : 10∿20

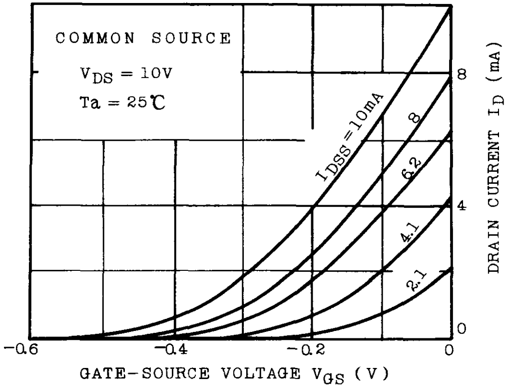
STATIC CHARACTERISTICS



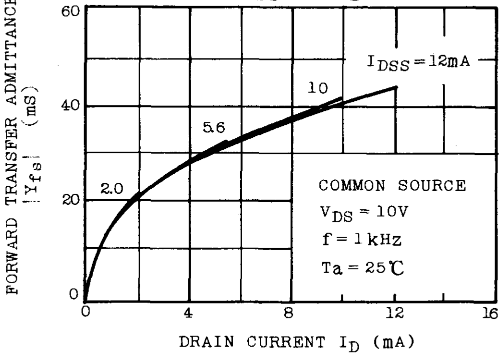
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



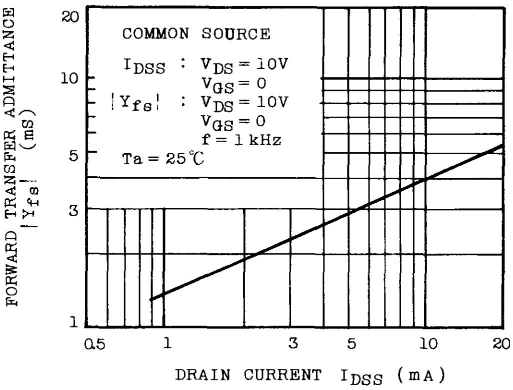
$I_D - V_{GS}$



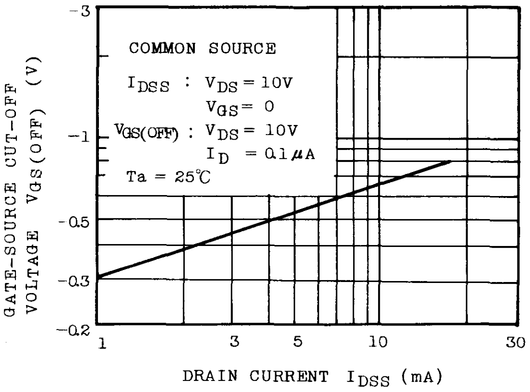
$|Y_{fs}| - I_D$

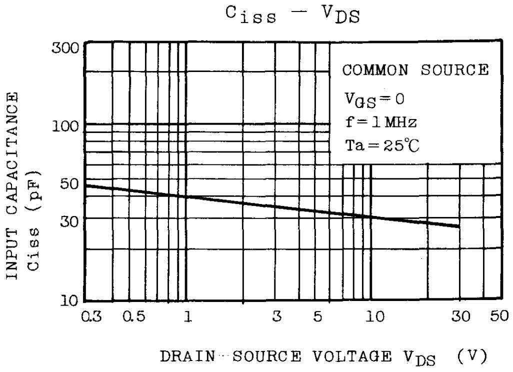


$|Y_{fs}| - I_{DSS}$

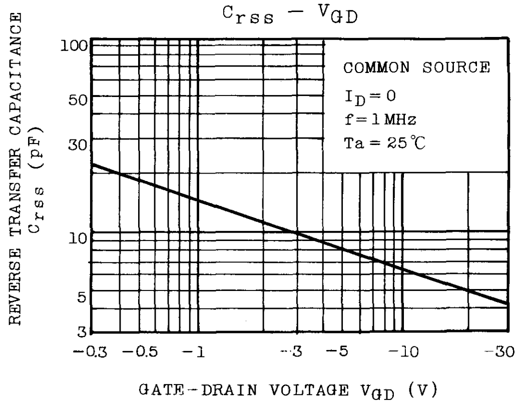


$V_{GS(OFF)} - I_{DSS}$

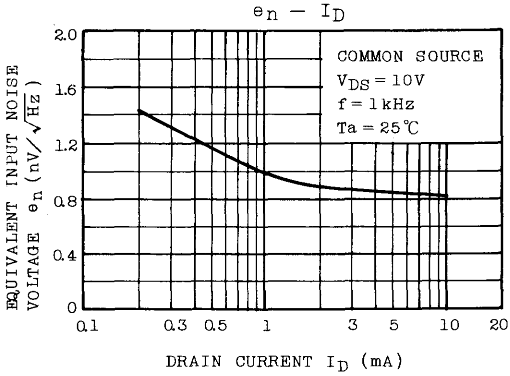




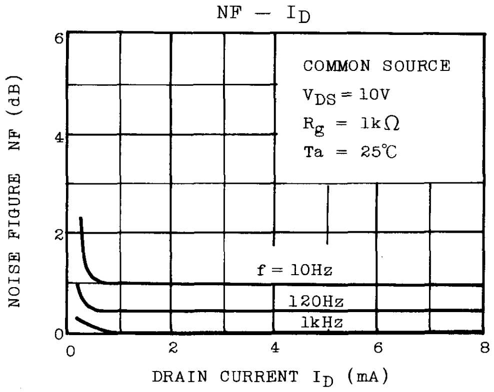
C_{iss} — V_{DS}



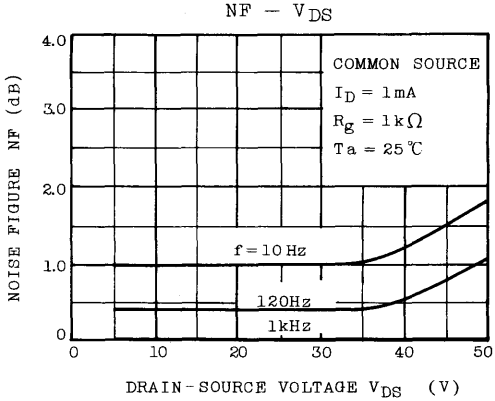
C_{rss} — V_{GD}



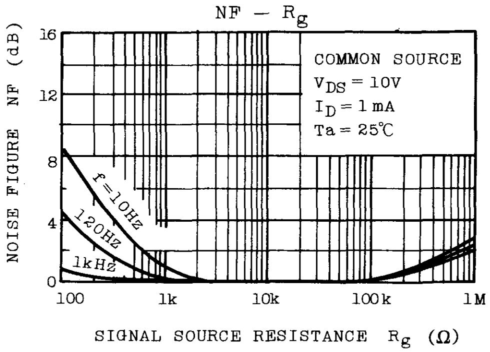
e_n — I_D



NF — I_D

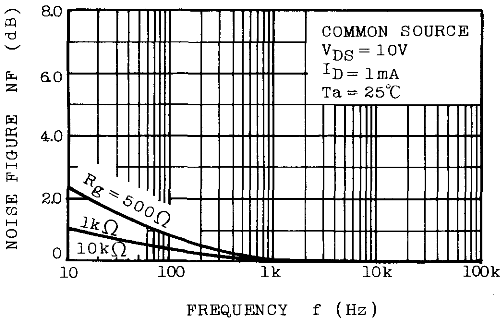


NF — V_{DS}

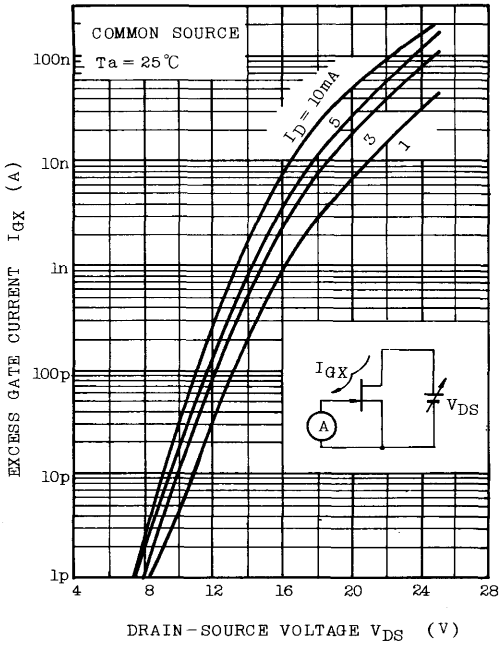


NF — R_g

NF — f


COMMON SOURCE
V_{DS} = 10V
I_D = 1mA
Ta = 25℃
NOISE FIGURE NF (dB)
8.0
6.0
4.0
2.0
0
R_g = 500Ω
1kΩ
10kΩ
10
100
1k
10k
100k
FREQUENCY f (Hz)

I_{GX} — V_{DS}


COMMON SOURCE
Ta = 25℃
EXCESS GATE CURRENT I_{GX} (A)
100n
10n
1n
100p
10p
1p
I_D = 10mA
5
3
1
I_{GX}
V_{DS}
A
4
8
12
16
20
24
28
DRAIN-SOURCE VOLTAGE V_{DS} (V)

2SK241

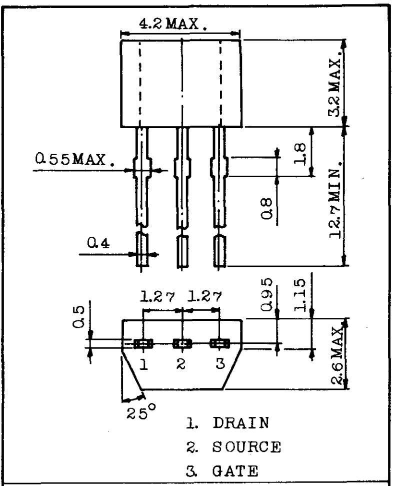
SILICON N CHANNEL MOS TYPE

FM TUNER, VHF AND RF AMPLIFIER APPLICATIONS.

FEATURES:

- Low Reverse Transfer Capacitance
  : C_{rss}=0.035pF (Typ.)
- Low Noise Figure : NF=1.7dB (Typ.)
- High Power Gain : G_{PS}=28dB (Typ.)
- Recommend Operation Voltage : 5～15V

Unit in mm



JEDEC	—
EIAJ	—
TOSHIBA	2-4E1D

Weight : 0.13g

MAXIMUM RATINGS (T_a=25°C)

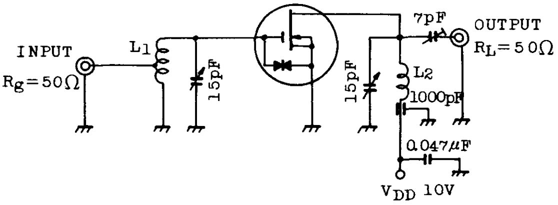
CHARACTERISTIC	SYMBOL	RATING	UNIT
Drain-Source Voltage	V_{DS}	20	V
Gate -Source Voltage	V_{GS}	±5	V
Drain Current	I_D	30	mA
Drain Power Dissipation	P_D	200	mW
Channel Temperature	T_{ch}	125	°C
Storage Temperature Range	T_{stg}	-55～125	°C

ELECTRICAL CHARACTERISTICS (T_a=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{DS}=0, V_{GS}=±5V	-	-	±50	nA
Drain-Source Voltage	V_{DSX}	V_{GS}=-4V, I_D=100μA	20	-	-	V
Drain Current	I_{DSS}	V_{DS}=10V, V_{GS}=0 (Note)	1.5	-	14	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=100μA	-	-	-2.5	V
Forward Transfer Admittance	$\lvert Y_{fs} \rvert$	V_{DS}=10V, V_{GS}=0, f=1kHz	-	10	-	mS
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	3.0	-	pF
Reverse Transfer Capacitance	C_{rss}		-	0.035	0.050	pF
Power Gain	G_{ps}	V_{DS}=10V, V_{GS}=0, f=100MHz (Fig.)	-	28	-	dB
Noise Figure	NF		-	1.7	3.0	dB

Note : I_{DSS} Classification O:1.5～3.5 Y:3.0～7.0 GR:6.0～14.0

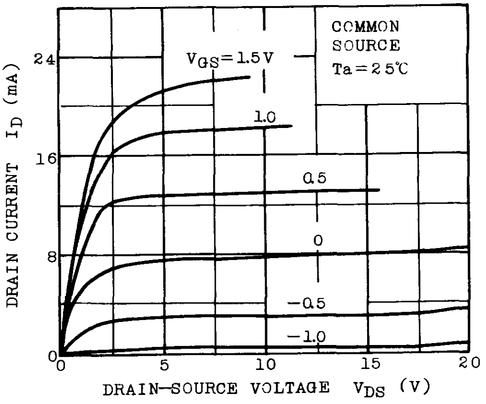
Fig. Gps, NF TEST CIRCUIT



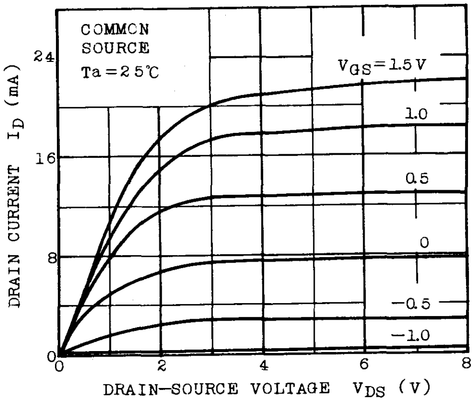
L1: 1.0mmφ SILVER PLATED COPPER WIRE
4.0T, 8mmφ ID
TAPAT 1.0T FROM COLD END

L2: 1.0mmφ SILVER PLATED COPPER WIRE
3.0T, 8mmφ IB, 10mm LENGTH

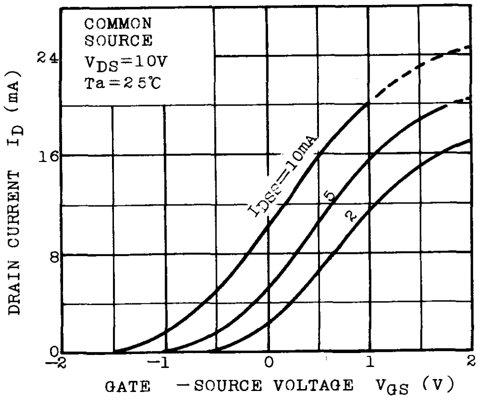
$I_D - V_{DS}$



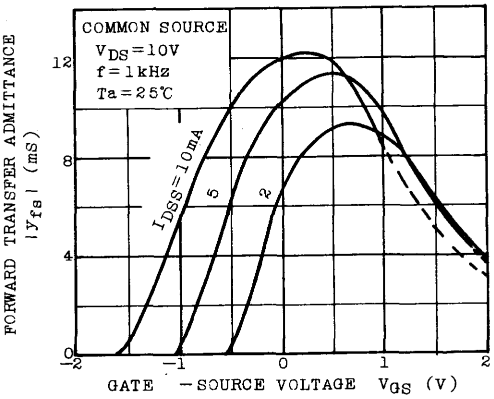
$I_D - V_{DS}$



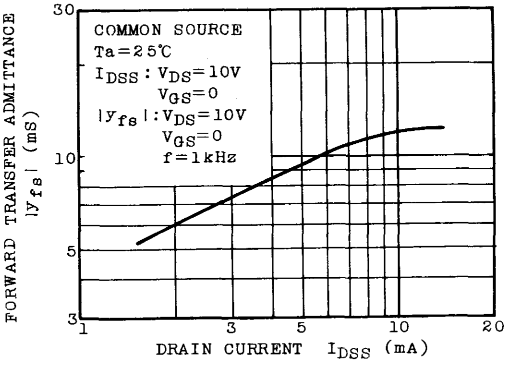
$I_D - V_{GS}$



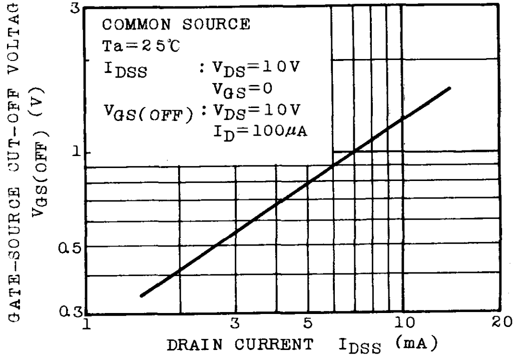
$|y_{fs}| - V_{GS}$



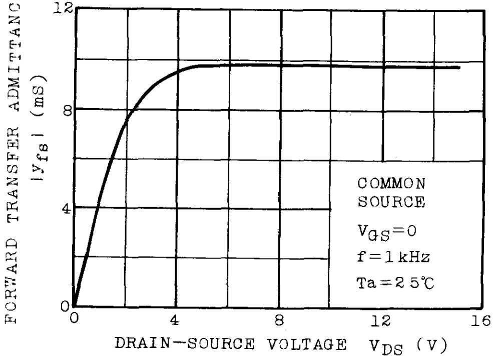
$|y_{fs}| - I_{DSS}$



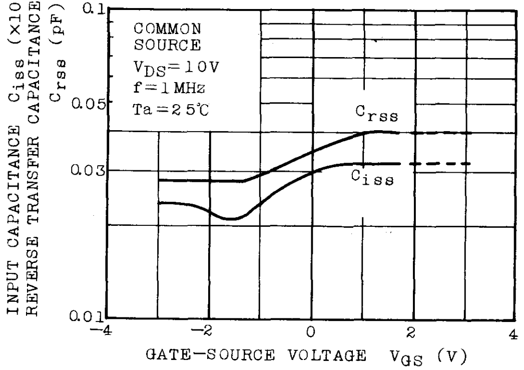
$V_{GS(OFF)} - I_{DSS}$



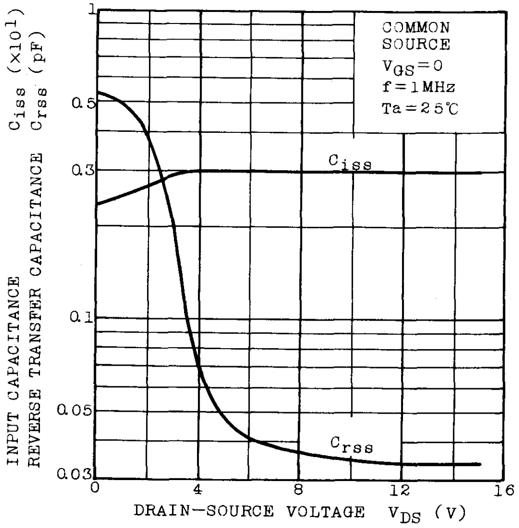
$|y_{fs}|$ — V_{DS}



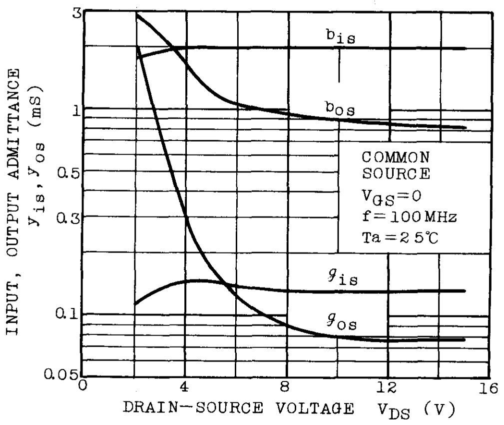
C_{iss}, C_{rss} — V_{GS}



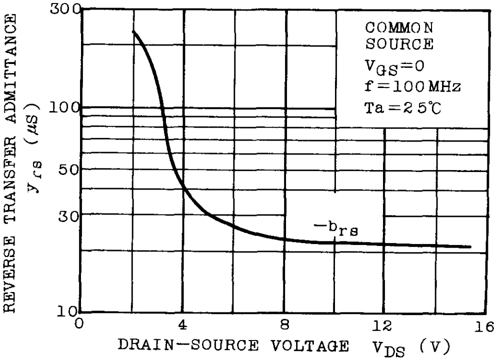
C_{iss}, C_{rss} — V_{DS}



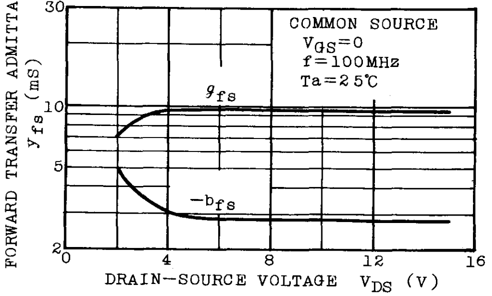
y_{is}, y_{os} — V_{DS}



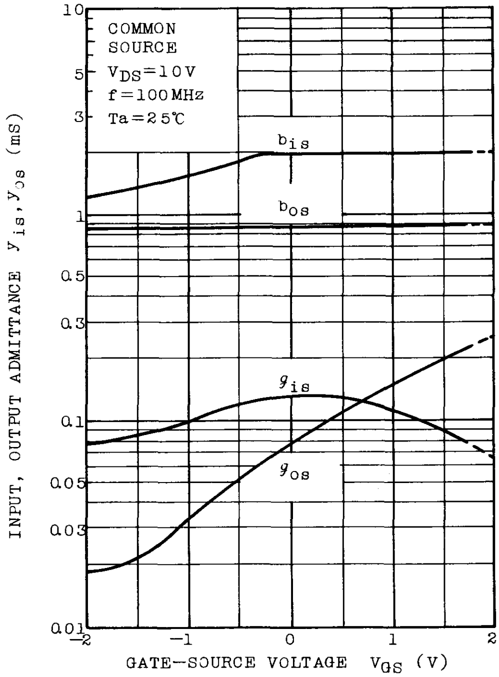
y_{rs} — V_{DS}



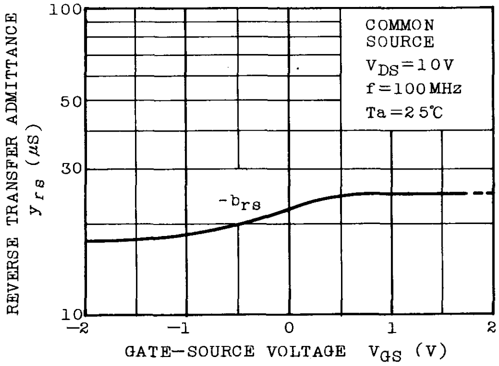
y_{fs} — V_{DS}



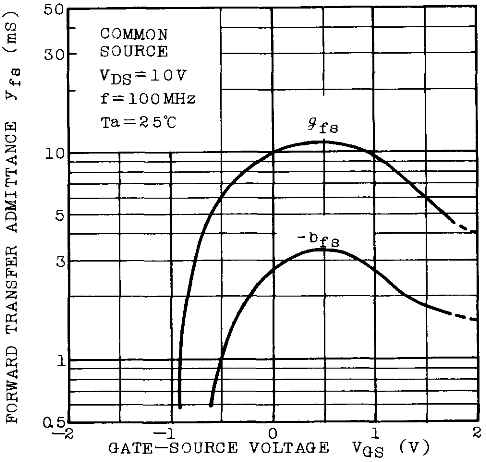
y_{is}, y_{os} — V_{GS}



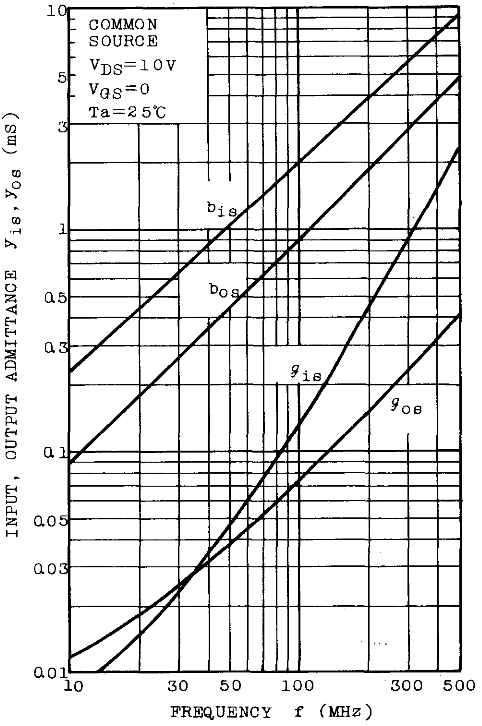
y_{rs} — V_{GS}



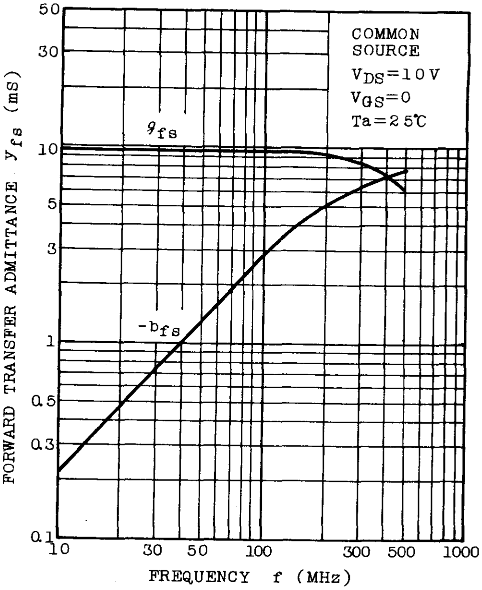
y_{fs} — V_{GS}



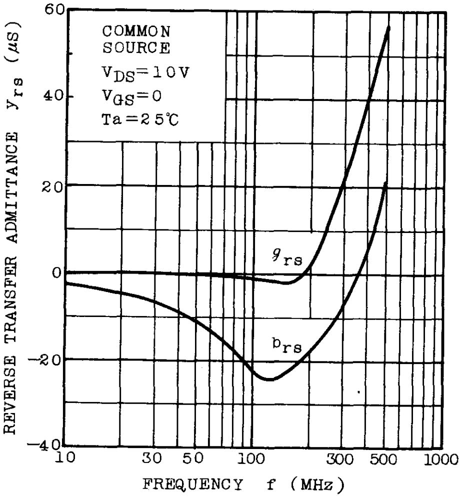
y_{is}, y_{os} — f



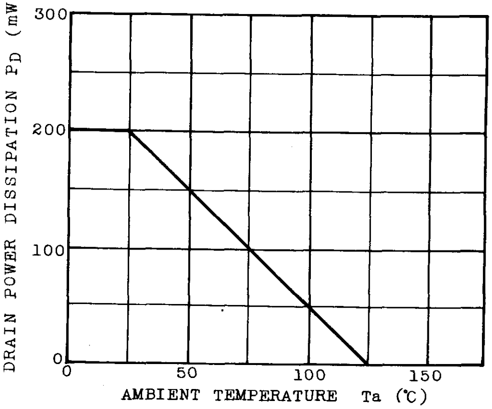
y_{fs} — f



y_{rs} — f



P_D — Ta



SILICON N CHANNEL JUNCTION TYPE

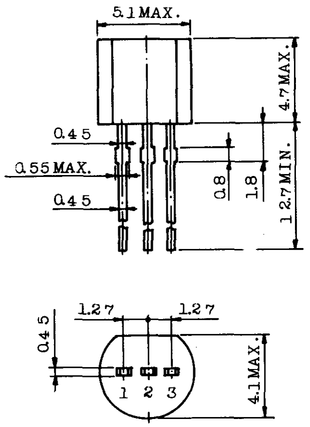
2SK246

FOR CONSTANT CURRENT, IMPEDANCE CONVERTER AND DC-AC HIGH INPUT IMPEDANCE AMPLIFIER CIRCUIT APPLICATIONS.

FEATURES:

- High Breakdown Voltage : V_{GDS}=-50V
- High Input Impedance : I_{GSS}=1nA(Max.) (V_{GS}=-30V)

Unit in mm



1. SOURCE
2. GATE
3. DRAIN

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1C

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

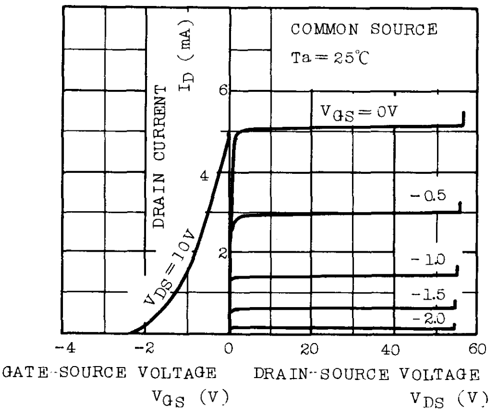
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-50	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	300	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

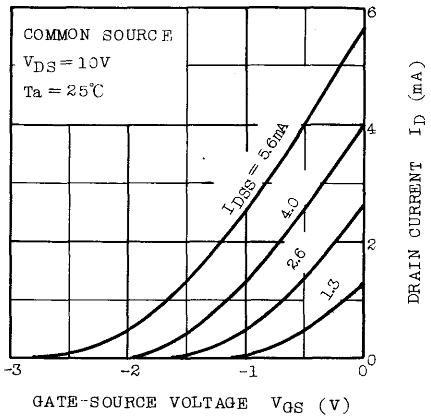
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-50	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=10V, V_{GS}=0	1.2	-	14	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.7	-	-6.0	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz	1.5	-	-	mS
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	9.0	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=10V, I_D=0, f=1MHz	-	2.5	-	pF

Note : I_{DSS} Classification Y:1.2~3.0mA, GR:2.6~6.5mA, BL:6~14mA

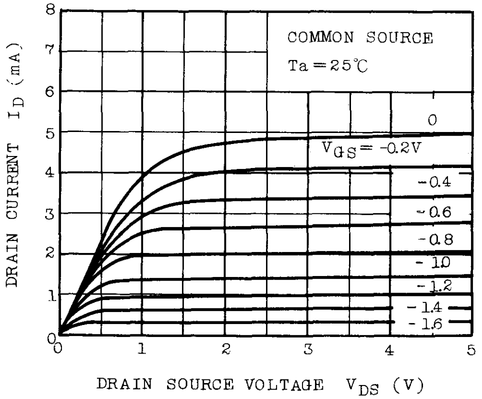
STATIC CHARACTERISTICS

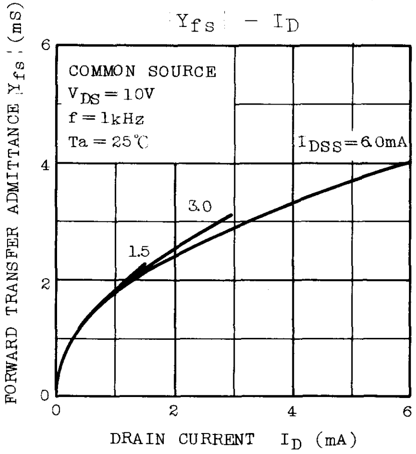


I_D – V_{GS}

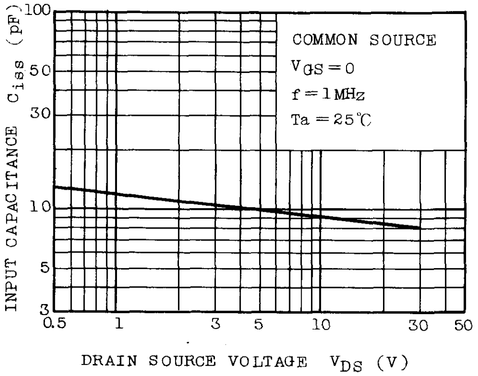


I_D – V_{DS}(LOW VOLTAGE RIGION)

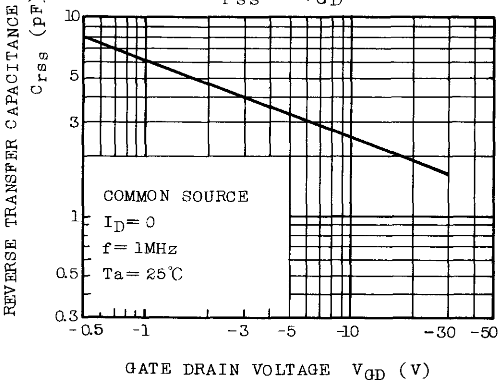


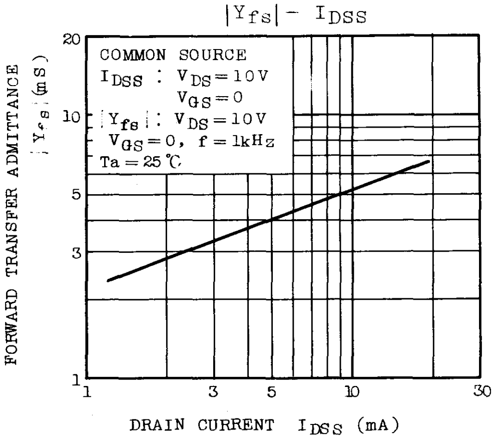


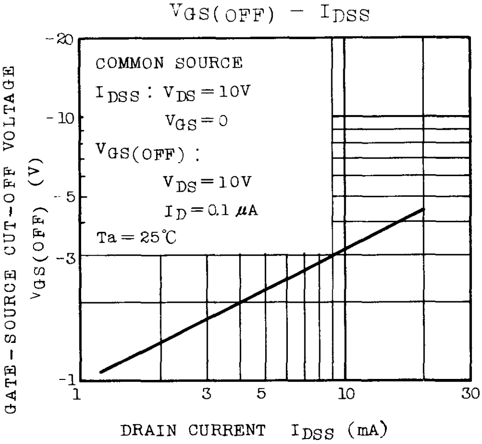
C_{iss} – V_{DS}

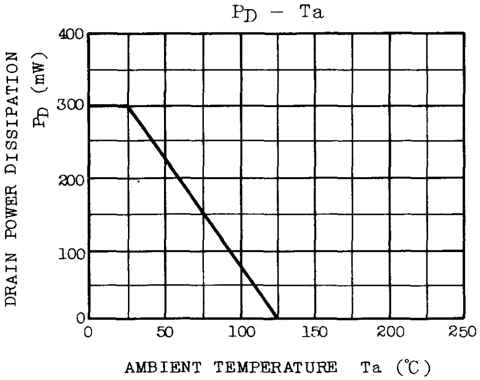


C_{rss} – V_{GD}




|Yfs| – IDSS
COMMON SOURCE
IDSS : VDS = 10V
VGS = 0
|Yfs| : VDS = 10V
VGS = 0, f = 1kHz
Ta = 25℃
FORWARD TRANSFER ADMITTANCE |Yfs| (mS)
20
10
5
3
1
1
3
5
10
30
DRAIN CURRENT IDSS (mA)


VGS(OFF) – IDSS
COMMON SOURCE
IDSS : VDS = 10V
VGS = 0
VGS(OFF) :
VDS = 10V
ID = 0.1 μA
Ta = 25℃
GATE-SOURCE CUT-OFF VOLTAGE VGS(OFF) (V)
-20
-10
-5
-3
-1
1
3
5
10
30
DRAIN CURRENT IDSS (mA)


PD – Ta
DRAIN POWER DISSIPATION PD (mW)
400
300
200
100
0
0
50
100
150
200
250
AMBIENT TEMPERATURE Ta (℃)

2SK270

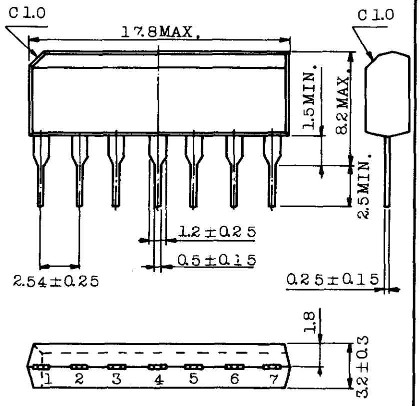
SILICON MONOLITHIC N CHANNEL JUNCTION TYPE

LOW NOISE AUDIO AND DIFFERENTIAL AMPLIFIER APPLICATIONS.

FEATURES:

. 1 Chip Dual Type.
. Recommended for First Differential Stages of DC Amplifiers.
. Very High $|Y_{fs}|$: $|Y_{fs}|$ =20mS(Typ.)
(V_{DS}=10V, V_{GS}=0, f=1kHz, I_{DSS}=3mA)
. Good Pair Characteristics :
$|V_{GS1}-V_{GS2}|$=30mV(Max.)(V_{DS}=10V, I_D=1mA)
. High Breakdown Voltage : V_{GDS}=-40(Min.)
. Very Low Noise : NF=0.5dB(Typ.)
(V_{DS}=10V, I_D=1mA, R_g=1kΩ, f=1kHz)
. High Input Impedance : I_{GSS}=-10nA(Max.)(V_{GS}=-30V)
. Complementary to 2SJ90.

Unit in mm



1. DRAIN 1
2. GATE 1
3. SOURCE 1
4. SUBSTRATE
5. SOURCE 2
6. GATE 2
7. DRAIN 2

JEDEC	―
TOSHIBA	2-18A1A

Weight : 0.7g

MAXIMUM RATINGS (Ta=25°C)

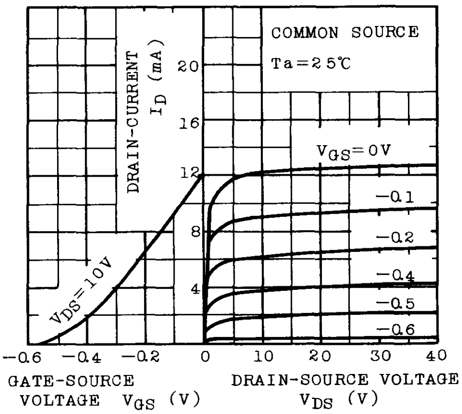
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-40	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	300	mW/UNIT
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55～125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

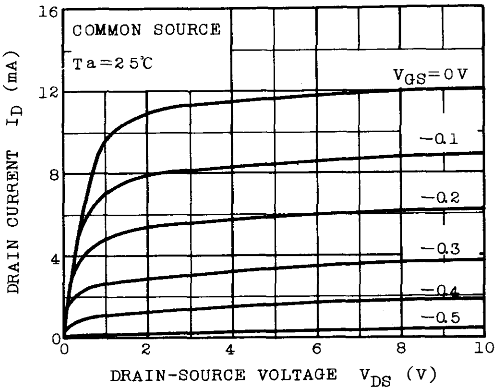
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-10	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-40	-	-	V
Drain Current	I_{DSS}(Note)	V_{DS}=10V, V_{GS}=0	1	-	20	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.2	-	-2.0	V
Forward Transfer Admittance	$|Y_{fs}|$	V_{DS}=10V, V_{GS}=0, f=1kHz, I_{DSS}=3mA	8	20	-	mS
Forward Transfer Admittance Ratio	$|Y_{fs}$(小)$|$/$|Y_{fs}$(大)$|$	V_{DS}=10V, V_{GS}=0, f=1kHz	0.9	-	-	-
Differential Gate Voltage	$|V_{GS1}-V_{GS2}|$	V_{DS}=10V, I_D=1mA	-	-	30	mV
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	25	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=10V, I_D=0, f=1MHz	-	5.5	-	pF
Noise Figure	NF(1)	V_{DS}=10V, R_g=1kΩ, I_D=1mA f=10Hz	-	-	11	dB
	NF(2)	V_{DS}=10V, R_g=1kΩ, I_D=1mA f=1kHz	-	-	2	

Note : I_{DSS} Classification Y:1.0～3.0mA, GR:2.6～6.5mA, BL:6～12mA, V:10～20mA

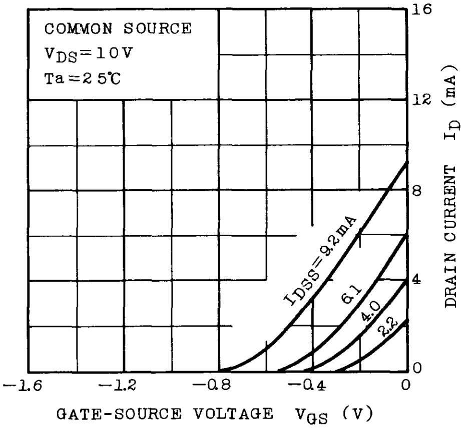
STATIC CHARACTERISTICS



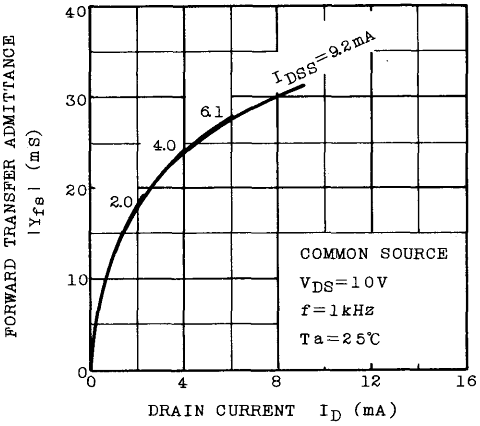
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



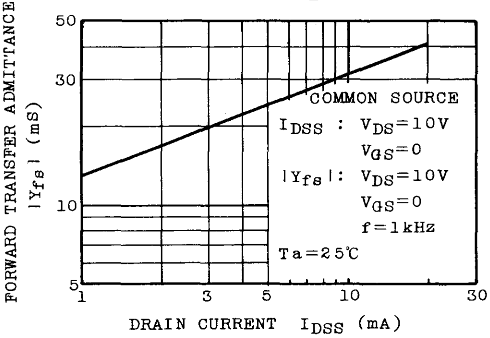
$I_D - V_{GS}$



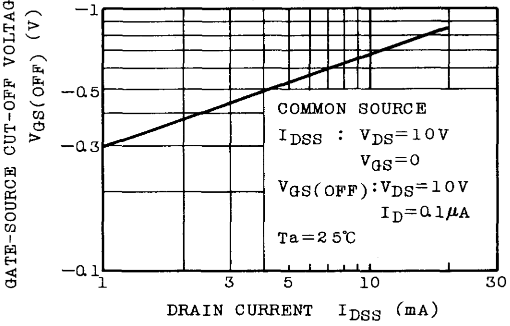
$|Y_{fs}| - I_D$



$|Y_{fs}| - I_{DSS}$

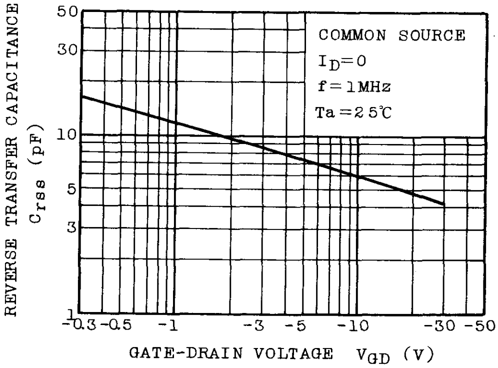


$V_{GS(OFF)} - I_{DSS}$

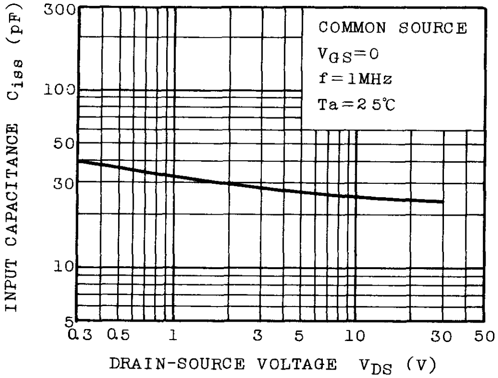


2SK270

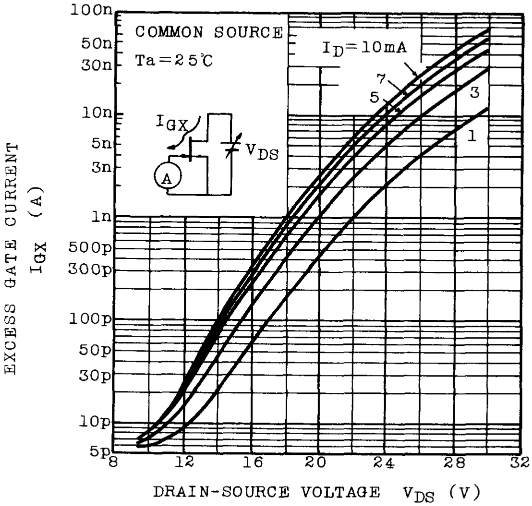
$C_{rss} - V_{GD}$



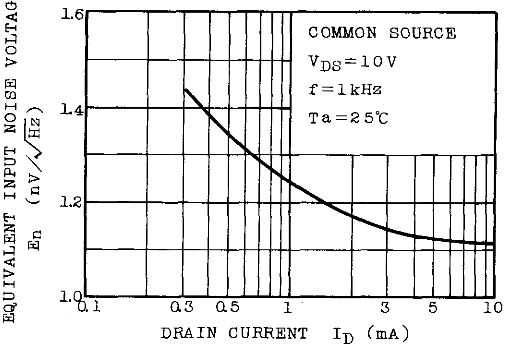
$C_{iss} - V_{DS}$



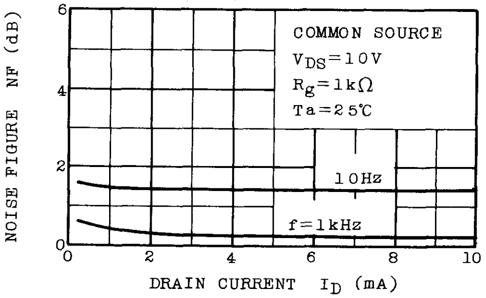
$I_{GX} - V_{DS}$



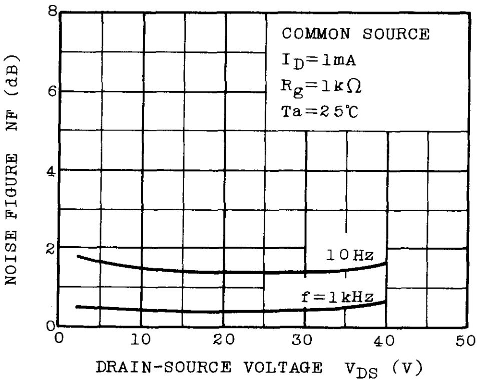
$E_n - I_D$

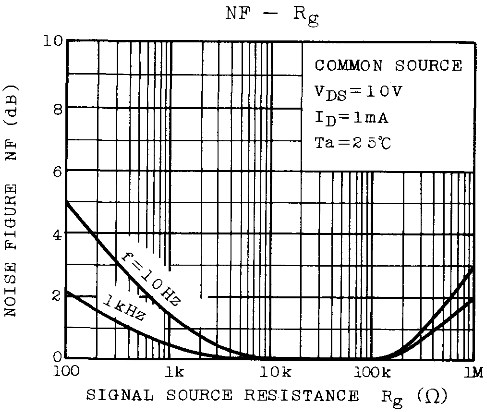


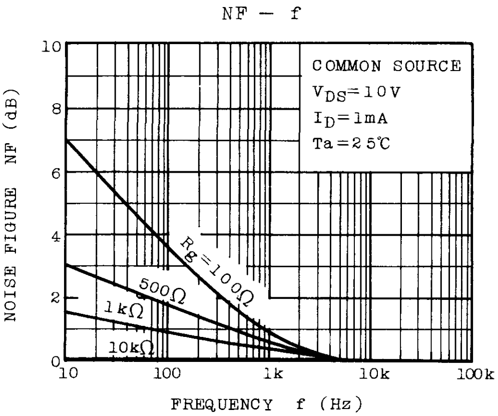
$NF - I_D$



$NF - V_{DS}$




NF – Rg
COMMON SOURCE
V_{DS}=10V
I_D=1mA
Ta=25℃
NOISE FIGURE NF (dB)
SIGNAL SOURCE RESISTANCE Rg (Ω)
f=10Hz
1kHz
0
2
4
6
8
10
100
1k
10k
100k
1M

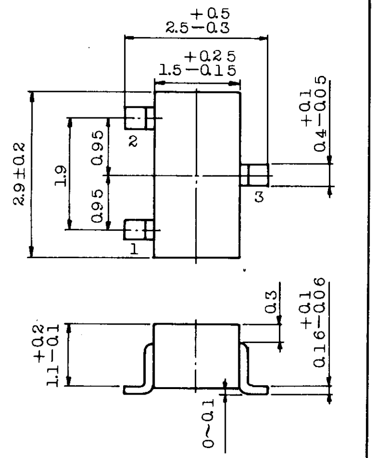

NF – f
COMMON SOURCE
V_{DS}=10V
I_D=1mA
Ta=25℃
NOISE FIGURE NF (dB)
FREQUENCY f (Hz)
Rg=100Ω
500Ω
1kΩ
10kΩ
0
2
4
6
8
10
10
100
1k
10k
100k

2SK302

SILICON N CHANNEL MOS TYPE

FM TUNER, VHF RF AMPLIFIER APPLICATIONS.

Unit in mm



1. GATE
2. DRAIN
3. SOURCE

JEDEC	TO−236
EIAJ	—
TOSHIBA	2−3F1C

Weight: 0.012g

FEATURES:

- Low Reverse Transfer Capacitance: C_{rss}=0.035pF(Typ.)
- Low Noise Figure : NF=1.7dB (Typ.)
- High Power Gain : G_{ps}=28dB(Typ.)
- Recommend Operation Voltage : 5~15V

MAXIMUM RATINGS (Ta=25°C)

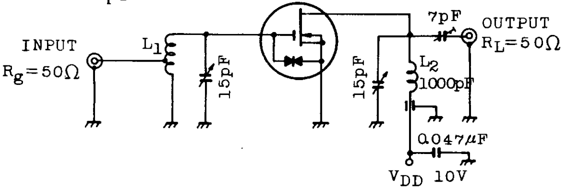
CHARACTERISTIC	SYMBOL	RATING	UNIT
Drain−Source Voltage	V_{DS}	20	V
Gate−Source Voltage	V_{GS}	±5	V
Drain Current	I_D	30	mA
Drain Power Dissipation	P_D	150	mW
Channel Temperature	T_{ch}	125	°C
Storage Temperature	T_{stg}	−55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{DS}=0, V_{GS}=±5V	−	−	±50	nA
Drain−Source Voltage	V_{DSX}	V_{GS}=−4V, I_D=100μA	20	−	−	V
Drain Current	I_{DSS} (Note)	V_{DS}=10V, V_{GS}=0	1.5	−	14	mA
Gate−Source Cut−off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=100μA	−	−	−2.5	V
Forward Transfer Admittance	$\|y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz	−	10	−	mS
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	−	3.0	−	pF
Reverse Transfer Capacitance	C_{rss}		−	0.035	0.050	pF
Power Gain	G_{ps}	V_{DS}=10V, V_{GS}=0, f=100MHz (Fig. 1)	−	28	−	dB
Noise Figure	NF		−	1.7	3.0	dB

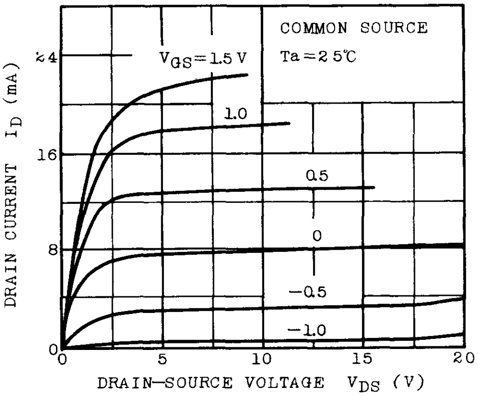
Note : I_{DSS} Classification O : 1.5~3.5 Y : 3.0~7.0 GR(G) : 6.0~14.0

Fig. 1 G_{ps}, NF TEST CIRCUIT

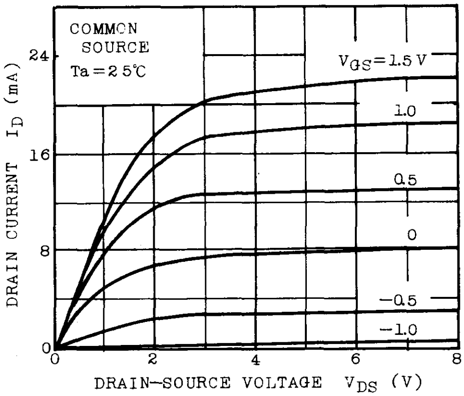


L_1 : 1.0mmϕ SILVER PLATED COPPER WIRE
4.0T, 8mmϕ ID
TAPAT 1.0T FROM COLD END

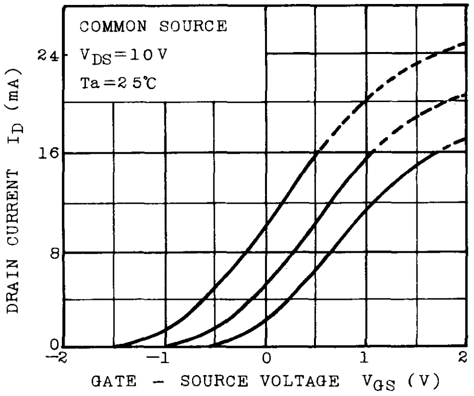
L_2 : 1.0mmϕ SILVER PLATED COPPER WIRE
3.0T, 8mmϕ ID, 10mm LENGTH



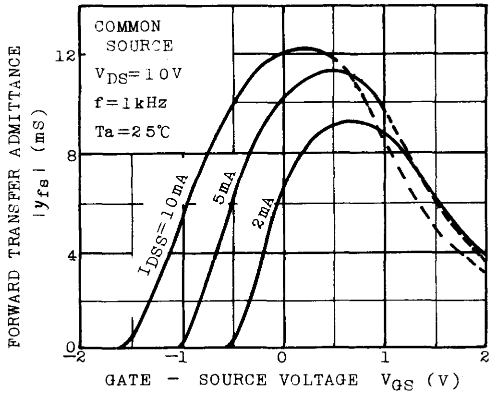
$I_D - V_{DS}$



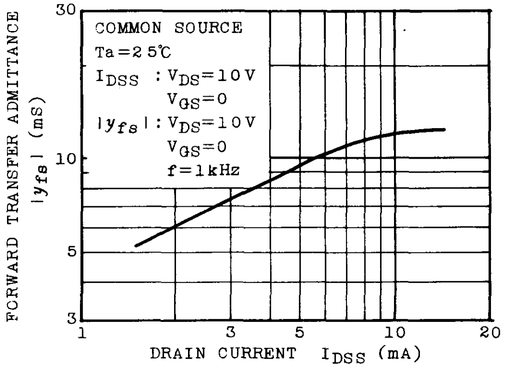
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



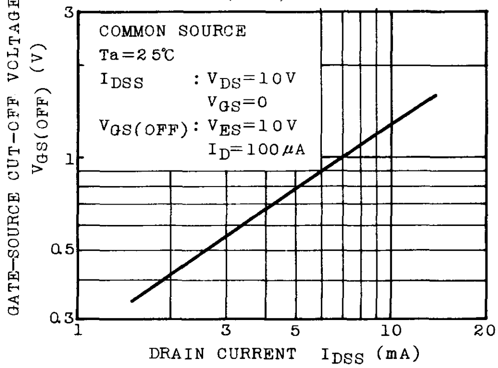
$I_D - V_{GS}$



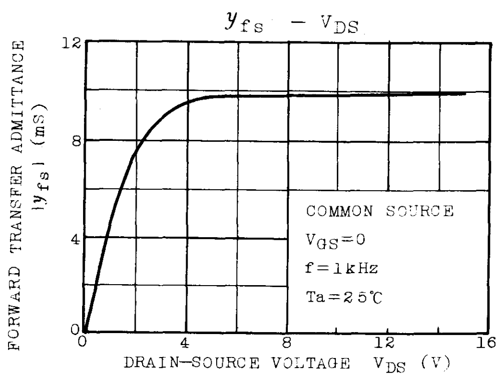
$y_{fs} - V_{GS}$

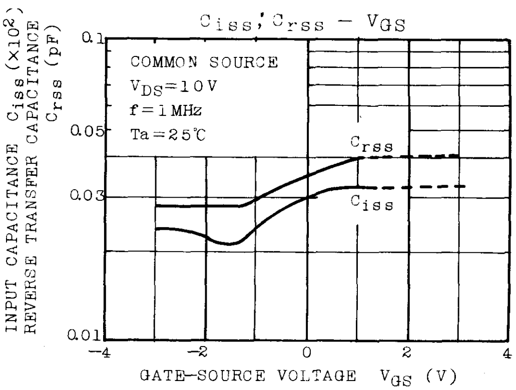


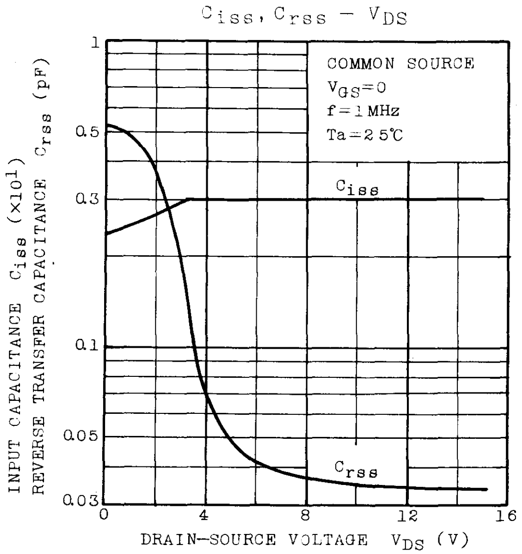
$y_{fs} - I_{DSS}$

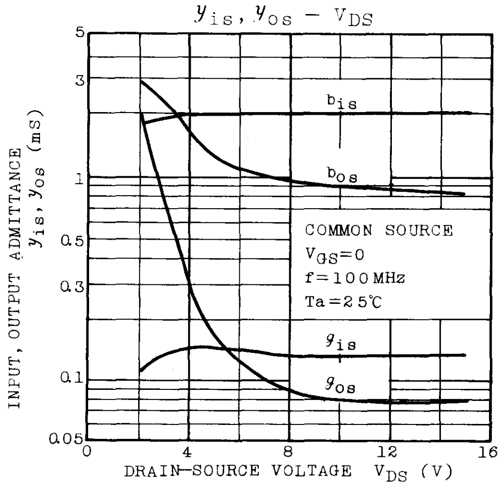


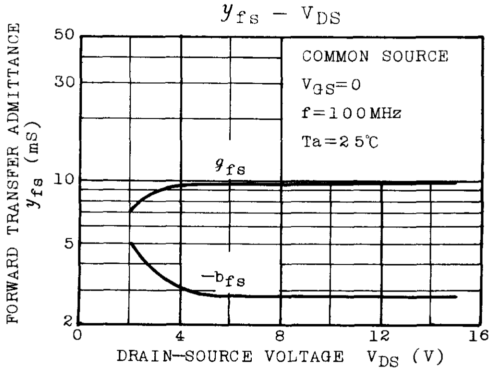
$V_{GS(OFF)} - I_{DSS}$

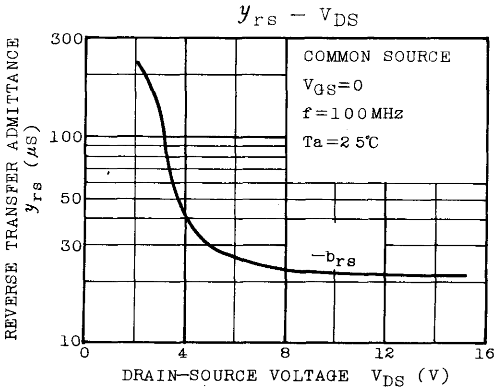

y_{fs} — V_{DS}
FORWARD TRANSFER ADMITTANCE $|y_{fs}|$ (mS)
12
8
4
0
COMMON SOURCE
$V_{GS}=0$
f=1kHz
Ta=25℃
0
4
8
12
16
DRAIN–SOURCE VOLTAGE V_{DS} (V)


C_{iss}, C_{rss} — V_{GS}
INPUT CAPACITANCE C_{iss} ($\times 10^2$)
REVERSE TRANSFER CAPACITANCE C_{rss} (pF)
0.1
0.05
0.03
0.01
COMMON SOURCE
V_{DS}=10V
f=1MHz
Ta=25℃
C_{rss}
C_{iss}
−4
−2
0
2
4
GATE–SOURCE VOLTAGE V_{GS} (V)

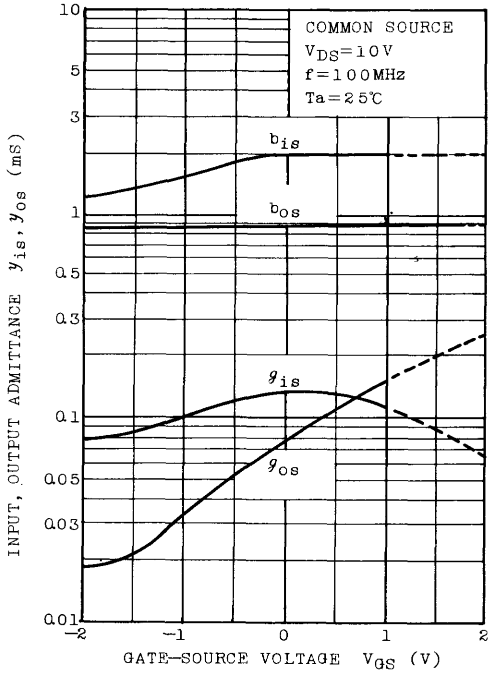

C_{iss}, C_{rss} — V_{DS}
INPUT CAPACITANCE C_{iss} ($\times 10^1$)
REVERSE TRANSFER CAPACITANCE C_{rss} (pF)
1
0.5
0.3
0.1
0.05
0.03
COMMON SOURCE
$V_{GS}=0$
f=1MHz
Ta=25℃
C_{iss}
C_{rss}
0
4
8
12
16
DRAIN–SOURCE VOLTAGE V_{DS} (V)


y_{is}, y_{os} — V_{DS}
INPUT, OUTPUT ADMITTANCE y_{is}, y_{os} (mS)
5
3
1
0.5
0.3
0.1
0.05
b_{is}
b_{os}
COMMON SOURCE
$V_{GS}=0$
f=100MHz
Ta=25℃
g_{is}
g_{os}
0
4
8
12
16
DRAIN–SOURCE VOLTAGE V_{DS} (V)

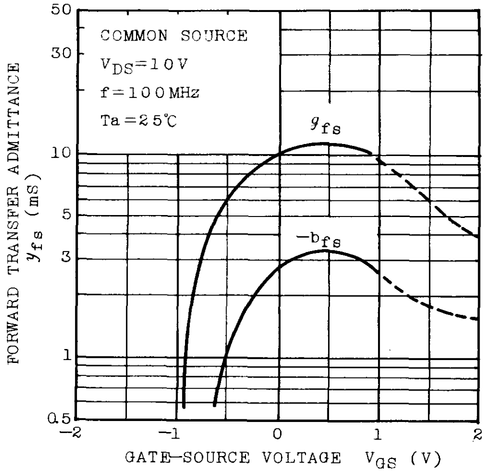

y_{fs} — V_{DS}
FORWARD TRANSFER ADMITTANCE y_{fs} (mS)
50
30
10
5
2
COMMON SOURCE
$V_{GS}=0$
f=100MHz
Ta=25℃
g_{fs}
$-b_{fs}$
0
4
8
12
16
DRAIN–SOURCE VOLTAGE V_{DS} (V)


y_{rs} — V_{DS}
REVERSE TRANSFER ADMITTANCE y_{rs} (μS)
300
100
50
30
10
COMMON SOURCE
$V_{GS}=0$
f=100MHz
Ta=25℃
$-b_{rs}$
0
4
8
12
16
DRAIN–SOURCE VOLTAGE V_{DS} (V)

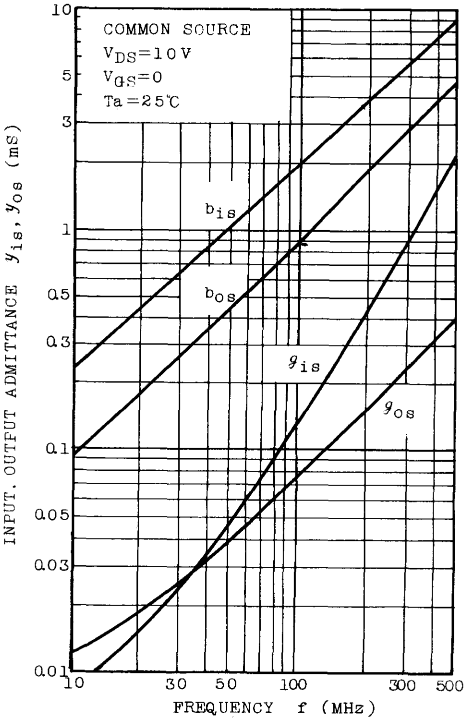
$y_{is}, y_{os} - V_{GS}$



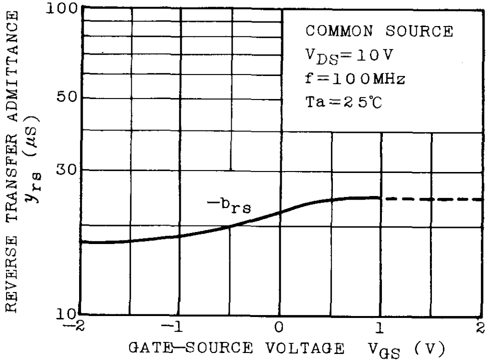
$y_{fs} - V_{GS}$

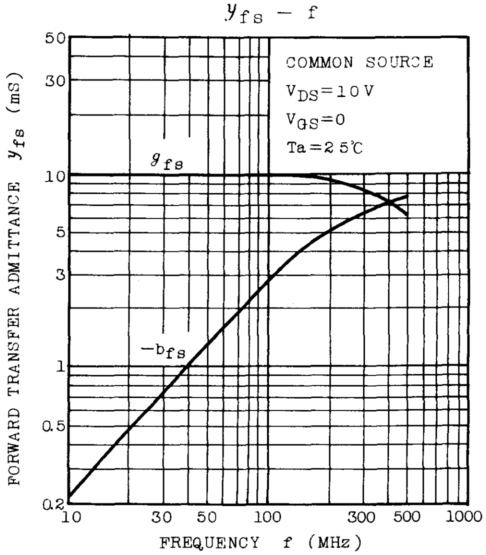


$y_{is}, y_{os} - f$

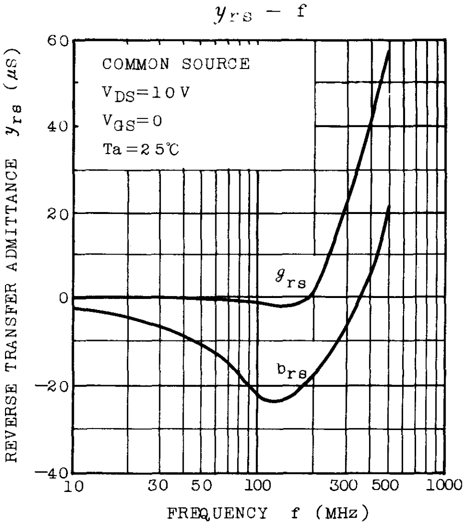


$y_{rs} - V_{GS}$

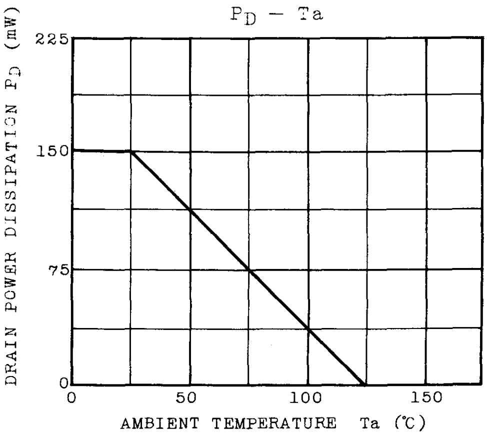




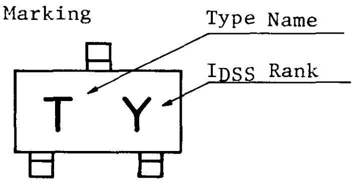
y_{fs} − f



y_{rs} − f



P_D − Ta

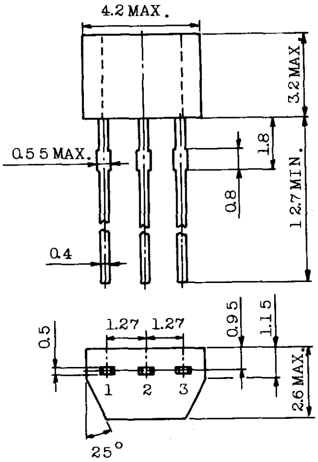


SILICON N CHANNEL JUNCTION TYPE

2SK330

FOR AUDIO AMPLIFIER, ANALOG SWITCH, CONSTANT CURRENT AND IMPEDANCE CONVERTER APPLICATIONS.

Unit in mm



1. SOURCE
2. GATE
3. DRAIN

JEDEC	–
EIAJ	–
TOSHIBA	2–4E1B

Weight : 0.13g

FEATURES:

- High Breakdown Voltage : V_{GDS}=-50V
- High Input Impedance : I_{GSS}=-1nA (Max.) (V_{GS}=-30V)
- Low $R_{DS(ON)}$: $R_{DS(ON)}$=320Ω (Typ.) (I_{DSS}=5mA)
- Complementary to 2SJ105
- Small Package

MAXIMUM RATINGS (Ta=25°C)

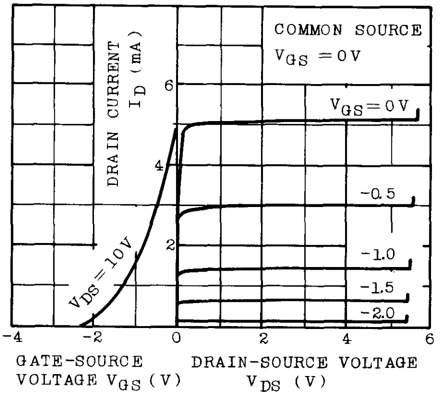
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-50	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	200	mW
Junction Temperature	Tj	125	°C
Storage Temperature Range	Tstg	-55～125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

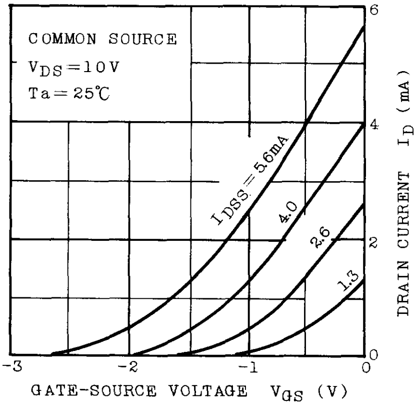
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-50	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=10V, V_{GS}=0	1.2	-	14	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.7	-	-6.0	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz	1.5	4	-	mS
Drain-Source ON Resistance	$R_{DS(ON)}$	V_{DS}=10mV, V_{GS}=0 I_{DSS}=5mA	-	320	-	Ω
Input Capacitance	Ciss	V_{DS}=10V, V_{GS}=0, f=1MHz	-	9.0	-	pF
Reverse Transfer Capacitance	Crss	V_{DG}=10V, I_D=0, f=1MHz	-	2.5	-	pF

Note : I_{DSS} Classification Y : 1.2～3.0mA, GR : 2.6～6.5mA, BL : 6～14mA

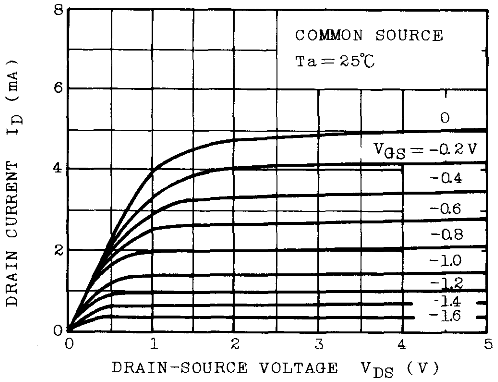
STATIC CHARACTERISTIC



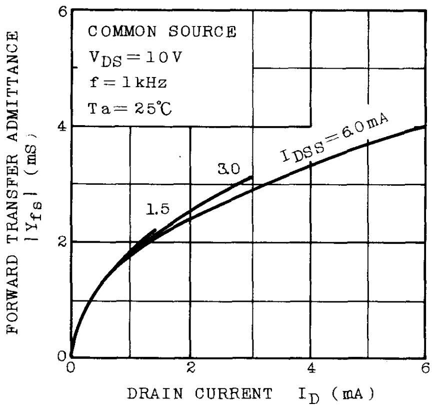
I_D − V_{GS}



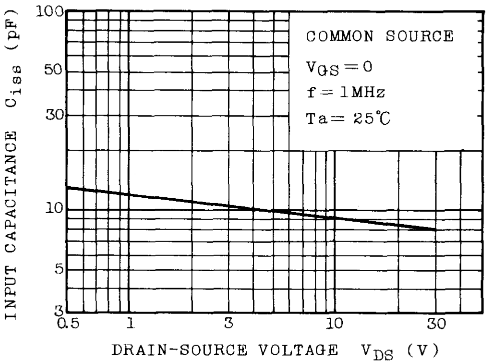
I_D − V_{DS} (LOW VOLTAGE REGION)



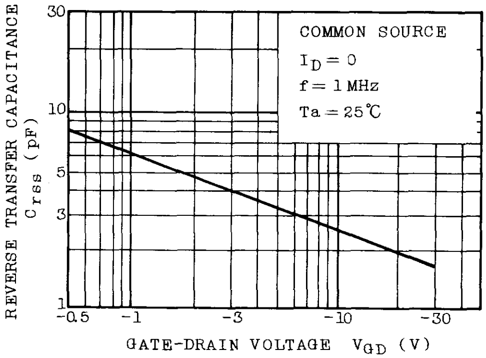
$|Y_{fs}|$ − I_D



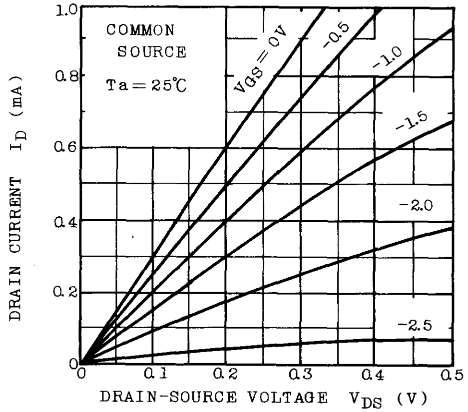
C_{iss} − V_{DS}



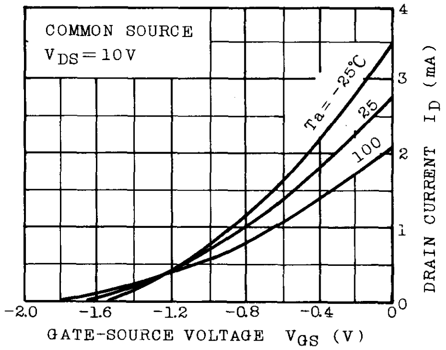
C_{rss} − V_{GD}



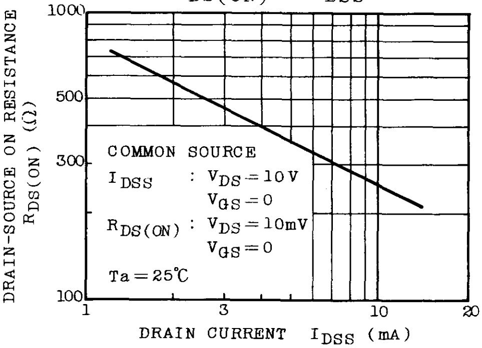
$I_D - V_{DS}$



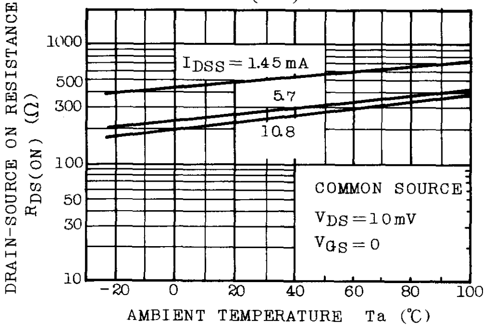
$I_D - V_{GS}$



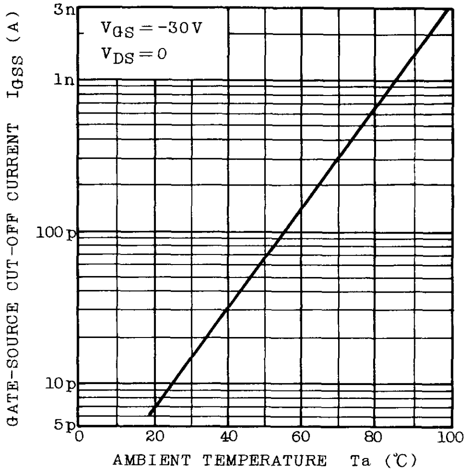
$R_{DS(ON)} - I_{DSS}$



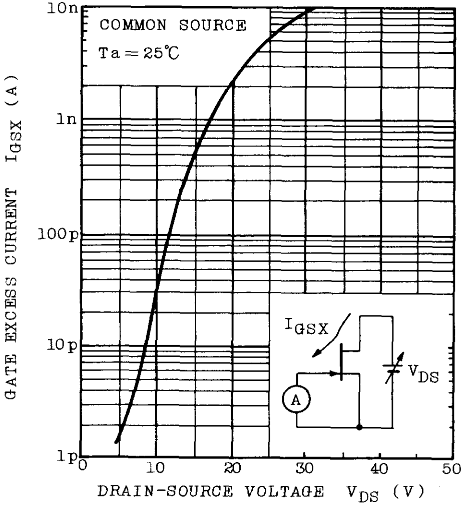
$R_{DS(ON)} - Ta$

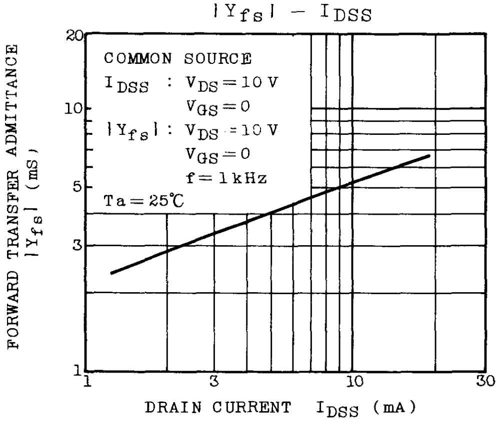


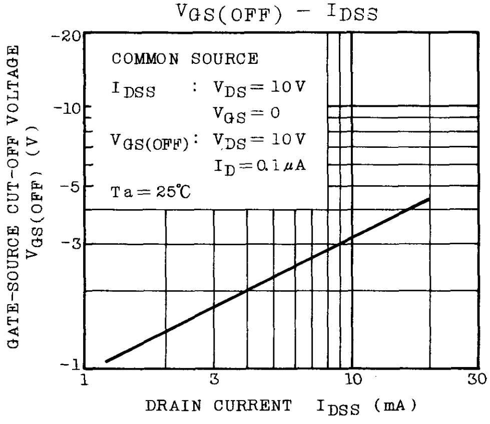
$I_{GSS} - Ta$

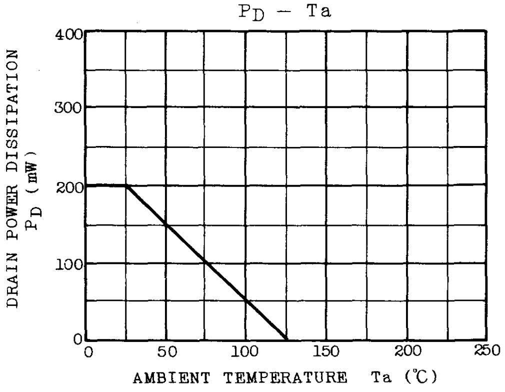


$I_{GSX} - V_{DS}$




|Yfs| – IDSS
COMMON SOURCE
IDSS : VDS = 10 V
VGS = 0
|Yfs| : VDS = 10 V
VGS = 0
f = 1 kHz
Ta = 25℃
FORWARD TRANSFER ADMITTANCE |Yfs| (mS)
20
10
5
3
1
1
3
10
30
DRAIN CURRENT IDSS (mA)


VGS(OFF) – IDSS
COMMON SOURCE
IDSS : VDS = 10 V
VGS = 0
VGS(OFF) : VDS = 10 V
ID = 0.1 μA
Ta = 25℃
GATE-SOURCE CUT-OFF VOLTAGE VGS(OFF) (V)
-20
-10
-5
-3
-1
1
3
10
30
DRAIN CURRENT IDSS (mA)


PD – Ta
DRAIN POWER DISSIPATION PD (mW)
400
300
200
100
0
0
50
100
150
200
250
AMBIENT TEMPERATURE Ta (℃)

SILICON N CHANNEL JUNCTION TYPE

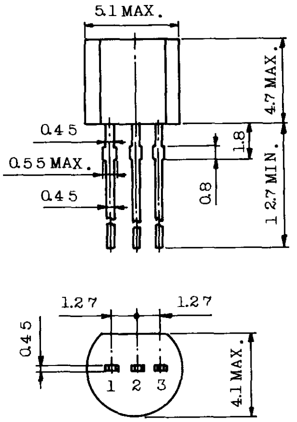
2SK362

FOR AUDIO AMPLIFIER, ANALOG SWITCH, CONSTANT CURRENT AND IMPEDANCE CONVERTER APPLICATIONS.

FEATURES:

- High Breakdown Voltage : V_{GDS}=-50V
- High Input Impedance
  : I_{GSS}=-1.0nA (Max.) (V_{GS}=-30V)
- Low $R_{DS(ON)}$: $R_{DS(ON)}$=80Ω (Typ.) (I_{DSS}=5mA)

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1D

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-50	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	300	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55～125	°C

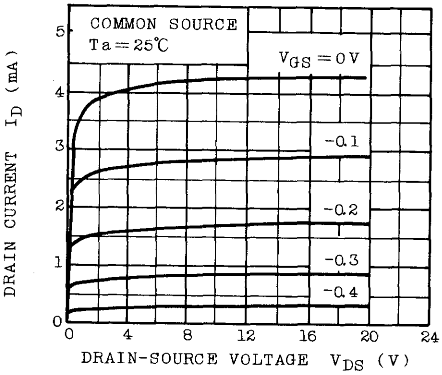
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-50	-	-	V
Drain Current	I_{DSS} (Note 1)	V_{DS}=10V, V_{GS}=0	1.2	-	14	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.25	-	-1.5	V
Forward Transfer Admittance	$\lvert Y_{fs} \rvert$	V_{DS}=10V, V_{GS}=0, f=1kHz (Note 2)	5.0	19	-	mS
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	13	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=10V, I_D=0, f=1MHz	-	3	-	pF
Drain-Source ON Resistance	$R_{DS(ON)}$	V_{DS}=10mV, V_{GS}=0 (Note 2)	-	80	-	Ω

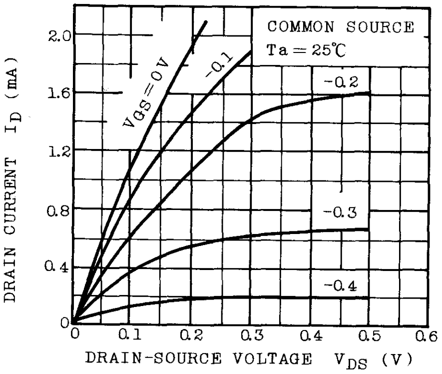
Note 1 : I_{DSS} Classification Y : 1.2～3.0, GR : 2.6～6.5, BL : 6～14

2 : Condition of the typical value I_{DSS}=5mA

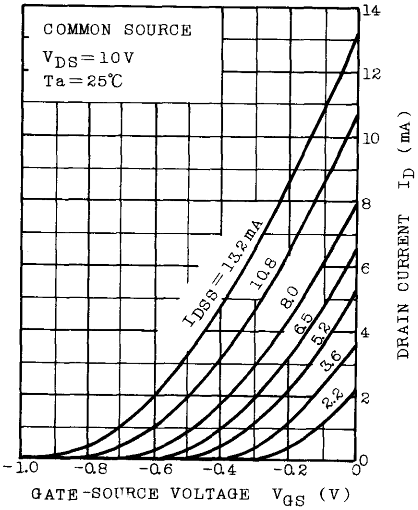
I_D – V_{DS}



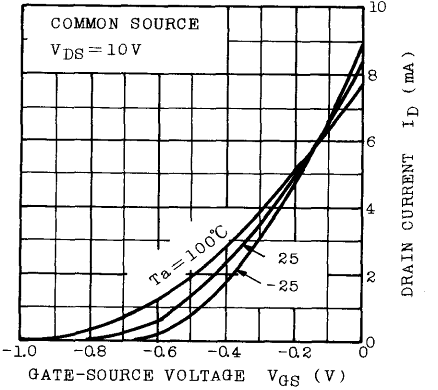
I_D – V_{DS} (LOW VOLTAGE REGION)



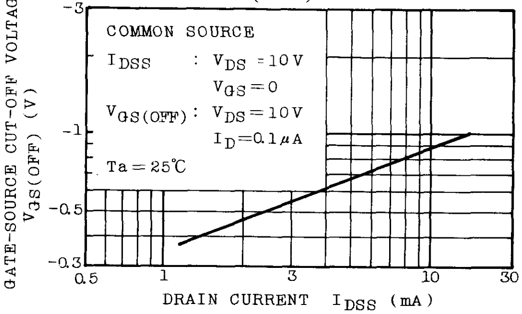
I_D – V_{GS}



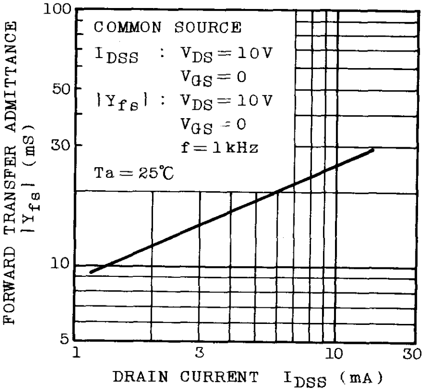
I_D – V_{GS} (TEMPERATURE DEPENDENCY)



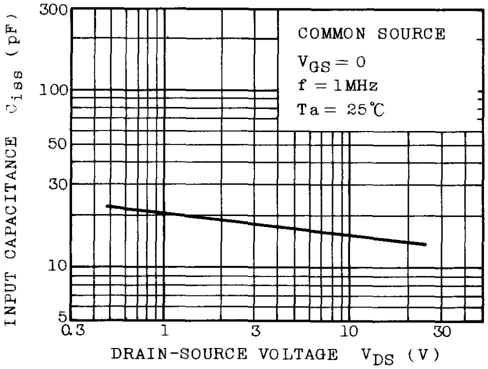
$V_{GS(OFF)}$ – I_{DSS}



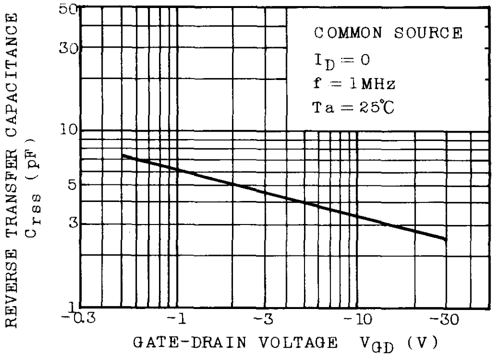
$|Y_{fs}|$ – I_{DSS}



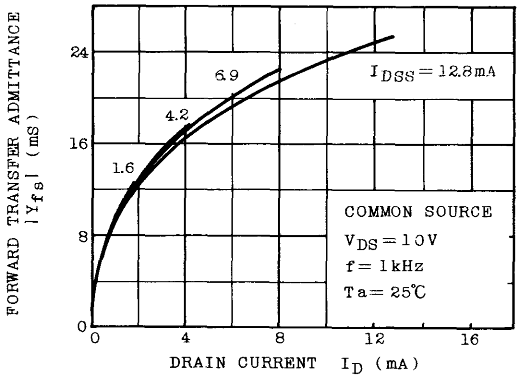
$C_{iss} - V_{DS}$



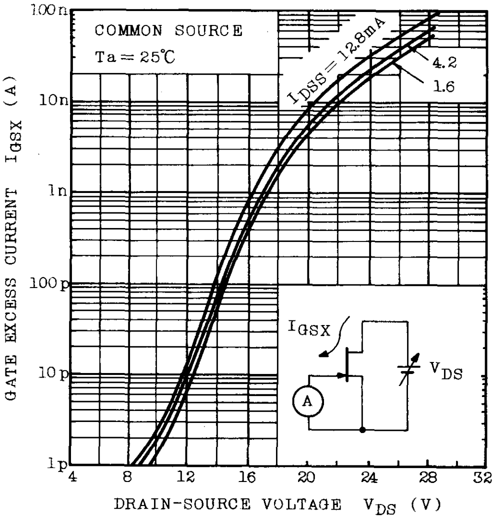
$C_{rss} - V_{GD}$



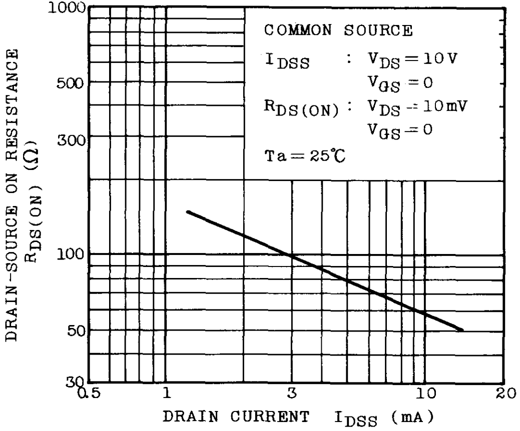
$|Y_{fs}| - I_D$



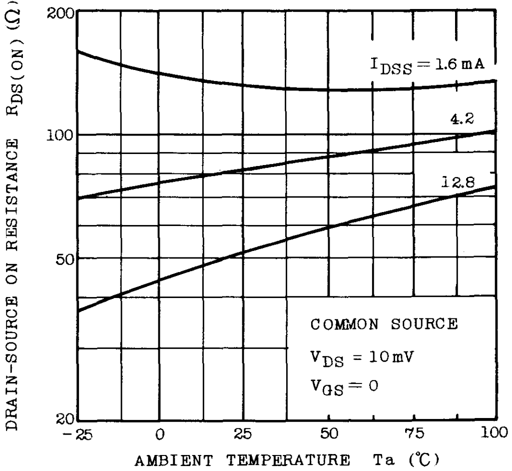
$I_{GSX} - V_{DS}$



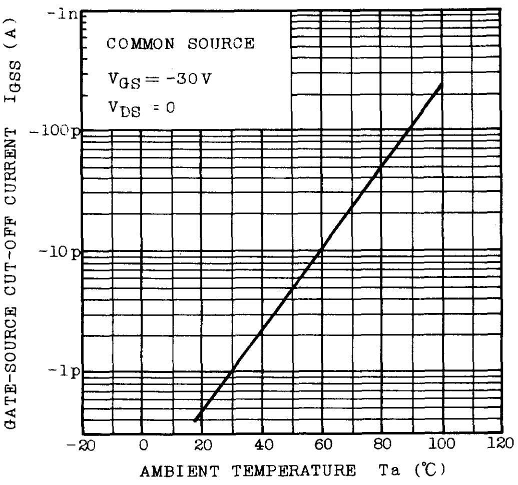
$R_{DS(ON)} - I_{DSS}$



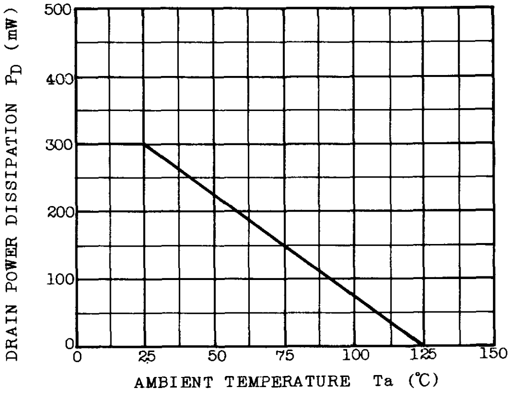
$R_{DS(ON)}$ – Ta



I_{GSS} – Ta



P_D – Ta



SILICON N CHANNEL JUNCTION TYPE

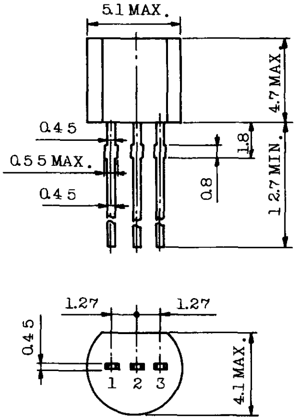
2SK363

FOR AUDIO AMPLIFIER, ANALOG SWITCH, CONSTANT CURRENT AND IMPEDANCE CONVERTER APPLICATIONS.

FEATURES:

- High Breakdown Voltage : V_{GDS}=-40V
- High Input Impedance
  : I_{GSS}=-1.0nA (Max.) (V_{GS}=-30V)
- Low $R_{DS(ON)}$
  : $R_{DS(ON)}$=20Ω (Typ.) (I_{DSS}=15mA)
- Complementary to 2SJ110

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1D

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

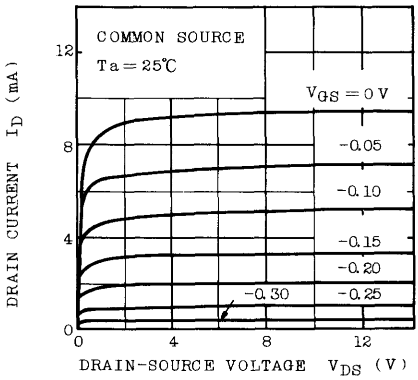
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate Drain Voltage	V_{GDS}	-40	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

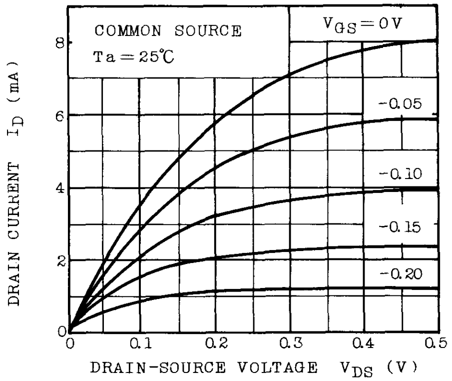
ELECTRICAL CHARACTERISTICS (Ta=25°C)

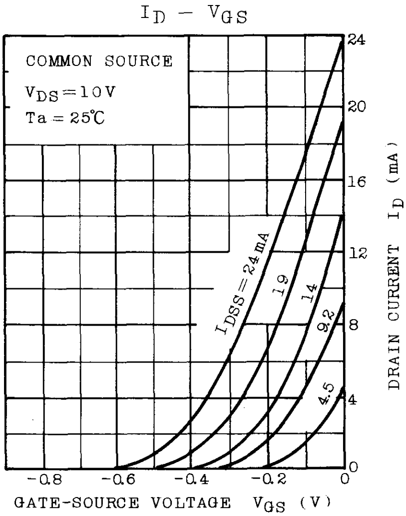
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-40	-	-	V
Drain Current	I_{DSS} (Note 1)	V_{DS}=10V, V_{GS}=0	5.0	-	30	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.3	-	-1.2	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=10V, V_{GS}=0 f=1kHz (Note 2)	25	60	-	mS
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	75	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=10V, I_D=0, f=1MHz	-	15	-	pF
Drain-Source ON Resistance	$R_{DS(ON)}$	V_{DS}=10mV, V_{GS}=0 (Note 2)	-	20	-	Ω

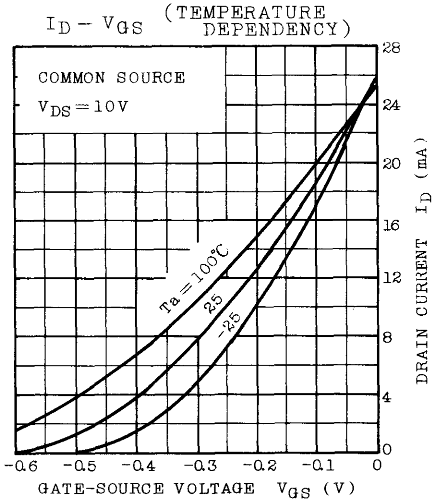
Note 1 : I_{DSS} Classification GR : 5.0~10.0, BL : 8.0~16.0, V : 14.0~30.0

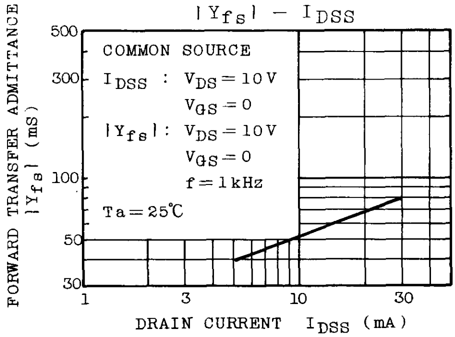
2 : Condition of the typical value I_{DSS}=15mA

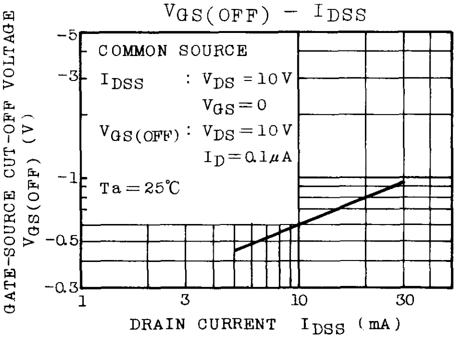

$I_D - V_{DS}$


$I_D - V_{DS}$ (LOW VOLTAGE REGION)

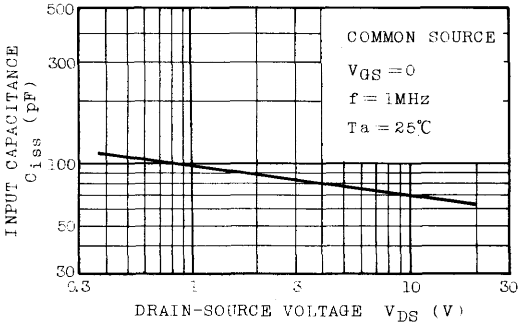

$I_D - V_{GS}$


$I_D - V_{GS}$ (TEMPERATURE DEPENDENCY)

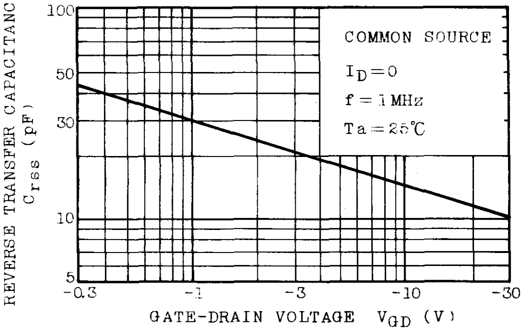

$|Y_{fs}| - I_{DSS}$


$V_{GS(OFF)} - I_{DSS}$

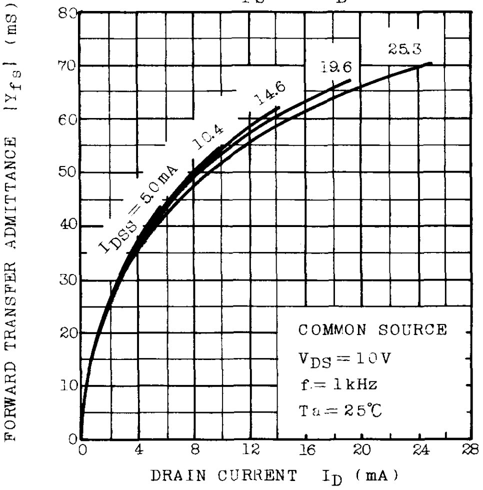
C_{iss} — V_{DS}



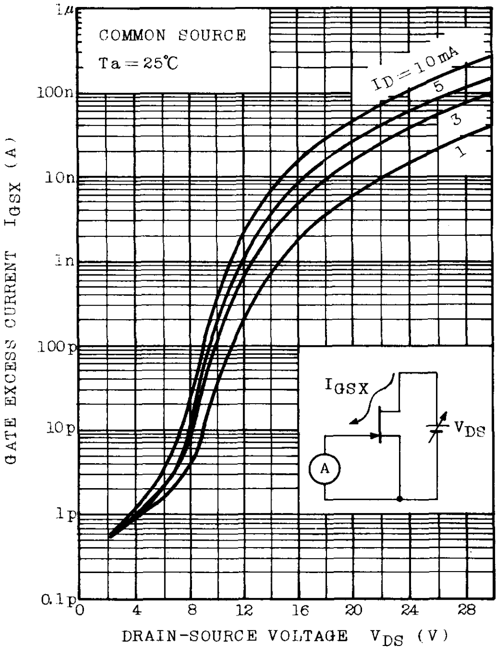
C_{rss} — V_{GD}



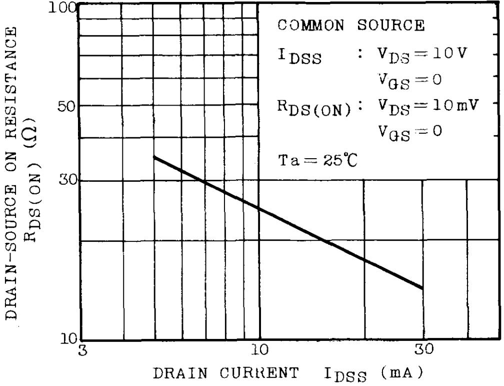
$|Y_{fs}|$ — I_D

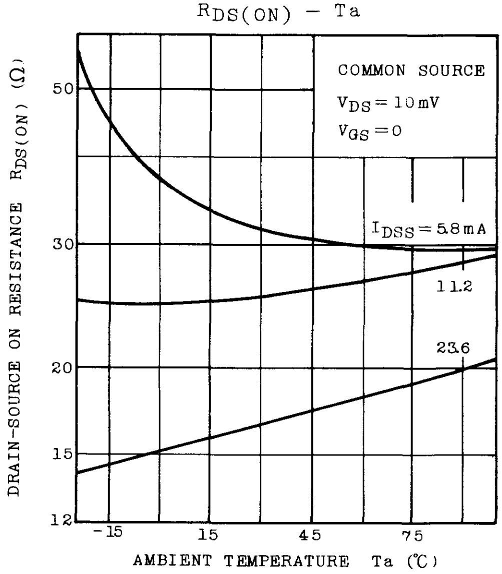


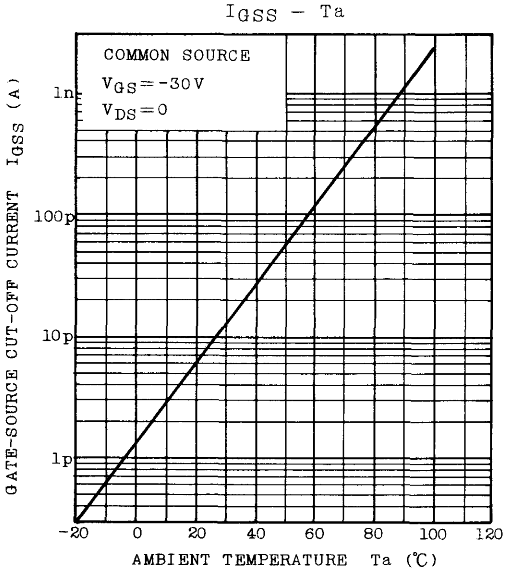
I_{GSX} — V_{DS}

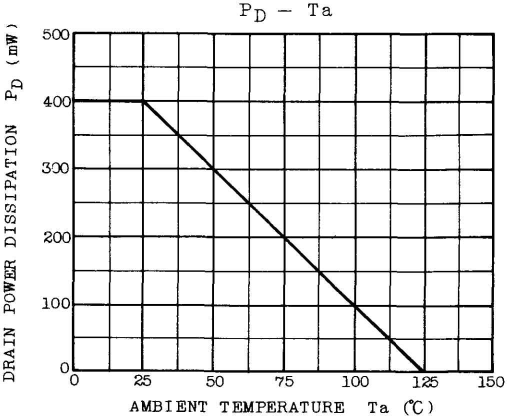


$R_{DS(ON)}$ — I_{DSS}




$R_{DS(ON)}$ − Ta
COMMON SOURCE
V_{DS} = 10 mV
V_{GS} = 0
I_{DSS} = 5.8 mA
11.2
23.6
DRAIN-SOURCE ON RESISTANCE $R_{DS(ON)}$ (Ω)
50
30
20
15
12
−15
15
45
75
AMBIENT TEMPERATURE Ta (℃)


I_{GSS} − Ta
COMMON SOURCE
V_{GS} = −30 V
V_{DS} = 0
GATE-SOURCE CUT-OFF CURRENT I_{GSS} (A)
1n
100p
10p
1p
−20
0
20
40
60
80
100
120
AMBIENT TEMPERATURE Ta (℃)

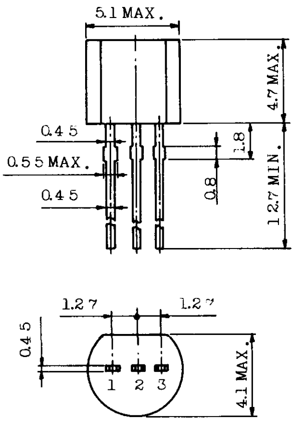

P_D − Ta
DRAIN POWER DISSIPATION P_D (mW)
500
400
300
200
100
0
0
25
50
75
100
125
150
AMBIENT TEMPERATURE Ta (℃)

SILICON N CHANNEL JUNCTION TYPE

2SK364

FOR AUDIO AMPLIFIER, ANALOG SWITCH, CONSTANT CURRENT AND IMPEDANCE CONVERTER APPLICATIONS.

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1D

Weight : 0.21g

FEATURES:

- High Breakdown Voltage : $V_{GDS}=-40V$
- High Input Impedance
  : $I_{GSS}=-1.0nA$ (Max.) ($V_{GS}=-30V$)
- Low $R_{DS(ON)}$: $R_{DS(ON)}=50\Omega$ (Typ.) ($I_{DSS}=5mA$)
- Complementary to 2SJ104

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-40	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

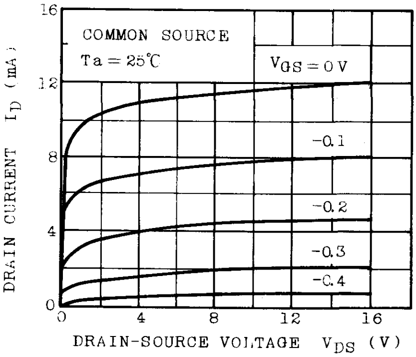
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	$V_{GS}=-30V$, $V_{DS}=0$	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	$V_{DS}=0$, $I_G=-100\mu A$	-40	-	-	V
Drain Current	I_{DSS} (Note 1)	$V_{DS}=10V$, $V_{GS}=0$	2.6	-	20	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	$V_{DS}=10V$, $I_D=0.1\mu A$	-0.2	-	-1.5	V
Forward Transfer Admittance	$\lvert Y_{fs}\rvert$	$V_{DS}=10V$, $V_{GS}=0$, f=1kHz (Note 2)	12	28	-	mS
Input Capacitance	C_{iss}	$V_{DS}=10V$, $V_{GS}=0$, f=1MHz	-	30	-	pF
Reverse Transfer Capacitance	C_{rss}	$V_{DG}=10V$, $I_D=0$, f=1MHz	-	6	-	pF
Drain-Source ON Resistance	$R_{DS(ON)}$	$V_{DS}=10mA$, $V_{GS}=0$ (Note 2)	-	50	-	Ω

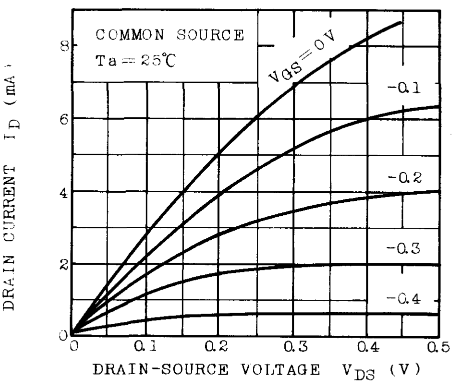
Note 1 : I_{DSS} Classification GR : 2.6~6.5, BL : 6~12, V : 10~20

2 : Condition of the typical value $I_{DSS}=5mA$

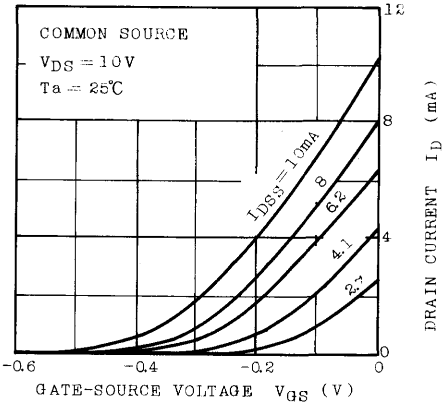
$I_D - V_{DS}$



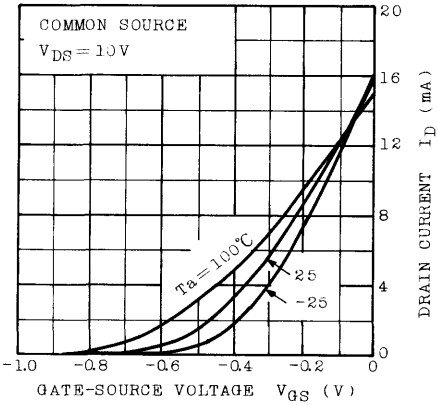
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



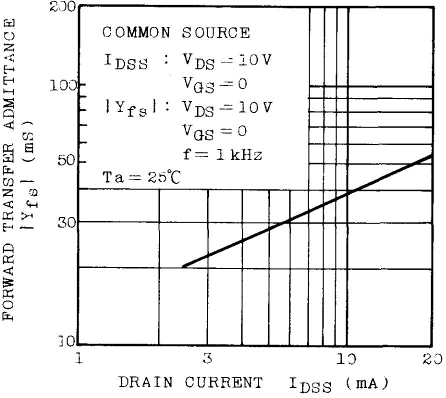
$I_D - V_{GS}$



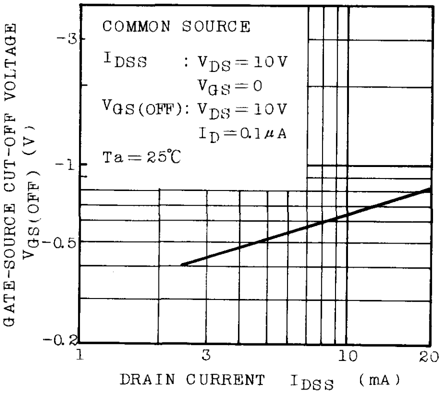
$I_D - V_{GS}$ (TEMPERATURE DEPENDENCY)

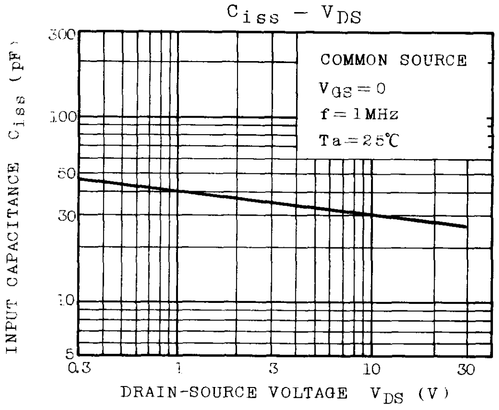


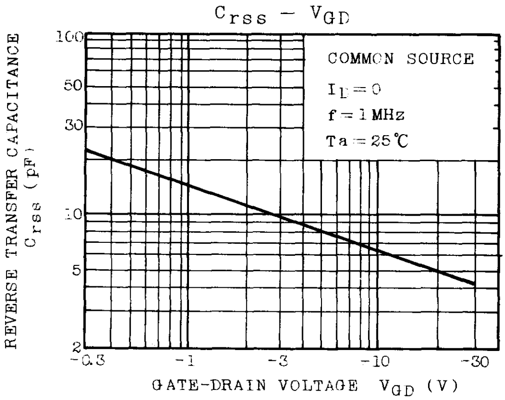
$|Y_{fs}| - I_{DSS}$

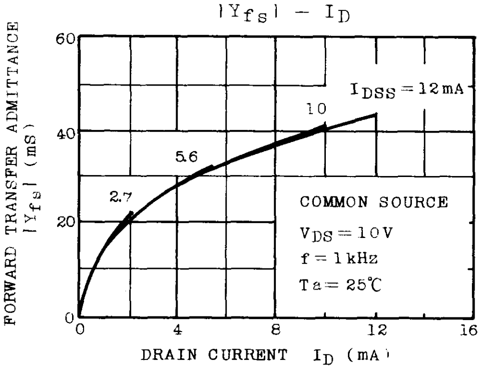


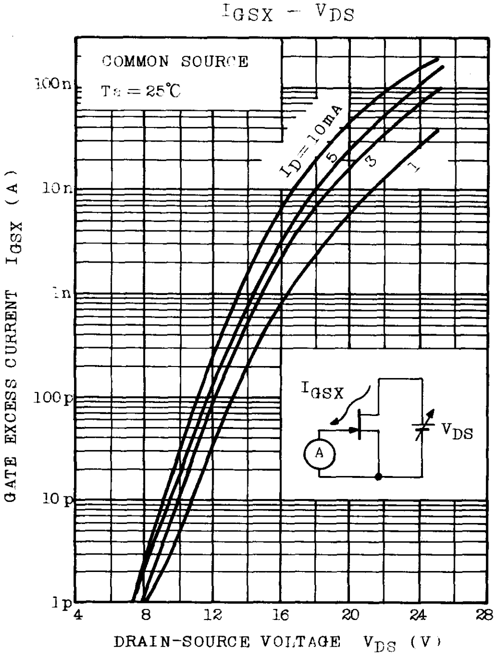
$V_{GS(OFF)} - I_{DSS}$

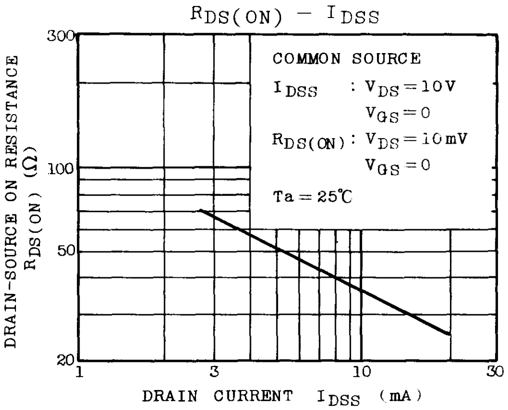



C_{iss} – V_{DS}
INPUT CAPACITANCE C_{iss} (pF)
DRAIN-SOURCE VOLTAGE V_{DS} (V)
COMMON SOURCE
$V_{GS}=0$
f = 1 MHz
Ta = 25℃
300
100
50
30
10
5
0.3
1
3
10
30

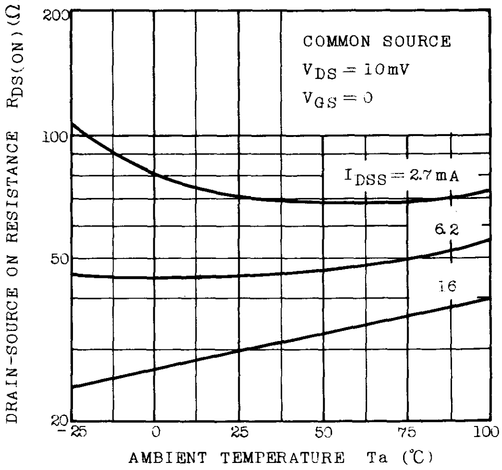

C_{rss} – V_{GD}
REVERSE TRANSFER CAPACITANCE C_{rss} (pF)
GATE-DRAIN VOLTAGE V_{GD} (V)
COMMON SOURCE
$I_D=0$
f = 1 MHz
Ta = 25℃
100
50
30
10
5
2
-0.3
-1
-3
-10
-30


$|Y_{fs}|$ – I_D
FORWARD TRANSFER ADMITTANCE $|Y_{fs}|$ (mS)
DRAIN CURRENT I_D (mA)
$I_{DSS}=12$ mA
10
5.6
2.7
COMMON SOURCE
$V_{DS}=10$ V
f = 1 kHz
Ta = 25℃
60
40
20
0
0
4
8
12
16

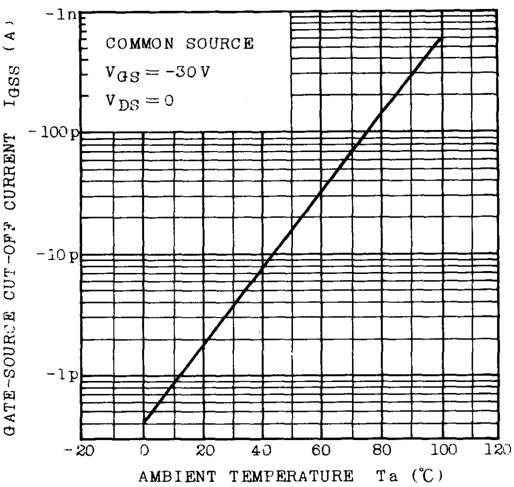

I_{GSX} – V_{DS}
GATE EXCESS CURRENT I_{GSX} (A)
DRAIN-SOURCE VOLTAGE V_{DS} (V)
COMMON SOURCE
Ta = 25℃
$I_D=10$ mA
5
3
1
I_{GSX}
V_{DS}
A
100n
10n
1n
100p
10p
1p
4
8
12
16
20
24
28


$R_{DS(ON)}$ – I_{DSS}
DRAIN-SOURCE ON RESISTANCE $R_{DS(ON)}$ (Ω)
DRAIN CURRENT I_{DSS} (mA)
COMMON SOURCE
I_{DSS} : $V_{DS}=10$ V
$V_{GS}=0$
$R_{DS(ON)}$: $V_{DS}=10$ mV
$V_{GS}=0$
Ta = 25℃
300
100
50
20
1
3
10
30

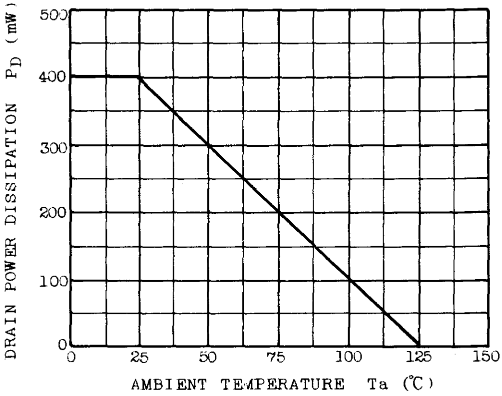
$R_{DS(ON)}$ – Ta



I_{GSS} – Ta



P_D – Ta



SILICON N CHANNEL JUNCTION TYPE

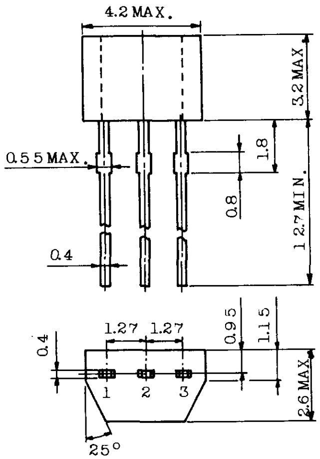
2SK365

FOR AUDIO AMPLIFIER, ANALOG-SWITCH, CONSTANT CURRENT AND IMPEDANCE CONVERTER APPLICATIONS.

FEATURES:

- High Breakdown Voltage : V_{GDS}=-50V
- High Input Impedance : I_{GSS}=-1.0nA(Max.) (V_{GS}=-30V)
- Low $R_{DS(ON)}$: $R_{DS(ON)}$=80Ω (Typ.) (I_{DSS}=5mA)
- Small Package

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

JEDEC	–
EIAJ	–
TOSHIBA	2-4E1C

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-50	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

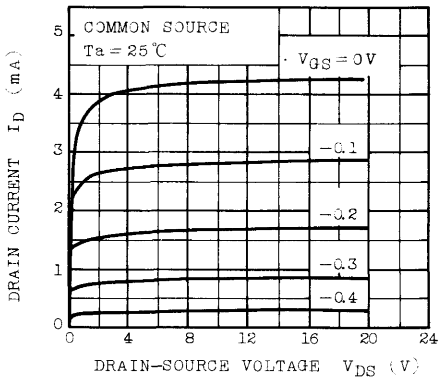
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-50	-	-	V
Drain Current	I_{DSS} (Note 1)	V_{DS}=10V, V_{GS}=0	1.2	-	14	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.25	-	-1.5	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=10V, V_{GS}=0 f=1kHz (Note 2)	5.0	19	-	mS
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	13	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=10V, I_D=0, f=1MHz	-	3	-	pF
Drain-Source ON Resistance	$R_{DS(ON)}$	V_{DS}=10mV, V_{GS}=0 (Note 2)	-	80	-	Ω

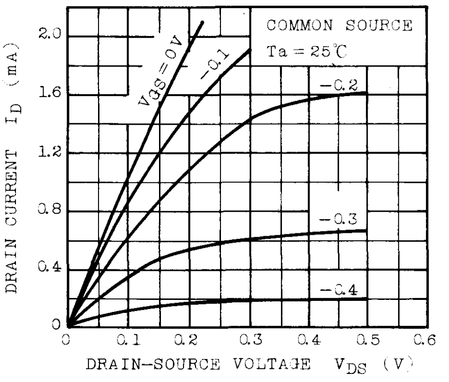
Note 1 : I_{DSS} Classification Y : 1.2~3.0mA, GR : 2.6~6.5mA, BL : 6~14mA

2 : Condition of the typical value I_{DSS}=5mA

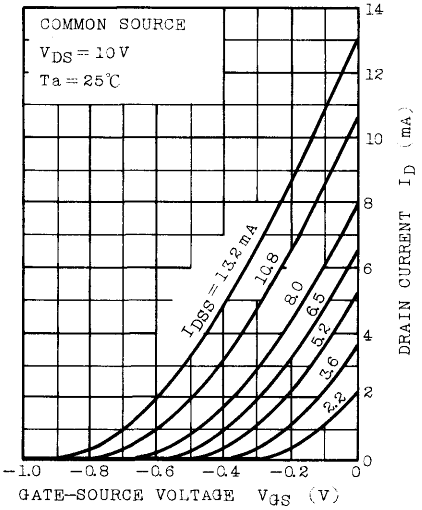
I_D – V_{DS}



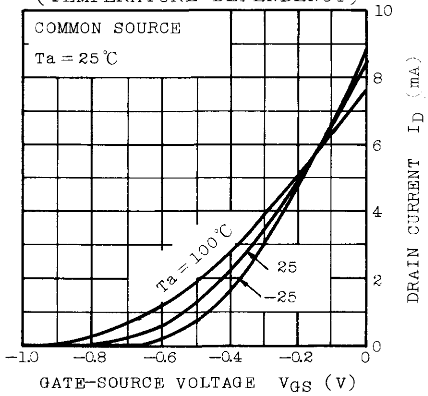
I_D – V_{DS} (LOW VOLTAGE REGION)



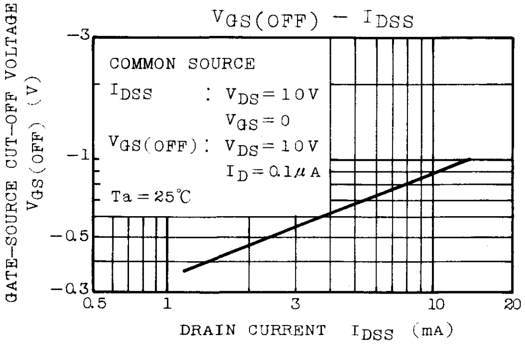
I_D – V_{GS}



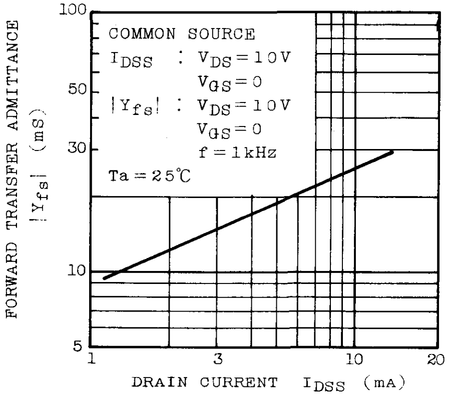
I_D – V_{GS}
(TEMPERATURE DEPENDENCY)

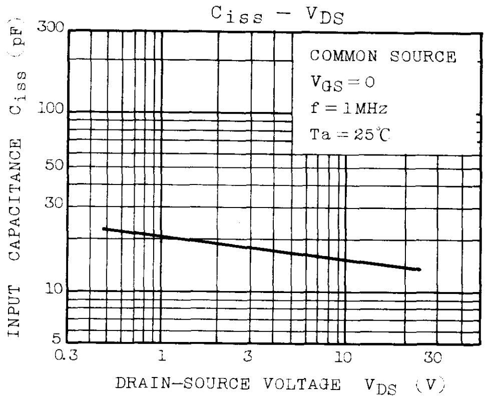


$V_{GS(OFF)}$ – I_{DSS}

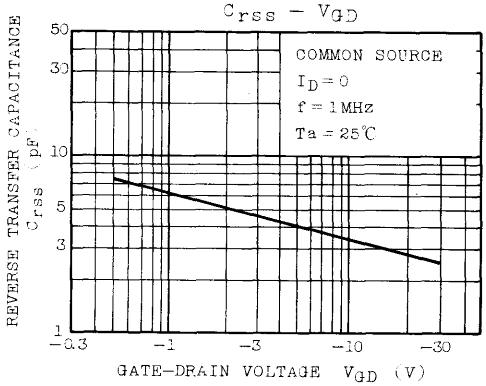


$|Y_{fs}|$ – I_{DSS}

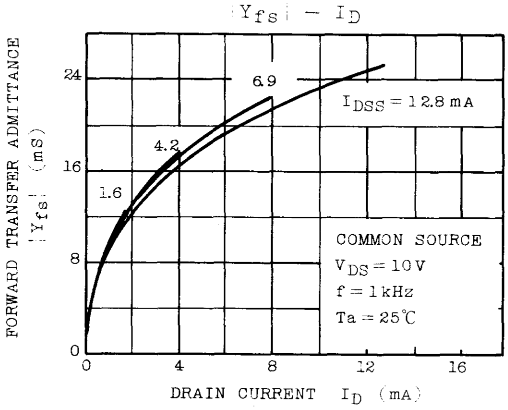




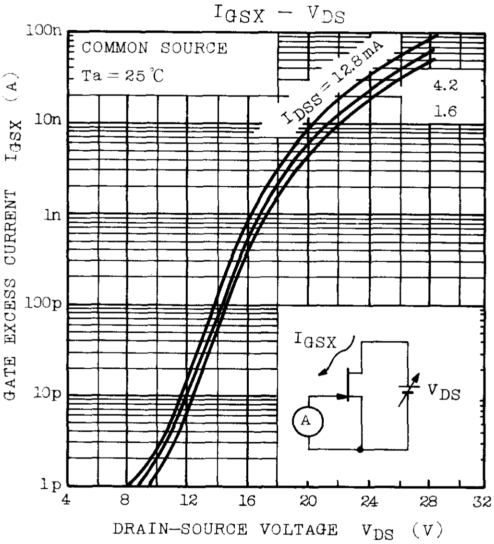
C_{iss} – V_{DS}



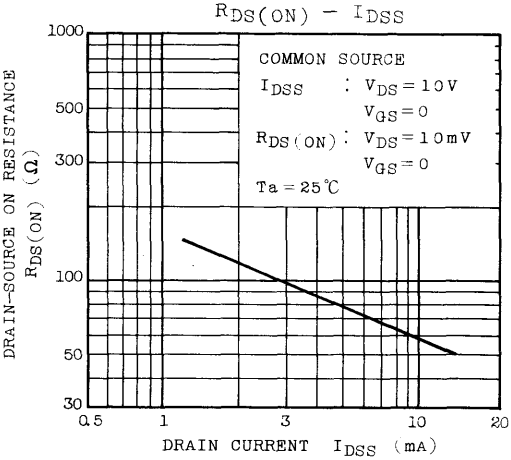
C_{rss} – V_{GD}



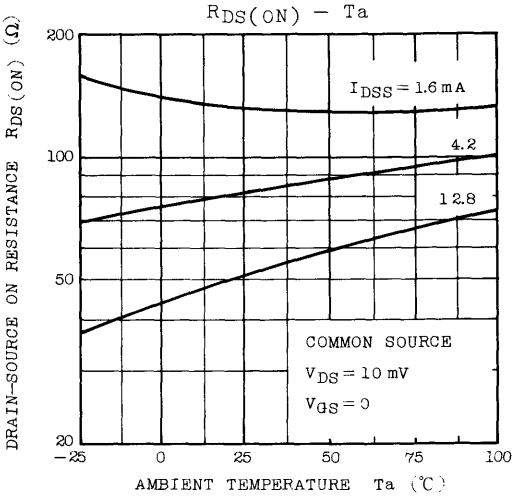
|Y_{fs}| – I_D

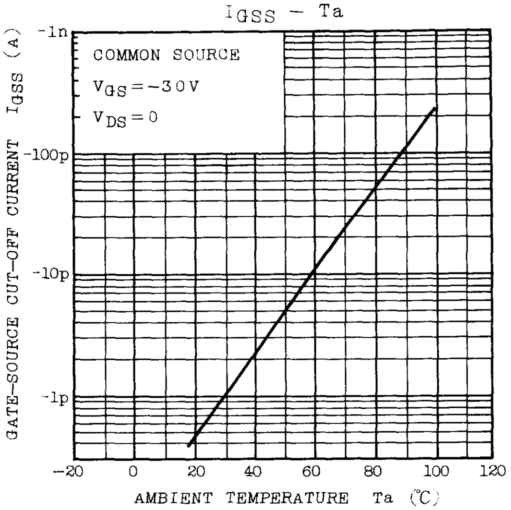


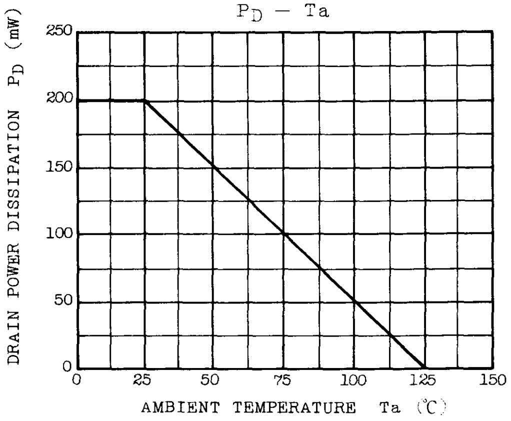
I_{GSX} – V_{DS}



$R_{DS(ON)}$ – I_{DSS}


RDS(ON) − Ta
DRAIN-SOURCE ON RESISTANCE RDS(ON) (Ω)
200
100
50
20
IDSS = 1.6 mA
4.2
12.8
COMMON SOURCE
VDS = 10 mV
VGS = 0
−25
0
25
50
75
100
AMBIENT TEMPERATURE Ta (℃)


IGSS − Ta
GATE-SOURCE CUT-OFF CURRENT IGSS (A)
-1n
-100p
-10p
-1p
COMMON SOURCE
VGS = −30V
VDS = 0
−20
0
20
40
60
80
100
120
AMBIENT TEMPERATURE Ta (℃)


PD − Ta
DRAIN POWER DISSIPATION PD (mW)
250
200
150
100
50
0
0
25
50
75
100
125
150
AMBIENT TEMPERATURE Ta (℃)

SILICON N CHANNEL JUNCTION TYPE

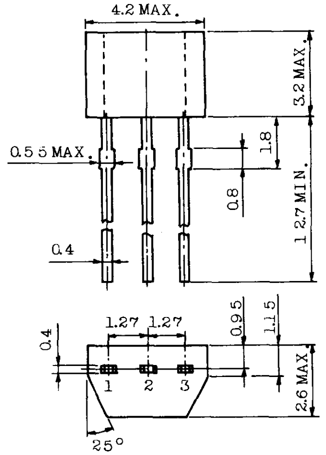
2SK366

FOR AUDIO AMPLIFIER, ANALOG-SWITCH, CONSTANT CURRENT AND IMPEDANCE CONVERTER APPLICATIONS.

FEATURES:

- High Voltage : V_{GDS}=-40V
- High Input Impedance : I_{GSS}=-1.0nA(Max.) (V_{GS}=-30V)
- Low $R_{DS(ON)}$: $R_{DS(ON)}$=50Ω(Typ.) (I_{DSS}=5mA)
- Small Package
- Complementary to 2SJ107.

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

JEDEC	–
EIAJ	–
TOSHIBA	2–4E1C

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-40	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55～125	°C

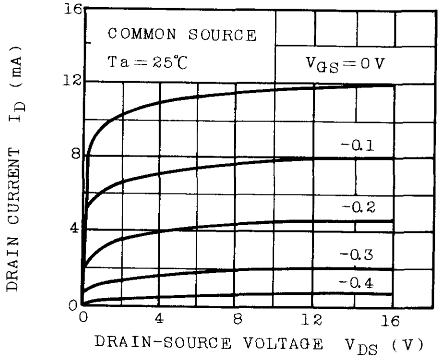
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_C=-100μA	-40	-	-	V
Drain Current	I_{DSS} (Note 1)	V_{DS}=10V, V_{GS}=0	2.6	-	20	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.2	-	-1.5	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz (Note 2)	12	28	-	mS
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	30	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=10V, I_D=0, f=1MHz	-	6	-	pF
Drain-Source ON Resistance	$R_{DS(ON)}$	V_{DS}=10mV, V_{GS}=0 (Note 2)	-	50	-	Ω

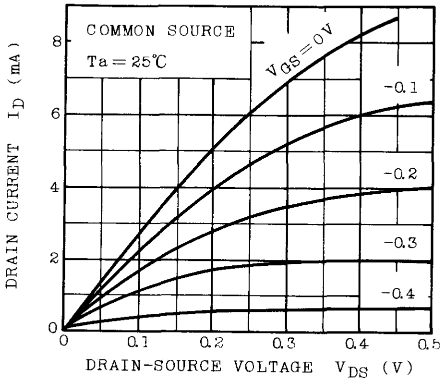
Note 1 : I_{DSS} Classification GR : 2.6～6.5mA, BL : 6～12mA, V : 10～20mA

2 : Condition of the typical value I_{DSS}=5mA

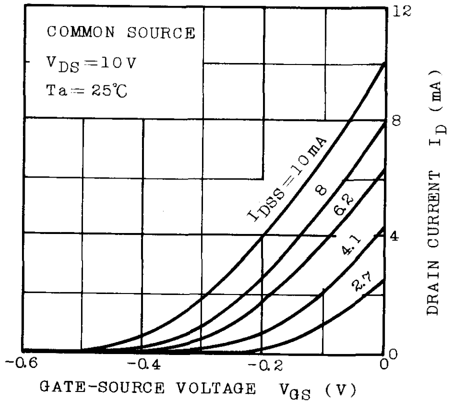
$I_D - V_{DS}$



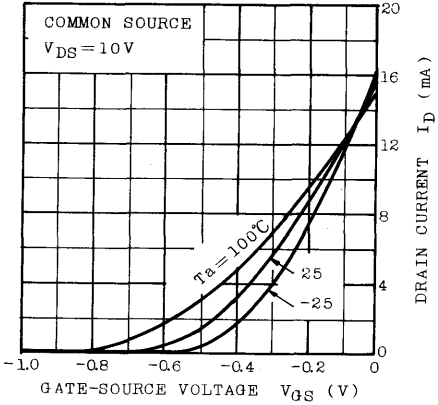
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



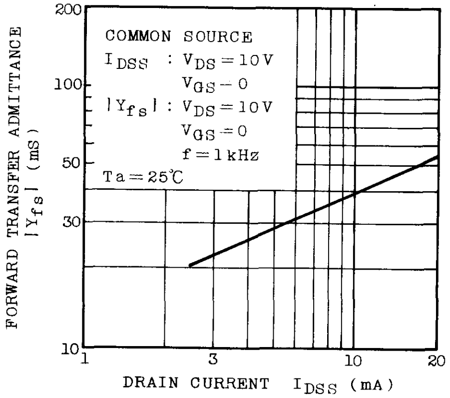
$I_D - V_{GS}$



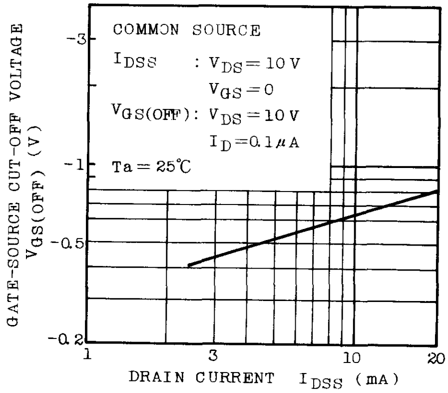
$I_D - V_{GS}$ (TEMPERATURE DEPENDENCY)



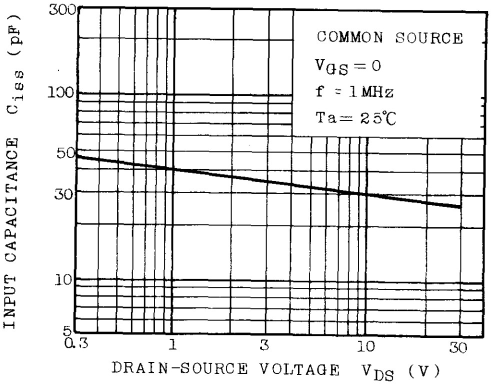
$|Y_{fs}| - I_{DSS}$



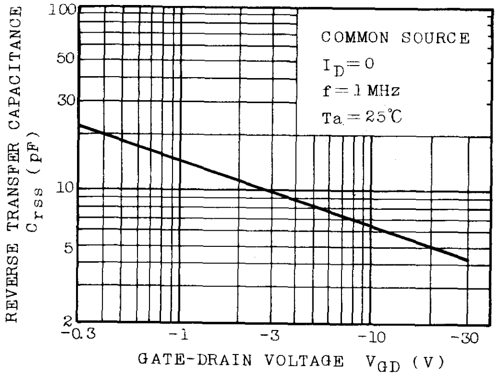
$V_{GS(OFF)} - I_{DSS}$



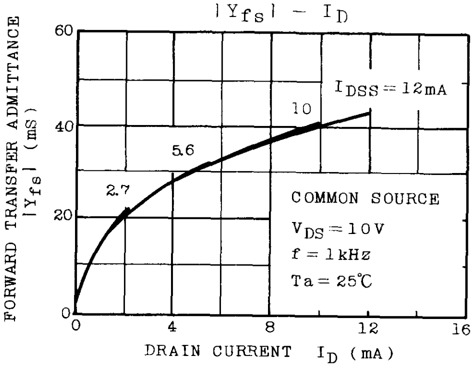
C_{iss} – V_{DS}



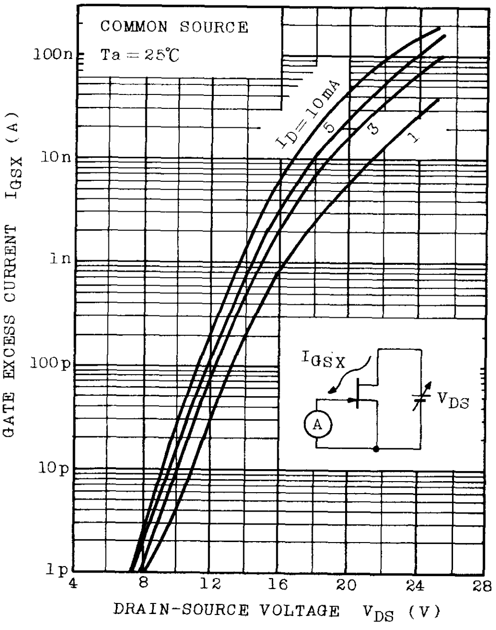
C_{rss} – V_{GD}



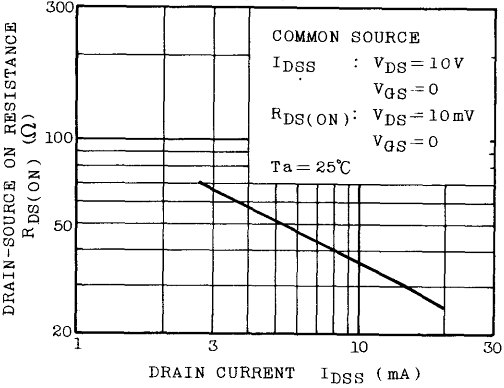
$|Y_{fs}|$ – I_D

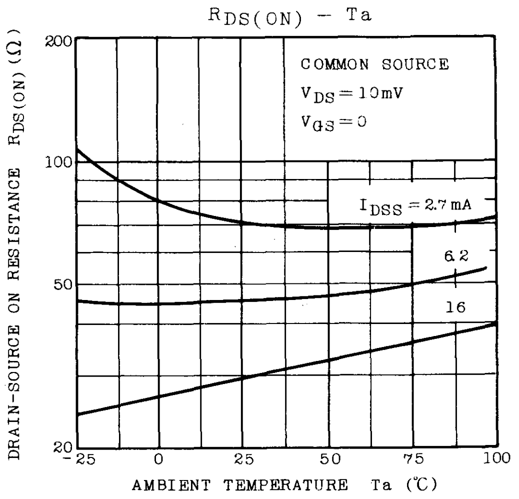


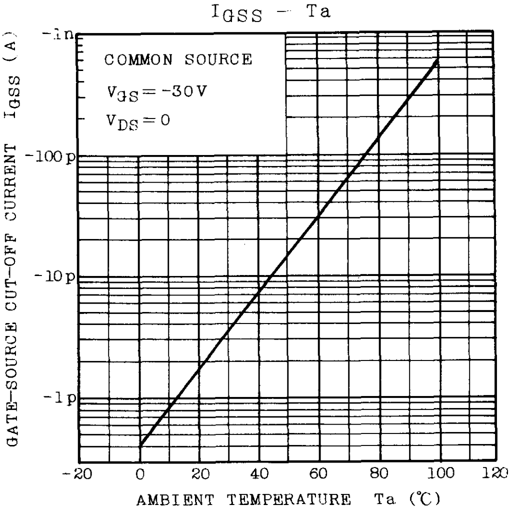
I_{GSX} – V_{DS}

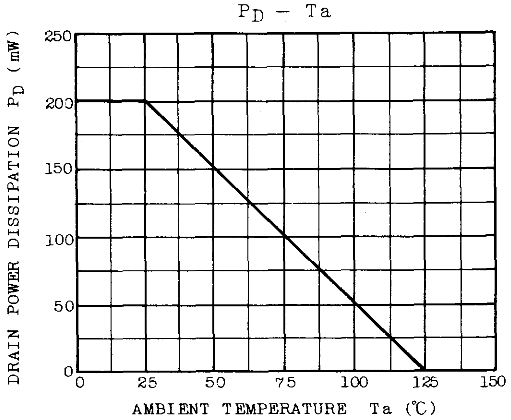


$R_{DS(ON)}$ – I_{DSS}




RDS(ON) – Ta
COMMON SOURCE
$V_{DS}=10mV$
$V_{GS}=0$
$I_{DSS}=2.7mA$
6.2
16
DRAIN-SOURCE ON RESISTANCE $R_{DS(ON)}$ (Ω)
200
100
50
20
−25
0
25
50
75
100
AMBIENT TEMPERATURE Ta (℃)


IGSS – Ta
COMMON SOURCE
$V_{GS}=-30V$
$V_{DS}=0$
GATE-SOURCE CUT-OFF CURRENT I_{GSS} (A)
−1n
−100p
−10p
−1p
−20
0
20
40
60
80
100
120
AMBIENT TEMPERATURE Ta (℃)


PD – Ta
DRAIN POWER DISSIPATION P_D (mW)
250
200
150
100
50
0
0
25
50
75
100
125
150
AMBIENT TEMPERATURE Ta (℃)

SILICON N CHANNEL JUNCTION TYPE

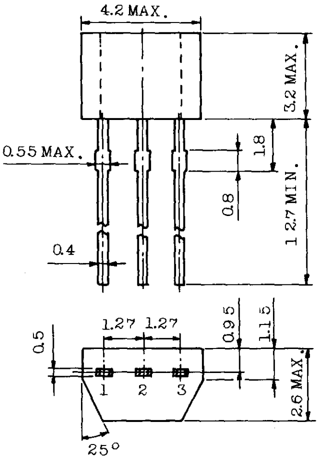
2SK367

FOR AUDIO, HIGH VOLTAGE AMPLIFIER AND CONSTANT CURRENT APPLICATIONS.

FEATURES:

- High Breakdown Voltage : V_{GDS}=-100V (Min.)
- High Input Impedance : I_{GSS}=-1.0nA(Max.) (V_{GS}=-80V)
- Small Package

Unit in mm



1. SOURCE
2. GATE
3. DRAIN

JEDEC	–
EIAJ	–
TOSHIBA	2–4E1B

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

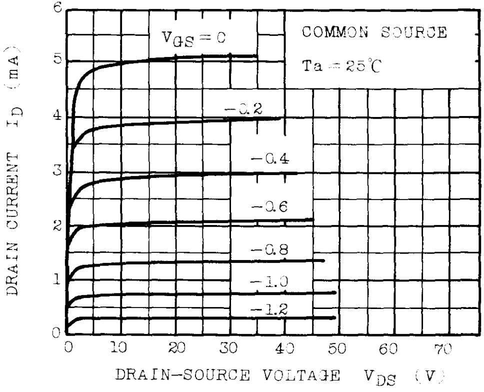
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-100	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

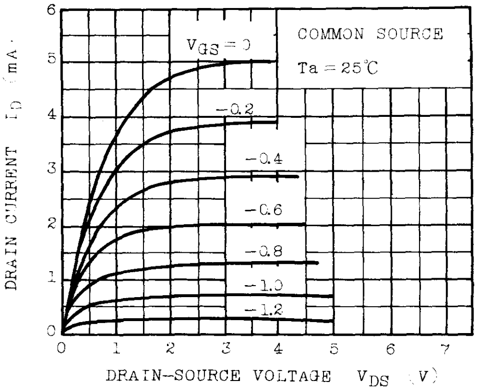
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=-80V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-100	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=10V, V_{GS}=0	0.6	-	6.5	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.4	-	-3.5	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz	1.5	4.6	-	mS
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	13	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DS}=10V, I_D=0, f=1MHz	-	3	-	pF
Noise Figure	NF	V_{DS}=10V, V_{GS}=0 R_g=100kΩ, f=100Hz	-	0.5	-	dB

Note : I_{DSS} Classification O : 0.6~1.4, Y : 1.2~3.0, GR : 2.6~6.5

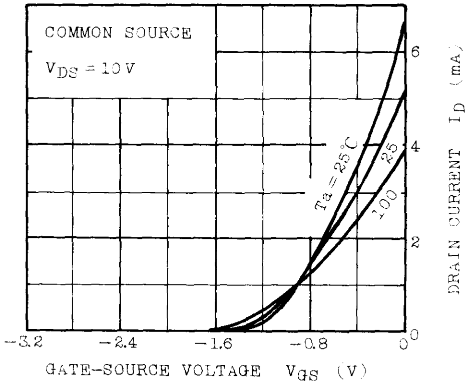
$I_D - V_{DS}$



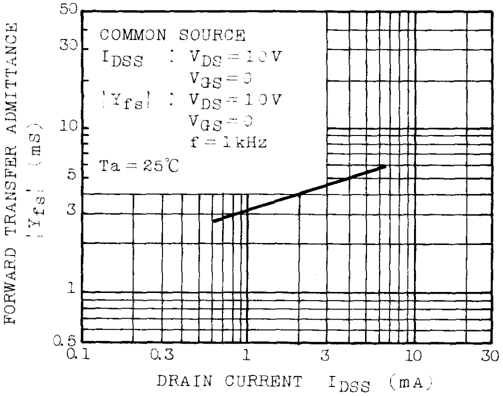
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



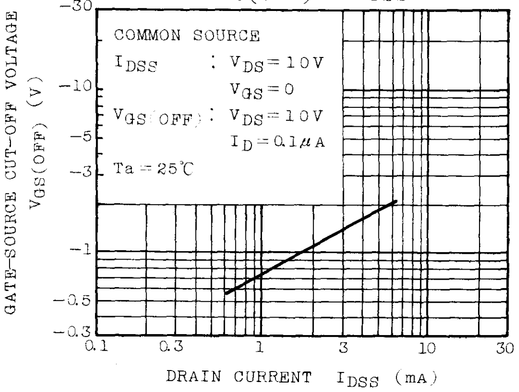
$I_D - V_{GS}$



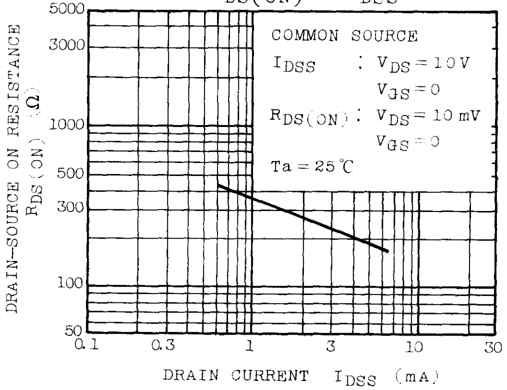
$|Y_{fs}| - I_{DSS}$

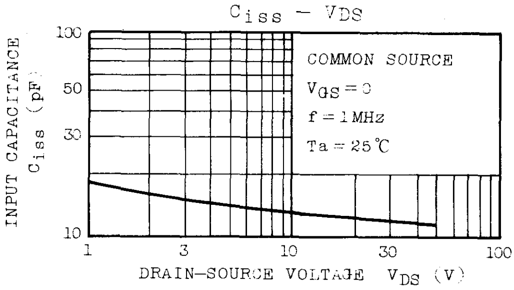


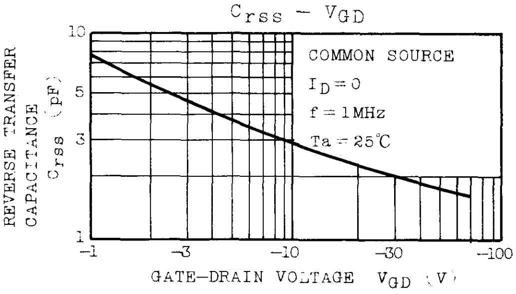
$V_{GS(OFF)} - I_{DSS}$

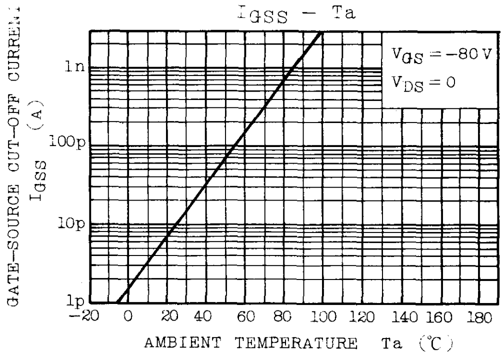


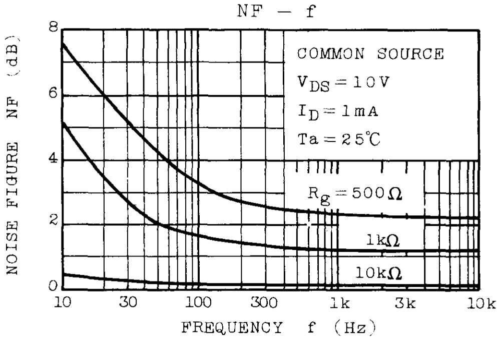
$R_{DS(ON)} - I_{DSS}$

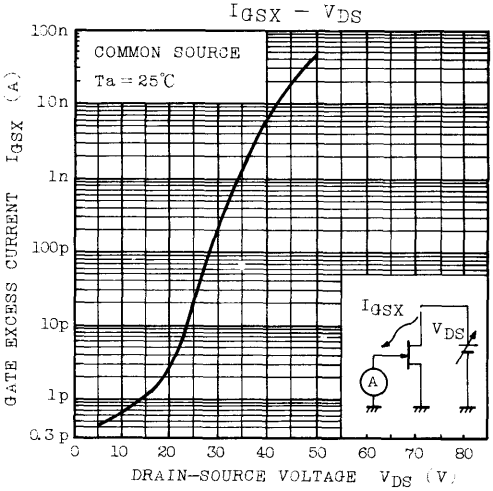


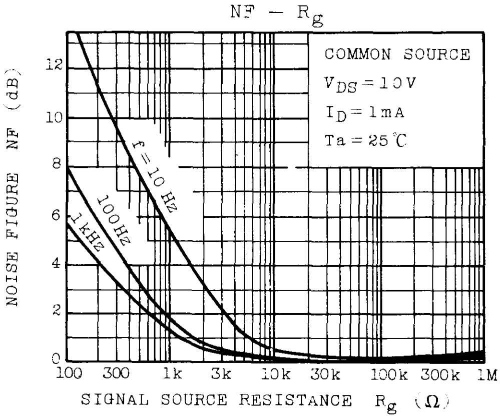

C_{iss} – V_{DS}
INPUT CAPACITANCE C_{iss} (pF)
100
50
30
10
1
3
10
30
100
DRAIN–SOURCE VOLTAGE V_{DS} (V)
COMMON SOURCE
$V_{GS}=0$
f = 1 MHz
Ta = 25℃

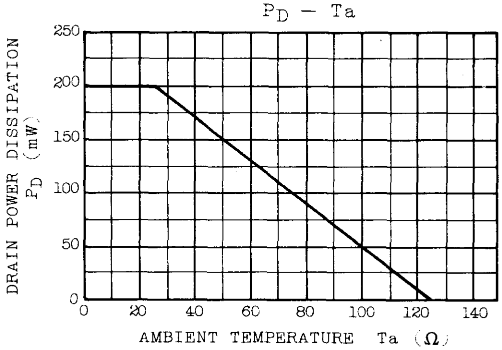

C_{rss} – V_{GD}
REVERSE TRANSFER CAPACITANCE C_{rss} (pF)
10
5
3
1
–1
–3
–10
–30
–100
GATE–DRAIN VOLTAGE V_{GD} (V)
COMMON SOURCE
$I_D=0$
f = 1 MHz
Ta = 25℃


I_{GSS} – Ta
GATE–SOURCE CUT-OFF CURRENT I_{GSS} (A)
1n
100p
10p
1p
–20
0
20
40
60
80
100
120
140
160
180
AMBIENT TEMPERATURE Ta (℃)
$V_{GS}=-80$ V
$V_{DS}=0$


NF – f
NOISE FIGURE NF (dB)
8
6
4
2
0
10
30
100
300
1k
3k
10k
FREQUENCY f (Hz)
COMMON SOURCE
$V_{DS}=10$ V
$I_D=1$ mA
Ta = 25℃
$R_g=500\Omega$
1kΩ
10kΩ


I_{GSX} – V_{DS}
GATE EXCESS CURRENT I_{GSX} (A)
100n
10n
1n
100p
10p
1p
0.3 p
0
10
20
30
40
50
60
70
80
DRAIN–SOURCE VOLTAGE V_{DS} (V)
COMMON SOURCE
Ta = 25℃
I_{GSX}
V_{DS}
A


NF – R_g
NOISE FIGURE NF (dB)
12
10
8
6
4
2
0
100
300
1k
3k
10k
30k
100k
300k
1M
SIGNAL SOURCE RESISTANCE R_g (Ω)
COMMON SOURCE
$V_{DS}=10$ V
$I_D=1$ mA
Ta = 25℃
f = 10 Hz
100Hz
1kHz

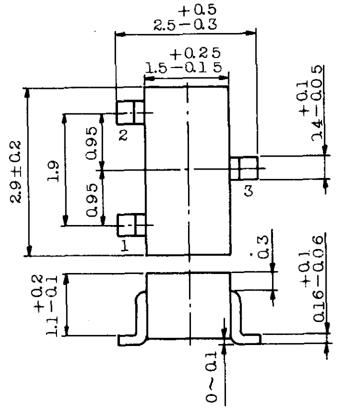

P_D – Ta
DRAIN POWER DISSIPATION P_D (mW)
250
200
150
100
50
0
0
20
40
60
80
100
120
140
AMBIENT TEMPERATURE Ta (Ω)

2SK368

SILICON N CHANNEL JUNCTION TYPE

AUDIO FREQUENCY AND HIGH VOLTAGE AMPLIFIER APPLICATIONS.
CONSTANT CURRENT APPLICATIONS.

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

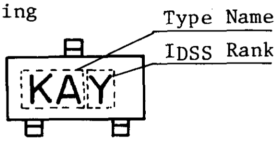
JEDEC	TO−236MOD
EIAJ	−
TOSHIBA	2−3F1B

Weight : 0.012g

FEATURES:

- High Breakdown Voltage : V_{GDS}=-100V (Min.)
- High Input Impedance
  : I_{GSS}=-1.0nA (Max.) (V_{GS}=-80V)
- Small Package

Marking



MAXIMUM RATINGS (Ta=25°C)

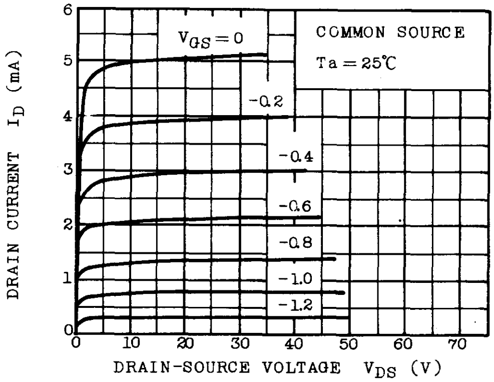
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate Drain Voltage	V_{GDS}	-100	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	150	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

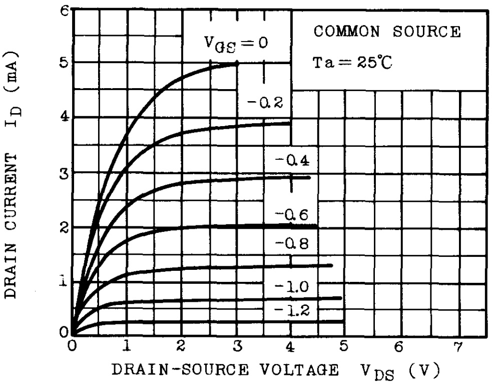
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-80V, V_{DS}=0	-	-	-1.0	nA
Gate Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-100	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=10V, V_{GS}=0	0.6	-	6.5	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.4	-	-3.5	V
Forward Transfer Admittance	$\lvert Y_{fs} \rvert$	V_{DS}=10V, V_{GS}=0, f=1kHz	1.5	4.6	-	mS
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	13	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DS}=10V, I_D=0, f=1MHz	-	3	-	pF
Noise Figure	NF	V_{DS}=10V, V_{GS}=0 Rg=100kΩ, f=100Hz	-	0.5	-	dB

Note : I_{DSS} Classification O : 0.6~1.4mA, Y : 1.2~3.0mA, GR(G) : 2.6~6.5mA

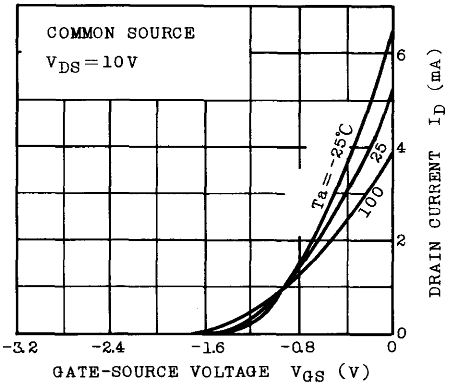
I_D – V_{DS}



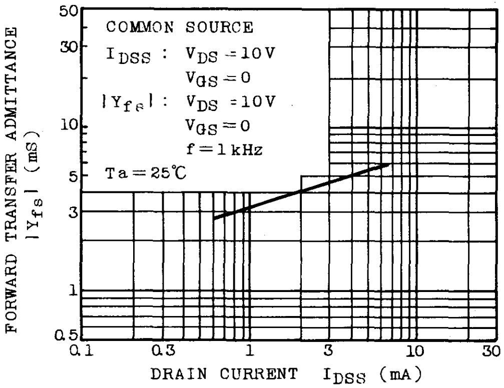
I_D – V_{DS} (LOW VOLTAGE REGION)



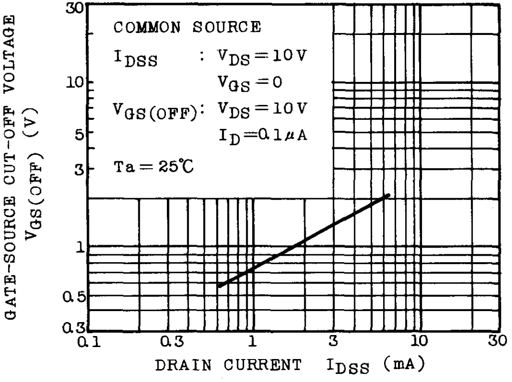
I_D – V_{GS}



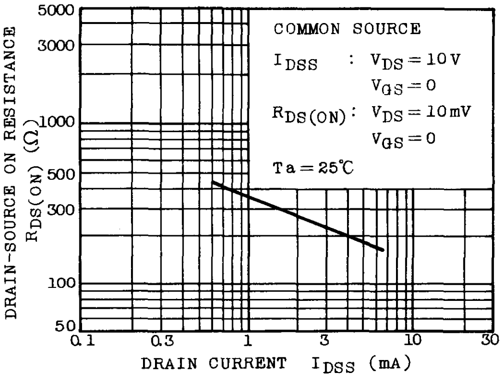
$|Y_{fs}|$ – I_{DSS}



$V_{GS(OFF)}$ – I_{DSS}

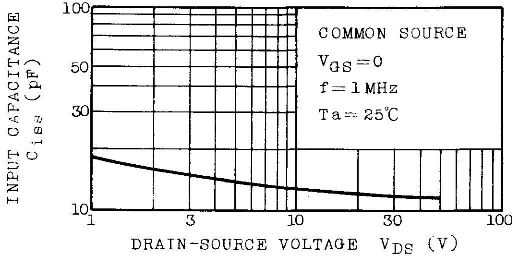


$R_{DS(ON)}$ – I_{DSS}

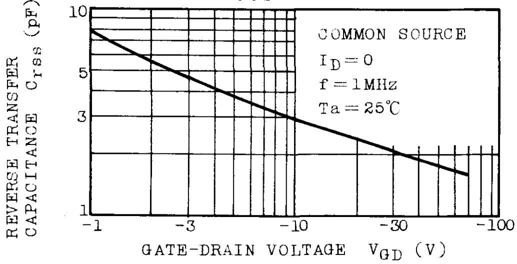


2SK368

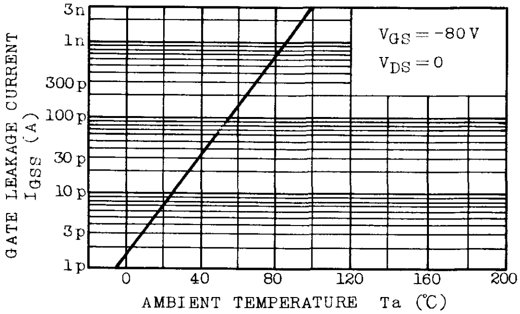
C_{iss} – V_{DS}



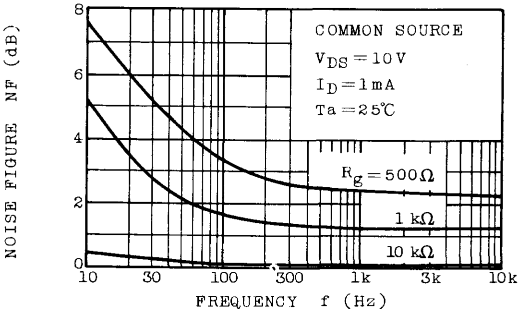
C_{rss} – V_{GD}



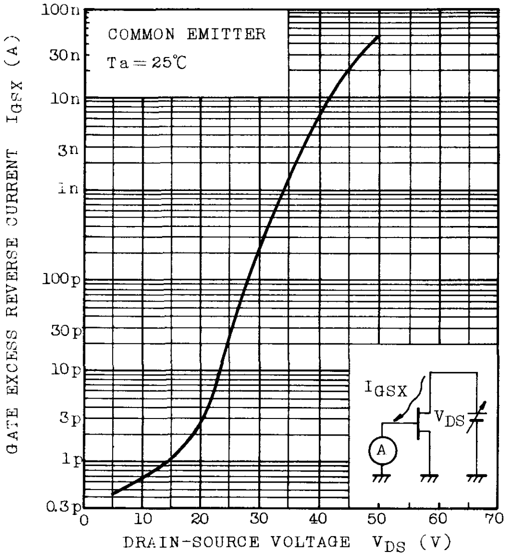
I_{GSS} – Ta



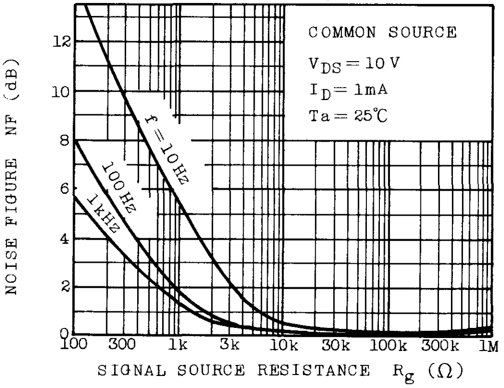
NF – f



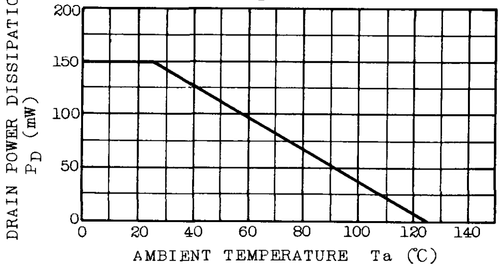
I_{GSX} – V_{DS}



NF – R_g



P_D – Ta



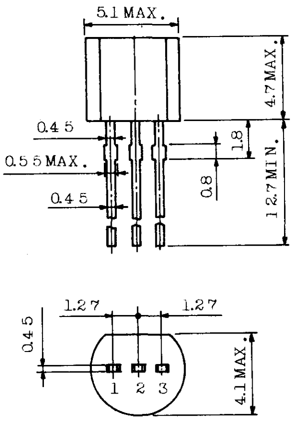
SILICON N CHANNEL JUNCTION TYPE

2SK369

FOR LOW NOISE AUDIO AMPLIFIER APPLICATIONS.

Unit in mm

FEATURES:
- Suitable for Use as First Stage for Equalizer and MC Head Amplifiers.
- High $|Y_{fs}|$
  : $|Y_{fs}|$ =40mS(Typ.)(V_{DS}=10V, V_{GS}=0, I_{DSS}=5mA)
- High Breakdown Voltage : V_{GDS}=-40V(Min.)
- Super Low Noise : NF=1.0dB(Typ.)
  (V_{DS}=10V, I_D=5mA, f=1kHz, R_g=100Ω)
- High Input Impedance : I_{GSS}=-1nA(Max.)(V_{DG}=30V)



1. DRAIN
2. GATE
3. SOURCE

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1D

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-40	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

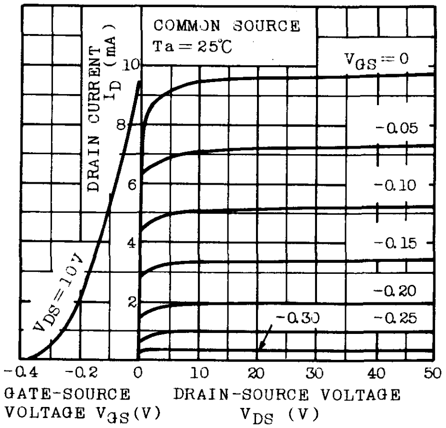
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-40	-	-	V
Drain Current	I_{DSS} (Note 1)	V_{DS}=10V, V_{GS}=0	5.0	-	30	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.3	-	-1.2	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz (I_{DSS}=5mA)	25	40	-	mS
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	75	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=10V, I_D=0, f=1MHz	-	15	-	pF
Noise Figure (Note 2)	NF(1)	V_{DS}=10V, R_g=100Ω I_D=5mA, f=100Hz	-	5	10	dB
	NF(2)	V_{DS}=10V, R_g=100Ω I_D=5mA, f=1kHz	-	1	2	

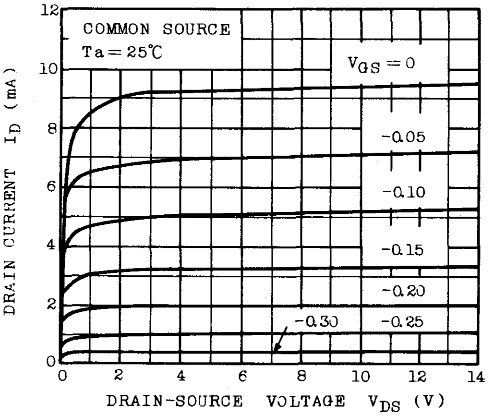
Note 1 : I_{DSS} Classification GR : 5.0~10.0mA, BL : 8.0~16.0mA, V : 14.0~30.0mA

2 : Use this in the low voltage region (V_{DS}<15V) for low noise applications.

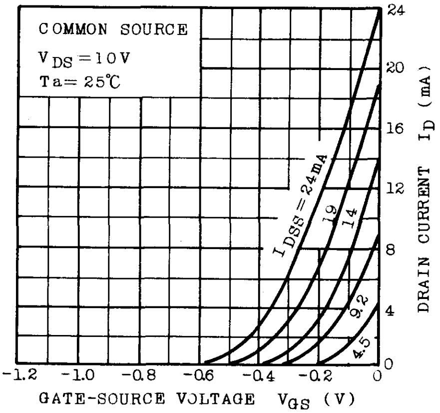
STATIC CHARACTERISTIC



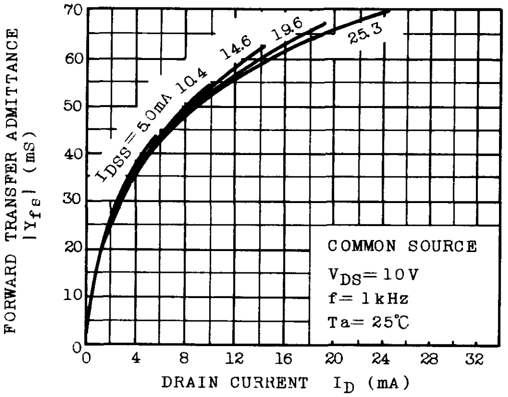
I_D – V_{DS} (LOW VOLTAGE REGION)



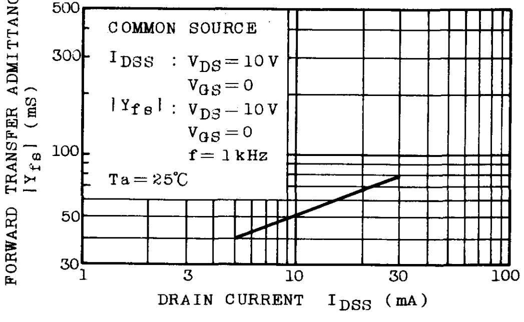
I_D – V_{GS}



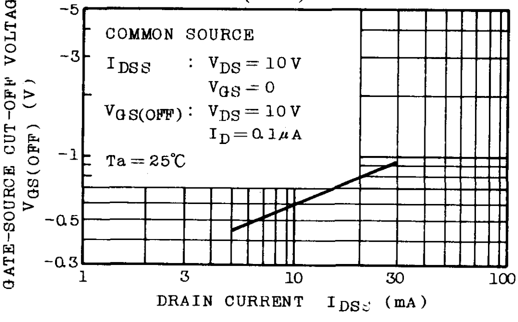
$|Y_{fs}|$ – I_D

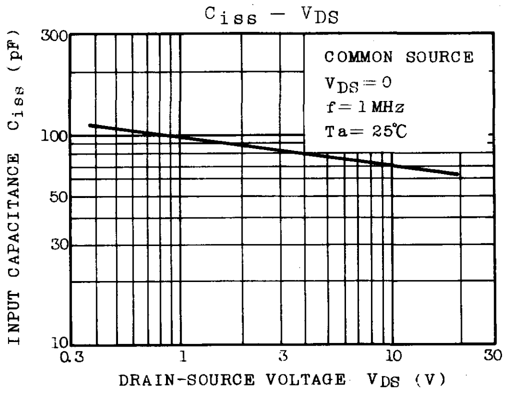


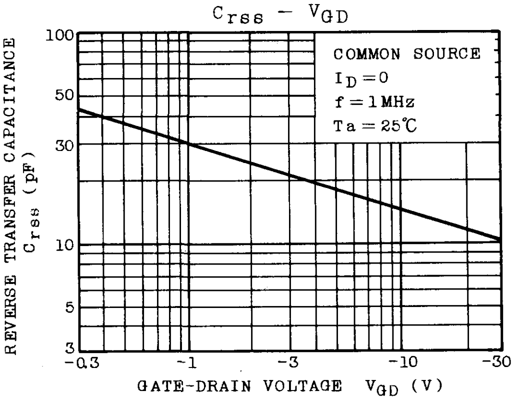
$|Y_{fs}|$ – I_{DSS}

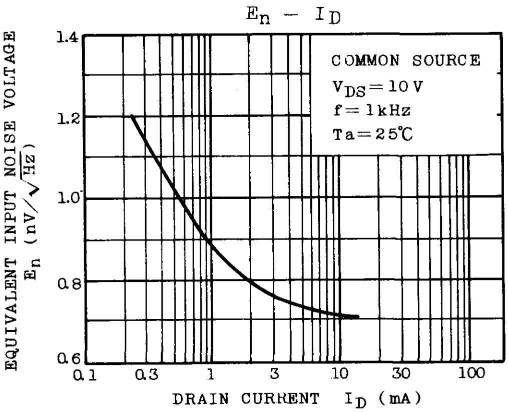


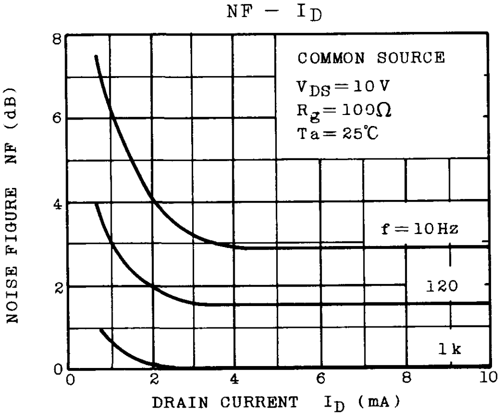
$V_{GS(OFF)}$ – I_{DSS}

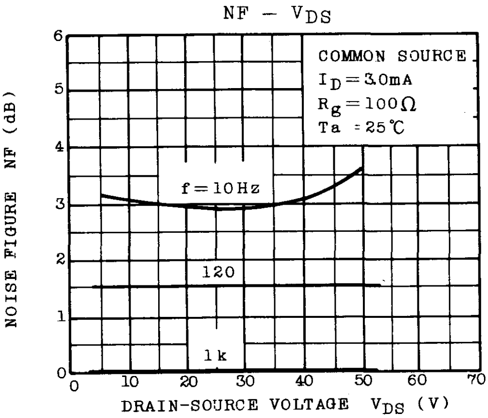


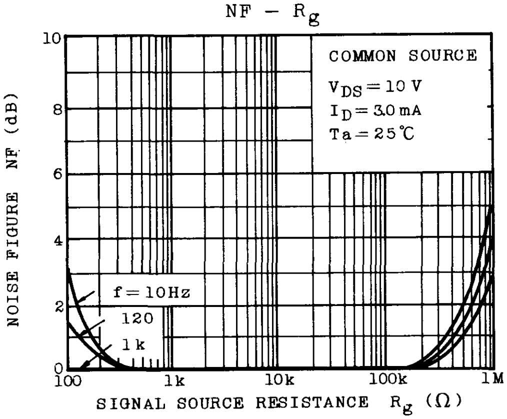

C_{iss} – V_{DS}


C_{rss} – V_{GD}

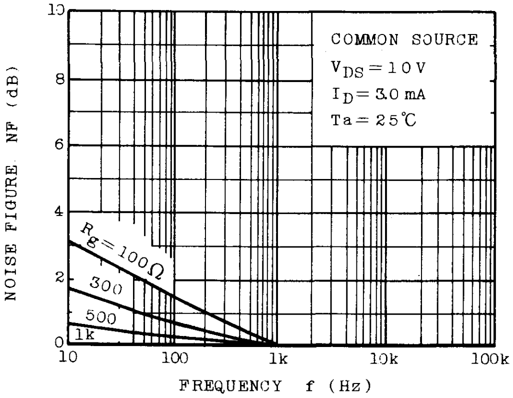

E_n – I_D


NF – I_D

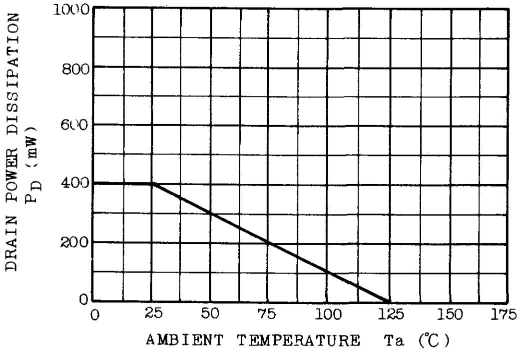

NF – V_{DS}


NF – R_g

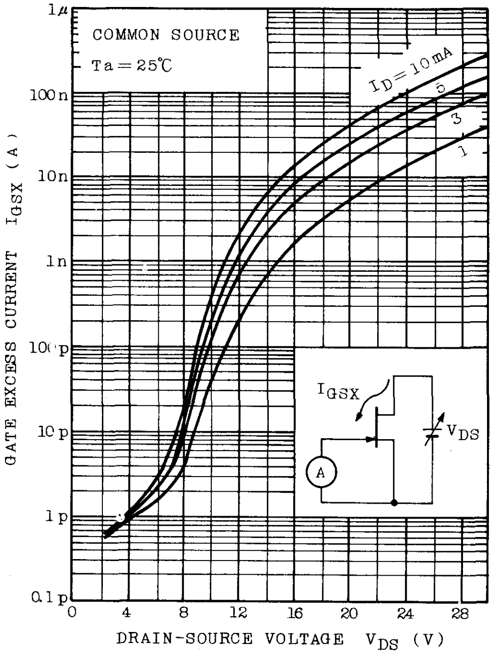
NF − f



P_D − Ta



I_{GSX} − V_{DS}



SILICON N CHANNEL JUNCTION TYPE

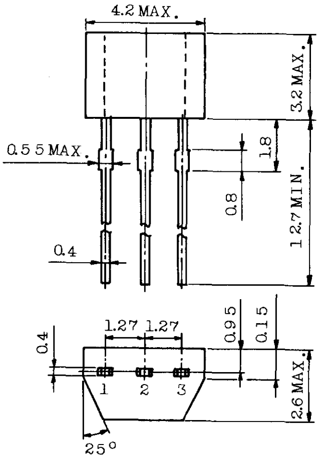
2SK370

FOR LOW NOISE AUDIO AMPLIFIER APPLICATIONS.

FEATURES:

- Suitable for Use as First Stage for Equalizer and MC Head Amplifiers.
- High $|Y_{fs}|$: $|Y_{fs}|$=22mS (Typ.)
  (V_{DS}=10V, V_{GS}=0, I_{DSS}=3mA)
- High Breakdown Voltage : V_{GDS}=-40V
- Super Low Noise : E_n=0.95nV/$\sqrt{Hz}$ (Typ.)
  (V_{DS}=10V, I_D=1mA, f=1kHz)
- High Input Impedance : I_{GSS}=-1nA (Max.) (V_{DG}=30V)
- Complementary to 2SJ108
- Small Package

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

JEDEC	–
EIAJ	–
TOSHIBA	2-4E1C

Weight : 0.13g

MAXIMUM RATINGS (T_a=25°C)

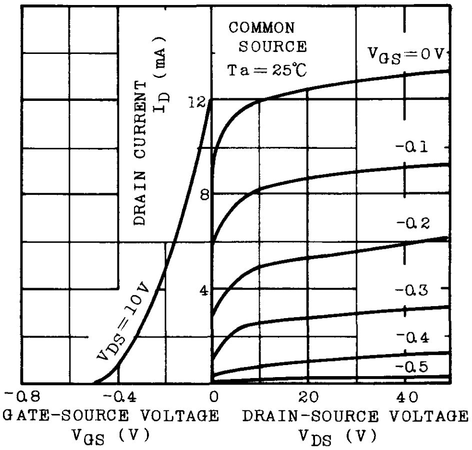
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-40	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55～125	°C

ELECTRICAL CHARACTERISTICS (T_a=25°C)

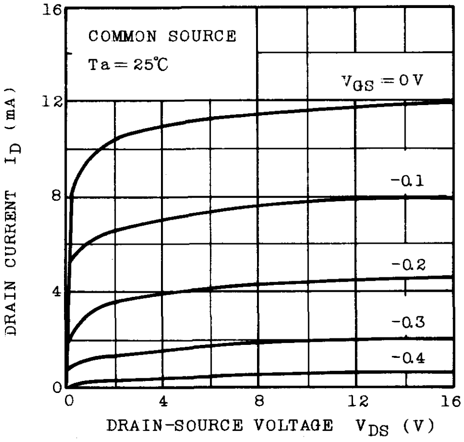
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-40	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=10V, V_{GS}=0	2.6	-	20	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.2	-	-1.5	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz, I_{DSS}=3mA	8	22	-	mS
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	30	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=10V, I_D=0, f=1MHz	-	6	-	pF
Noise Figure	NF(1)	V_{DS}=10V, I_D=1.0mA, R_g=1kΩ , f=10Hz	-	1.0	10	dB
	NF(2)	V_{DS}=10V, I_D=1.0mA, R_g=1kΩ , f=1kHz	-	0.5	2	

Note : I_{DSS} Classification GR : 2.6～6.5mA, BL : 6.0～12mA, V : 10～20mA

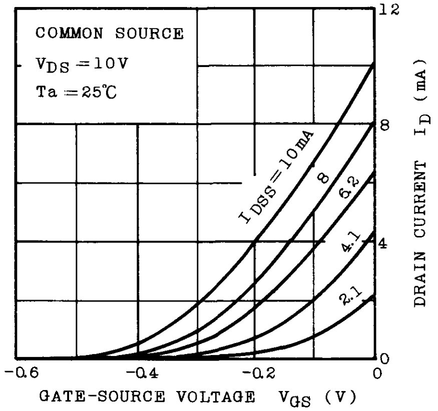
STATIC CHARACTERISTICS



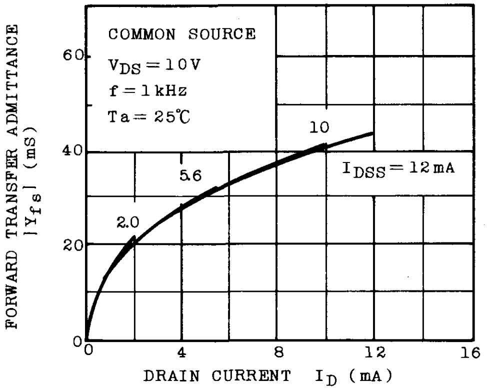
I_D – V_{DS} (LOW VOLTAGE REGION)



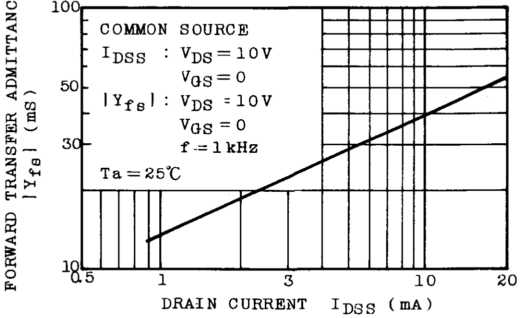
I_D – V_{GS}



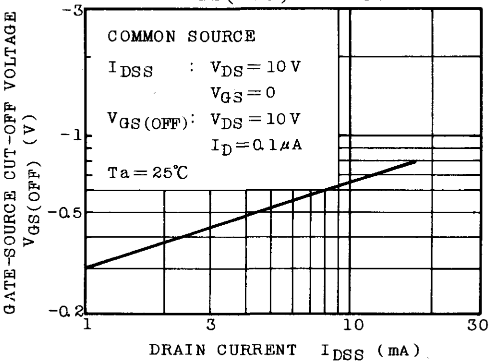
|Y_{fs}| – I_D



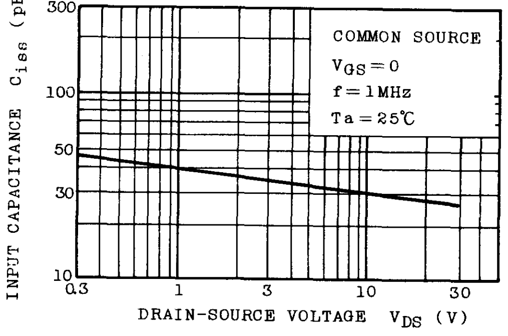
|Y_{fs}| – I_{DSS}



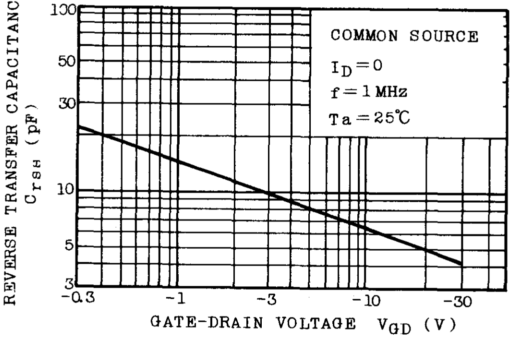
$V_{GS(OFF)}$ – I_{DSS}



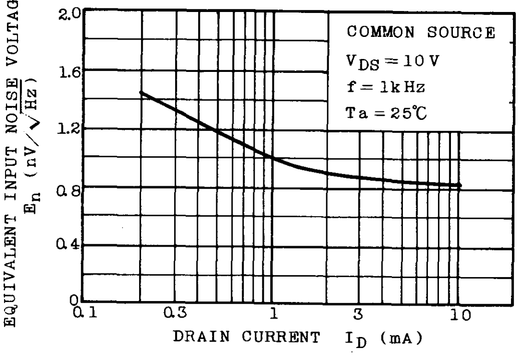
C_{iss} – V_{DS}



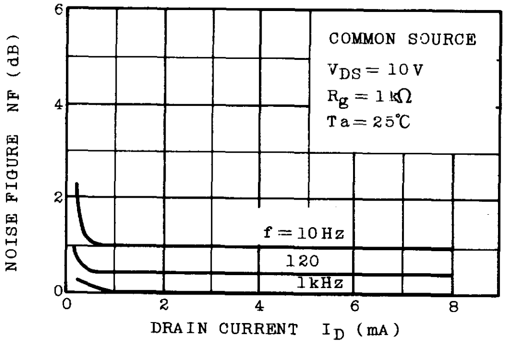
C_{rss} – V_{GD}



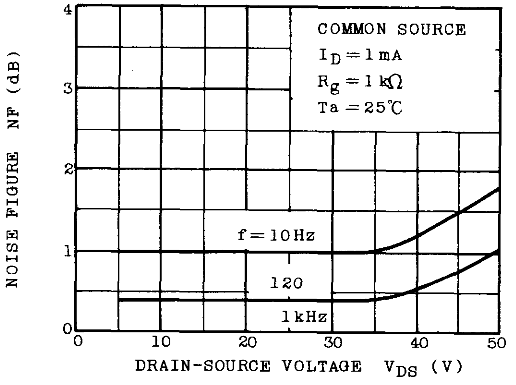
E_n – I_D



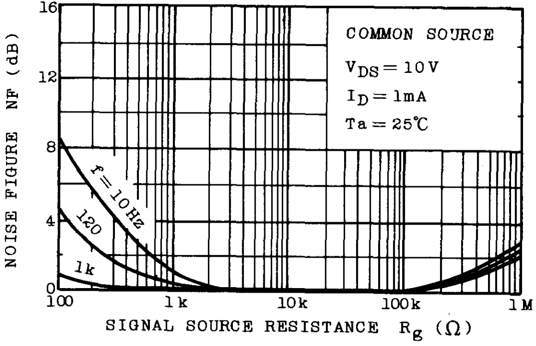
NF – I_D



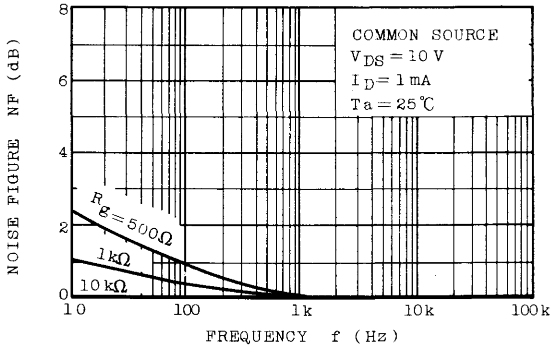
NF – V_{DS}



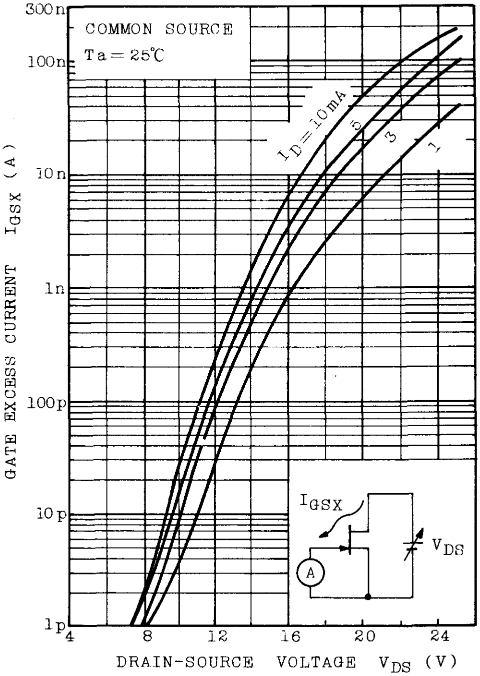
NF – R_g



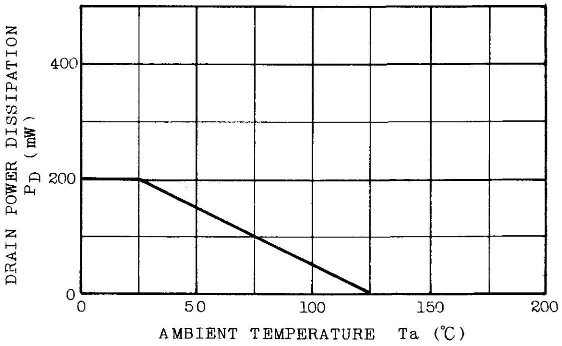
NF — f



I_{GSX} — V_{DS}



P_D — Ta



SILICON N CHANNEL JUNCTION TYPE

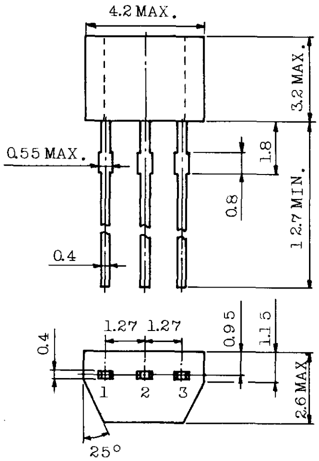
2SK371

FOR LOW NOISE AUDIO AMPLIFIER APPLICATIONS.

FEATURES:

- Suitable for Use as First Stage for Equalizer and MC Head Amplifiers.
- High $|Y_{fs}|$
  : $|Y_{fs}|$=40mS(Typ.) (V_{DS}=10V, V_{GS}=0, I_{DSS}=5mA)
- High Breakdown Voltage : V_{GDS}=-40V
- Super Low Noise : NF=1.0dB(Typ.)
  (V_{DS}=10V, I_D=5mA, f=1kHz, R_g=100Ω)
- High Input Impedance : I_{GSS}=-1nA(Max.) (V_{DG}=30V)
- Small Package

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

JEDEC	–
EIAJ	–
TOSHIBA	2-4E1C

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-40	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55 ~ 125	°C

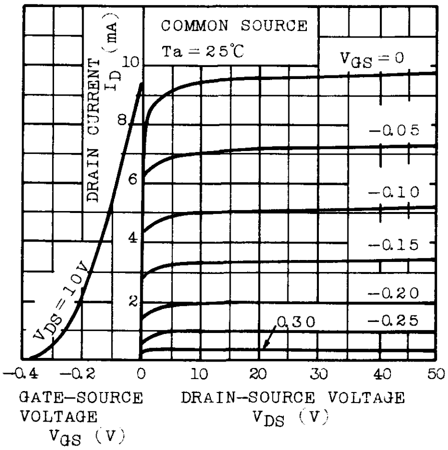
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-40	-	-	V
Drain Current	I_{DSS} (Note 1)	V_{DS}=10V, V_{GS}=0	5.0	-	30	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.3	-	-1.2	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz (TYP:I_{DSS}=5mA)	25	40	-	mS
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	75	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=10V, I_D=0, f=1MHz	-	15	-	pF
Noise Figure	NF(1)	V_{DS}=10V, R_g=100Ω I_D=5mA, f=100Hz	-	5	10	dB
	NF(2)	V_{DS}=10V, R_g=100Ω I_D=5mA, f=1kHz	-	1	2	

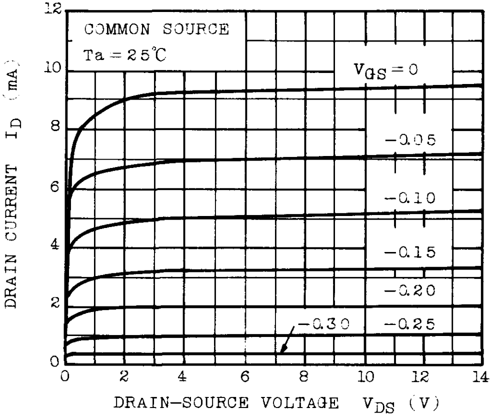
Note 1 : I_{DSS} Classification GR : 5.0~10.0mA, BL : 8.0~16.0mA, V : 14.0~30.0mA

2 : Use this in the low voltage region (V_{DS}<15V) for low noise applications.

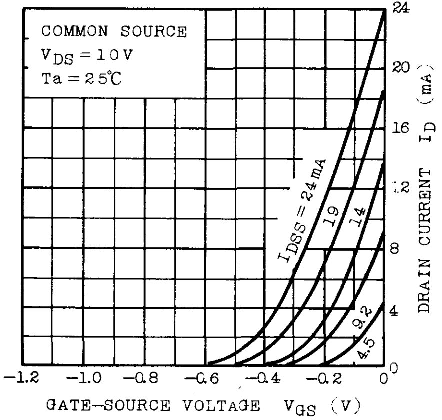
STATIC CHARACTERISTIC



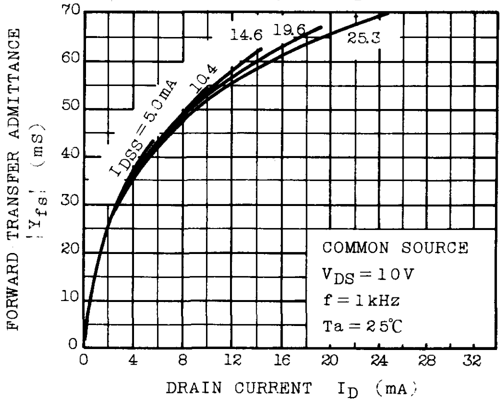
I_D − V_{DS} (LOW VOLTAGE REGION)



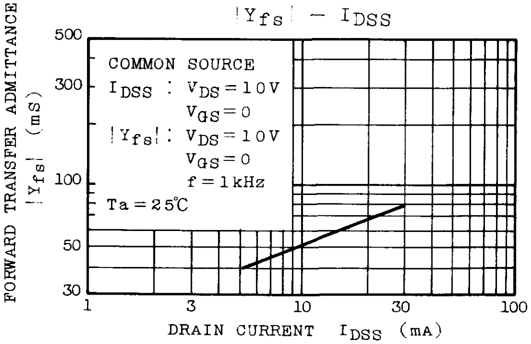
I_D − V_{GS}



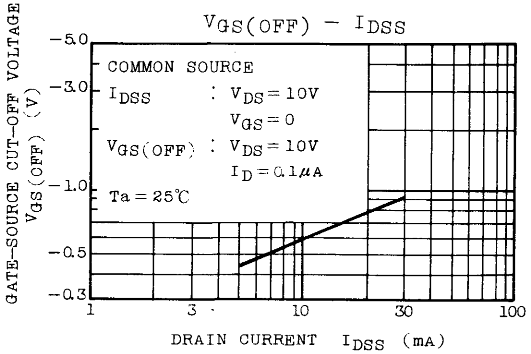
Y_{fs} − I_D



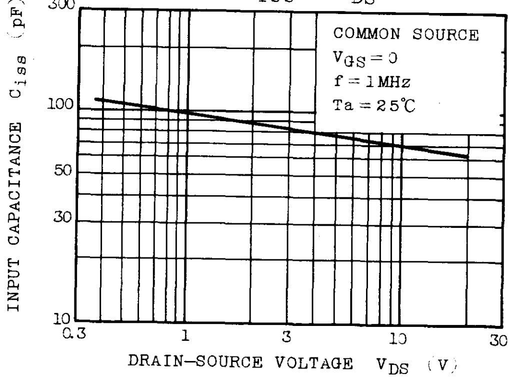
$|Y_{fs}|$ − I_{DSS}



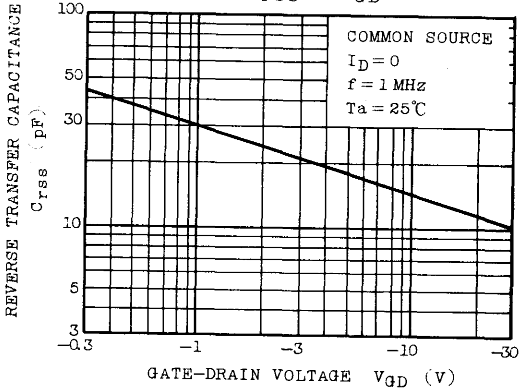
$V_{GS(OFF)}$ − I_{DSS}



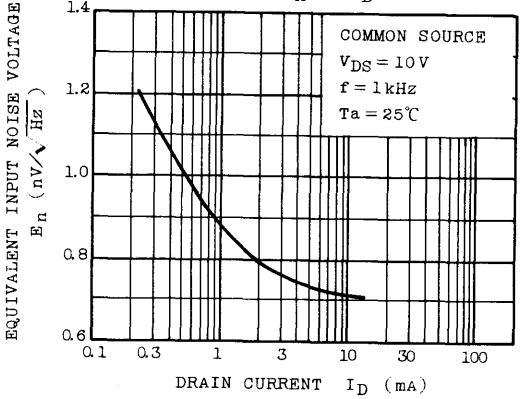
$C_{iss} - V_{DS}$



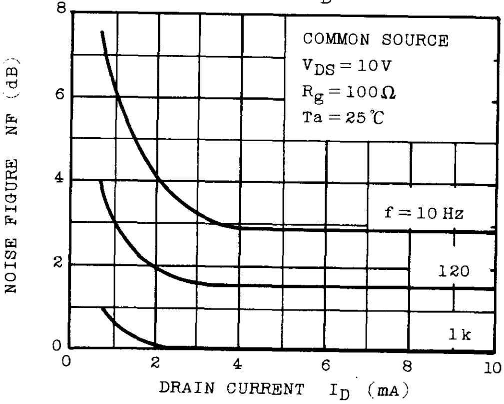
$C_{rss} - V_{GD}$



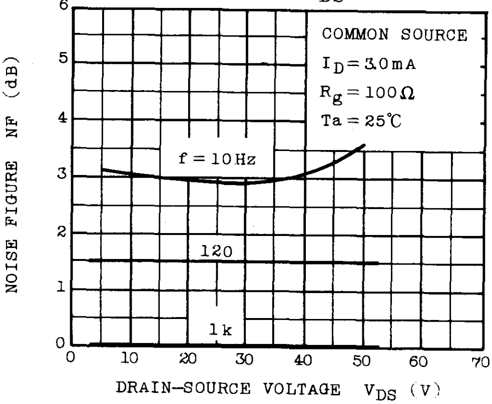
$E_n - I_D$



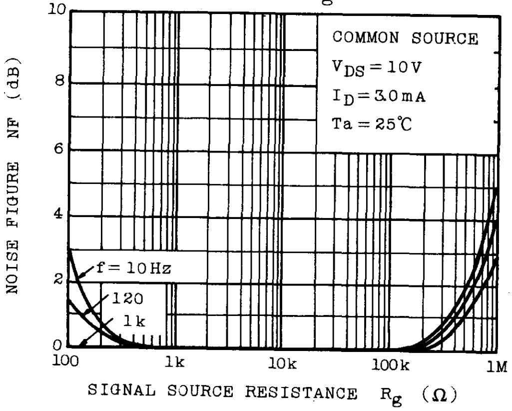
$NF - I_D$

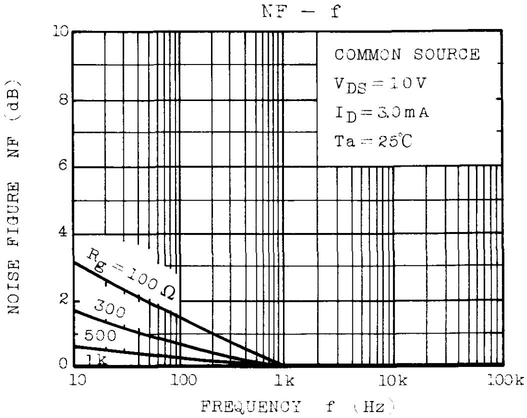


$NF - V_{DS}$

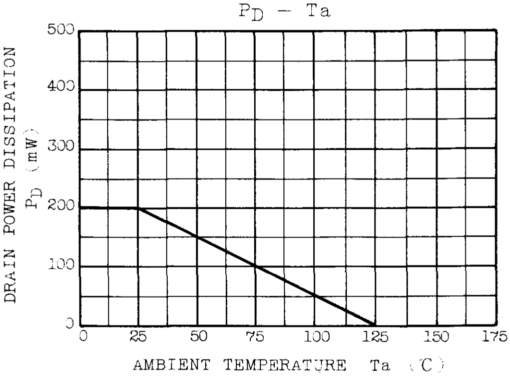


$NF - R_g$

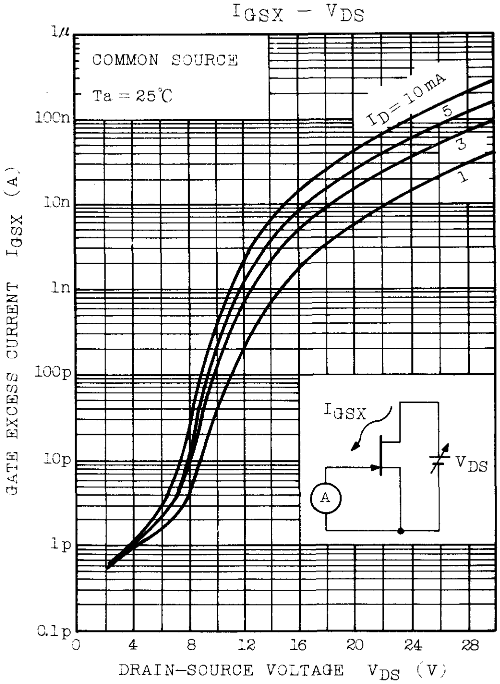




NF – f



P_D – Ta



I_{GSX} – V_{DS}

SILICON N CHANNEL JUNCTION TYPE

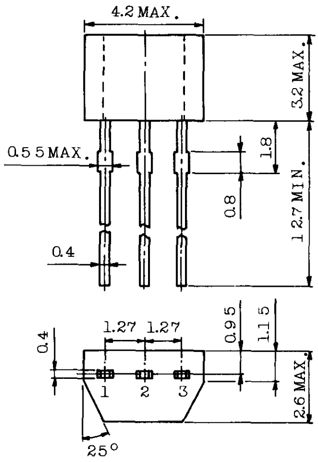
2SK372

FOR AUDIO AMPLIFIER, ANALOG-SWITCH,
CONSTANT CURRENT AND IMPEDANCE CONVERTER APPLICATIONS.

FEATURES:

- High Breakdown Voltage : V_{GDS}=-40V
- High Input Impedance : I_{GSS}=-1.0nA(Max.) (V_{GS}=-30V)
- Low $R_{DS(ON)}$: $R_{DS(ON)}$=20Ω (Typ.) (I_{DSS}=15mA)
- Small Package

Unit in mm



1. DRAIN
2. GATE
3. SOURCE

JEDEC	–
EIAJ	–
TOSHIBA	2-4E1C

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-40	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	200	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55～125	°C

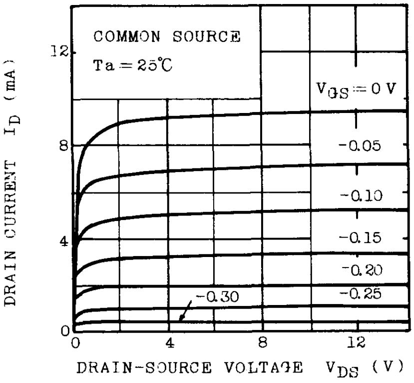
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-40	-	-	V
Drain Current	I_{DSS} (Note 1)	V_{DS}=10V, V_{GS}=0	5.0	-	30	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.3	-	-1.2	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz (Note 2)	25	60	-	mS
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	75	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=10V, I_D=0, f=1MHz	-	15	-	pF
Drain-Source ON Resistance	$R_{DS(ON)}$	V_{DS}=10mV, V_{GS}=0 (Note 2)	-	20	-	Ω

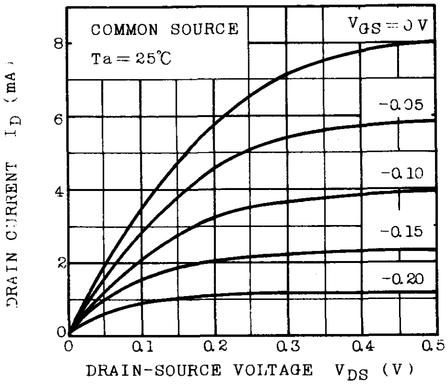
Note 1 : I_{DSS} Classification GR : 5.0～10.0mA, BL : 8.0～16.0mA, V : 14.0～30.0mA

2 : Condition of the typical value I_{DSS}=15mA

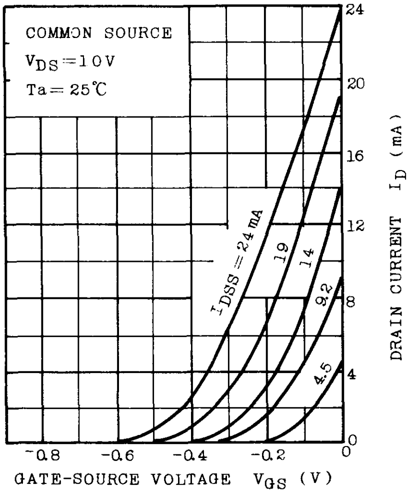
$I_D - V_{DS}$



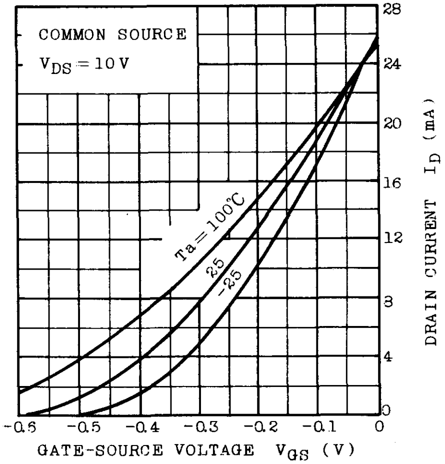
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



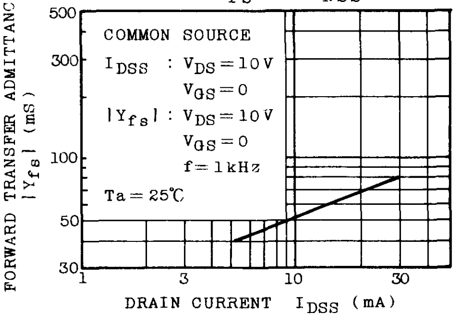
$I_D - V_{GS}$



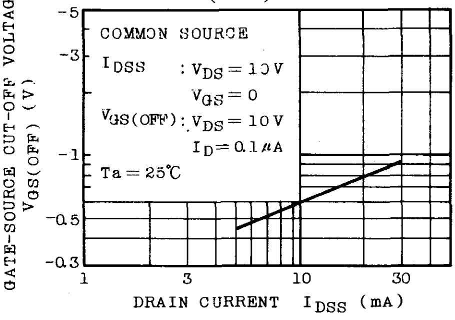
$I_D - V_{GS}$ (TEMPERATURE DEPENDENCY)

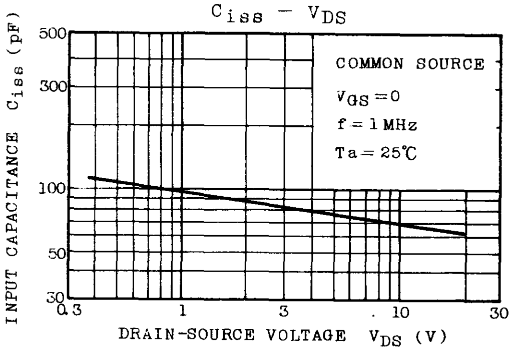


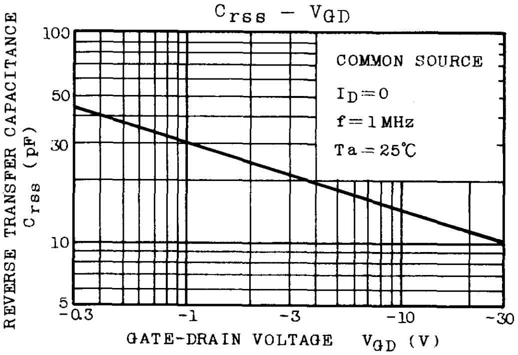
$|Y_{fs}| - I_{DSS}$

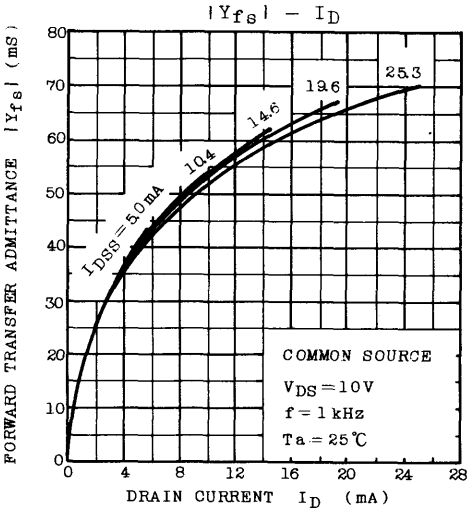


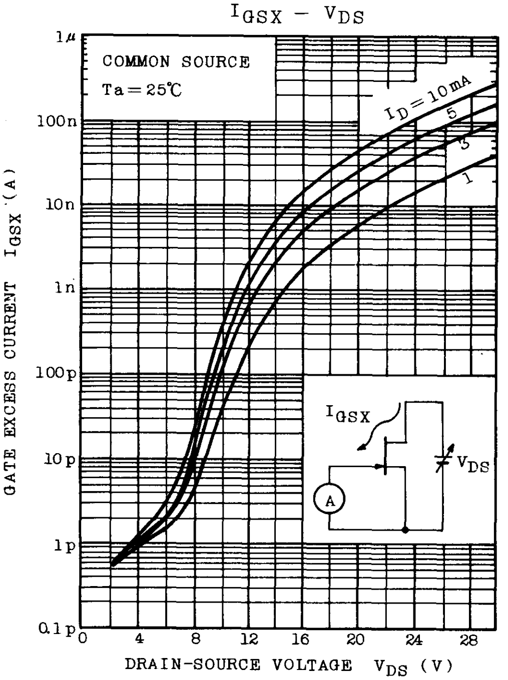
$V_{GS(OFF)} - I_{DSS}$

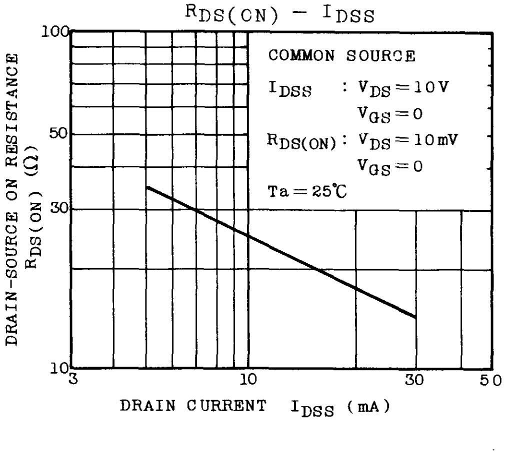



C_{iss} – V_{DS}
COMMON SOURCE
$V_{GS}=0$
$f=1$ MHz
$Ta=25$℃
INPUT CAPACITANCE C_{iss} (pF)
500
300
100
50
30
0.3
1
3
10
30
DRAIN-SOURCE VOLTAGE V_{DS} (V)

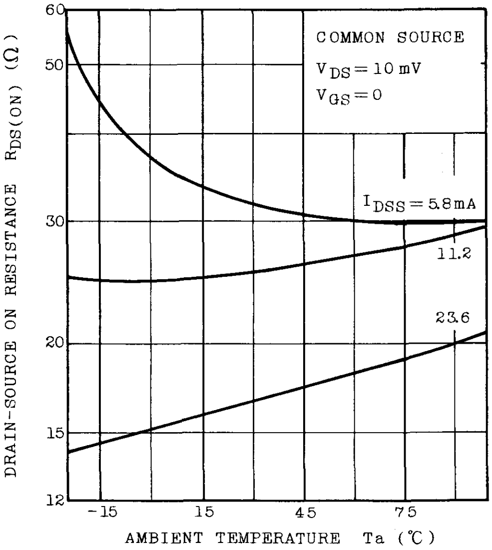

C_{rss} – V_{GD}
COMMON SOURCE
$I_D=0$
$f=1$ MHz
$Ta=25$℃
REVERSE TRANSFER CAPACITANCE C_{rss} (pF)
100
50
30
10
5
-0.3
-1
-3
-10
-30
GATE-DRAIN VOLTAGE V_{GD} (V)


$|Y_{fs}|$ – I_D
$I_{DSS}=5.0$ mA
10.4
14.6
19.6
25.3
COMMON SOURCE
$V_{DS}=10$ V
$f=1$ kHz
$Ta=25$℃
FORWARD TRANSFER ADMITTANCE $|Y_{fs}|$ (mS)
80
70
60
50
40
30
20
10
0
0
4
8
12
16
20
24
28
DRAIN CURRENT I_D (mA)

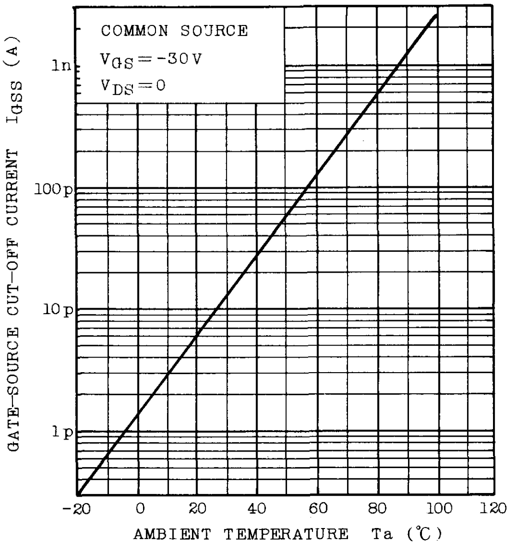

I_{GSX} – V_{DS}
COMMON SOURCE
$Ta=25$℃
$I_D=10$ mA
5
3
1
I_{GSX}
V_{DS}
A
GATE EXCESS CURRENT I_{GSX} (A)
1μ
100n
10n
1n
100p
10p
1p
0.1p
0
4
8
12
16
20
24
28
DRAIN-SOURCE VOLTAGE V_{DS} (V)


$R_{DS(ON)}$ – I_{DSS}
COMMON SOURCE
I_{DSS} : $V_{DS}=10$ V
$V_{GS}=0$
$R_{DS(ON)}$: $V_{DS}=10$ mV
$V_{GS}=0$
$Ta=25$℃
DRAIN-SOURCE ON RESISTANCE $R_{DS(ON)}$ (Ω)
100
50
30
10
3
10
30
50
DRAIN CURRENT I_{DSS} (mA)

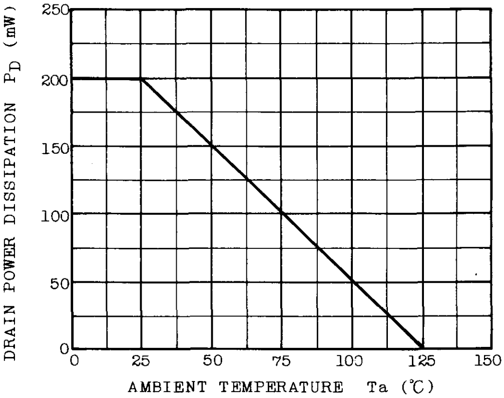
$R_{DS(ON)}$ – Ta



I_{GSS} – Ta



P_D – Ta



SILICON N CHANNEL JUNCTION TYPE

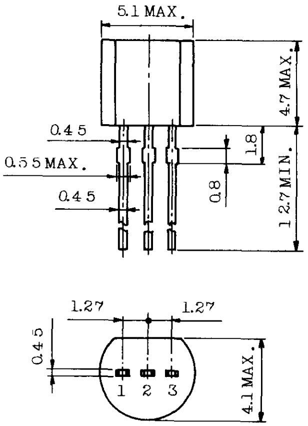
2SK373

FOR AUDIO, HIGH VOLTAGE AMPLIFIER AND CONSTANT CURRENT APPLICATIONS.

FEATURES:

- High Breakdown Voltage : V_{GDS}=-100V (Min.)
- High Input Impedance : I_{GSS}=-1.0nA(Max.) (V_{GS}=-80V)

Unit in mm



1. SOURCE
2. GATE
3. DRAIN

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1C

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

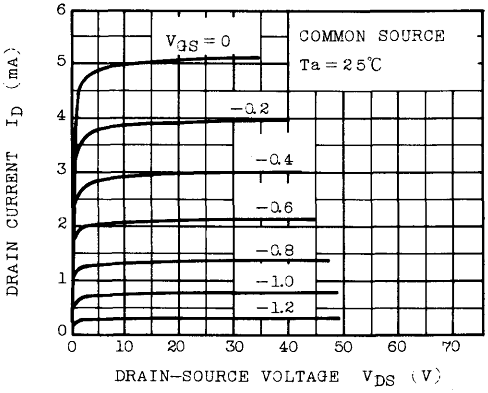
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-100	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

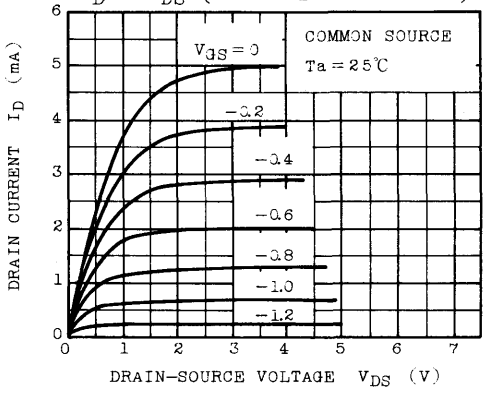
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=-80V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-100	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=10V, V_{GS}=0	0.6	-	6.5	mA
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.4	-	-3.5	V
Forward Transfer Admittance	$\lvert Y_{fs} \rvert$	V_{DS}=10V, V_{GS}=0, f=1kHz	1.5	4.6	-	mS
Input Capacitance	Ciss	V_{DS}=10V, V_{GS}=0, f=1MHz	-	13	-	pF
Reverse Transfer Capacitance	Crss	V_{DS}=10V, I_D=0, f=1MHz	-	3	-	pF
Noise Figure	NF	V_{DS}=10V, V_{GS}=0 R_g=100kΩ, f=100Hz	-	0.5	-	dB

Note : I_{DSS} Classification O : 0.6~1.4, Y : 1.2~3.0, GR : 2.6~6.5

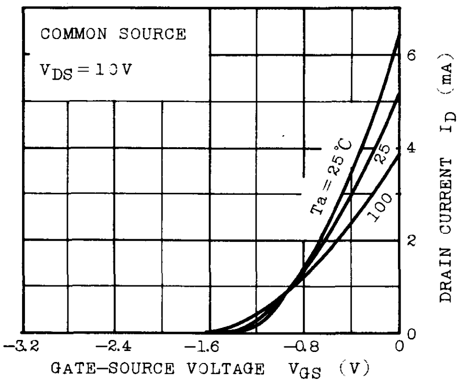
$I_D - V_{DS}$



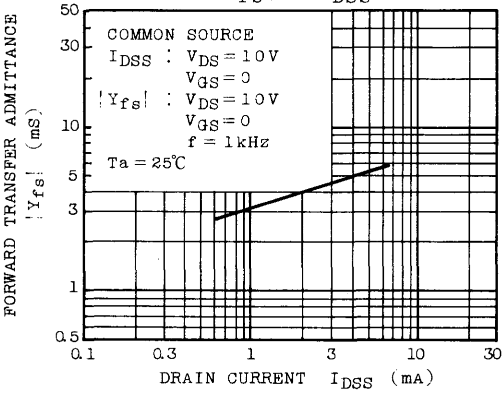
$I_D - V_{DS}$ (LOW VOLTAGE REGION)



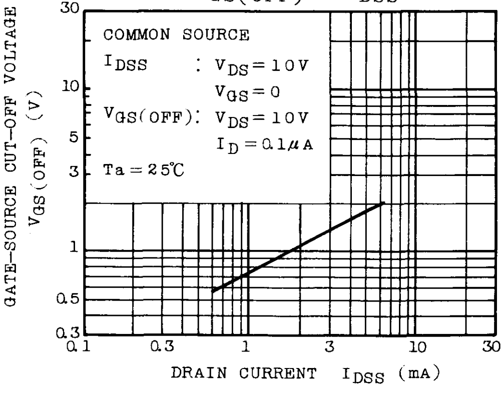
$I_D - V_{GS}$



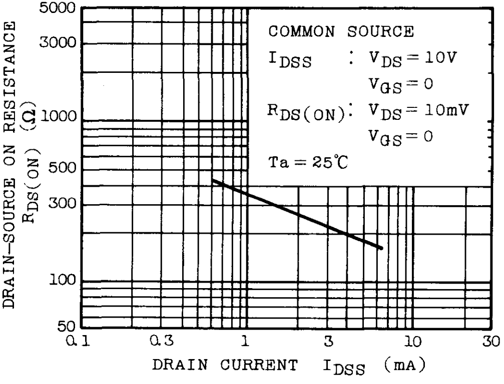
$|Y_{fs}| - I_{DSS}$



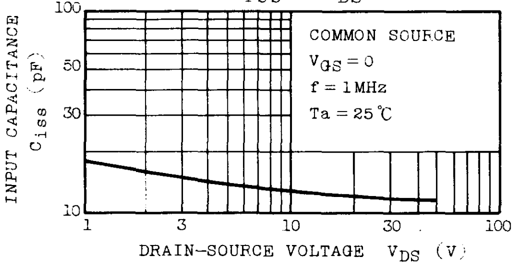
$V_{GS(OFF)} - I_{DSS}$



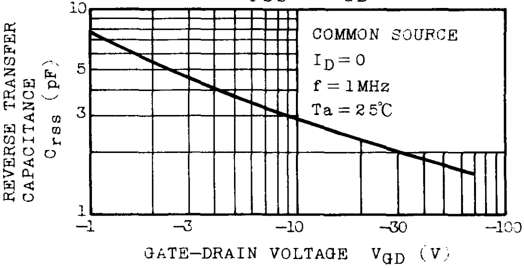
$R_{DS(ON)} - I_{DSS}$



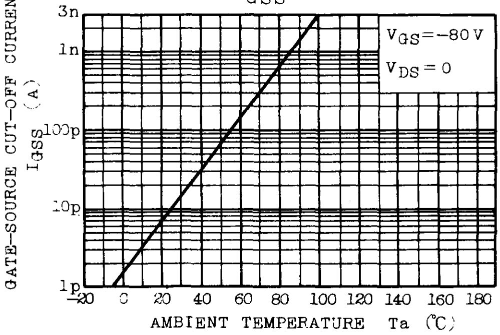
C_{iss} − V_{DS}



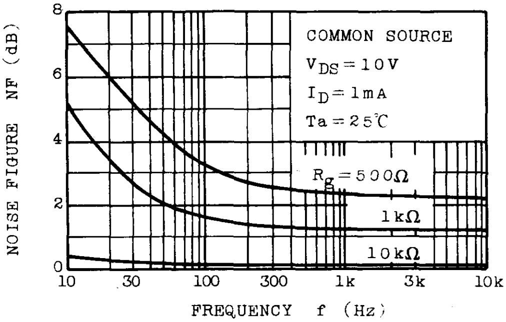
C_{rss} − V_{GD}



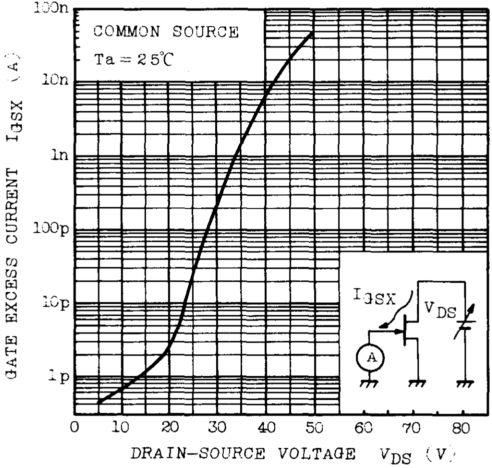
I_{GSS} − Ta



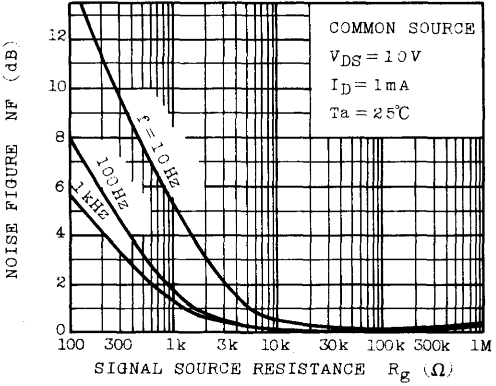
NF − f



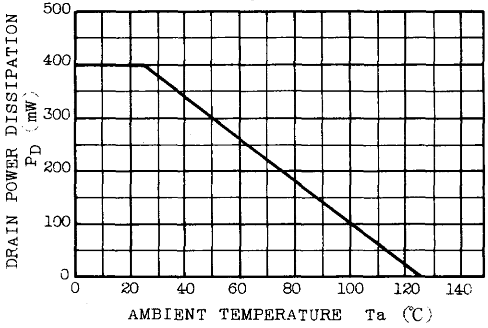
I_{GSX} − V_{DS}



NF − R_g



P_D − Ta

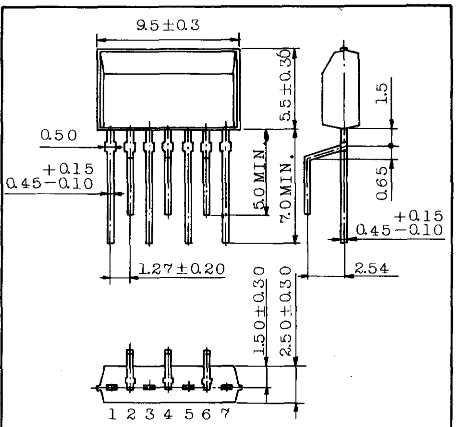


2SK389

SILICON MONOLITHIC N CHANNEL JUNCTION TYPE

LOW NOISE AUDIO AND DIFFERENTIAL AMPLIFIER APPLICATIONS.

Unit in mm



1. DRAIN 1	5. SOURCE 2
2. GATE 1	6. GATE 2
3. SOURCE 1	7. DRAIN 2
4. SUBSTRATE	

JEDEC	–
EIAJ	–
TOSHIBA	2-10M1A

Weight : 0.37g

FEATURES:

- 1 Chip Dual Type.
- Recommended for First Differential Stages of DC Amplifiers.
- Very High $|Y_{fs}|$: $|Y_{fs}|$ =20mS(Typ.) (V_{DS}=10V,V_{GS}=0,f=1kHz,I_{DSS}=3mA)
- Good Pair Characteristics : $|V_{GS1}-V_{GS2}|$ =20mV(Max.)(V_{DS}=10V, I_D=1mA)
- High Breakdown Voltage : V_{GDS}=-50V(Min.)
- Very Low Noise : NF=0.5dB(Typ.) (V_{DS}=10V,I_D=1mA,R_g=1kΩ,f=1kHz)
- High Input Impedance : I_{GSS}=-1.0nA(Max.)(V_{GD}=-30V)
- Complementary to 2SJ109

MAXIMUM RATINGS (Ta=25°C)

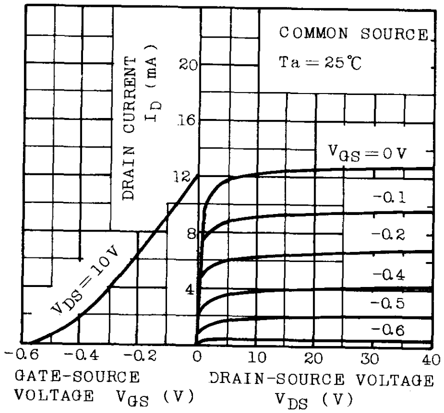
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{GDS}	-50	V
Gate Current	I_G	10	mA
Drain Power Dissipation	P_D	200	mW/UNIT
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-55~125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

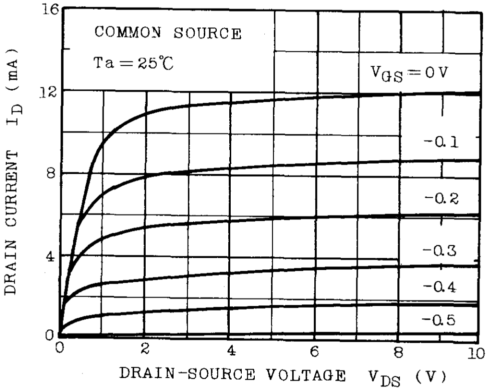
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate-Source Cut-off Current	I_{GSS}	V_{GS}=-30V, V_{DS}=0	-	-	-1.0	nA
Gate-Drain Breakdown Voltage	$V_{(BR)GDS}$	V_{DS}=0, I_G=-100μA	-50	-	-	V
Drian Current	I_{DSS}(Note)	V_{DS}=10V, V_{GS}=0	2.6	-	20	mA
Drain Current Ratio	$I_{DSS(S)}/I_{DSS(L)}$	V_{DS}=10V, V_{GS}=0	0.9	-	-	-
Gate-Source Cut-off Voltage	$V_{GS(OFF)}$	V_{DS}=10V, I_D=0.1μA	-0.2	-	-2.0	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz I_{DSS}=3mA	8	20	-	mS
Forward Transfer Admittance Ratio	$\|Y_{fs(S)}\|/\|Y_{fs(L)}\|$	V_{DS}=10V, V_{GS}=0, f=1kHz	0.9	-	-	-
Differential Gate-Source Voltage	$\|V_{GS1}-V_{GS2}\|$	V_{DS}=10V, I_D=1mA	-	-	20	mV
Input Capacitance	C_{iss}	V_{DS}=10V, V_{GS}=0, f=1MHz	-	25	-	pF
Reverse Transfer Capacitance	C_{rss}	V_{DG}=10V, I_D=0, f=1MHz	-	5.5	-	pF
Noise Figure	NF(1)	V_{DS}=10V, R_g=1kΩ, I_D=1mA, f=10Hz	-	-	10	dB
	NF(2)	V_{DS}=10V, R_g=1kΩ, I_D=1mA, f=1kHz	-	-	2	

Note : I_{DSS} Classification GR : 2.6~6.5mA, BL : 6~12mA, V : 10~20mA

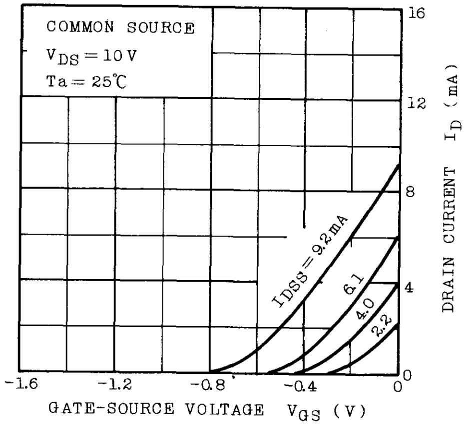
STATIC CHARACTERISTICS



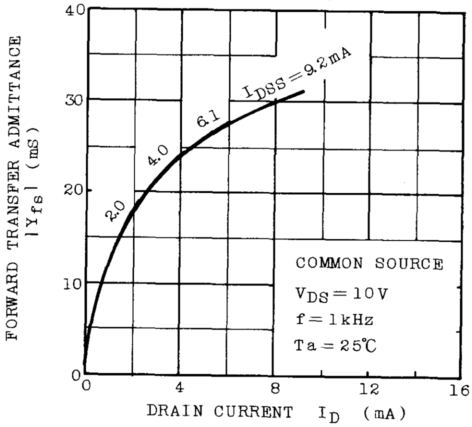
I_D – V_{DS} (LOW VOLTAGE REGION)



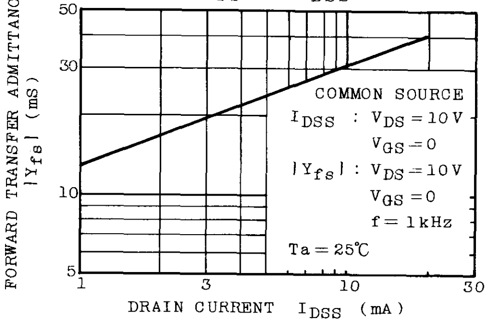
I_D – V_{GS}



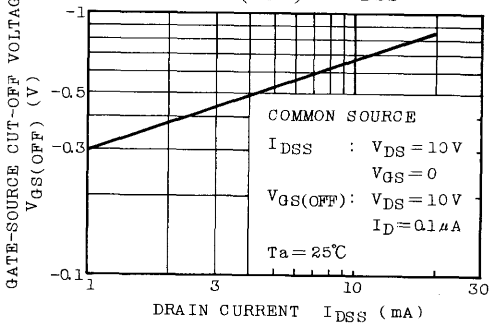
|Y_{fs}| – I_D



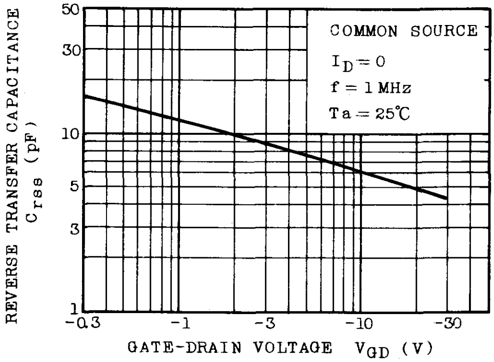
|Y_{fs}| – I_{DSS}



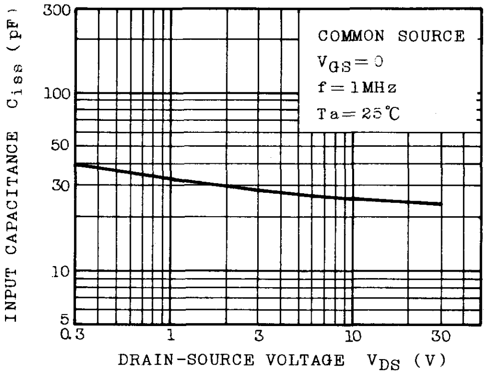
$V_{GS(OFF)}$ – I_{DSS}



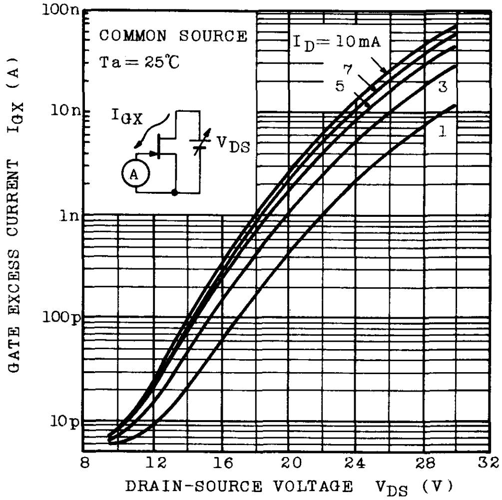
$C_{rss} - V_{GD}$



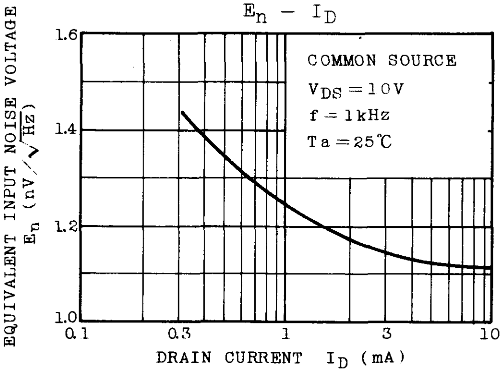
$C_{iss} - V_{DS}$



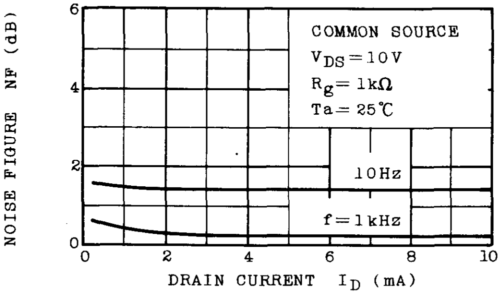
$I_{GX} - V_{DS}$



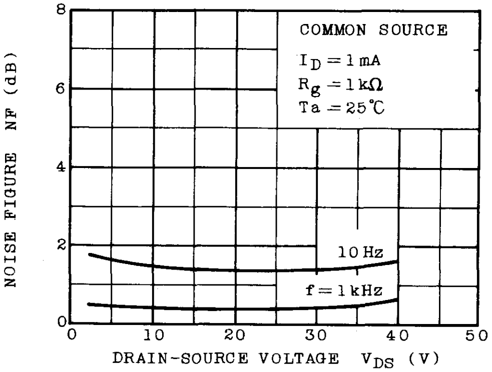
$E_n - I_D$

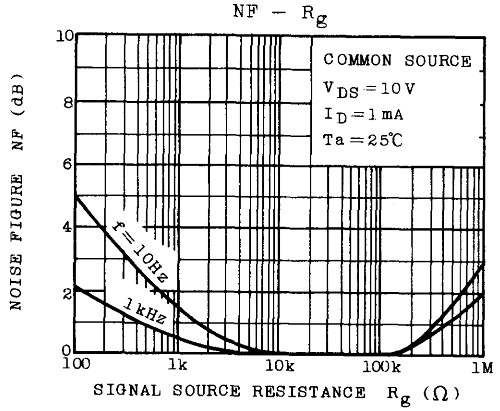


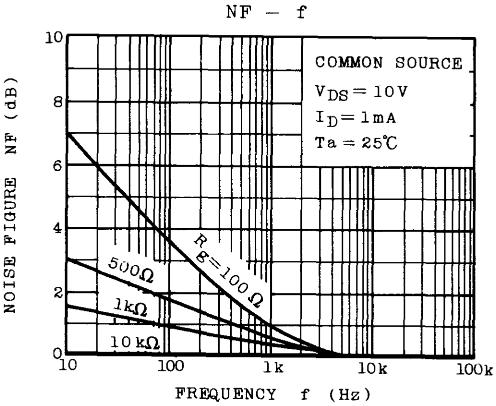
NF − I_D



NF − V_{DS}




NF – Rg
COMMON SOURCE
VDS = 10 V
ID = 1 mA
Ta = 25°C
f = 10Hz
1 kHz
NOISE FIGURE NF (dB)
0
2
4
6
8
10
100
1k
10k
100k
1M
SIGNAL SOURCE RESISTANCE Rg (Ω)


NF – f
COMMON SOURCE
VDS = 10 V
ID = 1 mA
Ta = 25°C
Rg = 100 Ω
500Ω
1kΩ
10 kΩ
NOISE FIGURE NF (dB)
0
2
4
6
8
10
10
100
1k
10k
100k
FREQUENCY f (Hz)

3SK series

SILICON N CHANNEL JUNCTION TYPE

3SK22

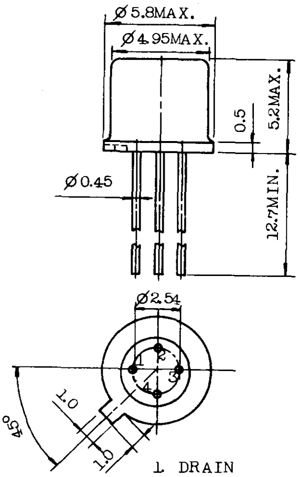
FM TUNER APPLICATIONS.

VHF BAND AMPLIFIER APPLICATIONS.

FEATURES:

- High Power Gain : G_{ps}=20dB (Typ.)(f=100MHz)
- Low Noise Figure : NF=2dB (Typ.)(f=100MHz)
- High Forward Transfer Admittance
  : $|y_{fs}|$ = 7ms (Typ.) (f=1kHz)
- High Input Impedance
  : R_{iss} = 12kΩ (Typ.) (f=100MHz)
- Low Reverse Transfer Capacitance
  : C_{rss}=0.6pF (Max.)

Unit in mm



1. DRAIN
2. SOURCE
3. GATE 1
4. GATE 2 (CASE)

JEDEC	TO − 72
EIAJ	TC − 7, TB − 9C
TOSHIBA	2 − 5C1C

Weight : 0.35g

MAXIMUM RATINGS (Ta=25°C)

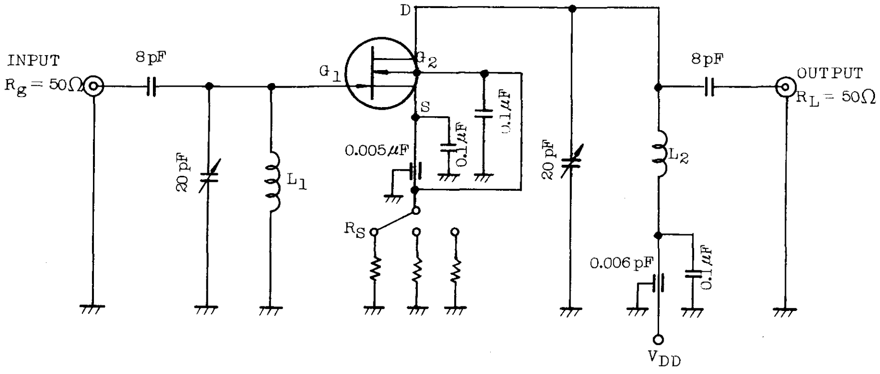
CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate-Drain Voltage	V_{G1DO}, V_{G2DO}	-18	V
Gate Current	I_{G1}, I_{G2}	10	mA
Drain Power Dissipation	P_D	200	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-65∼150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{GS}=-10V, V_{DS}=0, G1,G2 Connection	-	-	-100	nA
Gate-Drain Voltage	$V_{(BR)GDO}$	I_G=-100 A, G_1,G_2 Connection	-18	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=10V V_{G1S}=V_{G2S}=0	3	-	24	mA
Gate.1-Source Cut-off Voltage	$V_{G1S(OFF)}$	V_{DS}=10V, I_D=1μA, V_{G2S}=0	-1.2	-3	-	V
Gate.2-Source Cut-off Voltage	$V_{G2S(OFF)}$	V_{DS}=10V, I_D=1μA, V_{G1S}=0	-	-	-20	V
Forward Transfer Admittance	$\|y_{fs}\|$	V_{DS}=10V, f=1kHz V_{G1S}=V_{G2S}=0	-	7	-	ms
Reverse Transfer Capacitance	C_{rss}	V_{G1D}=-10V, f=1MHz	-	-	0.6	pF
Power Gain	G_{ps}	V_{DD}=10V, V_{G2S}=0, f=100MHz (Fig.)	-	20	-	dB
Noise Figure	NF	V_{DD}=10V, V_{G2S}=0, f=100MHz (Fig.)	-	2.0	3.5	dB

Note : I_{DSS} Classification Y : 3.0∼7.0, GR : 6.0∼14.0, BL : 12.0∼24.0

Fig. 100MHz G_{ps} AND NF TEST CIRCUIT



L_1 : 0.8mmØ SILVER PLATED COPPER WIRE, 3T, 10 ID, 10 LENGTH

L_2 : 0.8mmØ SILVER PLATED COPPER WIRE, 3.5T, 10 ID, 10 LENGTH

3SK22 is measured at each group by changing R_S.

GROUP	R_S (Ω)
3SK22 − Y	33Ω ± 5%
3SK22 − GR	82Ω ± 5%
3SK22 − BL	180Ω ± 5%

SILICON N CHANNEL JUNCTION TYPE
(INDUSTRIAL APPLICATIONS)

3SK28

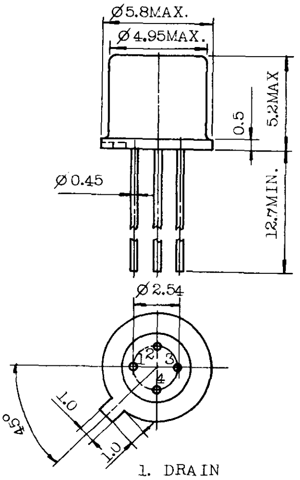
VIDEO PRE-AMPLIFIER APPLICATIONS.

VHF BAND AMPLIFIER APPLICATIONS.

FEATURES:

- High Gain : $|y_{fs}|$=4.5∿13mS
- High Power Gain : G_{ps}=17dB (Min.) at f=100MHz
- Low Reverse Transfer Capacitance : C_{rss}=0.6pF (Max.)
- Low Noise : NF=2.5dB (Max.) at f=100MHz
  NF=3.0dB (Max.) at f=30Hz

Unit in mm



1. DRAIN
2. SOURCE
3. GATE 1
4. GATE 2 (CASE)

JEDEC	TO – 72
EIAJ	TC – 7, TB – 9C
TOSHIBA	2 – 5C1C

Weight : 0.35g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Gate.1-Drain Voltage	V_{G1DS}	-18	V
Gate.2-Drain Voltage	V_{G2DS}	-18	V
Gate.1 Current	I_{G1}	10	mA
Gate.2 Current	I_{G2}	10	mA
Drain Power Dissipation	P_D	200	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-65∿150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current	I_{GSS}	V_{G1S}=-15V, V_{G1S}=0, V_{DS}=0	-	-	-10	nA
Gate.1-Drain Breakdown Voltage	$V_{(BR)G1DS}$	I_{G1}=-100μA, I_{G2}=0, V_{DS}=0 (Note 2)	-18	-	-	V
Gate.2-Drain Breakdown Voltage	$V_{(BR)G2DS}$	I_{G2}=-100μA, I_{G1}=0, V_{DS}=0 (Note 3)	-18	-	-	V
Drain Current	I_{DSS} (Note 1)	V_{DS}=10V, V_{G1S}=V_{G2S}=0	3.7	-	22	mA
Gate.1-Source Cut-off Voltage	$V_{G1S(OFF)}$	V_{DS}=10V, I_D=1μA, V_{G2S}=0 (Note 2)	-1.2	-	-5.5	V

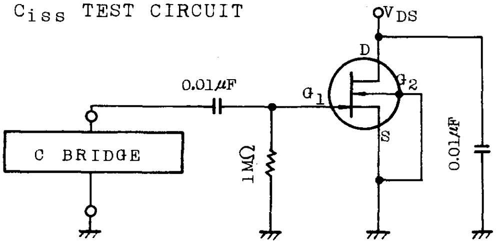
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate.2-Source Cut-off Voltage	$V_{G2S(OFF)}$	V_{DS}=10V, I_D=1μA V_{G1S}=0 (Note 3)	-3	-	-20	V
Forward Transfer Admittance	$\|y_{fs1}\|$	V_{DS}=10V,f=1kHz V_{G1S}=V_{G2S}=0	4.5	-	13	ms
Forward Transfer Admittance	$\|y_{fs1}\|$	V_{DS}=10V,f=100MHz V_{G1S}=V_{G2S}=0	4.5	-	-	ms
Input Capacitance	C_{iss}	V_{DS}=10V,f=1MHz V_{G2S}=0 (Fig. 1)	-	-	6.0	pF
Reverse Transfer Capacitance	C_{rss}	V_{G1D}=-10V, f=1MHz (Fig. 2)	-	-	0.6	pF
Power Gain	G_{PS}	V_{DD}=10V, V_{G2S}=0, f=100MHz (Fig. 3)	17	-	-	dB
Noise Figure	NF	V_{DD}=10V, V_{G2S}=0, f=100MHz (Fig. 3)	-	-	2.5	dB
		V_{DS}=10V, V_{G1S}=V_{G2S}=0 f=1kHz, R_g=1M Ω	-	-	2.5	dB
		V_{DS}=10V, V_{G1S}=V_{G2S}=0 f=30Hz, R_g=1M Ω	-	-	3.0	dB

Note 1 : I_{DSS} Classification Y : 3.7∿7.5, GR : 6.5∿13.0, BL : 11.0∿22.0

Note 2: V_{G1S} should not exceed $V_{C1S(OFF)}$ when gate 2 connected to source.

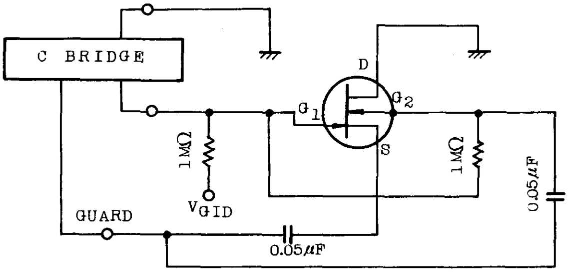
Note 3: V_{G2S} should not exceed $V_{G2S(OFF)}$ when gate 1 connected to source.

Fig.1 C_{iss} TEST CIRCUIT



C BRIDGE : BOONTON C BRIDGE

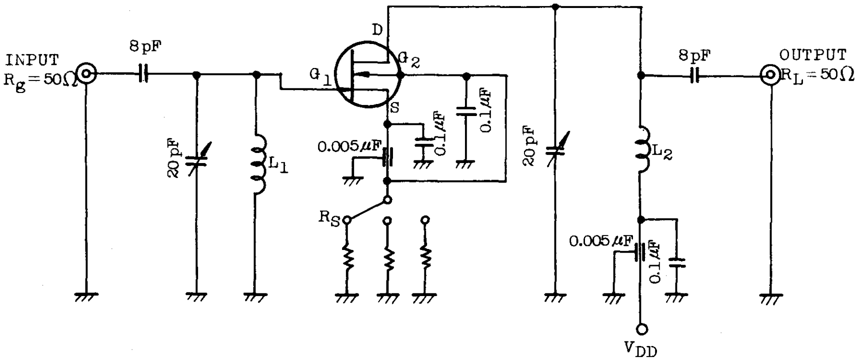
Fig.2 C_{rss} TEST CIRCUIT



C BRIDGE :

BOONTON C BRIDGE

Fig.3 100 MHz G_{ps} & NF TEST CIRCUIT



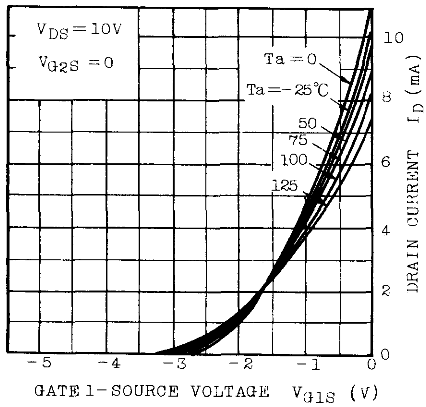
L_1 : 0.8mmØ SILVER PLATED WIRE, 3T, 10 ID, 10 LENGTH

L_2 : 0.8mmØ SILVER PLATED WIRE, 3.5T, 10 ID, 10 LENGTH

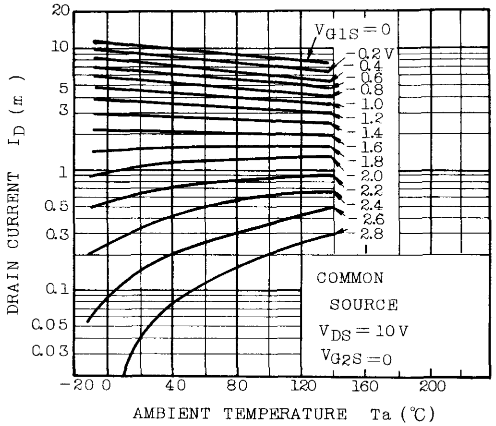
In the test R_S must be selected according to the I_{DSS} classification.

CLASSIFICATION	R_S
3SK28 — Y	33Ω ± 5%
3SK28 — GR	82Ω ± 5%
3SK28 — BL	180Ω ± 5%

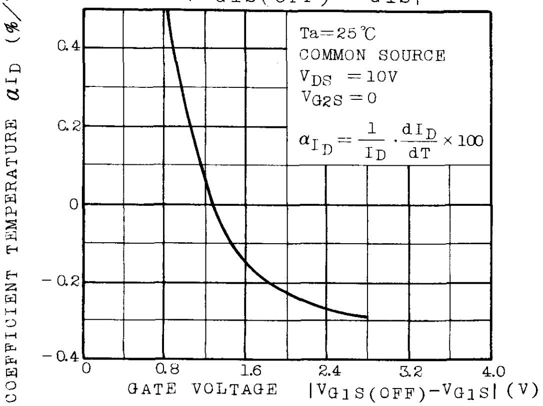
I_D - V_{G1S}



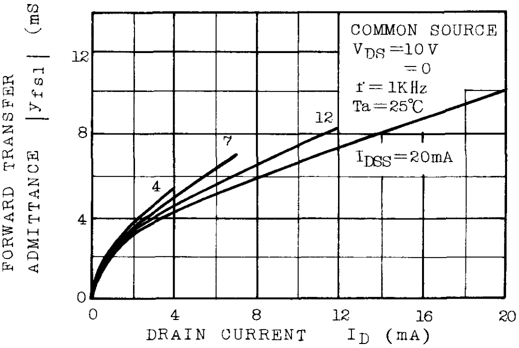
I_D - Ta



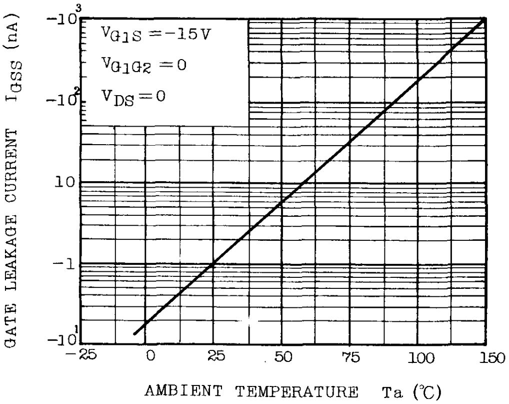
αI_D - $|V_{G1S(OFF)} - V_{G1S}|$



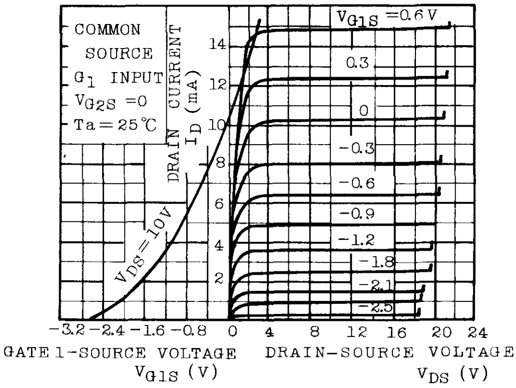
$|y_{fs1}|$ - I_D



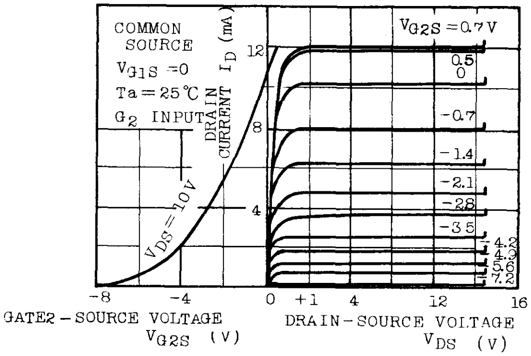
I_{GSS} - Ta



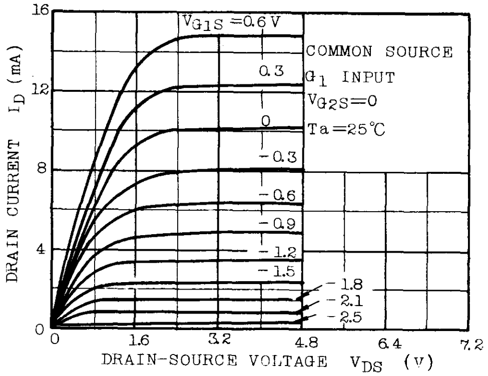
STATIC CHARACTERISTICS (1)



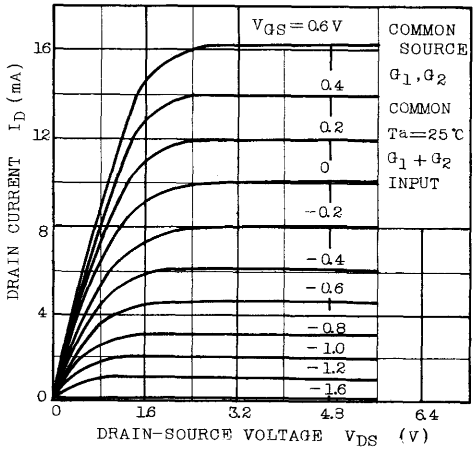
STATIC CHARACTERISTICS (2)



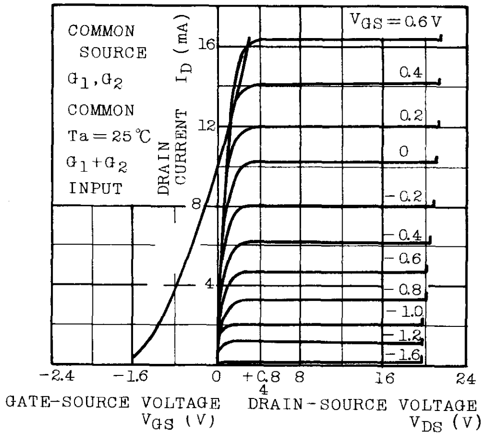
I_D - V_{DS} (LOW VOLTAGE REGION)



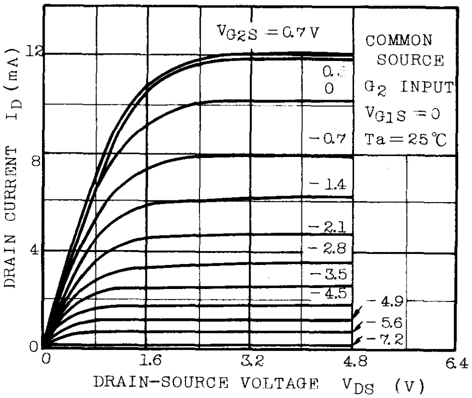
I_D - V_{DS} (LOW VOLTAGE REGION)



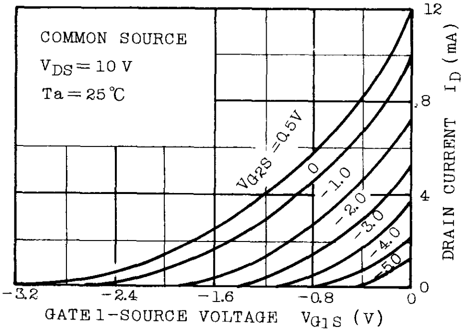
STATIC CHARACTERISTICS (3)



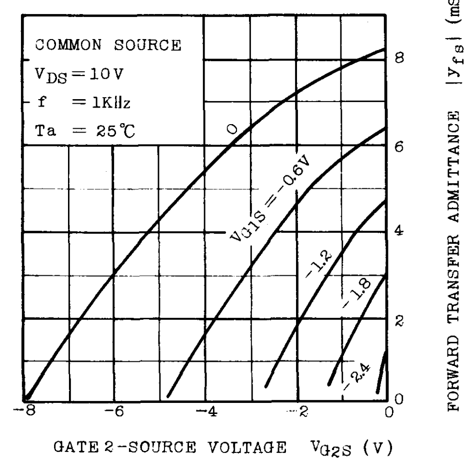
I_D - V_{DS} (LOW VOLTAGE REGION)



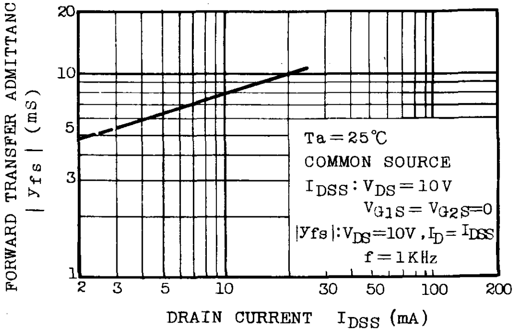
I_D - V_{G1S}



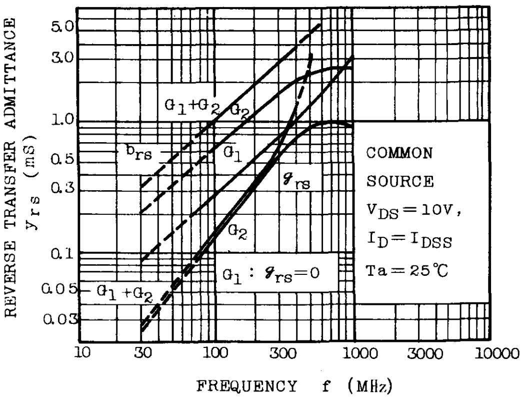
$|y_{fs}|$ − V_{G2S}



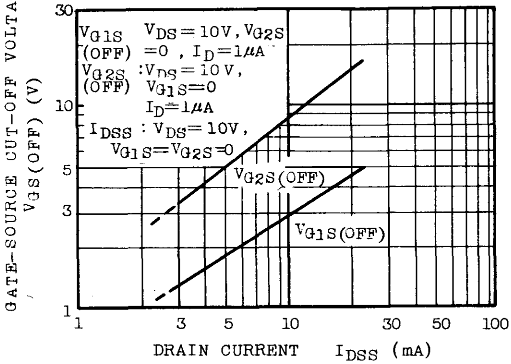
$|y_{fs}|$ − I_{DSS}



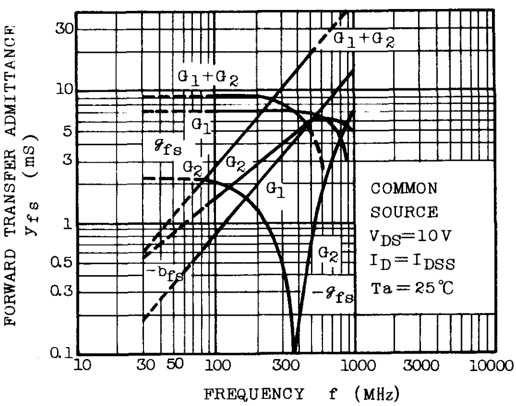
y_{rs} − f



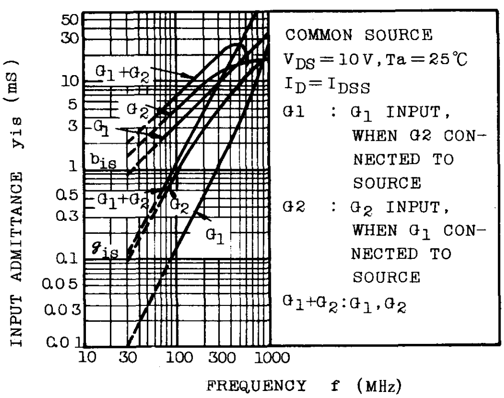
$V_{G1S(OFF)}$, $V_{G2S(OFF)}$ − I_{DSS}

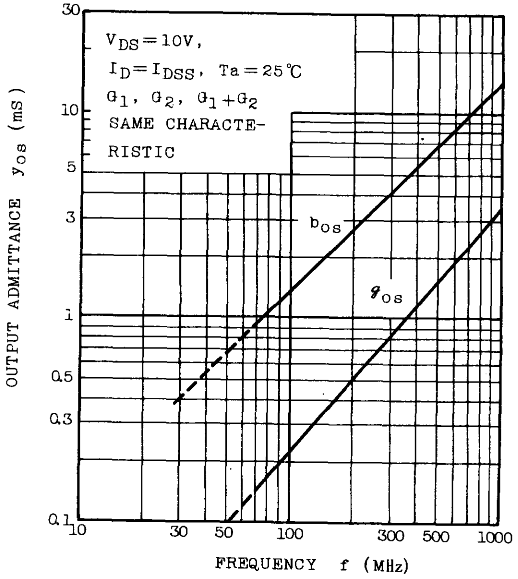


y_{fs} − f

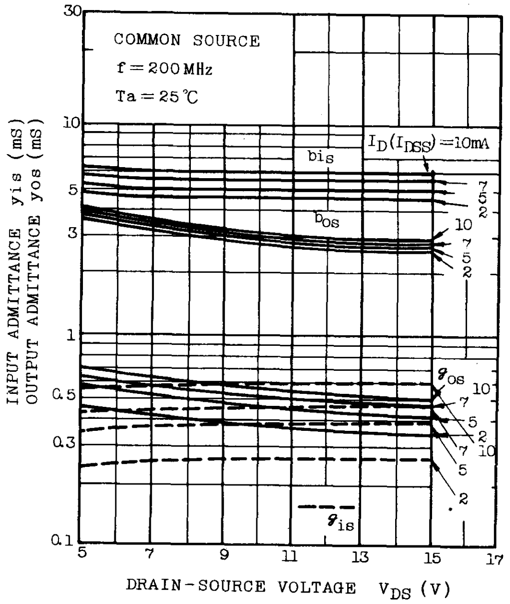


y_{is} − f

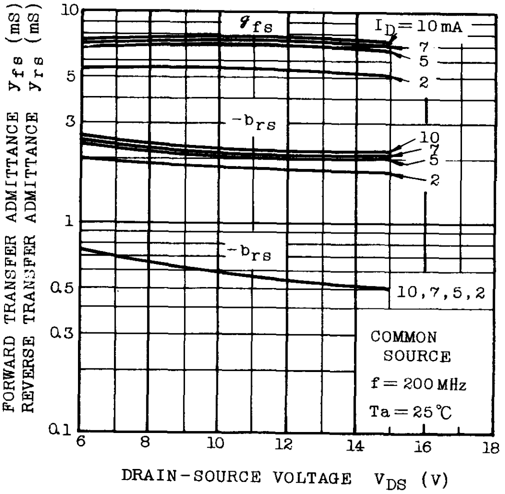




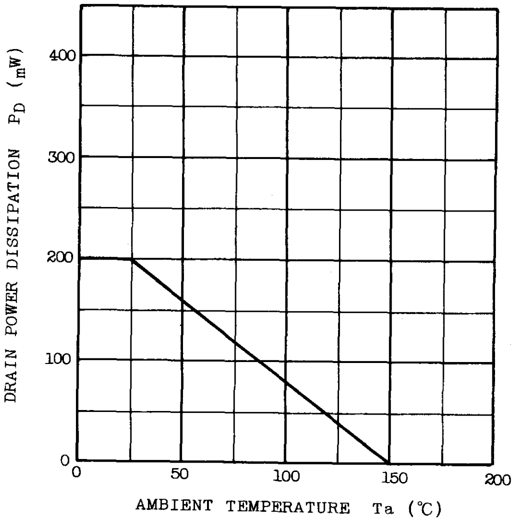
y_{os} - f



yis,yos - V_{DS}



y_{fs} , y_{re} - V_{DS}



P_D - Ta

3SK38A

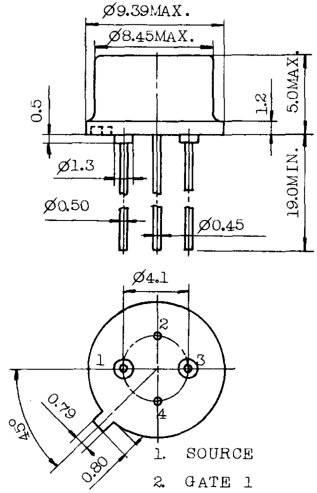
SILICON N CHANNEL MOS TYPE
(INDUSTRIAL APPLICATIONS)

CHOPPER CIRCUIT APPLICATIONS.
SWITCHING CIRCUIT APPLICATIONS.
IMPEDANCE CONVERTER APPLICATIONS.

FEATURES :

- Ultra Small Drain-Source Thermoelectromotive Force
  : Vemf = 1.3 μV/°C (Typ.)
- High Resistance Ratio
  : r_{DS}(ON) = 500Ω (Max.) at. V_{G1S}=3V
  : r_{DS}(OFF)= 100MΩ (Min.) at. V_{C1S}=0V
- Low Gate Capacitance and Offset
  : C_D = 2.5pF(Max.), ΔC_G=0.3pF(Max.)
- Contains Gates Protection Diode.

Unit in mm



1. SOURCE
2. GATE 1
3. DRAIN
4. GATE 2 (CASE)

JEDEC	—
EIAJ	—
TOSHIBA	2 — 8E1A

Weight : 1.1g

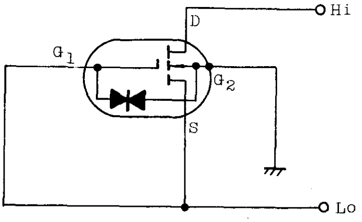
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Drain-Source Voltage	V_{DSS}	20	V
Gate 1-Source Voltage	V_{G1SS}	±12	V
Gate 2-Source Voltage	V_{G2SS}	-20	V
Drain-Source Current	I_{DS}	10	mA
Drain Power Dissipation	P_D	200	mW
Channel Temperature	T_{ch}	125	°C
Storage Temperature Range	T_{stg}	-65∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate Leakage Current		I_{G1SS}	V_{G1S}=12V, V_{G2S}=0, V_{DS}=0	-	-	25	nA
		I_{G1SS}	V_{G1S}=12V, V_{G2S}=0, V_{DS}=0	-	-	-25	nA
Drain Current		I_{DSS}	V_{G1S}=0, V_{G2S}=0, V_{DS}=6V	-	-	50	nA
Gate-Source Cut-off Voltage		$V_{GS(OFF)}$	V_{G2S}=0, V_{DS}=6V, I_D=50nA	0	-	3	V
Forward Transfer Admittance		$\lvert y_{fs} \rvert$	V_{G1S}=3V, V_{G2S}=0, V_{DS}=6V, f=1kHz	0.35	-	-	mS
Gate-Drain Capacitance		C_{G1D}	Fig. 1	-	-	2.5	pF
Gate-Source Capacitance		C_{G1S}	Fig. 2	-	-	2.5	pF
Differential Gate Capacitance		C_D	$\lvert C_{G1D}-C_{G1S} \rvert$	-	-	0.3	pF
Drain-Source ON Resistance		$r_{DS(ON)}$	V_{G1S}=3V, V_{G2S}=0, V_{DS}=10mV	-	-	500	Ω
Drain-Source OFF Resistance		$r_{DS(OFF)}$	V_{G1S}=0, V_{G2S}=0, V_{DS}=±10mV	100	-	-	MΩ
Drain-Source Thermoelectromotive Force		V_{emf}	V_{G1S}=3V, V_{G2S}=0, Ta=0∿55°C	-	1.3	2	μv/°C
Switching Time	Turn-on Time	t_{on}	Fig. 3	-	50	-	ns
	Turn-off Time	t_{off}		-	900	-	

Fig.1 C_{G1D} TEST CIRCUIT

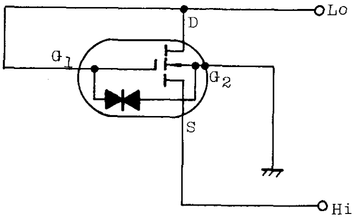


CAPACITANCE BRIDGE

f = 1MHz

$V_{G1S} = 0$

Fig.2 C_{G1S} TEST CIRCUIT

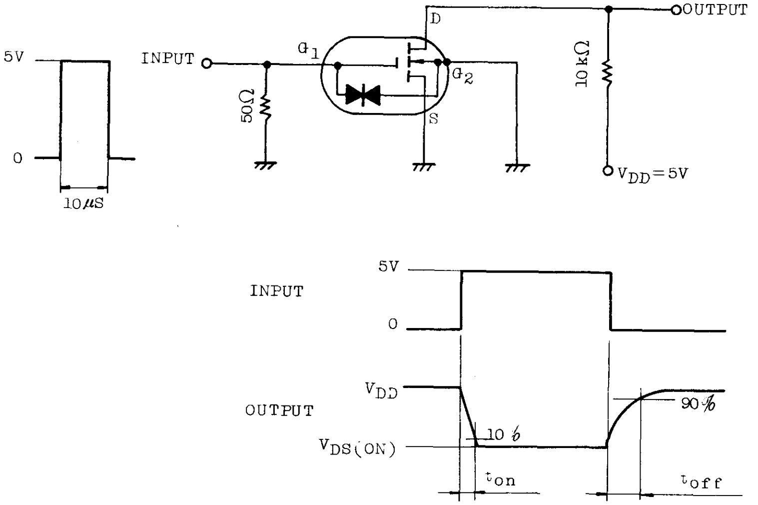


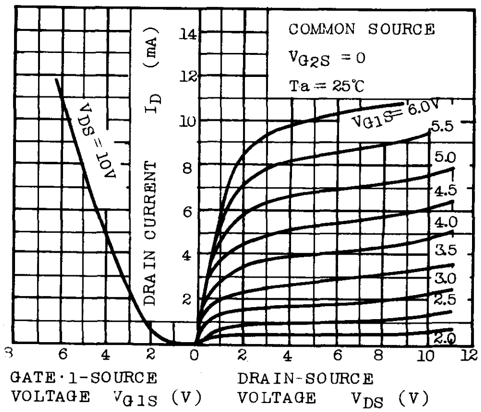
CAPACITANCE BRIDGE

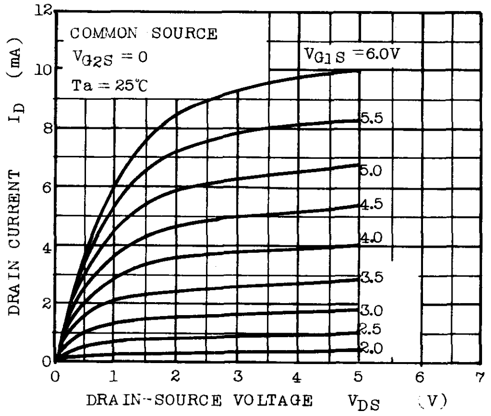
f = 1MHz

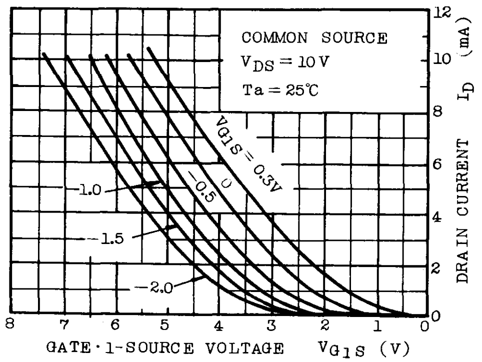
$V_{G1D} = 0$

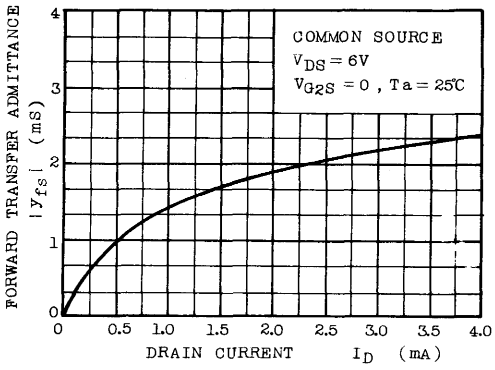
Fig.3 SWITCHING TIME TEST CIRCUIT



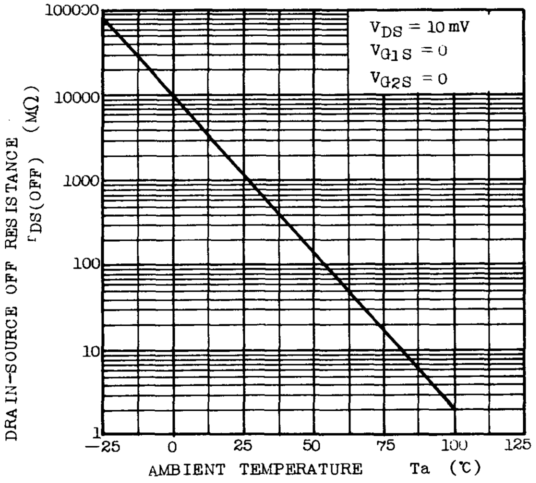

STATIC CHARACTERISTICS


I_D − V_{DS}

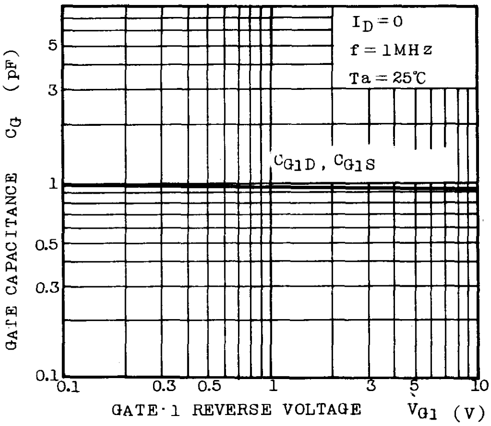

I_D − V_{G1S}


$|y_{fs}|$ − I_D

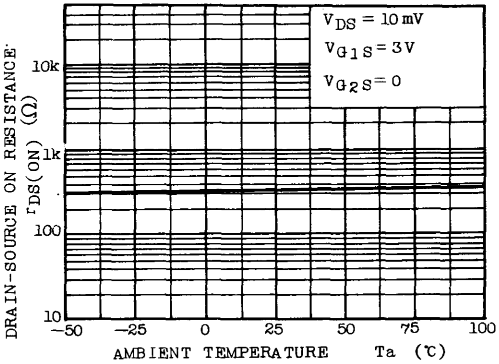
$r_{DS(OFF)}$ — Ta



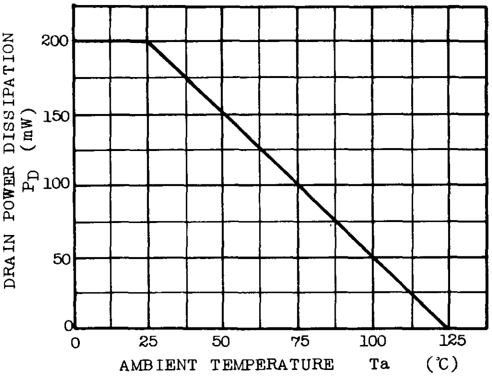
C_G — V_{G1}



$r_{DS(ON)}$ — Ta



P_D — Ta



3SK73

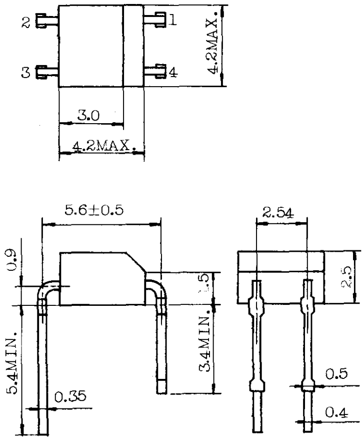
SILICON N CHANNEL DEPLETION DUAL INSULATED GATE MOS TYPE

FM TUNER, VHF AMPLIFIER APPLICATIONS.

FEATURES :

- Wide AGC Range and Few Changes of Response
- Extremely Low Reverse Transfer Capcitance
  : Crss=0.03pF (Typ.)
- Low Noise Figure
  : NF=2.2dB (Typ.) (f=100MHz)
- Possibility Low Operation Voltage.
- Superior Cross Modulation Performance.
- Contains Gate Protection Diodes.

Unit in mm



1. SOURCE
2. DRAIN
3. GATE 2
4. GATE 1

JEDEC	—
EIAJ	—
TOSHIBA	2 — 4D2A

Weight : 0.13g

MAXIMUM RATINGS (Ta=25°C)

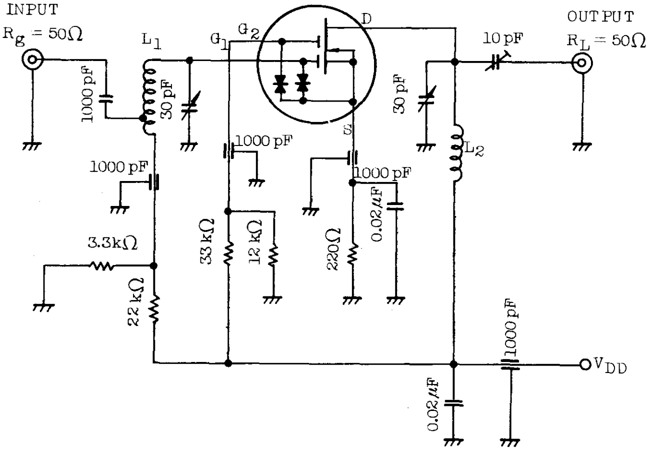
CHARACTERISTIC	SYMBOL	RATING	UNIT
Drain-Source Voltage	V_{DS}	20	V
Gate 1-Source Voltage	V_{G1S}	±9	V
Gate 2-Source Voltage	V_{G2S}	±9	V
Drain Current	I_D	30	mA
Drain Power Dissipation	P_D	300	mW
Channel Temperature	T_{ch}	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (COMMON SOURCE, Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate 1 Cut-off Current	I_{G1SS}	$V_{DS}=0, V_{G1S}=\pm7V, V_{G2S}=0$	-	-	±50	nA
Gate 2 Cut-off Current	I_{G2SS}	$V_{DS}=0, V_{G1S}=0, V_{G2S}=\pm7V$	-	-	±50	nA
Drain-Source Voltage	V_{DSX}	$V_{G1S}=-4V, V_{G2S}=-4V, I_D=100\mu A$	20	-	-	V
Drain Current	I_{DSS} (Note)	$V_{DS}=15V, V_{G1S}=0, V_{G2S}=4V$	3	-	14	mA
Gate1-Source Cut-off Voltage	$V_{G1S(OFF)}$	$V_{DS}=15V, V_{G2S}=4V, I_D=100\mu A$	-	-	-2.5	V
Gate2-Source Cut-off Voltage	$V_{G2S(OFF)}$	$V_{DS}=15V, V_{G1S}=0, I_D=100\mu A$	-	-	-2.5	V
Forward Transfer Admittance	$\|Y_{fs}\|$	$V_{DS}=15V$ $V_{G2S}=4V$, $I_D=10mA$, f=1kHz, G1 INPUT	-	20	-	mS
Input Capacitance	C_{iss}	$V_{DS}=15V$, $V_{G2S}=4V$, $I_D=10mA$, f=1MHz	-	5.0	-	pF
Reverse Transfer Capacitance	C_{rss}	$V_{DS}=15V$, $V_{G2S}=4V$, $I_D=10mA$, f=1MHz	-	0.03	0.05	pF
Power Gain	G_{ps}	$V_{DD}=15V$, f=100MHz (Fig.)	20	25	-	dB
Noise Figure	NF	$V_{DD}=15V$, f=100MHz (Fig.)	-	2.2	3.5	dB

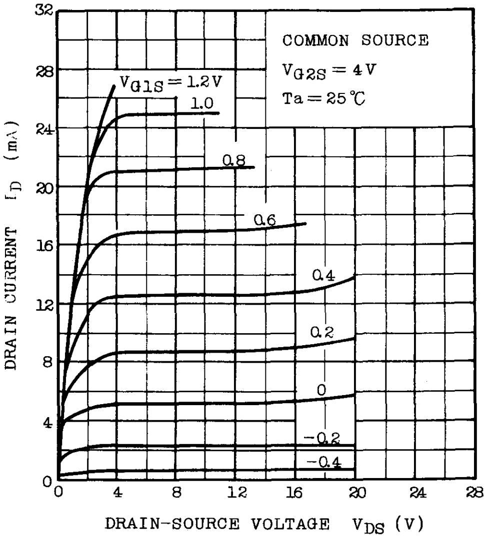
Note : I_{DSS} Classification Y : 3∿7, GR : 6∿14

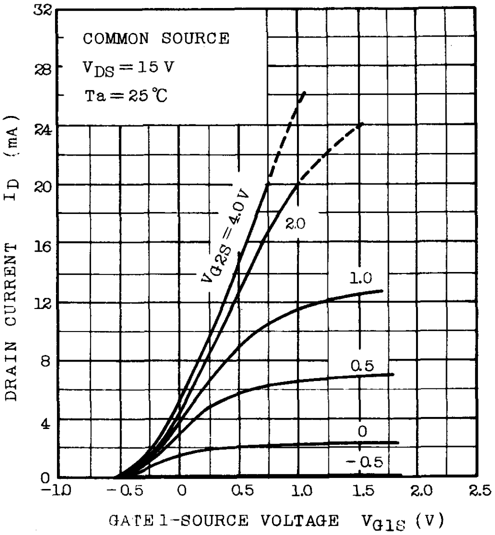
Fig. 100 MHz G_{ps}, NF TEST CIRCUIT

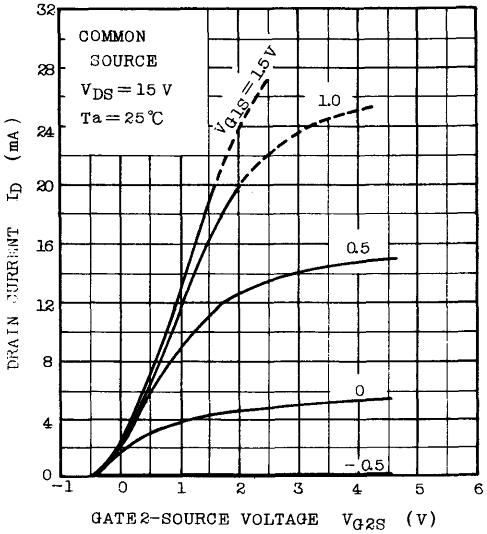


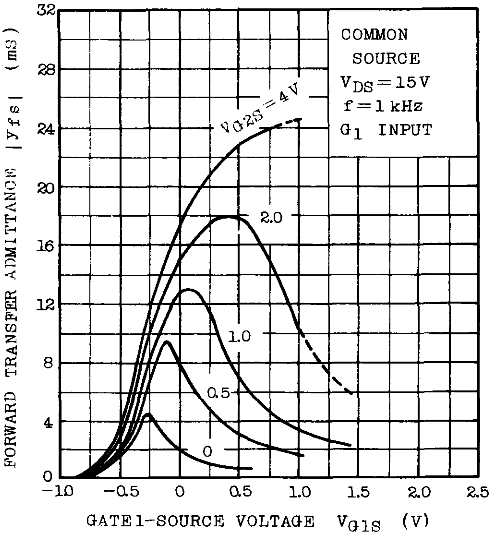
L_1 : 1.0mmØ SILVER PLATED COPPER WIRE
4.0T, 8 ID, TAPAT 1.0T FROM COLD END

L_2 : 1.0mmØ SILVER PLATED COPPER WIRE
3.0T, 8 ID, 10 LENGTH

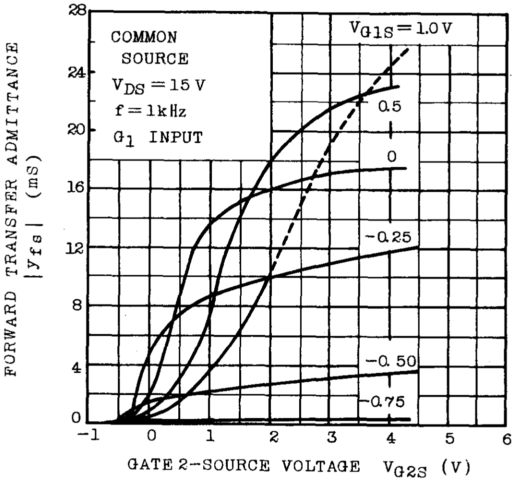

$I_D - V_{DS}$


$I_D - V_{G1S}$

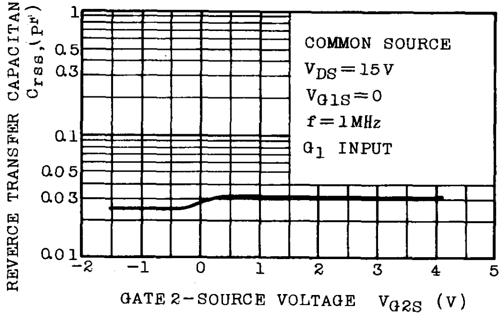

$I_D - V_{G2S}$


$|y_{fs}| - V_{G1S}$

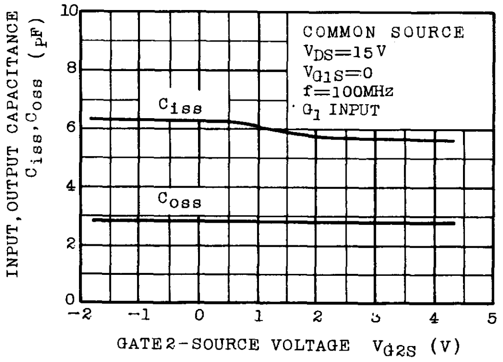
$|y_{fs}| - V_{G2S}$



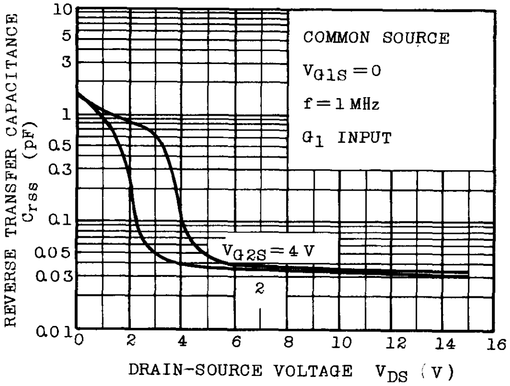
$C_{rss} - V_{G2S}$



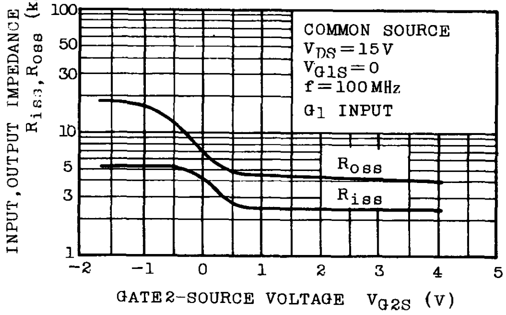
$C_{iss}, C_{oss} - V_{G2S}$



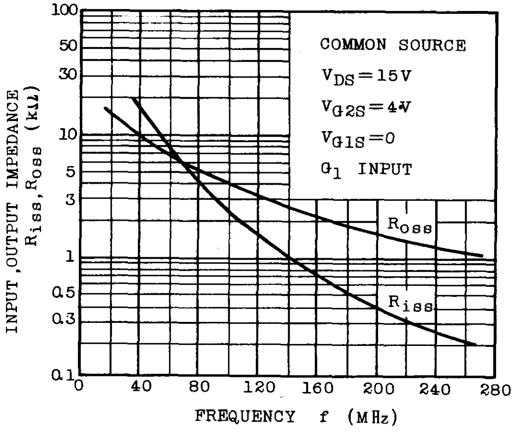
$C_{rss} - V_{DS}$



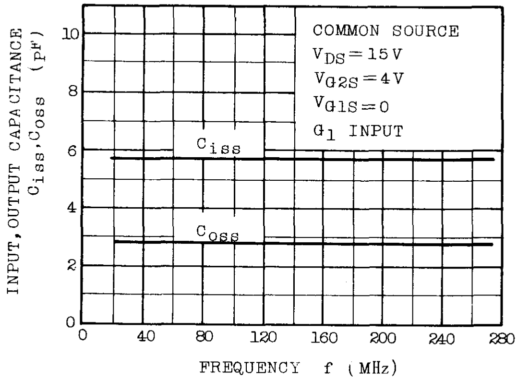
$R_{iss}, R_{oss} - V_{G2S}$



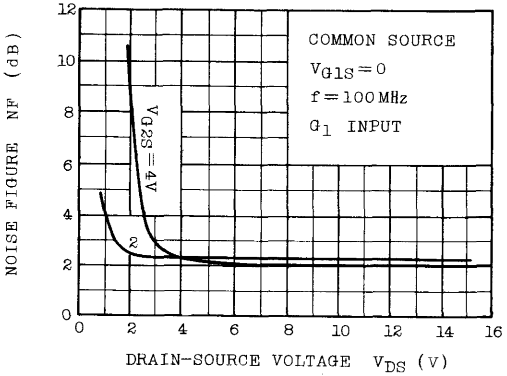
$R_{iss}, R_{oss} - f$



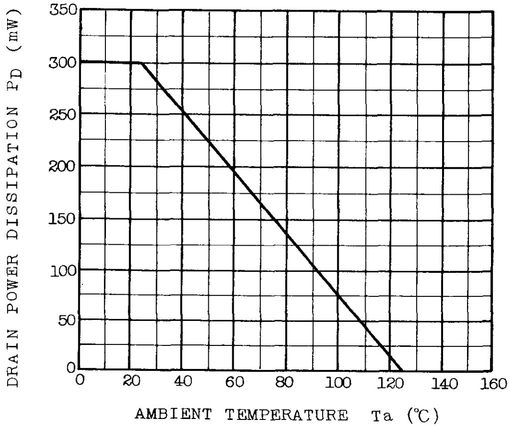
C_{iss}, C_{oss} - f



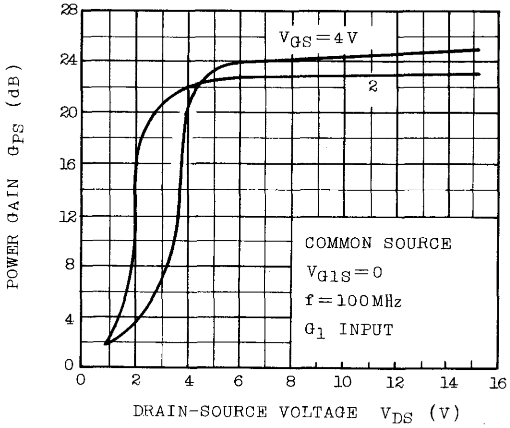
NF - V_{DS}



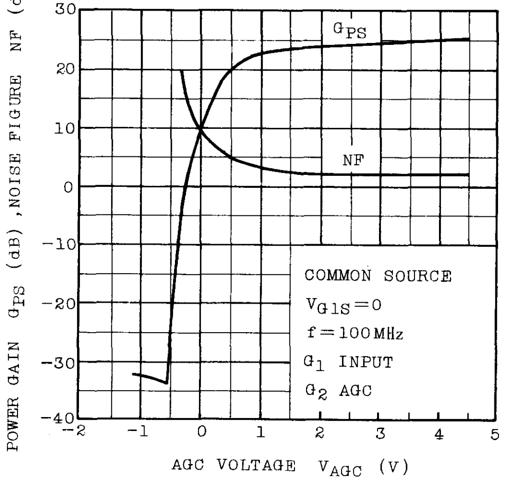
P_D - Ta



G_{PS} - V_{DS}



G_{PS}, NF - V_{AGC}



SILICON N CHANNEL DUAL GATE MOS TYPE

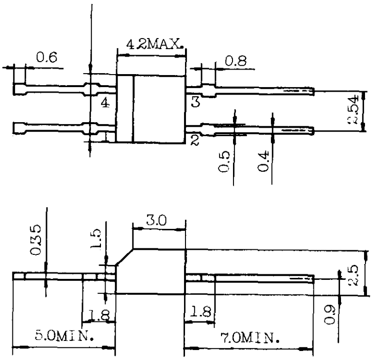
3SK77

VHF TV TUNER RF AMPLIFIER APPLICATIONS.

FEATURES:

- Extremely Low Reverse Transfer Capacitance.
  : C_{rss}=0.03pF (Typ.)
- Low Noise Figure : NF=2.2dB (Typ.) at f =200MHz
- Superior Cross Modulation Performance.
- Contains Gate Protection Diodes.

Unit in mm



1. SOURCE
2. DRAIN
3. GATE 2
4. GATE 1

JEDEC	—
EIAJ	—
TOSHIBA	2−4D1B

Weight : 0.12g

MAXIMUM RATINGS (Ta=25°C)

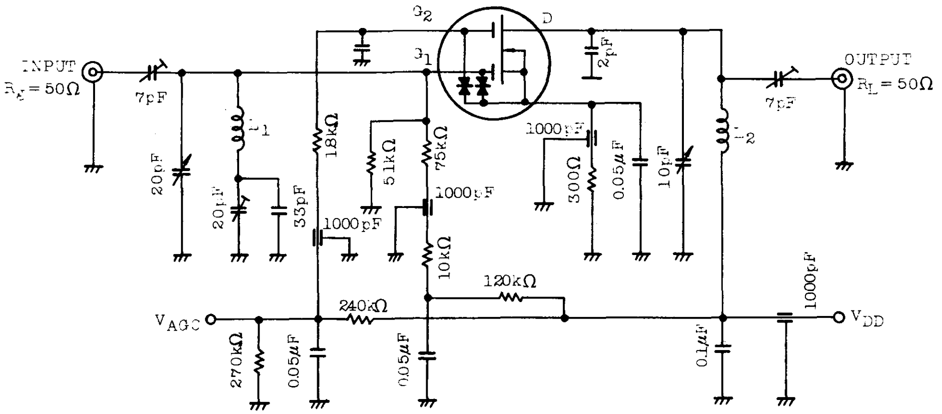
CHARACTERISTIC	SYMBOL	RATING	UNIT
Drain-Source Voltage	V_{DS}	20	V
Gate1-Source Voltage	V_{G1S}	±9	V
Gate2-Source Voltage	V_{G2S}	±9	V
Drain Current	I_D	30	mA
Drain Power Dissipation	P_D	300	mW
Channel Temperature	T_{ch}	125	°C
Storage Temperature Range	T_{stg}	-55∿125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate1 Leakage Current	I_{G1SS}	$V_{DS}=0, V_{G1S}=\pm 7V, V_{G2S}=0$	-	-	±50	nA
Gate2 Leakage Current	I_{G2SS}	$V_{DS}=0, V_{G1S}=0, V_{G2S}=\pm 7V$	-	-	±50	nA
Drain-Source Breakdown Voltage	$V_{(BR)DSX}$	$V_{G1S}=-4V, V_{G2S}=-4V$, $I_D=100\mu A$	20	-	-	V
Drain Current (Note)	I_{DSS}	$V_{DS}=15V, V_{G1S}=0, V_{G2S}=4V$	3	-	24	mA
Gate1-Source Cut-off Voltage	$V_{G1S(off)}$	$V_{DS}=15V, V_{G2S}=4V, I_D=100\mu A$	-0.3	-	-2.5	V
Gate2-Source Cut-off Voltage	$V_{G2S(off)}$	$V_{DS}=15V, V_{G1S}=0, I_D=100\mu A$	-0.3	-	-2.5	V
Forward Transfer Admittance	$\|Y_{fs}\|$	$V_{DS}=15V$, $V_{G2S}=4V$ $I_D=10mA$, f=1kHz	-	20	-	ms
Input Capacitance	C_{iss}	$V_{DS}=15V, V_{G2S}=4V$ $I_D=10mA$, f=1MHz	-	4.25	-	pF
Reverse Transfer Capacitance	C_{rss}	$V_{DS}=15V, V_{G2S}=4V$ $I_D=10mA$, f=1MHz	-	0.03	0.05	pF
Power Gain	G_{PS}	$V_{DD}=15V$, f=200MHz (Fig.)	16	20	-	dB
Noise Figure	NF	$V_{DD}=15V$, f=200MHz (Fig.)	-	2.2	3.2	dB

Note : I_{DSS} Classification Y : 3∿7, GR : 6∿14, BL : 12∿24

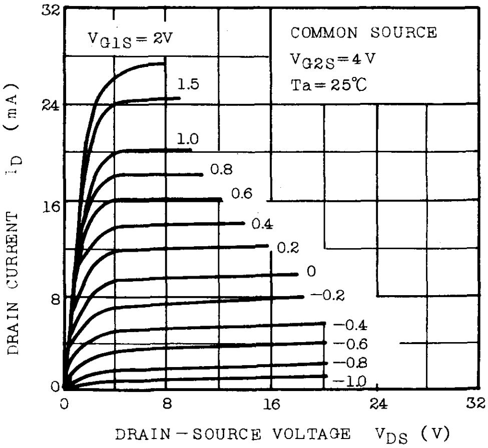
Fig. 200MHz G_{PS}, NF TEST CIRCUIT



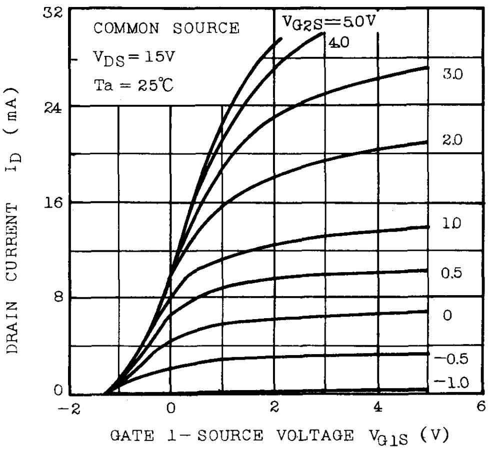
L_1 : 1.0mmø SILVER PLATED COPPER WIRE 1.0T 10ID

L_2 : 1.0mmø SILVER PLATED COPPER WIRE 1.5T 10ID

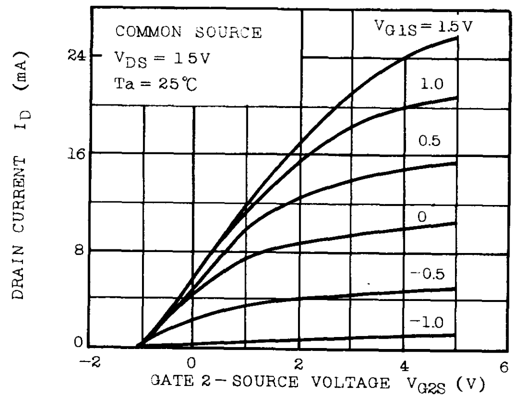
$I_D - V_{DS}$



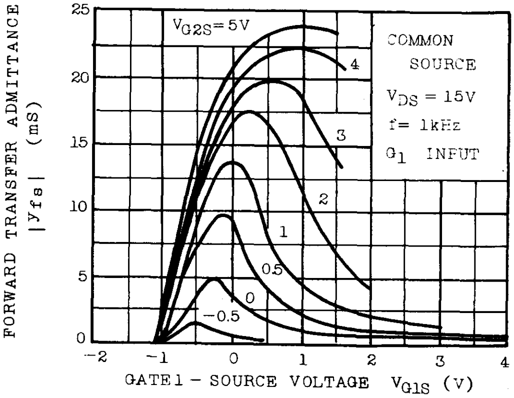
$I_D - V_{G1S}$



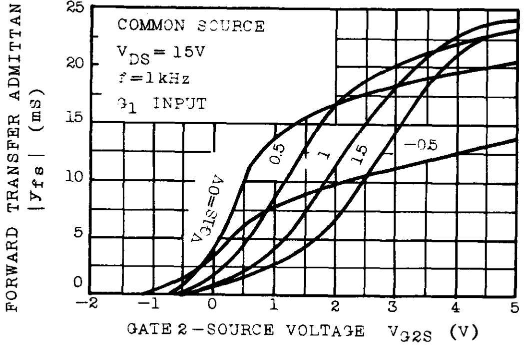
$I_D - V_{G2S}$



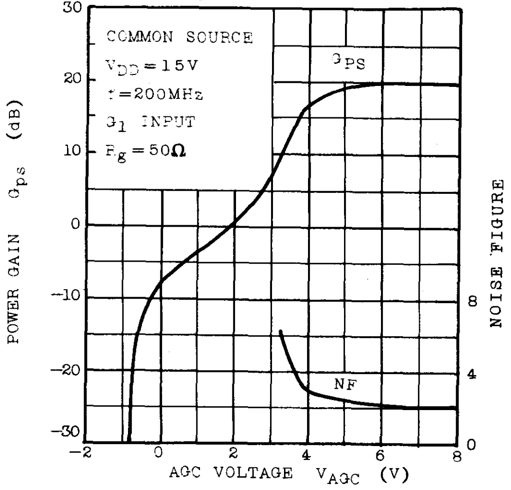
$|y_{fs}| - V_{G1S}$



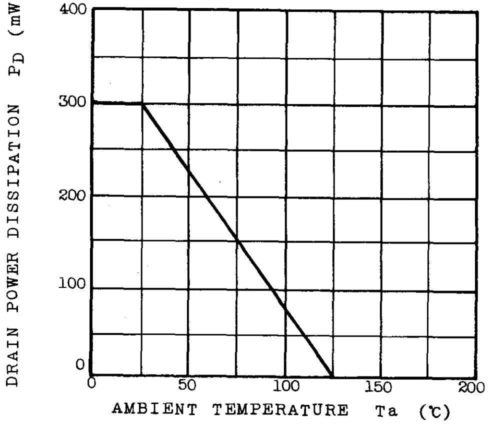
$|y_{fs}| - V_{G2S}$



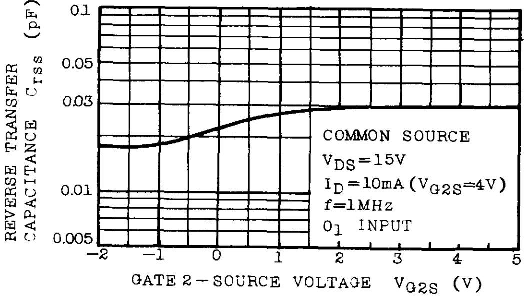
$G_{ps}, NF - V_{AGC}$



$P_D - Ta$



$C_{rss} - V_{G2S}$



3SK101

SILICON N CHANNEL DUAL GATE MOS TYPE

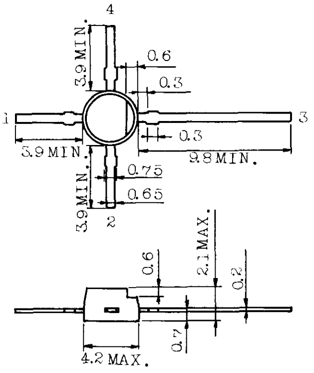
TV TUNER, VHF RF AMPLIFIER APPLICATIONS.

TV TUNER VHF MIXER APPLICATIONS.

FEATURES:

- Superior Cross Modulation Performance.
- Low Reverse Transfer Capacitance : C_{rss}=0.03pF(Typ.)
- Low Noise Figure : NF=2.2dB(Typ.)

Unit in mm



1. GATE 1
2. SOURCE
3. DRAIN
4. GATE 2

JEDEC	—
EIAJ	—
	2−4F1A

Weight : 0.08g

MAXIMUM RATINGS (Ta=25°C)

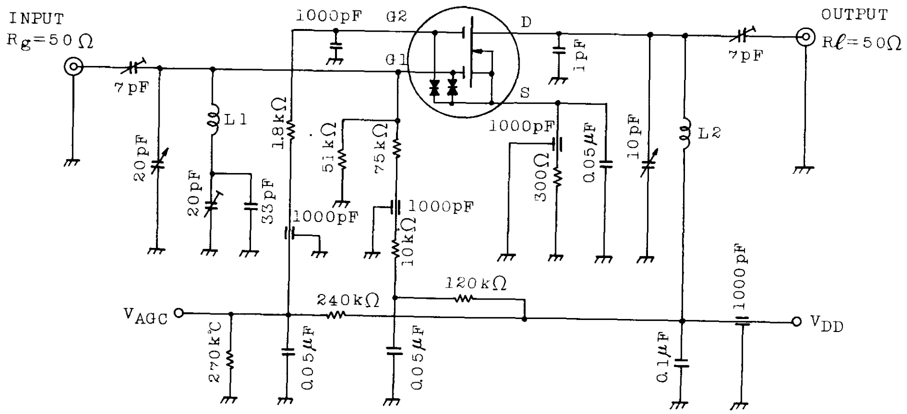
CHARACTERISTIC	SYMBOL	RATING	UNIT
Drain-Source Voltage	V_{DS}	20	V
Gate1-Source Voltage	V_{G1S}	±9	V
Gate2-Source Voltage	V_{G2S}	±9	V
Drain Current	I_D	30	mA
Drain Power Dissipation	P_D	200	mW
Channel Temperature	Tch	125	°C
Storage Temperature Range	Tstg	−55~+125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate1 Leakage Current	I_{G1SS}	V_{DS}=0, V_{G1S}=±7V, V_{G2S}=0	−	−	±50	nA
Gate2 Leakage Current	I_{G2SS}	V_{DS}=0, V_{G1S}=0, V_{G2S}=±7V	−	−	±50	nA
Drain-Source Voltage	$V_{(BR)DSX}$	V_{G1S}=−4V, V_{G2S}=−4V I_D=100μA	20	−	−	V
Drain Current	I_{DSS} (Note)	V_{DS}=15V, V_{G1S}=0, V_{G2S}=4V	3	−	24	mA
Gate1-Source Cut-off Voltage	$V_{G1S(OFF)}$	V_{DS}=15V, V_{G2S}=4V, I_D=100μA	0	−	−2.5	V
Gate2-Source Cut-off Voltage	$V_{G2S(OFF)}$	V_{DS}=15V, V_{G1S}=0, I_D=100μA	0	−	−2.5	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=15V, V_{G2S}=4V, I_D=10mA, f=1kHz	−	20	−	mS
Input Capacitance	C_{iss}	V_{DS}=15V, V_{G2S}=4V, I_D=10mA, f=1MHz	−	4.25	−	pF
Reverse Transfer Capacitance	C_{rss}		−	0.03	0.05	pF
Power Gain	G_{ps}	V_{DD}=15V, f=200MHz (Fig.)	16	20	−	dB
Noise Figure	NF		−	2.2	3.2	dB

Note : I_{DSS} Classification: Y:3.0~7.0 GR:6.0~14.0 BL:12.0~24.0 (mA)

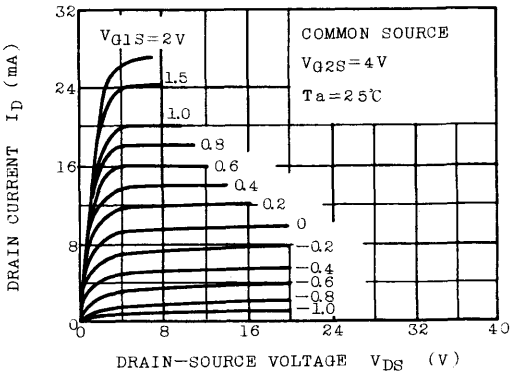
Fig. G_{ps}, NF TEST CIRCUIT



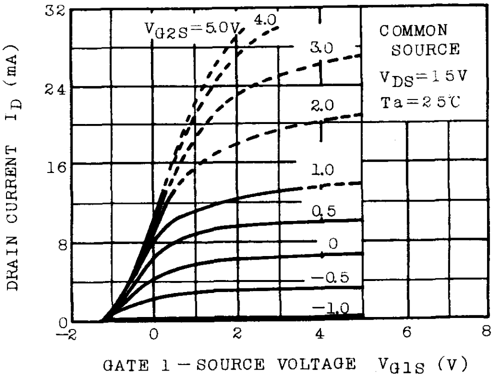
L1 : 1.0mmϕ SILVER PLATED COPPER WIRE 1.0T 10mm ID

L2 : 1.0mmϕ SILVER PLATED COPPER WIRE 1.5T 10mm ID

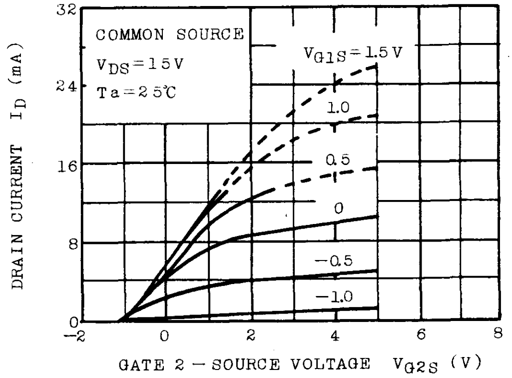
$I_D - V_{DS}$



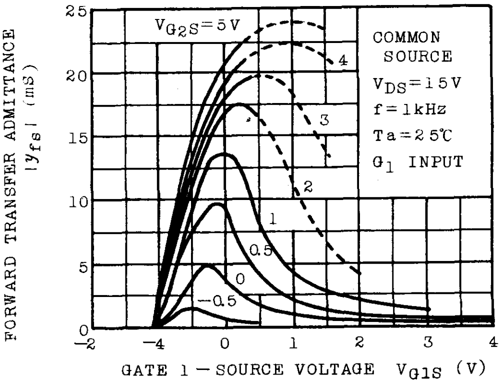
$I_D - V_{G1S}$



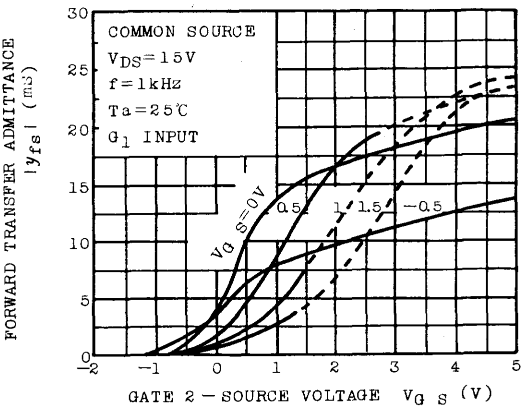
$I_D - V_{G2S}$



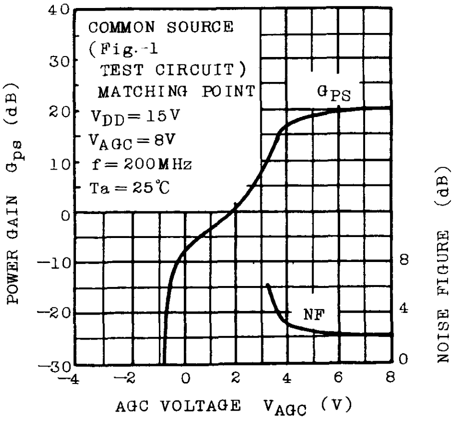
$|y_{fs}| - V_{G1S}$



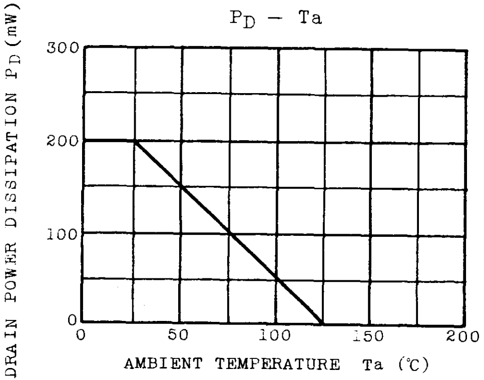
$|y_{fs}| - V_{G2S}$



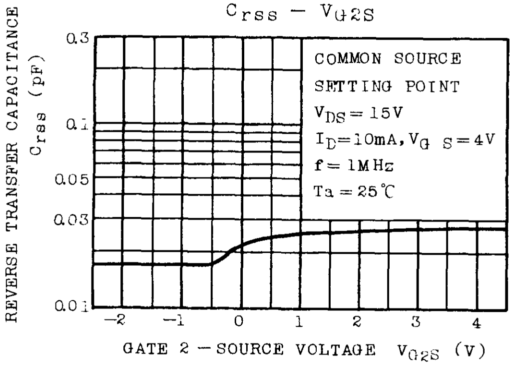
G_{ps}, NF − V_{AGC}



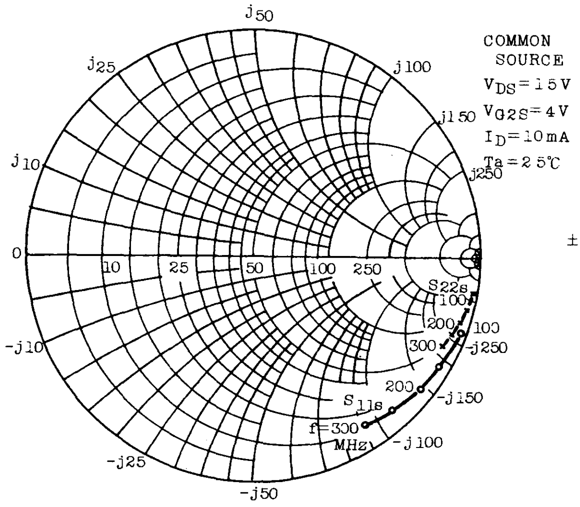
P_D — Ta



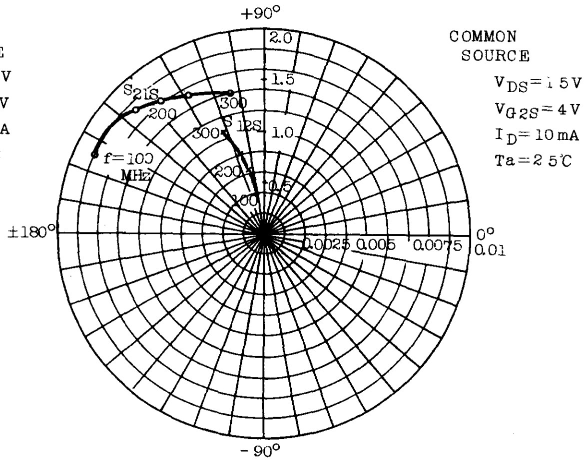
C_{rss} — V_{G2S}



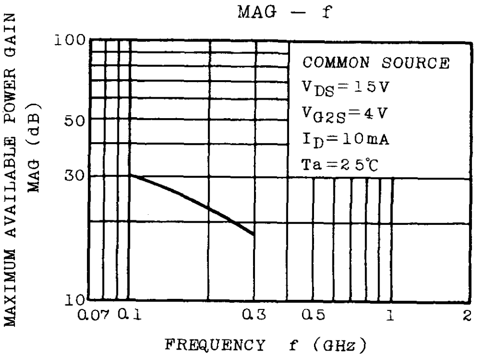
S_{11S}, S_{22S} — f



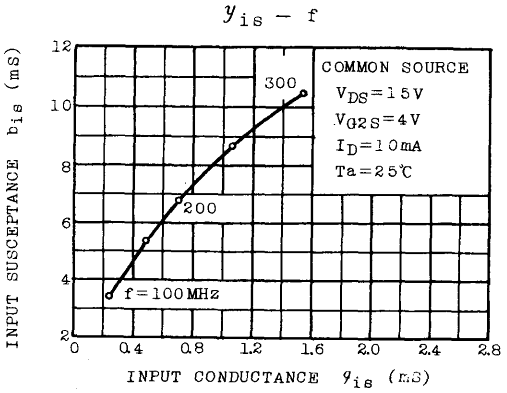
S_{12S}, S_{21S} — f



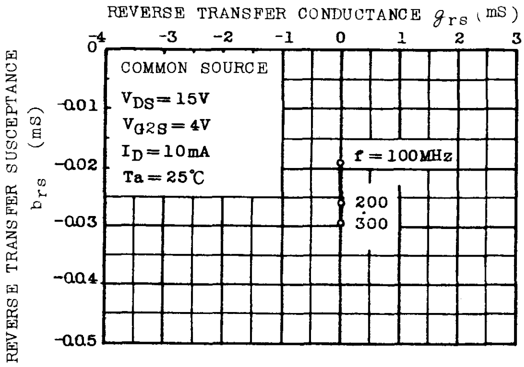
MAG — f



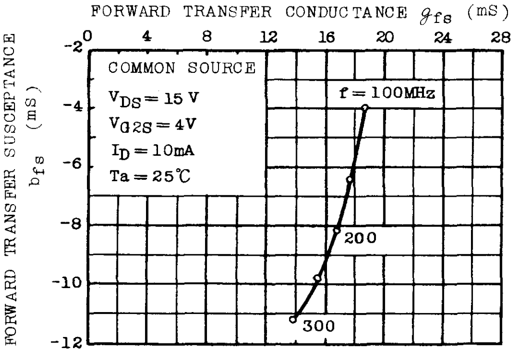
y_{is} — f



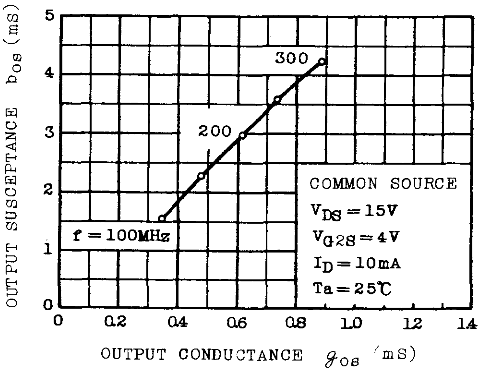
y_{rs} − f



y_{fs} − f



y_{os} − f



SILICON N CHANNEL DUAL GATE MOS TYPE

3SK102

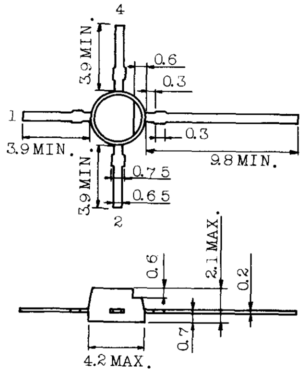
TV TUNER,UHF RF AMPLIFIER APPLICATIONS.

TV TUNER,UHF MIXER APPLICATIONS.

FEATURES:

- Superior Cross Modulation Performance.
- Low Reverse Transfer Capacitance : Crss=0.03pF(Max.)
- Low Noise Figure : NF=4.0dB(Typ.)

Unit in mm



1. GATE 1
2. SOURCE
3. DRAIN
4. GATE 2

JEDEC	—
EIAJ	—
TOSHIBA	2−4F1A

Weight : 0.08g

MAXIMUN RATINGS (Ta=25°C)

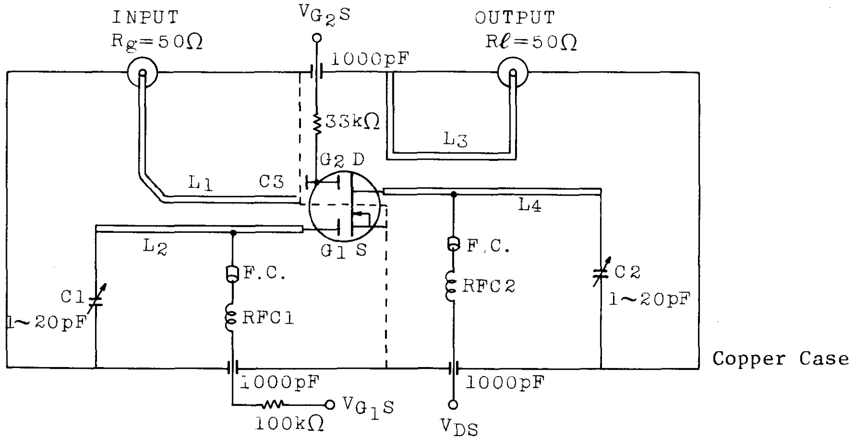
CHARACTERISTIC	SYMBOL	RATING	UNIT
Drain-Source Voltage	V_{DS}	20	V
Gate1-Source Voltage	V_{G1S}	±9	V
Gate2-Source Voltage	V_{G2S}	±9	V
Drain Current	I_D	30	mA
Drain Power Dissipation	P_D	200	mW
Channel Temperature	Tch	125	°C
Storage Temperature Range	Tstg	-55~+125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate1 Leakage Current	I_{G1SS}	$V_{DS}=0, V_{G1S}=\pm7V, V_{G2S}=0$	-	-	±50	nA
Gate2 Leakage Current	I_{G2SS}	$V_{DS}=0, V_{G1S}=0, V_{G2S}=\pm7V$	-	-	±50	nA
Drain-Source Voltage	$V_{(BR)DSX}$	$V_{G1S}=-4V$, $V_{G2S}=-4V$, $I_D=100\mu A$	20	-	-	V
Drain Current	I_{DSS} (Note)	$V_{DS}=15V, V_{G1S}=0, V_{G2S}=4V$	3	-	24	mA
Gate1-Source Cut-off Voltage	$V_{G1S(OFF)}$	$V_{DS}=15V, V_{G2S}=4V, I_D=100\mu A$	0	-	-3.5	V
Gate2-Source Cut-off Voltage	$V_{G2S(OFF)}$	$V_{DS}=15V, V_{G1S}=0, I_D=100\mu A$	0	-	-3.5	V
Forward Transfer Admittance	$\lvert Y_{fs}\rvert$	$V_{DS}=15V$, $V_{G2S}=4V$, $I_D=10mA$, f=1kHz	8	-	-	mS
Input Capacitance	Ciss	$V_{DS}=15V$, $V_{G2S}=4V$, $I_D=10mA$, f=1MHz	-	1.7	-	pF
Reverse Transfer Capacitance	Crss		-	-	0.03	pF
Power Gain	Gps	$V_{DS}=15V$, $V_{G2S}=4V$, $I_D=10mA$, f=800MHz (Fig.)	-	16	-	dB
Noise Figure	NF		-	4.0	5.0	dB

Note : I_{DSS} Classification: Y:3.0~7.0 GR:6.0~14.0 BL:12.0~24.0 (mA)

Fig. Gps, NF TEST CIRCUIT



L1~ L4 ; 1.0mmϕ SILVER PLATED COPPER WIRE

RFC1 ; 0.35mmϕ COPPER WIRE 7.0T 3mm ID

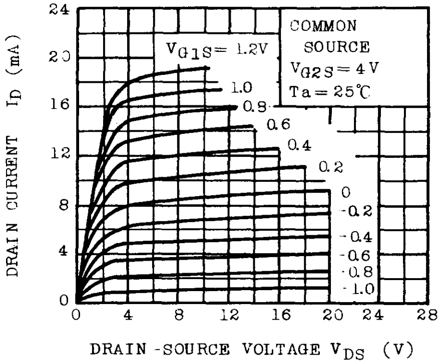
RFC2 ; 0.35mmϕ COPPER WIRE 10.0T 3mm ID

C1, C2 ; AIR TRIMMER TTA25A200A MURATA MFG. CO., LTD. or EQUIVALENT

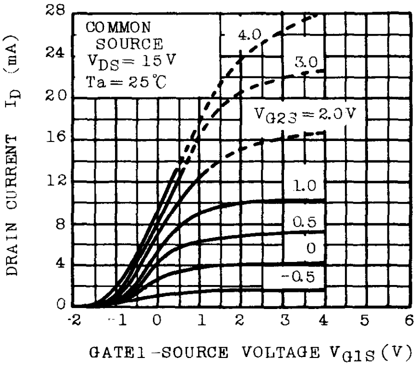
C3 ; 1000pF DISC CAPACITOR

F.C. ; FERRITE CORE

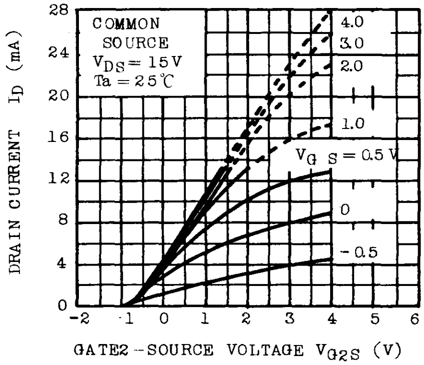
I_D – V_{DS}



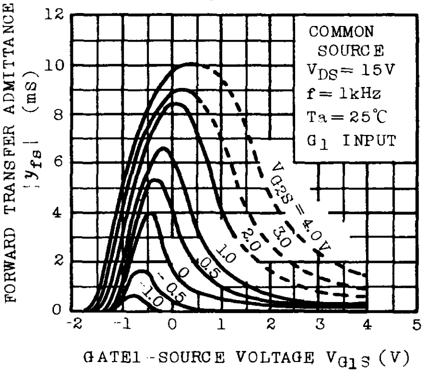
I_D – V_{G1S}



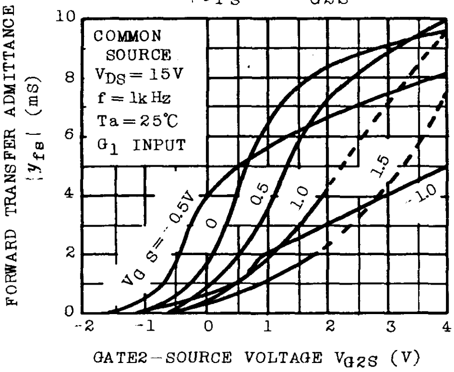
I_D – V_{G2S}



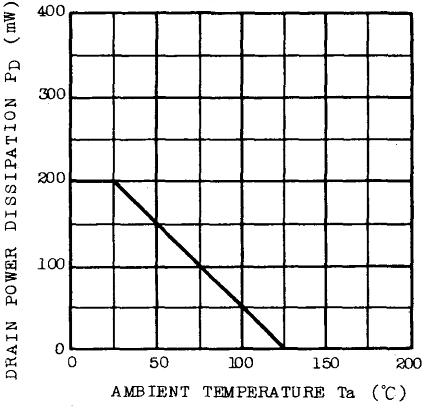
y_{fs} – V_{G1S}

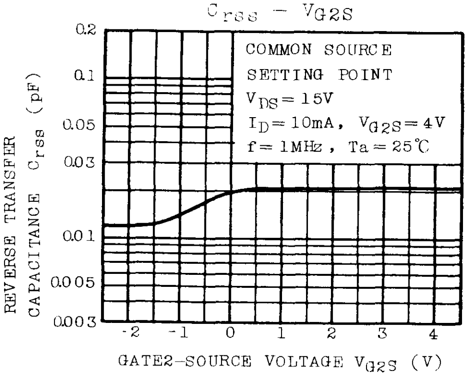


$|y_{fs}|$ – V_{G2S}

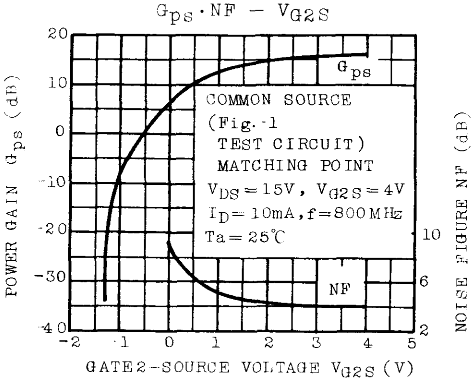


P_D – Ta

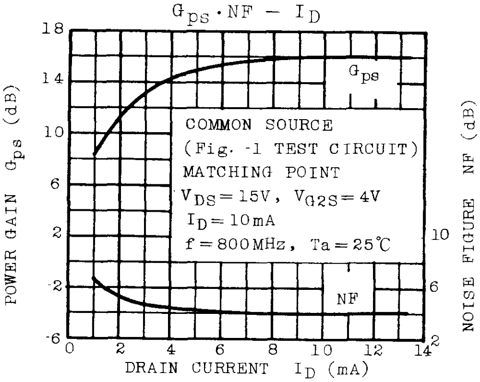




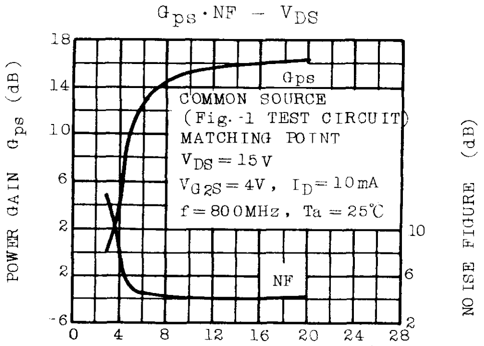
$C_{rss} - V_{G2S}$



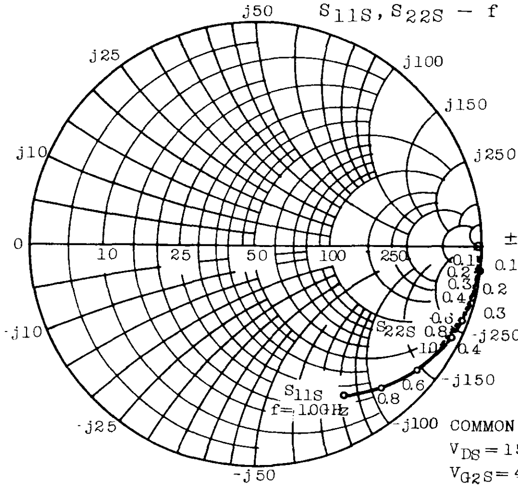
$G_{ps}\cdot NF - V_{G2S}$



$G_{ps}\cdot NF - I_D$

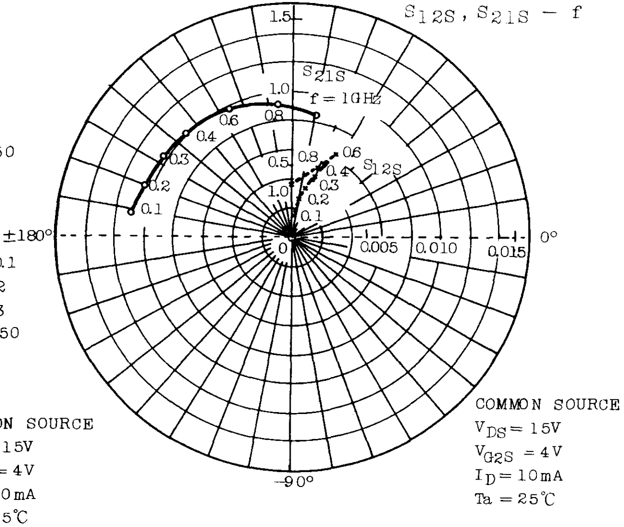


$G_{ps}\cdot NF - V_{DS}$



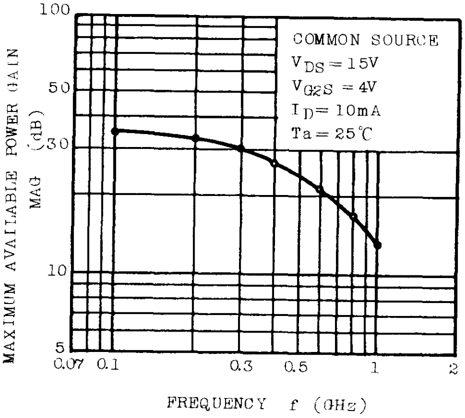
$S_{11S}, S_{22S} - f$

COMMON SOURCE
V_{DS} = 15V
V_{G2S}= 4V
I_D= 10mA
Ta= 25℃

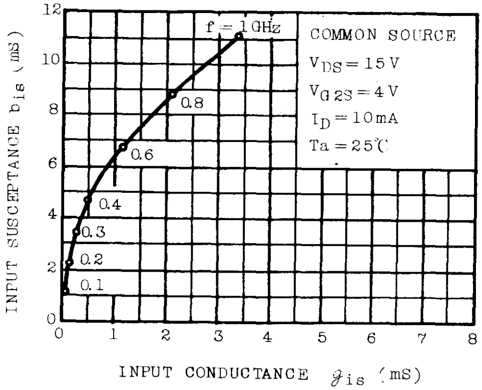


$S_{12S}, S_{21S} - f$

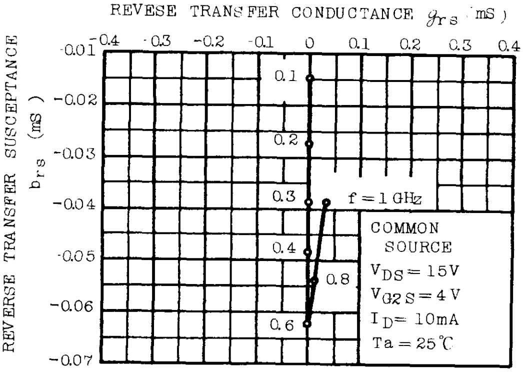
MAG − f



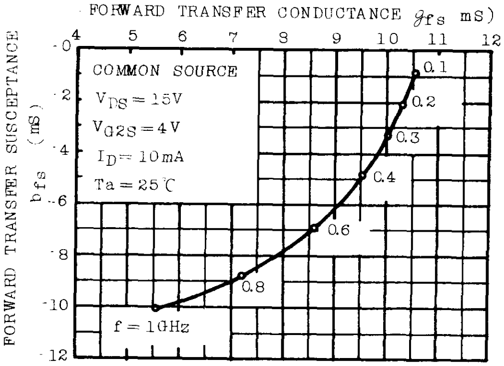
y_{is} − f



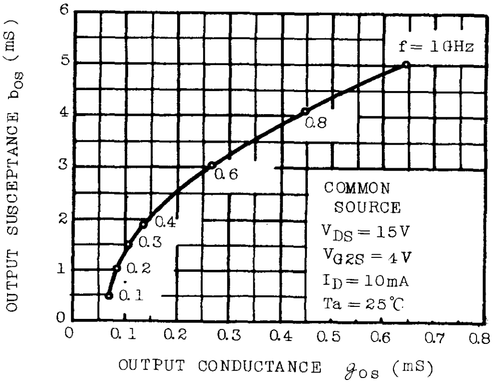
y_{rs} − f



y_{fs} − f



y_{os} − f



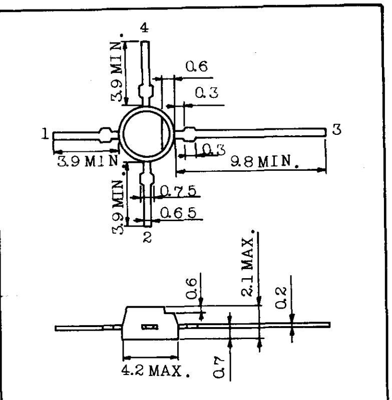
3SK114

SILICON N CHANNEL DUAL GATE MOS TYPE

TV TUNER, VHF RF AMPLIFIER APPLICATIONS.

TV TUNER VHF MIXER APPLICATIONS.

Unit in mm



1. GATE 1
2. SOURCE
3. DRAIN
4. GATE 2

JEDEC	–
EIAJ	–
TOSHIBA	2–4F1A

Weight : 0.08g

FEATURES:

- Superior Cross Modulation Performance.
- Low Reverse Transfer Capacitance : C_{rss}=0.03pF (Typ.)
- Low Noise Figure : NF=1.4dB(Typ.)

MAXIMUM RATINGS (Ta=25°C)

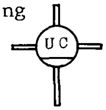
CHARACTERISTIC	SYMBOL	RATING	UNIT
Drain-Source Voltage	V_{DS}	15	V
Gate 1 - Source Voltage	V_{G1S}	±9	V
Gate 2 - Source Voltage	V_{G2S}	±9	V
Drain Current	I_D	30	mA
Drain Power Dissipation	P_D	200	mW
Channel Temperature	Tch	125	°C
Storage Temperature Range	Tstg	-55~+125	°C

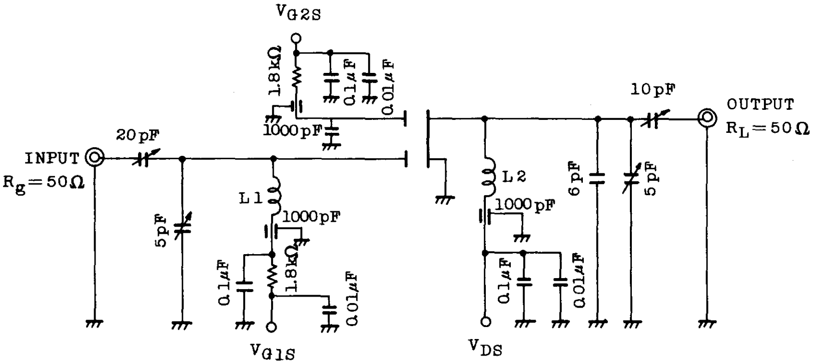
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate 1 Leakage Current	I_{G1SS}	V_{DS}=0, V_{G1S}=±7V, V_{G2S}=0	-	-	±50	nA
Gate 2 Leakage Current	I_{G2SS}	V_{DS}=0, V_{G1S}=0, V_{G2S}=±7V	-	-	±50	nA
Drain-Source Voltage	$V_{(BR)DSX}$	V_{G1S}=-4V, V_{G2S}=-4V I_D=100μA	15	-	-	V
Drain Current	I_{DSS} (Note)	V_{DS}=6V, V_{G1S}=0, V_{G2S}=3V	0	-	6	mA
Gatel-Source Cut-off Voltage	$V_{G1S(OFF)}$	V_{DS}=6V, V_{G2S}=3V, I_D=100μA	-1	-	1	V
Gate2-Source Cut-off Voltage	$V_{G2S(OFF)}$	V_{DS}=6V, V_{G1S}=3V, I_D=100μA	-0.5	-	1	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=6V, V_{G2S}=3V, I_D=10mA, f=1kHz	13	20	-	mS
Input Capacitance	Ciss	V_{DS}=6V, V_{G2S}=3V I_D=10mA, f=1MHz	-	4.25	5.5	pF
Reverse Transfer Capacitance	Crss		-	0.03	0.05	pF
Power Gain	Gps	V_{DS}=6V, V_{G2S}=3V I_D=10mA, f=200MHz	20	25	-	dB
Noise Figure	NF		-	1.4	2.8	dB

Note : I_{DSS} Classification O : 0~2mA, Y : 1~6mA

Marking

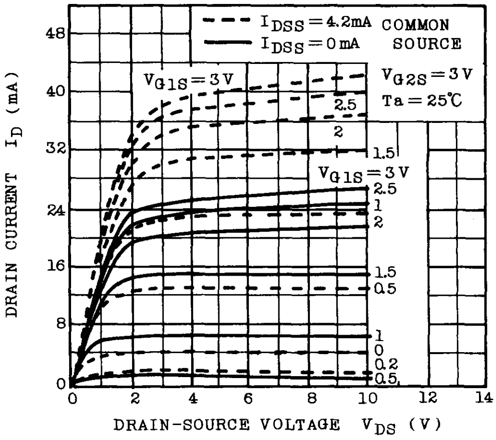




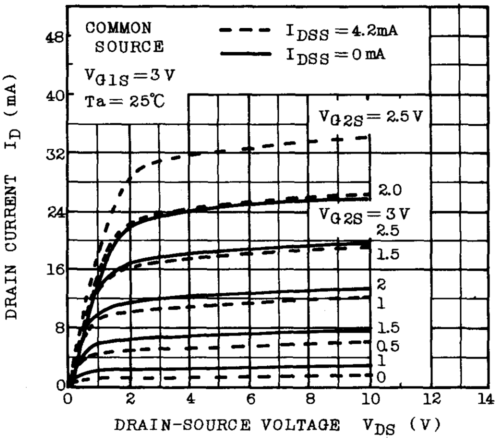
L1 : 1mmϕ Ag Plated Copper Wire, 2 Turns, 8mm ID

L2 : 1mmϕ Ag Plated Copper Wire, 2.5 Turns, 8mm ID

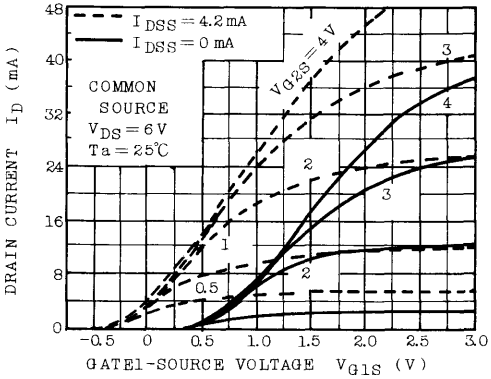
$I_D - V_{DS}$



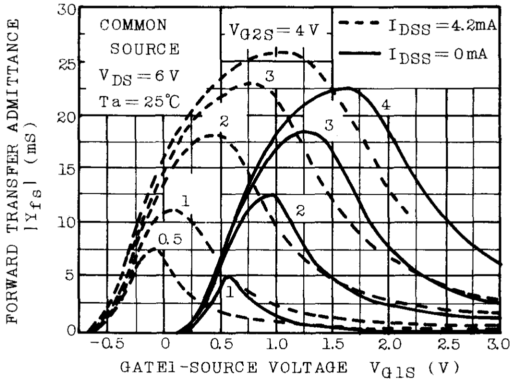
$I_D - V_{DS}$



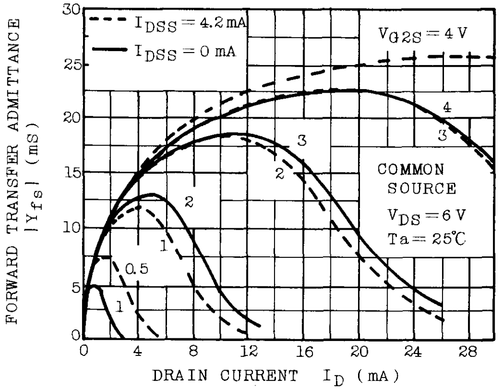
I_D — V_{G1S}



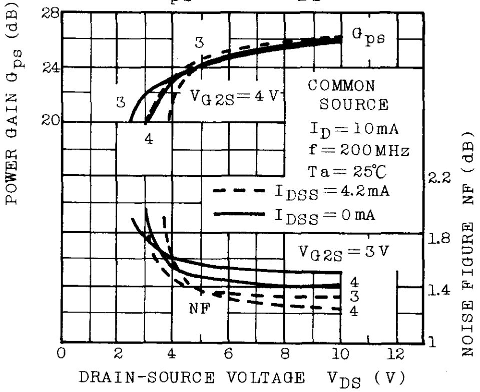
|Yfs| — V_{G1S}



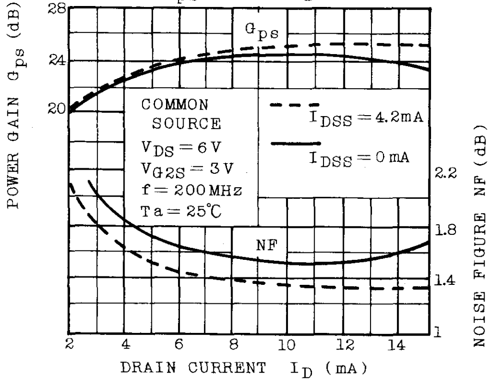
|Yfs| — I_D



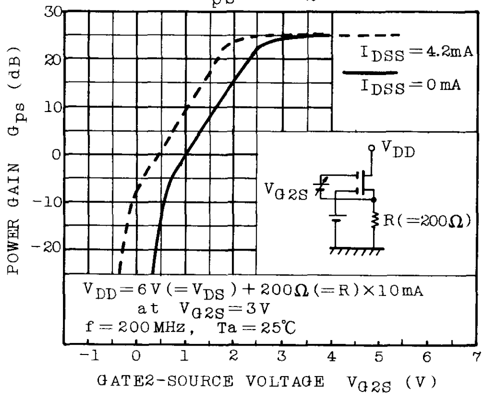
G_{ps}, NF — V_{DS}

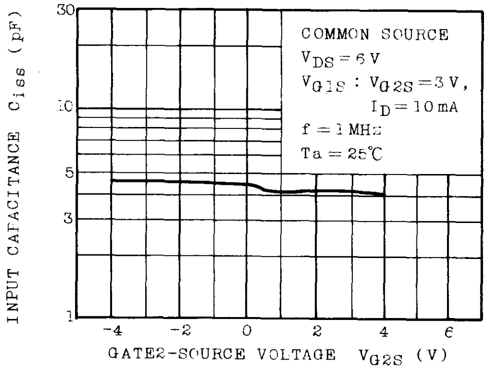


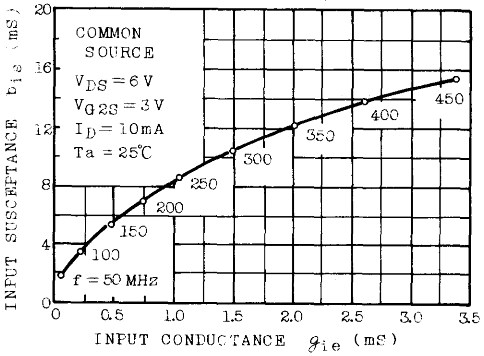
G_{ps}, NF — I_D

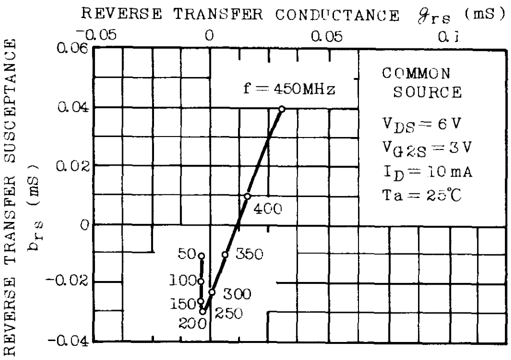


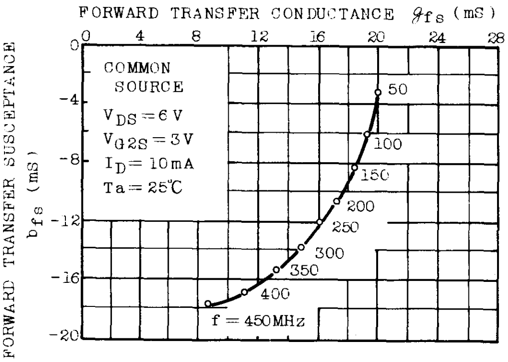
G_{ps} — V_{G2S}

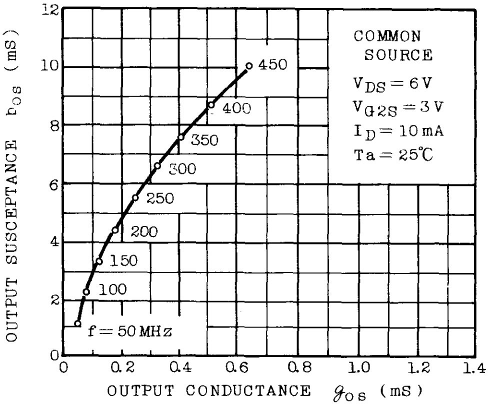


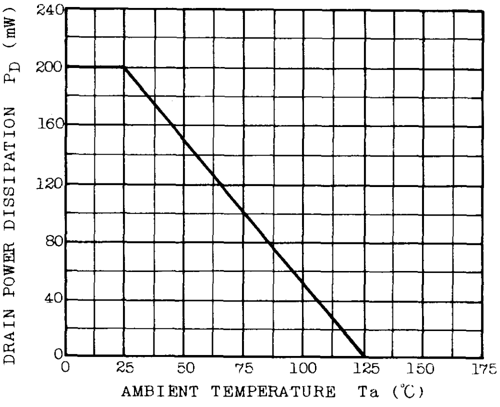

C_{iss} − V_{G2S}


Y_{is} − f


Y_{rs} − f


Y_{fs} − f


Y_{os} − f


P_D − Ta

3SK115

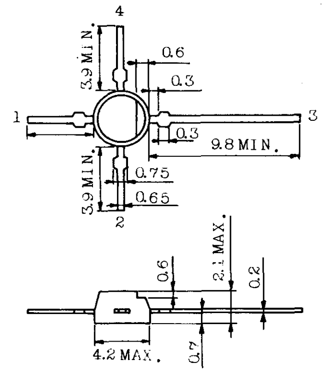
SILICON N CHANNEL DUAL GATE MOS TYPE

TV TUNER, UHF RF AMPLIFIER APPLICATION.

FEATURES:

- Superior Cross Modulation Performance
- Low Crss : C_{rss}=0.03pF
- Low Noise : NF=3.2dB

Unit in mm



1. GATE 1
2. SOURCE
3. DRAIN
4. GATE 2

JEDEC	–
EIAJ	–
TOSHIBA	2–4F1A

Weight : 0.08g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Drain-Source Voltage	V_{DS}	15	V
Gate1-Source Voltage	V_{G1S}	±8	V
Gate2-Source Voltage	V_{G2S}	±8	V
Drain Current	I_D	30	mA
Power Dissipation	P_D	200	mW
Channel Temperature	T_{ch}	125	°C
Storage Temperature Range	T_{stg}	-55~ +125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate1 Leakage Current	I_{G1SS}	$V_{DS}=0,\ V_{G1S}=\pm 6V,\ V_{G2S}=0$	-	-	±50	nA
Gate2 Leakage Current	I_{G2SS}	$V_{DS}=0,\ V_{G1S}=0,\ V_{G2S}=\pm 6V$	-	-	±50	nA
Drain Source Voltage	$V_{(BR)DSX}$	$V_{G1S}=-4V,\ V_{G2S}=-4V$ $I_D=100\mu A$	15	-	-	V
Drain Current	I_{DSS} (Note)	$V_{DS}=6V,\ V_{G1S}=0,\ V_{G2S}=3V$	0	-	6	mA
Gate1-Source Cut-off Voltage	$V_{G1S(OFF)}$	$V_{DS}=6V, V_{G2S}=3V, I_D=100\mu A$	-1.5	-	+1	V
Gate2-Source Cut-off Voltage	$V_{G2S(OFF)}$	$V_{DS}=6V, V_{G1S}=3V, I_D=100\mu A$	-1.0	-	+1	V
Forward Transfer Admittance	$\|Y_{fs}\|$	$V_{DS}=6V,\ V_{G2S}=3V$ $I_D=10mA,\ f=1kHz$	-	17	-	mS
Input Capacitance	C_{iss}	$V_{DS}=6V,\ V_{G2S}=3V$ $I_D=10mA,\ f=1MHz$	-	2.0	-	pF
Reverse Transfer Capacitance	C_{rss}		-	0.02	0.03	pF
Power Gain	G_{ps}	$V_{DS}=6V,\ V_{G2S}=3V$ $I_D=10mA,\ f=800MHz$	13	16	-	dB
Noise Figure	NF		-	3.2	4.5	dB

Note : I_{DSS} Classification O : 0~2mA, Y : 1~6mA

Marking

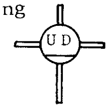
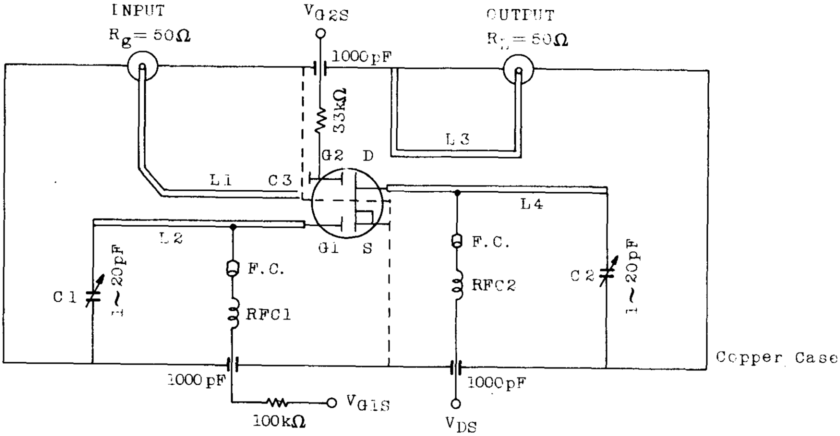
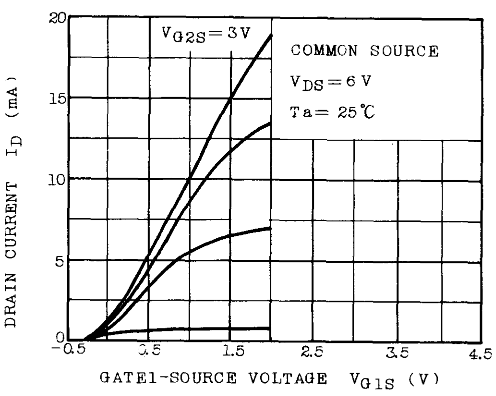


Fig. 1 800MHz Gps, NF TEST CIRCUIT

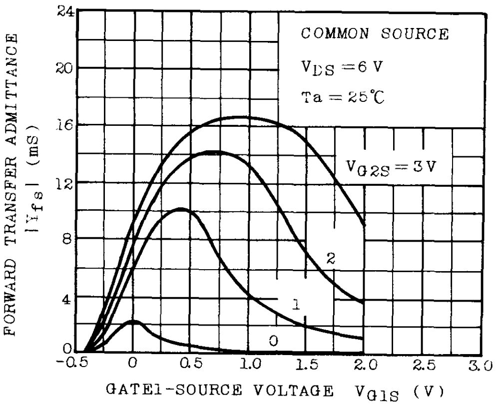


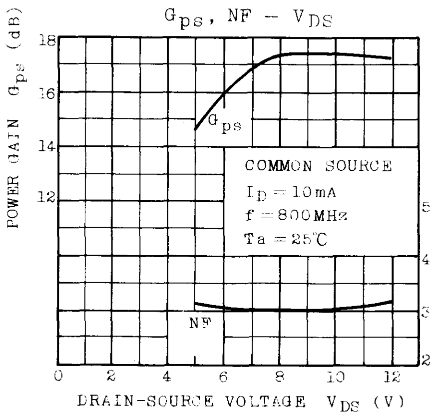
L1 ~ L4 : 1.0mmφ SILVER PLATED COPPER WIRE
RFC1 : 0.35mmφ COPPER WIRE 7.0T 3mm ID
RFC2 : 0.35mmφ COPPER WIRE 10.0T 3mm ID
C1,C2 : AIR TRIMMER TTA25A200A(MURATA MFG. Co., LTD.) OR EQUIVALENT
C3 : 1000pF DISC CAPACITOR
F.C : FERRATE CORE

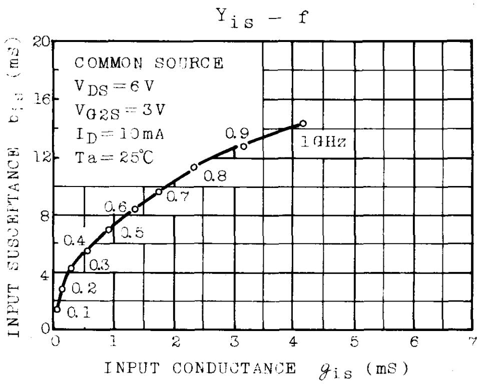
$I_D - V_{G1S}$

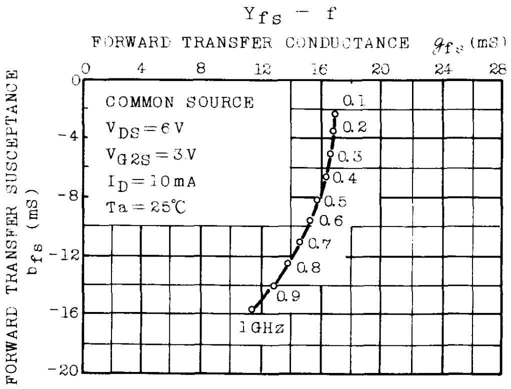


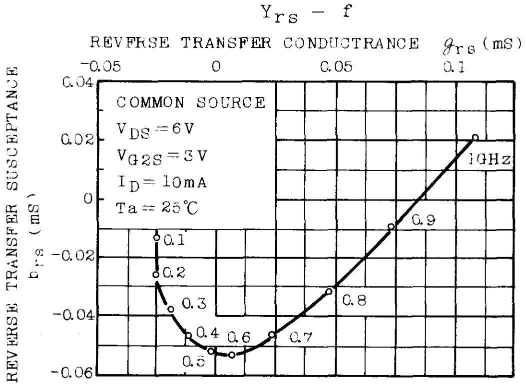
$|Y_{fs}| - V_{G1S}$

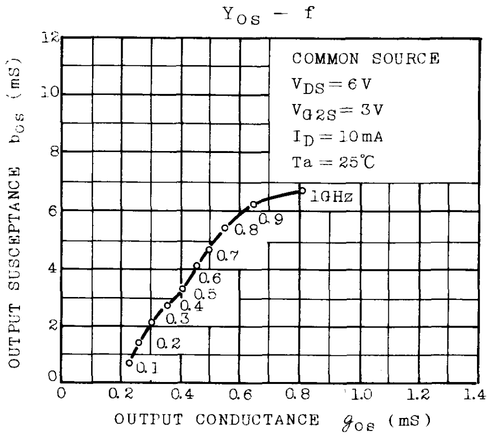


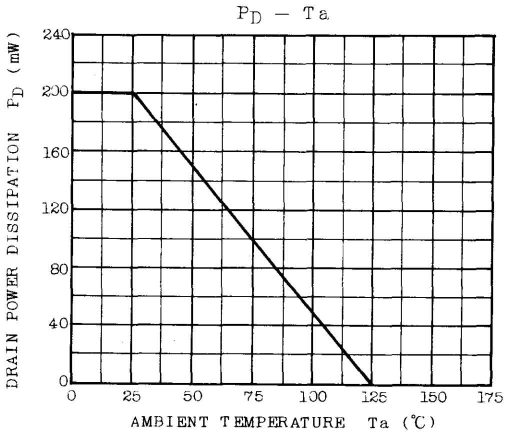

G_{ps}, NF — V_{DS}


Y_{is} — f


Y_{fs} — f


Y_{rs} — f


Y_{os} — f


P_D — Ta

GaAs N-CHANNEL DUAL GATE MES TYPE

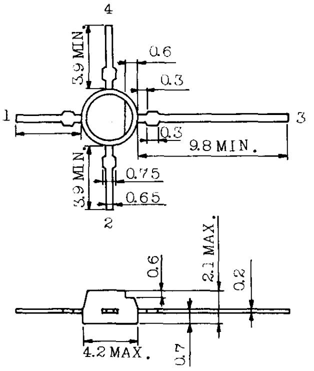
3SK121

TV TUNER, UHF RF AMPLIFIER APPLICATIONS.

FEATURES:

- Superior Cross Modulation Performance
- Low Reverse Transfer Capacitance : C_{rss}=20fF (Typ.)
- Low Noise Figure : NF=1.5dB (Typ.)

Unit in mm



1. GATE 1
2. SOURCE
3. DRAIN
4. GATE 2

JEDEC	—
EIAJ	—
TOSHIBA	2-4F1A

Weight : 0.08g

MAXIMUM RATINGS (Ta=25°C)

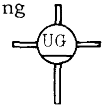
CHARACTERISTIC	SYMBOL	RATING	UNIT
Drain-Source Voltage	V_{DS}	10	V
Gate1-Source Voltage	V_{G1S}	-6	V
Gate2-Source Voltage	V_{G2S}	-6	V
Drain Current	I_D	50	mA
Power Dissipation	P_D	200	mW
Channel Temperature	T_{ch}	125	°C
Storage Temperature Range	T_{stg}	-55~+125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Gate1 Leakage Current	I_{G1SS}	V_{DS}=0, V_{G1S}=-5V, V_{G2S}=0	-	-	20	μA
Gate2 Leakage Current	I_{G2SS}	V_{DS}=0, V_{G1S}=0, V_{G2S}=-5V	-	-	20	μA
Drain-Source Current	I_{DSX}	V_{G1S}=-5V, V_{G2S}=-5V V_{DS}=10V	-	-	100	μA
Drain Current	I_{DSS} (Note)	V_{DS}=5V, V_{G1S}=0, V_{G2S}=0	20	-	45	mA
Gate1-Source Cut-off Voltage	$V_{G1S(OFF)}$	V_{DS}=5V, V_{G2S}=0, I_D=100μA	-	-2.5	-4	V
Gate2-Source Cut-off Voltage	$V_{G2S(OFF)}$	V_{DS}=5V, V_{G1S}=0, I_D=100μA	-	-2.5	-4	V
Forward Transfer Admittance	$\|Y_{fs}\|$	V_{DS}=5V, V_{G2S}=0 I_D=10mA, f=1kHz	-	17	-	mS
Input Capacitance	C_{iss}	V_{DS}=5V, V_{G2S}=0 I_D=10mA, f=1MHz	-	0.9	2.0	pF
Reverse Transfer Capacitance	C_{rss}		-	0.02	0.05	pF
Power Gain	G_{ps}	V_{DS}=5V, V_{G2S}=1V, I_D=10mA, f=800MHz Fig.1	16	20.5	-	dB
Noise Figure	NF		-	1.5	2.5	dB

Note : I_{DSS} Classification Y : 20~35mA, GR : 30~45mA

Marking



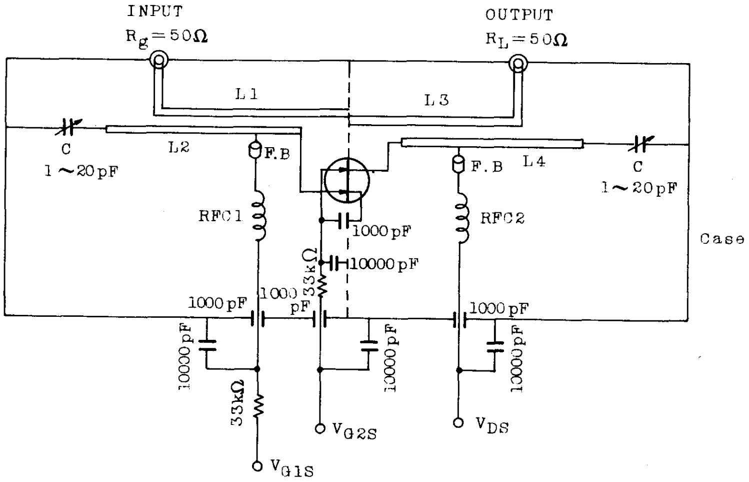
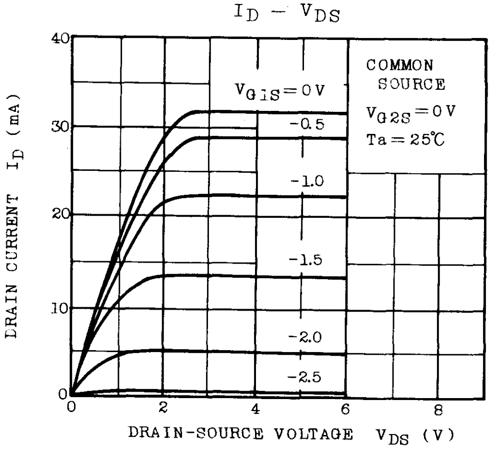
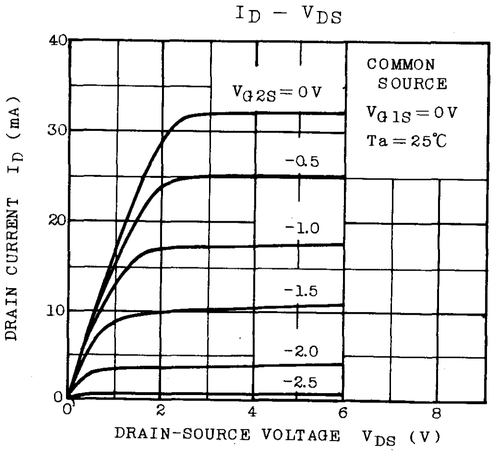


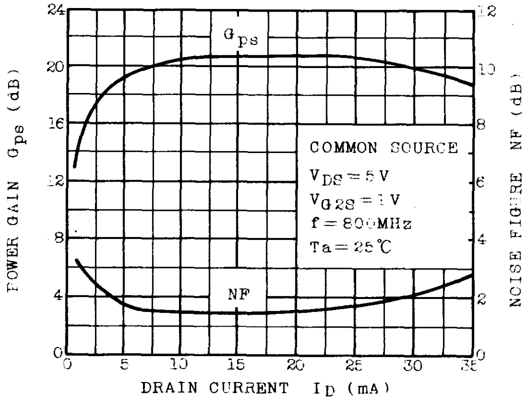
Fig. 1 800MHz G_{ps}, NF TEST CIRCUIT

L1 ~ L4 : 1.0mmϕ SILVER PLATED COPPER WIRE
C : AIR TRIMMER TTA25A200A (MURATA MFG. Co., LTD.)
RFC1 : 0.35mmϕ COPPER WIRE 3mm ID, 7T
RFC2 : 0.35mmϕ COPPER WIRE 3mm ID, 10T

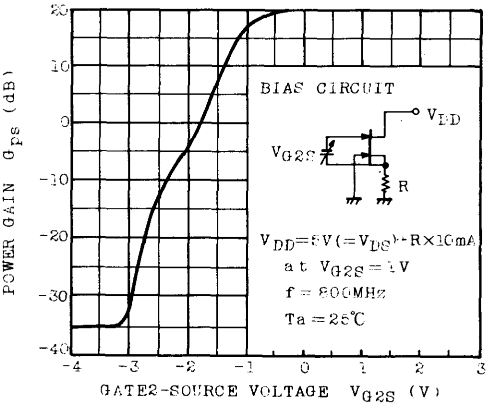




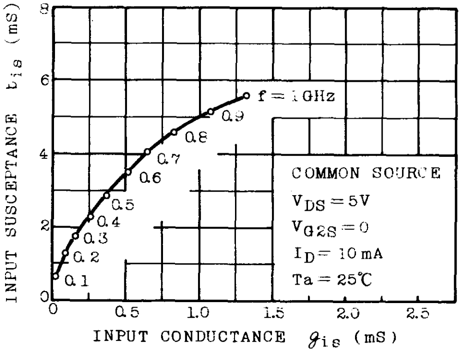
G_{ps}, NF – I_D



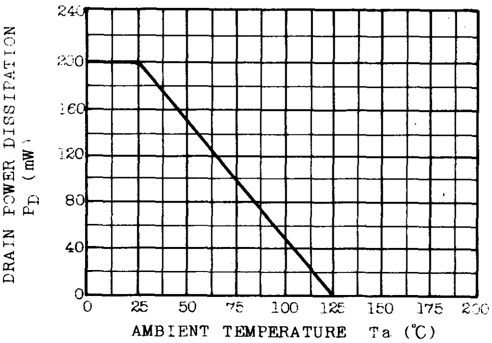
G_{ps} – V_{G2S}



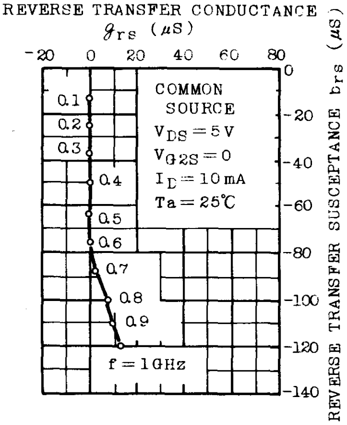
Y_{is} – f



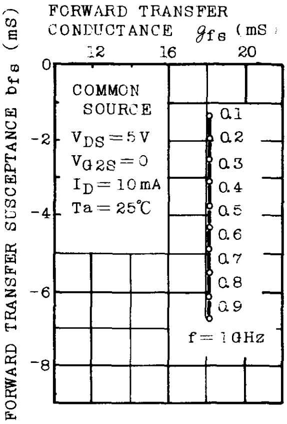
P_D – Ta



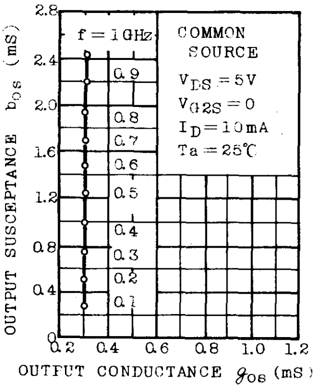
y_{rs} – f

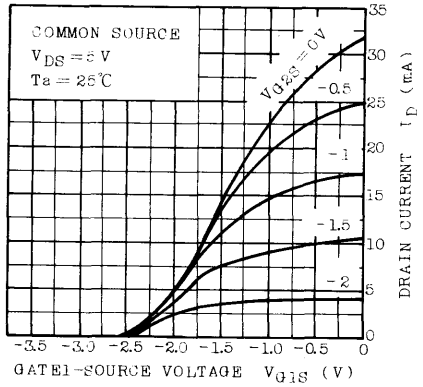


y_{fs} – f

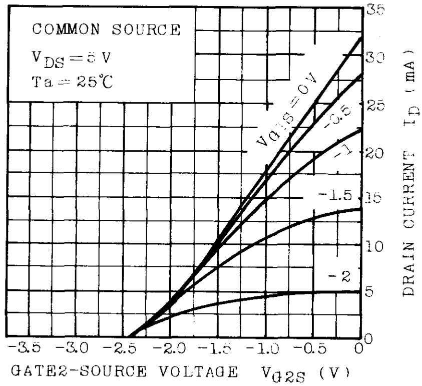


y_{os} – f

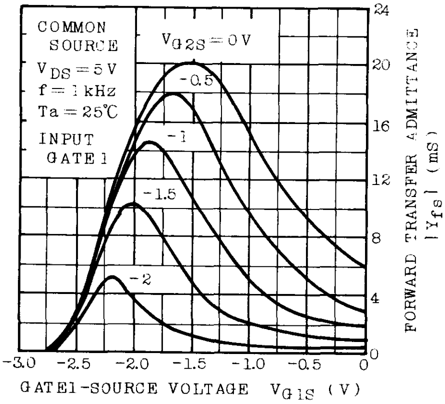




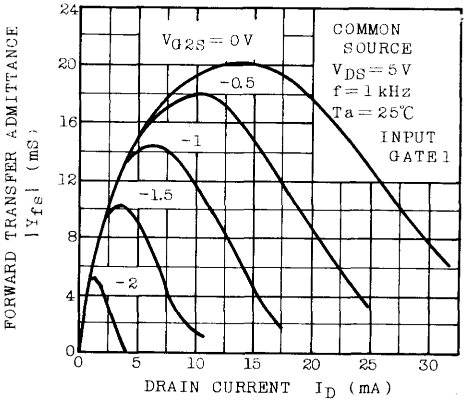
$I_D - V_{G1S}$



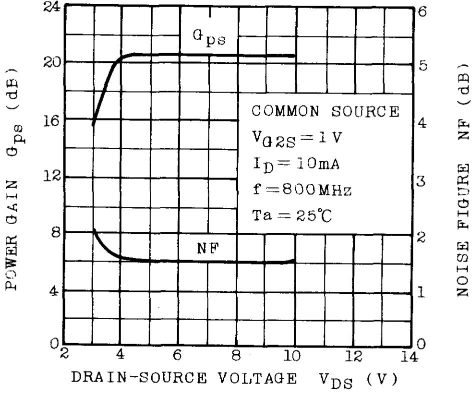
$I_D - V_{G2S}$



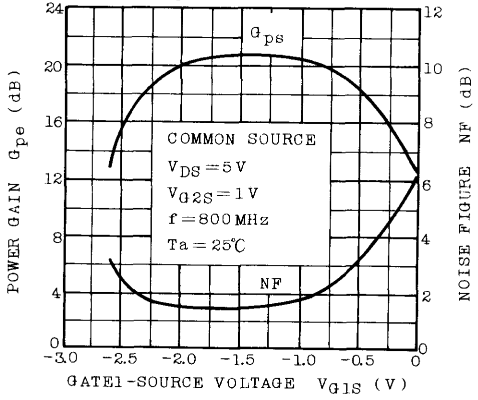
$|Y_{fs}| - V_{G1S}$



$|Y_{fs}| - I_D$



$G_{ps}, NF - V_{DS}$



$G_{ps}, NF - V_{G1S}$

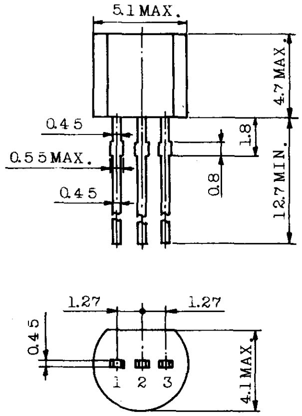
2N
series

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

2N3903

FOR GENERAL PURPOSE USE SWITCHING AND AMPLIFIER APPLICATIONS.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO−92
EIAJ	SC−43
TOSHIBA	2−5F1F

Weight : 0.21g

FEATURES:

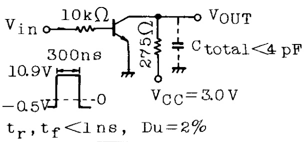
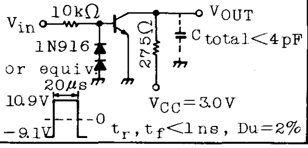
- Low Leakage Current
  : I_{CEV}=50nA(Max.), I_{BEV}=−50nA(Max.)
  @ V_{CE}=30V, V_{BE}=−3V
- Excellent DC Current Gain Linearity
- Low Saturation Voltage
  : $V_{CE(sat)}$=0.3V(Max.) @ I_C=50mA, I_B=5mA
- Low Collector Output Capacitance
  : C_{ob}=4pF(Max.) @ V_{CB}=5V
- Complementary to 2N3905

MAXIMUM RATINGS (Ta=25°C)

	CHARACTERISTIC	SYMBOL	RATING	UNIT
※	Collector-Base Voltage	V_{CBO}	60	V
※	Collector-Emitter Voltage	V_{CEO}	40	V
※	Emitter-Base Voltage	V_{EBO}	6	V
※	Collector Current	I_C	200	mA
	Base Current	I_B	50	mA
※	Collector Power Dissipation (Ta=25°C) Derate Linearly 25°C	P_C	350	mW
			2.8	mW/°C
※	Collector Power Dissipation (Tc=25°C) Derate Linearly 25°C	P_C	1.0	W
			8	mW/°C
※	Thermal Resistance (Junction to Ambient)	$R_{th(j-a)}$	357	°C/W
※	Thermal Resistance (Junction to Case)	$R_{th(j-c)}$	125	°C/W
※	Junction Temperature	T_j	150	°C
※	Storage Temperature Range	T_{stg}	−55～150	°C

※In accordance with JEDEC registration data.

ELECTRICAL CHARACTERISTICS (Ta=25°C)

	CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
※	Collector Cut-off Current		I_{CEV}	V_{CE}=30V, V_{BE}=-3V	-	-	50	nA
※	Base Cut-off Current		I_{BEV}	V_{CE}=30V, V_{BE}=-3V	-	-	-50	nA
※	Collector-Base Breakdown Voltage		$V_{(BR)CBO}$	I_C=10μA, I_E=0	60	-	-	V
※	Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	I_C=1mA, I_B=0	40	-	-	V
※	Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$	I_E=10μA, I_C=0	6	-	-	V
※	DC Current Gain		$h_{FE(1)}$	V_{CE}=1V, I_C=0.1mA	20	-	-	
			$h_{FE(2)}$	V_{CE}=1V, I_C=1mA	35	-	-	
			$h_{FE(3)}$	V_{CE}=1V, I_C=10mA	50	-	150	
			$h_{FE(4)}$	V_{CE}=1V, I_C=50mA	30	-	-	
			$h_{FE(5)}$	V_{CE}=1V, I_C=100mA	15	-	-	
※	Collector-Emitter Saturation Voltage		$V_{CE(sat)1}$	I_C=10mA, I_B=1mA	-	-	0.2	V
			$V_{CE(sat)2}$	I_C=50mA, I_B=5mA	-	-	0.3	
※	Base-Emitter Saturation Voltage		$V_{BE(sat)1}$	I_C=10mA, I_B=1mA	0.65	-	0.85	V
			$V_{BE(sat)2}$	I_C=50mA, I_B=5mA	-	-	0.95	
※	Transition Frequency		f_T	V_{CE}=20V, I_C=10mA f=100MHz	250	-	-	MHz
※	Collector Output Capacitance		Cob	V_{CB}=5V, I_E=0, f=1MHz	-	-	4	pF
※	Input Capacitance		Cib	V_{EB}=0.5V, I_C=0, f=1MHz	-	-	8	pF
※	Input Impedance		hie	V_{CE}=10V, I_C=1mA f=1kHz	0.5	-	8	kΩ
※	Voltage Feedback Ratio		hre		0.1	-	5	$\times10^{-4}$
※	Small-Signal Current Gain		hfe		50	-	200	
※	Collector Output Admittance		hoe		1	-	40	μS
※	Noise Figure		NF	V_{CE}=5V, I_C=0.1mA R_g=1kΩ, f=10Hz ~ 15.7kHz	-	-	6	dB
※	Switching Time	Delay Time	t_d		-	-	35	ns
		Rise Time	t_r		-	-	35	
		Storage Time	tstg		-	-	175	
		Fall Time	tf		-	-	50	

※ In accordance with JEDEC registration data.

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

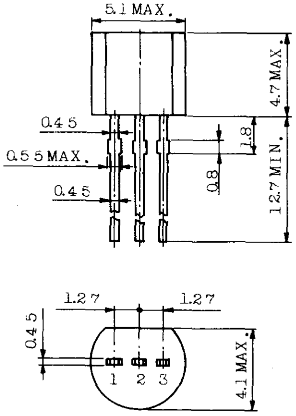
2N3904

FOR GENERAL PURPOSE USE SWITCHING AND AMPLIFIER APPLICATIONS.

FEATURES:

- Low Leakage Current
  : I_{CEV}=50nA(Max.), I_{BEV}=-50nA(Max.)
  @ V_{CE}=30V, V_{BE}=-3V
- Excellent DC Current Gain Linearity
- Low Saturation Voltage
  : $V_{CE(sat)}$=0.3V(Max.) @ I_C=50mA, I_B=5mA
- Low Collector Output Capacitance
  : C_{ob}=4pF(Max.) @ V_{CB}=5V
- Complementary to 2N3906

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO−92
EIAJ	SC−43
TOSHIBA	2−5F1F

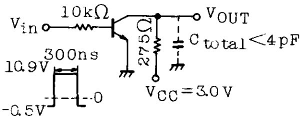
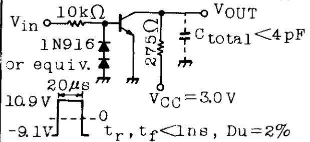
Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
※ Collector-Base Voltage	V_{CBO}	60	V
※ Collector-Emitter Voltage	V_{CEO}	40	V
※ Emitter-Base Voltage	V_{EBO}	6	V
※ Collector Current	I_C	200	mA
Base Current	I_B	50	mA
※ Collector Power Dissipation (Ta=25°C) Derate Linearly 25°C	P_C	350	mW
		2.8	mW/°C
※ Collector Power Dissipation (Tc=25°C) Derate Linearly 25°C	P_C	1.0	W
		8	mW/°C
※ Thermal Resistance (Junction to Ambient)	$R_{th(j-a)}$	357	°C/W
※ Thermal Resistance (Junction to Case)	$R_{th(j-c)}$	125	°C/W
※ Junction Temperature	T_j	150	°C
※ Storage Temperature Range	T_{stg}	-55~150	°C

※In accordance with JEDEC registration data.

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
※ Collector Cut-off Current		I_{CEV}	V_{CE}=30V, V_{BE}=-3V	-	-	50	nA
※ Base Cut-off Current		I_{BEV}	V_{CE}=30V, V_{BE}=-3V	-	-	-50	nA
※ Collector-Base Breakdown Voltage		$V_{(BR)CBO}$	I_C=10μA, I_E=0	60	-	-	V
※ Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	I_C=1mA, I_B=0	40	-	-	V
※ Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$	I_E=10μA, I_C=0	6	-	-	V
※ DC Current Gain		$h_{FE(1)}$	V_{CE}=1V, I_C=0.1mA	40	-	-	
		$h_{FE(2)}$	V_{CE}=1V, I_C=1mA	70	-	-	
		$h_{FE(3)}$	V_{CE}=1V, I_C=10mA	100	-	300	
		$h_{FE(4)}$	V_{CE}=1V, I_C=50mA	60	-	-	
		$h_{FE(5)}$	V_{CE}=1V, I_C=100mA	30	-	-	
※ Collector-Emitter Saturation Voltage		$V_{CE(sat)1}$	I_C=10mA, I_B=1mA	-	-	0.2	V
		$V_{CE(sat)2}$	I_C=50mA, I_B=5mA	-	-	0.3	
※ Base-Emitter Saturation Voltage		$V_{BE(sat)1}$	I_C=10mA, I_B=1mA	0.65	-	0.85	V
		$V_{BE(sat)2}$	I_C=50mA, I_B=5mA	-	-	0.95	
※ Transition Frequency		f_T	V_{CE}=20V, I_C=10mA f=100MHz	300	-	-	MHz
※ Collector Output Capacitance		C_{ob}	V_{CB}=5V, I_E=0, f=1MHz	-	-	4	pF
※ Input Capacitance		C_{ib}	V_{EB}=0.5V, I_C=0, f=1MHz	-	-	8	pF
※ Input Impedance		h_{ie}	V_{CE}=10V, I_C=1mA f=1kHz	1.0	-	10	kΩ
※ Voltage Feedback Ratio		h_{re}		0.5	-	8	$\times 10^{-4}$
※ Small-Signal Current Gain		h_{fe}		100	-	400	
※ Collector Output Admittance		h_{oe}		1.0	-	40	μS
※ Noise Figure		NF	V_{CE}=5V, I_C=0.1mA R_g=1kΩ, f=10Hz ~ 15.7kHz	-	-	5	dB
※ Switching Time	Delay Time	t_d	 t_r, t_f<1ns, Du=2%	-	-	35	ns
	Rise Time	t_r		-	-	35	
	Storage Time	t_{stg}	 t_r, t_f<1ns, Du=2%	-	-	200	
	Fall Time	t_f		-	-	50	

※ In accordance with JEDEC registration data.

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

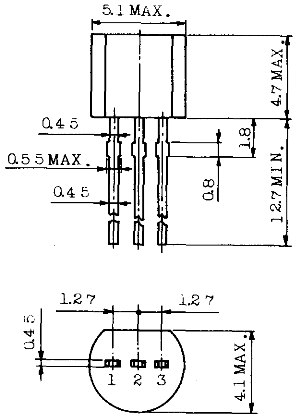
2N3905

FOR GENERAL PURPOSE USE SWITCHING AND AMPLIFIER APPLICATIONS.

FEATURES:

- Low Leakage Current
  : I_{CEV}=-50nA(Max.), I_{BEV}=50nA(Max.)
  @ V_{CE}=-30V, V_{BE}=3V
- Excellent DC Current Gain Linearity
- Low Saturation Voltage
  : $V_{CE(sat)}$=-0.4V(Max.) @ I_C=-50mA, I_B=-5mA
- Low Collector Output Capacitance
  : C_{ob}=4.5pF(Max.) @ V_{CB}=-5V
- Complementary to 2N3903

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

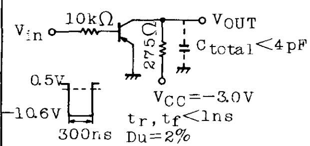
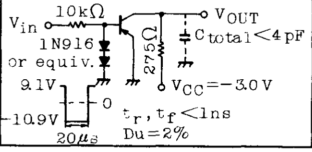
Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

	CHARACTERISTIC	SYMBOL	RATING	UNIT
※	Collector-Base Voltage	V_{CBO}	-40	V
※	Collector-Emitter Voltage	V_{CEO}	-40	V
※	Emitter-Base Voltage	V_{EBO}	-5	V
※	Collector Current	I_C	-200	mA
	Base Current	I_B	-50	mA
※	Collector Power Dissipation (Ta=25°C) Derate Linearly 25°C	P_C	350	mW
			2.8	mW/°C
※	Collector Power Dissipation (Tc=25°C) Detate Linearly 25°C	P_C	1.0	W
			8	mW/°C
※	Thermal Resistance (Junction to Ambient)	$R_{th(j-a)}$	357	°C/W
※	Thermal Resistance (Junction to Case)	$R_{th(j-c)}$	125	°C/W
※	Junction Temperature	T_j	150	°C
※	Storage Temperature Range	T_{stg}	-55~150	°C

※In Accordance with JEDEC registration data.

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
※ Collector Cut-off Current	I_{CEV}	V_{CE}=-30V, V_{BE}=3V	-	-	-50	nA
※ Base Cut-off Current	I_{BEV}	V_{CE}=-30V, V_{BE}=3V	-	-	50	nA
※ Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C=-10μA, I_E=0	-40	-	-	V
※ Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-1mA, I_B=0	-40	-	-	V
※ Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=-10μA, I_C=0	-5	-	-	V
※ DC Current Gain	$h_{FE(1)}$	V_{CE}=-1V, I_C=-0.1mA	30	-	-	
	$h_{FE(2)}$	V_{CE}=-1V, I_C=-1mA	40	-	-	
	$h_{FE(3)}$	V_{CE}=-1V, I_C=-10mA	50	-	150	
	$h_{FE(4)}$	V_{CE}=-1V, I_C=-50mA	30	-	-	
	$h_{FE(5)}$	V_{CE}=-1V, I_C=-100mA	15	-	-	
※ Collector-Emitter Saturation Voltage	$V_{CE(sat)1}$	I_C=-10mA, I_B=-1mA	-	-	-0.25	V
	$V_{CE(sat)2}$	I_C=-50mA, I_B=-5mA	-	-	-0.4	
※ Base-Emitter Saturation Voltage	$V_{BE(sat)1}$	I_C=-10mA, I_B=-1mA	-0.65	-	-0.85	V
	$V_{BE(sat)2}$	I_C=-50mA, I_B=-5mA	-	-	-0.95	
※ Transition Frequency	f_T	V_{CE}=-20V, I_C=-10mA f=100MHz	200	-	-	MHz
※ Collector Output Capacitance	C_{ob}	V_{CB}=-5V, I_E=0, f=1MHz	-	-	4.5	pF
※ Input Capacitance	C_{ib}	V_{EB}=-0.5V, I_C=0 f=1MHz	-	-	10	pF
※ Input Impedance	h_{ie}	V_{CE}=-10V, I_C=-1mA f=1kHz	0.5	-	8	kΩ
※ Voltage Feedback Ratio	h_{re}		0.1	-	5	$\times 10^{-4}$
※ Small-Signal Current Gain	h_{fe}		50	-	200	
※ Collector Output Admittance	h_{oe}		1.0	-	40	μS
※ Noise Figure	NF	V_{CE}=-5V, I_C=-0.1mA R_g=1kΩ, f=10Hz ~ 15.7kHz	-	-	5	dB
※ Switching Time Delay Time	$t_{d(ON)}$		-	-	35	ns
Rise Time	t_r		-	-	35	
Storage Time	t_{stg}		-	-	200	
Fall Time	t_f		-	-	60	

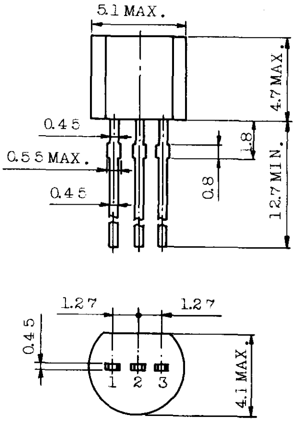
In accordance with JEDEC registration data.

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

2N3906

FOR GENERAL PURPOSE USE SWITCHING AND AMPLIFIER APPLICATIONS.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

FEATURES:

- Low Leakage Current
  : $I_{CEV}=-50nA(Max.)$, $I_{BEV}=50nA(Max.)$
  @ $V_{CE}=-30V$, $V_{BE}=3V$
- Excellent DC Current Gain Linearity
- Low Saturation Voltage
  : $V_{CE(sat)}=-0.4V(Max.)$ @ $I_C=-50mA$, $I_B=-5mA$
- Low Collector Output Capacitance
  : $C_{ob}=4.5pF(Max.)$ @ $V_{CB}=-5V$
- Complementary to 2N3904

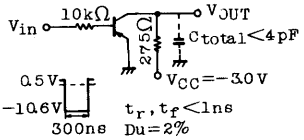
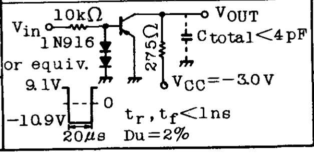
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
※ Collector-Base Voltage	V_{CBO}	-40	V
※ Collector-Emitter Voltage	V_{CEO}	-40	V
※ Emitter-Base Voltage	V_{EBO}	-5	V
※ Collector Current	I_C	-200	mA
Base Current	I_B	-50	mA
※ Collector Power Dissipation (Ta=25°C) Derate Linearly 25°C	P_C	350	mW
		2.8	mW/°C
※ Collector Power Dissipation (Tc=25°C) Derate Linearly 25°C	P_C	1.0	W
		8	mW/°C
※ Thermal Resistance (Junction to Ambient)	$R_{th(j-a)}$	357	°C/W
※ Thermal Resistance (Junction to Case)	$R_{th(j-c)}$	125	°C/W
※ Junction Temperature	T_j	150	°C
※ Storage Temperature Range	T_{stg}	-55~150	°C

※In accordance with JEDEC registration data.

2N3906

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
※ Collector Cut-off Current		I_{CEV}	$V_{CE}=-30V$, $V_{BE}=3V$	-	-	-50	nA
※ Base Cut-off Current		I_{BEV}	$V_{CE}=-30V$, $V_{BE}=3V$	-	-	50	nA
※ Collector-Base Breakdown Voltage		$V_{(BR)CBO}$	$I_C=-10\mu A$, $I_E=0$	-40	-	-	V
※ Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	$I_C=-1mA$, $I_B=0$	-40	-	-	V
※ Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$	$I_E=-10\mu A$, $I_C=0$	-5	-	-	V
※ DC Current Gain		$h_{FE}(1)$	$V_{CE}=-1V$, $I_C=-0.1mA$	60	-	-	
		$h_{FE}(2)$	$V_{CE}=-1V$, $I_C=-1mA$	80	-	-	
		$h_{FE}(3)$	$V_{CE}=-1V$, $I_C=-10mA$	100	-	300	
		$h_{FE}(4)$	$V_{CE}=-1V$, $I_C=-50mA$	60	-	-	
		$h_{FE}(5)$	$V_{CE}=-1V$, $I_C=-100mA$	30	-	-	
※ Collector-Emitter Saturation Voltage		$V_{CE(sat)1}$	$I_C=-10mA$, $I_B=-1mA$	-	-	-0.25	V
		$V_{CE(sat)2}$	$I_C=-50mA$, $I_B=-5mA$	-	-	-0.4	
※ Base-Emitter Saturation Voltage		$V_{BE(sat)1}$	$I_C=-10mA$, $I_B=-1mA$	-0.65	-	-0.85	V
		$V_{BE(sat)2}$	$I_C=-50mA$, $I_B=-5mA$	-	-	-0.95	
※ Transition Frequency		f_T	$V_{CE}=-20V$, $I_C=-10mA$ $f=100MHz$	250	-	-	MHz
※ Collector Output Capacitance		C_{ob}	$V_{CB}=-5V$, $I_E=0$, $f=1MHz$	-	-	4.5	pF
※ Input Capacitance		C_{ib}	$V_{EB}=-0.5V$, $I_C=0$, $f=1MHz$	-	-	10	pF
※ Input Impedance		h_{ie}	$V_{CE}=-10V$, $I_C=-1mA$ $f=1kHz$	2.0	-	12	kΩ
※ Voltage Feedback Ratio		h_{re}		1.0	-	10	$\times10^{-4}$
※ Small-Signal Current Gain		h_{fe}		100	-	400	
※ Collector Output Admittance		h_{oe}		3.0	-	60	μS
※ Noise Figure		NF	$V_{CE}=-5V$, $I_C=-0.1mA$ $R_g=1k\Omega$, $f=10Hz \sim 15.7kHz$	-	-	4	dB
※ Switching Time	Delay Time	t_d		-	-	35	ns
	Rise Time	t_r		-	-	35	
	Storage Time	t_{stg}		-	-	225	
	Fall Time	t_f		-	-	75	

※ In accordance with JEDEC registration data.

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

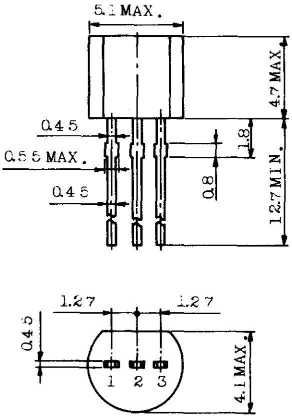
2N4123

FOR GENERAL PURPOSE USE SWITCHING AND AMPLIFIER APPLICATIONS.

FEATURES:

- Low Leakage Current
  - : I_{CBO}=50nA(Max.) @ V_{CB}=20V
  - I_{EBO}=50nA(Max.) @ V_{EB}=3V
- Low Saturation Voltage
  - : $V_{CE(sat)}$=0.3V(Max.) @ I_C=50mA, I_B=5mA
- Low Collector Output Capacitance
  - : C_{ob}=4pF(Max.) @ V_{CB}=5V
- Complementary to 2N4125

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

	CHARACTERISTIC	SYMBOL	RATING	UNIT
※	Collector-Base Voltage	V_{CBO}	40	V
※	Collector-Emitter Voltage	V_{CEO}	30	V
※	Emitter-Base Voltage	V_{EBO}	5	V
※	Collector Current	I_C	200	mA
	Base Current	I_B	50	mA
※	Collector Power Dissipation (Ta=25°C) Derate Linearly 25°C	P_C	350	mW
			2.8	mW/°C
※	Collector Power Dissipation (Tc=25°C) Derate Linearly 25°C	P_C	1.0	W
			8	mW/°C
※	Thermal Reisstance (Junction to Ambient)	$R_{th(j-a)}$	357	°C/W
※	Thermal Resistance (Junction to Case)	$R_{th(j-c)}$	125	°C/W
※	Junction Temperature	T_j	150	°C
※	Storage Temperature Range	T_{stg}	-55 ~ 150	°C

※In accordance with JEDEC registration data.

ELECTRICAL CHARACTERISTICS (Ta=25°C)

	CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
※	Collector Cut-off Current	I_{CBO}	V_{CB}=20V, I_E=0	-	-	50	nA
※	Emitter Cut-off Current	I_{EBO}	V_{EB}=3V, I_C=0	-	-	50	nA
※	Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C=10μA, I_E=0	40	-	-	V
※	Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	30	-	-	V
※	Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=10μA, I_C=0	5	-	-	V
※	DC Current Gain	$h_{FE}(1)$	V_{CE}=1V, I_C=2mA	50	-	150	
		$h_{FE}(2)$	V_{CE}=1V, I_C=50mA	25	-	-	
※	Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=50mA, I_B=5mA	-	-	0.3	V
※	Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=50mA, I_B=5mA	-	-	0.95	V
※	Small Signal Forward Current Transfer Ratio	$\|h_{fe}\|$	V_{CE}=20V, I_C=10mA, f=100MHz	2.5	-	-	
※	Transition Frequency	f_T	V_{CE}=20V, I_C=10mA f=100MHz	250	-	-	MHz
※	Collector Output Capacitance	C_{ob}	V_{CB}=5V, I_E=0, f=1MHz	-	-	4	pF
※	Input Capacitance	C_{ib}	V_{EB}=0.5V, I_C=0, f=1MHz	-	-	8	pF
※	Small Siganl Current Gain	h_{fe}	V_{CE}=10V, I_C=2mA, f=1kHz	50	-	200	
※	Noise Figure	NF	V_{CE}=5V, I_C=100μA, R_g=1kΩ, f=10Hz ~ 15.7kHz	-	-	6	dB

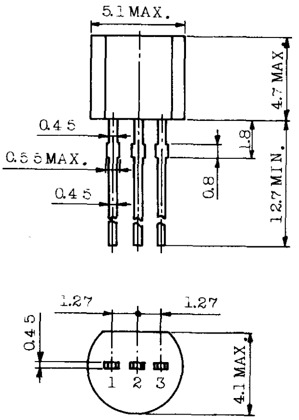
※In accordance with JEDEC registration data.

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

2N4124

FOR GENERAL PURPOSE USE SWITCHING AND AMPLIFIER APPLICATIONS.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

FEATURES:

- Low Leakage Current
  - : I_{CBO}=50nA(Max.) @ V_{CB}=20V
  - I_{EBO}=50nA(Max.) @ V_{EB}=3V
- Low Saturation Voltage
  - : $V_{CE(sat)}$=0.3V(Max.) @ I_C=50mA, I_B=5mA
- Low Collector Output Capacitance
  - : C_{ob}=4pF(Max.) @ V_{CB}=5V
- Complementary to 2N4126

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
※ Collector-Base Voltage	V_{CBO}	30	V
※ Collector-Emitter Voltage	V_{CEO}	25	V
※ Emitter-Base Voltage	V_{EBO}	5	V
※ Collector Current	I_C	200	mA
Base Current	I_B	50	mA
※ Collector Power Dissipation (Ta=25°C) Derate Linearly 25°C	P_C	350	mW
		2.8	mW/°C
※ Collector Power Dissipation (Tc=25°C) Derate Linearly 25°C	P_C	1.0	W
		8	mW/°C
※ Thermal Resistance (Junction to Ambient)	$R_{th(j-a)}$	357	°C/W
※ Thermal Reisstance (Junction to Case)	$R_{th(j-c)}$	125	°C/W
※ Junction Temperature	T_j	150	°C
※ Storage Temperature Range	T_{stg}	-55 ~ 150	°C

※In accordance with JEDEC registration data.

2N4124

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
※ Collector Cut-off Current	I_{CBO}	V_{CB}=20V, I_E=0	-	-	50	nA
※ Emitter Cut-off Current	I_{EBO}	V_{EB}=3V, I_C=0	-	-	50	nA
※ Collector-Base Breakdwon Voltage	$V_{(BR)CBO}$	I_C=10μA, I_E=0	30	-	-	V
※ Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	25	-	-	V
※ Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=10μA, I_C=0	5	-	-	V
※ DC Current Gain	$h_{FE(1)}$	V_{CE}=1V, I_C=2mA	120	-	360	
	$h_{FE(2)}$	V_{CE}=1V, I_C=50mA	60	-	-	
※ Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=50mA, I_B=5mA	-	-	0.3	V
※ Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=50mA, I_B=5mA	-	-	0.95	V
※ Small Signal Forward Current Transfer Ratio	$\|h_{fe}\|$	V_{CE}=20V, I_C=10mA, f=100MHz	3.0	-	-	
※ Transition Frequency	f_T	V_{CE}=20V, I_C=10mA, f=100MHz	300	-	-	MHz
※ Collector Output Capacitance	C_{ob}	V_{CB}=5V, I_E=0, f=1MHz	-	-	4	pF
※ Input Capacitance	C_{ib}	V_{EB}=0.5V, I_C=0, f=1MHz	-	-	8	pF
※ Small Signal Current Gain	h_{fe}	V_{CE}=10V, I_C=2mA, f=1kHz	120	-	480	
※ Noise Figure	NF	V_{CE}=5V, I_C=100μA R_g=1kΩ, f=10Hz ~ 15.7kHz	-	-	5	dB

※ In accordance with JEDEC registration data.

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

2N4125

FOR GENERAL PURPOSE USE SWITCHING AND AMPLIFIER APPLICATIONS.

FEATURES:

. Low Leakage Current

: $I_{CBO}=-50nA$(Max.) @ $V_{CB}=-20V$

$I_{EBO}=-50nA$(Max.) @ $V_{EB}=-3V$

. Low Saturation Voltage

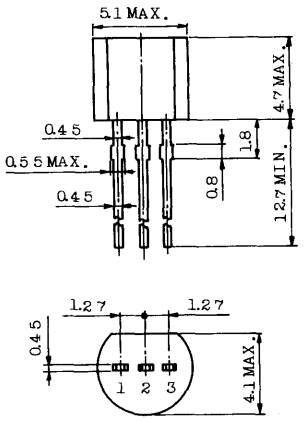
: $V_{CE(sat)}=-0.4V$(Max.) @ $I_C=-50mA$, $I_B=-5mA$

. Low Collector Output Capacitance

: $C_{ob}=4.5pF$(Max.) @ $V_{CB}=-5V$

. Complementary to 2N4123

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

	CHARACTERISTIC	SYMBOL	RATING	UNIT
※	Collector-Base Voltage	V_{CBO}	-30	V
※	Collector-Emitter Voltage	V_{CEO}	-30	V
※	Emitter-Base Voltage	V_{EBO}	-4	V
※	Collector Current	I_C	-200	mA
	Base Current	I_B	-50	mA
※	Collector Power Dissipation (Ta=25°C) Derate Linearly 25°C	P_C	350	mW
			2.8	mW/°C
※	Collector Power Dissipation (Tc=25°C) Derate Linearly 25°C	P_C	1.0	W
			8	mW/°C
※	Thermal Resistance (Junction to Ambient)	$R_{th(j-a)}$	357	°C/W
※	Thermal Resistance (Junction to Case)	$R_{th(j-c)}$	125	°C/W
※	Junction Temperature	T_j	150	°C
※	Storage Temperature Range	T_{stg}	-55~150	°C

※In accordance with JEDEC registration data.

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
※ Collector Cut-off Current	I_{CBO}	$V_{CB}=-20V$, $I_E=0$	-	-	-50	nA
※ Emitter Cut-off Current	I_{EBO}	$V_{EB}=-3V$, $I_C=0$	-	-	-50	nA
※ Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	$I_C=-10\mu A$, $I_E=0$	-30	-	-	V
※ Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	$I_C=-1mA$, $I_B=0$	-30	-	-	V
※ Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	$I_E=-10\mu A$, $I_C=0$	-4	-	-	V
※ DC Current Gain	$h_{FE(1)}$	$V_{CE}=-1V$, $I_C=-2mA$	50	-	150	
	$h_{FE(2)}$	$V_{CE}=-1V$, $I_C=-50mA$	25	-	-	
※ Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C=-50mA$, $I_B=-5mA$	-	-	-0.4	V
※ Base-Emitter Saturation Voltage	$V_{BE(sat)}$	$I_C=-50mA$, $I_B=-5mA$	-	-	-0.95	V
※ Small Signal Forward Current Transfer Ratio	$\|h_{fe}\|$	$V_{CE}=-20V$, $I_C=-10mA$, $f=100MHz$	2.0	-	-	
※ Transition Frequency	f_T	$V_{CE}=-20V$, $I_C=-10mA$, $f=100MHz$	200	-	-	MHz
※ Collector Output Capacitance	C_{ob}	$V_{CB}=-5V$, $I_E=0$, $f=1MHz$	-	-	4.5	pF
※ Input Capacitance	C_{ib}	$V_{EB}=-0.5V$, $I_C=0$, $f=1MHz$	-	-	10	pF
※ Small Signal Current Gain	h_{fe}	$V_{CE}=-10V$, $I_C=-2mA$, $f=1kHz$	50	-	200	
※ Noise Figure	NF	$V_{CE}=-5V$, $I_C=-100\mu A$ $R_g=1k\Omega$, $f=10Hz\sim15.7kHz$	-	-	5	dB

※ In accordance with JEDEC registration data.

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

2N4126

FOR GENERAL PURPOSE USE SWITCHING AND AMPLIFIER APPLICATIONS.

FEATURES:

. Low Leakage Current

: I_{CBO}=-50nA(Max.) @ V_{CB}=-20V

I_{EBO}=-50nA(Max.) @ V_{EB}=-3V

. Low Saturation Voltage

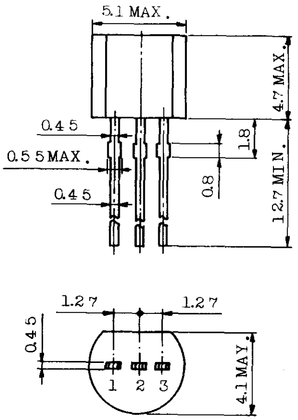
: $V_{CE(sat)}$=-0.4V(Max.) @ I_C=-50mA, I_B=-5mA

. Low Collector Output Capacitance

: C_{ob}=4.5pF(Max.) @ V_{CB}=-5V

. Complementary to 2N4124

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
※ Collector-Base Voltage	V_{CBO}	-25	V
※ Collector-Emitter Voltage	V_{CEO}	-25	V
※ Emitter-Base Voltage	V_{EBO}	-4	V
※ Collector Current	I_C	-200	mA
Base Current	I_B	-50	mA
※ Collector Power Dissipation (Ta=25°C) Derate Linearly 25°C	P_C	350	mW
		2.8	mW/°C
※ Collector Power Dissipation (Tc=25°C) Derate Linearly 25°C	P_C	1.0	W
		8	mW/°C
※ Thermal Resistance (Junction to Ambient)	$R_{th(j-a)}$	357	°C/W
※ Thermal Resistance (Junction to Case)	$R_{th(j-c)}$	125	°C/W
※ Junction Temperature	T_j	150	°C
※ Storage Temperature Range	T_{stg}	-55 ~150	°C

※In accordance with JEDEC registration data.

2N4126

ELECTRICAL CHARACTERISTICS (Ta=25°C)

	CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
※	Collector Cut-off Current	I_{CBO}	V_{CB}=-20V, I_E=0	-	-	-50	nA
※	Emitter Cut-off Current	I_{EBO}	V_{EB}=-3V, I_C=0	-	-	-50	nA
※	Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C=-10μA, I_E=0	-25	-	-	V
※	Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-1mA, I_B=0	-25	-	-	V
※	Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=-10μA, I_C=0	-4	-	-	V
※	DC Current Gain	$h_{FE(1)}$	V_{CE}=-1V, I_C=-2mA	120	-	360	
		$h_{FE(2)}$	V_{CE}=-1V, I_C=-50mA	60	-	-	
※	Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-50mA, I_B=-5mA	-	-	-0.4	V
※	Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=-50mA, I_B=-5mA	-	-	-0.95	V
※	Small Signal Forward Current Transfer Ratio	h_{fe}	V_{CE}=-20V, I_C=-10mA, f=100MHz	2.5	-	-	
※	Transition Frequency	f_T	V_{CE}=-20V, I_C=-10mA, f=100MHz	250	-	-	MHz
※	Collector Output Capacitance	C_{ob}	V_{CB}=-5V, I_E=0, f=1MHz	-	-	4.5	pF
※	Input Capacitance	C_{ib}	V_{EB}=-0.5V, I_C=0, f=1MHz	-	-	10	pF
※	Small Signal Current Gain	h_{fe}	V_{CE}=-10V, I_C=-2mA, f=1kHz	120	-	480	
※	Noise Figure	NF	V_{CE}=-5V, I_C=-100μA R_g=1kΩ, f=10Hz ~ 15.7kHz	-	-	4	dB

※ In accordance with JEDEC registration data.

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

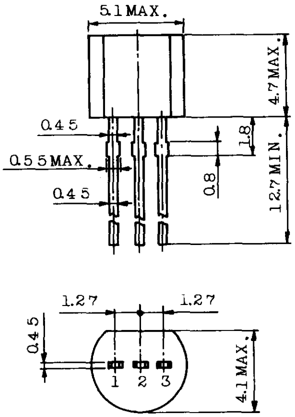
2N4400

FOR GENERAL PURPOSE USE SWITCHING AND AMPLIFIER APPLICATIONS.

FEATURES:

- Low Leakage Current
  : I_{CEV}=100nA(Max.), I_{BEV}=-100nA(Max.)
  @ V_{CE}=35V, V_{BE}=-0.4V
- Excellent DC Current Gain Linearity
- Low Saturation Voltage
  : $V_{CE(sat)}$=0.4V(Max.) @ I_C=150mA, I_B=15mA
- Low Collector Output Capacitance
  : C_{ob}=6.5pF(Max.) @ V_{CB}=5V
- Complementary to 2N4402

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

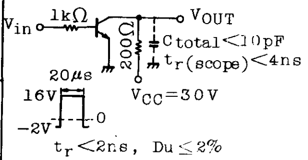
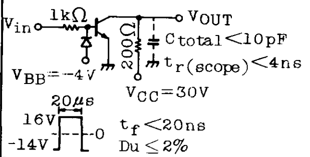
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
※ Collector-Base Voltage	V_{CBO}	60	V
※ Collector-Emitter Voltage	V_{CEO}	40	V
※ Emitter-Base Voltage	V_{EBO}	6	V
※ Collector Current	I_C	600	mA
Base Current	I_B	100	mA
※ Collector Power Dissipation (Ta=25°C) Derate Linearly 25°C	P_C	350	mW
		2.8	mW/°C
※ Collector Power Dissipation (Tc=25°C) Derate Linearly 25°C	P_C	1.0	W
		8	mW/°C
※ Thermal Resistance (Junction to Ambient)	$R_{th(j-a)}$	357	°C/W
※ Thermal Resistance (Junction to Case)	$R_{th(j-c)}$	125	°C/W
※ Junction Temperature	T_j	150	°C
※ Storage Temperature Range	T_{stg}	-55～150	°C

※In accordance with JEDEC registration data.

2N4400

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
※Collector Cut-off Current		I_{CEV}	V_{CE}=35V, V_{BE}=-0.4V	-	-	100	nA
※Base Cut-off Current		I_{BEV}	V_{CE}=35V, V_{BE}=-0.4V	-	-	-100	nA
※Collector-Base Breakdown Voltage		$V_{(BR)CBO}$	I_C=0.1mA, I_E=0	60	-	-	V
※Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	I_C=1mA, I_B=0	40	-	-	V
※Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$	I_E=0.1mA, I_C=0	6	-	-	V
※DC Current Gain		$h_{FE(1)}$	V_{CE}=1V, I_C=1mA	20	-	-	
		$h_{FE(2)}$	V_{CE}=1V, I_C=10mA	40	-	-	
		$h_{FE(3)}$	V_{CE}=1V, I_C=150mA	50	-	150	
		$h_{FE(4)}$	V_{CE}=2V, I_C=500mA	20	-	-	
※Collector-Emitter Saturation Voltage		$V_{CE(sat)1}$	I_C=150mA, I_B=15mA	-	-	0.4	V
		$V_{CE(sat)2}$	I_C=500mA, I_B=50mA	-	-	0.75	
※Base-Emitter Saturation Voltage		$V_{BE(sat)1}$	I_C=150mA, I_B=15mA	0.75	-	0.95	V
		$V_{BE(sat)2}$	I_C=500mA, I_B=50mA	-	-	1.2	
※Transition Frequency		f_T	V_{CE}=10V, I_C=20mA f=100MHz	200	-	-	MHz
※Collector Output Capacitance		C_{ob}	V_{CB}=5V, I_E=0, f=1MHz	-	-	6.5	pF
※Input Capacitance		C_{ib}	V_{EB}=0.5V, I_C=0, f=1MHz	-	-	30	pF
※Input Impedance		h_{ie}	V_{CE}=10V, I_C=1mA f=1kHz	0.5	-	7.5	kΩ
※Voltage Feedback Ratio		h_{re}		0.1	-	8	×10-4
※Small-Signal Current Gain		h_{fe}		20	-	250	
※Collector Output Admittance		h_{oe}		1.0	-	30	μS
※Switching Time	Delay Time	t_d		-	-	15	ns
	Rise Time	t_r		-	-	20	
	Storage Time	t_{stg}		-	-	225	
	Fall Time	t_f		-	-	30	

※ In accordance with JEDEC registration data.

SILICON NPN EPITAXIAL PLANAR (PCT PROCESS)

2N4401

FOR GENERAL PURPOSE USE SWITCHING AND AMPLIFIER APPLICATIONS.

FEATURES:

- Low Leakage Current

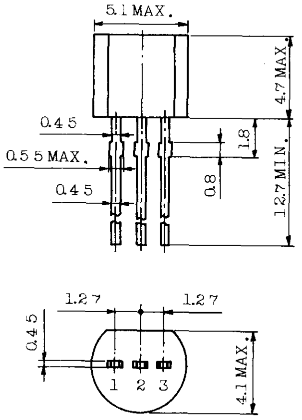
  : I_{CEV}=100nA(Max.), I_{BEV}=-100nA(Max.)

  @ V_{CE}=35V, V_{BE}=-0.4V
- Excellent DC Current Gain Linearity
- Low Saturation Voltage

  : $V_{CE(sat)}$=0.4V(Max.) @ I_C=150mA, I_B=15mA
- Low Collector Output Capacitance

  : C_{ob}=6.5pF(Max.) @ V_{CB}=5V
- Complementary to 2N4403

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

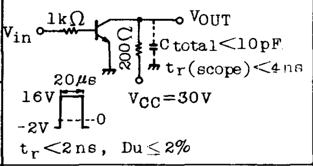
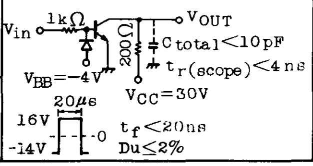
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
※ Collector-Base Voltage	V_{CBO}	60	V
※ Collector-Emitter Voltage	V_{CEO}	40	V
※ Emitter-Base Voltage	V_{EBO}	6	V
※ Collector Current	I_C	600	mA
Base Current	I_B	100	mA
※ Collector Power Dissipation (Ta=25°C) Derate Linearly 25°C	P_C	350	mW
		2.8	mW/°C
※ Collector Power Dissipation (Tc=25°C) Detate Linearly 25°C	Pc	1.0	W
		8	mW/°C
※ Thermal Resistance (Junction to Ambient)	$R_{th(j-a)}$	357	°C/W
※ Thermal Resistance (Junction to Case)	$R_{th(j-c)}$	125	°C/W
※ Junction Temperature	T_j	150	°C
※ Storage Temperature Range	Tstg	-55～150	°C

※In accordance with JEDEC registration data.

2N4401

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
※Collector Cut-off Current		I_{CEV}	V_{CE}=35V, V_{BE}=-0.4V	-	-	100	nA
※Base Cut-off Current		I_{BEV}	V_{CE}=35V, V_{BE}=-0.4V	-	-	-100	nA
※Collector-Base Breakdown Voltage		$V_{(BR)CBO}$	I_C=0.1mA, I_E=0	60	-	-	V
※Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	I_C=1mA, I_B=0	40	-	-	V
※Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$	I_E=0.1mA, I_C=0	6	-	-	V
※DC Current Gain		$h_{FE(1)}$	V_{CE}=1V, I_C=0.1mA	20	-	-	
		$h_{FE(2)}$	V_{CE}=1V, I_C=1mA	40	-	-	
		$h_{FE(3)}$	V_{CE}=1V, I_C=10mA	80	-	-	
		$h_{FE(4)}$	V_{CE}=1V, I_C=150mA	100	-	300	
		$h_{FE(5)}$	V_{CE}=2V, I_C=500mA	40	-	-	
※Collector-Emitter Saturation Voltage		$V_{CE(sat)1}$	I_C=150mA, I_B=15mA	-	-	0.4	V
		$V_{CE(sat)2}$	I_C=500mA, I_B=50mA	-	-	0.75	
※Base-Emitter Saturation Voltage		$V_{BE(sat)1}$	I_C=150mA, I_B=15mA	0.75	-	0.95	V
		$V_{BE(sat)2}$	I_C=500mA, I_B=50mA	-	-	1.2	
※Transition Frequency		f_T	V_{CE}=10V, I_C=20mA f=100MHz	250	-	-	MHz
※Collector Output Capacitance		C_{ob}	V_{CB}=5V, I_E=0, f=1MHz	-	-	6.5	pF
※Input Capacitance		C_{ib}	V_{EB}=0.5V, I_C=0, f=1MHz	-	-	30	pF
※Input Impedance		h_{ie}	V_{CE}=10V, I_C=1mA f=1kHz	1.0	-	15	kΩ
※Voltage Feedback Ratio		h_{re}		0.1	-	8	$\times 10^{-4}$
※Small-Signal Current Gain		h_{fe}		40	-	500	
※Collector Output Admittance		h_{oe}		1.0	-	30	μS
※Switching Time	Delay Time	t_d		-	-	15	ns
	Rise Time	t_r		-	-	20	
	Storage Time	t_{stg}		-	-	225	
	Fall Time	t_f		-	-	30	

※ In accordance with JEDEC registration data.

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

2N4402

FOR GENERAL PURPOSE USE SWITCHING AND AMPLIFIER APPLICATIONS.

FEATURES:

. Low Leakage Current

: I_{CEV}=-100nA(Max.), I_{BEV}=100nA(Max.)
@ V_{CE}=-35V, V_{BE}=0.4V

. Excellent DC Current Gain Linearity

. Low Saturation Voltage

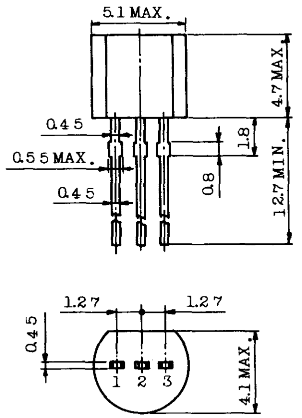
: $V_{CE(sat)}$=-0.4V(Max.) @ I_C=-150mA, I_B=-15mA

. Low Collector Output Capacitance

: C_{ob}=8.5pF(Max.) @ V_{CB}=-10V

. Complementary to 2N4400

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

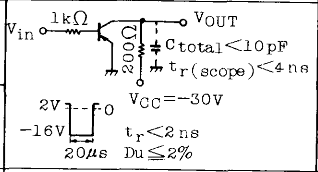
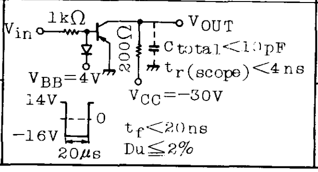
Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

	CHARACTERISTIC	SYMBOL	RATING	UNIT
※	Collector-Base Voltage	V_{CBO}	-40	V
※	Collector-Emitter Voltage	V_{CEO}	-40	V
※	Emitter-Base Voltage	V_{EBO}	-5	V
※	Collector Current	I_C	-600	mA
	Base Current	I_B	-100	mA
※	Collector Power Dissipation (Ta=25°C) Derate Linearly 25°C	P_C	350	mW
			2.8	mW/°C
※	Collector Power Dissipation (Tc=25°C) Detate Linearly 25°C	P_C	1.0	W
			8	mW/°C
※	Thermal Resistance (Junction to Ambient)	$R_{th(j-a)}$	357	°C/W
※	Thermal Resistance (Junction to Case)	$R_{th(j-c)}$	125	°C/W
※	Junction Temperature	T_j	150	°C
※	Storage Temperature Range	T_{stg}	-55~150	°C

※In accordance with JEDEC registration data.

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
※ Collector Cut-off Current		I_{CEV}	$V_{CE}=-35V$, $V_{BE}=0.4V$	-	-	-100	nA
※ Base Cut-off Current		I_{BEV}	$V_{CE}=-35V$, $V_{BE}=0.4V$	-	-	100	nA
※ Collector-Base Breakdown Voltage		$V_{(BR)CBO}$	$I_C=-0.1mA$, $I_E=0$	-40	-	-	V
※ Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	$I_C=-1mA$, $I_B=0$	-40	-	-	V
※ Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$	$I_E=-0.1mA$, $I_C=0$	-5	-	-	V
※ DC Current Gain		$h_{FE(1)}$	$V_{CE}=-1V$, $I_C=-1mA$	30	-	-	
		$h_{FE(2)}$	$V_{CE}=-1V$, $I_C=-10mA$	50	-	-	
		$h_{FE(3)}$	$V_{CE}=-1V$, $I_C=-150mA$	50	-	150	
		$h_{FE(4)}$	$V_{CE}=-2V$, $I_C=-500mA$	20	-	-	
※ Collector-Emitter Saturation Voltage		$V_{CE(sat)1}$	$I_C=-150mA$, $I_B=-15mA$	-	-	-0.4	V
		$V_{CE(sat)2}$	$I_C=-500mA$, $I_B=-50mA$	-	-	-0.75	
※ Base-Emitter Saturation Voltage		$V_{BE(sat)1}$	$I_C=-150mA$, $I_B=-15mA$	-0.75	-	-0.95	V
		$V_{BE(sat)2}$	$I_C=-500mA$, $I_B=-50mA$	-	-	-1.3	
※ Transition Frequency		f_T	$V_{CE}=-10V$, $I_C=-20mA$ $f=100MHz$	150	-	-	MHz
※ Collector Output Capacitance		C_{ob}	$V_{CB}=-10V$, $I_E=0$, $f=1MHz$	-	-	8.5	pF
※ Input Capacitance		C_{ib}	$V_{EB}=-0.5V$, $I_C=0$, $f=1MHz$	-	-	30	pF
※ Input Impedance		h_{ie}	$V_{CE}=-10V$, $I_C=-1mA$ $f=1kHz$	0.75	-	7.5	kΩ
※ Voltage Feedback Ratio		h_{re}		0.1	-	8	$\times10^{-4}$
※ Small-Signal Current Gain		h_{fe}		30	-	250	
※ Collector Output Admittance		h_{oe}		1.0	-	100	μS
※ Switching Time	Delay Time	t_d		-	-	15	ns
	Rise Time	t_r		-	-	20	
	Storage Time	t_{stg}		-	-	225	
	Fall Time	t_f		-	-	30	

※ In accordance with JEDEC registration data.

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

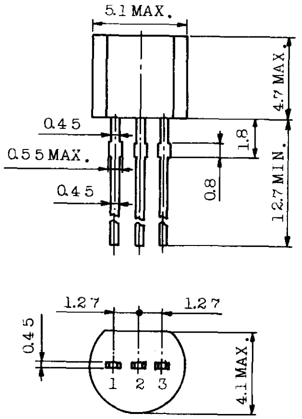
2N4403

FOR GENERAL PURPOSE USE SWITCHING AND AMPLIFIER APPLICATIONS.

FEATURES:

- Low Leakage Current
  - : I_{CEV}=-100nA(Max.), I_{BEV}=100nA(Max.)
  - @ V_{CE}=-35V, V_{BE}=0.4V
- Excellent DC Current Gain Linearity
- Low Saturation Voltage
  - : $V_{CE(sat)}$=-0.4V(Max.) @ I_C=-150mA, I_B=-15mA
- Low Collector Output Capacitance
  - : C_{ob}=8.5pF(Max.) @ V_{CB}=-10V
- Complementary to 2N4401

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

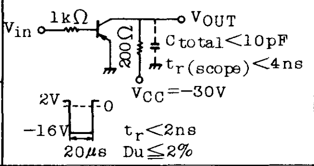
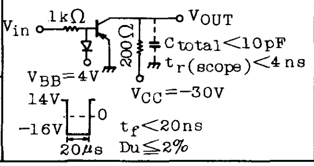
Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
※ Collector-Base Voltage	V_{CBO}	-40	V
※ Collector-Emitter Voltage	V_{CEO}	-40	V
※ Emitter-Base Voltage	V_{EBO}	-5	V
※ Collector Current	I_C	-600	mA
Base Current	I_B	-100	mA
※ Collector Power Dissipation (Ta=25°C) Derate Linearly 25°C	P_C	350	mW
		2.8	mW/°C
※ Collector Power Dissipation (Tc=25°C) Derate Linearly 25°C	P_C	1.0	W
		8	mW/°C
※ Thermal Resistance (Junction to Ambient)	$R_{th(j-a)}$	357	°C/W
※ Thermal Resistance (Junction to Case)	$R_{th(j-c)}$	125	°C/W
※ Junction Temperature	T_j	150	°C
※ Storage Temperature Range	T_{stg}	-55~150	°C

※In accordance with JEDEC registration data.

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
※ Collector Cut-off Current		I_{CEV}	V_{CE}=-35V, V_{BE}=0.4V	-	-	-100	nA
※ Base Cut-off Current		I_{BEV}	V_{CE}=-35V, V_{BE}=0.4V	-	-	100	nA
※ Collector-Base Breakdown Voltage		$V_{(BR)CBO}$	I_C=-0.1mA, I_E=0	-40	-	-	V
※ Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$	I_C=-1mA, I_B=0	-40	-	-	V
※ Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$	I_E=-0.1mA, I_C=0	-5	-	-	V
※ DC Current Gain		$h_{FE(1)}$	V_{CE}=-1V, I_C=-0.1mA	30	-	-	
		$h_{FE(2)}$	V_{CE}=-1V, I_C=-1mA	60	-	-	
		$h_{FE(3)}$	V_{CE}=-1V, I_C=-10mA	100	-	-	
		$h_{FE(4)}$	V_{CE}=-1V, I_C=-150mA	100	-	300	
		$h_{FE(5)}$	V_{CE}=-2V, I_C=-500mA	20	-	-	
※ Collector-Emitter Saturation Voltage		$V_{CE(sat)1}$	I_C=-150mA, I_B=-15mA	-	-	-0.4	V
		$V_{CE(sat)2}$	I_C=-500mA, I_B=-50mA	-	-	-0.75	
※ Base-Emitter Saturation Voltage		$V_{BE(sat)1}$	I_C=-150mA, I_B=-15mA	-0.75	-	-0.95	V
		$V_{BE(sat)2}$	I_C=-500mA, I_B=-50mA	-	-	-1.3	
※ Transition Frequency		f_T	V_{CE}=-10V, I_C=-20mA f=100MHz	200	-	-	MHz
※ Collector Output Capacitance		C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	-	8.5	pF
※ Input Capacitance		C_{ib}	V_{EB}=-0.5V, I_C=0, f=1MHz	-	-	30	pF
※ Input Impedance		h_{ie}	V_{CE}=-10V, I_C=-1mA f=1kHz	1.5	-	15	kΩ
※ Voltage Feedback Ratio		h_{re}		0.1	-	8	$\times10^{-4}$
※ Small-Signal Current Gain		h_{fe}		60	-	500	
※ Collector Output Admittance		h_{oe}		1.0	-	100	μS
※ Switching Time	Delay Time	t_d		-	-	15	ns
	Rise Time	t_r		-	-	20	
	Storage Time	t_{stg}		-	-	225	
	Fall Time	f_f		-	-	30	

※ In accordance with JEDEC registration data.

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

2N5400

FOR GENERAL PURPOSE USE HIGH VOLTAGE AMPLIFIER APPLICATIONS.

FEATURES:

. High Collector Breakdown Voltage

: V_{CBO}=-130V, V_{CEO}=-120V

. Low Leakage Current

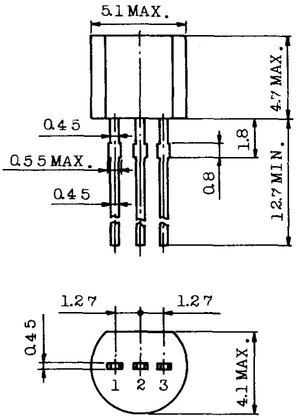
: I_{CBO}=-100nA(Max.) @ V_{CB}=-100V

. Low Saturation Voltage

: $V_{CE(sat)}$=-0.5V(Max.) @ I_C=-50mA, I_B=-5mA

. Low Noise : NF=8dB(Max.)

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

	CHARACTERISTIC	SYMBOL	RATING	UNIT
※	Collector-Base Voltage	V_{CBO}	-130	V
※	Collector-Emitter Voltage	V_{CEO}	-120	V
※	Emitter-Base Voltage	V_{EBO}	-5	V
※	Collector Current	I_C	-600	mA
	Base Current	I_B	-100	mA
※	Collector Power Dissipation (Ta=25°C) Derate Linearly 25°C	P_C	350	mW
			2.8	mW/°C
※	Collector Power Dissipation (Tc=25°C) Derate Linearly 25°C	P_C	1.0	W
			8	mW/°C
※	Thermal Resistance (Junction to Ambient)	$R_{th(j-a)}$	357	°C/W
※	Thermal Resistance (Junction to Case)	$R_{th(j-c)}$	125	°C/W
※	Junction Temperature	T_j	150	°C
※	Storage Temperature Range	T_{stg}	-55~150	°C

※In accordance with JEDEC registration data.

ELECTRICAL CHARACTERISTICS (Ta=25°C)

	CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN	TYP.	MAX.	UNIT
※	Collector Cut-off Current	I_{CBO}	V_{CB}=-100V, I_E=0	-	-	-100	nA
			V_{CB}=-100V, I_E=0,Ta=100°C	-	-	-100	μA
※	Emitter Cut-off Current	I_{EBO}	V_{EB}=-3V, I_C=0	-	-	-50	nA
※	Collector-Base Breakdown Voltage	V(BR)CBO	I_C=-0.1mA, I_E=0	-130	-	-	V
※	Collector-Emitter Breakdown Voltage	V(BR)CEO	I_C=-1mA, I_B=0	-120	-	-	V
※	Emitter-Base Breakdown Voltage	V(BR)EBO	I_E=-10μA, I_C=0	-5	-	-	V
※	DC Current Gain	$h_{FE}(1)$	V_{CE}=-5V, I_C=-1mA	30	-	-	
		$h_{FE}(2)$	V_{CE}=-5V, I_C=-10mA	40	-	180	
		$h_{FE}(3)$	V_{CE}=-5V, I_C=-50mA	40	-	-	
※	Collector-Emitter Saturation Voltage	$V_{CE(sat)}$ 1	I_C=-10mA, I_B=-1mA	-	-	-0.2	V
		$V_{CE(sat)}$ 2	I_C=-50mA, I_B=-5mA	-	-	-0.5	
※	Base-Emitter Saturation Voltage	$V_{BE(sat)}$ 1	I_C=-10mA, I_B=-1mA	-	-	-1.0	V
		$V_{BE(sat)}$ 2	I_C=-50mA, I_B=-5mA	-	-	-1.0	
※	Transition Frequency	f_T	V_{CE}=-10V, I_C=-10mA, f=100MHz	100	-	400	MHz
※	Collector Output Capacitance	Cob	V_{CB}=-10V, I_E=0, f=1MHz	-	-	6	pF
※	Small Siganl Current Gain	h_{fe}	V_{CE}=-10V,I_C=-1mA,f=1kHz	30	-	200	
※	Noise Figure	NF	V_{CE}=-5V, I_C=-250μA R_g=1kΩ, f=10Hz～15.7kHz	-	-	8	dB

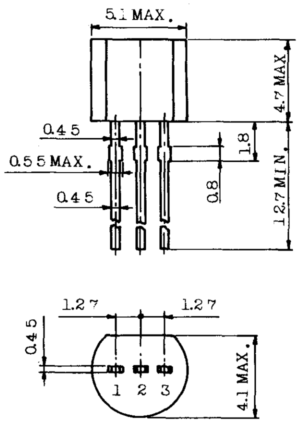
※ In accordance with JEDEC registration data.

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

2N5401

FOR GENERAL PURPOSE USE HIGH VOLTAGE AMPLIFIER APPLICATIONS.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

FEATURES:

- High Collector Breakdown Voltage
  : V_{CBO}=-160V, V_{CEO}=-150V
- Low Leakage Current
  : I_{CBO}=-50nA(Max.) @ V_{CB}=-120V
- Low Saturation Voltage
  : $V_{CE(sat)}$=-0.5V(Max.) @ I_C=-50mA, I_B=-5mA
- Low Noise : NF=8dB(Max.)

MAXIMUM RATINGS (Ta=25°C)

	CHARACTERISTIC	SYMBOL	RATING	UNIT
※	Collector-Base Voltage	V_{CBO}	-160	V
※	Collector-Emitter Voltage	V_{CEO}	-150	V
※	Emitter-Base Voltage	V_{EBO}	-5	V
※	Collector Current	I_C	-600	mA
	Base Current	I_B	-100	mA
※	Collector Power Dissipation (Ta=25°C) Derate Linearly 25°C	P_C	350	mW
			2.8	mW/°C
※	Collector Power Dissipation (Tc=25°C) Derate Linearly 25°C	P_C	1.0	W
			8	mW/°C
※	Thermal Resistance (Junction to Ambient)	$R_{th(j-a)}$	357	°C/W
※	Thermal Resistance (Junction to Case)	$R_{th(j-c)}$	125	°C/W
※	Junction Temperature	T_j	150	°C
※	Storage Temperature Range	T_{stg}	-55~150	°C

※In accordance with JEDEC registration data.

2N5401

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
※ Collector Cut-off Current	I_{CBO}	V_{CB}=-120V, I_E=0	-	-	-50	nA
		V_{CB}=-120V, I_E=0, Ta=100°C	-	-	-50	μA
※ Emitter Cut-off Current	I_{EBO}	V_{EB}=-3V, I_C=0	-	-	-50	nA
※ Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C=-0.1mA, I_E=0	-160	-	-	V
※ Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-1mA, I_B=0	-150	-	-	V
※ Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=-10μA, I_C=0	-5	-	-	V
※ DC Current Gain	$h_{FE(1)}$	V_{CE}=-5V, I_C=-1mA	50	-	-	
	$h_{FE(2)}$	V_{CE}=-5V, I_C=-10mA	60	-	240	
	$h_{FE(3)}$	V_{CE}=-5V, I_C=-50mA	50	-	-	
※ Collector-Emitter Saturation Voltage	$V_{CE(sat)}$ 1	I_C=-10mA, I_B=-1mA	-	-	-0.2	V
	$V_{CE(sat)}$ 2	I_C=-50mA, I_B=-5mA	-	-	-0.5	
※ Base-Emitter Saturation Voltage	$V_{BE(sat)}$ 1	I_C=-10mA, I_B=-1mA	-	-	-1.0	V
	$V_{BE(sat)}$ 2	I_C=-50mA, I_B=-5mA	-	-	-1.0	
※ Transition Frequency	f_T	V_{CE}=-10V, I_C=-10mA, f=100MHz	100	-	300	MHz
※ Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	-	6	pF
※ Small Siganl Current Gain	h_{fe}	V_{CE}=-10V, I_C=-1mA, f=1kHz	40	-	200	
※ Noise Figure	NF	V_{CE}=-5V, I_C=-250μA R_g=1kΩ, f=10Hz ~ 15.7kHz	-	-	8	dB

※ In accordance with JEDEC registration data.

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

2N5550

FOR GENERAL PURPOSE USE HIGH VOLTAGE AMPLIFIER APPLICATIONS.

FEATURES:

. High Collector Breakdown Voltage

: V_{CBO}=160V, V_{CEO}=140V

. Low Leakage Current

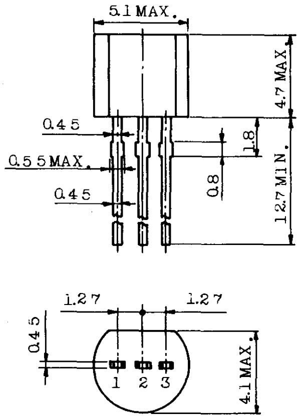
: I_{CBO}=100nA(Max.) @ V_{CB}=100V

. Low Saturation Voltage

: $V_{CE(sat)}$=0.25V(Max.) @ I_C=50mA, I_B=5mA

. Low Noise : NF=10dB(Max.)

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

	CHARACTERISTIC	SYMBOL	RATING	UNIT
※	Collector-Base Voltage	V_{CBO}	160	V
※	Collector-Emitter Voltage	V_{CEO}	140	V
※	Emitter-Base Voltage	V_{EBO}	6	V
※	Collector Current	I_C	600	mA
	Base Current	I_B	100	mA
※	Collector Power Dissipation (Ta=25°C) Derate Linearly 25°C	P_C	350	mW
			2.8	mW/°C
※	Collector Power Dissipation (Tc=25°C) Derate Linearly 25°C	P_C	1.0	W
			8	mW/°C
※	Thermal Resistance (Junction to Ambient)	$R_{th(j-a)}$	357	°C/W
※	Thermal Resistance (Junction to Case)	$R_{th(j-c)}$	125	°C/W
※	Junction Temperature	T_j	150	°C
※	Storage Temperature Range	T_{stg}	-55~150	°C

※ In accordance with JEDEC registration data.

2N5550

ELECTRICAL CHARACTERISTICS (Ta=25°C)

	CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
※	Collector Cut-off Current	I_{CBO}	V_{CB}=100V, I_E=0	-	-	100	nA
			V_{CB}=100V, I_E=0, Ta=100°C	-	-	100	μA
※	Emitter Cut-off Current	I_{EBO}	V_{EB}=4V, I_C=0	-	-	50	nA
※	Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C=0.1mA, I_E=0	160	-	-	V
※	Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	140	-	-	V
※	Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=10μA, I_C=0	6	-	-	V
※	DC Current Gain	$h_{FE}(1)$	V_{CE}=5V, I_C=1mA	60	-	-	
		$h_{FE}(2)$	V_{CE}=5V, I_C=10mA	60	-	250	
		$h_{FE}(3)$	V_{CE}=5V, I_C=50mA	20	-	-	
※	Collector-Emitter Saturation Voltage	$V_{CE(sat)}$ 1	I_C=10mA, I_B=1mA	-	-	0.15	V
		$V_{CE(sat)}$ 2	I_C=50mA, I_B=5mA	-	-	0.25	
※	Base-Emitter Saturation Voltage	$V_{BE(sat)}$ 1	I_C=10mA, I_B=1mA	-	-	1.0	V
		$V_{BE(sat)}$ 2	I_C=50mA, I_B=5mA	-	-	1.2	
※	Transition Frequency	f_T	V_{CE}=10V, I_C=10mA, f=100MHz	100	-	300	MHz
※	Collector Output Capacitance	Cob	V_{CB}=10V, I_E=0, f=1MHz	-	-	6	pF
※	Input Capacitance	Cib	V_{EB}=0.5V, I_C=0, f=1MHz	-	-	30	pF
※	Small Signal Current Gain	hfe	V_{CE}=10V, I_C=1mA, f=1kHz	50	-	200	
※	Noise Figure	NF	V_{CE}=5V, I_C=250μA R_g=1kΩ, f=10Hz ~ 15.7kHz	-	-	10	dB

※ In accordance with JEDEC registration data.

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

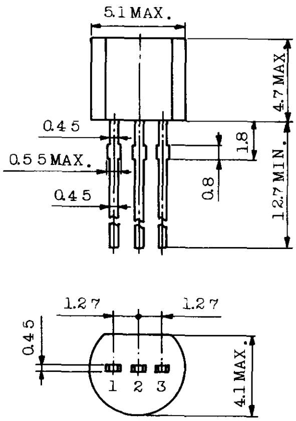
2N5551

FOR GENERAL PURPOSE USE HIGH VOLTAGE AMPLIFIER APPLICATIONS.

FEATURES:

- High Collector Breakdown Voltage
  : V_{CBO}=180V, V_{CEO}=160V
- Low Leakage Current
  : I_{CBO}=50nA(Max.) @ V_{CB}=120V
- Low Saturation Voltage
  : $V_{CE(sat)}$=0.2V(Max.) @ I_C=50mA, I_B=5mA
- Low Noise : NF=8dB(Max.)

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO−92
EIAJ	SC−43
TOSHIBA	2−5F1F

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
※ Collector-Base Voltage	V_{CBO}	180	V
※ Collector-Emitter Voltage	V_{CEO}	160	V
※ Emitter-Base Voltage	V_{EBO}	6	V
※ Collector Current	I_C	600	mA
Base Current	I_B	100	mA
※ Collector Power Dissipation (Ta=25°C) Detate Linearly 25°C	P_C	350	mW
		2.8	mW/°C
※ Collector Power Dissipation (Tc=25°C) Derate Linearly 25°C	P_C	1.0	W
		8	mW/°C
※ Thermal Resistance (Junction to Ambient)	$R_{th(j-a)}$	357	°C/W
※ Thermal Resistance (Junction to Case)	$R_{th(j-c)}$	125	°C/W
※ Junction Temperature	T_j	150	°C
※ Storage Temperature Range	T_{stg}	-55 ~150	°C

※ In accordance with JEDEC registration data.

2N5551

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
※ Collector Cut-off Current	I_{CBO}	V_{CB}=120V, I_E=0	-	-	50	nA
		V_{CB}=120V, I_E=0, Ta=100°C	-	-	50	µA
※ Emitter Cut-off Current	I_{EBO}	V_{EB}=4V, I_C=0	-	-	50	nA
※ Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C=0.1mA, I_E=0	180	-	-	V
※ Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	160	-	-	V
※ Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E=10µA, I_C=0	6	-	-	V
※ DC Current Gain	$h_{FE}(1)$	V_{CE}=5V, I_C=1mA	80	-	-	
	$h_{FE}(2)$	V_{CE}=5V, I_C=10mA	80	-	250	
	$h_{FE}(3)$	V_{CE}=5V, I_C=50mA	30	-	-	
※ Collector-Emitter Saturation Voltage	$V_{CE(sat)}$ 1	I_C=10mA, I_B=1mA	-	-	0.15	V
	$V_{CE(sat)}$ 2	I_C=50mA, I_B=5mA	-	-	0.2	
※ Base-Emitter Saturation Voltage	$V_{BE(sat)}$ 1	I_C=10mA, I_B=1mA	-	-	1.0	V
	$V_{BE(sat)}$ 2	I_C=50mA, I_B=5mA	-	-	1.0	
※ Transition Frequency	f_T	V_{CE}=10V, I_C=10mA, f=100MHz	100	-	300	MHz
※ Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	-	6	pF
※ Input Capacitance	C_{ib}	V_{EB}=0.5V, I_C=0, f=1MHz	-	-	20	pF
※ Small Signal Current Gain	h_{fe}	V_{CE}=10V, I_C=1mA, f=1kHz	50	-	200	
※ Noise Figure	NF	V_{CE}=5V, I_C=250µA R_g=1kΩ, f=10Hz~15.7kHz	-	-	8	dB

※ In accordance with JEDEC registration data.

BF
series

SILICON NPN TRIPLE DIFFUSED TYPE (PCT PROCESS)

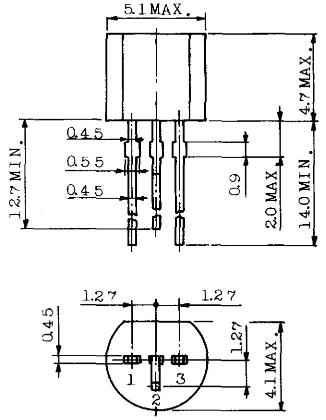
BF422

HIGH VOLTAGE SWITCHING AND AMPLIFIER APPLICATIONS.
COLOR TV CHROMA OUTPUT APPLICATIONS.

FEATURES:

- PNP Complements are BF423

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	—
TOSHIBA	2-5F103

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Voltage		V_{CBO}	250	V
Collector-Emitter Voltage		V_{CEO}	250	V
Emitter-Base Voltage		V_{EBO}	5	V
Collector Current	DC	I_C	50	mA
	Peak	I_{CP}	100	
Total Power Dissipation		P_{tot}	830	mW
Base Current		I_B	20	mA
Junction Temperature		T_j	150	°C
Storage Temperature Range		Tstg	-65 ~ 150	°C
Solder Temperature, 1.5mm from Case for 10 Seconds.		-	350	°C

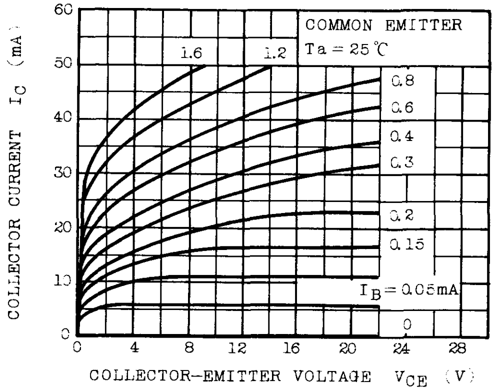
THERMAL CHARACTERISTICS

CHARACTERISTIC	SYMBOL	RATING	UNIT
Thermal Resistance (Junction to Ambient)	$R_{\theta JA}$	151	°C/W

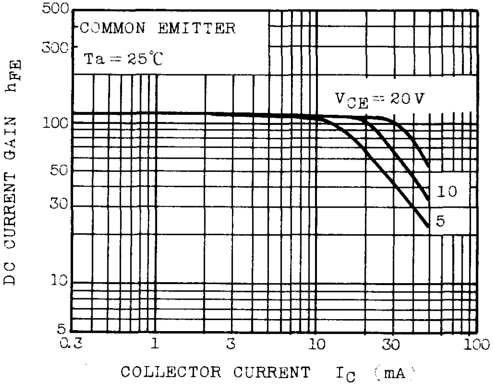
ELECTRICAL CHARACTERISTICS (Ta=25°C Unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=200V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	10	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	250	-	-	V
High Temperature Collector Cut-off Current	I_{CER}	V_{CE}=200V, R_{BE}=2.7kΩ T_j=150°C	-	-	10	μA
DC Current Gain	h_{FE}	V_{CE}=20V, I_C=25mA	50	-	-	
Collector-Emitter RF Saturation Voltage	$V_{CE(sat)}$ RF	I_C=25mA, T_j=150°C	-	20	-	V
Base-Emitter Voltage	V_{BE}	V_{CE}=20V, I_C=25mA	-	0.75	-	V
Transition Frequency	f_T	V_{CE}=10V, I_C=10mA	60	100	-	MHz
Reverse Transfer Capacitance	C_{re}	V_{CB}=30V, I_E=0, f=1MHz	-	-	1.6	pF

$I_C - V_{CE}$ (LOW VOLTAGE REGION)



$h_{FE} - I_C$



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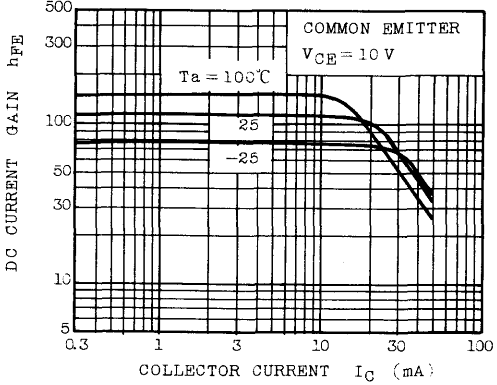
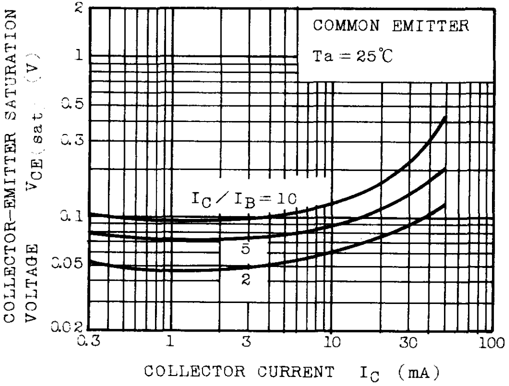
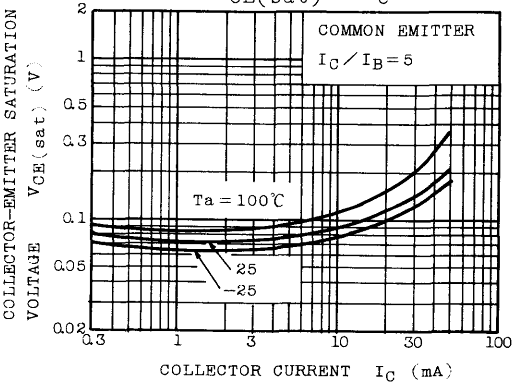


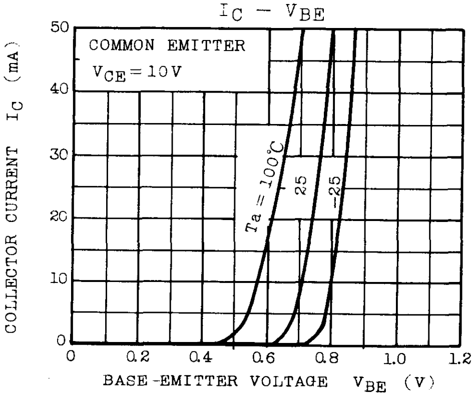
$V_{CE(sat)} - I_C$

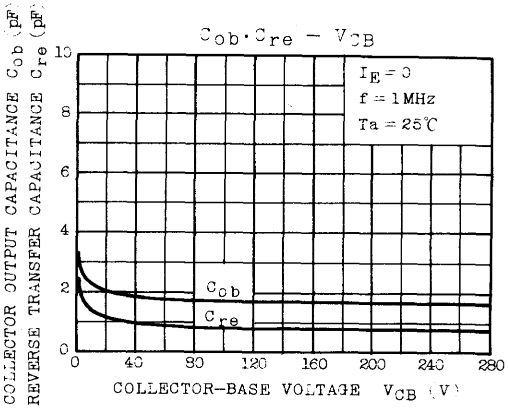


$V_{CE(sat)} - I_C$

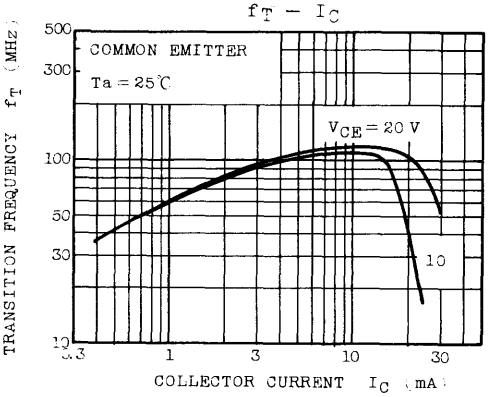


$I_C - V_{BE}$

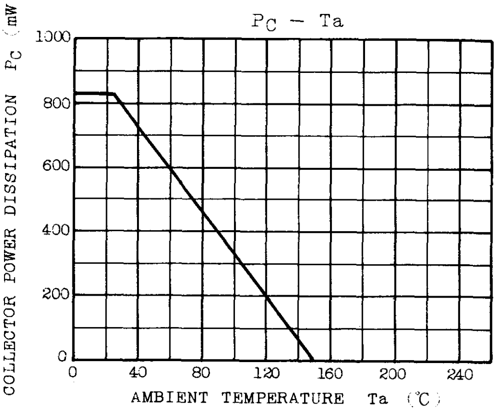




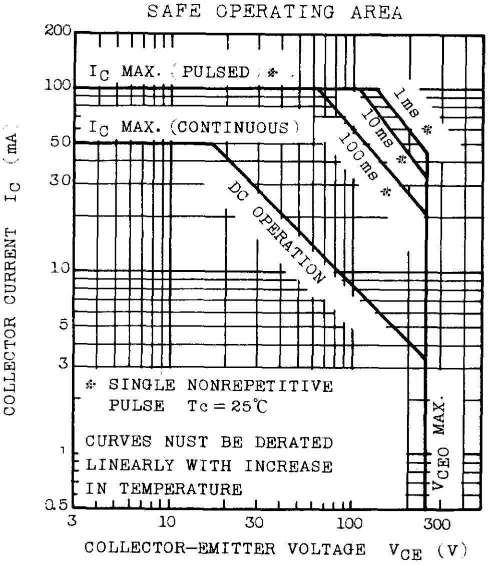
$C_{ob} \cdot C_{re}$ — V_{CB}



f_T — I_C



P_C — Ta



SAFE OPERATING AREA

BF423

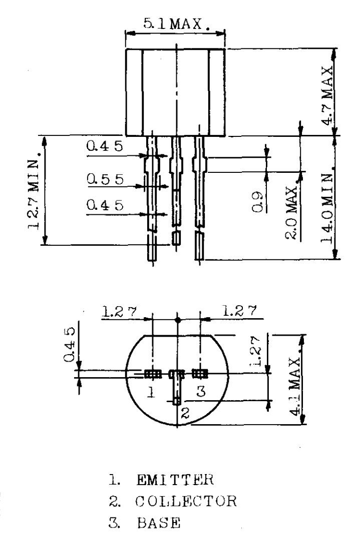
SILICON PNP TRIPLE DIFFUSED TYPE (PCT PROCESS)

HIGH VOLTAGE SWITCHING AND AMPLIFIER APPLICATIONS.
COLOR TV CHROMA OUTPUT APPLICATIONS.

FEATURES:

. NPN Complements are BF422

Unit in mm



1. EMITTER
2. COLLECTOR
3. BASE

JEDEC	TO-92
EIAJ	–
TOSHIBA	2-5F103

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Voltage		V_{CBO}	-250	V
Collector-Emitter Voltage		V_{CEO}	-250	V
Emitter-Base Voltage		V_{EBO}	-5	V
Collector Current	DC	I_C	-50	mA
	Peak	I_{CP}	-100	
Total Power Dissipation		P_{tot}	830	mW
Base Current		I_B	-20	mA
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_{stg}	-65 ~ 150	°C
Solder Temperature, 1.5mm from Case for 10 Seconds.		-	350	°C

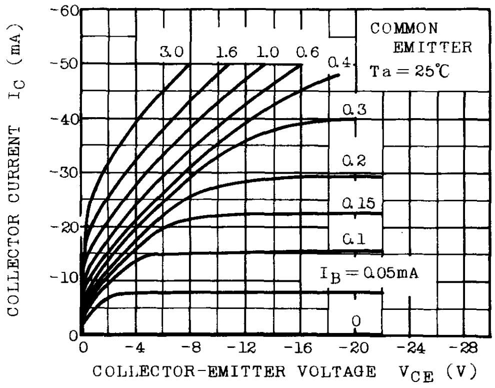
THERMAL CHARACTERISTICS

CHARACTERISTIC	SYMBOL	RATING	UNIT
Thermal Resistance (Junction to Ambient)	$R\theta_{JA}$	151	°C/W

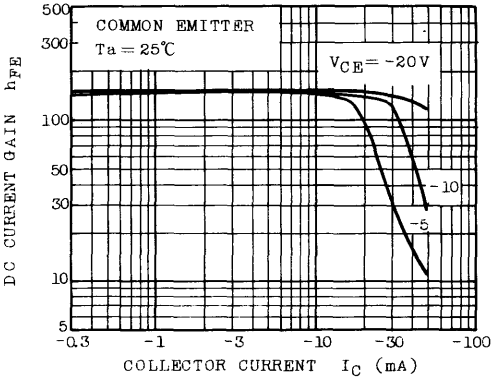
ELECTRICAL CHARACTERISTICS (Ta=25°C Unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-200V, I_E=0	-	-	-0.1	µA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-10	µA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-1mA, I_B=0	-250	-	-	V
High Temperature Collector Cut-off Current	I_{CER}	V_{CE}=-200V, R_{BE}=2.7kΩ T_j=150°C	-	-	-10	µA
DC Current Gain	h_{FE}	V_{CE}=-20V, I_C=-25mA	50	-	-	
Collector-Emitter RF Saturation Voltage	$V_{CE(sat)}$ RF	I_C=-25mA, T_j=150°C	-	-20	-	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-20V, I_C=-25mA	-	-0.75	-	V
Transition Frequency	f_T	V_{CE}=-10V, I_C=-10mA	60	80	-	MHz
Reverse Transfer Capacitance	C_{re}	V_{CB}=-30V, I_E=0, f=1MHz	-	-	1.6	pF

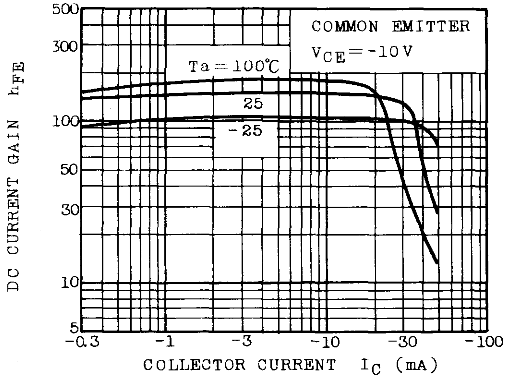
$I_C - V_{CE}$ (LOW VOLTAGE REGION)



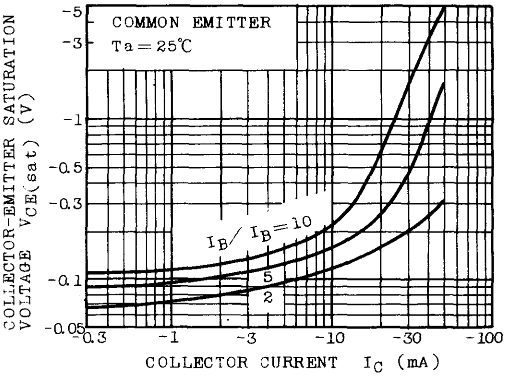
$h_{FE} - I_C$



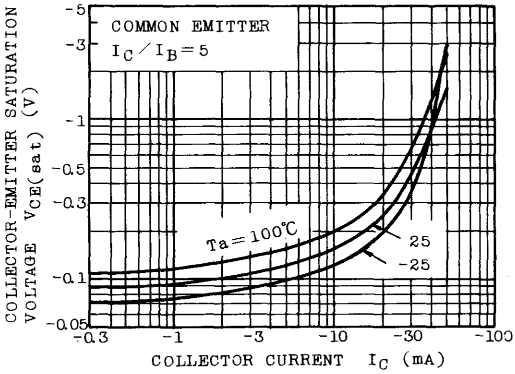
$h_{FE} - I_C$



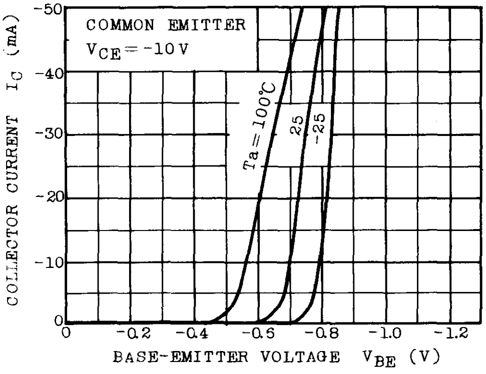
$V_{CE(sat)} - I_C$

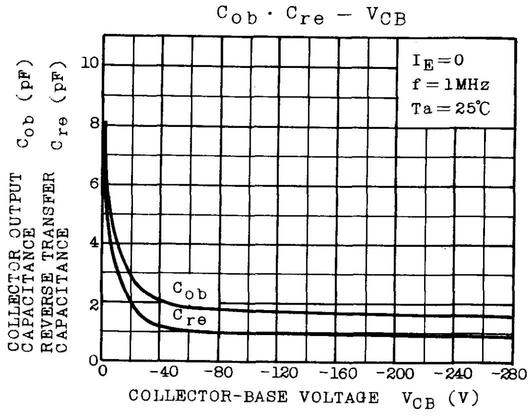


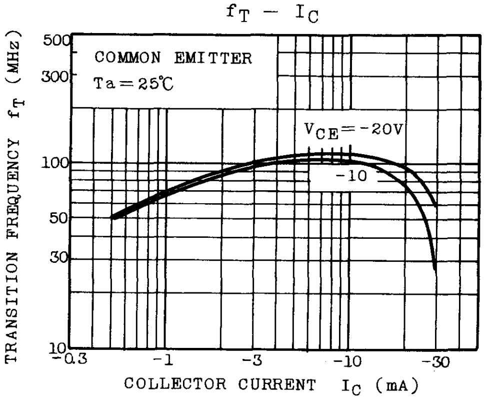
$V_{CE(sat)} - I_C$

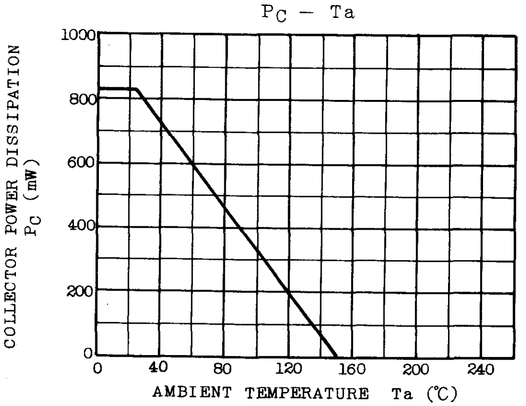


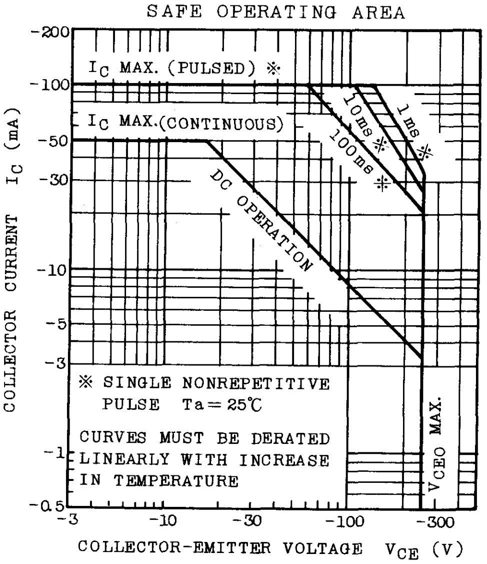
$I_C - V_{BE}$




Cob · Cre – VCB


fT – IC


PC – Ta


SAFE OPERATING AREA

※ SINGLE NONREPETITIVE PULSE Ta = 25℃

CURVES MUST BE DERATED LINEARLY WITH INCREASE IN TEMPERATURE

TBC
series

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

TBC327
TBC328

PRIMARILY INTENDED FOR USE IN DRIVER AND OUTPUT STAGE OF AUDIO AMPLIFIERS.

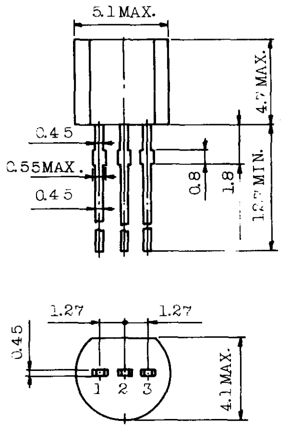
NPN COMPLEMENTS ARE TBC337 AND TBC338.

FEATURES:

. High V_{CEO} : -45V (TBC327)
-25V (TBC328)

. Low Saturation Voltage
: $V_{CE(sat)}$=-0.7V (Max.) at I_C=-500mA

Unit in mm



1. COLLECTOR
2. BASE
3. EMITTER

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1G

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Breakdown Voltage	TBC327	$V_{(BR)CBO}$	-50	V
	TBC328		-30	
Collector-Emitter Breakdown Voltage	TBC327	$V_{(BR)CEO}$	-45	V
	TBC328		-25	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$	-5	V
Collector Current	DC	I_C	-500	mA
	Peak	I_{CP}	-1000	
Base Current (DC)		I_B	-100	mA
Collector Power Dissipation		P_C	625	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		Tstg	-65 ~ 150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=-20V, I_E=0	-	-	-100	nA
Emitter Cut-off Current		I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-10	μA
Collector-Emitter Breakdown Voltage	TBC327	$V_{(BR)CEO}$	I_C=-10mA, I_B=0	-45	-	-	V
	TBC328			-25	-	-	
DC Current Gain		$h_{FE(1)}$ (Note)	V_{CE}=-1V, I_C=-100mA	100	-	400	
		$h_{FE(2)}$	V_{CE}=-1V, I_C=-500mA	40	-	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=-500mA, I_B=-50mA	-	-	-0.7	V
Base-Emitter Voltage		V_{BE}	V_{CE}=-1V, I_C=-500mA	-	-	-1.2	V
Transition Frequency		f_T	V_{CE}=-5V, I_C=-10mA, f=35MHz	-	100	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=-10V, f=1MHz	-	22	-	pF

Note: $h_{FE(1)}$ Classification 327-A , 328-A : 100 ~ 250
327-B , 328-B : 160 ~ 400

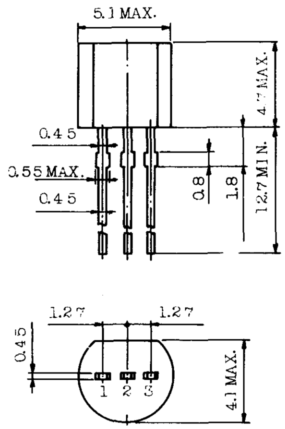
TBC337
TBC338

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

PRIMARILY INTENDED FOR USE IN DRIVER AND OUTPUT STAGE OF AUDIO AMPLIFIERS.

PNP COMPLEMENTS ARE TBC327 AND TBC328.

Unit in mm



1. COLLECTOR
2. BASE
3. EMITTER

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1G

Weight : 0.21g

FEATURES:
- . High V_{CEO} : 45V (TBC337)
  25V (TBC338)
- . Low Saturation Voltage
  : $V_{CE(sat)}$=0.7V (Max.) at I_C=500mA

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Breakdown Voltage	TBC337	$V_{(BR)CBO}$	50	V
	TBC338		30	
Collector-Emitter Breakdown Voltage	TBC337	$V_{(BR)CEO}$	45	V
	TBC338		25	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$	5	V
Collector Current	DC	I_C	500	mA
	Peak	I_{CP}	1000	
Base Current (DC)		I_B	100	mA
Collector Power Dissipation		P_C	625	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_{stg}	-65~150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=20V, I_E=0	-	-	100	nA
Emitter Cut-off Current		I_{EBO}	V_{EB}=5V, I_C=0	-	-	10	μA
Collector-Emitter Breakdown Voltage	TBC337	$V_{(BR)CEO}$	I_C=10mA, I_B=0	45	-	-	V
	TBC338			25	-	-	
DC Current Gain		$h_{FE(1)}$ (Note)	V_{CE}=1V, I_C=100mA	100	-	400	
		$h_{FE(2)}$	V_{CE}=1V, I_C=500mA	40	-	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=500mA, I_B=50mA	-	-	0.7	V
Base-Emitter Voltage		V_{BE}	V_{CE}=1V, I_C=500mA	-	-	1.2	V
Transition Frequency		f_T	V_{CE}=5V, I_C=10mA, f=35MHz	-	100	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=10V, f=1MHz	-	12	-	pF

Note: $h_{FE(1)}$ Classification 337-A , 338-A : 100∿250
337-B , 338-B : 160∿400

TBC546
TBC547
TBC548

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

PRIMARILY INTENDED FOR USE IN DRIVER STAGE OF AUDIO AMPLIFIERS.

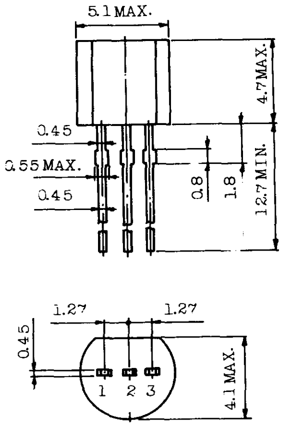
FEATURES:

. High V_{CEO} : 65V (TBC546)
45V (TBC547)
30V (TBC548)

. High h_{FE} : 110 ~ 800

. Low Noise

Unit in mm



1. COLLECTOR
2. BASE
3. EMITTER

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1G

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Breakdown Voltage	TBC546	$V_{(BR)CBO}$	80	V
	TBC547		50	
	TBC548		30	
Collector-Emitter Breakdown Voltage	TBC546	$V_{(BR)CEO}$	65	V
	TBC547		45	
	TBC548		30	
Emitter-Base Breakdown Voltage	TBC546	$V_{(BR)EBO}$	6	V
	TBC547		6	
	TBC548		5	
Collector Current	DC	I_C	100	mA
	Peak	I_{CP}	200	
Base Current (Peak)		I_{BP}	200	mA
Collector Power Dissipation		P_C	500	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_{stg}	-65 ~ 150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=30V, I_E=0	-	-	15	nA
Emitter Cut-off Current	TBC546 TBC547	I_{EBO}	V_{EB}=6V, I_C=0	-	-	1	μA
	TBC548		V_{EB}=5V, I_C=0	-	-	1	
Collector-Emitter Breakdown Voltage	TBC546	$V_{(BR)CEO}$	I_C=1mA, I_B=0	65	-	-	V
	TBC547			45	-	-	
	TBC548			30	-	-	
DC Current Gain		h_{FE} (Note)	V_{CE}=5V, I_C=2mA	110	-	800	
Small Signal Current Gain		h_{fe}	V_{CE}=5V, I_C=2mA, f=1kHz	120	-	900	
Base-Emitter Voltage		V_{BE}	V_{CE}=5V, I_C=2mA	580	660	700	mV
			V_{CE}=5V, I_C=10mA	-	-	770	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=10mA, I_B=0.5mA	-	-	250	mV
			I_C=100mA, I_B=5mA	-	-	600	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=10mA, I_B=0.5mA	-	720	-	mV
			I_C=100mA, I_B=5mA	-	900	-	
Knee Voltage		V_{CEK}	I_C=10mA, I_B=Value, for Which I_C=11mA, at V_{CE}=1V	-	400	600	mV
Transition Frequency		f_T	V_{CE}=5V, I_C=10mA	-	300	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=10V, f=1MHz	-	3.5	4.5	pF
Noise Figure		NF	V_{CE}=5V, I_C=0.2mA, f=1kHz, R_g=2kΩ	-	2	10	dB

Note: h_{FE} Classification
546-A , 547-A , 548-A : 110 ~ 220
546-B , 547-B , 548-B : 200 ~ 450
546-C , 547-C , 548-C : 420 ~ 800

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

TBC549
TBC550

PRIMARILY INTENDED FOR LOW NOISE STAGE OF AUDIO AMPLIFIERS.

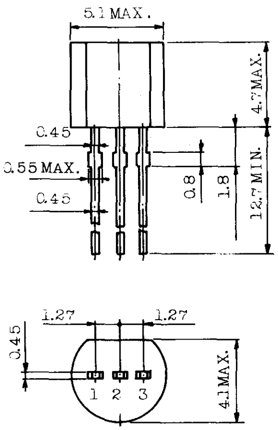
FEATURES:

. Low Noise : 4dB Max. (TBC549)
3dB Max. (TBC550)

. High V_{CEO} : 30V (TBC549)
45V (TBC550)

. High h_{FE} : 200 ~ 800

Unit in mm



1. COLLECTOR
2. BASE
3. EMITTER

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1G

Weight : 0.21g

MAXIMUM RATINGS ($Ta=25^{\circ}C$)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Breakdown Voltage	TBC549	$V_{(BR)CBO}$	30	V
	TBC550		50	
Collector-Emitter Breakdown Voltage	TBC549	$V_{(BR)CEO}$	30	V
	TBC550		45	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$	5	V
Collector Current	DC	I_C	100	mA
	Peak	I_{CP}	200	
Base Current (Peak)		I_{BP}	200	mA
Collector Power Dissipation		P_C	500	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_{stg}	-65 ~ 150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=30V, I_E=0	-	-	15	nA
Emitter Cut-off Current		I_{EBO}	V_{EB}=5V, I_C=0	-	-	1	μA
Collector-Emitter Breakdown Voltage	TBC549	$V_{(BR)CEO}$	I_C=1mA, I_B=0	45	-	-	V
	TBC550			30	-	-	
DC Current Gain	TBC549-B TBC550-B	h_{FE}	V_{CE}=5V, I_C=2mA	200	-	450	
	TBC549-C TBC550-C			420	-	800	
Small Signal Current Gain		h_{fe}	V_{CE}=5V, I_C=2mA, f=1kHz	240	-	900	
Base-Emitter Voltage		V_{BE}	V_{CE}=5V, I_C=2mA	580	660	700	mV
			V_{CE}=5V, I_C=10mA	-	-	770	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=10mA, I_B=0.5mA	-	-	250	mV
			I_C=100mA, I_B=5mA	-	-	600	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=10mA, I_B=0.5mA	-	720	-	mV
			I_C=100mA, I_B=5mA	-	900	-	
Knee Voltage		V_{CEK}	I_C=10mA, I_B=Value for which I_C=11mA, at V_{CE}=1V	-	400	600	mV
Transition Frequency		f_T	V_{CE}=5V, I_C=10mA	-	300	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=10V, f=1MHz	-	3.5	4.5	pF
Noise Figure	TBC549	NF	V_{CE}=5V, I_C=0.2mA, R_g=2kΩ, f=30Hz ~ 15kHz	-	1.4	4	dB
	TBC550			-	1.4	3	
Noise Figure	TBC549	NF	V_{CE}=5V, I_C=0.2mA R_g=2kΩ, f=1kHz	-	1	4	dB
	TBC550			-	1	4	
Equivalent Noise Voltage	TBC550	V_n	V_{CE}=5V, I_C=0.2mA R_g=2kΩ, f=10 ~ 50Hz	-	-	0.135	μV

TBC556
TBC557
TBC558

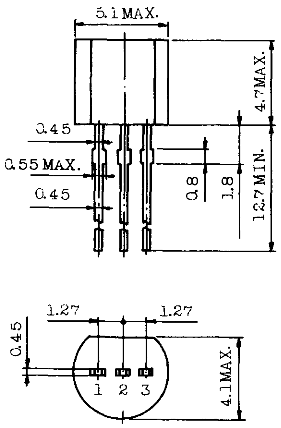
SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

PRIMARILY INTENDED FOR USE DRIVER STAGE OF AUDIO AMPLIFIERS.

FEATURES:

- High V_{CEO} : -65V (TBC556)
-45V (TBC557)
-30V (TBC558)
- Low Noise

Unit in mm



1. COLLECTOR
2. BASE
3. EMITTER

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1G

Weight : 0.21g

MAXIMUM RATINGS ($Ta=25^{\circ}C$)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Breakdown Voltage	TBC556	$V_{(BR)CBO}$	-80	V
	TBC557		-50	
	TBC558		-30	
Collector-Emitter Breakdown Voltage	TBC556	$V_{(BR)CEO}$	-65	V
	TBC557		-45	
	TBC558		-30	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$	-5	V
Collector Current	DC	I_C	-100	mA
	Peak	I_{CP}	-200	
Base Current (Peak)		I_{BP}	-200	mA
Collector Power Dissipation		P_C	500	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_{stg}	-65 ~ 150	°C

TBC556
TBC557
TBC558

ELECTRICAL CHARACTERISTICS (T_a=25°C)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=-30V, I_E=0	-	-	-15	nA
Emitter Cut-off Current		I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-1	μA
Collector-Emitter Breakdown Voltage	TBC556	$V_{(BR)CEO}$	I_C=-1mA, I_B=0	-65	-	-	V
	TBC557			-45	-	-	
	TBC558			-30	-	-	
DC Current Gain		h_{FE} (Note)	V_{CE}=-5V, I_C=-2mA	75	-	475	
Small Signal Current Gain		h_{fe}	V_{CE}=-5V, I_C=-2mA f=1kHz	75	-	500	
Base-Emitter Voltage		V_{BE}	V_{CE}=-5V, I_C=-2mA	-600	-650	-750	mV
			V_{CE}=-5V, I_C=-10mA	-	-	-820	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=-10mA, I_B=-0.5mA	-	-	-300	mV
			I_C=-100mA, I_B=-5mA	-	-	-650	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=-10mA, I_B=-0.5mA	-	-700	-	mV
			I_C=-100mA, I_B=-5mA	-	-850	-	
Knee Voltage		V_{CEK}	I_C=-10mA, I_B=Value for Which I_C=-11mA, at V_{CE}=-1V	-	-250	-600	mV
Transition Frequency		f_T	V_{CE}=-5V, I_C=-10mA	-	300	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=-10V, f=1MHz	-	4.5	-	pF
Noise Figure		NF	V_{CE}=-5V, I_C=-0.2mA R_g=2kΩ, f=1kHz	-	2	10	dB

Note: h_{FE} Classification 556, 557, 558, : 75~250
556-A, 557-A, 558-A : 125~250
556-B, 557-B, 558-B : 220~475

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

TBC559
TBC560

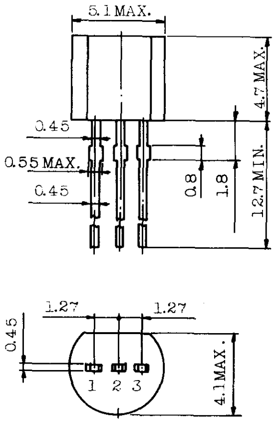
PRIMARILY INTENDED FOR USE IN DRIVER STAGE OF AUDIO AMPLIFIERS.

THE TBC559 AND TBC560 IS LOW NOISE TYPE FOR INPUT STAGE OF AUDIO AMPLIFIERS.

FEATURES:

- High V_{CEO} : -45V (TBC560)
  -25V (TBC559)
- High h_{FE} : 125～475

Unit in mm



1. COLLECTOR
2. BASE
3. EMITTER

JEDEC	TO−92
EIAJ	SC−43
TOSHIBA	2−5F1G

Weight : 0.21g

MAXIMUM RATINGS ($Ta=25^{o}C$)

CHARACTERISTIC		SYMBOL	RATING	UNIT
Collector-Base Breakdown Voltage	TBC559	$V_{(BR)CBO}$	-30	V
	TBC560		-50	
Collector-Emitter Breakdown Voltage	TBC559	$V_{(BR)CEO}$	-25	V
	TBC560		-45	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$	-5	V
Collector Current	DC	I_C	-100	mA
	Peak	I_{CP}	-200	
Base Current (Peak)		I_{BP}	-200	mA
Collector Power Dissipation		P_C	500	mW
Junction Temperature		T_j	150	^{o}C
Storage Temperature Range		T_{stg}	-65～150	^{o}C

ELECTRICAL CHARACTERISTICS (T_a=25°C)

CHARACTERISTIC		SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current		I_{CBO}	V_{CB}=-30V, I_E=0	-	-	-15	nA
Emitter Cut-off Current		I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-1	μA
Collector-Emitter Breakdown Voltage	TBC559	$V_{(BR)CEO}$	I_C=-1mA, I_B=0	-30	-	-	V
	TBC560			-45	-	-	
DC Current Gain		h_{FE} (Note)	V_{CE}=-5V, I_C=-2mA	125	-	475	
Small Signal Current Gain		h_{fe}	V_{CE}=-5V, I_C=-2mA f=1kHz	130	-	500	
Base-Emitter Voltage		V_{BE}	V_{CE}=-5V, I_C=-2mA	-600	-650	-750	V
			V_{CE}=-5V, I_C=-10mA	-	-	-820	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	I_C=-10mA, I_B=-0.5mA	-	-	-300	mV
			I_C=-100mA, I_B=-5mA	-	-	-650	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	I_C=-10mA, I_B=-0.5mA	-	-700	-	mV
			I_C=-100mA, I_B=-5mA	-	-850	-	
Knee Voltage		V_{CEK}	I_C=-10mA, I_B=Value for Which I_C=-11mA, at V_{CE}=-1V	-	-250	-600	mV
Transition Frequency		f_T	V_{CE}=-5V, I_C=-10mA	-	300	-	MHz
Collector Output Capacitance		C_{ob}	V_{CB}=-10V, f=1MHz	-	4.5	-	pF
Noise Figure	TBC559	NF	V_{CE}=-5V, I_C=-0.2mA R_g=2kΩ, f=1kHz	-	1	4	dB
	TBC560			-	1	4	
	TBC559		V_{CE}=-5V, I_C=-0.2mA R_g=2kΩ, f=30Hz ~15kHz	-	1.2	4	
	TBC560			-	1.2	2	

Note: h_{FE} Classification 559-A , 560-A : 125∿250
559-B , 560-B : 220∿475

TEC series

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

TEC8012

DRIVER STAGE AMPLIFIER APPLICATIONS.

SWITCHING APPLICATIONS.

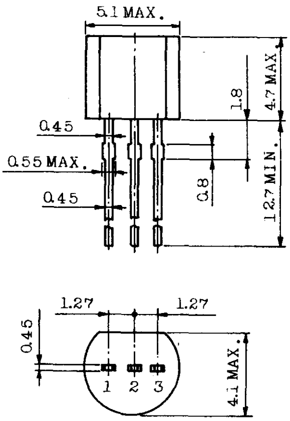
FEATURES:

. Excellent h_{FE} Linearity
    : $h_{FE(2)}$=23(Min.) at V_{CE}=-1V, I_C=-400mA

. 1 Watt Amplifier Application

. Complementary to TEC8013

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

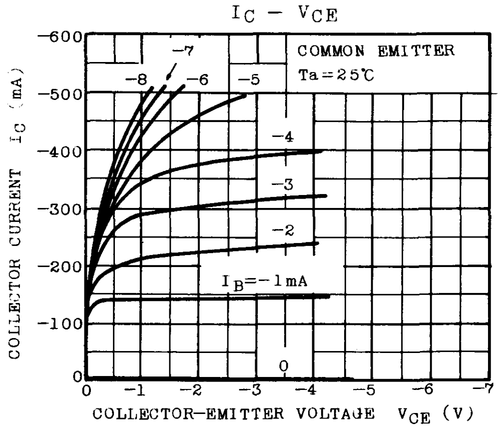
MAXIMUM RATINGS (Ta=25°C)

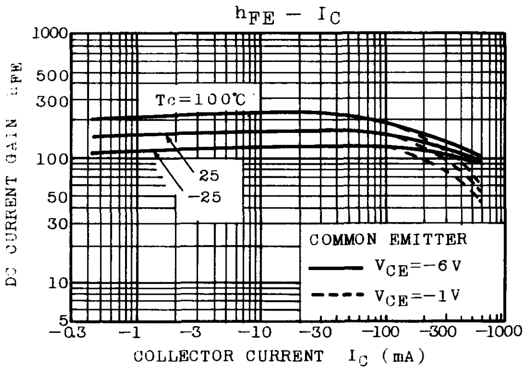
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-40	V
Collector-Emitter Voltage	V_{CEO}	-30	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-500	mA
Base Current	I_B	-100	mA
Collector Power Dissipation	P_C	625	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55 ~ 150	°C

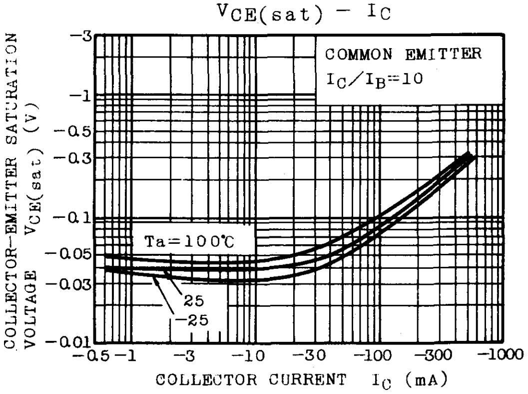
ELECTRICAL CHARACTERISTICS (Ta=25°C)

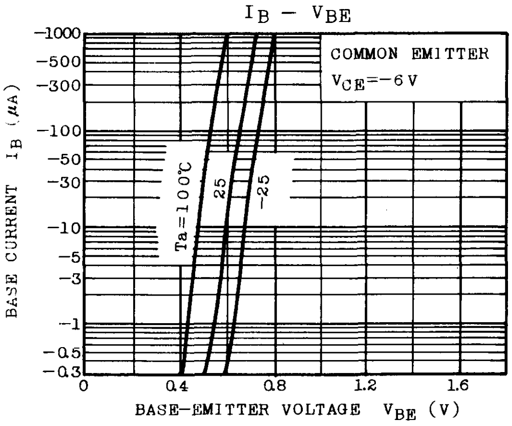
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-35V, I_E=0	-	-	-0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=-1V, I_C=-50mA	64	-	202	-
	$h_{FE(2)}$	V_{CE}=-1V, I_C=-400mA	23	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-100mA, I_B=-50mA	-	-0.1	-0.25	V
Base-Emitter Voltage	V_{BE}	I_C=-50mA, V_{CE}=-1V	-0.65	-0.72	-0.80	V
Transition Frequency	f_T	V_{CE}=-6V, I_C=-20mA	150	200	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-6V, I_E=0, f=1MHz	-	7	-	pF
Collector-Emitter Breakdwon Voltage	$V_{(BR)CEO}$	I_C=-1mA, I_B=0	-30	-	-	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=-100mA, I_B=-50mA	-	-	-1.2	V

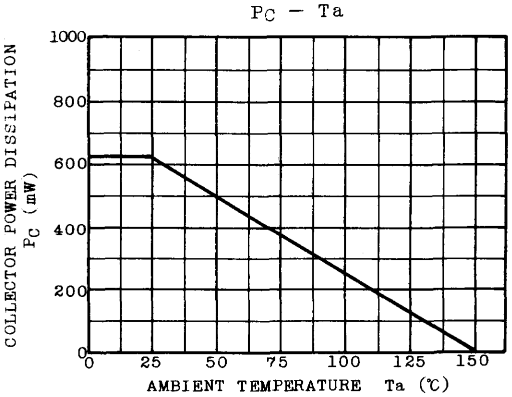
Note: $h_{FE(1)}$ Classification D : 64 ~ 91, E : 73~112, F : 96 ~ 135, G : 118 ~ 166,
H : 144 ~ 202


$I_C - V_{CE}$


$h_{FE} - I_C$


$V_{CE(sat)} - I_C$


$I_B - V_{BE}$


$P_C - Ta$

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

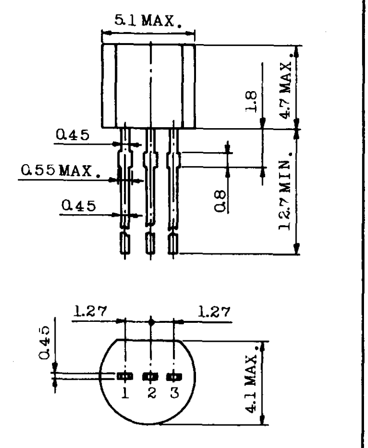
TEC8013

AUDIO FREQUENCY LOW POWER AMPLIFIER APPLICATIONS.
DRIVER STAGE AMPLIFIER APPLICATIONS.
SWITCHING APPLICATIONS.

FEATURES:

- Excellent h_{FE} Linearity
  : $h_{FE(2)}$=23(Min.) at V_{CE}=1V, I_C=400mA
- 1 Watt Amplifier Applications
- Complementary to TEC8012

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

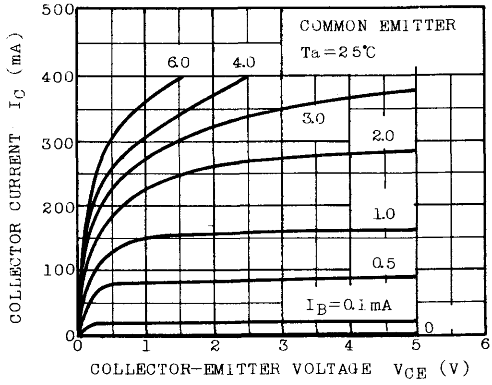
MAXIMUM RATINGS ($Ta=25^{\circ}C$)

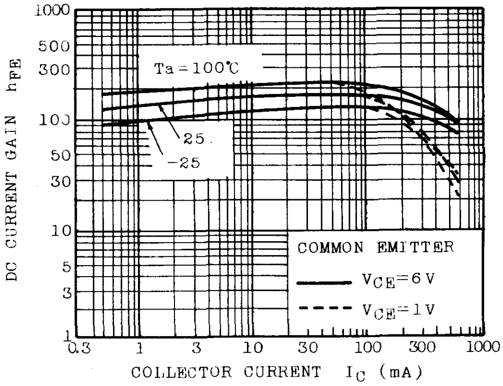
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	40	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	500	mA
Base Current	I_B	100	mA
Collector Power Dissipation	P_C	625	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

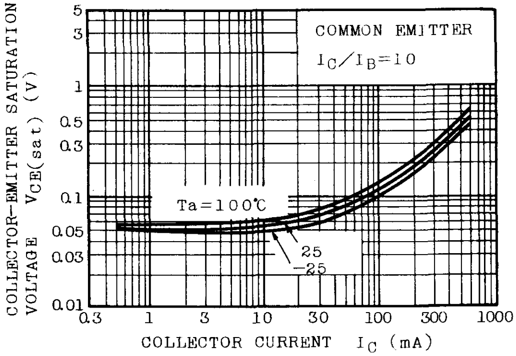
ELECTRICAL CHARACTERISTICS ($Ta=25^{\circ}C$)

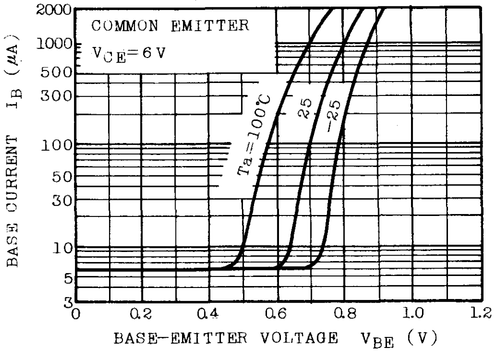
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=35V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=1V, I_C=50mA	64	-	202	
	$h_{FE(2)}$	V_{CE}=1V, I_C=400mA	23	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=100mA, I_B=50mA	-	0.1	0.25	V
Base-Emitter Voltage	V_{BE}	I_C=50mA, V_{CE}=1V	0.65	0.73	0.80	V
Transition Frequency	f_T	V_{CE}=6V, I_C=20mA	140	300	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=6V, I_E=0, f=1MHz	-	7	-	pF
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	30	-	-	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=100mA, I_B=50mA	-	-	1.2	V

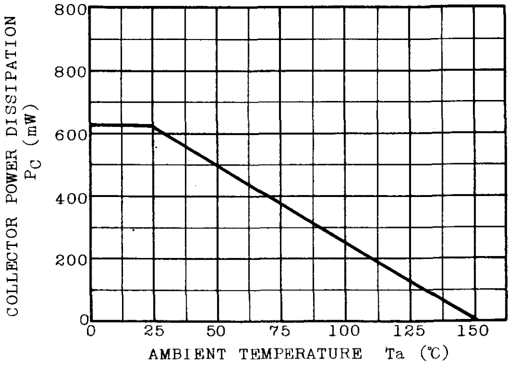
Note : $h_{FE(1)}$ Classification D : 64~91, E : 78~112, F : 96~135,
G : 118~166, H : 144~202


$I_C - V_{CE}$


$h_{FE} - I_C$


$V_{CE(sat)} - I_C$


$I_B - V_{BE}$


$P_C - Ta$

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

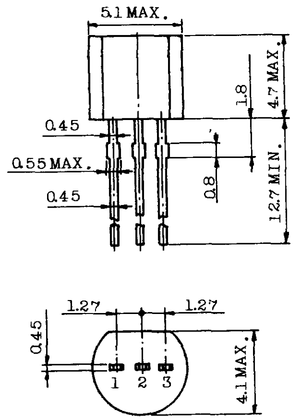
TEC9011

FM IF, OSC AND AM CONV, IF AMPLIFIER APPLICATIONS.

FEATURES:

- Excellent Noise Figure : NF=2.0dB(Typ.)

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

MAXIMUM RATINGS ($T_a=25^{\circ}C$)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	50	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	50	mA
Base Current	I_B	5	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

ELECTRICAL CHARACTERISTICS ($T_a=25^{\circ}C$)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	$V_{CB}=50V,\ I_E=0$	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	$V_{EB}=4V,\ I_C=0$	-	-	0.1	μA
DC Current Gain	h_{FE} (Note)	$V_{CE}=5V,\ I_C=1mA$	39	-	198	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C=10mA,\ I_B=1mA$	-	-	0.3	V
Base-Emitter Voltage	V_{BE}	$I_C=5mA,\ I_B=1mA$	0.65	0.70	0.75	V
Transition Frequency	f_T	$V_{CE}=5V,\ I_C=1mA$	100	-	-	MHz
Collector Output Capacitance	C_{ob}	$V_{CB}=10V,\ I_E=0,\ f=1MHz$	-	1.5	-	pF
Noise Figure	NF	$V_{CC}=5V,\ I_E=-1mA,$ $R_g=500\Omega$, f=1kHz	-	2.0	4.0	dB

Note : h_{FE} Classification E : 39~60, F : 54~80, G : 72~108, H : 97~146
I : 132~198

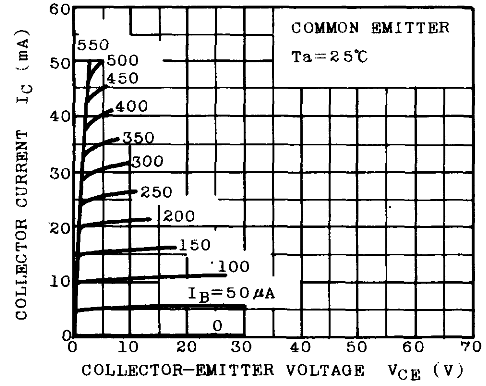
PARAMETERS (Typ.)

(1) COMMON EMITTER (f=455kHz, V_{CE}=6V, I_E=-1mA, Ta=25°C)

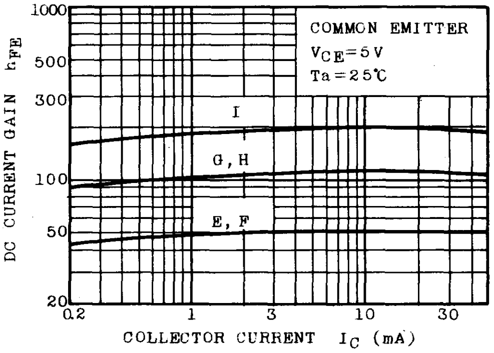
CHARACTERISTIC	SYMBOL	TEC9011-E,F	TEC9011-G,H	TEC9011-I	UNIT
Input Conductance	g_{ie}	0.58	0.41	0.26	m
Input Capacitance	C_{ie}	53	46	38	pF
Output Conductance	g_{oe}	1.9	2.7	4.8	μ
Output Capacitance	C_{oe}	2.6	2.8	3.6	pF
Forward Transfer Admittance	y_{fe}	38	38	38	m
Forward Transfer Admittance Phase Angle	θ_{fe}	-0.79	-0.83	-0.92	°C
Reverse Transfer Admittance	y_{re}	5.7	5.7	6.2	μ
Reverse Transfer Admittance Phase Angle	θ_{re}	-90	-90	-90	°C

(2) COMMON EMITTER (f=10.7MHz, V_{CE}=6V, I_E=-1mA, Ta=25°C)

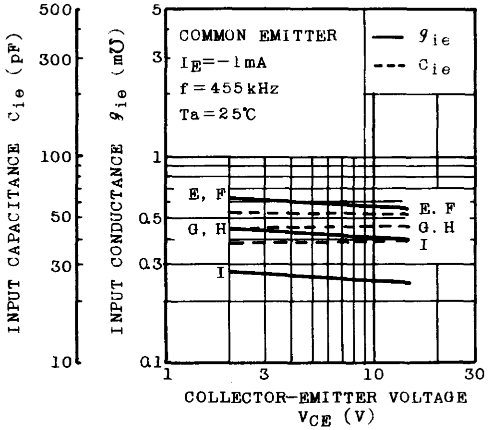
CHARACTERISTIC	SYMBOL	TEC9011-E,F	TEC9011-G,H	TEC9011-I	UNIT
Input Conductance	g_{ie}	1.04	0.85	0.65	m
Input Capacitance	C_{ie}	49	43	36	pF
Output Conductance	g_{oe}	10	15	28	μ
Output Capacitance	C_{oe}	2.7	2.9	3.6	pF
Forward Transfer Admittance	y_{fe}	37	37	37	m
Forward Transfer Admittance Phase Angle	θ_{fe}	-9.6	-10.4	-11.5	°C
Reverse Transfer Admittance	y_{re}	120	120	140	μ
Reverse Transfer Admittance Phase Angle	θ_{re}	-90	-90	-90	°C



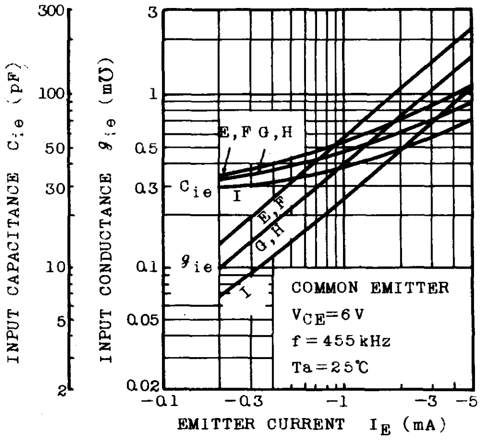
STATIC CHARACTERISTICS



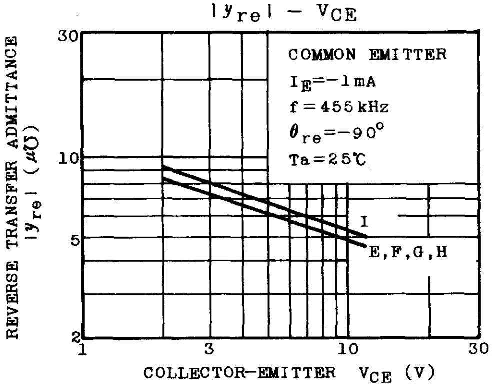
h_{FE} – I_C



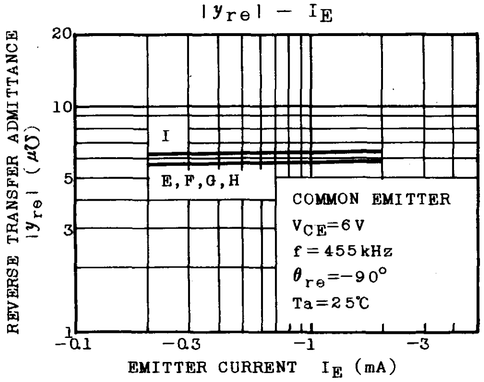
g_{ie}, C_{ie} – V_{CE}



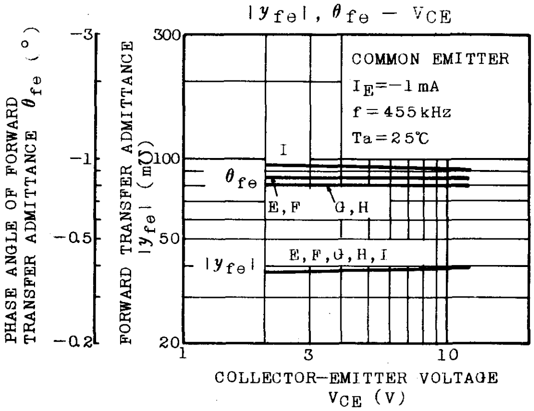
g_{ie}, C_{ie} – I_E

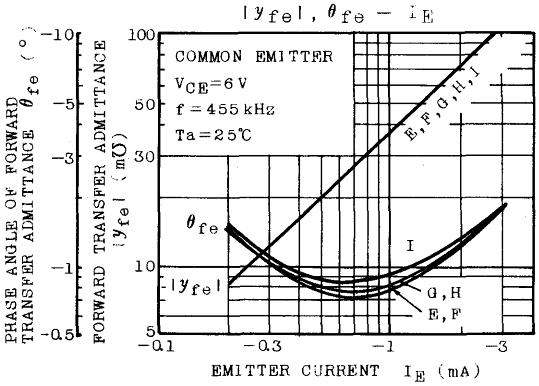


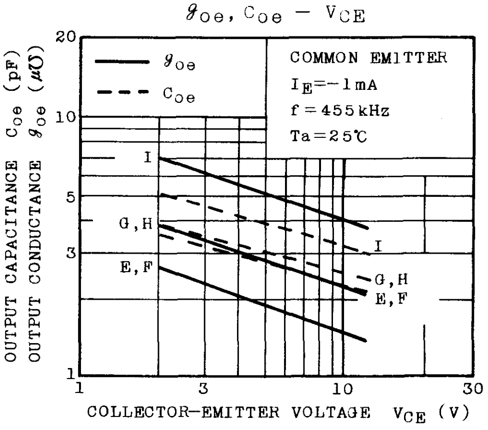
$|y_{re}|$ – V_{CE}

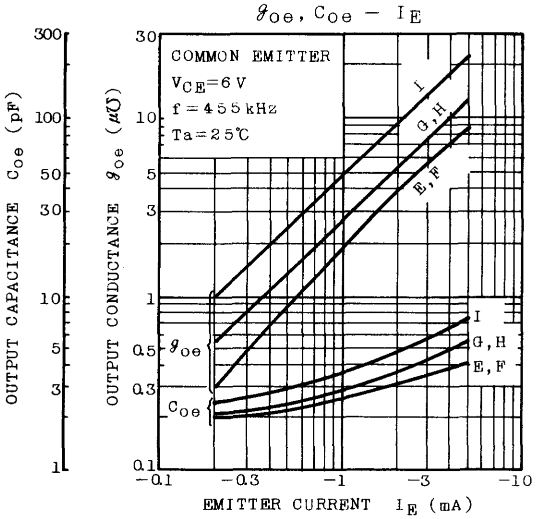


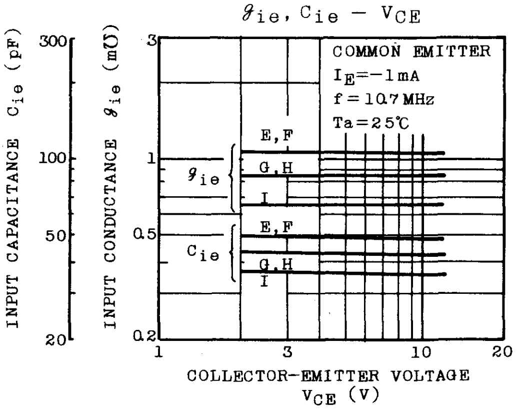
$|y_{re}|$ – I_E

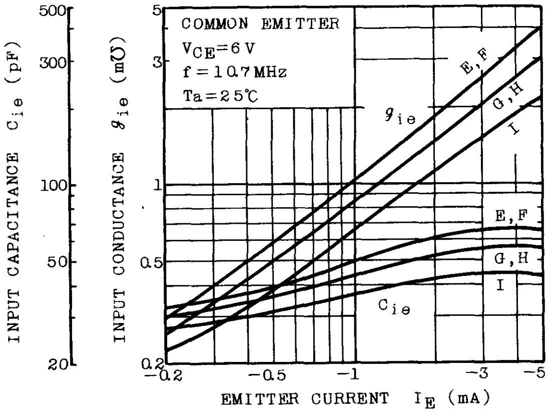

|yfe|, θfe — VCE
COMMON EMITTER
IE=−1 mA
f = 455 kHz
Ta = 25℃
PHASE ANGLE OF FORWARD TRANSFER ADMITTANCE θfe (°)
FORWARD TRANSFER ADMITTANCE |yfe| (m℧)
θfe
|yfe|
I
E, F
G, H
E, F, G, H, I
−3
−1
−0.5
−0.2
300
100
50
20
1
3
10
COLLECTOR-EMITTER VOLTAGE VCE (V)


|yfe|, θfe — IE
COMMON EMITTER
VCE=6 V
f = 455 kHz
Ta = 25℃
PHASE ANGLE OF FORWARD TRANSFER ADMITTANCE θfe (°)
FORWARD TRANSFER ADMITTANCE |yfe| (m℧)
E, F, G, H, I
θfe
|yfe|
I
G, H
E, F
−10
−5
−3
−1
−0.5
100
50
30
10
5
−0.1
−0.3
−1
−3
EMITTER CURRENT IE (mA)

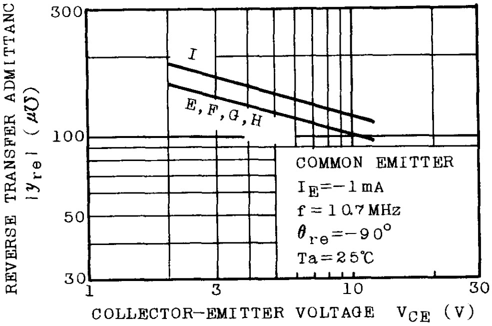

goe, Coe — VCE
goe
Coe
COMMON EMITTER
IE=−1 mA
f = 455 kHz
Ta = 25℃
OUTPUT CAPACITANCE Coe (pF)
OUTPUT CONDUCTANCE goe (μ℧)
I
G, H
E, F
I
G, H
E, F
20
10
5
3
1
1
3
10
30
COLLECTOR-EMITTER VOLTAGE VCE (V)


goe, Coe — IE
COMMON EMITTER
VCE=6 V
f = 455 kHz
Ta = 25℃
OUTPUT CAPACITANCE Coe (pF)
OUTPUT CONDUCTANCE goe (μ℧)
I
G, H
E, F
goe
Coe
I
G, H
E, F
300
100
50
30
10
5
3
1
30
10
5
3
1
0.5
0.3
0.1
−0.1
−0.3
−1
−3
−10
EMITTER CURRENT IE (mA)

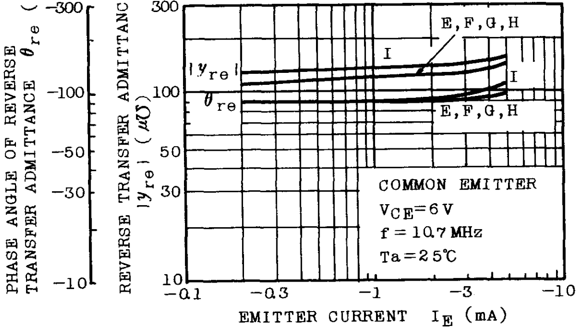

gie, Cie — VCE
COMMON EMITTER
IE=−1 mA
f = 10.7 MHz
Ta = 25℃
INPUT CAPACITANCE Cie (pF)
INPUT CONDUCTANCE gie (m℧)
gie
Cie
E, F
G, H
I
E, F
G, H
I
300
100
50
20
3
1
0.5
0.2
1
3
10
20
COLLECTOR-EMITTER VOLTAGE VCE (V)



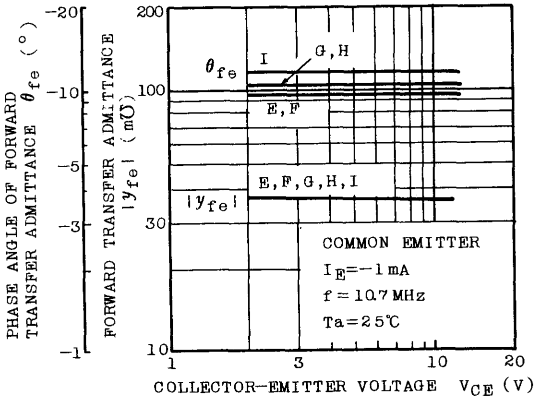
g_{ie}, C_{ie} – I_E



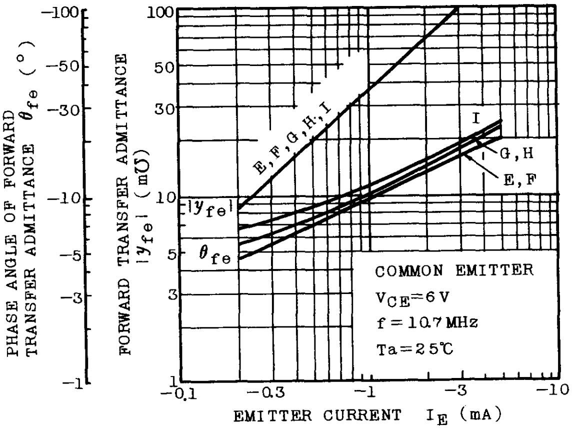
$|y_{re}|$ – V_{CE}



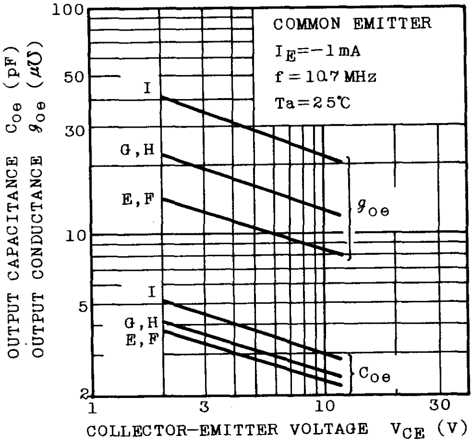
$|y_{re}|$, θ_{re} – I_E



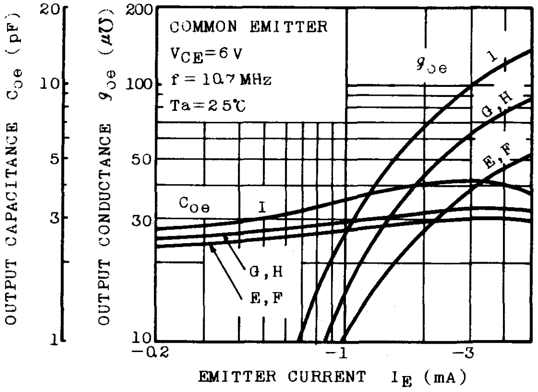
$|y_{fe}|$, θ_{fe} – V_{CE}



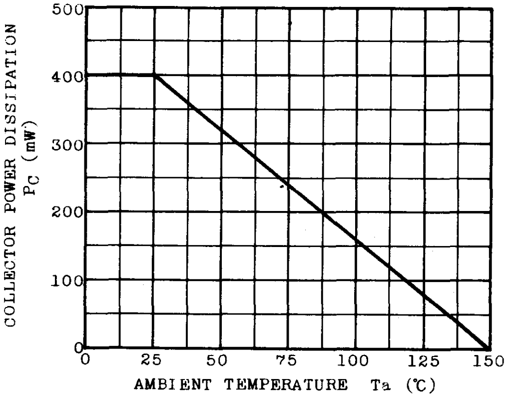
$|y_{fe}|$, θ_{fe} – I_E



g_{oe}, C_{oe} – V_{CE}



g_{oe}, C_{oe} — I_E



P_C — Ta

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

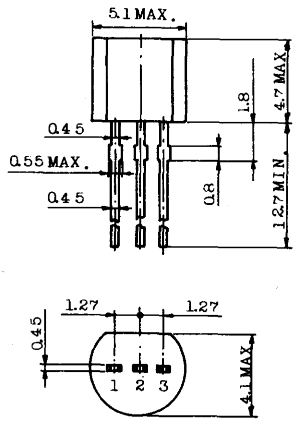
TEC9012

. AUDIO POWER AMPLIFIER APPLICATIONS.

FEATURES:

- High h_{FE} : h_{FE}=96 ~ 300
- 1W Output Applications
- Complementary to TEC9013

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

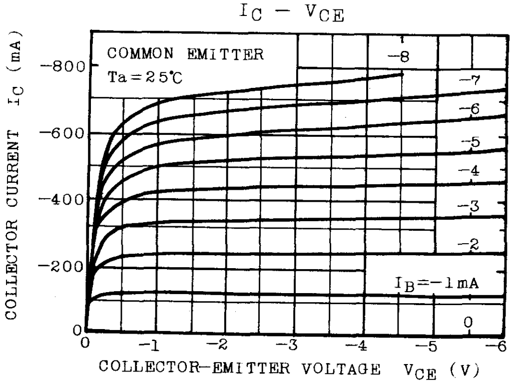
MAXIMUM RATINGS (Ta=25°C)

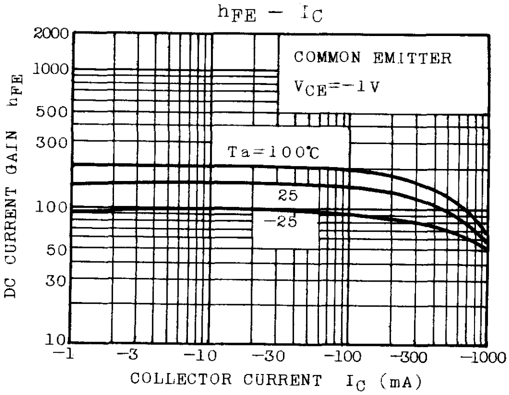
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-30	V
Collector-Emitter Voltage	V_{CEO}	-25	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-800	mA
Base Current	I_B	80	mA
Collector Power Dissipation	P_C	625	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55 ~ 150	°C

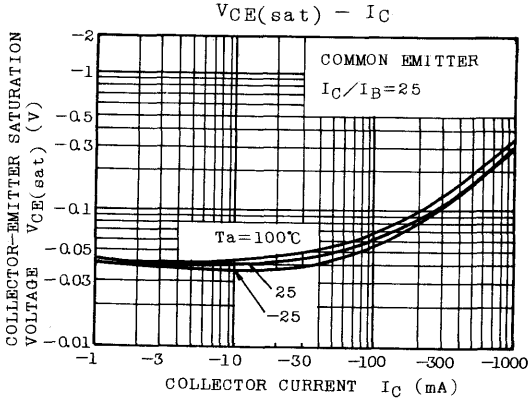
ELECTRICAL CHARACTERISTICS (Ta=25°C)

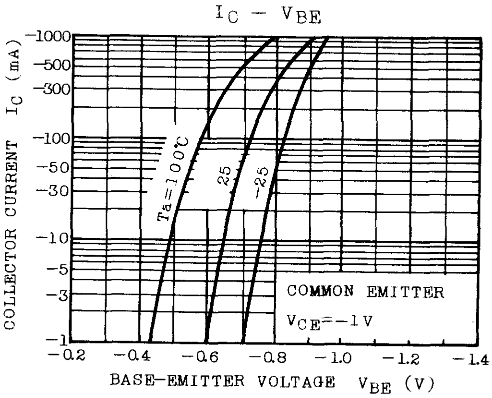
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-30V, I_E=0	-	-	-100	nA
Emitter- Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-1mA	-30	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=-1V, I_C=-50mA	96	-	300	
	$h_{FE(2)}$	V_{CE}=-1V, I_C=-500mA	40	70	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-500mA, I_B=20mA	-	-0.19	-0.7	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-1V, I_C=-50mA	-0.6	-	-0.75	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=-500mA, I_B=-20mA	-	-0.91	-1.20	V

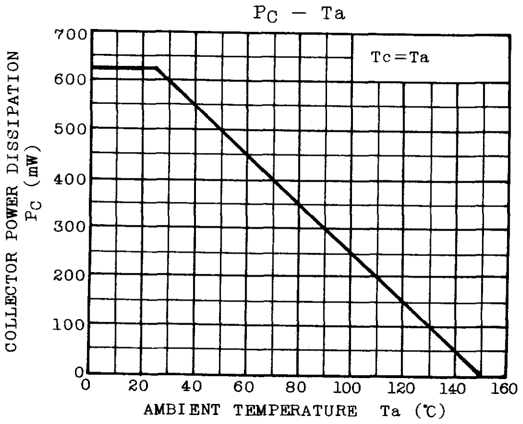
Note : $h_{FE(1)}$ Classification F : 96 ~ 135, G : 118 ~ 166, H : 144 ~ 202
I : 176 ~ 246, J : 214 ~ 300


I_C − V_{CE}
COMMON EMITTER
Ta=25℃
−8
−7
−6
−5
−4
−3
−2
I_B=−1mA
0
COLLECTOR CURRENT I_C (mA)
−800
−600
−400
−200
0
0
−1
−2
−3
−4
−5
−6
COLLECTOR−EMITTER VOLTAGE V_{CE} (V)


h_{FE} − I_C
COMMON EMITTER
V_{CE}=−1V
Ta=100℃
25
−25
DC CURRENT GAIN h_{FE}
2000
1000
500
300
100
50
30
10
−1
−3
−10
−30
−100
−300
−1000
COLLECTOR CURRENT I_C (mA)


$V_{CE(sat)}$ − I_C
COMMON EMITTER
I_C/I_B=25
Ta=100℃
25
−25
COLLECTOR−EMITTER SATURATION VOLTAGE $V_{CE(sat)}$ (V)
−2
−1
−0.5
−0.3
−0.1
−0.05
−0.03
−0.01
−1
−3
−10
−30
−100
−300
−1000
COLLECTOR CURRENT I_C (mA)


I_C − V_{BE}
Ta=100℃
25
−25
COMMON EMITTER
V_{CE}=−1V
COLLECTOR CURRENT I_C (mA)
−1000
−500
−300
−100
−50
−30
−10
−5
−3
−1
−0.2
−0.4
−0.6
−0.8
−1.0
−1.2
−1.4
BASE−EMITTER VOLTAGE V_{BE} (V)


P_C − Ta
Tc=Ta
COLLECTOR POWER DISSIPATION P_C (mW)
700
600
500
400
300
200
100
0
0
20
40
60
80
100
120
140
160
AMBIENT TEMPERATURE Ta (℃)

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

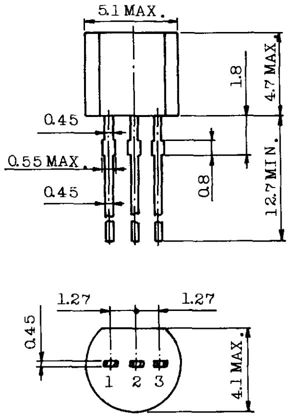
TEC9013

AUDIO POWER AMPLIFIER APPLICATIONS.

FEATURES:

- High h_{FE} : h_{FE}=96 ~ 300
- 1 Watts Amplifier Applications
- Complementary to TEC9012

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

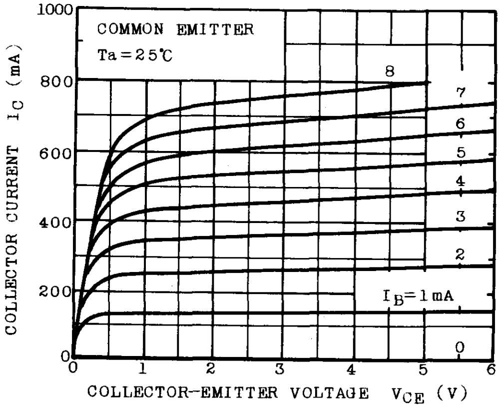
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	30	V
Collector-Emitter Voltage	V_{CEO}	25	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	800	mA
Base Current	I_B	-80	mA
Collector Power Dissipation	P_C	625	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55 ~ 150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

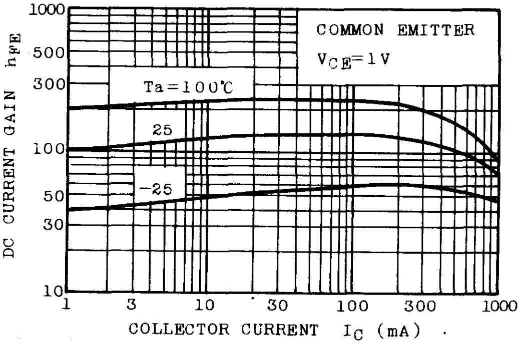
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=30V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA	30	-	-	V
DC Current Gain	$h_{FE(1)}$ (Note)	V_{CE}=1V, I_C=50mA	96	-	300	
	$h_{FE(2)}$	V_{CE}-1V, I_C=500mA	40	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=500mA, I_B=20mA	-	0.15	0.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=1V, I_C=50mA	0.6	-	0.75	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=500mA, I_B=20mA	-	0.91	1.20	V

Note : $h_{FE(1)}$ Classification F : 96 ~ 135, G : 118 ~ 166, H : 144 ~ 202,
I : 176 ~ 246, J : 214 ~ 300

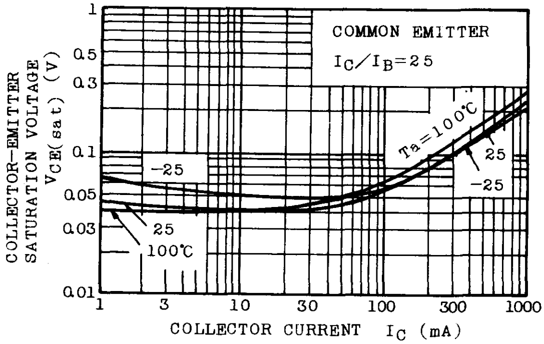
I_C — V_{CE}



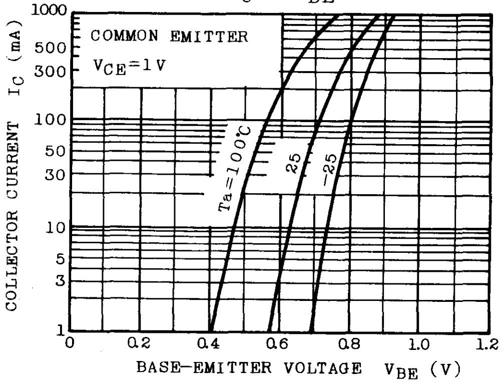
h_{FE} — I_C



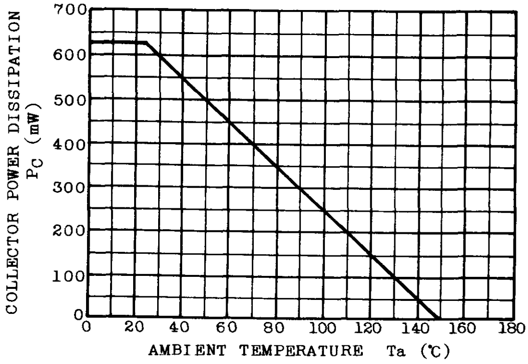
$V_{CE(sat)}$ — I_C



I_C — V_{BE}



P_C — Ta



SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

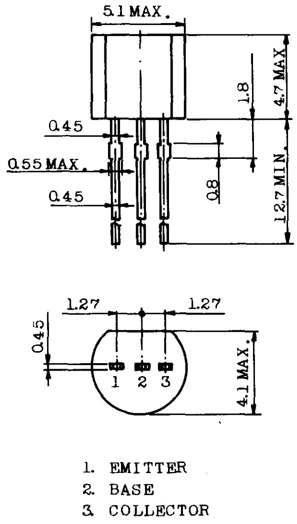
TEC9014

AUDIO FREQUENCY GENERAL PURPOSE AMPLIFIER APPLICATIONS.
DRIVER STAGE AMPLIFIER APPLICATIONS.

FEATURES:

- High Voltage and High Current
  : V_{CEO}=50V(Min.), I_C=150mA(Max.)
- Low Noise : NF=0.9dB(Typ.) *at* f=1kHz
- Complementary to TEC9015

Unit in mm



JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

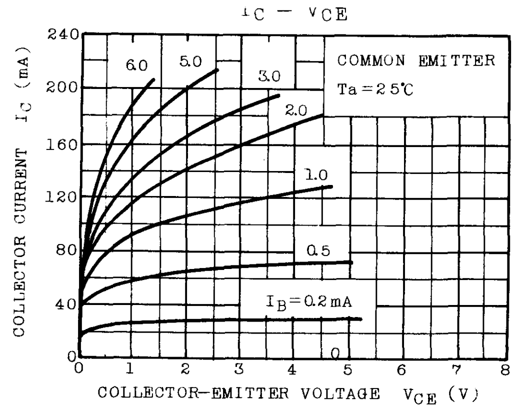
MAXIMUM RATINGS ($Ta=25^{\circ}C$)

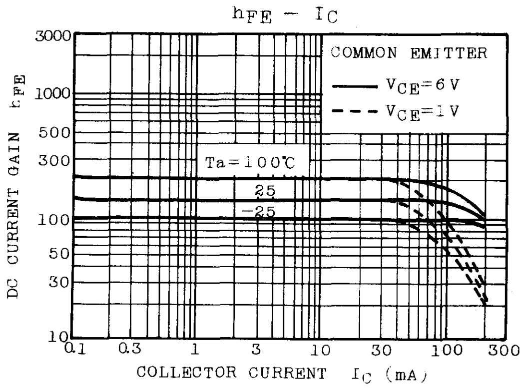
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	60	V
Collector-Emitter Voltage	V_{CEO}	50	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	150	mA
Base Current Range	I_B	50	mA
Collector Power Dissipation	P_C	625	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

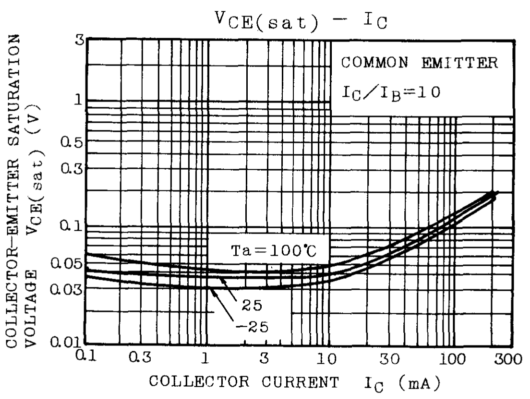
ELECTRICAL CHARACTERISTICS ($Ta=25^{\circ}C$)

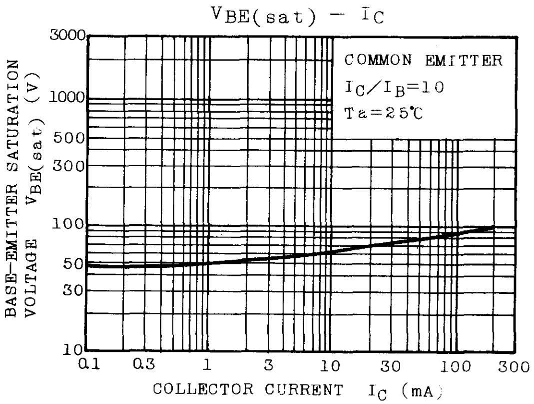
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=50V, I_E=0	-	-	50	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	50	nA
DC Current Gain	h_{FE} (Note)	V_{CE}=5V, I_C=1mA	60	-	1000	-
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	50	-	-	V
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=100mA, I_B=10mA	-	0.1	0.25	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=100mA, I_B=10mA	-	-	1.0	V
Transition Frequency	f_T	V_{CE}=5V, I_E=10mA	150	-	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	2.0	3.5	pF
Base-Emitter Voltage	V_{BE}	V_{CE}=5V, I_C=2mA	0.58	0.63	0.70	V
Noise Figure	NF	V_{CE}=5V, I_C=0.2mA, R_g=2kΩ, f=1kHz	-	0.9	10	dB

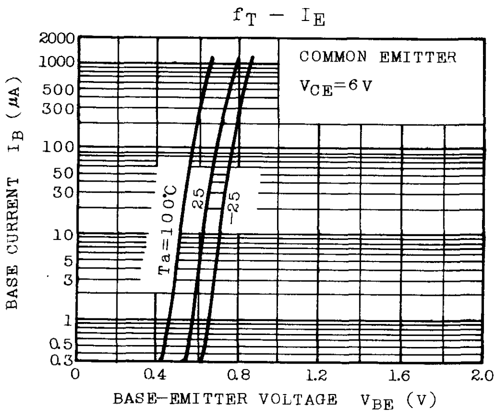
Note : h_{FE} Classification A : 60~150, B : 100~300, C : 200~600 D : 400~1000

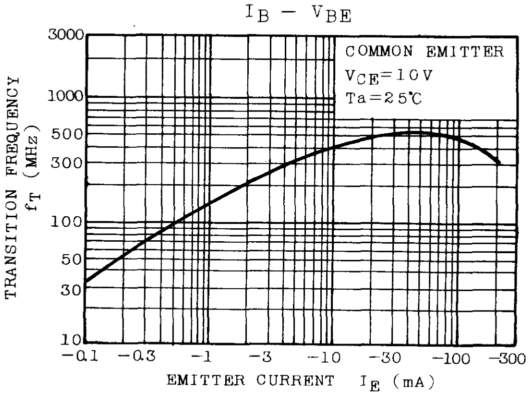

I_C — V_{CE}
COMMON EMITTER
Ta=25℃
6.0
5.0
3.0
2.0
1.0
0.5
I_B=0.2mA
0
COLLECTOR CURRENT I_C (mA)
240
200
160
120
80
40
0
0
1
2
3
4
5
6
7
8
COLLECTOR—EMITTER VOLTAGE V_{CE} (V)

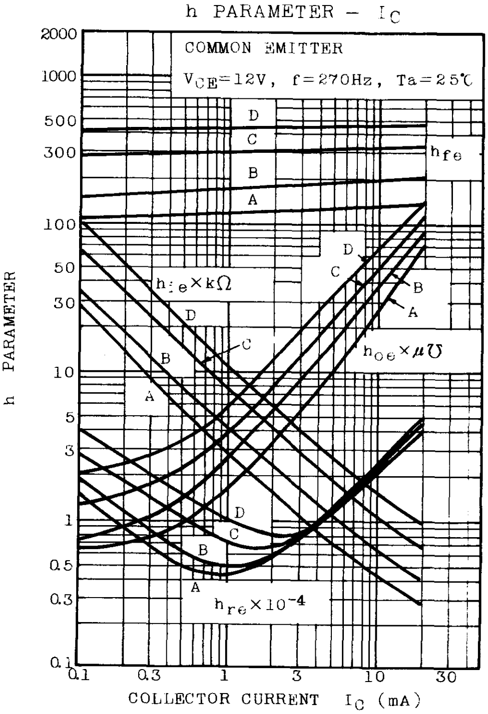

h_{FE} — I_C
COMMON EMITTER
V_{CE}=6V
V_{CE}=1V
Ta=100℃
25
−25
DC CURRENT GAIN h_{FE}
3000
1000
500
300
100
50
30
10
0.1
0.3
1
3
10
30
100
300
COLLECTOR CURRENT I_C (mA)

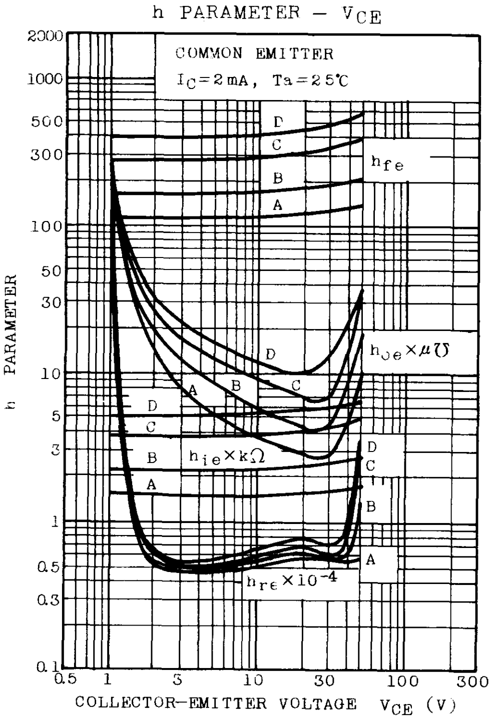

$V_{CE(sat)}$ — I_C
COMMON EMITTER
I_C/I_B=10
Ta=100℃
25
−25
COLLECTOR—EMITTER SATURATION VOLTAGE $V_{CE(sat)}$ (V)
3
1
0.5
0.3
0.1
0.05
0.03
0.01
0.1
0.3
1
3
10
30
100
300
COLLECTOR CURRENT I_C (mA)

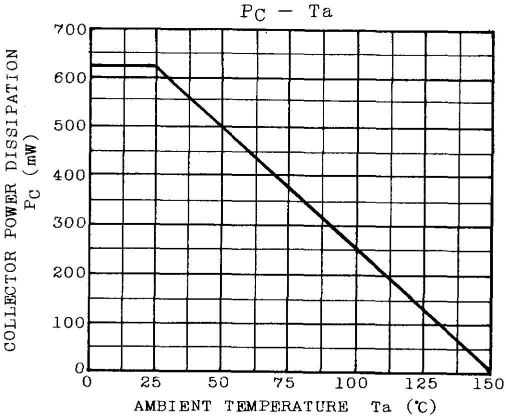

$V_{BE(sat)}$ — I_C
COMMON EMITTER
I_C/I_B=10
Ta=25℃
BASE—EMITTER SATURATION VOLTAGE $V_{BE(sat)}$ (V)
3000
1000
500
300
100
50
30
10
0.1
0.3
1
3
10
30
100
300
COLLECTOR CURRENT I_C (mA)


f_T — I_E
COMMON EMITTER
V_{CE}=6V
Ta=100℃
25
−25
BASE CURRENT I_B (μA)
2000
1000
500
300
100
50
30
10
5
3
1
0.5
0.3
0
0.4
0.8
1.2
1.6
2.0
BASE—EMITTER VOLTAGE V_{BE} (V)


I_B — V_{BE}
COMMON EMITTER
V_{CE}=10V
Ta=25℃
TRANSITION FREQUENCY f_T (MHz)
3000
1000
500
300
100
50
30
10
−0.1
−0.3
−1
−3
−10
−30
−100
−300
EMITTER CURRENT I_E (mA)


h PARAMETER – I_C


h PARAMETER – V_{CE}


P_C – Ta

TEC9015

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

AUDIO FREQUENCY GENERAL PURPOSE AMPLIFIER APPLICATIONS.
DRIVER STAGE AMPLIFIER APPLICATIONS.

FEATURES:

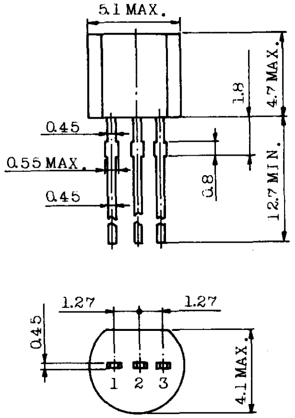
. High Voltage and High Current

: V_{CEO}=-50V(Min.), I_C=-150mA(Max.)

. Low Noise : NF=0.7dB(Typ.) at f=1kHz

. Complementary to TEC9014

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

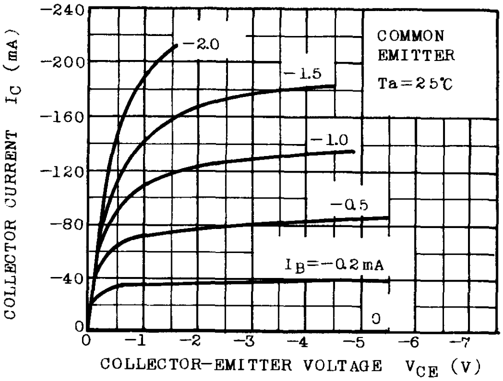
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-50	V
Collector-Emitter Voltage	V_{CEO}	-50	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-150	mA
Base Current	I_B	-50	mA
Collector Power Dissipation	P_C	625	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

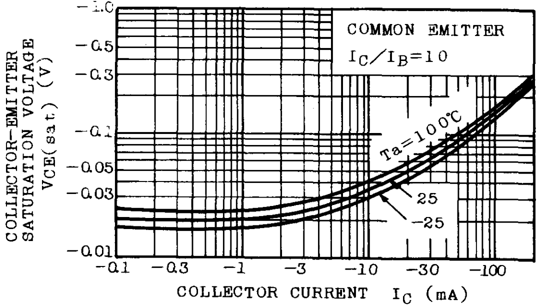
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-50V, I_E=0	-	-	-50	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=-5V, I_C=-1mA	60	-	600	-
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-1mA, I_B=0	-50	-	-	V
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-100mA, I_B=-10mA	-	-0.1	-0.3	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=-100mA, I_B=-10mA	-	-	-1.1	V
Transition Frequency	f_T	V_{CE}=-5V, I_E=10mA	100	-	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	4	7	pF
Base-Emitter Voltage	V_{BE}	V_{CE}=-5V, I_C=-2mA	-0.60	-0.69	-0.75	V
Noise Figure	NF	V_{CE}=-5V, I_C=-0.2mA R_g=2kΩ, f=1kHz	-	0.7	10	dB

Note : h_{FE} Classification A : 60~150, B : 100~300, C : 200~600

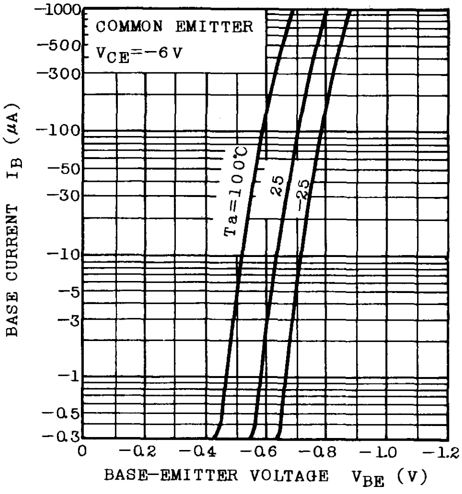
$I_C - V_{CE}$



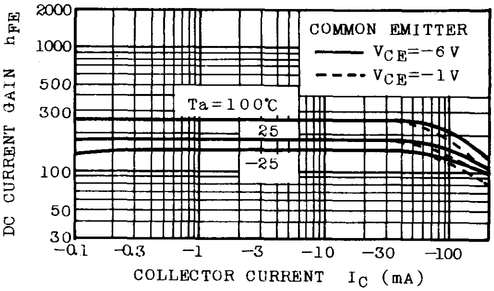
$V_{CE(sat)} - I_C$



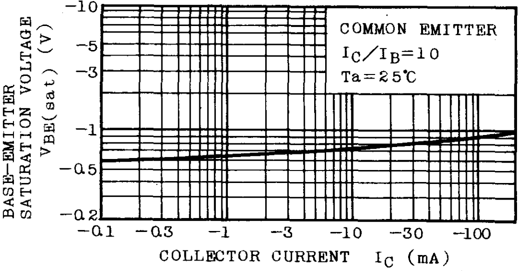
$I_B - V_{BE}$



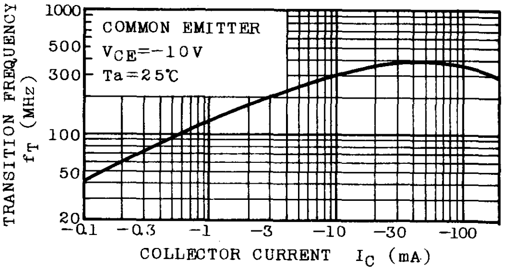
$h_{FE} - I_C$



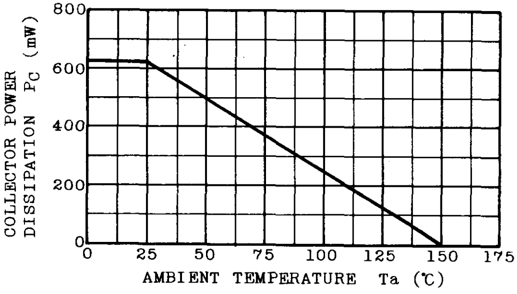
$V_{BE(sat)} - I_C$



$f_T - I_C$



$P_C - Ta$



TEC9016

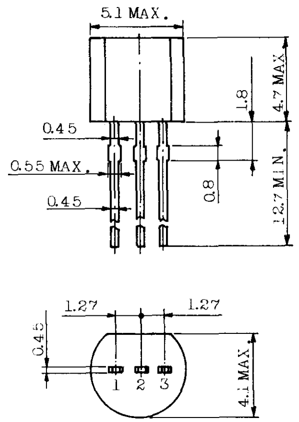
SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

HGIH FREQUENCY AMPLIFIER APPLICATIONS.
FM, RF, MIX, IF AMPLIFIER APPLICATIONS.

FEATURES:

- Small Collector Output Capacitance : C_{ob}=1.2pF(Typ.)
- Low Noise Figure : NF=2.5dB(Typ.) (f=100MHz)

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

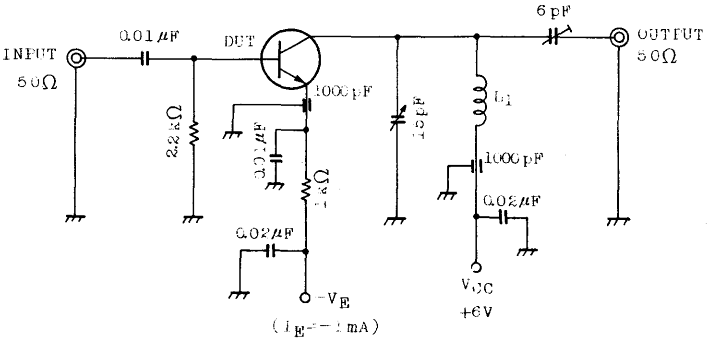
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	40	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	25	mA
Base Current	I_B	2.5	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55 ~ 150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=40V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=4V, I_C=0	-	-	0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=5V, I_C=1mA	54	-	198	
Collector Output Capacitance	C_{ob}	V_{CE}=10V, f=1MHz, I_E=0	-	1.2	1.6	pF
Transition Frequency	f_T	V_{CE}=5V, I_C=1mA	400	620	-	MHz
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	30	-	-	V
Noise Figure	NF	V_{CE}=6V, I_E=-1mA f=100MHz, Fig.	-	2.5	5.0	dB
Power Gain	G_{pe}		15	18	-	dB
Base-Emitter Voltage	V_{BE}	V_{CE}=5V, I_C=1mA	-	0.72	-	V
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	0.1	0.3	V

Note : h_{FE} Classification F : 54 ~ 80, G : 72 ~ 108, H : 97 ~ 146, I : 132 ~ 198

Fig. NF, G_{pe} TEST CIRCUIT



L_1 : 0.8mmϕ SILVER PLATED COPPER WIRE, 4T, 10ID, 8 LENGTH

y PARAMETER (Typ.)

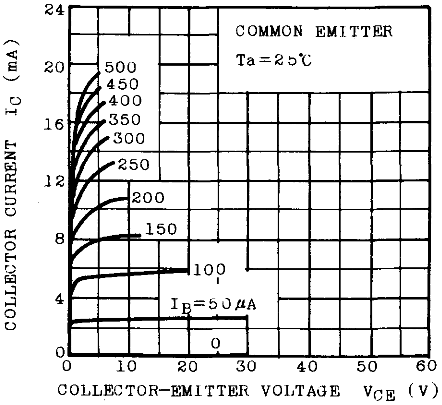
(1) COMMON EMITTER (V_{CE}=6V, I_E=-1mA, f=100MHz)

CHARACTERISTIC	SYMBOL	TYP.	UNIT
Input Conductance	g_{ie}	2.9	m℧
Input Capacitance	Cie	10.2	pF
Reverse Transfer Admittance	$\lvert y_{re} \rvert$	0.33	m℧
Phase Angle of Reverse Transfer Admittance	θ_{re}	-90	°
Forward Transfer Admittance	$\lvert y_{fe} \rvert$	40	m℧
Phase Angle of Forward Transfer Admittance	θ_{fe}	-20	°
Output Conductance	g_{oe}	45	μ℧
Output Capacitance	Coe	1.1	pF

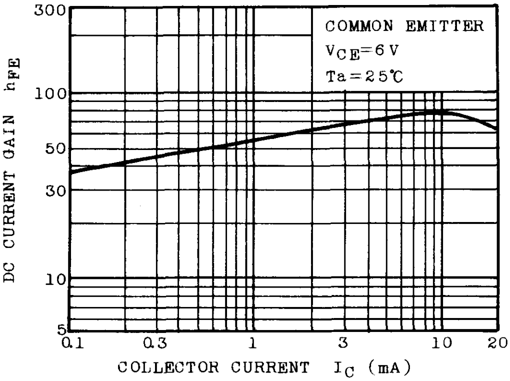
(2) COMMON BASE (V_{CE}=6V, I_E=-1mA, f=100MHz)

CHARACTERISTIC	SYMBOL	TYP.	UNIT
Input Conductance	g_{ib}	34	m℧
Input Capacitance	Cib	-10	pF
Reverse Transfer Admittance	$\lvert y_{rb} \rvert$	0.27	m℧
Phase Angle of Reverse Transfer Admittance	θ_{rb}	-105	°
Forward Transfer Admittance	$\lvert y_{fb} \rvert$	34	m℧
Phase Angle of Forward Transfer Admittance	θ_{fb}	165	°
Output Conductance	g_{ob}	45	μ℧
Output Capacitance	Cob	1.1	pF

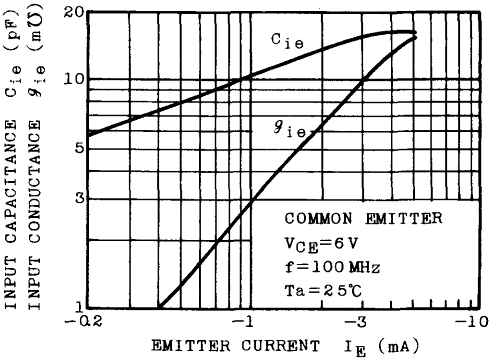
STATIC CHARACTERISTICS



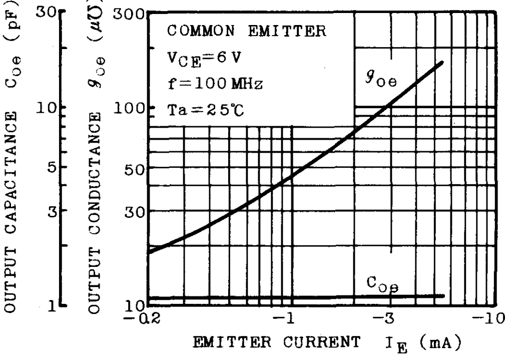
h_{FE} – I_C



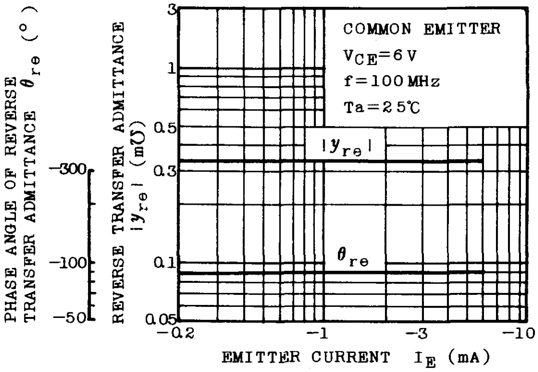
C_{ie}, g_{ie} – I_E



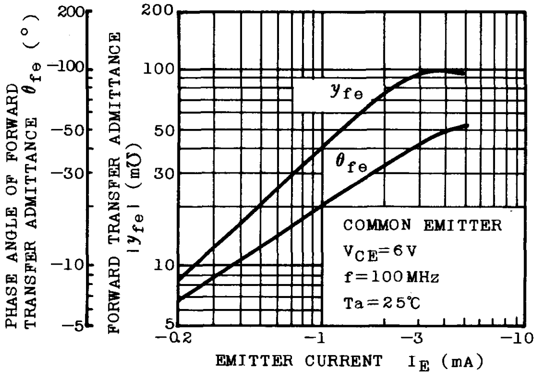
C_{oe}, g_{oe} – I_E

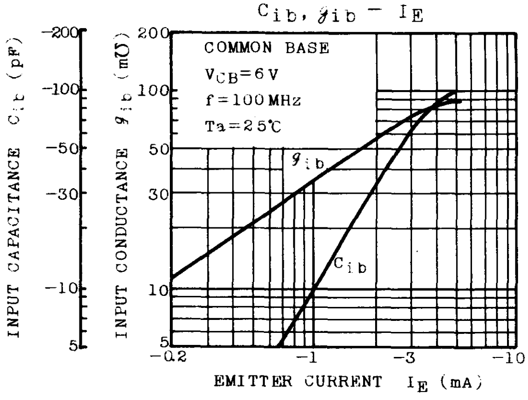


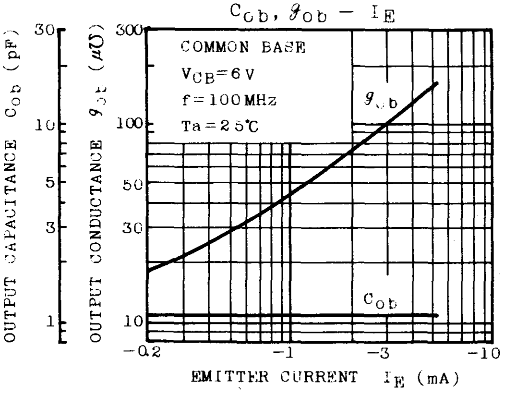
$|y_{re}|$, θ_{re} – I_E

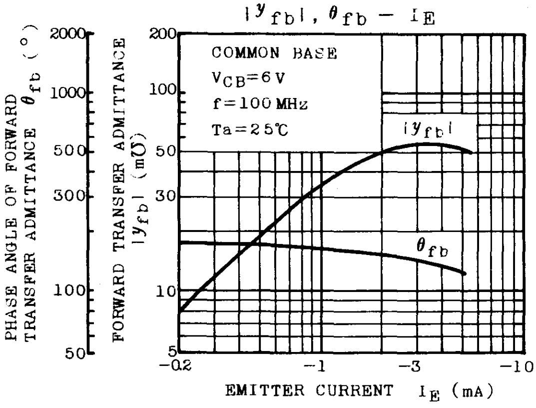


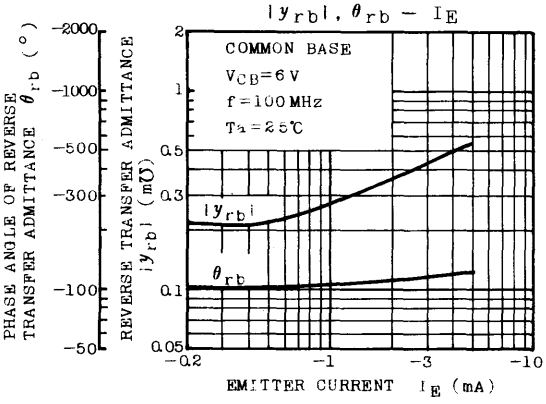
$|y_{fe}|$, θ_{fe} – I_E

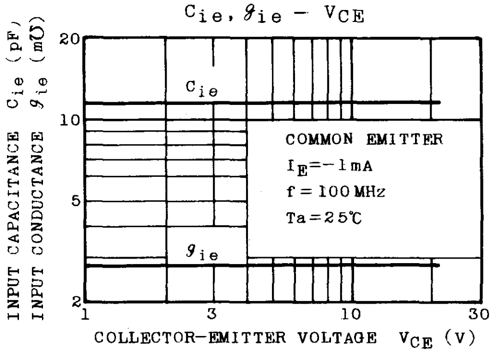


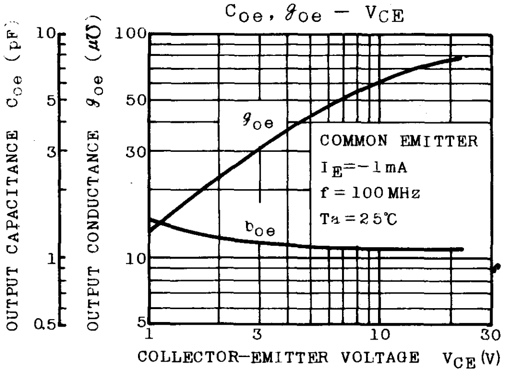

$C_{ib}, g_{ib} - I_E$

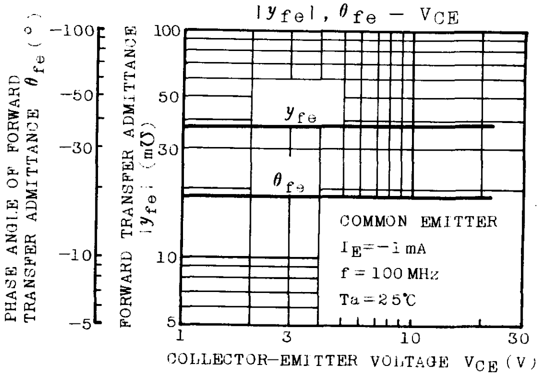

$C_{ob}, g_{ob} - I_E$

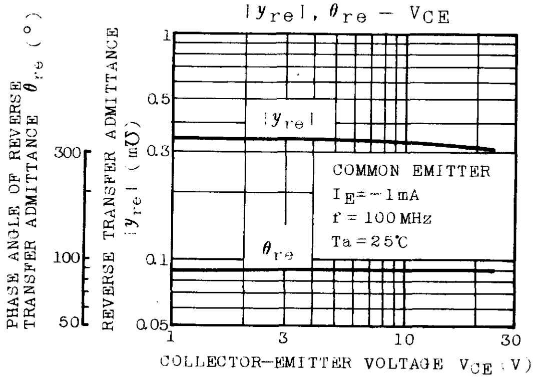

$|y_{fb}|, \theta_{fb} - I_E$

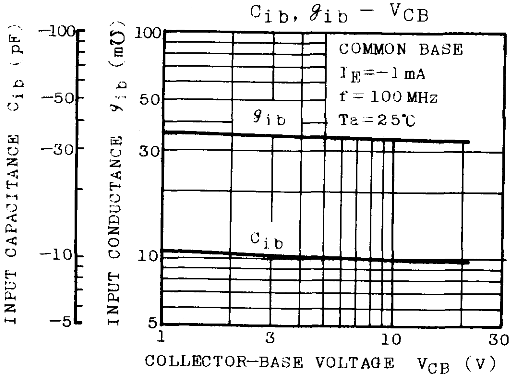

$|y_{rb}|, \theta_{rb} - I_E$

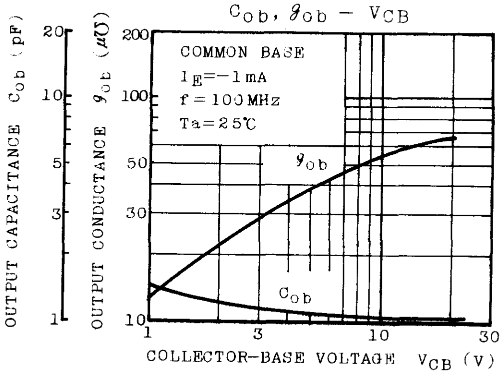

$C_{ie}, g_{ie} - V_{CE}$

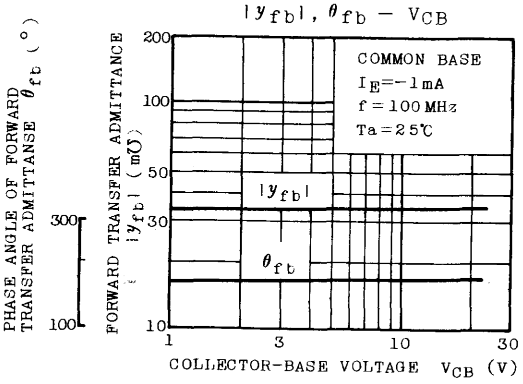

$C_{oe}, g_{oe} - V_{CE}$

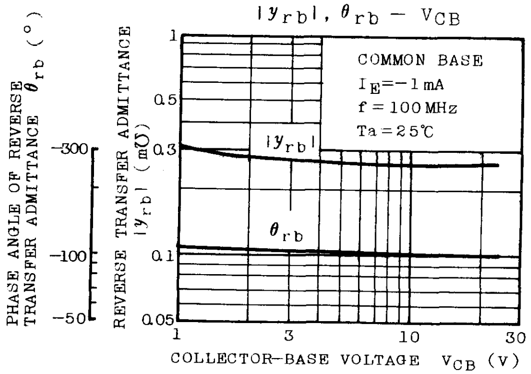

$|y_{fe}|, \theta_{fe} - V_{CE}$

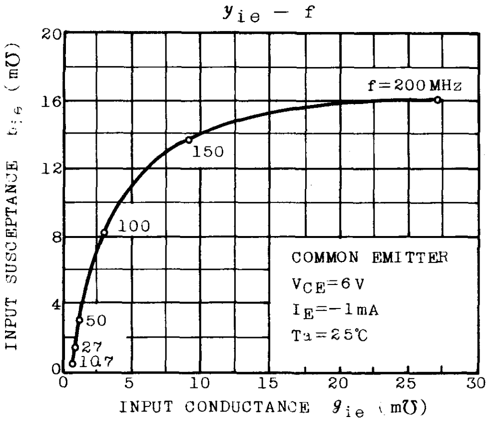

$|y_{re}|, \theta_{re} - V_{CE}$

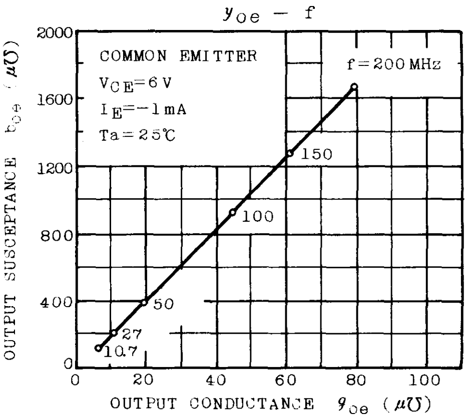

$C_{ib}, g_{ib} - V_{CB}$

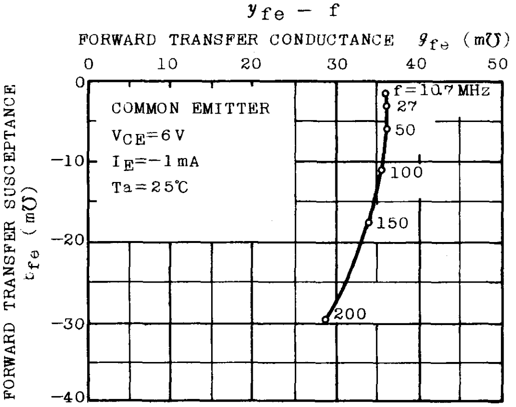

$C_{ob}, g_{ob} - V_{CB}$

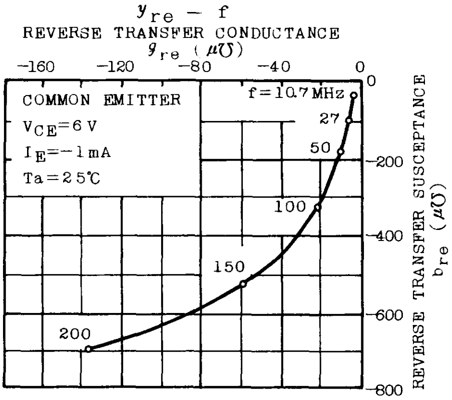

$|y_{fb}|, \theta_{fb} - V_{CB}$

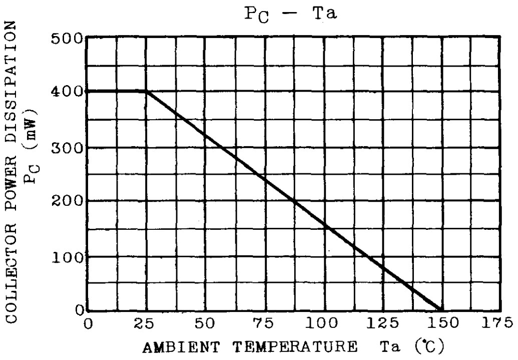

$|y_{rb}|, \theta_{rb} - V_{CB}$


y_{ie} − f
INPUT SUSCEPTANCE b_{ie} (m℧)
INPUT CONDUCTANCE g_{ie} (m℧)
20
16
12
8
4
0
0
5
10
15
20
25
30
f=200 MHz
150
100
50
27
10.7
COMMON EMITTER
V_{CE}=6 V
I_E=−1 mA
Ta=25℃


y_{oe} − f
OUTPUT SUSCEPTANCE b_{oe} (μ℧)
OUTPUT CONDUCTANCE g_{oe} (μ℧)
2000
1600
1200
800
400
0
0
20
40
60
80
100
COMMON EMITTER
V_{CE}=6 V
I_E=−1 mA
Ta=25℃
f=200 MHz
150
100
50
27
10.7


y_{fe} − f
FORWARD TRANSFER CONDUCTANCE g_{fe} (m℧)
0
10
20
30
40
50
FORWARD TRANSFER SUSCEPTANCE b_{fe} (m℧)
0
−10
−20
−30
−40
COMMON EMITTER
V_{CE}=6 V
I_E=−1 mA
Ta=25℃
f=10.7 MHz
27
50
100
150
200


y_{re} − f
REVERSE TRANSFER CONDUCTANCE g_{re} (μ℧)
−160
−120
−80
−40
0
REVERSE TRANSFER SUSCEPTANCE b_{re} (μ℧)
0
−200
−400
−600
−800
COMMON EMITTER
V_{CE}=6 V
I_E=−1 mA
Ta=25℃
f=10.7 MHz
27
50
100
150
200


P_C − Ta
COLLECTOR POWER DISSIPATION P_C (mW)
500
400
300
200
100
0
0
25
50
75
100
125
150
175
AMBIENT TEMPERATURE Ta (℃)

TED
series

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

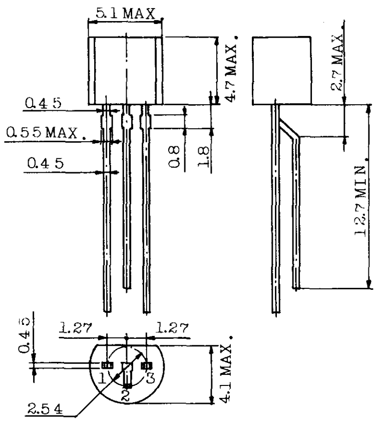
TED1402

AUDIO FREQUENCY GENERAL PURPOSE AMPLIFIER APPLICATIONS.
DRIVER STAGE AMPLIFIER APPLICATIONS.

FEATURES:

- High Voltage and High Current
  : V_{CEO}=50V(Min.), I_C=150mA(Max.)
- Excellent h_{FE} Linearity
  : $h_{FE}(I_C=0.1mA)/h_{FE}(I_C=2mA)=0.95$(Typ.)
- Low Noise : NF=1dB(Typ.) at f=1kHz
- Complementary to TED1602.

Unit in mm



1. COLLECTOR
2. BASE
3. EMITTER

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F2G

Weight : 0.21g

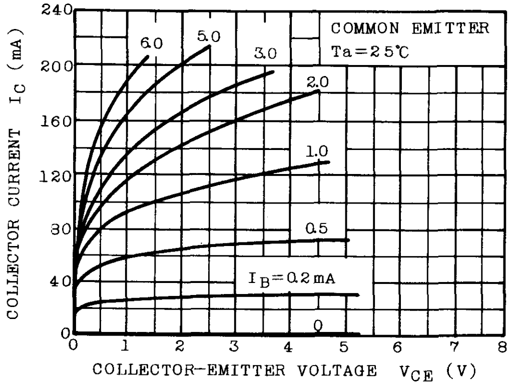
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	60	V
Collector-Emitter Voltage	V_{CEO}	50	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	150	mA
Base Current	I_B	50	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-65 ~ 125	°C

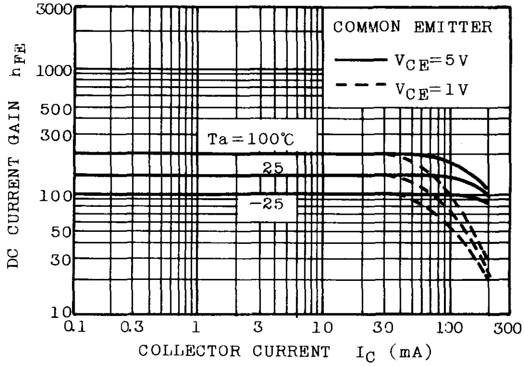
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	$I_{CBO(1)}$	V_{CB}=60V, I_E=0	-	-	0.1	μA
	$I_{CBO(2)}$	V_{CB}=60V, I_E=0, Ta=125°C	-	-	10	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=5V, I_C=2mA	110	-	810	
Collector-Emitter Saturation Voltage	$V_{CE(sat)(1)}$	I_C=10mA, I_B=1mA	-	0.04	0.25	V
	$V_{CE(sat)(2)}$	I_C=100mA, I_B=5mA	-	0.2	-	
Base-Emitter Voltage	V_{BE}	V_{CE}=5V, I_C=1mA	0.53	0.60	0.68	V
Transition Frequency	f_T	V_{CE}=10V, I_E=-1mA	-	175	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	1.9	-	pF
Noise Figure	NF(1)	V_{CE}=5V, I_E=-0.2mA R_g=2kΩ, f=1kHz	-	1.0	10	dB
	NF(2)	V_{CE}=5V, I_E=-1mA R_g=800Ω, f=1MHz	-	2.0	-	

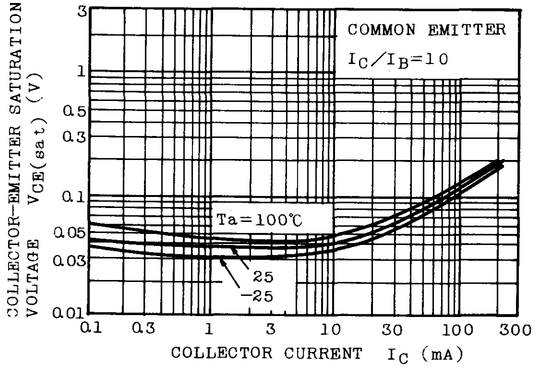
Note : h_{FE} Classification A:110 ~ 165, B:150 ~ 225, C:202 ~ 318, D:290 ~ 450, E:414 ~ 810



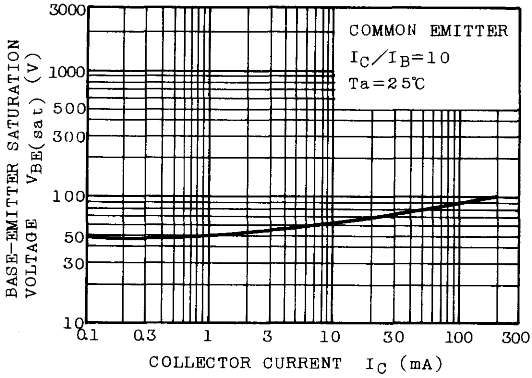
$I_C - V_{CE}$



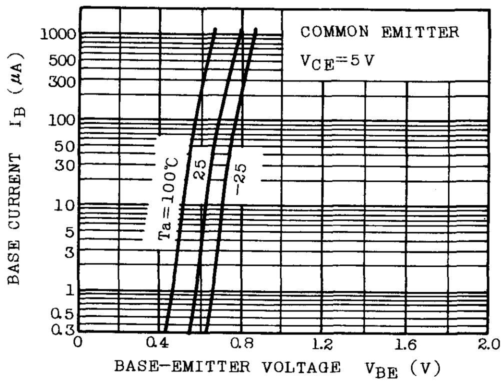
$h_{FE} - I_C$



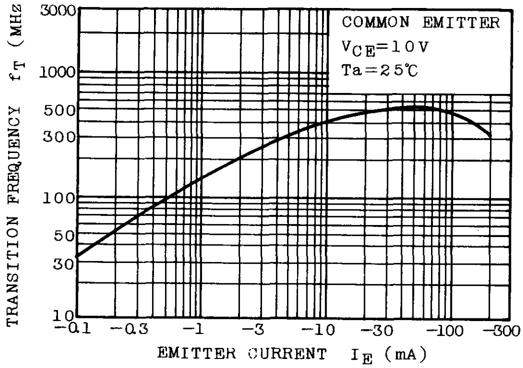
$V_{CE(sat)} - I_C$



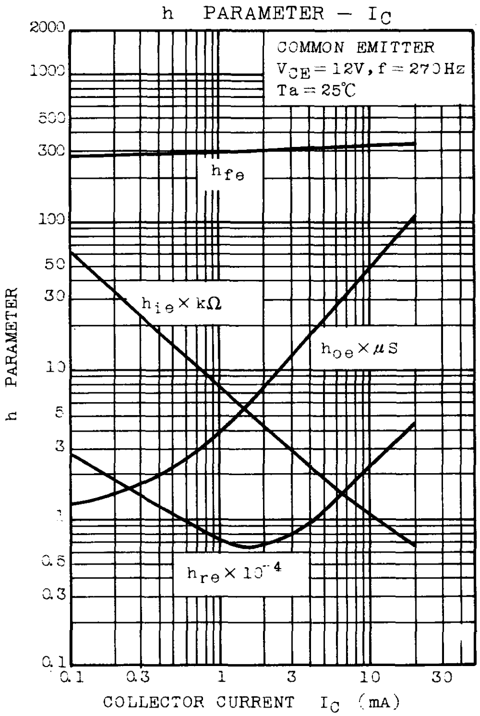
$V_{BE(sat)} - I_C$

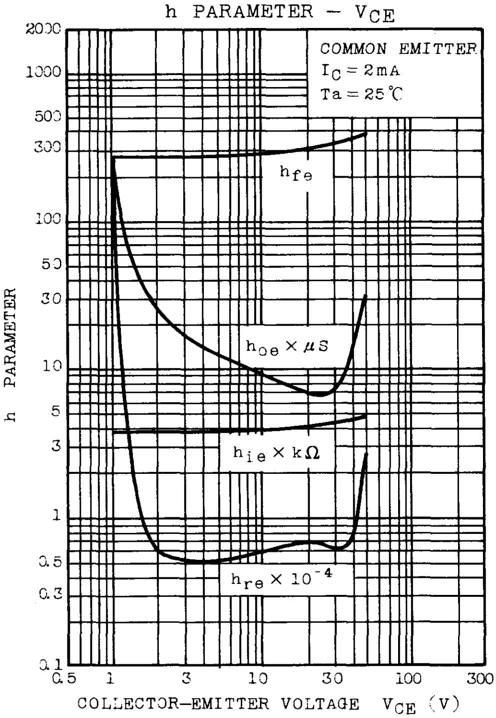


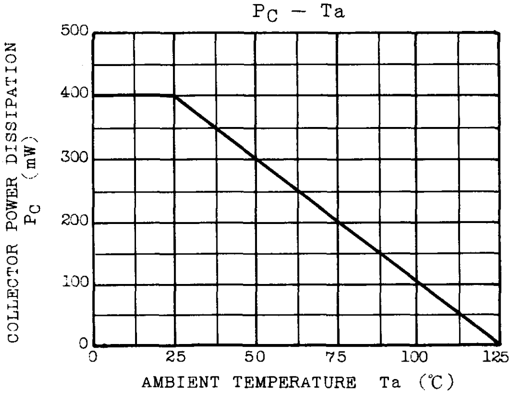
$I_B - V_{BE}$



$f_T - I_E$


h PARAMETER − I_C
COMMON EMITTER
V_{CE} = 12V, f = 270Hz
Ta = 25℃
h_{fe}
h_{ie} × kΩ
h_{oe} × μS
h_{re} × 10^{-4}
h PARAMETER
2000
1000
500
300
100
50
30
10
5
3
1
0.5
0.3
0.1
0.1
0.3
1
3
10
30
COLLECTOR CURRENT I_C (mA)


h PARAMETER − V_{CE}
COMMON EMITTER
I_C = 2mA
Ta = 25℃
h_{fe}
h_{oe} × μS
h_{ie} × kΩ
h_{re} × 10^{-4}
h PARAMETER
2000
1000
500
300
100
50
30
10
5
3
1
0.5
0.3
0.1
0.5
1
3
10
30
100
300
COLLECTOR−EMITTER VOLTAGE V_{CE} (V)


P_C − Ta
COLLECTOR POWER DISSIPATION
P_C (mW)
500
400
300
200
100
0
0
25
50
75
100
125
AMBIENT TEMPERATURE Ta (℃)

TED1502

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

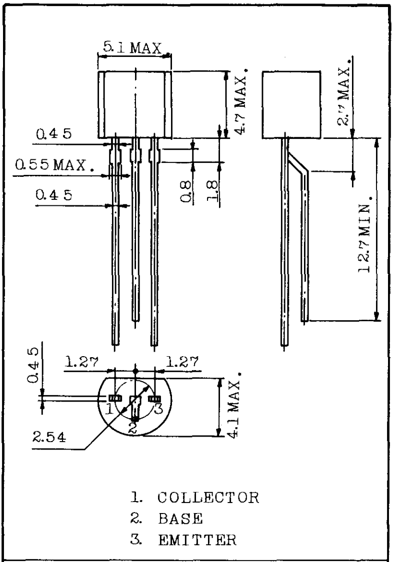
HIGH FREQUENCY AMPLIFIER APPLICATIONS.
FM, RF, MIX, IF AMPLIFIER APPLICATIONS.

FEATURES:

. Small Reverse Transfer Capacitance : C_{re}=0.7pF (Typ.)

. Low Noise Figure : NF=2.5dB (Typ.) (f=100MHz)

Unit in mm



1. COLLECTOR
2. BASE
3. EMITTER

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F2G

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

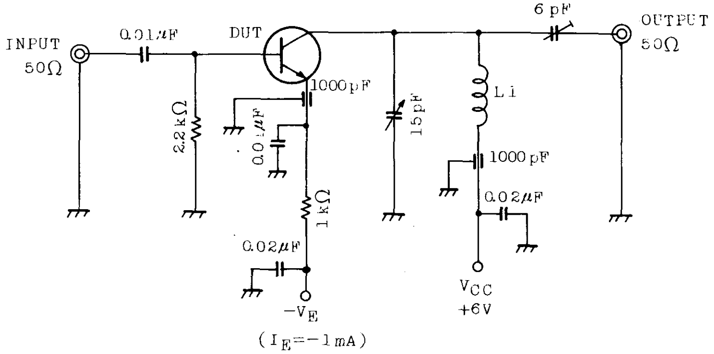
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	40	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	30	mA
Emitter Current	I_E	-30	mA
Collector Power Dissipation	P_C	250	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-65 ~ 125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=15V, I_E=0	-	-	50	nA
Base-Emitter Voltage	V_{BE}	V_{CE}=10V, I_C=1mA	0.65	-	0.75	V
DC Current Gain	h_{FE} (Note)	V_{CE}=10V, I_C=1mA	36	-	210	
Reverse Transfer Capacitance	C_{re}	V_{CE}=6V, f=1MHz	-	0.70	-	pF
Transition Frequency	f_T	V_{CE}=10V, I_C=1mA	-	550	-	MHz
Noise Figure	NF(1)	V_{CE}=10V, I_E=-1mA R_g=650Ω, f=1MHz	-	1.2	-	dB
	NF(2)	V_{CE}=6V, I_E=-1mA f=100MHz, Fig.	-	2.5	5.0	
Power Gain	G_{pe}		15	18	-	dB

Note : h_{FE} Classification A:36 ~ 55, B:48 ~ 75, C:66 ~ 100, D:84 ~ 127, E:105 ~ 210

Fig. NF(2), G_{pe} TEST CIRCUIT



L1 : 0.8mmϕ SILVER PLATED COPPER WIRE, 4T, 10ID, 8 LENGTH

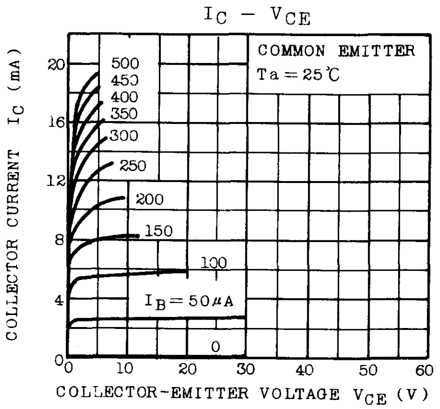
y PARAMETER (Typ.)

(1) COMMON EMITTER (V_{CE}=6V, I_E=-1mA, f=100MHz)

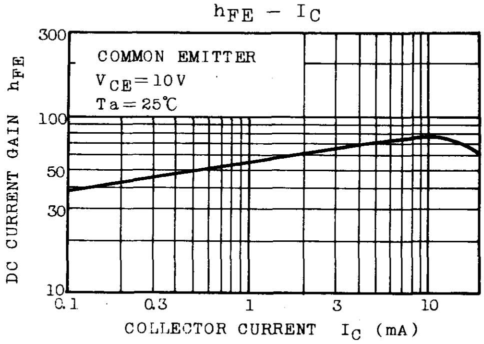
CHARACTERISTIC	SYMBOL	TYP.	UNIT
Input Conductance	g_{ie}	2.9	mS
Input Capacitance	C_{ie}	10.2	pF
Reverse Transfer Admittance	$\lvert y_{re} \rvert$	0.33	mS
Phase Angle of Reverse Transfer Admittance	θ_{re}	-90	°
Forward Transfer Admittance	$\lvert y_{fe} \rvert$	40	mS
Phase Angle of Forward Transfer Admittance	θ_{fe}	-20	°
Output Conductance	g_{oe}	45	μS
Output Capacitance	C_{oe}	1.1	pF

(2) COMMON BASE (V_{CE}=6V, I_E=-1mA, f=100MHz)

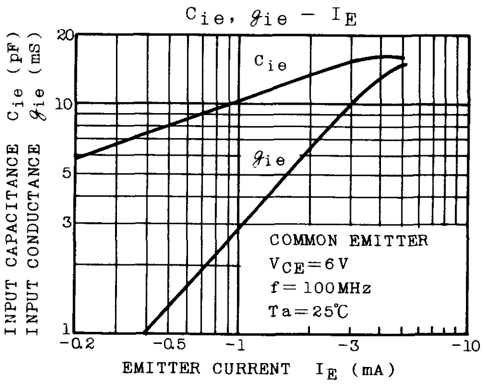
CHARACTERISTIC	SYMBOL	TYP.	UNIT
Input Conductance	g_{ib}	34	mS
Input Capacitance	C_{ib}	-10	pF
Reverse Transfer Admittance	$\lvert y_{rb} \rvert$	0.27	mS
Phase Angle of Reverse Transfer Admittance	θ_{rb}	-105	°
Forward Transfer Admittance	$\lvert y_{fb} \rvert$	34	mS
Phase Angle of Forward Transfer Admittance	θ_{fb}	165	°
Output Conductance	g_{ob}	45	μS
Output Capacitance	C_{ob}	1.1	pF



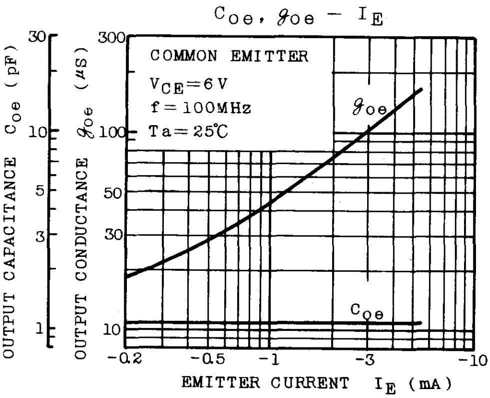
IC − VCE
COMMON EMITTER
Ta = 25℃
500
450
400
350
300
250
200
150
100
IB = 50μA
0
COLLECTOR CURRENT IC (mA)
0
4
8
12
16
20
0
10
20
30
40
50
60
COLLECTOR-EMITTER VOLTAGE VCE (V)



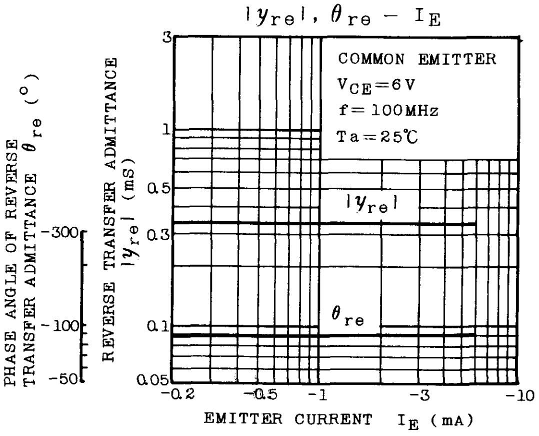
hFE − IC
COMMON EMITTER
VCE = 10V
Ta = 25℃
DC CURRENT GAIN hFE
10
30
50
100
300
0.1
0.3
1
3
10
COLLECTOR CURRENT IC (mA)



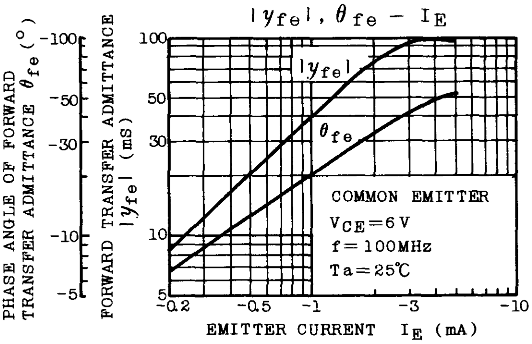
Cie, gie − IE
Cie
gie
COMMON EMITTER
VCE = 6V
f = 100MHz
Ta = 25℃
INPUT CAPACITANCE Cie (pF)
INPUT CONDUCTANCE gie (mS)
1
3
5
10
20
−0.2
−0.5
−1
−3
−10
EMITTER CURRENT IE (mA)



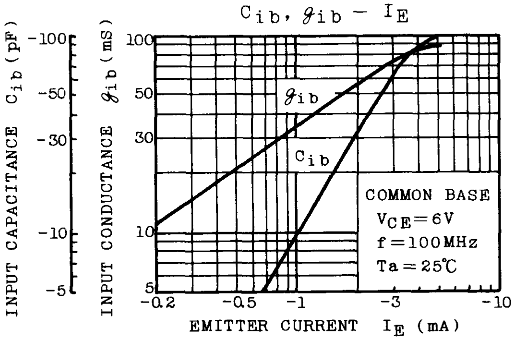
Coe, goe − IE
COMMON EMITTER
VCE = 6V
f = 100MHz
Ta = 25℃
goe
Coe
OUTPUT CAPACITANCE Coe (pF)
OUTPUT CONDUCTANCE goe (μS)
1
3
5
10
30
10
30
50
100
300
−0.2
−0.5
−1
−3
−10
EMITTER CURRENT IE (mA)



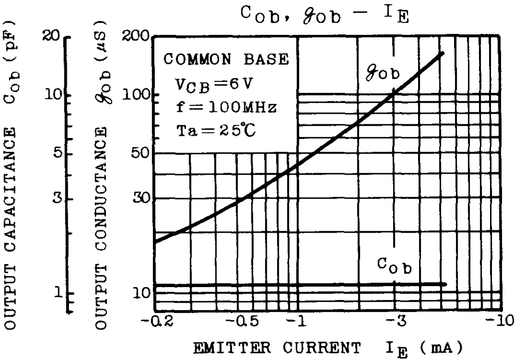
|yre|, θre − IE
COMMON EMITTER
VCE = 6V
f = 100MHz
Ta = 25℃
|yre|
θre
PHASE ANGLE OF REVERSE TRANSFER ADMITTANCE θre (°)
REVERSE TRANSFER ADMITTANCE |yre| (mS)
−300
−100
−50
0.05
0.1
0.3
0.5
1
3
−0.2
−0.5
−1
−3
−10
EMITTER CURRENT IE (mA)



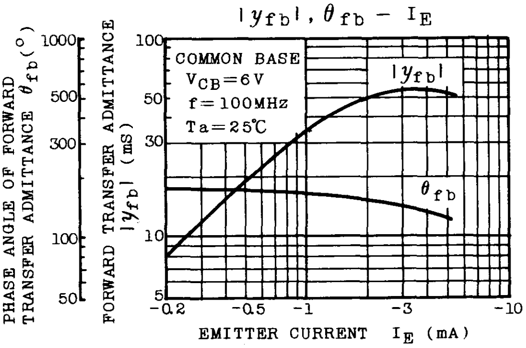
$|y_{fe}|, \theta_{fe} - I_E$



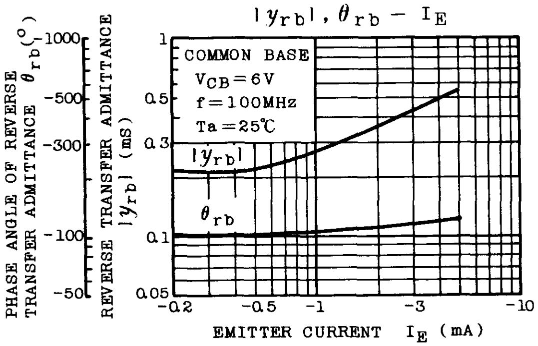
$C_{ib}, g_{ib} - I_E$



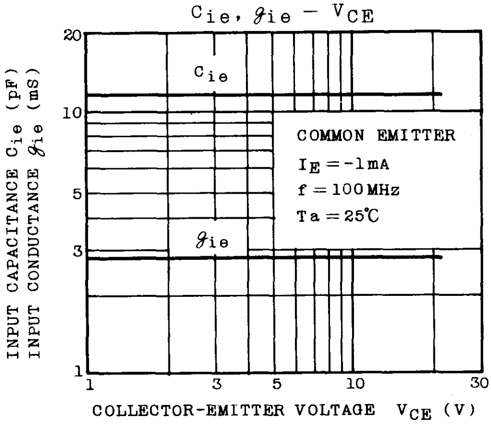
$C_{ob}, g_{ob} - I_E$



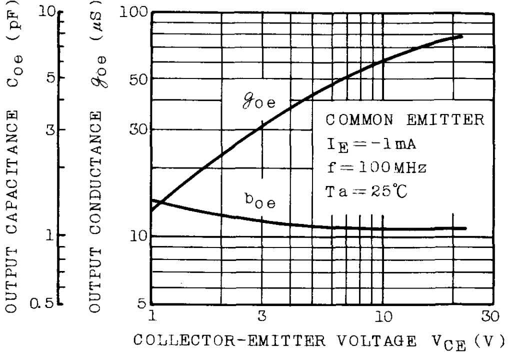
$|y_{fb}|, \theta_{fb} - I_E$

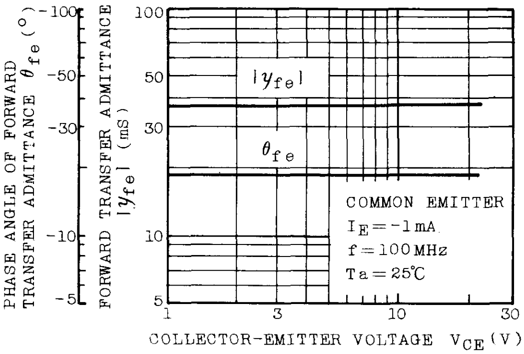


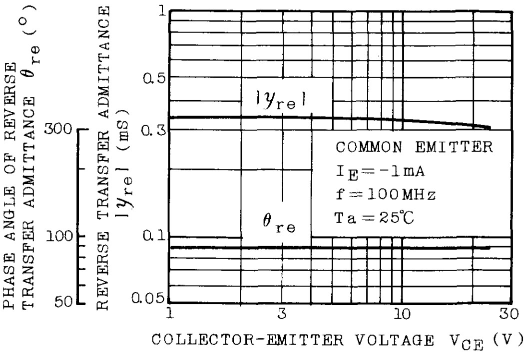
$|y_{rb}|, \theta_{rb} - I_E$

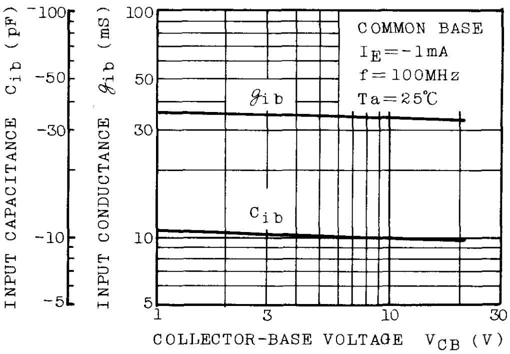


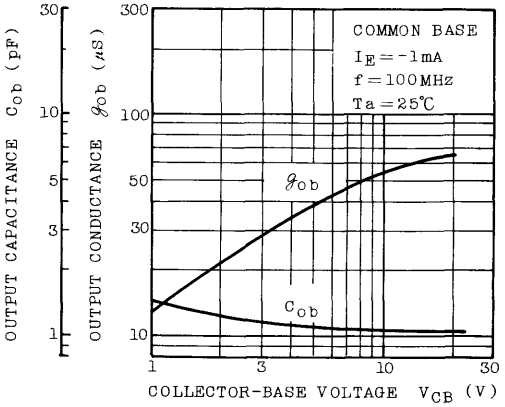
$C_{ie}, g_{ie} - V_{CE}$

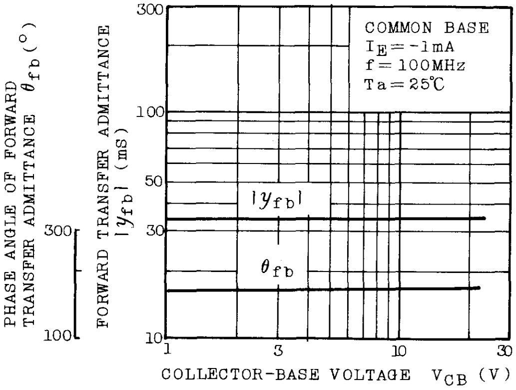

C_{oe}, g_{oe} — V_{CE}


$|y_{fe}|$, θ_{fe} — V_{CE}

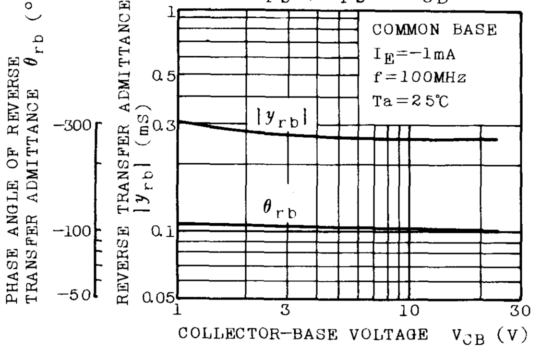

$|y_{re}|$, θ_{re} — V_{CE}


C_{ib}, g_{ib} — V_{CB}

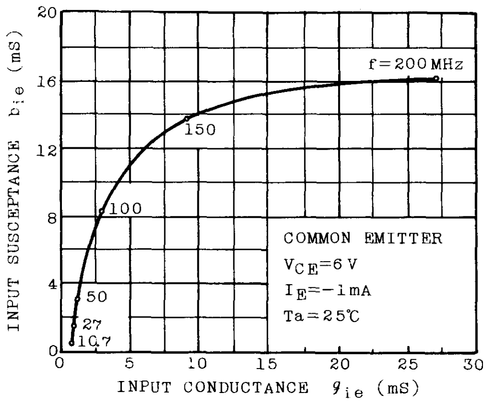

C_{ob}, g_{ob} — V_{CB}


$|y_{fb}|$, θ_{fb} — V_{CB}

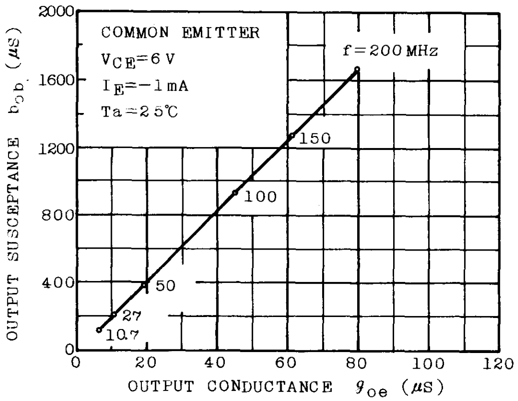
$|y_{rb}|, \theta_{rb} - V_{CB}$



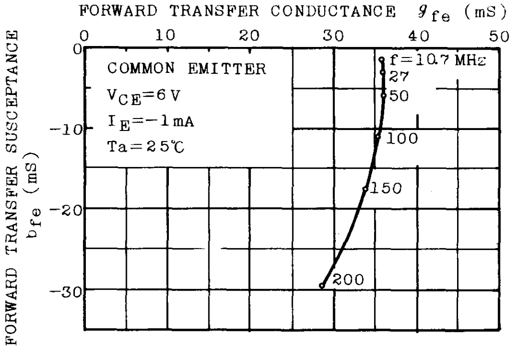
$y_{ie} - f$



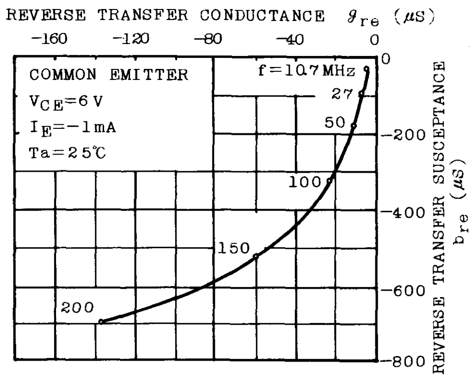
$y_{oe} - f$



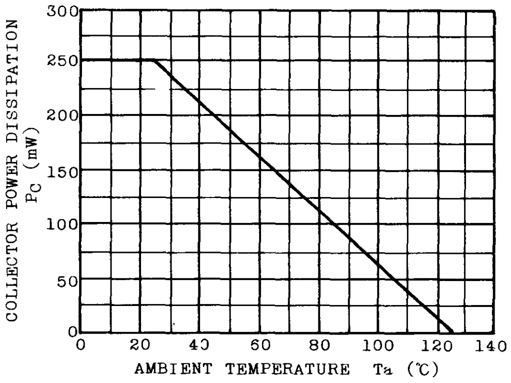
$y_{fe} - f$



$y_{re} - f$



$P_C - Ta$



TED1602

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

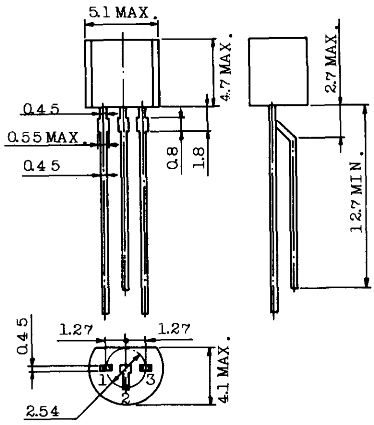
AUDIO FREQUENCY GENERAL PURPOSE AMPLIFIER APPLICATIONS.

DRIVER STAGE AMPLIFIER APPLICATIONS.

Unit in mm

FEATURES:

- High Voltage and High Current
  : V_{CEO}=-50V(Min.), I_C=-150mA(Max.)
- Excellent h_{FE} Linearity
  : $h_{FE}(I_C=0.1mA)/h_{FE}(I_C=2mA)=0.95$(Typ.)
- Low Noise : NF=1.8dB(Typ.) at f=1kHz
- Complementary to TED1402



1. COLLECTOR
2. BASE
3. EMITTER

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F2G

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

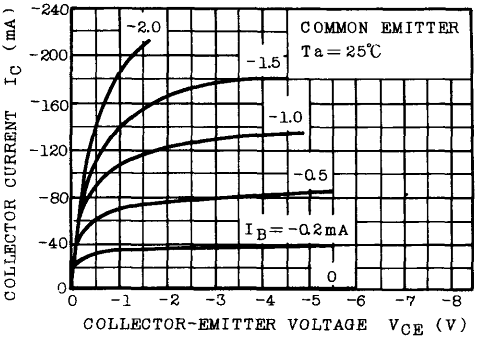
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-50	V
Collector-Emitter Voltage	V_{CEO}	-50	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-150	mA
Base Current	I_B	-50	mA
Collector Power Dissipation	P_C	400	mW
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_{stg}	-65 ~ 125	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

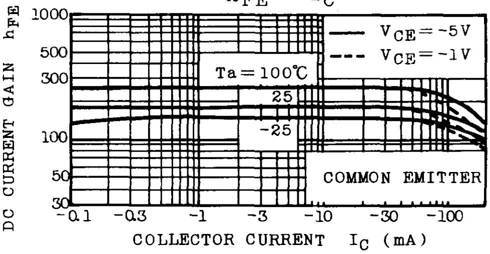
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	$I_{CBO(1)}$	V_{CB}=-50V, I_E=0	-	-	-0.1	μA
	$I_{CBO(2)}$	V_{CB}=-50V, I_E=0, Ta=125°C	-	-	-10	
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-0.1	μA
DC Current Gain	h_{FE} (Note)	V_{CE}=-5V, I_C=-2mA	70	-	475	
Collector-Emitter Saturation Voltage	$V_{CE(sat)(1)}$	I_C=-10mA, I_B=-1mA	-	-0.03	-0.3	V
	$V_{CE(sat)(2)}$	I_C=-100mA, I_B=-5mA	-	-0.25	-	
Base-Emitter Voltage	V_{BE}	V_{CE}=-5V, I_C=-2mA	-0.6	-0.69	-0.75	V
Transition Frequency	f_T	V_{CE}=-10V, I_E=1mA	-	150	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	3.5	-	pF
Noise Figure	NF	V_{CE}=-5V, I_E=0.2mA R_g=2kΩ, f=1kHz	-	1.8	-	dB

Note : h_{FE} Classification A:70 ~ 105, B:90~140, C:125 ~ 190, D:176 ~ 260, E:223 ~ 475

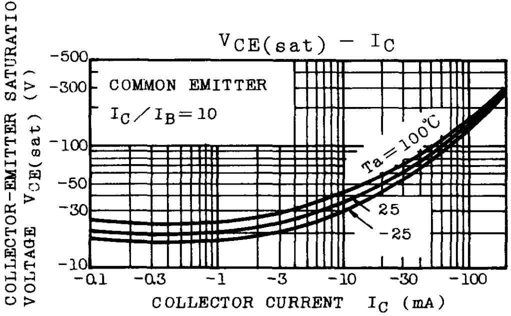
I_C − V_{CE}



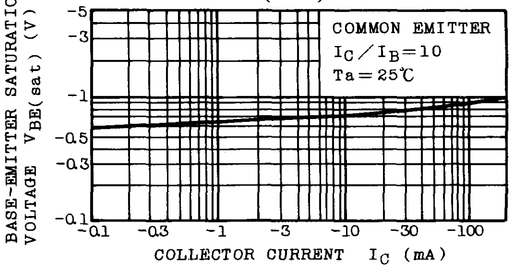
h_{FE} − I_C



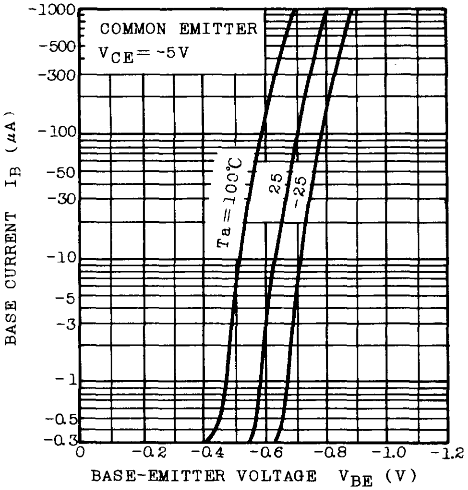
$V_{CE(sat)}$ − I_C



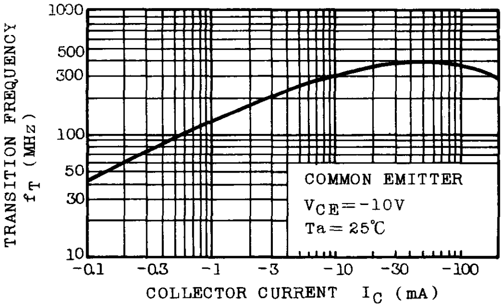
$V_{BE(sat)}$ − I_C



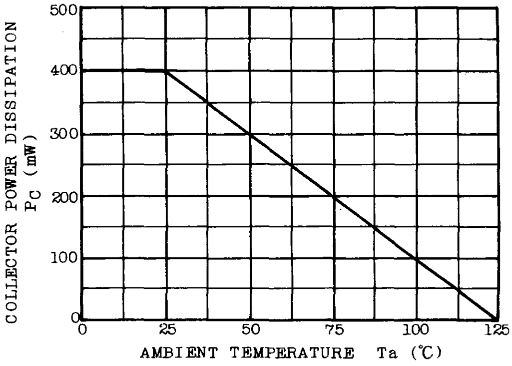
I_B − V_{BE}



f_T − I_C



P_C − Ta

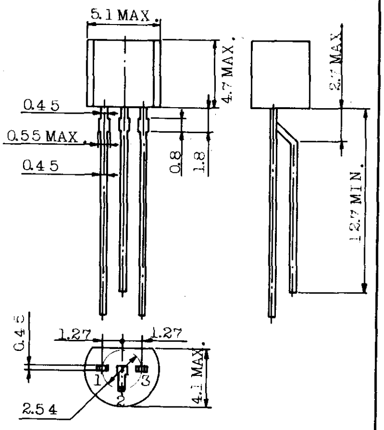


TED1702

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

AUDIO POWER AMPLIFIER APPLICATIONS.

Unit in mm



1. COLLECTOR
2. BASE
3. EMITTER

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F2G

Weight : 0.21g

FEATURES:

- High h_{FE} : $h_{FE}=106 \sim 300$
- 1 Watts Amplifier Applications.
- Complementary to TED1802

MAXIMUM RATINGS (Ta=25°C)

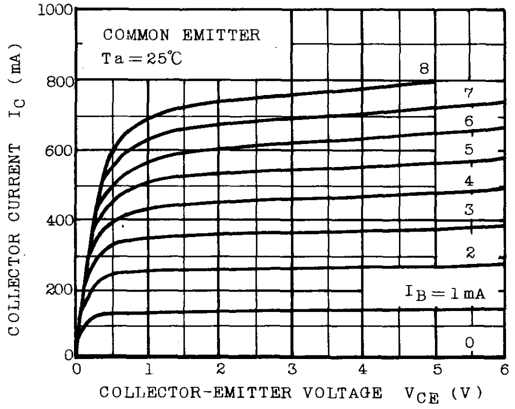
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	35	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	800	mA
Emitter Current	I_E	-800	mA
Collector Power Dissipation	P_C	600	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-65 ~ 150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

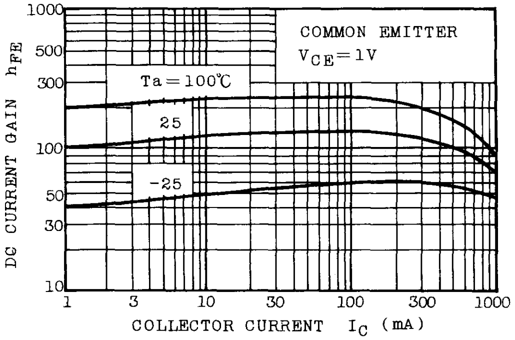
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	$I_{CBO(1)}$	$V_{CB}=30V$, $I_E=0$	-	-	0.1	μA
	$I_{CBO(2)}$	$V_{CB}=30V$, $I_E=0$, Ta=150°C	-	-	5	
Emitter Cut-off Current	I_{EBO}	$V_{EB}=5V$, $I_C=0$	-	-	100	nA
DC Current Gain	$h_{FE(1)}$ (Note)	$V_{CE}=1V$, $I_C=100mA$	106	-	300	
	$h_{FE(2)}$	$V_{CE}=1V$, $I_C=500mA$	40	-		
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C=500mA$, $I_B=20mA$	-	0.15	0.5	V
Base-Emitter Voltage	V_{BE}	$V_{CE}=1V$, $I_C=500mA$	-	-	1.2	V
Transition Frequency	f_T	$V_{CE}=5V$, $I_C=10mA$	-	120	-	MHz
Collector Output Capacitance	C_{ob}	$V_{CB}=10V$, f=1MHz, $I_E=0$	-	13	-	pF

Note : $h_{FE(1)}$ Classification K:106 ~ 150, L:132 ~ 188, M:170 ~ 230, N:213 ~ 300

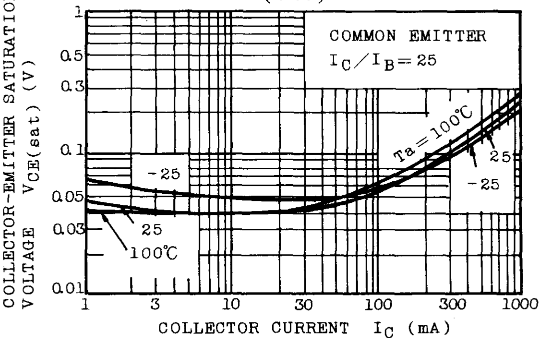
I_C − V_{CE}



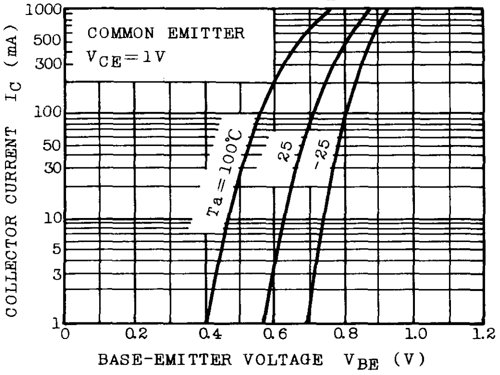
h_{FE} − I_C



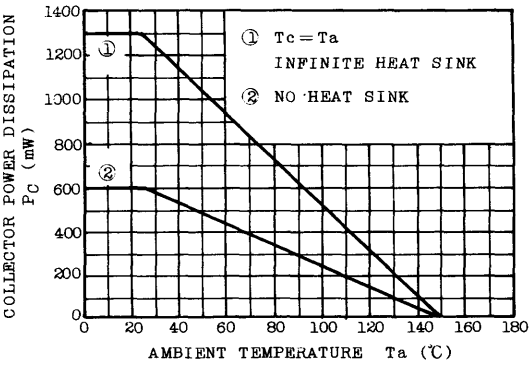
$V_{CE(sat)}$ − I_C



I_C − V_{BE}



P_C − Ta

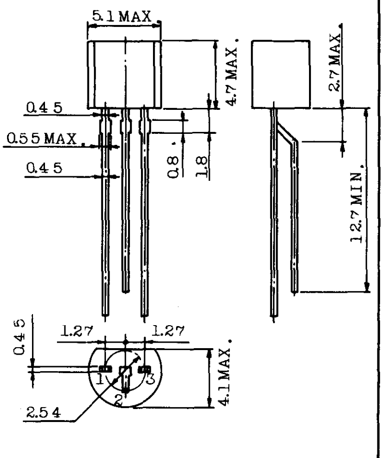


TED1802

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

AUDIO POWER AMPLIFIAER APPLICATIONS.

Unit in mm



1. COLLECTOR
2. BASE
3. EMITTER

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F2G

Weight : 0.21g

FEATURES:

- High h_{FE} : h_{FE}=106 ~ 300
- 1W Output Applications.
- Complementary to TED1702.

MAXIMUM RATINGS (Ta=25°C)

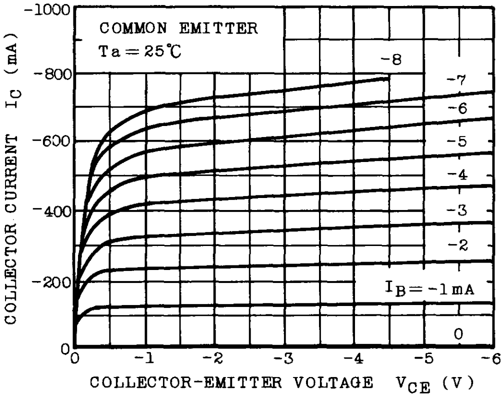
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-35	V
Collector-Emitter Voltage	V_{CEO}	-30	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-800	mA
Emitter Current	I_E	800	mA
Collector Power Dissipation	P_C	600	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-65 ~ 150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

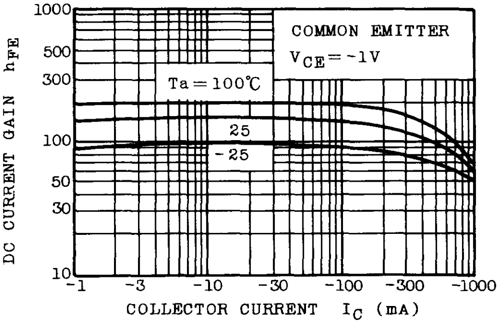
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	$I_{CBO}(1)$	V_{CB}=-30V, I_E=0	-	-	-0.1	μA
	$I_{CBO}(2)$	V_{CB}=-30V, I_E=0, Ta=150°C	-	-	-5	
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-100	nA
DC Current Gain	$h_{FE}(1)$ (Note)	V_{CE}=-1V, I_C=-100mA	106	-	300	
	$h_{FE}(2)$	V_{CE}=-1V, I_C=-500mA	40	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-500mA, I_B=-20mA	-	-0.19	-0.7	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-1V, I_C=-500mA	-	-	-1.2	V
Transition Frequency	f_T	V_{CE}=-5V, I_C=-10mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, f=1MHz, I_E=0	-	19	-	pF

Note : $h_{FE}(1)$ Classification K:106 ~ 150, L:132 ~ 188, M:170 ~ 230, N:213 ~ 300

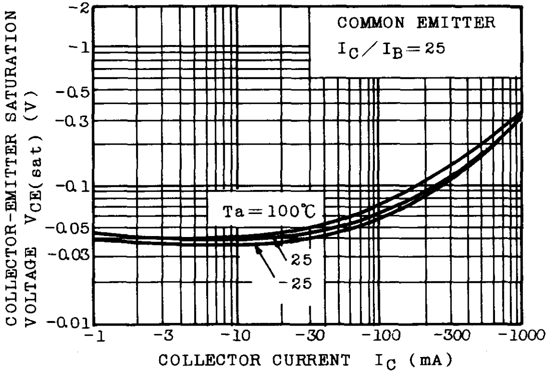
$I_C - V_{CE}$



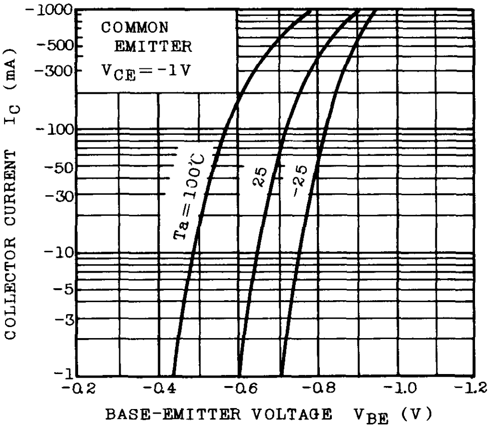
$h_{FE} - I_C$



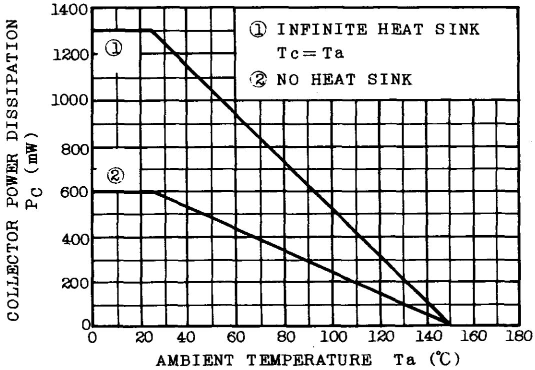
$V_{CE(sat)} - I_C$



$I_C - V_{BE}$



$P_C - Ta$



THS
series

(HALL SENSOR)

GaAs ION IMPLANTED PLANAR TYPE

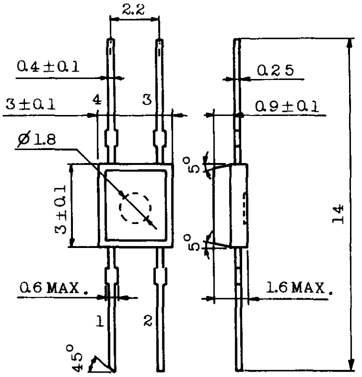
THS102A

HIGH STABILITY MOTOR CONTROL.
ENERGY SAVING FOR COOLING FAN MOTOR.
DIGITAL TACHOMETER.
CRANK SHAFT POSITION SENSOR.

FEATURES:

- Excellent Temperature Characteristics.
- Wide Operating Temperature Range Capability.
  (; -55°C ~ +125°C)
- Excellent Output Voltage Linearity.
  (; up to 15k Gausses)

Unit in mm



1(+) − 3(−) I_C (INPUT)
2 − 4 V_H (OUTPUT)

JEDEC	−
EIAJ	−
TOSHIBA	10−3B1A

Weight : 0.045g

MAXIMUM RATINGS ($T_a=25^\circ C$)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Control Current (DC)	I_C	10	mA
Control Current (Peak)	I_C	15	mA
Operating Temperature Range	Top	-55~ +125	°C
Storage Temperature Range	Tstg	-55~ +150	°C

ELECTRICAL CHARACTERISTICS ($T_a=25^\circ C$)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Internal Resistance	Rd	I_C=1mA	450	-	900	Ω
Residual Voltage Ratio	V_{HO}/V_H	I_C=1mA, B=0/B=1KG	-	-	±10	%
Hall Voltage (Note 1)	V_H	I_C=1mA, B=1KG	10	-	30	mV
Temperature Coefficient (Note 2)	V_{HT}	I_C=1mA, B=5KG T1=25°C, T2=125°C	-	-	-0.06	%/°C
Linearity (Note 3)	ΔK_H	I_C=1mA, B_1=1KG, B_2=5KG	-	-	2	%

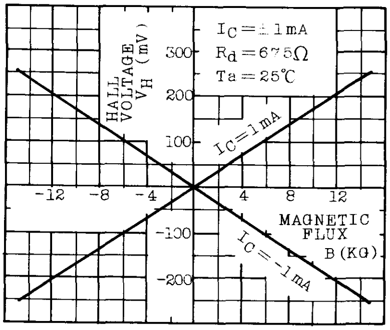
Note 1 : $V_H = V_{HM} - V_{HO}$ (V_{HM} is meter indication)

Note 2 : $V_{HT} = \frac{1}{V_H(T1)} \cdot \frac{V_H(T2)-V_H(T1)}{T2-T1} \times 100$ (%/°C)

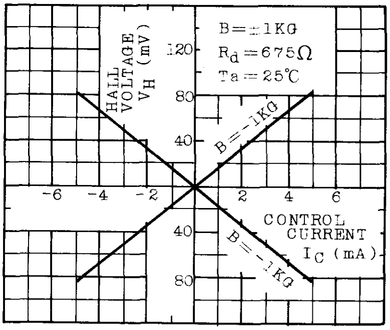
V_{HO} : Residual Voltage

Note 3 : $\Delta K_H = \frac{K_H(B2)-K_H(B1)}{1/2\{K_H(B1)+K_H(B2)\}} \times 100$ (%), $K_H = \frac{V_H}{I_C \cdot B}$

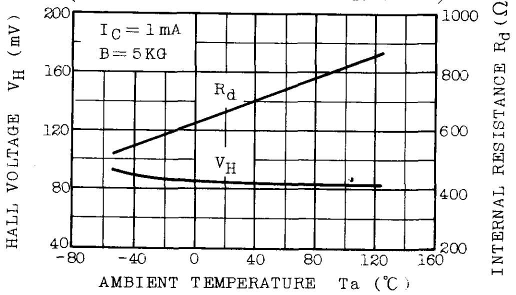
K_H : Product Sensitivity



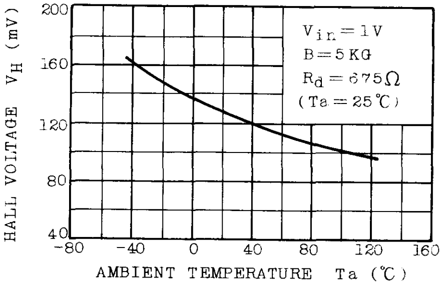
V_H − B CHARACTERISTICS



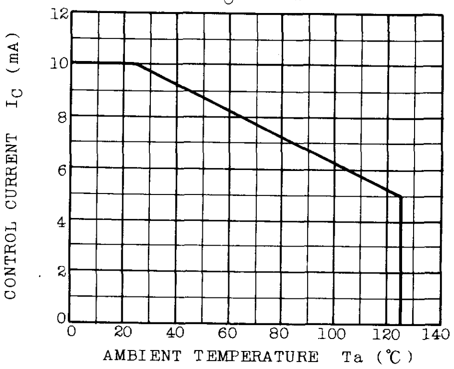
V_H − I_C CHARACTERISTICS



V_H − Ta, R_d − Ta CHARACTERISTICS (CONSTANT CURRENT OPERATION)



V_H − Ta CHARACTERISTICS (CONSTANT VOLTAGE OPERATION)



I_C − Ta

GaAs ION IMPLANTED PLANAR TYPE

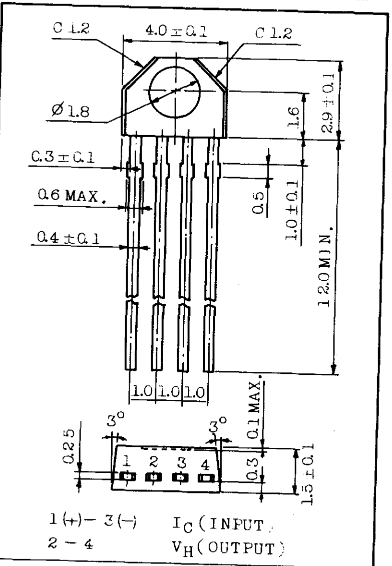
THS103A

HIGH STABILITY MOTOR CONTROL.
ENERGY SAVING FOR COOLING FAN MOTOR.
DIGITAL TACHOMETER.
CRANK SHAT POSITION SENSOR.

FEATURES:

- Excellent Temperature Characteristics.
- Wide Operating Temperature Range Capability.
  (; -55°C ~ +125°C)
- Excellent Output Voltage Linearity.
  (; up to 15k Gausses)

Unit in mm



JEDEC	–
EIAJ	
TOSHIBA	10−4A1A

Weight : 0.085g

MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Control Current (DC)	I_C	10	mA
Control Current (Peak)	I_C	15	mA
Operating Temperature Range	T_{op}	-55~ +125	°C
Storage Temperature Range	T_{stg}	-55~ +150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Internal Resistance	R_d	I_C=5mA	450	-	900	Ω
Residual Voltage Ratio	V_{HO}/V_H	I_C=5mA, B=0/B=1KG	-	-	±10	%
Hall Voltage (Note 1)	V_H	I_C=5mA, B=1KG	50	80	120	mV
Temperature Coefficient (Note 2)	V_{HT}	I_C=5mA, B=5KG T1=25°C, T2=125°C	-	-	-0.06	%/°C
Linearity (Note 3)	ΔK_H	I_C=5mA, B_1=1KG, B_2=5KG	-	-	2	%

Note 1 : $V_H = V_{HM} - V_{HO}$ (V_{HM} is meter indication)

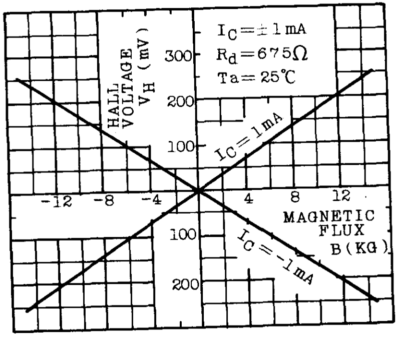
Note 2 : $V_{HT} = \frac{1}{V_H(T1)} \cdot \frac{V_H(T2) - V_H(T1)}{T2 - T1} \times 100$ (%/°C)

Note 3 : $\Delta K_H = \frac{K_H(B2) - K_H(B1)}{1/2\{K_H(B1) + K_H(B2)\}} \times 100$ (%), $K_H = \frac{V_H}{I_C \cdot B}$

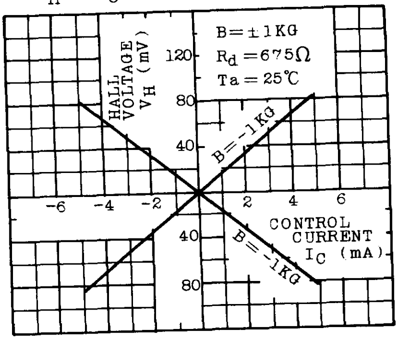
V_{HO} : Residual Voltage

K_H : Product Sensitivity

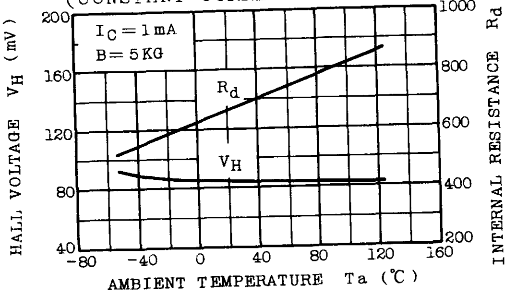
$V_H - B$ CHARACTERISTICS



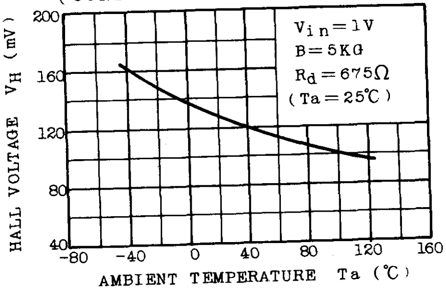
$V_H - I_C$ CHARACTERISTICS



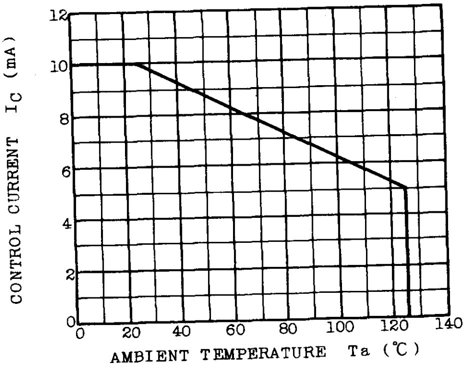
V_H – Ta, R_d – Ta CHARACTERISTICS (CONSTANT CURRENT OPERATION)



V_H – Ta CHARACTERISTICS (CONSTANT VOLTAGE OPERATION)



I_C – Ta



GaAs ION IMPLANTED PLANAR TYPE

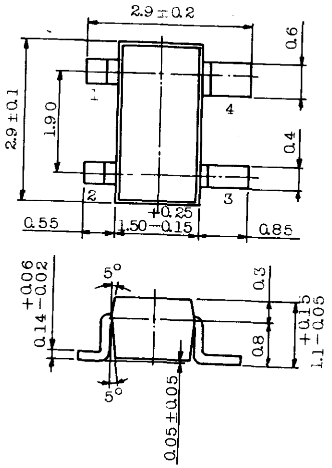
THS105

HIGH STABILITY MOTOR CONTROL.
ENERGY SAVING FOR COOLING FAN MOTOR.
DIGITAL TACHOMETER.
CRANK SHAFT POSITION SENSOR.

FEATURES:

- Excellent Temperature Characteristics.
- Wide Operating Temperature Range Capability.
  (; $-55^{\circ}C \sim +125^{\circ}C$)
- Excellent Output Voltage Linearity.
  (; up to 15k Gausses)

Unit in mm



1(+)−3(−) I_C (INPUT)
2 − 4 V_H (OUTPUT)

JEDEC	−
EIAJ	−
TOSHIBA	10−3C1A

Weight : 0.013g

MAXIMUM RATINGS ($Ta=25^{\circ}C$)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Control Current	I_C	10	mA
Control Current (peak)	I_C	15	mA
Operating Temperature Range	Top	−55~ +125	°C
Storage Temperature Range	Tstg	−55~ +150	°C

ELECTRICAL CHARACTERISTICS ($Ta=25^{\circ}C$)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Internal Resistance	R_d	$I_C=5mA$	450	-	900	Ω
Residual Voltage Ratio	V_{HO}/V_H	$I_C=5mA$, B=0/B=1KG	-	-	±10	%
Hall Voltage (Note 1)	V_H	$I_C=5mA$, B=1KG	50	80	120	mV
Temperature Coefficient (Note 2)	V_{HT}	$I_C=5mA$, B=5KG $T1=25^{\circ}C$, $T2=125^{\circ}C$	-	-	-0.06	%/°C
Linearity (Note 3)	ΔK_H	$I_C=5mA$, $B_1=1KG$, $B_2=5KG$	-	-	2	%

Note 1 : $V_H=V_{HM}-V_{HO}$ (V_{HM} is meter indication)

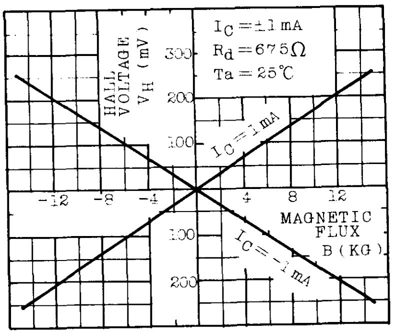
Note 2 : $V_{HT}=\frac{1}{V_H(T1)}\,\frac{V_H(T2)-V_H(T1)}{T2-T1}\times 100$ (%/°C)

V_{HO} : Residual Voltage

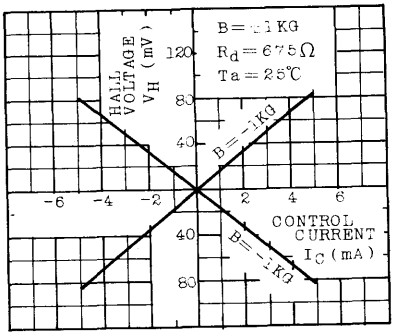
Note 3 : $\Delta K_H=\frac{K_H(B2)-K_H(B1)}{1/2\{K_H(B1)+K_H(B2)\}}\times 100$ (%), $K_H=\frac{V_H}{I_C\cdot B}$

K_H : Product Sensitivity

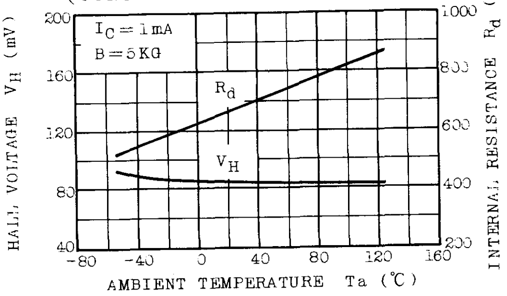
V_H − B CHARACTERISTICS



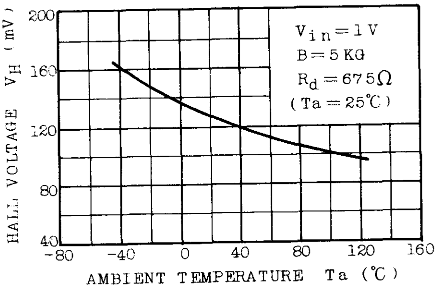
V_H − I_C CHARACTERISTICS



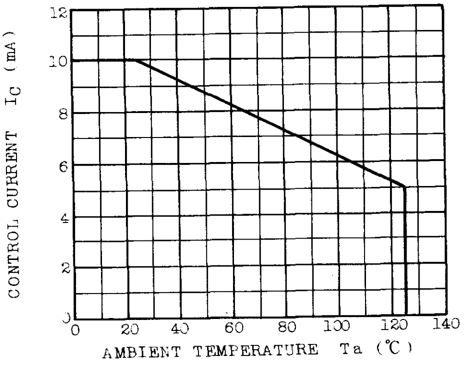
V_H − Ta, R_d − Ta CHARACTERISTICS
(CONSTANT CURRENT OPERATION)



V_H − Ta CHARACTERISTICS
(CONSTANT VOLTAGE OPERATION)



I_C − Ta



S

series

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

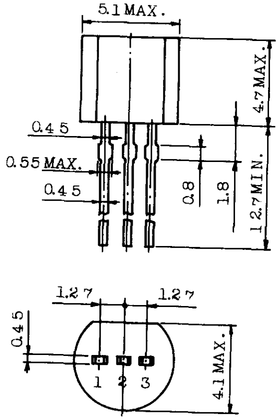
S1420

GENERAL PURPOSE AMPLIFIER AND LOW NOISE AMPLIFIER APPLICATIONS.

FEATURES:

- Excellent h_{FE} Linearity : $h_{FE}(0.1mA)/h_{FE}(2mA) = 0.95$ (Typ.)
- Designed for Complementary Use with S1423(h_{FE}=70~400)
- Small Collector Output Capacitance: C_{ob}=3.5pF(Max.)

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

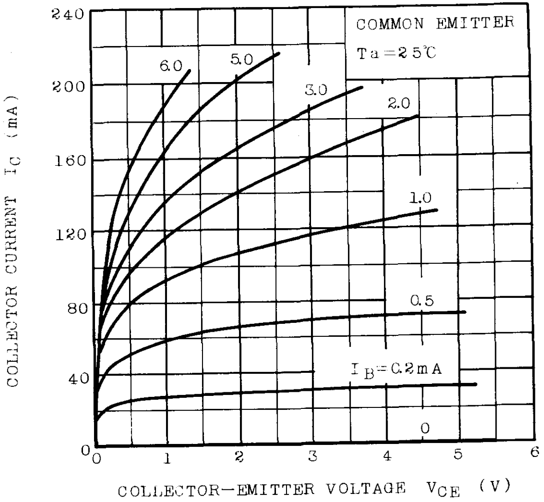
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	60	V
Collector-Emitter Voltage	V_{CEO}	60	V
Emitter-Base Voltage	V_{EBO}	7	V
Collector Current	I_C	200	mA
Base Current	I_B	200	mA
Collector Power Dissipation	P_C	625	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

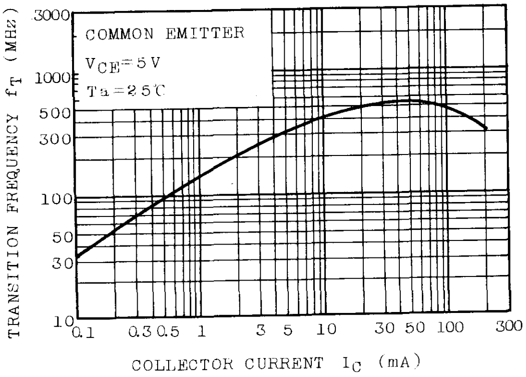
CHARACTERISTIC	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=40V, I_E=0	-	-	50	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=6V, I_C=0	-	-	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	60	-	-	V
DC Current Gain	h_{FE}	V_{CE}=5V, I_C=2mA	70	-	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=50mA, I_B=10mA	-	-	0.22	V
Base-Emitter Voltage	V_{BE}	V_{CE}=5V, I_C=2mA	-	0.65	-	V
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	-	3.5	pF
Transition Frequency	f_T	V_{CE}=5V, I_C=10mA	150	400	-	MHz

S1420

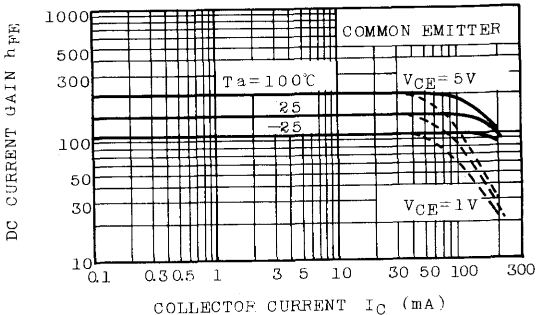
$I_C - V_{CE}$



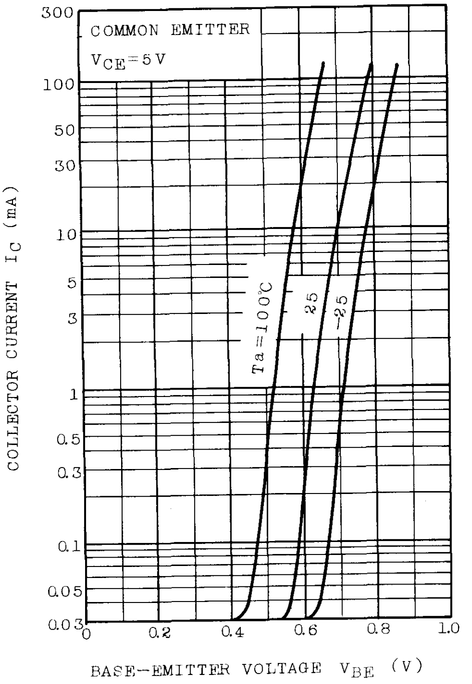
$f_T - I_C$



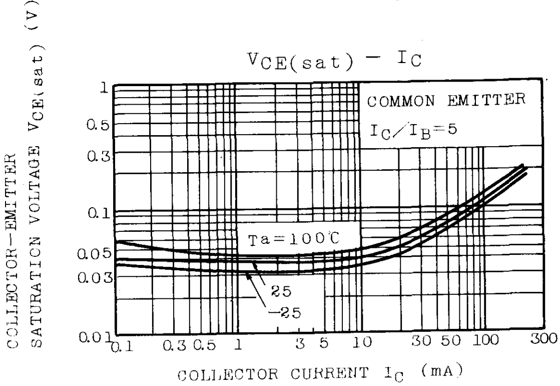
$h_{FE} - I_C$



$I_C - V_{BE}$



$V_{CE(sat)} - I_C$



SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

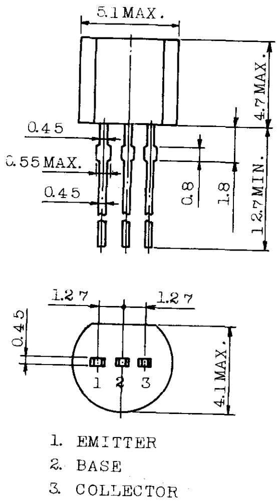
S1423

GENERAL-PURPOSE AMPLIFIER AND LOW NOISE AMPLIFIER APPLICATIONS.

FEATURES:

- Excellent h_{FE} Linearity : $h_{FE}(0.1mA)$ $h_{FE}(2mA)$ =0.95(Typ.)
- Designed for Complementary Use with S1420(h_{FE}=70 700)
- Small Collector Output Capacitance: C_{ob}=4.5pF(Max.)

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO−92
EIAJ	SC−43
TOSHIBA	2−5F1F

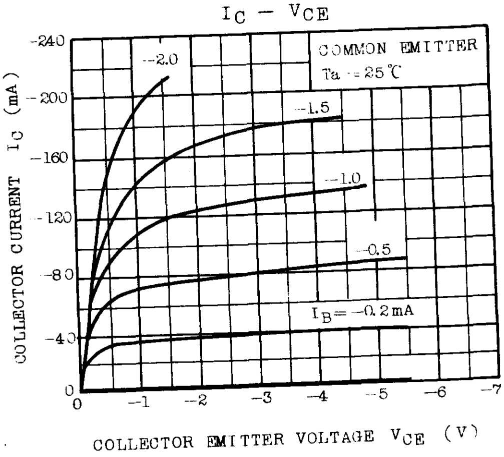
Weight : 0.21g

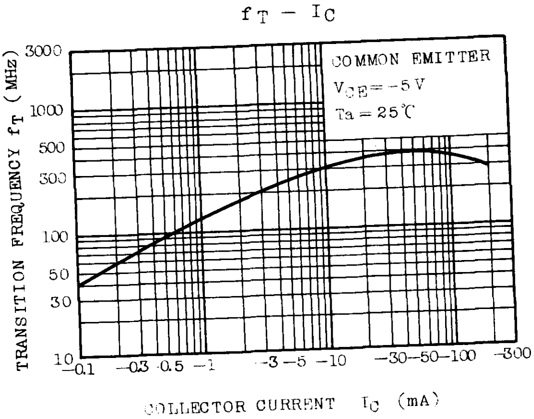
MAXIMUM RATINGS (Ta=25°C)

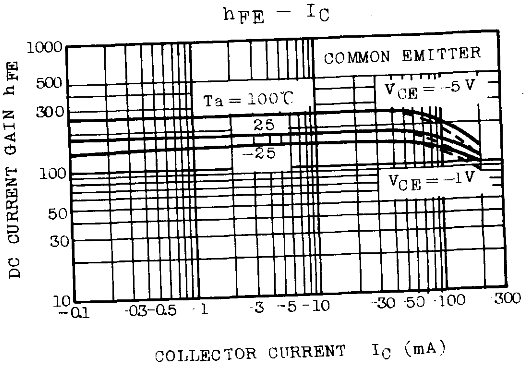
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-40	V
Collector-Emitter Voltage	V_{CEO}	-40	V
Emitter-Base Voltage	V_{EBO}	-7	V
Collector Current	I_C	-200	mA
Base Current	I_B	-200	mA
Collector Power Dissipation	P_C	625	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

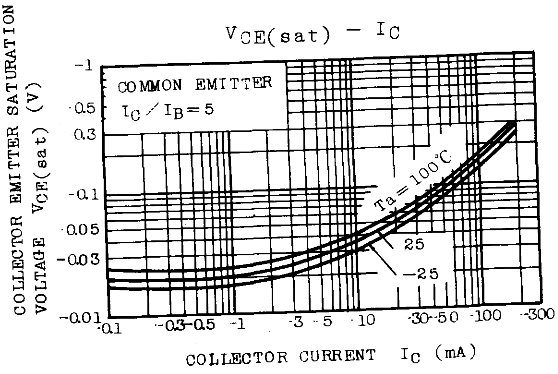
ELECTRICAL CHARACTERISTICS (Ta=25°C)

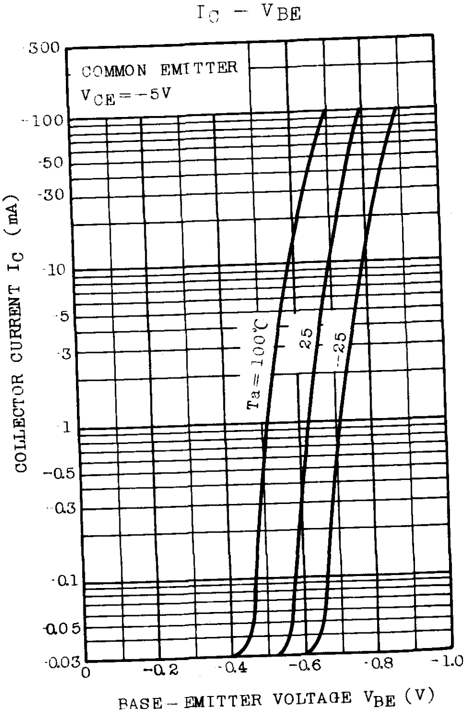
CHARACTERISTIC	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cutoff Current	I_{CBO}	V_{CB}=-30V, I_E=0	-	-	-50	nA
Emitter Cutoff Current	I_{EBO}	V_{EB}=-6V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-1mA, I_B=0	-40	-	-	V
DC Current Gain	h_{FE}	V_{CE}=-5V, I_C=-2mA	70	-	400	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-50mA, I_B=-10mA	-	-	-0.22	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-5V, I_C=-2mA	-	-0.65	-	V
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	-	4.5	pF
Transition Frequency	f_T	V_{CE}=-5V, I_C=-10mA	150	300	-	MHz


I_C — V_{CE}
COMMON EMITTER
Ta = 25℃
−2.0
−1.5
−1.0
−0.5
I_B = −0.2 mA
−240
−200
−160
−120
−80
−40
0
0
−1
−2
−3
−4
−5
−6
−7
COLLECTOR CURRENT I_C (mA)
COLLECTOR EMITTER VOLTAGE V_{CE} (V)


f_T — I_C
COMMON EMITTER
V_{CE} = −5 V
Ta = 25℃
3000
1000
500
300
100
50
30
10
−0.1
−0.3
−0.5
−1
−3
−5
−10
−30
−50
−100
−300
TRANSITION FREQUENCY f_T (MHz)
COLLECTOR CURRENT I_C (mA)


h_{FE} — I_C
COMMON EMITTER
Ta = 100℃
25
−25
V_{CE} = −5 V
V_{CE} = −1V
1000
500
300
100
50
30
10
−0.1
−0.3
−0.5
−1
−3
−5
−10
−30
−50
−100
300
DC CURRENT GAIN h_{FE}
COLLECTOR CURRENT I_C (mA)


$V_{CE(sat)}$ — I_C
COMMON EMITTER
I_C / I_B = 5
Ta = 100℃
25
−25
−1
−0.5
−0.3
−0.1
−0.05
−0.03
−0.01
−0.1
−0.3
−0.5
−1
−3
−5
−10
−30
−50
−100
−300
COLLECTOR EMITTER SATURATION VOLTAGE $V_{CE(sat)}$ (V)
COLLECTOR CURRENT I_C (mA)


I_C — V_{BE}
COMMON EMITTER
V_{CE} = −5V
Ta = 100℃
25
−25
−300
−100
−50
−30
−10
−5
−3
−1
−0.5
−0.3
−0.1
−0.05
−0.03
0
−0.2
−0.4
−0.6
−0.8
−1.0
COLLECTOR CURRENT I_C (mA)
BASE − EMITTER VOLTAGE V_{BE} (V)

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

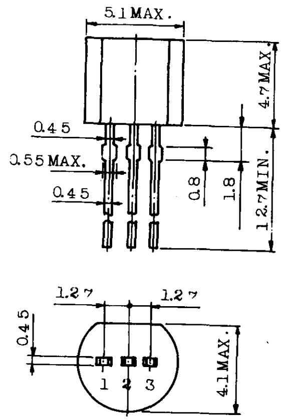
S1805

DESIGNED FOR USE IN AUDIO STAGE MEDIUM POWER AMPLIFIERS.
RECOMMENDED FOR OUTPUT AMPLIFIER STAGE IN CLASS B PUSH-PULL OPERATION.

HIGH RELIABILITY.

LOW FREQUENCY MEDIUM POWER AMPLIFIERS.
DRIVER STAGE AMPLIFIERS.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

FEATURES:

- Excellent h_{FE} vs. Collector Current Characteristics, $h_{FE}(2)$=23Min. at V_{CE}=1V, I_C=400mA
- Complementary to S1806.

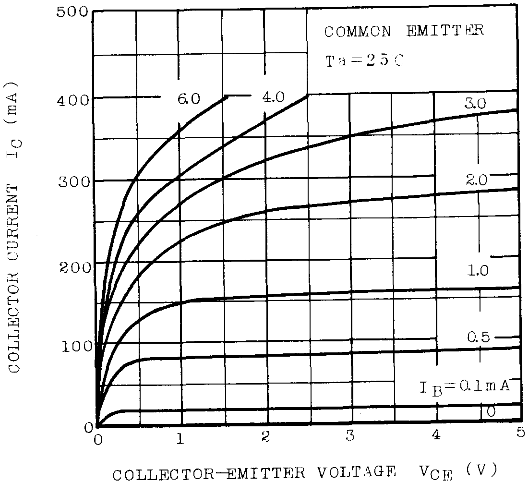
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	40	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	500	mA
Base Current	I_B	250	mA
Collector Power Dissipation	P_C	625	mW
Junction Temperature Range	T_j	150	°C
Storage Temperature	T_{stg}	-55~150	°C

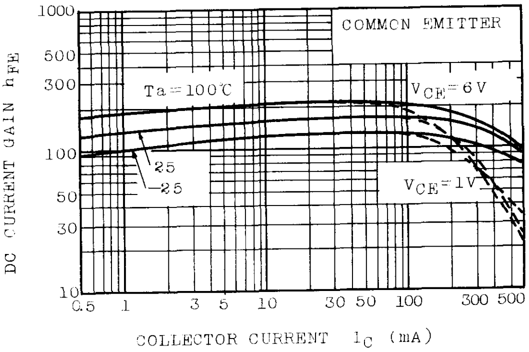
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
DC Current Gain (1)	$h_{FE}(1)$	V_{CE}=1V, I_C=50mA	70	-	240	
DC Current Gain (2)	$h_{FE}(2)$	V_{CE}=1V, I_C=400mA	23	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=100mA, I_B=5mA	-	-	0.25	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=100mA, I_B=5mA	-	-	1.20	V
Base-Emitter Voltage	V_{BE}	V_{CE}=1V, I_C=50mA	0.65	0.73	0.80	V
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C=0.1mA, I_E=0	40	-	-	V
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	30	-	-	V
Collector Cut-off Current	I_{CBO}	V_{CB}=35V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA

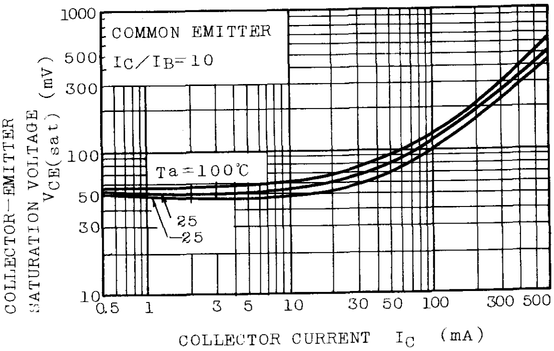
I_C — V_{CE}



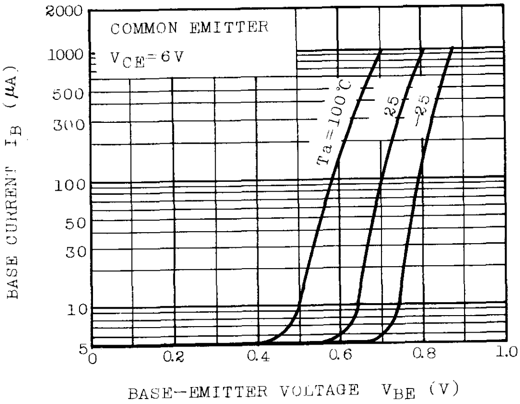
h_{FE} — I_C



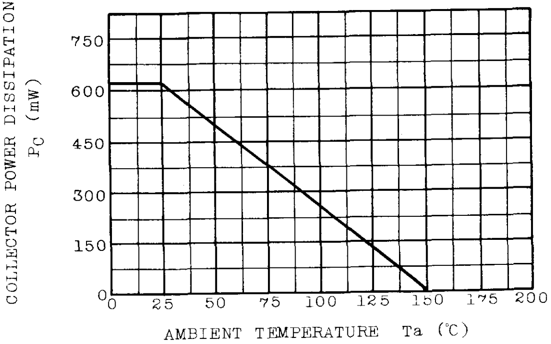
$V_{CE(sat)}$ — I_C



I_B — V_{BE}



P_C — Ta



SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

S1806

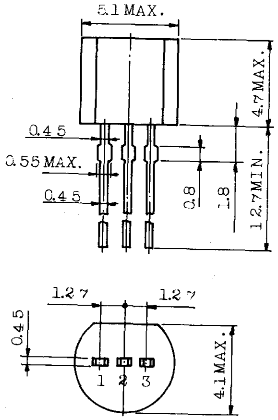
DESIGNED FOR USE IN AUDIO STAGE MEDIUM POWER AMPLIFIER.
RECOMMENDED FOR OUTPUT AMPLIFIER STAGE IN CLASS B PUSH-PULL OPERATION.

LOW FREQUENCY, MEDIUM POWER AMPLIFIERS.
DRIVER STAGE AMPLIFIERS.

FEATURES:

- Excellent h_{FE} vs. Collector Current Characteristics,
  $h_{FE(2)}$=23Min. at V_{CE}=-1V, I_C=-400mA
- Complementary to S1805.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

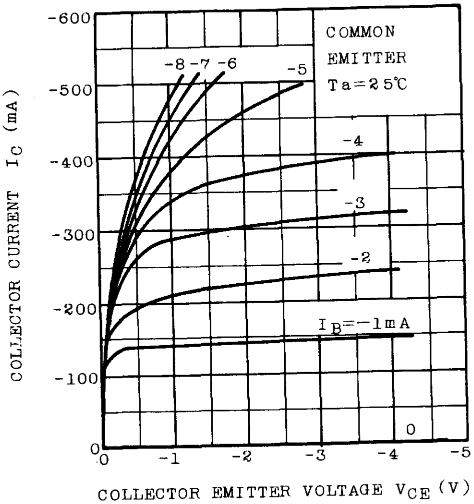
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-40	V
Collector-Emitter Voltage	V_{CEO}	-30	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-500	mA
Base Current	I_B	-250	mA
Collector Power Dissipation	P_C	625	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

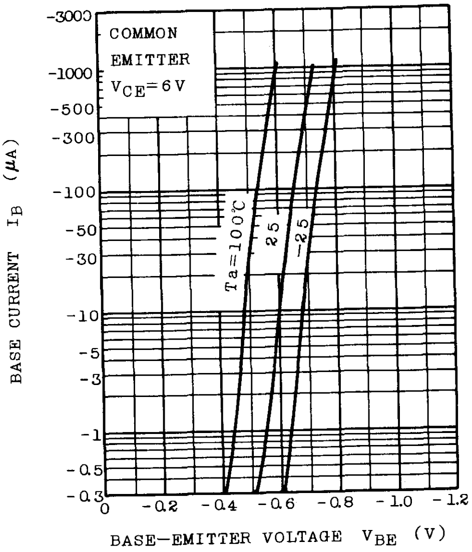
CHARACTERISTIC	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
DC Current Gain (1)	$h_{FE(1)}$	V_{CE}=1V, I_C=-50mA	70	-	240	
DC Current Gain (2)	$h_{FE(2)}$	V_{CE}=-1V, I_C=-400mA	23	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-100mA, I_B=-5mA	-	-	-0.25	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=-100mA, I_B=-5mA	-	-	-1.2	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-1V, I_C=-50mA	-0.65	-0.72	-0.80	V
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C=-0.1mA, I_E=0	-40	-	-	V
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-1mA, I_B=0	-30	-	-	V
Collector Cut-off Current	I_{CBO}	V_{CB}=-35V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-100	nA

S1806

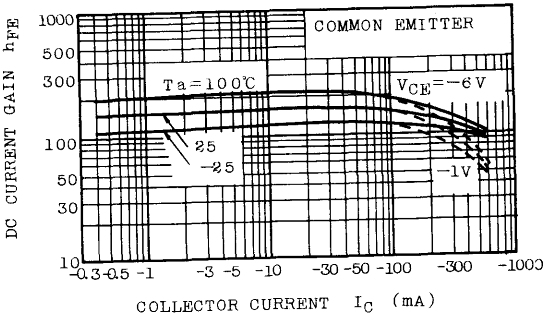
I_C — V_{CE}



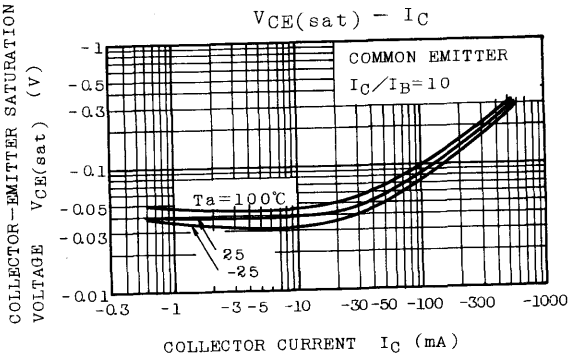
I_B — V_{BE}



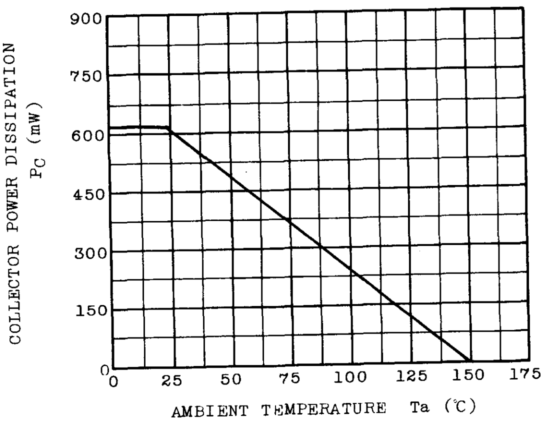
h_{FE} — I_C



$V_{CE(sat)}$ — I_C



P_C — Ta



SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

S1807

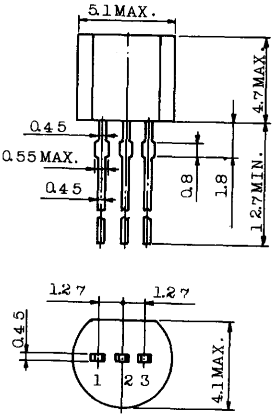
PRIMARILY INTENDED FOR USE IN DRIVER AND OUTPUT STAGE OF AUDIO AMPLIFIERS.

DESIGNED FOR COMPLEMENTARY USE WITH S1808.

FEATURES:

- Low Saturation Voltage : $V_{CE(sat)}=0.5V$(Max.)
  at $I_C=500mA$
- Complementary to S1808.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO−92
EIAJ	SC−43
TOSHIBA	2−5F1F

Weight : 0.21g

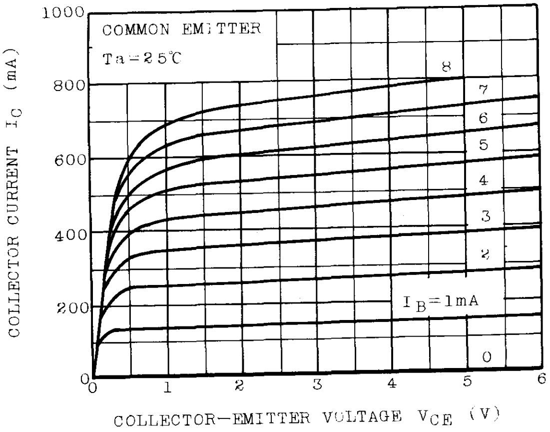
MAXIMUM RATINGS ($T_a=25^{\circ}C$)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	35	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	800	mA
Base Current	I_B	200	mA
Collector Power Dissipation	P_C	625	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

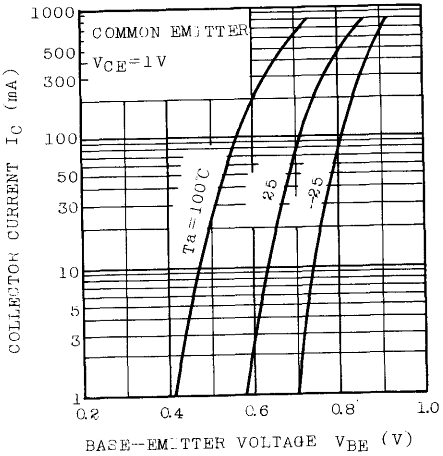
ELECTRICAL CHARACTERISTICS ($T_a=25^{\circ}C$)

CHARACTERISTIC	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	$V_{CB}=20V,\ I_E=0$	−	−	100	nA
Emitter Cut-off Current	I_{EBO}	$V_{EB}=5V,\ I_C=0$	−	−	100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	$I_C=10mA,\ I_B=0$	30	−	−	V
DC Current Gain (1)	$h_{FE(1)}$	$V_{CE}=1V,\ I_C=100mA$	100	−	320	
DC Current Gain (2)	$h_{FE(2)}$	$V_{CE}=1V,\ I_C=700mA$	35	−	−	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C=500mA,\ I_B=20mA$	−	−	0.5	V
Base-Emitter Voltage	V_{BE}	$V_{CE}=1V,\ I_C=10mA$	0.5	−	0.8	V
Transition Frequency	f_T	$V_{CE}=5V,\ I_C=10mA$	−	120	−	MHz
Collector Output Capacitance	C_{ob}	$V_{CB}=10V,\ I_E=0,\ f=1MHz$	−	13	−	pF

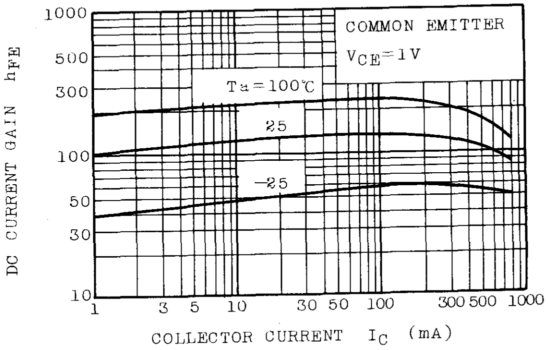
I_C – V_{CE}



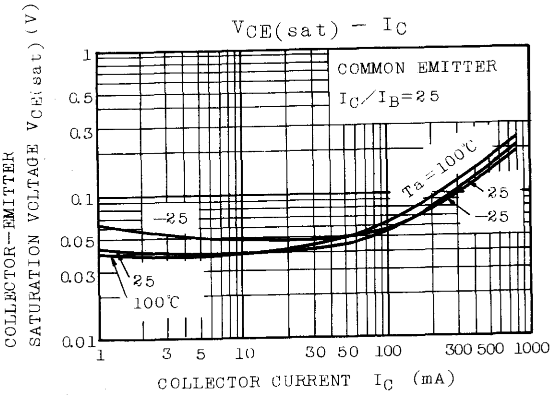
I_C – V_{BE}



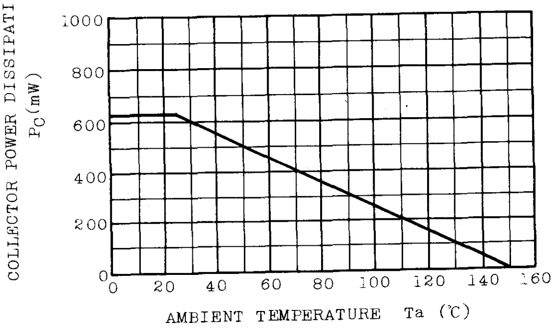
h_{FE} – I_C



$V_{CE(sat)}$ – I_C



P_C – Ta



SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

S1808

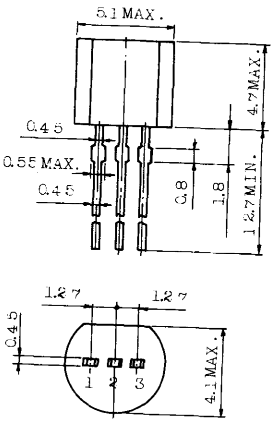
PRIMARILY INTENDED FOR USE IN DRIVER AND OUTPUT STAGE OF AUDIO AMPLIFIERS.

DESIGNED FOR COMPLEMENTARY USE WITH S1807.

FEATURES:

- Low Saturation Voltage : $V_{CE(sat)}$=-0.7V(Max.) at I_C=-500mA
- Complementaty to S1807

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

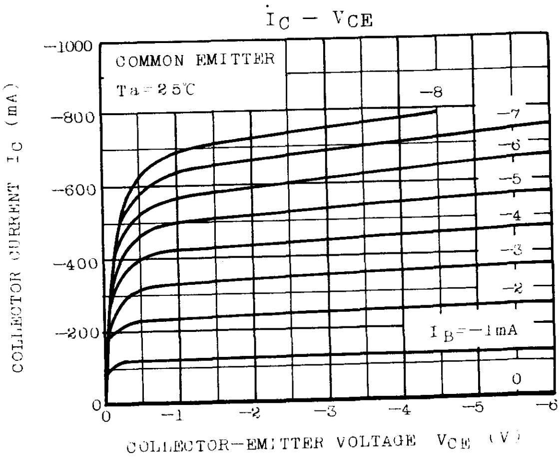
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-35	V
Collector-Emitter Voltage	V_{CEO}	-30	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-800	mA
Base Current	I_B	-200	mA
Collector Power Dissipation	P_C	625	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

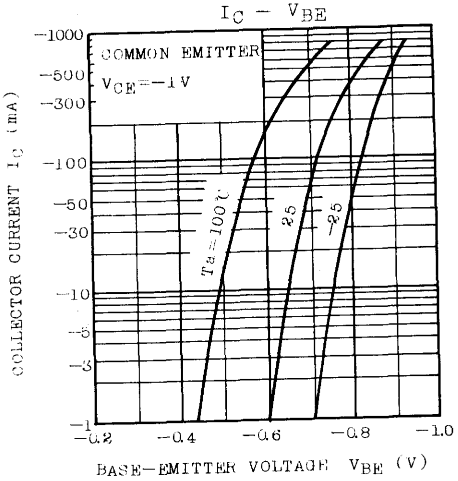
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=-20V, I_E=0	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=-5V, I_C=0	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=-10mA, I_B=0	-30	-	-	V
DC Current Gain (1)	$h_{FE(1)}$	V_{CE}=-1V, I_C=-100mA	100	-	320	
DC Current Gain (2)	$h_{FE(2)}$	V_{CE}=-1V, I_C=-700mA	35	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=-500mA, I_B=-20mA	-	-	-0.7	V
Base-Emitter Voltage	V_{BE}	V_{CE}=-1V, I_C=-10mA	-0.5	-	-0.8	V
Transition Frequency	f_T	V_{CE}=-5V, I_C=-10mA	-	120	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=-10V, I_E=0, f=1MHz	-	19	-	pF

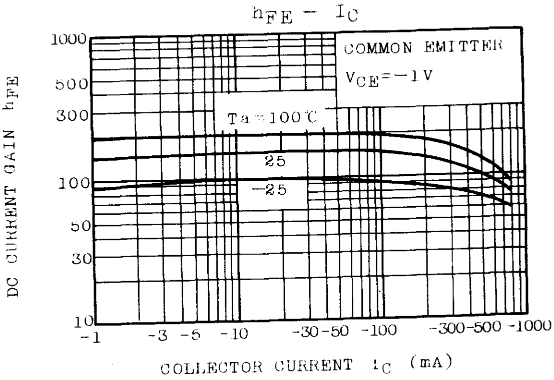
S1808



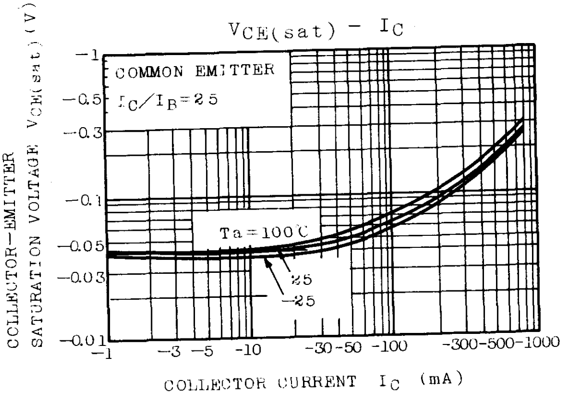
$I_C - V_{CE}$
COMMON EMITTER
Ta=25℃
COLLECTOR CURRENT I_C (mA)
-1000
-800
-600
-400
-200
0
-8
-7
-6
-5
-4
-3
-2
I_B=-1mA
0
-1
-2
-3
-4
-5
-6
COLLECTOR-EMITTER VOLTAGE V_{CE} (V)



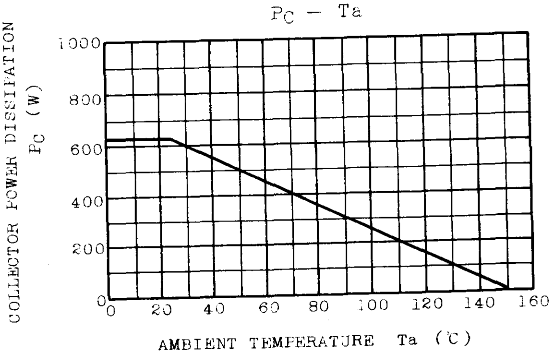
$I_C - V_{BE}$
COMMON EMITTER
V_{CE}=-1V
COLLECTOR CURRENT I_C (mA)
-1000
-500
-300
-100
-50
-30
-10
-5
-3
-1
Ta=100℃
25
-25
-0.2
-0.4
-0.6
-0.8
-1.0
BASE-EMITTER VOLTAGE V_{BE} (V)



$h_{FE} - I_C$
COMMON EMITTER
V_{CE}=-1V
DC CURRENT GAIN h_{FE}
1000
500
300
100
50
30
10
Ta=100℃
25
-25
-1
-3
-5
-10
-30
-50
-100
-300
-500
-1000
COLLECTOR CURRENT I_C (mA)



$V_{CE(sat)} - I_C$
COMMON EMITTER
I_C/I_B=25
COLLECTOR-EMITTER SATURATION VOLTAGE $V_{CE(sat)}$ (V)
-1
-0.5
-0.3
-0.1
-0.05
-0.03
-0.01
Ta=100℃
25
-25
-1
-3
-5
-10
-30
-50
-100
-300
-500
-1000
COLLECTOR CURRENT I_C (mA)



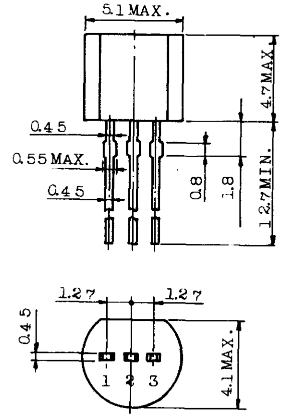
P_C - Ta
COLLECTOR POWER DISSIPATION P_C (W)
1000
800
600
400
200
0
0
20
40
60
80
100
120
140
160
AMBIENT TEMPERATURE Ta (℃)

SILICON NPN TRIPLE DIFFUSED TYPE (PCT PROCESS)

S1836

FOR HIGH VOLTAGE AMPLIFIER APPLICATIONS.
PLASMA DISPLAY, NIXIE TUBE DRIVER APPLICATIONS.
COLOR TV VIDEO OUTPUT APPLICATIONS.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO−92
EIAJ	SC−43
TOSIBA	2−5F1F

Weight : 0.21g

FEATURES:

- Complementary to S1837.
- 300V Minimum $V_{(BR)CEO}$.
- Low Saturation Voltage : $V_{CE(sat)}=0.5V$(Max.)
- Small Collector Output Capacitance.

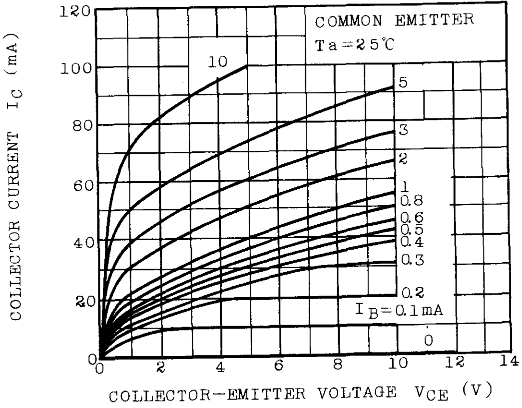
MAXIMUM RATINGS ($Ta=25^{\circ}C$)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	300	V
Collector-Emitter Voltage	V_{CEO}	300	V
Emitter-Base Voltage	V_{EBO}	6	V
Collector Current	I_C	100	mA
Collector Power Dissipation	P_C	625	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

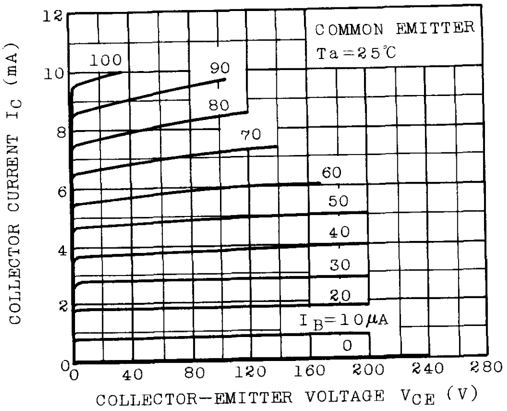
ELECTRICAL CHARACTERISTICS ($Ta=25^{\circ}C$)

CHARACTERISTIC	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	$V_{CB}=300V,\ I_E=0$	−	−	0.1	μA
Emitter Cut-off Current	I_{EBO}	$V_{EB}=6V,\ I_C=0$	−	−	0.1	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	$I_C=1mA,\ I_B=0$	300	−	−	V
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	$I_C=0.1mA,\ I_E=0$	300	−	−	V
DC Current Gain	$h_{FE(1)}$	$V_{CE}=10V,\ I_C=1mA$	20	−	−	
	$h_{FE(2)}$	$V_{CE}=10V,\ I_C=20mA$	30	−	150	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C=20mA,\ I_B=2mA$	−	−	0.5	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	$I_C=20mA,\ I_B=2mA$	−	−	1.2	V
Transition Frequency	f_T	$V_{CE}=10V,\ I_C=20mA$	50	80	−	MHz
Collector Output Capacitance	C_{ob}	$V_{CB}=20V,\ I_E=0,\ f=1MHz$	−	3	4	pF

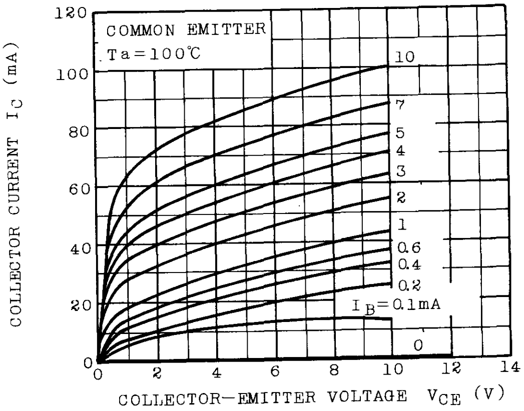
$I_C - V_{CE}$ (LOW VOLTAGE REGION)



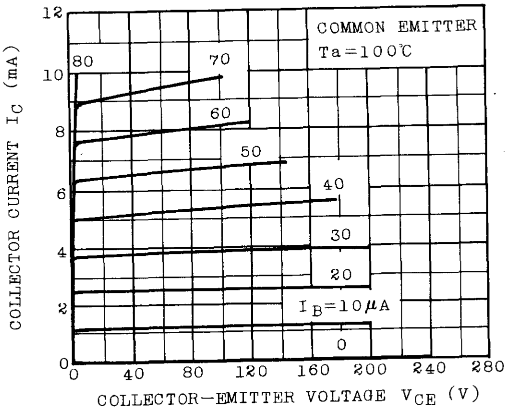
$I_C - V_{CE}$ (LOW CURRENT REGION)



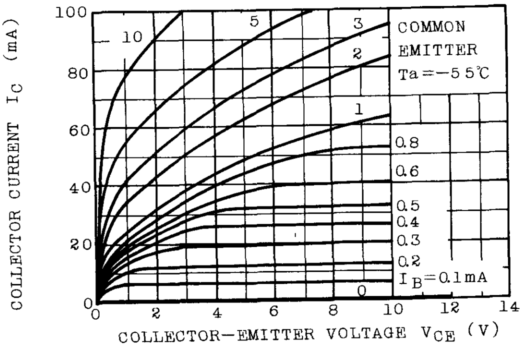
$I_C - V_{CE}$ (LOW VOLTAGE REGION)



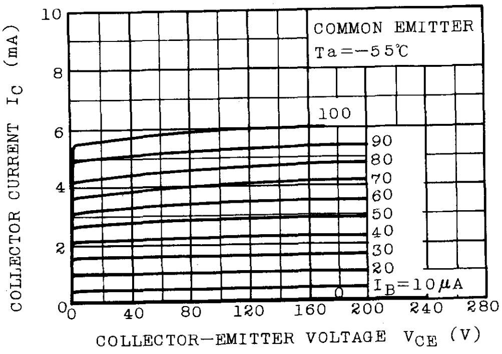
$I_C - V_{CE}$ (LOW CURRENT REGION)

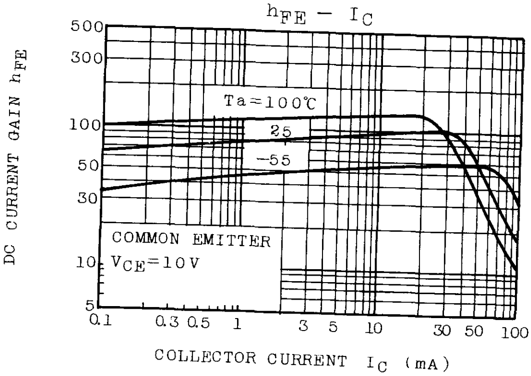


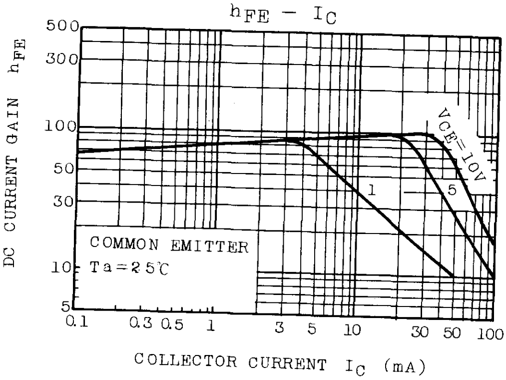
$I_C - V_{CE}$ (LOW VOLTAGE REGION)

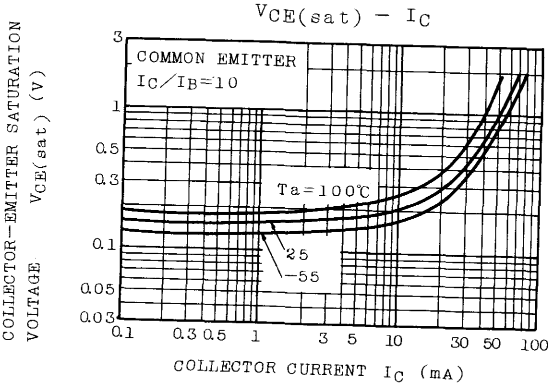


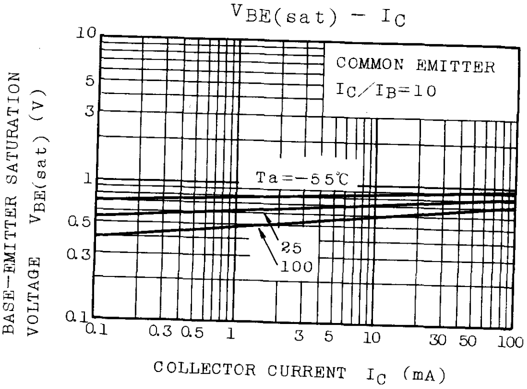
$I_C - V_{CE}$ (LOW CURRENT REGION)

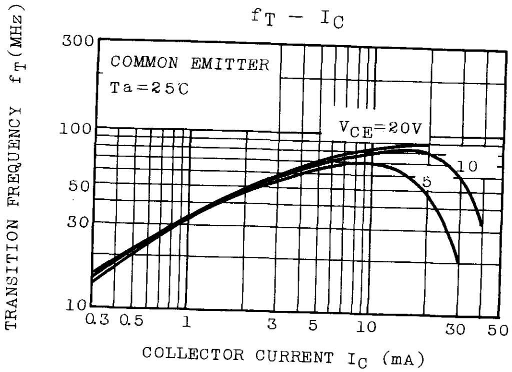


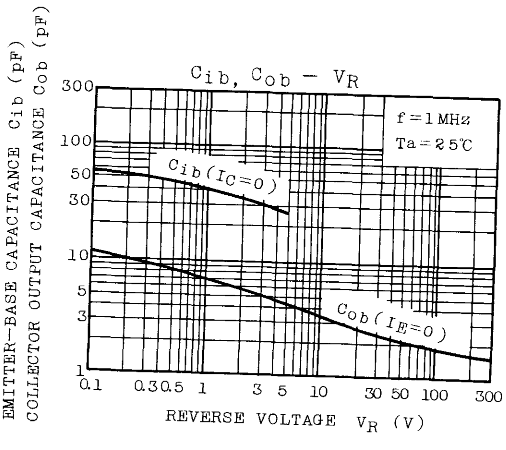

hFE − IC
DC CURRENT GAIN hFE
500
300
100
50
30
10
5
Ta=100℃
25
−55
COMMON EMITTER
VCE=10V
0.1
0.3 0.5
1
3
5
10
30
50
100
COLLECTOR CURRENT IC (mA)


hFE − IC
DC CURRENT GAIN hFE
500
300
100
50
30
10
5
VCE=10V
1
5
COMMON EMITTER
Ta=25℃
0.1
0.3 0.5
1
3
5
10
30
50
100
COLLECTOR CURRENT IC (mA)


VCE(sat) − IC
COLLECTOR-EMITTER SATURATION VOLTAGE VCE(sat) (V)
3
1
0.5
0.3
0.1
0.05
0.03
COMMON EMITTER
IC/IB=10
Ta=100℃
25
−55
0.1
0.3 0.5
1
3
5
10
30
50
100
COLLECTOR CURRENT IC (mA)


VBE(sat) − IC
BASE-EMITTER SATURATION VOLTAGE VBE(sat) (V)
10
5
3
1
0.5
0.3
0.1
COMMON EMITTER
IC/IB=10
Ta=−55℃
25
100
0.1
0.3 0.5
1
3
5
10
30
50
100
COLLECTOR CURRENT IC (mA)


fT − IC
TRANSITION FREQUENCY fT (MHz)
300
100
50
30
10
COMMON EMITTER
Ta=25℃
VCE=20V
10
5
0.3
0.5
1
3
5
10
30
50
COLLECTOR CURRENT IC (mA)


Cib, Cob − VR
EMITTER-BASE CAPACITANCE Cib (pF)
COLLECTOR OUTPUT CAPACITANCE Cob (pF)
300
100
50
30
10
5
3
1
f=1MHz
Ta=25℃
Cib (IC=0)
Cob (IE=0)
0.1
0.3 0.5
1
3
5
10
30
50
100
300
REVERSE VOLTAGE VR (V)

S1837

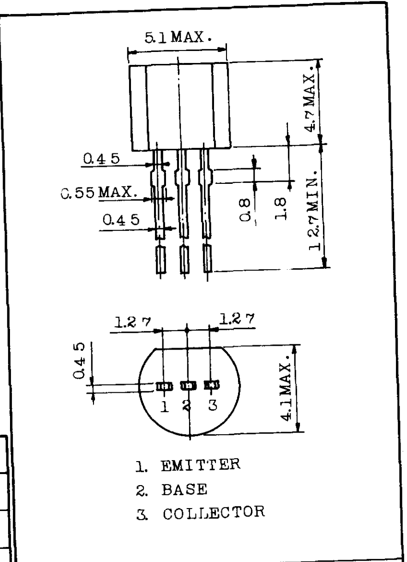
SILICON PNP TRIPLE DIFFUSED TYPE (PCT PROCESS)

FOR HIGH VOLTAGE AMPLIFIER APPLICATIONS.
PLASMA DISPLAY, NIXIE TUBE DRIVER APPLICATIONS.
COLOR TV VIDEO OUTPUT APPLICATIONS.

FEATURES:

- Complementary to S1836
- 300V Minimum $V_{(BR)CEO}$.
- Low Saturation Voltage : $V_{CE(sat)}=-0.5V$(Max.)
- Small Collector Output Capacitance.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

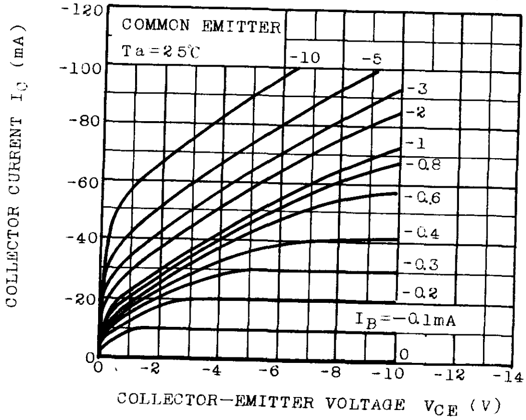
MAXIMUM RATINGS (Ta=25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-300	V
Collector-Emitter Voltage	V_{CEO}	-300	V
Emitter-Base Voltage	V_{EBO}	-8	V
Collector Current	I_C	-100	mA
Collector Power Dissipation	P_C	625	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

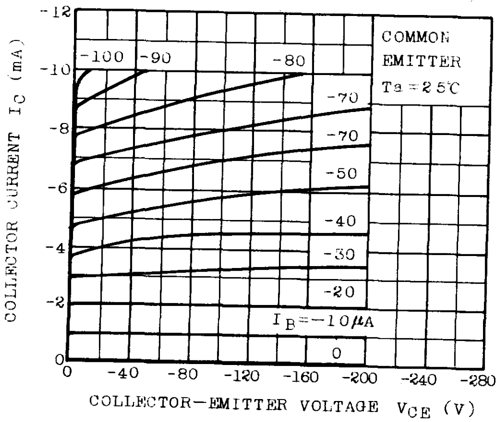
ELECTRICAL CHARACTERISTICS (Ta=25°C)

CHARACTERISTIC	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	$V_{CB}=-300V$, $I_E=0$	-	-	-0.1	μA
Emitter Cut-off Current	I_{EBO}	$V_{EB}=-8V$, $I_C=0$	-	-	-0.1	μA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	$I_C=-1mA$, $I_B=0$	-300	-	-	V
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	$I_C=-0.1mA$, $I_E=0$	-300	-	-	V
DC Current Gain	$h_{FE(1)}$	$V_{CE}=-10V$, $I_C=-1mA$	20	-	-	
	$h_{FE(2)}$	$V_{CE}=-10V$, $I_C=-20mA$	30	-	150	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C=-20mA$, $I_B=-2mA$	-	-	-0.5	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	$I_C=-20mA$, $I_B=-2mA$	-	-	-1.2	V
Transition Frequency	f_T	$V_{CE}=-10V$, $I_C=-20mA$	40	60	-	MHz
Collector Output Capacitance	C_{ob}	$V_{CB}=-20V$, $I_E=0$, f=1MHz	-	6	8	pF

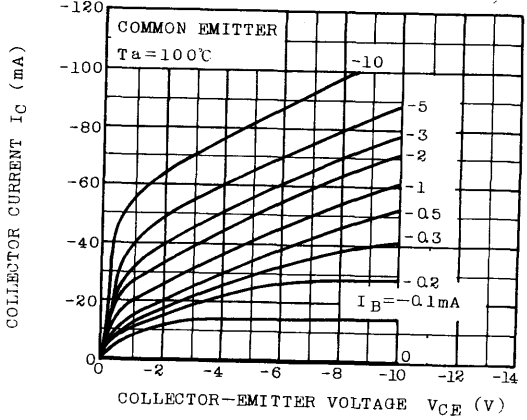
I_C-V_{CE} (LOW VOLTAGE REGION)



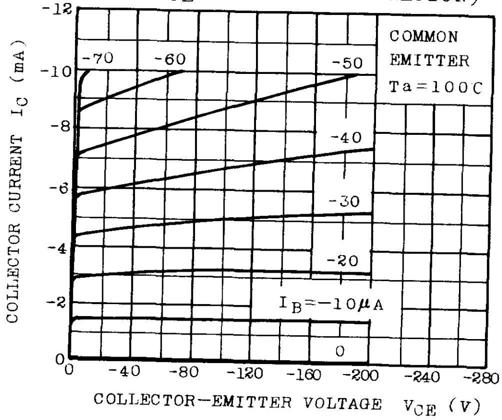
I_C-V_{CE} (LOW CURRENT REGION)



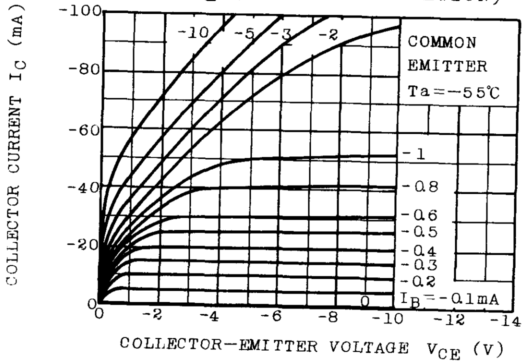
I_C-V_{CE} (LOW VOLTAGE REGION)



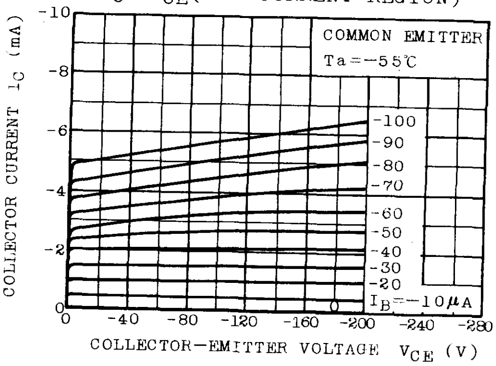
I_C-V_{CE} (LOW CURRENT REGION)

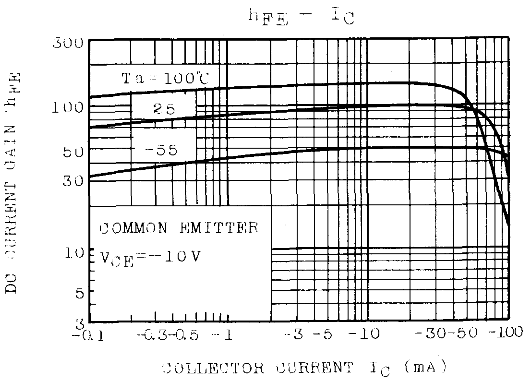


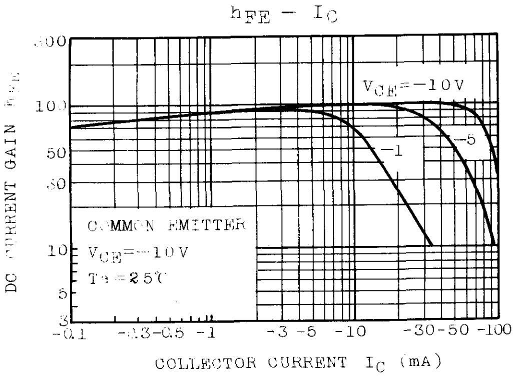
I_C-V_{CE} (LOW VOLTAGE REGION)

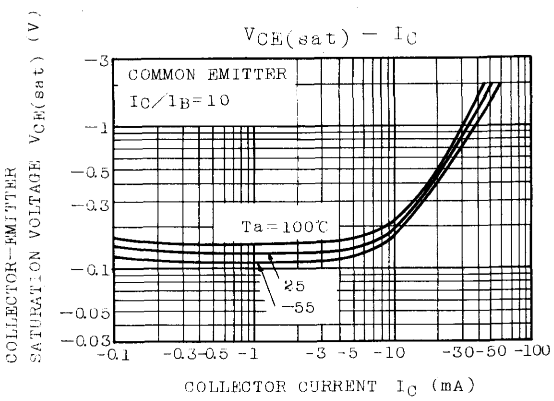


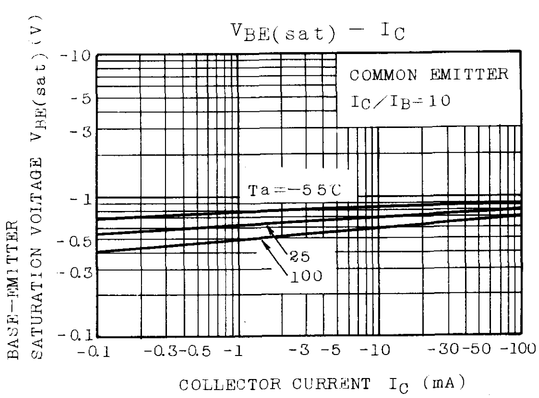
I_C-V_{CE}(LOW CURRENT REGION)

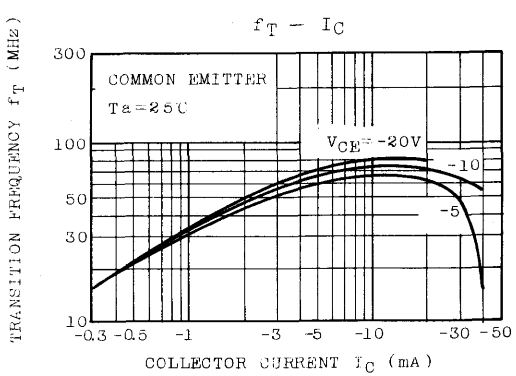


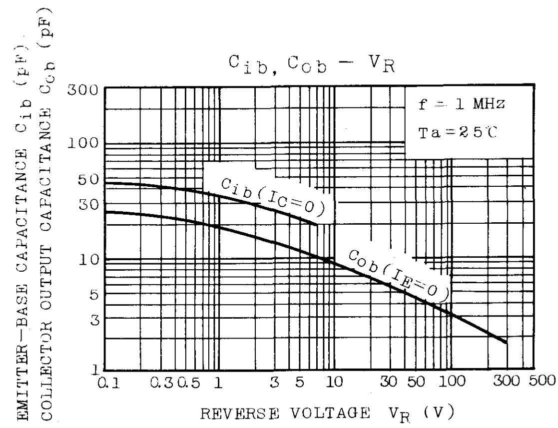

hFE − IC
DC CURRENT GAIN hFE
Ta = 100℃
25
−55
COMMON EMITTER
VCE = −10 V
300
100
50
30
10
5
3
−0.1
−0.3
−0.5
−1
−3
−5
−10
−30
−50
−100
COLLECTOR CURRENT IC (mA)


hFE − IC
DC CURRENT GAIN hFE
VCE = −10 V
−1
−5
COMMON EMITTER
VCE = −10 V
Ta = 25℃
300
100
50
30
10
5
3
−0.1
−0.3
−0.5
−1
−3
−5
−10
−30
−50
−100
COLLECTOR CURRENT IC (mA)


VCE(sat) − IC
COLLECTOR−EMITTER SATURATION VOLTAGE VCE(sat) (V)
COMMON EMITTER
IC/IB = 10
Ta = 100℃
25
−55
−3
−1
−0.5
−0.3
−0.1
−0.05
−0.03
−0.1
−0.3
−0.5
−1
−3
−5
−10
−30
−50
−100
COLLECTOR CURRENT IC (mA)


VBE(sat) − IC
BASE−EMITTER SATURATION VOLTAGE VBE(sat) (V)
COMMON EMITTER
IC/IB = 10
Ta = −55℃
25
100
−10
−5
−3
−1
−0.5
−0.3
−0.1
−0.1
−0.3
−0.5
−1
−3
−5
−10
−30
−50
−100
COLLECTOR CURRENT IC (mA)


fT − IC
TRANSITION FREQUENCY fT (MHz)
COMMON EMITTER
Ta = 25℃
VCE = −20V
−10
−5
300
100
50
30
10
−0.3
−0.5
−1
−3
−5
−10
−30
−50
COLLECTOR CURRENT IC (mA)


Cib, Cob − VR
EMITTER−BASE CAPACITANCE Cib (pF)
COLLECTOR OUTPUT CAPACITANCE Cob (pF)
f = 1 MHz
Ta = 25℃
Cib (IC = 0)
Cob (IE = 0)
300
100
50
30
10
5
3
1
0.1
0.3
0.5
1
3
5
10
30
50
100
300
500
REVERSE VOLTAGE VR (V)

SILICON NPN EPITAXIAL TYPE (PCT PROCESS)

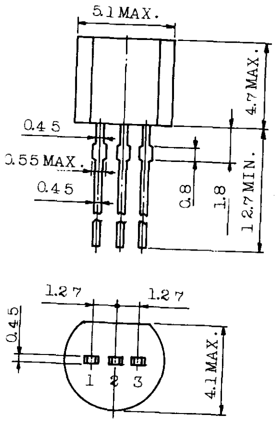
S1838

DRIVER STAGE AMPLIFIER APPLICATIONS.
VOLTAGE AMPLIFIER APPLICATIONS.

FEATURES:

- Complementary to S1839.
- Driver Stage Application of 20 to 25 Watts Amplifiers.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

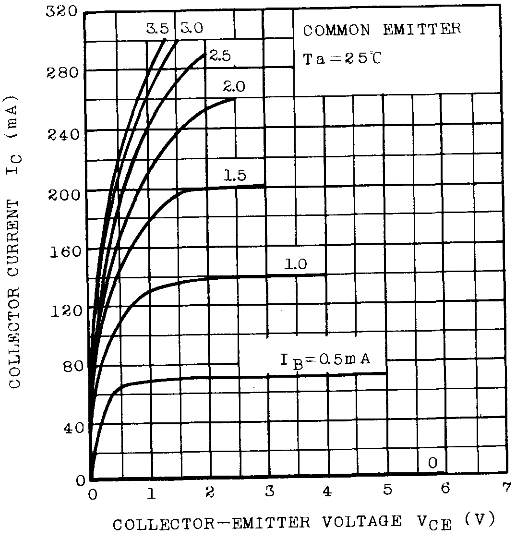
Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

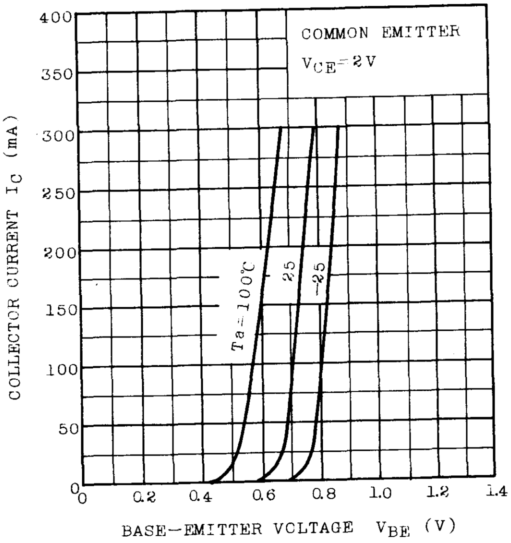
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	80	V
Collector-Emitter Voltage	V_{CEO}	80	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	300	mA
Base Current	I_B	100	mA
Collector Power Dissipation	P_C	625	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

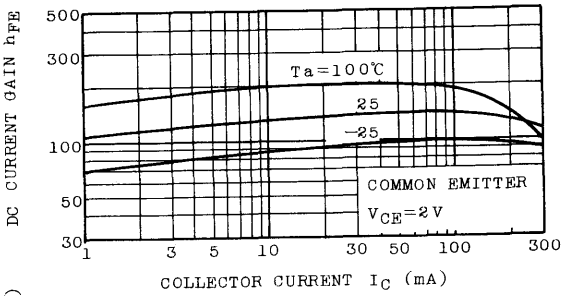
CHARACTERISTIC	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=50V, I_E=0	-	-	100	nA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA
Collector-Emitter Brrakdown Voltage	$V_{(BR)CEO}$	I_C=5mA, I_B=0	80	-	-	V
DC Current Gain	$h_{FE(1)}$	V_{CE}=2V, I_C=50mA	70	-	240	
	$h_{FE(2)}$	V_{CE}=2V, I_C=200mA	40	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=200mA, I_B=10mA	-	-	0.5	V
Base-Emitter Voltage	V_{BE}	V_{CE}=2V, I_C=5mA	0.55	-	0.8	V
Transition Frequency	f_T	V_{CE}=10V, I_C=10mA	-	100	-	MHz
Collector Output Capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	10	-	pF



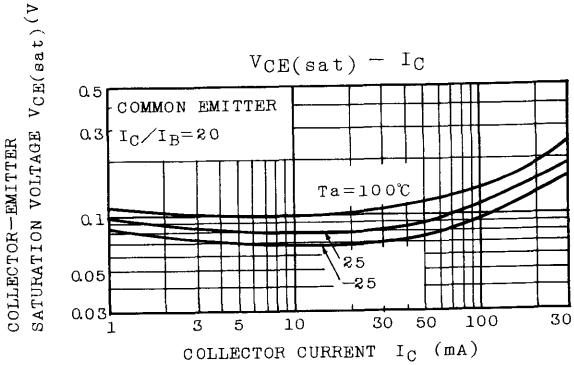
$I_C - V_{CE}$



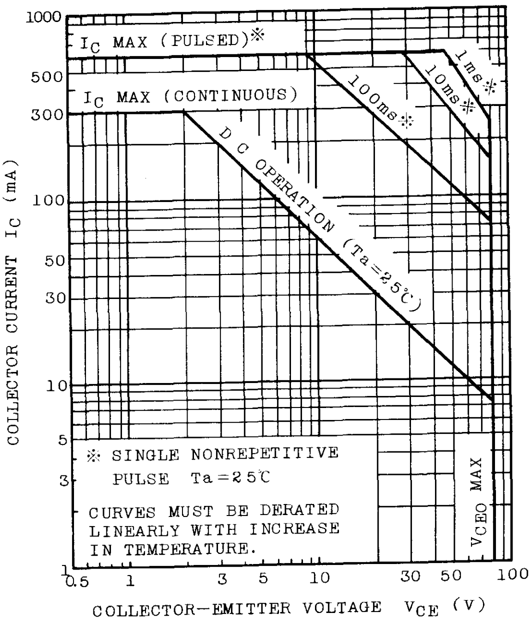
$I_C - V_{BE}$



$h_{FE} - I_C$



$V_{CE(sat)} - I_C$



SAFE OPERATING AREA

SILICON PNP EPITAXIAL TYPE (PCT PROCESS)

S1839

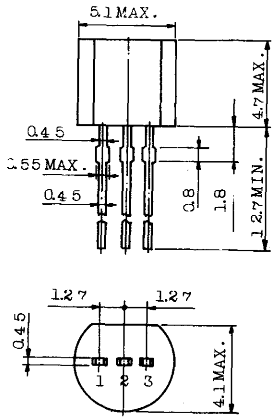
DRIVER STAGE AMPLIFIER APPLICATIONS.

VOLTAGE AMPLIFIER APPLICATIONS.

FEATURES:

- Complementary to S1838.
- Driver Stage Application of 20 to 25 Watts Amplifiers.

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

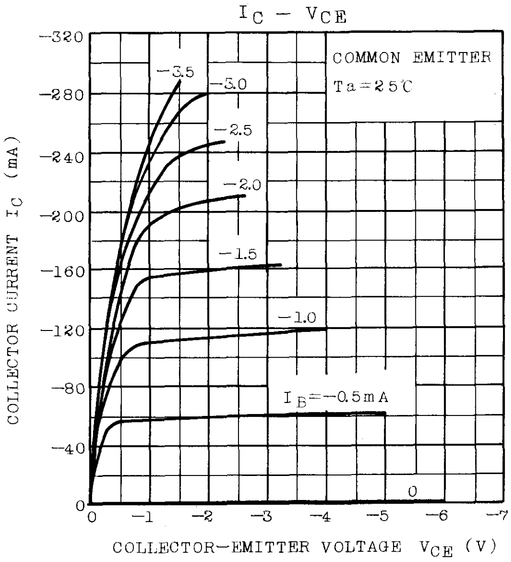
MAXIMUM RATINGS ($Ta=25^{\circ}C$)

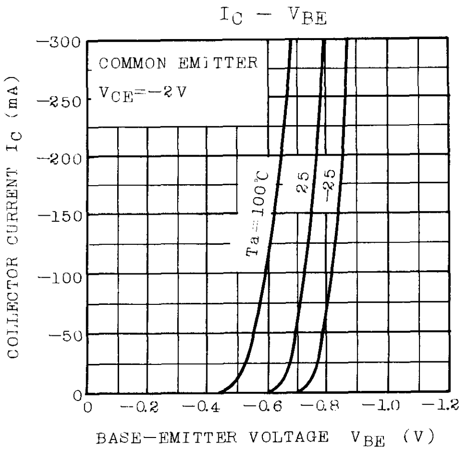
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	-80	V
Collector-Emitter Voltage	V_{CEO}	-80	V
Emitter-Base Voltage	V_{EBO}	-5	V
Collector Current	I_C	-300	mA
Base Current	I_B	-100	mA
Collector Power Dissipation	P_C	625	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

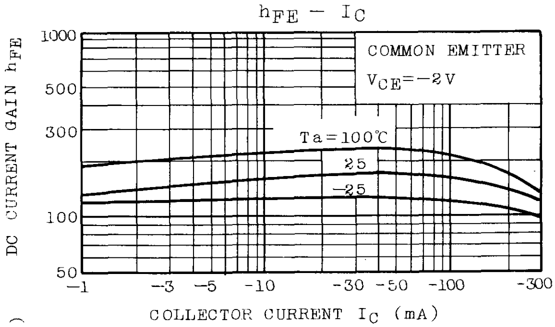
ELECTRICAL CHARACTERISTICS ($Ta=25^{\circ}C$)

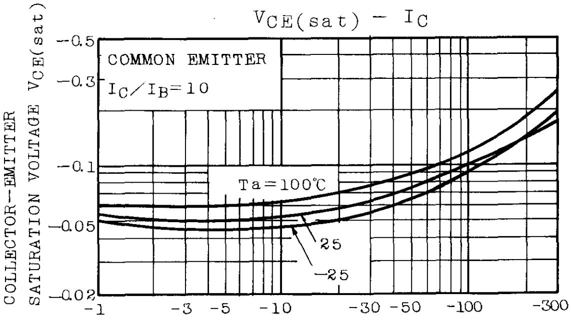
CHARACTERISTIC	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	$V_{CB}=-50V$, $I_E=0$	-	-	-100	nA
Emitter Cut-off Current	I_{EBO}	$V_{EB}=-5V$, $I_C=0$	-	-	-100	nA
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	$I_C=-5mA$, $I_B=0$	-80	-	-	V
DC Current Gain	$h_{FE(1)}$	$V_{CE}=-2V$, $I_C=-50mA$	70	-	240	
	$h_{FE(2)}$	$V_{CE}=-2V$, $I_C=-200mA$	40	-	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C=-200mA$, $I_B=-20mA$	-	-	-0.4	V
Base-Emitter Voltage	V_{BE}	$V_{CE}=-2V$, $I_C=-5mA$	-0.55	-	-0.8	V
Transition Frequency	f_T	$V_{CE}=-10V$, $I_C=-10mA$	70	100	-	MHz
Collector Output Capacitance	C_{ob}	$V_{CB}=-10V$, $I_E=0$, $f=1MHz$	-	14	-	pF

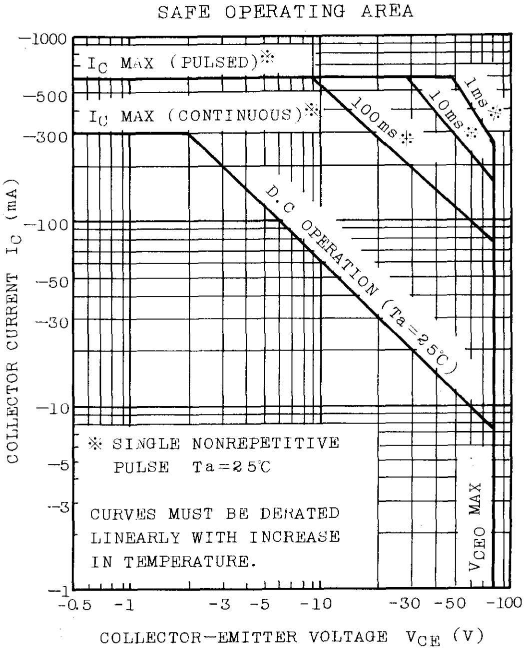
S1839


$I_C - V_{CE}$


$I_C - V_{BE}$


$h_{FE} - I_C$


$V_{CE(sat)} - I_C$


SAFE OPERATING AREA

※ SINGLE NONREPETITIVE PULSE Ta=25℃

CURVES MUST BE DERATED LINEARLY WITH INCREASE IN TEMPERATURE.

SILICON NPN TRIPLE DIFFUSED (PCT PROCESS)

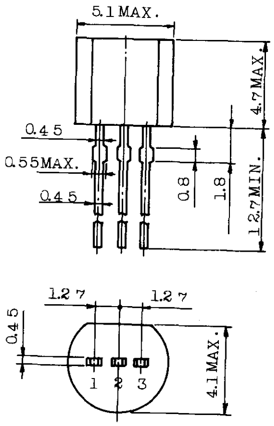
S1840

VIDEO OUTPUT STAGE FOR B/W TV.
HIGH VOLTAGE SWITCHING APPLICATONS.

FEATURES:

- High Voltage : V_{CBO}=150V, V_{CEO}=150V
- Low Saturation Voltage : $V_{CE(sat)}$=0.5V(Max.)

Unit in mm



1. EMITTER
2. BASE
3. COLLECTOR

JEDEC	TO-92
EIAJ	SC-43
TOSHIBA	2-5F1F

Weight : 0.21g

MAXIMUM RATINGS (Ta=25°C)

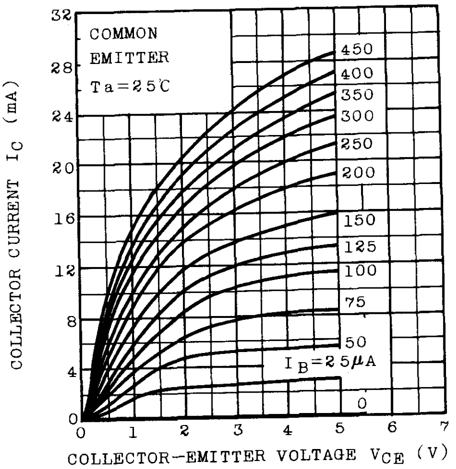
CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	150	V
Collector-Emitter Voltage	V_{CEO}	150	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	30	mA
Base Current	I_B	10	mA
Collector Power Dissipation	P_C	625	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	-55~150	°C

ELECTRICAL CHARACTERISTICS (Ta=25°C)

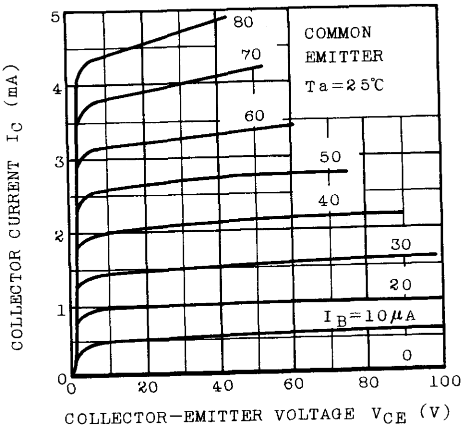
CHARACTERISTIC	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Collector Cut-off Current	I_{CBO}	V_{CB}=150V, I_E=0	-	-	0.1	μA
Emitter Cut-off Current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	0.1	μA
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C=0.1mA, I_E=0	150	-	-	V
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C=1mA, I_B=0	150	-	-	V
DC Current Gain	h_{FE}	V_{CE}=3V, I_C=10mA	40	-	240	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C=10mA, I_B=1mA	-	-	0.5	V
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C=10mA, I_B=1mA	-	-	1.5	V
Transition Frequency	f_T	V_{CE}=10V, I_C=2mA	50	100	-	MHz
Collecotr Output Capacitance	Cob	V_{CB}=10V, I_E=0, f=1MHz	-	2.5	4	pF

S1840

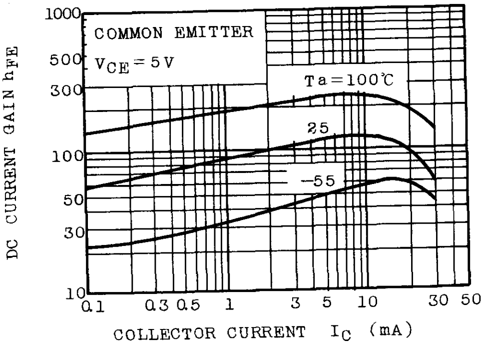
IC− VCE (LOW VOLTAGE REGION)



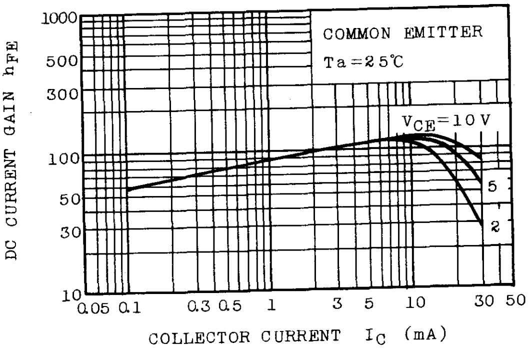
IC− VCE (LOW CURRENT REGION)



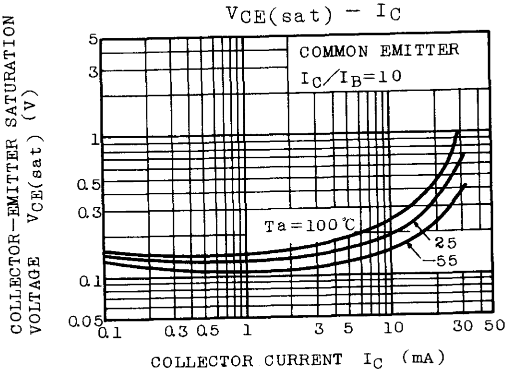
hFE − IC



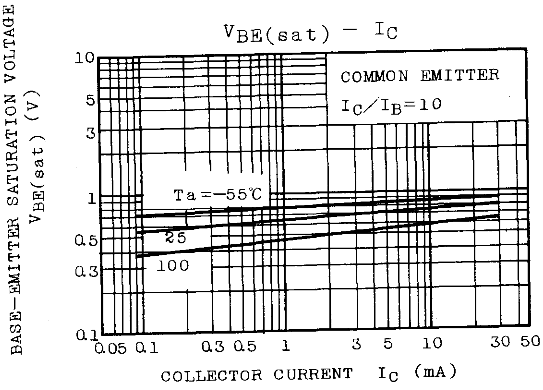
hFE − IC

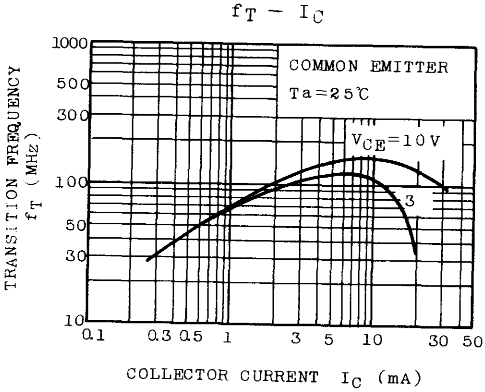


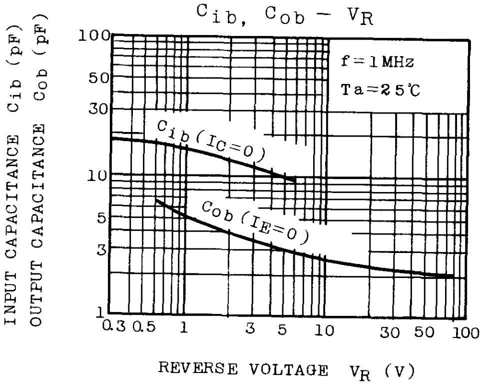
VCE(sat) − IC



VBE(sat) − IC




$f_T - I_C$
COMMON EMITTER
Ta=25℃
V_{CE}=10V
3
TRANSITION FREQUENCY f_T (MHz)
1000
500
300
100
50
30
10
0.1
0.3
0.5
1
3
5
10
30
50
COLLECTOR CURRENT I_C (mA)


$C_{ib}, C_{ob} - V_R$
f=1MHz
Ta=25℃
C_{ib} (I_C=0)
C_{ob} (I_E=0)
INPUT CAPACITANCE Cib (pF)
OUTPUT CAPACITANCE Cob (pF)
100
50
30
10
5
3
1
0.3
0.5
1
3
5
10
30
50
100
REVERSE VOLTAGE V_R (V)

APPLICATION CIRCUIT

Radio

FM Stereo unit

Audio amplifier circuit

Switching circuit

Dropper Regulator Circuit

Circuit incroporating FET's

Low-frequency amplifier circuit

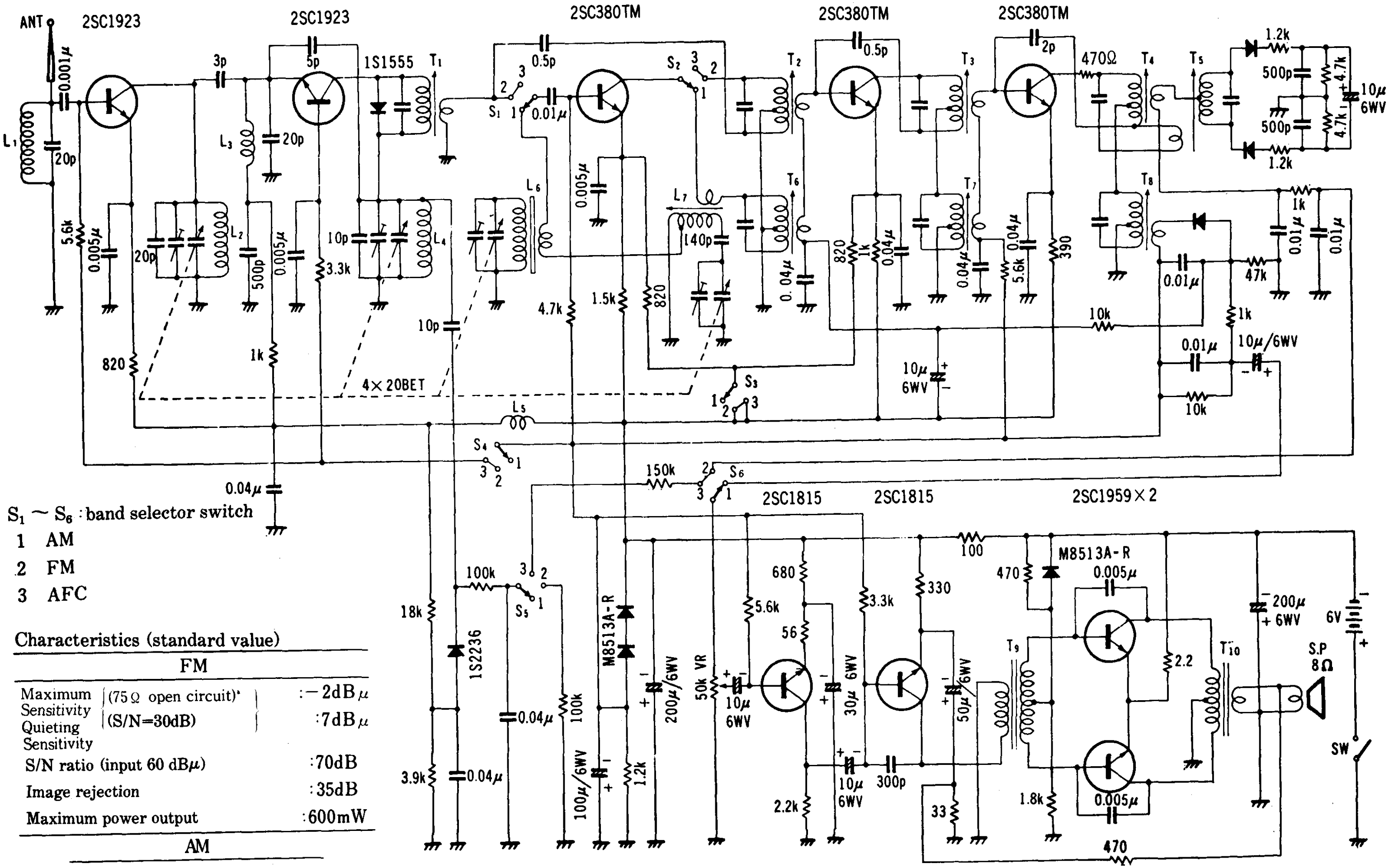
High-frequency power amplifier circuit

Applied circuit of large-power transistor and transistor modules (motor drive circuit)

Application of low-saturation voltage transistors

GaAs Hall sensor

1. 9-transistor FM/AM radio circuit



S1 ~ S6 : band selector switch
1 AM
2 FM
3 AFC

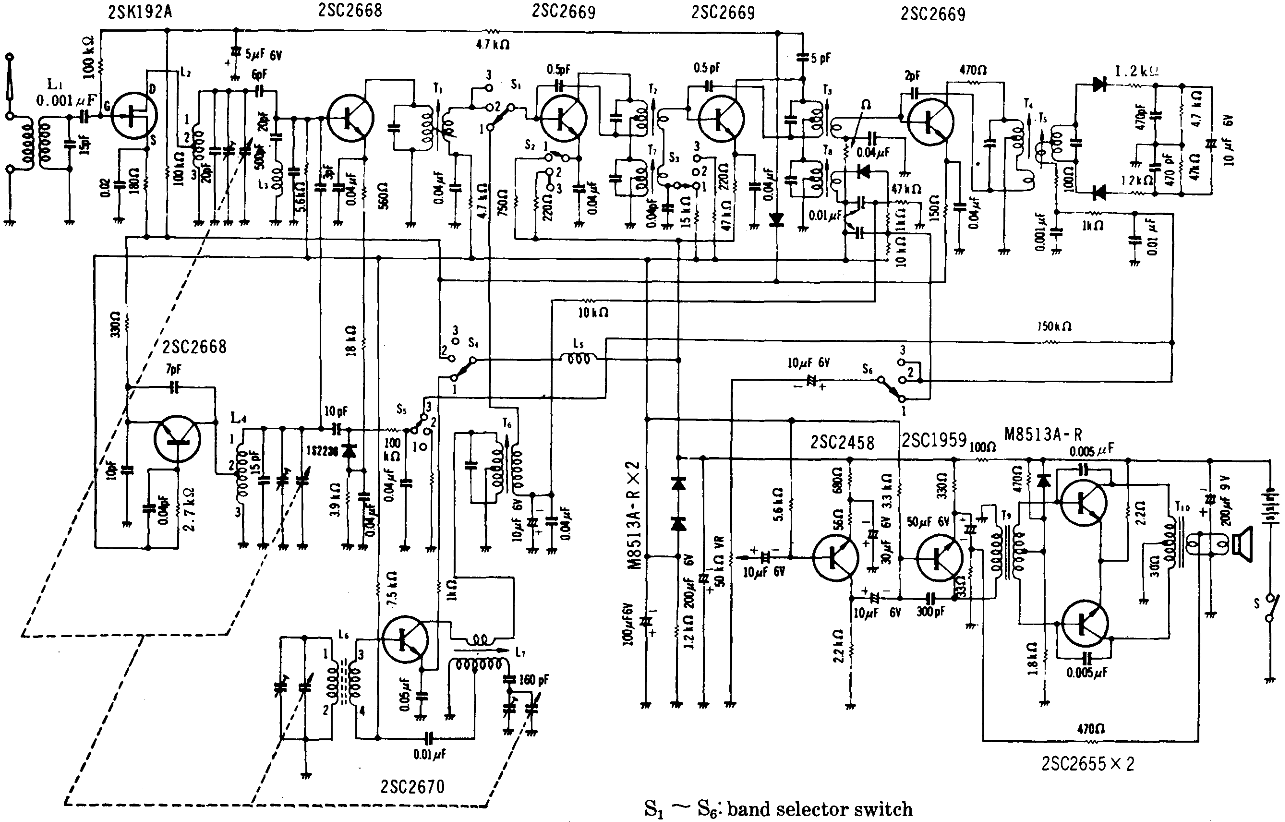
Characteristics (standard value)

FM	
Maximum Sensitivity (75 Ω open circuit)	: −2dBµ
Quieting Sensitivity (S/N=30dB)	: 7dBµ
S/N ratio (input 60 dBµ)	: 70dB
Image rejection	: 35dB
Maximum power output	: 600mW

AM	
Sensitivity (maximum)	: 33dBµ
S/N ratio (input 60 dBµ)	: 35dB
Selectivity (±10kHz)	: 24dB
Maximum power output	: 600mW

Units for passive elements are R(Ω), C(F) and L (H) unless otherwise specified.

2. 10-transistor FM/AM radio circuit

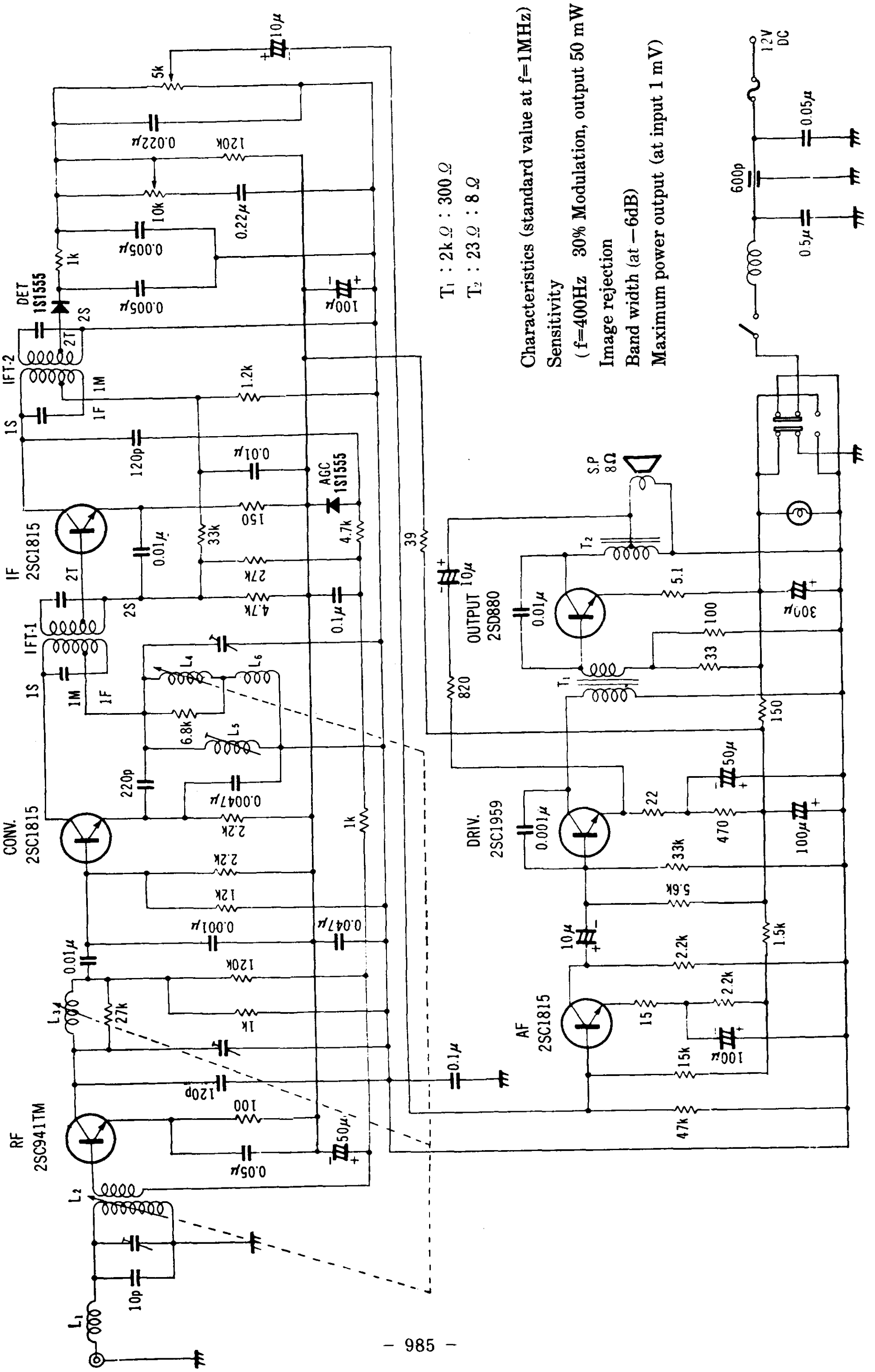


S₁ ~ S₆: band selector switch

1. AM
2. FM
3. AFC

Characteristics (standard value)	FM	AM
Maximum sensitivity (S/N=30dB)	− 2dBμ	35dBμ/m
Maximum sensitivity (75Ω open circuit)	7dBμ	
Quieting sensitivity	66dB	33dB
S/N ratio (input 60 dBμ)	50dB	
Image rejection		
Maximum power output	2500mW	2500mW
Selectivity (±10kHz)		25dB

3. 6-transistor car radio circuit



Characteristics (standard value at f=1MHz)

Sensitivity

(f=400Hz 30% Modulation, output 50 mW) : 25μV

Image rejection : 61dB

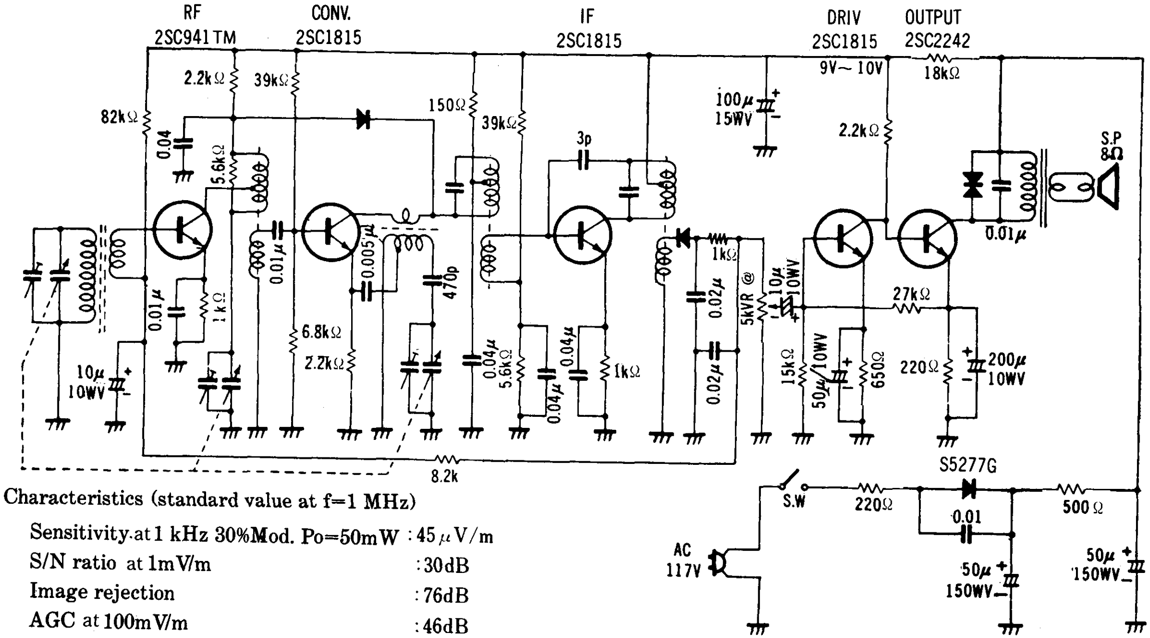
Band width (at −6dB) : 7kHz

Maximum power output (at input 1 mV) : 2.0W

T_1 : 2kΩ : 300Ω

T_2 : 23Ω : 8Ω

4. 5-transistor line operate radio circuit

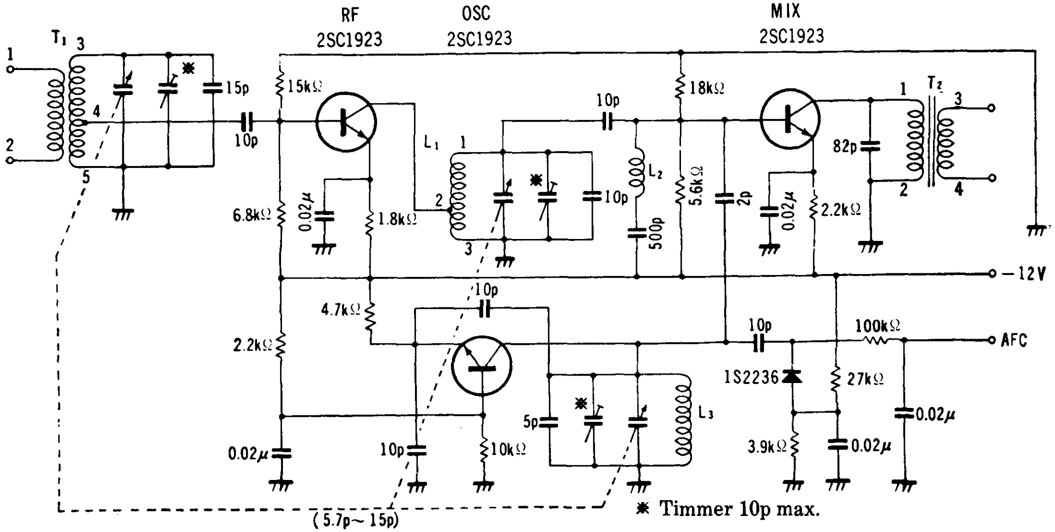


Characteristics (standard value at f=1 MHz)

Sensitivity at 1 kHz 30%Mod. Po=50mW	: 45μV/m
S/N ratio at 1mV/m	:30dB
Image rejection	:76dB
AGC at 100mV/m	:46dB
Band width at −6dB	:6kHz
Maximum power output at 5mV/m	:2.0W

FM stereo unit

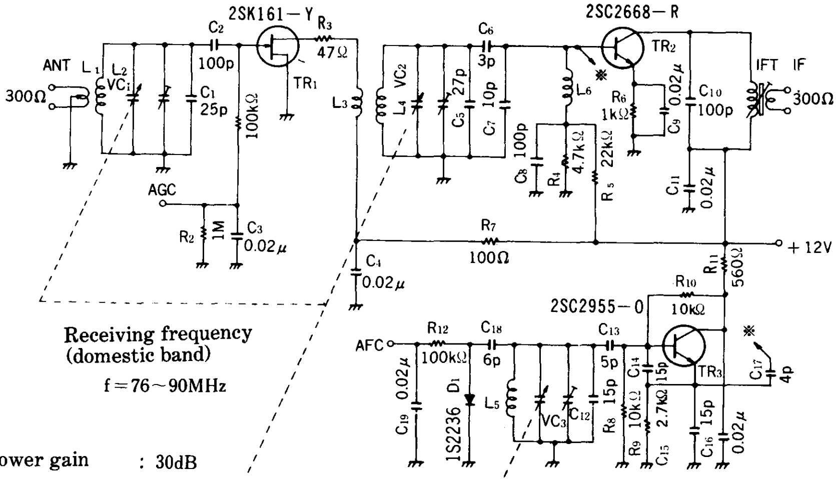
1. FM tuner circuit (1)



Characteristics (standard value)

Receiving frequency	:88∼108MHz
Input impedance	:75Ω
Power gain	:32dB
Image rejection	:50dB
Oscillation voltage	:190mV
Oscillator dropout voltage	:3.2V

2. FM tuner circuit (2)

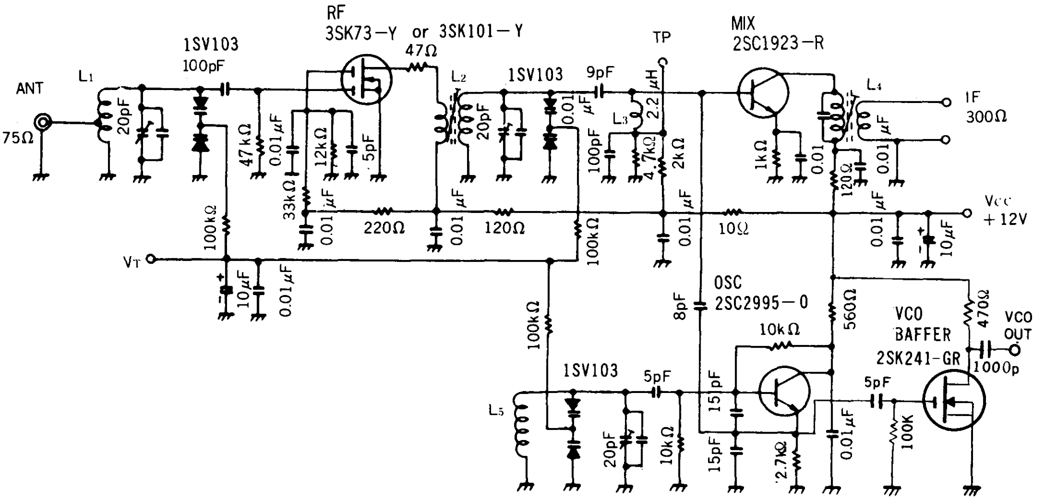


Receiving frequency
(domestic band)

f=76~90MHz

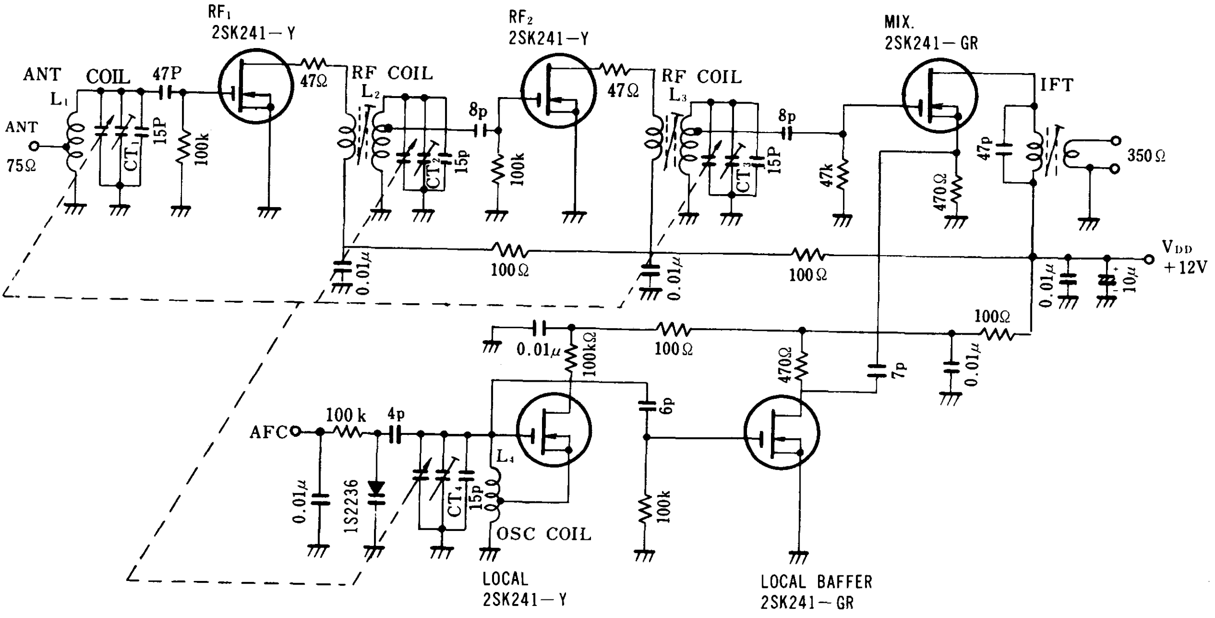
Power gain	: 30dB
Image rejection	: 68dB
S/N ratio	: 77dB

3. FM electronic tuner Circuit



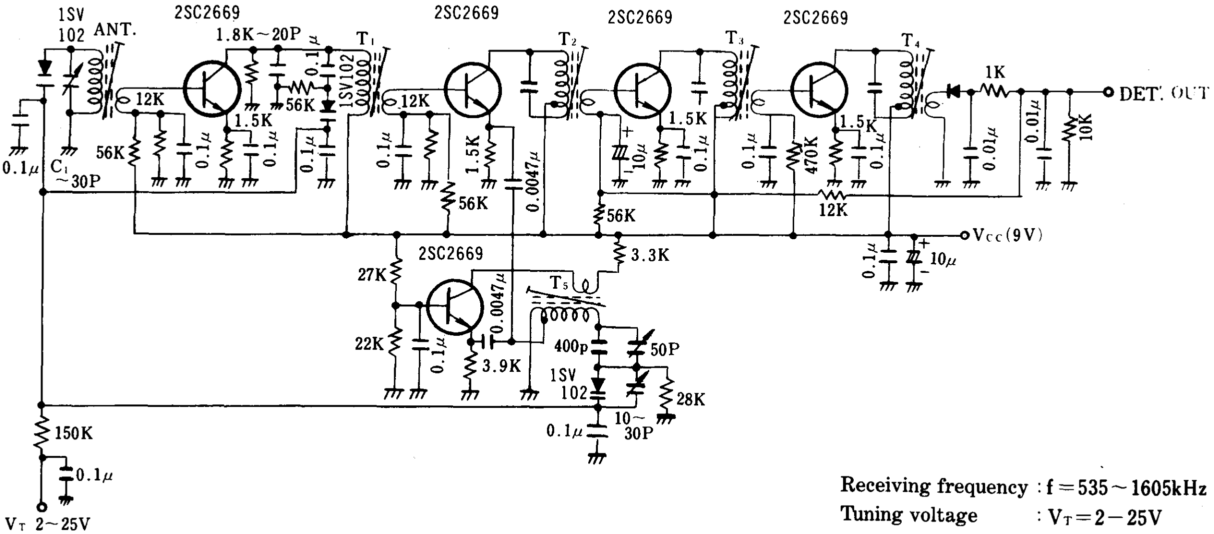
Receiving frequency	: f=76~90MHz
Tuning voltage	: VT=3~25V
Power gain	: 32dB
Image rejection	: 62dB
S/N ratio	: 74dB

4. Hi-Fi FM tuner Circuit



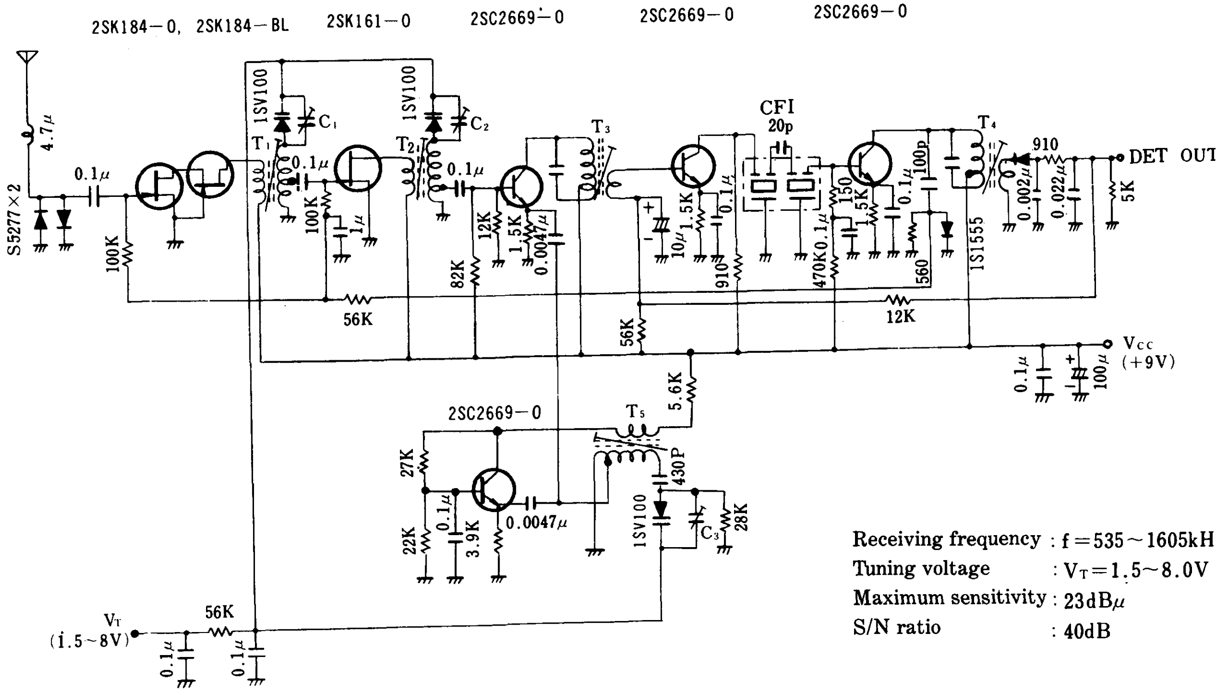
Receiving frequency : f＝76～90MHz
Power gain : 33dB
Image rejection : 85dB
S/N ratio : 80dB

5. Electronic tuning AM tuner Circuit (for Hi-Fi)



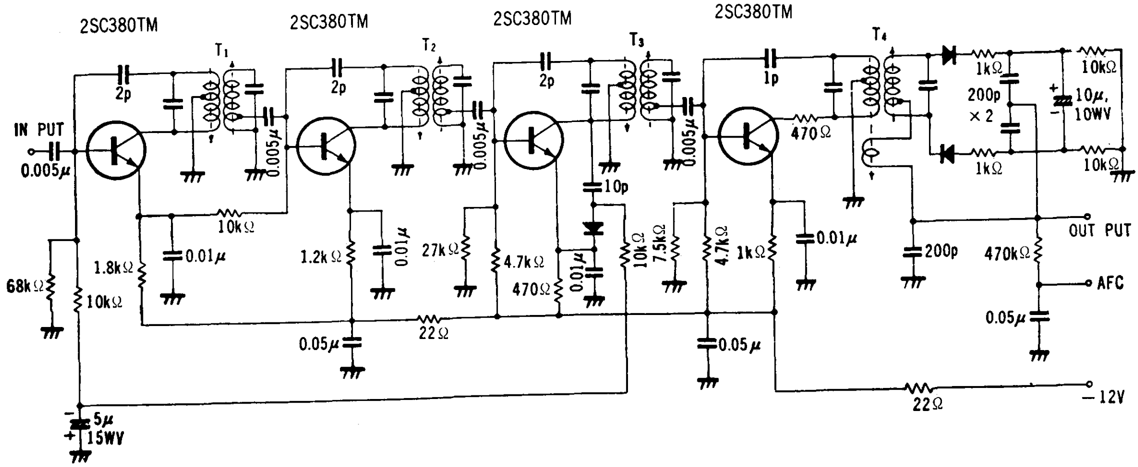
Receiving frequency : f＝535～1605kHz
Tuning voltage : V_T＝2－25V
Maximum sensitivity : 33dBμ
S/N ratio : 48dB

6. Electronic tuning AM tuner Circuit (for automotive use)

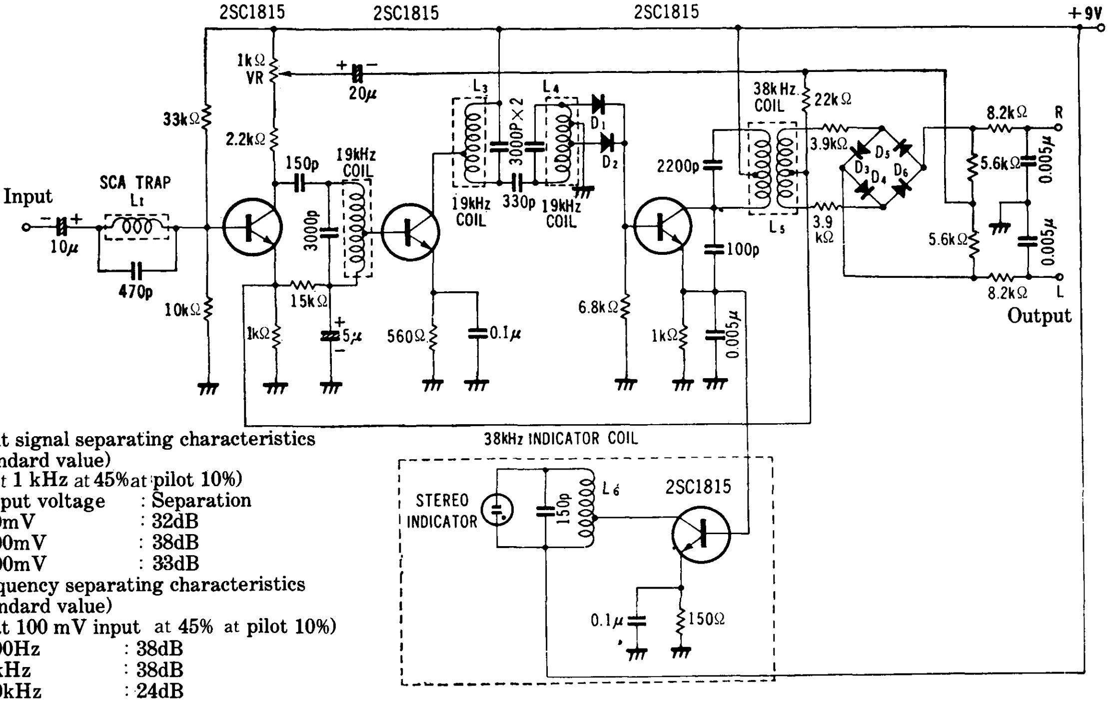


Receiving frequency : f=535~1605kH
Tuning voltage : V_T=1.5~8.0V
Maximum sensitivity : 23dBμ
S/N ratio : 40dB

7. FM IF amplifier circuit



8. FM multiplex circuit



Input signal separating characteristics
(standard value)
(at 1 kHz at 45% at pilot 10%)

Input voltage	: Separation
30mV	: 32dB
100mV	: 38dB
200mV	: 33dB

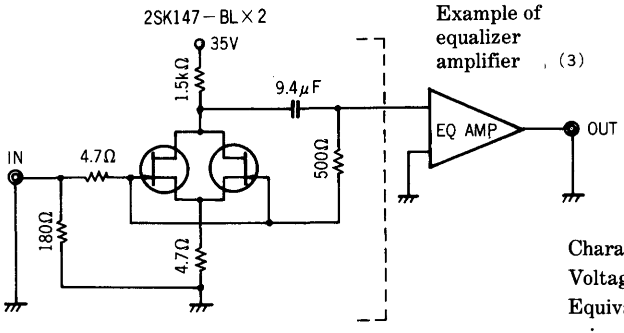
Frequency separating characteristics
(standard value)
(at 100 mV input at 45% at pilot 10%)

100Hz	: 38dB
1kHz	: 38dB
10kHz	: 24dB

Audio amplifier circuits

1. Preamplifier cırcuit

(1) MC head amplifier using 2SK147

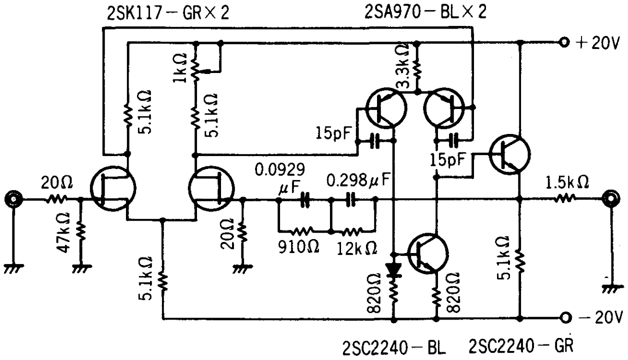


Characteristics

Voltage gain	: f=1kHz (head)	27dB
Equivalent input noise voltage	: Input open	−158.5dBV
S/N	: Vi=0.2mV	84.5dB

2. Preamplifier circuit

(2) First-stage equalizer amplifier using 2SK117

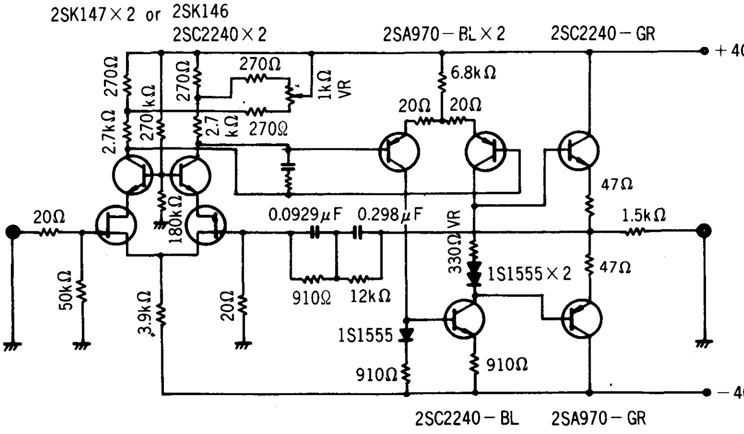


Characteristics

Input impedance	: f=1kHz	47kΩ
Voltage gain	: f=1kHz	35.0dB
Equivalent input noise voltage	: Input short-circuited, IHF A curve	−140.2dBV
S/N	Vi=2mV	86.2dB

3. Preamplifier circuit

(3) First-stage equalizer amplifier using 2SK147 or 2SK146

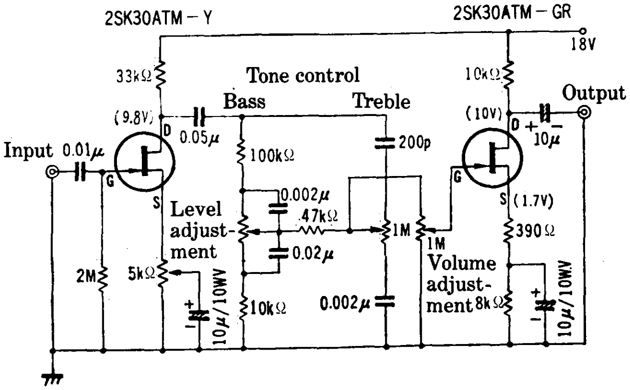


Characteristics

Input impedance	: f=1kHz	50kΩ
Voltage gain	f=1kHz	35dB
Equivalent input noise voltage input, short-circuited	IHF A curve	−143.8dBV
S/N	: Vi=2mV,	89.9dB

4. Preamplifier circuit

(4) Ceramic crystal cartridge application



Item	Level adjustment		Conditions
	Min.	Max.	
Gain	14dB	28dB	Frequency response: flat, volume max.
S/N	70dB or more	80dB or more	Frequency response: flat, volume max. 1kHz, 100mV, Input opened
TOTAL HARMONIC DISTORTION	0.5% or less	3% or less	1kHz, 1V output, volume medium

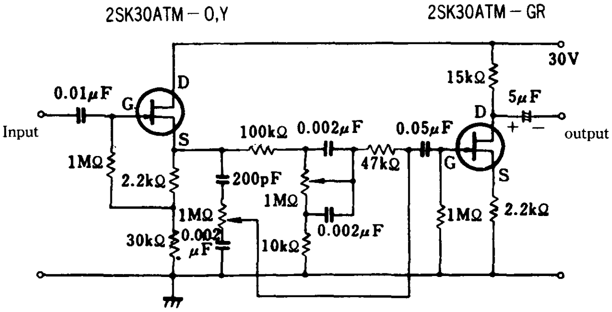
Tone control characteristics

Bass : ± 12dB @ 100Hz

Treble : ± 12dB @ 10kHz

5. Preamplifier circuit

(5) CR-type tone control circuit

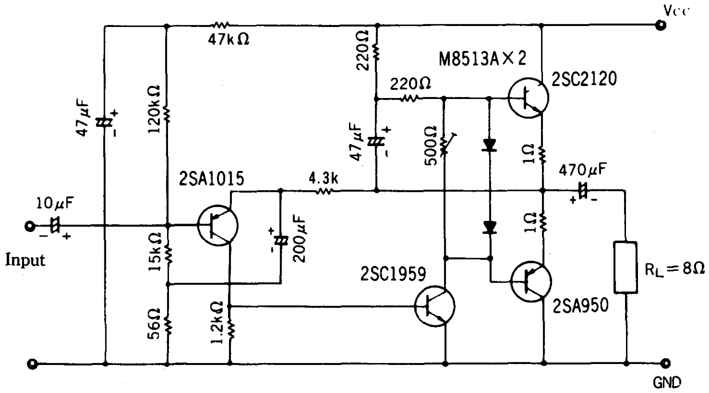


Input impedance : 10kΩ (MIN)

Gain reduction : －8.9dB (f＝1kHz)

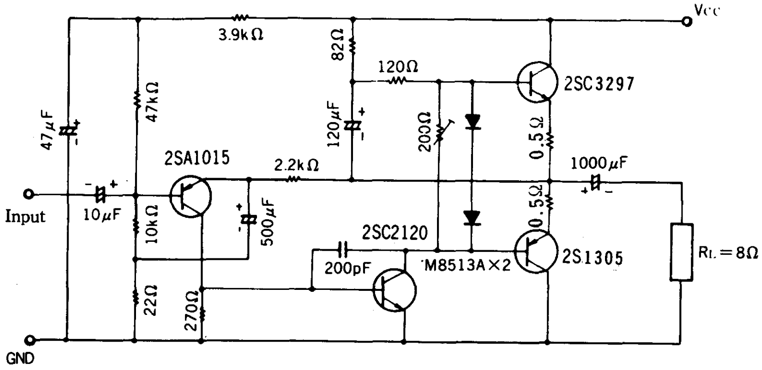
Maximum output voltage : 5V (f＝1kHz)

6. Power amplifier circuit for 1.5W output power



Supply voltage : 13V
Load impedance : 8 Ω
Input impedance : 17kΩ
Voltage gain : 38dB
Negative feedback : 28dB
Output power : 1.5W @ KF= 5 %, f =1kHz
Idle current : 10mA
Frequency response : 20Hz ~ 50kHz @ − 3 dB
T. H. D. : 0.6% @ P_0=0.1W f =1kHz
: 1.5% @ P_0= 1 W f =1kHz

7. Power amplifier circuit for 5W output power



Supply voltage : 20V
Load impedance : 8 Ω
Input impedance : 15kΩ @ f =1kHz
Voltage gain : 40dB @ f =1kHz
Negative feedback : 27.5dB @ f =1kHz
Output power : 5 W @ KF= 5 %, f =1kHz
Idle current : 7 mA
Freguency Response : 20Hz ~ 50kHz @ −3dB
T. H. D. : 0.3% @ 0.1W, f =1kHz
0.2% @ 1 W, f =1kHz
0.5% @ 4 W, f =1kHz

8. Power amplifier circuit for 35～80W output power

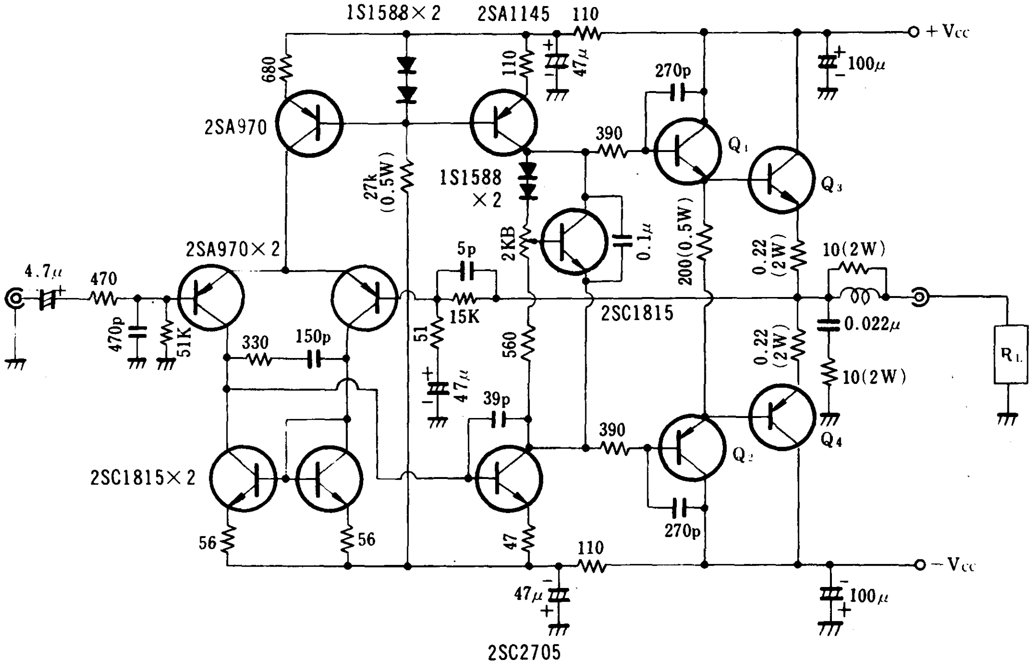


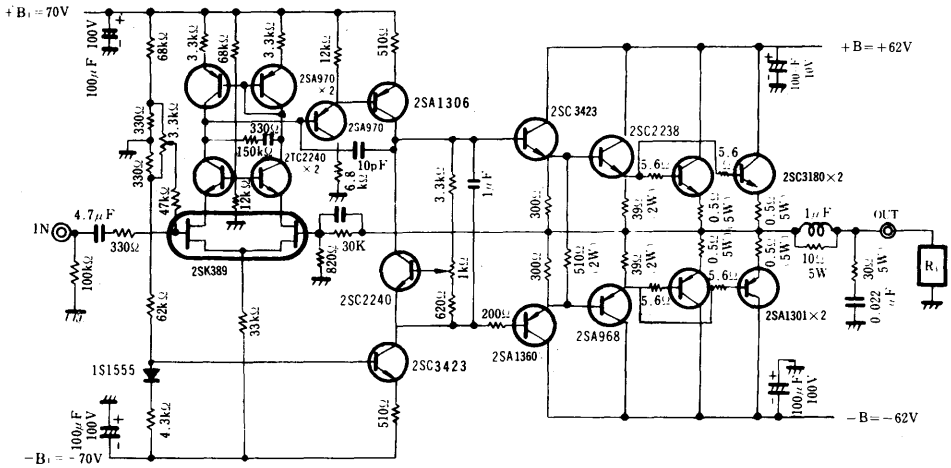
Fig. 1

Output power Po(W)	Supply voltage ±Vcc(V)	Transistors			
		Q_1	Q_2	Q_3	Q_4
35	±31	2SC1627A	2SA817	2SC3180	2SA1263
50	±36	2SC2235	2SA965	2SC3181	2SA1264
70	±41	2SC2824	2SA1184	2SC3182	2SA1265
80	±45	2SC3298	2SA1306	2SC3280	2SA1301

Load impedance : 8Ω
Input impedance : 51kΩ @f=1kHz
Voltage gain : 29.7dB @f=1kHz
Output power : Po (See Fig. 1) @f=20～20kHz THD=0.02%
Idle current : 30mA

Frequency response : 20～100kHz @−1dB
T. H. D. : 0.002% @Po=30W f=1kHz

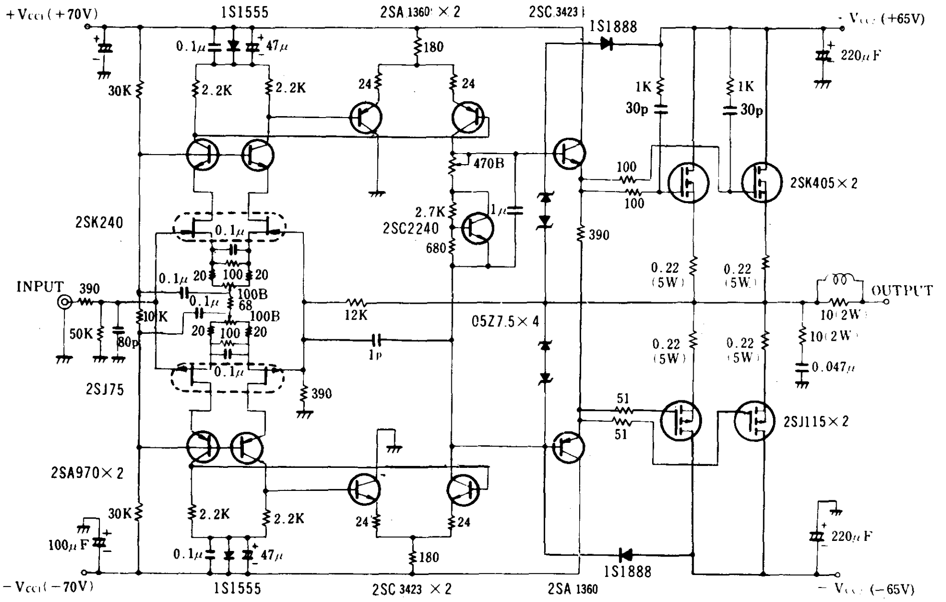
9. Power amplifier circuit for 120W output power



Supply voltage : $\pm B_1 = \pm 70V$, $\pm B_2 = \pm 62V$ (No Signal)
Load impedance : 8Ω
Input impedance : 32kΩ @f=1kHz
Voltage gain : 31dB @f=1kHz
Output power : 120W @f=20~20kHz THD=0.01%
Idle current : 50mA

Frequency Response : 20~100kHz @−1dB
T.H.D. : 0.0054% @P_O=1W f=1kHz
0.0022% @P_O=10W f=1kHz
0.0016% @P_O=30W f=1kHz
0.0015% @P_O=60W f=1kHz
0.0015% @P_O=120W f=1kHz

10. Power amplifier circuit for 120W output power (using POWER MOS FET)

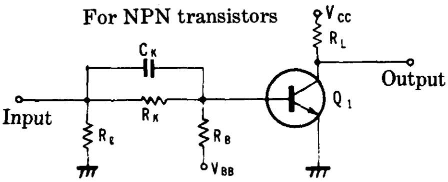


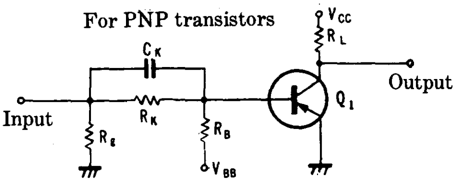
Supply voltage : $\pm V_{CC1} = \pm 70V$, $\pm V_{CC2} = \pm 65V$ (No Signal)
Load impedance : 8Ω
Input impedance : 56kΩ @f=1kHz
Voltage gain : 30dB @f=1kHz
Output power : 120W @20~100kHz THD=0.01%
Idle current : 500mA

Frequency response : 20~100kHz @−1dB
T. H. D. : 0.0015 @P_O=120W f=1kHz
0.0025 @P_O=120W f=20kHz
0.007 @P_O=120W f=100kHz

Switching circuits

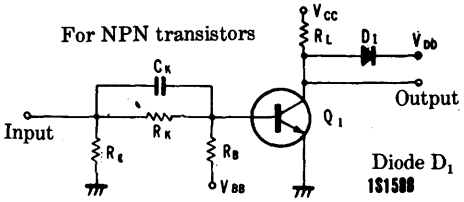
1. Inverter circuit (1)

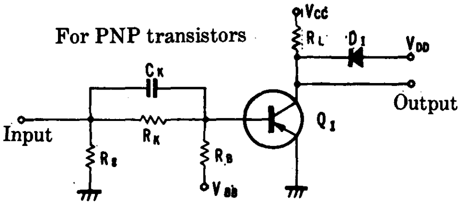




Transistor Q_1 Q:	Circuit constant								Switching time (standard value)			
	V_{CC} (V)	V_{BB} (V)	V_I (V)	R_L (Ω)	R_B (kΩ)	R_K (kΩ)	R_E (Ω)	C_K (pF)	t_d (ns)	t_r (ns)	t_{stg} (ns)	t_f (ns)
2SA495 Ⓖ TM – O	– 12	3	– 6	1 k	8.2	5.6	50	100	4	4	20	35
– Y	〃	〃	〃	〃	15	10	〃	〃	〃	〃	〃	〃
2SA499 2SA500 – R	– 12	3	– 6	1 k	3.9	2.7	50	100	4	4	20	35
– O	〃	〃	〃	〃	6.8	5.1	〃	〃	〃	〃	〃	〃
– Y	〃	〃	〃	〃	12	8.2	〃	〃	〃	〃	〃	〃
2SC395A – O	12	– 3	6	390	2.2	1.5	50	30	3	3	4	10
– Y	〃	〃	〃	〃	3.9	2.7	〃	〃	〃	〃	〃	〃
2SC400 – O	12	– 3	6	1 k	6.8	5.1	50	100	4	4	20	35
– Y	〃	〃	〃	〃	12	8.2	〃	〃	〃	〃	〃	〃
– GR	〃	〃	〃	〃	18	12	〃	〃	〃	〃	〃	〃
2SC752 Ⓖ TM – R	12	– 3	6	1 k	3.9	2.7	50	15	3	3	4	30
– O	〃	〃	〃	〃	6.8	5.1	〃	〃	〃	〃	〃	〃
– Y	〃	〃	〃	〃	12	8.2	〃	〃	〃	〃	〃	〃
2SC752 Ⓖ TM – R	12	– 3	6	390	1.5	1.0	50	20	3	3	3	10
– O	〃	〃	〃	〃	2.7	1.8	〃	〃	〃	〃	〃	〃
– Y	〃	〃	〃	〃	4.7	3.3	〃	〃	〃	〃	〃	〃
2SC503 2SC504 – O	15	3	6	100	2.2	0.39	50	470	20	10	25	30
– Y	〃	〃	〃	〃	3.9	0.68	〃	560	〃	〃	〃	〃
– GR	〃	〃	〃	〃	7.5	1.5	〃	680	〃	〃	〃	〃
2SC372 Ⓖ TM – O	12	3	6	1k	8.2	5.6	50	100	4	4	20	35
2SC372 Ⓖ TM – Y	〃	〃	〃	〃	15	10	〃	〃	〃	〃	〃	〃
2SC373 Ⓖ TM	〃	〃	〃	〃	22	15	〃	〃	〃	〃	〃	〃
2SC980 Ⓖ TM,	24	3	6	2.2k	6.8	3.9	50	100	5	10	40	70
A Ⓖ TM – O	〃	〃	〃	〃	12	6.8	〃	〃	〃	〃	〃	〃
2SC980 Ⓖ TM – Y	〃	〃	〃	〃	22	12	〃	〃	〃	〃	〃	〃

2. Inverter circuit (2)

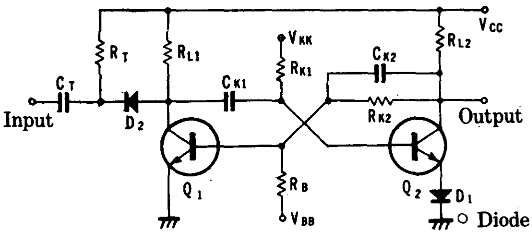




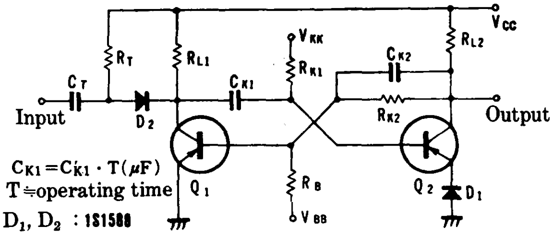
Transistor Q₁		Circuit constant									Switching time			
		V_{CC} (V)	V_{BB} (V)	V_{DD} (V)	R_L (Ω)	R_B (kΩ)	R_K (kΩ)	R_g (Ω)	C_K (pF)	V_i (V)	t_d (ns)	t_r (ns)	t_{stg} (ns)	t_f (ns)
2SA495ⒼTM	−O	−12	3	−6	1 k	8.2	5.6	50	100	−6	4	4	15	10
	−Y	〃	〃	〃	〃	15	10	〃	〃	〃	〃	〃	〃	〃
2SA499 2SA500	−R	−12	3	−6	1 k	3.9	2.7	50	100	−6	4	4	15	10
	−O	〃	〃	〃	〃	6.8	5.1	〃	〃	〃	〃	〃	〃	〃
	−Y	〃	〃	〃	〃	12	8.2	〃	〃	〃	〃	〃	〃	〃
2SC395A	−O	12	−3	6	390	2.2	1.5	50	30	6	3	3	4	4
	−Y	〃	〃	〃	〃	3.9	2.7	〃	〃	〃	〃	〃	〃	〃
2SC752ⒼTM	−R	12	−3	6	390	1.5	1.0	50	20	6	3	4	3	4
	−O	〃	〃	〃	〃	2.7	1.8	〃	〃	〃	〃	〃	〃	〃
	−Y	〃	〃	〃	〃	4.7	3.3	〃	〃	〃	〃	〃	〃	〃
2SC372ⒼTM	−O	12	−3	6	1 k	8.2	5.6	50	100	6	4	4	15	10
2SC372ⒼTM	−Y	〃	〃	〃	〃	15	10	〃	〃	〃	〃	〃	〃	〃
2SC373ⒼTM		〃	〃	〃	〃	22	15	〃	〃	〃	〃	〃	〃	〃
2SC400	−O	12	−3	6	1 k	6.8	5.1	50	100	6	4	4	15	10
	−Y	〃	〃	〃	〃	12	8.2	〃	〃	〃	〃	〃	〃	〃
	−GR	〃	〃	〃	〃	18	12	〃	〃	〃	〃	〃	〃	〃

3. Monostable multivibrator circuit

For NPN transistors



For PNP transistors



$C_{K1} = C'_{K1} \cdot T(\mu F)$

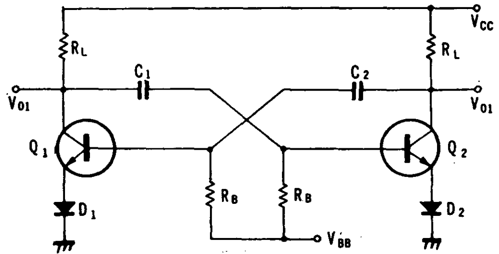
T≒operating time

○ Diode D_1, D_2 : 1S1588

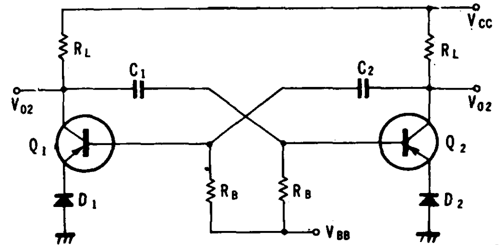
Transistor Q_1, Q_2	Circuit constant												
	V_{CC} (V)	V_{KK} (V)	V_{BB} (V)	V_1 (V)	R_{L1} (Ω)	R_{L2} (Ω)	R_{K1} (Ω)	R_{K2} (kΩ)	R_B (kΩ)	R_T (kΩ)	C'_{K1}	C_{K2} (pF)	C_T (pF)
2SA495Ⓖ TM −O	−12	−12	12	6	1 k	1 k	22	22	68	10	66	50	200
−Y	〃	〃	〃	〃	〃	〃	33	33	120	〃	44	〃	〃
2SA499 2SA500 −R	−12	−12	12	6	1 k	1 k	8.2	8.2	27	10	177	50	200
−O	〃	〃	〃	〃	〃	〃	15	15	56	〃	97	〃	〃
−Y	〃	〃	〃	〃	〃	〃	27	27	100	〃	54	〃	〃
2SC372Ⓖ TM −O	12	12	−12	−6	1 k	1 k	22	22	68	10	66	50	200
2SC372Ⓖ TM −Y	〃	〃	〃	〃	〃	〃	33	33	120	〃	44	〃	〃
2SC373Ⓖ TM	〃	〃	〃	〃	〃	〃	56	56	180	〃	26	〃	〃
2SC395A −O	12	12	−12	−6	390	390	6.8	6.8	68	3.9	214	20	50
−Y	〃	〃	〃	〃	〃	〃	12	12	120	〃	121	〃	〃
2SC400 −R	12	12	−12	−6	1 k	1 k	8.2	8.2	27	10	177	50	200
−O	〃	〃	〃	〃	〃	〃	15	15	56	〃	97	〃	〃
−Y	〃	〃	〃	〃	〃	〃	27	27	100	〃	54	〃	〃
−GR	〃	〃	〃	〃	〃	〃	42	42	156	〃	35	〃	〃
2SC752Ⓖ TM −R	12	12	−12	−6	390	390	5.1	5.1	51	3.9	284	20	50
−O	〃	〃	〃	〃	〃	〃	8.2	8.2	82	〃	179	〃	〃
−Y	〃	〃	〃	〃	〃	〃	15	15	150	〃	97	〃	〃
2SC980Ⓖ TM,	24	24	−12	−6	2.2k	2.2k	33	27	68	22	43	30	300
AⒼ TM−O	〃	〃	〃	〃	〃	〃	56	39	100	〃	26	〃	〃
2SC980Ⓖ TM−Y	〃	〃	〃	〃	〃	〃	100	75	180	〃	15	〃	〃

4. Astable multivibrator circuit

For NPN transistors



For PNP transistors



$C_1 = C'_1 \cdot T_1 \times 10^{-6}$ (F)　　T_1≒operating time of Q_1

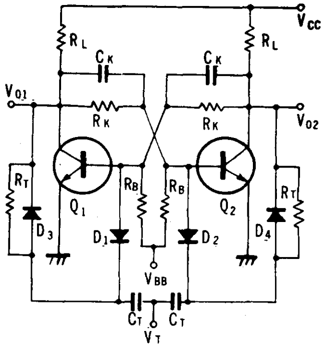
$C_2 = C'_2 \cdot T_2 \times 10^{-6}$ (F)　　T_2≒Operating time of Q_2

○ Diodes D_1, D_2 : 1S1588

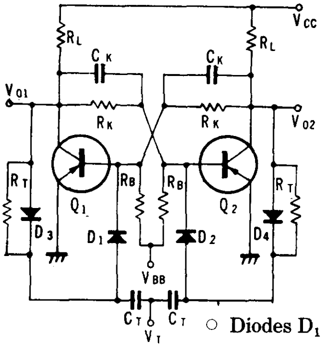
Transistors Q_1, Q_2	Circuit constant					
	V_{CC} (V)	V_{BB} (V)	R_L (Ω)	R_B (kΩ)	C'_1	C'_2
2SA495Ⓖ TM −O	−12	−12	1 k	27	54	54
−Y	〃	〃	〃	47	31	31
2SA499 2SA500 −R	−12	−12	1 k	12	121	121
−O	〃	〃	〃	22	66	66
−Y	〃	〃	〃	39	37	37
2SC395A −O	12	12	390	6.8	214	214
−Y	〃	〃	〃	12	121	121
2SC752Ⓖ TM −R	12	12	390	5.1	284	284
−O	〃	〃	〃	8.2	177	177
−Y	〃	〃	〃	15	97	97
2SC372Ⓖ TM −O	12	12	1 k	27	54	54
2SC372Ⓖ TM −Y	〃	〃	〃	47	31	1
2SC373Ⓖ TM	〃	〃	〃	68	21	21
2SC400 −O	12	12	1 k	22	66	66
−Y	〃	〃	〃	39	37	37
−GR	〃	〃	〃	56	26	26
2SC980Ⓖ TM,	24	24	2.2k	33	44	44
AⒼ TM−O	〃	〃	〃	56	26	26
2SC980Ⓖ TM−Y	〃	〃	〃	100	15	15

5. Fixed-bias type flip-flop circuit

For NPN transistors



For PNP transistors

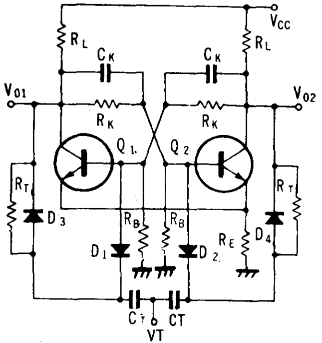


Transistors Q_1, Q_2	Circuit constant								
	V_{CC} (V)	V_{BB} (V)	V_T (V)	R_L (Ω)	R_K kΩ	R_B (kΩ)	R_T kΩ	C_K (pF)	C_T pF
2SA495Ⓖ TM −O −Y	−12 〃	12 〃	6 〃	1 k 〃	22 39	100 180	10 〃	50 〃	200 〃
2SA499 −R 2SA500 −O −Y	−12 〃 〃	12 〃 〃	6 〃 〃	1 k 〃 〃	8.2 18 33	39 82 150	10 〃 〃	50 〃 〃	200 〃 〃
2SC395A −O −Y	12 〃	−12 〃	−6 〃	390 〃	6.8 12	68 120	10 〃	15 〃	50 〃
−R 2SC752Ⓖ TM −O −Y	12 〃 〃	−12 〃 〃	−6 〃 〃	390 〃 〃	5.1 8.2 15	56 82 150	10 〃 〃	15 〃 〃	50 〃 〃
2SC372Ⓖ TM −O 2SC372Ⓖ TM −Y 2SC373Ⓖ TM	12 〃 〃	−12 〃 〃	−6 〃 〃	1 k 〃 〃	22 39 68	100 180 270	10 〃 〃	50 〃 〃	200 〃 〃
2SC400 −O −Y −GR	12 〃 〃	−12 〃 〃	−6 〃 〃	1 k 〃 〃	18 33 56	82 150 220	10 〃 〃	50 〃 〃	200 〃 〃
2SC980Ⓖ TM, AⒼ TM−O 2SC980Ⓖ TM−Y	24 〃 〃	−12 〃 〃	−6 〃 〃	2.2k 〃 〃	27 39 75	68 100 180	22 〃 〃	30 〃 〃	250 〃 〃

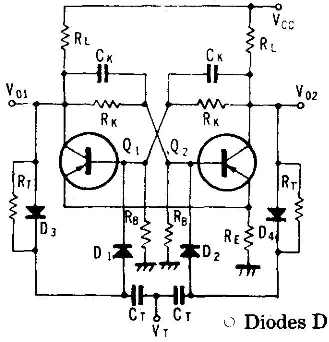
○ Diodes D_1, D_2, D_3, and D_4 : 1S1588

6. Self-bias type flip-flop circuit

For NPN transistors



For PNP transistors

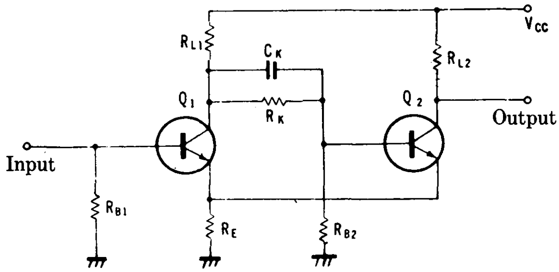


Transistors Q_1, Q_2	Circuit constant								
	V_{CC} (V)	V_T (V)	R_L (Ω)	R_K (kΩ)	R_B (kΩ)	R_E (Ω)	R_T (kΩ)	C_K pF	C_T pF
2SA495Ⓖ TM −O −Y	−12 〃	6 〃	1 k 〃	15 27	8.2 18	120 150	10 〃	50 〃	200 〃
2SA499 −R 2SA500 −O −Y	−12 〃 〃	6 〃 〃	1 k 〃 〃	6.8 12 18	2.7 5.6 10	56 120 150	10 〃 〃	50 〃 〃	200 〃 〃
2SC395A −O −Y	12 〃	−6 〃	330 〃	4.7 8.2	2.7 5.6	47 56	10 〃	20 〃	50 〃
−R 2SC752Ⓖ TM −O −Y	12 〃 〃	−6 〃 〃	330 〃 〃	3.3 6.8 10	1.8 5.6 6.8	33 51 56	10 〃 〃	20 〃 〃	50 〃 〃
2SC372Ⓖ TM −O 2SC372Ⓖ TM −Y 2SC373Ⓖ TM	12 〃 〃	−6 〃 〃	1 k 〃 〃	15 27 47	8.2 18 27	120 150 180	10 〃 〃	50 〃 〃	200 〃 〃
2SC400 −O −Y −GR	12 〃 〃	−6 〃 〃	1 k 〃 〃	12 18 33	5.6 10 18	120 150 180	10 〃 〃	50 〃 〃	200 〃 〃
2SC980Ⓖ TM, AⒼ TM−O 2SC980Ⓖ TM−Y	24 〃 〃	−6 〃 〃	2.2k 〃 〃	27 39 68	18 33 56	220 〃 〃	22 〃 〃	30 〃 〃	300 〃 〃

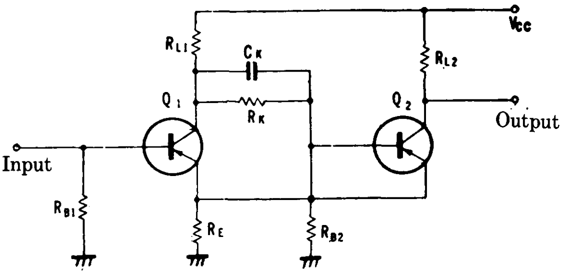
○ Diodes D_1, D_2, D_3, and D_4 : 1S1588

7. Schmidt circuit

For NPN transistors



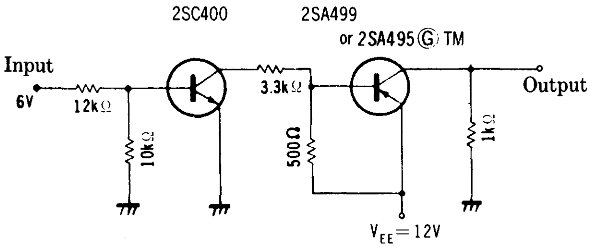
For PNP transistors



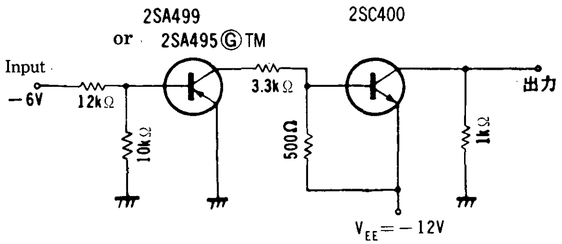
Transistors Q1, Q2		Circuit constant								Switching time (standard value)		
	Vcc (V)	V1 (V)	RL1 (Ω)	RL2 (Ω)	RK (kΩ)	RE (Ω)	RB1 (kΩ)	RB2 (kΩ)	CK (pF)	ton (ns)	toff (ns)	VH * (V)
2SA495Ⓖ TM - O	12	3	1 k	1 k	15	180	10	10	50	60	120	−1.0
- Y	〃	〃	〃	〃	27	〃	18	18	〃	〃	〃	〃
2SA499 - R	−12	−3	1 k	1 k	6.8	180	5.6	5.6	50	60	120	−1.0
2SA500 - O	〃	〃	〃	〃	15	〃	12	12	〃	〃	〃	〃
- Y	〃	〃	〃	〃	22	〃	15	15	〃	〃	〃	〃
2SC372Ⓖ TM - O	12	3	1 k	1kk	15	180	10	10	50	60	120	1.0
2SC372Ⓖ TM Y	〃	〃	〃	〃	27	〃	18	18	〃	〃	〃	〃
2SC373Ⓖ TM	〃	〃	〃	〃	47	〃	33	33	〃	〃	〃	〃
2SC395A - O	12	3	330	330	4.7	68	3.9	3.9	20	20	20	−0.5
- Y	〃	〃	〃	〃	6.8	〃	5.6	5.6	〃	〃	〃	〃
2SC400 - O	12	3	1k	1 k	15	180	12	12	50	60	120	−1.0
- Y	〃	〃	〃	〃	22	〃	15	15	〃	〃	〃	〃
- GR	〃	〃	〃	〃	39	〃	22	22	〃	〃	〃	〃
R	12	3	330	330	3.3	68	3.3	3.3	20	20	25	−0.5
2SC752Ⓖ TM - O	〃	〃	〃	〃	5.1	〃	3.9	3.9	〃	〃	〃	〃
- Y	〃	〃	〃	〃	8.2	〃	5.6	5.6	〃	〃	〃	〃

* Hysterisis voltage .

8. Positive pulse amplifier circuit



9. Negative pulse amplifier circuit

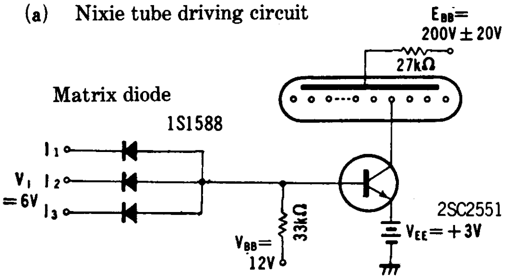


Input/Output switching time. (standard value) unit:ns

	td	tr	tstg	tf
Positive pulse	110	50	600	45
Negative pulse	125	70	600	45

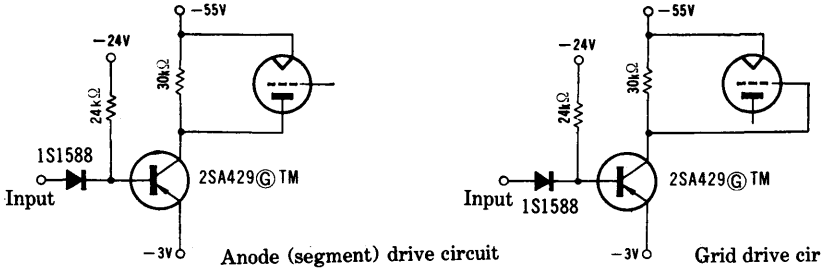
10. Indication tube driving circuit

(a) Nixie tube driving circuit



Operating temperature range			−10°C ~ +55°C
Minimum input voltage for lighting on			4 V
Maximum input voltage for lighting off			2.5 V
Indicator characteristics	Discharge sustaining voltage		~140 V
	Allowable average cathode DC current	Figure pole	1.5~3.0mA
		Decimal point pole	0.6~1.5mA

(b) Indication tube driving circuit (Digitron or others)

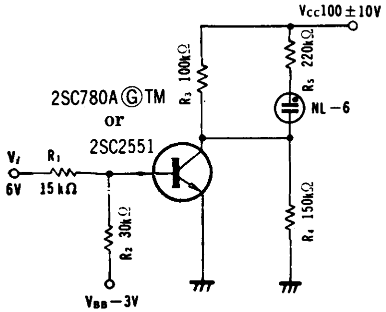


Anode (segment) drive circuit

Grid drive circuit

Operating temperature range			−10°C ~ 60°C
Minimum input voltage for lighting on			− 4 V
Maximum input voltage for lighting off			− 2.5 V
Indicator characteristics	Max./min. fluorescent segment voltage		± 20 ~ ± 30 V dc
	Average current for fluorescent segment	Pole	1 ~ 3 mA
		Figure	0.1 ~ 0.2mA

(c) Neon tube driving circuit



Transistors used : 2SC780AⒼTM

Supply voltage : $V_{cc}=100\pm10$ V

Input drive voltage : $V_i=6$ V

Base bias current : $V_{BB}=-3$ V

Neon lamp lighting characteristics

Rated voltage : $V_P=100$ V

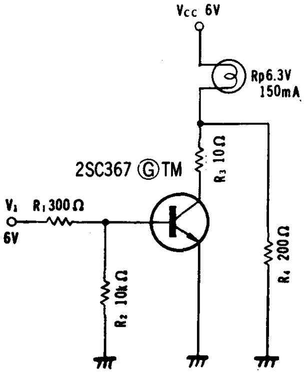
Rated current : $I_P=0.3$ A

Discharge starting voltage : $V_K=85$ V

Discharge stopping voltage : $V_F=55$ V

External series resistance : $R_5=220$ kΩ

(d) Pilot lamp driving circuit



Transistors used : 2SC367ⒼTM

Supply voltage : $V_{cc}=6$ V

Input drive voltage : $V_i=6$ V

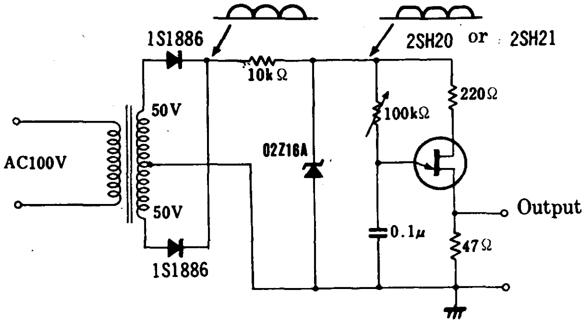
Lamp characteristics

Rated voltage : $V_P=6.3$ V

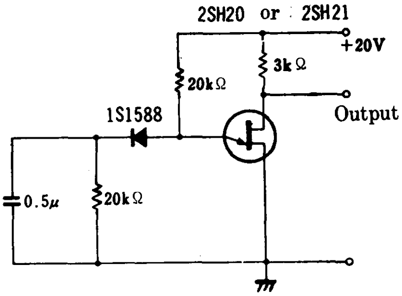
Rated current : $I_P=150$ mA

11. UJT application circuits

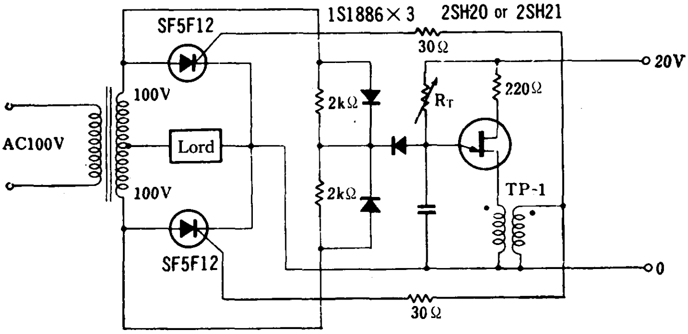
(1) Synchronous circuit with AC power source



(2) Square-wave oscillating circuit

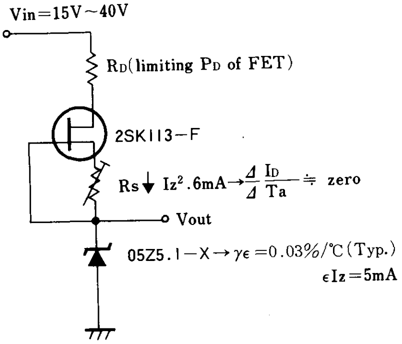


(3) SCR igniting phase controlling circuit

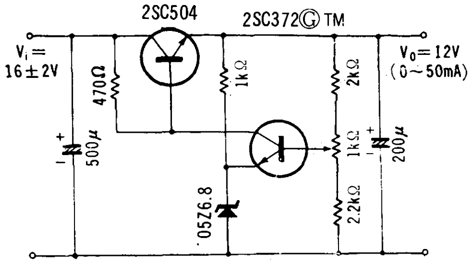


Dropper Regulator Circuit

1. High-stability reference regulator circuit

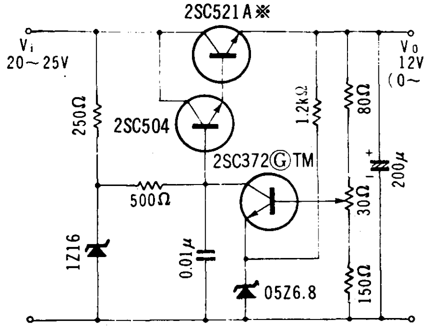


2. Constant-voltage regulator circuit (1) 12V, 50 mA



Ambient temperature~70°C

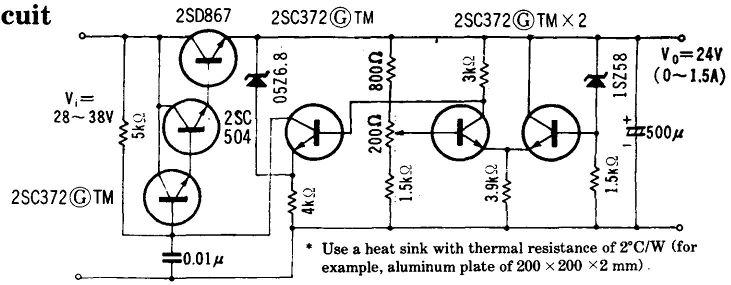
3. Constant-voltage regulator circuit (2) 12V, 1A



Ambient temperatureTa=−20~70°C

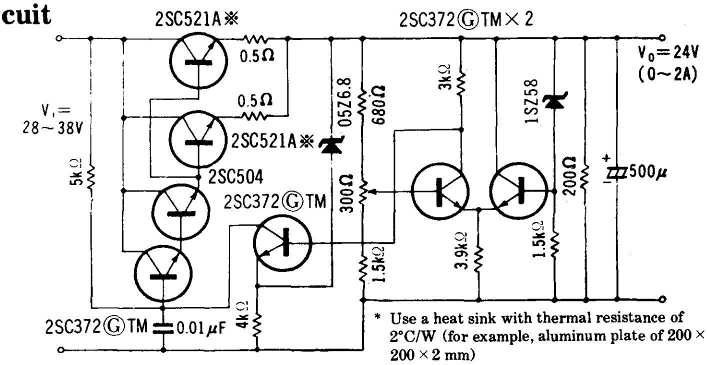
* Use a heat sink with thermal resistance of 2°C/W (for example, aluminum plate of 200 ×200 ×2 mm)

4. Constant-voltage regulator circuit (3) 24V, 1.5A



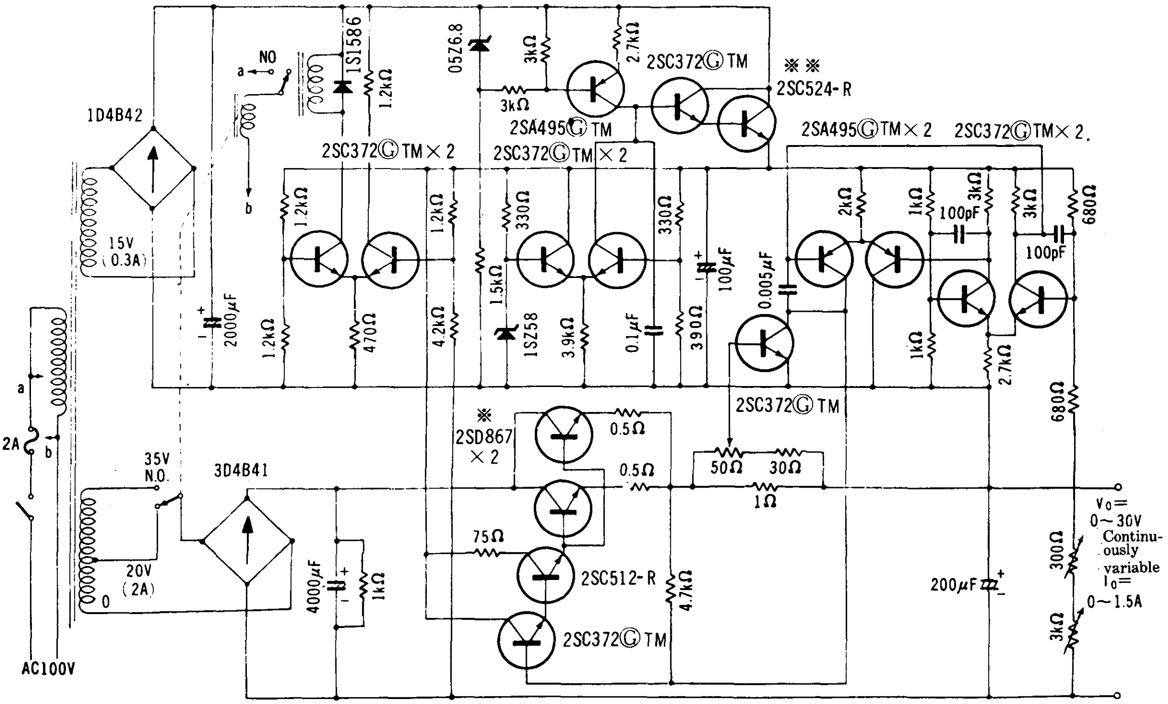
* Use a heat sink with thermal resistance of 2°C/W (for example, aluminum plate of 200 × 200 ×2 mm).

5. Constant-voltage regulator circuit
(4) 24V, 2A



- * Use a heat sink with thermal resistance of 2°C/W (for example, aluminum plate of 200 × 200 × 2 mm)
  Ambient temperature Ta = −20 ~ 70°C

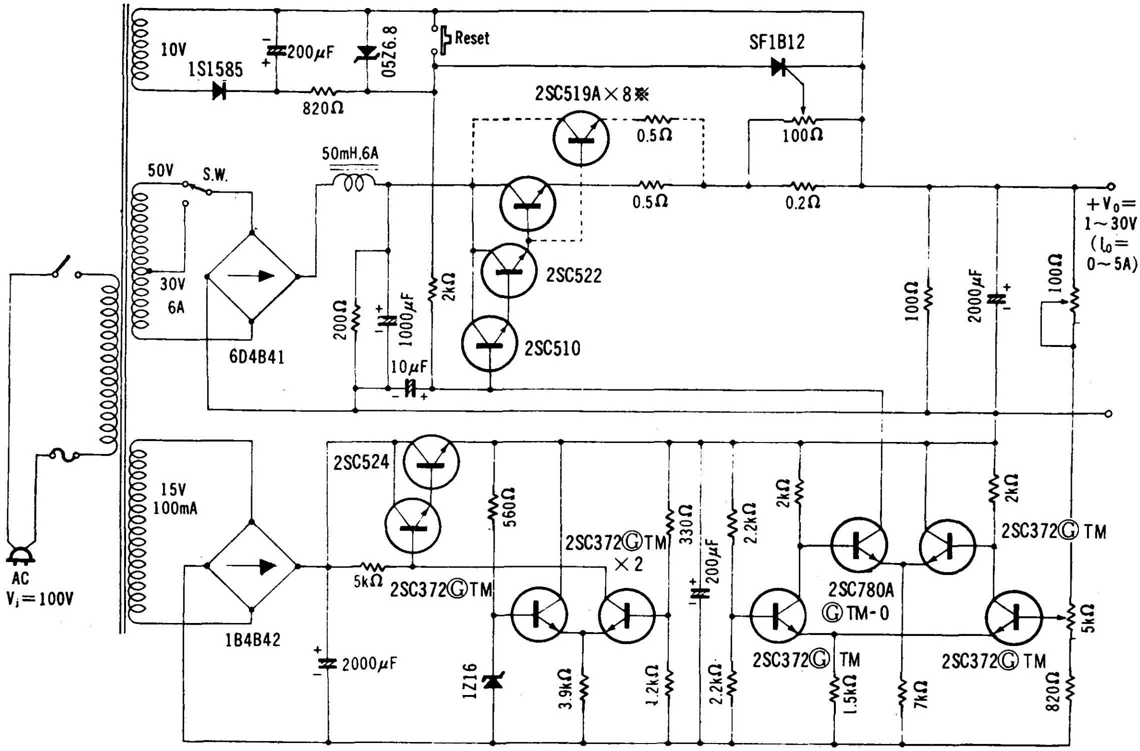
6. Constant-voltage regulator circuit (5) 0 ~ 30V, 1.5A



- * Use a heat sink with thermal resistance of 2°C/W (for example, aluminum plate of 200 × 200 × 2 mm)
- ** Use a heat sink with thermal resistance of 6°C/W (for example, aluminum plate of 100 × 100 × 2 mm)
  Internal resistance r_0 > 5mΩ

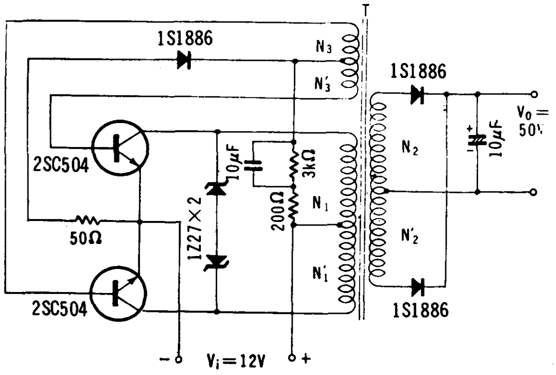
Ripple voltage : V_{0r} < 1.5mV (p-p)
Output voltage fluctuation (±10%) caused by supply voltage fluctuation △ V_0 < 2.5mV
Ambient temperature Ta = −20 ~ 70°C

7. Constant-voltage regulator circuit



* 200 mm × 200 mm × 2 mm (Aluminum heat sink) (thermal resistance 2°C/W)
Note: For output voltage of 0 ~ 17V, use 30V tap for S.W. and for 17 ~ 30V use 50V tap.

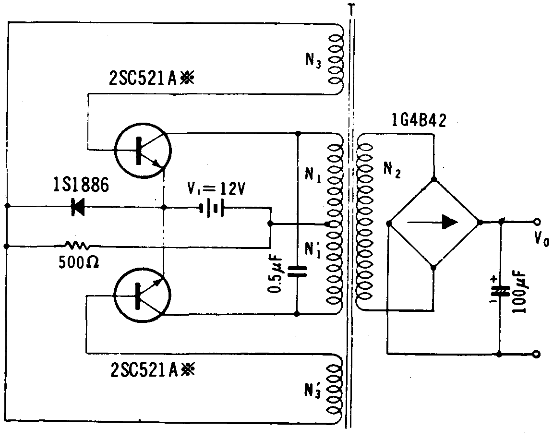
8. Multivibrator-type DC-DC converter circuit (1), 50V, 3W ($V_i = 12V$)



T : TDK ferrite core $H_{5A}P_{30/19}$

N_1, N_1' : 10T φ 0.32mm Oscillating frequency: f = 1kHz
N_2, N_2' : 43T φ 0.28mm Efficiency: η = 70%
N_3, N_3' : 2T φ 0.25mm Ambient temperature: Ta = −20 ~ 70°C

9. Multivibrator-type DC-DC converter circuit (2), 300V, 40W ($V_i = 12V$)

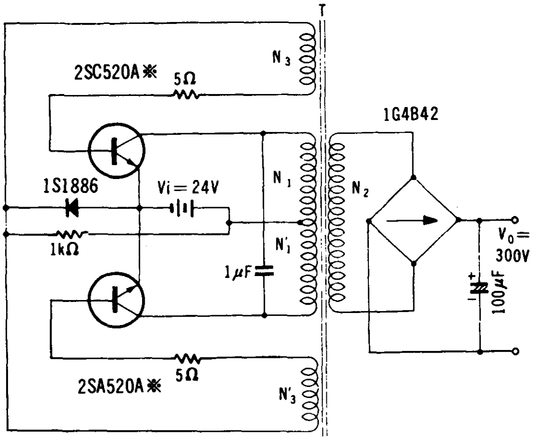


T : Toshiba RNE (Rectalloy) Core R-60

N_1, N_1' : 20T φ 1.0mm
N_2 : 550T φ φ 32mm
N_3, N_3' : 6T φ 0.32mm
※ : 100mm × 100mm × 2 mm (Aluminum heat sink)

TDK ferrite core: $H_{5A}P_{30/19}$
Oscillating frequency: f = 10kHz
Efficiency: η = 80%
Ambient temperature: Ta = −20 ~ 70°C
T: Toshiba RNE (Rectalloy) Core R-60

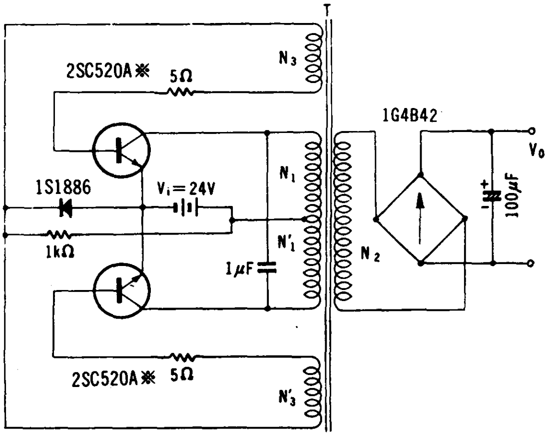
10. Multivibrator-type DC-DC converter circuit (3), 300V, 40W ($V_i = 24V$)



T : Toshiba RNE (Rectalloy) core R-45
N₁, N'₁ : 52T ϕ 0.8mm
N₂ : 715T ϕ 0.32mm
N₃, N'₃ : 5T ϕ 0.32mm
※ : 100mm × 100mm × 2 mm (Alminum heat sink)

Oscillating frequency: f = 1kHz
Efficiency: η = 80%
Ambient temperature: Ta = −20 ~ 70°C

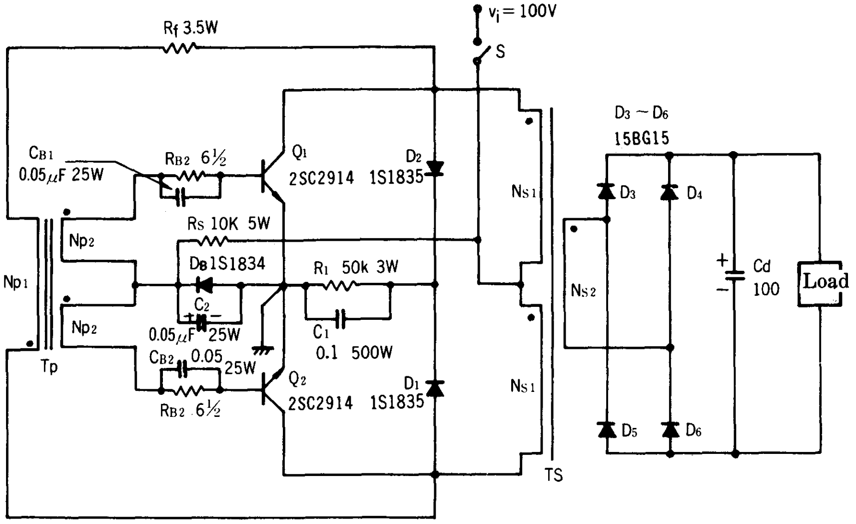
11. Multivibrator-type DC-DC converter circuit (4), 300V, 80W ($V_i = 24V$)



T : Toshiba RNE (Rectalloy) core R-60
N₁, N'₁ : 39T ϕ 1.0mm
N₂ : 550T ϕ 0.5mm
N₃, N'₃ : 5T ϕ 0.32mm
※ : 100mm × 100mm × 2 mm (Alminum heat sink)

Oscillating frequency: f = 1kHz
Efficiency: η = 80%
Ambient temperature: Ta = −20 ~ 70°C

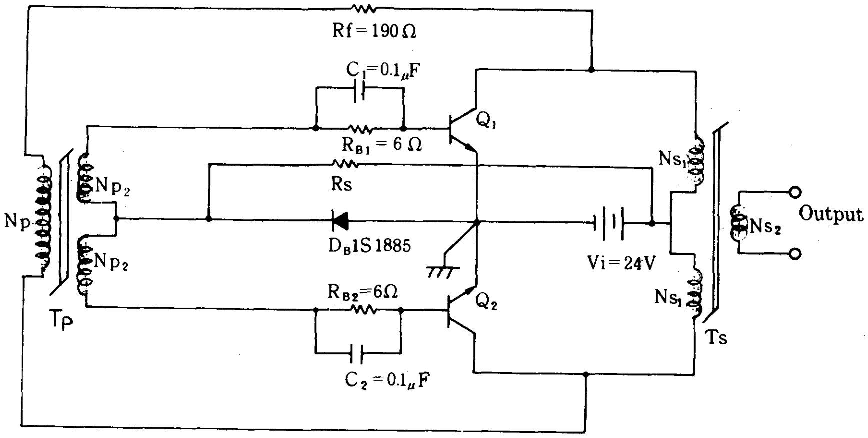
12.- Multivibrator-type DC-DC converter circuit (5), 5V, 150W (V_i=100V)



2SC2914: (with heat sink, $\theta_f \leq 2.8$°C/W)
Tp; TDK H6AT10-20-5 Ferrite core
Ts; TDK EI60 H3C
Np_1; 75Tϕ 0.2mm
Np_2; 8Tϕ 0.5mm

Ns_1; 21Tϕ 1.2mm
Ns_2; 4Tϕ 2.5mm
Oscillating frequency; f=20kHz
Efficiency: η = 80%
Ambient temperature: Ta = −20~60°C

13. Multivibrator-type DC-AC inverter circuit(6) 100V, 80W, (V_i=24V)

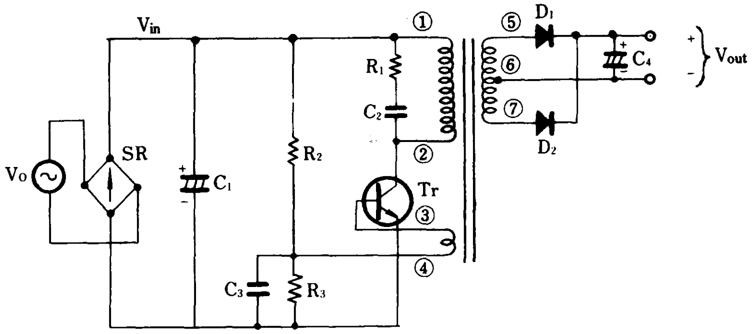


Q_1, Q_2: 2SC2913
or 2SC2555

Tp; TDK H7A EE12
Np_1; 29Tϕ 0.35mm
Np_2; 12Tϕ 0.52mm
Ns_1; 6Tϕ 1.8mm
Ns_2; 25Tϕ 0.17mm

Oscillating frequency; f=25kHz
Efficiency: η = 80%
Ambient temperature: Ta = −20°C~60°C

14. Example: Circuit incorporating a ringing choke-converter circuit



Specifications:

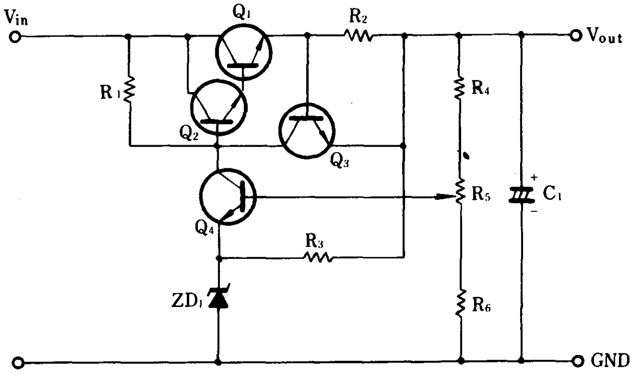
Supply voltage: Vo=AC100V
Output voltage: Vout=2.0V
Output current: Iout=1.0A
Oscillating frequency: f=22kHz

Oscillating cycle: T=45μsec
On-time: t_{on}=10μsec
Off-time: t_{off}=35μsec

Tr: 2SC2552
SR: 1D4B41
Δ_1: 1S1834
D_2: 1S1834
R_1: 220Ω 1W
T_1: EE-12.8, TDK H_3S
R_2: 68Ω¼W
R_3 : 1.5kΩ¼W
Note 1: C_4 is not required if used for battery charger circuit Application

C_1: 4.7μF 250V
C_2: 0.001μf
C_3: 0.022μF
C_4: 220μF 35V

15. 20V, 2A Output dropper regulator, (Dropper regulator circuit application)



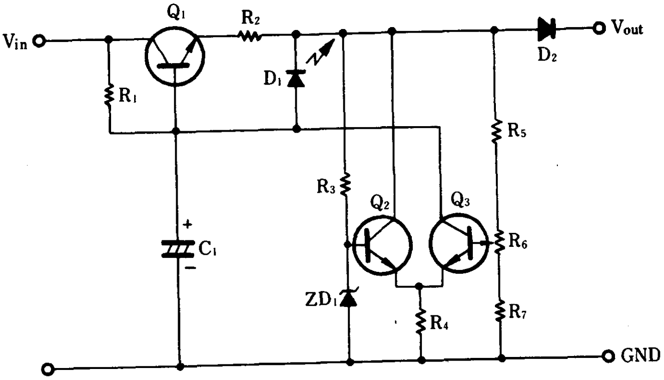
Specifications

Output voltage : 20V
Output current : 2A
Input voltage fluctuation : 25~30V
(Operating temperature) : (−20~60°C)

Q_1 : 2N3055
Q_2 : 2SD234Ⓖ
Q_3, Q_4 : 2SC372ⒼTM
ZD_1 : 05Z6.2
R_5 : 330Ω, VR
R_6 : 560Ω, ¼W
C_1 : 470μF, 25V

R_1 : 1.2kΩ, ¼W
R_2 : 0.3Ω, 2W
R_3 : 2.8kΩ, ¼W
R_4 : 1.2kΩ, ¼W

16. 12V, 1A Output dropper regulator



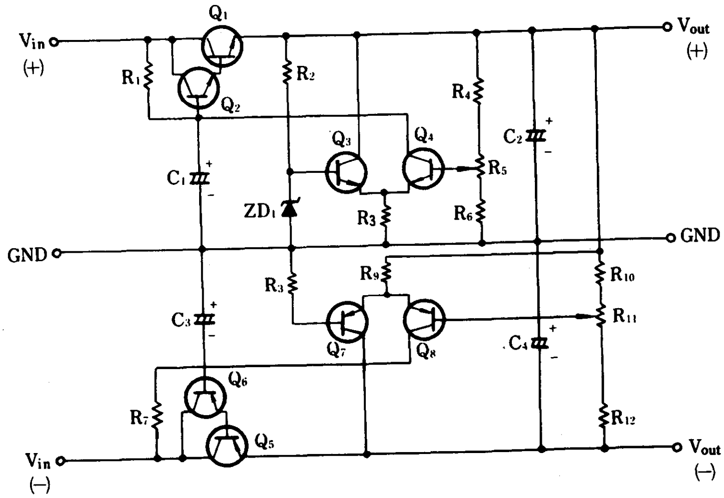
Specifications:
Output voltage: 12V
Output current: 1A
Input voltage fluctuation: 15~18V

Q_1 : 2SD234Ⓖ (or 2SD880)
Q_2, Q_3 : 2SC372ⒼTM
ZD_1 : 05Z5.1
D_1 : TLR103
D_2 : 1S1885
C_1 : 10μF, 25V

R_1 : 470Ω, ¼W
R_2 : 20Ω, 2W
R_3 : 1.5kΩ, ¼W
R_4 : 330Ω, ¼W
R_5 : 680Ω, ¼W
R_6 : 100Ω, VR
R_7 : 470Ω, ¼W

17. ±15V, 2A Output dropper regulator

Shown below is applied circuit incorporating transistors 2N3771 and 2N4398.



Specifications
Output voltage : ±15V
Output current : 2A
Input voltage fluctuation
: 18~24V

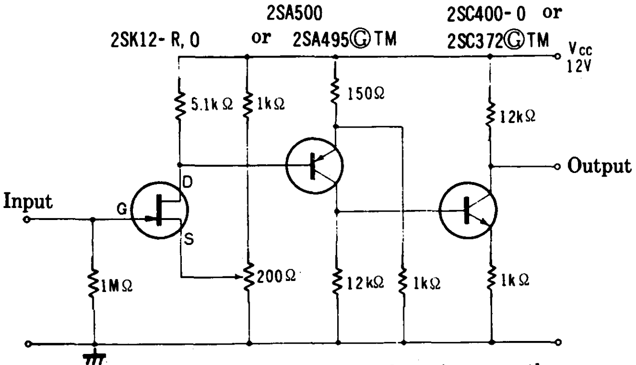
Q_1 : 2N3771
Q_2 : 2SC2562
Q_3 : 2SC2240
Q_4 : 2SC2240
Q_5 : 2N4398
Q_6 : 2SA1012
Q_7, Q_8: 2SA970

ZD_1 : 05Z5.6
R_1 : 330Ω, ¼W
R_2 : 2kΩ, ¼W
R_3 : 220Ω, ¼W
R_4 : 680Ω, ¼W
R_5 : 500Ω, VR
R_6 : 560Ω, ¼W

R_7 : 330Ω, ¼W
R_8 : 1kΩ, ¼W
R_9 : 560Ω, ½W
R_{10}, R_{12} : 1kΩ, ¼W
R_{11} : 1kΩ, VR
C_1, C_3 : 10μF, 25V
C_2, C_4 : 470μF, 25V

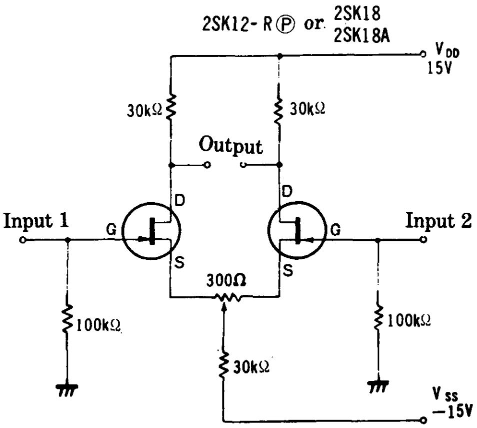
Circuits incorporating FET's

1. Amplifier circuit with direct-coupled FET, voltage gain 62 dB, min. sensing signal ~ 1mV

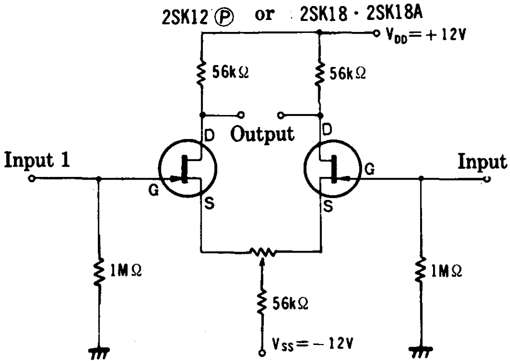


Select as the bias drain current of 2SK12 a value more than that at which the temperature coefficient of drain current may be zero, the drain current thus possessing a negative temperature coefficient. Then compensate the temperature to offset this temperature coefficient with that of VBE of the subsequent stage to reduce the temperature drift of output.

2. FET differential amplifier circuit (1), voltage gain 26 dB



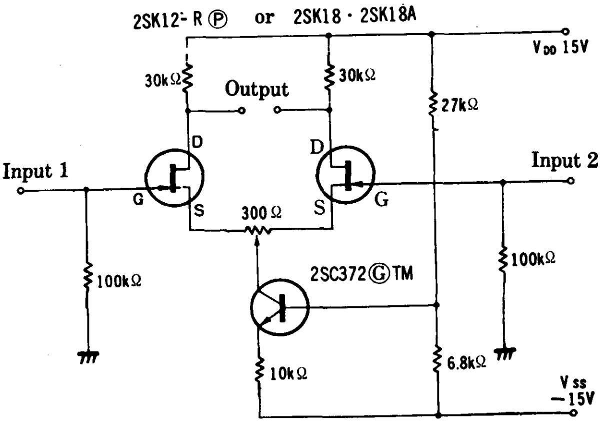
3. FET differential amplifier circuit (2), voltage gain 16 dB



Equivalent input temperature drift voltage
($V_D/\Delta T$): 40 μV/°C
Voltage drift
(V_D/V_{DD}): 0.04%

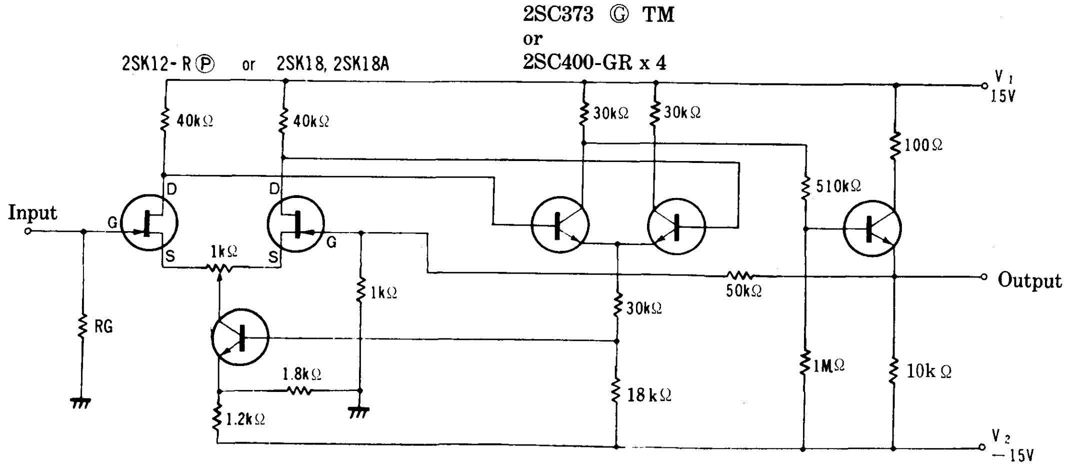
Voltage drift
(V_D/V_{SS}) 0.9%
V_D : Equivalent input temperature drift voltage (V)

4. FET differential amplifier circuit (3), voltage gain 26 dB

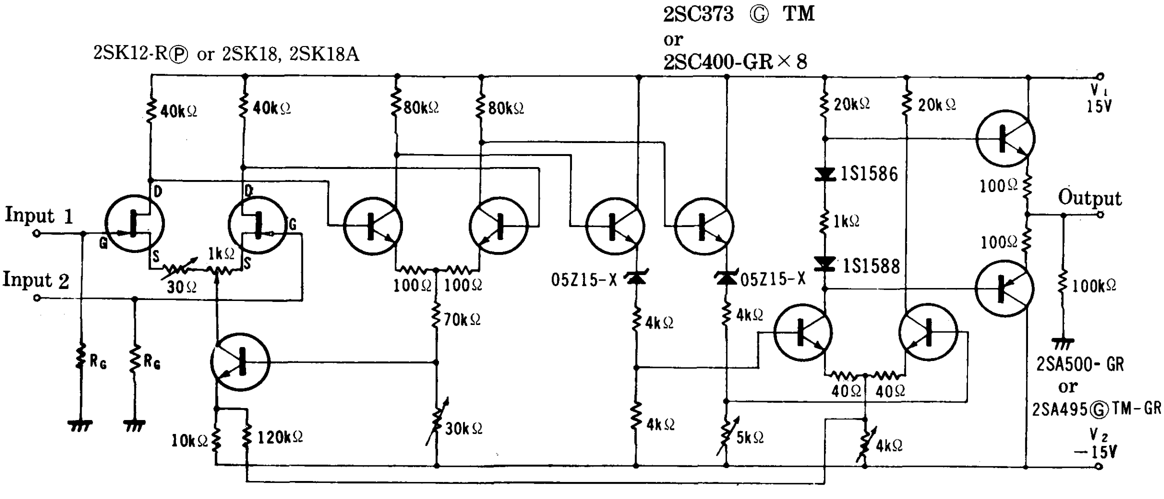


Common mode rejection ratio CMR ≒ 76dB ($\Delta I_{DSS}/I_{DSS} = 10\%$)

5.- FET 2-stage differential-amplifier circuit, voltage gain 34 dB (open loop gain: 53 dB)



6. FET 3-stage differential amplifier circuit (open loop gain 98 dB)



7. Digital switch

Specifications

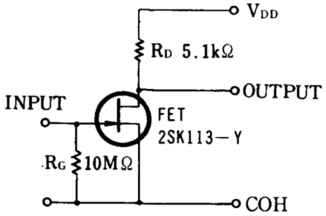
Supply voltage : $V_{DD}=20V$

Input drive voltage : $V_{GS(ON)}=0V$

$V_{GS(OFF)}=-15V$

Input impedance : 10MΩ

Example



FET used 2SK113−Y

Operating temperature Ta=−20°C ~ +100°C

8. Analog switch

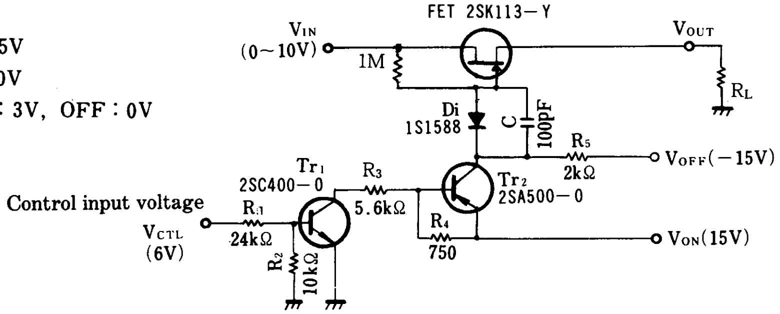
Specifications

Supply voltage : $V_{ON}=15V$

$V_{OFF}=-15V$

Input voltage : $V_{IN}=0\sim10V$

Control voltage : V_{CTL}=ON : 3V, OFF : 0V



9. Sample hold circuit

Example of Circuit

Specifications

Supply voltage : $V_{CC}=7V$, $V_{EE}=-9V$

Input voltage : $V_{IN}=0\sim5V$

Control voltage : $V_{CTL}=2V$

Reset voltage : $V_{RST}=2V$

Sampling time : 10ms

Retention time : 10s

Operating temperature : −20°C ~ 50°C

※ $R_7=R_8=2\sim3k\Omega$

R_7 : OP Amp For input protection

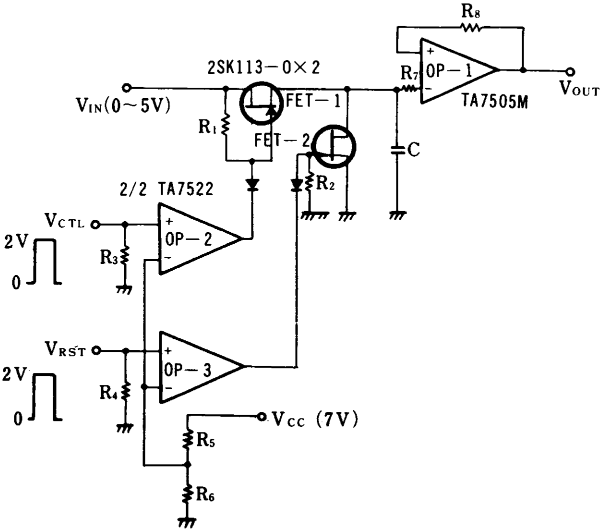
R_8 : For offsetting output and reducing drift

Transistors used : FET : 2SK113−Y

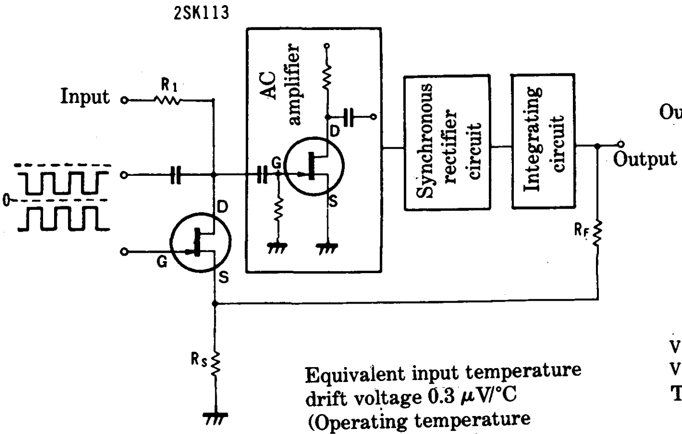
Tr_1 : 2SC400−O

Tr_2 : 2SA500−O

Circuit diagram

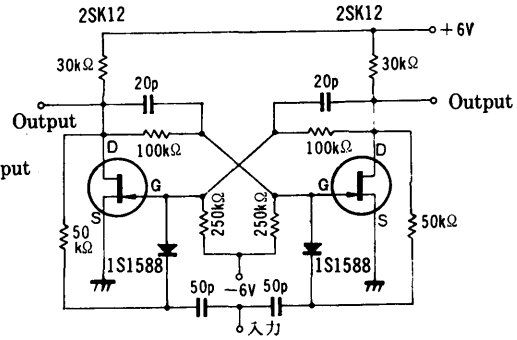


10. FET chopper amplifier circuit



Equivalent input temperature drift voltage 0.3 μV/°C (Operating temperature range 0°C ~ 60°C)

11. FET flip-flop circuit

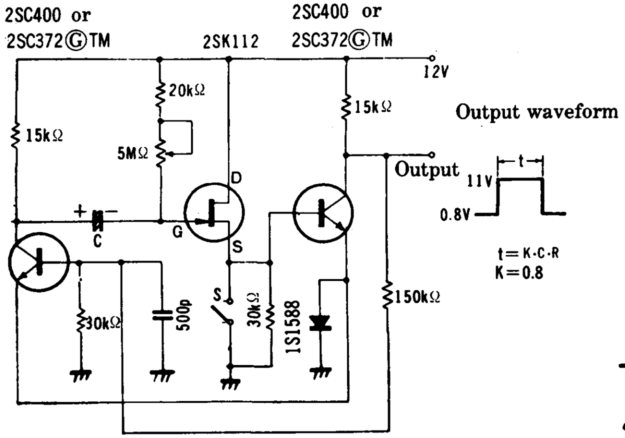


V_T (max) = 20V

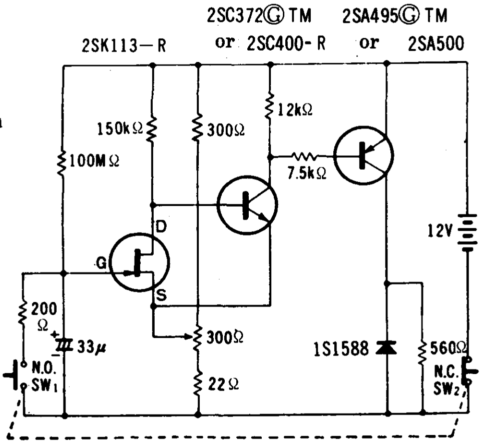
V_T (min) = 4.5V V_T: Trigger voltage

Trigger frequency f = 0.5 ~ 100kHz)

12. FET timer circuit (1)

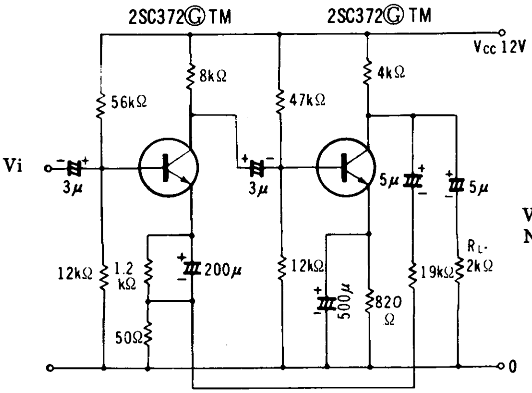


13. FET timer circuit (2) (operating time: 10 min.)



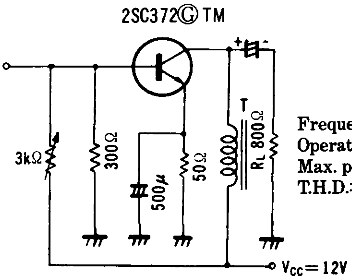
Low-frequency amplifier circuit

1. RC coupled amplifier circuit



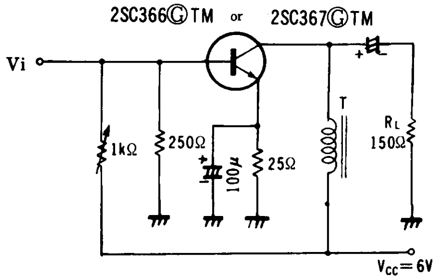
Voltage gain : 48dB (f = 8Hz ~ 2MHz Rg = 1kΩ)
Negative feedback : 15dB

2. Class A single amplifier circuit (1), Po = 55mW



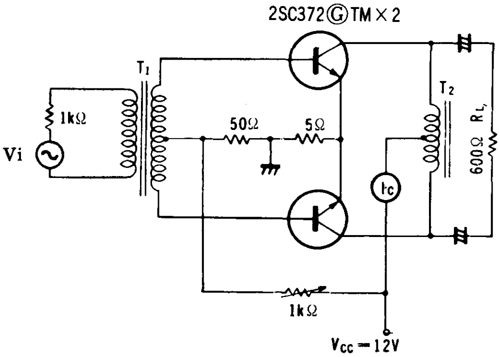
Frequency: f = 1kHz
Operating current: 15mA
Max. power gain: 44dB
T.H.D.: 4.9% (at maximum output)

3. Class A single amplifier circuit (2), Po = 75mW



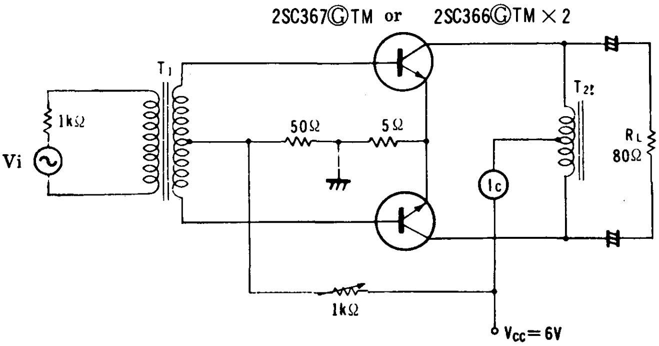
Frequency: f = 1kH
Operating current: 22mA
Max. power gain: 31dB
T.H.D. 5.1% : (at maximum output power)

4. Class B push-pull amplifier circuit (1), Po = 200mW



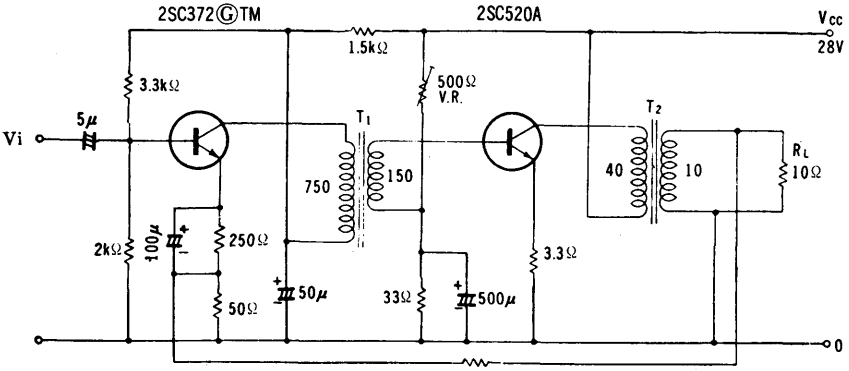
Frequency :f = 1kHz
Operating current:20mA
(average value of the two)
Max. power gain:30.1dB
T.H.D. 2.8% (at maximum output power)

5. Class B push-pull amplifier circuit (2), Po = 400mW



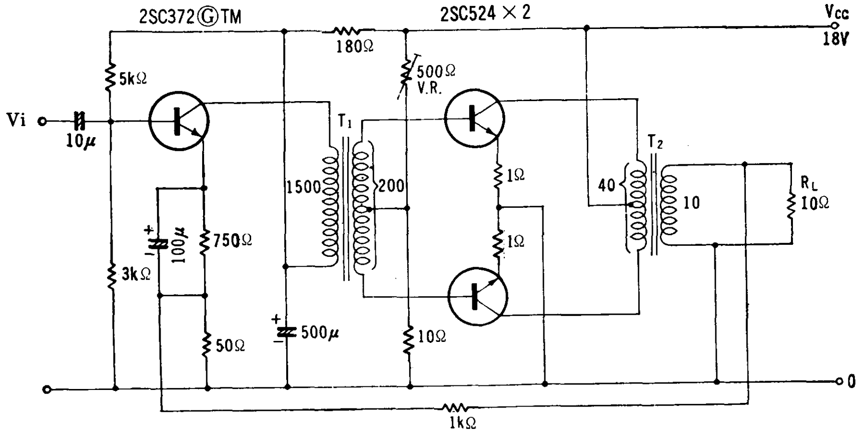
Frequency : f = 1kHz
Operating current:140mA
(average value of the two)
Max. power gain 21dB
T.H.D.:4.7% at maximum output power

6. Transformer-coupled Class A power amplifier circuit, Po = 5W (Vi = 0.4V)



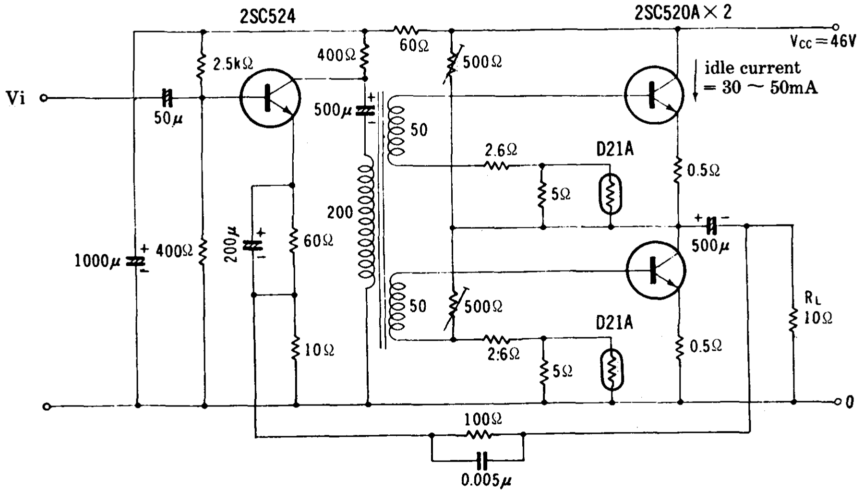
Ambient temperature Ta = −20 ~ 60°C

7. Transformer-coupled Class B power amplifier circuit, Po = 7W (Vi = 0.6V)



Ambient temperature:Ta = −20 ~ 60°C

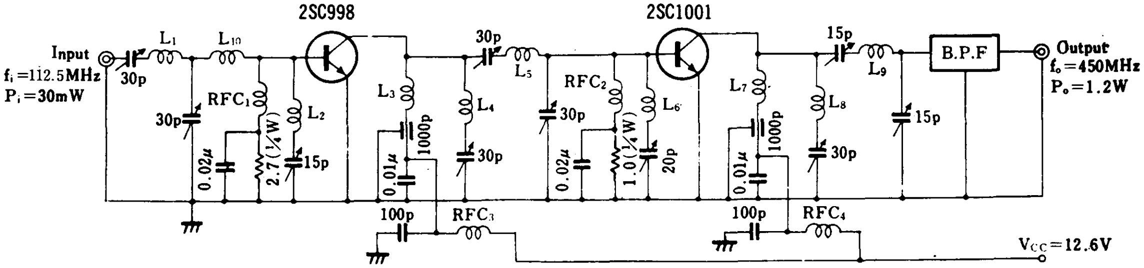
8. SEPP power amplifier circuit with input transformer, Po = 200W (Vi = 1.5V)



Ambient temperature:Ta = −20 ~ 60°C

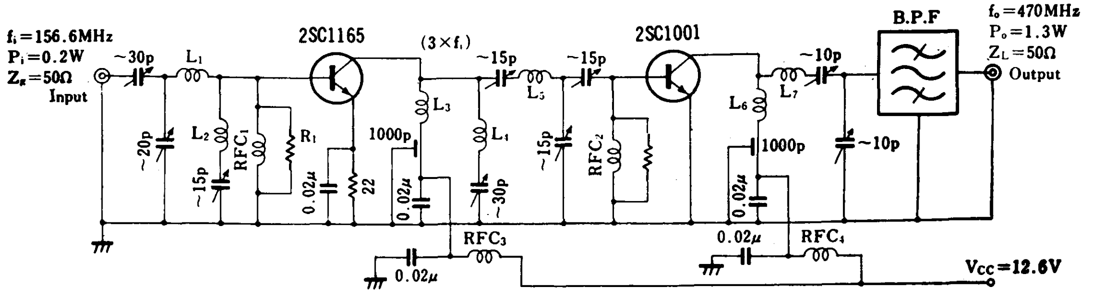
High-frequency power amplifier circuit

1. Double-multiplier power amplifier circuit (112.5 MHz~450 MHz)



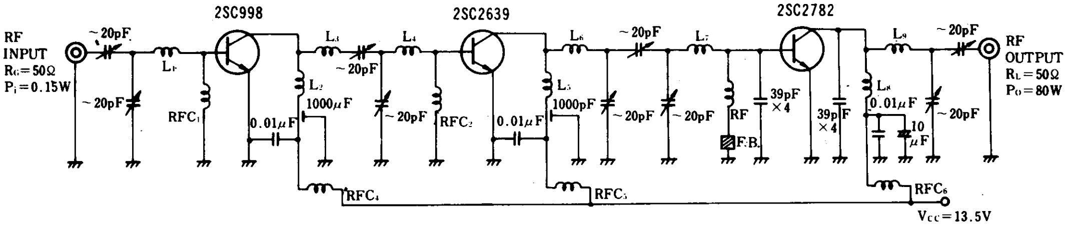
L_1: ϕ 0.8mm Silver-plated copper wire, 2T, 7ID, 3P
L_2: ϕ 0.8mm Silver-plated copper wire, 2T, 7ID, 2P
L_3: ϕ 0.8mm Silver-plated copper wire, 2T, 7ID, 2P
L_4: ϕ 0.8mm Silver-plated copper wire, 2T, 7ID, 2P
L_5: ϕ 0.8mm Silver-plated copper wire, 2T, 7ID, 2P
L_6: ϕ 0.8mm Silver-plated copper wire, 1T, 7ID
L_7: ϕ 0.8mm Silver-plated copper wire, 1T, 7ID
L_8: ϕ 0.8mm Silver-plated copper wire, 3T, 7ID, 2P
L_9: ϕ 0.8mm Enamel-coated copper wire, 2T, 7ID, 2P
L_{10}: ϕ 0.8mm Enamel-coated copper wire, 2T, 7ID, 2P
RFC_1: ϕ 0.6mm Enamel-coated copper wire, 2T, 7ID, 2P
RFC_2: ϕ 0.6mm Enamel-coated copper wire, 2T, 7ID, 2P
RFC_3: ϕ 0.6mm Enamel-coated copper wire, 2T, 7ID, 2P
RFC_4: ϕ 1.0mm Enamel-coated copper wire, 10T, 5ID,
B.P.F: BAND PASS FILTER

2. Triple-multiplier 2-stage power amplifier circuit (156.6 MHz~470 MHz)



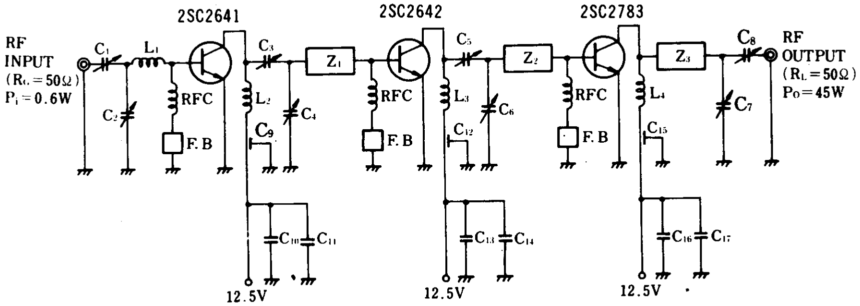
L_1: ϕ 0.8mm Silver-plated copper wire, 2T, 10ID, 2P
L_2: ϕ 1.2mm Silver-plated copper wire, 1T, 10ID
L_3,L_4: ϕ 0.8mm Silver-plated copper wire, 1T, 8ID
L_5: ϕ 1.2mm Silver-plated copper wire, 2T, 10ID, 2P
L_6: ϕ 1.2mm Silver-plated copper wire, 1T, 8ID
L_7: ϕ 1.2mm Silver-plated copper wire, 2T, 8ID, 2P
RFC_1,RFC_2: ϕ 0.6mm Enamel-coated copper wire, 15T, 3.5ID
RFC_3: ϕ 1.0mm Enamel-coated copper wire, 20T, 8ID
RFC_4: ϕ 1.0m Enamel-coated copper wire, 17T, 8ID
B.P.F: BAND PASS FILTER

3. Power amplifier circuit (175 MHz, FM 70W)



- L_1: ϕ1mm Silver-plated copper wire 1T, 8ID
- L_2: ϕ1mm Silver-plated copper wire 2T, 8ID
- L_3: ϕ1mm Silver-plated copper wire 2T, 8ID
- L_4: ϕ1mm Silver-plated copper wire 2T, 8ID
- L_5: ϕ1mm Silver-plated copper wire 2T, 8ID
- L_6: ϕ1mm Silver-plated copper wire 1T, 8ID
- L_7: ϕ1mm Silver-plated copper wire 1T, 10ID
- L: ϕ1.5mm Silver-plated copper wire 2T, 10ID
- L_9: ϕ1.5mm Silver-plated copper wire 1T, 10ID
- RFC_1, RFC_2: ϕ0.5mm enamel wire closely wound around 220Ω solid resistance
- RFC_3: ϕ1mm enamel-coated wire 10T, 6ID
- RFC_4, RFC_5: ϕ1mm enamel-coated wire 10T, 6ID
- RFC_6: ϕ1.5mm enamel-coated wire 10T, 6ID

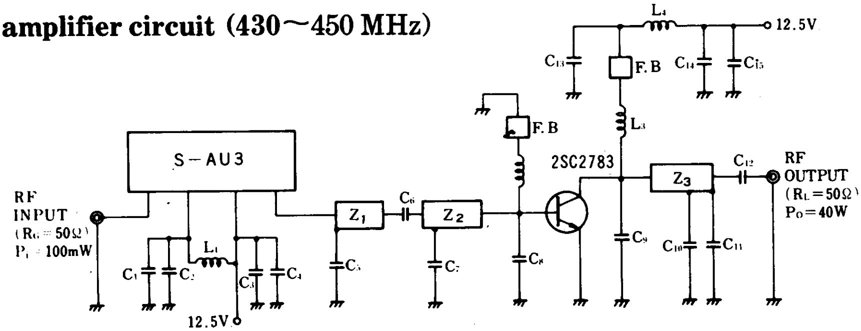
4. Power amplifier circuit (470 MHz, FM 40W)



- C_1, C_2, C_3, C_4, C_5, C_6: ~8pF Ceramic trimmer capacitor
- C_7, C_8: ~20pF Air trimmer capacitor
- C_9, C_{12}, C_{15}: 1000pF Feedthrough capacitor
- C_{10}, C_{13}, C_{16}: 0.05μF Ceramic capacitor
- C_{11}, C_{14}, C_{17}: 10μF Electrolytic capacitor

- F.B.: Ferrite bead
- L_1: 0.3 mm-thick copper plate, 4mm wide ϕ8ID, 1/2T
- L_2, L_3, L_4: ϕ1mm silver-plated copper wire ϕ3ID, 2T
- RFC: ϕ0.8mm Enamel-coated copper wire ϕ3ID, 10T
- Z_1, Z_2, Z_3: 4x10mm Board pattern
- Board: paper epoxy board

5. Power amplifier circuit (430~450 MHz)



- C_1, C_4, C_{15}: 10μF
- C_2, C_3, C_{13}, C_{14}: 0.05μF
- C_5, C_7, C_{10}, C_{11}: 5pF Ceramic chip capacitor
- C_6: 240pF Ceramic chip capacitor
- C_8, C_9: 50pF (10pFx5) Ceramic chip capacitor
- C_{12}: 660pF Ceramic chip capacitor

- L1, L2, L4: ϕ0.5mm copper wire ϕ2ID, 5T
- L_3: ϕ0.5mm copper wire ϕ2ID, 3T
- F.B: Ferrite bead
- Z_1: 5x11mm Microstrip line
- Z_2: 5x29mm Microstrip line
- Z_3: 5x32mm Microstrip line
- Board: ϵ_r=2.7 t=1.6mm Teflon-glass board

Applied circuit of large-power transistors and transistor modules (motor drive circuit)

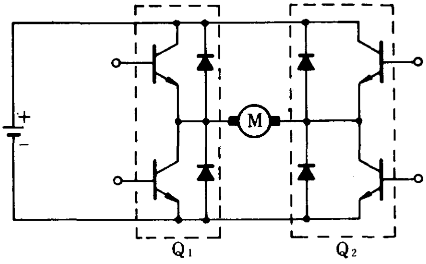


Fig. 1

1. DC motor control (1)

To be employed when using a DC motor control for quick starting/stopping, reverse rotating, and controlling speeds of motors:

Application: Computer-controlled NC machines, machine tools, and spinning and weaving machines

Recommended transistors (Darlington transistors):

Q_1 and Q_2: MG30G2CL 3, MG50G2CL 3,

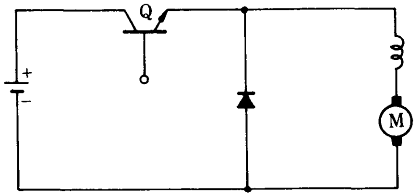


Fig. 2

2. DC motor control (2)

To be employed when controlling DC motor speeds with relative ease

Application: Electric cars, battery-operated vehicles (such as golf carts and fork lifts)

Recommended transistors (Darlington transistors):

Q = 2SD648, 2SD698

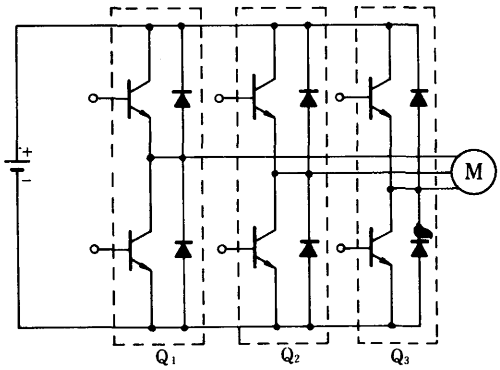


Fig. 3

3. AC motor control

Induction motors which require less maintenance are employed when motor speeds are continuously controlled, thereby not so much time need be allocated to maintenance.

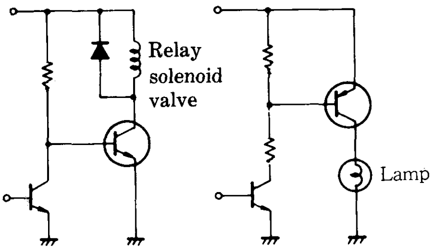
Application: 3-phase induction motor control for brush-less electronic motors, machine tools, marine motors, spinning and weaving machines

Recommended transistors (Darlingron transistors):

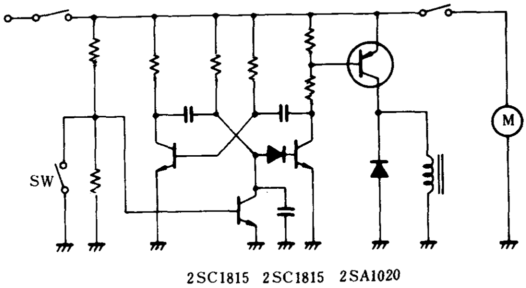
Q_1 and Q_2 = MG3OG2CL2, MG5OG2CL2 MG75H2CL1, MG100H2CL1

Application of low-saturation voltage transistors

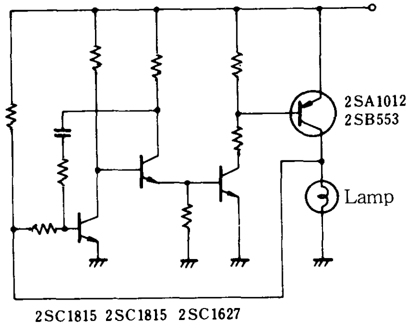
1. Various inductance and lamp drives



2. Wiper control



3. Flasher



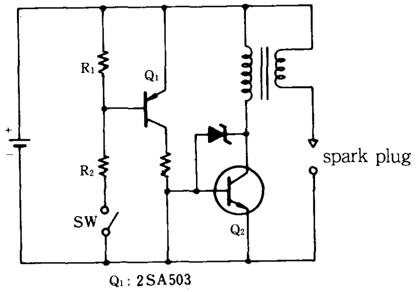
4. Ignitor

Recommended Darlington transistors (Q_2)

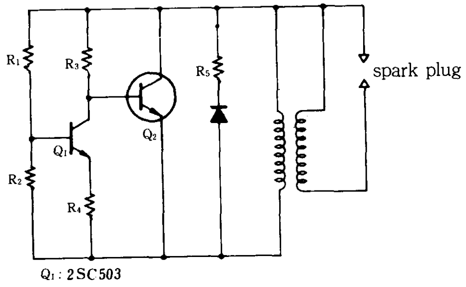
Method (1): 2SD685, 2SD799

Method (2): 2SD798, 2SD1088

(1) Battery drive

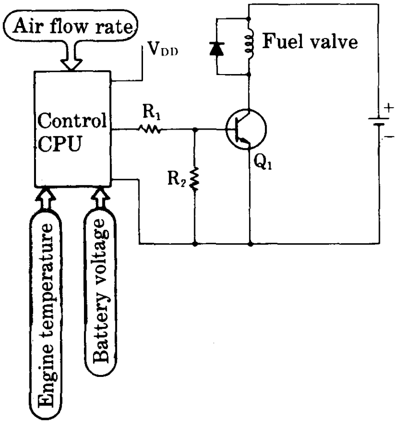


(2) Magnet drive



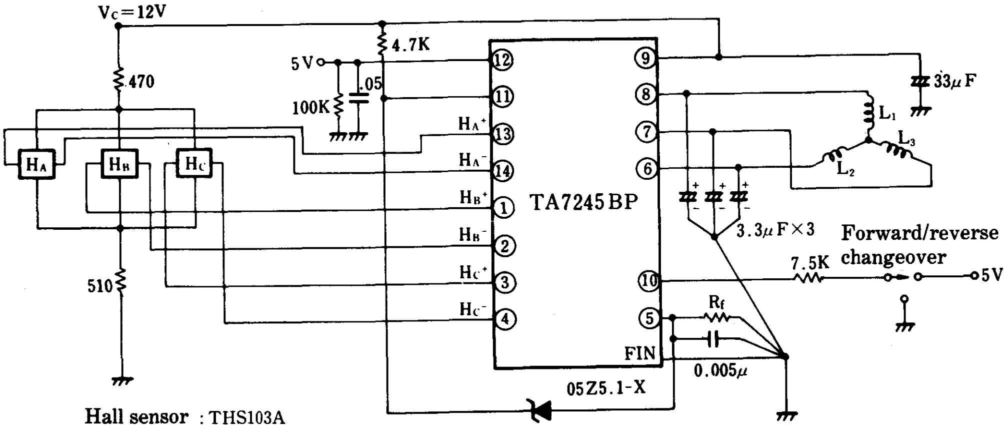
5. Electronic fuel injection control

Recommended Darlington transistors (Q_1): 2SD1087
2SD1500'
2SD633'



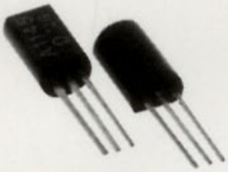
GaAs Hall sensor

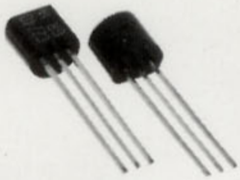
Example circuit using GaAs Hall sensor (Hall motor control)

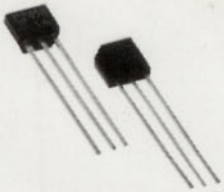


Hall sensor : THS103A

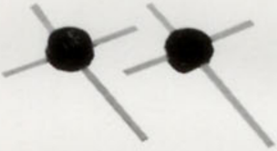
L₁, L₂, L₃ : Field coil

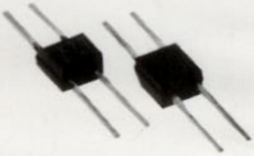

TO-92MOD


TO-92


MINI


H-STM


μ-X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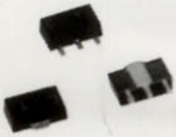
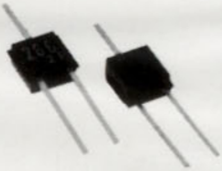
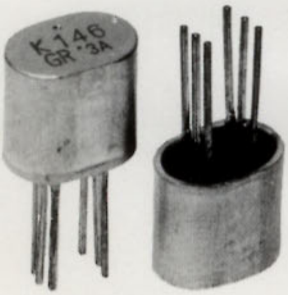
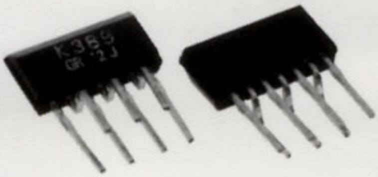

POWER-MINI

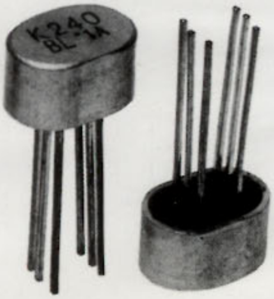

SUPER-MINI


Y-STM





ZIP



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