ROHDE&SCHWARZ

Test and Measurement
Division

# Operating Manual

# Power Meter

# NRVD

857.8008.02

Printed in the Federal
Republic of Germany

# Tabbed Divider Overview

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Certificate of quality
EC Certificate of Conformity
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Tabbed Divider

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This is to certify that:

| Equipment type | Order No. | Designation |
|---|---|---|
| NRVD | 0857.8008.02 | Dual Channel Power Meter |
| NRVD-B2 | 0857.8908.02 | Input-/Output Option |

complies with the provisions of the Directive of the Council of the European Union on the approximation of the laws of the Member States

- relating to electrical equipment for use within defined voltage limits (73/23/EEC revised by 93/68/EEC)

- relating to electromagnetic compatibility (89/336/EEC revised by 91/263/EEC, 92/31/EEC)

Conformity is proven by compliance with the following standards:

EN60950 : 1992 + A1 : 1993
EN50081-1 : 1992
EN50082-1 : 1992

Affixing the EC conformity mark as from 1995

**ROHDE & SCHWARZ GmbH & Co. KG**
**Mühldorfstr. 15, D-81671 München**

Munich, 30.10.95

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# 2 Preparation for Use and Operation

## 2.1 Initial Start-up

### 2.1.1 Setting up the Instrument

The instrument may be operated in any position; when using a power cable with an angle connector (R&S stock number DS 086.4400), it may also be operated in the upright position. The instrument is equipped with tilt feet at the bottom.

- Do not obstruct the ventilation holes!
- Ambient temperature 0 to 50 °C
- Prevent moisture condensation. Once the instrument has become wet, it must be dried out before it is switched on.

### 2.1.2 Rackmounting

The Adapter ZZA-98 (order number 0827.4533) permits the instrument to be mounted in 19" racks according to the mounting instructions enclosed.

### 2.1.3 Power Supply

The instrument is designed for operation from AC supply voltages of 100 V, 120 V, 220 V, 230 V and 240 V and frequencies between 47 and 440 Hz.

The voltages may deviate as follows from the nominal values of the AC supply voltage:



| Nominal AC supply voltage | permissible AC supply voltage | |
|---|---|---|
| 100 V | ± 10 % | 90 to 110 V |
| 120 V | ± 10 % | 108 to 132 V |
| 220 V | ± 10 % | 198 to 242 V |
| 230 (240) V | - 10% / + 15% (-14% / + 10%) | 207 to 264 V |

The instrument is factory-set to 230 V.

Adjusting to other AC supply voltages:

- Disconnect the power cable.
- Lift off the cover of the voltage selector at the rear using a screwdriver.
- Remove the coding cylinder and reinsert it such that the desired voltage value can be read.
- For an AC supply voltage of 240 V set the coding cylinder to 230 V.
- If necessary, lift off the fuse holder marked by an arrow, insert appropriate fuses and reinsert the holder.
  Fuses for 100 V or 120 V: IEC 127-T 500H/250 V
  220 V or 230 (240) V: IEC 127-T 250H/250 V
  (See also the labelling at the rear of the instrument).

Connect the instrument to the power outlet using the power plug and the power cable supplied.
Note the relevant provisions according to VDE/IEC.

## 2.1.4 Switching On, Basic Setting

The instrument is switched on using the power switch on the front. The display will subsequently read out the following messages:

| | |
|---|---|
| NRVD V x.y IECADR zz | NRVD : instrument designation<br>V x.y: firmware version number<br>zz : IEC-bus address set |
| OPTION INCLUDED | Option NRVD-B2 installed |
| | or |
| NO OPTION | not installed |
| INT.CHECK [DIGTL] | Self-test software and calibration data |
| INT.CHECK [ANALG] | Self-test analog hardware |
| READ SENSOR | Read data memory of measuring head |
| * ALL TESTS PASSED * | No fault has been detected in the self-test.<br>(Error messages in the case of faults see 3.6). |

If measuring heads are connected, their data are read in and checked following the switch-on sequence. The instrument is then ready for measurements.

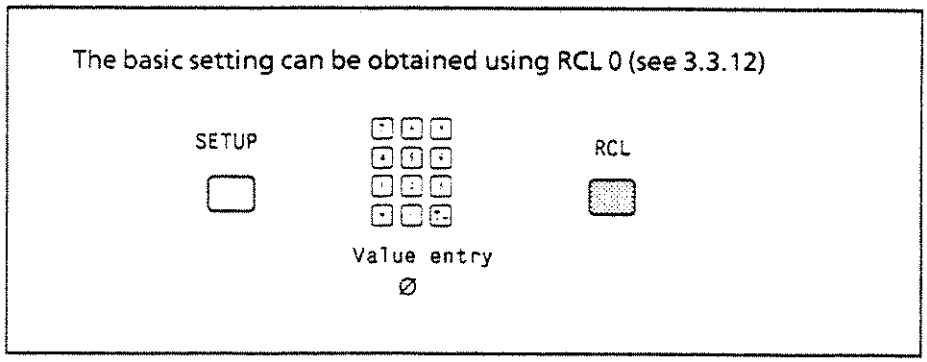
**If NRVD**

- two measuring heads are connected to the NRVD or
- a measuring head is connected without changing the channel,

the instrument assumes its previous status prior to last switch-off. Exception: Zero correction is not switched on again.

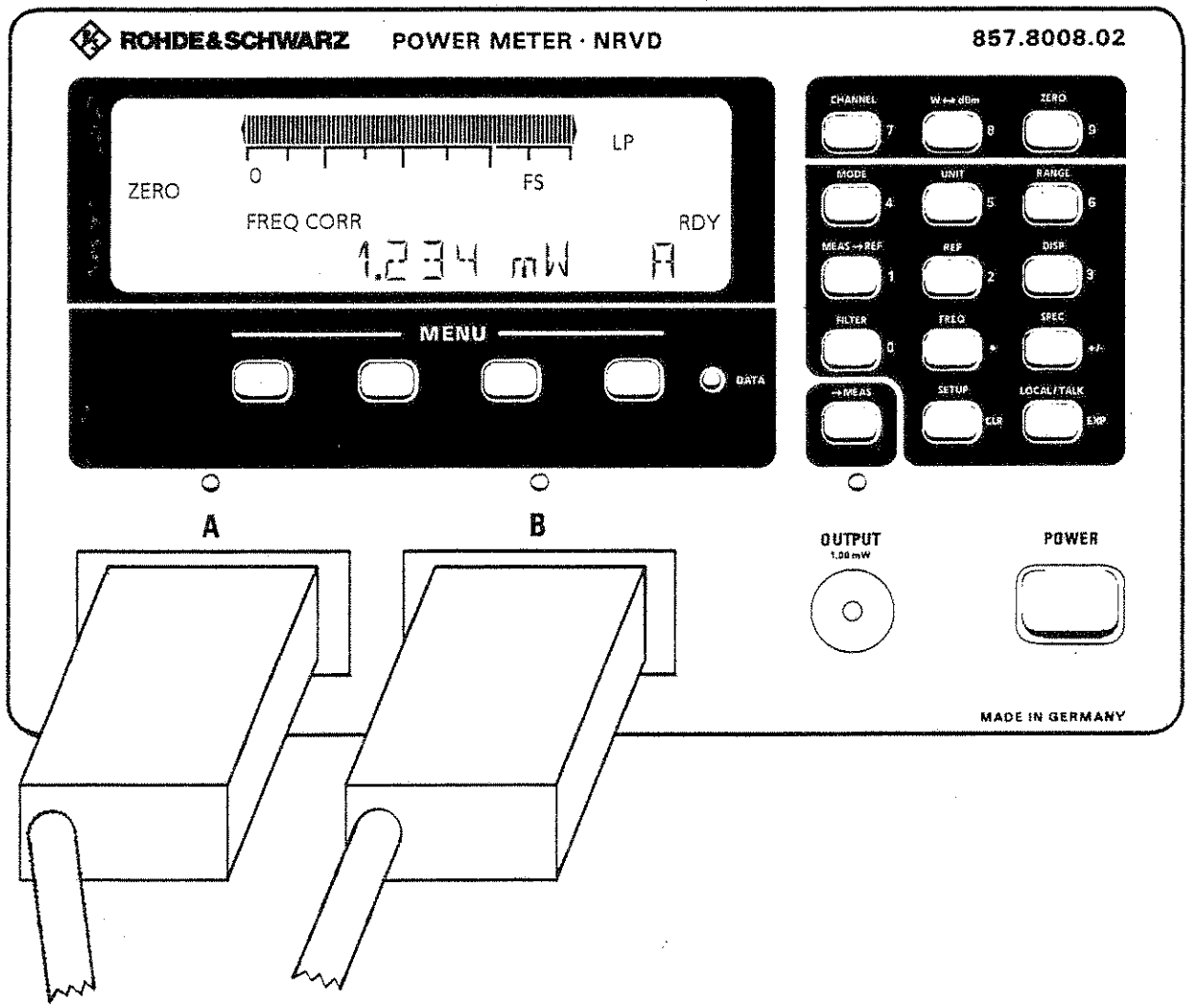
The response of the instrument changing of the measuring heads will be described in the next section.

The basic setting can be obtained using RCL 0 (see 3.3.12)



## 2.1.5 Connecting the Measuring Heads

The measuring heads are connected to the NRVD by inserting the plug-in adapter into the receptacles of the NRVD as far as possible:




It is possible to measure with one or two (identical or different) measuring heads at the same time.

Connection and disconnection are automatically detected and indicated by the NRVD. With the instrument switched on, this should only be done in manual operation (Connection and disconnection in the remote status of remote control see 3.8.1.7).

When a measuring head is connected, the following message appears in the display:

| R E A D  S E N S O R |
|---|

- If no measuring head is connected, channel A is automatically set. Operation is then only possible in channel A. Instead of a measured value, the following is displayed:



- If only one measuring head is connected with the instrument switched on, the instrument automatically switches on the associated channel and selects measurement mode AVG. Zero correction (ZERO) is switched off. Operation is only possible in the channel switched on.

- If, with two measuring heads connected, one power sensor is disconnected while a measurement is being performed in its associated channel, the instrument automatically switches to the other channel. If the measurement is performed in an operating mode which requires two measuring heads (e.g. reference measurement or reflection measurement), the measurement mode AVG is set.

- When a measuring head is connected in the switch-on status, its data are read out and taken into account in the subsequent measurement.

### 2.1.6 Fitting Sensor Connectors to Rear Panel

The two front-panel sensor connectors as supplied from the factory can be refitted to the rear panel by carrying out the following steps:

1. Screw off rear-panel feet (2 x 2 screws)
2. Take off bottom panel to the rear
3. Dismantle blank panel covering the sensor connectors (three screws)
4. Screw off front-panel plate (four screws).
5. Screw off plug-in with sensor connectors from the front panel (three screws) and fix it to rear panel
6. Fit rear-panel blank panel to front panel.
7. Mount again front-panel plate, cover and feet at he rear.

## 2.2 Input/Output Option NRVD-B2

**Features of the option:**

- Two simultaneous analog outputs for measurement channels A and B
- Trigger input for triggering the start of the measurement
- Ready output signal with valid measurement result
- Frequency-proportional DC voltage input for analog frequency response correction

### 2.2.1 Fitting the Option

- Unscrew the feet on the rear panel (4 Phillips screws).
- Push the top and bottom cover towards the rear of the instrument and remove.
- Remove the covers of the connectors at the rear of the instrument
- Screw the connector panel of the option to the rear panel of the instrument by means of two Phillips screws and run the flat cable to the top of the instrument.
- Insert the plastic spacers supplied (4 pieces) into the holes on the computer board (top of the instrument).
- Engage the option board into the plastic spacers.
- Remove the cable from plug X60.
- Connect three flat cables:
  - 26-wire cable from the option to plug X60 of the computer board
  - 10-wire cable from the connector panel to plug X8 of the option board
  - 3-wire cable from the connector panel to plug X103 of the analog board.
- Reassemble the instrument.

### 2.2.2 Calibration of the Option

After fitting the Option NRVD-B2, the two analog outputs must be calibrated.

The output voltages of the analog outputs are measured one after the other via an external connection between the analog outputs and the frequency control input (DC-FREQ). This assumes that the NRVD has already been calibrated.

To perform the calibration, the instrument itself measures the DC voltages of the analog outputs and calculates correction values, which are stored in a nonvolatile memory.

**Calibrierung:**

- Press the keys "SPEC" "mre" "DC-OUTP" "CAL"
- Use a BNC cable to connect analog output DC-1 to the input for analog frequency response correction DC (FREQ) (see page 3.4)
- Press "EXEC" key
- Connect output DC-2 to input DC (FREQ)
- press "EXEC" key
- Continue the measurement using the →MEAS key.

## 2.3 Selection and Use of the Measuring heads

The power sensors for the NRVD permit voltage and power measurements according to various methods and for a variety of applications. All power sensors have in common a few characteristics which the user should make himself familiar with in order to avoid measurement errors and for safety reasons:

### Ground terminal

***The ground terminal of all power sensors is DC coupled with the metal casing of the NRVD! In order to avoid current surges, do not connect the ground terminal with dangerous contact voltages exceeding 50 V!***

### Power-handling capacity and max. input voltage

***Do not exceed the voltage and power limit values given in the Specifications of the power sensors! Fire hazard! Risk of current surges!***

### Zero adjustment

Prior to measuring very small voltages and powers (recommended value: sensititity of measuring head ... + 30 dB), a zero adjustment of the NRVD must be performed (ZERO, see 3.3.16).

### Weighting errors

Voltage and power measuring heads with diode rectifiers measure with rms weighting only with relatively small levels up to about 22 mV/10 µW (220 mV/1 mW with preceding 20-dB divider). With greater level values, display errors are to be expected for non-sinusoidal or amplitude-modulated signals.

Thermal sensors (NRV-Z51 and NRV-Z52) measure with true rms weighting over the entire measurement range, irrespective of the waveform and type of modulation. No weighting error is produced.

## 2.3.1 Power Measurement

High-frequency sources such as RF and microwave generators and also the outputs of passive components (directional couplers, attenuator pads, power dividers, filters, etc.) to which power is applied are characterized by the reflection coefficient as well as by their available power.

In the field of measurements, the power available in the case of impedance matching (termination of the source with 50 or 75 Ω) is of particular interest. It can be measured over a large frequency and level range using the power sensors NRV-Z... (Fig. 2-1). The high calibration accuracy and the excellent matching of these power sensors result in very small measurement errors.

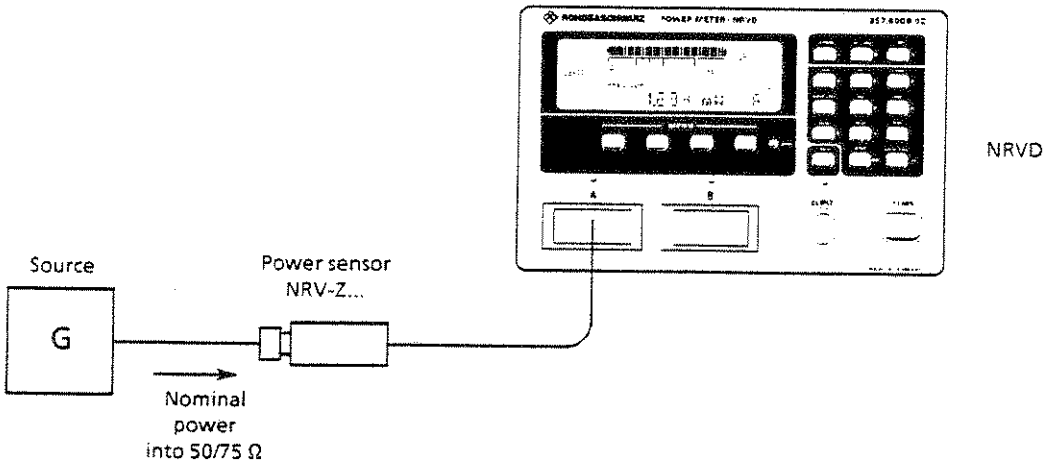



Fig. 2-1 Power measurement using Power Sensor NRV-Z and NRVD

In the RF range, the Insertion Units URV5-Z2/Z4 and the RF Probe URV5-Z7 can also be used for power measurements (Fig. 2-2). They offer advantages over the NRV Power Sensors if a larger dynamic range and higher power-handling capacity are required. Since the insertion units and the RF probe are connected up in the same way for the calibration (probe in the 50-Ω adapter), a relatively small measurement uncertainty can also be obtained.

In order to display the voltage measured by the RF probe in the display units W and dBm, the reference impedance of the adapter must be entered before (REF → IMP → 50/75 → STO). The insertion units already contain this information in their data memory.

The sensor-specific frequency response correction is described in section 3.3.4.

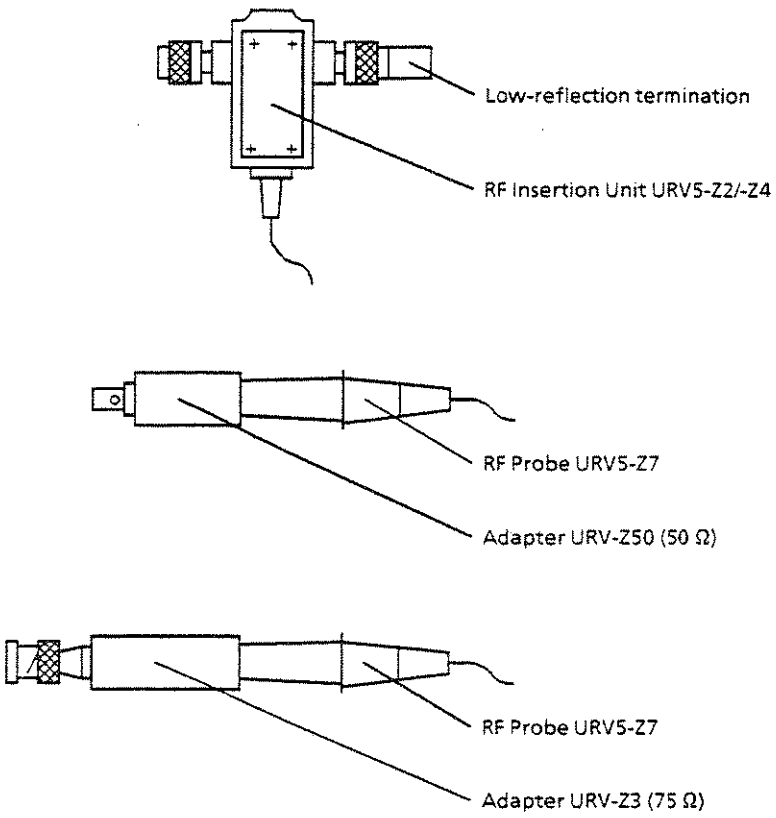



Fig. 2-2 Connection of insertion unit and RF probe for power measurement

Table 2-1 Recommended application ranges for power measurements

| | Power Sensors NRV-Z... | Insertion Head URV5-Z2 | Insertion Head URV5-Z4/50 | RF Probe in Adapter URV-Z50 | Insertion Unit URV5-Z4/75 | RF Probe in Adapter URV-Z3 |
|---|---|---|---|---|---|---|
| Frequency range | 0 to 26.5 GHz | 9 kHz to 2 GHz | 200 kHz to 2 GHz | 20 kHz to 1 GHz | 200 kHz to 2 GHz | 20 kHz to 500 MHz |
| Level measurement range | -63 to + 27 dBm | -60 to + 33 dBm | -40 to + 53 dBm | -60 to + 33 dBm | -42 to + 51 dBm | -62 to + 31 dBm |
| Power measurement range | 0.5 nW to 0.5 W | 1 nW to 2 W | 100 nW to 200 W | 1 nW to 2 W | 50 nW to 130 W | 500 pW to 1.3 W |
| Max. power-handling capacity | --- | 4.5 W | 450 W | 2 W | 300 W | 2 W |
| Impedance | 50 and 75 Ω | 50 Ω | 50 Ω | 50 Ω | 75 Ω | 75 Ω |
| Measurement accuracy | + + + + | + + + | + + + | + + | + + + | + + |
| Frequency response correction | yes | yes | yes | yes | yes | no |

## 2.3.2 Level Measurement on Coaxial Lines

If the signal level is to be measured on a transmission line with simple means, the coaxial voltage measurement can be used (Fig. 2-3). With a small VSWR, the voltage is constant along the line and constitutes a measure for the signal level or the transmitted power.

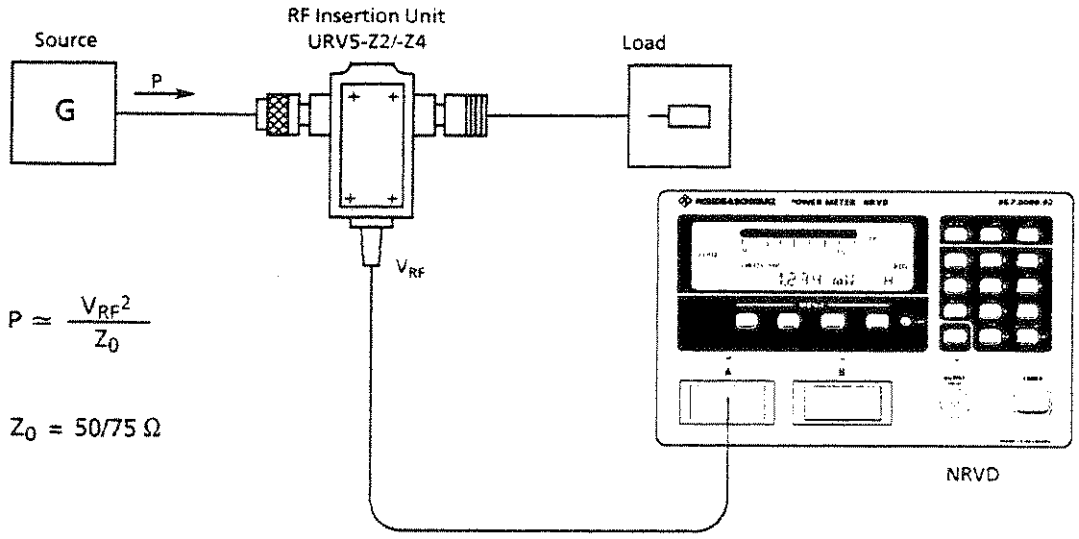



Fig. 2-3 RF level measurement using insertion unit and NRVD

For this measurement, 3 insertion units and the RF probe with adapter and plug-on divider are available (Fig. 2-4 and Table 2-2).

Table 2-2 Recommended application ranges for coaxial level measurement (insertion loss <0.5 dB and SWR <1.2 for the specified frequency ranges - typ. values unless stated otherwise in the Specifications).

| | Insertion Head URV5-Z2 | Insertion Head URV5-Z4/50 | RF probe in adapter (URV-Z6) | Divider 20 dB (URV-Z6) | Divider 40 dB (URV-Z6) | Insertion Head URV5-Z4/75 |
|---|---|---|---|---|---|---|
| Frequency range | 9 kHz to 1 GHz | 200 kHz to 2 GHz | 20 kHz to 300 MHz | 2 MHz to 400 MHz | 1 MHz to 500 MHz | 200 kHz to 2 GHz |
| Voltage measurement range | 200 µV to 10 V | 2 mV to 100 V | 200 µV to 10 V | 2 mV to 32 V | 20 mV to 32 V | 2 mV to 100 V |
| Level measurement range | -60 to +33 dBm | -40 to +53 dBm | -60 to +33 dBm | -40 to +43 dBm | -20 to +43 dBm | -42 to +51 dBm |
| Power measurement range | 1 nW to 2 W | 100 nW to 200 W | 1 nW to 2 W | 100 nW to 20 W | 10 µW to 20 W | 50 nW to 130 W |
| Max. input voltage | 44 $V_{pp}$/50 $V_{=}$/ 15 $V_{rms}$ | 440 $V_{pp}$/1 kV$_{=}$/ 150 $V_{rms}$ | 44 $V_{pp}$/400 $V_{=}$/ 15 $V_{rms}$ | 440 $V_{pp}$/750 $V_{pk}$/ 32 $V_{rms}$ | 1,5 kV$_{pp}$/ 750V$_{pk}$/ 32 $V_{rms}$ | 440 $V_{pp}$/1 kV$_{=}$/ 150 $V_{rms}$ |
| Impedance | 50 Ω | 50 Ω | 50 Ω | 50 Ω | 50 Ω | 75 Ω |
| Measurement accuracy | + + | + + + | + + | o | + | + + + |
| Frequency response correction | yes | yes | no | no | no | yes |

Level and power can be displayed by selecting the display unit dBm or W (key W↔dBm). In the case of the RF probe, the impedance must be set before (only 50 Ω!) (REF → IMP → 50 → STO, see 3.3.11). The insertion units already contain the impedance information in their data memory. To reduce the measurement uncertainty, the frequency response correction data of the insertion unit can be taken into account (see 3.3.4).

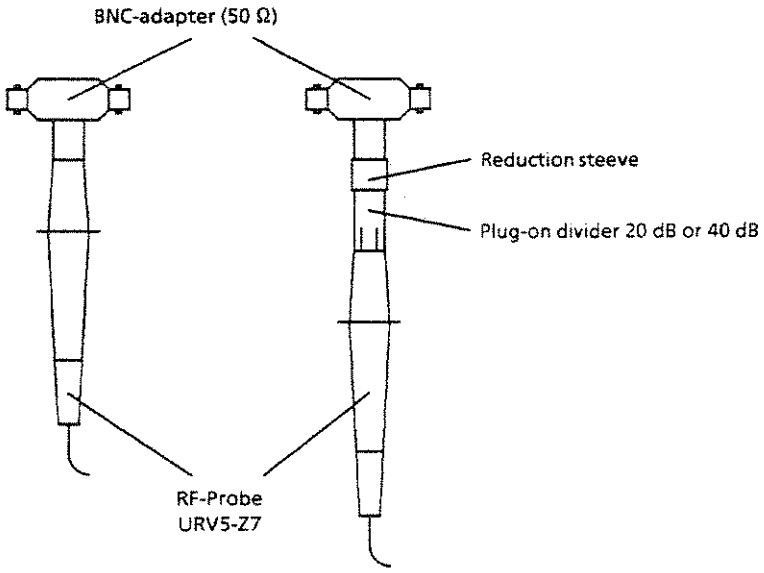



Fig. 2-4 Connection of the RF probe for coaxial level measurement

### 2.3.3 High-impedance AC Voltage Measurement Using RF Probe

The RF Probe URV5-Z7 permits no-load high-frequency AC voltage measurements in electronic circuits (Fig. 2-5). The frequency range for this application extends from 20 kHz to about 400 MHz (to 1 GHz for indication). The voltage measurement range extends from 200 µV to 10 V (to 100 V or 1000 V with plug-on divider).

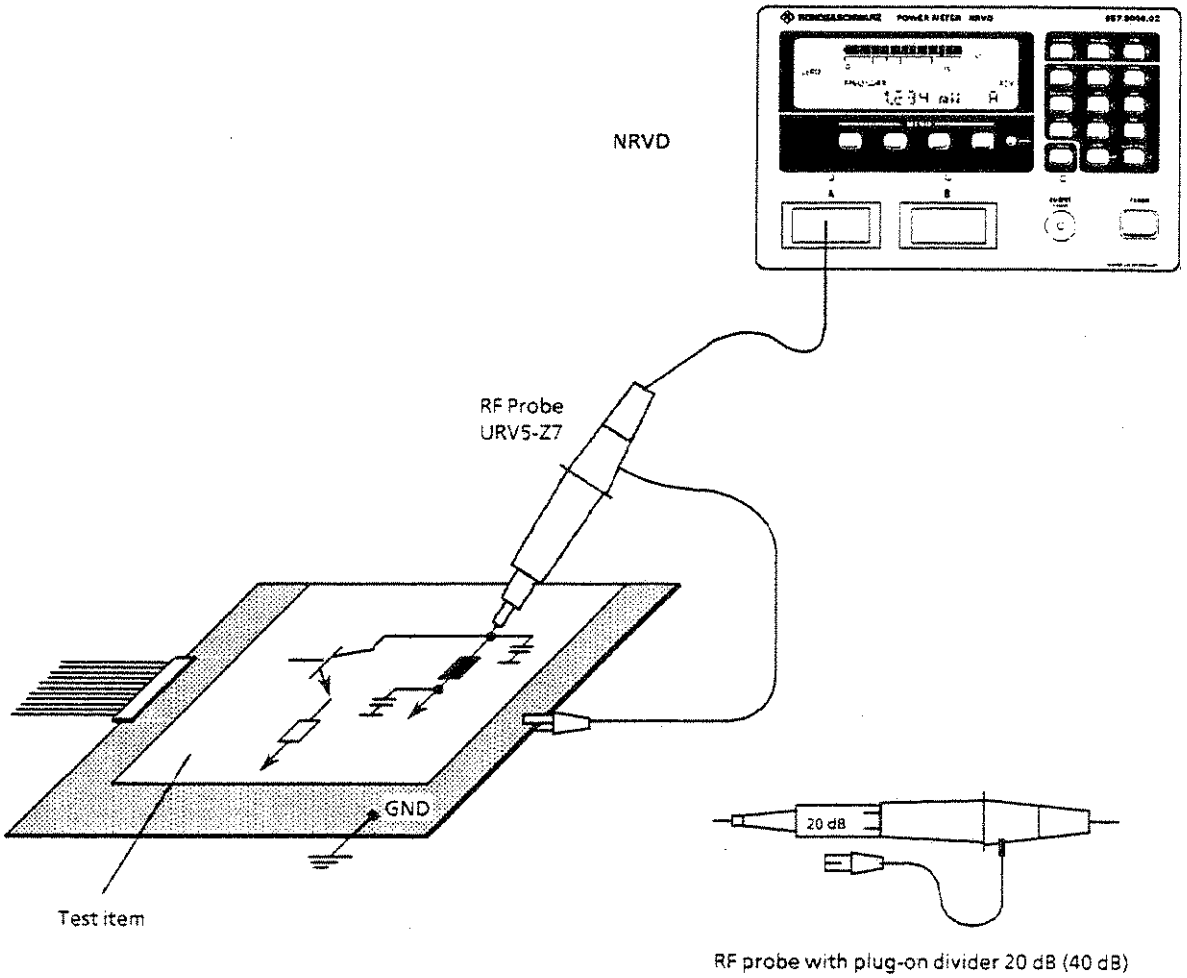



Fig. 2-5 AC voltage measurement in RF circuits with probe and NRVD

The plug-on dividers do not only extend the voltage measurement range, but also increase the input impedance (Table 2-3). The attenuation value of 20 or 40 dB can immediately be taken into account in the display using the function REF → ATT CORR.BY→ ..

***The ground terminal of the RF probe is DC coupled with the metal casing of the NRVD! In order to avoid current surges, do not connect the ground terminal to dangerous contact voltages exceeding 50 V!***

Table 2-3 Recommended application ranges for power measurements

| | RF-probe URV5-Z7 | with divider 20 dB (URV-Z6) | with divider 40 dB (URV-Z6) |
|---|---|---|---|
| Frequency range | 20 kHz to 300 MHz | 1 MHz to 400 MHz | 0.5 MHz to 500 MHz |
| Voltage measurement range | 200 µV to 10 V | 2 mV to 100 V | 20 mV to 1000 V |
| Input im pedance (with 10 MHz) | 2.5 pF ‖ 80 kΩ | 1pF ‖ 1 MΩ | 0.5 pF ‖ 10 MΩ |
| Max-input voltage | 44 $V_{pp}$/400 $V_{=}$/15 $V_{rms}$ | 440 $V_{pp}$/ 1 kV$_{=}$/150 $V_{rms}$ | 3 $kV_{pp}$/1 kV$_{=}$/1050 $V_{rms}$ [1] |
| Frequency response correction | no | no | no |

[1] Max. input voltage up to 40 MHz, for higher frequencies see Specifications URV5-Z7.

The measurement uncertainty for frequencies above 10 MHz considerably depends on the matching of the measuring head. Instead of the ground cable, the low-inductance ground connection according to Fig. 2-6 should be used. This considerably improves the frequency response of the test setup and simultaneously reduces the magnetic field sensitivity.

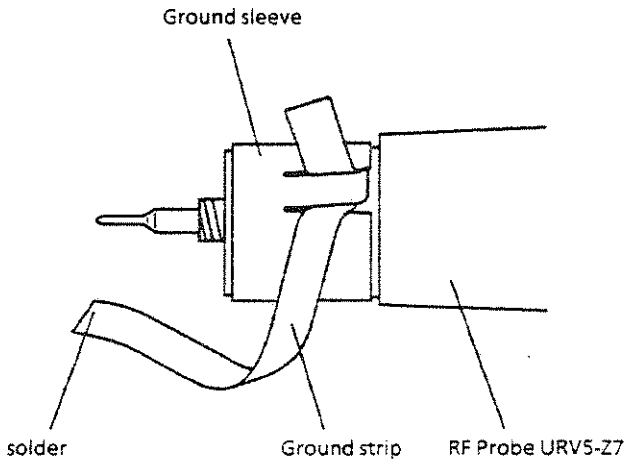



Fig. 2-6 Low-inductance ground connection

## 2.3.4 DC Voltage Measurement Using DC Probe

Due to its high input impedance, the DC Probe URV5-Z1 is particularly suited for applications in RF circuits: operating-point determination of amplifiers, checking of supply voltages etc. (Fig. 2-7).

Table 2-4 Characteristics of DC Probe URV5-Z1

| | |
|---|---|
| Voltage measurement range | ± (1 mV ... 400 V) |
| Resolution | 0,1 mV |
| input impedance | 9 MΩ ‖ 3 pF |

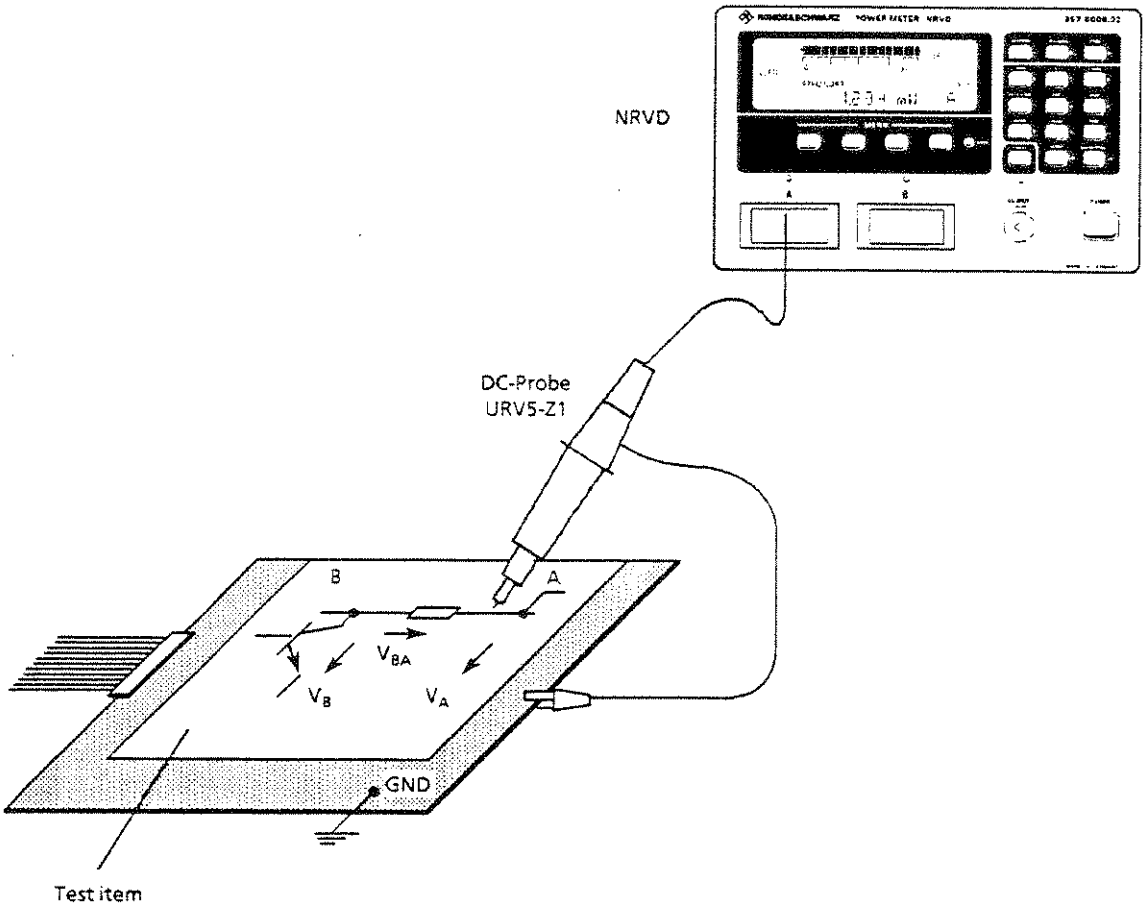



Fig. 2-7 Measuring voltages and voltage differences referred to ground using DC Probe URV5-Z1 and NRVD.

***The ground terminal of the DC probe is DC coupled with the metal casing of the NRVD! In order to avoid current surges, do not connect the ground terminal to dangerous contact voltages exceeding 50 V!***

The ground terminal should remain connected to the circuit ground.

Voltage differences between two high-level test points ($V_{BA}$ in Fig. 2-7) are measured as follows:

| Test setup | NRVD |
|---|---|
| Lightly touch reference point (A) (reference measurement) | Check $V_A$.<br>Shift zero of NRVD (→ ZERO).<br>Check display: 0 V.<br>"ZERO" must be read out in the display. |
| Lightly touch test point (B). | Read off $V_{BA}$.<br>By pressing the ZERO key for a longer period of time, the display referred to ground is selected again.<br><br>***Note:***<br>**The zero adjustment can be performed using the DC probe up to max. ± 20 V.** |

## 2.4 Applications

The following examples of measurement illustrate the large range of applications of the NRVD. Power measurements are shown almost exclusively since they represent the largest range of applications. Depending on the application, a Power Sensor NRV-Z..., an Insertion Unit URV5-Z2/Z4 or the RF Probe URV5-Z7 with 50-Ω/75-Ω adapter can be used. For the sake of simplicity, the illustrations always show power sensors.

### 2.4.1 Attenuation Measurement

The NRV permits coaxial attenuation measurements up to 70 dB (NRV-Z...) or 90 dB (URV5-Z...) (Fig. 2-8). As far as allowed by the test item and the measuring head, the source is to be set to the highest possible level. RF and microwave generators should be improved with respect to their matching by using a low-reflection attenuator pad 3 to 10 dB.

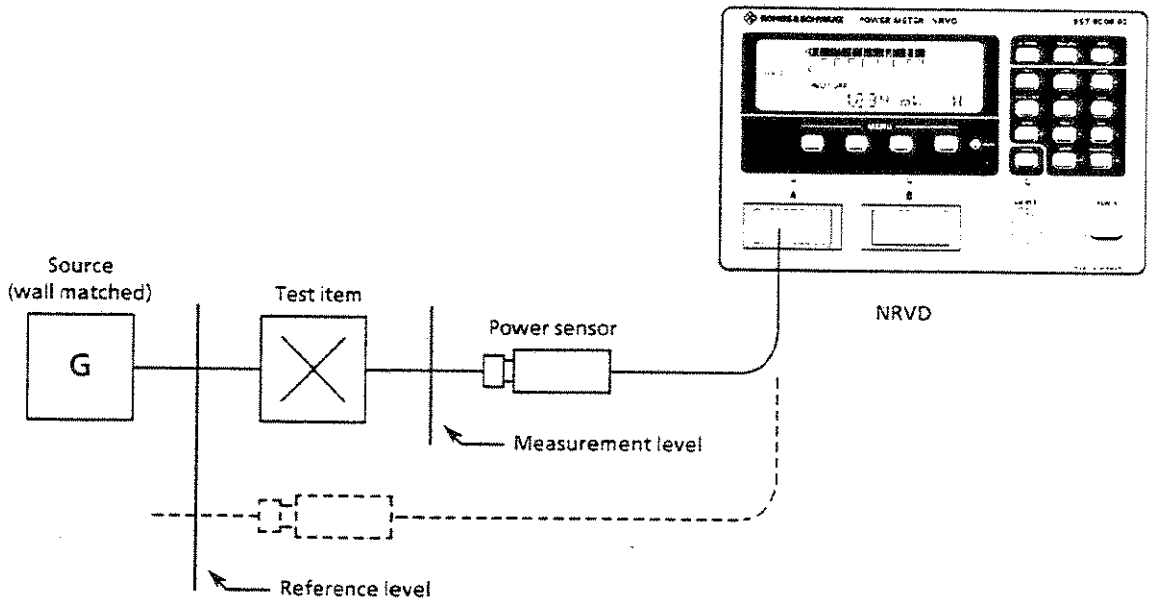



Fig. 2-8 Attenuation measurement by power comparison according to the substitution method

**Procedure**

| Test setup | NRVD |
|---|---|
| Connect measuring head to source (reference measurement). | Set unit dB (UNIT → REL → Δ dB).<br>Store measured value as reference value (MEAS→REF → STO).<br>Check display: 0 dB |
| Set unit dB (UNIT dB). | Read off attenuation value |

Fig. 2-9 presents a setup for an attenuation measurement which allows for a particularly high accuracy. This is achieved by using a power splitter containing two 50-Ω resistors. In general, its VSWR is considerably smaller than the source impedance of a signal generator, so that a smaller mismatch is obtained. (cf. section 3.7.1).

Level variations of the signal generator during the two measurements, which cause errors as shown in Fig. 2-8, can be neglected in this case due to the almost simultaneous measurements using two measuring heads.

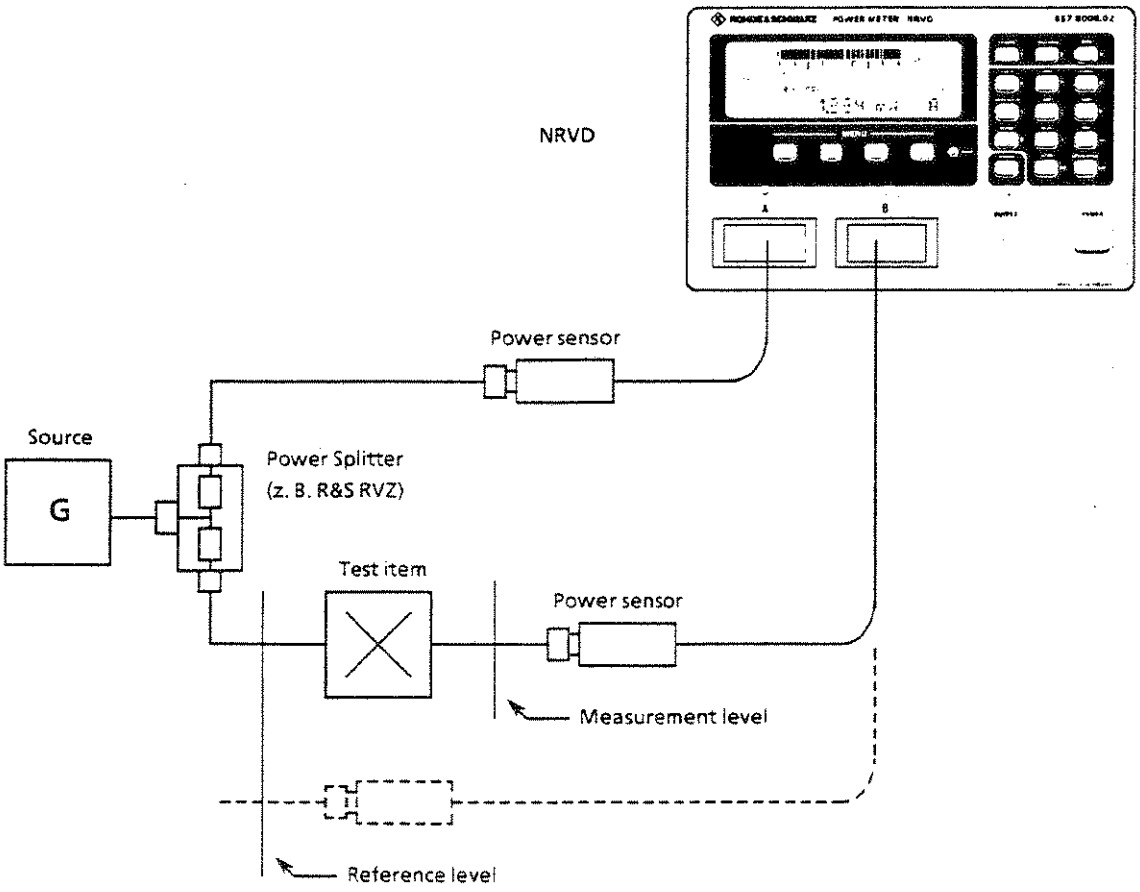



Fig. 2-9 Attenuation measurement using a power splitter

Procedure:

| Test setup | NRVD |
|---|---|
| Connect power sensor B to reference level. | Select channel B.<br>Set relative measurement and unit dB.<br>(UNIT → REL → OTHER.CHN → ΔdB)<br>Specify measured value 0 dB:<br>(REF → ATT → ADJ.T0 → 0 → STO)<br>Check display: 0 dB |
| Connect test item | Read off attenuation. |

## 2.4.2 Sweep Tester for Transmission Measurements

The determination of attenuation or gain according to the substitution method (section 2.4.1) is very accurate, however, it always requires reconnection of the measuring head for the reference measurement.

Many transmission measurements allow higher measurement uncertainties, and often only relative attenuation values are required. Fig. 2-10 shows an appropriate test setup with a level-controlled generator, NRVD and XY-recorder for documentation of the frequency-dependent attenuation characteristic.

The sawtooth output of the generator provides a DC voltage which is linearly dependent on the frequency to the X-input of the recorder (frequency axis) and the input DC (FREQ) of the NRVD for the frequency response correction.

The level-proportional output voltage of the NRVD (DC1 or DC2) is applied to the Y-input of the recorder.

The NRVD must contain the option NRVD-B2.

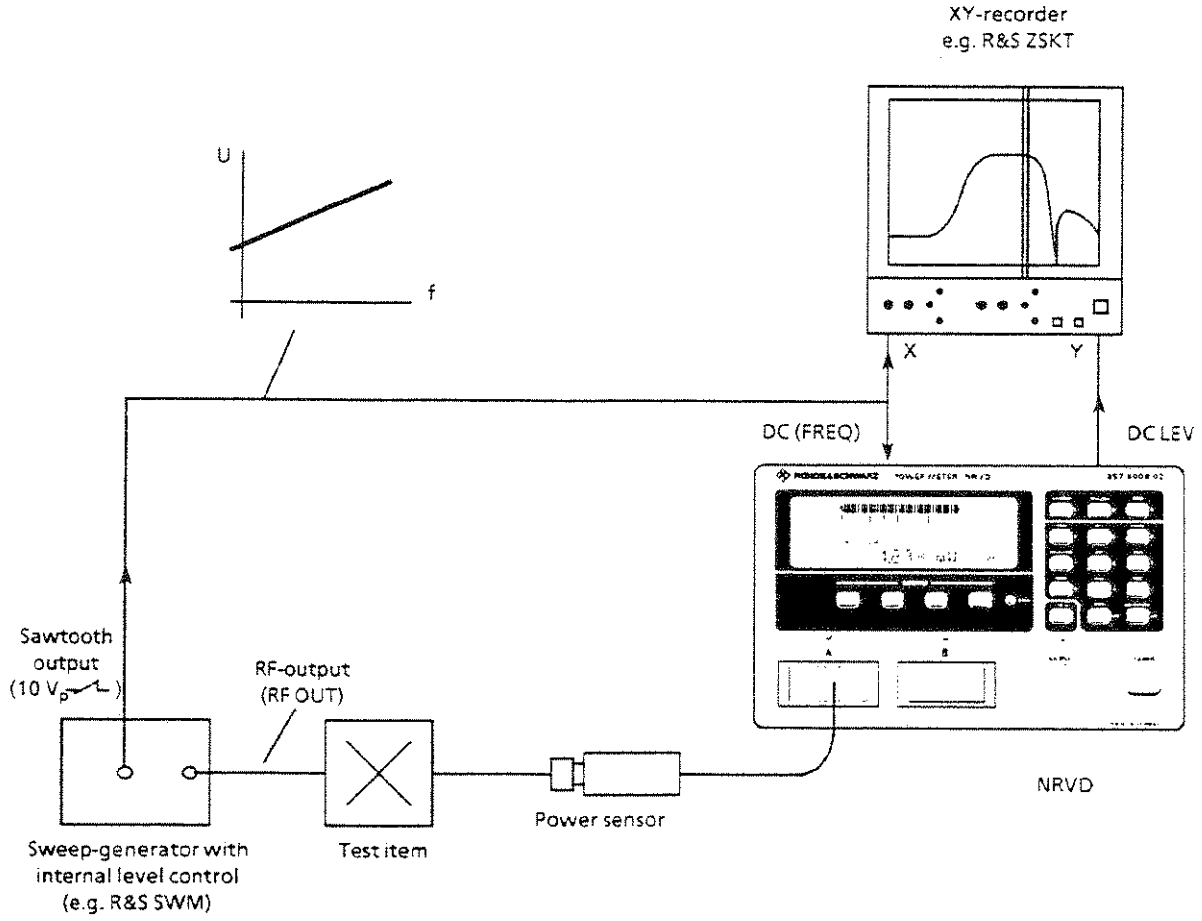



Fig. 2-10 Sweep tester with NRVD and XY-recorder for transmission measurements

## Operation

| Sweep Generator | NRVD (V), Recorder (S) |
|---|---|
| Set RF level.<br>Switch on internal level control. | S: Set Y-sensitivity 0.2 V/cm (deviation 0 to 15 cm).<br><br>V: Set unit ΔdB (UNIT → REL → ΔdB)<br>Set filter no. 5 (FILTER → MANUAL → 5 → STO):<br>Scale analog display (DISP → BARGRPH → SCALE ...):<br>Sensitivity 10 dB/cm → display range 150 dB, e.g. -120 to + 30 dB<br>5 dB/cm → display range 75 dB, e.g. -70 to + 5 dB<br>2 dB/cm → display range 30 dB, e.g. -20 to + 10 dB<br>1 dB/cm → display range 15 dB, e.g. -15 to 0 dB |
| Enter start/stop frequency.<br>Set manual sweep.<br>Set reference frequency<br>(0-dB point). | V: Enter voltage/frequency characteristic of sawtooth output<br>(FREQ → DC-INPUT → ADJUST ...).<br>e.g. 0 V/start frequency and 10 V/stop frequency for SWM.<br><br>Check display of reference frequency.<br><br>Store current measured value as reference value<br>(MEAS-REF → STO).<br>Check display: 0 dB.<br><br>S: Set 0-dB position.<br><br>Set X-sensitivity.<br>e.g. 0.5 V/cm for 20 cm deflection with 10 V deviation (SWM).<br><br>Set position for reference frequency. |
| Start automatic sweep.<br>Optimize sweep rate. | |

## 2.4.3 Reflection Measurement using Directional Coupler or SWR Bridge

Due to their large dynamic range the power sensors for the NRVD are excellently suitable for measuring small reflection coefficients, e.g. using SWR bridges of high directivity (Figs. 2-14 and 2-15). The power reflected by the test item and the incident power are measured and displayed as reflection coefficient, SWR or return loss.

A short circuit and/or a shielded open circuit are required for the measurement. The measuring head should feature a sensitivity of at least 1 nW (-60 dBm), the source is to be set to a possibly large output power (1 to 20 mW, 0 to + 13 dBm).

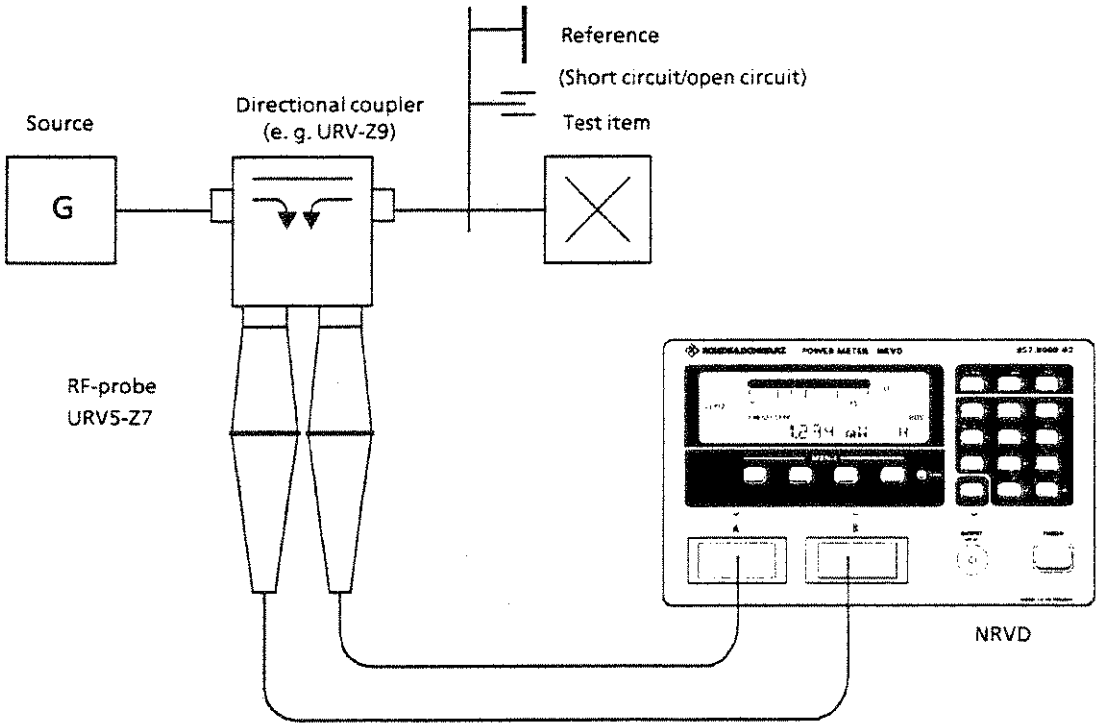



Fig. 2-14 Reflection measurement using directional coupler

**Procedure**

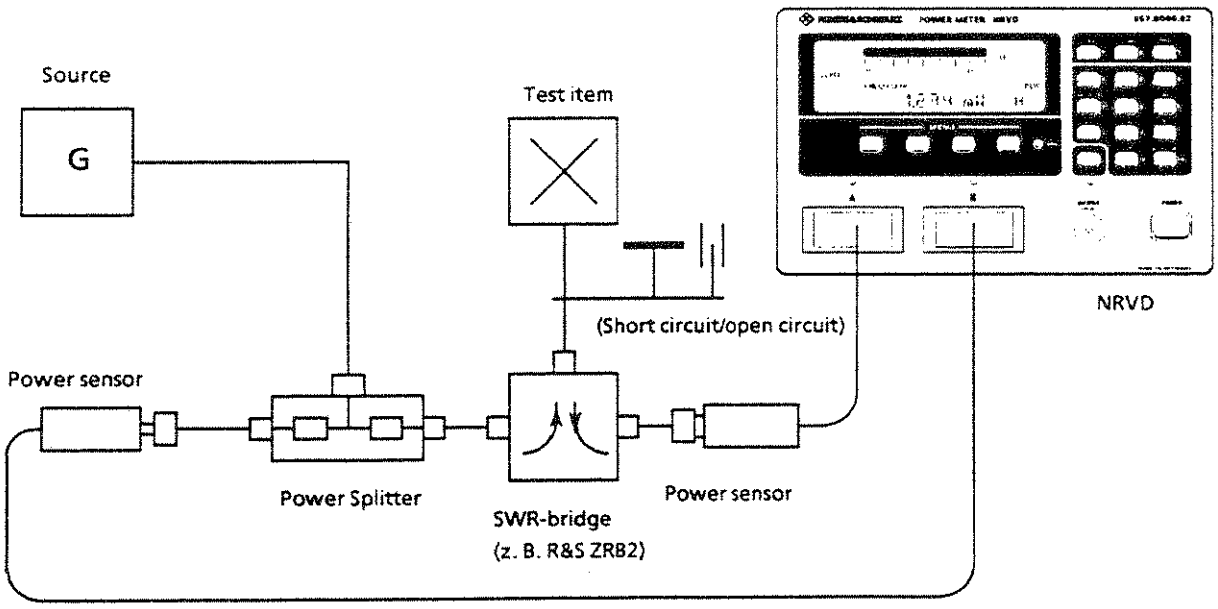



Fig. 2-15 Reflection measurement using SWR bridge

| Test Port | NRVD |
|---|---|
| Reference measurement<br><br>Connect short circuit<br><br><br>If present:<br>Connect shielded open circuit of the same electrical length | Set channel A and reflection mode.<br>(MODE → REFL → RTL → INCID.CHN* B)<br>Read off displayed value and enter as attenuation reference value.<br>(REF → ATT CORR.BY → Wert → STO)<br>Check display: 0 dB<br><br>Correct attenuation reference value such that the displayed return loss for short circuit and open circuit are symmetrical about 0 dB. |
| Connect test item. | Select display reflection coefficient, SWR or return loss.<br>REF<br>(MODE → REFL → SWR → INCID.CHN* B<br>RTL |

## 2.4.4 Power Measurement in the Shortwave Range

A lot of measuring tasks require the signal level to be continuously monitored on the feeder between source and load, e.g. between mobile phone and antenna. Exact measurement of the transmitted power, above all with poor matching, is only possible using directional couplers.

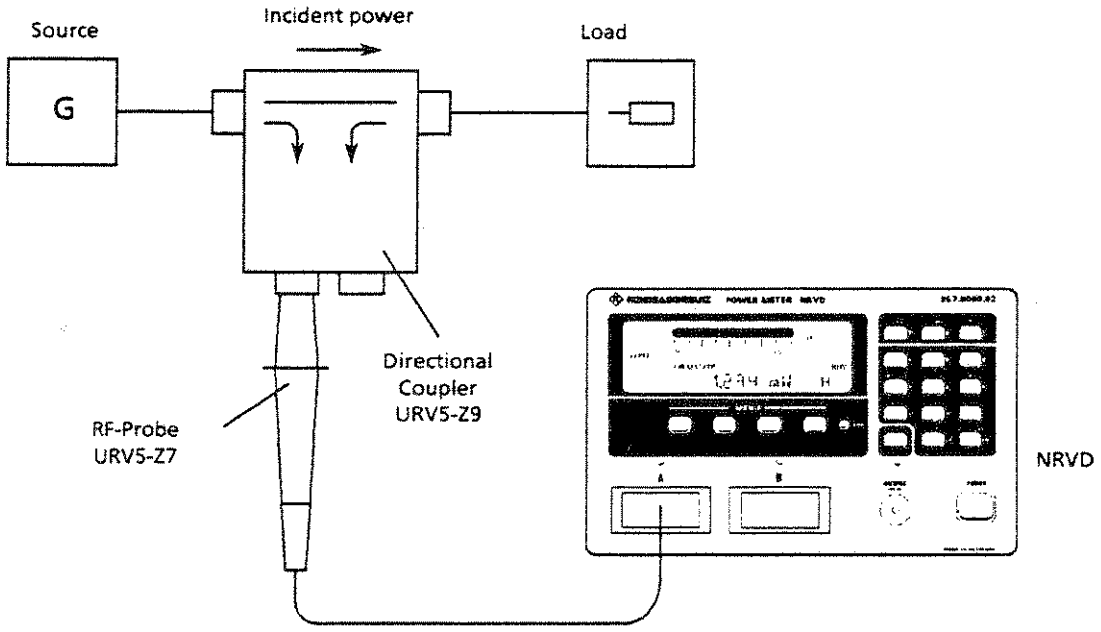



Fig. 2-16 Measurement of incident power of 10 µW to 2 kW and 100 kHz to 80 MHz with NRVD

The Dual Directional Coupler URV5-Z9 is available in particular for the shortwave range and the adjacent bands. It permits to measure the power transmitted to the load (incident power) using an RF Probe URV5-Z7 and the NRVD. The probe for the reflected power output can be dispensed with without reducing the accuracy. By connecting it to measurement channel B, the reflected power can also be measured and checked for illegally large mismatching.

The function REF → ATT COR.BY → ... permits to take into account the coupling attenuation (typ. 40 dB) in the display. The individual values can be obtained from a detailed calibration report for the URV5-Z9.

The reference impedance is to be set to 50 Ω (REF → IMP → 50 → STO).

## 2.4.5 RF Current Measurement

RF currents up to 300 MHz can be measured without opening up the circuit using current probes (Fig. 2-15). Such current probes provide a voltage V proportional to to RF current I into a 50-Ω termination.

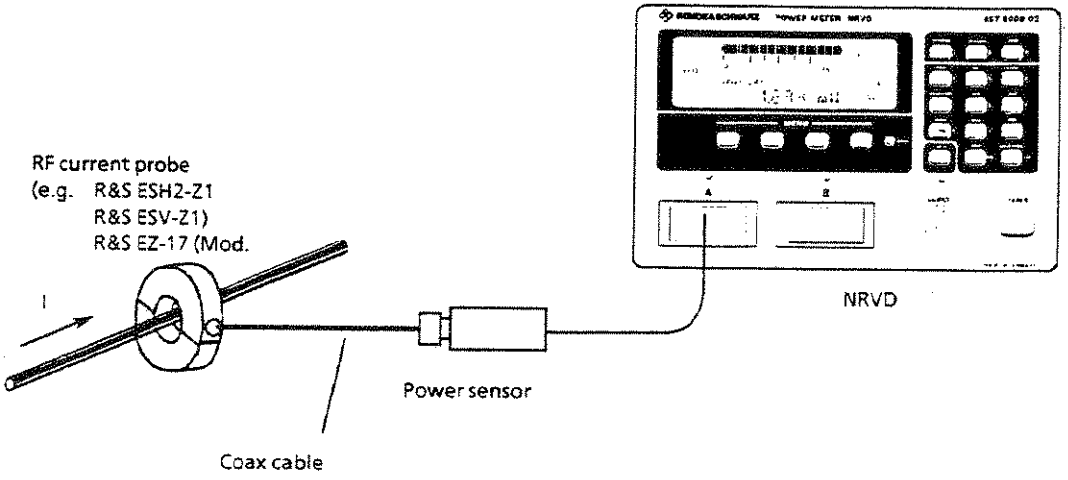



Fig. 2-17 RF current measurement using current probe

The transmission function is marked by the logarithmic conversion figure k:

$$V/V = I/A \cdot 10^{-k/20\,dB}$$

k must be entered into the NRVD with its sign as attenuation reference value (REF → ATT ...). The numerical value displayed in the unit V (UNIT → V) is then equal to the current in A.

The current probes ESH2-Z1, ESV-Z1 and EZ-17 (mod. 02) can be appropriately combined with a terminated Insertion Unit URV5-Z2 (Table 2-5).

Table 2-5 Combination of current probe and RF probe for RF voltage measurement

| | ESH2-Z1 + URV5-Z2 | ESV-Z1 + URV5-Z2 | EZ-17 (Mod. 02) + URV5-Z2 |
|---|---|---|---|
| Frequency range | 100 (9) kHz to 30 MHz | 20 MHz to 100 (300) MHz | 5 MHz (9 kHz) to 100 MHz |
| Current measurement range | 200 µA to 10 A | 20 µA to 1A | 50 µA to 2A |
| Conversion figure | 0 dB | -20 dB | -10 dB |
| Max. current | 10 $A_{eff}$ / 15 $A_{pk}$ | 1,5 $A_{eff}$ / 2 $A_{pk}$ | 2 $A_{eff}$ / 3 $A_{pk}$ |

*) values in ( ): extended available frequency range with a frequency dependent conversion factor.

# 3 Operation

Operation of the NRVD is designed such that the two channels are available to the user like two measuring instruments. They are operated via a common keyboard, which is assigned to the respective channel after channel selection.

## 3.1 Explanation of Front and Rear-panel Views

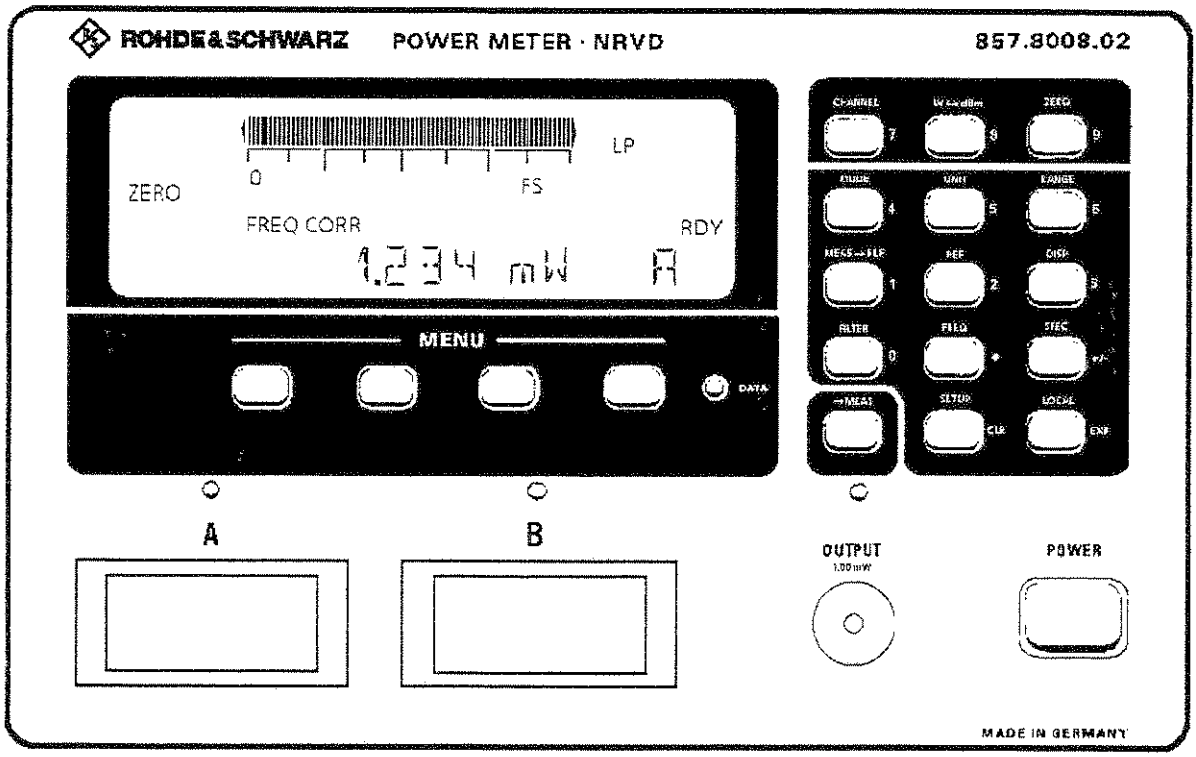



Fig. 3-1 Front view

| | | |
|---|---|---|
| CHANNEL 7 | Switchover between channel A and B | (3.3.1) |
| W↔dBm 8 | Direct selection of the display units W or dBm | (3.3.15) |
| ZERO 9 | Zero correction | (3.3.16) |
| MODE 4 | Measurement modes AVG, PULSE, REFLEXION, AM, DC | (3.3.8) |
| UNIT 5 | Display units absolute V, dBV, dBµV<br>relative dB, P/Pr, %W, W, V/$V_r$, %V, V | (3.3.14) |
| RANGE 6 | Automatical or manual measurement range selection | (3.3.9) |
| MEAS→REF 1 | Store measured value as reference value | (3.3.7) |
| REF 2 | Reference value entry for impedance, attenuation and level | (3.3.11) |

| | | | |
|---|---|---|---|
| DISP 3 | Display setting | Analog display<br>Numerical resolution<br>Extreme values<br>Single or dual-channel display<br>Frequency display for frequency response correction<br>Display of measurement uncertainty | (3.3.2) |
| FILTER 0 | Automatical or manual filter selection | | (3.3.3) |
| FREQ . | Correction of frequency response of measuring head | | (3.3.4) |
| SPEC +/- | Special functions | IEC-bus-address<br>Test generator<br>External trigger<br>Analog output<br>Display illumination<br>Test front panel<br>Memory protection for instrument setups<br>Calibrate option | (3.3.13) |

| | | |
|---|---|---|
| →MEAS | Return to measurement function | (3.3.6) |
| SETUP CLR | Store or recall complete instrument setups, basic setting | (3.3.12) |
| LOCAL EXP | Display IEC-bus address, return to manual operation | (3.3.5) |

MENU

Menu keys for further entries according to the messages in the display

| | | |
|---|---|---|
| A | Channel A selected | (3.3.1) |
| B | Channel B selected | (3.3.1) |
| DATA | Keyboard switched to numerical entry | |
| | Test generator switched on | (3.3.13) |

OUTPUT
1.00 mW

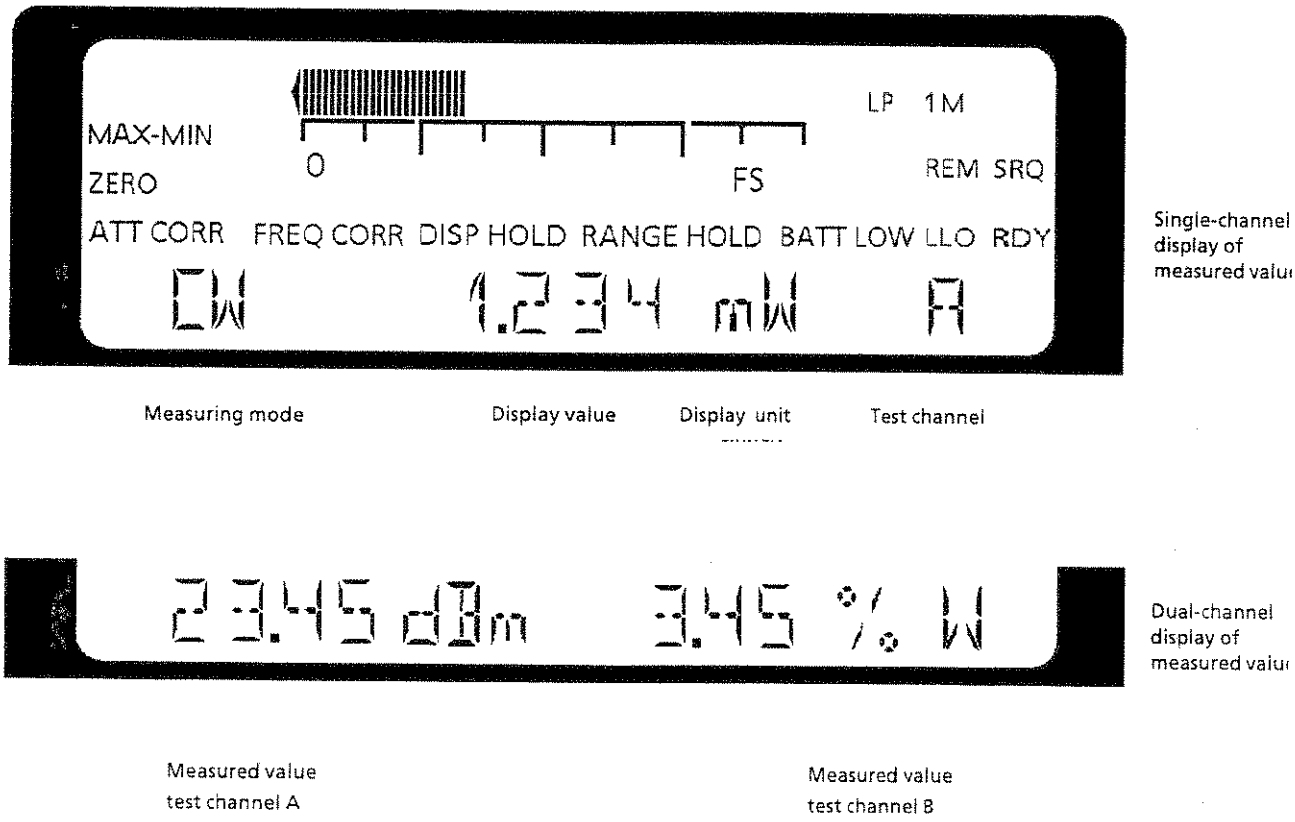



Fig. 3-2 Meaning of permanent messages in the display

| | | |
|---|---|---|
| MIN | Display of minimum possible level | (3.3.2) |
| MAX | Display of maximum possible level | (3.3.2) |
| MAX-MIN | Display of difference between maximum and minimum level | (3.3.2) |
| ATT.CORR | An attenuation is taken into account in the measurement | (3.3.11) |
| FREQ.CORR | Frequency response correction switched on | (3.3.4) |
| DISP HOLD | Measurement result is retained | |
| RANGE HOLD | Measurement range is retained | (3.3.9) |
| BATT LOW | Battery voltage for the battery-backed RAM is too low | |
| LLO | Switchover to manual operation using LOCAL key is locked | (3.3.5) |
| REM | Instrument is in remote state | |
| SRQ | Instrument requests service from controller | |
| RDY | Measurement result is available | |
| LP 1 | Filter 1 (0 to 12) is cut in (automatically) | (3.3.3) |
| LP 2 M | Filter 2 (0 to 12) is cut in (manually) | (3.3.3) |

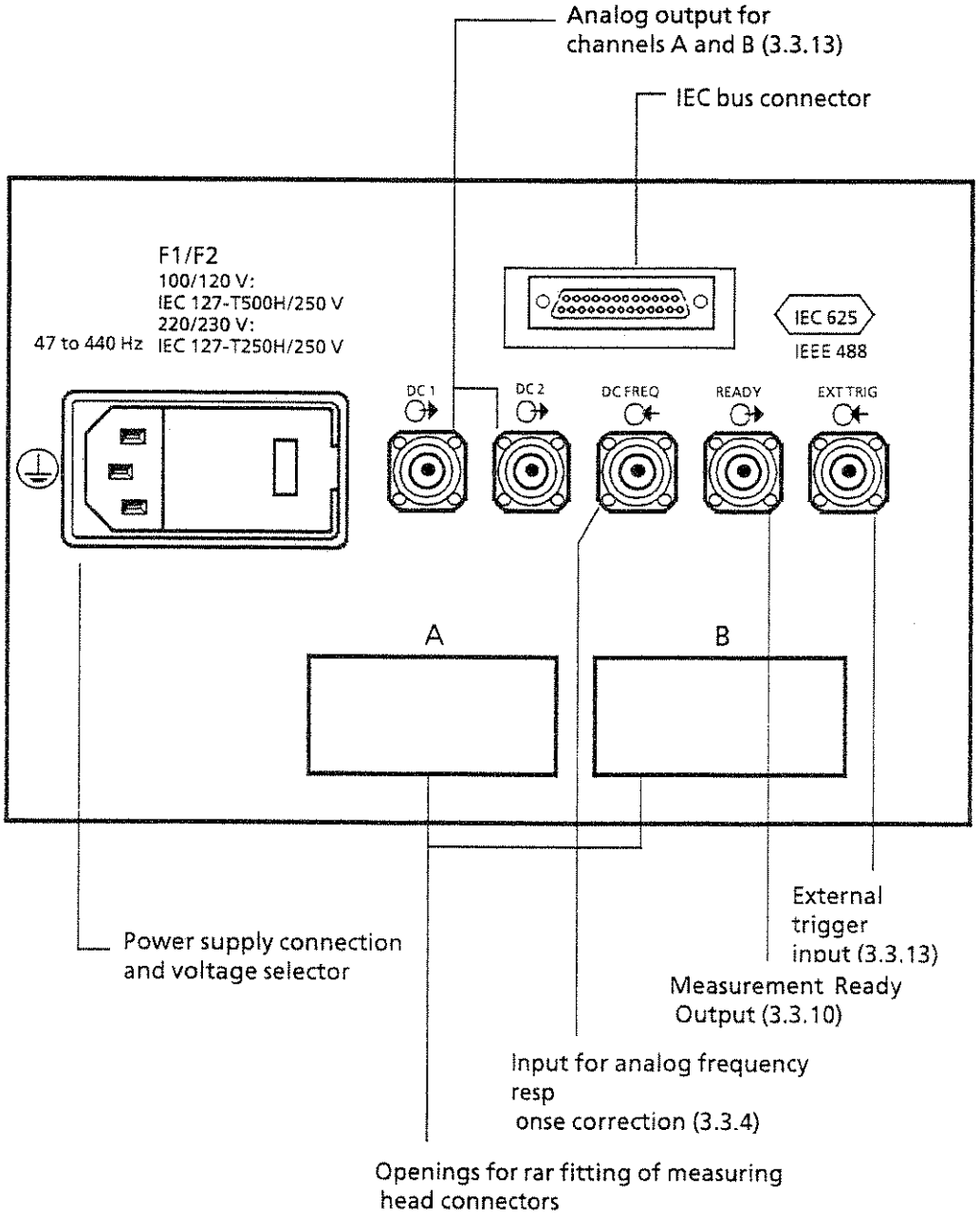



Fig. 3-3 Rear view

## 3.2 Manual Operation

### 3.2.1 Menu Operation and Numerical Entries

To permit convenient setting of the manifold functions using a simple keyboard, the instrument is provided with menu operation: Ten of the 15 keys in the righthand part of the front panel are used to call a menu. The alphanumerical display line of the display shows up to four subfunctions, which can be selected by pressing the menu key below.

**Meaning of general menu messages or characters**

| | |
|---|---|
| more<br>mre | More possible menus can be selected than can be read out in the display line.<br>By pressing more (mre),<br>the next menu level is called up. |
| menü | Back to the beginning of the menu |
| ...* | A message followed by an asterix represents a comment. Pressing of the menu key below does not produce any effect. |

Pressing of a menu key causes one of the following reactions:

- Immediate setting of the menu function
- Next menu level
- Request for data entry

**Numerical entries:**

Some instrument setups require the entry of numbers. Whenever the LED marked by "DATA" is illuminated, the keys in the righthand keypad assume the meaning indicated by the blue notation. The entry of a numerical value must be terminated by pressing the menu key "STO".

**Help in the case of operating errors:**




This key can be used to abort a menu at any place (even during numerical entry). The measurement will then be continued in the operating mode set before the menu was called up.

**Direct keys which do not call up a menu:**






## 3.2.2 List of Operating Functions


| Function | Page |
|---|---|
| Absolute display units | 3.38 |
| Amplitude modulation | 3.25 |
| Analog display | 3.8 |
| Analog output | 3.34 |
| Attenuation reference value | 3.29 |
| Average power | 3.21 |
| Channel selection | 3.7 |
| Display of correction frequency | 3.14 |
| Display of measurement result | 3.14 |
| Display of measurement uncertainty | 3.13 |
| Display units | 3.38 |
| Error messages | 3.51 |
| Extreme-value display | 3.11 |
| Filter setting | 3.15 |
| Frequency response correction analog | 3.17 |
| Frequency response correction numerical | 3.16 |
| Impedance reference value | 3.28 |
| INIT | 3.37 |
| Level reference value | 3.30 |
| Measurement range selection | 3.26 |
| Measurement start by external trigger | 3.33 |
| Memory protection for instrument setups | 3.36 |
| Pulse modulation | 3.21 |
| Ready output | 3.27 |
| Reference value entry | 3.28 |
| Reflection | 3.23 |
| Relative display units | 3.39 |
| Resolution of displayed value | 3.10 |
| Setting the display illumination | 3.35 |
| Setting the IEC-bus address | 3.31 |
| Setting manual operation (LOCAL) | 3.19 |
| Single/dual-channel readout | 3.12 |
| Special functions | 3.31 |
| Storing and recalling instrument setups | 3.30 |
| Switching off frequency response correction | 3.18 |
| Switching on/off the test generator | 3.32 |
| Testing the front panel | 3.35 |
| Zero correction | 3.42 |

## 3.3 Description of Operating Functions

Notes on the IEC-bus commands described in this section:

The IEC-bus commands described are examples with a possibly simple format. In many cases, however, further notations are possible (see 3.8).

If the commands may apply to both channels, the desired channel is to be set before (see 3.3.1). Section 3.8 contains further possibilities of channel selection.

The expression [unit] permits a unit to be entered. Otherwise, the basic unit (Hz, V, W) is used. In the case of <unit>, a unit must be transmitted.

In the case of <Value>, a numerical value must be transmitted (decimal number optionally with sign, point and exponent, permissible range as with value entry in manual operation).

Square and angled brackets [ ] < > must not be transmitted.

'may also be sent instead of " within a command.

### 3.3.1 CHANNEL (Channel Selection)

Function Selection of the measurement channel to which the keyboard is to be assigned and whose operating mode setting and measurement result is to be indicated in the display. Key with scroll function for alternate switchover between channels A and B.

Operation




IEC bus command: **INP:SEL "A"** or **INP:NSEL 1**
**INP:SEL "B"** or **INP:NSEL 2**

Displays The active channel is indicated by illumination of LED A or B. In the case of single-channel readout (3.3.2), the designation of the channel (A or B) is read out at the bottom right of the display.

Notes If no measuring heads are connected, channel A is automatically selected, switchover to channel B is not permissible. If only one measuring head is connected, the other channel cannot be selected.

### 3.3.2 DISP (Display Settings)

The following functions can be set in the display menu:

- Analog display (BARGRAPH)
- Resolution of display value (RESOLUTION)
- Extreme-value display (EXTREME)
- Single or dual-channel display of measurement result
- Display of measurement uncertainty (UNCERTAINTY)
- Frequency display for frequency response correction (FREQ)
- Reset to single measured value display (MEA.VAL)

**Analog display**

Function — Switch analog display off

Operation




IEC bus command: **DISP:ANN:BARG OFF**
**DISP:ANN:BARG ON** (switch on)

Funktion — The scale of the analog display is automatically selected by the instrument according to the displayed value.

Operation




IEC bus command: **DISP:ANN:BARG:AUTO**

Function

The VOL display (volume display) indicates the volume within the selected measurement range. The designation FS of the righthand full scale refers to the nominal value of the selected measurement range (see Measurement Range Selection 3.3.9). Underrange or overrange can be easily detected using the VOL display.

Operation

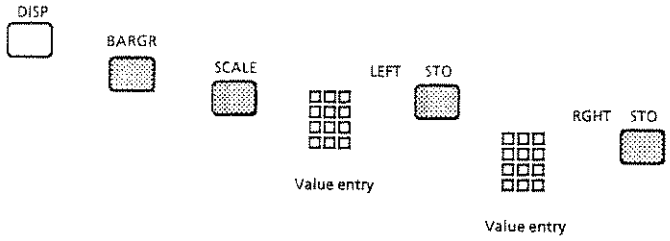



IEC bus command: **DISP:ANN:BARG:VOL**

Function

Fixed scale of analog display freely selectable by the user. The first value entry determines the lefthand full-scale value, the second the righthand full-scale value. The zero point can lie inside or outside the analog scale. Thus it is possible to expand the display range at will, which is particularly suitable for adjustment procedures.

Operation




IEC-bus-command **DISP:ANN:BARG ON**
**DISP:ANN:BARG:SCAL:LOW <Value>; UPP <Value>**

Note

The full-scale values can be entered at will. However, they can only be read out with a maximally three-digit mantissa in the display. If the entry comprises more than three digits, the digits which can no longer be displayed are cut off. In order for the mantissa of the input value to comply exactly with the displayed full-scale values, it is recommended to enter a value with a maximally three-digit mantissa and the same exponents.

## Resolution of the displayed value

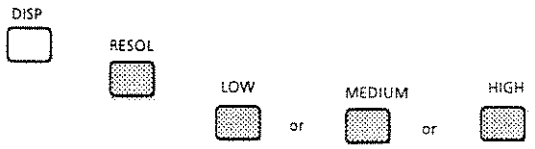
Function

The display value can be read out with different fractional parts so that the following resolutions are obtained relative to the nominal value of the measurement range:

For linear values (e.g. V, W, %, $P/P_R$): 0.01 %, 0.1 %, 1 %

For logarithmic values (e.g. dB, dBµV): 0.001 dB, 0.01 dB, 0.1 dB

Operation




IEC bus command: **DISP:ANN:AMPL:RES "LOW"**
**DISP:ANN:AMPL:RES "MED"**
**DISP:ANN:AMPL:RES "HIGH"**

Note

In the case of automatic filter selection (see 3.3.3), the selected resolution affects the measurement rate. The highest measurement rate is achieved with the resolution LOW, the lowest with the resolution HIGH.

If resolution HIGH is selected in the case of two indications in the display (e.g. dual-channel measurement or display of level and correction frequency), the filter setting corresponding to this resolution is effected, however, the resolution of the value displayed corresponds to the MEDIUM setting. The warning

SET - But Can't DISP

is displayed.

In IEC bus mode, numerical values are output as they are read out in the display. In order to obtain full resolution in dual-channel measurements with the setting HIGH, the display can be switched off.

IEC bus command: **DISP OFF** (Switching the display off)
**DISP ON** (Switching the display on again)

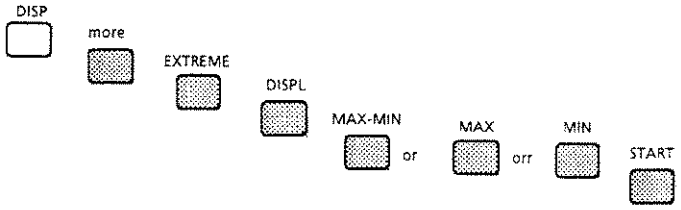
## Extreme-value display

Function

The extreme-value display indicates from the point of activation

- the highest possible measured value (MAX),
- the lowest possible measured value (MIN) or their
- difference (MAX-MIN).

Operation




IEC bus command: **DISP:ANN:AMPL:EXTR MIN**
**DISP:ANN:AMPL:EXTR MAX**
**DISP:ANN:AMPL:EXTR MAXM**
**CALC:EXTR:INIT** (Start)

Readout

The start of extreme-value generation is indicated by the message

* START EXTREME *

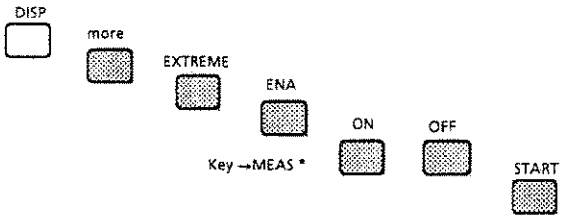
The readout of extreme values is marked in the display by the messages

"MAX" or "MIN" or "MAX-MIN".

Note

Extreme-value generation is started

- by pressing the menu key START
  or, with extreme-value display switched on,
- by changing the measurement mode (see 3.3.8) or
- by changing the display unit (see 3.3.14).
- by pressing the →MEAS key, if enabled for the start of extreme-value generation. The key is enabled or disabled by entering




With extreme-value generation switched on, all three extreme values (MAX, MIN, MAX-MIN) are always simultaneously stored so that their display can be switched over at will.

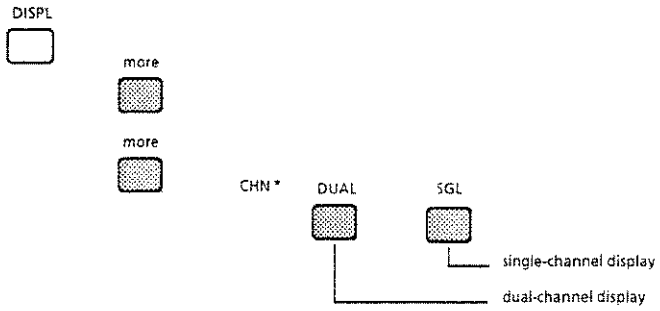
Using menu key OFF, extreme-value generation is aborted and the display of the current measured value switched on again.

## Single or dual-channel readout

Function

If two measuring heads are connected for the measurement, the measurement results of both channels can be read out at the same time.

Operation




IEC bus command: **DISP:ANN:AMPL SING**
**DISP:ANN:AMPL DUAL**

Readout

Measurement mode, measured value, channel (single-channel display)
Measured value channel A, measured value channel B (dual-channel display)

Note

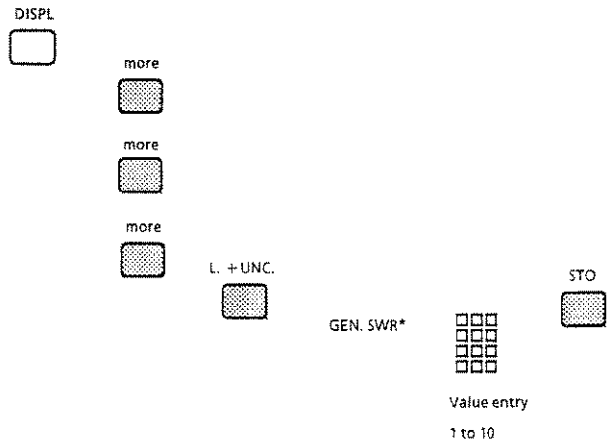
The analog display applies to the channel selected using the CHANNEL key.

## Display of measurement uncertainty

Function

In the case of some measuring heads for the NRVD, the instrument can display the measurement uncertainty under the current conditions of measurement. Since this value also depends on the VSWR of the source, it is to be entered as generator SWR.

Operation




IEC bus command: **DISP:ANN:UNC:GSWR <Value>**

Readout

In addition to the measurement result, the measurement uncertainty is displayed in dB.

Note

The measurement uncertainty comprises the following components:

- Frequency-dependent calibration uncertainty of the measuring head
- Mismatch attenuation between generator and measuring head
- Temperature and linearity error of measuring head
- Level-dependent measurement uncertainty resulting from noise
- Instrument error of the NRVD.
- Zero error

Since the individual errors are independent of each other and vary statistically within particular error limits, the complete measurement uncertainty can be calculated as the square root of the sum of the individual uncertainties squared. This error covers a confidence interval of 95 %, i.e. 95 % of all measurement results do not exceed the displayed measurement uncertainty (see. 3.7.7).

The displayed value is valid in the measurement mode AVG at the correction frequency entered.With frequency response correction switched off, an initializing value depending on the sensor is taken as a basis as frequency (for checking this frequency, cf. 3.3.2 "Display of Correction Frequency").

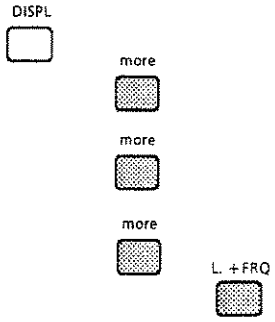
In the other modes, additional external errors have to be considered.

## Display of correction frequency

Function

Display the correction frequency contributing to the measurement result (frequency response correction see 3.3.4)

Operation




IEC bus command: **DISP:ANN:FREQ ON**

Readout

In addition to the measurement result, the effective correction frequency is displayed.

Examples:

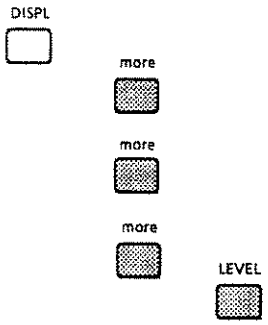
| | | | | |
|---|---|---|---|---|
| 1.234 mW | @ | 1.5 GHz | B | (numerical correction) |
| 2.345 dBm | | 2.6 GHz | A | (analog correction) |

## Display of measurement result

Function

The display of the measurement uncertainty or the correction frequency is cleared; only the measurement result is read out.

Operation




IEC bus command: **DISP:ANN:AMPL SING**

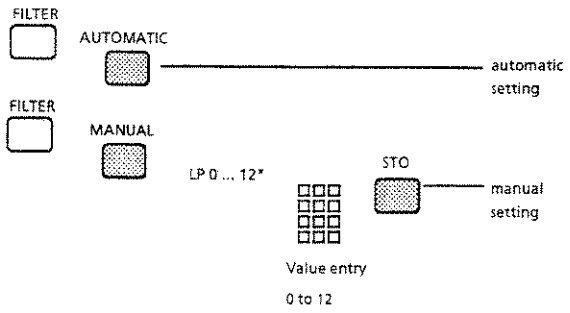
### 3.3.3 FILTER (Filter Setting)

Function

For suppression of larger display variations due to noisy signals, the NRVD is provided with various filters, which are either automatically selected by the instrument depending on the measurement range and display resolution or manually set by the user.

Filtering consists of average-value generation of various numbers of subsequent measured values.

Operation




IEC bus command: **CALC:FILT:AUTO ON**
**CALC:FILT:NSEL <0 ... 12>**

Readout

On the right of display:

LP dd (dd = 0 to 12, automatic setting)
LP dd M (dd = 0 to 12, manual setting)

Note

The automatic filter setting makes sure that the optimum filter is set depending on the measurement range and the display resolution selected by the user (see 3.3.2). The measurement rate results from the filter setting. Very small test signals (low measurement range) and a high display resolution require the most efficient filter and thus result in the smallest measurement rate.

If the automatic filter selection seems to be unsuitable for a particular measuring task, in which e.g. a greater measurement rate is required (which increases the display noise), a different filter can be manually set.

The connection between filter number, measurement rate and noise is to be obtained from the Specifications.

## 3.3.4 FREQ (Frequency Response Correction)

By entering the frequency at which the measurement is made, the frequency response of the measuring head can be corrected.

The frequency-dependent calibration factor is individually measured during production for each RF probe which can be connected to the NRVD and stored in the nonvolatile data memory of the probe.

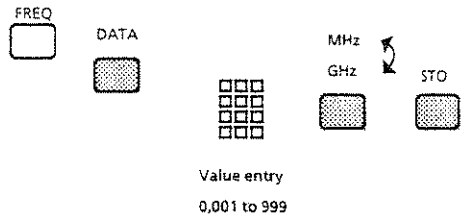
*The frequency response curve is not automatically evaluated, since the NRVD does not contain a frequency meter.*
*The correction frequency entered and the frequency at which the measurement is made must comply with each other; otherwise, the measurement error may become greater as it would be without correction.*

The correction frequency can be fed numerically into the rear input DC (FREQ) via the keyboard or the IEC bus (numerical frequency response correction) or as a frequency-proportional DC voltage as supplied by a sweep generator for example (analog frequency response correction).

### 3.3.4.1 Frequency response correction (numerical)

Function — Numerical entry of the test frequency and switching on of frequency response correction.

Operation




IEC bus command: **SENS:CORR:FREF <Value>[unit]**

Readout — On the left of the display: FREQ CORR

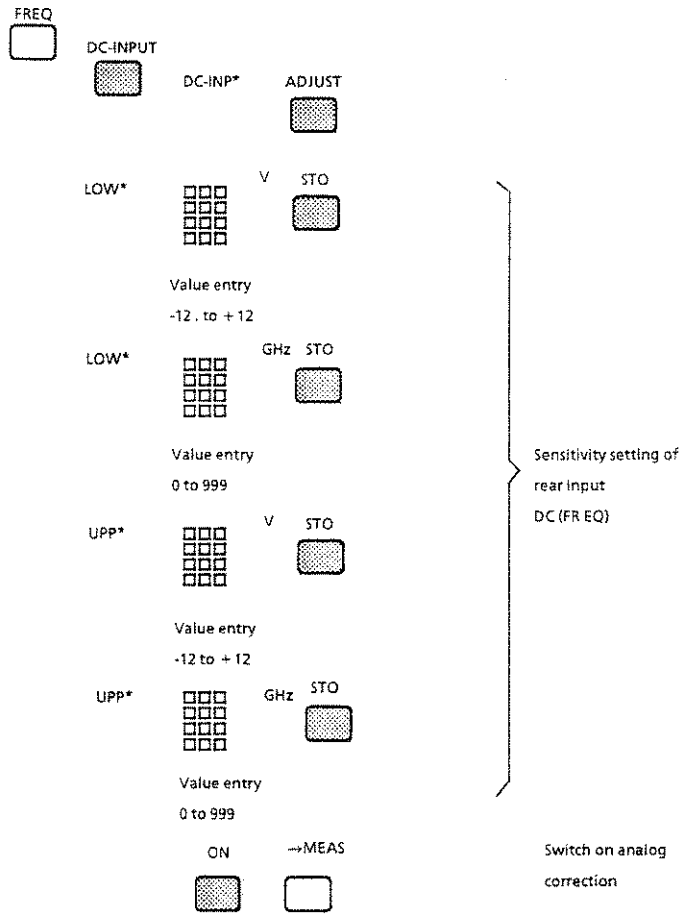
Note — If the frequency entered lies between two calibration frequencies, the calibration factor is calculated by linear interpolation.
For frequency response correction for external components see section 3.3.4.3

## 3.3.4.2 Frequency response correction (analog)

Function

Sensitivity setting of the DC (FREQ) input at two different test frequencies and with the associated DC voltages.

Operation




IEC bus command:

**SENS:FREQ:ADJ:LOW <Value>V, <Value><unit>**
**SENS:FREQ:ADJ:UPP <Value>V,<Value><unit>**
(unit: HZ, KHZ, MHZ or GHZ)

**SENS:FREQ:STAT ON**
**SENS:CORR:FREF:STAT ON**

Readout

On the left of the display: FREQ CORR

Note

The analog frequency response correction assumes a proportional relationship between test frequency and DC voltage. During each measurement run, the current correction frequency and the associated calibration factor are calculated from the applied DC voltage and the entered sensitivity setting by means of linear interpolation (display of the correction frequency see 3.3.2).

## 3.3.4.3 Frequency response correction (extern numerical)

In firmware version 1.50 and higher, the NRVD offers the possibility of including a frequency response correction for external components (e. g. an attenuator connected ahead) in the display calculation in addition to the existing numerical calculation functions.

***Preliminary remark:***

It is possible to load two independent frequency-response correction lists into the instrument, i. e. one list per cannel. Even in this case, the two channels can be operated independently of each others as previously. (The lists can be loaded/deleted separately and the status can be switched on/off separately).

Each list can be loaded with a maximum of ***60 Frequeny response points;*** this can however only be done via the IEC/IEEE bus.

The lists are not stored in the SAVE/RCL memories; the status (**SENS:CORR:FREF:EDAT:USE ON** I **Off**) , i. e. whether the list is switched on or off; is integrated in the general device status and thus also in the SAVE/RCL memories.

The data are effective, i. e. included in the disply calculation, only if the frequency response correction is on (**SENS:CORR:FREF:STAT ON**) and the data list is activated (**SENS:CORR:FREF:EDAT:USE ON**) . The user can select a simple numerical correction with sensor data (as usal) or, if an external frequency response correction list was loaded, a calculation with internel sensor data and this external frequency response list (external numerical).

***Note:***
After a firmware update, the error message "DEVICE-ERROR* 0002"is displayed on switching on the instrument because list data are missing. An initialization is possible with the SPEC function: INIT-> PRESET SETUP* EXEC. This clears all SAVE/RCL memories.

***Calculation:***

**Display value = display function ($k_{int}$ * $k_{x\,ext}$ * measured value )**

Attenuation correction value: $k_{int} = 10^{\frac{att_{entry}}{B}}$ B = 10 for power , 20 for Volt

Correction factor (ext. data): $k_{x\,ext}$

Display function : all existing display calculations
(see section 3.3.14 UNIT, for example)

---

***External numerical correction switched off (or no list was loaded):***

$k_{x\,ext} = 1$

---

***External numerical correction switched on:***

loaded list data: $f_1$ to $f_n$ , $att_1$ to $att_n$ (n reference values)

current frequency: $f_x$ = test frequency (numerically entered)

correction factor: $k_{x\,ext}$

for $f_x <= f_1$ : $k_{x\,ext} = 10^{\frac{att_1}{B}}$

for $f_x >= f_n$ : $k_{x\,ext} = 10^{\frac{att_n}{B}}$

} **No** extrapolation is performed outside the defined frequency range $f_1$ to $f_n$

B = 10 for power , 20 for Volt

for $f_1 < f_x < f_n$: $k_{x\,ext} = 10^{\frac{att_x}{B}}$

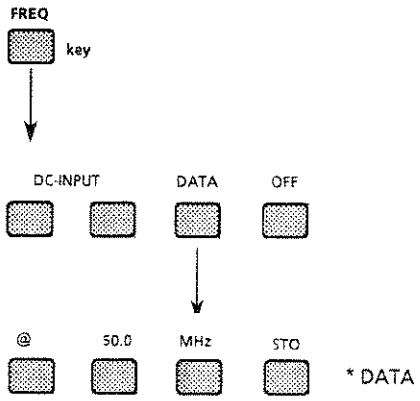
Linear interpolation is performed between the reference points

where

$$att_x = att_m + \frac{att_{m+1} - att_m}{f_{m+1} - f_m} * (f_x - f_m)$$ $f_x$ in the interval $f_m < f_x < f_{m+1}$

After pressing FREQ key (menus below), operation depends on whether a list with externel frequency response correction data was loaded or not.

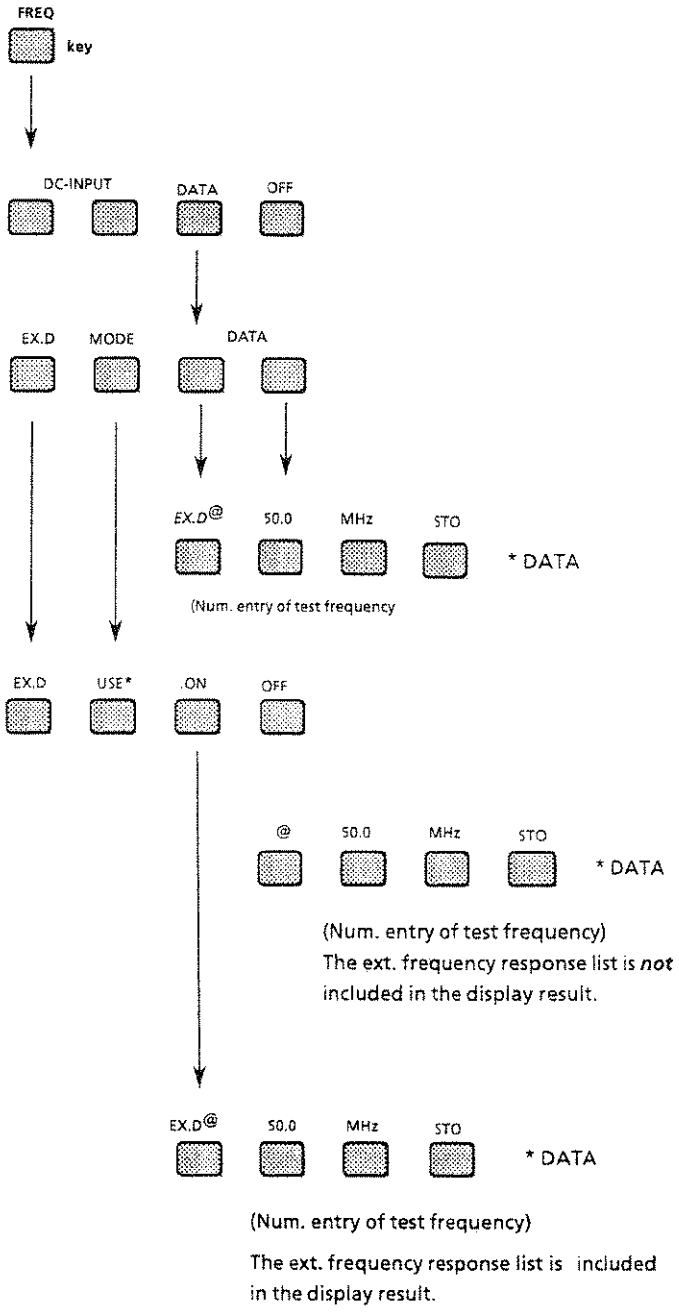
***No frequency response correction list*** was loaded or all were deleted.




(Num. entry of test frequency)

Operation is the same as with previous firmware versions an is described in section 3.3.4.1.

A *(valid) frequency response correction list* for the current channel was loaded via the IEC/IEEE bus.



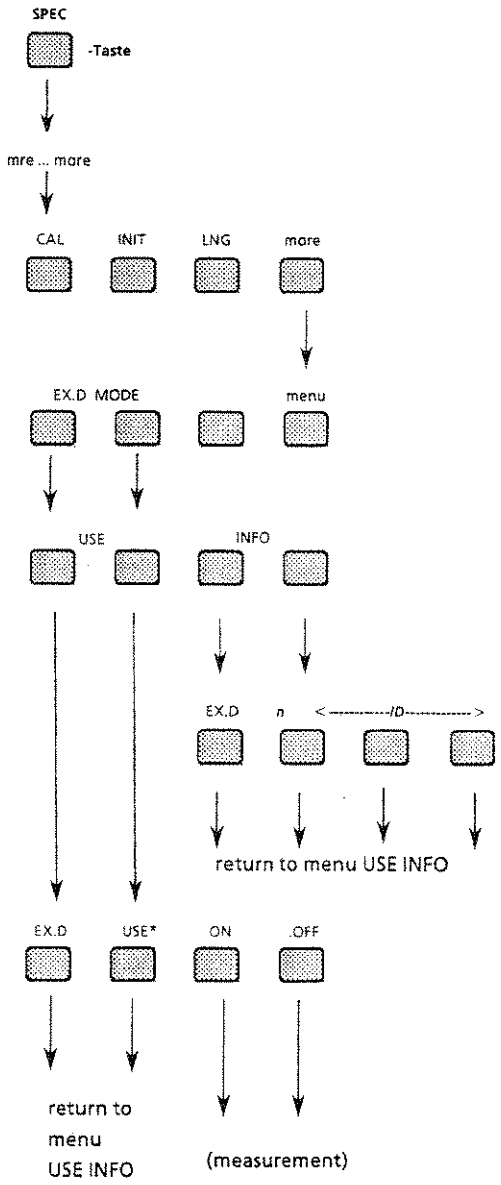

**EX.D** is an identification indicating that the frequency response associated with the channel is included in the calculation of the display value with the frequency response correction being switched on.

IEC/IEEE-bus command: **:SENS:CORR:FREF:EDATA....**
(see section 3.8.5.2, Table 3-11)

Example: Switching on the ext. frequency response correction

**:SENS:CORR:FREF:EDAT:USE** ON

The special functions menu (sections. 3.3.13, 3.4.9) has been extended by one level externel to permit numerical frequency response correction.




The menu does not depend on the load state of the frequency response correction lists. As an alternative to the menu under the FREQ key, an external frequency correction list can be included in or exluded from tha calculation of the display value via menu item USE.

Thge status of the data list for external frequency response correction can be checked via menu item INFO.

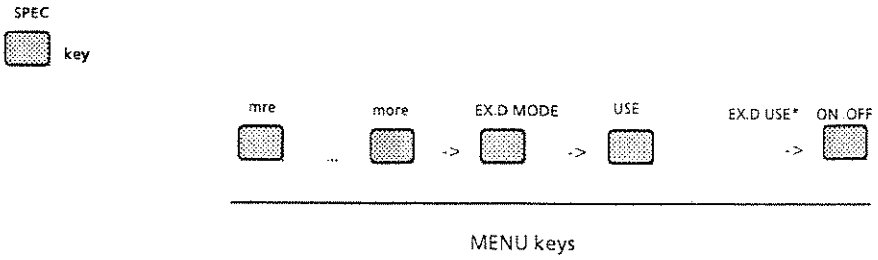
| | | | |
|---|---|---|---|
| *n* | Number of list points | (1to60) | |
| *ID* | Text identification for loaded list | no LIST | (no list) |
| | | no ID | (list available, no name entered) |

The text "no List" and " no ID" are generated by the NRVD.

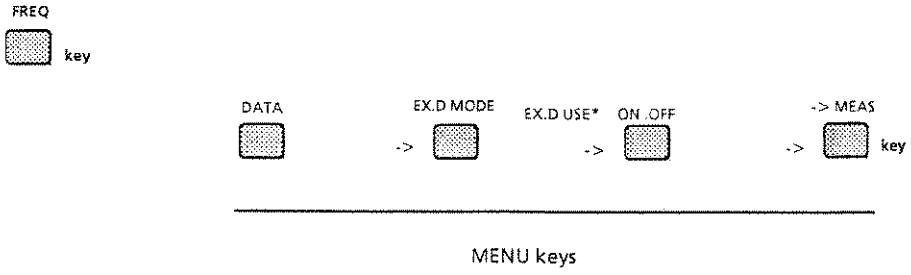
## 3.3.4.2.1 Frequency response correction (external analog)

When the DC input (FREQ) (section 3.3.4.2) is used for the automatic determination of the test frequency, the external frequency response correction values can be included in the display result.

The ext. data correction is switched on/off either via the SPEC menu




or via the FREQ menu



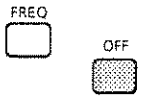

IEC/IEEE-bus command: **SENS:CORR:FREF EDAT:USE ON**

## 3.3.4.4 Switching of frequency response correction

Function

This function switches off the frequency response correction at the frequency entered by the user numerically or via the rear input DC (FREQ)

Operation




IEC bus command: **SENS:CORR:FREF:STAT OFF**

Note

The frequency response correction permits to take into account the frequency response of the measuring head.

With frequency response correction switched off, the displayed value is based on the sensitivity of the measuring head at the reference frequency (display of this frequency see 3.3.2).

It is recommended to switch off frequency response correction if an RF probe (URV5-Z7) is used under measurement conditions that are different from the conditions of calibration (e.g. measurement using the probe tip, whereas frequency correction applies to operation with Adapter URV-Z50).

### 3.3.5 LOCAL (Back to Manual Operation, Diplay IEC Address)

Function

If the instrument is in the remote control state (REM is read out in the display), manual operation via the keyboard is disabled. It is enabled again by pressing the LOCAL key.
In manual operation, the IEC-bus address set is briefly displayed after pressing the LOCAL key.

Operation




Readout

In remote mode: REM display is cleared.
In manual mode: IEC-bus address is displayed

Note

Switchover from remote control to manual operation is only possible if it is not disabled by the IEC-bus command LOCAL LOCKOUT (LLO read out in the display).

### 3.3.6 →MEAS (Continue Measurement)

Function

This key function permits to terminate or abort menu entries at any place. The same applies to numerical entries. The numerical value entered so far is lost and the measurement is continued in the operating mode set before the menu was called up.

Operation



### 3.3.7 MEAS → REF (Store Measurement Result as Reference Value)

Function — The measurement result can be stored as reference value.

Operation




IEC bus command: **AMPL:REF:MVAL**

Readout — After calling up the menu, the measurement result is retained for checking. Readout in the display: DISP HOLD

Note — Continue measurement without storage:




In the case of display values with relative units dB, $P/P_r$, %W, Δ W, $V/V_r$, %V or Δ V, the power or voltage value on which the measurement is based is stored as the reference value.

With extreme-value display (see 3.3.2), not the displayed extreme value, but the measured value valid on pressing of the MEAS→REF key is stored.

### 3.3.8 MODE (Measurement Modes)

Using the RF probes, the instrument can be operated in the measurement modes average power (AVG), pulse modulation (PULSE), reflection (RFL) and amplitude modulation (AM) (AM only with thermal sensors). The DC Probe URV-Z1 permits (only) DC measurements.

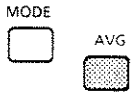
Connection of a peak power sensor causes the letters PEP to be read out in the display. The measurement modes PULSE or AM cannot be set.

Peak power sensors measure the peak envelope power of modulated signals and the average power of unmodulated signals.

#### Average Power (AVG)

Function — Measurement of average value of power of modulated or unmodulated signals

Operation



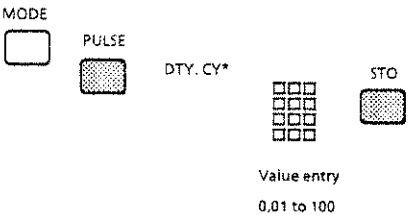

IEC bus command: **FUNC "POW:AC"**

Readout — With single-channel measurement: measurement result channel

#### Pulse modulation (PULSE)

Function — For squarewave modulation, the rms value of the carrier signal is calculated from the rms value of the modulated test signal and the duty cycle and displayed.

Operation

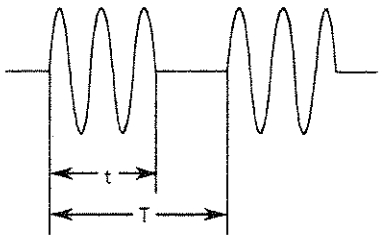



IEC bus command: **FUNC "POW:PULS <Value>"**

Readout — With single-channel measurement: PUL measurement result channel

Note The value

$\frac{t}{T}$ is stated in % as duty cycle.



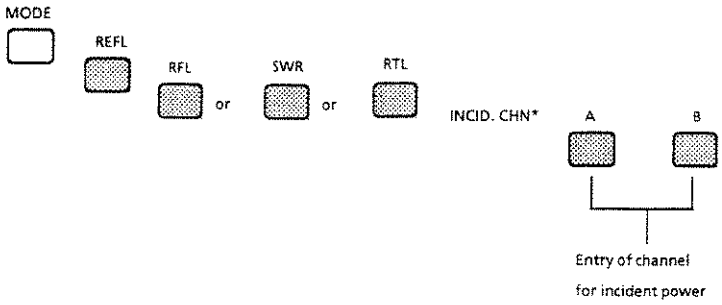

Determination of pulse power requires rms weighting of the measurement signal. If the measuring range for rms weighting is exceeded in the case of diode sensors, additional measurement errors have to be considered, the measured value blinks.

## Reflection (RFL)

Function

When two sensors are used which measure incident and reflected power at a directional coupler or a VSWR bridge, reflection is calculated from this and displayed as reflection factor, VSWR or as return loss in dB.

Operation




IEC bus command: **FUNC "RFL"**
**FUNC "SWR"**
**FUNC "RTL"**

Readout

RFL measurement result incident channel . reflected channel

Note

Reflection factor p, VSWR and return loss $a_{RTL}$ are calculated from incident power $P_{Inc}$ and reflected power $P_{Ref}$ as follows:

$$p = \sqrt{P_{Ref}/P_{Inc}}$$

$$VSWR = \frac{1 + \sqrt{P_{Ref}/P_{Inc}}}{1 - \sqrt{P_{Ref}/P_{Inc}}}$$

$$a_{RTL}[dB] = 10 * lg\,(P_{Inc}/P_{Ref})$$

In the case of different coupling attenuations for incident and reflected power and for the setting of the display to p=1 in the case of total reflection (open circuit or short circuit) a positive or negative attenuation value can be entered (cf. 3.3.11).

In IEC bus mode, the channel in which the reflection measurement is carried out is always taken as incident channel.

For reflection measurements in which a peak power sensor together with a second sensor for average-value measurement (eg NRV-Z1, NRZ-Z51) is used, please note the following:

a) With unmodulated signals, operation is the same as described above.

b) With modulated signals, peak power sensors always measure the peak envelope power, other sensors measure the average power in AVG mode.

This is why with squarewave modulation, the duty cycle associated with the modulation in PULSE mode must first be entered in the channel in which the sensor for average power measurements is connected. Then the reflection can be measured in the REFL mode. As long as no other mode than REFL is selected, reflection is calculated taking the entered duty cycle into account.

In the case of (sinewave) amplitude modulation, reflection measurements using different power sensors are not possible.

Reflection measurements with different sensors causes the following hint to be displayed:

NOTE DIFF. SENSORS

IEC bus command:

a) Reflection measurement in the channel (eg A) in which the peak power sensor is connected:

```
INP:SEL "A"
SENS:FUNC "POW:PULS <Wert>","RFL"
```

b) Reflection measurement in the channel (eg B) in which the sensor for average-value measurements is connected:

```
INP:SEL "B"
SENS:FUNC "POW:PULS <value>"
INP:SEL "A"
FUNC "RFL"
```

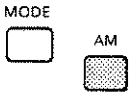
## Amplitude modulation (AM)

Function

The sideband frequencies produced during amplitude modulation cause the transmitter power to be increased. The modulation depth can be derived from the ratio of the power of the unmodulated signal to the power of the modulated signal.

By pressing the menu key AM, the carrier power applied at this point in time is stored as reference value. The transmitter signal must then still be unmodulated, the readout 0 % appears on the display. After switching on the modulation, the modulation depth is read out.

Operation




IEC bus command: **FUNC "AM"**

Note

The measurement is only possible using thermal sensors. Accurate measurements require sinewave modulation and constant carrier average value during modulation. The mdoulation depth is calculated as follows:

$$m[\%] = 100 * \sqrt{2 * (P_{mod}/P_{unmod} - 1)}$$

In order to avoid periodical display variations, the modulation frequency should not fall below 500 Hz.

## 3.3.9 RANGE (Measurement Range Selection)

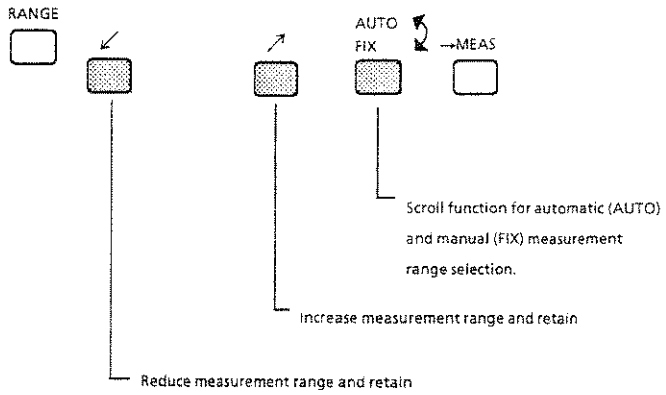
Function

The entire measurement range of the NRVD is divided into several subranges whose number and size depends on the measuring head used.

The instrument can perform measurements with automatic or manual measurement range selection:

With automatic range selection (AUTO RANGE), the appropriate measurement range is automatically set by the instrument depending on the test level. With manual range selection (FIX RANGE), the user can set a fixed measurement range. This permits to prevent that the most sensitive measurement range is automatically set each time the test level is temporarily removed.

Operation




IEC bus command: **AMPL:RANG:AUTO ON**
**AMPL:RANGE:AUTO OFF**
**AMPL:RANGE <Value>**

In the case of voltage probes, the maximum expected RF voltage in V or, in the case of power sensors, the maximum power in W is to be entered as <Value>, irrespective of the operating mode set. The upper range limits depending on the measuring head used can be displayed in manual mode by pressing the keys ↙ ↗

Readout

During menu operation the nominal range value is displayed between the signs and . After setting FIX RANGE in the display: RANGE HOLD

Note

With the measurement range retained, the measurement accuracy is reduced if the test level falls too much below the lower range limit. According to the reduced accuracy, the number of digits used for display of the measurement result is also reduced.

### 3.3.10 READY Output (Option NRVD-B2)

Function

The READY output at the rear is set to logic 1 (+5 V) if a valid measurement result is available for output on the display or via IEC bus. At the same time, the message RDY is read out in the display. In the case of dual-channel measurement, RDY is read out when the results of both channels are provided.

The READY output is set to logic 0 (0 V) and the RDY message in the display is deleted

- when a measurement result has been read out using the IECIN command,
- when a new measurement has been triggered,
- after key operation or
- when a setting has been performed via IEC bus.

### 3.3.11 REF (Reference Value Entrie)

Impedance, attenuation and level can be entered as reference values for calculating the measurement result.

**Impedance reference value**

Function

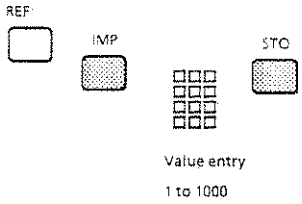
Power P and voltage V applied to a load are linked via its impedance Z:

$$P = \frac{V^2}{Z}$$

To convert voltage into power and vice versa, the impedance Z of the load must be known. With power sensors and insertion units (e.g. URV5-Z2), the impedance Z is the characteristic impedance of the power sensor given in the data sheet. It is automatically read from the data memory of the power sensor and stored as impedance reference value when switching on or connecting the power sensor.

When using probes (e.g. URV5-Z7) the value of the load impedance is to be entered .

Operation




IEC bus command: **INP:IMP <Value>**

Note

With terminating measuring heads and insertion units their impedance is automatically read from the data memory of the power sensor. If this value is changed by a manual input, the warning

OVERWRITE SENS.IMP

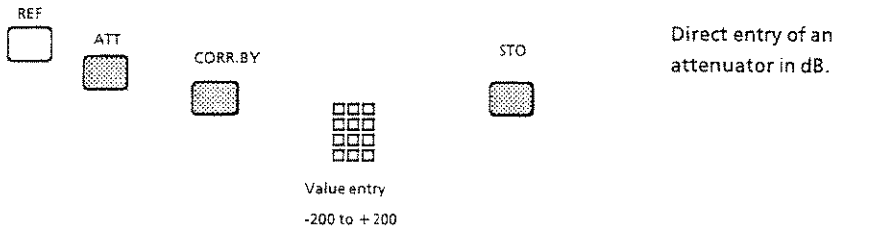
is displayed as an indication that in the case of power sensors the voltage and in the case of voltage sensors the power is no longer calculated from the actual sensor impedance.

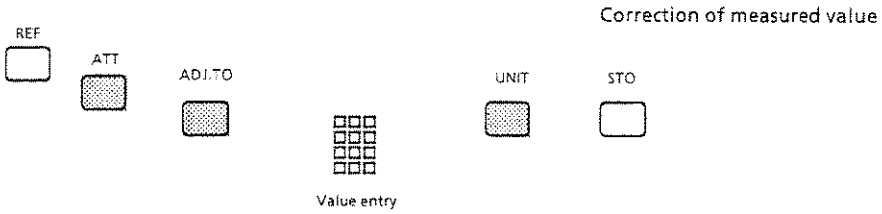
## Attenuation reference value

Function

An attenuation or gain (negative attenuation) between signal source and measuring head is taken into account in the readout of the measurement result

Operation




IEC bus command: **AMPL:ATT** **<Value>** Value: attenuator in dB

Readout

With attenuation correction ON in the display: ATT CORR

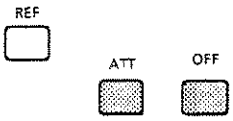
Note

For measured value correction, the user can enter a new measured value for which the NRVD calculates the attenuation (only in measurement mode AVG). The UNIT key permits to enter the new measured value in the units V, W, dBV, dBµV and dBm if the measurement is made in one of these units. If the measurement is made in a relative unit (dB, %, Δ , $P/P_r$), the new measured value can only be entered in this unit. Value entries which do not exceed an attenuation of ±200 dB are permissible.

Function

Switch off attenuation correction

Operation



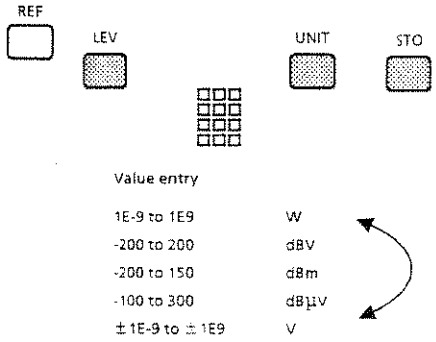

IEC bus command: **AMPL:ATT 0**

**Level reference value**

Function

Storage of a level reference value for relative measurements with the units dB, $P/P_r$, %W, Δ W, $V/V_r$, %V and Δ V.

Operation




IEC bus command: **AMPL:REF <Value><unit>**
<unit>: MV, V, MW, W, DBV, DBM, or DBUV

Note

The reference value can be stored in all available units. For display of relative measurement results, it is automatically converted into the unit which is required for calculating the displayed value.

## 3.3.12 SETUP (Storing and Recalling Instrument Setups)

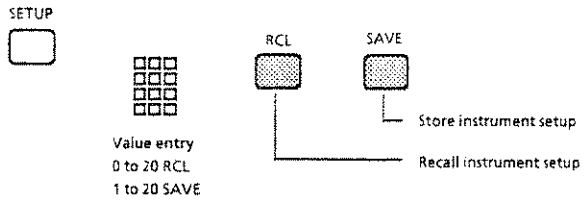
Function

20 different complete instrument setups can be stored in a non-volatile memory at storage locations 1 to 20 and recalled.

Each complete instrument setup comprises the operating mode settings of both channels.

Storage location 0 is reserved for the basic setting (see 3.8.2).

Operation




Note

To prevent unintentional modifications storage is only possible in the enabled status (see 3.3.13). If the setups stored in a memory location can no longer be performed (e.g. after disconnecting the second measuring head or the DC probe instead of the RF probe), the following readout appears:

* SETTING CHANGED *

## 3.3.13 SPEC (Special Functions)

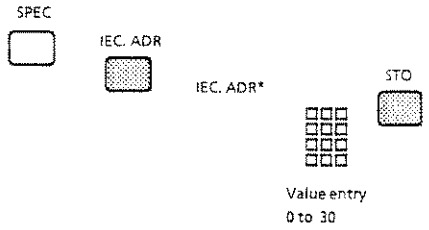
The following instrument setups are possible in the menu of special functions:

Setting the IEC-bus address
Switching on the test generator
Measurement start by external trigger
Switching on/off and calibrating the analog output
Setting the display illumination
Memory protection for complete instrument setups
Settings / information concerning the external frequncy response correction list

### Setting the IEC-bus address

Function — Assignment of IEC-bus address which is stored in a non-volatile memory

Operation




Readout — The IEC-bus address stored is read out during the switch-on sequence (see 2.1.4). It can be checked by pressing the LOCAL key during manual operation.

## Switching on/off the test generator

Function — Switch on or off 50-MHz test generator.

Operation




IEC bus command: **OUTP:ROSZ ON**
**OUTP:ROSZ OFF**

Readout — If the test generator is switched on, the LED above the connector lights up.

Note — The test generator provides an output level of 1 mW with high accuracy for checking the sensitivity of the measuring head.

*CAUTION: The sensitivity of the measuring head is only correctly displayed if the entered correction frequency (see 3.3.4) complies with the frequency of the test generator. When the test generator is switched on, the following note briefly appears:*

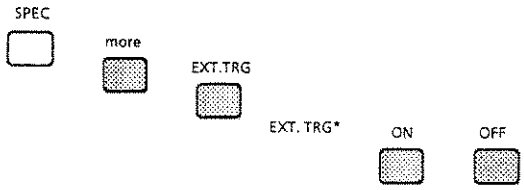
CHECK CORR.FREQ

## Measurementstart by external trigger

Function

With the setting EXTERNAL TRIGGER ON, a measurement is started each time the signal level "LOW" (0 V) is applied at the external trigger input. With the signal level "HIGH" (+5 V), the last measurement result is retained in the display. External triggering is possible both in manual and in IEC-bus operation.
In addition, the key →MEAS can be used to start the measurement: Each time this key is pressed, a single measurement is started, the measurement result being retained in the display until the key is pressed again.

Operation




Readout

After pressing of the menu key ON until the first measurement start, WAIT is read out instead of a measurement result. Then, the retained measurement results are indicated by the message DISP HOLD.

Note

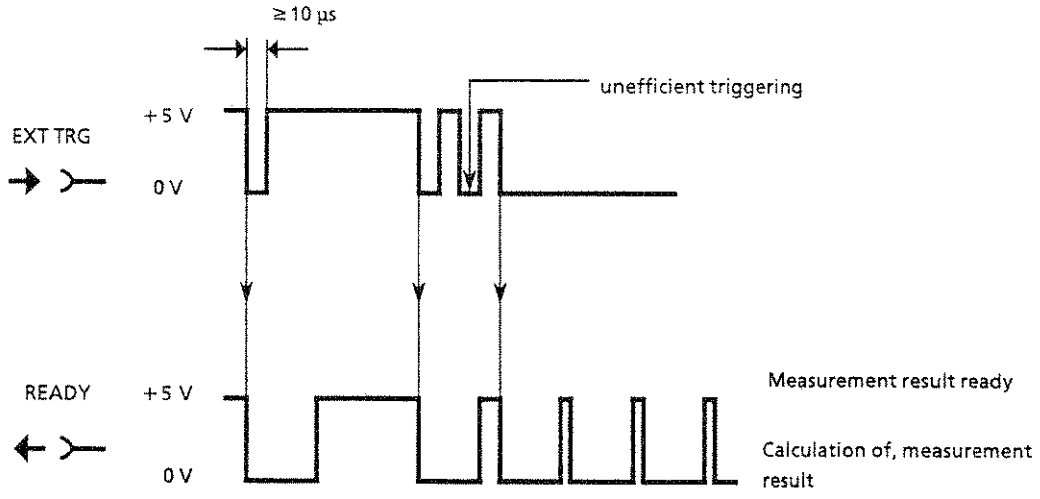



Fig. 3-4 Timing diagram external trigger with IEC-bus control

## Analog Output

Function

The rear analog outputs DC1 and DC2 of the option NRVD-B2 provide for each channel DC voltages ranging from -0.6 to 3.6 V which are proportional to the displayed value. These DC voltages can be used for recording frequency responses on a level recorder or X/Y recorder or for automatic level control of sweep generators equipped with an appropriate ALC input.

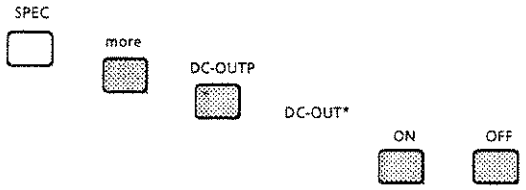
The value of the output voltage at the analog outputs is derived from the range of the analog display (see 3.3.2): The lefthand full-scale value corresponds to a voltage of 0 V, the righthand full-scale value corresponds to +3.0 V. This assignment is always valid, irrespective of the scale of the analog display.

The displayed value is derived from the output voltage as follows:

$$A = L + \frac{V}{3V} * (R - L)$$

A: displayed value
V: Output voltage
L: Lefthand full-scale value
R: Righthand full-scalle value

Operation




IEC bus command: **OUTP[n]:DC ON**
**OUTP[n]:DC OFF**
(n: 1 or 2 according to channel 1 or 2).

Note

After the option has been fitted, the analog outputs must be calibrated before using the option for the first time (Calibration instructions see 2.2.2).
In the setting DC-OUTP ON, the output voltages are available even with the analog display switched off.

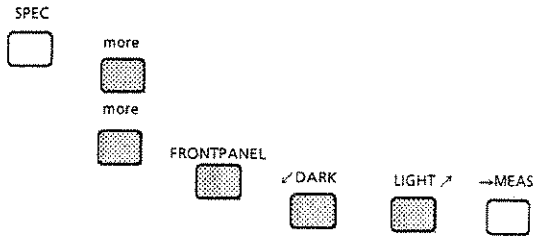
The output impedance of the analog outputs is 1 k Ω. In order to keep the errors of the output voltage small, the load impedances should exceed 1 MΩ.

## Setting the display illumination

Function

Continuously adjustable backlighting of the LCD for adapting to the ambient lighting.

Operation

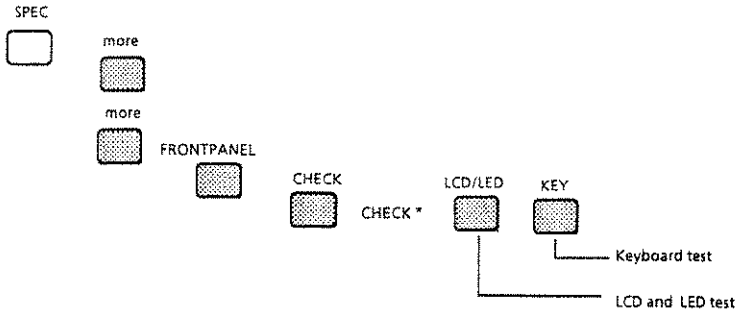



## Testing the front panel

Function

Function test for keyboard, LCD and LED

Operation




Readout

During the keyboard test, the display shows the designation of the pressed key.

During the LCD/LED test, all segments of the display and all LEDs are checked.

Note

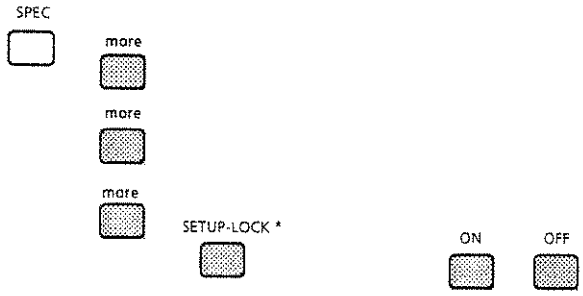
The keyboard test is aborted by pressing the key →MEAS twice.
Pressing any other key than →MEAS twice causes the letters ReP (Repeat) to be displayed in addition to the key lettering. The display of ReP although the key has been pressed only once indicates that the key bounces.

## Memory protection for instrument setups

Function

The memory protection prevents stored instrument setups from being unintentionally changed. Storage is only possible with the memory protection switched off.

Operation




Note

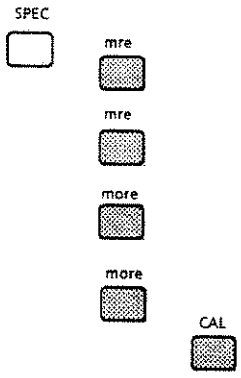
The memory protection always applies to all memory locations from 1 to 20.

## Calibration date

Function

Readout of date the instrument was calibrated last.

Operation

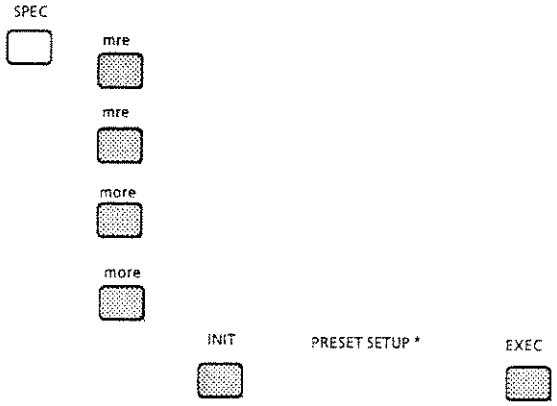


## Initialization

Function

All 20 memory locations for storing instrument setups are assigned the default setting (see 3.3.12 and 3.8.2). The NRVD is set to the default setting. All stored instrument settings are cleared.

Operation

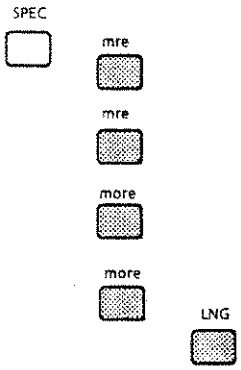



## Switchover of IEC/IEEE bus syntax

Function

Via IEC/IEEE bus, NRVD can be remote-controlled using SCPI commands or the commands of the NRV-family (see also 3.8.9).

Operation



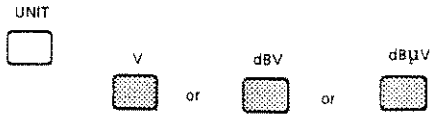
### 3.3.14 UNIT (Display Units)

The UNIT key permits to set the absolute units V, dBV, dBµV and the relative units dB, $P/P_r$, %W, Δ W, $V/V_r$, %V and Δ V.

**Absolute display units**

Function — Level readout in V, dBV or dBµV

Operation




IEC bus command:
**AMPL:UNIT W**
**AMPL:UNIT DBM**
**AMPL:UNIT DBV**
**AMPL:UNIT DBUV**

Readout — The displayed value is assigned the selected unit.

Note — The following applies to the voltage:

$$V[dBV] = 20 * lg(\frac{V}{1V})$$

$$V[dB\mu V] = 20 * lg(\frac{V}{1\mu V})$$

In the case of power sensors, the displayed voltage is derived from the measured power P and the power sensor impedance Z:

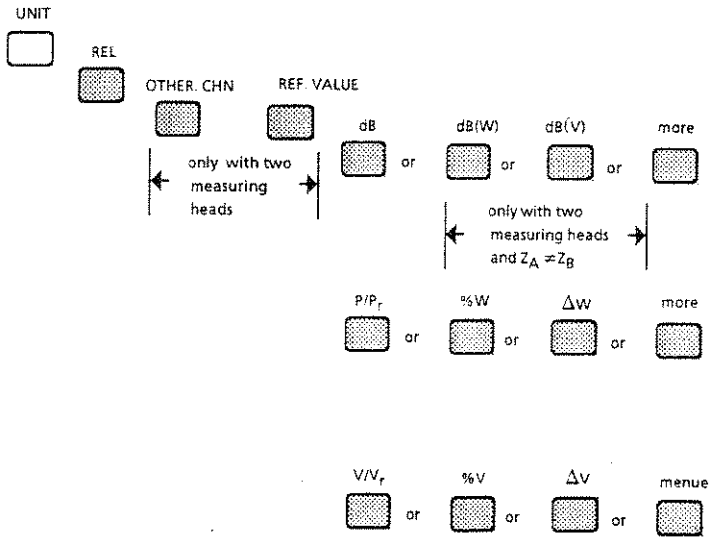
$$V = \sqrt{P * Z}$$

## Relative display units

Function

By selecting a relative display unit, the measurement result can be displayed relative to a reference value. As reference value, the fixed reference value stored in the set channel (menu key REF.VAL) (storage of reference values see 3.3.7 and 3.3.11) or, if two measuring heads are connected, the measured value of the other channel (menu key OTHER.CHN) can be used.

Operation




IEC bus command:

| | |
|---|---|
| **POW:UNIT DB** | dB(W) |
| **VOLT:UNIT DB** | dB(V) |
| **POW:UNIT REL** | $P/P_r$ |
| **POW:UNIT PCT** | %W |
| **POW:UNIT LIN** | ΔW |
| **VOLT:UNIT REL** | $V/V_r$ |
| **VOLT:UNIT PCT** | %V |
| **VOLT:UNIT LIN** | ΔV |

With the given notation of the IEC commands, the fixed reference value stored in the selected channel is used as reference value. If (with two measuring heads connected) the current measured value of the other channel is to be used as reference value, the units DB...LIN are to be preceded by an X.

Readout

With single-channel display: Mode measurement result channel reference channel

e.g. PUL 1.234 %W A.B

Note

The displayed value A is derived from the measured value and the reference value as follows:

$$Difference\ A\ [\Delta] = meas\ value - referenc\ value$$

$$Percentage\ A[\%] = 100 * (\frac{meas\ value}{reference\ value} - 1)$$

$$Ratio\ A = \frac{meas\ value}{reference\ value}$$

$$A[dB] = 10 * lg \frac{meas\ value}{reference\ value}\ (for\ power)$$

$$A[dB] = 20 * lg \frac{meas\ value}{reference\ value}\ (for\ voltages)$$

If the measured value of the other channel is used as reference value (dual-channel measurement), the display values in dB, calculated from voltage or power, are equal only if the same measuring head impedances are stored in both channels. In the case of different impedances, the display units dB(W) and dB(V) appear in the menu, allowing to determine whether the displayed value is to be calculated from power or voltage.

The reference value can be stored or measured in all available units. It is automatically converted into a value with the unit required for calculation of the displayed value.

### 3.3.15 W↔dBm (Direct Setting W and dBm)

Function

Direct setting of the display units W or dBm. Key with scroll function for alternately switching between W and dBm.

Operation




IEC bus command: **AMPL:UNIT W**
**AMPL:UNIT DBM**

Readout

The displayed value is assigned the unit W or dBm.

Note

If a measurement mode (see 3.3.8) is set in which the measurement result cannot be calculated in W or dBm (e.g. reflection RFL or amplitude modulation AM), the warning

CHANGED TO AVG - MODE

appears in the display and the measurement mode AVG is set.

### 3.3.16 ZERO (Zero Correction)

Function

Zero adjustment with the internal offset being measured so that, without test power applied, the power 0 is actually measured.

Operation




IEC bus command: **CORR:ZERO:INIT**

Readout

The following is displayed during zero adjustment: e.g. ZERO * CHN.A *

When the instrument is again ready for measurement, the message ZERO is displayed on the left side of the display.

Note

ZERO is only performed in the selected channel! Zero errors result in measurement errors which are the larger, the smaller the test power is. For exact zero adjustment note the following:

- No test power may be applied at the measuring head.
- After measuring large powers only start zero adjustment when the displayed value has stabilized.
- With varying ambient temperature or if the instrument has not yet fully started up, check the zero adjustment from time to time without test power applied and repeat, if necessary.
- Ground loops may produce external offsets. If they cannot be completely removed by correct grounding, the measuring head remains connected to the signal generator (with the test power cut off) even during zero adjustment. Thus, the external offset is also measured and considered in the calculation of the displayed value.
- The zero adjustment is not stored after switching off the instrument. Therefore, it should be performed each time the instrument is switched on.
- In the case of automatic filter selection, zero correction is carried out using filter setting 9 and takes approx. 4 s. The zero error remaining due to noise can be reduced when one of filters 10 to 12 is set manually before zero correction. Then the time the sensor takes for carrying out zero correction is approx. 25 to 40 s depending on the sensor.
- Zero correction takes into account the measured offset using a special algorithm. It can be switched off by pressing the ZERO key for a larger period of time until the display

  ZERO TURNED OFF

  has stabilized.

  IEC bus command: **CORR:ZERO OFF**
- If the instrument recognizes a measuring power which is substantially larger than the internal offset after the "ZERO" key has been pressed, the display

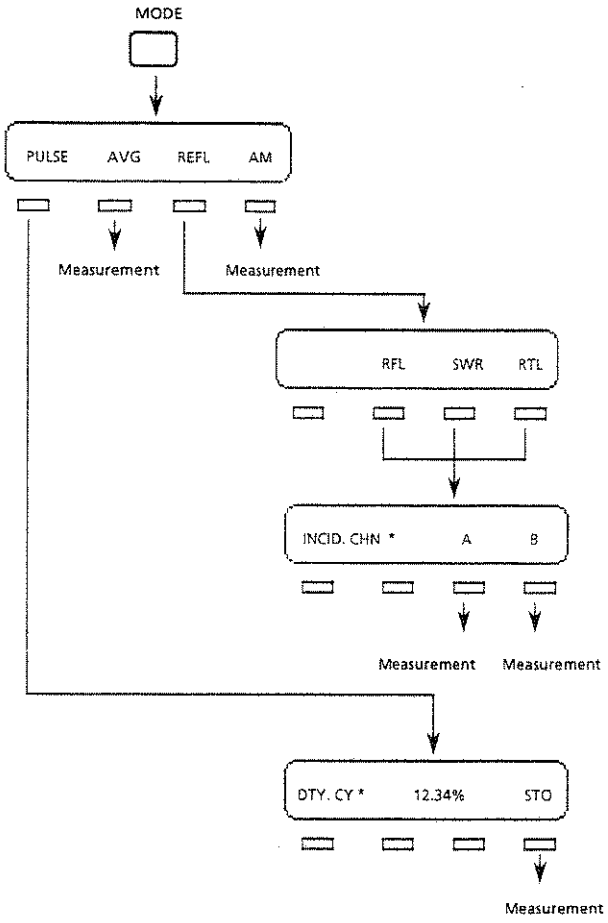
  ERROR ZERO

  blinks for approx. 3 s and zero correction is not carried out.

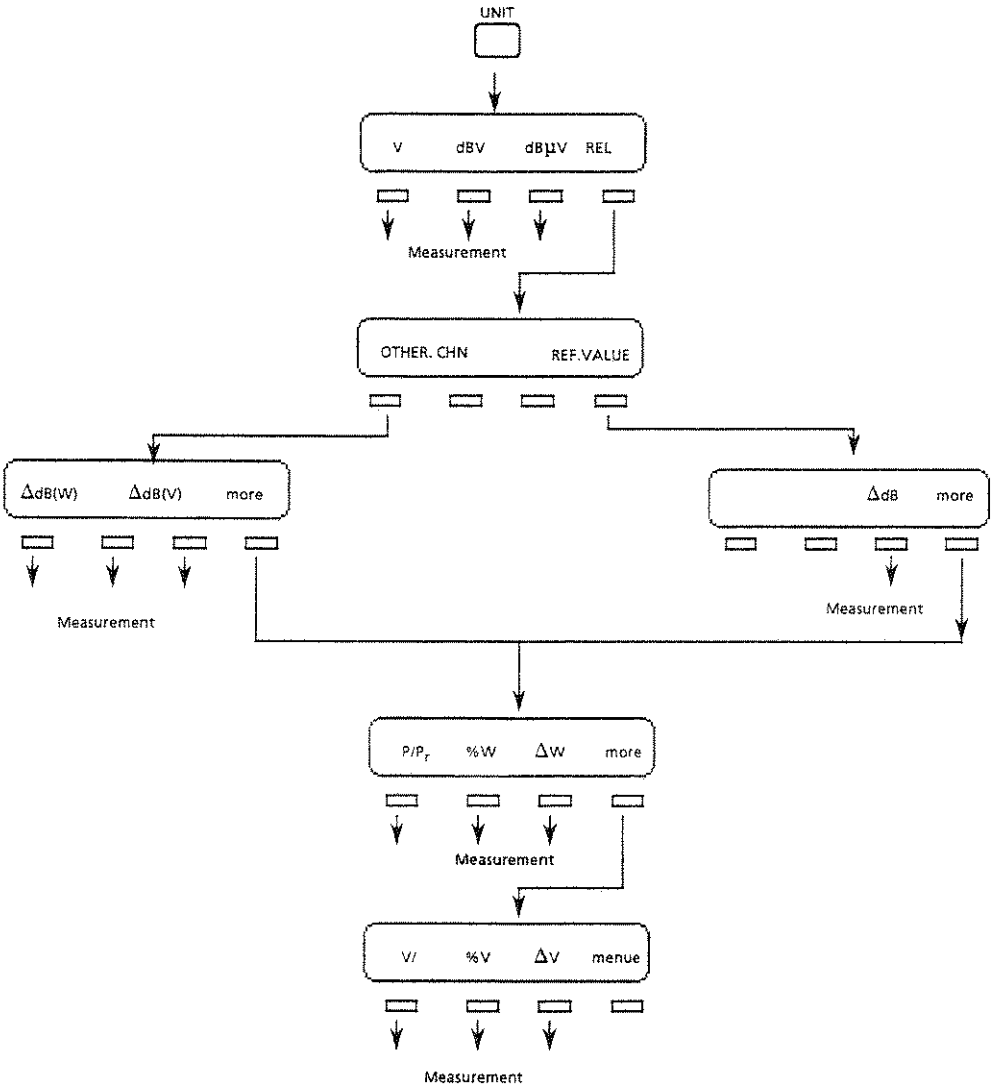
## 3.4 Menu Trees

The following illustrations are to provide an overview of the structure of the individual menus.

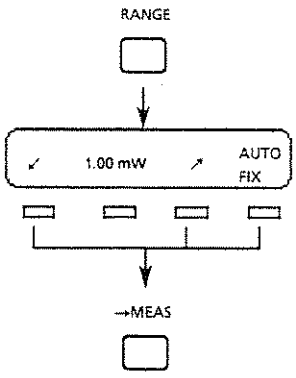
### 3.4.1 MODE Menu



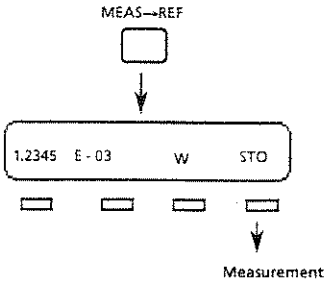
### 3.4.2 UNIT Menu



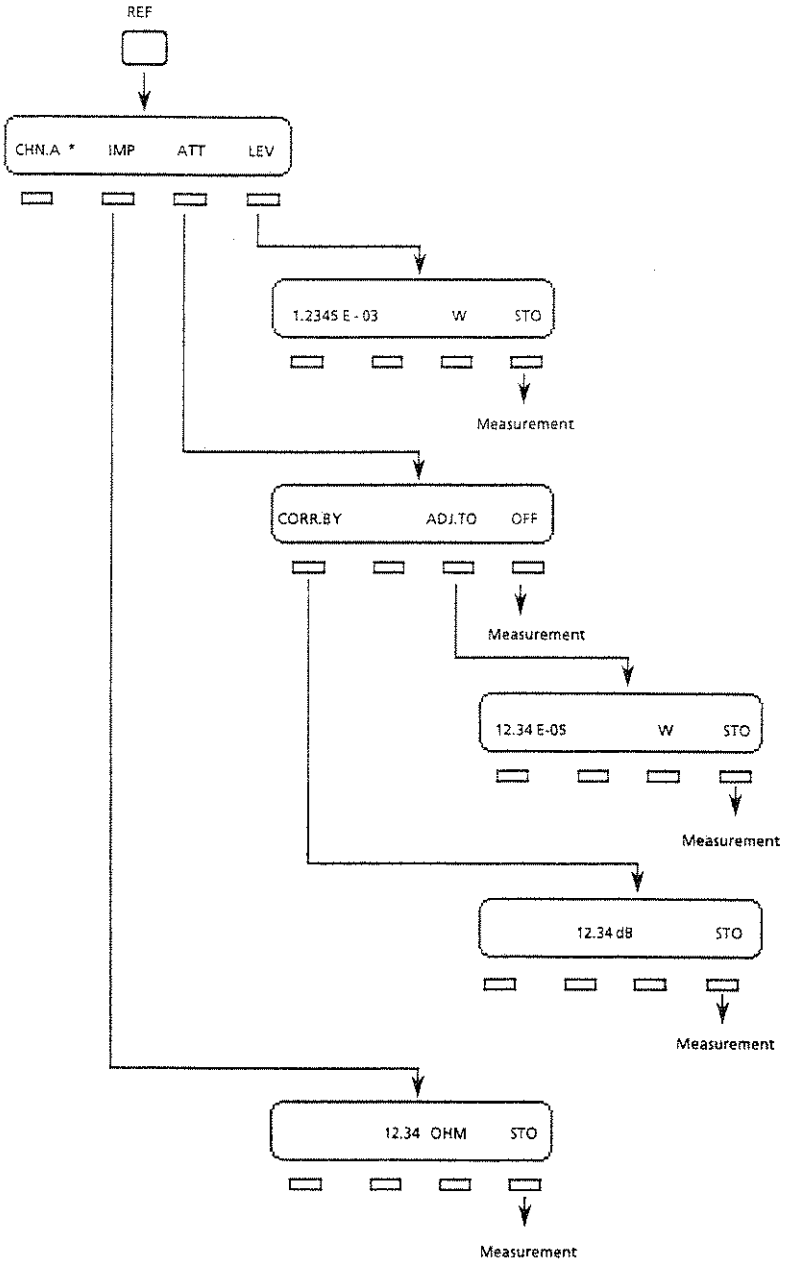

### 3.4.3 RANGE Menu



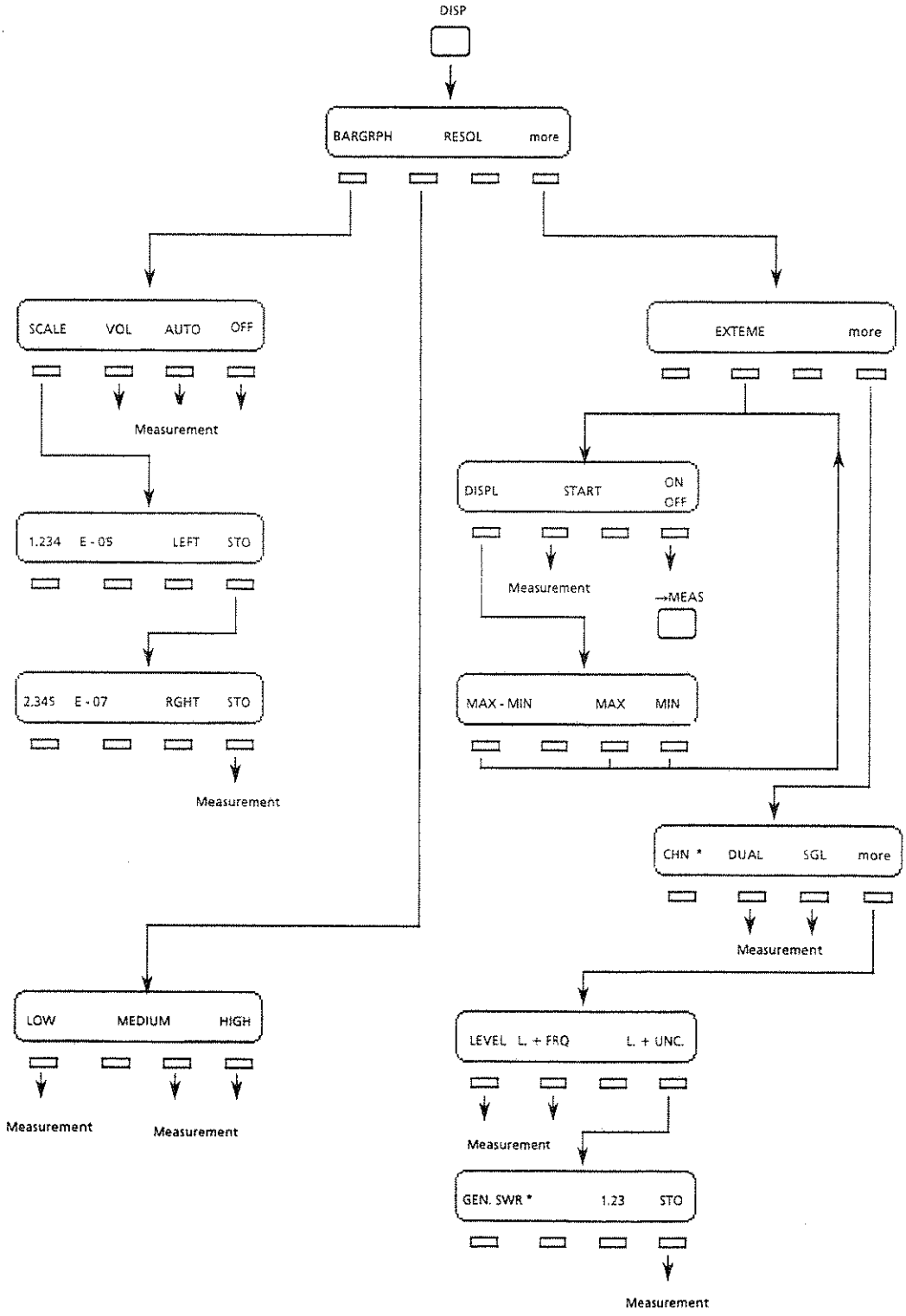
### 3.4.4 MEAS→REF Menu



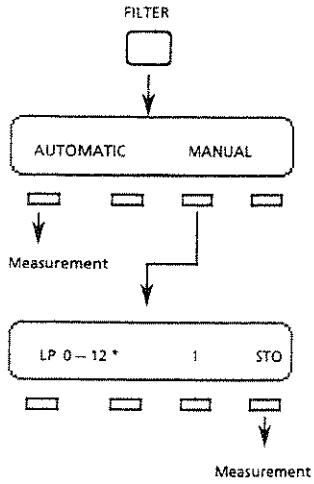

### 3.4.5 REF Menu



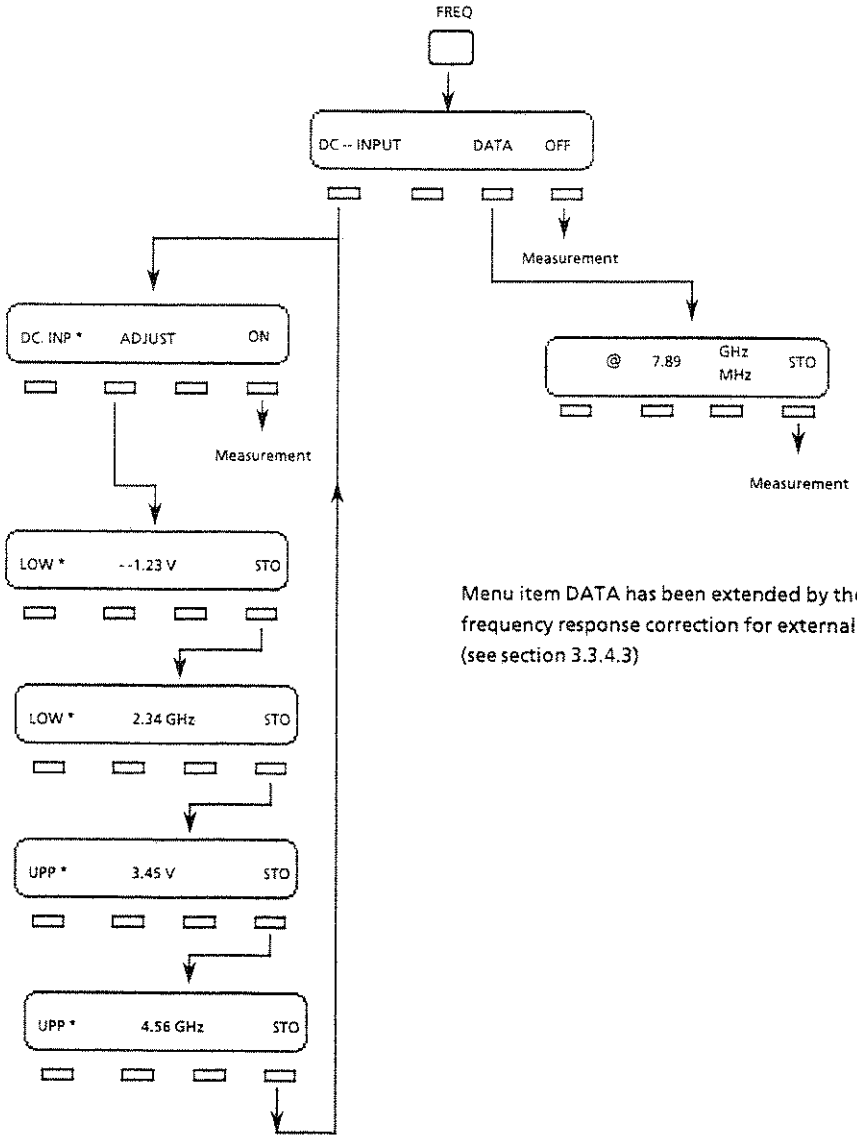
### 3.4.6 DISP - Menu



### 3.4.7 FILTER Menu

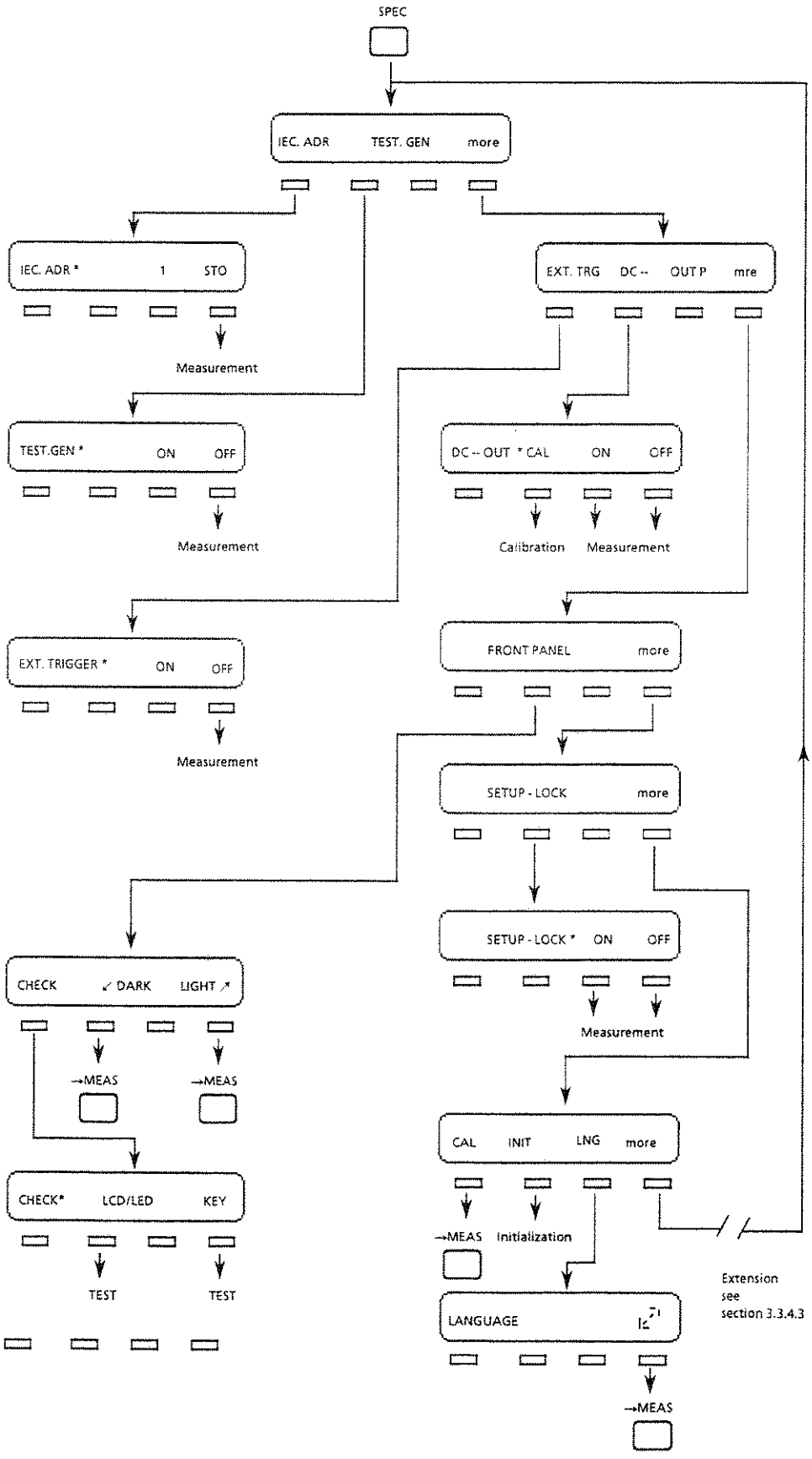



### 3.4.8 FREQ Menu

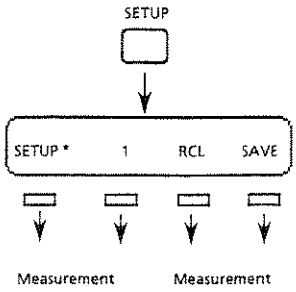



Menu item DATA has been extended by the items for the frequency response correction for external components (see section 3.3.4.3)

### 3.4.9 SPEC Menu



### 3.4.10 SETUP Menu



## 3.5 Readout of the Measurement Result in the Display

If the measurement range is exceeded, this is indicated in the display as follows:

| | |
|---|---|
| Message "RANGE HOLD" blinks: | With the measurement range retained (see 3.3.9 RANGE), the test power exceeds the nominal value of the upper range limit, however, the measured value can still be measured without errors. |
| instead of measurement result "r.OFLO": | Upper range limit exceeded with the measurement range retained (see 3.3.9 RANGE). |
| Display value blinks: | With pulse power measurement using diode sensors, the measuring range for rms weighting is exceeded. |

OVERLOAD

The maximum permissible power of the measuring head is exceeded.

CAUTION: **The measuring head may be damaged!**

Depending on whether the message appears on the left or on the right, channel A or B is overdriven.

## 3.6 Error Messages

### 3.6.1 Operating Errors

A faulty entry during menu operation causes an error message in the display for approx. 3 seconds. Then the menu line in which the operating error has occurred appears again.

| Error Message | Cause |
|---|---|
| WRNG. 1 /Can`t RCL | The memory location called up does not contain a complete instrument setup. |
| WRNG. 2/OUT OF LIM | The value entered lies outside the permissible limits. The permissible range is indicated in the value entry of the respective operating function. |
| WRNG. 3/NO OPTION | The selected operating function can only be performed with the option NRVD-B2 fitted. |
| WRNG. 4/NO SENSOR | No measuring head is connected to the selected channel. |
| WRNG. 5/NEED 2 SENR | Execution of the measuring function requires measuring heads to be connected to both channels. (Measurement reflection, dual-channel display). |
| WRNG. 6/AVG ONLY | The operating function is only possible in the measurement mode "AVG". (Display of measurement uncertainty). |
| WRNG. 8 /Cant'DISP | The measurement result cannot be displayed. (Dual-channel display and display resolution "HIGH"). |
| WRNG. 9 /SETUP LOCK | Storage of complete instrument setups is disabled (see 3.3.13). |
| WRNG. 10 /DC SENSOR | A DC probe is connected, however, the selected operating function can only be performed using an RF probe. |
| WRNG. 11 /NO THERM.SNR | The measurement is only possible using a thermal sensor (e.g. NRV-Z51/Z52) (amplitude modulation). |
| WRNG. 12/NOT AVAIL. | The operating function is not available (e.g. display of the measurement uncertainty is not possible for all measuring heads). |
| WRNG. 13/NOT ALLOW' D | Operating function is not permissible (e.g. function ADJ.TO with mode PULSE, REFL or AM). |
| WRNG. 14/PEP SENSOR | PULSE mode not permissible with peak power sensors |
| WRNG. 20/CAL OUT O.T. | Analog output cannot be calibrated (e.g. connecting cable missing). |

| Error Message | Cause |
|---|---|
| n. OFLO | Numerical range exceeded |
| r. OFLO | Measurement range exceeded |
| P, ≤ $P_r$ | Incident power smaller than reflected power (only in reflection mode) |
| $P_m$ ≤ P | Modulated power smaller than reference power (only in AM mode) |

### 3.6.2 Device Errors

The following device errors are detected in the self-test and indicated in the display:

| Error Message | Cause, remedy |
|---|---|
| DEVICE-ERROR * 1 | Check sum error EPROM |
| DEVICE-ERROR * 2 | RAM data missing |
| DEVICE-ERROR * 4 | Battery faulty (display BATT LOW) |
| DEVICE-ERROR * 8 | Calibration data missing |
| DEVICE-ERROR * 10 | Time exceeded for transmission to analog board |
| DEVICE-ERROR * 20 | Time exceeded for reception from analog board |
| DEVICE-ERROR * 40 | Error in data transmission between analog and computer board |
| DEVICE-ERROR * 80 | Parity error in data transmission between analog and computer board |
| DEVICE-ERROR * 100 | Hardware error analog board or sensor |
| DEVICE-ERROR * 400 | Operating voltage for sensor faulty |

Note

Several errors may occur at the same time. The error message then contains the sum of the individual errors in hexadecimal notation.
(e.g. battery faulty, RAM data and calibration data missing: 4 + 2 + 8 = 14 ≡ E → DEVICE ERROR * 000E)

Notes on error elimination see section 4.

## 3.7 Measurement Accuracy

Inevitably, measurement errors of different causes are possible with every measurement. The actual value of the error occurring with an arbitrary measurement is almost never known. The only thing one can do is give information on the possible maximal values of the single values and calculate limits from these between which the total error can be.

### 3.7.1 Mismatching

The high-frequency power sensors for the NRVD are used to measure the power which a source is to provide to a load with the impedance $Z_0$. In general, both the impedance of the source and the impedance of the power sensor constituting the load deviate from the value $Z_0$. The power error resulting from this mutual mismatch can be calculated as follows:

$$E_P = \frac{1 - |\Gamma_l|^2}{|1 - \Gamma_g \Gamma_l|^2} - 1$$

$\Gamma_g$: complex reflection coefficient of the source
$\Gamma_l$: complex reflection coefficient of the load

The numerator in equation 1 - $|\Gamma_l|^2$ includes an error component solely caused by the load. It can be measured during calibration of the power sensors for the NRVD and is taken into account in the calibration factor (see 3.7.2).

A second error component is produced by the denominator $|1-\Gamma_g \Gamma_l|^2$. Since $\Gamma_l$ and $\Gamma_g$ are complex alternating current quantities, the error may be positive or negative depending on their phasing. In general, the reflection coefficient rg of the source is not known according to magnitude and phase, which is why the magnitude of this error cannot be specified in the data sheet and cannot be calculated in practice either.
However, the error limits can be determined from the maximum values of the magnitudes of the reflection coefficients. The mismatch uncertainty $M_u$ produced between source and load can be calculated in percent of power:

$$M_u[\%] = 100 * [(1 \pm r_g r_l)^2 - 1]$$

Approximately:

$$M_u[\%] \approx \pm 200 * r_g * r_l$$

$r_g$: Magnitude reflection coefficient of soure.
$r_l$: Magnitude reflection coefficient of Load.

### 3.7.2 Calibration Factor

Since the reflection coefficient of a power sensor is unavoidably greater than zero (or its VSWR >1), part of the power offered to the measuring head is reflected. A further part is absorbed by power losses between RF connector and power sensor. All RF power sensors for the NRVD are individually measured at a great number of calibration frequencies during production. The measured power is compared with that provided by the calibration system, and the ratio between both values is stored as the calibration factor. If a measurement is performed using the NRVD with frequency response correction switched on, the measurement result is set off against the calibration factor associated with the entered test frequency before.

*All measuring systems used by R&S for calibration of power sensors are based on the appropriate primary standards of the "Physikalisch-Technische Bundesanstalt PTB".*

Nevertheless, the determination of the calibration factor also includes measurement uncertainties resulting from mismatch, power transmission errors and the measurement uncertainty of the primary standards. Depending on the frequency and the measuring head used, the error limits of the calibration factor are specified as RSS errors in the data sheet (see 3.7.7).

### 3.7.3 Linearity Error

An ideal power meter is supposed to feature a strictly proportional relationship between the applied test power and the displayed test power over the complete measurement range. In reality, however, power meters feature a linearity error which depends on the output range and, in the case of power sensors with semiconductor diodes, also on the frequency.

The power sensors manufactured by R&S feature a very small linearity error, since the power characteristic of each power sensor is individually measured during production and stored in the non-volatile data memory. These data are used to correct the power displayed by the NRVD using a special algorithm so as to produce an almost perfect linearity. The residual error is indicated in the specifications of the power sensors.

### 3.7.4 Display Noise

The noise superimposed on the output signal generated by the power sensor causes small variations of the displayed value resulting in a measurement error. Since the generation of noise is statistical, it is useful to describe the noise quantity using the methods of probability analysis.

R&S specifies the double value of the standard deviation for the noise power. This means that in the case of 95% of a statistically sufficient number of measurements this value of the noise power is not exceeded.

The display noise is an additive value, i.e. the error caused by noise is the smaller, the greater the measuring power.

The value of the display noise can be affected by the filter setting (see 3.3.3): Each additional doubling during average-value generation reduces the display noise power by approx. 30%.

### 3.7.5 Zero Error

A zero error is produced if a power other than zero is displayed without test power applied. In most cases, this offset is caused by temperature variations to which the power sensor is subjected. During zero adjustment (see 3.3.16), the offset is measured and subtracted from the measured value in the following measurement.

The zero error is also an additive value whose error influence is the smaller the greater the test power. When measuring small powers, it is therefore advisable to minimize temperature variations which might be produced by body heat transferred to the power sensor or heated RF connectors of signal generators and repeat the zero adjustment from time to time.

### 3.7.6 Temperature Influence

The temperature influence is an additional error which is produced at a constant temperature deviating from 23 °C.

In the basic instrument NRVD, an additional error may arise outside the temperature range 18 to 28 °C, whose maximum value is indicated in the Specifications.

All power sensors feature a temperature coefficient which may achieve up to 0.5 %/degree. In the case of R&S power sensors, the temperature influence is corrected using a special algorithm: The temperature coefficient is stored in the non-volatile data memory of the power sensor, and each power sensor contains a temperature sensor, which the NRVD uses to carry out cyclical temperature measurements. This permits the temperature influence to be corrected except for a small residual error indicated in the Specifications.

### 3.7.7 Maximum and RSS Error

A correct error specification must include the two statements:

> Error limits and size of the confidence interval, i.e. how many measurement results of a large number of measurements do not exceed the error limits.

With the maximum error, the confidence interval corresponds to 100%: The error limits are never exceeded. The maximum error $E_{max}$ is the sum of the individual maximum errors $(E_{max})_i$:

$$E_{max} = \sum_{i=1}^{N} (E_{max})_i$$

In practice, the maximum error is only rarely achieved. If the complete error is the sum of a number of individual errors which have independent causes (and this is the case with the individual errors described so far), it is very rare, statistically, that all individual errors simultaneously occur in a measurement with their maximum value and the same sign.

In the field of power measurements, it is therefore common practice to specify the RSS error (root sum of the squares).
This is the square root of the sum of the individual RSS errors squared $(E_{RSS})i$:

$$E_{RSS} = \sqrt{\sum_{i=1}^{N} (E_{RSS})_i^2}$$

The RSS error of a sum of individual errors is the error which, in general, is not exceeded by 95% of all measurement results.

## 3.8 Remote Control

The instrument is fitted with an IEC-bus interface as standard. The interface corresponds to the IEC625-1/IEEE488-1 standard. The common commands and data transfer formats are defined according to the IEC625-2/IEEE488-2 standard. The device-specific commands have been implemented as far as possible according to the recommendation of the SCPI consortium (Standard Commands for Programmable Instruments). The same applies to error handling and general status evaluation. SCPI commands are independent of manufacturer and instrument so that a simple and universal control language is provided. Deviations from this are marked as such. According to SCPI, only the short or long form of a command can be transmitted as the syntactically correct input sequence to an instrument. The short form is marked by upper-case letters (e.g. DISPlay).

Both the standards IEC625-1/IEEE488-1 and the extensions IEC625-2/IEEE488-2 define general commands. In the following, the commands according to IEC625-1 will be referred to as universal commands, the commands according to IEC625-2 as common commands.

### 3.8.1 Preparation for IEC-bus Operation

#### 3.8.1.1 IEC-bus Interface

Interface characteristics:

The IEC-bus interface permits the NRVD to be remote-controlled by an external controller.

- Data bus 8-bit parallel.
- Bidirectional data transfer
- 3-wire handshake
- Data transfer rate max. 350 kB/s
- Up to 15 devices can be connected
- Total length of the connection cables up to 15 m (individual connection up to 2 m)

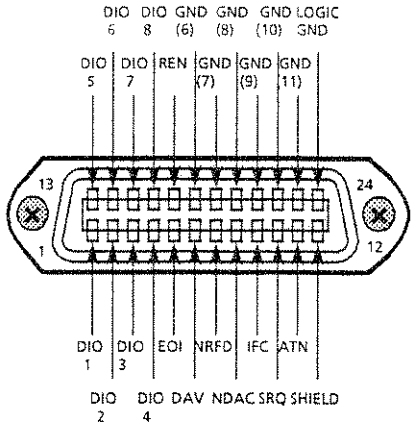



Fig. 3-5 Pin assignment and signal designations of IEC-bus connector

Further information on electrical characteristics and the meaning/function of the individual lines can be obtained from the IEC625-1/IEEE488-1 standard.

#### 3.8.1.2 IEC-bus Connector

The IEC-bus connection between controller and instrument should be made using a shielded cable (R&S stock number 0292.2013.15 / 1 m) in order to avoid EMI during operation.

### 3.8.1.3 IEC-bus Interface Function

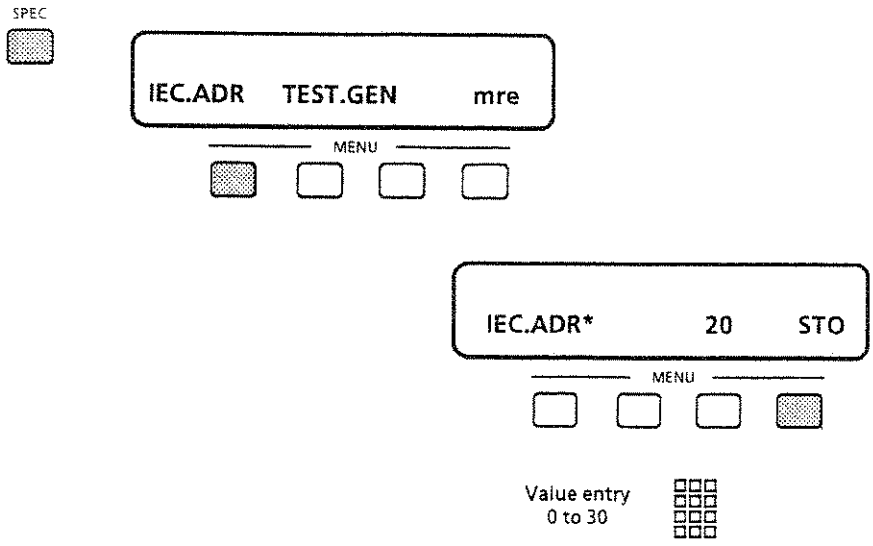
In line with the IEC625-1/IEEE488-1 standard, the devices can be equipped with various interface functions. Table 3-1 lists the functions provided for the NRVD.

Table 3-1 Interface functions

| Control characters | Interface function |
|---|---|
| SH1 | Source handshake function, full capability |
| AH1 | Acceptor handshake function, full capability |
| L4 | Listener function, full capability, unaddress if ML |
| T6 | Talker function, full capability, capability to reply to serial poll, unaddress if MLA |
| SR1 | Service request function, full capability |
| PP1 | Parallel poll function, full capability |
| RL1 | Remote/local switchover function, full capability |
| DC1 | Device clear function, full capability |
| DT1 | Device trigger function, full capability |

### 3.8.1.4 Setting the IEC-bus Address

The IEC-bus address of the NRVD is factory-set to 20 (listener/talker address are identical). It can be set manually or via IEC-bus to values from 0 to 30.




The IEC-bus address remains stored in a non-volatile memory in the instrument.

The key [→MEAS] permits to quit the menu without changing the stored and valid address.

The associated remote control command reads:

| | |
|---|---|
| **SYSTem: COMMunicate:GPIB:ADDRess <N>** | < N> 0 ... 30 |

Note that the instrument can then only be addressed under its new address.

### 3.8.1.5 Operation in Local Mode

If the REN line (see Fig. 3-5) is deactivated, the NRVD remains in local mode even after transmission of its listener address. Operation of the NRVD on the IEC bus is still possible with restrictions. Settings can be made, measured values generated and read into the computer. Avoid simultaneous operation via the interface and the keyboard!

**CAUTION:** Complete operation of the NRVD via IEC bus is only possible in the remote state.

### 3.8.1.6 Local Remote ⟷ Switchover

After switching on, the instrument is always set to local mode. When the NRVD is addressed as a listener by the controller, it enters the remote state in line with the standard (e.g. R&S BASIC IECLAD or IECOUT). This is indicated in the display by the message REM. All keys on the front panel except the LOCAL key are disabled; operation via the front panel is no longer possible.

**Return to 'local' state:**

1. Pressing the [LOCAL] key

   (The local key may have been disabled by the controller using the universal command LLO (R&S BASIC IECLLO). This is indicated in the display by the message LLO. Switchover from remote to local mode using the [LOCAL] key is no longer possible then.

2. Transmission of the addressed universal command 'GTL' (R&S BASIC IECGTL; no restrictions).

   Instrument setups are not changed when switching from local to remote or vice versa.

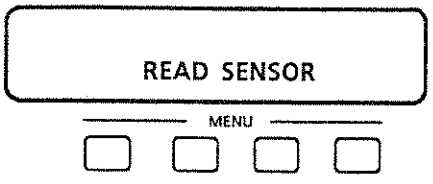
### 3.8.1.7 Replacing a Power Sensor during IEC-bus Operation (Remote)

The power sensors should only be connected to the basic instrument in local state, since the data of the power sensor will subsequently be evalutated; then the instrument is ready for measurement.
If a sensor is inserted in the remote state, there is NO automatic initialization of the measuring head data. The controller can only detect this via SRQ, if enabled. The user may then achieve initialization by switching the instrument to LOCAL (LOCAL key or 'GTL' command) or by transmitting the command

| **INPut: SENSors: INITiate** |
|---|

to the NRVD. (see also note Table 3-5)

The display shows the following reading:




When a sensor is disconnected, a running measurement is only interrupted if this sensor was used for collection of measured values (sensor was in the current main channel, or dual-channel measurement/reflection measurement). The controller is again informed via SRQ.

### 3.8.2 Basic Setting

The basic setting of the instrument can be obtained via the SETUP menu using RCL 0 during manual operation or via remote control by transmitting the common command '*RST'.

Basic setting of the NRVD:

- Channel — A (B, sensor only in this channel)
- Mode — AVG (DC with DC-sensor)
- Unit — W (V with DC sensor, voltage sensors)
- Range — auto
- Zero — off
- Filter — automatic
- ATT.Corr — off
- REF.Att — 0 dB
- FRQ.Corr — off
- REF.Freq — 50 MHz (depending on sensor)
- Bargraph — off / (automatic)
- Lefthand full-scale value — 0.1E-3
- Righthand full-scale value — 1.0
- REF.Level — 1.0 V
- REF.impedance — 50 Ω (depending on sensor)
- Extreme-value collection — off (-> MEAS key for start of extreme-value collection disabled)
- Display resolution — medium (4 digits)
- Display — single-channel
- Duty cyle for measurement mode pulse — 100 %
- Generator SWR for calculating the measurement uncertainty — 1.0
- Test generator — off

Option :

- DC-Output — off
- Ext.trigger — disabled

IEC-bus-operation:

- Display control after trigger — on

  Unchanged (with command ***RST**):

  IEC-bus address set
  SETUP LOCK
  Scale (ADJUST) for DC (FREQ) input (option)

- Status register/masking — see 3.8.6.2

  no evaluation of measuring head data

**A complete initialization sequence which also resets the internal status management reads as follows:**

```
*RST; *CLS;* ESE  0; *SRE  0; STAT:PRESET
```

**Note that the universal commands 'DCL' and 'SDC' (device clear/selected device clear) do NOT lead to a basic setting of the instrument.**

### 3.8.3 Universal Commands (to IEC625-1/IEEE488-1)

The universal commands can be divided into addressed and unaddressed commands. (Commands/addresses are transmitted with ATN = true); the appropriate values are indicated in brackets).

## Universal commands in line with IEEE488-1

Table 3-2a

| Group of unaddressed universal commands | | |
|---|---|---|
| **Command** | **R&S-Basic** | **Function** |
| Local Lockout (11H) | IECLLO | LOCAL key is disabled |
| Serial Poll Enable/Disable (18H/19H) | IECSPE<br>IECSPD | Serial poll capability, see below R&S command IECSPL |
| Parallel Poll Unconfigure (15H) | IECPPU | Parallel poll capability, disabled for all devices |
| Device Clear (14 H) | IECDCL | Aborts internal command execution and sets the IEC-bus software to a defined initial status.<br>NO basic setting |

Table 3-2b

| Adressierungsbefehle | | |
|---|---|---|
| **command** | **R&S-Basic** | **Function** |
| Listener address (20H-3FH) | IECLAD | The following data are determined for the addressed device. LOCAL → REMOTE switchover. With all addressed commands, the listener address must be transmitted. |
| Talker addresse (40H-5FH) | IECTAD | The addressed device is to provide data for the controller. The controller must have requested the data before (trigger/query command). |

Table 3-2c

| Group of unaddressed universal commands | | |
|---|---|---|
| **command** | **R&S-Basic** | **Function** |
| Group Execute Trigger (08H) | IECGET | Measurement start. In the case of the NRVD, the string can be read in by the controller after execution. Further synchronization is not necessary.<br>**After an error has occurred (DEVICE ERROR / IEC Error), it must first be cleared by sending a command (for example *CLS or SYST:ERR?).**<br>Common command '*TRG' functions in the same way. |
| Go to Local (01H) | IECGTL | Remote → Local switchover |
| Parallel Poll Configure (05H) | IECPPC<br><br>IECPCON | Parallel poll capability<br>The R&S BASIC command IECPCON adr, p, d includes the command sequence for preparing the device for a parallel poll.<br><br>(IECPPL, see below)<br>adr: device address<br>p: 0/1 as message via<br>d: 1 to 8 data line DIO1 to DIO8 |
| Selected Device Clear (04H) | IECSDC | Aborts internal command execution and sets the IEC-bus software to a defined initial status<br>NO basic setting |

R&S BASIC provides 2 commands which permit easy handling of serial and parallel poll.

| Command | R&S-BASIC | Function |
|---|---|---|
| Serial Poll | IECSPL | Serial poll capability<br><br>The R&S BASIC command IECSPL adr, s% includes the command sequence IECSPE/IECTAD/data-read/IECSPD for a complete serial poll.<br>adr: device address<br>s%: integer variable |
| Parallel Poll | IECPPL | Parallel poll (IECPPLp%)<br>p%: integer-variable |

**Note:** *The parallel poll capability described here must not be confused with the common commands for the parallel poll ('*PRE' and 'IST?', see below). The command '*PRE' is necessary to enable a poll of the 'IST' state; evaluation via PPOLL requires the instrument to be additionally configured with PPC (PC0N).*
*Polling via PPOLL is faster than evaluation of the common command '*IST?', however, it must be performed carefully since a register of the IEC-bus controller is directly polled so that undefined intermediate states may be produced originating from run times of the instrument firmware.*

### 3.8.4 Common Commands (According to IEC625-2/IEEE488-2)

The IEC625-2/IEEE488-2 standard defines a number of commands which are to be understood by each device operating according to this standard. These commands referred to as common commands always begin with '*' and consist of at least 3 letters (e.g. '*TRG'). Abbreviations are not possible.
After a query (e.g. '*IDN?'), the controller can read in the response string.

## Common commands in line with IEEE488-2

Table 3-3a

| Command | Meaning |
|---|---|
| *RST | Basic instrument setting (see 3.8.2) |
| *CLS | Reset of registers ESR, STB, SCPI Event Clear output buffer and error queue<br>(see 3.8.6, not DCL IEEE488-1) |
| *PSC d | Power On Status Clear<br>d>0: Reset/preset all status registers (on power-up)<br>d=0: Register contents are retained<br>(*PSC 0; an SRQ may be generated on power-up). |
| *PSC? | ower On Status Clear Query<br>**0 \| 1** (in output buffer) |
| *SAV dd<br>*RCL dd | Instrument setup<br>save dd = 1 to 20<br>recall dd = 0 to 20<br>*RCL 0 = *RST (basic instrument setting) |
| *TRG | Starts a measurement (#GET IEEE488-1)<br>(measurement result can be read by controller) |
| *OPC<br><br>*OPC?<br><br><br>*WAI | Synchronization during measurement (see example)<br>OPC = 1 in ESR, if measurement is complete<br>like *OPC, additionally MAV = 1 in STB and<br>1 (in output buffer)<br><br>Wait until measurement is completed, write measurement result in output buffer, continue syntax analysis |
| *IDN? | Identification query<br>**ROHDE & SCHWARZ, NRVD, 0, V1.1**<br>or<br>**ROHDE & SCHWARZ, NRVD, 101967/002, V1.3 V1.20** |
| *OPT? | Query option status<br>**0** (option not fitted)<br>**1,"NRVD option included"** |
| *TST? | Query self-test<br>**0** (switch-on test without error)<br>**1** (error on power-up) |
| *CAL? | Query calibration data<br>**0** (Cal data okay)<br>**1** (Cal data faulty or instrument in Cal mode) |

Example: (*OPC)

```
*SRE 32;*ESE 1;*TRG;*OPC
```

After terminating the measurement, bit 1 (OPC) is set in the ESR register. This results in service request (SRQ) (*SRE 32;*ESE 1).

Important: The string of the measured value has to be read first (cf. example 3.8.7, note 2), 3) of SRQ routine as well).

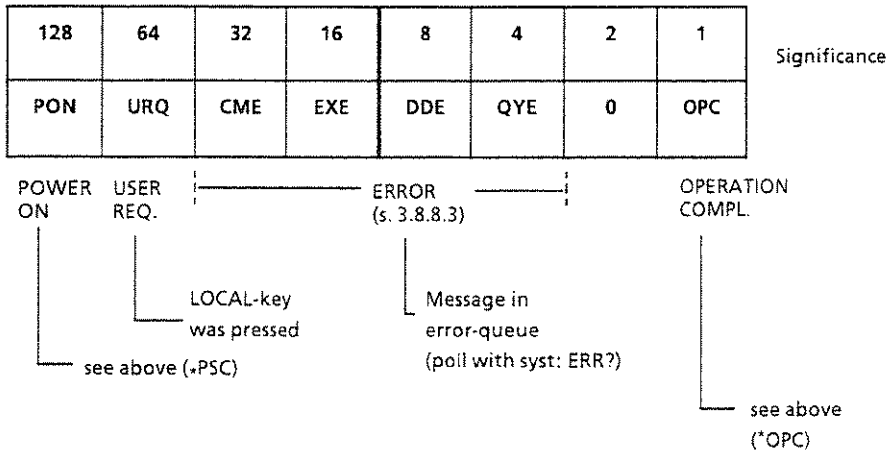
Notes: Synchronization commands ***opc, *opc?, *wai** do not interrupt data transmission via the IEC/IEEE bus, but only the internal command processing.

Hint: Commands ***opc, *opc?**, should be used only after triggering a measurement (*trg etc) since they only fefer to measurements.

## Common commands for evaluation of the Event Status Register ESR

Table 3-3b

**Evaluation of Event Status Register (ESR)**

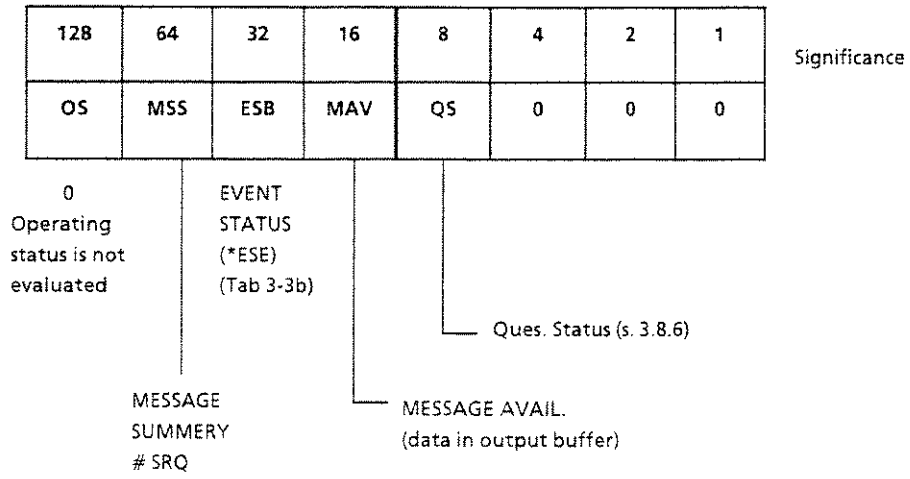



| Command | Meaning |
|---|---|
| *ESE ddd | Sets the Event Status Enable Mask<br>ddd = 0 to 255 |
| *ESE? | Query the ESE mask<br>**ddd** (in output buffer) |
| *ESR? | Query/reading of event status register<br>**<NR1>** (in output buffer)<br>(the ESR register is cleared with reading; also a pending SRQ) |

## Common commands for Serial/Parallel Poll in line with IEEE4888-2

Table 3-3c

**Evaluation of the Status Byte (STE)**




| Command | Meaning |
|---|---|
| *SRE ddd | Setting the Service Request Enable mask<br>ddd = 0 to 255 (MSS need not be set)<br>(Enable mask is used for SRQ generation; STB bits are always set) |
| *SRE? | Query for SRE mask (without MSS)<br>**ddd** (in output buffer) |
| *STB? | Query/reading of status byte register<br><NR1> (in output buffer)<br>(By reading the STB register using the command *STB? a pending SRQ is NOT cleared)<br>see serial poll, IEEE488-1, section 3.8.3 |
| *PRE ddd | Setting the Parallel Poll Enable mask<br>ddd = 0 to 255<br>(The enable mask PRE determines which bits of STB cause the 'Ist' state to be generated and can be read using *IST?) |
| *PRE? | Query for PRE mask<br>**ddd** (in output buffer) |
| *IST? | Query/reading of status/message 'Ist'<br>0 \| 1 (in output buffer)<br>(an evaluation via the universal commands for PPOLL must be additionally programmed; see section 3.8.3) |

***Note:*** *For management and evaluation of the device-internal status see also section 3.8.6. For evaluation Serial/Parallel Poll see section 3.8.7.*

Since the commands for macro definition '*DMC' etc. have not been implemented in this instrument, the measurement result string can be read in by the controller in line with the standard using the command '*TRG' after completion of the measurement. An additional command is not necessary although, strictly speaking, the '*TRG' command is not a query command. The synchronization '*TRG' → data transfer is performed automatically. When data is requested by the controller (IECTAD), the handshake is stopped until the end of the measurement. It is therefore necessary with this method to set a timeout on the controller which corresponds to at least the duration of measurement!

After a measured value has been triggered ('*TRG'), the following measured value or result string can be read in by the controller.

| | |
|---|---|
| **9.9E + 37** | OFLO - Measured value (in valid) |

If the mode TEST1 ('DIAG:TEST1 ON') is switched on, the following strings can be read in depending on the error cause. The structure corresponds to that of the error string.

| | |
|---|---|
| **9.9 + E 37, " NRVD no sensor"** | Instrument is in the remote state, no sensor is connected<br>(IEC error 4) |
| **9.9E + 37," NRVD Device-Error XXXX"** | Instrument signals a hardware error<br>XXXX = error code (see 3-21)<br>(IEC error 240) |

Error evaluation using the command

| |
|---|
| **SYSTem:ERRor?** |

is additionally possible. (see 3.8.8)

## 3.8.5 Device-specific Commands (version 1.50 or higher)

### 3.8.5.1 Rules for Using Device-specific Commands

- ; several commands in one command line are separated by semicolon ';'
- NL Terminator of a command line is New Line (NL)
  EOI and/or EOI
  (white space characters (0 to 9, 11 to 32 decimal) ahead of the terminator are ignored)
- 255 characters constitute the max. length of a command string

- [] Programming is optional, need not be sent

  e.g. **CALC:EXTR[:STAT]?** → **CALC:EXTR?**

- | ("Or") measn selection, only one element can be transmitted

  e.g. **DISP:ENABLE ON** or **DISP:ENABLE OFF**

- The output terminator (measured values, data after ?-commands) is
  **NL + EOI**
  and cannot be changed.

Note:

If the string transfer was aborted or interrupted by the controller, the partial string which was transfered up to this point remains in the input buffer. In some cases this can lead to a syntax error when the next transfer takes place. (Can be cleared using IECDCL.)

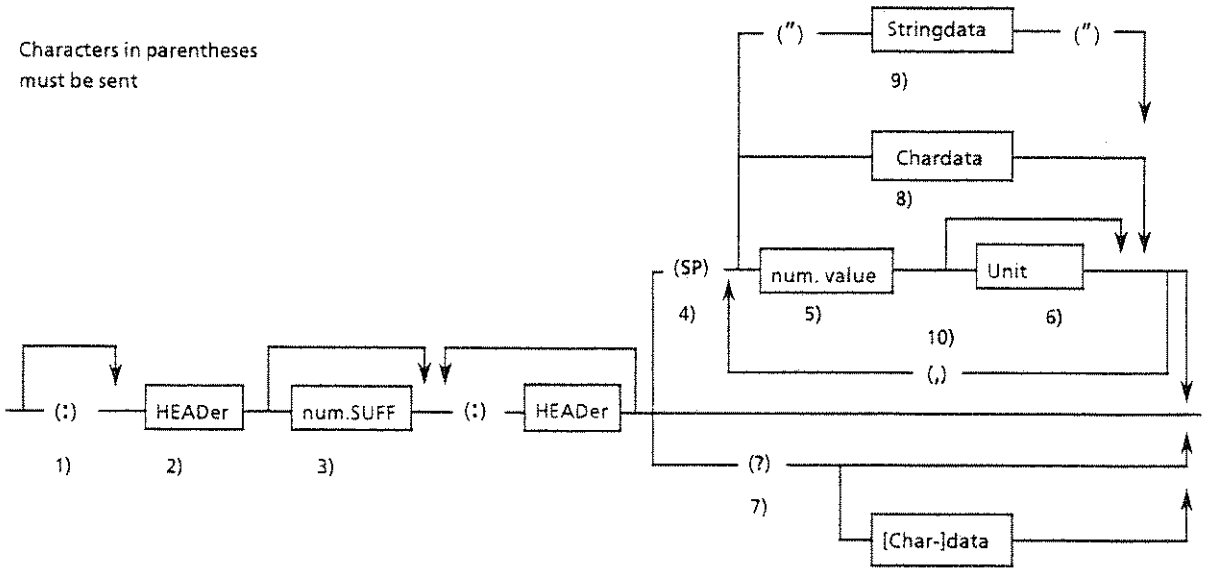



Fig. 3-6 Command structure

The numbers indicated refer to the following notes

1.) In the SCPI parser, the currently valid command level (node) is stored. This means that an abbreviated notation is possible in the case of command sequences with a common root. If continued in this way (same level) the command header must not be preceded by a color, e.g.:

**DISP:ANN:BARG:STAT ON; SCAL:LOW -3;UPP 3**

or

**DISP:ANN:BARG ON;BARG:SCAL:LOW -3;UPP 3**

If this is not the case, a leading colon (:) must be set ahead of the next command header. Thus, the parser again starts syntax analysis at the lowest level.E.g.:

**DISP:ANN:BARG ON; :DISP:ANN:BARG:SCAL:LOW - 3;UPP 3**

or

**CALC:EXTR ON; :DISP:ANN:AMPL:EXTR MIN**

2.) According to SCPI, 2 valid notations of the header/data are possible. Either the complete HEADER or the given short form (marked by upper-case letters, HEAD) is programmed.

e.g.: DISPlay: either **disp** or **DISPLAY** or **Display**

In general, all headers and string/char data can be transmitted both in upper-case and lower-case notation.

3.) **Contrary to the definition according to SCPI, omission of the numerical suffix does not automatically mean that the suffix = 1. The default value is determined by channel selection. (e.g. after INP:NSEL 2/ [channel B], the command INP:IMP 50 is identical with INP2:IMP 50)**

**The numerical suffix can also be transmitted irrespective of the selected channel.**

**A SPACE is not allowed between a header 2) and a numerical suffix 3).**

4.) The command header and the following data must be separated by at least one space.

5.) Numbers:

| | |
|---|---|
| **<number/NR1>** | = integer (without point and exponent e.g.: 10) |
| **<vaule/NRf>** | = decimal number (optionally with sign, point and exponent e.g.: 10., 10e0, 1e+1,10.0000 etc.) |
| **<NR3>** | = decimal number (including sign, point and exponent, e.g. 10.000E + 00) |

6.) Unit /[Unit]:

Optional entry; if not specified, the respective default unit is assumed.

(e.g.: ...: **FREQuency 1E6** # Hz → 1 MHz)

***Note:** With the NRVD, AMPLitude / VOLTage / POWer are terms to be used equally. The default units (unit) form an exception: with AMPL/VOLT: V, with POW = W.*

7.) A query command is marked by a (?). The appropriate response of the instrument is indicated. New Line (NL) with EOI is always sent as terminator.

8.) E.g. **ON** or **OFF**
(instead of ON, **1** can be sent and instead of OFF, **0** can be sent.)

9.) In the case of string data, the inverted commas in the string (") or (') must also be transmitted (e.g. **sens:func"am"**, or **sens:func'am'**).

10.) Separator between several data is the comma (,).

Examples of permissible command sequences:

| Range selection (fixed or automatic) | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| [SENSe[1\|2]] | | |
| :AMPLiitude | | |
| \|:VOLTage | | |
| \|:POWer | | |
| :RANGe | | |
| [:UPPer] | <value/NRf> [unit] \| MIN \| MAX \| DEF | |
| [:UPPer]? | [MIN \| MAX \|DEF] | Y |
| :UNIT? | | |
| :AUTO | ON \|OFF \|ONCE | |
| :AUTO? | | Y |

( Range specifications are valid for sensor: NRV-Z52 (100 mW) )

SENS1:AMPL:RANGE 100 mW
VOLT1:RANG:UPP MAX
sense1:POWER:range:upper 100e-3W
→ have the same effect

↕

only the same when channel A is selected

↕

power:range:upper 0.1 W
Pow:Range .1
sense:volt:range 0.100 W
→ have the same effect

| | |
|---|---|
| sens2:ampl:range:auto once | internally triggers a measurement and sets the measurement range to a range which is appropriate for the applied power. (when channel A is used: no change of channel) |
| inp:nsel 2;:power:rang:auto on | changes to channel B (sensor is present) and switches on the automatic range selection for channel B. |

### 3.8.5.2 Tables and Remarks on Device-specific Commands

The following command tables 3-4 to 3-17 are arranged according to their functions. Whether the commands are in line with SCPI is indicated by 'Y' (yes) or 'N' (no).


| | | Page |
|---|---|---|
| Table 3-4 | Measured-value collection | 3.77 |
| Table 3-5 | Setting of channel and initialization of sensors | 3.80 |
| Table 3-6 | Setting of measured-value filtering (average value) | 3.82 |
| Table 3-7 | Readout on the display | 3.83 |
| Table 3-8 | Setting of analog bar | 3.85 |
| Table 3-9 | Evaluation with extreme-value collection | 3.86 |
| Table 3-10 | Entry of reference value | 3.87 |
| Table 3-11 | Frequency response correction / frequency measurement | 3.89 |
| Table 3-12 | Reading the measured-value memory | 3.93 |
| Table 3-13 | Setting the test generator | 3.93 |
| Table 3-14 | Setting the analog output / external trigger input | 3.94 |
| Table 3-15 | Device-internal status management ('STATus') | 3.95 |
| Table 3-16 | 'SYSTem' commands | 3.97 |
| Table 3-17 | DIAGnostic' commands | 3.98 |


Reference list of IEC-bus commands associated with front-panel keys
(in examples to provide a fast overview, in short notation)

| | | |
|---|---|---|
| CHANNEL: | **INP:SEL "A"** or **INP:SEL "B"** | Tab. 3-5 |
| W↔dBm: | **SENS:POW:UNIT W** or **POW:UNIT DBM** | Tab. 3-4 |
| ZERO: | **CORR:ZERO:INIT** | Tab. 3-4 |
| MODE: | **FUNC "POW:AC"** | Tab. 3-4 |
| UNIT: | **POW:UNIT DBV** | Tab. 3-4 |
| RANGE: | **POW:RANG 100mW;RANG:AUTO OFF** or<br>**POW:RANG:AUTO ON** | Tab. 3-4 |
| MEAS→REF: | **VOLT:REF:MVAL** | Tab. 3-10 |
| REF: | **VOLT:REF 10 DBV** or<br>**POW:ATT 20 DB** or<br>**INP:IMP 50 OHM** | Tab. 3-10 |
| DISP: | **DISP:ENAB OFF**<br>**DISP:ANN:BARG ON**<br>Extreme-value collection | Tab. 3-7<br>Tab. 3-8<br>Tab. 3-9 |
| FILTER: | **CALC:FILT:NSEL 5** | Tab. 3-6 |
| FREQ: | **CORR:FREF 200 MHZ** | Tab. 3-11 |
| →MEAS: | ***TRG** or **GET (to. IEEE488-1)** or **MEAS?** | |
| SETUP: | ***RCL 10** | Tab. 3-3a-c |
| SPEC: | **Test generator, DC-analog output** | Tab. 3-13/14 |

Table 3-4 Commands for measured-value collection

| Setting the measuring function (Mode) | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| [SENSe[1\|2]] | | |
| :FUNCtion | | |
| [:ON] | "<function>" | J |
| :FUNCtion | | |
| [:ON]? | ["POWer:PULSe MIN \| MAX \| DEF"] | J |
| [SENSe] | | |
| :FUNCtion | | |
| :CONCurrent | ON \| OFF | J |
| :FUNCtion | | |
| :CONCurrent? | | J |

Value range "<function>" only DC sensor
"VOLTage [:DC]"
"POWer [:DC]"
not DC sensor
"VOLTage: AC"
"POWer: AC"
"POWer: PULSe <value/NRf> [%|PCT]"
|"POWer :PULSe MIN|MAX|DEF"
"AM"
"SWR"
"RTL"
"RFL"

<value/NRf> $+10^{-2}$ ... + 100

Response string: "<function>" e. g.: **"POW:AC"**

***Note:*** *In the case of "...:Pulse", the duty cycle must be given.*
*The "AM" function is only possible with thermal power sensors.*
*Upon transmission of the "AM" function, the carrier power currently applied is stored as a reference value.*
*With SWR/RTL/RFL the respective test channel = incident channel; two sensors are required.*

Syntax of FUNC:CONC ON:

[SENSe]:FUNCtion[:ON] "<function>[1|2]" [,"<function>[1|2]"] [,"FREQ"]
[SENSe]:FUNCtion[:OFF] "<function>[1|2]" [,"<function>[1|2]"] [,"FREQ" | "FREQ"

**Without** index [1|2], the 1st parameter sets the **current main channel** (!), and the 2nd parameter the adjacent channel.

Response string (e. g.):

[SENSe]:FUNCtion:ON? "POW:AC1","RFL2"
[SENSe]:FUNCtion:OFF? "FREQ"

This allows the user to set a 2-channel measurement as follows:
FUNC "pow:ac", "pow:ac" or FUNC "pow:ac1", "pow:ac2"

Additional frequency output in the IEC/IEEE-bus string (it contains 3 values separated by;):

FUNC "pow:ac", "pow:ac","freq" or
FUNC "pow:ac2","freq" single-chanal measurement in channel 2 (B)

| Setting the display unit | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| [SENSe[1\|2]] | | |
| :AMPLitude | | |
| \|:VOLTage | | |
| \|:POWer | | |
| :UNIT | W \| DBM \| V \| DBV \| DBUV | Y |
| | \| DB \| PCT \| REL \| LIN | N |
| | \|XDB \| XPCT \| XREL \| XLIN | N |
| :UNIT? | | Y |

For definitions see section 3.3.14
(REL = measured value/reference value, LIN = measured value - reference value

X... = Reference value of the measured value of the other channel

Response string: <unit> e.g.: **POW DBM** or **VOLT XDB**

***Note:*** *With :VOLT = :AMPL and :POW, the unit (V or W) of the relative functions used for the calculation is determined.*

*(e.g.: ...:POW:LIN # Measured value (W) - reference value (W)*
*...:VOLT:LIN # Measured value (V) - reference value (V))*

| Switching on/off zero function ( offset correction)<br>Triggering a zero measurement | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| [SENSe]<br>:CORRection<br>:ZERO<br>[:STATe] | ON \| OFF | |
| [:STATe]? | | N |
| :INITiate | | |
| :INITiate? | | N |

A zero measurement is only possible in the selected channel.

Response string: **1 | 0** (with ...:**STAT?**)
**0 | 1** (with ...:**INIT?** 0 = ok; 1 = error)

*Note:* *Synchronization in the run of a BASIC program*
*IECTRERM1:IECTIME10000:' Timeout 10 sec*
*IECOUT20, "CORR:ZERO:INIT?"*
*IECIN20, ERS:IF VAL (ERRS)>0 THEN PRINT "ZERO ERROR"*
*Upon transmission of command ...:INIT[?], the ZERO function is automatically activated.*

| Range selection (fixed or automatic) | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| [SENSe[1\|2]]<br>:AMPLitude<br>\|:VOLTage<br>\|:POWer<br>:RANGe | | |
| [:UPPer] | <value/NRf> [unit] \| MIN \| MAX \| DEF | |
| [:UPPer]? | [MIN \| MAX \| DEF] | Y |
| :UNIT? | | |
| :AUTO | ON \| OFF \| ONCE | |
| :AUTO? | | Y |

The range selection (fixed range) is effected by indicating the expected measured value (not the displayed value) and switching off automatic range selection.
e.g.: **SENS1:POW:RANG :AUTO OFF; UPP 60mW**

Value range <value/NRf>: depending on the sensor
(unit: all basic units:
[U | M] **V**, [P | N | U | M]**W**, **DBM**, **DBV**, **DBUV**)

Response string: **<NR3>** e.g.: **100.000E-03** (with ...:**UPP?**)

(Nominal value of selected measurement range)

**1 | 0** (with ...:**AUTO?**)
**V | W** (with...:**UNIT?**)

*Note:* *using* **AMPL:RANG: AUTO ONCE**
*an internal measurement is triggered and a measurement range appropriate for the applied level/power is set.*
*This measurement range is then retained.*

Table 3-5 Setting of channel and initialization of sensors

| Selection of channel | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| **INPut** | | |
| **:SELect** | **"A" \| "B"** | |
| **:SELect?** | | **N** |
| **:NSELect** | **<number/NR1>** | |
| **:NSELect?** | | **N** |

(as string command or via num. entry)

Value range <number/NR1>: 1 | 2

Response string: **"A" | "B"** or 1 | 2

| Initialization of connected sensors | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| INPut | | |
| :SENSors | | |
| :INITiate | | N |
| INPut[1\|2] | | |
| :SENSors | | |
| :INITiate? | | N |
| :UNIT? | | |
| :SENSors? | | |
| | | |
| INPut[1\|2] | | |
| :SENSors | | |
| :INITiate? | | N |
| :UNIT? | | |
| :INFO? | | |
| :TEMPerature? | [CELSius] | |
| :SENSors? | | |

Response string: with ...:**UNIT?** or with ...:**SENS?**
x;y oder x, if ...

with **UNIT?** (e. g.)
W;0
with ...:**INFO?**

```
1,"1:NRV-Z51 / 50:0857.9004.02:101146/006:R&S Muenchen          :25.02.92;crnl
0,"2:          :          :          :                          :      nl+EOI
                                      └ calibration center      └ Data of calibration
                                 └ Serial number
                            └ R&S stocck no.
                       └ Designation of sensors
                  └ Channal
             └ Status
               0: no sensor
               1: sensor
```

With ...:**TEMP?** (sensor temperature)

| | |
|---|---|
| 0 | → no temperature sensor available |
| 300.0 | in K(elvin) |
| 23.0 | in Celsius, if specified |

Note: *Upon initialization of the connected sensors, an update/preset is performed for some data of the device-internal status.*

- *AVG, W (or V with voltage measuring sensors) or DC, V with DC sensor)*
- *Autorange*
- *Automatic channel assignment A or B if only 1 sensor*
- *Zero correction off*
- *Reset of extreme-value memory*
- *Impedance with power sensors (e.g. 50 ohms)*

Detection of a sensor replacement via SRQ is possible by evaluating the Ques.Status/Volt Bit 4/12 (section 3.8.6)

Table 3-6 Commands for setting the measured value filtering (average value)

| Setting measured-value filtering (automatically according to measured value/resolution) | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| CALCulate[1\|2]<br>:FILTer<br>:AUTO | ON \| OFF \| ONCE | |
| :AUTO? | | N |

Response string: 1 | 0

***Note:*** ... ONCE *internal measurement, current filter setting is set and retained*

| Setting measured-value filtering (fixed) | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| CALCulate[1\|2]<br>:FILTer<br>:NSELect | <number/NR1> \| MIN \| MAX \| DEF | |
| :NSELect? | [MIN \| MAX \| DEF] | N |

Value range <number/NR1>: 0 to 12
0 no / 12 maximum filtering

Response string: 0 ... 12

(with setting ...:**AUTO ON** current filter setting
of Last measured value)
The tables for setting the filters in the automaticc mode or the tables for measurement times as a function of filter setting are specified in the data sheet.

The tables for setting the filters in the automatic mode or the tables for measurement times as a function of filter setting are specified in the data sheet.

Table 3-7 Commands for readout on the display and with IEC/IEEE-bus output

| Switching on/off of numerical readout | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| DISPlay | | |
| [:ENABle] | ON \| OFF | |
| [:ENABle]? | | Y |

Response string: 1 | 0

| Setting the display value resolution | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| DISPlay [1\|2] | | |
| :ANNotation | | |
| :AMPLitude | | |
| \|:VOLTage | | |
| \|:POWer | | |
| :RESolution | "LOW" \| "MEDium" \| "HIGH" | |
| :RESolution? | | N |
| :NRESolution | <zahl/NR1> \| MIN \| MAX \| DEF | |
| :NRESolution? | [MIN \| MAX \| DEF] | N |

(as string command or by num. specification)

Value range <number/NR1>: 3 ... 5

Response string: "LOW" | "MED" | "HIGH" or 3 ... 5

*Note:* *This also defines the resolution of the output value for IEC-bus transfer.*

| Switching beteen single-channel and dual-channel display / measurement | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| **DISPlay** | | |
| **:ANNotation** | | |
| **:AMPLitude** | | |
| **\|:VOLTage** | | |
| **\|:POWer** | **SINGle \| DUAL** | **N** |
| **:AMPLitude?** | | |
| **\|:VOLTage?** | | **N** |
| **\|:POWer?** | | |

Response string: **SING / DUAL**

***Note:*** *DUAL is only possible with 2 sensors, dual-channel display implies dual-channel measurement.*

*In this mode, the maximum measured value resolution* **cannot** *be used. This is possible after switching off the display (DISP OFF)*

*IEC/IEEE-bus command:*
*DISP:ANN:AMPL:RES HIGH; :DISP OFF*

*(see also table 3-17, DIAG:EST5 ON)*

*With ...* **SINGle** *always switches to simple reading of the amplitude value and may thus also switch off a possible display of the frequency or measurement uncertainty.*

| Switching on/off of frequency display<br>Display of measurement uncertainty of measured amplitude value | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| DISPlay [1\|2] | | |
| :ANNotation | | |
| :FREQuency | ON \| OFF | |
| :FREQuency? | | Y |
| :UNCertainty | | |
| [:STATe] | ON \| OFF | |
| [:STATe]? | | N |
| :GSWR | <value/NRf> \|MIN \| MAX \| DEF | |
| :GSWR? | [MIN \| MAX \| DEF] | N |

Value range <value/NRf>: +1 ... +10

Response string: 1 | 0 (with ...:STAT?)
<NR3> (with ...:GSWR?)

For displaying the measurement uncertainty, the SWR of the generator must be specified which is not possible for every sensor.

Table 3 -8 Commands for setting the analog bar

| Switching on/off/scaling of analog bar display | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| DISPlay [1\|2] | | |
| :ANNotation | | |
| :BARGraph | | |
| [:STATe] | ON \| OFF | |
| [:STATe]? | | N |
| :SCALe | [ON] \| OFF | |
| :SCALe? | | N |
| :LOWer | <value/NRf> \|MIN \| MAX \| DEF | |
| :LOWer? | [MIN \| MAX \| DEF] | N |
| :UPPer | <value/NRf> \|MIN \|MAX \| DEF | |
| :UPPer? | [MIN \| MAX \| DEF] | N |
| :AUTO | [ON] \| OFF \| ONCE | |
| :AUTO? | | N |
| :VOLume | [ON] \| OFF | |
| :VOLume? | | N |

Value range <value/NRf>: $+/-10^{+/-12}$

Response string: 1 | 0 (with ...STAT?/SCAL?...)
<NR3> e.g.: 10.000E+00 (with ...:LOW?/UPP?)

*Note:* *See also sequence example for setting with fixed scale in section 3.8.5.1*
...ONCE *internal measurement and retained setting (SCALe) corresponding to measured value*

Table 3-9 Commands for evaluation with extreme-value collection

| Switching on/off of extreme-value collection | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| **CALCulate[1\|2]** | | |
| **:EXTReme** | | |
| **[:STATe]** | **ON \| OFF** | |
| **[:STATe]?** | | **N** |

Response string: **1 | 0**

| Reset extreme-value memory | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| **CALCulate[1\|2]** | | |
| **:EXTReme** | | |
| **:INITiate** | | **N** |

Response string: no query possible

| Reading the extreme-value memory (only query command) | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| **CALCulate[1\|2]** | | |
| **:EXTReme** | | |
| **:DATA?** | **[MINimum \| MAXimum \| MAXMin]** | **N** |

Response string: **<NR3>** e.g.: **1.000E+00**

(independent of display setting since parameters are specified)

| Selection of readout with extreme-value collection | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| **DISPlay[1\|2]** | | |
| **:ANNotation** | | |
| **:AMPLitude** | | |
| **\|:VOLTage** | | |
| **\|:POWer** | | |
| **:EXTReme** | **[ON \| OFF \| MINimum \| MAXimum \| MAXMin]** | |
| **:EXTReme?** | | **N** |

Response string: **0 | MIN | MAX | MAXM**

***Note:*** *With 'OFF' and IEC-bus operation, extreme-value collection is nevertheless possible in the background.*

Table 3- 10 Commands for reference value entry

| Entry of a reference value for relative display<br>Transfer of the last measured value including display unit | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| [SENSe[1\|2]]<br>:AMPLitude<br>\|:VOLTage<br>\|:POWer<br>:REFerence<br>:UNIT?<br>:REFerence?<br>:REFerence<br>:MVALue[2\|1] | <value/NRf> \|MIN \| MAX \| DEF<br><br>[MIN \| MAX \| DEF] | <br><br><br><br><br>Y<br>N |

Value range <value/NRf>: +/-10+/-9 with V (default unit with:VOLT)
+10+/-9 with W (default unit with :POW)
-200 ... +200 with dBV
-100 ... +300 with dBuV
-200 ... +200 with dBm
( unit : mV, V, mW, W, dBV, dBm, dBuV )
DEF: 1 V

Response string: <NR3> e.g.: **20.000E+00** (with... : REF?)
<UNIT> e.g.: **DBM** or **V** (with... : REF:UNIT?)

*Note:* Transfer of the measured value from the other channel with entry of the numerical suffix with **MVAL**;
*e.g.:* **SENS1:AMPL:REF:MVAL2**

*Sequence measured value trigger + transfer of the measured value:*
***TRG;*WAI; :AMPL :REF :MVAL**

Command sequence for triggering and acceptance of the measured value as a reference value

| Entry of attenuation correction | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| [SENSe[1\|2]]<br>:AMPLitude<br>\|:VOLTage<br>\|:POWer<br>:ATTenuation<br>:UNIT?<br>:ATTenuation? | <value/NRf> [DB] \|MIN \| MAX \| DEF<br><br>[MIN \| MAX \| DEF] | <br><br>Y |

Value range <value/NRf>: ± 200 (0 dB = OFF)

Response string: <NR3> e.g.: **20.000E+00**

| Input impedance of connected sensor | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| **INPut[1\|2]**<br>**:IMPedance?**<br>**UNIT?**<br>**:IMPedance?** | **<value/NRf> \|MIN \| MAX \| DEF**<br><br>**[MIN \| MAX \| DEF]** | <br><br>Y |

Value range <value/NRf>: +1 to +1000
(is correctly set during evaluation of power sensor data).

DEF: depends on sensor

Response string: **<NR3>** e.g.: **50.000E+00**

Table 3-11 Commands for frequency response correction

| Setting for frequency response correction | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| [SENSe[1\|2]] | | |
| :CORRection | | |
| :FREFerence | <value/NRf> [unit] \|MIN \| MAX \| DEF | N |
| :STATe | ON \| OFF | |
| :STATe? | | N |
| :FREFerence? | [MIN \| MAX \| DEF] | N |

Value range <value/NRf>: $+10^3$ ... $+10^{12}$ Hz (unit : Hz, kHz, MHz, GHz)

Response string: 1 | 0 (with...:STAT?)
<NR3> e.g.: 10.000E+06 (with ...:FREF?)

*Note:* *By transmitting* **CORR:FREF <value/NRf>**, *numerical frequency response correction is automatically switched on.*
*In the case of entries exeeding the specified limits of the connected sensor, the correction value of the limit parameter is used for calculation.*
*(e. g. NRV-Z5: $f_{max}$ = 6GHz, $f_{NRVD}$ = 20 GHz -> corrected as for 6 GHz)*

| Switching on/off of frequency measurement (via DC FREQ input) Scale of DC-FREQ input | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| [SENSe[1\|2]] | | |
| :FREQuency | | |
| :STATe | ON \| OFF | |
| :STATe? | | N |
| [SENSe] | | |
| :FREQuency | | |
| :ADJust | | |
| :LOWer | <value/NRf> V,<value/NRf> [k\|M\|G]HZ | |
| :LOWer? | | N |
| :UPPer | <value/NRf> V,<value/NRf> [k\|M\|G]HZ | |
| :UPPer? | | N |

Value range <value/NRf> V: +/-12
<value/NRf> Hz: +0 ... +999 $10^9$

Response string: 1 | 0 (with ...:STAT?)
<NR3>,<NR3> e.g.: 10.00,10.00E+06 (with...:LOW?)

*Note:* *Switchover between numerical and analog frequency response correction*
*Command sequence for numerical frequency response correction:*
**SENS:CORR:FREF <value/NRf>**

*Command sequence for analog frequency response correction:*
**SENS:FREQ:STAT ON;:SENS:CORR:FREF:STAT ON**

*MIN | MAX | DEF can be sent, also for a single parameter, however 2 parameters must always be entered.*
*DEF: current setting*
*e.g.* **FREQ: ADJ:LOW DEF, 0GHz** *or* **FREQ: ADJ:UPP? DEF, MAX**

| Setting for zur external frequency response correction | | SCPI 1992.0 |
|---|---|---|
| Header | Dat sectiopn | |
| [SENSe[1\|2]] | | |
| :CORRection | | |
| :FREFerence | | |
| :EDATa | <freq.wert/NRf> [unit], <att.wert/NRf>[dB] [ ,...,.] | N |
| :EDATa | | |
| :USE | ON \| OFF | N |
| :ID | "text-string" | N |
| :REMove:ALL | | |
| :ID? | | |
| :POINTs? | | |
| :FREE? | | |
| :EDATa | <index> | N |

Description of individual commands:

*Loading a list*

| :SENS:CORR:FREF | |
|---|---|
| :EDATa | <freq.wert/NRf> [unit], <att.wert/ NRf>[dB] [ ,...,.] |

Thiss command must be transmitted at least once to the NRVD for each point of the frequency response correction list, the values being transmitted in ascending order of frequencies.

a list of several pairs of values can alkso be transmitted. When the unit (dB) is specified, <freq.wert> and <att.wert> can be interchanged at one frequency response point.

A maximum of 60 frequency response points (pairs of values) is permissible.

Value range:

**freq.value: (0 to + $10^{12}$), $f_{n+1}$ -> $f_n$ + 10 kHz**
**att.value: (±200) current attenuation value**
(A positive att. value increases the display value)

*Note:* For reloading a list, the current list must be deleted with command CORR:FREF:EDAT:REM:ALL.
This command can always be transmitted to the NRVD prior to loading a list.

After loading the list, CORR:FREF:EDAT:USE ON" is automatically executed.

**Possible error message:**

| | |
|---|---|
| **-222, "Data out of range"** | outside the value range |
| **-109, "Missing parameter"** | no pair of values |
| **-131, "Invalid suffix"** | unit error |
| **-224, "Illegal parameter value"** | $f_{n+1} < f_n$ + 10 kHz |
| **-225, "Data out of memory"** | n > 60 |

*Querying a list point*

```
:SENS:CORR:FREF
        :EDATa?          <index>
```

| | | |
|---|---|---|
| **Value range:** | **<index>** | 0 to (points-1), max = 59 |
| **Response string:** | **<NR3>,<NR3>** | (frequency, att. value) |
| **Possible error message:** | **-15, "No list defined"** | no list loaded |
| | **-109, "Missing parameter"** | Index missing |
| | **-223, "Too much data"** | only 1 index permissible |
| | **-224, "Illegal parameter value"** | outside the value range |

*Switching on the correction with the data of the loaded list*

```
:SENS:CORR:FREF
        :EDATa
            :USE          ON | OFF
            :USE?
```

| | | |
|---|---|---|
| **Response string:** | **1 \| 0** | |
| **Possible error message:** | **15, "No list defined"** | no list loaded |

*Entering a text identification for the loaded list*

```
:SENS:CORR:FREF
        :EDATa
            :ID           "text-string"
            :ID?
```

| | | |
|---|---|---|
| **Value range:** | **max. 12 characters** | Limitation automatic<br>only characters that can be displayed are permitted |
| **Response string:** | **text string** | |

***Note:*** A list can grt an ID only if a least 1 list point is defined.

| | | |
|---|---|---|
| **Possible error message:** | **15, "No list defined"** | no list loaded |

*Querying the number of used or free list points*

```
:SENS:CORR:FREF

        :EDATa
            :POINTs?
            :FREE?
```

**Response string** **<NR1>**

*Deleting the complete list*

```
:SENS:CORR:FREF

        :EDATa
            :REMove:ALL
```

Table 3-12 Commands for reading out the measured-value memory

| Reading the last valid measured values (only query command) | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| SENSe[1\|2]<br>:DATA<br>:AMPLitude?<br>\|:VOLTage?<br>\|:POWer? | | Y |
| SENSe<br>:DATA<br>:FREQuency? | | Y |

Response string: <NR3> e.g.: 13.010E+00

***Note:*** *These commands need not necessarily be used with* ***TRG** *or* **GET**
*These commands also permit to read measured values in local mode.*

Table 3-13 Commands for setting the test generator

| Switching on/off of the test | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| OUTPut<br>:ROSZillator<br>[:STATe] | ON \| OFF | |
| [:STATe]? | | Y |

Response string: 1 | 0

Table 3-14 Commands for setting the analog output/external trigger input

| Switching on/off of the DC analog output (option) | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| OUTPut[1\|2]]<br>:DC<br>[:STATe]<br>[:STATe]? | <br><br>ON \| OFF<br> | <br><br><br>N |

Response string: 1 | 0

***Note:*** *Scaling is possible via the analog bar (setting commands see Table 3-8). It need not be switched on for this purpose.*

| Switching on/off of the external trigger input (option) | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| TRIGger<br>:SOURce<br>:SOURce? | <br>EXTernal \| BUS \| IMMediate<br> | <br><br>Y |

Response string : EXT | BUS | IMM

***Note:*** *:TRIG:SOUR EXT*
*only enables the external trigger input *trg can be sent in this mode any time.*

*:TRG:SOUR IMM*
*means free-running measurement. The measurement rate is equal to that LOCAL mode; i. e. intermdiate values are output.*

*The measurement results can be read without additional command via the IEC/IEEE bus.*

*Sending*trg automatically switches off this mode again.*

Table 3-15 Commands for device-internal status management ('STATus')

| Command 'STATus: OPERation' | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| STATus | | |
| :OPERation | | |
| [:EVENt]? | | Y |
| :CONDition? | | Y |
| :ENABle | <value/NRf> | Y |
| :ENABle? | | Y |

The commands 'STATus: OPERation'...have no effect with the NRVD, however they must be implemented according to SCPI.

Value range <value/NRf>: 0 ... 65535

Response string: <NR1> or. 0

| Evaluation of an exceptional case with the NRVD | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| STATus | | |
| :QUEStionable | | |
| [:EVENt]? | | Y |
| :CONDition? | | Y |
| :ENABle | <value/NRf> | Y |
| :ENABle? | | Y |
| :AMPLitude | | |
| \|:VOLTage | | |
| \|:POWer | | |
| [:EVENt]? | | Y |
| :CONDition? | | Y |
| :ENABle | <value/NRf> | Y |
| :ENABle? | | Y |
| :FREQuency | | |
| [:EVENt]? | | Y |
| :CONDition? | | Y |
| :ENABle | <value/NRf> | Y |
| :ENABle? | | Y |

Value range <value/NRf>: 0 ... 65535

Response string: <NR1> e.g.: 5

*Note:* *AMPL/VOLT/POW are equal and affect the same register.*

| Reset all status registers (except EVENT register) | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| STATus<br>:PRESet | | Y |

Response string: No query possible

Note *For evaluation of the different internal status registers see section 3.8.6 and the program example in section 3.8.7.*

Table 3-16 'SYSTem' commands

| Reading the SCPI error queue (only query) | SCPI 1992.0 |
|---|---|
| Header / Data section | |
| SYSTem<br>:ERRor? | Y |

Response string : <error number>,"error text [;cause]"
e.g. **0,"No error"** (see 3.8.8.2)

| Setting/changing the IEC-bus address | SCPI 1992.0 |
|---|---|
| Header / Data section | |
| SYSTem<br>:COMMunicate<br>:GPIB<br>:BUS<br>:ADDRess <number/NR1> | Y |

Value range <number/NR1>: 0 to 30

Response string: no query possible

| Reading the SCPI version relevant to the instrument (only query) | SCPI 1992.0 |
|---|---|
| Header / Data section | |
| SYSTem<br>:VERSion? | Y |

Response string: e.g. **1992.0**

| Switchover to commands for instrument calibration or IEC-bus language | SCPI 1992.0 |
|---|---|
| Header / Data section | |
| SYSTem<br>:LANGuage "TO_CALibrate_the_device"<br>\| "COMPatibility" \| "NRV"<br>\| " SCPI" \| "NRVD" | Y |

Response string: no query possible

| Reading out the hardware error string (only query) | | SCPI 1992.0 |
|---|---|---|
| Header | Data section | |
| DIAGnostic<br>:AHARdware? | [<number/NR1>] | – |

Value range: <number/NR1> : 0 ... 46, 48 ... 51

With an index specified, the measured value associated with the error bit can be read out including its limit values (**e.g.: DIAG:AHAR? 0**). The index 0 is the last bit in the error string (**DIAG:AHAR?**). If bits ('-' code) are not defined, the value 0 is output.

Response string: (without parameter)
if no errors have been detected,

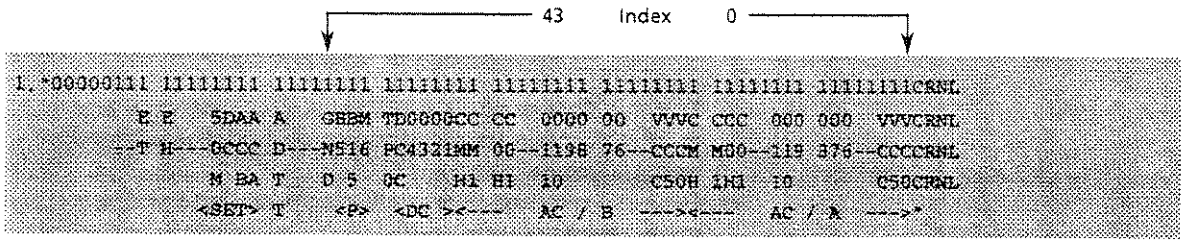
```
0,"No error"
```

in the case of hardware error,

```
1,"00000000 10000000 00000000 00000000 00001000 00000000 00000000 00000011"
```

(meaning of the individual bits see section 7.3.2.2).

An additional identification can be activated using the command DIAG:TEST1 ON and is to be viewed column by column.




Since the error bits are placed ahead, they can be easily evaluated in the controller (only 1st line).
(All lines are filled up with <space> = 20H and terminated by CRNL.)
E.g.:

```
1,"00000000 10000000 00000000 00000000 00001000 00000000 00000000 00000011CRNL
E 0 VVCRNL
M 1 CCCRNL
1 50CRNL
<SET> T <P> <DC ><--- AC / B ---><--- AC / A --->"
```

Response string : ( with parameter , 0 to 46 )

```
<NR3>;<NR3>;<NR3>                    z. B.: 1.00000E+00; 2.00000E+00; 3.00000E+00
```

lower limit value  current measured value  upper limit value

Response string : ( with parameter , 48 ... 51 )

3 hex numbers (internal conversion values)

```
#H<Hex>,#H<Hex>,#H<Hex>              z. B.: #H02;#H8A, #HFC
```

lower  current  upper limit value

The following commands can be used to further examine the analog hardware:

| | |
|---|---|
| **DIAGnostic :AHARdware** | **<NR>** |
| **DIAGnostic :ASET** | **<NR>** |
| **DIAGnostic :ATEST** | **<NR>** |
| **DIAGnostic :ACONverter?** | **<NR>** |

see section 7.3.2.2 / Service Manual

### 3.8.5.3 Triggering a Measurement

When the NRVD is operated in the remote state, a measurement must be triggered intentionally by the controller (after modifying/setting all necessary parameters):

The appropriate commands are as follows:

1. Universal command (Group Execute Trigger) to IEEE488-1 / R&S BASIC e.g. (BUS-Adr 20)

```
IECLAD20:IECGET
```

2. Common command (to IEEE488-2)

```
*TRG
```

3. Query command (no further parameters possible)

```
MEASure?
```

The three commands can be used independently of one another in the same way. The measurement result string can be read by the controller after completion of the measurement (without additional commands), an internal handshake synchronization taking place with the measurement, i.e. upon polling prior to the end of the measurement, the bus handshake is stopped until the end of measurement.
(note the timeout!)

When the external trigger input is enabled (TRIGger: SOURce EXTernal), a measurement can also be started via the external trigger input.

If no measurement is triggered and no measurement result is provided in the output buffer, the exceptional measured value 9.9E+37 is issued by the NRVD. This can be switched off by the command DIAGnostic:TEST2 OFF. Note that the described query (addressed to talk with nothing to say) causes a BUS TIMEOUT or handshake error.

| INIT | FETCh? | ABORt |
|---|---|---|

**INIT** This command starts a measurement and stores the result in the output buffer, **without** generating an **IEC/IEEE-bus-String** that a controller could read.

The following measured values that are triggered with INIT are also stored in the output buffer.

**FETCh?** With this query, all measured values generated by INIT can be read into the controller..

*CAUTION:*
INIT;*WAI;*IDN? generate the following IEC/IEEE-bus-string:

20.01E-03;ROHDE&SCHWARZ;NRVD.....

i. e. the complete output buffer is sent upon a query

**ABORt** Abort of the running measurement

### 3.8.5.3.1 Measurement Rate

The measurement rate of the NRVD, i.e. the response time during remote control via IEC bus, is influenced by a number of settings.

**a) Setting FILTER**

0 : fastest measurement mode
12 : slowest measurement mode (greatest filtering of measured values)

Depends on the test level (power) in the case of automatic filter

**b) Display unit(s)**

Fastest display in the basic unit, since no conversion takes place
with voltage probes: V
with power sensors: W

**c) Additional measurements/displays; corrections** (FREQ. / ATT-Corr.)

Each additional measuring or display task (e.g. analog bar display) requires processing time.

**d) Value display**

To obtain shorter response times via IEC bus, the value display can be switched off.

| DISPlay:ENABle OFF |
|---|

(The analog bar must be switched off separately).

**e) Use of trigger command**

The trigger GET (to IEEE488-1, Group Execute Trigger) requires the shortest internal processing time of the NRVD.

| IECLAD 20 : IECGET |
|---|

It is useful to set the NRVD (or test set) first and then send the trigger command separately, since the trigger command will be immediately executed in this case. If the NRVD is to be set for each measurement, the trigger command ***TRG** may be appended without losing much time.

It should also be mentioned that, apart from the response time of the measuring instrument, the structure of the (BASIC) control program is also relevant to an optimum measurement run. (E.g. if measurement curves are included, calculations or the drawing of the curve may be nested into the measuring time of the next measurement)

A setting sequence taking into account items a) to d) reads as follows:

| *RCL 0 ; CALC:FILT:NSEL 0 ; :DISP:ENAB OFF |
|---|

If necessary, a complete initialization sequence (see 3.8.2) is to be sent first.

## 3.8.6 Status Management in line with IEEE488-2/SCPI

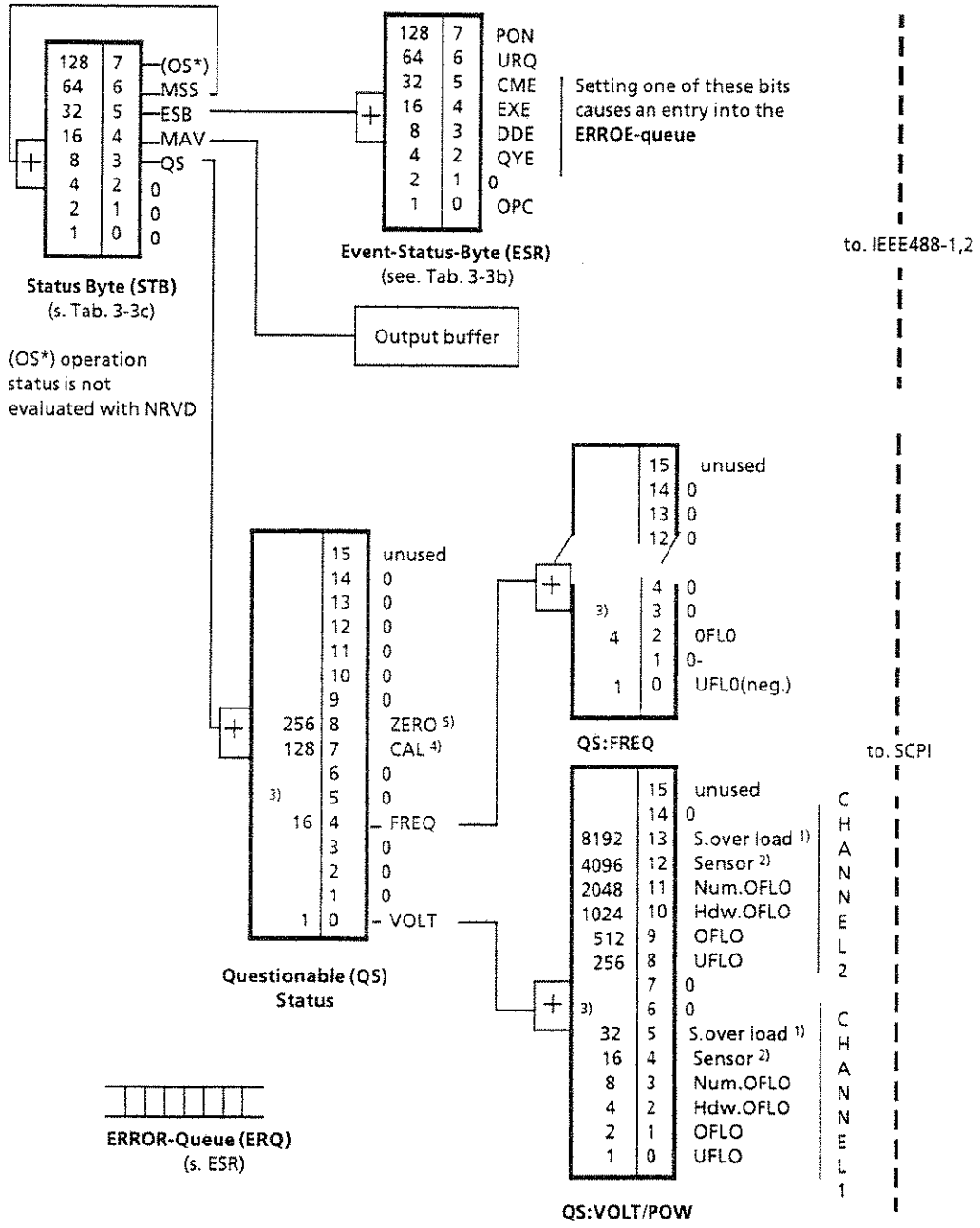



Fig. 3-7 Structure of the status registers in line with IEEE488-1,2/SCPI

*Notes:*

1) *Sensor overload: Sensor is operated at its upper limit. (danger of being damaged)*
2) *Bit set means that a sensor is plugged in, but not initialized. If no sensor is plugged in, bits 0 to 3 or 8 to 11 are set, COND bit 4/12 is reset; EVENT bit 4/12 is set. Thus, the EVENT bit 4/12 permits to detect or evaluate sensor replacement. (Bits 0-5 / 8-13 = 0: device in the channel is ready to measure, only applies to calibrated sensors.)*
3) *The significance of the bits is given to the left of the registers.*
4) *End of calibration measurement*
5) *Zero error*
   *The end of a zero measurement can be recognized via the EVENT bit.*
   *Associated COND bit = 1 → ZERO ERROR*

*[+: logic ORing (sum bit)]*

### 3.8.6.1 Structure and Comparison of the Individual Registers of the NRVD

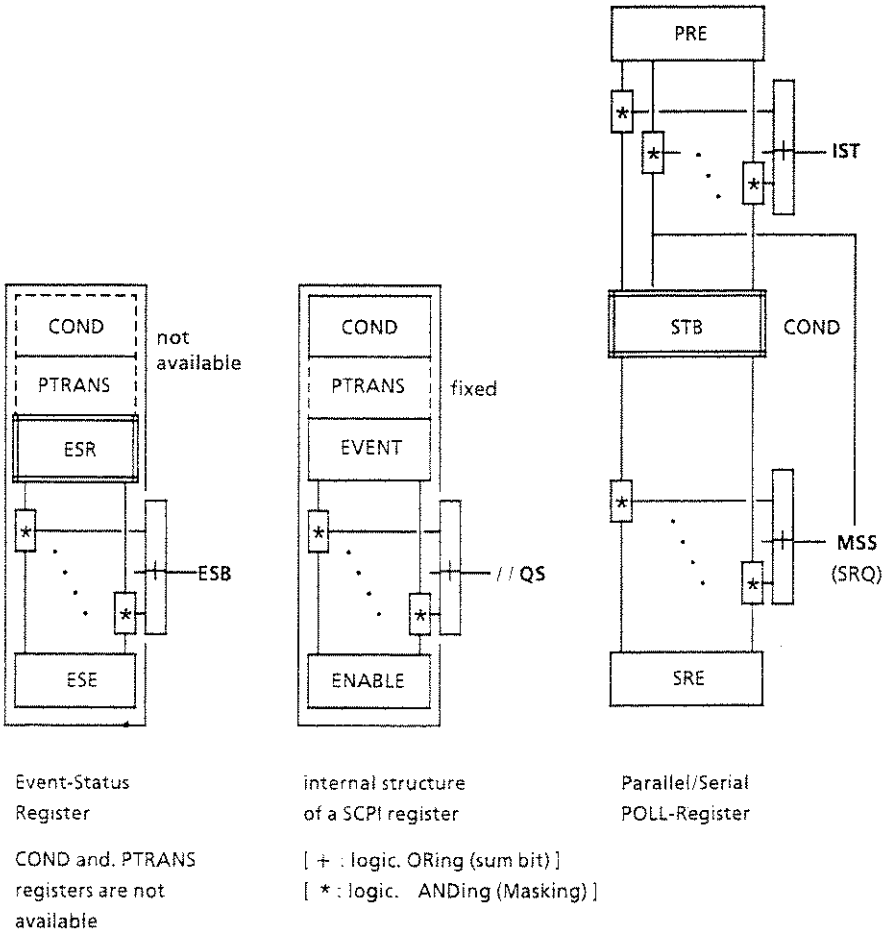



Fig. 3-7 Status registers (comparable registers are at the same level)

An SCPI status register actually consists of 2 status registers (CONDition/EVENT): the 'COND' register contains the current instrument status, whereas, depending on the 'TRANS'ition register, the 'EVENT' register stores this status as an event that has occurred once. In the case of the NRVD, the 'TRANS' register is installed as unchangeable 'PTRANS'ition register, i.e. changing the 'COND' register from 0 to 1 causes the corresponding bit in the 'EVENT' register to be set. This is reset when the 'EVENT' register is read. As illustrated in Fig. 3-7, the status management is hierarchically structured. When enabled via the 'ENABLE' register, the superior registers can be caused to generate an SRQ.
The meaning of the individual bits of the two registers for VOLTage (AMPLitude/POWer) and FREQency can be obtained from Fig. 3-7.
The Event Status Register (ESR) features a similar structure, except that the 'COND'ition and 'TRANS'ition part are not accessible to the user. Since the 'COND' register is described internally, the ESR register should always be additionally read during SRQ evaluation (ESB bit set) so that every new event leads to a new SRQ. To allow a comparison, the equivalents of the status byte STB are given. 'IST' and PRE are to be viewed separately.
The commands associated with the SCPI registers are indicated in Table 3-15. Their usage is to be explained by way of an example. (See also demo program in section 3.8.7).

Example:
Automatic frequency response correction via the DC-FREQ input. An interrupt (SRQ) is to be triggered when an error flag is set by the frequency measurement (UFLO or OFLO).

1. Setting the FREQ-EVENT mask (enable)

```
STAT: QUES: FREQ: ENABLE 7
```

2. Enable questionable FREQ status

```
STAT: QUES: ENABLE 16
```

3. Enable SRQ/status byte

```
*SRE 8
```

or
in one command line

```
STAT: QUES: ENABLE 16; FREQ: ENABLE 7; *SRE 8
```

By setting the bits in the QS:FREQ-'COND' register an SRQ is generated.

By reading the 'EVENT' registers (in the SRQ routine)

```
STAT: QUES: EVENT?; FREQ: EVENT?
```

they are deleted. The following string may be read in as result

**16;1**

16 being the FREQ bit of the questionable status and 1 marking an invalid frequency measurement result.

Reading of the QS:FREQ 'COND' register without SRQ evaluation is also possible.

### 3.8.6.2 Clearing/Resetting the Status Registers

Table 3-18 Influence of Clear/Reset on the status registers

| | SCPI-Register | | IEEE488-2-Register | |
|---|---|---|---|---|
| | ENABLE | EVENT | ESE/SRE | ESR/STB |
| *RST | - | - | - | - |
| *CLS | - | clear | - | clear |
| power-on | reset# | clear# | clear# | clear# |
| STATus:PRESet | reset | - | - | - |

# only if Power On Status Clear Flag is set (*PSC 1, Table 3-3a)

A complete initialization sequence, which resets the internal status management (including a basic instrument setup), therefore reads as follows:

```
*RST;* CLS;*ESE 0; SRE 0; STAT: PRESET
```

## 3.8.7 Serial/Parallel Poll IEC-bus Demo Program (R&S BASIC)

The evaluation of serial/parallel poll is to be illustrated using a reconstructable demo program (R&S BASIC) and its printout. In addition to the comments in the program printout refer to the description of the used commands.

**Demo-program**

```
10 IEC TERM 10: IEC TIME 10000: Nrvd=20
30 ON SRQ1 GOSUB Srq_req
40 '
50 PRINT "INIT"
60 GOSUB Init_sequenz
70 '
80 PRINT "Faulty command sequence"
90 IEC OUT Nrvd,"ERROR STRING;*trg"
100 GOSUB Do_anything_or_wait
110 '
120 PRINT "Trigger measured string 1"
130 IEC OUT Nrvd,"*trg"
140 GOSUB Do_anything_or_wait
150 '
160 PRINT "Trigger measured value 2"
170 IEC OUT Nrvd,"pow:range 1mW;range:auto off;*trg"
180 GOSUB Do_anything_or_wait
190 '
200 PRINT "End"
210 END
220 ' ****************************************************
```

**Printourt**

Comments

```
INIT
Faulty command sequence
                    Request from NRVD
                    -----------------
                    Status Byte =  96
                    Event-Status Register = 48
                              'Command error'
                              'execution error'
                    Error-Queue
                              -113,"Undefined header;ERROR STRING"
                              -211,"Trigger ignored;*TRG"        ---- if an error is detected
                                 0,"No erro"                          in a command line.
                                                                      an included trigger
                                                                      command is not evaluated

Trigger measured value 1
                    Request from NRVD
                    -----------------
                    Status Byte =  80
                    Messwert= 20.000E-03
 Trigger measured value 2
                    Request from NRVD
                    -----------------
                    Status Byte =  88
                    Measured value=    9.9E+37                          <-- Hardware-Overflow
                    Ques. Events = 1;4;0
                              Ques. Status Voltage Channel 1 = 00000100
                              Ques. Status Voltage Channel 2 = 00001111
                    Measured value channel 1 invalid
    End                                                                   <-- no sensor in
                                                                              channel 2
```

```
900 ' ********************************** WAIT-ROUTINE *
910Do_anything_or_wait:
920 Wait=1
930 WHILE Wait=1
940   WEND
950 RETURN
960 ' ************************************************


1000 ' ********************************** INIT-ROUTINE *
1010Init_sequenz:
1020 IEC OUT Nrvd,"*rst;*cls;*ese 0;*sre 0;stat:pres"
1030 '                                                  ------------------------------------
1040 '                                                  Enable ERROR in ESR, SRQ on ESB, MAV, PPOLL
1050 IEC OUT Nrvd,"*ese 60;*sre 48;*pre 64 "              4)
1060 '                                                  ------------------------------------
1070 '                                                  Enable EVENT-Register evaluation
1080 IEC OUT Nrvd,"stat:ques:enable 17;volt:enable 65535"
1090 '                                                  ------------------------------------
1100 '                                                  PPOLL 1 on DIO4 # 8  (zul. DIO1-DIO8)
1110 IEC PCON Nrvd,1,4
1120 '                                                  ------------------------------------
1130 RETURN
1140 ' ************************************************


2000 ' ********************************** SRQ-ROUTINE *
2010Srq_req:
2020 '                                                  ------------------------------------
2030 '                                                  check whether NRVD has sent SCQ
2040 IEC PPL Pp%
2050 IF (Pp% AND 8)=0 THEN GOTO Srq_end                   1)
2060 '                                                  ------------------------------------
2070 PRINT TAB(20);"Request from NRVD"
2080 PRINT TAB(20);"-----------------"
2090 '                                                  ------------------------------------
2100 '                                                  check whether SRQ is valid (MSS set)
2110 IEC SPL Nrvd,Stb%: PRINT TAB(20);"Status Byte = ";Stb%
2120 IF (Stb% AND 64)=0 THEN GOTO Srq_end                 1)
2130 '
2140 IF (Stb% AND 16)<>0 GOSUB Mav_ready                  2)
2150 IF (Stb% AND 32)<>0 GOSUB Esr_check                  3)
2160 IF (Stb% AND 08)<>0 GOSUB Qs_check
2170 '                                                  ------------------------------------
2180 '                                                  End of wait loop
2190 Wait=0
2200Srq_end:
2210 ON SRQ1 GOSUB Srq_req: RETURN

2220 ' ************************************************
```

1) Every SRQ routine should contain these queries so that only true SRQs are processed.

2) A measured value must be read first, since the output buffer is cleared by transmitting commands. (However, it can again be requested by the NRVD using the command VOLT?)

3) If the ESB bit is set, the ESR register must be read out; otherwise no further SRQs can be generated..

4) Bit QS (= Ques. Event reg.) is not directly enable. Since this bit is nevertheless set (Enable: line 1080), the ques. status can be evaluated with SRQ (e.g. MAV = 1), if necessary (QS = 1). QS can be set asynchronously.

```
3000 ' ********************************** ESR-EVALUATION *
3010Esr_check:
3020 IEC OUT Nrvd,"*ESR?": IEC IN Nrvd,Esr$
3030 '                                                    ------------------------------------
3040 '                                                     Evaluation of ERROR status only
3050 Esr=VAL(Esr$): IF (Esr AND 60)=0 THEN RETURN
3060 '                                                    ------------------------------------
3070 PRINT TAB(20);"Event-Status Register = ";Esr$
3080 IF (Esr AND 32)=32 THEN PRINT TAB(30);"'Command error'"
3090 IF (Esr AND 16)=16 THEN PRINT TAB(30);"'execution error'"
3100 IF (Esr AND 08)=08 THEN PRINT TAB(30);"'device dependent error'"
3110 IF (Esr AND 04)=04 THEN PRINT TAB(30);"'query error'"
3120 PRINT TAB(20);"Error-Queue"
3130Err_queue:
3140 IEC OUT Nrvd,"syst:err?": IEC IN Nrvd,Err$: PRINT TAB(30);Err$
3150 '                                                    ------------------------------------
3160 '                                                     check whether 0, "No error"
3170 IF NOT (LEFT$(Err$,1)="0") THEN GOTO Err_queue
3180 RETURN
3190 ' ************************************************


4000 ' ************************ QUES.REGISTER EVALUATION *
4010Qs_check:
4020 '                                                    ------------------------------------
4030 '                                                      Read all 'EVENT' - registers
4040 IEC OUT Nrvd,"STAT:QUES:EVENT?;VOLT:EVENT?;:STAT:QUES:FREQ:EVENT?"
4050 IEC IN Nrvd,Qs$
4060 PRINT TAB(20);"Ques. Events = ";Qs$
4070 '                                                    ------------------------------------
4080 '                                                     Evaluation of Ques. status only for
                                                              amplitude(VOLT)
4085 '                                                     1st.element
4090 IF (VAL(Qs$) AND 1)=0 THEN RETURN
4100 '                                                   ----------------------------------
4110 IEC OUT Nrvd,"STAT:QUES:VOLT:COND?": IEC IN Nrvd,Qs$: Qs_v=VAL(Qs$)
4120 Qs_v1=(Qs_v AND 255): Qs_v2=Qs_v/256
4130 PRINT TAB(30);"Ques. Status Voltage channel 1 = ";RIGHT$(BIN$(Qs_v1),8)
4140 PRINT TAB(30);"Ques. Status Voltage channel 2 = ";RIGHT$(BIN$(Qs_v2),8)
4150 '                                                  ----------------------------------
4160 '                                                    check, OFLO channel 1
4170 IF (Qs_v1 AND 14)=0 THEN RETURN
4180 PRINT TAB(20);"Measured value channel 1 invalid"
4190 RETURN
4200 ' ************************************************

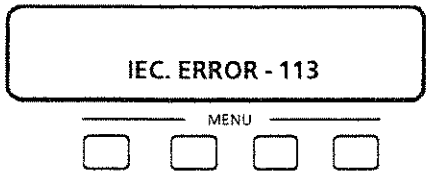

5000 ' ********************************** MAV-EVALATION *

5010Mav_ready:
5020 IEC IN Nrvd,Mw$: PRINT TAB(20);"Measured value=";Mw$
5030 RETURN
5040 ' ************************************************
```

### 3.8.8 Error Messages

#### 3.8.8.1 Error Handling to IEC625-2 or IEEE488-2 and SCPI

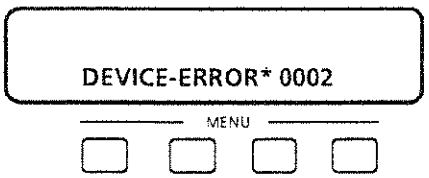
Errors detected by the NRVD during IEC-bus operation may be indicated on the display by the message




At the same time, the corresponding bits are set in the Event Status Register (ESR). If the associated enable mask ('*ESE') is set accordingly, a service request (SRQ) can be caused. The bits in the Event Status Register remain set until this is read out or cleared by the commands '*RST' or '*CLS'.

Error codes with a negative sign are generally defined by SCPI; positive error codes are device-specific. Particular device-specific error codes (warnings) as output in manual operation are assigned the error codes defined according to SCPI in remote operation. (Tables 3-19/3-20)
(e.g. WRNG. 1/Can't RCL = -314, "Save/recall memory lost")

Hardware errors detected by the NRVD during the switch-on routine or during permanent self-monitoring, may be indicated on the display by the message (e.g.)




The command 'SYSTem:ERRor?' causes the error string '-240,"Hardware error;0002" to be output.

The code 0002 is a hexadecimal code of the individual error bits. For the meaning of the error codes (device error), refer to Table 3-21 and the explanations given in sections 3.6.2 and 4.3.

#### 3.8.8.2 Reading in the Error String

All errors detected by the instrument are stored in an error queue for further evaluation (max. 5 entries possible). This queue functions according to the FIFO principle, i.e. the first entry stored is read out first, the last entry is read out last.

To determine the error cause via IEC bus, e.g. after a Service Request (SRQ) has been triggered, the command

| **SYSTem: ERRor?** |
|---|

permits a string to be read in by the controller as follows:

<Error number>,"Error text [;cause]"

e.g.

**-113,"Undefined header;UNBEKANNTER:BEFEHL"**

or

**5,"2 sensors needed"**

If the error queue is full, no further error messages are written to the queue. This is indicated to the user by the string

**-350,"Queue overflow",**

which can be read out as the last error string.

If no error has been detected before calling up of this command (SYST:ERR?) or all stored entries have been read, the NRVD sends the string

**0,"No error"**

to the controller, deleting the queue.

### 3.8.8.3 Tables of Error Messages

### 3.8.8.3.2 Device-dependent Error Messages

Table 3-19 Device-dependent error

| | | | | Execution Error | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Device Dep. Err | | | |
| Event-Status-Register (ESR) | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |

| Error-string | EXE | DDE |
|---|---|---|
| 3, "Available with option only" | X* | X |
| 4, "Missing sensor" | | X |
| 5, "2 sensors needed" | | X |
| 6, "Allowed with AVG-mode only" | | X |
| 8, "Can't display" | | X |
| 9, "Save was locked" | | X |
| 10,"DC-Sensor plugged in" | | X |
| 11,"With thermal sensor only" | | X |
| 12,"Not available with this sensor" | | X |
| 13,"Not allowed with this setting" | | X |
| 14,"Peak-sensor plugges in" | | |
| 15,"No list defined" | | |
| 20,"CAL OUTP, out of tolerance" | | |
| 21,"DC(FREQ) not calibrated" | | |
| 99,"Function not implemented" | | X |

* If the NRVD detects these errors during a measurement (after '*TRG* or GET), error bit 4 (EXE) is set in addition to error bit 3 (DDE).

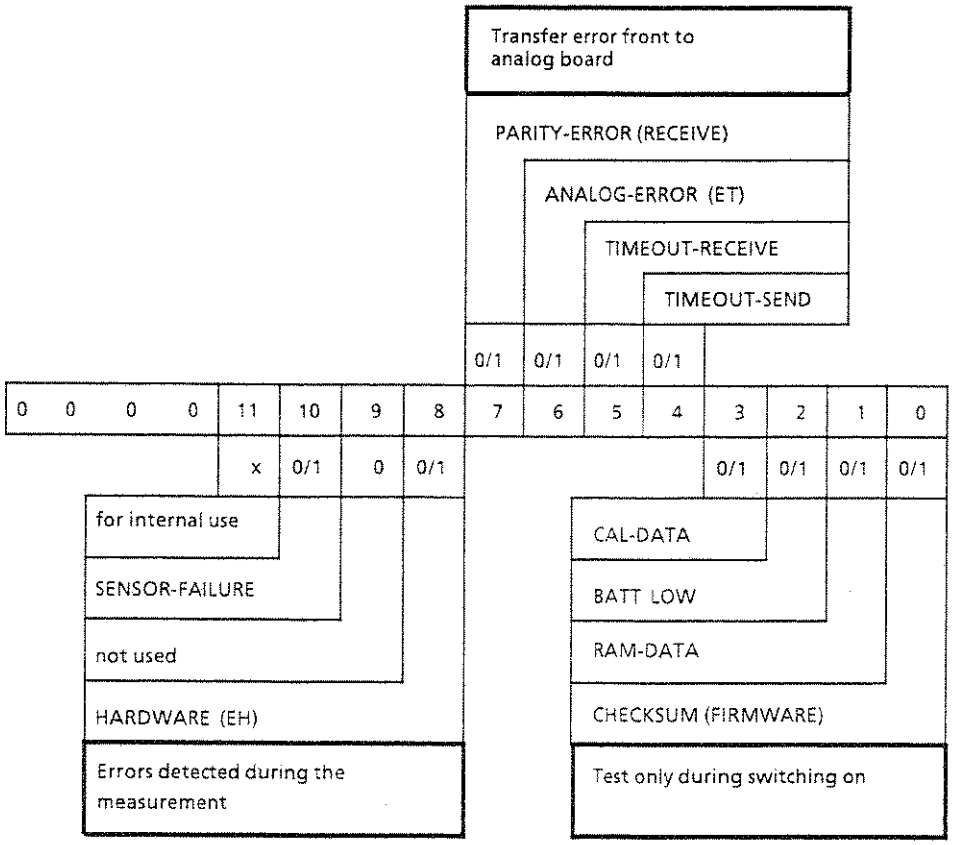
### 3.8.8.3.2 SCPI Error Messages

Tables 3-20 Error messages in line with SCPI

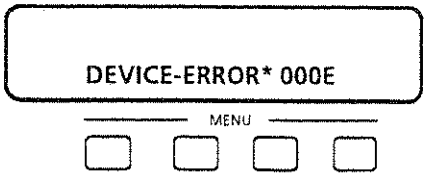
| | | | Command Error | Execution Error | Device Dep. Err | Query Error | | |
|---|---|---|---|---|---|---|---|---|
| Event-Status-Register (ESR) | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Error-string | | | CME | EXE | DDE | QYE | | |
| -101, "Invalid character" | | | X | | | | | |
| -102, "Syntax error" | | | X | | | | | |
| -103, "Invalid seperator | | | X | | | | | |
| -104, "Data type error" | | | X | | | | | |
| -105, "GET not allowed" | | | | | | | | |
| -109, "Missing Parameter" | | | X | | | | | |
| -112, "Program mnemonic too long" | | | X | | | | | |
| -113, "Undefined header" | | | X | | | | | |
| -114, "Header suffix out of range" | | | X | | | | | |
| | | | X | | | | | |
| -123, "Exponent too large" | | | X | | | | | |
| -124, "Too many digits" | | | X | | | | | |
| -128, "Numeric data not allowed" | | | X | | | | | |
| -131, "Invalid suffix" | | | X | | | | | |
| -134, "Suffix too long" | | | X | | | | | |
| -138, "Suffix not allowed" | | | X | | | | | |
| -141, "Invalid character data" | | | X | | | | | |
| -144, "Character data too long" | | | X | | | | | |
| -148, "Character data not allowed | | | X | | | | | |
| -151, "Invalid string data" | | | X | | | | | |
| -158, "String data not allowed" | | | X | | | | | |
| -168, "Block data not allowed | | | X | | | | | |
| -178, "Expression data not allowed" | | | X | | | | | |
| -200, "Execution error" | | | | X | | | | |
| -211, "Trigger ignored" | | | | X | | | | |
| -222, "Data out of range" | | | | X | | | | |
| -223, "To much data " | | | | X | | | | |
| -224, "Illegal parameter value" | | | | X | | | | |
| -225, "Out of memory" | | | | X | | | | |
| -240, "Hardware error" | | | | X | | | | |
| -314, "Save/recall memory lost" | | | | | X | | | |
| -330, "Self-test failed" | | | | | X | | | |
| -350, "Queue overflow" | | | | | X | | | |
| -400, "Query error" | | | | | | X | | |
| -410, "Query INTERRUPTED" | | | | | | X | | |
| -420, "Query UNTERMINATED" | | | | | | X | | |
| -430, "Query DEADLOCKED" | | | | | | X | | |

### 3.8.8.3.3 Hardware Error (DEVICE ERROR*)

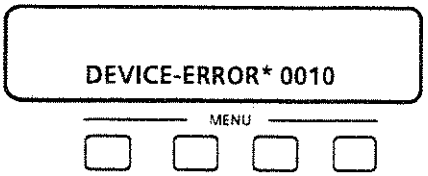
Table 3-21 Hardware error (DEVICE error)




**Examples:**




or.-240,"Hardware error;000E"
means that faulty data have been found in the RAM on switching on of the instrument and that the battery is empty.




or.-240,"Hardware error;0010"

means that the connection to the measuring hardware (analog board) is interrupted, which is why no measured value can be produced (servicing required).

If the bit 'HARDWARE' error is set, an additional error string can be read in by the controller

| **DIAGnostic:AHARdware?** |
|---|

(see Table 3-17) using the command

### 3.8.9 COMPATIBILITY MODE With NRVD

**Legend:**

√ = identical function as with NRV

\- = Function is not available with NRVD.

Commands in brackets lead to a syntax error with NRVD.

E. g.: E0 (E1) : E0 -> okay, E1 -> syntax error

**1 to 6** = see the following notes

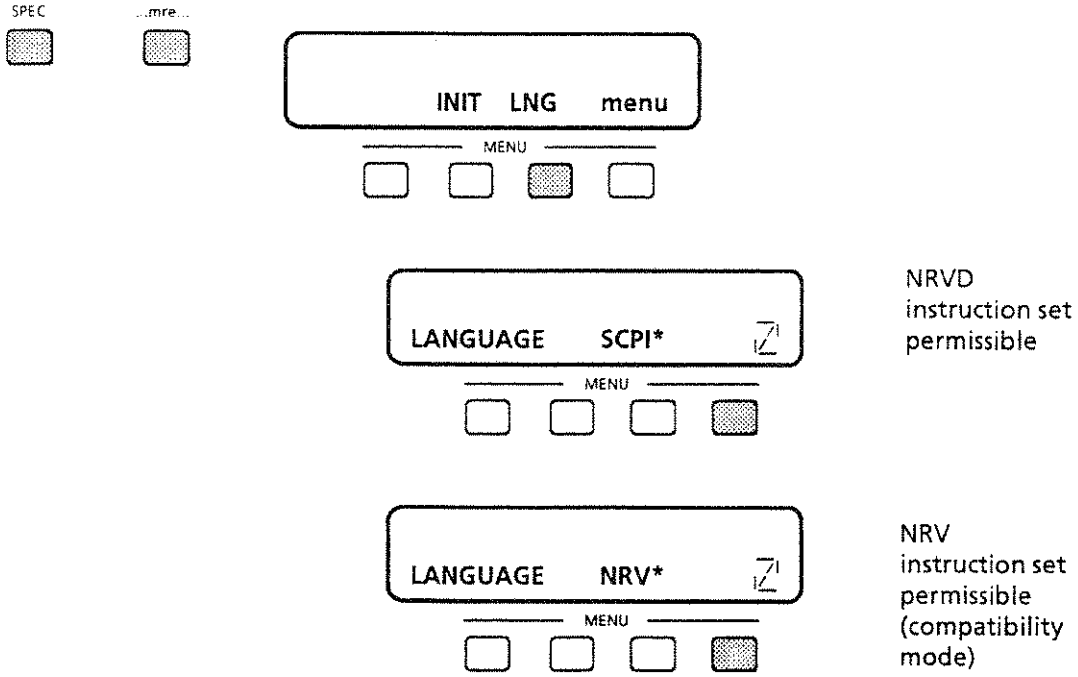
***Note:*** *No <space> may be inserted between 1st letter and index (<number>).*
*E. g., KA 1 is wrong, KA1 or KA01 is correct.*

*<DATA> can be added to the command with or without <space>.*
*E. g., DU5.0 or DU 5 or DU 5.0 is correct.*

#### 3.8.9.1 Switch-over between SCPI and Compatibility Mode

is possible in the LOCAL as well as in the REMOTE state.

LOCAL




NRVD instruction set permissible

NRV instruction set permissible (compatibility mode)

REMOTE

Command:

`SYST:LANG 'COMPatibility'` → NRV commands

or

`SYST:LANG 'NRV'` → NRV commands

and/or

`SYST:LANG 'SCPI'` → NRVD commands (SCPI)

## 3.8.9.2 Comparison of IEC-Bus Commands URV5/NRV <-> NRVD

| NRV (URV5) | NRVD V1.3 | |
|---|---|---|
| | Compatibility Mode | SCPI (short form) |
| ',' separation character | √ | ';' separation character between commands |
| C0 | √ | INP:SENS:INIT |
| C1 | √ 8) | * RST |
| DU, DV >DATA> | √ | SENS:VOLT:REF <DATA> <UNIT> V, |
| DW, DM, DB <DATA> | √ 3) | W, DBM, DBV, DBUV |
| DZ, DR <DATA> | √ | INP:IMP <DATA>[OHM] |
| DF <DATA> | √ | SENS:CORR:FREF <DATA> [[K \| M \| G]HZ]] |
| DA <DATA> | √ | SENS:VOLT:ATT <DATA> [DB] |
| D = [AA\|BB] | √ 7) | not available |
| E0 (E1) | - | not available (no hardware) |
| F0 to F5 | √ 5) | CALC;FILT:NSEL 1 to 12 (filter)<br>DISP:ANN:VOLT:NRES 3 to 5 (resolution) |
| F0 | √ | CALC:FILT:NSEL 11;:DISP:ANN:VOLT:NRES 5 |
| F1 | √ | CALC:FILT:NSEL 9;:DISP:ANN:VOLT:NRES 5 |
| F2 | √ | CALC:FILT:NSEL 7;:DISP:ANN:VOLT:NRES 5 |
| F3 | √ | CALC:FILT:NSEL 5;:DISP:ANN:VOLT:NRES 5 |
| F4 | √ | CALC:FILT:NSEL 3;:DISP:ANN:VOLT:NRES 5 |
| F5 | √ | CALC:FILT:NSEL 0;:DISP:ANN:VOLT:NRES 4 |
| H0 (H1) | - | not available (obsolete) |
| IA/IB | √ | the numerical suffix 1 or 2 (without space, for channel 1/2) can be added to almost every command, e. g.: SENS2:VOLT:ATT 20 |
| KA0/KA1 | √ | SENS:VOLT:ATT <DATA><br>DATA = 0 → off<br>DATA ≠ 0 → on |
| KF0/KF1 | √ | FREQ:STAT OFF;:CORR:FREF:STAT OFF \| ON |
| N0/N1 | √ | not avail. in this way (num. string changed) or DIAG:TEST1 ON \| OFF |
| O0/O1 | √ 1) | SENS:CORR:ZERO:INIT (trigger + on)<br>SENS:CORR:ZERO:STAT OFF \| ON |
| PA/PB | √ | INP:NSEL 1 \| 2 |
| Q0 to Q3 | √ 4) | not available (other concept for SRQ), comparable commands: *ESE ../*SRE.. |
| Q1 | √ | *ESE 0; *SRE 16 → SRQ (80) MAV |
| Q2 | √ | |
| Q3 | √ | |

| NRV (URV5) | NRVD V1.3 | |
|---|---|---|
| | Compatibility Mode | SCPI (short form) |
| RG..., RG1 to RG4 | √ 2) | **SENS:VOLT:RANG** <DATA>; **RANG:AUTO OFF**<br>The setting of a measuring range is effected by specifying the measured value expected |
| RG, RG0 | √ | **SENS:VOLT:RANG:AUTO ON [ \| OFF]**<br>Autorange |
| U0 to U7 [W\|V] [X] | √ | **SENS:POW:UNIT** <UNIT> (with respect to W) |
| UV, UW | √ | |
| U0, U1, U7, U2, -<br>U5W, U4W, U6W, U3W<br>U5WX, U4WX, U6WX, U3WX | 3) | <unit> W, DBM, V, DBV, DBUV<br>DB, PCT; REL; LIN<br>XDB, XPCT, XREL, XLIN (ΔEXT) |
| | | or<br>**SENS:VOLT:UNIT** <UNIT> (with respect to V) |
| U0, U1, U7, U2,-<br>U5V, U4V, U6V, U3V<br>U5VX, U4VX, U6VX, U3VX | 3) | <unit> W, DBM, V, DBV, DBUV<br>DB, PCT, REL, LIN<br>XDB, XPCT, XREL, XLIN (ΔEXT) |
| W0 to W8 | √ 6) | not available |
| W2, W7 | - | |
| W5 | √ | NL + EOI is terminator with NRVD |
| S0 to ST | | not available or not available in this way |
| S0 | √ | not available |
| S4 | √ | **CAL:INFO?** (after CAL:CLEAR) |
| S5 | - | **DIAG:AHAR?** (other output string)<br>or **SYST:ERR?** |
| S6 | √ | The instrument automatically checks its check sum on switching on. A version number is displayed or can be evaluated using ***IDN?**. |
| ST | √ | By adding a '?' to the respective command, each instrument status can be polled in principle. |
| SP | √ | **INP:SENS?** (only sensor status 0,1) |
| X0, X3 | √ | not available |
| X4 | √ | **TRIG:SOUR IMM** |
| X1 | √ | **[DISP:ANN:VOLT SING;] *TRG** |
| X2 | √ | ***TRG; *WAI; SENS:VOLT:REF:MVAL** |
| X8 *) | √ | **[DISP:ANN:VOLT DUAL;] *TRG**<br>The setting command 'DISP:ANN:VOLT DUAL' does not have to be sent each time; both measurement results can be read in one string and are separated by ';', e. g.: "3.072E-03; 1.000E+00" |
| (Y0) Y1 (YX,Y?) | - | not available |
| Z0 to Z3 | √ | By adding a '?' to the respective command the corresponding value can be read out. |
| Z0 | √ | **SENS:VOLT:REF?** |
| Z1 | √ | **INP:IMP?** |
| Z2 | √ | **SENS:CORR:FREF?** |
| Z3 | √ | **SENS:VOLT:ATT?** |

*) Note: The LOCAL keys is evaluated onle if the two substrings are read into the controller.

### 3.8.9.3 Notes for the Use of the COMPATIBILITY Mode

Data transmission with the NRVD is effected via DMA. This means that the instrument takes the complete setting string from the control computer and begins evaluation only then.
When sending several commands in one string, the NRVD, compared with the NRV/URV5, behaves as if only a single command had been sent to the NRV/URV5. The control computer is not stopped during the string evaluation in the measuring instrument.

**Notes/Supplements (additional commands):**

For easier adaption of the NRVD to existing NRV programs, several additional commands have been implemented, i.e. existing programs should run on the new NRVD without or with only minimal adaptions to be made.

---

Syntactic problems can be evaluated using the **SYST:ERR?** command, with so-called query errors (-400 ff.) being unimportant.

E. g.: **-102, "Syntax error; W4",** Terminator W2 not available.
W4, W5 (W0) or W6 (W1), W8 (W3) are permissible

---

1) **02** like 01, however, an instrument response is generated after the end of the zero measurement which can be read into the controller using IECIN.
**0** = okay, **1** = error (see Timing as well)

**01, 02** When evaluation takes place via the IEC-bus, the power is output with a positive sign.

2) **RG1 to RG4** sets the uppermost NRVD sensor ranges. The measuring ranges of the NRVD sensors are expanded or altered compared to NRV.

E. g.: URV5-Z1 (DC sensor)

| | | |
|---|---|---|
| NRV | → 4 measuring ranges | 1 V, 10 V, 100 V, 400 V |
| NRVD | → 5 measuring ranges | 100 mV, 1 V, 10 V, 100 V, 400 V |
| RG4 | → measuring range 5 (NRVD) = 400 V | |

NRV-Z1

| | | |
|---|---|---|
| NRV | → 3 measuring ranges | 10 mV (2µW) 100 mV (200 µW), 1 V (20 mW) |
| NRVD | → 7 measuring ranges | 10 nW, 100 nW, 1 µW, 10 µW, 100 µW, 1 mW, 20 mW |

**R01 to...** Using R1 to R15 the original NRVD measuring ranges can be set, the maximal range number depends on the sensor.

| | | |
|---|---|---|
| **RN <DATA>** | V, W corr. to measuring sensor | |
| **RU <DATA>** | in V | |
| **RV <DATA>** | in V | fixed range setting |
| **RW <DATA>** | in W | by specifying the measured value expected |
| **RM <DATA>** | in dBm | (This does not alter the display unit) |
| **RB <DATA>** | in dBV | |
| **RS <DATA>** | in dBµV | |

**RG, RG0** : autorange for all range commands.
**ST** : returns the respective 'true' NRVD measuring ranges,
e. g. 400 V (DC sensor) = R05

*Caution:* *With NRVD, fixed ranges are set, i.e. an 'upwardly' ranging 'away' is not possible.*

3) **U8** dBµV
**DS <DATA>** respective data input command (in dBµV)

4) **Q1 to Q3** The use of Q1 to Q3 and the commands *SRE, *ESE, *PPE are mutually exclusive and can thus not be used at the same time.

5) **FA** Auto filter can be set additionally.
ST then returns FA (possibly, substantially longer measuring times have to be observed!)

6) **W0, W1, W3** are accepted, but W5, W6 or W8 are set, i. e. EOI is sent with the defined terminators in principle.

7) **D=** does not copy the impedance.

8) **C1** W8 is the basic state for terminators.
Measuring range indication using RG0 or Rxy e. g. R05.

| | | |
|---|---|---|
| **SOI0/SOU1** | Switching on/off of test generator | after C1 : SOU0 |
| **SOU?** | Poll: **0** \| **1** SRQ (85) | |
| **G0/G1** | Switching on/off of measured value display | after C1 : G1 |
| **G?** | Poll: **0** \| **1** SRQ (85) | |
| **RN?** | Poll of measuring range: | |
| | e. g.: " **W 1.00E-3** SRQ (85) | |
| | Power sensor/1mW range | |

---

In the compatibility mode of the NRVD, the following commands are available in addition:

- all '*' commands (e. g. ***IDN?** or ***RCL** / ***SAV** etc.)
Trigger status (X3, X4), SRQ status (Q1 to Q3), N0, Wx cannot be stored using *SAV/*RCL.

- SCPI commands:

  **SYSTem:...**

  **DIAGnostic:...**

  **STATus:...**

  **CALibration:...**

  When evaluating these commands and in the case of SRQ evaluation, the common commands *SRE, *PPE, *ESE should be used.

  Exception: SYST:ERR? leads to SRQ (85) with Q1/Q2.

- IECDCL or IECSDC executes a basic setting as in the case of NRV/URV5.

# 4 Maintenance and Troubleshooting

For regular checks and calibration of the basic instrument NRVD the Service Kit UZ-9 (order no. 350.7818.02) is recommended for use. It allows for computer-controlled testing, calibration and troubleshooting in the analog unit of the NRVD (analog board and option NRVD-B2). The service kit contains a specific sensor adapter for the analog test inputs as well as the necessary calibration and test software for R&S- or IBM-compatible computers. A D.C. voltage calibrator and a digital multimeter (UDS 5) are also required.
To avoid the loss of the calibration data, it is recommended to check the lithium buffer battery and output N-socket as well as the contacts of the IEC bus connectors at the rear panel approx. every 2 years. Furthermore, the front and display panel should be cleaned.

## 4.1 Maintenance

### 4.1.1 Cleaning the Front Panel and Display Panel

For cleaning these parts, only use a soft rag and, if required, a non-alcoholic detergent (no spirit or benzine). The labelling panel can be removed after unscrewing the four screws at the front panel edges.

### 4.1.2 Checking and Replacing the Lithium Buffer Battery

A memory with battery back-up on the processor board provides for the preservation of the stored calibration data and reference values and of complete NRVD setups when the instrument is switched off. The current consumption of the data memory and self-discharge of the battery are subject to large manufacturing tolerances especially at higher temperatures, affecting the service life of the buffer battery. It is therefore recommended to replace the batteries approx. every 4 to 5 years or after recalibration.

Battery check:

- Remove the two rear panel feet (4 Phillips screws)
- Slide the upper cover towards the rear panel and withdraw.
- NRVD is switched off (the battery is loaded by the current consumption of the data memory)
- Measure the battery voltage at the terminals X1 and X2, making sure that the positive terminal of the battery (X1) is not short-circuited to ground.
  The battery voltage should be at least 3.2 V.
- If it is below this value, the battery must be replaced.

**Note:**
With a battery voltage of less than approx. 2.8 V the error messages "DEVICE-ERROR * 4" and "BATT LOW" are output on power-up of the NRVD. The battery undervoltage usually leads to the loss of calibration data.

**Replacing the Battery:**

Loss of the calibration data in a calibrated instrument (no error message "DEVICE-ERROR * 8") can be prevented by replacing the battery very carefully. Recalibration is not necessary in this case.

- Switch on the instrument (data memory is mains-operated)
- Cut the fastening strap of the battery and unsolder the terminals; make sure that the battery is not short-circuited (use ungrounded soldering iron).
- Solder in new battery and fasten using a new strap..
- Switch off instrument and complete.
- Put the instrument into operation.

If there is no errror message, the instrument is again ready for use.

If the error message "DEVICE-ERROR * 8" (calibration data missing) is displayed, recalibrate the instrument.

***Caution!***

- The batteries must not be charged.
- Remove flat batteries from the instrument immediately and dispose of as toxic waste.
- Make sure that the new batteries are correctly connected to the poles (see bottom of battery holder).
- Note the manufacturer's instructions.
- Danger of explosion or leakage, if the instructions above are not followed.

## 4.2 Function Test

The function test on the most important instrument features is automatically performed whenever the instrument is switched on. After the switch-on sequence has been completed without the detection of errors, correct operation of the instrument is largely ensured.
Processing of the individual self-test stages is read out on the display:

| | |
|---|---|
| NRVD V abc IECADR xy | Firmware version. abc IEC adr. xy |
| OPTION INCLUDED (NO OPTION) | Opt. NRVD-B2 included (no option) |
| INT.CHECK (DIGTL) | Self-test/digital unit |
| INT.CHECK (ANALG) | Self-test/analog unit |
| INIT SENSOR | Initialization of sensor |
| * ALL TESTS PASSED * | Self-test correctly completed |
|  | No sensors connected |

- With sensors connected, their data are read, checked and the current measured value is displayed. → The instrument state is perfect.

- If any errors have been detected during the self-test, the error message "DEVICE-ERROR * xxx" is output on the display. In the case of a faulty module, error location has been considerably relieved by self-test stages and hexadecimal coding. Error coding is referred to in section 3.6.2, Instrument Errors.

## 4.3 Troubleshooting

Order and scope of the self-test stages and coding of any possible errors allows for error location in a relatively small circuit range.

- **The instrument does not respond to activation of the power switch. No segments visible in the display, no control LEDs illuminated.**
  Check the power supply of instrument, setting of the voltage selector and the fuses in the voltage selector. Continue with examining the output voltages in the power pack.

- **After power-up only incomplete letters are output on the display.**
  Call the display test routine using the key "SPEC" + "mre + mre + FRONTPANEL + CHECK + LCD/LED". All the segments in the display should be switched on, all the four control LEDs on the front panel must be illuminated, otherwise continue with troubleshooting in the display unit.

- **Keyboard error:**
  Call the test routine via "SPEC" + "mre + mre + FRONTPANEL + CHECK + KEY". Each depression on the keyboard must be followed by the corresponding basic function name in the display. Quit the test routine by pressing the "MEAS" key twice. Troubleshooting starts with the module display unit and, if there are no responses, continues with the processor board.

- **Faulty responses of the instrument following power-up, no error message.**
  Check the voltages on the processor board, 16-MHz clock oscillator, reset circuit. Continue with troubleshooting in the data- and address bus range.

- **The instrument can be manually operated via the front panel, however shows no response via IEC bus.**
  Check the set IEC bus address ("LOCAL" key in manual mode). Address the NRVD via process controller and check the signals at the bidirectional driver components D31, D32 (processor board).

Troubleshooting with the help of diagnostic means:

| Error message | Cause | Remedy/Test |
|---|---|---|
| DEVICE ERROR * 1 | Checksum error of EPROM | Replace EPROM (D5,D6 /processor board) |
| DEVICE ERROR * 2 | RAM data missing | Call SPEC function INIT |
| DEVICE ERROR * 4 | Lith. battery flat (Displ.: "BATT.LOW") | Replace battery |
| DEVICE ERROR * 8 | Calibration data missing | Recalibrate |
| DEVICE ERROR * 10 | Time limit exceeded in transmission to analog board | Check serial interface to analog card. Trigger service routine (analog board, X710 short-circ.). Check signals at U704, D700, (poss. U703). |
| DEVICE ERROR * 20 | Time limit exceeded in reception from analog board | |
| DEVICE ERROR * 40 | Error during data transfer processor → analog board | |
| DEVICE ERROR * 80 | Parity error during data transfer analog board → processor | |
| DEVICE ERROR *100 | Hardware error in analog board | Location using error string (table 4-1) |
| DEVICE ERROR *400 | Faulty operating voltage for sensor | Check filter board (A4), connection to analog board and voltage conditioning (analog board, A2). |

## Meaning of the Bits in the Hardware Error String

The hardware error string is read using the command "DIAG:AHAR? [Nr]". With specification of the (error bit) no., the appertaining measured value is additionally output.
The structure of a string and reading of furthe irnformation are referred to in table 3-17.

Table 4-1

| Error bit no. | Meaning | Test channel | Value range (test) | | Remark |
|---|---|---|---|---|---|
| 0 | $U_{cc1}$ (0 V) | A | 0.000 | 0.025 | |
| 1 | $U_{cc1}$ (+5 V) | A | +0.245 | +0.282 | |
| 2 | $U_{cc1}$ (+12 V) | A | +0.583 | +0.670 | |
| 3, 4 | Reserved | | | | |
| 5 | Offset AC, ran. 6 | A | -0.480 | +0.480 | |
| 6 | 7 | A | -0.230 | +0.230 | |
| 7 | 8 | A | -0.075 | +0.075 | |
| 8 | 9 | A | -0.064 | +0.064 | |
| 9 | 10 | A | -0.040 | +0.040 | |
| 10 | 11 | A | -0.030 | +0.030 | |
| 11, 12 | Reserved | | | | |
| 13 | Deviation 100 -µA sensor | A | +0.100 | +5.000 | |
| 14 | Offset 1-mA sensor | A | -0.100 | +0.100 | |
| 15 | Test volt. 1 00-µA sensor | A | -0.410 | -0.190 | |
| 16 | Test volt. 1-mA sensor | A | -3.540 | -2.420 | |
| 17 | $U_{cc2}$ (0 V) | B | 0.000 | 0.025 | |
| 18 | $U_{cc2}$ (+5 V) | B | +0.245 | +0.282 | |
| 19 | $U_{cc2}$ (+12 V) | B | +0.583 | +0.670 | |
| 20, 21 | Reserved | | | | |
| 22 | Offset AC, Ran. 6 | B | -0.480 | +0.480 | |
| 23 | 7 | B | -0.230 | +0.230 | |
| 24 | 8 | B | -0.075 | +0.075 | |
| 25 | 9 | B | -0.064 | +0.064 | |
| 26 | 10 | B | -0.040 | +0.040 | |
| 27 | 11 | B | -0.030 | +0.030 | |
| 28, 29 | Reserved | | | | |
| 30 | Deviation 100-µA sensor | B | +0.100 | +5.000 | |
| 31 | Offset 1-mA sensor | B | -0.100 | +0.100 | |
| 32 | Test volt. 100-µA sensor | B | -0.410 | -0.190 | |
| 33 | Test volt. 1-mA sensor | B | -3.540 | -2.420 | |
| 34 | Offs. DC, ran. 1 | | -0.500 | +0.500 | |
| 35 | 2 | | -0.050 | +0.050 | |
| 36 | 3 | | -0.010 | +0.010 | |
| 37 | 4 | | -0.010 | +0.010 | |
| 38 | (I Offs DC)*3GΩ | | -0.075 | +0.075 | |
| 39 | Tuning volt. [TPO] | | -1.200 | -0.040 | |
| 40 | -6 V | | -0.575 | -0.611 | |
| 41 | Σ (±15 V) | | -0.077 | +0.077 | |
| 42 | Σ (±5 V) | | -0.026 | +0.026 | |
| 43 | Offset A/D converter | | -0.250 | +0.250 | |
| 44 - 46 | Reserved | | | | |
| 47 | Timeout A/D | | | | |
| 48 | D/A set. AC | A | 2 ..... | 0FEh | |
| 49 | D/A set. AC | B | 2 ..... | 0FEh | |
| 50 | D/A set. DC | | 2 ..... | 0FEh | |
| 51 | D/A set. 50 MHz | | 2 ..... | 0FEh | |
| 52 - 54 | Reserved | | | | |
| 55 | Hardware error | | | | |
| 56 | Transmisions error | | | | |
| 57/58 | Reserved | | | | |

## 4.4 Module Replacement

### 4.4.1 Analog Board

- Remove both rear panel feet after having loosened 4 Phillips screws and withdraw the lower instrument cover toward the rear (do not damage RF seal at the rear panel).
- Remove ribbon cable W150 from connector X102 and ribbon cable W 3 from connector X103.
- Withdraw ribbon cable W4 from the holder at the screening cover of the analog board and unplug connector X101. Put the levers of the connectors to their original positions.
- Unscrew the coaxial cable W10 from the analog board. (Fork wrench, size 6).
- Remove the screws with washer assembly from the analog board.
- Withdraw the analog board.

### 4.4.2 Service Position

The analog board withdrawn can be brought into its service position:

- Remove the screws from the screening cover, if required, and withdraw.
- Insert the analog board (side with connector X102) into the slots provided at the inner side of the left-hand side panel of the instrument.
- Pull the folded ribbon cable W150 out of the opening to the processor board and connect it to connector X102 (analog board).
- Connect the ribbon cable W4 to X101.

In the service position the analog board can be accessed from both sides for measurement purposes and can be operated.

Installation:
Complete the analog board with the screening cover and fit it into the basic unit in the reverse order to that of removal. Fold the cable W150 in the opening to the processor board. The cable must not be lain together with cable W4 (disturbances) and must not touch the switch rod. Take care of the RF seal position at the rear panel during assembly.

### 4.4.3 Filter Board

- Remove both rear panel feet after having loosened 4 Phillips screws and withdraw the lower instrument cover toward the rear (do not damage RF seal at the rear panel).
- Remove ribbon cable W4 from connector X101.

#### 4.4.3.1 Filter Board at the Front Panel

- Remove the four screws from the front panel cover and and withdraw.
- Remove three Phillips screws from the filter board and withdraw the filter board with the two female connectors for the sensors and cable W4 towards the rear.

#### 4.4.3.2 Filter Board at the Rear Panel

- Remove three Phillips screws from the filter board and withdraw the filter board with the two female connectors for the sensors and cable W4 towards the front panel.

Assembly:
Assemble the instrument in reverse order to that of removal.
During assembly at the rear panel, make sure that the cable W4 is not lain together with the ribbon cable W150 (disturbances).

## 4.5 Display Board

- Remove both rear panel feet after having loosened 4 Phillips screws and withdraw the upper cover.
- Remove the four screws from the front panel cover and withdraw the covering plate.
- Remove the ribbon cable W1 from connector X40 on the processor board.
- Withdraw the display board with the front carrier board towards the front panel, pulling the ribbon cable with the connector strip through the opening in the frame.
- Remove the four screws from the front panel and the front carrier board.

  Caution: *Remove only the screws marked by * in figure 4-1. The other screws (#) serve to fasten the sheets between keys and PC board.*

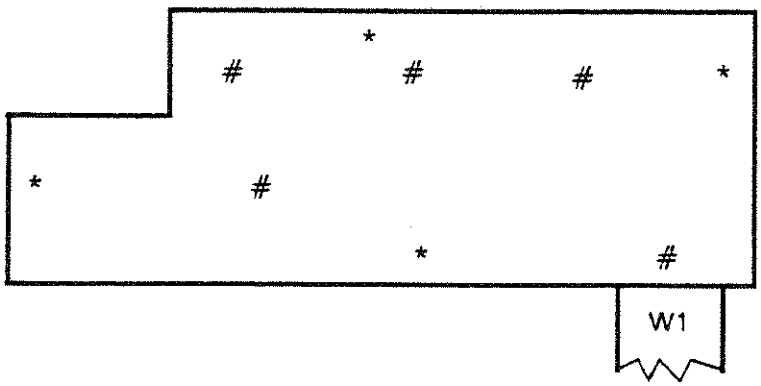



Fig. 4-1 Screws to fasten the display board

For troubleshooting the removed display board can be connected to the processor board.

Assembly:
Fit the individual parts in reverse order to that of removal.

## 4.6 I/O Option NRVD-B2

- Remove both rear panel feet after having loosened 4 Phillips screws and withdraw the upper and lower instrument cover.
- Remove both ribbon cable sockets (W2/processor board, W1 on option).
- Press the four plastic holders from the upper side of the option together and withdraw the PC board upwards.

### 4.6.1 Connector Plate

- Remove the connecting cables W3 and W1 on the analog board and I/O option, respectively.
- Untighten the screws of the connector plate at the rear panel and withdraw the connector plate.

Installation:
Reassemble the individual parts in the reverse order to that of removal.

Caution:
*When fitting the lower instrument cover, the User's Guide must not be damaged by clamping it between the front frame.*

# 5 Checking the Rated Specifications

## 5.1 Measuring Equipment and Auxiliary Means

| Item | Type of Instrument | Required Specifications | Suitable R&S instrument | Order No. |
|---|---|---|---|---|
| 1 | DC probe | | URV5-Z1 | 395.0512.02 |
| 2 | Insertion unit | | URV5-Z2 | 395.1019.04 |
| 3 | Thermo-coupled power sensor | | NRV-Z51 | 857.9004.02 |
| 4 | D.C. calibrator | 1 ... 400 V, ± 0.01 % | | |
| 5 | A.C. calibrator | 200 µV...10 V ± 0.1%; 100 (200) kHz | | |
| 6 | Digital multimeter | DC ±0.02%, R ±0.02%, 5 1/2 dig. | UDS 5 | 349.1510.02 |
| 7 | Frequency counter | min. 50 MHz, 0.1%, $V_i \leq 0.2$ V | FAM | 334.2015.54 |
| 8 | Process controller | IEC625 interface | PCA 5<br>PCA 15 | 375.2010.04<br>376.1100.02 |
| 9 | Oscilloscope | BW > 10 MHz | | |

## 5.2 Test Procedure

Wait for approx. 1 hour (thermal response time of instrument) before testing the measuring accuracy. Some of the tests involve the use of a sensor to check the behaviour of the entire test setup, which always consists of a basic unit and a sensor. Therefore the tolerances indicated in the test report exeed the limits specified for NRVD alone. Service Kit NRVD-S1 (1029.2808.02) is recommended for calibrating NRVD.

### 5.2.1 Checking the Front Panel

#### 5.2.1.1 Key Functions

Select the NRVD test menu "KEY" via the key sequence:
**"SPEC" + Softk. "mre"-"mre"-"FRONTPANEL"-CHECK"-"KEY".**

- Check the function of the front panel keys. Each key depression must lead to the display of the appertaining basic function name.

#### 5.2.1.2 Display Test

Test the function of display illumination using the key sequence:
**"SPEC" + Softk. "mre"-"mre"-"FRONTPANEL"-"DARK" (LIGHT).**
Activate the softkeys **"CHECK"-"LCD/LED"** in the current menu.

- All four LEDs on the front panel must light up. All segments must be visible in the display.

### 5.2.2 Testing the Measuring Head Interface Channel A (B)

Connect the passive measuring heads URV5-Z1 and URV5-Z2 one after the other to channel A and check recognition as well as reading out of data. After having connected a measuring head "INIT SENSOR" is displayed and after some time required for reading out data, the current measured value is indicated. For testing the power supply of active measuring heads, connect the Thermo-Coupled Power Sensor NRV-Z51 to channel A and test generator and subsequently switch on the 50-MHz test generator. The measured value is supposed to be in the range of 0.98 to 1.02 mW.
Perform this test also in channel B.

### 5.2.3 IEC625 Interface

Connect the device under test to the process controller via an appropriate cable. Check the intercommunication capability using the NRVD IEC control commands (Tab. *-*).

### 5.2.4 D.C. Measuring Accuracy

The output voltage of the D.C. calibrator is tested using the D.C. Probe URV5-Z1 and NRVD. Check all the voltages in channel A as described in the test report (5.3). As a common D.C. amplifier is used for channel A and B, channel B needs to be tested only at 1 V. Testing the measuring accuracy in channel B requires the D.C. measuring head to be inserted into channel B.

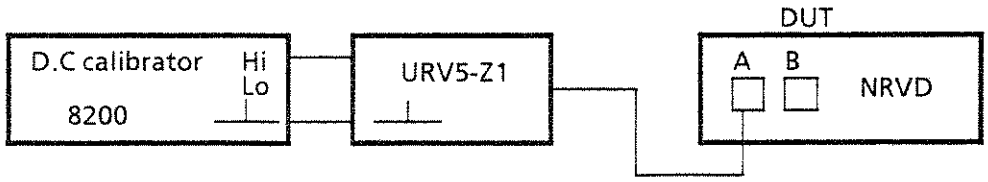



Fig. 5-1 Testing the D.C. measuring accuracy

### 5.2.5 A.C. Measuring Accuracy

A.C. measuring accuracy is checked by measuring the output voltages of an A.C. calibrator using the Insertion Unit URV5-Z2 (fig. 5-2). The noise voltage at the calibrator output (determined in broadband measurement) must not exceed 200 µV; otherwise a lowpass filter or voltage divider is required.

Zero adjustment:
Set 0.2 mV /10 Hz on the calibrator and trigger zero adjustment in channel A. Due to the low test frequency only the residual noise voltage is measured and eliminated like an offset voltage.

Set the frequency to 100 kHz on the calibrator and measure the output voltage at the following values:

0.2 mV / 10 mV / 100 mV / 1 V / 10 V

The permissible measured values are given in the test report (5.3).

It is recommended to perform the measurements in the order specified, since the measuring heads need some recovery time before small levels can be measured again.
Reconnect the measuring head to NRVD channel B instead of channel A and perform the test in channel B analog to that in channel A.

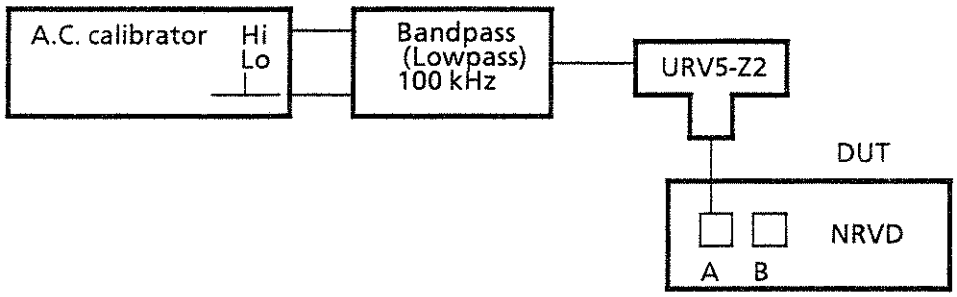



Fig. 5-2 Testing the A.C. measuring accuracy

### 5.2.6 Testing the Analog Outputs (Option NRVD-B2)

The output voltage range of the analog outputs is about -0.6 to 3.8 V. Scaling via the analog meter has been designed such that the left-hand scale marker is assigned an output voltage of 0 V and the right-hand scale marker an output voltage of 3 V, respectively.

- Make a test setup according to fig. 5-3: connect the D.C. Probe URV5-Z1 to channel A, the D.C. voltmeter to the output DC1.
- Feed in 1 V from the D.C. calibrator via URV5-Z1.
- NRVD: Store measured value as reference value. Select display mode $V/V_R$.
- Freely selectable scaling allows to define 0 V for the left-hand scale marker and 1 V for the right-hand scale marker, respectively.
  The output voltage at DC1 must be 3 V ± 3 mV. Display = 1.000

- Freely selectable scaling allows to define 1 V for the left-hand scale marker and 2 V for the right-hand scale marker, respectively.
  The output voltage at DC1 must be 0 V ± 3 mV.

- Check the analog output DC2 and channel B analog to the procedure described above.

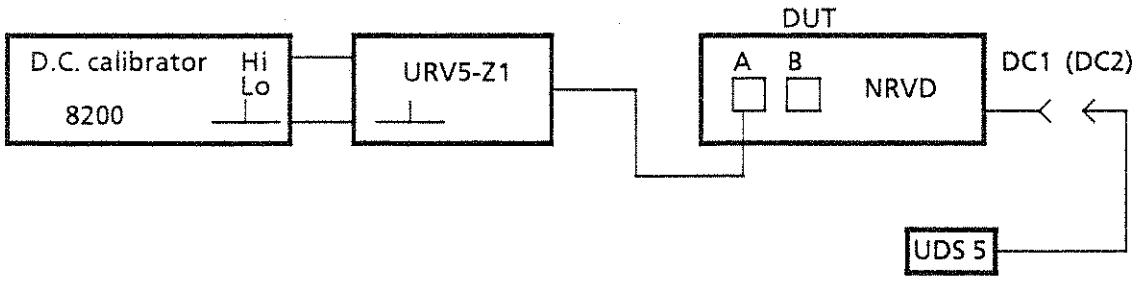



Fig. 5-3 Test setup for checking the analog outputs

### 5.2.6.1 Testing the D.C. FREQ Input

- Connect the D.C. calibrator to the DC-FREQ input and set the voltage to 0 V.
- Set the sensitivity of the DC-FREQ input in the frequency response correction menu of the NRVD:

  0 V to 0 GHz
  10 V to 1 GHz

- Switch on frequency response correction.
- Select display of the correction frequency in the display menu.

  The frequencies indicated for the calibrator voltages = 0 V and 10 V may deviate by max. 1 MHz from the specified nominal value.

### 5.2.6.2 Testing the EXT-TRIG Input and READY Output

- Switch on TRIGGER-EXTERN in the SPEC menu of the NRVD.
- Set FILTER ... >5.
- Connect an oscilloscope to the READY output.

  The voltage at the READY output is to be logic '0'(0 V).

- Press the "MEAS" key on the instrument.

  After the measuring time the voltage should be logic '1' (+5 V) at the READY output.

- By pressing any key (except for "MEAS") the READY output is returned statically to the logic state '0'.

  When starting the measurement again, '0' is only output during the measurement, itself.

- Repeat the test for the external trigger signal analog to the test above (logic '0' or short-circuit at the TRIGGER-EXTERN input to ground).

**Note:**
*A continued short circuit leads to the immediate start of a new measurement as soon as the preceding one has been completed, i.e. a square signal with a pulse duty factor corresponding to the measuring time and measured value output time appears at the READY output.*

### 5.2.7 Testing the 50-MHz Test Generator

- Connect the Thermo-Coupled Power Sensor NRV-Z51 to the test generator.
- Switch on 50-MHz test generator and read off the measured value $P_{50}$.
- WithWith the frequency response correction (50 Mhz ) of the NRV-Z51 switched on, output power $P_{50}$ must be within the limit values indicated in test report (see page 5.6)

## 5.3 Test Report

R&S
POWER METER NRVD
Part No.: 0857.8008.02
Serial No.: .....

Date:.....

Name:.....

| Item No. | Characteristics | Measure-ment to section | Min. | Actual | Max. | Unit |
|---|---|---|---|---|---|---|
| 1 | Front panel / functions | 5.2.1 | -- | | -- | --- |
| 2 | Measuring head connections | 5.2.2 | -- | | -- | --- |
| 3 | IEC - 625 connection | 5.2.3 | -- | | -- | --- |
| 4 | D.C. measuring accuracy | 5.2.4 | | | | |
| | 0 V | | - 6E-4 | ..... | 6E-4 | V |
| | + 1 V channel A | | 0.9955 | ..... | 1.0045 | V |
| | + 1 V channel B | | 0.9955 | ..... | 1.0045 | V |
| | - 1 V | | -0.9955 | ..... | -1.0045 | V |
| | 10 V | | 9.959 | ..... | 10.041 | V |
| | 100 V | | 99.59 | ..... | 100.41 | V |
| | 400 V | | 397.6 | ..... | 402.4 | V |
| 5 | A.C. measuring accuracy Channel A | 5.2.5 | | | | |
| | Zeroing | | -- | ..... | -- | mV |
| | 0.2 mV | | 0.174 | ..... | 0.223 | mV |
| | 10 mV | | 9.883 | ..... | 10.117 | mV |
| | 100 mV | | 98.83 | ..... | 101.17 | mV |
| | 1 V | | 0.9883 | ..... | 1.0117 | V |
| | 10 V | | 9.883 | | 10.117 | V |
| 6 | A.C. measuring accuracy Channel B | 5.2.5 | | | | |
| | Zeroing | | -- | ..... | -- | mV |
| | 0.2 mV | | 0.174 | ..... | 0.223 | mV |
| | 10 mV | | 9.883 | ..... | 10.117 | mV |
| | 100 mV | | 98.83 | ..... | 101.17 | mV |
| | 1 V | | 0.9883 | ..... | 1.0117 | V |
| | 10 V | | 9.883 | | 10.117 | V |
| 7 | Analog outputs | 5.2.6 | | | | |
| | D.C.1 0 V | | -0.005 | ..... | 0.005 | V |
| | 3 V | | 2.995 | ..... | 3.005 | V |
| | D.C.2 0 V | | -0.005 | ..... | 0.005 | V |
| | 3 V | | 2.995 | ..... | 3.005 | V |
| 8 | Test generator | 5.2.7 | | | | |
| | 50 MHz $P_{OUT}$ | | 0.98 | ..... | 1.02 | mW |

## 5.2.8 Checking the Constant Currents Required for Temperature Measurement

The two constant currents (1 mA / 0.1 mA) are checked using the calibration adapter with an adapter connected ahead (fig. 5-3) in both channels.
The test can only be performed via IEC bus (calibration level).

- Connect the calibration adapter UZ-9 with connected adapter instead of the calibrator to the NRVD measuring head socket A in accordance with figure 5-3.

- Wait for completion of initialization.

The check is started using the following command strings:

- "SYST:LANG 'TO_CAL' "
- "CAL:DATE year,month,day" ..... [e. g.: "CAL:DATE 1999, 11,11"]
- "CAL:AMPL TEMP, value" ..... Value = -0.3 for 0.1mA sensor
  = -3 for 1mA sensor

The measurement is subsequently triggered

- "*TRG"

and the measured value appertaining to the sensor is read out via process controller.

- Insert the calibration adapter into channel B and initialize:

- "CAL:SENS:INIT"

- Perform the measurement for both temperature sensors analog to that in channel A.

The measured voltage can be defined as voltage drop at test resistor R1 caused by the constant current selected for measuring the temperature

$$V = \frac{3.01 * 200}{3.01 + 200} * I_{temp} \quad [V; mA]$$

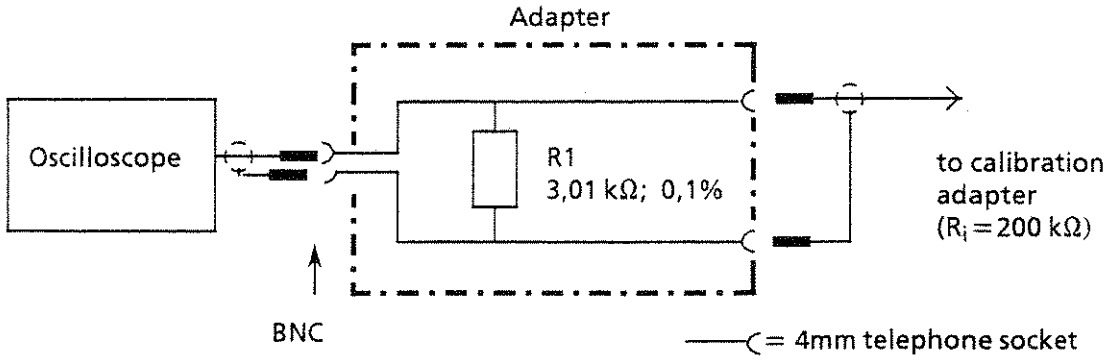



Bild 5-3 Test setup for checking the currents required for temperature measurement