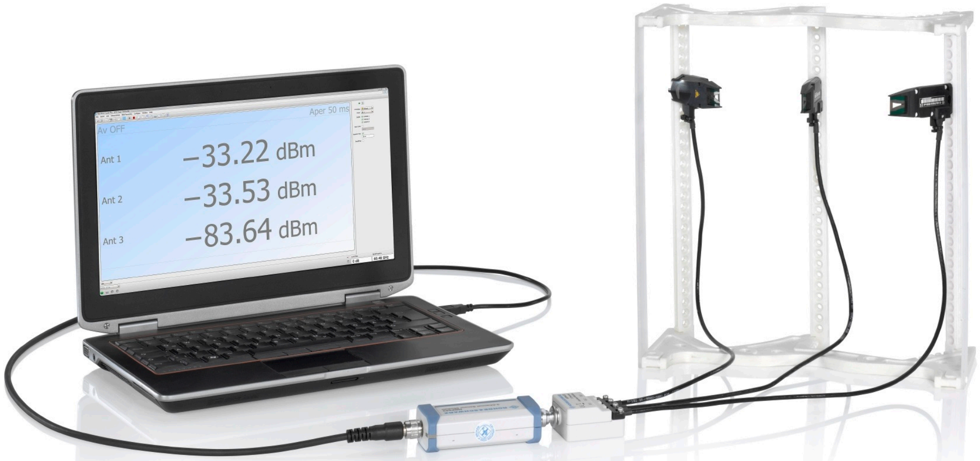
R&S®NRPM OTA Power Measurement Solution Manual



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Version 12

ROHDE&SCHWARZ
Make ideas real

This document describes the R&S®NRPM OTA power measurement solution, with firmware version 03.50 and higher, including the following components:

- R&S®NRPM3N three-channel sensor module LAN, 1425.8592.02
- R&S®NRPM3 three-channel sensor module, 1425.8563.02
- R&S®NRPM-A90 single-polarized antenna module, 1426.7760.02/.03/.04/.05
- R&S®NRPM-A90D dual-polarized antenna module, 1426.7777.02/.03/.04/.05
- R&S®NRPM-ZD3 feedthrough module, 1425.8786.02
- R&S®NRPM-Z3 three-channel interface module, 1426.7602.02

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1425.8663.02 | Version 12 | R&S®NRPM

Throughout this document, R&S® is indicated as R&S.

Contents

1 Safety and regulatory information

The product documentation helps you use the product safely and efficiently. Follow the instructions provided here and in the following sections.

Intended use

The R&S NRPM OTA power measurement solution is intended for accurate power measurements in production, R&D and calibration labs, and for installation and maintenance tasks. Observe the operating conditions and performance limits stated in the specifications document.

The R&S NRPM OTA power measurement solution is designed for use in anechoic environments as RF shielded boxes or benchtop applications in RF test chambers. You can use it for Over-the-Air (OTA) beamforming verification in 5G, WLAN IEEE 802.11ad and IEEE 802.11ay and the calibration of the transmit antenna output power.

Observe the operating conditions and performance limits stated in the specifications document.

Target audience

The target audience is developers and technicians. The required skills and experience in power measurements depend on the used operating concept.

Where do I find safety information?

Safety information is part of the product documentation. It warns you of potential dangers and gives instructions on how to prevent personal injury or damage caused by dangerous situations. Safety information is provided as follows:

- In Section 1.1, "Safety instructions", on page 10. The same information is provided in many languages in printed format. The printed "Safety Instructions" for "Power Sensors" (document number 1171.1865.99) are delivered with the product.
- Throughout the documentation, safety instructions are provided when you need to take care during setup or operation.

1.1 Safety instructions

Products from the Rohde & Schwarz group of companies are manufactured according to the highest technical standards. To use the products safely, follow the instructions provided here and in the product documentation. Keep the product documentation nearby and offer it to other users.

Use the product only for its intended use and within its performance limits. Intended use and limits are described in the product documentation such as the specifications document, manuals and the printed "Safety Instructions" document. If you are unsure about the appropriate use, contact Rohde & Schwarz customer support.

Using the product requires skilled persons or specially trained personnel. These users also need sound knowledge of at least one of the languages in which the user interfaces and the product documentation are available.

Reconfigure or adjust the product only as described in the product documentation or the specifications document. Any other modifications can affect safety and are not permitted.

Never open the casing of the product. Only service personnel authorized by Rohde & Schwarz are allowed to repair the product. If any part of the product is damaged or broken, stop using the product. Contact Rohde & Schwarz customer support at https://www.rohde-schwarz.com/support.

Operating the product

Only use the product indoors. The product casing is not waterproof.

Observe the ambient conditions stated in the specifications document. Examples of ambient conditions are altitude, operating temperature and climatic loads.

Meaning of safety labels

Safety labels on the product and its accessories warn against potential hazards.

⚠	Potential hazard Read the product documentation to avoid personal injury or product damage.

	Hot surface Do not touch. Risk of skin burns. Risk of fire.

1.2 Labels on the product

Labels on the product inform about:

- Personal safety
  See "Meaning of safety labels" on page 10.
- Environment safety
  See Table 1-2.
- Identification of the product
  A sticker on the product shows the product ID, a combination of the order number and the serial number of the product. The serial number identifies the product uniquely.
  See also Section 6.3.5.1, "Using hostnames", on page 55.
- Sensitive components
  See Table 1-1.

Table 1-1: Labels regarding product damage

	Potential product damage Read the product documentation to avoid product damage.
	Electrostatically sensitive components Indicates sensitivity to touch. Follow the instructions in the product documentation to avoid product damage. For more information, see "Disposing of electrical and electronic equipment" on page 221.

Table 1-2: Labels regarding environment safety

	Labeling in line with EN 50419 for disposal of electrical and electronic equipment after the product has come to the end of its life. For more information, see "Disposing of electrical and electronic equipment" on page 221.

1.3 Warning messages in the documentation

A warning message points out a risk or danger that you need to be aware of. The signal word indicates the severity of the safety hazard and how likely it will occur if you do not follow the safety precautions.

NOTICE

Potential risks of damage. Could result in damage to the supported product or to other property.

1.4 CE declaration of conformity

The CE declaration of conformity is delivered with the product. Keep the document for further reference.

The current version of this CE declaration of conformity is available at:

www.rohde-schwarz.com/product/nrpm

1.5 Where to find key documents on Rohde & Schwarz

Certificates issued to Rohde & Schwarz that are relevant for your country are provided at www.rohde-schwarz.com/key-documents, e.g. concerning:

- Quality management
- Environmental management
- Information security management
- Accreditations

2 Welcome to the R&S NRPM OTA power measurement solution

Introduces the R&S NRPM OTA power measurement solution.

In the manuals, the terms sensor and power sensor module are used synonymously.

2.1 Key features

The R&S NRPM OTA power measurement solution is designed to calibrate the transmit antenna output power and test the beamforming function over the air. Applications are in high frequency bands, used in modern high performance wireless system standards, e.g. 5G NR, IEE802.11ad and IEEE802.11ay.

Providing measurements of radiated RF power, the R&S NRPM OTA power measurement solution features:

- Single and dual polarized receiver antenna modules with integrated diode detector
- R&S NRPM3(N) sensor module for readings of receiver antenna modules
- OTA power measurements with up to three antenna modules per R&S NRPM sensor module
- Ethernet and high speed host USB communication interfaces
- Mode for processing frequency lists for short settling times and fast measuring of predefined random frequency points
- High sensitivity
- Fully calibrated system with specified system uncertainty
- Low-reflection antenna module
- Wide range of supported operating systems
- Easy operation with PC measurement applications, or remotely with SCPI commands

For detailed specification, refer to the specifications document.

2.2 About the R&S NRPM OTA power measurement solution

The power measurement solution consists of antenna modules, a three-channel sensor module, and interface modules for connecting the antenna modules to the sensor module. A PC measurement application demonstrates the use of the OTA power measurement solution.

The R&S NRPM3 sensor modules provide a high-speed USB interface that constitutes both, the communication port and the power supply connection. The R&S NRPM3N LAN sensor module adds a Gigabit Ethernet interface with Power-over-Ethernet (PoE) power supply.

The single or dual-polarized antenna modules (R&S NRPM-A90, R&S NRPM-A90D) are usually installed within an anechoic chamber, that can be:

- An RF shielded box, e.g. the R&S CMQ200.
  The antenna modules are positioned inside the RF shielded box, the sensor module is outside. The sensor module is connected by the feedthrough module R&S NRPM-ZD3 that provides the interface for up to three antenna modules.
  Especially designed for use with the R&S CMQ200, you can install up to six of the feedthrough modules. An antenna ring inside the R&S CMQ200 allows you to position and align the antenna modules flexibly according to the application.
- An RF test chamber of larger dimensions.
  The antenna modules and the sensor module are positioned inside the RF test chamber. The interface module R&S NRPM-Z3, directly connected to the sensor module provides the interface for up to three antenna modules.

With the single and dual polarized antenna modules (R&S NRPM-A90, R&S NRPM-A90D), you can calibrate the DUT (transmit antenna) output power and test the beamforming function.

The R&S NRPM measurement is controlled by an arbitrary user-definable measurement application. For a quick startup, Rohde & Schwarz provides the free interactive application R&S Power Viewer, which supports multiple sensor modules in the measurement modes "Continuous Average" and "Trace".

As an alternative way to operate an R&S NRPM3N sensor module, you can use the browser based web user interface.

For communication over the USB with the standardized protocol USBTMC, the drivers and APIs are provided at our website. It is required that you install a VISA driver on the host operating system, to use the I/O services provided by this standardized software interface library.

The sensor module supports SCPI remote control, e.g. to automate a measurement with a scripting environment.

3 Documentation overview

This section provides an overview of the R&S NRPM user documentation. Unless specified otherwise, you find the documents at:

www.rohde-schwarz.com/manual/nrpm.

3.1 Manual

Introduces the R&S NRPM and describes how to set up and start working with the product. The manual includes general information, and the typical measurement application with programming examples. The sensor module specific functions, and an introduction to remote control and a complete description of the remote control commands are described.

A printed version is delivered with the R&S NRPM OTA Power Measurement Solution.

3.2 Tutorials

Tutorials offer guided examples and demonstrations on operating the R&S NRPM. They are provided on the product page of the internet.

3.3 Videos

Find various videos on Rohde & Schwarz products and test and measurement topics on YouTube: https://www.youtube.com/@Rohde-Schwarz

3.4 Service manual

Describes the performance test for checking the rated specifications, module replacement and repair, firmware update, troubleshooting and fault elimination, and contains mechanical drawings and spare part lists.

The service manual is available for registered users on the global Rohde & Schwarz information system (GLORIS):

3.5 Instrument security procedures

Deals with security issues when working with the R&S NRPM in secure areas. It is available for download on the internet.

3.6 Printed safety instructions

Provides safety information in many languages. The printed document is delivered with the product.

3.7 Specifications and product brochures

The specifications document, also known as the data sheet, contains the technical specifications of the R&S NRPM. It also lists the firmware applications and their order numbers, and optional accessories.

The brochure provides an overview of the instrument and deals with the specific characteristics.

See www.rohde-schwarz.com/brochure-datasheet/nrpm.

3.8 Calibration certificate

The document is available on https://gloris.rohde-schwarz.com/calcert. You need the device ID of your instrument, which you can find on a label on the rear panel.

3.9 Release notes and open-source acknowledgment (OSA)

The release notes list new features, improvements and known issues of the current software version, and describe the software installation.

The software uses several valuable open source software packages. An open source acknowledgment document provides verbatim license texts of the used open source software.

The open source acknowledgment document is provided on the software CD-ROM, included in the delivery.

See www.rohde-schwarz.com/firmware/nrpm.

3.9.1 Application notes, application cards, white papers, etc.

These documents deal with special applications or background information on particular topics.

www.rohde-schwarz.com/application/nrpm

4 Preparing for use

Here, you can find basic information about setting up the product for the first time.

4.1 Unpacking and checking

1. Unpack the product carefully.
2. Retain the original packing material. Use it when transporting or shipping the product later.
3. Using the delivery notes, check the equipment for completeness.
4. Check the equipment for damage.

   If the delivery is incomplete or equipment is damaged, contact Rohde & Schwarz.

4.2 Choosing the operating site

Specific operating conditions ensure proper operation and avoid damage to the product and connected devices. For information on environmental conditions such as ambient temperature and humidity, see the specifications document.

Electromagnetic compatibility classes

The electromagnetic compatibility (EMC) class indicates where you can operate the product. The EMC class of the product is given in the specifications document.

- Class B equipment is suitable for use in:

  - Residential environments
  - Environments that are directly connected to a low-voltage supply network that supplies residential buildings
- Class A equipment is intended for use in industrial environments. It can cause radio disturbances in residential environments due to possible conducted and radiated disturbances. It is therefore not suitable for class B environments.
  If class A equipment causes radio disturbances, take appropriate measures to eliminate them.

4.3 Considerations for test setup

Give particular attention to the following aspects when handling the components of the R&S NRPM OTA power measurement solution.

For information on the options for connecting the sensor modules and test setups for the measurements, see Section 6, "Setting up a measurement", on page 38.

To prevent antenna damage

Damage is most likely to occur when you connect or disconnect an antenna modules.

1. **NOTICE!** Electrostatic discharge can quickly and imperceptibly damage or destroy the electrostatic sensitive antenna modules.

   Ground yourself to prevent electrostatic discharge damage:

   a) Use a wrist strap and cord to connect yourself to the ground.
   b) Use a conductive floor mat and heel strap combination.
2. **NOTICE!** If you touch the PCB (printed circuit board) of the antenna module, it can bend and thus lead to measurement inaccuracies.

   Always hold the antenna modules by the housing. Take care not to touch the exposed top or bottom of the antenna module PCB.

EMI impact on measurement results

Electromagnetic interference (EMI) can affect the measurement results.

To suppress electromagnetic radiation during operation:

- Use high-quality shielded cables, for example, double-shielded RF and interface cables.
- Always terminate open cable ends.
- Ensure that connected external devices comply with EMC regulations.
- When using the filtered cable feedthrough module R&S NRPM-ZD3, make sure that the housing of the RF shielded box is grounded, since the feedthrough module is grounded by the housing.

Since the antenna module receives signals in a wideband, also outside the specified frequency bands, always measure in a controlled EM environment. In particular, when working with the R&S NRPM-Z3 interface module.

Signal input and output levels

Information on signal levels is provided in the specifications document. Keep the signal levels within the specified ranges to avoid damage to the product and connected devices.

4.4 Powering the R&S NRPM3(N) sensor module

The electrical power for a R&S NRPM3(N) sensor module is supplied over one of the following interfaces:

- Host interface
  See "Host interface connector (3)" on page 30.
- LAN PoE interface
  Only available for R&S NRPM3N sensor modules, see"LAN PoE interface (6)" on page 31.

If you use the Ethernet interface of the R&S NRPM3N sensor module, you have to provide the electrical power by power over Ethernet (PoE). In this case, you *cannot* provide the electrical power over the host interface instead.

Choose the PoE power sourcing equipment (PSE) with care

Only use PoE power sourcing equipment (PSE) as specified in the IEEE standards 802.3af or IEEE 802.3at. Otherwise, the following can happen:

- If too much power is supplied, the R&S NRPM3N sensor module can get overheated and become damaged as a result.
- If the supplied power is not sufficient, the R&S NRPM3N sensor module does not work properly or not at all.

4.5 Hardware requirements

The basic measurement equipment for an OTA power measurement with the R&S NRPM consists of:

- Three channels sensor module R&S NRPM3N or R&S NRPM3.
- Antenna modules:
  - R&S NRPM-A90: one at a minimum, and three at a maximum per sensor module.
  - R&S NRPM-A90D: occupies two channels of the sensor module. You can split the antenna module cables of one R&S NRPM-A90D antenna module on two interface or feedthrough modules.

- One of the following:
  – Filtered cable feedthrough module R&S NRPM-ZD3 (RF shielded box) and the interface cable R&S NRPM-ZKD3.
  – Three channel interface module R&S NRPM-Z3 (RF test chamber). Tool for fixing the strain relieve: torx screwdriver TX8.
- Desktop PC or laptop with:
  – Required software, see Software requirements and installation. The required operating system depends on the software.
  – USB interface
- LAN connection cables
  RJ-45 Ethernet cable (at least CAT6 STP).
  How to: Section 6.3.4, "Using the LAN connection", on page 50
- USB connection cables
  Double shielded cables, e.g. R&S NRP-ZKU, or NRP-ZK6.

  For this connection, Rohde & Schwarz provides two types of cables:
  – R&S NRP-ZKU cable with a USB connector
  – NRP-ZK6 cable with a push-pull type connector

  You can get both cables with different lengths up to 5 meters.
  How to: Section 6.3.3, "Using the USB connection", on page 47.

See Section 6, "Setting up a measurement", on page 38 for examples on how to set up an R&S NRPM OTA power measurement.

4.6 Software requirements and installation

The sensor module is a smart sensor module that you can directly connect to a controlling PC.

To communicate with the sensor module, you can use the VISA I/O standard.

Install the following software on the controlling PC:

- Section 4.6.1, "R&S VISA", on page 24
- Section 4.6.2, "R&S NRP-Toolkit", on page 24

The installation of the other software packages is optional.

4.6.1 R&S VISA

A driver software that supports I/O communication functions is known as VISA software library. You can use any VISA software library, but we recommend that you use the R&S VISA.

► Download the R&S VISA for different operating systems at www.rohde-schwarz.com/rsvisa.

R&S VISA allows fast communication with the sensor module. It includes a trace tool for communication analysis, a testing tool for connection check, and a configuration tool for the definition of resources.

4.6.2 R&S NRP-Toolkit

Before you start using an R&S sensor or sensor module, we recommend installing the latest R&S NRP-Toolkit.

The R&S NRP-Toolkit is the basic software package that supplies low-level drivers and tools for all R&S sensors, sensor modules and power standards.

4.6.2.1 Versions and downloads

The R&S NRP-Toolkit is available for:

- Microsoft Windows® operating system, as listed in Section 4.6.2.2, "System requirements", on page 25
- macOS

The latest versions for Windows and macOS are available at:

www.rohde-schwarz.com/software/nrpm

To obtain an R&S NRP-Toolkit for other operating systems, contact the Rohde & Schwarz customer support, see Section 13.8, "Contacting customer support", on page 218.

4.6.2.2 System requirements

Hardware requirements:

- Desktop computer or laptop, or an Intel-based Apple Mac
- LAN interface and equipment for setting up a LAN connection.
  See Section 6.3.4, "Using the LAN connection", on page 50.

For supported Microsoft Windows versions, see the release notes.

4.6.2.3 R&S NRP-Toolkit for Windows

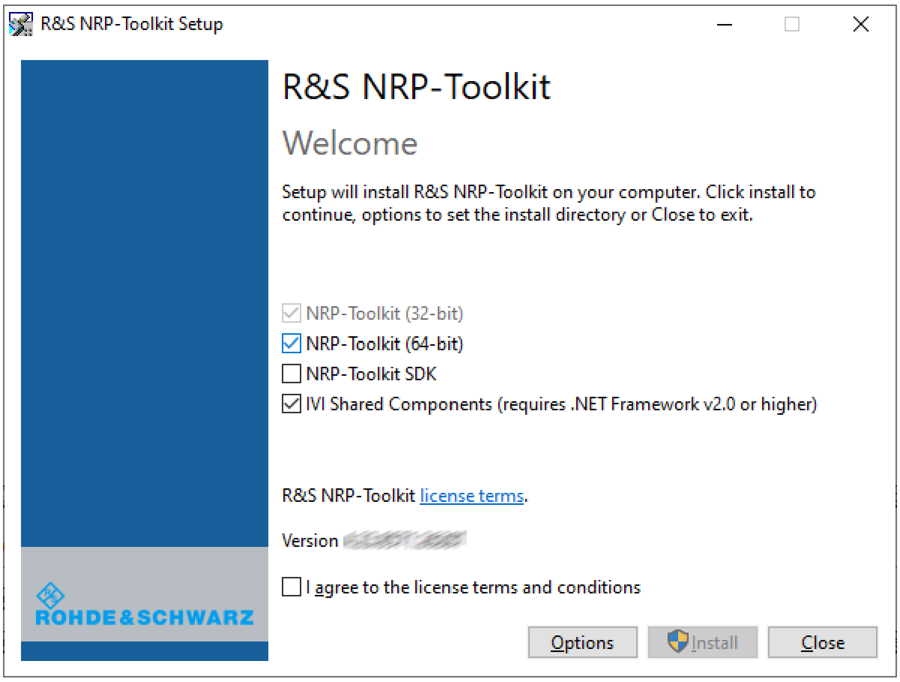
The R&S NRP-Toolkit installer for Windows-based systems contains the components described in the release notes.

To install the R&S NRP-Toolkit

1. Start the R&S NRP-Toolkit installer on the Windows-based computer.

   In the "NRP-Toolkit Setup" dialog, the correct R&S NRP-Toolkit version for your operating system, 32-bit or 64-bit, is already selected.

2. Enable the packages that you want to install.
   - "NRP-Toolkit (SDK)"
     See "Software development kit (SDK)" on page 26.
   - "IVI Shared Components"
     Installs the USBTMC driver. Enabled by default because the installation is recommended.
     See also "Computer requirements" on page 185



3. Accept the license terms to continue with the installation.
4. Click "Next" and complete the installation process.

To uninstall the R&S NRP-Toolkit

Use the Windows functionality for removing apps and features. The R&S NRP-Toolkit itself has no uninstall functionality.

Software development kit (SDK)

The software development kit (SDK) is a package of the R&S NRP-Toolkit. It provides programming examples for the R&S sensors.

See Section 10, "Programming examples", on page 169.

Components of the R&S NRP-Toolkit for Windows

Access: "Start" > "NRP-Toolkit"

The components of the R&S NRP-Toolkit depend on the operating system. The following tools are part of the R&S NRP-Toolkit for Windows.

Configure Network Sensor

Useful if you have trouble establishing a LAN connection with a LAN sensor.

The tool provides the following functions:

- Configuring the network settings by temporarily using a USB connection.
- Discovering the sensors that have been configured via the zeroconf (APIA) protocol.

The tool comes with a guide (PDF) that is also available in the "Start" menu. The guide explains the network setup.

Firmware Update

Installs new firmware on the sensor.

See Section 8, "Firmware update", on page 83.

NRP Uncertainty Calculator

Determines the expanded measurement uncertainty. The tool comes with a manual (PDF) that is also available in the "Start" menu.

NRP Version Display

Displays version information of all installed, power measurement-relevant software packages.

Terminal

Low-level communication program for sending commands to the sensor.

4.6.3 R&S Power Viewer

The R&S Power Viewer is an interactive power measurement software application from Rohde & Schwarz for measurements and evaluation of results with the sensor module.

The R&S Power Viewer is a separate standalone installation package. The installation package is provided on the Rohde & Schwarz website at:

www.rohde-schwarz.com/software/nrpm

As a prerequisite, the R&S Power Viewer requires the following software installed:

- R&S VISA
- R&S NRP-Toolkit

With the R&S Power Viewer software, the user manual is installed.

4.6.4 Programming examples for customer-specific applications

Rohde & Schwarz provides various programming examples containing:

- Programming examples in C/C++ or Python source code for VISA communication protocols
- Project and auxiliary files

The programming examples are included in the SDK (software development kit) of the R&S NRP-Toolkit. You can select the SDK during installation, see "To install the R&S NRP-Toolkit" on page 25.

If you install the optional software development kit (SDK) of the R&S NRP-Toolkit, programming examples are provided. See Section 4.6.2, "R&S NRP-Toolkit", on page 24.

Under Windows, these examples are installed under:

`C:\ProgramData\Rohde-Schwarz\NRP-Toolkit-SDK\examples`

5 R&S NRPM tour

The following chapters introduce the main hardware components of the R&S NRPM OTA power measurement solution.

5.1 R&S NRPM3(N) sensor modules

The R&S NRPM3(N) three-channel sensor module processes the measured values from up to three antenna modules in three separate channels.

This chapter provides an overview of the available connectors and LEDs of the R&S NRPM3(N) sensor modules. Figure 5-1 shows the LAN sensor module on the left, and the USB sensor module on the right.

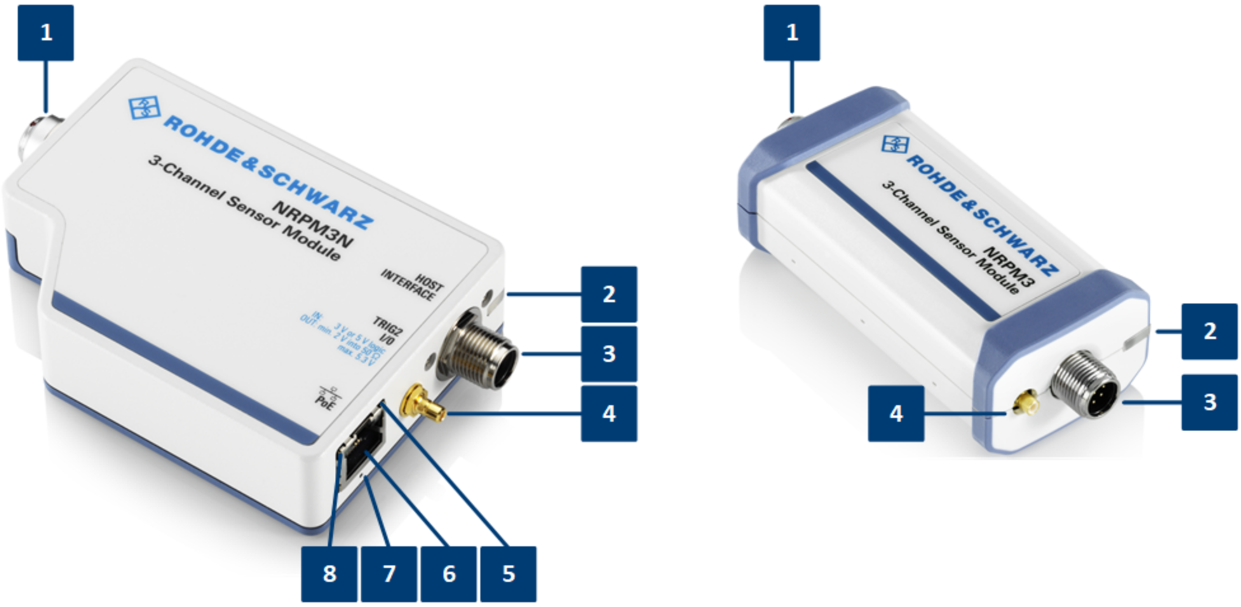


Figure 5-1: R&S NRPM3N and R&S NRPM3

1 = Antenna connector, see "Antenna connector (1)" on page 30
2 = Status LED, see "Status LED (2)" on page 30
3 = Host interface connector, see "Host interface connector (3)" on page 30
4 = Trigger I/O connector, see "Trigger I/O connector (4)" on page 31
5 = Network status LED, see "Network status LED (5)" on page 31
6 = LAN connector, see "LAN PoE interface (6)" on page 31
7 = LAN reset button, see "LAN reset (7)" on page 32
8 = Power over Ethernet status LED, see "Power over Ethernet status LED (8)" on page 32

Antenna connector (1)

Multipole antenna connector for connecting the

- R&S NRPM3(N) to the interface module R&S NRPM-Z3.
- R&S NRPM3(N) to the filtered cable feedthrough module R&S NRPM-ZD3 with the interface cable R&S NRPM-ZKD3.

Note: Measurements with R&S NRPM3N LAN sensor modules require that you use the latest version of the R&S NRPM-ZKD3 interface cable (1436.2984.02).

Status LED (2)

	Color	Indication	State
○	White	Steady	Idle The sensor module performs no measurement and is ready for use.
☼	White	Fast flashing	Firmware update or reboot is in progress. When the firm-ware update or reboot is finished, the LED changes to glowing white steadily, indicating the idle state.
¤	White	Slow flashing	Sanitizing is in progress.
●	Yellow	Steady	Waiting for trigger state.
●	Green	Steady	Measurement is running.
●	Turquoise blue	Steady	Zeroing is in progress.
✱	Red	Slow flashing	Static error
✱	Red	Fast flashing	Critical static error **Note:** If a critical error occurs after a firmware update, the update was not successful. Perform the firmware update again. See also Section 13.4, "Problems during a firmware update", on page 212.

Further information:

- Section 13.1, "Displaying status information", on page 208
- Section 13.2, "Error messages", on page 209

Host interface connector (3)

The host interface connector is used for establishing a connection between the sensor module and the USB host. For the connection, you need an external cable.

See:
- Section 4.5, "Hardware requirements", on page 22
- Section 6.3.3, "Using the USB connection", on page 47

The host interface connector also contains the trigger1 connection for input or output of a trigger signal, e.g., to synchronize several sensor modules in trigger sender or in receiver mode.

For information on how to assign the signals to the ports, see Section 9.9, "Configuring the trigger", on page 154.

Trigger I/O connector (4)
The trigger I/O is a connector of SMB type.

You can use this interface as an input for an external trigger signal.

Optionally, you can use it as an output, e.g. to synchronize several sensor modules with the sensor working in the trigger sender mode, see "Host interface connector (3)" on page 30.

For information on how to assign the signals to the ports, see Section 9.9, "Configuring the trigger", on page 154.

Network status LED (5)
Indicates whether the LAN connection to the network is established.

Indication		State
●	Green	The R&S NRPM3N sensor module is connected to the network. The IP address assigned by the DCHP or manually is valid.
●	Red	The R&S NRPM3N is not connected to the network properly. Either the connection is erroneous or the assigned IP address of the sensor module is not valid.

LAN PoE interface (6)
R&S NRPM3N LAN sensor modules only

RJ-45 connector to connect the Ethernet interface of a R&S NRPM3N sensor module to a local area network (LAN).

Note: Ethernet interface requires PoE (power over Ethernet). This Ethernet interface provides the electrical power by power over Ethernet (PoE) for the sensor modules. PoE is mandatory, when using the LAN interface, since the USB port does not provide sufficient power. See Section 4.4, "Powering the R&S NRPM3(N) sensor module", on page 22.

LAN reset (7)
Button for resetting the Ethernet connection parameters of the R&S NRPM3N sensor module to its default values.

Power over Ethernet status LED (8)
Indicates whether the R&S NRPM3N sensor modules is powered over PoE.

Indication		State
🟢	Green	The interface provides PoE. The sensor module is powered.
⚪	Not illuminated	PoE power is not applied.

5.2 R&S NRPM-A90 and R&S NRPM-A90D antenna modules

This section introduces the antenna modules of the R&S NRPM OTA power measurement solution.

For more information, see the specifications document.

R&S NRPM-A90

Single polarized antenna module with integrated diode detector

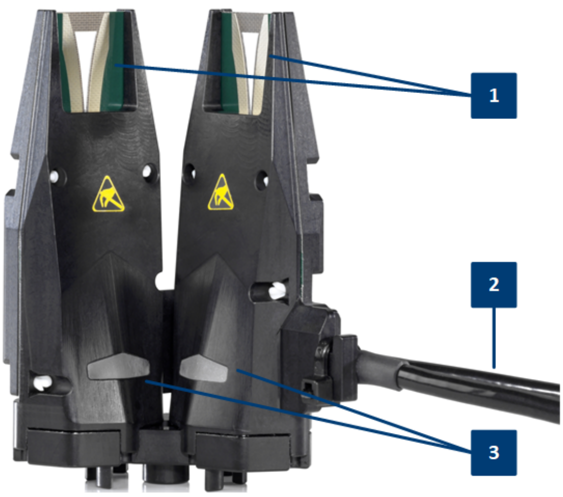
1 = PCB (printed circuit board)

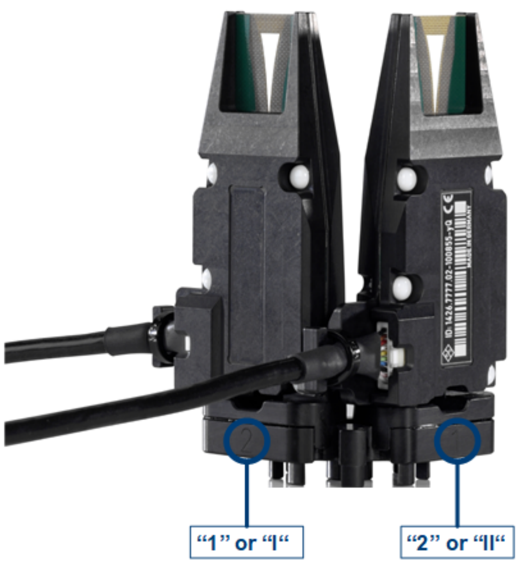
2 = Interface cable

3 = Signaling LED

R&S NRPM-A90D

Dual polarized antenna module with integrated diode detectors





1 = PCBs (printed circuit boards)
2 = Interface cables
3 = Signaling LEDs

To distinguish the feeds, the carrier of the R&S NRPM-A90D antenna module is labeled on the back with the corresponding letters "1" and "2", or "I" and "II".

An R&S NRPM-A90D module occupies two channels on the R&S NRPM3.

The R&S NRPM-A90/-A90D antenna modules are designed to work with the R&S NRPM3(N) sensor modules.

Electrostatically sensitive components. Follow the instructions described in "To prevent antenna damage" on page 20.

R&S NRPM OTA power measurements with the antenna modules R&S NRPM-A90 and R&S NRPM-A90D require at least FW version NRPM3_18.05.08.03.rsu or NRPM3N_18.05.08.03.rsu on the sensor module. Earlier FW versions support only the predecessor antenna modules R&S NRPM-A66.

Antenna module cable (2)
Cable firmly connected to the antenna modules for connection to the R&S NRPM-ZD3 feedthrough or the R&S NRPM-Z3 interface modules.

Note: The contact durability of these connectors is limited, therefore note the plug-in cycles specified in the specifications document.

Signaling LED (3)
LED for signaling purposes.

You can use the LED for mapping between the antenna module location and the sensor module channel, or for own signaling purposes.

To turn on the LED, use the SCPI command SYSTem:LED:CHANnel<Channel>:COLor on page 109. The LED color is blue.

5.3 R&S NRPM-ZD3 feedthrough module

The R&S NRPM-ZD3 filtered cable feedthrough module combines up to three antenna modules to one connector. From the cable feedthrough module, three independent antenna measurements are led to the R&S NRPM3(N) sensor module over the R&S NRPM-ZKD3 interface cable.

Measurements with R&S NRPM3N LAN sensor modules require that you use the latest version of the R&S NRPM-ZKD3 interface cable (1436.2984.02).

The filtered cable feedthrough is developed for use with a shielded RF shielded box, e.g. the R&S CMQ200.

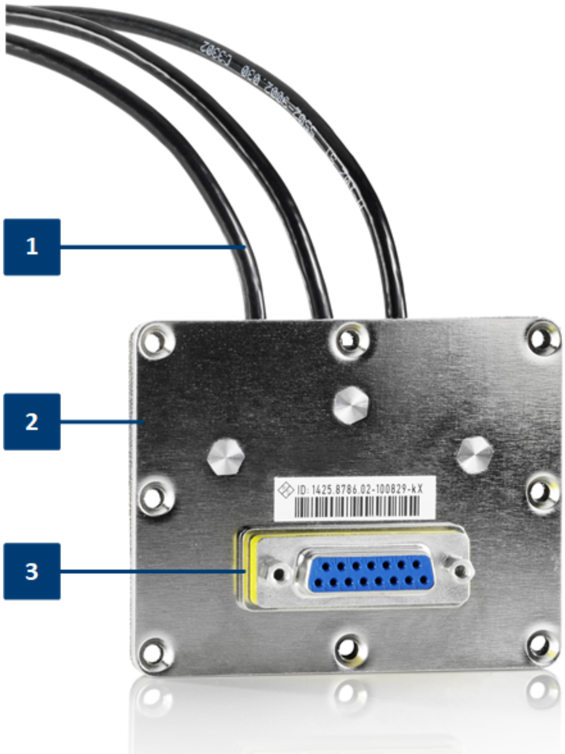


Figure 5-2: The R&S NRPM-ZD3 feedthrough module

1 = Antenna module cable connectors
2 = Cable feedthrough module
3 = Sensor module cable connector

Antenna module cable connectors (1)
Micro miniature connectors (10 pin) for connecting up to three antenna module cables.

Filtered cable feedthrough module (2)
R&S NRPM-ZD3 filtered cable feedthrough for combining three antenna module cables to one sensor module cable R&S NRPM-ZKD3.

Sensor module cable connector (3)
SUB-D connector (15 pin) for connecting to the sensor modules with the interface cable R&S NRPM-ZKD3.

5.4 R&S NRPM-Z3 interface module

For direct connection inside an EM controlled environment, you can use the R&S NRPM-Z3 interface module. Plugged directly to the R&S NRPM3(N) three channel sensor module, the R&S NRPM-Z3 interface module can host up to three antenna modules without additional cables required.

This section introduces the interface module for connecting, e.g. three antenna module cables for OTA power measurements in an EM-controlled environment, e. in an RF test chamber.

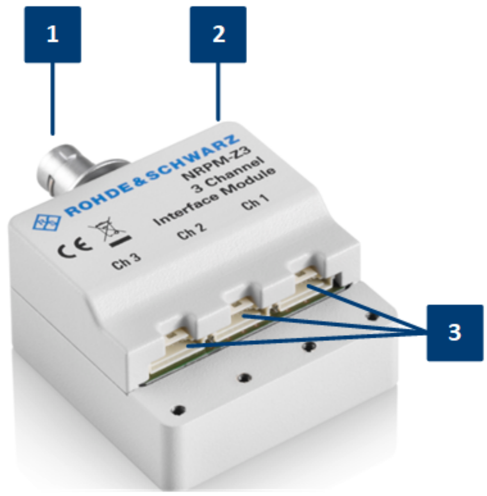


Figure 5-3: The R&S NRPM-Z3 interface module

1 = Connector to sensor module
2 = Interface module
3 = Antenna module cable connectors

Connector to sensor module (1)
16-pin push-pull connector for connecting to the sensor module.

Interface module (2)
R&S NRPM-Z3 three channel interface module to pass up to three antenna module cables to one R&S NRPM3(N) sensor module.

Antenna module cable connectors (3)
Micro miniature connectors (10 pin) for connecting the antenna module cables.

5.5 R&S NRPM-Z3 connected to the R&S NRPM3

Figure 5-4: R&S NRPM-Z3 connected to R&S NRPM3

1 = R&S NRP-ZKU
2 = R&S NRPM3
3 = R&S NRPM-Z3
4 = Strain relieve
5 = Antenna module cables

Strain relieve (4)
Strain relieve for the antenna module cable connections.

Antenna module cables (5)
Cables firmly connected to the antenna modules for connection to the R&S NRPM-Z3 interface module or the R&S NRPM-ZD3 feedthrough interface modules.

6 Setting up a measurement

This section points out important aspects to consider when setting up an R&S NRPM OTA power measurement. It shows some test setup examples and brief instructions on how to connect the components. You can also find references to the product page and the user manual of the RF shielded box R&S CMQ200 or an RF test chamber.

6.1 Test setup examples

The following section shows some test setups examples with an RF shielded box and within an RF test chamber. The main difference is that the sensor module is either inside, or outside the EM-controlled test environment:

- **RF shielded box**
  The sensor module is outside the RF shielded box, connected to the antenna modules via the feedthrough module (R&S NRPM-ZD3) and the interface cable (R&S NRPM-ZKD3).
- **RF test chamber**
  The sensor module is inside an RF test chamber, directly connected to the antenna modules via the interface module (R&S NRPM-Z3).

See also the application note 1GP118.

Always operate the antenna modules in an environment that is protected against electromagnetic interference.

The described examples refer to measurements performed with R&S Power Viewer, which allows you to measure the readings of up to four R&S NRPM3(N) sensor modules (12 antenna module channels) at a time. This number corresponds to 12 single or 6 dual polarized antenna modules. Technically, more are possible, i.e. you can select any number of antenna modules for your measurement.

Test setups with R&S NRPM3N LAN sensor modules and the R&S NRPM-ZKD3 interface cables for connection to a RF shielded box, require that you use the latest version of the interface cable (1436.2984.02).

Single antenna module solution

The base configuration with one antenna module measures the power of the incident wave from the DUT to the antenna module, e.g. to calibrate the output power of your DUT.

Example:

Setup with one single polarized R&S NRPM-A90 antenna module installed in an RF shielded box (feedthrough module):

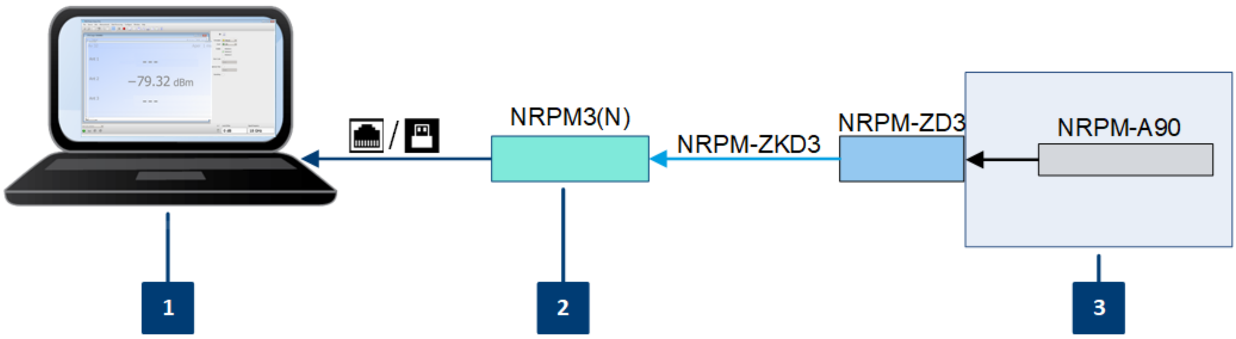


Figure 6-1: One R&S NRPM-A90 in an RF shielded box

1 = Controller PC
2 = Sensor module
3 = RF shielded box

Multiple spatially distributed antenna modules

With several antenna modules distributed in an area, you can test the beamforming function of a DUT. The more antenna modules are installed, the higher is the measurement accuracy during beamforming tests. In addition, you can derive matrices for swiveling the beam of the antenna module around two axes.

Example:

Setup with multiple single polarized R&S NRPM-A90 antenna modules in an RF shielded box (feedthrough modules):

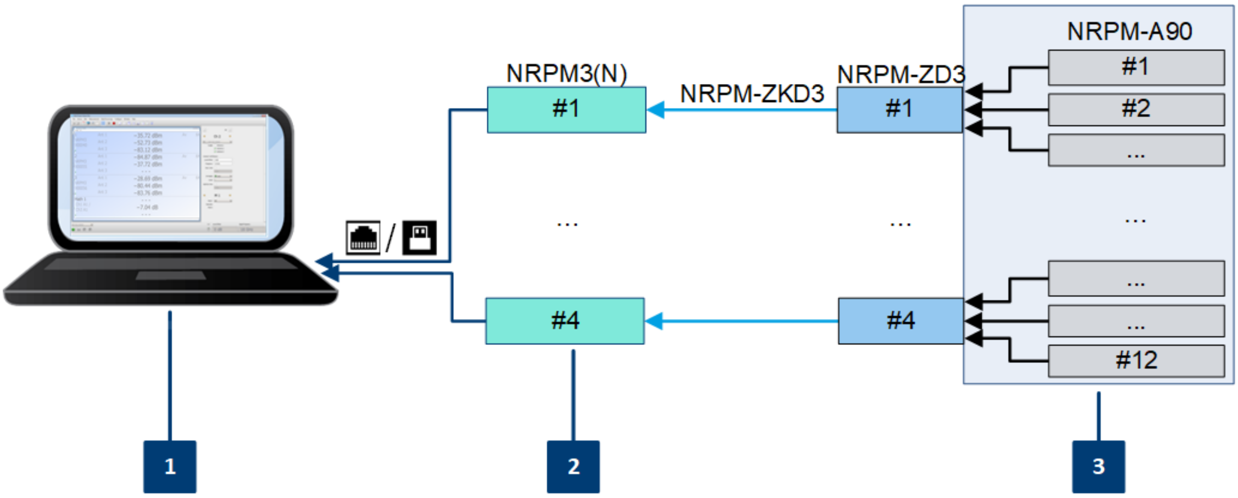


Figure 6-2: Multiple R&S NRPM-A90 in an RF shielded box

1 = Controller PC
2 = Sensor modules
3 = RF shielded box

Example:

Setup with multiple single polarized R&S NRPM-A90 antenna modules in an RF test chamber (interface modules):

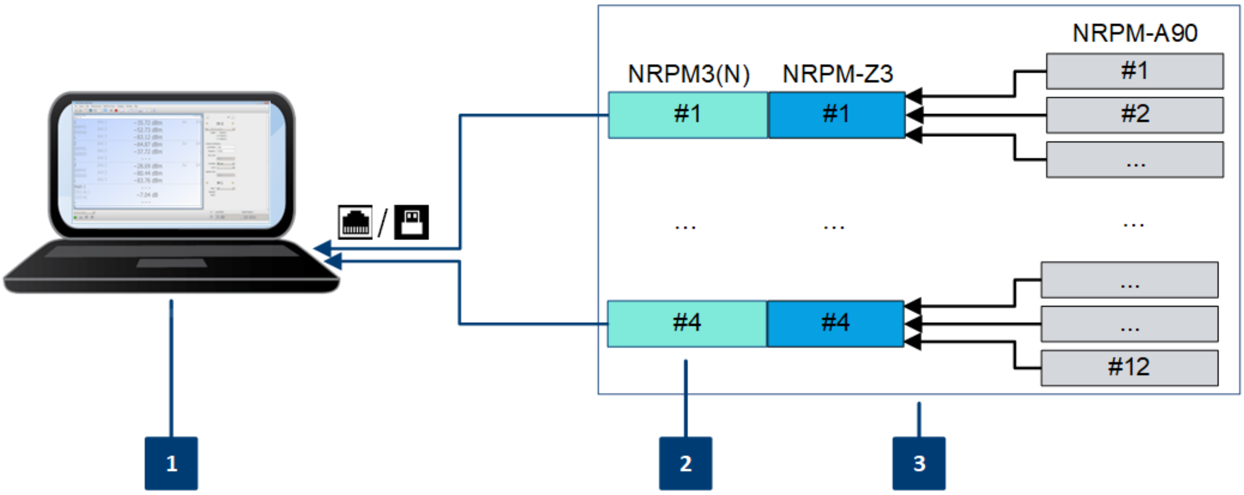


Figure 6-3: Multiple R&S NRPM-A90 in an RF test chamber

1 = Controller PC
2 = Sensor modules
3 = RF test chamber

Example:

Setup with dual polarized R&S NRPM-A90D antenna modules in an RF shielded box with feedthrough modules:

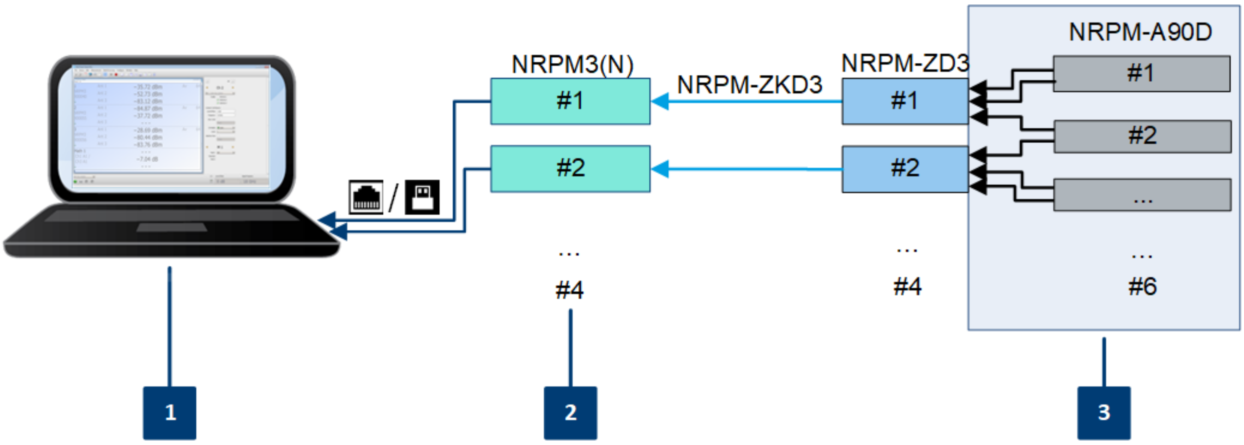


Figure 6-4: Setup with multiple R&S NRPM-A90D in an RF shielded box

1 = Controller PC
2 = Sensor modules
3 = RF shielded box

Note: Since one dual polarized antenna module allocates two channels of the sensor module, you can use a maximum of three antenna modules with two sensor modules. If your test setup requires more antenna modules, use additional sensor modules. In this test setup, you can measure the readings of up to six antenna modules with four sensor modules.

To set up a measurement with R&S NRPM-A90D dual polarized antenna modules in an RF test chamber, use the corresponding modules, as shown above.

6.2 R&S CMQ200 shielding cube

The R&S CMQ200 Shielding Cube, in this manual referred to as RF shielded box, enables reliable and reproducible measurements when a controlled EM test environment is needed.

As the R&S CMQ200 is a stand-alone product of Rohde & Schwarz, this section does not describe the box and measurement setups in detail. If you perform an OTA measurement with the box, you find the necessary information at:

- www.rohde-schwarz.com/product/cmq200, providing an overview of the R&S CMQ200 RF shielded box with the available models and the variety of antenna holders and feedthrough options.
- www.rohde-schwarz.com/manual/cmq200, providing the user manual, which describes the hardware, the options and the accessories, and how to install and configure the antenna modules.
- www.rohde-schwarz.com/brochure-datasheet/cmq200, providing the product brochure, which deals with specific characteristics, and contains the technical specifications and ordering information.

6.3 Connecting an R&S NRPM OTA power measurement

To start up an R&S NRPM OTA power measurement, it is assumed that the following conditions are met:

- All required hardware is available and ready for use, see Section 4.6, "Software requirements and installation", on page 23.
- The firmware version of the sensor module has release 2.00 or later, required for R&S NRPM OTA power measurements with the antenna modules R&S NRPM-A90 or R&S NRPM-A90D.
  How to: see Section 8, "Firmware update", on page 83.
- The software is installed on the controller PC.
  How to: see Section 4.6, "Software requirements and installation", on page 23.
- The (DUT) is installed and ready for operation.
- The R&S NRPM OTA power measurement components are powered off.

6.3.1 Connecting the RF frontend

The following steps describe how to connect the antenna modules and a sensor module in both, an RF shielded box or an RF test chamber.

6.3.1.1 Connecting the RF frontend in an RF shielded box

When you are working with the dual-polarized antenna modules R&S NRPM-A90D, notice the feeds of the vertical and horizontal antenna modules. You can find out the alignment with the identification numbers "1" or "I" (vertical) and "2" or "II" (horizontal) on the carrier of the antenna modules.

Required equipment

- RF shielded box, e.g. the R&S CMQ200
- Suitable antenna ring, see the accessories available for the corresponding RF shielded box
- One or more antenna modules, e.g. R&S NRPM-A90D or R&S NRPM-A90
- R&S NRPM-ZD3 (2) mounted in the RF shielded box
- R&S NRPM-ZKD3 interface cable.
- R&S NRPM3(N) (1) sensor module

To connect the RF frontend in the RF shielded box

1. In the RF shielded box, install the antenna ring.
2. **NOTICE!** Risk of antenna damage. Observe "To prevent antenna damage" on page 20.

   Mount the antenna modules.
   For connecting options, see the user documentation of the RF shielded box you are using, e.g. as referred to in Section 6.2, "R&S CMQ200 shielding cube", on page 42.
3. **NOTICE!** Risk of cable breakage. The connectivity of the antenna cable ends is sensitive, and therefore the contact durability of the connection is limited. Do not connect and disconnect the cables to the feedthrough board frequently.

Connect each antenna module cable to the antenna module cable connectors of the feedthrough module R&S NRPM-ZD3 (2).

4. Outside the RF shielded box, make sure that the sensor module is powered off, i.e. not yet connected to the power sourcing interface, see Section 4.4, "Powering the R&S NRPM3(N) sensor module", on page 22.
5. To connect the R&S NRPM3(N) (1) sensor module to the feedthrough module R&S NRPM-ZD3 (3):
   a) Connect the 15-pin Sub-D connector of the interface cable R&S NRPM-ZKD3 to the R&S NRPM-ZD3 (3) feedthrough module.
   b) Observe the guide gap of the sensor connector to ensure correct alignment to the mating antenna connector of the sensor module.
   c) Insert the sensor connector of the interface cable straight into the antenna connector of the sensor module.
6. Continue with Connecting to the controller PC.

To disconnect the R&S NRPM-ZKD3 from the sensor module

1. Disconnect the power sourcing interface of the sensor module.
2. Pull the sensor connector of the cable from the antenna connector of the sensor module. Take care not to tilt it.

6.3.1.2 Connecting the RF frontend in an RF test chamber

When you are working with the dual-polarized antenna modules R&S NRPM-A90D, notice the feeds of the vertical and horizontal antenna modules. You can find out the alignment with the identification numbers "1" or "I" (vertical) and "2" or "II" (horizontal) on the carrier of the antenna modules.

Required equipment

- Suitable antenna ring, see the accessories available for the R&S NRPM3(N) OTA power measurement solution
- One or more antenna modules, e.g. R&S NRPM-A90D or R&S NRPM-A90
- NRPM-Z3 (3)
- R&S NRPM3(N) (1) sensor module

To connect RF frontend with the sensor module in an RF test chamber

1. **NOTICE!** Risk of antenna damage. Observe "To prevent antenna damage" on page 20.

   In the RF test chamber, mount the antenna modules.
   For information on the connecting options, refer to the documentation of the antenna equipment.

2. On the interface module NRPM-Z3 (3), dismount the strain relieve NRPM-Z3 (4) using a torx screwdriver TX8.

3. **NOTICE!** Risk of broken cables. The connectivity of the antenna cable ends is sensitive, and therefore the contact durability of the connection is limited.
   Do not connect and disconnect the cables to the interface module frequently.

   Connect each antenna module cable to the antenna module cable connectors of the interface module.

4. Mount the strain relieve of the interface module.

5. To connect the R&S NRPM-Z3 interface module to the R&S NRPM3(N) sensor module, see R&S NRPM-Z3 connected to R&S NRPM3:
   a) Make sure that the sensor module is powered off, i.e. not yet connected to the power sourcing interface, see Section 4.4, "Powering the R&S NRPM3(N) sensor module", on page 22.
   b) Insert the 16-pin sensor connector of the R&S NRPM-Z3 interface module straight into the antenna connector of the R&S NRPM3(N). Take care that the guide gap of the sensor connector fits to the guide lug of the mating antenna connector of the sensor module.

6. Continue with Connecting to the controller PC.

To disconnect the R&S NRPM-Z3 from the sensor module

1. Disconnect the power sourcing interface of the sensor module.

2. Pull the sensor connector of the interface module from the antenna connector of the sensor module. Take care not to tilt it.

6.3.2 Connecting to the controller PC

The controlling host of the R&S NRPM OTA power measurement solution is a computer, using a supported software for controlling the R&S NRPM3(N) sensor modules, see Section 4.6, "Software requirements and installation", on page 23.

You can connect the sensor module using the LAN interface, when working with the R&S NRPM3N. To connect the R&S NRPM3, use the USB host interface.

To connect the sensor module to the controller PC, see:

- Section 6.3.3, "Using the USB connection", on page 47
- Section 6.3.4, "Using the LAN connection", on page 50

6.3.3 Using the USB connection

You can connect all R&S NRPM3(N) sensor modules to the USB interface of a computer. The high-speed USB connection supports control of all R&S NRPM3(N) types. It also provides the power supply for the R&S NRPM3 sensor modules.

USB power is not sufficient for R&S NRPM3N sensor modules. See Section 4.4, "Powering the R&S NRPM3(N) sensor module", on page 22.

6.3.3.1 Simple USB connection

Required equipment

- R&S NRPM3(N)
- R&S NRP-ZKU
- Controller PC with USB host interface and installed VISA driver or R&S NRP-Toolkit and R&S Power Viewer Mobile

Setup

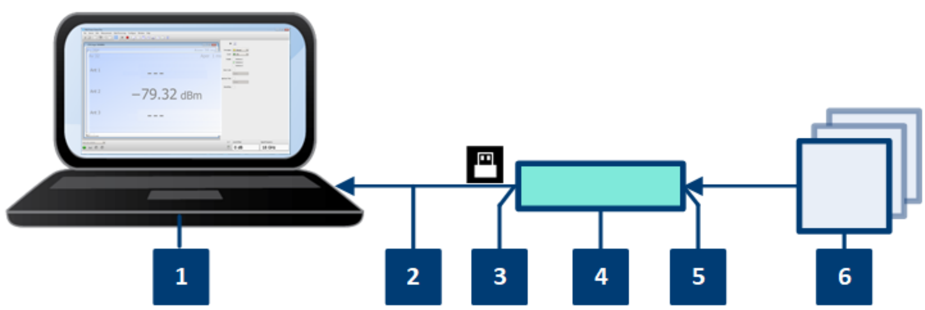


Figure 6-5: Setup with an R&S NRP-ZKU

1 = Controller PC
2 = R&S NRP-ZKU
3 = USB host interface connector
4 = R&S NRPM3 sensor module
5 = Antenna connector
6 = Antenna module(s)

To connect the R&S NRPM3 sensor module and the controller PC

Setup as shown in Figure 6-5.

1. Use the cable provided for the setup to connect to the R&S NRPM3 host interface, see Section 4.5, "Hardware requirements", on page 22.
   a) Insert the screw-lock cable connector of the R&S NRP-ZKU into the host interface R&S NRPM3 (2) connector of the sensor module.
   b) Tighten the union nut manually.
2. Connect the R&S NRP-ZKU USB connector to the controller PC.

To disconnect the R&S NRP-ZKU cable from the sensor module

1. Loosen the union nut of the screw-lock cable connector.
2. Remove the cable.

6.3.3.2 Sensor hub R&S NRP-Z5

The R&S NRP-Z5 sensor hub (high-speed USB 2.0) can host up to four sensor modules and provides simultaneous external triggering to all connected sensors.

Required equipment

- 1 to 4 R&S NRPM3 sensor module
- 1 NRP-ZK6 per sensor
- R&S NRP-Z5 sensor hub with external power supply unit and USB cable
- Controller PC with USB host interface and installed VISA driver, R&S NRP-Toolkit and R&S Power Viewer Mobile

Setup

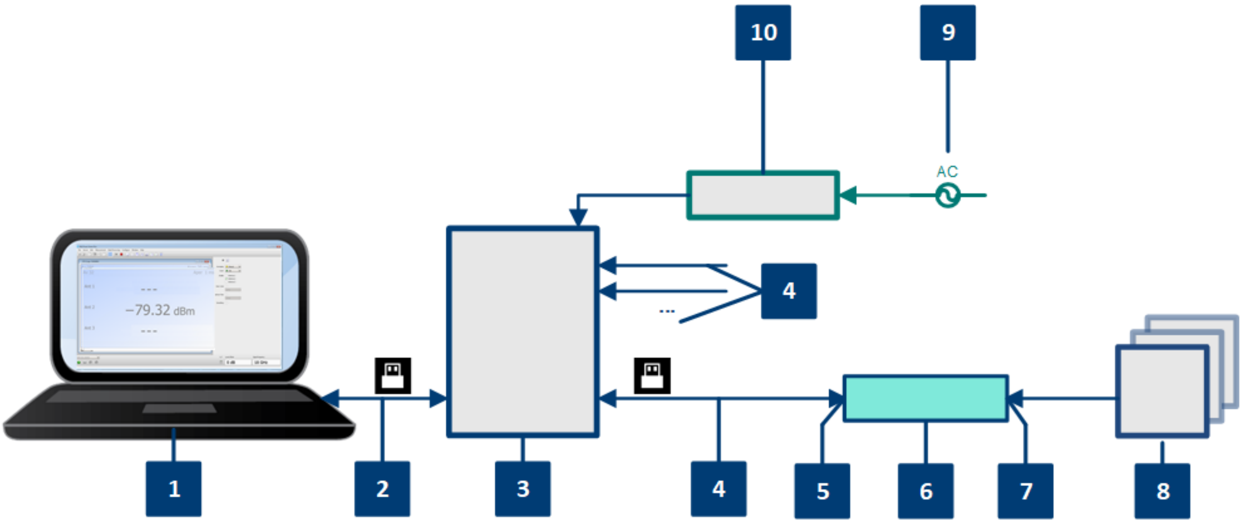


Figure 6-6: Setup with an R&S NRP-Z5 sensor hub

1 = Controller PC
2 = USB cable
3 = R&S NRP-Z5 sensor hub
4 = NRP-ZK6 cables
5 = USB host interface connector
6 = R&S NRPM3 sensor module
7 = Antenna connector
8 = Antenna module(s)
9 = AC power supply
10 = External power supply unit

To connect a setup with several sensor modules using the R&S NRP-Z5

Setup as shown in Figure 6-6.

1. Connect the R&S NRP-Z5 to the computer.
2. Connect the NRP-ZK6 to the power sensor, see "To connect the R&S NRPM3 sensor module and the controller PC" on page 48.
3. Connect the USB connector of the NRP-ZK6 to the R&S NRP-Z5 sensor hub.
4. If necessary, connect further sensor modules to the sensor hub accordingly.
5. Connect the external power supply unit to the R&S NRP-Z5 and to the mains.
6. Establish the connection of the antenna modules as described in Section 6.3.1, "Connecting the RF frontend", on page 44.

7. On the computer, start a software application to execute the measurement, see Section 7, "Performing measurements", on page 58.

6.3.4 Using the LAN connection

Requires the R&S NRPM3N LAN sensor module with networking capabilities.

Depending on the available equipment, you have several options to connect a R&S NRPM3N LAN sensor module to the controller PC.

Setup with a PoE Ethernet switch

To connect the R&S NRPM3N to a LAN, use a PoE switch, e.g. the R&S NRP-ZAP1. This switch provides the power supply and control for the antenna modules.

Required equipment

- 1 R&S NRPM3N sensor module
- 2 RJ-45 Ethernet cables,
  To avoid any impact, use at least category 6 STP cables for the LAN connection, see Section 4.5, "Hardware requirements", on page 22.
- 1 Ethernet switch, supporting PoE power delivery, e.g., R&S NRP-ZAP1
- Controller PC with LAN interface and installed VISA driver or R&S NRP-Toolkit and R&S Power Viewer Mobile

Setup

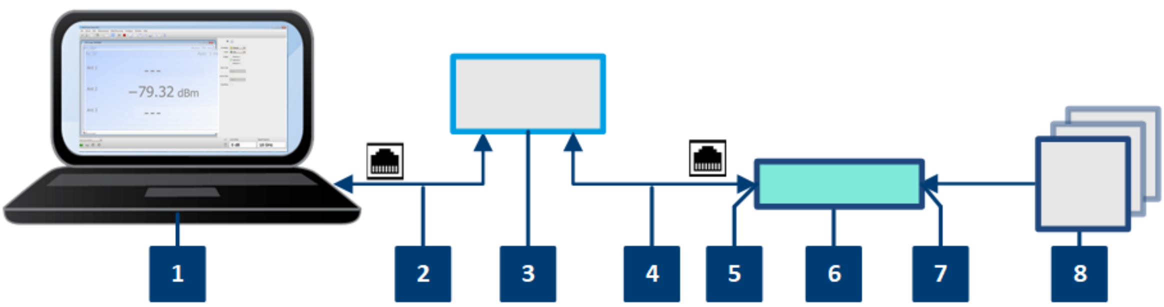


Figure 6-7: Setup with a PoE Ethernet switch

1 = Controller PC
2, 4 = RJ-45 Ethernet cables
3 = Ethernet switch
5 = LAN connector (RJ-45 Ethernet PoE interface)
6 = R&S NRPM3N LAN sensor module
7 = Antenna connector
8 = Antenna module(s)

To connect the R&S NRPM3N to the controller PC with the PoE Ethernet switch

1. **NOTICE!** Risk of sensor damage. Only use PoE power sourcing equipment (PSE) as described in Section 4.4, "Powering the R&S NRPM3(N) sensor module", on page 22.

   Connect the LAN PoE interface (5) of the sensor module to the Ethernet switch.
2. Connect the controller PC to the Ethernet switch.
3. On the controller, establish a connection between the sensor module and the network, see Section 6.3.5, "Connecting to the network", on page 54.

Setup with a PoE injector and a non-PoE Ethernet switch

Required equipment

- 1 R&S NRPM3N sensor module
- 3 RJ-45 Ethernet cables
  To avoid any impact, use at least category 6 STP cables for the LAN connection, see Section 4.5, "Hardware requirements", on page 22.
- 1 PoE injector
- 1 non-PoE Ethernet switch
- Controller PC with LAN interface and installed VISA driver or R&S NRP-Toolkit and R&S Power Viewer Mobile
- Controller PC

Setup

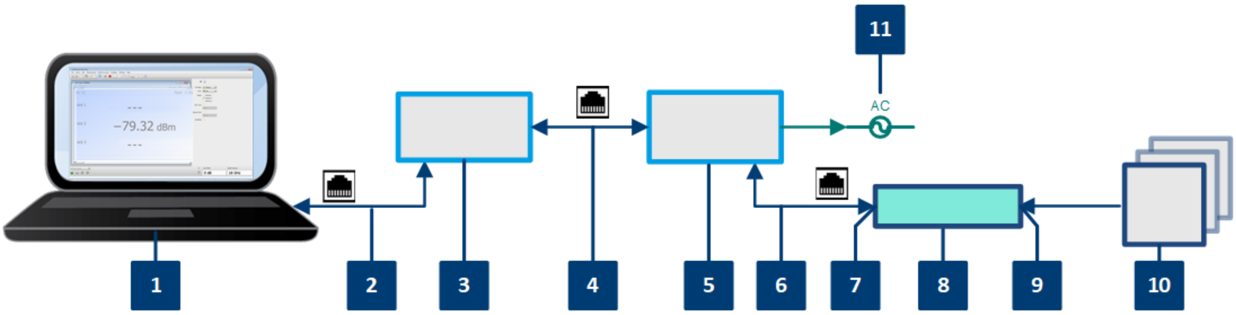


Figure 6-8: Setup with a PoE injector and a non-PoE Ethernet switch

1 = Controller PC
2,4,6 = RJ-45 Ethernet cables
3 = Non-PoE Ethernet switch
5 = PoE injector
7 = LAN connector (RJ-45 Ethernet PoE interface)
8 = R&S NRPM3N LAN sensor module
9 = Antenna connector
10 = Antenna module(s)
11 = AC power supply

To connect the R&S NRPM3N to the controller PC with the PoE injector and a non-PoE Ethernet switch

1. **NOTICE!** Risk of sensor damage. Only use PoE power sourcing equipment (PSE) as described in Section 4.4, "Powering the R&S NRPM3(N) sensor module", on page 22.

   Connect the LAN PoE interface (5) of the sensor module to the PoE injector.
2. Connect the PoE injector to the AC supply (mains).
3. Connect the input of the PoE injector to the non-PoE Ethernet switch.
4. Connect the controller PC to the non-PoE Ethernet switch.
5. On the controller, establish a connection between the sensor module and the network, see Section 6.3.5, "Connecting to the network", on page 54.

Setup with a PoE injector

Required equipment

- 1 R&S NRPM3N sensor module
- 2 RJ-45 Ethernet cables

To avoid any impact, use at least category 6 STP cables for the LAN connection, see Section 4.5, "Hardware requirements", on page 22.

- 1 PoE injector
- Controller PC with LAN interface and installed VISA driver or R&S NRP-Toolkit and R&S Power Viewer Mobile

Setup

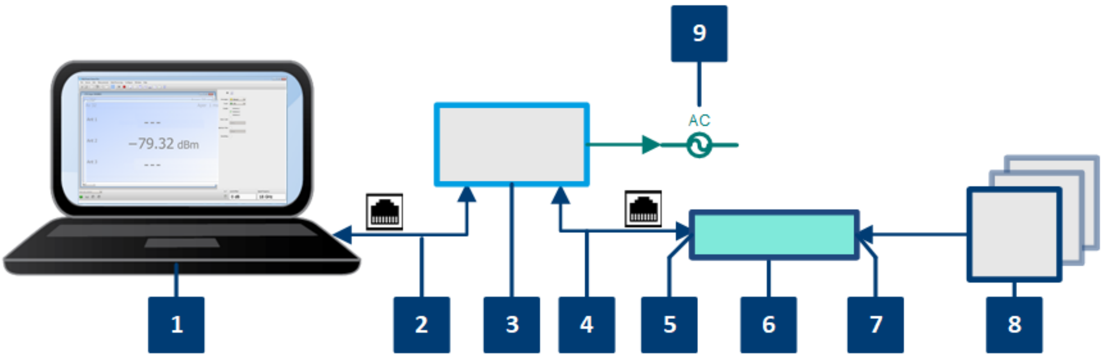


Figure 6-9: Setup with a PoE injector

1 = Controller PC
2, 4 = RJ-45 Ethernet cable
3 = PoE injector
5 = LAN connector (RJ-45 Ethernet PoE interface)
6 = R&S NRPM3N R&S NRPM3N LAN sensor module
7 = Antenna connector
8 = Antenna module(s)
9 = AC power supply

To connect the R&S NRPM3N to the controller PC with the PoE injector

1. **NOTICE!** Risk of sensor damage. Only use PoE power sourcing equipment (PSE) as described in Section 4.4, "Powering the R&S NRPM3(N) sensor module", on page 22.

   Connect the LAN PoE interface (5) of the sensor module to the PoE injector.
2. Connect the PoE injector to the AC supply (mains).
3. Connect the controlling host to the input of the PoE injector.
4. On the controller, establish a connection between the sensor module and the network.

6.3.5 Connecting to the network

There are two methods to establish a network connection:

- The R&S NRPM3N LAN sensor module and controlling host are connected to a common network (infrastructure network).
- The R&S NRPM3N LAN sensor module and controlling host are connected only over the switch (peer-to-peer network).

For both connections, the common network or the peer -to-peer connection over the switch, you address the sensor module as follows:

- Section 6.3.5.1, "Using hostnames", on page 55
- Section 6.3.5.2, "Assigning the IP address", on page 56

To set up a network Ethernet connection

1. Connect the sensor module as described in Section 6.3.4, "Using the LAN connection", on page 50.
   By default, the R&S NRPM3N uses dynamic TCP/IP configuration (DHCP) and obtains the address information automatically.
   If both network status LEDs light up in green color, the connection of the R&S NRPM3N to the network is established successfully.

   Note: Establishing a connection can take up to 2 minutes.

2. If the network status LEDs indicate another state, no connection is possible.
   For reasons and possible solutions, see:
   - "Power over Ethernet status LED (8)" on page 32
   - "Network status LED (5)" on page 31
   - "To check the network connection" on page 54

Troubleshooting for peer-to-peer connections

To check the network connection

1. Check that the assigned IP address of the used network adapter starts with `169.254`. The IANA (Internet assigned numbers authority) has reserved the range `169.254.0.0` to `169.254.255.255` for the allocation of automatic private IP addresses (APIPA). Addresses from this range are guaranteed to cause no conflicts with any routable IP address.

2. Try to establish a connection to the R&S NRPM3N with both the default host-name and the hostname extended with `.local`, for example:

```
nrpm3n-101441
nrpm3n-101441.local
```

6.3.5.1 Using hostnames

In a LAN that uses a domain name system (DNS) server, each connected computer or instrument can be accessed via an unambiguous hostname instead of an IP address. The DNS server translates the hostname to the IP address. Using the hostname is especially useful when a DHCP server is used, as a new IP address can be assigned each time the instrument is restarted.

Each sensor module is delivered with a default hostname assigned. You can change the default hostname.

Default hostname

The default hostname follows the syntax:

`<device name>-<serial number>`, where:

- `<device name>` is the short name of your sensor module.
  For example, the `<device name>` of R&S NRPM3N is `nrpm3n`.
- `<serial number>` is the individual serial number of the sensor module. The serial number is printed on the name plate at the rear side of the sensor module. It is part of the device ID printed above the barcode:

Example:

Serial number of the R&S NRPM3N: 102333

Default hostname: NRPM3N-102333

Hostname in zero configuration networks, including peer-to-peer networks

The sensor module supports zero configuration networking, used in networks without DHCP server, such as peer-to-peer networks. Thus, you can connect the sensor module to a network without setting up services such as dynamic host configuration protocol (DHCP) and domain name system (DNS), or configuring the network settings manually.

For establishing a connection to the sensor module, try the default hostname and the hostname extended with `.local` as shown in the example below. All communication for resolving names in the top-level-domain (TLD) `.local` are defined to be executed using dedicated local services and ports if no other DNS (domain name server) is available.

Example:

Default hostname: `nrpm3n-102333`

Extended hostname: `nrpm3n-102333.local`

6.3.5.2 Assigning the IP address

Depending on the network capabilities, the TCP/IP address information for the R&S NRPM3N LAN sensor module can be obtained in different ways:

- If the network supports dynamic TCP/IP configuration using the dynamic host configuration protocol (DHCP), the address information can be assigned automatically.
- If the network does not support DHCP, the R&S NRPM3N LAN sensor module tries to obtain the IP address via the zeroconf (APIA) protocol. If this attempt does not succeed or if the instrument is set to use alternate TCP/IP configuration, the IP address must be set manually.

Use hostnames to identify the sensor module

In networks using a DHCP server, it is recommended that you address the sensor module by its unambiguous hostnames, see Section 6.3.5.1, "Using hostnames", on page 55.

A *hostname* is a unique identifier of the sensor module that remains permanent as long as it is not explicitly changed. Hence, you can address a sensor module by the same identification, irrespectively if a network or a point-to-point connection is used.

6.4 Starting the measurement

To start the measurement

To start an R&S NRPM OTA power measurement, it is assumed that all components of the test setup are connected.

An easy way for configuring the measurement and displaying results is given by the R&S Power Viewer software:

► Start the R&S Power Viewer application, see "To start the application" on page 60.

  The R&S Power Viewer identifies sensor modules that are connected to USB automatically. If you are working with an R&S NRPM3N network sensor module, define the corresponding network connection in the R&S Power Viewer "Sensor' > VISA Connection" dialog, before you start a measurement.

7 Performing measurements

7.1 Sensor module readings

The antenna modules R&S NRPM-A90 and R&S NRPM-A90D have an integrated diode detector each that converts the RF signal and transmits it directly to the sensor module.

You can measure the power of the incident electromagnetic wave towards the antenna module in various quantities:

- Equivalent isotropically received power $P_{ISO} = P_i$ in W or dBm (default): Equivalent detected power of an isotropic antenna with an ideal power detector at the phase center location of the antenna module assuming radiation only from boresight direction.
- Power at the internal RF detector in W or dBm: The measurement result without including antenna gain and frequency-dependent calibration factors. $P_{Det}=(G_{RF,i}/k_{att,A,i}(f))\cdot P_{ISO}$
- Power density S in W/m^2, calculated as: $S=(4\pi/\lambda^2)\cdot P_{ISO}$
- Electric field strength E_{eff} in V/m, calculated as: $E_{eff}=\sqrt{(S\cdot Z_0)}$ with: $Z_0=376.73\ \Omega$.
- Magnetic field strength H_{eff} in A/m, calculated as: $H_{eff}=\sqrt{(S/Z_0)}$ with: $Z_0=376.73\ \Omega$.

► To convert the data, use the remote command: `CALCulate:MATH[:EXPRession]` on page 131

7.2 Measurement applications

For power measurement with the R&S NRPM3(N), you can either use the PC application R&S Power Viewer, the WebGUI (Web User Interface) or an application that supports direct remote control of the sensor module.

The following sections introduce the power measurement with the R&S Power Viewer and the WebGUI (web user interface). Section Section 10, "Programming examples", on page 169 describes the corresponding programming examples for working in remote control mode. See the R&S Power Viewer manual for more information on how to use the various functions of the application.

The descriptions refer to the applications running on an MS Windows system. It is assumed that the measurement is set up, and the required software and drivers are installed on the PC.

7.2.1 Using R&S Power Viewer

This section shows how to start the application and access the settings relevant for OTA measurements.

For handling and using the tool in detail, see the "R&S Power Viewer Software Manual" that comes with the installation. See also Section 4.6.3, "R&S Power Viewer", on page 27.

The R&S Power Viewer supports measuring the received signals of up to 12 antenna modules, and enables you to perform simultaneous OTA measurements of four sensor module, each transmitting the readings of up to three antenna modules.

The R&S Power Viewer provides the following measurement modes for OTA measurements:

- "OTA Single"
  Evaluates the continuous average power of up to 3 antenna module signals measured by an R&S NRPM3(N).
  Controls one R&S NRPM3(N) sensor module, i.e. you can measure the continuous average power of up to 3 antenna module signals.
- "OTA Multi Sensor"
  Supports the measurements of up to four sensor modules, i.e. you can measure the continuous average power of up to 12 antenna module signals.
- "OTA Trace Measurement"
  Controls one sensor module, i.e. you can measure the power of up to 3 antenna module signals in trace mode.

Outlined are:

- To start the application.

- To configure an OTA single sensor ContAV measurement, for using the R&S NRPM3(N) with up to three antenna modules.
- To configure an OTA multi-sensor ContAV measurement, for using up to four sensor modules with up to three antenna modules each.
- To configure an OTA single sensor trace power measurement, for using the sensor module with up to three antenna modules.

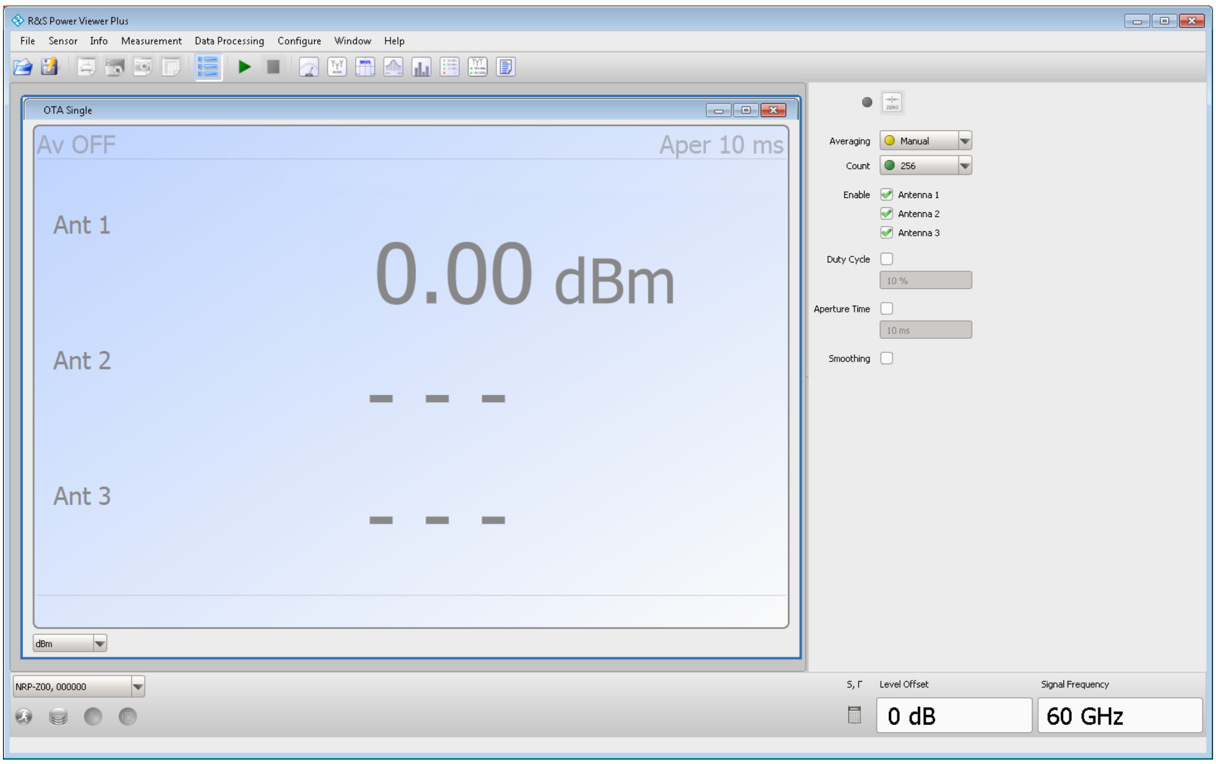
To start the application

► In the MS Windows start menu, select "Start" > "R&S Power Viewer" > "Power Viewer".

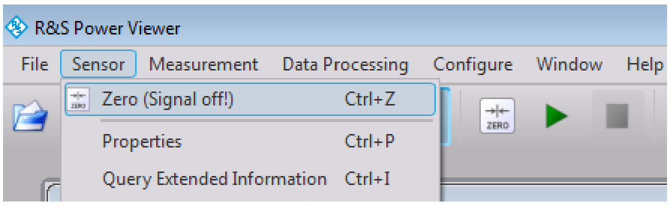
The application starts. It provides buttons for OTA measurements in the toolbar.

To configure an OTA single sensor ContAV measurement

1. In the toolbar, select the "OTA Single" button to open the panel for the OTA measurements with one R&S NRPM3(N).



2. In the lower border toolbar, select the sensor module.
3. Execute zeroing:
   Note: Turn off all measurement power signals before zeroing. An active measurement during zeroing causes an error.
   a) Turn off the measurement signal.
   b) Select "Sensor > Zero (Signal off)".



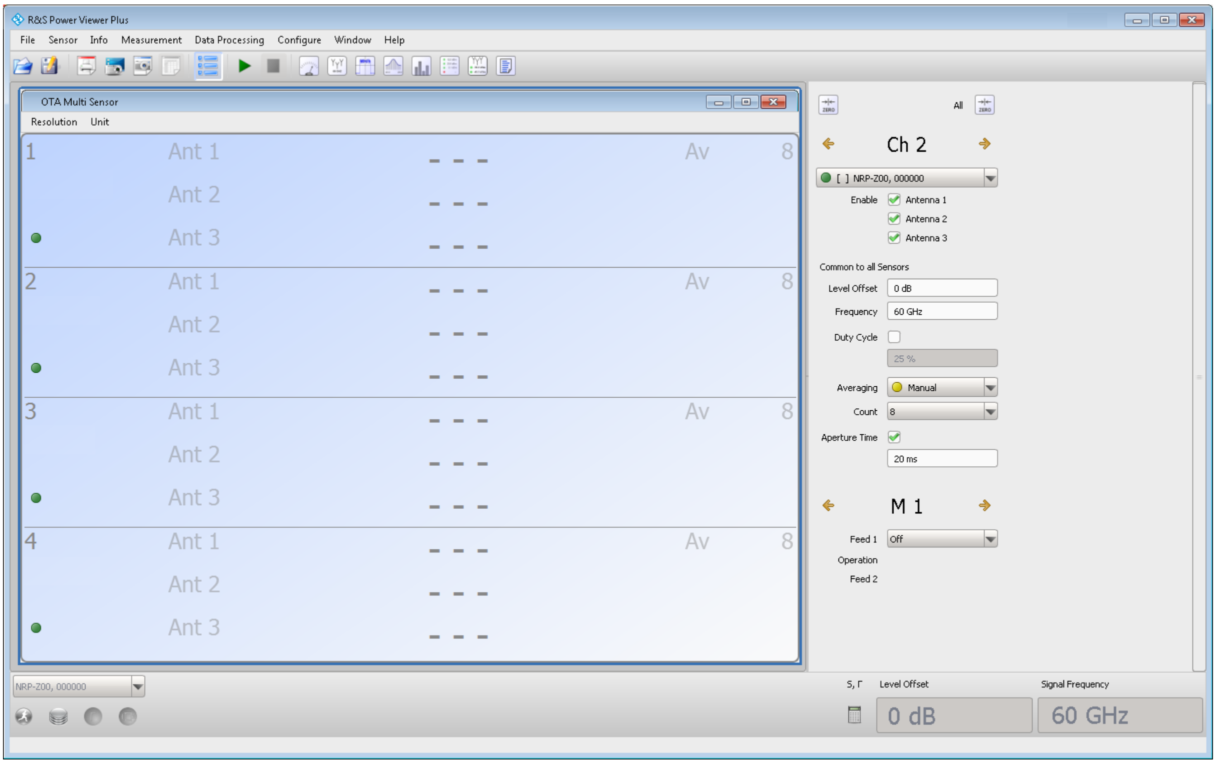
4. In the panel on the right, select the antenna modules for the measurement.
5. If necessary, set the parameters to configure the continuous average power measurement.
6. Set the frequency.
7. Start the measurement.

The measurement result window displays measured power in the sensor module channels.

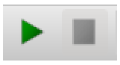
To configure an OTA multi-sensor ContAV measurement

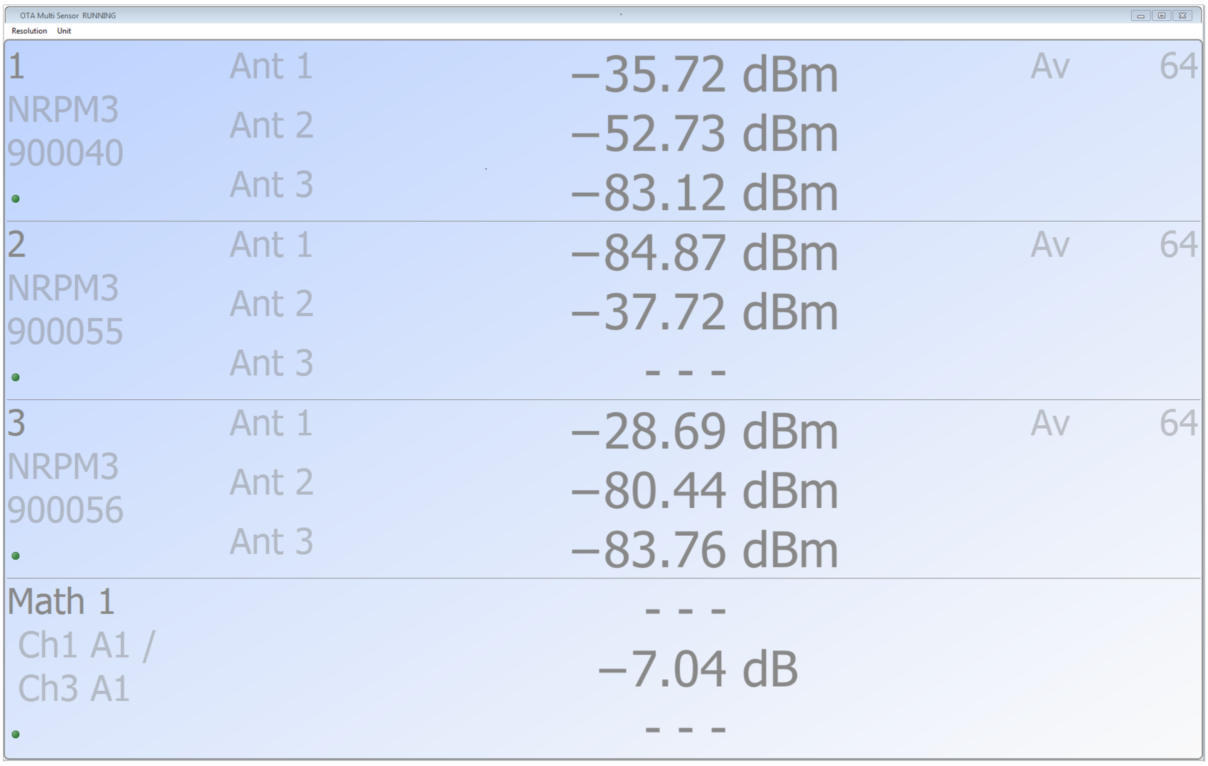
1. 

   In the toolbar, select the "OTA Multi Sensor" button to open the panel for the OTA measurements with several sensor modules.



2. In the lower border toolbar, select the sensor module.
3. In the panel on the right, select the channel.
4. Enable the antenna modules of the selected channel.
5. If necessary, set the parameters provided for the measurement mode.
6. Repeat step 3 to step 5 for each channel.
7. Repeat step 2 to step 6 for each connected sensor module.
8. Set the frequency.
9. Start the measurement.



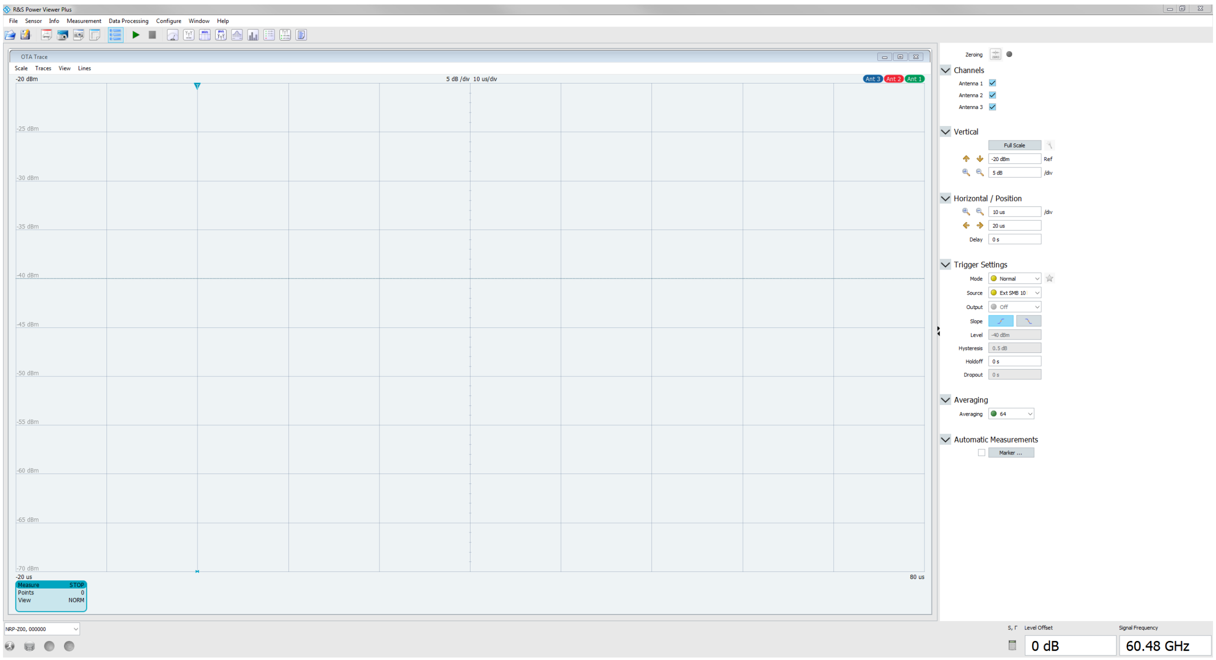


The measurement results window displays the results of the multi-channel measurement.

To configure an OTA single sensor trace power measurement

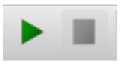
1. 

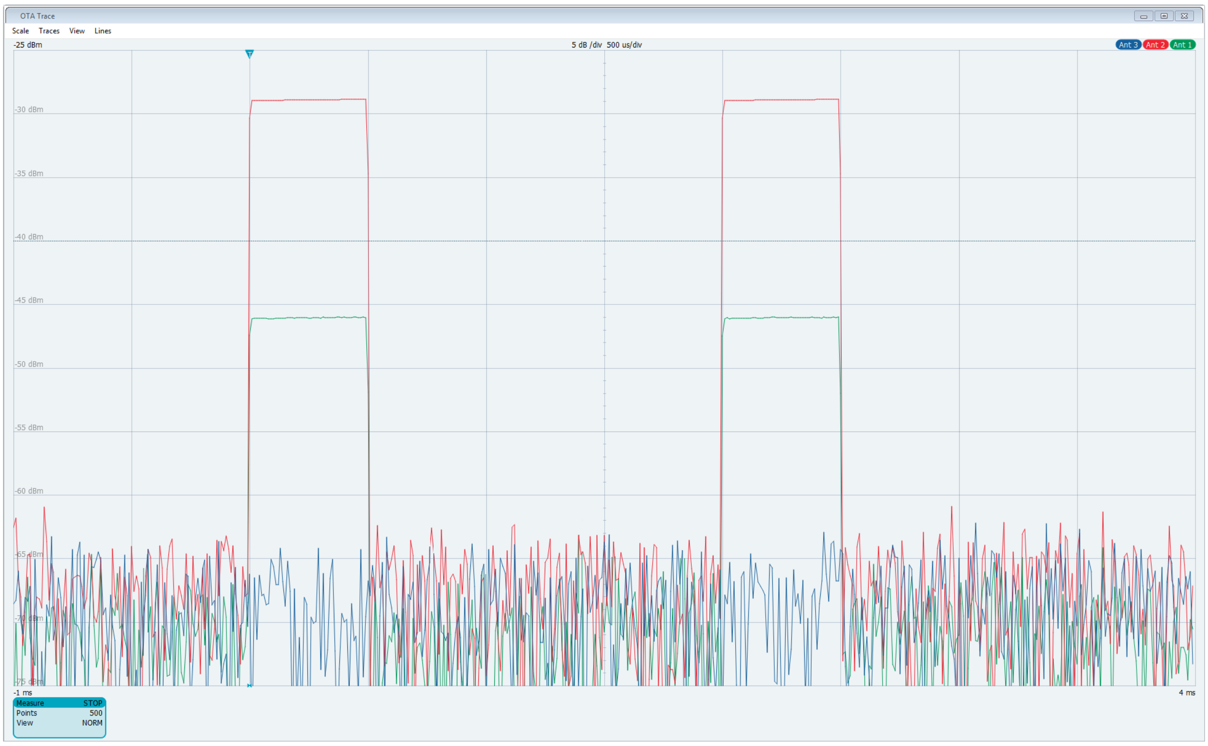
   In the toolbar, select the button to open the panel for trace measurements.



The R&S Power Viewer displays the trace measurement results windows, and the setting parameters in the panel on the right.

2. In the lower border toolbar, select the sensor module.
3. In the panel on the right, select the antenna modules for the measurement.
4. If necessary, adjust the scaling of the measurement results window.
5. If necessary, set the trigger and averaging parameters provided for "Trace" measurements.
6. Set the frequency.
7. Start the measurement.





The results window displays the trace measurement results of the three antenna modules.

7.2.2 Using the web user interface

Requires a sensor module with networking capabilities, an R&S NRPM3N.

The web user interface is an alternative way to operate an R&S NRPM3N LAN sensor module. With the integrated, browser-based graphical user interface of the R&S NRPM3N sensor module, you can configure the most common settings and measure in the provided measurement modes.

On the sensor module, there is no installation required. With the integrated web user interface, you can easily configure the most common settings of the sensor module and measure in the provided measurement modes.

The following browsers are supported:

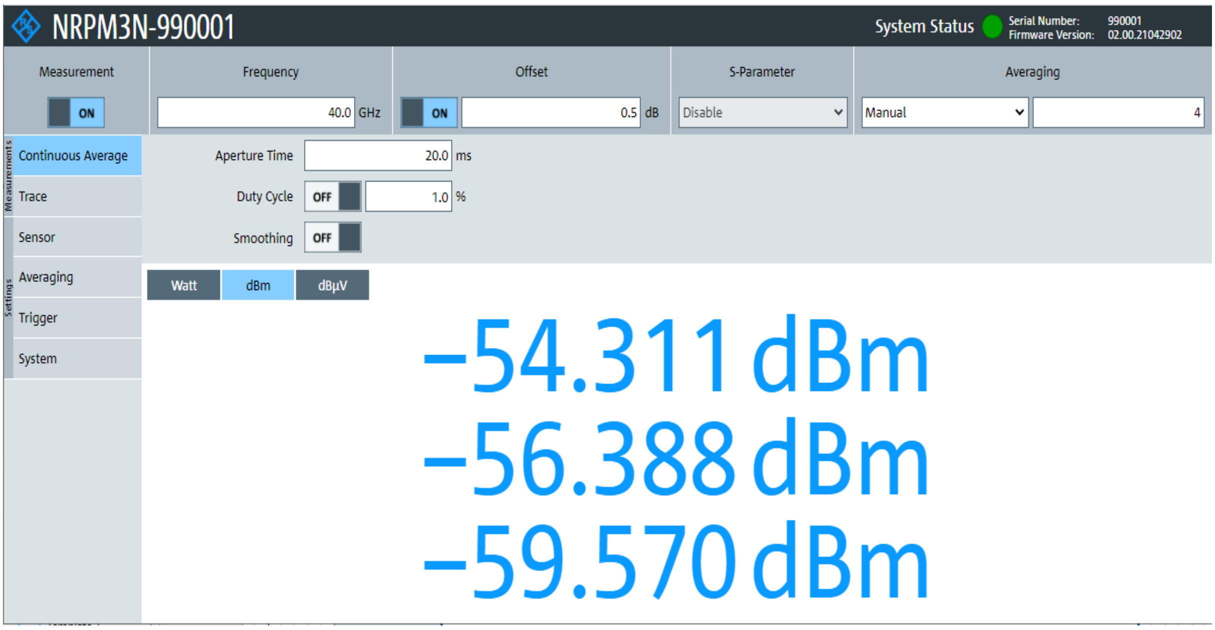
- Mozilla Firefox

- Google Chrome
- Microsoft Edge
- Safari

You can use the web user interface with all devices and operating systems, including tablets and smart phones that are connected to the same network as the sensor module.

Starting a measurement

1. Set up the LAN connection, as described in Section 6.3.4, "Using the LAN connection", on page 50.
2. Open a supported web browser.
3. Enter the instrument name or the IP address of the sensor module you want to connect to.
   `Example: http://nrpm3n-990001`
   For details on how to find out the IP address or hostname, refer to Section 6.3.5.2, "Assigning the IP address", on page 56 and Section 6.3.5.1, "Using hostnames", on page 55.

   The main dialog of the web user interface opens.
4. In the "Measurements" navigation pane, select "Continuous Average".
5. Enter your settings.
6. Select "Measurement > ON" to start the measurement.

The following chapters describe the functions and parameters of the web user interface in detail.

7.2.2.1 Main dialog of the web user interface

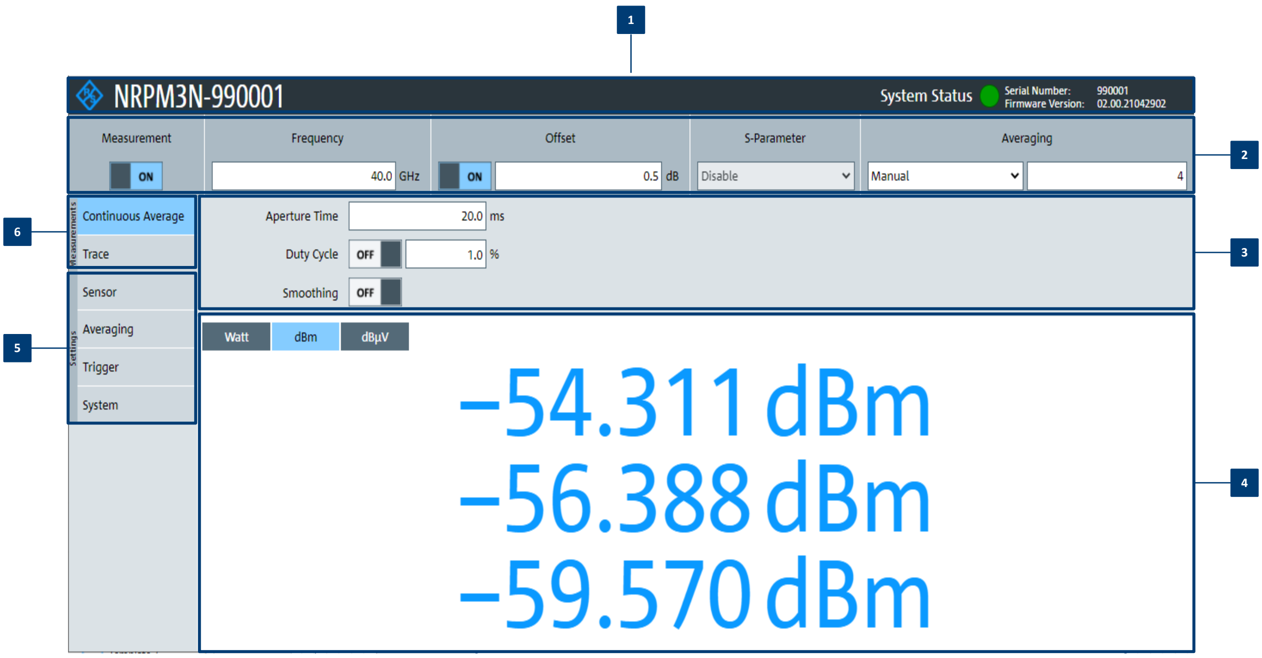


Figure 7-1: Layout of the web user interface

1 = Title bar
2 = Common settings, see Section 7.2.2.3, "Common settings", on page 69
3 = Parameter pane
4 = Result pane
5 = "Settings" navigation pane, see Section 7.2.2.5, "Settings", on page 73
6 = "Measurements" navigation pane, see Section 7.2.2.4, "Measurement modes", on page 71

Title bar

Shows the following information:

- R&S logo

If you click the R&S logo, the Rohde & Schwarz homepage is displayed on a new browser tab.

- Sensor module name or host name
  If you click the name, the product page of the sensor module is displayed on a new browser tab.
  See Section 6.3.5.1, "Using hostnames", on page 55.
- System status
  Confirms that there is a connection between the sensor module and the remote computer and that the sensor module is recognized by the software.
  The presentation of this symbolic LED mirrors the physical LED of the sensor module.
  See "Status LED (2)" on page 30.

Parameter pane

Displays the content selected in the navigation pane.

Result pane

Displays the measurement result for the selected measurement mode. It can display only a value or a graph, depending on the selected measurement mode.

7.2.2.2 Setting the unit

You can set the unit for the different parameters by typing the corresponding letter after the entered value.

Example:

Figure 7-2: Parameter

1 = Parameter name
2 = Value
3 = Unit

The following abbreviations are available:

Unit	Keyboard key
Decibel	*d*
Hertz	*h*
Second	*s*
Volt	*v*
Watt	*w*

Unit multiples	Keyboard key
Giga	*g*
Mega	*m*
Kilo	*k*
milli	*m*
micro	*u*
nano	*n*

Example:

To set the unit to 1 GHz, enter *1g*.

For certain units, you can select a different representation, depending on the requirements. For example, for the representation of the "Trigger Level", you can choose Watt, dBm or dBµV. To change the unit, you must specify the desired value together with the full new unit once.

Example:

To change the representation of a "Trigger Level" of 100µW into dBm, enter *-10dbm* in the "Trigger Level" field. All future entries of solely numbers represent the value in dBm. If you enter *-15* in the field, the "Trigger Level" value is set to -15.00 dBm.

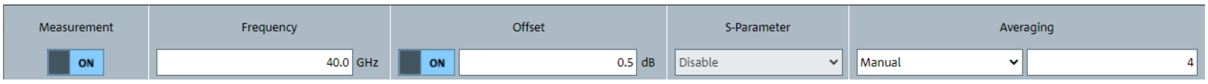
If you want to revert the value to Watt, enter *50uW*. The "Trigger Level" value is set a value of 50.00 µW, thus changing the unit for the further numeric entries.

7.2.2.3 Common settings

Describes common measurement settings that are available for all measurement modes.

Access:

► In the common settings pane of the web user interface main dialog, select the corresponding parameter.



The remote commands required to define the common settings are described in:
- Section 9.8, "Starting and ending a measurement", on page 152
- Section 9.7.3, "Configuring corrections", on page 150

System Status

Displayed in the title bar. The status confirms that there is a connection between the sensor and the remote computer and that the sensor is recognized by the software.

The presentation of this symbolic LED mirrors the physical LED of the sensor, see "Status LED (2)" on page 30.

Measurement

Activates the measurement.

Remote command:
`INITiate:CONTinuous` on page 154

Frequency

Sets the carrier frequency of the applied signal. This value is used for frequency-response correction of the measurement result.

Remote command:
`[SENSe<Sensor>:]FREQuency` on page 149

Offset

Sets and enables a level offset.

<State> ← Offset

Activates the level offset.

Remote command:

[SENSe<Sensor>:]CORRection:OFFSet:STATe on page 152

<Value> ← Offset

Adds a fixed level offset in dB to account for external losses.

Remote command:

[SENSe<Sensor>:]CORRection:OFFSet on page 152

S-Parameter

Note: S-parameter compensation is not supported by the R&S NRPM3 sensor modules.

Averaging

See Section 9.7.1, "Configuring averaging", on page 147.

7.2.2.4 Measurement modes

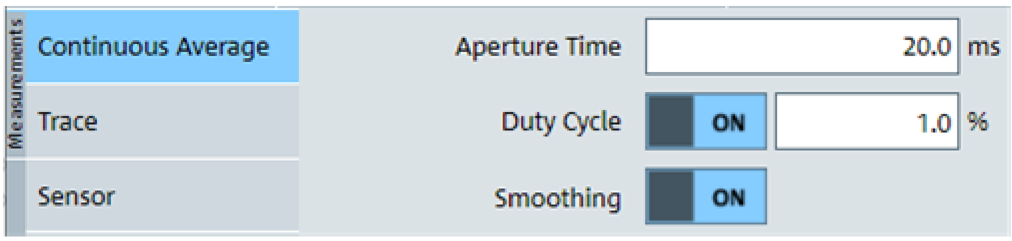
Provides the parameters for the supported measurement modes.

Continuous Average mode

Describes the parameters of the continuous average measurement.

Access:

► In the measurement navigation pane of the web user interface, select "Continuous Average".



The remote commands required to define the continuous average settings are described in Section 9.6.1, "Configuring a continuous average measurement", on page 133.

Aperture Time

Sets the aperture time, the width of the sampling windows.

Remote command:

`[SENSe<Sensor>:][POWer:][AVG:]APERture` on page 135

Duty Cycle

Sets the duty cycle, the percentage of one period during which the signal is active, for pulse modulated signals. If activated, the sensor calculates the signal pulse power from its value and the average power.

Remote command:

`[SENSe<Sensor>:]CORRection:DCYCle:STATe` on page 151

`[SENSe<Sensor>:]CORRection:DCYCle` on page 151

Smoothing

Activates the smoothing filter, a steep-cut off digital low-pass filter. The filter reduces result fluctuations caused by modulation.

Remote command:

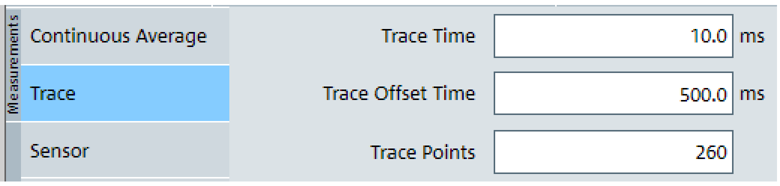
`[SENSe<Sensor>:][POWer:][AVG:]SMOothing:STATe` on page 137

Trace mode

Provides the parameters of the trace measurement.

Access:

► In the measurement navigation pane of the web user interface main dialog, select "Trace".



The remote commands required to define the trace settings are described in Section 9.6.3, "Configuring a trace measurement", on page 139.

Trace Time

Sets the trace length.

Remote command:
[SENSe<Sensor>:]TRACe:TIME on page 145

Trace Offset Time

Sets the relative position of the trigger event in relation to the beginning of the trace measurement sequence. Used to specify the start of recording for the trace mode.

Remote command:
[SENSe<Sensor>:]TRACe:OFFSet:TIME on page 144

Trace Points

Sets the number of required values per trace sequence. For achieving a good optimum between the measurement speed and the resolution, you can set a value of, e.g. 200 trace points.

Remote command:
[SENSe<Sensor>:]TRACe:POINts on page 144

7.2.2.5 Settings

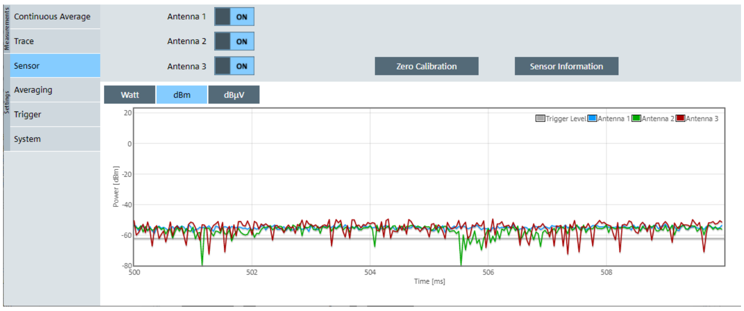
Describes the parameters for general configuration.

Sensor settings

The sensor settings window provides the parameters for optimizing the measurement results for specific measurement requirements.

Access:

► In the settings navigation pane of the web user interface, select "Sensor".



The remote commands required to define the sensor settings are described in:

- Section 9.3.2, "Handling of available antenna modules", on page 114
- Section 9.7.3, "Configuring corrections", on page 150
- Section 9.12, "Calibrating/zeroing the R&S NRPM3(N) sensor module", on page 167
- Section 9.11, "Running a self-test", on page 166

Antenna

Activates an antenna module module for the measurement.

Remote command:

`[SENSe<Sensor>:]CHANnel<Channel>:PRESence?` on page 114

`[SENSe<Sensor>:]CHANnel<Channel>[:ENABle]` on page 115

Zero Calibration

Executes zeroing using the signal at the sensor module input, see Section 9.12, "Calibrating/zeroing the R&S NRPM3(N) sensor module", on page 167.

Note:

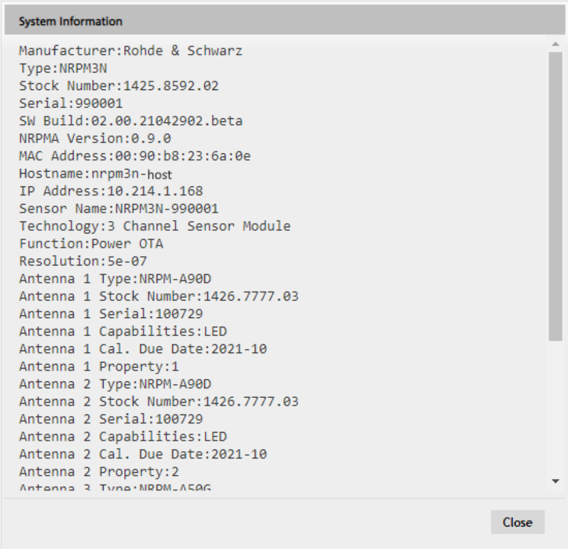
Turn off all test signals before zeroing. An active test signal during zeroing causes an error.

Remote command:

`CALibration<Channel>:ZERO:AUTO` on page 168

Sensor Information

Provides information on the R&S NRPM OTA power measurement system.

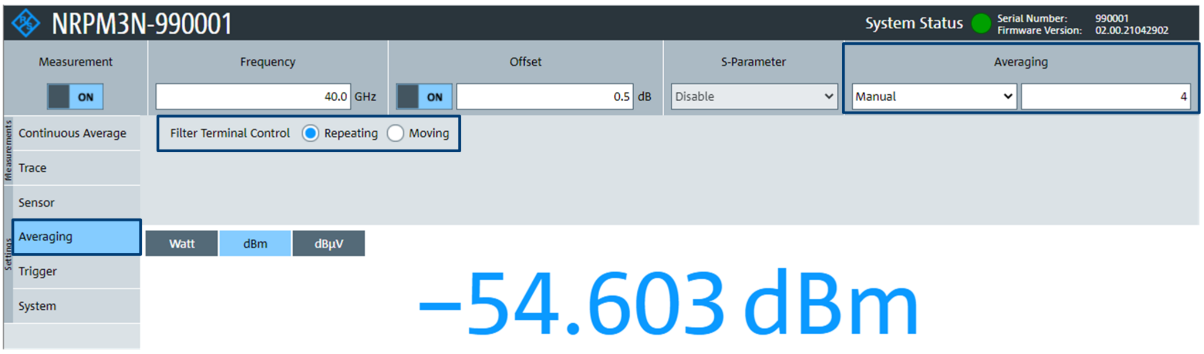


Averaging settings

Describes the parameters for automatic averaging.

Access:

► In the settings navigation pane of the web user interface, select "Averaging".



The remote commands required to define the averaging settings are described in Section 9.7.1, "Configuring averaging", on page 147.

Averaging Mode

Indicates that the R&S NRPM3N works in manual averaging mode and enables you to set the average count, also considered as averaging factor.

See Section 9.7.1, "Configuring averaging", on page 147.

<Mode> ← Averaging Mode

Displays the averaging mode.

"manual" Operates in manual mode only.
Enter the average count under <Value>.

Remote command:
`[SENSe<Sensor>:]AVERage[:STATe]` on page 149

<Value> ← Averaging Mode

Sets the average count.

Remote command:
`[SENSe<Sensor>:]AVERage:COUNt` on page 147

Filter Terminal Control

Defines the output mode for the measurement results, denoted as termination control.

See also Section 9.4, "Controlling the measurement", on page 117.

"Repeating" Provides the measurement result only after the entire measurement has been completed.
The number of measurement cycle repetitions corresponds to the set averaging factor, and thus directly relates to the measurement duration: the higher the averaging factor, the longer the measurement time.

"Moving" Provides intermediate values to facilitate early detection of changes in the measured quantity. In the settled state, i.e. when the number of measurements specified by the averaging factor has been performed, the sensor module provides a moving average.

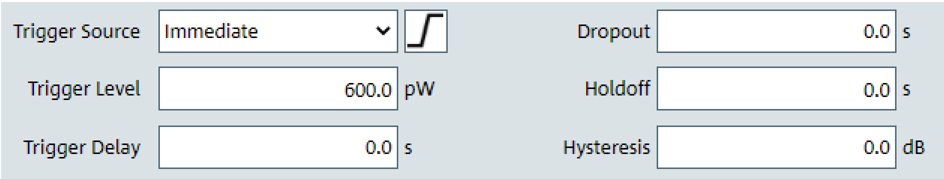
Remote command:
`[SENSe<Sensor>:]AVERage:TCONtrol` on page 148

Trigger settings

Provides the trigger parameters. You can define the conditions that have to be fulfilled for a triggered measurement.

Access:

► In the settings navigation pane of the web user interface, select "Trigger".



The remote commands required to define the trigger settings are described in:

- Section 9.9, "Configuring the trigger", on page 154
- Section 9.4, "Controlling the measurement", on page 117

Trigger Source

Selects the source and slope polarity of the trigger signal.

You can use an internal or externally applied trigger signal.

<Source> ← Trigger Source

Selects the trigger source, see "Trigger sources" on page 119.

Remote command:

`TRIGger:SOURce` on page 160

<Slope> ← Trigger Source

Sets the polarity of the active slope of the trigger signal.

"Positive" Uses the rising edge of the trigger signal.

"Negative" Uses the falling edge of the trigger signal.

Remote command:

`TRIGger:SLOPe` on page 160

Trigger Level

Sets the trigger threshold for internal triggering derived from the test signal.

Remote command:
TRIGger:LEVel on page 158
TRIGger:LEVel:UNIT on page 159

Trigger Delay

Sets the delay between the trigger event and the actual start of the measurement.

Remote command:
TRIGger:DELay on page 156
TRIGger:DELay:AUTO on page 157

Dropout

With a positive (negative) trigger slope, the dropout time is the minimum time for which the signal must be below (above) the power level defined by Trigger Level.

Remote command:
TRIGger:DTIMe on page 157

Holdoff

Sets the hold-off time.

After a trigger event, the sensor module suppresses all trigger events that occur within this time period.

Remote command:
TRIGger:HOLDoff on page 158

Hysteresis

Sets the hysteresis in dB. A trigger event occurs, if the trigger level:
- Falls below the set value on a rising slope.
- Rises above the set value on a falling slope.

Thus, you can use this setting to eliminate the effects of noise in the signal for the edge detector of the trigger system.

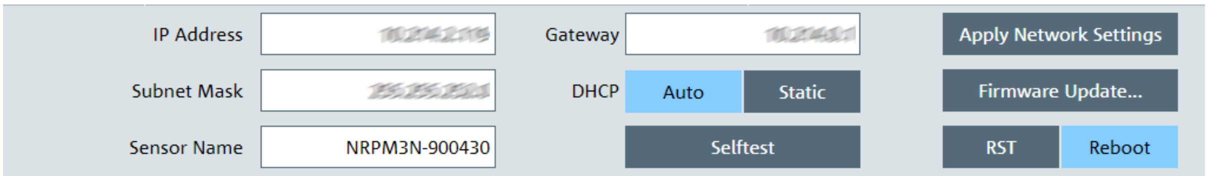
Remote command:
TRIGger:HYSTeresis on page 158

7.2.2.6 System settings

Provides the parameters of the general network environment and specific identification parameters of the sensor module in the network.

Access:

► In the settings navigation pane of the web user interface, select "System".



The remote commands required to define the system settings are described in Section 9.3.1, "Configuring the system", on page 96.

IP Address

Sets the IP address of the sensor module.

Remote command:

`SYSTem:COMMunicate:NETWork:IPADdress` on page 101

Subnet Mask

Sets the subnet mask.

The subnet mask consists of four number blocks separated by dots. Every block contains 3 digits at a maximum.

Remote command:

`SYSTem:COMMunicate:NETWork:IPADdress:SUBNet:MASK` on page 103

Sensor Name

Assigns a name for the sensor module. The web user interface indicates the name in the title bar, see Figure 7-1.

If you do not specify a sensor name, the hostname is used as default, see `SYSTem:COMMunicate:NETWork[:COMMon]:HOSTname` on page 100.

Remote command:
`SYSTem[:SENSor]:NAME` on page 109

Gateway

Sets the address of the default gateway that means the router that is used to forward traffic to destinations beyond the local network. This router is on the same network as the instrument.

Remote command:
`SYSTem:COMMunicate:NETWork:IPADdress:GATeway` on page 102

DHCP

Selects the mode for assigning the IP address.

"Auto"	Assigns the IP address automatically, provided the network supports DHCP (dynamic host configuration protocol).
"Static"	Enables you to assign the IP address manually.

Remote command:
`SYSTem:COMMunicate:NETWork:IPADdress:MODE` on page 102

Selftest

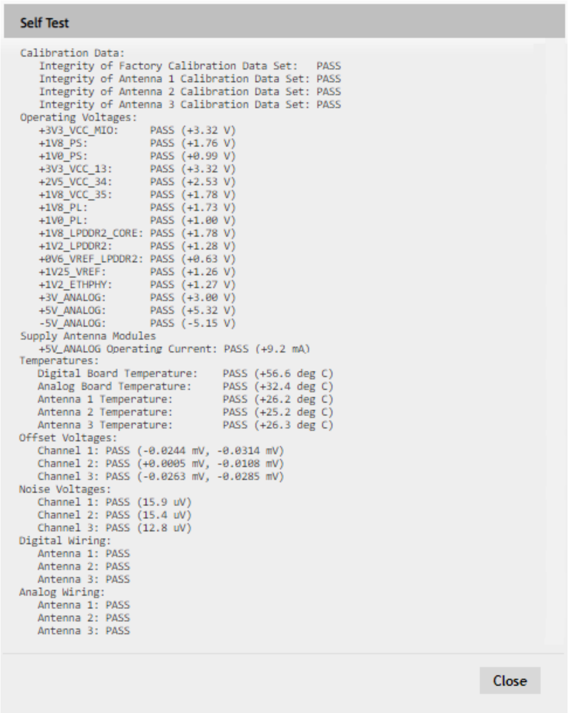
Initiates a selftest of the sensor.

Note:

Do not apply a signal to the sensor module while the selftest is running.

Executing the self-test with an active signal assigned, can erroneously result in error messages at the test steps *Offset Voltages* and/or *Noise Voltages*.

When completed, the web user interface displays a report with the test results.



Remote command:
`TEST:SENSor?` on page 167

Apply Network Settings
After you have completed the required network settings changes, confirm the modification with "Apply Network Settings".

Update
Opens a dialog to start the firmware update. For further information, see Section 8.2.2, "Using the web user interface", on page 85.

Alternatively, you can update the firmware with the firmware update program, see Section 8.2.1, "Using the Firmware Update program", on page 84, or remotely, see Section 8.2.4, "Using remote control", on page 88.

Remote command:
`SYSTem:FWUPdate` on page 98
`SYSTem:FWUPdate:STATus?` on page 98

Sensor Preset
Click the "RST" button to perform a preset. The R&S NRPM stops the running measurement, changes to the continuous average measurement and awaits the start of a new measurement.

Use the preset functionality to set the R&S NRPM to a defined state. The preset allows you to change parameter values from a defined starting point.

Remote command:
*RST on page 94

Reboot Sensor

Reboots the R&S NRPM. When the reboot is completed, press [F5] to reload the web browser page.

Remote command:
SYSTem:REBoot on page 97

8 Firmware update

8.1 Downloading the firmware update file

Firmware update files of R&S sensor modules generally have an RSU extension, RSU meaning Rohde & Schwarz update.

To download the RSU file

1. Download the most recent firmware version from the Rohde & Schwarz homepage on the internet. The latest firmware update files are available at:
   www.rohde-schwarz.com/firmware/NRPM
2. Save the RSU file on the computer.
3. If the RSU file is packed in a `*.zip` archive, extract it.

8.2 Updating the firmware

Do not interrupt the firmware update because an interruption can lead to missing or faulty firmware. Take special care not to disconnect the power supply while the update is in progress. Interrupting the power supply during the firmware update most likely leads to an unusable sensor that needs to be sent in for maintenance.

You can choose from several methods to update the firmware installed on the sensor.

If you want to downgrade to an older version, you cannot use an RSU file downloaded from the Rohde & Schwarz homepage on the internet. Contact our costumer support to receive a special downgrade file for your sensor. See Section 13.8, "Contacting customer support", on page 218.

8.2.1 Using the Firmware Update program

The Firmware Update program is part of the R&S NRP-Toolkit. See also Section 4.6.2, "R&S NRP-Toolkit", on page 24.

You can use the Firmware Update program only if the sensor is recognized as a VISA device.

To check the prerequisites

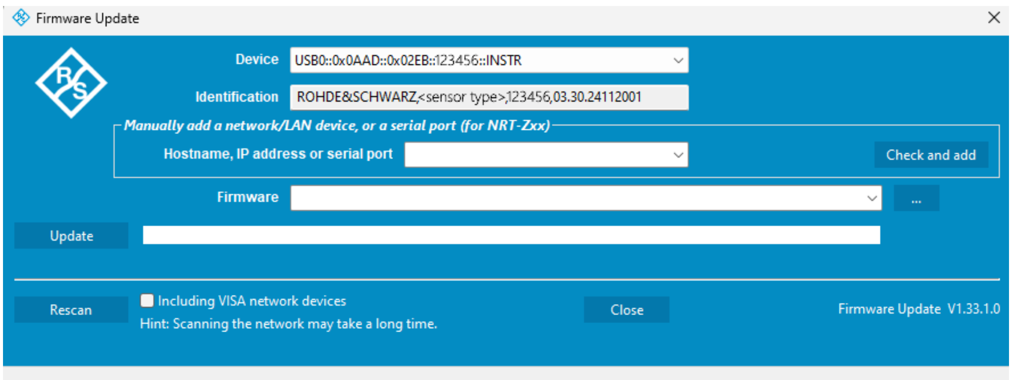
1. Ensure that a recent VISA software is installed on the computer.
   The latest version is provided on the Rohde & Schwarz website at www.rohde-schwarz.com/rsvisa.
2. Ensure that the R&S NRP-Toolkit for Windows is installed on the computer.
   See Section 4.6.2, "R&S NRP-Toolkit", on page 24.

To update the firmware over USB

A firmware update can take up to 5 minutes. Ensure that the update is not interrupted.

1. Ensure that the prerequisites are fulfilled. See "To check the prerequisites" on page 84.
2. Connect the sensor to the computer.
   See Section 6.3.2, "Connecting to the controller PC", on page 46
3. Start the Firmware Update program:
   "Start" menu > "NRP-Toolkit" > "Firmware Update".

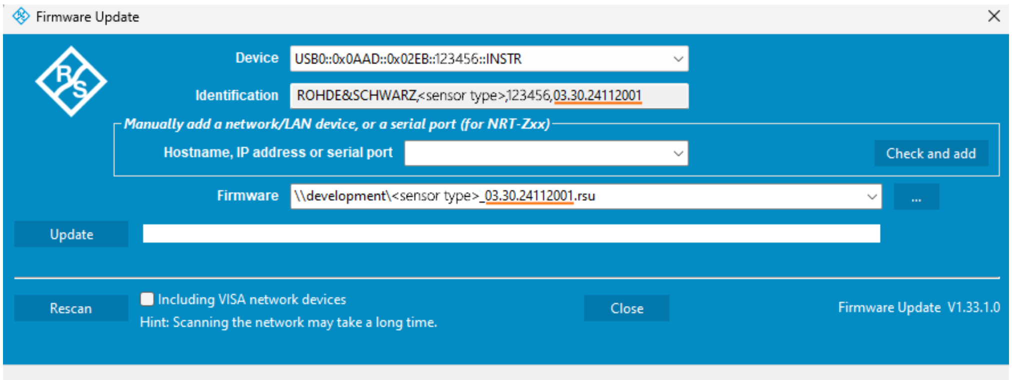
   The program automatically starts scanning for R&S sensors connected via USB.
   When the scan is completed, all recognized sensors are listed under "Device".



4. If the sensor you want to update is not listed, perform one of the following actions:
   - Click "Rescan" to search for attached sensors.
   - Check whether all necessary drivers are installed on the computer.
     For example, if the VISA library is not installed on the computer, no VISA sensor is accessible.
     See alsoSection 13.4, "Problems during a firmware update", on page 212 .
5. Under "Device", select the sensor you want to update.

   Note: The "Hostname, IP Address or Serial Port" field is not used during this procedure. Therefore, leave it empty.
6. Under "Firmware", enter the full path and filename of the update file. Alternatively, click ... next to the field.
7. Click "Update".

   During the update process, a progress bar is displayed.
   The update sequence can take a couple of minutes. When the update has been completed, a message is displayed.
8. Check if the update was successful. The firmware version in the "Identification" field must match the version you selected in the "Firmware" field.

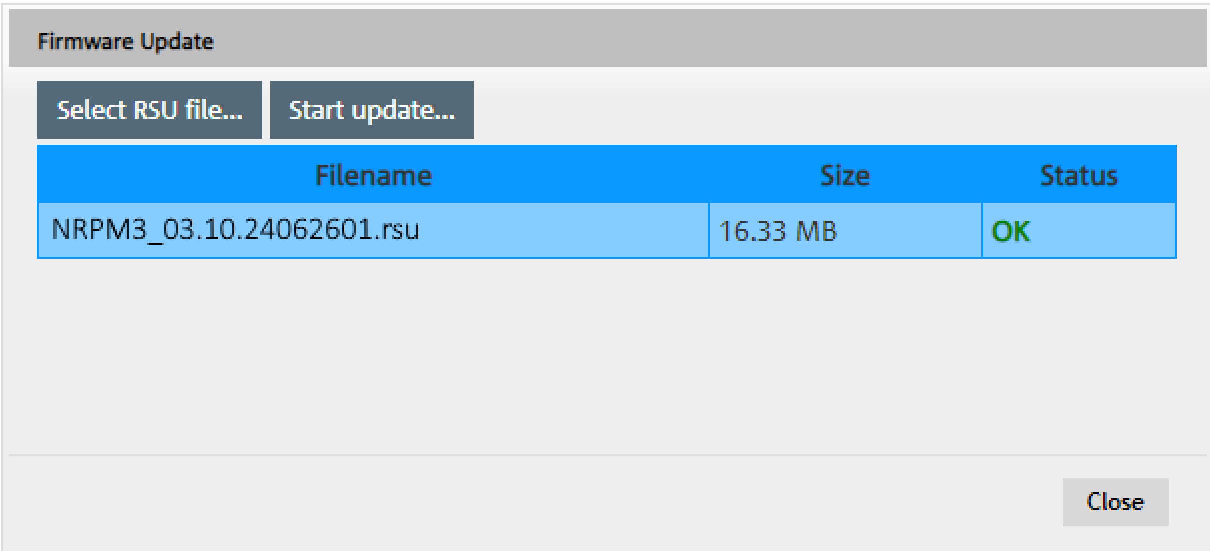


8.2.2 Using the web user interface

Requires a sensor module with networking capabilities, an R&S NRPM3N.

1. Connect the sensor module to the computer as described in Section 6.3.4, "Using the LAN connection", on page 50.
2. Open the web user interface as described in Section 7.2.2, "Using the web user interface", on page 65.
3. In the navigation pane, select "System".
4. Select "Firmware Update".
5. In the "Firmware Update" dialog, select "Select RSU file".
6. In the file browser, select the `*.rsu` file for upload.

   The dialog displays the selected file with file size and status.



7. Select "Start update".

   During the update process, the program displays a progress bar and information on the current state. The update sequence can take a couple of minutes. When completed, the dialog closes automatically.

8.2.3 Using SCP or SFTP

Requires a sensor with networking capabilities, a LAN sensor.

You can transfer an update file by using either secure copy protocol (SCP) or secure file transfer protocol (SFTP).

To prepare for the transfer

1. Connect the sensor to the computer on which you have saved the RSU file.

See Section 6.3.4, "Using the LAN connection", on page 50.

2. On the computer, open Command Prompt.

   By default, your user directory on the computer is opened `C:/Users/<your name>`.

To transfer an update file by using SCP

1. In Command Prompt, enter
   `scp <RSU file path> <user name>@<host name>:/home/instrument/update`
   Example:
   `scp NRPxSN_03.50.25102101.rsu instrument@NRP33SN-999994:/home/instrument/update`
2. Enter the password when prompted.

To transfer an update file by using SFTP

1. In Command Prompt, enter `sftp <user name>@<host name>`.
   Example: `sftp instrument@nrp33SN-999994`
2. Enter the password when prompted.

   Connection is confirmed with "Connected to <host name>."
3. Change to the sensor update directory:
   `cd /home/instrument/update`
4. Copy the new RSU file into the update directory of the sensor:
   `put <RSU file path> <user name>@<host name>`
   Example: `put NRPxSN_03.50.25102101.rsu instrument@nrp33SN-999994`
5. If you want to display the list of the available commands, enter `help`.

Table 8-1: Input data explanations

Input data	Description
<user name>	User name of the sensor, preconfigured as *instrument*.
<host name>	See Section 6.3.5.1, "Using hostnames", on page 55. Instead of the host name, you can use the IP address.

Input data	Description
Password	User password configured with SYSTem:SECurity:PASSword:USER.
<RSU file path>	Path and name of the RSU file. If the RSU file is in your user directory on the computer C:/Users/<your name>, the <RSU file path> is just the RSU filename, as shown in the example.

After the file transfer

When the copy process is completed, the firmware update starts automatically.

The files in the update directory are deleted automatically at every reboot.

8.2.4 Using remote control

If you want to integrate a firmware update function in an application, use SYSTem:FWUPdate on page 98.

Example:

You want to update the sensor with the NRPM3_03.50.24121801.rsu file. This file has a size of 10242884 bytes.

To send the file to the sensor for updating the firmware, your application has to assemble a memory block containing:

SYST:FWUP <block_data>

The <block_data> are definite length-arbitrary block data.

See SYSTem:FWUPdate on page 98.

The size of the file is 10242884. This number has 8 digits. Thus, the <block_data> consist of the following:

- #
- 8
  How many digits follow to specify the file size.
- 10242884
  The number that specifies the file size.
- <file_contents>
  Contents of the RSU file, byte-by-byte
- 0x0a
  Delimiter

In this example, you write exactly 10242905 bytes to the sensor, for example by using a 'viWrite()' function.

The 10242905 bytes result from the values of the list above:

9 + 1 + 1 + 1 + 8 + 10242884 + 1

In a (pseudo) string notation, the memory block looks like this:

```
SYST:FWUP #810242884<file_contents>0x0a,
```

9 Remote control commands

Remote control of sensor modules enables you to integrate them into custom automatic test equipment (ATE) systems.

In the following sections, all commands implemented in the sensor are listed according to the command system and then described in detail. Mostly, the notation used complies with SCPI specifications.

For general information on remote control of Rohde & Schwarz products via SCPI, refer to www.rohde-schwarz.com/rc-via-scpi.

Further information:

- Section 11.1, "Remote control interfaces and protocols", on page 185
- Section 11, "Remote control basics", on page 185

9.1 Conventions used in SCPI command descriptions

The following conventions are used in the remote command descriptions:

- *Command usage*
  If not specified otherwise, commands can be used both for setting and for querying parameters.
  If a command can be used for setting or querying only, or if it initiates an event, the usage is stated explicitly.
- *Parameter usage*
  If not specified otherwise, a parameter can be used to set a value, and it is the result of a query.
  Parameters required only for setting are indicated as "Setting parameters".
  Parameters required only to refine a query are indicated as "Query parameters".
  Parameters that are only returned as the result of a query are indicated as "Return values".
- *Conformity*
  Commands that are taken from the SCPI standard are indicated as "SCPI confirmed". All commands used by the R&S NRPM follow the SCPI syntax rules.

- *Asynchronous commands*
  A command which does not automatically finish executing before the next command starts executing (overlapping command) is indicated as an "Asynchronous command".
- *Reset values (*RST)*
  Default parameter values that are used directly after resetting the instrument (`*RST` command) are indicated as "*RST" values, if available.
- *Default unit*
  The default unit is used for numeric values if no other unit is provided with the parameter.

Units

Units and prefixes, as defined by the international system of units (SI), are allowed and recognized. If you need decimal multiples and submultiples of a unit, you can use SCPI prefixes. Because SCPI uses only capital letters, it cannot distinguish between upper and lower case characters. Therefore, if SI prefixes use the same letter in upper and lower case, SCPI defines the meaning. An example is milli (m) and mega (M). In SCPI, M means milli for all units except Hz and Ohm - `MHZ` means mega Hz, 10^6 Hz.

Table 9-1: SCPI prefixes

Factor	SI name	SI symbol	SCPI prefix
10^3	kilo	k	K
10^6	mega	M	MA; also allowed are MOHM and MHZ
10^9	giga	G	G
10^{12}	tera	T	T
10^{-3}	milli	m	M Exception: Hz and Ohm
10^{-6}	micro	µ	U
10^{-9}	nano	n	N
10^{-12}	pico	p	P

9.2 Common commands

The common commands are taken from the IEEE 488.2 (IEC 625–2) standard. The headers of these commands consist of an asterisk * followed by three letters.

***CLS**

Clear status

Resets the following:

- Status byte (`STB`)
- Standard event register (`ESR`)
- `EVENt` part of the `QUEStionable` and the `OPERation` register
- Error/event queue

The command does not alter the `ENABle` and `TRANsition` parts of the registers.

Usage: Event

***ESE** <register>

Event status enable

Sets the event status enable register to the specified value. The query returns the contents of the event status enable register in decimal form.

Parameters:

<register>	Range:	0 to 255
	*RST:	0

***ESR?**

Event status read

Returns the contents of the event status register in decimal form (0 to 255) and then sets the register to zero.

Usage: Query only

***IDN?**

Identification

Returns a string containing information on the identity of the sensor (device identification code). In addition, the version number of the installed firmware is indicated.

Usage: Query only

***IST?**

Individual status

Returns the current value of the IST flag in decimal form. The IST flag is the status bit which is sent during a parallel poll.

Usage: Query only

***OPC**

Operation complete

Sets bit 0 in the event status register when all preceding commands have been executed. Send this command at the end of a program message. It is important that the read timeout is set sufficiently long.

The query always returns 1 because the query waits until all previous commands are executed.

*OPC? basically functions like *WAI, but also returns a response. The response is an advantage, because you can query the execution of commands from a controller program before sending new commands. Thus preventing overflow of the input queue when too many commands are sent that cannot be executed.

***OPT?**

Option identification

Returns a comma-separated list of installed options.

Usage: Query only

***PRE** <register>

Parallel poll register enable

Sets the parallel poll enable register to the specified value or queries the current value.

Parameters:

<register> Range: 0 to 255
*RST: 0

***RCL** <number>

Recall

Calls the device state which has been stored with the *SAV command under the specified number.

Setting parameters:

<number> Range: 0 to 9
*RST: 0

Usage: Setting only

***RST**

Reset

Sets the instrument to a defined default status. The default settings are indicated in the description of commands.

The command corresponds to the SYSTem:PRESet command.

Usage: Event

Manual operation: See "Sensor Preset" on page 81

***SAV** <number>

Save

Stores the current device state under the specified number.

Setting parameters:

<number>	Range:	0 to 9
	*RST:	0

Usage: Setting only

***SRE** <register>

Service request enable

Sets the service request enable register to the specified value. This command determines under which conditions a service request is triggered.

Parameters:

<register>	Range:	0 to 255
	*RST:	0

***STB?**

Status byte

Returns the contents of the status byte in decimal form.

Usage: Query only

***TRG**

Trigger

Triggers a measurement if the following conditions are met:

- Sensor is in the waiting for trigger state.
- Trigger source is set to `BUS`.

See`TRIGger:SOURce > BUS` `BUS`.

Usage: Event

***TST?**

Self-test

Triggers a self-test of the sensor and outputs the result. `0` indicates that no errors have occurred.

Usage: Query only

***WAI**

Wait to continue

Prevents the execution of the subsequent commands until all preceding commands have been executed and all signals have settled.

Usage: Event

9.3 Configuring the general functions

9.3.1 Configuring the system

The `SYSTem` subsystem contains a series of commands for general functions that do not directly affect the measurement.

9.3.1.1 Preset and initialize

SYSTem:PRESet

Resets the sensor.

The command corresponds to the `*RST` command.

Usage: Event

SYSTem:INITialize

Sets the sensor to the standard state.

The sensor loads the default settings for all test parameters in the same way as when using `*RST`. The sensor outputs a complete list of all supported commands and parameters. The remote control software can automatically adapt to the features of different types of sensors with different functionality.

Usage: Event

9.3.1.2 Reboot and restart

SYSTem:REBoot

Reboots the sensor.

Usage: Event

Manual operation: See "Reboot Sensor" on page 82

SYSTem:RESTart

Restarts the firmware of the sensor.

Usage: Event

9.3.1.3 Firmware update

See also Section 8, "Firmware update", on page 83.

SYSTem:FWUPdate <fwudata>

Loads new operating firmware into the sensor. Rohde & Schwarz provides the update file. For further details, see Section 8, "Firmware update", on page 83.

If you want to integrate a firmware update function in an application, see the example given in Section 8.2.4, "Using remote control", on page 88.

Setting parameters:

<fwudata> <block_data>

Definite length arbitrary block data containing the direct copy of the binary `*.rsu` file in the following format:
#
Single digit indicating how many digits follow to specify the size of the binary file.
Number that specifies the size of the binary file.
Binary data
0x0a as appended delimiter (single '\n' character) for line feed

Usage: Setting only

Manual operation: See "Update" on page 81

SYSTem:FWUPdate:STATus?

Reads the result of the firmware update performed using `SYSTem:FWUPdate` on page 98.

While a firmware update is in progress, the LED of the sensor flashes in bright white color. When the firmware update is completed, you can read the result.

The result of the query is a readable string.

Example: `SYST:FWUP:STAT?`
Query
`"Success"`
Response

Usage: Query only

Manual operation: See "Update" on page 81

9.3.1.4 Password management

We recommend that you change the preconfigured instrument password before connecting the sensor to a network.

SYSTem:SECurity:PASSword:SECurity <passwd1>, <passwd2>

For future use.

Setting parameters:
<passwd1>

<passwd2>

Usage: Setting only

SYSTem:SECurity:PASSword:USER <passwd1>, <passwd2>

Sets a new user password, also called instrument password. You need this password to access the LAN sensors by SCP or SFTP. See also Section 8.2.3, "Using SCP or SFTP", on page 86.

The preconfigured user name and instrument password are *instrument*.

The command is restricted to remote control over the USB interface (USBTMC).

Setting parameters:

<passwd1> Old user password, entered as a string.

<passwd2> New user password, entered as a string.

Example:
```
SYST:SEC:PASS:USER "instrument",
"rohdeandschwarz"
```

Usage: Setting only

9.3.1.5 Network settings

Requires a sensor with networking capabilities, a LAN sensor.

SYSTem:COMMunicate:NETWork[:COMMon]:DOMain <domain>

Requires a sensor with networking capabilities, a LAN sensor.

Sets the domain of the network.

Parameters:
<domain>

Example: `SYST:COMM:NETW:COMM:DOM 'ABC.DE'`
Sets *ABC.DE* as domain of the network.

SYSTem:COMMunicate:NETWork[:COMMon]:HOSTname <hostname>

Requires a sensor with networking capabilities, a LAN sensor.

Sets the individual host name of the sensor.

In a LAN that uses a DNS server (domain name system server), you can access each connected sensor using a unique host name instead of its IP address. The DNS server translates the host name to the IP address. Using a host name is especially useful if a DHCP server is used, as a new IP address can be assigned each time the sensor is restarted.

The sensor performs the change of the host name immediately after the command is sent. For this purpose, the sensor restarts its connection to the network, which can take several seconds. During this time, you cannot address the sensor. After the restart, you can only address the sensor using the newly set host name.

Note: We recommend that you do not change the default host name to avoid problems with the network connection. However, if you change the host name, be sure to use a unique name.

Parameters:
<hostname>

Example: `SYST:COMM:NETW:COMM:HOST 'powersensor-2nd-floor'`
Sets *powersensor-2nd-floor* as new host name.

SYSTem:COMMunicate:NETWork:CONFigure <value>

Requires a sensor with networking capabilities, a LAN sensor.

Sets a static address. Combines the three commands to set the IP address, the subnet mask and the gateway.

Setting parameters:
<value> **"<mode>,<IP address>,<subnet mask>,<gateway>"**
The string has to start with <mode> = STAT. Otherwise, it is ignored.
<IP address> see SYSTem:COMMunicate:NETWork:IPADdress on page 101.
<subnet mask> see SYSTem:COMMunicate:NETWork:IPADdress:SUBNet:MASK on page 103.
<gateway> see SYSTem:COMMunicate:NETWork:IPADdress:GATeway on page 102.

Example: `SYST:COMM:NETW:CONF 'STAT, 147.161.235.79,255.255.255.0,192.168.1.200'`

Usage: Setting only

SYSTem:COMMunicate:NETWork:IPADdress <ipaddress>

Requires a sensor with networking capabilities, a LAN sensor.

Effective only if `SYSTem:COMMunicate:NETWork:IPADdress:MODE` is set to `STATic`.

Sets the IP address of the sensor.

Parameters:
<ipaddress>

Example: `SYST:COMM:NETW:IPAD '147.161.235.79'`
Sets *147.161.235.79* as IP address.

Manual operation: See "IP Address" on page 79

SYSTem:COMMunicate:NETWork:IPADdress:GATeway <gateway>

Requires a sensor with networking capabilities, a LAN sensor.

Effective only if `SYSTem:COMMunicate:NETWork:IPADdress:MODE` is set to `STATic`.

Sets the IP address of the default gateway.

Parameters:
<gateway>

Example: `SYST:COMM:NETW:IPAD:GAT '192.168.1.200'`
Sets *192.168.1.200* as IP address of the default gateway.

Manual operation: See "Gateway" on page 80

SYSTem:COMMunicate:NETWork:IPADdress:INFO?

Requires a sensor with networking capabilities, a LAN sensor.

Queries the network status information.

Usage: Query only

SYSTem:COMMunicate:NETWork:IPADdress:MODE <mode>

Requires a sensor with networking capabilities, a LAN sensor.

Sets how the IP address is assigned.

Parameters:

<mode> AUTO | STATic

AUTO
Assigns the IP address automatically, provided the network supports DHCP.

STATic
Enables assigning the IP address manually.

*RST: AUTO

Example: `SYST:COMM:NETW:IPAD:MODE AUTO`
The IP address is assigned automatically.

Manual operation: See "DHCP" on page 80

SYSTem:COMMunicate:NETWork:IPADdress:SUBNet:MASK <netmask>

Requires a sensor with networking capabilities, a LAN sensor.

Effective only if `SYSTem:COMMunicate:NETWork:IPADdress:MODE` is set to `STATic`.

Sets the subnet mask.

Parameters:
<netmask> The subnet mask consists of four number blocks separated by dots. Every block contains 3 numbers in maximum.

Example: `SYST:COMM:NETW:IPAD:SUBN:MASK '255.255.255.0'`
Sets *255.255.255.0* as subnet mask.

Manual operation: See "Subnet Mask" on page 79

SYSTem:COMMunicate:NETWork:RESet

Requires a sensor with networking capabilities, a LAN sensor.

Resets the LAN network settings to the default values.

Usage: Event

SYSTem:COMMunicate:NETWork:RESTart

Requires a sensor with networking capabilities, a LAN sensor.

Restarts the network connection to the DUT that means terminates the connection and sets it up again.

Example: `SYST:COMM:NETW:REST`

Usage: Event

SYSTem:COMMunicate:NETWork:STATus?

Requires a sensor with networking capabilities, a LAN sensor.

Queries the network configuration state.

Example: `SYST:COMM:NETW:STAT?`
Query
`UP`
Response: The network is active.

Usage: Query only

9.3.1.6 Remote settings

SYSTem:HELP:HEADers? [<Item>]

Returns a list of all SCPI commands supported by the sensor.

Query parameters:
<Item> <block_data>

Usage: Query only

SYSTem:HELP:SYNTax? [<Item>]

Queries the relevant parameter information for the specified SCPI command.

Query parameters:
<Item>

Example: `SYST:HELP:SYNT? 'sens:aver:coun'`

Usage: Query only

SYSTem:HELP:SYNTax:ALL?

Queries the implemented SCPI commands and their parameters. Returns the result as a block data.

Usage: Query only

SYSTem:LANGuage <language>

Selects an emulation of a different command set.

Parameters:

<language> SCPI

*RST: SCPI

SYSTem:PARameters?

Returns an XML-output containing all commands with the following information, if available for the command:

- Default value
- Minimum value
- Maximum value
- Parameters
- Limits

Each command is shortened to a command token, consisting only of the mnemonics short form. For example, `CALibration:DATA` is shortened to `CALDATA` as command token.

Usage: Query only

SYSTem:PARameters:DELTa?

Returns an XML-output containing all commands that differ from the defined default status set by `*RST` on page 94.

The commands are accompanied by the same information as for `SYSTem:PARameters?`.

Usage: Query only

SYSTem:TRANsaction:BEGin

Starts a series of settings.

Usage: Event

SYSTem:TRANsaction:END

Ends a series of settings.

Usage: Event

SYSTem:VERSion?

Queries the SCPI version that the command set of the sensor complies with.

Example: `SYST:VERS?`
Query
`1999.0`
Response: SCPI version from 1999.

Usage: Query only

9.3.1.7 Sensor information

Device footprint

The device footprint contains information about the sensor hardware, the installed software, and license data.


```
#41679<?xml version="1.0" encoding="utf-8" ?>
<DeviceFootprint formatVersion="03.05" creationDate="1970-01-01T00:00:17"
 checksum="ed0d683e83adbfbf66943b5e9030fa24">
  <DeviceData deviceId="1425.8592.02-900434-fi" partChangeIndex="--.--"
   type="NRPM3N" upgradeType="NRPM3N" upgradePartNumber="1425.8592.02"
   hostName="nrpm3n-900434"/>
  <HardwareData cpu="ARMv7 Processor rev 0 (v7l)" ramSize="129630208">
    <HardwareList>
      <Hardware id="12003" partNumber="1426.7725.00" sn="000000"
       partName="ED ANALOGBOARD NRPXX"/>
      <Hardware id="12004" partNumber="1436.2378.00" sn="000000"
       partName="ED DIGITALBOARD NRPXX"/>
      <Hardware id="12005" partNumber="1419.0529.00" sn="000000"
```

```
      partName="ED INTERFACE BOARD"/>
    </HardwareList>
  </HardwareData>
  <SoftwareData>
    <Bios name="U-Boot" version="2013.01.01 (Oct 22 2024 - 12:22:41)"/>
    <OperatingSystem name="Linux - Linux Platform Kit 2.3.4-6 (pyro)"
     version="2.3.4-6" imageName="Linux Platform Kit 2.3.4-6 (pyro)"
     imageVersion="2.3.4-6" systemWordSize="32-Bit" systemLanguage="C"
     kernelRelease="3.14.34"
     kernelVersion="#1 SMP PREEMPT Tue Oct 22 12:20:36 UTC 2024"/>
    <SoftwareList>
      <Software name="RSU build" version="03.50.25101601"
       vendorName="Rohde&amp;Schwarz"/>
      <Software name="SW build" version="25.10.16 17:06"
       vendorName="Rohde&amp;Schwarz"/>
      <Software name="FPGA image" version="1.10.1"
       vendorName="Rohde&amp;Schwarz"/>
    </SoftwareList>
  </SoftwareData>
  <LicenseData conformToTvr320="false">
    <ActiveLicenseList>
      <ActiveLicense type="NRPS-K1" partNumber="1419.0135.02"
       keyCode="1b4d5bedb18da6e2361743f8559f3638"/>
    </ActiveLicenseList>
  </LicenseData>
</DeviceFootprint>
```


SYSTem:DFPRint<Channel>?

Queries the current device footprint.

See "Device footprint" on page 106.

Suffix:

<Channel> 1...4
Measurement channel if more than one channel is available.

Usage: Query only

SYSTem:INFO? [<item>]

Queries information about the sensor.

If queried without parameters, the command returns all available information in the form of a list of strings separated by commas.

If you want to query specific information, add the query parameter:

`SYST:INFO? "<string>"`

Query parameters:

<item> "Manufacturer", "Type", "Stock Number", "Serial", "SW Build", "Sensor Name", "Technology", "Function", "MinPower", "MaxPower", "MinFreq", "MaxFreq", "Resolution", "Cal. Misc.", "Cal. Abs.", "Cal. Temp.", "Cal. Lin.", "Cal. Due Date", " Antenna 1 Type", " Antenna 1 Stock number", "Antenna 1 Serial", "Antenna 1 Cal. Due Date", "Antenna 1 Property", Antenna 2 Type", " Antenna 2 Stock number", "Antenna 2 Serial", "Antenna 2 Cal. Due Date", "Antenna 2 Property", Antenna 3 Type", " Antenna 3 Stock number", "Antenna 3 Serial", "Antenna 3 Cal. Due Date", "Antenna 3 Property", "Uptime"

Usage: Query only

SYSTem:INFO:SUPPort?

Queries the diagnostic and troubleshooting data. Returns the results as a definite length-arbitrary block data containing a compressed archive (`.tar.gz`) of the diagnostic and troubleshooting data in the following format:

- #
- Single digit indicating how many digits follow to specify the size of the compressed archive.
- Number that specifies the size of the compressed archive.
- Compressed archive data
- 0x0a as appended delimiter (single '\n' character) for line feed

See also Section 13.7, "Collecting information for technical support", on page 217.

Usage: Query only

SYSTem[:SENSor]:NAME <sensorname>

Sets the name of the sensor according to your requirements.

The name that you specify here is independent from the host name of the sensor. However, if you do not specify a name, the host name is used as default.

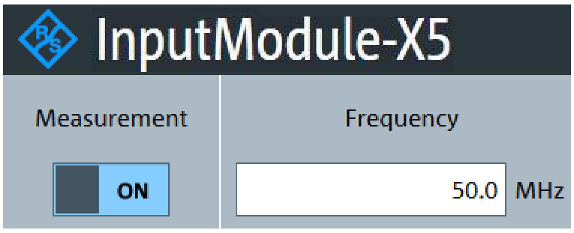


Figure 9-1: Sensor name displayed in the web user interface

Parameters:
<sensorname>

Example: `SYST:NAME "InputModule-X5"`

Manual operation: See "Sensor Name" on page 79

9.3.1.8 Status display and update

See also "Status LED (2)" on page 30.

SYSTem:LED:CHANnel<Channel>:COLor <color>

Sets the color of the antenna module LED.

The suffix <channel> selects the corresponding antenna module, and the suffix <color> selects LED on/off.

Suffix:
<Channel> 1...3

Parameters:
<color> **0**
The LED is off.

> 0
The LED shines blue.

Range: 0 to 255
*RST: 0

SYSTem:LED:COLor <color>

Effective if the status LED is user-controlled, see `SYSTem:LED:MODE` `USER`.

Sets the color and the flash code of the status LED.

Parameters:

<color> Hexadecimal code: #H0<emitting type><color>
With
<emitting type>: 0 = steady on; 1 = slowly flashing; 2 = fast flashing
<color>: FF0000 = red, 00FF00 = green, 0000FF = blue

Range: 0 to #H0FFFFFFF
*RST: #H00A0A0A0

Example:

`SYST:LED:MODE USER`
The status LED is user-controlled.

`SYST:LED:COL #H01FF0000`
The LED flashes slowly in red.

`SYST:LED:MODE SENS`
The status LED is controlled by the sensor firmware.

SYSTem:LED:MODE <mode>

Sets whether the color and flash code of the status LED are controlled by the sensor firmware or by the user settings.

For more information, see `SYSTem:LED:COLor`.

Parameters:

<mode> USER | SENSor

*RST: SENSor

9.3.1.9 Measurement limits and levels

SYSTem:MINPower?

Queries the lower power measurement limit. Use this query to determine a useful resolution for the result display near the lower measurement limit.

The lower measurement limit refers to the sensor or to the combination of a sensor and the components connected ahead of it.

Set the unit using `SYSTem:MINPower:UNIT`.

Usage: Query only

SYSTem:MINPower:UNIT <unit>

Sets the unit for the lower power measurement limit, queried by `SYSTem:MINPower?`.

Parameters:

<unit> DBM | W | DBUV

*RST: W

9.3.1.10 Errors

See also Section 13.2, "Error messages", on page 209.

SYSTem:ERRor:ALL?

Queries all unread entries in the SCPI communication error queue and removes them from the queue.

Returns a comma-separated list of error numbers and a short error description in the first-in first-out order.

Example: `SYST:ERR:ALL?`
Query
`0,"No error"`
Response

Usage: Query only

SYSTem:ERRor:CODE:ALL?

Queries all unread entries in the SCPI communication error queue and removes them from the queue.

Returns a comma-separated list of error numbers, but no error description.

Example: `SYST:ERR:CODE:ALL?`
Query
`0`
Response: No errors have occurred since the error queue was last read out.

Usage: Query only

SYSTem:ERRor:CODE[:NEXT]?

Queries the SCPI communication error queue for the oldest entry and removes it from the queue.

Returns the error number, but no error description.

Example: `SYST:ERR:CODE?`
Query
`0`
Response: No errors have occurred since the error queue was last read out.

Usage: Query only

SYSTem:ERRor:COUNt?

Queries the number of entries in the SCPI communication error queue.

Example: `SYST:ERR:COUN?`
Query
`1`
Response: One error has occurred since the error queue was last read out.

Usage: Query only

SYSTem:ERRor[:NEXT]?

Queries the SCPI communication error queue for the oldest entry and removes it from the queue.

Returns an error number and a short description of the error.

Example: `SYST:ERR?`
Query
`0, 'no error'`
Response: No errors have occurred since the error queue was last read out.

Usage: Query only

SYSTem:SERRor?

Queries the next static error, if available.

Static errors, as a rule, prevent the execution of normal measurements.

Errors in SCPI communication are queried using `SYSTem:ERRor[:NEXT]?`.

Usage: Query only

SYSTem:SERRor:LIST:ALL?

Queries all changes in the static error queue that have not been read yet and removes them from the queue.

Example: `SYST:SERR:LIST:ALL?`
Query
`0,"reported at uptime:2942; notice; auto-averaging exceeded maximum time; Notification",0,"removed at uptime:2944; notice; auto-averaging exceeded maximum time; Notification"`
Response

Usage: Query only

SYSTem:SERRor:LIST[:NEXT]?

Queries the list of static error changes for the oldest entry and removes it from the queue.

Returns an error number and a short description of the error.

Example: `SYST:SERR:LIST?`
Query
`0,"reported at uptime:2942; notice; auto-averaging exceeded maximum time; Notification"`
Response

Usage: Query only

9.3.2 Handling of available antenna modules

The `SENSe:CHANnel` subsystem contains commands for checking connected antenna modules, and activating individual antenna modules.

Remote commands:

[SENSe<Sensor>:]CHANnel<Channel>:PRESence?

Queries whether an antenna module is connected to a channel.

Suffix:
<Sensor> 1

<Channel> 1...3

Usage: Query only

Manual operation: See "Antenna" on page 74

[SENSe<Sensor>:]CHANnel<Channel>[:ENABle] <state>

Deactivates channels without an antenna module connected.

Note: A sensor module channel which does not have a connected antenna module causes a static error condition. The static error leads to a blinking LED. Therefore we recommend that you disable unconnected channels by this command.

Suffix:

<Sensor> 1

<Channel> 1...3

Parameters:

<state> *RST: ON

Manual operation: See "Antenna" on page 74

9.3.3 Selecting the reference source

The `ROSCillator` subsystem contains commands for configuring the reference source.

[SENSe<Sensor>:]ROSCillator:SOURce <source>

Selects the source of the reference frequency.

Suffix:

<Sensor> 1

Parameters:

<source> INTernal | EXTernal | HOST

INTernal
Internal precision oscillator.

EXTernal | HOST
External signal supplied at the host interface connector.

*RST: INTernal

Example: `ROSCillator:SOURce EXTernal`

9.3.4 Setting the power unit

The `UNIT` subsystem contains command for setting up the power unit.

UNIT:POWer <unit>

Sets the output unit for the measured power values.

Parameters:

<unit> DBM | W

*RST: W

9.3.5 Setting the result format

The `FORMat` subsystem sets the format of numeric data (measured values) that is exchanged between the remote control computer and the sensor modules if high-level measurement commands are used.

Remote commands:

FORMat:BORDer <border>

Selects the order of bytes in 64-bit binary data.

Parameters:

<border> NORMal | SWAPped

NORMal
The 1st byte is the LSB, the 8th byte the MSB.
This format fulfills the "Little Endian" convention.

SWAPped
The 1st byte is the most significant byte (MSB), the 8th byte the least significant byte (LSB).
This format fulfills the "Big Endian" (big end comes first) convention.

*RST: NORMal

FORMat:SREGister <sregister>

Specifies the format used for the return value of *STB?.

Parameters:

<sregister>	ASCii | HEXadecimal | OCTal | BINary *RST: ASCii

FORMat[:DATA] [<data,length>, <length>]

Specifies whether block data is transferred in plain text or binary format.

Parameters:

<data,length>	ASCii | REAL **ASCii** Transmits data as character strings in plain text. **REAL** Transmits data in binary blocks with 32 bit or 64 bit length. *RST: ASCii
<length>	Range: 32, 64 *RST: 0

Example:

`FORMat:DATA REAL,64`
Binary DOUBLE

`FORMat:DATA ASCii,3`
3.124

9.4 Controlling the measurement

The sensor module offers a bunch of possibilities to control the measurement:

- Do you want to start the measurement immediately after the initiate command or do you want to wait for a trigger event?
- Do you want to start a single measurement cycle or a sequence of measurement cycles?
- Do you want to retrieve each new average value as a measurement result or do you want to bundle more measured values into one result?

The following chapter introduces in general the principle of triggering and the controlling mechanisms for the output of the measurement results.

9.4.1 Triggering

In a basic continuous measurement, the measurement is started immediately after the initiate command. However, sometimes you want that the measurement starts only if a specific condition is fulfilled. For example, if a signal level is exceeded, or in certain time intervals. For these cases, you can define a trigger for the measurement.

Trigger states

The sensor module has trigger states to define the exact start and stop times of a measurement and the sequence of a measurement cycle.

The following states are defined:

- Idle
  The sensor module does not execute a measurement. After powered on, the sensor module is in the idle state.
  When a measurement has been started by one of the `INIT` commands, the sensor module switches to the waiting for trigger state.
  See Waiting for a trigger event.
- Waiting for trigger
  The sensor module waits for a trigger event that is defined by the trigger source, see "Trigger sources" on page 119.
  When the trigger event occurs, the sensor module enters the measuring state.
- Measuring
  The sensor module is measuring data. It remains in this state during the measurement. When the measurement is completed, the sensor module either continues with the next measurement, or finishes the current measurement and returns to IDLE state, depending on the initial mode you have started the measurement before.

Waiting for a trigger event

Before a trigger can be executed, you must set the sensor module to the waiting for trigger state. Depending on whether you want to measure continuously or want to execute one dedicated measurement, use the corresponding command:

- `INITiate:CONTinuous` on page 154

Starts a new measurement cycle automatically after the previous one has been completed.

- INITiate[:IMMediate] on page 153
  Starts a single measurement only. Depending on the selected measurement function, a *single measurement* can lead to an array of results, e.g., in trace mode.
  See [SENSe<Sensor>:]FUNCtion on page 129.

Trigger sources

The possible trigger conditions and the execution of a trigger depend on the selected trigger source.

If the signal power exceeds or falls below a reference level set by the trigger level, the measurement starts after the defined delay time. Waiting for a trigger event can be skipped by selecting TRIGger:IMMediate.

Trigger source	Description	Remote commands to initiate the measurement unconditionally
Hold	Triggered by the remote command.	TRIGger:IMMediate
Immediate	Measures immediately, does not wait for trigger condition.	-
Internal	Uses the input signal as trigger signal.	TRIGger:IMMediate
External 1	Uses the digital input signal supplied using a differential pair in the 8-pin sensor module cable.	TRIGger:IMMediate
External 2	Uses the digital input signal supplied at the SMB connector.	TRIGger:IMMediate
Bus	Triggered by the remote command.	*TRG TRIGger:IMMediate

Dropout time

The dropout time is useful when dealing with signal with several active slots, for example GSM signals, as, e.g., shown in Figure 9-2. When measuring in sync with the signal, a trigger event is to be produced at A, but not at B or C.

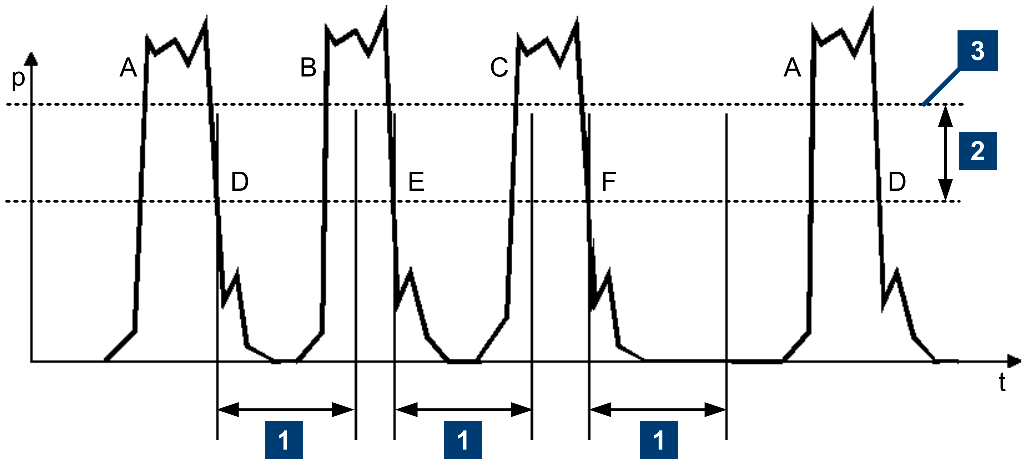


Figure 9-2: Significance of the drop-out time parameter

1 = Dropout time
2 = Trigger hysteresis
3 = Trigger level

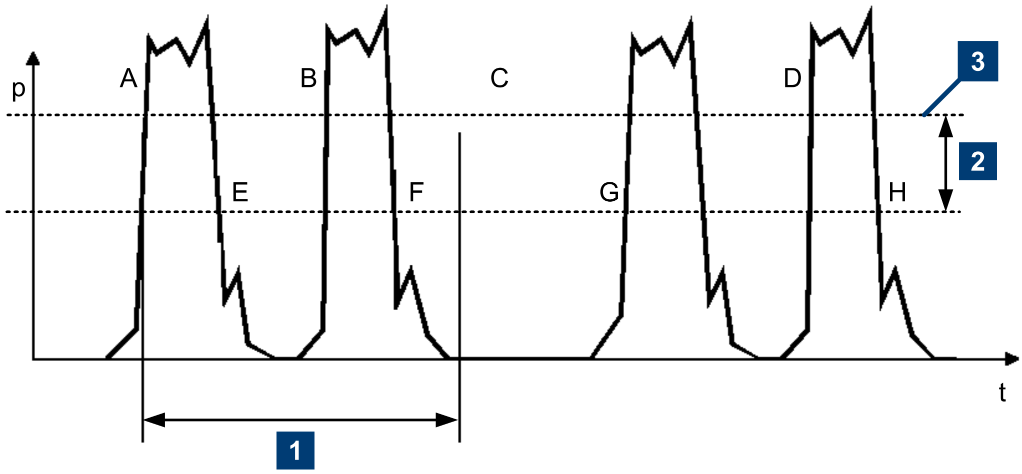
The RF power between the slots is below the threshold defined by the trigger level and the trigger hysteresis. Therefore, the trigger hysteresis alone cannot prevent triggering at B or at C. Therefore, set the dropout time greater than the time elapsed between points D and B and between E and C, but smaller than the time elapsed between F and A. Therefore, ensure that triggering takes place at A.

Because the mechanism associated with the dropout time is reactivated whenever the trigger threshold is crossed, you can obtain also unambiguous triggering for many complex signals.

If you use a hold-off time instead of a dropout time, you can obtain stable triggering conditions - regular triggering at the same point. But you cannot achieve exclusive triggering at A.

Hold-off time

During the hold-off time, a period after a trigger event, all trigger events are ignored.



1 = Hold-off time
2 = Trigger hysteresis
3 = Trigger level

9.4.2 Controlling the measurement results

The R&S NRPM3(N) sensor module can cope with the wide range of measurement scenarios with the help of the so-called "termination control". Depending on how fast your measurement results change, you can define, how to retrieve the measurement results.

In continuous average mode, use `[SENSe<Sensor>:]AVERage:TCONtrol`.

In trace mode, use `[SENSe<Sensor>:]TRACe:AVERage:TCONtrol`.

Repeating termination control

Returns a measurement result when the average filter has been filled completely. The number of measurement cycle repetitions is equal to the set average count. If the average count is large, the measurement time can take long time.

Useful if you expect slow changes in the results, and you want to avoid the output of redundant data.

Select repeating termination control when executing remote control applications, as you are usually only interested in the results of the fully settled average filter.

Moving termination control

Returns intermediate values to facilitate early detection of changes in the measured quantity. For each partial measurement, the sensor module returns a new average value as an intermediate measurement result. Thus, the individual result is a moving average of the last partial measurements. The parameter average count defines how many partial measurements are included.

Select the moving termination control when you want to observe and detect trends in the results during an ongoing measurement.

9.4.3 Interplay of the controlling mechanisms

The following examples use continuous measurement scenarios. But these scenarios apply also to single measurements. The only difference is that a single measurement is not repeated.

9.4.3.1 Continuous average mode

General settings for these examples:

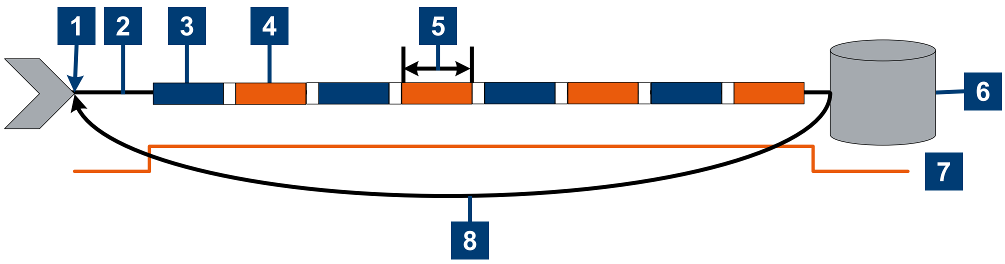
- `INITiate:CONTinuous ON`
- `[SENSe<Sensor>:]AVERage:COUNt 4`
- `[SENSe<Sensor>:]AVERage[:STATe] ON`

Example: Repeating termination control

Further settings for this example:

- `[SENSe<Sensor>:]AVERage:TCONtrol REPeat`

The measurement is started by the trigger event. Due to the chopper phases, one measurement lasts twice the defined aperture time. As defined by the average count, after 4 measurements, the result is averaged and available. During the whole measurement cycle, the trigger synchronization is high (`TRIGger:SYNC:STATe ON`).



1 = Start of the measurement cycle
2 = Trigger event
3 = Noninverted chopper phase
4 = Inverted chopper phase
5 = Duration of one aperture time (1 x t_{AP}) ≙ length of one chopper phase
6 = Measurement result
7 = Trigger synchronization
8 = Return to the start of the measurement cycle

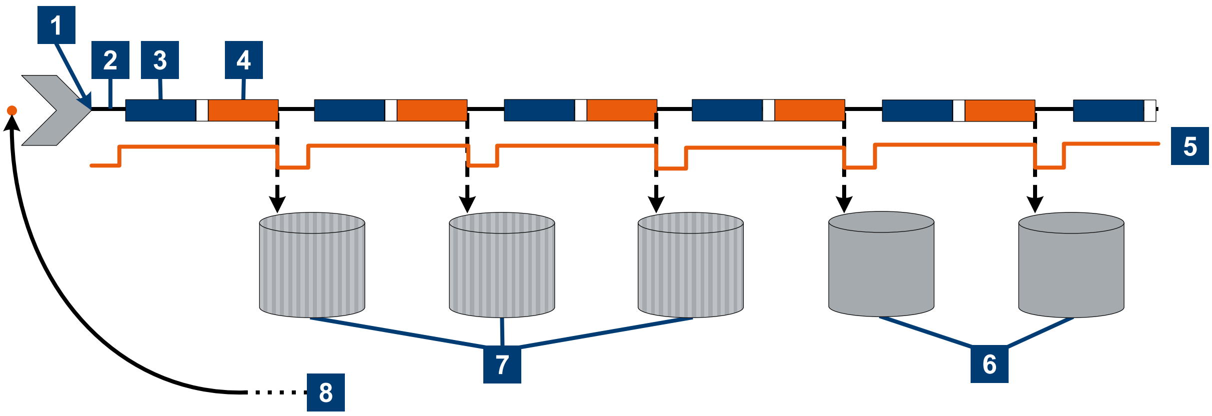
Example: Moving termination control

Further settings for this example:

- `[SENSe<Sensor>:]AVERage:TCONtrol MOVing`
- `TRIGger:COUNt 16`

Every measurement is started by a trigger event. Due to the chopper phases, one measurement lasts twice the defined aperture time. During each measurement, the trigger synchronization is high (`TRIGger:SYNC:STATe ON`). Every measurement provides a result. During the settling phase, the amount of the result is already correct, but the noise is higher. After 4 measurements, when the average count is reached, settled data are available.

When the trigger count is reached (`TRIGger:COUNt`), the sensor module returns to the idle state.

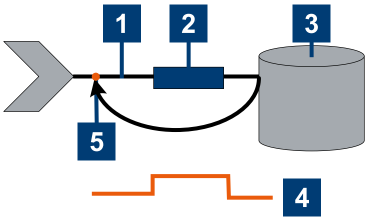


1 = Start of the measurement cycle
2 = Trigger event
3 = Noninverted chopper phase
4 = Inverted chopper phase
5 = Trigger synchronization
6 = Averaged measurement result after average count is reached
7 = Measurement result before average count is reached
8 = Return to idle state after trigger count (= 16 in this example) is reached

Example: Average count = 1

[SENSe<Sensor>:]AVERage:COUNt 1

For average count 1, the setting of the termination control has no impact. In both cases, the measurement runs for the duration of one aperture time. Then, settled data are available, and the sensor module returns to the idle state.



1 = Trigger event
2 = Noninverted chopper phase
3 = Measurement result
4 = Trigger synchronization
5 = Return to idle state

9.4.3.2 Trace mode

General settings for the first two examples:

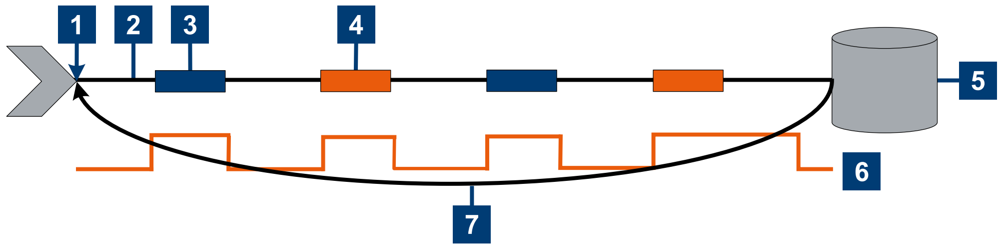
- INITiate:CONTinuous ON
- [SENSe<Sensor>:]TRACe:AVERage:COUNt 2 (count 2 is mandatory in trace mode)
- [SENSe<Sensor>:]TRACe:AVERage[:STATe] ON

Example: Repeating termination control

Further settings for this example:

- [SENSe<Sensor>:]TRACe:AVERage:TCONtrol REPeat (termination control REPeat is mandatory in trace mode)

Every chopper phase is started by a trigger event and lasts the defined trace time. During a chopper phase, the trigger synchronization is high (TRIGger:SYNC:STATe ON). After 2 chopper phases, 1 measurement is completed. As defined by the trace average count, after 2 measurements, the trace measurement result is averaged and available.



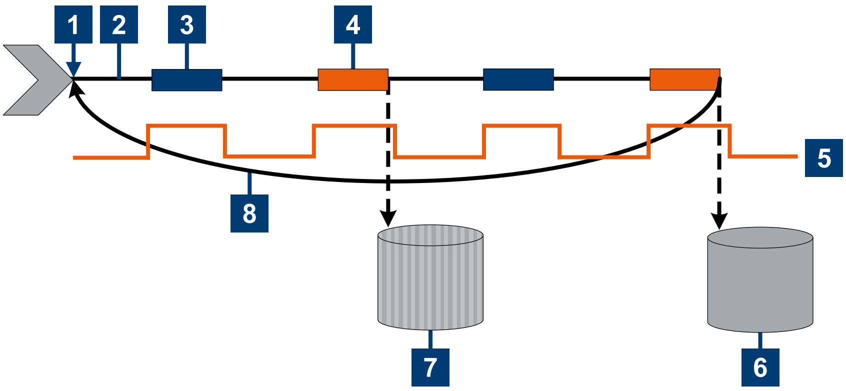
1 = Start of the measurement cycle
2 = Trigger event
3 = Noninverted chopper phase
4 = Inverted chopper phase
5 = Trace measurement result
6 = Trigger synchronization
7 = Return to the start of the measurement cycle

Example: Moving termination control

Further settings for this example:

- [SENSe<Sensor>:]TRACe:AVERage:TCONtrol MOVing

Every chopper phase is started by a trigger event and lasts the defined trace time. During a chopper phase, the trigger synchronization is high (TRIGger:SYNC:STATe ON). Every measurement provides a result. After 2 measurements, when the trace average count is reached, settled trace data result is available.

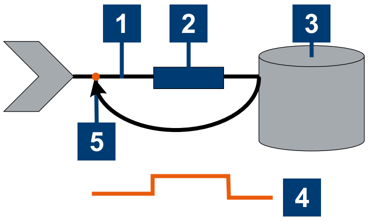


1 = Start of the measurement cycle
2 = Trigger event
3 = Noninverted chopper phase
4 = Inverted chopper phase
5 = Trigger synchronization
6 = Averaged trace data result after trace average count is reached
7 = Trace measurement result before trace average count is reached
8 = Return to the start of the measurement cycle

Example: Average count = 1

`[SENSe<Sensor>:]TRACe:AVERage:COUNt 1`

For average count 1, the setting of the termination control has no impact. In both cases, the measurement runs for the duration of one trace time. Then, settled trace data are available, and the sensor module returns to the idle state.



1 = Trigger event
2 = Noninverted chopper phase
3 = Trace measurement result
4 = Trigger synchronization
5 = Return to idle state

9.5 Selecting a measurement mode and retrieving results

Before starting a measurement, select the measurement mode using: `[SENSe<Sensor>:]FUNCtion`.

The following modes are available:

- Continuous average (`"POWer:AVG"`): After a trigger event, the power is integrated over a time interval, see Section 9.6.1, "Configuring a continuous average measurement", on page 133.
- Trace (`"XTIMe:POWer"`): A sequence of measurements is performed, see Section 9.6.3, "Configuring a trace measurement", on page 139.

After measuring, you can query the measurement results with the correspondent `FETCh` command.

Example: Selecting a measurement mode

```
*RST

// Select continuous average mode
SENSe:FUNCtion "POWer:AVG"

INITiate
FETCh?
```

Remote commands:

[SENSe<Sensor>:]FUNCtion <function>

Sets the measurement mode.

Suffix:

<Sensor> 1

Parameters:

<function>

"POWer:AVG"
Continuous Average
After a trigger event, the power is integrated over a time interval (aperture) set with `[SENSe<Sensor>:][POWer:][AVG:]APERture`.

XTIMe:POWer
Trace
In this mode, power over time is measured. Therefore several measurement points are defined (`[SENSe<Sensor>:]TRACe:POINts`) where the length of an individual measurement is determined from the ratio of total time (`[SENSe<Sensor>:]TRACe:TIME`) and the defined number of measurement points.

*RST: "POWer:AVG"

FETCh<Channel>[:SCALar][:POWer][:AVG]?

Queries the measurement results of a particular channel of the sensor module.

Suffix:
<Channel> 1...3

Usage: Query only

FETCh<Sensor>:ALL[:SCALar][:POWer][:AVG]?

Queries the measurement results of all channels of a sensor module.

The sensor module returns the results in a string, separated by commas.

Suffix:
<Sensor> 1

Usage: Query only

CALCulate:FEED <mode>

When you query measurement data using `FETCh<Channel>[:SCALar][:POWer][:AVG]?`, the sensor module returns data of the measurand that was configured before, but it can also return data of different measurands. By default, the reading is the average power.

To determine the measurand for the `FETCh<Channel>[:SCALar][:POWer][:AVG]?` command, use the `CALCulate:FEED` before initiating the measurement.

Depending on the measurement mode, the following settings are possible:

SENS:FUNC	Possible CALC:FEED	Meaning
"POWer:AVG"	"POWer:AVERage"	Average value
	"POWer:PEAK"	Peak value
	"POWer:RANDom"	Randomly selected value from the measurement interval
"XTIMe:POWer"	"POWer:TRACe"	Measurement sequence
	"POWer:PEAK:TRACe"	Peak value of the samples per trace point
	"POWer:RANDom:TRACe"	Randomly selected value of the samples per trace point

Parameters:

<mode> *RST: "POWer:AVERage"

Example: The following sequence of commands configures a peak trace measurement:

```
SENSe:FUNCtion "XTIMe:POWer"
SENSe:FREQuency 1.0e9
SENSe:TRACe:POINts 500
SENS:TRAC:TIME 20e-3
TRIGger:SOURce INTernal
TRIGger:SLOPe POSitive
TRIGger:DTIMe 0.001
TRIGger:HYSTeresis 0.1
TRIGger:LEVel 30e-6
SENSe:TRACe:AVERage:COUNt 8
SENSe:TRACe:AVERage:STATe ON
CALCulate:FEED "POWer:PEAK:TRACe"
INITiate
FETCh?
```

CALCulate:MATH[:EXPRession] <mode>

Selects the measurement quantity for the power of the incident electromagnetic wave towards the antenna module.

String	Meaning
"PISotropic"	Equivalent isotropically received power P_{ISO} in W or dBm (default): Equivalent detected power of an isotropic antenna with an ideal power detector at the phase center location of the R&S NRPM antenna module assuming radiation only from boresight direction. $P_{ISO}=P_i$
"PDENsity"	Power density S in W/m², calculated as: $S=(4\pi/\lambda^2)\cdot P_{ISO}$
"EFDensity"	Electric field strength E_{eff} in V/m, calculated as: $E_{eff}=\sqrt{(S\cdot Z_0)}$ with: Z_0=376,73 Ω.

String	Meaning
"MFDensity"	Magnetic field strength H_{eff} in A/m, calculated as: $H_{eff}=\sqrt{(S/Z_0)}$ with: $Z_0=376,73\ \Omega$.
"DETPower"	Power at the internal RF detector in W or dBm: The measurement result without including antenna gain and frequency-dependent calibration factors is returned. $P_{Det}=(G_{RF,i}/k_{att,A,i}(f))\cdot P_{ISO}$

Parameters:

<mode> *RST: "PISotropic"

Example: `CALC:MATH "PDEN"`

Selects power density in W/m² as the equivalent resulting unit.

CALCulate:MATH[:EXPRession]:CATalog?

Lists all supported calculation functions.

The result is a list of strings, separated by comma.

Example: `CALC:MATH:CAT?`

Response: `"PISotropic","PDENsitiy",`
`"EFDensity","MFDensity","DETPower"`

Usage: Query only

[SENSe<Sensor>:]AUXiliary <mode>

Activates the measurement of additional measurands that are determined together with the main measured value.

Suffix:

<Sensor> 1

Parameters:

<mode> NONE | MINMax | RNDMax

NONE
No additional values are measured.

MINMax
In addition to the average trace, the sensor module also determines the minimum and maximum traces. You can read out the resulting traces (min & max) afterwards with the command `[SENSe<Sensor>:]TRACe:DATA??`.

RNDMax
Determines a trace of randomly selected samples within the min & max range instead of the minimum trace. You can read out the resulting traces (random & max) afterwards with the command `[SENSe<Sensor>:]TRACe:DATA??`.

*RST: NONE

9.6 Configuring the measurement modes

The following chapter describes the settings needed for configuring a measurement mode.

9.6.1 Configuring a continuous average measurement

The "Continuous Average" mode measures the signal average power asynchronously within definable time intervals (sampling windows). The aperture time (width of the sampling windows) can be defined.

Reducing noise and zero offset

The continuous average measurement can be performed with chopper stabilization to obtain more accurate results with reduced noise and zero offset. When chopper stabilization is used, a single measurement is performed over two sampling windows, the polarity of the detector output signal being reversed for the second window. By taking the difference of the output signals, the effect of the video path on noise and zero drift is minimized.

The smoothing filter can further reduce result fluctuations caused by modulation. But when activated it increases the inherent noise of the sensor module by approx. 20%, so it should remain deactivated if it is not required.

Configuring continuous average measurements of modulated signals

When measuring modulated signals in continuous average mode, the measurement can show fluctuation due to the modulation. If that is the case, adapt the size of the sampling window exactly to the modulation period to get an optimally stable display. If the modulation period varies or is not precisely known, you can also activate the smoothing function.

With smoothing activated, the selected sampling window has to be 5 to 9 times larger than the modulation period for the fluctuations caused by modulation to be sufficiently reduced. The sampling values are subjected to weighting (raised-von-Hann window), which corresponds to video filtering.

If you deactivate the smoothing filter, 300 to 3000 periods are required to obtain the same effect. The sampling values are considered equivalent and averaged in a sampling window, which yields an integrating behavior of the measuring instrument. To obtain optimum suppression of variations in the result, exactly adapt the modulation period to the size of the sampling window. Otherwise, the modulation can have a considerable influence, even if the sampling window is much larger than the modulation period.

Calculating the measurement time

The measurement time is calculated as follows:

$MT = 2 * AC * APER + (2 * AC - 1) * 100\ \mu s$

with:

MT: overall measurement time

AC: average count

APER: aperture time

100 µs is the time for switching the chopper phase.

Remote commands:

[SENSe<Sensor>:][POWer:][AVG:]APERture <integration_time>

Sets the aperture, sampling window (time interval) for the continuous average mode. The aperture time defines the length of the unsynchronized time interval used to measure the average signal power.

Suffix:
<Sensor> 1

Parameters:
<integration_time> Range: 10.0e-6 s to 2.00 s
*RST: 0.02 s
Default unit: s

Manual operation: See "Aperture Time" on page 72

[SENSe<Sensor>:][POWer:][AVG:]BUFFer:CLEar

Erases the contents of the result buffer continuous average mode.

Suffix:
<Sensor> 1

Example: `[SENSe1:][POWer:][AVG:]BUFFer:CLEar`

Usage: Event

[SENSe<Sensor>:][POWer:][AVG:]BUFFer:COUNt?

Available in continuous average mode.

Queries the number of results that are currently saved in the result buffer.

Suffix:
<Sensor> 1

Example: `[SENSe1:][POWer:][AVG:]BUFFer:COUNt?`

Usage: Query only

[SENSe<Sensor>:][POWer:][AVG:]BUFFer:DATA?

Queries the data of the continuous average result buffer and returns them even if the buffer is not full.

In contrast, `FETCh<Channel>[:SCALar][:POWer][:AVG]?` returns a result only if the buffer is full.

Suffix:
<Sensor> 1

Example: [SENSe1:][POWer:][AVG:]BUFFer:DATA?

Usage: Query only

[SENSe<Sensor>:][POWer:][AVG:]BUFFer:INFO? [<ITEM>]

Queries the data of the continuous average result buffer.

Suffix:
<Sensor> 1

Query parameters:
<ITEM>

Example: `[SENSe1:][POWer:][AVG:]BUFFer:INFO?`

Usage: Query only

[SENSe<Sensor>:][POWer:][AVG:]BUFFer:SIZE <count>

Sets the size of the result buffer in continuous average mode.

You can enable the buffer using `[SENSe<Sensor>:][POWer:][AVG:]BUFFer:STATe`.

Suffix:
<Sensor> 1

Parameters:
<count> Range: 1 to 8192
*RST: 1

Example: `[SENSe<Sensor>:][POWer:][AVG:]BUFFer:SIZE 10`

[SENSe<Sensor>:][POWer:][AVG:]BUFFer:STATe <state>

Enables or disables the buffered continuous average mode. If the buffer mode is enabled, all results generated by trigger events are collected in the sensor module until the buffer is filled.

You can set the size of the buffer using `[SENSe<Sensor>:][POWer:][AVG:]BUFFer:SIZE`.

Suffix:

<Sensor> 1

Parameters:

<state> *RST: OFF

Example: `[SENSe<Sensor>:][POWer:][AVG:]BUFFer:STATe OFF`

[SENSe<Sensor>:][POWer:][AVG:]SMOothing:STATe <state>

Activates the smoothing filter, a steep-edge digital lowpass filter. If you cannot adjust the aperture time exactly to the modulation period, the filter reduces result fluctuations caused by modulation.

Suffix:

<Sensor> 1

Parameters:

<state> ON | OFF

*RST: OFF

Example: `SMOothing:STATe OFF`

Manual operation: See "Smoothing" on page 72

9.6.2 Configuring a list mode measurement

The list mode measurement enables you to execute a sequence of measurements at various frequency points in continuous average mode automatically.

Remote commands:

[SENSe<Sensor>:]LIST:FREQuency <frequency>...

Sets the frequency values for list processing mode.

Suffix:
<Sensor> 1

Parameters:
<frequency>
Range: 0 Hz to 110e9 Hz
*RST: 10e9 Hz
Default unit: Hz

Example:
```
[SENSe1:]LIST:FREQuency
40e09,45e09,58e09,75e09
```

[SENSe<Sensor>:]LIST:FREQuency:POINts?

Sets the number (points) of frequency entries in list processing mode.

Suffix:
<Sensor> 1

Example:
```
[SENSe1:]LIST:FREQuency:POINts 4
```

Usage: Query only

CONTrol<Sensor>:FREQuency:MODE <mode>

Selects the frequency list mode.

Suffix:
<Sensor> 1

Parameters:
<mode> FIXed | RXList
*RST: FIXed

Example:
```
CONTrol1:FREQuency:MODE RXList
```

9.6.3 Configuring a trace measurement

The trace measurement is used to acquire the course of power over a certain time. During the measurement time ([SENSe<Sensor>:]TRACe:TIME) a large number of measurements are made and the result is returned to the user as an array of values with a predefined size [SENSe<Sensor>:]TRACe:POINts. The length of an individual measurement(-point) is determined from the ratio of measurement time and measurement points. The entire result is called a "trace". Each trace must be triggered separately.

Remote commands:

[SENSe<Sensor>:]TRACe:AVERage:COUNt <count>

Sets the trace filter length, i.e. the number of acquired traces which are to be averaged for one trace. The higher the count the lower the noise and the longer it takes to obtain a trace result.

Suffix:

<Sensor>	1	

Parameters:

<count>	Range:	1 to 65536
	*RST:	4

[SENSe<Sensor>:]TRACe:AVERage:TCONtrol <mode>

Sets the termination control mode for trace mode, defining how you retrieve the measurement results.

When a new intermediate trace is shifted to the FIR filter, a new average trace is available at the filter output. It is composed of the last acquired trace and the other trace data already stored in the filter.

See Section 9.4.2, "Controlling the measurement results", on page 121.

Suffix:
<Sensor> 1

Parameters:
<mode> MOVing | REPeat

MOVing
Returns each new average trace as a measurement result, even if the FIR filter is not yet filled completely with measured traces.
This mode is suitable for measurements, where tendencies in the result have to be recognized during the measurement procedure.

REPeat
Returns a final trace result only after the FIR filter has been filled with acquired traces.
This mode is suitable to avoid redundant results in measurements.

*RST: REPeat

Example: `TRACe:AVERage:TCONtrol REPeat`

[SENSe<Sensor>:]TRACe:AVERage[:STATe] <state>

Activates the averaging filter in trace mode.

Suffix:
<Sensor> 1

Parameters:
<state> *RST: ON

[SENSe<Sensor>:]TRACe:DATA?

Returns the measured trace data in a pre-defined format. Unlike the `FETCh?` command, this command considers the settings of `[SENSe<Sensor>:]AUXiliary` on page 132 as explained below.

Command response

Besides the average power, the R&S NRPM sensor module can measure additional measurands like "Minimum", "Maximum" or "Random". These additional measurands are denoted as auxiliary measurands and are selected by the `[SENSe<Sensor>:]AUXiliary` on page 132 command.

A trace measurement with the R&S NRPM can therefore be configured to return up to three measurands on each channel/antenna module. As a consequence, the resulting data which is provided by a `[SENSe<Sensor>:]TRACe:DATA` query can contain between 1 and 9 blocks of measurement data. For example, 1 resulting measurement data block if only one antenna module is used and only average power is to be measured on that channel. 9 resulting measurement data blocks if three antenna modules are used and average, min & max power is to be measured on each channel.

To obtain a single measurement data block, you must first extract the contents of the "Definite Length Arbitrary Block" which is returned from the `SENSe:TRACe:DATA` query. The format is defined in IEEE488.2.

In principle the response has the format as shown in Figure 9-3:

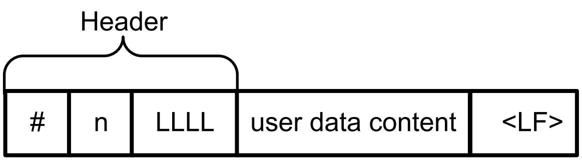


Figure 9-3: Response format

Header	#	Starting character
	n	Single digit that defines how many of the following digits are interpreted as the size of the content.
	LLLLL	Number consisting of as many digits as specified by "n". This number determines the size of the content.
User data content		See Figure 9-4. As many bytes as specified by "LLLLL".
<LF>		Single linefeed character

Example:

The arbitrary block response data for a user data that contains 45182 bytes is:

`#545182xxxxxx.......xxxxxx <LF>`

The arbitrary block response data for a user data content `'THIS IS A TEST'` is:

`#214THIS IS A TEST<LF>`

Explanation: `'THIS IS A TEST'` has 14 bytes, and '14' has 2 digits, hence the `#214`.

User-data-content

In the further description, the term "user data content" is used for the totality of the contained measurement results.

In the user data content, there are similar mechanisms as with arbitrary block response data. As indicated above, the user data content can have one or more blocks with trace measurement results, depending on the selection of auxiliary measurands. Each section is composed of:

0 : 2	3	4	5 : (5+x-1)	(5+x) : (5+x+y * (size of data type) – 1)
1	2	3	4	5

Figure 9-4: User data content format (byte)

y = number of values which follow the header
x = number of digits of y

1	Result type Always 3 bytes, one for `AVG`, one for `MIN` and one for `MAX` or `RND`
2	Data type Designator for the contained data type with the size of 1 byte. Currently, the only possible designator is "f" for 4-byte IEEE754 float data type, little endian.
3	Single digit that defines how many of the following digits are interpreted as the number of contained float values.
4	User data length Number consisting of as many digits as specified by (3). This number gives the number of contained float values contained in the user data.
5	User data Measurement result values in the format that is described by the data type. Currently IEEE754 float only.

Suffix:
<Sensor> 1

Example:

```
C1Af3260xxxxyyyy
C1                    Channel 1
  A                   The letter 'A' to denote
                        the Average-Trace
   f                  The letter 'f' to denote
                        float format
    3                 3 bytes for length of the number
                        of points that follows
     260              260 float values (4 bytes each)
        xxxxyyyy...   260 float values...
```

This example shows one of up to nine measurement data blocks which could be contained in the user data content. Referring to the example above, if the min and max traces are also selected (by `SENS:AUX MINMAX`) the subsequent data would contain:

```
C1mf3260mmmmnnnn
C1                    Channel 1
  m                   The letter 'm' to denote
                        the Min-Trace
   f                  The letter 'f' to denote
                        float format
    3                 3 bytes for length of the
                        number of points that follows
     260              260 float values (4 bytes each)
        mmmmnnnn...   260 float values...
```

```
C1Mf3260gggghhhh
C1                    Channel 1
  M                   The letter 'M' to denote
                        the Max-Trace
   f                  The letter 'f' to denote
                        float format
    3                 3 bytes for length of the
                        number of points that follows
     260              260 float values (4 bytes each)
        gggghhhh...   260 float values...
```

For further information, see the `...[NRPM3]\Trace-M3\Visa\visaTraceBinaryData-M3` project from the accompanying programming examples (included). The source-code shows how to extract the measurement data from the "user-data-content".

Usage: Query only

[SENSe<Sensor>:]TRACe:MPWidth?

Queries the attainable time resolution of the trace mode. The result is the smallest possible distance between two pixels, i.e. it is the smallest time interval that can be assigned to a pixel.

Suffix:

<Sensor>	1

Usage: Query only

[SENSe<Sensor>:]TRACe:OFFSet:TIME <time>

Sets the relative position of the trigger event in relation to the beginning of the trace measurement sequence. It is used to specify the start of recording for trace mode.

The start of recording is referenced to the delayed trigger point that is set with `TRIGger:DELay`. Negative values indicate that the start of recording occurs before the trigger point.

Suffix:

<Sensor>	1

Parameters:

<time>	Range: -3.0 s to 3.0 s *RST: 0.0 s Default unit: s

Manual operation: See "Trace Offset Time" on page 73

[SENSe<Sensor>:]TRACe:POINts <points>

Sets the number of required values per trace sequence.

Suffix:

<Sensor>	1

Parameters:

<points>	Range: 1 to 100000 *RST: 260

Manual operation: See "Trace Points" on page 73

[SENSe<Sensor>:]TRACe:REALtime <state>

Activates realtime processing of the trace mode.

If disabled, each measurement from the sensor module is averaged. If enabled, only one sampling sequence per measurement is recorded, thus increasing the measurement speed. With a higher measurement speed, the measured values of an individual measurement are immediately delivered.

The averaging filter is not used, i.e. the following settings are ignored:

- `[SENSe<Sensor>:]TRACe:AVERage[:STATe]`
- `[SENSe<Sensor>:]TRACe:AVERage:COUNt`

Suffix:
<Sensor> 1

Parameters:
<state> *RST: OFF

[SENSe<Sensor>:]TRACe:TIME <time>

Sets the trace length, i.e. the time to be covered by the trace sequence. This time period is divided into several equal intervals, in which the average power is determined. The number of intervals equals the number of trace points, which is set with the command `[SENSe<Sensor>:]TRACe:POINts`.

Suffix:
<Sensor> 1

Parameters:
<time> Range: 10.0e-6 s to 3.0 s
*RST: 0.01 s
Default unit: s

Manual operation: See "Trace Time" on page 73

[SENSe<Sensor>:]TRACe:UPSample[:TYPE] <type>

Selects an output mode for the acquired trace data.

Suffix:

<Sensor> 1

Parameters:

<type> SINC | HOLD

HOLD

Returns the trace data unchanged. The course of power over time is represented as sampled by the sensor module's data acquisition and processing logic.

SINC

Returns the trace data as the result of a SINC interpolation of the acquired samples. This setting is only reasonable if the selected number of trace points is higher than the number of samples which results from the internal sample rate in the selected trace time. The SINC interpolation reconstructs the original signal sequence best from the sampled values. Use it to get a smooth resulting curve.

*RST: SINC

Example:

```
SENS:TRAC:TIME 100E-6
```

Sets the trace time to 100 µs. With an internal sample rate of 2 MHz, the sensor module performs 200 measurements.

```
SENS:TRAC:POIN 400
SENS1:TRACe:UPS:TYPE SINC
```

If you select the number of trace points higher than the number of physical measurements, you achieve a smooth result curve using the `SINC` interpolation.

```
SENS:TRAC:POIN 200
SENS1:TRACe:UPS:TYPE SINC
```

If the trace points are up to the number of physical measurements, the `SINC` interpolation does not affect the trace results.

9.7 Configuring basic measurement parameters

The following section describes the settings common for several measurement modes.

9.7.1 Configuring averaging

This chapter includes the commands required for averaging in the continuous average measurements.

[SENSe<Sensor>:]AVERage:COUNt <count>

Sets the number of readings that are averaged for one measured value. The higher the count, the lower the noise, and the longer it takes to obtain a measured value.

Average count is often also called averaging factor, but it designates the same parameter, i.e the number of measured values that have to be averaged for forming the measurement result.

Averaging is only effective, when `[SENSe<Sensor>:]AVERage[:STATe]` is turned on.

Suffix:
<Sensor> 1

Parameters:
<count> Range: 1 to 65536
*RST: 4

Example: `AVERage:COUNt 4`

Manual operation: See "<Value>" on page 76

[SENSe<Sensor>:]AVERage:RESet

Deletes all previous measurement results that the averaging filter contains and initializes the averaging filter. The filter length gradually increases from 1 to the set averaging factor. Thus, trends in the measurement result become quickly apparent. Note that the measurement time required for the averaging filter to settle completely remains unchanged.

Use this command if:

- A high averaging factor is set.

[SENSe<Sensor>:]AVERage:COUNt

- Intermediate values are output as measurement results.
[SENSe<Sensor>:]AVERage:TCONtrol MOVing.
- Power has significantly decreased since the previous measurement, for example by several powers of 10.

In this case, previous measurement results still contained in the averaging filter strongly affect the settling of the display. As a result, the advantage of detecting trends in the measurement result while the measurement is still in progress, is lost.

Suffix:
<Sensor> 1

Example: AVERage:RESet

Usage: Event

[SENSe<Sensor>:]AVERage:TCONtrol <mode>

Sets the termination control mode for averaging mode, defining how you retrieve the measurement results.

When a new measured value is shifted to the FIR filter, a new average value is available at the filter output. It is composed of the last measured value and the other values already stored in the filter.

See Section 9.4, "Controlling the measurement", on page 117.

Suffix:
<Sensor> 1

Parameters:
<mode> MOVing | REPeat

MOVing
Provides every new average value at the output as a measurement result.
This mode is suitable for measurements, where tendencies in the result have to be recognized during the measurement procedure.

REPeat
A new result is output after the FIR filter has been filled with new measured values.
This mode is suitable for measurements, where no redundant information has to be output.
*RST: REPeat

Example: `AVERage:TCONtrol REPeat`

Manual operation: See "Filter Terminal Control" on page 76

[SENSe<Sensor>:]AVERage[:STATe] <state>

Activates the averaging filter for the continuous average mode.

Suffix:
<Sensor> 1

Parameters:
<state> *RST: ON

Manual operation: See "<Mode>" on page 76

9.7.2 Setting the frequency

The frequency of the signal to be measured is not automatically determined. For achieving better accuracy, the carrier frequency of the applied signal must be set.

[SENSe<Sensor>:]FREQuency <frequency>

Transfers the carrier frequency of the RF signal to be measured. This frequency is used for the frequency-response correction of the measurement result.

The center frequency is set for broadband signals, e.g. spread-spectrum signals, multicarrier signals.

The data of the connected antenna module determines the frequency limits.

Suffix:
<Sensor> 1

Parameters:

<frequency> Range: antenna-specific
*RST: 10.0e9 Hz
Default unit: Hz

Example: `FREQuency 4.2e10`

Manual operation: See "Frequency" on page 70

[SENSe<Sensor>:]RANGe <range>

In trace measurement mode, this command can be used to select a certain antenna module for reading the trace data.

There is also the possibility to read the data of **all** measured trace channels, see `[SENSe<Sensor>:]TRACe:DATA?` on page 140.

Suffix:

<Sensor> 1

Parameters:

<range> Range: 0 to 2
*RST: 0

9.7.3 Configuring corrections

It is possible to set some parameters that compensate for a change of the measured signal due to fixed external influences.

9.7.3.1 Duty cycle corrections

The duty cycle is the percentage of one period in which the signal is active, when pulse-modulated signals are corrected. The duty cycle is only evaluated in the Continuous Average mode.

Remote commands:

[SENSe<Sensor>:]CORRection:DCYCle <duty_cycle>

Effective in continuous average mode.

Sets the duty cycle for measuring pulse-modulated signals. The duty cycle defines the percentage of one period when the signal is active.

If the duty cycle is enabled, the R&S NRPM calculates the signal pulse power from the average power considering the duty cycle in percent.

Suffix:

<Sensor> 1

Parameters:

<duty_cycle> Range: 0.001 percent to 100.00 percent
*RST: 1.00 percent
Default unit: PCT

Example: `CORRection:DCYCle 0.01`

Manual operation: See "Duty Cycle" on page 72

[SENSe<Sensor>:]CORRection:DCYCle:STATe <state>

Activates the duty cycle correction for the measured value.

Suffix:

<Sensor> 1

Parameters:

<state> *RST: OFF

Example: `CORRection:DCYCle:STATe ON`

Manual operation: See "Duty Cycle" on page 72

9.7.3.2 Offset corrections

The offset accounts for external losses by adding a fixed level offset in dB.

The attenuation of an attenuator located ahead of the sensor module (or the coupling attenuation of a directional coupler) is considered with a positive offset, i.e. the sensor module calculates the power at the input of the attenuator or the directional coupler. You can use a negative offset to compensate the influence of an upstream amplifier.

Remote commands:

[SENSe<Sensor>:]CORRection:OFFSet <offset>

Sets a fixed offset that is added to correct the measured value.

Suffix:
<Sensor> 1

Parameters:
<offset> Range: -200.00 dB to 200.00 dB
*RST: 0 dB
Default unit: dB

Example: `CORRection:OFFSet 2`

Manual operation: See "<Value>" on page 71

[SENSe<Sensor>:]CORRection:OFFSet:STATe <state>

Activates the offset correction.

Suffix:
<Sensor> 1

Parameters:
<state> *RST: OFF

Example: `CORRection:OFFSet:STATe ON`

Manual operation: See "<State>" on page 71

9.8 Starting and ending a measurement

ABORt

Immediately interrupts the current measurement.

Depending on the selected measurement mode, the trigger system of the sensor module exits the measuring state and switches to:

- Idle state
  If a single measurement was previously initiated with command `INITiate[:IMMediate]`, or `INITiate:ALL`.
- Waiting for trigger
  If a continuous measurement was initiated with `INITiate:CONTinuous ON`.
  The sensor module starts the next measurement when a trigger event occurs that meets the set trigger conditions.

Usage: Event

INITiate:ALL
INITiate[:IMMediate]

Starts a single measurement cycle. The sensor module changes from the idle state to the wait for trigger state. When the trigger condition is fulfilled, the sensor module starts measuring. Depending on the number of trigger events that are required, e.g. for averaging, the sensor module enters the wait for trigger state several times. When the entire measurement is completed, the measurement readings are available, and the sensor module returns to the idle state.

Use the command only after the continuous measurement mode has been turned off (`INITiate:CONTinuous OFF`).

Example: See Section 10.2, "Performing measurements in continuous average mode", on page 169.

Usage: Event

INITiate:CONTinuous <state>

Activates the continuous measurement mode. In continuous measurement mode, the sensor module does not change to idle state after a measurement cycle has been completed, but enters the wait for trigger state. When a trigger event occurs, it starts the next measurement cycle. This mode is also known as free-running mode, although each measurement cycle depends on the trigger conditions.

Parameters:

<state>
ON
Measures continuously. If a measurement is completed, the sensor module enters the wait for trigger state again.
OFF
Stops the continuous measurement mode. The sensor module switches to idle state.
*RST: OFF

Example: See Section 10.2, "Performing measurements in continuous average mode", on page 169.

Manual operation: See "Measurement" on page 70

9.9 Configuring the trigger

Further information:

- Section 9.4, "Controlling the measurement", on page 117

Remote commands:

TRIGger:BURSt:DELay <delay>

List processing mode only

Sets the initial delay after the start burst until the first measurement starts.

Parameters:

<delay> Range: 10e-6 to 1 s
*RST: 1e-3 s
Default unit: s

Example: `TRIGger:BURSt:DELay 2e-3`

TRIGger:ATRigger:DELay <delay>

For `TRIGger:ATRigger[:STATe] ON`, this parameter determines after which time an artificial trigger event is created, if no real trigger event has occurred.

Parameters:

<delay> Range: 250e-6 s to 5.0 s
*RST: 0.3 s
Default unit: s

TRIGger:ATRigger:EXECuted?

Queries the number of measurements which were triggered automatically, provided `TRIGger:ATRigger[:STATe]` is activated.

In scalar measurements, this number can only be 0 or 1. If you execute a buffered measurement the number indicates how many results in the returned array of measurement data were executed without a real trigger event.

Usage: Query only

TRIGger:ATRigger[:STATe] <state>

Activates the artificial trigger.

An artificial trigger is generated if the time set with `TRIGger:ATRigger:DELay` has elapsed after the start of measurement and no trigger event has occurred.

Parameters:

<state>	*RST:	OFF

Example: `TRIG:ATR:STAT ON`

TRIGger:COUNt <count>

Sets the number of measurement cycles to be performed when the measurement is started. This number equals the number of results which can be obtained from the sensor module after a single `INITiate[:IMMediate]`. As long as the defined number of measurements are not yet executed, the sensor module automatically initiates another measurement internally after the current result is available.

Use this command in particular in conjunction with buffered measurements, for example, to fill a buffer with a predefined size with measurements which have been triggered with the `*TRG` command or with the configured trigger condition.

Parameters:

<count>	Range:	1 to 8192
	*RST:	1

TRIGger:DELay <delay>

Sets the delay between the trigger event and the beginning of the actual measurement (integration).

Parameters:

<delay>	Range:	-5.0 s to 10.0 s
	*RST:	0.0 s
	Default unit:	s

Manual operation: See "Trigger Delay" on page 78

TRIGger:DELay:AUTO <state>

Activates the automatic setting of the delay time.

If activated, the measurement starts only after the R&S NRPM input is settled.

The function determines the delay value automatically. It is ignored if the set `TRIGger:DELay` time is longer than the automatically determined value.

Parameters:

<state> *RST: OFF

Manual operation: See "Trigger Delay" on page 78

TRIGger:DTIMe <dropout_time>

Sets the dropout time for the internal trigger source. During this time, the signal power must exceed (negative trigger slope) or undercut (positive trigger slope) the level defined by the trigger level `TRIGger:LEVel` and and trigger hysteresis `TRIGger:HYSTeresis`.

At least, this time must elapse before triggering can occur again.

See "Dropout time" on page 119

Parameters:

<dropout_time> Range: 0.00 s to 10.00 s
*RST: 0.00 s
Default unit: s

Manual operation: See "Dropout" on page 78

TRIGger:EXTernal<2...2>:IMPedance <impedance>

Sets the termination resistance of the second external trigger input (`EXTernal2`). You can select between `HIGH`(~ 10 kOhm) and `LOW` (50 Ohms) to fit the impedance of the trigger source and thus minimize reflections on the trigger signals.

Suffix:

<2...2> 1..n

Parameters:

<impedance> HIGH | LOW

*RST: HIGH

TRIGger:HOLDoff <holdoff>

Sets the hold off time, see "Hold-off time" on page 120.

Parameters:

<holdoff>	Range:	0.00 s to 10.00 s
	*RST:	0.00 s
	Default unit:	s

Manual operation: See "Holdoff" on page 78

TRIGger:HYSTeresis <hysteresis>

Sets the hysteresis thresholds. A trigger event occurs, if the trigger level:

- Falls below the set value on a rising slope.
- Rises above the set value on a falling slope.

You can use the hysteresis to eliminate the effects of noise in the signal on the edge detector of the trigger system.

Parameters:

<hysteresis>	Range:	0.00 dB to 10.00 dB
	*RST:	0.00 dB
	Default unit:	dB

Manual operation: See "Hysteresis" on page 78

TRIGger:IMMediate

Triggers a generic trigger event that causes the sensor module to exit the WAIT_FOR_TRIGGER state immediately, irrespective of the trigger source and the trigger delay and start the measurement. The command is the only means of starting a measurement when the trigger source is set to HOLD. Only one measurement cycle is executed irrespective of the averaging factor.

Usage: Event

TRIGger:LEVel <level>

Sets the trigger threshold for internal triggering derived from the test signal.

This setting is effective only for the internal `TRIGger:SOURce`.

Parameters:

<level>	Range: 1.0e-7 W to 200.0e-3 W *RST: 1.0e-3 W Default unit: W

Manual operation: See "Trigger Level" on page 77

TRIGger:LEVel:UNIT <unit>

Sets the unit of the trigger level if this value is entered without a unit.

See `TRIGger:LEVel`.

Parameters:

<unit>	DBM | W | DBUV *RST: W

Example: `TRIGger:LEVel:UNIT W`

Manual operation: See "Trigger Level" on page 77

TRIGger:SENDer:PORT <sender_port>

Selects the port where the R&S NRPM provides its internal trigger signal at the output, provided it is trigger sender (see `TRIGger:SENDer:STATe`).

You can assign either the port `EXTernal[1]` or `EXTernal2` for the trigger sender. If you want to trigger the sender sensor module externally with its own trigger signal, assign the trigger source to the other port accordingly, e.g:

`TRIGger:SENDer:PORT`	`EXT1`
`TRIGger:SOURce`	`EXT2`
`TRIGger:SENDer:STATe`	`ON`

or

`TRIGger:SENDer:PORT`	`EXT2`
`TRIGger:SOURce`	`EXT1`
`TRIGger:SENDer:STATe`	`ON`

Parameters:

<sender_port> EXT1 | EXTernal1 | EXT2 | EXTernal2

*RST: EXT1

TRIGger:SENDer:STATe <state>

Activates the trigger sender mode of the sensor module. In this state, the sensor module can output a digital trigger signal in synchronization with its own trigger event.

If activated, select the output port the trigger signal using `TRIGger:SENDer:PORT`.

Typically, the trigger sender uses its internal trigger source. But you can also trigger the trigger sender externally, since the R&S NRPM provides two external trigger connectors. If you trigger the sender externally, use `EXTernal1` as external trigger input port (trigger source) and `EXTernal2` as trigger sender output port or vice versa.

Parameters:

<state> *RST: OFF

TRIGger:SLOPe <slope>

Available only if `TRIGger:SOURce INTernal/EXTernal`.

Determines what is used for triggering, depending on the trigger source:

- `TRIGger:SOURce INTernal`: uses the rising or falling edge of the envelope power.
- `TRIGger:SOURce EXTernal`: uses the increasing voltage.

Parameters:

<slope> POSitive | NEGative

*RST: POSitive

Manual operation: See "<Slope>" on page 77

TRIGger:SOURce <source>

Selects the source for the trigger event detector.

See Section 9.4.1, "Triggering", on page 118.

Parameters:

<source> HOLD | IMMediate | INTernal | INT1 | INT2 | INT3 | INTernal1 | INTernal2 | INTernal3 | BUS | EXTernal | EXT1 | EXTernal1 | EXT2 | EXT3 | EXTernal2 | EXTernal3 | BURSt1 | BURS1 | BURSt2 | BURS2 | BURSt3 | BURS3

BUS
Triggers the measurement with the `*TRG` or `TRIGger:IMMediate` commands, where `TRIGger:IMMediate` shortens the measurement. In this case, the other trigger settings are meaningless.

EXTernal
Initiates the measurement by the hardware trigger bus, e.g of the base unit. Waiting for a trigger event can be skipped by `TRIGger:IMMediate`.
`EXT`, `EXT1`, `EXTernal` and `EXTernal1` denote the same, an external trigger is applied through the round 8 pin connector.
`EXT2` and `EXTernal2` refer to external triggering initiated by the dedicated SMB type connector, TRIG2 I/O, at the rear of the sensor module.

HOLD
Triggers the measurement with the command `TRIGger:IMMediate`.

IMMediate
Starts the measurement immediately.

INTernal | INT1 | INT2 | INT3
Determines to consider the RF signal level at the specified antenna (1, 2 or 3) for launching a measurement. The parameter `INTernal` is a synonym for `INT1 | INTernal1`.
The measurement starts when the signal exceeds (`TRIGger:SLOPe POSitive`) or drops below (`TRIGger:SLOPe NEGative`) the power set with `TRIGger:LEVel`, after the `TRIGger:DELay` has elapsed. Similar to trigger source `EXT`, waiting for a trigger event can also be skipped by `TRIGger:IMMediate`.

*RST: IMMediate

Manual operation: See "<Source>" on page 77

TRIGger:SYNC:PORT <sync_port>

Selects the external connection for the sensor module's sync output, see also `TRIGger:SYNC:STATe`.

Parameters:

<sync_port> EXT1 | EXTernal1 | EXT2 | EXTernal2

*RST: EXT1

TRIGger:SYNC:STATe <state>

Usually used in combination with `TRIGger:SENDer:STATe ON`.

If activated, blocks the external trigger bus as long as the sensor modules remains in the measurement state.

This function makes sure, that a new measurement only starts after all sensor modules have completed their last measurement.

Make sure that the number of repetitions is the same for all the sensor modules involved in the measurement. Otherwise, the trigger bus is blocked by any sensor module that has completed its measurements before other sensor module and has returned to the IDLE state.

Parameters:

<state> *RST: OFF

9.10 Using the status register

Further information:

- Section 11.2, "Status reporting system", on page 189

Contents:

9.10.1 General status register commands

Remote commands:

STATus:PRESet

Resets the edge detectors and `ENABle` parts of all registers to a defined value.

Usage: Event

STATus:QUEue[:NEXT]?

Queries the most recent error queue entry and deletes it.

Positive error numbers indicate sensor module specific errors. Negative error numbers are error messages defined by SCPI.

If the error queue is empty, the querry returns 0 ("No error").

Usage: Query only

9.10.2 Reading out the CONDition part

For more information on the CONDition part see Section 11.2.2, "Structure of an SCPI status register", on page 191.

STATus:DEVice:CONDition?
STATus:OPERation:CALibrating:CONDition?
STATus:OPERation:CONDition?
STATus:OPERation:LLFail:CONDition?
STATus:OPERation:MEASuring:CONDition?
STATus:OPERation:SENSe:CONDition?
STATus:OPERation:TRIGger:CONDition?
STATus:OPERation:ULFail:CONDition?

STATus:QUEStionable:CALibration:CONDition?
STATus:QUEStionable:CONDition?
STATus:QUEStionable:POWer:CONDition?

These commands read out the `CONDition` section of the status register.

The commands do not delete the contents of the `CONDition` section.

Usage: Query only

9.10.3 Reading out the EVENt part

For more information on the EVENt part see Section 11.2.2, "Structure of an SCPI status register", on page 191.

STATus:DEVice[:EVENt]?
STATus:OPERation:CALibrating[:SUMMary][:EVENt]?
STATus:OPERation[:EVENt]?
STATus:OPERation:LLFail[:SUMMary][:EVENt]?
STATus:OPERation:MEASuring[:SUMMary][:EVENt]?
STATus:OPERation:SENSe[:SUMMary][:EVENt]?
STATus:OPERation:TRIGger[:SUMMary][:EVENt]?
STATus:OPERation:ULFail[:SUMMary][:EVENt]?
STATus:QUEStionable[:EVENt]?
STATus:QUEStionable:CALibration[:SUMMary][:EVENt]?
STATus:QUEStionable:POWer[:SUMMary][:EVENt]?

These commands read out the `EVENt` section of the status register.

At the same time, the commands delete the contents of the `EVENt` section.

Usage: Query only

9.10.4 Controlling the ENABle part

For more information on the ENABLe part see Section 11.2.2, "Structure of an SCPI status register", on page 191.

STATus:DEVice:ENABle <value>
STATus:OPERation:CALibrating:ENABle <value>
STATus:OPERation:ENABle <value>
STATus:OPERation:LLFail:ENABle <value>
STATus:OPERation:MEASuring:ENABle <value>

STATus:OPERation:SENSe:ENABle <value>
STATus:OPERation:TRIGger:ENABle <value>
STATus:OPERation:ULFail:ENABle <value>
STATus:QUEStionable:CALibration:ENABle <value>
STATus:QUEStionable:ENABle <value>
STATus:QUEStionable:POWer:ENABle <value>

These commands control the `ENABle` part of a register.

The `ENABle` part allows true conditions in the `EVENt` part of the status register to be reported in the summary bit. If a bit is 1 in the enable register and its associated event bit transitions to true, a positive transition will occur in the summary bit reported to the next higher level.

Parameters:

<value> *RST: 0

9.10.5 Controlling the negative transition part

For more information on the negative transition part see Section 11.2.2, "Structure of an SCPI status register", on page 191.

STATus:DEVice:NTRansition <value>
STATus:OPERation:CALibrating:NTRansition <value>
STATus:OPERation:NTRansition <value>
STATus:OPERation:LLFail:NTRansition <value>
STATus:OPERation:MEASuring:NTRansition <value>
STATus:OPERation:SENSe:NTRansition <value>
STATus:OPERation:TRIGger:NTRansition <value>
STATus:OPERation:ULFail:NTRansition <value>
STATus:QUEStionable:CALibration:NTRansition <value>
STATus:QUEStionable:NTRansition <value>
STATus:QUEStionable:POWer:NTRansition <value>

These commands control the Negative TRansition part of a register.

Setting a bit causes a 1 to 0 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding `EVENt` register.

Parameters:

<value> *RST: 0

9.10.6 Controlling the positive transition part

For more information on the positive transition part see Section 11.2.2, "Structure of an SCPI status register", on page 191.

STATus:DEVice:PTRansition <value>
STATus:OPERation:CALibrating:PTRansition <value>
STATus:OPERation:PTRansition <value>
STATus:OPERation:LLFail:PTRansition <value>
STATus:OPERation:MEASuring:PTRansition <value>
STATus:OPERation:SENSe:PTRansition <value>
STATus:OPERation:TRIGger:PTRansition <value>
STATus:OPERation:ULFail:PTRansition <value>
STATus:QUEStionable:CALibration:PTRansition <value>
STATus:QUEStionable:PTRansition <value>
STATus:QUEStionable:POWer:PTRansition <value>

These commands control the Positive TRansition part of a register.

Setting a bit causes a 0 to 1 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding `EVENt` register.

Parameters:

<value>	*RST:	65535

9.11 Running a self-test

The self-test allows a test of the internal circuitry of the sensor.

Do not apply a signal to the sensor while the self-test is running. If the self-test is carried out with a signal being present, error messages can erroneously be output for the following test steps:

- Offset Voltages
- Noise Voltages
- Noise Voltage

TEST:SENSor? [<Item>]

Starts a self-test of the sensor.

In contrast to `*TST?`, this command returns detailed information that you can use for troubleshooting. If one test step or a part of it fails, the overall result is FAIL.

For result examples and interpretation of the results, see Section 13.3, "Performing a self-test", on page 209.

Query parameters:

<Item> String

Usage: Query only

Manual operation: See "Selftest" on page 80

9.12 Calibrating/zeroing the R&S NRPM3(N) sensor module

Zeroing removes offset voltages from the analog circuitry of the sensor modules, so that there are only low powers displayed when there is no power applied. The zeroing process may take more than 8 seconds to complete.

We recommend that you zero in regular intrervals (at least once a day), if :

- The temperature has varied by more than 5 K.
- The sensor module has been replaced.
- No zeroing was performed in the last 24 hours.
- Signals of very low power are to be measured, for instance, if the expected measured value is less than 10 dB above the lower measurement range limit.

Turn off all test signals before zeroing. An active test signal during zeroing causes an error.

Remote commands:

CALibration<1...4>:DATA <caldata>

Writes a binary calibration data set in the memory of the sensor module.

Suffix:

<1...4> 1..n

Parameters:

<caldata> <block_data>

CALibration<1...4>:DATA:LENGth?

Queries the length in bytes of the calibration data set currently stored in the flash memory. Programs that read out the calibration data set can use this information to determine the capacity of the buffer memory required.

Suffix:

<1...4> 1..n

Usage: Query only

CALibration<Channel>:ZERO:AUTO <state>

Performs zeroing using the signal at the sensor module input.

Disconnect the sensor module from all power sources, since any signal at the RF input of the sensor module affects the calibration.

While zero calibration is in progress, no queries or other setting commands are allowed. Any communication attempt can run into a timeout.

The setting command accepts only the parameter `ONCE`; `OFF` and `ON` are ignored.

The query returns the value `ON` if a calibration is in progress, otherwise the value `OFF`.

Suffix:

<Channel> 1...4
The channel suffix is ignored.

Parameters:

<state> *RST: OFF

Manual operation: See "Zero Calibration" on page 74

10 Programming examples

This section provides programming examples for R&S NRPM OTA power measurement tasks. It includes examples for continuous average and trace power measurements in the common SCPI syntax.

In addition, Rohde & Schwarz provides archives with source code, project and auxiliary files, and programming examples under C/C++ and Python. The samples can be integrated into customer-specific applications.

The programming examples are part of the R&S NRP-Toolkit, see Section 4.6.2, "R&S NRP-Toolkit", on page 24.

10.1 Performing a simple measurement

The simplest way to obtain a result is to use the following sequence of SCPI commands:

Example:

```
*RST          // sets the continuous average mode and all parameters to default
INITiate      // initiates the measurement
FETCh?        // delivers measurement result to the output queue
```

When the measurement is complete, you can retrieve the result from the output queue.

10.2 Performing measurements in continuous average mode

This section describes programming examples for measuring continuous average power with one R&S NRPM. The examples demonstrate the sequences in SCPI syntax, pseudo code, and also show the corresponding source codes for using VISA protocol.

Example: SCPI sequence for measuring the power of three antenna modules

The command sequence measures the continuous average power of the three channels of an R&S NRPM.

```
// Query the resource identifier and reset the sensor module to default
*IDN?
// Response: ROHDE&SCHWARZ,NRPM3,100001,16.09.20.01
*RST
// Enable all channels of the sensor module
SENSe:CHAnnel1:ENABle 1
SENSe:CHAnnel2:ENABle 1
SENSe:CHAnnel3:ENABle 1
// Select measurement mode and set the time interval to 10 µs
SENSe:FUNCtion "POWer:AVG"
SENSe:POWer:AVG:APERture 10e-6
//Set the averaging filter length to 1
SENSe:AVERage:COUNt 1
// Select the trigger source
TRIGger:SOURce IMMediate
// Activate a measurement
INITiate:IMMediate
// Query the measurement results
FETCh:ALL?
// Response:
// 6.118910E-10,1.185138E-10,4.612524E-10
// Read out all errors / Clear error queue
SYSTem:ERRor?
SYSTem:SERRor?
```

Example: Pseudo code for measuring the power of two antenna modules

This example, written in pseudo code, shows a reduced set of basic steps to set up and execute a continuous average measurement.

```
// resource = "NRPM3-100001"
// Open the device
sensor = Open( resource )
// Query the resource identifier and reset the sensor module to default
Query( sensor, "*IDN?" )
Write( sensor, "*RST" )
// Measure only on channels 1 & 3
Write( sensor, "SENS:CHAN1:ENAB ON" )
Write( sensor, "SENS:CHAN2:ENAB OFF" )
Write( sensor, "SENS:CHAN3:ENAB ON" )
Write( sensor, "SENS:FUNC \"POW:AVG\"" )
Write( sensor, "TRIG:SOUR IMM" )
Query( sensor, "SYST:ERR?" )
Query( sensor, "SYST:SERR?" )
Write( sensor, "INIT:IMM" )
Query( sensor, "FETCH:ALL?" )
Close( sensor )
```

Example: C/C++ (VISA) source code

This sequence shows the VISA source code, based on the *pseudo code* example above.

```
// Determine the resource identifier, e.g.
// resource = "NRPM3-100001"
// resource identifier = USB0::0x0aad::0x0195::100001
// Open the device
viOpen( defaultRM, “USB0::0x0aad::0x0195::100001”, VI_NULL, VI_NULL,&session );
// Select the measurement mode
viWrite( session, “SENS:FUNC \”POW:AVG\”\n”, 20, &uiSent );
// Initiate a single measurement
viWrite( session, “INIT:IMM\n”, 9, &uiSent );
// Read the measurement result
viWrite( session, “FETCH:ALL?\n”, 7, &uiSent );
viRead( session, buffer, sizeof(buffer), &uiCnt );
// buffer = “1.468872E-09,3.682521E-10,3.829144E-09”
// Close the device
viClose( session );
```

Example: Python (VISA) source code

This sequence shows the Python source code, based on the *pseudo code* example above.

```
####################################################################
## Name:         contAv-M3.py
## Purpose:      Measuring RF power with the R&S NRPM3 OTA sensor module
## Description: This example demonstrates the use of an R&S NRPM3
##               sensor module measuring continuously average power
##               on up to 3 channels
## Author:       Juergen D. Geltinger
## Created:      2016-01-14
## Modified by: Juergen D. Geltinger
## Modified:     2016-07-21
## Copyright:    (c) Rohde & Schwarz, Munich
####################################################################

# This is a Visa sample, so import that module
import visa
from time import sleep
from math import fabs, log10

####################################################################
# Find a R&S NRPM3 power sensor modules. That sensor module is
# characterized by a Product ID of 0x0195
####################################################################
def OpenFirstNRPM3():
   rm = visa.ResourceManager()
   resources=list(rm.list_resources())
   for s in resources:
      # NRPM3 RF sensor module has a USB Product ID of '0x0195'
      if -1 != s.find("0195::"):
         print
         print "Opening NRPM3 sensor '" + s + "'..."
         sensor = rm.open_resource( s )
         if sensor != None:
            sensor.timeout = 20000
            # Setting Aperture Time
            sensor.write( "sens:pow:avg:aper 10e-6" )
            # Setting Average Filter Length
            sensor.write( "sens:aver:count 16" )
            print "Querying *IDN?..."
            print sensor.ask( "*idn?" )
            # Enable the available/connected antenna modules
            result = ""
            for antenna in range(3):
```

```
               cmd = "SENS:CHAN{}:PRES?".format( antenna + 1 )
               res = sensor.ask(cmd)
               if int(res) == 1:
                  cmd = "SENS:CHAN{}:ENAB ON".format( antenna + 1 )
               else:
                  cmd = "SENS:CHAN{}:ENAB OFF".format( antenna + 1 )
               sensor.write(cmd)
            print "SYST:ERR?  --> " + sensor.ask("SYST:ERR?")
            print "SYST:SERR? --> " + sensor.ask("SYST:SERR?")
            return sensor
            break
   return None

###################################################################
# Convert a power value of Watt unit to dBm unit
###################################################################
def Watt2dBm( dW ):
   if fabs( dW ) < 1.0e-19:
      return -160.0
   return 10.0 * log10( fabs( dW ) ) + 30.0

###################################################################
###################################################################
###################################################################
sensor = None
sensor = OpenFirstNRPM3()
if sensor != None:
   for meas in range(1,10):
      sensor.write("init:imm")
      result = sensor.ask("fetch:all?")
      antenna = [float(x) for x in result.split(",")]
      if antenna[0] < 9.9e37:
         print ('Antenna A = %4.1f dBm' % Watt2dBm( antenna[0] ) )
      if antenna[1] < 9.9e37:
         print ('Antenna B = %4.1f dBm' % Watt2dBm( antenna[1] ) )
      if antenna[2] < 9.9e37:
         print ('Antenna C = %4.1f dBm' % Watt2dBm( antenna[2] ) )
      print
   sensor.close()
else:
   print "No NRPM3 sensor found"
```

10.3 Performing measurements in list mode

This section briefly introduces the list mode operation, and describes a programming example for measuring average power sequentially at predefined RF frequency points with the R&S NRPM OTA Power Measurement Solution in list mode. The example represents the execution of a R&S NRPM OTA power sensor measurement under VISA environment in pseudo code.

About list mode

The list mode enables you, to define a series of measurements at different frequency points in advance. The factors and values, that must be recalculated for each frequency point, are determined and saved internally before the measurement starts. Both, the R&S NRPM3(N) sensor module, and the DUT get the list of frequency points, and the R&S NRPM3(N) pre-calculates the corresponding parameters required for the measurement.

Synchronized by an initial RF pulse and a short delay time, the DUT and the R&S NRPM OTA power sensor measurement system perform the measurement for each frequency point automatically. They switch to the next frequency point controlled by a defined time interval.

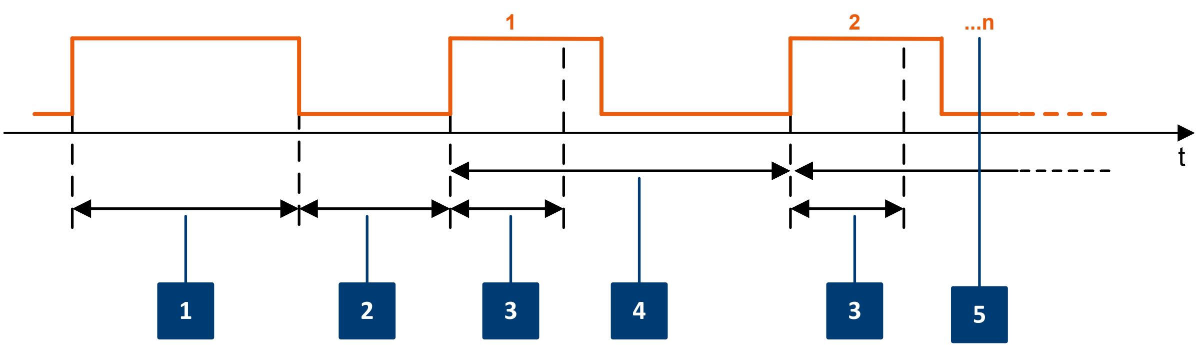


Figure 10-1: Time scheme in list mode processing

1 = Start burst
2 = Initial delay
3 = Single measurement time X
4 = Measurement period
5 = Frequency points n

Related list mode parameters

- **Start burst** = RF pulse of at least 10 µs minimum length, sent by the DUT
- **Initial delay** = time after the start burst until the measurement starts

- **Measurement period** = time from the beginning until the end of a step at one frequency point
- **n** = number of frequency points in the list
- **X** = actual time for a single measurement, calculated according to the formula:
  X = 2 * AverageCount * (ApertureTime + 100µs)
- **AverageCount** = number of averaged measurement readings
- **ApertureTime** = width of the sampling window

Aspects to consider

- Minimum measurement time **220µs**
  The time span of the measurement pulse must not be below the minimum value, derived from:
  AverageCount (min) = 1, ApertureTime (min) = 10 µs:
  X = 2 * 1 * (10 µs+100 µs) = 220 µs
  Shorter pulses cannot be measured.
- The total number of pulses is summed up of the number of frequency points and the start burst.

Example: Pseudo code for measuring the power in list mode

This example, written in pseudo code, shows how to set up and execute a power measurement in list mode.

```
===================================
 Description of Receiver List Mode
===================================

The execution of a configured frequency list shall start with an RF pulse
sent by the DUT with a certain minimal length (= calling this 'start burst').

     _________________..._________________
     |                                    |
     |<--- min. length of start burst --->|
_____|                                    |_______...


After the FALLING edge of the start burst, the sensor will apply a
configurable initial delay and then cycles over the configured frequency list,
doing power measurements with pre-configured aperture windows and average
counts. Each new measurement starts after a selectable measurement period.

   _________________                   ____________            ____________
   |                | <-initial delay-> |        |  |          |        |  |
   | -start burst-  |                   |<- X ->|  |          |<- X ->|  |
___|  (see above)   |_______..._________|          |___..._____|          |__...

                                         <-measurement period->

'X' is the time for a single measurement. It is calculated as follows:

 X = 2 * Average-Count * (ApertureTime + 100us)

*/

  ViSession    session;
  string       strCmd;
  string       strRead;
  unsigned int uiAvgCount              = 2;          //  2
  double       dAperture               = 100.0e-6;   //  100 us
  double       dTriggerLevel           = 100.0e-9;   //  100 nW (= -40 dBm)
  int          iTriggerAntenna         = 1;          //  Trigger-Burst re-
                                                     //  cognition on Ant 1
  double       dMinLengthOfStartBurst  = 950.0e-6;   //  950 us
  double       dInitialDelayAfterBurst = 1.0e-3;     //  1 ms
```

```
double       dMeasurementPeriod       = 2.0e-3;    //  2 ms
double       arFreqList[]             = { 24.0e9, 24.5e9, 25.0e9,
                                          25.5e9, 26.0e9, 26.5e9,
                                          27.0e9, 27.5e9, 28.0e9 };


session = OpenfirstNRPM3onUSBorNetwork();

//=====================================================================
// *RST and *IDN?
WriteCmd(session, "*RST");
printf( Query(session, "*IDN?");


//=====================================================================
// Use only those antennas which are physically connected
for (size_t nAntenna = 0; nAntenna < 3; nAntenna++)
{
  strCmd = "SENS:CHAN" + str(1+nAntenna) + ":PRES?";
  strRead = Query(session, strCmd);
  if ( atoi(strRead) != 0 )
    strCmd = "SENS:CHAN" + str(1+nAntenna) + ":ENAB ON";
  else
    strCmd = "SENS:CHAN" + str(1+nAntenna) + ":ENAB OFF";

  WriteCmd(session, szCmd);
}


//=====================================================================
// Prepare Event Registers to recognize a finished measurement
//
// We want to detect the End of a Measurement;
//   This is reflected by a negative transition of the
//   'Sensor Measuring' bit (bit value = 2)
WriteCmd(session, "STAT:OPER:MEAS:PTR  0");
WriteCmd(session, "STAT:OPER:MEAS:NTR  2");
WriteCmd(session, "STAT:OPER:MEAS:ENAB 2");

// We want to detect the MEAS summary bit (as a
//   results of the finished measurement as defined
//   above). This is reflected by a positive transition
//   'MEAS summary' bit in the Operation Status Register
//   (bit value = 16)
WriteCmd(session, "STAT:OPER:PTR  16");
WriteCmd(session, "STAT:OPER:NTR   0");
```

```
WriteCmd(session, "STAT:OPER:ENAB 16");


//=====================================================================
// Setup the Measurement...
//
// Configure Averaging
strCmd = "SENS:AVER:COUNT " + str(uiAvgCount);
WriteCmd(session, strCmd);
WriteCmd(session, "SENS:AVER:STAT ON");

// Aperture time
strCmd = "SENS:POW:AVG:APER " + str(dAperture);
WriteCmd(session, strCmd);


// Prepare the triggering of the measurement start
// (= start of execution of the configured freq. list)
//
// The execution of the configured frequency list shall
// start with an RF pulse from the DUT with a certain
// minimal length (here 950 us). The sensor setting
// 'trigger dropout' time is used to recognize this,
// and the execution shall start after the FALLING edge
// of this initial 'start burst':
//      _________________...__________________
//      |                                    |
//      |<--- min. length of start burst --->|
// _____|                                    |_______...
//
//
// Trigger on falling edge (= neg. slope)
WriteCmd(session, "TRIG:SLOP NEG");

// Minimal length of start burst (= Trigger Dropout)
strCmd = "TRIG:DTIM " + str(dMinLengthOfStartBurst);
WriteCmd(session, strCmd);

// Trigger on the signal level on a selected antenna
strCmd = "TRIG:SOUR BURST " + str(iTriggerAntenna);
WriteCmd(session, strCmd);

// Trigger Level
strCmd = "TRIG:LEV " + str(dTriggerLevel);
WriteCmd(session, strCmd);
```

```
// After the initial start pulse a continuous sequence of
// measurements are executed. The number of measurements is
// selected by the length of the frequency list -- see entries
// in 'arFreqList[]' above (here 9)
//
// There very first measurement starts after a short initial delay
// (= 'trigger burst delay') to give the DUT time to setup/prepare
// its sending of the planned frequencies
//   _________________                    __________          __________
//   |                 | <-initial delay-> |      |  |          |      |  |
//   | -start burst-   |                  |<-X->|  |          |<-X->|  |
// __|  (see above)   |________..._________|        |___...__|         |__...
//
//                                          <- meas. period ->
//                                          (= trigger holdoff)
//
// 'X' is the Time for a single measurement. 'X' shall be shorter than
//     the receiving pulse from the DUT.
//
// X = 2 * Average-Count * (ApertureTime + 100us)
//


// Initial delay before the very first measurement
// (= 'trigger burst delay')
strCmd = "TRIG:BURS:DEL " + str(dInitialDelayAfterBurst);
WriteCmd(session, strCmd);

// The measurement period is timed by the 'trigger holdoff' parameter
// This is simply the distance from one measurement start to the next
strCmd = "TRIG:HOLD " + str(dMeasurementPeriod);
WriteCmd(session, strCmd);

// Freq List
strCmd = "SENS:LIST:FREQ ";
strCmd += ConvertListToString(arFreqList, 9);
WriteCmd(session, strCmd);

WriteCmd(session, "CONT:FREQ:MODE RXLIST");

// Desired Result Data Format (here ASCII)
WriteCmd(session, "FORM:DATA ASC");


// Check for any setting errors
```

```
print(Query(session, "SYST:ERR?");

// Check for static errors
print(Query(session, "SYST:SERR?");

//===================================================================
// Execute the list mode measurement
//
// resetting the event information by an initial readout
Query(session, "STAT:OPER:MEAS:EVEN?");
Query(session, "STAT:OPER:EVEN?");

// Start a measurement
WriteCmd(session, "INIT:IMM");

// Synchronize with end of measurement...
// (We will prematurely end this function if we do not get a trigger
//  within approx. 30 seconds)
bool bMeasReady = FALSE;
unsigned int uiSleep = 10;  // 10 ms
unsigned int uiWaitForTriggerTimeoutCount = 5000 / uiSleep;
unsigned short usEvent = 0;
while (!bMeasReady)
{
  Query(pSensor->session, "STAT:OPER:MEAS:EVEN?", szReadBuff,
        sizeof(szReadBuff));
  usEvent = atoi(Query(session, "STAT:OPER:MEAS:EVEN?"));
  bMeasReady = ((usEvent & 0x02) != 0);
  if (bMeasReady)
    break;

  if (uiWaitForTriggerTimeoutCount > 0)
  {
    --uiWaitForTriggerTimeoutCount;
    _sleep(10);
  }
  else
    break;
}

// If no trigger burst has been recognized, we prematurely end here!
if (!bMeasReady)
  return 0;  // No results


// Fetch AVERAGE results
```

```
WriteCmd(session, "CALC:FEED \"POW:AVER\"");
strRead = Query(session, "FETCH:ALL?");

print( strRead );   // all measurement results

close(session);
```

10.4 Performing measurements in trace mode

This section describes programming examples for measuring power over time with the R&S NRPM OTA Power Measurement Solution. The examples demonstrate the sequences in SCPI syntax, pseudo code, and also show the source codes for using VISA protocol.

Example: SCPI sequence for measuring the power of three antenna modules

The command sequence measures the envelope power over time in the three channels of the R&S NRPM antenna module.

```
// Query the resource identifier and
// reset the sensor module to default
*IDN?
// Response: ROHDE&SCHWARZ,NRPM3,100001,16.09.20.01
*RST
// Enable all channels of the sensor module
SENSe:CHAnnel1:ENABle 1
SENSe:CHAnnel2:ENABle 1
SENSe:CHAnnel3:ENABle 1
// Set the trace measurement mode
SENSe:FUNCtion "XTIME:POWer"
// Set the trace time.It influences the time length of a point
// since each point represents the time period resulting from
// the trace time divided by the number of points
SENSe:TRACe:TIMe 10e-3
// Set the number of points for the trace measurement
// Using 500 points usually represents a good compromise
// between USB transfer speed and resolution
SENSe:TRACe:POINTs 10
// Enable and configure the averaging filter
SENSe:TRACe:AVERage:COUNt 8
SENSe:TRACe:AVERage:STATe ON
// Configure the trigger
TRIGger:SOURce INTernal
TRIGger:SLOPe POSitive
TRIGger:DTIMe 0.001
TRIGger:HYSTeresis 0.1
TRIGger:LEVel 100e-9
// Activate the measurement
INITiate
// Query the measurement results
FETCh:ALL?
// Response (10 points per channel):
// 1.247340E-07,9.701300E-11,1.249202E-07,1.255408E-10,1.248314E-07,
// 9.718711E-11,1.248812E-07,6.739847E-11,1.248604E-07,2.118106E-10,
// 1.644239E-09,4.748356E-11,1.676801E-09,6.181332E-12,1.670082E-09,
// -1.933849E-11,1.719137E-09,-4.777736E-12,1.678197E-09,3.814278E-12,
// -4.753650E-11,-7.962022E-12,-4.782197E-11,-3.001128E-11,-8.387346E-12,
// -5.910127E-11,5.714555E-11,-5.767460E-12,7.732340E-11,-1.816896E-11
// Read out all errors / Clear error queue
SYSTem:ERRor?
```

```
SYSTem:SERRor?
// Stop the continuous measurement.
INITiate:CONTinuous OFF
```

Example: Pseudo code for measuring the power of two antenna modules

This example, written in pseudo code, shows how to set up and execute a trace power measurement.

```
// resource = "NRPM3-100001"
// Open the device
sensor = Open( resource )
// Query the resource identifier and reset the sensor module to default
Query( sensor, "*IDN?" )
Write( sensor, "*RST" )
// Measure only on channels 1 & 3
Write( sensor, "SENS:CHAN1:ENAB ON" )
Write( sensor, "SENS:CHAN2:ENAB OFF" )
Write( sensor, "SENS:CHAN3:ENAB ON" )
Write( sensor, "SENS:FUNC \"XTIM:POW\"" )
Write( sensor, "TRIG:SOUR IMM" )
Query( sensor, "SYST:ERR?" )
Query( sensor, "SYST:SERR?" )
Write( sensor, "INIT:IMM" )
Query( sensor, "FETCH:ALL?" )
Close( sensor )
```

Example: C/C++ (VISA) source code

This sequence shows the VISA source code, based on the *pseudo code* example above.

```
// Determine the resource identifier, e.g.
// resource = "NRPM3-100001"
// resource identifier = USB0::0x0aad::0x0195::100001
// Open the device
viOpen( defaultRM, “USB0::0x0aad::0x0195::100001”, VI_NULL, VI_NULL,&session );
// Select the trace measurement mode
viWrite( session, “SENS:FUNC \”XTIM:POW\”\n”, 21, &uiSent );
// Set the overall length (10 ms) of the trace
// select the number of measurment points (500 points)
viWrite( session, “SENS:TRAC:TIME 10.0e-3\n”, 23, &uiSent );
viWrite( session, “SENS:TRAC:POINTS 500\n”, 21, &uiSent );
// Initiate a single measurement
viWrite( session, “INIT:IMM\n”, 9, &uiSent );
// Read the measurement result
viWrite( session, “FETCH1?\n”, 7, &uiSent );
viRead( session, resA, sizeof(resA), &uiCnt );
viWrite( session, “FETCH2?\n”, 7, &uiSent );
viRead( session, resB, sizeof(resB), &uiCnt );
viWrite( session, “FETCH3?\n”, 7, &uiSent );
viRead( session, resC, sizeof(resC), &uiCnt );
// process resA, resB and resC. Every buffer contains
// the measurement data of one channel
// Close the device
viClose( session );
```

11 Remote control basics

For general information on remote control of Rohde & Schwarz products via SCPI, refer to www.rohde-schwarz.com/rc-via-scpi.

11.1 Remote control interfaces and protocols

For remote control, communication between the sensors and the controlling host is established based on various interfaces and protocols.

Depending on the sensor type, the sensors support different interfaces for remote control.

- USB sensors are always accessed using USB.
  See Section 11.1.1, "USB interface", on page 185.
- LAN sensors can be accessed using USB or Ethernet.
  See Section 11.1.2, "Ethernet interface", on page 186.

11.1.1 USB interface

Connect the computer and the sensors as described in:

- Section 6.3, "Connecting an R&S NRPM OTA power measurement", on page 43

11.1.1.1 USBTMC protocol

The USB test & measurement class specification (USBTMC) is a protocol that is built on top of USB for communication with USB devices from the test & measurement category. It defines a dedicated class code that identifies a device's functionality. The device also uses this class code to identify itself as a member of the test & measurement class. Using a VISA library, such devices support service request, trigger and other operations that are commonly found in GPIB devices.

Computer requirements

- VISA library

VISA is a standardized software interface library providing input and output functions to communicate with instruments. A VISA installation on the controller is a prerequisite for remote control over USBTMC.
VISA detects and configures the product automatically when the USB connection is established.

- USBTMC driver
  Apart from the USBTMC driver, which comes with the installation of VISA, you do not have to install a separate driver.

USB resource string

The VISA resource string for USBTMC device communication represents an addressing scheme that is used to establish a communication session with the product. It is based on the product address and some product- and vendor-specific information. The syntax of the used USB resource string is:

USB[board]::<vendor ID>::<product ID>::<serial number>[::INSTR]

- *<vendor ID>* is the vendor ID for Rohde & Schwarz, 0x0AAD.
- *<product ID>* is the product ID for the product.
- *<serial number>* is the individual serial number of the product, printed on the casing.

Example:

`USB::0x0AAD::0x0196::100001::INSTR`

0x0AAD is the vendor ID for Rohde & Schwarz.

0x0195 is the product ID.

100001 is the serial number of the product.

Table 11-1: R&S NRPM3(N) USB product IDs

Sensor module	USB product ID
R&S NRPM3	0x0195
R&S NRPM3N	0x0196

11.1.2 Ethernet interface

Requires a sensor with networking capabilities, a LAN sensor.

Using the Ethernet interface, you can integrate the product in a local area network (LAN).

11.1.2.1 Requirements

Local area network

The local area network must support the TCP/IP network protocol.

The TCP/IP network protocol and the associated network services are preconfigured on the product.

Computer

- VISA library
  VISA is a standardized software interface library providing input and output functions to communicate with instruments. A VISA installation on the controller is a prerequisite for remote control over LAN when using VXI-11 or HiSLIP protocols.
- Software for device control

11.1.2.2 Protocols

- VXI-11
  See "VXI-11" on page 188.
- HiSLIP: High-speed LAN instrument protocol (IVI-6.1)
  See "HiSLIP" on page 188.
- Socket communication (LAN Ethernet)
  See "Socket communication" on page 189.

11.1.2.3 VISA resource strings

The VISA resource string is required to establish a communication session between the controller and the product in a LAN. The resource string is a unique identifier, composed of the specific IP address of the product and some network and VISA-specific keywords.

TCPIP::<IP address or host name>[::<LAN device name>][::INSTR]

- *TCPIP* designates the network protocol used.

- *<IP address or host name>* is the IP address or host name of the device.
- *[::<LAN device name>]* defines the protocol and the instance number of a sub-instrument.
- *[::INSTR]* indicates the product resource class (optional).

The IP address or host name is used by the programs to identify and control the product. While the host name is determined by settings in the product, the IP address is assigned by a DHCP server when the product requests one. Alternatively the IP address is determined with a procedure called zeroconf.

You can also assign a *LAN device name* which defines the protocol characteristics of the connection. See the description of the VISA resource string below for the corresponding interface protocols. The string of the *LAN device name* is emphasized in italics.

VXI-11

TCPIP::<IP address or host name>*[::inst0]*[::INSTR]

inst0 is the LAN device name, indicating that the VXI-11 protocol is used (optional)

inst0 currently selects the VXI-11 protocol by default and can be omitted.

Examples:

- If the product has the IP address *10.111.11.20*, the valid resource string is TCPIP::10.111.11.20::INSTR
- If the DNS host name is *nrpm3n-100001*, the valid resource string is TCPIP::nrpm3n-100001::inst0

HiSLIP

TCPIP::<IP address or host name>*::hislip0*[::INSTR]

hislip0 is the HiSLIP device name, designates that the interface protocol HiSLIP is used (mandatory)

hislip0 is composed of [::HiSLIP device name[,HiSLIP port]] and must be assigned.

Example:

If the DNS host name is *nrpm3n-100001*, the valid resource string is

TCPIP::nrpm3n-100001::hislip0

Socket communication

TCPIP::<IP address or host name>*::port::SOCKET*

- *port* determines the used port number.
- *SOCKET* indicates the raw network socket resource class.

Socket communication requires the specification of the port (commonly referred to as port number) and of *SOCKET* to complete the VISA resource string with the associated protocol used.

The default port for socket communication is port 5025.

Examples:

- TCPIP::10.111.11.20::5025::SOCKET
- TCPIP::nrpm3n-100001::5025::SOCKET

11.2 Status reporting system

The status reporting system stores all information on the current operating state of the sensor module, and on errors which have occurred. This information is stored in the status registers and in the error queue. You can query both with the commands of the `STATus` subsystem.

11.2.1 Hierarchy of the status registers

Fig.11-1 shows the hierarchical structure of information in the status registers.

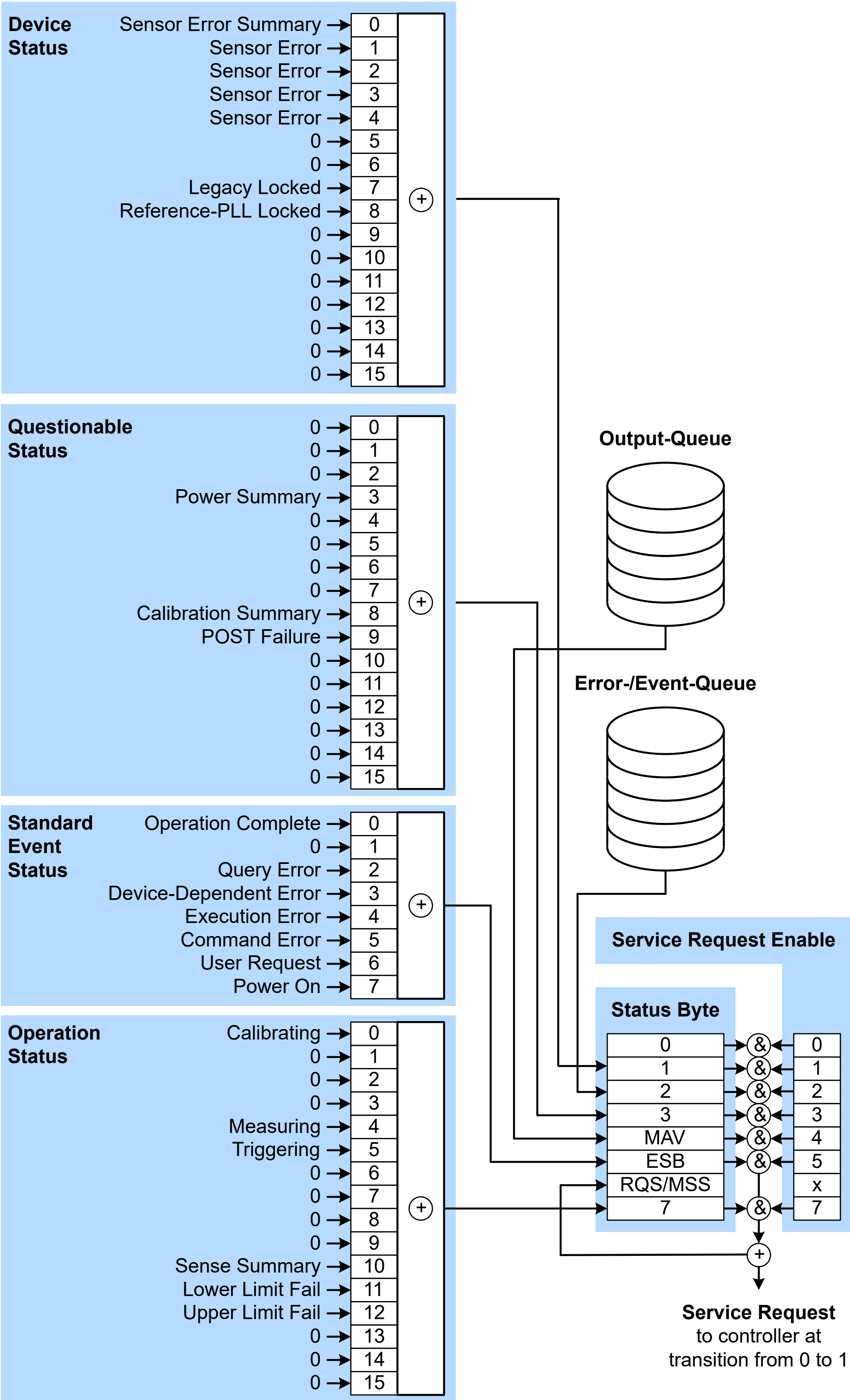


Figure 11-1: Graphical overview of the status registers hierarchy

The highest level is formed by the status byte register (`STB`) and the associated service request enable (`SRE`) register.

The `STB` receives its information from the standard event status register (`ESR`) and the associated Standard Event Status Enable (`ESE`) Register, as well as from the SCPI-defined operation status register, and the questionable status register, which contain detailed information on the device, and from the device status register.

11.2.2 Structure of an SCPI status register

Each SCPI register consists of five 16-bit registers which have different functions (see Figure 11-2). The individual bits are independent of each other, i.e. each hardware status is assigned a bit number which is the same for all five registers. Bit 15 (the most-significant bit) is set to zero in all registers. This prevents problems some controllers have with the processing of unsigned integers.

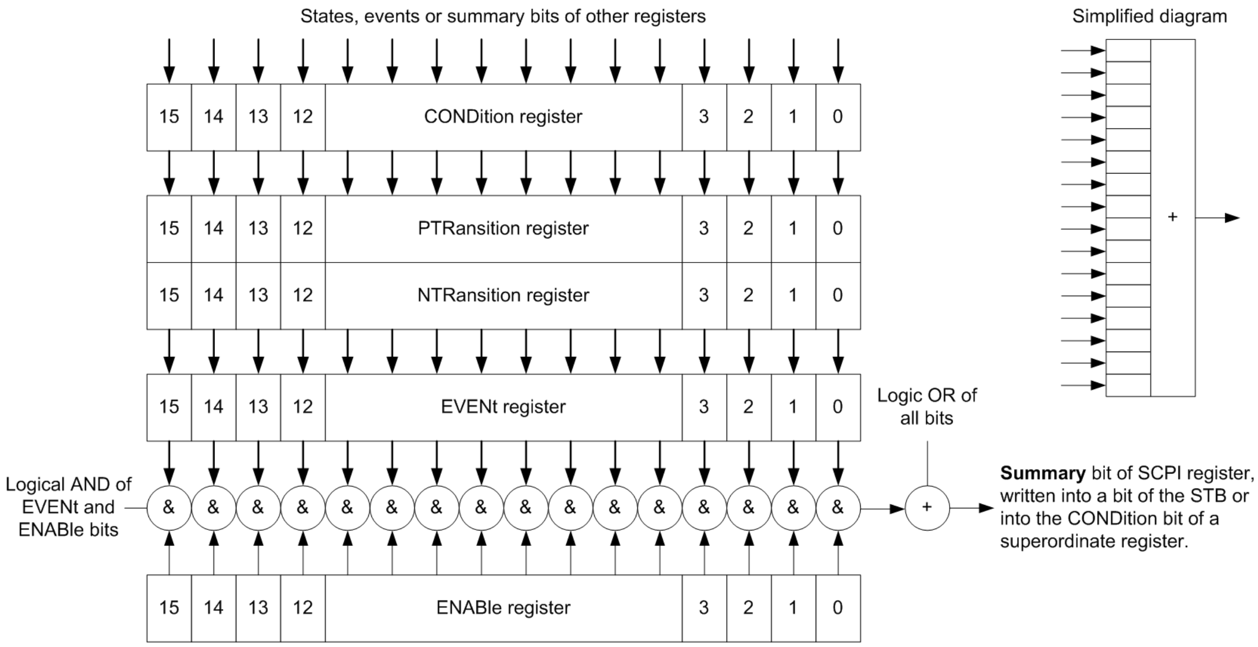


Figure 11-2: Standard SCPI status register

CONDition status register part

The five parts of an SCPI register have different properties and functions:

The `CONDition` part is written into directly by the hardware or the sum bit of the next lower register. Its contents reflect the current instrument status. This register part can only be read, but not written into or cleared. Its contents are not affected by reading.

PTRansition / NTRansition status register part

The two transition register parts define which state transition of the CONDition part (none, 0 to 1, 1 to 0 or both) is stored in the EVENt part.

The *Positive TRansition* part acts as a transition filter. When a bit of the CONDition part is changed from 0 to 1, the associated PTR bit decides whether the EVENt bit is set to 1.

- PTR bit =1: the EVENt bit is set.
- PTR bit =0: the EVENt bit is not set.

This part can be written into and read as required. Its contents are not affected by reading.

The *Negative TRansition* part also acts as a transition filter. When a bit of the CONDition part is changed from 1 to 0, the associated NTR bit decides whether the EVENt bit is set to 1.

- NTR bit =1: the EVENt bit is set.
- NTR bit =0: the EVENt bit is not set.

This part can be written into and read as required. Its contents are not affected by reading.

EVENt status register part

The EVENt part indicates whether an event has occurred since the last reading, it is the "memory" of the condition part. It only indicates events passed on by the transition filters. It is permanently updated by the instrument.

This part can only be read by the user. Reading the register clears it. This part is often equated with the entire register.

ENABle status register part

The ENABle part determines whether the associated EVENt bit contributes to the sum bit (see below). Each bit of the EVENt part is "ANDed" with the associated ENABle bit (symbol '&'). The results of all logical operations of this part are passed on to the sum bit via an "OR" function (symbol '+').

ENABle bit = 0: the associated EVENt bit does not contribute to the sum bit.

ENABle bit = 1: if the associated EVENt bit is "1", the sum bit is set to "1" as well.

This part can be written into and read by the user as required. Its contents are not affected by reading.

Sum bit

The sum bit is obtained from the EVENt and ENABle part for each register. The result is then entered into a bit of the CONDition part of the higher-order register.

The instrument automatically generates the sum bit for each register. Thus an event can lead to a service request throughout all levels of the hierarchy.

11.2.3 Status byte (STB) and service request enable register (SRE)

The STB is already defined in IEEE 488.2. It gives a rough overview of the sensor module status, collecting information from the lower-level registers. It is comparable with the CONDition register of an SCPI defined register and is at the highest level of the SCPI hierarchy. Its special feature is that bit 6 acts as the summary bit of all other bits of the Status Byte Register.

The status byte is read by the query *STB? or a serial poll. The SRE is associated with the STB. The function of the SRE corresponds to that of the ENABle register of the SCPI registers. Each bit of the STB is assigned a bit in the SRE. Bit 6 of the SRE is ignored. If a bit is set in the SRE and the associated bit in the STB changes from 0 to 1, a service request (SRQ) is generated on the IEC/IEEE bus, which triggers an interrupt in the controller configured for this purpose, and can be further processed by the controller.

The SRE can be set by the command *SRE and read by the query *SRE?.

Table 11-2: Meaning of bits used in the status byte

Bit No.	Meaning
0	Not used
1	**Device status register summary bit** Depending on the configuration of the sensor modules status register, this bit is set when a sensor module is connected or disconnected or when an error has occurred in a sensor module. See Section 11.2.5, "Device status register", on page 195.

Bit No.	Meaning
2	**Error queue not empty** The bit is set if the error queue has an entry. If this bit is enabled by the SRE, each entry of the error queue generates a service request. An error can thus be recognized and specified in detail by querying the error queue. The query yields a conclusive error message. This procedure is recommended since it considerably reduces the problems of IEC/IEEE-bus control.
3	**Questionable status register summary bit** This bit is set if an `EVENt` bit is set in the `QUEStionable` status register and the associated `ENABLe` bit is set to 1. A set bit denotes a questionable device status which can be specified in greater detail by querying the QUEStionable Status Register. See Section 11.2.6, "Questionable status register", on page 196.
4	**MAV bit** (Message available) This bit is set if a readable message is in the output queue. This bit may be used to automate reading of data from the sensor module into the controller.
5	**ESB: Standard event status register summary bit** This bit is set if one of the bits in the standard event status register is set and enabled in the event status enable register. Setting this bit denotes a serious error which can be specified in greater detail by querying the standard event status register. See Section 11.2.7, "Standard event status and enable register (ESR, ESE)", on page 198.
6	**MSS: Master status summary bit** This bit is set if the sensor module triggers a service request. This is the case if one of the other bits of this register is set together with its enable bit in the service request enable register (SRE).
7	**Operation status register summary bit** This bit is set if an `EVENt` bit is set in the operation status register and the associated `ENABLe` bit is set to 1. A set bit denotes that an action is being performed by the sensor module. Information on the type of action can be obtained by querying the operation status register. See Section 11.2.8, "Operation status register", on page 199.

11.2.4 IST flag and parallel poll enable register (PPE)

Similar to the SRQ, the IST flag combines the complete status information in a single bit. It can be queried by a parallel poll or by the `*IST?` command.

The Parallel Poll Enable Register (PPE) determines which bits of the STB affect the IST flag. The bits of the STB are ANDed with the corresponding bits of the

PPE; bit 6 is also used - in contrast to the SRE. The IST flag is obtained by `ORing` all results together.

The PPE can be set by the `*PRE` command and read by the `*PRE?` query.

11.2.5 Device status register

Contains information on the state of the static errors.

Querying the register:

- `STATus:DEVice:CONDition?`
- `STATus:DEVice[:EVENt]?`

Querying the static errors:

- `SYSTem:SERRor?`

Table 11-3: Meaning of bits used in the device status register

Bit No.	Meaning
0	**Sum of SERR bits** The sum/combination of SERR bits 1 to 4.
1	**SERR measurement not possible**
2	**SERR erroneous results** Static error exists; the measurement result is possibly incorrect.
3	**SERR warning** A static error exists therefore the Status LED of the sensor module is blinking slowly in red.
4	**SERR critical** A critical static error exists therefore the Status LED of the sensor module is blinking fast in red.
5 to 6	Not used

Bit No.	Meaning
8	**Reference PLL locked state** This bit signals whether the PLL for the clock reference is synchronized. The bit is useful when selecting an external clock source. The following states are possible: ● Internal clock (`[SENSe<Sensor>:]ROSCillator:SOURce INTernal INT`): – `1` (always) ● External clock (`[SENSe<Sensor>:]ROSCillator:SOURce EXTernal`): – `1` if the sensor module was able to synchronize with external clock – `0` if the sensor module could not synchronize with external clock
9 to 15	Not used

11.2.6 Questionable status register

Contains information on questionable sensor module states. Such states may occur when the sensor module is not operated in compliance with its specifications.

Querying the register:

- `STATus:QUEStionable:CONDition?`
- `STATus:QUEStionable[:EVENt]?`

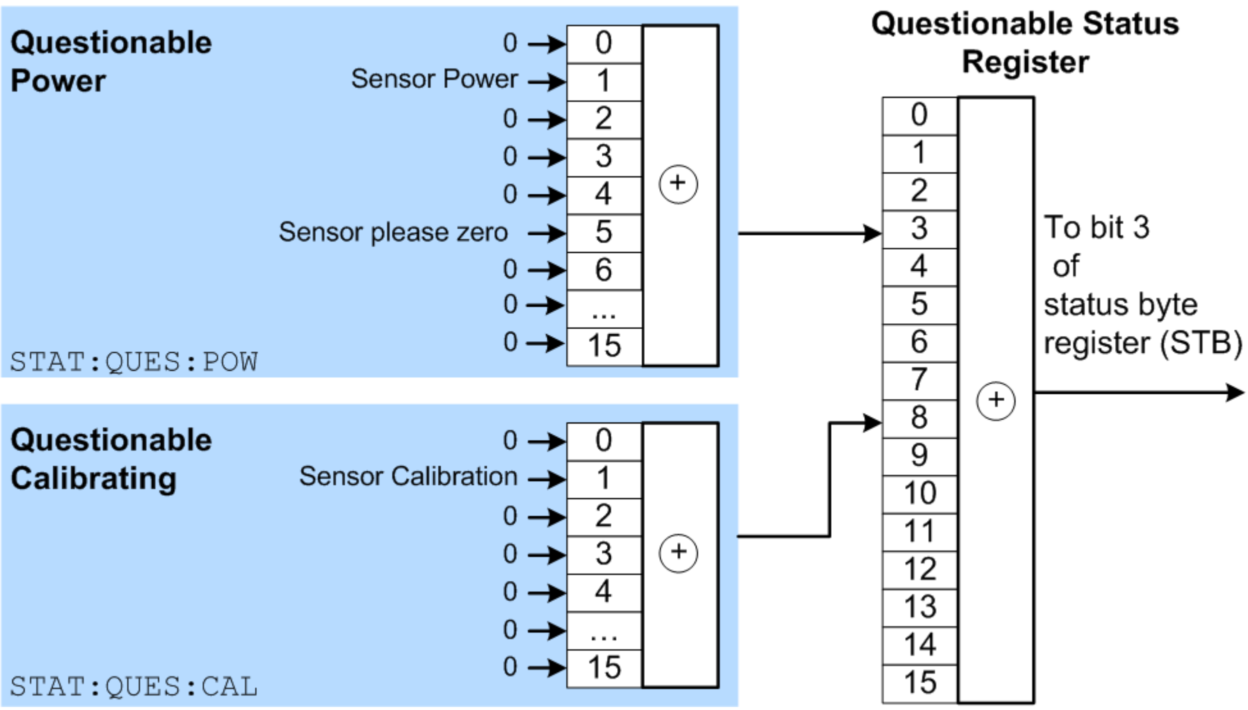


Table 11-4: Meaning of bits used in the questionable status register

Bit No.	Meaning
0 to 2	Not used
3	**Questionable power status register summary bit** Corresponds to the summary bit of the questionable power status register. See Section 11.2.6.1, "Questionable power status register", on page 197.
4 to 7	Not used
8	**Questionable calibration status register summary bit** Corresponds to the summary bit of the questionable calibration status register. See Section 11.2.6.2, "Questionable calibration status register", on page 198.
9	**POST failure** The built-in test of the R&S NRPM carried out automatically upon power-up has generated an error.
10 to 15	Not used

11.2.6.1 Questionable power status register

The `CONDition` register contains information whether the measured power values are questionable.

Querying the register:

- `STATus:QUEStionable:POWer:CONDition?`
- `STATus:QUEStionable:POWer[:SUMMary][:EVENt]?`

Table 11-5: Meaning of bits used in the questionable power status register

Bit No.	Meaning
0	Not used
1	**sensor module power** The measurement data of the sensor module is corrupt.
2 to 4	Not used
5	**sensor module please zero** The zero correction for the sensor module is no longer correct and should be repeated.
6 to 15	Not used

11.2.6.2 Questionable calibration status register

The EVENt register and the CONDition register contain information whether the zero offset of a sensor module is still valid.

Querying the register:

- STATus:QUEStionable:CALibration:CONDition?
- STATus:QUEStionable:CALibration[:SUMMary][:EVENt]?

Table 11-6: Meaning of bits used in the questionable calibration status register

Bit No.	Meaning
0	Not used
1	**sensor module calibration** Zeroing of the sensor module was not successful.
2 to 15	Not used

11.2.7 Standard event status and enable register (ESR, ESE)

The ESR is already defined in the IEEE 488.2 standard. It is comparable to the EVENt register of an SCPI register. The standard event status register can be read out by the query *ESR.

The ESE forms the associated ENABle register. It can be set and read out with the command/query *ESE.

Table 11-7: Meaning of bits used in the standard event status register

Bit No.	Meaning
0	**Operation complete** When the *OPC command is received, this bit is set if all previous commands have been executed.
1	Not used
2	**Query error** This bit is set in either of the two following cases: the controller wants to read data from the sensor module but has not sent a query, or it sends new commands to the sensor module before it retrieves existing requested data. A frequent cause is a faulty query which cannot be executed.
3	**Device-dependent error** This bit is set if a sensor module dependent error occurs. An error message with a number between -300 and -399 or a positive error number denoting the error in greater detail is entered in the error queue.

Bit No.	Meaning
4	**Execution error** This bit is set if the syntax of a received command is correct but the command cannot be executed due to various marginal conditions. An error message with a number between -200 and -300 denoting the error in greater detail is entered in the error queue.
5	**Command error** This bit is set if an undefined command or a command with incorrect syntax is received. An error message with a number between -100 and -200 denoting the error in greater detail is entered in the error queue.
6	**User request** This bit is set when the sensor module is switched over to manual control.
7	**Power on** This bit is set when the sensor module is switched on.

11.2.8 Operation status register

The `CONDition` register contains information on the operations currently being performed by the sensor module, while the EVENt register contains information on the operations performed by the since the last readout of the register.

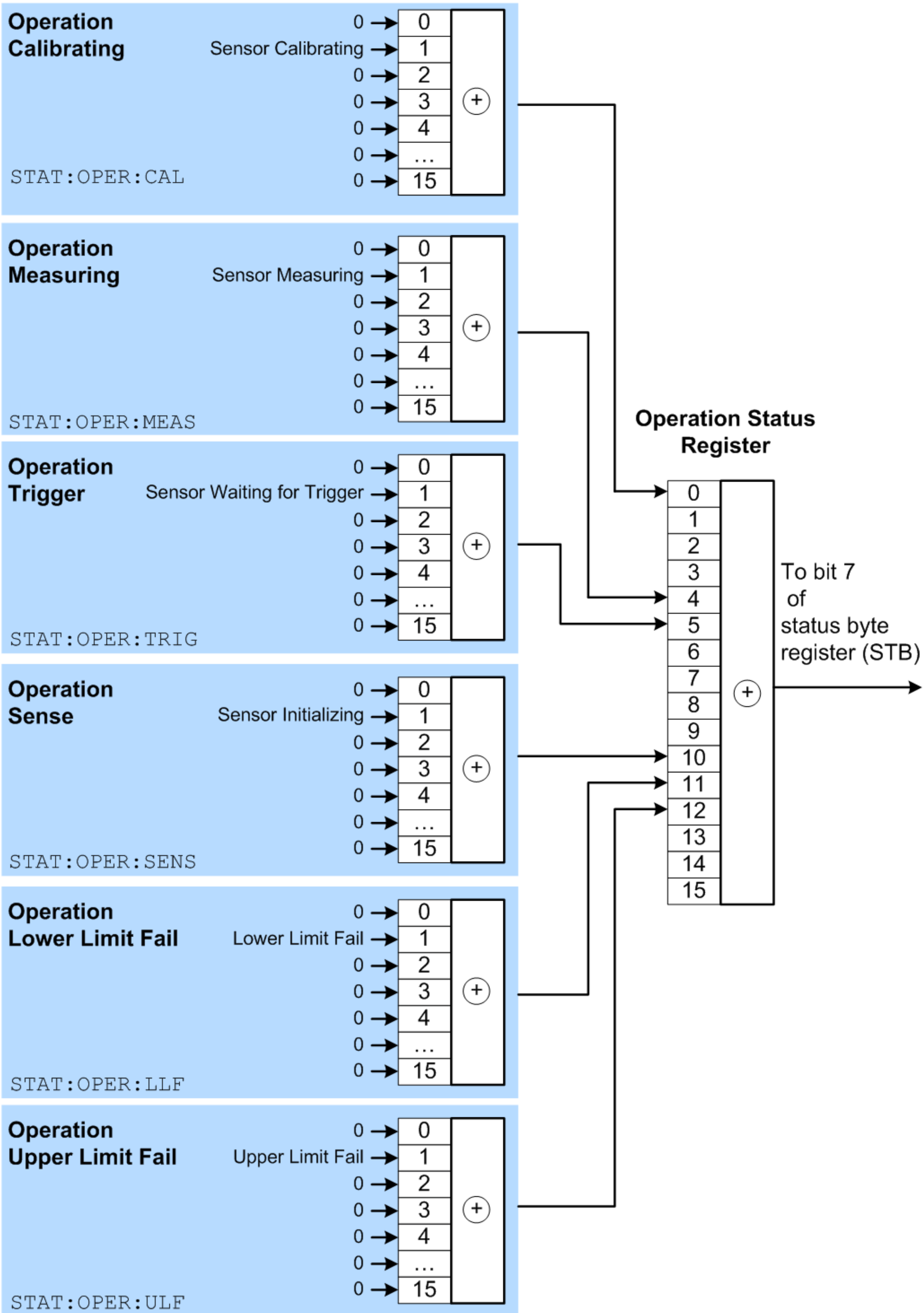
Querying the register:

- `STATus:OPERation:CONDition?`
- `STATus:OPERation[:EVENt]?`

Table 11-8: Meaning of bits used in the operation status register

Bit No.	Meaning
0	**Calibrating status register summary bit** This bit is set if the sensor module is being calibrated. See Section 11.2.8.1, "Operation calibrating status register", on page 202.
1 to 3	Not used
4	**Measuring status register summary bit** This bit is set if the sensor module is performing a measurement. See Section 11.2.8.2, "Operation measuring status register", on page 202.
5	**Trigger status register summary bit** This bit is set if the sensor module is in the waiting for trigger state, i.e. waiting for a trigger event. See Section 11.2.8.3, "Operation trigger status register", on page 203.
6	Not used

Bit No.	Meaning
7 to 9	Not used
10	**Sense status register summary bit** This bit is set if a sensor module is initialized. See Section 11.2.8.4, "Operation sense status register", on page 203.
11	**Lower limit fail status register** This bit is set if a displayed value has dropped below a lower limit value. See Section 11.2.8.5, "Operation lower limit fail status register", on page 204.
12	**Upper limit fail status register** This bit is set if a displayed value has exceeded an upper limit value. See Section 11.2.8.6, "Operation upper limit fail status register", on page 204.
13 to 14	Not used
15	Bit 15 will never be used.


Operation Calibrating
Sensor Calibrating
STAT:OPER:CAL
Operation Measuring
Sensor Measuring
STAT:OPER:MEAS
Operation Trigger
Sensor Waiting for Trigger
STAT:OPER:TRIG
Operation Sense
Sensor Initializing
STAT:OPER:SENS
Operation Lower Limit Fail
Lower Limit Fail
STAT:OPER:LLF
Operation Upper Limit Fail
Upper Limit Fail
STAT:OPER:ULF
Operation Status Register
To bit 7 of status byte register (STB)

11.2.8.1 Operation calibrating status register

The CONDition register contains information about whether a sensor module is currently being calibrated and, depending on the configuration of the transition register. The EVENt register indicates whether a calibration was started or completed since the last readout of this register.

Querying the register:

- STATus:OPERation:CALibrating:CONDition?
- STATus:OPERation:CALibrating[:SUMMary][:EVENt]?

Table 11-9: Meaning of bits used in the operation calibrating status register

Bit No.	Meaning
0	Not used
1	**sensor module calibrating** The sensor module is being calibrated
5 to 15	Not used

11.2.8.2 Operation measuring status register

The CONDition register contains information about whether a measurement is being performed by a sensor module and, depending on the configuration of the transition register. The EVENt register indicates whether a measurement was started or completed since the last readout of this register.

Querying the register:

- STATus:OPERation:MEASuring:CONDition?
- STATus:OPERation:MEASuring[:SUMMary][:EVENt]?

Table 11-10: Meaning of bits used in the operation measuring status register

Bit No.	Meaning
0	Not used
1	**sensor module measuring** The sensor module is performing a measurement.
5 to 15	Not used

11.2.8.3 Operation trigger status register

The CONDition register contains information about whether a sensor module is currently in the waiting for trigger state, i.e. expecting a trigger event and, depending on the configuration of the transition register. TheEVENt register indicates whether the waiting for trigger state was entered or quit by a sensor module since the last readout of the register.

Querying the register:

- STATus:OPERation:TRIGger:CONDition?
- STATus:OPERation:TRIGger[:SUMMary][:EVENt]?

Table 11-11: Meaning of bits used in the operation trigger status register

Bit No.	Meaning
0	Not used
1	**sensor module waiting for trigger** The sensor module is in the waiting for trigger state and is waiting for a trigger event. When the trigger event occurs, the sensor module changes into the measuring state.
5 to 15	Not used

11.2.8.4 Operation sense status register

The CONDition register contains information about whether a sensor module is currently being initialized and, depending on the configuration of the transition register. The EVENt register indicates whether a sensor module initialization was started or completed since the last readout of this register.

This status is assumed by a sensor module if one of the following conditions is met:

- The supply voltage is switched on (power up)
- The sensor module was just connected
- A reset was performed using:
  - *RST
  - SYSTem:PRESet

Querying the register:

- STATus:OPERation:SENSe:CONDition?
- STATus:OPERation:SENSe[:SUMMary][:EVENt]?

Table 11-12: Meaning of bits used in the operation sense status register

Bit No.	Meaning
0	Not used
1	**sensor module initializing** The sensor module is being initialized.
5 to 15	Not used

11.2.8.5 Operation lower limit fail status register

The `CONDition` register contains information about whether a displayed value is currently below a configured lower limit. The `EVENt` register indicates whether a measured value dropped below a limit value since the last readout of the Operation Lower Limit Fail Status Register. Details of the behavior are defined by the transition register.

Querying the register:

- `STATus:OPERation:LLFail:CONDition?`
- `STATus:OPERation:LLFail[:SUMMary][:EVENt]?`

Table 11-13: Meaning of bits used in the operation lower limit fail status register

Bit No.	Meaning
0	Not used
1	**Lower limit fail** The measured value drops below the lower limit value.
5 to 15	Not used

11.2.8.6 Operation upper limit fail status register

The `CONDition` register contains information about whether a displayed value is currently above a configured upper limit. The `EVENt` register indicates whether a limit value was exceeded since the last readout of the Operation Upper Limit Fail Status Register.

Querying the register:

- `STATus:OPERation:ULFail:CONDition?`
- `STATus:OPERation:ULFail[:SUMMary][:EVENt]?`

Table 11-14: Meaning of bits used in the operation lower limit fail status register

Bit No.	Meaning
0	Not used
1	**Upper limit fail** The measured value exceeds the upper limit value.
5 to 15	Not used

12 Data management

Depending on the origin and content, this description distinguishes between the following data types:

- Operational data
- Non-operational data

Operational data (data for intended use)

The power sensor uses and creates this data because of its intended use and according to the settings and configuration you have made. Thus, this data makes up most of the data that the R&S NRPM creates, such as user files that contain user-defined configurations or data, like sensor settings or measurement data.

Non-operational data (usage data)

The R&S NRPM creates this data during and through its use. Such data is collected e.g. for troubleshooting, to help our customer support center find solutions quickly.

The R&S NRPM generates this data continuously and in real-time. This data is saved on the power sensor. The power sensor is not capable of storing this data on a remote server.

The R&S NRPM generates the following data and saves it in the non-volatile memory:

- Diagnostic and troubleshooting data
  On demand, this data is returned as block data containing a compressed archive of files in text and binary format. The volume of the non-operational data depends on the usage of the product and typically amounts to about 20 kbyte.
  You can access, retrieve and delete this data. See Section 13.7, "Collecting information for technical support", on page 217.

The R&S NRPM generates the following data and saves it temporarily. When you disconnect the power sensor from its power source, this data is deleted.

- Environmental conditions
  You can access and retrieve this data using the `TEST:SENSor?` command.
- Hardware component metadata

You can access and retrieve this data using the `SYSTem:DFPRint<Channel>?` command.

For additional information on the different memory types and on how to clear the internal memory to protect sensitive data, see the instrument security procedures document at:

www.rohde-schwarz.com/manual/nrpm

13 Troubleshooting

13.1 Displaying status information

Status information is available in several ways.

Status LED of the sensor

The position of the status LED is indicated in:

Section 5, "R&S NRPM tour", on page 29.

The meaning of the different colors and flashing frequencies is explained in:

"Status LED (2)" on page 30

Title bar of the web user interface

Requires a sensor with networking capabilities, a LAN sensor.

The position of the status icon is indicated in:

Figure 7-1

The colors are explained in:

"Status LED (2)" on page 30.

13.2 Error messages

Querying errors (remote control)

In remote control, the commands querying errors are part of `SYSTem`.

See Section 9.3.1, "Configuring the system", on page 96.

The severity of the error is distinguished:

- Normal error
  Results from, for example, unknown commands or syntax errors and generally affect a single parameter or setting.
- Static error
  More severe than a normal error. Prevents the execution of normal measurements.

Positive error numbers are instrument-dependent. Negative error numbers are reserved by the SCPI standard.

You can query the error queue using:

- `SYSTem:ERRor:ALL?`
- `SYSTem:ERRor:COUNt?`
- `SYSTem:ERRor[:NEXT]?`

If you want to look only at static errors, use:

- `SYSTem:SERRor?`
- `SYSTem:SERRor:LIST[:NEXT]?`

13.3 Performing a self-test

The self-test gives you detailed information that you can use for troubleshooting.

Do not apply a signal to the sensor while the self-test is running. If the self-test is carried out with a signal being present, error messages can erroneously be output for the following test steps:

- Offset Voltages
- Noise Voltages
- Noise Voltage

Using the web user interface (LAN sensors)

1. In the navigation pane of the main dialog, select "Sensor".
2. Under "Diagnostics", click "Selftest".
   See also "Selftest" on page 80.

Using remote control

► For a quick check, send:
  `TEST:SENSor?`

  For each test step, PASS or FAIL is listed.

```
Calibration Data:
   Integrity of Factory Calibration Data Set:   PASS
   Integrity of Antenna 1 Calibration Data Set: PASS
   Integrity of Antenna 2 Calibration Data Set: PASS
   Integrity of Antenna 3 Calibration Data Set: PASS
Operating Voltages:
   +3V3_VCC_MIO:      PASS (+3.30 V)
   +1V8_PS:           PASS (+1.76 V)
   +1V0_PS:           PASS (+0.99 V)
   +3V3_VCC_13:       PASS (+3.28 V)
   +2V5_VCC_34:       PASS (+2.50 V)
   +1V8_VCC_35:       PASS (+1.78 V)
   +1V8_PL:           PASS (+1.75 V)
   +1V0_PL:           PASS (+1.00 V)
   +1V8_LPDDR2_CORE:  PASS (+1.78 V)
   +1V2_LPDDR2:       PASS (+1.26 V)
   +0V6_VREF_LPDDR2:  PASS (+0.63 V)
   +1V25_VREF:        PASS (+1.24 V)
   +3V_ANALOG:        PASS (+3.00 V)
   +5V_ANALOG:        PASS (+5.34 V)
   -5V_ANALOG:        PASS (-5.19 V)
Supply Antenna Modules
   +5V_ANALOG Operating Current: PASS (+9.0 mA)
```

```
Temperatures:
   Digital Board Temperature:    PASS (+37.3 deg C)
   Analog Board Temperature:     PASS (+25.2 deg C)
   Antenna 1 Temperature:        PASS (+24.8 deg C)
   Antenna 2 Temperature:        PASS (+23.5 deg C)
   Antenna 3 Temperature:        PASS (+24.9 deg C)
Offset Voltages:
   Channel 1: PASS (-0.0377 mV, -0.0391 mV)
   Channel 2: PASS (-0.1012 mV, -0.1022 mV)
   Channel 3: PASS (+0.0781 mV, +0.0756 mV)
Noise Voltages:
   Channel 1: PASS (15.6 uV)
   Channel 2: PASS (15.6 uV)
   Channel 3: PASS (15.1 uV)
Digital Wiring:
   Antenna 1: PASS
   Antenna 2: PASS
   Antenna 3: PASS
Analog Wiring:
   Antenna 1: PASS
   Antenna 2: PASS
   Antenna 3: PASS
```

13.3.1 Interpreting the test results

If all test steps or parts pass, the overall result is PASS. If one test step or a part of it fails, the overall result is FAIL. What you need to do in this case is described in the following.

Operating Voltages, Reference Voltages, Offset Voltages, Noise Voltage

Checks the voltages.

If the test fails:

1. Disconnect all signal sources and connectors except LAN or USB.
2. Perform the self-test again.
   If it fails again, a hardware defect is probable.
3. Contact the customer support.

Calibration Data

Checks the integrity of the calibration data sets.

If the test fails:

1. Perform the self-test again.
   If it fails again, the sensor has to be calibrated.
2. Contact the customer support.

Temperatures

Checks the temperature at several measurement points, whether they are plausible and whether the limits are met.

Is the ambient temperature OK?

► Check whether the ambient temperature lies within the range rated in the specifications document of the R&S NRPM.
  If the ambient temperature is higher or lower, adjust the air conditioning of the room or move the test setup into a room with a fitting temperature.

Digital Wiring, Analog Wiring

Checks the analog and digital wiring of the antennas.

If the test fails:

1. Disconnect all antennas.
2. Perform the self-test again.
   If it fails again, replace the antenna cables. See Section 13.6, "Replacing antenna cables", on page 214.

13.4 Problems during a firmware update

Further information:

- Firmware update. See Section 8, "Firmware update", on page 83.

Sensor is not in the "Device" list

If you do not find the sensor in the "Device" list, the driver assigned to the sensor is the legacy driver.

► Install a recent VISA software.

Sensor is highlighted in the Windows device manager

If the sensor is highlighted by a yellow exclamation mark in the Windows device manager, Windows tries in vain to find a USB driver for the sensor.

► Install a recent VISA software.

Firmware update was interrupted

If for example, a power cut happened during the firmware update, problems can occur.

1. Perform the firmware update again. Sometimes, a further update fixes the problems.
2. If the sensor is not accessible anymore, contact the service.

Firmware update was aborted

If there is not enough free storage space, the firmware update is aborted. An error message is displayed, and the status LED of the sensor starts flashing red.

1. Perform a sanitization procedure, as described in the instrument security procedures. This document is available on the product page.
   See Section 3, "Documentation overview", on page 16.
2. Perform the firmware update again.

13.5 Cannot establish a LAN connection

If you have problems to establish a LAN connection, try the following measures:

- Use the Configure Network Sensor component of the R&S NRP-Toolkit, see "Configure Network Sensor" on page 26.
- "Troubleshooting for peer-to-peer connections" on page 54

13.6 Replacing antenna cables

13.6.1 Spare parts and recommended tools

The available cable replacement kits are listed in the table that follows:

Description	Part no.	Applicable for A90	Applicable for A90D
Cable replacement Kit, 550 mm	1436.2855.02	yes	yes
Cable replacement Kit, 750 mm	1436.2855.03	yes	yes
Cable replacement Kit, 1000 mm	1436.2855.04	yes	yes
Cable replacement Kit, 1500 mm	1436.2855.05	yes	yes

The recommended tools are listed in the table that follows:

Tool	Description, part no.
Screwdriver, flat tip Blade width 3 mm max.	Commercial off the shelf **Example:** WERA Werk Hermann Werner GmbH & Co. KG 160 i VDE insulated screwdriver for slotted screws Part no. 05006100001 www.wera.de
Cable tie tool (Force: 50 N ± 5 N)	Commercial off the shelf **Example:** PANDUIT® GS2B tension Part no.: GSB2 www.panduit.com
Electronics side cutter	Commercial off the shelf **Example:** KNIPEX-Werk C. Gustav Putsch KG Electronic Super Knips® Part no. 78 71 125 www.knipex.com

13.6.2 Cable replacement

- There are two versions of the strain relief.
  The old version is shown on the left hand side of the figures. The new version is shown on the right hand side of the figures.
- The procedure of cable replacement is shown for the single variant of the strain relief. The procedure is also applicable for the dual variant of the strain relief.

To change the antenna cable

1. Remove the cable tie.
   Use the electronics side cutter (part no. 78 71 125 or equivalent).

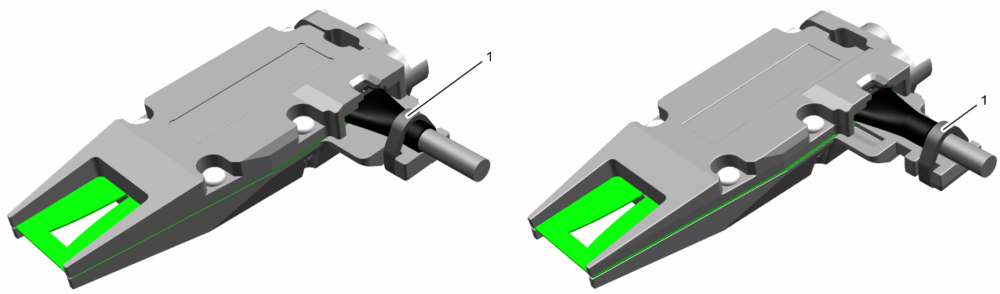


Figure 13-1: Removing cable tie

2. Hold the locking lug down to unlock the cable.
   Use the flat tip screwdriver (part no. 05006100001 or equivalent).

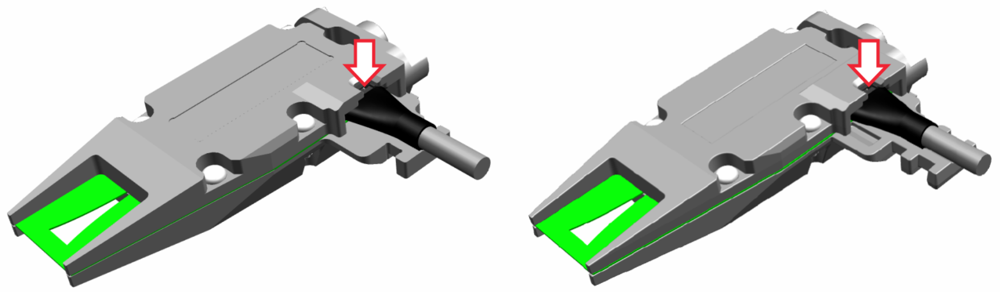


Figure 13-2: Unlocking cable

3. **NOTICE!** Remove the cable in a linear movement to prevent damage.
   While you hold down the locking lug, remove the cable.
4. Place the new cable in the notch.

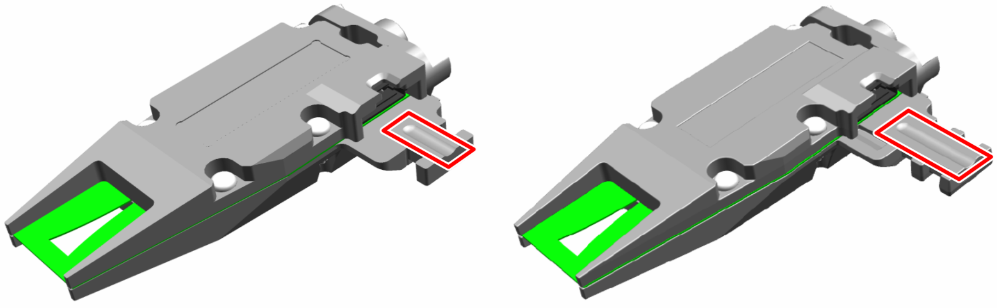


Figure 13-3: Placing the new cable

5. **NOTICE!** Connect the new cable in a linear movement to prevent damage.

   Connect the new cable until it snaps in.

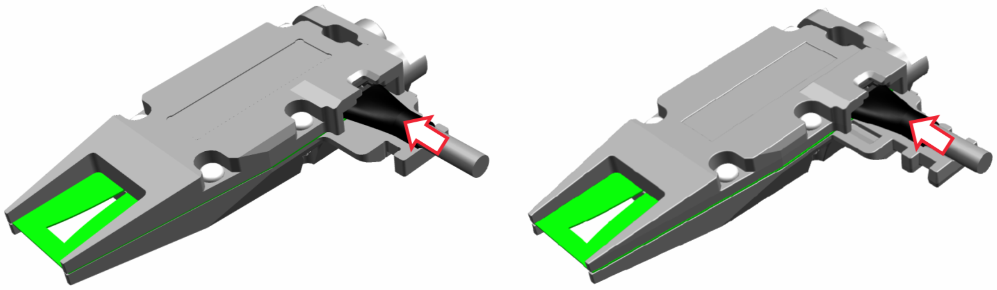


Figure 13-4: Connect new cable

6. **NOTICE!** Monitor the position of the cable tie head.

   Place the cable tie. Use the notch to place the cable tie correctly.

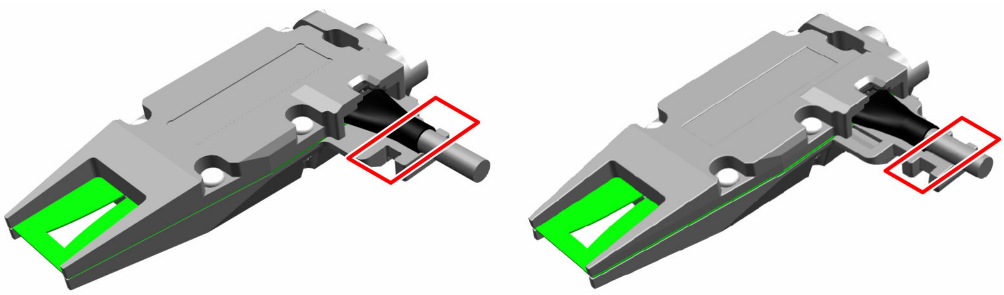


Figure 13-5: Placing a cable tie

7. **NOTICE!** Risk of damage of the cable and the connector. Make sure that the force of the automatic cable tie gun is set correctly to prevent cable damage. Make sure that the cable is free of load.

   Fasten the cable tie.
   Use the cable tie tool (part no. GSB2 or equivalent). Set the force of the cable tie tool to 50 N ±5 N.

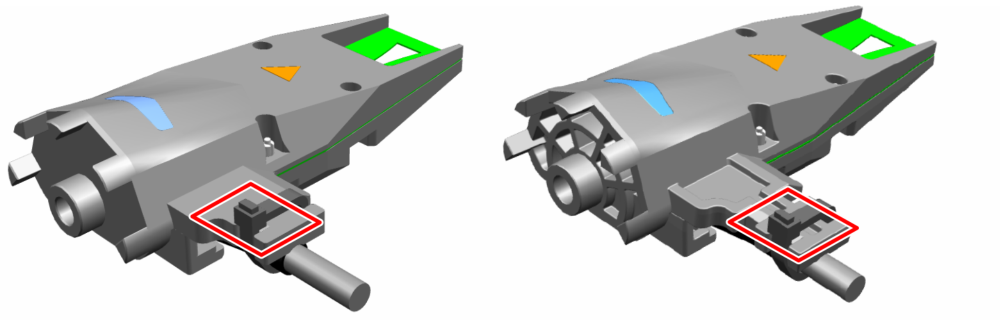


Figure 13-6: Position of the cable tie head

8. Cut off the protruding cable tie.
   Use the electronics side cutter (part no. 78 71 125 or equivalent).
9. **NOTICE!** We recommend that you execute a selftest after replacing the cables and reassembling the system.
   Execute a selftest with the command:
   `TEST:SENSor?`
10. Check the selftest for passed or failed, using the query of the same command.

13.7 Collecting information for technical support

If you encounter problems that you cannot solve yourself, contact your Rohde & Schwarz support center, see Section 13.8, "Contacting customer support", on page 218. Our support center staff is optimally trained to assist you in solving problems.

The support center finds solutions more quickly and efficiently if you provide them with information on the instrument and an error description.

Obtaining information from the sensor firmware

To create, collect and save the diagnostic and troubleshooting data, use the remote control. See `SYSTem:INFO:SUPPort?` on page 108.

Collect also the error information. See Section 13.2, "Error messages", on page 209.

Attach the collected information to an email in which you describe the problem.

If you need to transport or ship the product, see Section 14, "Transporting", on page 219.

13.8 Contacting customer support

Technical support – where and when you need it

For quick, expert help with any Rohde & Schwarz product, contact our customer support center. A team of highly qualified engineers provides support and works with you to find a solution to your query on any aspect of the operation, programming or applications of Rohde & Schwarz products.

Contact information

Contact our customer support center at www.rohde-schwarz.com/support, or follow this QR code:

Figure 13-7: QR code to the Rohde & Schwarz support page

14 Transporting

Packing

Use the original packaging material. It consists of antistatic wrap for electrostatic protection and packing material designed for the product.

If you do not have the original packaging, use similar materials that provide the same level of protection. You can also contact your local Rohde & Schwarz service center for advice.

Securing

When moving the product in a vehicle or using transporting equipment, make sure that the product is properly secured. Only use items intended for securing objects.

Transport altitude

The maximum transport altitude without pressure compensation is specified in the specifications document.

15 Maintenance, storage and disposal

The product does not require regular maintenance. It only requires occasional cleaning. It is however advisable to check the nominal data from time to time.

15.1 Cleaning

To clean the R&S NRPM3(N) sensor module

1. Disconnect the sensor module from the antenna modules.
2. Disconnect the sensor module from the controller PC.
3. Clean the outside of the R&S NRPM3(N) sensor module using a lint-free cloth. You can dampen the cloth with water but keep in mind that the casing is not waterproof. If you use isopropyl alcohol or ethanol instead of water, be careful not to damage the labeling.
   Do not use cleaning agents that can damage the instrument such as solvents, acids or alkalis.
4. To dislodge any particels from the antenna interface connector, use clean compressed air.

To clean the antenna modules

► To dislodge any particels from the waveguide of an antenna module, use clean compressed air only.

Do not use any liquids for cleaning.

15.2 Storage

Put plastic end caps on the RF connectors to protect them from damage. Protect the product against dust.

Ensure that the environmental conditions, e.g. temperature range and climatic load, meet the values specified in the specifications document.

Always store the antenna modules in the original package to avoid mechanical damage.

15.3 Disposal

Rohde & Schwarz is committed to making careful, ecologically sound use of natural resources and minimizing the environmental footprint of our products. Help us by disposing of waste in a way that causes minimum environmental impact.

Disposing of electrical and electronic equipment

A product that is labeled as follows cannot be disposed of in normal household waste after it has come to the end of its life. Even disposal via the municipal collection points for waste electrical and electronic equipment is not permitted.

Figure 15-1: Labeling in line with EU directive WEEE

Rohde & Schwarz has developed a disposal concept for the eco-friendly disposal or recycling of waste material. As a manufacturer, Rohde & Schwarz completely fulfills its obligation to take back and dispose of electrical and electronic waste. Contact your local service representative to dispose of the product.

Glossary: List of used terms and abbreviations

A

anechoic chamber: Non-reflective, non-echoing box (RF shielded box) or chamber (RF test chamber) that absorbs reflections of radio frequencies, used to test antennas, radars or electromagnetic interference.

API: Application Programming Interface

Average count: Number of averaged readings

Average factor: see Average count

B

Beamforming: Steering a beam in the direction of the receiver.

C

Computer name: An unambiguous indication of the instrument in a LAN that uses a DNS server.
The default computer name follows the syntax `NRPM3-<serial number>`, e.g. *NRPM3-100099*.
Synonym: Hostname
See Serial number.

CW: Continuous Wave

D

DUT: Device Under Test

E

EIRP: Equivalent Isotropically Radiated Power

Ethernet: Linking technology to connect computers and electronic devices in wired local area networks (LANs).

G

Glossary: List of the often used terms and abbreviations

GUI: Graphical User Interface

H

Hostname: Computer name

L

LAN: Local Area Network. A network that connects computers and electical devices within a small area.

O

OS: Operating System

OTA: Over The Air

P

PC: Personal Computer, desktop or laptop PC

PoE: Power over Ethernet: Technology for local area networks (LAN) that provides the electrical power for a device over the Ethernet cable.

Power: A term describing the signal level in the RF domain or defining the length of the I/Q vector in the Baseband domain.

product page: A designation of the R&S NRPM product page.

R

R&S NRP-Toolkit: Software package, which provides drivers for Linux, Mac OS X or MS Windows.

Remote control: The operation of the R&S NRPM by remote control commands or programs to perform automated tests. The instrument is connected to a system controller via LAN/VXI-11, GPIB or USB using Virtual Instrument Software Architecture (VISA). The instrument is controlled either directly, or supported by instrument drivers.

RF: Radio Frequency

RF shielded box: Anechoic test box with very low reflectivity. Provides a shielded test environment for OTA measurements of radio frequencies.

RF test chamber: Larger anechoic RF test chamber up to RF test room sizes with very low reflectivity. Provides a shielded test environment for OTA measurements of radio frequencies.

rsu: Rohde & Schwarz Update. A file format which contains updated device software. Processed by a firmware update program.

S

Shielded box: See anechoic chamber.

Shielded cube: See anechoic chamber.

T

Trigger: Internally generated or externally supplied signal which starts signal generation at a particular point in time.

Trigger event: A trigger event is caused by the received trigger signal or executed manual trigger.

U

USB: Universal Serial Bus. A standard type of connection for many different kinds of devices.

USBTMC: (USB Test & Measurement Class)
A protocol built on top of USB for communication with USB devices. Using VISA library, it supports service request, triggers, and other specific operations, similar to GPIB.

V

VISA: Virtual Instrument Software Architecture
A standardized software interface library providing input and output functions to communicate with instruments.

W

WPTC: (Wireless Performance Test Chamber)

Anechoic chamber with very low reflectivity. Provides a shielded test environment for OTA measurements of radio frequencies.

List of commands

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O

P

R