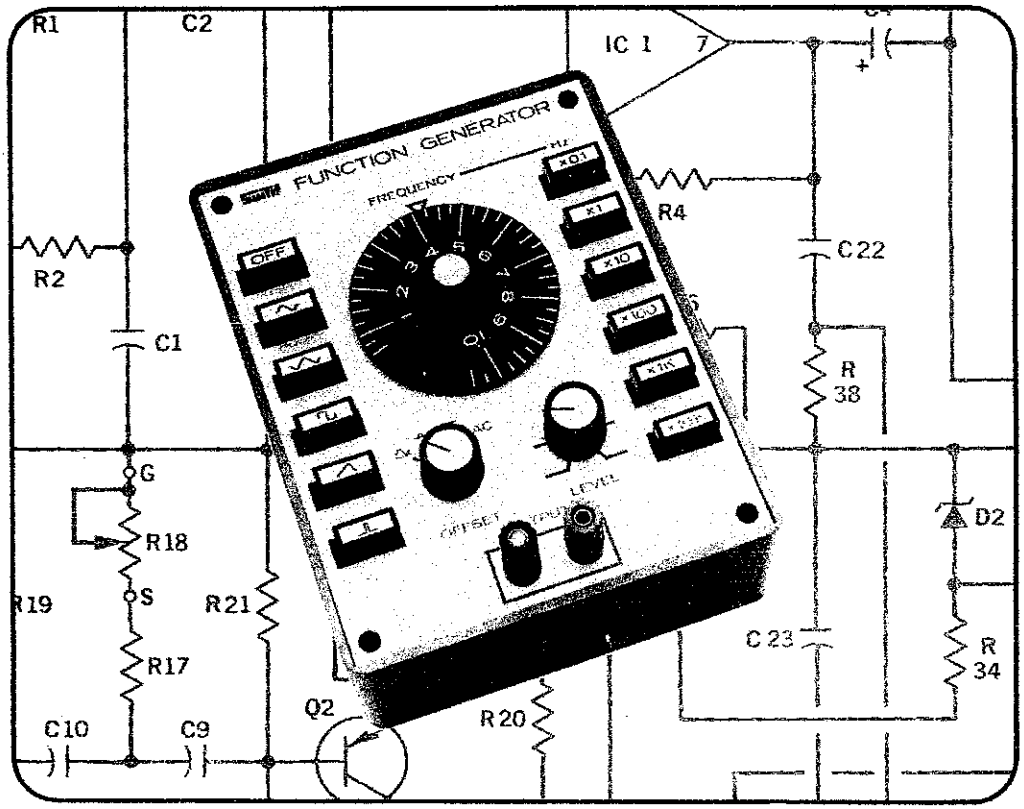


FUNCTION GENERATOR

FG-2 Function Generator

C-1, 2, 3, 4, 5, and 6; the 5% tolerance frequency determining capacitors are in this bag. C-2 will be marked in pf in most cases. (10,000 pf = .01 mfd). C-6 is the largest metal cased unit and is marked brown, black, brown, if not otherwise identified. C-5 is marked brown, black, black and C-4 is marked with only a brown band. The lead coming from the glass seal end of the case is positive on C-4, 5 and 6. The banded end on C-1 and 2 is the outside foil end of the capacitor and although it makes no difference electrically, best shielding is obtained if this side is connected to ground, or negative. Capacitors 1 through 5 are under the frame of S-2 when the generator is completed, so be sure that these parts are mounted carefully and pulled down against the board. Check the fit of S-2 before soldering the capacitors in place so that there will be no shorts, or other problems later.

Identification - FG-2 Capacitors

C-3, 8, 12 and 14 may be supplied with only color code markings. If this is the case the markings will be bands of color - brown, black, red and yellow, starting at the side of the case furtherest from the leads. C-4, 5 and 6 are metal case units and will also be color coded if not otherwise marked. The 1.0 Mfd capacitor has a black mark. The 10.0 Mfd a Brown and two Black and the 100.0 Mfd is marked with Brown, Black and Brown stripes. The larger package is the higher value capacitor also if these markings are not clear. Note that the polarity is not marked, but that the lead coming out the glass seal end is always positive on this type capacitor. Capacitors C-1 through 6 have all been measured to a tolerance of $\pm$ 5%.

The FG-2 is versatile source of five different waveforms over a frequency range of 0.1 Hz to 100 KHz. Sine, square, ramp, triangular and pulse waveforms at any level up to 4.0 Volts Peak-to-Peak can be supplied by this instrument. An offset selector switch gives you the choice of three types of DC coupled output and AC coupling. Output amplitude of signal is constant within less than ± 1.0dB over the instruments complete range.

The excellent performance and low cost of the FG-2 is primarily due to the 8038 waveform generator integrated circuit. A detailed schematic of this circuit, is shown in Figure 1. Waveforms are generated by integrating the current supplied by the portion labled "current sources". This is done in an external capacitor connected to pin 10. Integrating the current from a current source generates a linear ramp. In the 8038 this ramp is stopped at an amplitude determined by the portion of the circuit labeled "comparator". When the ramp reaches this level the current sources are switched by the comparator so that they now linearly discharge the capacitor. At a predetermined lower limit, another comparator again switches the current sources back to the original condition and the positive going ramp is again begun. If the currents used to charge and discharge the capacitor are equal the result is a triangular wave at pin 3. This triangular waveform can be converted to a sine wave by rounding off the triangle in the proper manner. This is the function of the sine converter portion of the circuit. It "bends" over the triangular waveform at eight separate points on the top and bottom of the waveform. The result is a very close approximation of a sine wave. Distortion will be less than 1%.

Square waves are generated by driving the flip-flop portion of the circuit from the comparators. The square output is available at pin 9. The pulse and ramp waveforms are obtained by making the charging and discharging currents into the capacitor unequal. The result is a ramp at pin 3 and a pulse at pin 9. Since doing this changes the frequency of the waveform a tracking conrol is provided to change both currents in such a way that the original frequency is still obtained.

The frequency is shifted over a ten-to-one range by changing the voltage that is applied to pin 8. The various ranges are obtained by changing the size of the capacitor connected to pin 10.

The output of the waveform generator is fed into buffer circuit IC-2. This circuit provides a low output impedance to the external jacks on all waveforms and protects the waveform generator from damage by external connections. The output level is determined by the "Level" control which changes the amount of feedback around IC-2. R-25 supplies an offset to IC-2 that may be made positive, or negative. The signal is direct coupled in all but the AC position giving a waveform free of tilt, or other low frequency distortion.

Assembly

( ) Clean the foil side of all three printed circuit boards with a piece of Scotchbrite® or a piece of fine steel wool to remove any oxidation that may be present. If you use steel wool, be sure to rinse the boards to remove all traces of the conductive steel fibers.

*Scotchbrite® is a registered trademark of the 3M Company.

( ) Attach and solder the jumpers to the #PC1 circuit board. Use some of the single conductor hook-up wire supplied with the kit to make the jumpers and connect them from the component side of the board between the pads connected by a solid line and marked with the letter "J".

( ) Attach and solder all of the resistors and capacitors to the circuit boards, except R13, R22, C15 and C16. As with all other component installation unless otherwise noted: mount the components flush with the top of the board, bend the leads on the back side of the board and trim so that 1/16" to 1/8" of wire remains. Be sure to orientate all of the electrolytic capacitors so their polarity agrees with that printed on the component side of the board.

( ) Attach all of the semiconductors to the board making sure their orientation agrees with that printed on the component side of the board. Leave about 1/8" between the bottoms of the transistors and the top of the board. It will be necessary to cut off two of the pins on IC 2. By orientating the IC so its tab matches with that printed on the board, it should be clear as to which pins to cut. The diodes must be orientated so the banded end of the diodes matches the bar end (end opposite the triangle) of the diode symbol printed on the component side of the board. The #1 or key pin of IC 1 may be indicated by a semicircle notch on the pin itself which is not visible when looking at the top of the package.

( ) Trim the three power transformer secondary (red) wires so each is 2" long. Trim one of two transformer primary wires so it is 2" long and the other so it is 4" long. Strip 1/4" of insulation from each end. Orientate the transformer so the secondary leads are adjacent the two large electrolytic capacitors and secure the transformer using #6-32 x 1/4" screws, lockwashers and nuts.

( ) Connect the five transformer wires to their appropiate pads on the board and solder. Wire connections are indicated by the printing on the component side of the board. The transformer secondary center tap (CT) lead is the secondary wire marked with a tracer.

( ) Attach the two fuse clips to the circuit board using #4-40 x 1/4" screws, lockwashers, and nuts. Snap the fuse in place.

( ) Attach and solder the two large pushbutton switches to the #PC 2 and #PC 3 circuit boards. Be sure the switches are firmly pressed onto the boards before soldering. Check position of C-5 to be sure it is not touching the switch frame on either end.

( ) Attach, but do not tighten the four angle brackets to the four outside holes of the #PC 1 circuit board. Use the unthreaded hole of the bracket with #4-40 x 1/4" screws, lockwashers and nuts and insert the screws from the foil side of the board.

( ) Attach the #PC 2 and #PC 3 circuit boards to the main board using #6-32 x 1/4" screws, temporarily place the metal finishing plate over the switch buttons, align the switches so they center properly and tighten the angle bracket screws.

( ) Using some hook-up wire with the insulation stripped off, connect and solder the edge pads of the #PC 1 board to those of the #PC2 and #PC 3 boards.

( ) Attach resistors R13 and R22, switch S3 and the two binding posts to the front panel. Orientate these so they match with that of the wiring diagram, and be sure to put a ground lug under the black binding post.

( ) Attach capacitors C15 and C16 to the appropiate lugs of the front panel components. Be sure to run the C15 lead through the switch lugs indicated in the wiring diagram.

( ) Cut, attach and solder all of the wires shown in the wiring diagram. It is best to divide the wires off into four bundles. Use a different color of wire for each in the bundle. Cut each wire of the bundle to the length indicated on the wiring diagram and twist the wires of the bundle together. Strip the insulation from the end of each wire and attach and solder it to its correct terminal using the color coding of the wire for proper identification.

( ) Run the line cord through the 7/16" hole of the plastic box and attach the ends to the two pads on the end of the board marked AC line.

( ) Check to see that all connections have been soldered.

( ) Run the 4-40 x 1/2" flat head screws from the outside of the case up through into the bottom of the case. Place a 1/4" spacer over each screw, orientate the board so the AC line end of the board is nearest the hole in the case provided for the line cord, and press the board down onto the screws. Place a #4-40 lockwasher and nut over each screw, but do not tighten yet. Set the front panel onto the unit and position the board assembly so the push-buttons are centered. Remove the front panel and tighten the mounting screws.

( ) Place the decals on the appropiate switch buttons using the photograph to show proper location. The best way to do this is to cut out each marking with a pair of scissors while leaving a large margin. Peel the protective backing off of the decal to be set and place it onto the pushbutton. Use a hobby knife or razor blade to cut the acetate along the plastic ridge surrounding the aluminum insert of the pushbutton. Remove the excess film and firmly press the decal onto the pushbutton.

( ) Again set the front panel on the case and press the knobs onto the potentiometer and switch shafts.

Calibration

Note: During the calibration procedure power must be applied to the unit with the front panel off, so touch only those controls mentioned in the calibration procedure to avoid electrical shock.

Prior to calibration, depress the "OFF" switch and the "X100" frequency select switch. Set the tabs on the knurls of all six of the trimmer resistors so they are midway between the two extremes. Set the offset control to the AC position, turn the level control fully clockwise and set the frequency control to 5. Plug the line cord into a wall outlet, connect an oscillascope to the output posts, and depress the "square wave" function button. A square wave should be present at the output posts, if not unplug the unit and recheck all assembly procedures. If the unit does generate a square wave, use the following procedure to calibrate the unit.

( ) Adjust the "symmetry" potentiometer to give a square wave with a 50% duty cycle.

( ) Depress the "sine wave" button and adjust the "sine +" and "sine -" control for the best looking sine wave. The controls interact so it will be necessary to go back and forth between the two controls several times.

( ) Using a well calibrated scope or oscillator as a reference you should next set the maximum and minimum frequency trimmer of the unit. Set the function switch back to "square wave" and set the frequency control knob to 1. Adjust the "min frq" control for an output frequency of 100 Hz. Now set the frequency control knob to 10 and adjust the "max frq", control for an output frequency of 1000 Hz. It will be necessary to go back and forth between these two adjustments several times since the two controls interact. The frequency adjustments are accurate $\pm$ 5% from one frequency range to another.

( ) Depress the "X10K" frequency button and set the frequency control knob to 10. Set the sweep frequency of the scope so that one square wave cycle appears on the screen then depress the "pulse" button and adjust the

"tracking" control so that one complete waveform appears on the screen.

( ) If you have a distortion analyzer, you can calibrate the unit for minimum possible distortion. Depress the "sine wave" function and set the output frequency to 1KHz. Adjust the "sine+" "sine -" and "symmetry" controls for minimum distortion.

The unit is now calibrated. Check all other switch positions to make sure all functions are working properly.

( ) Attach the front cover to the unit using #6-32 x 1/4" round head Phillips screws.

( ) Crimp the strain onto the line cord at a point just outside the case. While compressing the strain relief with a pair of pliers insert the strain relief into the hole in the case.

Operation

All of the external controls on the unit should be readily understandable, however, the offset control might need some clairfication. Its purpose is to provide a waveform whose negative peak rides on ground potential, whose waveform is symmetrical about ground potential, whose positive peak rides on ground potential, or whose output is AC coupled.

The AC coupled position must be used if there is any voltage present on the point that signal is to be applied to. Connecting the FG-2 to a point having DC voltage present, while the "Offset" selector is in other than the AC position can damage IC-2 if the voltage is high enough, or the connection is left on too long.

The positive offset position (full CCW) should be used for testing RTL, DTL and TTL logic circuits. In this position the signals negative peak remains on DC ground and the positive peak moves up as the "Level" is increased. This allows easy and accurate testing of logic operating levels.

The next position of the "Offset" switch provides an output signal that is symmetrical about DC ground. This should be used for general purpose testing of audio and other circuits where an input signal of this type is desirable. This position is particularly useful in square wave testing low frequency response of DC coupled audio circuits, since the generator is completely DC coupled in this position and does not add any distortion to the signal before it is applied to the circuit being tested.

The third offset position provides a signal whose positive peak remains on DC ground, and the negative peak moves down as the "Level" is increased. This position is used for testing all types of ECL logic system in which negative supply voltage is used.

Parts List - Function Generator FG-2

Resistors

R1	1K ohm trimmer resistor
R2, R6	5K ohm " "
R3, R4	100K ohm " "
R5	50K ohm " "
R7	2.7K ohms 1/4 watt resistor
R8	1K ohm " "
R9	2.2K ohm " "
R10, R11,	10K ohm " "
R12	33K ohm " "
R13	10K ohm special linear taper pot. #EF-7925
R14	2.2K ohm 1/4 watt resistor
R15, R16	3.3K ohm " "
R17	4.7K ohm " "
R18	3.3K ohm " "
R19, R20, R24	470 ohm " "
R21	47 ohm 1/4 watt resistor
R22	10K ohm linear taper potentiometer #SS-9858
R23	4.7K ohms 1/4 watt resistor
R25	27K ohms 1/4 watt resistor

Capacitors

C1	820 pfd capacitor
C2	0.01 ufd capacitor
C3, C8, C12, C14	0.1 ufd capacitor
C4	1 ufd tantalum electrolytic capacitor
C5	10 ufd tantalum electrolytic capacitor
C6	100 ufd " " "
C7	10 ufd electrolytic capacitor
C9, C10	1000 ufd @25 VDC electrolytic capacitor
C11, C13	500 ufd @15 VDC " "
C15	1 ufd 400 volt mylar or paper capacitor soldered across terminals of switch S3
C16	4.7 pfd disc capacitor soldered across potentiometer R22

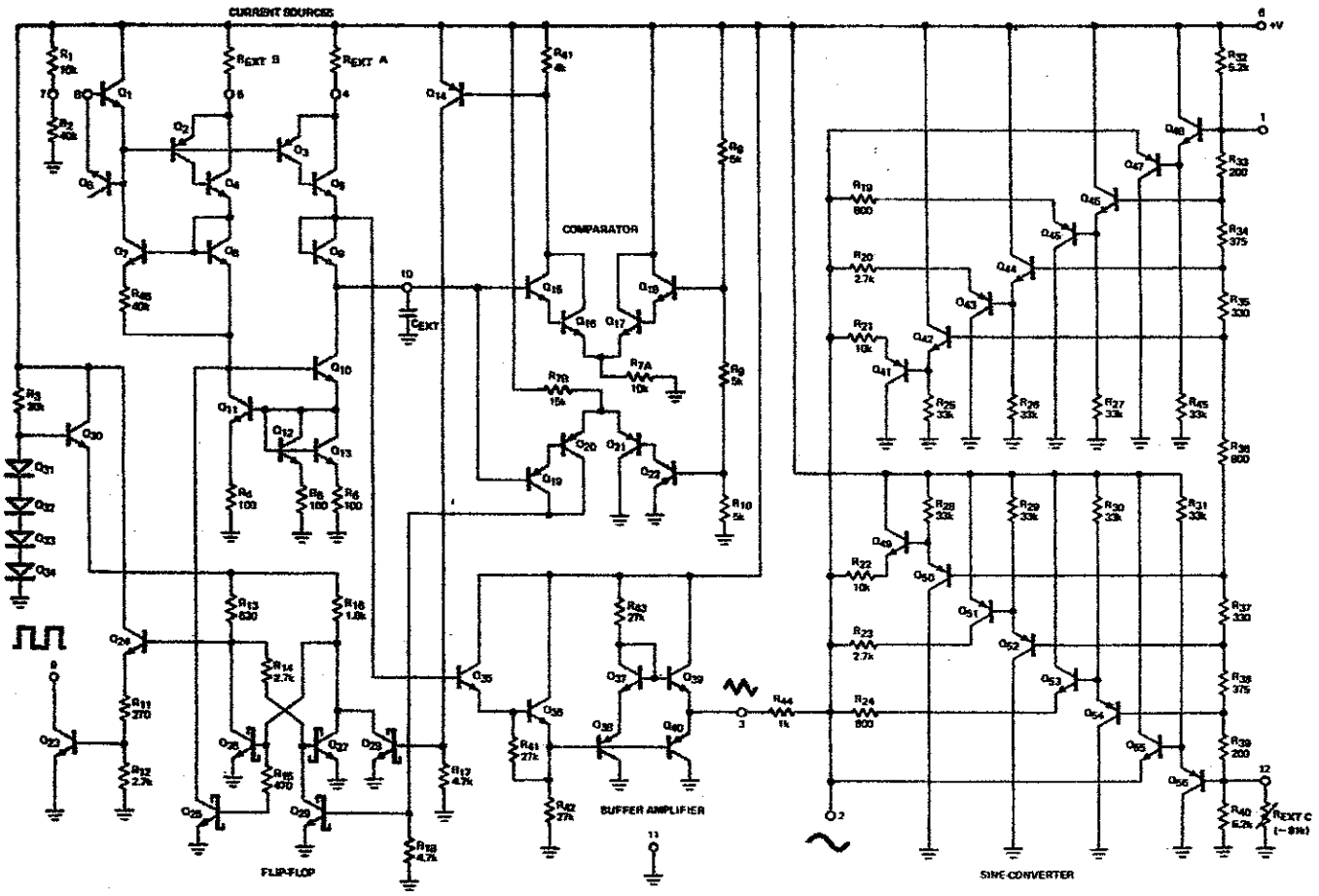
Semiconductors

D1 - D4	1N5060 or 1N4004 silicon rectifier
D5, D8	1N914 silicon diode
D6, D7	7.5 Volt Zener 1N5236B or 1N4737
IC1	8038-CC integrated circuit
IC2	LM318 or LS2630 "
Q1	2N5139 silicon transistor
Q2	2N5129 " "

Miscellaneous

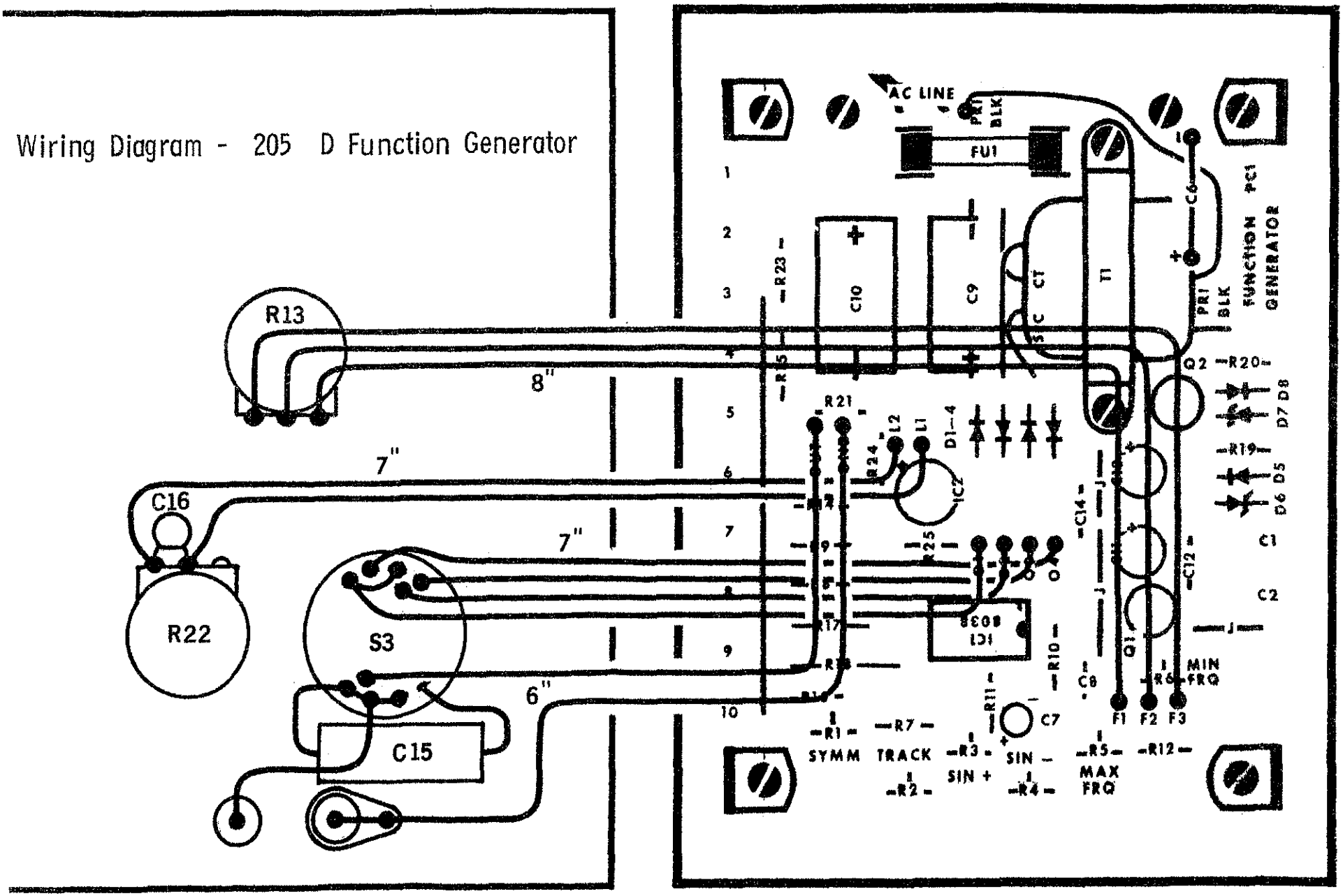
FU-1	0.1 amp standard fuse
T1	24 volt C.T. 100ma secondary 117 VAC primary power transformer
S1, S2	

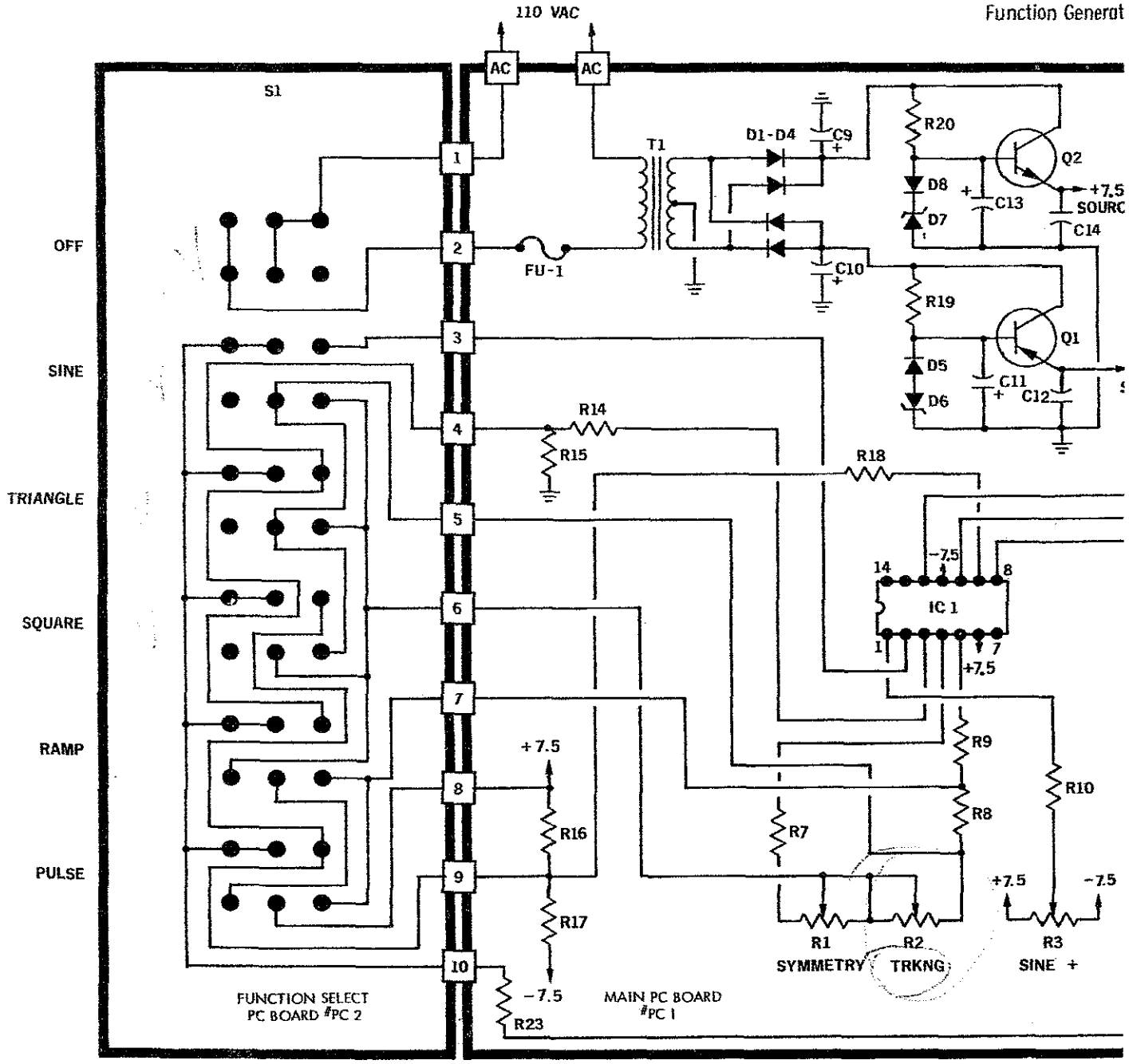
DETAILED SCHEMATIC



"Figure 1"

Wiring Diagram - 205 D Function Generator




110 VAC
AC
AC
S1
OFF
SINE
TRIANGLE
SQUARE
RAMP
PULSE
1
2
3
4
5
6
7
8
9
10
T1
FU-1
D1-D4
C9
C10
R20
Q2
D8
D7
C13
C14
+7.5
SOURC
R19
Q1
D5
D6
C11
C12
R14
R15
R18
IC 1
14
8
1
7
-7.5
+7.5
R9
R8
R10
R7
+7.5
R16
R17
-7.5
R23
R1
SYMMETRY
R2
TRKNG
+7.5
-7.5
R3
SINE +
FUNCTION SELECT
PC BOARD #PC 2
MAIN PC BOARD
#PC 1

ion Generator Schematic - No. 205-D