# R&S®FSW-K95/-K97
# 802.11ad/ay Measurements
# User Manual


1177596202
Version 20

**ROHDE&SCHWARZ**
Make ideas real

This manual applies to the following FSW models with firmware version 6.10 and later:

- R&S®FSW8 (1331.5003K08 / 1312.8000K08)
- R&S®FSW13 (1331.5003K13 / 1312.8000K13)
- R&S®FSW26 (1331.5003K26 / 1312.8000K26)
- R&S®FSW43 (1331.5003K43 / 1312.8000K43)
- R&S®FSW50 (1331.5003K50 / 1312.8000K50)
- R&S®FSW67 (1331.5003K67 / 1312.8000K67)
- R&S®FSW85 (1331.5003K85 / 1312.8000K85)

The following firmware options are described:

- FSW-K95 802.11ad measurements (1313.1639.02)
- FSW-K97 802.11ay measurements (1338.4902.16)


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1177.5962.02 | Version 20 | R&S®FSW-K95/-K97

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

# Contents

# 1 Documentation overview

This section provides an overview of the FSW user documentation. Unless specified otherwise, you find the documents at:

www.rohde-schwarz.com/manual/FSW

Further documents are available at:

www.rohde-schwarz.com/product/FSW

## 1.1 Getting started manual

Introduces the FSW 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 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 FSW is not included.

The contents of the user manuals are available as help in the FSW. 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.

## 1.3 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

## 1.4 Instrument security procedures

Deals with security issues when working with the FSW in secure areas. It is available for download on the internet.

## 1.5 Printed safety instructions

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

## 1.6 Specifications and brochures

The specifications document, also known as the data sheet, contains the technical specifications of the FSW. 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/FSW

## 1.7 Release notes and open-source acknowledgment (OSA)

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

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

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

## 1.8 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/FSW

## 1.9 Videos

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

# 2 Welcome to the R&S FSW 802.11ad/ay applications

The R&S FSW 802.11ad/ay applications extend the functionality of the FSW to enable accurate and reproducible Tx measurements of a device under test (DUT) in accordance with the IEEE standard 802.11ad or IEEE 802.11ay.

The R&S FSW 802.11ad/ay applications feature:

- Support for data rates of up to 7 Gbit/s
- Use of the 60 GHz unlicensed band
  – Provide global availability
  – Avoids the overcrowded 2.4 GHz and 5 GHz bands
  – Uses short wavelengths (5 mm at 60 GHz), making compact and affordable antennas or antenna arrays possible
- Backward compatibility with the IEEE 802.11 universe:
  Seamless use of IEEE 802.11a,b,g,n across both bands 2.4 GHz and 5 GHz, plus 11ad in the 60 GHz range -> "triband" devices

Typical applications for IEEE 802.11ad/ay are:

- Wireless Display
- Distribution of HDTV content (e.g. in residential living rooms)
- Wireless PC connection to transmit huge files quickly
- Automatic sync applications (e.g. uploading images from a camera to a PC, "kiosk" applications)

Due to the use of a 2 GHz bandwidth, the R&S FSW 802.11ad/ay applications requires an optional bandwidth extension of at least 2 GHz to analyze IEEE 802.11ad/ay signals.

This user manual contains a description of the functionality that is specific to the application, including remote control operation.

**General FSW functions**

The application-independent functions for general tasks on the FSW are also available for IEEE 802.11ad/ay measurements and are described in the FSW user manual. In particular, this comprises the following functionality:

- Data management
- General software preferences and information

The latest version is available for download at the product homepage:

http://www.rohde-schwarz.com/product/FSW.html.

**Installation**

You can find detailed installation instructions in the FSW Getting Started manual or in the Release Notes.

## 2.1 Starting the R&S FSW 802.11ad/ay applications

The IEEE 802.11ad/ay measurements require a special application on the FSW.

Furthermore, an optional bandwidth extension of at least 2 GHz must be installed and active to analyze IEEE 802.11ad or IEEE 802.11ay signals. For information on available options, see the FSW specifications document.

For details on using and setting up bandwidth extension options that require an oscilloscope, see the FSW I/Q Analyzer and I/Q Input User Manual and the oscilloscope documentation.

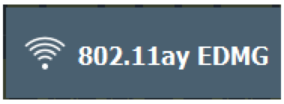
**To activate the R&S FSW 802.11ad/ay applications**

1. Select [MODE].

   A dialog box opens that contains all operating modes and applications currently available on your FSW.

2. Select the "IEEE 802.11ad"/"IEEE 802.11ay" item.

   The FSW opens a new measurement channel for the IEEE 802.11ad/ay measurement.

The measurement is started immediately with the default settings. You can configure it in the "Overview" dialog box, which is displayed when you select "Overview" from any menu (see Chapter 5.2.1, "Configuration overview", on page 44).

**Multiple Measurement Channels and Sequencer Function**

When you activate an application, a new measurement channel is created which determines the measurement settings for that application. The same application can be activated with different measurement settings by creating several channels for the same application.

The number of channels that can be configured at the same time depends on the available memory on the instrument.

Only one measurement can be performed at any time, namely the one in the currently active channel. However, to perform the configured measurements consecutively, a Sequencer function is provided.

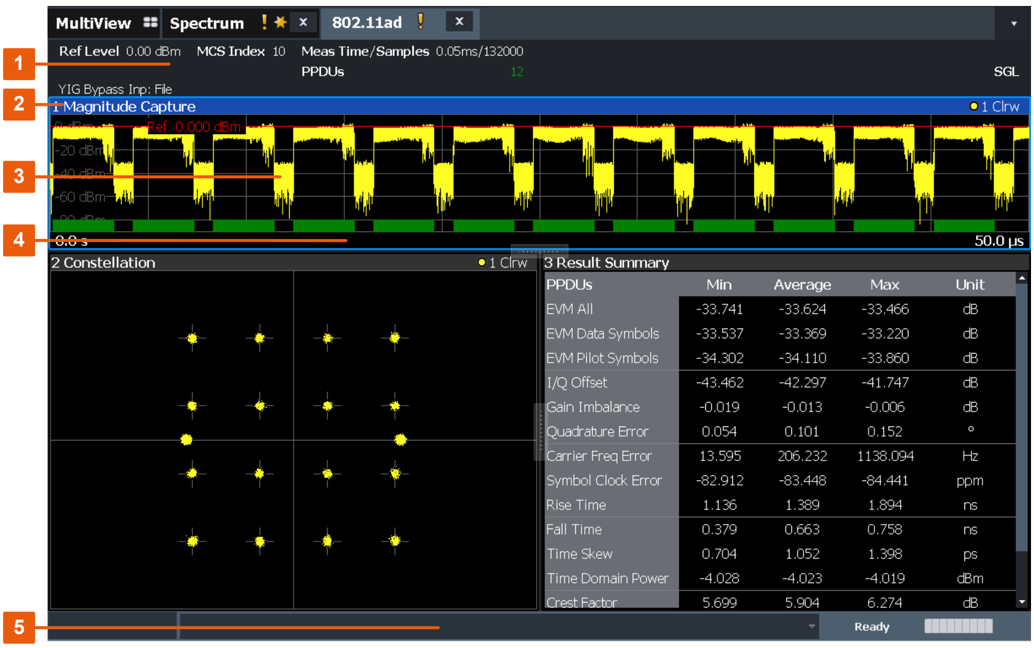
If activated, the measurements configured in the currently active channels are performed one after the other in the order of the tabs. The currently active measurement is indicated by a ⚙ symbol in the tab label. The result displays of the individual channels are updated in the tabs (including the "MultiView") as the measurements are performed. Sequential operation itself is independent of the currently *displayed* tab.

For details on the Sequencer function, see the FSW User Manual.

## 2.2 Understanding the display information

The following figure shows a measurement diagram during analyzer operation. All information areas are labeled. They are explained in more detail in the following sections.

Although the illustration shows the display for a IEEE 802.11ad measurement, the display elements for a IEEE 802.11ay measurement are identical unless specified otherwise.




1 = Channel bar for firmware and measurement settings
2 = Window title bar with diagram-specific (trace) information
3 = Diagram area with marker information
4 = Diagram footer with diagram-specific information, depending on result display
5 = Instrument status bar with error messages, progress bar and date/time display

### Channel bar information

In the R&S FSW 802.11ad/ay applications, the FSW shows the following settings:

*Table 2-1: Information displayed in the channel bar in the R&S FSW 802.11ad/ay applications*

| Label | Description |
|---|---|
| Ref Level | Reference level |
| Att | Mechanical and electronic RF attenuation |
| "PPDU / MCS Index / GI" | The PPDU type, MCS index and guard interval (GI) used for the analysis of the signal; Detected automatically from the signal.<br>See Table 4-1 and Table 4-2. |
| Freq | Center frequency for the RF signal |
| Meas time / Samples | Duration of signal capture and number of samples captured |
| SGL | The sweep is set to single sweep mode. |
| PPDUs | Number of analyzed PPDUs for statistical evaluation |

In addition, the channel bar also displays information on instrument settings that affect the measurement results, even though it is not immediately apparent from the display of the measured values (e.g. transducer or trigger settings). This information is displayed only when applicable for the current measurement. For details, see the FSW Getting Started manual.

### Window title bar information

For each diagram, the header provides the following information:

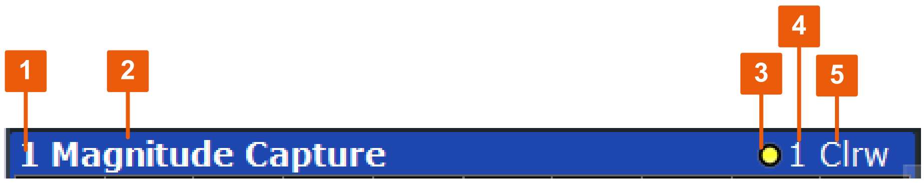



*Figure 2-1: Window title bar information in the R&S FSW 802.11ad/ay applications*

1 = Window number
2 = Window type
3 = Trace color
4 = Trace number
6 = Trace mode

### Diagram footer information

The diagram footer (beneath the diagram) contains the start and stop values for the displayed x-axis range.

### 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. Click on a displayed warning or error message to obtain more details.

# 3 Measurements and result displays

The R&S FSW 802.11ad/ay applications provides several different measurements to determine the parameters described by the IEEE 802.11ad/ay specifications.



## 3.1 IEEE 802.11ad/ay modulation accuracy measurement

**Access**: "Overview" > "Select Measurement" > "Modulation Accuracy"

**Or:** [MEAS] > "Select Measurement" > "Modulation Accuracy"

The default IEEE 802.11ad/ay Modulation Accuracy measurement captures I/Q data from the RF Input of the FSW with a bandwidth up to 2 GHz. This I/Q data is used by the R&S FSW 802.11ad/ay applications to demodulate broadband signals and determine various characteristic signal parameters such as modulation accuracy, channel frequency response and power.

Other IEEE 802.11ad/ay-specific measurements such as Spectrum Emission Mask can also be performed by sweeping over the desired frequency range using a filter with a smaller measurement bandwidth. The advantage of using a smaller bandwidth is an increased signal-to-noise-ratio (see Chapter 3.2, "SEM measurements", on page 29).



### 3.1.1 Evaluation methods for IEEE 802.11ad/ay modulation accuracy measurements

**Access**: "Overview" > "Display Config"

**Or:** [MEAS] > "Display Config"

The R&S FSW 802.11ad/ay applications provides various different methods to evaluate the captured signal without having to start a new measurement or sweep. Which results are displayed depends on the selected measurement and evaluation.

The selected evaluation method not only affects the result display in a window, but also the results of the trace data query in remote control (see `TRACe<n>[:DATA]?` on page 217).

All evaluations available for the selected IEEE 802.11ad/ay measurement are displayed in SmartGrid mode.

For details on working with the SmartGrid, see the FSW Getting Started manual.

The IEEE 802.11ad/ay measurements provide the following evaluation methods:



**Bitstream**

This result display shows a data stream for all analyzed PPDUs of the currently captured I/Q data as indicated in the "Magnitude Capture" display. The bitstream is derived from the constellation diagram points using the 'constellation bit encoding' from the corresponding IEEE 802.11ad/ay standard.

The following different bitstream displays are available:

- "Bitstream Header Decoded" - header data, decoded using the IEEE 802.11ad/ay specific LDPC decoder
- "Bitstream Header Raw" - header data, non-decoded
- "Bitstream Data Decoded" - payload data, decoded using the IEEE 802.11ad/ay specific LDPC decoder
- "Bitstream Data Raw" - payload data, non-decoded

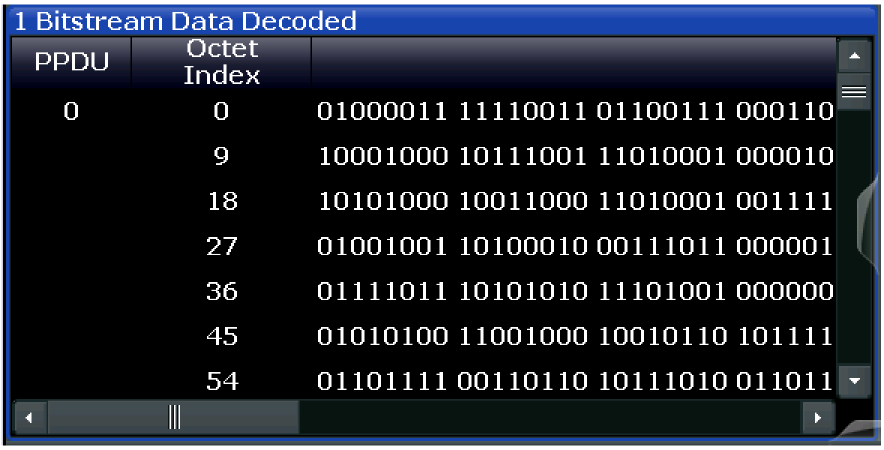



*Figure 3-1: Bitstream result display for decoded payload data*

Note that the raw and the decoded bitstreams only differ from each other when bit errors occur.

The PPDU number refers to the number in the capture buffer. The symbol index refers to the position relative to the analyzed PPDU start. The bitstream shows one value per symbol for each PPDU.

Remote command:
`LAY:ADD? '1',RIGH, DBST`
`LAY:ADD? '1',RIGH, DDBS`
`LAY:ADD? '1',RIGH, HBST`
`LAY:ADD? '1',RIGH, HDBS`
See `LAYout:ADD[:WINDow]?` on page 178
Querying results:
`TRACe<n>[:DATA]?`, see Chapter 9.10.4.1, "Bitstream", on page 219

**Channel Frequency Response**
The Channel frequency response trace shows the amplitude of the channel transfer function vs frequency.

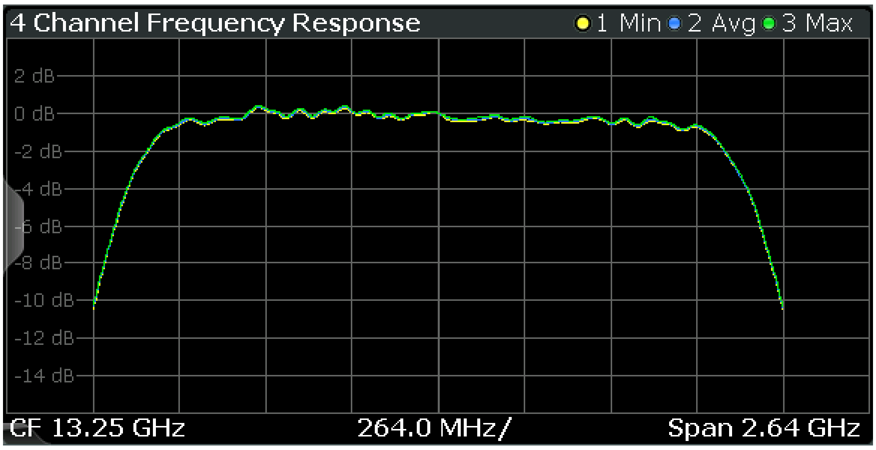



*Figure 3-2: Channel Frequency Response for IEEE 802.11 ad measurement*

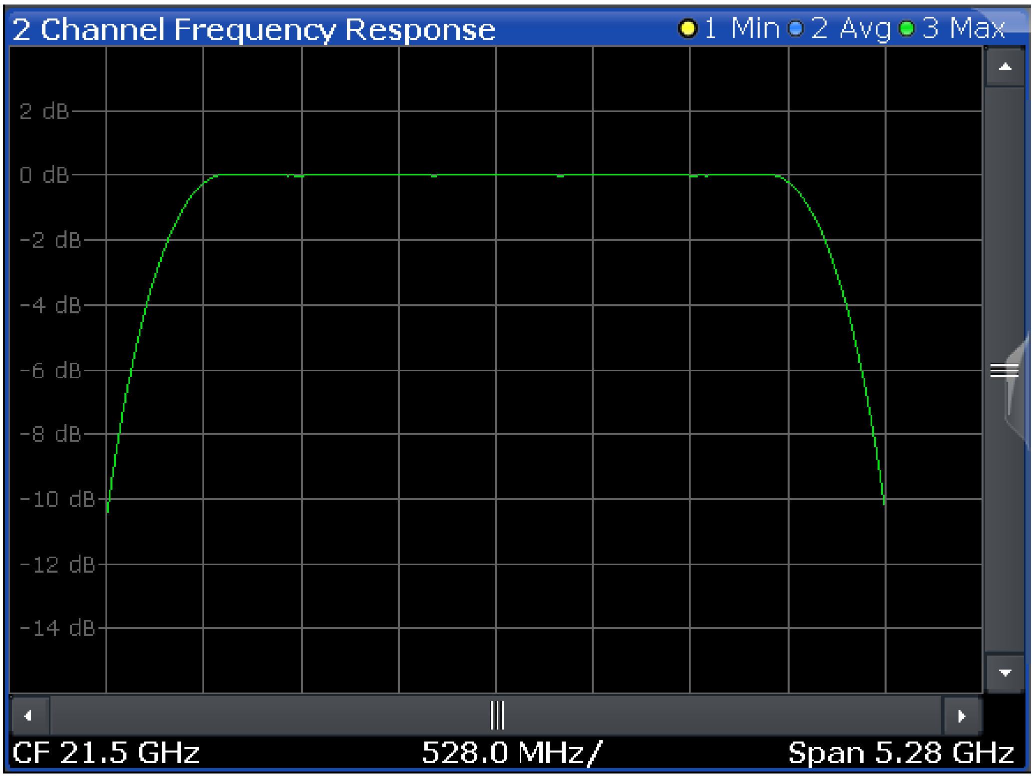


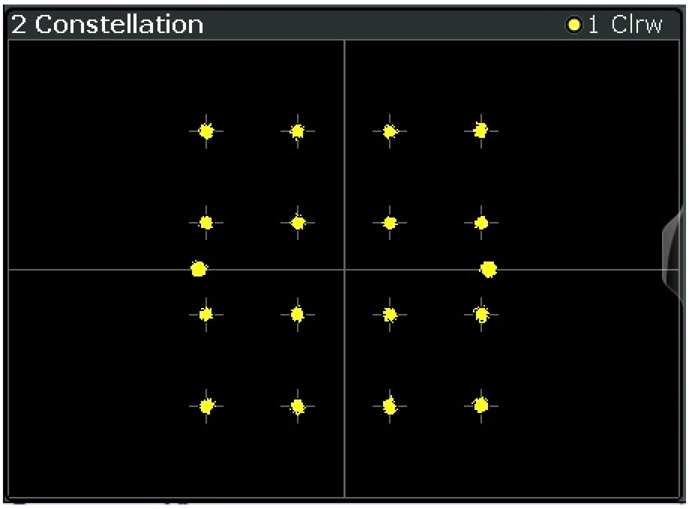

*Figure 3-3: Channel Frequency Response for 2-contiguous-channel measurement (IEEE 802.11 ay)*

The numeric trace results for this evaluation method are described in Chapter 9.10.4.2, "Channel frequency response", on page 219.

Remote command:
`LAY:ADD? '1',RIGH, CFR`, see `LAYout:ADD[:WINDow]?` on page 178
Querying results:
`TRACe<n>[:DATA]?`, see Chapter 9.10.4.2, "Channel frequency response", on page 219

**Constellation**
This result display shows the in-phase and quadrature phase results for all payload symbols and all carriers for the analyzed PPDUs of the current capture buffer. The Tracking/Channel Estimation according to the user settings is applied.

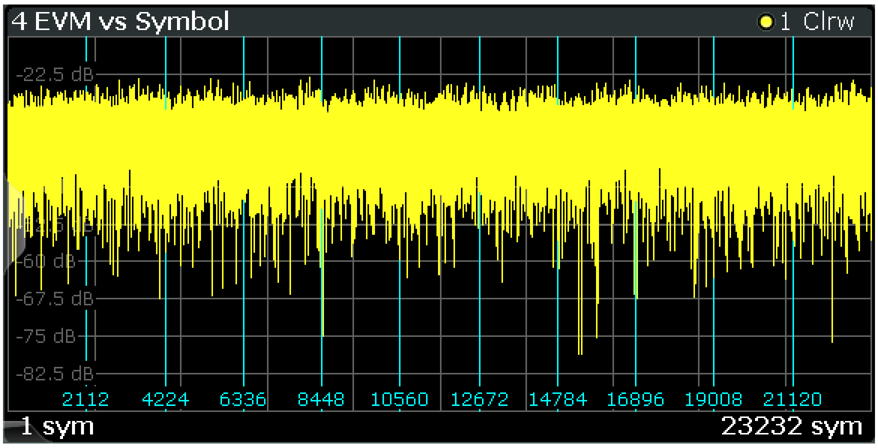
The inphase results (I) are displayed on the x-axis, the quadrature phase (Q) results on the y-axis.




The numeric trace results for this evaluation method are described in Chapter 9.10.4.3, "Constellation", on page 220.

Remote command:
`LAY:ADD? '1',RIGH, CONS`, see `LAYout:ADD[:WINDow]?` on page 178
Querying results:
`TRACe<n>[:DATA]?`, see Chapter 9.10.4.3, "Constellation", on page 220

**EVM vs Symbol**
This result display shows all EVM values per symbol over the number of analyzed PPDUs as defined by the "Evaluation Range" settings (see "PPDU to Analyze / Index of Specific PPDU" on page 78). The Tracking/Channel Estimation according to the user settings is applied (see Chapter 5.2.5, "Tracking", on page 68).

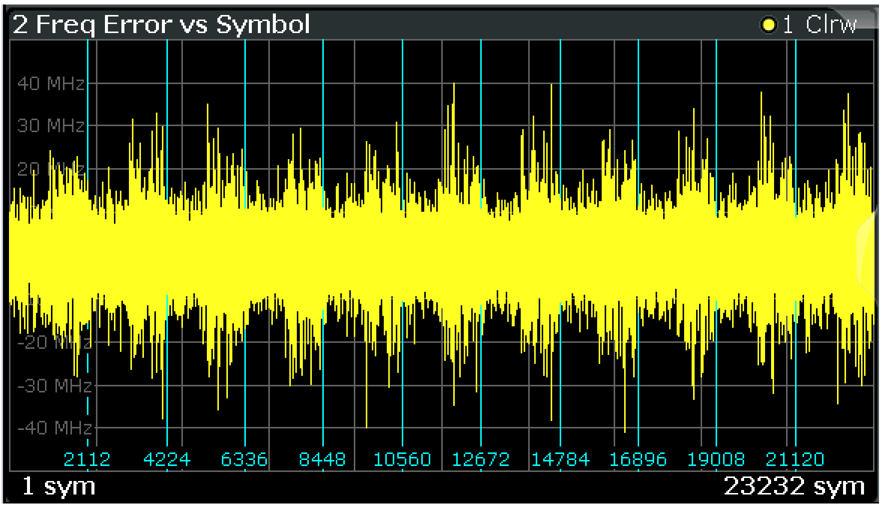



Vertical lines indicate the start of the next PPDU. The numbers at the bottom of the lines indicate the corresponding symbol positions.

Remote command:
`LAY:ADD? '1',RIGH, EVSY`, see `LAYout:ADD[:WINDow]?` on page 178
Querying results:
`TRACe<n>[:DATA]?`, see Chapter 9.10.4.4, "EVM vs symbol", on page 220

**Freq. Error vs Symbol**

Displays the frequency error values per (analyzed) symbol in the PPDU.




Vertical lines indicate the start of the next PPDU. The numbers at the bottom of the lines indicate the corresponding symbol positions.

Remote command:

`LAY:ADD? '1',RIGH,FEVS`, see `LAYout:ADD[:WINDow]?` on page 178

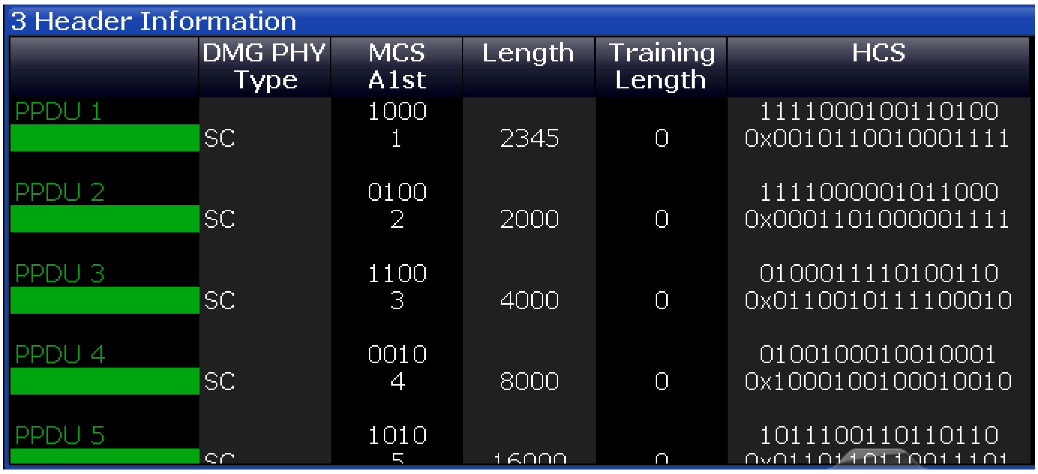
Or:

Querying results:

`TRACe<n>[:DATA]?`, see Chapter 9.10.4.5, "Frequency error vs symbol", on page 220

**Header information**

Displays information that has been decoded from the headers of the PPDUs. The header contains information on the modulation used for transmission.



3 Header Information

| | DMG PHY Type | MCS A1st | Length | Training Length | HCS |
|---|---|---|---|---|---|
| PPDU 1 | SC | 1000<br>1 | 2345 | 0 | 1111000100110100<br>0x0010110010001111 |
| PPDU 2 | SC | 0100<br>2 | 2000 | 0 | 1111000001011000<br>0x0001101000001111 |
| PPDU 3 | SC | 1100<br>3 | 4000 | 0 | 0100011110100110<br>0x0110010111100010 |
| PPDU 4 | SC | 0010<br>4 | 8000 | 0 | 0100100010010001<br>0x1000100100010010 |
| PPDU 5 | | 1010 | | | 1011100110110110 |

The header information is provided as a decoded bit sequence and, where appropriate, also in human-readable form, beneath the bit sequence for each PPDU.

*Table 3-1: Results for Header Info result display*

| Parameter | Description |
|---|---|
| MCS | Modulation and Coding Scheme (MCS) index of the PPDU as defined in IEEE Std 802.11-2012 section "21.2.2 TXVECTOR and RXVECTOR parameters"<br>(lower value: human-readable value) |
| DMG PHY Type | Single carrier ("SC") or control PHY (OFDM and "Low power SC PHY" currently not supported); see "Types of PHYs" on page 34 |
| Length | Length of the PPDU in symbols |
| Training Length | Length of the optional beam-forming training field; see "Beamforming" on page 35 |
| HCS | Header check sum (CRC)<br>(lower value: human-readable value) |

The numeric trace results for this evaluation method are described in Chapter 9.10.4.6, "Header info", on page 220.

Remote command:
`LAY:ADD? '1',RIGH,HEAD`, see `LAYout:ADD[:WINDow]?` on page 178
Querying results:
`TRACe<n>[:DATA]?`, see Chapter 9.10.4.6, "Header info", on page 220

**Magnitude Capture**

The "Magnitude Capture" Buffer display shows the magnitude vs time for the complete range of captured data for the last sweep. Green bars at the bottom of the "Magnitude Capture" buffer display indicate the positions of the analyzed PPDUs. A single green bar possibly indicates that the evaluation range is limited to a single PPDU (see "PPDU to Analyze / Index of Specific PPDU" on page 78).

The trigger position is indicated by a vertical red line, if it lies within the displayed x-axis span.

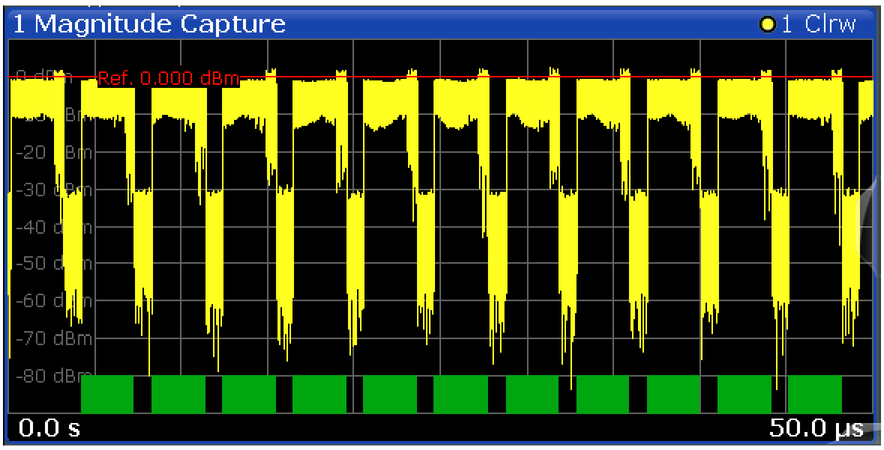
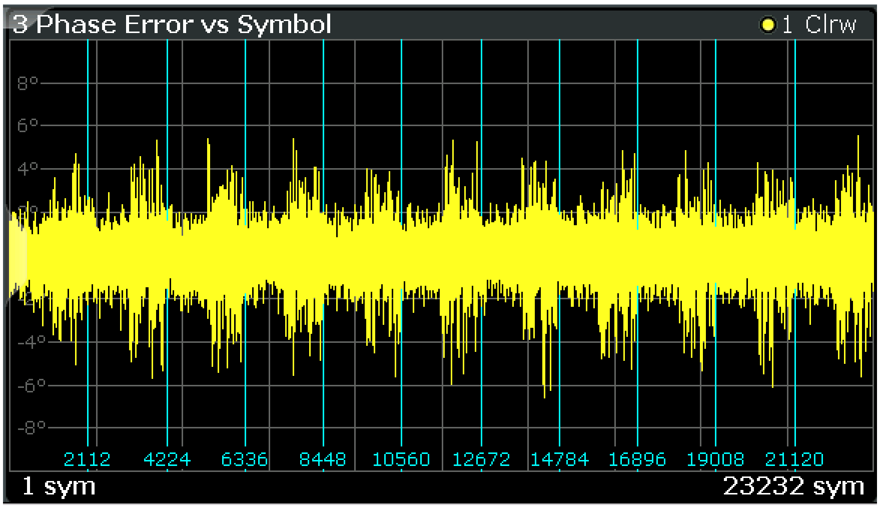



*Figure 3-4: Magnitude capture display for single PPDU evaluation*

Remote command:
`LAY:ADD? '1',RIGH, MCAP`, see `LAYout:ADD[:WINDow]?` on page 178
Querying results:
`TRACe<n>[:DATA]?`, see Chapter 9.10.4.7, "Magnitude capture", on page 221

**Phase Error vs Symbol**
Displays the phase error values in degrees or radians per symbol. The phase error is calculated as the difference between the ideal reference signal and the measured signal (with any active compensation applied). Thus, this result display shows the remaining phase error that has not been compensated for by phase tracking.

Tip: The Phase Tracking vs Symbol result display shows the actual compensation values that were applied by the R&S FSW 802.11ad/ay applications.




Vertical lines indicate the start of the next PPDU. The numbers at the bottom of the lines indicate the corresponding symbol positions.

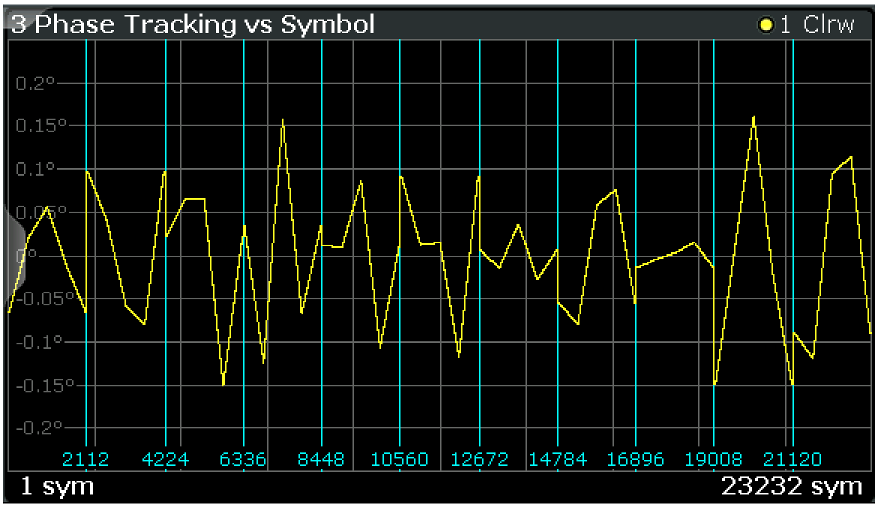
Remote command:
`LAY:ADD? '1',RIGH,PEVS`, see `LAYout:ADD[:WINDow]?` on page 178
Querying results:
`TRACe<n>[:DATA]?`, see Chapter 9.10.4.8, "Phase error vs symbol", on page 221

**Phase Tracking vs Symbol**
Shows the average compensated phase drift in degrees or radians vs symbol for phase tracking (see "Phase, level and timing tracking" on page 35). Thus, you can see which compensation has been applied by the R&S FSW 802.11ad/ay applications.

Since phase tracking is performed based on data symbol blocks (=512 symbols), it represents the low-frequency part of the Phase Error vs Symbol, if phase tracking is off.

Tip: The Phase Error vs Symbol result display shows the remaining phase error *after* compensation has been applied.

Note that this result display is also available if Phase Tracking is not active.

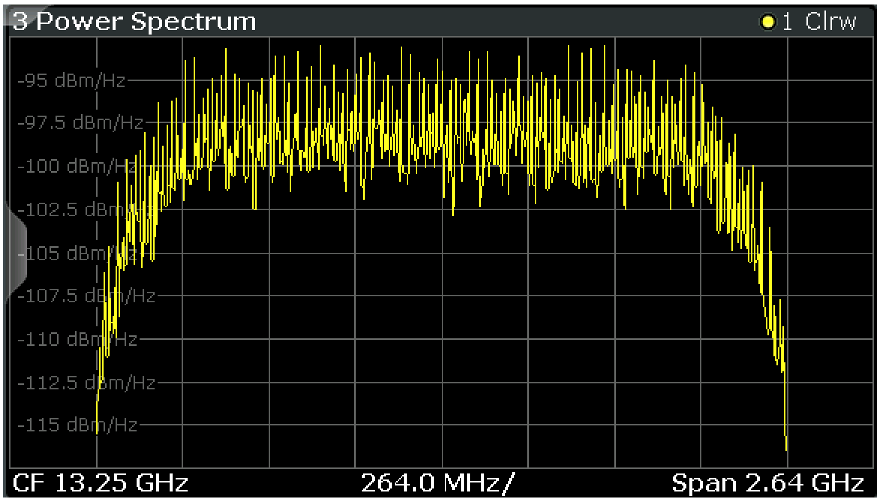



Vertical lines indicate the start of the next PPDU. The numbers at the bottom of the lines indicate the corresponding symbol positions.

Remote command:
`LAY:ADD? '1',RIGH,PTVS`, see `LAYout:ADD[:WINDow]?` on page 178
Querying results:
`TRACe<n>[:DATA]?`, see Chapter 9.10.4.9, "Phase tracking vs. symbol", on page 221

**Power Spectrum**

This result display shows the power vs frequency values obtained from an FFT. The FFT is performed over the complete data in the current capture buffer, without any correction or compensation.




The numeric trace results for this evaluation method are described in Chapter 9.10.4.10, "Power spectrum", on page 221.

Remote command:
`LAY:ADD? '1',RIGH, PSP`, see `LAYout:ADD[:WINDow]?` on page 178
Querying results:
`TRACe<n>[:DATA]?`, see Chapter 9.10.4.10, "Power spectrum", on page 221

**PvT Full PPDU**

Displays the minimum, average and maximum power vs time traces for all PPDUs.

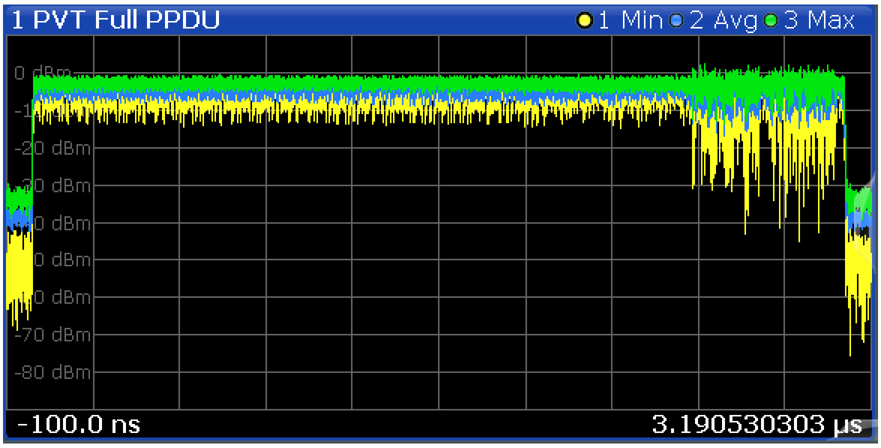



*Figure 3-5: PvT Full PPDU result display*

Remote command:

`LAY:ADD:WIND '2',RIGH,PFPP` see `LAYout:ADD[:WINDow]?` on page 178

Querying results:

`TRACe<n>[:DATA]?`, see Chapter 9.10.4.11, "Power vs time (PVT)", on page 222

**PvT Rising Edge**

Displays the minimum, average and maximum power vs time traces for the rising edge of all PPDUs.

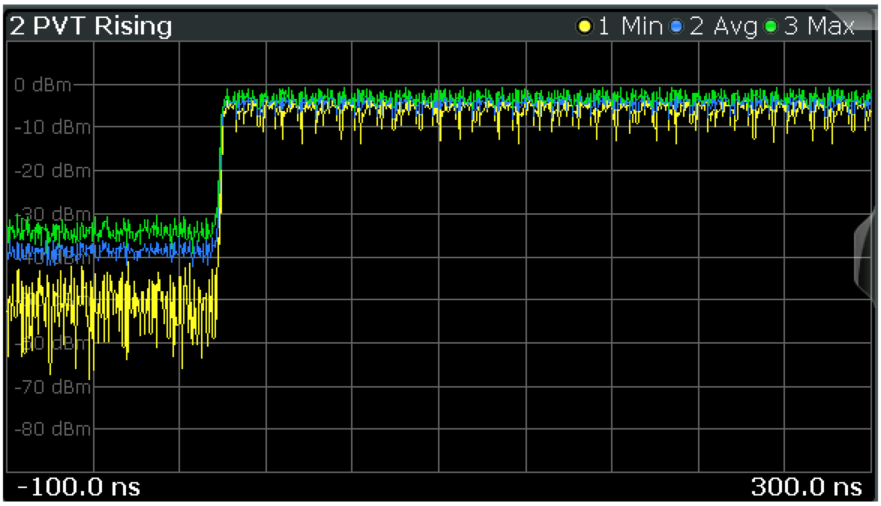



*Figure 3-6: PvT Rising Edge result display*

Remote command:

`LAY:ADD:WIND '2',RIGH,PRIS` see `LAYout:ADD[:WINDow]?` on page 178

Querying results:

`TRACe<n>[:DATA]?`, see Chapter 9.10.4.11, "Power vs time (PVT)", on page 222

**PvT Falling Edge**

Displays the minimum, average and maximum power vs time traces for the falling edge of all PPDUs.

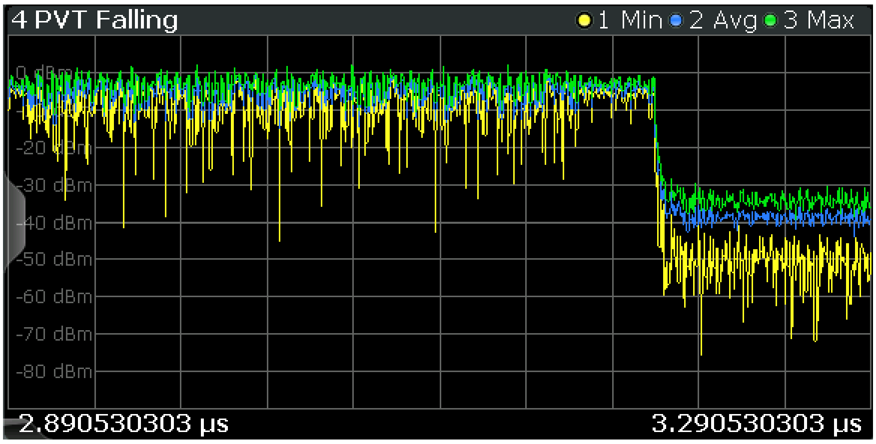



*Figure 3-7: PvT Falling Edge result display*

Remote command:
`LAY:ADD:WIND '2',RIGH,PFAL` see `LAYout:ADD[:WINDow]?` on page 178
Querying results:
`TRACe<n>[:DATA]?`, see Chapter 9.10.4.11, "Power vs time (PVT)", on page 222

**Result Summary**

The result summary provides measurement results based on the complete captured signal.

3 Result Summary

| PPDUs | Min | Average | Max | Unit |
|---|---|---|---|---|
| EVM All | -24.274 | 3.766 | 15.321 | dB |
| EVM Data Symbols | -24.216 | 3.946 | 15.505 | dB |
| EVM Pilot Symbols | -25.880 | -17.998 | -9.492 | dB |
| I/Q Offset | -50.413 | -40.257 | -37.675 | dB |
| Gain Imbalance | 0.061 | 0.293 | 0.929 | dB |
| Quadrature Error | -0.259 | -0.164 | 0.033 | ° |
| Carrier Freq Error | 40.048 | -7721.139 | -29974.2... | Hz |
| Symbol Clock Error | 0.077 | 0.020 | -0.198 | ppm |
| Rise Time | 0.379 | 0.864 | 1.136 | ns |
| Fall Time | 0.379 | 0.660 | 0.758 | ns |
| Time Skew | -6.756 | -4.171 | 3.389 | ps |
| Time Domain Power | -8.231 | -8.226 | -8.223 | dBm |
| Crest Factor | 5.775 | 6.077 | 6.328 | dB |
| Header BER | 0.000 | 0.000 | 0.000 | |
| Payload BER | 0.000 | 0.000 | 0.000 | |

***Figure 3-8: Result summary***

**Note:** You can configure which results are displayed (see Chapter 5.2.8.1, "Table configuration", on page 71). However, the results are always calculated, regardless of their visibility.

For details on the individual results and the summarized values, see Chapter 3.1.2, "Modulation accuracy parameters", on page 24.

Remote command:
`LAY:ADD? '1',RIGH, RSGL`, see `LAYout:ADD[:WINDow]?` on page 178
Querying results:
`FETCh:BURSt:ALL?` on page 210

## 3.1.2 Modulation accuracy parameters

The default IEEE 802.11ad/ay Modulation Accuracy measurement captures I/Q data from the RF input of the FSW and determines the following I/Q parameters in a single capture.

For each parameter, the R&S FSW 802.11ad/ay applications also performs statistical evaluation over several PPDUs and displays the following results:

*Table 3-2: Calculated summary results*

| Result type | Description |
|---|---|
| Min | Minimum value in current capture buffer |
| Average | Average value in current capture buffer |
| Max | Maximum value in current capture buffer |

**EVM All [dB]**
EVM over all symbols in PPDUS to analyze in capture buffer

The PPDU EVM (direct) method evaluates the root mean square EVM over one PPDU. That is the square root of the averaged error power normalized by the averaged reference power:

$$EVM = \sqrt{\frac{\sum_{n=0}^{N-1} |x_{meas}(n) - x_{ref}(n)|^2}{\sum_{n=0}^{N-1} |x_{ref}(n)|^2}} = \sqrt{\frac{\sum_{n=0}^{N-1} |e(n)|^2}{\sum_{n=0}^{N-1} |x_{ref}(n)|^2}}$$

Before calculation of the EVM, tracking errors in the measured signal are compensated for if specified by the user. In the ideal reference signal, the tracking errors are always compensated for. Tracking errors include phase (center frequency error + common phase error), timing (sampling frequency error) and gain errors. Quadrature offset and gain imbalance errors, however, are not corrected.

The PPDU EVM is not part of the IEEE standard and no limit check is specified. Nevertheless, this commonly used EVM calculation can provide some insight in modulation quality and enables comparisons to other modulation standards.

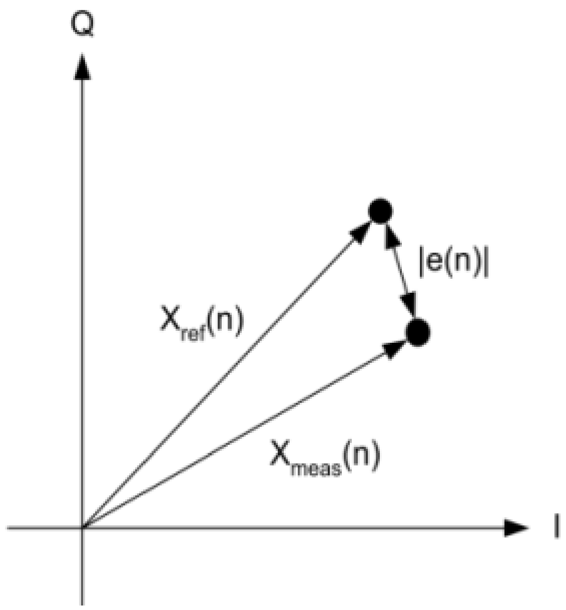



*Figure 3-9: I/Q diagram for EVM calculation*

Remote command:
`FETCh:EVM:ALL:MINimum?` on page 212

**EVM Data Symbols [dB]**
EVM over data symbols in PPDUS to analyze in capture buffer

Remote command:
`FETCh:EVM:DATA:MINimum?` on page 212

**EVM Pilot Symbols [dB]**
EVM over pilot symbols in PPDUS to analyze in capture buffer

Remote command:
`FETCh:EVM:PILot:MINimum?` on page 212

**I/Q Offset [dB]**
Transmitter center frequency leakage relative to the total Tx channel power.

An I/Q offset indicates a carrier offset with fixed amplitude. This results in a constant shift of the I/Q axes. The offset is normalized by the mean symbol power and displayed in dB.

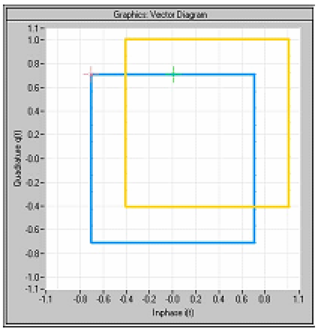



***Figure 3-10: I/Q offset in a vector diagram***

Remote command:
`FETCh:IQOFfset:MINimum?` on page 213

**Gain Imbalance [%/dB]**
Amplification of the quadrature phase component of the signal relative to the amplification of the in-phase component.

An ideal I/Q modulator amplifies the I and Q signal path by exactly the same degree. The imbalance corresponds to the difference in amplification of the I and Q channel and therefore to the difference in amplitude of the signal components. In the vector diagram, the length of the I vector changes relative to the length of the Q vector.

The result is displayed in dB and %, where 1 dB offset corresponds to roughly 12 % difference between the I and Q gain, according to the following equation:

*Imbalance [dB] = 20 log (| $Gain_Q$ |/| $Gain_I$ |)*

Positive values mean that the Q vector is amplified more than the I vector by the corresponding percentage. For example, using the figures mentioned above:

0.98 ≈ 20*log10(1.12/1)

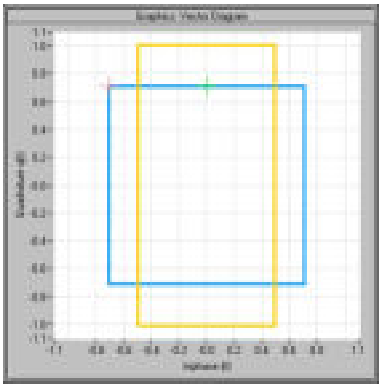


*Figure 3-11: Positive gain imbalance*

Negative values mean that the I vector is amplified more than the Q vector by the corresponding percentage. For example, using the figures mentioned above:

-0.98 ≈ 20*log10(1/1.12)

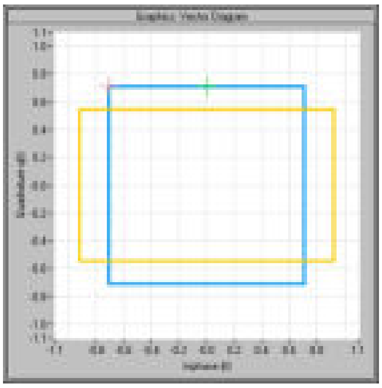


*Figure 3-12: Negative gain imbalance*

Remote command:
`FETCh:GIMBalance:MINimum?` on page 213

**Quadrature Error [°]**
Deviation of the quadrature phase angle from the ideal 90°.

An ideal I/Q modulator sets the phase angle between the I and Q path mixer to exactly 90 degrees. With a quadrature offset, the phase angle deviates from the ideal 90 degrees, the amplitudes of both components are of the same size. In the vector diagram, the quadrature offset causes the coordinate system to shift.

A positive quadrature offset means a phase angle greater than 90 degrees:

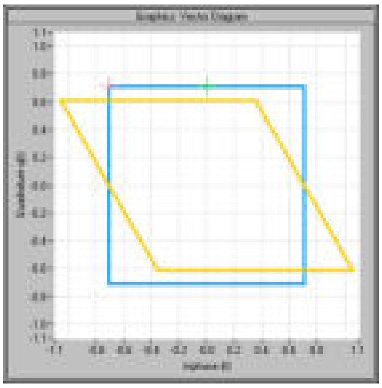


*Figure 3-13: Positive quadrature offset*

A negative quadrature offset means a phase angle less than 90 degrees:

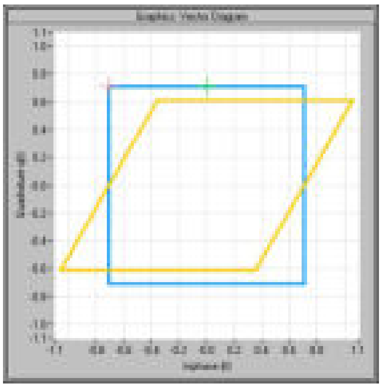


*Figure 3-14: Negative quadrature offset*

Remote command:
FETCh:QUADerror:MINimum? on page 213

**Center Frequency Error [Hz]**
Frequency error between the signal and the current center frequency of the FSW

Remote command:
FETCh:CFERror:MINimum? on page 212

**Symbol Clock Error [ppm]**
Clock error between the signal and the sample clock of the FSW in parts per million (ppm), i.e. the symbol timing error

Remote command:
FETCh:SYMBolerror:MINimum? on page 214

**Rise Time [s]**
The time required for the PPDU to transition from the base to the top level. This is the difference between the time at which the PPDU exceeds the lower 10 % and upper 90 % thresholds.

Remote command:
`FETCh:RTIMe:MINimum?` on page 214

**Fall Time [s]**
The time required for the PPDU to transition from the top to the base level. This is the difference between the time at which the PPDU drops below the upper 90 % and lower 10 %thresholds.

Remote command:
`FETCh:FTIMe:MINimum?` on page 213

**Time Skew [s]**
A constant time difference between the I and Q data, for example due to different cable lengths

Remote command:
`FETCh:TSKew:MINimum?` on page 214

**Time Domain Power [dBm]**
Power of the captured signal vs time

Remote command:
`FETCh:TDPower:MINimum?` on page 214

**Crest factor [dB]**
The ratio of the peak power to the mean power of the signal (also called Peak to Average Power Ratio, PAPR)

Remote command:
`FETCh:CFACtor:MINimum?` on page 212

**SNR**
Signal to noise ratio of the PPDU

Remote command:
`FETCh:SNR:MINimum?` on page 214

**Header BER**
The Bit Error Rate of the PPDU header determined by LDPC decoding

Remote command:
`FETCh:HBERate:MINimum?` on page 215

**Payload BER**
The Bit Error Rate of the PPDU payload determined by LDPC decoding

Remote command:
`FETCh:PBERate:MINimum?` on page 215

## 3.2 SEM measurements

**Access**: "Overview" > "Select Measurement" > "SEM"

**Or:** [MEAS] > "Select Measurement" > "SEM"

In addition to the default IEEE 802.11ad/ay Modulation Accuracy measurement, which captures I/Q data from the RF Input of the FSW with a bandwidth up to 2 GHz, the R&S FSW 802.11ad/ay applications also provides an SEM measurement. The SEM measurement sweeps over the desired frequency range using a filter with a smaller measurement bandwidth. The advantage of using a smaller bandwidth is an increased signal-to-noise-ratio.

The SEM measurement provided by the R&S FSW 802.11ad/ay applications is identical to the corresponding measurements in the base unit, but it is pre-configured according to the requirements of the IEEE 802.11ad/ay standard.

If you require any other frequency sweep measurements, use the Spectrum application.

For details on frequency sweep measurements, see the FSW User Manual.

The Spectrum Emission Mask (SEM) measurement determines the power of the IEEE 802.11ad/ay signal in defined offsets from the carrier. It then compares the measured power values to a spectral mask specified by the IEEE 802.11ad/ay specifications. The limits depend on the selected band class. Thus, the performance of the DUT can be tested and the emissions and their distance to the limit be identified.

> The IEEE 802.11ad/ay standard does not distinguish between spurious and spectral emissions.

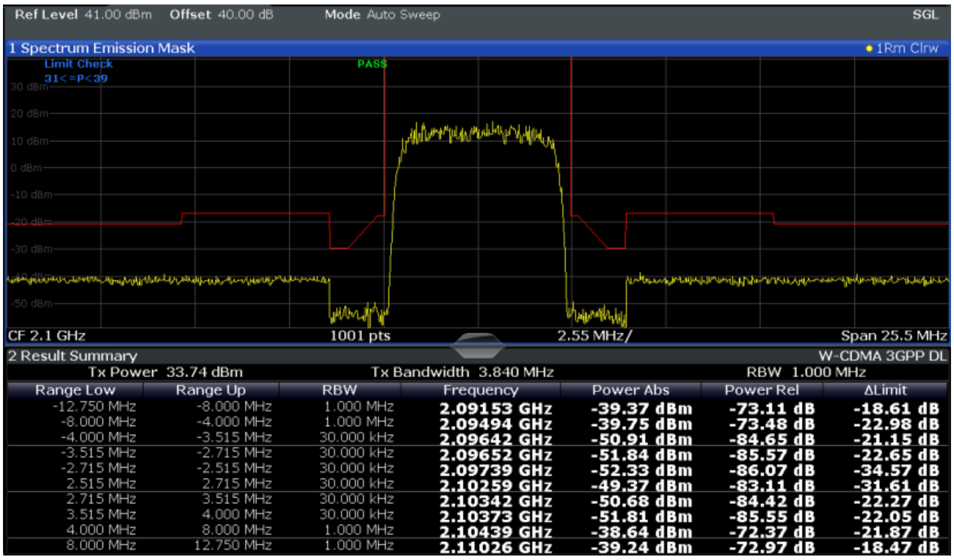



*Figure 3-15: SEM measurement results*

**Remote commands:**

`[SENSe:]SWEep:MODE` on page 101

Querying results:

`CALCulate<n>:LIMit<li>:FAIL?` on page 215

TRAC:DATA? LIST, see TRACe<n>[:DATA]? on page 217

### Evaluation methods

The evaluation methods for SEM measurements in the R&S FSW 802.11ad/ay applications are identical to the methods in the FSW base unit (Spectrum application).



**Diagram**

Displays a basic level vs. frequency or level vs. time diagram of the measured data to evaluate the results graphically. This is the default evaluation method. Which data is displayed in the diagram depends on the "Trace" settings. Scaling for the y-axis can be configured.

Remote command:
LAY:ADD? '1',RIGH, DIAG, see LAYout:ADD[:WINDow]? on page 178
Results:

**Result Summary**

Result summaries provide the results of specific measurement functions in a table for numerical evaluation. The contents of the result summary vary depending on the selected measurement function. See the description of the individual measurement functions for details.

2 Result Summary

| Channel | Bandwidth | Offset | Power | |
|---|---|---|---|---|
| TX1 (Ref) | 1.229 MHz | | -0.86 dBm | |
| Tx Total | | | -0.86 dBm | |
| Channel | Bandwidth | Offset | Lower | Upper |
| Adj | 30.000 kHz | 750.000 kHz | -79.59 dB | -80.34 dB |
| Alt1 | 30.000 kHz | 1.980 MHz | -85.04 dB | -83.85 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, RSUM, see LAYout:ADD[:WINDow]? on page 178

**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 178
Results:
CALCulate<n>:MARKer<m>:X on page 196

**Marker Peak List**

The marker peak list determines the frequencies and levels of peaks in the spectrum or time domain. How many peaks are displayed can be defined, as well as the sort order. In addition, the detected peaks can be indicated in the diagram. The peak list can also be exported to a file for analysis in an external application.

3 Marker Peak List

| Wnd | No | X-Value | Y-Value |
|---|---|---|---|
| 2 | 1 | 1.086245 ms | -75.810 dBm |
| 2 | 2 | 2.172490 ms | -6.797 dBm |
| 2 | 3 | 3.258736 ms | -76.448 dBm |
| 2 | 4 | 4.831918 ms | -76.676 dBm |
| 2 | 5 | 6.255274 ms | -76.482 dBm |
| 2 | 6 | 6.798397 ms | -6.800 dBm |
| 2 | 7 | 9.233084 ms | -76.519 dBm |
| 2 | 8 | 10.075861 ms | -76.172 dBm |
| 2 | 9 | 11.405574 ms | -6.801 dBm |

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

Remote command:

`LAY:ADD? '1',RIGH, PEAK`, see `LAYout:ADD[:WINDow]?` on page 178

Results:

`CALCulate<n>:MARKer<m>:X` on page 196

# 4 Measurement basics

Some background knowledge on basic terms and principles used in IEEE 802.11ad/IEEE 802.11ay measurements is provided here for a better understanding of the required configuration settings.

Additional background information is available in the Rohde & Schwarz White Paper: 1MA220: 802.11ad - WLAN at 60 GHz A Technology Introduction.

## 4.1 Characteristics of the IEEE 802.11ad standard

The popular wireless transmission standard WLAN [(IEEE 802.11)] has been amended and updated regularly since it was first published to accommodate for constant demands of transmitting higher data rates and larger bandwidths. Multimedia data streams, for example, require very high throughput over large periods of time.

To meet this need, the Wireless Gigabit Alliance (WiGig) has developed a specification for wireless transmission of data in the 60 GHz band at speeds in the multi-Gigabit range.

Thus, the 11ad physical layer was added as an amendment to the existing WLAN standard, in chapter 21 of the 802.11-2012 standard [1]. It is called "**Directional Multi-Gigabit (DMG) PHY**" (or short: *PHY*).

#### Used bandwidths

The outstanding new feature of the IEEE 802.11ad standard is the use of the 60 GHz band; however, to maintain compatibility with existing WLAN devices, the 2.4 GHz and 5 GHz ranges defined by the IEEE 802.11a, b, g, and n standards are also supported.

In the range around 60 GHz, an unlicensed frequency band is available everywhere in the world. This range permits higher channel bandwidths for greater throughput. Another advantage is the small wavelengths (approx. 5 mm). Thus, compact and competitive antennas or antenna arrays can be used (e.g. for beamforming).

On the down side, this band has a very high free-field attenuation and oxygen ($O_2$) absorption. However, transmission typically takes place within a limited range of under 10 m (the typical living room). Thus, the high degree of attenuation can also be seen as an advantage. Interference from adjacent transmissions is very unlikely. Transmission is very difficult to intercept, making it even more secure. Finally, beamforming can be used to focus the power to the receiver.

Even when the IEEE 802.11ad transmission takes place in the open ISM band, interference of other applications must be minimized. Thus, a spectrum mask is defined by the standard, which must be adhered to during transmission. Therefore, an SEM measurement is provided by the R&S FSW 802.11ad/ay applications.

### Types of PHYs

In principle, four different types of DMG PHYs are available using different package structures and modulation modes. They make it possible to fulfill differing requirements, such as high throughput or robustness.

*Table 4-1: PHY types and modulation modes*

| PHY type | MCS | Data rate | Modulation | Usage |
|---|---|---|---|---|
| Control PHY | 0 | 27.5 Mbps | DBPSK | Control messages for connection and monitoring, small data rates, but must be very robust |
| Single carrier (SC) PHY | 1 to 12.6 | 385-8085 Mbps | BPSK<br>QPSK<br>16QAM<br>64QAM | Robust data transmission of large data rates |
| Low power SC PHY | 25 to 31 | 626-2053 Mbps | BPSK<br>QPSK | Transmission using battery-operated devices |
| OFDM PHY | 13 to 24 | 693-6756 Mbps | SQPSK<br>QPSK<br>16QAM<br>64QAM | Very high data rates, strong power supply<br>(Currently not supported by R&S FSW 802.11ad/ay applications) |

All DMG PHYs use the same package structure, but they differ in how the individual fields are defined as well as in the coding and modulation that is used.

### Package structure

The general structure of a package in the IEEE 802.11ad physical layer consists of the following common parts:

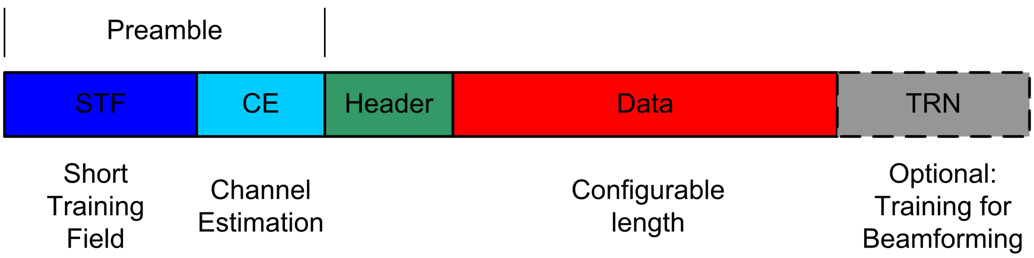



*Figure 4-1: General package structure in IEEE 802.11ad*

- **Preamble**
  The preamble consists of the **short training field** (STF) and the **channel estimation** (CE) field. It is required in every package. It supports the receiver during automatic gain control (AGC), when recognizing the package, and in estimating the frequency offset. The preamble also indicates the type of PHY that is used (SC or OFDM). The receiver can also use the known CE field to estimate the channel.
- **Header**

The header is different for every PHY and contains additional important information for the receiver, such as the modulation mode (MCS), the length of the data field or a checksum.

- **Data**
  This part is used to transmit the actual data with different modulations (MCS). The length of the field varies (number of bytes/octets).
- TRN
  This field is optional and can be appended to all packages. It includes beamforming information (see "Beamforming" on page 35)

### Golay sequences

In radiocommunications, training sequences are used for channel estimation. Predefined sequences that are already known to the receiver are transmitted over the channel and evaluated by the receiver to estimate the channel. Complementary Golay sequences are perfectly suited to this task.

The individual fields in the IEEE 802.11ad signal packages (e.g. the preamble) are made up of Golay sequences. Each sequence consists of bipolar symbols (±1). They are constructed mathematically to achieve specific autocorrelation characteristics. Each consists of a complementary pair (a and b). An additional index contains the length of the sequence. For example, $G_a$128 and $G_b$128 represent a complementary sequence with a length of 128. In addition, four specific $G_x$128 are then logically combined into $G_u$512 or $G_v$512.

The single carrier physical layers (SC, low power SC and control) nominally use a bandwidth of 1760 MHz, while the OFDM physical layer uses 1830.47 MHz.

### Beamforming

Transmission in the 60 GHz range is subject to greater free-space loss than in the 2.4 GHz or 5 GHz range. The channel conditions can change dramatically during a connection (for example, someone moves between a BluRay player and a projector during a 3DHD connection). Both can be managed in real-time by using beamforming. Because the antenna size in the 60 GHz band is very compact, small and competitive antenna arrays can be used. IEEE 802.11ad supports beamforming in real-time. During the beam refinement process, training sequences for beamforming are sent between the transmitter and receiver and evaluated. The best antenna weightings for each situation can then be set.

Beamforming training sequences can be appended to all PHY packages (control, SC, low-power SC and OFDM) for this purpose. The package type and training length are set accordingly in the corresponding header.

### Phase, level and timing tracking

Golay sequences are also used as guard intervals, which are inserted after each set of 512 symbols (see Figure 4-2). These guard intervals are used for phase tracking, that is: compensating the estimated phase error. The values that have been compensated by the R&S FSW 802.11ad/ay applications based on this phase estimation are displayed in the "Phase Tracking vs Symbol" on page 20 result display. After the phase tracking and other compensation (for example for level or time) has been applied, further results such as the EVM are calculated.

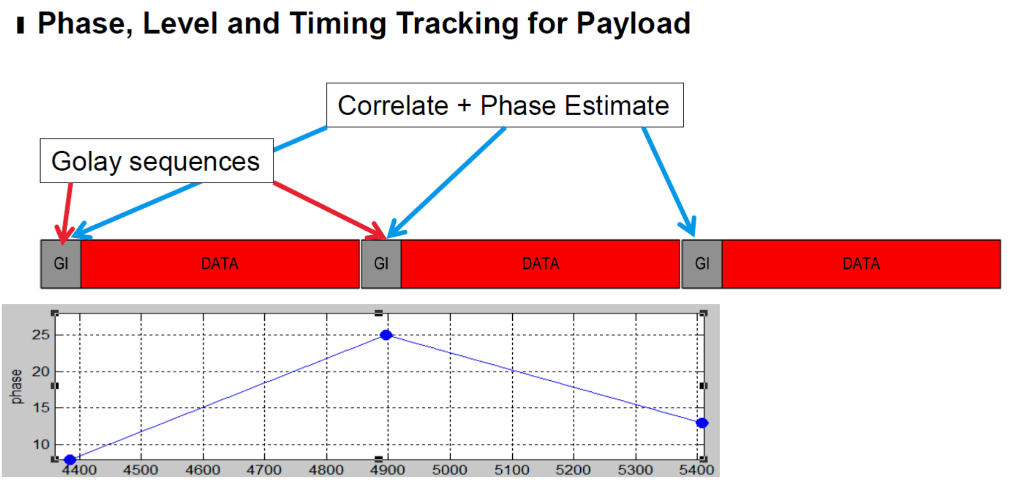



*Figure 4-2: Phase tracking using guard intervals and Golay sequences*

## 4.2 Characteristics of the IEEE 802.11ay standard

The IEEE 802.11ay enhanced directional multi-gigabit (EDMG) standard provides some additional features compared to the IEEE 802.11ad DMG standard:

- Support of 4.32 GHz contiguous channel width
- Support of 6.48 GHz contiguous channel width
- Support of 8.64 GHz contiguous channel width
- Support of EDMG SU PPDUs (transmit and receive) using OFDM modulation
- Support of EDMG MU PPDUs (transmit and receive) using SC or OFDM modulations
- Support of new modulation types for the EDMG SC mode:
  - π/2-8-PSK
  - π/2-64-NUC

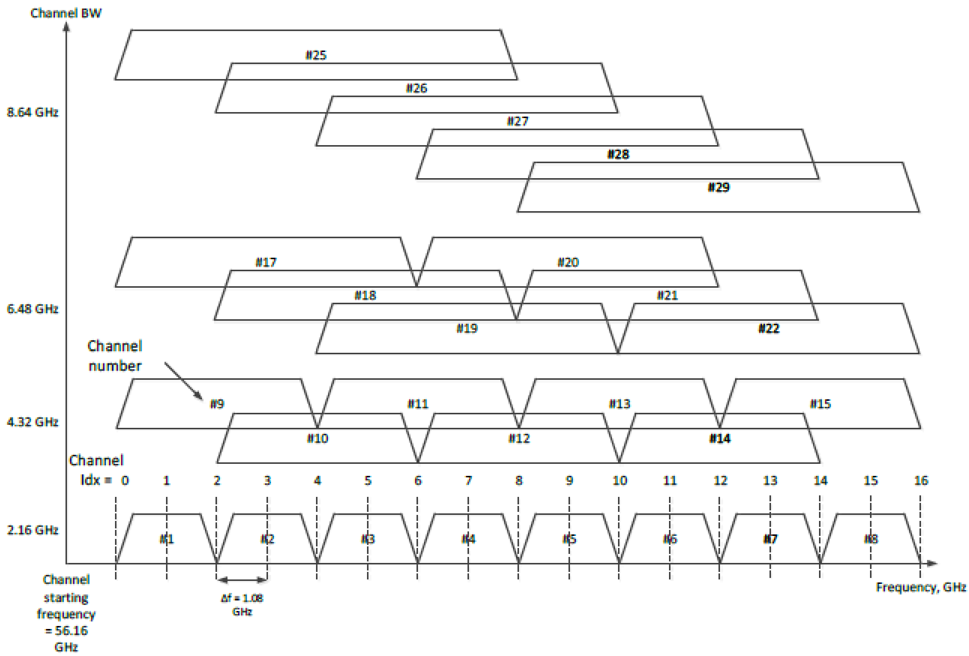



**Figure 28-7 – Channelization used by EDMG STAs**

### Modulation and coding schemes (MCS)

Currently, the IEEE 802.11ay application only supports EDMG single carrier mode, with the following modulation and coding schemes (MCS).

*Table 4-2: Modulation and coding schemes (MCS)*

| MCS | Modulation | Code rate |
|---|---|---|
| 1 | π/2-BPSK | 1/2 |
| 2 | π/2-BPSK | 1/2 |
| 3 | π/2-BPSK | 5/8 |
| 4 | π/2-BPSK | 3/4 |
| 5 | π/2-BPSK | 13/16 |
| 6 | π/2-BPSK | 7/8 |
| 7 | π/2-QPSK | 1/2 |
| 8 | π/2-QPSK | 5/8 |
| 9 | π/2-QPSK | 3/4 |
| 10 | π/2-QPSK | 13/16 |
| 11 | π/2-QPSK | 7/8 |
| 12 | 8-PSK | 2/3 |
| | π/2-16-QAM | 1/2 |
| 13 | 8-PSK | 5/6 |

| MCS | Modulation | Code rate |
|---|---|---|
| | π/2-16-QAM | 5/8 |
| 14 | π/2-16-QAM | 3/4 |
| 15 | π/2-16-QAM | 13/16 |
| 16 | π/2-16-QAM | 7/8 |
| 17 | π/2-64-QAM | 1/2 |
| | 64-NUC | 1/2 |
| 18 | π/2-64-QAM | 5/8 |
| | 64-NUC | 5/8 |
| 19 | π/2-64-QAM | 3/4 |
| | 64-NUC | 3/4 |
| 20 | π/2-64-QAM | 13/16 |
| | 64-NUC | 13/16 |
| 21 | π/2-64-QAM | 7/8 |
| | 64-NUC | 7/8 |

## 4.3 Basics on input from I/Q data files

The I/Q data to be evaluated in a particular FSW application cannot only be captured by the application itself, it can also be loaded from a file, provided it has the correct format. The file is then used as the input source for the application.

For example, you can capture I/Q data using the I/Q Analyzer application, store it to a file, and then analyze the signal parameters for that data later using the AM/FM/PM Modulation Analysis application.

The I/Q data file must be in one of the following supported formats:

- `.iq.tar`
- `.iqw`
- `.csv`
- `.mat`
- `.wv`
- `.aid`

An application note on converting Rohde & Schwarz I/Q data files is available from the Rohde & Schwarz website:

1EF85: Converting R&S I/Q data files

When importing data from an I/Q data file using the import functions provided by some FSW applications, the data is only stored temporarily in the capture buffer. It overwrites the current measurement data and is in turn overwritten by a new measurement. If you use an I/Q data file as input, the stored I/Q data remains available for any number of subsequent measurements. Furthermore, the (temporary) data import requires the current measurement settings in the current application to match the settings that were applied when the measurement results were stored (possibly in a different application). When the data is used as an input source, however, the data acquisition settings in the current application (attenuation, center frequency, measurement bandwidth, sample rate) can be ignored. As a result, these settings cannot be changed in the current application. Only the measurement time can be decreased, to perform measurements on an extract of the available data (from the beginning of the file) only.

For input files that contain multiple data streams from different channels, you can define which data stream to be used for the currently selected channel in the input settings. You can define whether the data stream is used only once, or repeatedly, to create a larger amount of input data.

When using input from an I/Q data file, the [RUN SINGLE] function starts a single measurement (i.e. analysis) of the stored I/Q data, while the [RUN CONT] function repeatedly analyzes the same data from the file.

**Sample iq.tar files**

If you have the optional FSW VSA application (R&S FSW-K70), some sample `iq.tar` files are provided in the `C:\R_S\INSTR\USER\vsa\DemoSignals` directory on the FSW.

**Pre-trigger and post-trigger samples**

In applications that use pre-triggers or post-triggers, if no pre-trigger or post-trigger samples are specified in the I/Q data file, or too few trigger samples are provided to satisfy the requirements of the application, the missing pre- or post-trigger values are filled up with zeros. Superfluous samples in the file are dropped, if necessary. For pre-trigger samples, values are filled up or omitted at the beginning of the capture buffer. For post-trigger samples, values are filled up or omitted at the end of the capture buffer.

## 4.4 Trigger basics

In a basic measurement with default settings, the measurement is started immediately. However, sometimes you want the measurement to start only when a specific condition is fulfilled, for example a signal level is exceeded, or in certain time intervals. For these cases, you can define a trigger for the measurement. In FFT sweep mode, the trigger defines when the data acquisition starts for the FFT conversion.

An "Offset" can be defined to delay the measurement after the trigger event, or to include data before the actual trigger event in time domain measurements (pre-trigger offset).

For complex tasks, advanced trigger settings are available:

- Hysteresis to avoid unwanted trigger events caused by noise

- Holdoff to define exactly which trigger event causes the trigger in a jittering signal



### 4.4.1 Trigger offset

An offset can be defined to delay the measurement after the trigger event, or to include data before the actual trigger event in time domain measurements (pre-trigger offset). Pre-trigger offsets are possible because the FSW captures data continuously in the time domain, even before the trigger occurs.

See "Trigger Offset" on page 65.

### 4.4.2 Trigger hysteresis

Setting a hysteresis for the trigger helps avoid unwanted trigger events caused by noise, for example. The hysteresis is a threshold to the trigger level that the signal must fall below on a rising slope or rise above on a falling slope before another trigger event occurs.

**Example:**

In the following example, the signal does not drop below the hysteresis (threshold) before it reaches the trigger level again. Thus, the second possible trigger event on the rising edge is ignored. On the falling edge, however, two trigger events occur. The signal exceeds the hysteresis before it falls to the trigger level the second time.

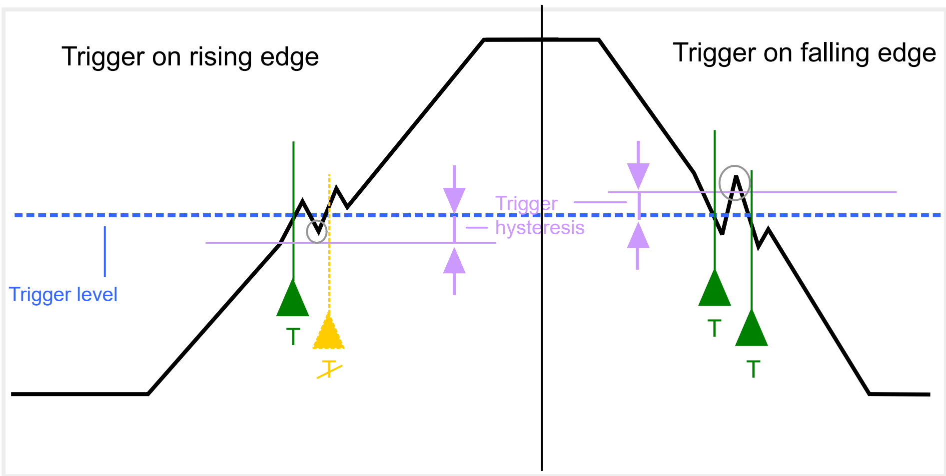



*Figure 4-3: Effects of the trigger hysteresis*

See "Hysteresis" on page 66

### 4.4.3 Trigger drop-out time

If a modulated signal is instable and produces occasional "drop-outs" during a burst, you can define a minimum duration that the input signal must stay below the trigger level before triggering again. This is called the "drop-out" time. Defining a dropout time helps you stabilize triggering when the analyzer is triggering on undesired events.

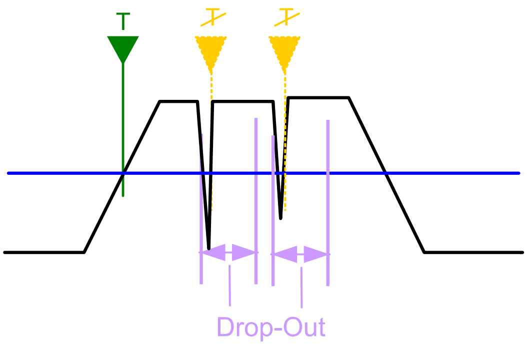



*Figure 4-4: Effect of the trigger drop-out time*

See "Drop-Out Time" on page 65.

**Drop-out times for falling edge triggers**

If a trigger is set to a falling edge ("Slope" = "Falling", see "Slope" on page 66) the measurement is to start when the power level falls below a certain level. This is useful, for example, to trigger at the end of a burst, similar to triggering on the rising edge for the beginning of a burst.

If a drop-out time is defined, the power level must remain below the trigger level at least for the duration of the drop-out time (as defined above). However, if a drop-out time is defined that is longer than the pulse width, this condition cannot be met before the final pulse. Thus, a trigger event does not occur until the pulsed signal is over.

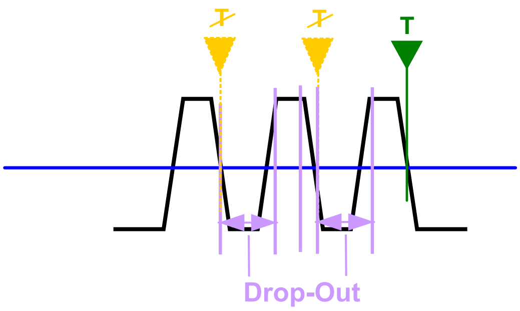



*Figure 4-5: Trigger drop-out time for falling edge trigger*

For gated measurements, a combination of a falling edge trigger and a drop-out time is generally not allowed.

### 4.4.4 Trigger holdoff

The trigger holdoff defines a waiting period before the next trigger after the current one will be recognized.

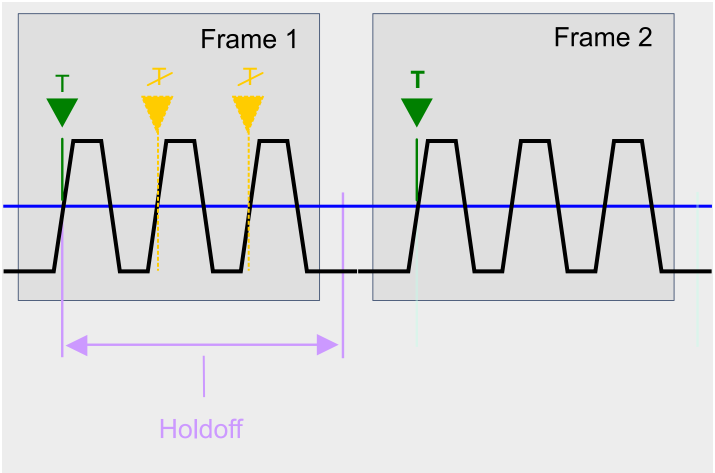



*Figure 4-6: Effect of the trigger holdoff*

See "Trigger Holdoff" on page 66.

# 5 Configuration

**Access**: [MODE] > "802.11ad"/"802.11ay EDMG"

IEEE 802.11ad/ay measurements require a special application on the FSW.

Furthermore, an optional bandwidth extension of at least 2 GHz must be installed and active to analyze IEEE 802.11ad/ay signals. For information on available options, see the FSW specifications document.

For details on using and setting up bandwidth extension options that require an oscilloscope, see the FSW I/Q Analyzer and I/Q Input User Manual and the oscilloscope documentation.

The default IEEE 802.11ad/ay Modulation Accuracy measurement captures the I/Q data from the IEEE 802.11ad/ay Modulation Accuracy measurement signal and determines various characteristic signal parameters such as the modulation accuracy, channel frequency response, and power gain in just one measurement (see Chapter 3.1, "IEEE 802.11ad/ay modulation accuracy measurement", on page 13).

Other parameters specified in the IEEE 802.11ad/ay standard must be determined in separate measurements (see Chapter 3.2, "SEM measurements", on page 29).

The settings required to configure each of these measurements are described here.



## 5.1 Display configuration

**Access**: "Overview" > "Display Config"

**Or:** [MEAS CONFIG] > "Display Config"

The measurement results can be displayed using various evaluation methods. All evaluation methods available for the R&S FSW 802.11ad/ay applications are displayed in the evaluation bar in SmartGrid mode.

Drag one or more evaluations to the display area and configure the layout as required.

Up to 16 evaluation methods can be displayed simultaneously in separate windows. The IEEE 802.11ad/ay evaluation methods are described in Chapter 3.1.1, "Evaluation methods for IEEE 802.11ad/ay modulation accuracy measurements", on page 13.

To close the SmartGrid mode and restore the previous softkey menu select the "Close" icon in the righthand corner of the toolbar, or press any key.

For details on working with the SmartGrid, see the FSW Getting Started manual.

## 5.2 IEEE 802.11ad/ay modulation accuracy measurement

**Access**: "Overview" > "Select Measurement" > "Modulation Accuracy"

**Or:** [MEAS] > "Select Measurement" > "Modulation Accuracy"

When you activate the R&S FSW 802.11ad/ay applications, an I/Q measurement of the input signal is started automatically with the default configuration. The "WiGig Meas" menu is displayed and provides access to the most important configuration functions.

The "Span", "Bandwidth", "Lines", and "Marker Functions" menus are not available for IEEE 802.11ad/ay Modulation Accuracy measurements.

**Multiple access paths to functionality**

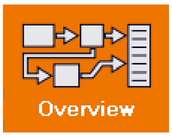
The easiest way to configure a measurement channel is via the "Overview" dialog box, which is displayed when you select "Overview" from any IEEE 802.11ad/ay menu.

Alternatively, you can access the individual dialog boxes via softkeys from the corresponding menus, or via tools in the toolbars, if available.

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

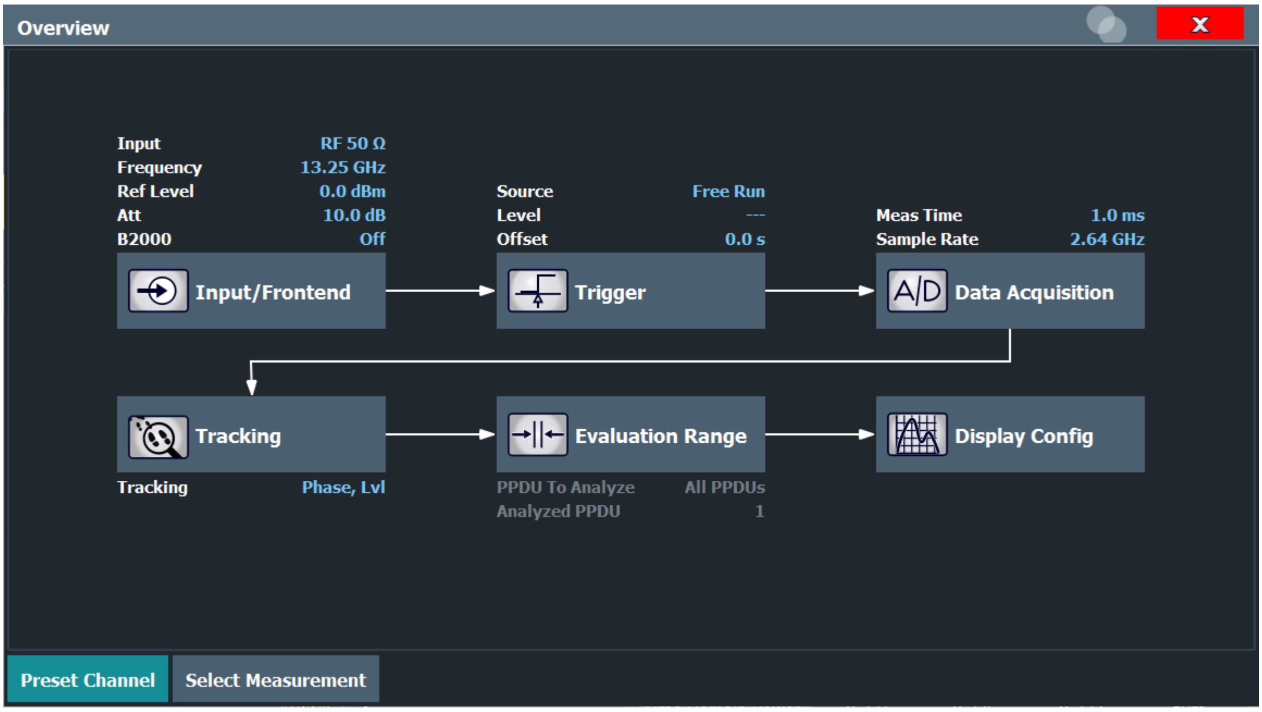


### 5.2.1 Configuration overview




**Access**: all menus

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




The "Overview" not only shows the main measurement settings, it also provides quick access to the main settings dialog boxes. The indicated signal flow shows which parameters affect which processing stage in the measurement. 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".

The available settings and functions in the "Overview" vary depending on the currently selected measurement. For SEM measurements, see Chapter 3.2, "SEM measurements", on page 29.

For the IEEE 802.11ad/ay Modulation Accuracy measurement, the "Overview" provides quick access to the following configuration dialog boxes (listed in the recommended order of processing):

1. "Select Measurement"
   See "Select Measurement" on page 46
2. "Input/ Frontend"
   See Chapter 5.2.2, "Input, output and frontend settings", on page 46
3. "Data Acquisition"
   See Chapter 5.2.3, "Data acquisition", on page 59
4. "Tracking"
   See Chapter 5.2.5, "Tracking", on page 68
5. "Evaluation Range"
   See Chapter 6.1, "Evaluation range", on page 78

6. "Display Configuration"
   See Chapter 5.1, "Display configuration", on page 43

**To configure settings**

► Select any button in the "Overview" to open the corresponding dialog box.

**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 FSW (except for the default channel)!

Remote command:
`SYSTem:PRESet:CHANnel[:EXEC]` on page 100

**Select Measurement**
Selects a measurement to be performed.

See Chapter 3, "Measurements and result displays", on page 13.

**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.

### 5.2.2 Input, output and frontend settings

**Access**: "Overview" ≥ "Input/Frontend"

**Or:** [INPUT/OUTPUT]

The FSW can analyze signals from different input sources and provide various types of output (such as noise or trigger signals).

**Importing and Exporting I/Q Data**
The I/Q data to be analyzed for IEEE 802.11ad/ay cannot only be measured by the R&S FSW 802.11ad/ay applications itself, it can also be imported to the application, provided it has the correct format. Furthermore, the analyzed I/Q data from the R&S FSW 802.11ad/ay applications can be exported for further analysis in external applications.

See the FSW user manual.

Frequency, amplitude and y-axis scaling settings represent the "frontend" of the measurement setup.



### 5.2.2.1 Input source settings

**Access**: "Overview" ≥ "Input/Frontend" > "Input Source Config"

**Or:** [INPUT/OUTPUT] > "Input Source Config"

The input source determines which data the FSW analyzes.

**Further input sources**

The R&S FSW 802.11ad/ay applications application can also process input from the following optional sources:

- I/Q Input files
- External mixer
- External frontend
- Baseband oscilloscope input (FSW-B2071)
- 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000)
- Active modular probes

For details see the FSW I/Q Analyzer and I/Q Input User Manual.

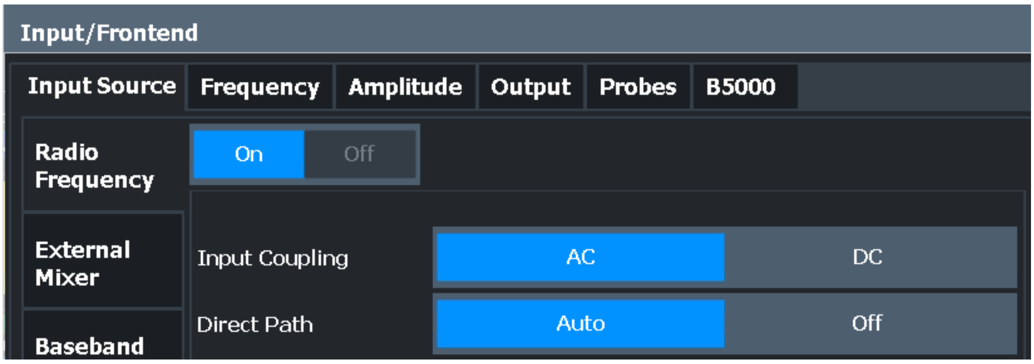


#### Radio frequency input

**Access**: "Overview" ≥ "Input/Frontend" > "Input Source Config"> "Radio Frequency"

**Or:** [INPUT/OUTPUT] > "Input Source Config" > "Input Source" > "Radio Frequency"

The default input source for the FSW is "Radio Frequency", i.e. the signal at the [RF Input] connector of the FSW. If no additional options are installed, this is the only available input source.






**Radio Frequency State**

Activates input from the "RF Input" connector.

For FSW85 models with two input connectors, you must define which input source is used for each measurement channel.


If an external frontend is active, select the connector the external frontend is connected to. You cannot use the other RF input connector simultaneously for the same channel. However, you can configure the use of the other RF input connector for another active channel at the same time.

"Input 1" 1.00 mm RF input connector for frequencies up to 85 GHz (90 GHz with option R&S FSW-B90G)

"Input 2" 1.85 mm RF input connector for frequencies up to 67 GHz

Remote command:
`INPut:SELect` on page 103
`INPut:TYPE` on page 103

**Input Coupling**

The RF input of the FSW can be coupled by alternating current (AC) or direct current (DC).

For an active external frontend, input coupling is always AC.

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 102

**Preamplifier**
If the (optional) internal preamplifier hardware is installed on the FSW, a preamplifier can be activated for the RF input signal.

You can use a preamplifier to analyze signals from DUTs with low output power.

**Note:** If an optional external preamplifier is activated, the internal preamplifier is automatically disabled, and vice versa.

For an active external frontend, a preamplifier is not available.

For all FSW models except for FSW85, the following settings are available:

| | |
|---|---|
| "Off" | Deactivates the preamplifier. |
| "15 dB" | The RF input signal is amplified by about 15 dB. |
| "30 dB" | The RF input signal is amplified by about 30 dB. |

For older FSW43/FSW50/FSW67 models, the input signal is always ampilfied by about 30 dB when the preamplifier is active.

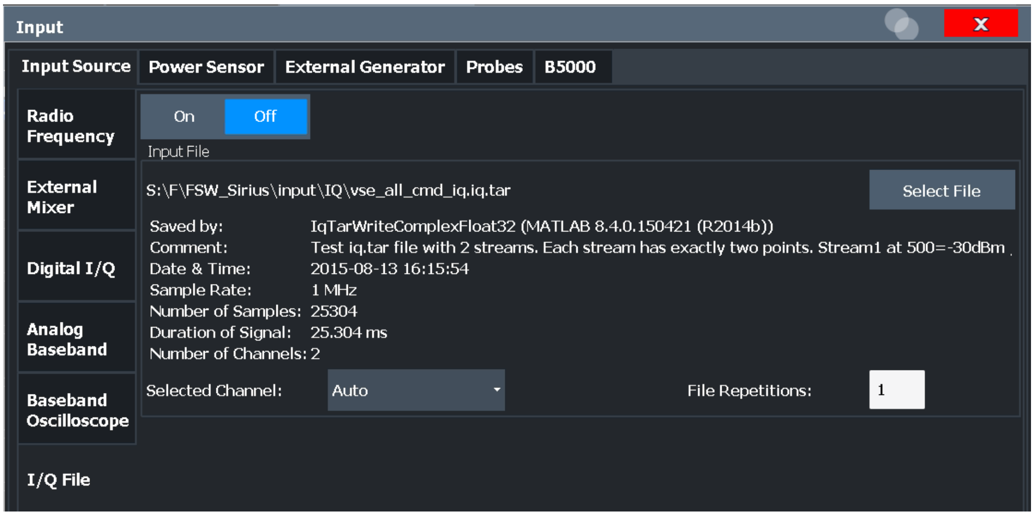
For FSW85 models, no preamplifier is available.

Remote command:
`INPut:GAIN:STATe` on page 156
`INPut:GAIN[:VALue]` on page 157

### Settings for input from I/Q data files

**Access**: "Overview" > "Input/Frontend" > "Input Source" > "I/Q File"

**Or:** [INPUT/OUTPUT] > "Input Source Config" > "Input Source" > "I/Q File"






**I/Q Input File State**
Enables input from the selected I/Q input file.

If enabled, the application performs measurements on the data from this file. Thus, most measurement settings related to data acquisition (attenuation, center frequency, measurement bandwidth, sample rate) cannot be changed. The measurement time can only be decreased to perform measurements on an extract of the available data only.

**Note:** Even when the file input is disabled, the input file remains selected and can be enabled again quickly by changing the state.

Remote command:
`INPut:SELect` on page 103

**Select I/Q data file**

Opens a file selection dialog box to select an input file that contains I/Q data.

The I/Q data file must be in one of the following supported formats:

- `.iq.tar`
- `.iqw`
- `.csv`
- `.mat`
- `.wv`
- `.aid`

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.

**Note:** Only a single data stream or channel can be used as input, even if multiple streams or channels are stored in the file.

**Note:** For some file formats that do not provide the sample rate and measurement time or record length, you must define these parameters manually. Otherwise the traces are not visible in the result displays.

The default storage location for I/Q data files is `C:\R_S\INSTR\USER`.

Remote command:
`INPut:FILE:PATH` on page 104

**Selected Channel**

Only available for files that contain more than one data stream from multiple channels: selects the data stream to be used as input for the currently selected channel.

In "Auto" mode (default), the first data stream in the file is used as input for the channel. Applications that support multiple data streams use the first data stream in the file for the first input stream, the second for the second stream etc.

Remote command:
`MMEMory:LOAD:IQ:STReam` on page 105
`MMEMory:LOAD:IQ:STReam:AUTO` on page 105
`MMEMory:LOAD:IQ:STReam:LIST?` on page 106

**File Repetitions**

Determines how often the data stream is repeatedly copied in the I/Q data memory to create a longer record. If the available memory is not sufficient for the specified number of repetitions, the largest possible number of complete data streams is used.

Remote command:
`TRACe:IQ:FILE:REPetition:COUNt` on page 106

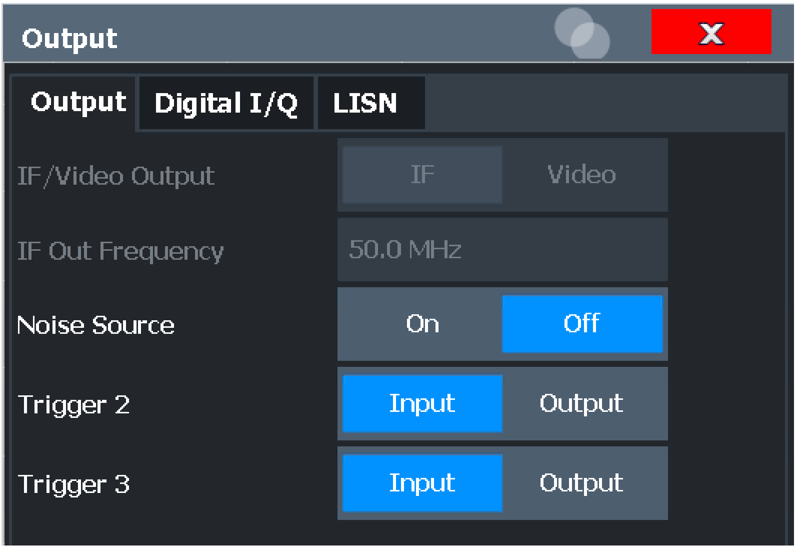
### 5.2.2.2 Output settings

**Access**: [Input/Output] > "Output"

The FSW can provide output to special connectors for other devices.

For details on connectors, refer to the FSW Getting Started manual, "Front / Rear Panel View" chapters.

How to provide trigger signals as output is described in detail in the FSW base unit user manual.






**Data Output**
Defines the type of signal available at one of the output connectors of the FSW.

For restrictions and additional information, see the FSW I/Q Analyzer and I/Q Input User Manual.

"IF" The measured IF value is provided at the IF/VIDEO/DEMOD output connector.
For bandwidths up to 80 MHZ, the IF output is provided at the specified "IF Out Frequency".
If an optional bandwidth extension FSW-B160/-B320/-B512 is used, the measured IF value is available at the "IF WIDE OUTPUT" connector. The frequency at which this value is output is determined automatically. It is displayed as the "IF Wide Out Frequency". For details on the used frequencies, see the specifications document.
This setting is not available for bandwidths larger than 512 MHz.

"2ND IF" The measured IF value is provided at the "IF OUT 2 GHz/ IF OUT 5 GHz" output connector, if available, at a frequency of 2 GHz and with a bandwidth of 2 GHz. The availability of this connector depends on the instrument model.
This setting is not available if the optional 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000) is active.

Remote command:
`OUTPut:IF[:SOURce]` on page 149
`OUTPut:IF:IFFRequency` on page 149

**Noise Source Control**
Enables or disables the 28 V voltage supply for an external noise source connected to the "Noise source control / Power sensor") connector. By switching the supply voltage for an external noise source on or off in the firmware, you can enable or disable the device as required.

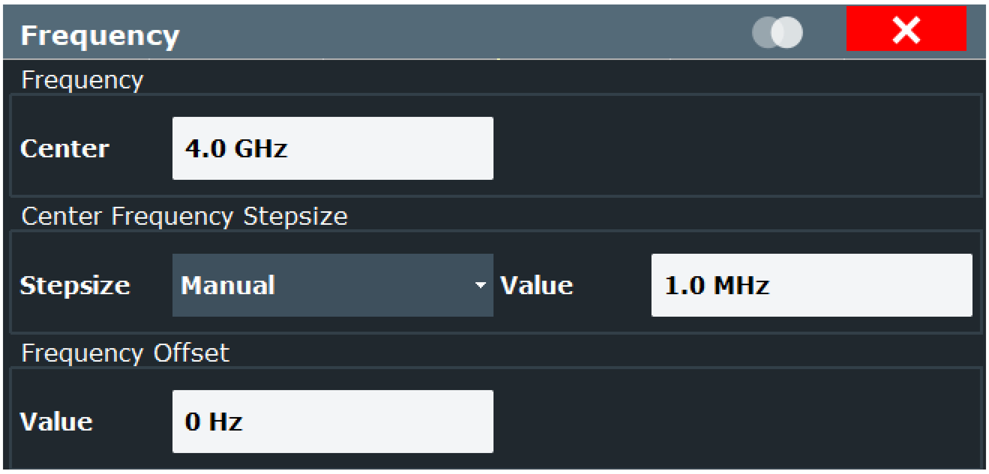
External noise sources are useful when you are measuring power levels that fall below the noise floor of the FSW itself, for example when measuring the noise level of an amplifier.

In this case, you can first connect an external noise source (whose noise power level is known in advance) to the FSW and measure the total noise power. From this value, you can determine the noise power of the FSW. Then when you measure the power level of the actual DUT, you can deduct the known noise level from the total power to obtain the power level of the DUT.

Remote command:
`DIAGnostic:SERVice:NSOurce` on page 148

### 5.2.2.3 Frequency settings

**Access**: "Overview" > "Input/Frontend" > "Frequency"



**Center Frequency**

Defines the center frequency of the signal in Hertz.

Remote command:
[SENSe:]FREQuency:CENTer on page 149

**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.

| | |
|---|---|
| "= Center" | Sets the step size to the value of the center frequency. 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 150

**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 150

### 5.2.2.4 Amplitude settings

**Access**: "Overview" > "Input/Frontend" > "Amplitude"

Amplitude settings determine how the FSW must process or display the expected input power levels.

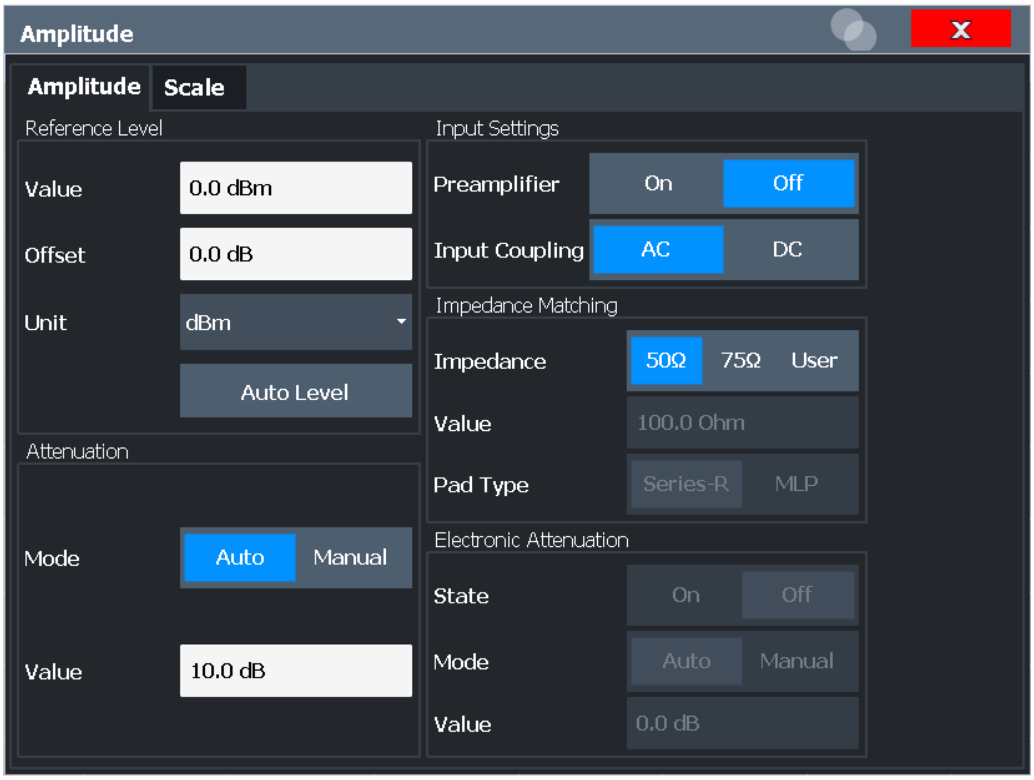
Configuring amplitude settings allows you to:

- Adapt the instrument hardware to the expected maximum signal level by setting the Reference Level to this maximum
- Consider an external attenuator or preamplifier (using the "Offset").
- Optimize the SNR of the measurement for low signal levels by configuring the Reference Level as high as possible without introducing compression, clipping or overload. Use early amplification by the preamplifier and a low attenuation.

- Optimize the SNR for high signal levels and ensure that the instrument hardware is not damaged, using high attenuation and AC coupling (for DC input voltage).
- Adapt the reference impedance for power results when measuring in a 75-Ohm system by connecting an external matching pad to the RF input.

**Using external frontends**

For an active external frontend, the amplitude settings refer to the RF input at the external frontend, not the levels at the RF input of the FSW. You can configure the attenuation at the external frontend and the analyzer separately. Electronic attenuation, preamplifier and noise cancellation are not available. Input coupling is always DC. Impedance is always 50 Ω.



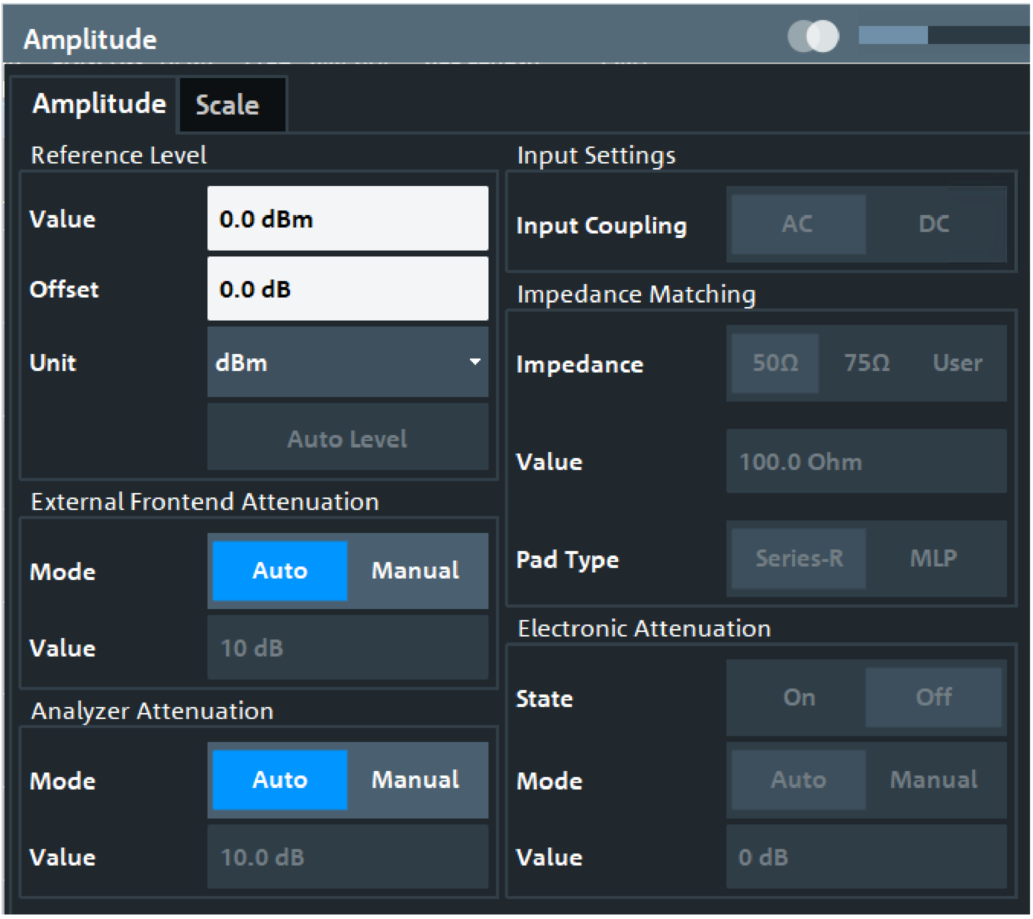



*Figure 5-1: Amplitude settings for active external frontend*

In the R&S FSW 802.11ad/ay applications, the impedance is fixed to 50 Ω and cannot be changed.



**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 FSW 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 FSW-B21) the maximum reference level also depends on the conversion loss; see the FSW base unit user manual for details.

For an active external frontend, the reference level refers to the RF input at the external frontend, not the levels at the RF input of the FSW. The hardware is adjusted to the defined reference level optimally for input signals with a crest factor of 10 dB. Thus, the required reference level for an optimal measurement can differ depending on the crest factor of the input signal.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel` on page 152

**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 FSW 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 FSW 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 153

**Unit ← Reference Level**

The FSW measures the signal voltage at the RF input.

Remote command:
`CALCulate<n>:UNIT:POWer` on page 187

**Setting the Reference Level Automatically (Auto Level) ← Reference Level**

To determine the required reference level, a level measurement is performed on the FSW.

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 171

**External Frontend Attenuation**
If an external frontend is active, you can configure the attenuation for the external frontend and the analyzer separately.

For more information, see the FSW User Manual.

When using an external frontend, only mechanical attenuation is available.

The RF attenuation can be set automatically as a function of the selected reference level (Auto mode). Automatic attenuation ensures that no overload occurs at the RF Input connector for the current reference level. It is the default setting.

In "Manual" mode, you can set the RF attenuation in 1 dB steps (down to 0 dB). Other entries are rounded to the next integer value. The range is specified in the specifications document. If the defined reference level cannot be set for the defined RF attenuation, the reference level is adjusted accordingly and the warning "limit reached" is displayed.

**NOTICE!** Risk of hardware damage due to high power levels. When decreasing the attenuation manually, ensure that the power level does not exceed the maximum level allowed at the RF input, as an overload can lead to hardware damage.

Remote command:
`INPut:ATTenuation` on page 154
`INPut:ATTenuation:AUTO` on page 154

**Attenuation Mode / Value**
Defines the attenuation applied to the RF input of the FSW.

The RF attenuation can be set automatically as a function of the selected reference level (Auto mode). Automatic attenuation ensures that no overload occurs at the RF Input connector for the current reference level. It is the default setting.

**Note:** Using an external frontend. If an external frontend is active, you can configure the attenuation for the external frontend and the analyzer separately. When using an external frontend, only mechanical attenuation is available.
For more information, see the FSW base unit user manual.

By default and when no (optional) electronic attenuation is available, mechanical attenuation is applied.

In "Manual" mode, you can set the RF attenuation in 1 dB steps (down to 0 dB). Other entries are rounded to the next integer value. The range is specified in the specifications document. If the defined reference level cannot be set for the defined RF attenuation, the reference level is adjusted accordingly and the warning "limit reached" is displayed.

**NOTICE!** Risk of hardware damage due to high power levels. When decreasing the attenuation manually, ensure that the power level does not exceed the maximum level allowed at the RF input, as an overload can lead to hardware damage.

Remote command:
`INPut:ATTenuation` on page 154
`INPut:ATTenuation:AUTO` on page 154
Defining attenuation for the analyzer when using an external frontend:
`INPut:SANalyzer:ATTenuation:AUTO` on page 157
`INPut:SANalyzer:ATTenuation` on page 157

**Using Electronic Attenuation**
If the (optional) Electronic Attenuation hardware is installed on the FSW, you can also activate an electronic attenuator.

In "Auto" mode, the settings are defined automatically; in "Manual" mode, you can define the mechanical and electronic attenuation separately.

For an active external frontend, electronic attenuation is not available.

**Note:** Electronic attenuation is not available for stop frequencies (or center frequencies in zero span) above 15 GHz.
In "Auto" mode, RF attenuation is provided by the electronic attenuator as much as possible to reduce the amount of mechanical switching required. Mechanical attenuation can provide a better signal-to-noise ratio, however.

When you switch off electronic attenuation, the RF attenuation is automatically set to the same mode (auto/manual) as the electronic attenuation was set to. Thus, the RF attenuation can be set to automatic mode, and the full attenuation is provided by the mechanical attenuator, if possible.

The electronic attenuation can be varied in 1 dB steps. If the electronic attenuation is on, the mechanical attenuation can be varied in 5 dB steps. Other entries are rounded to the next lower integer value.

For the FSW85, the mechanical attenuation can be varied only in 10 dB steps.

If the defined reference level cannot be set for the given attenuation, the reference level is adjusted accordingly and the warning "limit reached" is displayed in the status bar.

Remote command:
`INPut:EATT:STATe` on page 155
`INPut:EATT:AUTO` on page 155
`INPut:EATT` on page 154

**Input Settings**
Some input settings affect the measured amplitude of the signal, as well.

The parameters "Input Coupling" and "Impedance" are identical to those in the "Input" settings.

See Chapter 5.2.2.1, "Input source settings", on page 47.

**Preamplifier ← Input Settings**
If the (optional) internal preamplifier hardware is installed on the FSW, a preamplifier can be activated for the RF input signal.

You can use a preamplifier to analyze signals from DUTs with low output power.

**Note:** If an optional external preamplifier is activated, the internal preamplifier is automatically disabled, and vice versa.

For an active external frontend, a preamplifier is not available.

For all FSW models except for FSW85, the following settings are available:

| | |
|---|---|
| "Off" | Deactivates the preamplifier. |
| "15 dB" | The RF input signal is amplified by about 15 dB. |

"30 dB" The RF input signal is amplified by about 30 dB.

For older FSW43/FSW50/FSW67 models, the input signal is always ampilfied by about 30 dB when the preamplifier is active.

For FSW85 models, no preamplifier is available.

Remote command:
INPut:GAIN:STATe on page 156
INPut:GAIN[:VALue] on page 157

**Ext. PA Correction ← Input Settings**

This function is only available if an external preamplifier is connected to the FSW, and only for frequencies above 1 GHz. For details on connection, see the preamplifier's documentation.

Using an external preamplifier, you can measure signals from devices under test with low output power, using measurement devices which feature a low sensitivity and do not have a built-in RF preamplifier.

When you connect the external preamplifier, the FSW reads out the touchdown (.S2P) file from the EEPROM of the preamplifier. This file contains the s-parameters of the preamplifier. As soon as you connect the preamplifier to the FSW, the preamplifier is permanently on and ready to use. However, you must enable data correction based on the stored data explicitly on the FSW using this setting.

When enabled, the FSW automatically compensates the magnitude and phase characteristics of the external preamplifier in the measurement results. Any internal preamplifier, if available, is disabled.

For FSW85 models with two RF inputs, you can enable correction from the external preamplifier for each input individually, but not for both at the same time.

When disabled, no compensation is performed even if an external preamplifier remains connected.

Remote command:
INPut:EGAin[:STATe] on page 156

### 5.2.3 Data acquisition

**Access**: "Overview" > "Data Acquisition"

**Or**: [MEAS CONFIG] > "Data Acquisition"

You can define how much and how data is captured from the input signal.

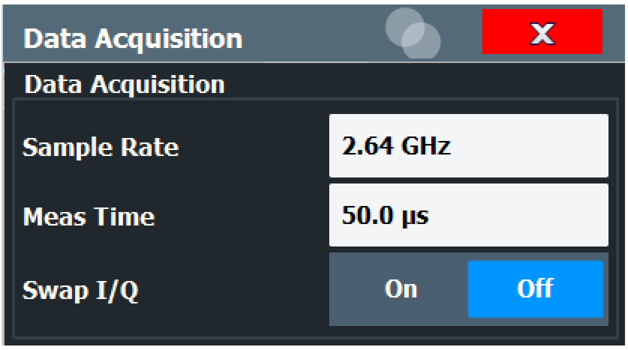



*Figure 5-2: Data acquisition settings for IEEE 802.11ad measurements*

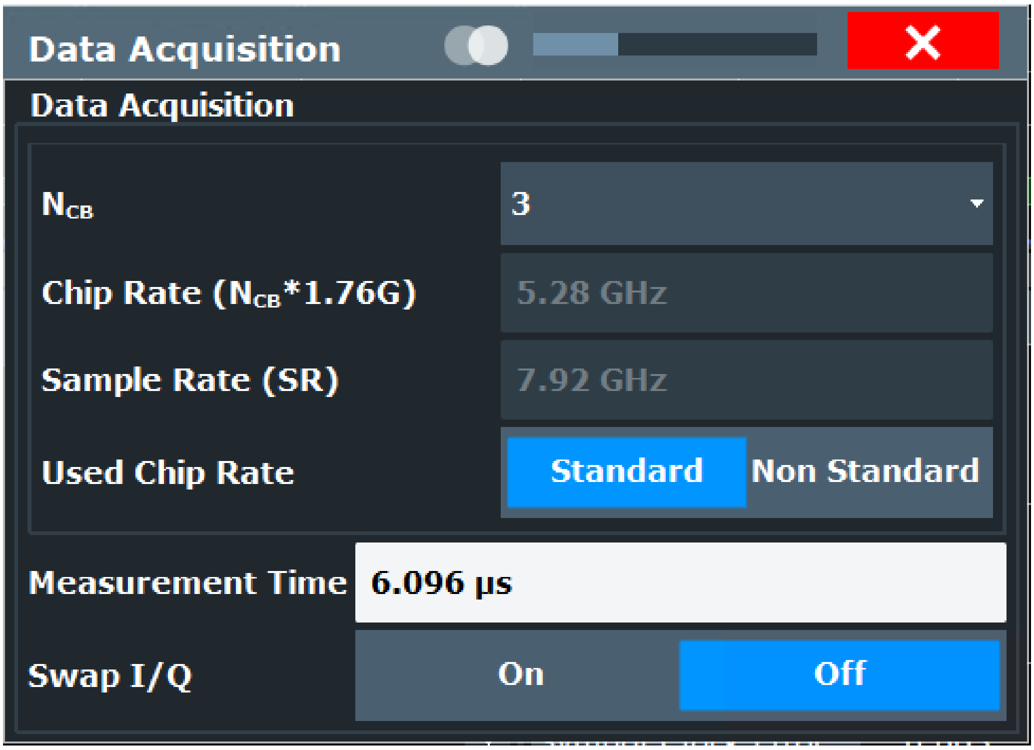



*Figure 5-3: Data acquisition settings for IEEE 802.11ay measurements*



**$N_{CB}$ (IEEE 802.11 ay only)**

Indicates the number of contiguous 2.16 GHz channels in the signal.

Note that the FSW hardware currently only supports measurement bandwidths up to a maximum of 8 GHz (using bandwidth extension options). Thus, measurements with 4 channels can only be performed on data from input files or using downsampling (see "Sample Rate (SR) (IEEE 802.11 ay only)" on page 61).

Remote command:
`CONFigure:EDMG:NCB` on page 159

**Chip Rate (CR) (IEEE 802.11 ay only)**
Chip rate used for transmission; specified in the IEEE 802.11 ay standard as:

$N_{CB}$ * 1.76 GHz

Remote command:
`CONFigure:EDMG:CRATe` on page 158

**Sample Rate (SR) (IEEE 802.11 ay only)**
For reference only: Sample rate used for transmission; specified in the IEEE 802.11 ay standard as:

2* <chip_rate>

Remote command:
`TRACe:IQ:SRATe` on page 160

**Used Chip Rate (IEEE 802.11 ay only)**
By default, data acquisition is set to the chip rate and sample rate specified in the IEEE 802.11 ay standard. To change the chip rate (and thus the sample rate), you can perform a non-standard measurement. When you switch to "Non Standard", the Chip Rate (CR) (IEEE 802.11 ay only) setting becomes available.

For example, you can reduce the chip rate to obtain an overview of a signal with 4 channels, which normally requires a sample rate that is not supported by the FSW.

Remote command:
`CONFigure:EDMG:UCRate` on page 159

**Sample Rate (IEEE 802.11ad)**
This is the sample rate the R&S FSW 802.11ad/ay applications expects the I/Q input data to have. For standard IEEE 802.11ad measurements, a sample rate of 2.64 MHz is used.

The R&S FSW 802.11ad/ay applications does not resample the data. To measure signals with a sample rate other than the standard 2.64 MHz for IEEE 802.11ad signals, change this setting.

Remote command:
`TRACe:IQ:SRATe` on page 160

**Measurement Time**
Specifies the duration (and therefore the amount of data) to be captured in the capture buffer. If the measurement time is too short, demodulation fails. In particular, if the result length does not fit in the capture buffer, demodulation fails.

Remote command:
`[SENSe:]SWEep:TIME` on page 160

**Swap I/Q**

Activates or deactivates the inverted I/Q modulation. If the I and Q parts of the signal from the DUT are interchanged, the FSW can do the same to compensate for it.

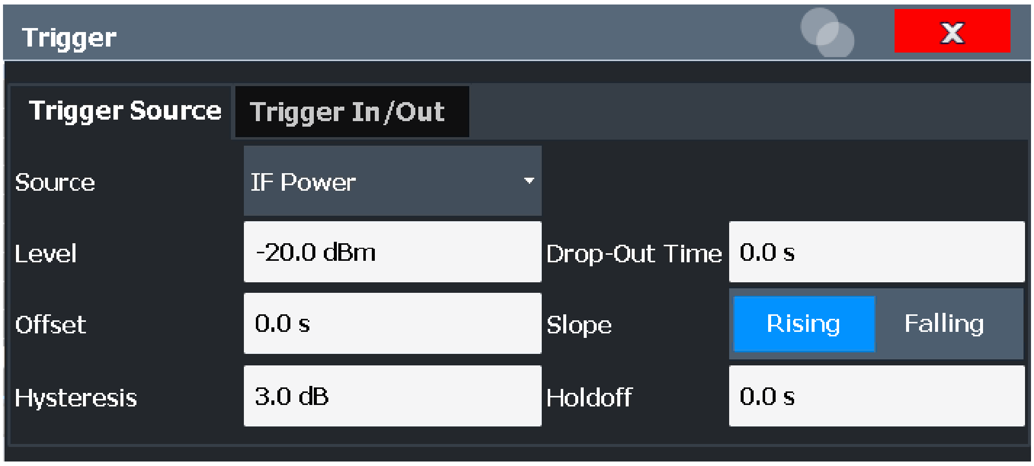
| | |
|---|---|
| On | I and Q signals are interchanged<br>Inverted sideband, Q+j*I |
| Off | I and Q signals are not interchanged<br>Normal sideband, I+j*Q |

Remote command:
[SENSe:]SWAPiq on page 159

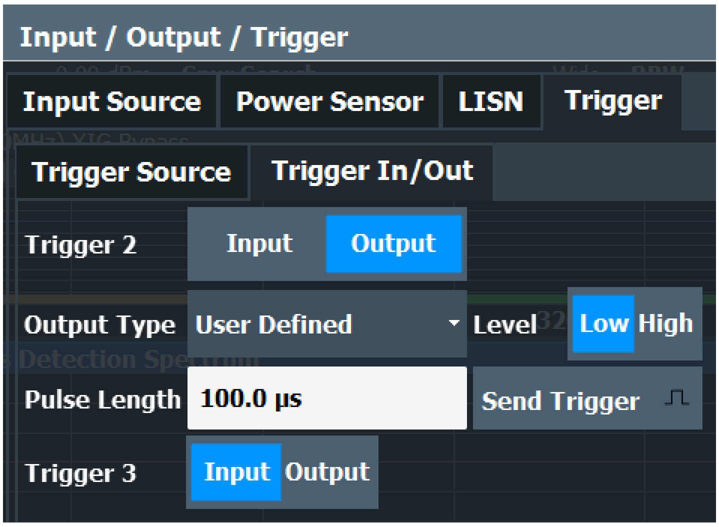
## 5.2.4 Trigger settings

**Access**: "Overview" > "Trigger"

Trigger settings determine when the input signal is measured.




External triggers from one of the [TRIGGER INPUT/OUTPUT] connectors on the FSW are configured in a separate tab of the dialog box.




For step-by-step instructions on configuring triggered measurements, see the main FSW User Manual.



**Trigger Source**

The trigger settings define the beginning of a measurement.

**Trigger Source ← 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[:SEQuence]:SOURce` on page 164

**Free Run ← Trigger Source ← Trigger Source**
No trigger source is considered. Data acquisition is started manually or automatically and continues until stopped explicitly.

Remote command:
`TRIG:SOUR IMM`, see `TRIGger[:SEQuence]:SOURce` on page 164

**External Trigger 1/2/3 ← Trigger Source ← Trigger Source**
Data acquisition starts when the TTL signal fed into the specified input connector meets or exceeds the specified trigger level.

(See "Trigger Level" on page 65).

**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 FSW 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.
For FSW85 models, "Trigger 2" is not available due to the second RF input connector on the front panel.

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

Remote command:
`TRIG:SOUR EXT`, `TRIG:SOUR EXT2`
`TRIG:SOUR EXT3`
See `TRIGger[:SEQuence]:SOURce` on page 164

**External Analog ← Trigger Source ← Trigger Source**
Data acquisition starts when the signal fed into the EXT TRIGGER INPUT connector on the oscilloscope meets or exceeds the specified trigger level.

For details, see the FSW I/Q Analyzer and I/Q Input User Manual.

Remote command:
`TRIG:SOUR EXT`
See `TRIGger[:SEQuence]:SOURce` on page 164

**IF Power ← Trigger Source ← Trigger Source**
The FSW starts capturing data as soon as the trigger level is exceeded around the third intermediate frequency.

For frequency sweeps, the third IF represents the start frequency. The trigger threshold depends on the defined trigger level, as well as on the RF attenuation and preamplification. A reference level offset, if defined, is also considered. The trigger bandwidth at the intermediate frequency depends on the RBW and sweep type. For details on available trigger levels and trigger bandwidths, see the instrument specifications document.

For measurements on a fixed frequency (e.g. zero span or I/Q measurements), the third IF represents the center frequency.

This trigger source is only available for RF input.

The available trigger levels depend on the RF attenuation and preamplification. A reference level offset, if defined, is also considered.

For details on available trigger levels and trigger bandwidths, see the specifications document.

Remote command:
`TRIG:SOUR IFP`, see `TRIGger[:SEQuence]:SOURce` on page 164

**RF Power ← Trigger Source ← Trigger Source**
Defines triggering of the measurement via signals which are outside the displayed measurement range.

For this purpose, the instrument uses a level detector at the first intermediate frequency.

The resulting trigger level at the RF input depends on the RF attenuation and preamplification. For details on available trigger levels, see the instrument's specifications document.

**Note:** If the input signal contains frequencies outside of this range (e.g. for fullspan measurements), the measurement can be aborted. A message indicating the allowed input frequencies is displayed in the status bar.

A "Trigger Offset", "Trigger Polarity" and "Trigger Holdoff" (to improve the trigger stability) can be defined for the RF trigger, but no "Hysteresis".

Remote command:
`TRIG:SOUR RFP`, see `TRIGger[:SEQuence]:SOURce` on page 164

**I/Q Power ← Trigger Source ← Trigger Source**
Triggers the measurement when the magnitude of the sampled I/Q data exceeds the trigger threshold.

Remote command:
`TRIG:SOUR IQP`, see `TRIGger[:SEQuence]:SOURce` on page 164

**Trigger Level ← Trigger Source**
Defines the trigger level for the specified trigger source.

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

Remote command:
`TRIGger[:SEQuence]:LEVel:IFPower` on page 162
`TRIGger[:SEQuence]:LEVel:IQPower` on page 163
`TRIGger[:SEQuence]:LEVel[:EXTernal<port>]` on page 162
`TRIGger[:SEQuence]:LEVel:RFPower` on page 163

**Drop-Out Time ← Trigger Source**
Defines the time that the input signal must stay below the trigger level before triggering again.

Remote command:
`TRIGger[:SEQuence]:DTIMe` on page 161

**Trigger Offset ← Trigger Source**
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[:SEQuence]:HOLDoff[:TIME]` on page 161

**Hysteresis ← Trigger Source**
Defines the distance in dB to the trigger level that the trigger source must exceed before a trigger event occurs. Setting a hysteresis avoids unwanted trigger events caused by noise oscillation around the trigger level.

This setting is only available for "IF Power" trigger sources. The range of the value is between 3 dB and 50 dB with a step width of 1 dB.

Remote command:
`TRIGger[:SEQuence]:IFPower:HYSTeresis` on page 162

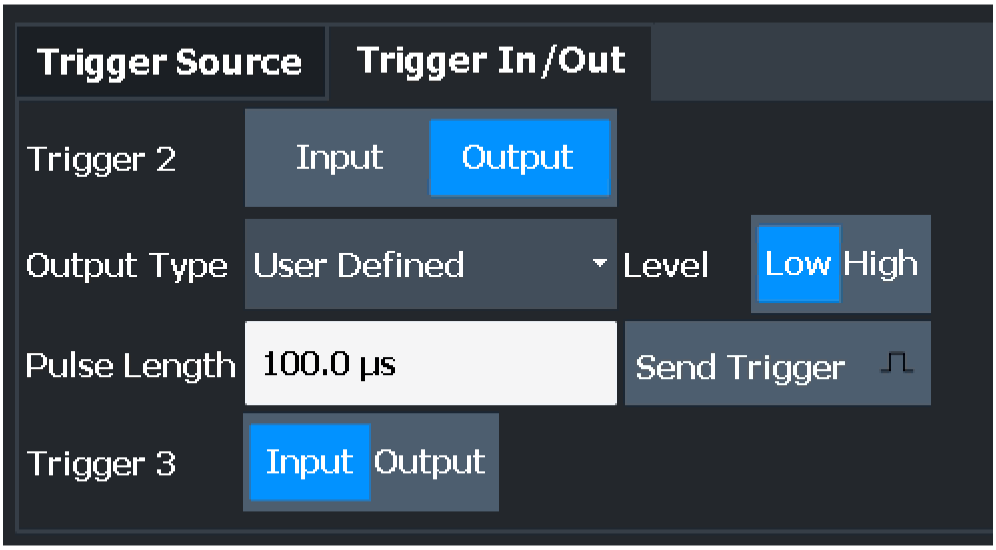
**Trigger Holdoff ← Trigger Source**
Defines the minimum time (in seconds) that must pass between two trigger events. Trigger events that occur during the holdoff time are ignored.

Remote command:
`TRIGger[:SEQuence]:IFPower:HOLDoff` on page 161

**Slope ← Trigger Source**
For all trigger sources except time, you can define whether triggering occurs when the signal rises to the trigger level or falls down to it.

Remote command:
`TRIGger[:SEQuence]:SLOPe` on page 163

**Trigger 2/3**




The trigger input and output functionality depends on how the variable "Trigger Input/ Output" connectors are used.

**Note:** Providing trigger signals as output is described in detail in the FSW base unit user manual.

| | |
|---|---|
| "Trigger 1" | "Trigger 1" is input only. |
| "Trigger 2" | Defines the usage of the variable "Trigger Input/Output" connector on the front panel<br>(not available for FSW85 models with 2 RF input connectors) |
| "Trigger 3" | Defines the usage of the variable "Trigger 3 Input/Output" connector on the rear panel |
| "Input" | The signal at the connector is used as an external trigger source by the FSW. Trigger input parameters are available in the "Trigger" dialog box. |
| "Output" | The FSW sends a trigger signal to the output connector to be used by connected devices.<br>Further trigger parameters are available for the connector. |

Remote command:
`OUTPut:TRIGger<tp>:DIRection` on page 165

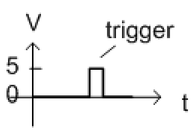
**Output Type ← Trigger 2/3**
Type of signal to be sent to the output

| | |
|---|---|
| "Device Triggered" | (Default) Sends a trigger when the FSW triggers. |
| "Trigger Armed" | Sends a (high level) trigger when the FSW is in "Ready for trigger" state.<br>This state is indicated by a status bit in the `STATus:OPERation` register (bit 5), as well as by a low-level signal at the "AUX" port (pin 9). |
| "User Defined" | Sends a trigger when you select "Send Trigger".<br>In this case, further parameters are available for the output signal. |

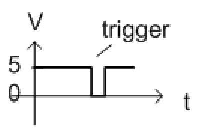
Remote command:
`OUTPut:TRIGger<tp>:OTYPe` on page 166

**Level ← Output Type ← Trigger 2/3**
Defines whether a high (1) or low (0) constant signal is sent to the trigger output connector (for "Output Type": "User Defined".

The trigger pulse level is always opposite to the constant signal level defined here. For example, for "Level" = "High", a constant high signal is output to the connector until you select the Send Trigger function. Then, a low pulse is provided.




low-level constant, high-level trigger




high-level constant, low-level trigger

Remote command:
`OUTPut:TRIGger<tp>:LEVel` on page 166

**Pulse Length ← Output Type ← Trigger 2/3**

Defines the duration of the pulse (pulse width) sent as a trigger to the output connector.

Remote command:
`OUTPut:TRIGger<tp>:PULSe:LENGth` on page 167

**Send Trigger ← Output Type ← Trigger 2/3**

Sends a user-defined trigger to the output connector immediately.

Note that the trigger pulse level is always opposite to the constant signal level defined by the output Level setting. For example, for "Level" = "High", a constant high signal is output to the connector until you select the "Send Trigger" function. Then, a low pulse is sent.

Which pulse level is sent is indicated by a graphic on the button.

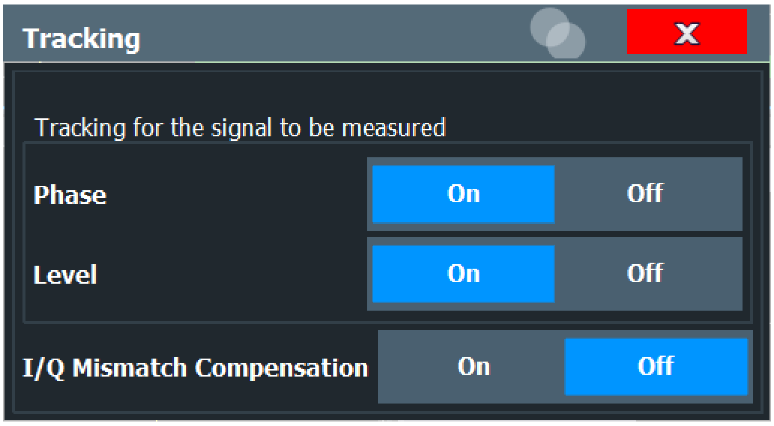
Remote command:
`OUTPut:TRIGger<tp>:PULSe:IMMediate` on page 167

## 5.2.5 Tracking

**Access**: "Overview" > "Tracking"

**Or**: [MEAS CONFIG] > "Tracking"

Tracking settings allow for compensation of some transmission effects in the signal (see "Phase, level and timing tracking" on page 35).






**Phase Tracking**

Activates or deactivates the compensation for phase drifts. If activated, the measurement results are compensated for phase drifts based on data symbol blocks (=512 symbols).

Tip: the phase drifts which are used for compensation are displayed in the Phase Tracking vs Symbol result display.

Remote command:
`SENSe:TRACking:PHASe` on page 168

**Level Error (Gain) Tracking**
Activates or deactivates the compensation for level drifts within a single PPDU. If activated, the measurement results are compensated for level error on a per-symbol basis.

Remote command:
`SENSe:TRACking:LEVel` on page 168

**I/Q Mismatch Compensation**
Activates or deactivates the compensation for I/Q mismatch.

If activated, the measurement results are compensated for gain imbalance and quadrature offset.

Remote command:
`[SENSe:]TRACking:IQMComp` on page 167

## 5.2.6 Automatic settings

**Access**: [AUTO SET]

Some settings can be adjusted by the FSW automatically according to the current measurement settings and signal characteristics.

**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 FSW 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. The trigger level is adjusted as follows for "IF Power" and "RF Power" triggers:
  Trigger level = Reference level - 15 dB

**Remote command:**

`[SENSe:]ADJust:CONFigure:TRIGger` on page 172



**Setting the Reference Level Automatically (Auto Level)**
To determine the required reference level, a level measurement is performed on the FSW.

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 171

### 5.2.7 Sweep settings

**Access**: [Sweep]

The sweep settings define how the data is measured.



**Continuous Sweep / Run Cont**
After triggering, starts the sweep and repeats it continuously until stopped. This is the default setting.

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. If the Sequencer is active, "Continuous Sweep" only controls the sweep mode for the currently selected channel. However, the sweep mode only takes effect the next time the Sequencer activates that channel, and only for a channel-defined sequence. In this case, a channel in continuous sweep mode is swept repeatedly.
Furthermore, [RUN CONT] controls the Sequencer, not individual sweeps. [RUN CONT] starts the Sequencer in continuous mode.

For details on the Sequencer, see the FSW base unit user manual.

Remote command:
`INITiate<n>:CONTinuous` on page 191

**Single Sweep / Run Single**
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. If the Sequencer is active, "Single Sweep" only controls the sweep mode for the currently selected channel. However, the sweep mode only takes effect the next time the Sequencer activates that channel, and only for a channel-defined sequence. In this case, the Sequencer sweeps a channel in single sweep mode only once.
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.

For details on the Sequencer, see the FSW base unit user manual.

Remote command:
`INITiate<n>[:IMMediate]` on page 192

**Continue Single Sweep**
After triggering, repeats the number of sweeps set in "Sweep Count", without deleting the trace of the last measurement.

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

**Measurement Time**
Specifies the duration (and therefore the amount of data) to be captured in the capture buffer. If the measurement time is too short, demodulation fails. In particular, if the result length does not fit in the capture buffer, demodulation fails.

Remote command:
`[SENSe:]SWEep:TIME` on page 160

**Sweep/Average 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.

Remote command:
`[SENSe:]SWEep:COUNt` on page 207

## 5.2.8 Result configuration

**Access**: "Overview" ≥ "Result Config"

**Or**: [MEAS CONFIG] > "Result Config"

Some evaluation methods require or allow for additional settings to configure the result display. Note that the available settings depend on the selected window (see "Specific Settings for" on page 46).



### 5.2.8.1 Table configuration

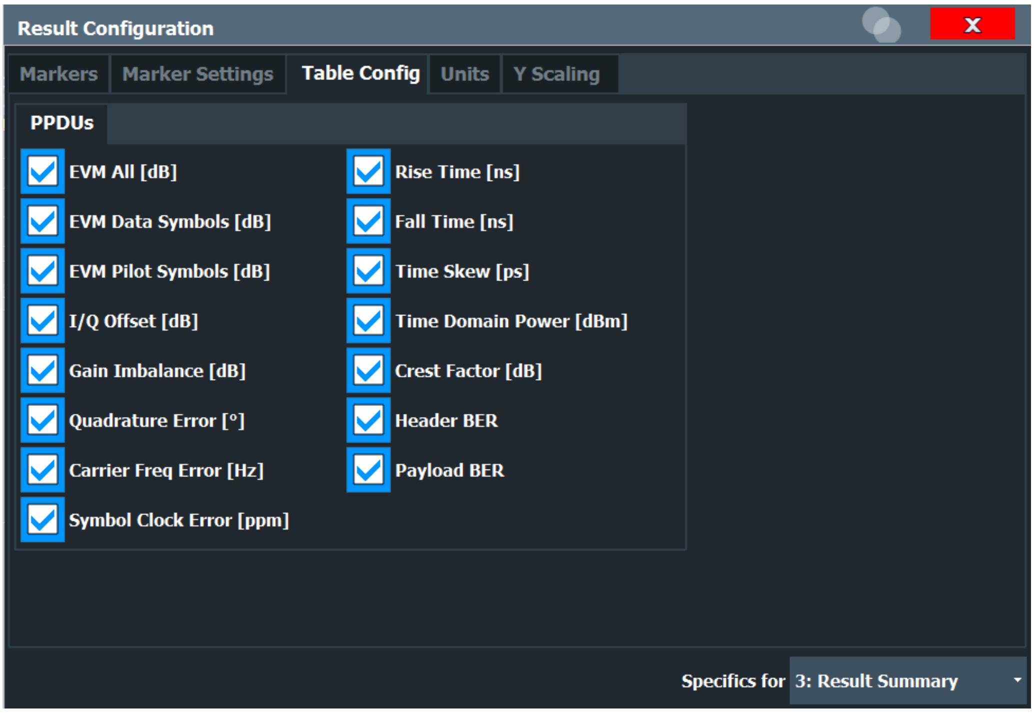
**Access**: "Overview" > "Result Config" > "Table Config"

**Or**: [MEAS CONFIG] > "Result Config" > "Table Config"

During each measurement, many statistical and characteristic values are determined. The "Result Summary" provides an overview of the parameters selected here.

You can configure which results are displayed in "Result Summary" displays (see "Result Summary" on page 23). However, the results are always *calculated*, regardless of their visibility on the screen.

Note that the "Result Configuration" dialog box is window-specific; table configuration settings are only available if a table display is selected.




Select the parameters to be included in the table. For a description of the individual parameters see Chapter 3.1.2, "Modulation accuracy parameters", on page 24.

**Remote command:**

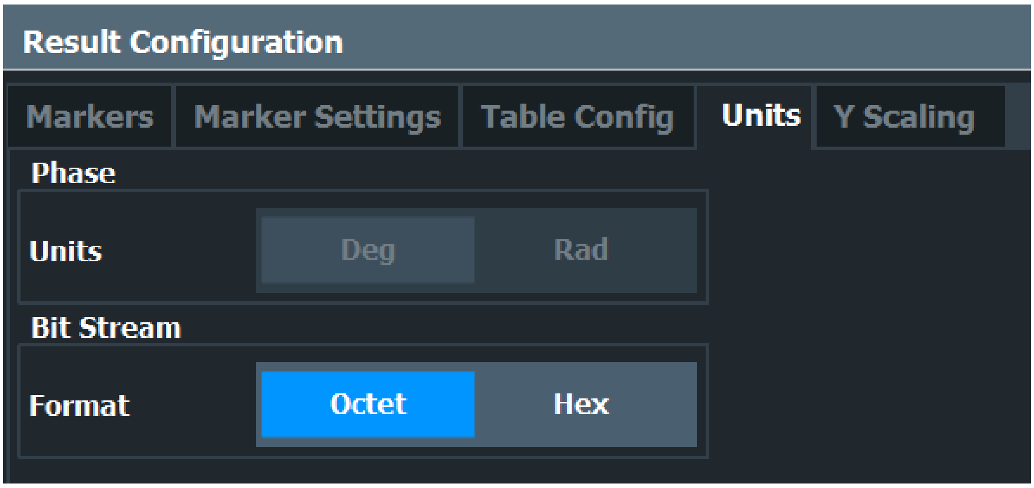
DISPlay[:WINDow<n>]:TABLe:ITEM on page 185

### 5.2.8.2 Units

**Access**: "Overview" > "Result Config" > "Units"

**Or**: [MEAS CONFIG] > "Result Config" > "Units"

The unit for phase display is configurable. This setting is described here.






**Phase Unit**

Defines the unit in which phases are displayed (degree or rad).

Remote command:

UNIT:ANGLe on page 187

**Bitstream Format**

Switches the format of the bitstream between octet and hexadecimal values.

Remote command:

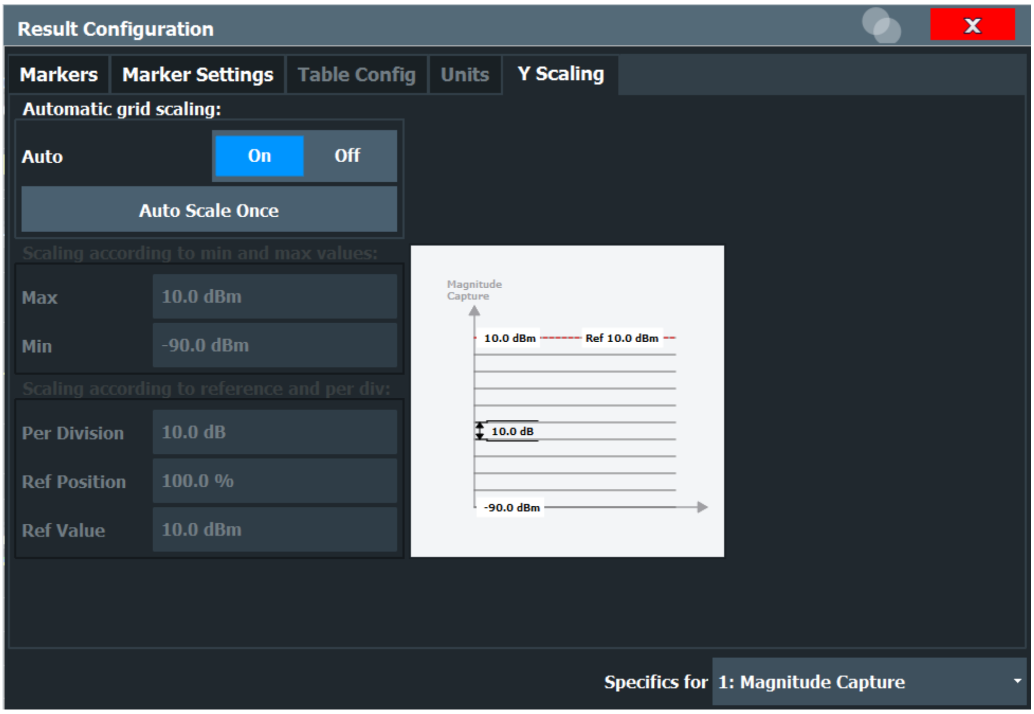
FORMat:BSTReam on page 190

### 5.2.8.3 Y-scaling

**Access**: "Overview" > "Result Config" > "Y Scaling"

**Or**: [MEAS CONFIG] > "Result Config" > "Y Scaling"

The scaling for the vertical axis in (most) graphical displays is highly configurable, using either absolute or relative values. These settings are described here.






**Automatic Grid Scaling**

The y-axis is scaled automatically according to the current measurement settings and results.

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<n>]:TRACe<t>:Y[:SCALe]:AUTO
on page 188

**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<n>]:TRACe<t>:Y[:SCALe]:AUTO
on page 188

**Absolute Scaling (Min/Max Values)**

Define the scaling using absolute minimum and maximum values.

Remote command:
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MAXimum on page 153
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MINimum on page 153

**Relative Scaling (Reference/ per Division)**
Define the scaling relative to a reference value, with a specified value range per division.

**Per Division ← Relative Scaling (Reference/ per Division)**
Defines the value range to be displayed per division of the diagram (1/10 of total range).

**Note:** The value defined per division refers to the default display of 10 divisions on the y-axis. If fewer divisions are displayed (e.g. because the window is reduced in height), the range per division is increased to display the same result range in the smaller window. In this case, the per division value does not correspond to the actual display.

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:PDIVision on page 188

**Ref Position ← Relative Scaling (Reference/ per Division)**
Defines the position of the reference value in percent of the total y-axis range.

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RPOSition on page 189

**Ref Value ← Relative Scaling (Reference/ per Division)**
Defines the reference value to be displayed at the specified reference position.

Remote command:
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RVALue on page 189

## 5.3 SEM measurements

**Access**: "Overview" > "Select Measurement"

**Or**: [MEAS] > "Select Measurement"

When you activate a measurement channel in IEEE 802.11ad/ay mode, an IQ measurement of the input signal is started automatically (see Chapter 3.1, "IEEE 802.11ad/ay modulation accuracy measurement", on page 13). However, some parameters specified in the IEEE 802.11ad/ay standard require a better signal-to-noise level or a smaller bandwidth filter than the default measurement on I/Q data provides and must be determined in separate measurements based on RF data (see Chapter 3.2, "SEM measurements", on page 29). In these measurements, demodulation is not performed.

The R&S FSW 802.11ad/ay applications uses the functionality of the FSW base system (Spectrum application) to perform the IEEE 802.11ad/ay SEM measurements. Some parameters are set automatically according to the IEEE 802.11ad/ay standard the first time a measurement is selected (since the last [PRESET] operation). These parameters can be changed, but are not reset automatically the next time you re-enter the measurement. Refer to the description of each measurement type for details.

The main measurement configuration menus for the IEEE 802.11ad/ay SEM measurements are identical to the Spectrum application.

For details refer to "Measurements" in the FSW User Manual.



### 5.3.1 Spectrum emission mask

**Access**: "Overview" > "Select Measurement" > "SEM"

**Or**: [MEAS] > "Select Measurement" > "SEM"

The Spectrum Emission Mask measurement shows the quality of the measured signal by comparing the power values in the frequency range near the carrier against a spectral mask that is defined by the IEEE 802.11ad/ay specifications. Thus, the performance of the DUT can be tested and the emissions and their distance to the limit are identified.

Note that the IEEE 802.11ad/ay standard does not distinguish between spurious and spectral emissions.

The "Result Summary" contains a peak list with the values for the largest spectral emissions including their frequency and power.

The R&S FSW 802.11ad/ay applications performs the SEM measurement as in the Spectrum application with the following settings:

***Table 5-1: Predefined settings for IEEE 802.11ad SEM measurements***

| Setting | Default value |
|---|---|
| Number of ranges | 7 |
| Frequency Span | +/- 3.06 GHz |
| Fast SEM | OFF |
| Sweep time | 1 ms to 1.88 ms (depending on range) |
| RBW | 1 MHz |
| Power reference type | Peak Power |
| Tx Bandwidth | 1.88 MHz |
| Number of power classes | 1 |

For further details about the Spectrum Emission Mask measurements, refer to "Spectrum Emission Mask Measurement" in the FSW User Manual.

To restore adapted measurement parameters, the following parameters are saved on exiting and are restored on re-entering this measurement:

- Reference level and reference level offset
- Sweep time
- Span

The main measurement menus for the SEM measurements are identical to the Spectrum application.

**Remote command:**

`SENS:SWE:MODE SEM`

# 6 Analysis

After a IEEE 802.11ad measurement has been performed, you can analyze the results in various ways.

**Analysis of SEM measurements**

General result analysis settings concerning the trace, markers, lines etc. for RF measurements are identical to the analysis functions in the Spectrum application. Only some special marker functions and spectrograms are not available in the R&S FSW 802.11ad/ay applications.

For details see the "Common Analysis and Display Functions" chapter in the FSW User Manual.

The remote commands required to perform these tasks are described in Chapter 9.9, "Analysis", on page 194.



## 6.1 Evaluation range

**Access**: "Overview" > "Evaluation Range"

**Or**: [MEAS CONFIG] > "Evaluation Range"

The evaluation range defines which objects the result displays are based on.

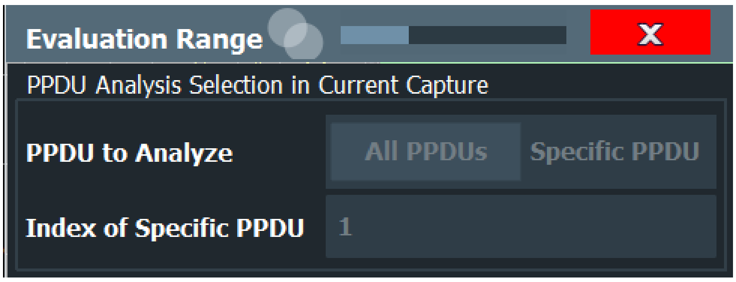



*Figure 6-1: Evaluation range settings*



**PPDU to Analyze / Index of Specific PPDU**

If "All PPDUs" is enabled, the I/Q results are based on all PPDUs in the current capture buffer.

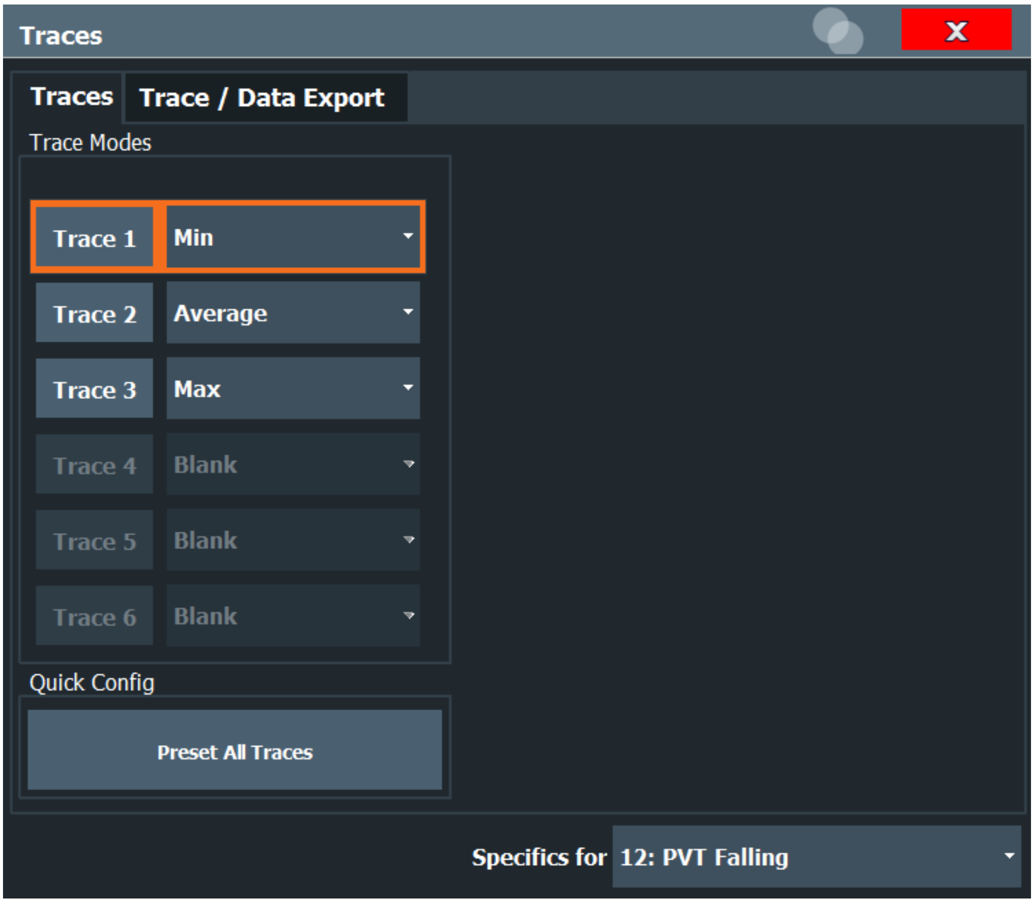
If "Specific PPDU" is enabled, the IEEE 802.11ad I/Q results are based on one individual PPDU only, namely the one with the specified index. The result displays are updated to show the results for the new evaluation range. The selected PPDU is marked by a blue bar in PPDU-based results (see "Magnitude Capture" on page 19).

**Note:** Note that this setting is only applicable *after* a measurement has been performed. As soon as a new measurement is started, the evaluation range is reset to all PPDUs in the current capture buffer.

Remote command:
`[SENSe:]BURSt:SELect:STATe` on page 170
`[SENSe:]BURSt:SELect` on page 169

## 6.2 Trace configuration

**Access**: [Trace] > "Trace Config"




For the Power vs Time and "Channel Frequency Response" result displays, a maximum of three traces are available, for all other result displays in the R&S FSW 802.11ad/ay applications, only one trace is available. The trace modes cannot be changed.

Trace data can also be exported to an ASCII file for further analysis. For details see Chapter 6.2.1, "Trace / data export configuration", on page 80.

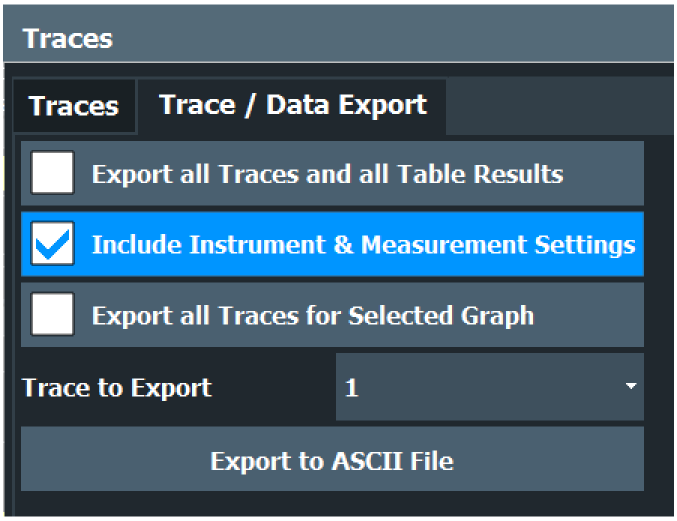
## 6.2.1 Trace / data export configuration

**Access**: "Save" > "Export" > "Export Configuration"

**Or**: [TRACE] > "Trace Config" > "Trace / Data Export"

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

See the FSW 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 228

**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 227

**Export All Traces for Selected Graph**
Includes all traces for the currently selected graphical result display in the export file.

Remote command:
`FORMat:DEXPort:GRAPh` on page 227

**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 227

**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.

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.

**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 FSW base unit user manual.

Remote command:
`MMEMory:STORe<n>:TRACe` on page 228

## 6.3 Markers

**Access**: [MKR]

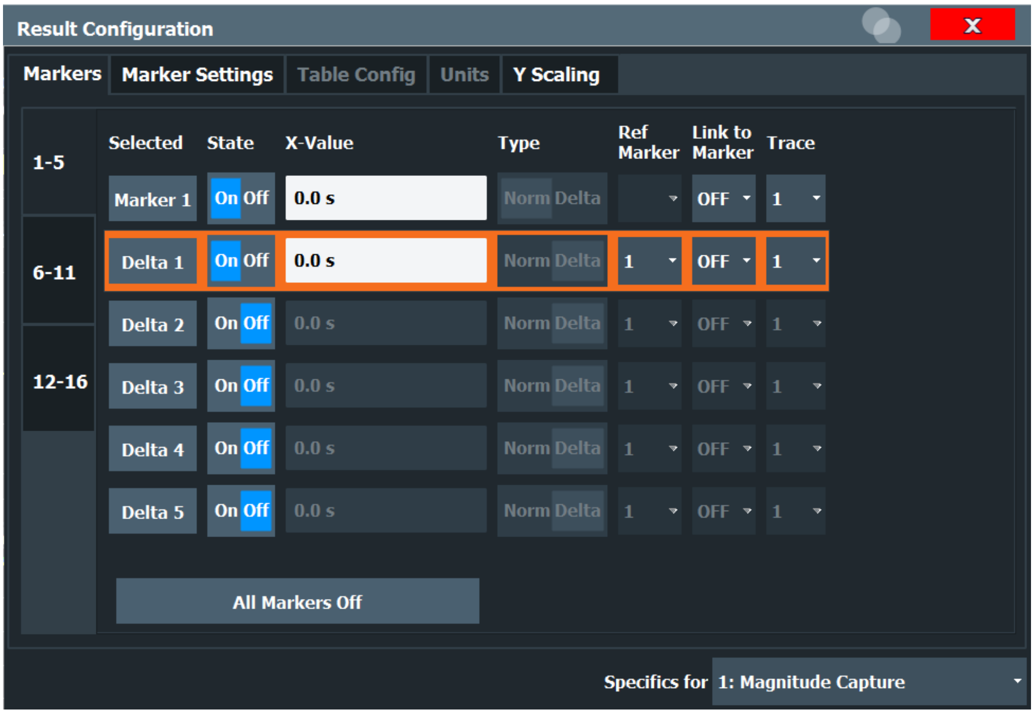
Markers help you analyze your measurement results by determining particular values in the diagram. Thus you can extract numeric values from a graphical display.



### 6.3.1 Individual marker settings

**Access**: [MKR] > "Marker Config"

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






**Delta Marker 1 / Marker 2 / Marker 3 / ... Marker 16 / Norm / Delta**

"Marker X" activates the corresponding marker and opens an edit dialog box to enter the marker position ("X-value"). Pressing the softkey again deactivates the selected marker.

Marker 1 is always the default reference marker for relative measurements. If activated, markers 2 to 16 are delta markers that refer to marker 1. These markers can be converted into markers with absolute value display using the "Marker Type" function.

**Note:** If normal marker 1 is the active marker, pressing "Mkr Type" switches on an additional delta marker 1.

Remote command:

`CALCulate<n>:MARKer<m>[:STATe]` on page 195
`CALCulate<n>:MARKer<m>:X` on page 196
`CALCulate<n>:MARKer<m>:Y?` on page 223
`CALCulate<n>:DELTamarker<m>[:STATe]` on page 198
`CALCulate<n>:DELTamarker<m>:X` on page 199
`CALCulate<n>:DELTamarker<m>:X:RELative?` on page 222
`CALCulate<n>:DELTamarker<m>:Y?` on page 223

**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 195
`CALCulate<n>:DELTamarker<m>[:STATe]` on page 198

**X-value**

Defines the position of the marker on the x-axis.

**Note:** Setting markers in Parameter Trend Displays. In Parameter Trend displays, especially when the x-axis unit is not pulse number, positioning a marker by defining its x-axis value can be very difficult or unambiguous. Thus, markers can be positioned by defining the corresponding pulse number in the "Marker" edit field for all parameter trend displays, regardless of the displayed x-axis parameter. The "Marker" edit field is displayed when you select one of the "Marker" softkeys.

Remote command:
`CALCulate<n>:DELTamarker<m>:X` on page 199
`CALCulate<n>:MARKer<m>:X` on page 196

**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 195
`CALCulate<n>:DELTamarker<m>[:STATe]` on page 198

**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 198

**Linking to Another Marker**

Links the current marker to the marker selected from the list of active markers. If the x-axis value of the initial marker is changed, the linked marker follows to the same position on the x-axis. Linking is off by default.

Using this function you can set two markers on different traces to measure the difference (e.g. between a max hold trace and a min hold trace or between a measurement and a reference trace).

For linked delta markers, the x-value of the delta marker is 0 Hz by default. To create a delta marker in a fixed distance to another marker, define the distance as the x-value for the linked delta marker.

Remote command:
CALCulate<n>:MARKer<ms>:LINK:TO:MARKer<md> on page 195
CALCulate<n>:DELTamarker<ms>:LINK:TO:MARKer<md> on page 198
CALCulate<n>:DELTamarker<m>:LINK on page 197

**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.

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

Remote command:
CALCulate<n>:MARKer<m>:TRACe on page 196

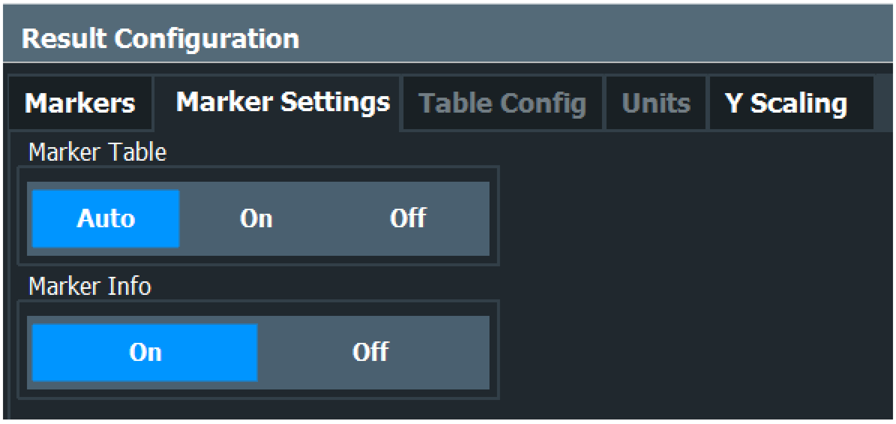
**All Markers Off**

Deactivates all markers in one step.

Remote command:
CALCulate<n>:MARKer<m>:AOFF on page 195

## 6.3.2 General marker settings

**Access**: [MKR ->]"Marker Config" > "Marker Settings"






**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.

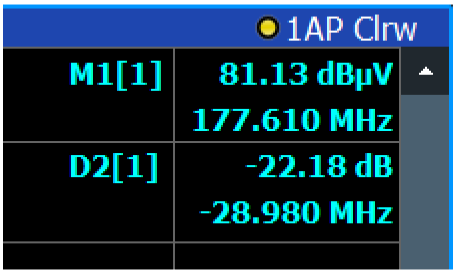
"Off" — No separate marker table is displayed.
If Marker Info is active, the marker information is displayed within the diagram area.

"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 200

**Marker Info**

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




Remote command:
`DISPlay[:WINDow<n>]:MINFo[:STATe]` on page 200

# 7 I/Q data import and export

Baseband signals mostly occur as so-called complex baseband signals, i.e. a signal representation that consists of two channels; the inphase (I) and the quadrature (Q) channel. Such signals are referred to as I/Q signals. The complete modulation information and even distortion that originates from the RF, IF or baseband domains can be analyzed in the I/Q baseband.

Importing and exporting I/Q signals is useful for various applications:

- Generating and saving I/Q signals in an RF or baseband signal generator or in external software tools to analyze them with the FSW later.
  The FSW supports various I/Q data formats for import.
- Capturing and saving I/Q signals with the FSW to analyze them with the FSW or an external software tool later
  As opposed to storing trace data, which can be averaged or restricted to peak values, I/Q data is stored as it was captured, without further processing. Multi-channel data is not supported.
  The data is stored as complex values in 32-bit floating-point format.
  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.
  For a detailed description, see the FSW I/Q Analyzer and I/Q Input User Manual.

For example, you can capture I/Q data using the I/Q Analyzer application, if available, and then analyze that data later using the R&S FSW 802.11ad/ay applications.

An application note on converting Rohde & Schwarz I/Q data files is available from the Rohde & Schwarz website:

1EF85: Converting R&S I/Q data files

The import and export functions are available in the "Save/Recall" menu which is displayed when you select the "Save" or "Open" icon in the toolbar.

See the FSW I/Q Analyzer and I/Q Input User Manual.

# 8 How to perform measurements in the R&S FSW 802.11ad/ay applications

The following step-by-step instructions demonstrate how to perform measurements in the R&S FSW 802.11ad/ay applications. The following tasks are described:



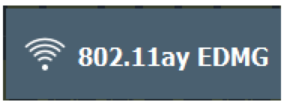
## 8.1 How to determine modulation accuracy parameters for IEEE 802.11ad/IEEE 802.11ay signals

This description assumes the required bandwidth extension options are installed and active.
See the FSW I/Q Analyzer and I/Q Input User Manual for details.

1. Press [PRESET].
2. Press [MODE].

   A dialog box opens that contains all operating modes and applications currently available on your FSW.
3. Select the "IEEE 802.11ad" item.

   The FSW opens a new measurement channel for the IEEE 802.11ad/IEEE 802.11ay measurement.
4. Select "Overview" to display the "Overview" for a IEEE 802.11ad/IEEE 802.11ay measurement.
5. Select the "Frequency" tab to define the input signal's center frequency.
6. Select "Data Acquisition" to define how much and which data to capture from the input signal.
   For IEEE 802.11ay measurements, define the number of contiguous channels ("$N_{CB}$") used for measurement.

7. Select "Tracking" to define which distortions will be compensated for.
8. Select "Demod" to provide information on the modulated signal and how the PPDUs detected in the capture buffer are to be demodulated.
9. Select "Evaluation Range" to define which data in the capture buffer you want to analyze.
10. Select "Display Config" and select the displays that are of interest to you (up to 16). Arrange them on the display to suit your preferences.
11. Exit the SmartGrid mode.
12. Start a new sweep with the defined settings.
    - To perform a single sweep measurement, press RUN SINGLE.
    - To perform a continuous sweep measurement, press RUN CONT.

    Measurement results are updated once the measurement has completed.

## 8.2 How to determine the SEM for IEEE 802.11ad/IEEE 802.11ay signals

1. Press [MODE] and select the "IEEE 802.11ad" / "IEEE 802.11ay" application.

   The FSW opens a new measurement channel for the IEEE 802.11ad/IEEE 802.11ay measurement. I/Q data acquisition is performed by default.
2. Select the required measurement:
   a) Press [MEAS].
   b) In the "Select Measurement" dialog box, select the required measurement.

   The selected measurement is activated with the default settings for IEEE 802.11ad immediately.
3. Select "Display Config" and select the evaluation methods that are of interest to you.
   Arrange them on the display to suit your preferences.
4. Exit the SmartGrid mode and select "Overview" to display the "Overview" again.
5. Select "Analysis" in the "Overview" to make use of the advanced analysis functions in the result displays.
   - Configure a trace to display the average over a series of sweeps; if necessary, increase the "Sweep Count" in the "Sweep" settings.
   - Configure markers and delta markers to determine deviations and offsets within the evaluated signal.
   - Use special marker functions to calculate noise or a peak list.
   - Configure a limit check to detect excessive deviations.
6. Optionally, export the trace data of the graphical evaluation results to a file.

a) In the "Traces" tab of the "Analysis" dialog box, switch to the "Trace Export" tab.
b) Select "Export Trace to ASCII File".
c) Define a file name and storage location and select "OK".

# 9 Remote commands for IEEE 802.11ad measurements

The following commands are required to perform measurements in the R&S FSW 802.11ad/ay applications in a remote environment.

It is assumed that the FSW has already been set up for remote control in a network as described in the FSW User Manual.

Note that basic tasks that are independent of the application are not described here. For a description of such tasks, see the FSW 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

**SCPI Recorder - automating tasks with remote command scripts**

The R&S FSW 802.11ad/ay applications also supports the SCPI Recorder functionality.

Using the SCPI Recorder functions, you can create a SCPI script directly on the instrument and then export the script for use on the controller. You can also edit or write a script manually, using a suitable editor on the controller. For manual creation, the instrument supports you by showing the corresponding command syntax for the current setting value.

For details see the "Network and Remote Operation" chapter in the FSW User Manual.

After an introduction to SCPI commands, the following tasks specific to the R&S FSW 802.11ad/ay applications are described here:

## 9.1 Common suffixes

In the R&S FSW 802.11ad/ay applications, the following common suffixes are used in remote commands:

*Table 9-1: Common suffixes used in remote commands in the R&S FSW 802.11ad/ay applications*

| Suffix | Value range | Description |
|---|---|---|
| <m> | 1 to 4 (SEM: 16) | Marker |
| <n> | 1 to 16 | Window (**in the currently selected channel**) |
| <t> | irrelevant (SEM: 6) | Trace |
| <li> | 1 to 8 | Limit line |

## 9.2 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 FSW.

**Remote command examples**

Note that some remote command examples mentioned in this general introduction are possibly not supported by this particular application.

### 9.2.1 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 FSW 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.

### 9.2.2 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`.

### 9.2.3 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.

## 9.2.4 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.

## 9.2.5 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.

## 9.2.6 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.



### 9.2.6.1 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.

#### 9.2.6.2 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`

#### 9.2.6.3 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 9.2.2, "Long and short form", on page 92.

**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`

#### 9.2.6.4 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'`

#### 9.2.6.5 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.

## 9.3 Activating IEEE 802.11ad measurements

IEEE 802.11ad measurements require a special application on the FSW (FSW-K91). The measurement is started immediately with the default settings.

These are basic FSW commands, listed here for your convenience.



---

**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 'IQAnalyzer'`
`INST:CRE:DUPL`
Duplicates the channel named 'IQAnalyzer' and creates a new channel named 'IQAnalyzer2'.

**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 97.

<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 97.

<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 97).
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 'IQAnalyzer2',IQ,'IQAnalyzer'`
Replaces the channel named "IQAnalyzer2" by a new channel of type "IQ Analyzer" named "IQAnalyzer".

**Usage:** Setting only

---

**INSTrument:DELete** <ChannelName>

Deletes a channel.

If you delete the last channel, the default "Spectrum" 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 'IQAnalyzer4'`
Deletes the channel with the name 'IQAnalyzer4'.

**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 3 channels:
`'ADEM','Analog Demod','IQ','IQ Analyzer','IQ','IQ Analyzer2'`

**Usage:** Query only

*Table 9-2: Available channel types and default channel names in Signal and Spectrum Analyzer mode*

| Application | <ChannelType> parameter | Default Channel name*) |
|---|---|---|
| Spectrum | SANALYZER | Spectrum |
| 1xEV-DO BTS (R&S FSW-K84) | BDO | 1xEV-DO BTS |
| 1xEV-DO MS (R&S FSW-K85) | MDO | 1xEV-DO MS |
| 3GPP FDD BTS (R&S FSW-K72) | BWCD | 3G FDD BTS |
| 3GPP FDD UE (R&S FSW-K73) | MWCD | 3G FDD UE |
| 802.11ad (R&S FSW-K95) | WIGIG | 802.11ad |
| 802.11ay (R&S FSW-K97) | EDMG | 802.11ay EDMG |
| Amplifier Measurements (R&S FSW-K18) | AMPLifier | Amplifier |
| AM/FM/PM Modulation Analysis (R&S FSW-K7) | ADEM | Analog Demod |
| Avionics (R&S FSW-K15) | AVIonics | Avionics |
| Bluetooth (R&S FSW-K8) | BTO | Bluetooth |
| cdma2000 BTS (R&S FSW-K82) | BC2K | CDMA2000 BTS |
| cdma2000 MS (R&S FSW-K83) | MC2K | CDMA2000 MS |
| DOCSIS 3.1 (R&S FSW-K192/193) | DOCSis | DOCSIS 3.1 |
| Fast Spur Search (R&S FSW-K50) | SPUR | Spurious |
| GSM (R&S FSW-K10) | GSM | GSM |
| HRP UWB (R&S FSW-K149) | UWB | HRP UWB |
| I/Q Analyzer | IQ | IQ Analyzer |
| LTE (R&S FSW-K10x) | LTE | LTE |
| Multi-Carrier "Group Delay" (R&S FSW-K17) | MCGD | MC "Group Delay" |
| NB-IoT (R&S FSW-K106) | NIOT | NB-IoT |
| Noise (R&S FSW-K30) | NOISE | Noise |
| *) If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel. | | |

| Application | <ChannelType> parameter | Default Channel name*) |
|---|---|---|
| 5G NR (R&S FSW-K144) | NR5G | 5G NR |
| OFDM VSA (R&S FSW-K96) | OFDMVSA | OFDM VSA |
| OneWeb (R&S FSW-K201) | OWEB | OneWeb |
| Phase Noise (R&S FSW-K40) | PNOISE | Phase Noise |
| Pulse (R&S FSW-K6) | PULSE | Pulse |
| "Real-Time Spectrum" | RTIM | "Real-Time Spectrum" |
| TD-SCDMA BTS (R&S FSW-K76) | BTDS | TD-SCDMA BTS |
| TD-SCDMA UE (R&S FSW-K77) | MTDS | TD-SCDMA UE |
| Transient Analysis (R&S FSW-K60) | TA | Transient Analysis |
| Verizon 5GTF Measurement Application (V5GTF, R&S FSW-K118) | V5GT | V5GT |
| VSA (R&S FSW-K70) | DDEM | VSA |
| WLAN (R&S FSW-K91) | WLAN | WLAN |
| *) 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 'IQAnalyzer2','IQAnalyzer3'`
Renames the channel with the name 'IQAnalyzer2' to 'IQAnalyzer3'.

**Usage:** Setting only

**INSTrument[:SELect]** <ChannelType> | <ChannelName>

This command activates a new measurement channel with the defined channel type, or selects an existing measurement channel with the specified name.

See also `INSTrument:CREate[:NEW]` on page 96.

For a list of available channel types see `INSTrument:LIST?` on page 97.

**Parameters:**

<ChannelType> Channel type of the new channel.
For a list of available channel types see `INSTrument:LIST?` on page 97.

**WIGIG**
802.11ad option, FSW–K95

**EDMG**
802.11ay option, FSW–K97

<ChannelName> String containing the name of the channel.

**Example:** `INST WIGIG`
Activates a measurement channel for the R&S FSW 802.11ad/ay applications.
`INST '802.11ad'`
Selects the measurement channel named '802.11ad' (for example before executing further commands for that channel).

---

**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 46

## 9.4 Selecting a measurement

The following commands are required to define the measurement type in a remote environment. The selected measurement must be started explicitly (see Chapter 9.8, "Starting a measurement", on page 190)!

For details on available measurements see Chapter 3, "Measurements and result displays", on page 13.

The IEEE 802.11ad Modulation Accuracy measurement captures the I/Q data from the IEEE 802.11ad signal using a (nearly rectangular) filter with a relatively large bandwidth. This measurement is selected when the IEEE 802.11ad measurement channel is activated. The commands to select a different measurement or return to the IEEE 802.11ad Modulation Accuracy measurement are described here.

Note that the `CONF:BURS:<ResultType>:IMM` commands change the screen layout to display the "Magnitude Capture" buffer in window 1 at the top of the screen and the selected result type in window 2 below that. Any other active windows are closed.

Use the `LAYout` commands to change the display (see Chapter 9.7, "Configuring the result display", on page 176).



### 9.4.1 Selecting the IEEE 802.11ad modulation accuracy measurement

Any of the following commands can be used to return to the IEEE 802.11ad Modulation Accuracy measurement. Each of these results is automatically determined when the IEEE 802.11ad Modulation Accuracy measurement is performed.

### 9.4.2 Selecting a common RF measurement for IEEE 802.11ad signals

The following commands are required to select a common RF measurement for IEEE 802.11ad signals in a remote environment.

For details on available measurements see Chapter 3.2, "SEM measurements", on page 29.



---

**[SENSe:]SWEep:MODE** <Mode>

Selects the measurement to be performed.

**Parameters:**

<Mode> AUTO | ESPectrum

**AUTO**
Standard IEEE 802.11ad I/Q measurement

**ESPectrum**
Spectrum emission mask measurement

*RST: AUTO

**Example:** `SENS:SWE:MODE ESP`

# 9.5 Configuring the IEEE 802.11ad modulation accuracy measurement

The following commands are required to configure the IEEE 802.11ad Modulation Accuracy measurement described in Chapter 3.1, "IEEE 802.11ad/ay modulation accuracy measurement", on page 13.



## 9.5.1 Configuring the data input and output



### 9.5.1.1 RF input



---

**INPut:ATTenuation:PROTection:RESet**

Resets the attenuator and reconnects the RF input with the input mixer for the FSW after an overload condition occurred and the protection mechanism intervened. The error status bit (bit 3 in the `STAT:QUES:POW` status register) and the `INPUT OVLD` message in the status bar are cleared.

The command works only if the overload condition has been eliminated first.

**Example:** `INP:ATT:PROT:RES`

---

**INPut:COUPling** <CouplingType>

Selects the coupling type of the RF input.

If an external frontend is active, the coupling is automatically set to `AC`.

**Parameters:**
<CouplingType> AC | DC

**AC**
AC coupling

**DC**
DC coupling

*RST: AC

**Example:** `INP:COUP DC`

**Manual operation:** See "Input Coupling" on page 48

---

**INPut:SELect** <Source>

Selects the signal source for measurements, i.e. it defines which connector is used to input data to the FSW.

For FSW85 models with two RF input connectors, you must select the input connector to configure first using `INPut:TYPE`.

**Parameters:**

<Source>

**RF**
Radio Frequency ("RF INPUT" connector)

**FIQ**
I/Q data file
(selected by `INPut:FILE:PATH` on page 104)
Not available for Input2.

*RST: RF

**Example:** `INP:TYPE INP1`
For FSW85 models with two RF input connectors: selects the 1.00 mm RF input connector for configuration.
`INP:SEL RF`

**Manual operation:** See "Radio Frequency State" on page 48
See "I/Q Input File State" on page 49

---

**INPut:TYPE** <Input>

The command selects the input path.

**Parameters:**

<Input>

**INPUT1**
Selects RF input 1.
1 mm [RF Input] connector

**INPUT2**
Selects RF input 2.
For FSW85 models with two RF input connectors:
1.85 mm [RF2 Input] connector
For all other models: not available

*RST: INPUT1

**Example:** //Select input path
`INP:TYPE INPUT1`

**Manual operation:** See "Radio Frequency State" on page 48

### 9.5.1.2 Input from I/Q data files

The input for measurements can be provided from I/Q data files. The commands required to configure the use of such files are described here.

Useful commands for retrieving results described elsewhere:

- `INPut:SELect` on page 103

**Remote commands exclusive to input from I/Q data files:**



---

**INPut:FILE:PATH** <FileName>[, <AnalysisBW>]

Selects the I/Q data file to be used as input for further measurements.

The I/Q data file must be in one of the following supported formats:

- `.iq.tar`
- `.iqw`
- `.csv`
- `.mat`
- `.wv`
- `.aid`

Only a single data stream or channel can be used as input, even if multiple streams or channels are stored in the file.

For some file formats that do not provide the sample rate and measurement time or record length, you must define these parameters manually. Otherwise the traces are not visible in the result displays.

**Parameters:**

<FileName> String containing the path and name of the source 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.

<AnalysisBW> Optionally: The analysis bandwidth to be used by the measurement. The bandwidth must be smaller than or equal to the bandwidth of the data that was stored in the file.
Default unit: HZ

**Example:** `INP:FILE:PATH 'C:\R_S\Instr\user\data.iq.tar'`
Uses I/Q data from the specified file as input.

**Example:**
```
//Load an IQW file
INP:SEL:FIQ
INP:FILE:PATH 'C:\R_S\Instr\user\data.iqw'
//Define the sample rate
TRAC:IQ:SRAT 10MHz
//Define the measurement time
SENSe:SWEep:TIME  0.001001
//Start the measurement
INIT:IMM
```

**Manual operation:** See "Select I/Q data file" on page 50

---

**MMEMory:LOAD:IQ:STReam** <Channel>

Only available for files that contain more than one data stream from multiple channels: selects the data stream to be used as input for the currently selected channel.

Automatic mode (`MMEMory:LOAD:IQ:STReam:AUTO`) is set to OFF.

**Parameters:**
<Channel> String containing the channel name.

**Example:**
```
MMEM:LOAD:IQ:STR?
//Result: 'Channel1','Channel2'
MMEM:LOAD:IQ:STR 'Channel2'
```

**Manual operation:** See "Selected Channel" on page 50

---

**MMEMory:LOAD:IQ:STReam:AUTO** <State>

Only available for files that contain more than one data stream from multiple channels: automatically defines which data stream in the file is used as input for the channel.

**Parameters:**
<State> ON | OFF | 0 | 1

**OFF | 0**
The data stream specified by `MMEMory:LOAD:IQ:STReam` is used as input for the channel.

**ON | 1**
The first data stream in the file is used as input for the channel. Applications that support multiple data streams use the first data stream in the file for the first input stream, the second for the second stream etc.

*RST: 1

**Manual operation:** See "Selected Channel" on page 50

**MMEMory:LOAD:IQ:STReam:LIST?**

Returns the available channels in the currently loaded input file.

**Example:**
```
MMEM:LOAD:IQ:STR?
//Result: 'Channel1','Channel2'
```

**Usage:** Query only

**Manual operation:** See "Selected Channel" on page 50

**TRACe:IQ:FILE:REPetition:COUNt** <RepetitionCount>

Determines how often the data stream is repeatedly copied in the I/Q data memory. If the available memory is not sufficient for the specified number of repetitions, the largest possible number of complete data streams is used.

**Parameters:**
<RepetitionCount> integer

**Example:**
```
TRAC:IQ:FILE:REP:COUN 3
```

**Manual operation:** See "File Repetitions" on page 50

### 9.5.1.3 Using external mixers

The commands required to work with external mixers in a remote environment are described here. Note that these commands require the FSW to have an external mixer option installed and an external mixer to be connected to the FSW.

For details on working with external mixers see the FSW User Manual.



#### Basic settings

The basic settings concern general usage of an external mixer.



**[SENSe:]MIXer<x>[:STATe]** <State>

Activates or deactivates the use of a connected external mixer as input for the measurement. This command is only available if the optional External Mixer is installed and an external mixer is connected.

**Suffix:**
<x> 1..n
irrelevant

**Parameters:**
<State> ON | OFF | 1 | 0
*RST: 0

**Example:** `MIX ON`

**[SENSe:]MIXer<x>:BIAS:HIGH** <BiasSetting>

Defines the bias current for the high (last) range.

Is only available if the external mixer is active (see `[SENSe:]MIXer<x>[:STATe]` on page 106).

**Suffix:**
<x> 1..n
irrelevant

**Parameters:**
<BiasSetting> *RST: 0.0 A
Default unit: A

**[SENSe:]MIXer<x>:BIAS[:LOW]** <BiasSetting>

Defines the bias current for the low (first) range.

Is only available if the external mixer is active (see `[SENSe:]MIXer<x>[:STATe]` on page 106).

**Suffix:**
<x> 1..n
irrelevant

**Parameters:**
<BiasSetting> *RST: 0.0 A
Default unit: A

**[SENSe:]MIXer<x>:LOPower** <Level>

Specifies the LO level of the external mixer's LO port.

**Suffix:**
<x> 1..n
irrelevant

**Parameters:**
<Level> Range: 13.0 dBm to 17.0 dBm
Increment: 0.1 dB
*RST: 15.5 dBm
Default unit: DBM

**Example:** `MIX:LOP 16.0dBm`

---

**[SENSe:]MIXer<x>:SIGNal** <State>

Specifies whether automatic signal detection is active or not.

Note that automatic signal identification is only available for measurements that perform frequency sweeps (not in vector signal analysis or the I/Q Analyzer, for instance).

**Suffix:**

<x> 1..n
irrelevant

**Parameters:**

<State> OFF | ON | AUTO | ALL

**OFF | ON | AUTO | ALL**

**OFF**
No automatic signal detection is active.

**ON**
Automatic signal detection (Signal ID) is active.

**AUTO**
Automatic signal detection (Auto ID) is active.

**ALL**
Both automatic signal detection functions (Signal ID+Auto ID) are active.

*RST: OFF

---

**[SENSe:]MIXer<x>:THReshold** <Value>

Defines the maximum permissible level difference between test sweep and reference sweep to be corrected during automatic comparison (see `[SENSe:]MIXer<x>:SIGNal` on page 108).

**Suffix:**

<x> 1..n
irrelevant

**Parameters:**

<Value> <numeric value>

Range: 0.1 dB to 100 dB
*RST: 10 dB
Default unit: DB

**Example:** `MIX:PORT 3`

### Mixer settings

The following commands are required to configure the band and specific mixer settings.

---

**[SENSe:]MIXer<x>:FREQuency:HANDover** <Frequency>

Defines the frequency at which the mixer switches from one range to the next (if two different ranges are selected). The handover frequency for each band can be selected freely within the overlapping frequency range.

Is only available if the external mixer is active (see `[SENSe:]MIXer<x>[:STATe]` on page 106).

**Suffix:**

<x> 1..n
irrelevant

**Parameters:**

<Frequency> Default unit: HZ

**Example:**
`MIX ON`
Activates the external mixer.
`MIX:FREQ:HAND 78.0299GHz`
Sets the handover frequency to 78.0299 GHz.

---

**[SENSe:]MIXer<x>:FREQuency:STARt**

Sets or queries the frequency at which the external mixer band starts.

**Suffix:**

<x> 1..n
irrelevant

**Example:**
`MIX:FREQ:STAR?`
Queries the start frequency of the band.

---

**[SENSe:]MIXer<x>:FREQuency:STOP**

Sets or queries the frequency at which the external mixer band stops.

**Suffix:**
<x> 1..n
irrelevant

**Example:** `MIX:FREQ:STOP?`
Queries the stop frequency of the band.

---

**[SENSe:]MIXer<x>:HARMonic:BAND:PRESet**

Restores the preset frequency ranges for the selected standard waveguide band.

**Note:** Changes to the band and mixer settings are maintained even after using the [PRESET] function. Use this command to restore the predefined band ranges.

**Suffix:**
<x> 1..n
irrelevant

**Example:** `MIX:HARM:BAND:PRES`
Presets the selected waveguide band.

---

**[SENSe:]MIXer<x>:HARMonic:BAND** <Band>

Selects the external mixer band. The query returns the currently selected band.

Is only available if the external mixer is active (see [SENSe:]MIXer<x>[:STATe] on page 106).

**Suffix:**
<x> 1..n
irrelevant

**Parameters:**
<Band> KA | Q | U | V | E | W | F | D | G | Y | J | USER
Standard waveguide band or user-defined band.

*Table 9-3: Frequency ranges for pre-defined bands*

| Band | Frequency start [GHz] | Frequency stop [GHz] |
|---|---|---|
| KA (A) *) | 26.5 | 40.0 |
| Q | 33.0 | 50.0 |
| U | 40.0 | 60.0 |
| V | 50.0 | 75.0 |
| E | 60.0 | 90.0 |
| W | 75.0 | 110.0 |
| F | 90.0 | 140.0 |
| D | 110.0 | 170.0 |
| G | 140.0 | 220.0 |
| *) The band formerly referred to as "A" is now named "KA". | | |

| Band | Frequency start [GHz] | Frequency stop [GHz] |
|---|---|---|
| J | 220.0 | 325.0 |
| Y | 325.0 | 500.0 |
| USER | 32.18<br>(default) | 68.22<br>(default) |
| ***)** The band formerly referred to as "A" is now named "KA". | | |

**[SENSe:]MIXer<x>:HARMonic:HIGH:STATe** <State>

Specifies whether a second (high) harmonic is to be used to cover the band's frequency range.

**Suffix:**
<x> 1..n

**Parameters:**
<State> ON | OFF
*RST: ON

**Example:** `MIX:HARM:HIGH:STAT ON`

**[SENSe:]MIXer<x>:HARMonic:HIGH[:VALue]** <HarmOrder>

Specifies the harmonic order to be used for the high (second) range.

**Suffix:**
<x> 1..n
irrelevant

**Parameters:**
<HarmOrder> Range: 2 to 128 (USER band); for other bands: see band definition

**Example:**
```
MIX:HARM:HIGH:STAT ON
MIX:HARM:HIGH 3
```

**[SENSe:]MIXer<x>:HARMonic:TYPE** <OddEven>

Specifies whether the harmonic order to be used should be odd, even, or both.

Which harmonics are supported depends on the mixer type.

**Suffix:**
<x> 1..n
irrelevant

**Parameters:**
<OddEven> ODD | EVEN | EODD
**ODD | EVEN | EODD**
*RST: EVEN

**Example:** `MIX:HARM:TYPE ODD`

---

**[SENSe:]MIXer<x>:HARMonic[:LOW]** <HarmOrder>

Specifies the harmonic order to be used for the low (first) range.

**Suffix:**
<x> 1..n
irrelevant

**Parameters:**
<HarmOrder> Range: 2 to 128 (USER band); for other bands: see band definition
*RST: 2 (for band F)

**Example:** `MIX:HARM 3`

---

**[SENSe:]MIXer<x>:IF?**

Queries the intermediate frequency currently used by the external mixer.

**Suffix:**
<x> 1..n
irrelevant

**Example:** `MIX:IF?`

**Example:** See "Programming example: working with an external mixer" on page 118.

**Usage:** Query only

---

**[SENSe:]MIXer<x>:LOSS:HIGH** <Average>

Defines the average conversion loss to be used for the entire high (second) range.

**Suffix:**
<x> 1..n
irrelevant

**Parameters:**
<Average> Range: 0 to 100
*RST: 24.0 dB
Default unit: dB

**Example:** `MIX:LOSS:HIGH 20dB`

---

**[SENSe:]MIXer<x>:LOSS:TABLe:HIGH** <FileName>

Defines the conversion loss table to be used for the high (second) range.

**Suffix:**
<x> 1..n
irrelevant

**Parameters:**

<FileName> String containing the path and name of the file, or the serial number of the external mixer whose file is required. The FSW automatically selects the correct cvl file for the current IF. As an alternative, you can also select a user-defined conversion loss table (`.acl` file).

**Example:**

```
MIX:LOSS:TABL:HIGH '101567'
MIX:LOSS:TABL:HIGH?
//Result for installed B5000, bw<= 4.4 GHz: 101567_B5000_2G8.B5G:
//'101567_MAG_6_B5000_2G8.B5G'
//Result for installed B5000, bw> 4.4 GHz: 101567_B5000_2G8.B5G:
//'101567_MAG_6_B5000_3G5.B5G'
//Result for installed B2001 and bw> 80 MHz:
//'101567_MAG_6_B1200_B2001.B2G'
//Result for installed B2001 and bw<= 80 MHz:
//'101567_MAG_6.ACL'
```

---

**[SENSe:]MIXer<x>:LOSS:TABLe[:LOW]** <FileName>

Defines the file name of the conversion loss table to be used for the low (first) range.

**Suffix:**

<x> 1..n
irrelevant

**Parameters:**

<FileName> String containing the path and name of the file, or the serial number of the external mixer whose file is required. The FSW automatically selects the correct cvl file for the current IF. As an alternative, you can also select a user-defined conversion loss table (`.acl` file).

**Example:**

```
MIX:LOSS:TABL '101567'
MIX:LOSS:TABL?
//Result:
'101567_MAG_6_B5000_3G5.B5G'
```

---

**[SENSe:]MIXer<x>:LOSS[:LOW]** <Average>

Defines the average conversion loss to be used for the entire low (first) range.

**Suffix:**

<x> 1..n
irrelevant

**Parameters:**

<Average> Range: 0 to 100
*RST: 24.0 dB
Default unit: dB

**Example:**

```
MIX:LOSS 20dB
```

**[SENSe:]MIXer<x>:PORTs** <PortType>

Selects the mixer type.

**Suffix:**

<x> 1..n
irrelevant

**Parameters:**

<PortType> **2 | 3**

**2**
Two-port mixer.

**3**
Three-port mixer.

*RST: 2

**Example:** `MIX:PORT 3`

**[SENSe:]MIXer<x>:RFOVerrange[:STATe]** <State>

If enabled, the band limits are extended beyond "RF Start" and "RF Stop" due to the capabilities of the used harmonics.

**Suffix:**

<x> 1..n
irrelevant

**Parameters:**

<State> ON | OFF | 1 | 0

*RST: 0

### Conversion loss table settings

The following settings are required to configure and manage conversion loss tables.

**[SENSe:]CORRection:CVL:BAND** <Band>

Defines the waveguide band for which the conversion loss table is to be used. This setting is checked against the current mixer setting before the table can be assigned to the range.

Before this command can be performed, the conversion loss table must be selected (see `[SENSe:]CORRection:CVL:SELect` on page 117).

Is only available with option B21 (External Mixer) installed.

**Parameters:**

<Band> K | KA | Q | U | V | E | W | F | D | G | Y | J | USER

Standard waveguide band or user-defined band.
For a definition of the frequency range for the pre-defined bands, see Table 9-3).

*RST: F (90 GHz - 140 GHz)

**Example:**
`CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:BAND KA`
Sets the band to KA (26.5 GHz - 40 GHz).

**[SENSe:]CORRection:CVL:BIAS** <BiasSetting>

Defines the bias setting to be used with the conversion loss table.

Before this command can be performed, the conversion loss table must be selected (see `[SENSe:]CORRection:CVL:SELect` on page 117.

Is only available with option B21 (External Mixer) installed.

**Parameters:**

<BiasSetting> *RST: 0.0 A
Default unit: A

**Example:**
`CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:BIAS 3A`

**[SENSe:]CORRection:CVL:CATalog?**

Queries all available conversion loss tables saved in the `C:\R_S\INSTR\USER\cvl\` directory on the instrument.

Is only available with option B21 (External Mixer) installed.

**Return values:**

<Files> 'string'

Comma-separated list of strings containing the file names.

**Example:** CORR:CVL:CAT?

**Usage:** Query only

**[SENSe:]CORRection:CVL:CLEar**

Deletes the selected conversion loss table. Before this command can be performed, the conversion loss table must be selected (see `[SENSe:]CORRection:CVL:SELect` on page 117).

Is only available with option B21 (External Mixer) installed.

**Example:**
`CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:CLE`

**[SENSe:]CORRection:CVL:COMMent** <Text>

Defines a comment for the conversion loss table. Before this command can be performed, the conversion loss table must be selected (see `[SENSe:]CORRection:CVL:SELect` on page 117).

Is only available with option B21 (External Mixer) installed.

**Parameters:**
<Text>

**Example:**
`CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:COMM 'Conversion loss table for FS_Z60'`

**[SENSe:]CORRection:CVL:DATA** {<Freq>, <Level>}...

Defines the reference values of the selected conversion loss tables. The values are entered as a set of frequency/level pairs. You can define a maximum of 500 frequency/level pairs. Before this command can be performed, you must select the conversion loss table (see `[SENSe:]CORRection:CVL:SELect` on page 117).

Is only available with option B21 (External Mixer) installed.

**Parameters:**

<Freq> The frequencies have to be sent in ascending order.
Default unit: HZ

<Level> Default unit: DB

**Example:**
`CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:DATA 1MHZ,-30DB,2MHZ,-40DB`

**[SENSe:]CORRection:CVL:HARMonic** <HarmOrder>

Defines the harmonic order for which the conversion loss table is to be used. This setting is checked against the current mixer setting before the table can be assigned to the range.

Before this command can be performed, the conversion loss table must be selected (see `[SENSe:]CORRection:CVL:SELect` on page 117.

Is only available with option B21 (External Mixer) installed.

**Parameters:**

<HarmOrder> Range: 2 to 65

**Example:**
`CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:HARM 3`

---

**[SENSe:]CORRection:CVL:MIXer** <Type>

Defines the mixer name in the conversion loss table. This setting is checked against the current mixer setting before the table can be assigned to the range.

Before this command can be performed, the conversion loss table must be selected (see `[SENSe:]CORRection:CVL:SELect` on page 117).

Is only available with option B21 (External Mixer) installed.

**Parameters:**

<Type> string

Name of mixer with a maximum of 16 characters

**Example:**
`CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:MIX 'FS_Z60'`

---

**[SENSe:]CORRection:CVL:PORTs** <PortType>

Defines the mixer type in the conversion loss table. This setting is checked against the current mixer setting before the table can be assigned to the range.

Before this command can be performed, the conversion loss table must be selected (see `[SENSe:]CORRection:CVL:SELect` on page 117).

Is only available with option B21 (External Mixer) installed.

**Parameters:**

<PortType> 2 | 3

*RST: 2

**Example:**
`CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:PORT 3`

---

**[SENSe:]CORRection:CVL:SELect** <FileName>

Selects the conversion loss table with the specified file name. If <file_name> is not available, a new conversion loss table is created.

Is only available with option B21 (External Mixer) installed.

**Parameters:**
<FileName> String containing the path and name of the file.

**Example:** `CORR:CVL:SEL 'LOSS_TAB_4'`

**[SENSe:]CORRection:CVL:SNUMber** <SerialNo>

Defines the serial number of the mixer for which the conversion loss table is to be used. This setting is checked against the current mixer setting before the table can be assigned to the range.

Before this command can be performed, the conversion loss table must be selected (see [SENSe:]CORRection:CVL:SELect on page 117).

Is only available with option B21 (External Mixer) installed.

**Parameters:**
<SerialNo> Serial number with a maximum of 16 characters

**Example:** `CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:MIX '123.4567'`

### Programming example: working with an external mixer

This example demonstrates how to work with an external mixer in a remote environment. It is performed in the Spectrum application in the default layout configuration. Note that without a real input signal and connected mixer, this measurement will not return useful results.

```
//--------------Preparing the instrument -----------
//Reset the instrument
*RST
//Activate the use of the connected external mixer.
SENS:MIX ON
//----------- Configuring basic mixer behavior -------------
//Set the LO level of the mixer's LO port to 15 dBm.
SENS:MIX:LOP 15dBm
//Set the bias current to -1 mA .
SENS:MIX:BIAS:LOW -1mA
//----------- Configuring the mixer and band settings -------------
//Use band "V" to full possible range extent for assigned harmonic (6).
SENS:MIX:HARM:BAND V
SENS:MIX:RFOV ON
//Query the possible range
SENS:MIX:FREQ:STAR?
//Result: 47480000000 (47.48 GHz)
SENS:MIX:FREQ:STOP?
//Result: 138020000000 (138.02 GHz)
//Use a 3-port mixer type
SENS:MIX:PORT 3
//Split the frequency range into two ranges;
```

```
//range 1 covers 47.48 GHz GHz to 80 GHz; harmonic 6, average conv. loss of 20 dB
//range 2 covers 80 GHz to 138.02 GHz; harmonic 8, average conv.loss of 30 dB
SENS:MIX:HARM:TYPE EVEN
SENS:MIX:HARM:HIGH:STAT ON
SENS:MIX:FREQ:HAND 80GHz
SENS:MIX:HARM:LOW 6
SENS:MIX:LOSS:LOW  20dB
SENS:MIX:HARM:HIGH 8
SENS:MIX:LOSS:HIGH 30dB
//--------- Activating automatic signal identification functions -----------
//Activate both automatic signal identification functions.
SENS:MIX:SIGN ALL
//Use auto ID threshold of 8 dB.
SENS:MIX:THR 8dB

//--------------Performing the Measurement-----
//Select single sweep mode.
INIT:CONT OFF
//Initiate a basic frequency sweep and wait until the sweep has finished.
INIT;*WAI
//---------------Retrieving Results-------------
//Return the trace data for the input signal without distortions
//(default screen configuration)
TRAC:DATA? TRACE3
```

### Configuring a conversion loss table for a user-defined band

```
//--------------Preparing the instrument -----------
//Reset the instrument
*RST
//Activate the use of the connected external mixer.
SENS:MIX ON
//--------------Configuring a new conversion loss table --------------
//Define cvl table for range 1 of band as described in previous example
// (extended V band)
SENS:CORR:CVL:SEL 'UserTable'
SENS:CORR:CVL:COMM 'User-defined conversion loss table for USER band'
SENS:CORR:CVL:BAND USER
SENS:CORR:CVL:HARM 6
SENS:CORR:CVL:BIAS -1mA
SENS:CORR:CVL:MIX 'FS_Z60'
SENS:CORR:CVL:SNUM '123.4567'
SENS:CORR:CVL:PORT 3
//Conversion loss is linear from 55 GHz to 75 GHz
SENS:CORR:CVL:DATA 55GHZ,-20DB,75GHZ,-30DB
//----------- Configuring the mixer and band settings -------------
//Use user-defined band and assign new cvl table.
SENS:MIX:HARM:BAND USER
//Define band by two ranges;
```

```
//range 1 covers 47.48 GHz to 80 GHz; harmonic 6, cvl table 'UserTable'
//range 2 covers 80 GHz to 138.02 GHz; harmonic 8, average conv.loss of 30 dB
SENS:MIX:HARM:TYPE EVEN
SENS:MIX:HARM:HIGH:STAT ON
SENS:MIX:FREQ:HAND 80GHz
SENS:MIX:HARM:LOW 6
SENS:MIX:LOSS:TABL:LOW 'UserTable'
SENS:MIX:HARM:HIGH 8

SENS:MIX:LOSS:HIGH 30dB
//Query the possible range
SENS:MIX:FREQ:STAR?
//Result: 47480000000 (47.48 GHz)
SENS:MIX:FREQ:STOP?
//Result: 138020000000 (138.02 GHz)

//--------------Performing the Measurement-----
//Select single sweep mode.
INIT:CONT OFF
//Initiate a basic frequency sweep and wait until the sweep has finished.
INIT;*WAI
//---------------Retrieving Results-------------
//Return the trace data (default screen configuration)
TRAC:DATA? TRACe1
```

### 9.5.1.4 Remote commands for external frontend control

The following commands are available and required only if the external frontend control option (R&S FSW-K553) is installed.

Further commands for external frontend control described elsewhere:

- `INPut:SELect RF`; see `INPut:SELect` on page 103
- `[SENSe:]FREQuency:CENTer` on page 149
- `DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel` on page 152
- `INPut:ATTenuation:AUTO` on page 154
- `INPut:ATTenuation` on page 154
- `INPut:SANalyzer:ATTenuation:AUTO` on page 157

### Commands for initial configuration

The following commands are required when you initially set up an external frontend.



---

**[SENSe:]EFRontend:CONNection[:STATe]** <State>

Queries the external frontend connection state in the firmware.

Note: to query the physical connection state of the external frontend, use `[SENSe:]EFRontend:CONNection:CSTate?` on page 122.

**Parameters:**

<State> ON | OFF | 0 | 1

**OFF | 0**
The connection to the frontend is deactivated temporarily. The frontend is thus available for use elsewhere, for example by a signal generator. The measurement settings on the FSW remain untouched.

**ON | 1**
Frontend connection enabled.
The frontend is reserved for exclusive use by the FSW.

*RST: 0

**Example:**

```
//Global activation of external frontend
EFR ON
//Configure frontend
EFR:CONN:CONF "FE44S","123.456.789"
//Activate exclusive use of frontend by FSW.
EFR:CONN ON
```

**[SENSe:]EFRontend:CONNection:CONFig** <Type>, <IPAddress>[, <DeviceID>, <SymbolicName>]

Configures the connection to the external frontend.

**Parameters:**

<Type> | "FE44S" | "FE50DTR" | "FE170SR" | "FE110SR"

String in double quotes containing the type of frontend to be connected.

<IPAddress> string in double quotes

The IP address or computer name of the frontend connected to the FSW via LAN. The IP address and computer name are indicated on the electronic ink display on the side panel of the frontend.

<DeviceID> string in double quotes

Unique device ID consisting of <type>-<serialnumber>
Not required or relevant for the FSW.

<SymbolicName> string in double quotes

Symbolic name of the external frontend.
Not required or relevant for the FSW.

**Example:**

```
//Global activation of external frontend
EFR ON
//Configure frontend
EFR:CONN:CONF "FE44S","123.456.789"
//Activate exclusive use of frontend by FSW.
EFR:CONN ON
```

**[SENSe:]EFRontend:CONNection:CSTate?**

Queries the status of the physical connection to the external frontend.

**Return values:**

<State> ON | OFF | 0 | 1

**OFF | 0**
Frontend not connected; connection error

**ON | 1**
Frontend connected

**Usage:** Query only

**[SENSe:]EFRontend:FREQuency:BAND:COUNt?**

Queries the number of frequency bands provided by the selected frontend.

**Return values:**

<NoBands> integer

Number of frequency bands

**Example:**
```
//Query number of frequency bands
EFR:FREQ:BAND:COUN?
//Result: 2
```

**Usage:** Query only

---

**[SENSe:]EFRontend:FREQuency:BAND<b>:LOWer?**

Queries the start of the frequency range supported by the selected frontend frequency band.

**Suffix:**
<b> 1..n
Band for multi-band frontends
Use [SENSe:]EFRontend:FREQuency:BAND:COUNt? on page 122 to determine the number of available bands.

**Return values:**
<StartFreq> Start frequency of the specified band

**Example:**
```
//Query start frequency of second band
EFR:FREQ:BAND2:LOW?
//Result: 24000000000
```

**Usage:** Query only

---

**[SENSe:]EFRontend:FREQuency:BAND<b>:UPPer?**

Queries the end of the frequency range supported by the selected frontend frequency band.

**Suffix:**
<b> 1..n
Band for multi-band frontends
Use [SENSe:]EFRontend:FREQuency:BAND:COUNt? on page 122 to determine the number of available bands.

**Return values:**
<StopFreq> End frequency of the specified band

**Example:**
```
//Query end frequency of second band
EFR:FREQ:BAND2:UPP?
//Result: 44000000000
```

**Usage:** Query only

---

**[SENSe:]EFRontend:FREQuency:BCONfig:AUTO** <State>

Determines whether the frequency band of the external frontend is configured automatically or manually.

**Parameters:**
<State> ON | OFF | 0 | 1

**OFF | 0**
Uses the frequency band configured by `[SENSe:]EFRontend:FREQuency:BCONfig:SELect` on page 124.

**ON | 1**
Configures the frequency band automatically
Currently, auto mode always applies the "IF Low" range.

*RST: 1

**Example:** //Configures the use of the IF high band manually.

```
EFR:FREQ:BCON:AUTO 0
EFR:FREQ:BCON:SEL "IF HIGH"
```

---

**[SENSe:]EFRontend:FREQuency:BCONfig:LIST?**

Returns the intermediate frequency (output) range of the external frontend.

**Return values:**

<BandConfigs> string

**"IF LOW"**
(Not for R&S FE170SR/R&S FE110SR frontends.)
A higher intermediate frequency is used on the external frontend, resulting in a higher input frequency at the FSW.

**"IF HIGH"**
(Not for R&S FE170SR/R&S FE110SR frontends.)
A lower intermediate frequency is used on the external frontend, resulting in a lower input frequency at the FSW.

**"Spur Optimized"**
The selected IF range avoids unwanted spurious effects.

**"EVM Optimized"**
The selected IF range provides an optimal EVM result.

**Example:**

```
EFR:FREQ:BCON:LIST?
//Result: "IF HIGH", "IF LOW"
EFR:FREQ:BCON:SEL "IF HIGH"
```

**Usage:** Query only

---

**[SENSe:]EFRontend:FREQuency:BCONfig:SELect** <BandConfig>

Defines the intermediate frequency (output) range of the external frontend.

**Parameters:**

<BandConfig>

**"IF HIGH"**
(R&S FE44S/ R&S FE50DTR)
A higher intermediate frequency is used on the external frontend, resulting in a higher input frequency at the FSW.

**"IF LOW"**
(R&S FE44S/ R&S FE50DTR)
A lower intermediate frequency is used on the external frontend, resulting in a lower input frequency at the FSW.

**"Spur Optimized"**
(R&S FE170SR/R&S FE110SR only)
The selected IF range avoids unwanted spurious effects.

**"EVM Optimized"**
(R&S FE170SR/R&S FE110SR only)
The selected IF range provides an optimal EVM result.

**"Shared LO"**
(R&S FE170SR/R&S FE110SR only)
Ensures that multiple external frontends (R&S FE170SR/R&S FE170ST or R&S FE110SR/R&S FE110ST) use the same LO frequencies for upconversion and downconversion.

**Example:**
```
EFR:FREQ:BCON:LIST?
//Result: "IF HIGH", "IF LOW"
EFR:FREQ:BCON:SEL "IF HIGH"
```

---

**[SENSe:]EFRontend:FREQuency:IFRequency:MAXimum?**

Queries the maximum used intermediate frequency (IF) for frequency conversion for a frequency span.

**Return values:**
<IFFrequency> numeric

**Example:** `EFR:FREQ:IFR:MAX?`

**Usage:** Query only

---

**[SENSe:]EFRontend:FREQuency:IFRequency:MINimum?**

Queries the minimum used intermediate frequency (IF) for frequency conversion for a frequency span.

**Return values:**
<IFFrequency> numeric

**Example:** `EFR:FREQ:IFR:MIN?`

**Usage:** Query only

---

**[SENSe:]EFRontend:FREQuency:IFRequency:SIDeband?**

Queries the currently used sideband for frequency conversion.

**Return values:**
<Sideband> "USB" | "LSB"

**"USB"**
Upper sideband

**"LSB"**
Lower sideband

**Example:** `EFR:FREQ:IFR?`
`EFR:FREQ:IFR:SID?`

**Usage:** Query only

---

**[SENSe:]EFRontend:FREQuency:IFRequency[:VALue]?**

Queries the currently used intermediate frequency (IF) for frequency conversion.

To query the maximum and minimum IF for the selected frequency range, use `[SENSe:]EFRontend:FREQuency:IFRequency:MAXimum?` on page 125 and `[SENSe:]EFRontend:FREQuency:IFRequency:MINimum?` on page 125.

**Return values:**
<IFFrequency> numeric

**Example:** `EFR:FREQ:IFR?`

**Usage:** Query only

---

**[SENSe:]EFRontend:FREQuency:LOSCillator:INPut:FREQuency?**

Queries the frequency of the LO input for `[SENSe:]EFRontend:FREQuency:LOSCillator:MODE` `EXT`.

**Return values:**
<LOInFreq> Default unit: Hz

**Example:** The external frontend uses the external LO provided at the "LO IN" connector.
`EFR:FREQ:LOSC:MODE EXT`
Query the frequency that the external LO must be provided at.
`EFR:FREQ:LOSC:INP:FREQ?`
`//Result: 10615000000`

**Usage:** Query only

---

**[SENSe:]EFRontend:FREQuency:LOSCillator:MODE** <Type>

Determines whether the external frontend uses its internal LO or an external LO.

**Parameters:**
<Type> EXTernal | INTernal

**EXTernal**
Uses the external LO provided at the LO input connector of the external frontend. Query the frequency at which the LO must be input to the external frontend using `[SENSe:]EFRontend:FREQuency:LOSCillator:INPut:FREQuency?` on page 126.

**INTernal**
Uses the internal LO.

*RST: EXTernal

**Example:**
```
EFR:FREQ:LOSC:MODE EXT
EFR:FREQ:LOSC:INP:FREQ?
//Result: 10615000000
```

---

**[SENSe:]EFRontend:FREQuency:LOSCillator:OUTPut:FREQuency?**

Queries the frequency of the LO output for [SENSe:]EFRontend:FREQuency:LOSCillator:OUTPut:STATe ON.

**Return values:**

<LOOutFreq> Default unit: Hz

**Example:** The external frontend uses the internal LO and provides it as output to the "LO OUT" connector.
```
EFR:FREQ:LOSC:MODE INT
EFR:FREQ:LOSC:OUTP:STAT ON
```
Query the frequency of the LO output.
```
EFR:FREQ:LOSC:OUTP:FREQ?
//Result: 10615000000
```

**Usage:** Query only

---

**[SENSe:]EFRontend:FREQuency:LOSCillator:OUTPut:STATe** <State>

Enables or disables output of the LO by the external frontend. The output frequency is returned by [SENSe:]EFRontend:FREQuency:LOSCillator:OUTPut:FREQuency? on page 127.

**Parameters:**

<State> ON | OFF | 0 | 1

**OFF | 0**
Switches the function off

**ON | 1**
Switches the function on

*RST: 0

**Example:** The external frontend provides the LO as output at the "LO OUT" connector.
```
EFR:FREQ:LOSC:OUTP:STAT ON
```
Query the frequency of the LO output.
```
EFR:FREQ:LOSC:OUTP:FREQ?
//Result: 10615000000
```

---

**[SENSe:]EFRontend:FREQuency:REFerence** <Frequency>

Sets the reference frequency that is used for frequency conversion on the frontend. Depending on the connected type of frontend, different values are available. To determine which reference levels are available, use [SENSe:]EFRontend:FREQuency:REFerence:LIST? on page 128.

**Parameters:**
<Frequency> Default unit: HZ

**Example:**
```
//Query the available reference levels
EFR:FREQ:REF:LIST?
//Result: 10000000,640000000,1000000000
//Use 640 MHz reference
EFR:FREQ:REF 640000000
```

---

**[SENSe:]EFRontend:FREQuency:REFerence:LIST?**

Queries the available reference signals for the connected frontend type.

**Return values:**
<References> 10000000 | 640000000 | 1000000000

**Example:**
```
//Query the available reference levels
EFR:FREQ:REF:LIST?
//Result: 10000000,640000000,1000000000
//Use 640 MHz reference
EFR:FREQ:REF 640000000
```

**Usage:** Query only

---

**[SENSe:]EFRontend:IDN?**

Queries the device identifcation information (`*IDN?`) of the frontend.

**Return values:**
<DevInfo> string without quotes

Rohde&Schwarz,<device type>,<part number>/<serial number>,<firmware version>

**Example:**
```
EFR:IDN?
//Result: Rohde&Schwarz,FE44S,
1234.5678K00/123456,0.8.0
```

**Usage:** Query only

---

**[SENSe:]EFRontend:NETWork** <IPAddress>, <Subnet>, <DHCP State>

Sets or queries the network information for the frontend.

This information is also indicated on the electronic paper display on the side panel of the device.

Beware that if you change the network setting to DHCP = ON, the connection is aborted and you must re-establish a connection to the frontend (see `[SENSe:]EFRontend:CONNection[:STATe]` on page 121).

**Parameters:**
<IPAddress> string in double quotes

IP address of the frontend

<Subnet> string in double quotes
Subnet mask of the frontend

<DHCP State> ON | OFF | 0 | 1
Indicates whether a DHCP server is used.

**OFF | 0**
DHCP off

**ON | 1**
DHCP on

*RST: 0

**Example:**
```
EFR:NETW?
//Result: "123.456.78.90","255.255.255.0",ON
```

---

**[SENSe:]EFRontend[:STATe]** <State>

Enables or disables the general use of an external frontend for the application.

**Parameters:**

<State> ON | OFF | 0 | 1

**OFF | 0**
The frontend is disconnected. The application adapts the measurement settings to the common settings supported by the FSW.

**ON | 1**
The FSW allows you to configure and connect an external frontend for the application. The application adapts the available measurement settings to the connected frontend.
The channel bar indicates "Inp: ExtFe".

*RST: 0

**Example:**
```
EFR ON
```

### Commands for test, alignment, and diagnosis

The following commands are required to test and optimize the connection after it has initially been set up.



---

**[SENSe:]EFRontend:ALIGnment<ch>:FILE** <File>

Selects or queries the touchstone file that contains correction data to compensate for signal losses in the cable occurring at different IF signal frequencies.

**Suffix:**
<ch> 1..n
Currently irrelevant

**Parameters:**
<File> string in double quotes
Path and file name of the correction data file. The file must be in `s2p` format.
If the specified file is not found or does not have the correct format, an error message is returned (`-256, "File name not found"`, `-150, "String data error"`).

**Example:** `EFR:ALIG:FILE "FE44S.s2p"`

---

**[SENSe:]EFRontend:ALIGnment<ch>:STATe** <State>

Activates correction of the IF signal due to cable loss from the frontend to the analyzer. Specify the file with correction data using `[SENSe:]EFRontend:ALIGnment<ch>:FILE` on page 129.

**Suffix:**
<ch> 1..n
Currently irrelevant

**Parameters:**
<State> ON | OFF | 0 | 1

**OFF | 0**
Switches the function off

**ON | 1**
Switches the function on

*RST: 0

---

**[SENSe:]EFRontend:FWUPdate**

Updates the firmware on the external frontend. Note that this process can take some time.

**Usage:** Event

---

**[SENSe:]EFRontend<fe>:SELFtest?**

Performs a selftest on the frontend to compare the current performance and characteristic values with the specified values for the frontend.

As a result, the success is returned.

**Suffix:**
<fe> 1
Connected frontend

**Return values:**
<Result> **0**
No error

**>0**
Error

*RST: 0

**Example:** `EFR:SELF?`
`//Result: 0`

**Usage:** Query only

---

**[SENSe:]EFRontend<fe>:SELFtest:RESult?**

Queries the results of the selftest on the frontend.

**Suffix:**
<fe> 1
Connected frontend

**Return values:**
<Result> string containing xml data in double quotes

**Example:** `EFR:SELF:RES?`

**Usage:** Query only

### Commands for external devices

You can insert additional external devices in the signal path between the DUT and the external frontend, such as preamplifiers or filters. The external frontend must then consider the additional gain or correction values.



---

**[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:CORRection:FILE** <File>

Defines the correction file to compensate for signal losses by the external devices occurring at different IF signal frequencies.

To query whether the loaded file is valid or not, use [SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:CORRection:VALid? on page 132.

**Suffix:**

<ch> 1..n
For future use.

<di> 1..n
irrelevant

**Parameters:**

<File>

**Example:**

```
SENS:EFR:CHAN:EXTD:CORR:FILE 'ExtDev_Corr.s2p'
SENS:EFR:CHAN:EXTD:CORR:STAT ON
SENS:EFR:CHAN:EXTD:CORR:FILE:VAL?
```

**[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:CORRection:STATe** <State>

Enables or disables the use of a correction file for the connected external devices. The file is defined by [SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:CORRection:FILE on page 131.

**Suffix:**

<ch> 1..n
For future use.

<di> 1..n
irrelevant

**Parameters:**

<State> ON | OFF | 0 | 1

**OFF | 0**
Switches the function off

**ON | 1**
Switches the function on

*RST: 0

**Example:**

```
SENS:EFR:CHAN:EXTD:CORR:FILE 'ExtDev_Corr.s2p'
SENS:EFR:CHAN:EXTD:CORR:STAT ON
```

**[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:CORRection:VALid?**

Queries whether the loaded correction file for an external device is valid or not.

**Suffix:**

<ch> 1..n
For future use.

<di> 1..n
irrelevant

**Return values:**
<Result> ON | OFF | 0 | 1

**OFF | 0**
File is valid.

**ON | 1**
File is not valid.

**Example:**
```
SENS:EFR:CHAN:EXTD:CORR:STAT ON
SENS:EFR:CHAN:EXTD:CORR:FILE 'ExtDev_Corr.s2p'
SENS:EFR:CHAN:EXTD:CORR:VAL?
```

**Usage:** Query only

**[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:LIST?**

Queries the names of all detected connected devices at the external frontend.

**Suffix:**
<ch> 1..n
For future use.

<di> 1..n
irrelevant

**Return values:**
<Devices> Comma-separated list of the names of the devices.

**Example:**
```
:SENSe1:EFRontend1:CHANnel1:EXTDevice1:LIST?
//Result:
//"fe170_z50","fe170_z01"
```

**Usage:** Query only

**[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:REFResh**

Scans the ports of the external frontend and refreshes the display with detected information on connected devices. This function is useful after connecting a new device to the frontend.

**Suffix:**
<ch> 1..n
For future use.

<di> 1..n
irrelevant

**Example:**
```
SENSe1:EFRontend1:CHANnel:EXTDevice1:REFResh
```

**Usage:** Event

**[SENSe:]EFRontend[:CHANNel<ch>]:EXTDevice<di>:FREQuency:MAXimum?**

Queries the upper limit of the supported frequency range of the connected device.

**Suffix:**

| | |
|---|---|
| <ch> | 1..n<br>For future use. |
| <di> | 1..n<br>Connected external device |

**Return values:**

| | |
|---|---|
| <RFFrequency> | numeric value<br>Maximum frequency<br>Default unit: Hz |

**Example:**
```
SENS:EFR:EXTD1:FREQ:MAX?
//Result:
170000000000
```

**Usage:** Query only

**[SENSe:]EFRontend[:CHANNel<ch>]:EXTDevice<di>:FREQuency:MINimum?**

Queries the lower limit of the supported frequency range of the connected device.

**Suffix:**

| | |
|---|---|
| <ch> | 1..n<br>For future use. |
| <di> | 1..n<br>Connected external device |

**Return values:**

| | |
|---|---|
| <RFFrequency> | numeric value<br>Minimum frequency<br>Default unit: Hz |

**Example:**
```
SENS:EFR:EXTD1:FREQ:MIN?
//Result:
110000000000
```

**Usage:** Query only

**[SENSe:]EFRontend[:CHANNel<ch>]:EXTDevice<di>:GAIN?**

Queries the gain provided by a connected external amplifier.

**Suffix:**

| | |
|---|---|
| <ch> | 1..n<br>For future use. |
| <di> | 1..n<br>Connected external device |

**Return values:**

<Gain> numeric value

Default unit: dB

**Example:**
```
SENSe1:EFRontend1:CHANnel1:EXTDevice1:GAIN?
//Result:
//10
```

**Usage:** Query only

**[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:NAME?**

Queries the name of the external device for reference.

**Suffix:**

<ch> 1..n
For future use.

<di> 1..n
Connected external device

**Return values:**

<Type> string

**Example:**
```
SENS:EFR:CHAN:EXTD1:NAME?
//Result:
//'fe170_z50'
```

**Usage:** Query only

**[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:TYPE?**

Queries the type of the detected device for reference.

**Suffix:**

<ch> 1..n
For future use.

<di> 1..n
Connected external device

**Return values:**

<Type> 'Amplifier' | 'Filter'

**Example:**
```
SENSe1:EFRontend1:CHANnel1:EXTDevice1:TYPE?
//Result:
//'Filter'
```

**Usage:** Query only

### Format of selftest result file

As a result of the selftest, an XML file with test details is created. It contains the following information in the specified order. Mandatory elements and attributes are indicated in bold font.

| Element | Attributes | Description |
|---|---|---|
| **<Sequence>** | | Main element |
| | **Name** | ="Selftest" |
| | Description | Optional description of the test process |
| | **FirmwareVersion** | Firmware version of the controlling instrument (FSW) |
| | **FrontendLibrary-Version** | Version of the `control.dll` with the format `x.y.z` |
| | FrontendServerVer-sion | Version of the RRH server with the format `x.y.z` (FE44A only) |
| | **Date** | Date the selftest was performed, with the format `dd/mm/yyyy` |
| | **Time** | Time the selftest was performed, with the format `hh:mm:ss` |
| | **State** | Test result state, combined result of all <SequenceCate-gory>s: `"PASSED"`/ `"FAILED"` |
| | **Version** | For internal use. |
| | Comment | Optional comment on the test process |
| **<SequenceCate-gory>** | | Set of test steps |
| | **Name** | Name of the test sequence, e.g. "Frontend voltages" |
| | Description | Optional description of the test sequence |
| | **State** | Test sequence result state, combined result of all <Sequence-Step>s: `"PASSED"`/ `"FAILED"` |
| | **Version** | For internal use. |
| | Comment | Optional comment on the test sequence |
| **<SequenceStep>** | | Subelement of **<SequenceCategory>** for an individual test step |
| | **Name** | Name of the individual test step, e.g. FE1_3V3 |
| | Description | Optional description of the test step |
| | LimitLow | Optional: lower limit to be checked |
| | LimitHigh | Optional: upper limit to be checked |
| | MeasValue | Optional: measured value |
| | Unit | Optional: unit of the measured value |
| | **State** | Test step result state:`"PASSED"`/ `"FAILED"` |
| | **Version** | For internal use. |
| | Comment | Optional comment on the test step |

### Example for selftest result xml file

```
<?xml version="1.0" encoding="UTF-8"?>
<Sequence xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
```

```
         xsi:noNamespaceSchemaLocation="SelfTest_Schema.xsd">
<Name>DeviceCheck</Name>
<FirmwareVersion>1.50-21.1.1.0 Beta</FirmwareVersion>
<FrontendLibraryVersion>0.8.0</FrontendLibraryVersion>
<Date>15/01/2021</Date>
<Time>08:51:35</Time>
<State>FAILED</State>
<Version>1.0.0</Version>
<SequenceCategory>
 <Name>Frontend Voltages</Name>
 <Description>test description</Description>
 <State>FAILED</State>
 <Version>1.0.0</Version>
 <Type>Diagnose</Type>
 <SequenceStep>
  <Name>FE1_3V3</Name>
  <LimitLow>3.000</LimitLow>
  <LimitHigh>3.600</LimitHigh>
  <MeasValue>3.311</MeasValue>
  <State>PASSED</State>
  <Version>1.0.0</Version>
 </SequenceStep>
 <SequenceStep>
  <Name>FE1_5V</Name>
  <LimitLow>4.250</LimitLow>
  <LimitHigh>5.750</LimitHigh>
  <MeasValue>5.027</MeasValue>
  <State>PASSED</State>
  <Version>1.0.0</Version>
 </SequenceStep>
 <SequenceStep>
  <Name>FE1_6V5</Name>
  <LimitLow>6.000</LimitLow>
  <LimitHigh>7.000</LimitHigh>
  <MeasValue>5.893</MeasValue>
  <State>FAILED</State>
  <Version>1.0.0</Version>
 </SequenceStep>
 <SequenceStep>
  <Name>FE1_M3V3</Name>
  <LimitLow>-3.600</LimitLow>
  <LimitHigh>-3.000</LimitHigh>
  <MeasValue>3.347</MeasValue>
  <State>FAILED</State>
  <Version>1.0.0</Version>
 </SequenceStep>
</SequenceCategory>
<SequenceCategory>
 <Name>Frontend Temperature</Name>
 <Description>test description</Description>
```

```
   <State>PASSED</State>
   <Version>1.0.0</Version>
   <Type>Diagnose</Type>
   <SequenceStep>
    <Name>TEMP_FE1</Name>
    <LimitLow>0.000</LimitLow>
    <LimitHigh>60.000</LimitHigh>
    <MeasValue>39.300</MeasValue>
    <State>PASSED</State>
    <Version>1.0.0</Version>
   </SequenceStep>
  </SequenceCategory>
  <SequenceCategory>
   <Name>Synthesizer Voltage</Name>
   <Description>test description</Description>
   <State>PASSED</State>
   <Version>1.0.0</Version>
   <Type>Diagnose</Type>
   <SequenceStep>
    <Name>SYNTH_3V4</Name>
    <LimitLow>3.200</LimitLow>
    <LimitHigh>3.910</LimitHigh>
    <MeasValue>3.576</MeasValue>
    <State>PASSED</State>
    <Version>1.0.0</Version>
   </SequenceStep>
   <SequenceStep>
    <Name>SYNTH_5V4_SYN</Name>
    <LimitLow>4.860</LimitLow>
    <LimitHigh>5.940</LimitHigh>
    <MeasValue>5.405</MeasValue>
    <State>PASSED</State>
    <Version>1.0.0</Version>
   </SequenceStep>
   <SequenceStep>
    <Name>SYNTH_5V4_YIG</Name>
    <LimitLow>4.860</LimitLow>
    <LimitHigh>5.940</LimitHigh>
    <MeasValue>5.438</MeasValue>
    <State>PASSED</State>
    <Version>1.0.0</Version>
   </SequenceStep>
   <SequenceStep>
    <Name>SYNTH_M5V</Name>
    <LimitLow>-5.500</LimitLow>
    <LimitHigh>-4.500</LimitHigh>
    <MeasValue>-4.948</MeasValue>
    <State>PASSED</State>
    <Version>1.0.0</Version>
   </SequenceStep>
```

```
  <SequenceStep>
   <Name>SYNTH_REF5V</Name>
   <LimitLow>4.500</LimitLow>
   <LimitHigh>5.500</LimitHigh>
   <MeasValue>5.031</MeasValue>
   <State>PASSED</State>
   <Version>1.0.0</Version>
  </SequenceStep>
 </SequenceCategory>
 <SequenceCategory>
  <Name>Supply Voltage</Name>
  <Description>test description</Description>
  <State>PASSED</State>
  <Version>1.0.0</Version>
  <Type>Diagnose</Type>
  <SequenceStep>
   <Name>SUPPLY_12V</Name>
   <LimitLow>10.800</LimitLow>
   <LimitHigh>13.200</LimitHigh>
   <MeasValue>11.909</MeasValue>
   <State>PASSED</State>
   <Version>1.0.0</Version>
  </SequenceStep>
  <SequenceStep>
   <Name>SUPPLY_3V3D</Name>
   <LimitLow>2.970</LimitLow>
   <LimitHigh>3.630</LimitHigh>
   <MeasValue>3.318</MeasValue>
   <State>PASSED</State>
   <Version>1.0.0</Version>
  </SequenceStep>
  <SequenceStep>
   <Name>SUPPLY_4V</Name>
   <LimitLow>3.650</LimitLow>
   <LimitHigh>4.460</LimitHigh>
   <MeasValue>4.053</MeasValue>
   <State>PASSED</State>
   <Version>1.0.0</Version>
  </SequenceStep>
  <SequenceStep>
   <Name>SUPPLY_6V</Name>
   <LimitLow>5.400</LimitLow>
   <LimitHigh>6.600</LimitHigh>
   <MeasValue>6.076</MeasValue>
   <State>PASSED</State>
   <Version>1.0.0</Version>
  </SequenceStep>
  <SequenceStep>
   <Name>SUPPLY_M5V</Name>
   <LimitLow>-6.050</LimitLow>
```

```
    <LimitHigh>-4.950</LimitHigh>
    <MeasValue>-5.507</MeasValue>
    <State>PASSED</State>
    <Version>1.0.0</Version>
  </SequenceStep>
 </SequenceCategory>
</Sequence>
```

### Programming example: Configuring an external frontend

The following example describes how to configure RF frontend settings in remote operation.

```
// Prepare the instrument
// Preset
*RST
// Create new IQ-Analyzer channel
:INST:SEL IQ
// Enable 640MHz Reference
:ROSC:O640 ON

//Enable general use of external frontend
SENSe:EFRontend:STATe ON
//Configure connection to ext. FE named "FE44S-1000826"
SENSe:EFRontend:CONNection:CONFig "FE44S","FE44S-1000826"
//Activate exclusive use of frontend by FSW.
SENSe:EFRontend:CONNection:STATe ON

//For demonstration purposes only: assign a static IP address
SENSe:EFRontend:NETWork "123.456.7.8", "255.255.255.00", OFF

// Query information about the connected RF frontend.
SENSe:EFRontend:CONNection:CSTAte?
// Response: 1 (connected)
SENSe:EFRontend:IDN?
////Result: Rohde&Schwarz,FE44S,1234.5678K00/123456,0.8.0

// Specify frontend settings
//Query available intermediate frequency bands
SENSe:EFRontend:FREQuency:BCONfig:LIST?
//Result: "IF HIGH", "IF LOW"
//Use high IF
SENSe:EFRontend:FREQuency:BCONfig:SELect "IF HIGH"
//Query used intermediate frequency
SENSe:EFRontend:FREQuency:IFRequency?
//Result: 8.595000000

//Query available reference frequencies
SENSe:EFRontend:FREQuency:REFerence:LIST?
//Result: 10000000,640000000,1000000000
```

```
//Use 640 MHz reference
SENSe:EFRontend:FREQuency:REFerence 640000000

// Query ranges of the operating frequency band.
SENSe:EFRontend:FREQuency:BAND1:LOWer?
// Response in Hz: "24000000000" (= 24 GHz)
SENSe:EFRontend:FREQuency:BAND1:UPPer?
// Response in Hz: "44000000000" (= 44 GHz)

// Add cable correction data by loading an *.s2p file.
SENSe:EFRontend:ALIGnment:FILE "C:\R_S\Instr\user\external_frontends\FE44S\
touchstonefiles\if_default_cable_1347_7552_00.s2p"
SENSe:EFRontend:ALIGnment:STATe ON

//Update FW version on frontend (only available if external frontend firmware
//is incompatible to FSW firmware)
SENSe:EFRontend:FWUPdate
//Perform a selftest on the frontend and query results
SENSe:EFRontend:SELFtest?
//Result: 0 (no errors)
SENSe:EFRontend:SELFtest:RESult?
//Result: "<?xml version="1.0" encoding="UTF-8"?>
//<Sequence xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
//xsi:noNamespaceSchemaLocation="
//<Name>DeviceCheck</Name>
//<FirmwareVersion>1.50-21.1.1.0 Beta</FirmwareVersion>
//..."
```

### Programming example 2: Configuring an external frontend with a connected amplifier

The following example demonstrates how to configure an R&S FE170SR external frontend with a connected amplifier.

Some commands may not be necessary as they reflect the default settings; however, they are included to demonstrate the command usage.

```
// Prepare the instrument
// Preset
*RST
// Create new IQ-Analyzer channel
:INST:SEL IQ
// Enable 640MHz Reference
:ROSC:O640 ON

//Enable general use of external frontend
SENSe:EFRontend:STATe ON
//Configure connection to ext. FE named "FE170SR-123456"
SENSe:EFRontend:CONNection:CONFig "FE170SR","FE170SR-123456"
//Activate exclusive use of frontend by FSW.
SENSe:EFRontend:CONNection:STATe ON
```

```
// Query information about the connected RF frontend.
SENSe:EFRontend:CONNection:CSTAte?
// Response: 1 (connected)
SENSe:EFRontend:IDN?
////Result: Rohde&Schwarz,FE170SR,1234.5678K00/123456,0.8.0

// Specify frontend settings
//Query available intermediate frequency bands
SENSe:EFRontend:FREQuency:BCONfig:LIST?
//Result: "Spur Optimized","EVM Optimized"
//Use spur optimized
SENSe:EFRontend:FREQuency:BCONfig:SELect "Spur Optimized"
//Query used intermediate frequency
SENSe:EFRontend:FREQuency:IFRequency?
//Result: 9940000000


//Query available reference frequencies
SENSe:EFRontend:FREQuency:REFerence:LIST?
//Result: 10000000,640000000,1000000000
//Use 1 GHz reference
SENSe:EFRontend:FREQuency:REFerence 1000000000

// Query ranges of the operating frequency band.
SENSe:EFRontend:FREQuency:BAND1:LOWer?
// Response in Hz: "110000000000" (= 110 GHz)
SENSe:EFRontend:FREQuency:BAND1:UPPer?
// Response in Hz: "170000000000" (= 170 GHz)

// Add cable correction data by loading an *.s2p file.
SENSe:EFRontend:ALIGnment:FILE "C:\R_S\Instr\user\external_frontends\FE170SR\
touchstonefiles\if_default_cable_1348_3850_00.s2p"
SENSe:EFRontend:ALIGnment:STATe ON

//Configure external amplifier named "fe170_z50" connected to frontend
//Refresh and query the list of detected external devices
SENSe:EFRontend:EXTDevice:REFResh
SENSe:EFRontend:EXTDevice:LIST?
//Result:
//"fe170_z50"
//Query the type of the external device
SENSe:EFRontend:EXTDevice:TYPE?
//Result:
//'Amplifier'
//Query the supported frequency range of the amplifier
SENSe:EFRontend:EXTDevice1:FREQuency:MINimum?
//Result:
//110000000000
SENSe:EFRontend:EXTDevice1:FREQuency:MAXimum?
//Result:
//170000000000
//Query the gain of the amplifier
SENSe:EFRontend:EXTDevice1:GAIN?
```

```
//Result:
//10
//Only for demonstration purposes:
//Load and enable a correction file for the amplifier.
//The correction file is automatically considered if the IX cable is used to connect
//the external device to the frontend.
SENSe:EFRontend:EXTDevice1:CORRection:FILE 'C:\temp\ExtDev_Corr.s2p'
SENSe:EFRontend:EXTDevice1:CORRection:STATe ON
//Check if the loaded file is valid
SENSe:EFRontend:EXTDevice1:CORRection:VALid?
```

### 9.5.1.5 Configuring the 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000)

The following commands are required to use the optional 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000).

**Remote commands exclusive to configuring the 2 GHz / 5 GHz bandwidth extensions:**



---

**EXPort:WAVeform:DISPlayoff** <FastExport>

Enables or disables the display update on the oscilloscope during data acquisition with the optional 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000).

Note that this command is **only executable by the oscilloscope**, not by the FSW.

As soon as the FSW-B2000/B5000 is activated, the display on the oscilloscope is turned off to improve performance during data export. As soon as the FSW closes the connection to the oscilloscope, the display is reactivated and the oscilloscope can be operated as usual. However, if the LAN connection is lost for any reason, the display of the oscilloscope remains deactivated. Use this command to re-activate it.

For details on the optional 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000), see FSW I/Q Analyzer and I/Q Input User Manual.

**Parameters:**

<FastExport> ON | OFF | 1 | 0

ON | 1: Disables the display update for maximum export speed.
OFF | 0: Enables the display update. The export is slower.

*RST: 1

---

**SYSTem:COMMunicate:RDEVice:OSCilloscope[:STATe]** <State>

Activates the optional 2 GHz / 5 GHz bandwidth extension (R&S FSW-B2000/B5000).

**Note**: Manual operation on the connected oscilloscope, or remote operation other than by the FSW, is not possible while the B2000/B5000 option is active.

**Parameters:**

<State> ON | OFF | 0 | 1

**OFF | 0**
Switches the function off

**ON | 1**
Switches the function on

**Example:** `SYST:COMM:RDEV:OSC ON`

---

**SYSTem:COMMunicate:RDEVice:OSCilloscope:ALIGnment:STEP<st>[:STATe]** <State>

Performs the alignment of the oscilloscope itself and the oscilloscope ADC for the optional 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000). The correction data for the oscilloscope (including the connection cable between the FSW and the oscilloscope) is recorded. As a result, the state of the alignment is returned.

Alignment is required only once after setup. If alignment was performed successfully, the alignment data is stored on the oscilloscope.

Thus, alignment need only be repeated if one of the following applies:

- A new oscilloscope is connected to the "IF OUT 2 GHz/ IF OUT 5 GHz" connector of the FSW
- A new cable is used between the "IF OUT 2 GHz/ IF OUT 5 GHz" connector of the FSW and the oscilloscope
- A power splitter is inserted between the "IF OUT 2 GHz/ IF OUT 5 GHz" connector of the FSW and the oscilloscope
- New firmware is installed on the oscilloscope or the FSW

**Suffix:**

<st> 1..n

**Parameters:**

<State> Returns the state of the second alignment step.

**ON | 1**
Alignment was successful.

**OFF | 0**
Alignment was not yet performed (successfully).

**Example:**
```
SYST:COMM:RDEV:OSC:ALIG:STEP?
//Result: 1
```

---

**SYSTem:COMMunicate:RDEVice:OSCilloscope:ALIGnment:DATE** <Date>

Returns the date of alignment of the "IF OUT 2 GHz/ IF OUT 5 GHz" to the oscilloscope for the optional 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000).

**Parameters:**
<Date> Returns the date of alignment.

**Example:**
```
SYST:COMM:RDEV:OSC:ALIG:DATE?
//Result: 2014-02-28
```

---

**SYSTem:COMMunicate:RDEVice:OSCilloscope:ALIGnment:FALignment** <State>

Performs a self-alignment on the oscilloscope before the B2000/B5000 alignment on the FSW.

**Parameters:**
<State> ON | OFF | 0 | 1

**OFF | 0**
Switches the function off

**ON | 1**
Switches the function on

*RST: 0

**Example:**
```
SYST:COMM:RDEV:OSC:ALIG:FAL ON
```

---

**SYSTem:COMMunicate:RDEVice:OSCilloscope:IDN** <IDString>

Returns the identification string of the oscilloscope connected to the FSW.

**Parameters:**
<IDString>

**Example:**
```
SYST:COMM:RDEV:OSC:IDN?
//Result: Rohde&Schwarz,RTO,
1316.1000k14/200153,2.45.1.1
```

---

**SYSTem:COMMunicate:RDEVice:OSCilloscope:LEDState** <Color>

Returns the state of the LAN connection to the oscilloscope for the optional 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000).

**Parameters:**
<Color> OFF | SUCCessful | ERRor

**SUCCessful**
Connection to the instrument has been established successfully.

**OFF**
No instrument configured.

**ERRor**
Connection to the instrument could not be established.
Check the connection between the FSW and the oscilloscope, and make sure the IP address of the oscilloscope has been defined (see `SYSTem:COMMunicate:RDEVice:OSCilloscope:TCPip` on page 147).

**Example:**
```
SYST:COMM:RDEV:OSC:LEDS?
//Result: 'SUCC'
```

---

**SYSTem:COMMunicate:RDEVice:OSCilloscope:PSMode[:STATe]** <State>

Activates the use of the power splitter inserted between the "IF 2 GHZ OUT" connector of the FSW and the "CH1" and "CH3" input connectors of the oscilloscope. Note that this mode requires an additional alignment with the power splitter.

For details see the FSW I/Q Analyzer and I/Q Input User Manual.

**Parameters:**
<State> ON | OFF | 0 | 1

**OFF | 0**
Switches the function off

**ON | 1**
Switches the function on

**Example:**
```
SYST:COMM:RDEV:OSC:PSM ON
```

---

**SYSTem:COMMunicate:RDEVice:OSCilloscope:SRATe** <Rate>

Determines whether the 10 GHz mode (default) or 20 GHz mode of the connected oscilloscope is used. The 20 GHZ mode achieves a higher decimation gain, but reduces the record length by half.

**Parameters:**
<Rate> 10 GHz | 20 GHz

No other sample rate values are allowed.

*RST: 10 GHz
Default unit: HZ

**Example:**

```
TRAC:IQ:SRAT?
//Result: 100000000
TRAC:IQ:RLEN?
//Result: 3128
SYST:COMM:RDEV:OSC:SRAT 20GHZ
TRAC:IQ:SRAT?
//Result: 200000000
TRAC:IQ:RLEN?
//Result: 1564
```

---

**SYSTem:COMMunicate:RDEVice:OSCilloscope:TCPip** <Address>

Defines the TCPIP address or computer name of the oscilloscope connected to the FSW via LAN.

**Note**: The IP address is maintained after a [PRESET], and is transferred between applications.

**Parameters:**

<Address> computer name or IP address

**Example:** `SYST:COMM:RDEV:OSC:TCP '192.0.2.0'`

**Example:** `SYST:COMM:RDEV:OSC:TCP 'FSW43-12345'`

---

**SYSTem:COMMunicate:RDEVice:OSCilloscope:VDEVice?**

Queries whether the connected instrument is supported by the 2 GHz / 5 GHz bandwidth extension option(B2000/B5000).

**Return values:**

<State> ON | OFF | 0 | 1

**OFF | 0**
Switches the function off

**ON | 1**
Switches the function on

**Example:** `SYST:COMM:RDEV:OSC:VDEV?`

**Usage:** Query only

---

**SYSTem:COMMunicate:RDEVice:OSCilloscope:VFIRmware?**

Queries whether the firmware on the connected oscilloscope is supported by the 2 GHz / 5 GHz bandwidth extension (B2000/B5000) option.

**Return values:**

<State> ON | OFF | 0 | 1

**OFF | 0**
Switches the function off

**ON | 1**
Switches the function on

**Example:** `SYST:COMM:RDEV:OSC:VFIR?`

**Usage:** Query only

---

**TRIGger[:SEQuence]:OSCilloscope:COUPling** <CoupType>

Configures the coupling of the external trigger to the oscilloscope.

**Parameters:**

<CoupType> Coupling type

**DC**
Direct connection with 50 Ω termination, passes both DC and AC components of the trigger signal.

**CDLimit**
Direct connection with 1 MΩ termination, passes both DC and AC components of the trigger signal.

**AC**
Connection through capacitor, removes unwanted DC and very low-frequency components.

*RST: DC

### 9.5.1.6 Configuring the outputs

Configuring trigger input/output is described in "Configuring the trigger output" on page 165.



---

**DIAGnostic:SERVice:NSOurce** <State>

Turns the 28 V supply of the BNC connector labeled [noise source control] on the FSW on and off.

**Parameters:**

<State> ON | OFF | 0 | 1

**OFF | 0**
Switches the function off

**ON | 1**
Switches the function on

**Example:** `DIAG:SERV:NSO ON`

**Manual operation:** See "Noise Source Control" on page 52

**OUTPut:IF:IFFRequency** <Frequency>

Defines the frequency for the IF output of the FSW. The IF frequency of the signal is converted accordingly.

Is available in the time domain and if the IF/VIDEO/DEMOD output is configured for IF.

**Parameters:**

<Frequency> *RST: 50.0 MHz
Default unit: HZ

**Manual operation:** See "Data Output" on page 51

**OUTPut:IF[:SOURce]** <Source>

Defines the type of signal available at one of the output connectors of the FSW.

**Parameters:**

<Source> **IF**
The measured IF value is available at the IF/VIDEO/DEMOD output connector.
The frequency at which the IF value is provided is defined using the `OUTPut:IF:IFFRequency` command.
*RST: IF

**Example:** `OUTP:IF VID`
Selects the video signal for the IF/VIDEO/DEMOD output connector.

**Manual operation:** See "Data Output" on page 51

## 9.5.2 Frontend configuration

The following commands configure frequency, amplitude and y-axis scaling settings, which represent the "frontend" of the measurement setup.



### 9.5.2.1 Frequency



**[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 53

---

**[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 53

---

**[SENSe:]FREQuency:CENTer:STEP:AUTO** <State>

Couples or decouples the center frequency step size to the span.

**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: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 53

### 9.5.2.2 Amplitude settings

The following commands are required to configure the amplitude settings in a remote environment.

Useful commands for amplitude settings described elsewhere:

- `INPut:COUPling` on page 102
- `[SENSe:]ADJust:LEVel` on page 171
- `CALCulate<n>:UNIT:POWer` on page 187

**Remote commands exclusive to amplitude settings:**



---

**CONFigure:POWer:AUTO** <Mode>

Is used to switch on or off automatic power level detection.

**Parameters:**

<Mode> **ON**
Automatic power level detection is performed at the start of each measurement sweep, and the reference level is adapted accordingly.

**OFF**
The reference level must be defined manually (see `DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel` on page 152)

**ONCE**
Automatic power level detection is performed once at the start of the next measurement sweep, and the reference level is adapted accordingly.
The command with this parameter corresponds to `[SENSe:]ADJust:LEVel` on page 171.

*RST: ON

---

**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<br>Not supported by all applications |
| <t> | irrelevant |

**Example:** `DISP:TRAC:Y 110dB`

---

**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<br>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 55

**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 56

**DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MAXimum** <Value>

Defines the maximum value on the y-axis in the specified window.

**Suffix:**

<n> Window

<t> irrelevant

**Parameters:**

<Max> numeric value

**Example:** `DISP:WIND2:TRAC:Y:SCAL:MAX 10`

**Manual operation:** See "Absolute Scaling (Min/Max Values)" on page 74

**DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MINimum** <Value>

Defines the minimum value on the y-axis in the specified window.

**Suffix:**

<n> Window

<t> irrelevant

**Parameters:**

<Min> numeric value

**Example:** `DISP:WIND2:TRAC:Y:SCAL:MIN -90`

**Manual operation:** See "Absolute Scaling (Min/Max Values)" on page 74

**INPut:ATTenuation** <Attenuation>

Defines the total attenuation for RF input.

If you set the attenuation manually, it is no longer coupled to the reference level, but the reference level is coupled to the attenuation. Thus, if the current reference level is not compatible with an attenuation that has been set manually, the command also adjusts the reference level.

If an external frontend is active (see `[SENSe:]EFRontend[:STATe]` on page 129), you can configure the attenuation of the external frontend and the analyzer separately. See also `INPut:SANalyzer:ATTenuation:AUTO` on page 157 and `INPut:SANalyzer:ATTenuation` on page 157.

**Parameters:**

| | | |
|---|---|---|
| <Attenuation> | Range: | see specifications document |
| | Increment: | 5 dB (with optional electr. attenuator: 1 dB) |
| | *RST: | 10 dB (AUTO is set to ON) |
| | Default unit: | DB |

**Example:**
`INP:ATT 30dB`
Defines a 30 dB attenuation and decouples the attenuation from the reference level.

**Manual operation:**
See "External Frontend Attenuation" on page 57
See "Attenuation Mode / Value" on page 57

**INPut:ATTenuation:AUTO** <State>

Couples or decouples the attenuation to the reference level. Thus, when the reference level is changed, the FSW determines the signal level for optimal internal data processing and sets the required attenuation accordingly.

If an external frontend is active (see `[SENSe:]EFRontend[:STATe]` on page 129), you can configure the attenuation of the external frontend and the analyzer separately. See also `INPut:SANalyzer:ATTenuation:AUTO` on page 157 and `INPut:SANalyzer:ATTenuation` on page 157.

**Parameters:**

<State> ON | OFF | 0 | 1
*RST: 1

**Example:**
`INP:ATT:AUTO ON`
Couples the attenuation to the reference level.

**Manual operation:**
See "External Frontend Attenuation" on page 57
See "Attenuation Mode / Value" on page 57

**INPut:EATT** <Attenuation>

Defines an electronic attenuation manually. Automatic mode must be switched off (`INP:EATT:AUTO OFF`, see `INPut:EATT:AUTO` on page 155).

If the current reference level is not compatible with an attenuation that has been set manually, the command also adjusts the reference level.

**Parameters:**
<Attenuation> attenuation in dB

Range: see specifications document
Increment: 1 dB
*RST: 0 dB (OFF)
Default unit: DB

**Example:**
```
INP:EATT:AUTO OFF
INP:EATT 10 dB
```

**Manual operation:** See "Using Electronic Attenuation" on page 58

---

**INPut:EATT:AUTO** <State>

Turns automatic selection of the electronic attenuation on and off.

If on, electronic attenuation reduces the mechanical attenuation whenever possible.

**Parameters:**
<State> ON | OFF | 0 | 1

**OFF | 0**
Switches the function off

**ON | 1**
Switches the function on

*RST: 1

**Example:**
```
INP:EATT:AUTO OFF
```

**Manual operation:** See "Using Electronic Attenuation" on page 58

---

**INPut:EATT:STATe** <State>

Turns the electronic attenuator on and off.

**Parameters:**
<State> ON | OFF | 0 | 1

**OFF | 0**
Switches the function off

**ON | 1**
Switches the function on

*RST: 0

**Example:**
```
INP:EATT:STAT ON
```
Switches the electronic attenuator into the signal path.

**Manual operation:** See "Using Electronic Attenuation" on page 58

**INPut:EGAin[:STATe]** <State>

Before this command can be used, the external preamplifier must be connected to the FSW. See the preamplifier's documentation for details.

When activated, the FSW automatically compensates the magnitude and phase characteristics of the external preamplifier in the measurement results.

Note that when an optional external preamplifier is activated, the internal preamplifier is automatically disabled, and vice versa.

For FSW85 models with two RF inputs, you must enable correction from the external preamplifier for each input individually. Correction cannot be enabled for both inputs at the same time.

When deactivated, no compensation is performed even if an external preamplifier remains connected.

**Parameters:**

<State> ON | OFF | 0 | 1

**OFF | 0**
No data correction is performed based on the external preamplifier

**ON | 1**
Performs data corrections based on the external preamplifier

*RST: 0

**Example:** `INP:EGA ON`

**Manual operation:** See "Ext. PA Correction" on page 59

**INPut:GAIN:STATe** <State>

Turns the internal preamplifier on and off. It requires the optional preamplifier hardware.

Note that if an optional external preamplifier is activated, the internal preamplifier is automatically disabled, and vice versa.

For FSW85 models, no preamplifier is available.

If option R&S FSW-B22 is installed, the preamplifier is only active below 7 GHz.

If option R&S FSW-B24 is installed, the preamplifier is active for all frequencies.

**Parameters:**

<State> ON | OFF | 0 | 1

**OFF | 0**
Switches the function off

**ON | 1**
Switches the function on

*RST: 0

**Example:** `INP:GAIN:STAT ON`
`INP:GAIN:VAL 15`
Switches on 15 dB preamplification.

**Manual operation:** See "Preamplifier" on page 49

---

**INPut:GAIN[:VALue]** <Gain>

Selects the "gain" if the preamplifier is activated (`INP:GAIN:STAT ON`, see `INPut:GAIN:STATe` on page 156).

The command requires the additional preamplifier hardware option.

**Parameters:**
<Gain> For all FSW models except for FSW85, the following settings are available:
15 dB and 30 dB
All other values are rounded to the nearest of these two.
30 dB
For older FSW43/FSW50/FSW67 models, the input signal is always ampilfied by about 30 dB when the preamplifier is active.
For FSW85 models, no preamplifier is available.
Default unit: DB

**Example:** `INP:GAIN:STAT ON`
`INP:GAIN:VAL 30`
Switches on 30 dB preamplification.

**Manual operation:** See "Preamplifier" on page 49

---

**INPut:SANalyzer:ATTenuation** <Attenuation>

Configures attenuation at the analyzer input for an active external frontend manually.

**Parameters:**
<Attenuation> Range: see specifications document
Increment: 1 dB
Default unit: DB

**Manual operation:** See "Attenuation Mode / Value" on page 57

---

**INPut:SANalyzer:ATTenuation:AUTO** <State>

Enables or disables automatic configuration of attenuation at the analyzer input for an active external frontend.

By default, the attenuation settings are applied at the input of the external frontend.

See `INPut:ATTenuation:AUTO` on page 154 and `INPut:ATTenuation` on page 154.

**Parameters:**
<State> ON | OFF | 0 | 1

**OFF | 0**
Auto mode for analyzer attenuation is disabled. Allows you to configure attenuation at the analyzer using `INPut:SANalyzer:ATTenuation` on page 157.

**ON | 1**
Auto mode for analyzer attenuation is enabled. No attenuation is configured at the analyzer.

*RST: 0

**Example:**

```
//Enable external frontend
EFR ON
//Query the currently configured RF attenuation
INP:ATT?
//Result: 10 dB
//Disable auto mode for analyzer attenuation
INP:SAN:ATT:AUTO OFF
//Configure 10 dB attenuation at the analyzer
INP:SAN:ATT 10
//Query the currently configured RF attenuation at the ext. FE
INP:ATT?
//Result: 0 dB
```

**Manual operation:** See "Attenuation Mode / Value" on page 57

## 9.5.3 Data acquisition

The following commands are required to configure how much and how data is captured from the input signal.



### 9.5.3.1 General capture settings



---

**CONFigure:EDMG:CRATe** <ChipRate>

Chip rate used for transmission; specified in the IEEE 802.11 ay standard as:

$N_{CB}$ * 1.76 GHz

**Parameters:**

<ChipRate> Default unit: HZ

**Example:** `TRACe:IQ:CRATe 3.52GHZ`

**Manual operation:** See "Chip Rate (CR) (IEEE 802.11 ay only)" on page 61

---

**CONFigure:EDMG:NCB** <NCB>

Indicates the number of contiguous 2.16 GHz channels the measurement was made for.

Note that the FSW hardware currently only supports measurement bandwidths up to a maximum of 5 GHz (using bandwidth extension options). Thus, measurements with 3 or 4 channels can only be performed on data from input files or using downsampling (see `CONFigure:EDMG:CRATe` on page 158).

**Parameters:**

<NCB> 1 | 2 | 3 | 4

**Example:** `CONF:EDMG:NCB 1`

**Manual operation:** See "$N_{CB}$ (IEEE 802.11 ay only)" on page 60

---

**CONFigure:EDMG:UCRate** <Src>

Determines whether the chip rate according to standard is used or a non-standard measurement is performed with a user-defined chip rate.

**Parameters:**

<Src> STANdard | CUSTom

**STANdard**
Data acquisition is set to the chip rate and sample rate specified in the IEEE 802.11 ay standard.

**CUSTom**
The chip rate can be defined freely to perform a non-standard measurement.

**Example:**
```
CONFigure:EDMG:UCRate CUST
CONFigure:EDMG:CRATe 3 GHz
```

**Manual operation:** See "Used Chip Rate (IEEE 802.11 ay only)" on page 61

---

**[SENSe:]SWAPiq** <State>

Defines whether or not the recorded I/Q pairs should be swapped (I<->Q) before being processed. Swapping I and Q inverts the sideband.

This is useful if the DUT interchanged the I and Q parts of the signal; then the FSW can do the same to compensate for it.

**Parameters:**

<State> **ON | 1**
I and Q signals are interchanged
Inverted sideband, Q+j*I

**OFF | 0**
I and Q signals are not interchanged
Normal sideband, I+j*Q
*RST: 0

**Manual operation:** See "Swap I/Q" on page 62

---

**[SENSe:]SWEep:TIME** <Time>

Defines the measurement time. It automatically decouples the time from any other settings.

**Parameters:**
<Time> refer to specifications document
*RST: depends on current settings (determined automatically)
Default unit: S

**Manual operation:** See "Measurement Time" on page 61

---

**TRACe:IQ:SRATe** <SampleRate>

**Parameters:**
<SampleRate> For standard IEEE 802.11ad signals, a sample rate of 2.64 GHz is used (requires an optional bandwidth extension with at least 2 GHz).
Default unit: HZ

**Manual operation:** See "Sample Rate (SR) (IEEE 802.11 ay only)" on page 61
See "Sample Rate (IEEE 802.11ad)" on page 61

### 9.5.3.2 Configuring triggered measurements

The following commands are required to configure a triggered measurement in a remote environment. The tasks for manual operation are described in Chapter 5.2.4, "Trigger settings", on page 62.

The `*OPC` command should be used after commands that retrieve data so that subsequent commands to change the selected trigger source are held off until after the sweep is completed and the data has been returned.



#### Configuring the triggering conditions

The following commands are required to configure a triggered measurement.

---

**TRIGger[:SEQuence]:DTIMe** <DropoutTime>

Defines the time the input signal must stay below the trigger level before a trigger is detected again.

**Parameters:**

<DropoutTime> Dropout time of the trigger.

Range: 0 s to 10.0 s
*RST: 0 s
Default unit: S

**Manual operation:** See "Drop-Out Time" on page 65

---

**TRIGger[:SEQuence]:HOLDoff[:TIME]** <Offset>

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

**Parameters:**

<Offset> *RST: 0 s
Default unit: S

**Example:** `TRIG:HOLD 500us`

**Manual operation:** See "Trigger Offset" on page 65

---

**TRIGger[:SEQuence]:IFPower:HOLDoff** <Period>

Defines the holding time before the next trigger event.

Note that this command can be used for **any trigger source**, not just IF Power (despite the legacy keyword).

**Parameters:**

<Period> Range: 0 s to 10 s
*RST: 0 s
Default unit: S

**Example:** `TRIG:SOUR EXT`
Sets an external trigger source.
`TRIG:IFP:HOLD 200 ns`
Sets the holding time to 200 ns.

**Manual operation:** See "Trigger Holdoff" on page 66

---

**TRIGger[:SEQuence]:IFPower:HYSTeresis** <Hysteresis>

Defines the trigger hysteresis, which is only available for "IF Power" trigger sources.

**Parameters:**
<Hysteresis> Range: 3 dB to 50 dB
*RST: 3 dB
Default unit: DB

**Example:** `TRIG:SOUR IFP`
Sets the IF power trigger source.
`TRIG:IFP:HYST 10DB`
Sets the hysteresis limit value.

**Manual operation:** See "Hysteresis" on page 66

---

**TRIGger[:SEQuence]:LEVel[:EXTernal<port>]** <TriggerLevel>

Defines the level the external signal must exceed to cause a trigger event.

**Suffix:**
<port> Selects the trigger port.
1 = trigger port 1 (TRIGGER INPUT connector on front panel)
2 = trigger port 2 (TRIGGER INPUT/OUTPUT connector on front panel)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (TRIGGER3 INPUT/OUTPUT connector on rear panel)

**Parameters:**
<TriggerLevel> Range: 0.5 V to 3.5 V
*RST: 1.4 V
Default unit: V

**Example:** `TRIG:LEV 2V`

**Manual operation:** See "Trigger Level" on page 65

---

**TRIGger[:SEQuence]:LEVel:IFPower** <TriggerLevel>

Defines the power level at the third intermediate frequency that must be exceeded to cause a trigger event.

Note that any RF attenuation or preamplification is considered when the trigger level is analyzed. If defined, a reference level offset is also considered.

**Parameters:**
<TriggerLevel> For details on available trigger levels and trigger bandwidths, see the specifications document.
*RST: -20 dBm
Default unit: DBM

**Example:** `TRIG:LEV:IFP -30DBM`

**Manual operation:** See "Trigger Level" on page 65

---

**TRIGger[:SEQuence]:LEVel:IQPower** <TriggerLevel>

Defines the magnitude the I/Q data must exceed to cause a trigger event.

Note that any RF attenuation or preamplification is considered when the trigger level is analyzed. If defined, a reference level offset is also considered.

**Parameters:**
<TriggerLevel> Range: -130 dBm to 30 dBm
*RST: -20 dBm
Default unit: DBM

**Example:** `TRIG:LEV:IQP -30DBM`

**Manual operation:** See "Trigger Level" on page 65

---

**TRIGger[:SEQuence]:LEVel:RFPower** <TriggerLevel>

Defines the power level the RF input must exceed to cause a trigger event. Note that any RF attenuation or preamplification is considered when the trigger level is analyzed. If defined, a reference level offset is also considered.

The input signal must be between 500 MHz and 8 GHz.

**Parameters:**
<TriggerLevel> For details on available trigger levels and trigger bandwidths, see the specifications document.
*RST: -20 dBm
Default unit: DBM

**Example:** `TRIG:LEV:RFP -30dBm`

**Manual operation:** See "Trigger Level" on page 65

---

**TRIGger[:SEQuence]:SLOPe** <Type>

**Parameters:**
<Type> POSitive | NEGative

**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:** `TRIG:SLOP NEG`

**Manual operation:** See "Slope" on page 66

---

**TRIGger[: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.

**Parameters:**

<Source>

**IMMediate**
Free Run

**EXTernal**
Trigger signal from the "Trigger Input" connector.
If power splitter mode is active, this parameter activates the "EXT TRIGGER INPUT" connector on the oscilloscope. Then the FSW triggers when the signal fed into the "EXT TRIGGER INPUT" connector on the oscilloscope meets or exceeds the specified trigger level.

**EXT2**
Trigger signal from the "Trigger Input/Output" connector.
For FSW85 models, Trigger 2 is not available due to the second RF input connector on the front panel. The trigger signal is taken from the "Trigger Input/Output" connector on the rear panel.
Note: Connector must be configured for "Input".

**EXT3**
Trigger signal from the "TRIGGER 3 INPUT/ OUTPUT" connector.
Note: Connector must be configured for "Input".

**RFPower**
First intermediate frequency
(Frequency and time domain measurements only.)

**IFPower**
Second intermediate frequency

**IQPower**
Magnitude of sampled I/Q data
For applications that process I/Q data, such as the I/Q Analyzer or optional applications.

*RST: IMMediate

**Example:** `TRIG:SOUR EXT`
Selects the external trigger input as source of the trigger signal

**Manual operation:** See "Trigger Source" on page 63
See "Free Run" on page 64
See "External Trigger 1/2/3" on page 64
See "External Analog" on page 64
See "IF Power" on page 64
See "RF Power" on page 65
See "I/Q Power" on page 65

---

**TRIGger[:SEQuence]:TIME:RINTerval** <Interval>

Defines the repetition interval for the time trigger.

**Parameters:**

<Interval> numeric value

Range: 2 ms to 5000 s
*RST: 1.0 s
Default unit: S

**Example:**
`TRIG:SOUR TIME`
Selects the time trigger input for triggering.
`TRIG:TIME:RINT 5`
The measurement starts every 5 s.

### Configuring the trigger output

The following commands are required to send the trigger signal to one of the variable "TRIGGER INPUT/OUTPUT" connectors on the FSW.



---

**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)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (rear panel)

**Parameters:**

<Direction> INPut | OUTPut

**INPut**
Port works as an input.

**OUTPut**
Port works as an output.

*RST: INPut

**Manual operation:** See "Trigger 2/3" on page 66

---

**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)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (rear)

**Parameters:**
<Level> **HIGH**
5 V

**LOW**
0 V

*RST: LOW

**Example:** `OUTP:TRIG2:LEV HIGH`

**Manual operation:** See "Level" on page 67

---

**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)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (rear)

**Parameters:**
<OutputType> **DEVice**
Sends a trigger signal when the FSW 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

**Manual operation:** See "Output Type" on page 67

**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)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (rear)

**Manual operation:** See "Send Trigger" on page 68

**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)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (rear)

**Parameters:**

<Length> Pulse length in seconds.
Default unit: S

**Example:** `OUTP:TRIG2:PULS:LENG 0.02`

**Manual operation:** See "Pulse Length" on page 68

## 9.5.4 Tracking



**[SENSe:]TRACking:IQMComp** <State>

Activates or deactivates the compensation for I/Q mismatch (gain imbalance, quadrature offset, I/Q skew, see Chapter 3.1.2, "Modulation accuracy parameters", on page 24).

**Parameters:**

<State> ON | OFF | 1 | 0

**ON | 1**
Compensation for gain imbalance, quadrature offset, and I/Q skew impairments is applied.

**OFF | 0**
Compensation is not applied; this setting is required for measurements strictly according to the IEEE 802.11ad standard
*RST: 0

**Manual operation:** See "I/Q Mismatch Compensation" on page 69

---

**SENSe:TRACking:LEVel** <State>

Activates or deactivates the compensation for level variations within a single PPDU. If activated, the measurement results are compensated for level error on a per-symbol basis.

**Parameters:**
<State> ON | OFF | 1 | 0
*RST: 0

**Example:** `SENS:TRAC:LEV ON`

**Manual operation:** See "Level Error (Gain) Tracking" on page 69

---

**SENSe:TRACking:PHASe** <State>

Activates or deactivates the compensation for phase drifts.

**Parameters:**
<State> ON | OFF | 0 | 1

**OFF | 0**
Switches the function off

**ON | 1**
Switches the function on. The measurement results are compensated for phase drifts on a per-symbol basis.
*RST: 1

**Example:** `SENS:TRAC:PHAS ON`

**Manual operation:** See "Phase Tracking" on page 68

---

**[SENSe] (see also SENSe: commands!)**

### 9.5.5 Evaluation range

The evaluation range defines which data is evaluated in the result display.

Note that, as opposed to manual operation, the PPDUs to be analyzed can be defined either by the number of data symbols, the number of data bytes, or the measurement duration.

**[SENSe:]BURSt:COUNt** <Value>

If the statistic count is enabled (see `[SENSe:]BURSt:COUNt:STATe` on page 169), the specified number of PPDUs is taken into consideration for the statistical evaluation (maximally the number of PPDUs detected in the current capture buffer).

If disabled, all detected PPDUs in the current capture buffer are considered.

**Parameters:**

<Value> integer

*RST: 1

**Example:**

```
SENS:BURS:COUN:STAT ON
SENS:BURS:COUN 10
```

**[SENSe:]BURSt:COUNt:STATe** <State>

If the statistic count is enabled, the specified number of PPDUs is taken into consideration for the statistical evaluation (maximally the number of PPDUs detected in the current capture buffer).

If disabled, all detected PPDUs in the current capture buffer are considered.

**Parameters:**

<State> ON | OFF | 1 | 0

*RST: 0

**Example:**

```
SENS:BURS:COUN:STAT ON
SENS:BURS:COUN 10
```

**[SENSe:]BURSt:SELect** <Count>

If single PPDU analysis is enabled (see `[SENSe:]BURSt:SELect:STATe` on page 170), the IEEE 802.11ad I/Q results are based on the specified PPDU.

If disabled, all detected PPDUs in the current capture buffer are evaluated.

**Parameters:**

<Count> *RST: 1

**Example:**

```
SENS:BURS:SEL:STAT ON
SENS:BURS:SEL 2
```

Results are based on the PPDU number 2 only.

**Manual operation:** See "PPDU to Analyze / Index of Specific PPDU" on page 78

**[SENSe:]BURSt:SELect:STATe** <State>

Defines the evaluation basis for result displays.

Note that this setting is only applicable *after* a measurement has been performed.

**Parameters:**

<State> ON | OFF | 0 | 1

**OFF | 0**
All detected PPDUs in the current capture buffer are evaluated.

**ON | 1**
The IEEE 802.11ad I/Q results are based on one individual PPDU only, namely the defined using `[SENSe:]BURSt:SELect` on page 169. As soon as a new measurement is started, the evaluation range is reset to all PPDUs in the current capture buffer.

*RST: 0

**Example:**
```
SENS:BURS:SEL:STAT ON
SENS:BURS:SEL 2
```
Results are based on the PPDU number 2 only.

**Manual operation:** See "PPDU to Analyze / Index of Specific PPDU" on page 78

**[SENSe:]DEMod:FORMat:BANalyze:SYMBols:EQUal** <State>

If **enabled**, only PPDUs with a **specific** number of symbols are considered for measurement analysis.

If **disabled**, only PPDUs whose length is within a specified **range** are considered.

The number of symbols is specified by the `[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MIN` command.

A **range** of data symbols is defined as a minimum and maximum number of symbols the payload may contain (see `[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MAX` on page 170 and `[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MIN` on page 171).

**Parameters:**

<State> ON | OFF | 1 | 0

*RST: 0

**[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MAX** <NumDataSymbols>

If the `[SENSe:]DEMod:FORMat:BANalyze:SYMBols:EQUal` command is set to **false**, this command specifies the maximum number of payload symbols allowed for a PPDU to take part in measurement analysis.

The number of payload symbols is defined as the uncoded bits including service and tail bits.

If the [SENSe:]DEMod:FORMat:BANalyze:SYMBols:EQUal command has been set to **true**, then this command has no effect.

**Parameters:**
<NumDataSymbols> integer
*RST: 64

**[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MIN** <NumDataSymbols>

If the [SENSe:]DEMod:FORMat:BANalyze:SYMBols:EQUal command has been set to **true**, then this command specifies the exact number of payload symbols a PPDU must have to take part in measurement analysis.

If the [SENSe:]DEMod:FORMat:BANalyze:SYMBols:EQUal command is set to **false**, this command specifies the minimum number of payload symbols required for a PPDU to take part in measurement analysis.

The number of payload symbols is defined as the uncoded bits including service and tail bits.

**Parameters:**
<NumDataSymbols> integer
*RST: 1

**Example:**
```
SENS:DEM:FORM:BAN:SYMB:EQU ON
SENS:DEMO:FORM:BANA:SYMB:MIN
```

## 9.5.6 Automatic settings

**Remote commands exclusive to automatic configuration:**



**[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 FSW 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 56

**[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
```

## 9.6 Configuring SEM measurements on IEEE 802.11ad signals

The R&S FSW 802.11ad/ay applications uses the functionality of the FSW base system (Spectrum application, see the FSW User Manual) to perform the IEEE 802.11ad SEM measurements. The R&S FSW 802.11ad/ay applications automatically sets the parameters to predefined settings as described in Chapter 5.3, "SEM measurements", on page 75.

The IEEE 802.11ad RF measurements must be activated for a measurement channel in the R&S FSW 802.11ad/ay applications, see Chapter 9.3, "Activating IEEE 802.11ad measurements", on page 96.

For details on configuring these RF measurements in a remote environment, see the Remote Commands chapter of the FSW User Manual.

**Remote commands exclusive to SEM measurements in the R&S FSW 802.11ad/ay applications:**

**MMEMory:LOAD:SEM:STATe** <1>, <FileName>

Loads a spectrum emission mask setup from an xml file.

Note that this command is maintained for compatibility reasons only. Use the `SENS:ESP:PRES` command for new remote control programs.

See the FSW User Manual, "Remote commands for SEM measurements" chapter.

**Parameters:**
<1>

<FileName> string
Path and name of the `.xml` file that contains the SEM setup information.

**Example:**
```
MMEM:LOAD:SEM:STAT 1,
'..\sem_std\WLAN\802_11a\802_11a_10MHz_5GHz_band.XML'
```

**[SENSe:]FREQuency:SPAN** <Span>

Defines the frequency span.

**[SENSe:]FREQuency:STARt** <Frequency>

**Parameters:**
<Frequency> 0 to (fmax - min span)
*RST: 0
Default unit: HZ

**Example:**
```
FREQ:STAR 20MHz
```

**[SENSe:]FREQuency:STOP** <Frequency>

**Parameters:**
<Frequency> min span to fmax
*RST: fmax
Default unit: HZ

**Example:**
```
FREQ:STOP 2000 MHz
```

**[SENSe:]POWer:SEM** <Standard>

Sets the "Spectrum Emission Mask" (SEM) measurement type.

**Parameters:**
<Standard> IEEE | ETSI | User

**User**
Settings and limits are configured via a user-defined XML file.
Load the file using `MMEMory:LOAD:SEM:STATe` on page 173.

**IEEE**
Settings and limits are as specified in the IEEE Std 802.11n™-2009 Figure 20-17—Transmit spectral mask for 20 MHz transmission. For other IEEE standards see the parameter values in the table below.
After a query, `IEEE` is returned for all IEEE standards.

**ETSI**
Settings and limits are as specified in the ETSI standard.

*RST: IEEE

**Example:** `POW:SEM ETSI`

*Table 9-4: Supported IEEE standards*

| Manual operation | The spectrum emission mask measurement is performed according to the standard | Parameter value |
|---|---|---|
| IEEE 802.11n-2009 20M@2.4G | IEEE Std 802.11n™-2009<br>Figure 20-17—Transmit spectral mask for 20 MHz transmission | IEEE or<br>'IEEE_2009_20_2_4' |
| IEEE 802.11n-2009 40M@2.4G | IEEE Std 802.11n™-2009<br>Figure 20-18—Transmit spectral mask for a 40 MHz channel | 'IEEE_2009_40_2_4' |
| IEEE 802.11n-2009 20M@5G | IEEE Std 802.11n™-2009<br>Figure 20-17—Transmit spectral mask for 20 MHz transmission | 'IEEE_2009_20_5' |
| IEEE 802.11n-2009 40M@5G | IEEE Std 802.11n™-2009<br>Figure 20-18—Transmit spectral mask for a 40 MHz channel | 'IEEE_2009_40_5' |
| | | |
| IEEE 802.11mb/D08 20M@2.4G | IEEE Std 802.11n™-2009<br>Figure 20-17—Transmit spectral mask for 20 MHz transmission<br>IEEE Draft P802.11-REVmb™/D8.0, March 2011<br>Figure 19-17—Transmit spectral mask for 20 MHz transmission in the 2.4 GHz band | 'IEEE_D08_20_2_4' |
| IEEE 802.11mb/D08 40M@2.4G | IEEE Std 802.11n™-2009<br>Figure 20-18—Transmit spectral mask for a 40 MHz channel<br>IEEE Draft P802.11-REVmb™/D8.0, March 2011<br>Figure 19-18—Transmit spectral mask for a 40 MHz channel in the 2.4 GHz band | 'IEEE_D08_40_2_4' |
| IEEE 802.11mb/D08 20M@5G | IEEE Draft P802.11-REVmb™/D8.0, March 2011<br>Figure 19-19—Transmit spectral mask for 20 MHz transmission in the 5 GHz band | 'IEEE_D08_20_5' |
| IEEE 802.11mb/D08 40M@5G | IEEE Draft P802.11-REVmb™/D8.0, March 2011<br>Figure 19-20—Transmit spectral mask for a 40 MHz channel in the 5 GHz band | 'IEEE_D08_40_5' |
| | | |
| IEEE 802.11ac/D1.1 20M@5G | IEEE P802.11ac™/D1.1, August 2011<br>Figure 22-17—Transmit spectral mask for a 20 MHz channel | 'IEEE_AC_D1_1_20_5' |

| Manual operation | The spectrum emission mask measurement is performed according to the standard | Parameter value |
|---|---|---|
| IEEE 802.11ac/D1.1 40M@5G | IEEE P802.11ac™/D1.1, August 2011<br>Figure 22-18—Transmit spectral mask for a 40 MHz channel | 'IEEE_AC_D1_1_40_5' |
| IEEE 802.11ac/D1.1 80M@5G | IEEE P802.11ac™/D1.1, August 2011<br>Figure 22-19—Transmit spectral mask for a 80 MHz channel | 'IEEE_AC_D1_1_80_5' |
| | | |
| IEEE 802.11ax-2021 20M@5G | IEEE Std 802.11ax-2021 Figure 27-47—Example transmit spectral mask for a 20 MHz mask PPDU | 'IEEE_AX_2021_20' |
| IEEE 802.11ax-2021 40M@5G | IEEE Std 802.11ax-2021 Figure 27-48—Example transmit spectral mask for a 40 MHz mask PPDU | 'IEEE_AX_2021_40' |
| IEEE 802.11ax-2021 80M@5G | IEEE Std 802.11ax-2021 Figure 27-49—Example transmit spectral mask for an 80 MHz mask PPDU | 'IEEE_AX_2021_80' |
| IEEE 802.11ax-2021 160M@5G | IEEE Std 802.11ax-2021 Figure 27-50—Example transmit spectral mask for a 160 MHz mask PPDU | 'IEEE_AX_2021_160' |
| | | |
| IEEE 802.11be/D1.4 20M@5G | IEEE Std 802.11be/D1.4 January 2022 Figure 36-64—Example transmit spectral mask for a 20 MHz mask PPDU | 'IEEE_BE_D1_4_20' |
| IEEE 802.11be/D1.4 40M@5G | IEEE Std 802.11be/D1.4 January 2022 Figure 36-65—Example transmit spectral mask for a 40 MHz mask PPDU | 'IEEE_BE_D1_4_40' |
| IEEE 802.11be/D1.4 80M@5G | IEEE Std 802.11 be/D1.4 January 2022 Figure 36-66—Example transmit spectral mask for an 80 MHz mask PPDU | 'IEEE_BE_D1_4_80' |
| IEEE 802.11be/D1.4 160M@5G | IEEE Std 802.11 be/D1.4 January 2022 Figure 36-67—Example transmit spectral mask for a 160 MHz mask PPDU | 'IEEE_BE_D1_4_160' |
| IEEE 802.11be/D1.4 320M@5G | IEEE Std 802.11 be/D1.4 January 2022 Figure 36-68—Example transmit spectral mask for a 320 MHz mask PPDU | 'IEEE_BE_D1_4_320' |
| | | |
| IEEE 802.11ad-2016 2160M@60G | IEEE Std 802.11-2016 Figure 20-1—Transmit mask | 'IEEE_AD_2016_2160' |
| | | |
| IEEE 802.11ay/D7.0 2160M@60G | IEEE Std 802.11ay/D7.0 December 2020 IEEE Std 802.11-2016 Figure 20-1—Transmit mask | 'IEEE_AD_2016_2160' |
| IEEE 802.11ay/D7.0 4320M@60G | IEEE Std 802.11ay/D7.0 December 2020 Figure 28-8 – Example transmit spectral mask for a 4.32 GHz mask PPDU | 'IEEE_AY_D7_0_4320' |
| IEEE 802.11ay/D7.0 6480M@60G | IEEE Std 802.11ay/D7.0 December 2020 Figure 28-9 – Example transmit spectral mask for a 6.48 GHz mask PPDU | 'IEEE_AY_D7_0_6480' |
| IEEE 802.11ay/D7.0 8640M@60G | IEEE Std 802.11ay/D7.0 December 2020 Figure 28-10 – Example transmit spectral mask for an 8.64 GHz mask PPDU | 'IEEE_AY_D7_0_8640' |

**[SENSe:]POWer:SEM:CLASs** <Index>

Sets the "Spectrum Emission Mask" (SEM) power class index. The index represents the power classes to be applied. The index is directly related to the entries displayed in the power class drop-down box, within the SEM settings configuration page.

**Parameters:**

| | | |
|---|---|---|
| <Index> | *RST: | 0 |

## 9.7 Configuring the result display

The following commands are required to configure the screen display in a remote environment. The corresponding tasks for manual operation are described in Chapter 5.1, "Display configuration", on page 43.

The suffix <n> in the following remote commands represents the window (1..16) in the currently selected measurement channel.



### 9.7.1 General window commands

The following commands are required to configure general window layout, independent of the application.

Note that the suffix <n> always refers to the window *in the currently selected channel* (see `INSTrument[:SELect]` on page 99).



**DISPlay:FORMat** <Format>

Determines which tab is displayed.

**Parameters:**

<Format>

**SPLit**
Displays the MultiView tab with an overview of all active channels

**SINGle**
Displays the measurement channel that was previously focused.

*RST: SING

**Example:** `DISP:FORM SPL`

**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 182).

**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`

**DISPlay[:WINDow<n>][:SUBWindow<w>]:SELect**

Sets the focus on the selected result display window.

This window is then the active window.

For measurements with multiple results in subwindows, the command also selects the subwindow. Use this command to select the (sub)window before querying trace data.

**Suffix:**

<n> Window

<w> subwindow
Not supported by all applications

**Example:** //Put the focus on window 1
`DISP:WIND1:SEL`

**Example:** //Put the focus on subwindow 2 in window 1
`DISP:WIND1:SUBW2:SEL`

## 9.7.2 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 "Bitstream" on page 14
See "Channel Frequency Response" on page 15
See "Constellation" on page 16
See "EVM vs Symbol" on page 17
See "Freq. Error vs Symbol" on page 18
See "Header information" on page 18
See "Magnitude Capture" on page 19
See "Phase Error vs Symbol" on page 20
See "Phase Tracking vs Symbol" on page 20
See "Power Spectrum" on page 21
See "PvT Full PPDU" on page 22
See "PvT Rising Edge" on page 22
See "PvT Falling Edge" on page 23
See "Result Summary" on page 23
See "Diagram" on page 31
See "Result Summary" on page 31
See "Marker Table" on page 31
See "Marker Peak List" on page 32

*Table 9-5: <WindowType> parameter values for 802.11ad application*

| Parameter value | Window type |
|---|---|
| **Window types for I/Q data** | |
| CFR | "Channel Frequency Response" |
| CONStellation | "Constellation" |
| DBSTream | Data "Bitstream" (raw) |
| DDBStream | Data "Bitstream" (decoded) |
| EVSYmbol | "EVM vs. Symbol" |
| FEVSymbol | "Frequency Error vs. Symbol" |
| HBSTream | Header "Bitstream" (raw) |
| HDBStream | Header "Bitstream" (decoded) |
| HEADer | Header Info |
| MCAPture | "Magnitude Capture" |
| PEVSymbol | "Phase Error vs. Symbol" |
| PTVSymbol | "Phase Tracking vs. Symbol" |
| PFALling | "PvT Falling Edge" |
| PFPPdu | "PvT Full PPDU" |
| PRISing | "PvT Rising Edge" |
| PSPectrum | "Power Spectrum" |
| RSGLobal | "Result Summary" |
| **Window types for RF data** | |
| DIAGram | "Diagram" |

| Parameter value | Window type |
|---|---|
| MTABle | "Marker table" |
| PEAKlist | "Marker peak list" |
| RSUMmary | "Result summary" |

**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 178 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.

Compared to the `DISPlay[:WINDow<n>]:SIZE` on page 177 command, the `LAYout:SPLitter` changes the size of all windows to either side of the splitter permanently, it does not just maximize a single window temporarily.

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.

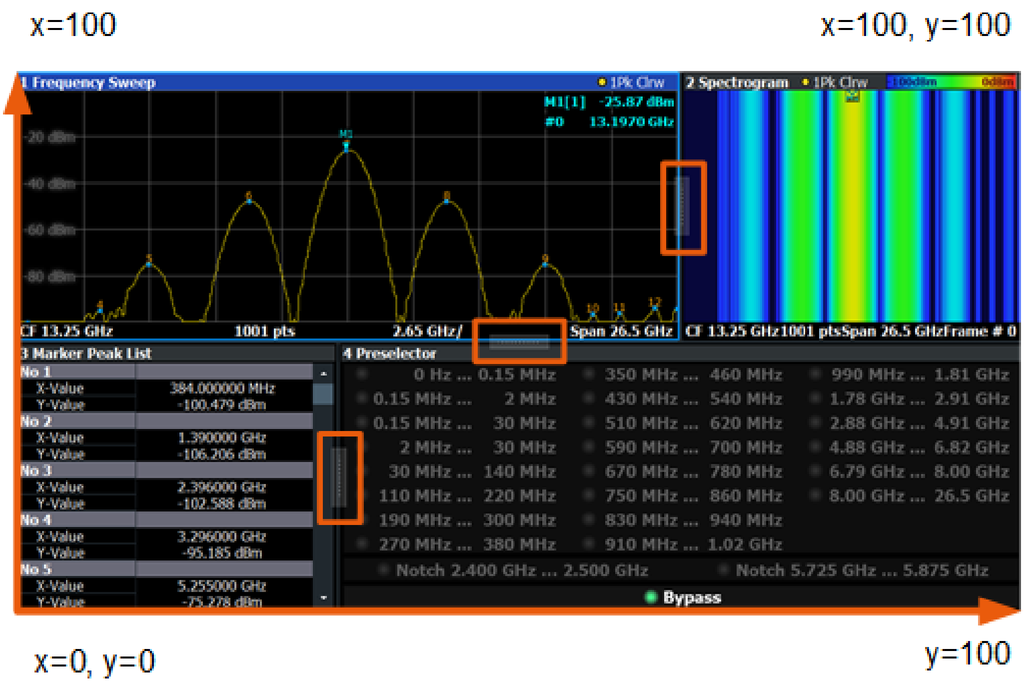



*Figure 9-1: SmartGrid coordinates for remote control of the splitters*

**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 9-1.)
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 178 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 178 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

### 9.7.3 Selecting items to display in result summary

The following command defines which items are displayed in the "Result Summary".

**DISPlay[:WINDow<n>]:TABLe:ITEM** <Item>,<State>

Defines which items are *displayed* in the "Result Summary" (see "Result Summary" on page 23).

Note that the results are always *calculated*, regardless of their visibility in the "Result Summary".

**Suffix:**
<n> Window

**Parameters:**
<State> ON | OFF | 0 | 1

**OFF | 0**
Switches the function off

**ON | 1**
Switches the function on

**Parameters for setting and query:**
<Item> EVM | EVMD | EVMP | IQOF | GIMB | QERR | CFER | SCER | RTI | FTIM | TSK | TDP | CFAC | HBER | PBER
Item to be included in "Result Summary". For the mapping of the result to the command parameter, see Parameters for the items of the "Result Summary" below.
For a description of the individual parameters see Chapter 3.1.2, "Modulation accuracy parameters", on page 24.

**Example:** `DISP:WIND:TABL:ITEM EVM,ON`

*Table 9-6: Parameters for the items of the "Result Summary"*

| Result in table | SCPI parameter |
|---|---|
| EVM All | EVM |
| EVM Data Symbols | EVMD |

| Result in table | SCPI parameter |
|---|---|
| EVM Pilot Symbols | EVMP |
| I/Q Offset | IQOF |
| Gain Imbalance | GIMB |
| Quadrature Error | QERR |
| Center Frequency Error | CFER |
| Symbol Clock Error | SCER |
| Rise Time | RTI |
| Fall Time | FTIM |
| Time Skew | TSK |
| Time Domain Power | TDP |
| Crest factor | CFAC |
| Header BER | HBER |
| Payload BER | PBER |

## 9.7.4 Configuring the y-axis scaling and units

The scaling for the vertical axis is highly configurable, using either absolute or relative values. These commands are described here.

Useful commands for configuring scaling described elsewhere:

- `DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel` on page 152

### Remote commands exclusive to scaling the y-axis

**CALCulate<n>:UNIT:ANGLe** <Unit>
**UNIT:ANGLe** <Unit>

Selects the global unit for all phase results.

**Parameters:**

<Unit> DEG | RAD

**Manual operation:** See "Phase Unit" on page 73

**CALCulate<n>:UNIT:FREQuency** <Unit>

Selects the global unit for all frequency results.

**Suffix:**

<n> 1..n
irrelevant

**Parameters:**

<Unit> REL | ABS
*RST: REL

**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 56

**DISPlay[:WINDow<n>]:TRACe<t>:X[:SCALe]:UNIT?**

This command reads the unit type currently configured for the X-axis

**Suffix:**

<n> 1..n
Window

<t> 1..n
Trace

**Usage:** Query only

**DISPlay[:WINDow<n>][:SUBWindow<n>]:TRACe<t>:Y[:SCALe]:AUTO** <State>

If enabled, the Y-axis is scaled automatically according to the current measurement.

**Suffix:**

| | |
|---|---|
| <n> | Window |
| <w> | subwindow<br>Not supported by all applications |
| <t> | irrelevant |

**Parameters for setting and query:**

<State>

**OFF**
Switch the function off

**ON**
Switch the function on

**ONCE**
Execute the function once

*RST: ON

**Manual operation:** See "Automatic Grid Scaling" on page 74
See "Auto Scale Once" on page 74

**DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:PDIVision** <Value>

This remote command determines the grid spacing on the Y-axis for all diagrams, where possible.

In spectrum displays, for example, this command is not available.

**Suffix:**

| | |
|---|---|
| <n> | Window |
| <w> | subwindow<br>Not supported by all applications |
| <t> | irrelevant |

**Parameters:**

<Value>

numeric value WITHOUT UNIT (unit according to the result display)

Defines the range per division (total range = 10*<Value>)

*RST: depends on the result display
Default unit: DBM

**Example:**

```
DISP:TRAC:Y:PDIV 10
```

Sets the grid spacing to 10 units (e.g. dB) per division

**Manual operation:** See "Per Division" on page 75

**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 FSW adjusts the scaling of the y-axis accordingly.

**Suffix:**

| | |
|---|---|
| <n> | Window |
| <w> | subwindow<br>Not supported by all applications |
| <t> | irrelevant |

**Example:** `DISP:TRAC:Y:RPOS 50PCT`

**Manual operation:** See "Ref Position" on page 75

**DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RVALue** <Value>

This command defines the reference value assigned to the reference position in the specified window. Separate reference values are maintained for the various displays.

**Suffix:**

| | |
|---|---|
| <n> | Window |
| <t> | irrelevant |

**Parameters:**

| | |
|---|---|
| <Value> | numeric value WITHOUT UNIT<br>Default unit: dBm |

**Manual operation:** See "Ref Value" on page 75

**DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RVALue:MAXimum** <Value>

Defines the maximum value on the y-axis for all traces in the specified window.

**Suffix:**

| | |
|---|---|
| <n> | Window |
| <t> | irrelevant |

**Parameters:**

| | |
|---|---|
| <Value> | numeric value<br>Default unit: dBm |

**DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RVALue:MINimum** <Value>

Defines the minimum value on the y-axis for all traces in the specified window.

**Suffix:**

| | |
|---|---|
| <n> | Window |

<t> irrelevant

**Parameters:**

<Value> numeric_value

Default unit: dBm

**DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:UNIT?**

This command reads the unit type currently configured for the Y-axis

**Suffix:**

<n> 1..n
Window

<t> 1..n
Trace

**Usage:** Query only

**FORMat:BSTReam** <BitStreamFormat>

Switches the format of the bitstream between octet and hexadecimal values.

**Parameters:**

<BitStreamFormat> OCTet | HEXadecimal

**Manual operation:** See "Bitstream Format" on page 73

## 9.8 Starting a measurement

When a IEEE 802.11ad measurement channel is activated on the FSW, a IEEE 802.11ad Modulation Accuracy Measurement, see Chapter 3.1, "IEEE 802.11ad/ay modulation accuracy measurement", on page 13), is started immediately. However, you can stop and start a new measurement any time.

Furthermore, you can perform a sequence of measurements using the Sequencer (see "Multiple Measurement Channels and Sequencer Function" on page 9).



**ABORt**

Aborts the measurement in the current 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 `ABOR` and before the next command.

For details on overlapping execution see Remote control via SCPI.

**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 and the remote channel to the FSW is blocked for further commands. In this case, you must interrupt processing on the remote channel first in order to abort the measurement.

To do so, send a "Device Clear" command from the control instrument to the FSW 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 performing the measurement.

**Example:** `ABOR;:INIT:IMM`
Aborts the current measurement and immediately starts a new one.

**Example:** `ABOR;*WAI`
`INIT:IMM`
Aborts the current measurement and starts a new one once abortion has been completed.

**Usage:** Event

---

**CALCulate<n>:BURSt[:IMMediate]**

Forces the IQ measurement results to be recalculated according to the current settings.

**Suffix:**
<n> 1..n
Window

---

**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> irrelevant

**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 70

---

**INITiate<n>[:IMMediate]**

Starts a (single) new measurement.

You can synchronize to the end of the measurement with *OPC, *OPC? or *WAI.

For details on synchronization see Remote control via SCPI.

**Suffix:**
<n> irrelevant

**Usage:** Asynchronous command

**Manual operation:** See "Single Sweep / Run Single" on page 70

---

**INITiate:SEQuencer:ABORt**

Stops the currently active sequence of measurements.

You can start a new sequence any time using `INITiate:SEQuencer:IMMediate` on page 192.

**Usage:** Event

---

**INITiate:SEQuencer:IMMediate**

Starts a new sequence of measurements by the Sequencer.

Its effect is similar to the `INITiate<n>[:IMMediate]` command used for a single measurement.

Before this command can be executed, the Sequencer must be activated (see `SYSTem:SEQuencer` on page 193).

**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`

## 9.9 Analysis

The following commands define general result analysis settings concerning the traces and markers in standard IEEE 802.11ad measurements. Currently, only one (Clear/ Write) trace and one marker are available for standard IEEE 802.11ad measurements.

**Analysis for RF measurements**

General result analysis settings concerning the trace, markers, lines etc. for RF measurements are identical to the analysis functions in the Spectrum application except for some special marker functions and spectrograms, which are not available in the R&S FSW 802.11ad/ay applications.

For details see the "General Measurement Analysis and Display" chapter in the FSW User Manual.



### 9.9.1 Working with markers



#### 9.9.1.1 Individual marker settings

**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 84

**CALCulate<n>:MARKer<ms>:LINK:TO:MARKer<md>** <State>

Links the normal source marker <ms> to any active destination marker <md> (normal or delta marker).

If you change the horizontal position of marker <md>, marker <ms> changes its horizontal position to the same value.

**Suffix:**

<n> Window

<ms> source marker, see Marker

<md> destination marker, see Marker

**Parameters:**

<State> ON | OFF | 0 | 1

**OFF | 0**
Switches the function off

**ON | 1**
Switches the function on

**Example:** `CALC:MARK4:LINK:TO:MARK2 ON`
Links marker 4 to marker 2.

**Manual operation:** See "Linking to Another Marker" on page 84

**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 "Delta Marker 1 / Marker 2 / Marker 3 / ... Marker 16 / Norm / Delta" on page 82
See "Marker State" on page 83
See "Marker Type" on page 83

---

**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 6**
Trace number the marker is assigned to.

**Example:** //Assign marker to trace 1
`CALC:MARK3:TRAC 2`

**Manual operation:** See "Assigning the Marker to a Trace" on page 84

---

**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 31
See "Marker Peak List" on page 32
See "Delta Marker 1 / Marker 2 / Marker 3 / ... Marker 16 / Norm / Delta" on page 82
See "X-value" on page 83

---

**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`

**Manual operation:** See "Linking to Another Marker" on page 84

**CALCulate<n>:DELTamarker<ms>:LINK:TO:MARKer<md>** <State>

Links the delta source marker <ms> to any active destination marker <md> (normal or delta marker).

**Suffix:**

| | |
|---|---|
| <n> | Window |
| <ms> | source marker, see Marker |
| <md> | destination marker, see Marker |

**Parameters:**

<State> ON | OFF | 0 | 1

**OFF | 0**
Switches the function off

**ON | 1**
Switches the function on

**Example:** `CALC:DELT4:LINK:TO:MARK2 ON`
Links the delta marker 4 to the marker 2.

**Manual operation:** See "Linking to Another Marker" on page 84

**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> **D1**
Selects the deltamarker 1 as the 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 83

**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 "Delta Marker 1 / Marker 2 / Marker 3 / ... Marker 16 / Norm / Delta" on page 82
See "Marker State" on page 83
See "Marker Type" on page 83

---

**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 "Delta Marker 1 / Marker 2 / Marker 3 / ... Marker 16 / Norm / Delta" on page 82
See "X-value" on page 83

### 9.9.1.2 General marker settings



---

**CALCulate<n>:MARKer<m>:LINK** <State>

Defines whether the markers in all diagrams with the same x-axis are linked. If enabled, and you move one marker along the x-axis, all other markers are moved to the same x-axis position.

**Suffix:**

<m> irrelevant

<n> irrelevant

**Parameters:**

<State> ON | OFF | 1 | 0

*RST: 0

**Example:** `CALC2:MARK:LINK ON`

Links all markers across all diagrams. The window selection `2` is irrelevant.

---

**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 85

---

**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.

**AUTO**
Turns on the marker table if 3 or more markers are active.

*RST: AUTO

**Example:** `DISP:MTAB ON`
Activates the marker table.

**Manual operation:** See "Marker Table Display" on page 85

### 9.9.1.3 Configuring and performing a marker search

The following commands control the 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`

---

**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

### 9.9.1.4 Positioning the marker

This chapter contains remote commands necessary to position the marker on a trace.



#### Positioning normal markers

The following commands position markers on the trace.



---

**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 |

---

**CALCulate<n>:MARKer<m>:MAXimum:NEXT**

Moves a marker to the next positive peak.

**Suffix:**

| | |
|---|---|
| <n> | Window |
| <m> | Marker |

---

**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 |

**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 |

**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 |

**CALCulate<n>:MARKer<m>:MINimum:NEXT**

Moves a marker to the next minimum peak value.

**Suffix:**

| | |
|---|---|
| <n> | Window |
| <m> | Marker |

**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 |

**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 |

### Positioning delta markers

The following commands position delta markers on the trace.



---

**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 |

---

**CALCulate<n>:DELTamarker<m>:MAXimum:NEXT**

Moves a marker to the next positive peak value.

**Suffix:**

| | |
|---|---|
| <n> | 1..n<br>Window |
| <m> | 1..n<br>Marker |

---

**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 |

---

**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 |

---

**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 |

---

**CALCulate<n>:DELTamarker<m>:MINimum:NEXT**

Moves a marker to the next minimum peak value.

**Suffix:**

| | |
|---|---|
| <n> | Window |
| <m> | Marker |

---

**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 |

---

**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 |

## 9.9.2 Configuring standard traces



---

**DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MODE** <Mode>

Selects the trace mode. If necessary, the selected trace is also activated.

For max hold, min hold or average trace mode, you can set the number of single measurements with `[SENSe:]SWEep:COUNt`. Note that synchronization to the end of the measurement is possible only in single sweep mode.

**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.

**AVERage**
The average is formed over several sweeps. The "Sweep/Average Count" determines the number of averaging procedures.

**MAXHold**
The maximum value is determined over several sweeps and displayed. The FSW 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 FSW saves the sweep result in the trace memory only if the new value is lower than the previous one.

**VIEW**
The current contents of the trace memory are frozen and displayed.

**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.

---

**DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>[:STATe]** <State>

Turns a trace on and off.

The measurement continues in the background.

**Suffix:**

<n> Window

<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`

---

**[SENSe:]SWEep:POINts** <SweepPoints>

Sets/queries the number of trace points to be displayed and used for statistical evaluation.

**Parameters:**

<SweepPoints>

---

**[SENSe:]AVERage<n>:COUNt** <AverageCount>
**[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/Average Count" on page 71

---

**[SENSe:]SWEep:COUNt:CURRent?**

**Return values:**
<CurrentCount>

**Usage:** Query only

## 9.10 Retrieving results

The following commands are required to retrieve the results from a IEEE 802.11ad measurement in a remote environment.

The `*OPC` command should be used after commands that retrieve data so that subsequent commands to change the trigger or data capturing settings are held off until after the data capture is completed and the data has been returned.



### 9.10.1 Numeric modulation accuracy results

The following commands describe how to retrieve the numeric results from the standard IEEE 802.11ad measurements.

The commands to retrieve results from SEM measurements for IEEE 802.11ad signals are described in Chapter 9.10.2, "Numeric results for SEM measurements", on page 215.

#### 9.10.1.1 PPDU and symbol count results

The following commands are required to retrieve PPDU and symbol count results from the IEEE 802.11ad Modulation Accuracy measurement on the captured I/Q data (see Chapter 3.1.2, "Modulation accuracy parameters", on page 24).



---

**FETCh:BURSt:COUNt?**

Returns the number of analyzed PPDUs from the current capture buffer.

**Return values:**
<Value> integer

**Usage:** Query only

---

**FETCh:BURSt:LENGths?**

Returns the EVM symbol count of the analyzed PPDUs from the current measurement.

The result is a comma-separated list of symbol counts, one for each PPDU.

**Return values:**
<PPDULength> integer value
number of symbols as counted for the EVM calculation

**Usage:** Query only

---

**FETCh:BURSt:STARts?**

Returns the start position of each analyzed PPDU in the current capture buffer.

**Return values:**
<Position> Comma-separated list of samples indicating the start position of each PPDU.

**Usage:** Query only

#### 9.10.1.2 Error parameter results

The following commands are required to retrieve individual results from the IEEE 802.11ad Modulation Accuracy measurement on the captured I/Q data (see Chapter 3.1.2, "Modulation accuracy parameters", on page 24).

**FETCh:BURSt:ALL?**

Returns all results from the default IEEE 802.11ad I/Q measurement (see "Result Summary" on page 23).

For details on individual parameters see Chapter 3.1.2, "Modulation accuracy parameters", on page 24.

The results are output as a list of result strings separated by commas in ASCII format. The results are output in the following order:

**Return values:**

<Result> <char_data>

<min_EVM_All>,<avg_EVM_All>,<max_EVM_All>,
<min_EVM_Data>,<avg_EVM_Data>,<max_EVM_Data>,
<min_EVM_Pilots>,<avg_EVM_Pilots>,<max_EVM_Pilots>,
<min_IQ_Offset>, <avg_IQ_Offset>,<max_IQ_Offset>,
<min_Gain_Imb>,<avg_Gain_Imb>,<max_Gain_Imb>,
<min_Quad_Error>,<avg_Quad_Error>,<max_Quad_Error>,
<min_CFreqErr>,<avg_CFreqErr>,<max_CFreqErr>,
<min_SymClockErr>,<avg_SymClockErr>,<max_SymClockErr>,
<min_RiseTime>,<avg_RiseTime>,<max_RiseTime>,
<min_FallTime>,<avg_FallTime>,<max_FallTime>,
<min_TimeSkew>,<avg_TimeSkew>,<max_TimeSkew>,
<min_TDPow>,<avg_TDPow>,<max_TDPow>,
<min_CrestFactor>,<avg_CrestFactor>,<max_CrestFactor>,
<min_SNR>,<avg_SNR>,<max_SNR>,
<min_HeadBER>,<avg_HeadBER>,<max_HeadBER>,
<min_PayLBER>,<avg_PayLBER>,<max_PayLBER>,

**Example:**

```
FETC:BURS:ALL?
//Result:
-61.387783,-61.387783,-61.387783,
-61.700256,-61.700256,-61.700256,
-59.464706,-59.464706,-59.464706,
-102.15703,-102.15703,-102.15703,
0.00015738525,0.00015738525,0.00015738525,
-0.00036883022,-0.00036883022,-0.00036883022,
3.0269439,3.0269439,3.0269439,
0.075500488,0.075500488,0.075500488,
0.56818181,0.56818181,0.56818181,
0.18939394,0.18939394,0.18939394,
-0.0021183537,-0.0021183537,-0.0021183537,
3.4685879,3.4685879,3.4685879,
5.9298511,5.9298511,5.9298511,
36.791008,36.791008,36.791008,
0,0,0,
0,0,0
```

**Usage:** Query only

**Manual operation:** See "Result Summary" on page 23

**FETCh:CFACtor:AVERage?**
**FETCh:CFACtor:MAXimum?**
**FETCh:CFACtor:MINimum?**

Returns the average, maximum or minimum crest factor for the PPDU in dB.

For details see "Crest factor [dB]" on page 29.

**Usage:** Query only

**Manual operation:** See "Crest factor [dB]" on page 29

**FETCh:CFERror:AVERage?**
**FETCh:CFERror:MAXimum?**
**FETCh:CFERror:MINimum?**

Returns the average, maximum or minimum center frequency error for the PPDU in Hz.

For details see "Center Frequency Error [Hz]" on page 28.

**Usage:** Query only

**Manual operation:** See "Center Frequency Error [Hz]" on page 28

**FETCh:EVM:ALL:AVERage?**
**FETCh:EVM:ALL:MAXimum?**
**FETCh:EVM:ALL:MINimum?**

Returns the average, maximum or minimum EVM for all symbols for the PPDU in dB.

For details see "EVM All [dB]" on page 25.

**Usage:** Query only

**Manual operation:** See "EVM All [dB]" on page 25

**FETCh:EVM:DATA:AVERage?**
**FETCh:EVM:DATA:MAXimum?**
**FETCh:EVM:DATA:MINimum?**

Returns the average, maximum or minimum EVM for data symbols for the PPDU in dB.

For details see "EVM Data Symbols [dB]" on page 26.

**Usage:** Query only

**Manual operation:** See "EVM Data Symbols [dB]" on page 26

**FETCh:EVM:PILot:AVERage?**
**FETCh:EVM:PILot:MAXimum?**
**FETCh:EVM:PILot:MINimum?**

Returns the average, maximum or minimum EVM for pilot symbols for the PPDU in dB.

For details see "EVM Pilot Symbols [dB]" on page 26.

**Usage:** Query only

**Manual operation:** See "EVM Pilot Symbols [dB]" on page 26

---

**FETCh:FTIMe:AVERage?**
**FETCh:FTIMe:MAXimum?**
**FETCh:FTIMe:MINimum?**

Returns the average, maximum or minimum fall time for the PPDU in s.

For details see "Fall Time [s]" on page 29.

**Usage:** Query only

**Manual operation:** See "Fall Time [s]" on page 29

---

**FETCh:GIMBalance:AVERage?**
**FETCh:GIMBalance:MAXimum?**
**FETCh:GIMBalance:MINimum?**

Returns the average, maximum or minimum gain imbalance for the PPDU in dB.

For details see "Gain Imbalance [%/dB]" on page 26.

**Usage:** Query only

**Manual operation:** See "Gain Imbalance [%/dB]" on page 26

---

**FETCh:IQOFfset:AVERage?**
**FETCh:IQOFfset:MAXimum?**
**FETCh:IQOFfset:MINimum?**

Returns the average, maximum or minimum I/Q offset for the PPDU in dB.

For details see "I/Q Offset [dB]" on page 26.

**Usage:** Query only

**Manual operation:** See "I/Q Offset [dB]" on page 26

---

**FETCh:QUADerror:AVERage?**
**FETCh:QUADerror:MAXimum?**
**FETCh:QUADerror:MINimum?**

Returns the average, maximum or minimum quadrature error for the PPDU in degrees (°).

For details see "Quadrature Error [°]" on page 27.

**Usage:** Query only

**Manual operation:** See "Quadrature Error [°]" on page 27

**FETCh:RTIMe:AVERage?**
**FETCh:RTIMe:MAXimum?**
**FETCh:RTIMe:MINimum?**

Returns the average, maximum or minimum rise time for the PPDU in s.

For details see "Rise Time [s]" on page 28.

**Usage:** Query only

**Manual operation:** See "Rise Time [s]" on page 28

**FETCh:SNR:AVERage?**
**FETCh:SNR:MAXimum?**
**FETCh:SNR:MINimum?**

Returns the average, maximum or minimum signal-to-noise ratio for the PPDU in dB.

For details see "Rise Time [s]" on page 28.

**Usage:** Query only

**Manual operation:** See "SNR" on page 29

**FETCh:SYMBolerror:AVERage?**
**FETCh:SYMBolerror:MAXimum?**
**FETCh:SYMBolerror:MINimum?**

Returns the average, maximum or minimum symbol clock error for the PPDu in ppm.

For details see "Symbol Clock Error [ppm]" on page 28.

**Usage:** Query only

**Manual operation:** See "Symbol Clock Error [ppm]" on page 28

**FETCh:TDPower:AVERage?**
**FETCh:TDPower:MAXimum?**
**FETCh:TDPower:MINimum?**

Returns the average, maximum or minimum time domain power for the PPDU in dBm.

For details see "Time Domain Power [dBm]" on page 29.

**Usage:** Query only

**Manual operation:** See "Time Domain Power [dBm]" on page 29

**FETCh:TSKew:AVERage?**
**FETCh:TSKew:MAXimum?**
**FETCh:TSKew:MINimum?**

Returns the average, maximum or minimum time skew for the PPDU in ps.

For details see "Time Skew [s]" on page 29.

**Usage:** Query only

**Manual operation:** See "Time Skew [s]" on page 29

---

**FETCh:HBERate:AVERage?**
**FETCh:HBERate:MAXimum?**
**FETCh:HBERate:MINimum?**

Returns the average, maximum or minimum Bit Error Rate of the PPDU header.

For details see Chapter 3.1, "IEEE 802.11ad/ay modulation accuracy measurement", on page 13.

**Usage:** Query only

**Manual operation:** See "Header BER" on page 29

---

**FETCh:PBERate:AVERage?**
**FETCh:PBERate:MAXimum?**
**FETCh:PBERate:MINimum?**

Returns the average, maximum or minimum Bit Error Rate of the PPDU payload.

For details see Chapter 3.1.2, "Modulation accuracy parameters", on page 24.

**Usage:** Query only

**Manual operation:** See "Payload BER" on page 29

## 9.10.2 Numeric results for SEM measurements

The following commands are required to retrieve the numeric results of the IEEE 802.11ad SEM measurements (see Chapter 3.2, "SEM measurements", on page 29.

In the following commands used to retrieve the numeric results for RF data, the suffixes <n> for CALCulate and <k> for LIMit are irrelevant.

Useful commands for retrieving SEM results described elsewhere:

- `CALCulate<n>:MARKer<m>:X` on page 196

**Remote commands exclusive to retrieving SEM results:**



---

**CALCulate<n>:LIMit<li>:FAIL?**

Queries the result of a limit check in the specified window.

Note that for SEM measurements, the limit line suffix <li> is irrelevant, as only one specific SEM limit line is checked for the currently relevant power class.

To get a valid result, you have to perform a complete measurement with synchronization to the end of the measurement before reading out the result. This is only possible for single measurement mode.

See also `INITiate<n>:CONTinuous` on page 191.

**Suffix:**

| | |
|---|---|
| <n> | Window |
| <li> | Limit line |

**Return values:**

<Result>

**0**
PASS

**1**
FAIL

**Example:**

`INIT;*WAI`
Starts a new sweep and waits for its end.
`CALC2:LIM3:FAIL?`
Queries the result of the check for limit line 3 in window 2.

**Usage:** Query only

## 9.10.3 Retrieving trace results

The following commands describe how to retrieve the trace data from the IEEE 802.11ad Modulation Accuracy measurement. Note that for these measurements, only 1 trace per window can be configured.

The traces for SEM measurements are identical to those in the Spectrum application.

**Remote commands exclusive to retrieving trace results:**



---

**FORMat[:DATA]** <Format>[, <BitLength>]

Selects the data format that is used for transmission of trace data from the FSW to the controlling computer.

Note that the command has no effect for data that you send to the FSW. The FSW 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".
In the Spectrum application, 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]?** <Trace>

Queries current trace data and measurement results from the specified window.

For details see Chapter 9.10.4, "Measurement results for TRACe<n>[:DATA]? TRACE<n>", on page 218.

**Suffix:**
<n> 1..n
irrelevant

**Query parameters:**
<Trace> Selects the type of result to be returned.

**TRACE1 | ... | TRACE6**
Returns the trace data for the corresponding trace.
Note that for the default IEEE 802.11ad I/Q measurement (Modulation Accuracy, Flatness and Tolerance), only 1 trace per window (TRACE1) is available.
For I/Q data traces, the results depend on the evaluation method (window type) selected for the current window (see `LAYout:ADD[:WINDow]?` on page 178. The results for the various window types are described in Chapter 9.10.4, "Measurement results for TRACe<n>[:DATA]? TRACE<n>", on page 218.
For RF data traces, the trace data consists of a list of 1001 measured power levels. The unit depends on the measurement and on the configured unit.
For SEM measurements, the x-values should be queried as well, as they are not equi-distant (see `TRACe<n>[:DATA]:X?` on page 218).

**LIST**
Returns the results of the peak list evaluation for Spectrum Emission Mask measurements. One peak per range is returned.

**Example:**
`DISP:WIND2:SEL`
`TRAC? TRACE3`
Queries the data of trace 3 in window 2.

**Usage:** Query only

**Manual operation:**
See "Bitstream" on page 14
See "Channel Frequency Response" on page 15
See "Constellation" on page 16
See "EVM vs Symbol" on page 17
See "Freq. Error vs Symbol" on page 18
See "Header information" on page 18
See "Magnitude Capture" on page 19
See "Phase Error vs Symbol" on page 20
See "Phase Tracking vs Symbol" on page 20
See "Power Spectrum" on page 21
See "PvT Full PPDU" on page 22
See "PvT Rising Edge" on page 22
See "PvT Falling Edge" on page 23

---

**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.

This is especially useful for traces with non-equidistant x-values, e.g. for SEM or Spurious Emissions measurements.

**Suffix:**
<n> Window

**Query parameters:**
<TraceNumber> Trace number.
**TRACE1 | TRACE2 | TRACE3 | TRACE4 | TRACE5 | TRACE6**

**Return values:**
<X-Values>

**Example:**
`TRAC3:X? TRACE1`
Returns the x-values for trace 1 in window 3.

**Usage:** Query only

## 9.10.4 Measurement results for TRACe<n>[:DATA]? TRACE<n>

The evaluation method selected by the `LAY:ADD:WIND` command also affects the results of the trace data query (see `TRACe<n>[:DATA]? TRACE<n>`).

Details on the returned trace data depending on the evaluation method are provided here.

No trace data is available for the following evaluation methods:

- "Magnitude Capture"
- "Result Summary" (Global/Detailed)

For details on the graphical results of these evaluation methods, see Chapter 3.1.1, "Evaluation methods for IEEE 802.11ad/ay modulation accuracy measurements", on page 13.



### 9.10.4.1 Bitstream

For a given OFDM symbol and a given subcarrier, the bitstream result is derived from the corresponding complex constellation point according to *Std IEEE802.11-2012 "Figure 18-10—BPSK, QPSK, 16-QAM, and 64-QAM constellation bit encoding"*. The bit pattern (binary representation) is converted to its equivalent integer value as the final measurement result. The number of values returned for each analyzed OFDM symbol corresponds to the number of data subcarriers plus the number of pilot subcarriers ($N_{SD}+N_{SP}$) in remote mode.

As opposed to the graphical "Bitstream" results, the DC and NULL carriers are not available in remote mode.

### 9.10.4.2 Channel frequency response

The "Channel Frequency Response" evaluation returns absolute power values per carrier.

Two trace types are provided for this evaluation:

***Table 9-7: Query parameter and results for Channel Frequency Response***

| | |
|---|---|
| TRACE1 | All channel frequency response values per channel |
| TRACE2 | An average channel frequency response value for each of the 53 (or 57/117 within the IEEE 802.11 n standard) carriers |

Absolute power results are returned in dB.

Supported data formats (FORMat:DATA): ASCii|REAL

### 9.10.4.3 Constellation

This measurement represents the complex constellation points as I and Q data. See for example "*IEEE Std 802.11ad™-2012 'Fig. 21-13 BPSK, Fig. 21-14 QPSK, Fig. 21-15 16-QAM'*".

Data is returned as one pair of I and Q data for each symbol. Each I and Q point is returned in floating point format.

### 9.10.4.4 EVM vs symbol

EVM value as measured for each symbol over the complete capture period.

Each EVM value is returned as a floating point number, expressed in units of dBm.

Supported data formats (see `FORMat[:DATA]` on page 216): `ASCii|REAL`

### 9.10.4.5 Frequency error vs symbol

Frequency offset as measured for each symbol over the complete capture period.

Each offset value is returned as a floating point number, expressed in units of Hz.

### 9.10.4.6 Header info

The `TRAC:DATA?` command returns a comma-separated list of header information results for each analyzed PPDU. The results are returned in the following order:

| Result | Description |
|---|---|
| ID | PPDU number (1..Number of PPDUs captured) |
| Scrambler Initialisa-tion | |
| MCS Index | |
| Length | |
| Additional PPDU | |
| Packet Type | |
| Training Length | |
| Aggregation | |
| Beam Tracking Request | |
| Last RSSI | |
| Turnaround | |

| Result | Description |
|---|---|
| Extended SC MCS | |
| Reserved1 | Currently not supported - always returns 0 |
| Reserved2 | Currently not supported - always returns 0 |
| Reserved3 | Currently not supported - always returns 0 |
| HCS | |

### 9.10.4.7 Magnitude capture

Returns the magnitude for each measurement point as measured over the complete capture period. The number of measurement points depends on the input sample rate and the capture time (see "Sample Rate (IEEE 802.11ad)" on page 61 and "Measurement Time" on page 61).

### 9.10.4.8 Phase error vs symbol

Phase error value as calculated for each symbol over the complete capture period. The number of values is:

<No of symbols> * <No of PPDUs>

Each offset value is returned as a floating point number, expressed in units of degrees (°).

### 9.10.4.9 Phase tracking vs. symbol

Returns the average phase tracking result for each symbol over the complete capture period. The number of values is:

<No of symbols> * <No of PPDUs>

Each value is returned as a floating point number, expressed in units of degrees (°).

### 9.10.4.10 Power spectrum

Returns the power vs frequency values obtained from the FFT. This is an exhaustive call, due to the fact that there are nearly always more FFT points than I/Q samples. The number of FFT points is a power of 2 that is higher than the total number of I/Q samples, i.e.; number of FFT points := round number of I/Q-samples to next power of 2.

E.g. if there were 20000 samples, then 32768 FFT points are returned.

Data is returned in floating point format in dBm.

#### 9.10.4.11 Power vs time (PVT)

All complete PPDUs within the capture time are analyzed in three primary PPDUs. The three primary PPDUs relate to the minimum, maximum and average values across all complete PPDUs. This data is returned in dBm values on a per sample basis. Each sample relates to an analysis of each corresponding sample within each processed PPDU.

For PVT Rising and PVT Falling displays, the results are restricted to the rising or falling edge of the analyzed PPDUs.

The type of PVT data returned is determined by the TRACE number passed as an argument to the SCPI command:

| | |
|---|---|
| TRACE1 | minimum PPDU data values |
| TRACE2 | mean PPDU data values |
| TRACE3 | maximum PPDU data values |

Supported data formats (see `FORMat[:DATA]` on page 216): `ASCii|REAL`

### 9.10.5 Retrieving marker results

The following commands are required to retrieve marker results.

Useful commands for retrieving marker results described elsewhere:

- `CALCulate<n>:DELTamarker<m>:X` on page 199
- `CALCulate<n>:MARKer<m>:X` on page 196

**Remote commands exclusive to retrieving marker results:**



---

**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

**Manual operation:** See "Delta Marker 1 / Marker 2 / Marker 3 / ... Marker 16 / Norm / Delta" on page 82

---

**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 "Delta Marker 1 / Marker 2 / Marker 3 / ... Marker 16 / Norm / Delta" on page 82

---

**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 "Delta Marker 1 / Marker 2 / Marker 3 / ... Marker 16 / Norm / Delta" on page 82

## 9.10.6 Retrieving captured I/Q data

The raw captured I/Q data is output in the form of a list.



---

**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:MEMory?** [<OffsetSamples>,<NoOfSamples>]

Queries the I/Q data currently stored in the capture buffer of the FSW.

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.

In this case, the command returns the same results as `TRACe:IQ:DATA?`. (Note, however, that the `TRAC:IQ:DATA?` command initiates a new measurement before returning the captured values, rather than returning the existing data in the memory.)

This command is not available for traces captured with the optional 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000).

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.
The first half of the list contains the I values, the second half the Q values.
The data format of the individual values depends on `FORMat[:DATA]` on page 216.

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

## 9.10.7 Importing and exporting I/Q data and results

The I/Q data to be evaluated in the R&S FSW 802.11ad/ay applications can not only be measured by the R&S FSW 802.11ad/ay applications itself, it can also be imported to the application, provided it has the correct format. Furthermore, the evaluated I/Q data from the R&S FSW 802.11ad/ay applications can be exported for further analysis in external applications.

For details on importing and exporting I/Q data see the FSW User Manual.



---

**MMEMory:LOAD:IQ:STATe** 1, <FileName>

Restores I/Q data from a file.

**Setting parameters:**

<FileName> string

String containing the path and name of the source 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:** Loads IQ data from the specified file.

**Usage:** Setting only

---

**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.

---

**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

### 9.10.8 Exporting trace results to an ASCII file

Trace results can be exported to an ASCII file for further evaluation in other (external) applications.



---

**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 81

---

**FORMat:DEXPort:GRAPh** <State>

If enabled, all traces for the currently selected graphical result display are included in the export file.

**Parameters:**

<State> ON | OFF | 0 | 1

**OFF | 0**
Switches the function off

**ON | 1**
Switches the function on

*RST: 0

**Manual operation:** See "Export All Traces for Selected Graph" on page 81

---

**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 80

---

**FORMat:DEXPort:TRACes** <Selection>

Selects the data to be included in a data export file (see `MMEMory:STORe<n>:TRACe` on page 228).

**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 80

---

**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 FSW 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 "Export Trace to ASCII File" on page 81

## 9.11 Status registers

The R&S FSW 802.11ad/ay applications uses the standard status registers of the FSW (depending on the measurement type). However, some registers are used differently. Only those differences are described in the following sections.

For details on the common FSW status registers refer to the description of remote control basics in the FSW User Manual.

*RST does not influence the status registers.



### 9.11.1 The STATus:QUEStionable:SYNC register

The `STATus:QUEStionable:SYNC` register contains application-specific information about synchronization errors or errors during pilot symbol detection. If any errors occur in this register, the status bit #11 in the `STATus:QUEStionable` register is set to 1.

Each active channel uses a separate `STATus:QUEStionable:SYNC` register. Thus, if the status bit #11 in the `STATus:QUEStionable` register indicates an error, the error may have occurred in any of the channel-specific `STATus:QUEStionable:SYNC` registers. In this case, you must check the register of each channel to determine which channel caused the error. By default, querying the status of a register always returns the result for the currently selected channel. However, you can specify any other channel name as a query parameter.

***Table 9-8: Meaning of the bits used in the STATus:QUEStionable:SYNC register***

| Bit No. | Meaning |
|---|---|
| 0 | PPDU not found<br>This bit is set if an I/Q measurement is performed and no PPDUs are detected |
| 1 - 14 | These bits are not used. |
| 15 | This bit is always 0. |

### 9.11.2 Querying the status registers

The following commands are required to query the status of the FSW and the R&S FSW 802.11ad/ay applications.

For details on the common FSW status registers refer to the description of remote control basics in the FSW User Manual.

### 9.11.2.1 General status register commands



---

**STATus:PRESet**

Resets the edge detectors and `ENABle` parts of all registers to a defined value. All `PTRansition` parts are set to `FFFFh`, i.e. all transitions from 0 to 1 are detected. All `NTRansition` parts are set to 0, i.e. a transition from 1 to 0 in a `CONDition` bit is not detected. The `ENABle` part of the `STATus:OPERation` and `STATus:QUEStionable` registers are set to 0, i.e. all events in these registers are not passed on.

**Usage:** Event

---

**STATus:QUEue[:NEXT]?**

Queries the most recent error queue entry and deletes it.

Positive error numbers indicate device-specific errors, negative error numbers are error messages defined by SCPI. If the error queue is empty, the error number 0, "No error", is returned.

**Usage:** Query only

### 9.11.2.2 Reading out the EVENt part

---

**STATus:OPERation[:EVENt]?**
**STATus:QUEStionable[:EVENt]?**
**STATus:QUEStionable:SYNC[:EVENt]?** <ChannelName>

Reads out the EVENt section of the status register.

The command also 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.

**Usage:** Query only

### 9.11.2.3 Reading out the CONDition part

**STATus:OPERation:CONDition?**
**STATus:QUEStionable:CONDition?**
**STATus:QUEStionable:SYNC:CONDition?** <ChannelName>

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.<br>The parameter is optional. If you omit it, the command works for the currently active channel. |
| **Usage:** | Query only |

### 9.11.2.4 Controlling the ENABle part

**STATus:OPERation:ENABle** <SumBit>
**STATus:QUEStionable:ENABle** <SumBit>
**STATus:QUEStionable:SYNC:ENABle** <BitDefinition>, <ChannelName>

Controls the ENABle part of a register.

The ENABle part allows true conditions in the EVENt part of the status register to be reported in the summary bit. If a bit is 1 in the enable register and its associated event bit transitions to true, a positive transition will occur in the summary bit reported to the next higher level.

**Parameters:**

| | |
|---|---|
| <BitDefinition> | Range: 0 to 65535 |
| <ChannelName> | String containing the name of the channel.<br>The parameter is optional. If you omit it, the command works for the currently active channel. |

### 9.11.2.5 Controlling the negative transition part

**STATus:OPERation:NTRansition** <SumBit>
**STATus:QUEStionable:NTRansition** <SumBit>
**STATus:QUEStionable:SYNC:NTRansition** <BitDefinition>[,<ChannelName>]

Controls the Negative TRansition part of a register.

Setting a bit causes a 1 to 0 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding EVENt register.

**Parameters:**

| | |
|---|---|
| <BitDefinition> | 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.

#### 9.11.2.6 Controlling the positive transition part

**STATus:OPERation:PTRansition** <SumBit>
**STATus:QUEStionable:PTRansition** <SumBit>
**STATus:QUEStionable:SYNC:PTRansition** <BitDefinition>[,<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.

**Parameters:**

<BitDefinition> 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.

## 9.12 Programming examples (R&S FSW 802.11ad/ay applications)

This example demonstrates how to configure a IEEE 802.11ad measurement in a remote environment.



### 9.12.1 Measurement 1: measuring modulation accuracy for IEEE 802.11ad signals

This example demonstrates how to configure a IEEE 802.11ad I/Q measurement according to the IEEE 802.11ad standard in a remote environment.

Note that some commands may not be necessary as they reflect the default settings, but are included to demonstrate the commands.

```
//---------- Preparing the application ------------
// Preset the instrument
*RST
// Enter the 802.11ad option K95
INSTrument:SELect WiGig
// Switch to single sweep mode and stop sweep
INITiate:CONTinuous OFF;:ABORt
```

```
//---------- Configuring the result display ------------
// Activate following result displays:
// 1: Magnitude Capture (default, top)
// 2: Bitstream of data, decoded (lower left)
// 3: Result Summary (default, lower right)
// 4: EVM vs Symbol (next to Mag Capt)

LAY:ADD:WIND? '1',RIGH,EVSY
//Result: '4'
LAY:REPL:WIND '2',DDBS


//---------- Configuring Data Acquisition ---------------------
//Each measurement captures data for 1 ms.
SWE:TIME 1ms
//Perform 10 measurements
SENS:SWE:COUN 10
//Set the input sample rate for the captured I/Q data to 2.64 GHz
TRAC:IQ:SRAT 2.64GHZ

// Number of samples captured per measurement: 0.001s * 2.64e9 samples per second
// = 2 640 000 samples



//---------- Tracking -----------------
//Disable all tracking and compensation functions
SENS:TRAC:LEV OFF
SENS:TRAC:PHAS OFF
SENS:TRAC:IQMC OFF


//---------- Result configuration settings --------------------
//Define units for EVM (dBm)and bitstream (hexa) results
CALC:UNIT:POW DBM
FORM:BSTR HEXA

//---------- Performing the Measurements -----
// Run 10 (blocking) single measurements
INITiate:IMMediate;*WAI

//---------- Evaluation range settings -----------------
//Analyze only the first PPDU
SENS:BURS:SEL:STAT ON
SENS:BURS:SEL 1

//---------- Retrieving Results -------------
//Query the I/Q data from magnitude capture buffer for first ms
// 2 640 000 samples per second -> 2640 samples
TRACe1:IQ:DATA:MEMory? 0,2640
```

```
//Note: result will be too long to display in IECWIN, but is stored in log file
//Query the I/Q data from magnitude capture buffer for second ms
TRACe1:IQ:DATA:MEMory? 2641,5282
//Note: result will be too long to display in IECWIN, but is stored in log file


//Query the current EVM vs symbol trace (window 4)
TRAC4:DATA? TRACE1
//Note: result will be too long to display in IECWIN, but is stored in log file

//Query the result of the average EVM for all symbols in the PPDU
FETC:EVM:ALL:AVER?

//---------- Exporting Captured I/Q Data-------------
//Store the captured I/Q data to a file.
MMEM:STOR:IQ:STAT 1, 'C:\R_S\Instr\user\data.iq.tar'
```

### 9.12.2 Measurement 2: determining the spectrum emission mask

```
//---------- Preparing the application ------------
*RST
//Reset the instrument
INST:CRE:NEW WiGig,'SEMMeasurement'
//Activate a 802.11ad measurement channel named "SEMMeasurement"

//---------- Configuring the measurement ------------
DISP:TRAC:Y:SCAL:RLEV 0
//Set the reference level to 0 dBm
FREQ:CENT 2.1175 GHz
//Set the center frequency to 2.1175 GHz
SENS:SWE:MODE ESP
//Select the spectrum emission mask measurement

//---------- Performing the Measurement-----
INIT:CONT OFF
//Stops continuous sweep
SWE:COUN 100
//Sets the number of sweeps to be performed to 100
INIT;*WAI
//Start a new measurement with 100 sweeps and wait for the end

//---------- Retrieving Results-------------
CALC:LIM:FAIL?
//Queries the result of the limit check
//Result: 0 [passed]
TRAC:DATA? LIST
//Retrieves the peak list of the spectrum emission mask measurement
//Result:
//+1.000000000,-1.275000000E+007,-8.500000000E+006,+1.000000000E+006,
```

```
//+2.108782336E+009,-8.057177734E+001,-7.882799530E+001,-2.982799530E+001,
//+0.000000000,+0.000000000,+0.000000000,

//+2.000000000,-8.500000000E+006,-7.500000000E+006,+1.000000000E+006,
//+2.109000064E+009,-8.158547211E+001,-7.984169006E+001,-3.084169006E+001,
//+0.000000000,+0.000000000,+0.000000000,

//+3.000000000,-7.500000000E+006,-3.500000000E+006,+1.000000000E+006,
//+2.113987200E+009,-4.202708435E+001,-4.028330231E+001,-5.270565033,
//+0.000000000,+0.000000000,+0.000000000,

// [...]
```

*Table 9-9: Trace results for SEM measurement*

| Range No. | Start freq. [Hz] | Stop freq. [Hz] | RBW [Hz] | Freq. peak power [Hz] | Abs. peak power [dBm] | Rel. peak power [%] | Delta to margin [dB] | Limit check result | - | - | - |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | +1.000000000 | -1.275000000E+007 | -8.500000000E+006 | +1.000000000E+006 | +2.108782336E+009 | -8.057177734E+001 | -7.882799530E+001 | -2.982799530E+001 | +0.000000000 | +0.000000000 | +0.000000000 |
| 2 | +2.000000000 | -8.500000000E+006 | -7.500000000E+006 | +1.000000000E+006 | +2.109000064E+009 | -8.158547211E+001 | -7.984169006E+001 | -3.084169006E+001 | +0.000000000 | +0.000000000 | +0.000000000 |
| 3 | +3.000000000 | -7.500000000E+006 | -3.500000000E+006 | +1.000000000E+006 | +2.113987200E+009 | -4.202708435E+001 | -4.028330231E+001 | -5.270565033 | +0.000000000 | +0.000000000 | +0.000000000 |
| ... | ... | | | | | | | | | | |

# Annex

# A References

[1] IEEE: IEEE Std 802.11ad™-2012. Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 3: Enhancements for Very High Throughput in the 60 GHz Band

# List of commands (802.11ad)

# Index