Section 3

Operation and Control

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LIST OF ABBREVIATIONS

A	Initial Value
APF	Analog Patch Panel
BDZ	Operating Unit (Control Unit of Slave Computer)
DB	Print Instruction
DBG	Digital Control Panel (Control Unit of Master Computer)
DE	Printer ON
DPF	Digital Patch Panel
DVM	Digital Voltmeter
DZ 772	Digital Adapter
ERS 702	Electronic Resolver
F	Sequences (Operating Condition of a Store)
FA	Ink-pen Start (XY-Plotter)
FF	Flipflop
GT	Basic Clock
H	Hold, Hold Instruction
HE	Hold-Phase End
HT	Manual Clock
IPV	Duty Cycle
K	Comperator
LSZ	Paper-Tape Control Unit
Lö, lö	Erase
LZ	Space Line
ME	Machine Unit (= 10 V)
MF	Monoflop
NN	Non-Linear Networks

NNT 801	Drawer, Non-Linear Networks
NNT 701	Drawer, Non-Linear Networks
Os	Oscilloscope
OD	Oscilloscope Blanking
OH	Oscilloscope Unblanking
R	Computing
RE	Computing Phase End
Sch	Plotter
SR	Shift Register
SR2	Shift Register
St	Connector
Ü	Over-amplify
ÜH	Over-amplify Hold
VA	Amplifier Selection
VFG	Variable Function Generator
WT	Selection Clock
WTR	Continue
Z	Sweep Generator
Z	Counter
ZL	Counter
ZL 2	Counter
ZG	Timer
ZS	Time Constant Control (10 times faster)

LIST OF IMPORTANT DESIGNATIONS AND SYMBOLS

C_1	Integrator capacitor C_1 = 5000, 500, 50, 5 nF
$K_o = \frac{1}{C_1 \times R_1}$	Integration factor k_o = 1, 10, 100, 1000 1/s
ME	Machine unit 1ME = 10 V
mn	Address, m digit of tenth, n digit of units
F_P	Factor of pause phase $T_P = F_P \times GT$
F_R	Factor of computing phase $T_R = F_R \times GT$
F_H	Factor of hold phase $F_H = 1$
GT	Period of basic clock
T_P	Period of pause phase
T_R	Period of computing phase
T_H	Period of hold phase
R_1 = 200 kOhm R_{10} = 20 kOhm	Input or feedback resistor
R_A = 5 kOhm	Resistor within network for initial value
"0", "1"	Binary values

3. Operation and Control

The total operation of the computer is centralized in the digital control unit DBG 771. By means of push-buttons and rotary switches on the front plate, all different functions can be controlled for selection of the computing elements, setting of timers as well as of operation and program modes. Special control circuits are provided for all different operation modes, which need not to be established by patching freely programmable elements, but by depressing a push-button only.

The control possibilities of the computer can be considerably increased when further using a digital adapter unit, permitting a farmost automation of computing and output processes as well as an individual control of integrators and stores.

Except the decoding circuits for the selection position, only digital circuits are used for the control unit. To avoid explanation of technical details within this section (operation and control) the whole functional description is given in the technical manual.

The control unit contains three functional groups:

1. Selection
2. Time selection
3. Control

To each functional group, push-buttons or rotary switches are assigned whose allocation to the respective functional groups is definitely determined by means of a respective designation on the front plate (see annex).

Additionally, the control unit contains:

4. two push-buttons for central overload indication and random overload stop

5. Zero-instrument for balancing of the operational amplifier by means of two respective push-buttons and balancing potentiometers.

The control unit supplies the respective signals for connected output devices and for a possibly connected digital adapter unit. Further explanations to 1.)-5.) are given in the following.

The functional groups "Selection" and "Control" can be remotely controlled by digital signals with respective coding. In this case, the push-buttons must not be actuated but indicate the arrival and length of the respective signals when illuminated.

Such remote control is possible when using the computer within a hybrid computer system, i.e. when used in combination with a digital computer via a hybrid coupling unit or when connecting a punched-tape control unit LSZ 100.

All push-buttons of the control unit are normally locked in depressed position and simultaneously illuminate. The push-buttons within one push-button row thereby release each other. If, however, the remaining push-buttons within a row should remain in their positions, the respective individual push-button can be released by slightly depressing this push-button or another one of the same row. After activation of a push-button function, the respective push-button illuminates irrespective to a locked position or not (e.g. when used in combination with other push-buttons, automatic run, remote control). They again extinguish, after their function is interrupted by depressing other push-buttons or caused by automatic control.

Any exceptions as to the locking and release of push-buttons are mentioned in the respective descriptions.

3.1. Selection

The selection push-button panel is combined within a special panel, designated "selection". The selection also includes the operation of a digital printer. Also connected to the panel is the respective panel for setting the values for servo-set coefficient potentiometers. The selection panel contains all push-buttons for decade selection of the computing elements and six control push-buttons provided in the lower left-hand panel field.

. The dynamic behavior of the computing element changes
. during selection because of the connection of the
. measuring line.

3.1.1. Push-Buttons for Decade Selection of Computing Elements

The selection panel contains one push-button row with six push-buttons, designated P and V, as well as two rows with ten push-buttons each, designated 0...9. By depressing a push-button, other push-buttons within the same row are released. For single push-button release, a slight touch must be applied. The whole panel serves for selection of a maximum of 600 computing elements of three computer racks (three analog patch panels) with 200 selectable computing elements each. However, the system must be a combination of a master computer equipped with control unit DBG 771 and one or two slave computers without own control unit. Computers with own control unit DBG 771 being switched in-parallel do not permit a selection from a second control unit, but in this case must be equipped with an adapter control unit BDZ 801 instead of DBG 771.

Of the 200 computing elements that can be selected on each analog patch panel or computer rack, 84 are coefficient potentiometers, 9 are controllable supply voltages, whereas 100 are other elements, such as operational amplifier, multipliers, function generators and special addresses. The remaining positions are not occupied.

The two-decade panel consisting of two push-button rows with ten push-buttons each, designated 0...9 permit entering of 100 address positions between 00 and 99. Coefficient potentiometers and supply voltages thereby are selected via the push-button "P", whereas for amplifiers and other computing elements, push-button "V" is used. Three pairs of push-buttons "P" and "V" are available, designated 0, 1, and 2. The push-button pair designated 0 serves for selection of all elements of the computer in which the control unit is arranged. The push-button pairs 1 and 2 are for selection of elements of the slave computer 1 or 2, which are not equipped with control units.

This means, that an address for selection consists of a letter (P or V) and a two-digit number between 00 and 99. The tens position of the address thereby designates one of the ten fields of the APF, designated 0 to 9, whereas the unit position of the address defines the output of the computing element or a special connection within this field. The unit position always corresponds to the jack designation of the field. Since equal computing elements also have equal unit addresses (exceptions possible only with center fields 2 and 7), the addressing system is easy to learn.

3.1.2. Address Indication on Digital Voltmeter Display

Part of the selection is the digital voltmeter display. After entering an address, it appears in the address field of the digital voltmeter. Thereby, a few modifications are possible. E.g. the address is indicated with three digits, containing the leading computer number 0, 1, or 2 according to the computer address (or APF-address) for which the push-buttons "P" or "V" were used.

The computer further contains a real feedback for the selected computing elements, which is based on a letter designation. If, for example, no computing element is available under the selected address (e.g. with partially equipped computers) the indication of a leading letter in the address field of the digital voltmeter does not take place. In all other cases, a letter appears on first position before the three-digit address, according to the following table:

Depressed letter push-button	Code letter	Selected computing element	Address tens position	units position
P	P	Coefficient potentiometer	0 - 9 (without 2 and 7) 2, 7	0 - 7.9
P	K	Supply voltages	0 - 8	8
V	I	Integrator, complementary integrator, store, complementary store, open amplifier	0 - 9	0,1,2,
V	S	Summer, open amplifier	0 - 9	0 - 5
V	S	Inverter of electronic resolver	2,7	7
V	M	Modulation multiplier	0 - 9 (without 2 and 7)	7,8
V	F S	Variable function generator as inverter	0 - 9 (without 2 and 7)	9
V	Z	Selectable jacks on APF	0,2,4 5,7,9	6
		on DPF	7	9

For example, the selection of V (0)11 causes an address feedback I011 or S011, depending on the respective operational amplifier being programmed as integrator or summer.

An exception is given with the servo potentiometers, (units position 0,1,2,5,6,7). In this case, the feedback "P" is not provided by each single potentiometer, but by the respective potentiometer unit comprising 9 or 10 potentiometers each.

3.1.3. Control Push-Buttons for Selection

Six push-buttons in the lower left-hand panel field are provided for special tasks in combination with automatic selection or output of output values of selected computing elements via a connected digital printer. The push-buttons are explained in the sequence of the coupled functions:

a) Push-button "Hand" (manual)

This push-button must be actuated prior to all selection of addresses which are to be entered manually.

b) Push-button "Aut." (automatic)

The selection system contains an automatic selection during which a block of succeeding addresses is scanned subsequently. The block length is 100 positions maximum. As start address, any address can be taken. For operation of the autmatic selection system, the following must be observed:

1. Depress push-button "Hand"(manual) and subsequently enter the start address between 00 and 99 via the selection panel.
2. Depress push-button "Aut." and wait unitl illumination of the push-button lamp after arrival of the first selection clock. After one second, the automatic address scanning is started. It is continued within a 0.5 Hz-clock. On the digital voltmeter display, any two seconds the complete address designations of the computing elements subsequently appear together with the output values being indicated for visual observation. If a digital voltmeter display is also to be print-out, refer to the respective explanations given under push-button "Print-on". If no final block address is pregiven, the automatic system continuously scans the addresses until reaching position 99, then returns to the start address and remains there.This address scanning is also indicated via the subsequently illuminated address push-buttons. The push-button "Aut." again extinguishes after termination of the scanning, and the lamp of the push-button "Hand" (manual) again illuminates.
3. If after depressing of push-button "Aut." and automatic start any final address with higher number is entered, the automatic system interrupts the selection after reaching this address. See also the notes under point 2.
4. Also in case of automatic selection, the respectively selected address is indicated by illumination of the respective push-buttons.
5. The automatic selection can be stopped at any time by depressing the push-button "Hand" (manual), causing the selection to go over to the entered address.

6. The automatic selection can also be interrupted by depressing the push-button "Stop". In this case, push-button "Aut." remains illuminated. After depressing the"Stop"-push-button, which also illuminates, the digital voltmeter is operated periodically. When again depressing the push-button "Aut.", the automatic selection continues from the stopped position to the entered final address or until 99, with return to the start address or to address 00, if no push-button was depressed. Further notes see point 2.

c) Push-button "Stop"

See also push-button "Aut." point 6. The "Stop"-push-button cannot be released by depressing the push-button "Hand"(manual) which causes the selection to go over to the respective address being entered.

d) Push-button "Print-on" (printer on)

For print-out of addresses and measuring values being indicated on the digital voltmeter, a digital printer can be connected to the computer. When depressing the push-button "Print-on", a print instruction is supplied to the digital voltmeter together with a certain measuring instruction, which become effective. At the following time points:

1. During operation of the automatic selection (push-button "Aut."depressed). Each automatically scanned address is print-out by indicating the complete address feedback and value. The scanning clock thereby increases from 0.5 Hz to 2 Hz, so that scanning, indication and print-out of an address position takes place within a 0.5 s-period. If no address feedback takes place, i.e. element not available within the system, the position will not be print-out.The manually entered start address also is not print-out at the start, but after termination of the scanning sequence, after repeated return to the start address. E.g. in case of 100 positions, print-out of start address 00 takes place after reaching position 99.

   When entering a final address, no return to the start address will take place, and thus also a print-out will not occur. A desired print-out must then be initiated by shifting the start address by one position. Print-out of start address 00 with subsequent entering of a final address is not possible during automatic mode, and must be individually carried out by depressing the push-button"Print-instr."or via the digital adapter unit.

2. During program modes "Repetitive computing" and "Automatic iterating computing".
   Print-out takes place at the end of the preset computing time. Print-out of address and address value thereby takes place within the phase Hold, (which must be given for at least 100 ms) following to the phase computing.

3. Automatically after each terminated setting of a servo-set coefficient potentiometer. Setting of the potentiometer value takes place via the setting panel, whereby the setting process is initiated by depressing the respective push-button "POT" located beside.

Then the respective potentiometer address and the value reached by the servo-set potentiometer is indicated on the digital voltmeter and print-out via the printer (not however, the entered potentiometer value).

e) Push-button "Druckbef." (print instruction)

By means of this push-button, print-instructions can be given at any time. In such a case, the respective address being indicated on the digital voltmeter is print-out together with the address value, if the push-button "Print-on" previously was actuated. The push-button "Druckbef."(print-instruction) is not locking and therefore must be again actuated for each print-out. A parallel print-instruction is possible from the digital adapter unit.

f) Push-button "Extern"

After depressing this push-button, all other push-buttons of the selection panel become ineffective, which also applies for the setting panel of the servo potentiometers.

Simultaneously, a switch-over takes place to external address input by using digital signals, which can be connected via a jack provided on the rear side of the control unit. Input of servo potentiometer setting values is possible via a central setting line (e.g. from a hybrid coupling unit). By depressing the push-buttons "Hand" (manual) or "Aut."(automatic), the effect of the push-button "Extern" can be cancelled. Normally, the push-button "Extern" is used within hybrid computer systems or when using a punched-tape control unit.

3.2. Timers

3.2.1. Programs of the Digital Control Unit

The digital control unit contains fixed-wired programs for control of integrators or stores. A detailed description is given in section 3.3. In the following, a general survey is given.

On the front panel of the digital control unit, there are two vertical push-button rows arranged within a field, designated "Control".

The following programs can be set via the left-hand row:

Program	Push-button
Continuous	Dauer
Computation with Hold	mit Halt
Repetitive computation	Repet.
Autmatic iterative computation	It.aut.
Manual iterative computation	It.Hand

The following operation modes can be entered via the right-hand push-button row:

Operation mode	Push-button
Pause	Pause
Compute	Rechnen
Hold	Halt
Continue	Weiter

After depressing the push-button "Compute", the selected program is started, beginning with a 1/0-edge of the basic clock. Thereby, a delay time Δt, between 0.5 and 2 seconds (see Fig. 3.2.1/1) is given due to relay switching times.

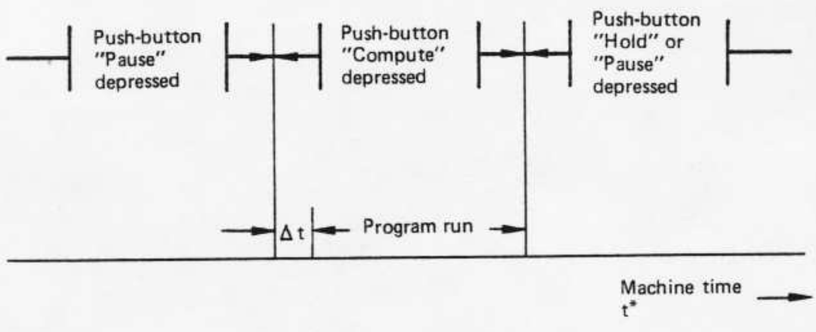


Fig. 3.2.1/1 Program start and program end

A program is characterized by a certain phase sequence. One distinguishes between:

a) Phase Pause 1,	phase endurance T_P1	with normal integrators
Phase Compute 1,	phase endurance T_R1	
Phase Hold 1,	phase endurance T_H1	
b) Phase Pause 2,	phase endurance T_P2	with complementary integrators
Phase Compute 2,	phase endurance T_R2	
Phase Hold 2,	phase endurance T_H2	

For the programs "Continuous","with Hold", "Repet." only the phases of group a) are of importance, thereby index 1 can be omitted. During a phase, the control signals of the active control lines (e.g. r, h, $\overline{r}$, $\overline{h}$, ZG1) have a constant value of binary 1 or binary 0.

The phase endurance is set on the digital control unit in the respective field designated with"time selection". The upper field half thereby is used for the phases of group a), with phase endurance T_P1, T_R1, T_H1 or T_P, T_R, T_H. The lower field half is provided for the phases of group b) with the phase endurance T_P2, T_R2, T_H2, respectively.

In the following, the programs of the digital control unit are outlined:

1) Program "Continuous computation"
   The program starts with the Pause-phase, followed by a computing phase, which is unlimitted by the program and thus is not depending on the setting of the timers.

2) Program "Compute with Hold"
   Program run: Phase Pause, phase Compute, phase Hold. The Hold-phase is independent from the timer setting. It can be terminated by depressing the push-button "Continue". Then, phase Compute and phase Hold are following.

3) Program "Repetitive computation"
   The program consists of a sequence of same cycles. Each cycle contains three phases in the following time sequence: Pause, Compute, Hold.

4) Programs "Automatic iterative computation" and "Manual interative computation".
   These programs consist of an alternative sequence of two cycles which are controlled by a normal and complementary computing circuit.

a) Normal computing circuit

normal partial cycle	Pause phase Z 1	normal partial cycle	Pause phase Z 1

b) Complementary computing circuit

Pause phase Z 2	complementary partial cycle	Pause phase Z 2	complementary partial cycle

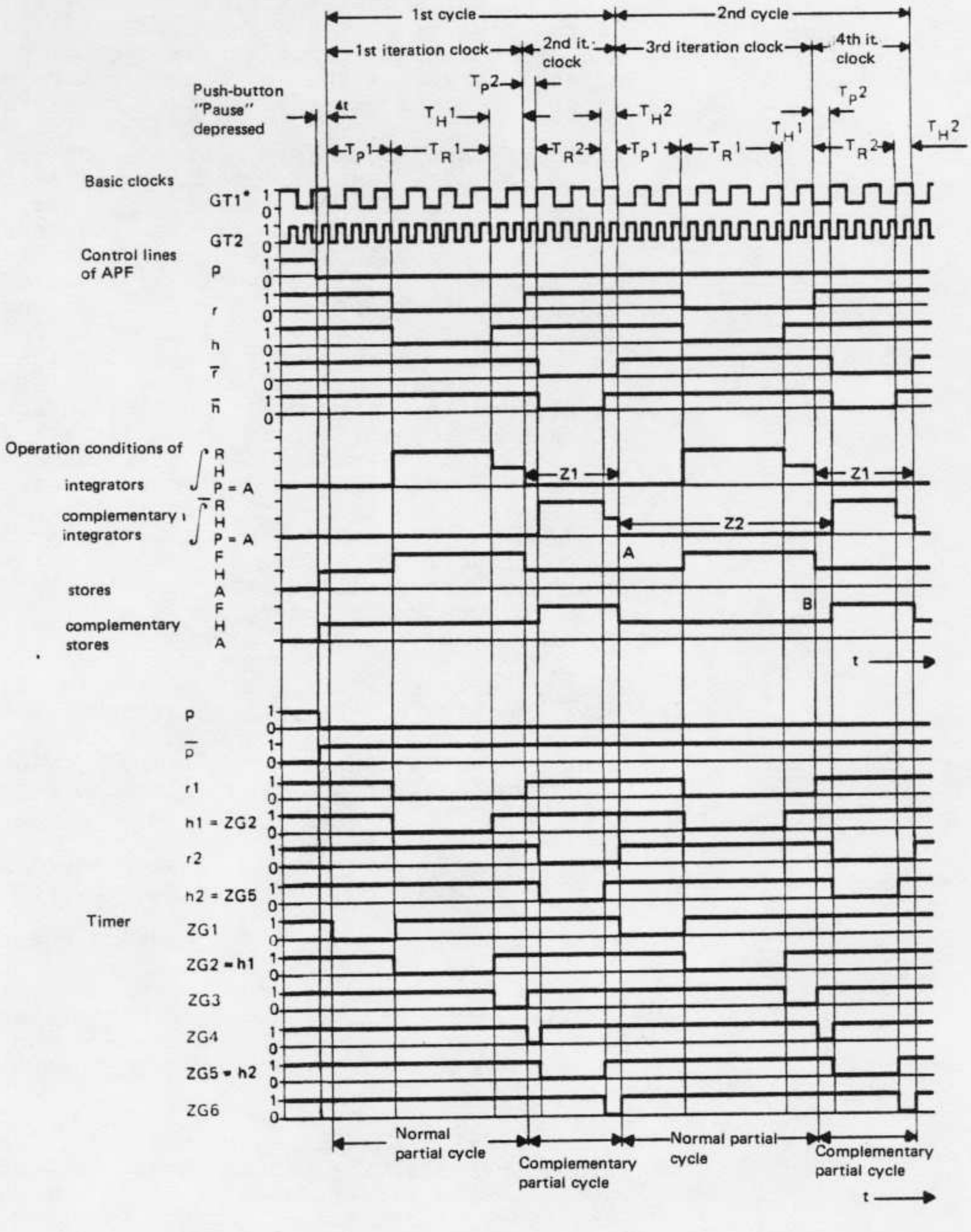
Machine time t* ⟶

In their timely sequence, the cycles are composed of following phases:

a) normal partial cycle
phase Pause 1, phase Compute 1, phase Hold 1

b) complementary partial cycle
phase Pause 2, phase Compute 2, phase Hold 2

Whereas one computing circuit performs a cycle, the other has a Pause-phase, which is abbreviated Z 1 or Z 2. The normal partial cycle is identical to the cycle of the program "Repetitive computation", since an integrator with certain wiring of its control inputs performs the same computing operations during a cycle of program "Repet." and during a normal partial cycle of program "It.aut."



Due to graphic reasons, GT1/GT2 given in a ration of 1:2.
Practically, this ratio can be set only in powers of tens.

Fig. 3.2.1/2
Time diagram of active control lines of DGB 771 and of digital adapter unit DZ 772 for program "It.aut."

3.2.2.
Setting of Timers

All clocks for computer programs as well as for control of the digital elements in the digital adapter unit are centrally generated in the control unit. All freely selectable clocks thereby can be set by means of ten rotary switches provided on the front plate.

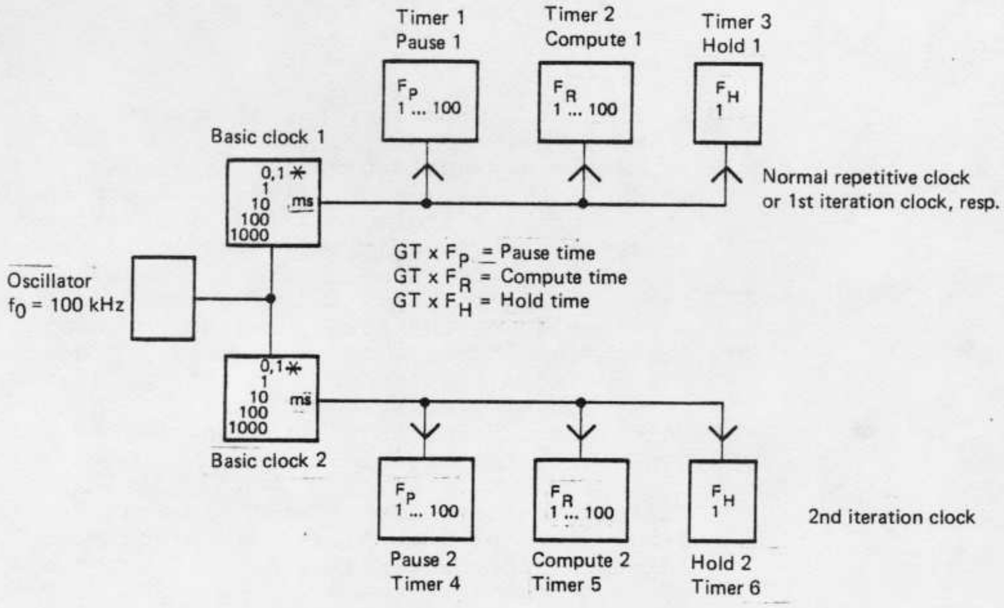
All different clocks are derived from the 100 kHz basic clock of a central crystal oscillator. Two basic clocks GT1 and GT2 are generated by means of a 5-stage frequency divider which permits independent clock setting to 1 kHz, 100 Hz, 10 Hz and 1 Hz. Accordingly, the designation of the two rotary switches for basic clock 1 and 2 are 1 ms, 10 ms, 100 ms and 1 s. Because of the operating condition "10x faster", which for example can be set by depressing the push-button "10x", an additional basic clock of 0.1 ms ≙ 10 kHz is reached in switch position "1ms". Each of the basic clocks thereby influences three digital timers, (see Fig. 3.2.2.). The timers 1,2 or 4,5 can be preset between 1 and 100 by means of two rotary switches, whereas timers 3 and 6 are fixed to 1. The timers are controlled by the preset basic clock in a fixed sequence, by counting reverse from the preset position. After reaching Zero-position, they supply the different signals for control of computing elements via central control lines.

The settable time results from a multiplication of the timer setting by the setting of the respective basic clock. The respective computing condition of the system is indicated via three lamps provided in the upper and lower half of the time selection panel:

Yellow lamp on:	Pause phase 1 or 2 effective or push-button "Pause" depressed
Green lamp on:	Computing phase 1 or 2 effective
Red lamp on:	Hold phase 1 or 2 effective or push-button "Hold" depressed or Hold-control operative.

By depressing the push-button "10x" in the manual potentiometer field, the basic clocks GT1 and GT2 are reduced by the factor 10 (e.g. from 1 ms to 100 µs). Thus, the times of all timers are also shortened by factor 10.

Together with time shortening, the integration factors of the integrators are enlarged by factor 10 because of the integrator capacitor switch-over (e.g from k_0 = 100 s^{-1} to k_0 = 1000 s^{-1}). This means, that a fast-time scale by factor 10 is reached after depressing the push-button "10x", or a slow-time scale by factor 10, after the depressed push-button "10x" is again released.



* Only during operation mode "10x faster"

Fig. 3.2.2. Clock generation and timer control

The operation mode "10xfaster" can be controlled also by the DPF, see also 3.4.3.

Example:

Setting of the Pause-phase endurance

For example, Pause-phase 1 is given as to the operation in the "time selection"-field, whereby the black designation of the field is valid. The settings of both rotary switches for timer 1 result in factor F_P (see Fig. 3.2.2) according to the black designation. The factor being within 1 and 100 must be multiplied by the setting of the rotary switch for basic clock 1. The phase endurance is resulting, if the computer is not operated "10xfaster". In this condition, the phase length is smaller by the factor 0.1 than the read value. Setting of phases between 0.1 ms and 100 s with two digits is possible.

The time setting for other phases takes place accordingly, except the phases Hold 1 and Hold 2, which are identical to the times of basic clock 1 and basic clock 2.

Phase	Time period settable by means of	
Pause 1	Timer 1	two digit
Pause 2	Timer 4	two digit
Compute 1	Timer 2 Timer 2 and 1	two digit four digit
Compute 2	Timer 5	two digit
Hold 1	Basic clock 1	one digit
Hold 2	Basic clock 2	one digit

The white designation of the time selection panel refers to the four-digit setting of phase Compute 1, whereas the black designation is used for all other phases.

Four-digit setting of computing phase length

The four-digit setting is limitted to the program types "Repetitive computation" and "Compute with hold". The rotary switches of timer 1 which otherwise are used for setting of the time period T_P1 are used also for setting the computing phase. The white designation becomes valid, the rotary switch for basic clock 1 must be set to 10 ms or to 1 ms. With regard to the white designation, the setting of timers 2 and 1 results in factors by sum formation, which are between 1 and 10 000.

This factor must be multiplied by the setting of the rotary switch for basic clock 1. If not set to operation mode "10xfaster", the computing time is resulting. Computing phase lengths between 0.1 ms and 100 s are possible. The Pause-phase length cannot be set, it is determined to 1 s. The time period of the Hold-phase amounts to approx. 1 s.

For four-digit setting of the computing phase period, the time sweep generator (jacks Z on APF) is switched-off.

3.3. Control Elements on Digital Control Unit

The control panel for setting of operation modes, computing programs and test operations is combined in a push-button panel designated "Steuerung"(control).

The two push-button rows thereby are allocated as follows:

The left-hand push-button row contains all functions for program selection. The push-buttons, however, do not initiate active processes but are used only for respective preparation. The push-buttons of the right-hand push-button row are used for active functions (operation modes) which partially must be prepared by actuating respective push-buttons of the left-hand row. This arrangement provides a better information about the operating conditions of the computer and furthermore enables a more flexible remote control of the modes. The latter is especially important when using the computer within a hybrid computer system, in which a digital computer supplies coded instructions for selection of the computing program and for different settings within the programs to the control unit via direct control lines.

All push-buttons illuminate when depressed, and also if not depressed but if the respective program or operation mode is activated by remote control.

The colors of the push-buttons are allocated as follows:

green push-buttons
- left-hand: presetting of computing programs,
- right-hand: compute start, continue instruction

yellow push-buttons
- left-hand: external program control
- right-hand: operation modes Pause and potentiometer setting

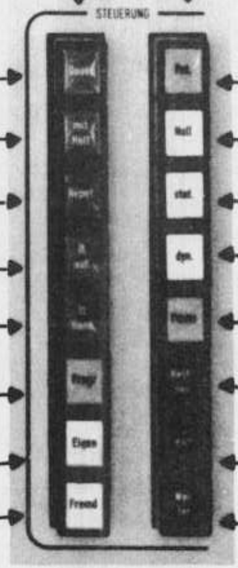
red push-buttons: operation mode Hold

white push-buttons
- left-hand: setting for self and external control
- right-hand: setting for balancing and testing

Program selection

Selection of computer program types of analog computer

Push-button	Program
Dauer	Continuous computation
mit Halt	Compute with Hold
Repet.	Repetitive computation
It. aut.	Automatic iterative computation
It. Hand	Manual iterative computation
Progr.	External program control recommended only for programs "Repet." or "It.aut." or "It.Hand"
Eigen	Program self-control
Fremd	External control



Operation modes

Selection of operation modes of analog computer

Push-button	Function	
Pot.	Potentiometer setting 1)	Test operation
Null	Zero-balancing of operational amplifiers	
stat.	Static program testing	
dyn.	Dynamic testing	
Pause	Pause = (initial value setting)	Operation modes
Rechnen	Computation (i.e. start of programs prepared via program selection push-buttons)	
Halt	Hold	
Weiter	Continue instruction	

1) This push-button permits control preparation of the analog computer for potentiometer setting. The setting process for the servo-set potentiometers is started only after depressing the push-button "POT" on the desired value-input panel.

Fig. 3.3. Functions of the control panel of digital control unit DBG 771

If computing runs within preselected programs are started in one of the two modes for computation (push-buttons "Compute" and "Continue"), the function group "Control" and "Time selection" are combined. The same applies for operation mode "dynamic testing" of the integrators. (Push-button "dyn.").

3.3.1. Push-Buttons for Mode Control: "Pause","Compute","Hold", "Continue"

Prior to the following description of the push-button functions of the "Control"panel, it is necessary to point-out to the different functional behavior between the

operation condition of the computer
with the different modes"Pause", "Compute", "Hold", according to the depressed mode push-buttons

and the

computing run in the computer,
which in the compute mode consists of the subsequent following phases "Pause", "Compute", "Hold" or variations thereof.

<u>Push-button "Pause" (operation mode "Pause")</u>

By depressing the yellow push-button "Pause", all previously started computing runs being either in the phases "Pause", "Compute" or "Hold" (push-buttons "Compute" or "Continue") or in operation mode "Hold"(push-button "Hold" depressed), are terminated and replaced by the "Pause"-mode. All other push-buttons of the same row are released and thus also other operation modes are replaced by "Pause"-mode. In this mode, all integrators and stores carry out the initial condition programmed on the APF (charging of computing or storing capacitors to initial value). In the "Pause"-phase, only the integrators take-over the initial conditions.

During operation mode "Pause", programming is effected on the analog patch panel, whereas program selection takes place on the left-hand push-button row of the control field. When switching-on the computer by means of the push-button "On", the push-button "Pause" also should be depressed.

<u>Push-button "Compute" (operation mode "Computation"</u>

By depressing the gree push-button "Compute", all computing runs are started whose program previously was prepared by means of the green program selection push-buttons of the left-hand push-button row. When depressing the push-button "Compute", the previously set modes "Pause" or "Hold" are replaced and the respective push-buttons are released.

All computing runs are started after depressing the push-button "Compute" with a Pause-phase T_P, whose period was fixed by means of the rotary switch setting in the "time selection"-field (timer 1 and basic clock 1 or timer 4 and basic clock 2). The length of the desired computing phase T_R is preset by a respective rotary switch setting of timer 2 and basic clock 1 or timer 5 and basic clock 2, respectively. The "Compute"-mode is terminated by the "Pause"-mode (take-over of new initial conditions for integrators and stores, patched on the APF). This takes place by depressing the push-button "Pause".

The "Compute"-mode is interrupted by different control instructions and replaced by the mode "Hold" (integrators maintain the momentarily given output voltages, as stated in the following section under 1 to 5).

Push-button "Hold" (operation mode "Hold")

By depressing the red push-button "Hold", all computing runs during the "Compute"-phase are interrupted and go to operating condition "Hold". The integrators and stores thereby maintain the respective momentary output voltage. If during actuation of the "Hold"-push-button, a computing run is in the phases "Pause" or "Hold", these phases will follow. A repeated start of the computing run is then possible only by releasing the push-button "Hold" via the push-button "Compute"or "Pause" and subsequent actuation of the "Compute"-push-button.

The following possibilities are given to interrupt the "Compute"-mode and to replace it by the mode "Hold" or phase "Hold":

1. By depressing the push-button "Hold"

2. By patching relay ground to the white jack H with green diagonal in field 2 or 7 on the APF.

3. By connecting binary "0" to jack II on the digital patch panel of the digital adapter unit.

4. By means of an overload of a computing element, if the white push-button "with Hold" located beside the red push-button "Ü" on the left-hand front panel was actuated, (white push-button illuminates).

5. After the preset time T_R of the "Compute"-phase, if the programs "with Hold" or "It.Hand" were entered.

The following possibilities are given to again clear the "Hold"-operation mode:

1. By depressing the push-button "Compute" precondition is however, that the push-button "Hold" was depressed during the "Compute"-phase.

a) Program type "Continuous computing"(push-button "Continuous"). Computation is started from the momentary values.

From this time on, a time sweep voltage is used.

b) Further program types (push-buttons "with Hold", "Repet.","It.aut.", "It.Hand"):

Computation starts with the momentarily reached values. According to the setting of GT1 or GT2, up to 2 x basic clock time is loss for the preset computing time T_R1 or T_R2. A time sweep voltage is started at the reached values, but because of the missing computing time (which is not considered by the saw tooth generator) does no longer reach value 1 (+ 10 V) at the end of the "Compute"-phase. To prevent this error, a respective computing time setting should be used for the program "with Hold", to replace the depression of push-button "Hold", e.g. for observing intermediate values. A repeated computation start then takes place by means of the push-button "Continue".

2. By depressing the push-button "Pause".

3. By depressing the push-button "Continue". Only in combination with the programs "with Hold" or "It.Hand", during which the "Hold"-phase is automatically reached after a preset time T_R. The computing run is then continued with the phase compute, (based on the momentarily reached values) or with the phase "Pause". If previously the "Hold"-push-button was depressed, the limitation under 1b must be observed (can be avoided by basic clock synchronous holding and starting via the DPF).

4. By removing the relay ground on the APF from the white jack H with gree diagonal in fields 2 and 7. Then a computing run interrupted in the "Compute"-phase is continued with phase "Compute" without intermediate "Pause"-phase. Limitations are given as mentioned under 1b (see push-button "Compute", see also 3.).

5. By removing the binary "0" from the red jack H on the DPF of the digital adapter unit. Then a computing run interrupted in the "Compute"-phase is continued with phase "Compute" without intermediate "Pause"-pahse. Limitations are given as mentioned under 1 b (see push-button "Compute",see also 3.).

6. After "Hold" caused by overload of a computing element.

   a) By depressing the push-button "Pause" and removal of the overload. Repeated start is then possible by depressing the push-button "Compute".

   b) By releasing the large white push-button "with Hold" at the left-hand side of the control unit.

The cancellation of a Hold-lock caused by overload results in a continued "Compute"-phase, started from the momentarily reached values.

Limitations are given as mentioned under 1 b (see push-button "Compute", see also 3.).

Push-button "Continue"

By depressing the freen push-button "Continue", a computing run is again automatically started which previously was stopped in operation mode "Hold". The push-button "Continue" is used only in combination with the depressed program selection push-buttons "with Hold", "Continuous" or "It.Hand". The program "It.Hand" (manual) is started with a "Pause"-phase.

Program "with Hold",however, is started with a "Compute"-phase, based on the momentarily reached values. This differs from the normal use of starting a computing run with a "Pause"-phase.

When depressing the push-button "Continue" in combination with the "Continuous"-program, a single sweep voltage (Z-voltage) is caused with time values set by means of timer 2.

The function of the "Continue"-push-button can be controlled in-parallel from the DPF of the digital adapter unit. This requires programming of a 1/0-change at the freen jack WTR.

3.3.2.
Push-Buttons for Program Selection: "Dauer"(continuous), "mit Halt"(with Hold) "Repet.", "It.aut.", "It.Hand" (manual)

The green program selection push-buttons of the left-hand row serve for presetting computing programs which can be controlled in different operation modes by means of the push-buttons mentioned under 3.3.1. A short survey of the fixed-wired programs of the digital control unit is given in section 3.2.1. In the following, a few additional details are given.

Push-button "Continuous" (program "Continuous computation")

The program "Continuous computation" is prepared by depressing the gree push-button "Continuous". The computing time is stopped only by depressing the push-button "Pause". For interrupting the program with succeeding transfer to the "Hold"-mode, the possibilities 1 to 4 are given, as mentioned under 3.3.1. (push-button "HOld"). The different start possibilities are explained in subsections 1, 2 and 4 to 6.

Push-button "with Hold" (program "Computation with Hold"

The program "Computation with Hold" is prepared by depressing the green push-button "with Hold". The program starts with the"Pause"-phase (phase length T_P). The computing phase can be set either two or four T_R digit; for two-digit setting by means of timer 2 and basic clock 1, for four-digit setting by means of timer 2, timer 1 and basic clock 1 (white designation). After the computing phase T_R the operational condition "Hold" is reached. Further computing phases may then be started by depressing the not locking push-button "Continue", whereby further computing phases are always terminated in condition "Hold". The "Pause"-phase T_P thereby will be omitted, so that between the subsequent computing phases no initial value conditions are taken over by integrators and stores. The length of the subsequent computing phases can be changed by adjusting the "Pause"-phases T_R after reaching operation mode "Hold".

The computing run is terminated only by depressing the push-button "Pause".

For interruption before reaching the preset computing time with subsequent transfer to operation mode "Hold", the same possibilities 1 to 5 are given, as mentioned under 3.3.1. (push-button "Hold"). The different start possibilities also correspond to those mentioned under points 1 to 6.

The function of the push-button "Continue" can be controlled in-parallel from the DPF of the digital adapter unit. Therefore, programming of a 1/0-change at the green jack WTR is required.

Push-button "Repet." (program "Repetitive computing)

The program "Repetitive computing" is initiated by depressing the green push-button "Repet." and again terminated by push-button "Pause". For interruption of the computing run by means of the push-button "Hold", see also respective notes given in section 3.3.1, points 1 to 4. As to a repeated start, points 1, 2 and 4 to 6 are valid.

When setting the Pause time T_P, it must be observed that its value is $1/k_0$ of the smallest integration factor k_0 of the integrators patched on the APF. (E.g. 1 s at k_0 = 1 s-1). Otherwise, computing errors could occur because of incomplete charging of the integrator capacitor to the voltage value of the initial conditions.

Push-button "It.Aut."(program "Automatic interative computation")

The program "Automatic interative computation" is prepared by depressing the green push-button "It.aut.".

The program is used for automatic iterative computing with two groups of integrators or stores. These two groups are formed by programming integrators and stores as normal or complementary computing elements on the APF. The program run can be seen in Fig. 3.2.1/2. A four-digit setting of the computing phase is not possible.

The basic clocks 1 and 2 and the timer settings can be selected different for each of the two alternating interation clocks. Thereby, it must be observed that the sum for the phases "Pause", "Compute" and "Hold" of the iteration clock plus the smaller basic clock time must be equal to the basic clock time of the second iteration clock or an even multiple of it. Otherwise, no defined clock transfer is ensured.

The following equation must be given:

$(F_p + F^R + 1) \times GT_K = n \times GT_l$ ($n \geqq 1$, even) with

GT_K	=	set shorter basic clock
GT_l	=	set longer basic clock
F_p	=	setting of Pause time factor with shorter basic clock time
F^R	=	setting of computing time factor with shorter basic clock time

With same basic clock setting for both iteration clocks, the equation is always given so that no further attention must be paid.

The program is terminated by depressing the push-button "Pause". For interrupting the com

For interrupting the computing run by means of the push-button "Hold", see respective section 3.3.1.,points 1 to 4, or points 1, 2 and 4 to 6 for repeated start, respectively.

It must always be observed that the resulting Pause time prior to the "Compute"-phase must be at least $1/k_0$ of the smallest integration factor k_0 of the integrators patched on the APF.(E.g. 1 s at $k_0 = 1\ s^{-1}$). The resulting Pause-phase for an interation clock is composed of the length of the second iteration clock plus the set Pause-time T_P. This condition can always be met by prolongation of T_P. If not, computig errors may occur because of an incomplete charging of the integrator capacitor to the voltage value of the initial conditions.

Push-button "It.Hand" (It.manual)
(program iterative computation with manual start)

This program is prepared by depressing the green push-button "It.Hand"(It.manual). It farmost corresponds to the automatic iterative computation, with the following differences:

After termination of the first iteration clock with the phases "Pause 1", "Compute 1" and "Hold 1", all normal integrators remain in phase "Hold". The normal stores remain in condition "Follow". The illumination of the red lamp for the first iteration clock, located in the upper part of the "Time selection "-field, indicates that the "Hold"-phase is reached. This phase remains until actuating the push-button "Continue". Then, the phase "Hold" for the first iteration clock goes over into a Pause condition "Pause Z1". (Red lamp extinguishes, yellow lamp illuminates). Now, the normal integrators patched on the APF will take-over the initial conditions, whereas the normal stores keep their output values given at the switching time point.

Simultaneously, the second iteration clock is started, running through the phases "Pause 2", "Compute 2", "Hold 2" until finally stopped in phase "Hold 2" (red lamp of lower part of "Time selection"-field illuminates). Now the complementary integrators keep their values, and the complementary stores follow-up, whereas the normal integrators are still in the Pause-condition, and the normal stores keep their values.

A repeated actuation of the push-button "Continue" then causes the complementary integrators to go over into Pause-condition "Pause Z2", and the complementary stores to go over from "Follow" to "Hold", whereas the normal integrators run through the phases "Pause 1", "Compute 1", "Hold 1" being followed by the normal stores.

Each actuation of the "Continue"-push-button thus causes an iteration clock which is started with the settable time T_P of the "Pause"-phase. As to the setting of Pause-phases, Compute-phases and Hold-phases, see also respective chapter push-button "It.aut.".

There are no conditions for the selection of the basic clocks. A four-digit setting of the compute-phase T_R1 is not possible.

The program is terminated by depressing the push-button "Pause". For interruption of the computing run by means of the push-button "Hold", see respective notes given under 3.3.1. points 1 to 5, as well as points 1 to 6 for a repeated start.

A change of the iteration clocks can be controlled not only by means of the push-button "Continue", but also from the DPF of the digital adapter unit. There, the blue jacks H1E, H2E, 1T2 and 2T1 are used. Further details see section 3.4.3.

It must be observed that the resulting pause time prior to the start of the "Compute"phase must be at least $1/k_0$ of the smallest integration factor k_0 of the integrators patched on the APF (e.g. 1 s at $k_0 = 1\ s^{-1}$). The resulting pause phase for an iteration clock is composed of the length of the respective second iteration clock, of the time period until generation of a "Continue"-instruction and of the settable pause time T_P. With manual actuation of the "Continue"-push-button, this condition practically is always met, but must be considered in case of control for the digital adapter unit.

The condition can always be met by a respective prolongation of T_P. If not, computing errors may occur by incomplete charging of the integrator capacitors to the voltage value of the initial condition.

3.3.3.
Program
"Single Run"
(1 x R)

By depressing the push-buttons "Fremd" (external) and "Progr."(program), the "Single Run"-program is called. Further push-buttons of the control panel may be depressed, but do not influence the program run. After program call, the push-buttons "Progr.", "Eigen"(self) "Fremd"(external) and "Halt"(hold) will illuminate.

The program can be started:

from the DPF via the jack "1 x R".

After the start, the phases

"Pause" - "Compute" - "Hold"

are run-through only once, followed by a pause-phase being terminated by the next start instruction. This pause-phase should be at least 1 s. The time length of the phases "Pause"(T_P) and "Compute"(T_R) are set by means of the timers 1 and 2. The length of the phase "Hold" is approx. 15 ms, independent from the selected basic clock 1. The start instruction is given by means of a pulse of the length t, by

connecting the jack "1 x R" to binary "0" during a time t.

The pulse must be applied for at least 10 ms and must be terminated before start of the "Hold"-phase. After start, the indicating lamp of the push-button "Hold" will extinguish, whereas the push-button "Compute" illuminates and permits monitoring until termination of the "Hold"-phase; in the following the "Pause"push-button shortly illuminates (simulataneously, the p-control supplies binary "0"), which is again followed by the "Hold"-push-button illumination.

3.3.4.
Push-Buttons for Parallel Switching Functions and External Control: "Eigen"(Self),"Fremd" (External)

These two push-buttons are used only in case of parallel operation of the computer with other computers having their own digital control units DBG 771, or if the control takes place via a digital computer or punched-tape control unit.

Parallel control:
After connecting the computers via respective parallel switching cables and after switch-on, the push-buttons "Fremd"(external) of all control units illuminate. By depressing the push-button "Eigen"(self) on one of the control units, the commanding unit is determined. Its "External"push-button extinguishes, whereas the "Self"-push-button illuminate. With each switch-on of the total system, all computers first are set for external control, so that the commanding unit must be determined each time.

As commanding computer, always a computer with digital adapter unit should be selected.

The push-buttons of the right-hand row of the field "Control" are then only actuated on the commanding unit, i.e. the selection of operation modes, the potentiometer setting as well as testing and balancing functions are carried out centrally. The push-buttons of the parallel connected computers however also illuminate according to the entered functions. The push-buttons of the left-hand row must be actuated on all computers of the system, according to the desired computing program.

The selection of computing elements, the value display on the digital voltmeter, a print-out of measuring values via connected printers as well as setting of the timers must be carried out separately at the different computers of a system. Setting of basic clocks and timers can be different at both control units. The central overload indication is displayed on all computers of a system in case of overload of a computing element. Independent operation of parallel-connected computers is possible only after removing the parallel-connecting cables.

External control:
For control by means of a digital computer or a punched-tape control unit, the push-button "Fremd"(external) must be depressed and in this case illuminates together with the "Self"-push-button.

3.3.5.
Notes for Push-Buttons "Progr.", "Pot.", "Null", "stat.","dyn."

Push-button designation	Function	Description given in section
"Prog."	1) External program control, start of a new computing cycle can be controlled on DPF	3.4.3.
	2) Program "Single Run"	3.3.3.
"Pot."	1) Potentiometer setting	4.3.
	2) Setting of function generators in drawer VFG 801	4.5.1.
"Null"	Zero-balancing of operational amplifier	3.6.3.
"stat."	Static program check	3.6.4.
"dyn."	Dynamic check. Testing of integrator capacitor and of integrator function	3.6.5.

3.3.6.
Push-Button for Overload Stop

Two large push-buttons for control of computer functions at overload of rational amplifiers are provided on the left-hand side of the control unit front plate below the Zero-instrument.

The red push-button"Ü" thereby serves as central overload indication for the whole system. Its function is described under 4.2.

The push-button "with hold" controls two functions, depending on the respective operation. This push-button is not interlocking.

1. Push-button not depressed:
   The computing run is continued even in case of overload of one or several operational amplifiers. The push-button "Ü" or the respective overload lamps illuminate shortly or permanently.

2. Push-button depressed (illuminated):
   In case of overload the computer goes to operation mode "Hold" independent from the selected computer program.

Push-button "Ü" and the lamps of the overload operational amplifiers than illuminate.

The computing can be again started only after depressing the push-button"Pause" and after removing the overload on the APF. Repeated start takes place by depressing the push-button "Compute".

The computing run can further be continued without depressing the push-button "Pause" by means of the push-button "with hold". In this case, however, the preset computing phase may show time errors.

3.4.
Control Function of the Digital Adapter Unit

This section informs about the cooperation of the digital adapter unit with the digital control unit, the output devices and the hybrid coupling unit in case the hybrid analog computer is used in combination with a digital computer within a hybrid computer system. Further explanations as to the function of the digital adapter unit are given in the following sections:

Single control of integrators	4.2.3.5.
Control lines of comparators	4.10.
Replacable, digital computing elements	4.17.
Stepping switch	4.18.
Manual switch of DPF	4.21.
Binary "0", binary "12, multiple	4.20.

In the following tables, the color and position of the jacks on the digital patch panel (DPF) are listed in column DZ 772.

<u>General determinations</u>

1a) Assignment of the Boolean variables "0" and "1" (≙"L") to the respective electrical potentials on the DPF:

Binary Zero ("0") ≙ 0...+ 1 V

(for external wiring, -1...+ 1V is required);

binary One ("1" or L) ≙ +8...+12 V,

(for external wiring, the same values are required).

1b) Not wired inputs are assumed to be connected to "1".

1c) Static inputs are activated by "0".

1d) Clock inputs react on to a 1/0-change. Required height: 9V $\pm$ 1 V, steepness: 50 ns/V.

1e) Lamp display on card backs of freely programmable components as well as of comparator switches and of stepping switch:

The respective lamp allocated to the different components and comparator switches illuminate, if their output leads binary "1".

The lamps of the stepping switch card indicate the respective position of the switch.

2) Color code of digital patch panel

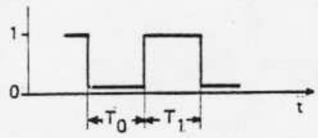
green:	inputs of freely programmable digital elements, control input to stepping switch. Inputs to hybrid coupling unit.
orange:	outputs of freely programmable digital elements, of comparator amplifiers, of the stepping switch. Outputs of hybrid coupling unit.
yellow:	outputs of clocks, timers, control outputs.
white:	control inputs to peripheral devices. Free diodes, multiples, cross-connection lines.
red:	binary "1".
blue:	special control inputs to digital control unit.
brown:	control inputs of switches (integrator control switch, comparator switch.Free computer control, manual switch.
black:	binary "0" and not occupied jacks.

3.4.1. Push-Buttons of Digital Adapter Unit Stop, Run, Lö, HT

The two push-buttons Run and Stop influence the yellow jack row WT. Push-button Run thereby supplies a clock being selected via the rotary switch. The Stop push-button interrupts this clock. The operation mode is indicated by illumination of the respective push-button (see also 3.4.2.1.4.

The push-button Lö is used for clearing the digital elements FF, ZL 2 and SR 2 (see also 3.4.2.4.)

The push-button HT is provided for manual clock (see also 3.4.2.1.4., and 3.4.2.1.5.).

Number	Meaning of Jacks	Jack Designation	DZ 772			Function
			Color	Line	Column	
3.4.2..	Clocks and control signals of DPF					
3.4.2.1	Clocks					All clocks are derived from the central 100 kHz generator clock of the DBG. The square-wave clock pulses have different duty cycles (IPV).[1] Between the decade spaced clocks, a time shifting of 3.5 µs is given. 1) IPV: IPV = $T_0 : T_1$ 
3.4.2.1.1.	Fixed clocks	10 µs	yellow	27	3-4	Duty cycle: symmetrical
		100 µs	yellow	27	1-2	Duty cycle: symmetrical
		1 ms	yellow	26.	3-4	Duty cycle: symmetrical
		10 ms	yellow	26	1-2	Duty cycle: symmetrical
		100 ms	yellow	25	3-4	Duty cycle: symmetrical
		1 s	yellow	25	1-2	Duty cycle: symmetrical
		0.5 s	yellow	26	49-50	Duty cycle: 4 : 1
		2 s	yellow	27	49-50	Duty cycle: symmetrical
3.4.2.1.2.	Basic clocks (GT)	GT 1	yellow	28	1-4	These jacks provide the basic clock 1 (GT 1) set on the DBG
		GT 2	yellow	29	1-4	These jacks provide the basic clock 2 (GT 2) set on the DBG

Number	Meaning of Jacks	Jack Designation	DZ 772			Function
			Color	Line	Column	
3.4.2.1.3.	Clock for stepping switch (counter magnet)	0.5 / 2s	yellow	26	51-52	0.5 s-clock applied with depressed push-button "Print-on" on DBG or if jack DE is connected to "0", otherwise a 2 s-clock is applied without clock amplifier.
3.4.2.1.4.	Clocks of the selector switch	WT	yellow	19	11-42	These jacks provide the clock set on the rotary switch (rh-side from DPF on drawer panel) as long as push-button "Run"(below switch) is effective and illuminated.With push-button "Stop" being effective,(illuminated), the selected clock is switched-off. "Run" and "Stop" are caused by push-buttons, whereby the other mode is automatically cancelled. The following clocks can be selected: GT1 and GT2, 1ms, 10ms, 100ms, 1s, HT. All clocks are blocked if ÜH="0", i.e. if a) white push-button"with Hold' is depressed on DBG <u>and</u> b) one amplifier is overload In position "HT" of the rotary switch, a single clock (manual clock) can be initiated by means of the yellow push-button "HT"(see 3.4.2.1.5
3.4.2.1.5.	Manual clock	HT	yellow	25	49-52	A single clock is caused via push-button "HT" on the digital adapter unit. The jacks HT supply a binary "1". With actuation of the push-button, a change from binary "1" to binary "0" takes place which remains as long as push-button HT is depressed.
3.4.2.2.	Timers Timer 1	ZG1	yellow	17 30-32	3-4 15	During phase $T_p 1$, binary"0" is applied, otherwise"1".

Number	Meaning of Jacks	Jack Designation	DZ 772			Function
			Color	Line	Column	
	Timer 2	ZG 2	yellow	17 30-32	11-12 16	During phase T_R1, binary "0"is applied, otherwise "1".
	Timer 3	ZG 3	yellow	17 30-32	19-20 17	During phase T_H1 binary "0" is applied, otherwise "1".
	Timer 4	ZG 4	yellow	17 30-32	27-28 18	During phase T_P2, binary "0" is applied, otherwise "1".
	Timer 5	ZG 5	yellow	17 30-32	35-36 19	During phase T_R2, binary "0" is applied, otherwise "1".
	Timer 6	ZG 6	yellow	17 30-32	43-44 20	During phase T_H2, binary "0" is applied, otherwise "1".
3.4.2.3.	Control lines					
	Signal from Pause-push-button	p	yellow	30-32	21	After depressing the Pause-push-button on the DBG 771, binary "1" is available at p, whereas "0" is given at $\bar{p}$. If not depressed, p = "0" and $\bar{p}$ = "1".
	Normal partial cycle	p	yellow	30-32 31	22 38	During phase compute 1(T_R1) and Hold 1 (T_H1), "1" is given, otherwise "0".
		r1 r1	yellow	30-32	23	During phase compute 1(T_R1) and Hold 1(T_H1),"0" is given, otherwise "1".
		h1	yellow	30-32	24	During phase compute 1(T_R1) "0"is given, ohterwise "1",h1 =ZG 2.

Number	Meaning of Jacks	Jack Designation	DZ 772			Function
			Color	Line	Column	
	complementary partial cycle					
		r2	yellow	30-32	25	During phase compute 2 ($T_R 2$) and Hold 2 ($T_H 2$), "0" is given, otherwise "1".
		h2	yellow	30-32	26	During phase compute 2 ($T_R 2$) "0" is given, otherwise "1". h2 = ZG 5.
3.4.2.4.	Clearing					The FF are cleared if their outputs A = "0" and $\bar{A}$ = "1". The shift registers are cleared after their stages (consisting of flip-flops) are cleared. The counters are cleared in position "0".
		Lö	white	30	38	Jack Lö influences all static clearing inputs of flip-flops on the FF-cards and supplies a return signal at the respective jacks lö of the cards SR2 and ZL2. "0" at Lö clears all FFs and also all SR2 and ZL2, if at the latter Lö is connected to N_s. If jack Lö is connected to the below situated jack $\bar{p}$(31/38), clearing takes place when depressing the push-button "Pause" on the DBG. Push-button "Lö" on the panel of the digital adapter unit has the same effect than "0" on jack Lö.
3.4.2.5.	Overload signalling (overload hold)	ÜH	yellow	30-32	31	To this jack ÜH (overload hold), "0" is applied if push-button "with hold" on the DBG is depressed and if an amplifier is overload. Otherwise "1" is given.

Number	Meaning of Jacks	Jack Designation	DZ 772 Color	DZ 772 Line	DZ 772 Column	Function
3.4.3.	Program control via the DPF					
3.4.3.1.	Free Computer Control via the Central Control Lines					

The free computer control permits program control via the active control lines r, h, $\bar{r}$, $\bar{h}$, p of the APF 1) only from the digital adapter unit 2) from the digital adapter unit and from the digital control unit.

1). For exclusive control from the digital adapter unit, push-button "Pause" must be depressed. The active control lines then lead the signals supplied to the above mentioned jacks of the DPF. (Not connected ≙binary "1"). The automatic control of output devices (oscilloscope, printer, digital voltmeter, XY-plotter, 8-channel-recorder) and the time sweep generator (saw tooth) thereby are not operative. The control via jacks OD, OH, DE, DB, LZ, FA of the DPF is effective.

2). With simultaneous control from digital control unit (DBG) and digital adapter unit (DZ) it must be observed that the binary value of the resulting signal is given by conjunctive linking.

$$S = S\ (DBG) \wedge (DZ)$$

x Thereby, each program of the DBG may run. Output devices are controlled normally. Example: repetitive computing (push-buttons "Repet." and "Compute" depressed). $\bar{h}$ (DBG) = constans="1", $\bar{h}$ = "0" if jack OH1 is connected to "0", $\bar{h}$ = "1", if OH1 is not connected or connected to "1", p = p,(DBG)= constans = "0" independent from connection of jack OP.

Number	Meaning of Jacks	Jack Designation	DZ 772 Color	DZ 772 Line	DZ 772 Column	Function
p-control line	p-control line	0P	brown	30	10	Applying "0" causes activation of the p-control line of master computer
		1P	brown	31	10	Applying "0" causes activation of the p-control line of first slave computer
		2P	brown	32	10	Applying "0" causes activation of the p-control line of second slave computer
	r1-control line*)	0R1	brown	30	11	Applying "0"causes activation of the r1-control line of master computer
		1R1	brown	31	11	Applying "0"causes activation of the r1-line of first slave computer
		2R1	brown	32	11	Applying "0"causes activation of the r1-control line of second slave computer

*) h1, h2, r1, r2 jack designations on DPF, whereby the respective signals on the APF are h, $\bar{h}$, r, $\bar{r}$.

Number	Meaning of Jacks	Jack Designation	DZ 772			Function
			Color	Line	Column	
	h1-control line	0H1	brown	30	12	Applying "0" causes activation of h1-control line of master computer
		1H1	brown	31	12	Applying"0" causes activation of h1-control line of first slave computer
		2H1	brown	32	12	Applying"0" causes activation of h1-control line of second slave computer
	r2-control line	0R2	brown	30	13	Applying "0" causes avtivation of r2-control line of master computer.
		1R2	brown	31	13	Applying "0" causes activation of r2-control line of first slave computer.
		2R2	brown	32	13	Applying "0" causes activation of r2-control line of second slave computer.
	h2-control line	0H2	brown	30	14	Applying "0" causes activation of h2-control line of master computer.
		1H2	brown	31	14	Applying "0" causes activation of h2-control line of first slave computer
		2H2	brown	32	14	Applying "0" causes activation of h2-control line of second slave computer.
3.4.3.2.	Hold-instruction	H	green	31	27	Applying of "0" in phase Compute 1 (T_R1) or Compute 2(T_R2) causes: The timer of the respective computing phase is stopped. The computer goes over to Hold. Removal of the "0" causes the computer to continue. If the connection or disconnection of "0" to jack H is not carried out synchronously with the basic clock, time errors up to 2 basic clock lengths may occur. Applying of "0"in phase Hold 1 (T_H1) or Compute 2(T_R2) causes:

If"0" remains connected for more than the preset Hold-phase(basic clock period),the Hold-phase is prolonged respectively. The start of the succeeding phase is then synchronized to the basic clock arriving after removal of"0" from H.
Connection of "0"during phase Pause 1 (T_P1) or Pause 2 (T_P2) causes:if"0"remains effective longer than the preset Päuse-phase, the Päuse-phase is prolonged respectively. After transfer from H=1, the following computing phase is started synchronously to the basic clock.

Number	Meaning of Jacks	Jack Designation	DZ 772			Function
			Color	Line	Column	
3.4.3.3.	Continue instruction	WTR	green	31	29	Only effective, during program modes:"with Hold","It. Hand".A change from 1/0 at WTR again starts a new computing phase (T_R) synchronous to the basic clock. The minimum Hold-phase (T_H) is approx.0.5 s,i.e.it is smaller than 1 s for GT= 1ms,10ms,100ms, at GT = 1s it equals 1s.
3.4.3.4.	End of Hold period and start of new computing cycle (Hold time end)	HE	green	31	38	Jack "HE"permits to differ from times being preset on timer 2 and 5,i.e.to operate with smaller computing times during the programs"Repet. Comp.""Aut.It.Comp."and "Manual It.Comp.".For example, for an iterative solution of subsidiary problems for which the computing time is undetermined, i.e.depending on the problem size, a computing time is set at the timers which must be larger than the longest expected computing time (100 s max.can be preset).

With such programs, jack "HE" can be used with or without jack "H". "HE" is activated by binary "0", i.e. the change from 1/0 causes an computing time end instruction with the following effect:

a) "HE" without "H":

The computing phase is immediately terminated after the 1/0-signal, the Hold-phase is started, which

a1) in case of repetitive computing and autm.iter.comp. is between approx.10 µs and a basic clock time,

a2) which during iter.comp. with manual start is terminated by a continue instruction. The following Pause-phase is always started synchronous to the basic clock.

b) "HE" with "H":

By using the H-jack, first the computing phase is interrupted. Any Hold-phase length can be generated. The HE-signal can be generated together with the H-signal or after removal of the H-signal. In any case, however, signal HE prevents a subsequent termination of the preset computing time and the program is continued as under a1) or a2), which means that the Hold-phase is prolonged by 1 basic clock period maximum in case of a program type as under a1).

Signals"H" and "HE" can be derived from a common control flip-flop, which normally is set by a comparator. Resetting is then carried out by the desired Hold-time end signal. A control the HE-jack also causes a print instruction. Further control modifications are possible by means of push-button "Progr.".

Number	Meaning of Jacks	Jack Designation	DZ 772			Function
			Color	Line	Column	
3.4.3.5.	Computing time end signal blocking	RE	green	32	27	By applying binary"0" to jack "RE", the compute time end signal is blocked, which occurs at the end of each computing phase (only T_R1). Thus, the compute phase may exceed the preset computing time. Especially repetitive computing cycles with phases T_R 100 s can be programmed. The jacks "H" and "HE" are used additionally. "RE" first blocks the compute time end signal, whereas "H" terminates the computing phase and "HE" again starts the new cycle. Note: Saw tooth voltage goes to overload. If necessary, a recovery time must be considered.
3.4.3.6.	End of Hold-phase					Only effective after depressing push-button "Progr." on DBG and during program modes "Repet.", "It.aut." or "It.Hand".
	End of Hold-time 1 (Hold-time end 1)	H1E	blue	30	27	With the above given conditions, the length of the Hold-phase T_H1 is independent from the preset basic clock time GT 1), but must be at least equal to one basic clock time period. The Hold-phase is terminated by a change from 1/0 at "H1E". Then, the Pause-phase follows (T_P1 and T_P2). Phase start is synchronous to the basic clock only after the 1/0-change was synchronous. For program "It.Hand", an additional 1/0-change must be applied to jack "WTR".

Number	Meaning of Jacks	Jack Designation	DZ 772			Function
			Color	Line	Column	
	End of Hold-time 2 (Hold-time end 2)	H2E	blue	30	28	With above given conditions, the length of the Hold-phase T_H2 is independent from the preset basic clock time (GT 2), but must be at least equal to one basic clock time period. The Hold-phase is terminated by a change from 1/0 at "H2E". Then, the Pause-phase follows (T_P1 and T_P2). Phase start is synchronous to the basic clock after the 1/0-change was synchronous. For program "It.Hand", an additional 1/0-change must be applied to jack "WTR".
3.4.3.7.	Computing cycle change (change of iteration clocks)					Only effective, after depressing push-button "Progr."on the DBG and during program modes "It.aut." or "It.Hand" (for program "It.Hand", an additional 1/0-change must be applied to jack "WTR").
	Clock change from normal (1) to complementary (2)	1T2	blue	30	29	A change 1/0 at "1T2"causes a transfer from normal to complementary partial cycle, i.e. from phase T_H1 to phase T_P2. Tis 1/0-change must occur at least one basic clock period before the 1/0-change at "H1E". The 1/o-change for clock change must occur only after end of computing phase, i.e. the Hold-phase T_H1 must have at least the length of a basic clock period. To prevent time errors in the following Pause-phase, the pulse at "H1E" should be synchronized to the respective basic clock or a slower clock.

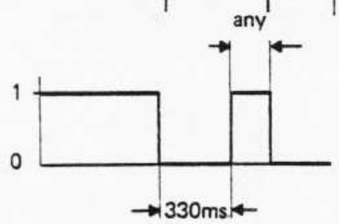
Number	Meaning of Jacks	Jack Designation	DZ 772 Color	Line	Column	F u n c t i o n
	Clock change from complementary (2) to normal (1)	2T1	blue	30	30	A change from 1/0 at "2T1" causes transfer from complementary to normal partial cycle, i.e. from phase $T_H 2$ to phase $T_P 1$. Timely conditions are similar to those at "1T2".
3.4.3.8.	Computer control (10 x faster or time constant control input)	ZSE	brown	31	30	Connection of "0" causes: a) Increasing of both basic clock frequencies GT 1 and GT 2 by the factor 10, thus also increase of the clocks of selector switch and control line, i.e. shortening of all phase-times by factor 0.1. b) Increasing of timer clock frequencies (ZG1...ZG6) by factor 10. c) Switch-over of all integrator capacitors to a next following with a value smaller by factor 10. d) Switch-over of saw tooth voltage, jack Z on APF. e) Illumination of luminous push-button "10x" in the manual potentiometer field. f) Return signalling of the "0" to the jacks "ZSA" of MF1.
	Time constant control output	ZSA	yellow	32	29,30	After actuating the push-button "10x" or after connecting "0" to jack ZSE, a "0" is available at jack row 32/29, 30 and at the respective monoflop jacks ZSA. The monoflops MF also take part of the "10x" process if their jacks ZSA are connected to F.

Number	Meaning of Jacks	Jack Designation	DZ 772			Function
			Color	Line	Column	
3.4.3.9.	Group control of time constants					By means of three jack pairs the integrators of fields 2 and 7, (integrator number 21, 22, 70, 71 and 72) can be disconnected from the 10x-faster switch-over (10 x push-button and jack) of the integration speed (capacitor switch-over) independent from each other at the master and at two slave computers. Thus, the change-over can be carried out independent from the central control at any desired time.
	Switch-over of time constants control	0ZSU	brown	30	8	By connecting "0", the integrators 20, 21,22,70,71,72 of the master computer are disconnected from the central 10 x-faster line, so that the push-button "10x" and ZSE remain ineffective.
		1ZSU	brown	31	8	As 0ZSU, but for slave computer 1.
		2ZSU	brown	32	8	As 0ZSU, but for slave computer 2.
	Time constants control input for single group control	0ZSE	brown	30	7	If 0ZSU is connected to "0", the integrators 20,21,22,70,71, 72 of the master computer are switched to 10x-faster.
		1ZSE	brown	31	7	If 1 ZSU is connected to "0", the integrators 20,21,22,70, 71,72 of the first slave computer are switched to 10x-faster.
		2ZSE	brown	32	7	If 2 ZSU is connected to "0", the intergrators 20,21,22,70, 71,72 of the second slave computer are switched to 10x-faster.

Number	Meaning of Jacks	Jack Designation	DZ 772 Color	Line	Column	F u n c t i o n
3.4.3.10.	Single compute instruction	1xR	green	32	18	see 3.3.3.
3.4.3.11.	Control of time sweep generator	Z	brown	30	35	see 4.9.4.
3.4.3.12.	Freely programmable control possibilities	Q00... Q11	brown	26,28	7..12	The jacks Q00...Q11 are relay amplifier inputs separated from each other which are activated by "0". They control relays for switching-through relay ground or control ground to the APF. The switch outputs are connected to connector St17 provided on the rear side of the digital adapter unit. When changing the normal cable connection between St1 or connection panel 2 and St10 of the digital adapter unit to St17, the switch outputs are connected to the jacks Q00...Q11 of the APF.

Number	Meaning of Jacks	Jack Designation	DZ 772 Color	Line	Column	Function
3.4.4.	Control of input and output devices					
3.4.4.1.	Oscillos-cope					
3.4.4.1.1.	Oscillos-cope un-blanking	OH	white	31	34	"0" causes unblanking of the oscilloscope at any time.
3.4.4.1.2.	Oscillos-cope blan-king	OD	white	32	34	"0" causes blanking of the oscilloscope. OD is dominant, as compared to OH.
3.4.4.2.	Digital Voltmeter					
3.4.4.2.1	Measuring instruction (print in-struction)	DB	white	30	36	A change 1/0 also causes a measuring-print instruction for the digital voltmeter during the computing phase (see 3.4.4.3.4.) Note: With push-button "Print-on" depressed on the DBG - but without a printer being con-nected - a measuring process requires approx. 800 ms. With connected printer, the ack-nowledgment signal is awaited; in this case two instructions per second are possible.

Number	Meaning of Jacks	Jack Designation	DZ 772			Function
			Color	Line	Column	
3.4.4.3.	Digital printer					
3.4.4.3.1.	Printer control (printer on)	DE	white	32	35	This input is disjunctively linked to the push-button "Printer on" of the DBG. "0" connects the printer to the output of the digital voltmeter.
3.4.4.3.2.	Print-instruction blocking 1	DB1	white	31	36,37	Connection of both jacks prevents the measuring-print instruction at the end of the normal partial cycle. Note: Jack 31/37 leads - 15 V!
3.4.4.3.3.	Print-instruction blocking 2	DB2	white	32	36,37	Connection of both jacks prevents the measuring-print instruction at the end of the normal partial cycle. Note: Jack 32/37 leads - 15 V!
3.4.4.3.4.	Print-instruction	DB	white	30	36	A change 1/0 at any time causes: a) measuring instruction to the digital voltmeter. b) Print-instruction to digital printer. DB is dominant as compared to DB1 and DB2. (See 3.4.4.2.2.)
3.4.4.3.5.	Empty line	LZ	white	30	37	"0" causes print-out of an empty line, i.e. single line feed without printing after connection. Max. sequence 2 per sec. Minimum pulse length 330 ms. LZ is dominant as compared to DB1 and DB2. With push-button "Print-on" being depressed, a measuring process requires approx. 800 ms without connected printer.



Number	Meaning of Jacks	Jack Designation	DZ 772			Function
			Color	Line	Column	
3.4.4.4.	XY-plotter					
3.4.4.4.1	Pen drop blocking 1	FA1	white	31	32,33	Connection of both jacks prevents pen dropping of a connected plotter within phase T_R1. During phases T_P1 and T_H1 the pen is always lifted.
3.4.4.4.2.	Pen drop blocking 2	FA2	white	32	32,33	During complementary partial cycle, FA2 has the same effect than FA1 during the normal partial cycle.
3.4.4.4.3.	Pen drop instruction (pen control)	FA	white	30	32	FA is dominant as compared to FA1 and FA2. For free control of the pen, the fixed programmed pen drop control is switched-off via FA1 or/and FA2, and a special drop control is reached by connecting "0".
3.4.5.	Control data transfer between digital adapter unit and hybrid coupling unit					
3.4.5.1.	Parallel output					
3.4.5.1.1.	Static parallel output PA1 and PA2					
	Static parallel output 1	PA1 1...6	orange	33	1..6	These jacks are outputs of the parallel output register 1.
	Static parallel output 2	PA2 1...6	orange	34	1..6	These jacks are outputs of the parallel output register 2.

Number	Meaning of Jacks	Jack Designation	DZ 772			Function
			Color	Line	Column	
3.4.5.1.2.	Dynamic parallel output					
	Parallel output	PA 1...12	orange	33	7..18	These jacks are outputs of the HKW-buffer register. Evaluation of the available information is controlled by the parallel output clock.
	Parallel output clock	PAT	yellow	33	19	With a clock pulse supplied to the jack of the parallel output clock, the information of the HKW-buffer register is determined for evaluation at the digital adapter unit.
3.4.5.1.3.	Buffered control word output	PPA 1...12	orange	34	31... 42	Outputs of PPA-register (no standard euqipment)
3.4.5.2.	Parallel input	PE 1...12	green	34		Jacks PE are provided for parallel input of a binary information.
3.4.5.3.	Scanning lines	AL 10...24	green	33	23... 37	The jacks lead to freely programmable selection lines. They are scanned from the digital computer. See Makro-description of respective digital computer.
3.4.5.4.	Interrupt lines	UB 5...16	green	34	19... 30	These jacks are inputs of the interrupt unit. A change from 1/0 causes setting of a monoflop for approx. 2.5 µs, which again causes interruption in the digital computer.

Number	Meaning of Jacks	Jack Designation	DZ 772			Function
			Color	Line	Column	
3.4.5.5.	External control of cycle time counter					
	External count clock	EZT	white	33	20	Via this jack, the cycle time counter of the hybrid coupling unit can be externally clocked from the digital adapter unit, if bits 15 and 16 in the cycle time register are "0".
	Cycle time counter erase block-ing	ZLS	white	33	21	The cycle time counter of the hybrid coupling unit is erased at stop of the analog computer, with the following exceptions: 1) if the jacks ZLS are supp-lied with "0". 2) During program "Compute with Hold" 3) If the Hold-instruction jack (APF or DPF) is supp-lied with "0".
	Cycle time end signal	ZES	white	33	20	To activate jack ZES, the switch DZ on the control pa-nel of the hybrid coupling unit must be depressed. Then, the cycle time end can be set via ZES (1/0-change) which is normally only supplied on-ly from the cycle time coun-ter.
	External control of cylce time counter	ZEX	green	34	43	Binary "0" permits external control of the cycle time counter (no standard equip-ment).
	Clock re-lease of cycle time counter	ZTF	green	34	44	Binary "0" permits counting of the cycle time counter at external control. Binary "1" interrupts the counting pro-cess (no standard equipment).
	Clearing of normal time counter	ZNO	green	34	45	Binary "0" clears the cycle time counter, i.e. setting to "0". When removing binary "0", the counter takes-over the value from the cycle time register (no standard equip-ment).

Number	Meaning of Jacks	Jack Designation	DZ 772 Color	Line	Column	F u n c t i o n
3.4.5.6.	External control of buffered data input and output					
	Cycle time end	ZZE	orange	34	46	After the cycle time counter has reached value "0", a pulse is supplied whose length depends on the selected basic clock. During the cycle time end, binary "0" is given, otherwise "1"(no standard equipment).
	Parallel hold	PAHA	green	34	48	With binary "0" the scanning and hold-circuits are in condition "Hold"(no standard equipment).
	Control of common clock from D to A	GTDA	green	34	47	Binary "0" blocks the common transfer clock if during this blocking a data transfer with clock arrives, another transfer clock will be generated after removing the blocking (no standard equipment).
3.4.6.	Cross-connection lines	0...39	white	1..20	1,2	See 4.14. Connections to St8 and St9 on rear side of digital adapter unit.
		0...39	white	1..20	1,2	
		0...39	white	1..20	51,52	See 4.14. Connection to St10 and St11 on rear side of digital adapter unit. These cross-connection lines can also be connected to the jacks Q0, Q1, or Q2, Q3 of the APF via a connecting cable on the rear side of the computer.
		0...39	white	1..20	51,52	

3.4.7. Alphabetic Listing of Jacks on the DPF

Jack designation	Section number
a	4.10.
$\underline{A}$	4.18.
$\overline{A}$	4.18.
AL 10...24	3.4.5.3.
b	4.10.
D0...9	4.21.
DB	3.4.4.2.1.
DB1	3.4.4.3.2.
DB2	3.4.4.3.3.
DE	3.4.4.3.1.
EZT	3.4.5.5.
FA	3.4.4.4.3.
FA1	3.4.4.4.1.
FA2	3.4.4.4.2.
FF1	4.18.
FF2	4.18.
GT1...2	3.4.2.1.2.
GTDA	3.4.5.6.
H	3.4.3.2.
H00...H92	4.2.3.5.
h1	3.4.2.3.
h2	3.4.2.3.
H1E	3.4.3.6.
H2E	3.4.3.6.
HE	3.4.3.4.
HT	3.4.2.1.5.
K0...9	4.10.
Lö	3.4.2.4.
LZ	3.4.4.3.5.
MFA	4.18.
MFE	4.18.
OD	3.4.4.1.2.
OH	3.4.4.1.1.
$\underline{P}$	3.4.2.3.
P	3.4.2.3.
PA1...12	3.4.5.1.2.
PA1, 1...6	3.4.5.1.1.
PA2, 1...6	3.4.5.1.1.
PAHA	3.4.5.6.
PE1...12	3.4.5.2.
PPA1...12	3.4.5.1.3.
Q00...Q11	3.4.3.12

3.5.
Internal Output Devices

3.5.1.
Digital Voltmeter

3.5.1.1.
General

The digital voltmeter contains the digital voltmeter display and the electronic circuitry.

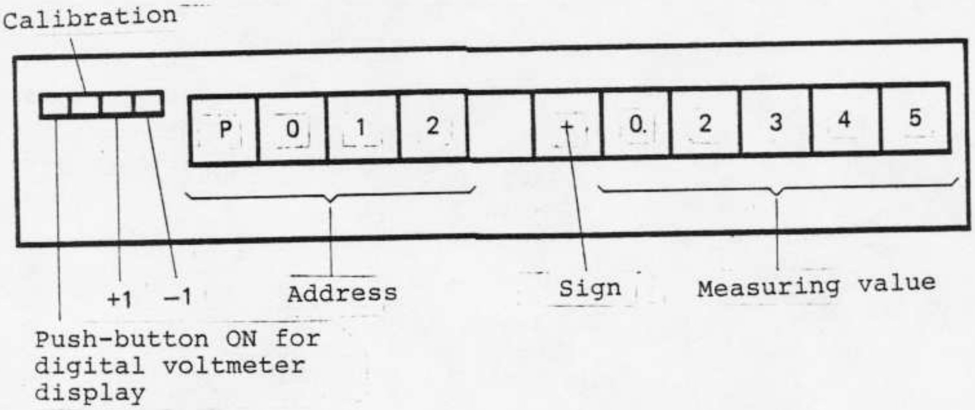


Fig. 3.5.1/1 Digital voltmeter display

The measuring value display reaches from ± 1 mV to 12.5 V, the measuring value is indicated in decimal form in machine units. One machine unit (ME) corresponds to 10 V. When selecting a function generator the last digit of the measuring value is switched-off for optical suppression of the diode noise.

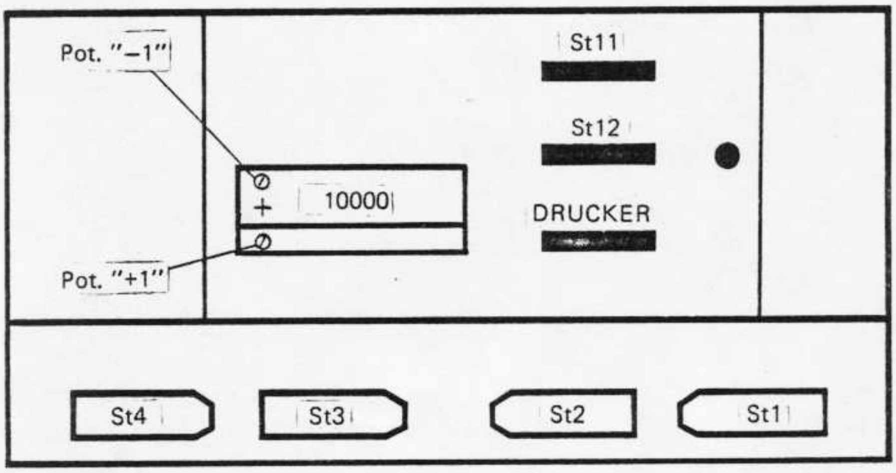


Fig. 3.5.1/2 Rear side of the digital voltmeter electronics (this drawer is accessible at the right-hand side below the table top, whereas the potentiometers are accessible after removing the covering plate.

3.5.1.2.
Measuring Sequence

The digital voltmeter control normally takes place periodically at 50 Hz, in some cases however, aperiodically (see table 3.5.1.).

Table 3.5.1 Measuring sequence of digital voltmeter

A measuring instruction takes place: periodically all 20 ms	aperiodically with a minimum spacing of 350 ms
for the program types: 1. Continuous computing, push-button"Continuous" 2. Compute with Hold, push-button"with Hold" 3. Iterative computing with manual start, push-button"It.Hand" 4. Zero-balancing of operational amplifiers, push-button "Null"(Zero) 5. Static program check, push-button "stat." 6. Dynamic check, push-button "dyn." 7. Potentiometer setting, push-button "Pot."	at the end of the computing phase of the following program runs: 1. Repetitive computing, push-button "Repet." 2. Automatic iterative computing, push-button "It.aut." A measuring instruction also occurs in case of: 1. Automatic selection, push-button "Aut." 2. Print instruction, push-button "Print Instr." or jack DB on DPF see 3.4.4.3. 3. Scanning by punched-tape control unit 4. Scanning by digital computer 5. Setting of FF1 of the stepping switch of digital adapter unit 6. Reaching of desired value of a servo-set potentiometer.

The different applications of aperiodic measuring are explained by the following example:

When depressing the push-button "Progr." in either the operation mode "Repetitive computing" and "Automatic iterative computing", the computer remains in the "Hold"-phase after a cycle, and the exact final value of the selected integrator is permanently displayed on the digital voltmeter. When computing "with Hold", however, the real final value can not be read correctly on the display because of the smaller computing capacitors and larger losses and because every 20 ms a new value display is caused by drift.

3.5.1.3.
Calibration

The push-button "Calibration" must be depressed to check the accuracy of the digital voltmeter. During "Calibration", the digital voltmeter must indicate the value 00000, whereas the sign should be between ±; the balance then takes place automatically. After depressing the "Calibration"-push-button and "+1", the display on the digital voltmeter is adjusted to +10000 by means of potentiometer +1. The same process is then carried out with potentiometer -1 and display -10000, respectively.

3.5.1.4.
Printer Control

Each aperiodic measuring instruction simultaneously causes a print instruction if the push-button "Print-on" was actuated and if the selected element is available in the computer. The printer then prints-out the measuring value momentarily available on the digital voltmeter display. A suppression of a measuring instruction for one or several partial cycles or at a certain time can also be programmed on the digital patch panel of the digital adapter unit.

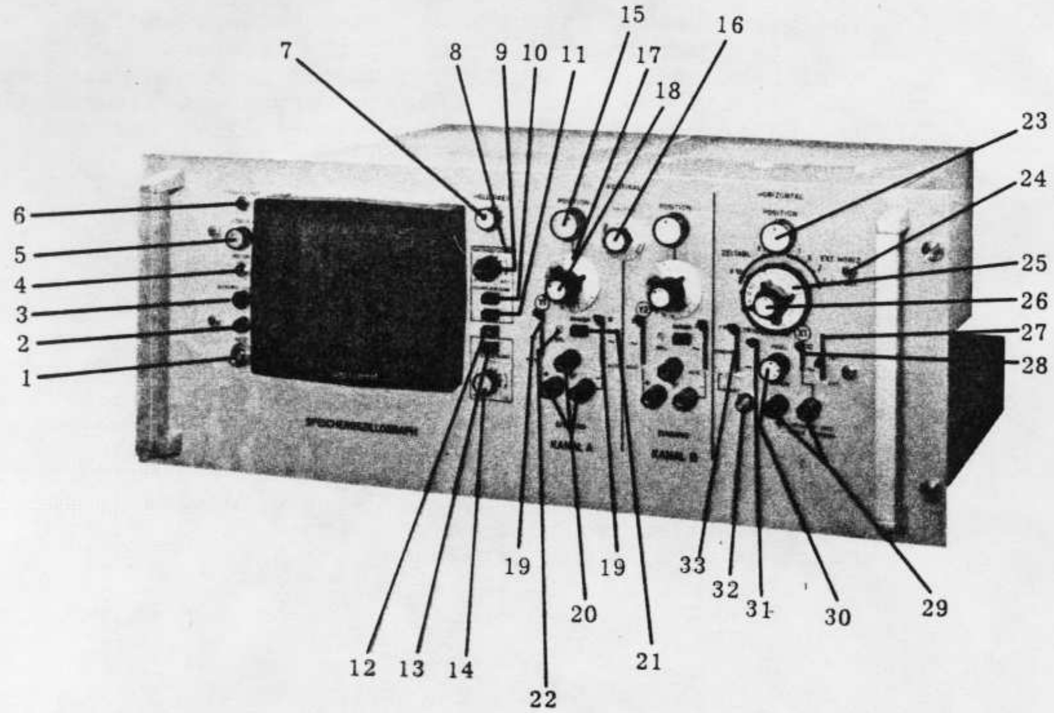


Fig. 3.5.2 Front view of HPO 771

1.	NETZ (Mains)	Mains switch
2.		Mains indication lamp
3.	EICHSP 1VOLT (Calibrated voltage 1 V)	Calibrating voltage 1 V, square-wave, 50 Hz,
4.	ASTIGM. FOCUS	Setting of beam focus
6.	STRAHLSUCHER (Beam finder)	For beam finding on the screen
7.	HELLIGKEIT (Brightness)	Setting of beam brightness
8.	NACHLEUCHTEN (Persistance)	Setting of persistance time (0.2 s to 60 s)
9.	ERASE	Erasing of stored or written display
10.	FAST	Fast write speed (up to 1/2 subdivisions µs) and variable persistance time
11.	STD.	Operation at normal write speed and variable persitance time
12.	CONV.	Operation as oscilloscope without storage
13.	STORE	Storing of signals

14.	SPEICHERUNG ZEIT (Storage time)	Setting of storage time (15 s to 8 hours)
15.	VERTICAL-POSITION	Vertical shifting
16.	ANZEIGE (Display)	Display channel A or B, A and B chopped or alternating or channel A above channel B.
17.	VOLT/TEILUNG (Volt/Division)	Amplification of Y-amplifiers
18.	▶ CAL	Fine setting. With ▶ Cal, calibrated amplification
19.	= ∼ AUS (Off)	Switching of inputs of differential amplifiers: DC-voltage (=), AC-voltage (∼), Zero-potential (AUS,off)
20.	+, -	"-"-inputs of differential amplifiiers of channel A and B "+"-inputs are led to the jacks (Y1) and (Y2) of analog patch panel
21.	BANDBR. (Bandwidth)	Push-button for reduction of bandwidth from 500 kHz to 50 kHz. Push-button release by repeated depressing.
22.	BAL	Balancing to prevent beam deviation at change of amplification ranges
23.	HORIZONTAL-POSITION	Horizontal shifting
24.	ZEITABL./EXT.HORIZ. (Time sweep ext.horiz)	Switch position: time sweep: either single (x1) or 10-fold (x10) sweep external horizontal deflection: selection of input amplification (Volt/div).
25.	ZEITABLENKUNG (Time sweep)	Switch for time sweep
26.	▶ CAL	Fine setting for horizontal deflection.
27.	NETZ,INT.,EXT. (Mains,int.,ext.)	Triggered time sweep
28.	= ∼	Switching of horizontal amplifier to DC-voltage input (=) or AC-voltage input (∼).
29.	TRIGGER- UND HORIZ.EINGANG (Trigger and horiz. input)	Input jack for horizontal amplifier or for trigger pulses in case of internal sweep.
30.	TRIGGER PEGEL (Trigger level)	Setting of Trigger level for sweep. In position AUTOM., Trigger-pulses of approx. 40 Hz are automatically generated.
31.	TRIGGERUNG + -	Selection of positive or negative triggering edge
32.	START	With single deflection, this push-button causes resetting of the time sweep to Zero, and repeated start. The push-button illuminates as long as the cycle runs.
33.	TRIGGERUNG: FREI, SYNCHR, 1X (Free, synchr.1X)	Time sweep started without Trigger-pulses (FREI, free) with synchronous input signal (SYNCHR) or single deflection after depressing the"START"push-button.

3.5.2.
Dual-Beam Storage
Oscilloscope HPO 771

3.5.2.1.
General

The oscilloscope HPO 771 serves for display and evaluation of the computing results. It is especially suited for this purpose because of the long persistance time and storage capacity.

Two separate input channels A and B for vertical deflection are accessible via the jacks Y_1 and Y_2 on the analog patch panel (field "Os"). The input amplifiers thereby provide differential inputs which can be connected to DC-voltage (AC-voltage) or Zero-potential. Normally, the positive inputs are connected to DC-voltage (=) whereas the negative inputs are patched to Zero-potential (AUS). In this position, the input impedance of jacks Y_1 and Y_2 amounts to 50 kOhm, parallel 50 pF. Accuracy of the individual ranges is $\pm$ 3 % with switched-off fine adjustment. The bandwidth can be reduced from 500 kHz to 50 kHz by means of the push-button "BANDBR."

The input EXT.HORIZ. is led to jack X_1 on the analog patch panel. The input amplification is divided into the steps 0, 1/0, 2/0, 5 and 1.0 V per division. By means of a fine adjustment control element, the amplification can be continuously adjusted until the largest input voltage of 2.5 V per division. Since for special measuring procedures, an internal time generator is available it must be observed that the selector switch is set to "EXT.HORIZ". Additionally, the switch of the amplifier input must be set to DC-voltage (=).

The following modes of display are possible:

Y_1 or Y_2	X_1 or T	
Y_1 and Y_2	X_1 or T	chopped of alternating
Y_1	Y_2	

The basic brightness can be set by means of a respective potentiometer on the front panel of the oscilloscope. A blanking system is supplied from the DBG during the computing time. An additional signal from the DPF again is provided for darkening.

Via jack Y_2, brightness modulation is possible. The total range amounts $\pm$ 10 V.

Persistance time: the persistance time can be continuously adjusted between 0.2 s and 60 s by means of the potentiometer "NACHLEUCHTEN"(persistance), position 8 on front panel of oscilloscope. A written signal can again be cleared by depressing the push-button "ERASE".

Write speed: Normal or fast write speed can be set by means of the push-buttons "STD". or "FAST".

Storage: The storage is switched-off when depressing push-button "CONV.". By means of push-button "STORE", a written signal can be stored. The storage time thereby can be adjusted by means of the potentiometer provided below the push-button. The stored signal thereby becomes invisible and can be again made visible by again turning the potentiometer.

3.5.2.2. Operation

The oscilloscope HPO 771 normally is used for display and evaluation of computing results. The vertical amplifier with differential inputs and large amplification as well as the internal horizontal sweep generator are special features of the HPO 771 when using this oscilloscope as output device of an analog computer, it is operated as follows:

1. Display type selection:

   Set channel selector switch between channels A and B to respective display type. Switch positive inputs Y_1 and Y_2 to (=) and negative inputs to (AUS). Adjust Zero-position and amplification.

2. Setting of horizontal deflection

   Set central switch to desired amplification within EXT.HORIZ sector. When connecting the saw tooth voltage generated in the analog computer to input X_1 for horizontal deflection: set switch to 1 V/SKT and adjust the desired display width by using fine control ▶ CAL. The X_1- input must be switched to (=).
   Horizontal position shifting takes place by means of the potentiometer.

Use as service oscilloscope:

The voltages to be measured are connected at the front side. The jacks Y_1, Y_2 and X_1 must not be patched on the analog patch panel.

At jack "EICHSPG."(calibr.,position 3 at front side of oscilloscope) a calibration voltage of 1 V ($\pm$ 1.5%) square-wave mains frequency is available. The horizontal sweep generator may be triggered either with mains frequency, internally or externally. It can also run free or be deflected a single time by means of the "START"-push-button.

The sweep speed can be adjusted in coarse steps of 0.1 µs per division up to 5 s per division and additionally be varied via the setting button. The smallest sweep speed is 12.5 s per division.

3.6. Balancing and Testing

Balancing must be carried out in regular time periods, since an accurate Zero-setting of the computing amplifiers considerably influences the accuracy when solving computing problems. Additional Zero-balancing is recommended prior to important computations. The same applies for dynamic check of all computing amplifiers switched as integrators.

Zeroing of Zero-setting of the computing amplifiers means a balancing to a minimum of the residual voltage at the amplifier output without applying input voltages.

Dynamic zeroing is an additional balancing to a minimum residual voltage at the amplifier output of integrators. This is much more difficult since each voltage varying from Zero will be integrated at the amplifier input according to the time constant of the integrator. After normal zeroing of the operational amplifier, a subsequent dynamic zeroing should take place by means of the same trimming potentiometer, in case a use as integrator is wanted. The trimming potentiometer settings for both balancing procedures are not identical (amplifier leakage). In this case, the minimum setting for dynamic zeroing should be maintained.

"Dynamic check" serves for testing the function ability of integrators and informs about the deviations from desired values of integrator capacitors. Therefore, the integrator must integrate to the desired value of the output voltage within a pregiven computing time T_R and smallest possible deviation at given fixed setting of the integration factor and intput voltage.

"Static program check" is no special testing but an operation mode for testing the computing circuit patched on the APF. All integrator outputs are disconnected from the amplifiers. Instead of integrator output voltages, test voltages can be applied to the computing circuit so that programming errors, failures of computine elements and false coefficient settings can be detected by comparison to previously calculated problem solutions.

3.6.1. Zero-Instrument

The control unit contains a Zero-instrument with an in-series operational amplifier for display amplification in the µV-range. It is used for zeroing of operational amplifiers, for balancing of modulation multipliers and for display of supply voltages.

Balancing of the display amplifier:

From time to time, a balancing of the internal display amplifier is required. Therefore, the Zero-instrument is used, in combination with the respective push-button N and the respective trimming potentiometer.

1. Mechanical Zero position is set with switched-off device.

2. Amplifier zeroing. Carried out in operation mode "Zero".

   By simultaneously depressing the push-button N and adjusting the trimming potentiometer N, the pointer deflection of the Zero-instrument is set to center position.

Instrument scale:

The scale of the instrument has different designations. For Zero-balancing, the black center line and the red display range is used. Range switch-over can be carried out by means of the switch provided behind the lamp panel. If set to position 240 µV, the limits of the red display range are at -60 µV and +60 µV, and in the range of +1mV...-1mV when setting the switch to position 4 mV (for zeroing of drift compensated amplifiers and operational amplifiers realized with integrator circuit card H-SK24 (ANE-781). These sensitivity values, however, become valid only when depressing the push-button "Zero" in the "Control"field.

All further designations on the scale are provided for indication of supply voltages (see also 3.8.8.).

3.6.2.
Balancing of the Time Sweep Generator

During normal operation, the time sweep generator of the control unit used for generation of a saw tooth voltage (see 4.9.4) does not require a balancing. Compensation of the hold drift by compensation of residual currents for the respective electronic switch is normally carried out by the manufacturer. If however the saw tooth voltage shows a larger drift during the hold-time, this can also be corrected subsequently.

Respective setting can be achieved by means of the setting element provided below the push-button "Z" of the Zero-instrument. Therefore, connect jack "Z" on the APF to one of the jacks Z 06,26,46,56,76 or 96, then select the respective address on the control unit and permit the saw tooth to run from 0 to +10 V during operation mode "Compute with hold" at a computing phase of T_R= 100 ms. After reaching the "Hold"-phase, the saw tooth voltage must only little vary. The setting element is provided for setting a minimum variation.

3.6.3.
Zero-Balancing of the Operational Amplifiers Push-Button "Zero"

By depressing the "Zero"-push-button on the control unit, the Zero-point measuring amplifier is connected to the central measuring line. The output voltage of each selected computing element is then amplified and indicated on the Zero-instrument. Different computine elements, however, differ from normal standards and are described in the following.

3.6.3.1.
Operational Amplifiers with Addresses 0 to 5

By depressing the push-button "Zero", all operational amplifiers are prepared for Zero-balancing independent from the respective programming on the APF. All input networks are disconnected from the respective amplifiers by relay contacts and simultaneously a resistor is connected into the return line of all not-summers, so that also integrators and open amplifiers are switched as summers for the balancing procedure.

A possibly connected initial value is disconnected from the amplifier input.

The balance is initiated by selecting the respective operational amplifiers according to 3.1.1. The respective output residual voltage is indicated on the Zero-instrument.

Balancing to center position of the instrument pointer is carried out by means of the trimming potentiometer arranged behind the lamp panel and being assigned to the respective operational amplifier by its description.

3.6.3.2.
Op.Amps. of Adapter Units

3.6.3.2.1.
Drawer Function Generator VFG 801

Each drawer VFG 801 contains 4 variable function generators, each being connected to two operational amplifiers. One of these Op.Amps. can be disconnected for use as free inverter amplifier by depressing the push-button beside the overload signal lamp. It may then be selected under the address of the function generator, i.e. it can also be balanced by using the respective trimming potentiometer, provided on the left-hand push-button side. Zeroing of the second operational amplifier also takes place after selection of the function generator, but during normal operation mode, i.e. with push-button released. The respective trimming potentiometer is provided on the right-hand side of the overload signal lamp. The above mentioned sequence must be maintained for zeroing.

(The output value of the inverter amplifier selected under the function generator address is displayed on the digital voltmeter and can also be print-out according to 3.1.3.).

3.6.3.2.2.
Drawer Non-Linear Networks NNT 801 1)

All operational amplifiers of drawer NNT 801 (8 max.) can be indirectly selected by the selection panel of the control unit. Each Op.Amp. has its own selection push-button on the front panel of the drawer being combined with the overload signal lamp. On the APF, the output of the central measuring line is generally connected to all not directly selectable Op.Amps., i.e. the white jack NN of field 2 on the APF is connected to the jack Z 26 arranged below. By entering V 26 at the selection panel. Z 26 is reached. Selection of each operational amplifiers takes place by depressing the respective selection push-button on the front plate of the drawer. Zero-balancing takes place by using the respective trimming potentiometer and depressed push-button.

Beside the overload signal lamps, the number of address field is designated, which contains the input and output jack of the respective operational amplifier.

(The output values are displayed on the digital voltmeter and can be print out according to 3.1.3.).

1) can no more be delivered.

3.6.3.2.3. Drawer Electronic Resolver ERS 702

The six operational amplifiers used in the resolver circuit of each drawer ERS 702 can be partly reached direct and partly indirect via the selection panel after the control unit.

Each Op.Amp. has its own selection push-button on the front plate of the drawer, being combined with an overload signal lamp. Each drawer ERS 702 permits direct selection of one operational amplifier via the selection panel of the control unit (addresses V27 or V77), without actuation of the push-button of same address (27,77) provided on the front plate of the drawer. Per drawer, five further Op.Amps. can be selected by depressing the respective push-button at simultaneous address display on the digital voltmeter (push-buttons R1, R2, A, B). In case the drawer is equipped with four additional Op.Amps., they are selected via the push-buttons 02, 03, 04, 05.(The output values of the selected Op.Amps. then are displayed on the digital voltmeter with the address of the direct selectable amplifier.Print-out is possible according to 3.1.3.).

Zero-balancing for all Op.Amps. is carried out in the selected condition by using the respective trimming potentiometers provided below or beside the respective push-button.

The address designation on the overload lamps correspond to the complete address on the APF in case of pure digit indications, whereas in case of letter indications they correspond to the respective jack designations of the resolver field on the APF being determined by the address for the directly selectable Op.Amp.

Beside the already mentioned selection possibilities, another possibility is given for all six operational amplifiers via the jacks NN and Z 26 on the APF. This is described in the section dealing with drawer NNT 801. Also a mixture of both selection types is possible.

3.6.3.2.4. Drawer Non-Linear Networks NNT 771

The operational amplifiers of drawer NNT 771 (max.24) can be partly reached direct or indirect via the selection panel of the control unit.

A single overload of the eight follow-up amplifiers (X-inverters) is indicated via signal lamps with address designation 07,17,37,47,57,67,87,97 on the front plate of the drawer. These amplifiers are used as follow-up amplifiers of the non-linear networks or in case of free use as inverters. They are accessible on the APF via the NNE-fields. The input jack is designated with "X", whereas the output jacks are identified by the units position 7 of the address. The follow-up amplifiers are part of the selection system and can be selected by their respective address.

For selection of the A-and N-inverters, the address of the respectively assigned NNE-field must be entered (e.g. V37, i.e. the NNE-field within address field 3 is selected). Additionally, push-button A or push-button N on the front plate of the drawer must be depressed.

These inverters are either used free or as input amplifiers of the networks. Their jacks are located within the NNE-fields, input jack "+A" or "+N", output jack "-A" or "-N".

For zeroing of follow-up amplifiers as well as A-and N-inverters, the networks are disconnected when depressing the push-button "Zero" on the control unit. For selection, the sensitivity of the Zero-instrument is switched over, so that balancing can be carried out by means of the respective Zero-potentiometer. The Zero-potentiometers are located above the overload signal lamps (of the follow-up amplifiers) in the sequence A, N, X on the front plate of the drawer.

3.6.3.3. Drift-Compensated Operational Amplifiers

In different magazines of the computer, drift-compensated operational amplifiers are used. These amplifiers are prepared for Zero-balancing by depressing the push-button "Zero". Although they cannot be selected, the push-button "Zero"must be depressed to connect the Zero-point measuring amplifier to the instrument.

Preparation of Zero-balancing:

1. Connect output of the amplifier to a selectable jack "Z6".
2. Patch inputs according to the following instructions
3. Depress push-button "Zero"
4. Set switch near thc Zero-potentiometers (behind lamp field) to position 4 mV.
5. Connect amplifier output to the Zero-instrument by selecting the connected jack"Z6".

3.6.3.3.1. Amplifiers Allocated to the NN-Computer Magazine

The NN-computer magazine which is accessible from the rear, is followed by an amplifier magazine with ten inverters maximum being allocated to the NN-computer magazine. They are called A-inverters and can be accessed on the NNR-field, input jack"+A", output jack "-A". According to their position on the APF they are designated A0...A9. (The digits thereby indicate the address field number). For zeroing of an amplifier the input must be connected to computing ground. Balancing at the Zero-instrument is carried out in center position of the pointer by using the trimming potentiometer arranged behind the lamp panel and allocated to the respective amplifier by its designation.

3.6.3.3.2. C-Inverters

The amplifier magazine mentioned in section 3.6.3.3.1. also contains 8 C-inverters maximum. Their jack fields are located within the address fields 0, 1, 3, 4, 5, 6, 8, 9 of the APF, thus they are designated C0, C1, C3, C4,C5, C6, C8, C9, respectively.

For zeroing of the amplifiers the summing point input "S" must be separated and the tens-input must be connected to computing ground.Balancing at the Zero-instrument is carried out in center position of the pointer by using the trimming potentiometer arranged behind the lamp panel and allocated to the respective amplifier by its designation.

3.6.3.3.3. Inverters in the Noise Generators-Amplifier Magazine

In the noise generator-amplifier-magazine (RGV-magazine), up to six inverters can be arranged. They are called D-inverters and have no fixed allocation to certain jack fields on the APF. For their designation, small letters are used instead of address field numbers (Da, Db,...Df). For zeroing of the amplifiers, the input jack must be connected to computing ground. Balancing at the Zero-instrument is carried out in center position of the pointer by using the trimming potentiometer arranged behind the lamp panel and allocated to the respective amplifier which is given by the designation (Da, Db,...Df) of the potentiometer.(As to the location of the D-inverters on the APF, see section 2.3.3.).

3.6.4. Static Program Check, Push-Button "stat."

A special operating condition of the computer permits a static program check, which enables testing of correct programming, proper function of computing elements and correct setting of coefficient potentiometers of all computing circuits patched on the APF.Thereby, previous numerical determined solution values for discreet parameters of mathematic problems are compared to static solution values of the computing circuit being available after selection of the respective computing elements for indication or print-out of the output values. Although each integrator disconnects a computing circuit in a Pause- or Hold-condition, both the sum of the voltages at its inputs must be possible to be measured as well as a spare voltage for the missing output voltage must be possible to be connected to succeeding computing elements without changing the respective computing circuit patched on the APF.

By depressing the push-button "stat.", the output jacks of all integrators on the APF are disconnected from the respective amplifier outputs and connected to the green jack P of the integrator jack field. The computing voltage fixly programmed to P is then distributed to the succeeding computing elements. The initial value voltages patched on the APF (green jacks A) are disconnected from the amplifier inputs (see also 3.6.6.2.). Additionally, all operational amplifiers patched as integrator on the APF become summers by adding a feedback resistor.

The amplifier output which is no longer connected to the output jacks on the APF then can be further selected under the integrator address, so that the sum of all input voltages is displayed on the digital voltmeter and can also be print-out with integrator identification and address.

The resistor which is automatically connected in-series to the return line of all operational amplifiers programmed as integrators has a value of R_0 = 5 kOhm. Thus, the weight factors of all intergrator inputs are multiplied by the factor 0.025. On this way, overload during static program check is prevented.

3.6.5. Dynamic Check, Push-Button "dyn."

The dynamic check of the integrators permits testing of proper function of the operational amplifier together with its integrator capacitors.

By depressing the push-button "dyn.", a test voltage of +1 V is applied to an 200 kOhm input of each computing amplifier patched as integrator on the APF. Thus, the four directly selectable integration factors k_0 are each multiplied by the factor 0.1. Any initial value possibly patched on the APF, as well as the whole input network are disconnected from the amplifier input, as are also the output jacks from the amplifier output (see 3.6.6.4.). The program "dynamic check" can be followed by looking to the graphic illustration given under 3.6.6.4. After depressing the push-button "dyn." the following phase sequence is reached:

Phase initial value setting	Phase length Δt
Phase Pause	Phase length T_P
Phase Compute	Phase length T_R
Phase Hold	Phase length unlimitted

During the phase "Initial value setting", the integrator capacitor C_1 discharges via the resistor R_A. This phase corresponds to the intermediate time Δt, which lies between depressing of the push-button "Compute" and start of the selected program (see Fig. 3.2.1.). It is:

$$0.5 \text{ s} \leq \Delta t \leq 2 \text{ s}$$

The initial value Y = 0 can also be set with given maximum time constant of the initial value setting network of 25 ms (R_A = 5 kOhm, C_1 = 5 µF) and minimum intermediate time by meeting the required accuracy. The computing phase is initiated by reaction of the central switch DY*, causing all integrators to be connected with 0.1 ME (≙ 1 V).

3.6.6.
Principle Circuits of"Check Modes "

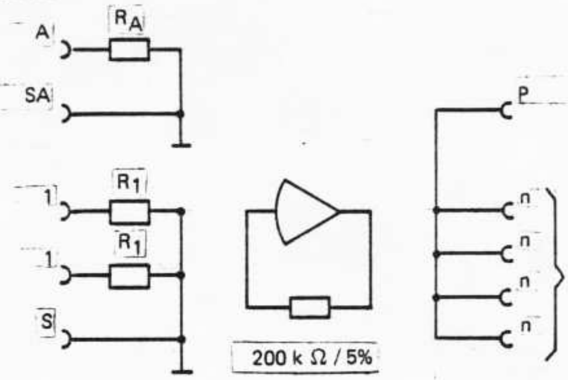
Designations: R_A = 5 kOhm R_1 = 200 kOhm R_{10}= 20 kOhm

C_1 Integrator capacitor

Jack on APF

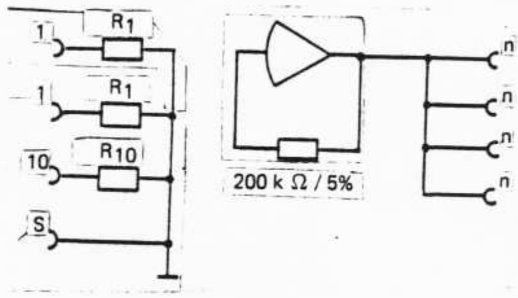
3.6.6.1.
Potentiometer Setting, Push-Button "Pot." depressed

a) Integrator



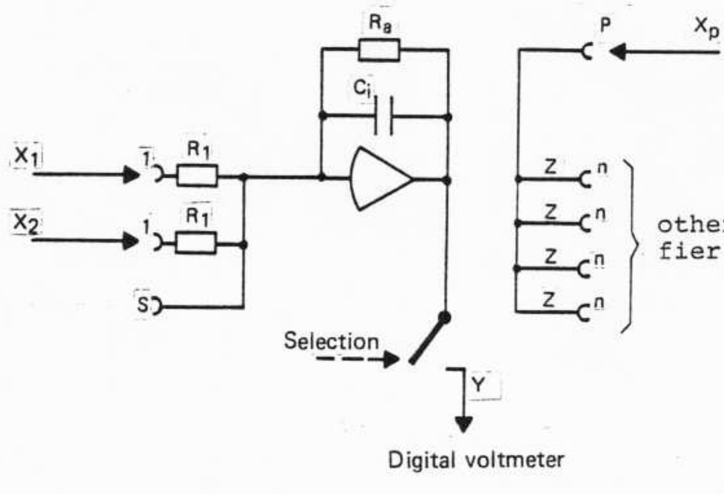
otherwise amplifier outputs

b) Summers



3.6.6.2.
Static Program Check, Push-Button "stat." depressed

a) Integrators

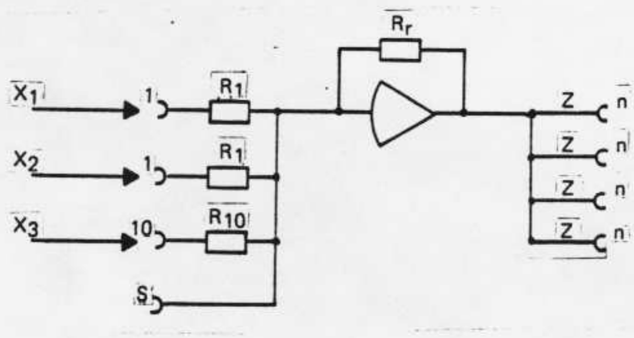


otherwise amplifier outputs

when selecting $Z = X_p$

$$Y = \frac{1}{40}(X_1+X_2)$$

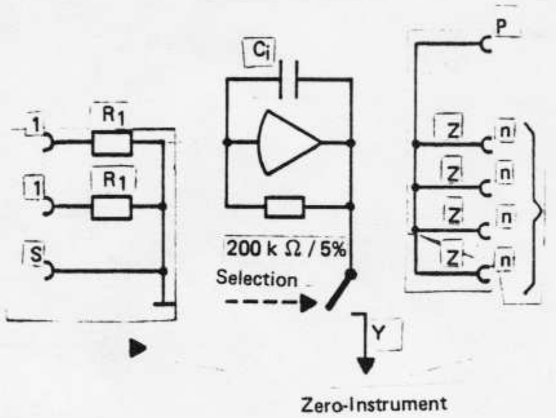
b) Summers



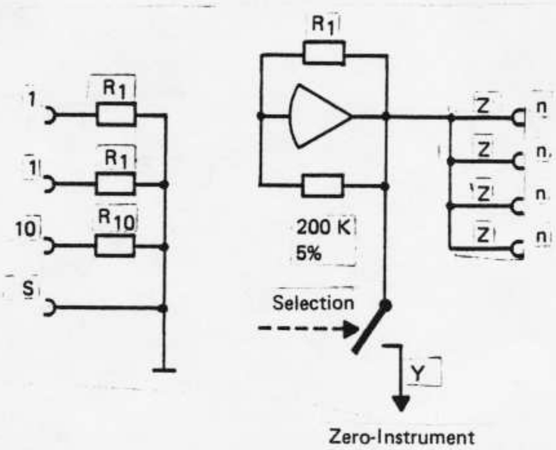
$$Z = -(X_1 + X_2 + 10\,X_3)$$

3.6.6.3.
Zero-Balancing of Operational Amplifiers, Push-Button "Zero" depressed

a) Integrator

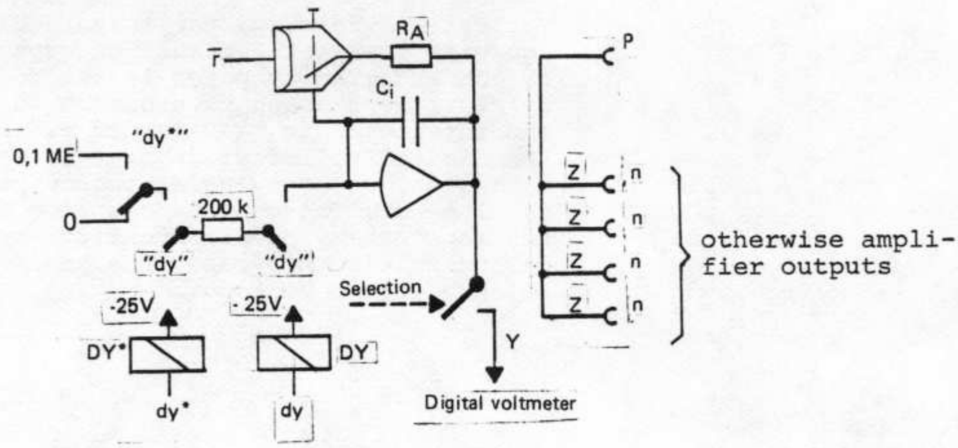


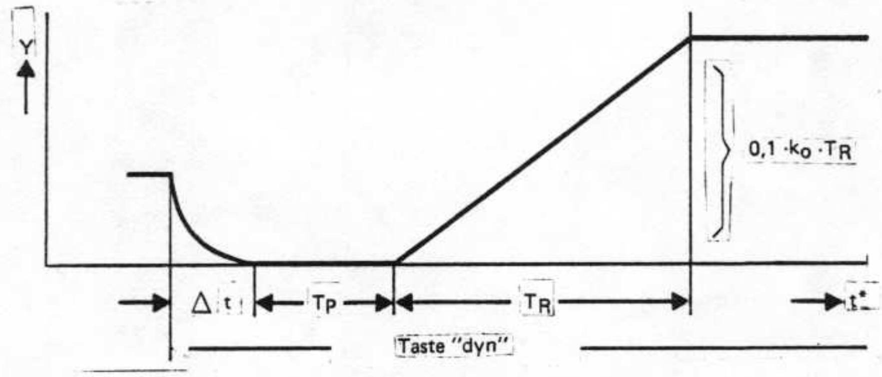
b) Summers

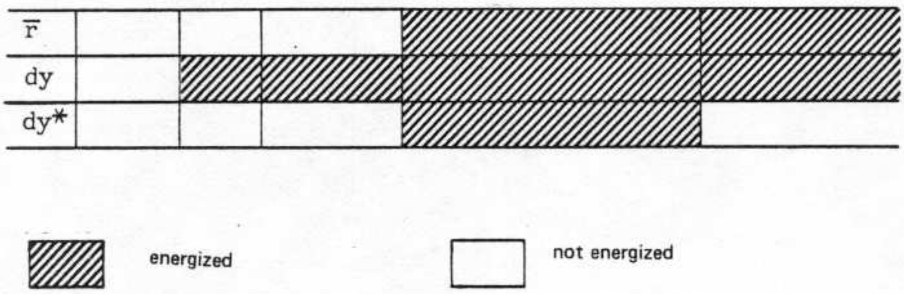


3.6.6.4.
Dynamic Check,
Push-Button "dyn." depressed

Only effective for integrators







T_P set on timer 1

T_R set on timer 2

3.6.7.
Dynamic Zeroing of the Integrators

The dynamic zeroing of the integrators is carried out in addition to the static zeroing, but is required only in case upmost accuracy is required. In general, the zeroing of operational amplifiers as described under 3.6.3. will be sufficient, also if they are programmed as integrators.

For dynamic zeroing, the integrators are to be programmed with smallest integration capacitor (100 $\int$, 10 x) on the APF. The computer is set to phase "Hold" (e.g. by first depressing push-button "Compute", then "Hold"). The integrator to be balanced is then selected and the digital voltmeter display is then adjusted to a constant value by using the respective trimming potentiometer. The optimum position of the trimming potentiometer may be different for static and dynamic balancing. In this case, the position of the dynamic balance should be kept.

3.6.8.
Testing of Supply Voltages

Table 3.6.8. Supply voltages

Selection Address	Return an DVM	Voltage	Display on DVM	Display on Zero-instrument
P 08	K 08	+ 10 V	+ 1.0000	red line within right-hand scale half
P 18	K 18	- 10 V	- 1.0000	blue line within left-hand scale half
P 28	K 28	+ 15 V_I	0.0000	red point at the right-hand scale end
P 38	K 38	- 15 V_I	0.0000	blue point at the left-hand scale end
P 48	K 48	+ 15 V_{II}	0.0000	red point at the right-hand scale end
P 58	K 58	- 15 V_{II}	0.0000	blue point at the left-hand scale end
P 68	K 68	+ 15 V_{III}	0.0000	red point at the right-hand scale end
P 78	K 78	- 15 V_{III}	0.0000	blue point at the left-hand scale end
P 88	K 88	+ 30 V	0.0000	red point at the right-hand scale end