Section 3

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LIST OF ABBREVIATIONS

A
APF
BDZ
DB
DBG
DE
DPF
DVM
DZ 772
ERS 702
F
FA
FF
GT
H
HE
HT
IPV
K
LSZ
L8, L8
L2
ME
MP
NN

Initial Value
Analog Patch Panel
Operating Unit (Control Unit of Slave Computer)
Print Instruction
Digital Control Panel (Control Unit of Master Computer)
Printer ON
Digital Patch Panel
Digital Voltmeter
Digital Adapter
Electronic Resolver
Sequences (Operating Condition of a Store)
Ink-pen Start (XY-Plotter)
Flipflop
Basic Clock
Hold, Hold Instruction
Hold-Phase End
Manual Clock
Duty Cycle
Comperator
Paper-Tape Control Unit
Erase
Space Line
Machine Unit (= 10 V)
Monoflop
Non-Linear Networks
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tr>
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<td>Drawer, Non-Linear Networks</td>
</tr>
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<td>NNT 701</td>
<td>Drawer, Non-Linear Networks</td>
</tr>
<tr>
<td>Os</td>
<td>Oscilloscope</td>
</tr>
<tr>
<td>OD</td>
<td>Oscilloscope Blanking</td>
</tr>
<tr>
<td>OH</td>
<td>Oscilloscope Unblanking</td>
</tr>
<tr>
<td>R</td>
<td>Computing</td>
</tr>
<tr>
<td>RE</td>
<td>Computing Phase End</td>
</tr>
<tr>
<td>Sch</td>
<td>Plotter</td>
</tr>
<tr>
<td>SR</td>
<td>Shift Register</td>
</tr>
<tr>
<td>SR2</td>
<td>Shift Register</td>
</tr>
<tr>
<td>St</td>
<td>Connector</td>
</tr>
<tr>
<td>U</td>
<td>Over-amplify</td>
</tr>
<tr>
<td>UH</td>
<td>Over-amplify Hold</td>
</tr>
<tr>
<td>VA</td>
<td>Amplifier Selection</td>
</tr>
<tr>
<td>VFG</td>
<td>Variable Function Generator</td>
</tr>
<tr>
<td>WT</td>
<td>Selection Clock</td>
</tr>
<tr>
<td>WTR</td>
<td>Continue</td>
</tr>
<tr>
<td>Z</td>
<td>Sweep Generator</td>
</tr>
<tr>
<td>Z</td>
<td>Counter</td>
</tr>
<tr>
<td>ZL</td>
<td>Counter</td>
</tr>
<tr>
<td>ZL 2</td>
<td>Counter</td>
</tr>
<tr>
<td>ZG</td>
<td>Timer</td>
</tr>
<tr>
<td>ZS</td>
<td>Time Constant Control (10 times faster)</td>
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</table>
LIST OF IMPORTANT DESIGNATIONS AND SYMBOLS

\[ C_1 \]  
Integrator capacitor \( C_1 = 5000, 500, 50, 5 \text{ nF} \)

\[ k_o = \frac{1}{C_1 \times R_1} \]  
Integration factor \( k_o = 1, 10, 100, 1000 \text{ 1/s} \)

\[ \text{ME} \]  
Machine unit \( 1\text{ME} = 10 \text{ V} \)

\[ \text{mn} \]  
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 \( F_H = 1 \)

\[ \text{GT} \]  
Period of basic clock

\[ T_P \]  
Period of pause phase

\[ T_R \]  
Period of computing phase

\[ T_H \]  
Period of hold phase

\[ R_1 = 200 \text{ kOhm} \]  
Input or feedback resistor

\[ R_{10} = 20 \text{ kOhm} \]  
Resistor within network for initial value

\[ R_A = 5 \text{ kOhm} \]  
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:
<table>
<thead>
<tr>
<th>Depressed letter push-button</th>
<th>Code letter</th>
<th>Selected computing element</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>P</td>
<td>Coefficient potentiometer</td>
<td>0 - 9 (without 2 and 7) 0 - 7.9</td>
</tr>
<tr>
<td>P</td>
<td>K</td>
<td>Supply voltages</td>
<td>0 - 8 8</td>
</tr>
<tr>
<td>V</td>
<td>I</td>
<td>Integrator, complementary integrator, store, complementary store, open amplifier</td>
<td>0 - 9 0,1,2,</td>
</tr>
<tr>
<td>V</td>
<td>S</td>
<td>Summer, open amplifier</td>
<td>0 - 9 0 - 5</td>
</tr>
<tr>
<td>V</td>
<td>S</td>
<td>Inverter of electronic resolver</td>
<td>2,7 7</td>
</tr>
<tr>
<td>V</td>
<td>M</td>
<td>Modulation multiplier</td>
<td>0 - 9 (without 2 and 7) 7,8</td>
</tr>
<tr>
<td>V</td>
<td>F</td>
<td>Variable function generator as inverter</td>
<td>0 - 9 (without 2 and 7) 9</td>
</tr>
<tr>
<td>V</td>
<td>S</td>
<td>Selectable jacks on APP</td>
<td>0,2,4 5,7,9 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>on DPF</td>
<td>7 9</td>
</tr>
</tbody>
</table>

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.
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 automatic 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 until 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 de-
pressing the "Stop"-push-button, which also illuminates, the digital voltmeter is operated periodical-
ly. 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 selec-
tion to go over to the respective address being en-
tered.

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

For print-out of addresses and measuring values
being indicated on the digital voltmeter, a digi-
tal 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 po-
sition will not be print-out. The manually entered
start address also is not print-out at the
start, but after termination of the scanning se-
quency, after repeated return to the start addr-
ness. 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 add-
ress 00 with subsequent entering of a final add-
ress 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) follo-
wing 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:

<table>
<thead>
<tr>
<th>Program</th>
<th>Push-button</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous</td>
<td>Dauer</td>
</tr>
<tr>
<td>Computation with Hold</td>
<td>mit Halt</td>
</tr>
<tr>
<td>Repetitive computation</td>
<td>Repet.</td>
</tr>
<tr>
<td>Automatic iterative computation</td>
<td>It.aut.</td>
</tr>
<tr>
<td>Manual iterative computation</td>
<td>It.Hand</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Operation mode</th>
<th>Push-button</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pause</td>
<td>Pause</td>
</tr>
<tr>
<td>Compute</td>
<td>Rechnen</td>
</tr>
<tr>
<td>Hold</td>
<td>Halt</td>
</tr>
<tr>
<td>Continue</td>
<td>Weiter</td>
</tr>
</tbody>
</table>

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 $\Delta t$, 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 $T_p^1$
   Phase Compute 1, phase endurance $T_r^1$
   Phase Hold 1, phase endurance $T_h^1$

b) Phase Pause 2, phase endurance $T_p^2$
   Phase Compute 2, phase endurance $T_r^2$
   Phase Hold 2, phase endurance $T_h^2$

with normal integrators

with complementary integrators

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. $r$, $h$, $R$, $H$, $ZG$) 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 $T_p^1$, $T_r^1$, $T_h^1$ or $T_p^2$, $T_r^2$, $T_h^2$. The lower field half is provided for the phases of group b) with the phase endurance $T_p^2$, $T_r^2$, $T_h^2$, respectively.

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

1) Program "Continuous computation"
   The program starts with the Phase-phase, followed by a computing phase, which is unlimited 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 iterative 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 "Rep.fov." 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 \( k_0 = 100 \text{ s}^{-1} \) to \( k_0 = 1000 \text{ s}^{-1} \)). 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.
Fig. 3.2.2. Clock generation and timer control

* Only during operation mode "10x faster"
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 \( T_p \) (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.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Time period settable by means of</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pause 1</td>
<td>Timer 1</td>
</tr>
<tr>
<td></td>
<td>two digit</td>
</tr>
<tr>
<td>Pause 2</td>
<td>Timer 4</td>
</tr>
<tr>
<td></td>
<td>two digit</td>
</tr>
<tr>
<td>Compute 1</td>
<td>Timer 2</td>
</tr>
<tr>
<td></td>
<td>two digit</td>
</tr>
<tr>
<td></td>
<td>Timer 2 and 1</td>
</tr>
<tr>
<td></td>
<td>four digit</td>
</tr>
<tr>
<td>Compute 2</td>
<td>Timer 5</td>
</tr>
<tr>
<td></td>
<td>two digit</td>
</tr>
<tr>
<td>Hold 1</td>
<td>Basic clock 1</td>
</tr>
<tr>
<td></td>
<td>one digit</td>
</tr>
<tr>
<td>Hold 2</td>
<td>Basic clock 2</td>
</tr>
<tr>
<td></td>
<td>one digit</td>
</tr>
</tbody>
</table>

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 limited 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 \( T_p \) 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 "10×faster", 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.

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:

<table>
<thead>
<tr>
<th>Color</th>
<th>Left-hand:</th>
<th>Right-hand:</th>
</tr>
</thead>
<tbody>
<tr>
<td>green push-buttons</td>
<td>presetting of computing programs, compute start, continue instruction</td>
<td></td>
</tr>
<tr>
<td>yellow push-buttons</td>
<td>external program control</td>
<td></td>
</tr>
<tr>
<td>red push-buttons</td>
<td>operation modes Pause and potentiometer setting</td>
<td></td>
</tr>
<tr>
<td>white push-buttons</td>
<td>operation mode Hold</td>
<td></td>
</tr>
<tr>
<td></td>
<td>setting for self and external control setting for balancing and testing</td>
<td></td>
</tr>
</tbody>
</table>
Program selection

Selection of computer program types of analog computer

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

Push-button | Function
---|---
Pot. | Potentiometer setting 1)
Null | Zero-balancing of operational amplifiers
stat. | Static program testing
dyn. | Dynamic testing
Pause | Pause = (initial value setting)
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.

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

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 APP (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.

Push-button "Compute" (operation mode "Computation")

By depressing the green 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 "U" on the left-hand front panel was actuated, (white push-button illuminates).

5. After the preset time $T_p$ 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" precondi-
tion 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 T1 or T2. A time sweep voltage is started at the \( R \) 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", 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 \( T \). 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 \( \mathcal{H} \) with grese 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 \( \mathcal{H} \) 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"-phase. Limitations are given as mentioned under 1b (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 over-load 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 free 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 green 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-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 $T_p$ 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. $1 \text{s at } k_0 = 1 \text{s}^{-1}$). 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 interactive computation"

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

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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 iteration 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:

\[(F_2 + F^0 + 1) \times GT_k = n \times GT_1 \quad (n \geq 1, \text{even})\] with

- \(GT_k\) = set shorter basic clock
- \(GT_1\) = set longer basic clock
- \(F_2\) = setting of Pause time factor with shorter basic clock time
- \(F^0\) = 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 computer.

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 \(k_0 = 1 \text{ s}^{-1}\). The resulting Pause-phase for an iteration 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, computing 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 foremost 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 2!". (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 2!", 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 $T_R$ 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 $T_R$ 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 APP (e.g. 1 s at \(k_0 = 1 \text{s}^{-1}\)). 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.

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"(\(T_N\)) 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 (simultaneously, 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 777, 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 illuminates. 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."

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

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 "U" 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 "U" 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 "0" 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
- Control lines of comparators
- Replacable, digital computing elements
- Stepping switch
- Manual switch of DPF
- Binary "0", binary "12, multiple

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

General determinations
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 a 1/0-change.
    Required height: 9V ± 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.).
<table>
<thead>
<tr>
<th>Number</th>
<th>Meaning of Jacks</th>
<th>Jack Designation</th>
<th>D2 772 Color</th>
<th>Line</th>
<th>Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.2..</td>
<td>Clocks and control signals of DPF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.4.2.1</td>
<td>Clocks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3.4.2.1.1</th>
<th>Fixed clocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 μs</td>
<td>yellow 27</td>
</tr>
<tr>
<td>100 μs</td>
<td>yellow 27</td>
</tr>
<tr>
<td>1 ms</td>
<td>yellow 26</td>
</tr>
<tr>
<td>10 ms</td>
<td>yellow 26</td>
</tr>
<tr>
<td>100 ms</td>
<td>yellow 25</td>
</tr>
<tr>
<td>1 s</td>
<td>yellow 25</td>
</tr>
<tr>
<td>0.5 s</td>
<td>yellow 26</td>
</tr>
<tr>
<td>2 s</td>
<td>yellow 27</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3.4.2.1.2</th>
<th>Basic clocks (GT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GT 1</td>
<td>yellow 28</td>
</tr>
</tbody>
</table>

All clocks are derived from the central 100 kHz generator clock of the DBG. The square-wave clock pulses have different duty cycles (IPV). Between the decade spaced clocks, a time shifting of 3.5 μs is given.

![Diagram showing duty cycle](image)

Duty cycle: symmetrical
These jacks provide the basic clock 1 (GT 1) set on the DBG

Duty cycle: symmetrical
These jacks provide the basic clock 2 (GT 2) set on the DBG
<table>
<thead>
<tr>
<th>Number</th>
<th>Meaning of Jacks</th>
<th>Jack Designation</th>
<th>D3 772 Color</th>
<th>Line</th>
<th>Column</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.2.1.3.</td>
<td>Clock for stepping switch (counter magnet)</td>
<td>0.5 / 2s</td>
<td>yellow</td>
<td>26</td>
<td>51-52</td>
<td>0.5 s-clock applied with depressed push-button &quot;Print-on&quot; on DBG or if jack DE is connected to &quot;0&quot;, otherwise a 2 s-clock is applied without clock amplifier.</td>
</tr>
<tr>
<td>3.4.2.1.4.</td>
<td>Clocks of the selector switch</td>
<td>NW</td>
<td>yellow</td>
<td>19</td>
<td>11-42</td>
<td>These jacks provide the clock set on the rotary switch (rh-side from DPF on drawer panel) as long as push-button &quot;Run&quot; (below switch) is effective and illuminated. With push-button &quot;Stop&quot; being effective (illuminated), the selected clock is switched-off. &quot;Run&quot; and &quot;Stop&quot; 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 UH=&quot;0&quot;, i.e. if a) white push-button &quot;Hold&quot; is depressed on DBG and b) one amplifier is overload</td>
</tr>
<tr>
<td>3.4.2.1.5.</td>
<td>Manual clock</td>
<td>HT</td>
<td>yellow</td>
<td>25</td>
<td>49-52</td>
<td>In position &quot;HT&quot; of the rotary switch, a single clock (manual clock) can be initiated by means of the yellow push-button &quot;HT&quot; (see 3.4.2.1.5)</td>
</tr>
<tr>
<td>3.4.2.2.</td>
<td>Timers</td>
<td>Timer 1</td>
<td>ZG1</td>
<td>yellow</td>
<td>17</td>
<td>3-4 30-32 15 A single clock is caused via push-button &quot;HT&quot; on the digital adapter unit. The jacks supply a binary &quot;1&quot;. With actuation of the push-button, a change from binary &quot;1&quot; to binary &quot;0&quot; takes place which remains as long as push-button HT is depressed. During phase T₃, binary &quot;0&quot; is applied, otherwise &quot;1&quot;.</td>
</tr>
<tr>
<td>Number</td>
<td>Meaning of Jacks</td>
<td>Jack Designation</td>
<td>Color</td>
<td>Line Column</td>
<td>Function</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>----------------</td>
<td>-----------------</td>
<td>-------</td>
<td>-------------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>Timer 2</td>
<td>ZG 2</td>
<td>yellow</td>
<td>17</td>
<td>30-32 16</td>
<td>During phase T₁, binary &quot;0&quot; is applied, otherwise &quot;1&quot;.</td>
<td></td>
</tr>
<tr>
<td>Timer 3</td>
<td>ZG 3</td>
<td>yellow</td>
<td>17</td>
<td>30-32 17</td>
<td>During phase T₂, binary &quot;0&quot; is applied, otherwise &quot;1&quot;.</td>
<td></td>
</tr>
<tr>
<td>Timer 4</td>
<td>ZG 4</td>
<td>yellow</td>
<td>17</td>
<td>30-32 18</td>
<td>During phase T₂, binary &quot;0&quot; is applied, otherwise &quot;1&quot;.</td>
<td></td>
</tr>
<tr>
<td>Timer 5</td>
<td>ZG 5</td>
<td>yellow</td>
<td>17</td>
<td>30-32 19</td>
<td>During phase T₂, binary &quot;0&quot; is applied, otherwise &quot;1&quot;.</td>
<td></td>
</tr>
<tr>
<td>Timer 6</td>
<td>ZG 6</td>
<td>yellow</td>
<td>17</td>
<td>30-32 20</td>
<td>During phase T₂, binary &quot;0&quot; is applied, otherwise &quot;1&quot;.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.4.2.3.</td>
<td>Control lines</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signal from Pause-push-button</td>
<td>p</td>
<td>yellow</td>
<td>30-32 21</td>
<td>After depressing the Pause-push-button on the DBG 771, binary &quot;1&quot; is available at p, whereas &quot;0&quot; is given at p. If not depressed, p = &quot;0&quot; and ( \bar{p} = &quot;1&quot; ).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal partial cycle</td>
<td>p</td>
<td>yellow</td>
<td>30-32 22</td>
<td>During phase compute ( \Gamma(T₁) ) and Hold ( \Gamma(T₂) ), &quot;1&quot; is given, otherwise &quot;0&quot;.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>r₁</td>
<td>yellow</td>
<td>30-32 23</td>
<td>During phase compute ( \Gamma(T₁) ) and Hold ( \Gamma(T₂) ), &quot;0&quot; is given, otherwise &quot;1&quot;.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>h₁</td>
<td>yellow</td>
<td>30-32 24</td>
<td>During phase compute ( \Gamma(T₁) ) &quot;0&quot; is given, otherwise &quot;1&quot;, h₁ = ZG 2.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>Meaning of Jacks</td>
<td>Jack Designation</td>
<td>Color</td>
<td>Line</td>
<td>Column</td>
<td>Function</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------</td>
<td>------------------</td>
<td>-------</td>
<td>------</td>
<td>--------</td>
<td>----------</td>
</tr>
<tr>
<td></td>
<td>complementary partial cycle</td>
<td>r2</td>
<td>yellow</td>
<td>30-32</td>
<td>25</td>
<td>During phase compute 2 (T2) and Hold 2 (T2), &quot;0&quot; is given, otherwise &quot;1&quot;.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>h2</td>
<td>yellow</td>
<td>30-32</td>
<td>26</td>
<td>During phase compute 2 (T2) &quot;0&quot; is given, otherwise &quot;1&quot;. h2 = 2G 5.</td>
</tr>
<tr>
<td>3.4.2.4.</td>
<td>Clearing</td>
<td>L6</td>
<td>white</td>
<td>30</td>
<td>38</td>
<td>The FF are cleared if their outputs A = &quot;0&quot; and A = &quot;1&quot;. The shift registers are cleared after their stages (consisting of flip-flops) are cleared. The counters are cleared in position &quot;0&quot;.</td>
</tr>
<tr>
<td>3.4.2.5.</td>
<td>Overload signalling (overload hold)</td>
<td>UH</td>
<td>yellow</td>
<td>30-32</td>
<td>31</td>
<td>Jack L6 influences all static clearing inputs of flip-flops on the FF-cards and supplies a return signal at the respective jacks L6 of the cards SR2 and ZL2. &quot;0&quot; at L6 clears all FFs and also all SR2 and ZL2, if at the latter L6 is connected to N. If jack L6 is connected to the below situated jack P(31/38), clearing takes place when depress- ing the push-button &quot;Pause&quot; on the DBG. Push-button &quot;L6&quot; on the panel of the digital adapter unit has the same effect than &quot;0&quot; on jack L6.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>To this jack UH (overload hold), &quot;0&quot; is applied if push- button &quot;with hold&quot; on the DBG is depressed and if an ampli- fier is overload. Otherwise &quot;1&quot; is given.</td>
</tr>
</tbody>
</table>

3-33
<table>
<thead>
<tr>
<th>Number</th>
<th>Meaning of Jacks</th>
<th>Jack Designation</th>
<th>D2 772</th>
<th>Color</th>
<th>Line</th>
<th>Column</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.3.</td>
<td>Program control via the DPF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.4.3.1.</td>
<td>Free Computer Control via the active control lines r, h, F, p of the Central Control APP 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The free computer control permits program control via the active control lines r, h, F, p of the Central Control APP 1 only from the digital adapter unit D2 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-plottter, 8-channel-recorder) and the time sweep generator (saw tooth) thereby are not operative. The control via jacks OD, OH, DE, DB, L2, FA of the DPF is effective.

2. With simultaneous control from digital control unit (DBG) and digital adapter unit (D2) it must be observed that the binary value of the resulting signal is given by conjunctive linking. 

\[ S = S \text{(DBG)} \land (D2) \]

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

<table>
<thead>
<tr>
<th>p-control line</th>
<th>p-control line</th>
<th>0P</th>
<th>brown</th>
<th>30</th>
<th>10</th>
<th>Applying &quot;0&quot; causes activation of the p-control line of master computer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1P</td>
<td>brown</td>
<td>31</td>
<td>10</td>
<td>Applying &quot;0&quot; causes activation of the p-control line of first slave computer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2P</td>
<td>brown</td>
<td>32</td>
<td>10</td>
<td>Applying &quot;0&quot; causes activation of the p-control line of second slave computer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>r1-control line*</td>
<td>0R1</td>
<td>brown</td>
<td>30</td>
<td>11</td>
<td>Applying &quot;0&quot; causes activation of the r1-control line of master computer</td>
<td></td>
</tr>
<tr>
<td>1R1</td>
<td>brown</td>
<td>31</td>
<td>11</td>
<td>Applying &quot;0&quot; causes activation of the r1-line of first slave computer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2R1</td>
<td>brown</td>
<td>32</td>
<td>11</td>
<td>Applying &quot;0&quot; causes activation of the r1-control line of second slave computer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* h1, h2, F1, r2 jack designations on DPF, whereby the respective signals on the APP are h, h, r, f.
<table>
<thead>
<tr>
<th>Number</th>
<th>Meaning of Jacks</th>
<th>Jack Designation</th>
<th>Color</th>
<th>Line</th>
<th>Column</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>h1-control line</td>
<td>0H1</td>
<td>brown</td>
<td>30</td>
<td>12</td>
<td>Applying &quot;0&quot; causes activation of h1-control line of master computer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1H1</td>
<td>brown</td>
<td>31</td>
<td>12</td>
<td>Applying &quot;0&quot; causes activation of h1-control line of first slave computer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2H1</td>
<td>brown</td>
<td>32</td>
<td>12</td>
<td>Applying &quot;0&quot; causes activation of h1-control line of second slave computer</td>
</tr>
<tr>
<td></td>
<td>r2-control line</td>
<td>0R2</td>
<td>brown</td>
<td>30</td>
<td>13</td>
<td>Applying &quot;0&quot; causes activation of r2-control line of master computer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1R2</td>
<td>brown</td>
<td>31</td>
<td>13</td>
<td>Applying &quot;0&quot; causes activation of r2-control line of first slave computer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2R2</td>
<td>brown</td>
<td>32</td>
<td>13</td>
<td>Applying &quot;0&quot; causes activation of r2-control line of second slave computer</td>
</tr>
<tr>
<td></td>
<td>h2-control line</td>
<td>0H2</td>
<td>brown</td>
<td>30</td>
<td>14</td>
<td>Applying &quot;0&quot; causes activation of h2-control line of master computer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1H2</td>
<td>brown</td>
<td>31</td>
<td>14</td>
<td>Applying &quot;0&quot; causes activation of h2-control line of first slave computer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2H2</td>
<td>brown</td>
<td>32</td>
<td>14</td>
<td>Applying &quot;0&quot; causes activation of h2-control line of second slave computer</td>
</tr>
</tbody>
</table>
|       | 3.4.3.2.        | Hold-instruction H | green | 31   | 27     | Applying of "0" in phase Hold 1 \(T_{p1}\) or Compute 2 \(T_{p2}\) 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 \(T_{p1}\) or Compute 2 \(T_{p2}\) 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 Pause-phase, the Pause-phase is prolonged respectively. After transfer from \(H=1\), the following computing phase is started synchronously to the basic clock.

3-35
<table>
<thead>
<tr>
<th>Number</th>
<th>Meaning of Jacks</th>
<th>Jack Designation</th>
<th>DZ 772</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.3.3</td>
<td>Continue instruction</td>
<td>WTR</td>
<td>green</td>
<td>31 29</td>
</tr>
<tr>
<td>3.4.3.4</td>
<td>End of Hold period and start of new computing cycle (Hold time end)</td>
<td>HE</td>
<td>green</td>
<td>31 38</td>
</tr>
</tbody>
</table>

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 and signal. A control the HE-jack also causes a print instruction. Further control modifications are possible by means of push-button "Progr.".
<table>
<thead>
<tr>
<th>Number</th>
<th>Meaning of Jacks</th>
<th>Jack Designation</th>
<th>Color</th>
<th>Line</th>
<th>Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.3.5.</td>
<td>Computing time end signal blocking</td>
<td>RE</td>
<td>green</td>
<td>32</td>
<td>27</td>
</tr>
</tbody>
</table>

By applying binary '0' to jack "RE", the compute time end signal is blocked, which occurs at the end of each computing phase (only $T_1$). Thus, the compute phase may exceed the preset computing time. Especially repetitive computing cycles with phases $T_n$ 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.

<table>
<thead>
<tr>
<th>Number</th>
<th>End of Hold-phase</th>
<th>End of Hold-time 1 (Hold-time end 1)</th>
<th>Color</th>
<th>Line</th>
<th>Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.3.6.</td>
<td></td>
<td>H1E</td>
<td>blue</td>
<td>30</td>
<td>27</td>
</tr>
</tbody>
</table>

Only effective after depressing push-button "Progr." on DBG and during program modes "Repet."."It.aut."or"It.Hand".

With the above given conditions, the length of the Hold-phase $T_1$ 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".
<table>
<thead>
<tr>
<th>Number</th>
<th>Meaning of Jacks</th>
<th>Jack Designation</th>
<th>Color</th>
<th>Line</th>
<th>Column</th>
<th>Function</th>
</tr>
</thead>
</table>
|        | End of Hold-time 2 (Hold-time end 2) | H2E | blue | 30   | 28     | With above given conditions, the length of the Hold-phase $T_2$ 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) | IT2 | blue | 30   | 29     | 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"). A change 1/0 at "IT2" causes a transfer from normal to complementary partial cycle, i.e. from phase $T_{p1}$ to phase $T_{p2}$.

The 1/0-change must occur at least one basic clock period before the 1/0-change at "H1E". The 1/0-change for clock change must occur only after end of computing phase, i.e. the Hold-phase $T_{p1}$ 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. |
<table>
<thead>
<tr>
<th>Number</th>
<th>Meaning of Jacks</th>
<th>Jack Designation</th>
<th>D2 772</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clock change from complementary (2) to normal (1)</td>
<td>2T1</td>
<td>blue</td>
<td>30</td>
</tr>
<tr>
<td>3.4.3.8</td>
<td>Computer control (10 x faster or time constant control input)</td>
<td>ZSE</td>
<td>brown</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

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 P.
<table>
<thead>
<tr>
<th>Number</th>
<th>Meaning of Jacks</th>
<th>Jack Designation</th>
<th>Color</th>
<th>Line</th>
<th>Column</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.3.9.</td>
<td>Group control of time constants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>Switch-over of time constants control</td>
<td>0ZSU</td>
<td>brown</td>
<td>30</td>
<td>8</td>
<td>By connecting &quot;0&quot;, 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 &quot;10x&quot; and 0SE remain ineffective.</td>
</tr>
<tr>
<td></td>
<td>Time constants control input 0ZSE for single group control</td>
<td>1ZSU</td>
<td>brown</td>
<td>31</td>
<td>8</td>
<td>As 0ZSU, but for slave computer 1.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2ZSU</td>
<td>brown</td>
<td>32</td>
<td>8</td>
<td>As 0ZSU, but for slave computer 2.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0ZSE</td>
<td>brown</td>
<td>30</td>
<td>7</td>
<td>If 0ZSU is connected to &quot;0&quot;, the integrators 20, 21, 22, 70, 71, 72 of the master computer are switched to 10x-faster.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1ZSE</td>
<td>brown</td>
<td>31</td>
<td>7</td>
<td>If 1 ZSU is connected to &quot;0&quot;, the integrators 20, 21, 22, 70, 71, 72 of the first slave computer are switched to 10x-faster.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2ZSE</td>
<td>brown</td>
<td>32</td>
<td>7</td>
<td>If 2 ZSU is connected to &quot;0&quot;, the integrators 20, 21, 22, 70, 71, 72 of the second slave computer are switched to 10x-faster.</td>
</tr>
<tr>
<td>Number</td>
<td>Meaning of Jacks</td>
<td>Jack Designation</td>
<td>Color</td>
<td>Line</td>
<td>Column</td>
<td>Function</td>
</tr>
<tr>
<td>---------</td>
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<td>------</td>
<td>--------</td>
<td>----------</td>
</tr>
<tr>
<td>3.4.3.10.</td>
<td>Single compute instruction</td>
<td>1xR</td>
<td>green</td>
<td>32</td>
<td>18</td>
<td>see 3.3.3.</td>
</tr>
<tr>
<td>3.4.3.11.</td>
<td>Control of time sweep generator</td>
<td>Z</td>
<td>brown</td>
<td>30</td>
<td>35</td>
<td>see 4.9.4.</td>
</tr>
<tr>
<td>3.4.3.12.</td>
<td>Freely programmable control possibilities</td>
<td>Q00... Q11</td>
<td>brown</td>
<td>26,28</td>
<td>7...12</td>
<td></td>
</tr>
</tbody>
</table>

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.
<table>
<thead>
<tr>
<th>Number</th>
<th>Meaning of Jacks</th>
<th>Jack Designation</th>
<th>D2 772</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.4</td>
<td>Control of input and output devices</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.4.4.1</td>
<td>Oscilloscope</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.4.4.1.1</td>
<td>Oscilloscope unblanking</td>
<td>OH</td>
<td>white</td>
<td>31</td>
</tr>
<tr>
<td>3.4.4.1.2</td>
<td>Oscilloscope blanking</td>
<td>OD</td>
<td>white</td>
<td>32</td>
</tr>
<tr>
<td>3.4.4.2</td>
<td>Digital Voltmeter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.4.4.2.1</td>
<td>Measuring instruction (print instruction)</td>
<td>DB</td>
<td>white</td>
<td>30</td>
</tr>
</tbody>
</table>

Note:
With push-button "Print-on" depressed on the DBG - but without a printer being connected - a measuring process requires approx. 800 ms. With connected printer, the acknowledgment signal is awaited; in this case two instructions per second are possible.
<table>
<thead>
<tr>
<th>Number</th>
<th>Meaning of Jacks</th>
<th>Jack Designation</th>
<th>Color</th>
<th>Line</th>
<th>Column</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.4.3.1.</td>
<td>Printer control (printer on)</td>
<td>DE</td>
<td>white</td>
<td>32</td>
<td>35</td>
<td>This input is disjunctively linked to the push-button &quot;Printer on&quot; of the DBG. &quot;0&quot; connects the printer to the output of the digital voltmeter.</td>
</tr>
<tr>
<td>3.4.4.3.2.</td>
<td>Print-instruction blocking 1</td>
<td>DB1</td>
<td>white</td>
<td>31</td>
<td>36,37</td>
<td>Connection of both jacks prevents the measuring-print instruction at the end of the normal partial cycle. Note: Jack 31/37 leads - 15 V!</td>
</tr>
<tr>
<td>3.4.4.3.3.</td>
<td>Print-instruction blocking 2</td>
<td>DB2</td>
<td>white</td>
<td>32</td>
<td>36,37</td>
<td>Connection of both jacks prevents the measuring-print instruction at the end of the normal partial cycle. Note: Jack 32/37 leads - 15 V!</td>
</tr>
<tr>
<td>3.4.4.3.4.</td>
<td>Print-instruction</td>
<td>DB</td>
<td>white</td>
<td>30</td>
<td>36</td>
<td>A change 1/0 at any time causes:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a) measuring instruction to the digital voltmeter.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>b) Print-instruction to digital printer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DB is dominant as compared to DB1 and DB2. (See 3.4.4.2.2.)</td>
</tr>
<tr>
<td>3.4.4.3.5.</td>
<td>Empty line</td>
<td>LZ</td>
<td>white</td>
<td>30</td>
<td>37</td>
<td>&quot;0&quot; 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 &quot;Print-on&quot; being depressed, a measuring process requires approx. 800 ms without connected printer.</td>
</tr>
</tbody>
</table>

![Diagram](image-url)
<table>
<thead>
<tr>
<th>Number</th>
<th>Meaning of Jacks</th>
<th>Jack Designation</th>
<th>Color</th>
<th>Line</th>
<th>Column</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.4.4.</td>
<td>XY-plotter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.4.4.4.1</td>
<td>Pen drop blocking 1</td>
<td>FA1</td>
<td>white</td>
<td>31</td>
<td>32,33</td>
<td>Connection of both jacks prevents pen dropping of a connected plotter within phase T_{1}'. During phases T_{2}' and T_{3}' the pen is always lifted.</td>
</tr>
<tr>
<td>3.4.4.4.2</td>
<td>Pen drop blocking 2</td>
<td>FA2</td>
<td>white</td>
<td>32</td>
<td>32,33</td>
<td>During complementary partial cycle, FA2 has the same effect than FA1 during the normal partial cycle.</td>
</tr>
<tr>
<td>3.4.4.4.3</td>
<td>Pen drop instruction (pen control)</td>
<td>FA</td>
<td>white</td>
<td>30</td>
<td>32</td>
<td>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 &quot;0&quot;.</td>
</tr>
<tr>
<td>3.4.5.</td>
<td>Control data transfer between digital adapter unit and hybrid coupling unit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.4.5.1.</td>
<td>Parallel output</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.4.5.1.1</td>
<td>Static parallel output PA1 and PA2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Static parallel output 1</td>
<td>PA1</td>
<td>orange</td>
<td>33</td>
<td>1,6</td>
<td>These jacks are outputs of the parallel output register 1.</td>
</tr>
<tr>
<td></td>
<td>Static parallel output 2</td>
<td>PA2</td>
<td>orange</td>
<td>34</td>
<td>1,6</td>
<td>These jacks are outputs of the parallel output register 2.</td>
</tr>
<tr>
<td>Number</td>
<td>Meaning of Jacks</td>
<td>Jack Designation</td>
<td>Color</td>
<td>Line Column</td>
<td>Function</td>
<td></td>
</tr>
<tr>
<td>--------</td>
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<td></td>
</tr>
<tr>
<td>3.4.5.1.2.</td>
<td>Dynamic parallel output</td>
<td>Parallel output PA 1...12</td>
<td>orange</td>
<td>33 7..18</td>
<td>These jacks are outputs of the HKW-buffer register. Evaluation of the available information is controlled by the parallel output clock.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parallel output PAT</td>
<td>yellow</td>
<td>33 19</td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>3.4.5.1.3.</td>
<td>Buffered control word output</td>
<td>Buffered control word output PPA 1...12</td>
<td>orange</td>
<td>34 31...42</td>
<td>Outputs of PPA-register (no standard equipment)</td>
<td></td>
</tr>
<tr>
<td>3.4.5.2.</td>
<td>Parallel input</td>
<td>Parallel input PE 1...12</td>
<td>green</td>
<td>34</td>
<td>Jacks PE are provided for parallel input of a binary information.</td>
<td></td>
</tr>
<tr>
<td>3.4.5.3.</td>
<td>Scanning lines</td>
<td>Scanning lines AL 10...24</td>
<td>green</td>
<td>33 23...37</td>
<td>The jacks lead to freely programmable selection lines. They are scanned from the digital computer. See Makro-description of respective digital computer.</td>
<td></td>
</tr>
<tr>
<td>3.4.5.4.</td>
<td>Interrupt lines</td>
<td>Interrupt lines UB 5...16</td>
<td>green</td>
<td>34 19...30</td>
<td>These jacks are inputs of the interrupt unit. A change from 1/0 causes setting of a monoflop for approx. 2.5 ms, which again causes interruption in the digital computer.</td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>Meaning of Jacks</td>
<td>Jack Designation</td>
<td>Color</td>
<td>Line</td>
<td>Column</td>
<td>Function</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------------------</td>
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<td>------</td>
<td>--------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>3.4.5.5.</td>
<td>External control of cycle time counter</td>
<td>EZT</td>
<td>white</td>
<td>33</td>
<td>20</td>
<td>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 &quot;0&quot;. 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 supplied with &quot;0&quot; . 2) During program &quot;Compute with Hold&quot;. 3) If the Hold-instruction jack (APF or DPF) is supplied with &quot;0&quot; . To activate jack ZES, the switch D2 on the control panel 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 only from the cycle time counter. Binary &quot;0&quot; permits external control of the cycle time counter (no standard equipment). Binary &quot;0&quot; permits counting of the cycle time counter at external control. Binary &quot;1&quot; interrupts the counting process (no standard equipment). Binary &quot;0&quot; clears the cycle time counter, i.e. setting to &quot;0&quot;. When removing binary &quot;0&quot;, the counter takes-over the value from the cycle time register (no standard equipment).</td>
</tr>
<tr>
<td></td>
<td>External count clock</td>
<td>ZLS</td>
<td>white</td>
<td>33</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cycle time counter erase blocking</td>
<td>ZES</td>
<td>white</td>
<td>33</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cycle time end signal</td>
<td>ZEX</td>
<td>green</td>
<td>34</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td></td>
<td>External control of cycle time counter</td>
<td>ZTF</td>
<td>green</td>
<td>34</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clock release of cycle time counter</td>
<td>ZNO</td>
<td>green</td>
<td>34</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>Meaning of Jacks</td>
<td>Jack Designation</td>
<td>Color</td>
<td>Line</td>
<td>Column</td>
<td>Function</td>
</tr>
<tr>
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<td>----------</td>
</tr>
<tr>
<td>3.4.5.6</td>
<td>External control of buffered data input and output</td>
<td>Cycle time end</td>
<td>ZZE</td>
<td>orange</td>
<td>34</td>
<td>46</td>
</tr>
<tr>
<td>3.4.5.6</td>
<td>Parallel hold</td>
<td>PAHA</td>
<td>green</td>
<td>34</td>
<td>48</td>
<td>With binary &quot;0&quot; the scanning and hold-circuits are in condition &quot;Hold&quot; (no standard equipment).</td>
</tr>
<tr>
<td>3.4.5.6</td>
<td>Control of common clock from D to A</td>
<td>GTDA</td>
<td>green</td>
<td>34</td>
<td>47</td>
<td>Binary &quot;0&quot; 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).</td>
</tr>
<tr>
<td>3.4.6.</td>
<td>Cross-connection lines</td>
<td>0...39</td>
<td>white</td>
<td>1...20</td>
<td>1,2</td>
<td>See 4.14. Connections to St8 and St9 on rear side of digital adapter unit.</td>
</tr>
<tr>
<td>3.4.6.</td>
<td></td>
<td>0...39</td>
<td>white</td>
<td>1...20</td>
<td>1,2</td>
<td></td>
</tr>
<tr>
<td>3.4.6.</td>
<td></td>
<td>0...39</td>
<td>white</td>
<td>1...20</td>
<td>51,52</td>
<td>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 APP via a connecting cable on the rear side of the computer.</td>
</tr>
<tr>
<td>3.4.6.</td>
<td></td>
<td>0...39</td>
<td>white</td>
<td>1...20</td>
<td>51,52</td>
<td></td>
</tr>
</tbody>
</table>
### Alphabetic Listing of Jacks on the DPF

<table>
<thead>
<tr>
<th>Jack designation</th>
<th>Section number</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>4.10.</td>
</tr>
<tr>
<td>A</td>
<td>4.18.</td>
</tr>
<tr>
<td>A</td>
<td>4.18.</td>
</tr>
<tr>
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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.

![Digital Voltmeter Display Diagram](image)

**Fig. 3.5.1/1 Digital voltmeter display**

The measuring value display reaches from $\pm 1 \, \text{mV}$ 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.

![Rear Side of Digital Voltmeter Diagram](image)

**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).**

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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

<table>
<thead>
<tr>
<th>A measuring instruction takes place: periodically all 20 ms</th>
<th>Aperiodically with a minimum spacing of 350 ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>for the program types:</td>
<td>at the end of the computing phase of the following program runs:</td>
</tr>
<tr>
<td>1. Continuous computing, push-button &quot;Continuous&quot;</td>
<td>1. Repetitive computing, push-button &quot;Repet.&quot;</td>
</tr>
<tr>
<td>2. Compute with Hold, push-button &quot;With Hold&quot;</td>
<td>2. Automatic iterative computing, push-button &quot;It.aut.&quot;</td>
</tr>
<tr>
<td>3. Iterative computing with manual start,</td>
<td>A measuring instruction also occurs in case of:</td>
</tr>
<tr>
<td>push-button &quot;It.Hand&quot;</td>
<td>1. Automatic selection, push-button &quot;Aut.&quot;</td>
</tr>
<tr>
<td>4. Zero-balancing of operational amplifiers,</td>
<td>2. Print instruction, push-button &quot;Print Instr.&quot; or jack DB on DPF see 3.4.4.3.</td>
</tr>
<tr>
<td>push-button &quot;Null&quot; (Zero)</td>
<td>3. Scanning by punched-tape control unit</td>
</tr>
<tr>
<td>5. Static program check, push-button &quot;stat.&quot;</td>
<td>4. Scanning by digital computer</td>
</tr>
<tr>
<td>6. Dynamic check, push-button &quot;dyn.&quot;</td>
<td>5. Setting of FF1 of the stepping switch of digital adapter unit</td>
</tr>
</tbody>
</table>

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.
1. **NETZ**
   (Mains)
   Mains switch

2. **EICHSP 1VOLT**
   (Calibrated voltage 1 V)
   Calibrating voltage 1 V, square-wave, 50 Hz

3. **ASTIGM.**
   FOCUS
   Setting of beam focus

4. **STRAHLBÜCHER**
   (Beam finder)
   For beam finding on the screen

5. **HELLIGKEIT**
   (Brightness)
   Setting of beam brightness

6. **NACHLEUCHTEN**
   (Persistance)
   Setting of persistance time (0.2 s to 60 s)

7. **ERASE**
   Erasing of stored or written display

8. **FAST**
   Fast write speed (up to 1/2 subdivisions μs) and
   variable persistance time

9. **STD.**
   Operation at normal write speed and variable persistance time

10. **CONV.**
    Operation as oscilloscope without storage

11. **STORE**
    Storing of signals

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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/DIV) 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 amplifiers of channel A and B
"+" inputs are led to the jacks Y1 and Y2 of analog patch panel
21. BANDBRE (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:
switch position: 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 PEDEL (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 Time sweep started without Trigger-pulses (FREI, free) with synchronous input signal (SYNCHR) or single deflection after depressing the "START" push-button.
The oscilloscope HPO 771 serves for display and evaluation of the computing results. It is especially suited for this purpose because of the long persistence 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 "0s"). 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 $Y_1$ and $Y_2$ amounts to 50 kOhm, parallel 50 pF. Accuracy of the individual ranges is ± 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 $\text{EXT.HORIZ}$. 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 "\text{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 $Y_2$
- $Y_1$ and $Y_2$
- $X_1$ or T
- $X_1$ or T chopped
- $Y_1$
- $Y_2$
- $X_1$ or T alternating

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 $Y_1$, brightness modulation is possible. The total range amounts ± 10 V.

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

Write speed: Normal or fast write speed can be set by means of the push-buttons "\text{STD}" or "\text{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 Y₁ and Y₂ 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 X₁ for horizontal deflection: set switch to 1 V/SKT and adjust the desired display width by using fine control ▶ CAL. The X₁ 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 Y₁, Y₂ and X₁ 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 (± 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 input 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 computing 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 +1 mV...-1 mV when setting the switch to position 4 mV (for zeroing of drift compensated amplifiers and operational amplifiers realized with integrator circuit card H-5K24 (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 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 = 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 computing 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)

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.
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 APP 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 APP 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 APP. This is described in the section dealing with drawer NNT 801. Also a mixture of both selection types is possible.

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 APP 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.
3.6.3.3. Drift-Compensated Operational Amplifiers

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.

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 "26".
2. Patch inputs according to the following instructions
3. Depress push-button "Zero"
4. Set switch near the Zero-potentiometers (behind lamp field) to position 4 mV.
5. Connect amplifier output to the Zero-instrument by selecting the connected jack "26".

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.

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).

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 discrete 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 fically 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 $R_i = 5 \text{ kOhm}$. Thus, the weight factors of all integrator 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 $+1 \text{ V}$ is applied to an 200 kOhm input of each computing amplifier patched as integrator on the APF. Thus, the four directly selectable integration factors $k$, 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 Pause**
- **Phase Compute**
- **Phase Hold**

<table>
<thead>
<tr>
<th>Phase initial value setting</th>
<th>Phase length $A_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase Pause</td>
<td>Phase length $T_p$</td>
</tr>
<tr>
<td>Phase Compute</td>
<td>Phase length $T_r$</td>
</tr>
<tr>
<td>Phase Hold</td>
<td>unlimited</td>
</tr>
</tbody>
</table>

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

$$0.5 \text{ s} \leq A_t \leq 2 \text{ s}$$

The initial value $Y = 0$ can also be set with given maximum time constant of the initial value setting network of 25 ms ($R_i = 5 \text{ kOhm}$, $C_i = 5 \mu\text{F}$) 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 ($\pm 1 \text{ V}$).
3.6.6. Principle Circuits of "Check Modes"

Designations: \( R_A = 5 \text{kOhm} \quad R_1 = 200 \text{kOhm} \quad R_{10} = 20 \text{kOhm} \)

\( C_1 \) Integrator capacitor

a) Integrator

b) Summers

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

a) Integrators

when selecting \( Z = X_p \)

\[ Y = \frac{1}{40} (X_1 + X_2) \]
3.6.6.3. Zero-Balancing of Operational Amplifiers, Push-Button "Zero" depressed

\[ Z = -(X_1 + X_2 + 10X_3) \]

b) Summers

a) Integrator

otherwise amplifier outputs

b) Summers

Zero-Instrument
Only effective for integrators

Dynamic Check,
Push-Button "dyn." depressed

![Diagram of electronic circuit and graph]

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>dy</td>
<td>dy*</td>
<td></td>
</tr>
<tr>
<td>energized</td>
<td>not energized</td>
<td></td>
</tr>
</tbody>
</table>

$T_p$ 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 utmost 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 n, 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>
<thead>
<tr>
<th>Selection Address</th>
<th>Return an DVM</th>
<th>Voltage</th>
<th>Display on DVM</th>
<th>Display on Zero-instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>P 08</td>
<td>K 08</td>
<td>+ 10 V</td>
<td>+ 1.0000</td>
<td>red line within right-hand scale half</td>
</tr>
<tr>
<td>P 18</td>
<td>K 18</td>
<td>- 10 V</td>
<td>- 1.0000</td>
<td>blue line within left-hand scale half</td>
</tr>
<tr>
<td>P 28</td>
<td>K 28</td>
<td>+ 15 V_I</td>
<td>0.0000</td>
<td>red point at the right-hand scale end</td>
</tr>
<tr>
<td>P 38</td>
<td>K 38</td>
<td>- 15 V_I</td>
<td>0.0000</td>
<td>blue point at the left-hand scale end</td>
</tr>
<tr>
<td>P 48</td>
<td>K 48</td>
<td>+ 15 V_II</td>
<td>0.0000</td>
<td>red point at the right-hand scale end</td>
</tr>
<tr>
<td>P 58</td>
<td>K 58</td>
<td>- 15 V_II</td>
<td>0.0000</td>
<td>blue point at the left-hand scale end</td>
</tr>
<tr>
<td>P 68</td>
<td>K 68</td>
<td>+ 15 V_III</td>
<td>0.0000</td>
<td>red point at the right-hand scale end</td>
</tr>
<tr>
<td>P 78</td>
<td>K 78</td>
<td>- 15 V_III</td>
<td>0.0000</td>
<td>blue point at the left-hand scale end</td>
</tr>
<tr>
<td>P 88</td>
<td>K 88</td>
<td>+ 30 V</td>
<td>0.0000</td>
<td>red point at the right-hand scale end</td>
</tr>
</tbody>
</table>

Table 3.6.8. Supply voltages