Software Manual

R&S® Power Viewer

Version 11.0

Printed in Germany

ROHDE&SCHWARZ

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2 Overview

The new R&S NRP power sensors from Rohde & Schwarz represent the latest in power measurement technology. They offer all the functionality of conventional power meters, and more, within the small housing of a power sensor. The USB interface on an R&S NRP sensor enables operation with an R&S NRP power meter, or with a PC running under either Microsoft® Windows®, Mac OS X, or Linux.
R&S Power Viewer is an easy-to-use, feature-packed software package that offers capabilities beyond those of a regular power meter. It simplifies measurement tasks, such as average-power, timeslot, statistics and trace measurements. In addition, up to 16 sensors can be utilized for measuring average power simultaneously. Results, such as the reflection coefficient or gain, can be computed from the measured values.
Particularly the capabilities for use with a desktop or laptop PC make an R&S NRP sensor an ideal and cost-effective solution for lab testing or for automated systems. The rugged design is suitable for use in the field for performing such tasks as servicing antenna systems.

This manual describes the installation and use of the Power Viewer software. This application is available free of charge from the Rohde & Schwarz website. As a prerequisite it requires the installation of the R&S®NRP Toolkit. This toolkit contains drivers and small applications. It is also available free of charge from the Rohde & Schwarz website.

To enable integration of the sensor into custom ATE systems, a versatile and powerful VXI PnP driver is available for Microsoft® Windows®, Mac OS X, and Linux-based systems. The new R&S NRP power sensor family also supports SCPI remote control commands via USB-TCM.

Coding examples can be found in the application note 1GP69.

3 Key Software Features

Power Viewer is powerful PC software that simplifies many measurement tasks. This software is part of the R&S NRP Toolkit and is available free of charge. The following overview lists some of the key features that Power Viewer offers.

- Measuring the average and peak powers and viewing the numeric results. Optionally, adding an analog bar display, a trend chart or statistical analysis.

Fig. 3.1: Viewing measurement results.

- Viewing the RF power envelope down to a resolution of 5 ns/div; measuring pulse parameters with automatic pulse analysis; using markers, and measuring within time gates.

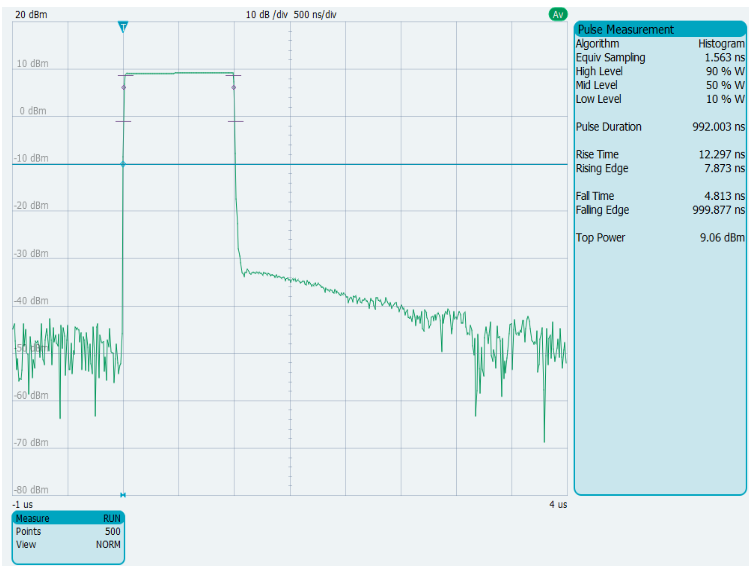


Fig. 3.2: Pulse measurement.

- Measuring the average power of up to 16 sensors, and optionally computing results from the measured values.

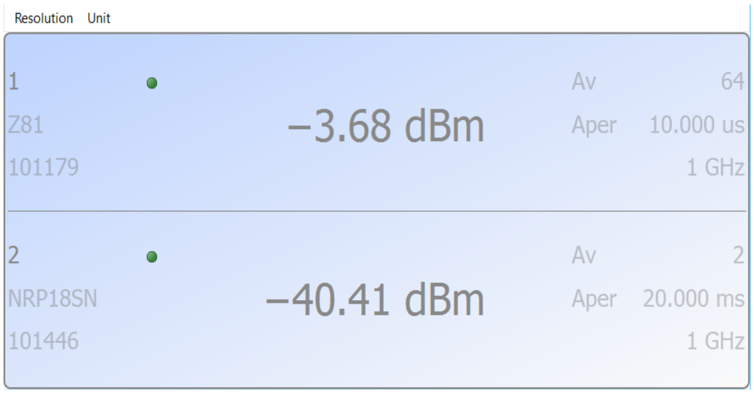


Fig. 3.3: Measuring average power.

- Viewing the average and peak powers for up to 16 consecutive timeslots in a bar chart.

Fig. 3.4: Viewing average and peak powers.

- Performing statistical CCDF, CDF, or PDF analysis of the envelope power.

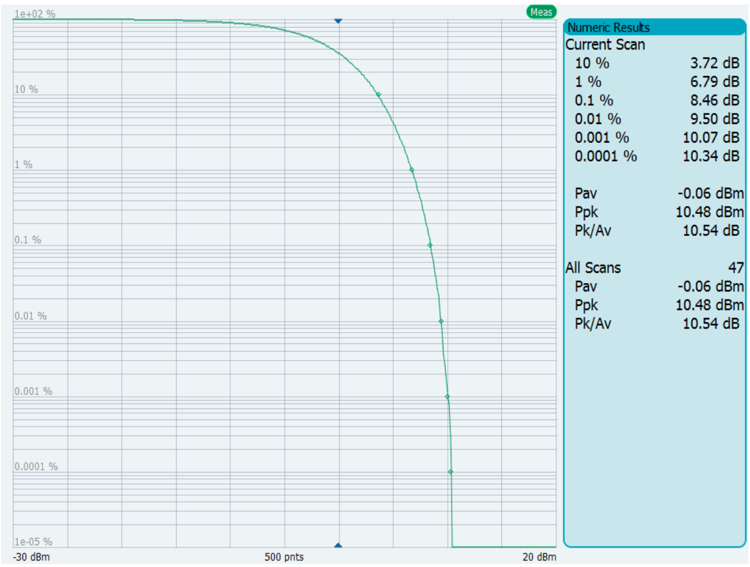


Fig. 3.5: Statistical analysis.

- Recording up to 4 channels of any measured data to memory and/or to a file.

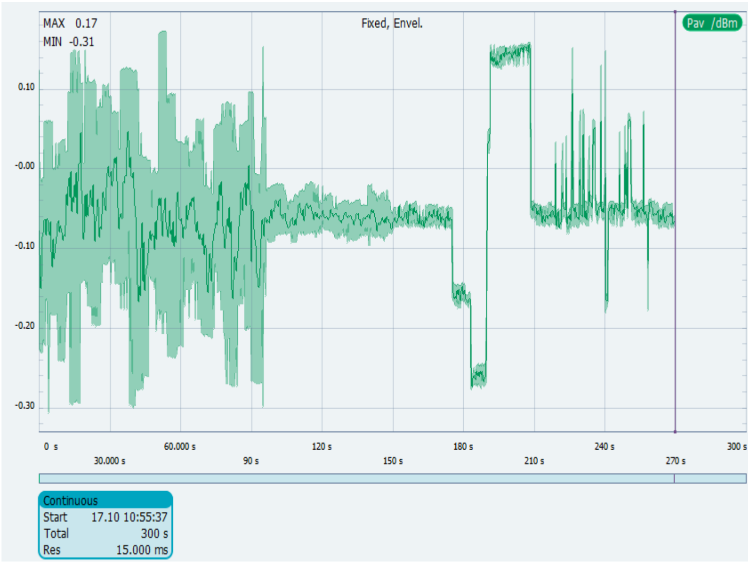


Fig. 3.6: Recording measured data.

- Performing 4-channel statistical analysis on any measured data.

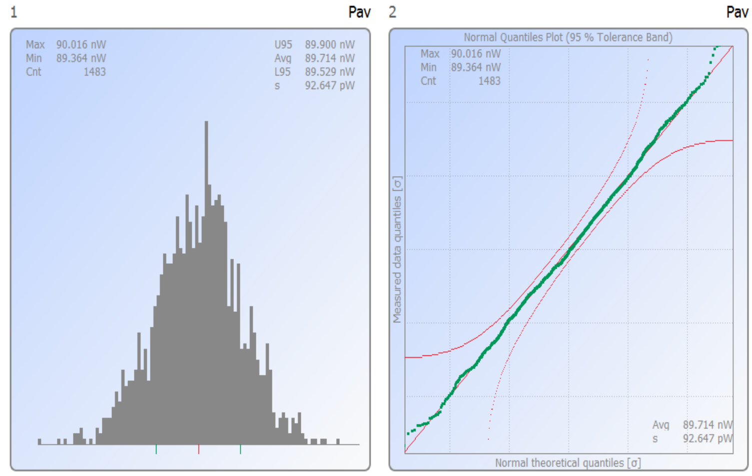


Fig. 3.7: Four-channel statistical analysis.

- Configuring 16-channel limit monitoring for any measured data; optionally, sending limit violations to a remote host via a TCP/IP server.

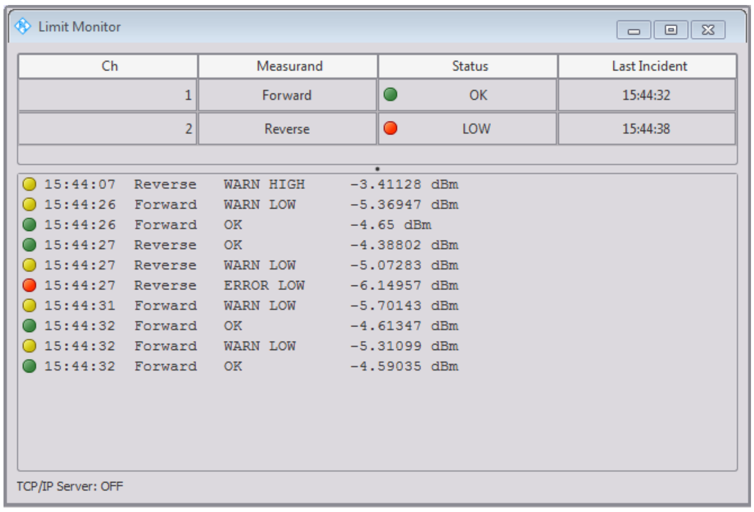


Fig. 3.8: Limit monitoring.

- Creating custom measurements in script mode.

Fig. 3.9: Script mode for custom measurements.

- Configurable analog and digital gauges.

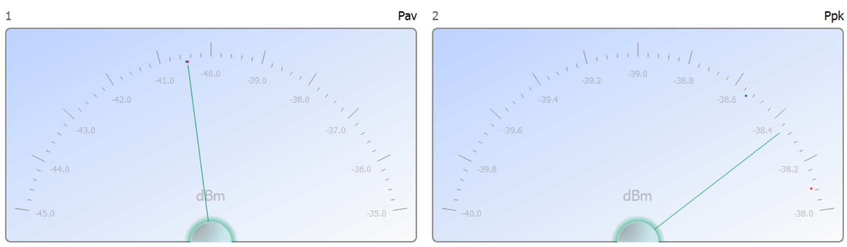


Fig. 3.10: Two gauges showing measurement values.

Please note that some of the features listed above are only supported by certain R&S NRP power sensors. For example, thermal sensors do not provide statistical signal analysis or trace measurements.

4 Power Sensor Technologies

Rohde & Schwarz offers a large choice of USB power sensors that use different technologies and cover a wide range of frequencies and power levels. This chapter briefly outlines the differences between the sensor technologies and indicates which sensor would best fit certain measurement tasks.
All R&S NRP power sensors are standalone instruments that contain the detector, the analog circuitry, and the digital signal processing in a single housing. The entire instrument is fully characterized during the production process, which eliminates the need for later calibration using a reference power source.
Zeroing is generally only required for measuring low power levels, in which case the zeroing offset, noise, and drift stated in the specification sheet contribute to the overall accuracy.

4.1 Thermal Power Sensors

Thermal sensors use a load resistor for converting the RF power into heat. The temperature difference between this resistor and the surrounding area is measured by thermocouples. The resulting DC voltage is proportional to the RF power.

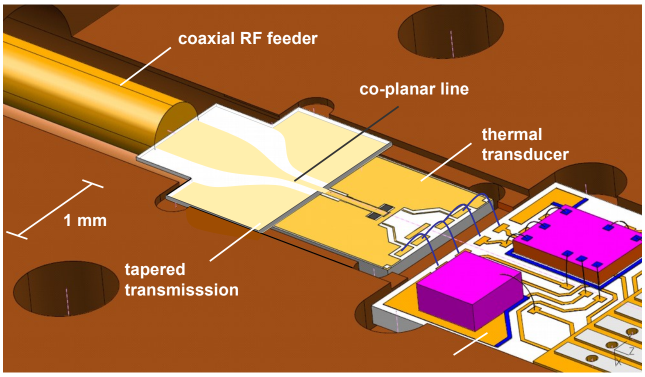


Fig. 4.1.1: Detector design in thermal power sensor.

The Rohde & Schwarz thermal power sensors can be used from DC up to their specified upper frequency limit. The dynamic range is typically in the order of 55 dB and starts at power levels of around –35 dBm.
Thermal power sensors provide the highest accuracy and linearity of all power sensors on the market. Their measurements are not influenced by the modulation or harmonics, and the results always represent the average signal power.
However, the nature of the underlying sensor technology limits the dynamic range. Furthermore, the measurement speed is generally slower than that of diode sensors. Thermal sensors cannot measure the envelope of an RF signal.

4.2 CW Power Sensors

CW sensors are simple diode sensors that contain a half-wave or full-wave rectifier as the detector element. At power levels below -20 dBm, the diode characteristic provides an almost linear relationship between the detector output voltage and the RF power. This power range is referred to as the square-law region of the detector diode.
CW sensors typically use the diode at power levels beyond the square-law region, and the software must compensate for the resulting

non-linearities. With CW signals, this compensation is possible, and the sensor provides correct readings of the average RF power. Modulated or pulsed signals, as well as signals containing harmonics, may lead to large measurement errors at levels that exceed the detector's square-law region.
Due to these limitations, the Rohde & Schwarz NRP product range does not include CW sensors.

4.3 Multi-Path Diode Power Sensors

The Rohde & Schwarz multi-path diode sensors use up to three independent full-wave diode detectors. These detectors, along with their analog and digital signal processing, are referred to as paths. Each path is designed for operation in a separate power range, with a 6 dB overlap between the paths.

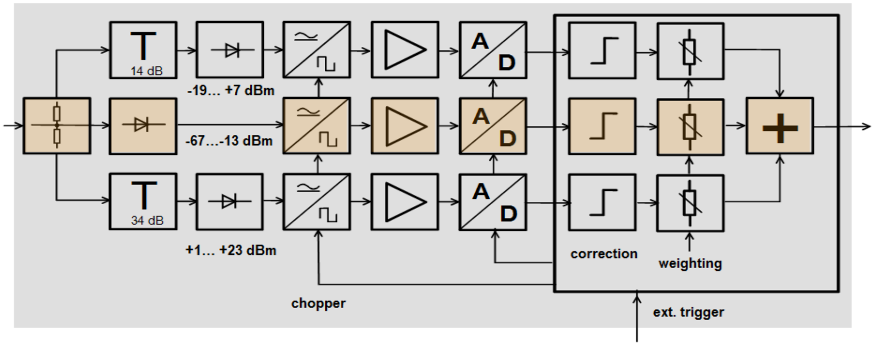


Fig. 4.3.1: Multi-path diode sensor design.

The data from all paths is processed in parallel. For each power level within the specified sensor limits, at least one path operates within the detector's square-law region and delivers an output signal that is proportional to the RF energy. The sensor software automatically determines the path that best fits the incident RF power.
As a result, these sensors exhibit little sensitivity to modulation and harmonics. The sensors always measure the average signal power at a performance level that is close to that of thermal sensors. Due to the ease of use and excellent performance offered by these sensors, Rohde & Schwarz calls these devices R&S Universal Power Sensors. The universal power sensors' dynamic range and measurement speed are higher than can be achieved with thermal sensors. For most signals and measurement tasks, universal power sensors are ideal devices. These sensors also allow measurement of the RF envelope, but the sampling rate of about 150 kHz must be considered as a limiting factor in such cases.

4.4 Average Power Sensors

The Rohde & Schwarz Average Power Sensors also use three diode paths. Unlike the universal power sensors, the detector design used for average power sensors allows an RF frequency as low as 9 kHz. Due to this detector design, the bandwidth is lower. Consequently, this sensor is only intended for performing average power measurements.

4.5 Wideband Diode Power Sensors

Wideband diode sensors use a single full-wave diode detector and operate it across the entire useful power range. The detector's bandwidth is much higher than with CW sensors, and the sample rate is in the order of 80 MHz.

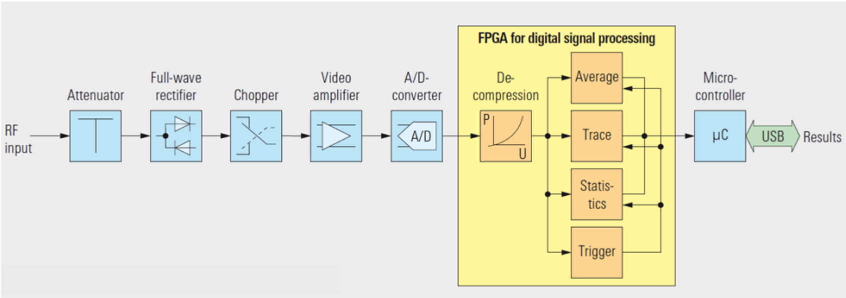


Fig. 4.5.1: Wideband power sensor design.

Similar to CW sensors, the wideband diode sensor's digital signal processing circuitry compensates the non-linear diode characteristic in real-time. Due to the wider bandwidth and fast sampling rate, this is even possible for fast amplitude changes (AM) of the RF envelope. Wideband diode sensors are ideal when the RF envelope should be measured, e.g. for the analysis of pulsed signals. Additionally, these devices can measure the signal statistics, such as the PDF, CDF, CCDF, and average power for modulated signals.

The following chart shows the relationship between power levels and applications that generally fit a wideband diode sensor.

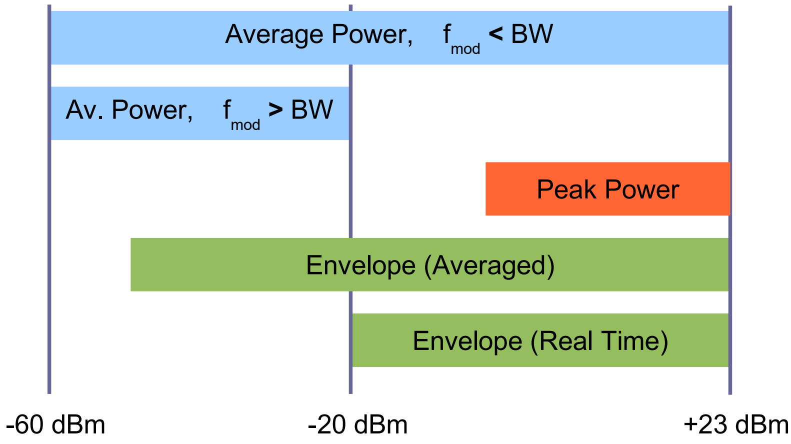


Fig. 4.5.2: Wideband power sensor applications.

At power levels below –20 dBm (square-law region), these sensors exhibit little sensitivity to modulation and harmonics. Average power measurements are possible down to a level of about –60 dBm.
For higher power levels, care must be taken when the RF envelope is amplitude modulated at frequencies that exceed the detector's analog bandwidth. In such cases, it is no longer possible to compensate the RF envelope in real-time, and measurement errors in the order of several percent may occur.
The wider bandwidth used by these sensors generally implies a higher noise floor. Average power measurements overcome this issue by using averaging techniques. When taking single-shot measurements, however, the higher noise floor must be considered.
This is especially the case with peak power measurements. Please see the chapter 14.4, "Continuous Power Measurements – Accuracy of Peak Power Measurements" in this document for more details.
It must also be noted that triggering is always a real-time process that is based on samples that have not yet been subject to averaging. As a result, power levels in the order of –20 dBm or higher are required when

using the sensor's internal trigger feature. Decreasing the sensor's bandwidth decreases the noise floor and, therefore, also decreases the lower trigger-level limit.

4.6 Sensor Modules (OTA)

The sensor modules provide reliable over the air (OTA) measurement of RF power on up to three antennas simultaneously. The sensor modules do not contain internal RF detector diodes. Instead they provide an interface for connecting up to three antennas with integrated power detector.

Fig. 4.6.1: OTA antenna.

The power sensor is designed for measuring power in high frequency bands, used in modern high-performance wireless system standard, e.g. IEEE802.11ad and 5G. This sensor module and the specific antennas have been developed to provide measurements of radiated RF power.

4.7 NRQ Frequency Selective Power Sensor

The R&S®NRQ6 combines the accuracy of a power meter with the dynamic range of a spectrum analyzer. It performs extremely precise and fast power measurements down to -130 dBm.
This sensor is based on receiver technology and can perform band-limited power measurements.

In addition to conventional continuous average measurements, the R&S®NRQ6 has a trace display function and also performs ACLR measurements. With option NRQ6-K1 installed, I/Q data can be downloaded from the power sensor to a PC for further analysis.
This sensor is controlled via LAN, requiring power over Ethernet (PoE+).

5 Uncertainty Calculation

This chapter briefly explains how to calculate the measurement uncertainty based on the figures provided in the sensor's specifications. The data sheet lists the absolute uncertainty for power measurements in dB depending on the power level and frequency. Other contributors, such as zero offset or noise, are provided in watts and can be converted into dB using the following equation.

$$e = 10\,dB \cdot \log\left(\frac{P + \Delta P}{P}\right)$$

This equation uses P as the power level of interest and ΔP as the relative error. The result is the error e in dB.
Uncertainties are statistical measures, and they must be added by summing up the squared uncertainties and then calculating the square root:

$$U = \sqrt{U_1^2 + U_2^2 + U_3^2 + \ldots}$$

This equation can be used for uncertainties in logarithmic scale (dB) or in percent (%).
Uncertainties are commonly provided in dB, but the following equation permits conversion into percent:

$$U_{\%} = 100\% \cdot \left(10^{\frac{U_{dB}}{10\,dB}} - 1\right)$$

To gain a simple approximation, the following formula can be used:

$$U_{\%} \approx 10 \cdot \ln 10 \cdot U_{dB} = 23 \cdot U_{dB}$$

5.1 Measurements at –10 dBm

The power level range from –10 dBm to 0 dBm is widely used. Therefore, our first example here calculates the absolute uncertainty for the R&S NRP-Z11 when measuring a CW signal at 2 GHz and at a power level of –10 dBm. The temperature shall be 30 ºC.
All values marked with an arrow (►) are taken from the R&S NRPZxx Power Sensor Specifications that are available on the Rohde & Schwarz website.

Power level in W	100 µW		
► Used path[1]	2		
► Uncertainty for absolute power measurements		**0.077**	**dB**
► Zero Offset[2]	47 nW	**0.002**	**dB**
► Zero Drift	3 nW	**N/A**	**dB**
► Measurement noise	6.3 nW		
Multiplier for 40 ms integration Time is sqrt(10.24s/T)	x 16		
	= 100.8 nW	**0.004**	**dB**
Total expanded uncertainty		**0.077**	**dB**
		1.79	**%**

The example shows that the influence of zero offset and drift is negligible. Consequently, zeroing of the sensor is not required when performing practical measurement tasks. The integration time can be set to a very short value of 40 ms. This means that an averaging count of one, combined with two chopper cycles and a measurement window (aperture) of 20 ms, is sufficient.
The total integration time is twice the aperture time multiplied by the averaging filter count.

[1] Automatic path selection, see *Transition regions* in data sheet.
[2] Without zeroing

5.2 Measurements at –50 dBm

This example calculates the absolute uncertainty for the R&S NRPZ11 when used for measuring a CW signal at 2 GHz and at a very low power level of –50 dBm. The temperature shall be 30 ºC.
All values marked with an arrow (►) are taken from the R&S NRPZxx Power Sensor Specifications that are available from the Rohde & Schwarz website.

Power level in W	10 nW			
► Used path	1			
► Uncertainty for absolute power measurements		0.081	dB	
► Zero offset after zeroing		104 pW	0.045	dB
► Zero drift after zeroing		35 pW	0.0015	dB
► Measurement noise		65 pW		
Multiplier for 1.28 s integration time is sqrt(10.24s/T)	x 2.8			
		= 182 pW	0.078	dB
Total expanded uncertainty			0.12	dB
			2.8	%

After zeroing, the absolute accuracy is 0.12 dB when using an integration time of 1.28 s. This integration time can be achieved with an average filter count of 32 and a measurement window of 20 ms. Further improvement of the uncertainty is possible by increasing the averaging filter count.
The total integration time is twice the aperture time multiplied by the averaging filter count.

5.3 The Influence of Mismatch

Power sensors are always calibrated to measure the power of the incident RF wave. This means that the sensor corrects the reading for the internal losses and reflections. As a result, different power sensors that were connected to an ideal 50 ohm source would all show exactly the same result.
In the real world, however, neither the power sensor nor the source match an impedance of 50 ohms exactly. The reflection that is caused by the power sensor itself is specified by the standing wave ratio (SWR), which is typically around 1.2. This means that a small portion of the RF wave is reflected back towards the source as a return wave. An ideal source would absorb this return wave entirely. Since the power sensor is calibrated to measure the incident wave and compensates for its own reflections, the reading is correct.
Real signal sources are not ideal either. They also reflect a portion of the return wave back to the power sensor. This portion adds to the incident RF wave and influences the measurement result.
The uncertainty calculations in the previous chapter did not include the error caused by mismatch.

The following equation shows the minimum and maximum possible incident power based on the reflection coefficient of the source and the load:

$$\frac{P_{GZ0}}{(1+r_G r_L)^2} \leq P_i \leq \frac{P_{GZ0}}{(1-r_G r_L)^2}$$

P_{GZ0}: Power from signal source
P_i: Incident power to power sensor
r_G: Generator reflection coefficient
r_L: Load reflection coefficient

Depending on the phase angle, the incident power varies between the left and right term of the equation. The following equations can approximate the maximum relative deviation ε_{max} between the source power P_{GZ0} and the incident power P_i:

$$\varepsilon_{max\%} \approx 200\% \, r_G r_L \qquad for\ \varepsilon_{max} < 20\%$$
$$\varepsilon_{max\,dB} \approx 8.7\,dB\, r_G r_L \qquad for\ \varepsilon_{max} < 1\,dB$$

Uncertainty calculations use statistical figures instead of the ε_{max} errors from the equations above. The following equation shows the relationship between the expanded uncertainty (k = 2) and the error.

$$U_{dB} = 2 \cdot \frac{\varepsilon_{max\,dB}}{\sqrt{2}}$$

This shows that the expanded uncertainty used for the uncertainty calculation is higher than the maximum error.

Data sheets often express the impedance matching of a device as a standing wave ratio (SWR). The relationship between the SWR and the reflection coefficient is expressed by the following equations:

$$s = \frac{1+r_L}{1-r_L} \qquad r_L = \frac{s-1}{s+1}$$

The example below demonstrates the influence of mismatch caused by a signal source that is directly connected to a power sensor:

Load:	R&S NRPZ11	SWR = 1.2	$r_L = 0.09$
Source:	R&S SMBV100A	SWR = 1.6	$r_G = 0.23$

U_{dB} = 2 · 0.707 · ± 8.7 dB · 0.09 · 0.23 = **± 0.25 dB**

6 Software Installation

The following section outlines the process for installing Power Viewer on various platforms.

6.1 System Requirements

The following hardware and software prerequisites must be fulfilled for running the Power Viewer application.

Hardware requirements

- Standard desktop PC or laptop, or an Intel-based Apple Mac
- 1024 x 768 screen resolution
- USB 2.0 interface
- 100 Mbit LAN

- R&S NRP-Z3, R&S NRP-Z4, or R&S NRP-Z5 adapter (required for R&S NRP-Z power sensors)

Operating systems (choice of)

- Microsoft® Windows® 7, Microsoft® Windows® 8, Microsoft® Windows® 10

  Microsoft Windows XP or Microsoft Windows XP Embedded is not supported by the standard Power Viewer installer package. Please contact the R&S customer support for a special copy that runs on these operating systems.

- Mac OS X 10.6 or later
- 32/64-Bit Linux distribution with kernel ≥ 2.6.x (e.g. Ubuntu 10.4 LTS x86, 11.4 x86)

Software packages

- **R&S NRP Toolkit V4.10** or later. The toolkit provides the required USB and low level drivers for all R&S NRP-Z power sensors.

- R&S VISA or National Instruments VISA required for all new R&S NRP power sensors. Please see http://www.rohde-schwarz.com/rsvisa for details.

6.2 Installation on Windows-Based Systems

Since fall 2015 the Power Viewer is not part of the R&S NRP Toolkit anymore. Instead it is now a separate installer package.

Please note that the installation of the R&S NRP Toolkit is required before installing the Power Viewer application.

1. Disconnect all NRP power sensors from the PC.
2. Install or update the R&S NRP Toolkit on your PC.
3. Start the R&S Power Viewer installer

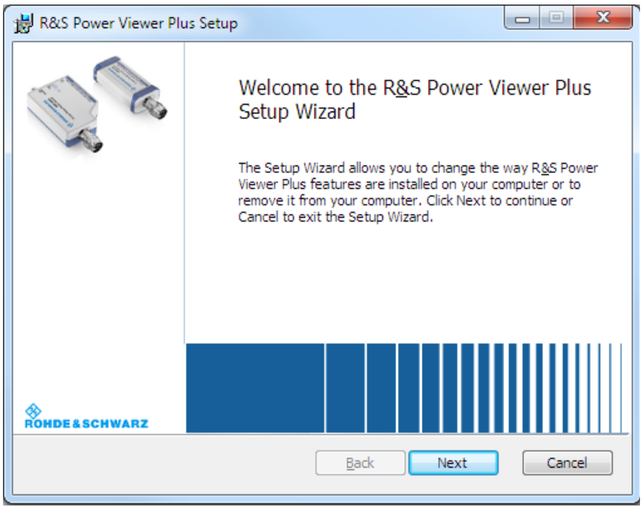


Fig. 6.2.1: R&S Power Viewer installer.

4. Please follow the installer steps until the process completed.

After the installation has completed, the sensors can be connected to the PC. If the USB drivers were updated or newly installed, recognizing the sensor may take more time when it is plugged in for the very first time.

The installer writes data to the following location on your system:

Application Files
`%COMMONPROGRAMFILES(x86)%\Rohde-Schwarz\Power Viewer`

Example Scripts
`%PUBLIC%\Documents\Rohde-Schwarz\Power Viewer`

6.3 Installation on Mac OS X

In contrast to the Windows R&S NRP Toolkit, the Mac OS X toolkit installer contains the following components:

- RsNrpLib.framework (low-level driver)
- RsNrpz.framework (VXI PnP driver)
- HTML help files for the VXI PnP driver
- Power Viewer and documentation
- Example programs for use with the VXI PnP driver

The toolkit comes as a .pkg installer. Double-click this file from any folder on your desktop. Please follow all instructions provided by the installer.

After successful installation, the Power Viewer application can be started from the `Rohde-Schwarz / Power Viewer` folder that was created in the Mac OS X application directory.

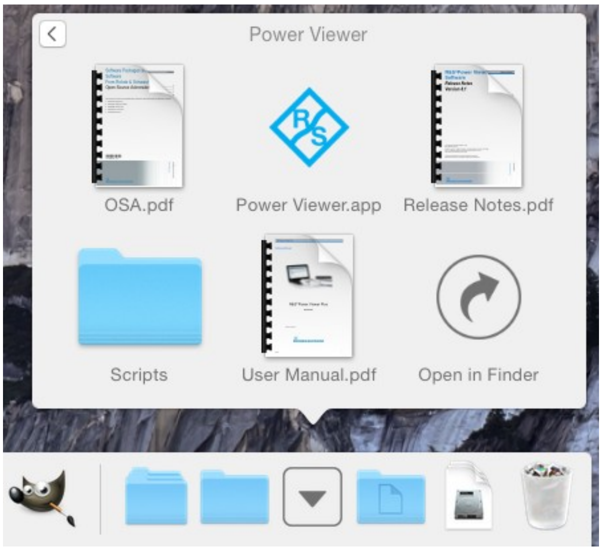


Fig. 6.3.1: The "Power Viewer" folder.

The folder `Scripts` contains examples for the Power Viewer script-based measurement mode. Please see the chapter Script-Based Measurement in this book for details.

The current .pkg installer cleans up any existing Power Viewer installation from the previous disk image based installers.

In addition to the files placed in the `/Application` folder the installer also adds two frameworks to the `/Frameworks` folder. The NrpLib framework is the low level driver for all USB communication to the NRP-Z power sensors. It can also be used to communicatate in legacy mode with the newer NRP sensors.
The RsNrpZ driver is the VXI PnP driver. It provides a C interface and can be used for own applications.
Power Viewer communicates through the NrpLib driver with all NRP-Z sensors and it uses VISA for all new NRP power sensors.

6.4 Sensor Firmware Requirements

Power Viewer may require newer firmware versions on certain power sensors. Please see the firmware update section in this manual for more details on updating the sensor firmware. The latest firmware files are available free of charge from the Rohde & Schwarz website.

NRP-Z Power Sensors

R&S NRP-Z8x	**1.20 or later**
R&S NRP-Z1x	**4.08 or later**
R&S NRP-Z2x	**4.08 or later**
R&S NRP-Z3x	**4.08 or later**
R&S NRP-Z5x	**4.08 or later**

New generation NRP Power Sensors

R&S NRPxxS(N)	**15.03 or later**
R&S NRPxxA(N)	**16.05 or later**
R&S NRPxxT(N)	**15.12 or later**
R&S NRPM3	**16.01 or later**
R&S NRQ6	**18.04 or later**

6.5 Supported Power Sensors and USB IDs

The following table provides an overview of the sensors that are supported in Power Viewer.
The vendor ID for all R&S NRP sensors is 0x0AAD.

Sensor	USB ID	Supported Measurement			
		Cont	Trace	Timeslot	Statistics
NRP-Z11	0x0C	●	●	●	
NRP-Z21	0x03	●	●	●	
NRP-Z211	0xA6	●	●	●	
NRP-Z22	0x13	●	●	●	
NRP-Z221	0xA7	●	●	●	
NRP-Z23	0x14	●	●	●	
NRP-Z24	0x15	●	●	●	
NRP-Z31	0x2C	●	●	●	
NRP-Z41	0x96	●	●	●	
NRP-Z51	0x16	●			
NRP-Z52	0x17	●			
NRP-Z55	0x18	●			
NRP-Z56	0x19	●			
NRP-Z57	0x70	●			
NRP-Z58	0xA8	●			
NRP-Z91	0x21	●			
NRP-Z81	0x23	●	●	●	●
NRP-Z85	0x83	●	●	●	●
NRP-Z86	0x95	●	●	●	●
NRP-Z27	0x2F	●			
NRP-Z28	0x51	●	●	●	
NRP-Z37	0x2D	●			
NRP-Z92	0x62	●			
NRP-Z98	0x52	●			
NRPC33	0xB6	●			
NRPC40	0x8F	●			
NRPC50	0x90	●			
NRPC33-B1	0xC2	●			
NRPC40-B1	0xC3	●			
NRPC50-B1	0xC4	●			
FSH-Z1	0x0B	●			
FSH-Z18	0x1A	●			

The following tables list the new generation NRP power sensors introduced by the end of 2014. These sensors are available with USB interface and LAN interface. The LAN sensors use the N (Network) suffix in their device name.

The USB interface supports both, legacy USB communication using the existing VXI PnP drivers as well as USB-TMC with VISA.

3-Path Diode Sensors

Sensor	USB ID	Supported Measurement			
		Cont	Trace	Timeslot	Statistics
NRP8S	0x00E2	●	●	●	
NRP8SN	0x0137	●	●	●	
NRP18S	0x0138	●	●	●	
NRP18SN	0x0139	●	●	●	
NRP33S	0x0145	●	●	●	
NRP33SN	0x0146	●	●	●	
NRP40S	0x015F	●	●	●	
NRP40SN	0x0160	●	●	●	
NRP50S	0x0161	●	●	●	
NRP50SN	0x0162	●	●	●	
NRP67S	0x024A	●	●	●	
NRP67SN	0x024B	●	●	●	
NRP33SN-V	0x0168	●	●	●	

Thermal Sensors

Sensor	USB ID	Supported Measurement			
		Cont	Trace	Timeslot	Statistics
NRP18T	0x0150	●			
NRP18TN	0x0151	●			
NRP33T	0x0152	●			
NRP33TN	0x0153	●			
NRP40T	0x0154	●			
NRP40TN	0x0155	●			
NRP50T	0x0156	●			
NRP50TN	0x0157	●			
NRP67T	0x0158	●			
NRP67TN	0x0159	●			
NRP110T	0x015A	●			
NRP75TWG	0x01D1	●			
NRP90TWG	0x01D2	●			
NRP110TWG	0x01D3	●			

Average Sensors for EMC Applications

Sensor	USB ID	Supported Measurement			
		Cont	Trace	Timeslot	Statistics
NRP6A	0x0178	●			
NRP6AN	0x0179	●			
NRP18A	0x014E	●			
NRP18AN	0x014F	●			

Sensor Modules (OTA)

Sensor	USB ID	Supported Measurement			
		Cont	Trace	Timeslot	Statistics
NRPM3	0x0195	●	●		
NRPM3N	0x0196	●	●		

Frequency-Selective Power Sensors

Sensor	USB ID	Supported Measurement			
		Cont	Trace	ACLR	Spectrum
NRQ6	0x015B	●	●	●	●

If no sensor is detected, Power Viewer automatically activates a simulated sensor called NRP-Z00.

6.6 Running Multiple Instances

Since fall 2015 the low level drivers can handle multiple applications using the drivers simultaneously. The drivers grant exclusive access to the application opening a specific power sensor. Trying to open the same sensor from another application generates a 'sensor in use' error message. Starting with V8.0 Power Viewer supports this new driver feature.

Power Viewer checks to see if any other instance is already running on the system. If so, a warning message appears.

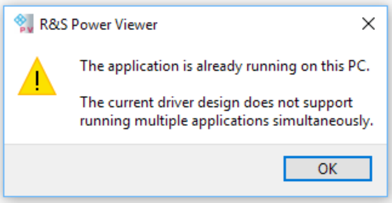


Fig. 6.6.1: Warning message indicating that an application is already running.

7 Connecting Sensors to the PC

Please see your R&S NRP power sensor's manual for information on how to put the sensor into operation. Follow these instructions to prevent damage to the sensor, particularly if you are putting it into operation for the first time.
The following section provides additional information that is related to the USB interface or to operating multiple sensors simultaneously.

7.1 Using Multiple Sensors

If multiple sensors need to be connected to a single computer, check to ensure that the overall current requirements for operating all sensors can be met. Each single sensor draws between 300 mA and 500 mA, depending on the sensor type.

Example:
The R&S NRP-Z81 sensor is rated at up to 500 mA supply current. Using four sensors simultaneously on one hub requires a total current of at least two amperes. Many consumer hubs cannot provide this current over a long period of time, even if they are rated for this value.

7.2 Using USB Extension Hardware

7.2.1 R&S NRP-Z3 Active USB Adapter

The figure shows the configuration with the R&S NRP-Z3 active USB adapter, which also makes it possible to feed in a trigger signal for the timeslot and trace modes. The order in which the cables are connected is not critical.

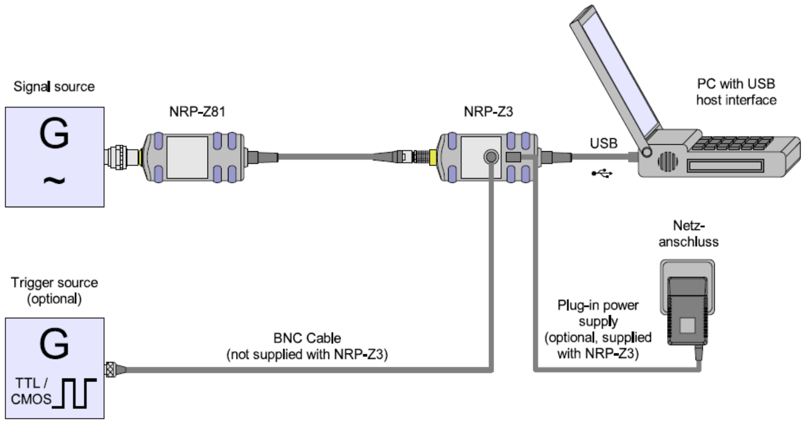


Fig. 7.2.1: Configuration with the active USB adapter.

7.2.2 R&S NRP-Z4 Passive USB Adapter

The figure below is a schematic of the measurement setup. The order in which the cables are connected is not critical.

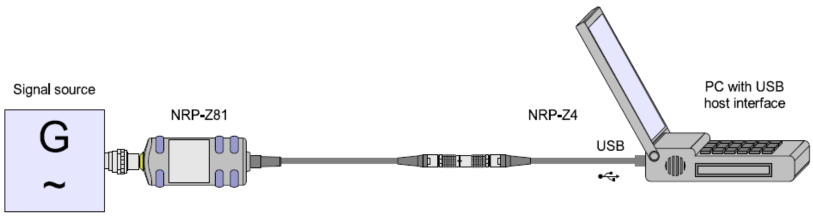


Fig. 7.2.2: Configuration with the passive USB adapter

7.2.3 R&S NRP-Z5 Sensor Hub

The R&S NRP-Z5 sensor hub allows up to four power sensors to be operated on one PC. It combines the following functions:
• 4-port USB 2.0 hub with Multi-TT architecture
• Power supply
• Through-wired trigger bus
• Trigger input and trigger output via BNC sockets

It is possible to cascade several R&S NRP-Z5 sensor hubs by connecting the *R&S Instrument* port of an R&S NRP-Z5 to one of the sensor ports of another R&S NRP-Z5. However, external triggering and the use of the *Trigger Master* function are then not possible. Instead, it is recommended that you connect all R&S NRP-Z5 hubs individually to the USB host or to an interposed USB hub. Then feed the external trigger signal to all R&S NRP-Z5 hubs via their trigger inputs.

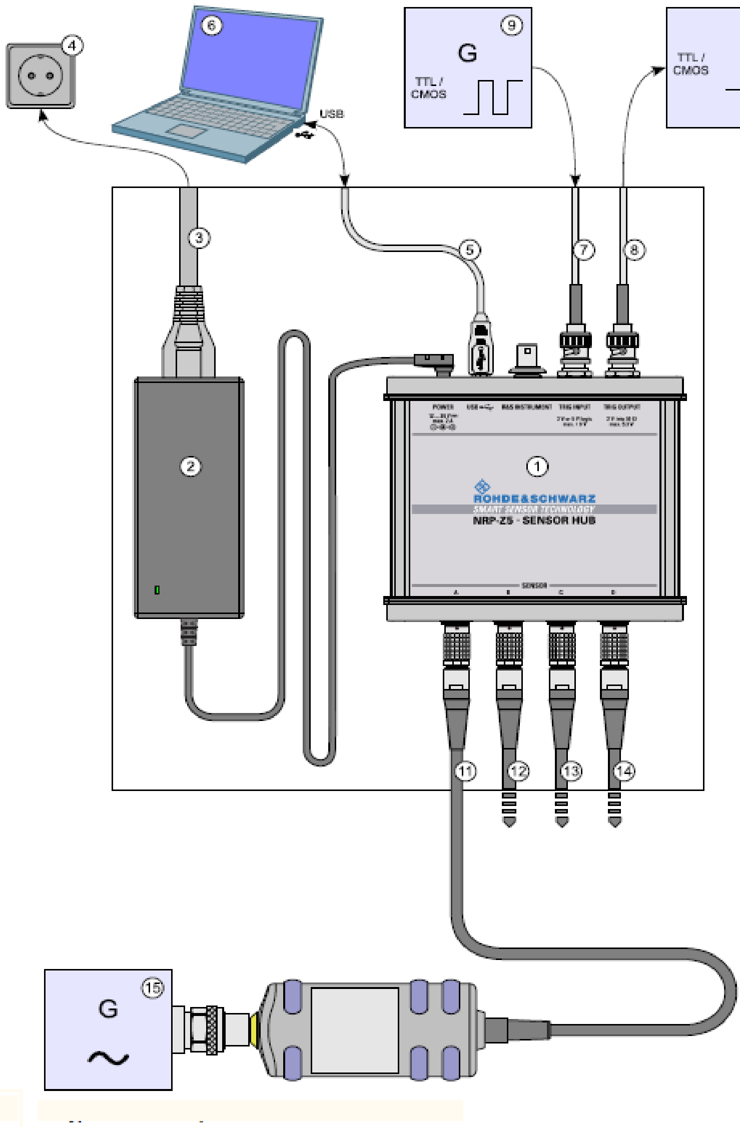


Fig. 7.2.3: Connecting the USB hub.

7.2.4 Third-Party Products

This section lists devices that are manufactured by other vendors and have been used successfully with R&S NRP-Zxx power sensors. Rohde & Schwarz cannot provide a continuous guarantee that these products will work with R&S NRP-Zxx sensors, because technical changes or newer versions of these products are not retested:

Icron (www.icron.com) offers the USB Ranger 110/410 products that are compliant with the USB 1.1 specification and can be used to cover a distance of up to 100 meters by using standard Cat 5 UTP cabling.

Icron (www.icron.com) offers the USB Ranger 2224 product that is compliant with the USB 2.0 specification and can be used to cover a distance of up to 500 meters by using a multi-mode optical fiber. When large distances between the control PC and the sensor(s) are required, a combination of the USB Ranger 2224 and the R&S NRP-Z5 has demonstrated reliable operation.

Fig. 7.2.4: Setup with 100 m optical fibre.

Digi (www.digi.com) makes the AnywhereUSB® Network-enabled USB hub. This product is used to access a USB device over a TCP/IP network.

8 Configuring the Application

Power Viewer provides a settings dialog that can be accessed by selecting Configure → Options from the main menu.
This dialog box is structured using separate tabs for drawing operations, timeouts, hard copies, USB, and debugging.

8.1 Data Format

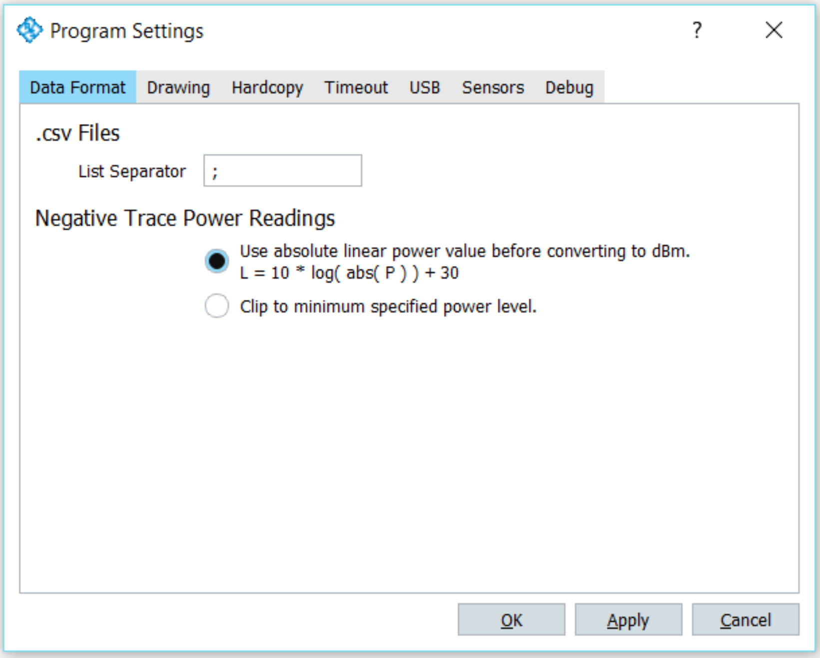


Fig. 8.1.1: Data format settings.

.csv Files
The list separator is the character that separates columns in a .csv file. The default character is the semicolon.

Negative Power Readings
The power sensor zeroing procedure sets the zero power reference level to the current A/D converter reading. Due to the Gaussian nature of sample noise readings below this reference value may occur. The sensor returns these readings as negative power values in Watts. Mathematically it is not possible to convert negative numbers to a logarithmic scale. This settings allows the user to select between two methods for the conversion. By default the software uses the absolute reading for the calculation of the logarithmic value. This method produces naturally looking noise but undershoots following a falling edge may appear as overshoots or ringing. The other clipping method sets all power readings that fall below the sensor lower measurement range to exactly this power level. Noise does not look quite as natural anymore but it is clearly visible which numbers fall below the zero reference level.

8.2 Drawing Performance

The drawing performance can be adjusted to accommodate slow PCs. Activating these features lowers CPU load or adds additional idle time.

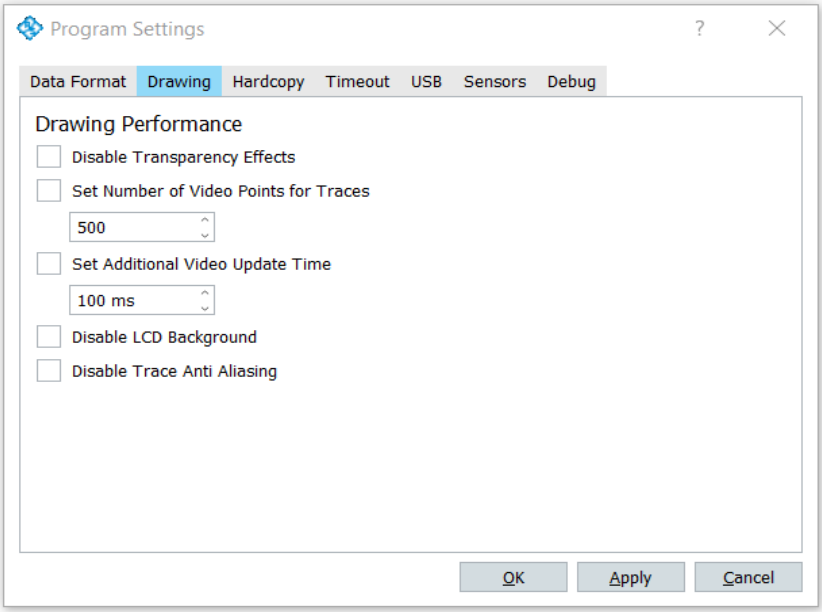


Fig. 8.2.1: Drawing performance settings.

Disable Transparency Effects
Lowers CPU consumption by avoiding semi-transparent drawing operations. Transparent drawing is used, for example, for the grid lines in the trace mode, because it makes it possible to see trace points that fall exactly onto a grid line.

Number of Video Points for Traces
Set to 500 by default, this number provides a good compromise between measurement speed and resolution. The higher the number of video points, the higher the CPU load and acquisition time. On low-performance PCs, it may be desirable to lower this number.

Set Additional Video Update Time
Adds idle time between two measurements. This reduces CPU load and provides resources to other applications. The default idle time between two measurements is in the order of 100 ms.

Disable LCD Background
Replaces the blue color gradient used in all LCD displays with a simple gray color. This option is useful for increasing the display contrast and for reducing CPU usage.

Disable Trace Anti-Aliasing
Turns off anti-aliasing in all trace and statistics measurement panels. Turning anti-aliasing off speeds up drawing operations and reduces CPU usage.

8.3 Hardcopy Settings

Power Viewer creates print reports or copies measurement results to the system clipboard. This greatly simplifies documentation tasks. Please see the "Hardcopy Features" and "Copy to Clipboard" sections for additional details.

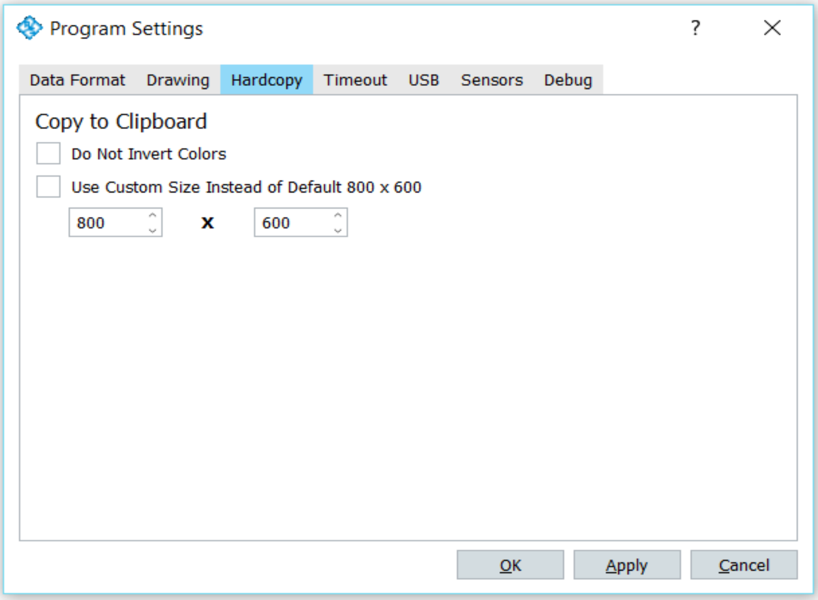


Fig. 8.3.1: Hardcopy settings.

Do Not Invert Colors
By default, the application uses printer-friendly colors when copying data to the system clipboard. This feature can be turned off by choosing not to invert the screen colors.

Use Custom Size...
The Copy to Clipboard function always creates a bitmap of a fixed size. This simplifies documentation tasks, since any display resolution may be used, and you do not need to specifically rescale captured images.

8.4 Timeout-Related Settings

The Timeout tab is shown below and is mainly used for connections across USB extenders or USB-to-LAN interfaces. These devices often introduce large turnaround times that need to be taken care of.

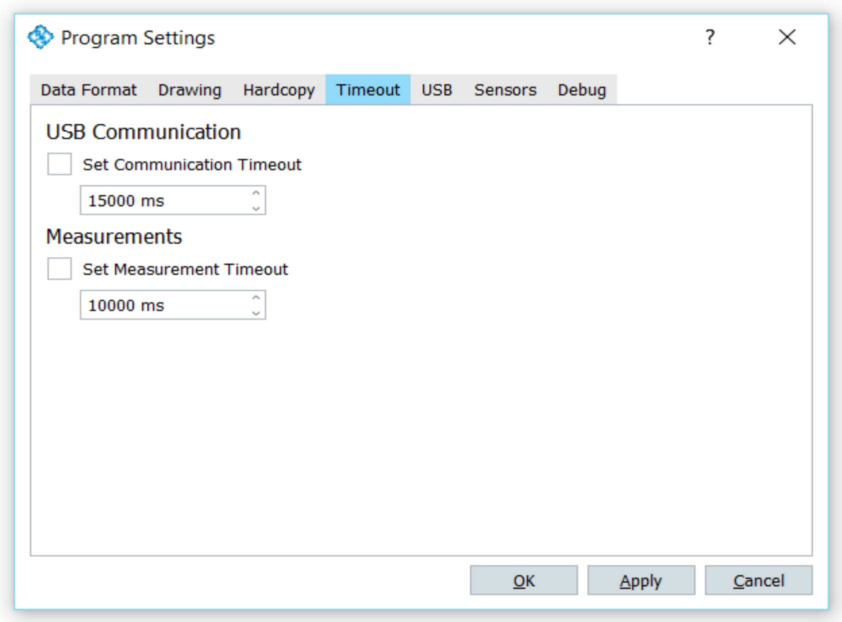


Fig. 8.4.1: Timeout settings.

Set USB Communication
By default, this value is set internally to 5 seconds. Connections across the Internet (e.g. using the Digi AnywhereUSB® device, www.digi.com) may require values of up to 15 seconds.

Set Measurement Timeout
This function is used internally to set the time between the point when a measurement is initiated and the maximum waiting time for the result. Normally, the internal time of 5 seconds should be sufficient. However, very slow connections may make it necessary to increase this time.

8.5 USB-Related Settings

The USB tab is shown below and is used for altering USB interface related settings on Microsoft Windows-based operating systems.

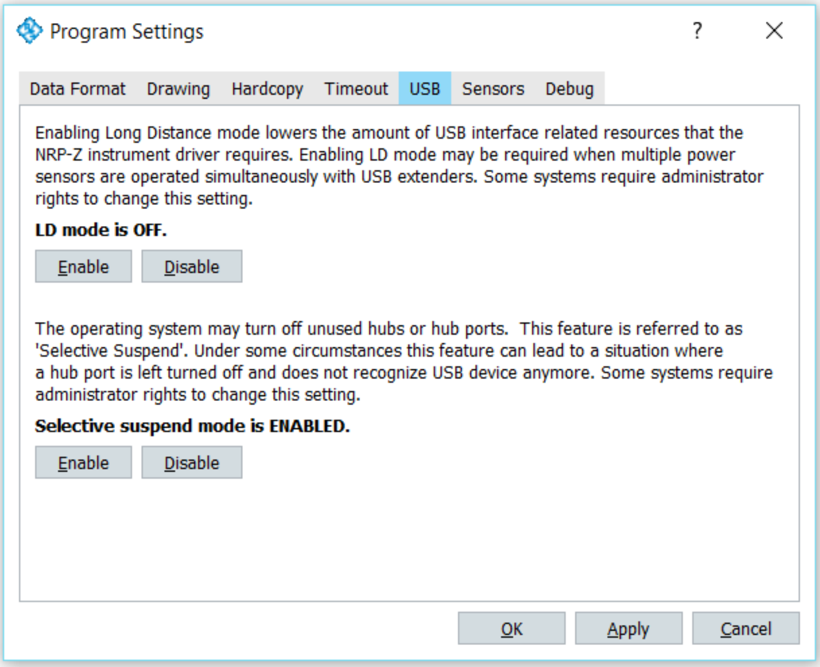


Fig. 8.5.1: USB settings.

Long Distance Mode
This mode is only available for Windows-based operating systems. It reduces the number of simultaneous read processes, which lowers USB resource allocation in the operation systems dramatically. AnywhereUSB® connections, for example, require activation of the Long Distance Connection mode.

Selective Suspend Mode
Windows can turn off unused USB hubs or unused ports on USB hubs. This is the default setting on most fresh installations. In some situations this mechanism does not work properly and can leave a hub turned off or in an undefined state. Disabling selective suspend turns this power saving mechanism off for all hubs and subsequently requires a system reboot. The selective suspend should only be turned off if USB devices do not get activated after they were plugged into a USB port.

8.6 USB Device Tree

The Sensors tab is shown below and is used for analyzing the USB device tree on Microsoft Windows-based operating systems. The tree is mainly intended for diagnostic purposes because some sensor / hub configurations have shown poor performance. These configurations are highlighted with a yellow exclamation mark.

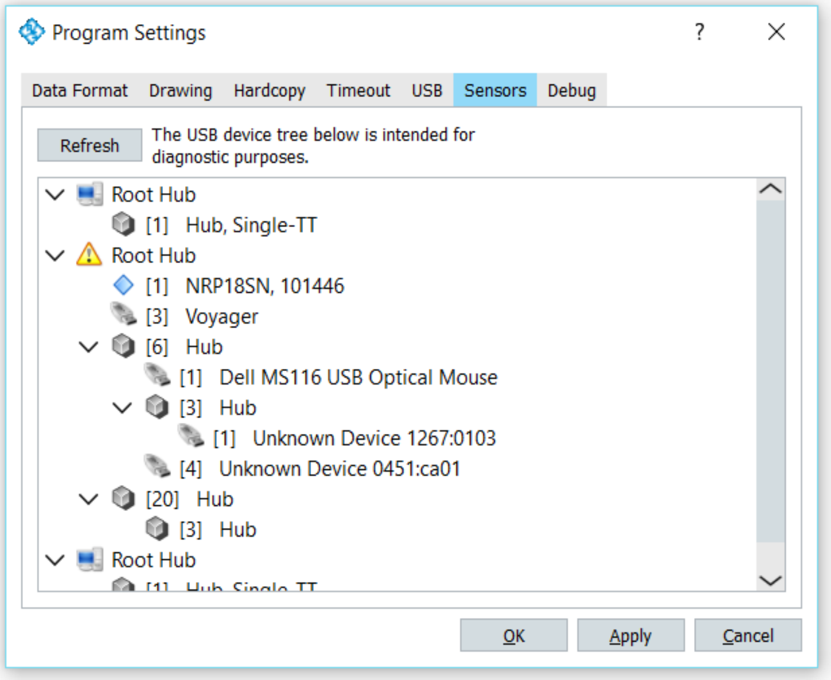


Fig. 8.6.1: USB device tree.

The following USB configurations should be avoided:

- NRP-Z sensors that are directly connected to Single-TT USB hubs.
- NRP-Z sensors that are directly connected to bus powered USB hubs.
- NRP-Z sensors that are directly connected to the PC's USB port (root hub).

Rohde & Schwarz generally recommends to operate NRP-Z power sensors with Multi-TT USB hubs. The hub should be equipped with a power supply that is rated for the total current of all connected sensors. Each individual hub port should be capable of delivering up to 500 mA to the USB device.

8.7 Debug Options

The debug options are mainly intended for debugging purposes. The following list contains debug options that may be used with certain measurements:

`contav.fastmode=1`
`multi.fastmode=1`
This option increases the measurement rate in the continuous power or multi-channel measurement mode and is explained in more detail in the related section in this manual.

`trace.thick=1`
This option draws bold traces in the trace measurement instead of using thin lines. Combined with a low trace point count, this setting is useful for outdoor service applications.

`trace.meastime=1`
When this option is enabled, the Power Viewer software displays the total trace measurement time in the trace window. This time is the period starting at the initiation of the measurement and ending when all data is received by the host.

`tsl.peak=0`
When this setting is disabled, the Power Viewer software omits peak readings in the timeslot measurement mode. Please note that peak measurements are subject to higher noise content, and the readings are only useful for levels greater than –5 dBm.

`contav.cmd=<cmd_list>`
`trace.cmd=<cmd_list>`
`multi.cmd<ch>=<cmd_list>`
If set accordingly, Power Viewer appends the SCPI commands provided in the command list `<cmd_list>` at the end of the measurement configuration. The command list can either be a single SCPI command or a list of commands separated by a semicolon (;). For the multi-channel measurement mode, the channel number must also be provided.
Using these commands is risky, because it may leave the sensor and user interface in different states.

`trace.noinfo=1`
This option suppresses the *Measure* information box in the trace window.

8.8 Setting the Application Colors

Power Viewer provides a color settings dialog box that can be accessed by selecting Configure → Colors from the main menu.
All color changes are applied immediately in all application windows. Therefore, it is possible to open windows, such as the trace measurement, and observe the color changes directly.

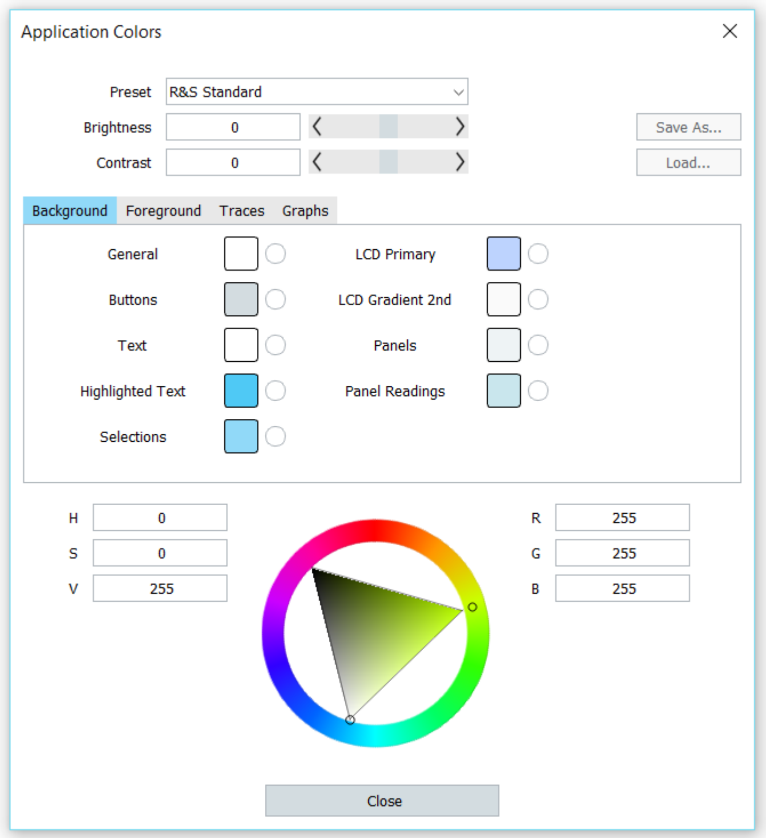


Fig. 8.8.1: Color settings dialog box.

Preset
The entire application can be set to one of the predefined color schemes or to a user-defined color set.

Save As…
This button saves the user color scheme to a file.

Load…
This button loads a color scheme from a file and replaces the current user color set.

Brightness
The brightness control changes the brightness for the entire application. Changing the brightness setting does not affect any of the user's color definitions.

Contrast
The contrast control changes the contrast setting for the entire application. Increasing the contrast reduces the brightness of background colors and increases the brightness of foreground colors. Changing the contrast does not affect any of the user's color definitions.

Color tiles
The small colored tiles represent the color of the individual elements.

One of these tiles can be selected for editing using the HSV color controls.

HSV color control

The application uses the HSV color model to define the application colors. This color model uses hue, saturation and value instead of red, green and blue components.
The hue represents the angle on the color wheel between 0° and 360°. This value is meaningless for non-chromatic colors, such as gray. The saturation is set in the range between 0 and 255; it defines how strong the color is. Grayish colors have very low saturation, whereas strong colors use high saturation values. The value defines the lightness; this parameter is also set between 0 and 255. The brighter the color is, the higher the value is.

9 First Steps

The main application window is divided into three major sections.

- The measurement window area
- The settings panel on the right side
- The upper and lower toolbars

Only one measurement can be active at a time, but it is possible to tile multiple measurement windows and switch from one to the other. All measurement windows have the same sensor assigned.
If the settings panel is enabled, it is always located on the right side. Its content changes with the currently activated measurement window.

Fig. 9.1: The main application window.

9.1 Numeric Entry Fields

The Power Viewer Software uses custom entry fields for most numeric data. These entry fields are closely related to regular text entry boxes that allow the user to enter any text. Custom entry fields differ from regular entry fields in that they format and validate the user input when the enter button is pressed, or the field looses the focus.

Numbers are entered with or without their SI prefix. The SI prefix can be one of the following letters:

G	Giga
M	Mega
k	kilo
m	milli
n	nano
u	micro
p	pico
f	femto

The entry fields also provide a "tooltip" help function that shows the minimum and maximum permissible input value. Additionally, a step size can be defined to increase or decrease the value when the mouse wheel is turned.

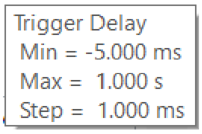


Fig. 9.1.1 Example of the help tooltip function.

The step value is defined by the current cursor position within the entry field.

9.2 The Menu Bar

9.2.1 File

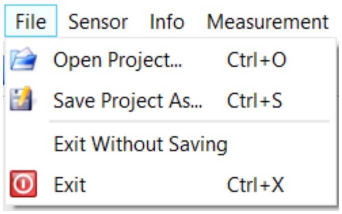


Fig. 9.2.1: File settings.

File → Open Project
Loads a previously saved configuration. These settings affect all measurements and fully restore the state of the entire application, including window positions.

File → Save Project As
Saves the configuration of the entire application to a file. This file may later be used to restore a measurement configuration. Measurement data is not saved as part of the settings file.

File → Exit
Aborts all running measurements, disconnects from the power sensor, and subsequently ends the application. All settings are saved.

9.2.2 Sensor

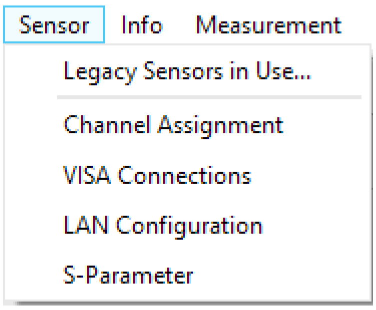


Fig. 9.2.2: Sensor menu.

Sensor → Legacy Sensors in Use
Opens a window that shows which application is using an R&S NRP-Z Power Sensor in legacy mode.

Fig. 9.2.3: Sensor usage by application.

The window only lists NRP-Z Power Sensors that are in use by the low level drivers in legacy mode. All newer R&S NRP Power Sensors are controlled via the VISA interface and are not listed here.

Sensor → Channel Assignment
Displays a panel that allows the user to assign alias names to each sensor. This simplifies working with multiple sensors. Alias names are only valid within Power Viewer.

Sensor → VISA Connections
Displays a panel that allows the user to manage connections to R&S NRP sensors. These sensors must be manually configured for use with the application. Power Viewer supports LAN VXI-11 and USB-TMC connections.

Sensor → LAN Configuration
Displays a panel that allows the user to configure the network settings of the currently selected LAN sensor.

Sensor → S-Parameter
Opens the s-parameter profile editing dialog. This dialog is used to download s-parameter sets of two-port devices to the sensor.

9.2.3 Info

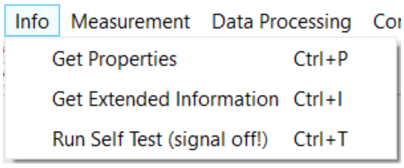


Fig. 9.2.4: Info menu.

Info → Get Properties
Displays a panel that contains a set of important sensor properties, such as the frequency and power range, as well as the firmware version.

Info → Get Extended Information
Reads all available information from the selected sensor. This menu option is only available when no measurements are running.

Info → Run Self Test
Performs a self-test on the selected sensor and returns the results as text message. The detector's noise level is measured as part of the sensor self-test routines. This only works when no RF signal is applied to the sensor's input while the test is running.

9.2.4 Measurement

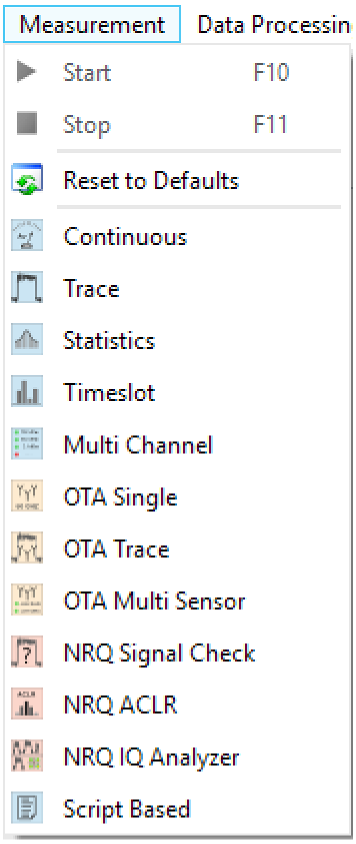


Fig. 9.2.5: Measurement menu.

Measurement → Start
Starts the measurement in the window that is currently active. This button is disabled when another measurement window is already running. Please note that some sensors may not support all measurement modes. In such cases, the start button is disabled, even if the measurement window is open and no measurement is running.

Measurement → Stop
Stops the currently active measurement. To add a level of protection, a measurement can only be stopped when its window is active and selected. This prevents unintentional stopping of a measurement.

Measurement → Reset to Defaults
Reset the currently active measurement settings back to default parameters.

Measurement → Continuous
Opens the panel for the Continuous measurement mode. In this mode, the power sensors perform asynchronous measurements on the signal power over a definable time interval (aperture time).

Measurement → Trace
Opens the panel for the Trace measurement mode. The panel displays the envelope power versus time.

Measurement → Statistics
Opens the panel for the Statistics measurement mode. In this mode, the signals CDF, CCDF, or PDF can be measured.

Measurement → Timeslot
Opens the panel for the Timeslot measurement mode. This mode measures the average and peak power of a definable number of successive timeslots.

Measurement → Multi Channel
Opens a panel that can display continuous power readings for up to 16 sensors.

Measurement → OTA Single (only R&S NRPM)
Opens the panel for the OTA Continuous measurement mode. In this mode, the power sensors perform asynchronous measurements of up to three channels on the signal power over a definable time interval (aperture time).

Measurement → OTA Trace (only R&S NRPM)
Opens the panel for the OTA Trace measurement mode. The panel displays the envelope power of up to three channels versus time.

Measurement → OTA Multi Channel (only R&S NRPM)
Opens a panel that can display continuous power readings for up to 16 OTA sensors. Each sensor measures the signal power of up to three channels.

Measurement → NRQ Signal Check
Opens the panel for the NRQ Signal Check. The panel displays the power spectrum of the signal.

Measurement → NRQ ACLR
Opens the panel for the NRQ Adjacent Channel Power measurement. The panel displays the ACLR as bar graph of the signal.

Measurement → NRQ IQ Analyzer

Opens the panel for the NRQ IQ Analysis measurement. The panel displays the I/Q baseband signal versus time as well as a constellation diagram and a power spectrum.

Measurement → Script Based
Opens the scripting window. The scripting measurement module is used to execute SCPI scripts or to define custom measurements. Please see the scripting section for additional details.

9.2.5 Data Processing

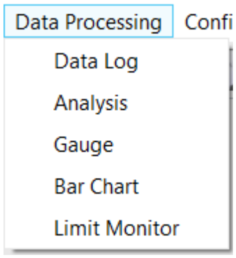


Fig. 9.2.6: Data Processing menu.

This menu contains functions that do not perform measurements but receive measured values for evaluation. Most data processing functions must be started manually after the measurement has begun. Typically, the data processing automatically finishes when the measurement stops.

Data Processing → Data Log
The data log captures up to four different values over a definable period. The data is captured in two ways: The default method stores the readings in up to 20000 data bins (memory). This data can be viewed and exported to a file. The second method writes the captured values directly to a file while the measurement is running. There is no limitation on the number of data points when writing to a file.

Data Processing → Analysis
The analysis window evaluates up to four measurands statistically. In the default configuration, the Power Viewer creates a histogram view in each analysis channel.

Data Processing → Gauges
The gauges window displays up to four numerical values on a large display. Each gauge can be switched between a digital and an analog display. The gauges panel is useful if values need to be read from a greater distance.

Data Processing → Limit Monitor
The limit monitor module compares up to 16 measurands against upper and lower warning and error limits. It can send limit violations to a remote host via its internal TCP/IP server.

9.2.6 Window

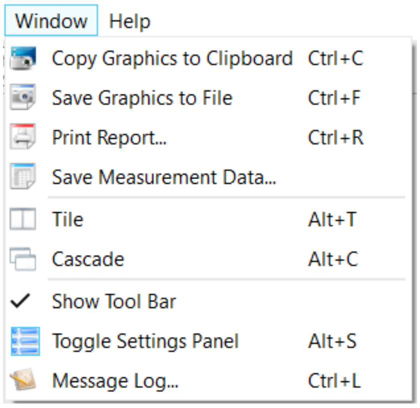


Fig.9.2.7: Window menu.

Window → Copy Graphics to Clipboard
Sends the content of the currently activated measurement window to the system clipboard. This option is only available for measurements that display their results in graphical form (such as trace, statistics, timeslot and data log measurements). The copy-to-clipboard function simplifies documentation tasks, because the graphics can simply be pasted into other applications.
Please see chapter 10.2 "Copy to Clipboard" for a detailed description.

Window → Save Graphics to File
This function is similar to the above menu option, but it creates a .png file on the user's desktop that contains the screen shot.

Window → Print Report
Creates a printout of the measurement that is currently activated. The printout is a one-page document that contains the measurement and all important sensor settings. Colors are inverted where necessary to avoid a black background. This option is only available for measurements that display their result as graphics (such as trace, statistics, timeslot, and data log measurements).
Please see chapter 10.1 "Print Report" for additional details.

Window → Save Measurement Data
Saves measurement data from the currently active window to a .csv file. This extension stands for comma-separated values. Files in this format list data in columns that are separated by a single comma. This option is only available for measurements such as the trace, statistics or data log measurements. Comma-separated value lists can easily be imported into most applications, such as Microsoft® Excel® or Open Office.

Window → Show Tool Bar
Enables or disables the upper tool bar. Disabling the tool bar is useful if the application shall be used with screen resolutions of 800 x 600 pixels or less.

Window → Toggle Settings Panel
Enables or disables the settings panel on the right side of the application window. Removing the settings panel frees some display space and can be useful if the screen resolution is limited, e.g. 640x480 pixels.

Window → Message Log
The log window captures all internal messages generated by the

application. By default only information and error messages are captured. Starting the application with the command line argument `--debug` also enables log messages. The log message window is automatically activated in case of an error. This menu item is used to bring up the log window manually.

9.2.7 Help

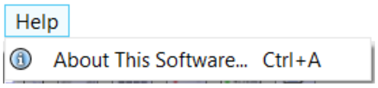


Fig. 9.2.8: Help menu option.

Help → About This Software
Displays program information, such as the software version number and licensing information.

9.3 The Toolbar

The application provides a main toolbar that is located at the top of the main program window. This toolbar hosts shortcuts to commonly used functions and measurements.

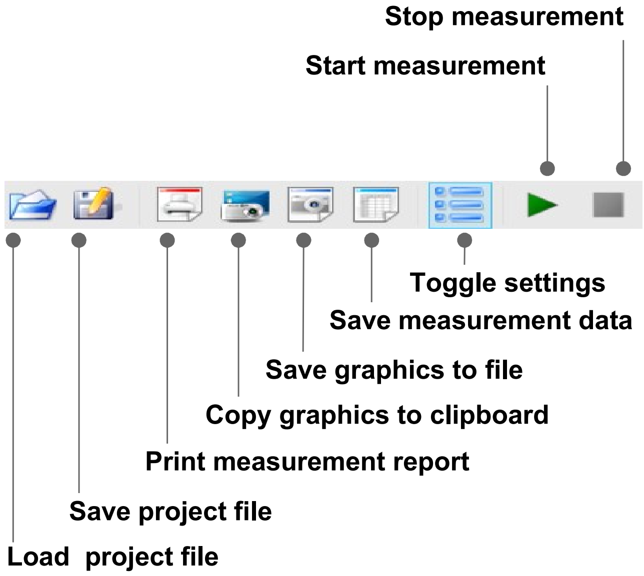


Fig. 9.3.1: The main toolbar.

9.4 Selecting a Sensor

A second toolbar is located at the lower border. It is used for sensor selection and for general settings. This toolbar is divided into two sections: The left side provides measurement and data-log running indicators as well as a control for sensor selection. If no sensor was detected during the last USB bus scan, only the sensor simulation function (NRP-Z00) is available. This simulation capability can be used for basic demonstration and testing of the program's functionality.

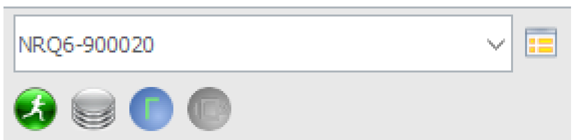


Fig. 9.4.1: Second toolbar with sensor selection.

The application remembers the last sensor selection and tries to reuse this device if it was detected during a USB scan. If the last sensor that was used is no longer detected, the first detected sensor is used instead.
Please note that changing the sensor type may affect measurement settings. Power Viewer double-checks measurement settings before a measurement is started and corrects values if necessary.

9.5 General Measurement Settings

The right toolbar section provides general settings for defining the signal frequency, level offset, or gamma correction settings, or for selecting the use of an S-parameter set.

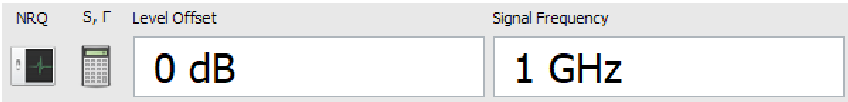


Fig. 9.5.1: Second toolbar with general settings.

Please note that the general settings are applicable to all measurement functions, except for multi-channel measurements. The multi-channel measurement function provides individual settings for each sensor.

Signal Frequency
This frequency is used to correct measurement results in various ways. It is essential that the current carrier frequency be set. Otherwise, non-linearities or temperature dependencies considerably greater than those stated in the data sheet can arise.

Level Offset
The offset accounts for external losses. If, for example, a 60 dB directional coupler is used to sense power from a DVB-T transmitter, the coupling loss can be used as the offset. Power Viewer sets up the sensor accordingly and displays the corrected power measurements.

9.6 Corrections Dialog

The Corrections dialog contains advanced correction options that are less frequently used. The dialog settings apply to all power measurements, except for multi-channel mode and the script mode.

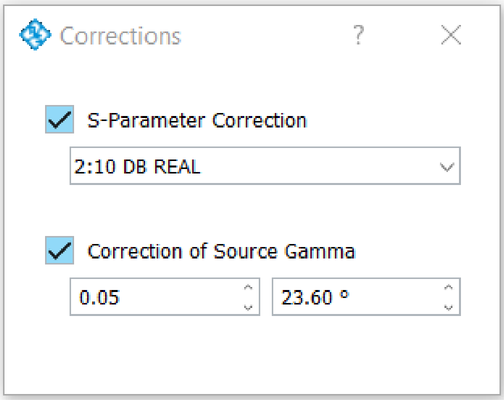


Fig. 9.6.1: Corrections dialog.

S-Parameters (embedding)
This check box activates one of the S-parameter correction data sets stored in the sensor. S-parameter correction is used to compensate for a component (attenuator, directional coupler) connected ahead of the sensor by means of its S-parameter data set. Using S-parameters instead of a fixed offset allows more precise measurements, because the interaction between the sensor and the component can be taken into account.

The S-parameter controls may be grayed out if the s-parameter state is locked in the sensor. Please see the S-Parameters section in this manual for detailed information on how to lock or unlock S-parameters.

Further information about practical applications in which S-parameter correction is useful can be found in the application note 1GP70 on the Rohde&Schwarz web site.

Gamma Correction
The gamma correction value sets the source's complex reflection coefficient. A magnitude value of zero corresponds to an ideally matched source, and a value of one to total reflection. The phase angle can be set between –360.0 and +360.0 degrees.

9.7 NRQ Settings Dialog

The NRQ settings dialog contains specific settings related to the frequency selective power sensors. The dialog settings apply to all NRQ power measurements, except for the script mode.

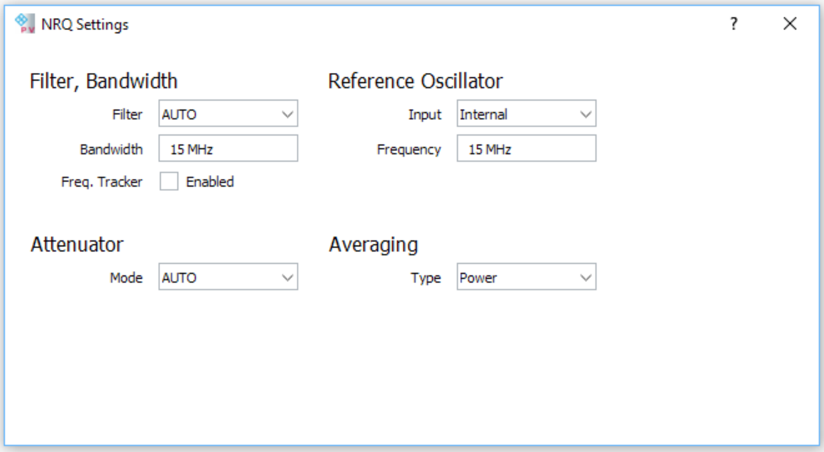


Fig. 9.7.1: NRQ settings dialog.

Filter, Bandwidth
The R&S NRQ sensor supports different filter types. Each filter type is optimized for a different purpose.

Flat
Possesses a flat passband with a nearly linear phase response. If the signal bandwidth does not exceed the passband bandwidth, the signal shape is not affected by the filter. Otherwise, the filter reduces the bandwidth of the signal.

Normal (RRC) - Bandwidth >= 25 MHz
Gaussian-like filter that is optimized for a small rise time, where the overshoot in the power domain caused by the filter itself is limited to 5 %. Since the filter is not flat, the power of the input signal decreases away from the center frequency. The spectral components in the middle of the filter are correctly leveled.

Normal (Gaussian) - Bandwidth <= 10 MHz
Gaussian filter with configurable 3 dB bandwidths. Gaussian filters have a short impulse response, which makes the Gaussian filter advantages for very short measurement times. In this case, the settling time which subtracts from the total measurement time is minimized and the effective measurement time is maximized. As a side effect, the shortest possible measurement time is decreased. Furthermore, the filter is smooth both in the frequency and in the time domain.

Attenuator
Adjust the input attenuator to prevent that mixers and amplifiers operate close to their compression points. Thus, uncertainties in the measurement result due to nonlinear effects such as intermodulation products and gain compression are decreased. However, as a side effect, the signal-to-noise ratio (SNR) is decreased. This increases the measurement uncertainty.

Reference Oscillator
By default, the R&S NRQ generates its conversion frequency, sampling

clock and reference clock internally. Alternatively, you can use external clock sources.

Averaging

In continuous average and trace mode, the R&S NRQ supports three different averaging domains with the following characteristics.

	Power	Video	Linear
Averaging Unit	Watt	dBm	V
Bias caused by noise floor	High	Low	Medium
Uncertainty caused by noise floor	Low	High	Medium

Frequency Tracker

The R&S NRQ offers an in-built frequency tracker. The frequency tracker is available for bandwidths ≤ 10 MHz. The frequency tracker is suitable to correct slow drifts and constant offsets for CW signal levels of 20 dB above the noise floor.

10 Hardcopy Features

Power Viewer provides two features that greatly simplify documentation tasks. With a simple mouse click, it is possible to create a print report for the trace, statistics, or data log panel. Additionally, the current graphics can be copied to the system clipboard and pasted into any other application.

10.1 Print Report

The print button in the toolbar automatically creates a one-page measurement report from the current data. Colors are inverted for printer friendliness. The picture below shows an example of the generated form.

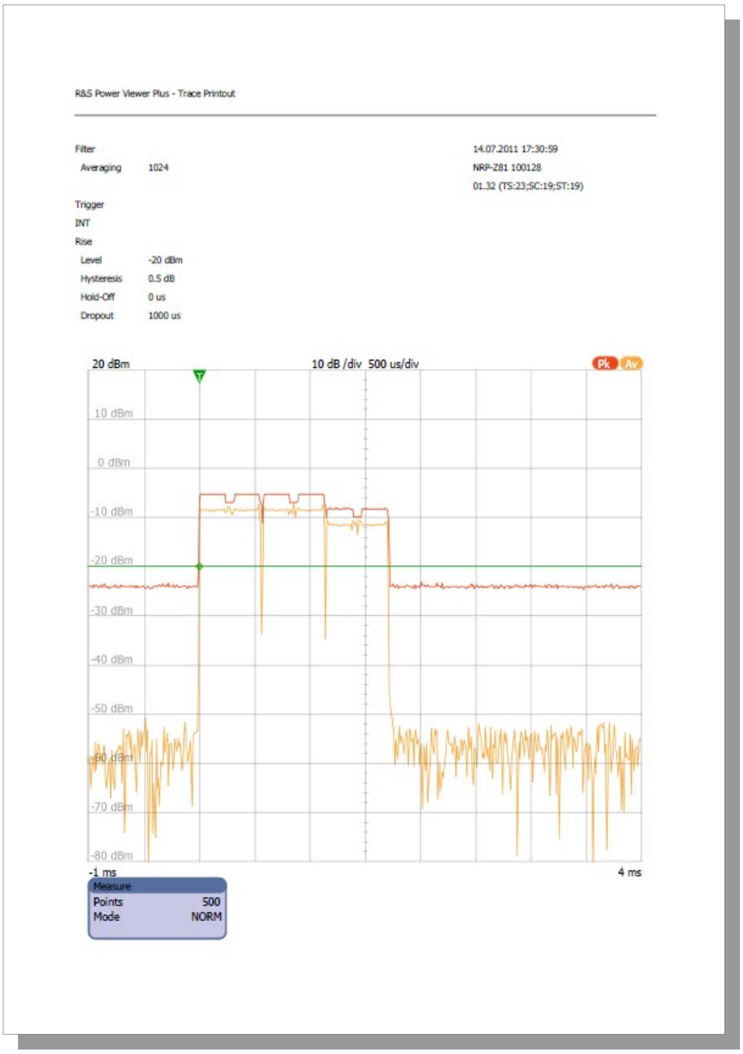


Fig. 10.1.1: Example of a printed report.

On Linux-based systems, the printer selection dialog offers printing directly to a .pdf file, in which case a PDF document is created without the use of any third-party software.

10.2 Copy to Clipboard

The copy-to-clipboard function creates a bitmap of fixed size from the current measurement and subsequently places the bitmap into the system clipboard.
By default, colors are inverted, and a resolution of 800 x 600 pixels is used. If this is not acceptable, these parameters can be changed in the settings dialog box.
The figure below shows a captured measurement at a resolution of 800 x 600 pixels.

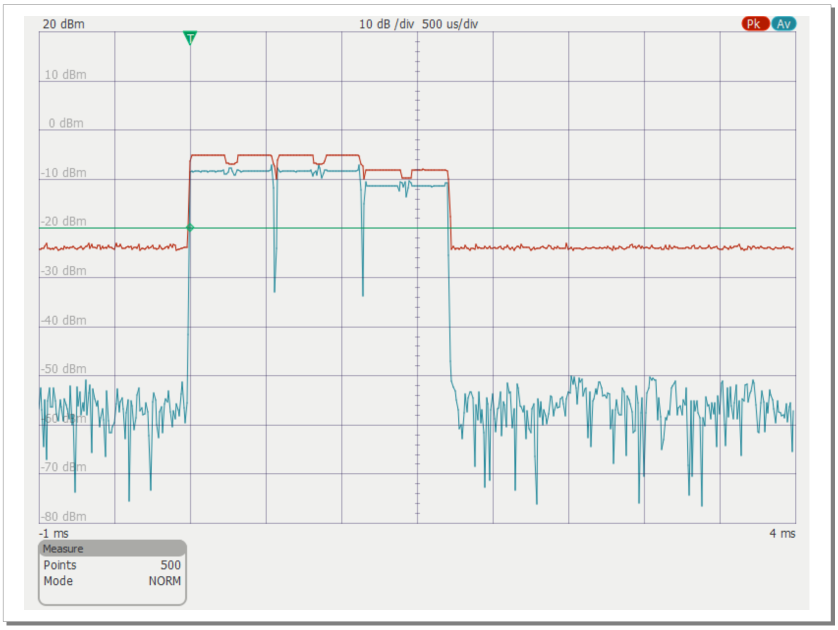
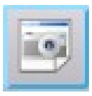


Fig. 10.2.1: Graphics copied to clipboard.



10.3 Save Graphics to File

The save graphics to file function creates a bitmap of fixed size from the current measurement and subsequently creates a .png file on the desktop or in the user's home directory.
By default, colors are inverted, and a resolution of 800 x 600 pixels is used. If this is not acceptable, these parameters can be changed in the settings dialog box.

11 The Message Log

The Message Log window can be activated from the Window menu. This window lists text messages, warnings, and errors that are generated by the application or by the VXI PnP driver.

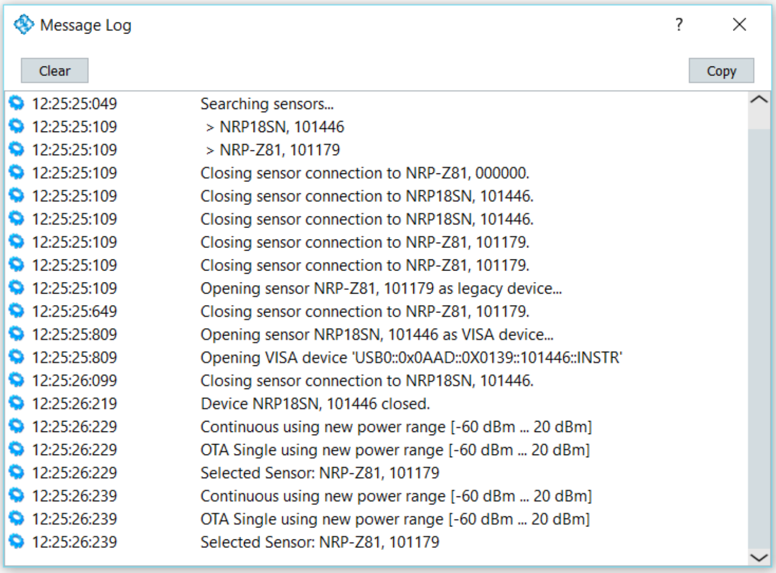


Fig. 11.1: The message log window.

Clear
Clears all of the window's content.

Copy
Copies the window content as text to the system clipboard. This text may then be pasted into other applications, such as email clients.

Dealing with unexpected behavior
If the program or sensor displays unexpected behavior, it is advisable to forward a detailed problem description along with system information (such as the sensor type, serial number and firmware version string) to the R&S customer support:

customersupport@rohde-schwarz.com

12 Channel Assignment

Power Viewer maintains a list of alias names that can be assigned to sensors. Each R&S NRP sensor can have an individual name assigned to it, which is displayed throughout the application as an additional piece of information.
If no alias name is set for a sensor, the application only displays its type and serial number in all sensor selection controls.
The Channel Assignment dialog uses the placeholder <name> if no alias name has been defined. Double-clicking the name field allows the user to edit the entry.

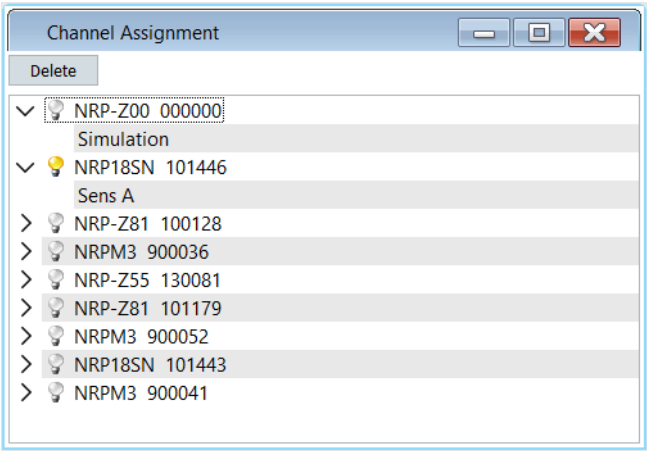
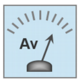


Fig. 12.1: The channel assignment dialog.

Using alias names simplifies measurement tasks that involve multiple sensors. For example, calculating an amplifier gain requires measurement of the input and output power. Alias names, such as “input” or “output,” may be assigned to the sensors connected to these ports.
Sensors that are detected during a scan are indicated by illuminated light bulbs, whereas unavailable devices appear as gray bulbs.

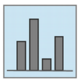
13 Measurements Overview

The following list briefly describes all measurements available in Power Viewer. The availability of the individual measurements depends on the selected sensor. Not all sensors support all measurement modes, e.g. a thermal power sensor does not offer a trace measurement.



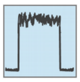
Continuous Average
Continuous average power measurement with one single sensor.

OTA (Continuous Average)
Continuous average power measurement with all antenna elements connected to the OTA sensor.

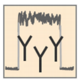


Timeslot
Average power measurement in consecutive timeslots.

Statistics
Measure the power distribution such as CCDF or PDF.

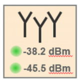


Trace
Measure the RF power envelope.



OTA (Trace)
Measure the RF power envelope with all antennas connected to the OTA sensor.

Multi Channel
Measure the average power with multiple sensors simultaneously.

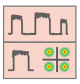


OTA (Multi Channel)
Measure the average power with multiple OTA sensors simultaneously.

Script
Use Java Script for custom measurement tasks.

NRQ Signal Checking
Shows the power spectrum.

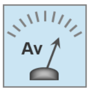
NRQ ACLR
Measures the Adjacent channel power of a signal.



NRQ I/Q Analyzer
Shows the I/Q signal versus time, a constellation plot and the power spectrum.

Please see the following chapters for a detailed description of these measurements.

14 Continuous Power Measurement



In this mode, the measurement signal's average power is measured asynchronously within definable time intervals. This time interval is referred to as the sampling window or aperture time. The width of a sampling window is preset to a length that is optimal for the selected sensor, but it can be changed to other values. The measurements are performed with chopper stabilization to obtain more accurate results with reduced noise and zero offset. Therefore, a measurement is always performed over two sampling windows, with the polarity of the detector output signal being reversed for the second window. Taking the difference between the output signals minimizes the video path's influence on noise and on zero drift. When the averaging function is activated, the averaging factor determines how often the described measurement cycle is repeated.

14.1 Settings

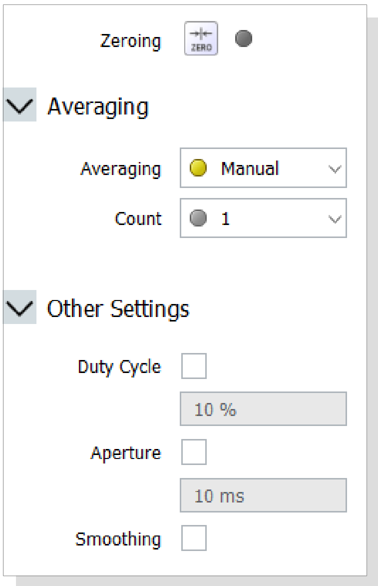


Fig. 14.1.1: Settings for continuous power measurements.

Zero
This option is only available while the measurement is running. It starts the zeroing sequence for the current sensor. For this purpose, the RF signal must be switched off, or the sensor must be disconnected from the signal source. The sensor automatically detects the presence of any significant power, which causes zeroing to be aborted and an error to be generated. The LED next to the zeroing button changes it's color depending on the current zeroing state.

Grey	Zeroing was not performed since the measurement got started.
Blue	Zeroing is in progress. The measurement results are not updated during this time.
Green	Zeroing finished successfully.
Red	Zeroing failed. In this case the LED initially flashes and

then turns red continuously.

The zeroing process may take more then 8 seconds to complete and varies with the sensor model.
Generally, it is possible to run the sensor zeroing with a small signal (such as broadband noise) applied to the sensor. This makes it possible to compensate for this signal in later measurements.

Averaging
The averaging mode can be set to either Auto or Manual. In manual mode, the sensor uses an averaging factor that is set by the user between 1 (no averaging) and 65536.
In auto mode, the sensor determines the optimum average filter count based on a resolution of 0.01 dB.

Count
This is the number of measured values that have to be averaged to generate the measurement results. Raising the averaging factor reduces fluctuation in measured values and lengthens the amount of time required to complete the measurement.

Duty Cycle
The duty cycle can be set as a percentage when pulse-modulated signals are corrected. With correction activated, the sensor calculates pulse power from the duty cycle and the average power.

Aperture Time (Sampling Window)
The sampling window (aperture time) is the time period that is used to form one sample. The Power Viewer software automatically uses a default window that best fits the selected sensor. Wider sampling windows may be required if the measurement result exhibits fluctuations due to modulation. In this case, it is beneficial to set the sampling window length to a value equal to the modulation period.

Smoothing
The smoothing filter is a steep-slope digital lowpass filter used to suppress result variations due to modulation. Smoothing should be activated to reduce result variations due to modulation when the size of the sampling window cannot, or should not, be set to exactly equal the modulation period. If the selected sampling window is 5 to 9 times larger than a modulation period, the display variations are usually sufficiently reduced. With smoothing deactivated, 300 to 3000 periods are required to obtain the same effect.
When smoothing is deactivated, the sampling values are considered to be equivalent, and they are averaged in a sampling window, which means that the measuring instrument acts as an integrator. As described above, optimum suppression of result variations is obtained when the size of the sampling window exactly equals the modulation period. Otherwise, modulation can have a considerable influence, even if the sampling window is much larger than the modulation period. The response can be improved considerably by weighting samples, which is equivalent to video filtering. This is exactly what happens when smoothing is activated.
Since the smoothing filter increases the sensor's inherent noise by approx. 20%, it should always be deactivated when it is not required.

Debug settings
Debug settings are entered in the debug options field in the program settings dialog. Open this dialog from the program menu by selecting Configure → Options → Debug.

```
contav.fastmode=0|1
```

In normal measurement mode, the sensor measurements are initiated at a lower rate. All measurements are forwarded to the data processing panels. Only one measurement within a time period of 100 ms is sent to the numeric display. This ensures a convenient display update rate while simultaneously allowing for fast settling of the moving average filter.
In applications in which CPU consumption is not critical, it is possible to increase the measurement rate to capture more sensor readings in data processing panels, such as the data log.

14.2 Numerical Data View

Power Viewer displays average power readings in numerical and graphical form. The numerical display shows the main measurement as well as additional information, such as the averaging count, measurement mode, and measurement window (aperture).

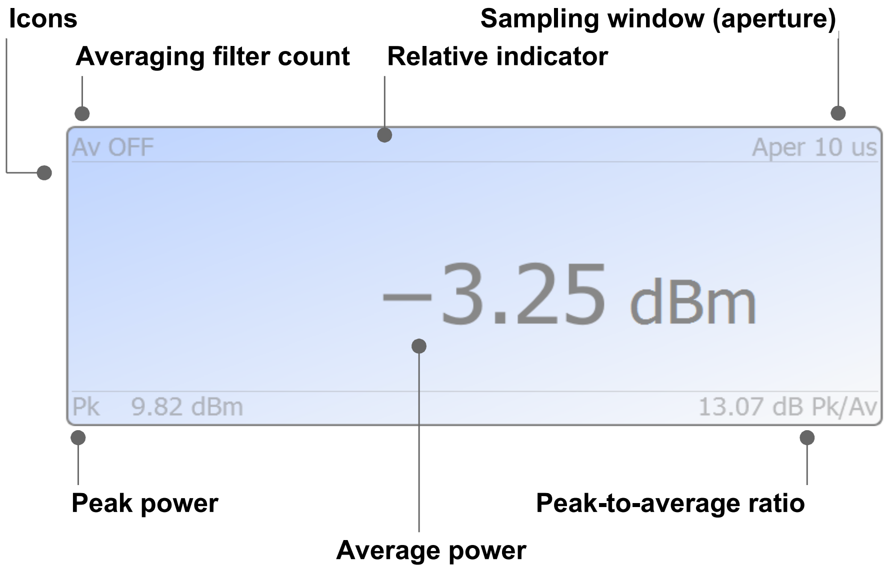


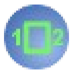
Fig. 14.2.1: The numerical data view.

The units can be switched between dBm, dBW, dBμV, and W.
A context menu can be activated by right-clicking in the display area. This menu sets the display resolution to 0.001, 0.01, or 0.1. The display resolution setting does not affect the measurement itself, it only limits the number of visible digits.

Both linear and logarithmic power readings are average measurements based on the current average filter setting. If the sensor provides peak power data, these readings are displayed below the main reading.

In the upper left display corner, a set of icons informs the user about the measurement state.

Duty-cycle correction
This icon is displayed in the display's upper left corner when duty-cycle correction is active.

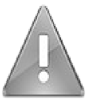


S-parameter device
This icon is displayed in the display's upper left corner when S-parameter correction is active.

Offset
This icon is displayed in the display's upper left corner when a level offset is set.

Over-range warning
This icon is displayed in the display's upper left corner when the power level approaches the sensor destruction limit.

14.3 Negative Power Readings



When a noisy signal is measured close to the power level at which the sensor was zeroed, negative power readings may occur in the linear scale. The logarithmic scale ignores the polarity and always uses the linear power reading's absolute value.
In rare cases, the reading may be exactly zero. Since it is impossible to convert zero into a logarithmic scale, a value that is 20 dB below the minimum specified measurement level is used instead.

14.4 Accuracy of Peak Power Measurements

Please note that care must be taken to ensure the accuracy of peak power readings. Chopper stabilization or averaging techniques cannot be used with peak measurements. As a result, the measurement noise level is substantially higher. The following section discusses the influence of the higher noise level in great detail.
Noise needs to be looked at as a statistical process which can be described by a normal distribution. The figure below shows the shape of this distribution. The dark area marks values that are less than one standard deviation away from the mean value μ. For a normal distribution, 68.2 % of all values fall into this range.

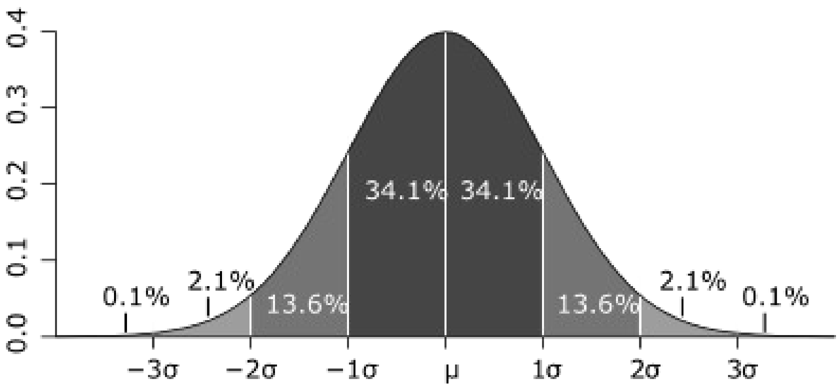


Fig. 14.4.1: Normal distribution.

Peak power measurements record the maximum power that was detected within the observation period. The longer this observation period is, the more likely it is that a higher power value will occur. The following discussion explains the influence of noise on the peak-power measurement accuracy. This example uses the technical data for the R&S NRP-Z81 wideband power sensor.

- An observation time of 500 µs at full bandwidth (a 12.5 ns sampling time) results in 40000 samples that are to be evaluated.
- The sample noise specified for the NRP-Z81 sensor running at full bandwidth is typically 2 µW (for 2 standard deviations). This means that 34.1 % of all values are less than 1 µW above the average value.
- The probability for one sample out of the given 40000 values is 1 / 40000 = 2.5^{-5}. The associated σ value for this probability for the normal distribution is about 4.5 according to the following equation:

$$\phi(x)=\frac{1}{\sqrt{2\cdot\pi}}e^{-\frac{1}{2}x^2}$$

- The peak sampling noise that needs to be expected based on the normal distribution is, therefore: 1 µW * 4.5 = 4.5 µW.
- Due to the detector's non-linear response, additional noise multiplying factors need to be considered depending on the signal level applied to the sensor. These factors are provided in the sensor's technical specifications. For a signal level of 1 mW at room temperature, the noise multiplication factor is 3.8.
- The overall noise power that needs to be expected calculates to: 4.5 µW * 3.8 = 17.1 µW.
- The total error based on the above assumption for a 0 dBm signal would then be:

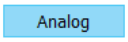
$$100\%\cdot\frac{17.1\,\mu W}{1\,mW}=1.71\%$$

Power Viewer removes the numeric peak and peak-to-average ratio for peak readings below –3 dBm.

14.5 Relative Measurements

Relative measurements display the current reading relative to a previously set reference power level. This measurement mode is useful when the measurement task requires analysis of a power reading's stability or drift.
When the measurement mode is changed to relative, Power Viewer saves the current reading as a reference value. Subsequent mode changes then no longer alter this reference power level, and a new level is set using the →REF button.

14.6 Analog Meter



Power Viewer also displays power readings graphically as an analog bar graph. The bar graph shows the average power level as a blue arrow and the peak power level as a red arrow. Each arrow holds the maximum value for a time period of about 5 seconds. Maximum readings are indicated by the smaller and darker arrows.

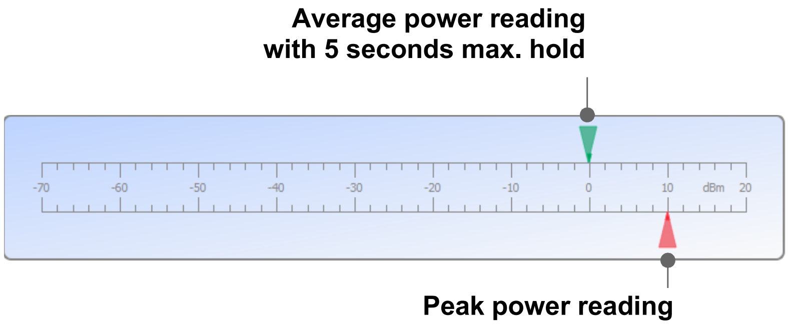


Fig. 14.6.1: Analog meter in absolute measurement mode.

The analog meter can also be used in the relative measurement mode, in which case it displays the change in the measured value relative to a previously set value. A context menu can be invoked by a right mouse click and used to change the display range between a 20 dB, 10 dB, 2 dB, and 1 dB full scale.

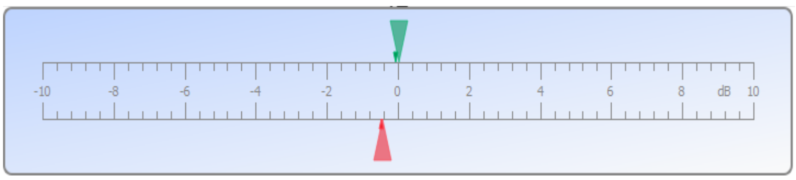


Fig. 14.6.2: Analog meter in relative measurement mode.

Please note that some sensors only provide average power measurements. In such cases, the red arrow is not visible.

14.7 Trend Chart

Statistics

For analysis of power readings over time, Power Viewer provides an additional statistics panel. This panel supports multiple views, such as a trend chart, a histogram, or the Q-Q-plot. The view mode is selected via the panel's context menu.
The trend display shows past measured values over time. New values are appended on the right side of the chart, and they move to the left side with time.

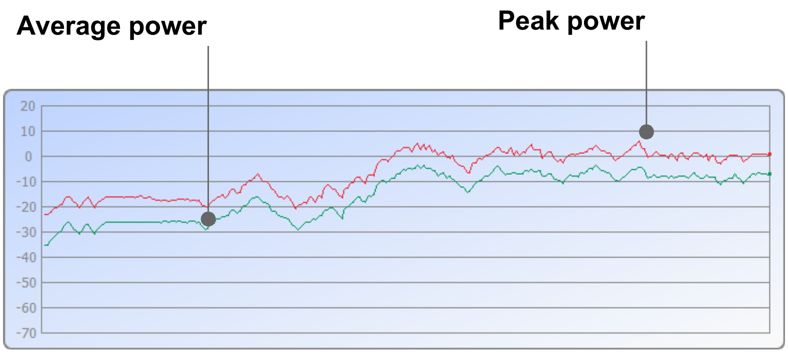


Fig. 14.7.1: Trend chart in absolute measurement mode.

Analogously to the analog meter, the blue trace indicates average power, whereas the red trace is used for peak power readings. The trend chart does not provide a time scale, because the time varies depending on the filter and measurement-window settings.

Please note that Power Viewer sets the sensor to a moving average filter mode. This ensures a constant measurement rate regardless of the averaging filter count or sampling window length. As a result, fast level changes do not appear as a step in the trend chart. Instead, they exhibit a smooth transition from one level to the other.

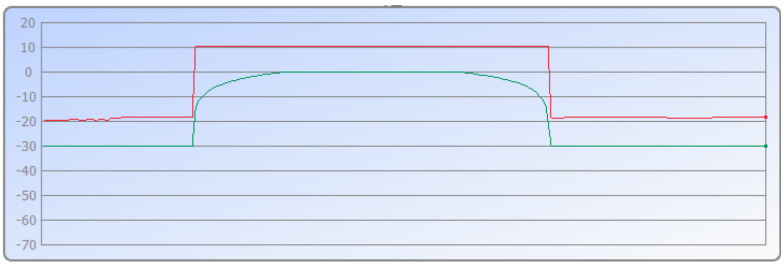


Fig. 14.7.2: Step response for a measurement taken with an NRP-Z81 on a 3GPP signal with the manual averaging filter set to 256 and the aperture set to 10 ms.

14.8 Histogram Display

The histogram sorts the measured values into categories (data bins) that are evenly distributed between the minimum and maximum readings. The results are displayed as a bar chart in which the height of a bar indicates how many measurements fall into each category. The number of samples that are used for evaluation can be 250, 1000 or 5000.

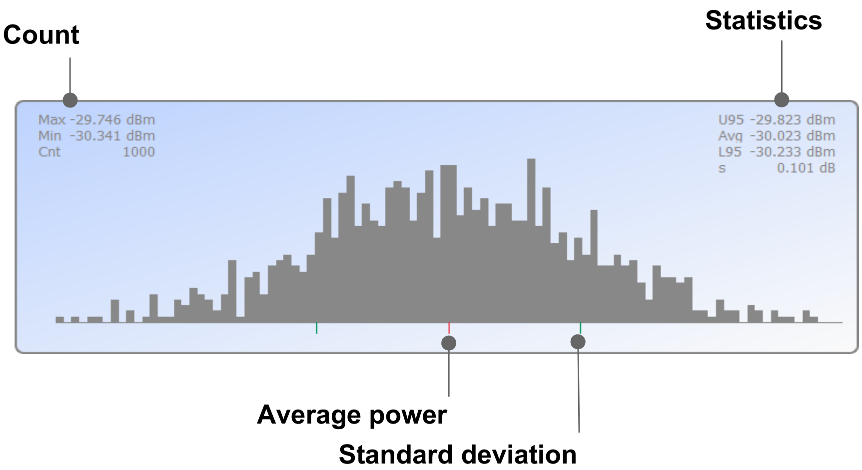


Fig. 14.8.1: Histogram display.

The minimum (Min) and maximum (Max) power readings are displayed in the upper left corner.
The count (Cnt) indicates how many readings were accumulated for the analysis. The count remains at a constant value as soon as the set number of readings has been reached.
The average (Avg) power of all accumulated readings and the sample standard deviation (s) is displayed in the panel's upper right corner. The following formulas are used to calculate these two parameters:

$$\bar{x} = \frac{1}{N} \sum_{i=1}^{N} x_i$$

$$s = \sqrt{\frac{1}{N-1} \sum_{i=1}^{N} (x_i - \bar{x})^2}$$

The terms "L95" and "U95" are used for the 95 % confidence intervals for the average power level:

$$L95 \simeq \bar{x} - \frac{2 \cdot s}{\sqrt{N}} \qquad U95 \simeq \bar{x} + \frac{2 \cdot s}{\sqrt{N}}$$

14.9 Q-Q-Plot

The Q-Q-Plot (Quantile-Quantile-Plot) is a graphical method for comparing two probability distributions.
The Power Viewer software provides a normal probability plot that compares the probability distribution of the measured values against an ideal normal distribution.
If the measured values are distributed normally, all graph points are located on a straight line. Departures from this straight line indicate that the normal distribution model is a poor fit for the distribution of the measured values.

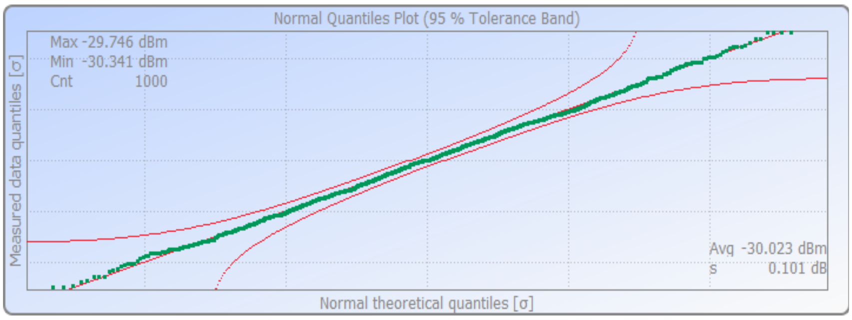


Fig. 14.9.1: Q-Q-Plot display.

Two additional red lines mark the 95 % confidence band. If all graph points are located within this band, the measured values have a normal distribution at a 95 % confidence level.
The diagram is vertically and horizontally scaled to σ. Therefore, each grid line represents a step size of 1 σ.
The Q-Normal-Plot is used as a graphical test for normal distribution.

15 OTA Continuous Power Measurement

The OTA continuous average power measurement is very similar to the regular continuous average power measurement. The main difference is that OTA sensors deliver three individual power readings from their individual antenna elements. The OTA measurement therefore displays three continuous average power readings simultaneously.

This chapter only describes the differences to the regular continuous average power measurement.

15.1 Settings

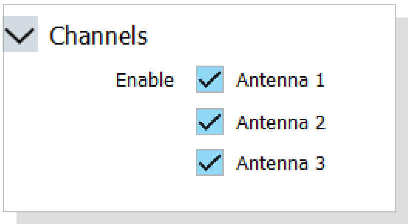
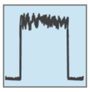


Fig. 15.1.1: Settings for OTA continuous power measurements.

Channels
The three channels of the OTA sensor can be individually enabled or disabled. Channels without an antenna connection must be disabled to avoid error messages.

16 Trace Measurements



In the trace mode, the envelope power can be recorded as a function of time. This is done by sampling power over a time interval that can be specified by the user. The power values are assigned to a number of pixels (video points) that each contain data, such as the average power, the maximum power and a randomly sampled value.

16.1 Measurement Settings

Fig. 16.1.1: Zeroing controls.

Zero
This option is only available while the measurement is running. It starts the zeroing sequence for the current sensor. For this purpose, the RF signal must be switched off, or the sensor must be disconnected from the signal source. The sensor automatically detects the presence of any significant power, which causes zeroing to be aborted and an error to be generated. The LED next to the zeroing button changes it's color depending on the current zeroing state.

Grey	Zeroing was not performed since the measurement got started.
Blue	Zeroing is in progress. The measurement results are not updated during this time.
Green	Zeroing finished successfully.
Red	Zeroing failed. In this case the LED initially flashes and then turns red continuously.

The zeroing process may take more then 8 seconds to complete and varies with the sensor model.
Generally, it is possible to run the sensor zeroing with a small signal (such as broadband noise) applied to the sensor. This makes it possible to compensate for this signal in later measurements.

The power scale is defined by two parameters: the reference level and the level step per division. Both values can be changed in steps by pressing the plus and minus buttons on the settings panel. In addition, values can be entered manually in a logarithmic or linear scale.

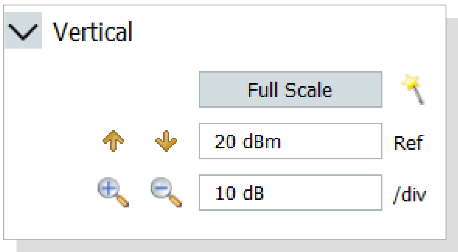


Fig. 16.1.2: Setting the vertical scale.

Reference level (Ref)
Specifies the upper limit of the trace view area. This setting only affects the graphical data representation in the application. It has no influence on the measurement or sensor configuration.

/div
Sets the scaling of the level axis. Zooming operations keep the reference level constant and adjust the lower level accordingly.

Auto Set
Tries to adjust the level scaling, trigger level and timing to match the applied signal. All other parameters are set back to defaults. If the auto set process fails, all settings are left untouched.

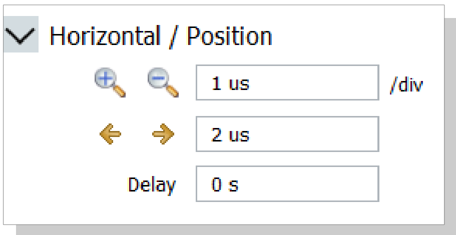


Fig. 16.1.3: Setting the horizontal scale.

Power Viewer uses a fixed grid of 10 divisions for the time scale. The time resolution is set per division with the lowest possible value being 5 ns/div.
Please note that not all sensors support the same time resolution. Additional information can be found in the sensor data sheets.
The two buttons (plus and minus) increase or decrease the time per division value in fixed steps. These steps follow the order
1 → 2 → 5 → 10 or vice versa. The appropriate unit is automatically added to the numeric value.

Trigger Position
This setting defines the trigger point's position within the trace view area. The arrow buttons move the trace back or forth by one division. The trace position setting allows the user to view the signal at times before the physical trigger point. Please note that this time interval (pre-trigger) depends on the sensor hardware used. Power Viewer automatically corrects invalid ranges for the current sensor.

Delay
The trigger delay creates a delayed trigger point that is not identical to the physical trigger point. Power Viewer uses the delayed trigger point as the zero position for the time axis. The delay setting can be used to compensate for signal delays caused by long cabling and external trigger source.

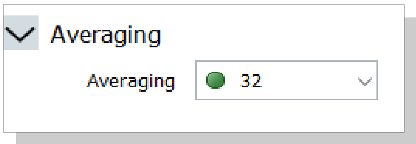


Fig. 16.1.4: Setting the averaging count.

Averaging Count
This value sets the number of traces to be evaluated to form one measurement result. Averaging reduces the noise level of the average trace but increases measurement time. Changing the averaging count does not have any effect on traces that represent random sampling data. A peak trace representation usually increases slightly in level with an increase in the averaging count.
It should also be noted that using trace averaging requires a stable trigger event. Otherwise, traces with different timings are averaged, which leads to erratic results.
The averaging count can be set to Real Time, in which case all averaging is turned off entirely. This is useful for measuring single-shot events. When the averaging function is deactivated, measurements are performed without chopper stabilization, meaning that a measurement then consists of a single sampling sequence activated by a trigger event. Otherwise, the detector’s output-voltage polarity is reversed automatically for alternate sampling sequences. This suppresses low-frequency noise and increases the accuracy with which the average power is measured at each pixel. Averaging has no effect on the randomly selected samples; the largest values for each averaging sequence are output as peak values.

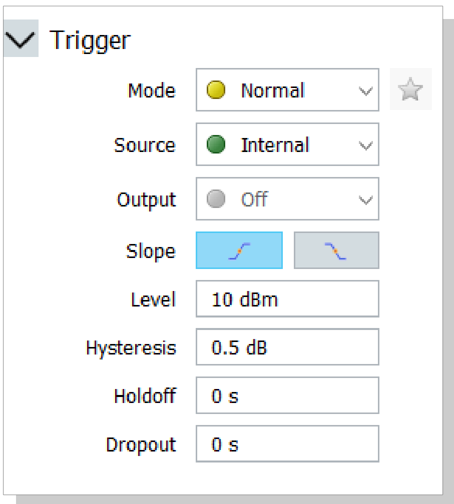


Fig. 16.1.5: Setting the trigger.

Mode
The trigger mode can be set to Free Run, Auto, Normal, or Single mode.

In *free run* mode, the sensor does not wait for trigger events and continuously acquires waveforms. The waveform display is not synchronized, and the waveforms typically roll across the display. Averaging is disabled in this mode.
In *auto* trigger mode, the sensor acquires data, even if no trigger event occurs. Auto mode uses a timer that starts when a trigger occurs. After 1 s has elapsed, the software forces a trigger release and restarts its timer. In the absence of valid trigger events, the acquired waveforms are not synchronized. Average filter settings do not apply in this case. When valid triggers exist, the waveforms become synchronized and averaging can be used.
In *normal* mode, the sensor only acquires a waveform when it is triggered by an internal or external trigger event. If no trigger event occurs over a period of about 2 seconds, the Trig? indication is shown on the user interface. The last waveform acquired remains on the display, and the sensor keeps waiting for the next trigger event. If no waveform has been acquired, the display remains blank.
In *single* mode, the sensor arms its trigger unit when the ARM button is pressed. Subsequently, it performs one acquisition as soon as the trigger condition is met. If no trigger event occurs over a period of about 2 seconds, the Trig? indication is shown on the user interface. The waveform acquisition includes averaging, which means that 2*N trigger events must occur before the acquisition completes. If single-shot events are to be analyzed, the averaging filter count must be set to Real Time.

Source
This setting establishes the trigger signal's source. Internal means that the trigger event is generated by the applied RF signal and by the set trigger level. The External setting uses the BNC input signal from the R&S NRP-Z3 or R&S NRP-Z5 adapter. When an external source is used, the trigger level and hysteresis functions are not effective. The option 'External SMB' activates the SMB trigger input that is available on all new generation NRP power sensors. In the case the user can select between an input impedance of 10 kOhms or 50 Ohms.

Output
The new R&S NRP Power Sensors can use their built in SMB connector as trigger output. In this case a rising edge is generated when the power measurement starts. Please see the power sensor user manual for details on how to use this feature.

Slope
The trigger slope can be set to either the positive or negative edge. This setting is available for all trigger sources.

Level
This level setting establishes the trigger threshold for internal triggering derived from the test signal. In order to achieve stable triggering conditions, a trigger level above −40 dBm is advisable.

Holdoff
The holdoff setting suppresses trigger events within the set holdoff time (in seconds), starting from the time of the last successful triggering. The holdoff time must be larger than the total trace time.

Dropout
This setting establishes the dropout time in microseconds. With a positive (or alternatively: negative) trigger slope, the dropout time is the minimum time for which the signal must be below (above) the trigger power level before triggering can occur again. As with the holdoff parameter, unwanted trigger events can be excluded. The set dropout

time only affects the internal trigger source.

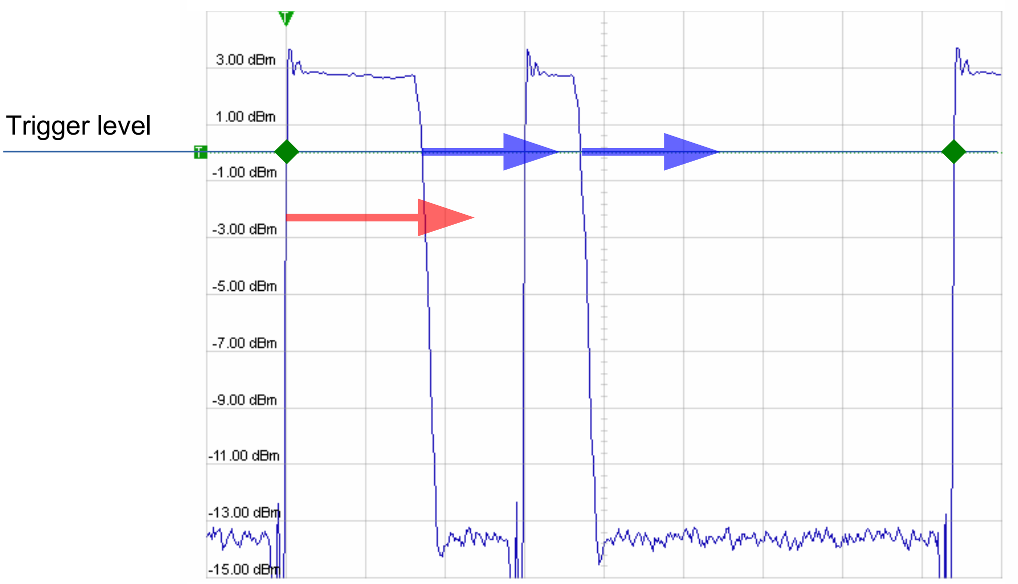


Fig. 16.1.6: Holdoff time (red) and dropout time (blue).

The figure above shows the various times related to a trigger event. The green diamonds mark the trigger point in time, located on the rising edge of a pulse. The red arrow marks the holdoff time. This time must elapse before the trigger system is rearmed and the system can re-trigger. The blue arrows mark the dropout time periods. The signal level must remain below the trigger threshold before the system can re-trigger.

Using the dropout time is useful in many applications:

- Triggering on the first pulse of a pulse train.
- Triggering on bursts that contain intra-pulse modulation with AM content.
- Triggering on levels that are close to the pulse top.

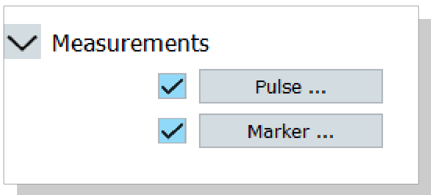


Fig. 16.1.7: Additional measurement settings.

Pulse
This button opens the Auto Pulse Settings panel. Use this panel to configure all parameters that are relevant to the automatic pulse measurement. The check-box is used to enable or disable the automatic pulse measurement globally.

Marker
This button opens the Advanced Marker Settings panel. Use this panel to configure all parameters that are relevant to the marker measurements. The check-box is used to enable or disable the marker measurements globally.

16.2 Custom Settings

The Power Viewer software provides a mechanism for adding custom settings to the trace measurement configuration. For this purpose, SCPI commands can be sent at the end of the trace measurement configuration. Adding these commands is generally not required, but it may be useful for special applications or for debugging.
The SCPI commands can be specified on the debug page for the program settings dialog. This dialog is reached from the menu bar by selecting Configure → Options → Debug.
The syntax for adding custom commands is:

```
trace.cmd=<command>
```

Multiple lines may be appended after each other. Lines starting with a hash mark (#) are treated as a comment and ignored.

- Disabling the NRP-Z81 equivalent sampling mode:

  ```
  trace.cmd=SENS:TRAC:ESAM:AUTO OFF
  ```

- NRP-Z81 trace measurements at reduced bandwidth:

  ```
  trace.cmd=SENS:BWID:VID "5 MHz"
  ```

- Using a specific sensor path with the 3-path diode sensors:

  ```
  trace.cmd=SENS:RANG:AUTO OFF
  trace.cmd=SENS:RANG 2
  ```

16.3 Graphical Trace View

The graphical trace view contains the information shown below.

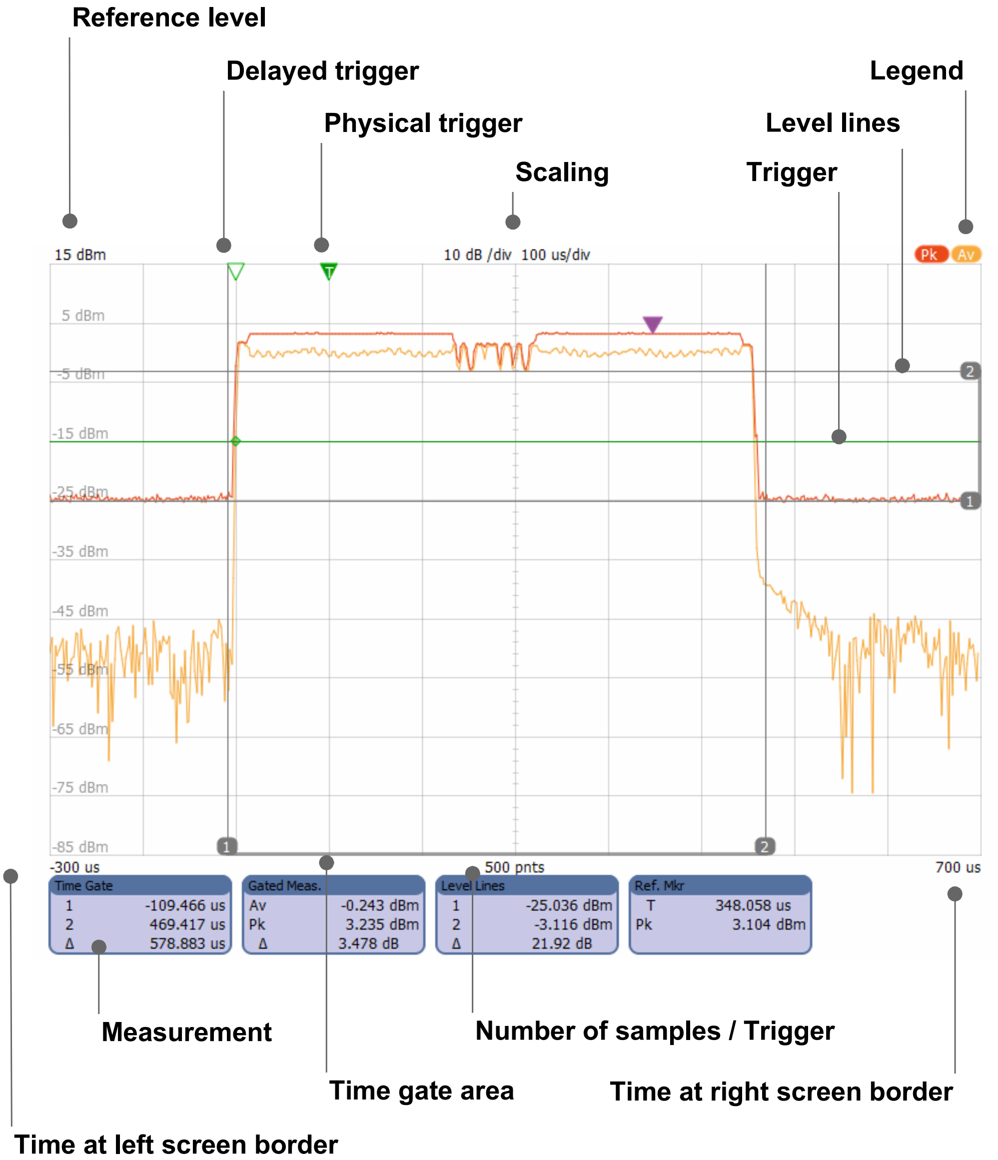


Fig. 16.3.1: The graphical trace view.

If the trigger level is located outside of the visible area, the green trigger level line disappears. In its place, a little arrow next to the T indicates the direction in which the trigger level is located.

Fig. 16.3.2: Trigger level located above the visible area.

If the trigger position (time) is located outside the display area, the green arrow rotates and indicates the direction in which the physical trigger position is located.

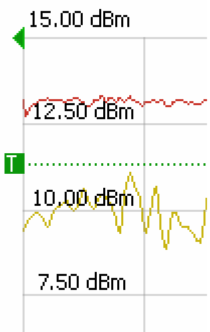


Fig. 16.3.3: Trigger position to the left of the visible area.

16.4 Context Menu

The graphical trace view provides a context menu that can be activated by right-clicking the mouse. This context menu contains all functions directly related to the graphical data representation, and its settings do not affect sensor settings.

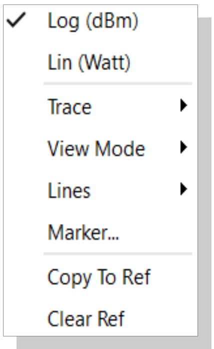


Fig. 16.4.1: Context menu for the graphical trace view.

Log / Lin
Trace data can be viewed in a linear scale (watts) or in a logarithmic scale (dBm). The menu switches back and forth between these two views. However, when switching from linear to log mode, negative y-values are truncated, and the lowest dBm level set to −60 dBm.

16.5 Trace Representations

Some power sensors (e.g. the R&S® NRP-Z8x) return multiple trace data representations. Due to the high sampling rate that these sensors use, the average, random and peak power information is available for each video point. The difference between these representations is outlined below.

Average
This representation averages the power values of identical measurement points, i.e. points at the same distance from the trigger point. This reduces noise, since the noise reduction is proportional to the square root of the averaging factor. This is the default representation, and it is available with all sensors.

Peak
The maximum of all samples taken at identical measurement points, i.e. points at the same distance from the trigger point, are found and output.

Random
The random values are obtained from the first measurement cycle. Repetition of the measurement cycle has no effect on the result.

16.6 View Modes

The view modes affect the way that trace data is rendered on the display. View modes do not affect the sensor configuration. Therefore, any view mode can be combined with any sensor configuration.

Normal
In normal mode, each trace captured by the sensor is rendered on the screen. Newer traces replace older ones. This is the default view mode, and it is useful for most applications.

Envelope
In the envelope mode, trace data is accumulated over up to 256 traces, and the area between the minimum and maximum readings is filled with a semi-transparent color. The current trace is highlighted within this area. This mode is very useful for finding glitches, transients, or other random events.
The screen shot below shows an EDGE burst in the envelope view mode, and all traces average, random and peak activated.

Fig. 16.6.1: EDGE burst in envelope view mode.

Persistent Dots
In the persistent-dots mode, the software collects data on up to 32 trace measurements. These trace data points are displayed without interconnecting lines. This mode is useful for analyzing waveform anomalies.
The example below shows a jittered AM signal that is captured in realtime mode (no averaging).

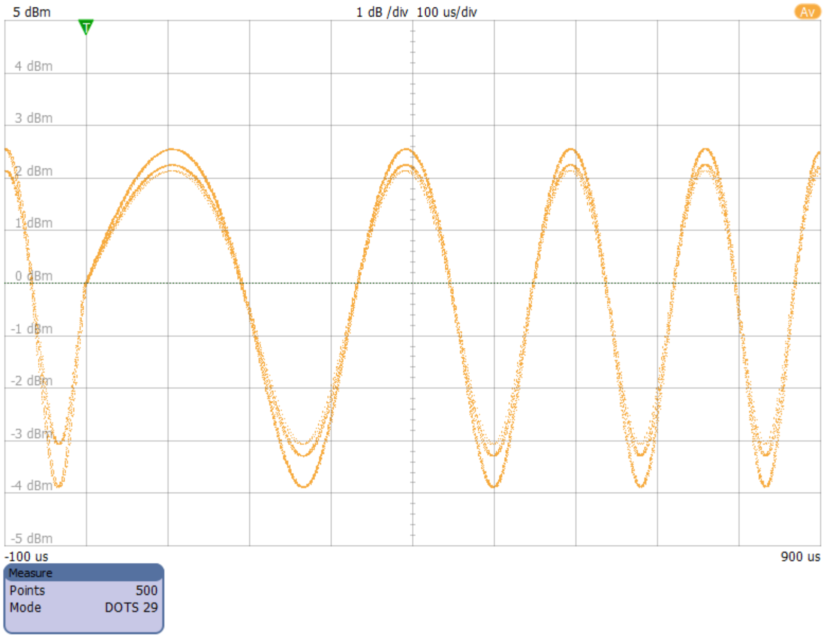


Fig. 16.6.2: Jittered AM signal in persistent dots view mode.

Moving Average and Exp. Moving Average
The moving average modes provide additional video filtering of up to 512 trace measurements. The regular moving-average mode displays the average trace data of the last 512 measurements. All traces are weighted equally. This filter provides the best noise reduction.
The exponential moving average filter uses an exponential weighting of the last 512 measurements. The last measurement is weighted the most, whereas older measurements only have little influence on the displayed result. This filter responds faster to signal changes but provides less noise reduction.
Since the view modes do not affect the measurement itself, it is generally possible to combine these video averaging filters with un-triggered measurements, e.g. noise-like signals. The result is the average power of uncorrelated signal portions.

16.7 Lines

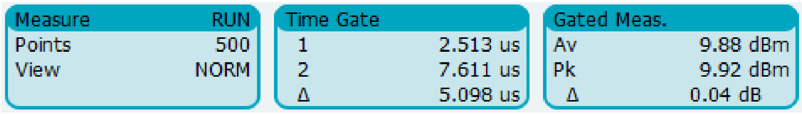


Fig. 16.7.1: Measurements related to level lines and the time gate.

Time-gate and level lines may be activated for simple measurement tasks. Both line sets can be dragged by holding down the left mouse button. Text boxes at the lower border show all related readings, such as delta values and power readings within the gated area.

Time Gate

- 1 The position of line 1 relative to the trigger position
- 2 The position of line 2 relative to the trigger position
- Δ The time difference between both lines

Gated Meas.

- Av The average power between the time-gate lines
- Pk The peak power between the time-gate lines
- Δ The ratio of the peak and average powers

Level Lines

- 1 The level at which line 1 is positioned
- 2 The level at which line 2 is positioned
- Δ The ratio of both levels

Measure Mod. Depth

The level lines can optionally be used for measuring a signal's modulation depth according to the following equation:

$$Depth_{\%} = 100 \cdot \left| \frac{\sqrt{P_1} - \sqrt{P_2}}{\sqrt{P_1} + \sqrt{P_2}} \right|$$

16.8 Reference Trace

Trace data can be saved to memory and shown as a reference curve. The To Ref context menu entry saves all active traces to memory and displays them in a slightly darker color together with the measured traces. Reference trace data gets scaled or moved when the x- or y-scaling is changed. Clicking Clear Ref removes all reference trace data from memory.

16.9 Using Markers

Markers can be tied to trace points for performing automated measurements. The context menu is used to activate the Marker Configuration dialog shown below.

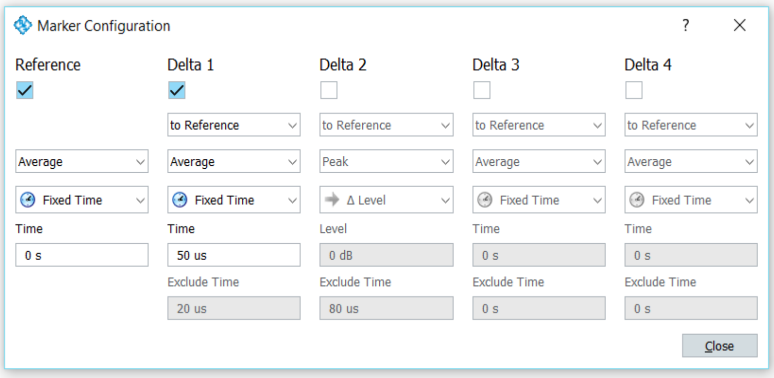


Fig. 16.9.1: Marker configuration dialog.

Power Viewer offers one reference and up to four delta markers. Each of the markers can be assigned to the average, random, or peak trace. This assignment is independent of whether the trace is enabled for viewing.
The reference marker is set to a point in time relative to the trigger point. Alternatively, it may be set to automatic peak-tracking mode, which positions the marker to the maximum power value within the visible trace area.

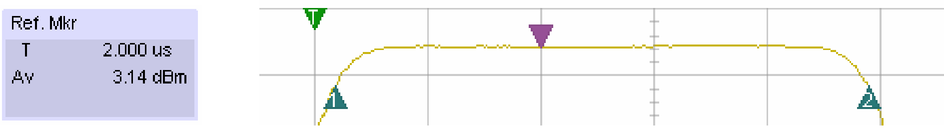


Fig. 16.9.2: Markers in trace display.

The reference marker is indicated with a small purple arrow that points downward to the trace that it is associated with.
Delta markers can be defined relative to the reference marker or relative to other delta markers. This allows the user to build chains of markers and perform measurements between marker points.
Each delta marker can be operated in different operating modes. These modes are outlined below.

Fixed Time
This mode is available for the reference and the delta markers. The marker is positioned at a fixed point in time. This time is relative to the trigger point, whereas the delta marker time is related to the marker that it is dependent on. Fixed time markers can be dragged using the mouse.

Auto Peak
This option is only available for the reference marker. If selected, this marker automatically tracks the peak-power value within the visible trace area.

Δ Level
This option is only available for the delta markers. If selected, this marker is automatically positioned at the desired signal level by

searching to the right or left. The level is entered as a value that is relative to the power level upon which the marker is dependent. An additional exclude time can be set to inhibit searching within this period of time.

Next Peak
This option is only available for the delta markers. If selected, this marker automatically searches for the next signal peak. The level value defines a relative threshold for the peak search. It should be set so that noise peaks are not accidentally evaluated as signal peaks. An additional exclude time can be set to inhibit searching within this period.

16.9.1 Pulse Width Measurements

An automatic pulse width measurement can be performed using three markers. The reference marker is set to a fixed point in time at which its level exactly matches the pulse top power.
The first delta marker is set to search a level that is 3 dB down from the reference marker to the left side. This positions marker one at the rising edge's 50 % power level.
The second delta marker is set to search the same power level to the right side. It is related to the first delta marker and thus marks positions at the same power level on the falling edge.
The result is shown in the figure below.

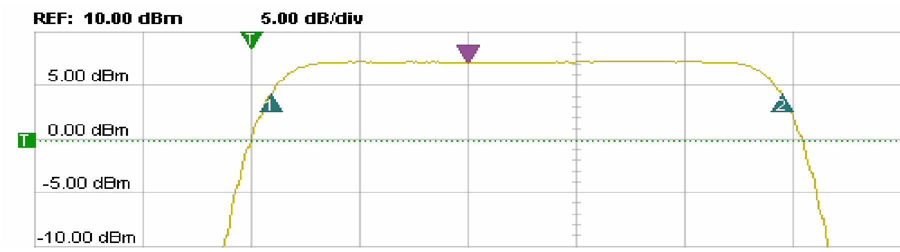


Fig. 16.9.3: Markers in a pulse-width measurement.

The pulse width can be read from the ΔT measurement for delta marker two.

Ref. Mkr		Delta Mkr	1>R	Delta Mkr	2>1
T	2.000 us	T	187.3 ns	T	4.901 us
Av	7.17 dBm	ΔT	1.813 us	ΔT	4.714 us
			(N dB)		(N dB)

Fig. 16.9.4: Marker readings for the pulse width measurement.

16.9.2 Pulse Rise-Time Measurements

The rise or fall time of a pulse can be measured using a set of two delta markers and the reference marker. The reference marker is set to a fixed point in time at which its level exactly matches the pulse top power.
The first delta marker is set to search a level that is 1 dB down to the left side. It is related to the reference marker.
The second delta marker is set to search a level that is 19 dB down to the left side. It is related to the first delta marker.
The result is shown in the figure below.

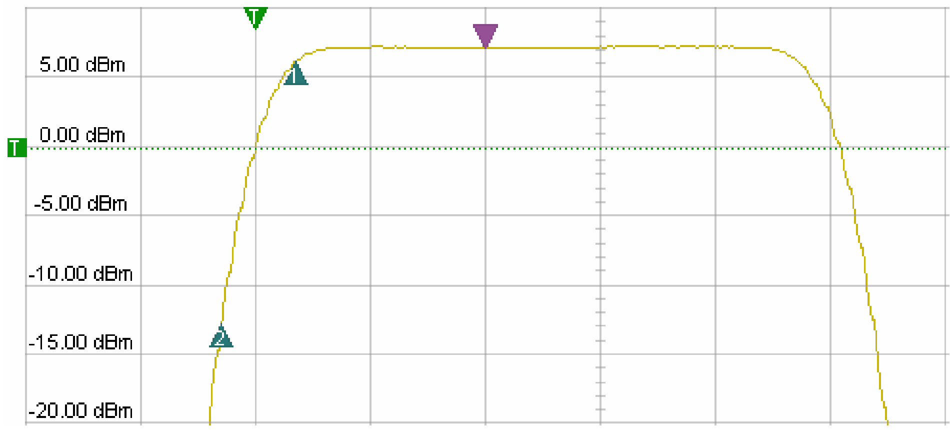


Fig. 16.9.5: Rise time measurement using markers.

The pulse rise time can be read from the ΔT measurement for delta marker two.

Fig. 16.9.6: Marker readings for the pulse rise-time measurement.

16.10 Zooming

The Power Viewer Software supports time and level zooming in the trace panel. Both zoom operations are controlled using the left mouse key and the mouse wheel. Time zoom operations always reconfigure the sensor, whereas level zooms only adjust the view port.

16.10.1 Time Zoom

The time zoom mode is entered by holding the left mouse key down while dragging the mouse cursor horizontally. A blue area highlights the minimum area that will be shown when the zoom operation completes. When the left mouse key is released, two horizontal arrows indicate that the zoom operation can now be performed using the mouse wheel.

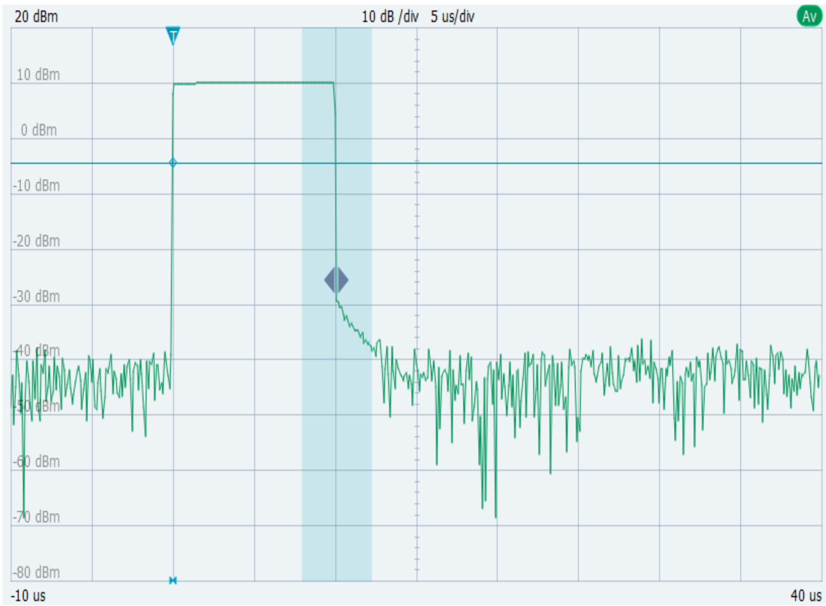


Fig. 16.10.1: Time zoom in a trace measurement.

Rolling the mouse (scroll) wheel forward or clicking into the marked area zooms into the trace and magnifies the marked area. The time resolution is rounded to the next useful value on a 1-2-5 scale.
Rolling the mouse wheel backwards zooms out. The center point for the zoom operation is the center point of the marked area. The time resolution is rounded to the next useful value on a 1-2-5 scale.
After the zoom operation has completed, the marked area and the arrows disappear. The zoom operation can be aborted by clicking the right or left mouse key instead of rolling the mouse wheel.

Undo
When no zoom area is selected, the mouse wheel serves as an undo function for the time zoom. Rolling the mouse wheel backwards restores the previous timing.

16.10.2 Level Zoom

The level zoom mode is activated by clicking and releasing the left mouse key in the trace window. A set of vertical arrows marks the zoom level and indicates that the zoom operation can now be completed using the mouse wheel.

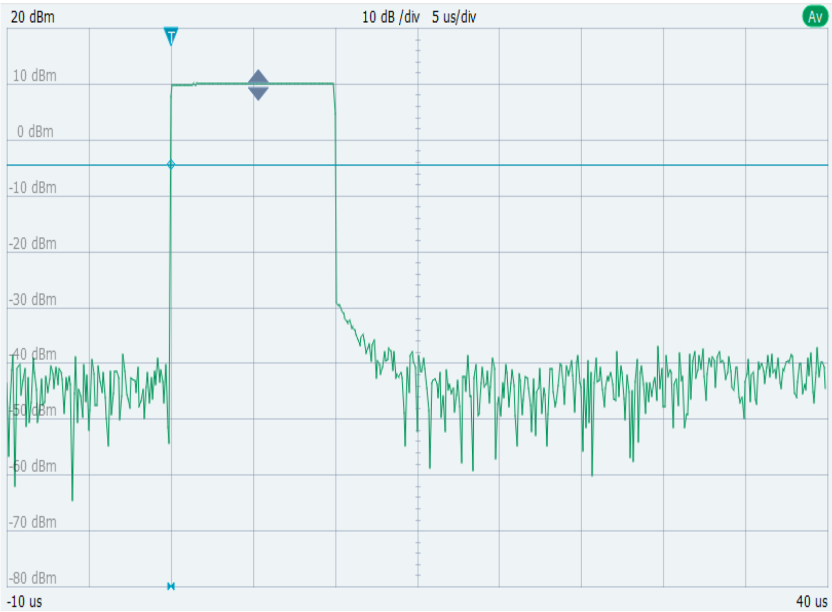


Fig. 16.10.2: Level zoom in a trace measurement.

Rolling the mouse wheel forward magnifies the trace and centers it around the selected zoom point.
Rolling the mouse wheel backwards undoes the last level-zoom operation.
The level-zoom mode is automatically aborted if the mouse cursor is moved without rolling the wheel. This prevents users from remaining in level zoom-mode unintentionally.

16.11 Automatic Pulse Measurement

Pulses are measured in line with the international IEC 469 standard. The algorithm in the power sensor first determines the pulse amplitude of the measured trace by establishing the distance between the top power and base power. This pulse amplitude then serves as the basis for the percentage values for the three reference levels that can be preset – high, mid, and low. These three levels are used to measure the pulse. Typical values are 90 %, 50 %, and 10 %. While the low and high reference levels are only employed to determine the pulse's rise and fall times, the "mid" reference level is used to determine all other timing parameters.

Automatic pulse measurement can be activated in the trace settings if the sensor supports this feature (e.g. R&S NRP Z-8x). The measurement is performed inside the sensor, and data is provided for each captured trace.

Pulse measurement data can also be sent to the data processing panels.

The following figure explains the terms used with the automatic pulse measurement.

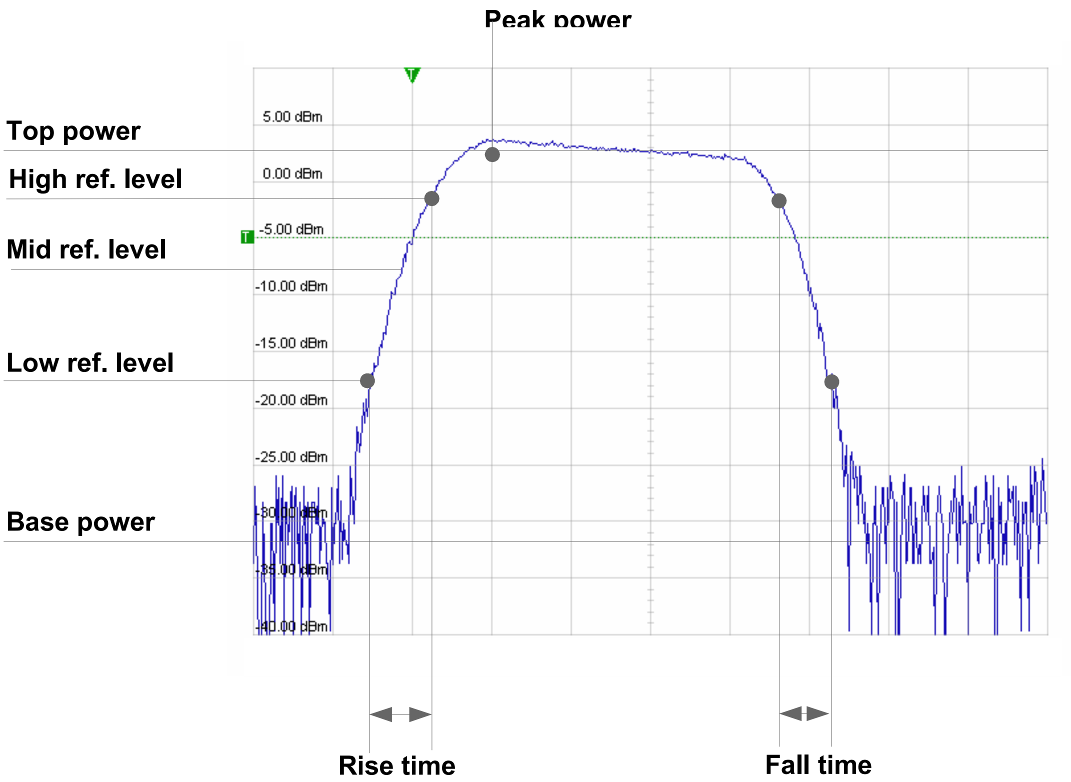


Fig. 16.11.1: Automatic pulse measurement.

Base power

The base power is the average power for the period without any signal content. Typically, this is the average noise power. The base power is referred to as the 0 % level.

Top power
The top power is the pulse power excluding any overshot at the beginning of the pulse. This power level is referred to as the 100 % level.

Peak power
The peak power is the maximum power value captured in the trace.

The low, mid, and high reference levels
The three reference power levels are specified by the user as a percentage of the pulse amplitude. The amplitude is the power difference between the pulse's top power and its base power.
The three reference power levels are used to determine all pulse timing related values, such as the rise time and fall time or the pulse width and pulse repetition time.

Please note that automatic pulse measurements are based on the average trace data returned from the sensor. It is important that stable trigger conditions exist and that the average count is set high enough in order to run the automatic pulse measurement function.
Enabling automatic pulse measurement slightly slows down the measurement rate. This is normal and is due to the sensor's internal processing routines.

The automatic pulse measurement settings are configured in a separate dialog that is accessible from the trace measurement configuration dialog box.

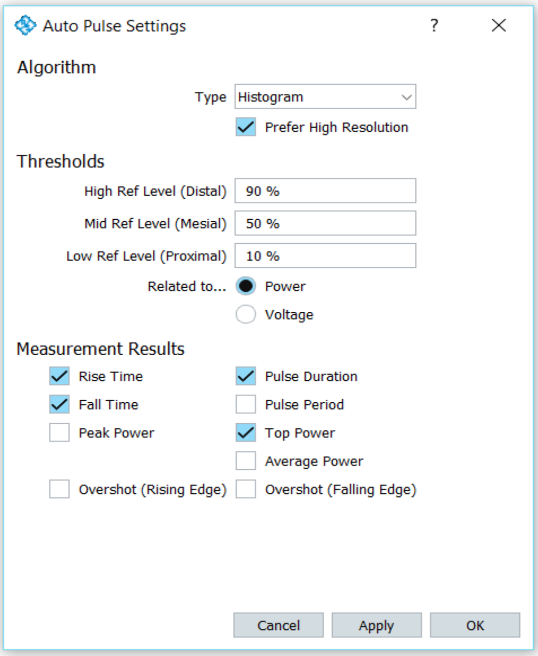


Fig. 16.11.2: Automatic pulse measurement settings.

Algorithm
This control is used to select the analysis algorithm for determining the pulse-top and pulse-base powers. These two power levels are fundamental for all further signal analysis.
The default setting, Histogram*,* determines the pulse-top and pulse-

base power levels by evaluating the probability density of all the values for one recorded trace. This algorithm is recommended for most pulses.
The Integration algorithm approximates the pulse by an ideal signal with the same energy content, pulse duration, and pulse period. Use this algorithms for pulses with fast rise times and fall times as well as for pulses with amplitude variations (e.g. modulation).
The Peak algorithm is not available on all of the wideband power sensor's firmware versions. Please consult the sensor firmware's release notes to see if this feature is supported. The algorithm uses the overall peak power as the reference and is useful for Gaussian pulse shapes.

Prefer High Res.
This check box enables high-resolution pulse analysis if the sensor firmware supports this feature. High-resolution pulse analysis uses an equivalent sampling technique and provides more precise measurement results. Measurement time increases when high-resolution pulse analysis is used.
When the sensor uses high-resolution pulse analysis, an additional line in the results table displays the equivalent sampling time.

Ref Level
The low, mid, and high reference-level values define the levels used for determining the pulse timing. All values are specified as a percentage of the pulse amplitude (the difference between the top and base powers). Levels are related to power readings in watts. The following table compares levels expressed in volts, watts and dBW.

Level (% V)	Level (% W)	Level (dBW)
10	1	20
50	25	6
90	81	0.92
	10	10
	50	3
	90	0.46

16.11.1 Measurement Results

These check boxes select which results are shown in the graphical trace view. Low-level and high-level values are marked by small horizontal lines for the rising and falling edge that the sensor evaluates. The positions of the rising and falling edge are marked with small diamonds.

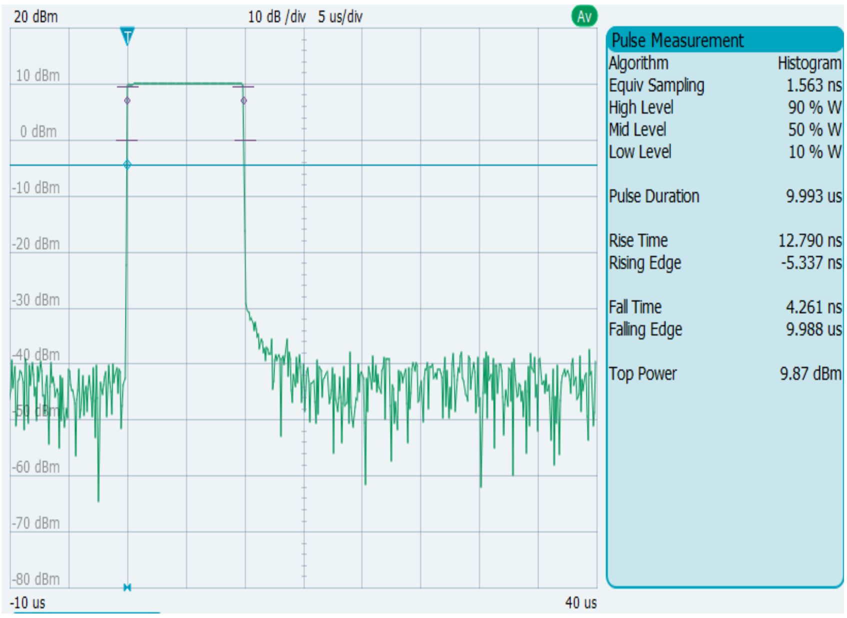


Fig. 16.11.3: Automatic pulse measurement in trace view.

Algorithm
The analysis algorithm is used to determine the pulse-top and pulse-base powers. These two power levels are fundamental for the pulse analysis, because they are required for calculating the pulse amplitude. The reference levels are specified as a percentage of the pulse amplitude, and they are required for measuring the entire pulse timing.

Equiv Sampling
This entry is only displayed if the high-resolution pulse analysis is used by the sensor firmware and shows the equivalent sampling time. This time provides a good measure of the accuracy that is achieved with the automatic pulse measurements. The following example demonstrates the difference in resolution:

Without equivalent sampling:

20 µs/div @ 500 video points	< 400 ns / sample

With equivalent sampling:

Signal dependent	2.5 ns

High-resolution pulse analysis is useful when pulses with large duty cycles need to be measured (for example, in radar applications).

Unit
The reference level values are specified as a percentage of the pulse amplitude, and they can be voltage or power related.

Level
The low, mid, and high reference levels that are used for the automatic pulse measurement. The levels are set as a percentage of the pulse amplitude.

Pulse Duration
The time between the pulse's first rising edge and subsequent falling edge. If the duration cannot be determined, "---" is displayed.

Pulse Period
The time between two consecutive edges of the same type. If the period cannot be determined, "---" is displayed.

Rise Time
The time of the first rising edge. The rise time is defined as the period between the point in time when the signal exceeds the lower reference level and the point in time when it exceeds the upper reference level. If no rising edge can be detected, "---" is displayed.

Rising Edge
The point in time when the first rising edge occurs, i.e. the point in time at which the signal exceeds the average reference level. The rising edge position is based on the delayed trigger point.

Rising Edge To Phys. Trig.
Unlike the standard rising edge time, this time is related to the physical trigger. If no trigger delay is set, this measurement is omitted.

Fall Time
The time of the first falling edge. The fall time is defined as the period between the point in time when the signal falls below the upper reference level and the point in time when it falls below the lower reference level. If no falling edge can be detected, "---" is displayed.

Falling Edge
The point in time when the first falling edge occurs, i.e. the point in time at which the signal falls below the average reference level. The falling-edge position is referenced to the delayed trigger point.

Falling Edge To Phys. Trig.
In contrast to the standard falling-edge time, this time is related to the physical trigger. If no trigger delay is set, this measurement is omitted.

Peak Power
The maximum power value for the entire trace.

Top Power
The pulse's top power. This power level is determined by the analysis algorithm and is fundamental for the entire pulse analysis.

16.12 Common Measurement Tasks

The trace panel can be used for many different measurement tasks. The following overview provides advice on how to configure the trace measurement for common signals.

Repetitive pulsed signals without jitter

Trigger	Normal
Averaging	≥ 2
View	Normal

This is the most commonly used setting. It measures the signal's envelope power continuously.

Repetitive pulsed signals with jitter

Trigger	Normal
Averaging	Real Time (OFF)
View	Envelope, Persistent Dots

Continuously measures the envelope power. Averaging should not be used if the jitter needs to be observed.

CW-like signals, e.g. WCDMA without trigger

Trigger	Free Run
Averaging	N/A
View	Moving Average

Continuously measures the average power level of asynchronous trace measurements.

Single-shot signals

Trigger	Single → ARM
Averaging	Real Time (OFF)
View	Normal

The averaging should be set to real time, because the sensor otherwise requires multiple trigger events to generate one measurement result.

17 OTA Trace Measurement

The OTA trace measurement is very similar to the regular trace measurement. The main difference is that OTA sensors deliver three individual power traces from their individual antenna elements. The OTA measurement therefore displays three average power traces rather than an average power, peak power and random sample trace.

This chapter only describes the differences to the regular trace measurement.

17.1 Settings

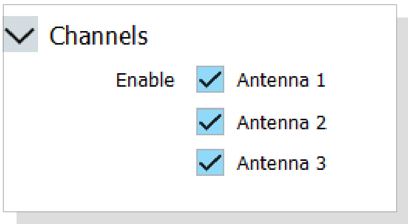


Fig. 17.1.1: Settings for OTA trace measurements.

Channels
The three channels of the OTA sensor can be individually enabled or disabled. Channels without an antenna connection must be disabled to avoid error messages.

18 Statistics

The Statistics mode makes it possible to measure the envelope power's complementary cumulative distribution function (*CCDF*) or probability density function (*PDF*).

18.1 Settings

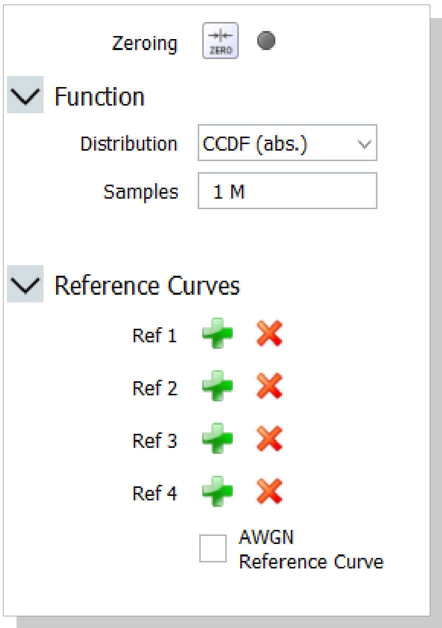


Fig. 18.1.1: Settings for the statistics mode.

Zero
This option is only available while the measurement is running. It starts the zeroing sequence for the current sensor. For this purpose, the RF signal must be switched off, or the sensor must be disconnected from the signal source. The sensor automatically detects the presence of any significant power, which causes zeroing to be aborted and an error to be generated. The LED next to the zeroing button changes it's color depending on the current zeroing state.

Grey	Zeroing was not performed since the measurement got started.
Blue	Zeroing is in progress. The measurement results are not updated during this time.
Green	Zeroing finished successfully.
Red	Zeroing failed. In this case the LED initially flashes and then turns red continuously.

The zeroing process may take more then 8 seconds to complete and varies with the sensor model.
Generally, it is possible to run the sensor zeroing with a small signal (such as broadband noise) applied to the sensor. This makes it possible to compensate for this signal in later measurements.

Distribution Function
Power Viewer displays the CDF, CCDF, or PDF for a signal.
The CCDF shows how often a measured power value is above a certain

level. For this purpose, the x-axis uses a logarithmic power scale. The y-coordinate is scaled logarithmically and in probabilities from 100 % down to 10^{-4} %. The CCDF can also be viewed as a relative graph, in which case the x-axis is scaled to the signal's average power.

Total Samples
The number of samples determines the length of the evaluation window. The overall window length is calculated from the sampling rate (80 MHz, 12.5 ns interval) and the sample count.
The default evaluation length is one million samples, and the maximum permissible value is 768 million samples.
The application uses an asynchronous measurement mode for the statistics measurement. Thus, a measurement is started without waiting for any trigger event and stopped when the set evaluation period has elapsed.

Sample counts larger than 24 million points are divided into up to 32 sets of measurements, each of which evaluates up to 24 million points. At full bandwidth, the time required for one measurement with 24 million samples is 0.3 seconds. Therefore, larger sample counts require more time for the measurement to stabilize.

Reference Curves
The current curve can be saved as a reference curve and used for comparisons with later measurements. Any reference curve data is only stored locally in the graphics view. It cannot be saved to a file.
The statistics view supports up to four reference curves in addition to live measurement data.

Show AWGN Reference Curve
When this function is enabled, the system plots an ideal AWGN curve. This reference curve can be used with all statistics modes.

18.2 Graphical Data View

The graphical data view may contain the information shown below. The level and probability lines are activated with a right mouse click into the graphics area.

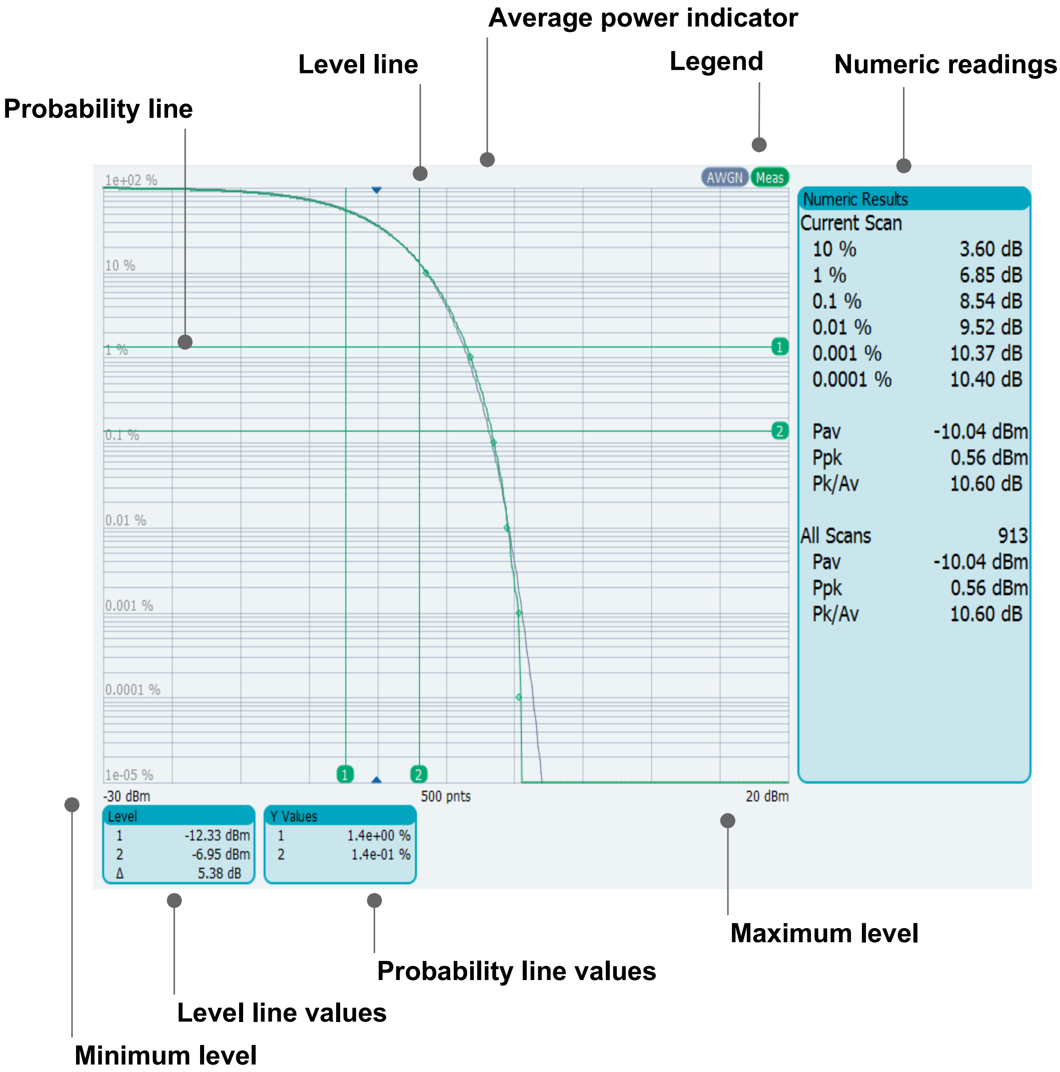


Fig. 18.2.1: The graphical data view.

The application supports absolute or relative CCDF displays as well as the PDF and CDF displays.
If numeric results are required, the display can be tiled to show the table with numeric results on the right side.

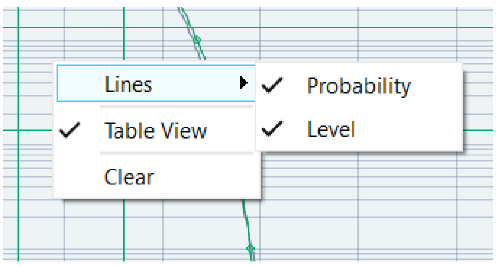


Fig. 18.2.2: Tiling the display to show the table with numeric results.

Table mode
This mode is activated by calling up the context menu (by right clicking

into the graphics area) and selecting Table View.

18.3 PDF Mode

PDF stands for probability density function. It shows the probability at which readings occur at a given level.
For this purpose, the logarithmic level scale is divided into sections, which are referred to as bins. Each measurement that falls within a bin increases the bin counter by one. At the end of the measurement cycle, all bin counts are normalized by the linear scale's bin boundaries.

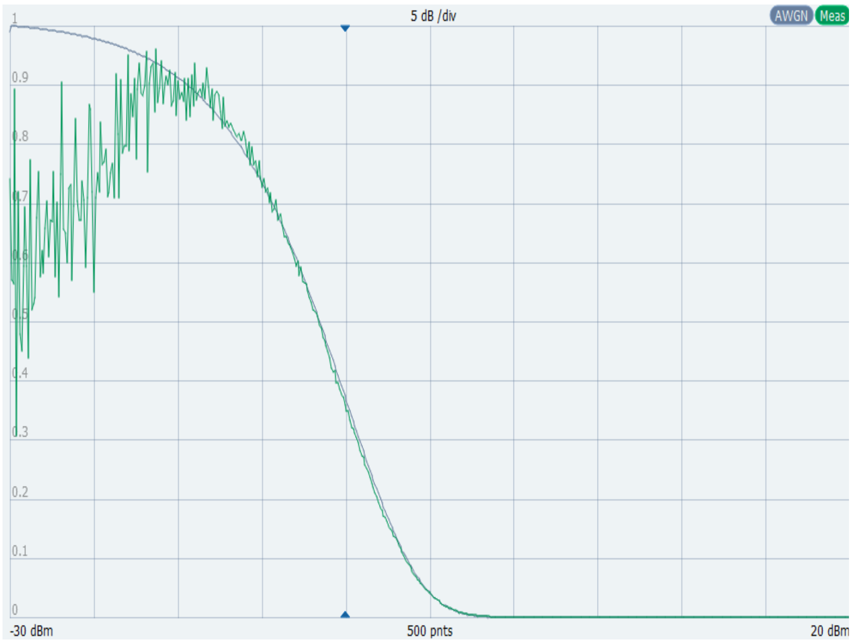


Fig. 18.3.1: The PDF curve of a 3GPP signal with an AWGN reference curve at an average power level of 0 dBm.

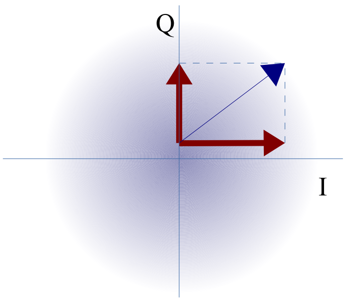
The figure above shows a 3GPP signal that has a power distribution similar to that of AWGN. At low signal levels (left side) the resolution of the sensor's A/D converter might become visible.

18.3.1 PDF Background Information

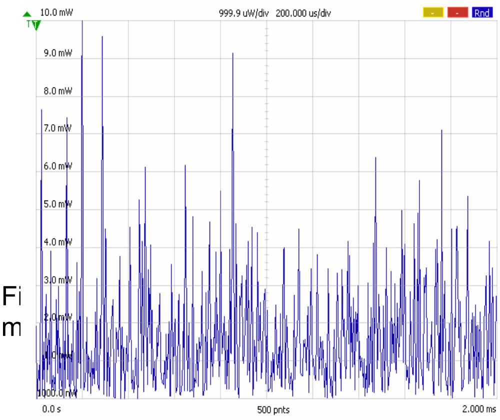
This section outlines the relationship between the displayed PDF curve and various signals, such as 3GPP or WCDMA.
For a (gauss) noise-like signal, it can be assumed that the signal is being generated by I/Q modulation of an RF carrier. Both the I-signal and the Q-signal are normally distributed with a mean value of zero and a standard deviation of one. The resulting carrier envelope power is proportional to the sum of I^2 and Q^2:

$$P \propto I^2 + Q^2$$

The figure below shows the resulting vector and RF signal based on the two normally distributed baseband signals.



Fi
m



The PDF of a normal distribution can be described by the following formula:

$$f(\sigma, \mu, x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(\frac{-(x-\mu)^2}{2\sigma^2}\right)$$

If a new random variable is created from k independent, normally distributed random variables with a mean of zero (μ=0) and a variance of one (σ=1), the resulting distribution is the chi-square distribution:

$$f(x,k) = \begin{cases} \frac{(1/2)^{k/2}}{\Gamma(k/2)} x^{k/2-1} e^{-x/2} & x > 0 \\ 0 & x \leqslant 0 \end{cases}$$

In the case of I/Q modulation, the degree of freedom is two (k=2), which simplifies the PDF according to the following equation:

$$f(x,2)=\frac{1}{2}e^{-\frac{1}{2}x}$$

This equation demonstrates that the AWGN signal produces a PDF that can be approximated by the exponential function. This is the AWGN reference curve that the Power Viewer Software adds as the reference.

The statistics become more complex when the signal consists of two components, such as a constant RF carrier with a modulated signal.

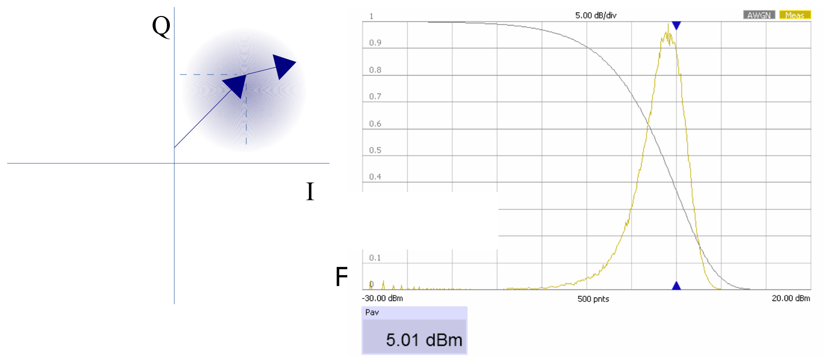


Fig. 18.3.4: Constant signal with added I/Q modulation and PDF.

In this case, the mean values of the I- and Q-signals are not zero (μ≠0) and the chi-square distribution cannot be used for the resulting envelope power.
Please note that the assumptions above are valid for power levels that are significantly higher than the power-sensor noise level.

18.4 CDF Mode

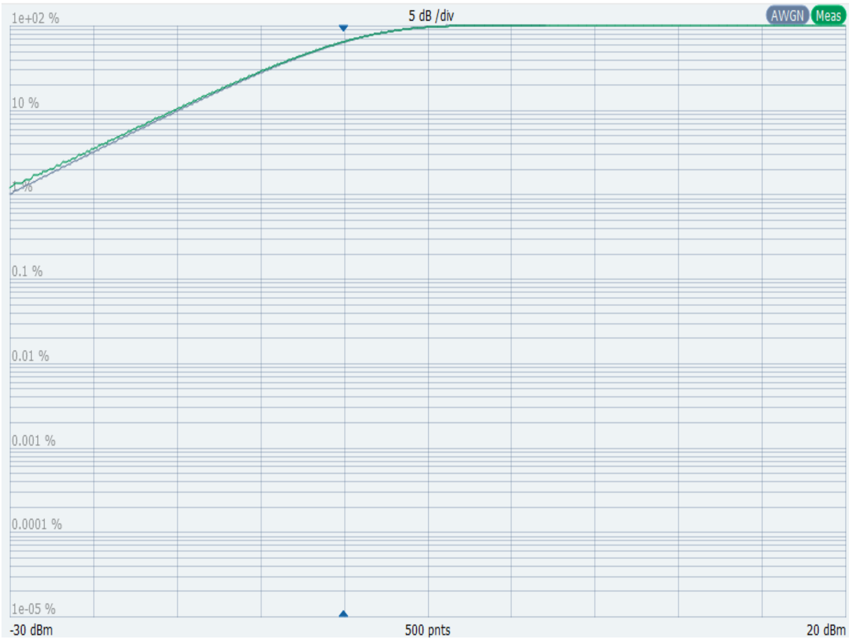


Fig. 18.4.1: The CDF curve of a 3GPP signal with an AWGN reference curve at an average power level of 0 dBm.

CDF stands for cumulative distribution function and is the integral of the PDF curve. The advantage of the CDF curve is that it emphasizes minimum power values.
The ideal AWGN reference signal remains the exponential function, because the integral of e^x remains e^x.

18.5 CCDF Mode

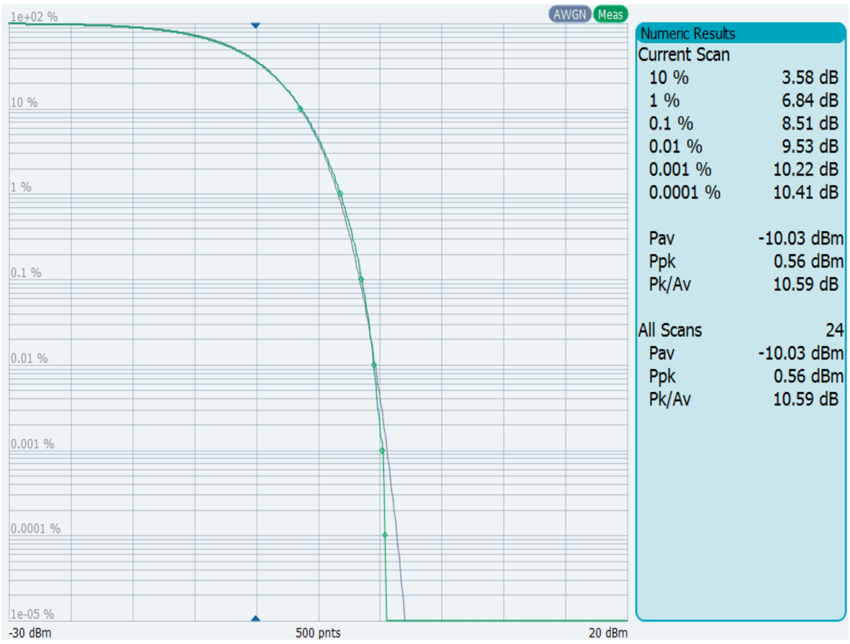


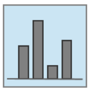
Fig. 18.5.1 The CCDF curve of a 3GPP signal with an AWGN reference curve at an average power level of 0 dBm.

CCDF stands for complementary cumulative distribution function and is the complement of the CDF curve. Its curve is calculated using the following equation:

$$CCDF = 1 - CDF$$

The advantage of the CCDF curve is that it emphasizes peak power values. That is the main reason why the CCDF plays an important role in many applications.
The ideal AWGN reference signal is described by the exponential function.

19 Timeslot Mode



This mode measures the average power of a definable number (up to 16) of successive timeslots within a frame structure with equal spacing. When the averaging function is activated (averaging factor of two or more), measurements are performed with chopper stabilization to obtain more accurate results with reduced noise and zero offset. Chopper stabilization involves reversing the polarity of the detector output signal from frame to frame. Taking the difference of the output signals minimizes the video path's effect on noise and zero drift.

19.1 Settings

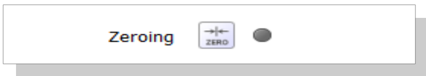


Fig. 19.1.1: Zeroing controls.

Zero
This option is only available while the measurement is running. It starts the zeroing sequence for the current sensor. For this purpose, the RF signal must be switched off, or the sensor must be disconnected from the signal source. The sensor automatically detects the presence of any significant power, which causes zeroing to be aborted and an error to be generated. The LED next to the zeroing button changes it's color depending on the current zeroing state.

Grey	Zeroing was not performed since the measurement got started.
Blue	Zeroing is in progress. The measurement results are not updated during this time.
Green	Zeroing finished successfully.
Red	Zeroing failed. In this case the LED initially flashes and then turns red continuously.

The zeroing process may take more then 8 seconds to complete and varies with the sensor model.
Generally, it is possible to run the sensor zeroing with a small signal (such as broadband noise) applied to the sensor. This makes it possible to compensate for this signal in later measurements.

The power scale section sets the y-axis for the timeslot display. The numbers do not affect the measurement itself.

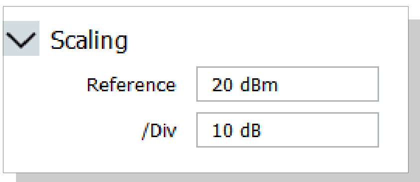


Fig. 19.1.2: Setting the power scale.

Reference
Sets the maximum power level for the timeslot display.

/div

Defines the scaling between 0.1 dB/div and 20 dB/div.

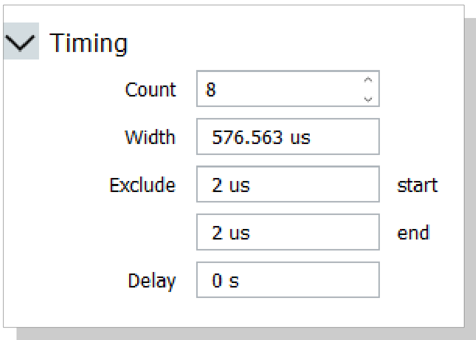


Fig. 19.1.3: Setting the timeslot structure.

The timing section sets all parameters that are required to precisely define the timeslot structure for the signal to be analyzed. To obtain stable and reliable results, it is essential that these parameters match the signal exactly.

Number
Defines the number of timeslots that belong to a single frame. The permissible range is from one to 16.

Width
Sets the width of a single timeslot within the frame structure. Each timeslot has exactly the same width.

Exclude
Defines the time gaps at the beginning or at the end of a timeslot that is not evaluated for the measurement. These parameters are used to define the spacing between adjacent timeslots.

Delay
Specifies the time between the physical trigger event and the start of the first timeslot.

The averaging filter reduces the noise level significantly.

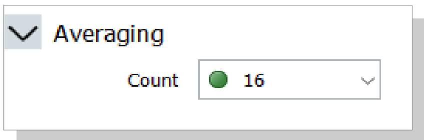


Fig. 19.1.4: Setting the filter count for the averaging filter.

Count
The filter count sets the number of frames that are to be evaluated to form one measurement result.

Timeslot measurements always require stable and reliable trigger conditions. This is particularly important when averaging is enabled and multiple measurements are used for one result.

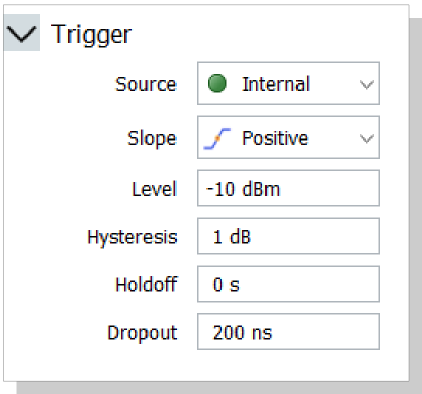


Fig. 19.1.5: Trigger settings.

Source
The trigger source can be either internal or external. When an external source is used (R&S NRP-Z3 or R&S NRP-Z5 adapter), only the settings for polarity and holdoff time are available. The new generation NRP power sensors provide a second SMB trigger input. This option is available as External SMB.

Slope
The trigger slope can be set to either the positive or negative edge. This setting is available for all trigger sources.

Level
Sets the trigger threshold for internal triggering derived from the test signal. In order to achieve stable trigger conditions, it is advisable to use a trigger level above –20 dBm.

Holdoff
Suppresses trigger events within the set holdoff time (in seconds), starting from the time of the last successful triggering.

Dropout
Sets the dropout time in microseconds. With a positive (or alternatively: negative) trigger slope, the dropout time is the minimum time for which the signal must be below (above) the trigger power level before triggering can reoccur. As with the holdoff parameter, unwanted trigger events can be excluded. The set dropout time only affects the internal trigger source.

19.2 Graphical Data View

The graphical timeslot power view contains the information shown in the figure below.

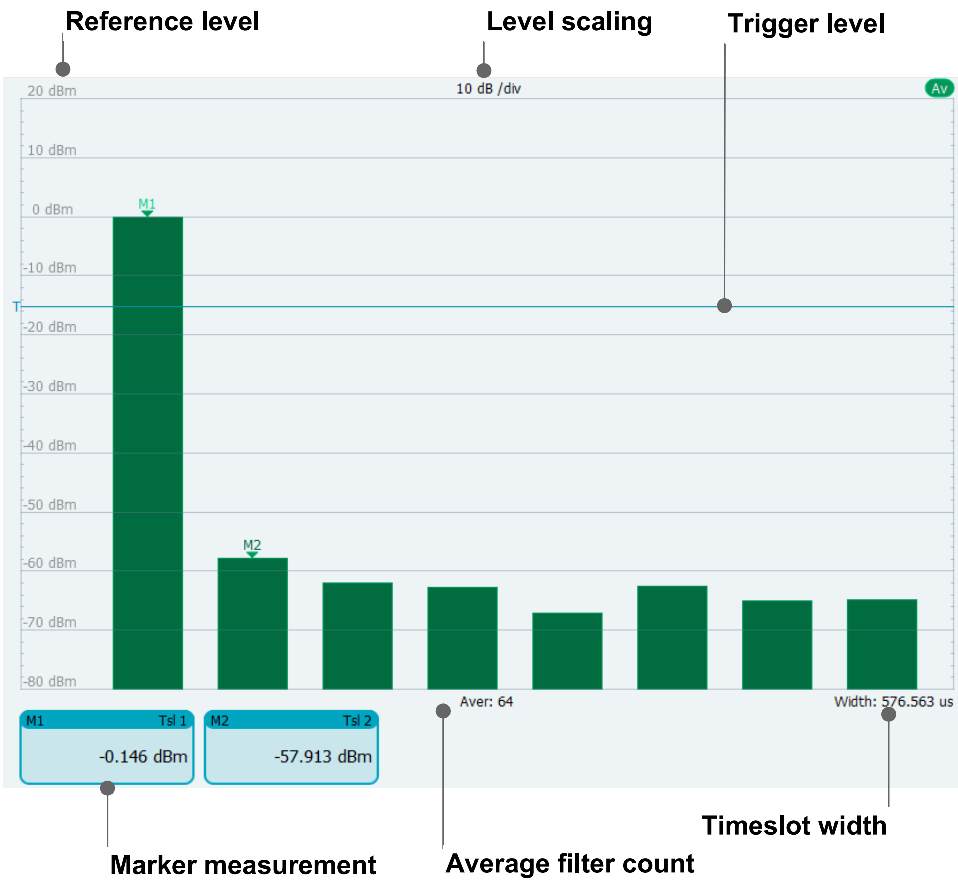


Fig. 19.2.1: The timeslot panel.

All bars are updated continuously. The update rate depends mainly on the setting for the average filter count. The higher the filter count, the lower the update rate and the noise level.

Markers
A maximum of four markers can be placed on any of the 16 timeslots to achieve precise average power readings. These readings are displayed below the bar graph area.

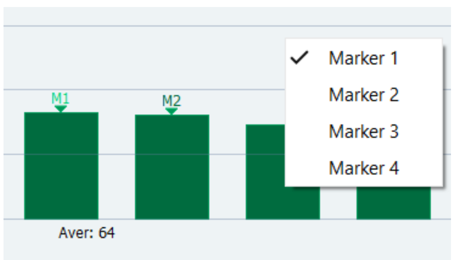


Fig. 19.2.2: Context menu in the timeslot average view.

A context menu can be activated within the bargraph view by right-clicking with the mouse. This menu is used for selecting the active marker (one to four). As a next step, markers can be dragged by holding down the left mouse button within the graphics area. A thin line displays the column on which the marker is to be placed. Moving the mouse to the very left or very right border disables the marker.

20 Multi-Channel Power Measurements

Many power measurement tasks require simultaneous measurement of multiple channels. The multi-channel measurement panel provides up to 16 parallel power measurements. In addition, four results can be computed using mathematical expressions.

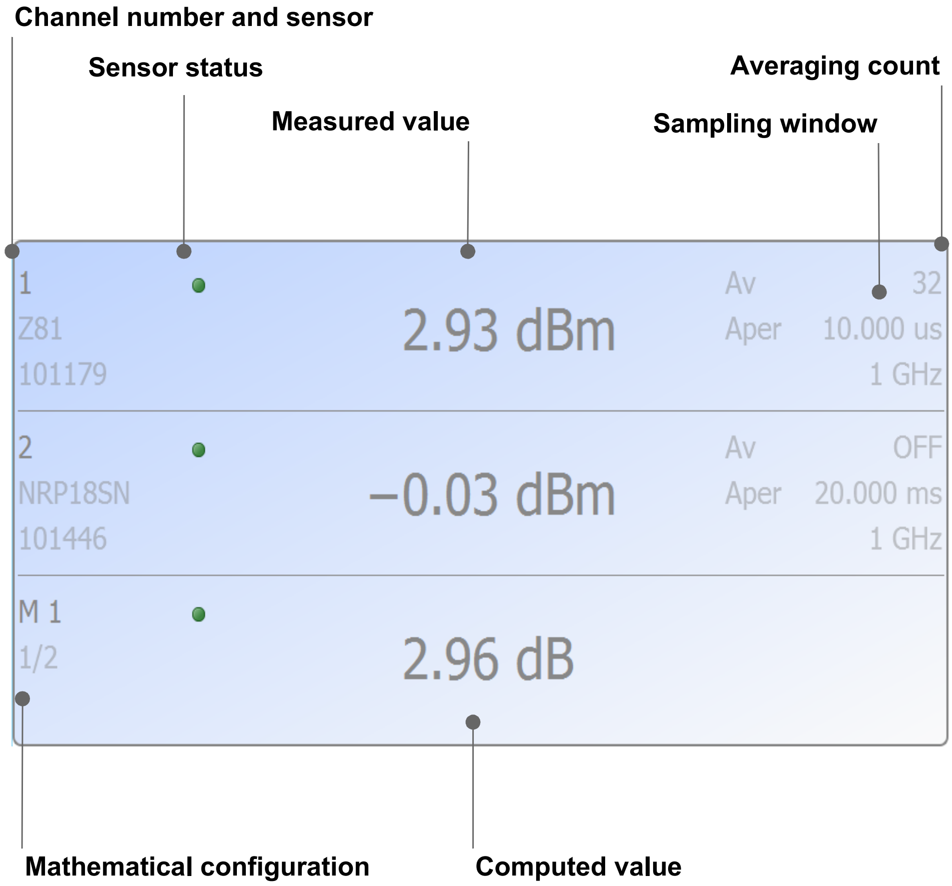


Fig. 20.1: Multi-channel measurement.

Each of the 16 channels use a separate sensor configuration. Therefore, assigning the same sensor to multiple channels is not permitted.

Data Processing
All measured values are automatically forwarded to the data processing panels.

20.1 Channel Configuration

Power Viewer continuously measures the average power of up to 16 sensors. These measurements are referred to as channels (Ch 1 through Ch 16). Each channel must be either turned OFF or assigned to an R&S NRP sensor.

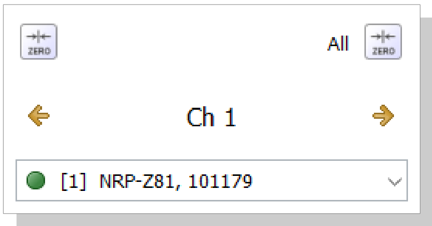


Fig. 20.1.1: Sensor zeroing settings.

Zero
This button starts the sensor zeroing process for the currently selected channel only. None of the other channels are affected. For sensor zeroing to work, no RF power may be applied to the sensor and no measurement may be running.

All Zero
Starts the sensor zeroing process for all configured sensors. Only sensors that are marked by a green LED can be zeroed.

Left and right arrow
These buttons switch the system to the previous or next channel.

Sensor selection
This control lists all sensors that were discovered during the last scan and the sensors required by the currently loaded project. Available devices are marked with a green LED. Devices that are required by the currently loaded project but appear to be unavailable are marked with a yellow LED.
Sensors that are already assigned to a measurement channel display their channel numbers in square brackets. These devices cannot be assigned again to a different channel.
Each sensor can be configured individually. This accounts for the use of different sensor technologies or individual path losses or measurement frequencies within one setup.
If an alias name has been assigned to a sensor, this name is displayed first followed by the sensor type and serial number in parentheses.

20.2 Measurement Settings

The measurement settings are similar to the ones available for the continuous power average mode. Please refer to the chapter 14, "Continuous Power Measurements," for a more detailed discussion of these parameters.

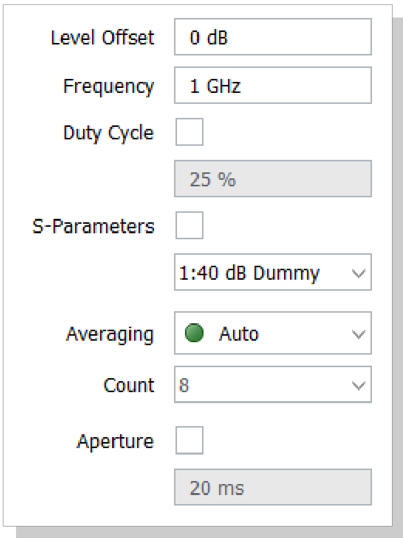


Fig. 20.2.1: Multi-channel measurement settings.

The general correction settings, such as the frequency, level offset, or S-parameter correction, are not used in multi-channel measurement mode. Instead, each channel provides its own settings.

20.3 Mathematical Expressions

Power Viewer provides a set containing the most commonly required mathematical operations that can be computed from two measured values. These four computed values are referred to as channels M1, M2, M3 and M4.

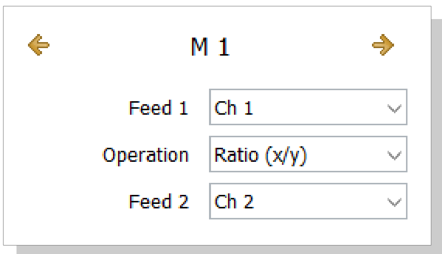


Fig. 20.3.1: Mathematical settings for multi-channel measurements.

Sum
Two measured power values are added in linear scale (watts). The result is displayed in watts or dBm.

Diff
Two measured values are subtracted from each other in linear scale (watts). The result is displayed in watts or dBm.

Ratio
The ratio is calculated by dividing one measurement by the other one. The result is displayed without a unit or is converted to dB.

RCoeff

The reflection coefficient is computed from two measured values in logarithmic scale using the following equation:

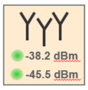
$$RC = 10^{\frac{|P_1 - P_2|}{20}}$$

SWR

The standing wave ratio is computed from two measured values using the following equation:

$$SWR = \frac{1 + RC}{1 - RC}$$

21 OTA Multi-Channel Measurement



The OTA multi-channel measurement is very similar to the regular multi-channel measurement. The main difference is that OTA sensors deliver three individual power values from their individual antenna elements. The OTA measurement therefore displays three average power values per sensor.

This chapter only describes the differences to the regular multi-channel measurement.

21.1 Settings

Fig. 21.1.1: Settings for OTA multi-channel measurement.

Channels
The three channels of the OTA sensor can be individually enabled or disabled. Channels without an antenna connection must be disabled to avoid error messages.

22 NRQ Signal Check

The NRQ Signal Check measurement displays the intermediate frequency (IF) spectrum of the test signal in the selected bandwidth.

The signal check measurement does not require any specific settings. It only depends on the global NRQ settings. These settings are accessible via the NRQ settings dialog. Use the NRQ icon in the lower right toolbar to open this dialog.

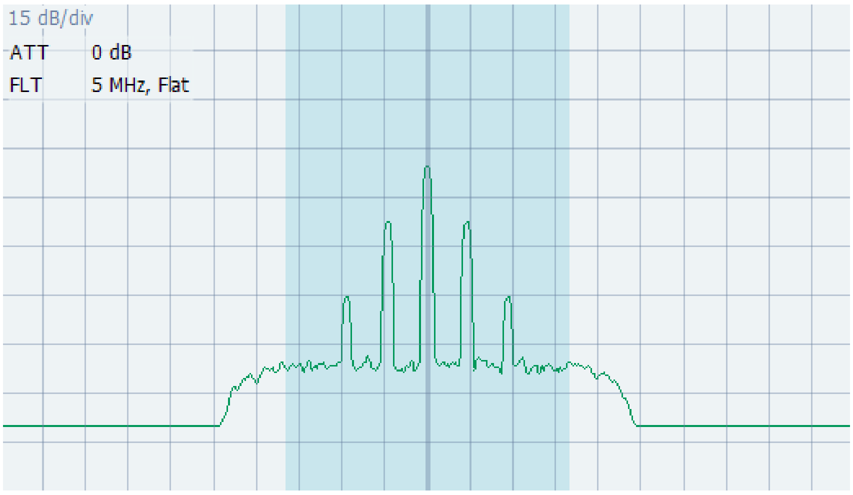
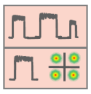


Fig. 22.1: NRQ Signal Check Measurement.

23 NRQ IQ Analyzer



The NRQ IQ Analyzer measurement displays the IQ data versus time, the power spectrum, and an IQ constellation diagram of the test signal in the selected bandwidth.

This measurement is only available if the option NRQ-K1 is installed on the connected NRQ sensor.

The configuration parameters differ from the trace measurement. The main difference to the trace measurement is that the IQ Analyzer captures a defined number of samples. In contrast, the trace measurement captures data over a defined amount of time and then computes video points from the captured data.

The capture time in the IQ Analyzer depends on the number of samples to be captured as well as the NRQ sample rate. The sample rate is automatically derived from the filter bandwidth and shown in the upper right corner of the time domain plot.

All NRQ specific settings, such as the filter bandwidth are accessible via the NRQ settings dialog. Use the NRQ icon in the lower right toolbar to open this dialog.

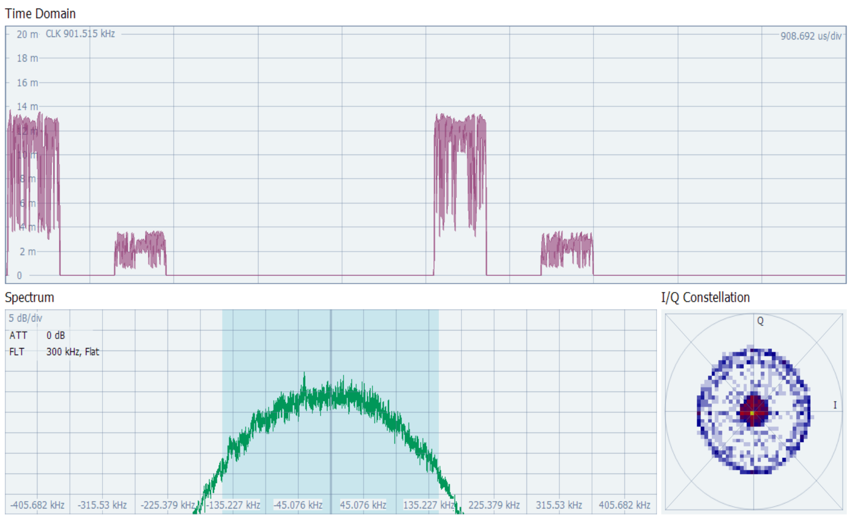


Fig. 23.1: NRQ IQ Analyzer with bursted EDGE signal.

23.1 Settings

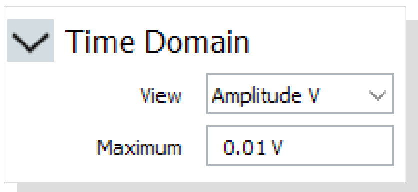


Fig. 23.1.1: Configuring the time domain display.

The time domain settings configure the view in the upper time domain display of the IQ Analyzer panel. These settings do not affect the data

View
Sets how the captured IQ samples are shown in the time domain display.

Amplitude V	Calculates the voltage of the IQ sample
Amplitude W	Calculates the power based on 50 Ohms
Level dBm	Calculates a power level in dBm
I/Q	Displays the raw I/Q data
Phase	Calculates the wrapped phase from the IQ samples
Frequency	Calculates the baseband frequency offset from the IQ samples

Maximum
Sets the maximum voltage value for the time domain view. The default is 1.0 volt. Setting the maximum voltage to smaller values allows to visualize weak signals.
This setting affects the modes Amplitude and I/Q as well as the constellation diagram.

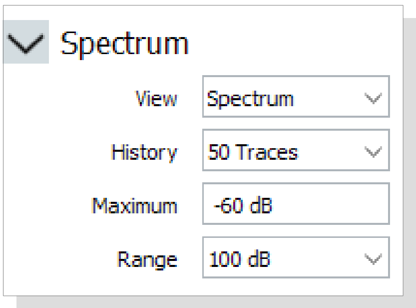


Fig. 23.1.2: Configuring the spectrum display.

The spectrum display shows the power spectrum of the captured IQ signals. Power Viewer calculates the FFT spectrum for each received IQ trace and stores this spectrum in an internal ring buffer.

View, History
The spectrum display can be set to either spectrum or spectrogram (waterfall) mode. In spectrum mode the history parameter defines how many FFTs from the ring buffer are used to calculate the average power spectrum. In spectrogram mode the history parameter defines the number of lines in the spectrogram.

Maximum
Sets the upper border of the spectrum or spectrogram display in dBm. Lowering this parameter allows to analyze weak signals.

Range
Sets the overall power level range used in the spectrum or spectrogram display.

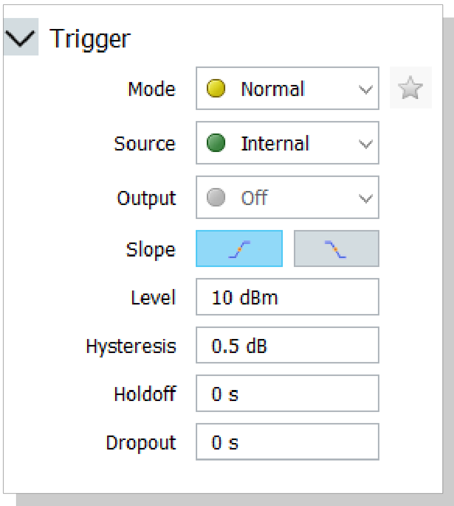


Fig. 23.1.3: Setting the trigger.

The trigger settings in the IQ Analyzer are identical to the trigger settings in the trace measurement.

Mode
The trigger mode can be set to Free Run, Auto, Normal, or Single mode.
In *free run* mode, the sensor does not wait for trigger events and continuously acquires waveforms. The waveform display is not synchronized, and the waveforms typically roll across the display. Averaging is disabled in this mode.
In *auto* trigger mode, the sensor acquires data, even if no trigger event occurs. Auto mode uses a timer that starts when a trigger occurs. After 1 s has elapsed, the software forces a trigger release and restarts its timer. In the absence of valid trigger events, the acquired waveforms are not synchronized. Average filter settings do not apply in this case. When valid triggers exist, the waveforms become synchronized and averaging can be used.
In *normal* mode, the sensor only acquires a waveform when it is triggered by an internal or external trigger event. If no trigger event occurs over a period of about 2 seconds, the Trig? indication is shown on the user interface. The last waveform acquired remains on the display, and the sensor keeps waiting for the next trigger event. If no waveform has been acquired, the display remains blank.
In *single* mode, the sensor arms its trigger unit when the ARM button is pressed. Subsequently, it performs one acquisition as soon as the trigger condition is met. If no trigger event occurs over a period of about 2 seconds, the Trig? indication is shown on the user interface. The waveform acquisition includes averaging, which means that 2*N trigger events must occur before the acquisition completes. If single-shot events are to be analyzed, the averaging filter count must be set to Real Time.

Source
This setting establishes the trigger signal's source. Internal means that the trigger event is generated by the applied RF signal and by the set trigger level. When an external source is used, the trigger level and hysteresis functions are not effective. The option 'External SMB' activates the SMB trigger input that is available on all new generation NRP power sensors. In that case the user can select between an input impedance of 10 kOhms or 50 Ohms.

Output
The new R&S NRP Power Sensors can use their built in SMB connector as trigger output. In this case a rising edge is generated when the power measurement starts. Please see the power sensor user manual for details on how to use this feature.

Slope
The trigger slope can be set to either the positive or negative edge. This setting is available for all trigger sources.

Level
This level setting establishes the trigger threshold for internal triggering derived from the test signal.

Holdoff
The holdoff setting suppresses trigger events within the set holdoff time (in seconds), starting from the time of the last successful triggering. The holdoff time must be larger than the total trace time.

Dropout
This setting establishes the dropout time in microseconds. With a positive (or alternatively: negative) trigger slope, the dropout time is the minimum time for which the signal must be below (above) the trigger power level before triggering can occur again. As with the holdoff parameter, unwanted trigger events can be excluded. The set dropout time only affects the internal trigger source.

Fig. 23.1.4: IQ capturing settings.

Samples
Sets the length of each IQ capturing in samples. The capture time results from the sample rate and the number of samples. The sample rate depends on the NRQ filter bandwidth and is shown in the upper left corner of the time domain display.

24 Script-Based Measurement

The script-based measurement function is useful for implementing custom measurement tasks that cannot be covered by the measurement panels provided in Power Viewer. For this purpose, a script language is used. This language is based on the ECMAScript scripting language, as defined in the standard ECMA-262. Microsoft's JScript, and Netscape's JavaScript are also based on the ECMAScript standard.

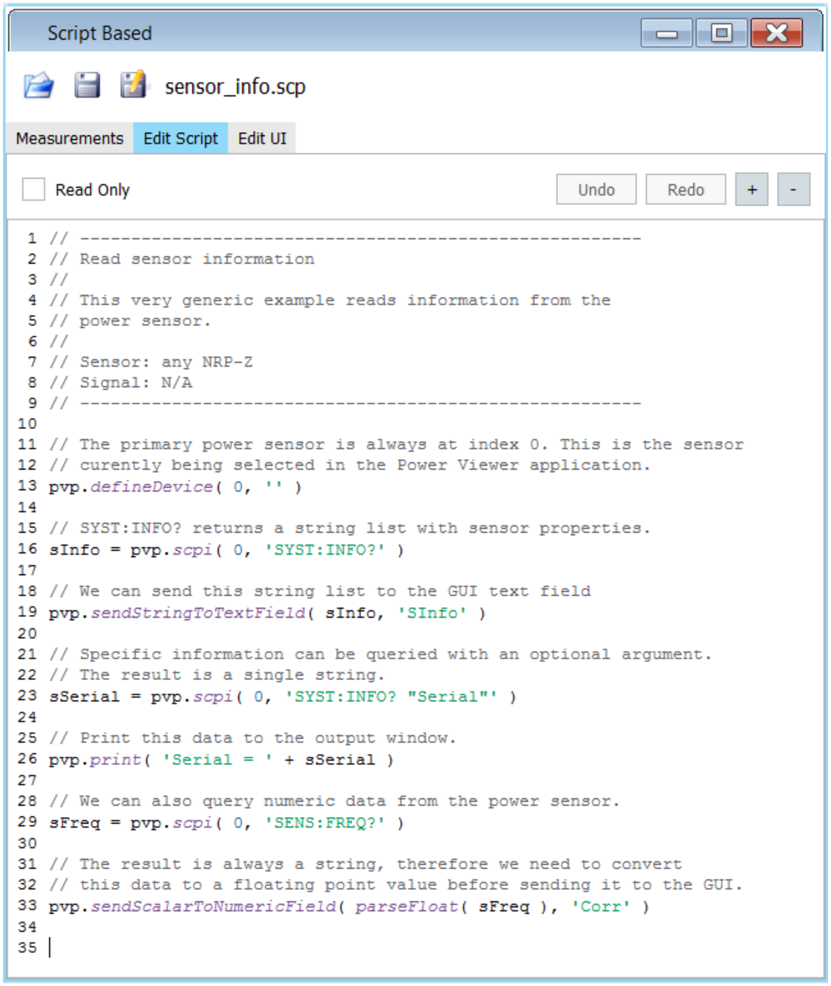


Fig. 24.1: The script window.

The scripting panel provides three pages. The first page shows the measurement results and status messages during script execution. This page is automatically activated when the script gets started. Data can be viewed numerically or graphically as trace or bar chart.
The layout of this panel is designed by the UI editor which is located on the third page.
The second page contains the script editor itself.

24.1 Script Syntax

The detailed description of the script syntax is out of scope of this user manual. Please refer to the script standard, that can be found under the following link:

http://www.ecma-international.org/publications/standards/Ecma-262.htm

Alternatively, any tutorial or documentation on JavaScript could be used.

In addition to the script standard the global object **pvp** exists within the Power Viewer script context. This global object extends the script functionality. This section mainly describes the **pvp** script extension.

24.2 Printing to the Script Output Window

Any text or string variable can be printed to the script output window. The `print` method is used to do this. Non-string variables must be converted into strings before using them with this method.

```
pvp.print( 'My Text' )

var dVal = 1e-3
pvp.print( 'Measurement = ' + dVal.toString() )
```

24.3 Printing to the Message Window

Three methods exists to output text messages to the application's message log. By default only information and error messages are shown on the message log. Debug output can be enabled by starting the application with the command line argument `--debug`.

```
pvp.info( 'This is an info text.' )
pvp.debug( 'This is a debug message.' )
pvp.error( 'This is an error message.' )
```

24.4 Waiting Periods

The `sleep` method is used to wait for a definable amount of time. The waiting period is specified in milliseconds, and script execution is suspended for at least this amount of time.

```
var iTimeMs = 500
pvp.sleep( iTimeMs )
```

24.5 Timers

The script extension provides built in timers. These timers can be used to measure the execution time of measurement tasks.

The following method returns the current timer resolution in seconds.

```
var dResolution = pvp.timerResolution()
```

This **time** method returns the time since script start in seconds.

```
var dCurrTime = pvp.time()
```

The following method returns the time of the last SCPI execution in seconds.

```
var dLastExecTime = pvp.lastExecTime()
```

This `userTime` method returns the elapsed time since the last call to this method in seconds.

```
userTime()
// do something …
double dElapsed = userTime()
```

24.6 Power Conversion

Two conversion methods exist for the commonly required task to convert from linear power in Watts to logarithmic power levels.

The `toDbm` method converts a power value from Watts to dBm.

```
var dPowdBm = pvp.toDbm( 1e-3 )
pvp.print( 'Power Level in dBm is ' +
              dPowdBm.toString() )
```

The `toDbW` method converts a power value from Watts to dBW.

```
var dPowdBW = pvp.toDbW( 1e-3 )
pvp.print( 'Power Level in dBW is ' +
              dPowdBW.toString() )
```

24.7 File Operations

The script language contains three functions related to file-based output operations. All file operations should be used with great care because they provide full access to the entire file system using the current user account of the application.

The following function call removes a file from the hard drive.

```
pvp.removeFile( 'C:/Temp/MyFile.tmp' )
```

Writing text data to a file is possible using the following two functions.

```
pvp.writeToFile( 'C:/Temp/MyFile.tmp',
                 'String to write' )

pvp.appendToFile( 'C:/Temp/MyFile.tmp',
                  'String to append' )
```

Both functions write a single line of text. The first function removes the content of an existing file and then writes the text string. The second function appends the string to the end of the file.

24.8 Defining Devices

The primary task for the script language is to remote control power sensors or other measurement equipment via SCPI commands. Before sending remote control commands to an instrument it is required to define this instrument as a device. The currently selected sensor is available as device with the index zero. Other sensors may be defined for use with the script language in which case device index values starting at one will be assigned.
The `defineDevice` method defines a sensor ID and also opens the sensor connection. It must always be used before attempting to send SCPI commands to a sensor.
All sensor connections are automatically closed when the script finishes. If this is not desired an infinite loop must be added to the end of the script.
The `defineDevice` method may also be used to define VISA interface connections to Rohde&Schwarz signal generators. In this case the argument is interpreted as the VISA resource string.

Prepare the primary power sensor for use with the script. If device index 0 is used the second argument is ignored. The method automatically uses the resource string of the currently selected power sensor.

```
pvp.defineDevice( 0, '' )
```

It is also possible to open other R&S instruments for use in the script. In this case the second argument sets the VISA resource string of the instrument.

```
pvp.defineDevice( 1, 'TCPIP::10.111.10.123::INSTR' )
```

24.9 Communication Timeout

The `setDeviceTimeout` method sets the timeout for all instrument communication. The first parameter is the device ID used with the `defineDevice` method. The second parameter is the timeout value in seconds.

```
pvp.setDeviceTimeout( 1, 10 )
```

24.10 Suppressing SCPI Log Messages

By default all SCPI communication is logged to the applications message log. The logging can be turned on or off with the `setEchoState` method. The logging state affects all devices.

```
pvp.setEchoState( 0 )
...
pvp.setEchoState( 1 )
```

24.11 SCPI Commands and Queries

SCPI commands are directly send to the instrument. The list of available commands can be found in the instrument's user manual. It is important to note that the capital letters used in the commands are the short form, whereas the lower case letters describe the complete command.

Command in user manual:	`SENSe:AVERage:COUNt 32`
Possible use:	`SENS:AVER:COUN 32`

```
SENSE:AVERAGE:COUNT 32
```

Queries are used similarly to SCPI commands, but they end with a question mark.

The `scpi` method requires the device index as the first argument. The device index 0 is used for the primary power sensor. Before using the `scpi` method the sensor must be initialized by a call to `defineDevice`.

```
pvp.defineDevice( 0, '' )

pvp.scpi( 0, '*RST' )

var sInfo = pvp.scpi( 0, 'SYST:INFO?' )
pvp.print( 'Info = ' + sInfo )

var sSerial = pvp.scpi( 0, 'SYST:INFO? "Serial"' )
pvp.print( 'Serial = ' + sSerial )

var sFreq = pvp.scpi( 0, 'SENS:FREQ?' )
pvp.print( 'Correction Frequency = ' + sFreq )
```

The `scpi` method sends the command text provided as second argument to the instrument. If the command contains a question mark the method subsequently reads the instrument's response. The method can therefore be used for write and read operations.

The returned data is always a string. Use the JavaScript's `parseFloat()` function to convert a string to a floating point value.

24.11.1 Simulated Queries for Use With NRP-Z sensors

The following queries conform to the SCPI language but cannot be found in the NRP-Z sensor's user manual, because the sensors do not directly support them. Instead, these sensors send their measured values in binary format to the driver layer. The driver caches this information and provide them to the application using the driver. In order to access this cached information a set of queries are implemented in the **`scpi`** method.

Reading scalar measurement data is achieved by using the `READ?` or `FETCH?` queries.

Command Syntax:

```
READ[:AUX]?
FETCH[:AUX]?
```

The `READ?` query initiates a measurement, waits for up to 5 seconds, and then fetches one single float-type result.
The `READ:AUX?` query initiates a measurement, waits for up to 5 seconds, and then fetches a set of three scalar results. The `READ:AUX?` query can only be used if the sensor is configured for `AUX` mode.
The `FETCH?` queries are similar to the `READ?` queries, but they do not initiate a measurement. Instead, the sensor is immediately queried for a result. An error is generated if no result is available.

Four additional queries read or fetch buffer (array) measurement data from the sensor.

Syntax:

```
READ:BUFF[:AUX]?
```

```
FETCH:BUFF[:AUX]?
```

In contrast to the `READ?` and `FETCH?` queries, which read scalar results, these queries return an entire array of floating-point values.
If the returned data is saved to a variable, this variable is automatically set to the floating-point array data type.

24.11.2 Reading Results from New Generation Sensors

The new generation NRP power sensors support the SCPI language internally. In contrast to the SCPI standard the FETCH? query automatically waits for completion. This simplifies synchronization.

```
pvp.scpi( 'INIT:IMM' )
var sResult = pvp.scpi( 'FETCH?' )
```

The result string contains either a single value or a list of values separated by comma. This depends on the measurement mode.

24.12 Waiting for Measurement Completion

The `sync method` waits for the completion of a task or until the definable timeout has expired. This is useful when it is necessary to synchronize to the measurement completion state. During the waiting period, the user can stop the script using the Stop button.

```
// start ARB in signal generator
pvp.scpi( 1, 'BB:ARB:STAT ON' )
pvp.sync( 1, 5 )

// continue...
```

Note:
The time granularity of the instrument polling depends on the operating system. On Windows installations the minimum polling interval is in the order of 10 to 15 ms. For time critical applications it is therefore recommended to use the READ? query instead.

This method is generally not required for NRP-Z power sensors. Instead use the READ? Query with these sensors.

The new generation NRP power sensors do not provide the READ? query. Instead these sensors use a combination of INIT and FETCH? to read measurement results.

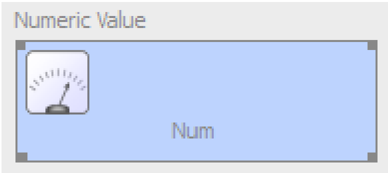
24.13 Checking for Errors

The `checkError` method executes the SYST:ERR? query repeatedly until no more errors are read from the instrument. The return value of this method is true if no errors were read from the instrument.
The argument is the instrument's device index.

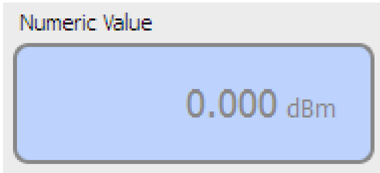
```
if( pvp.checkError( 0 ) == 0 ) {
   pvp.print( 'Errors occurred' )
}
```

24.14 Displaying Scalar Results

Scalar variable data can be displayed in one of the three numeric displays using the `sendScalarToNumericField method`.
The first parameter is the value to be displayed. The second parameter is the reference name of the numeric display. The third parameter is optional and sets the unit.



GUI Editor



Measurement Panel

```
var dLevel = pvp.toDbm( 1e-3 )
pvp.sendScalarToNumericField( dLevel, 'Num', 'dBm' )
```

24.15 Displaying Array Data Numerically

Array data can be displayed numerically in a table field using the `sendArrayToTable` method. The array data is passed to the bar graph as comma-separated values in a single text string. The second parameter is the reference name of the table display.

```
var sValues = '1e-3,1e-4,1e-5,1e-6'
pvp.sendArrayToTable( sValues, 'Table' )
```

24.16 Displaying Array Data as a Bar Graph

Array data of up to 32 elements can be displayed as bar graphs using the `sendArrayToBars` method.
The data representation for the bar graph always uses a logarithmic scale (dBm). All input data must be provided as linear power values in Watts. The array data is passed to the bar graph as comma-separated values in a single string. The second parameter is the reference name of the bar graph display.

```
var sValues = '1e-3,1e-4,1e-5,1e-6'
pvp.sendArrayToBars( sValues, 'Bar' )
```

24.17 Displaying Array Data as a Trace

Array data of any length can be displayed as trace graphs using the `sendArrayToTrace` method.
The data representation for the trace always uses a logarithmic scale (dBm). All input data must be provided as linear power values in Watts. The array data is passed to the bar graph as comma-separated values in a single string. The second parameter is the reference name of the trace graph display.

```
var SValues = '0'
for( var i = 1; i < 360; i++ ) {
       sValues = sValues.concat( ',' )
       dVal    = 1e-3+5e-4*Math.sin( 2*3.14*i/90 )
       sValues = sValues.concat( dVal.toString() )
}
pvp.sendArrayToTrace( sValues, 'Trace' );
```

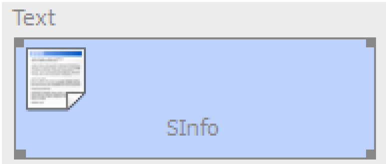
24.18 Displaying Array Data as a Time Series Plot

Arrays data of any length can be displayed as time-series plots using the `sendArrayToTimeSeries` method.
The plot's Y-axis is automatically scaled based on the maximum value in the array. The data representation for the trace always uses a logarithmic scale (dBm). All input data must be provided in linear power values in Watts. The array data is passed to the bar graph as comma-separated values in a single string. The second parameter is the reference name of the time series graph display.

```
...
pvp.sendArrayToTimeSeries( sValues, 'TSer' );
```

24.19 Displaying Text

String variables can be sent to a text element on the UI. Use the `sendStringToTextField` method to do this.



GUI Editor

Measurement Panel

```
var sText = 'Test\nMultiLine\nText'
pvp.sendStringToTextField( sText, 'SInfo' )
```

24.20 Sending Data to Processing Panels

Scalar variable data can be forwarded to all data sinks using the `sendScalarToSink` instruction.
The channel number must be in the range between one and four. It addresses the channel in the data-processing panels.

```
var dValue = 1e-3
var iChannel = 1
pvp.sendScalarToSink( dValue, iChannel )
```

24.21 Examples

24.21.1 Triggered Average Power Measurement

The triggered continuous average measurement measures a single scalar power value once a trigger event occurs.
In the example below, a pulse with a duration of 50 ms occurs once every second. The pulse's power level varies slowly. The sensor should provide an individual reading for each pulse.
The example script uses a measurement window of 10 ms. Each result is generated from two internal measurements (with chopper enabled) within the sensor.

```
var dFreq    = 1e9
 var dTrigLev = 1e-3

// connect to primary sensor
 pvp.defineDevice( 0, '' )

// configure power measurement
 pvp.scpi( 0, '*RST' )
pvp.scpi( 0, 'SENS:FUNC "POW:AVG"' )
pvp.scpi( 0, 'SENS:FREQ ' + dFreq.toString() )
pvp.scpi( 0, 'TRIG:LEV ' + dTrigLev.toString() )
pvp.scpi( 0, 'TRIG:SOUR INT' )
pvp.scpi( 0, 'TRIG:SLOP POS' )
pvp.scpi( 0, 'SENS:AVER:STAT ON' )
pvp.scpi( 0, 'SENS:AVER:COUN 1' )
pvp.scpi( 0, 'SENS:POW:AVG:APER 10e-3' )

// infinite loop
do {
    pvp.scpi( 0, 'INIT' )               // new sensor generation
     var sAvPwr = pvp.scpi( 0, 'FETCH?' )

    var dAvPwr = parseFloat( sAvPwr )
    var dLevel = pvp.toDbm( dAvPwr )
    pvp.sendScalarToNumericField( dLevel, 'Av Power', 'dBm' )
    pvp.sendScalarToSink( dAvPwr, 1 )

    pvp.sleep( 10 )
} while( 1 )
```

The screen shot below shows the readings as they were captured in the data log window:

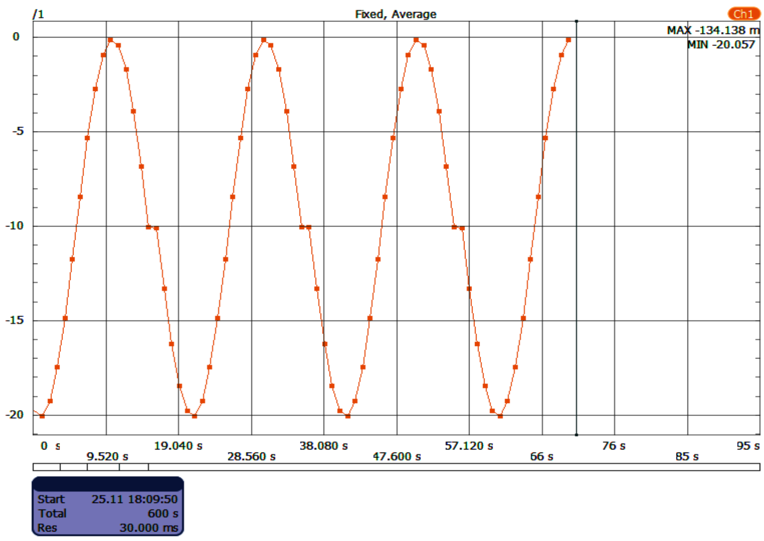


Fig 24.21.1: Triggered average power measurement readings.

24.21.2 Burst Power Measurement

The average burst measurement measures the average burst power. The burst timing is determined automatically based on the trigger threshold and the exclude times.
The following signal is used with this measurement:

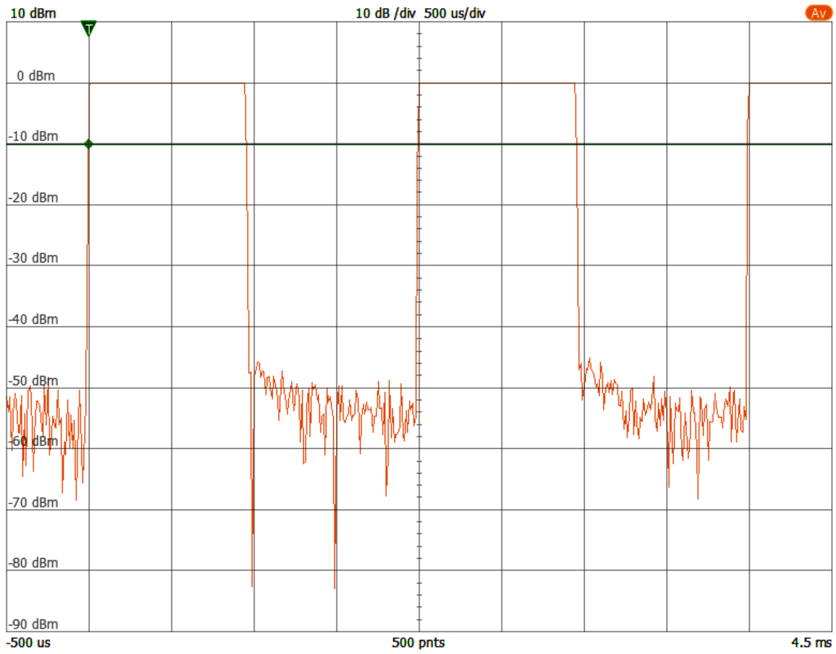


Fig. 24.21.2: Signal for the average burst measurement.

This example script measures the average burst power in dBm.

```
var dFreq    = 1e9
var dTrigLev = 0.1e-3

// connect to primary sensor
pvp.defineDevice( 0, '' )

// configure power measurement
pvp.scpi( 0, '*RST' )
pvp.scpi( 0, 'SENS:FUNC "POW:BURST:AVG"')
pvp.scpi( 0, 'SENS:FREQ ' + dFreq.toString() )
pvp.scpi( 0, 'TRIG:LEV ' + dTrigLev.toString() + ' W' )
pvp.scpi( 0, 'TRIG:HYST 3 DB' )
pvp.scpi( 0, 'SENS:POW:BURST:DTOL 1e-6' )
pvp.scpi( 0, 'SENS:TIM:EXCL:START 10e-6' )
pvp.scpi( 0, 'SENS:TIM:EXCL:STOP 10e-6' )
pvp.scpi( 0, 'SENS:AVER:COUN 4' )
pvp.scpi( 0, 'SENS:AVER:STAT ON' )
pvp.scpi( 0, 'SENS:AVER:TCON REP' )

// infinite loop
do {
    pvp.scpi( 0, 'INIT' )                // new sensor generation
    var sAvPwr = pvp.scpi( 0, 'FETCH?' )

    var dAvPwr = parseFloat( sAvPwr )
    var dLevel = pvp.toDbm( dAvPwr )

    pvp.sendScalarToNumericField( dLevel, 'Burst Av', 'dBm' )
    pvp.sendScalarToSink( dAvPwr, 1 )
    pvp.sleep( 100 )

} while( 1 )
```

24.21.3 Buffered-Mode Measurements

In buffered mode, the sensor captures a predefined number of measurements and then sends all results back to the PC. In the example below, a single-shot sequence of 20 bursts is measured using an individual trigger for each burst.

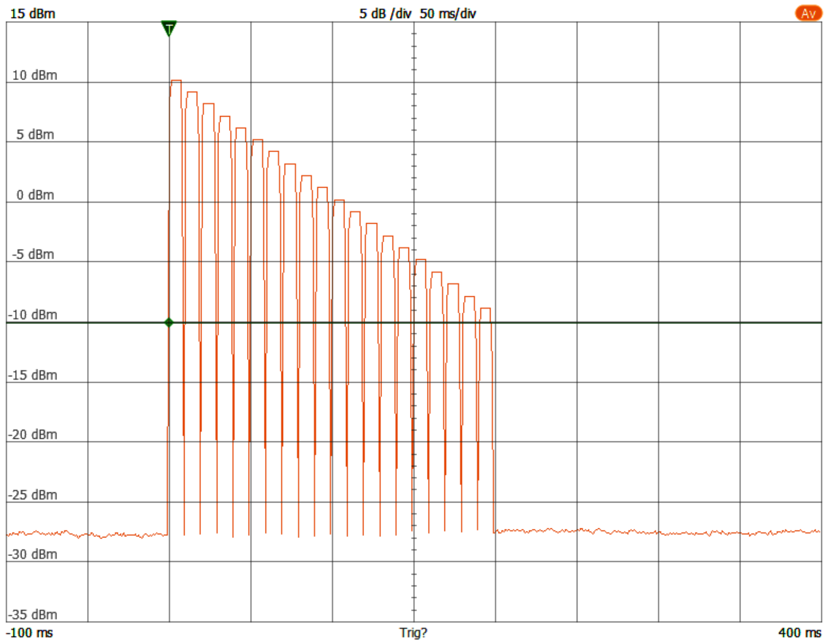


Fig. 24.21.3: Buffered-mode measurement of a 20-burst sequence.

The `INIT` command starts the measurement cycle. The sensor evaluates 20 trigger events and sets a flag once the measurement has been completed. The `FETCH?` query synchronizes to the measurement completion state.

```
var dFreq    = 1e9
var dTrigLev = 1.0e-5                    // -20 dBm

// connect to primary sensor
pvp.defineDevice( 0, '' )

// configure power measurement
pvp.scpi( 0, '*RST' )
pvp.scpi( 0, 'SENS:FUNC "POW:AVG"' )
pvp.scpi( 0, 'SENS:FREQ ' + dFreq.toString() )
pvp.scpi( 0, 'TRIG:LEV ' + dTrigLev.toString() )
pvp.scpi( 0, 'TRIG:SOUR INT' )
pvp.scpi( 0, 'TRIG:SLOP POS' )
pvp.scpi( 0, 'TRIG:DELAY 0.1e-3' )
pvp.scpi( 0, 'TRIG:COUNT 16' )
pvp.scpi( 0, 'SENS:AVER:STAT ON' )
pvp.scpi( 0, 'SENS:AVER:COUN 2' )
pvp.scpi( 0, 'SENS:POW:AVG:APER 2e-3' )
pvp.scpi( 0, 'SENS:POW:AVG:BUFF:SIZE 16' )
pvp.scpi( 0, 'SENS:POW:AVG:BUFF:STATE ON' )

pvp.scpi( 0, 'INIT' )                    // new sensor generation
var sValues = pvp.scpi( 0, 'FETCH?' )

pvp.print( 'Result: ' + sValues )

pvp.sendArrayToBars( sValues, 'Readings' )
```

24.21.4 Connecting to the R&S®NRP2 Base Unit

The script may also be used to access other Rohde&Schwarz instruments such as the NRP2 base unit. The following example code demonstrates how to read numeric data from channel A and B. The results are sent to numeric displays.

```
// NRP2 base unit connected via LAN
pvp.defineDevice( 1, 'TCPIP::10.111.1.200::INSTR' )

pvp.scpi( 1, '*RST' )
pvp.scpi( 1, '*CLS' )

pvp.scpi( 1, 'SYST:SPEED FAST' )
pvp.scpi( 1, 'SENS1:AVER:COUNT:AUTO OFF; :SENS2:AVER:COUNT:AUTO OFF' )
pvp.scpi( 1, 'SENS1:AVER:STAT OFF; :SENS2:AVER:STAT OFF' )
pvp.scpi( 1, 'INIT1:CONT OFF; :INIT2:CONT OFF' )
pvp.scpi( 1, 'SENS1:FREQ 1 GHz; :SENS2:FREQ 1 GHz' )

if( pvp.checkError( 1 ) ) {

     do {

        pvp.scpi( 1, 'INIT1; :INIT2' )
        var sResults = pvp.scpi( 1, 'FETCH1?; FETCH2?' )

        var sResultList = sResults.split( ';' )
        dVal1 = parseFloat( sResultList[0] )
        dVal2 = parseFloat( sResultList[1] )

        pvp.sendScalarToNumericField( dVal1, 'P1', 'dBm' )
        pvp.sendScalarToNumericField( dVal1, 'P2', 'dBm' )

        pvp.sleep( 200 )

    } while( 1 )

}
```

24.21.5 Connecting to the R&S®NRT Base Unit

The script may also be used to access other Rohde&Schwarz instruments such as the NRT base unit. The following example code demonstrates how to read numeric data from this base unit. The results are printed to the script output window.

```
pvp.defineDevice( 0, 'GPIB0::28::INSTR' )

pvp.scpi( '*RST' )

pvp.print( pvp.scpi( 1, '*IDN?' ) )
pvp.print( pvp.scpi( 1, 'TEST:SENS?' ) )

pvp.scpi( 1, 'SENS1:FREQ 1e9' )
pvp.scpi( 1, 'SENS1:FUNC:CONC OFF' )            // no concurrent meas.
pvp.scpi( 1, 'UNIT1:POW:REL:STAT OFF' )         // no relative meas.
pvp.scpi( 1, 'UNIT1:POW W' )                    // read watts
pvp.scpi( 1, 'SENS1:FUNC "POW:FORW:AVER"' )     // mode

pvp.scpi( 1, 'TRIG; *OPC?' )

sResult = pvp.scpi( 1, 'SENS1:DATA? "POW:FORW:AVER"')

pvp.print( 'Result = ' + sResult )
```

25 Data Processing Panels

Power Viewer distinguishes between measurements and data processing panels. Measurements (continuous, trace, etc.) generate data, whereas the data processing panels only receive these measurands. Internally, all measurands are supplemented with an exact time stamp and sent to the data processing panels. These panels feature input filters and sort out values of interest.
The figure below shows the principle architecture implemented in Power Viewer.

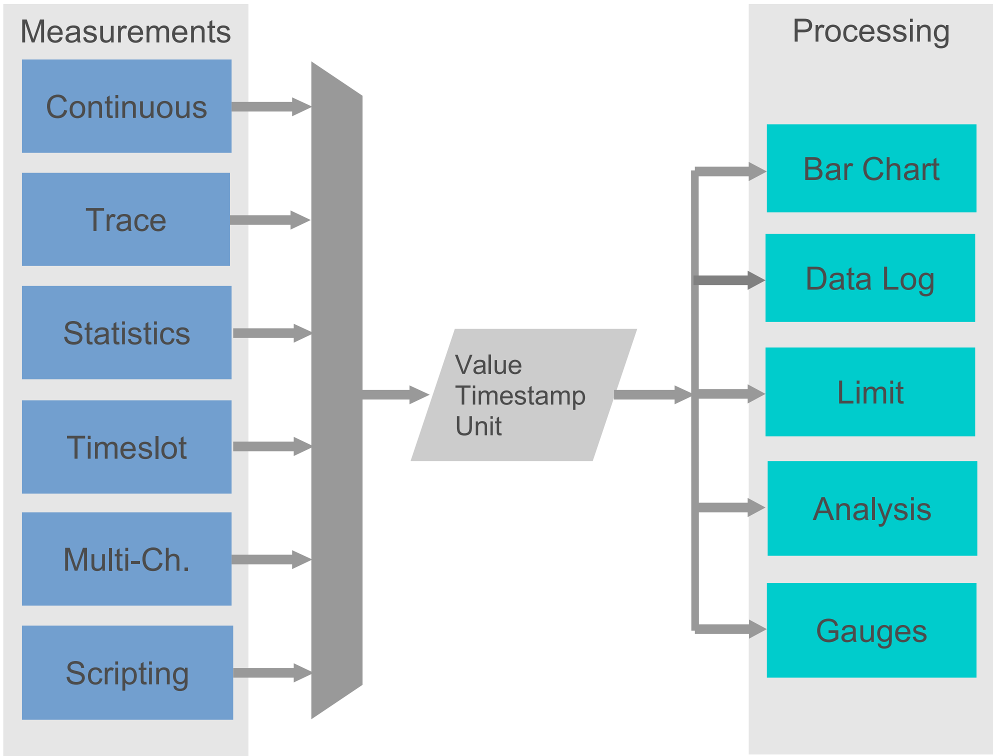


Fig. 25.1: Power Viewer data flow.

Each data processing panel can be configured individually. Therefore, different data-processing panels could evaluate different data simultaneously.
The input filter of each data processing panel is configured by the following parameters.

- Source
- Measurand 1 … 4

The Source denominates the measurement from which the panel may receive data. Depending on which measurement this is, there is a corresponding set of measurands that can be assigned to the data-processing panel's input channels.

The table below lists data that is available to the data-processing panels for each measurement.

Cont.	P_{av}	W	Average power
	P_{pk}	W	Peak power
	P_{av}, rel	1	Average power, relative
	P_{av}, rel	%	Average power, relative
	Average	1	Average filter count
Multi Ch.	Ch 1...16	W	Measurement channel 1...16
	M 1...4		Math channel 1...4
Timeslot	Mkr 1	W	Marker 1 reading
	Mkr 2	W	Marker 2 reading
	Mkr 3	W	Marker 3 reading
	Mkr 3	W	Marker 4 reading
Statistics	P_{av}	W	Average power
	R @ n%	dB	Reading at n %
Trace	Gate P_{av}	W	Gated measurement, average
	Gate P_{pk}	W	Gated measurement, peak
	Mkr Ref P	W	Reference marker, power
	Mkr D_n dP	1	Marker n, power ratio
	Mkr D_n dT	s	Marker n, time difference
	Rise Time	s	Pulse rise time
	Fall Time	s	Pulse fall time
	Pulse Width	s	Pulse width
	Period Time	s	Pulse period time
	Pulse P_{top}	dBm	Pulse top power
	Pulse P_{pk}	dBm	Pulse peak power
Script	Ch 1...8		Channel 1...8

25.1 The Data Log

The Data Log panel captures up to four scalar measurements over a period of several days. A maximum of 20000 data points is available for memory recordings in the log panel. Writing captured data to a file places no restrictions on the number of recorded samples (other than file size restrictions imposed by the underlying operating system). Memory recording and file recording are independent and can be configured separately.
The log panel shows a preview of all 20000 data points. If multiple measured values fall within the time period covered by one video point, statistics containing minimum, maximum, and average values are automatically generated.

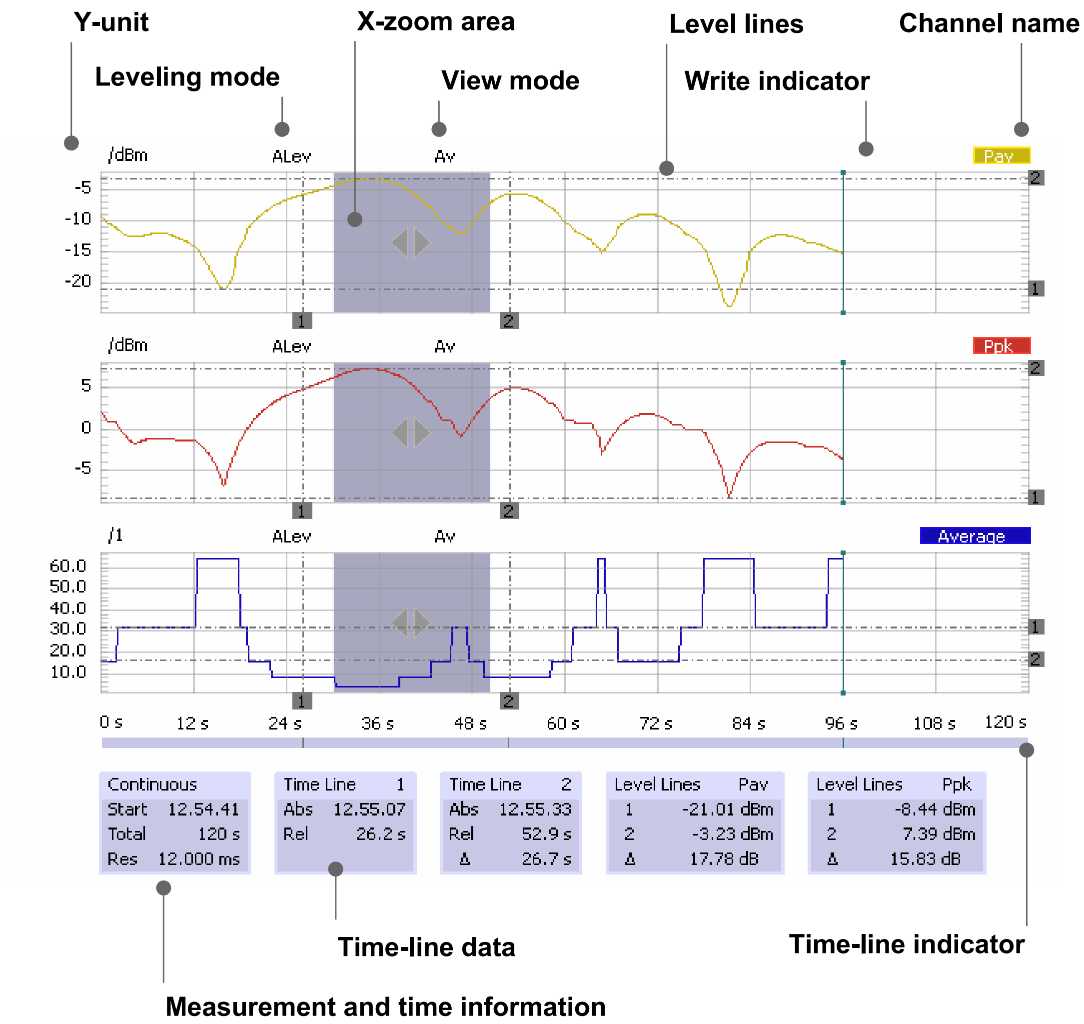


Fig. 25.1.1: Data log panel.

25.1.1 Settings

The data-log panel has its own settings dialog similar to the one for measurements. Unlike measurements, the data log does not generate data but rather processes measurands from active measurements.

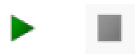


Fig. 25.1.2: State controls.

Start / Stop
The data log process does not start automatically when a measurement is started; it needs to be activated separately. This allows the user to setup the measurement first and then start the log.
Starting the log erases all previous data from the log memory.
The data log's capturing state is indicated by a hard disk icon in the lower left corner of the application window.

The data log is not active.

The data log captures data.

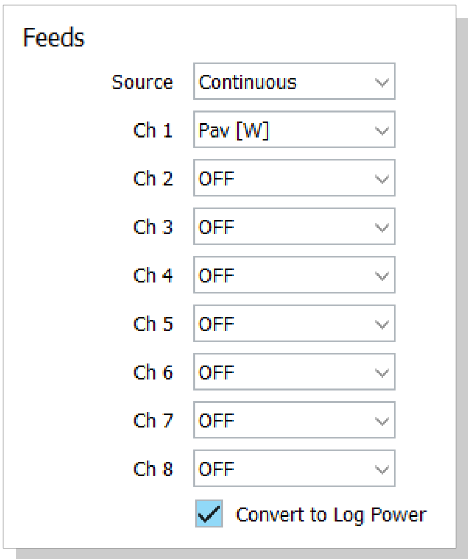


Fig. 25.1.3: Feed definitions.

Feeds
First, set the **Source** to select the measurement that feeds data into the log panel. Second, select up to eight measurands for the eight data-log channels.
Power values are normally received in watts but may be converted into dBm.

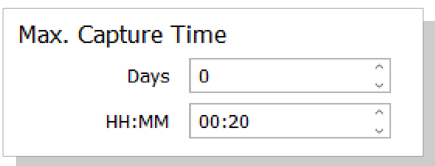


Fig. 25.1.4: Capture time settings.

Max. Capture Time

The maximum capture time can be set to a period of up to seven days. The 20000 data points in the panel's internal buffer are spaced evenly across the capture time. Once the capture time has elapsed, the data log is automatically deactivated, and no more data is recorded.

Please note that the data recorder captures up to 20000 data points to memory. Additionally, live file writing can be activated with no limit for the number of data points. These two processes are independent of each other.

The data-log panel's captured data may also be saved to a file with the save button from the application's tool bar.

The output format is ASCII .csv, which saves data in individual columns that are separated by commas.

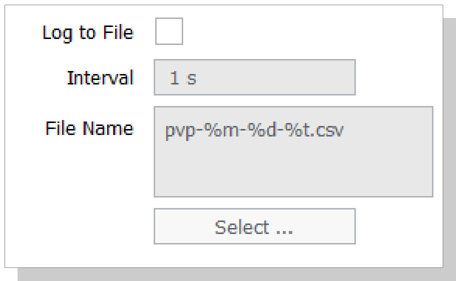


Fig. 25.1.5: Live file output settings.

Log Data to File

The data log can be configured for writing measured data to a file while the measurement is running. Writing takes place instantaneously and may, therefore, slow down the measurement.

Interval

The interval sets the time period for collecting sensor readings. At the end of each time interval the software writes a record to the log file. This record contains the minimum, maximum, and average value of the accumulated readings. The time interval should be set such that the file size remains within acceptable limits.

File Name

The file name specifies the file to which data is appended during the log process. The file format is .csv. Besides regular file names, there is a set of place holders that can be used within the file name.

`$t`	The temporary directory
`$h`	The user's home directory
`%m`	The name of the measurement
`%d`	The day when the data log was started
`%t`	The time when the data log was started

<u>Example:</u>

`$t\pvp-%m-%d-%t.csv`

This creates log files with the name `pvp-continuous-20090624-154627.csv` if used with the "continuous" measurement mode. The storage location is the temporary folder set in the operating system, e.g. C:\TEMP.

25.1.2 The Context Menu

The data-log panel provides a context menu that can be activated by right-clicking in the graphics area. When multiple traces are visible, the context menu is invoked for the trace that is located at the current mouse position.

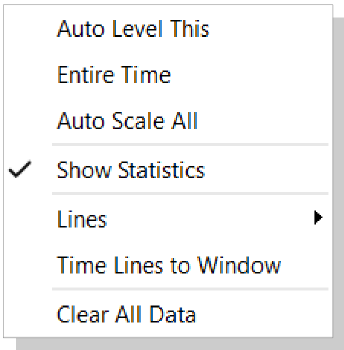


Fig. 25.1.6: Context menu for the data-log panel

Auto Level This
This option sets the current trace back to full auto leveling. This is useful when previous zoom actions were used to magnify trace details.

Entire Time
This menu item sets all traces back to the entire log time. This option is useful when previous zoom actions were used to magnify trace details. The time axis is always common for all traces. Therefore, this action involves all traces.

Auto Scale All
This option combines both of the above options. It sets the x-axis back to the entire log time and returns all traces back to full auto leveling.

Show Statistics
The data log always uses 20000 data points evenly spaced across the total log time. Each data point represents a bin that may contain multiple measured values. To prevent the loss of any information, each bin is represented by the average, minimum, and maximum value that was received.
By default, the envelope of the recorded data is displayed (minimum and maximum). If this is not desired, the statistics view can be disabled so that it only shows average data.

Lines
This menu item activates level lines and time lines. The functionality of these lines is similar to the ones described in the chapter 15.1, "Trace Measurements."

Time Lines to Window
Places the time lines back into the viewing area at the 10 % and 90 % points.

Clear All Data
This menu entry stops the data log and removes all data from the log. To prevent unintentional deletions, the user is queried before the log is stopped and data is erased.

25.1.3 The Time Line Indicator

The time-line indicator is located below the data log traces. It shows the overall log time and the currently visible area in case a trace section is magnified using the zoom operations.

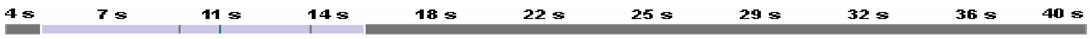


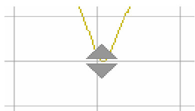
Fig. 25.1.7: The time-line indicator.

Additionally, the time-line indicator displays a small marker at the current write position as well as the position of the two time lines.

25.1.4 Zooming

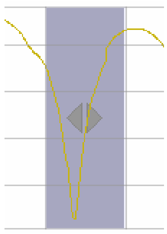
Zooming can be performed in the x- or y-direction separately by using the left mouse button and the mouse wheel.

Y-direction



- Select the center point for the y-zoom and click once using the left mouse button. A zoom-point indicator is placed at this point.
- Turn the mouse wheel forward to zoom in.
- Turn the mouse wheel backwards to zoom out.
- Press the left mouse key again to disable zoom mode and remove the zoom-point indicator.

X-direction



- Position the mouse at the beginning of the x-range that should be magnified.
- Press the left mouse key and hold it while you move the mouse to the right side. Release the left mouse key at the right end of the x-zoom area. A semi-transparent area marks the zoom range.
- Turn the mouse wheel forward to zoom into the highlighted area.

The the system remembers the x-zoom ranges. Turning the mouse wheel backwards restores the last display range.

25.2 Limit Monitoring

The limit monitoring panel receives up to 16 scalar measurands and compares them against warning and error thresholds. The limit monitoring panel does not take measurements itself; instead, it evaluates data that is generated by the measurement panels (continuous, trace, timeslot, etc.).
The screen shot below shows the limit-monitoring panel receiving data from a continuous power measurement.

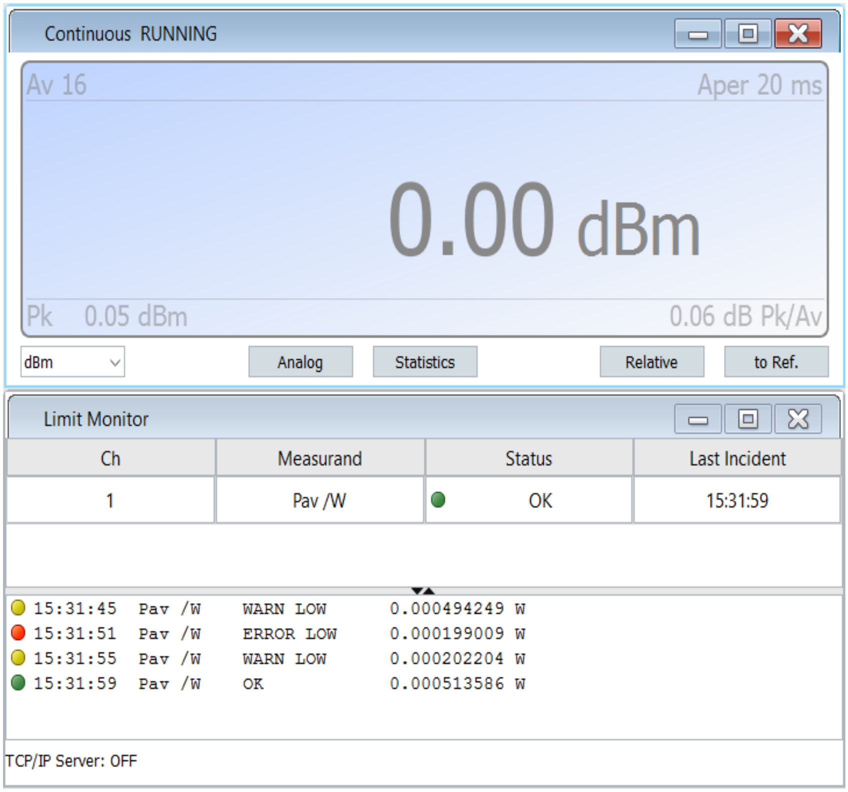


Fig. 25.2.1: Limit monitoring panel.

The limit monitor continuously compares incoming data against high and low warning thresholds and error thresholds. Each time a measurand passes one of these thresholds, the software generates an entry in the incident log. The capacity of this log is limited, and it only displays the most recent entries.
Besides playing an acoustic warning signal, the limit monitor can also log the incidents in a file or send them via TCP/IP to a remote host.

25.2.1 Settings

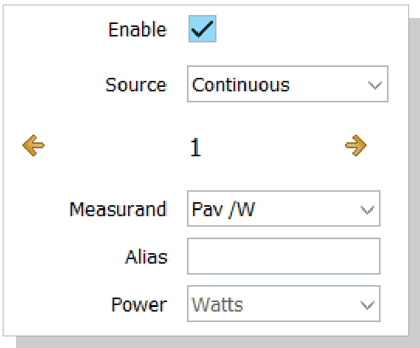


Fig. 25.2.2: The limit monitor settings.

Enable

Enables or disables limit monitoring globally.

Source / Channels
These settings define the origin of the measurands that are to be monitored for limit violations.

Alias Name
Each channel can use an alias name instead of the combination of measurement and measurand.

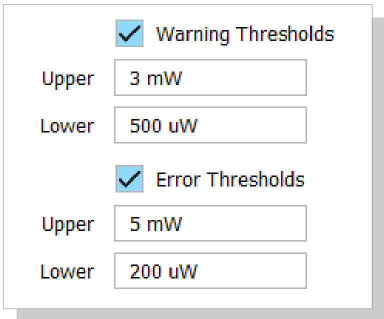


Fig. 25.2.3: Settings for warning and error levels.

Warning Thresholds / Error Thresholds

When these functions are enabled, the system compares the measurand against the upper and lower limit values. Each time the measurand passes one of these thresholds, an entry is generated in the incident log. Power values can be entered in watts (default) or in dBm.

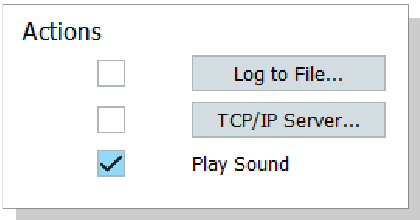


Fig. 25.2.4: Action settings for responses to threshold incidents.

Actions
By default, incidents are logged to the incident log. The capacity of this log is limited, and it only displays the most recent entries. The action settings are used to enable additional features, such as writing to a log file or sending incidents to a remote host.

Log to File
A file entry is generated each time a limit violation occurs or ceases. New incidents are appended to the end of the log file. Writing occurs immediately. Consequently, this can slow down the measurement rate.

TCP/IP Server
The limit monitor can be configured to start a TCP/IP server process for as long as a measurement is active. Remote applications can connect to this server and receive incidents.

Play Sound
An acoustic signal is generated each time a limit violation occurs or ceases.

25.2.2 Configuring the Server

The server process allows for one TCP/IP connection from a remote host. Once this connection is established, all incidents are sent to the remote host as text messages.
The limit monitor starts the server when the measurement is started and stops it when the measurement is stopped. Only one client connection is allowed at a time.

Note: Running the server process may present a security risk to your IT network. By default, the server is configured to only allow connections from the local host (127.0.0.1). It may also be required to configure your local firewall software to allow for inbound traffic on the port used by the server.

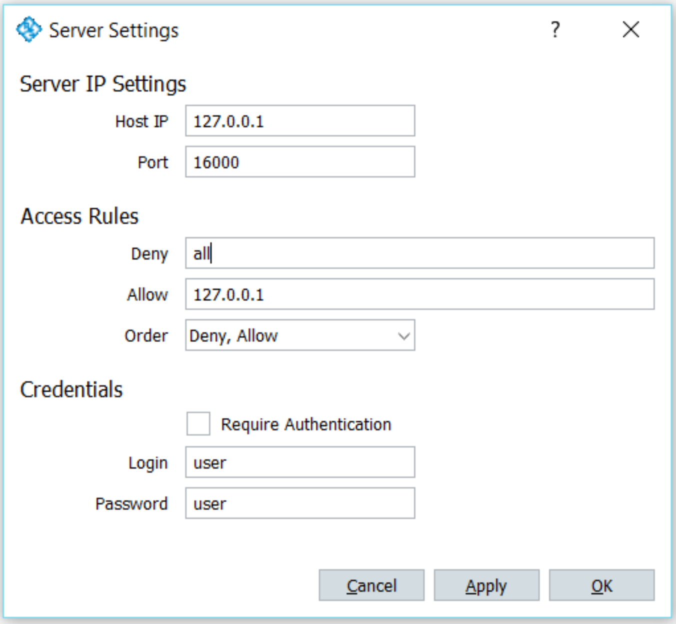


Fig. 25.2.5: The server settings dialog.

Host IP
Sets the IP address for the network interface at which the server is listening for incoming connections. By default, the IP address 127.0.0.1 is used for the local machine.

Port
Sets the port at which the server listens for incoming connections. It must be ensured that the port is not already being used by another service.

The command:

```
netstat -an | find /i “listening”
```

provides a list of all ports that the system is currently listening to.

Access Rules
The access rules define which clients are allowed to connect to the limit monitoring server. For this purpose, two lists of IP addresses define hosts that are denied and hosts that are allowed to connect. The order in which these two lists are evaluated can be selected. The second list to be evaluated takes precedence over the list that is evaluated first. Each list may contain the keyword "All" or a comma-separated list of IP addresses, or fractions of IP addresses.

Example:

Order:	Deny, Allow
Deny:	All
Allow:	192.168

In the example above, the deny list is evaluated first. The keyword "All" indicates that any incoming request will be rejected. Second, the allow list is evaluated. All servers that match 192.168.x.x are allowed to connect.

Require Authentication
When this authentications setting is enabled, the server prompts a

connecting client for a login and a password.

Server status messages are shown on the application's message-log panel. This window can be activated from the menu bar by selecting Window → Message Log.

25.2.3 Client Connections

The *telnet* and *netcat* tools can be used as clients for connecting to the limit-monitoring server. The client is invoked from the command line using one of the following commands:

- `telnet <ip-address> <port>`
- `nc <ip-address> <port>`

If the server can be reached, a welcome message is printed and the user may be requested to enter the authentication data.

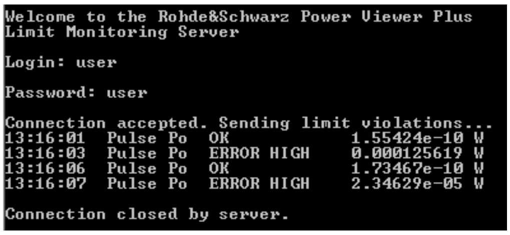


Fig. 25.2.6: Client communication.

Note: Netcat is a very versatile tool, and it can also be used to install malicious "backdoors" on the host PC. For this reason, most virus protection software packages classify nc.exe as a threat and disable its execution.

The limit monitoring server uses port 16000 by default. This port is not typically used by other applications. The default telnet port is 23.

25.3 Statistical Analysis

The analysis panel receives up to four scalar measurands and performs a statistical analysis on this data. Similar to the data log, the analysis panel does not take measurements itself but merely evaluates data that is generated in the measurement panels (continuous, trace, timeslot, etc.).
The screen shot below shows the analysis panel receiving data from a trace measurement (pulse analysis).

Fig. 25.3.1: The analysis panel.

Each of the four views within the analysis panel can be configured to a histogram display or a quantile plot. The four analysis views operate independently and can be freely assigned to any available measurand. By default, each view is configured to the histogram display and for evaluation of the last 1000 measurements. These settings can be changed using the context menu for the individual view.

25.3.1 Histogram Display

The histogram sorts the measured values into categories (data bins) that are evenly distributed between the minimum and maximum reading. The result is displayed as a bar chart, with the height of the bars indicating how many measurements fall into each category. The number of samples that are used for evaluation can be selected to be 250, 1000, or 5000.

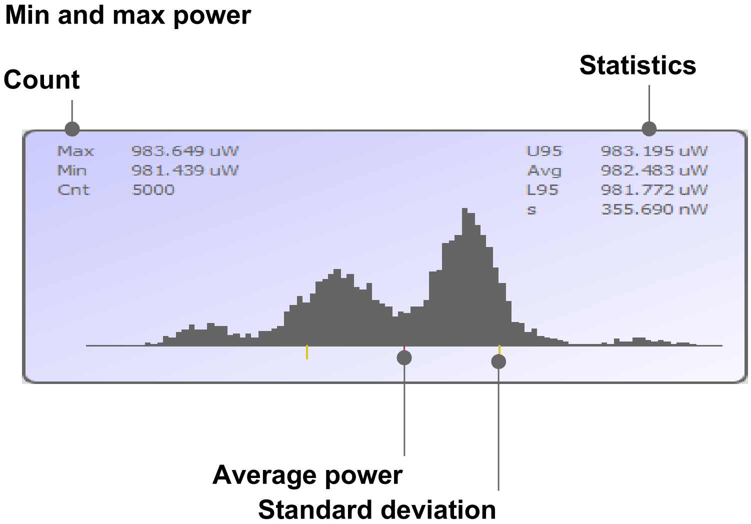


Fig. 25.3.2: Histogram display.

The *minimum* (Min) and *maximum* (Max) power readings are displayed in the upper left corner.
The *count* (Cnt) indicates how many readings were accumulated for the analysis. The count remains at a constant value as soon as the set number of readings has been reached.
The *average* (Avg) power of all accumulated readings and the *sample standard deviation* (s) is displayed in the panel's upper right corner. The following formulas are used to calculate these two parameters:

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i$$

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2}$$

The terms **L95** and **U95** are used for the 95 % confidence intervals for the average power level:

$$L95 \simeq \bar{x} - \frac{2 \cdot s}{\sqrt{N}} \qquad U95 \simeq \bar{x} + \frac{2 \cdot s}{\sqrt{N}}$$

25.3.2 Q-Q-Plot

The Q-Q-Plot (Quantile-Quantile-Plot) is a graphical method for comparing two probability distributions.
The Power Viewer software provides a normal probability plot that compares the probability distribution of the measured values against a normal distribution. The Q-Normal-Plot is, therefore, used as a graphical test for normal distribution.

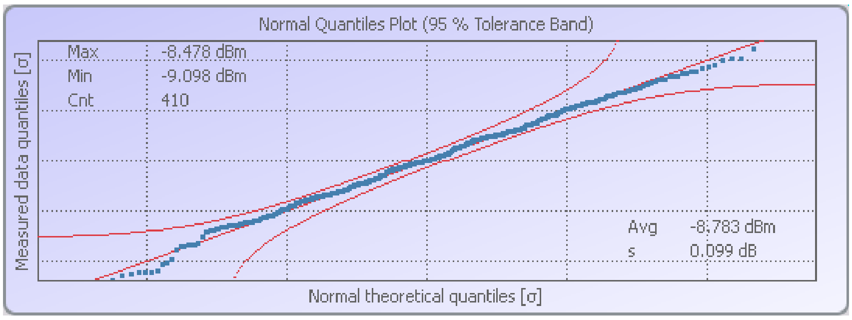


Fig. 25.3.3: Q-Q-Plot display.

The outer pair of red lines marks the 95 % confidence band. If all graph points are located within this band, the normal probability test is positive at a 95 % confidence level.
The diagram is vertically and horizontally scaled to steps of one σ. When all measured values are distributed normally, all graph points are located on a straight line. Departures from this straight line indicate that the normal distribution model is a poor fit for the distribution of the measured values.

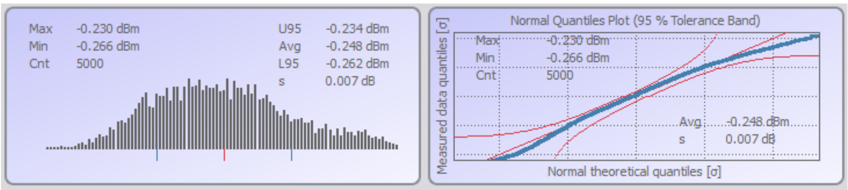


Fig. 25.3.4: Example distribution.

Fig. 25.3.4 shows a non-ideal normal distribution. The number of measured quantiles for higher values (on the right side in the histogram) is larger than it should be for normally distributed data. The Q-Q-Plot shows this deviation in the upper right corner.

25.3.3 The Context Menu

Each view has its own context menu that is used to configure the data representation in this view.

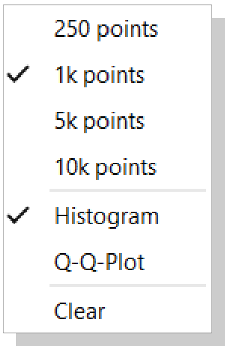


Fig. 25.3.5: Context menu for a view.

Points
The view always captures the last 5000 measured values, but the number of evaluated samples can be set to the last 250 or 1000 values or to all 5000 of them. Changing the number of evaluated samples does not erase any data.

Histogram / Q-Q-Plot
These settings determine the view to the histogram or the quantiles display. Both representations are calculated from the same data, and changing the representation does not erase any data.

Clear
Clears all data in this view.
After the data is cleared, the message “Waiting for data...” appears in the quantile plot representation until 50 samples have been collected. In the histogram representation, the histogram is not painted for less than 50 samples.

25.3.4 Analysis-Panel Settings

The analysis panel has its own settings dialog similar to the measurements. Unlike measurements, the analysis panel does not generate any data but merely captures readings from active measurements.

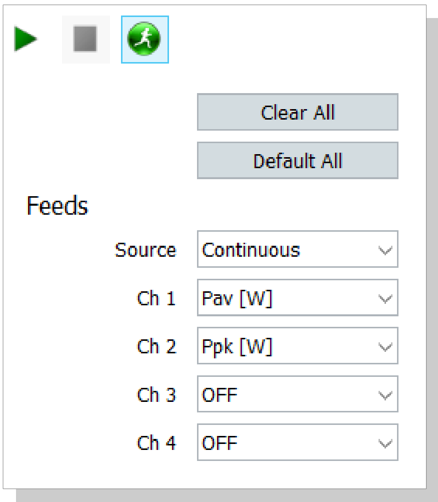


Fig. 25.3.6: Analysis-panel settings.

Start / Stop
The analysis process does not start automatically when a measurement is started. Instead, it needs to be activated separately. This allows the user to setup the measurement before starting the analysis.
Starting the analysis erases all previous data from the views.

Auto Start / Stop
The auto start/stop option automatically starts the analysis process when a measurement is started and valid data is received. The analysis is topped when the measurement stops.

Clear All
This button clears the data in all analysis views.

Default All
This button sets all views back to the histogram display of the last 1000 measurements. It also deletes the data in all views.

Feeds
First, set the Source to select the measurement that feeds data into the log panel. Second, select up to four measurands for the four data log channels.

25.4 Gauges Panel

The gauges panel receives up to four scalar measurands and displays the value on a sizable gauge. Similar to the analysis, the gauges panel does not take measurements itself but merely evaluates data that is generated in the measurement panels (continuous, trace, timeslot, etc.). The screen shot below shows the gauges panel receiving data from a trace measurement (pulse analysis).

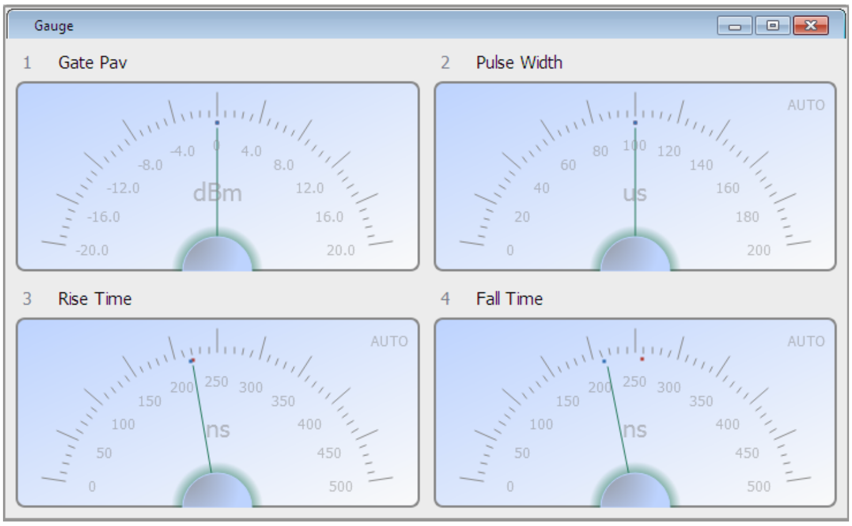


Fig. 25.4.1: Gauges-panel.

Each of the four views within the gauges panel can be configured to a digital or analog display. The four gauge views operate independently and can be freely assigned to any available measurand.
By default, each view is configured to the digital display. This setting can be changed using the context menu for the individual view.

25.4.1 Analog Meter

The needle of the analog meter displays the filtered measurand. The filter is an exponential moving average filter with 8 bins.

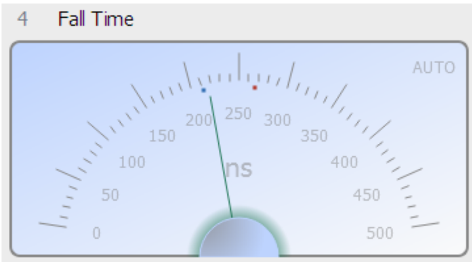


Fig. 25.4.2: Context menu for a view.

The blue and red dots show the minimum and maximum value in the moving average filter buffer.

The text AUTO in the upper right corner indicates that the meter is currently set to auto scaling. This works in most cases but it may also be desirable to set a specific scale. Setting the scale is possible by using the muse wheel and the Ctrl key.

Mouse Wheel
Changes the upper border of the meter. This option is only available for logarithmic meters (dBm scale).

Ctrl + Mouse Wheel
Pressing and holding the Ctrl key replaces the unit text in the center by the currently selected measurement range. Turning the mouse wheel while the Ctrl key is pressed increases or decreases the measurement range.

25.4.2 The Context Menu

Each view has its own context menu that is used to configure the data representation in this view.

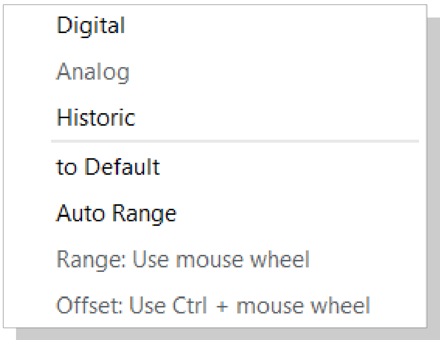


Fig. 25.4.3: Context menu for a view.

Digital
The view shows a numeric value on a digital display. The values are displayed as they are send by the measurement. Absolute power values in Watts are automatically converted to dBm.

Analog
Turns the view into the analog meter mode.

Historic
Enables a digital display using ancient Nixie tubes.

25.4.3 Gauges-Panel Settings

The gauges panel are identical with the analysis panel settings.

26 Using S-Parameter Profiles

This functionality is currently only available in the Windows-based version of Power Viewer.

S-parameter correction compensates for the losses and reflections introduced by a component – such as an attenuator, directional coupler, or matching pad – that is attached to a power sensor. Using S-parameters instead of a fixed offset increases measurement accuracy by accounting for the interaction between the sensor and the component. As a result, the sensor's reference plane shifts from the sensor's RF connector to the input of the device being applied externally. This procedure is also referred to as *embedding* a device.

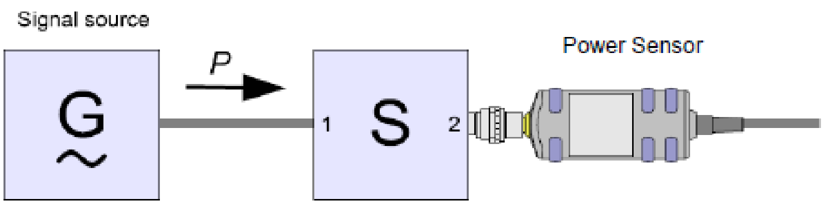


Fig. 26.1: Schematic view of embedding a device

S-parameter data sets are stored in the sensor's internal calibration data structure. As a result this data is not lost during a device reset or a power cycle. In addition, S-parameter data can be configured such that it becomes active automatically when the sensor is powered up. This feature is useful if a two-port device such as an attenuator pad is permanently attached to a sensor.

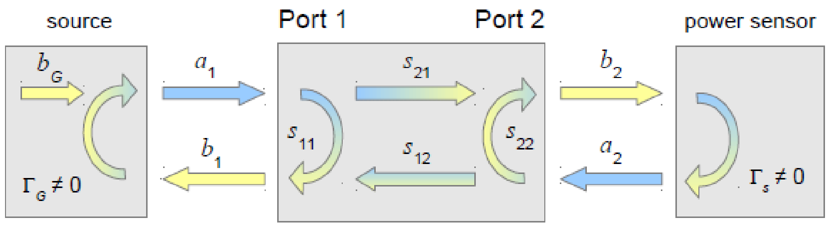


Fig. 26.2: Schematic view of scattering parameters

The equation below includes the S-parameter device, the power sensor's reflection coefficient, and the source reflection coefficient. The sensor firmware uses this equation when the source reflection coefficient is also specified (when gamma correction is enabled).

$$b_G = b_2 \left[\frac{(1 - s_{22}\Gamma_S)(1 - s_{11}\Gamma_G)}{s_{21}} - \Gamma_G \Gamma_S s_{12} \right]$$

The measurement error caused by using a simple offset table instead of the s-parameter correction can be calculated by the following equation:

$$Error_{\%} \approx \pm 100\,\% \left[(2 - (1 - s_{22}\Gamma_S)(1 - s_{11}\Gamma_G))^2 - 1 \right]$$

Power Viewer provides a dialog for updating s-parameter profiles in R&S NRP and R&S NRP-Z power sensors. You can call up the dialog for this by selecting Sensor → S-Parameter from the menu bar.

S-parameter data is stored permanently in the sensor flash memory. All s-parameter data is organized in profiles. Each profile consists of the complex correction values, a mnemonic, a level range and additional flags. All R&S NRP and R&S NRP-Z power sensors support s-parameter correction (single profile) but some models also support switching between different profiles.

In all R&S NRP-Z sensors the s-parameter profiles are part of the factory calibration data set. The new generation R&S NRP sensors contain a factory calibration data set and a user data set. For safety reasons Power Viewer only allows access to the user data set in these sensors.

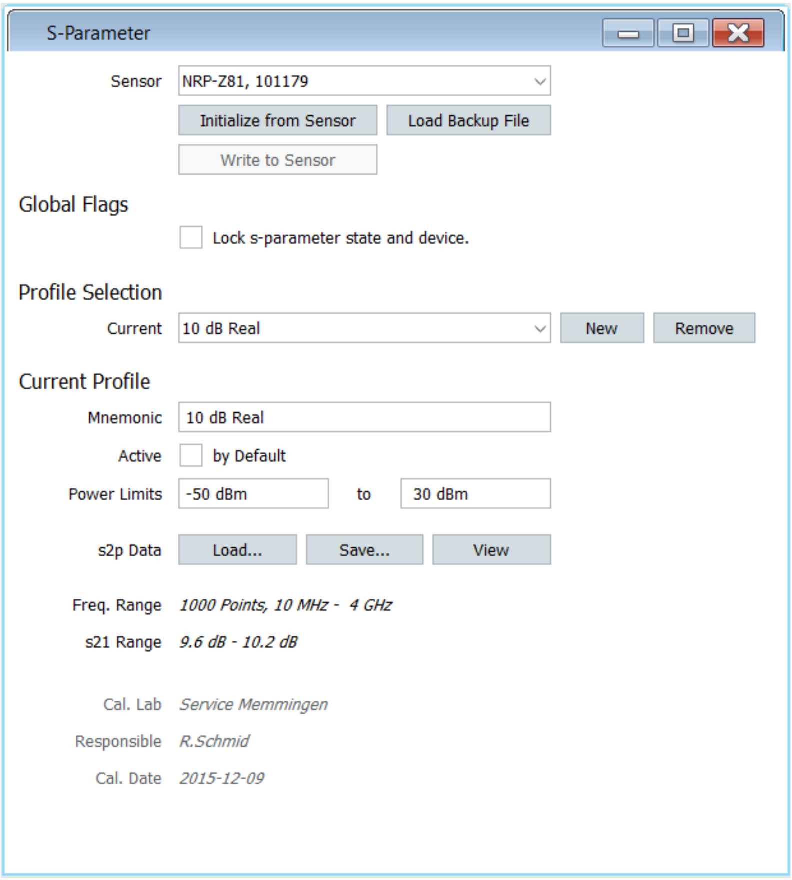


Fig. 26.3: S-Parameter Profile Editor

Initialize from Sensor
Reads the entire calibration data structure from the sensor flash memory and extracts the s-parameter device data. S-parameter sets are always stored as part of the sensor non-volatile calibration data. Reading the calibration data set does not alter any data in the sensor.

Load Backup File
Power Viewer always creates a backup copy of the calibration data before attempting to update the sensor flash memory. If the write operation fails, e.g. due to a power loss during the write operation the data can simply be recovered from the backup file. Power Viewer compares the sensor type and serial number in the backup file with the

selected sensor. If the numbers disagree the backup file cannot be loaded.

Write to Sensor
Updated s-parameter data sets must be written back to the sensor flash memory in order to become effective. Before the flashing process starts Power Viewer creates a backup copy of the existing calibration data set on the local hard drive.

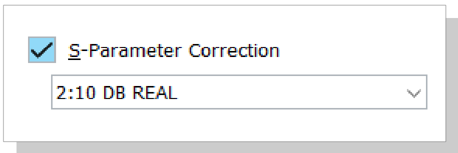
Flags: Lock s-parameter state and device
Locking the s-parameter state activates or deactivates the s-parameter state permanently. The user cannot change the state and the related controls are grayed out in the Power Viewer application.

The central section of this dialog contains all the controls required for the s-parameter management. A prerequisite for these controls to become active is that a data set was successfully loaded from a sensor or a matching backup file.

Flags: Use flags from USER data set
All new generation R&S NRP power sensors contain two data sets that may contain s-parameter profiles. The *factory data set* contains sensor calibration data and is written during production. This data set may contain s-parameter profile information, for example if sensors are shipped with a permanently attached attenuator. The second data set is the *user data set*. Power Viewer only allows access to this user data set for all new generation R&S NRP power sensors.

Setting this flag overrides the *Lock* and *Default* flag from the factory data set. Use this flag if the s-parameter state is locked in the factory data set and you need to use other s-parameter profiles than the one stored in the factory data set.

A locked s-parameter data set typically disables all related controls in the correction dialog.



S-parameter profiles residing in the user data set start at index 1001 whereas profiles from the factory data set start at index one.

Current Profile
This control contains all s-parameter profiles that are currently available in the calibration data set. New empty records can be added to the list by using the **New** button. Existing records can be removed from the list with the **Delete** button. These changes do not become effective immediately in the sensor. Instead all modifications are applied to a memory copy of the calibration data set. Once changes are made a sensor update is required and can be initiated by clicking the **Write to Sensor** button.

Mnemonic
The mnemonic defines a name that is used to name an s-parameter device. The mnemonic is also stored as part of the sensor s-parameter profile.

Load / Save
Loads or saves s-parameter data from or to a file. If data is loaded all existing s-parameter data in the selected profile is lost. Saving data does not alter the s-parameter profile.

View
Starts the viewer dialog and displays all s-parameter data of the currently selected profile.

Fig. 26.4: S-Parameter Viewer

Frequency Range
This line displays the frequency range covered by the s-parameter set.

S21 Range
This line displays the minimum and maximum s21 value in the s-parameter set.

Power Limits
Depending on the loss or gain introduced by the s-parameter device the sensor's measurement power range changes. These settings define the upper and lower sensor power limit if the s-parameter profile is selected during a measurement. Power Viewer populates both entry fields with recommended values when s-parameter data is loaded from a file.

Active by Default
This option automatically enables the selected s-parameter profile when the sensor is powered up. This option is useful if components such as attenuator pads remain attached to a sensor.

27 VXI PnP Programming Guide

The Power Viewer software is based entirely on the Rohde & Schwarz VXI PnP drivers for the R&S NRP power sensors. This driver provides a C function interface and is recommended for all user applications.
Please see the NRP software download section for the latest version of the VXI PnP driver.
Custom applications must include the `rsnrpz.h` file when using the VXI PnP driver. This driver uses VISA data types, but if VISA is not installed, the required data types are defined in the header file itself.
It should be noted that multiple applications cannot access the NRP driver simultaneously.
The minimum requirement for using the VXI PnP driver functions is installation of the R&S NRP Toolkit. The toolkit package contains the USB drivers as well as the NrpControl2 low-level driver DLL.
Generally, it is possible to build applications with the `rsnrpz.c` and `rsnrpz.h` files directly compiled into the application. In this case, the application only depends on `NrpControl2.lib`. Alternatively, the application can include `rsnrpz.h` and link against `rsnrpz.lib`.
The following diagram shows the NRP-Z driver architecture and possible application options.

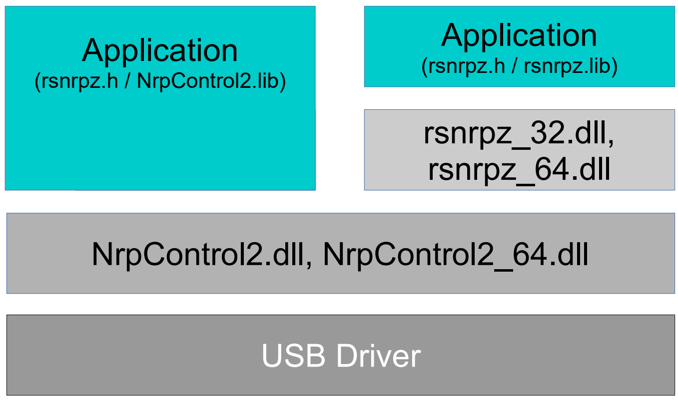


Fig. 27.1: Driver architecture on Windows-based systems.

27.1 Sensor Resource Strings

The power sensors are identified by a unique VISA resource string. This string is passed on to the `rsnrpz_init()` function in order to open the sensor connection.
The resource string has the following format:

```
USB::0x0AAD::<usb-id>::<serial>
```

The value `0x0AAD` is the Rohde & Schwarz vendor ID, and it cannot be changed. The USB ID is unique for each sensor type. A list of USB device ID numbers is provided in chapter 6.5, "Supported R&S NRPZ Sensors." The serial number is the serial number for the individual sensor.

27.2 Numeric Results

All numeric power readings are provided in watts. The reading includes a level offset that is either set by the user or provided by the S-parameter device.
In many applications, however, it is desirable to show power readings on a logarithmic scale. Conversion can be performed by taking the absolute value of the power reading, adding a very small offset, and then using the log10() function:

```
double dValdBm = 30.0 +
                    10.0 * log10( fabs( dValW ) + 1e-32 )
```

The small offset ensures that the log10 function's argument can never be exactly zero.

27.3 Opening and Closing the Sensor Connection

The first step is to open the sensor connection. The following code lines demonstrate how this is done using the driver functions. The example sets the USB timeout to 5 seconds and does not reset the sensor. The return value is the USB session that must be used in all further communication with the sensor:

```
ViStatus lErr
ViSession ulUSBSession
rsnrpz_setTimeout( 5000 )
lErr = rsnrpz_init ( <USB resource string>,
                    false, false,
                    &ulUSBSession )
if( lErr!=0 ) ...error handling...
```

If the sensor is no longer needed for further measurements, the connection should be closed. The following lines demonstrate how to do this. After the sensor is closed, the session number must not be used anymore:

```
lErr = rsnrpz_close( ulUSBSession )
ulUSBSession = 0
```

27.4 Multiple Sensors

Multiple sensors may be opened simultaneously within one application. The **`rsnrpz_init()`** function must be called once for each sensor using the sensor resource string. The USB session ID numbers returned from this function are then used to access the individual sensors.

27.5 Error Handling

Most `rsnrpz_` driver functions return an error code. If the function call is successful, the return value is zero. If an error was returned, further information may be obtained from the `rsnrpz_error_message()` function. This function translates the error code into a human-readable text message:

```
char szMessage[256]
rsnrpz_error_message( ulUSBSession,
                      lErr, szMessage )
```

Additionally, errors that arise inside the sensor can be queried from the sensor error queue. The `rsnrpz_error_query()` should be called as long as the `lErr2` return variable is not equal to zero and the return code `lErr` is zero:

```
lErr = rsnrpz_error_query( ulUSBSession,
                      &lErr2, szMessage )
```

Please note that both functions require a valid session number. If the `rsnrpz_init()` function fails and no valid session number is available (session is zero), these functions cannot be used. In most cases, this indicates that the sensor has already been opened by another application, or that the sensor firmware is outdated.

27.6 Zeroing

Zeroing the sensor might be required if very low signal levels need to be measured. The time required for the zeroing procedure varies from sensor to sensor. It must also be noted that the zero offset value is not permanent. A sensor reset command does not clear the zero offset, but a power loss requires re-zeroing.
The following example starts the zeroing process with the function `rsnrpz_chan_zero()`. This function returns immediately. The following call to `rsnrpz_chan_isZeroComplete()` determines the completion state of the zeroing process. The function should be called repeatedly in a loop, but it must be ensured that there is enough CPU time available for the driver process (→ `Sleep()`, → `SwitchToThread()`). Using a short sleep that gives the CPU away to the background thread is recommended. If the zeroing fails, an error code that is not equal to zero is returned:

```
lErr = rsnrpz_chan_zero( ulUSBSession, 1 )

unsigned short usMeasCompleted
lErr = rsnrpz_chan_isZeroComplete(
             ulUSBSession, 1,
             &usMeasCompleted )
```

27.7 Identifying a Sensor (*IDN?)

It is often necessary to identify a sensor and retrieve its type and serial number. The `*IDN?` command is available in the SCPI language for this task. The C-based VXIPnP driver provides functions that read extended sensor information and can be used for this purpose:

```
char szManuf[256];
lErr = rsnrpz_chan_info( ulUSBSession, 1,
             "Manufacturer", 256, szManuf );

char szType[256];
lErr = rsnrpz_chan_info( ulUSBSession, 1,
             "Type", 256, szType );

char szSerial[256];
lErr = rsnrpz_chan_info( ulUSBSession, 1,
             "Serial", 256, szSerial );

printf( "%s,%s,%s", szManuf, szType, szSerial );
```

27.8 Continuous Average Power Measurement

This example demonstrates how to implement a simple continuous average power measurement.
First, the sensor's operation mode needs to be set. This step only needs to be performed once when multiple average power measurements are required:

```
lErr = rsnrpz_chan_mode( ulUSBSession, 1,
             RSNRPZ_SENSOR_MODE_CONTAV )
```

Second, the carrier frequency must be set. Setting the carrier frequency is always required for precise measurements:

```
lErr = rsnrpz_chan_setCorrectionFrequency(
        ulUSBSession, 1, dCarrierHz )
```

In many cases, the power sensor is not directly connected to the DUT and compensation must be made for additional cable loss. The two functions described below enable and set the level offset. Please note that further level-related commands expect levels that include the correction factor:

```
lErr = rsnrpz_corr_setOffset(
       ulUSBSession, 1, dOffsetdB )
lErr = rsnrpz_corr_setOffsetEnabled(
       ulUSBSession, 1, true )
```

The aperture time is the time for which the sensor integrates the signal in order to generate a a single sample. Normally, the sensor uses a default aperture that is best for noise and measurement speed. When measuring AM modulated signals with a known period time, it is advisable to set the aperture time to multiples of the period time. In such cases, using a low averaging filter count, such as two, can deliver stable measurement results:

```
lErr = rsnrpz_chan_setContAvAperture(
       ulUSBSession, 1, dWindowS )
```

The averaging filter can be configured to either manual mode or automatic mode. The auto mode example below sets the filter to a 0.01 dB resolution:

```
lErr = rsnrpz_avg_configureAvgAuto(
       ulUSBSession, 1, 3 )
```

Alternatively, the averaging filter mode can be set to a fixed value, such as 2, 4, 8, or 16. This setting is best if a constant measurement time is required and the signal level does not change much:

```
lErr = rsnrpz_avg_configureAvgManual(
       ulUSBSession, 1, ulAvCnt )
```

The averaging filter can be configured to repeating mode or moving filter mode. In repeating mode, each measurement cycle initially clears the filter and then accumulates measurements until the filter is entirely filled:

```
lErr = rsnrpz_avg_setTerminalControl(
       ulUSBSession, 1,
       RSNRPZ_TERMINAL_CONTROL_REPEAT )
```

The `rsnrpz_chan_initiate()` function starts one measurement cycle. The function returns immediately. Therefore, the application must subsequently poll the sensor for measurement completion:

```
lErr = rsnrpz_chan_initiate( ulUSBSession, 1)
```

The completion state should be polled in a loop, but it must be ensured that the CPU is made available to the driver thread between subsequent polls:

```
Sleep( 100 )  or  SwitchToThread()
ViBoolean bMeasCompleted
lErr = rsnrpz_chan_isMeasurementComplete(
       ulUSBSession, 1, &bMeasCompleted )
```

When the measurement cycle has completed successfully, the result can be read, and a new measurement cycle may be started:

```
ViReal64 fMeasResult
lErr = rsnrpz_meass_fetchMeasurement(
       ulUSBSession, 1, &fMeasResult )
```

27.9 Trace Measurements

This example demonstrates how to implement a trace measurement for a repeating signal that provides a stable trigger condition.

First, the sensor's operation mode needs to be set. This step is only required initially:

```
lErr = rsnrpz_chan_mode(
       ulUSBSession, 1, RSNRPZ_SENSOR_MODE_SCOPE )
```

Second, the carrier frequency must be set. Setting the carrier frequency is required for precise power measurements:

```
lErr = rsnrpz_chan_setCorrectionFrequency(
       ulUSBSession, 1, dCarrierHz )
```

In many cases, the power sensor is not directly connected to the DUT, and compensation must be made for additional cable loss. The following two functions enable and set the level offset:

```
lErr = rsnrpz_corr_setOffset(
       ulUSBSession, 1, dOffsetdB )
lErr = rsnrpz_corr_setOffsetEnabled(
       ulUSBSession, 1, bEnOffset )
```

The function below configures the measurement bandwidth. Using a lower bandwidth decreases measurement noise and increases trigger sensitivity. The list of available bandwidth IDs can be obtained using `rsnrpz_bandwidth_getBwList()`:

```
lErr = rsnrpz_bandwidth_setBw(
       ulUSBSession, 1, 0 )
```

The number of video points for the trace measurement is set using `rsnrpz_scope_setPoints()`. Using 500 points usually represents a good compromise between USB transfer speed and resolution. The trace data's transfer time increases with the number of video points:

```
lErr = rsnrpz_scope_setPoints(
       ulUSBSession, 1, iVideoPoints )
```

The trace time sets the overall capture time for one trace measurement. Each video point represents the time period resulting from the trace time divided by the number of video points:

```
lErr = rsnrpz_scope_setTime(
       ulUSBSession, 1, dTraceTime )
```

The offset time is used to capture signal portions before the trigger point. The valid time range depends on the sensor and must be looked up in the sensor manual. The function call is not required if this feature is not needed. An offset time of zero starts trace capturing at the trigger position:

```
lErr = rsnrpz_scope_setOffsetTime(
       ulUSBSession, 1, dOffsetTime )
```

Configuring the trigger condition is crucial for all trace measurements. The following lines configure the trigger system to internal triggering on a positive slope. The hysteresis should be set to a small value (e.g. 1 dB) to allow for stable triggering. The dropout time can be set optionally and requires the signal to fall below the trigger threshold for the defined period of time before the trigger system rearms again. Please note that the trigger level is set in linear units.

```
lErr = rsnrpz_trigger_setSource(
       ulUSBSession, 1,
        RSNRPZ_TRIGGER_SOURCE_INTERNAL )
lErr = rsnrpz_trigger_setSlope(
       ulUSBSession, 1, RSNRPZ_SLOPE_POSITIVE )
lErr = rsnrpz_trigger_setDropoutTime(
       ulUSBSession, 1, dDropoutTime )
lErr = rsnrpz_trigger_setHysteresis(
       ulUSBSession, 1, 1 )
lErr = rsnrpz_trigger_setLevel(
       ulUSBSession, 1, dTrigLevelW )
```

Setting an averaging filter is, in most cases, desired when trace data is to be measured. Averaging reduces the noise dramatically and therefore increases the dynamic range:

```
lErr = rsnrpz_scope_setAverageCount(
       ulUSBSession, 1, iAverageCount )
lErr = rsnrpz_scope_setAverageEnabled(
       ulUSBSession, 1, true )
```

The averaging filter can be operated in either repeating or moving mode. In repeating mode, the filter content is cleared at the beginning of the measurement cycle. Once the filter is entirely filled, the measurement terminates and the result can be read:

```
lErr = rsnrpz_scope_setAverageTerminalControl(
       ulUSBSession, 1,
       RSNRPZ_TERMINAL_CONTROL_REPEAT )
```

The `rsnrpz_chan_initiate()` function call starts the measurement cycle and returns immediately.

```
lErr = rsnrpz_chan_initiate( ulUSBSession, 1)
```

Before any data can be read from the sensor, the measurement status must be polled repeatedly. This polling must be implemented in such a way that the CPU becomes available to the driver thread periodically:

```
Sleep( 100 )  or  SwitchToThread()
ViBoolean bMeasCompleted
lErr = rsnrpz_chan_isMeasurementComplete(
       ulUSBSession, 1, &bMeasCompleted )
```

After the measurement has completed, the data array can be read using the **rsnrpz_meass_fetchBufferMeasurement()** function. The values that are returned are in linear units and include any offset configured using **rsnrpz_corr_setOffset()**. The number of trace points must match the number of video points set with **rsnrpz_scope_setPoints()**:

```
ViReal64 pdMeasAv[iTracePoints]
ViInt32 iReadCount
lErr = rsnrpz_meass_fetchBufferMeasurement(
       ulUSBSession, 1,
       iTracePoints, pdMeasAv, &iReadCount )
```

The settings from the above example return the *average* trace representation. Based on the averaging filter settings and the trace time, the sensor captures multiple samples and calculates the average trace data.
The return data is provided in linear units. However, many applications require power values on a logarithmic scale. The conversion can be done using the following equation:

$$P_{log} = 10 \cdot log_{10}(P_{lin}) \text{ dBm} + 30 \text{ dBm}$$

Care must be taken if signal portions close to the noise floor must be converted. Depending on the zero reference point for the internal analog-to-digital converter, negative power readings may occur.
This is normal behavior, and in most cases, it is possible to simply use the linear power reading's absolute value for the $\log_{10}()$ function. The low power values do not typically contribute to any measurement.
In very rare cases, a power value that is exactly zero may arise. Zero cannot be converted into the logarithmic scale and must, therefore, be replaced by another value. The Power Viewer software uses the closest valid point in such cases.

27.9.1 Single-Shot Events

Measuring single-shot events requires slightly different averaging filter settings. Please note that disabling averaging also reduces the sensor's dynamic range.

The average filter count is set to one, and the filter is disabled:

```
lErr = rsnrpz_scope_setAverageCount(
       ulUSBSession, 1, 1 )
lErr = rsnrpz_scope_setAverageEnabled(
       ulUSBSession, 1, false )
```

Additionally, non-Z81 sensors require enabling of the real-time mode. In this mode, the chopper is turned off and only one single trace is processed. (The Z81 sensor does not require this command.):

```
rsnrpz_scope_setRealtimeEnabled(
       ulUSBSession, 1, true )
```

27.9.2 Peak Trace Data

Wideband sensors, such as the NRP-Z81, provide multiple trace data representations. The AVERAGE trace representation is always sent and cannot be deselected. Alternatively, the sensor can be switched to auxiliary mode, and it can send two additional representations, such as the RANDOM and MAXIMUM trace data:

```
lErr = rsnrpz_chan_setAuxiliary(
       ulUSBSession, 1, RSNRPZ_AUX_RNDMAX )
```

When auxiliary data is enabled, the trace data must be read from the driver cache using the
`rsnrpz_meass_fetchBufferMeasurementAux()`
function. In a way similar to the regular fetch function, all data is provided in linear units and contains the level offset:

```
ViReal64 pdMeasAv[iTracePoints]
ViReal64 pdMeasRnd[iTracePoints]
ViReal64 pdMeasPeak[iTracePoints]
ViInt32 iReadCount
lErr = rsnrpz_meass_fetchBufferMeasurementAux(
       ulUSBSession, 1, 0, iTracePoints,
       pdMeasAv, pdMeasRnd, pdMeasPeak,
       &iReadCount )
```

27.9.3 Automatic Pulse Measurement

Wideband sensors, such as the NRP-Z81, can perform automatic pulse measurements in trace mode. Enabling the automated pulse measurement increases the measurement and processing time inside the sensor.

The following two functions enable the automatic pulse measurement and set the algorithm to the histogram type.

```
lErr = rsnrpz_scope_meas_setMeasEnabled(
       ulUSBSession, 1, true )

lErr = rsnrpz_scope_meas_setMeasAlgorithm(
       ulUSBSession, 1,
       RSNRPZ_SCOPE_MEAS_ALG_HIST )
```

The only three configuration parameters required by the automatic pulse analysis are the low, mid, and high thresholds as a percentage of the pulse top power.

```
lErr = rsnrpz_scope_meas_setLevelThresholds(
       ulUSBSession, 1,
       dLevMidPercent, dLevLowPercent, dLevHighPercent )
```

After completion of the trace measurement, the pulse measurement results can be read from the driver cache using the functions listed below. Values that cannot be determined are indicated using a quiet NaN.

```
#ifdef LINUX
  #define __isnan(_X) (fpclassify((float)_X)==FP_NAN)
#else
  #define __isnan(_X) ((_X)!=(_X))
#endif
```

The general pulse timing can be read using the **`rsnrpz_scope_meas_getPulseTimes()`** function. The duty cycle and period time require at least two pulses to fall into the trace window. The measurement of the pulse width requires at least a rising and falling edge.

```
rsnrpz_scope_meas_getPulseTimes( ulUSBSession, 1,
       &dDutyCycle, &dPulseWidth, &dPeriodTime )
```

The rising and falling edge times are read using the same function twice:

```
rsnrpz_scope_meas_getPulseTransition(
       ulUSBSession, 1,
       RSNRPZ_SLOPE_POSITIVE,
       &dRiseTime, &dRisePosition, &dRiseOvershot )

rsnrpz_scope_meas_getPulseTransition(
       ulUSBSession, 1,
       RSNRPZ_SLOPE_NEGATIVE,
       &dFallTime, &dFallPosition, &dFallOvershot )
```

There is a series of functions available for the measuring the different pulse-power levels. The pulse peak power and the pulse top power are typically of greater interest:

```
rsnrpz_scope_meas_getPulsePower(
       ulUSBSession, 1,
       &dAveragePower, &dMinPeak, &dMaxPeak )

rsnrpz_scope_meas_getPulseLevels(
       ulUSBSession, 1,
       &dTopPower, &dBasePower )

rsnrpz_scope_meas_getPulseReferenceLevels(
       ulUSBSession, 1,
       &dLowRefLevel, &dHighRefLevel, &dMidRefLevel )
```

Please note that all power readings are in linear units, and they contain any level offset that was previously set.

28 Customer Support

Technical support – where and when you need it

For quick, expert help with any Rohde & Schwarz equipment, contact one of our Customer Support Centers. A team of highly qualified engineers provides telephone support and will work with you to find a solution to your query on any aspect of the operation, programming or application of Rohde & Schwarz equipment.

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29 Appendix

29.1 Command Line Options

The Power Viewer software supports a set of command line options that affect the application's look and feel as well its startup behavior:

`--native`
The user interface look is left as native as possible.

`--classic-pv`
This option starts Power Viewer in a mode in which it only displays the continuous power measurement window. This is similar to the classic Power Viewer application:

- Disables all features but the continuous power measurement.
- Always starts with a fixed application window size.
- Continuous power measurement is activated.
- The analog bar and trend display are not available.
- The measurement starts automatically if a sensor is detected.

`--no-splash`
This option omits the initial splash screen and speeds up the application startup.

`--project <file>`
This option loads a specific project file at startup. If the application is available, the default project file is written. If the specified project file is not available, the default settings are applied.

`--sensor <sensor>`
This option includes `-no-splash` and omits the initial sensor scanning. Instead, the specified sensor is made available regardless of its physical availability. The sensor must be defined by the sensor type and by its serial number (for example: “Z11,123456”).

`--no-multi`
Disables the multi-channel measurement mode.

--no-timeslot
Disables the timeslot measurement mode.

--no-statistics
Disables the statistics measurement mode.

--no-trace
Disables the trace measurement mode.

--no-scripting
Disables the scripting measurement mode.

--no-ota
Disables all OTA measurements (NRPM3 sensor module).

--no-datalog
Disables the data log window.

--no-analysis
Disables the data analysis window.

--no-monitor
Disables the limit monitoring window.

--no-gauges
Disables the gauges window.

--no-barchart
Disables the bar chart window.

--no-sparam
Disables the s-parameter configuration dialog.

--debug
Writes additional log messages to the message log window. This may be useful for debugging software problems.

--visa=<VISA vendor>
Selects a specific VISA driver. Permissible arguments are RS, NI and Agilent.

--no-portcheck
Does not perform a connection test to port 111 before opening a VXI-11 VISA device.

At startup the Power Viewer application looks for a file named `.pvoptions.txt` in the user's home directory. If the file is present then all lines not starting with the # character will be added to the command line arguments. Thus, the file can be utilized to add command line options without creating a special desktop link.

Example:

```
# .pvoptions.txt
# Permanent command line options for Power Viewer
#
--debug
--visa=rs
--no-splash
--no-ota
```

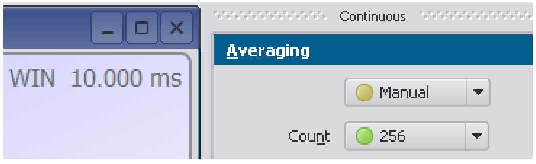
29.2 Setting the Application Style

The style of the Power Viewer user interface can be changed using the `-style` command-line option. Changing the style might be useful if the application should use the operating system's look and feel. By default, Power Viewer uses an internal style that is independent of the underlying operating system.

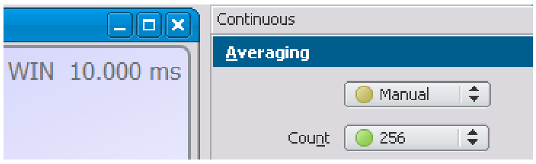
`-style <style>`

<style> User Interface Example

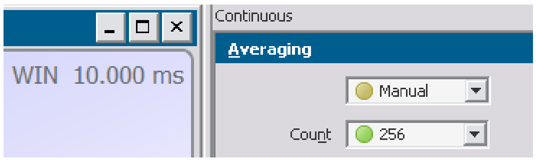
Plastique



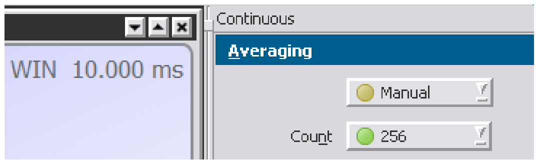
Cleanlooks



Windows



Motif



WindowsXP