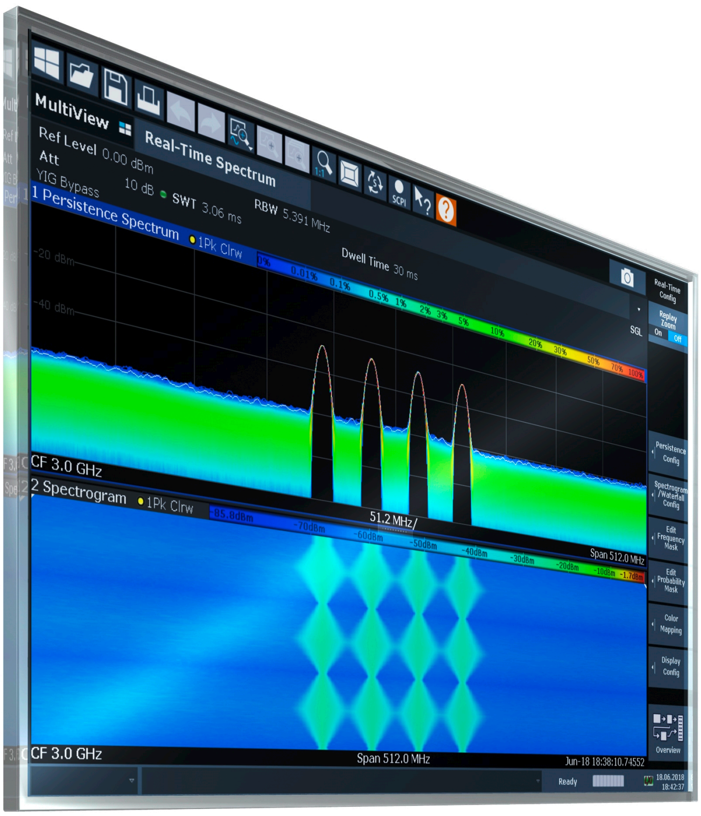
R&S®ESW-K55
Real-Time Analysis
User Manual



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Version 11

ROHDE&SCHWARZ
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This manual describes the following R&S®ESW models:

- R&S®ESW8 (1328.4100K08)
- R&S®ESW8 (1328.4100K09)
- R&S®ESW26 (1328.4100K26)
- R&S®ESW26 (1328.4100K27)
- R&S®ESW44 (1328.4100K44)
- R&S®ESW44 (1328.4100K45)

The contents of this manual correspond to firmware version 3.20 and higher.
The following firmware options are described:

- R&S®ESW-K55 (1328.4968K02)

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1177.6323.02 | Version 11 | R&S®ESW-K55

Throughout this manual, products from Rohde & Schwarz are indicated without the ® symbol , e.g. R&S®ESW is indicated as R&S ESW.

Contents

1 Preface

1.1 About this manual

This R&S ESW Real-Time User Manual provides all the information . All general instrument functions and settings common to all applications and operating modes are described in the main R&S ESW User Manual.

The main focus in this manual is on the Real-Time Spectrum measurement results and the tasks required to obtain them. The following topics are included:

- **Welcome to the R&S ESW Real-Time application**
  Introduction to and getting familiar with the application
- **Measurements and Result Displays**
  Details on supported Real-Time Spectrum measurements and their result types
- **Real-Time Basics**
  Background information on basic terms and principles in the context of Real-Time Spectrum measurements
- **Configuration and Analysis**
  A concise description of all functions and settings available to configure and analyze Real-Time Spectrum measurements with their corresponding remote control command
- **How to Perform Measurements in the R&S ESW Real-Time application**
  The basic procedure to perform a Real-Time Spectrum measurement with step-by-step instructions
- **Measurement Examples**
  Detailed measurement examples to guide you through typical Real-Time Spectrum measurement scenarios and allow you to try out the application immediately
- **Optimizing and Troubleshooting the Measurement**
  Hints and tips on how to handle errors and optimize the test setup
- **Remote Commands for Real-Time Spectrum Measurements**
  Remote commands required to configure and perform Real-Time Spectrum measurements in a remote environment, sorted by tasks
  (Commands required to set up the environment or to perform common tasks on the instrument are provided in the main R&S ESW User Manual)
  Programming examples demonstrate the use of many commands and can usually be executed directly for test purposes
- **List of remote commands**
  Alphabetical list of all remote commands described in the manual
- **Index**

1.2 Documentation overview

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

www.rohde-schwarz.com/manual/esw

1.2.1 Getting started manual

Introduces the R&S ESW and describes how to set up and start working with the product. Includes basic operations, typical measurement examples, and general information, e.g. safety instructions, etc.

A printed version is delivered with the instrument. A PDF version is available for download on the Internet.

1.2.2 User manuals and help

Separate user manuals are provided for the base unit and the firmware applications:

- Base unit manual
  Contains the description of all instrument modes and functions. It also provides an introduction to remote control, a complete description of the remote control commands with programming examples, and information on maintenance, instrument interfaces and error messages. Includes the contents of the getting started manual.
- Firmware application manual
  Contains the description of the specific functions of a firmware application, including remote control commands. Basic information on operating the R&S ESW is not included.

The contents of the user manuals are available as help in the R&S ESW. The help offers quick, context-sensitive access to the complete information for the base unit and the firmware applications.

All user manuals are also available for download or for immediate display on the Internet.

1.2.3 Service manual

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

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

https://gloris.rohde-schwarz.com

1.2.4 Instrument security procedures

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

1.2.5 Printed safety instructions

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

1.2.6 Specifications and brochures

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

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

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

1.2.7 Release notes and open source acknowledgment (OSA)

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

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

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

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

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

See www.rohde-schwarz.com/application/esw

1.2.9 Videos

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

1.3 Conventions used in the documentation

1.3.1 Typographical conventions

The following text markers are used throughout this documentation:

Convention	Description
"Graphical user interface elements"	All names of graphical user interface elements on the screen, such as dialog boxes, menus, options, buttons, and softkeys are enclosed by quotation marks.
[Keys]	Key and knob names are enclosed by square brackets.
`Filenames, commands, program code`	Filenames, commands, coding samples and screen output are distinguished by their font.
Input	Input to be entered by the user is displayed in italics.
Links	Links that you can click are displayed in blue font.
"References"	References to other parts of the documentation are enclosed by quotation marks.

1.3.2 Conventions for procedure descriptions

When operating the instrument, several alternative methods may be available to perform the same task. In this case, the procedure using the touchscreen is described. Any elements that can be activated by touching can also be clicked using an additionally connected mouse. The alternative procedure using the keys on the instrument or the on-screen keyboard is only described if it deviates from the standard operating procedures.

The term "select" may refer to any of the described methods, i.e. using a finger on the touchscreen, a mouse pointer in the display, or a key on the instrument or on a keyboard.

1.3.3 Notes on screenshots

When describing the functions of the product, we use sample screenshots. These screenshots are meant to illustrate as many as possible of the provided functions and possible interdependencies between parameters. The shown values may not represent realistic usage scenarios.

The screenshots usually show a fully equipped product, that is: with all options installed. Thus, some functions shown in the screenshots may not be available in your particular product configuration.

2 Welcome to the R&S ESW real-time extension

The R&S ESW real-time extension options provide both an application and an operating mode to display RF spectra in real-time and gapless, allowing for quick and simple error analysis and signal characterization.

This user manual contains a description of the functionality specific to the "Real-Time Spectrum" application, including remote control operation.

Functions not discussed in this manual are the same as in Signal and Spectrum Analyzer mode and are described in the R&S ESW User Manual. The latest version is available for download at the product homepage (http://www.rohde-schwarz.com/product/FSW.html).

Additional information

An application note discussing the implementation of real-time spectrum analysis using the R&S ESW is available from the Rohde & Schwarz website:

1EF77: Implementation of Real-Time Spectrum Analysis

Installation

You can find detailed installation instructions in the R&S ESW Getting Started manual or in the Release Notes.

2.1 Starting the R&S ESW Real-Time application

The "Real-Time Spectrum" application adds real-time measurement analysis to the R&S ESW. It is available with the optional real-time hardware component.

To activate the R&S ESW Real-Time application

1. Press [MODE] on the front panel of the R&S ESW.

   A dialog box opens that contains all operating modes and applications currently available on your R&S ESW.

2. Select the "Real-Time Spectrum" item.

   The R&S ESW opens a new measurement channel for the R&S ESW Real-Time application.

The measurement is started immediately with the default settings. It can be configured in the "Real-Time Spectrum" "Overview".

(See Chapter 6.1, "Configuration overview", on page 54)

2.2 Understanding the display information

2.2.1 R&S ESW Real-Time application

The following figure shows a measurement diagram in the R&S ESW Real-Time application. All different information areas are labeled. They are explained in more detail in the following sections.

Figure 2-1: Screen elements in the Real-Time Spectrum channel

1 = Channel bar for firmware and measurement settings
2 = Window title bar with diagram-specific (trace) information
3 = Spectrum display
4+7 = Diagram footer with diagram-specific information, depending on evaluation
5 = "Spectrogram" color map legend
6 = "Spectrogram" display
8 = Instrument status bar with error messages, progress bar and date/time display

Channel bar information

In the R&S ESW Real-Time application, the R&S ESW shows the following settings:

Table 2-1: Information displayed in the channel bar in the R&S ESW Real-Time application

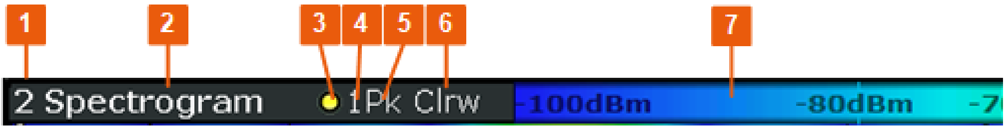
"Ref Level"	Reference level
"Att" / "m.+el.Att"	Mechanical RF attenuation / Mechanical and electronic RF attenuation

"Offset"	Reference level offset
"SWT"	Data acquisition time for single spectrogram line in frequency domain
"RBW"	Resolution bandwidth
"TRG"	Trigger source
"PreTrigger"/ "Post-Trigger"	Data acquisition time before / after the trigger event
"SGL"	The measurement is set to single sweep mode.

In addition, the channel bar also displays information on instrument settings that affect the measurement results even though this is not immediately apparent from the display of the measured values. This information is displayed only when applicable for the current measurement. For details see the R&S ESW Getting Started manual.

Window title bar information

For each diagram, the header provides the following information:



1 = Window number
2 = Window type
3 = Trace color
4 = Trace number
5 = Trace detector
6 = Trace mode
7 = Color map legend

Diagram footer information

The diagram footer (beneath the diagram) contains the following information, depending on the evaluation.

Spectrum displays:

- Center frequency (CF)
- Displayed frequency span per division
- Displayed frequency span

Spectrograms:

- Center frequency (CF)
- Displayed frequency span
- Timestamp or index of current frame

Time domain displays:

- Center frequency (CF)
- Displayed time span per division

Status bar information

Global instrument settings, the instrument status and any irregularities are indicated in the status bar beneath the diagram. Furthermore, the progress of the current operation is displayed in the status bar.

3 Typical applications

A common challenge when developing RF applications are sporadic and transient interferences. In order to keep the time for development short, it is essential that such interferences are detected quickly and that the exact cause is determined. Possible causes may be interference from digital circuits or short-term effects from frequency hopping techniques in sending devices. Thus, a seamless data acquisition and a frequency mask trigger are required.

A further application for Real-Time Spectrum measurement is various standards working in the same frequency range, for example Bluetooth and WLAN. Frequent collisions reduce the data rates. To develop effective algorithms that elude collisions, the spectrum must be analyzed seamlessly.

Precise analysis of frequency-variant senders (hoppers) is not only indispensable for wireless data transfer, but also for radar applications or satellite communication. Administrative or regulatory authorities also depend on seamless spectrum analysis to supervise the frequency bands.

4 Measurements and result displays

In order to accommodate for different requirements, different measurement types and result displays are provided for Real-Time Spectrum measurements.

4.1 Real-Time Spectrum result displays

The R&S ESW Real-Time Spectrum measurements not only process data in real-time, but also offer several result displays that help you analyze the data as it is displayed. The human eye has a limited capability of detecting changes – therefore the R&S ESW Real-Time application result displays visualize the time axis, i.e. the changes of a signal over time. Display modes with information on past and present spectra at the same time allow for a quick analysis of changes for human eyes.

For Real-Time Spectrum measurements, up to 6 result displays can be displayed simultaneously in separate windows.

Real-Time Spectrum

The "Real-Time Spectrum" diagram displays the measured power levels for a frequency span of 80 MHz around the selected center frequency.

The displayed data corresponds to one particular frame in the spectrogram. During a running measurement, the most recently captured frame is always displayed. During analysis, which frame is displayed depends on the selected frame in the spectrogram configuration (see "Selecting a frame to display" on page 82) or the marker position in the spectrogram (see "Frame" on page 93). The displayed frame is indicated by small white arrows on the left and right border of the "Spectrogram"/"PVT waterfall".

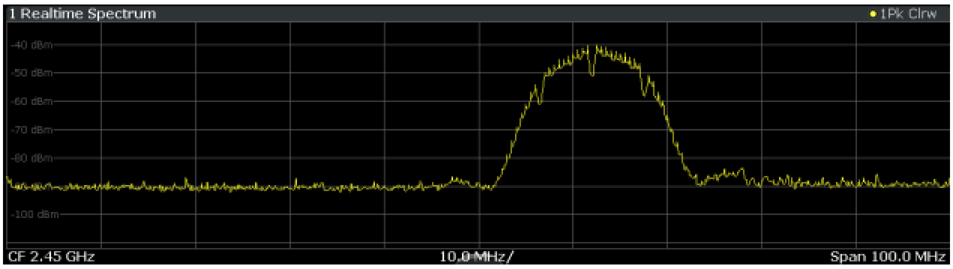


Figure 4-1: Real-Time Spectrum result display

Thus, the "Real-Time Spectrum" is useful to analyze the input signal measured at a specific time in more detail.

Remote command:
`LAY:ADD? '1',RIGH, 'XFRequency'`, see `LAYout:ADD[:WINDow]?` on page 167
Results:
`TRAC<n>:DATA? TRACEx`, see `TRACe<n>[:DATA]` on page 179
`TRACe<n>[:DATA]:X?` on page 180
`MMEMory:STORe<n>:TRACe` on page 184

Spectrogram

The spectrogram is a way of displaying multiple consecutive spectrums over time. The power level, which is usually displayed over frequency, is displayed over frequency and time. Graphically, time and frequency represent the vertical and horizontal axes of the diagram. The color of each point of the diagram represents the power level for the corresponding frequency and time.

At the beginning of a measurement, the diagram is empty. As the measurement advances, the graph is filled line by line. Lines in the spectrogram are called frames, as each frame represents one spectrum.

As the graph fills from top to bottom, the latest spectrum is always the topmost line, whereas older frames move towards the bottom.

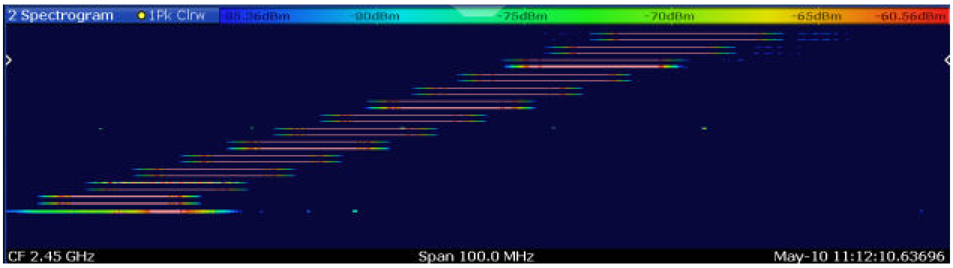


Figure 4-2: Frequency hopper exhibiting a transition with significant RF level from lowest to intermediate frequency

The currently selected frame is indicated by small white arrows on the left and right border of the spectrogram.

The spectrogram is a powerful tool to analyze time-variant spectrums. Typical applications are the transient oscillation of a VCO and the analysis of frequency hopping signals. In Figure 4-2 a frequency hopper is shown. It is clearly visible that the signal is not completely off during the first hop (lowest frequency to middle frequency), whereas no significant RF level can be observed during the second hop.

Real-Time spectrograms are highly configurable. In particular, the number of frames and the colors used to display the power levels can be defined by the user.

Spectrograms are particularly useful in combination with a spectrum display. In this case, the spectrogram provides an overview of events over time, whereas the spectrum provides details for a specific frame.

For more information on working with spectrograms see Chapter 5.6, "Working with Spectrogram diagrams", on page 36.

Remote command:
`LAY:ADD? '1',RIGH,'XFRequency:SGRam'`, see `LAYout:ADD[:WINDow]?` on page 167
Results:
`TRAC<n>:DATA? SPEC`, see `TRACe<n>[:DATA]` on page 179
`TRACe<n>[:DATA]:X?` on page 180
`MMEMory:STORe<n>:SPECtrogram` on page 183

Persistence Spectrum
In a persistence spectrum, the probability of appearance for each frequency/level pair is displayed.

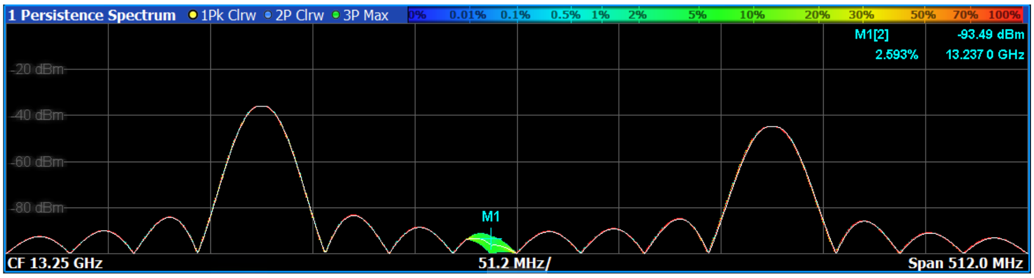


Figure 4-3: Persistence Spectrum result display

The "Persistence Spectrum" result displays 3 traces:

- Trace 1 is a standard trace in clear/write mode with a peak detector, which corresponds to the current "Real-Time Spectrum" trace.
  This trace is displayed for reference and can be disabled using the common trace settings.
  (See Chapter 7.5, "Trace settings", on page 85).
- Trace 2 shows the persistence spectrum in clear/write mode
- Trace 3 shows the persistence spectrum in Max Hold mode. This trace indicates the maximum probabilities ever measured during the entire measurement for each point in the diagram. The intensity of the Max Hold display is configurable so that it can be distinguished from the current trace, but it is not time-dependant (indefinite persistence).
  (See Chapter 7.2, "Persistence spectrum settings", on page 78).

The persistence spectrum result is also referred to as a spectrum histogram. Both terms indicate the main features of this result display: persistence and histogram information. Persistence helps you view even very short events that the human eye could not capture otherwise. Moreover, it also allows for comparison between two events that are separated in time, but which share a time frame called *persistence granularity*. This time frame specifies the amount of time it takes for a singular event to fade completely.

Histogram information is basically a counter that sums up the appearance of a certain frequency/level pair within a certain amount of time. Instead of displaying the total of a counter, the "Persistence Spectrum" displays the counter result normalized to the maximum achievable count, which yields a probability of appearance for each frequency/level pair.

The "Persistence Spectrum" is made up of a horizontal frequency axis and a vertical level axis just as a normal spectrum display. The color of each dot in the "Persistence Spectrum" contains the histogram information, i.e. the probability information.

A typical application for the "Persistence Spectrum" is the analysis of signals that vary over time. It is an especially powerful tool to provide an overview of a signal, before it can be analyzed in detail.

Using a "Persistence Spectrum", fast frequency hops can be distinguished clearly from amplitude drops, whereas conventional analyzers may mislead the user. As opposed to the spectrogram display, the "Persistence Spectrum" offers a higher level resolution, as it does not employ color coding for the power.

Another application for the "Persistence Spectrum" is the separation of superimposed signals if they can be distinguished in terms of probability distribution of frequency/level pairs.

Figure 4-4 shows a "Persistence Spectrum" of a noise-like signal resulting from a motor with brushes. A weak GSM signal is clearly visible in the center of the span. A standard spectrum analyzer cannot resolve the two different signals, as it does not display probabilities for each signal point.

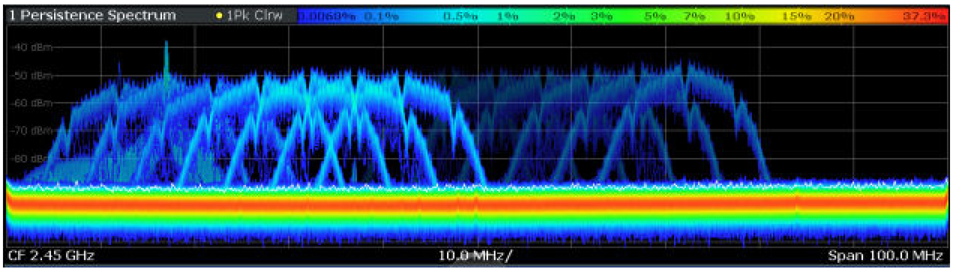


Figure 4-4: Wideband noise-like signal covering a GSM signal

Markers in the Persistence Spectrum

Markers can be assigned to any of the three traces in the "Persistence Spectrum" display. Markers on the persistence traces are 2-dimensional markers defined by a frequency and level value, similar to fixed reference markers (see "Defining a Fixed Reference" on page 96). The marker result indicates the probability of appearance for the frequency/level pair.

Dedicated fixed reference markers are not supported in "Persistence Spectrum" displays. Use a normal marker and a delta marker instead.

For more information about markers, see Chapter 7.8, "Marker settings", on page 91.

For more information on how the histogram and persistence are evaluated see Chapter 5.7, "Understanding persistence", on page 48.

Remote command:
`LAY:ADD? '1',RIGH,'XFRequency:PSPectrum'`, see `LAYout:ADD[:WINDow]?` on page 167
Results:
`TRAC<n>:DATA? TRACEx`, `TRAC<n>:DATA? PSP`, `TRAC<n>:DATA? HMAX`, see `TRACe<n>[:DATA]` on page 179
`TRACe<n>[:DATA]:X?` on page 180
`MMEMory:STORe<n>:PSPectrum` on page 182

Marker Table

Displays a table with the current marker values for the active markers.

This table is displayed automatically if configured accordingly.

1 Marker Table

Wnd	Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
2	M1		1	2.1725 ms	-6.80 dBm		
2	D2	M1	1	13.859 ms	-0.00 dB		
2	D3	M1	1	4.6259 ms	-0.00 dB		
2	D4	M1	1	9.2331 ms	-0.00 dB		

Tip: To navigate within long marker tables, simply scroll through the entries with your finger on the touchscreen.

Remote command:
`LAY:ADD? '1',RIGH, MTAB`, see `LAYout:ADD[:WINDow]?` on page 167
Results:
`CALCulate<n>:MARKer<m>:X` on page 198
`CALCulate<n>:MARKer<m>:Y?` on page 198

5 Real-time basics

Some background knowledge on basic terms and principles used in Real-Time Spectrum measurements is provided here for a better understanding of the required configuration settings. For example, the mechanisms behind data capturing without blind times and triggering on frequency masks are described here.

5.1 Increasing measurement sensitivity (or avoiding an input mixer overload)

Measurements often confront you with unknown or unintentional signals with unknown signal levels (and often with pulse characteristics). Such signals can either have very weak signal levels, in which case you might miss them during the measurement. Or they can have very strong signal levels, in which case they can damage the input mixer.

Protecting the input mixer

Always consider how to protect the input mixer from damage when setting up a measurement.

► **NOTICE!** EMC measurements often measure unknown signals that contain pulses with possibly strong signal levels. Strong signal levels can damage the input mixer.

Read the following topics carefully before you apply a signal to learn more about protecting the input mixer and avoid an overload.

Note that pulses have different level characteristics. Refer to the specifications document for more information on the allowed maximum pulse energy.

The signal level at the input mixer is calculated as follows.

Mixer Level = Input Level - attenuation + gain

The R&S ESW is equipped with an overload protection mechanism. This mechanism becomes active as soon as the signal level at the input mixer exceeds the specified limit. It ensures that the connection between RF input and input mixer is cut off.

In this case, you must decrease the level at the RF input connector and then close the message box. Then measurements are possible again.

5.1.1 Using the RF attenuator

The first tool provided by the R&S ESW to control measurement sensitivity is the RF attenuator.

The RF attenuator is available in all hardware configurations of the R&S ESW.

Attenuation has the following effects on the measurement:

- High attenuation protects the input mixer: the main purpose of the attenuator is to protect the input mixer.
- High attenuation makes sure that the measurement results are reliable (signals that are stronger than allowed can distort the results)
- High attenuation helps you to avoid intermodulation
- High attenuation increases inherent noise (i.e. the noise floor) and thus decreases measurement sensitivity: if you increase attenuation by 10 dB, the sensitivity is reduced by 10 dB (in other words: the displayed noise increases by 10 dB)

Depending on the required test setup, you must find a compromise between a high sensitivity, low intermodulation and input mixer protection. We recommend to let the R&S ESW determine the ideal attenuation automatically.

You can determine the attenuation automatically with the auto ranging feature in the receiver application and the auto attenuation feature in the other applications. Determining the attenuation automatically might not necessarily utilize the maximum dynamic range, but still yields valid and reliable results.

When you select the attenuation manually and are measuring unknown signals, especially DUTs with a high RFI voltage, always select the highest possible attenuation level before you apply the signal.

If you need a better sensitivity or signal-to-noise ratio, make sure that the applied signal does not exceed the specified limits, before you lower the attenuation.

For further protection of the input mixer, the R&S ESW does not allow you to select attenuation levels of less than 10 dB unless you explicitly turn on this feature ("10 dB Minimum Attenuation").

Protecting the input mixer

1. **NOTICE!** EMC measurements often measure unknown signals that contain pulses with possibly strong signal levels. Strong signal levels can damage the input mixer.

   Select an appropriate attenuation when you measure unknown signals or RFI voltage in combination with an artificial network (LISN). Do not apply a 0 dB attenuation for such measurements.
   During phase switching, such test setups generate very strong pulses which can damage the input mixer.

2. Make sure that the signal level at the RF input does not exceed the allowed limits when you allow attenuation of less than 10 dB in combination with auto ranging Exceeding the limits can damage the input mixer.

5.1.2 Using the preamplifier

The second tool that allows you to control measurement sensitivity is the preamplifier.

In addition to the standard preamplifier available in every R&S ESW, an additional low noise amplifier is available as an optional component (R&S ESW-B24).

Signal gain has the following effects on the measurement:

- The preamplifier allows you to detect even weak signals.
- The preamplifier reduces the noise figure of the R&S ESW and thus increases its sensitivity. Thus, it is recommended to use the preamplifier for measurements that require maximum sensitivity.
- The preamplifier reduces the dynamic range. To perform a measurement using the maximum dynamic range, turn off the preamplifier.
- The preamplifier is located after the preselection filters, reducing the risk of overloading the input mixer by strong out-of-band signals.
- The optional low noise amplifier is located in front of the preselection filters which increases the measurement sensitivity.

The gain of the preamplifier is automatically considered in the level display. The disadvantage of a lower large-signal immunity (intermodulation) is reduced by the "preselector".

5.1.3 Using the preselector

Note: The preselector is unavailable in the real-time application.

The "preselector" is another tool to control measurement sensitivity.

Preselection has the following effects on the measurement:

- Preselection rejects most of the spectral energy which helps to protect the input mixer and thus makes sure that the measurement results are valid and reliable.
- Preselection filters out signals that you do not want to be displayed (selectivity) and thus allows you to analyze only the frequency range you are interested in.

The preselector of the R&S ESW consists of several filters which are automatically applied during measurements. The filter that is used depends on the frequency that is currently measured. You can see the list of filters and the progress in the "Preselector" result display. The currently applied filter is indicated by a green LED, filters that are outside the scan range are ignored.

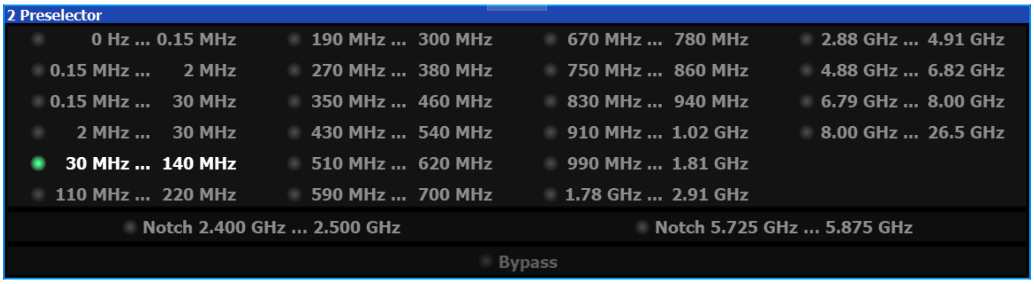


Figure 5-1: Preselector result display. The green LED indicates the currently applied filter.

In the frequency range from 150 kHz to 30 MHz, you can preselect in a single stage (150 kHz to 30 MHz). Or, you can split the preselection into two stages, each of which applies a separate filter: one from 150 kHz to 2 MHz, and another from 2 MHz to 30 MHz.

In addition, the R&S ESW provides several notch filters to suppress certain frequency ranges completely.

Using the preselector

Switching the filters is a mechanical process. Avoid excessive filters switches, because the hardware can wear out.

Note that results in a frequency band are only displayed if there is at least one valid measurement point in the corresponding range. If a particular measurement point is captured by more than one filter, the R&S ESW displays the combined results.

Notch filter

The R&S ESW provides additional notch filters that suppress signals in the frequency bands from 2.4 GHz to 2.5 GHz and 5.725 GHz to 5.875 GHz.

5.2 Data acquisition and processing in real-time

This chapter shows the way the R&S ESW Real-Time application acquires and processes the data compared to a conventional spectrum analyzer.

For more background information, see the Rohde & Schwarz White Paper "Implementation of "Real-Time Spectrum" Analysis" available at: http://www.rohde-schwarz.com/appnote/1ef77.

A conventional spectrum analyzer typically loses information after it has captured the signal ('blind time'). The blind time is because the LO has to return to the start frequency after a sweep of the selected frequency range (LO flyback). Blind time therefore occurs after the data capture and signal processing and before the next data capture can begin.

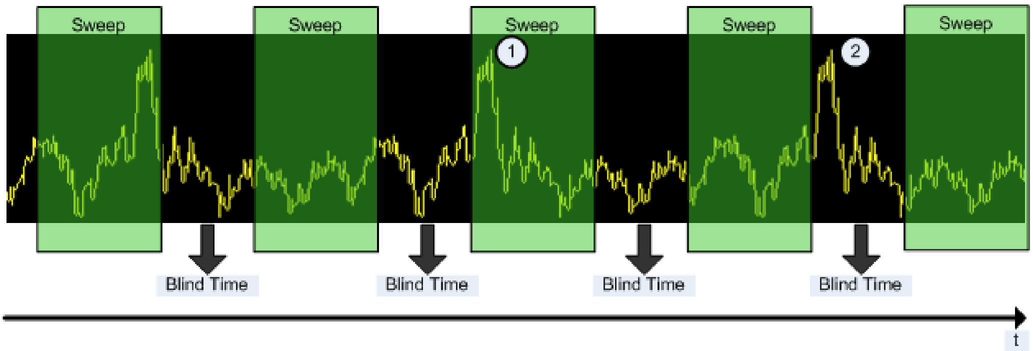


Figure 5-2: Conventional spectrum analyzer measurement principle

1 = Signals are captured by the sweep.
2 = Signal is missed by the sweep because of LO flyback (blind time; extended for clarity).

A real-time spectrum analyzer does not lose any information for the following reasons:

- There is no LO flyback because the LO is set to a fixed frequency in the real-time spectrum analyzer.
- It performs overlapping Fast Fourier transformations (FFT) instead of sweeping the spectrum or performing one FFT after another.
- The R&S ESW captures data and performs FFTs at the same time instead of sequentially.

To get the results, the R&S ESW simultaneously performs several processing stages:

- Acquiring the data
- Processing the data
- Displaying the data

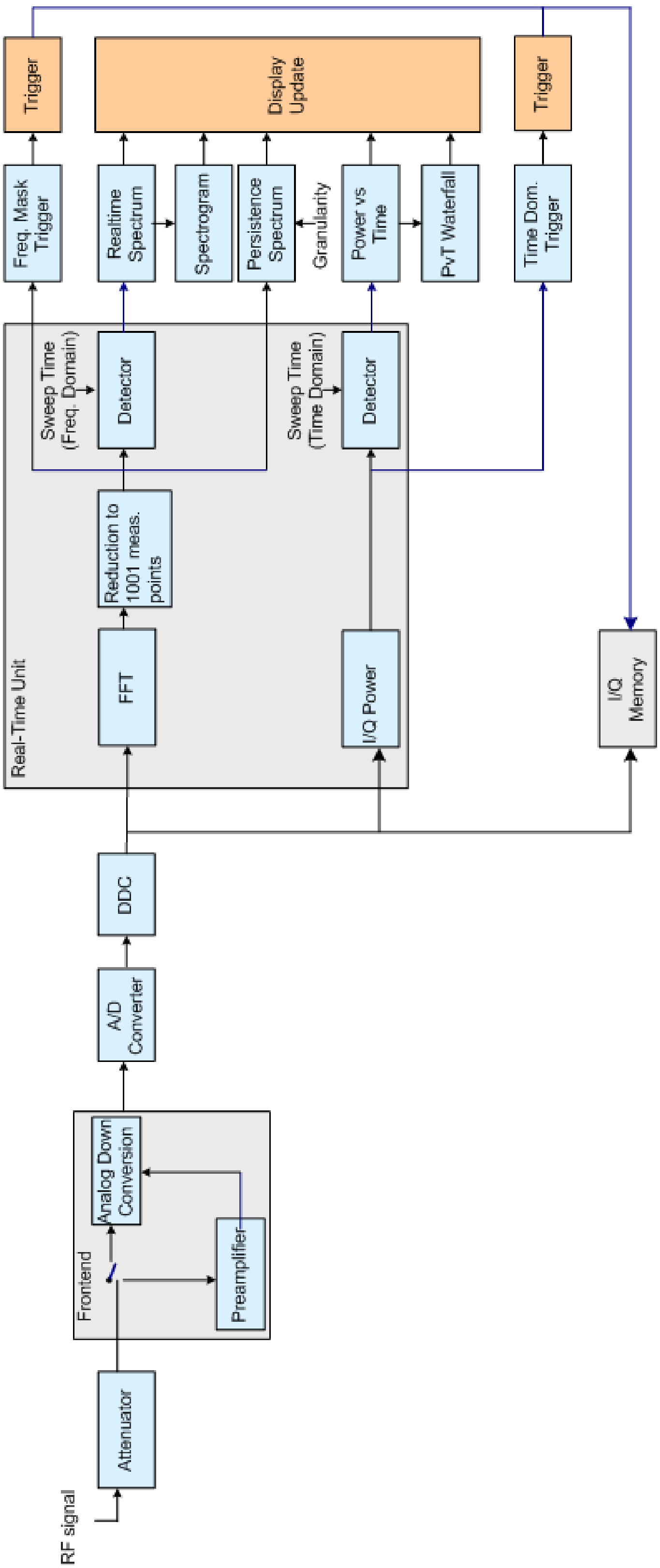


Figure 5-3: Block diagram of the R&S ESW

Acquiring the data

The data acquisition process is the same as in a conventional spectrum analyzer. First, the R&S ESW attenuates the signal that you have applied to the RF input to get a signal level that the R&S ESW can handle. If you have a weak signal, the R&S ESW preamplifies the signal and then down-converts the RF signal to an intermediary frequency (IF), usually in several stages.

After the down-conversion, the R&S ESW samples the signal into a digital data stream that is the basis for the Fast Fourier transformation (FFT). The sample rate the R&S ESW uses for sampling is variable, but depends on the span you have set.

At the same time, the A/D data is down-converted and captured in the I/Q memory.

The memory extension option R&S ESW-B106 is not available for real-time measurements.

Processing the data

The R&S ESW then splits the data stream stored in the I/Q memory into data blocks whose length is between 1024 and 16384 samples each to prepare it for the FFT.

Then the R&S ESW performs the FFT on all data blocks it has acquired. The FFT processing rate of the R&S ESW is variable with a maximum of approximately 600.000 FFTs per second.

The distinctive feature of a real-time analyzer is that it uses a particular amount of data more than once to get the measurement results. It takes the first data block of 1024 samples, for example, and performs the FFT on it. The second and all subsequent data blocks, however, do not start at the next sample (for the second block, the 1025th), but at an earlier one. In fact, all data, except the first few samples, is processed more than once and overlapped to get the results.

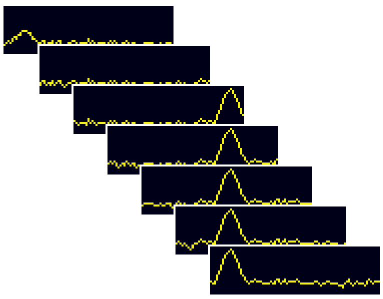


Figure 5-4: Overlapping FFTs

After the FFT is done and the spectra have been calculated, the result is a stream of spectra without information loss.

5.3 Defining the resolution bandwidth

The resolution bandwidth affects how the spectrum is measured and displayed. It determines the frequency resolution of the measured spectrum. A small resolution bandwidth has several advantages. The smaller the resolution bandwidth, the better you can observe signals whose frequencies are close together and the less noise is displayed. However, a small resolution bandwidth also increases the time required to ensure that *all* possible signal distortions are detected and the level is measured accurately. This requirement is also referred to as *100% probability of intercept (POI)*.

The resolution bandwidth parameters can be defined in the bandwidth configuration, see Chapter 6.7, "Bandwidth and sweep settings", on page 72.

5.4 Sweep time and detector

The Sweep Time parameter determines the amount of time used to sample data for one spectrum. One spectrum is defined by all FFTs calculated and combined from the sampled data in one sweep time period. In conventional spectrum analysis, the sweep time parameter describes the amount of time needed to sweep over the selected frequency span. As the effect is the same, i.e. it takes the sweep time to complete one spectrum, the real-time parameter is also called sweep time.

Combining several FFTs into one spectrum during the selected sweep time offers several possibilities of weighting the FFT results: determining the maximum level is an obvious one. Other possibilities of combining several FFTs are selecting the minimum for each frequency point, determining the average result, or selecting an arbitrary FFT result to represent the entire sweep time. The FFTs are combined by detectors.

A detector is available for each of the mentioned methods:

- "Positive Peak"
- "Negative Peak"
- "Average"
- "Sample"

"Positive Peak" is the default selection to make sure that even the shortest events can be analyzed.

Thus, the detector and sweep time parameters describe the data reduction from multiple FFTs to a single spectrum. A detector is not required for the "Persistence Spectrogram" display, which evaluates the individual FFTs (see Chapter 5.7, "Understanding persistence", on page 48).

5.5 Triggering real-time measurements

Real-time measurements pose some specific challenges to triggering, which require special trigger functions and options.

5.5.1 Triggering on specific frequency events (frequency mask trigger)

One way to analyze rare events in a given frequency range is to capture real-time data over a very long time. This method requires large amounts of fast memory. As a consequence, post-processing the bulk of stored data to find the event can be extremely time consuming.

Another way is to trigger on the event in the frequency spectrum and to acquire exactly the data of interest. This method reduces the necessary memory size dramatically, and in addition keeps the time to spot the event of interest in the acquired memory low. The question is: how can the analyzer trigger on events which show up in a certain frequency range only now and then?

Detecting rare events

The answer is the *Frequency Mask Trigger*. Speaking graphically, the frequency mask trigger is a mask in the frequency domain, which is checked with every calculated FFT. Thus, a 100% probability of intercept with full level accuracy even on short pulses is possible.

The minimum detectable pulse length is specified in the specifications document.

The minimum detectable pulse length is specified in the specifications document.

Mask definition

The frequency mask is configured by a list of individual trace points, defined as frequency (position) / level (value) pairs, which are connected to form a mask area. The individual mask points can also be defined simply by dragging the points to the required position on the touchscreen. The frequency mask can consist of up to 1001 points and can have an arbitrary shape.

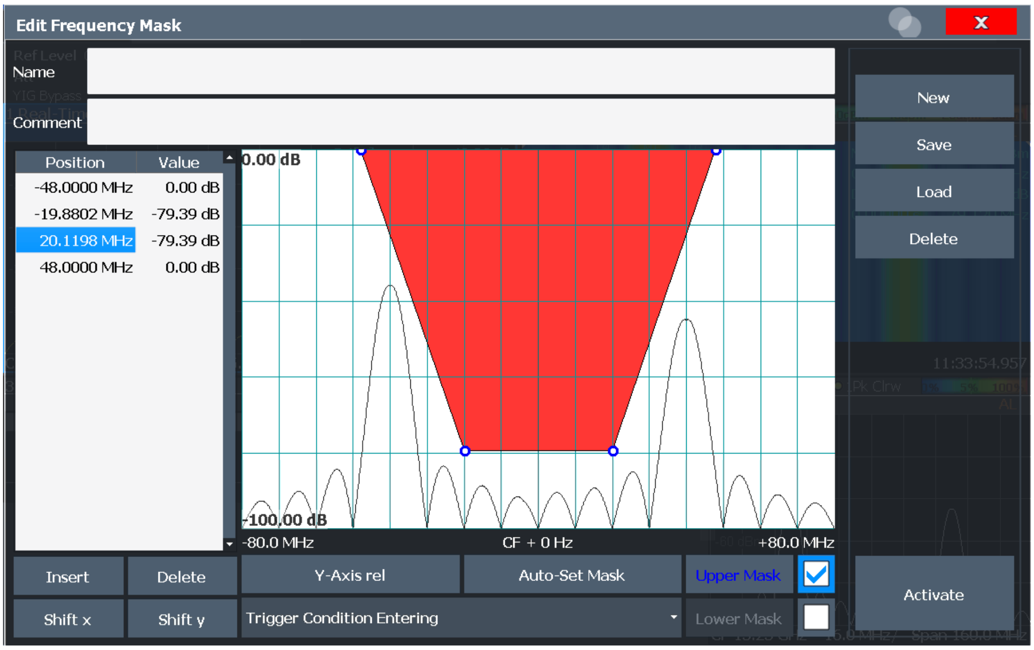


Figure 5-5: Frequency mask defined manually

Alternatively, a mask can be defined automatically according to the currently measured data. In this case, the mask is configured to follow the measurement trace with a specific distance to the power levels.

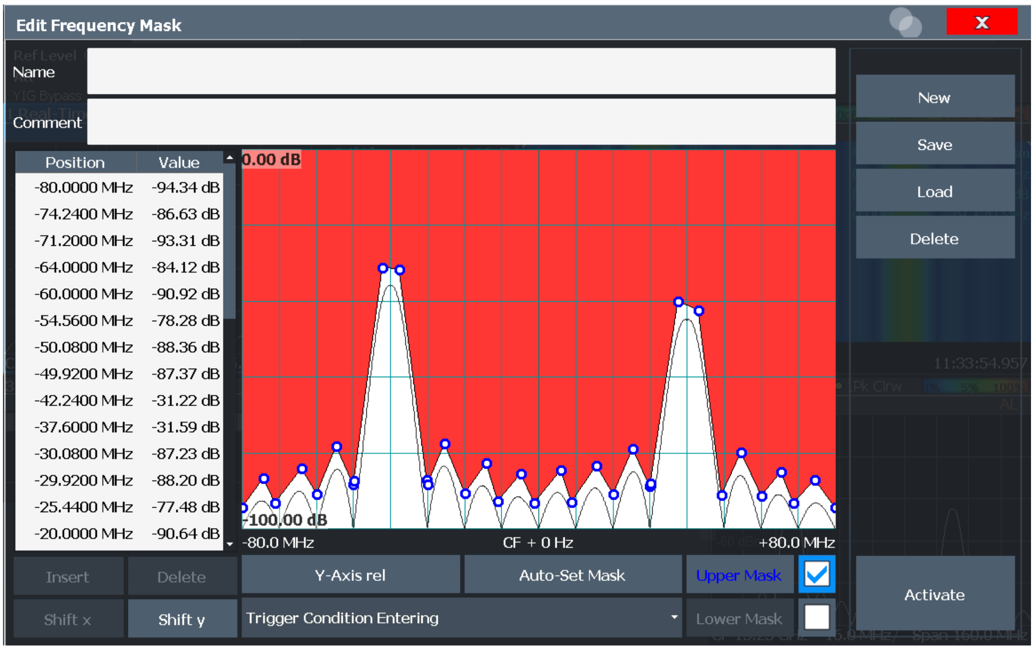


Figure 5-6: Frequency mask defined automatically according to measured data

Upper and lower masks

By default, the configured mask is an upper mask, i.e. the mask is the area *above* the configured mask points. In addition or alternatively, a mask can be defined as a lower mask. In this case, the mask is the area *below* the configured mask points. Lower masks are useful, for example, to determine if the measured signal leaves a defined "corridor" of allowed values.

The lower limit mask is configured in the same manner as the upper limit mask. However, it cannot be configured automatically according to the currently measured values.

Trigger conditions

The frequency mask can be evaluated in different ways to control data acquisition, depending on whether the mask area represents the relevant or irrelevant value range.

"Entering": mask area represents the relevant value range

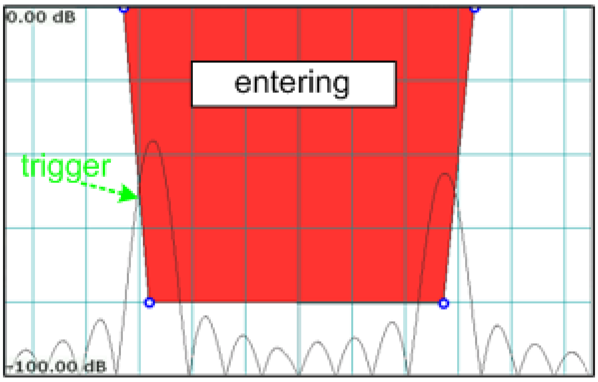


Figure 5-7: Trigger condition "entering": Data acquisition starts when the signal enters the mask area and continues until the measurement is stopped or completed.

"Leaving": mask area represents the irrelevant value range

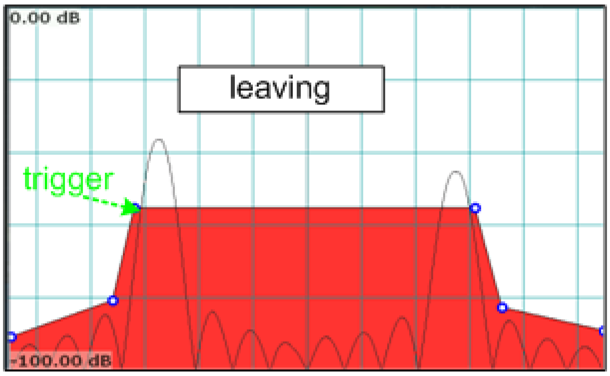


Figure 5-8: Trigger condition "leaving": Data acquisition starts when the signal leaves the mask area and continues until the measurement is stopped or completed.

The selected trigger condition applies to any active limits; that means the calculated FFTs are compared to the upper or lower, or both the upper and lower limits, if activated.

Availability

The frequency mask trigger can be selected as a trigger source for all measurements in the R&S ESW Real-Time application. As it is evaluated in parallel to the selected result displays, there is no influence on the real-time capabilities of the R&S ESW.

A detailed description of how to define a frequency mask trigger is provided in Chapter 9.4, "How to work with frequency mask triggers", on page 112.

Storing and loading frequency masks

As frequency masks can have a very complex structure, they can be stored for later use with other signals. The masks are stored in a file with the extension `.FMT` in the `C:\Program Files (x86)\Rohde-Schwarz\ESW\<version>\freqmask` directory. By default, the mask name is used as the file name.

Trigger output

The frequency mask trigger is a trigger source which exceeds the capabilities of standard spectrum analyzers. To allow other instruments in a test system to make use of it, R&S ESW provides a special connector ("Trigger Out 2 / 3"). This trigger pulse can be provided to a system setup as an external trigger source.

To output trigger pulses continuously, a special trigger mode is provided. See "Mark only mode" on page 36 and Chapter 9.6, "How to output trigger signals continuously", on page 115.

5.5.1.1 Technical process

Basically the frequency mask trigger is an extended limit line check: the frequency mask is compared to every FFT spectrum calculated by the real-time hardware.

The R&S ESW performs this mask check up to 600,000 times per second according to the FFT update rate. To ensure a real-time trigger, i.e. a given reaction time, the frequency mask trigger is evaluated by the real-time hardware.

Element-wise comparison of frequency mask with current FFT result shows the element-wise comparison of a real-time FFT with a frequency mask. The FFT-result is subtracted from the frequency mask value. If one result is negative, the R&S ESW triggers.

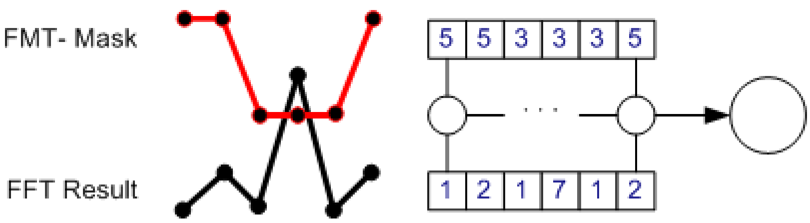


Figure 5-9: Element-wise comparison of frequency mask with current FFT result

Extended limit check means that the frequency mask trigger can link a complex condition to the limit line violation, such as entering or leaving the mask.

As already mentioned, the frequency mask can contain up to 1001 points, but can also be as short as 2 points. Shorter frequency mask trigger definitions are extended to 1001 points by interpolation within the firmware. The frequency mask trigger therefore always compares 1001 FFT points to 1001 frequency mask definition points. If the mask is violated at a single point, the frequency mask triggers.

To get a reliable frequency mask trigger with very short events, it is preferable to set the mask limit levels lower than the expected spectral power levels.

5.5.2 Using pretrigger and posttrigger settings

As described in Chapter 5.4, "Sweep time and detector", on page 28, the amount of time required to sample data for one spectrum (or one frame/line in a spectrogram) corresponds to the defined sweep time. If a trigger is used for the measurement, the displayed spectrum starts with the trigger event. However, you can define a pretrigger and posttrigger period in which data is also captured, in addition to the actual sweep time. (As the posttrigger time starts with the trigger event, it only has an effect if it is longer than the sweep time.) Pretrigger data allows you to analyze the data shortly before the actual trigger event or after the regular sweep period.

The data from this "extended" sweep time (pretrigger+posttrigger) is displayed in the real-time Spectrogram.

By default, the frame displayed in the results is the frame that begins with the trigger event. If a pretrigger time is defined, one or more additional frames are available in the spectrogram/waterfall beneath the frame currently displayed in the diagram window, respectively. If a posttrigger time is defined, one or more additional frames are available in the spectrogram/waterfall above the frame currently displayed in the diagram window.

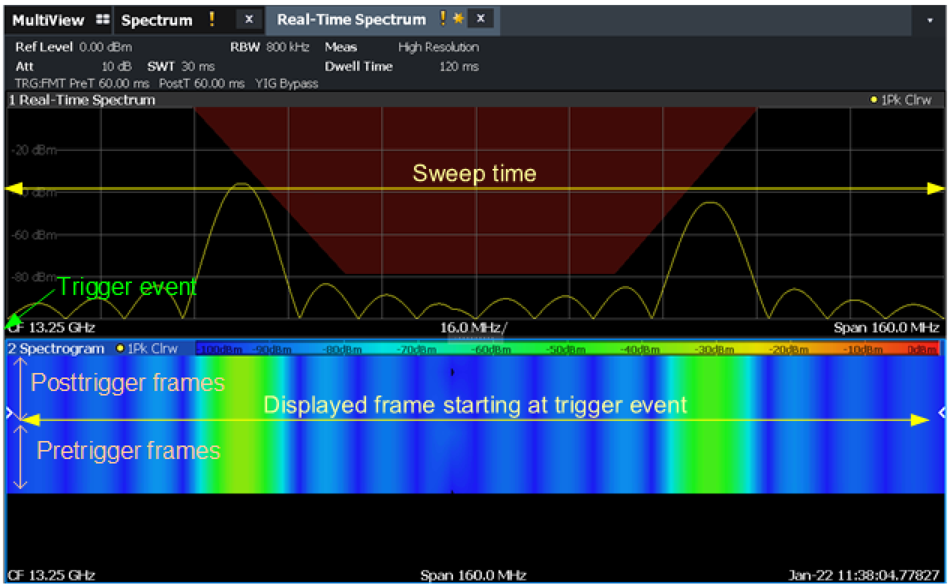


Figure 5-10: Pretrigger, currently displayed, and posttrigger frames

5.5.3 Trigger modes

By default, a trigger event causes the R&S ESW to start a measurement and to re-arm the trigger ("Auto Rearm") immediately. In Run continuous mode, measurements are continuously triggered and results can become obsolete with the next measurement.

However, possibly you are interested in the results after the first trigger event only. For this case, a "Stop on Trigger" option is provided. If active, the trigger is not re-armed after the first trigger event has occurred; thus, data acquisition stops after one measurement. The results for that measurement remain on the display, including the pretrigger and posttrigger periods.

Auto Rearm

When a triggered measurement starts in "Auto Rearm" mode, data is acquired. Once a trigger occurs, data acquisition continues for the posttrigger period. Then postprocessing takes place, in which the traces are calculated and displayed. Only then, the next measurement starts and data acquisition continues. The data from the pretrigger and posttrigger periods is processed to display the frequency and time domain results. In the spectrogram, the blind time due to postprocessing is indicated by black lines. Multiple frames are displayed for the measurement.

For the "PVT Waterfall" diagram, a single frame is displayed for the measurement, starting at (trigger time - trigger offset), and with a length specified by the PVT sweep time. For the next measurement, another frame is displayed, again starting at (trigger time - trigger offset). Thus, in the "PVT waterfall", all trigger events are neatly aligned one beneath the other.

For example, for a time domain trigger, the rising edges all start at the same time. The measurement ends after the specified sweep time is over ("Run single"), or when you stop the continuous measurement. Figure 5-11 shows the time domain results ("Power vs. Time" and "PVT Waterfall") for a triggered measurement in "Auto Rearm" trigger mode with trigger offset (ΔT) = -5 ms. All trigger events in the "PVT Waterfall" are neatly aligned.

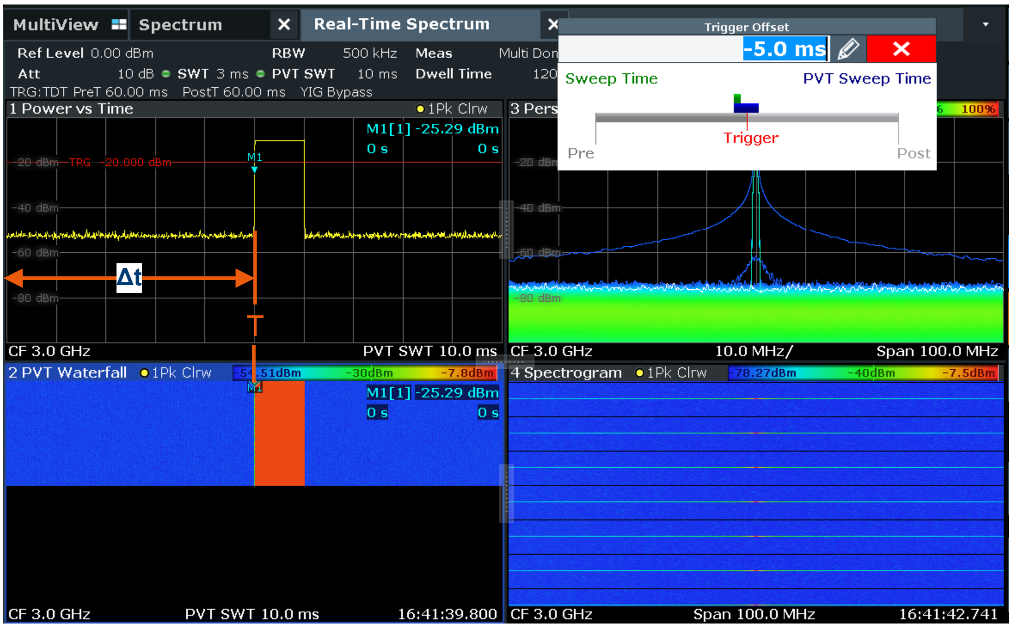


Figure 5-11: Triggered measurement in Auto Rearm trigger mode with a negative trigger offset

Stop on trigger

When a triggered measurement starts in "Stop on trigger" mode, data is acquired. If a trigger occurs during the pretrigger period, it is ignored. After the pretrigger period, once a trigger occurs, data acquisition continues for the posttrigger period. Then the measurement stops, both for "Run single" and continuous measurement mode. The acquired data is displayed in the frequency and time domain results without further postprocessing. The trigger event can appear anywhere in the PVT frame, depending on the time it occurred within the measurement. If you perform several successive measurements, the triggers in the "PVT waterfall" are not neatly aligned, as they occur at different times within the individual measurements and are not postprocessed.

Figure 5-12 shows the time domain results for multiple triggered measurements in "Stop on trigger" mode with trigger offset = 0. The pulses start at different times, since the location of the trigger event within the Power vs. Time measurement is not known when the measurement starts.

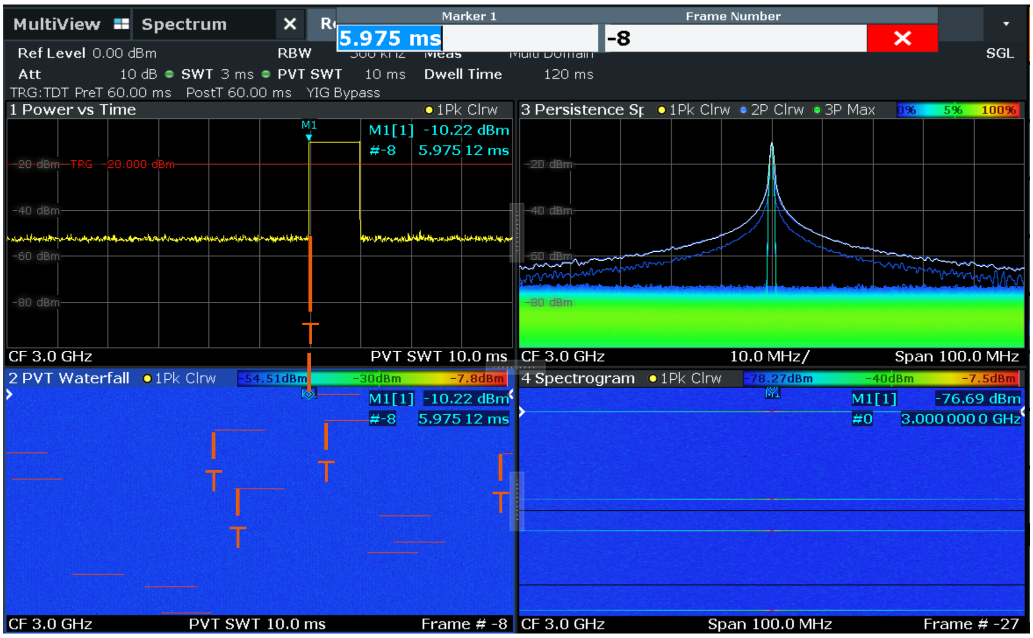


Figure 5-12: Triggered measurements in Stop on trigger mode

Mark only mode

For R&S ESW-B512R/-B800R only, a third trigger mode is available: "Mark only". In this case, a free-run measurement is performed. The trigger event is merely indicated in the measurement results, but does not change the behavior of the measurement.

If "Mark only" trigger mode is active, a trigger pulse can be provided to a system setup as an external trigger source. In this case, each time a trigger event occurs, a high-level signal is output to the "Trigger 2" or "Trigger 3" output connector for 100 µs. Using this trigger mode, all detected trigger events are output; there is no blind time.

For details, see Chapter 9.6, "How to output trigger signals continuously", on page 115.

5.6 Working with Spectrogram diagrams

In Real-Time measurements, data is captured seamlessly over a specified time. The most recently measured power levels vs. frequency can then be displayed in the "Real-Time Spectrum". In these displays, the results from previous measurements are not included.

However, since the R&S ESW Real-Time application stores the history of the measured data in its memory, the spectrogram display provides a record of the measured spectrum without gaps. You can then analyze the data in detail later by recalling one of the spectra in the spectrogram history.

5.6.1 Time frames

The time information in the Spectrogram is displayed vertically, along the y-axis. Each line (or trace) of the y-axis represents the data during one sweep time interval and is called a **time frame** or simply "frame". For spectrograms, as with standard spectrum traces, several measured values are combined in one sweep point using the selected detector (see Chapter 5.4, "Sweep time and detector", on page 28).

Frames are sorted in chronological order, beginning with the most recently recorded frame at the top of the diagram (frame number 0). With the next sweep, the previous frame is moved further down in the diagram, until the maximum number of captured frames is reached. The display is updated continuously during the measurement, and the measured trace data is stored. Spectrogram displays are continued even after single sweep measurements unless they are cleared manually.

Clearing the Spectrogram

To clear the history buffer and start a new Spectrogram, you must clear it explicitly (see Chapter 7.3, "Spectrogram settings", on page 81).

The maximum number of stored frames is defined by the *history depth*, which is user-configurable (see "History Depth" on page 82).

Displaying individual frames

In Chapter 5.4, "Sweep time and detector", on page 28, the term "frame" was introduced as *one spectrum containing all FFTs calculated and combined from the sampled data in one sweep time period*. Thus, one frame/line in the spectrogram corresponds to one spectrum in the "Real-Time Spectrum" view.

The Spectrogram diagram includes all stored frames since it was last cleared. Arrows on the left and right border of the Spectrogram indicate the currently selected frame.

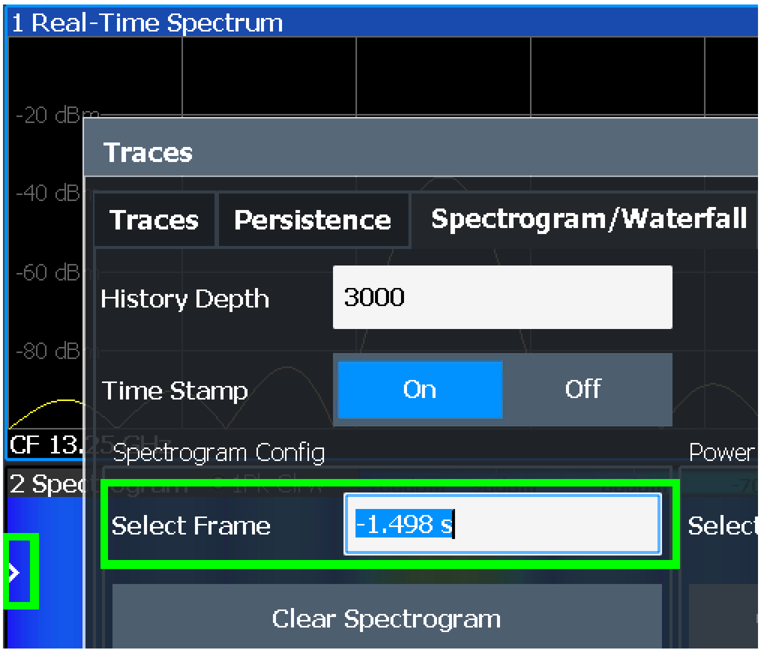


Figure 5-13: Display of a selected frame in the spectrogram

The Real-Time Spectrum diagram always displays the Real-Time Spectrum for the currently selected frame. The current frame number (or alternatively a time stamp, if activated) is indicated in the diagram footer of the Spectrogram. The most recent frame, displayed at the top of the diagram, is frame number 0. Older frames further down in the diagram are indicated by a negative index, e.g. "-10". You can display the Real-Time Spectrum diagram of a previous frame by selecting a different frame number.

Separate frame numbers can be selected for the Real-Time Spectrum diagrams.

The displayed frame can also change if a marker is set to a different frame in the Spectrogram result display (see Chapter 5.6.2, "Markers in the spectrogram", on page 39).

Displaying pretrigger and posttrigger results

By default, the frame displayed in the Real-Time Spectrum results is the frame that begins with the trigger event. To display *pre*trigger results, if available, select a frame in the Spectrogram *beneath* the currently selected frame. To display *post*trigger results (after the sweep time), if available, select a frame in the Spectrogram *above* the currently selected frame.

Scrolling through frames of a spectrogram

The Real-Time Spectrum diagram always displays a single frame of the Spectrogram, namely the currently selected frame. To scroll through the frames of the Spectrogram as they were recorded, use the rotary knob or arrow keys to change the selected frame continuously. The index or time stamp is increased or decreased in steps of one frame.

Time stamps vs. frame index

By default, the time information of the selected frame is provided as a time stamp in the footer of the Spectrogram. The time stamp shows the time and date that the selected frame was recorded. The length of one frame corresponds to the sweep time. To select a specific frame, you have to enter the (negative) time in seconds, relative to the frame that was recorded last. The largest (absolute) time available is the sweep time multiplied with the number of sweeps performed since the diagram was last cleared.

Alternatively to time stamps, the time information can be provided as an index. The index is also relative to the frame that was recorded last, which has the index number 0. The lowest index is a negative number that corresponds to the history depth. To select a specific frame, you have to enter the (negative) index number of the frame you want to analyze.

Frame count vs. sweep count

The maximum number of stored frames depends on the "History Depth" on page 82.

For standard spectrum sweeps, the sweep count defines how many sweeps are analyzed to create a single trace. Thus, for a trace in "Average" mode, for example, a sweep count of 10 means that 10 sweeps are averaged to create a single trace, or frame.

The frame count, on the other hand, determines how many frames are plotted during a single sweep measurement (as opposed to a continuous sweep). For a frame count of 2, for example, 2 frames are plotted during each single sweep. For continuous sweep mode, the frame count is irrelevant; one frame is plotted per sweep until the measurement is stopped.

If you combine the two settings, 20 sweeps are performed for each single sweep measurement. The first 10 are averaged to create the first frame, the next 10 are averaged to create the second frame.

As you can see, increasing the sweep count increases the accuracy of the individual traces, while increasing the frame count increases the number of traces in the diagram.

Especially for "Average" or "Min hold" and "Max hold" trace modes, the number of sweeps that are analyzed to create a single trace affects the accuracy of the results. Thus, you can also define whether the results from frames in previous traces are considered in the analysis for each new trace ("Continue frame").

5.6.2 Markers in the spectrogram

Markers and delta markers are shaped like diamonds in the spectrogram. They are only displayed in the spectrogram if the marker position is inside the visible area of the spectrogram. If more than two markers are active, the marker values are displayed in a separate marker table.

In the spectrum result display, the markers and their frequency and level values (1) are displayed as usual. Also, the frame number is displayed to indicate the position of the marker in time (2).

In the spectrogram result display, you can activate up to 16 markers or delta markers at the same time. Each marker can be assigned to a different frame. Therefore, in addition to the frequency you also define the frame number when activating a new marker. The frame to which a marker is assigned automatically becomes the currently selected frame. If no frame number is specified, the marker is positioned on the currently selected frame. (The selected frame is indicated by small white arrows on the left and right border of the diagram.)

All markers are visible that are positioned on a visible frame. Special search functions are provided for spectrogram markers (see Chapter 7.8.3, "Marker search settings", on page 97) to include the frame information as search criteria.

In the spectrum result display, only the markers positioned on the currently selected frame are visible. Thus, in "Continuous Sweep" mode, only markers positioned on frame 0 are visible. To view markers that are positioned on a frame other than frame 0 in the spectrum result display, you must stop the measurement and select the corresponding frame.

5.6.3 Color maps

Spectrogram displays assign power levels to different colors to visualize them. The legend above the Spectrogram display describes the power levels the colors represent. Similarly, "Persistence Spectrum" displays assign colors to the relative numbers of occurrence (percentage) of specific power levels.

The color display is highly configurable to adapt the spectrograms to your needs. You can define:

- Which colors to use (Color scheme)
- Which value range to apply the color scheme to
- How the colors are distributed within the value range, i.e where the focus of the visualization lies (shape of the color curve)

The individual colors are assigned to the power levels automatically by the R&S ESW.

The Color Scheme

- **Hot**

  Uses a color range from blue to red. Blue colors indicate low levels, red colors indicate high ones.
- **Cold**

  Uses a color range from red to blue. Red colors indicate low levels, blue colors indicate high ones.

The "Cold" color scheme is the inverse "Hot" color scheme.

- **Radar**

  Uses a color range from black over green to light turquoise with shades of green in between. Dark colors indicate low levels, light colors indicate high ones.

- **Grayscale**

  Shows the results in shades of gray. Dark gray indicates low levels, light gray indicates high ones.

The value range of the color map

If the measured values only cover a small area in the spectrogram, you can optimize the displayed value range. Then it becomes easier to distinguish between values that are close together. Display only parts of interest.

The shape and focus of the color curve

The color-mapping function assigns a specified color to a specified power level in the spectrogram display. By default, colors on the color map are distributed evenly. However, to visualize a certain area of the value range in greater detail than the rest, you can set the focus of the color mapping to that area. Changing the focus is performed by changing the shape of the color curve.

The color curve is a tool to shift the focus of the color distribution on the color map. By default, the color curve is linear. If you shift the curve to the left or right, the distribution becomes non-linear. The slope of the color curve increases or decreases. One end of the color palette then covers a large range of results, while the other end distributes several colors over a relatively small result range.

You can use this feature to put the focus on a particular region in the diagram and to be able to detect small variations of the signal.

Example:

In the color map based on the linear color curve, the range from -100 dBm to -60 dBm is covered by blue and a few shades of green only. The range from -60 dBm to -20 dBm is covered by red, yellow and a few shades of green.

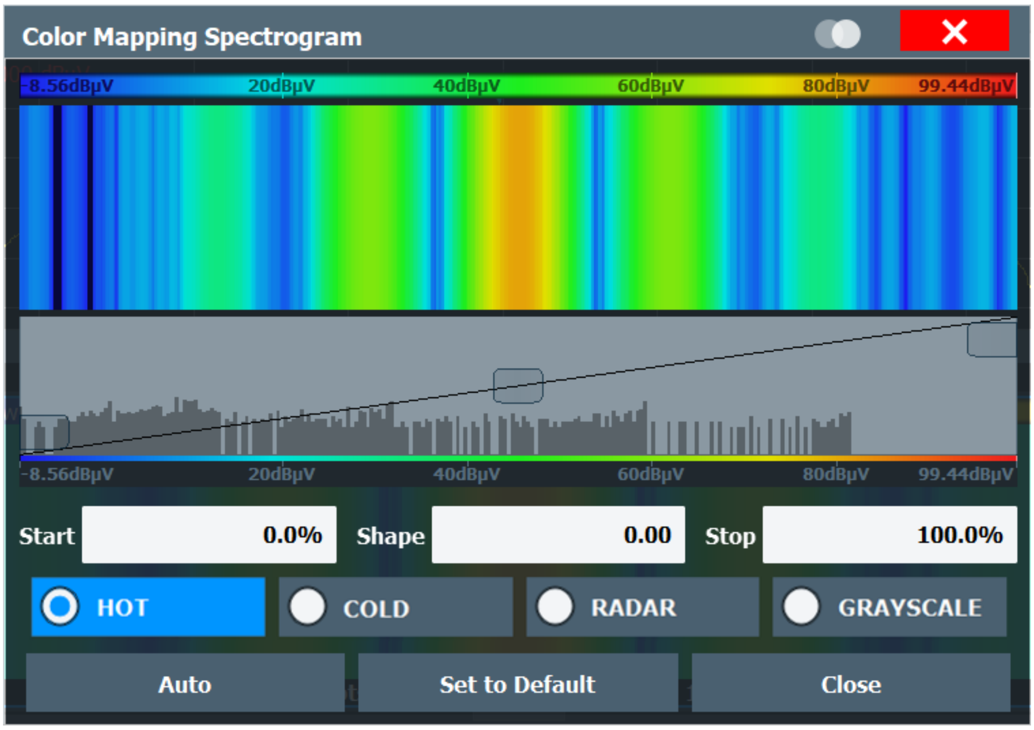


Figure 5-14: Spectrogram with (default) linear color curve shape = 0

The sample spectrogram is dominated by blue and green colors. After shifting the color curve to the left (negative value), more colors cover the range from -100 dBm to -60 dBm (blue, green and yellow). This range occurs more often in the example. The range from -60 dBm to -20 dBm, on the other hand, is dominated by various shades of red only.

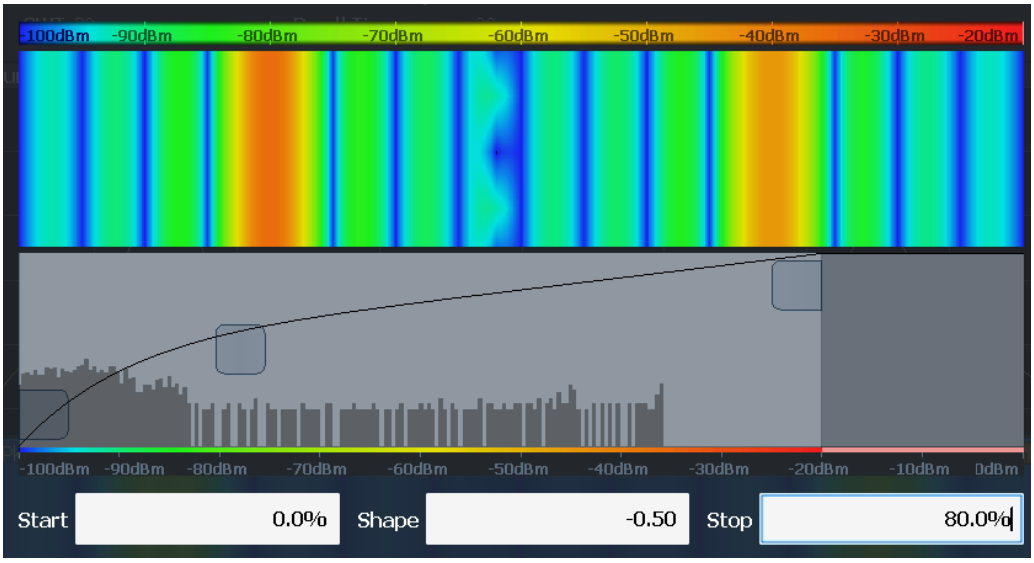


Figure 5-15: Spectrogram with non-linear color curve (shape = -0.5)

5.6.4 Zooming into the spectrogram

For further and more detailed analysis of the data you have captured, a zoom function is provided for real-time spectrogram diagrams.

The graphical zoom provided for other measurements on the R&S ESW is **not available** for Real-Time Spectrum measurements.

Instead, a more powerful data zoom is provided, which allows for zooming with increased frequency resolution.

For Real-Time Spectrum measurements, the zoom is available only for the spectrogram result display, but it has effects on other result displays (see "Effects on other result displays" on page 45). The zoom is only available if a spectrogram is active and selected (blue border).

The zoom is activated using the Single Zoom () icon in the toolbar. You define the zoom area by drawing a rectangle on the touchscreen. When you draw the zoom area, its boundaries are shown as a dashed line. The R&S ESW stops the Real-Time Spectrum measurement and recalculates the displays for the area you have selected. The definition of the color map remains the same.

When a zoom is activated in the spectrogram, the sweep time and/or resolution bandwidth and span are temporarily reduced. The selected data that was measured previously and stored in the R&S ESW memory is reprocessed and re-evaluated. Reprocessing improves the resolution of the data (while the graphical zoom available in other applications merely interpolates the data).

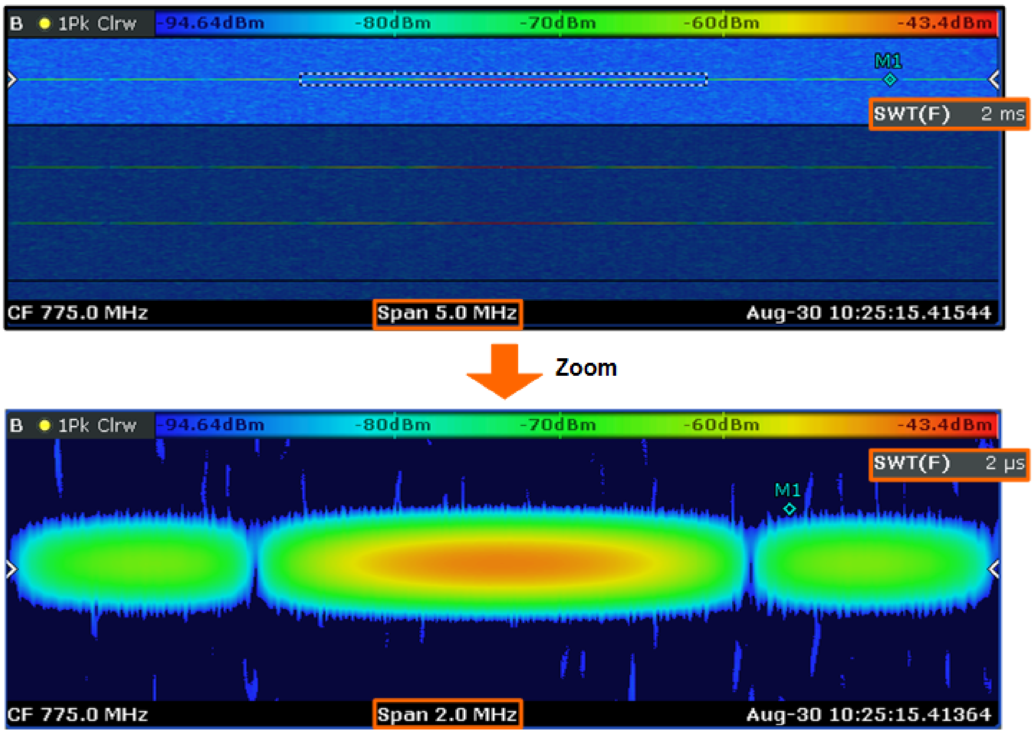


Figure 5-16: Zoomed spectrogram display with increased frequency and time resolution (due to reduced sweep time and span)

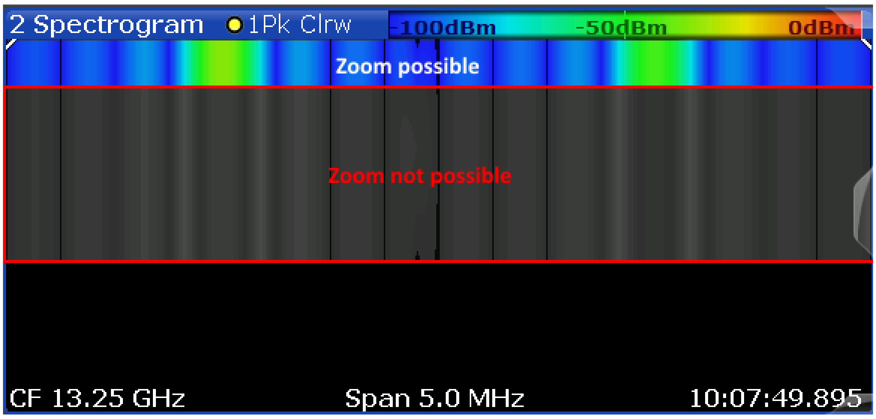
Because the zoom is based on I/Q data that has already been captured, the zoom also allows for faster sweep times (and thus spans) than are possible during live measurements.

Inside the zoom area, you can select frames as usual. The "Replay zoom" function allows you to switch between the zoomed display and the original display quickly for comparison (see "Replay Zoom" on page 104).

Zoom restrictions

Principally, the zoom is available for all measurement situations, whether you measure continuously or in single sweep mode. However, possible zoom areas are restricted by the size of the I/Q data memory. If it is not possible to zoom into a part of the spectrogram area, the R&S ESW colors that area in a darker color when you activate the zoom function.

The zoom factor is restricted to 10% of the original span of the frequency axis.



In addition, the zoom is also restricted by the originally defined bandwidth or span. Zooming into areas that are outside this bandwidth is not possible.

Note also that zoom availability depends on the trigger mode. You can only zoom while the measurement is running in "Free Run" mode. For all other trigger modes, you have to wait until the measurement is paused.

Effects on other result displays

Zooming also has an effect on the real-time spectrum and the power vs. time result displays. All other result displays are unaffected.

- The R&S ESW updates the frequency range of the real-time spectrum according to the zoomed (new) spectrogram span. The range has an effect on the start, stop and center frequency as well as the span.
  The "Real-Time Spectrum" updates the shown spectrum to the currently selected spectrogram frame.
- The R&S ESW updates the time range of the power vs. time result display according to the new height (sweep time) of the spectrogram.
  Note that it is not possible to change the sweep time or the trigger offset for the power vs. time diagram while the zoom is active.

Updates in the result displays only take effect if they are active when the spectrogram data is being recalculated.

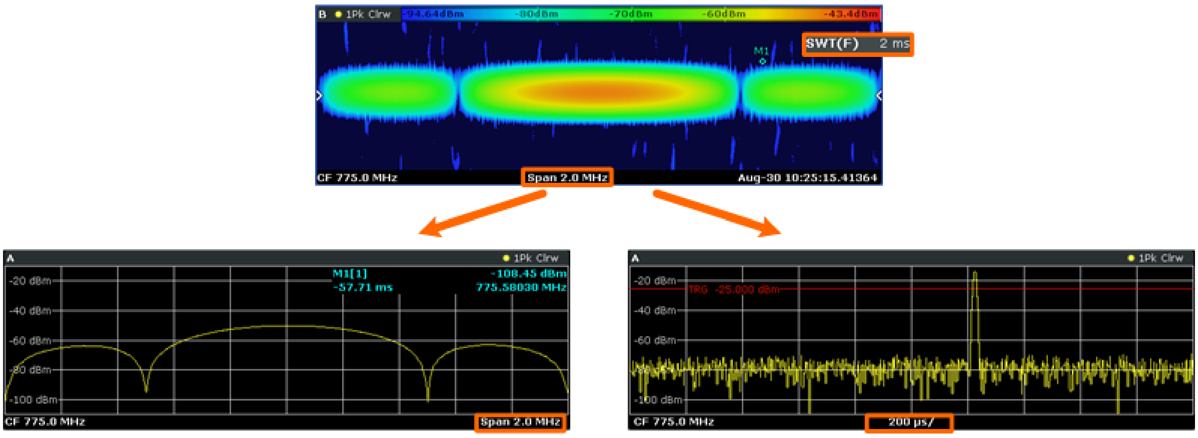


Figure 5-17: Effects of the Spectrogram zoom function on the Real-Time Spectrum displays

5.6.5 Three-dimensional Spectrogram

A common spectrogram shows the frequency on the x-axis, while the y-axis shows the time (in frames). The power level is indicated by different colors of the two-dimensional points.

In the new three-dimensional spectrogram, the power is indicated by a value in a third dimension, the z-axis. The color mapping is maintained for the point in the three-dimensional result display.

This new display provides an even better overview of how the strength of the signal varies over time for different frequencies.

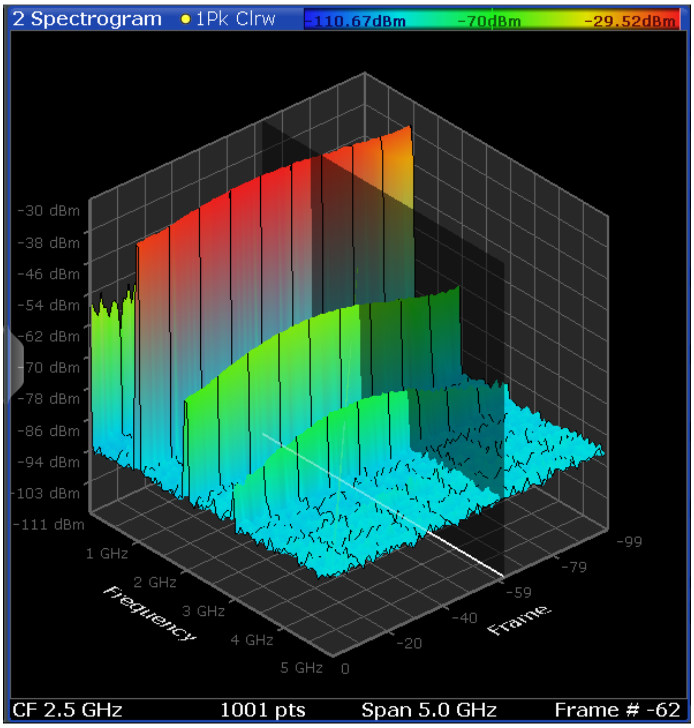


Figure 5-18: Three-dimensional spectrogram

Similarly, a three-dimensional power vs time waterfall diagram is available.

The number of frames displayed on the time (y-)axis is user-definable, whereas for two-dimensional Spectrogram, the number of frames is determined automatically according to the size of the window. All other Spectrogram settings are identical for 3D and 2D Spectrogram.

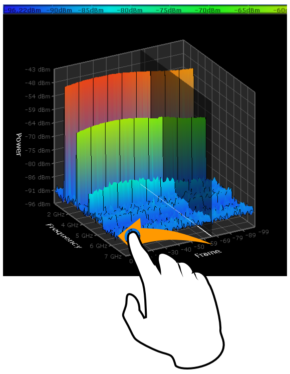
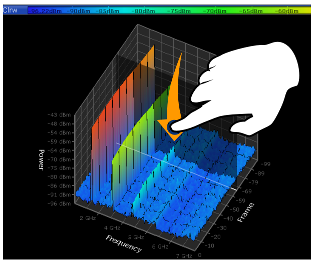
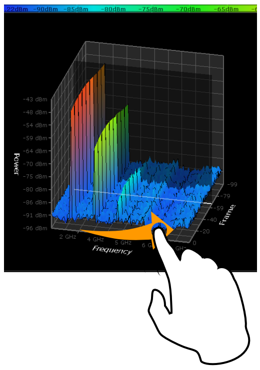
When the measurement is stopped or completed, the currently selected frame is indicated by a gray vertical plane. (As opposed to the small white arrows at the borders of the 2D display.) The spectrum diagram always displays the spectrum for the currently selected frame.

By default, the most recently recorded frame (frame 0) is selected, and added at the front of the diagram.

Rotating the Spectrogram in three dimensions

Depending on which aspect of the Spectrogram is currently of interest, you can rotate the display to have a closer look at the frequency, the time, or the power dimension. Simply drag your finger or the mouse pointer over the spectrogram in the direction you want to rotate it. You can rotate the display left or right, up and down. Note, however, that the degree of rotation is restricted in the upward direction to avoid confusing views. If you rotate the spectrogram such that you see the frequency-frame-plane directly from above, the display is identical to the two-dimensional spectrogram.

Table 5-1: Effect of rotating the spectrogram in three dimensions

		
Rotation to the left > focus on frame	Rotation down > focus on frequency and frame	Rotation to the right > focus on frequency

Markers in three-dimensional Spectrogram

In three-dimensional Spectrogram, the markers are indicated by the common arrows used in the spectrum display, for example. New markers are automatically placed on the current frame. You can move the markers to any position in all dimensions of the diagram. When you select a marker on the screen, three-dimensional cross-hairs indicate the position on all axes.

Sometimes, a marker can be hidden by other frames. If necessary, rotate the Spectrogram or select a different frame as the current frame.

5.7 Understanding persistence

Persistence describes the duration that past histogram traces remain visible in the display before fading away.

Historical term

The term persistence has its origins in cathode ray tube devices (CRTs). It describes the time period one point on the display stays illuminated after it has been lit by the cathode ray. The higher the persistence, the longer you could observe the illuminated point on the display.

Moving density

In the "Persistence Spectrum" result display, the persistence results from the moving 'density' (like a moving average) over a certain number of traces. The number of traces that are considered to calculate the density depends on the user-definable persistence duration. The longer the persistence, the more traces are part of the calculation and the deeper the history of displayed information gets. A spectral event that has occurred a single time is visible for up to 8 seconds. As densities get smaller at coordinates with signal parts that are not constantly there, the trace color changes. The rate of the color change is high with a low persistence and low with a high persistence.

Detecting changes over time

Note that a signal with constant frequency and level characteristics does not show the effects of persistence on the trace. As soon as the power or frequency of a signal change slightly, however, the effect of persistence becomes visible through color changes or changes in the shape of the trace.

You can remove persistence by setting its duration to 0 seconds.

Persistence Granularity

The amount of data that the R&S ESW uses to draw a single frame in the persistence spectrum is variable. By default, the data that was captured in 100 ms is used to calculate a frame. The time period in which data is captured and the mentioned density is calculated is referred to as the *persistence granularity*. The higher the granulation, i.e. the longer the data capturing time, the more data is included in each calculation.

A single histogram frame is calculated during the persistence granularity time. An initially empty matrix with 600 by 1001 elements, representing 600 discrete power levels and 1001 discrete frequency steps, is provided at the beginning of each histogram frame. After each newly calculated FFT, the matrix is updated according to the occurrence of each frequency/level pair. Every time the persistence granularity interval is completed, the matrix is reset to zero for each element and a new histogram frame is started.

Example: Calculating an individual persistence frame

Figure 5-19 demonstrates this process with a 6 by 8 elements matrix and a ratio of 2 for FFT time to granularity. Thus, two FFTs are calculated for each frame. Both FFTs contain the same signal and varying noise neighboring the signal. The FFTs are converted into a matrix of frequency/level pairs. The two matrices are summed up into the result matrix. The result matrix determines the color of the result trace in the histogram. In this example, red corresponds to a high count or probability, whereas the noise band is displayed in blue for a lower probability.

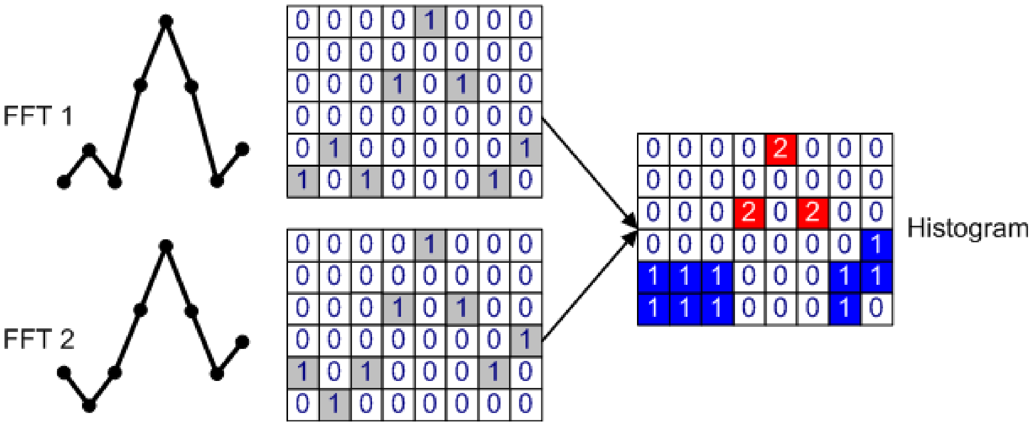


Figure 5-19: Schematic illustration of histogram calculation (dot style)

"Persistence Spectrum" and detectors

The "Persistence Spectrum" display calculates persistence and histogram information directly from the FFT results. There is no need to use detectors for data reduction as in the spectrogram, since the histogram algorithm already reduces data to a rate that can easily be displayed. For persistence spectrum results, the detector setting affects only the "Max hold" values that can be plotted on top of the persistence spectrum (see Chapter 5.7.1, "Analyzing maximum density - Max hold function", on page 52).

Matrix style

The individual traces in the persistence spectrum can be displayed using vectors or dots.

The FFT matrices in Figure 5-19 contain only a single value per frequency column. This value is the level value returned by the FFT. The example shows a matrix in dot style, i.e. the matrices are filled with dots only. Note that the resulting diagram can contain "holes" where signal levels for neighboring probabilities differ strongly.

In contrast, for vector style matrices, each element in the matrix with the value "1" is analyzed. If the neighboring frequency also has the value 1, regardless at which power level, the two frequency points are connected by additional (interpolated) value 1 elements. Thus, possible "holes" in the diagram are filled by interpolated values, resulting in a continuous trace. Interpolation is useful to detect discrete values with a high probability, which can otherwise be overlooked. On the other hand, noise can be assigned a higher probability due to the interpolation values, increasing the displayed noise level (visible as more blue fields in the resulting histogram matrix in Figure 5-21).

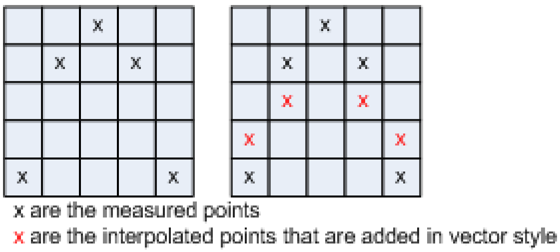


Figure 5-20: Dotted-style matrix vs. vector-style matrix

Example: Histogram for vector-style matrix

Figure 5-21 shows the vector-style representation for exactly the same example that was used in Figure 5-19 for dot style. To derive the vector-style matrices from the dot-style matrices, additional "1" elements are inserted to connect the "1" in column 4 to the neighboring "1" in columns 3 and 5.

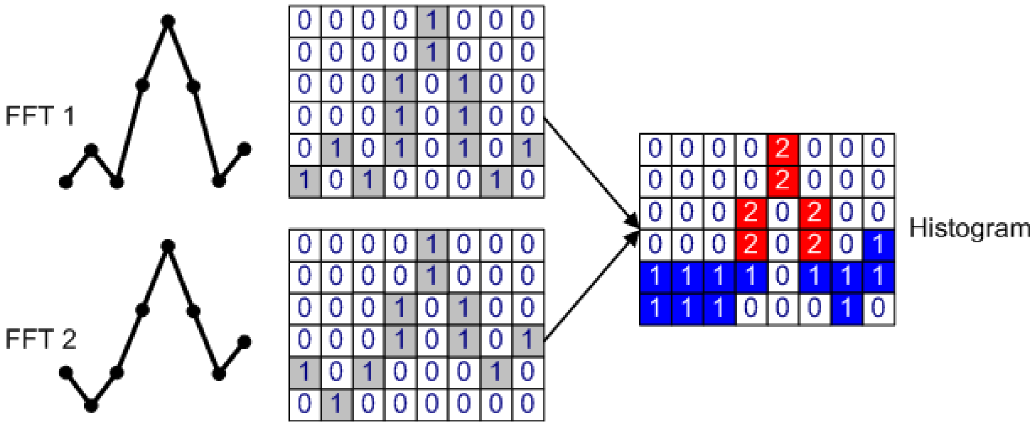


Figure 5-21: Histogram calculation using vector style

The additional "1" elements result in increased probability levels when changing from dot to vector mode. The increase is especially visible in areas with noise-like signals, that is, large level fluctuations.

Color mapping for different matrix styles

Color mapping for the persistence spectrum is identical to color mapping for the spectrogram or waterfall diagrams. The truncating function is especially useful to display only spectral components of a certain probability (see below).

Usually, you must adjust the color-mapping value range after changing the persistence style from vector to dot or vice versa, as the resulting probabilities can vary significantly as explained above.

For details on color mapping, see Chapter 5.6.3, "Color maps", on page 40.

Truncating the persistence spectrum

By default, results outside the defined value range of the color map are displayed in the colors for the minimum or maximum values in the range.

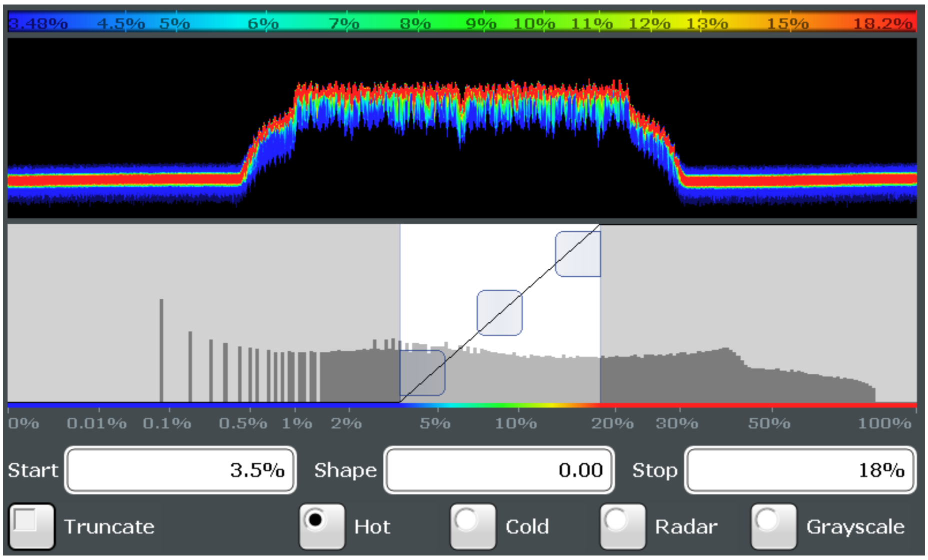


Figure 5-22: Default persistence spectrum coloring without truncating

Usually you restrict the value range displayed by the color map because only specific values are of interest. In that case, you can hide (or *truncate*) the results of the persistence spectrum outside the value range of the color map. Restricting the value range makes the display of the remaining - relevant - results clearer (see Figure 5-23), and allows you to eliminate the effects of noise, for example.

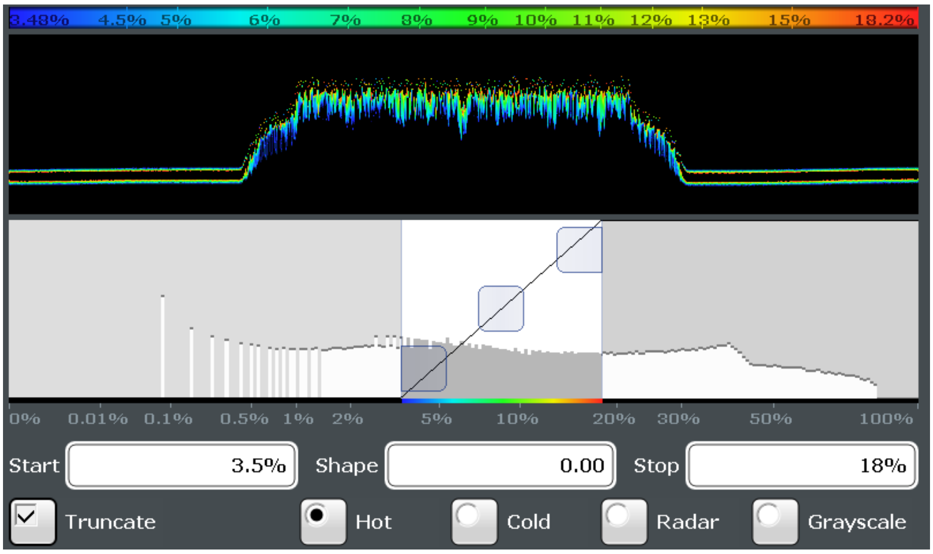


Figure 5-23: Persistence spectrum with truncated coloring

5.7.1 Analyzing maximum density - Max hold function

During analysis of a time-variant signal, level variations are usually of great interest; in particular, the ratio between the current signal and the maximum measured signal. The currently measured Real-Time spectrum is displayed as a standard trace in clear/write mode with a peak detector in the "Persistence Spectrum" diagram.

An optional *"Max hold"* function indicates the maximum probabilities ever measured during the entire measurement for each point in the diagram. It allows for a worst-case estimation of signal-to-noise-ratios (SNR), when talking about noise or interferers. For useful signals, it allows for an estimation of amplitude variation. The "Persistence Spectrum" display can display the "Max hold" values on top of the persistence spectrum diagram. As mentioned above, the persistence colors fade out by reducing their intensity over time. The "Max hold" values, on the other hand, are assigned a time-independent intensity value to allow you to distinguish the "Max hold" values and the current persistence spectrum.

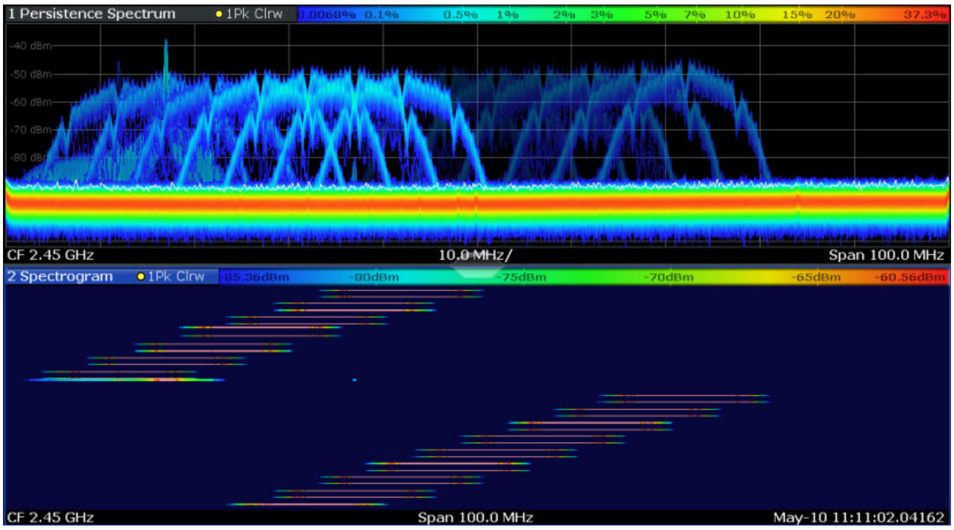


Figure 5-24: Persistence Spectrum with Max hold trace and Spectrogram display

Changing the color intensity

By default, the "Max hold" values are displayed. You can disable the function explicitly, or hide the values by reducing the color intensity to its minimum. The maximum intensity corresponds to one of the current "Persistence Spectrum" displays. Stored "Max hold" values are cleared automatically after each new setting, and can be reset manually by the user.

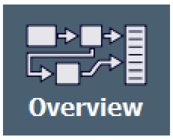
For details on all settings concerning the "Max hold" function and the "Persistence Spectrum" display in general, see Chapter 7.2, "Persistence spectrum settings", on page 78.

6 Configuring the real-time spectrum application

Access: [MODE] > "Real-Time"

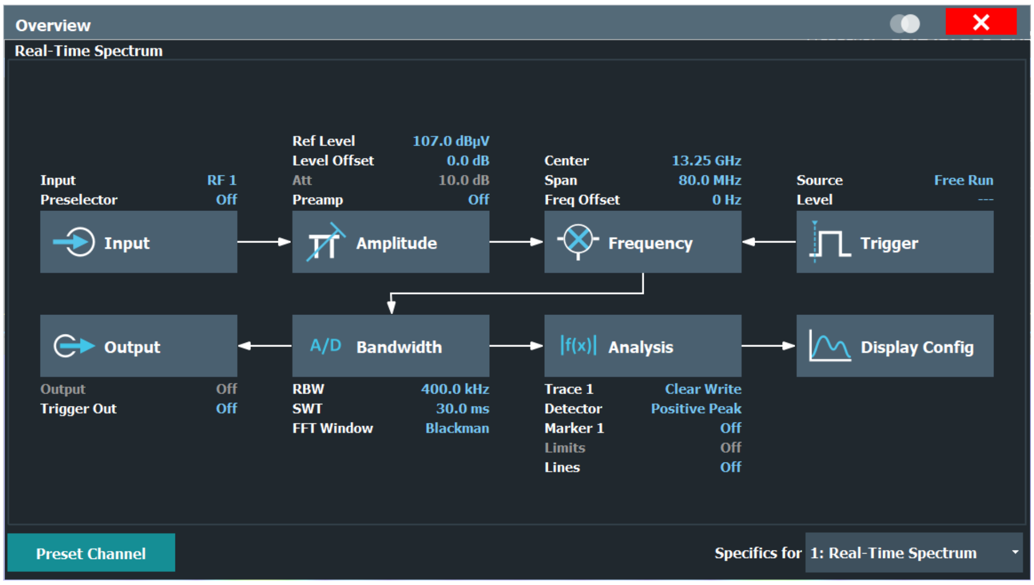
When you activate a measurement channel for the R&S ESW Real-Time application, a Real-Time Spectrum measurement for the input signal is started automatically with the default configuration. The "Real-Time Config" menu is displayed and provides access to the most important configuration functions.

6.1 Configuration overview



Access: all menus

Throughout the measurement channel configuration, an overview of the most important currently defined settings is provided in the "Overview" dialog box.



In addition to the main measurement settings, the "Overview" provides quick access to the main settings dialog boxes. The individual configuration steps are displayed in the order of the data flow. Thus, you can easily configure an entire measurement channel from input over processing to output and analysis by stepping through the dialog boxes as indicated in the "Overview".

Multiple access paths to functionality

The easiest way to configure a measurement channel is via the "Overview" dialog box.

In this documentation, only the most convenient method of accessing the dialog boxes is indicated - usually via the "Overview" dialog box.

In particular, the "Overview" dialog box provides quick access to the following configuration dialog boxes (listed in the recommended order of processing):

1. Input
   See Chapter 6.2, "Input and output settings", on page 56
2. Amplitude
   Amplitude: see Chapter 6.4, "Amplitude settings", on page 59
   Scale: see Chapter 6.5, "Scale of the Y-Axis", on page 62
3. Frequency
   See Chapter 6.3, "Frequency and span settings", on page 57
4. (Optionally:) Trigger
   See Chapter 6.6, "Trigger configuration", on page 64
5. Bandwidth
   See Chapter 6.7, "Bandwidth and sweep settings", on page 72
6. (Optionally:) Outputs
   See Chapter 6.2, "Input and output settings", on page 56
7. Analysis
   See Chapter 7, "Analysis", on page 78
8. Display Configuration
   See Chapter 7.1, "Display configuration", on page 78

For step-by-step instructions on configuring Real-Time Spectrum measurements, see Chapter 9, "How to perform Real-Time Spectrum measurements", on page 108.

Preset Channel

Select "Preset Channel" in the lower left-hand corner of the "Overview" to restore all measurement settings *in the current channel* to their default values.

Note: Do not confuse "Preset Channel" with the [Preset] *key*, which restores the entire instrument to its default values and thus closes *all channels* on the R&S ESW (except for the default channel)!

Remote command:

`SYSTem:PRESet:CHANnel[:EXEC]` on page 126

Specific Settings for
The channel can contain several windows for different results. Thus, the settings indicated in the "Overview" and configured in the dialog boxes vary depending on the selected window.

Select an active window from the "Specific Settings for" selection list that is displayed in the "Overview" and in all window-specific configuration dialog boxes.

The "Overview" and dialog boxes are updated to indicate the settings for the selected window.

6.2 Input and output settings

Access: "Overview" > "Input" / "Output"

The input and output settings are the same as in the Receiver application.

For more information refer to the user manual of the R&S ESW.

Input Selection
Selects the RF input connector you would like to use for a measurement.

Note that you cannot use both RF inputs simultaneously.

Remote command:
Global: `INPut:TYPE` on page 128

Impedance
For some measurements, the reference impedance for the measured levels of the R&S ESW can be set to 50 Ω or 75 Ω.

Select 75 Ω if the 50 Ω input impedance is transformed to a higher impedance using a 75 Ω adapter of the RAZ type. (That corresponds to 25Ω in series to the input impedance of the instrument.) The correction value in this case is 1.76 dB = 10 log (75Ω/50Ω).

This value also affects the unit conversion.

Remote command:
`INPut:IMPedance` on page 127

Input Coupling
The RF input of the R&S ESW can be coupled by alternating current (AC) or direct current (DC).

Note that the "Input Coupling" feature is only available for input 2 when the pulse limiter is turned off. When the pulse limiter is on, the input is always DC coupled.

AC coupling blocks any DC voltage from the input signal. AC coupling is activated by default to prevent damage to the instrument. Very low frequencies in the input signal can be distorted.

However, some specifications require DC coupling. In this case, you must protect the instrument from damaging DC input voltages manually. For details, refer to the specifications document.

Remote command:
`INPut:COUPling` on page 127

Pulse Limiter

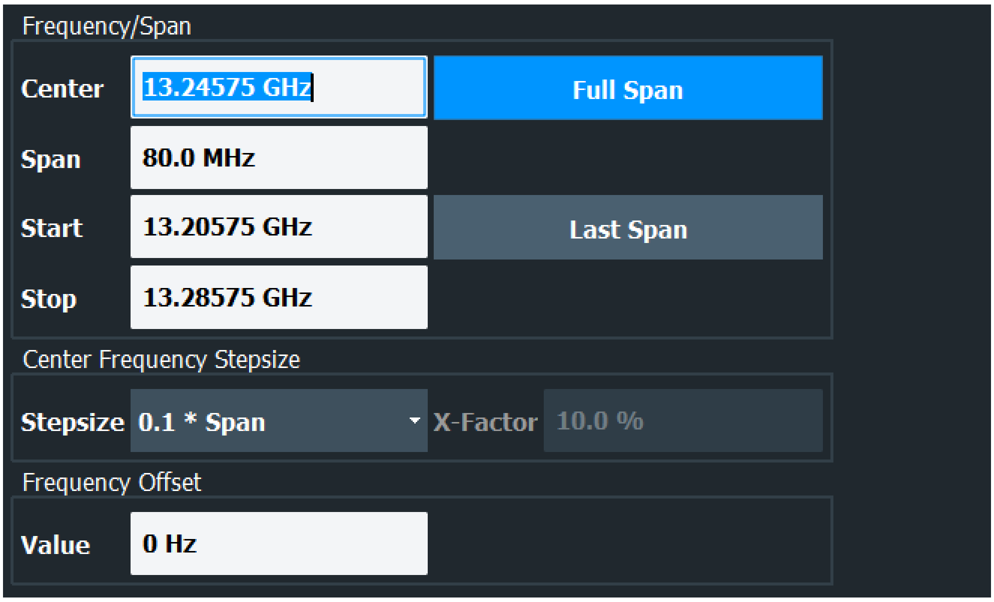
The pulse limiter, available for the second RF input, is a protection mechanism against high level pulses or signals (which can damage the input mixer).

When you turn on the pulse limiter, the attenuation is always at least 10 dB. Attenuation smaller than 10 dB is only available when you turn off the pulse limiter.

Remote command:
`INPut:ATTenuation:LIMiter[:STATe]` on page 127

6.3 Frequency and span settings

Access: "Overview" > "Frequency"



The remote commands required to configure the frequency and span are described in Chapter 10.4.5, "Frequency and span configuration", on page 135.

Center Frequency

Defines the center frequency of the signal in Hertz.

Remote command:
[SENSe:]FREQuency:CENTer on page 136

Span

Defines the frequency span. The center frequency is kept constant. The allowed range is specified in the data sheet.

Remote command:
[SENSe:]FREQuency:SPAN on page 138

Start / Stop

Defines the start and stop frequencies.

Remote command:
[SENSe:]FREQuency:STARt on page 138
[SENSe:]FREQuency:STOP on page 138

Full Span

Sets the span to the full frequency range of the R&S ESW specified in the specifications document. This setting is useful for overview measurements.

Remote command:
[SENSe:]FREQuency:SPAN:FULL on page 138

Last Span

Sets the span to the previous value. With this function you can switch between an overview measurement and a detailed measurement quickly.

Remote command:
[SENSe:]FREQuency:SPAN on page 138

Center Frequency Stepsize

Defines the step size by which the center frequency is increased or decreased using the arrow keys.

When you use the rotary knob the center frequency changes in steps of only 1/10 of the span.

The step size can be coupled to another value or it can be manually set to a fixed value.

"X * Span" Sets the step size for the center frequency to a defined factor of the span. The "X-Factor" defines the percentage of the span.
Values between 1 % and 100 % in steps of 1 % are allowed. The default setting is 10 %.

"= Center" Sets the step size to the value of the center frequency. The used value is indicated in the "Value" field.

"= Marker"	This setting is only available if a marker is active. Sets the step size to the value of the current marker and removes the coupling of the step size to span. The used value is indicated in the "Value" field.
"Manual"	Defines a fixed step size for the center frequency. Enter the step size in the "Value" field.

Remote command:
[SENSe:]FREQuency:CENTer:STEP on page 136

Frequency Offset
Shifts the displayed frequency range along the x-axis by the defined offset.

This parameter has no effect on the instrument's hardware, on the captured data, or on data processing. It is simply a manipulation of the final results in which absolute frequency values are displayed. Thus, the x-axis of a spectrum display is shifted by a constant offset if it shows absolute frequencies. However, if it shows frequencies relative to the signal's center frequency, it is not shifted.

A frequency offset can be used to correct the display of a signal that is slightly distorted by the measurement setup, for example.

The allowed values range from -1 THz to 1 THz. The default setting is 0 Hz.

Remote command:
[SENSe:]FREQuency:OFFSet on page 137

CISPR Band A / CISPR Band B
The "CISPR Band A" and "CISPR Band B" features automatically adjust the center frequency and span to the corresponding CISPR bands.

- CISPR band A: Defines a center frequency of 79.5 kHz, a span of 141 kHz (frequency range from 9 kHz to 150 kHz) and a measurement bandwidth of 200 Hz.
- CISPR band B: Defines a center frequency of 15.075 MHz, a span of 29.85 MHz (frequency range from 150 kHz to 30 MHz) and a measurement bandwidth of 9 kHz.

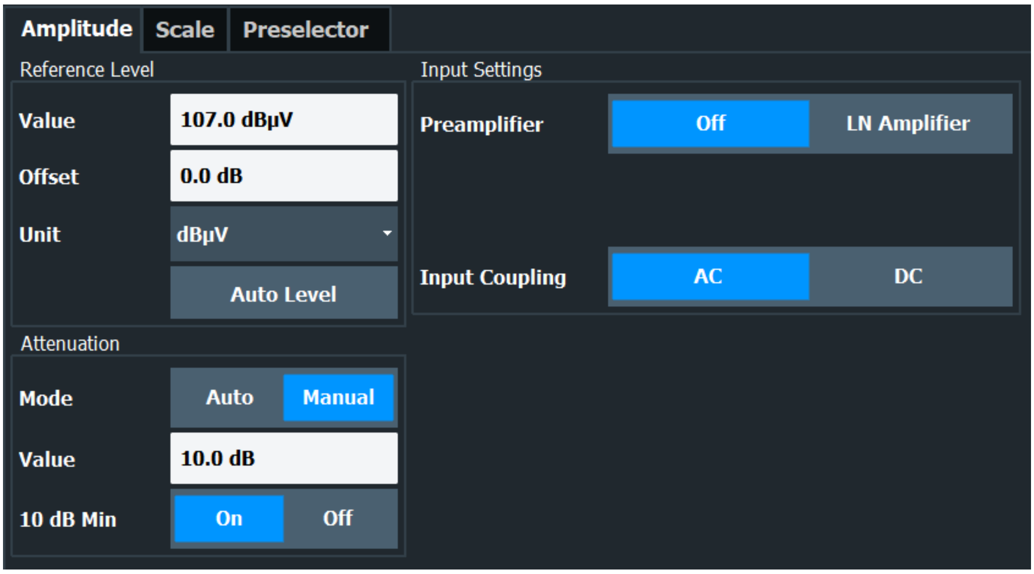
We recommend configuring the frequency properties for real-time measurements of CISPR band A and B in this way. Changing the center frequency afterwards might change the span settings (the available span depends on the selected center frequency).

Remote command:
[SENSe:]FREQuency:CISPr on page 137

6.4 Amplitude settings

Access

- "Overview" > "Amplitude"



Functions to configure the amplitude described elsewhere:

- "Input Coupling" on page 56
- "Impedance" on page 56

The remote commands required to configure the amplitude are described in Chapter 10.4.3, "Amplitude configuration", on page 130.

Reference Level

Defines the expected maximum reference level. Signal levels above this value are possibly not measured correctly. Signals above the reference level are indicated by an "IF Overload" or "OVLD" status display.

The reference level can also be used to scale power diagrams; the reference level is then used for the calculation of the maximum on the y-axis.

Since the hardware of the R&S ESW is adapted according to this value, it is recommended that you set the reference level close above the expected maximum signal level. Thus you ensure an optimal measurement (no compression, good signal-to-noise ratio).

Note that for input from the External Mixer (R&S ESW-B21) the maximum reference level also depends on the conversion loss; see the R&S ESW base unit user manual for details.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel`
on page 131

Shifting the Display (Offset) ← Reference Level

Defines an arithmetic level offset. This offset is added to the measured level. In some result displays, the scaling of the y-axis is changed accordingly.

Define an offset if the signal is attenuated or amplified before it is fed into the R&S ESW so the application shows correct power results. All displayed power level results are shifted by this value.

The setting range is ±200 dB in 0.01 dB steps.

Note, however, that the *internal* reference level (used to adjust the hardware settings to the expected signal) ignores any "Reference Level Offset". Thus, it is important to keep in mind the actual power level the R&S ESW must handle. Do not rely on the displayed reference level (internal reference level = displayed reference level - offset).

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel:OFFSet` on page 131

Unit ← Reference Level
The R&S ESW measures the signal voltage at the RF input.

Remote command:
`INPut:IMPedance` on page 127
`CALCulate<n>:UNIT:POWer` on page 131

Setting the Reference Level Automatically (Auto Level) ← Reference Level
Automatically determines a reference level which ensures that no overload occurs at the R&S ESW for the current input data. At the same time, the internal attenuators are adjusted. As a result, the signal-to-noise ratio is optimized, while signal compression and clipping are minimized.

To determine the required reference level, a level measurement is performed on the R&S ESW.

If necessary, you can optimize the reference level further. Decrease the attenuation level manually to the lowest possible value before an overload occurs, then decrease the reference level in the same way.

Remote command:
`[SENSe:]ADJust:LEVel` on page 165

Attenuation
Defines the attenuation of the signal.

You can attenuate the signal in 1 dB steps. The range is specified in the datasheet. Attenuation of less than 10 dB is only possible if you turn off 10 dB Minimum Attenuation.

If you are using the preamplifier in frequency ranges above 8 GHz, the available attenuation can be reduced.

For more information, see the Preamplifier description in the R&S ESW base unit user manual.

The auto ranging feature in the receiver remains active even if you change the attenuation and preamplifier properties in other measurement channels and then return to the receiver application.

The R&S ESW also allows you to determine the best attenuation automatically.
- In the receiver application, turn on the "Auto Ranging" feature.
- In the other applications, select attenuation "Mode" → "Auto"

Remote command:
Global: `INPut:ATTenuation[:VALue]` on page 132
Attenuation mode: `INPut:ATTenuation:AUTO` on page 132

10 dB Minimum Attenuation
Turns the availability of attenuation levels of less than 10 dB on and off.

When you turn on this feature, the attenuation is always at least 10 dB. This minimum attenuation protects the input mixer and avoids accidental setting of 0 dB, especially if you measure EUTs with high RFI voltage.

When you turn it off, you can also select attenuation levels of less than 10 dB.

The setting applies to a manual selection of the attenuation as well as the automatic selection of the attenuation.

Remote command:
`INPut:ATTenuation:PROTection[:STATe]` on page 132

Preamplifier
Configures the preamplifier.

In addition to the standard preamplifier, a low noise amplifier is available as an optional hardware component.

- **"Off"**
  Turns off the preamplifier.
- **"LN Amplifier"**
  Turns on the optional low noise amplifier.

Note that the real-time application only supports the optional low noise amplifier (because the normal preamplifier requires the preselector which is not supported).

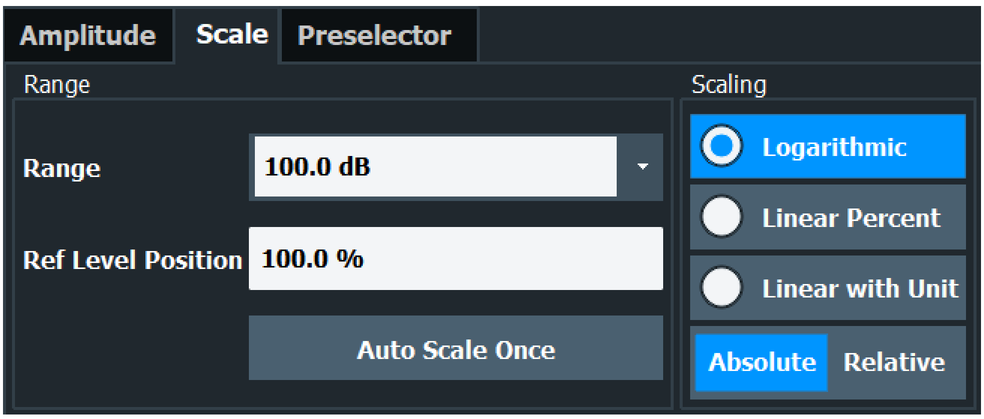
More information.

Remote command:
Preamplifier:
not supported
Low noise preamplifier:
State (global): `INPut:GAIN:LNA:STATe` on page 133

6.5 Scale of the Y-Axis

Access

- "Overview" > "Amplitude" > "Scale"



The remote commands required to scale the y-axis are described in Chapter 10.4.4, "Y-Axis scale", on page 133.

Range

Defines the displayed y-axis range in dB.

The default value is 100 dB.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]` on page 133

Ref Level Position

Defines the reference level position, i.e. the position of the maximum AD converter value on the level axis in %.

0 % corresponds to the lower and 100 % to the upper limit of the diagram.

Values from -120 % to +280 % are available.

Larger values are useful for small scales, such as a power range of 10 dB or 20 dB, and low signal levels, for example 60 dB below the reference level. In this case, large reference level position values allow you to see the trace again.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RPOSition` on page 134

Auto Scale Once

Automatically determines the optimal range and reference level position to be displayed for the current measurement settings.

The display is only set once; it is not adapted further if the measurement settings are changed again.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:AUTO ONCE` on page 134

Scaling

Defines the scaling method for the y-axis.

"Logarithmic"	Logarithmic scaling (only available for logarithmic units - dB..., and A, V, Watt)
"Linear with Unit"	Linear scaling in the unit of the measured signal
"Linear Percent"	Linear scaling in percentages from 0 to 100
"Absolute"	The labeling of the level lines refers to the absolute value of the reference level (not available for "Linear Percent")

"Relative" The scaling is in dB, relative to the reference level (only available for logarithmic units - dB...). The upper line of the grid (reference level) is always at 0 dB.

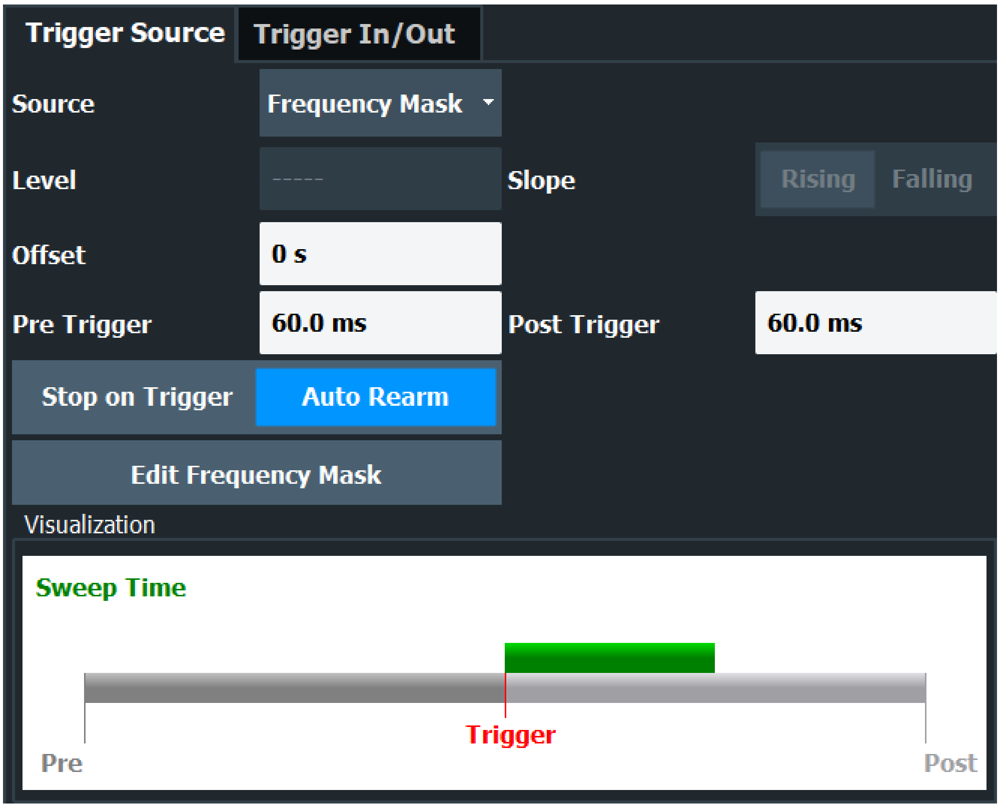
Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y:SPACing` on page 135
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:MODE` on page 134

6.6 Trigger configuration

6.6.1 Trigger source settings

Access: "Overview" > "Trigger"

Trigger settings determine when the input signal is measured.



The remote commands required to configure the trigger are described in Chapter 10.4.7, "Trigger configuration", on page 142.

Trigger Source

Defines the trigger source. If a trigger source other than "Free Run" is set, "TRG" is displayed in the channel bar and the trigger source is indicated.

Remote command:
`TRIGger<tp>[:SEQuence]:SOURce` on page 145

Free Run ← Trigger Source

No trigger source is considered. Data acquisition is started manually or automatically and continues until stopped explicitly.

Remote command:
`TRIGger<tp>[:SEQuence]:SOURce` on page 145

Ext. Trigger 1/2 ← Trigger Source

Data acquisition starts when the TTL signal fed into the specified input connector meets or exceeds the specified trigger level.

Note: "External Trigger 1" automatically selects the trigger signal from the "TRIGGER 1 INPUT" connector on the front panel.

For details, see the "Instrument Tour" chapter in the R&S ESW Getting Started manual.

"External Trigger 1"
Trigger signal from the "TRIGGER 1 INPUT" connector.

"External Trigger 2"
Trigger signal from the "TRIGGER 2 INPUT / OUTPUT" connector.

"External Trigger 3"
Trigger signal from the "TRIGGER 3 INPUT / OUTPUT" connector on the rear panel.

Remote command:
`TRIGger<tp>[:SEQuence]:SOURce` on page 145

Frequency Mask ← Trigger Source

Triggers when the measured signal violates the (selected) user-defined frequency mask.

For details see Chapter 5.5.1, "Triggering on specific frequency events (frequency mask trigger)", on page 29.

Remote command:
`TRIGger<tp>[:SEQuence]:SOURce` on page 145

Trigger Level
Defines the trigger level for the specified trigger source.

For details on supported trigger levels, see the instrument specifications document.

Remote command:
`TRIGger<tp>[:SEQuence]:LEVel[:EXTernal]` on page 143

Trigger Offset
Defines the time offset between the trigger event and the start of the measurement.

Offset > 0:	Start of the measurement is delayed
Offset < 0:	Measurement starts earlier (pretrigger)

Remote command:
`TRIGger<tp>[:SEQuence]:HOLDoff[:TIME]` on page 143

Slope
For all trigger sources except frequency mask, you can define whether triggering occurs when the signal rises to the trigger level or falls down to it.

Remote command:
`TRIGger<tp>[:SEQuence]:SLOPe` on page 144

Pretrigger capture time
Defines a time period *before* the actual trigger event in which data is also captured, in addition to the posttrigger time.

In this case, one or more additional frames will be available in the spectrogram/waterfall *beneath* the frame displayed in the "Real-Time Spectrum" or PVT diagram window by default.

Remote command:
`TRIGger[:SEQuence]:PRETrigger[:TIME]` on page 144

Posttrigger capture time
Defines a time period *after* the actual trigger event in which data is captured.

Posttrigger data after the sweep time are displayed as additional frames in the spectrogram/ PVT waterfall *above* the frame displayed in the "Real-Time Spectrum" or PVT diagram window by default.

Remote command:
`TRIGger[:SEQuence]:POSTtrigger[:TIME]` on page 144

Trigger mode (Auto Rearm/ Stop on Trigger/ Mark only)
Determines the behavior of the R&S ESW Real-Time application after a trigger event.

"Auto Rearm" (Default:) A trigger event causes the R&S ESW to start a measurement and to immediately rearm the trigger. In that case, measurements are continuously triggered and measurement results may become obsolete in a very short time. The pre- and posttrigger periods for each sweep time are displayed.

"Stop on Trigger"	The trigger is not rearmed after the first trigger event has occurred; thus, the measurement stops after one sweep. The measurement results for that sweep remain on the display, including the pretrigger and posttrigger periods. Note, however, that if the trigger event occurs before the defined pretrigger time has elapsed, the period between measurement start and the trigger event is shorter than the defined pretrigger time.
"Mark Only"	A free-run measurement is performed; the trigger event is merely indicated in the results, but does not change the behavior of the measurement. This setting is only available for R&S ESW-B512R/-B800R.

Remote command:
`TRIGger:MODE` on page 142

Edit Frequency Mask
Opens the "Edit Frequency Mask" dialog, only available if the "Frequency Mask" trigger source is selected.

For details see Chapter 6.6.2, "Frequency mask trigger configuration", on page 67.

6.6.2 Frequency mask trigger configuration

Access: [TRIG] > "Edit Frequency Mask"

The Frequency Mask Trigger (FMT) is a mask in the frequency domain, which is checked with every calculated FFT. When a specific condition concerning this mask occurs during the measurement of the input signal, data capturing is triggered.

When configuring a frequency mask, consider the effects an active transducer can have on the measurement results.

For details on transducers, see the R&S ESW user manual.

For details see Chapter 5.5.1, "Triggering on specific frequency events (frequency mask trigger)", on page 29.

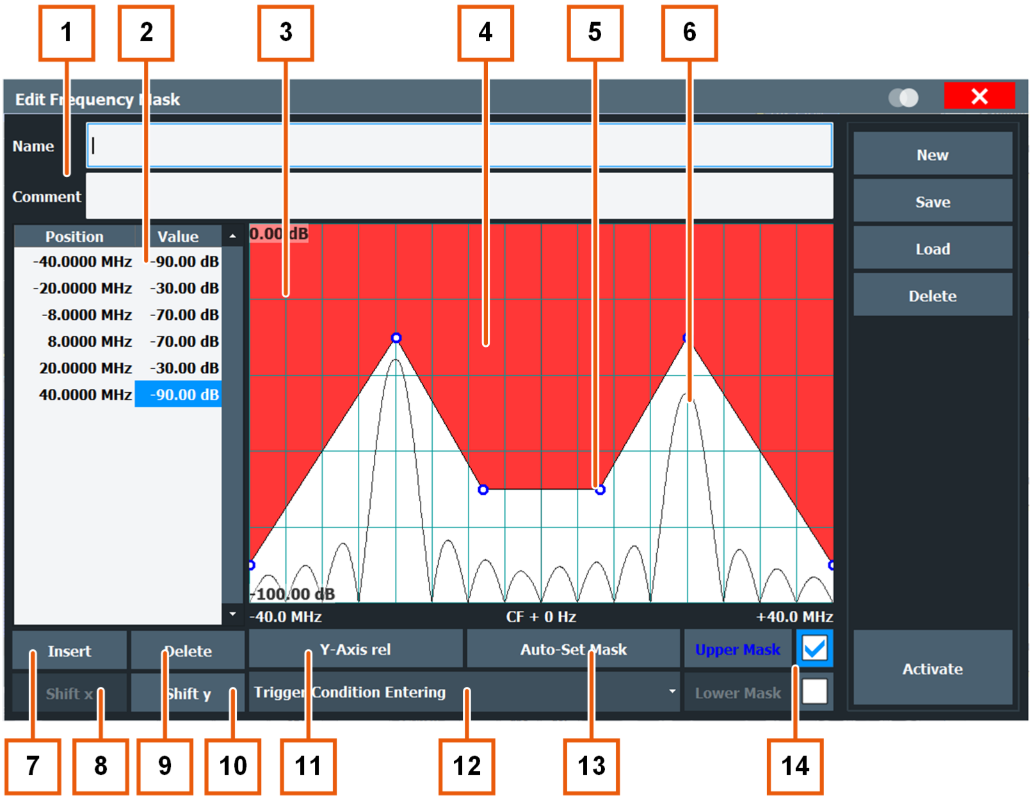


Figure 6-1: Edit Frequency Mask dialog box

1 = Name and description of the frequency mask
2 = Mask point table: list of position/value pairs defining mask coordinates
3 = Preview pane
4 = Frequency mask preview: the area the frequency mask currently covers is red
5 = Frequency mask mask points: define the shape of the frequency mask
6 = Preview of the current measurement trace; type and shape depend on currently selected measurement
7 = Insert: inserts a new mask point
8 = Shift X: shifts the complete frequency mask horizontally
9 = Delete: deletes an existing mask points
10 = Shift Y: shifts the complete frequency mask vertically
11 = Y-Axis Rel/Abs: switches between relative (dB) and absolute (dBm) amplitude values
12 = Auto Set Mask: creates a frequency mask automatically
13 = Trigger Condition selection: sets the trigger condition
14 = Upper Line/Lower Line: selects/deselects the upper and lower frequency mask lines

When you close the "Edit Frequency Mask" dialog box, the trigger source is not automatically set to "FMT". You must activate it manually (see "Activate" on page 69).

6.6.2.1 Frequency mask management

Access: [TRIG] > "Edit Frequency Mask"

As frequency masks can have a very complex structure, they can be stored for later use with other signals. The masks are stored in a file with the extension `.FMT` in the

C:\Program Files (x86)\Rohde-Schwarz\ESW\<version>\freqmask directory. By default, the mask name is used as the file name; however, it can be edited.

New
Clears the current mask configuration to define a new frequency mask.

Remote command:
CALCulate<n>:MASK:NAME on page 149

Save
Opens a file selection dialog box to save the current frequency mask configuration in a file.

By default, the mask name is used as the file name; however, it can be edited.

The mask is stored in a file with the extension .FMT in the C:\Program Files (x86)\Rohde-Schwarz\ESW\<version>\freqmask directory.

Remote command:
Path selection:
CALCulate<n>:MASK:CDIRectory on page 146
Define mask name:
CALCulate<n>:MASK:NAME on page 149

Load
Opens a file selection dialog box to restore a saved frequency mask.

The dialog box contains all frequency masks with the extension .FMT in the C:\Program Files (x86)\Rohde-Schwarz\ESW\<version>\freqmask directory.

Select the required mask and confirm the selection with "Load".

Remote command:
Path selection:
CALCulate<n>:MASK:CDIRectory on page 146
Load mask:
CALCulate<n>:MASK:NAME on page 149

Delete Mask
Opens a file selection dialog box to delete a previously saved frequency mask.

If confirmed, the file is deleted.

Remote command:
CALCulate<n>:MASK:DELete on page 147

Activate
This function sets the trigger source to "Frequency Mask" and closes the dialog box. Thus, it activates the selected mask or masks. To deactivate the use of a frequency mask trigger, change the trigger source (for example to "Free Run", see "Trigger Source" on page 65).

Only selected masks are used for triggering. To deselect a mask, remove the checkmark that defines the mask as an upper or lower mask (see "Selecting and deselecting upper and lower masks" on page 71).

Remote command:
TRIG:SOUR MASK, see TRIGger<tp>[:SEQuence]:SOURce on page 145

6.6.2.2 Frequency mask definition

Access: [TRIG] > "Edit Frequency Mask"

The "Edit Frequency Mask" dialog box provides a basic structure of an upper frequency mask in the live preview window.

Name
Defines the name of the frequency mask. This name is used as the default file name for storage.

Remote command:
CALCulate<n>:MASK:NAME on page 149

Comment
An optional description of the frequency mask.

Remote command:
CALCulate<n>:MASK:COMMent on page 146

Mask points
Each mask is defined by a minimum of 2 and a maximum of 1001 mask points. Each mask point is defined by its position (x-axis) and value (y-value). Mask points must be defined in ascending order and have unique positions.

Remote command:
CALCulate<n>:MASK:UPPer[:DATA] on page 151
CALCulate<n>:MASK:LOWer[:DATA] on page 148

Inserting points
Inserts a mask point in the frequency mask above the selected one in the "Position/Value" list and the preview pane.

Remote command:
Redefine the list of data points:
CALCulate<n>:MASK:UPPer[:DATA] on page 151
CALCulate<n>:MASK:LOWer[:DATA] on page 148

Deleting points
Deletes the selected mask point in the "Position/Value" list and the preview pane.

Remote command:
Redefine the list of data points:
CALCulate<n>:MASK:UPPer[:DATA] on page 151
CALCulate<n>:MASK:LOWer[:DATA] on page 148

Shifting the mask position horizontally (Shift x)

Shifts the x-value (position) of each mask point horizontally by the defined shift width.

Remote command:
CALCulate<n>:MASK:UPPer:SHIFt:X on page 150
CALCulate<n>:MASK:LOWer:SHIFt:X on page 147

Shifting the mask vertically (Shift y)

Shifts the y-value of each mask point vertically by the defined shift height

Remote command:
CALCulate<n>:MASK:UPPer:SHIFt:Y on page 150
CALCulate<n>:MASK:LOWer:SHIFt:Y on page 147

Changing the y-axis scaling (Y-Axis rel/abs)

Switches between absolute scaling (in dBm) or relative scaling (in dB) for the mask (y-)values.

Remote command:
CALCulate<n>:MASK:MODE on page 149

Defining a mask automatically (Auto-Set Mask)

Defines a mask automatically according to the currently measured data. The mask is configured to follow the measurement trace with a specific distance to the power levels.

Remote command:
CALCulate<n>:MASK:UPPer:AUTO on page 150

Setting the trigger condition

Defines how the frequency mask is evaluated to control data acquisition.

For details see "Trigger conditions" on page 31.

"Entering" Activates the trigger as soon as the signal enters the frequency mask.
To arm the trigger, the signal initially has to be outside the frequency mask.

"Leaving" Activates the trigger as soon as the signal leaves the frequency mask.
To arm the trigger, the signal initially has to be inside the frequency mask.

Remote command:
TRIGger[:SEQuence]:MASK:CONDition on page 151

Selecting and deselecting upper and lower masks

Select the masks to be used for triggering. Deselecting a mask allows you to configure it in advance without having to use it immediately.

By default, the configured mask is defined to be an upper mask, i.e. the mask is the area *above* the configured mask points. In addition or alternatively, a lower mask can be configured. In a lower mask, the mask is the area *below* the configured mask points.

The lower mask is configured in the same manner as the upper mask. However, it cannot be configured automatically according to the currently measured values ("Auto-Set Mask").

Both upper and lower masks can be configured at the same time, in order to define a "corridor" of allowed values.

For details see "Upper and lower masks" on page 31

Note that selecting an upper or lower mask to be used for a measurement does not automatically activate them. You must also set the trigger source to "Frequency Mask" (see "Activate" on page 69).

Remote command:
`CALCulate<n>:MASK:LOWer:STATe` on page 148
`CALCulate<n>:MASK:UPPer:STATe` on page 150

6.7 Bandwidth and sweep settings

Access: "Overview" > "Bandwidth"

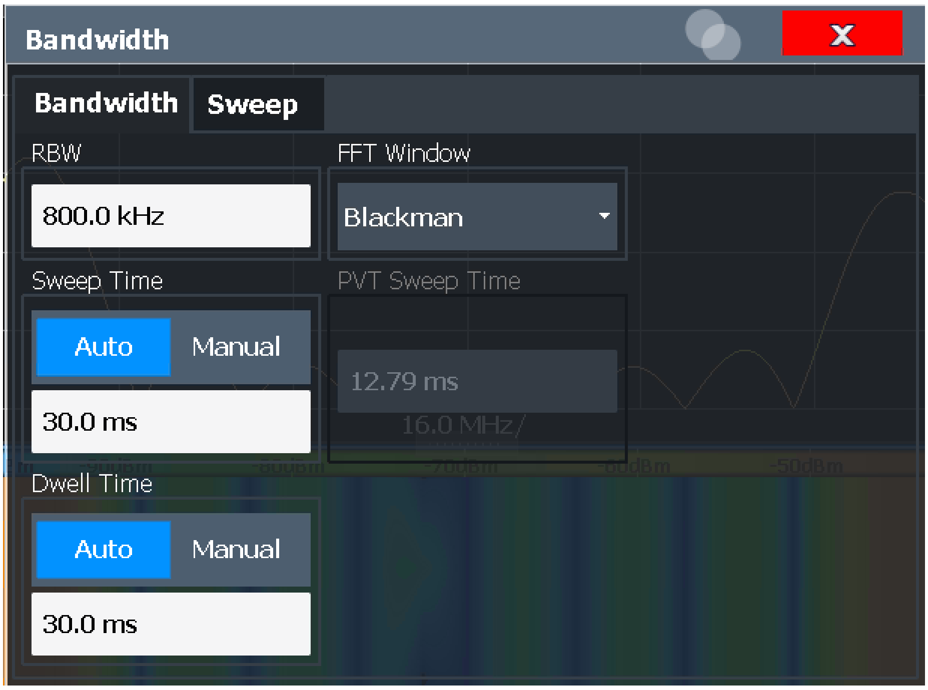


Figure 6-2: Bandwidth dialog box

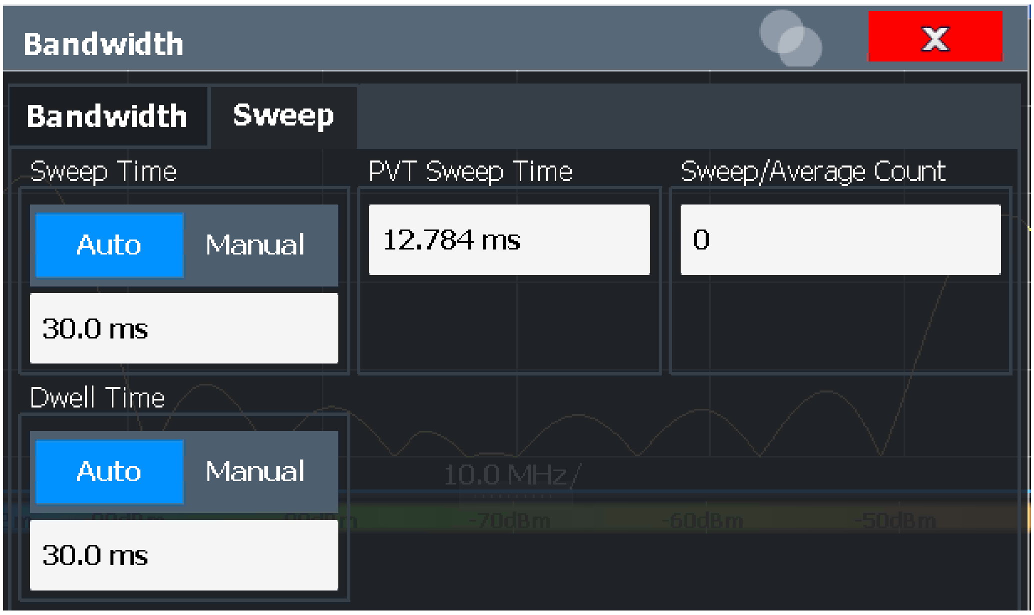


Figure 6-3: Sweep dialog box

Functions to configure the sweep described elsewhere:

- Select Frame

RBW

Defines the resolution bandwidth. The available resolution bandwidths are specified in the specifications document. Numeric input is always rounded to the nearest possible bandwidth according to the available Span/RBW coupling ratios.

Which coupling ratios are available depends on the selected FFT Window.

Which coupling ratios are available depends on the selected FFT Window.

The RBW can be defined independently of the selected span.

For more information see Chapter 5.3, "Defining the resolution bandwidth", on page 28.

Remote command:
`[SENSe:]BANDwidth[:RESolution]` on page 139
`[SENSe:]BANDwidth[:RESolution]:RATio` on page 139

FFT Window

In the R&S ESW Real-Time application you can select one of several FFT window types. The window type is coupled to the resolution bandwidth.

The following window types are available:
- Blackman
- Flattop
- Gaussian
- Rectangle
- Hanning
- Hamming
- Kaiser

Remote command:
[SENSe:]SWEep:FFT:WINDow:TYPE on page 141

Sweep Time
Determines the amount of time used to sample data for one spectrum. The sweep time can be defined automatically or manually.

The allowed sweep times depend on the device model; refer to the specifications document.

For more information see Chapter 5.4, "Sweep time and detector", on page 28.

"Auto" The sweep time is coupled to the span and resolution bandwidth (RBW). If the span or resolution bandwidth is changed, the sweep time is automatically adjusted.

"Manual" Define the sweep time manually. Allowed values depend on the coupling ratio of span to RBW. For details refer to the specifications document. Numeric input is always rounded to the nearest possible sweep time.

Remote command:
[SENSe:]SWEep:TIME:AUTO on page 142
[SENSe:]SWEep:TIME on page 141

Dwell Time
Determines the amount of time used to sample a continuous stream of I/Q data. The stream is displayed as multiple rows in the spectrogram or waterfall diagrams (as opposed to the Sweep Time, which defines the time to capture a *single* row in the diagrams). Dwell time is never applied for triggered measurements. It is only applied in single sweep mode or when the Sequencer is in continuous mode.

The dwell time can be defined automatically or manually.

For more information see Chapter 5.4, "Sweep time and detector", on page 28.

"Auto" The dwell time is set to the maximum of:
- "Sweep Time" on page 74
- 30 ms

"Manual" Define the dwell time manually. Values between 30 ms and 1 hour (3600 s) are allowed.

Remote command:
[SENSe:]SWEep:DTIMe:AUTO on page 140
[SENSe:]SWEep:DTIMe on page 140

Continuous Sweep / Run Cont

While the measurement is running, "Continuous Sweep" and [RUN CONT] are highlighted. The running measurement can be aborted by selecting the highlighted softkey or key again. The results are not deleted until a new measurement is started.

Note: Sequencer. Furthermore, [RUN CONT] controls the Sequencer, not individual sweeps. [RUN CONT] starts the Sequencer in continuous mode.

Remote command:
Measurement mode: `INITiate<n>:CONTinuous` on page 174
Run measurement: `INITiate<mt>[:IMMediate]` on page 175

Single Sweep / Run Single

[RUN SINGLE] initiates a single measurement. If no trigger is used, data is captured for the defined Dwell Time, resulting in one or more spectrogram frames. Otherwise, the measurement starts after triggering and the measurement time is defined by the post- and pretrigger times. Can result in more than one frame.

While the measurement is running, "Single Sweep" and [RUN SINGLE] are highlighted. The running measurement can be aborted by selecting the highlighted softkey or key again.

Note: Sequencer. Furthermore, [RUN SINGLE] controls the Sequencer, not individual sweeps. [RUN SINGLE] starts the Sequencer in single mode.
If the Sequencer is off, only the evaluation for the currently displayed channel is updated.

Remote command:
Measurement mode: `INITiate<n>:CONTinuous` on page 174
Run measurement: `INITiate<mt>[:IMMediate]` on page 175

Sweep Count

Defines the number of measurements to be performed in the single sweep mode. Values from 0 to 200000 are allowed. If the values 0 or 1 are set, one measurement is performed. The sweep count is applied to all the traces in all "Real-Time Spectrum" and "Persistence Spectrum" diagrams.

If the trace configurations "Average", "Max Hold" or "Min Hold" are set, this value also determines the number of averaging or maximum search procedures.

In continuous sweep mode, if sweep count = 0 (default), averaging is performed over 10 sweeps. For sweep count =1, no averaging, Max Hold or Min Hold operations are performed.

Remote command:
`[SENSe:]SWEep:COUNt` on page 140

Clear Spectrogram

Resets the spectrogram result display and clears the history buffer.

This function is only available if a spectrogram is selected.

Remote command:
`CALCulate<n>:SPECtrogram:CLEar[:IMMediate]` on page 152

6.8 Adjusting settings automatically

Access: [AUTO SET]

Some settings can be adjusted by the R&S ESW automatically according to the current measurement settings. In order to do so, a measurement is performed. The duration of this measurement can be defined automatically or manually.

Adjusting settings automatically during triggered measurements

When you select an auto adjust function a measurement is performed to determine the optimal settings. If you select an auto adjust function for a triggered measurement, you are asked how the R&S ESW should behave:

- (default:) The measurement for adjustment waits for the next trigger
- The measurement for adjustment is performed without waiting for a trigger.
  The trigger source is temporarily set to "Free Run". After the measurement is completed, the original trigger source is restored.

Remote command:

`[SENSe:]ADJust:CONFigure:TRIGger` on page 165

The remote commands required to configure the measurement automatically are described in Chapter 10.4.11, "Automatic configuration", on page 162.

Adjusting all Determinable Settings Automatically (Auto All)

Activates all automatic adjustment functions for the current measurement settings, including:

- Auto Frequency
- Auto Level

Remote command:
`[SENSe:]ADJust:ALL` on page 163

Adjusting the Center Frequency Automatically (Auto Frequency)

The R&S ESW adjusts the center frequency automatically.

The optimum center frequency is the frequency with the highest S/N ratio in the frequency span. As this function uses the signal counter, it is intended for use with sinusoidal signals.

Remote command:
`[SENSe:]ADJust:FREQuency` on page 164

Setting the Reference Level Automatically (Auto Level)
Automatically determines a reference level which ensures that no overload occurs at the R&S ESW for the current input data. At the same time, the internal attenuators are adjusted. As a result, the signal-to-noise ratio is optimized, while signal compression and clipping are minimized.

To determine the required reference level, a level measurement is performed on the R&S ESW.

If necessary, you can optimize the reference level further. Decrease the attenuation level manually to the lowest possible value before an overload occurs, then decrease the reference level in the same way.

Remote command:
`[SENSe:]ADJust:LEVel` on page 165

Resetting the Automatic Measurement Time (Meas Time Auto)
Resets the measurement duration for automatic settings to the default value.

Remote command:
`[SENSe:]ADJust:CONFigure:LEVel:DURation:MODE` on page 163

Changing the Automatic Measurement Time (Meas Time Manual)
This function allows you to change the measurement duration for automatic setting adjustments. Enter the value in seconds.

Note: The maximum measurement duration depends on the currently selected measurement and the installed (optional) hardware. Thus, the measurement duration actually used to determine the automatic settings can be shorter than the value you define here.

Remote command:
`[SENSe:]ADJust:CONFigure:LEVel:DURation:MODE` on page 163
`[SENSe:]ADJust:CONFigure:LEVel:DURation` on page 163

Upper Level Hysteresis
When the reference level is adjusted automatically using the Auto Level function, the internal attenuators and the preamplifier are also adjusted. To avoid frequent adaptation due to small changes in the input signal, you can define a hysteresis. This setting defines an upper threshold that the signal must exceed (compared to the last measurement) before the reference level is adapted automatically.

Remote command:
`[SENSe:]ADJust:CONFigure:HYSTeresis:UPPer` on page 164

Lower Level Hysteresis
When the reference level is adjusted automatically using the Auto Level function, the internal attenuators and the preamplifier are also adjusted. To avoid frequent adaptation due to small changes in the input signal, you can define a hysteresis. This setting defines a lower threshold that the signal must fall below (compared to the last measurement) before the reference level is adapted automatically.

Remote command:
`[SENSe:]ADJust:CONFigure:HYSTeresis:LOWer` on page 164

7 Analysis

Access: "Overview" > "Analysis"

Specific result configuration for persistence and spectrogram or waterfall displays, as well as general result analysis settings concerning the trace, markers, windows etc. can be configured.

7.1 Display configuration

Access: "Overview" > "Display Config"

The captured signal can be displayed using various evaluation methods. All evaluation methods available for the Real-Time Spectrum application are displayed in the evaluation bar in SmartGrid mode.

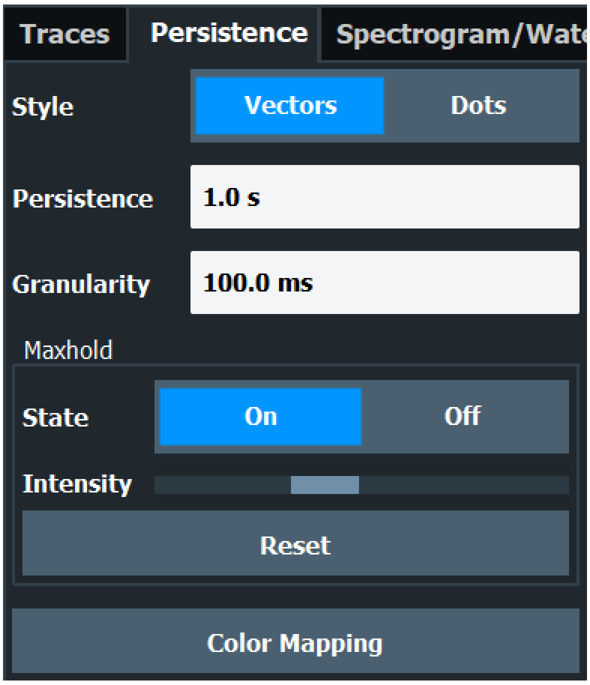
Up to 6 evaluation methods can be displayed simultaneously in separate windows. The real-Time evaluation methods are described in Chapter 4, "Measurements and result displays", on page 16.

For details on working with the SmartGrid see the R&S ESW Getting Started manual.

7.2 Persistence spectrum settings

Access: "Overview" > "Analysis" > "Persistence"

The persistence spectrum is highly configurable. You can change the colors with which the densities are visualized, the persistence of the data, and the style of the displayed results.



The remote commands required to configure the persistence spectrum are described in Chapter 10.4.9, "Persistence spectrum configuration", on page 154.

Diagram Style

The persistence spectrum can be displayed using vectors or dots.

For details see "Matrix style" on page 50.

"Vectors" Using vectors, the individual points - and thus the densities - are interpolated. The result is a persistence spectrum that contains no gaps between coordinates. Each point of the histogram is connected to the neighboring ones.

"Dots" Using dots, only those coordinates are displayed for which data has actually been measured. The result is a histogram made up out of individual points.

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:SYMBol on page 157

Persistence

Persistence defines the duration that shadows of past histogram traces remain visible in the display before fading away.

The number of traces that are considered when calculating the density depends on this persistence length.

For low persistence values, the density colors change quickly in the persistence spectrogram.

For high persistence values, the colors change slowly.

A value of 0 seconds deactivates persistence.

For details see Chapter 5.7, "Understanding persistence", on page 48.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:PERSistence:DURation` on page 156

Granularity

Defines the amount of data that the R&S ESW uses to draw a single frame in the persistence spectrum. By default, the moving density of the data that was captured in 100 ms is displayed for each frame.

For details see "Persistence Granularity" on page 49.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:PERSistence:GRANularity` on page 157

Configuring the Max Hold Function

The Max Hold function remembers and shows the maximum densities that have been measured at each point in the diagram.

If activated, the maximum values from all past sweeps are indicated in the persistence spectrum, together with the measured values from the current sweep.

Note: Setting the Intensity to 0 has the same effect as deactivating the Max Hold function.

For details see Chapter 5.7.1, "Analyzing maximum density - Max hold function", on page 52.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MAXHold[:STATe]` on page 155

Intensity ← Configuring the Max Hold Function

The maximum values (that is, the Max Hold trace) are displayed in the defined intensity. The higher the intensity, the brighter the maximum values are displayed. With maximum intensity, the maximum values are displayed just as bright as the currently measured values.

Note: Setting the intensity to 0 has the same effect as deactivating the Max Hold function.

To change the intensity, move the slider to the left (weaker) or right (stronger).

Note that while the intensity of the Max Hold trace may differ to the currently measured trace, the color *mapping* is the same for both traces.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MAXHold:INTensity`
on page 155

Resetting the Max Hold Function ← Configuring the Max Hold Function
The previous results of the Max Hold function are cleared and the function starts determining new maximum values.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MAXHold:RESet`
on page 155

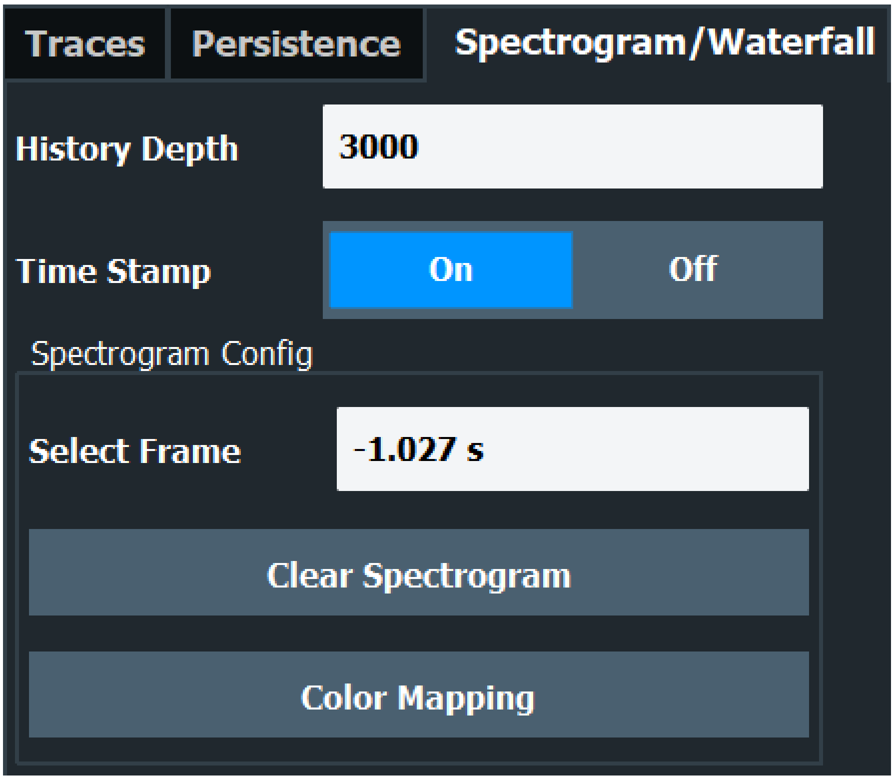
Color Mapping
Opens the "Color Map" dialog.

For details see Chapter 7.4, "Color map settings", on page 83.

7.3 Spectrogram settings

Access: "Overview" > "Analysis" > "Spectrogram"

The individual settings available for spectrogram and waterfall displays are described here. For settings on color mapping, see Chapter 7.4, "Color map settings", on page 83.



The remote commands required to configure the spectrogram are described in Chapter 10.4.8, "Spectrogram configuration", on page 152.

History Depth

Sets the number of frames that the R&S ESW stores in its memory. The maximum history depth is 100.000 frames.

If the memory is full, the R&S ESW deletes the oldest frames stored in the memory and replaces them with the new data.

Remote command:
`CALCulate<n>:SPECtrogram:HDEPth` on page 153

Time Stamp

Activates and deactivates the time stamp. If activated (default), the time stamp shows the system time while the measurement is running. In single sweep mode or if the sweep is stopped, the time stamp shows the time and date at the end of the sweep.

Individual frames are referred to by their time difference to the end of the sweep.

If deactivated, individual frames are referred to by their frame number in the spectrogram and waterfall diagrams.

For details see "Time stamps vs. frame index" on page 39.

Remote command:
`CALCulate<n>:SPECtrogram:TSTamp[:STATe]` on page 154
`CALCulate<n>:SPECtrogram:TSTamp:DATA?` on page 153

Selecting a frame to display

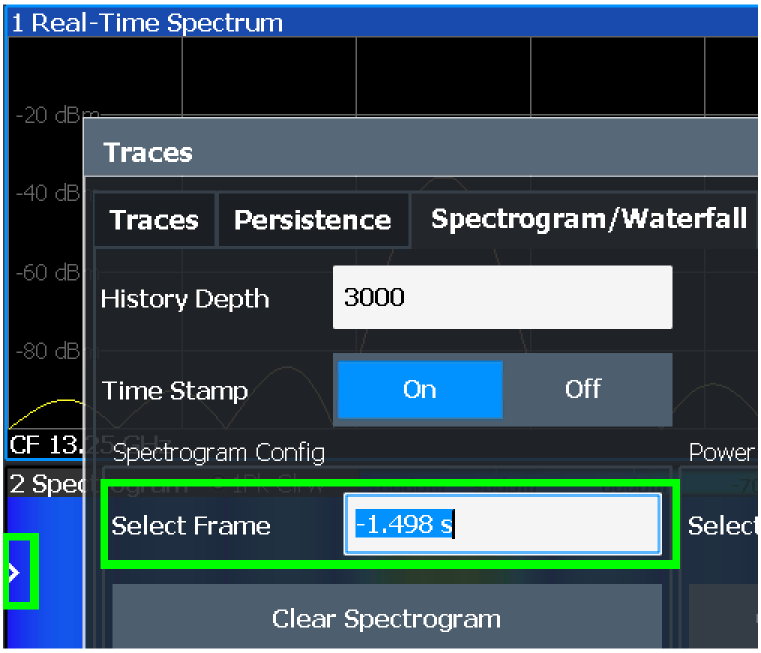
Selects a specific frame, loads the corresponding trace from the memory, and displays it in the "Real-Time Spectrum" window. Different frames can be displayed in the "Real-Time Spectrum" window.

This function is only available in single sweep mode or if the sweep is stopped.

The most recent frame is number 0, all previous frames have a negative number.

Note that activating a marker or changing the position of the active marker automatically selects the frame that belongs to that marker.

The selected frame is indicated by small white arrows on the left and right border of the spectrogram.



For more information see Chapter 5.6.1, "Time frames", on page 37.

Remote command:
`CALCulate<n>:SPECtrogram:FRAMe:SELect` on page 152

Clear Spectrogram
Resets the spectrogram result display and clears the history buffer.

This function is only available if a spectrogram is selected.

Remote command:
`CALCulate<n>:SPECtrogram:CLEar[:IMMediate]` on page 152

Color Mapping
Opens the "Color Map" dialog.

For details see Chapter 7.4, "Color map settings", on page 83.

7.4 Color map settings

Access: [MEAS CONFIG] > "Color Mapping"

The settings for color maps are available for spectrograms, persistence spectra, and waterfall displays.

For more information on color maps see Chapter 5.6.3, "Color maps", on page 40.

For details on changing color map settings see Chapter 9.3, "How to configure the color mapping", on page 110.

In addition to the available color settings, the dialog box displays the current color map and provides a preview of the display with the current settings.

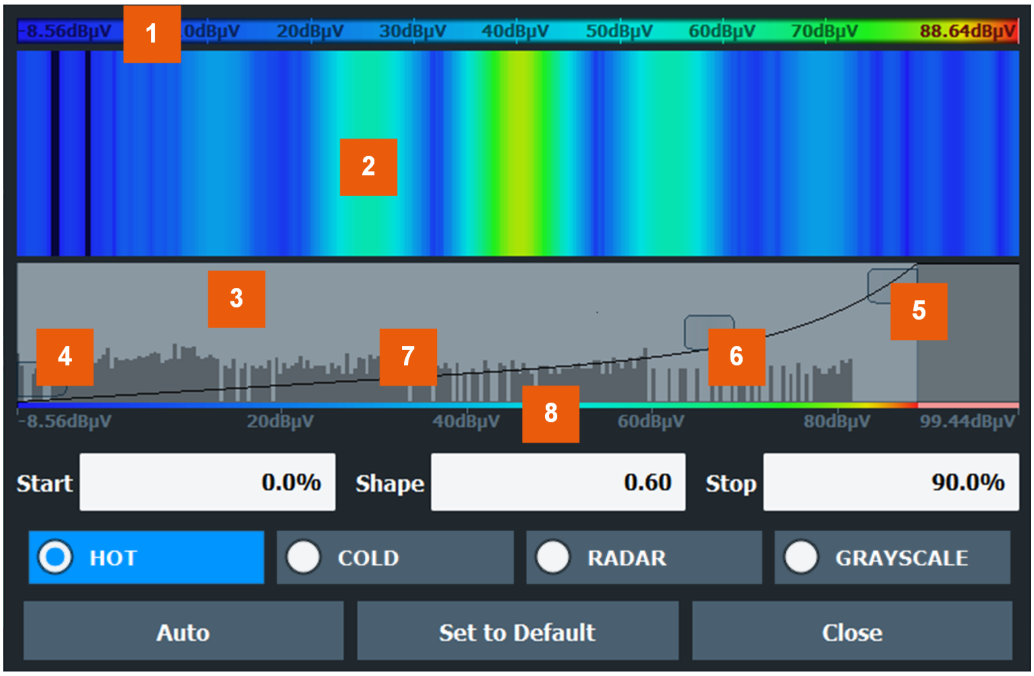


Figure 7-1: Color Mapping dialog box

1 = Color map: shows the current color distribution
2 = Preview pane: shows a preview of the diagram with any changes that you make to the color scheme
3 = Color curve pane: graphical representation of all settings available to customize the color scheme
4/5 = Color range start and stop sliders: define the range of the color map or amplitudes for the spectrogram
6 = Color curve slider: adjusts the focus of the color curve
7 = Histogram: shows the distribution of measured values
8 = Scale of the horizontal axis (value range)

Start / Stop

Defines the lower and upper boundaries of the value range of the diagram.

Remote command:
`DISPlay[:WINDow<n>]:SPECtrogram:COLor:LOWer` on page 161
`DISPlay[:WINDow<n>]:SPECtrogram:COLor:UPPer` on page 162
`DISPlay[:WINDow<n>]:PSPectrum:COLor:LOWer` on page 158
`DISPlay[:WINDow<n>]:PSPectrum:COLor:UPPer` on page 160

Shape

Defines the shape and focus of the color curve for the spectrogram result display.

"-1 to <0"	More colors are distributed among the lower values
"0"	Colors are distributed linearly among the values
">0 to 1"	More colors are distributed among the higher values

Remote command:
`DISPlay[:WINDow<n>]:SPECtrogram:COLor:SHAPe` on page 162
`DISPlay[:WINDow<n>]:PSPectrum:COLor:SHAPe` on page 159

Truncate

This command is available for "Persistence Spectrum" only.

By default, results that are smaller than the start value of the color map range are displayed in the color for the minimum value. Results that are larger than the stop value of the color map range are displayed in the color for the maximum value.

If the "Truncate" function is activated, the results of the persistence spectrum outside the value range of the color map are truncated, that is, not displayed.

Remote command:
DISPlay[:WINDow<n>]:PSPectrum:COLor:TRUNcate on page 159

Hot/Cold/Radar/Grayscale
Sets the color scheme for the spectrogram.

Remote command:
DISPlay[:WINDow<n>]:SPECtrogram:COLor[:STYLe] on page 160
DISPlay[:WINDow<n>]:PSPectrum:COLor[:STYLe] on page 160

Auto
Defines the color range automatically according to the existing measured values for optimized display.

Set to Default
Sets the color map to the default settings.

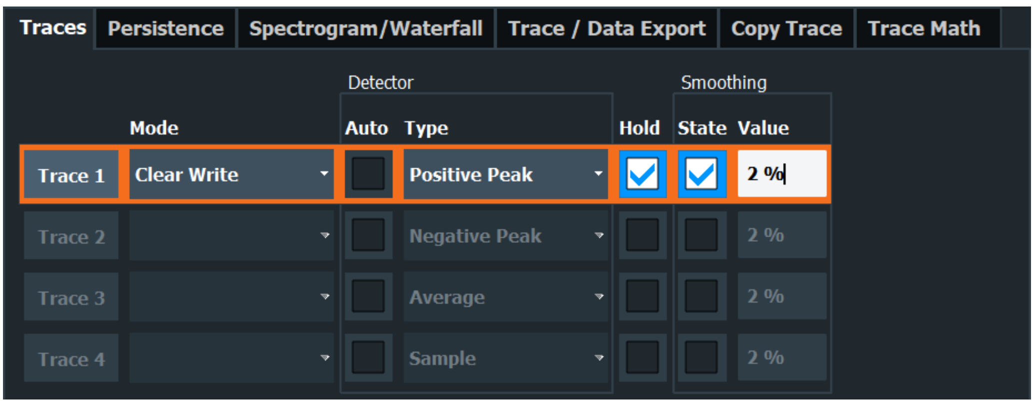
Remote command:
DISPlay[:WINDow<n>]:SPECtrogram:COLor:DEFault on page 161
DISPlay[:WINDow<n>]:PSPectrum:COLor:DEFault on page 158

7.5 Trace settings

Access: "Overview" > "Analysis" > "Traces"

The trace settings determine how the measured data is analyzed and displayed in the window. Depending on the result display, between 1 and 4 traces may be displayed.

Trace data can also be exported to an ASCII file for further analysis. For details see Chapter 7.6, "Trace / data export configuration", on page 88.



The remote commands required to configure the traces are described in Chapter 10.7.1, "Configuring traces", on page 191.

Trace 1/Trace 2/Trace 3/Trace 4

Selects the corresponding trace for configuration. The currently selected trace is highlighted orange.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>[:STATe]` on page 192
Selected via numeric suffix of `TRACe<t>` commands

Mode

Defines the update mode for subsequent traces.

"Clear Write" Overwrite mode: the trace is overwritten by each sweep. This is the default setting.

"Max Hold" The maximum value is determined over several sweeps and displayed. The R&S ESW saves the sweep result in the trace memory only if the new value is greater than the previous one.

"Min Hold" The minimum value is determined over several sweeps and displayed. The R&S ESW saves the sweep result in the trace memory only if the new value is greater than the previous one.

"View" The current contents of the trace memory are frozen and displayed.

"Blank" Removes the selected trace from the display.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MODE` on page 191

Detector

Defines the trace detector to be used for trace analysis.

Detectors perform a data reduction from the swept values to the displayed trace points. The detector type determines which of the samples are displayed for each trace point.

Note: The detector activated for the specific trace is indicated in the corresponding trace information in the window title bar by an abbreviation.

The trace detector can analyze the measured data using various methods:

"Positive Peak" Determines the largest of all positive peak values from the levels measured at the individual x-values which are displayed in one trace point

"Negative Peak" Determines the smallest of all negative peak values from the levels measured at the individual x-values which are displayed in one trace point

"Average" Calculates the linear average of all samples contained in a sweep point.
To this effect, R&S ESW uses the linear voltage after envelope detection. The sampled linear values are summed up and the sum is divided by the number of samples (= linear average value). Each sweep point thus corresponds to the average of the measured values summed up in the sweep point.
The average detector supplies the average value of the signal irrespective of the waveform (CW carrier, modulated carrier, white noise or impulsive signal).

"Sample" Selects the last measured value of the levels measured at the individual x-values which are displayed in one trace point; all other measured values for the x-axis range are ignored

"Persistence" The "Persistence Spectrogram" display does not require a detector. It evaluates the individual FFTs (see Chapter 5.7, "Understanding persistence", on page 48). The "Persistence" detector is indicated only to distinguish the traces in the "Persistence Spectrogram".

Remote command:
`[SENSe:][WINDow:]DETector<t>[:FUNCtion]` on page 193

Hold
If activated, traces in "Min Hold", "Max Hold" and "Average" mode are not reset after specific parameter changes have been made.

Normally, the measurement is started again after parameter changes, before the measurement results are analyzed (e.g. using a marker). In all cases that require a new measurement after parameter changes, the trace is reset automatically to avoid false results (e.g. with span changes). For applications that require no reset after parameter changes, the automatic reset can be switched off.

The default setting is off.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MODE:HCONtinuous`
on page 192

Average Count
Determines the number of averaging or maximum search procedures If the trace modes "Average", "Max Hold" or "Min Hold" are set.

In continuous measurement mode, if sweep count = 0 (default), averaging is performed over 10 measurements. For sweep count =1, no averaging, Max Hold or Min Hold operations are performed.

Remote command:
`[SENSe:]AVERage<n>:COUNt` on page 193

Trace 1/ Trace 2/ Trace 3/ Trace 4 (Softkeys)
Displays the "Traces" settings and focuses the "Mode" list for the selected trace.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>[:STATe]` on page 192

Copy Trace
Access: "Overview" > "Analysis" > "Traces" > "Copy Trace"

Copies trace data to another trace.

The first group of buttons (labeled "Trace 1" to "Trace 4") selects the source trace. The second group of buttons (labeled "Copy to Trace 1" to "Copy to Trace 4") selects the destination.

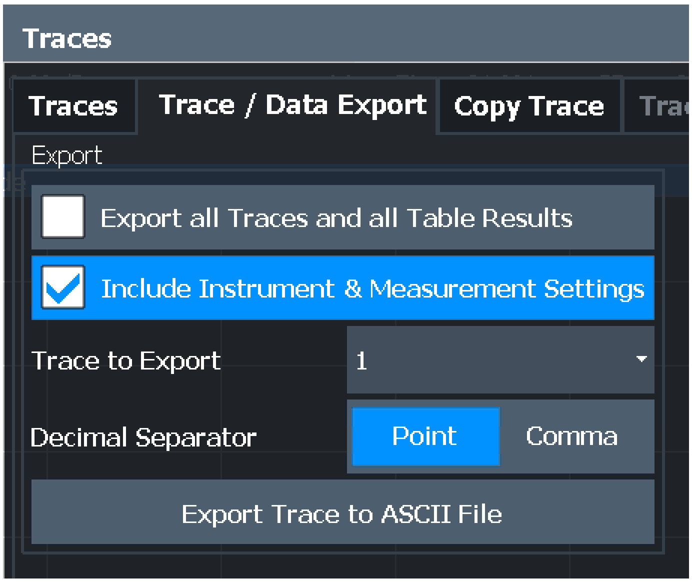
Remote command:
`TRACe<n>:COPY` on page 194

7.6 Trace / data export configuration

Or: "Overview" > "Analysis" > "Trace Export"

The standard data management functions (e.g. saving or loading instrument settings) that are available for all R&S ESW applications are not described here.

See the R&S ESW base unit user manual for a description of the standard functions.



Export all Traces and all Table Results
Selects all displayed traces and result tables (e.g. "Result Summary", marker table etc.) in the current application for export to an ASCII file.

Alternatively, you can select one specific trace only for export (see Trace to Export).

The results are output in the same order as they are displayed on the screen: window by window, trace by trace, and table row by table row.

Remote command:
`FORMat:DEXPort:TRACes` on page 185

Include Instrument & Measurement Settings
Includes additional instrument and measurement settings in the header of the export file for result data.

Remote command:
`FORMat:DEXPort:HEADer` on page 185

Trace to Export
Defines an individual trace to be exported to a file.

This setting is not available if Export all Traces and all Table Results is selected.

Decimal Separator
Defines the decimal separator for floating-point numerals for the data export/import files. Evaluation programs require different separators in different languages.

Remote command:
`FORMat:DEXPort:DSEParator` on page 184

Export Trace to ASCII File
Opens a file selection dialog box and saves the selected trace in ASCII format (**`.dat`**) to the specified file and directory.

"File Explorer": Instead of using the file manager of the R&S ESW firmware, you can also use the Microsoft Windows File Explorer to manage files.

The results are output in the same order as they are displayed on the screen: window by window, trace by trace, and table row by table row.

If the spectrogram display is selected when you perform this function, the entire histogram buffer with all frames is exported to a file. The data for a particular frame begins with information about the frame number and the time that frame was recorded. For large history buffers the export operation can take some time.

Remote command:
`MMEMory:STORe<n>:TRACe` on page 184

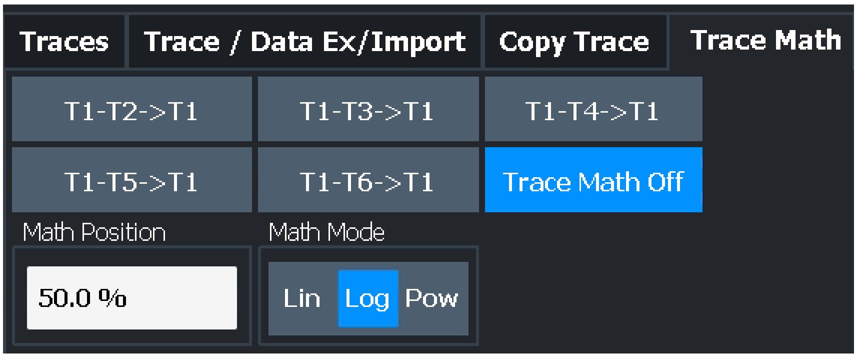
7.7 Trace math

Access: [TRACE] > "Trace Math"

Or: "Overview" > "Analysis" > "Traces" > "Trace Math"

If you have several traces with different modes, for example an average trace and a maximum trace, it may be of interest to compare the results of both traces. In this example, you could analyze the maximum difference between the average and maximum values. To analyze the span of result values, you could subtract the minimum trace from the maximum trace. For such tasks, the results from several traces can be combined using mathematical functions.

Trace math functions are not available for "Persistence Spectrum" displays.



Trace Math Function

You can select one of several different math operations.

Each operation subtracts one trace from another as indicated on the corresponding button and writes the result to one of the traces. "T1 - T3 > T1", for example, subtracts trace 3 from trace 1 and writes the result to trace 1. You can apply one operation at a time.

The result refers to the zero point defined with the Trace Math Position setting. The following subtractions can be performed:

"T1-T2->T1"	Subtracts trace 2 from trace 1.
"T1-T3->T1"	Subtracts trace 3 from trace 1
"T1-T4->T1"	Subtracts trace 4 from trace 1

To switch off the trace math, use the Trace Math Off button.

Remote command:
CALCulate<n>:MATH<t>[:EXPRession][:DEFine] on page 194
CALCulate<n>:MATH<t>:STATe on page 196

Trace Math Off

Deactivates any previously selected trace math functions.

Remote command:
CALC:MATH:STAT OFF, see CALCulate<n>:MATH<t>:STATe on page 196

Trace Math Position

Defines the zero point on the y-axis of the resulting trace in % of the diagram height. The range of values extends from -100 % to +200 %.

Remote command:
`CALCulate<n>:MATH<t>:POSition` on page 195

Trace Math Mode
Defines the mode for the trace math calculations.

"Lin" Activates linear subtraction, which means that the power level values are converted into linear units prior to subtraction. After the subtraction, the data is converted back into its original unit.
This setting takes effect if the grid is set to a linear scale. In this case, subtraction is done in two ways (depending on the set unit):

- The unit is set to either W or dBm: the data is converted into W prior to subtraction, i.e. averaging is done in W.
- The unit is set to either V, A, dBmV, dBμV, dBμA or dBpW: the data is converted into V prior to subtraction, i.e. subtraction is done in V.

"Log" Activates logarithmic subtraction.
This subtraction method only takes effect if the grid is set to a logarithmic scale, i.e. the unit of the data is dBm. In this case the values are subtracted in dBm. Otherwise (i.e. with linear scaling) the behavior is the same as with linear subtraction.

"Power" Activates linear power subtraction.
The power level values are converted into unit Watt prior to subtraction. After the subtraction, the data is converted back into its original unit.
Unlike the linear mode, the subtraction is always done in W.

Remote command:
`CALCulate<n>:MATH<t>:MODE` on page 195

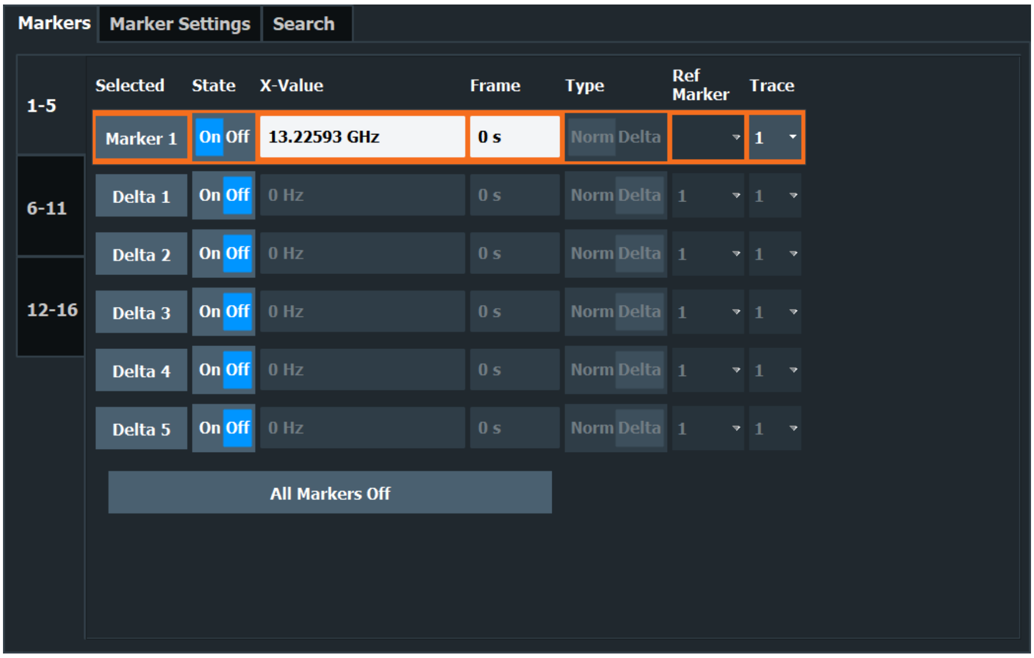
7.8 Marker settings

Access: "Overview" > "Analysis" > "Marker"

7.8.1 Individual marker setup

Access: "Overview" > "Analysis" > "Marker" > "Markers"

Up to 17 markers or delta markers can be activated for each window simultaneously.



The markers are distributed among 3 tabs for a better overview. By default, the first marker is defined as a normal marker, whereas all others are defined as delta markers with reference to the first marker. All markers are assigned to trace 1, but only the first marker is active.

The remote commands required to configure markers are described in Chapter 10.7.3, "Marker configuration", on page 196.

Selected Marker

Marker name. The marker which is currently selected for editing is highlighted orange.

Remote command:
Marker selected via suffix <m> in remote commands.

Marker State

Activates or deactivates the marker in the diagram.

Remote command:
`CALCulate<n>:MARKer<m>[:STATe]` on page 197
`CALCulate<n>:DELTamarker<m>[:STATe]` on page 200

Marker Position X-value
Defines the position (x-value) of the marker in the diagram. For normal markers, the absolute position is indicated. For delta markers, the position relative to the reference marker is provided.

Remote command:
CALCulate<n>:MARKer<m>:X on page 198
CALCulate<n>:DELTamarker<m>:X on page 201

Marker Level (Y-value)
Defines the level (y-value) of the marker in the "Persistence Spectrum" diagram.

Remote command:
CALCulate<n>:MARKer<m>:Y? on page 198
CALCulate<n>:DELTamarker<m>:Y? on page 201

Frame
"Spectrogram" frame number the marker is assigned to. The most recently swept frame is number 0, all previous frames have negative numbers.

The selected frame is indicated by small white arrows on the left and right border of the spectrogram/PVT waterfall.

Remote command:
CALCulate<n>:MARKer<m>:SPECtrogram:FRAMe on page 215

Marker Type
Toggles the marker type.

The type for marker 1 is always "Normal", the type for delta marker 1 is always "Delta". These types cannot be changed.

Note: If normal marker 1 is the active marker, switching the "Mkr Type" activates an additional delta marker 1. For any other marker, switching the marker type does not activate an additional marker, it only switches the type of the selected marker.

"Normal" A normal marker indicates the absolute value at the defined position in the diagram.

"Delta" A delta marker defines the value of the marker relative to the specified reference marker (marker 1 by default).

Remote command:
CALCulate<n>:MARKer<m>[:STATe] on page 197
CALCulate<n>:DELTamarker<m>[:STATe] on page 200

Reference Marker
Defines a marker as the reference marker which is used to determine relative analysis results (delta marker values).

If the reference marker is deactivated, the delta marker referring to it is also deactivated.

Remote command:
CALCulate<n>:DELTamarker<m>:MREFerence on page 200

Assigning the Marker to a Trace

The "Trace" setting assigns the selected marker to an active trace. The trace determines which value the marker shows at the marker position. If the marker was previously assigned to a different trace, the marker remains on the previous frequency or time, but indicates the value of the new trace.

Note: Markers in the persistence spectrum.
In the persistence spectrum result display, you can place each marker on one of the following traces:

- Trace 1: **Clear/write** positive peak (**Spectrum**) trace
- Trace 2: **Clear/write persistence** trace
- Trace 3: **Max Hold persistence** trace

Markers on the persistence traces are 2-dimensional markers defined by a frequency and level value. The marker result indicates the probability of appearance for the frequency/level pair. For details, see Chapter 5.7, "Understanding persistence", on page 48.

If a trace is turned off, the assigned markers and marker functions are also deactivated.

Remote command:
`CALCulate<n>:MARKer<m>:TRACe` on page 197

Select Marker

The "Select Marker" function opens a dialog box to select and activate or deactivate one or more markers quickly.

Remote command:
`CALCulate<n>:MARKer<m>[:STATe]` on page 197
`CALCulate<n>:DELTamarker<m>[:STATe]` on page 200

All Markers Off

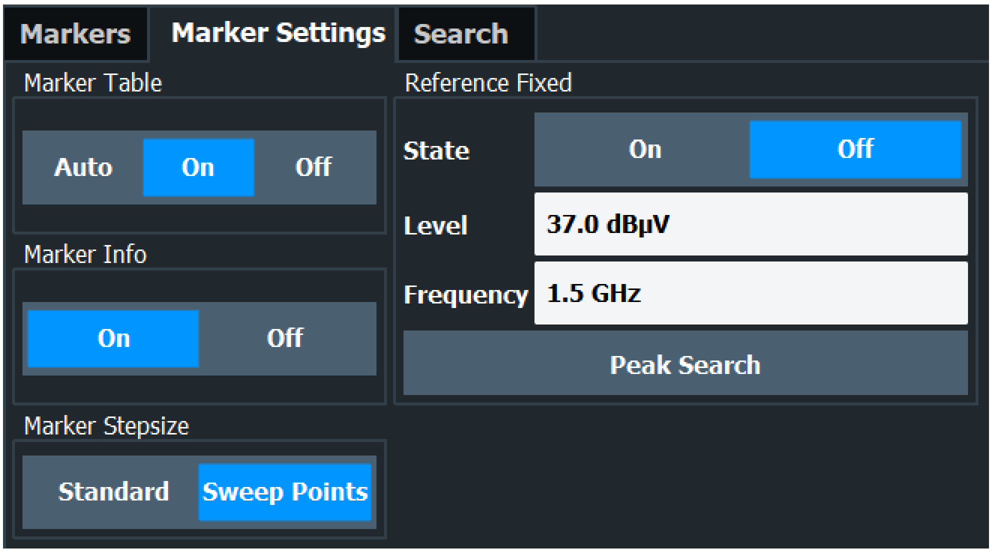
Deactivates all markers in one step.

Remote command:
`CALCulate<n>:MARKer<m>:AOFF` on page 197

7.8.2 General marker settings

Access: "Overview" > "Analysis" > "Marker" > "Marker Settings"

Some general marker settings allow you to influence the marker behavior for all markers.



The remote commands required to configure markers are described in Chapter 10.7.3, "Marker configuration", on page 196.

Marker Table Display
Defines how the marker information is displayed.

"On" Displays the marker information in a table in a separate area beneath the diagram.

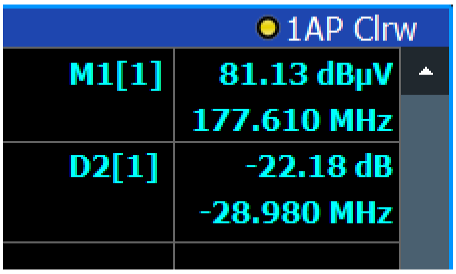
"Off" No separate marker table is displayed.
If Marker Info is active, the marker information is displayed within the diagram area.

"Auto" (Default) If more than two markers are active, the marker table is displayed automatically.
If Marker Info is active, the marker information for up to two markers is displayed in the diagram area.

Remote command:
`DISPlay[:WINDow<n>]:MTABle` on page 204

Marker Info

Turns the marker information displayed in the diagram on and off.



Remote command:

DISPlay[:WINDow<n>]:MINFo[:STATe] on page 204

Marker Stepsize

Defines the size of the steps that the marker position is moved using the rotary knob.

"Standard" The marker position is moved in steps of (Span/1000), which corresponds approximately to the number of pixels for the default display of 1001 measurement points. This setting is most suitable to move the marker over a larger distance.

"Sweep Points" The marker position is moved from one sweep point to the next. This setting is required for a very precise positioning if more sweep points are collected than the number of pixels that can be displayed on the screen. It is the default mode.

Remote command:

CALCulate<n>:MARKer<m>:X:SSIZe on page 204

Defining a Fixed Reference

Instead of using a reference marker whose position can vary depending on the measurement results, you can define a fixed reference marker for trace analysis.

Note that this function is not available in all result displays.

Note: Markers in the "Persistence Spectrum". In particular, fixed reference markers are not required and not supported in "Persistence Spectrum" displays. For details see "Persistence Spectrum" on page 18.

For "State" = "On", a vertical and a horizontal red display line are displayed, marked as "FXD". The normal marker 1 is activated and set to the peak value of the trace assigned to marker 1, and a delta marker to the next peak. The fixed reference marker is set to the position of marker 1 at the peak value. The delta marker refers to the fixed reference marker.

The "Level" and "Frequency" or "Time" settings define the position and value of the reference marker. To move the fixed reference, move the red display lines marked "FXD" in the diagram, or change the position settings in the "Marker Settings" tab of the "Marker" dialog box.

Peak Search sets the fixed reference marker to the current maximum value of the trace assigned to marker 1.

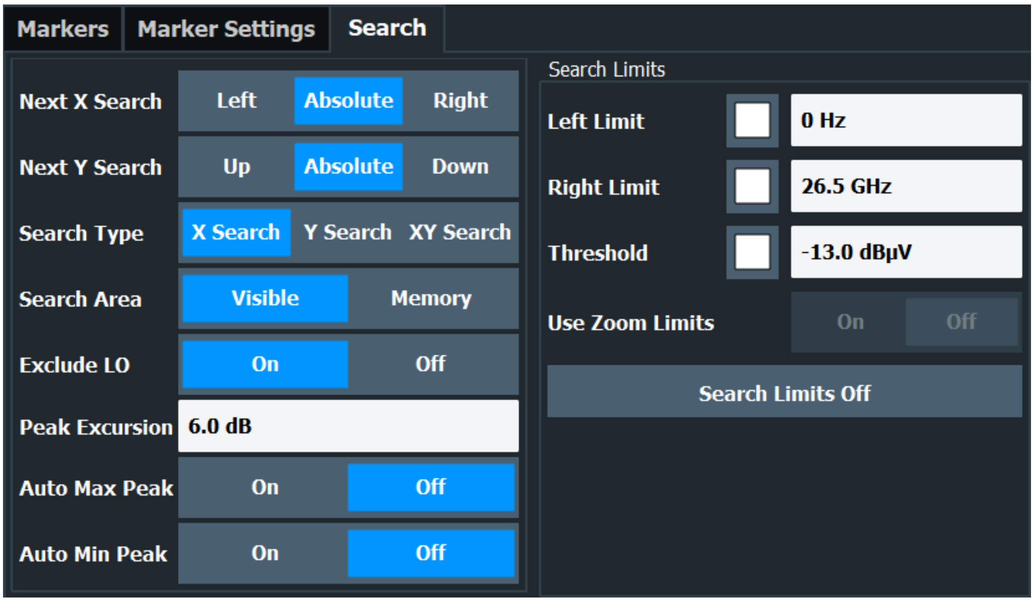
If activated, the fixed reference marker ("FXD") can also be selected as a Reference Marker instead of another marker.

Remote command:
`CALCulate<n>:DELTamarker<m>:FUNCtion:FIXed[:STATe]` on page 203
`CALCulate<n>:DELTamarker<m>:FUNCtion:FIXed:RPOint:Y` on page 203
`CALCulate<n>:DELTamarker<m>:FUNCtion:FIXed:RPOint:X` on page 202
`CALCulate<n>:DELTamarker<m>:FUNCtion:FIXed:RPOint:MAXimum[:PEAK]` on page 202

7.8.3 Marker search settings

Access: "Overview" > "Analysis" > "Marker" > "Search"

Spectrograms show not only the current sweep results, but also the sweep history. Thus, when searching for peaks, you must define the search settings within a single time frame (x-direction) and within several time frames (y-direction).



The remote commands required to configure markers are described in Chapter 10.7.3, "Marker configuration", on page 196.

Search Mode for Next Peak in X Direction
Selects the search mode for the next peak search within the currently selected frame.

"Left" Determines the next maximum/minimum to the left of the current peak.

"Absolute" Determines the next maximum/minimum to either side of the current peak.

"Right" Determines the next maximum/minimum to the right of the current peak.

Remote command:
`CALCulate<n>:MARKer<m>:MAXimum:LEFT` on page 210
`CALCulate<n>:MARKer<m>:MAXimum:NEXT` on page 210
`CALCulate<n>:MARKer<m>:MAXimum:RIGHt` on page 211
`CALCulate<n>:MARKer<m>:MINimum:LEFT` on page 211
`CALCulate<n>:MARKer<m>:MINimum:NEXT` on page 211
`CALCulate<n>:MARKer<m>:MINimum:RIGHt` on page 212

Search Mode for Next Peak in Y Direction
Selects the search mode for the next peak search within all frames at the current marker position.

This setting is only available for spectrogram displays.

"Up" Determines the next maximum/minimum above the current peak (in more recent frames).

"Absolute" Determines the next maximum/minimum above or below the current peak (in all frames).

"Down" Determines the next maximum/minimum below the current peak (in older frames).

Remote command:
`CALCulate<n>:MARKer<m>:SPECtrogram:Y:MAXimum:ABOVe` on page 216
`CALCulate<n>:DELTamarker<m>:SPECtrogram:Y:MAXimum:ABOVe` on page 221
`CALCulate<n>:MARKer<m>:SPECtrogram:Y:MAXimum:BELow` on page 217
`CALCulate<n>:DELTamarker<m>:SPECtrogram:Y:MAXimum:BELow` on page 221
`CALCulate<n>:MARKer<m>:SPECtrogram:Y:MAXimum:NEXT` on page 217
`CALCulate<n>:DELTamarker<m>:SPECtrogram:Y:MAXimum:NEXT` on page 222
`CALCulate<n>:MARKer<m>:SPECtrogram:Y:MINimum:ABOVe` on page 217
`CALCulate<n>:DELTamarker<m>:SPECtrogram:Y:MINimum:ABOVe` on page 222
`CALCulate<n>:MARKer<m>:SPECtrogram:Y:MINimum:BELow` on page 218
`CALCulate<n>:DELTamarker<m>:SPECtrogram:Y:MINimum:BELow` on page 222
`CALCulate<n>:MARKer<m>:SPECtrogram:Y:MINimum:NEXT` on page 218
`CALCulate<n>:DELTamarker<m>:SPECtrogram:Y:MINimum:NEXT` on page 223

Marker Search Type
Defines the type of search to be performed in the spectrogram.

"X-Search" Searches only within the currently selected frame.

"Y-Search" Searches within all frames but only at the current marker position.

"XY-Search" Searches in all frames at all positions.

Remote command:
CALCulate<n>:MARKer<m>:SPECtrogram:XY:MAXimum[:PEAK] on page 216
CALCulate<n>:DELTamarker<m>:SPECtrogram:XY:MAXimum[:PEAK] on page 221
CALCulate<n>:MARKer<m>:SPECtrogram:XY:MINimum[:PEAK] on page 216
CALCulate<n>:DELTamarker<m>:SPECtrogram:XY:MINimum[:PEAK] on page 221
CALCulate<n>:MARKer<m>:SPECtrogram:Y:MAXimum[:PEAK] on page 217
CALCulate<n>:DELTamarker<m>:SPECtrogram:Y:MAXimum[:PEAK] on page 222
CALCulate<n>:MARKer<m>:SPECtrogram:Y:MINimum[:PEAK] on page 218
CALCulate<n>:DELTamarker<m>:SPECtrogram:Y:MINimum[:PEAK] on page 223
CALCulate<n>:MARKer<m>:MAXimum[:PEAK] on page 210
CALCulate<n>:DELTamarker<m>:MAXimum[:PEAK] on page 213
CALCulate<n>:MARKer<m>:MINimum[:PEAK] on page 211
CALCulate<n>:DELTamarker<m>:MINimum[:PEAK] on page 213

Marker Search Area

Defines which frames the search is performed in.

This setting is only available for spectrogram displays.

"Visible" Only the visible frames are searched.

"Memory" All frames stored in the memory are searched.

Remote command:
CALCulate<n>:MARKer<m>:SPECtrogram:SARea on page 216
CALCulate<n>:DELTamarker<m>:SPECtrogram:SARea on page 220

Exclude LO

If activated, restricts the frequency range for the marker search functions.

"On" The minimum frequency included in the peak search range is ≥ 5 × resolution bandwidth (RBW).
Due to the interference by the first local oscillator to the first intermediate frequency at the input mixer, the LO is represented as a signal at 0 Hz. To avoid the peak marker jumping to the LO signal at 0 Hz, this frequency is excluded from the peak search.

"Off" No restriction to the search range. The frequency 0 Hz is included in the marker search functions.

Remote command:
CALCulate<n>:MARKer<m>:LOEXclude on page 205

Peak Excursion

Defines the minimum level value by which a signal must rise or fall so that it is identified as a maximum or a minimum by the search functions.

Remote command:
CALCulate<n>:MARKer<m>:PEXCursion on page 206

Auto Max Peak Search / Auto Min Peak Search
If activated, a maximum or minimum peak search is performed automatically for marker 1 after each measurement.

For spectrogram displays, define which frame the peak is to be searched in.

Remote command:
`CALCulate<n>:MARKer<m>:MAXimum:AUTO` on page 205
`CALCulate<n>:MARKer<m>:MINimum:AUTO` on page 206

Search Limits
The search results can be restricted by limiting the search area or adding search conditions.

Search Limits (Left / Right) ← Search Limits
If activated, limit lines are defined and displayed for the search. Only results within the limited search range are considered.

Remote command:
`CALCulate<n>:MARKer<m>:X:SLIMits[:STATe]` on page 207
`CALCulate<n>:MARKer<m>:X:SLIMits:LEFT` on page 207
`CALCulate<n>:MARKer<m>:X:SLIMits:RIGHt` on page 208

Search Threshold ← Search Limits
Defines an absolute threshold as an additional condition for the peak search. If enabled, only peaks that exceed the threshold are detected.

Remote command:
`CALCulate<n>:THReshold:STATe` on page 209
`CALCulate<n>:THReshold` on page 208

Search Limits Off ← Search Limits
Deactivates the search range limits.

Remote command:
`CALCulate<n>:MARKer<m>:X:SLIMits[:STATe]` on page 207
`CALCulate<n>:THReshold:STATe` on page 209

7.8.4 Positioning functions

Access: [MKR →]

The following functions set the currently selected marker to the result of a peak search or set other characteristic values to the current marker value.

The remote commands required to configure markers are described in Chapter 10.7.3, "Marker configuration", on page 196.

Peak Search

Sets the selected marker/delta marker to the maximum of the trace. If no marker is active, marker 1 is activated.

Remote command:
CALCulate<n>:MARKer<m>:MAXimum[:PEAK] on page 210
CALCulate<n>:DELTamarker<m>:MAXimum[:PEAK] on page 213

Search Next Peak

Sets the selected marker/delta marker to the next (lower) maximum of the assigned trace. If no marker is active, marker 1 is activated.

Remote command:
CALCulate<n>:MARKer<m>:MAXimum:NEXT on page 210
CALCulate<n>:MARKer<m>:MAXimum:RIGHt on page 211
CALCulate<n>:MARKer<m>:MAXimum:LEFT on page 210
CALCulate<n>:DELTamarker<m>:MAXimum:NEXT on page 212
CALCulate<n>:DELTamarker<m>:MAXimum:RIGHt on page 213
CALCulate<n>:DELTamarker<m>:MAXimum:LEFT on page 212

Search Minimum

Sets the selected marker/delta marker to the minimum of the trace. If no marker is active, marker 1 is activated.

Remote command:
CALCulate<n>:MARKer<m>:MINimum[:PEAK] on page 211
CALCulate<n>:DELTamarker<m>:MINimum[:PEAK] on page 213

Search Next Minimum

Sets the selected marker/delta marker to the next (higher) minimum of the selected trace. If no marker is active, marker 1 is activated.

Remote command:
CALCulate<n>:MARKer<m>:MINimum:NEXT on page 211
CALCulate<n>:MARKer<m>:MINimum:LEFT on page 211
CALCulate<n>:MARKer<m>:MINimum:RIGHt on page 212
CALCulate<n>:DELTamarker<m>:MINimum:NEXT on page 213
CALCulate<n>:DELTamarker<m>:MINimum:LEFT on page 213
CALCulate<n>:DELTamarker<m>:MINimum:RIGHt on page 214

Center Frequency = Marker Frequency

Sets the center frequency to the selected marker or delta marker frequency. A peak can thus be set as center frequency, for example to analyze it in detail with a smaller span.

This function is not available for zero span measurements.

Remote command:
CALCulate<n>:MARKer<m>:FUNCtion:CENTer on page 209

Reference Level = Marker Level
Sets the reference level to the selected marker level.

Remote command:
`CALCulate<n>:MARKer<m>:FUNCtion:REFerence` on page 130

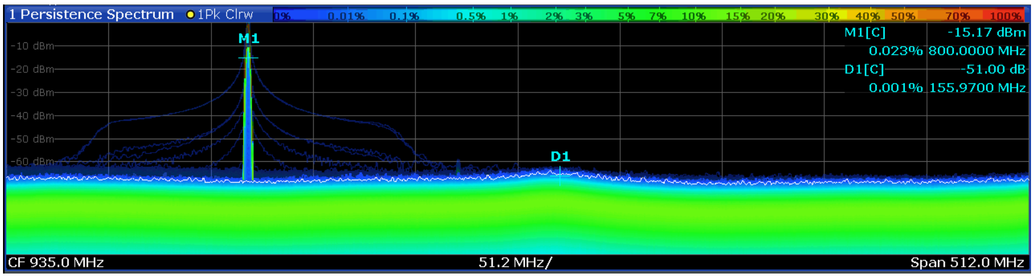
Marker to Trigger
Sets the marker directly on the most recent trigger event.

This function is only available for spectrograms, and only if a trigger event already occurred.

Remote command:
`CALCulate<n>:MARKer<m>:SPECtrogram:Y:TRIGger` on page 219

7.8.5 Example: defining a delta marker in a persistence spectrum

The following example demonstrates how to define a delta marker in a persistence spectrum. We want to determine the difference in power levels between the spur and the upper noise level.



1. Tap the "Persistence Spectrum" window to set the focus in it.
2. Select the [MKR] key.
3. Select "Marker 1".
   A normal marker ("M1") is displayed in the diagram.
4. Drag the marker 1 to the peak of the spur.
5. Select "Marker 2".
   A delta marker ("D2") is displayed in the diagram. The delta marker results indicate the difference in frequency, level, and probability of appearance to the normal marker 1.
6. Drag the delta marker to the upper noise level.
   The deviation in the power level of the spur is indicated in the delta marker results. In this example, it is -51 dB.

7.9 Display and limit lines

Access: "Overview" > "Analysis" > "Lines"

The display and limit line functionality is the same as in the Spectrum application.

For more information refer to the user manual of the Spectrum application.

7.10 Zoom functions

The zoom functions are only available from the toolbar.

For details on the zoom functions see Chapter 5.6.4, "Zooming into the spectrogram", on page 43.

Single Zoom

Define the zoom area by drawing a rectangle on the touchscreen. When you draw the zoom area, its boundaries are shown as a dashed line. The R&S ESW stops the Real-Time measurement and recalculates the displays for the area you have selected. The definition of the color map remains the same.

Note: In Real-Time measurements, this function is only available for an active spectrogram.
The graphical zoom provided for other measurements on the R&S ESW is **not available** for Real-Time measurements.

For details and restrictions see Chapter 5.6.4, "Zooming into the spectrogram", on page 43.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:ZOOM[:STATe]` on page 224
`DISPlay[:WINDow<n>]:ZOOM:AREA` on page 223

Restore Original Display

Restores the original display, that is, the originally calculated displays for the entire capture buffer, and closes all zoom windows.

Note: This function only restores graphically zoomed displays. Measurement zooms, for which measurement settings were adapted, are recalculated based on the adapted measurement settings. In this case, the zoomed display is maintained.

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<w>]:ZOOM[:STATe] on page 224

Deactivating Zoom (Selection Mode)

Deactivates any zoom mode.

Tapping the screen no longer invokes a zoom, but selects an object.

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<w>]:ZOOM[:STATe] on page 224

Replay Zoom

Switches between the zoomed displays and the original displays quickly for comparison.

If enabled, the zoomed displays are shown, that is, the recalculated displays for the selected zoom area.

If disabled, the original display is restored, that is, the originally calculated displays for the entire capture buffer.

This function is only available after a measurement has been performed.

For details see Chapter 5.6.4, "Zooming into the spectrogram", on page 43.

8 I/Q data export

Baseband signals mostly occur as so-called complex baseband signals, i.e. a signal representation that consists of two channels; the in phase (I) and the quadrature (Q) channel. Such signals are referred to as I/Q signals. I/Q signals are useful because the specific RF or IF frequencies are not needed. The complete modulation information and even distortion that originates from the RF, IF or baseband domains can be analyzed in the I/Q baseband.

Exporting I/Q signals is useful for example to capture and save I/Q signals with a signal analyzer to analyze them with another R&S ESW application or an external software tool (for example the R&S VSE software) later.

As opposed to storing trace data, which may be averaged or restricted to peak values, I/Q data is exported as it was captured, without further processing. The data is stored as complex values in 32-bit floating-point format.

For a detailed description see the R&S ESW I/Q Analyzer and I/Q Input User Manual.

8.1 Export functions

The export functions are available in the "Save/Recall" menu which is displayed when you select the "Save" icon in the toolbar.

Some functions for particular data types are (also) available via softkeys or dialog boxes in the corresponding menus, e.g. trace data.

For a description of the other functions in the "Save/Recall" menu see the R&S ESW User Manual.

Trace Export Configuration
Opens the "Traces" dialog box to configure the trace and data export settings.

I/Q Export
Opens a file selection dialog box to define an export file name to which the I/Q data is stored. This function is only available in single sweep mode.

"File Explorer": Instead of using the file manager of the R&S ESW firmware, you can also use the Microsoft Windows File Explorer to manage files.

For details, see the description in the R&S ESW I/Q Analyzer User Manual ("Importing and Exporting I/Q Data").

Note: Storing large amounts of I/Q data (several Gigabytes) can exceed the available (internal) storage space on the R&S ESW. In this case, it can be necessary to use an external storage medium.

Note: Secure user mode.
In secure user mode, settings that are stored on the instrument are stored to volatile memory, which is restricted to 256 MB. Thus, a "memory limit reached" error can occur although the hard disk indicates that storage space is still available.

To store data permanently, select an external storage location such as a USB memory device.

For details, see "Protecting Data Using the Secure User Mode" in the "Data Management" section of the R&S ESW base unit user manual.

Remote command:
`MMEMory:STORe<n>:IQ:STATe` on page 190
`MMEMory:STORe<n>:IQ:COMMent` on page 189

File Type ← I/Q Export
The I/Q data file can be in stored in one of the following supported formats:
- `.iq.tar`
- `.iqw`
- `.csv`
- `.mat`
- `.aid`

For details on formats, see the R&S ESW I/Q Analyzer and I/Q Input user manual.

File Explorer ← I/Q Export
Opens the Microsoft Windows File Explorer.

Remote command:
not supported

8.2 How to export I/Q data

Capturing and exporting I/Q data

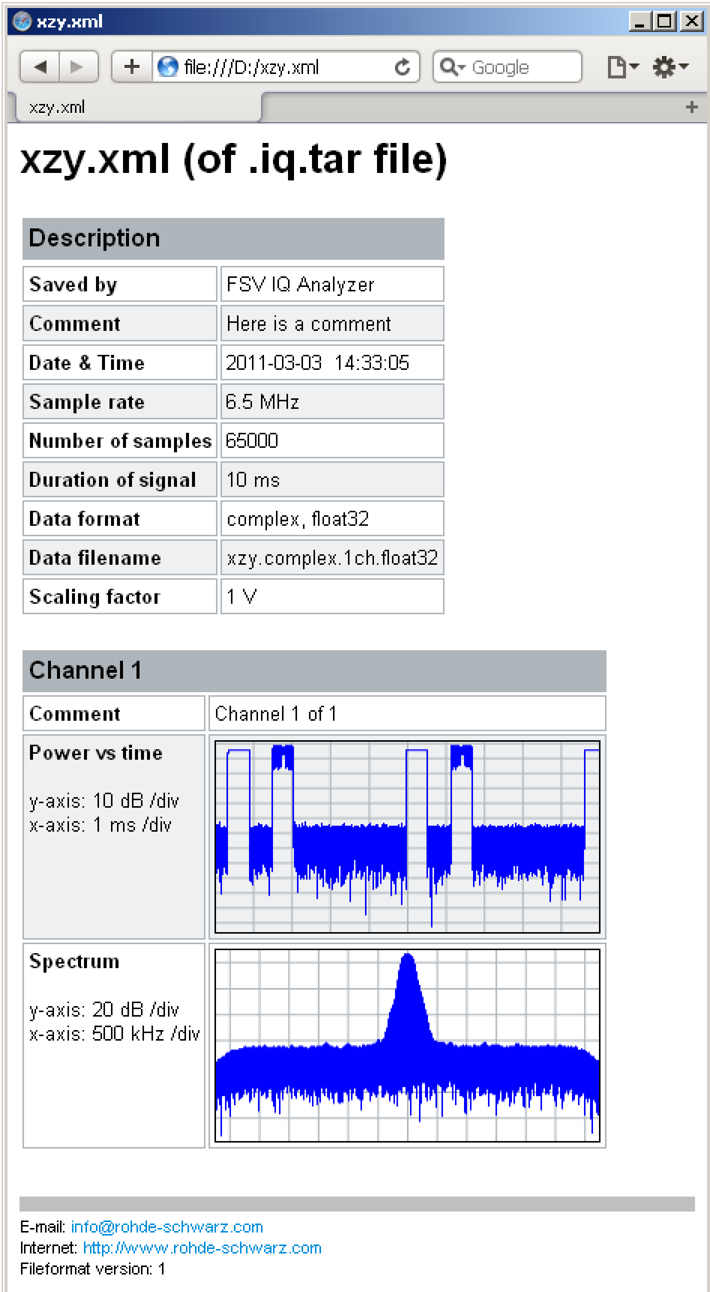
1. Configure the data acquisition.
2. Press the [RUN SINGLE] key to perform a single sweep measurement.
3. Select the "Save" icon in the toolbar.
4. Select "Export > I/Q Export".
5. In the file selection dialog box, select a storage location and enter a file name.
6. Select "Save".

   The captured data is stored to a file with the extension `.iq.tar`.
   The length of the captured data is equal to the defined "Sweep Time" on page 74.

Previewing the I/Q data in a web browser

The `iq-tar` file format allows you to preview the I/Q data in a web browser.

1. Use an archive tool (e.g. WinZip® or PowerArchiver®) to unpack the `iq-tar` file into a folder.
2. Locate the folder using Windows Explorer.
3. Open your web browser.
4. Drag the I/Q parameter XML file, e.g. `example.xml`, into your web browser.



9 How to perform Real-Time Spectrum measurements

9.1 How to perform a basic Real-Time Spectrum measurement

The following step-by-step instructions demonstrate how to perform a basic Real-Time Spectrum measurement with the R&S ESW Real-Time application.

1. Press [MODE] on the front panel and select the "Real-Time Spectrum" application.
2. Press [RUN CONT] to stop the default continuous measurement.
3. Select "Overview" to display the "Overview" for a Real-Time Spectrum measurement.
4. Select "Amplitude" to define the required reference level and configure the attenuation, if necessary.
5. Select "Frequency" to define the center frequency of the measurement.
6. Optionally, select "Trigger" to use an external trigger or to configure a frequency mask trigger for the measurement. For details on using a frequency mask trigger see Chapter 9.4, "How to work with frequency mask triggers", on page 112.
   To capture and analyze I/Q data for a specific time around a trigger event, define a pretrigger and posttrigger time in the "Trigger" settings.
7. Select "Bandwidth" to configure the FFT parameters.
   - "RBW": Define the resolution bandwidth in Hz
   - "FFT Window": Select the window function depending on the required characteristics
   - "Sweep Time": Define how long data is to be captured for one line in the spectrogram
8. Select "Analysis" and then the "Spectrogram/Waterfall" tab to configure the spectrogram.
   - "History Depth": number of lines (frames) to be stored in the spectrogram (possibly for several consecutive measurements).

- Optionally, deactivate the "Time Stamp" option to refer to the individual lines (frames) using an index number instead of the time they were captured.
- Optionally, select "Color Mapping" to change the colors with which the power levels are represented in the spectrogram. For details see Chapter 9.3, "How to configure the color mapping", on page 110.
- Select "Clear Spectrogram" to start a new spectrogram display.

9. Press [RUN SINGLE] to start a sweep with the defined settings.

   When the sweep is finished, the "Spectrogram" displays all captured lines captured during the dwell time, and the "Real-Time Spectrum" displays the spectrum that starts with the trigger event (or the most recently captured spectrum for free-run measurements).

10. Scroll through the individual frames of the "Spectrogram":
    a) Tap the "Spectrogram" window.
    b) Press [Sweep].
    c) Select "Select Frame" and change the index number (negative numbers from 0 downwards).

    The "Real-Time Spectrum" displays the stored spectrum for the selected frame.

11. Optionally, export the trace data of the spectrogram to a file.
    a) Select "Analysis" in the "Overview".
    b) In the "Traces" tab of the "Analysis" dialog box, switch to the "Trace Export" tab.
    c) From the "Specifics for" list, select the spectrogram display.
    d) Select "Export Trace to ASCII File".
    e) Define a file name and storage location and select "OK".

9.2 How to analyze persistency in Real-Time Spectrum measurements

The following step-by-step instructions demonstrate how to analyze persistency in the R&S ESW Real-Time application.

1. Configure the R&S ESW Real-Time application to perform a Real-Time Spectrum measurement as described in Chapter 9.1, "How to perform a basic Real-Time Spectrum measurement", on page 108.
2. Select "Display Config" and add a "Persistence Spectrum" window to the display.
3. Press [ESC] to exit the display configuration.
4. Select "Persistence Config" to configure the persistency.
   - "Persistence": Define how long each measured value is considered in the density calculation.

- "Granularity": Define the time frame used to calculate a single frame in the "Persistence Spectrum".
- Optionally, select "Dots" style to display only true values without interpolated data.
- Optionally, select "Color Mapping" to change the colors with which the density is represented in the "Persistence Spectrum". For details see Chapter 9.3, "How to configure the color mapping", on page 110.
- Optionally, deactivate or change the intensity of the "Max Hold" trace that shows only the maximum density for all frequencies.
  Select "Reset" to start a new "Max Hold" trace.

5. Press [RUN SINGLE] to start a sweep with the defined persistency settings.

   When the sweep is finished, the "Persistence Spectrum" displays the density of all measured values, and the "Real-Time Spectrum" displays the spectrum that starts with the trigger event (or the most recently captured spectrum for free-run measurements).

   Now you can analyze the colors in the "Persistence Spectrum", which indicate the probability of a particular level in the spectrum.

9.3 How to configure the color mapping

The color display is highly configurable to adapt the spectrogram to your needs.

The settings for color mapping are defined in the "Color Mapping" dialog box. To display this dialog box, do one of the following:

- Select the color map in the window title bar of the "Spectrogram" result display.
- Select "Color Mapping" in the "Real-Time Config" menu.

To select a color scheme

You can select which colors are assigned to the measured values.

► In the "Color Mapping" dialog box, select the option for the color scheme to be used.

Editing the value range of the color map

The distribution of the measured values is displayed as a histogram in the "Color Mapping" dialog box. To cover the entire measurement value range, make sure the first and last bar of the histogram are included.

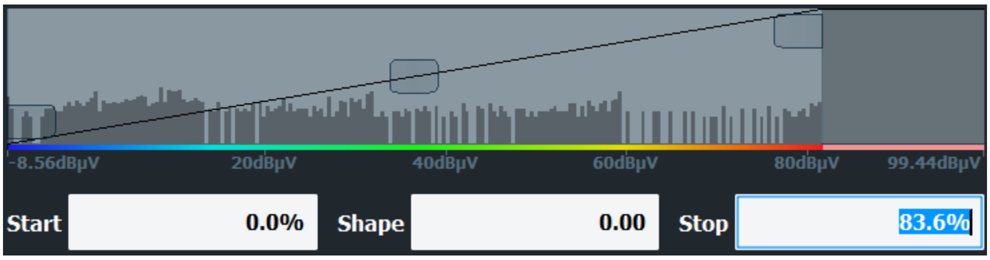
To ignore noise in a spectrogram, for example, exclude the lower power levels from the histogram.

The value range of the color map must cover at least 10% of the value range on the horizontal axis of the diagram, that means, the difference between the start and stop values must be at least 10%.

The value range of the color map can be set numerically or graphically.

To set the value range graphically using the color range sliders

1. Select and drag the bottom color curve slider (indicated by a gray box at the left of the color curve pane) to the lowest value you want to include in the color mapping.
2. Select and drag the top color curve slider (indicated by a gray box at the right of the color curve pane) to the highest value you want to include in the color mapping.



To set the value range of the color map numerically

1. In the "Start" field, enter the percentage from the left border of the histogram that marks the beginning of the value range.
2. In the "Stop" field, enter the percentage from the right border of the histogram that marks the end of the value range.

Example:

The color map starts at -110 dBm and ends at -10 dBm (that is: a range of 100 dB). In order to suppress the noise, you only want the color map to start at -90 dBm. Thus, you enter *10%* in the "Start" field. The R&S ESW shifts the start point 10% to the right, to -90 dBm.

Adjusting the reference level and level range

Since the color map is configured using percentages of the total value range, changing the reference level and level range of the measurement (and thus the power value range) also affects the color mapping in the spectrogram.

Truncating persistence spectrum results

By default, results that are smaller than the start value of the color map range are displayed in the color for the minimum value. Results that are larger than the stop value of the color map range are displayed in the color for the maximum value.

In order to hide results outside the value range of the color map, use the "Truncate" function (see "Truncate" on page 84).

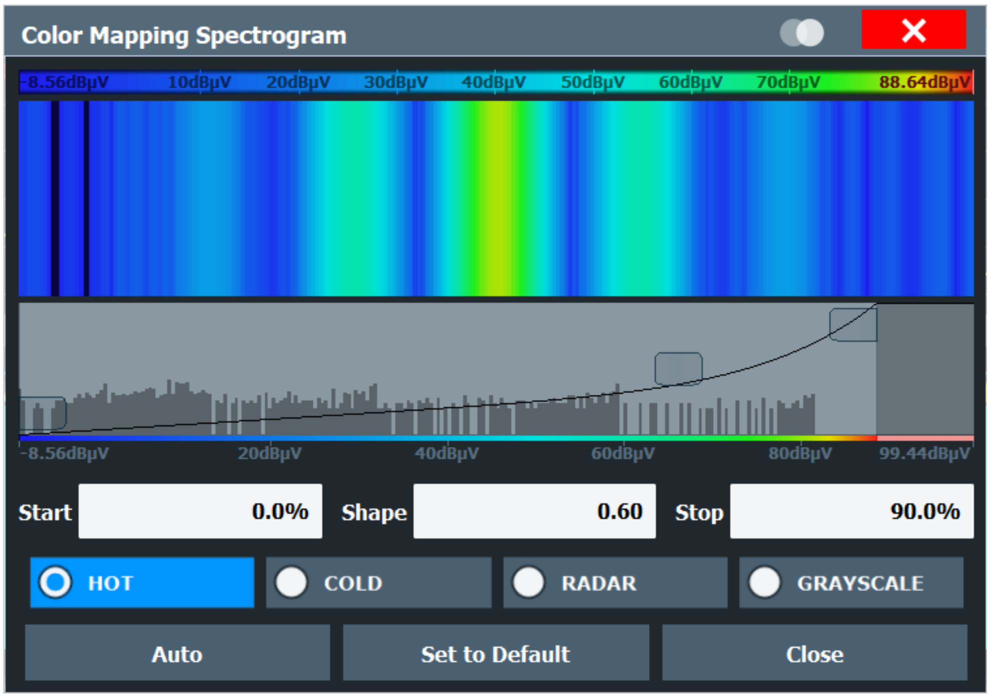
Editing the shape of the color curve

The color curve is a tool to shift the focus of the color distribution on the color map. By default, the color curve is linear, i.e. the colors on the color map are distributed evenly. If you shift the curve to the left or right, the distribution becomes non-linear. The slope of the color curve increases or decreases. One end of the color palette then covers a large number of results, while the other end distributes several colors over a relatively small result range.

The color curve shape can be set numerically or graphically.

To set the color curve shape graphically using the slider

► Select and drag the color curve shape slider (indicated by a gray box in the middle of the color curve) to the left or right. The area beneath the slider is focused, i.e. more colors are distributed there.



To set the color curve shape numerically

► In the "Shape" field, enter a value to change the shape of the curve:

- A negative value (-1 to <0) focuses the lower values
- 0 defines a linear distribution
- A positive value (>0 to 1) focuses the higher values

9.4 How to work with frequency mask triggers

The Frequency Mask Trigger (FMT) is a mask in the frequency domain, which is checked with every calculated FFT. When a specific condition concerning this mask occurs during the measurement of the input signal, I/Q data capturing is triggered.

For details see Chapter 5.5.1, "Triggering on specific frequency events (frequency mask trigger)", on page 29

9.4.1 How to create a new frequency mask

The frequency mask is configured by a set of individual trace points which are connected to form a mask area. The frequency mask may have any shape, defined by up to 1001 points.

There are several ways to create a new mask:

- Automatically, according to the currently measured values
- Graphically, by adding and moving mask points on the touchscreen
- Numerically, by defining the x- and y-values of the mask points

You can combine the methods. For example, first you sketch the mask quickly on the touchscreen, and then modify the point coordinates with precise values. Or you create an upper mask automatically and then add a lower mask manually.

To create a mask automatically

1. Press [MEAS CONFIG], then select th"Edit Frequency Mask".

   A default (upper) mask is displayed in the preview area of the "Edit Frequency Mask" dialog box.

2. Select "Auto-Set Mask".

   A mask in close proximity to the currently measured data is created.

3. If necessary, modify the mask or add a lower mask as described in "To create a mask manually" on page 113.

To create a mask manually

1. Press [MEAS CONFIG], then select "Edit Frequency Mask".

   A default (upper) mask with 4 points is displayed in the preview area of the "Edit Frequency Mask" dialog box.

2. If the mask you want to create is very different to the default mask, select "Delete Mask".

3. To define an upper mask, select the "Upper Mask" option.
   To define a lower mask, select the "Lower Mask" option.

4. For each mask, tap the corner points of the mask in the preview area and drag them to the required destination, or enter the position and value of each mask point in the list of coordinates to the left of the preview area.

5. If necessary, insert additional mask points to design a more complex shape:
   a) Tap an existing mask point in the preview area or in the list of coordinates before which you want to insert a new point.
   b) Select "Insert".
   An additional point is inserted in the mask in the preview area and in the list of coordinates.
   c) Drag the new point to the required destination, or define its coordinates.

6. To shift the entire mask (upper and lower) vertically or horizontally, for example to consider a frequency or reference level offset in the input signal, select "Shift x" or "Shift y".
7. Repeat these steps until the required mask shape is displayed.

   For upper masks, the display region above the defined mask points is defined as the frequency mask and filled with red color. For lower masks, the display region below the mask points is defined as the frequency mask and also filled in red.
8. Define how the frequency mask is to be evaluated, depending on whether the mask area represents the relevant or irrelevant value range. See "Trigger conditions" on page 31 for detailed descriptions of the possible conditions.
9. Optionally, store the frequency mask configuration for later use:
   a) Provide a name and, optionally, a comment for the mask.
   b) Select "Save Mask".
   c) In the file selection dialog box, select the storage location for the file (default: `C:\Program Files (x86)\Rohde-Schwarz\ESW\<version>\freqmask`).
      By default, the mask name is used as the file name; however, it can be edited.
   d) Select "Save".

   The mask is stored in a file with the extension `.FMT` in the selected directory.

9.4.2 How to use a frequency mask trigger

1. Press [TRIG], then select "Frequency Mask" to use a mask as the trigger source.
2. Press [MEAS CONFIG], then select "Edit Frequency Mask".
3. Define which frequency mask is to be used as a trigger source:
   a) Select "Load Mask" to select a stored frequency mask.
   b) In the file selection dialog box, select the storage location of the file (default: `C:\Program Files (x86)\Rohde-Schwarz\ESW\<version>\freqmask`) with the extension `.FMT`.
   c) If necessary, modify the mask as described in "To create a mask manually" on page 113.
4. Make sure the checkbox next to "Upper Mask" or "Lower Mask" is selected for use in the measurement.

   The next Real-Time Spectrum measurement will be triggered when the specified event concerning the frequency mask occurs.

9.5 How to output a trigger signal

Using the variable Trigger 2/3 connector of the R&S ESW, the internal trigger signal can be output for use by other connected devices.

For details on the connectors see the R&S ESW "Getting Started" manual.

To output a trigger to a connected device

1. Select [Trigger] > "Trigger Config".
2. Switch to the "Trigger In/Out" tab of "Trigger and Gate".
3. Set the trigger to be used to "Output".
4. Define whether the trigger signal is to be output automatically ("Output Type" = "Device triggered" or "Trigger Armed") or whether you want to start output manually ("Output Type" = "User-defined").
5. For manual output: Specify the constant signal level and the length of the trigger pulse to be output. Note that the level of the trigger pulse is opposite to the constant output "Level" setting (compare the graphic on "Send Trigger").
6. Connect a device that will receive the trigger signal to the configured Trigger 2/3 connector.
7. Start a measurement and wait for an internal trigger, or select "Send Trigger".

   The configured trigger is output to the connector.

9.6 How to output trigger signals continuously

Using the variable Trigger 2/3 connector of the R&S ESW and the "Mark only" trigger mode, an internal trigger signal can be output continuously for use by other connected devices. See also Chapter 5.5.3, "Trigger modes", on page 34.

For details on the connectors see the R&S ESW "Getting Started" manual.

To output a trigger to a connected device continuously

1. Select [Trigger] > "Trigger Config".
2. Select the trigger source, for example a frequency mask trigger.
3. Configure the trigger or frequency mask as required.
4. Select the "Mark only" trigger mode.
5. Switch to the "Trigger In/Out" tab.
6. Set the trigger to be used to "Output".
   (Note: Trigger 2 is output to the front panel connector, Trigger 3 is output to the rear panel connector. For R&S ESW85 models with two RF input connectors, Trigger 2 is not available.)

7. Set the trigger signal to be output automatically ("Output Type" = "Device triggered".
8. Connect a device that will receive the trigger signal to the configured Trigger 2/3 connector.
9. Start a measurement.

   Each trigger is output to the connector.

10 Remote commands in the real-time application

The following commands are specific to performing measurements in the Real-Time Spectrum application in a remote environment.

It is assumed that the R&S ESW has already been set up for remote control in a network as described in the R&S ESW user manual.

Note that basic tasks that are also performed in the base unit in the same way are not described here. For a description of such tasks, see the R&S ESW user manual.

In particular, this includes:

- Managing Settings and Results, i.e. storing and loading settings and result data
- Basic instrument configuration, e.g. checking the system configuration, customizing the screen layout, or configuring networks and remote operation
- Using the common status registers

The following tasks specific to Real-Time measurements are described here:

10.1 Introduction

Commands are program messages that a controller (e.g. a PC) sends to the instrument or software. They operate its functions ('setting commands' or 'events') and request information ('query commands'). Some commands can only be used in one way, others work in two ways (setting and query). If not indicated otherwise, the commands can be used for settings and queries.

The syntax of a SCPI command consists of a header and, usually, one or more parameters. To use a command as a query, you have to append a question mark after the last header element, even if the command contains a parameter.

A header contains one or more keywords, separated by a colon. Header and parameters are separated by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank). If there is more than one parameter for a command, they are separated by a comma from one another.

Only the most important characteristics that you need to know when working with SCPI commands are described here. For a more complete description, refer to the user manual of the R&S ESW.

Remote command examples

Note that some remote command examples mentioned in this general introduction are possibly not supported by this particular application.

10.1.1 Conventions used in descriptions

The following conventions are used in the remote command descriptions:

- **Command usage**
  If not specified otherwise, commands can be used both for setting and for querying parameters.
  If a command can be used for setting or querying only, or if it initiates an event, the usage is stated explicitly.
- **Parameter usage**
  If not specified otherwise, a parameter can be used to set a value, and it is the result of a query.
  Parameters required only for setting are indicated as **Setting parameters**.
  Parameters required only to refine a query are indicated as **Query parameters**.
  Parameters that are only returned as the result of a query are indicated as **Return values**.
- **Conformity**
  Commands that are taken from the SCPI standard are indicated as **SCPI confirmed**. All commands used by the R&S ESW follow the SCPI syntax rules.
- **Asynchronous commands**
  A command which does not automatically finish executing before the next command starts executing (overlapping command) is indicated as an **Asynchronous command**.
- **Reset values (*RST)**
  Default parameter values that are used directly after resetting the instrument (`*RST` command) are indicated as ***RST** values, if available.
- **Default unit**
  The default unit is used for numeric values if no other unit is provided with the parameter.
- **Manual operation**
  If the result of a remote command can also be achieved in manual operation, a link to the description is inserted.

10.1.2 Long and short form

The keywords have a long and a short form. You can use either the long or the short form, but no other abbreviations of the keywords.

The short form is emphasized in uppercase letters. Note however, that this emphasis only serves the purpose to distinguish the short from the long form in the manual. For the instrument, the case does not matter.

Example:

SENSe:FREQuency:CENTer is the same as SENS:FREQ:CENT.

10.1.3 Numeric suffixes

Some keywords have a numeric suffix if the command can be applied to multiple instances of an object. In that case, the suffix selects a particular instance (e.g. a measurement window).

Numeric suffixes are indicated by angular brackets (<n>) next to the keyword.

If you do not quote a suffix for keywords that support one, a 1 is assumed.

Example:

DISPlay[:WINDow<1...4>]:ZOOM:STATe enables the zoom in a particular measurement window, selected by the suffix at WINDow.

DISPlay:WINDow4:ZOOM:STATe ON refers to window 4.

10.1.4 Optional keywords

Some keywords are optional and are only part of the syntax because of SCPI compliance. You can include them in the header or not.

If an optional keyword has a numeric suffix and you need to use the suffix, you have to include the optional keyword. Otherwise, the suffix of the missing keyword is assumed to be the value 1.

Optional keywords are emphasized with square brackets.

Example:

Without a numeric suffix in the optional keyword:

[SENSe:]FREQuency:CENTer is the same as FREQuency:CENTer

With a numeric suffix in the optional keyword:

DISPlay[:WINDow<1...4>]:ZOOM:STATe

DISPlay:ZOOM:STATe ON enables the zoom in window 1 (no suffix).

DISPlay:WINDow4:ZOOM:STATe ON enables the zoom in window 4.

10.1.5 Alternative keywords

A vertical stroke indicates alternatives for a specific keyword. You can use both keywords to the same effect.

Example:

`[SENSe:]BANDwidth|BWIDth[:RESolution]`

In the short form without optional keywords, `BAND 1MHZ` would have the same effect as `BWID 1MHZ`.

10.1.6 SCPI parameters

Many commands feature one or more parameters.

If a command supports more than one parameter, they are separated by a comma.

Example:

`LAYout:ADD:WINDow Spectrum,LEFT,MTABle`

Parameters can have different forms of values.

10.1.6.1 Numeric values

Numeric values can be entered in any form, i.e. with sign, decimal point or exponent. For physical quantities, you can also add the unit. If the unit is missing, the command uses the basic unit.

Example:

With unit: `SENSe:FREQuency:CENTer 1GHZ`

Without unit: `SENSe:FREQuency:CENTer 1E9` would also set a frequency of 1 GHz.

Values exceeding the resolution of the instrument are rounded up or down.

If the number you have entered is not supported (e.g. for discrete steps), the command returns an error.

Instead of a number, you can also set numeric values with a text parameter in special cases.

- MIN/MAX
  Defines the minimum or maximum numeric value that is supported.
- DEF
  Defines the default value.
- UP/DOWN
  Increases or decreases the numeric value by one step. The step size depends on the setting. Sometimes, you can customize the step size with a corresponding command.

Querying numeric values

When you query numeric values, the system returns a number. For physical quantities, it applies the basic unit (e.g. Hz for frequencies). The number of digits after the decimal point depends on the type of numeric value.

Example:

Setting: `SENSe:FREQuency:CENTer 1GHZ`

Query: `SENSe:FREQuency:CENTer?` would return `1E9`

Sometimes, numeric values are returned as text.

- INF/NINF
  Infinity or negative infinity. Represents the numeric values 9.9E37 or -9.9E37.
- NAN
  Not a number. Represents the numeric value 9.91E37. NAN is returned if errors occur.

10.1.6.2 Boolean

Boolean parameters represent two states. The "on" state (logically true) is represented by "`ON`" or the numeric value 1. The "off" state (logically untrue) is represented by "`OFF`" or the numeric value 0.

Querying Boolean parameters

When you query Boolean parameters, the system returns either the value 1 ("`ON`") or the value 0 ("`OFF`").

Example:

Setting: `DISPlay:WINDow:ZOOM:STATe ON`

Query: `DISPlay:WINDow:ZOOM:STATe?` would return `1`

10.1.6.3 Character data

Character data follows the syntactic rules of keywords. You can enter text using a short or a long form. For more information, see Chapter 10.1.2, "Long and short form", on page 118.

Querying text parameters

When you query text parameters, the system returns its short form.

Example:

Setting: `SENSe:BANDwidth:RESolution:TYPE NORMal`

Query: `SENSe:BANDwidth:RESolution:TYPE?` would return `NORM`

10.1.6.4 Character strings

Strings are alphanumeric characters. They have to be in straight quotation marks. You can use a single quotation mark (') or a double quotation mark (").

Example:

```
INSTRument:DELete 'Spectrum'
```

10.1.6.5 Block data

Block data is a format which is suitable for the transmission of large amounts of data.

The ASCII character # introduces the data block. The next number indicates how many of the following digits describe the length of the data block. The data bytes follow. During the transmission of these data bytes, all end or other control signs are ignored until all bytes are transmitted. #0 specifies a data block of indefinite length. The use of the indefinite format requires an `NL^END` message to terminate the data block. This format is useful when the length of the transmission is not known or if speed or other considerations prevent segmentation of the data into blocks of definite length.

10.2 Common suffixes

In the R&S ESW Real-Time application, the following common suffixes are used in remote commands:

Table 10-1: Common suffixes used in remote commands in the R&S ESW Real-Time application

Suffix	Value range	Description
<m>	1..16	Marker
<n>	1..6	Window (**in the currently selected channel**)
<t>	1..4	Trace
	1 to 8	Limit line
<i>	1..3	Selects one of the analog output channels (1, 2 or Phones).
<k>	1..8 (Limit line) 1 | 2 (Display line)	Selects a limit or display line.
<peak>	1..3000	Selects a peak.
<sr>	1..10	Selects a scan range.

Selecting windows in multiple channels
Note that the suffix <n> always refers to a window in the currently selected channel.

10.3 Application selection

Real-Time measurements require a special application. A measurement is started immediately with the default settings.

INSTrument:CREate:DUPLicate

Duplicates the currently selected channel, i.e creates a new channel of the same type and with the identical measurement settings. The name of the new channel is the same as the copied channel, extended by a consecutive number (e.g. "IQAnalyzer" -> "IQAnalyzer 2").

The channel to be duplicated must be selected first using the `INST:SEL` command.

Example:
`INST:SEL 'Receiver'`
`INST:CRE:DUPL`
Duplicates the channel named 'Receiver' and creates a new channel named 'Receiver 2'.

Usage: Event

INSTrument:CREate[:NEW] <ChannelType>, <ChannelName>

Adds a measurement channel. You can configure up to 10 measurement channels at the same time (depending on available memory).

Parameters:

<ChannelType> Channel type of the new channel.
For a list of available channel types, see `INSTrument:LIST?` on page 124.

<ChannelName> String containing the name of the channel.
Note that you cannot assign an existing channel name to a new channel. If you do, an error occurs.

Example:
`INST:CRE SAN, 'Spectrum 2'`
Adds a spectrum display named "Spectrum 2".

INSTrument:CREate:REPLace <ChannelName1>, <ChannelType>, <ChannelName2>

Replaces a channel with another one.

Setting parameters:

<ChannelName1> String containing the name of the channel you want to replace.

<ChannelType> Channel type of the new channel.
For a list of available channel types, see `INSTrument:LIST?` on page 124.

<ChannelName2> String containing the name of the new channel.
Note: If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel (see `INSTrument:LIST?` on page 124).
Channel names can have a maximum of 31 characters, and must be compatible with the Windows conventions for file names. In particular, they must not contain special characters such as ":", "*", "?".

Example: `INST:CRE:REPL 'Receiver',REC,'REC2'`
Replaces the channel named "Receiver" by a new channel of type "Receiver" named "REC2".

Usage: Setting only

INSTrument:DELete <ChannelName>

Deletes a channel.

If you delete the last channel, the default "Receiver" channel is activated.

Setting parameters:

<ChannelName> String containing the name of the channel you want to delete.
A channel must exist to delete it.

Example: `INST:DEL 'Receiver'`
Deletes the channel with the name 'Receiver'.

Usage: Setting only

INSTrument:LIST?

Queries all active channels. The query is useful to obtain the names of the existing channels, which are required to replace or delete the channels.

Return values:

<ChannelType>, <ChannelName> For each channel, the command returns the channel type and channel name (see tables below).
Tip: to change the channel name, use the `INSTrument:REName` command.

Example: `INST:LIST?`
Result for 2 channels:
`'REC','Receiver','REC','Receiver 2'`

Usage: Query only

Table 10-2: Available channel types and default channel names

Application	<ChannelType> Parameter	Default Channel Name*)
Receiver	RECeiver	Receiver
CISPR APD	n/a Use `CALCulate:STATistics:CAPD[:STATe]`	CISPR APD
Real-Time Spectrogram	RTSG	Real-Time Spectrogram
Multi CISPR APD	MAPD	Multi CISPR APD
Spectrum	SANalyzer	Spectrum
I/Q Analyzer	IQ	IQ Analyzer
Real-Time Spectrum	RTIM	Real-Time Spectrum
Analog Modulation Analysis	ADEMod	Analog Demod
Note: the default channel name is also listed in the table. If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel.		

INSTrument:REName <ChannelName1>, <ChannelName2>

Renames a channel.

Setting parameters:

<ChannelName1> String containing the name of the channel you want to rename.

<ChannelName2> String containing the new channel name.
Note that you cannot assign an existing channel name to a new channel. If you do, an error occurs.
Channel names can have a maximum of 31 characters, and must be compatible with the Windows conventions for file names. In particular, they must not contain special characters such as ":", "*", "?".

Example: `INST:REN 'Receiver','REC'`
Renames the channel with the name 'Receiver' to 'REC'.

Usage: Setting only

INSTrument[:SELect] <ChannelType> | <ChannelName>

Activates a new channel with the defined channel type, or selects an existing channel with the specified name.

Also see

- `INSTrument:CREate[:NEW]` on page 123

Parameters:

<ChannelType> Channel type of the new channel.
For a list of available channel types see `INSTrument:LIST?` on page 124.

<ChannelName> String containing the name of the channel.

Example: `INST IQ`
Activates a channel for the I/Q Analyzer application (evaluation mode).
`INST 'MyIQSpectrum'`
Selects the channel named 'MyIQSpectrum' (for example before executing further commands for that channel).

SYSTem:PRESet:COMPatible <OpMode>

Defines the operating mode that is activated when you switch on the R&S ESW or press [PRESET].

Parameters:

<OpMode> **SANalyzer**
Defines Signal and Spectrum Analyzer operating mode as the presetting.
RECeiver
Selects the receiver application as the default application (default value).

SYSTem:PRESet:CHANnel[:EXEC]

Restores the default <instrument> settings in the current channel.

Use `INST:SEL` to select the channel.

Example: `INST:SEL 'Spectrum2'`
Selects the channel for "Spectrum2".
`SYST:PRES:CHAN:EXEC`
Restores the factory default settings to the "Spectrum2" channel.

Usage: Event

Manual operation: See "Preset Channel" on page 55

10.4 Measurement configuration

10.4.1 Input configuration

INPut:ATTenuation:LIMiter[:STATe] <State>

This command turns the pulse limiter on and off.

The pulse limiter is an additional protection mechanism for the second RF input that attenuates high level pulses.

Parameters:

<State> ON | OFF | 1 | 0

*RST: ON

Example: //Turn on pulse limiter
`INP:ATT:LIM ON`

Manual operation: See "Pulse Limiter" on page 57

INPut:COUPling <CouplingType>

Selects the coupling type of the RF input.

Parameters:

<CouplingType> AC | DC

AC
AC coupling

DC
DC coupling

*RST: AC

Example: `INP:COUP DC`

Manual operation: See "Input Coupling" on page 56

INPut:IMPedance <Impedance>

Selects the nominal input impedance of the RF input. In some applications, only 50 Ω are supported.

Parameters:

<Impedance> 50 | 75

*RST: 50 Ω
Default unit: OHM

Example: `INP:IMP 75`

Manual operation: See "Impedance" on page 56
See "Unit" on page 61

INPut:TYPE <Input>

The command selects the input path.

Parameters:

<Input>

INPUT1
Selects RF input 1.

INPUT2
Selects RF input 2.

*RST: INPUT1

Example: //Select input path
`INP:TYPE INPUT1`

Manual operation: See "Input Selection" on page 56

10.4.2 Output configuration

OUTPut:TRIGger<tp>:DIRection <Direction>

Selects the trigger direction for trigger ports that serve as an input as well as an output.

Suffix:

<tp> Selects the used trigger port.
2 = trigger port 2 (front)
3 = trigger port 3 (rear panel)

Parameters:

<Direction> INPut | OUTPut

INPut
Port works as an input.

OUTPut
Port works as an output.

*RST: INPut

OUTPut:TRIGger<tp>:LEVel <Level>

Defines the level of the (TTL compatible) signal generated at the trigger output.

Works only if you have selected a user-defined output with `OUTPut:TRIGger<tp>:OTYPe`.

Suffix:

<tp> 1..n
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Parameters:

<Level> **HIGH**
5 V

LOW
0 V

*RST: LOW

Example: `OUTP:TRIG2:LEV HIGH`

OUTPut:TRIGger<tp>:OTYPe <OutputType>

Selects the type of signal generated at the trigger output.

Suffix:

<tp> 1..n
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Parameters:

<OutputType> **DEVice**
Sends a trigger signal when the R&S ESW has triggered internally.

TARMed
Sends a trigger signal when the trigger is armed and ready for an external trigger event.

UDEFined
Sends a user-defined trigger signal. For more information, see `OUTPut:TRIGger<tp>:LEVel`.

*RST: DEVice

OUTPut:TRIGger<tp>:PULSe:IMMediate

Generates a pulse at the trigger output.

Suffix:
<tp> 1..n
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

OUTPut:TRIGger<tp>:PULSe:LENGth <Length>

Defines the length of the pulse generated at the trigger output.

Suffix:
<tp> Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Parameters:
<Length> Pulse length in seconds.
Default unit: S

Example: `OUTP:TRIG2:PULS:LENG 0.02`

10.4.3 Amplitude configuration

CALCulate<n>:MARKer<m>:FUNCtion:REFerence

Matches the reference level to the power level of a marker.

If you use the command in combination with a delta marker, that delta marker is turned into a normal marker.

Suffix:
<n> Window

<m> Marker

Example: `CALC:MARK2:FUNC:REF`
Sets the reference level to the level of marker 2.

Manual operation: See "Reference Level = Marker Level" on page 102

CALCulate<n>:UNIT:POWer <Unit>

Selects the power unit.

The unit applies to all power-based measurement windows with absolute values.

In addition, the unit of the reference level is adapted to the same unit.

Suffix:
<n> irrelevant

Parameters:
<Unit> *RST: dBm

Example: `CALC:UNIT:POW DBM`
Sets the power unit to dBm.

Manual operation: See "Unit" on page 61

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel <ReferenceLevel>

Defines the reference level (for all traces in all windows).

With a reference level offset ≠ 0, the value range of the reference level is modified by the offset.

Suffix:
<n> irrelevant

<w> subwindow
Not supported by all applications

<t> irrelevant

Parameters:
<ReferenceLevel> The unit is variable.
Range: see specifications document
*RST: 0 dBm
Default unit: DBM

Example: `DISP:TRAC:Y:RLEV -60dBm`

Manual operation: See "Reference Level" on page 60

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel:OFFSet <Offset>

Defines a reference level offset (for all traces in all windows).

Suffix:
<n> irrelevant

<w> subwindow
Not supported by all applications

<t> irrelevant

Parameters:

<Offset> Range: -200 dB to 200 dB
*RST: 0dB
Default unit: DB

Example: `DISP:TRAC:Y:RLEV:OFFS -10dB`

Manual operation: See "Shifting the Display (Offset)" on page 60

INPut:ATTenuation[:VALue] <Attenuation>

This command defines the attenuation at the RF input.

To protect the input mixer, attenuation levels of 10 dB or less are possible only if you have turned off the input protection with `INPut:ATTenuation:PROTection[:STATe]` on page 132.

Example: //Define attenuation
`INP:ATT 40dB`

Manual operation: See "Attenuation" on page 61

INPut:ATTenuation:AUTO <State>

This command turns automatic determination of the attenuation level on and off.

When you turn it on, the R&S ESW selects an attenuation that results in a good signal-to-noise ratio without overloading the RF input.

Parameters:

<State> ON | OFF

ON
Selects automatic attenuation mode.

OFF
Selects manual attenuation mode.

*RST: ON

Example: //Turn on auto ranging
`INP:ATT:AUTO ON`

Manual operation: See "Attenuation" on page 61

INPut:ATTenuation:PROTection[:STATe] <State>

This command turns the availability of attenuation levels of 10 dB or less on and off.

Parameters:

<State> ON | OFF | 1 | 0

*RST: 1

Example: //Turn on input protection
`INP:ATT:PROT ON`

Manual operation: See "10 dB Minimum Attenuation" on page 62

INPut:GAIN:LNA:AUTO <State>

This command includes and excludes the optional low noise amplifier from the auto ranging feature.

Parameters:
<State> ON | OFF | 1 | 0
*RST: OFF

Example: //Allow to turn the amplifier on and off manually
`INP:GAIN:LNA:STAT ON`
`INP:GAIN:LNA:AUTO OFF`

INPut:GAIN:LNA:STATe <State>

This command turns the optional low noise amplifier on and off.

Note that it is not possible to use the low noise amplifier and the preamplifier at the same time.

Parameters:
<State> ON | OFF | 1 | 0
*RST: OFF

Example: //Turn on low noise preamplifier
`INP:GAIN:LNA:STAT ON`

Manual operation: See "Preamplifier" on page 62

10.4.4 Y-Axis scale

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe] <Range>

Defines the display range of the y-axis (for all traces).

Suffix:
<n> Window

<w> subwindow
Not supported by all applications

<t> irrelevant

Parameters:
<Range> Range: 1 dB to 200 dB
*RST: 100 dB
Default unit: HZ

Example: `DISP:TRAC:Y 110dB`

Manual operation: See "Range" on page 63

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:AUTO ONCE

Automatic scaling of the y-axis is performed once, then switched off again (for all traces).

Suffix:
<n> Window

<t> irrelevant

Manual operation: See "Auto Scale Once" on page 63

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:MODE <Mode>

Selects the type of scaling of the y-axis (for all traces).

When the display update during remote control is off, this command has no immediate effect.

Suffix:
<n> Window

<w> subwindow

<t> irrelevant

Parameters:
<Mode> **ABSolute**
absolute scaling of the y-axis
RELative
relative scaling of the y-axis
*RST: ABSolute

Example: `DISP:TRAC:Y:MODE REL`

Manual operation: See "Scaling" on page 63

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RPOSition <Position>

Defines the vertical position of the reference level on the display grid (for all traces).

The R&S ESW adjusts the scaling of the y-axis accordingly.

Suffix:

<n>	Window
<w>	subwindow Not supported by all applications
<t>	irrelevant

Example: `DISP:TRAC:Y:RPOS 50PCT`

Manual operation: See "Ref Level Position" on page 63

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y:SPACing <ScalingType>

Selects the scaling of the y-axis (for all traces, <t> is irrelevant).

Suffix:

<n>	Window
<w>	subwindow
<t>	Trace

Parameters:

<ScalingType>

LOGarithmic
Logarithmic scaling.

LINear
Linear scaling in %.

LDB
Linear scaling in the specified unit.

PERCent
Linear scaling in %.

*RST: LOGarithmic

Example: `DISP:TRAC:Y:SPAC LIN`
Selects linear scaling in %.

Manual operation: See "Scaling" on page 63

10.4.5 Frequency and span configuration

[SENSe:]FREQuency:CENTer <Frequency>

Defines the center frequency.

Parameters:

<Frequency> For the allowed range and f_{max}, refer to the specifications document.

*RST: fmax/2
Default unit: Hz

Example:
```
FREQ:CENT 100 MHz
FREQ:CENT:STEP 10 MHz
FREQ:CENT UP
```
Sets the center frequency to 110 MHz.

Manual operation: See "Center Frequency" on page 58

[SENSe:]FREQuency:CENTer:STEP <StepSize>

Defines the center frequency step size.

Parameters:

<StepSize> For f_{max}, refer to the specifications document.

Range: 1 to fMAX
*RST: 0.1 x span
Default unit: Hz

Example: //Set the center frequency to 110 MHz.
```
FREQ:CENT 100 MHz
FREQ:CENT:STEP 10 MHz
FREQ:CENT UP
```

Manual operation: See "Center Frequency Stepsize" on page 58

[SENSe:]FREQuency:CENTer:STEP:AUTO <State>

Couples or decouples the center frequency step size to the span.

In time domain (zero span) measurements, the center frequency is coupled to the RBW.

Parameters:

<State> ON | OFF | 0 | 1

*RST: 1

Example:
```
FREQ:CENT:STEP:AUTO ON
```
Activates the coupling of the step size to the span.

[SENSe:]FREQuency:CENTer:STEP:LINK <CouplingType>

Couples and decouples the center frequency step size to the span or the resolution bandwidth.

Parameters:

<CouplingType> SPAN | RBW | OFF

SPAN
Couples the step size to the span. Available for measurements in the frequency domain.

OFF
Decouples the step size.

*RST: SPAN

Example: //Couple step size to span
```
FREQ:CENT:STEP:LINK SPAN
```

[SENSe:]FREQuency:CENTer:STEP:LINK:FACTor <Factor>

Parameters:

<Factor> 1 to 100 PCT

*RST: 10
Default unit: PCT

Example: //Couple frequency step size to span and define a step size factor
```
FREQ:CENT:STEP:LINK SPAN
FREQ:CENT:STEP:LINK:FACT 20PCT
```

[SENSe:]FREQuency:CISPr <Mode>

Setting parameters:

<Mode> ABANd | BBANd

Usage: Setting only

Manual operation: See "CISPR Band A / CISPR Band B" on page 59

[SENSe:]FREQuency:OFFSet <Offset>

Defines a frequency offset.

If this value is not 0 Hz, the application assumes that the input signal was frequency shifted outside the application. All results of type "frequency" will be corrected for this shift numerically by the application.

Parameters:

<Offset> Range: -1 THz to 1 THz
*RST: 0 Hz
Default unit: HZ

Example: `FREQ:OFFS 1GHZ`

Manual operation: See "Frequency Offset" on page 59

[SENSe:]FREQuency:SPAN <Span>

Defines the frequency span.

Parameters:

<Span> Range: 1 kHz to 80 MHz
*RST: fmax

Manual operation: See "Span" on page 58
See "Last Span" on page 58

[SENSe:]FREQuency:SPAN:FULL

Restores the full span.

Manual operation: See "Full Span" on page 58

[SENSe:]FREQuency:STARt <Frequency>

Defines the start frequency for a Real-Time measurement. If you set a start frequency that would exceed the maximum span, the R&S ESW adjusts the stop frequency to stay within the maximum span.

Defines the start frequency for a Real-Time measurement. If you set a start frequency that would exceed the maximum span, the R&S ESW adjusts the stop frequency to stay within the maximum span.

Parameters:

<Frequency> 0 to (fmax - min span)
*RST: 0
Default unit: HZ

Example: `FREQ:STAR 20MHz`

Manual operation: See "Start / Stop" on page 58

[SENSe:]FREQuency:STOP <Frequency>

Defines the stop frequency for a Real-Time measurement. If you set a start frequency that would exceed the maximum span, the R&S ESW adjusts the start frequency to stay within the maximum span.

Defines the stop frequency for a Real-Time measurement. If you set a start frequency that would exceed the maximum span, the R&S ESW adjusts the start frequency to stay within the maximum span.

Parameters:

<Frequency>	min span to fmax *RST: fmax Default unit: HZ
Example:	`FREQ:STOP 2000 MHz`
Manual operation:	See "Start / Stop" on page 58

10.4.6 Bandwidth and sweep configuration

Commands to configure the bandwidth and sweep described elsewhere.

- `[SENSe:]AVERage<n>:COUNt` on page 193

[SENSe:]BANDwidth[:RESolution] <Bandwidth>

Defines the resolution bandwidth and decouples the resolution bandwidth from the span.

Parameters:

<Bandwidth>	refer to specifications document Default unit: Hz
Example:	`BAND 1 MHz` Sets the resolution bandwidth to 1 MHz
Manual operation:	See "RBW" on page 73

[SENSe:]BANDwidth[:RESolution]:RATio <Ratio>

Defines the ratio between the resolution bandwidth (Hz) and the span (Hz).

Note that the ratio defined with this remote command (RBW/span) is reciprocal to that of the coupling ratio (span/RBW).

Changing this ratio also affects the FFT length, which in turn affects the time resolution of the FFT. Furthermore, the ratio also affects the RBW value according to:

RBW = Span / Coupling ratio

Parameters:

<Ratio>	Range: 0.0001 to 1
Example:	`BAND:RAT 0.1`

Example: Chapter 10.10.3, "Example 3: analyzing persistency", on page 236

Manual operation: See "RBW" on page 73

[SENSe:]SWEep:COUNt <SweepCount>

Defines the number of measurements that the application uses to average traces.

In continuous measurement mode, the application calculates the moving average over the average count.

In single measurement mode, the application stops the measurement and calculates the average after the average count has been reached.

Example:

`SWE:COUN 64`
Sets the number of measurements to 64.
`INIT:CONT OFF`
Switches to single measurement mode.
`INIT;*WAI`
Starts a measurement and waits for its end.

Manual operation: See "Sweep Count" on page 75

[SENSe:]SWEep:DTIMe <Time>

Determines the amount of time used to sample a continuous stream of I/Q data. The stream is displayed as multiple rows in the spectrogram or waterfall diagrams (as opposed to the *sweep time*, which defines the time to capture a *single* row in the diagrams). Dwell time is never applied for triggered measurements. It is only applied in single sweep mode or when the Sequencer is in continuous mode.

The query returns the amount of time used to sample I/Q data in the current measurement.

Tip: the dwell time can also be defined automatically, see `[SENSe:]SWEep:DTIMe:AUTO` on page 140.

For more information see Chapter 5.4, "Sweep time and detector", on page 28.

Parameters:

<Time> numeric value

Range: 30 ms to 3600 s
*RST: 30 ms
Default unit: s

Example:

```
SENS:SWE:DTIM:AUTO OFF
SENS:SWE:DTIM 1s
```

Manual operation: See "Dwell Time" on page 74

[SENSe:]SWEep:DTIMe:AUTO <State>

Determines whether the dwell time is defined automatically or manually.

For more information see Chapter 5.4, "Sweep time and detector", on page 28.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example:
```
SENS:SWE:DTIM:AUTO OFF
SENS:SWE:DTIM 1s
```

Manual operation: See "Dwell Time" on page 74

[SENSe:]SWEep:FFT:WINDow:TYPE <FFTWindow>

Selects the type of FFT window that you want to use in Real-Time mode.

Parameters:

<FFTWindow>

BLACkharris

FLATtop

GAUSsian

HAMMing

HANNing

KAISerbessel

RECTangular

*RST: BLACkharris

Example: `SWE:FFT:WIND:TYPE HANN`
Selects the Hanning FFT window.

Example: See Chapter 10.10.3, "Example 3: analyzing persistency", on page 236.

Manual operation: See "FFT Window" on page 73

[SENSe:]SWEep:TIME <Time>

Determines the amount of time used to sample data for one real-time spectrum.

For more information see Chapter 5.4, "Sweep time and detector", on page 28.

Parameters:

<Time> refer to specifications document

Default unit: S

Example: `SWE:TIME 0.3`
Defines an acquisition time of 0.3 s.

Manual operation: See "Sweep Time" on page 74

[SENSe:]SWEep:TIME:AUTO <State>

Activates and deactivates automatic sweep time definition.

Parameters:

<State> ON | OFF | 0 | 1

*RST: 1

Example: `SWE:TIME:AUTO ON`

Activates automatic sweep time.

Manual operation: See "Sweep Time" on page 74

10.4.7 Trigger configuration

*OPC should be used after requesting data. This will hold off any subsequent changes to the selected trigger source, until after the sweep is completed and the data is returned.

10.4.7.1 Trigger conditions

TRIGger:MODE <Mode>

Turns continuous triggering on and off.

Parameters:

<Mode>

CONTinuous
Continuous measurement

STOP
Measurement stops after the trigger event is done

MARK
A free-run measurement is performed; the trigger event is merely indicated in the results, but does not change the behavior of the measurement.
This setting is only available for R&S ESW-B512R/-B800R.

*RST: CONTinuous

Example: See Chapter 10.10.2, "Example 2: performing a basic real-time measurement", on page 233.

Example: See Chapter 10.10.3, "Example 3: analyzing persistency", on page 236.

Manual operation: See "Trigger mode (Auto Rearm/ Stop on Trigger/ Mark only)" on page 66

TRIGger<tp>[:SEQuence]:HOLDoff[:TIME] <Offset>

Defines the time offset between the trigger event and the start of the measurement (data capturing).

A negative offset is possible for time domain measurements.

For the trigger sources "External" or "IF Power", a common input signal is used for both trigger and gate. Therefore, changes to the gate delay affect the trigger offset as well.

Suffix:
<tp> irrelevant

Parameters:
<Offset> Range for measurements in the frequency domain:
0 s to 30 s
Range for measurements in the time domain:
negative sweep time to 30 s
*RST: 0 s
Default unit: s

Example: //Define a trigger offset
`TRIG:HOLD 500us`

Manual operation: See "Trigger Offset" on page 66

TRIGger<tp>[:SEQuence]:LEVel[:EXTernal] <Level>

Defines the level the external signal must exceed to cause a trigger event.

Note that the variable [Input/Output] connectors must be set for use as input using the `OUTPut:TRIGger<tp>:DIRection` command.

Suffix:
<tp> irrelevant

Parameters:
<Level> Default unit: V

Example: //Define a trigger level of 2 V for an external trigger source
`TRIG:SOUR EXT`
`TRIG:LEV 2V`

Manual operation: See "Trigger Level" on page 66

TRIGger[:SEQuence]:POSTtrigger[:TIME] <Time>

Defines the length of the posttrigger.

Parameters:

<Time> Length of the posttrigger in seconds.
Note that the pre- and posttrigger combined may not be longer than 1 second.

Range: 0 s to 1 s
*RST: 60 ms
Default unit: S

Example: `TRIG:POST 0.5s`
Selects a posttrigger time of 0.5 seconds.

Example: See Chapter 10.10.2, "Example 2: performing a basic real-time measurement", on page 233.

Example: See Chapter 10.10.3, "Example 3: analyzing persistency", on page 236.

Manual operation: See "Posttrigger capture time" on page 66

TRIGger[:SEQuence]:PRETrigger[:TIME] <Time>

Defines the length of the pretrigger.

Parameters:

<Time> Length of the pretrigger in seconds.
Note that the pre- and posttrigger combined may not be longer than 1 second.

Range: 0 s to 1 s
*RST: 60 ms
Default unit: S

Example: `TRIG:PRE 0.5s`
Selects a pretrigger time of 0.5 seconds.

Example: See Chapter 10.10.2, "Example 2: performing a basic real-time measurement", on page 233.

Example: See Chapter 10.10.3, "Example 3: analyzing persistency", on page 236.

Manual operation: See "Pretrigger capture time" on page 66

TRIGger<tp>[:SEQuence]:SLOPe <Type>

Selects the trigger slope.

Suffix:
<tp> irrelevant

Parameters:
<Type>

POSitive
Triggers when the signal rises to the trigger level (rising edge).

NEGative
Triggers when the signal drops to the trigger level (falling edge).

*RST: POSitive

Example: //Select trigger slope
`TRIG:SLOP NEG`

Manual operation: See "Slope" on page 66

TRIGger<tp>[:SEQuence]:SOURce <Source>

Selects the trigger source.

Note on external triggers:

If a measurement is configured to wait for an external trigger signal in a remote control program, remote control is blocked until the trigger is received and the program can continue. Make sure that this situation is avoided in your remote control programs.

Suffix:
<tp> irrelevant

Parameters:
<Source> See table below.

*RST: IMMediate

Example: //Select external trigger input as source of the trigger signal
`TRIG:SOUR EXT`

Manual operation: See "Trigger Source" on page 65
See "Free Run" on page 65
See "Ext. Trigger 1/2" on page 65
See "Frequency Mask" on page 65
See "Activate" on page 69

Table 10-3: Available trigger sources

SCPI parameter	Trigger source
EXTernal	Trigger signal from the [Trigger Input] connector.
EXT2 | EXT3	Trigger signal from the [Trigger Input/Output] connector. Note: Connector must be configured for "Input".
IMMediate	Free Run trigger.
MASK	Frequency mask trigger.

10.4.7.2 Frequency mask trigger

The Frequency Mask Trigger (FMT) is a mask in the frequency domain, which is checked with every calculated FFT. When a specific condition concerning this mask occurs during the measurement of the input signal, data capturing is triggered.

For details see Chapter 5.5.1, "Triggering on specific frequency events (frequency mask trigger)", on page 29.

CALCulate<n>:MASK:CDIRectory <Subdirectory>

Selects the directory the R&S ESW stores frequency masks in.

Suffix:
<n> Window

Parameters:
<Subdirectory> String containing the path to the directory. The directory has to be a subdirectory of the default directory. Thus the path is always relative to the default directory (`C:\R_S\INSTR\freqmask`).
An empty string selects the default directory.

Example: See Chapter 10.10.1, "Example 1: creating a frequency mask trigger", on page 232.

Example: See Chapter 10.10.2, "Example 2: performing a basic real-time measurement", on page 233.

Manual operation: See "Save" on page 69
See "Load" on page 69

CALCulate<n>:MASK:COMMent <Comment>

Defines a comment for the frequency mask that you have selected with `CALCulate<n>:MASK:NAME` on page 149.

Suffix:
<n> Window

Parameters:
<Comment> String containing the comment for the frequency mask.

Example: See Chapter 10.10.1, "Example 1: creating a frequency mask trigger", on page 232.

Manual operation: See "Comment" on page 70

CALCulate<n>:MASK:DELete

Suffix:
<n> 1..n

Manual operation: See "Delete Mask" on page 69

CALCulate<n>:MASK:LOWer:SHIFt:X <Frequency>

Shifts the lower frequency mask horizontally by a specified distance. Positive values move the mask to the right, negative values shift the mask to the left.

Before making any changes to a frequency mask, you have to select one by name with `CALCulate<n>:MASK:NAME` on page 149.

Suffix:
<n> Window

Parameters:
<Frequency> Defines the distance of the shift.
Default unit: Hz

Manual operation: See "Shifting the mask position horizontally (Shift x)" on page 71

CALCulate<n>:MASK:LOWer:SHIFt:Y <Level>

Shifts the lower frequency mask vertically by a specified distance. Positive values move the mask upwards, negative values shift the mask downwards.

Before making any changes to a frequency mask, you have to select one by name with `CALCulate<n>:MASK:NAME` on page 149.

Suffix:
<n> Window

Parameters:
<Level> Defines the distance of the shift. The shift is relative to the current position.
Default unit: dB

Example: See Chapter 10.10.1, "Example 1: creating a frequency mask trigger", on page 232.

Manual operation: See "Shifting the mask vertically (Shift y)" on page 71

CALCulate<n>:MASK:LOWer:STATe <State>

Turns the lower frequency mask on and off.

Before making any changes to a frequency mask, you have to select one by name with `CALCulate<n>:MASK:NAME` on page 149.

Suffix:
<n> Window

Parameters:
<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: See Chapter 10.10.1, "Example 1: creating a frequency mask trigger", on page 232.

Manual operation: See "Selecting and deselecting upper and lower masks" on page 71

CALCulate<n>:MASK:LOWer[:DATA] <Frequency>,<Level>,...

Defines the shape of the lower frequency mask.

Before making any changes to a frequency mask, you have to select one by name with `CALCulate<n>:MASK:NAME` on page 149.

The unit of the power levels depends on `CALCulate<n>:MASK:MODE` on page 149.

For R&S ESW-K70, this command is query only.

[N] pairs of numerical values. [N] is the number of data points the mask consists of.

Each data point is defined by the frequency and the level. All values are separated by commas.

Note that the data points have to be inside the current span.

Suffix:
<n> Window

Parameters:
<Frequency> Frequency of the data point
Default unit: Hz

<Level> Level of the data point
Default unit: DBM

Example: See Chapter 10.10.1, "Example 1: creating a frequency mask trigger", on page 232.

Manual operation: See "Mask points" on page 70
See "Inserting points" on page 70
See "Deleting points" on page 70

CALCulate<n>:MASK:MODE <Mode>

Defines the scaling of the level axis for frequency masks.

Suffix:
<n> Window

Parameters:
<Mode>

ABSolute
absolute scaling of the level axis.

RELative
relative scaling of the level axis.

*RST: RELative

Example: See Chapter 10.10.1, "Example 1: creating a frequency mask trigger", on page 232.

Manual operation: See "Changing the y-axis scaling (Y-Axis rel/abs)" on page 71

CALCulate<n>:MASK:NAME <Name>

Suffix:
<n> 1..n
Window

Parameters:
<Name> String containing the name of the mask.
Note that an empty string does not select a frequency mask.

Example: See Chapter 10.10.1, "Example 1: creating a frequency mask trigger", on page 232.

Manual operation: See "New" on page 69
See "Save" on page 69
See "Load" on page 69
See "Name" on page 70

CALCulate<n>:MASK:SPAN <Span>

Defines the frequency span of the frequency mask.

Suffix:
<n> Window

Parameters:
<Span>
Range: 1 kHz to 80 MHz
*RST: fmax
Default unit: HZ

Example: `CALC:MASK:SPAN 10 MHz`
Defines a span of 10 MHz.

Example: See Chapter 10.10.1, "Example 1: creating a frequency mask trigger", on page 232.

CALCulate<n>:MASK:UPPer:AUTO

Suffix:
<n> 1..n

Manual operation: See "Defining a mask automatically (Auto-Set Mask)" on page 71

CALCulate<n>:MASK:UPPer:SHIFt:X <Frequency>

Shifts the lower frequency mask horizontally by a specified distance. Positive values move the mask to the right, negative values shift the mask to the left.

You have to select a mask before you can use this command with `CALCulate<n>:MASK:NAME` on page 149.

Suffix:
<n> Window

Parameters:
<Frequency> Defines the distance of the shift.
Default unit: HZ

Manual operation: See "Shifting the mask position horizontally (Shift x)" on page 71

CALCulate<n>:MASK:UPPer:SHIFt:Y <Level>

Shifts the upper frequency mask vertically by a specified distance. Positive values move the mask upwards, negative values shift the mask downwards.

You have to select a mask before you can use this command with `CALCulate<n>:MASK:NAME` on page 149.

Suffix:
<n> Window

Parameters:
<Level> Defines the distance of the shift. The shift is relative to the current position.
Default unit: dB

Manual operation: See "Shifting the mask vertically (Shift y)" on page 71

CALCulate<n>:MASK:UPPer:STATe <State>

Turns the upper frequency mask on and off.

Before making any changes to a frequency mask, you have to select one by name with `CALCulate<n>:MASK:NAME` on page 149.

Suffix:

<n> Window

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Manual operation: See "Selecting and deselecting upper and lower masks" on page 71

CALCulate<n>:MASK:UPPer[:DATA] {<Frequency>,<Level>}

Activates and defines the shape of the upper frequency mask trigger mask.

You have to select a mask before you can use this command with `CALCulate<n>:MASK:NAME` on page 149.

[N] pairs of numerical values. [N] is the number of data points the mask consists of.

Each data point is defined by the frequency and the level. All values are separated by commas.

Suffix:

<n> Window

Parameters:

<Frequency> Frequency of the data point within the current span.
Default unit: Hz

<Level> Level of the data point. The unit of the power levels depends on `CALCulate<n>:MASK:MODE` on page 149.
Default unit: DBM

Example: See Chapter 10.10.1, "Example 1: creating a frequency mask trigger", on page 232.

Manual operation: See "Mask points" on page 70
See "Inserting points" on page 70
See "Deleting points" on page 70

TRIGger[:SEQuence]:MASK:CONDition <Condition>

Sets the condition that activates the frequency mask trigger.

For details see Chapter 5.5.1, "Triggering on specific frequency events (frequency mask trigger)", on page 29.

Parameters:

<Condition> **ENTer**
Triggers on entering the frequency mask.

LEAVing
Triggers on leaving the frequency mask.

*RST: ENTer

Example: See Chapter 10.10.2, "Example 2: performing a basic real-time measurement", on page 233.

Example: See Chapter 10.10.3, "Example 3: analyzing persistency", on page 236.

Manual operation: See "Setting the trigger condition" on page 71

10.4.8 Spectrogram configuration

CALCulate<n>:SPECtrogram:CLEar[:IMMediate]

Resets the spectrogram and clears the history buffer.

Suffix:

<n> Window

Example: //Reset the result display and clear the memory
`CALC:SGR:CLE`

Manual operation: See "Clear Spectrogram" on page 75

CALCulate<n>:SPECtrogram:FRAMe:SELect <Frame> | <Time>

Selects a specific frame for further analysis.

The command is available if no measurement is running or after a single sweep has ended.

Suffix:

<n> Window

Parameters:

<Frame> Selects a frame directly by the frame number. Valid if the time stamp is off.
The range depends on the history depth.

Default unit: S

<Time> Selects a frame via its time stamp. Valid if the time stamp is on. The number is the distance to frame 0 in seconds. The range depends on the history depth.

Example:
`INIT:CONT OFF`
Stop the continuous sweep.
`CALC:SGR:FRAM:SEL -25`
Selects frame number -25.

Manual operation: See "Selecting a frame to display" on page 82

CALCulate<n>:SPECtrogram:HDEPth <History>

Defines the number of frames to be stored in the R&S ESW memory.

Suffix:
<n> Window

Parameters:
<History> The maximum number of frames depends on the number of sweep points.

Range: 781 to 20000
Increment: 1
*RST: 3000

Example:
//Set the history depth to 1500
`CALC:SGR:SPEC 1500`

Manual operation: See "History Depth" on page 82

CALCulate<n>:SPECtrogram:TSTamp:DATA? <Frames>

Queries the starting time of the frames.

The return values consist of four values for each frame. If the "Spectrogram" is empty, the command returns '0,0,0,0'. The times are given as delta values, which simplifies evaluating relative results; however, you can also calculate the absolute date and time as displayed on the screen.

The frame results themselves are returned with `TRAC:DATA? SGR`

Suffix:
<n> Window

Query parameters:
<Frames>

CURRent
Returns the starting time of the current frame.

ALL
Returns the starting time for all frames. The results are sorted in descending order, beginning with the current frame.

Return values:
<Seconds> Number of seconds that have passed since 01.01.1970 until the frame start

<Nanoseconds> Number of nanoseconds that have passed *in addition to the <Seconds>* since 01.01.1970 until the frame start.

<Reserved> The third value is reserved for future uses.

<Reserved> The fourth value is reserved for future uses.

Example: `CALC:SGR:TST:DATA? ALL`
Returns the starting times of all frames sorted in a descending order.

Usage: Query only

Manual operation: See "Time Stamp" on page 82

CALCulate<n>:SPECtrogram:TSTamp[:STATe] <State>

Activates and deactivates the time stamp.

If the time stamp is active, some commands do not address frames as numbers, but as (relative) time values:

- `CALCulate<n>:DELTamarker<m>:SPECtrogram:FRAMe` on page 220
- `CALCulate<n>:MARKer<m>:SPECtrogram:FRAMe` on page 215
- `CALCulate<n>:SPECtrogram:FRAMe:SELect` on page 152

Suffix:

<n> 1..n
Window

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: //Activates the time stamp
`CALC:SGR:TST ON`

Manual operation: See "Time Stamp" on page 82

10.4.9 Persistence spectrum configuration

Compatibility with R&S FSVR

For compatiblity with the R&S FSVR, the following commands required to configure the persistence spectrum also accept the optional `SUBWindow` keyword (`DISPlay:WINDow[:SUBWindow]...`). However, this keyword is ignored and has no effect on remote control.

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MAXHold:RESet

Suffix:

<n>	1..n
<w>	1..n
<t>	1..n

Manual operation: See "Resetting the Max Hold Function" on page 81

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MAXHold:INTensity <Intensity>

Defines the color intensity of the maxhold persistence spectrum.

Note: Setting the intensity to 0 has the same effect as deactivating the Maxhold function (see `DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MAXHold[:STATe]` on page 155).

Suffix:

<n>	Window
<w>	subwindow
<t>	Trace

Parameters:

<Intensity> Sets the color intensity of the maxhold trace.

Range: 0 to 254
Increment: 1
*RST: 100

Example: `DISP:WIND:TRAC:MAXH:INT 120`
Sets the color intensity of the maxhold trace to 120.

Example: See Chapter 10.10.3, "Example 3: analyzing persistency", on page 236.

Manual operation: See "Intensity" on page 80

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MAXHold[:STATe] <State>

Switches the maxhold trace in the persistence spectrum on and off.

Note: Setting the intensity to 0 has the same effect as deactivating the Maxhold function (see `DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MAXHold:INTensity` on page 155).

Suffix:

<n>	Window
<w>	subwindow
<t>	Trace

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: See Chapter 10.10.3, "Example 3: analyzing persistency", on page 236.

Manual operation: See "Configuring the Max Hold Function" on page 80

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:PERSistence:DURation <Persistence>

Sets the duration of the persistence.

Setting the persistence to 0 turns it off and thus has the same effect as the command `DISP:WIND:TRAC:PERS OFF` (see `DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:PERSistence[:STATe]` on page 157).

Suffix:

<n>	Window
<w>	subwindow
<t>	Trace

Parameters:

<Persistence> Persistance in seconds.

Range: 0 to 8
Increment: 0.001
*RST: 1 seconds
Default unit: seconds

Example: `DISP:WIND:TRAC:PERS:DUR 4.3`
Sets the persistence to 4.3 seconds.

Example: See Chapter 10.10.3, "Example 3: analyzing persistency", on page 236.

Manual operation: See "Persistence" on page 79

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:PERSistence:GRANularity <Granularity>

Defines the duration that data is captured to build one persistence spectrum.

Suffix:

<n>	Window
<w>	subwindow
<t>	Trace

Parameters:

<Granularity> duration in seconds
*RST: 0.1s
Default unit: S

Example: See Chapter 10.10.3, "Example 3: analyzing persistency", on page 236.

Manual operation: See "Granularity" on page 80

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:PERSistence[:STATe] <State>

Switches persistence in the persistence spectrum on and off.

Note: Setting the persistence to 0 turns it off and thus has the same effect as this command (see `DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:PERSistence:DURation` on page 156).

Suffix:

<n>	Window
<w>	subwindow
<t>	Trace

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:SYMBol <Style>

Sets the display style of the persistence spectrum.

Suffix:

<n>	Window
<w>	subwindow

<t> Trace

Parameters:

<Style> **DOTS**
Displays the data as dots. The result is a persistence spectrum made up out of dots.

VECTor
Interpolates the measurement points. The result is an uninterrupted persistence spectrum.

*RST: VECTor

Example: `DISP:WIND:TRAC:SYMB DOTS`
Displays the persistence spectrum as dots.

Example: See Chapter 10.10.3, "Example 3: analyzing persistency", on page 236.

Manual operation: See "Diagram Style" on page 79

10.4.10 Color maps configuration

DISPlay[:WINDow<n>]:PSPectrum:COLor:DEFault

Suffix:

<n> 1..n

Manual operation: See "Set to Default" on page 85

DISPlay[:WINDow<n>]:PSPectrum:COLor:LOWer <Percentage>

Sets the lower percentage boundary of the persistence spectrum.

Suffix:

<n> Window

Parameters:

<Percentage> Statistical frequency percentage.

Range: 0 to 65,6
*RST: 0
Default unit: %

Example: `DISP:WIND:HIST:COL:LOW 10`
Sets the start of the color map to 10%.

Example: See Chapter 10.10.3, "Example 3: analyzing persistency", on page 236.

Manual operation: See "Start / Stop" on page 84

DISPlay[:WINDow<n>]:PSPectrum:COLor:SHAPe <Shape>

Defines the shape and focus of the color curve for the persistence spectrum result display.

Suffix:

<n> Window

Parameters:

<Shape> Shape of the color curve.

Range: -1 to 1
*RST: 0

Example: See Chapter 10.10.3, "Example 3: analyzing persistency", on page 236.

Manual operation: See "Shape" on page 84

DISPlay[:WINDow<n>]:PSPectrum:COLor:TRUNcate <State>

Reduces the range of the color map of the persistence spectrum if there are no hits at the start or end of the value range.

Suffix:

<n> Window

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `DISP:WIND:PSP:COL:TRUN ON`
Activates truncation of the color map.

Example: See Chapter 10.10.3, "Example 3: analyzing persistency", on page 236.

Manual operation: See "Truncate" on page 84

DISPlay[:WINDow<n>]:PSPectrum:COLor:UPPer <Percentage>

Sets the upper percentage boundary of the persistence spectrum.

Suffix:
<n> Window

Parameters:
<Percentage> Statistical frequency percentage.

Range: 0.01 to 100
*RST: 100
Default unit: %

Example: `DISP:WIND:HIST:COL:UPP 95`
Sets the upper boundary of the color map to 95%.

Example: See Chapter 10.10.3, "Example 3: analyzing persistency", on page 236.

Manual operation: See "Start / Stop" on page 84

DISPlay[:WINDow<n>]:PSPectrum:COLor[:STYLe] <ColorScheme>

Sets the color scheme for the persistance spectrum.

Suffix:
<n> Window

Parameters:
<ColorScheme>

HOT

COLD

RADar

GRAYscale

*RST: HOT

Example: `DISP:WIND:HIST:COL GRAY`
Changes the color scheme of the persistance spectrum to black and white.

Example: See Chapter 10.10.3, "Example 3: analyzing persistency", on page 236.

Manual operation: See "Hot/Cold/Radar/Grayscale" on page 85

CALCulate<n>:SPECtrogram:COLor <ColorScheme>
DISPlay[:WINDow<n>]:SPECtrogram:COLor[:STYLe] <ColorScheme>

Selects the color scheme.

Suffix:
<n> window; spectrograms and PVT waterfall displays can be selected

Parameters:
<ColorScheme>

HOT
Uses a color range from blue to red. Blue colors indicate low levels, red colors indicate high ones.

COLD
Uses a color range from red to blue. Red colors indicate low levels, blue colors indicate high ones.

RADar
Uses a color range from black over green to light turquoise with shades of green in between.

GRAYscale
Shows the results in shades of gray.

*RST: HOT

Example: `DISP:WIND:SPEC:COL GRAY`
Changes the color scheme of the spectrogram to black and white.

Example: See Chapter 10.10.2, "Example 2: performing a basic real-time measurement", on page 233.

Manual operation: See "Hot/Cold/Radar/Grayscale" on page 85

DISPlay[:WINDow<n>]:SPECtrogram:COLor:DEFault

Restores the original color map.

Suffix:
<n> Window

Manual operation: See "Set to Default" on page 85

DISPlay[:WINDow<n>]:SPECtrogram:COLor:LOWer <Percentage>

Defines the starting point of the color map.

Suffix:
<n> Window

Parameters:
<Percentage> Statistical frequency percentage.

Range: 0 to 66
*RST: 0
Default unit: %

Example: `DISP:WIND:SGR:COL:LOW 10`
Sets the start of the color map to 10%.

Example: See Chapter 10.10.2, "Example 2: performing a basic real-time measurement", on page 233.

Manual operation: See "Start / Stop" on page 84

DISPlay[:WINDow<n>]:SPECtrogram:COLor:SHAPe <Shape>

Defines the shape and focus of the color curve for the spectrogram result display.

Suffix:

<n> Window

Parameters:

<Shape> Shape of the color curve.

Range: -1 to 1
*RST: 0

Example: See Chapter 10.10.2, "Example 2: performing a basic real-time measurement", on page 233.

Manual operation: See "Shape" on page 84

DISPlay[:WINDow<n>]:SPECtrogram:COLor:UPPer <Percentage>

Defines the end point of the color map.

Suffix:

<n> Window

Parameters:

<Percentage> Statistical frequency percentage.

Range: 0 to 66
*RST: 0
Default unit: %

Example: `DISP:WIND:SGR:COL:UPP 95`
Sets the start of the color map to 95%.

Example: See Chapter 10.10.2, "Example 2: performing a basic real-time measurement", on page 233.

Manual operation: See "Start / Stop" on page 84

10.4.11 Automatic configuration

[SENSe:]ADJust:ALL

Initiates a measurement to determine and set the ideal settings for the current task automatically (only once for the current measurement).

This includes:

- Center frequency
- Reference level

Example: `ADJ:ALL`

Manual operation: See "Adjusting all Determinable Settings Automatically (Auto All)" on page 76

[SENSe:]ADJust:CONFigure:LEVel:DURation <Duration>

To determine the ideal reference level, the R&S ESW performs a measurement on the current input data. This command defines the length of the measurement if `[SENSe:]ADJust:CONFigure:LEVel:DURation:MODE` is set to `MANual`.

Parameters:

<Duration> Numeric value in seconds

Range: 0.001 to 16000.0
*RST: 0.001
Default unit: s

Example: `ADJ:CONF:DUR:MODE MAN`
Selects manual definition of the measurement length.
`ADJ:CONF:LEV:DUR 5ms`
Length of the measurement is 5 ms.

Manual operation: See "Changing the Automatic Measurement Time (Meas Time Manual)" on page 77

[SENSe:]ADJust:CONFigure:LEVel:DURation:MODE <Mode>

To determine the ideal reference level, the R&S ESW performs a measurement on the current input data. This command selects the way the R&S ESW determines the length of the measurement .

Parameters:

<Mode> **AUTO**
The R&S ESW determines the measurement length automatically according to the current input data.

MANual
The R&S ESW uses the measurement length defined by [SENSe:]ADJust:CONFigure:LEVel:DURation on page 163.

*RST: AUTO

Manual operation: See "Resetting the Automatic Measurement Time (Meas Time Auto)" on page 77
See "Changing the Automatic Measurement Time (Meas Time Manual)" on page 77

[SENSe:]ADJust:FREQuency

Sets the center frequency to the frequency with the highest signal level in the current frequency range.

Example: `ADJ:FREQ`

Manual operation: See "Adjusting the Center Frequency Automatically (Auto Frequency)" on page 76

[SENSe:]ADJust:CONFigure:HYSTeresis:LOWer <Threshold>

When the reference level is adjusted automatically using the [SENSe:]ADJust:LEVel on page 165 command, the internal attenuators and the preamplifier are also adjusted. To avoid frequent adaptation due to small changes in the input signal, you can define a hysteresis. This setting defines a lower threshold the signal must fall below (compared to the last measurement) before the reference level is adapted automatically.

Parameters:

<Threshold> Range: 0 dB to 200 dB
*RST: +1 dB
Default unit: dB

Example: `SENS:ADJ:CONF:HYST:LOW 2`
For an input signal level of currently 20 dBm, the reference level is only adjusted when the signal level falls below 18 dBm.

Manual operation: See "Lower Level Hysteresis" on page 77

[SENSe:]ADJust:CONFigure:HYSTeresis:UPPer <Threshold>

When the reference level is adjusted automatically using the [SENSe:]ADJust:LEVel on page 165 command, the internal attenuators and the preamplifier are also adjusted. To avoid frequent adaptation due to small changes in the input signal, you can define a hysteresis. This setting defines an upper threshold the signal must exceed (compared to the last measurement) before the reference level is adapted automatically.

Parameters:

<Threshold> Range: 0 dB to 200 dB
*RST: +1 dB
Default unit: dB

Example: `SENS:ADJ:CONF:HYST:UPP 2`

Example: For an input signal level of currently 20 dBm, the reference level is only adjusted when the signal level rises above 22 dBm.

Manual operation: See "Upper Level Hysteresis" on page 77

[SENSe:]ADJust:CONFigure:TRIGger <State>

Defines the behavior of a triggered measurement when adjusting a setting automatically (using `SENS:ADJ:LEV ON`, for example).

Parameters:

<State> ON | OFF | 0 | 1

ON | 1
(default:) The measurement for adjustment waits for the next trigger.

OFF | 0
The measurement for adjustment is performed without waiting for a trigger (corresponds to "Continue" in manual operation).

*RST: 0

Example:

```
//Use default ref level at 0.00 dBm.
//Define an RF power trigger at -20 dBm
:TRIG:SEQ:SOUR RFP
:TRIG:SEQ:LEV:RFP -20
//Perform adjustment measurement without waiting for trigger
SENS:ADJ:CONF:TRIG OFF
//Perform auto level adjustment
:SENS:ADJ:LEV;*WAI
```

[SENSe:]ADJust:LEVel

Initiates a single (internal) measurement that evaluates and sets the ideal reference level for the current input data and measurement settings. Thus, the settings of the RF attenuation and the reference level are optimized for the signal level. The R&S ESW is not overloaded and the dynamic range is not limited by an S/N ratio that is too small.

Example: `ADJ:LEV`

Manual operation: See "Setting the Reference Level Automatically (Auto Level)" on page 61

10.4.12 Result display Configuration

10.4.12.1 General window commands

The following commands are required to configure general window layout, independent of the application.

DISPlay[:WINDow<n>]:SIZE <Size>

Maximizes the size of the selected result display window *temporarily*. To change the size of several windows on the screen permanently, use the `LAY:SPL` command (see `LAYout:SPLitter` on page 170).

Suffix:

<n> Window

Parameters:

<Size>

LARGe
Maximizes the selected window to full screen.
Other windows are still active in the background.

SMALl
Reduces the size of the selected window to its original size.
If more than one measurement window was displayed originally, these are visible again.

*RST: SMALl

Example: `DISP:WIND2:SIZE LARG`

10.4.12.2 Working with windows in the display

The following commands are required to change the evaluation type and rearrange the screen layout for a channel as you do using the SmartGrid in manual operation. Since the available evaluation types depend on the selected application, some parameters for the following commands also depend on the selected channel.

Note that the suffix <n> always refers to the window *in the currently selected channel*.

LAYout:ADD[:WINDow]? <WindowName>, <Direction>, <WindowType>

Adds a window to the display in the active channel.

Is always used as a query so that you immediately obtain the name of the new window as a result.

To replace an existing window, use the `LAYout:REPLace[:WINDow]` command.

Query parameters:

<WindowName> String containing the name of the existing window the new window is inserted next to.
By default, the name of a window is the same as its index. To determine the name and index of all active windows, use the `LAYout:CATalog[:WINDow]?` query.

<Direction> LEFT | RIGHt | ABOVe | BELow
Direction the new window is added relative to the existing window.

<WindowType> text value
Type of result display (evaluation method) you want to add.
See the table below for available parameter values.

Return values:

<NewWindowName> When adding a new window, the command returns its name (by default the same as its number) as a result.

Example: `LAY:ADD? '1',LEFT,MTAB`
Result:
`'2'`
Adds a new window named '2' with a marker table to the left of window 1.

Usage: Query only

Manual operation: See "Real-Time Spectrum" on page 16
See "Spectrogram" on page 17
See "Persistence Spectrum" on page 18
See "Marker Table" on page 19

For a detailed example, see Chapter 10.10.3, "Example 3: analyzing persistency", on page 236.

Table 10-4: <WindowType> parameter values for Real-Time measurements

Parameter value	Window type
'XFRequency:RFPower[:SPECtrum]' 'XFRequency[:SPECtrum]'	"Real-Time Spectrum"
'XFRequency:RFPower:SGRam' 'XFRequency:SGRam'	"Spectrogram"
'XFRequency:RFPower:PSPectrum' 'XFRequency:PSPectrum'	"Persistence Spectrum"
MTABle	"Marker table"

LAYout:CATalog[:WINDow]?

Queries the name and index of all active windows in the active channel from top left to bottom right. The result is a comma-separated list of values for each window, with the syntax:

<WindowName_1>,<WindowIndex_1>..<WindowName_n>,<WindowIndex_n>

Return values:

<WindowName> string

Name of the window.
In the default state, the name of the window is its index.

<WindowIndex> **numeric value**
Index of the window.

Example: `LAY:CAT?`
Result:
`'2',2,'1',1`
Two windows are displayed, named '2' (at the top or left), and '1' (at the bottom or right).

Usage: Query only

LAYout:IDENtify[:WINDow]? <WindowName>

Queries the **index** of a particular display window in the active channel.

Note: to query the **name** of a particular window, use the `LAYout:WINDow<n>:IDENtify?` query.

Query parameters:

<WindowName> String containing the name of a window.

Return values:

<WindowIndex> Index number of the window.

Example: `LAY:IDEN:WIND? '2'`
Queries the index of the result display named '2'.
Response:
`2`

Usage: Query only

LAYout:MOVE[:WINDow] <WindowName>, <WindowName>, <Direction>

Setting parameters:

<WindowName> String containing the name of an existing window that is to be moved.
By default, the name of a window is the same as its index. To determine the name and index of all active windows in the active channel, use the `LAYout:CATalog[:WINDow]?` query.

<WindowName> String containing the name of an existing window the selected window is placed next to or replaces.
By default, the name of a window is the same as its index. To determine the name and index of all active windows in the active channel, use the `LAYout:CATalog[:WINDow]?` query.

<Direction> LEFT | RIGHt | ABOVe | BELow | REPLace

Destination the selected window is moved to, relative to the reference window.

Example: `LAY:MOVE '4','1',LEFT`
Moves the window named '4' to the left of window 1.

Example: `LAY:MOVE '1','3',REPL`
Replaces the window named '3' by window 1. Window 3 is deleted.

Usage: Setting only

LAYout:REMove[:WINDow] <WindowName>

Removes a window from the display in the active channel.

Setting parameters:

<WindowName> String containing the name of the window. In the default state, the name of the window is its index.

Example: `LAY:REM '2'`
Removes the result display in the window named '2'.

Usage: Setting only

LAYout:REPLace[:WINDow] <WindowName>,<WindowType>

Replaces the window type (for example from "Diagram" to "Result Summary") of an already existing window in the active channel while keeping its position, index and window name.

To add a new window, use the `LAYout:ADD[:WINDow]?` command.

Setting parameters:

<WindowName> String containing the name of the existing window.
By default, the name of a window is the same as its index. To determine the name and index of all active windows in the active channel, use the `LAYout:CATalog[:WINDow]?` query.

<WindowType> Type of result display you want to use in the existing window.
See `LAYout:ADD[:WINDow]?` on page 167 for a list of available window types.

Example: `LAY:REPL:WIND '1',MTAB`
Replaces the result display in window 1 with a marker table.

Usage: Setting only

LAYout:SPLitter <Index1>, <Index2>, <Position>

Changes the position of a splitter and thus controls the size of the windows on each side of the splitter.

Note that windows must have a certain minimum size. If the position you define conflicts with the minimum size of any of the affected windows, the command does not work, but does not return an error.

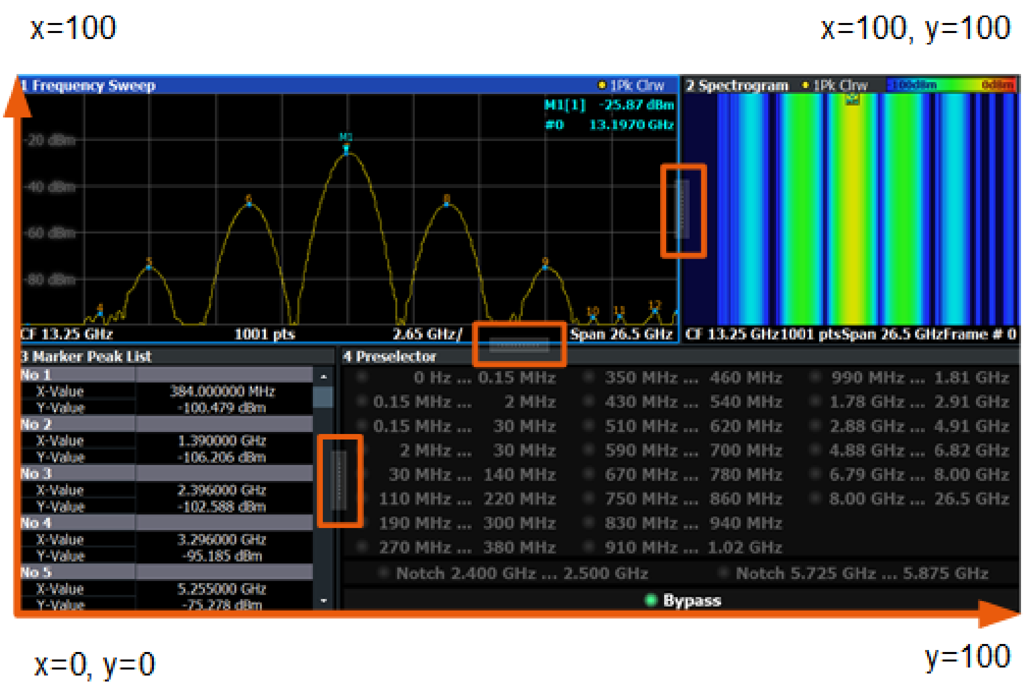


Figure 10-1: SmartGrid coordinates for remote control of the splitters

Setting parameters:

<Index1> The index of one window the splitter controls.

<Index2> The index of a window on the other side of the splitter.

<Position>	New vertical or horizontal position of the splitter as a fraction of the screen area (without channel and status bar and softkey menu). The point of origin (x = 0, y = 0) is in the lower left corner of the screen. The end point (x = 100, y = 100) is in the upper right corner of the screen. (See Figure 10-1.) The direction in which the splitter is moved depends on the screen layout. If the windows are positioned horizontally, the splitter also moves horizontally. If the windows are positioned vertically, the splitter also moves vertically. Range: 0 to 100
Example:	`LAY:SPL 1,3,50` Moves the splitter between window 1 ('Frequency Sweep') and 3 ('"Marker Table"') to the center (50%) of the screen, i.e. in the figure above, to the left.

Example:	`LAY:SPL 1,4,70`
	Moves the splitter between window 1 ('Frequency Sweep') and 3 ('"Marker Peak List"') towards the top (70%) of the screen.
	The following commands have the exact same effect, as any combination of windows above and below the splitter moves the splitter vertically.
	`LAY:SPL 3,2,70`
	`LAY:SPL 4,1,70`
	`LAY:SPL 2,1,70`

Usage:	Setting only

LAYout:WINDow<n>:ADD? <Direction>,<WindowType>

Adds a measurement window to the display. Note that with this command, the suffix <n> determines the existing window next to which the new window is added. Unlike `LAYout:ADD[:WINDow]?`, for which the existing window is defined by a parameter.

To replace an existing window, use the `LAYout:WINDow<n>:REPLace` command.

Is always used as a query so that you immediately obtain the name of the new window as a result.

Suffix:

<n>	Window

Query parameters:

<Direction>	LEFT | RIGHt | ABOVe | BELow
<WindowType>	Type of measurement window you want to add. See `LAYout:ADD[:WINDow]?` on page 167 for a list of available window types.

Return values:

<NewWindowName>	When adding a new window, the command returns its name (by default the same as its number) as a result.

Example: `LAY:WIND1:ADD? LEFT,MTAB`
Result:
`'2'`
Adds a new window named '2' with a marker table to the left of window 1.

Usage: Query only

LAYout:WINDow<n>:IDENtify?

Queries the **name** of a particular display window (indicated by the <n> suffix) in the active channel.

Note: to query the **index** of a particular window, use the `LAYout:IDENtify[:WINDow]?` command.

Suffix:
<n> Window

Return values:
<WindowName> String containing the name of a window.
In the default state, the name of the window is its index.

Example: `LAY:WIND2:IDEN?`
Queries the name of the result display in window 2.
Response:
`'2'`

Usage: Query only

LAYout:WINDow<n>:REMove

Removes the window specified by the suffix <n> from the display in the active channel.

The result of this command is identical to the `LAYout:REMove[:WINDow]` command.

Suffix:
<n> Window

Example: `LAY:WIND2:REM`
Removes the result display in window 2.

Usage: Event

LAYout:WINDow<n>:REPLace <WindowType>

Changes the window type of an existing window (specified by the suffix <n>) in the active channel.

The effect of this command is identical to the `LAYout:REPLace[:WINDow]` command.

To add a new window, use the `LAYout:WINDow<n>:ADD?` command.

Suffix:
<n> Window

Setting parameters:
<WindowType> Type of measurement window you want to replace another one with.
See LAYout:ADD[:WINDow]? on page 167 for a list of available window types.

Example: `LAY:WIND2:REPL MTAB`
Replaces the result display in window 2 with a marker table.

Usage: Setting only

10.5 Data capture and sweep

ABORt

This command aborts the measurement in the current measurement channel and resets the trigger system.

To prevent overlapping execution of the subsequent command before the measurement has been aborted successfully, use the `*OPC` or `*WAI` command after `ABORt` and before the next command.

To abort a sequence of measurements by the Sequencer, use the `INITiate:SEQuencer:ABORt` command.

Note on blocked remote control programs:

If a sequential command cannot be completed, for example because a triggered sweep never receives a trigger, the remote control program will never finish. The remote channel to the R&S ESW is blocked for further commands. In this case, you must interrupt processing on the remote channel first to abort the measurement.

To do so, send a "Device Clear" command from the control instrument to the R&S ESW on a parallel channel to clear all currently active remote channels. Depending on the used interface and protocol, send the following commands:

- **Visa**: `viClear()`
- **GPIB**: `ibclr()`
- **RSIB**: `RSDLLibclr()`

Now you can send the ABORt command on the remote channel that runs the measurement.

Example: ABOR;INIT:IMM
Aborts the measurement and restarts it.

Usage: Event

INITiate<n>:CONMeas

Restarts a (single) measurement that has been stopped (using ABORt) or finished in single measurement mode.

The measurement is restarted at the beginning, not where the previous measurement was stopped.

Suffix:
<n> irrelevant

Usage: Asynchronous command

INITiate<n>:CONTinuous <State>

Controls the measurement mode for an individual channel.

Note that in single measurement mode, you can synchronize to the end of the measurement with *OPC, *OPC? or *WAI. In continuous measurement mode, synchronization to the end of the measurement is not possible. Thus, it is not recommended that you use continuous measurement mode in remote control, as results like trace data or markers are only valid after a single measurement end synchronization.

For details on synchronization see Remote control via SCPI.

Suffix:
<n> 1 | 2
INITiate1 selects single or continuous bargraph measurements.
INITiate2 selects single or continuous scans.

Parameters:
<State> ON | OFF | 0 | 1

ON | 1
Continuous measurement

OFF | 0
Single measurement

*RST: 1 (some applications can differ)

Example: INIT:CONT OFF
Switches the measurement mode to single measurement.
INIT:CONT ON
Switches the measurement mode to continuous measurement.

Manual operation: See "Continuous Sweep / Run Cont" on page 75
See "Single Sweep / Run Single" on page 75

INITiate<mt>[:IMMediate]

The command initiates a new measurement.

For a single measurement, the R&S ESW stops measuring when it has reached the end frequency. When you start a continuous measurement, it stops only if you abort it deliberately.

If you are using trace modes MAXHold, MINHold and AVERage, previous results are reset when you restart the measurement.

- **Single measurements**
  Synchronization to the end of the measurement is possible with `*OPC`, `*OPC?` or `*WAI`.
- **Continuous measurements**
  Synchronization to the end of the measurement is not possible.
  It is thus recommended to use a single measurement for remote controlled measurements, because results like trace data or markers are only valid after synchronization.

Suffix:

<mt> INITiate1 initiates a bargraph measurement.
INITiate2 initiates a scan.

Example: //Start a single scan (with a scan count = 20), and wait until the measurement is done
```
INIT2:CONT OFF
SWE:COUN 20
INIT2;*WAI
```

Usage: Event

Manual operation: See "Continuous Sweep / Run Cont" on page 75
See "Single Sweep / Run Single" on page 75

INITiate:SEQuencer:ABORt

Stops the currently active sequence of measurements.

You can start a new sequence any time using `INITiate:SEQuencer:IMMediate` on page 175.

Usage: Event

INITiate:SEQuencer:IMMediate

Starts a new sequence of measurements by the Sequencer.

Before this command can be executed, the Sequencer must be activated (see `SYSTem:SEQuencer` on page 176).

Example: `SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single sequence mode so each active measurement is performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.

INITiate:SEQuencer:MODE <Mode>

Defines the capture mode for the entire measurement sequence and all measurement groups and channels it contains.

Note: To synchronize to the end of a measurement sequence using `*OPC`, `*OPC?` or `*WAI`, use `SINGle` Sequencer mode.

Parameters:

<Mode>

SINGle
Each measurement group is started one after the other in the order of definition. All measurement channels in a group are started simultaneously and performed once. After *all* measurements are completed, the next group is started. After the last group, the measurement sequence is finished.

CONTinuous
Each measurement group is started one after the other in the order of definition. All measurement channels in a group are started simultaneously and performed once. After *all* measurements are completed, the next group is started. After the last group, the measurement sequence restarts with the first one and continues until it is stopped explicitly.

*RST: CONTinuous

SYSTem:SEQuencer <State>

Turns the Sequencer on and off. The Sequencer must be active before any other Sequencer commands (`INIT:SEQ...`) are executed, otherwise an error occurs.

Parameters:

<State> ON | OFF | 0 | 1

ON | 1
The Sequencer is activated and a sequential measurement is started immediately.

OFF | 0
The Sequencer is deactivated. Any running sequential measurements are stopped. Further Sequencer commands (`INIT:SEQ...`) are not available.

*RST: 0

Example:

```
SYST:SEQ ON
```
Activates the Sequencer.
```
INIT:SEQ:MODE SING
```
Sets single Sequencer mode so each active measurement is performed once.
```
INIT:SEQ:IMM
```
Starts the sequential measurements.
```
SYST:SEQ OFF
```

10.6 Result retrieval

10.6.1 Marker results

Commands to retrieve results described elsewhere:

- `CALCulate<n>:DELTamarker<m>:X` on page 201
- `CALCulate<n>:DELTamarker<m>:Y?` on page 201
- `CALCulate<n>:MARKer<m>:X` on page 198
- `CALCulate<n>:MARKer<m>:Y?` on page 198

CALCulate<n>:DELTamarker<m>:X:RELative?

Queries the relative position of a delta marker on the x-axis.

If necessary, the command activates the delta marker first.

Suffix:

<n>	Window
<m>	Marker

Return values:

<Position>	Position of the delta marker in relation to the reference marker.

Example:

```
CALC:DELT3:X:REL?
```
Outputs the frequency of delta marker 3 relative to marker 1 or relative to the reference position.

Usage: Query only

CALCulate<n>:DELTamarker<m>:Z

Suffix:

<n> 1..n

<m> 1..n

CALCulate<n>:MARKer<m>:Z?

Queries the z-axis value of the indicated marker in the persistence spectrum result display.

You can select whether to query the results of the persistence trace or the maxhold trace with `CALCulate<n>:DELTamarker<m>:TRACe` on page 201.

Suffix:

<n> Window

<m> Marker

Return values:

<Result> The return value is the percentage of hits on the marker position.

Usage: Query only

10.6.2 Trace results

Commands to retrieve results described elsewhere:

- `CALCulate<n>:SPECtrogram:FRAMe:SELect` on page 152
- `CALCulate<n>:SPECtrogram:TSTamp:DATA?` on page 153

FORMat[:DATA] <Format>[, <BitLength>]

Selects the data format that is used for transmission of trace data from the R&S ESW to the controlling computer.

Note that the command has no effect for data that you send to the R&S ESW. The R&S ESW automatically recognizes the data it receives, regardless of the format.

Parameters:

<Format> **ASCii**
ASCii format, separated by commas.
This format is almost always suitable, regardless of the actual data format. However, the data is not as compact as other formats can be.

REAL
Floating-point numbers (according to IEEE 754) in the "definite length block format".
The format setting `REAL` is used for the binary transmission of trace data.

<BitLength> Length in bits for floating-point results

16
16-bit floating-point numbers.
Compared to `REAL,32` format, half as many numbers are returned.

32
32-bit floating-point numbers
For I/Q data, 8 bytes per sample are returned for this format setting.

64
64-bit floating-point numbers
Compared to `REAL,32` format, twice as many numbers are returned.

Example: `FORM REAL,32`

TRACe<n>[:DATA]

Queries current trace data and measurement results.

The data format depends on `FORMat[:DATA]` on page 178.

For details, see Chapter 10.6.3, "Measurement results for TRACe<n>[:DATA]?", on page 181.

Suffix:
<n> Window

Query parameters:
<ResultType> Selects the type of result to be returned.

TRACE1 | ... | TRACE4
Returns the trace data for the corresponding trace.
The trace data consists of a list of measured power levels. The number of power levels in the list depends on the currently selected number of sweep points. The unit depends on the measurement and on the configured unit.
For the auto peak detector, the command returns positive peak values only. (To retrieve negative peak values, define a second trace with a negative peak detector.)

SPECtrogram | SGRam
Returns the results of the spectrogram result display.
For every frame in the spectrogram, the command returns the measured power levels, one for each sweep point. The number of frames depends on the size of the history depth. The power level depends on the configured unit. For spectrogram trace results, only `REAL,32` format is supported

PSPectrum
Returns the result of the Clear/Write (trace 2) "Persistence Spectrum" result display.
For every sweep point in the "Persistence Spectrum", the command returns the probability values that have been determined.

HMAXhold
Returns the result of the Max Hold (trace 3) "Persistence Spectrum" result display.
For every sweep point in the "Persistence Spectrum", the command returns the probability values that have been determined.

Example: `TRAC? TRACE3`
Queries the data of trace 3.

Manual operation: See "Real-Time Spectrum" on page 16
See "Spectrogram" on page 17
See "Persistence Spectrum" on page 18

TRACe<n>[:DATA]:X? <TraceNumber>

Queries the horizontal trace data for each sweep point in the specified window, for example the frequency in frequency domain or the time in time domain measurements.

Suffix:
<n> Window

Query parameters:
<TraceNumber> Trace number.
TRACE1 | TRACE2 | TRACE3 | TRACE4

Return values:
<X-Values>

Example: `TRAC3:X? TRACE1`
Returns the x-values for trace 1 in window 3.

Usage: Query only

Manual operation: See "Real-Time Spectrum" on page 16
See "Spectrogram" on page 17
See "Persistence Spectrum" on page 18

TRACe<n>[:DATA]:MEMory? <Trace>,<OffsSwPoint>,<NoOfSwPoints>

Queries the previously captured trace data for the specified trace from the memory. As an offset and number of sweep points to be retrieved can be specified, the trace data can be retrieved in smaller portions, making the command faster than the `TRAC:DATA?` command. This is useful if only specific parts of the trace data are of interest.

If no parameters are specified with the command, the entire trace data is retrieved; in this case, the command returns the same results as `TRAC:DATA? TRACE1`.

For details on the returned values see the `TRAC:DATA? <TRACE...>` command.

Suffix:

<n>	Window

Query parameters:

<Trace>	TRACE1 | TRACE2 | TRACE3 | TRACE4
<OffsSwPoint>	The offset in sweep points related to the start of the measurement at which data retrieval is to start.
<NoOfSwPoints>	Number of sweep points to be retrieved from the trace.

Return values:

<SweepPointValues>

Example: `TRAC:DATA:MEM? TRACE1,25,100`
Retrieves 100 sweep points from trace 1, starting at sweep point 25.

Usage: Query only

10.6.3 Measurement results for TRACe<n>[:DATA]?

The result type selected by `LAYout:ADD[:WINDow]?` and the data format defined by `FORMat[:DATA]` also affect the results of the trace data query (see `TRACe<n>[:DATA]` on page 179). Details on the returned trace data depending on the result type and data format are provided here.

TRACe<n>[:DATA]? parameter	Result type	Result Format
TRACE1 | ... | TRACE4	"Persistence Spectrum" (TRACE1 only) "Real-Time Spectrum" "Spectrogram" (TRACE1 only) "Power vs Time" PVT Waterfall (TRACE1 only)	Depends on FORMat[:DATA]. By default, comma-separated floats in ASCII format. In Real-Time, traces are always 1001 points. For Waterfall displays, TRACE1 returns the newest frame. For the Persistence display, TRACE1 returns its TRACE1, which is also TRACE1 of the "Real-Time Spectrum".
SPECtrogram/SGRam	"Spectrogram" PVT Waterfall	Depends on FORMat[:DATA]. By default, comma-separated floats in ASCII format. REAL16 and 64 not supported. Comma-separated list, formatted as 1001 x <frame_count>. No delimiter between frames. Frames are returned from newest frame (top of the spectrogram) to oldest (bottom of the spectrogram).
PSPectrum	"Persistence Spectrum"	Returns the data of the Clear/Write histogram, Trace 2. Depends on FORMat[:DATA]. By default, 1001x600 comma-separated floats in ASCII format. REAL16 and 64 not supported. Data is returned in Row-Major order, from top to bottom (i.e. the first 1001 values returned are the top row of the display, from left to right; the last 1001 values returned are the bottom row of the display). Each value is the probability for a specific pixel, as a percentage in range [0.0, 100.0].
HMAXhold	"Persistence Spectrum"	Returns the data of the Max Hold histogram, Trace 3. Depends on FORMat[:DATA]. By default, 1001x600 comma-separated floats in ASCII format. REAL16 and 64 not supported. Data is returned in Row-Major order, from top to bottom (i.e. the first 1001 values returned are the top row of the display, from left to right; the last 1001 values returned are the bottom row of the display). Each value is the probability for a specific pixel, as a percentage in range [0.0, 100.0].

10.6.4 Trace export

MMEMory:STORe<n>:PSPectrum <FileName>

Exports persistence spectrum data to an ASCii file.

The file contains the most recently determined percentage value for each pixel in the persistence spectrum, that is, for 1001 frequency and 600 power values, followed by the 1001*600 maxhold percentages.

For details see Table A-2.

Note that, due to the large amount of data involved, the process of exporting the data can take a while.

Suffix:

<n>	Window

Parameters:

<FileName>	String containing the path and name of the target file.

Example: `MMEM:STOR:PSP 'C:\PersistentSpectrum'`
Copies the persistent spectrum data to a file.

Example: See Chapter 10.10.3, "Example 3: analyzing persistency", on page 236.

Manual operation: See "Persistence Spectrum" on page 18

MMEMory:STORe<n>:SPECtrogram <FileName>

Exports spectrogram data to an ASCII file.

The file contains the data for every frame in the history buffer. The data corresponding to a particular frame begins with information about the frame number and the time that frame was recorded.

Note that, depending on the size of the history buffer, the process of exporting the data can take a while.

Secure User Mode

In secure user mode, settings that are stored on the instrument are stored to volatile memory, which is restricted to 256 MB. Thus, a "memory limit reached" error can occur although the hard disk indicates that storage space is still available.

To store data permanently, select an external storage location such as a USB memory device.

For details, see "Protecting Data Using the Secure User Mode" in the "Data Management" section of the R&S ESW base unit user manual.

Suffix:

<n>	Window

Parameters:

<FileName>	String containing the path and name of the target file.

Example: `MMEM:STOR:SGR 'Spectrogram'`
Copies the spectrogram data to a file.

Example: See Chapter 10.10.2, "Example 2: performing a basic real-time measurement", on page 233.

Manual operation: See "Spectrogram" on page 17

MMEMory:STORe<n>:TRACe <Trace>, <FileName>

Exports trace data from the specified window to an ASCII file.

Secure User Mode

In secure user mode, settings that are stored on the instrument are stored to volatile memory, which is restricted to 256 MB. Thus, a "memory limit reached" error can occur although the hard disk indicates that storage space is still available.

To store data permanently, select an external storage location such as a USB memory device.

For details, see "Protecting Data Using the Secure User Mode" in the "Data Management" section of the R&S ESW base unit user manual.

Suffix:
<n> Window

Parameters:
<Trace> Number of the trace to be stored

<FileName> String containing the path and name of the target file.

Example: `MMEM:STOR1:TRAC 1,'C:\TEST.ASC'`
Stores trace 1 from window 1 in the file `TEST.ASC`.

Manual operation: See "Real-Time Spectrum" on page 16
See "Export Trace to ASCII File" on page 89

FORMat:DEXPort:DSEParator <Separator>

Selects the decimal separator for data exported in ASCII format.

Parameters:
<Separator> POINt | COMMa

COMMa
Uses a comma as decimal separator, e.g. *4,05*.

POINt
Uses a point as decimal separator, e.g. *4.05*.

*RST: *RST has no effect on the decimal separator.
Default is POINt.

Example: `FORM:DEXP:DSEP POIN`
Sets the decimal point as separator.

Manual operation: See "Decimal Separator" on page 89

FORMat:DEXPort:HEADer <State>

If enabled, additional instrument and measurement settings are included in the header of the export file for result data. If disabled, only the pure result data from the selected traces and tables is exported.

Parameters:

<State> ON | OFF | 0 | 1

*RST: 1

Manual operation: See "Include Instrument & Measurement Settings" on page 89

FORMat:DEXPort:TRACes <Selection>

Selects the data to be included in a data export file (see `MMEMory:STORe<n>:TRACe` on page 184).

Parameters:

<Selection> SINGle | ALL

SINGle
Only a single trace is selected for export, namely the one specified by the `MMEMory:STORe<n>:TRACe` command.

ALL
Selects all active traces and result tables (e.g. "Result Summary", marker peak list etc.) in the current application for export to an ASCII file.
The <trace> parameter for the `MMEMory:STORe<n>:TRACe` command is ignored.

*RST: SINGle

Manual operation: See "Export all Traces and all Table Results" on page 88

10.6.5 I/Q trace data export

[SENSe:]IQ:FFT:LENGth <NoOfBins>

Defines the number of frequency points determined by each FFT calculation. The more points are used, the higher the resolution in the spectrum becomes, but the longer the calculation takes.

Parameters:

<NoOfBins> integer value

Range: 3 to 524288
*RST: 4096

Example: `IQ:FFT:LENG 2048`

TRACe:IQ:BWIDth

Defines or queries the bandwidth of the resampling filter.

The bandwidth of the resampling filter depends on the sample rate.

Parameters:

<Bandwidth> Default unit: HZ

TRACe:IQ:DATA?

Initiates a measurement with the current settings and returns the captured data from I/Q measurements.

Corresponds to:

`INIT:IMM;*WAI;:TRACe:IQ:DATA:MEMory?`

However, the `TRACe:IQ:DATA?` command is quicker in comparison.

Return values:

<Results> Measured voltage for I and Q component for each sample that has been captured during the measurement.

Default unit: V

Example:

`TRAC:IQ:STAT ON`
Enables acquisition of I/Q data
`TRAC:IQ:SET NORM,10MHz,32MHz,EXT,POS,0,4096`
Measurement configuration:
Sample Rate = 32 MHz
Trigger Source = External
Trigger Slope = Positive
Pretrigger Samples = 0
Number of Samples = 4096
`FORMat REAL,32`
Selects format of response data
`TRAC:IQ:DATA?`
Starts measurement and reads results

Usage: Query only

TRACe:IQ:DATA:FORMat <Format>

Selects the order of the I/Q data.

Parameters:

<Format> COMPatible | IQBLock | IQPair

COMPatible
I and Q values are separated and collected in blocks: A block (512k) of I values is followed by a block (512k) of Q values, followed by a block of I values, followed by a block of Q values etc. (I,I,I,I,Q,Q,Q,Q,I,I,I,I,Q,Q,Q,Q...)

IQBLock
First all I-values are listed, then the Q-values
(I,I,I,I,I,I,...Q,Q,Q,Q,Q,Q)

IQPair
One pair of I/Q values after the other is listed
(I,Q,I,Q,I,Q...).

*RST: IQBL

TRACe:IQ:DATA:MEMory? [<OffsetSamples>,<NoOfSamples>]

Queries the I/Q data currently stored in the capture buffer of the R&S ESW.

By default, the command returns all I/Q data in the memory. You can, however, narrow down the amount of data that the command returns using the optional parameters.

If no parameters are specified with the command, the entire trace data is retrieved.

The command returns a comma-separated list of the measured values in floating point format (comma-separated values = CSV). The number of values returned is 2 * the number of complex samples.

The total number of complex samples is displayed in the channel bar in manual operation and can be calculated as:

<SampleRate> * <CaptureTime>

Query parameters:

<OffsetSamples> Selects an offset at which the output of data should start in relation to the first data. If omitted, all captured samples are output, starting with the first sample.

Range: 0 to <# of samples> – 1, with <# of samples> being the maximum number of captured values
*RST: 0

<NoOfSamples> Number of samples you want to query, beginning at the offset you have defined. If omitted, all captured samples (starting at offset) are output.

Range: 1 to <# of samples> - <offset samples> with <# of samples> maximum number of captured values
*RST: <# of samples>

Return values:

<IQData>
Measured value pair (I,Q) for each sample that has been recorded.
By default, the first half of the list contains the I values, the second half the Q values. The order can be configured using `TRACe:IQ:DATA:FORMat`.
The data format of the individual values depends on `FORMat[:DATA]` on page 178.
Default unit: V

Example:
// Perform a single I/Q capture.
`INIT;*WAI`
// Determine output format (binary float32)
`FORMat REAL,32`
// Read 1024 I/Q samples starting at sample 2048.
`TRAC:IQ:DATA:MEM? 2048,1024`

Usage: Query only

TRACe:IQ:RLENgth <NoOfSamples>

Sets the record length for the acquired I/Q data.

Increasing the record length also increases the measurement time.

Note: Alternatively, you can define the measurement time using the `SENS:SWE:TIME` command.

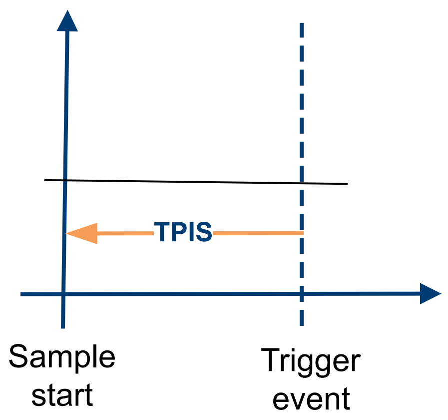
Parameters:

<NoOfSamples>
Number of samples to record.
*RST: 1001

Example: `TRAC:IQ:RLEN 256`

TRACe:IQ:TPISample?

Queries the time offset from the sample start to the trigger event (trigger point in sample = TPIS). Since the R&S ESW usually samples with a much higher sample rate than the specific application actually requires, the trigger point determined internally is much more precise than the one determined from the (downsampled) data in the application. Thus, the TPIS indicates the offset from the sample start to the actual trigger event.



This value can only be determined in triggered measurements using external or IFPower triggers, otherwise the value is 0.

Return values:

<TPIS>	numeric value Default unit: s
Example:	`TRAC:IQ:TPIS?` Result for a sample rate of 1 MHz: between 0 and 1/1 MHz, i.e. between 0 and 1 µs (the duration of 1 sample).
Usage:	Query only

10.6.6 (Raw) I/Q data export

MMEMory:STORe<n>:IQ:COMMent <Comment>

Adds a comment to a file that contains I/Q data.

Suffix:

<n>	irrelevant

Parameters:

<Comment>	String containing the comment.

Example:	`MMEM:STOR:IQ:COMM 'Device test 1b'`
	Creates a description for the export file.
	`MMEM:STOR:IQ:STAT 1, 'C:\R_S\Instr\user\data.iq.tar'`
	Stores I/Q data and the comment to the specified file.

Manual operation:	See "I/Q Export" on page 105

MMEMory:STORe<n>:IQ:FORMat <Format>,<DataFormat>

Sets or queries the format of the I/Q data to be stored.

Suffix:

<n> irrelevant

Parameters:

<Format>

FLOat32
32-bit floating point format.

INT32
32-bit integer format.

*RST: FLOat32

<DataFormat>

COMPlex
Exports complex data.

REAL
Exports real data.

*RST: COMPlex

Example: `MMEM:STOR:IQ:FORM INT32,REAL`

MMEMory:STORe<n>:IQ:STATe <1>, <FileName>

Writes the captured I/Q data to a file.

By default, the contents of the file are in 32-bit floating point format.

Suffix:

<n> 1..n

Parameters:

<1>

<FileName> String containing the path and name of the target file.
The file type is determined by the file extension. If no file extension is provided, the file type is assumed to be `.iq.tar`.
For `.mat` files, Matlab® v4 is assumed.

Example: `MMEM:STOR:IQ:STAT 1, 'C:\R_S\Instr\user\data.iq.tar'`
Stores the captured I/Q data to the specified file.

Usage: Asynchronous command

Manual operation: See "I/Q Export" on page 105

10.7 Analysis

10.7.1 Configuring traces

Commands to configure traces described elsewhere:

- `DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y:SPACing` on page 135
- `DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]` on page 133
- Chapter 10.6.4, "Trace export", on page 182

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MODE <Mode>

Selects the trace mode. If necessary, the selected trace is also activated.

Suffix:

<n> Window

<w> subwindow
Not supported by all applications

<t> Trace

Parameters:

<Mode>

WRITe
(default:) Overwrite mode: the trace is overwritten by each sweep.

MAXHold
The maximum value is determined over several sweeps and displayed. The R&S ESW saves the sweep result in the trace memory only if the new value is greater than the previous one.

MINHold
The minimum value is determined from several measurements and displayed. The R&S ESW saves the sweep result in the trace memory only if the new value is lower than the previous one.

BLANk
Hides the selected trace.

*RST: Trace 1: WRITe, Trace 2-6: BLANk

Example:

`INIT:CONT OFF`
Switching to single sweep mode.
`SWE:COUN 16`
Sets the number of measurements to 16.
`DISP:TRAC3:MODE WRIT`
Selects clear/write mode for trace 3.
`INIT;*WAI`
Starts the measurement and waits for the end of the measurement.

Manual operation: See "Mode" on page 86

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MODE:HCONtinuous <State>

Turns an automatic reset of a trace on and off after a parameter has changed.

The reset works for trace modes min hold, max hold and average.

Note that the command has no effect if critical parameters like the span have been changed to avoid invalid measurement results

Suffix:

<n>	Window
<w>	subwindow
<t>	Trace

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example:

`DISP:WIND:TRAC3:MODE:HCON ON`
Switches off the reset function.

Manual operation: See "Hold" on page 87

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>[:STATe] <State>

Turns a trace on and off.

The measurement continues in the background.

Suffix:

<n> Window
Irrelevant in the Receiver application.

<w>	subwindow Not supported by all applications
<t>	Trace

Parameters:

<State>	ON | OFF | 0 | 1 **OFF | 0** Switches the function off **ON | 1** Switches the function on

Example: `DISP:TRAC3 ON`

Manual operation: See "Trace 1/Trace 2/Trace 3/Trace 4" on page 86
See "Trace 1/ Trace 2/ Trace 3/ Trace 4 (Softkeys)" on page 87

[SENSe:]AVERage<n>:COUNt <AverageCount>

Defines the number of measurements that the application uses to average traces.

In case of continuous sweep mode, the application calculates the moving average over the average count.

In case of single sweep mode, the application stops the measurement and calculates the average after the average count has been reached.

Suffix:

<n>	irrelevant

Manual operation: See "Average Count" on page 87

[SENSe:]AVERage<n>[:STATe<t>] <State>

Turns averaging for a particular trace in a particular window on and off.

Suffix:

<n>	Window
<t>	Trace

Parameters:

<State>	ON | OFF | 1 | 0

[SENSe:][WINDow:]DETector<t>[:FUNCtion] <Detector>

Defines the trace detector to be used for trace analysis.

For details see Chapter 5.4, "Sweep time and detector", on page 28.

Parameters:

<Detector>	**NEGative** Negative peak

POSitive
Positive peak

SAMPle
First value detected per trace point

AVERage
Average

*RST: POS

Example: `DET POS`
Sets the detector to "positive peak".

Manual operation: See "Detector" on page 86

TRACe<n>:COPY <TraceNumber>, <TraceNumber>

Copies data from one trace to another.

Suffix:
<n> Window

Parameters:
<TraceNumber> **TRACE1 | TRACE2 | TRACE3 | TRACE4**
The first parameter is the destination trace, the second parameter is the source.
(Note the 'e' in the parameter is required!)

Example: `TRAC:COPY TRACE1,TRACE2`
Copies the data from trace 2 to trace 1.

Manual operation: See "Copy Trace" on page 88

10.7.2 Using trace mathematics

The following commands control trace mathematics.

CALCulate<n>:MATH<t>[:EXPRession][:DEFine] <Expression>

Selects the mathematical expression for trace mathematics.

Before you can use the command, you have to turn trace mathematics on.

Suffix:
<n> Window

<t> irrelevant

Parameters:

<Expression>

(TRACE1-TRACE2)
Subtracts trace 2 from trace 1.

(TRACE1-TRACE3)
Subtracts trace 3 from trace 1.

(TRACE1-TRACE4)
Subtracts trace 4 from trace 1.

Example:

`CALC:MATH:STAT ON`
Turns trace mathematics on.
`CALC:MATH:EXPR:DEF (TRACE1-TRACE3)`
Subtracts trace 3 from trace 1.

Manual operation: See "Trace Math Function" on page 90

CALCulate<n>:MATH<t>:MODE <Mode>

Selects the way the R&S ESW calculates trace mathematics.

Suffix:

<n> Window

<t> irrelevant

Parameters:

<Mode>

For more information on the way each mode works see Trace Math Mode.

LINear
Linear calculation.

LOGarithmic
Logarithmic calculation.

POWer
Linear power calculation.

*RST: LOGarithmic

Example:

`CALC:MATH:MODE LIN`
Selects linear calculation.

Manual operation: See "Trace Math Mode" on page 91

CALCulate<n>:MATH<t>:POSition <Position>

Defines the position of the trace resulting from the mathematical operation.

Suffix:

<n> Window

<t> irrelevant

Parameters:

<Position> Vertical position of the trace in % of the height of the diagram area.
100 PCT corresponds to the upper diagram border.

Range: -100 to 200
*RST: 50
Default unit: PCT

Example: `CALC:MATH:POS 100`
Moves the trace to the top of the diagram area.

Manual operation: See "Trace Math Position" on page 90

CALCulate<n>:MATH<t>:STATe <State>

Turns the trace mathematics on and off.

Suffix:

<n> Window

<t> irrelevant

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:MATH:STAT ON`
Turns on trace mathematics.

Manual operation: See "Trace Math Function" on page 90
See "Trace Math Off" on page 90

10.7.3 Marker configuration

10.7.3.1 Individual marker configuration

CALCulate<n>:MARKer<m>:AOFF

Turns off all markers.

Suffix:

<n>	Window
<m>	Marker

Example: `CALC:MARK:AOFF`
Switches off all markers.

Manual operation: See "All Markers Off" on page 94

CALCulate<n>:MARKer<m>[:STATe] <State>

Turns markers on and off. If the corresponding marker number is currently active as a delta marker, it is turned into a normal marker.

Suffix:

<n>	Window
<m>	Marker

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:MARK3 ON`
Switches on marker 3.

Manual operation: See "Marker State" on page 92
See "Marker Type" on page 93
See "Select Marker" on page 94

CALCulate<n>:MARKer<m>:TRACe <Trace>

Selects the trace the marker is positioned on.

Note that the corresponding trace must have a trace mode other than "Blank".

If necessary, the command activates the marker first.

Suffix:

<n> Window

<m> Marker

Parameters:

<Trace>

1 to 4
Trace number the marker is assigned to.

MAXHold
Marker is assigned to maxhold trace of persistent spectrum (only available in Persistent Spectrum window)

WRITe
Marker is assigned to clear/write trace of persistent spectrum (only available in Persistent Spectrum window)

Example: //Assign marker to trace 1
`CALC:MARK3:TRAC 2`

Manual operation: See "Assigning the Marker to a Trace" on page 94

CALCulate<n>:MARKer<m>:X <Position>

Moves a marker to a specific coordinate on the x-axis.

If necessary, the command activates the marker.

If the marker has been used as a delta marker, the command turns it into a normal marker.

Suffix:

<n> Window

<m> Marker

Parameters:

<Position> Numeric value that defines the marker position on the x-axis. The unit depends on the result display.

Range: The range depends on the current x-axis range.
Default unit: Hz

Example: `CALC:MARK2:X 1.7MHz`
Positions marker 2 to frequency 1.7 MHz.

Manual operation: See "Marker Table" on page 19
See "Marker Position X-value" on page 93

CALCulate<n>:MARKer<m>:Y?

Queries the result at the position of the specified marker.

Suffix:

<n> 1..n

<m> 1..n

Return values:

<Result> Default unit: DBM

Usage: Query only

Manual operation: See "Marker Table" on page 19
See "Marker Level (Y-value)" on page 93

CALCulate<n>:DELTamarker<m>:AOFF

Turns off *all* delta markers.

Suffix:

<n> Window

<m> irrelevant

Example: `CALC:DELT:AOFF`
Turns off all delta markers.

CALCulate<n>:DELTamarker<m>:LINK <State>

Links delta marker <m> to marker 1.

If you change the horizontal position (x-value) of marker 1, delta marker <m> changes its horizontal position to the same value.

Suffix:

<n> Window

<m> Marker

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:DELT2:LINK ON`

CALCulate<n>:DELTamarker<m>:MODE <Mode>

Defines whether the position of a delta marker is provided as an absolute value or relative to a reference marker. Note that this setting applies to *all* windows.

Note that when the position of a delta marker is *queried*, the result is always an absolute value (see `CALCulate<n>:DELTamarker<m>:X` on page 201)!

Suffix:

<n> irrelevant

<m> irrelevant

Parameters:
<Mode>

ABSolute
Delta marker position in absolute terms.

RELative
Delta marker position in relation to a reference marker.

*RST: RELative

Example: `CALC:DELT:MODE ABS`
Absolute delta marker position.

CALCulate<n>:DELTamarker<m>:MREFerence <Reference>

Selects a reference marker for a delta marker other than marker 1.

Suffix:
<n> Window

<m> Marker

Parameters:
<Reference>

Example: `CALC:DELT3:MREF 2`
Specifies that the values of delta marker 3 are relative to marker 2.

Manual operation: See "Reference Marker" on page 93

CALCulate<n>:DELTamarker<m>[:STATe] <State>

Turns delta markers on and off.

If necessary, the command activates the delta marker first.

No suffix at DELTamarker turns on delta marker 1.

Suffix:
<n> Window

<m> Marker

Parameters:
<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:DELT2 ON`
Turns on delta marker 2.

Manual operation: See "Marker State" on page 92
See "Marker Type" on page 93
See "Select Marker" on page 94

CALCulate<n>:DELTamarker<m>:TRACe <Trace>

Selects the trace a delta marker is positioned on.

Note that the corresponding trace must have a trace mode other than "Blank".

If necessary, the command activates the marker first.

Suffix:

<n> Window

<m> Marker

Parameters:

<Trace> Trace number the marker is assigned to.

Example: `CALC:DELT2:TRAC 2`
Positions delta marker 2 on trace 2.

CALCulate<n>:DELTamarker<m>:X <Position>

Moves a delta marker to a particular coordinate on the x-axis.

If necessary, the command activates the delta marker and positions a reference marker to the peak power.

Suffix:

<n> Window

<m> Marker

Example: `CALC:DELT:X?`
Outputs the absolute x-value of delta marker 1.

Manual operation: See "Marker Position X-value" on page 93

CALCulate<n>:DELTamarker<m>:Y?

Queries the result at the position of the specified delta marker.

Suffix:

<n> 1..n

<m> 1..n

Return values:

<Result> Result at the position of the delta marker.
The unit is variable and depends on the one you have currently set.
Default unit: DBM

Usage: Query only

Manual operation: See "Marker Level (Y-value)" on page 93

10.7.3.2 General marker configuration

CALCulate<n>:DELTamarker<m>:FUNCtion:FIXed:RPOint:MAXimum[:PEAK]

Moves the fixed reference marker to the peak power.

Suffix:
<n> Window

<m> Marker

Example: `CALC:DELT:FUNC:FIX:RPO:MAX`
Sets the reference point level for delta markers to the peak of the selected trace.

Manual operation: See "Defining a Fixed Reference" on page 96

CALCulate<n>:DELTamarker<m>:FUNCtion:FIXed:RPOint:X <RefPoint>

Defines the horizontal position of the fixed delta marker reference point. The coordinates of the reference may be anywhere in the diagram.

Suffix:
<n> Window

<m> Marker

Parameters:
<RefPoint> Numeric value that defines the horizontal position of the reference.
For frequency domain measurements, it is a frequency in Hz.
For time domain measurements, it is a point in time in s.
*RST: Fixed Reference: OFF
Default unit: HZ

Example: `CALC:DELT:FUNC:FIX:RPO:X 128 MHz`
Sets the frequency reference to 128 MHz.

Manual operation: See "Defining a Fixed Reference" on page 96

CALCulate<n>:DELTamarker<m>:FUNCtion:FIXed:RPOint:Y <RefPointLevel>

Defines the vertical position of the fixed delta marker reference point. The coordinates of the reference may be anywhere in the diagram.

Suffix:

<n> Window

<m> Marker

Parameters:

<RefPoint> Numeric value that defines the vertical position of the reference. The unit and value range is variable.

*RST: Fixed Reference: OFF
Default unit: DBM

Example: `CALC:DELT:FUNC:FIX:RPO:Y -10dBm`
Sets the reference point level for delta markers to -10 dBm.

Manual operation: See "Defining a Fixed Reference" on page 96

CALCulate<n>:DELTamarker<m>:FUNCtion:FIXed[:STATe] <State>

Activates or deactivates a marker that defines a fixed reference point for relative marker analysis.

If necessary, the command activates a marker and positions it on the peak power.

Subsequently, you can change the coordinates of the fixed reference independent of the marker. The fixed reference is independent of the trace and is applied to all active delta markers.

Suffix:

<n> Window

<m> Marker

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:DELT:FUNC:FIX ON`
Switches on the measurement with fixed reference value for all delta markers.
`CALC:DELT:FUNC:FIX:RPO:X 128 MHZ`
Sets the frequency reference to 128 MHz.
`CALC:DELT:FUNC:FIX:RPO:Y 30 DBM`
Sets the reference level to +30 dBm.

Manual operation: See "Defining a Fixed Reference" on page 96

CALCulate<n>:MARKer<m>:X:SSIZe <StepSize>

Selects the marker step size mode for *all* markers in *all* windows.

It therefore takes effect in manual operation only.

Suffix:

<n> irrelevant

<m> irrelevant

Parameters:

<StepSize> **STANdard**
the marker moves from one pixel to the next

POINts
the marker moves from one sweep point to the next

*RST: POINts

Example: `CALC:MARK:X:SSIZ STAN`
Sets the marker step size to one pixel.

Manual operation: See "Marker Stepsize" on page 96

DISPlay[:WINDow<n>]:MINFo[:STATe] <State>

Turns the marker information in all diagrams on and off.

Suffix:

<n> irrelevant

Parameters:

<State> **ON | 1**
Displays the marker information in the diagrams.

OFF | 0
Hides the marker information in the diagrams.

*RST: 1

Example: `DISP:MINF OFF`
Hides the marker information.

Manual operation: See "Marker Info" on page 96

DISPlay[:WINDow<n>]:MTABle <DisplayMode>

Turns the marker table on and off.

Suffix:

<n> irrelevant

Parameters:

<DisplayMode> **ON | 1**
Turns on the marker table.

OFF | 0
Turns off the marker table.

*RST: AUTO

Example: `DISP:MTAB ON`
Activates the marker table.

Manual operation: See "Marker Table Display" on page 95

10.7.3.3 Marker search

CALCulate<n>:MARKer<m>:LOEXclude <State>

Turns the suppression of the local oscillator during automatic marker positioning on and off (for *all* markers in *all* windows).

Suffix:

<n> irrelevant

<m> irrelevant

Parameters:

<State> ON | OFF | 0 | 1

*RST: 1

Example: `CALC:MARK:LOEX ON`

Manual operation: See "Exclude LO" on page 99

CALCulate<n>:MARKer<m>:MAXimum:AUTO <State>

Turns an automatic marker peak search for a trace maximum on and off (using marker 1). The R&S ESW performs the peak search after each sweep.

Suffix:

<n> Window

<m> irrelevant

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:MARK:MAX:AUTO ON`
Activates the automatic peak search function for marker 1 at the end of each particular sweep.

Manual operation: See "Auto Max Peak Search / Auto Min Peak Search" on page 100

CALCulate<n>:MARKer<m>:MINimum:AUTO <State>

Turns an automatic marker peak search for a trace minimum on and off (using marker 1). The R&S ESW performs the peak search after each sweep.

Suffix:

<n> Window

<m> irrelevant

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:MARK:MIN:AUTO ON`
Activates the automatic minimum value search function for marker 1 at the end of each particular sweep.

Manual operation: See "Auto Max Peak Search / Auto Min Peak Search" on page 100

CALCulate<n>:MARKer<m>:PEXCursion <Excursion>

Defines the peak excursion (for *all* markers in *all* windows).

The peak excursion sets the requirements for a peak to be detected during a peak search.

The unit depends on the measurement.

Suffix:

<n> irrelevant

<m> irrelevant

Parameters:

<Excursion> The excursion is the distance to a trace maximum that must be attained before a new maximum is recognized, or the distance to a trace minimum that must be attained before a new minimum is recognized

*RST: 6.0 dB

Manual operation: See "Peak Excursion" on page 99

CALCulate<n>:MARKer<m>:X:SLIMits[:STATe] <State>

Turns marker search limits on and off for *all* markers in *all* windows.

If you perform a measurement in the time domain, this command limits the range of the trace to be analyzed.

Suffix:

<n> irrelevant

<m> irrelevant

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example:

```
CALC:MARK:X:SLIM ON
```

Switches on search limitation.

Manual operation: See "Search Limits (Left / Right)" on page 100
See "Search Limits Off" on page 100

CALCulate<n>:MARKer<m>:X:SLIMits:LEFT <SearchLimit>

Defines the left limit of the marker search range for *all* markers in *all* windows.

If you perform a measurement in the time domain, this command limits the range of the trace to be analyzed.

Suffix:

<n> irrelevant

<m> irrelevant

Parameters:

<SearchLimit> The value range depends on the frequency range or measurement time.
The unit is Hz for frequency domain measurements and s for time domain measurements.

*RST: left diagram border
Default unit: HZ

Example:

```
CALC:MARK:X:SLIM ON
```

Switches the search limit function on.

```
CALC:MARK:X:SLIM:LEFT 10MHz
```

Sets the left limit of the search range to 10 MHz.

Manual operation: See "Search Limits (Left / Right)" on page 100

CALCulate<n>:MARKer<m>:X:SLIMits:RIGHt <SearchLimit>

Defines the right limit of the marker search range for *all* markers in *all* windows.

If you perform a measurement in the time domain, this command limits the range of the trace to be analyzed.

Suffix:

<n> irrelevant

<m> irrelevant

Parameters:

<Limit> The value range depends on the frequency range or measurement time.
The unit is Hz for frequency domain measurements and s for time domain measurements.
*RST: right diagram border
Default unit: HZ

Example:
`CALC:MARK:X:SLIM ON`
Switches the search limit function on.
`CALC:MARK:X:SLIM:RIGH 20MHz`
Sets the right limit of the search range to 20 MHz.

Manual operation: See "Search Limits (Left / Right)" on page 100

CALCulate<n>:MARKer<m>:X:SLIMits:ZOOM[:STATe] <State>

Adjusts the marker search range to the zoom area for *all* markers in *all* windows.

Suffix:

<n> irrelevant

<m> irrelevant

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example:
`CALC:MARK:X:SLIM:ZOOM ON`
Switches the search limit function on.
`CALC:MARK:X:SLIM:RIGH 20MHz`
Sets the right limit of the search range to 20 MHz.

CALCulate<n>:THReshold <Level>

Defines a threshold level for the marker peak search (for *all* markers in *all* windows).

Note that you must enable the use of the threshold using `CALCulate<n>:THReshold:STATe` on page 209.

Suffix:
<n> irrelevant

Parameters:
<Level> Numeric value. The value range and unit are variable.
*RST: -120 dBm
Default unit: DBM

Example: `CALC:THR:STAT ON`

Example: `CALC:THR -82DBM`
Enables the search threshold and sets the threshold value to -82 dBm.

Manual operation: See "Search Threshold" on page 100

CALCulate<n>:THReshold:STATe <State>

Turns a threshold for the marker peak search on and off (for *all* markers in *all* windows).

Suffix:
<n> irrelevant

Parameters:
<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:THR:STAT ON`
Switches on the threshold line.

Manual operation: See "Search Threshold" on page 100
See "Search Limits Off" on page 100

10.7.3.4 Marker positioning

CALCulate<n>:MARKer<m>:FUNCtion:CENTer

Matches the center frequency to the frequency of a marker.

If you use the command in combination with a delta marker, that delta marker is turned into a normal marker.

Suffix:

<n> Window

<m> Marker

Example: `CALC:MARK2:FUNC:CENT`
Sets the center frequency to the frequency of marker 2.

Manual operation: See "Center Frequency = Marker Frequency" on page 101

CALCulate<n>:MARKer<m>:MAXimum:LEFT

Moves a marker to the next positive peak.

The search includes only measurement values to the left of the current marker position.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Mode for Next Peak in X Direction" on page 97
See "Search Next Peak" on page 101

CALCulate<n>:MARKer<m>:MAXimum:NEXT

Moves a marker to the next positive peak.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Mode for Next Peak in X Direction" on page 97
See "Search Next Peak" on page 101

CALCulate<n>:MARKer<m>:MAXimum[:PEAK]

Moves a marker to the highest level.

If the marker is not yet active, the command first activates the marker.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Marker Search Type" on page 98
See "Peak Search" on page 101

CALCulate<n>:MARKer<m>:MAXimum:RIGHt

Moves a marker to the next positive peak.

The search includes only measurement values to the right of the current marker position.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Search Mode for Next Peak in X Direction" on page 97
See "Search Next Peak" on page 101

CALCulate<n>:MARKer<m>:MINimum:LEFT

Moves a marker to the next minimum peak value.

The search includes only measurement values to the right of the current marker position.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Search Mode for Next Peak in X Direction" on page 97
See "Search Next Minimum" on page 101

CALCulate<n>:MARKer<m>:MINimum:NEXT

Moves a marker to the next minimum peak value.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Search Mode for Next Peak in X Direction" on page 97
See "Search Next Minimum" on page 101

CALCulate<n>:MARKer<m>:MINimum[:PEAK]

Moves a marker to the minimum level.

If the marker is not yet active, the command first activates the marker.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Marker Search Type" on page 98
See "Search Minimum" on page 101

CALCulate<n>:MARKer<m>:MINimum:RIGHt

Moves a marker to the next minimum peak value.

The search includes only measurement values to the right of the current marker position.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Mode for Next Peak in X Direction" on page 97
See "Search Next Minimum" on page 101

10.7.3.5 Deltamarker positioning

CALCulate<n>:DELTamarker<m>:MAXimum:LEFT

Moves a delta marker to the next positive peak value.

The search includes only measurement values to the left of the current marker position.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Next Peak" on page 101

CALCulate<n>:DELTamarker<m>:MAXimum:NEXT

Moves a marker to the next positive peak value.

Suffix:

<n> 1..n
Window

<m> 1..n
Marker

Manual operation: See "Search Next Peak" on page 101

CALCulate<n>:DELTamarker<m>:MAXimum[:PEAK]

Moves a delta marker to the highest level.

If the marker is not yet active, the command first activates the marker.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Marker Search Type" on page 98
See "Peak Search" on page 101

CALCulate<n>:DELTamarker<m>:MAXimum:RIGHt

Moves a delta marker to the next positive peak value on the trace.

The search includes only measurement values to the right of the current marker position.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Search Next Peak" on page 101

CALCulate<n>:DELTamarker<m>:MINimum:LEFT

Moves a delta marker to the next minimum peak value.

The search includes only measurement values to the right of the current marker position.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Search Next Minimum" on page 101

CALCulate<n>:DELTamarker<m>:MINimum:NEXT

Moves a marker to the next minimum peak value.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Search Next Minimum" on page 101

CALCulate<n>:DELTamarker<m>:MINimum[:PEAK]

Moves a delta marker to the minimum level.

If the marker is not yet active, the command first activates the marker.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Marker Search Type" on page 98
See "Search Minimum" on page 101

CALCulate<n>:DELTamarker<m>:MINimum:RIGHt

Moves a delta marker to the next minimum peak value.

The search includes only measurement values to the right of the current marker position.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Search Next Minimum" on page 101

10.7.3.6 Marker search (spectrograms)

The following commands automatically define the marker and delta marker position in the spectrogram.

The usage of these markers is demonstrated in Chapter 10.10.2, "Example 2: performing a basic real-time measurement", on page 233.

Using markers

The following commands control spectrogram markers.

Useful commands for spectrogram markers described elsewhere

The following commands define the horizontal position of the markers.

- `CALCulate<n>:MARKer<m>:MAXimum:LEFT` on page 210
- `CALCulate<n>:MARKer<m>:MAXimum:NEXT` on page 210
- `CALCulate<n>:MARKer<m>:MAXimum[:PEAK]` on page 210
- `CALCulate<n>:MARKer<m>:MAXimum:RIGHt` on page 211
- `CALCulate<n>:MARKer<m>:MINimum:LEFT` on page 211
- `CALCulate<n>:MARKer<m>:MINimum:NEXT` on page 211
- `CALCulate<n>:MARKer<m>:MINimum[:PEAK]` on page 211
- `CALCulate<n>:MARKer<m>:MINimum:RIGHt` on page 212

Remote commands exclusive to spectrogram markers

CALCulate<n>:MARKer<m>:SGRam:FRAMe <Frame>
CALCulate<n>:MARKer<m>:SPECtrogram:FRAMe <Frame> | <Time>

Positions a marker on a particular frame.

Suffix:

<n> — Window

<m> — Marker

Parameters:

<Frame> — Selects a frame directly by the frame number. Valid if the time stamp is off.
The range depends on the history depth.
Default unit: S

<Time> — Selects a frame via its time stamp. Valid if the time stamp is on.
The number is the (negative) distance to frame 0 in seconds.
The range depends on the history depth.

Example:

`CALC:MARK:SGR:FRAM -20`
Sets the marker on the 20th frame before the present.
`CALC:MARK2:SGR:FRAM -2s`
Sets second marker on the frame 2 seconds ago.

Manual operation: See "Frame" on page 93

CALCulate<n>:MARKer<m>:SGRam:SARea <SearchArea>
CALCulate<n>:MARKer<m>:SPECtrogram:SARea <SearchArea>

Defines the marker search area for all spectrogram markers in the channel.

Parameters:

<SearchArea> **VISible**
Performs a search within the visible frames.
Note that the command does not work if the spectrogram is not visible for any reason (e.g. if the display update is off).

MEMory
Performs a search within all frames in the memory.

*RST: VISible

Manual operation: See "Marker Search Area" on page 99

CALCulate<n>:MARKer<m>:SGRam:XY:MAXimum[:PEAK]
CALCulate<n>:MARKer<m>:SPECtrogram:XY:MAXimum[:PEAK]

Moves a marker to the highest level of the spectrogram.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Marker Search Type" on page 98

CALCulate<n>:MARKer<m>:SGRam:XY:MINimum[:PEAK]
CALCulate<n>:MARKer<m>:SPECtrogram:XY:MINimum[:PEAK]

Moves a marker to the minimum level of the spectrogram.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Marker Search Type" on page 98

CALCulate<n>:MARKer<m>:SGRam:Y:MAXimum:ABOVe
CALCulate<n>:MARKer<m>:SPECtrogram:Y:MAXimum:ABOVe

Moves a marker vertically to the next lower peak level for the current frequency.

The search includes only frames above the current marker position. It does not change the horizontal position of the marker.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Mode for Next Peak in Y Direction" on page 98

CALCulate<n>:MARKer<m>:SGRam:Y:MAXimum:BELow
CALCulate<n>:MARKer<m>:SPECtrogram:Y:MAXimum:BELow

Moves a marker vertically to the next lower peak level for the current frequency.

The search includes only frames below the current marker position. It does not change the horizontal position of the marker.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Mode for Next Peak in Y Direction" on page 98

CALCulate<n>:MARKer<m>:SGRam:Y:MAXimum:NEXT
CALCulate<n>:MARKer<m>:SPECtrogram:Y:MAXimum:NEXT

Moves a marker vertically to the next lower peak level for the current frequency.

The search includes all frames. It does not change the horizontal position of the marker.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Mode for Next Peak in Y Direction" on page 98

CALCulate<n>:MARKer<m>:SGRam:Y:MAXimum[:PEAK]
CALCulate<n>:MARKer<m>:SPECtrogram:Y:MAXimum[:PEAK]

Moves a marker vertically to the highest level for the current frequency.

The search includes all frames. It does not change the horizontal position of the marker.

If the marker hasn't been active yet, the command looks for the peak level in the whole spectrogram.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Marker Search Type" on page 98

CALCulate<n>:MARKer<m>:SGRam:Y:MINimum:ABOVe
CALCulate<n>:MARKer<m>:SPECtrogram:Y:MINimum:ABOVe

Moves a marker vertically to the next higher minimum level for the current frequency.

The search includes only frames above the current marker position. It does not change the horizontal position of the marker.

Suffix:
<n> Window

<m> Marker

Manual operation: See "Search Mode for Next Peak in Y Direction" on page 98

CALCulate<n>:MARKer<m>:SGRam:Y:MINimum:BELow
CALCulate<n>:MARKer<m>:SPECtrogram:Y:MINimum:BELow

Moves a marker vertically to the next higher minimum level for the current frequency.

The search includes only frames below the current marker position. It does not change the horizontal position of the marker.

Suffix:
<n> Window

<m> Marker

Manual operation: See "Search Mode for Next Peak in Y Direction" on page 98

CALCulate<n>:MARKer<m>:SGRam:Y:MINimum:NEXT
CALCulate<n>:MARKer<m>:SPECtrogram:Y:MINimum:NEXT

Moves a marker vertically to the next higher minimum level for the current frequency.

The search includes all frames. It does not change the horizontal position of the marker.

Suffix:
<n> Window

<m> Marker

Manual operation: See "Search Mode for Next Peak in Y Direction" on page 98

CALCulate<n>:MARKer<m>:SGRam:Y:MINimum[:PEAK]
CALCulate<n>:MARKer<m>:SPECtrogram:Y:MINimum[:PEAK]

Moves a marker vertically to the minimum level for the current frequency.

The search includes all frames. It does not change the horizontal position of the marker.

If the marker hasn't been active yet, the command first looks for the peak level for all frequencies and moves the marker vertically to the minimum level.

Suffix:
<n> Window

<m> Marker

Manual operation: See "Marker Search Type" on page 98

CALCulate<n>:MARKer<m>:SGRam:Y:TRIGger
CALCulate<n>:MARKer<m>:SPECtrogram:Y:TRIGger

Positions a marker in the spectrogram on the most recent trigger event.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Marker to Trigger" on page 102

Using delta markers

The following commands control spectrogram delta markers.

Useful commands for spectrogram markers described elsewhere

The following commands define the horizontal position of the delta markers.

- CALCulate<n>:DELTamarker<m>:MAXimum:LEFT on page 212
- CALCulate<n>:DELTamarker<m>:MAXimum:NEXT on page 212
- CALCulate<n>:DELTamarker<m>:MAXimum[:PEAK] on page 213
- CALCulate<n>:DELTamarker<m>:MAXimum:RIGHt on page 213
- CALCulate<n>:DELTamarker<m>:MINimum:LEFT on page 213
- CALCulate<n>:DELTamarker<m>:MINimum:NEXT on page 213
- CALCulate<n>:DELTamarker<m>:MINimum[:PEAK] on page 213
- CALCulate<n>:DELTamarker<m>:MINimum:RIGHt on page 214

Remote commands exclusive to spectrogram markers

CALCulate<n>:DELTamarker<m>:SGRam:FRAMe <Frame>
CALCulate<n>:DELTamarker<m>:SPECtrogram:FRAMe <Frame>

Positions a delta marker on a particular frame. The frame is relative to the position of marker 1.

The command is available for the spectrogram.

Suffix:

<n> Window

<m> Marker

Parameters:

<Frame> Selects a frame either by its frame number or time stamp.
The frame number is available if the time stamp is off. The range depends on the history depth.
The time stamp is available if the time stamp is on. The number is the distance to frame 0 in seconds. The range depends on the history depth.

Default unit: S

Example:

`CALC:DELT4:SGR:FRAM -20`
Sets fourth deltamarker 20 frames below marker 1.
`CALC:DELT4:SGR:FRAM 2 s`
Sets fourth deltamarker 2 seconds above the position of marker 1.

CALCulate<n>:DELTamarker<m>:SGRam:SARea <SearchArea>
CALCulate<n>:DELTamarker<m>:SPECtrogram:SARea <SearchArea>

Defines the marker search area for *all* spectrogram markers in the channel.

Parameters:

<SearchArea> **VISible**
Performs a search within the visible frames.
Note that the command does not work if the spectrogram is not visible for any reason (e.g. if the display update is off).

MEMory
Performs a search within all frames in the memory.

*RST: VISible

Manual operation: See "Marker Search Area" on page 99

CALCulate<n>:DELTamarker<m>:SGRam:XY:MAXimum[:PEAK]
CALCulate<n>:DELTamarker<m>:SPECtrogram:XY:MAXimum[:PEAK]

Moves a marker to the highest level of the spectrogram over all frequencies.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Marker Search Type" on page 98

CALCulate<n>:DELTamarker<m>:SGRam:XY:MINimum[:PEAK]
CALCulate<n>:DELTamarker<m>:SPECtrogram:XY:MINimum[:PEAK]

Moves a delta marker to the minimum level of the spectrogram over all frequencies.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Marker Search Type" on page 98

CALCulate<n>:DELTamarker<m>:SGRam:Y:MAXimum:ABOVe
CALCulate<n>:DELTamarker<m>:SPECtrogram:Y:MAXimum:ABOVe

Moves a marker vertically to the next higher level for the current frequency.

The search includes only frames above the current marker position. It does not change the horizontal position of the marker.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Mode for Next Peak in Y Direction" on page 98

CALCulate<n>:DELTamarker<m>:SGRam:Y:MAXimum:BELow
CALCulate<n>:DELTamarker<m>:SPECtrogram:Y:MAXimum:BELow

Moves a marker vertically to the next higher level for the current frequency.

The search includes only frames below the current marker position. It does not change the horizontal position of the marker.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Mode for Next Peak in Y Direction" on page 98

CALCulate<n>:DELTamarker<m>:SGRam:Y:MAXimum:NEXT
CALCulate<n>:DELTamarker<m>:SPECtrogram:Y:MAXimum:NEXT

Moves a delta marker vertically to the next higher level for the current frequency.

The search includes all frames. It does not change the horizontal position of the marker.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Mode for Next Peak in Y Direction" on page 98

CALCulate<n>:DELTamarker<m>:SGRam:Y:MAXimum[:PEAK]
CALCulate<n>:DELTamarker<m>:SPECtrogram:Y:MAXimum[:PEAK]

Moves a delta marker vertically to the highest level for the current frequency.

The search includes all frames. It does not change the horizontal position of the marker.

If the marker hasn't been active yet, the command looks for the peak level in the whole spectrogram.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Marker Search Type" on page 98

CALCulate<n>:DELTamarker<m>:SGRam:Y:MINimum:ABOVe
CALCulate<n>:DELTamarker<m>:SPECtrogram:Y:MINimum:ABOVe

Moves a delta marker vertically to the next minimum level for the current frequency.

The search includes only frames above the current marker position. It does not change the horizontal position of the marker.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Mode for Next Peak in Y Direction" on page 98

CALCulate<n>:DELTamarker<m>:SGRam:Y:MINimum:BELow
CALCulate<n>:DELTamarker<m>:SPECtrogram:Y:MINimum:BELow

Moves a delta marker vertically to the next minimum level for the current frequency.

The search includes only frames below the current marker position. It does not change the horizontal position of the marker.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Mode for Next Peak in Y Direction" on page 98

CALCulate<n>:DELTamarker<m>:SGRam:Y:MINimum:NEXT
CALCulate<n>:DELTamarker<m>:SPECtrogram:Y:MINimum:NEXT

Moves a delta marker vertically to the next minimum level for the current frequency.

The search includes all frames. It does not change the horizontal position of the marker.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Mode for Next Peak in Y Direction" on page 98

CALCulate<n>:DELTamarker<m>:SGRam:Y:MINimum[:PEAK]
CALCulate<n>:DELTamarker<m>:SPECtrogram:Y:MINimum[:PEAK]

Moves a delta marker vertically to the minimum level for the current frequency.

The search includes all frames. It does not change the horizontal position of the marker.

If the marker hasn't been active yet, the command first looks for the peak level in the whole spectrogram and moves the marker vertically to the minimum level.

Suffix:

<n> Window

<m> Marker

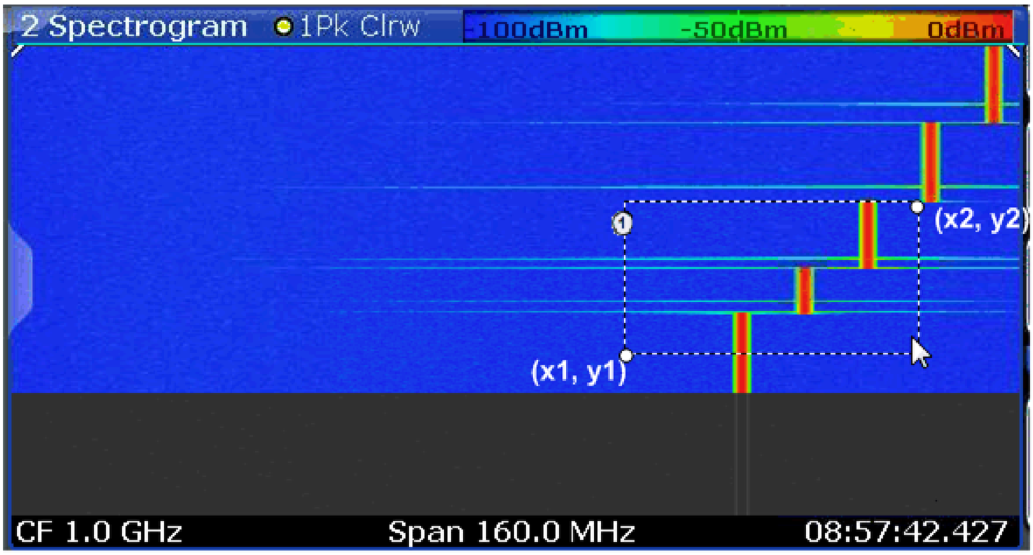
Manual operation: See "Marker Search Type" on page 98

10.7.4 Display zoom

DISPlay[:WINDow<n>]:ZOOM:AREA <x1>,<y1>,<x2>,<y2>

This command defines the zoom area for the spectrogram (see Chapter 5.6.4, "Zooming into the spectrogram", on page 43).

To define a zoom area, you first have to turn the zoom on (see `DISPlay[:WINDow<n>][:SUBWindow<w>]:ZOOM[:STATe]` on page 224).



1 = zoom area (e.g. x1 = 1020 MHz, y1 = -80 ms, x2 = 1060 MHz, y2 = -40 ms)
(x1,y1) = zoom area start
(x2,y2) = zoom area end

Suffix:
<n> Window

Parameters:
<x1> Starting frequency for the zoom area. Left side of zoom area.
Range: CF - Span/2 to CF + Span/2
Default unit: Hz

<y1> Oldest time for zoom area. Bottom side of zoom area.
Range: starting time of spectrogram to 0
Default unit: s

<x2> Ending frequency for the zoom area. Right side of zoom area.
Range: CF - Span/2 to CF + Span/2
Default unit: Hz

<y2> Most recent time for zoom area. Top side of zoom area.
Range: starting time of spectrogram to 0
Default unit: s

Example:
```
DISPlay:WINDow2:ZOOM:AREA 1020 MHZ, -0.08 s,
1060 MHZ, -0.040 s;
```

Manual operation: See "Single Zoom" on page 103

DISPlay[:WINDow<n>][:SUBWindow<w>]:ZOOM[:STATe] <State>

Turns the zoom on and off.

Suffix:
<n> Window

<w>	subwindow Not supported by all applications
Parameters:	
<State>	ON | OFF | 0 | 1 **OFF | 0** Switches the function off **ON | 1** Switches the function on
Example:	`DISP:ZOOM ON` Activates the zoom mode.
Manual operation:	See "Single Zoom" on page 103 See "Restore Original Display" on page 103 See "Deactivating Zoom (Selection Mode)" on page 104

10.8 Querying the status registers

The Real-Time Spectrum application uses the standard status registers of the R&S ESW, as well as the `STATus:QUEStionable:TIME` register.

This register and the commands required to query its contents are described here.

For details on the common R&S ESW status registers refer to the description of remote control basics in the R&S ESW user manual.

*RST does not influence the status registers.

10.8.1 STATus:OPERation register

The `STATus:OPERation` register contains information on current activities of the R&S ESW. It also contains information on activities that have been executed since the last read out.

You can read out the register with `STATus:OPERation:CONDition?` on page 227 or `STATus:OPERation[:EVENt]?` on page 228.

Table 10-5: Meaning of the bits used in the STATus:OPERation register

Bit No.	Meaning
0	CALibrating This bit is set as long as the instrument is performing a calibration.
1-2	Not used
3	SWEeping Sweep is being performed in base unit (applications are not considered); identical to bit 4 Available in the Spectrum application.
4	MEASuring Measurement is being performed in base unit (applications are not considered); identical to bit 3 Available in the Spectrum application.
5	Waiting for TRIgger Instrument is ready to trigger and waiting for trigger signal. Available in the Spectrum application.
6-7	Not used
8	HardCOPy in progress This bit is set while the instrument is printing a hardcopy.
9	SCAN results available This bit is set when a block of scan results is available. Must be enabled by TRAC:FEED:CONT ALWays. Available in the Receiver application.
10	Range completed In the Spectrum application, this bit is set when a range in the sweep list has been completed if "Stop after Range" has been activated. In the Receiver application, this bit is set when the end of a scan range has been reached. To resume the scan, use INITiate:CONMeas.
11-12	Not used
13	Threshold signal active Available for the Receiver application.
14	Not used
15	This bit is always 0.

10.8.2 STATus:QUEStionable:TIMe register

The STATus:QUEStionable:TIMe register contains information about possible time errors that may occur during operation of the R&S ESW. A separate time register exists for each active channel.

You can read out the register with STATus:QUEStionable:TIME:CONDition? or STATus:QUEStionable:TIME[:EVENt]?

Table 10-6: Meaning of the bits used in the STATus:QUEStionable:TIMe register

Bit No.	Meaning
0	Real-Time Data Loss This bit is set if the R&S ESW loses data during the measurement and measurements are no longer possible in Real-Time.
1 to 14	Unused
15	This bit is always 0.

10.8.3 Commands to query the STATus:OPERation register

The following commands are required to query the contents of the `STATus:OPERation` register.

STATus:OPERation:CONDition? <ChannelName>

This comand reads out the CONDition section of the status register.

The command does not delete the contents of the EVENt section.

Query parameters:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

STATus:OPERation:ENABle <SumBit>,<ChannelName>

Parameters:

<SumBit>

Query parameters:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

STATus:OPERation:NTRansition <SumBit>,<ChannelName>

Parameters:

<SumBit>

Query parameters:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

STATus:OPERation:PTRansition <SumBit>,<ChannelName>

Parameters:

<SumBit>

Query parameters:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

STATus:OPERation[:EVENt]? <ChannelName>

Queries the contents of the EVENt section of the status register.

A query deletes the contents of the EVENt section.

Query parameters:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Return values:

<RegisterContents> Range: 0 to 32767

Usage: Query only

10.8.4 Commands to query the STATus:QUEStionable:TIME register

The following commands are required to query the contents of the `STATus:QUEStionable:TIME` register.

STATus:QUEStionable:TIME:CONDition? [<ChannelName>]

These commands read out the CONDition section of the status register.

The commands do not delete the contents of the CONDition section.

Suffix:

<n> Window

Query parameters:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

STATus:QUEStionable:TIME:ENABle <SumBit>[, <ChannelName>]

These commands control the ENABle part of a register.

The ENABle part allows true conditions in the EVENt part of the status register to bereported in the summary bit. If a bit is 1 in the enable register and its associated event bit transitions to true, a positive transition will occur in the summary bit reported to the next higher level.

Suffix:

<n> Window

Parameters:

<SumBit> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

STATus:QUEStionable:TIME:NTRansition <SumBit>[, <ChannelName>]

These commands control the Negative TRansition part of a register.

Setting a bit causes a 1 to 0 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding EVENt register.

Suffix:

<n> Window

Parameters:

<SumBit> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

STATus:QUEStionable:TIME:PTRansition <SumBit>[, <ChannelName>]

These commands control the Positive TRansition part of a register.

Setting a bit causes a 0 to 1 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding EVENt register.

Suffix:

<n> Window

Parameters:

<SumBit>	Range: 0 to 65535
<ChannelName>	String containing the name of the channel. The parameter is optional. If you omit it, the command works for the currently active channel.

STATus:QUEStionable:TIME[:EVENt]? [<ChannelName>]

These commands read out the EVENt section of the status register.

At the same time, the commands delete the contents of the EVENt section.

Suffix:

<n>	Window

Query parameters:

<ChannelName>	String containing the name of the channel. The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

10.9 Commands for compatibility

Note that these commands are maintained for compatibility with the R&S FSVR only. Use the specified commands for new remote control programs.

DISPlay:WINDow[:SUBWindow] commands

For compatiblity with the R&S FSVR, the commands required to configure the persistence spectrum also accept the optional `SUBWindow` keyword (`DISPlay:WINDow[:SUBWindow]...`). However, this keyword is ignored and has no effect on remote control.

CALCulate<n>:FEED <Feed>

Selects the signal source (and for the equalizer also the result type) for evaluation.

Note that this command is maintained for compatibility reasons only. Use the `LAYout` commands for new remote control programs (see Chapter 10.4.12.2, "Working with windows in the display", on page 166).

Only for the "Equalizer Impulse Response" and "Equalizer Frequency Response", as well as the multi-source diagrams, this command is required.

Suffix:

<n>	1..n Window

Parameters:

<Feed>	string **'XTIM:DDEM:MEAS'** Measured signal **'XTIM:DDEM:REF'** Reference signal **'XTIM:DDEM:ERR:VECT'** Error vector **'XTIM:DDEM:ERR:MPH'** Modulation errors **'XTIM:DDEM:MACC'** Modulation accuracy **'XTIM:DDEM:SYMB'** Symbol table **'TCAP'** Capture buffer **'XTIM:DDEM:IMP'** Equalizer Impulse Response **'XFR:DDEM:RAT'** Equalizer Frequency Response **'XFR:DDEM:IRAT'** Equalizer Channel Frequency Response Group Delay **XTIM:DDEM:TCAP:ERR** Spectrum of Real/Imag for capture buffer and error vector **XTIM:DDEM:MEAS:ERR** Spectrum of Real/Imag for measurement and error vector

10.10 Programming examples: performing real-time measurements

The following programming examples demonstrate how to perform Real-Time measurements in a remote environment.

Some commands in the following examples may not be necessary as they reflect the default settings; however, they are included to demonstrate the command usage.

10.10.1 Example 1: creating a frequency mask trigger

In this example we will create a frequency mask trigger with an upper and lower mask. This trigger mask can be used in Example 2: performing a basic real-time measurement.

```
//------------ Configuring a frequency mask trigger -----------------
//Store trigger mask as 'C:\R_S\INSTR\freqmask\myFMTS\NewFreqMaskTrigger'
//Note the 'myFMTS' subdirectory must be created under 'C:\R_S\INSTR\freqmask'
//beforehand.
CALC:MASK:CDIR 'myFMTS'
CALC:MASK:NAME 'NewFreqMaskTrigger'
CALC:MASK:COMM 'Upper and lower frequency mask'

//------------ Defining an upper frequency mask automatically ----------------
//Use relative scaling for the level axis
CALC:MASK:MODE REL
//Define a span of 20 MHz
CALC:MASK:SPAN 20000000
//Configure automatic upper mask according to measured spectrum
CALC:MASK:UPP:AUTO
//Query the mask points for the upper mask
CALC:MASK:UPP:DATA?
//Result: comma-separated list of value pairs (Frequency, level);
//one for each data point
//Example:
//-9.990009990E+006,-9.600020599E+001,-9.230769231E+006,-8.738758087E+001,
//-8.831168831E+006,-9.565835571E+001,-7.972027972E+006,-8.494093323E+001,
//...
//+8.171828172E+006,-8.577051544E+001,+8.631368631E+006,-9.534964752E+001,
//+9.530469530E+006,-8.848562622E+001,+9.990009990E+006,-9.600020599E+001

//------------ Configuring the lower frequency mask manually -------------------
//Configure lower mask 20 dB lower than upper mask;
//Use upper mask as basis, then shift all values by 20 dB
CALC:MASK:LOW:STAT ON
CALC:MASK:LOW:DATA -9.990009990E+006,-9.600020599E+001,-9.230769231E+006,-8.738758087E+001,
-8.831168831E+006,-9.565835571E+001,-7.972027972E+006,-8.494093323E+001,
-7.492507493E+006,-9.450020599E+001,-6.793206793E+006,-7.878201294E+001,
-6.693306693E+006,-7.925418091E+001,-6.213786214E+006,-9.578102112E+001,
-5.414585415E+006,-3.991313553E+001,-4.995004995E+006,-3.050031662E+001,
-4.575424575E+006,-3.975288010E+001,-3.776223776E+006,-9.574020386E+001,
-3.296703297E+006,-7.856089020E+001,-2.777222777E+006,-8.525804901E+001,
-2.497502498E+006,-9.450020599E+001,-1.878121878E+006,-8.315855408E+001,
-1.258741259E+006,-9.424127960E+001,-1.238761239E+006,-9.424189758E+001,
-1.058941058E+006,-8.987026215E+001,-4.995004995E+005,-9.452841949E+001,
-3.308057785E-006,-9.450020599E+001,+5.394605395E+005,-8.521303558E+001,
+1.238761239E+006,-9.425141144E+001,+1.258741259E+006,-9.425095367E+001,
+1.858141858E+006,-8.382637787E+001,+2.497502497E+006,-9.450020599E+001,
+2.817182817E+006,-8.492385864E+001,+3.356643357E+006,-8.088692474E+001,
```

```
+3.756243756E+006,-9.698367310E+001,+4.535464535E+006,-4.851605225E+001,
+4.995004995E+006,-3.950028992E+001,+5.454545455E+006,-4.873092270E+001,
+6.213786214E+006,-9.597808838E+001,+6.273726274E+006,-9.304232788E+001,
+6.773226773E+006,-8.045437622E+001,+7.492507493E+006,-9.450020599E+001,
+8.171828172E+006,-8.577051544E+001,+8.631368631E+006,-9.534964752E+001,
+9.530469530E+006,-8.848562622E+001,+9.990009990E+006,-9.600020599E+001
CALC:MASK:LOW:SHIFT:Y -20
```

10.10.2 Example 2: performing a basic real-time measurement

The first measurement example performs a basic Real-Time measurement in the frequency domain with the default display configuration (Real-Time spectrum and spectrogram). It uses a frequency mask trigger stored as `C:\R_S\INSTR\freqmask\myFMTS\NewFreqMaskTrigger`, as described in Example 1: creating a frequency mask trigger.

To perform a basic Real-Time measurement without a frequency mask trigger, simply remove the section `Using a Frequency Mask Trigger` in the following example.

```
//--------------Preparing the instrument -----------
//Reset the instrument
*RST

//---------- Activating a Real-Time measurement channel -----------
//Activate a Real-Time measurement channel named "Real-Time"
INST:CRE:NEW RTIM,'Real-Time'

//Stop the current measurement
INIT:CONT OFF

//-------------- Configuring the Measurement -----
//Define the center frequency
FREQ:CENT 100MHz
//Set the span to 10 MHz on either side of the center frequency.
FREQ:SPAN 20MHz

//Set the reference level to 0 dBm
DISP:TRAC:Y:SCAL:RLEV 0

//Couple the RBW to the span, with RBW/span = 0.000625
BAND:RAT 0.000625
//Use a Gaussian FFT window function
SWE:FFT:WIND:TYPE GAUS
//Collect data for 20 ms for each spectrum
SWE:TIME 0.02

//----------- Using a Frequency Mask Trigger ------------------------
//Configure the use of an existing frequency mask (from Example 4) as a trigger
```

```
TRIG:SOUR MASK
//Select the mask to use
CALC:MASK:CDIR 'myFMTS'
CALC:MASK:NAME 'NewFreqMaskTrigger'
//Trigger on entering the frequency mask
TRIG:MASK:COND ENT

//Define a pretrigger period of 10 ms, posttrigger = 0.5 s
TRIG:PRET 0.001
TRIG:POST 0.5
//Use rearming trigger mode to perform continuous measurements
TRIG:MODE CONT

//-------------- Configuring the result displays -------------
//Clear the initial spectrogram results
CALC2:SPEC:CLE
//Store up to 1000 spectrogram frames
CALC2:SPEC:HDEP 1000

//-------------- Configuring spectrogram color mapping -----------------
//Use grayscale coloring
DISP:WIND2:SPEC:COL GRAY
//Configure a value range from 0.5% to 95%
DISP:WIND2:SPEC:COL:LOW 0.5
DISP:WIND2:SPEC:COL:UPP 95
//Change the shape of the color mapping function to distribute more colors among
//high values
DISP:WIND2:SPEC:COL:SHAP 0.35

//-------------- Performing the Measurement -----
//Initiate a new measurement
INIT:CONT ON
INIT:IMM
//Wait until some measurements have been performed.
INIT:CONT OFF

//--------------- Retrieving Results -------------
//Query the spectrogram results for the Real-Time measurement
CALC2:SPEC:TST:DATA? ALL
//Result: 4 values for each of the measured frames indicating the time passed
//since 01.01.1970 till the start of the frame, e.g.:
//1370524679,49559852,0,0,1370524679,18552034,0,0,
//1370524678,987161993,0,0,1370524678,971568114,0,0,
//...
//1370524670,79975615,0,0,1370524670,48813821,0,0
//First frame: 01.01.1970 + 1370524670 seconds
//Most recent frame: 01.01.1970 + 1370524679 seconds
//Measurement duration: 1370524679 s - 1370524670 s = 9 s

//Return the 1001 measured power levels for each of the measured frames
```

```
TRAC2:DATA? SPEC

//Store the spectrogram to a file
MMEM:STOR2:SPEC 'C:\temp\spectrogram'

//Query spectrum results for the most recent spectrum
CALC2:SPEC:FRAM:SEL 0
TRAC1:DATA:X? TRACE1
TRAC1:DATA? TRACE1

//Query spectrum results for the previous spectrum
CALC2:SPEC:TST OFF
//Use frame index instead of time stamp
CALC2:SPEC:FRAM:SEL -1
TRAC1:DATA:X? TRACE1
TRAC1:DATA? TRACE1
//Store these spectrum results to a file
MMEM:STOR1:TRAC 1,'C:\temp\FirstSpectrum'

//---------------- Analyzing the results using markers -------------------
//Set marker1 on the peak power in the most recent spectrum and query
//its position
CALC2:SPEC:FRAM:SEL 0
CALC2:MARK1 ON
CALC2:MARK1:X?
CALC2:MARK1:Y?

//Set marker2 on the peak power in frame -1 and query its position
CALC2:MARK2 ON
CALC2:MARK2:SGR:FRAM -1s
CALC2:MARK2:X?
CALC2:MARK2:Y?

//Set marker3 on peak power level in the entire spectrogram in memory and
//query its position
CALC2:MARK3 ON
CALC2:MARK:SPEC:SAR MEM
CALC2:MARK3:SPEC:XY:MAX
CALC2:MARK3:X?
CALC2:MARK3:Y?

//Move marker 3 to the next lower peak level for the same frequency
CALC2:MARK3:SPEC:Y:MAX:NEXT
CALC2:MARK3:X?
CALC2:MARK3:Y?

//Set marker4 on the most recent trigger event in the spectrogram and query
//its position
CALC2:MARK4 ON
CALC2:MARK4:SPEC:Y:TRIG
```

```
CALC2:MARK4:X?
CALC2:MARK4:Y?
```

10.10.3 Example 3: analyzing persistency

This measurement example performs a basic Real-Time measurement in the frequency domain with an additional persistence spectrum window. It uses a frequency mask trigger stored as `C:\R_S\INSTR\freqmask\myFMTS\NewFreqMaskTrigger`, as described in Example 1: creating a frequency mask trigger.

To perform a basic Real-Time measurement without a frequency mask trigger, simply remove the section `Using a Frequency Mask Trigger` in the following example.

```
//--------------Preparing the instrument -----------
//Reset the instrument
*RST

//---------- Activating a Real-Time measurement channel -----------
//Activate a Real-Time measurement channel named "Real-Time"
INST:CRE:NEW RTIM,'Real-Time'

//Stop the current measurement
INIT:CONT OFF

//-------------- Configuring the Measurement -----
//Define the center frequency
FREQ:CENT 100MHz
//Set the span to 10 MHz on either side of the center frequency.
FREQ:SPAN 20MHz

//Set the reference level to 0 dBm
DISP:TRAC:Y:SCAL:RLEV 0

//Couple the RBW to the span, with RBW/span = 0.000625
BAND:RAT 0.000625
//Use a Gaussian FFT window function
SWE:FFT:WIND:TYPE GAUS
//Collect data for 20 ms for each spectrum
SWE:TIME 0.02

//----------- Using a Frequency Mask Trigger ------------------------
//Configure the use of an existing frequency mask (from Example 4) as a trigger
TRIG:SOUR MASK
//Select the mask to use
CALC:MASK:CDIR 'myFMTS'
CALC:MASK:NAME 'NewFreqMaskTrigger'
//Trigger on entering the frequency mask
```

```
TRIG:MASK:COND ENT

//Define a pretrigger period of 10 ms, posttrigger = 0.5 s
TRIG:PRET 0.001
TRIG:POST 0.5
//Use rearming trigger mode to perform continuous measurements
TRIG:MODE CONT

//-------------- Configuring the result displays -------------
//Add a persistence spectrum result display
LAY:ADD? '1',RIGH,'XFRequency:PSPectrum'
//Result: '3'
//Clear the initial spectrogram results
CALC2:SPEC:CLE

//Configure vector-style trace for an uninterrupted (interpolated)
//persistence spectrum
DISP:WIND:TRAC:SYMB VECT

//Define a perstistence duration of 1.2 s
DISP:WIND:TRAC:PERS:DUR 1.2
//Use the data captured in 120 ms for a single frame (perstistence granularity)
DISP:WIND:TRAC:PERS:GRAN 0.12

//Activate the maxhold trace in the persistence spectrum display
DISP:WIND:TRAC:MAXH ON
//Define an intensity of 125 for the maxhold trace
DISP:WIND:TRAC:MAXH:INT 125
//Clear the maxhold trace
DISP:WIND:TRAC:MAXH:RES

//-------------- Configuring persistence color mapping -----------------
//Use greyscale coloring
DISP:WIND:PSP:COL GRAY
//Configure a value range from 0.5% to 95%
DISP:WIND:PSP:COL:LOW 0.5
DISP:WIND:PSP:COL:UPP 95
//Reduce the range of the color map if no hits are found at the value range edges
DISP:WIND:PSP:COL:TRUN ON
//Change the shape of the color mapping function to distribute more colors among
//high values
DISP:WIND:PSP:COL:SHAP 0.35

//-------------- Performing the Measurement -----
//Initiate a new measurement and wait until some measurements have been performed.
INIT:CONT ON
INIT:IMM
INIT:CONT OFF

//--------------- Retrieving Results -------------
```

```
//Query the persistence spectrum results
TRAC3:DATA? PSP
//Result: 1001*600 percentages, one for each pixel in the histogram

//Return the 1001 measured power levels for the most recent spectrum
TRAC3:DATA? TRACE1

//Return the 1001*600 maximum probabilities for the maxhold trace
TRAC3:DATA? HMAX

//Store the persistence spectrum to a file
MMEM:STOR3:PSP 'C:\temp\persistence'
```

Annex

A Reference: ASCII file export format

Trace data (for example Real-Time spectrum, persistence spectrum, or spectrogram) can be exported to a file in ASCII format for further evaluation in other applications.

The file consists of the header containing important measurement parameters and a data section containing the trace data.

Generally, the format of this ASCII file can be processed by spreadsheet calculation programs, e.g. MS-Excel. Different language versions of evaluation programs may require a different handling of the decimal point. Thus you can define the decimal separator to be used (decimal point or comma, see "Decimal Separator" on page 89).

The data of the file header consist of three columns, each separated by a semicolon: parameter name; numeric value; basic unit. The data section contains the measured data in two columns, which are also separated by a semicolon.

The file contents vary depending on the result type.

Table A-1: ASCII file format for Spectrum trace export

File contents	Description
Header data	
Type;R&S ESW;	Instrument model
Version;1.80;	Firmware version
Date;20.Jul 2013;	Date of data set storage
Mode;Real-Time;	Channel type
Preamplifier;OFF;	Preamplifier state
Transducer;OFF;	Transducer state
Center Freq;1000000000.000000;Hz	Center frequency
Freq Offset;0.000000;Hz	Frequency offset
Start;920000000.000000;Hz	Start frequency
Stop;1080000000.000000;Hz	Stop frequency
Span;160000000.000000;Hz	Measured span
Ref Level;0.000000;dBm	Reference level
Level Offset;0.000000;dB	Reference level offset
Rf Att;10.000000;dB	Input attenuation
El Att;0.000000;dB	Electronic attentuation
RBW;800000.000000;Hz	Resolution bandwidth
SWT;0.030000;s	Sweep time

File contents	Description
Sweep Count;0;	Number of sweeps
Window;1;"Real-Time Spectrum"	Window containing the exported results
Ref Position;100.000000; %	Reference level position in percent
Level Range;100.000000;dB	Power level (y-axis) range
x-Axis;LIN;	x-axis scaling mode (linear, log.)
y-Axis;LOG;	y-axis scaling mode (linear, log.)
x-Unit;Hz;	x-axis unit
y-Unit;dBm;	y-axis unit
Data section	
Trace;1;	Trace number
Trace Mode;CLR/WRITE;	Trace mode
Detector;MAXPEAK;	Detector used for trace
Values; 1001;	Number of measured frequencies
13170000000;-100.50020599365234; 13170160000;-100.16989898681641; ...;...;	Measured values: <frequency>, <power level>

Table A-2: ASCII file format for persistence spectrum trace export

File contents	Description
Header data	
Type;R&S ESW;	Instrument model
Version;1.80;	Firmware version
Date;20.Jul 2013;	Date of data set storage
Mode;Real-Time;	Channel type
Preamplifier;OFF;	Preamplifier state
Transducer;OFF;	Transducer state
Center Freq;1000000000.000000;Hz	Center frequency
Freq Offset;0.000000;Hz	Frequency offset
Start;920000000.000000;Hz	Start frequency
Stop;1080000000.000000;Hz	Stop frequency
Span;160000000.000000;Hz	Measured span
Ref Level;0.000000;dBm	Reference level
Level Offset;0.000000;dB	Reference level offset
Rf Att;10.000000;dB	Input attenuation

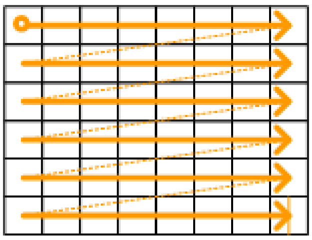
File contents	Description
El Att;0.000000;dB	Electronic attentuation
RBW;800000.000000;Hz	Resolution bandwidth
SWT;0.030000;s	Sweep time
Sweep Count;0;	Number of sweeps
Trace Mode;CLR/WRITE;MAXHOLD;	Display mode of traces: 1. CLR/WRITE; 2.MAXHOLD
Detector;PERSISTENCE;	Detector used for trace (none for persistence)
Data section	
Values; 1001;600;	Number of measurement points for x-axis (frequency) and y-axis (power)
920000000;920160000;920320000;920480000; ... 1079520000;1079680000;1079840000;1080000000	1001 frequency values used for histogram
-37.5;-37.583472454090149; ... -87.416527545909844;-87.5	600 power levels used for histogram
CLR/WRITE	Introduction for persistence spectrum data
0;0;0; 0.60534548759460449;0.37962344288825989	1000*600 most recently calculated percentage values in histogram from top left to bottom right, that is, starting with the lowest frequency and highest power value and ending with the highest frequency and lowest power level 
MAXHOLD	Introduction for MAXHOLD data
0;0;0; 0.90801829099655151;0.56943517923355103	1000*600 maximum percentage values for MAXHOLD trace from top left to bottom right, that is, starting with the lowest frequency and highest power value and ending with the highest frequency and lowest power level

Table A-3: ASCII file format for spectrogram trace export

File contents	Description
Header data	
Type;R&S ESW;	Instrument model
Version;1.80;	Firmware version
Date;20.Jul 2013;	Date of data set storage

File contents	Description
Mode;Real-Time;	Channel type
Preamplifier;OFF;	Preamplifier state
Transducer;OFF;	Transducer state
Center Freq;1000000000.000000;Hz	Center frequency
Freq Offset;0.000000;Hz	Frequency offset
Start;920000000.000000;Hz	Start frequency
Stop;1080000000.000000;Hz	Stop frequency
Span;160000000.000000;Hz	Measured span
Ref Level;0.000000;dBm	Reference level
Level Offset;0.000000;dB	Reference level offset
Rf Att;10.000000;dB	Input attenuation
El Att;0.000000;dB	Electronic attentuation
RBW;800000.000000;Hz	Resolution bandwidth
SWT;0.030000;s	Sweep time
Sweep Count;0;	Number of sweeps
Window;1;"Real-Time Spectrum"	Window containing the exported results
Ref Position;100.000000; %	Reference level position in percent
Level Range;100.000000;dB	Power level (y-axis) range
x-Axis;LIN;	x-axis scaling mode (linear, log.)
y-Axis;LOG;	y-axis scaling mode (linear, log.)
x-Unit;Hz;	x-axis unit
y-Unit;dBm;	y-axis unit
Data section	
Trace;1;	Trace number
Trace Mode;CLR/WRITE;	Trace mode
Detector;MAXPEAK;	Detector used for trace
Values; 1001;	Number of measured frequencies
Frames;130;	Number of exported frames
Data section for individual frame	
Frame;0;	Most recent frame number
Timestamp;29.Jul 13;08:51:19.355	Timestamp of this frame

File contents	Description
10000;-10.3;-15.7 10130;-11.5;-16.9 10360;-12.0;-17.4 ...;...;	Measured values: <frequency>; <power value1>; <power value2>; <power value 2> only for AUTOPEAK detector; contains the minimum of the two measured values for each measurement point
Data section for individual frame	
Frame;-1;	Previous frame
Timestamp;29.Jul 13;08:51:19.278	Timestamp of this frame
...	

List of Remote Commands (Real-Time)

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