



**ROHDE & SCHWARZ**

Test and Measurement  
Division

**Manual**

# **Directional Power Sensor**

**NRT-Z43**

1081.2905.02

**NRT-Z44**

1081.1309.02

Printed in the Federal  
Republic of Germany



# Tabbed Divider Overview

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Certificate No.: 960292

This is to certify that:

Equipment type	Order No.	Designation
NRT	1080.9506.02/.62	Power Reflection Meter
NRT-B1	1081.0902.02	Interface
NRT-B2	1081.0702.02	Two rear Input
NRT-B3	1081.0502.02	Battery Supply
NRT-Z3	1081.2705.02	RS232 Interface Adapter
NRT-Z4	1120.5005.02	PCMCIA Interface Adapter
NRT-Z43	1081.2905.02/.20	Directional Power Sensor
NRT-Z44	1081.1309.02/.03	Directional Power Sensor

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, 93/68/EEC)

Conformity is proven by compliance with the following standards:

EN61010-1 : 1993 + A2 : 1995  
EN50081-1 : 1992  
EN50082-1 : 1992

Affixing the EC conformity mark as from 1996

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

Munich, 2000-02-04

Central Quality Management FS-QZ / Becker



# 1 Putting into Operation

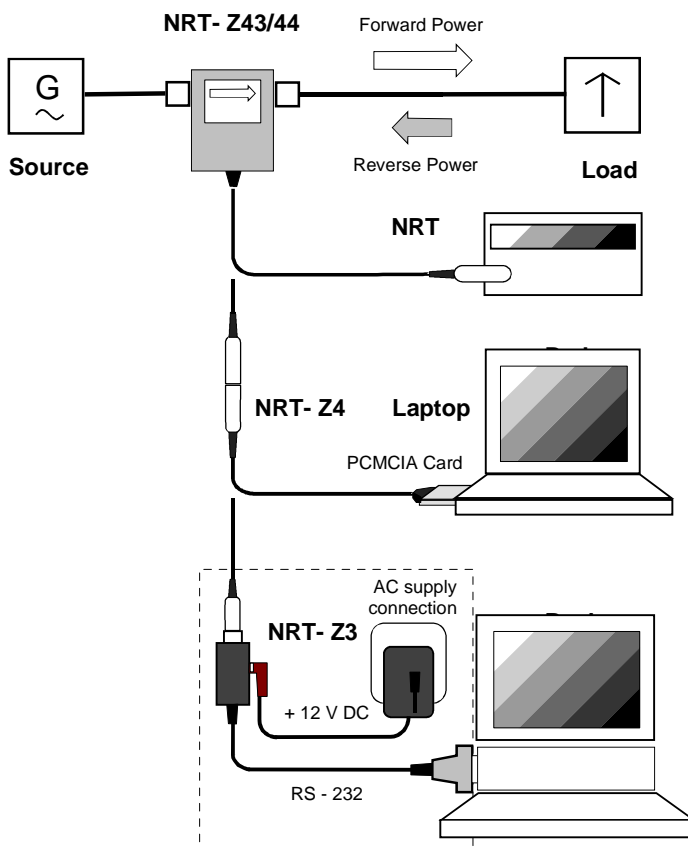


The following instructions should be strictly observed, in particular when putting the instrument into operation the first time, to avoid damage to the instrument and hazards to persons.

## 1.1 Unpacking

After unpacking the sensor, check for completeness of the delivery and carefully check all parts for any damage. In case of any damage you should immediately inform the responsible transport agent and keep all packing material so as not to forfeit your claims. The original packing should also be used for any later transport or shipment of the sensor.

## 1.2 Connecting the Sensor



**Fig. 1-1 Connection of power sensor**

The Directional Power Sensor may be operated from the basic unit NRT (see section 1.3) or from a PC/Laptop equipped with a serial RS-232 or PCMCIA interface. Interface adapter NRT-Z4 is required for the PCMCIA interface, interface adapter NRT-Z3 is required for the serial interface. The sensor is power-supplied via the NRT or the controller, the only exception being NRT-Z3 where an external plug-in power supply unit (provided with NRT-Z3) must be used.

The sensor between source and load and measures the power flow in both directions, ie from the source to the load (forward power) and conversely (reverse power). The ratio of forward and reverse power is a measure of the matching of the load which can be measured as standing wave ratio (SWR), return loss or reflection coefficient.

The Directional Power Sensors NRT-Z43/Z44 are of unsymmetrical design and should therefore be connected into the test circuit so that the arrow on the sensor points to the forward power direction. In this configuration, all measurement functions are available. Connecting the sensors the other way round is advisable if the average of forward powers below 7.5 W (NRT-Z43) or below 30 W (NRT-Z44) is to be measured with high accuracy and matching measurements are of secondary importance.

When measuring high power levels, the following instructions should be strictly observed to avoid damage to the sensor or injury to persons.



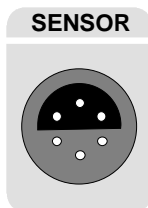
Do not exceed permissible continuous loading (see diagram on the rear).

Switch sensor into test circuit only with the RF power switched off.

Tighten RF connector by hand.

Non-observance may cause injuries, eg skin burns, damage to the instruments used and premature wear of the RF connectors.

## 1.3 Connecting the Sensor to Power Reflection Meter NRT



The sensor can be connected to the *SENSOR* connector on the front panel of NRT or to the *SENSOR 2* or *SENSOR 3* connector on the rear panel (only with Option NRT-B2). NRT should recognize the sensor in an initialization routine a few seconds after the connection is made or after power-up, respectively, and immediately start measurements.

Operation of NRT is described in detail in the associated operating manual.

## 1.4 Operating the Sensor via PCMCIA Interface Adapter NRT-Z4 from a PC

These applications require a controller with a PCMCIA type II connector and an interface adapter NRT-Z4. The sensor is power-supplied by the controller via the PCMCIA interface and handled as a peripheral unit equipped with a serial interface (COM1 to COM4).

The sensor may be operated using the supplied Windows™ user interface *Virtual NRT* (see chapter 2) or via an application program (chapter 3). The program *Virtual NRT* simulates the user interface of a power reflection meter on the monitor and enables manual power measurements.

### 1.4.1 Installing a PCMCIA Interface Card (SIO Card)

- Connect SIO card to sensor via connecting cable (see Fig. 1-2).
- Switch off controller and plug SIO card into the empty PCMCIA type II slot. The printed side of the SIO card must be turned upwards.
- Switch on controller and wait for booting.

The following steps depend upon the operating system used. They are described in detail on the installation disks of Interface Adapter NRT-Z4, see ASCII files *liesmich.txt* (German) or *readme.txt* (English).

The essential point is that the controller can access the SIO card after installation as a peripheral unit with serial interface.

- Connect sensor to the connecting cable and test it by means of the program *Virtual NRT* (chapter 2).

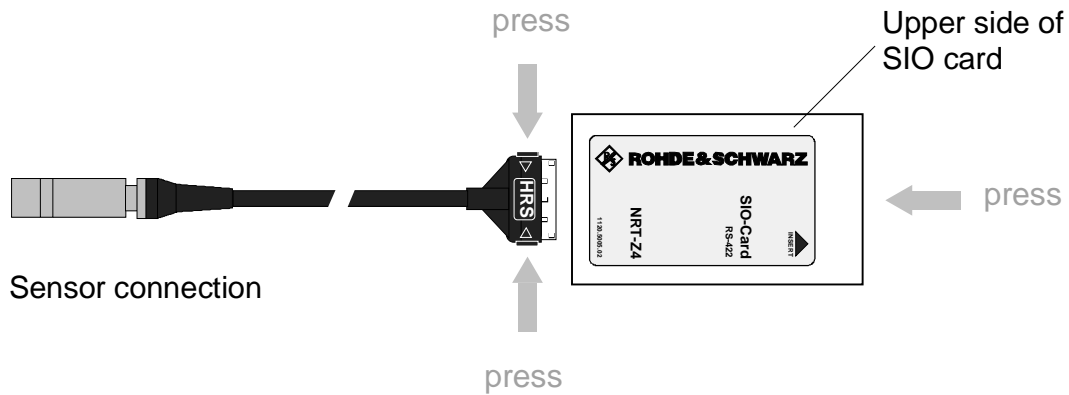
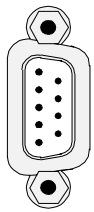


Fig. 1-2 Connecting the cable to the PCMCIA interface card (SIO card)

## 1.5 Operating the Sensor from PC via Interface Adapter NRT-Z3

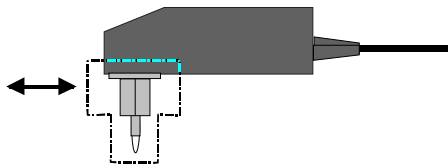


RS-232

The Directional Power Sensors NRT-Z43 and NRT-Z44 have been devised as a self-contained measuring instruments with remote-control capability via a serial RS-422 interface and can therefore be operated from a suitable computer. For use with a PC or laptop, Interface Adapter NRT-Z3 is available for connecting NRT-Z43/Z44 to a standard RS-232 interface (Fig. 1-1).

The sensor can be controlled via the supplied Windows™ user interface *Virtual NRT* (see chapter 2) or via a user program (chapter 3). The program *Virtual NRT* simulates the user interface of a power reflection meter on the monitor and enables manual power measurements.

## 1.6 Connection to AC Supply



The direct plug-in power supply for NRT-Z3 can be connected to any single-phase AC supply with a rated voltage from 100 to 240 V and a rated frequency from 50 to 60 Hz. It automatically adjusts itself to the local AC supply so that there is no need for external switchover.

Four adapter plugs (Euro, U.S.A., U.K., Australia) are supplied with the sensor to adapt the direct plug-in power supply to the socket outlet in question. For replacing an adapter, no tools are used but the adapter is withdrawn and another adapter inserted until it engages.

The following safety instructions should be observed:



**The direct plug-in power supply is intended for indoor use only.**

**Allow direct plug-in power supply with condensation to dry before connecting it to the AC supply.**

**Observe permissible ambient temperature range of 0°C to + 50°C.**

The direct plug-in power supply is internally fused. Replacement of fuse or opening of the unit is not possible.





## 2 Windows™ User Interface Virtual NRT (Rev. 1.50)

The disks supplied with sensors NRT-Z43/-Z44 contain a program simulating the main measurement functions of basic unit NRT in the form of a Windows user interface. The user interface was generated using the LabWindows CVI 5.01 development tool from National Instruments.

### 2.1 Installation

Two sets of floppy disks are available providing a 16-bit version of the program (for operation under Windows 3.x) and a 32-bit version (for operation under Windows 95/NT), respectively. Both program versions are installed by running the SETUP.EXE routine on disk 1 of the corresponding set.

### 2.2 Operation

Operation is on the whole self-explanatory. Before the program *Virtual NRT* is called up the sensor should be connected to the controller interfaces via the interface adapters NRT-Z3 or NRT-Z4, respectively. A few seconds after the user interface is displayed, when the pointers of the analog indication

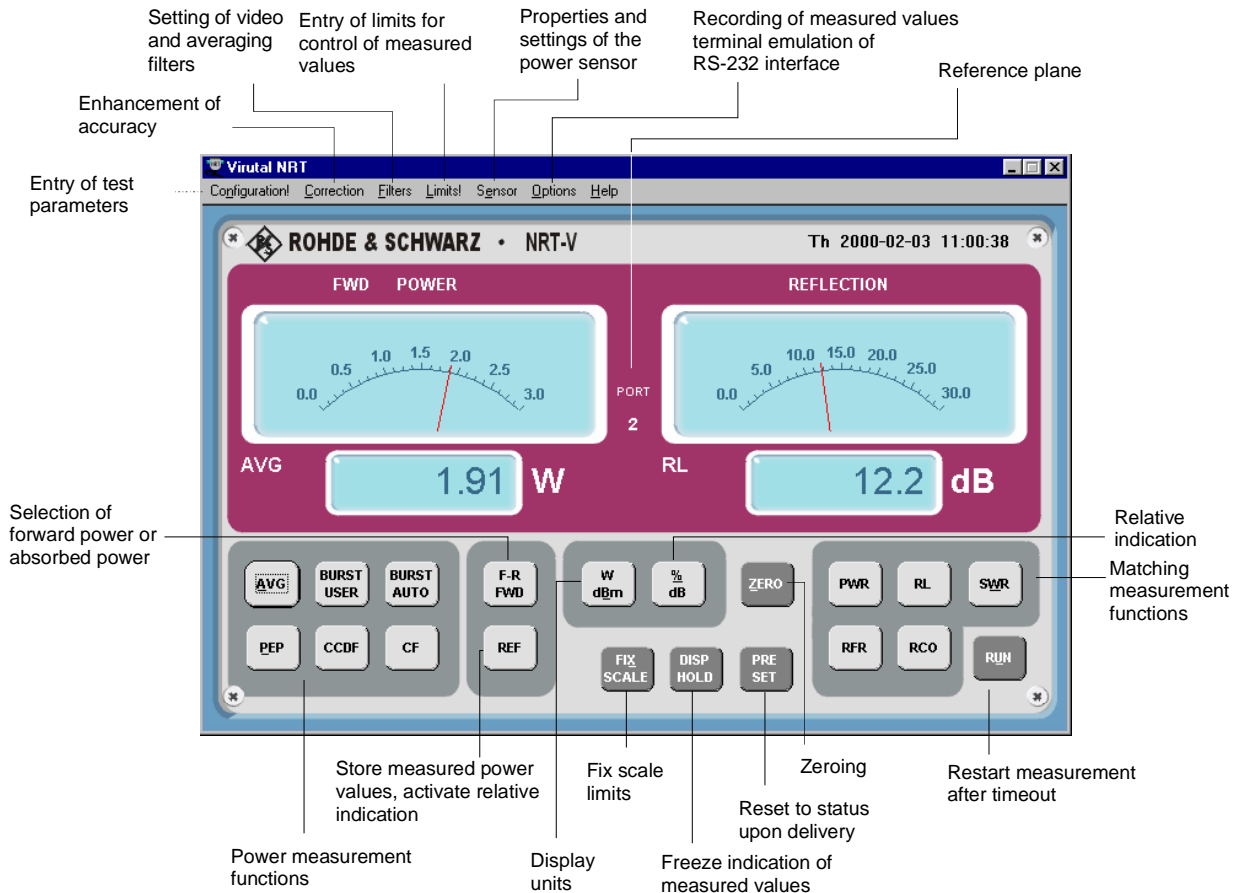


Fig. 2-1 Controls

start wiggling, the sensor is ready for operation. If communication with the sensor could not be established (display is grayed), the automatic configuration of the interface failed. In this case select the command *RS-232* in the *Options* menu and press the appropriate button to call up the automatic configuration again or configure manually. The interface settings are to be checked as explained below.

- Set baud rate to **38400** and check whether the sensor is set to this value, too (section 4.1).
- Select interface connection (**COMx**) assigned to the SIO card or used by interface adapter NRT-Z3,
- Press **OK** button,
- Press **RUN** button on the user interface.

The following tables give a rough survey of the measurement functions available. The on-line help provides a more detailed description.

Table 2-1 Key groups on the user interface

	General Parameter/Setting	Designation	Meaning	Section
<b>Control keys</b>	Power measurement functions (left)	<b>F-R FWD</b>	Switching over between forward power and absorbed power	<b>3.4.1.8</b>
		<b>AVG</b>	Average power	
		<b>BURST USER</b>	Average burst power (calculated)	
		<b>BURST AUTO</b>	Average burst power (measured)	
		<b>PEP</b>	Peak envelope power	
		<b>CCDF</b>	Complementary cumulative distribution function	
		<b>CF</b>	Crest factor in dB	
	Matching indication (right)	<b>PWR</b>	Reverse power	<b>3.4.1.12</b>
		<b>SWR</b>	Standing wave ratio	
		<b>RCO</b>	Reflection coefficient	
		<b>RL</b>	Return loss in dB	
		<b>RFR</b>	Ratio of reverse to forward power in %	
	Selection of unit	<b>W dBm</b>	Switching over between power indication in W and dBm	-----
	Relative indication	<b>% dB</b>	Switching over the relative indication between % and dB	-----
		<b>REF</b>	Stores measured power level as a reference value and switches on relative indication	-----
	Other	<b>ZERO</b>	Starts zeroing	<b>3.4.1.13</b>
		<b>PRESET</b>	Resets sensor to predefined values	<b>3.4.1.11</b>
<b>FIX SCALE</b>		Fixes scale end values of the analog display units	-----	
<b>DISP HOLD</b>		Freezes current measured values	-----	
On/off	<b>RUN</b>	Restarts measurement after RS232-timeout		

Table 2-2 Pop-up menus "Settings", "Sensor" and "Options"

	1st Level	2nd Level	Meaning	Section
<b>Menu Configuration!</b>	<b>Configuration</b>	<b>CCDF threshold</b>	CCDF threshold in W for forward power	<b>3.4.1.3</b>
		<b>Reference</b>	Reference power (see key REF)	-----
		<b>Burst width</b>	Burst width (for measurement function BURST(USER))	<b>3.4.1.2</b>
		<b>Burst period</b>	Period of a burst sequence (for measurement function BURST(USER))	
		<b>Integration time</b>	Integration time of A/D converter	<b>3.4.1.7</b>
<b>Menu Correction</b>	<b>Meas. Position...</b>	<b>Source</b>	Results referred to source port	<b>3.4.1.12</b>
		<b>Load</b>	Results referred to load port	
		<b>Offset</b>	Attenuation between power sensor and test point	<b>3.4.1.10</b>
	<b>Frequency...</b>		Frequency value for frequency response correction	<b>3.4.1.6</b>
	<b>Direction</b>	<b>Auto</b>	Automatic determination of forward power direction	<b>3.4.1.4</b>
		<b>1-&gt;2</b>	Forward power direction 1>2 (privileged direction)	
		<b>2-&gt;1</b>	Forward power direction 2>1 (inverse mode)	
	<b>Modulation</b>	<b>OFF</b>	Modulation correction off	<b>3.4.1.9</b>
		<b>IS95, DVB-T, DAB</b>	Modulation correction with fixed parameters for given standards	
		<b>WCDMA... / Chip Rate</b>	Modulation correction for digital standards with variable chip rate	
<b>Menu Filters</b>	<b>Video</b>	<b>4 kHz</b>	Video filter setting 4 kHz	<b>3.4.1.7</b>
		<b>200 kHz</b>	Video filter setting 200 kHz	
		<b>Full</b>	Video filter setting 4 MHz	
	<b>Smoothing</b>	<b>Auto</b>	Automatic setting of averaging filter (result-dependent)	
	<b>Length</b>	<b>1-256</b>	Number of results to be averaged with manual filter setting	
		<b>Resolution</b>	<b>Low</b>	
		<b>High</b>	Long averaging filter in Auto mode	

	1st Level	2nd Level	Meaning	Section	
<b>Menu Limits</b>	Limit entries	Upper / Lower limit	Dimensionless numerical value for upper/lower limit of monitored interval	-----	
		Warning if inside / out of bounds	Condition for warning to be displayed or for triggering	-----	
		Enabled	Warning on display enabled (results in red)	-----	
		Guardband trigger	Enables the guardband trigger for logging results	-----	
<b>Menu Sensor</b>	Specifications		Reads the power sensor specifications	3.4.2.4	
	Settings		Reads the power sensor status	3.4.2.5	
	Selftest		Triggers a selftest	3.4.4.3	
	Save / restore cal. data		Reads/enters calibration data	-----	
	Update firmware		Loads new firmware	-----	
<b>Menu Options</b>	Record functions...		Logs measurement results	S. 2.3	
	State Indicator		Window for response string from power sensor	3.3.2	
	Analog Panels		Switches the analog display off and on	-----	
	Direct communication...		Opens a window for direct communication with the sensor	3.3	
	Service functions...	Emulation mode		Alternating display of value 1 and 2 instead of results	-----
		Trigger Interval		Time interval between two display values for test and emulation mode	-----
	RS-232	COM Port		Sets the serial interface on the PC	-----
		Baud rate		Sets the baud rate on the PC	-----
		Auto config		Automatic configuration	-----
<b>Menu Help</b>	Help		Online help	-----	
	Info		Software version of <i>Virtual NRT</i> and connected sensor	-----	

## Recording measured data via the *Options - Record functions...* menu

The *REC* key opens a window for recording the measured values and displaying them graphically. The essential functions are described below.

<b>File Name</b> field	<p>The name of the file used to store the measured values is entered in this field. If no directory is available yet:</p> <ul style="list-style-type: none"><li>➤ Activate <i>Browse</i> softkey to call up a submenu and create a directory.</li></ul> <p><b>Note:</b> <i>The submenu can be closed only after a file name has been specified.</i></p>
Softkey <b>SHOW/HIDE FILE</b>	<p>Opens/closes a window indicating the file. From the left to the right, each line displays the following information:</p> <ul style="list-style-type: none"><li>Power measurement function, measured power,</li><li>Matching measurement function, measured matching,</li><li>date, time index and comment.</li></ul>
Softkey <b>SINGLE TRIGGER</b>	<p>Triggers a single measurement.</p>
Softkey <b>AUTO TRIGGER</b>	<p>Triggers continuous measurements. The functions available are described in detail under the <b>Auto Measurement</b> window.</p>
Softkey <b>SHOW/HIDE SCOPE</b>	<p>Opens/closes a window for continuous graphical display of the measured power and matching values. The trigger conditions are as described under the <b>Auto Measurement</b> window.</p> <p>The <b>FIX/AUTO SCALE</b> softkey can be used to toggle between manual and automatic scaling. Manual scaling implies that the scale end values are entered in the corresponding fields.</p> <p>The <b>SCALE ONCE</b> softkey enables a single autoscale procedure based on the measured values currently displayed.</p> <p>The <b>Number of Points</b> field is used to set the time resolution by specifying the number of points that can be displayed.</p>
<b>Index</b> field	<p>The current number of the next measurement can be set here (this number is automatically incremented).</p>
<b>Comment</b> field	<p>Comment field for the measured value. This visible string is appended to all following measured values.</p>
<b>Separator</b> field	<p>Defines the separator between the individual elements of the result (measurement function, measured value etc., refer to <b>SHOW FILE</b> softkey).</p>

---

<b>Auto Measurement window</b>	Enables continuous recording of measurement results.
<b>Guardband triggered</b>	Enables (a) measurement(s) as soon as the condition set in the <b>Limits!</b> menu (menu bar) is fulfilled. The time interval between the measurements is as set under <b>Interval [s]</b> .
<b>Time triggered</b>	<p>Enables (a) measurement(s) after a time interval set previously has passed. As soon as the start time defined for a timer listed in the <b>Active timers</b> table is reached, the number of measurements specified will be performed, separated by the selected time interval.</p> <p>The timers are configured by means of the fields <b>Start Time, Intervals [s]</b> and <b>Number of meas.</b> [alternatively: <b>Stop Time</b>] and the control pads <b>Daily, Workdaily</b> and <b>Weekly</b>. A timer is entered in the list via the <b>ENTER</b> softkey. The <b>DELETE</b> softkey allows to delete a timer marked previously.</p>
<b>TRIGGER NOW / STOP</b>	Starts/stops a series of measurements irrespective of the trigger conditions described above. The number of measurements and the time difference between them is set via the <b>Number of meas.</b> and <b>Interval [s]</b> fields.





## 3 Remote Control

This section is mainly directed at users who want to integrate Directional Power Sensors NRT-Z43 and NRT-Z44 into a remote-control measurement system or use the functions that are beyond the ordinary measurement mode.

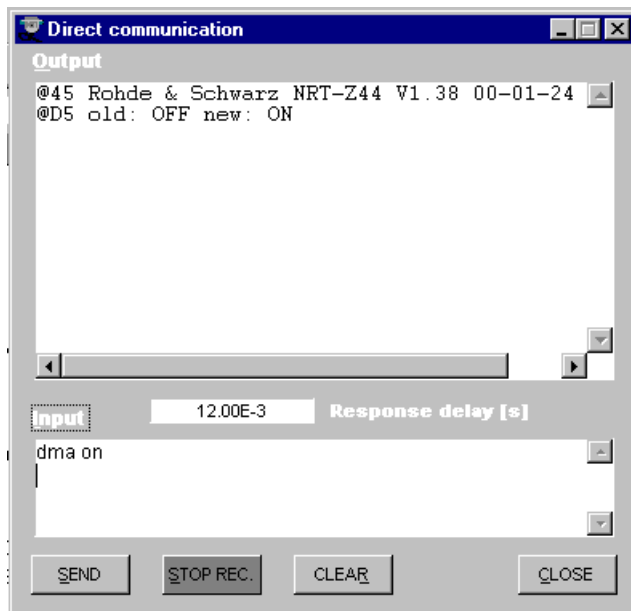
### 3.1 Remote Control via Virtual NRT

The program *Virtual NRT* allows to interrupt measurements controlled via the graphical user interface any time and to communicate with the sensor directly. In this way it is possible to monitor the sensor in remote control and to support the development of your own test program. Virtual NRT works like a terminal program (see next section), however, it is easier to handle all in all because it also manages the configuration of the host and the initialization of the sensor.

#### Proceed as follows:

- Start program *Virtual NRT* (see Chapter 2).
- Wait until measurement results are displayed.
- Call up *Options* menu, sub-menu *Direct Communication ...*:

The *Direct Communication* window is opened, the measurement is interrupted:



- Enter the desired command (e.g. ID) in the *Input* field and press the **SEND** button: The response of the sensor is displayed in the *Output* field.
- Before sending a new command, terminate the ready-to-receive state of *Virtual NRT* by pressing the **STOP REC.** button.
- Clear the receiver protocol as required using the **CLEAR** button and press **CLOSE** to terminate the direct communication.

## 3.2 Remote Control via Terminal Program

### 3.2.1 Interface Configuration of Sensor

To set up the connection successfully, the interface parameters of the sensor and the computer must correspond to each other. The sensor interface is set as follows:


Parity:	none
Data bits:	8
Stop bits:	1
Start bits:	1
Protocol:	XON / XOFF

The above settings are fixed except for the baud rate, which can be set to 4800, 9600, 19200 or 38400 baud (factory setting). The procedure for changing the baud rate is described in section 4.1.

### 3.2.2 Adaptation of Computer Interface

This section describes the configuration of the terminal programs supplied with 3.1™ and Windows 95/98/NT™.


#### Windows 3.1

- Open *Accessories* program group.
- Start *Terminal* program (double click on ).
- Open *Settings* menu and select *Communications* menu item.
- In the dialog field, set *Interface parameters* same as for sensor and select the port (*COM1 to COM4*) to which Interface Adapter NRT-Z3 is connected or which is emulated by Interface Adapter NRT-Z4.
- Conform entries with *OK*.
- Open *Settings* menu and select *Terminal preferences* menu item.
- In the dialog field, activate *Local echo* and *CR->CR/LF Outband* control boxes. This will cause the characters sent to the sensor to be displayed on the monitor. Confirm settings with *OK*.

The connection to the sensor should now be established (for test of connection see next section).

**Note:** *The settings made can be stored on exiting the terminal program and restored via the **File** menu and the **Open...** menu item when the program is called up again.*

#### Windows 95/98/NT

- Open *Hyper Terminal* directory via *Start*→*Programs*→(*Communication*→)*Accessories*.
- Start *Hypertrm.exe* program (double click on ).
- In the dialog field (*Description of connection* or *Connect to*), enter designation, eg *NRT\_Z44*, select any symbol and confirm with *OK*.
- In the next dialog field, enter the port to which Interface Adapter NRT-Z3 is connected or which is emulated by Interface Adapter NRT-Z4 and confirm entry with *OK*.
- In the COM characteristics dialog field, set interface parameters same as for sensor and confirm entries with *OK*.

- Open *File* menu and select *Characteristics* menu item. In the associated dialog field, click on *Settings* index card and there click on *ASCII Configuration*. The *ASCII Configuration* dialog field will open.
- Activate the following control boxes: end of transmitted lines with LF, and local echo. This will cause the characters sent to the sensor to be displayed on the monitor. Confirm settings with *OK*.

The connection to the sensor should now be established (for test of connection see next section).

**Note:** *On exiting Hyperterm.exe, the user is prompted to save the NRT-Z43/Z44 session. If **Yes** is entered, a new symbol with the name **NRT\_Zxx.ht** will be generated in the **Hyper Terminal** file. This symbol allows **Hyperterm.exe** to be called with the parameters set for the sensor.*

### 3.2.3 Testing the Connection

The Directional Power Sensors NRT-Z43 and NRT-Z44 re ready for operation immediately on power-up. If an entry is made, the sensors should respond with one or several lines.

**Example:**

- Enter the word *messen* via one of the two terminal programs and confirm with the return key. The sensor should respond with the line  

```
@96 Error SYNTAX (messen)_____
```

or, while the power-up test is active, with  

```
@9B busy_____
```

To be able to operate the sensor, the `appl` command must be sent so many numbers of times until the sensor responds with the line

```
@8E oper_____
```

(after 20 s at the latest). After this, settings can be made and results queried.

If the `id` command is output, the sensor should send its identification string in response, for example:

```
@7F Rohde & Schwarz NRT-Z44 V1.0 12/16/96 14:35_
```

The `ftrg` query command should produce the following response:

```
@3F +2.1234E+01 3.4567E-03 __avpw15511_____
```

The lefthand numerical value is the result obtained for measurement direction 1>2 (in this case 21.234 W average power), the righthand numerical value represents the result obtained for measurement direction 2>1 (in this case 3.45 mW reverse power). The righthand block of characters (`__avpw15511`) indicates the device status in coded form. Detailed information on the format and meaning of commands and device responses will be found in the following sections.

**Note on switch-on phase:**

On power-up, the sensor is in the boot mode. In this mode, new firmware can be loaded. The boot mode is exited automatically after 10 s, or with the `appl` command. In each case the sensor outputs the message

```
@8C boot_____
```

Then a power-up test is performed for approx. 7 s. The power-up test must not be interrupted. If a command is sent during this time, the sensor responds with

```
@9B busy_____
```

Upon completion of the power-up test, the `appl` command must be sent again to cause the sensor to go to the measurement mode. The following response is obtained:

```
@8C boot_____
```

After this, the sensor is ready for operation. If `appl` was sent one more time, the following response would be obtained:

```
@8E oper_____
```

### 3.3 Device-Dependent Messages

Device-dependent messages are transmitted on the TXD and RXD pair of lines of the serial RS-422 interface. The ASCII code (ISO 7-bit code) is used. All device-dependent messages are line-oriented. A message line consists of several ASCII characters terminated by at least one end-of-line character.

A message sent to the sensor may be max. 255 characters long. Accepted end-of-line characters are all characters in the ASCII code range 1 to 13 (0D hex). Power Sensor NRT-Z43/Z44 terminates its responses with the character combination 13 (0D hex) + 10 (0A hex).

#### 3.3.1 Structure and Syntax of Device-Dependent Messages

The command syntax was designed with a view to maximum speed rather than complete compliance with the SCPI standard. Device-dependent messages can be divided into three categories:

- **setting commands**
- **query commands**
- **device responses**

Messages belonging to the first two categories (commands) are sent by the controller to the sensor. Device responses are sent from the sensor to the controller.

#### 3.3.2 Setting Commands and Query Commands

The syntax has a tree structure comprising several hierarchical levels. Function calls are made from different hierarchical levels depending on the expected frequency of application, the logic group assignment and the required speed of execution.

The number of keywords that make up a command corresponds to the number of its hierarchical levels. The keywords of a command must be separated from one another by means of colons.

- The keywords except for the last one describe *command groups* and are in the following referred to as *group descriptors*.
- The last word describes the *function* and is referred to as *function descriptor*.

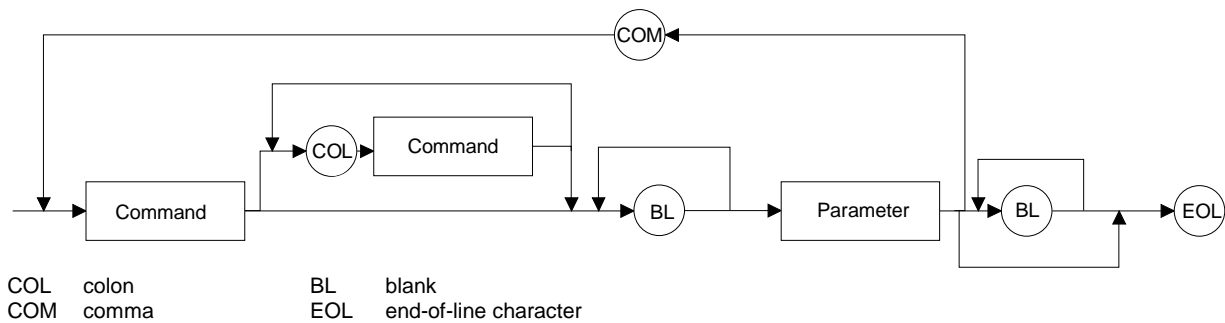
If an input parameter is added to a command, it must be separated from the function descriptor by at least one blank.

**Typical structure of hierarchical commands:**

```
main group : subgroup : function parameter
main group : function parameter
```

Group and function descriptors consist of two to five characters. Refer to the Annex for an alphabetical list of all commands used.

A command is complete with the function descriptor and, if applicable, the associated input parameter. Terminated with an end-of-line character, the command should be understandable to the sensor. Several commands can be strung in a command line; they must be separated by commas.



**Fig. 3-1 Syntax Graph of a Command Line**

If a command is not understood, the error message `Error SYNTAX(XXXX)` is returned. "XXXX" represents the command or part of command that was not understood.

### Examples:

The setting command

```
➤ FR: AVER
```

will produce the device response

```
@6C Error SYNTAX(fr:aver)_____
```

In this case, the command as a whole is not understood since the first group descriptor is erroneous.

In the next example, the function descriptor is not understood:

```
➤ FOR: AVR
```

```
@71 Error SYNTAX(avr)_____
```

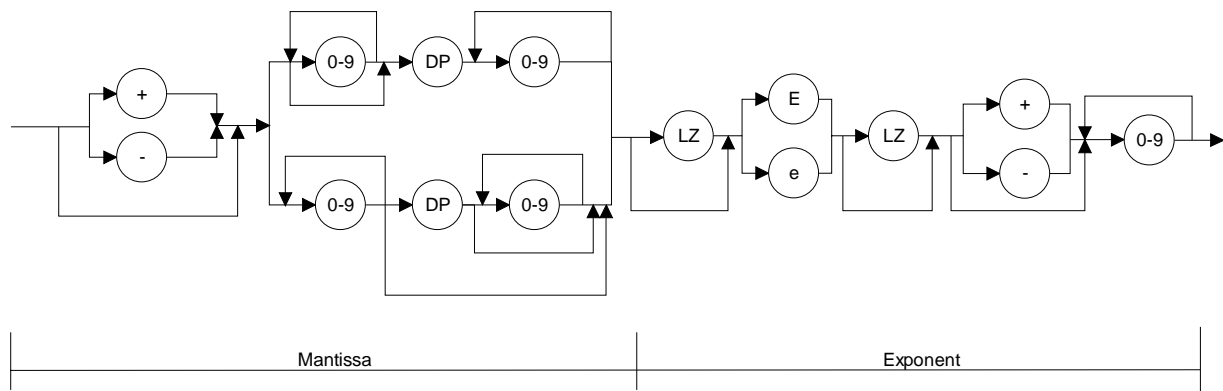
### 3.3.2.1 Input Parameters

Input parameters can represent several data types: floating-point numbers, integers and text:

**Floating-point numbers** are understood by the sensors NRT-Z43 and NRT-Z44 in all common representations. It is allowed to omit leading zeros, positive signs of mantissas or exponents, and a decimal point at the rightmost digit of the mantissa. The number 53, for example, can be entered in the following representations:

```
53
0.53e+2
.5300e+02
+005.3E01
5300e-002
```

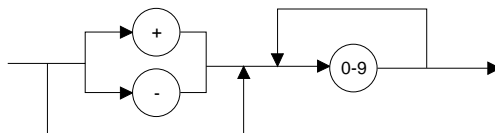
Exponent are to be introduced by the character **E** or **e** exclusively. The range of numbers is from -32000 to +32000. Exponents without mantissa are not allowed.



**Fig. 3-2 Syntax graph of floating-point number**

### Integers

may have a positive or negative sign depending on the range of values. Positive signs may be omitted. If an integer parameter contains a character not belonging to the character set [0 to 9, +, -], the character in question and all subsequent characters will be ignored. No error message will be output in this case.



**Fig. 3-3 Syntax graph of integer**

### Input limits

exist for all number parameters. Any attempt to enter a parameter outside the defined range of values will be rejected with the error message `Error RANGE`. Correct entries will be acknowledged with

```
old:<old parameter> new:<new parameter>
```

**Text parameters** are restricted to a few words such as USER, DEF, LOW, HIGH, etc. Text parameters may contain only the characters specified in the syntax tables. The use of upper- or lower-case letters is however optional.

## 3.3.3 Device Responses

The sensor returns **at least one** line in response to each message. If no response is received, this indicates that there is a communication problem between the controller and the sensor.

Device responses can be made up of texts, integers and floating-point numbers. The structure of device responses is explained in detail for each query command. All device responses have a header with a checksum. Apart from this, single-line and multiple-line responses have different structures.

### Line length

With the sensor switched on, all response lines have a uniform length of 50 characters including the end-of-line characters CR and LF. Device responses shorter than 50 characters are filled with '\_' (ASCII 95 dec., 5F hex.). This allows DMA-supported transfer to the controller.

For time-critical applications (without DMA), the filling-up to 50 characters can be switched off with the command `DMA OFF` (see section 3.4.3.4, DMA).

### 3.3.3.1 Checksum Header

A checksum header is placed at the beginning of each response line to enable the detection of transmission errors. The header starts with '@', which is followed by the last two digits of the hexadecimal checksum and a blank:

```
@EF +8.1234E-02 3.4567E-03_____CR
LF
```

The checksum is formed from the sum of all ASCII codes from the fifth character.

### 3.3.3.2 Status Field

The status field comprises 11 characters and holds information on the validity of measured values. The status field can optionally be added to the relevant device responses (see command `DISP:STAT ON|OFF` in section 3.4.1.5).

The first character of the status field indicates whether a hardware error is present. If no error is present, '\_' is output; an error is indicated by 'e' (error). The criteria for a hardware error are identical to those applicable to the response 'ERROR' in the selftest (see section 3.4.4.3, `SERV:TEST`).

The second character indicates whether defined measurement limits are complied with. Values below the specified power range or outside the allowed temperature range are indicated by 'i' (invalid). Values above the specified power range are indicated by 'o' (overrange). If all conditions are met, '\_' is output.

The third and fourth character of the status field indicate the test function of the forward channel (see section 3.4.1.8, `FOR`):

av	-	average power (AVER)
cd	-	distribution function (CCDF)
cf	-	crest factor (CF)
cb	-	calculated burst average (CBAV)
mb	-	measured burst average (MBAV)
pp	-	peak envelope power (PEP)

The fifth and the sixth character indicate the test function of the reverse channel (see section 3.4.1.14, `REV`):

pw	-	average power (POW)
rc	-	reflection coefficient (RCO)
rl	-	return loss (RL)
sw	-	standing wave ratio (SWR)

The seventh character indicates the forward power direction (see section 3.4.1.4, `DIR`):

1	-	privileged direction (source at port 1)
2	-	inverse mode (source at port 2)

The last four characters of the status field indicate the settings of the averaging filters for the physical measurement channel (see section 3.4.1.7, `FILT:AVER`):

average power (forward)	7th character
average power (reverse)	8th character
peak envelope power	9th character
distribution function	10th character

Averaging is made over  $2^N$  values. The exponent N (0 to 9) is output as an ASCII character for each measurement channel.



**Examples** of device responses with status field upon triggering a measured value:

```
➤ DISP:STAT ON, FTRG
@HH +2.1234E+01 3.4567E-03 __avpw15511_____
```

The response is valid: no hardware error, no overrange or underrange. The indicated measured values are the average powers in the forward and reverse channels. Averaging was made over  $2^5 = 32$  values in each channel.

```
@HH +9.4823E+03 5.9999E-03 e_mbrc12200_____
```

The response is invalid since a hardware error is signalled.

```
@HH +3.5277E-04 3.4567E-04 _ipprc22211_____
```

The response is questionable since the peak envelope power (specified min. 0.4 W for NRT-Z44 in data sheet) is smaller than the specified value.

```
@HH +3.3244E+02_1.2110E+01 _oavrc13300_____
```

Overrange: the forward power exceeds the permissible measurement range (max. 300 W average forward power for NRT-Z44).

### 3.3.3.3 Multiple-Line Responses

Some device responses take up several lines (eg for query command 'SPEC'). To reliably detect transmission errors in this case, too, and to make interpretation easier, multiple-line responses are output together with additional information:

The keyword 'pack xx' is placed at the beginning of the first line of a multiple-line response, with 'xx' indicating the number of lines to be expected. Each of the subsequent response lines come with a two-digit line number after the checksum header. It is thus easy to recognize missing lines if transmission is disturbed.

Below is an example of multiple-line response with 'HH' standing for the checksum header and 'xxxxxxx' representing the useful information:

```
@HH pack 06
@HH 01 xxxxxxx
@HH 02 xxxxxxx
@HH 03 xxxxxxx
@HH 04 xxxxxxx
@HH 05 xxxxxxx
@HH 06 xxxxxxx
```

### 3.3.3.4 'busy' Status Message

Following commands which require a long execution time, entry of a subsequent command might cause the sensor to issue the warning

```
@HH busy_____...
```

This means that the subsequent command was ignored and must be transmitted once again.

### 3.3.3.5 Status Messages via "?"-Command

Depending on the operating mode of the sensor the command "?" can cause two different responses:

@HH occupied\_\_\_\_\_... or @HH idle\_\_\_\_\_...

These responses are not subject to any processing time. `idle` indicates that the sensor is waiting for new commands to be executed immediately. `occupied` signals an ongoing measurement.

## 3.4 Description of Commands

In addition to the following detailed description of commands, the annex provides a list of all commands in alphabetical order.

### 3.4.1 Measurement Functions: Setting Commands

Measurement functions are understood to be all commands that directly or indirectly generate or influence results. The commands are divided into *setting commands* and *query commands*.

All parameters are given with the common basic units (W, s, Hz). It is however not permissible to transmit the unit together with the parameter.

#### 3.4.1.1 Overview of Setting Commands

**Table 3-1**                      **Setting Commands**

Command	Parameter	Default setting	Description / Response
BURS:PER	BURS:WIDT ... 1.0 (s)	0.01 (s)	Burst period (for measurement function FOR:CBAV)
BURS:WIDT	1E-9 ... BURS:PER	0.001 (s)	Burst width (for measurement function FOR:CBAV)
CCDF	1 to 300 (W) 0.25 to 75(W)	1 (W) 1 (W)	CCDF threshold for NRT-Z44 CCDF threshold for NRT-Z43
DIR	AUTO DIR:1>2 DIR:2>1	AUTO	Automatic determination of forward power direction Forward power direction 1 > 2 (privileged direction) Forward power direction 2 > 1 (inverse mode)
DISP:FORW	ON   OFF	ON	Device response with / without result for forward measurement function
DISP:REFL	ON   OFF	ON	Device response with / without result for reverse measurement function
DISP:STAT	ON   OFF	ON	Device response with / without status field
FREQ	2E8 to 4E9 (Hz)	1E9 (Hz)	Frequency value for frequency response correction
FILT:AVER:COUN	1, 2, 4, 8, 16, 32, 64, 128, 256	1	Count of averaging filter with user-defined setting
FILT:AVER:MODE	AUTO   USER	AUTO	Count of averaging filter is set automatically (as a function of measured value) or user-defined
FILT:INT:MODE	DEF   USER	DEF	Integration time of A/D converters is set to default value (0.037 s) or to user-defined value
FILT:INT:TIME	5E-3...0.111 (s)	0.037 (s)	Integration time of A/D converters with user-defined setting
FILT:RES	LOW   HIGH	LOW	Results are displayed with 3½ or 4½-digit resolution (in conjunction with FILT:AVER:MODE AUTO)
FILT:SPSP	ON   OFF	OFF	Video filter in spread-spectrum setting, replaced by MOD command group
FILT:VID	4E3, 2E5, 4E6 (Hz)	2E5 (Hz)	Video filter in setting 4 kHz, 200 kHz or 4 MHz

Command	Parameter	Default setting	Description / Response
<b>FOR: . . .</b>		AVER	<b>Forward measurement functions</b>
FOR:AVER			Average power
FOR:CBAV			Average burst power (calculated)
FOR:CCDF			Complementary cumulative distribution function
FOR:CF			Ratio of peak envelope power to average power
FOR:MBAV			Average burst power (measured)
FOR:PEP			Peak envelope power
MOD:RATE	0...8.2E6 (s <sup>-1</sup> )	4.096E6 (s <sup>-1</sup> )	Chip-Rate bei WCDMA
MOD:TYPE	IS95   WCDMA   DVBT   DAB   OFF	OFF	Meßwertkorrektur für digital modulierte Signale ein / aus
OFFS	0...100 (dB)	0 (dB)	Dämpfung eines Verbindungskabels berücksichtigen
PEP:HOLD	DEF   USER	DEF	Hold time of peak hold circuit is set to default value or to user-defined value
PEP:TIME	1E-3 to 0.1 (s)	0.06 (s)	Hold time with user-defined setting
PORT	SOUR   LOAD	LOAD	Results are referred to the source or load port
RESET			Unit is set to defined initial state
<b>REV: . . .</b>		RL	<b>Reverse measurement functions</b>
REV:POW			Power (for details see Table 3-3)
REV:RCO			Reflection coefficient
REV:RL			Return loss
REV:SWR			Standing wave ratio
ZERO	none   0		Zeroing   undo zeroing

### 3.4.1.2 BURS

Function descriptors: **PER, WIDT**

The measurement function CBAV (Calculated Burst Average, see section 3.4.1.8) calculates, for RF bursts with rectangular envelope, the average burst power on the basis of the average power. The burst period and the burst width must be entered into the power sensor.

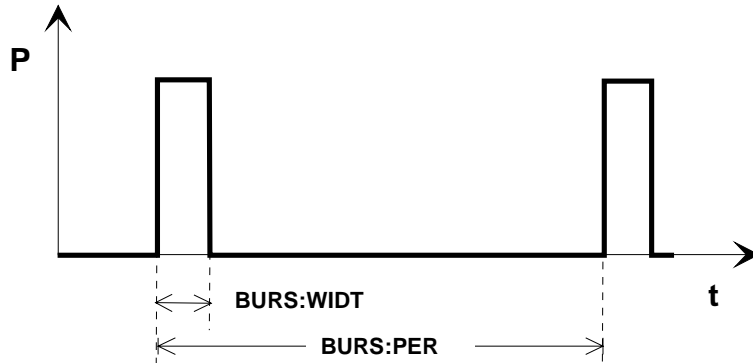


Fig. 3-4 Envelope power characteristic of a burst signal

**BURS:PER** <Burst period in s>

Input range: BURS:WIDT to 1.0

Default setting: 1E-2

**BURS:WIDT** <Burst width in s>

Input range:  $10^{-9}$  to BURS:PER

Default setting: 1E-3

**Example:**

```
➤ BURS:PER 40e-3
@HH_old:x.xxxxEsxx_new: 40E-5

➤ BURS:WIDT 6.667e-3
@HH_old:x.xxxxEsxx_new:6.6670e-03
```

### 3.4.1.3 CCDF

Parameter: CCDF threshold in W  
 Input range: 1 ... 300 (NRT-Z44)  
               0.25 ... 75 (NRT-Z43)  
 Default setting: 1

The CCDF function (complementary cumulative distribution function) measures the probability of the forward power envelope to exceed a given threshold (see section 3.4.1.8, FOR:CCDF). The threshold is entered with command CCDF. It applies to the measurement position defined with the commands PORT and OFFS (see sections 3.4.1.10 and 3.4.1.11).

### 3.4.1.4 DIR

Parameter: AUTO, 1>2, 2>1  
 Default setting: AUTO

With DIR, the direction of the forward power relative to the sensor ports 1 and 2 is fixed. In the AUTO mode, the assignment is made automatically by the power sensor, which interprets the greater of the two measured powers as forward power.

The AUTO mode may not be advisable if the forward and the reverse powers are approximately equal (total reflection). In this case it may happen that the automatic assignment is wrong because, due to a measurement error, a higher value is determined for the reverse than for the forward power. With DIR:1>2 and DIR:2>1, the direction of the forward power can be fixed independently of the powers measured.

In the normal case the power sensor should be inserted in the test circuit such that the source is connected to port 1 and the load to port 2. In this way the forward signal can be processed in the F path of the power sensor and the (usually smaller) reverse signal in the R path, whose sensitivity is 10 dB higher. Moreover, the F path is capable of measuring the peak power and the complementary cumulative distribution function (CCDF). To connect the power sensor, the other way round (ie source at port 2) is advisable if high-speed average measurements are to be made of forward powers below 7.5 W (NRT-Z43) or 30 W (NRT-Z44) and less importance is attached to SWR measurements.

**1>2**                    The wave from port 1 to port 2 is defined as the forward wave.  
**2>1**                    The wave from port 2 to port 1 is defined as the forward wave.  
**AUTO**                  The higher of the two averaged powers is interpreted as forward power.

### 3.4.1.5 DISP

**Function descriptors:                    FORW, REFL, STAT**

With the DISP command group, the triggered device responses can be set as follows:

<b>DISP:FORW</b>	<b>ON   OFF</b>	with / without result for forward measurement function
<b>DISP:REFL</b>	<b>ON   OFF</b>	with / without result for reverse measurement function
<b>DISP:STAT</b>	<b>ON   OFF</b>	with / without status field
Default setting:	ON	(valid for all of the three Function descriptors)

Switching off information that is not required will enhance the measurement speed.

#### Examples:

```
➤   RESET                               Activates default settings
@HH OK_____

➤   DMA OFF                             Switches filling-up to 50 characters off
@HH old:ON new:OFF

➤   RTRG                                 Requests result
@HH +1.2345E+02 +3.2851E-02 __avrc13200

➤   DISP:FORW OFF                       Switches off forward power display
@HH old:ON new:OFF

➤   RTRG
@HH +3.2851E-02 __avrc13200

➤   DISP:FORW ON, DISP:STAT OFF         Switches on forward power display
                                          and switches off status display
```

```
@HH old:OFF new:ON
@HH old:ON new:OFF

➤ RTRG
@HH +1.2345E+02 +3.2851E-02
```

For several commands separated by commas, the responses are output in consecutive order

### 3.4.1.6 FREQ

Parameters: Carrier frequency in Hz  
 Input range: 2E8 ... 4E9  
 Default setting: 1E9

This command is used for transmitting the carrier frequency of the test signal to the power sensor. With this information it is possible to take into account the characteristic frequency response of a power sensor and correct results accordingly. Correction is made for the forward and the reverse channel. The values between the stored correction factors are obtained by way of linear interpolation. To achieve the measurement accuracy specified in the data sheet, the frequency must be entered with an accuracy of about 5%.

### 3.4.1.7 FILT

Function descriptors: AVER, INT, RES, SPSP, VID

The FILT group of commands sets the averaging filters of the individual measurement paths, the integration time of the A/D converters and the video filters.

#### FILT:AVER

Function descriptors: COUN, MODE

Averaging of measured values can be performed to compensate for measured-value variations which may occur with unstable test signals or low powers. In the free-running mode (trigger setting FTRG), a "running average" is formed, ie a fixed number of measured values is averaged continuously, yielding a new output value with every new measured value. The oldest measured value is removed from the filtering process (Fig. 3-5). Averaging can be made over 2, 4, 8, 16, 32, 64, 128, or 256 measured values.

The higher the number of values averaged, the greater the filtering effect. In the optimal case, measured-value variations will be halved at four times the filter count. Since, on the other hand, measurement time increases proportionally to the filter count, averaging over more than 32 values is as a rule not advisable.

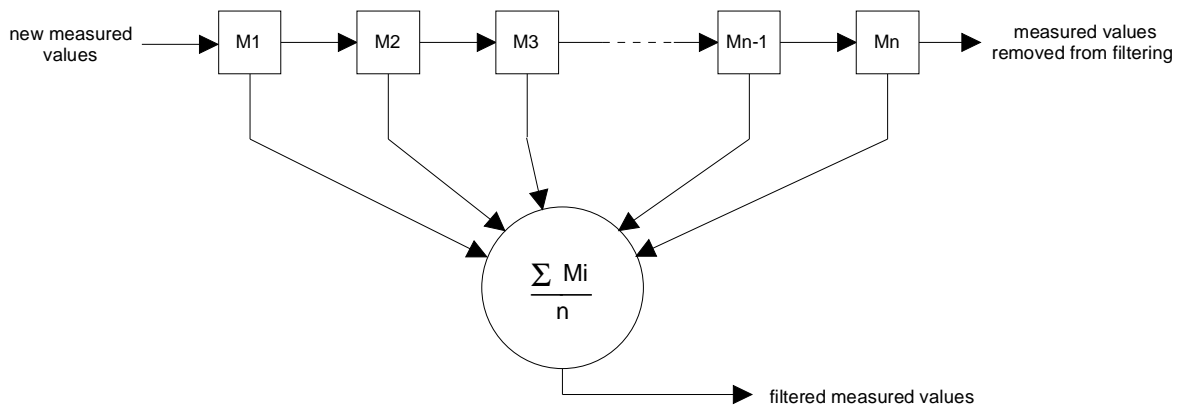


Fig. 3-5 Averaging filter

**FILT:AVER:COUN**

Parameters: 1, 2, 4, 8, 16, 32, 64, 128, 256

Default setting: 1

With this command, a unique, fixed count of the averaging filter can be entered for all measurement paths (average forward power, average reverse power, peak power and CCDF function). If the entry is valid, the USER mode is automatically switched on and automatic filtering switched off (see command `FILT:AVER:MODE`). A filter count of 1 means that no averaging takes place and each measured value is output immediately.

**FILT:AVER:MODE**

Parameters: AUTO, USER

Default setting: AUTO

In the AUTO mode, the count of the averaging filters is selected as a function of the forward power, the test function, the integration time of the A/D-converters, and the desired resolution of results (command `FILT:RES LOW|HIGH`). The smaller the power measured, ie the higher the relative percentage of random measured-value variations, and the higher the resolution, the greater the number of measured values averaged. Non-averaged measured values will be obtained in the AUTO mode only with low resolution (`FILT:RES LOW`) and at comparatively high powers (level depending on measurement function). For further information on measurement speed refer to specifications.

In the USER mode, the power sensor operates at a fixed filter count for all measurement paths, ie the value last entered by means of command `FILT:AVER:COUN` (see above).

**FILT:INT****Function descriptors: MODE, TIME**

These commands are used for selecting the integration time of the A/D converters in the two measurement channels. This setting has an effect on the stability of results at low powers (noise) and with low-frequency modulation of the envelope. The default value of 0.037 s, on which all specifications are based, results in a suppression of low-frequency modulation as from 20 Hz and in optimum noise reduction.

Modulation frequencies below 20 Hz, however, may require the integration time to be increased beyond its default value in order to stabilize the displayed power in the functions `FOR:AVER` (average forward power), `FOR:MBAV` and `FOR CBAV` (average burst power). Ideally, the integration time should be set equal to the period of the envelope modulation. Low-frequency envelope modulation may also occur for digitally modulated radio signals, due to the so-called idle bursts which are regularly included in the transmitted signal (about every 60 ms for GSM).

For triggered measurements, the measurement speed can be increased by reducing the integration time provided that the averaging factor remains unchanged. In the automatic filter setting mode (`FILT:AVER:MODE:AUTO`), this condition is fulfilled only for sufficiently high powers. If an averaging filter is already active while the integration time is set to its default value, further reduction of the integration time will generally result in an automatic enhancement of the averaging factor so that, on the whole, no gain in the measurement speed can be achieved.

**FILT:INT:MODE**

Parameters: DEF, USER

Default setting: DEF (0.037 s)

With this command, a default value (DEF) or a user-defined value (USER) can be selected as integration time. In the USER mode, the value last entered by means of command `FILT:INT:TIME` (see below) is used as integration time.



**FILT:INT:TIME**

Parameter: integration time in s  
 Input range: 5E-3 ... 0.1111  
 Default setting: 0.037

This command serves for user-defined setting of the integration time. If the entry is valid, the USER mode is switched on automatically and the default value is switched off (see above, command `FILT:INT:MODE`).

**FILT:RES**

Parameters: LOW, HIGH  
 Default setting: LOW

The resolution influences the automatic averaging of measured values. With high resolution (HIGH), the averaging effect will be greater so that results can be displayed with a greater number of digits. In the case of automatic filtering, the average of forward power above 0.1 W (NRT-Z43) or 1 W (NRT-Z44) can be displayed with 3½ (LOW) or 4½ digits (HIGH). The command `FILT:RES LOW|HIGH` will always result in automatic averaging; the command `FILT:AVER:MODE AUTO` need not be sent in this case.

**NOTE:** *Measured values are output in a fixed number format which is not affected by the resolution. Non-significant digits must be truncated by the user program in question corresponding to the desired resolution.*

**FILT:SPSP**

Parameters: ON | OFF  
 Default setting: OFF

With older firmware versions, this command was used for setting the video bandwidth for the functions CCDF, CF and PEP when spread-spectrum signals (IS95, WCDMA, DVBT, DAB) were to be measured. The function has been replaced by the *MOD* command group.

**FILT:VID**

Parameter: video bandwidth in Hz  
 Possible input: 4E3, 2E5, 4E6  
 Default setting: 2E5

The video bandwidth defines the passband (starting at DC) of the forward channel for the rectified signal. Fig. 3-6 shows that this setting has a decisive influence on the time characteristic of the envelope signal and thus on all measurement functions related to this signal:

- peak envelope power (PEP)
- crest factor (CF)
- complementary cumulative distribution function (CCDF)
- measured burst average (MBAV)

The video bandwidth should be selected as small as possible to obtain stable results even at low forward powers (noise reduction). It should not be selected too small, however, as otherwise significant distortion of the demodulated signal may result. As a rule of thumb, the video bandwidth should be about 2 to 3 times the bandwidth of the measured signal at the RF (exception: measurement function MBAV).

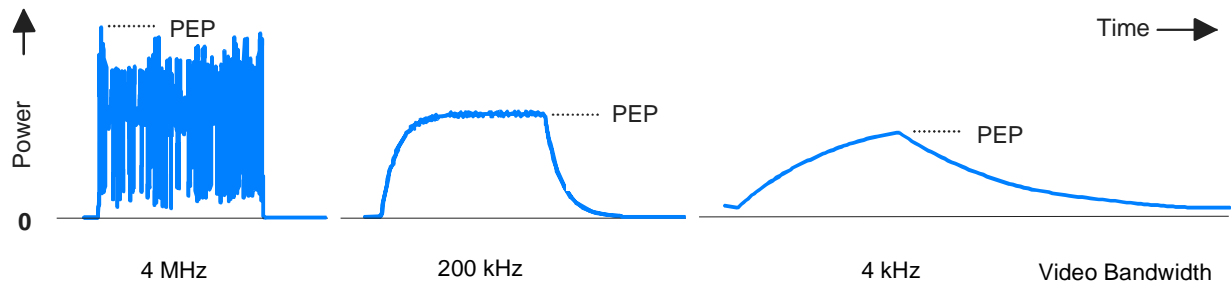


Fig. 3-6 Influence of video bandwidth on rectified signal

The following table shows the bandwidth settings for a number of common waveforms. The settings allow transmission of the rectified signal largely free from distortion.

Table 3-2 Video bandwidth settings for common waveforms

Waveform		Video-Bandbreite <b>FILT:VID...</b>
AM	Mod. frequency ≤ 1 kHz	4E3 (4 kHz)
AM	Mod. frequency ≤ 50 kHz	2E5 (200 kHz)
CW burst	Burst width ≥ 150 μs	4E3 (4 kHz)
CW burst	Burst width ≥ 3 μs	2E5 (200 kHz)
CW burst	Burst width ≥ 200 ns	4E6 (4 MHz)
π/4 DQPSK	Symbol rate ≤ 24 k/s	2E5 (200 kHz)
π/4 DQPSK	Symbol rate ≤ 200 k/s	4E6 (4 MHz)
CDMA / W-CDMA	Chip rate ≤ 8.2 M/s	4E6 (4 MHz *)
DAB/DVB-T	-----	4E6 (4 MHz *)

\*) To increase the measurement accuracy also activate the modulation correction (see section 3.4.1.9).

### 3.4.1.8 FOR

**Function descriptors:**

**AVER, CBAV, CCDF, CF, MBAV, PEP**

Default setting: AVER

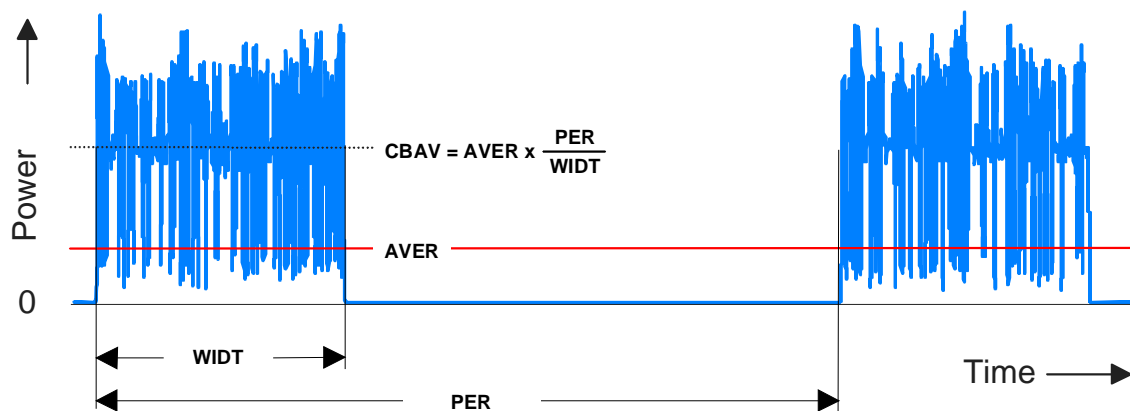
The commands of this group are used for setting the forward measurement function (see also section 3.4.1.5, DISP). For CCDF, CF, MBAV and PEP, the power sensor must be connected for the forward power in the privileged direction (see section 3.4.1.4, DIR) to ensure that the corresponding measurement paths are at sufficient power.

**FOR:AVER**

Measurement of average forward power (**AVER**age). This measurement function provides the lowest measurement uncertainty and the widest measurement range. To keep the measurement accuracy specified in the data sheet, it is absolutely necessary that the carrier frequency be entered (see section 3.4.1.6, FREQ). The accuracy for digitally modulated signals can be increased by activating the modulation correction (see section 3.4.1.9).

**FOR:CBAV**

Determination of average power of modulated or unmodulated RF bursts (CBAV: **calculated burst average**). The CBAV value is calculated from the average power and the duty cycle. For the CBAV function, the duty cycle must be defined (in contrast to the MBAV function, see below). The duty cycle is defined by entering the burst width (WIDT) and the burst period (PER) (see section 3.4.1.2, BURS). The accuracy for digitally modulated signals can be increased by activating the modulation correction (see section 3.4.1.9).



**Fig. 3-7** Definition of average burst power shown for a modulated burst sequence

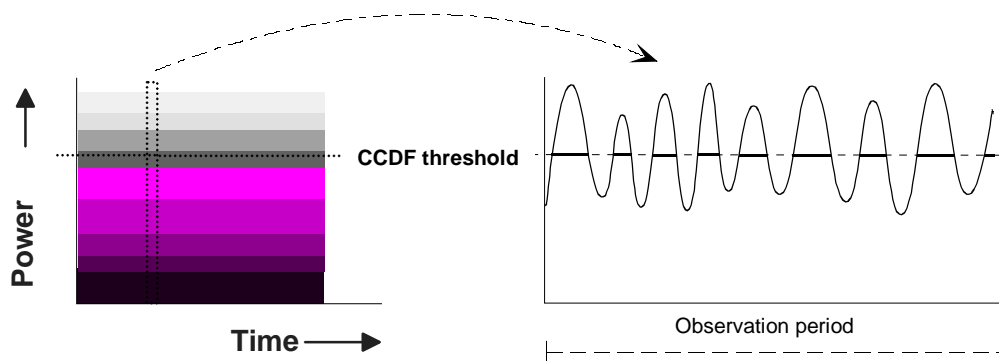
**NOTE:** For unmodulated bursts without envelope overshoot, the average burst power must be equal to the peak envelope power.

**FOR:CCDF**

Determination of complementary cumulative distribution function (CCDF). This measurement function indicates the probability in % of the forward envelope power exceeding a preset threshold. It thus describes the amplitude distribution of the envelope. The threshold is entered by means of command CCDF (see section 3.4.1.3).

Fig. 3-8 illustrates the CCDF function for an RF signal with a stochastic envelope. The thick lines in the righthand part of the figure mark the periods of time during which the envelope power exceeds the threshold. The percentage of these periods relative to the total measurement period equals the CCDF function for the given threshold.

Make sure that the video bandwidth is correct (see section 3.4.1.7, FILT:VID). The accuracy for digitally modulated signals can be increased by activating the modulation correction (see section 3.4.1.9).



**Fig. 3-8** CCDF function shown for a test signal with stochastic envelope

**Example** of CCDF measurement:

```

➤   RESET                               Default setting
@HH OK

➤   FOR:CCDF                             Sets CCDF measurement function
@HH old: AVER new: CCDF

➤   CCDF 20                              Sets CCDF threshold to 20 W
@HH old: x.xxxx new: +2.0000E+01

➤   RTRG                                  Triggers result
@HH +2.4356E+01 +2.2345E+01 __cdr113300
The CCDF value is 24.356%, the return loss 22.345 dB.

```

**FOR:CF**

Determination of **crest factor**. The crest factor is the (direct) ratio of peak envelope power (PEP) to average power (AVER). The crest factor provides information on the amount of modulation distortion and may assume very high values (approx. 5 to 10 with CDMA) in the case of burst or spread-spectrum signals. For accurate crest factor measurements the video filter must be set correctly (see section 3.4.1.7, command `FILT:VID`), and the modulation correction must be activated (see section 3.4.1.9). Further information on the correct setting of the power sensor will be found under `FOR:PEP` at the end of this section.

**Note:** *The CF softkey of the graphical user interface (see Table 2-1) differs from the command `FOR:CF` as it provides the crest factor as a logarithmic ratio (in dB).*

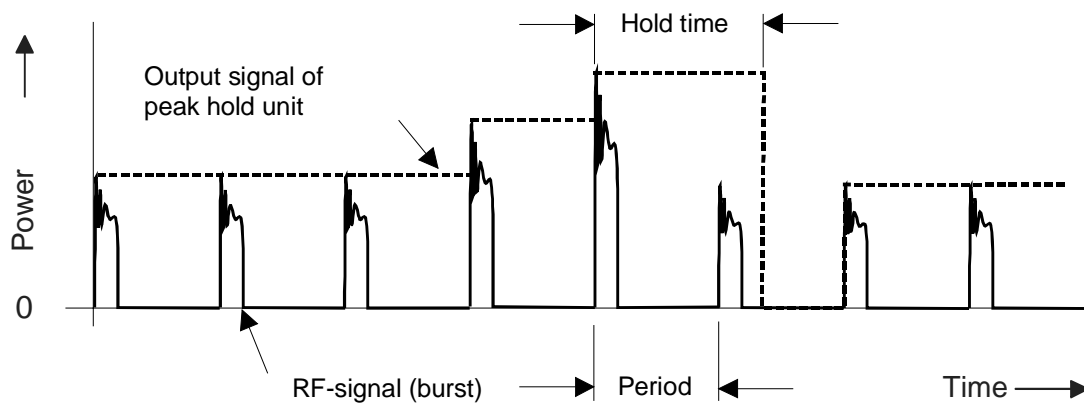
**FOR:MBAV**

Determination of average power of bursts (MBAV: **measured burst average**). The measured burst average MBAV is calculated from the average power and the duty cycle (see Fig. 3-7). In contrast to the CBAV function, the duty cycle need not be defined for the MBAV function but is automatically determined by the power sensor using the CCDF function, the CCDF threshold being set to half the peak value for this process.

To ensure correct calculation of the duty cycle also with modulated bursts, the video bandwidth should be selected narrow enough for the suppression of the modulation signal but still wide enough to prevent distortion of the rectangular envelope power characteristic (for appropriate setting see middle section of Fig. 3-6). The video bandwidths are best selected as indicated in Table 3-2 for CW bursts. The duty cycle should not be below 10% and the average burst power not below 0.5 W (NRT-Z43) and 2 W (NRT-Z44) to ensure the required measurement accuracy. The accuracy for digitally modulated signals can be increased by activating the modulation correction (see section 3.4.1.9).

**FOR:PEP**

Continuous measurement of **peak envelope power** (PEP) of modulated signals and bursts. The peak hold circuit operates such that the output signal directly follows each increase in the envelope power while it responds with a delay (delay: see `PEP:HOLD` and `PEP:TIME`) to any decrease of the envelope power (Fig. 3-9). To obtain stable results, the hold time must be selected somewhat longer than the interval between two consecutive peaks. The default setting of 60 ms allows measurements from modulation frequencies of about 20 Hz.



**Fig. 3-9** Operation of peak hold circuit

The output signal of the peak hold circuit is smoothed by digitization and subsequent averaging if any to such an extent that actual measured-value fluctuation is much lower than shown in Fig. 3-9.

The video bandwidth for the PEP measurement function must be selected as a function of the highest frequency component of the envelope signal unless unwanted components are to be blanked (see Table 3-2). The accuracy for digitally modulated signals can be increased by activating the modulation correction (see section 3.4.1.9).

### 3.4.1.9 MOD

**Function descriptors:** RATE, TYPE

The commands of this set are used for increasing the spread-spectrum signal measurement accuracy for all measurement functions (average power, peak power, crest factor and CCDF). Examples of spread-spectrum signals are the transmission signals of the digital communication standards IS-95-CDMA and WCDMA as well as DVB-T and DAB. When such signals are measured, the high crest factor and the large bandwidth of the carrier can cause measurement errors in the detector or during subsequent processing in the video section. As these are mainly systematic errors, they are quite easy to correct. The RF bandwidth of the signal is used as the correction parameter since it is fixed for most standards and related to the chip rate of WCDMA systems. The designation of the communication standard therefore is the parameter to be entered; with WCDMA the chip rate has to be entered as well. Spread-spectrum signals not included in the MOD:TYPE parameter list can be treated like WCDMA which are assigned a chip rate of 0.9 times the RF bandwidth.

#### MOD:RATE

Parameter: Chip rate in  $s^{-1}$   
 Entry range: 0 to 8.2E6  
 Default setting: 4.096E6

This command allows the user to enter the chip rate of WCDMA signals or other spread-spectrum signals that are not included in the MOD:TYPE parameter list. The setting will become active only if WCDMA is selected as the modulation standard (MOD:TYPE WCDMA).

**MOD:TYPE**

Parameter: Communication standard  
Possible entries: IS95, WCDMA, DVBT, DAB, OFF  
Default setting: OFF

This command informs the NRT power sensor about the communication standard. The parameter OFF serves for disabling the modulation correction.

**Notes:** The deviations which can be compensated with the command group *CORRection - MODULATION* are proportional to power for the AVG and AV.BRST functions. Since they are only a few per cent at nominal power (30 W for NRT-Z43, 120 W for NRT-Z44), the modulation correction will practically have no effect at much lower power values, i.e. below approx. 10 W for NRT-Z44.

To make sure that the modulation correction is activated for the PEP, CF and CCDF functions, the power sensor has to be set to full video bandwidth (4 MHz) by means of the command `FILT:VID 4E6`.

Systematic zero offsets of up to 1.5 W with NRT-Z44 and 0.4 W with NRT-Z43 are normal for the PEP measurement function at a video bandwidth of 4 MHz and with modulation correction on. These offsets do not have any influence on the measurement accuracy in the specified power range.

**3.4.1.10 OFFS**

Parameter: Attenuation of an RF cable in dB  
Entry range: 0 to 100  
Default setting: 0

Upon this command the unit takes into account the attenuation of an RF cable inserted between the power sensor and the desired test point. Depending on whether the cable is connected to the source or load port (referred to the sensor), the specified attenuation value has completely different effects on the measurement result. A detailed description is given in section 3.4.1.12 in connection with the definition of the reference plane.

**3.4.1.11 PEP**

**Function descriptors:** HOLD, TIME

The commands of this group are used for setting the hold time of the peak hold circuit.

**PEP:HOLD**

Parameters: DEF, USER  
Default setting: DEF (6E-2 s)

With this command, the user can set the hold time to a default value (DEF) or to the value last entered (see command `PEP:TIME` below).

**PEP:TIME**

Parameter: hold time in seconds  
Input range: 1E-3 to 1E-1  
Default setting: 6E-2

With this command, the user can define the hold time. If the entry is valid, the USER mode is switched on automatically and the default setting is switched off (see command `PEP:HOLD` above).

### 3.4.1.12 PORT

Parameters: SOUR, LOAD

Default setting: LOAD

With the `PORT` command, the source (SOUR) or the load (LOAD) can be selected as the reference plane for the measurement. This difference has to be made to meet more stringent measurement accuracy requirements since the power sensor absorbs part of the RF power and thus the outgoing waves from the power sensor are reduced by the insertion loss in comparison with the incoming waves (Fig. 3-10). Depending on the parameter to be determined (see table), the measurement has to be carried out at the source or load.

Parameter	Load matching	Power sensor setting	
		Meas. function / Evaluation	Ref. plane
Active power provided by source	any	( FOR AVER   CBAV   MBAV   PEP )	SOUR
Active power absorbed by load		* (1 - (REV RCO) * (REV RCO))	LOAD
Forward power (source)		FOR AVER   CBAV   MBAV   PEP	SOUR
Forward power (load)			LOAD
Load matching		REV RL   RCO   SWR	LOAD
Power of source into 50 Ω		good (SWR < 1.2)	FOR AVER

Since the test point itself (output connector of transmitter or antenna input) is often not accessible, the attenuation of a cable connecting the power sensor to the test point can be entered using the `OFFS` command (see section 3.4.1.10).

After reference plane and attenuation have been entered, power and matching are corrected as if the measurement were carried out at the inaccessible test point.

**Example 1:** The output power of a transmitter is to be measured. The power sensor is connected to the transmitter output via a cable with an insertion loss of 0.45 dB. Correct setting of power sensor: test position "SOUR" with 0.45 dB attenuation. Without considering the attenuation, the measured output power of the transmitter would be given 0.45 dB or 10% too low.

**Example 2:** The matching of an antenna is to be measured whose input is connected to the power sensor via a lengthy cable with an insertion loss of 1.2 dB. Correct setting of power sensor: test position "LOAD" with 1.2 dB attenuation. Without considering the cable loss, the measured return loss of the antenna would be given 2.4 dB too high.

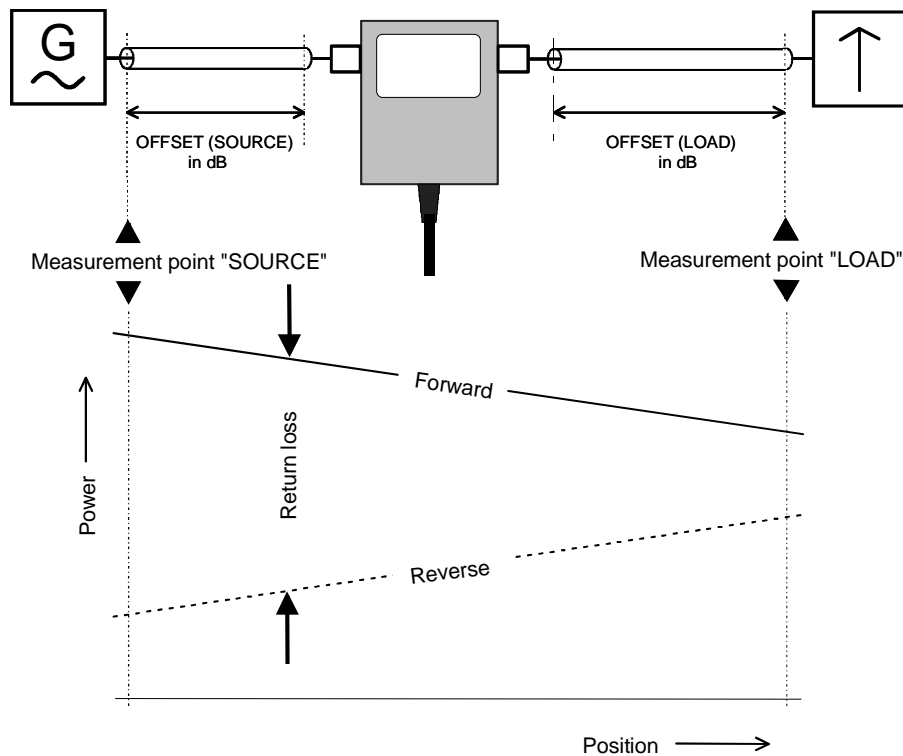


Fig. 3-10 Definition of test position

### 3.4.1.13 RESET

The RESET command causes all input parameters to be overwritten with their default values (see column *Default setting* in section 3.4.1.1). Default settings are usually not identical with the power-up status since on power-up the settings last active will be reinstated.

### 3.4.1.14 REV

**Function descriptors:** POW, RCO, RL, SWR

Default setting: RL

The commands of the REV group are used for setting the reverse measurement functions. The functions SWR, RL and RCO allow calculation of load matching in terms of SWR, return loss and reflection coefficient (for POW function see below).

#### REV:POW

The effect of this command depends on the selected forward measurement function; the command thus plays a special role. It yields the reverse power corresponding to the selected forward measurement function except for functions CF, PEP and CCDF (see Table 3-3).



Table 3-3 Reverse measurement functions

Forward measurement function	Measured quantity for reverse function REV:POW
AVER - Average forward power	Average reverse power
CBAV - Average forward burst power (calculated)	Average reverse burst power (calculated)
CCDF - Complementary cumulative distribution function	Average forward power
CF - Crest factor	Average forward power
MBAV - Average forward burst power (measured)	Average reverse burst power (measured)
PEP - Forward peak envelope power	Average reverse power

**Note:** The measured quantity for the PWR softkey of the graphical user interface (see Table 2-1) is assigned according to the power function selected and not according to Table 3-3.

**REV:RCO**

The reflection coefficient is defined as the ratio of reflected to incident wave. Values range from 0 (matching) to 1 (total reflection). The sensor calculates the reflection coefficient from the average values of the forward and the reverse power ( $P_i$ : forward power,  $P_r$ : reverse power):

$$RCO = \sqrt{\frac{P_r}{P_i}}$$

**REV:RL**

The return loss indicates the attenuation (in dB) of the reflected wave relative to the incident wave:

$$RL = 10 \cdot \lg \frac{P_i}{P_r} \text{ (dB)}$$

**REV:SWR**

The standing wave ratio indicates the ratio of maximum to minimum voltage on an RF line. The power sensor calculates this ratio as follows:

$$SWR = \frac{1 + \sqrt{\frac{P_r}{P_i}}}{1 - \sqrt{\frac{P_r}{P_i}}} \quad \text{or} \quad SWR = \frac{1 + RCO}{1 - RCO}$$

### 3.4.1.15 ZERO

Parameter: none (perform zeroing) or 0 (disable zero error correction)

To enhance the accuracy at low power levels, zeroing can be triggered by means of the `ZERO` command. Zeroing is required if significant power levels are measured although no RF signal is present (deviation from zero, zero offset). Zero offsets are detected during zeroing, which must be performed with the RF power switched off, and taken into account in the subsequent measurements.

The function PEP with active modulation correction forms an exception: After zeroing, residual zero offsets of up to approx. 1.5 W (NRT-Z44) or 0.4 W (NRT-Z43) are absolutely normal (see section 3.4.1.9).

After successful zeroing, the sensor outputs the calculated offset values as follows (all values in V, referred to detector output):

```
@DE pack 04_
@6A 01 zero1 = +2.3087E-06, zero2 = -1.0465E-06_
@1E 02 PEP zero for 4kHz filter : +5.3326E-06_
@3A 03 PEP zero for 200kHz filter : +6.6131E-05_
@FA 04 PEP zero for 4MHz filter : +2.0823E-04_
```

The first line indicates the offsets for measurement of the average power in the forward (zero1) and reverse (zero2) measurement paths. The remaining lines indicate the offset for the PEP function in the forward measurement path for various settings of the video filter. The error message `@6A Error ZERO` indicates that zeroing was carried out with the RF switched on. In such case, the results obtained by zeroing are ignored.

Zeroing can be performed any number of times. Each new zeroing will cause the results of previous zero measurements to be overwritten. Zero error correction can be disabled by means of command `ZERO 0` (this mode is active on power-up).

## 3.4.2 Measurement Functions: Query Commands

### 3.4.2.1 Short Overview

Table 3-4 Query commands

Command	Response	Description
FTRG	Result	Reads the result last obtained with free-running measurements (free-running trigger)
RTRG	Result	Causes a triggered measurement (remote trigger) to be performed and outputs the result
SPEC	Specifications	Reads the instrument specifications
STAT:MEAS	Device status	Reads the device status
STAT:ERR:TEXT	Error status	Reads the error status as a multiple-line response
STAT:ERR:CODE	Error code	Reads the error status as a code
STAT:ERR:VALS	Test voltages	Reads the internal test voltages together with their limit values

### 3.4.2.2 FTRG

The `FTRG` command causes continuous measurements to be performed at a high speed controlled by an internal timer but without any reference to an external trigger. `FTRG` causes the last result to be output. It has no effect on the internally controlled measurement processes.

Measurements are started automatically on completion of a power-up or an external trigger (see `RTRG` command in next section, 3.4.2.3). The measurement speed depends on the measurement function but is not affected by the setting of the averaging filter since a new average is formed automatically with every new measured value (see section 3.4.1.7, `FILT:AVER`).

After a reset of the sensor (command `RESET`), the response to `FTRG` will be two numerical values separated by a blank, one indicating the forward power in W and the other the reverse power in dB, followed by the status field:

```
@HH +4.2341E+01 1.5234E+01 __avr112200
```

### 3.4.2.3 RTRG

The `RTRG` command enables externally triggered measurements. It interrupts the current (internally controlled) measurement, starts a new measurement and outputs the result. If the averaging function is active, a result is output only when averaging is completed, ie when the required number of measurements has been performed. Results obtained with the `RTRG` command are at steady state when the measured quantity remains constant after the `RTRG` command has been sent. The measurement time depends on the measurement function, the setting of the averaging filter, and the integration time of the A/D converters (see data sheet). The output format corresponds to that of the `FTRG` command.

### 3.4.2.4 SPEC

The SPEC command causes all relevant data of the sensor to be read out. It supplies an electronic data sheet by means of which basic unit NRT can perform sensor-specific scaling and recognize the limit values of input parameters. A multiple-line response with the following structure is obtained:

```
➤ SPEC
@28 pack 72
@A4 01 ID:ID:Rohde & Schwarz NRT-Z43 V1.40
@53 02 ID:SER
@61 03 ID:CAL:REV
@44 04 ID:CAL:LAB
@4F 05 ID:CAL:DAT
@A8 06 ID:CAL:SIGN
@4A 07 ID:STOCK 1081.2905.02
@C5 08 TYPE POWER DIRECTIONAL
@74 09 FREQ:RANG:LOW 400E6
@12 10 FREQ:RANG:UPP 4E9
@EA 11 FREQ:RANG:DEF 1E9
@FC 12 POW 30
@EF 13 IMP 50
@CE 14 FORW:AVER:RANG:LOW 0.007
@49 15 FORW:AVER:RANG:UPP 75
@2D 16 FORW:AVER:RANG:LSD -4
@98 17 FORW:MBAV:RANG:LOW1 0.5
@9A 18 FORW:MBAV:RANG:LOW2 0.5
@CF 19 FORW:MBAV:RANG:LOW3 1.25
@C8 20 FORW:MBAV:RANG:LOW4 1.25
@3E 21 FORW:MBAV:RANG:UPP 75
@52 22 FORW:MBAV:RANG:LSD1 -3
@54 23 FORW:MBAV:RANG:LSD2 -3
@56 24 FORW:MBAV:RANG:LSD3 -3
@58 25 FORW:MBAV:RANG:LSD4 -3
@B8 26 FORW:CF:RANG:LSD1 -2
@BA 27 FORW:CF:RANG:LSD2 -2
@BC 28 FORW:CF:RANG:LSD3 -2
@BE 29 FORW:CF:RANG:LSD4 -2
@4E 30 FORW:PEP:RANG:LOW1 0.1
@86 31 FORW:PEP:RANG:LOW2 0.25
@56 32 FORW:PEP:RANG:LOW3 0.5
@54 33 FORW:PEP:RANG:LOW4 1.0
@01 34 FORW:PEP:RANG:UPP 75
@15 35 FORW:PEP:RANG:LSD1 -3
@16 36 FORW:PEP:RANG:LSD2 -2
@18 37 FORW:PEP:RANG:LSD3 -2
@1A 38 FORW:PEP:RANG:LSD4 -2
@74 39 FORW:PEP:TIME:LOW 1E-3
@CF 40 FORW:PEP:TIME:UPP 100E-3
@7F 41 FORW:PEP:TIME:DEF 60E-3
@B2 42 FORW:CCDF:RANG:LOW1 0.25
```

```

@B4 43 FORW:CCDF:RANG:LOW2 0.25
@B6 44 FORW:CCDF:RANG:LOW3 0.25
@B8 45 FORW:CCDF:RANG:LOW4 0.25
@2F 46 FORW:CCDF:RANG:UPP 75
@42 47 FORW:CCDF:RANG:LSD1 -2
@44 48 FORW:CCDF:RANG:LSD2 -2
@46 49 FORW:CCDF:RANG:LSD3 -2
@3F 50 FORW:CCDF:RANG:LSD4 -2
@EA 51 REFL:AVER:RANG:LOW 0.0007
@35 52 REFL:AVER:RANG:UPP 75
@1A 53 REFL:AVER:RANG:LSD -5
@93 54 FILT:AVER:AUTO
@7C 55 FILT:AVER:COUN:UPP 256
@EB 56 FILT:AVER:COUN:DEF 1
@FF 57 FILT:INT:TIME:LOW 1.06E-3
@D1 58 FILT:INT:TIME:UPP 111E-3
@1D 59 FILT:INT:TIME:DEF 36.67E-3
@99 60 FILT:VID:NRBW 4
@58 61 FILT:VID:BW1 4kHz
@B8 62 FILT:VID:BW2 200kHz
@3E 63 FILT:VID:BW3 4MHz
@43 64 FILT:VID:BW4 SPSP
@BC 65 MOD:TYPE:NRST 4
@8E 66 MOD:TYPE:ST IS95, WCDMA, DVB-T, DAB, OFF
@4F 67 MOD:RATE:LOW 0
@36 68 MOD:RATE:UPP 8.2E6
@7A 69 MOD:RATE:DEF 4.096E6
@93 70 OFFS:RANG:LOW 0
@F8 71 OFFS:RANG:UPP 100
@72 72 OFFS:RANG:DEF 0

```

The table below explains the meaning of data read out of the Directional Power Sensors NRT-Z43 and NRT-Z44 by means of the SPEC command.

**Table 3-5 Specifications**

Line	Parameter	Meaning
1	ID:ID	Identification string (company name, type, firmware version number)
2	ID:SER	Serial number
3	ID:CAL:REV	Version number of calibration program
4	ID:CAL:LAB	Calibration lab
5	ID:CAL:DAT	Calibration date
6	ID:CAL:SIGN	Name of person in charge
7	ID:STOCK	Stock No. of Directional Power Sensor NRT-Z43/Z44
8	TYPE	Type of power sensor

Line	Parameter	Meaning
9	FREQ:RANG:LOW	Lower frequency limit
10	FREQ:RANG:UPP	Upper frequency limit
11	FREQ:RANG:DEF	Default frequency
12	POW	Nominal power
13	IMP	Characteristic impedance
14	FORW:AVER:RANG:LOW	Lower measurement limit for average forward power in W, direction 1>2
15	FORW:AVER:RANG:UPP	Upper measurement limit for average forward power in W, direction 1>2
16	FORW:AVER:RANG:LSD	Least significant digit of measured value with decimal notation in W Example: -3 means that results are represented including the mW position
17 - 20	FORW:MBAV:RANG:LOWn	Lower measurement limit for average burst power (measured) n: coding of video bandwidth (see lines 60 to 64)
21	FORW:MBAV:RANG:UPP	Upper measurement limit for average burst power (measured)
22 - 25	FORW:MBAV:RANG:LSDn	Least significant digit of measured value with decimal notation in W n: coding of video bandwidth (see lines 60 to 64)
26 - 29	FORW:CF:RANG:LSDn	Least significant digit of measured value with decimal notation in dB n: coding of video bandwidth (see lines 60 to 64)
30 - 38	FORW:PEP:RANG:...	PEP measurement limit - definition analogous to FORW:MBAV:RANG
39	FORW:PEP:TIME:LOW	Minimum selectable hold time for PEP function
40	FORW:PEP:TIME:UPP	Maximum selectable hold time PEP function
41	FORW:PEP:TIME:DEF	Default hold time for PEP function
42 - 50	FORW:CCDF:RANG...	CCDF measurement limits - definition analogous to FORW:MBAV:RANG
51 - 53	REFL:AVER:RANG...	Measurement limits for reverse power - definition analogous to FORW:AVER:RANG
54	FILT:AVER:AUTO	Automatic averaging function available
55	FILT:AVER:COUN:UPP	Maximum selectable count of averaging filter
56	FILT:AVER:COUN:DEF	Default count of averaging filter
57	FILT:INT:TIME:LOW	Minimum selectable integration time for A/D converters
58	FILT:INT:TIME:UPP	Maximum selectable integration time for A/D converters
59	FILT:INT:TIME:DEF	Default integration time for A/D converters
60	FILT:VID:NRBW	Number of settings for video filter
61 - 64	FILT:VID:BWn	Video bandwidth for nth setting
65	MOD:TYPE:NRST	No. of communication standards with modulation correction (incl. OFF)

Line	Parameter	Meaning
66	MOD:TYPE:ST	Communication standards with modulation correction
67	MOD:RATE LOW	Minimum chip rate for modulation correction
68	MOD:RATE UPP	Maximum chip rate for modulation correction
69	MOD:RATE DEF	Default chip rate for modulation correction
70	OFFS:RANG:LOW	Minimum attenuation correction (connecting RF cable)
71	OFFS:RANG:UPP	Maximum attenuation correction (connecting RF cable)
72	OFFS:RANG:DEF	Default attenuation correction (connecting RF cable)

### 3.4.2.5 STAT

#### Function descriptors: MEAS, ERR

The STAT group of commands represents the status reporting system (see section 3.6). It enables inquiry of the instrument status according to device status and error status. The device status describes all current settings, the error status list includes all errors occurred.

#### STAT:MEAS

This command delivers the device status of the sensor in the form of a multiple-line response. For each parameter, the current value is output.

```

➤ STAT:MEAS
@26 pack 34
@04 01 Cal.mode lock:      ON
@CE 02 DMA mode:          OFF
@EE 03 Forward meas. func.: AVER
@AC 04 Reverse meas. func.: RCO
@84 05 Burst period:      1.0000E-01
@43 06 Burst width:       1.0000E-02
@01 07 PEP hold mode:     DEF
@35 08 PEP hold time:     6.0000E-02
@93 09 CCDF threshold:    4.0000E+01
@C3 10 Average filt mode:  AUTO
@C3 10 Average filt mode:  AUTO
@DD 12 ADC integ. time mode: USER
@47 13 ADC integration time: 3.6667E-02
@20 14 Video Bandwidth:    2.0000E+05
@75 15 Spread spectr.weight. OFF
@A9 16 Correction Frequency 1.0000E+09
@F0 17 Forward display    ON
@C7 18 Reflection display  ON
@5E 19 State display      ON
@DE 20 Sign. chan. assignmnt 1>2
@40 21 Reference port     SOUR
@40 22 Display resolution  LOW
@3E 23 Modulation type    OFF
@54 24 Modulation rate    4.0960E+05
@62 25 Attenuation        1.0000E+00
@40 26 C eff1             1.0000E-11

```

```

@48 27 C eff2          7.0000E-11
@4E 28 Measured parameters:
@50 29 Average zero value ADC1:  -3.3953E-06
@47 30 Average zero value ADC2:  -2.5194E-06
@3A 31 PEP zero value for 4kHz: +6.4601E-06
@56 32 PEP zero value for 200kHz: -3.2413E-05
@27 33 PEP zero value for 4MHz: -1.5866E-04
@E2 34 Current temperature: 27.045

```

**STAT:ERR****Function descriptors TEXT, CODE, VALS**

These commands are used for status checking of the power sensor. Results can be output in the form of a plain-text list (STAT:ERR:TEXT), a single-line error code (STAT:ERR:CODE), or a list of measured values for key test points (STAT:ERR:VALS). After status readout, all temporary errors (ie mainly operator errors) are cleared whereas permanent errors remain set.

**STAT:ERR:TEXT**

The plain-text error-status list provides information on the status of the analog hardware (HW PARAMETERS) and indicates the results of other checks (PERMANENT ERRORS) as well as operator errors (OPERATION ERRORS). The parameter checked are output together with the information OK or ERROR in a multiple-line response.

```

➤ STAT:ERR:TEXT
@DE pack 23
@7F 01 HW PARAMETERS:
@17 02 SUPPLY VOLTAGE +      OK
@1A 03 SUPPLY VOLTAGE -      OK
@31 04 MH SUPPLY             OK
@EF 05 FORW. CONTROL VOLTAGE OK
@DB 06 REFL. CONTROL VOLTAGE OK
@05 07 CCDF OUTPUT LOW      OK
@14 08 CCDF OUTPUT HIGH     OK
@D2 09 CCDF MEDIUM THRESHOLD OK
@9A 10 TEMPERATURE          OK
@4B 11 PERMANENT ERRORS:
@5D 12 COMMUNICATION ADC 1   ERROR
@5F 13 COMMUNICATION ADC 2   OK
@F9 14 PEP CIRCUIT OPERATION OK
@F3 15 FRAM READ             OK
@44 16 FRAM WRITE            OK
@95 17 CAL. VALUES CHECKSUM OK
@8C 18 CALIBRATION VALUES   OK
@5A 19 OPERATION ERRORS:
@1D 20 CAL.LOCKED           OK
@D5 21 SYNTAX                ERROR
@7C 22 RANGE                 OK
@70 23 ZERO                  ERROR

```

The above example indicates a communication error between the microprocessor and A/D converter 1 as well as a syntax error, and that zeroing was attempted in the presence of RF power, all these events having occurred since the previous readout of the error status.



**STAT:ERR:CODE**

The error status can be output in the form of a bit code for fast evaluation. . Each error condition is assigned one bit (see Table 3-9). Erroneous parameters are indicated by 1, correct parameters by 0. For the above example, the following bit code would be obtained:

```
@73 00000000010000000101_____
```

```

      ↑      ↑      ↑  ↑
      20     11     3  1  bit no.

```

The bit code has a constant length. The bit positions are assigned to the test points of the STAT:ERR:TEXT multiple-line response (bit 1 is assigned to the last line). For detailed information see section 3.6.2, Error Status.

**STAT:ERR:VALS**

With this command, the measured values for the relevant hardware test points (see HW PARAMETERS under STAT:ERR:TEXT) are output together with their limit values (lefthand and righthand column).

➤ STAT:ERR:VALS

```
@E3 pack 09_____
@1D 01 SUPPLY VOLTAGE +      : +4.3300E-02 +4.9138E-02 +5.5200E-02
@2F 02 SUPPLY VOLTAGE -      : -5.5200E-02 -4.8477E-02 -4.2800E-02
@3B 03 MH SUPPLY              : -1.1900E-01 -9.3720E-02 -7.7000E-02
@FA 04 FORW. CONTROL VOLTAGE : -4.2400E-02 -5.2947E-03 +4.2400E-02
@E7 05 REFL. CONTROL VOLTAGE : -4.2400E-02 -8.4457E-03 +4.2400E-02
@4D 06 CCDF OUTPUT LOW       : +1.0000E-01 +1.6733E-01 +3.0000E-01
@6B 07 CCDF OUTPUT HIGH      : +8.0000E-01 +8.4894E-01 +1.0000E+00
@B7 08 CCDF MEDIUM THRESHOLD : -1.3560E+00 -1.2196E+00 -1.1500E+00
@AE 09 TEMPERATURE           : -1.5600E-01 +2.2697E-01 +7.8000E-01
```

### 3.4.3 General Commands

#### 3.4.3.1 Short Overview

Table 3-6 General Commands

Command	Parameter	Default setting	Description / Response
APPL			Displays the operating mode (BOOT / OPER) and activates the measurement mode from the boot mode
BOOT			Activates the boot mode
DMA	ON / OFF	ON	Activates/Deactivates the filling-up of device response lines to 50 characters
HELP	None or A to Z		Lists all commands available in a command group
ID			Returns the identification string
PURGE			Deletes the input buffer of the serial interface
SETUP:SAVE	0 to 4	0	Saves sensor status in the EEPROM memories 0 to 4
SETUP:RCL	0 to 4	0	Recalls sensor status from the EEPROM memories 0 to 4
?			Returns the operating mode

#### 3.4.3.2 APPL

Parameter: none

Response: boot, busy or oper (depending on operating status)

The APPL (application) command switches the sensor to the measurement mode. The response line indicates the operating status of the sensor active before the command was sent:

boot: sensor was in boot mode

busy: sensor is currently not ready to accept commands (eg during the power-up test)

oper: sensor is in measurement mode

The boot mode, which is activated on power-up or on sending the BOOT command, allows new firmware to be loaded. The measurement mode is the normal operating mode of the sensor. It is activated by sending APPL at least once. For a detailed description refer to section 3.2.3, Testing the Connection.

#### 3.4.3.3 BOOT

Parameter: none

Response: none

With the BOOT command, the boot mode can be activated from any other operating mode to prepare the sensor for the loading of new firmware. The command has the same effect as switching on and off the supply voltage.

### 3.4.3.4 DMA

Parameter: ON / OFF  
 Default setting: ON

The DMA ON command allows all response lines to be filled up to a uniform length of 50 characters including the two end-of-line characters. This enables DMA-supported reception of device responses. Device response lines shorter than 50 characters are filled with '\_' (ASCII 95 decimal, 5F hex) between the message content and the end of the line. For time-critical applications (without DMA), the filling-up function can be switched off with the DMA OFF command.

### 3.4.3.5 HELP

Parameter: none or first letter of a command  
 Response: all commands addressed

The HELP command causes the output of a brief description of all commands addressed by a given parameter. If no parameter is specified, all commands of the corresponding level are listed. The command level is to be placed in front of the HELP command in the form of a group descriptor (eg SERV:HELP). Without group descriptor, HELP acts on the highest command level.

```
➤ HELP    all commands of the highest command level
@2A pack 29
@98 01 appl - operation mode 'boot' or 'oper'
@93 02 basever - base unit version control comm.
@C3 03 boot - soft reset
@A4 04 burs - burst form inputs (burs:help)
@A5 05 calib - calibration functs. (calib:help)
@64 06 ccdf - CCDF thresh.in W (float)
@B0 07 dir - signal chan.assign.(1>2,2>1,AUTO)
@3B 08 disp - display contr.settngs (disp:help)
@53 09 dma - supplement to 50 chrs. (ON/OFF)
@3F 10 filt - filter functions (filt:help)
@68 11 for - forward meas. funct. (for:help)
@82 12 freq - correction frequency [Hz]
@EF 13 ftrg - free run trigger
@72 14 help - this command
@2A 15 id - firmware ID
@26 16 mod - modulation type (mod:help)
@C7 17 offs - attenuation correction
@10 18 pep - PEP function settings (pep:help)
@D2 19 port - reference port (SOUR,LOAD,NONE)
@D2 20 purge - purge receive buffer
@9D 21 reset - initialization of all parameters
@7D 22 rev - reverse meas. funct. (rev:help)
@71 23 rtrg - remote trigger
@D1 24 serv - service functions (serv:help)
@00 25 setup - head setups (setup:help)
@31 26 spec - returns id telegram
@93 27 stat - device state (stat:help)
@D3 28 test - RS232 Test
@6D 29 zero - zero correction (# of meas.)

➤ HELP F  all commands of the highest command level starting with F
@DF pack 04 _____
@1B 01 filt - filter functions (filt:help)_____
@27 02 for - forward meas. funct. (for:help)___
@7B 03 freq - correction frequency [Hz]_____
```

@3F 04 ftrg - free run trigger\_\_\_\_\_

- CALIB:HELP all calibration commands
- @27 pack 26
- @50 01 acal - auto calibration of ADCs
- @C9 02 calc - calculation of lin. coefficients
- @58 03 ccdf - CCDF calibration
- @0E 04 err - calibration errors (calib:help)
- @FD 05 fcorr1 - freq. correction constant
- @FF 06 fcorr2 - freq. correction constant
- @96 07 freq1 - freq.cal.of forw.ch.(# pow. frq.)
- @9A 08 freq2 - freq.cal.of revs.ch.(# pow. frq.)
- @76 09 help - this command
- @6B 10 init - set all cal.values to deflt cond
- @FC 11 kappal - constant in correction formula
- @FE 12 kappa2 - constant in correction formula
- @86 13 lin1 - lin.cal. of forw.ch. (# pow.)
- @8A 14 lin2 - lin.cal. of revs.ch. (# pow.)
- @04 15 lnfreq1 - index of reference freq. for ADC1
- @07 16 lnfreq2 - index of reference freq. for ADC2
- @AA 17 lock - lock cal. mode
- @C8 18 offs - internal offset
- @E5 19 rcal - read cal. factors
- @3F 20 read - read cal. data file
- @E8 21 rvid - measurement of video resistance
- @44 22 show - show all calibration values
- @13 23 tcorr1 - temp. correction constant
- @15 24 tcorr2 - temp. correction constant
- @3A 25 trg - trigger for lin. and freq. cal.
- @91 26 unlock - unlock calib. mode (keyword)

### 3.4.3.6 PURGE

Parameter: none  
Response: none

With the PURGE command, the contents of the input buffer of the sensor can be deleted and thus the execution of waiting commands prevented. The sensor can in this way quickly be prepared for a new measurement task.

### 3.4.3.7 SETUP

**Function descriptors: SAVE, RCL**

Parameters: 0 ... 4  
Response: ok

The commands SETUP:SAVE und SETUP:RCL are used to store the sensor status in the EEPROM or recall it from there. The status stored in memory no. 0 corresponds to the switch-on status.

The default setting of the sensor can be recalled via the RESET command.

### 3.4.4 Service Functions

All commands including the `SERV` group descriptor make access to functions intended for troubleshooting and repair rather than for the normal measurement mode. Except for a few, these commands are therefore not described in detail in this manual but a list is given instead.

**Table 3-7 Service commands**

Command	Parameter	Default setting	Description / Response
<code>SERV</code>			
<code>:AINIT</code>			Initializes A/D converters
<code>:AMEAS</code>	ON   OFF	ON	Switches on/off background measurement of temperature and supply voltage as well as free-running mode for power measurement functions
<code>:CEFF1   2</code>			Enter effective load capacity (for modulation correction average power)
<code>:CH</code>	0   1		Selects measurement channel 0 or 1 (for both A/D converters)
<code>:CORR:FREQ</code>	ON   OFF	ON	Switches on/off frequency response correction
<code>:CORR:LIN</code>	ON   OFF	ON	Switches on/off linearity correction
<code>:CORR:OFF</code>	ON   OFF	ON	Switches on/off zeroing
<code>:CORR:TEMP</code>	ON   OFF	ON	Switches on/off temperature correction
<code>:CORR:PEP</code>	ON   OFF	ON	Switches on/off duty-cycle-dependent correction of PEP and CF functions
<code>:CORR:STAT</code>			Reads the correction status
<code>:CREG</code>			Reads the status check registers of both A/D converters
<code>:CS:BOOT</code>			Checksum of boot block
<code>:CS:APPL</code>			Checksum of measurement program
<code>:CS:ALL</code>			Checksum of complete flash EPROM
<code>:CS:CAL</code>			Checksum of calibration data record
<code>:DAC</code>	0 to 4095		Sets D/A converter for CCDF threshold
<code>:DACVL</code>			Reads current setting of D/A converter for CCDF threshold
<code>:DEBUG</code>			Output of intermediate results, input parameters etc.
<code>:DUTY</code>	ON   OFF	OFF	Returns the sampling ratio calculated for function MBAV (from status field)
<code>:GAIN</code>	0 to 7		Sets internal gain for A/D converters

Command	Parameter	Default setting	Description / Response
<b>SERV</b>			
:GNDON			Takes input to CCDF circuit to ground and opens signal paths via the three video filters
:HW:....			Command group acting on all control lines (HW:HELP)
:HWCODE			Reads the hardware status
:INSLSS			Outputs the ratio of output power to input power for instantaneous correction frequency
:MUX	0 to 7		Sets input multiplexer of A/D converter 2 (see section 3.5.1, Description of Hardware Functions)
:MXTRG	0 to 7		Same as MUX command, with measured-value trigger in addition
:NOISE:AVER			Performs noise measurement in both averaging amplifier paths and outputs 2- $\sigma$ noise (in V, referred to detector output)
:NOISE:PEP			Outputs offset voltages of peak hold circuit for the three settings of the video filter (in V, referred to detector output)
:RFRAM			Reads out test buffer of FRAM
:RNG	ON   OFF		Switches on/off autoranging
:SEPAR	<ASCII character>	_	Converts separator of device responses triggered by FTRG or RTRG to the character sent as parameter
:SHCAL			Returns calibration values
:SPEC:DAT	<Calibration date>		Input of calibration date (max. 15 characters)
:SPEC:LAB	<Calibration lab>		Input of calibration lab (max. 15 characters)
:SPEC:REV	<Version number>		Input of calibration software version (max. 15 characters)
:SPEC:SER	<Serial number>		Input of serial number (max. 15 characters)
:SPEC:SIGN	<Person in charge>		Input of person in charge (max. 15 characters)
:STRG			Triggers A/D conversion and outputs unprocessed results
:SUPPL			Measures positive and negative supply voltages, outputs results
:TEMP			Measures sensor temperature, outputs result (in °C)
:TEST			Selftest; generates current error status
:WFRAM	<Character string>		Writes character string into test buffer of FRAM

### 3.4.4.1 SERV:CS

**Function descriptors:** BOOT, APPL, FLASH, CAL

**Response:** hexadecimal 7-digit checksum

#### **SERV:CS:BOOT**

This command delivers a checksum of the boot block.

#### **SERV:CS:APPL**

This command delivers a checksum across the test program. The separation of boot block and test program is necessary for a clear identification of the two software blocks.

#### **SERV:CS:FLASH**

This command delivers a checksum across the complete flash EPROM.

#### **SERV:CS:CAL**

This command delivers a checksum across the calibration data record and thus enables each calibration to be identified.

### 3.4.4.2 SERV:NOISE

**Function descriptors:** AVER, PEP

#### **SERV:NOISE:AVER**

**Response:** 2- $\sigma$  noise obtained with average power measurement (forward and reverse)

The sensor forms 600 consecutive measured values for each of the two channels and determines the superimposed noise. This measurement may take several minutes. The voltages output by the sensor are referred to the respective detector outputs and are twice the rms value. To prevent results to be distorted by instable signals, this measurement should be performed with the RF power switched off.

#### **SERV:NOISE:PEP**

**Response:** offset voltage of peak hold circuit as a function of video filter setting

With the `FOR:PEP` and `FOR:CF` measurement functions, the noise superimposed on the test signal may lead not only to statistical variations of results but also to systematic measurement errors that increase as the video bandwidth increases. This behaviour is caused by the peaks of the noise signal. The test program corrects this behaviour by measuring the offset voltage of the peak hold circuit for all of the three video filter settings (each time when `ZERO` is called) and taking the results into account in the measurements.

The `SERV:NOISE:PEP` command, allows the offset voltages to be output as a function of the video filter setting. The differences between the respective values are a measure of the broadband noise in the PEP measurement path. The offset voltages are referred to the detector output.

**3.4.4.3 SERV:TEST**

Response:           OK or ERROR

The `SERV:TEST` command triggers a selftest and updates the error status, which can be read with the commands of the `STAT:ERR` group (see 3.4.2.5, `STAT`). `ERROR` is output only if a hardware error has occurred. Temporary errors, eg syntax or other input errors, are not taken into account.



### 3.4.5 Calibration Functions

All commands including the CALIB group descriptor relate to the calibration of Directional Power Sensor NRT-Z43/Z44. They are listed in the table below in alphabetical order. .

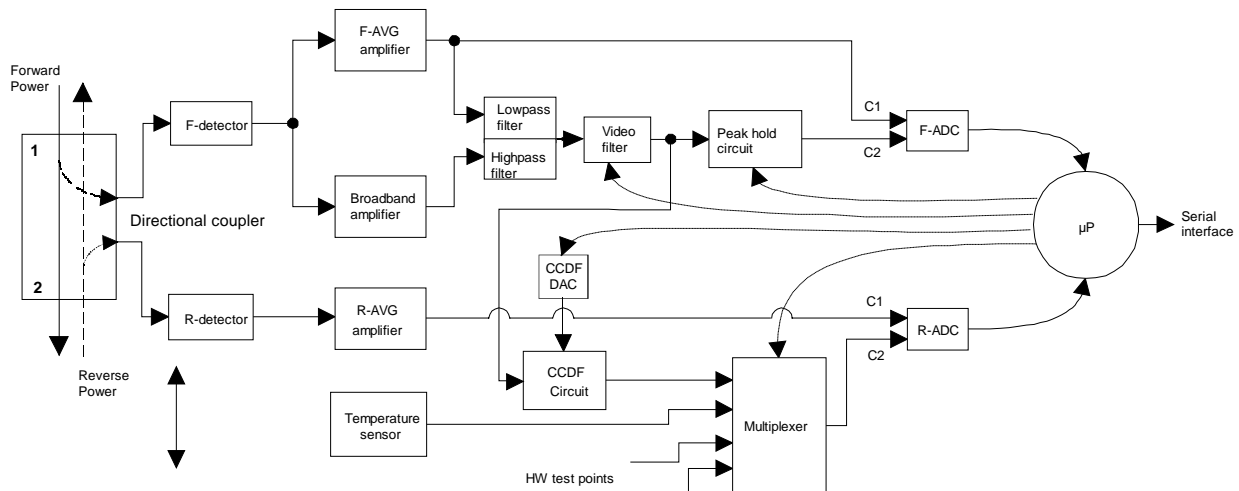
**Table 3-8 Calibration commands**

Command	Parameter	Description / Response
<b>CALIB</b>		
:ACAL		Self-calibration of A/D converters
:CALC		Calculation of calibration data from values measured for transmission characteristic and sensitivity
:CCDF		Calibration of D/A converter for CCDF threshold
:ERR:CODE		Readout of calibration errors as bit codes
:ERR:TEXT		Readout of calibration errors as plain text
:ERR:VALS		Readout of calibration data with limit values
:FCORR1   2	Correction value	Correction of the temperature dependence of the rectifier diode at the upper edge of the band in test channel 1 or 2
:FREQ1   2	Calibration point No., power, frequency	Entry of calibration point, power and frequency for measuring the sensitivity in test channel 1 or 2
:INIT		Overwriting of all calibration data with default values
:KAPPA1   2	Correction value	Correction of the temperature dependence of rectifier diode at the lower edge of the band in test channel 1 or 2
:LIN1   2	Calibration point No., power	Entry of calibration point and power for measuring the transmission characteristic of test channel 1 or 2
:LNFREQ1   2	Calibration point No.	Entry of calibration point number for the frequency used for linearization in test channel 1 or 2
:LOCK		Exiting of calibration mode and storage of calibration data in FRAM
:OFFS		Permanent zero error correction for all test functions
:RCAL		Readout of calibration data for the two A/D converters
:READ		Reading of calibration data
:RVID		Measuring the video impedances of the rectifier diode
:SHOW		Readout of all calibration data
:TCORR1   2	Correction value	Correction of the average temperature dependence of the rectifier diode in test channel 1 or 2
:TRG		Trigger for all calibration measurements
:UNLOCK	PASSWORD	Activation of calibration mode

### 3.5 Hardware Functions and Command Processing

The two functional diagrams (Fig. 3-11 and Fig. 3-12) given below illustrate the hardware functions and the command processing of the Directional Power Sensors NRT-Z43 and NRT-Z44.

#### 3.5.1 Description of Hardware Functions



**Fig. 3-11** Functional diagram of hardware

The Directional Power Sensors NRT-Z43 and NRT-Z44 are connected between the source and the load (see Fig. 1-1). Two RF signals proportional to the forward wave (from the source to the load) and the reflected wave (from the load to the source) are available at the outputs of the directional coupler. The output voltages of the two detectors follow the forward and reverse envelope powers. To measure the average powers, the output voltages undergo narrowband amplification (F-AVG and R-AVG amplifiers), digitization and error compensation in the microprocessor. The latter is effected with the aid of stored correction values, taking into account the temperature, frequency and linearity of the power sensor. From the ratio of the two average powers, the load matching can be determined in terms of return loss, SWR or reflection coefficient.

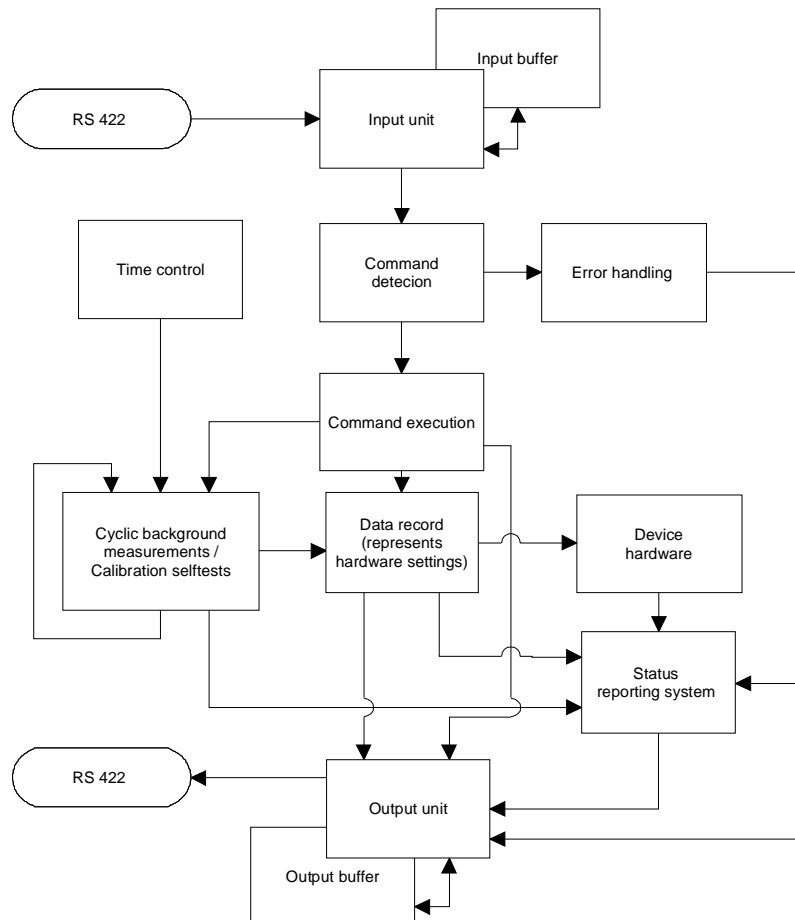
To measure the peak envelope power (PEP), the average burst power (MBAV) and the complementary cumulative distribution function (CCDF), the output signal of the forward detector must undergo broadband processing. To this end, the outputs of the F-AVG amplifier and an AC-coupled broadband amplifier are combined via a frequency filter. Unwanted signal components such as broadband noise or high-frequency modulation components can be eliminated by means of a switchable video lowpass filter (4 kHz, 200 kHz and 4 MHz, see section 3.4.1.7, FILT:VID) prior to further processing.

The peak hold circuit delivers an output voltage corresponding to the peak envelope power of the forward signal. The CCDF circuit outputs a pulsed signal whose average value is proportional to the probability of the envelope power exceeding a given reference level (CCDF threshold). The CCDF circuit is also used for measuring the average burst power. To this end, the CCDF threshold is set to half the PEP value so that the output signal corresponds to the duty cycle. The average burst power can be determined from the average power and the duty cycle.

Digitization is performed by means of two highly linear  $\Sigma\Delta$  A/D converters (F-ADC and R-ADC) with two measurement channels each. The preset measurement time of the two converters is 37 ms. This time can be varied by means of command `FILT:INT:TIME` (see section 3.4.1.7). Further parameters such as temperature and various test voltages can be measured during normal operation or in selftests by means of the multiplexer connected ahead of the reverse AD converter.

### 3.5.2 Description of Command Processing

The functional diagram shown in Fig. 3-12 illustrates the physical and logic function blocks used for command processing. Commands are processed and executed essentially from top to bottom.



**Fig. 3-12 Functional diagram of command processing**

The input unit receives commands character by character via the serial interface and stores them in the input buffer, which has a capacity of 256 characters. The input unit sends a message to the command detection circuit if the input buffer is full or a delimiter is received.

If the input buffer is full, bus traffic is stopped using the XON/XOFF protocol, and the data received up to this time are processed. Data traffic is then resumed. If the buffer is not yet full upon receipt of the delimiter, the input unit can receive the next command while the previous command is detected and executed.

The command detection circuit analyzes the data received from the input unit in the sequence of the data received. Each command detected is immediately passed on to command execution.

Syntax errors are passed on from the command detection circuit to the error handling unit. The rest of the command line is analyzed and processed as far as possible.

### 3.5.2.1 Device Hardware and Data Record

*Device hardware* is understood to be the analog circuitry used for performing the measurement functions. The controller is not part of the device hardware. The hardware settings are exactly represented by the *data record* of the measurement program.

Setting commands generally cause a change of the data record and the device hardware. The data record management will however not pass on any new values to the hardware until requested to do so by the command detection circuit.

### 3.5.2.2 Status Reporting System

The status reporting system collects information on the device status and supplies it to the output unit on request. A detailed structural and functional description is given in section 3.6 (Status Reporting System).

### 3.5.2.3 Output Unit

The output unit collects the information made available by the data record management, processes it in accordance with the rules described in section 3.3.3, Device Responses, and stores them in the output buffer, which has a capacity of 256 characters. If the requested information is longer than 256 characters, it is divided up into several lines (see section 3.3.3.3, Multiple-Line Responses).

### 3.5.2.4 Cyclic Background Power and Temperature Measurements

The cyclic background power and temperature measurements are performed independently of the interface data traffic. In the free-running trigger mode (FTRG), the background measurement continuously supplies measured power values and thus ensures a high refresh rate of the display. The background temperature measurement is performed at intervals of approx. 1 minute. The results are used for correcting the temperature response of the detectors.

## 3.6 Status Reporting System

The status reporting system provides information on the current status of the sensor. A differentiation is made between “error status” and “device status”. The device status describes the status of all device settings. The error status is a report of operator or hardware errors occurred.

### 3.6.1 Device Status

The device status covers all parameters relating to measurements. It is output as a multiple-line response by means of command `STAT:MEAS` (see section 3.4.2.5). All parameters relating to the device status can be reset to a defined initial status by means of command `RESET` (see section 3.4.1.13).

### 3.6.2 Error Status

The error status comprises both temporary and permanent errors. Temporary errors include, for example, operator errors such as *SYNTAX Error* or *RANGE Error*. Permanent errors are hardware errors or errors that have occurred during calibration.

The error status can be output as a plain-text multiple-line response or in the form of a code (see section 3.4.2.5 `STAT`). Table 3-9 gives an explanation of each error that might occur. The bit number indicates the position of an error within the code (see command `STAT:ERR:CODE`); the designation given in the “Error” column is identical with the multiple-line response obtained in return to command `STAT:ERR:TEXT`.

**Table 3-9 Error status**

Bit No.	Error description	Cause	Faulty board
<b>HARDWARE PARAMETERS:</b>			
20	SUPPLY VOLTAGE+ ERROR	+5 V not present or out of range	Controller board Analog board
19	SUPPLY VOLTAGE - ERROR	-5 V not present or out of range	Controller board Analog board
18	MH SUPPLY ERROR	Voltage supply of power sensor too low	Controller board NRT NRT-Z3/-Z4
17	FORW. CONTROL VOLTAGE ERROR	Offset control voltage for forward amplifier (test point D11.13) out of range	Analog board
16	REFL. CONTROL VOLTAGE ERROR	Offset control voltage for reverse amplifier (test point D11.14) out of range	Analog board
15	CCDF OUTPUT LOW ERROR	Min. settable CCDF threshold voltage out of tolerance	Analog board
14	CCDF OUTPUT HIGH ERROR	Max. settable CCDF threshold voltage out of tolerance	Analog board
13	CCDF MEDIUM THRESHOLD ERROR	Average CCDF threshold voltage (test point „DAW“) out of tolerance	Analog board
12	TEMPERATURE ERROR	Temperature test voltage (test point D11.4) out of tolerance	Analog board

Bit No.	Error description	Cause	Faulty board
<b>PERMANENT ERRORS</b>			
11	COMMUNICATION ADC 1 ERROR	Communication error between A/D converter in forward channel (D14) and processor	Controller board Analog board
10	COMMUNICATION ADC 2 ERROR	Communication error between A/D converter in reverse channel (D15) and processor	Controller board Analog board
9	PEP CIRCUIT OPERATION ERROR	Fault in peak-hold circuit (N9, V17, N8)	Analog board
8	FRAM READ ERROR	Fault when reading calibration data from the FRAM	Controller board
7	FRAM WRITE ERROR	Fault when writing calibration data into the FRAM	Controller board
6	CAL VALUES CHECKSUM ERROR	Checksum of calibration data set faulty	Controller board
5	CALIBRATION VALUES ERROR	Calibration fault or calibration value out of tolerance. Further information by means of CALIB:ERR:TEXT or CALIB:ERR:CODE (see Table 3-8).	Controller board
<b>OPERATION ERRORS</b>			
4	CAL. LOCKED ERROR	A calibration function has been called up without opening calibration mode by means of command CALIB:UNLOCK PASSWORD	Operating error
3	SYNTAX ERROR	An input has not been understood	Operating error
2	RANGE ERROR	A numerical parameter exceeds the input limits	Operating error
1	ZERO ERROR	An attempt has been made to perform a zeroing with the test power applied	Operating error

OPERATOR ERRORS are reset on readout of the error status. They must be buffered if they are to be evaluated by means of user programs. HARDWARE PARAMETERS and PERMANENT ERRORS remain set until their cause is eliminated.

Errors 8 to 11 occur only if the hardware is faulty, whereas errors 12 to 20 (HARDWARE PARAMETERS) may also be caused by low supply voltage of the power sensor.

### 3.6.2.1 Occurrence and Causes of Errors

**Errors 12 to 20** All HARDWARE PARAMETERS are measured upon power-up of the sensor and upon calling a selftest (SERV:TEST, see section 3.4.4.3). Besides the above general description, errors can be output as voltage values together with their tolerances (see section 3.4.2.5 (STAT:ERR:VALS)).

**Errors 10 and 11** may occur at any time and are immediately written into the error status report.

**Error 9** can occur only during a triggered measurement in the measurement functions PEP, MBAV and CF. Error reason: The hardware is faulty.

**Error 8** may occur only upon power-up. It suggests a faulty FRAM and would be expected to come in conjunction with error 6 or a loss of calibration data.

**Error 7** may occur only when leaving the calibration mode (see `CALIB:LOCK`). With successful calibration, the calibration data are written into the FRAM upon leaving the calibration mode. Possible causes of error: defective FRAM or a power supply fault.

**Error 6** may occur only upon power-up. Possible causes: the power sensor is not yet calibrated, the FRAM is defective or a power supply fault has occurred while data were being written into the FRAM.

**Error 5** represents the sum of all faults that might occur in calibration. Error 5 will be set if at least one calibration parameter is out of tolerance. More detailed information can be obtained with command `CALIB:ERR:TEXT` or `CALIB:ERR:CODE`.

**NOTE:** To facilitate troubleshooting, the storage of erroneous calibration data into the FRAM is not disabled.

Error 5 remains set until the supply voltage is switched off.





## 4 Maintenance and Troubleshooting

### 4.1 Setting the Baud Rate

The serial interface is factory-set to 38400 baud, which is compatible with the NRT basic unit. If the power sensor is operated via the serial interface of a PC (with Interface Adapter NRT-Z3 or NRT-Z4), a lower baud rate may be required. The baud rate can be changed to 19200, 9600 or 4800 baud by means of two DIP switches (see Fig. 4-1).

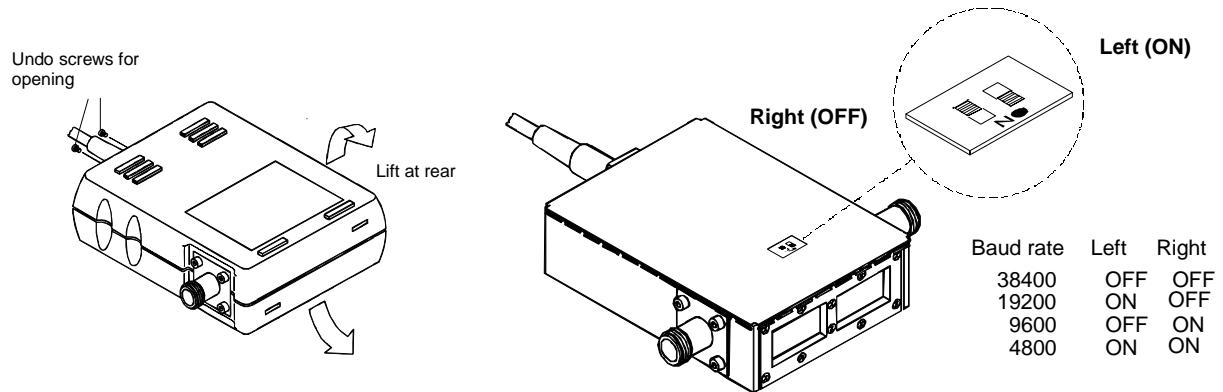


Fig. 4-1 Setting the baud rate (shown for 19200 baud)

### 4.2 Firmware Update

A new firmware is loaded from a PC via the Interface Adapters NRT-Z3 or NRT-Z4 using the graphical user interface *Virtual NRT*. An update via the NRT basic unit is not possible. The instructions for operating the sensors NRT-Z43/-Z44 via the interface adapters and the graphical user interface *Virtual NRT* can be found in sections 1.4, 1.5 and in chapter 2.

The current firmware for NRT-Z43/-Z44 can be obtained from R&S as a packed file named **NRT\_ZV.EXE**. After unpacking the file in a directory on the hard disk the new firmware including the current version of the graphical user interface *Virtual NRT* will be available. It is recommended to install *Virtual NRT* in a first step and to perform the firmware update via *Virtual NRT* afterwards. Details concerning the installation and update can be found in the files **NRT\_V.DOC** (for *Virtual NRT*) and **NRT\_Z.DOC** (for the firmware).

## 4.3 Functional Test

The functional test described in the following allows to determine faulty boards. Faults are detected either in the selftest (section 4.3.3) or in the tests for the individual boards described in section 4.3.4.

Whenever faults on the coupler board or analog board occur, a new calibration is required, which can only be performed by authorized and properly equipped service centers.

Checking the specifications for the measurement uncertainties given in the data sheet requires an extensive test equipment. The simple test setups described in section 5 feature somewhat higher measurement uncertainties. However, they are suitable to perform tests for determination of faulty boards.

The test is to be started only after the instruments have warmed up. Warming up is finished when the power indication on the NRT is stable with the test power switched off.

### 4.3.1 Measuring Instruments and Auxiliary Equipment

see section 5.1

Instead of using an NRT basic unit, the Directional Power Sensors NRT-Z43/Z44 can also be operated with the Interface Adapters NRT-Z3 or NRT-Z4 via the serial interface or the PCMCIA interface of a PC.

### 4.3.2 Power-up Test

#### Query error status via the serial interface

(via terminal program or *Virtual NRT* in **Direct Communication** mode):

The Directional Power Sensors NRT-Z43 and NRT-Z44 perform an automatic test of all hardware parameters approx. 10 s after power-up. The result is recorded as error status (see section 3.6.2) and can be queried by means of the commands `STAT:ERR:CODE` and `STAT:ERR:TEXT` (see section 3.4.2.5). The error status is also coded in the status field of a device response (see section 3.3.3.2).

**Note:** With the Windows user interface *Virtual NRT*, the status field can be permanently displayed in the **Options – State Indicator** menu.

#### Query error via NRT:

Errors in the power-up test are indicated by the message **SENS WARN**. They can be further decoded using the keys  or  under menu item **UTIL - TEST - SENS**.

### 4.3.3 Selftest

A selftest can be triggered at any time via the serial interface (see section 3.4.4.3, SERV:TEST), and the error status can be read (see section 3.4.2.5, STAT). The scope of the selftest is approximately the same as that of the power-up test.

#### Selftest with the Windows user interface *Virtual NRT*

- Select menu item *Sensor - Selftest*.
- All error state parameters must be marked *OK*.

#### Selftest via a terminal program

- Selftest with unit free of faults:

- SERV:TEST (triggering of selftest)  
@HH\_OK
- STAT:ERR:CODE (reading of error code)  
@HH\_00000000000000000000

- Selftest with faulty negative supply voltage:

- SERV:TEST  
@HH\_ERROR
- STAT:ERR:CODE  
@HH\_01000000000000000000

Error codes can be output not only in the form of error codes but also in plain text by means of command STAT:ERR:TEXT. For the second example, the following indication would be obtained:

```
@DE pack 23_____
@7F 01 HW PARAMETERS:_____
@17 02 SUPPLY VOLTAGE +      OK_____
@1A 03 SUPPLY VOLTAGE -      ERROR_____
@31 04 MH SUPPLY             OK_____
@EF 05 FORW. CONTROL VOLTAGE OK_____
@DB 06 REFL. CONTROL VOLTAGE OK_____
@05 07 CCDF OUTPUT LOW      OK_____
@14 08 CCDF OUTPUT HIGH     OK_____
@D2 09 CCDF MEDIUM THRESHOLD OK_____
@9A 10 TEMPERATURE          OK_____
@4B 11 PERMANENT ERRORS:_____
@5D 12 COMMUNICATION ADC 1   ERROR_____
@5F 13 COMMUNICATION ADC 2   OK_____
@F9 14 PEP CIRCUIT OPERATION OK_____
@F3 15 FRAM READ             OK_____
@44 16 FRAM WRITE            OK_____
@95 17 CAL. VALUES CHECKSUM OK_____
@8C 18 CALIBRATION VALUES  OK_____
@5A 19 OPERATION ERRORS:_____
@1D 20 CAL.LOCKED            OK_____
@D5 21 SYNTAX                ERROR_____
@7C 22 RANGE                 OK_____
@70 23 ZERO                  ERROR_____
```

#### Selftest with NRT

When the power sensor is operated with the NRT, a selftest can be triggered only by remote control. For this, the above commands must be put between “ ” and sent to the NRT with the header :TEST:DIR[ect]? (e.g. the command :TEST:DIR? “SERV:TEST” starts the selftest). The NRT in this case just passes on the command (for details see section 3.5.14 of NRT operating manual).

### 4.3.4 Determining Faulty Boards

Start selftest (section 4.3.3) and analyze the cause of the error messages according to Table 3-9.

#### 4.3.4.1 Controller Board

(Stock number 1081.1621.02)

The controller board serves the purpose of conditioning the power sensor supply voltage, controlling the analog board hardware, processing the measured data and communicating with the connected output device.

##### Test:

Perform the selftest according to section 4.3.3.

##### Optical error indication

If it is not possible at all to establish contact with the power sensor, the LED on the controller board may be used as additional test device.

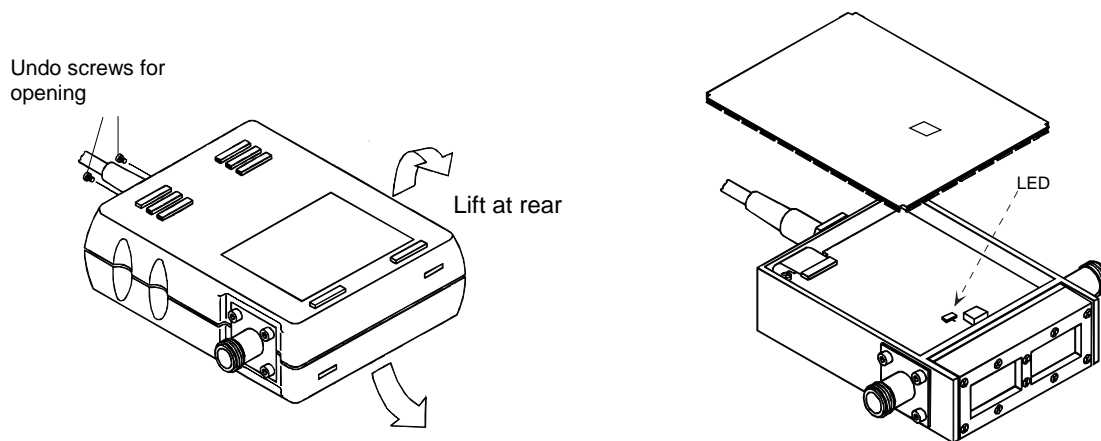
The condition for the optical test is that the Directional Power Sensors NRT-Z43 or NRT-Z44 are *not* addressed via the serial interface after the operating voltage has been applied. Therefore, this test is not possible in conjunction with the NRT.

##### Proceed as follows:

- Open sensor casing (siehe Fig. 4-2).
- Connect Interface Adapter NRT-Z3 to the power sensor.
- Interrupt serial interface to the controller/terminal.
- Switch power off and on again (disconnect jack plug from interface adapter and connect again).
- Observe LED: The diode must first flash for about 10 seconds (boot mode) and then switch off for a couple of seconds during the power-up test. Subsequently, the LED indicates the error status for about 30 seconds (Table 4-1):

**Table 4-1 LED status on power-up test**

LED status	Meaning
Flashing slowly, ie at intervals of 1 s	The power sensor functions properly.
Flashing fast, ie at intervals of approx. 100 ms	An error has been detected in the power-up test. A relevant HARDWARE PARAMETER is out of tolerance, or a PERMANENT ERROR is present. With this type of fault, the command SERV:TEST would produce the message ERROR.
Permanently on or off	The control processor (digital hardware) is defective.



**Fig. 4-2** Checking the LED status on power-up test

#### 4.3.4.2 Analog Board

(Stock number 1081.1638.02)

The Analog Board handles the complete signal processing for the output signals of the Coupler Board (see block diagram and description of function in section 3.5.1).

##### Testing the AVG test function (average power)

Perform the test as described in section 5.2.1.

##### Testing the CCDF threshold

Perform the test as described in section 5.2.2.

##### Testing the PEP test function (peak power)

Perform the test as described in section 5.2.3.

#### 4.3.4.3 Coupler Board

(Stock number 1081.1509.02)

The coupler board contains two directional couplers for measuring the forward and reverse power with connected two-way diode rectifiers, which generate voltages proportional to the decoupled RF powers.

For testing the coupler board (stock number 1081.1509.20 for NRT-Z43, 1081.1509.02 for NRT-Z44) measure the characteristics Item No. 1 and 4 according to the Performance Test Report. If the limits for the deviation specified there are exceeded, the power sensor will have to be recalibrated and, if required, the coupler board replaced.

If only the limit values for matching (Item No. 5 in the Performance Test Report) are exceeded, the RF connectors are to be checked for damage and replaced, if necessary (see section 4.4.2).

**4.3.4.4 Interface Adapter NRT-Z3**

(Stock number 1081.2705.02)

**Test:**

Perform the selftest according to section 4.3.3.

In the case of a fault, check the +5-V supply voltage at N2.1. Use the oscilloscope to test the pins TXD+, TXD-, RXD+ and RXD- of the serial RS-422 interface (N19) as well as the TXD and RXD pin of the RS-232 interface (D1).

For disassembly and assembly see section 4.4.3.

## 4.4 Replacement of Expendable Parts

Connection cables and RF connectors are often subject to particular wear. If they are damaged, they can be replaced without the need for a new calibration.

### 4.4.1 Power Sensor Cable



**Before opening the power sensor, disconnect the sensor cable from the NRT or Interface Adapter NRT-Z3 OR NRT-Z4.**

---

#### Opening the power sensor (see Fig. 4-2):

- Loosen the two Phillips screws next to the cable inlet.
- Separate the semicircular plastic parts and remove.
- Remove the plug-in bottom cover.

#### Replacing the cable

- Loosen two Phillips screws at the cable flange from the power sensor.
- Loosen four screws of the controller board and take the board out of the casing.
- Loosen cable plug from controller board.
- Plug new cable onto the multi-point connector of the controller board.

#### Closing the power sensor:

- For closing the sensor proceed in the reverse order.
- 



**When replacing the semicircular plastic parts make sure that the inscription "1" and "2" complies with the inscription on the metal casing.**

---

### 4.4.2 RF Connectors

Loosen the eight fixing screws of the two RF connectors (using a 2.5-mm ball-shaped-head Phillips screwdriver) and pull the connectors out of the casing. Push out the inner conductor using a round punch (2 to 3 mm of diameter).

Replace the damaged parts.

#### Proceed as follows:

- First insert the washers (stock number 1081.3360).
- Then insert the sleeves (stock number 1081.3382) such that the front bezzle point towards the RF connectors.
- Push inside the inner conductor, place the RF connectors onto the inner conductor and fasten with screws again.

### 4.4.3 Connection Cable for the Interface Adapter NRT-Z3

---



**Before opening the adapter disconnect jack plug.**

---

#### **Opening the adapter:**

- Press the lower semicircular plastic part together on the sides and remove both plastic parts.
- Loosen the four Phillips screws on the shielding cover and remove together with the shielding cover.
- Loosen the Phillips screw on the side and take the board out of the casing.
- Loosen the cable from the board.
- Insert cable plug of the new cable into the multi-point connector of the interface adapter.

#### **Reassembling the adapter**

- For reassembly, proceed in the reverse order.

## 4.5 Cleaning and Care

Wipe the power sensor with a damp cloth from time to time. Mild detergents such as washing-up liquid may be used. Do not use spirit, cellulose lacquer thinner or similar solvents as these may damage the type label and the enclosure.

If the power sensor is frequently used, check the two RF connectors for contamination and visible damage such as bent inner conductors, broken contact springs, etc. Loosen dirt with a pointed matchstick and blow it out.



## 5 Testing the Rated Specifications

### 5.1 Measuring Instruments and Auxiliary Equipment

Item No.	Instrument Characteristics	R&S type	Stock No.	Use in section
1	Power reflection meter or Windows user interface	NRT Virtual NRT	1080.9506.02	4.2.2...4.2.4 4.2.4.1...4.2.4.4 5.2.1...5.2.5
2	Interface adapter	NRT-Z3 OR NRT-Z4 (in conjunction with Virtual NRT)	1081.2705.02	4.2.2...4.2.4 4.2.4.1...4.2.4.4 5.2.1...5.2.4
3	Controller with RS-232 interface	in conjunction with Virtual NRT		4.2.2...4.2.4 4.2.4.1...4.2.4.4 5.2.1...5.2.4
4	Microwave generator 0.4 GHz to 4 GHz, 13 dBm	SMT 06	1039.2000.06	4.2.4.2 5.2.1...5.2.4
5	Power amplifier 0.4 GHz to 4 GHz, output power min. 5 W Gain > 25 dB, harmonic suppression > 25 dB			4.2.4.2 5.2.1...5.2.4
6	Power sensor 0.4 GHz to 4 GHz, 10 W or 30 W	NRV-Z53 NRV-Z54	0858.0500.02 0858.0800.02	4.2.4.2 5.2.1...5.2.4
7	Power meter	NRVS or NRVD or URV 35	1020.1809.02 0857.8008.02 1020.0002.02 1020.0002.03	4.2.4.2 5.2.1...5.2.4
8	Reflection meter 0.4 GHz to 4 GHz, 50 $\Omega$ with calibration set 50 $\Omega$	ZVR  ZV-Z21	1043.0009.60  1085.7099.02	5.2.5
9	Digital multimeter 1 mV to 300 V (DC)	URE2 or URE3	0350.5315.02 0350.5315.03	4.2.4.4
10	Oscilloscope 20 MHz			4.2.4.4

## 5.2 Test Sequence

The test is to be started only when the instruments have warmed up. Warming-up of the power sensor is finished when the power indication on the NRT is stable with the test power switched off.

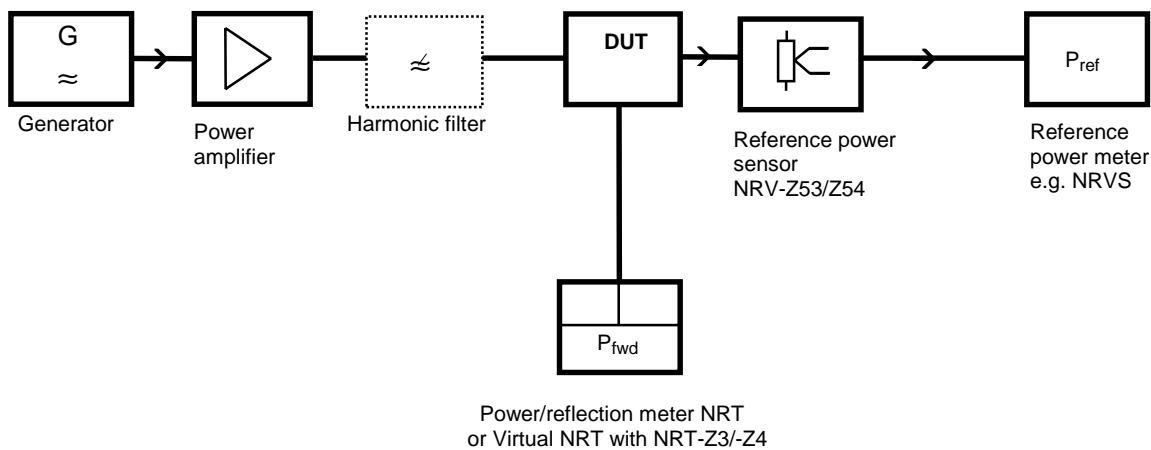
Directly connect the device under test and the reference power meter, since, due to their attenuation and reflection, connection cables produce errors in measurement. If adapters are required between RF connectors, precision adapters with low attenuation and reflection should be used.

The powers measured in the following tests using the Directional Power Sensors NRT-Z43/Z44 are the powers coming out of the power sensor. Therefore, set the NRT or *Virtual NRT* to the test level *MEAS.POS\* LOAD*.

Checking the specifications for the measurement uncertainties given in the data sheet requires an extensive test equipment. This chapter describes simpler test sets with somewhat higher measurement uncertainties. However, they are suitable to perform tests for determination of faulty boards.

The limit values specified in the Performance Test Report consider these additional measurement uncertainties.

### 5.2.1 Testing the AVG Measurement Function



**Fig. 5-1 Test setup for testing the AVG power indication**

Use a harmonic filter if the harmonic suppression of the amplifier is <25 dB.

#### Test sequence (to be performed for both directions of the sensor):

- Switch off output power on generator and set test frequency according to Performance Test Report.
- Set test function *AVG*, test level *MEAS.POS\* - LOAD* and forward direction *DIRECTION\* - AUTO* on the NRT or via user interface *Virtual NRT*.
- Enter test frequency on NRT or *Virtual NRT* and on the reference power meter, activate frequency response correction on the reference power meter.
- Prior to the first measurement perform zeroing on both instruments.
- Switch on output power on generator (test signal not modulated). Set level such that a power of approx. 1 W (for NRT-Z43) or 4 W (for NRT-Z44) is measured on the reference power meter.

- Calculate the power deviation of the device under test according to the following formula:

$$F_P = 100\% \cdot [(P_{\text{fwd}} / P_{\text{ref}}) - 1]$$

- Use the power sensor in reverse mode, calculate the power deviation for the reverse direction and compare with Performance Test Report.

## 5.2.2 Testing the CCDF Threshold

Test setup as in section 5.2.1

Test sequence:

- Switch off output power on generator and perform zeroing via the Power Meter NRT or the User Interface *Virtual NRT* as well as on the reference power meter.
- Enter test frequency of 1 GHz on generator, NRT or *Virtual NRT* and on the reference power meter. Activate frequency response correction on reference power meter.
- Switch on output power on generator (test signal not modulated). Set level such that a power of 3.8 W to 4.2 W is measured on the power meter.
- Select CCDF function, *CCDF* threshold 3 W and video bandwidth 4 kHz.
- Read CCDF value and compare with Performance Test Report.
- Select CCDF function, *CCDF* threshold 5 W and video bandwidth 4 kHz.
- Read CCDF value and compare with Performance Test Report.

## 5.2.3 Testing the PEP Function

Test setup as in section 5.2.1

The PEP function is checked with the CF power indication.

Test sequence:

- Switch off output power on the generator and perform zeroing via Power Meter NRT or User Interface *Virtual NRT* as well as on reference power meter.
- Enter test frequency 1 GHz on Generator, NRT or *Virtual NRT* and on reference power meter, activate frequency response correction on reference power meter.
- Select CF function with 4-kHz video bandwidth.
- Switch on output power on generator (test signal not modulated). Set level such that a power of 0.975 W to 1.025 W is measured on the reference power meter.
- Set 80% AM modulation on generator. Modulation frequency 0.4 kHz.
- Read CF value and compare with Performance Test Report.

## 5.2.4 Testing the Directivity

### Test setup as in section 5.2.1

The directivity is the value calculated from the ratio of forward and reverse power indicated by the NRT with 50-Ω termination of the device under test.

Using the shown test setup, the measured directivity can be directly indicated using the NRT or *Virtual NRT* in the measuring function *Return Loss (RL)*.

### Test sequence:

- Set forward test function *AVG*, reverse test function *RL* and *RESOLUTION HIGH* on the NRT or *Virtual NRT*. Input of the test frequency is not necessary.
- For determination of the directivity, connect generator to RF connector 1 and reference power sensor to RF connector 2. Set test level *MEAS.POS\* LOAD* and forward direction *DIRECTION\* AUTO* on the NRT.
- Switch off output power on generator and set the test frequency according to the Performance Test Report.
- Perform zeroing via NRT or *Virtual NRT*.
- Switch on maximum output power on generator (test signal not modulated).
- Record the directivity(RL).

## 5.2.5 Testing the Matching

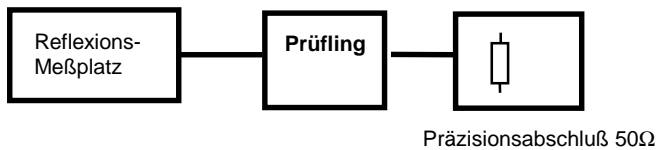


Fig. 5-2 Test setup for testing the matching

### Test sequence:

- Measure reflection coefficients  $s_{11}$  and  $s_{22}$  (both directions) of the power sensor in the frequency range 0.4 GHz to 4 GHz and record the maximum values of both directions for the specified frequency ranges.

### 5.3 Performance Test Report

R&S Directional Power Sensor NRT-Z43/Z44  
 NRT-Z43, stock number 1081.2905.02  
 NRT-Z44, stock number 1081.1309.02

Name: .....  
 Date: .....  
 Serial No.....

**Table 5-1: Performance Test Report**

Item No.	Characteristic	Measure according to section	Min.	act.		Max.	Unit
				1 → 2	2 → 1		
1	AVG power indication	5.2.1					
	0.4 GHz		-4.4 (-0.19)	.....	.....	4.4 (+0.19)	% (dB)
	0.5 GHz		-4.4 (-0.19)	.....	.....	4.4 (+0.19)	% (dB)
	0.7 GHz		-4.4 (-0.19)	.....	.....	4.4 (+0.19)	% (dB)
	0.9 GHz		-4.4 (-0.19)	.....	.....	4.4 (+0.19)	% (dB)
	1.2 GHz		-4.4 (-0.19)	.....	.....	4.4 (+0.19)	% (dB)
	1.5 GHz		-4.4 (-0.19)	.....	.....	4.4 (+0.19)	% (dB)
	1.8 GHz		-4.4 (-0.19)	.....	.....	4.4 (+0.19)	% (dB)
	2.1 GHz		-4.6 (-0.20)	.....	.....	4.6 (+0.20)	% (dB)
	2.5 GHz		-4.6 (-0.20)	.....	.....	4.6 (+0.20)	% (dB)
	3.0 GHz		-4.6 (-0.20)	.....	.....	4.6 (+0.20)	% (dB)
	3.5 GHz		-4.6 (-0.20)	.....	.....	4.6 (+0.20)	% (dB)
4.0 GHz	-4.6 (-0.20)	.....	.....	4.6 (+0.20)	% (dB)		
2	CCDF ratio with 3 W	5.2.2	100	.....	.....		%
	CCDF ratio with 5 W			.....	.....	0	%
3	Peak-power measurement (CF value)	5.2.3	3.53	.....	.....	4.27	dB
4	Directivity	5.2.4					
	0.4 GHz		21.5	.....	.....	---	dB
	0.9 GHz		21.5	.....	.....	---	dB
	1.3 GHz		21.5	.....	.....	---	dB
	1.8 GHz		21.5	.....	.....	---	dB
	2.4 GHz		17.7	.....	.....	---	dB
	3.0 GHz		17.7	.....	.....	---	dB
	3.5 GHz		16.5	.....	.....	---	dB
4.0 GHz	16.5	.....	.....	---	dB		
5	Matching (Reflection coeff $S_{11}$ , $S_{22}$ )	5.2.5					
	0.4 GHz to 3 GHz		---	.....	.....	0.06	
	> 3 GHz to 4 GHz		---	.....	.....	0.08	



# Annex List of Commands

The following list contains all commands of the sensor including their parameters, the default setting and a short description. For service and calibration functions refer to Table 3-7 and Table 3-8. The page numbers quoted refer to the detailed command description given in section 3.4.

**Table A-1 List of all remote control commands**

Command	Parameters	Default setting	Description	Page
APPL	–	–	Activate measurement mode	3.34
BOOT	–	–	Activate boot mode	3.34
BURS:PER	1E-9 to 1.0 (s)	0.01 s	Burst period	3.13
BURS:WIDT	1E-9 to 1.0 (s)	0.001 s	Burst width	3.13
CALIB	–	–	–	3.41
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