ROHDE&SCHWARZ

Manual

POWER SUPPLIES

Series NGPV

NGPV	8/10	192.0310.80
		192.0310.81
NGPV	20/5	192.0310.20
		192.0310.21
NGPV	20/10	192.0326.20
		192.0326.21
NGPV	40/3	192.0310.40
		192.0310.41
NGPV	40/5	192.0326.40
		192.0326.41
NGPV	100/1	192.0310.10
		192.0310.11
NGPV	100/2	192.0326.10
		192.0326.11
NGPV	300/0.3	192.0310.30
		192.0310.31
NGPV	300/0.6	192.0326.30
		192.0326.31

For general enquiries and ordering spare parts please specify type, order designation, and serial number of the unit.

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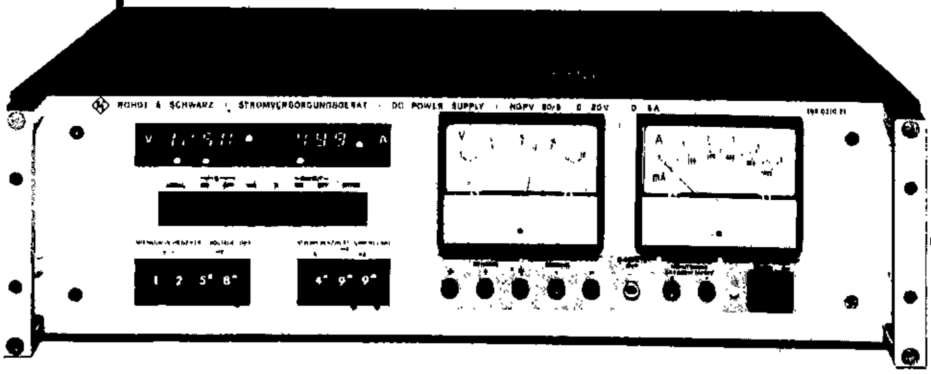
SYSTEM POWER SUPPLIES

NGPV



Programmable Power Supplies NGPV

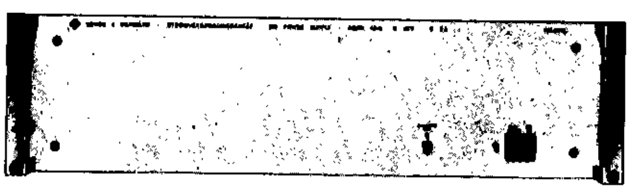
- Digital setting, high resolution
- No discrete output capacitance, true current source
- IEC-bus-programmed and manual operation
- Short down response time thanks to current sink
- Two current ranges – current monitoring output
- LEDs for operating status and errors

IEC 625 Bus

The **NGPV Power Supplies** are suitable for both system applications and general laboratory use. Nine models graded by voltage and current are available in the power range up to 200 W.

NGPV 8/10:	0 to 8 V / 0 to 10 A; 80 W,
NGPV 20/5:	0 to 20 V / 0 to 5 A; 100 W,
NGPV 20/10:	0 to 20 V / 0 to 10 A; 200 W,
NGPV 40/3:	0 to 40 V / 0 to 3 A; 120 W,
NGPV 40/5:	0 to 40 V / 0 to 5 A; 200 W,
NGPV 100/1:	0 to 100 V / 0 to 1 A; 100 W,
NGPV 100/2:	0 to 100 V / 0 to 2 A; 200 W,
NGPV 300/0.3:	0 to 300 V / 0 to 0.3 A; 90 W,
NGPV 300/0.6:	0 to 300 V / 0 to 0.6 A; 180 W.

The user has the choice of two versions. The one for system and laboratory use can be programmed via the IEC bus (IEC 625-1 or IEEE 488) or operated manually. The units of this version have the required operating controls, a LED display for the indication of all input data (including that entered via the IEC bus) and meters for actual voltage and current. The pure system version – without operating controls – provides particularly cost-effective IEC-bus-programmable 19″ units for rackmounting or for use on the bench.



Power Supply NGPV for system applications

System use The system power supply is characterized by the short settling time of 2 ms (for the rise and, thanks to a controlled current sink, also for the fall). The NGPVs do not have a discrete output capacitance so they can regulate very small currents. Relay contacts will not be damaged by the switching of current paths. An appreciable output capacitance, however, is provided internally and can be connected manually or via the program as required.

Remote sensing Remote sensing makes the NGPV particularly suitable for system applications. It is performed automatically; no sensing links are required. The compensation range is 1 V in each lead. When remote sensing is in operation the maximum output voltage of the power supply exceeds the nominal voltage by the amount of the voltage drop in the leads. The result is that with the NGPV 8/10, for example, the full value of 8 V is available at the load even if a voltage drop of up to 1 V exists in each lead. The maximum voltage increase occurring at the load due to an interruption of the sensing leads is 1 mV, which is negligible for practical purposes.

Current regulation The special capability of the NGPV as a current regulator is afforded by two current ranges, which ensure a high resolution of 1 mA and 0.1 mA, respectively.

Laboratory and system use The NGPV models equipped with meters and front-panel controls are also versatile laboratory power supplies. Output voltage and current can be read from large analog meters. LEDs indicate the operating mode and operating status. A digital display shows the values entered, also those programmed via the IEC bus. Parallel outputs and sockets for a current monitoring output (referred to the positive terminal) are located on the front and rear panels.

Cooling The blowers are thermostat-regulated and run at low RPM in the partial-load region.

SYSTEM POWER SUPPLIES

Specifications

Power Supply Type	NGPV 8/10	NGPV 20/5	NGPV 20/10	NGPV 40/3	NGPV 40/5	NGPV 100/1	NGPV 100/2	NGPV 300/0.3	NGPV 300/0.6
▶ **Order designation**									
System model[1])	192.0310.80	192.0310.20	192.0326.20	192.0310.40	192.0326.40	192.0310.10	192.0326.10	192.0310.30	192.0326.30
System and laboratory model[2])	192.0310.81	192.0310.21	192.0326.21	192.0310.41	192.0326.41	192.0310.11	192.0326.11	192.0310.31	192.0326.31
Voltage setting	0 to 7.99 V	0 to 19.99 V		0 to 39.99 V		0 to 99.9 V		0 to 299.9 V	
Resolution (mV/steps)	10 mV/800	10 mV/2000		10 mV/4000		100 mV/1000		100 mV/3000	
Deviation (of full scale)	$<10^{-3}$	$<10^{-3}$		$<10^{-3}$		$<10^{-3}$		$<10^{-3}$	
Current setting (2 ranges) in A range	0 to 9.99 A	0 to 4.99 A	0 to 9.99 A	0 to 2.99 A	0 to 4.99 A	0 to 0.999 A	0 to 1.99 A	0 to 0.299 A	0 to 0.599 A
Resolution (mA/steps)	10 mA/1000	10 mA/500	10 mA/1000	10 mA/300	10 mA/500	1 mA/1000	10 mA/200	1 mA/300	1 mA/600
Deviation (of full scale)	$<10^{-3}$	$<2 \times 10^{-3}$	$<10^{-3}$	$<3 \times 10^{-3}$	$<2 \times 10^{-3}$	$<10^{-3}$	$<4 \times 10^{-3}$	$<3 \times 10^{-3}$	$<2 \times 10^{-3}$
In mA range	0 to 999 mA	0 to 999 mA		0 to 999 mA		0 to 99.9 mA		0 to 99.9 mA	
Resolution (1000 steps)	1 mA	1 mA		1 mA		0.1 mA		0.1 mA	
Deviation (of full scale)	$<10^{-3}$	$<10^{-3}$		$<10^{-3}$		$<2 \times 10^{-3}$		$<2 \times 10^{-3}$	
PARD[3])	<200 µV	<250 µV		<400 µV		<600 µV		<900 µV	
Output C (OFF/ON)	500 pF/220 µF	500 pF/100 µF	750 pF/220 µF	500 pF/47 µF	750 pF/100 µF	500 pF/22 µF	750 pF/47 µF	500 pF/10 µF	750 pF/22 µF
Overvoltage protection	4.5 to 15 V	4.5 to 25 V		4.5 to 50 V		5 to 110 V		5 to 330 V	

[1]) System model for IEC-bus programming (no operating controls and meters) in 19" cabinet.
[2]) System and laboratory model for IEC-bus programmed and manual operation with meters for voltage and current.
[3]) PARD = periodic and random deviation.

Common data

Constant-voltage source
Deviation of output voltage
with AC supply variations of ±10% ... $< \pm 10^{-5}$
with temperature variations
from 0 to 50°C ... $< \pm 2 \times 10^{-5}$/K
with load variations from 10 to 90% ... $<10^{-4}$
Transient recovery time
(10 to 90%/90 to 10%) ... <75 µs (within $\pm 10^{-3}$)

Constant-current source
Deviation of output current
with AC supply variations of ±10% ... $<\pm 10^{-5}$
with temperature variations
from 0 to 50°C ... $<\pm 5 \times 10^{-5}$/K
with load variations from 10 to 90% ... $<10^{-4}$
Transient recovery time,
output C OFF/ON ... <50 µs/<2 ms
PARD rms
In mA range ... 10 µA
In A range ... 100 µA/A

Programming ... IEC 625-1 (IEEE 488)
Connector ... 24-contact
Functions ... SH0, AH1, T0, TE0, L1, LE0, SR0, RL1, PP1, DC1, DT1, C0
Setting time
0 to 100%/100 to 0% ... <2 ms (within $\pm 2 \times 10^{-3}$)
Remote sensing
max. voltage compensation ... 1 V in each lead

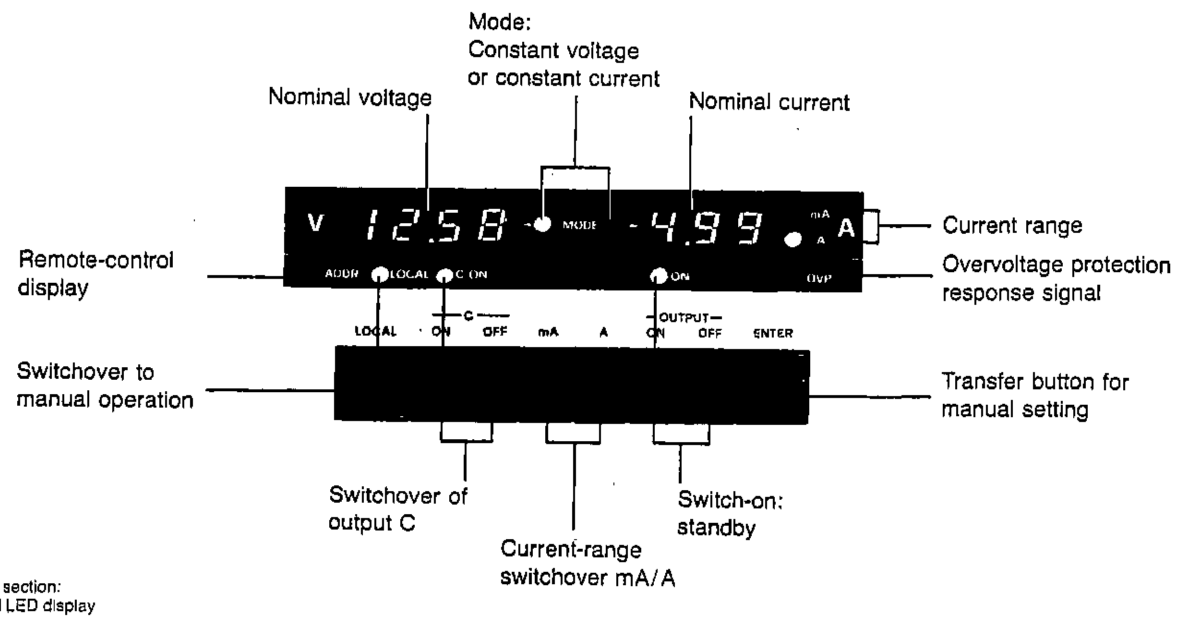
Current monitoring output, Z_{out} = 1 kΩ
(referred to positive terminal)
In mA range ... 100 mV ±1% for full scale
In A range ... 10 mV ±1%/A

General data

Meter error ... ±2.5% of full scale
Rated temperature range ... 0 to +50°C
Safety specifications ... comply with VDE 0411, class 1
EMI specifications ... comply with VDE 0871/6.78 level B
Output terminals ... 4 mm, floating; test voltage 1000 V/ground
AC supply ... 110/120/220/240 V ±10%, 47 to 63 Hz

Order No.	192.0310...	192.0326...
Power consumption	ca. 250 VA	ca. 500 VA
Dimensions (W×H×D) in mm	492×161×392	492×161×420
Weight	12 kg	19 kg
Panel engravings	German/English	

Order designations ... ▶ see table above



Front-panel section:
key row and LED display

2. Preparation for Use and Operating Instructions

2.1 Preparations for Operation

There are two models of the NGPV power supply unit produced:

- exclusively for IEC-bus-programming with blank front panel

- for OEC-bus-programming and manual operation with controls and displays on the front panel

A general specification for both models is given in the data sheet (see item 1.), including the front panel controls and displays.

In the subsequent sections the functions of manual operation are described where applicable to the particular model.

These power supply units are suitable for line voltages of 110 V, 127 V, 220 V and 242 V. They are factory-adjusted for an operational voltage of 220 V.

To adapt the unit to 110 V, set the slide switch on the rear panel to the left stop and insert the matching mains fuses.

If the transformer connections are changed from terminal 2 to 3, and terminal 5 to 6, selection is made via the slide switch between 127 V (left stop) and 242 V (right stop) with the appropriate fuses inserted for the voltage selected.

The fuse values for corresponding voltage operation are as follows:

	220/242 V	110/127 V
100 W-units:	T1.6D	T3.15D
200 W-units:	T3.15D	T6.3D

These fuse values are printed on the rear panel of the unit.

NGPV power supply units are delivered as bench top units with swing out supports for tilting. The units are 19" wide and are also suitable for mounting into 19" rack supports after first removing two covers which are released via side panel screws.

The model for IEC-bus-programming and manual operation is equipped with output terminals on both the front and rear panels, which are connected in parallel. They can arbitrarily by earthed.

All NGPV power supplies comply with VDE 0411 class I specifications (protective grounding). All inputs and outputs are floating and tested at 1000 V.

2.1.1 Switching on

When the unit is switched on (POWER ON) the following occurs:

- The green LED next to the mains switch lights up.
- The current range mA is switched on.
- The output capacitor is switched off (C OFF).
- The unit is in standby state (OUTPUT OFF).

On models for IEC-bus programming and manual operation (with control elements and instruments), the above mentionde featur-es are signalled by the appropriate LED displays.

Further:

- LED-display for manual operation (LOCAL) lights up and
- display as well as analog meters are at zero.

2.2 Manual Operation

When the display-LED LOCAL lights up the unit can be operated manually. If necessary it can be set to this state previously with the LOCAL key. If the key is blocked by the LEC-bus-command LOCAL LOCKOUT, it can be cleared by IEC-bus (see 2.3.6) or by switching the unit off and on (POWER OFF/ON).

2.2.1 Setting of Current and Voltage Limits

The desired current and voltage limits are set by the code switches and accepted by the unit with the key ENTER.

The settings can be changed at any time. Only when ENTER is pressed the values are accepted by the unit and the desired va-lues are indicated on the display.

The three digit code switch for the current limit allows set-tings within the A-range, which on some units of this model series may exceed the nominal value.

If such faulty settings are entered they are not accepted when ENTER is pressed, but the display starts flashing. If the unit was switched on (OUTPUT ON) it automatically turns to standby (OUTPUT OFF). After correction of the setting and ENTER/OUTPUT ON it is in operational mode again.

Exception: The NGPV 8/10 has no limit control. Voltage limits can be set exceeding the nominal value of 8 V up to 9.99 V. Full specifications are maintained at the output terminals, however on sensing operation limits at the load terminals must be observed (see 2.2.5).

2.2.2 Electronic Switch-On and Off

With OUTPUT ON the unit turns from standby to operational mode and the indicator-LED ON above the key lights up.

According to the applied load, the unit is in constant voltage (CV) or constant current (CC) mode. The present mode is indicated on the display by LEDs (MODE).

2.2.3 Current Range Selection

The unit can operate in two current ranges, in the mA- and the A-range. To select these ranges the keys mA or A are used. The relevant LEDs are in the display on the right hand side. On pressing the range keys the unit automatically turns to standby (OUTPUT OFF). In this way the load is protected against overloading, which may occur by pressing a key by mistake. The subsequent use of OUTPUT ON puts the unit into operational mode again.

2.2.4 Output Capacitor

With the key C ON (LED above the key) a capacitor can be switched in parallel to the output terminals. This reduces the output impendance and facilitates the compensation of possible inductive parts of the load.

Switching off the output capacitor with C OFF, the remaining capacitance then amounts to 750 or 500 pF respectively (see 1. Data Sheet/Technical Data).

With C ON/C OFF the unit turns to standby and has to be put into operation with OUTPUT ON afterwards.

Only in a voltage-free state can the capacitor be switched on. If an external voltage source of >100 mV is possibly present at the output terminals remove it first and then after C ON/OUTPUT ON it can be applied again.

2.2.5 Load Connection and Operation with Remote Error Sensing

On the only IEC-bus-programmable model (blank panel) the output sockets are located on the rear panel. The model for IEC-bus programming <u>and</u> manual operation is equipped with output sockets connected in parallel on the front and the rear panels.

Voltage drops in the supply lines to the load are compensated provided that the sensing lines are led from the sensing sockets to the connection terminals of the load. Take care of correct polarity.

When polarity is reversed the adjusted or programmed output voltage is exceeded by approx. 6 volts. If the sensing lines are broken the output voltage at the load decreases by the voltage drop caused by the supply lines.
The cross section of sensing lines is not critical, but the total resistance should not exceed 10 ohms. However, on installation be careful of buzz interferences etc. If necessary both sensing lines and load lines can be shielded and drilled together.

The maximum voltage drop in the load lines should not exceed 1 V per line. Thus the maximum voltage present at the output terminals exceeds the nominal voltage rate of the unit by 2 V. In practice this means that on the NGPV 8/10 the terminal voltage can increase up to 10 volts, so that the nominal voltage of 8 volts can be regulated at the load correctly.

2.2.6 Constant Current and Constant Voltage Operation

The units operate in the constant voltage mode (CV) if the load current is lower than the set current limit. If, as a result of variation in load, the output current increases and attains the current limit then the unit turns automatically to the constant current mode (CC) and vice versa.

The actual operation mode is indicated by LED MODE on the display.

The digital display indicates the set limits accepted by the unit by use of the ENTER key after setting with the code switches, or by programming via IEC-bus, this is the desired value indication. According to the applied mode, either the indicated voltage or current is regulated by the unit. The analog meters show the true values of voltage or current supplied.

2.2.7 Overvoltage Protection (OVP)

The screw potentiometer for setting the threshold of the overvoltage protection (OVP) is located on the front panel of both unit models.

If the output voltage of the unit exceeds the set threshold, through faulty operation or by another possibly external influence, a thyristor is triggered to short-circuit the output voltage down to a remaining residual voltage of about 1 volt. The OVP error-LED lights up.

This state can only be cleared by the OUTPUT OFF key or by the suitable IEC-bus command (provided the fault has been cleared; possibly by disconnecting an external voltage source).

The trigger threshold of the OVP refers to the sensing sockets, i.e. on sensing operation (see 2.2.5) the voltage directly present at the load is controlled.

A fuse protects the thyristor against high-output current sources, which may be connected externally.

Set the trigger threshold of the OVP:

- turn the screw potentiometer fully clockwise;
- set desired output voltage and press OUTPUT ON;
- turn the screw potentiometer slowly counterclockwise until OVP reacts and OVP LED lights up;
- raise the threshold slightly and press OUTPUT OFF/ON to reset.

By gradually increasing the output voltage, the exact responnse threshold can be determined.

2.2.8 Monitoring Output

Front and/or rear panels of both models of NGPV series are equipped with current monitor outputs (MONITORING). MONITORING and + OUTPUT are at the same potential (be careful with units which have a high output voltage!). The internal resistance amounts 1 kohms, on units with 300 volts output it amounts to 10 kohms.

The output voltage at MONITORING amounts to max. 100 mV. Valid are:

on NGPV: 8/10; 20/5; 20/10; 40/3; 40/5;
10 mA each mV within the mA-range
100 mA each mV within the A-range

on NGPV: 100/1; 300/0.3; 300/0.6;
1 mA each mV within the mA-range
10 mA each mV within the A-range

on NGPV 100/2
1 mA each mV within the mA-range
100 mA each mV within the A-range

The subsequent example is valid for NGPV 40/3

a) output current: 900 mA (0.9A)
monitoring output: 90 mV within the mA-range
9 mV within the A-range

b) output current: 2 A
monitoring output: 20 mV

With a suitable VDM connected to the monitoring output, the current consumption of the load can be measured via the controller.
The maximum value of the specific unit can be read above the MONITORING output sockets.

2.2.9 Series Connection

NGPV models can be connected in series to produce higher voltages. To protect units with different nominal currents, be careful that no set current limit exceeds the lowest nominal current of the units used.
Because of the danger of high contact potentials, observe the relevant VDE-regulations strictly. The test voltage is 1,000 volts, measured at output sockets against chassis or earth.

2.2.10 Parallel Connection

The NGPV models are equipped with an internally switched current sink to enable shorter settling times. In parallel connection and underloading, the unit with the highest set voltage limit is loaded by the sinks in the other units. Each current sink amounts to about 20% of the nominal unit current.

2.3 Remote Control by IEC-625-1-Bus

Configuration data is transmitted via a byte-serial bus system compatible with the following interface standards IEC 625-1 (formerly IEC 66.22), IEEE 488-1975.
The connecting socket IEC 625 is located at the rear panel (see Fig. 1 for connection details).
U.S. standard 488-1975 specifies a different connector for the more common IEEE 488 interface than the international IEC standard. NGPV series units are equipped with a 24 way connector for this interface.
Connection of equipment with a 25 way IEC standard connector is easily accomodated via an adapter. Control functions and data transmission are identical.

The standardized interface contains three groups of bus lines:

a) Data bus with 8 lines DI/O 1...DI/O 8.
   Data transmission is executed in bit-parallel and byte serial, the characters are transferred in ISO-7bit-Code (=ASCII code).

   DI/O 1 is the least significant bit and
   DI/O 8 is the most significant bit.

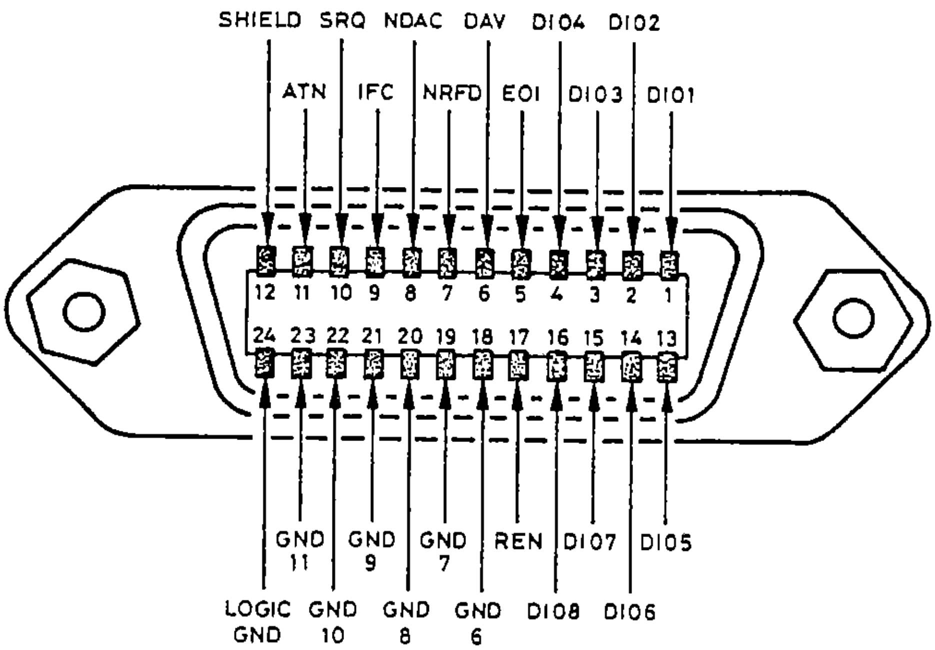


Fig. 1: Pin configuration IEC-625

b) Control bus with 5 lines for transfer of control functions.
   - ATN (Attention) becomes active LOW during address transfer to connected units.
   - REN (Remote Enable) is used for switching the unit to remote control mode.
   - SRQ (Service Request): a connected unit can request a service from the controller by activating this line.
   - IFC (Interface Clear): when activated it will set all the bus connected units to their defined initial conditions.
   - EOI (End or Identify): this signal can be used to identify the end of data transmission or for an enquiry after a service request.

c) Handshake-bus with 3 lines.
   This is used for controlling the timing of the transfer of data between units:
   - NRFD (not ready for data): active LOW on this line indicates to the controller that at least one of the connected units is not ready for data transfer.
   - NDAC (not data accepted) is held active LOW by the unit until it has accepted the data present on the data bus.

Units in the NGPV series in an IEC-bus system operate as LISTENERS only, i.e. they are able to accept and execute data and commands from the controller. They cannot transmit data but reply to a PARALLEL POLL whether operating in either constant voltage mode (CV) or constant current mode (CC). The signals SRQ and EOI are not processed.

2.3.1 Addressing

The unit address is set by a 5-pole DIP-switch (accessible through the rear panel of the unit). The ON position means "bit set". Address 12 is set by the manufacturer:

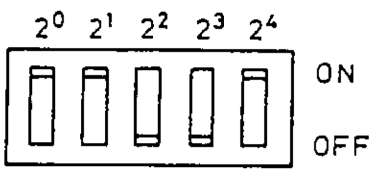


Fig. 2: Address code switch

To set the unit to the addressed state a corresponding command has to be transferred by the bus, e.g. by using a R&S process controller PPC or PUC:

```
...
100 IECLAD12
...
```

Ressetting the addressed state is performed by an UNLISTEN-command:

```
...
500 IECUNL
...
```

2.3.2 Programming of Current Limit

Programming of current limit is executed by a group of up to three digits in the range between 0 and the maximum value followed by an "A". "A" is used as a sign to accept the previous digits. Input of leading zeros can be omitted. Subsequent zeros must be put in. If more than three digits are put in, the unit accepts the last three.

If an illegal value (>nominal value) in the A-range is programmed, overflow is detected and the unit turns to standby (OUTPUT OFF) (display flashes). The programming must be corrected and the unit switched on again (see 2.3.5).

For easier reability of program commands a separator ("." or ",") or the character "M" can be added (for example setting commands 1.23A or 756MA). These characters are ignored by the unit and have no influence on the current range.

For example: setting command for NGPV 20/5

010 ECOUT12,"1.5MA" corresponds to either a current limit of 0.15 A or 15 mA according to the previously set current range, A or mA respectively.

Programming of a current limit has no influence on the OUTPUT state (exception: programmed value > nominal value).

Programming example on R&S controller PPC or PUC:

```
...
600 IECOUT12,"499A"
...
```

2.3.3 Programming of Voltage Limit

Programming of voltage limit is executed by a group of up to four digits (for 8 V and 100 V models 3 digits) in the range between 0 and the maximum value followed by a "V".
The character "V" is used as a sign to accept the previous digits. Input of leading zeros can be omitted, subsequent zeros must be put in. If more than four digits are put in (for 8 V and 100 V models 3 digits) the unit accepts the last four (three).

If an illegal value (>nominal value) is programmed, overflow is detected (display flashes) and the unit turns to standby (OUTPUT OFF). Programming must be corrected and the unit switched on again (see 2.3.5).

Exception:
The NGPV 8/10 contains no limit control and can be programmed up to 9.99 volts (see also 2.2.1).

Programming examples for 20 V and 40 V units:
setting command 1982 V = max. terminal voltage 19.82 V
setting command 70 V = max. terminal voltage 0.70 V

For easier readability of setting commands a separator ("." or ",") can be added (for example setting command 7.78V). These characters are ignored by the unit and have no influence on the programmed voltage.

Example for 8 V, 20 V and 40 V units:

xxx IECOUT12,"7.1V" corresponds to a maximum output voltage of 0.71 V

Programming a voltage limit has no influence on the OUTPUT state OFF or ON (Exception: programmed value > nominal value, see 2.2.2 and 2.3.3).

Programming example at R&S controller PPC or PUC:

```
...
400 IECOUT12,"15.73V"
...
```

2.3.4 Programming of Current Range and Output Capacitor

Selection of current ranges A or mA respectively is coupled with the connection of the output capacitor. Programming is executed by the selection of a number between 0 and 3 followed by an "R".

The meanings are:

0R	mA	/	C OFF
1R	A	/	C OFF
2R	mA	/	C ON
3R	A	/	C ON

If more than one digit is transmitted, the unit accepts the last one.

The character R serves as a sign to accept data. If a range is selected, the unit turns to standby (OUTPUT OFF) to switch the relays in a currentless state. Afterwards the unit must be switched on again (see 2.3.5).

The command for the mA range and C ON, execute on the R&S controller PPC or PUC as follows:

```
...
310 IECOUT12,"2R"
...
```

2.3.5 Electronic Switch-On and OFF

With the commands "C" (close = OUTPUT ON) and "S" (standby = OUTPUT OFF) the unit can be switched on and off electronically. If the switch on command shall simultaneously be valid for several units connected to the IEC-bus, the addressed command GXT (group execute trigger) has to be used. For switching off several connected units the addressed command SDC (select device clear) is used. For switching all connected units off, the universal command DCL (device clear) can be used.

Commands at R&S process controller PPC or PUC:

```
010 IECOUT12,"C": REM"ON"
020 IECOUT12,"S": REM"OFF"
030 IECLAD12:     REM"LISTENER ADDRESS"
040 IECGXT:       REM"GROUP EXECUTE TRIGGER"
050 IECSDC:       REM"SELECT DEVICE CLEAR"
060 IECUNL:       REM"UNLISTEN"
070 IECDCL:       REM"DEVICE CLEAR"
```

2.3.6 Switch Over between Remote Control (REMOTE) and Manual Operation (LOCAL)

When addressed by a controller the units of the NGPV series turn automatically to REMOTE and remain in this state. The front panel controls become ineffective when the unit is set to REMOTE. To make a manual adjustment, first stop the program on the controller then switch the unit to manual operation by pressing the LOCAL key (see 2.2).

Selection of LOCAL can also be executed through the controller with the addressed instruction GTL (GO TO LOCAL).

Selection back to REMOTE is automatically executed with the next set instruction.

The LOCAL key is ineffective if at any time, possibly at the beginning of the program run, the addressed instruction LLO (LOCAL LOCK OUT) is executed through the IEC-bus. The LOCAL key can only be released by the command ←REN (NOT REMOTE ENABLE) or by switching the power off and on.

Commands at R&S process-controller PPC or PUC:

```
xxx IECLAD12: REM"LISTENER ADDRESS"
xxx IECGTL:   REM"GO TO LOCAL"
xxx IECUNL:   REM"UNLISTEN"
xxx IECLLO:   REM"LOCAL LOCK OUT"
xxx IEC←REN:  REM"NOT REMOTE ENABLE"
xxx IECREN:   REM"REMOTE ENABLE"
```

2.3.7 Parallel Poll

To determine whether the unit is operating in constant voltage (CV) or constant current mode (CC) the parallel poll is applied. If the response bit is set, constant voltage is valid. With the addressed instruction PPC (Parallel Poll CONFIGURE) the unit is requested to participate in the parallel poll. The instruction PPE (Parallel poll enable) contains the information on which data line (DI/O) and bit state the unit has to reply to the poll. Bit 1... bit 3 (on line DI/O 1-DI/O 3) define in binary code the line DI/O which shall be replied on. Bit 4 defines the state of the activated bit for the reply "Constant Voltage".

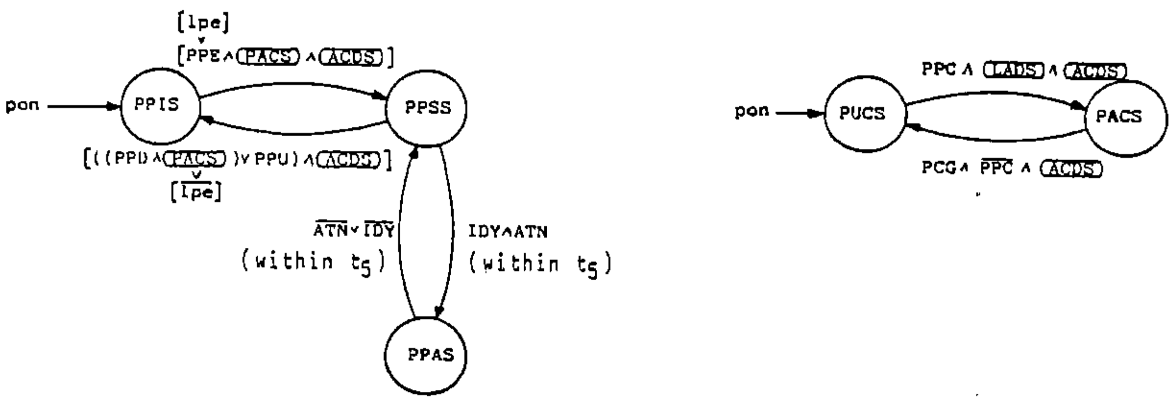


Fig. 3: Diagram of parallel-poll function

Messages

power on	pon
individual status	ist
local poll enabled	lpe
ATTENTION	ATN
IDENTIFY	IDY
PARALLEL POLL ENABLE	PPE
PARALLEL POLL DISABLE	PPD
PARALLEL POLL CONFIGURE	PPC
PRIMARY COMMAND GROUP	PCG
PARALLEL POLL UNCONFIGURE	PPU

Interface States

PARALLEL POLL IDLE STATE	PPIS
PARALLEL POLL STANDBY STATE	PPSS
PARALLEL POLL ACTIVE STATE	PPAS
PARALLEL POLL UNADDRESSED TO CONFIGURE STATE	PUCS
PARALLEL POLL ADDRESSED TO CONFIGURE STATE	PACS
ACCEPT DATA STATE	(ACDS)
LISTENER ADDRESSED STATE	(LADS)

Table 1: Abbreviations of parallel-poll function

Activated bit	Response bit Constant Voltage	Constant Current
true (=1)	true	false
false (=0)	false	true

The active state of parallel poll is applied by the message ATN IDY (instruction IECPPL).

Programming example at R & S process-controller PPC or PUC:

```
...
100 IECLAD12       LISTENER ADDRESS
110 IECPPC         PUCS → PACS
120 IECPPE 1 7     PPIS → PPSS
                   The unit has to res-
                   pond with "Constant
                   Voltage True" (=1) on
                   line DI/O 7
130 IECUNL         UNLISTEN
                   PACS → PUCS
...
510 IECPPL A%      PPSS → PPAS
                   PARALLEL POLL
                   response is stored at A%
                   PPAS → PPSS
...
```

The value of A% = 2^{x-1} (x = number of the DI/O-line) is with x=7 either 0 (constant current) or 64 (constant voltage), if no other unit connected to the bus has been polled at the same time. If several units connected to the IEC-bus are polled at the same time, the values of the single lines are added together.

2.3.8 Transformation of Variables at R & S Process Controller PPC or PUC:

If a value to be programmed by the controller is the result of a calculation, it may happen that the answer has too many decimal places, for example:

```
xxx U=19/3.5          (U=5.4285714 volts)
```

To avoid the non-relevant digits, we recommend a multiplication of the calculated value with factor 10^x, where x is the number of fraction digits programmable at the unit and, to avoid errors by rounding, the addition of the value 0.51. Then an integer number is calculated.

At the R&S process controller the following has to be programmed (multiplication factor valid for 8 V, 20 V and 40 V unit models):

100 U% = (U*100+0.51)
For the output to a unit a string variable must be formed:
110 U$ = STR$ (U%)
Then this output follows:
120 IECOUT12, U$ + "V"

The same edit mode is valid for milliampere and ampere values.

Several instructions can be comprised to one output instruction, for example programming of 17.57V, 135 mA, the mA-range, connection of the output capacitor and the instruction CLOSE (ON):
xxx IECOUT12,"17.57V 135MA 2R C"
It can be programmed faster, if blanks and the character "M" are left out. This however, influences the readability of the program:
xxx IECOUT12"1757V135A2RC"
The same is valid for programming 0 V or 0 A:
xxx IECOUT12,"V" or "A" (leading zeros can be left out)
Example:
Programming a step function between 0 V and 10 V:
At first the unit is prepared (0 V, 100 mA, mA-range, no output capacitor, switch-on):
10 IECOUT12,"0V 100 mA OR C"
Then the true program:
20 IECOUT12,"10.00V"
30 IECOUT12,"0V"
40 GOTO 20

2.3.9 Programming with the Commodore-Computer

To make use of a unit, a so-called logical FILE, or DATA FILE has to be opened, where data can be written into and read from. The FILE is opened by the command:
OPEN m1, (m2, m3, "NAME")
with:
m1 = logical FILE no., integer between 1 and 255,
m2 = unit-No. of unit to use
m3 = mode of data transfer
    0 = read
    1 = write
    2 = write with additional END OF TAPE-character
In our case it is m2 = 12 (LISTENER ADDRESS) and m3 = 1.

For true data output the PRINT # command is used:
PRINT # m1, data
with m1 = logical FILE-No., integer between 1 and 255
    data = string-variable

After programming the data, the FILE must be closed again:
CLOSE m1

Example for 20 V and 40 V units:
Programming of 15.23V (8 V-model max. 7.99 V, 100 V and 300 V models only one fraction) with subsequent "CLOSE":

```
10 OPEN1,12,1
20 A$="15.23V C"
30 PRINT#1,A$
40 CLOSE1
```

Many of the unit functions are very complicated or even impossible (Parallel-Poll) to be programmed on a Commodore computer.

3. Maintenance and Calibration

In general units of model series NGPV do not require any special maintenence. Only after exchange of components within the analog section calibration is necessary.

For testing and calibration we recommend the following measuring instruments:

a. To avoid oscillations of the oerational amplifiers, a battery operated DVM (e.g. R&S UDL 4) with a resolution of 100 µV is recommended (hereafter called DVM1), to adjust the offset values on the regulation board (202.236).

b. For adjustment of reference and output voltage a DVM with at least 4 1/2 digits is required (hereafter named DVM2).

c. For adjustment of current ranges, current shunts with a minimum precision of 0.03% are necessary, with which both current ranges of the unit can be measured.

For easier adjustment an illustration is shown in item 3.5 giving all test points and potentiometers with their corresponding designations that are used in the calibration instructions. Also provided is a table with the adjustment values for reference voltage of different unit models. Before starting calibration the zero point of the instruments has to be checked and adjusted if necessary, with the unit switched off.
Note:
Unless otherwise stated, all offset values have to be adjusted to within +/-0.2 mV.

3.1 Voltage Feed-Back Loop

a. Set current to approximately 10% of the maximum within the mA-range and a voltage of 0 volts.

b. Connect DVM 2 on DAC Board (202.237) to test points "⊥U" and "RU"

c. Adjust offset voltage with potentiometer R1158 (DAC Board 202.237)

(sections d. and e. are not relevant for 8 V and 100 V units).

d. Set a voltage value of 999 and adjust with R1159 (202.237) to obtain the values stated for this unit model in table 2.

e. Use the same method to calibrate the value 1000 with R1160 and the value 2000 with R1161.

f. Connect DVM 1 to socket "+SENSING" and test point DAC on regulator board (202.236).

g. Adjust offset voltage with potentiometer R38 (202.236)

h. Connect DVM 1 to socket " -SENSING " and test point "LSA" on regulator board and adjust the offset voltage with potentiometer R36.

i. Adjust offset voltage between points DAC and UR with potentiometer R1161 (202.236).

j. Set maximum voltage limit, connect DVM 2 to output sockets and adjust output voltage with potentiometer R1162 on DAC board (202.237) to the desired value.

3.2 Current Feed-Back Loop

a. Short-circuit output sockets via current shunt (pay attention to current range).

b. Set output voltage to 5 V and switch-on the unit with OUTPUT ON.

c. Set current value 000.

d. Connect DVM 2 to test point "⊥I" and "RI" on DAC board (202.237) and adjust offset voltage with potentio-meter R1163.

e. Set current value 999 and adjust potentiometer R1164 to 10.3896 V
(exception: NGPV 8/10 and 20/10 : 10.2 V;
NGPV 100/1 and 100/2 and 300/0.3 and 300/0.6 : 9.4 V)

f. Connect DVM 1 to points "IR" and "IS" on regulation board (202.236) and adjust offset voltage with potentiometer R40.

g. Set maximum current limit in mA-range and adjust output current with potentiometer R68 (R66) on auxiliary board II (202.238 resp. 202.241).

h. Set maximum current limit in A-range and adjust output current with potentiometer R67 (R65) (202.238 resp. 202.241).

3.3 Meters and Monitoring

a. Set maximum voltage limit and switch-on unit with key OUTPUT ON.

b. Set deflection of voltage meter with potentiometer R37 on regulation board (202.236).

c. Connect DVM 1 to test points "IM" on the regulation board (202.236) and to socket "+OUTPUT" and adjust offset voltage with potentiometer R43 (202.236) to within +/-2 mV (exception: NGPV 8/10:+/-8 mV; NGPV 20/10: +/-4 mV).

d. Short-circuit output and program maximum current limit in the A-range.

e. Adjust current meter with potentiometer R42 on regulation board (202.236).

f. Set maximum current limit in mA-range and adjust the meter with potentiometer R69 (R67) on auxiliary board II (202.238) again.

g. Connect DVM 1 to MONITORING.

h. Adjust the voltage value printed on the front panel above MONITORING with potentiometer R4.

3.4 Power Unit

An power unit is only necessary if one or more power transistors have been changed. However, ensure that power unit transistors are replaced only with genuine R&S spare parts, otherwise correct functions and adjustment procedures cannot be guaranteed. As the power unit has to be dismounted for power transistor exchange, it is useful to adjust it before reinstallation. For this procedure see the installation scheme shown in fig. 4 (first both output stage halves have to be wired completely).

Required equipment:

- Short-circuit proof power supply unit with an output voltage rating of approximately 10 V, its current limit responding to 1.5 times of the NGPV nominal current (in fig. 4 marked with "U1").
- Power supply with a minimum output current rating of 100 mA, an output voltage adjustable from 0 up to approximately 15 V (in fig. 4 marked with "U2").
- Current measuring instrument with at least 1% accuracy to detect the maximum output current of the output stage.
- Two voltage measuring instruments with a minimum input resistance of 10 kohms within the 1 V-range.

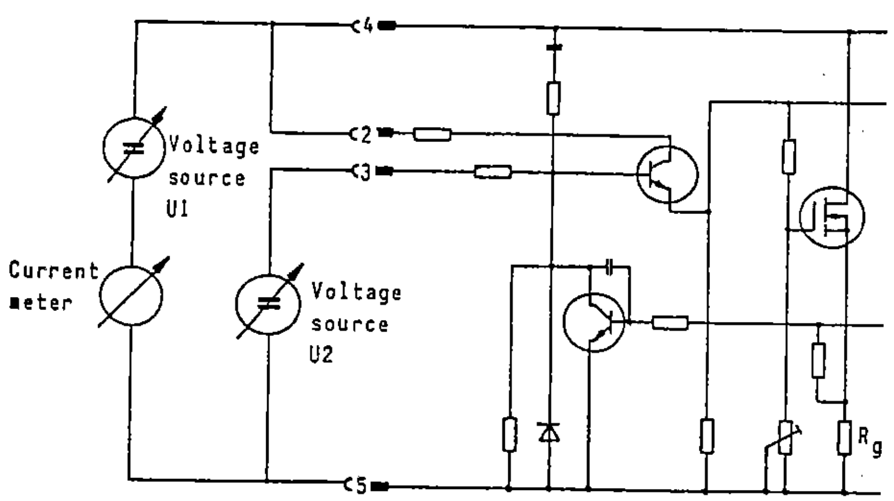


Fig. 4: Procedure for Power Unit Adjustment

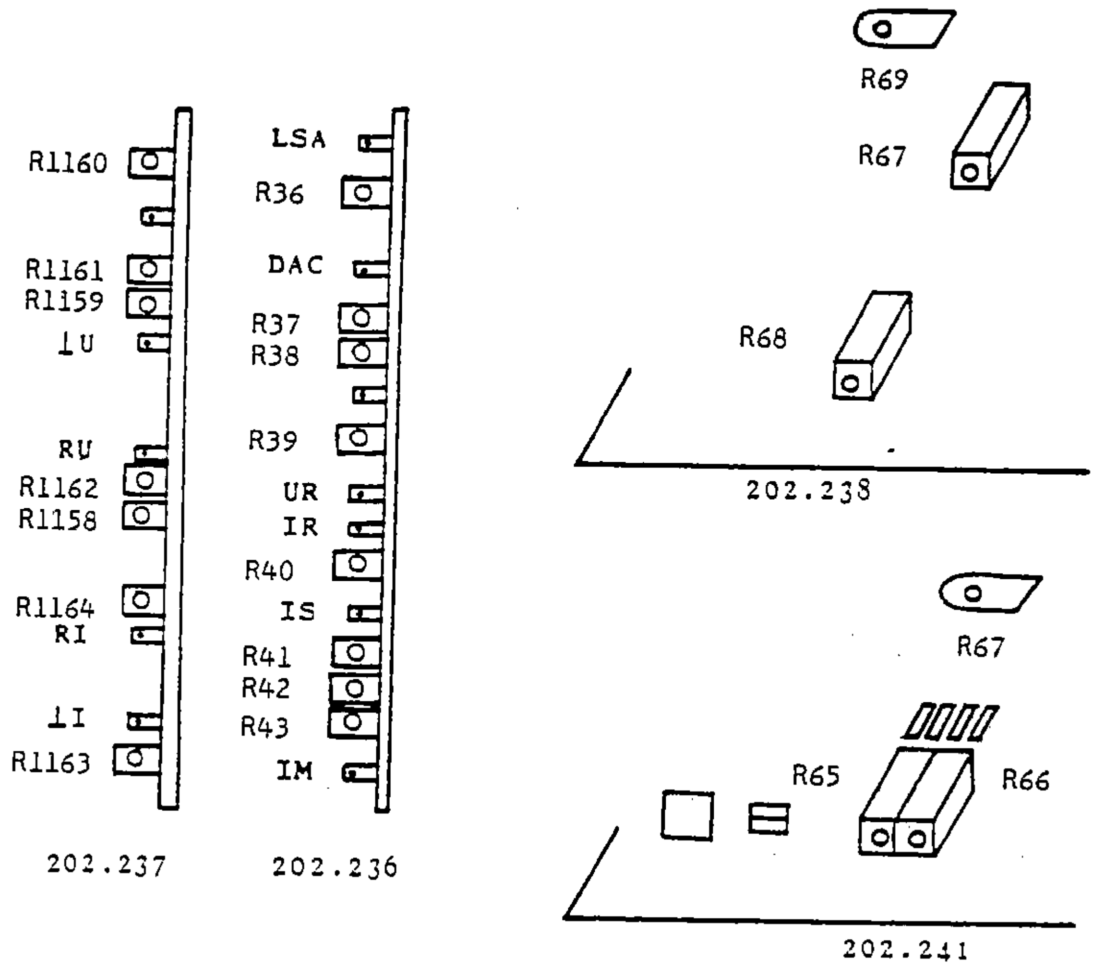
Before starting calibration make sure that the power unit of power supply unit U2 is at zero volts. Turn all potentiometers of the output stage fully clockwise (as seen from mounting side). Sufficient cooling must be provided during calibration if the output stages have a nominal current of more than 3 A.

Adjustment procedure:

- After connecting the power unit to the calibration assembly, U2 is slowly increased starting from zero volts until current meter indicates about 80% of unit nominal current rating.
- The voltages across the feedback resistors (Rg) of the power transistors are measured with a DVM. The DVM is connected to the resistor with the smallest voltage drop.
- A second voltmeter is connected across the other feedback resistors one after the other and the corresponding potentiometer is adjusted until the readings of both voltmeters are within 10% of each other.

If during this adjustment procedure the value indicated by the current meter falls below half of the NGPV nominal current rating, it can be increased by increasing of voltage U2. When the adjustment is completed, check the short-circuit current limit of the output stage.
For that increase voltage U2 watching the current meter at the same time. According to the power unit, the current limit must be 1.1 to 1.3 times higher than the nominal current rating of the unit.

3.5 Arrangement of the Adjustment Elements



	40 V-Unit 300 V-Unit	20 V-Unit	8 V-Unit 100 V-Unit
Bit 1 - 12 (999 Digits)	2.597 V	5.194 V	no adjustment
Bit 13 (1000 Digits)	2.600 V	5.200 V	no adjustment
Bit 14 (2000 Digits)	5.200 V	no adjustment	no adjustment

Table 2: Rated values for the individual bits of the voltage reference.

4. Description of Functions

4.1 Analog Section

The power MOSFETs of the output stage connected in series with the load are controlled by the regulators, that according to unit load state either output voltage or output current are regulated. Both the effects of mains voltage fluctuations as well as those of load changes are regulated. Switchover from constant voltage operation (CV) to constant current operation (CC) and vice versa are performed automatically.

4.1.1 Voltage Regulation and Voltmeter

A bridge is used for voltage regulation, consisting of reference voltage dividers Rx and Ry, of reference voltage and of output voltage buffered via amplifiers Op1 and Op2. Op3 is the regulator, to which the differential voltage of the bridge circuit is lead to as regulation criterion. This is zero, when the following equation is fulfilled:

reference voltage / output voltage = Rx / Ry

Since the voltage regulator always tries to control the output stage so that the voltage across the bridge amounts to 0 V, thus the output voltage must be strictly proportional to the programmed reference voltage.

The meter is connected between outputs of amplifiers Op1 and Op2, and therefore always indicates the voltage between the two sensing lines.

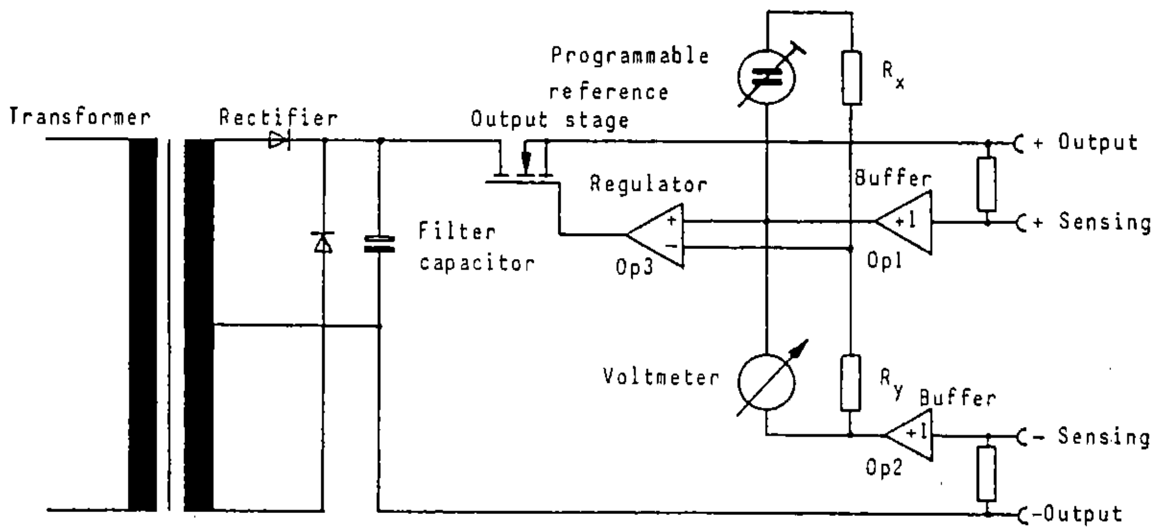


Fig. 5: Schematic circuit diagram of voltage regulation.

4.1.2 Current Regulation, Ammeter and Monitoring

For output current regulation the voltage drop at a current shunt is compared via an operational amplifier with a programmable reference voltage and the output stage is controlled in such a way that the voltage drop and the reference voltage are equal (fig. 6).

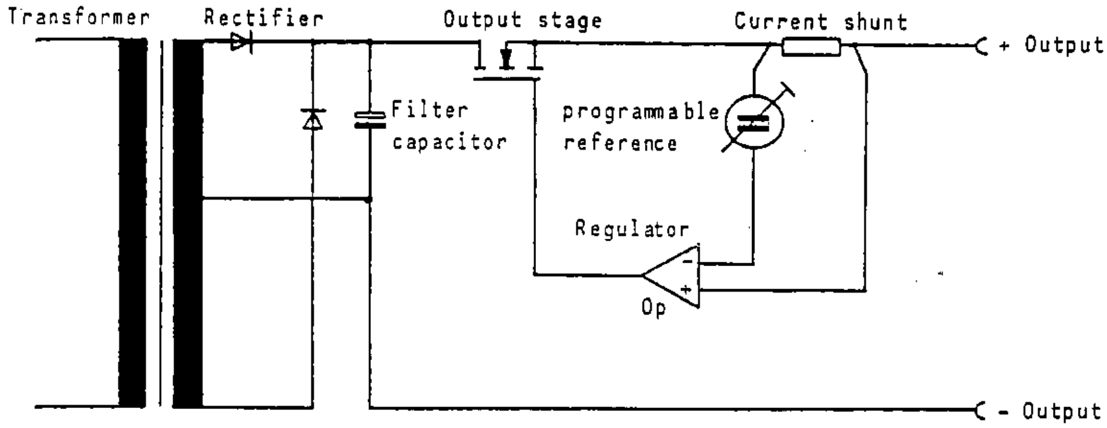


Fig. 6: Schematic circuit diagram of current regulation

The voltage drop at the current shunt is amplified by a buffer and applied to the meter as well as via a voltage divider to "MONITORING", where now a voltage is provided in proportion to the output current.

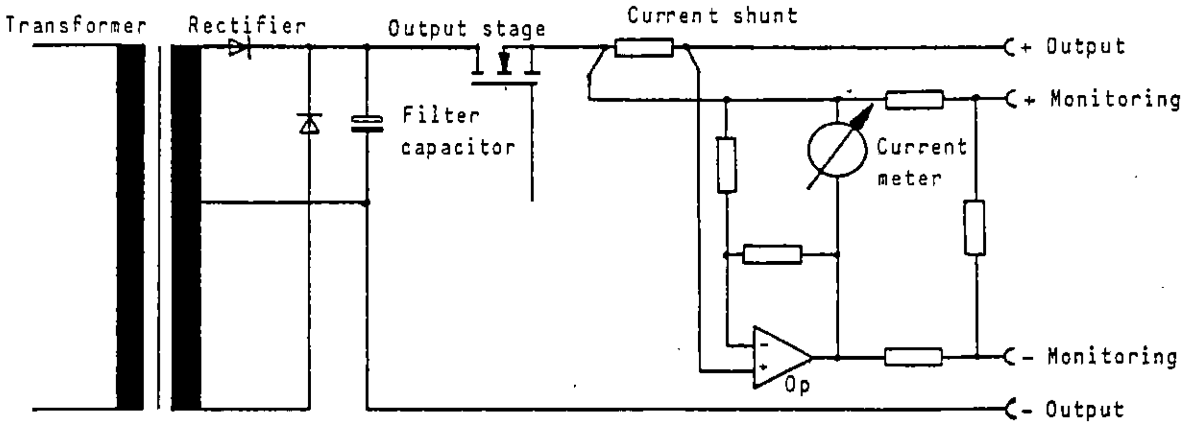


Fig. 7: Schematic circuit diagram of current monitoring

4.1.3 Remote Error Sensing

If an undesired voltage drop is caused by the resistance of the lines between unit and load, this can be compensated by using remote error sensing.

The load has to be connected as shown in fig. 8. The voltage at the load is then directly transferred via both sensing lines and the amplifiers Op1 and Op2 to the voltage feedback loop, which then keeps the voltage at the load constant.
Observe the correct polarity when connecting the sensing lines. If the sensing lines should be interchanged, the terminal voltage exceeds the programmed value only by 6 volts. The same is valid for short-circuits within the sensing lines. Damage of the sensing buffers Op1 and O2 (B3 and B2 on regulation board 202.236) is prevented by internal protective circuits.

The resistors (shown in the illustration below) between output and sensing line are directly soldered to the output sockets on the rear panel to achieve an as low as possible internal resistance at the terminals during operation without remote error sensing. They are laid out in a way that they cannot be damaged by short-circuits or by interchanging the sensing lines even at the highest output voltage rating on the one hand and that no remarkable voltage drop is caused by the input current of amplifiers and protective circuits on the other hand. The same is valid for the protective input resistors (R15 and R16 on regulation board 202.236) of the above mentioned amplifiers.

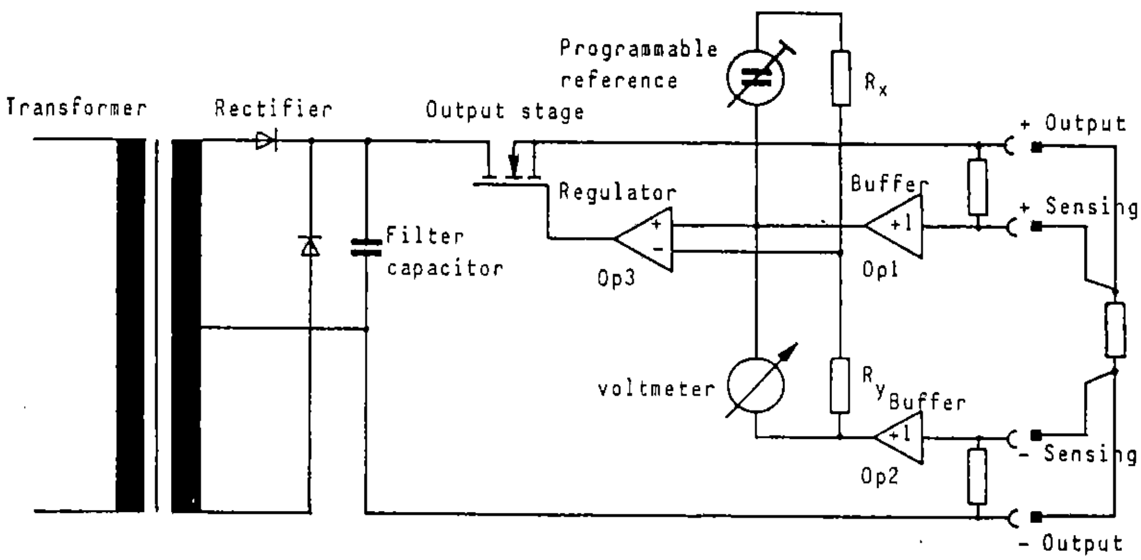


Fig. 8: Schematic circuit diagram of remote error sensing and load connection

4.1.4 DAC Board

Voltage reference as well as current reference are generated on the DAC board. Both circuit parts have different potentials.

Voltage Reference

The main component of voltage reference generation is the digital to analog converter, which converts 12 bits of the data present in BCD-code into an analog voltage. In 8 V- and 100 V units this voltage is transferred directly via resistor R1151 to potentiometer R1162 and resistor R1140. ICs B1113 - B1116 and their components are omitted (see also parts list).

With ICs B1113 and B1114 the internal reference of IC B1111 is high impendance buffered in units with a higher voltage resolution. The output voltages of B1111, B1113 and B1114 are weighted via resistors R1134, R1135, R1136 and potentiometers connected in series and lead to the amplifier B1115 operating as an adder. Transistors T1107 and T1109 together with diodes D1101 and D1102 for bit 13 (1000 digit) respectively transistors T1108 and T111(together with diodes D1103 and D1104 (2000 digit) act as switches for the two additional bits. Inverter B1116 reestablishes the required polarity of the reference voltage.

The data are transferred in BCD-code via transistor T1102 and one half of the dual optocoupler B1101 to the shift register B1107 and B1108. The clock is transmitted via transistor T1101 and the second half of optocoupler B1101 to the corresponding inputs of the shift registers. With the strobe pulse, the data now present in the shift registers are transferred to the output latches.

If the unit is switched on, "High" is applied to pins 15 of shift registers B1107 and B1108, by which the high impedance state of the tri-state output latches, is removed. Thus the data stored in the shift registers beforehand are transferred to the inputs of the D/A converter. If the unit is switched off again, the outputs of the shift registers switch to high impedance again. Via resistors R1124-R1128 and resistor network Rb1102 the information "0" is then present at the inputs of D/A converter.

Current Reference

The supply of this section of the circuit is provided by a voltage stabilization located on the regulation board. Data transmission and generation of current reference is performed analog to the voltage reference. Here, however, at OUTPUT OF (via resistors R1119, R1156 and R1157) a residual reference is generated, which enables the voltage-regulater to be adjusted to 0 volts. The residual reference value is unitspecific and varies between about 1% and 5% of the range limit. Due to this resistors R1119, R1156 and R1157 are mounted only when required.

To prevent falsification of reference voltage by voltage drops in supply lines, the logic ICs B1103, B1104, B1106, B1109 and B1110 have a ground separated from ICs B1112 and B1117. These two grounds are fed via their own lines to auxiliary board II and are only connected there.

4.1.5 Regulation Board

Voltage regulators B7, B8 and B9 provide the required stabilized voltages for operational amplifiers B3 - B6 and for the current reference generation on the DAC board. Via pin 19c (+VI) an unstabilized positive voltage is applied to the power unit. Via pin 17 c (⊥I) the return of this supply is led to auxiliary board II.

Operational amplifier B3 is the high-impedance buffer for the "+SENSING" terminal. Amplifier B4 controls the voltage regulation, B5 controls the current regulation. Via transistors T1 and T2 and optocoupler B1, the operation mode (CV, CC) is fed to the digital section. The voltage reference is present at resistors R23 - R35.
IC B6 serves as an amplifier for the voltage drop at the current shunts on auxiliary board II. Further it buffers the monitoring output and the current meter, which otherwise would reduce the output impedance on current regulation. Amplifier B2 serves as "-SENSING" buffer. Its supply is provided by auxiliary board II. The return of this supply is connected to "-OUTPUT".

4.1.6 Auxiliary Board II

The following functions are located on auxiliary board II:

- Rectifying and filtering of main and auxiliary supplies
- Current-range switch-over
- Overvoltage protection
- Capacitor switch-on and C-ON control
- Switched current sink

Note:
Component designations not written in parantheses are valid for auxiliary board II (202.238) in units with a nominal output of 100 W (reference number 192.0310...), the designations in parantheses refer to auxiliary board II 200 W (202.241) in units with a nominal output of 200 W (reference number 192.0326...).

Rectifying and filtering of main and auxiliary supplies

Diodes D5 (D5) and D6 (D6) are the rectifiers for main supply, their types are unit-specific (see also parts list). In units with 10 A output current they are replaced by a center-tap dual diode mounted to the base plate for cooling. The reverse diode D14 (D7) is mounted in the same way.

According to the unit model, the power supply filter capacitors C3, C4 and C5 (C1-C5) are connected in parallel or in series via jumpers Br3, Br4 and Br5. At series connection bleeder resistors R62 (R13) and R63 (R14) also balance the electrolytic capacitors.

The rectifiers D1 to D4 (D1-D4) and the electrolytic capacitors C1 and C2 (C6, C7, C8) produce a DC voltage, which supplies the overvoltage protection, the capacitor switch-on and the switched current sink.

Current range switch-over

On switching on the unit, the mA-range is always set. For current sensing resistors R56 and R57 (R12, R13) are used. Within the highest current range, the resistor R51-R55 (R2-R10) are switched in parallel via relay Rs2 in addition to the above mentioned resistors.
Depending on the unit model, only some of these resistors may be mounted (see also parts list).

The maximum voltage drop at the shunt resistors is about 1 V (exception: 8/10 approx. 0.25 V; 20/10 approx. 0.5 V).

Overvoltage Protection

For load protection the output terminals are short-circuited on overvoltage by means of a thyristor. In order to omit voltage drops at the supply lines, the threshold of the overvoltage protection is derived from the voltage between the sensing connections. It is transferred via amplifiers B2 and B3 to points "LSA" and "BU" on the regulation board (202.236). The potentiometer for overvoltage protection on the front panel is connected to points OP and OPM.

If the voltage between the sensing-lines exceeds the value adjusted with the potentiometer, transistors T2, T3 and T11 (T9, T10 and T11) are switched through and the thyristor is triggered. This thyristor is mounted on the base plate to aid cooling. To avoid an immediate switch-off of the thyristor on currents below its holding current, transistors T2 and T3 (T9 and T10) are connected as a bistable circuit, which then keeps the thyristor switched on even at lowest currents. Resetting of this trigger circuit is done by the signal OUTPUT OFF (manually or by IEC-bus) transferred from soldering pin "E/A" via optocoupler B4 (B4) to the base of T4 (T8).

However, the thyristor switches off only if its forward current falls below its holding current. If an external current source is connected to the unit, this source has to be disconnected first so that the thyristor may switch off. The thyristor is protected by the fuse F1 against an external current which is higher than the maximum output current of the unit.

Capacitor Switch-on and C ON Control

The capacitor is switched on by relay Rs1. Relay Rs1 is activated via transistor T13 (T2), optocoupler B2 (B2) and transistor T1 (T12).
To protect the relay contacts, switching-on of capacitor C6 (C11) is controlled. For this purpose the following signals are applied to the operational amplifier B1 (B6):

- Voltage at capacitor C6 (C11)

- Output terminal voltage

- Voltage ahead of the current shunts against "-OUTPUT"

Switch on is only possible if all these voltages are below 100 mV. Otherwise the output transistor of optocoupler B2 (B2) is locked via operational amplifier B1 (B6).
If the capacitor is connected and the unit is switched on, the C ON control would immediately switch off the capacitor, since the controlled voltages are now higher than 100 mV. To prevent this, the point between diodes D9 and D10, (D18 and D19) is set to earth via the second contact of relay Rs1. With this method an intervention of amplifier B1 (B6) is prevented. The capacitor can be switched off at any output voltage.

Discharging of the capacitor is done by resistors R8 and R9, which also limit the discharge current (protection of relay-contacts). Only after discharge below the above mentioned voltage limits the capacitor can be switched on again.

Switched current sink

The current sink mainly consists of the power MOSFET T10 (T7*), the feedback resistors R44, R45 (R26*, R27*) and the transistors T8 and T9 (T8*, T9*), which limit the sink current.

Its purpose is a quicker discharge of the internal or an externally connected capacitor in order to speed up automatic testing and checking procedures.

In normal operation, a basic current is drained off by the sink, its value determined by resistors R44 and R45 (R26*, R27*) and the base-emitter-voltage of transistor T8 (T8*) (the transistor limits the voltage drop to about 0.6 V). To discharge a capacitor the current sink is switched to a higher value by voltage regulator B4 (on regulation board 202.236 via transistor T14 (T6) and optocoupler B3 (B5).

This value is derived from the voltage of the Zener diode D20 + 0.6 V and resistors R44 and R45 (R26*, R27*). When the output voltage has reached the desired value, the current falls to the basic current rating.

) The 200 W units have two parallel operating current sinks; they are located on both output stage halves. Components marked with "" are located on the boards of the power unit (202.240) of these units.

4.1.7 Power Unit

This assembly consists of heat sinks for the power transistors, one fan, two thermoswitches and two boards with electronic components. To make the unit highly reliable, great attention was paid to the power unit.

Normally the fan operates on reduced power and is switched to full power operation by one of the thermoswitches with a rise in heat sink temperature. This facilitates a smooth fan run in normal operation and provides the necessary cooling for the power transistors on a higher load. An additional thermoswitch is installed, which switches the units off from the mains when the power unit overheats (e.g. unit operates at excessively high temperatures).

To prevent damage of the power unit by an external short-circuit or failure in regulation, an additional electronic current limit is installed in this power unit, which allows an about 1.1 to 1.3 times higher output current than the output maximum current of the unit, depending on the unit model.

A further increase of reliability is gained by application of power MOSFETSs. These have two important advantages compared to bipolar transistors in this particular application.

- Controlled adequately fast its response time can be disregarded and thus a faster regulation is possible.

- As power MOSFETs are free from second breakdown, they can be lined up together to form very robust power unit, even overloadable for a short time.

To utilize these advantages entirely, the operating point of these transistors has to be adjusted within the power unit, (an entire description of the calibration is to be found in chapter 3.4). If one transistor fails despite all the above mentioned protective measures, please use only original R&S spare parts for replacement. If others than R&S spare parts are used operational safety and accuracy of power unit adjustment cannot be guaranteed.

Power Unit 100 W

Note:
Component designations not put in parentheses are valid for power unit boards 202.230 (100 W units) and designations put in parentheses refer to power unit boards 202.240 (200 W unit).

For control of the output power MOSFETs are installed in the power unit. Driving of these is executed by the regulator via transistor T1 (T1) connected as an emitter follower. Its collector is tied to the unstabilized positive DC voltage of the regulator supply. With potentiometers R16 - R17 (R15 - R18) the operating points of the power MOSFETs are set. If the voltage at the feedback resistors R11 - R12 (R19-R26) exceeds about 0.6 V, the output current of the output stage is limited via transistor T2 (T2).

Power Unit 200 W

The functions of this power unit are entirely identical to those of the 100 W power unit. However, it is equipped with twice the number of power MOSFETs. Further each half of the power unit is equipped with a switched current sink. Their duties and functions are already described in item 4.1.6.

4.2 Digital Section

4.2.1 IEC 625 Bus line termination

All IEC-bus-lines are terminated on board 202.233 with resistors corresponding to the standard. The data lines and the command lines ATN, DAV, EOI, IFC and REN are inverted by Schmitt trigger drivers B1201 and B1207. Internal unit operation is executed with positive logic, i.e. "High" level = 1 and "Low" level = 0.

4.2.2 Handshaking

The handshake cycle is realized on board 202.233 by gating of the signals ATN, DAV, LADS, CARRY, WAIT and the internal transfer clock T. The bus line drivers are located on board 202.239. After switch on the open collector drivers (B1301) for NRFD- and NDAC-lines are not activated. The unit becomes active in handshake only when it is addressed and/or the signal attention (ATN) appears on the bus. In this case, the message NDAC goes low (NO DATA ACCEPTED). When the unit is addressed and ready for data acceptance (WAIT = 1 and CARRY = 1), NRFD remains high (READY FOR DATA). If there is WAIT = 0 or CARRY = 0, NRFD goes low (NOT READY FOR DATA). Receiving the signal ATN, the unit in any case responses with "READY FOR DATA". If the information DAV is true, NRFD goes low (NOT READY FOR DATA) and the mono-flop B1217a starts the internal transfer clocks T and $\overline{T}$ (approx. 10 µs). When the transfer clocks are finished flop-flop B1213b is set and NDAC goes high (DATA ACCEPTED). When DAV is removed, the flip-flop is reset and NDAC goes low again (only as long as ATN and/or LADS are true). NRFD goes high (READY FOR DATA), when the unit is addressed and neither WAIT nor CARRY are low, or when the signal ATN is present. CARRY is low as long as the clock generator for data shift is running, WAIT is low for 15 ms (because of relay switching times) when the letter R (range selection) is received via the bus.

4.2.3 Power-On Reset and Interface Clear

On switching the mains on a short (PON1, approx.120 ms) and a long (PON2, approx.240 ms) POWER-ON pulse are generated on board 202.234. The short pulse is used for resetting shift registers B502, B508, B514 and B520 on the same board and, inverted by B518, to reset all flip-flops in the digital section to their initial states. The long pulse is used for starting the shift-clock generator (on board 202.234) via B524 and B518 versus "low" on B511, pin 8, and via B516 and B517, to lead these shift-clocks to DAC shift registers B1107-B1110 (on board 202.237) in order to clear their contents. The command IFC resets the address flip-flop B713a on board 202.232.

4.2.4 Decoder

The decoder on board 202.233 consists of ICs B1204, B1205 (BCD-to-decimal-decoder) and B1210, B1211, B1214-B1216 and B1222 (AND-gate). It has to recognize all required signals and commands. It checks , whether the present bit-pattern on DI/O-lines 1-7, the signal ATN and the LADS-state correspond to a valid signal or command. When this is true, the information high appears on the corresponding line.

command signal	DI/O 1	2	3	4	5	6	7	ATN	LADS	required for
PPC	1	0	1	0	0	0	0	1	1	Parallel Poll
PPE	X	X	X	X	0	1	1	1	1	Parallel Poll
PPD	X	X	X	X	1	1	1	1	1	Parallel Poll
PPU	1	0	1	0	1	0	0	1	X	Parallel Poll
PCG	X	X	X	X	0	0	0	1	1	Parallel Poll
PCG	X	X	X	X	1	0	0	1	X	Parallel Poll
PCG	X	X	X	X	X	1	0	1	X	Parallel Poll
PCG	X	X	X	X	X	0	1	1	X	Parallel Poll
GET (GXT)	0	0	0	1	0	0	0	1	1	ON
SDC	0	0	1	0	0	0	0	1	1	OFF
DCL	0	0	1	0	1	0	0	1	X	OFF
GTL	1	0	0	0	0	0	0	1	1	LOCAL
LLO	1	0	0	0	1	0	0	1	X	LOCAL LOCK OUT
DIGIT	X	X	X	X	1	1	0	0	1	transfer pulse
A	1	0	0	0	0	0	1	0	1	ampere, shift clocks
V	0	1	1	0	1	0	1	0	1	volts, shift clocks
R	0	1	0	0	1	0	1	0	1	range
C	1	1	0	0	0	0	1	0	1	ON
S	1	1	0	0	1	0	1	0	1	OFF

Tabelle 3: Decoded commands and signal together with their bit-patterns (X=arbitrary, 1=high, 0=low)

4.2.5 Parallel Poll

The required ICs are located on boards 202.233 (B1221) and 202.234 (B501, B507 and B519).
When the command PPC is recognized, flip-flop B1221b is set with the internal transfer pulse. Now, with the commands PPE respectively PPD flip-flop B1221a can be set or reset. Reset is also possible with the command PPU.
With the signal CCP (=PPC $\wedge$ PPE), and acceptance clock T, the informations (line number, activation bit) present on the data lines DI/O 1-DI/O 4 are stored in four D-flip-flops B507. The line-number information is now present at the BCD-to-decimal-decoder B501 with o.c.- outputs. The 4-bit-comparator B519 determines whether PPE is true, the poll is executed (ATN and EOI true) and if the status bit is equal to the activation bit. When all these conditions are fulfilled, the decoder sets the selected DI/O-line to 0 V (information true).

Flip-flop B1221b is reset by any primary group command (PCG), but not with PPC.

4.2.6 Shift Register Organization

When the NGPV is addressed and a digital information is present at the bus, the informations of DI/O-line 1-4 are shifted right into the 4-bit shift registers B502, B508, B514 and B520 on board 202.234 (bit-parallel, byte-serial). Then when the characters "V" or "A" appear, it is shifted out left bit serial to the DAC- and display-shift registers. By this the following bit sequence is formed:

byte-No.4,	bit 4;	byte-No.3,	bit 4;	byte-No.2,	bit 4;
byte-No.1,	bit 4;	byte-No.4,	bit 3,	byte-No.3,	bit 3;
byte-No.2,	bit 3;	byte-No.1,	bit 3;	byte-No.4,	bit 2;
byte-No.3,	bit 2;	byte-No.2,	bit 2;	byte-No.1,	bit 2;
byte-No.4,	bit 1;	byte-No.3,	bit 1;	byte-No.2,	bit 1
byte-No.1,	bit 1				

At the same time a "0" is shifted in to clear the shift registers.

Shifting direction (right/left) is set at shift register inputs S1 and S0:

S1	S0	
0	0	Hold
0	1	shift right
1	0	shift left
1	1	parallel

S0=1, when the information DIGIT appears, otherwise S0=0.
S1=1, if either flip-flop B510a (A) or flip-flop B510b (V) is set.

These flip-flops are set according to the internal transfer clock, when either the character "A" or the character "V" appears at the decoder output. After termination of left shifting, they are reset by the strobe-pulse (generated by the shift-clock generator and the counter on board 202.234). The strobe-pulse is delayed by R502 and C514, so that the reset of S1 is always executed after the last shift pulse.

The shift-right clock is generated by gating DIGIT with T (B514 on DAC board 202.234), the shift-left clock is generated by the shift-clock generator.

To read a set range, with the positive edge of the signal R∧T (B517 on board 202.234) the digit present at the first positions in the shift register is stored in flip-flops B505b (bit 1 for current range) and B522a (bit 2 for C ON) on board 202.234.

At the same time the monoflop B512b on this board is activated (NOT READY FOR NEW DATA) to prevent further internal transfer clocks (see also 4.2.2) and to activate the over-flow control.

The reset pulse for the shift registers is released by the negative edge of signal R∧T via capacitor C517 (negative pulse).

4.2.7 Shift-Clock Generator

This start-stop oscillator on board 202.234 is started by PON2, bringing the 16-bit-counter B1106 into its initial state and loading the DAC-shift registers B1107...B1110 on board 202.237 with 1 (=information 0 V respectively 0 mA). It is also startet at the end of the internal transfer clock, when the signal "V v A" (B1121, pin 3) is present. With this signal flip-flop B1122b is set at the beginning of the internal transfer clock. Now "high" appears at the Q output, which applies "low" to gate B1111, pin 8, via B1124 and B1118 and by this starts the oscillator at control input B1118, pin 2. Now positive pulses appear at the generator output B1123, pin 10, (f = approx. 250 kHz). The first pulse resets flip- flop B1122b via gate B1124. This causes "high" at B1111, pin 8 and would stop the generator. But as at the same time the carry- output of counter B1106 goes "low", the generator is kept running via B1111, pin 1. If 16 positive edges have appeared at counter B1106, output "carry" goes "high" and "high" is present at B1111, pin 2. When the 16th pulse is finished, "high" is also present at B1111, pin 8 and the generator control input stops the oscillator.

4.2.8 Switch U/I-LOCAL/REMOTE

When data are put in via IEC-bus, they have to be shifted from the shift registers B502, B508, B514 and B520 on board 202.234 to the shift registers B4, B9, B13, B18 (I) and B5, B10, B14 and B19 (U) on board 202.231 (display) and to the DAC shift registers (on board 202.237) B9, B10 (I), B7 and B8 (U). This is executed after character "A" or "V" is recognized. These informations are stored in flip-flops B510b respectively B510a (on board 202.234) for the time of the shifting procedure. Thus is determined, whether (via gates B503 and B504 the shift goes to the U- or to the I-shift register. The flip-flops are reset by the delayed (R502, C514, approx. 1 µs) strobe pulse (applied by the shift-clock generator and the counter).
If flip-flop B509a (on board 202.234) is not set (state LOCAL), the data put in by manual operation (via gates B515 and B504) are transferred to the DAC-shift registers.

4.2.9 Strobe-Pulse

The strobe-pulse (approx. 9 µs) is applied by mono-flop B512a on board 202.234, when the shift-clock generator has released 16 pulses. It is used to load the data shifted into the DAC shift register into the internal output latches. Further it resets flip-flops B510a and B510b which consequently reset the control signal S1 of the bus registers to low.

4.2.10 Addressing

The address is set with a 5-pole DIP-switch. It is compared by 5 EXOR gates B1202 and B1208 on board 202.233 whether the address transmitted on the bus is the own one. If this is the casè, mono-flop B1217b is triggered at the beginning of the transfer pulse and its pulse MLA (approx. 5 µs) sets flip-flop B509a on 202.234 (REMOTE mode). At the end of the transfer pulse the address flip-flop B1213a on 202.233 is set. This flip-flop is reset, when either the UNLISTEN command, the signal IFC or the signal $\overline{\text{REN}}$ is received.

4.2.11 OFF/ON (Standby-Close)

The states OFF or ON are stored in flip-flop B505a on board 202.234. At the Q-output there is low=OFF and high=ON. On switching the unit on, the flip-flop is reset to OFF by the PON-pulse. The ON-state is achieved (in LOCAL mode) by pressing the key "ON" (LOCC-pulse) or (in REMOTE mode) by decoding the command GXT (GROUP EXECUTE TRIGGER) or the character C (CLOSE). In REMOTE mode resetting is executed by the commands SDC (SELECT DEVICE CLEAR) and DCL (DEVICE CLEAR) as well as by the characters S (STANDBY) or R (RANGE). It is also switched off when overflow is detected (OVERFLOW). When the unit is in LOCAL mode, it is also switched-off by pressing the key OFF (signal LOCS) or one of the keys A, mA, C ON or C OFF. The signals of these keys are gated with the OVERFLOW state in B706 on board 202.232.
During ON mode, the contents of their shift registers are present at the DACs. During OFF state, their outputs are in high impendance state (TRI-state). By pull-down resistors the U-DAC then receives the information 0 volts at its inputs. A residual reference necessary for regulation is set by pull up and pull down resistors at the I-DAC-inputs. According to the set current range and the unit model, a certain output current is admitted by this (approx. 1-5% of the range limit).

4.2.12 mA/A-Range / C ON (Output Capacitor)

By a digit between 0 and 3 with subsequent R, sent by the IEC-bus, the current range is set and the output capacitor is connected. When the character "R" is detected, the unit is set into OFF state at one hand and on the other hand bit 1 of bus shift register B520 is stored in flip-flop B505b and bit 2 of register B514 is stored in flip-flop B522a (see also item 4.2.6 - Shift Register Organisation). These ICs are on board 202.234.

bit 1 = low means mA-range
bit 1 = high means A-range
bit 2 = low means C OFF
bit 2 = high means C ON

At the output BER there is low = mA and high = A, at output C ON there is low = "no output capacitor" and high = "connect output capacitor".
The flip-flops can be set or reset by pressing the corresponding keys (pulse BA respectively BmA and C~ respectively $\overline{C\sim}$).

4.2.13 LOCAL/REMOTE, LOCAL LOCK OUT, REMOTE ENABLE

The ICs necessary for these functions are on board 202.234. On switching-on the mains, flip-flop B509a (LOCAL/REMOTE) is reset by the PON-pulse to LOCAL mode (output Q=low). The mode is changed when the unit is addressed (MLA-pulse). Reset to LOCAL mode is possible by the command GTL (GO TO LOCAL) or by pressing the key LOCAL (pos. pulse RTL). The pulse RTL is locked by gate B503 as long as the shift-clock generator is running (CARRY is low).
The command LLO sets output Q of flip-flop B509b low (LOCAL LOCK OUT). By this the pulse RTL is locked by gate B503. After this returning to the LOCAL mode is possible only by the command GTL.

Flip-flops B509b (LOCAL LOCK OUT), B509a (LOCAL/REMOTE) and B513a (ADDRESS, on board 202.233) are reset by the command $\overline{REN}$ (gated with PON in B524). As long as the signal $\overline{REN}$ is transmitted, addressing (and by this programming) of the unit is impossible.

4.2.14 Functions of the Keys

All keys are arranged on board 202.231.
The key LOCAL applies the pulse RTL (approx. 50 µs, C4, R18). This pulse resets the flip-flop B509a (LOCAL-REMOTE, on board 202.234. When LLO is programmed or the shift-clock generator is running, the pulse is locked. All other keys are active only in the LOCAL mode. The key OUTPUT ON applies the pulse LOCC (approx. 50 µs, C5, R19) and by this sets the flip-flop B505a (OFF/ON, on board 202.234).
By pressing the key OUTPUT OFF it can be reset (signal LOCS).
The key mA causes the state BmA, sets flip-flop B505b (I-range, on board 202.234) and sets flip-flop B505a (OFF/ ON, on board

202.234) by a pulse (approx. 10 µs, formed by C714 and R710 on 202.232) on line OVERFLOW to the OFF-state.
The key A sets the BA state, by this resets flip-flop B505b (I-range), and stets flip-flop B505a by a pulse (approx. 10 µs, C713 and R712 on 202.232) to the OFF-state. Additionally this pulse activates the overflow control.
The keys C ON and C OFF set respectively reset the C ON state via C~ and $\overline{C}$~ (B522a on 202.234). They also cause the change to OFF state (pulses by C717, R713 and C715, R711 on board 202.232, each approx. 10 µs).
After pressing the key ENTER, the debouncing flip-flop B711 on board 202.232 toggles and low appears at the output. Via an inverter the flip-flop B1306a on board 202.239 is set, so that S0=1. On release of this key, the debouncing flip-flop returns to its initial state again. Two pulses are released by the resulting positive edge on the board 202.239 : one to reset the overflow flip flops and the other one to act as clock-pulse for the display shift registers (read- in parallel), approx. 3 µs. The second pulse is inverted. When it is finished (positive edge), flip-flop B1306 is reset, i.e. S0=0 (shifting left). The positive edge appearing at Q-output generates a pulse (approx. 3 µs) by R1306, C1305 which is applied to flip-flop B522b V/A on board 202.234 after a delay of approx. 1 µs as START LOC-pulse. Then the shift-clock generator starts.
Resistor R20 on board 202.231 is required to enable the reset of the debouncing flip-flop, if the key is pressed in LOCAL mode but released in REMOTE mode.

4.2.15 Display Shift Register

These registers on board 202.232 are storage-registers for the digital display and parallel data transfer registers for manual operation. On switching on the mains, they are cleared by the reset-pulse (R701, C710, approx. 120 ms). On bus operation (REMOTE) the data of bus shift registers are shifted left into the display registers. The pulses are applied by the shift-clock generator. The shifted-in data are now displayed in a multiplexed mode.
When the key ENTER is pressed in LOCAL mode, the registers accept the values parallel, which were set at the code switches. By starting the shift-clock generator, they are shifted via the U/I-LOCAL/REMOTE switch (B503, B504, B515) on board 202.234 into the DAC shift registers (board 202.237) B1107-B1110 and back to the display registers again. To guarantee a safe data transfer to the DAC shift registers, the display register clock is delayed via two timing circuits on board 202.239 (approx. 1 µs, C1301, R1301 and C1302, R1302, clock delay).

4.2.16 Display

The digits, stored in the display registers, are indicated in a multiplexed mode (clock timing approx. 150 µs). Counter B702 together with the pulse generator (B711, R702, C711, on board 202.232) generates the corresponding addresses. It is led to the MUX-ICs B3, B8, B12, B17 and to the BCD-to-decimal decoder B1. By the multiplexers the bits of the actual address are switched to the 7-segment driver B2 on display card 202.231. According to the unit model, the decimal point in the voltage display is switched in a different way. The decimal points in the current display are switched on and off according to current range and unit model.

4.2.17 Overflow Control

On board 202.232 it is checked, whether the programmed current and voltage values are within the specified range. Therefore the digits 8000/4000/2000/1000 (voltage) and the digits 800/400/200/100 (current) are compared with fixed values by two 4-bit comparators B716 and B707. This control is activated (for current only within the A-range) after

- shift generator running off by the pulse STROBE,
- programming the range by the pulse WAIT (By C716, R709 shortened to approx. 10 µs),
- pressing the key A (signal BA by C713, R712 formed as pulse, approx. 10 µs).

When an overflow is detected, both flip-flops B701a and B701b store it and the signal OVERFLOW goes high. This signal is transferred to board 202.231 and the overflow pulse generator B3 is switched on. Via the enable inputs of the display-address decoder B1, the display starts flashing (f approx. = 3.5 Hz). At the same time the NGPV turns to OFF state, since the signal OVERFLOW resets flip-flop B505a (OFF/ON) on board 202.234 into the OFF state.

The overflow flip-flops B701a and b are reset when

- the mains is switched on,
- the characters V or A are accepted,
- the key ENTER is pressed.

4.2.18 Single LEDs

The LEDs are on board 202.231, flip-flop B1213a is on board 202.233, flip-flops B509a, B522a, B505a and B505b are on the board 202.234.

ADDR	indicates that the unit is addressed, i.e. B1213a is set.
LOCAL	indicates the state LOCAL, i.e. B509a is not set.
C ON	indicates that the output capacitor is switched on, i.e. B522a is set.
ON	indicates that the unit is in ON state, i.e. B505a is set.
OVP	indicates that the overflow protection has reacted.
mA	indicates the mA-range, i.e. B505b is set.
A	indicates the A-range, i.e. B505b is not set.
MODE	the left LED indicates constant voltage operation, i.e. status bit ZB = 1, the right LED indicates constant current operation, i.e. status bit ZB = 0.