R&S®FSW-K91
WLAN Measurements
User Manual

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Test & Measurement

User Manual

ROHDE&SCHWARZ

This manual applies to the following R&S®FSW models with firmware version 2.40 and higher:

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

The following firmware options are described:

- R&S FSW-K91 WLAN 802.11a (1313.1500.02)
- R&S FSW-K91ac WLAN 802.11ac (1313.4209.02)
- R&S FSW-K91n WLAN 802.11n (1313.1516.02)
- R&S FSW-K91p WLAN 802.11p (1321.5646.02)

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The following abbreviations are used throughout this manual: R&S®FSW is abbreviated as R&S FSW.

Contents

1 Preface

1.1 About this Manual

This WLAN User Manual provides all the information **specific to the application**. All general instrument functions and settings common to all applications and operating modes are described in the main R&S FSW User Manual.

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

- Chapter 2, "Welcome to the WLAN Application", on page 9
  Introduction to and getting familiar with the application
- Chapter 3, "Measurements and Result Displays", on page 13
  Details on supported measurements and their result types
- Chapter 4, "Measurement Basics", on page 57
  Background information on basic terms and principles in the context of the measurement
- Chapter 5, "Configuration", on page 90 and Chapter 6, "Analysis", on page 177
  A concise description of all functions and settings available to configure measurements and analyze results with their corresponding remote control command
- Chapter 7.1, "Import/Export Functions", on page 178
  Description of general functions to import and export raw I/Q (measurement) data
- Chapter 8, "How to Perform Measurements in the WLAN Application", on page 182
  The basic procedure to perform each measurement and step-by-step instructions for more complex tasks or alternative methods
- Chapter 9, "Optimizing and Troubleshooting the Measurement", on page 191
  Hints and tips on how to handle errors and optimize the test setup
- Chapter 10, "Remote Commands for WLAN 802.11 Measurements", on page 194
  Remote commands required to configure and perform WLAN measurements in a remote environment, sorted by tasks
  (Commands required to set up the environment or to perform common tasks on the instrument are provided in the main R&S FSW User Manual)
  Programming examples demonstrate the use of many commands and can usually be executed directly for test purposes
- Chapter A, "Annex: Reference", on page 366
  Reference material
- **List of remote commands**
  Alphabetical list of all remote commands described in the manual
- **Index**

1.2 Documentation Overview

The user documentation for the R&S FSW consists of the following parts:

- "Getting Started" printed manual
- Online Help system on the instrument
- User manuals and online manual for base unit and options provided on the product page
- Service manual provided on the internet for registered users
- Instrument security procedures provided on the product page
- Release notes provided on the product page
- Data sheet and brochures provided on the product page
- Application notes provided on the Rohde & Schwarz website

You find the user documentation on the R&S FSW product page mainly at:

http://www.rohde-schwarz.com/product/FSW > "Downloads" > "Manuals"

Additional download paths are stated directly in the following abstracts of the documentation types.

Getting Started

Introduces the R&S 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.

Online Help

Offers quick, context-sensitive access to the information needed for operation and programming. It contains the description for the base unit and the software options. The Online Help is embedded in the instrument's firmware; it is available using the ? icon on the toolbar of the R&S FSW.

User Manuals and Online Manual

Separate manuals are provided for the base unit and the software options:

- **Base unit** manual
  Contains the description of the graphical user interface, an introduction to remote control, the description of all SCPI remote control commands, programming examples, and information on maintenance, instrument interfaces and error messages. Includes the contents of the **Getting Started** manual.
- **Software option** manuals
  Describe the specific functions of the option. Basic information on operating the R&S FSW is not included.

The **online manual** provides the contents of the user manuals for the base unit and all software options for immediate display on the internet.

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).

Instrument Security Procedures

Deals with security issues when working with the R&S FSW in secure areas.

Data Sheet and Brochures

The data sheet contains the technical specifications of the R&S FSW. Brochures provide an overview of the instrument and deal with the specific characteristics, see:

http://www.rohde-schwarz.com/product/FSW > "Downloads" > "Brochures and Data Sheets"

Release Notes

Describes the firmware installation, new and modified features and fixed issues according to the current firmware version. You find the latest version at:

http://www.rohde-schwarz.com/product/FSW > "Firmware"

Application Notes, Application Cards, White Papers, etc.

These documents deal with special applications or background information on particular topics, see:

http://www.rohde-schwarz.com/ > "Downloads" > "Applications".

1.3 Conventions Used in the Documentation

1.3.1 Typographical Conventions

The following text markers are used throughout this documentation:

Convention	Description
"Graphical user interface elements"	All names of graphical user interface elements on the screen, such as dialog boxes, menus, options, buttons, and softkeys are enclosed by quotation marks.
KEYS	Key names are written in capital letters.
`File names, commands, program code`	File names, commands, coding samples and screen output are distinguished by their font.
Input	Input to be entered by the user is displayed in italics.

Convention	Description
Links	Links that you can click are displayed in blue font.
"References"	References to other parts of the documentation are enclosed by quotation marks.

1.3.2 Conventions for Procedure Descriptions

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

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

1.3.3 Notes on Screenshots

When describing the functions of the product, we use sample screenshots. These screenshots are meant to illustrate as much as possible of the provided functions and possible interdependencies between parameters.

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

2 Welcome to the WLAN Application

The R&S FSW WLAN application extends the functionality of the R&S FSW to enable accurate and reproducible Tx measurements of a WLAN device under test (DUT) in accordance with the standards specified for the device. The following standards are currently supported (if the corresponding firmware option is installed):

- IEEE standards 802.11a
- IEEE standards 802.11ac (SISO + MIMO)
- IEEE standards 802.11b
- IEEE standards 802.11g (OFDM)
- IEEE standards 802.11g (DSSS)
- IEEE standards 802.11j
- IEEE standards 802.11n (SISO + MIMO)
- IEEE standards 802.11p

The R&S FSW WLAN application features:

Modulation measurements

- Constellation diagram for demodulated signal
- Constellation diagram for individual carriers
- I/Q offset and I/Q imbalance
- Modulation error (EVM) for individual carriers or symbols
- Amplitude response and group-delay distortion (spectrum flatness)
- Carrier and symbol frequency errors

Further measurements and results

- Amplitude statistics (CCDF) and crest factor
- FFT, also over a selected part of the signal, e.g. preamble
- Payload bit information
- Freq/Phase Err vs. Preamble

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

Functions that are not discussed in this manual are the same as in the Spectrum application and are described in the R&S FSW User Manual. The latest version is available for download at the product homepage

http://www2.rohde-schwarz.com/product/FSW.html.

Installation

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

2.1 Starting the WLAN Application

The WLAN measurements require a special application on the R&S FSW.

To activate the WLAN application

1. Select the MODE key.

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

2. Select the "WLAN" item.

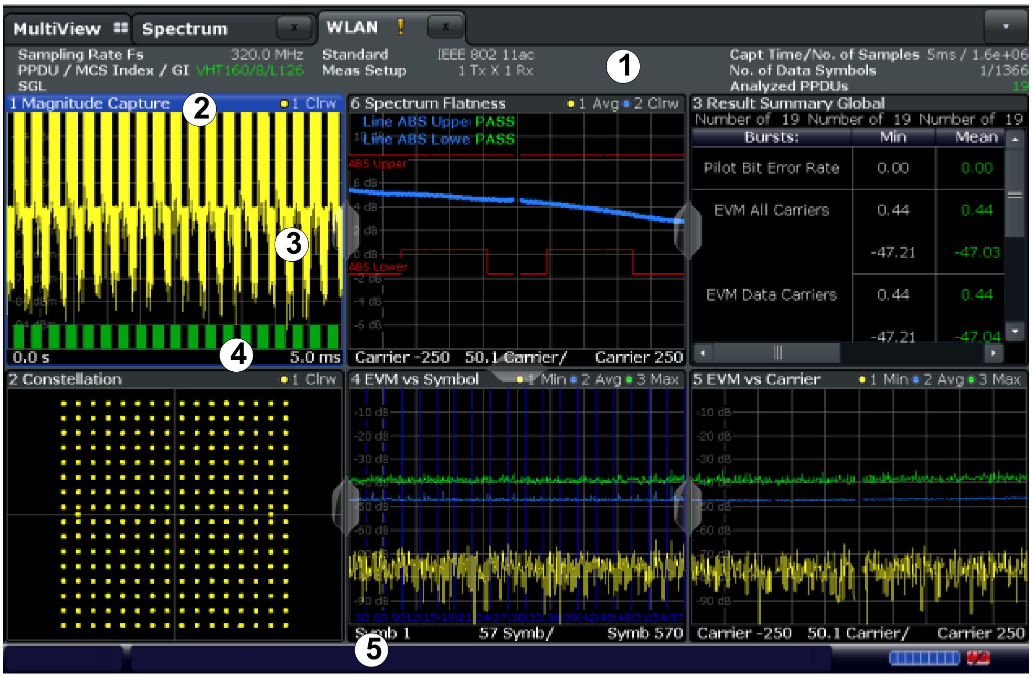
   

   The R&S FSW opens a new measurement channel for the WLAN application.

The measurement is started immediately with the default settings. It can be configured in the WLAN "Overview" dialog box, which is displayed when you select the "Overview" softkey from any menu (see Chapter 5.3.1, "Configuration Overview", on page 93).

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.



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

MSRA operating mode

In MSRA operating mode, additional tabs and elements are available. A colored background of the screen behind the measurement channel tabs indicates that you are in MSRA operating mode.

For details on the MSRA operating mode see the R&S FSW MSRA User Manual.

Channel bar information

In the WLAN application, the R&S FSW shows the following settings:

Table 2-1: Information displayed in the channel bar in the WLAN application

Label	Description
Sample Rate Fs	Input sample rate
PPDU / MCS Index / GI	WLAN 802.11**a, ac, n, j, p**: The PPDU type, MCS Index and Guard Interval used for the analysis of the signal; Depending on the demodulation settings, these values are either detected automatically from the signal or the user settings are applied.
PPDU / Data Rate	WLAN 802.11**b**: The PPDU type and data rate used for the analysis of the signal; Depending on the demodulation settings, these values are either detected automatically from the signal or the user settings are applied.
Standard	Selected WLAN measurement standard
Meas Setup	Number of Transmitter (Tx) and Receiver (Rx) channels used in the measurement (for MIMO)
Capt time / No. of Samples	Duration of signal capture and number of samples captured
No. of Data Symbols	The minimum and maximum number of data symbols that a PPDU may have if it is to be considered in results analysis.
Analyzed PPDUs [x of y (z)]	For statistical evaluation over PPDUs (see "PPDU Statistic Count / No of PPDUs to Analyze" on page 160): <x> PPDUs of totally required <y> PPDUs have been analyzed so far. <z> PPDUs were analyzed in the most recent sweep.

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

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 (see also .

3 Measurements and Result Displays

The R&S FSW WLAN application provides several different measurements in order to determine the parameters described by the WLAN 802.11 specifications.

For details on selecting measurements see "Selecting the measurement type" on page 90.

3.1 WLAN I/Q Measurement (Modulation Accuracy, Flatness and Tolerance)

The default WLAN I/Q measurement captures the I/Q data from the WLAN signal using a (nearly rectangular) filter with a relatively large bandwidth. The I/Q data captured with this filter includes magnitude and phase information, which allows the R&S FSW WLAN application to demodulate broadband signals and determine various characteristic signal parameters such as the modulation accuracy, spectrum flatness, center frequency tolerance and symbol clock tolerance in just one measurement.

Other parameters specified in the WLAN 802.11 standard require a better signal-to-noise level or a smaller bandwidth filter than the I/Q measurement provides and must be determined in separate measurements (see Chapter 3.2, "Frequency Sweep Measurements", on page 50).

3.1.1 Modulation Accuracy, Flatness and Tolerance Parameters

The default WLAN I/Q measurement (Modulation Accuracy, Flatness,...) captures the I/Q data from the WLAN signal and determines all the following I/Q parameters in a single sweep.

Table 3-1: WLAN I/Q parameters for IEEE 802.11a, g (OFDM), ac, j, n, p

Parameter	Description
General measurement parameters	
Sample Rate Fs	Input sample rate
PPDU	Type of analyzed PPDUs
MCS Index	Modulation and Coding Scheme (MCS) index of the analyzed PPDUs
Data Rate	Data rate used for analysis of the signal (IEEE 802.11A ONLY)
***)** the limits can be changed via remote control (not manually, see Chapter 10.5.9, "Limits", on page 284); in this case, the currently defined limits are displayed here	

Parameter	Description
GI	Guard interval length for current measurement
Standard	Selected WLAN measurement standard
Meas Setup	Number of Transmitter (Tx) and Receiver (Rx) channels used in the measurement
Capture time	Duration of signal capture
No. of Samples	Number of samples captured
No. of Data Symbols	The minimum and maximum number of data symbols that a PPDU may have if it is to be considered in results analysis.
Analyzed PPDUs	For statistical evaluation of PPDUs (see "PPDU Statistic Count / No of PPDUs to Analyze" on page 160): <x> PPDUs of totally required <y> PPDUs have been analyzed so far. <z> indicates the number of analyzed PPDUs in the most recent sweep.
Number of recognized PPDUs (global)	Number of PPDUs recognized in capture buffer
Number of analyzed PPDUs (global)	Number of analyzed PPDUs in capture buffer
Number of analyzed PPDUs in physical channel	Number of PPDUs analyzed in entire signal (if available)
TX and Rx carrier parameters	
I/Q offset [dB]	Transmitter center frequency leakage relative to the total Tx channel power (see Chapter 3.1.1.1, "I/Q Offset", on page 17)
Gain imbalance [%/dB]	Amplification of the quadrature phase component of the signal relative to the amplification of the in-phase component (see Chapter 3.1.1.2, "Gain Imbalance", on page 17)
Quadrature offset [°]	Deviation of the quadrature phase angle from the ideal 90° (see Chapter 3.1.1.3, "Quadrature Offset", on page 18).
I/Q skew [s]	Delay of the transmission of the data on the I path compared to the Q path (see Chapter 3.1.1.4, "I/Q Skew", on page 19)
PPDU power [dBm]	Mean PPDU power
Crest factor [dB]	The ratio of the peak power to the mean power of the signal (also called Peak to Average Power Ratio, PAPR).
MIMO Cross Power [dB]	
Center frequency error [Hz]	Frequency error between the signal and the current center frequency of the R&S FSW; the corresponding limits specified in the standard are also indicated***)** The absolute frequency error includes the frequency error of the R&S FSW and that of the DUT. If possible, the transmitterR&S FSW and the DUT should be synchronized (using an external reference). See R&S FSW User Manual > Instrument setup > External reference
***)** the limits can be changed via remote control (not manually, see Chapter 10.5.9, "Limits", on page 284); in this case, the currently defined limits are displayed here	

Parameter	Description
Symbol clock error [ppm]	Clock error between the signal and the sample clock of the R&S FSW in parts per million (ppm), i.e. the symbol timing error; the corresponding limits specified in the standard are also indicated ***)** If possible, the transmitterR&S FSW and the DUT should be synchronized (using an external reference). See R&S FSW User Manual > Instrument setup > External reference
CPE	Common phase error
Stream parameters	
Pilot bit error rate [%]	
EVM all carriers [%/dB]	EVM (Error Vector Magnitude) of the payload symbols over all carriers; the corresponding limits specified in the standard are also indicated***)**
EVM data carriers [%/dB]	EVM (Error Vector Magnitude) of the payload symbols over all data carriers; the corresponding limits specified in the standard are also indicated***)**
EVM pilot carriers [%/dB]	EVM (Error Vector Magnitude) of the payload symbols over all pilot carriers; the corresponding limits specified in the standard are also indicated***)**
***)** the limits can be changed via remote control (not manually, see Chapter 10.5.9, "Limits", on page 284); in this case, the currently defined limits are displayed here	

Table 3-2: WLAN I/Q parameters for IEEE 802.11b or g (DSSS)

Parameter	Description
Sample Rate Fs	Input sample rate
PPDU	Type of the analyzed PPDU
Data Rate	Data rate used for analysis of the signal
SGL	Indicates single measurement mode (as opposed to continuous)
Standard	Selected WLAN measurement standard
Meas Setup	Number of Transmitter (Tx) and Receiver (Rx) channels used in the measurement
Capture time	Duration of signal capture
No. of Samples	Number of samples captured (= sample rate * capture time)
No. of Data Symbols	The minimum and maximum number of data symbols that a PPDU may have if it is to be considered in results analysis
Analyzed PPDUs	For statistical evaluation of PPDUs (see "PPDU Statistic Count / No of PPDUs to Analyze" on page 160): <x> PPDUs of totally required <y> PPDUs have been analyzed so far. <z> indicates the number of analyzed PPDUs in the most recent sweep.
Number of recognized PPDUs (global)	Number of PPDUs recognized in capture buffer
Number of analyzed PPDUs (global)	Number of analyzed PPDUs in capture buffer
Number of analyzed PPDUs in physical channel	Number of PPDUs analyzed in entire signal (if available)

Parameter	Description
Peak vector error	Peak vector error (EVM) over the complete PPDU including the preamble in % and in dB; calculated according to the IEEE 802.11b or g (DSSS) definition of the normalized error vector magnitude (see "Peak Vector Error (IEEE method)" on page 21); The corresponding limits specified in the standard are also indicated ***)**
PPDU EVM	EVM (Error Vector Magnitude) over the complete PPDU including the preamble in % and dB
I/Q offset [dB]	Transmitter center frequency leakage relative to the total Tx channel power (see Chapter 3.1.1.1, "I/Q Offset", on page 17)
Gain imbalance [%/dB]	Amplification of the quadrature phase component of the signal relative to the amplification of the in-phase component (see Chapter 3.1.1.2, "Gain Imbalance", on page 17)
Quadrature error [°]	Measure for the crosstalk of the Q-branch into the I-branch (see "Gain imbalance, I/Q offset, quadrature error" on page 68).
Center frequency error [Hz]	Frequency error between the signal and the current center frequency of the R&S FSW; the corresponding limits specified in the standard are also indicated***)** The absolute frequency error includes the frequency error of the R&S FSW and that of the DUT. If possible, the transmitterR&S FSW and the DUT should be synchronized (using an external reference). See R&S FSW User Manual > Instrument setup > External reference
Chip clock error [ppm]	Clock error between the signal and the chip clock of the R&S FSW in parts per million (ppm), i.e. the chip timing error; the corresponding limits specified in the standard are also indicated ***)** If possible, the transmitterR&S FSW and the DUT should be synchronized (using an external reference). See R&S FSW User Manual > Instrument setup > External reference
Rise time	Time the signal needs to increase its power level from 10% to 90% of the maximum or the average power (depending on the reference power setting) The corresponding limits specified in the standard are also indicated ***)**
Fall time	Time the signal needs to decrease its power level from 90% to 10% of the maximum or the average power (depending on the reference power setting) The corresponding limits specified in the standard are also indicated ***)**
Mean power [dBm]	Mean PPDU power
Peak power [dBm]	Peak PPDU power
Crest factor [dB]	The ratio of the peak power to the mean power of the PPDU (also called Peak to Average Power Ratio, PAPR).

The R&S FSW WLAN application also performs statistical evaluation over several PPDUs and displays one or more of the following results:

Table 3-3: Calculated summary results

Result type	Description
Min	Minimum measured value
Mean/ Limit	Mean measured value / limit defined in standard
Max/Limit	Maximum measured value / limit defined in standard

3.1.1.1 I/Q Offset

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.

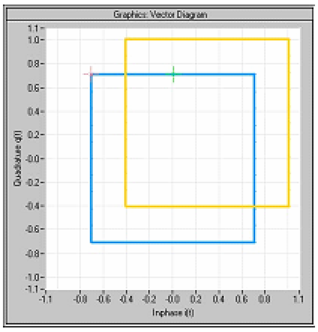


Figure 3-1: I/Q offset in a vector diagram

3.1.1.2 Gain Imbalance

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] = 20log (| $Gain_Q$ |/| $Gain_I$ |)

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)

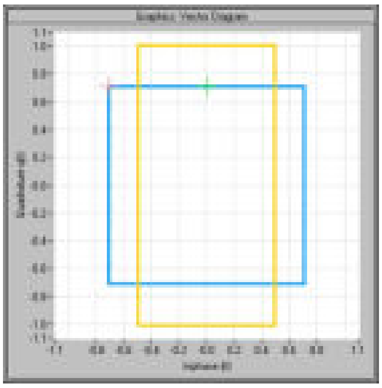


Figure 3-2: Positive gain imbalance

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)

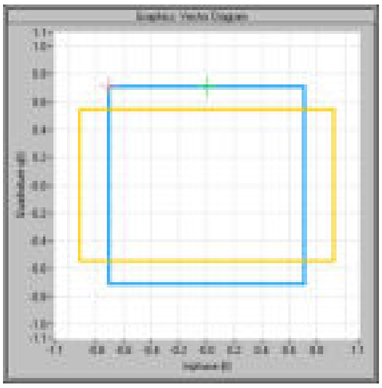


Figure 3-3: Negative gain imbalance

3.1.1.3 Quadrature Offset

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:

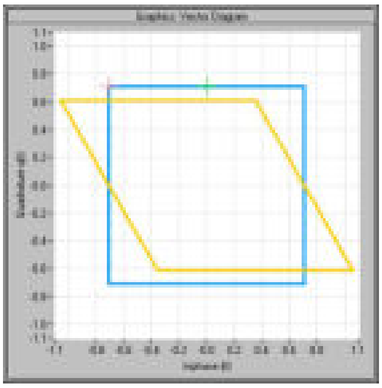


Figure 3-4: Positive quadrature offset

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

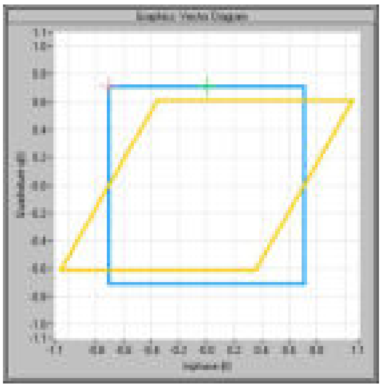


Figure 3-5: Negative quadrature offset

3.1.1.4 I/Q Skew

If transmission of the data on the I path is delayed compared to the Q path, or vice versa, the I/Q data becomes *skewed*.

The I/Q skew results are currently not measured directly, but can be compensated for together with Gain Imbalance and Quadrature Offset (see "I/Q Mismatch Compensation" on page 142).

3.1.1.5 I/Q Mismatch

I/Q mismatch is a comprehensive term for Gain Imbalance, Quadrature Offset, and I/Q Skew.

Compensation for I/Q mismatch is useful, for example, if the device under test is known to be affected by these impairments but the EVM without these effects is of interest. Note, however, that measurements strictly according to IEEE 802.11-2012, IEEE 802.11ac-2013 WLAN standard may not use compensation.

3.1.1.6 RF Carrier Suppression (IEEE 802.11b, g (DSSS))

Standard definition

The RF carrier suppression, measured at the channel center frequency, shall be at least 15 dB below the peak SIN(x)/x power spectrum. The RF carrier suppression shall be measured while transmitting a repetitive 01 data sequence with the scrambler disabled using DQPSK modulation. A 100 kHz resolution bandwidth shall be used to perform this measurement.

Comparison to IQ offset measurement in the R&S FSW WLAN application

The IQ offset measurement in the R&S FSW WLAN application returns the current carrier feedthrough normalized to the mean power at the symbol timings. This measurement does not require a special test signal and is independent of the transmit filter shape.

The RF carrier suppression measured according to the standard is inversely proportional to the IQ offset measured in the R&S FSW WLAN application. The difference (in dB) between the two values depends on the transmit filter shape and should be determined with a reference measurement.

The following table lists the difference exemplarily for three transmit filter shapes (±0.5 dB):

Transmit filter	– IQ-Offset [dB] – RF-Carrier-Suppression [dB]
Rectangular	11 dB
Root raised cosine, "α" = 0.3	10 dB
Gaussian, "α" = 0.3	9 dB

3.1.1.7 EVM Measurement

The R&S FSW WLAN application provides two different types of EVM calculation.

PPDU EVM (Direct method)

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:

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

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.

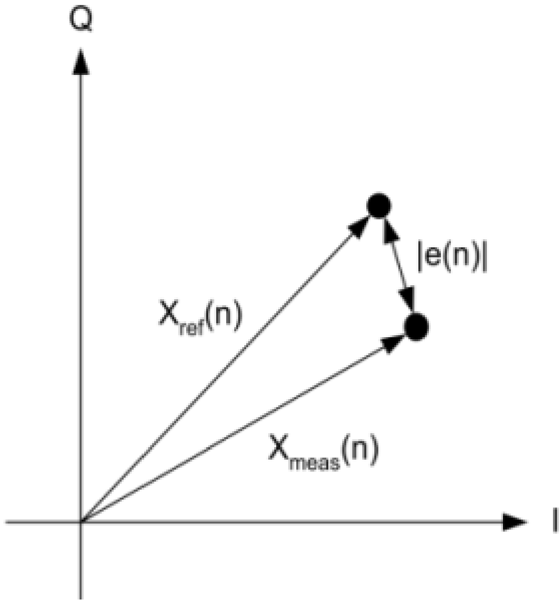


Figure 3-6: I/Q diagram for EVM calculation

Peak Vector Error (IEEE method)

The peak vector error (Peak EVM) is defined in section 18.4.7.8 "Transmit modulation accuracy" of the IEEE 802.11b standard. The phase, timing and gain tracking errors of the measurement signal (center frequency error, common phase error, sampling frequency error) are compensated for before EVM calculation.

The standard does not specify a normalization factor for the error vector magnitude. To get an EVM value that is independent of the level, the R&S FSW WLAN application normalizes the EVM values. Thus, an EVM of 100% indicates that the error power on the I- or Q-channels equals the mean power on the I- or Q-channels, respectively.

The peak vector error is the maximum EVM over all payload symbols and all active carriers for one PPDU. If more than one PPDU is analyzed (several analyzed PPDUs in the capture buffer or due to the PPDU Statistic Count / No of PPDUs to Analyze setting), the Min / Mean / Max columns show the minimum, mean or maximum Peak EVM of all analyzed PPDUs.

The IEEE 802.11b or g (DSSS) standards allow a peak vector error of less than 35%. In contrary to the specification, the R&S FSW WLAN application does not limit the measurement to 1000 chips length, but searches the maximum over the whole PPDU.

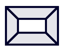
3.1.2 Evaluation Methods for WLAN IQ Measurements

The captured I/Q data from the WLAN signal can be evaluated using various different methods without having to start a new measurement or sweep. Which results are displayed depends on the selected 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 336).

All evaluations available for the selected WLAN measurement are displayed in SmartGrid mode.

To activate SmartGrid mode, do one of the following:

- 

  Select the "SmartGrid" icon from the toolbar.
- Select the "Display Config" button in the configuration "Overview" (see Chapter 5.2, "Display Configuration", on page 92).
- Press the MEAS CONFIG hardkey and then select the "Display Config" softkey.

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.

MIMO measurements

When you capture more than one data stream (MIMO measurement setup, see Chapter 4.3, "Signal Processing for MIMO Measurements (IEEE 802.11ac, n)", on page 70), each result display contains several tabs. The results for each data stream are displayed in a separate tab. In addition, an overview tab is provided in which all data streams are displayed at once, in individual subwindows.

The WLAN measurements provide the following evaluation methods:

AM/AM

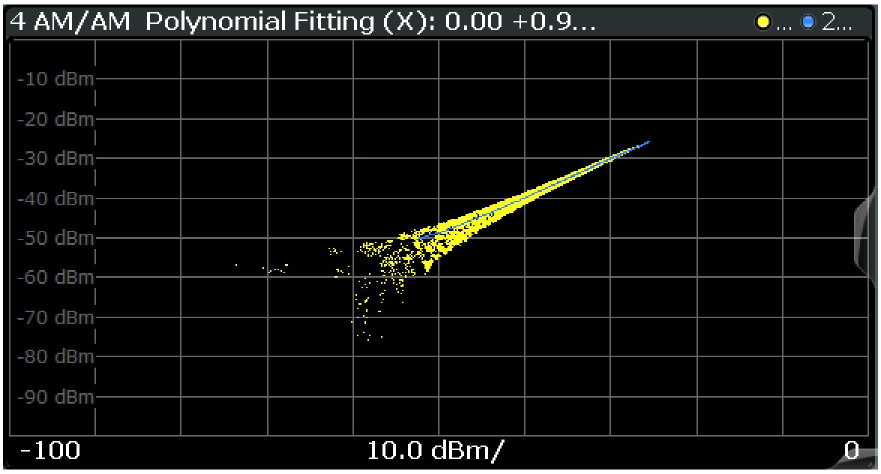
This result display shows the measured and the reference signal in the time domain. For each sample, the x-axis value represents the amplitude of the reference signal and the y-axis value represents the amplitude of the measured signal.

The reference signal is derived from the measured signal after frequency and time synchronization, channel equalization and demodulation of the signal. The equivalent time domain representation of the reference signal is calculated by reapplying all the impairments that have been removed prior to demodulation.

The trace is determined by calculating a *polynomial regression model* of a specified degree (see Chapter 5.3.10.3, "AM/AM Configuration", on page 165) for the scattered measurement vs. reference signal data. The resulting regression polynomial is indicated in the window title of the result display.

Note: The measured signal and reference signal are complex signals.

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).



Remote command:

`LAY:ADD? '1',RIGH,AMAM`, see `LAYout:ADD[:WINDow]?` on page 294

Or:

`CONFigure:BURSt:AM:AM[:IMMediate]` on page 205

Polynomial degree:

`CONFigure:BURSt:AM:AM:POLYnomial` on page 303

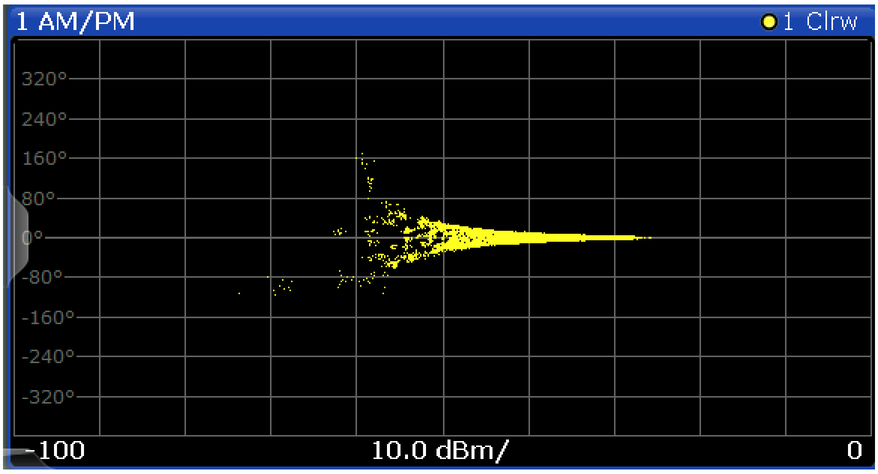
Results:

`TRACe<n>[:DATA]`, see Chapter 10.9.4.1, "AM/AM", on page 342

AM/PM

This result display shows the measured and the reference signal in the time domain. For each sample, the x-axis value represents the amplitude of the reference signal. The y-axis value represents the angle difference of the measured signal minus the reference signal.

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).



Remote command:

LAY:ADD? '1',RIGH,AMPM, see LAYout:ADD[:WINDow]? on page 294

Or:

CONFigure:BURSt:AM:PM[:IMMediate] on page 206

Querying results:

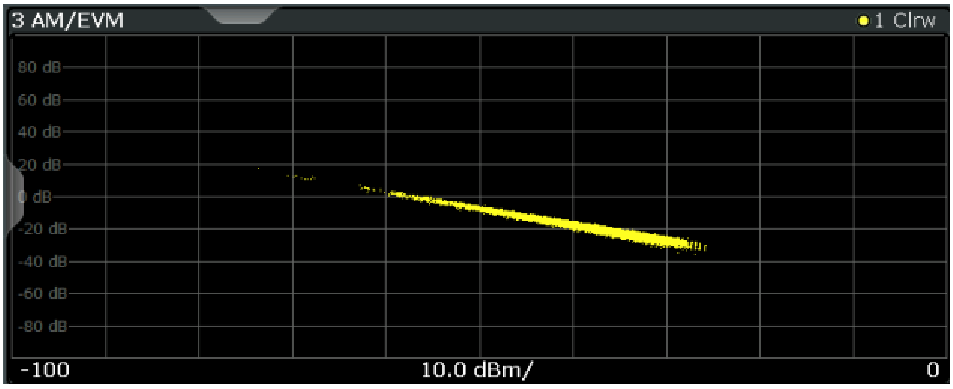
TRACe<n>[:DATA], see Chapter 10.9.4.2, "AM/PM", on page 342

AM/EVM

This result display shows the measured and the reference signal in the time domain. For each sample, the x-axis value represents the amplitude of the reference signal. The y-axis value represents the length of the error vector between the measured signal and the reference signal.

The length of the error vector is normalised with the power of the corresponding reference signal sample.

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).



Remote command:
`LAY:ADD? '1',RIGH,AMEV`, see `LAYout:ADD[:WINDow]?` on page 294
Or:
`CONFigure:BURSt:AM:EVM[:IMMediate]` on page 205
Querying results:
`TRACe<n>[:DATA]`, see Chapter 10.9.4.3, "AM/EVM", on page 342

Bitstream
This result display shows a demodulated payload 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 WLAN standard. See for example *IEEE Std. 802.11-2012 'Fig. 18-10 BPSK, QPSK, 16-QAM and 64-QAM constellation bit encoding'*. Thus, the bitstream is *NOT* channel-decoded.

For multicarrier measurements (**IEEE 802.11a, g (OFDM), ac, j, n, p**) the results are grouped by symbol and carrier.

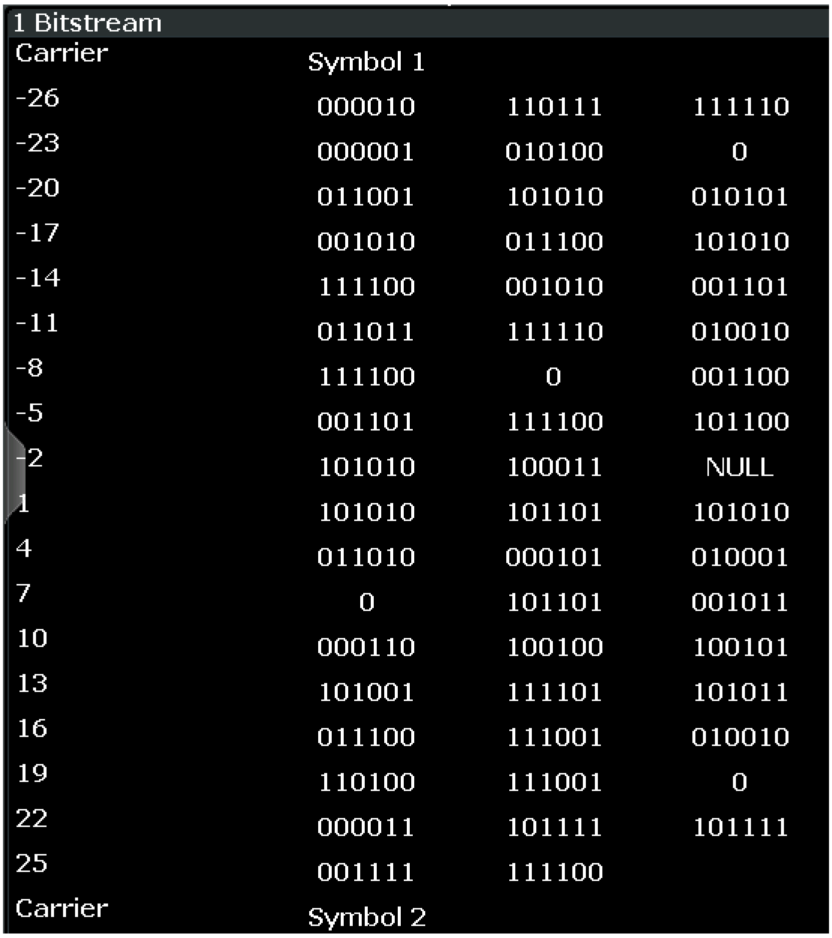


Figure 3-7: Bitstream result display for IEEE 802.11a, g (OFDM), ac, n, p standards

For MIMO measurements (**IEEE 802.11ac, n**) the results are grouped by stream, symbol and carrier.

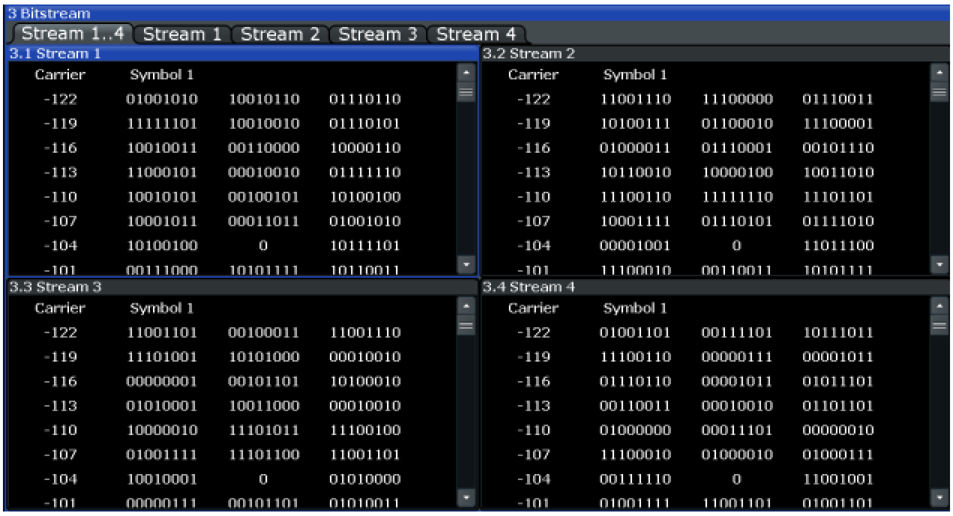


Figure 3-8: Bitstream result display for IEEE 802.11n MIMO measurements

For single-carrier measurements (**IEEE 802.11b, g (DSSS)**) the results are grouped by PPDU.

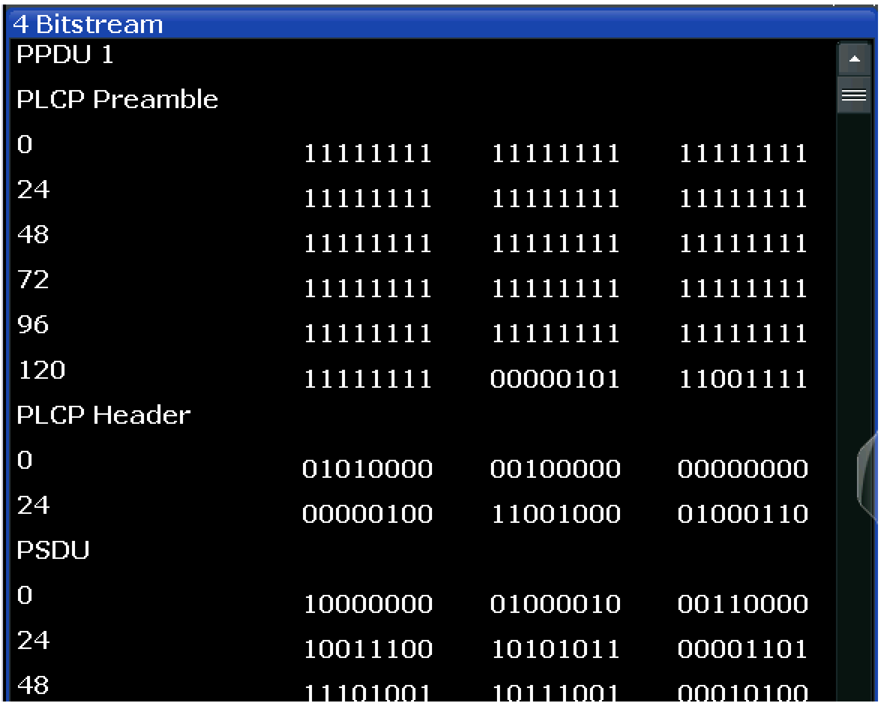


Figure 3-9: Bitstream result display for IEEE 802.11b, g (DSSS) standards

The numeric trace results for this evaluation method are described in Chapter 10.9.4.4, "Bitstream", on page 342.

Remote command:
`LAY:ADD? '1',RIGH, BITS`, see `LAYout:ADD[:WINDow]?` on page 294
Or:
`CONFigure:BURSt:STATistics:BSTReam[:IMMediate]` on page 210
Querying results:
`TRACe<n>[:DATA]`, see Chapter 10.9.4.4, "Bitstream", on page 342

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.

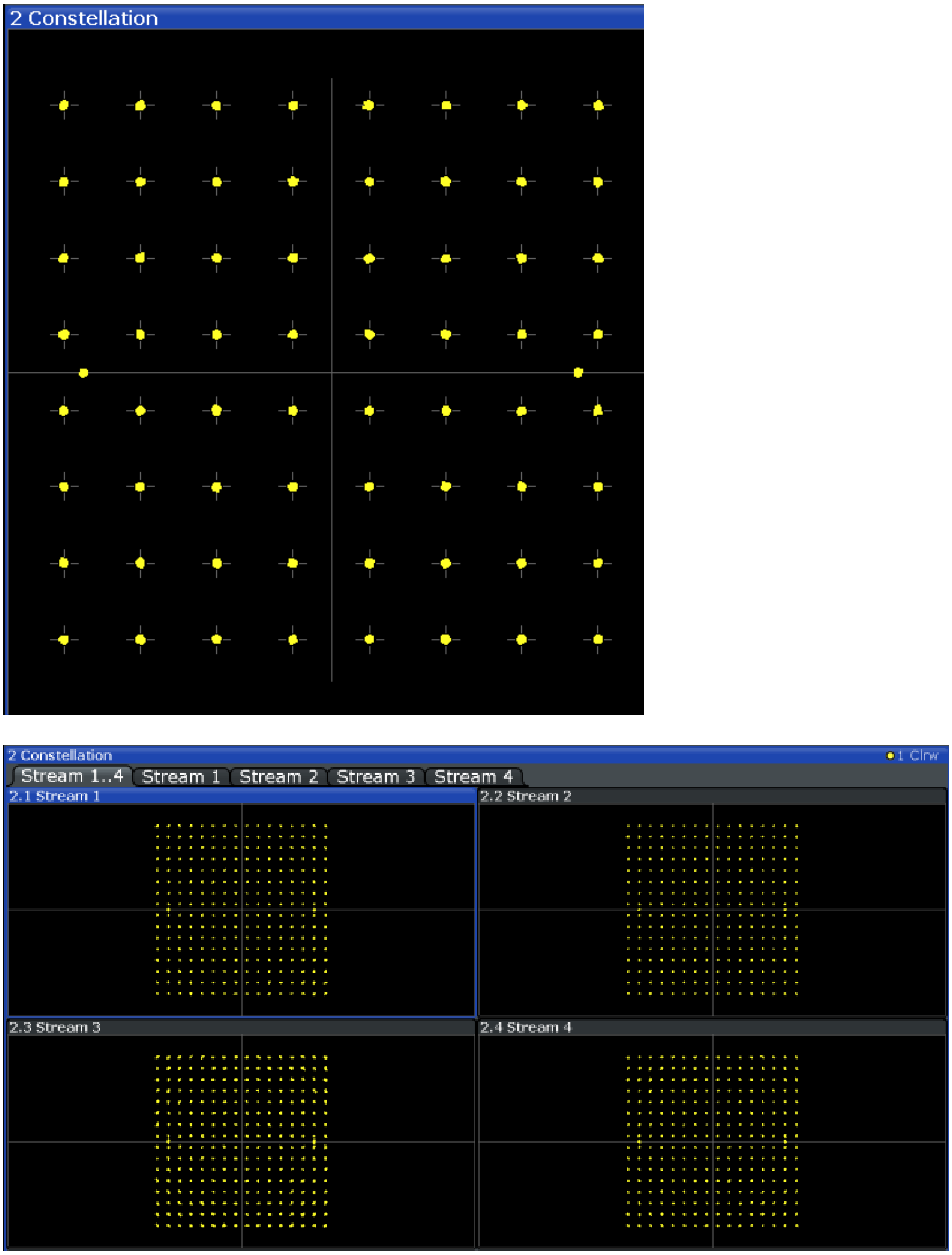


Figure 3-10: Constellation result display for IEEE 802.11n MIMO measurements

The numeric trace results for this evaluation method are described in Chapter 10.9.4.6, "Constellation", on page 344.

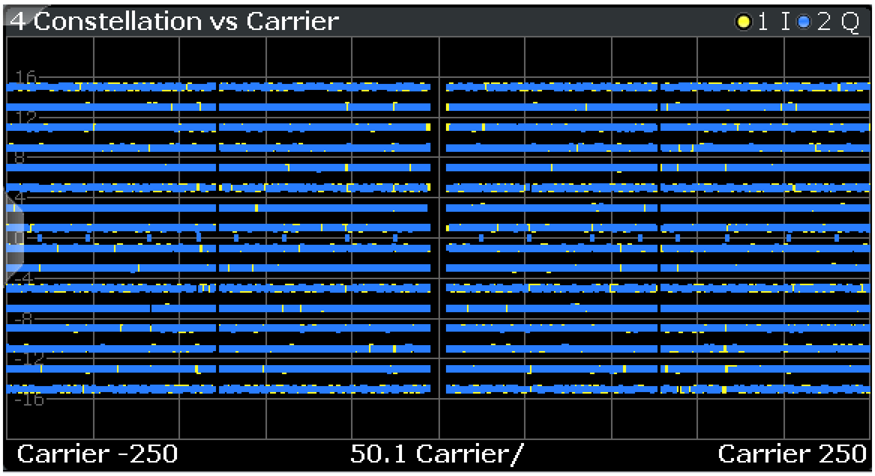
Remote command:
`LAY:ADD? '1',RIGH, CONS`, see `LAYout:ADD[:WINDow]?` on page 294
Or:
`CONFigure:BURSt:CONSt:CSYMbol[:IMMediate]` on page 206
Querying results:
`TRACe<n>[:DATA]`, see Chapter 10.9.4.6, "Constellation", on page 344

Constellation vs Carrier

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.

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).

The x-axis represents the carriers. The magnitude of the in-phase and quadrature part is shown on the y-axis, both are displayed as separate traces (I-> trace 1, Q-> trace 2).



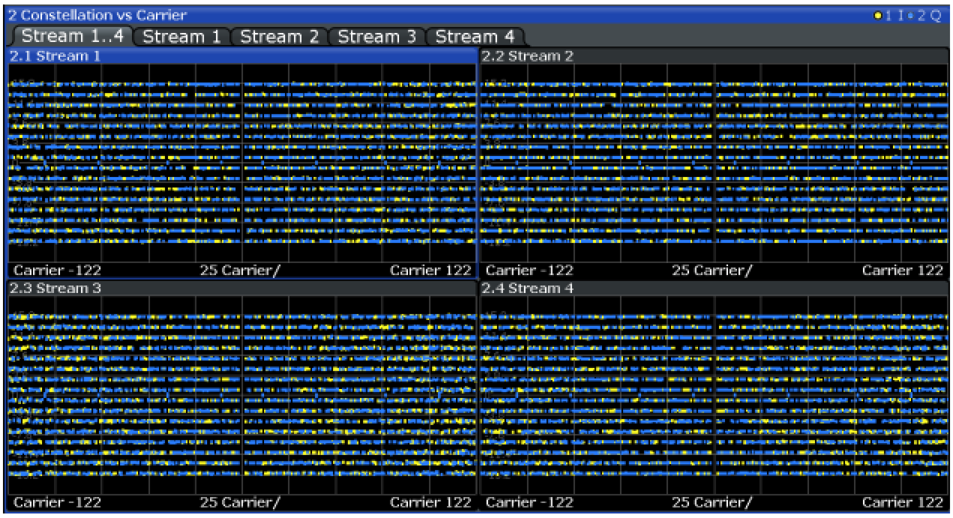


Figure 3-11: Constellation vs. carrier result display for IEEE 802.11n MIMO measurements

The numeric trace results for this evaluation method are described in Chapter 10.9.4.7, "Constellation vs Carrier", on page 345.

Remote command:

`LAY:ADD? '1',RIGH, CVC`, see `LAYout:ADD[:WINDow]?` on page 294

Or:

`CONFigure:BURSt:CONSt:CCARrier[:IMMediate]` on page 206

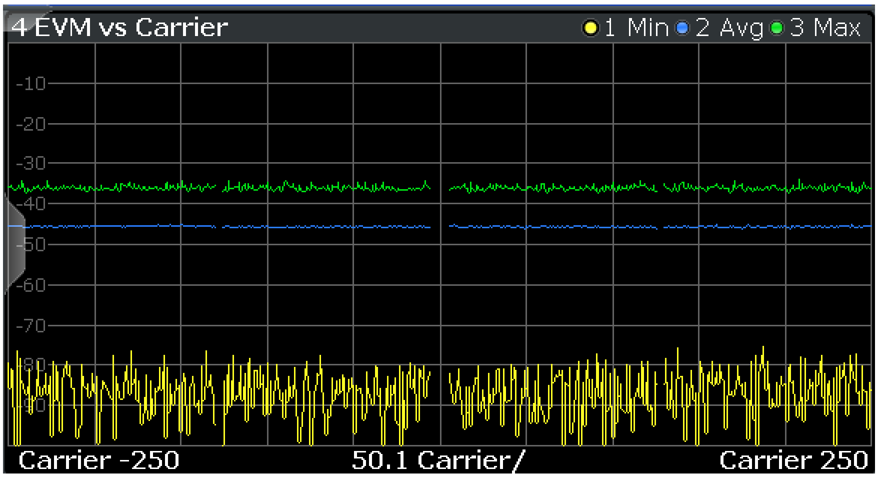
Querying results:

`TRACe<n>[:DATA]`, see Chapter 10.9.4.7, "Constellation vs Carrier", on page 345

EVM vs Carrier

This result display shows all EVM values recorded on a per-subcarrier basis over the number of analyzed PPDUs as defined by the "Evaluation Range > Statistics". The Tracking/Channel Estimation according to the user settings is applied (see Chapter 5.3.7, "Tracking and Channel Estimation", on page 140). The Minhold, Average and Maxhold traces are displayed.

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).



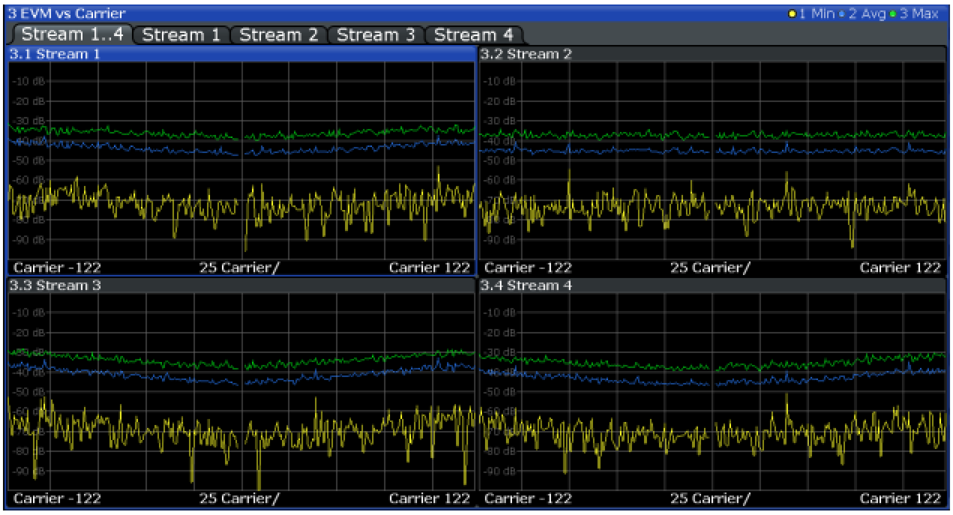


Figure 3-12: EVM vs carrier result display for IEEE 802.11n MIMO measurements

The numeric trace results for this evaluation method are described in Chapter 10.9.4.10, "EVM vs Carrier", on page 345.

Remote command:

`LAY:ADD? '1',RIGH, EVC`, see `LAYout:ADD[:WINDow]?` on page 294

Or:

`CONFigure:BURSt:EVM:ECARrier[:IMMediate]` on page 206

Querying results:

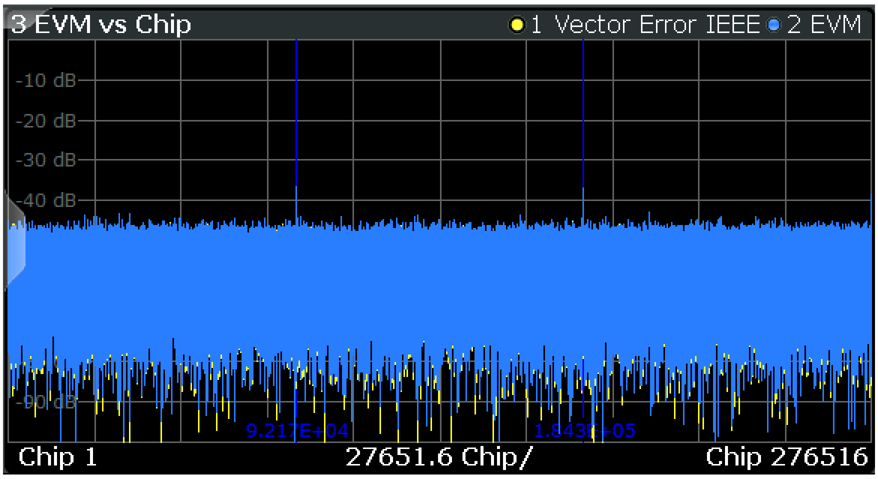
`TRACe<n>[:DATA]`, see Chapter 10.9.4.10, "EVM vs Carrier", on page 345

EVM vs Chip

This result display shows the error vector magnitude per chip.

This result display is **only** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).

Since the R&S FSW WLAN application provides two different methods to calculate the EVM, two traces are displayed:



- "Vector Error IEEE" shows the error vector magnitude as defined in the IEEE 802.11b or g (DSSS) standards (see also "Error vector magnitude (EVM) - IEEE 802.11b or g (DSSS) method" on page 69)
- "EVM" shows the error vector magnitude calculated with an alternative method that provides higher accuracy of the estimations (see also "Error vector magnitude (EVM) - R&S FSW method" on page 68).

Remote command:

`LAY:ADD? '1',RIGH, EVCH`, see `LAYout:ADD[:WINDow]?` on page 294

Or:

`CONFigure:BURSt:EVM:EChip[:IMMediate]` on page 207

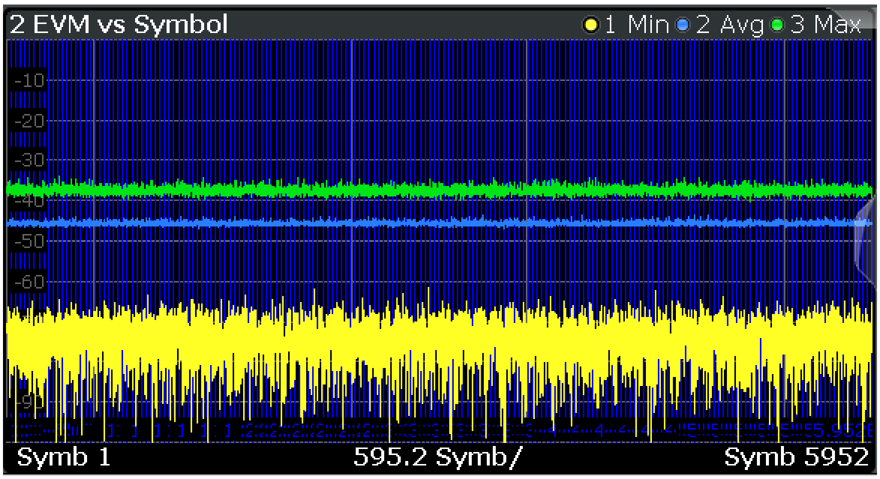
`CONFigure:BURSt:EVM:ESYMbol[:IMMediate]` on page 207

Querying results:

`TRACe<n>[:DATA]`, see Chapter 10.9.4.11, "EVM vs Chip", on page 346

EVM vs Symbol

This result display shows all EVM values calculated on a per-carrier basis over the number of analyzed PPDUs as defined by the "Evaluation Range > Statistics" settings (see "PPDU Statistic Count / No of PPDUs to Analyze" on page 160). The Tracking/Channel Estimation according to the user settings is applied (see Chapter 5.3.7, "Tracking and Channel Estimation", on page 140). The MinHold, Maxhold, and Average traces are displayed.



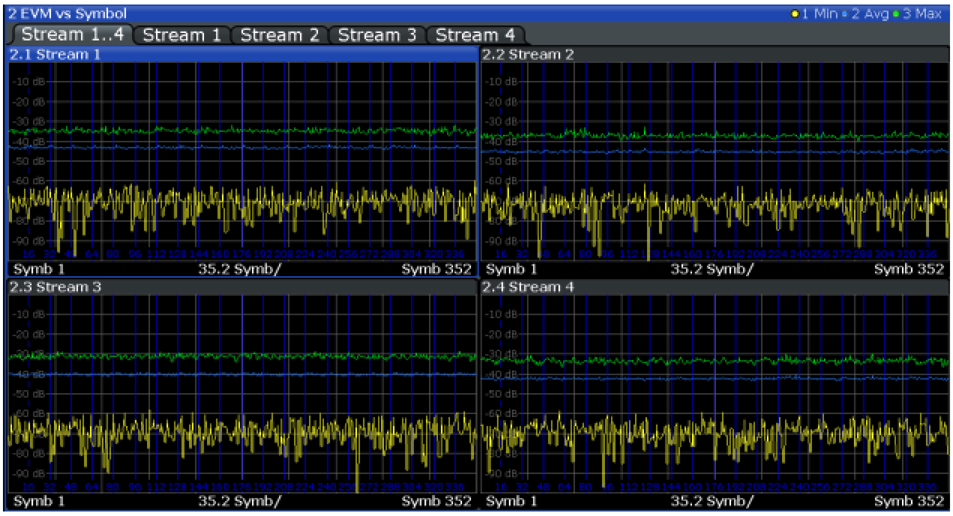


Figure 3-13: EVM vs symbol result display for IEEE 802.11n MIMO measurements

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).

Remote command:

`LAY:ADD? '1',RIGH, EVSY`, see `LAYout:ADD[:WINDow]?` on page 294

Or:

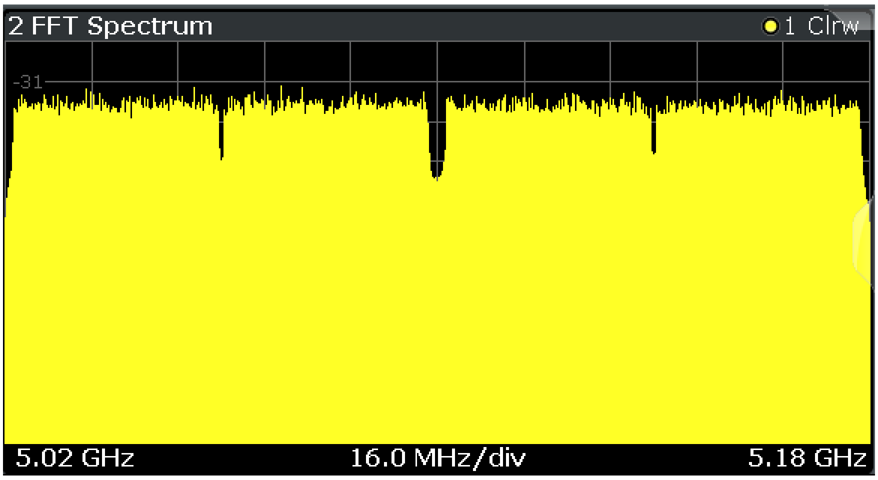
`CONFigure:BURSt:EVM:ESYMbol[:IMMediate]` on page 207

Querying results:

`TRACe<n>[:DATA]`, see Chapter 10.9.4.12, "EVM vs Symbol", on page 346

FFT 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.



Note: MIMO measurements. When you capture more than one data stream (MIMO measurement setup, see Chapter 4.3, "Signal Processing for MIMO Measurements (IEEE 802.11ac, n)", on page 70), each result display contains several tabs. The results for each data stream are displayed in a separate tab. In addition, an overview tab is provided in which all data streams are displayed at once, in individual subwindows.

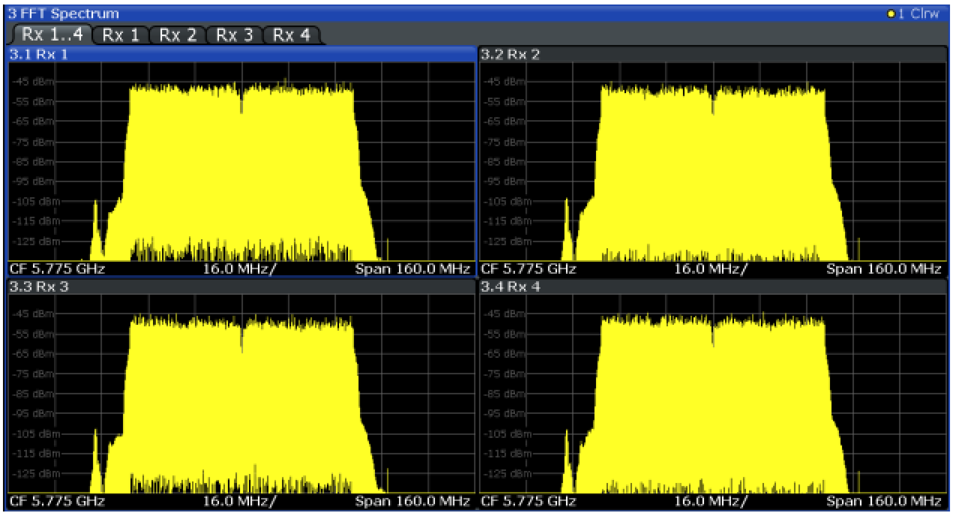


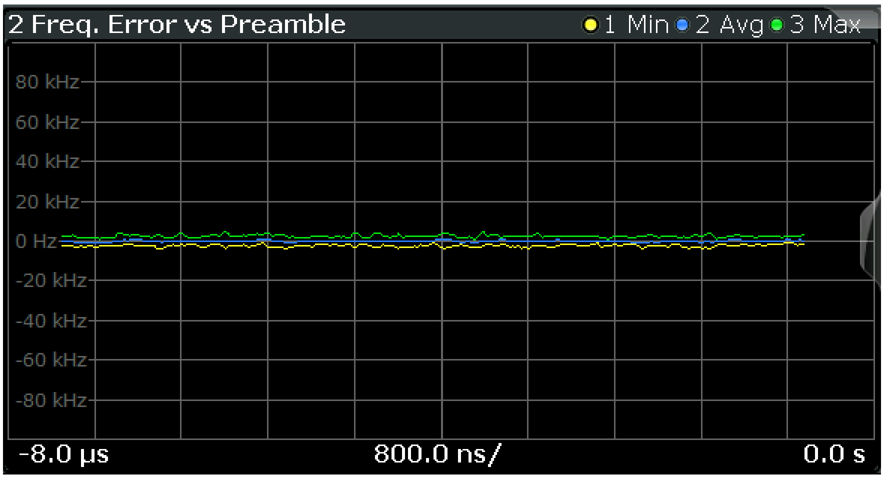
Figure 3-14: FFT spectrum result display for IEEE 802.11n MIMO measurements

The numeric trace results for this evaluation method are described in Chapter 10.9.4.13, "FFT Spectrum", on page 347.

Remote command:
`LAY:ADD? '1',RIGH, FSP`, see `LAYout:ADD[:WINDow]?` on page 294
Or:
`CONFigure:BURSt:SPECtrum:FFT[:IMMediate]` on page 209
Querying results:
`TRACe<n>[:DATA]`, see Chapter 10.9.4.13, "FFT Spectrum", on page 347

Freq. Error vs Preamble

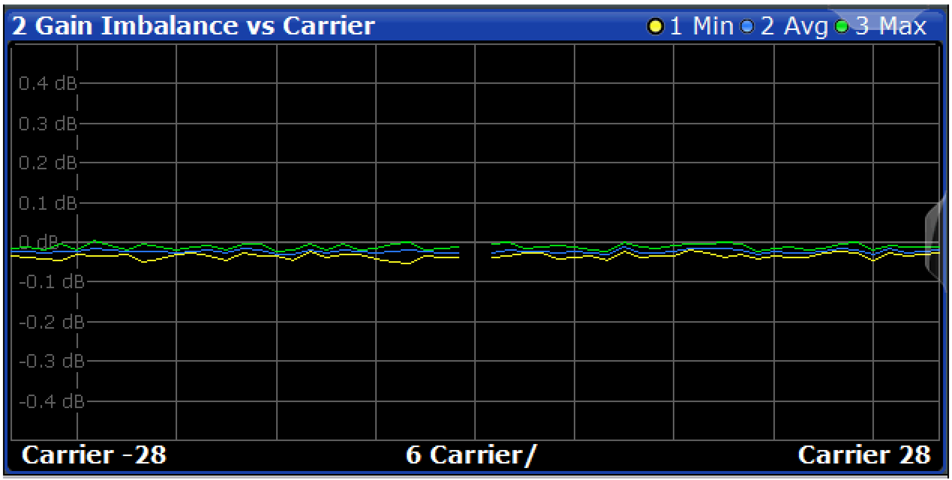
Displays the frequency error values recorded over the preamble part of the PPDU. A minimum, average and maximum trace are displayed.



Remote command:
LAY:ADD? '1',RIGH,FEVP, see LAYout:ADD[:WINDow]? on page 294
Or:
CONFigure:BURSt:PREamble[:IMMediate] on page 207
CONFigure:BURSt:PREamble:SELect on page 208
Querying results:
TRACe<n>[:DATA], see Chapter 10.9.4.9, "Error vs Preamble", on page 345

Gain Imbalance vs Carrier

Displays the minimum, average and maximum gain imbalance versus carrier in individual traces. For details on gain imbalance see Chapter 3.1.1.2, "Gain Imbalance", on page 17.



Remote command:
LAY:ADD? '1',RIGH,GAIN, see LAYout:ADD[:WINDow]? on page 294
Or:
CONFigure:BURSt:GAIN:GCARrier[:IMMediate] on page 207

Querying results:
`TRACe<n>[:DATA]`, see Chapter 10.9.4.8, "Error vs Carrier", on page 345

Group Delay
Displays all Group Delay (GD) values recorded on a per-subcarrier basis - over the number of analyzed PPDUs as defined by the "Evaluation Range > Statistics" settings (see "PPDU Statistic Count / No of PPDUs to Analyze" on page 160.

All 57 carriers are shown, including the unused carrier 0.

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).

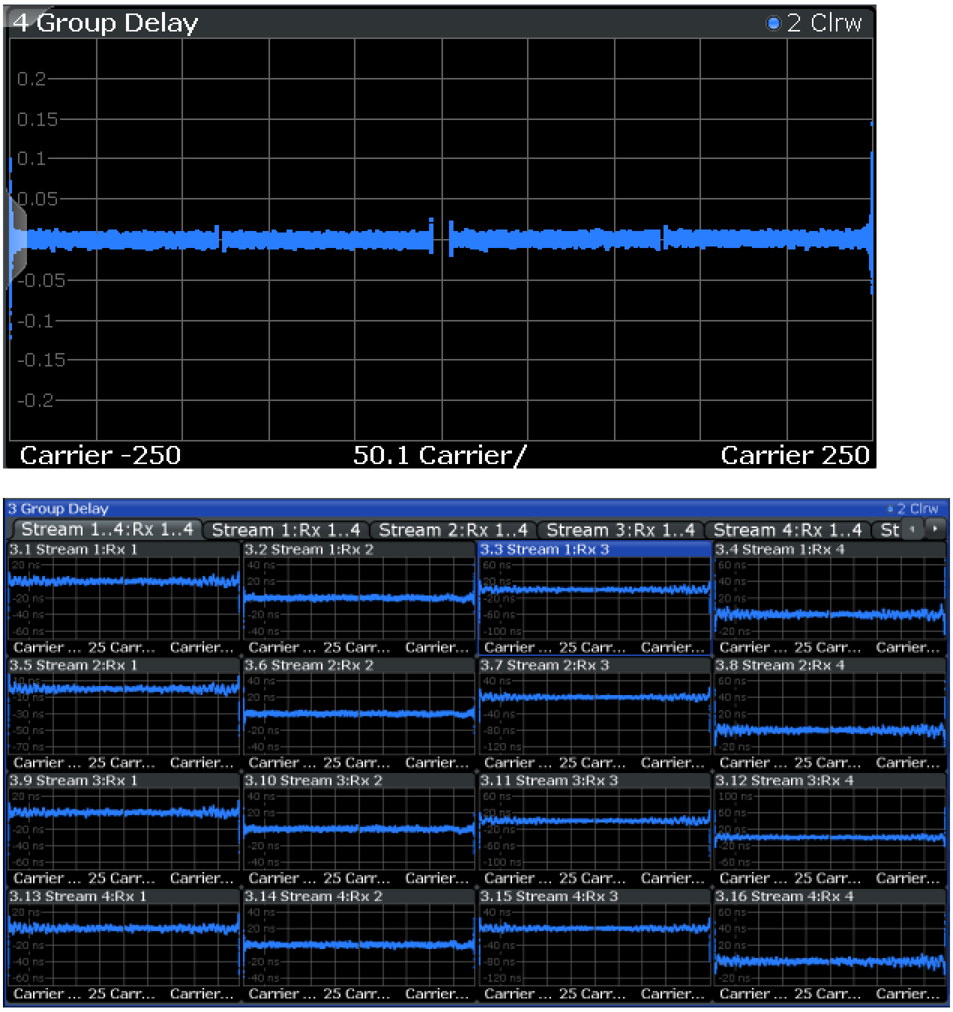


Figure 3-15: Group delay result display for IEEE 802.11n MIMO measurements

Group delay is a measure of phase distortion and defined as the derivation of phase over frequency.

To calculate the group delay, the estimated channel is upsampled, inactive carriers are interpolated and phases are unwrapped before they are differentiated over the carrier frequencies. Thus, the group delay indicates the time a pulse in the channel is delayed for each carrier frequency. However, not the absolute delay is of interest, but rather the deviation between carriers. Thus, the mean delay over all carriers is deducted.

For an ideal channel, the phase increases linearly, which causes a constant time delay over all carriers. In this case, a horizontal line at the zero value would be the result.

The numeric trace results for this evaluation method are described in Chapter 10.9.4.14, "Group Delay", on page 347.

Remote command:
`LAY:ADD? '1',RIGH, GDEL`, see `LAYout:ADD[:WINDow]?` on page 294
Or:
`CONF:BURS:SPEC:FLAT:SEL GRD`, see `CONFigure:BURSt:SPECtrum:FLATness:SELect` on page 209 and
`CONFigure:BURSt:SPECtrum:FLATness[:IMMediate]` on page 210
Querying results:
`TRACe<n>[:DATA]`, see Chapter 10.9.4.14, "Group Delay", on page 347

Magnitude Capture
The Magnitude Capture Buffer display shows 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 blue bar indicates the selected PPDU if the evaluation range is limited to a single PPDU (see "Analyze this PPDU / PPDU to Analyze" on page 159).

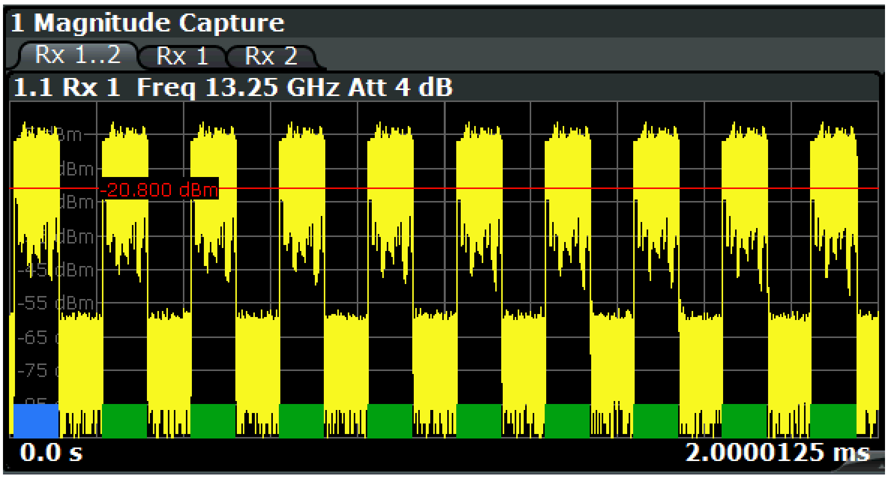


Figure 3-16: Magnitude capture display for single PPDU evaluation

Note: MIMO measurements. When you capture more than one data stream (MIMO measurement setup, see Chapter 4.3, "Signal Processing for MIMO Measurements (IEEE 802.11ac, n)", on page 70), each result display contains several tabs. The results for each data stream are displayed in a separate tab. In addition, an overview tab is provided in which all data streams are displayed at once, in individual subwindows.

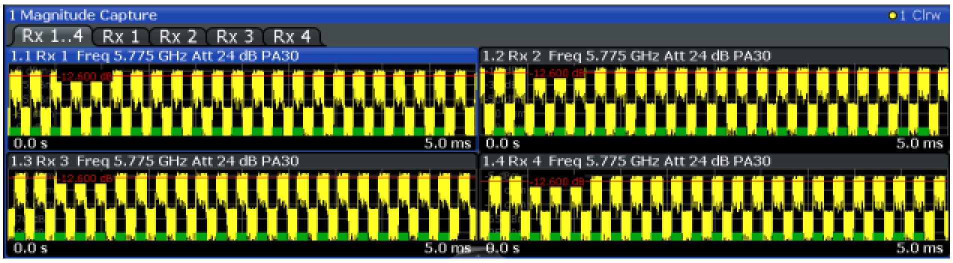


Figure 3-17: Magnitude Capture display for MIMO measurement with 4 Rx antennas

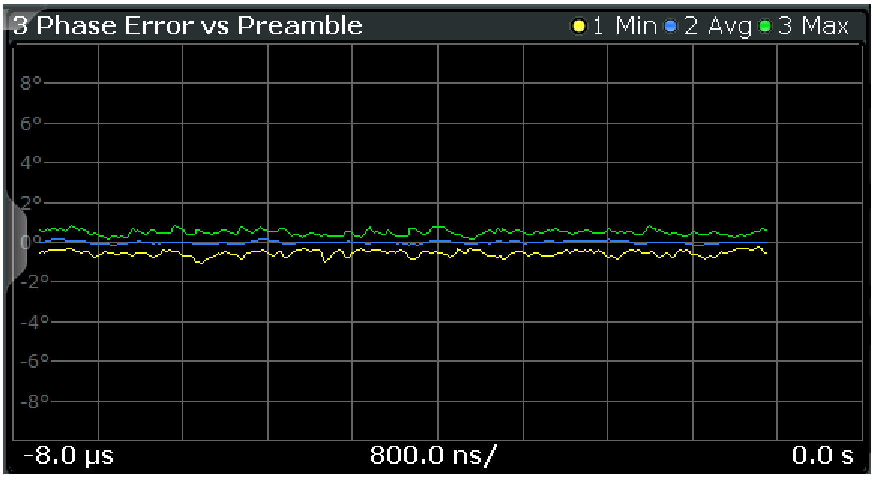
For the Magnitude Capture display, each subwindow contains additional information for each Rx antenna, namely:

- Antenna number
- Center frequency
- (Mechanical) attenuation (ATT) in dB
- Electronic attenuation (EL) in dB
- Reference offset (EXT) in dB
- Preamplification (PA) in dB

Numeric trace results are not available for this evaluation method.

Remote command:
`LAY:ADD? '1',RIGH, CMEM`, see `LAYout:ADD[:WINDow]?` on page 294
Querying results:
`TRACe<n>[:DATA]`, see Chapter 10.9.4.15, "Magnitude Capture", on page 348

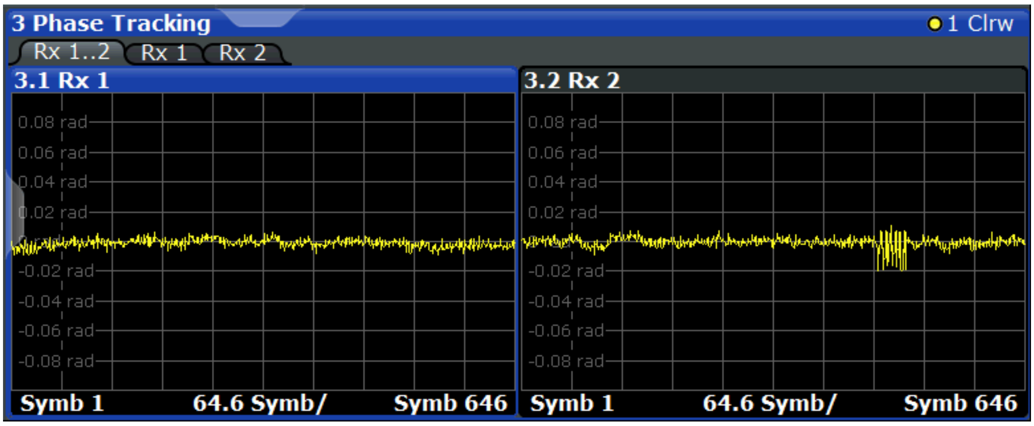
Phase Error vs Preamble
Displays the phase error values recorded over the preamble part of the PPDU. A minimum, average and maximum trace is displayed.



Remote command:
`LAY:ADD? '1',RIGH,PEVP`, see `LAYout:ADD[:WINDow]?` on page 294
Or:
`CONFigure:BURSt:PREamble[:IMMediate]` on page 207
`CONFigure:BURSt:PREamble:SELect` on page 208
Querying results:
`TRACe<n>[:DATA]`, see Chapter 10.9.4.9, "Error vs Preamble", on page 345

Phase Tracking
Displays the average phase tracking result per symbol (in Radians).

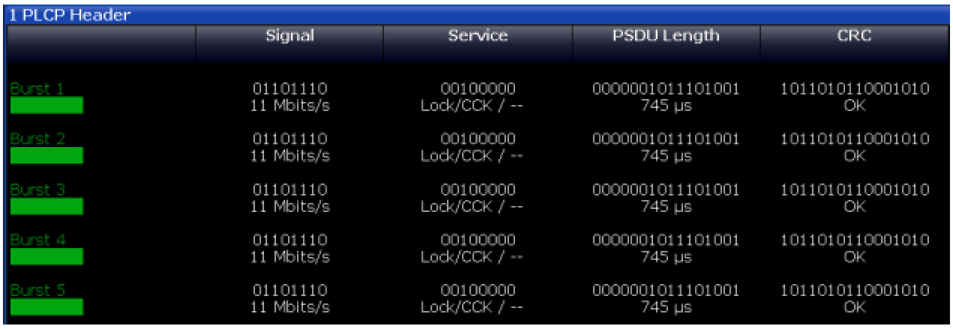
This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).



Remote command:
`LAY:ADD? '1',RIGH,PTR`, see `LAYout:ADD[:WINDow]?` on page 294
Or:
`CONFigure:BURSt:PTRacking[:IMMediate]` on page 208
Querying results:
`TRACe<n>[:DATA]`, see Chapter 10.9.4.16, "Phase Tracking", on page 348

PLCP Header (IEEE 802.11b, g (DSSS)
This result display shows the decoded data from the PLCP header of the PPDU.

This result display is **only** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**); for other standards, use Signal Field instead.



1 PLCP Header

	Signal	Service	PSDU Length	CRC
Burst 1	01101110 11 Mbits/s	00100000 Lock/CCK / --	0000001011101001 745 µs	1011010110001010 OK
Burst 2	01101110 11 Mbits/s	00100000 Lock/CCK / --	0000001011101001 745 µs	1011010110001010 OK
Burst 3	01101110 11 Mbits/s	00100000 Lock/CCK / --	0000001011101001 745 µs	1011010110001010 OK
Burst 4	01101110 11 Mbits/s	00100000 Lock/CCK / --	0000001011101001 745 µs	1011010110001010 OK
Burst 5	01101110 11 Mbits/s	00100000 Lock/CCK / --	0000001011101001 745 µs	1011010110001010 OK

Figure 3-18: PLCP Header result display for IEEE 802.11b, g (DSSS) standards

The following information is provided:

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

Table 3-4: Demodulation results in PLCP Header result display (IEEE 802.11b, g (DSSS))

Result	Description	Example
PPDU	Number of the decoded PPDU A colored block indicates that the PPDU was successfully deco-ded.	PPDU 1
Signal	Information in "signal" field The decoded data rate is shown below.	01101110 11 MBits/s
Service	Information in "service" field <Symbol clock state> /<Modulation format> / <Length extension bit state> where: <Symbol clock state>: Locked / - - <Modulation format>: see Table 4-1 <Length extension bit state>: 1 (set) / - - (not set)	00100000 Lock/CCK/- -
PSDU Length	Information in "length" field Time required to transmit the PSDU	0000000001111000 120 µs
CRC	Information in "CRC" field Result of cyclic redundancy code check: "OK" or "Failed"	1110100111001110 OK

Remote command:
`LAY:ADD? '1',RIGH, SFI`, see `LAYout:ADD[:WINDow]?` on page 294
Or:
`CONFigure:BURSt:STATistics:SFIeld[:IMMediate]` on page 210
Querying results:
`TRACe<n>[:DATA]`, see Chapter 10.9.4.18, "Signal Field", on page 349

PvT Full PPDU
Displays the minimum, average and maximum power vs time diagram for all PPDUs.

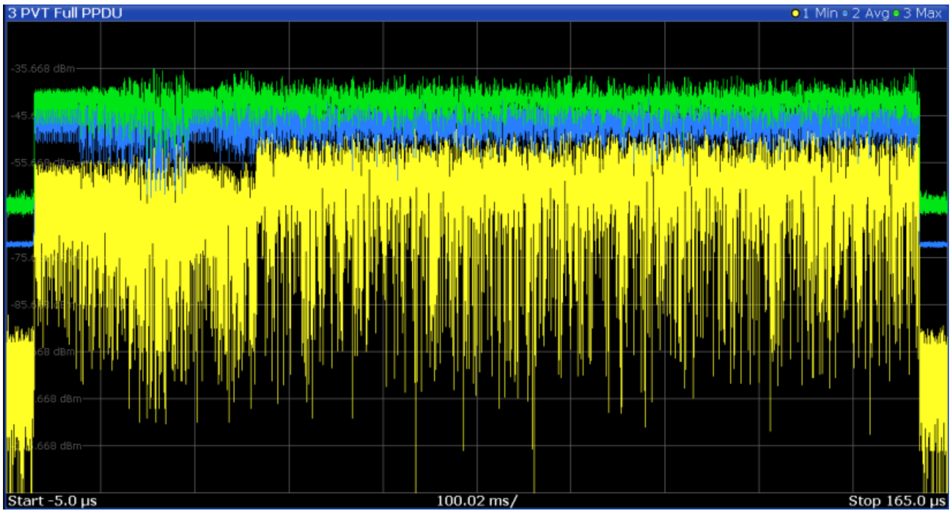


Figure 3-19: PvT Full PPDU result display for IEEE 802.11a, g (OFDM), ac, n, p standards

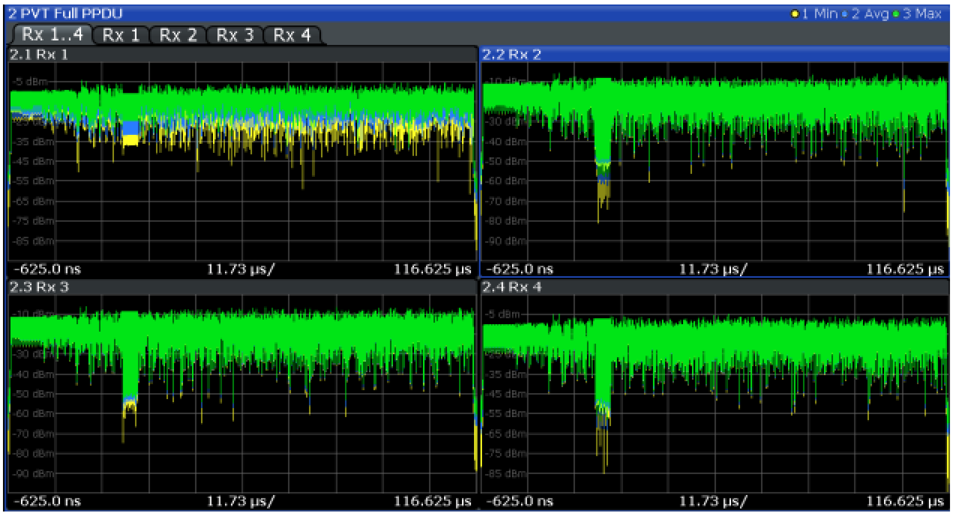


Figure 3-20: PvT Full PPDU result display for IEEE 802.11n MIMO measurements

For single-carrier measurements (**IEEE 802.11b, g (DSSS)**), the PVT results are displayed as percentage values of the reference power. The reference can be set to either the maximum or mean power of the PPDU.

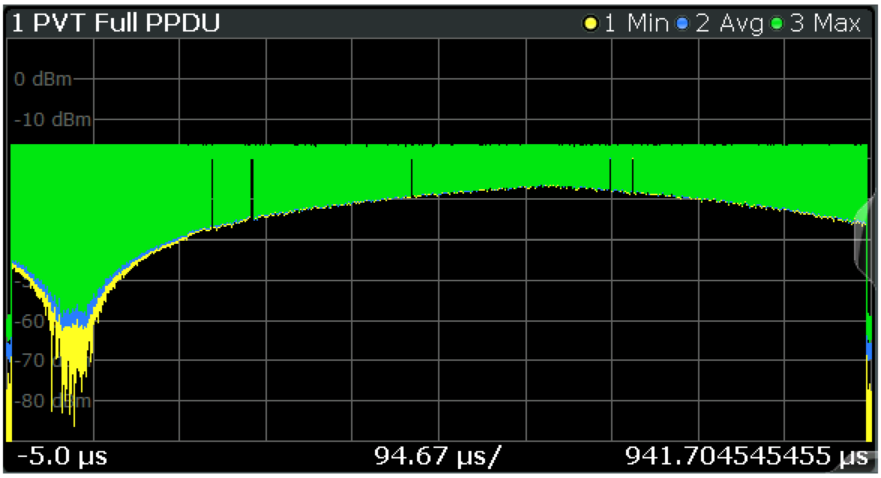


Figure 3-21: PvT Full PPDU result display for IEEE 802.11b, g (DSSS) standards

Remote command:
`LAY:ADD:WIND '2',RIGH,PFPP` see `LAYout:ADD[:WINDow]?` on page 294
Or:
`CONFigure:BURSt:PVT:SELect` on page 208
`CONFigure:BURSt:PVT[:IMMediate]` on page 208
Querying results:
`TRACe<n>[:DATA]`, see Chapter 10.9.4.17, "Power vs Time (PVT)", on page 348

PvT Rising Edge
Displays the minimum, average and maximum power vs time diagram for the rising edge of all PPDUs.

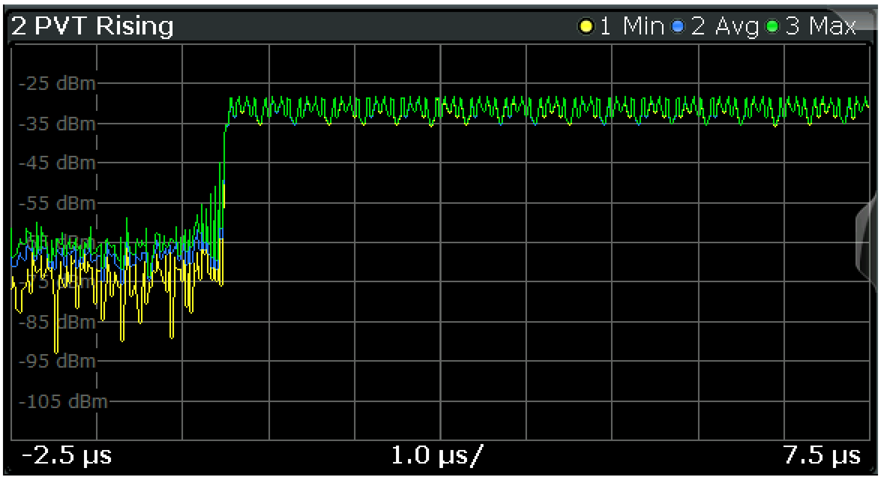


Figure 3-22: PvT Rising Edge result display

Remote command:
`LAY:ADD:WIND '2',RIGH,PRIS` see `LAYout:ADD[:WINDow]?` on page 294
Or:
`CONFigure:BURSt:PVT:SELect` on page 208
`CONFigure:BURSt:PVT[:IMMediate]` on page 208
Querying results:
`TRACe<n>[:DATA]`, see Chapter 10.9.4.17, "Power vs Time (PVT)", on page 348

PvT Falling Edge
Displays the minimum, average and maximum power vs time diagram for the falling edge of all PPDUs.

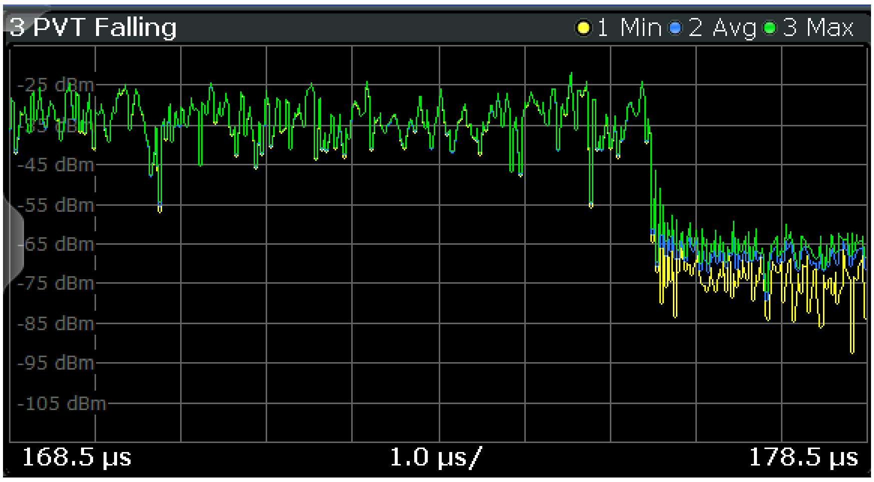


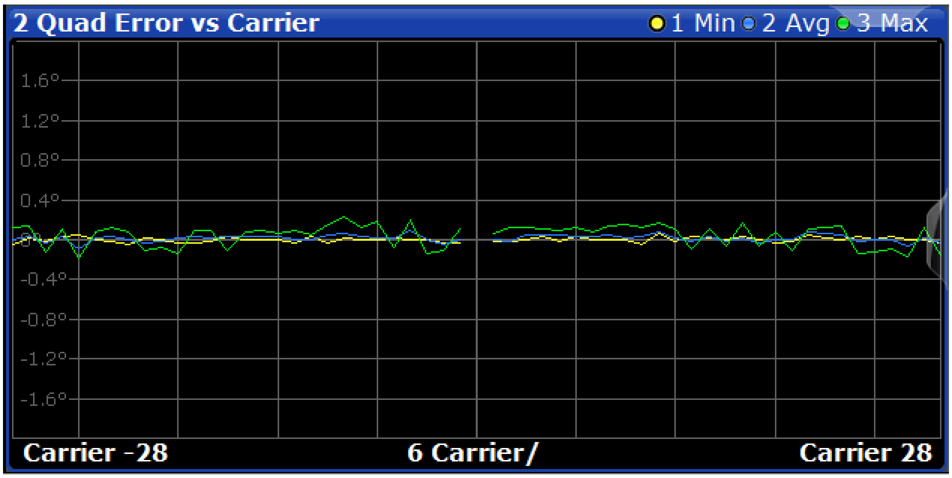
Figure 3-23: PvT Falling Edge result display

Remote command:
`LAY:ADD:WIND '2',RIGH,PFAL` see `LAYout:ADD[:WINDow]?` on page 294
Or:
`CONFigure:BURSt:PVT:SELect` on page 208
`CONFigure:BURSt:PVT[:IMMediate]` on page 208

Querying results:
TRACe<n>[:DATA], see Chapter 10.9.4.17, "Power vs Time (PVT)", on page 348

Quad Error vs Carrier

Displays the minimum, average and maximum quadrature offset (error) versus carrier in individual traces. For details on quadrature offset see Chapter 3.1.1.3, "Quadrature Offset", on page 18.



Remote command:
LAY:ADD? '1',RIGH,QUAD, see LAYout:ADD[:WINDow]? on page 294
Or:
CONFigure:BURSt:QUAD:QCARrier[:IMMediate] on page 209
Querying results:
TRACe<n>[:DATA], see Chapter 10.9.4.8, "Error vs Carrier", on page 345

Result Summary Detailed

The *detailed* result summary contains individual measurement results for the Transmitter and Receiver channels and for the bitstream.

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).

Figure 3-24: Detailed Result Summary result display for IEEE 802.11n MIMO measurements

The "Result Summary Detailed" contains the following information:

Note: You can configure which results are displayed (see Chapter 5.3.10, "Result Configuration", on page 163). However, the results are always calculated, regardless of their visibility.

Tx channel ("Tx All"):

- I/Q offset [dB]
- Gain imbalance [%/dB]
- Quadrature offset [°]
- I/Q skew [ps]
- PPDU power [dBm]
- Crest factor [dB]

Receive channel ("Rx All"):

- PPDU power [dBm]
- Crest factor [dB]
- MIMO cross power
- Center frequency error
- Symbol clock error
- CPE

Bitstream ("Stream All"):

- Pilot bit error rate [%]
- EVM all carriers [%/dB]
- EVM data carriers [%/dB]
- EVM pilot carriers [%/dB]

For details on the individual parameters and the summarized values see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Remote command:
`LAY:ADD? '1',RIGH, RSD`, see `LAYout:ADD[:WINDow]?` on page 294
Querying results:
`FETCh:BURSt:ALL` on page 318

Result Summary Global

The *global* result summary provides measurement results based on the complete signal, consisting of all channels and streams. The observation length is the number of PPDUs to be analyzed as defined by the "Evaluation Range > Statistics" settings. In contrast, the *detailed* result summary provides results for each individual channel and stream.

For MIMO measurements (IEEE 802.11ac, n), the global result summary provides the results for all data streams, whereas the detailed result summary provides the results for individual streams.

1 Result Summary Global
No. of PPDUs - Recognized: 19 Analyzed: 18 Analyzed Physical Channel: 18

PPDUs:	Min	Mean	Limit	Max	Limit	Unit
Pilot Bit Error Rate	0.00	0.00	0.00	0.00	0.00	%
EVM All Carriers	0.34	0.38	31.62	0.49	31.62	%
	-49.25	-48.46	-10.00	-46.15	-10.00	dB
EVM Data Carriers	0.34	0.38	31.62	0.50	31.62	%
	-49.25	-48.44	-10.00	-46.07	-10.00	dB
EVM Pilot Carriers	0.29	0.34	56.23	0.45	56.23	%
	-50.62	-49.31	-5.00	-46.99	-5.00	dB
Center Frequency Error	-4.34	-0.85	±100000.00	3.55	±100000.00	Hz
Symbol Clock Error	0.02	0.09	±20.00	0.17	±20.00	ppm

Figure 3-25: Global result summary for IEEE 802.11a, g (OFDM), ac, n, p standards

1 Result Summary Global
No. of PPDUs - Recognized: 3 Analyzed: 3 Analyzed Physical Channel: 0

PPDUs:	Min	Mean	Limit	Max	Limit	Unit
Peak Vector Error	1.18	1.37	35.00	1.47	35.00	%
PPDU EVM	0.19	0.19		0.19		%
	-54.59	-54.57		-54.54		dB
IQ Offset	-67.45	-67.33		-67.24		dB
Gain Imbalance	82.34	82.34		82.34		%
	-15.06	-15.06		-15.06		dB
Quadrature Error	0.00	0.00		0.00		°
Center Freq Error	0.00	0.00	±331250.00	0.00	±331250.00	Hz
Chip Clock Error	-0.00	-0.00	±25.00	-0.00	±25.00	ppm
Rise Time	1.00	1.00	2.00	1.00	2.00	uS
Fall Time	3.18	3.18*	2.00	3.18*	2.00	uS
Mean Power	-2.62	-2.62		-2.62		dBm
Peak Power	-1.67	-1.67		-1.66		dBm
Crest Factor	0.94	0.95		0.95		dB

Figure 3-26: Global result summary for IEEE 802.11b, g (DSSS) standards

The "Result Summary Global" contains the following information:

Note: You can configure which results are displayed (see Chapter 5.3.10, "Result Configuration", on page 163). However, the results are always calculated, regardless of their visibility.

- Number of recognized PPDUs
- Number of analyzed PPDUs
- Number of analyzed PPDUs in entire physical channel (if available)

IEEE 802.11a, g (OFDM), ac, j, n, p standards:

- Pilot bit error rate [%]
- EVM all carriers [%/dB]
- EVM data carriers [%/dB]
- EVM pilot carriers [%/dB]
- Center frequency error [Hz]
- Symbol clock error [ppm]

IEEE 802.11b, g (DSSS) standards:

- Peak vector error
- PPDU EVM
- Quadrature offset
- Gain imbalance

- Quadrature error
- Center frequency error
- Chip cock error
- Rise time
- Fall time
- Mean power
- Peak power
- Crest power

For details on the individual results and the summarized values see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Remote command:
`LAY:ADD? '1',RIGH, RSGL`, see `LAYout:ADD[:WINDow]?` on page 294
Querying results:
`FETCh:BURSt:ALL` on page 318

Signal Field

This result display shows the decoded data from the "Signal" field of each recognized PPDU. This field contains information on the modulation used for transmission.

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**); use PLCP Header (IEEE 802.11b, g (DSSS)) instead.

Figure 3-27: Signal Field display for IEEE 802.11n

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

The currently applied demodulation settings (as defined by the user, see Chapter 5.3.8, "Demodulation", on page 143) are indicated beneath the table header for reference. Since the demodulation settings define which PPDUs are to be analyzed, this *logical filter* may be the reason if the "Signal Field" display is not as expected.

Table 3-5: Demodulation parameters and results for Signal Field result display (IEEE 802.11a, g (OFDM), j, p)

Parameter	Description
Format	PPDU format used for measurement (Not part of the IEEE 802.11a, g (OFDM), p signal field, displayed for convenience; see "PPDU Format to measure" on page 144)
CBW	Channel bandwidth to measure (Not part of the signal field, displayed for convenience)
Rate / Mbit/s	Symbol rate per second
R	Reserved bit

Parameter	Description
Length / Sym	Human-readable length of payload in OFDM symbols
P	Parity bit
(Signal) Tail	Signal tail (preset to 0)

Table 3-6: Demodulation parameters and results for Signal Field result display (IEEE 802.11ac)

Parameter	Description
Format	PPDU format used for measurement (Not part of the IEEE 802.11ac signal field, displayed for convenience; see "PPDU Format to measure" on page 144)
MCS	Modulation and Coding Scheme (MCS) index of the PPDU as defined in IEEE Std 802.11-2012 section "20.6 Parameters for HT MCSs"
BW	Channel bandwidth to measure 0: 20 MHz 1: 40 MHz 2: 80 MHz 3: 80+80 MHz and 160MHz
L-SIG Length / Sym	Human-readable length of payload in OFDM symbols
STBC	Space-Time Block Coding 0: no spatial streams of any user have space time block coding 1: all spatial streams of all users have space time block coding
GI	Guard interval length PPDU must have to be measured 1: short guard interval is used in the Data field 0: short guard interval is not used in the Data field
Ness	Number of extension spatial streams (N_{ESS}, see "Extension Spatial Streams (sounding)" on page 156)
CRC	Cyclic redundancy code

Table 3-7: Demodulation parameters and results for Signal Field result display (IEEE 802.11n)

Parameter	Description
Format	PPDU format used for measurement (Not part of the IEEE 802.11n signal field, displayed for convenience; see "PPDU Format to measure" on page 144)
MCS	Modulation and Coding Scheme (MCS) index of the PPDU as defined in IEEE Std 802.11-2012 section "20.6 Parameters for HT MCSs"
CBW	Channel bandwidth to measure 0: 20 MHz or 40 MHz upper/lower 1: 40 MHz
HT-SIG Length / Sym	Human-readable length of payload in OFDM symbols The number of octets of data in the PSDU in the range of 0 to 65 535

Parameter	Description
SNRA	**S**moothing/**N**ot Sounding/**R**eserved/**A**ggregation: **Smoothing:** 1: channel estimate smoothing is recommended 0: only per-carrier independent (unsmoothed) channel estimate is recommended **Not Sounding:** 1: PPDU is not a sounding PPDU 0: PPDU is a sounding PPDU **Reserved:** Set to 1 **Aggregation:** 1: PPDU in the data portion of the packet contains an AMPDU 0: otherwise
STBC	Space-Time Block Coding 00: no STBC (NSTS = NSS) ≠0: the difference between the number of space-time streams (NSTS) and the number of spatial streams (NSS) indicated by the MCS
GI	Guard interval length PPDU must have to be measured 1: short GI used after HT training 0: otherwise
Ness	Number of extension spatial streams (N_{ESS}, see "Extension Spatial Streams (sounding)" on page 156)
CRC	Cyclic redundancy code of bits 0–23 in HT-SIG1 and bits 0–9 in HT-SIG2
Tail Bits	Used to terminate the trellis of the convolution coder. Set to 0.

The values for the individual demodulation parameters are described in Chapter 5.3.8, "Demodulation", on page 143. The following abbreviations are used in the "Signal Field" table:

Table 3-8: Abbreviations for demodulation parameters shown in "Signal Field" display

Abbreviation in "Signal Field" display	Parameter in "Demodulation" settings
A1st	Auto, same type as first PPDU
AI	Auto, individual for each PPDU
M<x>	Meas only the specified PPDUs (<x>)
D<x>	Demod all with specified parameter <y>

The Signal Field measurement indicates certain inconsistencies in the signal or discrepancies between the demodulation settings and the signal to be analyzed. In both cases, an appropriate warning is displayed and the results for the PPDU are highlighted orange - both in the "Signal Field" display and the "Magnitude Capture" display. If the signal was analyzed with warnings the results – indicated by a message - also contribute to the overall analysis results.

PPDUs detected in the signal that do not pass the logical filter, i.e. are not to be included in analysis, are dismissed. An appropriate message is provided. The corresponding PPDU in the capture buffer is not highlighted.

The numeric trace results for this evaluation method are described in Chapter 10.9.4.18, "Signal Field", on page 349.

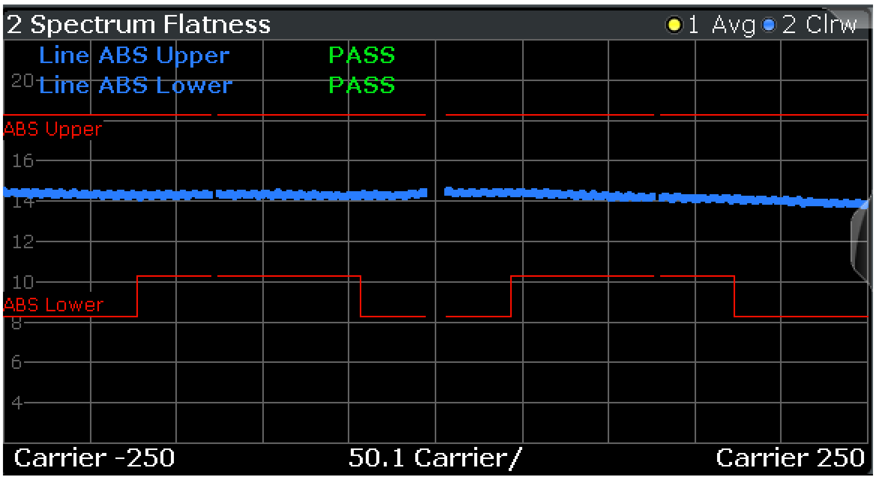
Remote command:
`LAY:ADD? '1',RIGH, SFI`, see `LAYout:ADD[:WINDow]?` on page 294
Or:
`CONFigure:BURSt:STATistics:SFIeld[:IMMediate]` on page 210
Querying results:
`TRACe<n>[:DATA]`, see Chapter 10.9.4.18, "Signal Field", on page 349

Spectrum Flatness
The Spectrum Flatness trace is derived from the magnitude of the estimated channel transfer function. Since this estimated channel is calculated from all payload symbols of the PPDU, it represents a carrier-wise mean gain of the channel. Assuming that we have a cable connection between the DUT and the R&S FSW that adds no residual channel distortion, the "Spectrum Flatness" shows the spectral distortion caused by the DUT (for example the transmit filter).

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).

The diagram shows the relative power per carrier. All carriers are displayed, including the unused carrier(s).

In contrast to the SISO measurements in previous Rohde & Schwarz signal and spectrum analyzers, the trace is no longer normalized to 0 dB (scaled by the mean gain of all carriers).



For more information see Chapter 4.3.6, "Crosstalk and Spectrum Flatness", on page 78.

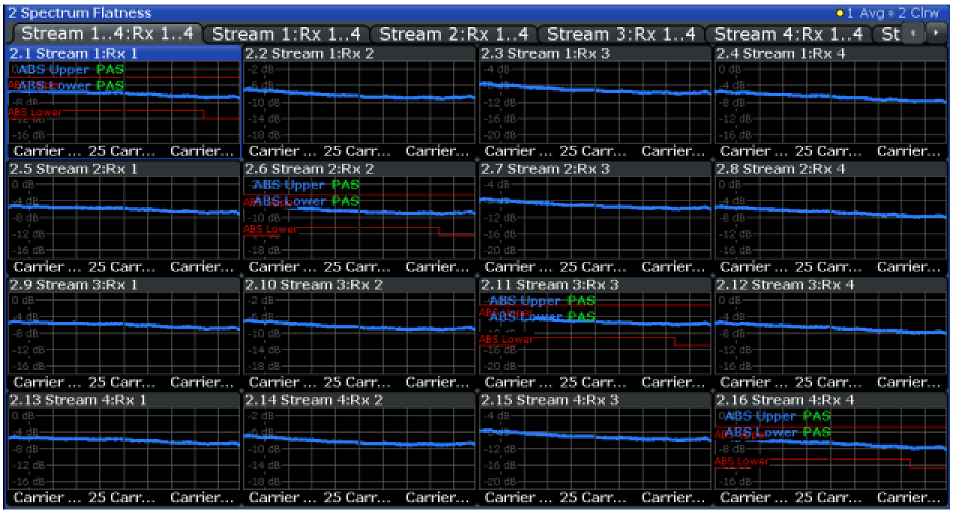


Figure 3-28: Spectrum flatness result display for IEEE 802.11n MIMO measurements

The numeric trace results for this evaluation method are described in Chapter 10.9.4.19, "Spectrum Flatness", on page 349.

Remote command:

`LAY:ADD? '1',RIGH, SFL`, see `LAYout:ADD[:WINDow]?` on page 294

Or:

`CONF:BURS:SPEC:FLAT:SEL FLAT` (see `CONFigure:BURSt:SPECtrum:FLATness:SELect` on page 209) and

`CONFigure:BURSt:SPECtrum:FLATness[:IMMediate]` on page 210

Querying results:

`TRACe<n>[:DATA]`, see Chapter 10.9.4.19, "Spectrum Flatness", on page 349

3.2 Frequency Sweep Measurements

As described above, the WLAN IQ measurement captures the I/Q data from the WLAN signal using a (nearly rectangular) filter with a relatively large bandwidth. However, some parameters specified in the WLAN 802.11 standard require a better signal-to-noise level or a smaller bandwidth filter than the I/Q measurement provides and must be determined in separate measurements.

Parameters that are common to several digital standards and are often required in signal and spectrum test scenarios can be determined by the standard measurements provided in the R&S FSW base unit (Spectrum application). These measurements are performed using a much narrower bandwidth filter, and they capture only the power level (magnitude, which we refer to as *RF data*) of the signal, as opposed to the two components provided by I/Q data.

Frequency sweep measurements can tune on a constant frequency ("Zero span measurement") or sweep a frequency range ("Frequency sweep measurement")

The signal cannot be demodulated based on the captured RF data. However, the required power information can be determined much more precisely, as more noise is filtered out of the signal.

The Frequency sweep measurements provided by the R&S FSW WLAN application are identical to the corresponding measurements in the base unit, but are pre-configured according to the requirements of the selected WLAN 802.11 standard.

For details on these measurements see the R&S FSW User Manual.

MSRA operating mode

Frequency sweep measurements are not available in MSRA operating mode.

For details on the MSRA operating mode see the R&S FSW MSRA User Manual.

The R&S FSW WLAN application provides the following frequency sweep measurements:

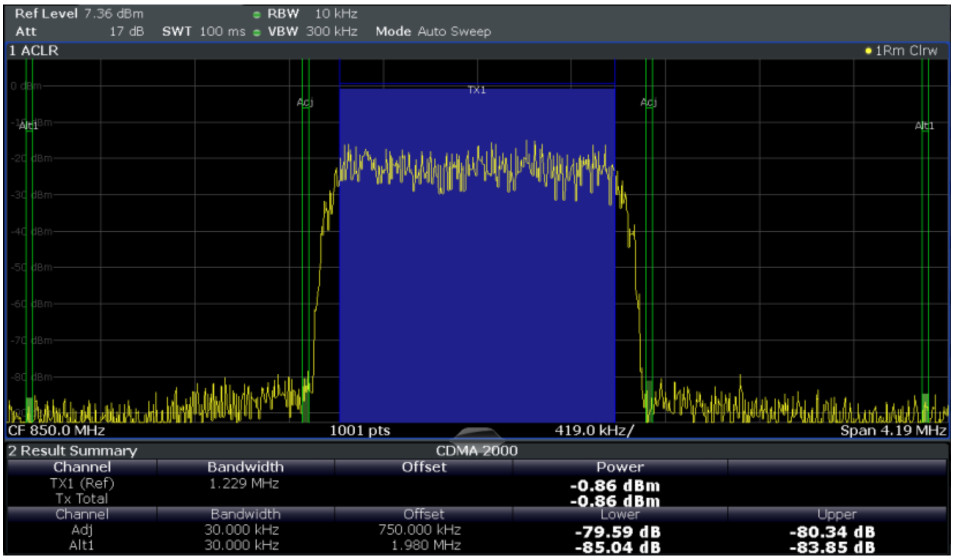
3.2.1 Measurement Types and Results for Frequency Sweep Measurements

The R&S FSW WLAN application provides the following pre-configured frequency sweep measurements:

Channel Power ACLR

Channel Power ACLR performs an adjacent channel power (also known as adjacent channel leakage ratio) measurement according to WLAN 802.11 specifications.

The R&S FSW measures the channel power and the relative power of the adjacent channels and of the alternate channels. The results are displayed in the Result Summary.



For details see Chapter 5.4.1, "Channel Power (ACLR) Measurements", on page 173.

Remote command:
`CONFigure:BURSt:SPECtrum:ACPR[:IMMediate]` on page 211
Querying results:
`CALC:MARK:FUNC:POW:RES? ACP`, see `CALCulate<n>:MARKer<m>:FUNCtion:POWer<sb>:RESult?` on page 331

Spectrum Emission Mask

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

Or: MEAS > "Select Measurement" > "SEM"

The Spectrum Emission Mask (SEM) measurement determines the power of the WLAN 802.11 signal in defined offsets from the carrier and compares the power values with a spectral mask specified by the WLAN 802.11 specifications. The limits depend on the selected bandclass. Thus, the performance of the DUT can be tested and the emissions and their distance to the limit be identified.

Note: The WLAN 802.11 standard does not distinguish between spurious and spectral emissions.

For details see Chapter 5.4.2, "Spectrum Emission Mask", on page 174.

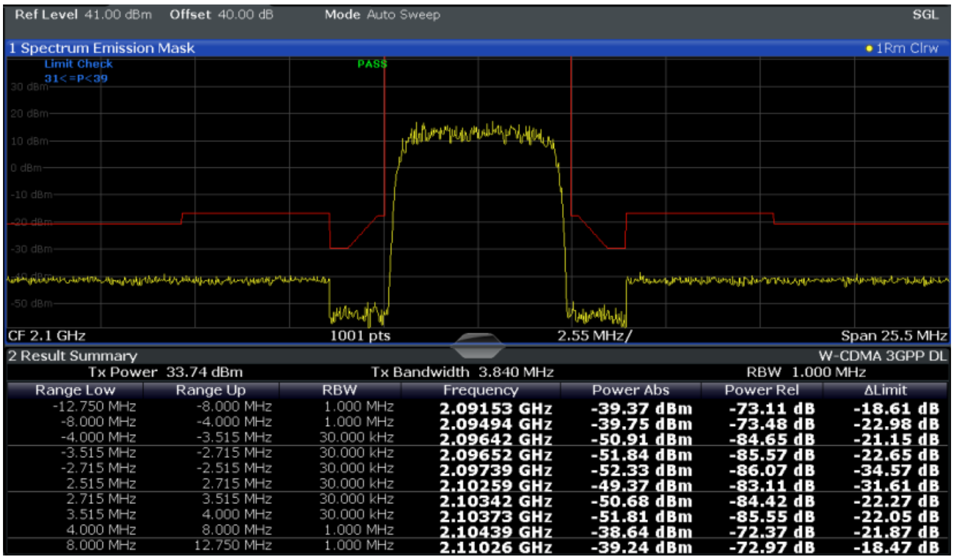


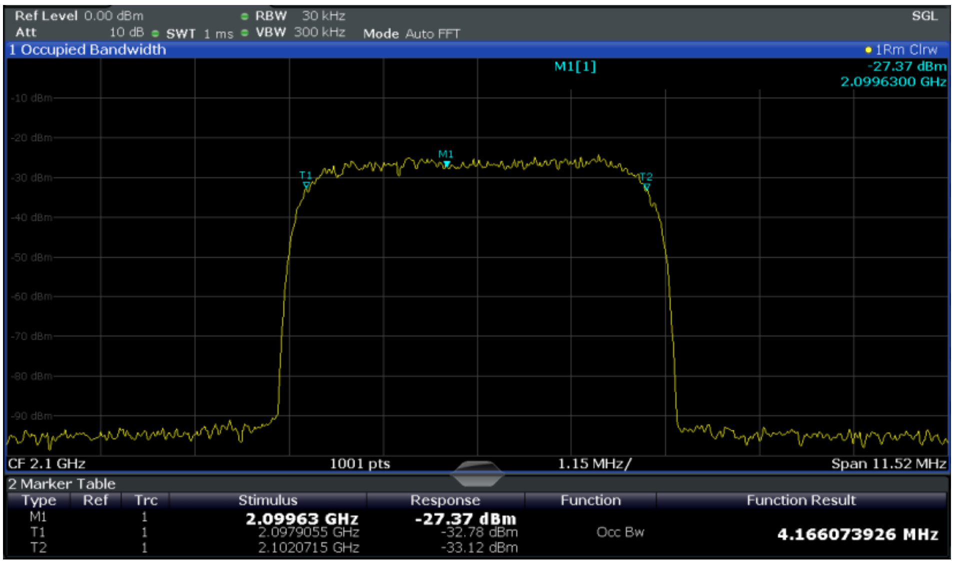
Figure 3-29: SEM measurement results

Remote command:
`CONFigure:BURSt:SPECtrum:MASK[:IMMediate]` on page 211
Querying results:
`CALCulate<n>:LIMit<k>:FAIL?` on page 330
`TRAC:DATA? LIST`, see `TRACe<n>[:DATA]` on page 336

Occupied Bandwidth

The Occupied Bandwidth (OBW) measurement determines the bandwidth in which a certain percentage of the total signal power is measured. The percentage of the signal power to be included in the bandwidth measurement can be changed; by default settings it is 99 %.

The occupied bandwidth is indicated as the "Occ BW" function result in the marker table; the frequency markers used to determine it are also displayed.



For details, see Chapter 5.4.3, "Occupied Bandwidth", on page 175.

Remote command:
`CONFigure:BURSt:SPECtrum:OBWidth[:IMMediate]` on page 211
Querying results:
`CALC:MARK:FUNC:POW:RES? OBW`, see `CALCulate<n>:MARKer<m>:FUNCtion:POWer<sb>:RESult?` on page 331

CCDF
The CCDF (complementary cumulative distribution function) measurement determines the distribution of the signal amplitudes. The measurement captures a user-definable number of samples and calculates their mean power. As a result, the probability that a sample's power is higher than the calculated mean power + x dB is displayed. The crest factor is displayed in the Result Summary.

For details see Chapter 5.4.4, "CCDF", on page 176.

Figure 3-30: CCDF measurement results

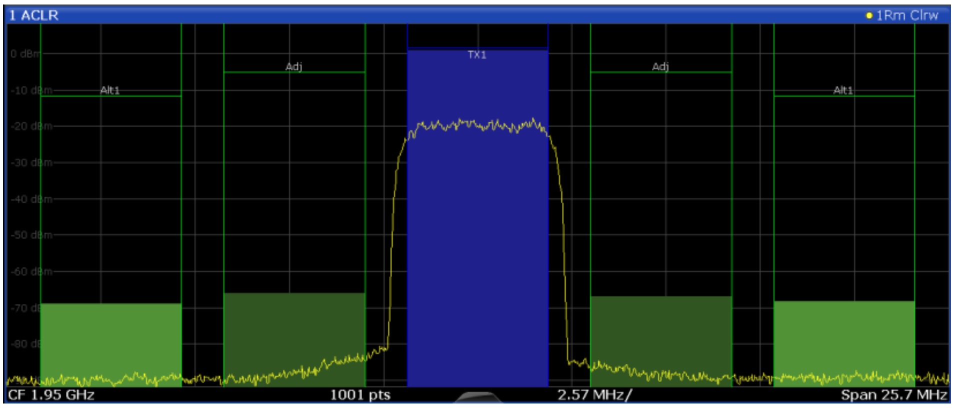
Remote command:
`CONFigure:BURSt:STATistics:CCDF[:IMMediate]` on page 212
Querying results:
`CALCulate<n>:MARKer<m>:Y?` on page 351
`CALCulate<n>:STATistics:RESult<t>?` on page 333

3.2.2 Evaluation Methods for Frequency Sweep Measurements

The evaluation methods for frequency sweep measurements in the R&S FSW WLAN application are identical to those in the R&S 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 294

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 result summary 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 294

Marker Table

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

4 Marker Table

Wnd	Type	Ref	Trc	X-value	Y-value
1	M1		1	13.25 GHz	-200.0 dBm
1	D2	M1	1	-600.0 kHz	0.0 dB
1	D3	M1	1	600.0 kHz	0.0 dB
1	D4	M1	1	-2.0 MHz	0.0 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 294

Results:

CALCulate<n>:MARKer<m>:X on page 333
CALCulate<n>:MARKer<m>:Y? on page 351

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.

2 Marker Peak List

No	Stimulus	Response
1	64.400000 MHz	-30.352 dBm
2	128.400000 MHz	-51.896 dBm
3	192.300000 MHz	-40.227 dBm
4	257.200000 MHz	-60.699 dBm
5	320.200000 MHz	-44.273 dBm
6	384.100000 MHz	-53.494 dBm
7	448.100000 MHz	-47.460 dBm
8	513.000000 MHz	-55.603 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 294
Results:
CALCulate<n>:MARKer<m>:X on page 333
CALCulate<n>:MARKer<m>:Y? on page 351

4 Measurement Basics

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

4.1 Signal Processing for Multicarrier Measurements (IEEE 802.11a, g (OFDM), j, p)

This description gives a rough view of the signal processing when using the R&S FSW WLAN application with the IEEE 802.11a, g (OFDM), j, p standards. Details are disregarded in order to provide a concept overview.

Abbreviations

$a_{l,k}$	Symbol at symbol l of subcarrier k
EVM_k	Error vector magnitude of subcarrier k
EVM	Error vector magnitude of current packet
g	Signal gain
Δf	Frequency deviation between Tx and Rx
l	Symbol index l = {1 ... nof_Symbols}
nof_symbols	Number of symbols of payload
H_k	Channel transfer function of subcarrier k
k	Channel index k = {–31 ... 32}
K_{mod}	Modulation-dependent normalization factor
ξ	Relative clock error of reference oscillator
$r_{l,k}$	Subcarrier of symbol l

4.1.1 Block Diagram for Multicarrier Measurements

A diagram of the significant blocks when using the IEEE 802.11a, g (OFDM), j, p standard in the R&S FSW WLAN application is shown in Figure 4-1.

First the RF signal is downconverted to the IF frequency f_{IF}. The resulting IF signal $r_{IF}(t)$ is shown on the left-hand side of the figure. After bandpass filtering, the signal is sampled by an analog to digital converter (ADC) at a sample rate of f_{s1}. This digital sequence is resampled. Thus, the sample rate of the downsampled sequence r(i) is the Nyquist rate of f_{s3} = 20 MHz. Up to this point the digital part is implemented in an ASIC.

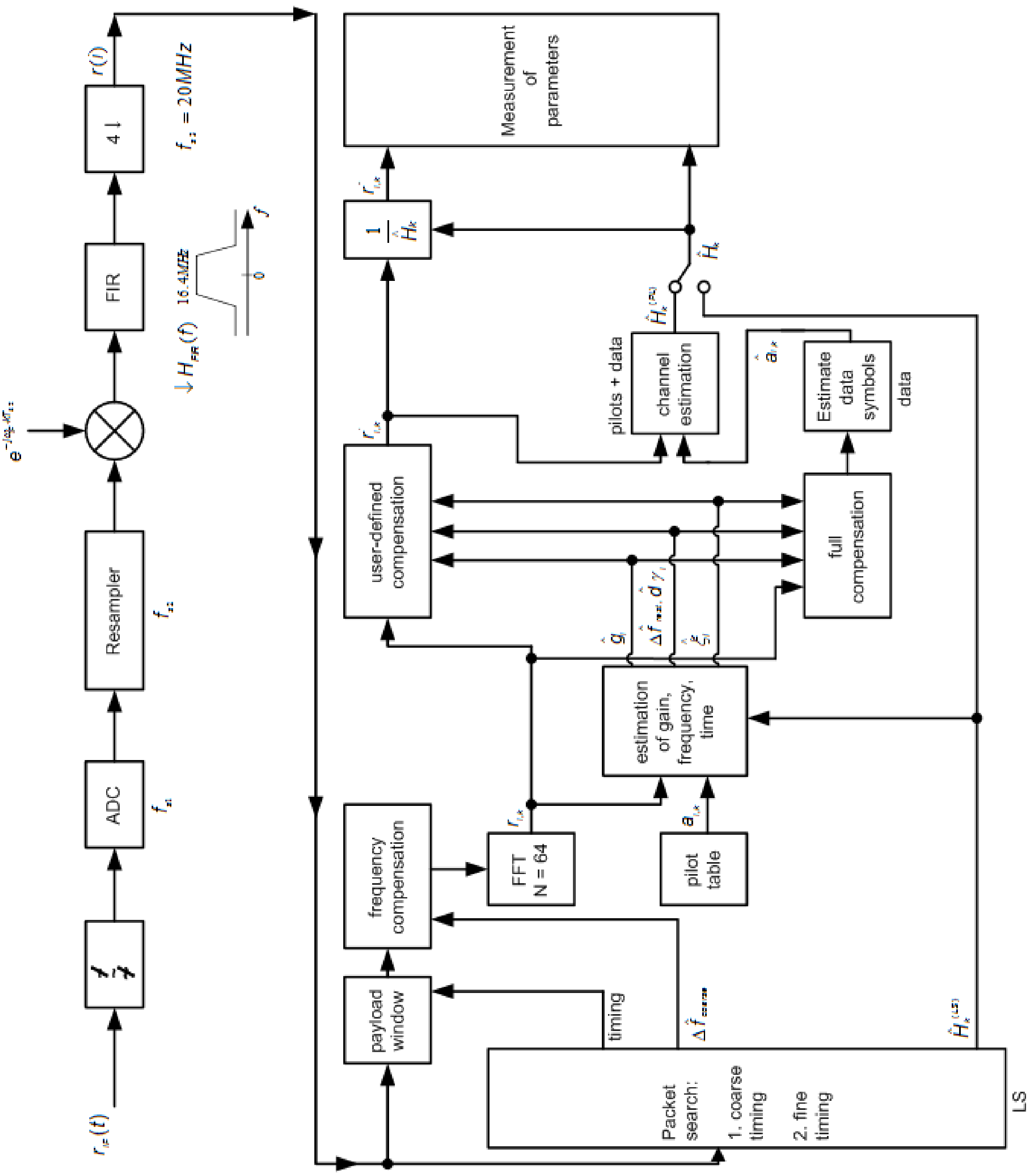


Figure 4-1: Block diagram for the R&S FSW WLAN application using the IEEE 802.11a, g (OFDM), j, p standard

In the lower part of the figure the subsequent digital signal processing is shown.

Packet search and timing detection

In the first block the **packet search** is performed. This block detects the *long symbol* (LS) and recovers the timing. The **coarse timing** is detected first. This search is implemented in the time domain. The algorithm is based on cyclic repetition within the LS after N = 64 samples. Numerous treatises exist on this subject, e.g. [1] to [3].

Furthermore, a coarse estimate $\Delta\hat{f}_{coarse}$ of the Rx-Tx frequency offset Δf is derived from the metric in [6]. (The hat generally indicates an estimate, e.g. $\hat{x}$ is the estimate of x.) This can easily be understood because the phase of *r(i) ·Δ r* (i + N)* is determined by the frequency offset. As the frequency deviation Δf can exceed half a bin (distance between neighboring subcarriers) the preceding *short symbol* (SS) is also analyzed in order to detect the ambiguity.

After the coarse timing calculation the time estimate is improved by the **fine timing** calculation. This is achieved by first estimating the coarse frequency response $\hat{H}^{(LS)}_k$, where k = {–26.. 26} denotes the channel index of the *occupied* subcarriers. First the FFT of the LS is calculated. After the FFT calculation the known symbol information of the LS subcarriers is removed by dividing by the symbols. The result is a coarse estimate $\hat{H}_k$ of the channel transfer function. In the next step, the complex channel impulse response is computed by an IFFT. Then the energy of the windowed impulse response (the window size is equal to the guard period) is calculated for each trial time. Afterwards the trial time of the maximum energy is detected. This trial time is used to adjust the timing.

Determing the payload window

Now the position of the LS is known and the starting point of the useful part of the first payload symbol can be derived. In the next block this calculated time instant is used to position the **payload window**. Only the payload part is windowed. This is sufficient because the payload is the only subject of the subsequent measurements.

In the next block the windowed sequence is **compensated** by the coarse frequency estimate $\Delta\hat{f}_{course}$. This is necessary because otherwise inter-channel interference (ICI) would occur in the frequency domain.

The transition to the frequency domain is achieved by an FFT of length 64. The FFT is performed symbol-wise for each symbol of the payload ("nof_symbols"). The calculated FFTs are described by$r_{l,k}$ with:

- l = {1 .. nof_symbols} as the symbol index
- k = {–31 .. 32} as the channel index

In case of an additive white Gaussian noise (AWGN) channel, the FFT is described by [4], [5]

$$r_{l,k} = K_{\mathrm{mod}} \times a_{l,k} \times g_l \times H_k \times e^{j(phase_l^{(common)} + phase_{l,k}^{(\mathrm{timing})})} + n_{l,k}$$

Equation 4-1: FFT

with:

- K_{mod}: the modulation-dependant normalization factor

- $a_{l,k}$: the symbol of subcarrier k at symbol l
- g_l: the gain at the symbol l in relation to the reference gain g = 1 at the long symbol (LS)
- H_k: the channel frequency response at the long symbol (LS)
- $phase_l^{(common)}$: the common phase drift phase of all subcarriers at symbol l (see Common phase drift)
- $phase_{l,k}^{(timing)}$: the phase of subcarrier k at symbol l caused by the timing drift (see Common phase drift)
- $n_{l,k}$: the independent Gaussian distributed noise samples

Phase drift and frequency deviation

The common phase drift in FFT is given by:

$$phase_l^{(common)} = 2\pi \times N_s / N \times \Delta f_{rest} T \times l + d\gamma_l$$

Equation 4-2: Common phase drift

with

- N_s = 80: the number of Nyquist samples of the symbol period
- N = 64: the number of Nyquist samples of the useful part of the symbol
- Δf_{rest}: the (not yet compensated) frequency deviation
- $d\Upsilon_l$: the phase jitter at the symbol l

In general, the coarse frequency estimate $\Delta\hat{f}_{coarse}$ (see Figure 4-1) is not error-free. Therefore the remaining frequency error Δf_{rest} represents the frequency deviation in $r_{l,k}$ not yet compensated. Consequently, the overall frequency deviation of the device under test (DUT) is calculated by:

$\Delta f = \Delta\hat{f}_{coarse} + \Delta f_{rest}$

The common phase drift in Common phase drift is divided into two parts to calculate the overall frequency deviation of the DUT.

The reason for the phase jitter $d\gamma_l$ in Common phase drift may be different. The nonlinear part of the phase jitter may be caused by the phase noise of the DUT oscillator. Another reason for nonlinear phase jitter may be the increase of the DUT amplifier temperature at the beginning of the PPDU. Note that besides the nonlinear part the phase jitter, $d\gamma_l$ also contains a constant part. This constant part is caused by the frequency deviation Δf_{rest} not yet compensated. To understand this, keep in mind that the measurement of the phase starts at the first symbol l = 1 of the payload. In contrast, the channel frequency response H_k in FFT represents the channel at the long symbol of the preamble. Consequently, the frequency deviation Δf_{rest} not yet compensated produces a phase drift between the long symbol and the first symbol of the payload. Therefore, this phase drift appears as a constant value ("DC value") in $d\Upsilon_l$.

Tracking the phase drift, timing jitter and gain

Referring to the IEEE 802.11a, g (OFDM), j, p measurement standard, chapter 17.3.9.7 "Transmit modulation accuracy test" [6], the common phase drift $phase_l^{(common)}$ must be estimated and compensated from the pilots. Therefore this "symbol-wise phase tracking" is activated as the default setting of the R&S FSW WLAN application (see "Phase Tracking" on page 142).

Furthermore, the timing drift in FFT is given by:

$$phase_{l,k}^{(\text{timing})} = 2\pi \times N_s / N \times \xi \times k \times l$$

Equation 4-3: Timing drift

with ξ: the relative clock deviation of the reference oscillator

Normally, a symbol-wise timing jitter is negligible and thus not modeled in Timing drift. However, there may be situations where the timing drift has to be taken into account. This is illustrated by an example: In accordance to [6], the allowed clock deviation of the DUT is up to ξ_{max} = 20 ppm. Furthermore, a long packet with 400 symbols is assumed. The result of FFT and Timing drift is that the phase drift of the highest sub-carrier k = 26 in the last symbol l = **nof_symbols** is 93 degrees. Even in the noise-free case, this would lead to symbol errors. The example shows that it is actually necessary to estimate and compensate the clock deviation, which is accomplished in the next block.

Referring to the IEEE 802.11a, g (OFDM), j, p measurement standard [6], the timing drift $phase_{l,k}^{(timing)}$ is not part of the requirements. Therefore the "time tracking" is not activated as the default setting of the R&S FSW WLAN application (see "Timing Error Tracking" on page 142). The time tracking option should rather be seen as a powerful analyzing option.

In addition, the tracking of the gain g_l in FFT is supported for each symbol in relation to the reference gain g = 1 at the time instant of the long symbol (LS). At this time the coarse channel transfer function $\hat{H}^{(LS)}_k$ is calculated.

This makes sense since the sequence $r'_{l,k}$ is compensated by the coarse channel transfer function $\hat{H}^{(LS)}_k$ before estimating the symbols. Consequently, a potential change of the gain at the symbol l (caused, for example, by the increase of the DUT amplifier temperature) may lead to symbol errors especially for a large symbol alphabet M of the MQAM transmission. In this case, the estimation and the subsequent compensation of the gain are useful.

Referring to the IEEE 802.11a, g (OFDM), j, p measurement standard [6], the compensation of the gain g_l is not part of the requirements. Therefore the "gain tracking" is not activated as the default setting of the R&S FSW WLAN application (see "Level Error (Gain) Tracking" on page 142).

Determining the error parameters (log likelihood function)

How can the parameters above be calculated? In this application the optimum maximum likelihood algorithm is used. In the first estimation step the symbol-independent parameters Δf_{rest} and ξ are estimated. The symbol-dependent parameters can be neglected in this step, i.e. the parameters are set to $g_l = 1$ and $d\gamma = 0$. Referring to FFT, the log likelihood function L must be calculated as a function of the trial parameters $\Delta\tilde{f}_{rest}$ and $\tilde{\xi}$. (The tilde generally describes a trial parameter. Example: $\tilde{x}$ is the trial parameter of x.)

$$L_1(\Delta\tilde{f}_{rest}, \tilde{\xi}) = \sum_{l=1}^{nof\_symbols} \sum_{k=-21,-7,7,21} \left| r_{l,k} - a_{l,k} \times \hat{H}_k^{(LS)} \times e^{j(\tilde{p}hase_l^{(common)} + \tilde{p}hase_{l,k}^{(timing)})} \right|^2$$

$$\text{with}$$

$$\tilde{p}hase_l^{(common)} = 2\pi \times N_s / N \times \Delta\tilde{f}_{rest} T \times l$$

$$\tilde{p}hase_l^{(timing)} = 2\pi \times N_s / N \times \tilde{\xi} \times k \times l$$

Equation 4-4: Log likelihood function (step 1)

The trial parameters leading to the minimum of the log likelihood function are used as estimates $\Delta\hat{f}_{rest}$ and $\hat{\xi}$. In Log likelihood function (step 1) the known pilot symbols $a_{l,k}$ are read from a table.

In the second step, the log likelihood function is calculated for every symbol l as a function of the trial parameters $\tilde{g}_l$ and $d\tilde{\gamma}_l$:

$$L_2(\tilde{g}_l, d\tilde{\gamma}_l) = \sum_{k=-21,-7,7,21} \left| r_{l,k} - a_{l,k} \times \tilde{g}_l \times \hat{H}_k^{(LS)} \times e^{j(\tilde{p}hase_l^{(common)} + \tilde{p}hase_{l,k}^{(timing)})} \right|^2$$

$$\text{with}$$

$$\tilde{p}hase_l^{(common)} = 2\pi \times N_s / N \times \Delta\hat{f}_{rest} T \times l + d\tilde{\gamma}_l$$

$$\hat{p}hase_l^{(timing)} = 2\pi \times N_s / N \times \hat{\xi} \times k \times l$$

Equation 4-5: Log likelihood function (step 2)

Finally, the trial parameters leading to the minimum of the log likelihood function are used as estimates $\hat{g}_l$ and $d\tilde{\gamma}_l$.

This robust algorithm works well even at low signal to noise ratios with the Cramer Rao Bound being reached.

Compensation

After estimation of the parameters, the sequence $r_{l,k}$ is compensated in the compensation blocks.

In the upper analyzing branch the compensation is user-defined i.e. the user determines which of the parameters are compensated. This is useful in order to extract the influence of these parameters. The resulting output sequence is described by: $\gamma'_{\delta,k}$.

Data symbol estimation

In the lower compensation branch the full compensation is always performed. This separate compensation is necessary in order to avoid symbol errors. After the full compensation the secure estimation of the data symbols $\hat{a}_{l,k}$ is performed. From FFT it is clear that first the channel transfer function H_k must be removed. This is achieved by dividing the known coarse channel estimate $\hat{H}^{(LS)}_k$ calculated from the LS. Usually an error free estimation of the data symbols can be assumed.

Improving the channel estimation

In the next block a better channel estimate $\hat{H}^{(PL)}_k$ of the data and pilot subcarriers is calculated by using all "nof_symbols" symbols of the payload (PL). This can be accomplished at this point because the phase is compensated and the data symbols are known. The long observation interval of nof_symbols symbols (compared to the short interval of 2 symbols for the estimation of $\hat{H}^{(LS)}_k$) leads to a nearly error-free channel estimate.

In the following equalizer block, $\hat{H}^{(LS)}_k$ is compensated by the channel estimate. The resulting channel-compensated sequence is described by $\gamma_{\delta,k}''$. The user may either choose the coarse channel estimate $\hat{H}^{(LS)}_k$ (from the long symbol) or the nearly error-free channel estimate $\hat{H}^{(PL)}_k$ (from the payload) for equalization. If the improved estimate $\hat{H}^{(LS)}_k$ is used, a 2 dB reduction of the subsequent EVM measurement can be expected.

According to the IEEE 802.11a measurement standard [6], the coarse channel estimation $\hat{H}^{(LS)}_k$ (from the long symbol) has to be used for equalization. Therefore the default setting of the R&S FSW WLAN application is equalization from the coarse channel estimate derived from the long symbol.

Calculating error parameters

In the last block the parameters of the demodulated signal are calculated. The most important parameter is the error vector magnitude of the subcarrier "k" of the current packet:

$$\overline{EVM} = \sqrt{\frac{1}{nof\_packets} \sum_{counter=1}^{nof\_packets} EVM^2(counter)}$$

Equation 4-6: Error vector magnitude of the subcarrier k in current packet

Furthermore, the packet error vector magnitude is derived by averaging the squared EVM_k versus k:

$$EVM = \sqrt{\frac{1}{52} \sum_{k=-26(k\neq 0)}^{26} EVM_k^2}$$

Equation 4-7: Error vector magnitude of the entire packet

Finally, the average error vector magnitude is calculated by averaging the packet EVM of all nof_symbols detected packets:

$$EVM_k = \sqrt{\frac{1}{nof\_symbols} \sum_{l=1}^{nof\_symbols} \left| r''_{l,k} - K_{\mathrm{mod}} \times a_{l,k} \right|^2}$$

Equation 4-8: Average error vector magnitude

This parameter is equivalent to the "RMS average of all errors": $Error_{RMS}$ of the IEEE 802.11a measurement commandment (see [6]).

4.1.2 Literature on the IEEE 802.11a Standard

[1]	Speth, Classen, Meyr: "Frame synchronization of OFDM systems in frequency selective fading channels", VTC '97, pp. 1807-1811
[2]	Schmidl, Cox: "Robust Frequency and Timing Synchronization of OFDM", IEEE Trans. on Comm., Dec. 1997, pp. 1613-621
[3]	Minn, Zeng, Bhargava: "On Timing Offset Estimation for OFDM", IEEE Communication Letters, July 2000, pp. 242-244
[4]	Speth, Fechtel, Fock, Meyr: "Optimum receive antenna Design for Wireless Broad-Band Systems Using OFDM – Part I", IEEE Trans. On Comm. VOL. 47, NO 11, Nov. 1999
[5]	Speth, Fechtel, Fock, Meyr: "Optimum receive antenna Design for Wireless Broad-Band Systems Using OFDM – Part II", IEEE Trans. On Comm. VOL. 49, NO 4, April. 2001
[6]	IEEE 802.11a, Part 11: WLAN Medium Access Control (MAC) and Physical Layer (PHY) specifications

4.2 Signal Processing for Single-Carrier Measurements (IEEE 802.11b, g (DSSS))

This description gives a rough overview of the signal processing concept of the WLAN 802.11 application for IEEE 802.11b or g (DSSS) signals.

Abbreviations

ε	timing offset
Δ"f"	frequency offset
$\Delta\Phi$	phase offset
$\hat{g}_I$	estimate of the gain factor in the I-branch
$\hat{g}_Q$	estimate of the gain factor in the Q-branch
$\Delta\hat{g}_Q$	accurate estimate of the crosstalk factor of the Q-branch in the I-branch
$\hat{h}_s(v)$	estimated baseband filter of the transmit antenna
$\hat{h}_r(v)$	estimated baseband filter of the receive antenna
$\hat{o}_I$	estimate of the IQ-offset in the I-branch
$\hat{o}_Q$	estimate of the IQ-offset in the I-branch
r(v)	measurement signal
$\hat{s}(v)$	estimate of the reference signal

$\hat{s}_n(v)$	estimate of the power-normalized and undisturbed reference signal
ARG{...}	calculation of the angle of a complex value
EVM	error vector magnitude
IMAG{...}	calculation of the imaginary part of a complex value
PPDU	protocol data unit - a burst in the signal containing transmission data
PSDU	protocol service data unit- a burst in the signal containing service data
REAL{...}	calculation of the real part of a complex value

4.2.1 Block Diagram for Single-Carrier Measurements

A block diagram of the measurement application is shown below in Figure 4-2. The baseband signal of an IEEE 802.11b or g (DSSS) wireless LAN system transmit antenna is sampled with a sample rate of 44 MHz.

The first task of the measurement application is to detect the position of the PPDU within the measurement signal $r_1(v)$. The detection algorithm is able to find the beginning of short and long PPDUs and can distinguish between them. The algorithm also detects the initial state of the scrambler, which is not specified by the IEEE 802.11 standard.

If the start position of the PPDU is known, the header of the PPDU can be demodulated. The bits transmitted in the header provide information about the length of the PPDU and the modulation type used in the PSDU.

Once the start position and the PPDU length are fully known, better estimates of timing offset, timing drift, frequency offset and phase offset can be calculated using the entire data of the PPDU.

At this point of the signal processing, demodulation can be performed without decision error. After demodulation the normalized (in terms of power) and undisturbed reference signal s(v) is available.

If the frequency offset is not constant and varies with time, the frequency offset and phase offset in several partitions of the PPDU must be estimated and corrected. Additionally, timing offset, timing drift and gain factor can be estimated and corrected in several partitions of the PPDU. These corrections can be switched off individually in the demodulation settings of the application.

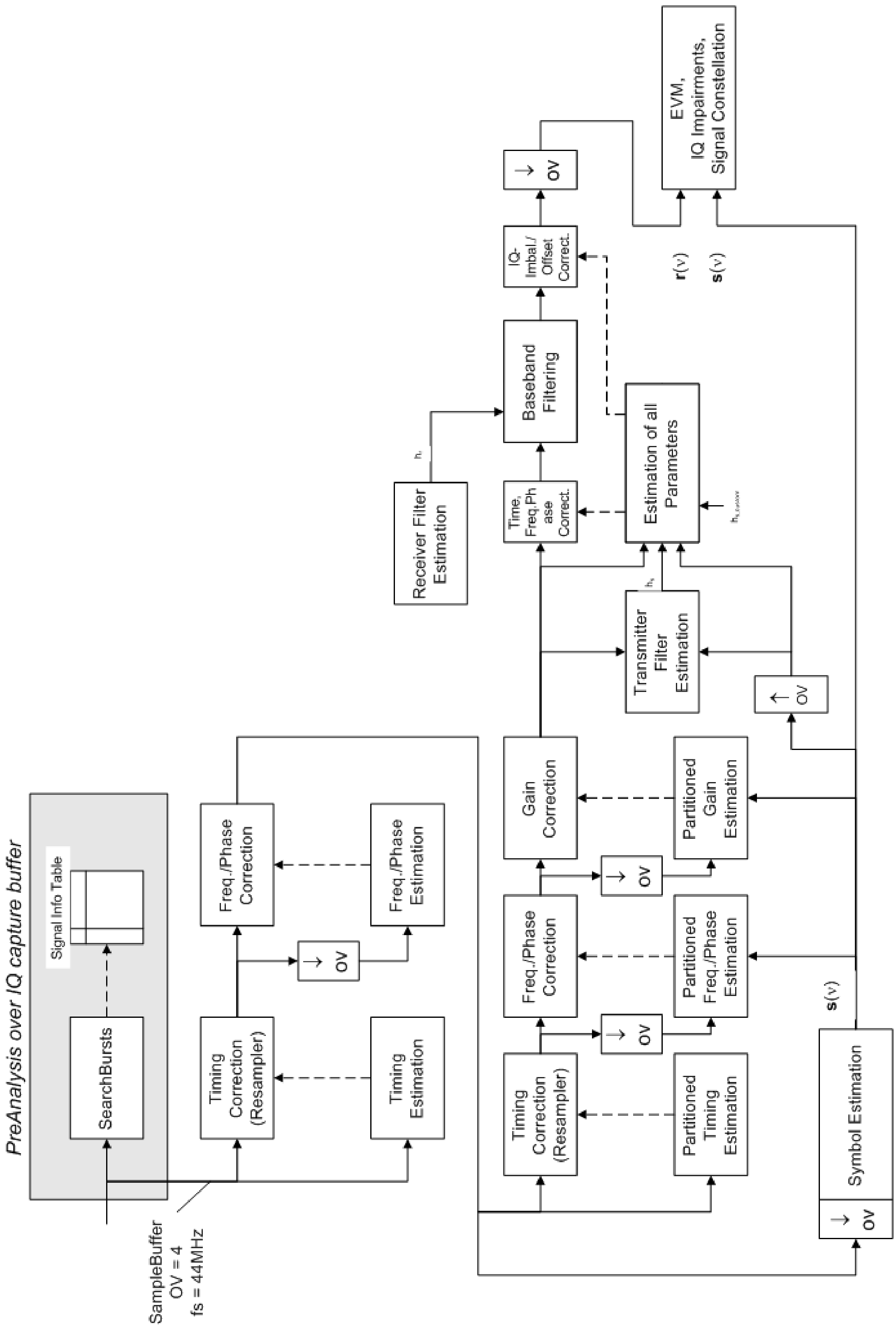


Figure 4-2: Signal processing for IEEE 802.11b or g (DSSS) signals

Once the normalized and undisturbed reference signal is available, the transmit antenna baseband filter (Tx filter) is estimated by minimizing the cost function of a maximum-likelihood-based estimator:

$$L_1 = \sum_{\nu=0}^{N-1} \left| r(\nu) \times e^{-j2\pi\Delta\tilde{f}\nu} \times e^{-j\Delta\tilde{\phi}} - \sum_{i=-L}^{+L} \tilde{h}_s(i) \times \hat{s}_n(\nu - i) - \tilde{o}_I - j\tilde{o}_Q \right|^2$$

Equation 4-9: transmit antenna baseband filter (Tx filter) estimation

where:

$r(\nu)$: the oversampled measurement signal

$\hat{s}_n(\nu)$: the normalized oversampled power of the undisturbed reference signal

N : the observation length

L : the filter length

$\Delta\tilde{f}\nu$: the variation parameters of the frequency offset

$\Delta\tilde{\phi}$: the variation parameters of the phase offset

$\tilde{o}_I$ $\tilde{o}_Q$: the variation parameters of the IQ-offset

$\tilde{h}_s(i)$: the coefficients of the transmitter filter

4.2.2 Calculation of Signal Parameters

The frequency offset, the phase offset and the IQ-offset are estimated jointly with the coefficients of the transmit filter to increase the estimation quality.

Once the transmit filter is known, all other unknown signal parameters are estimated with a maximum-likelihood-based estimation, which minimizes the cost function:

$$L_2 = \sum_{\nu=0}^{N-1} \left| r(\nu - \tilde{\varepsilon}) \times e^{-j2\pi\tilde{f}\nu} \times e^{-j\Delta\tilde{\phi}} - \tilde{g}_I \times s_I(\nu) - j\tilde{g}_Q \times s_Q(\nu) + \Delta\tilde{g}_Q \times s_Q(\nu) - \tilde{o}_I - j\tilde{o}_Q \right|^2$$

Equation 4-10: Cost function for signal parameters

where:

$\tilde{g}_I$ $\tilde{g}_Q$: the variation parameters of the gain used in the I/Q-branch

$\Delta\tilde{g}_Q$: the crosstalk factor of the Q-branch into the I-branch

$s_I(\nu)$ $s_Q(\nu)$: the filtered reference signal of the I/Q-branch

The unknown signal parameters are estimated in a joint estimation process to increase the accuracy of the estimates.

The accurate estimates of the frequency offset, the gain imbalance, the quadrature error and the normalized I/Q offset are displayed by the measurement software.

Gain imbalance, I/Q offset, quadrature error

The gain imbalance is the quotient of the estimates of the gain factor of the Q-branch, the crosstalk factor and the gain factor of the I-branch:

$$\boldsymbol{Gain-imbalance} = \left| \frac{\hat{g}_Q + \Delta\hat{g}_Q}{\hat{g}_I} \right|$$

Equation 4-11: Gain imbalance

The quadrature error is a measure for the crosstalk of the Q-branch into the I-branch:

$$\boldsymbol{Quadrature-Error} = \boldsymbol{ARG}\left\{\hat{g}_Q + j \times \Delta\hat{g}_Q\right\}$$

Equation 4-12: Quadrature error (crosstalk)

The normalized I/Q offset is defined as the magnitude of the I/Q offset normalized by the magnitude of the reference signal:

$$IQ-Offset = \frac{\sqrt{\hat{o}_I^2 + \hat{o}_Q^2}}{\sqrt{\frac{1}{2}\cdot\left[\hat{g}_I^2 + \hat{g}_Q^2\right]^2}}$$

Equation 4-13: I/Q offset

At this point of the signal processing all unknown signal parameters such as timing offset, frequency offset, phase offset, I/Q offset and gain imbalance have been evaluated and the measurement signal can be corrected accordingly.

Error vector magnitude (EVM) - R&S FSW method

Using the corrected measurement signal r(v) and the estimated reference signal ŝ(v), the modulation quality parameters can be calculated. The mean error vector magnitude (EVM) is the quotient of the root-mean-square values of the error signal power and the reference signal power:

$$EVM = \frac{\sqrt{\sum_{v=0}^{N-1} \left| r(v) - \hat{s}(v) \right|^2}}{\sqrt{\sum_{v=0}^{N-1} \left| \hat{s}(v) \right|^2}}$$

Equation 4-14: Mean error vector magnitude (EVM)

Whereas the symbol error vector magnitude is the momentary error signal magnitude normalized by the root mean square value of the reference signal power:

$$EVM(v)=\frac{\left|r(v)-\hat{s}(v)\right|}{\sqrt{\sum_{v=0}^{N-1}\left|\hat{s}(v)\right|^{2}}}$$

Equation 4-15: Symbol error vector magnitude

Error vector magnitude (EVM) - IEEE 802.11b or g (DSSS) method

In [2] a different algorithm is proposed to calculate the error vector magnitude. In a first step the IQ-offset in the I-branch and the IQ-offset of the Q-branch are estimated separately:

$$\hat{o}_I=\frac{1}{N}\sum_{v=0}^{N-1}\mathrm{REAL}\{r(v)\}$$

Equation 4-16: I/Q offset I-branch

$$\hat{o}_Q=\frac{1}{N}\sum_{v=0}^{N-1}\mathrm{IMAG}\{r(v)\}$$

Equation 4-17: I/Q offset Q-branch

where r(v) is the measurement signal which has been corrected with the estimates of the timing offset, frequency offset and phase offset, but not with the estimates of the gain imbalance and I/Q offset

With these values the gain imbalance of the I-branch and the gain imbalance of the Q-branch are estimated in a non-linear estimation in a second step:

$$\hat{g}_I=\frac{1}{N}\sum_{v=0}^{N-1}\left|\mathrm{REAL}\{r(v)-\hat{o}_I\}\right|$$

Equation 4-18: Gain imbalance I-branch

$$\hat{g}_Q=\frac{1}{N}\sum_{v=0}^{N-1}\left|\mathrm{IMAG}\{r(v)-\hat{o}_Q\}\right|$$

Equation 4-19: Gain imbalance Q-branch

Finally, the mean error vector magnitude can be calculated with a non-data-aided calculation:

$$V_{\mathrm{err}}(v)=\frac{\sqrt{\frac{1}{2}\sum_{v=0}^{N-1}\left[\left|\mathrm{REAL}\{r(v)\}-\hat{o}_I\right|-\hat{g}_I\right]^2+\frac{1}{2}\sum_{v=0}^{N-1}\left[\left|\mathrm{IMAG}\{r(v)\}-\hat{o}_Q\right|-\hat{g}_Q\right]^2}}{\sqrt{\frac{1}{2}\cdot\left[\hat{g}_I^2+\hat{g}_Q^2\right]}}$$

Equation 4-20: Mean error vector magnitude

The symbol error vector magnitude is the error signal magnitude normalized by the root mean square value of the estimate of the measurement signal power:

$$V_{\text{err}}(v) = \frac{\sqrt{\frac{1}{2}\left[\text{REAL}\{r(v)\} - \hat{o}_I\left| - \hat{g}_I\right]^2 + \frac{1}{2}\left[\text{IMAG}\{r(v)\} - \hat{o}_Q\right| - \hat{g}_Q\right]^2}}{\sqrt{\frac{1}{2}\cdot\left[\hat{g}_I^2 + \hat{g}_Q^2\right]^2}}$$

Equation 4-21: Symbol error vector magnitude

The advantage of this method is that no estimate of the reference signal is needed, but the I/Q offset and gain imbalance values are not estimated in a joint estimation procedure. Therefore, each estimation parameter disturbs the estimation of the other parameter and the accuracy of the estimates is lower than the accuracy of the estimations achieved by transmit antenna baseband filter (Tx filter) estimation. If the EVM value is dominated by Gaussian noise this method yields similar results as Cost function for signal parameters.

The EVM vs Symbol result display shows two traces, each using a different calculation method, so you can easily compare the results

(see "EVM vs Symbol" on page 31)

4.2.3 Literature on the IEEE 802.11b Standard

[1]	Institute of Electrical and Electronic Engineers, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications, IEEE Std 802.11-1999, Institute of Electrical and Electronic Engineers, Inc., 1999.
[2]	Institute of Electrical and Electronic Engineers, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher-Speed Physical Layer Extensions in the 2.4 GHz Band, IEEE Std 802.11b-1999, Institute of Electrical and Electronic Engineers, Inc., 1999.

4.3 Signal Processing for MIMO Measurements (IEEE 802.11ac, n)

For measurements according to the IEEE 802.11a, b, g standards, only a single transmit antenna and a single receive antenna are required (SISO = single in, single out). For measurements according to the IEEE 802.11ac or n standard, the R&S FSW can measure multiple data streams between multiple transmit antennas and multiple receive antennas (MIMO = multiple in, multiple out).

As opposed to other Rohde & Schwarz signal and spectrum analyzers, in the R&S FSW WLAN application, MIMO is not selected as a specific standard. Rather, when you select the IEEE 802.11ac or n standard, MIMO is automatically available. In the default configuration, a single transmit antenna and a single receive antenna are assumed, which corresponds to the common SISO setup.

Basic technologies

Some basic technologies used in MIMO systems are introduced briefly here. For more detailed information, see the Rohde & Schwarz Application Note (1MA142: "Introduction to MIMO"), available for download from the Rohde & Schwarz website.

MIMO systems use *transmit diversity* or *space-division multiplexing*, or both. With **transmit diversity**, a bit stream is transmitted simultaneously via two antennas, but with different coding in each case. This improves the signal-to-noise ratio and the cell edge capacity.

For **space-division multiplexing**, multiple (different) data streams are sent simultaneously from the transmit antennas. Each receive antenna captures the superposition of all transmit antennas. In addition, channel effects caused by reflections and scattering etc., are added to the received signals. The receiver determines the originally sent symbols by multiplying the received symbols with the inverted channel matrix (that is, the mapping between the streams and the transmit antennas, see Chapter 4.3.2, "Spatial Mapping", on page 72).

Using space-division multiplexing, the transmitted data rates can be increased significantly by using additional antennas.

To reduce the correlation between the propagation paths, the transmit antenna can delay all of the transmission signals except one. This method is referred to as *cyclic delay diversity* or ***cyclic delay shift***.

The basis of the majority of the applications for broadband transmission is the **OFDM method**. In contrast to single-carrier methods, an OFDM signal is a combination of many orthogonal, separately modulated carriers. Since the data is transmitted in parallel, the symbol length is significantly smaller than in single-carrier methods with identical transmission rates.

Signal processing chain

In a test setup with multiple antennas, the R&S FSW is likely to receive multiple spatial streams, one from each antenna. Each stream has gone through a variety of transformations during transmission. The signal processing chain is displayed in Figure 4-3, starting with the creation of the spatial streams in the transmitting device, through the wireless transmission and ending with the merging of the spatial streams in the receiving device. This processing chain has been defined by IEEE.

The following figure shows the basic processing steps performed by the transmit antenna and the complementary blocks in reverse order applied at the receive antenna:

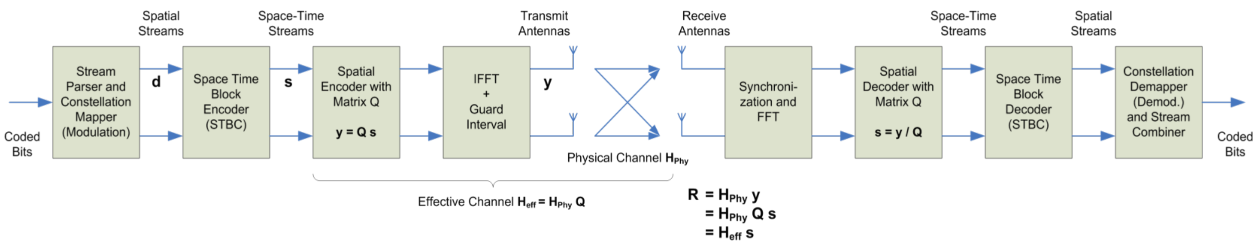


Figure 4-3: Data flow from the transmit antenna to the receive antenna

4.3.1 Space-Time Block Coding (STBC)

The coded bits to be transmitted are modulated to create a data stream, referred to as a *spatial stream*, by the stream parser in the transmitting device under test (see Figure 4-3).

The Space-Time Block Encoder (STBC) implements the transmit diversity technique (see "Basic technologies" on page 71). It creates multiple copies of the data streams, each encoded differently, which can then be transmitted by a number of antennas.

To do so, the STBC encodes only the *data* carriers in the spatial stream using a matrix. Each row in the matrix represents an OFDM symbol and each column represents one antenna's transmissions over time (thus the term *space-time encoder*). This means each block represents the same data, but with a different coding. The resulting blocks are referred to as *space-time streams* (STS). Each stream is sent to a different Tx antenna. This *diversity coding* increases the signal-to-noise ratio at the receive antenna. The *pilot* carriers are inserted after the data carriers went through the STBC. Thus, only the data carriers are decoded by the analyzer to determine characteristics of the demodulated data (see also Figure 4-6).

In order to transmit the space-time streams, two or more antennas are required by the sender, and one or more antennas are required by the receive antenna.

4.3.2 Spatial Mapping

The Spatial Encoder (see Figure 4-3) is responsible for the spatial multiplexing. It defines the mapping between the streams and the transmit antennas - referred to as *spatial mapping* - or as a matrix: the *spatial mapping matrix*.

In the R&S FSW WLAN application, the mapping can be defined using the following methods:

- **Direct mapping**: one single data stream is mapped to an exclusive Tx antenna (The spatial matrix contains "1" on the diagonal and otherwise zeros.)
- **Spatial Expansion**: multiple (different) data streams are assigned to each antenna in a defined pattern
- **User-defined mapping:** the data streams are mapped to the antennas by a user-defined matrix

User-defined spatial mapping

You can define your own spatial mapping between streams and Tx antennas.

For each antenna (Tx1..4), the complex element of each STS-stream is defined. The upper value is the real part of the complex element. The lower value is the imaginary part of the complex element.

Additionally, a "Time Shift" can be defined for cyclic delay diversity (CSD).

The stream for each antenna is calculated as:

$$\begin{pmatrix} Tx_1 - Stream \\ . \\ . \\ Tx_4 - Stream \end{pmatrix} = \begin{pmatrix} Tx_1, STS.1 & . & . & Tx_1, STS.4 \\ . & & & . \\ . & & & . \\ Tx_4, STS.1 & . & . & Tx_4, STS.4 \end{pmatrix} \begin{pmatrix} STS - Stream_1 \\ . \\ . \\ STS - Stream_4 \end{pmatrix}$$

4.3.3 Physical vs Effective Channels

The **effective channel** refers to the transmission path starting from the space-time stream and ending at the receive antenna. It is the product of the following components:

- the spatial mapping
- the crosstalk inside the device under test (DUT) transmission paths
- the crosstalk of the channel between the transmit antennas and the receive antennas

For each space-time stream, at least one training field (the (V)HT-LTF) is included in every PPDU preamble (see Figure 4-4). Each sender antenna transmits these training fields, which are known by the receive antenna. The effective channel can be calculated from the received (and known) (V)HT-LTF symbols of the preamble, without knowledge of the spatial mapping matrix or the physical channel. Thus, the effective channel can always be calculated.

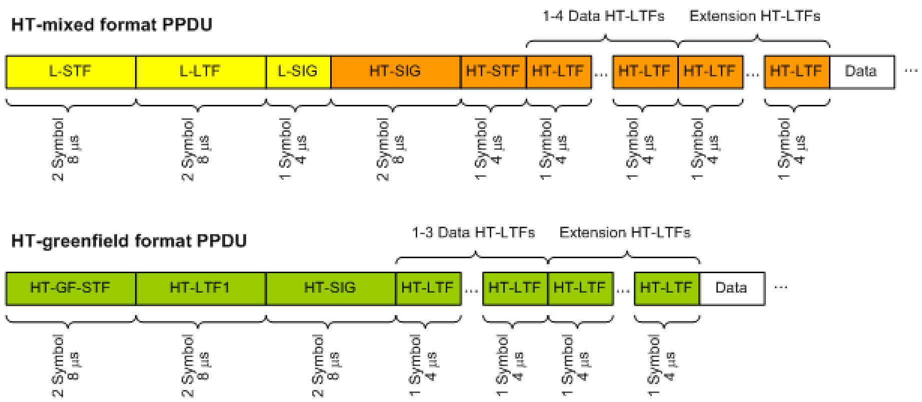


Figure 4-4: Training fields (TF) in the preamble of PPDUs in IEEE 802.11n standard

The effective channel is sufficient to calculate the EVM, the constellation diagram and the bitstream results of the measured signal, so these results are always available.

The **physical channel** refers to the transmission path starting from the transmit antenna streams and ending at the receive antenna. It is the product of the following components:

- the crosstalk inside the device under test (DUT) transmission paths
- the crosstalk of the channel between the transmit antennas and the receive antennas

The physical channel is derived from the effective channel using the inverted spatial mapping matrix Q:

$H_{phy} = H_{eff}Q^{-1}$

Thus, if the spatial mapping matrix cannot be inverted, the physical channel cannot be calculated. This may be the case, for example, if the signal contains fewer streams than Rx antenna signals, or if the spatial matrix is close to numerical singularity.

In this case, results that are based on the transmit antenna such as I/Q offset, gain imbalance and quadrature offset are not available.

Crosstalk in estimated channels

Note that the estimated channel transfer function contains crosstalk from various sources, for example:

- from the transmission paths inside the DUT
- from the connection between the analyzer and the DUT
- from the analyzer itself

The crosstalk from the analyzer can be neglected. If the analyzer and DUT are connected by cable, this source of crosstalk can also be neglected. For further information on crosstalk see Chapter 4.3.6, "Crosstalk and Spectrum Flatness", on page 78.

4.3.4 Capturing Data from MIMO Antennas

The primary purpose of many test applications that verify design parameters, or are used in production, is to determine if the transmitted signals adhere to the relevant standards and whether the physical characteristics fall within the specified limits. In such cases there is no need to measure the various transmit paths simultaneously. Instead, they can either be tested as single antenna measurements, or sequentially (with restrictions, see also Chapter 4.3.4.1, "Sequential MIMO Measurement", on page 75). Then only one analyzer is needed to measure parameters such as error vector magnitude (EVM), power and I/Q imbalance.

Measurements that have to be carried out for development or certification testing are significantly more extensive. In order to fully reproduce the data in transmit signals or analyze the crosstalk between the antennas, for example, measurements must be performed simultaneously on all antennas. One analyzer is still sufficient if the system is using transmit diversity (multiple input single output – MISO). However, space-division multiplexing requires two or more analyzers to calculate the precoding matrix and demodulate the signals.

The R&S FSW WLAN application provides the following methods to capture data from the MIMO antennas:

- **Simultaneous MIMO operation**
  The data streams are measured simultaneously by multiple analyzers. One of the analyzers is defined as a *master*, which receives the I/Q data from the other analyzers (the *slaves*). The IP addresses of each slave analyzer must be provided to

the master. The only function of the slaves is to record the data that is then accumulated centrally by the master.
(Note that only the MIMO master analyzer requires the R&S FSW-K91n or ac option. The slave analyzers do not require a R&S FSW WLAN application.)
The number of Tx antennas on the DUT defines the number of analyzers required for this measurement setup.
Tip: Use the master's trigger output (see Chapter 4.9.5, "Trigger Synchronization Using the Master's Trigger Output", on page 87) or an R&S Z11 trigger box (see Chapter 4.9.6, "Trigger Synchronization Using an R&S FS-Z11 Trigger Unit", on page 87) to send the same trigger signal to all devices.
The master calculates the measurement results based on the I/Q data captured by *all* analyzers (master and slaves) and displays them in the selected result displays.

- **Sequential using open switch platform**
  The data streams are measured sequentially by a single analyzer connected to an additional switch platform that switches between antenna signals. No manual interaction is necessary during the measurement. The R&S FSW WLAN application captures the I/Q data for all antennas sequentially and calculates and displays the results (individually for each data stream) in the selected result displays automatically.
  A single analyzer and the Rohde & Schwarz OSP Switch Platform is required to measure the multiple DUT Tx antennas (the switch platform must be fitted with at least one R&S®OSP-B101 option; the number depends on the number of Tx antennas to measure). The IP address of the OSP and the used module (configuration bank) must be defined on the analyzer; the required connections between the DUT Tx antennas, the switch box and the analyzer are indicated in the MIMO "Signal Capture" dialog box.
  For **important restrictions** concerning sequential measurement see Chapter 4.3.4.1, "Sequential MIMO Measurement", on page 75.
- **Sequential using manual operation**
  The data streams are captured sequentially by a single analyzer. The antenna signals must be connected to the single analyzer input sequentially by the user.
  In the R&S FSW WLAN application, individual capture buffers are provided (and displayed) for each antenna input source, so that results for the individual data streams can be calculated. The user must initiate data capturing for each antenna and result calculation for all data streams manually.
  For **important restrictions** concerning sequential measurement see Chapter 4.3.4.1, "Sequential MIMO Measurement", on page 75.
- **Single antenna measurement**
  The data from the Tx antenna is measured and evaluated as a single antenna (SISO) measurement ("DUT MIMO configuration" = "1 Tx antenna").

4.3.4.1 Sequential MIMO Measurement

Sequential MIMO measurement allows for MIMO analysis with a single analyzer by capturing the receive antennas one after another (sequentially). However, sequential MIMO measurement requires each Tx antenna to transmit ***the same PPDU over time***. (The PPDU *content* from different Tx antennas, on the other hand, may be different.) If this requirement can not be fulfilled, use the simultaneous MIMO capture method (see Chapter 4.3.4, "Capturing Data from MIMO Antennas", on page 74).

In addition, the following **PPDU attributes must be identical for ALL antennas**:

- PPDU length
- PPDU type
- Channel bandwidth
- MCS Index
- Guard Interval Length
- Number of STBC Streams
- Number of Extension Streams

Thus, for each PPDU the Signal Field bit vector has to be identical for ALL antennas!

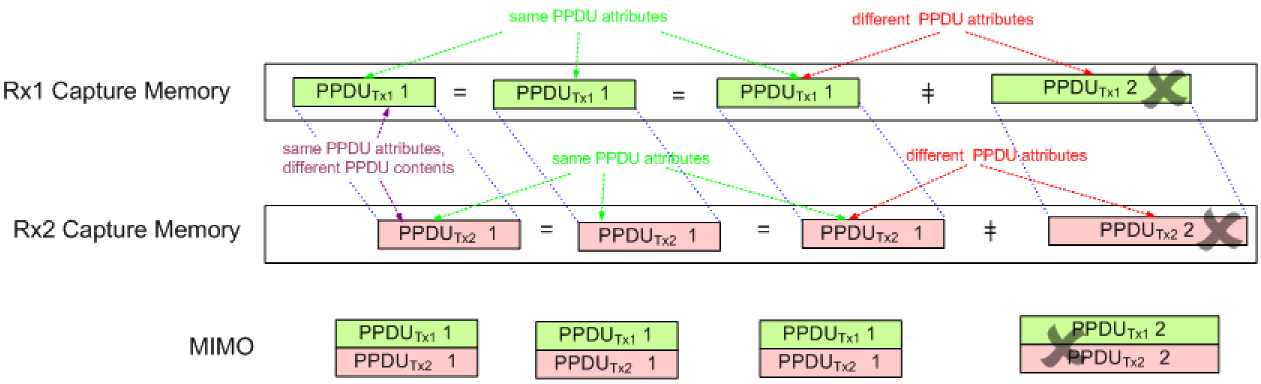


Figure 4-5: Basic principle of "Sequential MIMO Measurement" with 2 receive antennas

Note that, additionally, the data contents of the sent PPDU *payloads* must also be the same for each Tx antenna, but this is not checked. Thus, useless results are returned if different data was sent.

To provide identical PPDU content for each Tx antenna in the measurement, you can use the same pseudo-random bit sequence (PRBS) with the same PRBS seed (initial bit sequence), for example, when generating the useful data for the PPDU.

4.3.5 Calculating Results

When you analyze a WLAN signal in a MIMO setup, the R&S FSW acts as the receiving device. Since most measurement results have to be calculated at a particular stage in the processing chain, the R&S FSW WLAN application has to do the same decoding that the receive antenna does.

The following diagram takes a closer look at the processing chain and the results at its individual stages.

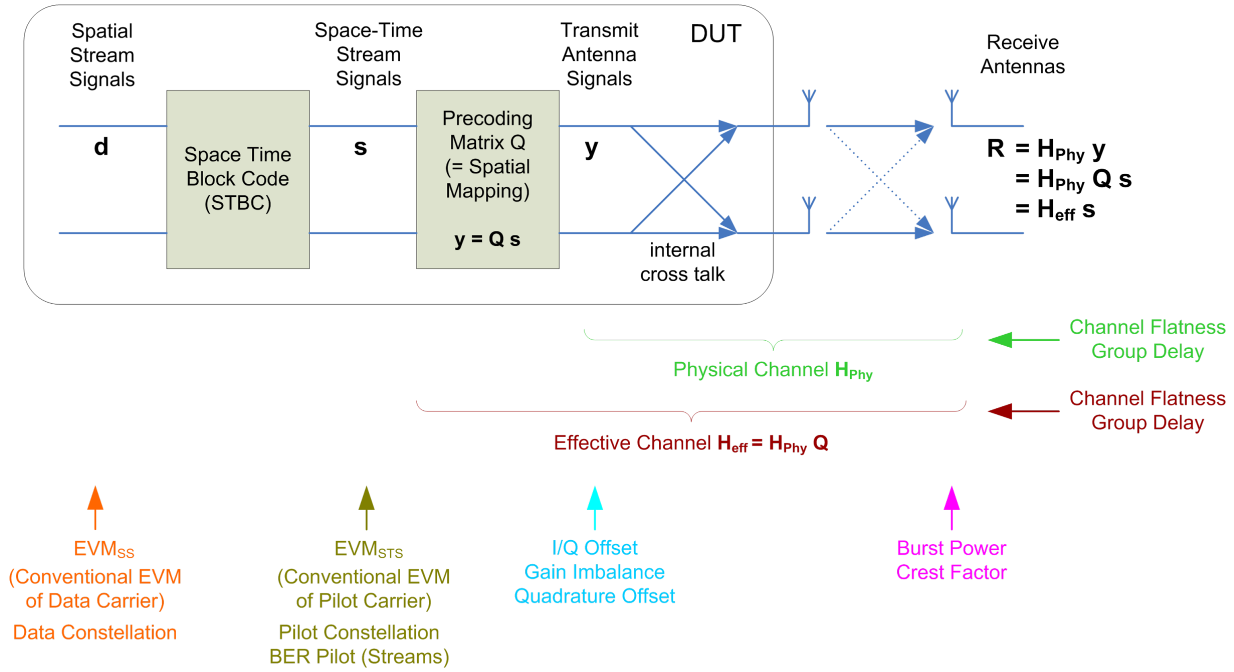


Figure 4-6: Results at individual processing stages

Receive antenna results

The R&S FSW WLAN application can determine receive antenna results directly from the captured data at the receive antenna, namely:

- PPDU Power
- Crest factor

For all other results, the R&S FSW WLAN application has to revert the processing steps to determine the signal characteristics at those stages.

Transmit antenna results (based on the physical channel)

If the R&S FSW WLAN application can determine the physical channel (see Chapter 4.3.3, "Physical vs Effective Channels", on page 73), it can evaluate the following results:

- Channel Flatness (based on the physical channel)
- Group Delay (based on the physical channel)
- I/Q Offset
- Quadrature Offset
- Gain Imbalance

Space-time stream results (based on the effective channel)

If the application knows the effective channel (see Chapter 4.3.3, "Physical vs Effective Channels", on page 73), it can evaluate the following results:

- Channel Flatness (based on the effective channel)
- Group Delay (based on the effective channel)
- EVM of pilot carriers
- Constellation of pilot carriers
- Bitstream of pilot carriers

Spatial stream results

If space-time encoding is implemented, the demodulated data must first be decoded to determine the following results:

- EVM of data carriers
- Constellation diagram
- Bitstream

The *pilot* carriers are inserted directly after the data carriers went through the STBC (see also Chapter 4.3.1, "Space-Time Block Coding (STBC)", on page 72). Thus, only the data carriers need to be decoded by the analyzer to determine characteristics of the demodulated data. Because of this approach to calculate the EVM, Constellation and Bitstream results, you might get results for a different number of streams for pilots and data carriers if STBC is applied.

4.3.6 Crosstalk and Spectrum Flatness

In contrast to the SISO measurements in previous Rohde & Schwarz signal and spectrum analyzers, the spectrum flatness trace is no longer normalized to 0 dB (scaled by the mean gain of all carriers).

For MIMO there may be different gains in the transmission paths and you do not want to lose the relation between these transmission paths. For example, in a MIMO transmission path matrix we have paths carrying power (usually the diagonal elements for the transmitted streams), but also elements with only residual crosstalk power. The power distribution of the transmission matrix depends on the spatial mapping of the transmitted streams. But even if all matrix elements carry power, the gains may be different. This is the reason why the traces are no longer scaled to 0 dB. Although the absolute gain of the Spectrum Flatness is not of interrest, it is now maintained in order to show the different gains in the transmission matrix elements. Nevertheless, the limit lines are still symmetric to the mean trace, individually for each element of the transmission matrix.

By default, full MIMO equalizing is performed by the R&S FSW WLAN application. However, you can deactivate compensation for crosstalk (see "Compensate Crosstalk (MIMO only)" on page 143). In this case, simple main path equalizing is performed only for direct connections between Tx and Rx antennas, disregarding ancillary transmission between the main paths (crosstalk). This is useful to investigate the effects of crosstalk on results such as EVM.

4.4 Channels and Carriers

In an OFDM system such as WLAN, the channel is divided into carriers using FFT / IFFT. Depending on the channel bandwidth, the FFT window varies between 64 and 512 (see also Chapter 4.6, "Demodulation Parameters - Logical Filters", on page 80). Some of these carriers can be used (active carriers), others are inactive (e.g. guard carriers at the edges). The channel can then be determined using the active carriers as known points; inactive carriers are interpolated.

4.5 Recognized vs. Analyzed PPDUs

A PPDU in a WLAN signal consists of the following parts:

(For IEEE 802.11n see also Figure 4-4)

- **Preamble**
  Information required to recognize the PPDU within the signal, for example training fields
- **Signal Field**
  Information on the modulation used for transmission of the useful data
- **Payload**
  The useful data

During signal processing, PPDUs are recognized by their preamble symbols. The recognized PPDUs and the information on the modulation used for transmission of the useful data are shown in the "Signal Field" result display

(see "Signal Field" on page 46)

Not all of the recognized PPDUs are analyzed. Some are dismissed because the PPDU parameters do not match the user-defined demodulation settings, which act as a *logical filter* (see also Chapter 4.6, "Demodulation Parameters - Logical Filters", on page 80). Others may be dismissed because they contain too many or too few payload symbols (as defined by the user), or due to other irregularities or inconsistency.

Dismissed PPDUs are indicated as such in the "Signal Field" result display (highlighted red, with a reason for dismissal).

PPDUs with detected inconsistencies are indicated by orange highlighting and a warning in the "Signal Field" result display, but are nevertheless analyzed and included in statistical and global evaluations.

The remaining correct PPDUs are highlighted green in the "Magnitude Capture" buffer and "Signal Field" result displays and analyzed according to the current user settings.

Example:

The evaluation range is configured to take the "Source of Payload Length" from the signal field. If the power period detected for a PPDU deviates from the PPDU length coded in the signal field, a warning is assigned to this PPDU. The decoded signal field length is used to analyze the PPDU. The decoded and measured PPDU length together with the appropriate information is shown in the "Signal Field" result display.

4.6 Demodulation Parameters - Logical Filters

The demodulation settings define which PPDUs are to be analyzed, thus they define a *logical filter*. They can either be defined using specific values or according to the first measured PPDU.

Which of the WLAN demodulation parameter values are supported depends on the selected digital standard, some are also interdependant.

Table 4-1: Supported modulation formats, PPDU formats and channel bandwidths depending on standard

Standard	Modulation formats	PPDU formats	Channel bandwidths
IEEE 802.11a, g (OFDM), j, p	BPSK (6 Mbps & 9 Mbps) QPSK (12 Mbps & 18 Mbps) 16QAM (24 Mbps & 36 Mbps) 64QAM (48 Mbps & 54 Mbps)	Non-HT Short PPDU Long PPDU	5 MHz, 10 MHz, 20 MHz*)
IEEE 802.11ac	16QAM 64QAM 256QAM 1024QAM	VHT	20 MHz*), 40 MHz*), 80 MHz*), 160 MHz*)
IEEE 802.11b, g (DSSS)	DBPSK (1 Mbps) DQPSK (2 Mbps) CCK (5.5 Mbps & 11 Mbps) PBCC (5.5 Mbps & 11 Mbps)	Short PPDU Long PPDU	22 MHz
*): requires R&S FSW bandwidth extension option, see Chapter A.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 366			

Standard	Modulation formats	PPDU formats	Channel bandwidths
IEEE 802.11n	**SISO:** BPSK (6.5, 7.2, 13.5 & 15 Mbps) QPSK (13, 14.4, 19.5, 21.7, 27, 30, 40,5 & 45 Mbps) 16QAM (26, 28.9, 39, 43.3, 54, 60, 81 & 90 Mbps) 64QAM (52, 57.8, 58.5, 65, 72.2, 108, 121.5, 135, 120, 135 & 150 Mbps)	HT-MF (Mixed format) HT-GF (Greenfield format)	20 MHz*), 40 MHz*)
	MIMO: depends on the MCS index		
*): requires R&S FSW bandwidth extension option, see Chapter A.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 366			

4.7 Receiving Data Input and Providing Data Output

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

4.7.1 RF Input Protection

The RF input connector of the R&S FSW must be protected against signal levels that exceed the ranges specified in the data sheet. Therefore, the R&S FSW is equipped with an overload protection mechanism. This mechanism becomes active as soon as the power at the input mixer exceeds the specified limit. It ensures that the connection between RF input and input mixer is cut off.

When the overload protection is activated, an error message is displayed in the status bar ("INPUT OVLD"), and a message box informs you that the RF Input was disconnected. Furthermore, a status bit (bit 3) in the `STAT:QUES:POW` status register is set. In this case you must decrease the level at the RF input connector and then close the message box. Then measurement is possible again. Reactivating the RF input is also possible via the remote command `INPut:ATTenuation:PROTection:RESet`.

4.7.2 Input from Noise Sources

The R&S FSW provides a connector (NOISE SOURCE CONTROL) with a voltage supply for an external noise source. By switching the supply voltage for an external noise source on or off in the firmware, you can activate or deactive the device as required.

External noise sources are useful when you are measuring power levels that fall below the noise floor of the R&S 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 R&S FSW and measure the total noise power. From this value you can determine the noise power of the R&S 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.

The noise source is controlled in the "Output" settings, see "Noise Source" on page 114

4.7.3 Receiving and Providing Trigger Signals

Using one of the TRIGGER INPUT / OUTPUT connectors of the R&S FSW, the R&S FSW can use a signal from an external device as a trigger to capture data. Alternatively, the internal trigger signal used by the R&S FSW can be output for use by other connected devices. Using the same trigger on several devices is useful to synchronize the transmitted and received signals within a measurement.

For details on the connectors see the R&S FSW "Getting Started" manual.

External trigger as input

If the trigger signal for the R&S FSW is provided by an external device, the trigger signal source must be connected to the R&S FSW and the trigger source must be defined as "External" for the R&S FSW.

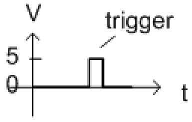
Trigger output

The R&S FSW can provide output to another device either to pass on the internal trigger signal, or to indicate that the R&S FSW itself is ready to trigger.

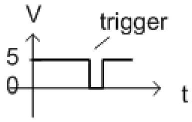
The trigger signal can be output by the R&S FSW automatically, or manually by the user. If it is provided automatically, a high signal is output when the R&S FSW has triggered due to a measurement start ("Device Triggered"), or when the R&S FSW is ready to receive a trigger signal after a measurement start ("Trigger Armed").

Manual triggering

If the trigger output signal is initiated manually, the length and level (high/low) of the trigger pulse is also user-definable. Note, however, that the trigger pulse level is always opposite to the constant signal level defined by the output "Level" setting, e.g. for "Level = High", a constant high signal is output to the connector until the "Send Trigger" button is selected. Then, a low pulse is provided.



low-level constant,
high-level trigger



high-level constant,
low-level trigger

Providing trigger signals as output is described in detail in the R&S FSW User Manual.

4.8 Preparing the R&S FSW for the Expected Input Signal - Frontend Parameters

On the R&S FSW, the input data can only be processed optimally if the hardware settings match the signal characteristics as closely as possible. On the other hand, the hardware must be protected from powers or frequencies that exceed the allowed limits. Therefore, you must set the hardware so that it is optimally prepared for the expected input signal, without being overloaded. You do this using the *frontend* parameters. Consider the following recommendations:

Reference level

Adapt the R&S FSW's hardware to the expected maximum signal level by setting the "Reference Level" to this maximum. Compensate for any external attenuation or gain by defining a "Reference Level" offset.

Attenuation

To optimize the signal-to-noise ratio of the measurement for high signal levels and to protect the R&S FSW from hardware damage, provide for a high attenuation. Use AC coupling for DC input voltage.

Amplification

To optimize the signal-to-noise ratio of the measurement for low signal levels, the signal level in the R&S FSW should be as high as possible but without introducing compression, clipping, or overload. Provide for early amplification by the preamplifier and a low attenuation.

Impedance

When measuring in a 75 Ω system, connect an external matching pad to the RF input and adapt the reference impedance for power results. The insertion loss is compensated for numerically.

4.9 Triggered Measurements

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 will cause the trigger in a jittering signal

4.9.1 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 R&S FSW captures data continuously in the time domain, even before the trigger occurs.

See "Trigger Offset" on page 129.

4.9.2 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 second possible trigger event is ignored as the signal does not exceed the hysteresis (threshold) before it reaches the trigger level again on the rising edge. On the falling edge, however, two trigger events occur as the signal exceeds the hysteresis before it falls to the trigger level the second time.

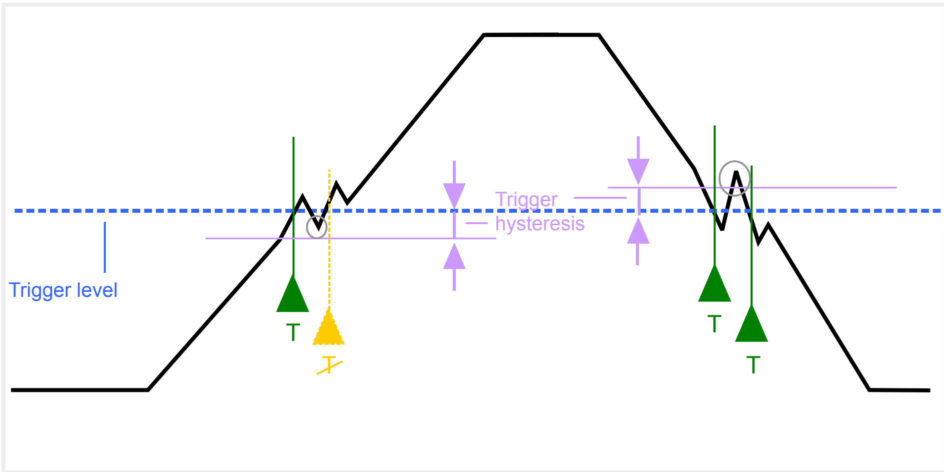


Figure 4-7: Effects of the trigger hysteresis

See "Hysteresis" on page 129

4.9.3 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.

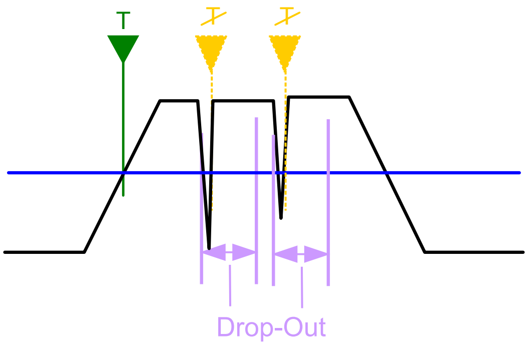


Figure 4-8: Effect of the trigger drop-out time

See "Drop-Out Time" on page 129.

Drop-out times for falling edge triggers

If a trigger is set to a falling edge ("Slope" = "Falling", see "Slope" on page 130) 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, so a trigger event will not occur until the pulsed signal is over!

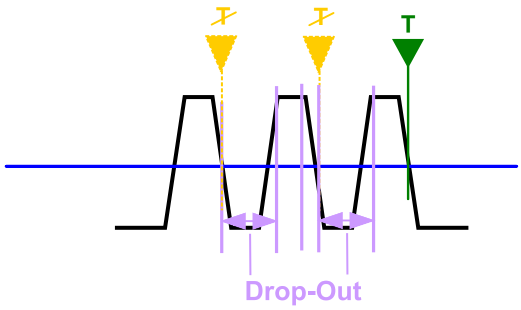


Figure 4-9: Trigger drop-out time for falling edge trigger

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

4.9.4 Trigger Holdoff

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

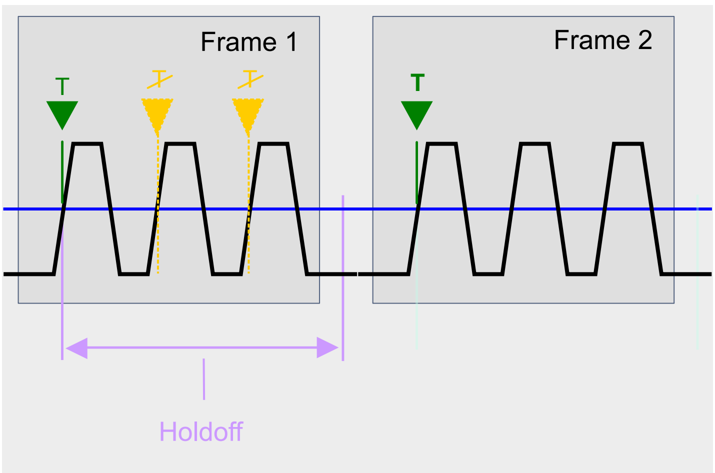


Figure 4-10: Effect of the trigger holdoff

See "Trigger Holdoff" on page 129.

4.9.5 Trigger Synchronization Using the Master's Trigger Output

For MIMO measurements in which the data from the multiple antennas is captured simultaneously by multiple analyzers (see "Simultaneous Signal Capture Setup" on page 134, the data streams to be analyzed must be synchronized in time. One possibility to ensure that all analyzers start capturing I/Q data at the same time is using the master's trigger output functionality.

The R&S FSW has variable input/output connectors for trigger signals. If you set the master's TRIGGER 2 INPUT/OUTPUT connector to "device-triggered" output, and connect it to the slaves' trigger input connectors, the master R&S FSW sends its trigger event signal to any connected slaves. The slaves are automatically configured to use the trigger source "External". The master itself can be configured to use any of the following trigger sources:

- External
- I/Q Power
- IF Power
- RF Power
- Power Sensor

4.9.6 Trigger Synchronization Using an R&S FS-Z11 Trigger Unit

For MIMO measurements in which the data from the multiple antennas is captured simultaneously by multiple analyzers (see "Simultaneous Signal Capture Setup" on page 134, the data streams to be analyzed must be synchronized in time. The R&S FS-Z11 Trigger Unit can ensure that all analyzers start capturing I/Q data at the same time. Compared to using the master's trigger out function, using the Trigger Unit provides a more accurate synchronization of the slaves. However, it requires the additional hardware.

The Trigger Unit is connected to the DUT and all involved analyzers. Then the Trigger Unit can be used in the following operating modes:

- **External mode:** If the DUT has a trigger output, the trigger signal from the DUT triggers all analyzers simultaneously.
  The DUT's TRIGGER OUTPUT is connected to the Trigger Unit's TRIG INPUT connector. Each of the Trigger Unit's TRIG OUT connectors is connected to one of the analyzer's TRIGGER INPUT connectors.
- **Free Run mode:** This mode is used if no trigger signal is available. The master analyzer sends a trigger impulse to the Trigger Unit to start the measurement as soon as all slave analyzers are ready to measure.
  The NOISE SOURCE output of the master analyzer is connected to the Trigger Unit's NOISE SOURCE input. Each of the Trigger Unit's TRIG OUT connectors is connected to one of the analyzer's TRIGGER INPUT connectors. When the master analyzer sends a signal to the Trigger Unit via its NOISE SOURCE output, the Trigger Unit triggers all analyzers simultaneously via its TRIGGER OUTPUT.
- **Manual mode:** a trigger is generated by the Trigger Unit and triggers all analyzers simultaneously. No connection to the DUT is required.

Each of the Trigger Unit's TRIG OUT connectors is connected to one of the analyzer's TRIGGER INPUT connectors. A trigger signal is generated when you press (release) the "TRIG MANUAL" button on the Trigger unit.
Note: In manual mode you must *turn on the NOISE SOURCE output* of the master analyzer manually (see the manual of the analyzer)!

A Trigger Unit is activated in the Trigger Source Settings. The required connections between the analyzers, the trigger unit, and the DUT are visualized in the dialog box.

The NOISE SOURCE output of the master analyzer must be connected to the Trigger Unit's NOISE SOURCE input for all operating modes to supply the power for the Trigger Unit.

For more detailed information on the R&S FS-Z11 Trigger Unit and the required connections, see the "R&S FS-Z11 Trigger Unit Manual".

4.10 WLAN I/Q Measurements in MSRA Operating Mode

The R&S FSW WLAN application can also be used to analyze I/Q data in MSRA operating mode.

In MSRA operating mode, the **IEEE 802.11b and g (DSSS)** standards are not supported.

In MSRA operating mode, only the MSRA Master actually captures data; the MSRA applications receive an extract of the captured data for analysis, referred to as the **application data**. For the R&S FSW WLAN application in MSRA operating mode, the application data range is defined by the same settings used to define the signal capture in Signal and Spectrum Analyzer mode. In addition, a capture offset can be defined, i.e. an offset from the start of the captured data to the start of the analysis interval for the WLAN I/Q measurement.

Data coverage for each active application

Generally, if a signal contains multiple data channels for multiple standards, separate applications are used to analyze each data channel. Thus, it is of interest to know which application is analyzing which data channel. The MSRA Master display indicates the data covered by each application, restricted to the channel bandwidth used by the corresponding standard, by vertical blue lines labeled with the application name.

Analysis interval

However, the individual result displays of the application need not analyze the complete data range. The data range that is actually analyzed by the individual result display is referred to as the **analysis interval**.

In the R&S FSW WLAN application the analysis interval is automatically determined according to the selected channel, carrier or PPDU to analyze which is defined for the evaluation range, depending on the result display. The analysis interval can not be edited directly in the R&S FSW WLAN application, but is changed automatically when you change the evaluation range.

Analysis line

A frequent question when analyzing multi-standard signals is how each data channel is correlated (in time) to others. Thus, an analysis line has been introduced. The analysis line is a common time marker for all MSRA slave applications. It can be positioned in any MSRA slave application or the MSRA Master and is then adjusted in all other slave applications. Thus, you can easily analyze the results at a specific time in the measurement in all slave applications and determine correlations.

If the marked point in time is contained in the analysis interval of the slave application, the line is indicated in all time-based result displays, such as time, symbol, slot or bit diagrams. By default, the analysis line is displayed, however, it can be hidden from view manually. In all result displays, the "AL" label in the window title bar indicates whether the analysis line lies within the analysis interval or not:

- **orange "AL"**: the line lies within the interval
- **white "AL"**: the line lies within the interval, but is not displayed (hidden)
- **no "AL"**: the line lies outside the interval

The analysis line is displayed in the following result displays.

- Magnitude Capture
- Power vs Time
- EVM vs Symbol

For details on the MSRA operating mode see the R&S FSW MSRA User Manual.

5 Configuration

The default WLAN I/Q measurement captures the I/Q data from the WLAN signal and determines various characteristic signal parameters such as the modulation accuracy, spectrum flatness, center frequency tolerance and symbol clock tolerance in just one measurement (see Chapter 3.1, "WLAN I/Q Measurement (Modulation Accuracy, Flatness and Tolerance)", on page 13)

Other parameters specified in the WLAN 802.11 standard must be determined in separate measurements (see Chapter 5.4, "Frequency Sweep Measurements", on page 172).

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

Selecting the measurement type

► To select a different measurement type, do one of the following:
  - Select the "Overview" softkey. In the "Overview", select the "Select Measurement" button. Select the required measurement.
  - Press the MEAS key. In the "Select Measurement" dialog box, select the required measurement.

5.1 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. These settings include the input source, the type of data to be processed (I/Q or RF data), frequency and level settings, measurement functions etc. If you want to perform the same measurement but with different center frequencies, for instance, or process the same input data with different measurement functions, there are two ways to do so:

- Change the settings in the measurement channel for each measurement scenario. In this case the results of each measurement are updated each time you change the settings and you cannot compare them or analyze them together without storing them on an external medium.
- Activate a new measurement channel for the same application.
  In the latter case, the two measurement scenarios with their different settings are displayed simultaneously in separate tabs, and you can switch between the tabs to compare the results.
  For example, you can activate one WLAN measurement channel to perform a WLAN modulation accuracy measurement, and a second channel to perform an

SEM measurement using the same WLAN input source. Then you can monitor all results at the same time in the "MultiView" tab.

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 on the R&S FSW at any time. If one measurement is running and you start another, or switch to another channel, the first measurement is stopped. In order to perform the different measurements you configured in multiple channels, you must switch from one tab to another.

However, you can enable a Sequencer function that automatically calls up each activated measurement channel in turn. This means the measurements configured in the 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 corresponding tab (as well as the "MultiView") as the measurements are performed. Sequencer operation is independent of the currently *displayed* tab; for example, you can analyze the SEM measurement while the modulation accuracy measurement is being performed by the Sequencer.

For details on the Sequencer function see the R&S FSW User Manual.

The Sequencer functions are only available in the "MultiView" tab.

Sequencer State

Activates or deactivates the Sequencer. If activated, sequential operation according to the selected Sequencer mode is started immediately.

Remote command:

SYSTem:SEQuencer on page 314
INITiate<n>:SEQuencer:IMMediate on page 312
INITiate<n>:SEQuencer:ABORt on page 311

Sequencer Mode

Defines how often which measurements are performed. The currently selected mode softkey is highlighted blue. During an active Sequencer process, the selected mode softkey is highlighted orange.

"Single Sequence"
Each measurement is performed once, until all measurements in all active channels have been performed.

"Continuous Sequence"
The measurements in each active channel are performed one after the other, repeatedly, in the same order, until sequential operation is stopped.
This is the default Sequencer mode.

Remote command:

INITiate<n>:SEQuencer:MODE on page 312

5.2 Display Configuration

The measurement results can be displayed using various evaluation methods. All evaluation methods available for the R&S FSW WLAN application are displayed in the evaluation bar in SmartGrid mode when you do one of the following:

- Select the "SmartGrid" icon from the toolbar.
- Select the "Display Config" button in the "Overview".
- Select the "Display Config" softkey in any WLAN menu.

Then you can 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 WLAN evaluation methods are described in Chapter 3, "Measurements and Result Displays", 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 R&S FSW Getting Started manual.

5.3 WLAN I/Q Measurement (Modulation Accuracy, Flatness, Tolerance...)

Access: MODE > "WLAN 802.11"

WLAN 802.11 measurements require a special application on the R&S FSW.

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

The "Span", "Bandwidth", "Lines", and "Marker Functions" menus are not available for WLAN I/Q measurements.

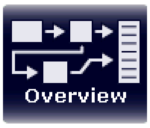
Multiple access paths to functionality

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

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

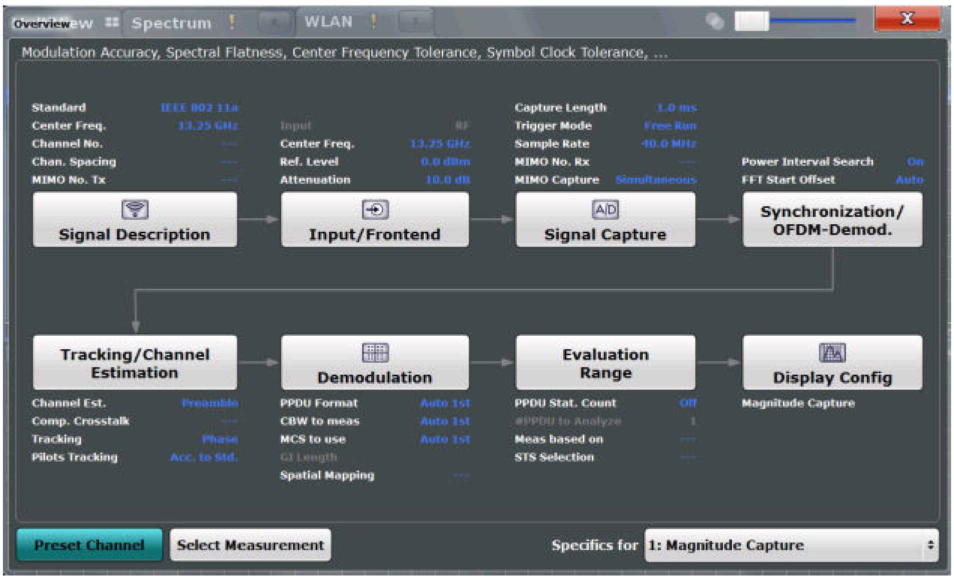
In this documentation, only the most convenient method of accessing the dialog boxes is indicated - usually via the "Overview".

5.3.1 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 frequency sweep measurements see Chapter 5.4, "Frequency Sweep Measurements", on page 172.

For the WLAN I/Q measurement, the "Overview" provides quick access to the following configuration dialog boxes (listed in the recommended order of processing):

1. "Select Measurement"
   See "Selecting the measurement type" on page 90
2. "Signal Description"
   See Chapter 5.3.2, "Signal Description", on page 95
3. "Input/ Frontend"
   See and Chapter 5.3.3, "Input and Frontend Settings", on page 96
4. "Signal Capture"
   See Chapter 5.3.4, "Signal Capture (Data Acquisition)", on page 122
5. "Synchronization / OFDM demodulation"
   See Chapter 5.3.6, "Synchronization and OFDM Demodulation", on page 139
6. "Tracking / Channel Estimation"
   See Chapter 5.3.7, "Tracking and Channel Estimation", on page 140
7. "Demodulation"
   See Chapter 5.3.8, "Demodulation", on page 143
8. "Evaluation Range"
   See Chapter 5.3.9, "Evaluation Range", on page 158
9. "Display Configuration"
   See Chapter 5.2, "Display Configuration", on page 92

To configure settings

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

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

Note that the PRESET key restores the entire instrument to its default values and thus closes **all measurement channels** on the R&S FSW (except for the default Spectrum application channel)!

Remote command:
`SYSTem:PRESet:CHANnel[:EXECute]` on page 204

Select Measurement
Selects a measurement to be performed.

See "Selecting the measurement type" on page 90.

Specifics for
The measurement channel may 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 "Specifics for" selection list that is displayed in the "Overview" and in all window-specific configuration dialog boxes.

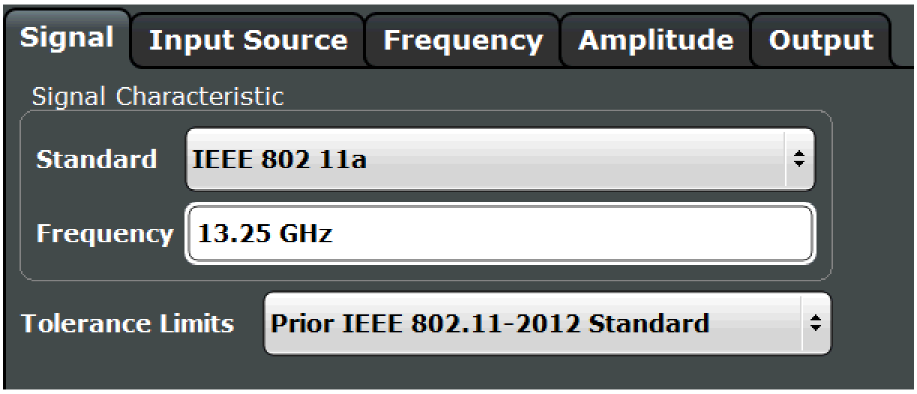
The "Overview" and dialog boxes are updated to indicate the settings for the selected window.

5.3.2 Signal Description

Access: "Overview" > "Signal Description"

Or: MEAS CONFIG > "Signal Description"

The signal description provides information on the expected input signal.



Standard

Defines the WLAN standard (depending on which WLAN options are installed). The measurements are performed according to the specified standard with the correct limit values and limit lines.

Many other WLAN measurement settings depend on the selected standard (see Chapter 4.6, "Demodulation Parameters - Logical Filters", on page 80).

Note: In MSRA operating mode, the **IEEE 802.11b and g (DSSS)** standards are not supported.

Remote command:

`CONFigure:STANdard` on page 212

Frequency

Specifies the center frequency of the signal to be measured.

Remote command:

`[SENSe:]FREQuency:CENTer` on page 237

Tolerance Limit

Defines the tolerance limit to be used for the measurement. The required tolerance limit depends on the used standard:

"Prior IEEE 802.11-2012 Standard"
Tolerance limits are based on the IEEE 802.11 specification **prior to 2012**.
Default for OFDM standards (except 802.11ac).

"In line with IEEE 802.11-2012 Standard"
Tolerance limits are based on the IEEE 802.11 specification from **2012.**
Required for DSSS standards. Also possible for OFDM standards (except 802.11ac).

"In line with IEEE 802.11ac standard"
Tolerance limits are based on the **IEEE 802.11ac** specification.
Required by IEEE 802.11ac standard.

Remote command:
`CALCulate:LIMit:TOLerance` on page 213

5.3.3 Input and Frontend Settings

Access: "Overview" > "Input/Frontend"

Or: MEAS CONFIG > "Input/Frontend"

The R&S 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 WLAN 802.11 can not only be measured by the WLAN application itself, it can also be imported to the application, provided it has the correct format. Furthermore, the analyzed I/Q data from the WLAN application can be exported for further analysis in external applications.

See Chapter 7.1, "Import/Export Functions", on page 178.

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

For more information on the use and effects of these settings, see Chapter 4.8, "Preparing the R&S FSW for the Expected Input Signal - Frontend Parameters", on page 83.

5.3.3.1 Input Source Settings

Access: "Overview" > "Input/Frontend" > "Input Source"

The input source determines which data the R&S FSW will analyze.

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

The Digital I/Q input source is currently not available in the R&S FSW WLAN application.

Radio Frequency Input

Access: "Overview" > "Input/Frontend" > "Input Source" > "Radio Frequency"

Radio Frequency State

Activates input from the RF INPUT connector.

Remote command:

`INPut:SELect` on page 217

Input Coupling

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

This function is not available for input from the optional Digital Baseband Interface or from the optional Analog Baseband Interface.

AC coupling blocks any DC voltage from the input signal. This is the default setting to prevent damage to the instrument. Very low frequencies in the input signal may 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 data sheet.

Remote command:
`INPut:COUPling` on page 215

Impedance

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

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

This function is not available for input from the optional Digital Baseband Interface or from the optional Analog Baseband Interface. For analog baseband input, an impedance of 50 Ω is always used.

Remote command:
`INPut:IMPedance` on page 217

Direct Path

Enables or disables the use of the direct path for small frequencies.

In spectrum analyzers, passive analog mixers are used for the first conversion of the input signal. In such mixers, the LO signal is coupled into the IF path due to its limited isolation. The coupled LO signal becomes visible at the RF frequency 0 Hz. This effect is referred to as LO feedthrough.

To avoid the LO feedthrough the spectrum analyzer provides an alternative signal path to the A/D converter, referred to as the *direct path*. By default, the direct path is selected automatically for RF frequencies close to zero. However, this behavior can be deactivated. If "Direct Path" is set to "Off", the spectrum analyzer always uses the analog mixer path.

"Auto" (Default) The direct path is used automatically for frequencies close to zero.

"Off" The analog mixer path is always used.

Remote command:
`INPut:DPATh` on page 215

High-Pass Filter 1...3 GHz

Activates an additional internal high-pass filter for RF input signals from 1 GHz to 3 GHz. This filter is used to remove the harmonics of the analyzer to measure the harmonics for a DUT, for example.

This function requires an additional hardware option.

(Note: for RF input signals outside the specified range, the high-pass filter has no effect. For signals with a frequency of approximately 4 GHz upwards, the harmonics are suppressed sufficiently by the YIG-preselector, if available.)

Remote command:

`INPut:FILTer:HPASs[:STATe]` on page 216

YIG-Preselector

Activates or deactivates the YIG-preselector, if available on the R&S FSW.

An internal YIG-preselector at the input of the R&S FSW ensures that image frequencies are rejected. However, the YIG-preselector can limit the bandwidth of the I/Q data and adds some magnitude and phase distortions. You can check the impact in the Spectrum Flatness and Group Delay result displays.

Note that the YIG-preselector is active only on frequencies greater than 8 GHz. Therefore, switching the YIG-preselector on or off has no effect if the frequency is below that value.

Remote command:

`INPut:FILTer:YIG[:STATe]` on page 216

Input Connector

Determines whether the RF input data is taken from the RF INPUT connector (default) or the optional BASEBAND INPUT I connector. This setting is only available if the optional Analog Baseband Interface is installed and active for input. It is not available for the R&S FSW67 or R&S FSW85.

For more information on the Analog Baseband Interface (R&S FSW-B71), see the R&S FSW I/Q Analyzer and I/Q Input User Manual.

Remote command:

`INPut:CONNector` on page 215

External Mixer Settings

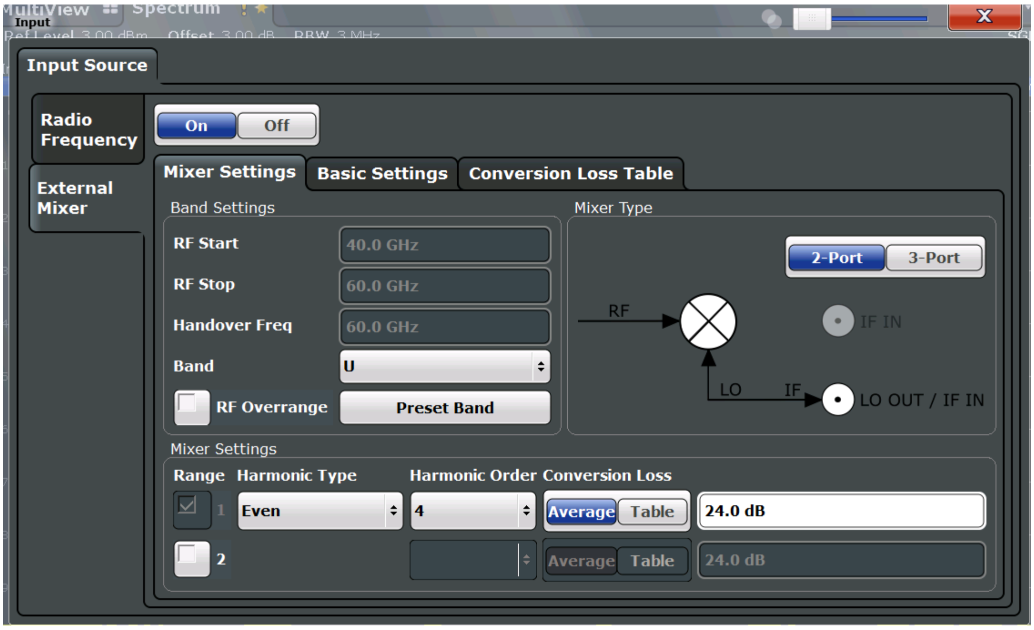
Access: INPUT/OUTPUT > "External Mixer Config"

If installed, the optional external mixer can be configured from the R&S FSW WLAN application.

Note that external mixers are not supported in MSRA mode.

Mixer Settings

Access: INPUT/OUTPUT > "External Mixer Config" > "Mixer Settings"



External Mixer State

Activates or deactivates the external mixer for input. If activated, "ExtMix" is indicated in the channel bar of the application, together with the used band (see "Band" on page 101).

Remote command:

[SENSe:]MIXer[:STATe] on page 218

RF Start / RF Stop

Displays the start and stop frequency of the selected band (read-only).

The frequency range for the user-defined band is defined via the harmonics configuration (see "Range 1/2" on page 102).

For details on available frequency ranges, see table 10-3 on page 221.

Remote command:

[SENSe:]MIXer:FREQuency:STARt? on page 220
[SENSe:]MIXer:FREQuency:STOP? on page 221

Handover Freq.

If due to the LO frequency the conversion of the input signal is not possible using one harmonic, the band must be split. An adjacent, partially overlapping frequency range can be defined using different harmonics (see "Mixer Settings (Harmonics Configuration)" on page 102). In this case, the sweep begins using the harmonic defined for the first range. At the specified "handover frequency" in the overlapping range, it switches to the harmonic for the second range.

The handover frequency can be selected freely within the overlapping frequency range.

Remote command:
`[SENSe:]MIXer:FREQuency:HANDover` on page 220

Band

Defines the waveguide frequency band or user-defined frequency band to be used by the mixer.

The start and stop frequencies of the selected band are displayed in the "RF Start" and "RF Stop" fields.

For a definition of the frequency range for the pre-defined bands, see table 10-3 on page 221.

The mixer settings for the user-defined band can be selected freely. The frequency range for the user-defined band is defined via the harmonics configuration (see "Range 1/2" on page 102).

Remote command:
`[SENSe:]MIXer:HARMonic:BAND[:VALue]` on page 221

RF Overrange

In some cases, the harmonics defined for a specific band allow for an even larger frequency range than the band requires. By default, the pre-defined range is used. However, you can take advantage of the extended frequency range by overriding the defined "RF Start" and "RF Stop" frequencies by the maximum values.

If "RF Overrange" is enabled, the frequency range is not restricted by the band limits ("RF Start" and "RF Stop"). In this case, the full frequency range that can be reached using the selected harmonics is used.

Remote command:
`[SENSe:]MIXer:RFOVerrange[:STATe]` on page 224

Preset Band

Restores the presettings for the selected band.

Note: changes to the band and mixer settings are maintained even after using the PRESET function. This function allows you to restore the original band settings.

Remote command:
`[SENSe:]MIXer:HARMonic:BAND:PRESet` on page 221

Mixer Type

The External Mixer option supports the following external mixer types:

"2 Port"	LO and IF data use the same port

"3 Port" LO and IF data use separate ports

Remote command:
[SENSe:]MIXer:PORTs on page 224

Mixer Settings (Harmonics Configuration)

The harmonics configuration determines the frequency range for user-defined bands (see "Band" on page 101).

Range 1/2 ← Mixer Settings (Harmonics Configuration)

Enables the use of one or two frequency ranges, where the second range is based on another harmonic frequency of the mixer to cover the band's frequency range.

For each range, you can define which harmonic to use and how the Conversion loss is handled.

Remote command:
[SENSe:]MIXer:HARMonic:HIGH:STATe on page 222

Harmonic Type ← Mixer Settings (Harmonics Configuration)

Defines if only even, only odd, or even and odd harmonics can be used for conversion. Depending on this selection, the order of harmonic to be used for conversion changes (see "Harmonic Order" on page 102). Which harmonics are supported depends on the mixer type.

Remote command:
[SENSe:]MIXer:HARMonic:TYPE on page 222

Harmonic Order ← Mixer Settings (Harmonics Configuration)

Defines which order of the harmonic of the LO frequencies is used to cover the frequency range.

By default, the lowest order of the specified harmonic type is selected that allows conversion of input signals in the whole band. If due to the LO frequency the conversion is not possible using one harmonic, the band is split.

For the "USER" band, you define the order of harmonic yourself. The order of harmonic can be between 2 and 61, the lowest usable frequency being 26.5 GHz.

Remote command:
[SENSe:]MIXer:HARMonic[:LOW] on page 223
[SENSe:]MIXer:HARMonic:HIGH[:VALue] on page 222

Conversion loss ← Mixer Settings (Harmonics Configuration)

Defines how the conversion loss is handled. The following methods are available:

"Average" Defines the average conversion loss for the entire frequency range in dB.

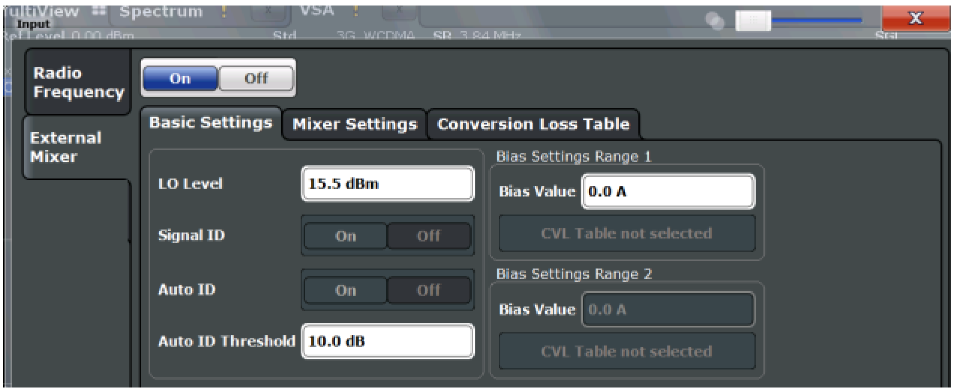
"Table" Defines the conversion loss via the table selected from the list. Pre-defined conversion loss tables are often provided with the external mixer and can be imported to the R&S FSW. Alternatively, you can define your own conversion loss tables. Imported tables are checked for compatibility with the current settings before being assigned.
Conversion loss tables are configured and managed in the Conversion Loss Table tab.
For details on importing tables, see "Import Table" on page 106.

Remote command:
Average for range 1:
`[SENSe:]MIXer:LOSS[:LOW]` on page 224
Table for range 1:
`[SENSe:]MIXer:LOSS:TABLe[:LOW]` on page 223
Average for range 2:
`[SENSe:]MIXer:LOSS:HIGH` on page 223
Table for range 2:
`[SENSe:]MIXer:LOSS:TABLe:HIGH` on page 223

Basic Settings

Access: INPUT/OUTPUT > "External Mixer Config" > "Basic Settings"

The basic settings concern general use of an external mixer. They are only available if the External Mixer State is "On".



LO Level

Defines the LO level of the external mixer's LO port. Possible values are from 13.0 dBm to 17.0 dBm in 0.1 dB steps. Default value is 15.5 dB.

Remote command:
`[SENSe:]MIXer:LOPower` on page 218

Signal ID

Activates or deactivates visual signal identification. Two sweeps are performed alternately. Trace 1 shows the trace measured on the upper side band (USB) of the LO (the test sweep). Trace 2 shows the trace measured on the lower side band (LSB), i.e. the reference sweep.

Note that automatic signal identification is only available for measurements that perform frequency sweeps (not in the VSA, the I/Q Analyzer, or the Real-Time Spectrum application, for instance).

Mathematical functions with traces and trace copy cannot be used with the Signal ID function.

Remote command:
`[SENSe:]MIXer:SIGNal` on page 219

Auto ID

Activates or deactivates automatic signal identification.

Auto ID basically functions like Signal ID. However, the test and reference sweeps are converted into a single trace by a comparison of maximum peak values of each sweep point. The result of this comparison is displayed in trace 3 if "Signal ID" is active at the same time. If "Signal ID" is not active, the result can be displayed in any of the traces 1 to 3. Unwanted mixer products are suppressed in this calculated trace.

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).

Remote command:
`[SENSe:]MIXer:SIGNal` on page 219

Auto ID Threshold

Defines the maximum permissible level difference between test sweep and reference sweep to be corrected during automatic comparison ("Auto ID" on page 104 function). The input range is between 0.1 dB and 100 dB. Values of about 10 dB (i.e. default setting) generally yield satisfactory results.

Remote command:
`[SENSe:]MIXer:THReshold` on page 219

Bias Settings

Define the bias current for each range, which is required to set the mixer to its optimum operating point. It corresponds to the short-circuit current. The bias current can range from -10 mA to 10 mA. The actual bias current is lower because of the forward voltage of the mixer diode(s).

Tip: The trace in the currently active result display (if applicable) is adapted to the settings immediately so you can check the results.

To store the bias setting in the currently selected conversion loss table, select the Write to <CVL table name> button.

Remote command:
`[SENSe:]MIXer:BIAS[:LOW]` on page 218
`[SENSe:]MIXer:BIAS:HIGH` on page 218

Write to <CVL table name> ← Bias Settings
Stores the bias setting in the currently selected "Conversion loss table" for the range (see "Managing Conversion Loss Tables" on page 105). If no conversion loss table is selected yet, this function is not available ("CVL Table not selected").

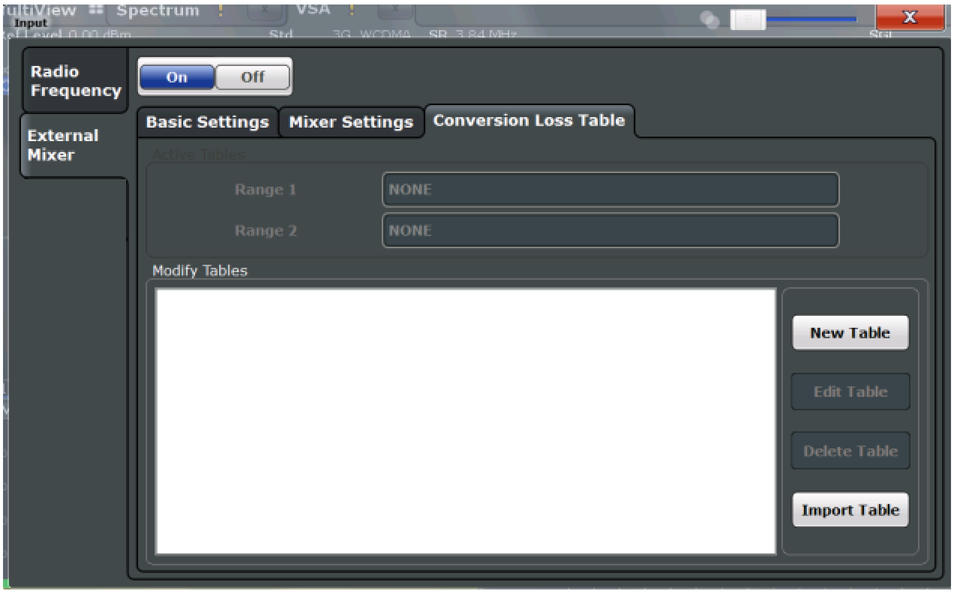
Remote command:
`[SENSe:]CORRection:CVL:BIAS` on page 225

Managing Conversion Loss Tables

Access: INPUT/OUTPUT > "External Mixer Config" > "Conversion Loss Table"

In this tab, you configure and manage conversion loss tables. Conversion loss tables consist of value pairs that describe the correction values for conversion loss at certain frequencies. The correction values for frequencies between the reference points are obtained via interpolation.

The currently selected table for each range is displayed at the top of the dialog box. All conversion loss tables found in the instrument's `C:\R_S\INSTR\USER\cvl\` directory are listed in the "Modify Tables" list.



New Table
Opens the "Edit Conversion loss table" dialog box to configure a new conversion loss table. For details on table configuration, see "Creating and Editing Conversion Loss Tables" on page 106.

Remote command:
`[SENSe:]CORRection:CVL:SELect` on page 228

Edit Table
Opens the "Edit Conversion loss table" dialog box to edit the selected conversion loss table. For details on table configuration, see "Creating and Editing Conversion Loss Tables" on page 106.

Remote command:
`[SENSe:]CORRection:CVL:SELect` on page 228

Delete Table
Deletes the currently selected conversion loss table after you confirm the action.

Remote command:
`[SENSe:]CORRection:CVL:CLEAr` on page 226

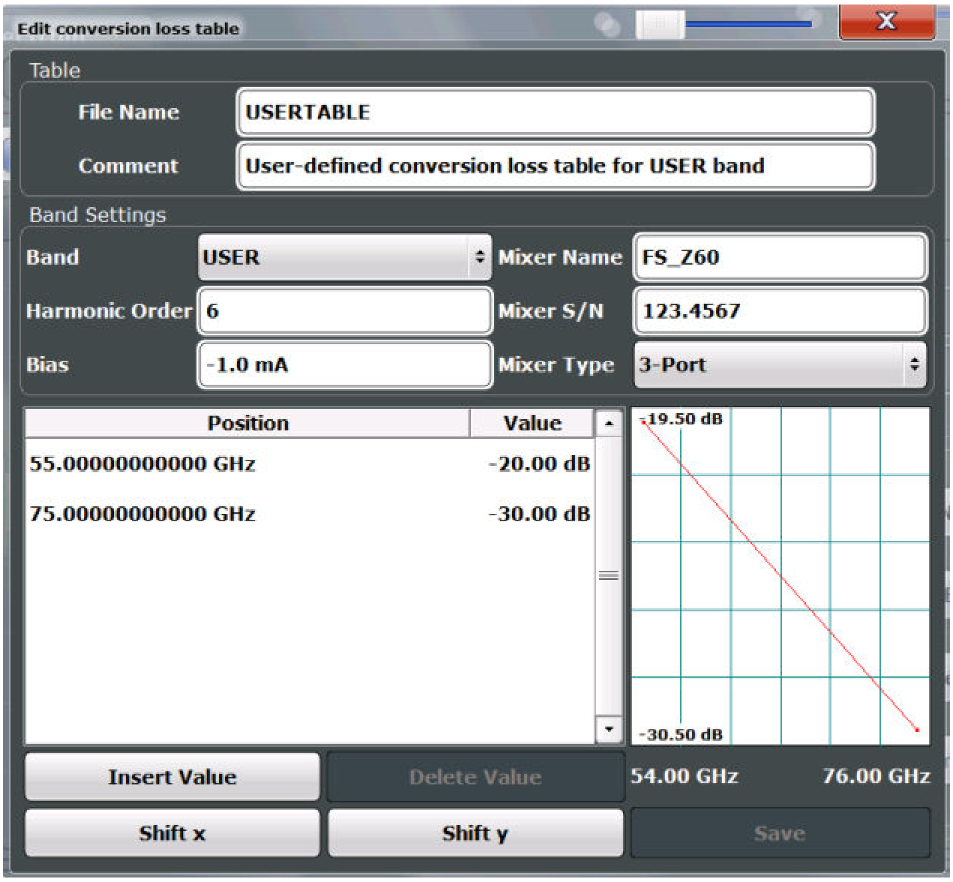
Import Table
Imports a stored conversion loss table from any directory and copies it to the instrument's `C:\R_S\INSTR\USER\cvl\` directory. It can then be assigned for use for a specific frequency range (see "Conversion loss" on page 102).

Creating and Editing Conversion Loss Tables

Access: INPUT/OUTPUT > "External Mixer Config" > "Conversion Loss Table" > "New Table" / "Edit Table"

Conversion loss tables can be newly defined and edited.

A preview pane displays the current configuration of the conversion loss function as described by the position/value entries.



File Name

Defines the name under which the table is stored in the `C:\R_S\INSTR\USER\cvl\` directory on the instrument. The name of the table is identical with the name of the file (without extension) in which the table is stored. This setting is mandatory. The `.ACL` extension is automatically appended during storage.

Remote command:

`[SENSe:]CORRection:CVL:SELect` on page 228

Comment
An optional comment that describes the conversion loss table. The comment is user-definable.

Remote command:
`[SENSe:]CORRection:CVL:COMMent` on page 226

Band
The waveguide or user-defined band to which the table applies. This setting is checked against the current mixer setting before the table can be assigned to the range.

For a definition of the frequency range for the pre-defined bands, see table 10-3 on page 221.

Remote command:
`[SENSe:]CORRection:CVL:BAND` on page 225

Harmonic Order
The harmonic order of the range to which the table applies. This setting is checked against the current mixer setting before the table can be assigned to the range.

Remote command:
`[SENSe:]CORRection:CVL:HARMonic` on page 227

Bias
The bias current which is required to set the mixer to its optimum operating point. It corresponds to the short-circuit current. The bias current can range from -10 mA to 10 mA. The actual bias current is lower because of the forward voltage of the mixer diode(s).

Tip: You can also define the bias interactively while a preview of the trace with the changed setting is displayed, see "Bias Settings" on page 104.

Remote command:
`[SENSe:]CORRection:CVL:BIAS` on page 225

Mixer Name
Specifies the name of the external mixer to which the table applies. This setting is checked against the current mixer setting before the table can be assigned to the range.

Remote command:
`[SENSe:]CORRection:CVL:MIXer` on page 227

Mixer S/N
Specifies the serial number of the external mixer to which the table applies.

The specified number is checked against the currently connected mixer number before the table can be assigned to the range.

Remote command:
`[SENSe:]CORRection:CVL:SNUMber` on page 228

Mixer Type
Specifies whether the external mixer to which the table applies is a two-port or three-port type. This setting is checked against the current mixer setting before the table can be assigned to the range.

Remote command:
`[SENSe:]CORRection:CVL:PORTs` on page 227

Position/Value
Each position/value pair defines the conversion loss value in dB for a specific frequency. The reference values must be entered in order of increasing frequencies. A maximum of 50 reference values can be entered. To enter a new value pair, select an empty space in the "Position/Value" table, or select the Insert Value button.

Correction values for frequencies between the reference values are interpolated. Linear interpolation is performed if the table contains only two values. If it contains more than two reference values, spline interpolation is carried out. Outside the frequency range covered by the table, the conversion loss is assumed to be the same as that for the first and last reference value.

The current configuration of the conversion loss function as described by the position/value entries is displayed in the preview pane to the right of the table.

Remote command:
`[SENSe:]CORRection:CVL:DATA` on page 226

Insert Value
Inserts a new position/value entry in the table.

If the table is empty, a new entry at 0 Hz is inserted.

If entries already exist, a new entry is inserted above the selected entry. The position of the new entry is selected such that it divides the span to the previous entry in half.

Delete Value
Deletes the currently selected position/value entry.

Shift x
Shifts all positions in the table by a specific value. The value can be entered in the edit dialog box. The conversion loss function in the preview pane is shifted along the x-axis.

Shift y
Shifts all conversion loss values by a specific value. The value can be entered in the edit dialog box. The conversion loss function in the preview pane is shifted along the y-axis.

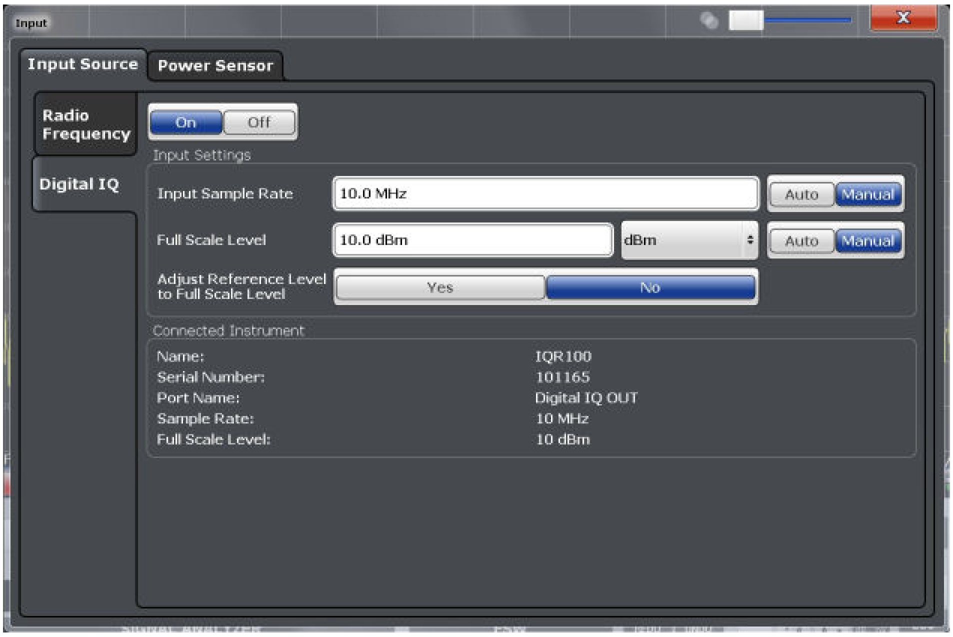
Save
The conversion loss table is stored under the specified file name in the `C:\R_S\INSTR\USER\cvl\` directory of the instrument.

Digital I/Q Input Settings

Access: INPUT/OUTPUT > "Input Source Config" > "Digital I/Q" tab

The following settings and functions are available to provide input via the optional Digital Baseband Interface in the applications that support it.

These settings are only available if the Digital Baseband Interface option is installed on the R&S FSW.



For more information, see the R&S FSW I/Q Analyzer and I/Q Input User Manual.

Digital I/Q Input State

Enables or disable the use of the "Digital IQ" input source for measurements.

"Digital IQ" is only available if the optional Digital Baseband Interface is installed.

Remote command:
`INPut:SELect` on page 217

Input Sample Rate

Defines the sample rate of the digital I/Q signal source. This sample rate must correspond with the sample rate provided by the connected device, e.g. a generator.

If "Auto" is selected, the sample rate is adjusted automatically by the connected device.

The allowed range is from 100 Hz to 10 GHz.

Remote command:
`INPut:DIQ:SRATe` on page 233
`INPut:DIQ:SRATe:AUTO` on page 234

Full Scale Level

The "Full Scale Level" defines the level and unit that should correspond to an I/Q sample with the magnitude "1".

If "Auto" is selected, the level is automatically set to the value provided by the connected device.

Remote command:
`INPut:DIQ:RANGe[:UPPer]` on page 233
`INPut:DIQ:RANGe[:UPPer]:UNIT` on page 233
`INPut:DIQ:RANGe[:UPPer]:AUTO` on page 232

Adjust Reference Level to Full Scale Level

If enabled, the reference level is adjusted to the full scale level automatically if any change occurs.

Remote command:
`INPut:DIQ:RANGe:COUPling` on page 233

Connected Instrument

Displays the status of the Digital Baseband Interface connection.

If an instrument is connected, the following information is displayed:

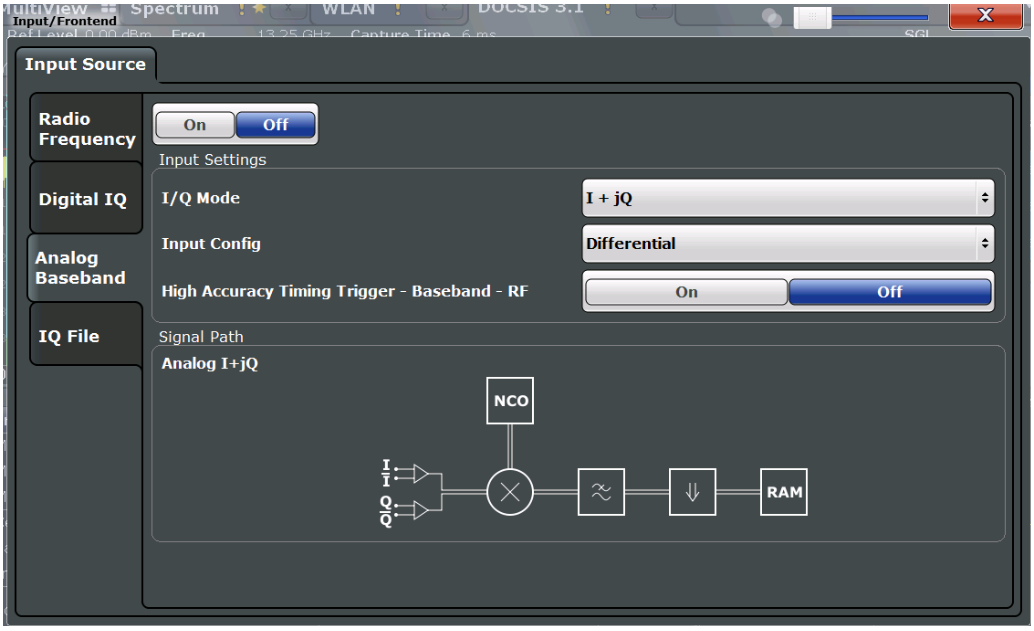
- Name and serial number of the instrument connected to the Digital Baseband Interface
- Used port
- Sample rate of the data currently being transferred via the Digital Baseband Interface
- Level and unit that corresponds to an I/Q sample with the magnitude "1" (Full Scale Level), if provided by connected instrument

Remote command:
`INPut:DIQ:CDEVice` on page 231

Analog Baseband Input Settings

Access: INPUT/OUTPUT > "Input Source Config" > "Analog Baseband" tab

The following settings and functions are available to provide input via the optional Analog Baseband Interface in the applications that support it.



For more information on the optional Analog Baseband Interface, see the R&S FSW I/Q Analyzer and I/Q Input User Manual.

Analog Baseband Input State

Enables or disable the use of the "Analog Baseband" input source for measurements. "Analog Baseband" is only available if the optional Analog Baseband Interface is installed.

Remote command:
`INPut:SELect` on page 217

I/Q Mode

Defines the format of the input signal.

"I + jQ" The input signal is filtered and resampled to the sample rate of the application.
Two inputs are required for a complex signal, one for the in-phase component, and one for the quadrature component.

"I Only / Low IF I"
The input signal at the BASEBAND INPUT I connector is filtered and resampled to the sample rate of the application.
If the center frequency is set to 0 Hz, the real baseband signal is displayed without down-conversion (**Real Baseband I**).
If a center frequency greater than 0 Hz is set, the input signal is down-converted with the center frequency (**Low IF I**).

"Q Only / Low IF Q"

The input signal at the BASEBAND INPUT Q connector is filtered and resampled to the sample rate of the application.
If the center frequency is set to 0 Hz, the real baseband signal is displayed without down-conversion (**Real Baseband Q**).
If a center frequency greater than 0 Hz is set, the input signal is down-converted with the center frequency (**Low IF Q**).

Remote command:
`INPut:IQ:TYPE` on page 235

Input Configuration
Defines whether the input is provided as a differential signal via all four Analog Baseband connectors or as a plain I/Q signal via two simple-ended lines.

Note: Both single-ended and differential probes are supported as input; however, since only one connector is occupied by a probe, the "Single-ended" setting must be used for all probes.

"Single Ended" I, Q data only

"Differential" I, Q and inverse I,Q data
(Not available for R&S FSW85)

Remote command:
`INPut:IQ:BALanced[:STATe]` on page 234

High Accuracy Timing Trigger - Baseband - RF
Activates a mode with enhanced timing accuracy between analog baseband, RF and external trigger signals.

Note: Prerequisites for previous models of R&S FSW.
For R&S FSW models with a serial number lower than 103000, special prerequisites and restrictions apply for high accuracy timing:

- To obtain this high timing precision, trigger port 1 and port 2 must be connected via the Cable for High Accuracy Timing (order number 1325.3777.00).
- As trigger port 1 and port 2 are connected via the cable, only trigger port 3 can be used to trigger a measurement.
- Trigger port 2 is configured as output if the high accuracy timing option is active. Make sure not to activate this option if you use trigger port 2 in your measurement setup.
- When you first enable this setting, you are prompted to connect the cable for high accuracy timing to trigger ports 1 and 2. If you cancel this prompt, the setting remains disabled. As soon as you confirm this prompt, the cable must be in place - the firmware does not check the connection. (In remote operation, the setting is activated without a prompt.)

For more information, see the R&S FSW I/Q Analyzer and I/Q Input User Manual.

Remote command:
`CALibration:AIQ:HATiming[:STATe]` on page 236

Center Frequency
Defines the center frequency for analog baseband input.

For real-type baseband input (I or Q only), the center frequency is always 0 Hz.

Note: If the analysis bandwidth to either side of the defined center frequency exceeds the minimum frequency (0 Hz) or the maximum frequency (40 MHz/80 MHz), an error is displayed. In this case, adjust the center frequency or the analysis bandwidth.

Remote command:
`[SENSe:]FREQuency:CENTer` on page 237

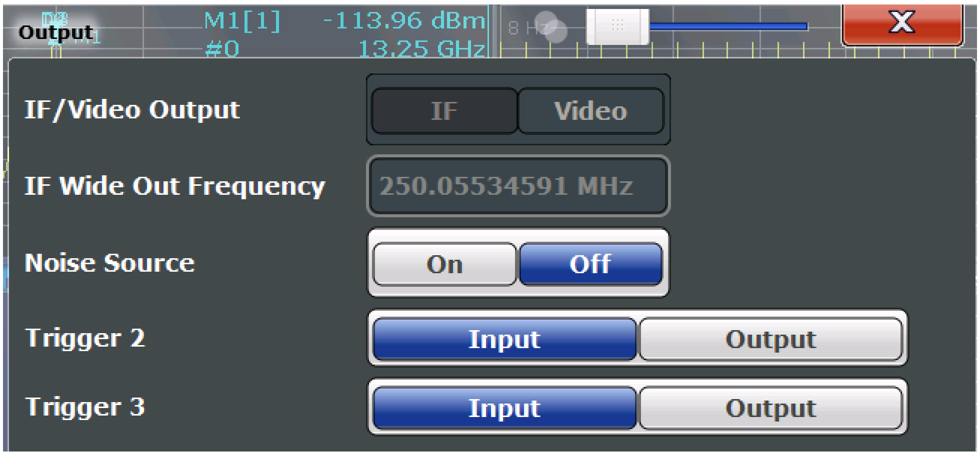
5.3.3.2 Output Settings

Access: INPUT/OUTPUT > "Output"

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

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

How to provide trigger signals as output is described in detail in the R&S FSW User Manual.

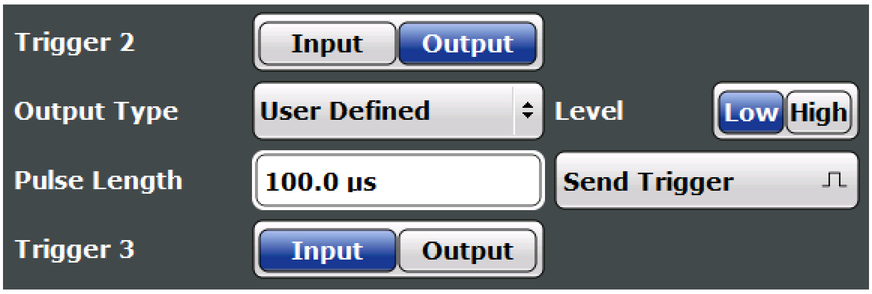


Noise Source
This command turns the 28 V supply of the BNC connector labeled NOISE SOURCE CONTROL on the R&S FSW on and off.

External noise sources are useful when you are measuring power levels that fall below the noise floor of the R&S FSW itself, for example when measuring the noise level of a DUT.

Remote command:
`DIAGnostic:SERVice:NSOurce` on page 237

Trigger 2/3



Defines the usage of the variable TRIGGER INPUT/OUTPUT connectors, where:

"Trigger 2": TRIGGER INPUT/OUTPUT connector on the front panel

"Trigger 3": TRIGGER 3 INPUT/ OUTPUT connector on the rear panel

(Trigger 1 is INPUT only.)

Note: Providing trigger signals as output is described in detail in the R&S FSW User Manual.

"Input"	The signal at the connector is used as an external trigger source by the R&S FSW. Trigger input parameters are available in the "Trigger" dialog box.
"Output"	The R&S FSW sends a trigger signal to the output connector to be used by connected devices. Further trigger parameters are available for the connector. **Note:** For simultaneous MIMO measurements (see "Simultaneous Signal Capture Setup" on page 134), if you set the master's TRIGGER 2 INPUT/OUTPUT connector to "device-triggered" output, the master R&S FSW sends its trigger event signal to any connected slaves. See also Chapter 4.9.5, "Trigger Synchronization Using the Master's Trigger Output", on page 87.

Remote command:
`OUTPut:TRIGger<port>:DIRection` on page 253

Output Type ← Trigger 2/3

Type of signal to be sent to the output

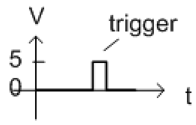
"Device Triggered"	(Default) Sends a trigger when the R&S FSW triggers.
"Trigger Armed"	Sends a (high level) trigger when the R&S FSW is in "Ready for trigger" state. This state is indicated by a status bit in the `STATus:OPERation` register (bit 5), as well as by a low-level signal at the AUX port (pin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

Remote command:
`OUTPut:TRIGger<port>:OTYPe` on page 254

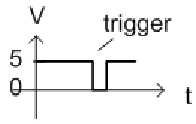
Level ← Output Type ← Trigger 2/3

Defines whether a high (1) or low (0) constant signal is sent to the trigger output connector.

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<port>:LEVel` on page 254

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<port>:PULSe:LENGth` on page 255

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.

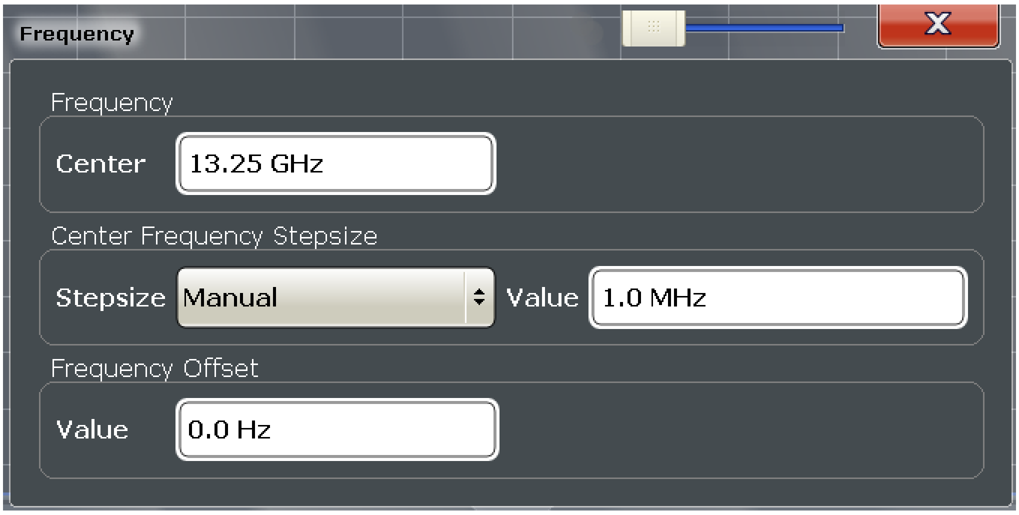
Which pulse level will be sent is indicated by a graphic on the button.

Remote command:

`OUTPut:TRIGger<port>:PULSe:IMMediate` on page 255

5.3.3.3 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 237

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 238

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, or 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, but not if it shows frequencies relative to the signal's center frequency.

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 -100 GHz to 100 GHz. The default setting is 0 Hz.

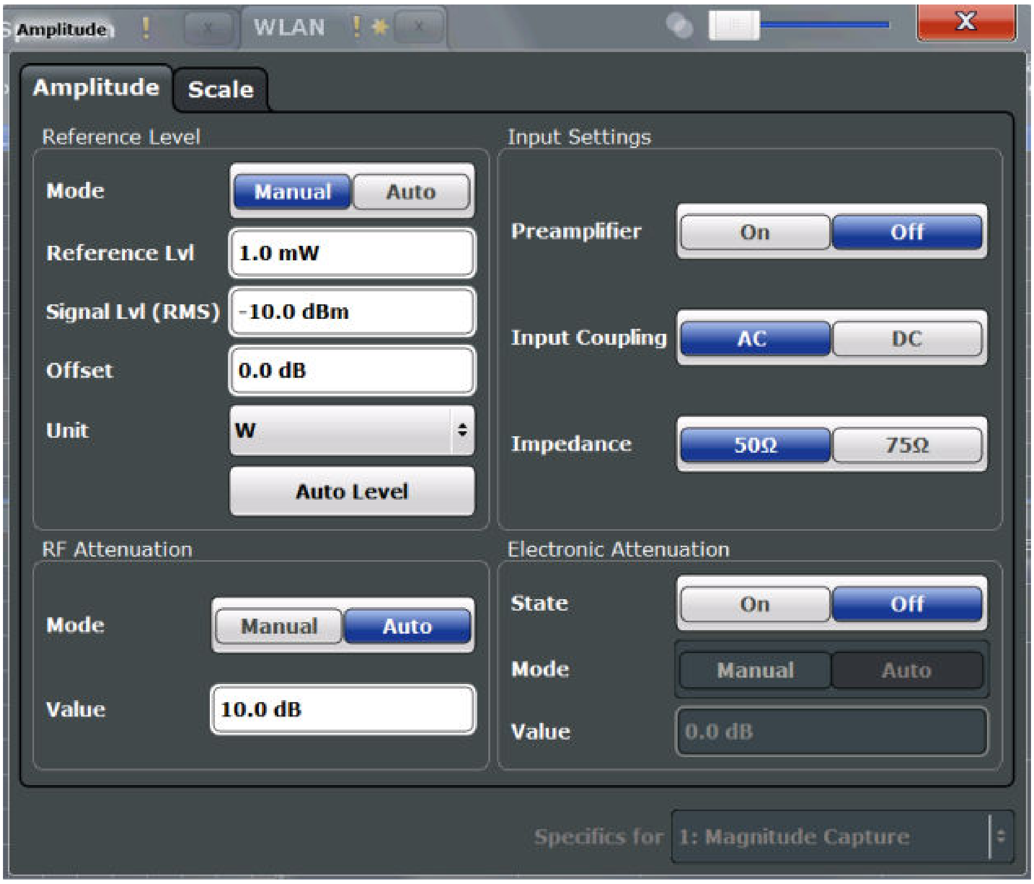
Note: In MSRA mode, this function is only available for the MSRA Master.

Remote command:
`[SENSe:]FREQuency:OFFSet` on page 239

5.3.3.4 Amplitude Settings

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

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



Reference Level Settings

The reference level defines the expected maximum signal level. Signal levels above this value may not be measured correctly, which is indicated by the "IF OVLD" status display.

Reference Level Mode ← Reference Level Settings

By default, the reference level is automatically adapted to its optimal value for the current input data (continuously). At the same time, the internal attenuators and the preamplifier are adjusted so the signal-to-noise ratio is optimized, while signal compression, clipping and overload conditions are minimized.

In order to define the reference level manually, switch to "Manual" mode. In this case you must define the following reference level parameters.

Remote command:
`CONF:POW:AUTO ON`, see `CONFigure:POWer:AUTO` on page 240

Reference Level ← Reference Level Settings

Defines the expected maximum signal level. Signal levels above this value may not be measured correctly, which is indicated by the "IF OVLD" status display.

This value is overwritten if "Auto Level" mode is turned on.

Remote command:
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel` on page 241

Signal Level (RMS) ← Reference Level Settings

Specifies the mean power level of the source signal as supplied to the instrument's RF input. This value is overwritten if "Auto Level" mode is turned on.

Remote command:
`CONFigure:POWer:EXPected:RF` on page 241

Shifting the Display (Offset) ← Reference Level Settings

Defines an arithmetic level offset. This offset is added to the measured level irrespective of the selected unit. The scaling of the y-axis is changed accordingly.

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

Note, however, that the Reference Level value ignores the "Reference Level Offset". It is important to know the actual power level the R&S FSW must handle.

To determine the required offset, consider the external attenuation or gain applied to the input signal. A positive value indicates that an attenuation took place (R&S FSW increases the displayed power values) , a negative value indicates an external gain (R&S FSW decreases the displayed power values).

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

Remote command:
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel:OFFSet` on page 241

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

The following units are available and directly convertible:
- dBm
- dBmV
- dBµV

Remote command:
`CALCulate<n>:UNIT:POWer` on page 240

Setting the Reference Level Automatically (Auto Level) ← Reference Level Settings
Automatically determines the optimal reference level for the current input data. At the same time, the internal attenuators and the preamplifier are adjusted so the signal-to-noise ratio is optimized, while signal compression, clipping and overload conditions are minimized.

In order to do so, a level measurement is performed to determine the optimal reference level.

This function is only available for the MSRA Master, not for the applications.

Remote command:
`CONFigure:POWer:AUTO` on page 240

RF Attenuation
Defines the attenuation applied to the RF input.

This function is not available for input from the Digital Baseband Interface (R&S FSW-B17).

This function is not available for input from the Digital Baseband Interface (R&S FSW-B17).

Attenuation Mode / Value ← RF Attenuation
The RF attenuation can be set automatically as a function of the selected reference level (Auto mode). This ensures that no overload occurs at the RF INPUT connector for the current reference level. It is the default setting.

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

This function is not available for input from the optional **Digital Baseband Interface**.

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 data sheet. 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 may lead to hardware damage.

Remote command:
INPut:ATTenuation on page 241
INPut:ATTenuation:AUTO on page 242

Using Electronic Attenuation
If the (optional) Electronic Attenuation hardware is installed on the R&S 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.

This function is not available for input from the optional **Digital Baseband Interface**.

Note: Electronic attenuation is not available for stop frequencies (or center frequencies in zero span) > 13.6 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 may 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.

Both the electronic and the mechanical attenuation can be varied in 1 dB steps. Other entries are rounded to the next lower integer value.

For the R&S 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 243
INPut:EATT:AUTO on page 243
INPut:EATT on page 242

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 5.3.3.1, "Input Source Settings", on page 96.

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

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

This function is not available for input from the (optional) **Digital Baseband Interface**.

For R&S FSW26 or higher models, the input signal is amplified by 30 dB if the preamplifier is activated.

For R&S FSW8 or 13 models, 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.

Remote command:
`INPut:GAIN:STATe` on page 244
`INPut:GAIN[:VALue]` on page 244

5.3.4 Signal Capture (Data Acquisition)

Access: "Overview" > "Signal Capture"

Or: MEAS CONFIG > "Signal Capture"

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

MSRA operating mode

In MSRA operating mode, only the MSRA Master channel actually captures data from the input signal. The data acquisition settings for the R&S FSW WLAN application in MSRA mode define the **application data extract**. See Chapter 5.3.5, "Slave Application Data (MSRA) ", on page 139.

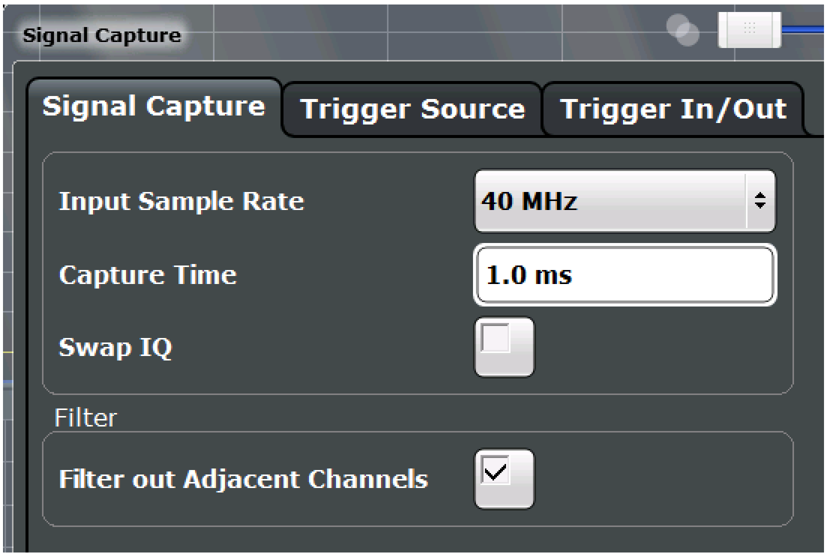
For details on the MSRA operating mode see the R&S FSW MSRA User Manual.

5.3.4.1 General Capture Settings

Access: "Overview" > "Signal Capture" > "Signal Capture" tab

Or: MEAS CONFIG > "Signal Capture" > "Signal Capture" tab

The general capture settings define how much and which data is to be captured during the WLAN I/Q measurement.



Input Sample Rate

This is the sample rate the R&S FSW WLAN application expects the I/Q input data to have. If necessary, the R&S FSW has to resample the data.

During data processing in the R&S FSW, the sample rate usually changes (decreases). The RF input is captured by the R&S FSW using a high sample rate, and is resampled before it is processed by the R&S FSW WLAN application.

Remote command:

`TRACe:IQ:SRATe` on page 246

Capture Time

Specifies the duration (and therefore the amount of data) to be captured in the capture buffer. If the capture time is too short, demodulation will fail.

Remote command:

`[SENSe:]SWEep:TIME` on page 246

Capture Offset

This setting is only available for slave applications in **MSRA operating mode**. It has a similar effect as the trigger offset in other measurements: it defines the time offset between the capture buffer start and the start of the extracted slave application data.

In MSRA mode, the offset must be a positive value, as the capture buffer starts at the trigger time = 0.

For details on the MSRA operating mode, see the R&S FSW MSRA User Manual.

For details on the MSRT operating mode, see the R&S FSW Real-Time Spectrum Application and MSRT Operating Mode User Manual.

Remote command:
[SENSe:]MSRA:CAPTure:OFFSet on page 289

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 R&S FSW can do the same to compensate for it.

On	I and Q signals are interchanged Inverted sideband, Q+j*I
Off	I and Q signals are not interchanged Normal sideband, I+j*Q

Remote command:
[SENSe:]SWAPiq on page 245

Suppressing (Filter out) Adjacent Channels (IEEE 802.11a, g (OFDM), ac, j, n, p)
If activated (default), only the useful signal is analyzed, all signal data in adjacent channels is removed by the filter.

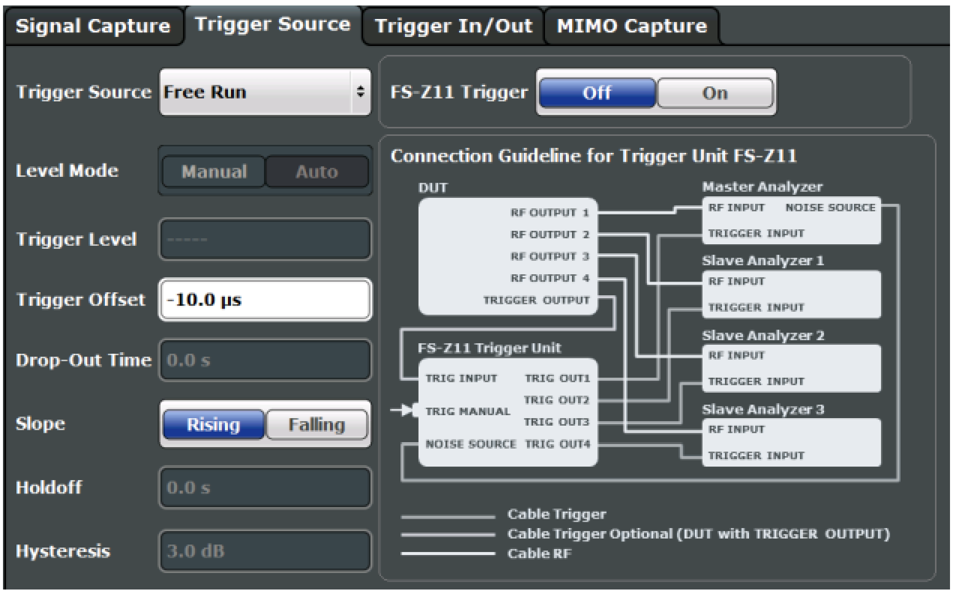
This setting improves the signal to noise ratio and thus the EVM results for signals with strong or a large number of adjacent channels. However, for some measurements information on the effects of adjacent channels on the measured signal may be of interest.

Remote command:
[SENSe:]BANDwidth[:RESolution]:FILTer[:STATe] on page 245

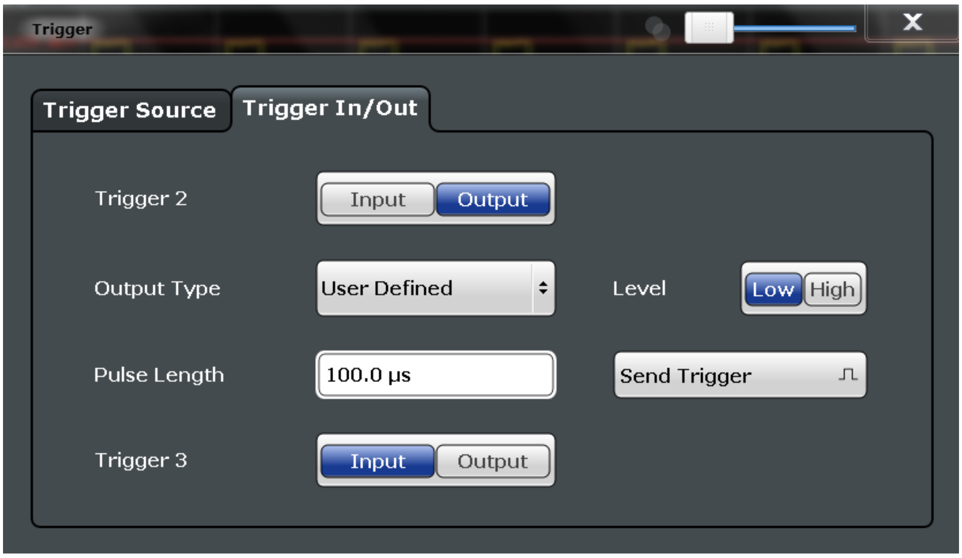
5.3.4.2 Trigger Settings

Access: "Overview" > "Signal Capture" > "Trigger Source"

Trigger settings determine when the R&S FSW starts to capture the input signal.



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



For more information on trigger settings see Chapter 4.9, "Triggered Measurements", on page 83.

Trigger Source Settings

The Trigger Source settings define when data is captured.

Trigger Source ← Trigger Source Settings
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 251

Free Run ← Trigger Source ← Trigger Source Settings
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 251

External Trigger 1/2/3 ← Trigger Source ← Trigger Source Settings
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 128).

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

For details, see the "Instrument Tour" chapter in the R&S 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.
Note: Connector must be configured for "Input" in the "Outputs" configuration (see "Trigger 2/3" on page 115).

"External Trigger 3"
Trigger signal from the TRIGGER 3 INPUT/ OUTPUT connector on the rear panel.
Note: Connector must be configured for "Input" in the "Outputs" configuration (see "Trigger 2/3" on page 115).

Remote command:
`TRIG:SOUR EXT`, `TRIG:SOUR EXT2`
`TRIG:SOUR EXT3`
See `TRIGger[:SEQuence]:SOURce` on page 251

Baseband Power ← Trigger Source ← Trigger Source Settings
Defines triggering on the baseband power (for baseband input via the optional Digital Baseband Interface or the optional Analog Baseband interface).

For more information on the Digital Baseband Interface or the Analog Baseband Interface, see the R&S FSW I/Q Analyzer and I/Q Input User Manual.

Remote command:
`TRIG:SOUR BBP`, see `TRIGger[:SEQuence]:SOURce` on page 251

Digital I/Q ← Trigger Source ← Trigger Source Settings

For applications that process I/Q data, such as the I/Q Analyzer or optional applications, and only if the optional Digital Baseband Interface is available:

Defines triggering of the measurement directly via the LVDS connector. In the selection list you must specify which general purpose bit (GP0 to GP5) will provide the trigger data.

Note:

If the Digital I/Q enhanced mode is used, i.e. the connected device supports transfer rates up to 200 Msps, only the general purpose bits GP0 and GP1 are available as a Digital I/Q trigger source.

The following table describes the assignment of the general purpose bits to the LVDS connector pins.

Table 5-1: Assignment of general purpose bits to LVDS connector pins

Bit	LVDS pin
GP0	SDATA4_P - Trigger1
GP1	SDATA4_P - Trigger2
GP2 *)	SDATA0_P - Reserve1
GP3 *)	SDATA4_P - Reserve2
GP4 *)	SDATA0_P - Marker1
GP5 *)	SDATA4_P - Marker2
*): not available for Digital I/Q enhanced mode	

Remote command:

`TRIG:SOUR GP0`, see `TRIGger[:SEQuence]:SOURce` on page 251

RF Power ← Trigger Source ← Trigger Source Settings

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 input signal must be in the frequency range between 500 MHz and 8 GHz.

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 data sheet.

Note: If the input signal contains frequencies outside of this range (e.g. for fullspan measurements), the measurement may 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".

This trigger source is not available for input from the optional Digital Baseband Interface or the optional Analog Baseband Interface . If the trigger source "RF Power" is selected and digital I/Q or analog baseband input is activated, the trigger source is automatically switched to "Free Run".

Remote command:
`TRIG:SOUR RFP`, see `TRIGger[:SEQuence]:SOURce` on page 251

I/Q Power ← Trigger Source ← Trigger Source Settings
This trigger source is not available if the optional Digital Baseband Interface or optional Analog Baseband Interface is used for input. It is also not available for analysis bandwidths ≥ 160 MHz.

Triggers the measurement when the magnitude of the sampled I/Q data exceeds the trigger threshold.

The trigger bandwidth corresponds to the "Usable I/Q Bandwidth", which depends on the sample rate of the captured I/Q data (see "Input Sample Rate" on page 123 and Chapter A.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 366).

Remote command:
`TRIG:SOUR IQP`, see `TRIGger[:SEQuence]:SOURce` on page 251

Power Sensor ← Trigger Source ← Trigger Source Settings
Uses an external power sensor as a trigger source. This option is only available if a power sensor is connected and configured.

Note: For R&S power sensors, the "Gate Mode" *Lvl* is not supported. The signal sent by these sensors merely reflects the instant the level is first exceeded, rather than a time period. However, only time periods can be used for gating in level mode. Thus, the trigger impulse from the sensors is not long enough for a fully gated measurement; the measurement cannot be completed.

Remote command:
`TRIG:SOUR PSE`, see `TRIGger[:SEQuence]:SOURce` on page 251

Time ← Trigger Source ← Trigger Source Settings
Triggers in a specified repetition interval.

Remote command:
`TRIG:SOUR TIME`, see `TRIGger[:SEQuence]:SOURce` on page 251

Trigger Level Mode ← Trigger Source Settings
By default, the optimum trigger level for power triggers is automatically measured and determined at the start of each sweep (for Modulation Accuracy, Flatness, Tolerance... measurements).

In order to define the trigger level manually, switch to "Manual" mode.

Remote command:
`TRIG:SEQ:LEV:POW:AUTO ON`, see `TRIGger:SEQuence:LEVel:POWer:AUTO` on page 250

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

For details on supported trigger levels, see the data sheet.

Remote command:
TRIGger[:SEQuence]:LEVel:IFPower on page 249
TRIGger[:SEQuence]:LEVel:IQPower on page 250
TRIGger[:SEQuence]:LEVel[:EXTernal<port>] on page 249
For analog baseband or digital baseband input only:
TRIGger[:SEQuence]:LEVel:BBPower on page 249
TRIGger[:SEQuence]:LEVel:RFPower on page 250

Repetition Interval ← Trigger Source Settings
Defines the repetition interval for a time trigger. The shortest interval is 2 ms.

The repetition interval should be set to the exact pulse period, burst length, frame length or other repetitive signal characteristic.

Remote command:
TRIGger[:SEQuence]:TIME:RINTerval on page 253

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

For more information on the drop-out time, see Chapter 4.9.3, "Trigger Drop-Out Time", on page 85.

Remote command:
TRIGger[:SEQuence]:DTIMe on page 247

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

For more information, see Chapter 4.9.1, "Trigger Offset", on page 84.

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

Remote command:
TRIGger[:SEQuence]:HOLDoff[:TIME] on page 248

Hysteresis ← Trigger Source Settings
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.

For more information, see Chapter 4.9.2, "Trigger Hysteresis", on page 84.

Remote command:
TRIGger[:SEQuence]:IFPower:HYSTeresis on page 248

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

For more information, see Chapter 4.9.4, "Trigger Holdoff", on page 86.

Remote command:
`TRIGger[:SEQuence]:IFPower:HOLDoff` on page 248

Slope ← Trigger Source Settings
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 251

FS-Z11 Trigger ← Trigger Source Settings
If activated, the measurement is triggered by a connected R&S FS-Z11 trigger unit, simultaneously for all connected analyzers. This is useful for MIMO measurements in simultaneous measurement mode (see "Simultaneous Signal Capture Setup" on page 134).

The Trigger Source is automatically set to "External Trigger 1/2/3" on page 126. The required connections between the analyzers, the trigger unit, and the DUT are indicated in the graphic.

For details see Chapter 4.9.6, "Trigger Synchronization Using an R&S FS-Z11 Trigger Unit", on page 87.

Remote command:
`TRIGger[:SEQuence]:SOURce` on page 251

Capture Offset ← Trigger Source Settings
This setting is only available for slave applications in **MSRA operating mode**. It has a similar effect as the trigger offset in other measurements: it defines the time offset between the capture buffer start and the start of the extracted slave application data.

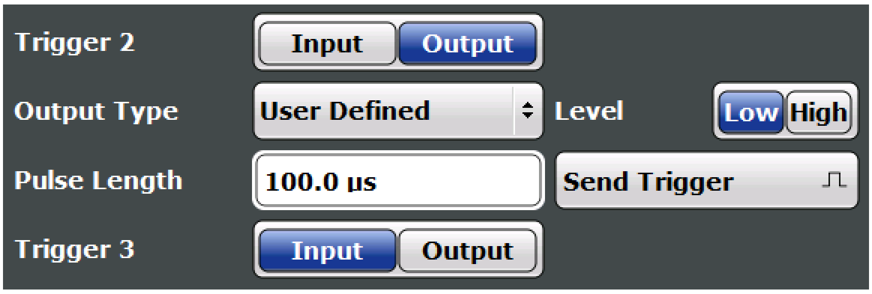
In MSRA mode, the offset must be a positive value, as the capture buffer starts at the trigger time = 0.

For details on the MSRA operating mode, see the R&S FSW MSRA User Manual.

For details on the MSRT operating mode, see the R&S FSW Real-Time Spectrum Application and MSRT Operating Mode User Manual.

Remote command:
`[SENSe:]MSRA:CAPTure:OFFSet` on page 289

Trigger 2/3



Defines the usage of the variable TRIGGER INPUT/OUTPUT connectors, where:

"Trigger 2": TRIGGER INPUT/OUTPUT connector on the front panel

"Trigger 3": TRIGGER 3 INPUT/ OUTPUT connector on the rear panel

(Trigger 1 is INPUT only.)

Note: Providing trigger signals as output is described in detail in the R&S FSW User Manual.

"Input" The signal at the connector is used as an external trigger source by the R&S FSW. Trigger input parameters are available in the "Trigger" dialog box.

"Output" The R&S FSW sends a trigger signal to the output connector to be used by connected devices.
Further trigger parameters are available for the connector.

Note: For simultaneous MIMO measurements (see "Simultaneous Signal Capture Setup" on page 134), if you set the master's TRIGGER 2 INPUT/OUTPUT connector to "device-triggered" output, the master R&S FSW sends its trigger event signal to any connected slaves. See also Chapter 4.9.5, "Trigger Synchronization Using the Master's Trigger Output", on page 87.

Remote command:
`OUTPut:TRIGger<port>:DIRection` on page 253

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

"Device Triggered" (Default) Sends a trigger when the R&S FSW triggers.

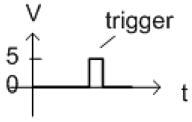
"Trigger Armed" Sends a (high level) trigger when the R&S FSW is in "Ready for trigger" state.
This state is indicated by a status bit in the `STATus:OPERation` register (bit 5), as well as by a low-level signal at the AUX port (pin 9).

"User Defined" Sends a trigger when you select the "Send Trigger" button.
In this case, further parameters are available for the output signal.

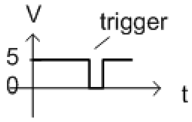
Remote command:
`OUTPut:TRIGger<port>:OTYPe` on page 254

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

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<port>:LEVel` on page 254

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<port>:PULSe:LENGth` on page 255

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 will be sent is indicated by a graphic on the button.

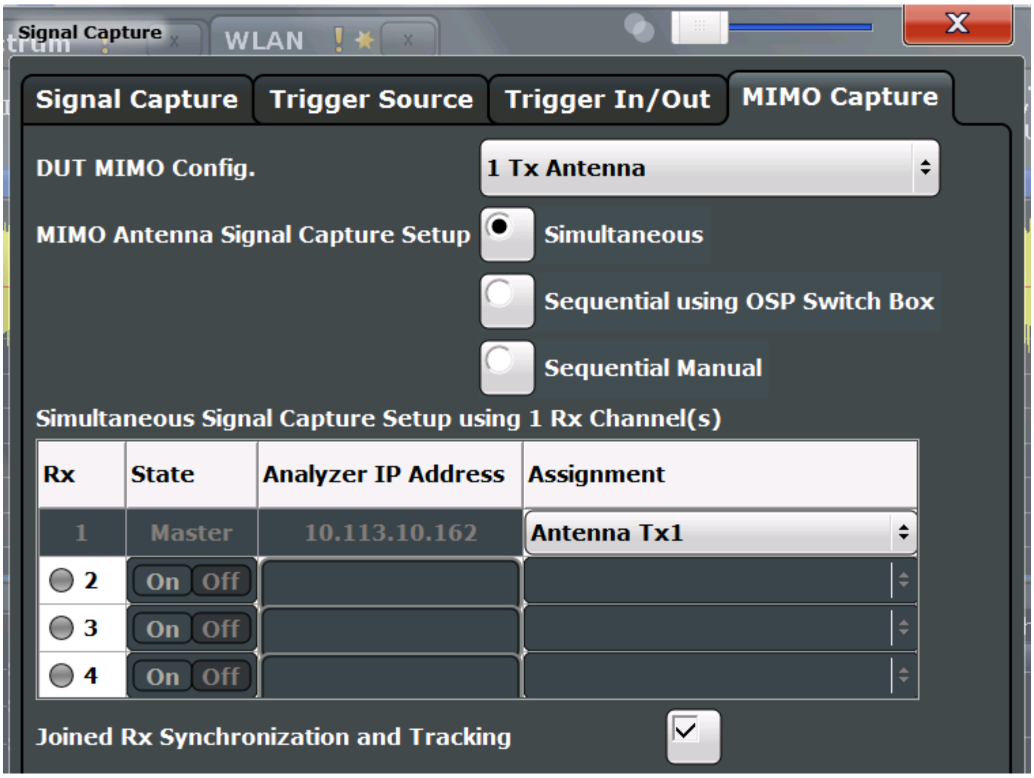
Remote command:
`OUTPut:TRIGger<port>:PULSe:IMMediate` on page 255

5.3.4.3 MIMO Capture Settings

Access: "Overview" > "Signal Capture" > "MIMO Capture" tab

Or: MEAS CONFIG > "Signal Capture" > "MIMO Capture" tab

The following settings are **only available for the IEEE 802.11ac and n** standards.



DUT MIMO Configuration

Defines the number of Tx antennas of the device under test (DUT). Currently up to eight Tx antennas are supported.

Remote command:

`CONFigure:WLAN:DUTConfig` on page 257

MIMO Antenna Signal Capture Setup
Defines the MIMO method used by the R&S FSW(s) to capture data from multiple Tx antennas sent by one device under test (DUT).

"Simultaneous" Simultaneous normal MIMO operation
The number of Tx antennas set in DUT MIMO Configuration defines the number of analyzers required for this measurement setup.

"Sequential using OSP switch" Sequential using open switch platform
A single analyzer and the Rohde & Schwarz OSP Switch Platform (with at least one fitted R&S®OSP-B101 option) is required to measure the number of DUT Tx Antennas as defined in DUT MIMO Configuration.

"Sequential manual" Sequential using manual operation
A single analyzer is required to measure the number of DUT Tx Antennas as defined in DUT MIMO Configuration. Data capturing is performed manually via the analyzer's user interface.

Remote command:
`CONFigure:WLAN:MIMO:CAPTure:TYPE` on page 258

Simultaneous Signal Capture Setup
For each RX antenna from which data is to be captured simultaneously, the settings are configured here.

LAN Status ← Simultaneous Signal Capture Setup
The LED symbol indicates the LAN connection state for each individual antenna (except for the master):

Table 5-2: Meaning of LED colors

Color	State
gray	antenna off or IP address not available/valid
red	antenna on and IP address valid, but not accessible
green	antenna on and IP address accessible

State ← Simultaneous Signal Capture Setup
Switches the corresponding slave analyzer on or off. In "On" state the slave analyzer captures data. This data is transferred via LAN to the master for analysis of the MIMO system.

Remote command:
`CONFigure:WLAN:ANTMatrix:STATe<antenna>` on page 257

Analyzer IP Address ← Simultaneous Signal Capture Setup
Defines the IP addresses of the slaves connected via LAN to the master.

Remote command:
`CONFigure:WLAN:ANTMatrix:ADDRess<add>` on page 256

Assignment ← Simultaneous Signal Capture Setup
Assignment of the expected antenna to an analyzer. For a wired connection the assignment of the Tx antenna connected to the analyzer is a possibility. For a wired connection and Direct Spatial Mapping the Spectrum Flatness traces in the diagonal contain the useful information, in case the signal transmitted from the antennas matches with the expected antennas. Otherwise the secondary diagonal will contain the useful traces.

Remote command:
`CONFigure:WLAN:ANTMatrix:ANTenna<Analyzer>` on page 256

Joined RX Sync and Tracking ← Simultaneous Signal Capture Setup
This command configures how PPDU synchronization and tracking is performed for multiple captured antenna signals.

"ON"	RX antennas are synchronized and tracked together.
"OFF"	RX antennas are synchronized and tracked separately.

Remote command:
`CONFigure:WLAN:RSYNc:JOINed` on page 259

Reference Frequency Coupling ← Simultaneous Signal Capture Setup
For simultaneous MIMO setups, you can set the reference frequency source for all slave devices to the same setting as the master device.

"Slaves Reference same as Master setting"	Both the master and all slaves use the same reference, according to the setting at the master.
"Slaves: External; Master: Internal"	The slave devices are set to use the external reference from the master. The master device uses its internal reference. Configure the master to send its reference frequency to all slave devices via one of its REF OUTPUT connectors. (See the R&S FSW User Manual for details.)
"Off"	Both the master and slave devices use their own internal references; the frequencies are not coupled.

Remote command:
`CONFigure:WLAN:ANTMatrix:SOURce:ROSCillator:SOURce` on page 256

Sequential Using OSP Switch Setup
A single analyzer and the Rohde & Schwarz OSP Switch Platform (with at least one fitted R&S®OSP-B101 option) is required to measure the DUT Tx Antennas.

Note: For sequential MIMO measurements the DUT has to transmit identical PPDUs over time! The signal field, for example, has to be identical for all PPDUs. For details see Chapter 4.3.4.1, "Sequential MIMO Measurement", on page 75.

This setup requires the analyzer and the OSP switch platform to be connected via LAN. A connection diagram is shown to assist you in connecting the specified number of DUT Tx antennas with the analyzer via the Rohde & Schwarz OSP switch platform.

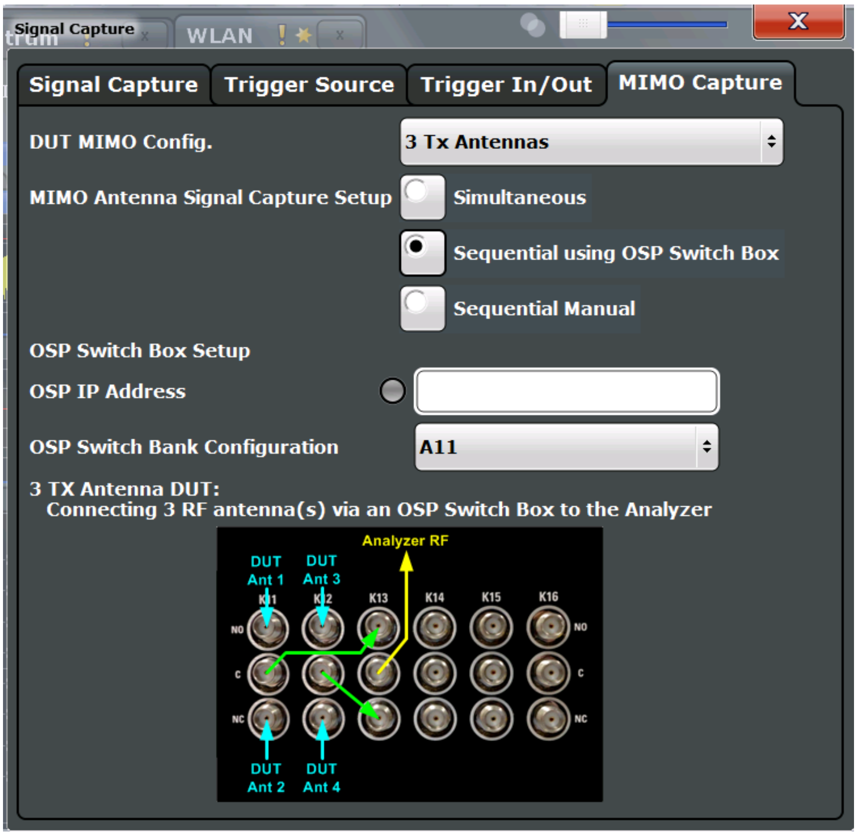


Figure 5-1: Connection instructions for sequential MIMO using an OSP switch

The diagram shows an R&S®OSP-B101 option fitted in one of the three module slots at the rear of the OSP switch platform. The DUT Tx antennas, the OSP switching box and the analyzer have to be connected as indicated in the diagram.

- **Blue** colored arrows represent the connections between the Tx antennas of the DUT and the corresponding SMA plugs of the R&S®OSP-B101 option.
- **Green** colored arrows represent auxiliary connections of SMA plugs of the R&S®OSP-B101 option.
- **Yellow** colored arrows represent the connection between the SMA plug of the R&S®OSP-B101 option with the RF or analog baseband input of the analyzer.

OSP IP Address ← Sequential Using OSP Switch Setup

The analyzer and the R&S OSP switch platform have to be connected via LAN. Enter the IP address of the OSP switch platform.

When using an R&S®OSP130 switch platform, the IP address is shown in the front display.

When using a R&S®OSP120 switch platform, connect an external monitor to get the IP address or use the default IP address of the OSP switch platform. For details read the OSP operation manual.

An online keyboard is displayed to enter the address in dotted IPV4 format.

Tip: the LED symbol indicates the state of the OSP switch box:

Color	State
gray	OSP switch box off or IP address not available/valid
red	OSP switch box on and IP address valid, but not accessible
green	OSP switch box on and IP address accessible

Remote command:
`CONFigure:WLAN:MIMO:OSP:ADDRess` on page 258

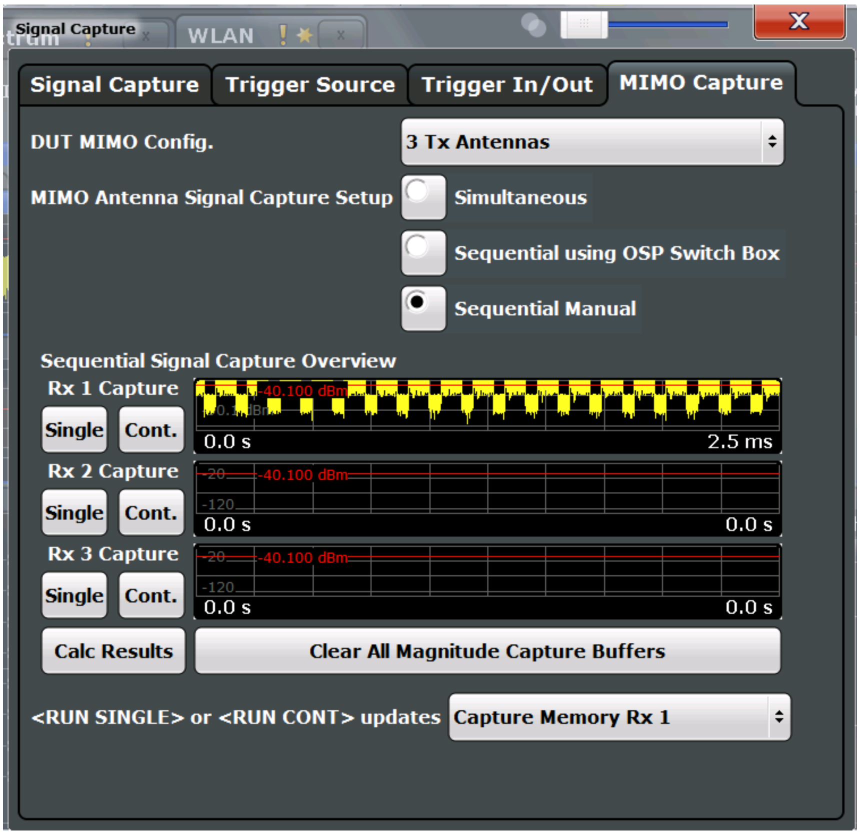
OSP Switch Bank Configuration ← Sequential Using OSP Switch Setup
The R&S®OSP-B101 option is fitted in one of the three module slots (*switch banks*) at the rear of the OSP switch platform. The DUT Tx antennas are connected with the analyzer via the R&S®OSP-B101 module fitted in the OSP switch platform. Select the R&S®OSP-B101 module that is used for this connection.

Remote command:
`CONFigure:WLAN:MIMO:OSP:MODule` on page 259

Manual Sequential MIMO Data Capture
Note: For sequential MIMO measurements the DUT has to transmit identical PPDUs over time! The signal field, for example, has to be identical for all PPDUs. For details see Chapter 4.3.4.1, "Sequential MIMO Measurement", on page 75.

For this MIMO method you must connect each Tx antenna of the WLAN DUT with the analyzer and start data capturing manually (see Chapter 5.3.12, "Sweep Settings", on page 171).

The dialog box shows a preview of the capture memories (one for each RX antenna).The PPDUs detected by the application are highlighted by the green bars.



Remote command:
`CONF:WLAN:MIMO:CAPT:TYP MAN`, see `CONFigure:WLAN:MIMO:CAPTure:TYPE` on page 258

Single / Cont. ← Manual Sequential MIMO Data Capture
Starts a single or continuous new measurement for the corresponding antenna.

Remote command:
`CONF:WLAN:MIMO:CAPT RX1`, see `CONFigure:WLAN:MIMO:CAPTure` on page 257
`INITiate<n>[:IMMediate]` on page 311

Calc Results ← Manual Sequential MIMO Data Capture
Calculates the results for the captured antenna signals.

Remote command:
`CALCulate<n>:BURSt[:IMMediate]` on page 310

Clear All Magnitude Capture Buffers ← Manual Sequential MIMO Data Capture
Clears all the capture buffers and previews.

RUN SGL / RUN CONT updates ← Manual Sequential MIMO Data Capture
Determines which capture buffer is used to store data if a measurement is started via the global RUN SGL / RUN CONT keys.

5.3.5 Slave Application Data (MSRA)

For the R&S FSW WLAN application in MSRA operating mode, the slave application data range is defined by the same settings used to define the signal capturing in Signal and Spectrum Analyzer mode (see Chapter 5.3.4, "Signal Capture (Data Acquisition)", on page 122.

In addition, a capture offset can be defined, i.e. an offset from the start of the captured data to the start of the analysis interval for the WLAN 802.11 I/Q measurement (see "Capture Offset" on page 123).

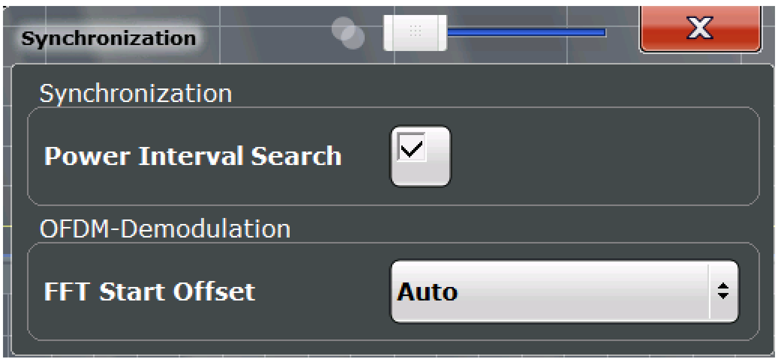
The **analysis interval** cannot be edited manually, but is determined automatically according to the selected channel, carrier or PPDU to analyze which is defined for the evaluation range, depending on the result display. Note that the channel/carrier/PPDU is analyzed *within the slave application data*.

5.3.6 Synchronization and OFDM Demodulation

Access: "Overview" > "Synchronization/ OFDM-Demod."

Or: MEAS CONFIG > "Synch./OFDM-Demod."

Synchronization settings have an effect on which parts of the input signal are processed during the WLAN 802.11 measurement.



Power Interval Search
If enabled, the R&S FSW WLAN application initially performs a coarse burst search on the input signal in which increases in the power vs time trace are detected. Further time-consuming processing is then only performed where bursts are assumed. This improves the measurement speed for signals with low duty cycle rates.

However, for signals in which the PPDU power levels differ significantly, this option should be disabled as otherwise some PPDUs may not be detected.

Remote command:
`[SENSe:]DEMod:TXARea` on page 260

FFT Start Offset
This command specifies the start offset of the FFT for OFDM demodulation (not for the FFT Spectrum display).

"AUTO"
The FFT start offset is automatically chosen to minimize the intersymbol interference.

"Guard Interval Cntr"
Guard Interval Center: The FFT start offset is placed to the center of the guard interval.

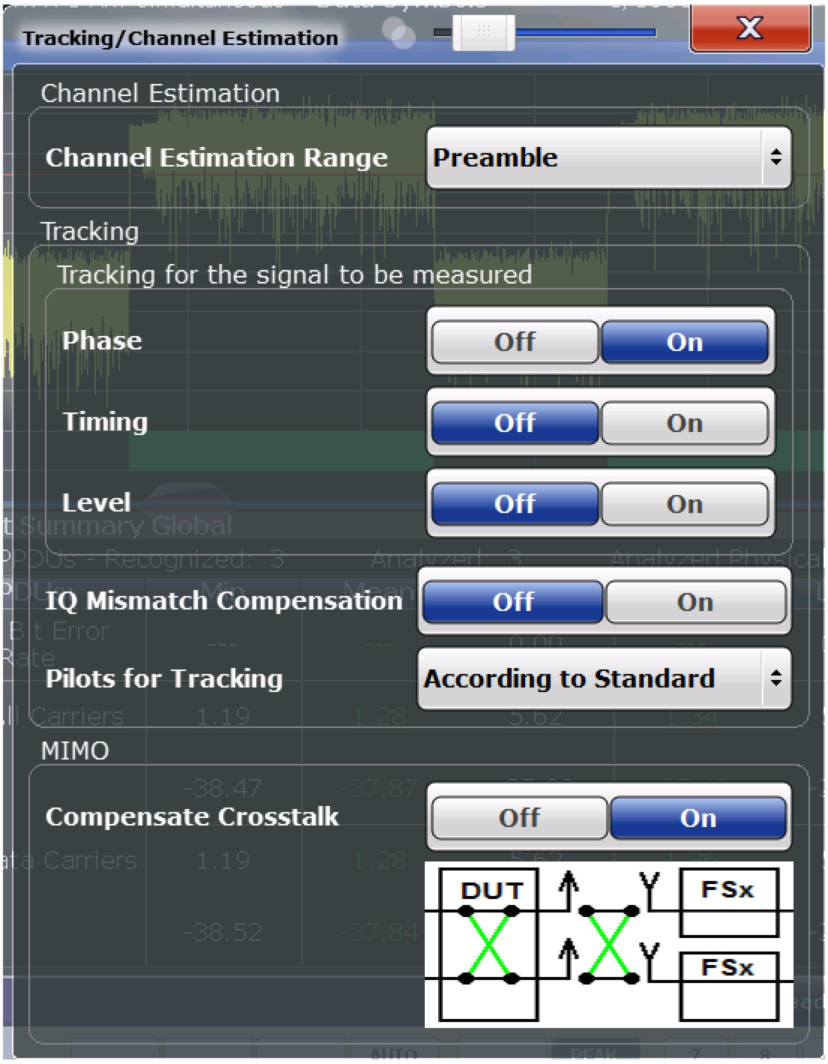
"Peak"
The peak of the fine timing metric is used to determine the FFT start offset.

Remote command:
`[SENSe:]DEMod:FFT:OFFSet` on page 259

5.3.7 Tracking and Channel Estimation

Access: "Overview" > "Tracking/Channel Estimation"

The channel estimation settings determine which channels are assumed in the input signal. Tracking settings allow for compensation of some transmission effects in the signal (see "Tracking the phase drift, timing jitter and gain" on page 61).



Channel Estimation Range

Specifies the signal range used to estimate the channels.

This function is **not** available for **IEEE 802.11b or g (DSSS)**.

"Preamble" The channel estimation is performed in the preamble as required in the standard.

"Payload" The channel estimation is performed in the preamble and the payload. The EVM results can be calculated more accurately.

Remote command:

[SENSe:]DEMod:CESTimation on page 261

Phase Tracking

Activates or deactivates the compensation for phase drifts. If activated, the measurement results are compensated for phase drifts on a per-symbol basis.

Remote command:

`SENSe:TRACking:PHASe` on page 262

Timing Error Tracking

Activates or deactivates the compensation for timing drift. If activated, the measurement results are compensated for timing error on a per-symbol basis.

Remote command:

`SENSe:TRACking:TIME` on page 263

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 262

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. Since the quadrature offset is compensated carrier-wise, I/Q skew impairments are compensated as well.

This setting is **not available for standards IEEE 802.11b and g (DSSS)**.

For details see Chapter 3.1.1.5, "I/Q Mismatch", on page 19.

Note: For EVM measurements according to the IEEE 802.11-2012, IEEE 802.11ac-2013 WLAN standard, I/Q mismatch compensation must be deactivated.

Remote command:

`SENSe:TRACking:IQMComp` on page 261

Pilots for Tracking

In case tracking is used, the used pilot sequence has an effect on the measurement results.

This function is **not** available for **IEEE 802.11b or g (DSSS)**.

"According to standard"

The pilot sequence is determined according to the corresponding WLAN standard. In case the pilot generation algorithm of the device under test (DUT) has a problem, the non-standard-conform pilot sequence might affect the measurement results, or the WLAN application might not synchronize at all onto the signal generated by the DUT.

"Detected"

The pilot sequence detected in the WLAN signal to be analyzed is used by the WLAN application. In case the pilot generation algorithm of the device under test (DUT) has a problem, the non-standard-conform pilot sequence will not affect the measurement results. In case the pilot sequence generated by the DUT is correct, it is recommended that you use the "According to Standard" setting because it generates more accurate measurement results.

Remote command:
`SENSe:TRACking:PILots` on page 262

Compensate Crosstalk (MIMO only)

Activates or deactivates the compensation for crosstalk in MIMO measurement setups.

This setting is **only available for standard IEEE 802.11ac or n (MIMO)**.

By default, full MIMO equalizing is performed by the R&S FSW WLAN application. However, you can deactivate compensation for crosstalk. In this case, simple main path equalizing is performed only for direct connections between Tx and Rx antennas, disregarding ancillary transmission between the main paths (crosstalk). This is useful to investigate the effects of crosstalk on results such as EVM.

On the other hand, for cable connections, which have practically no crosstalk, you may get better EVM results if crosstalk is compensated for.

For details see Chapter 4.3.6, "Crosstalk and Spectrum Flatness", on page 78.

Remote command:
`SENSe:TRACking:CROSstalk` on page 261

5.3.8 Demodulation

Access: "Overview" > "Demodulation"

Or: MEAS CONFIG > "Demod."

The demodulation settings define which PPDUs are to be analyzed, thus they define a *logical filter*.

The available demodulation settings vary depending on the selected digital standard in the "Signal Description" (see "Standard" on page 95).

5.3.8.1 Demodulation - IEEE 802.11a, g (OFDM), j, p

Access: "Overview" > "Demodulation"

Or: MEAS CONFIG > "Demod."

The following settings are available for demodulation of IEEE 802.11a, g (OFDM), j, p signals.

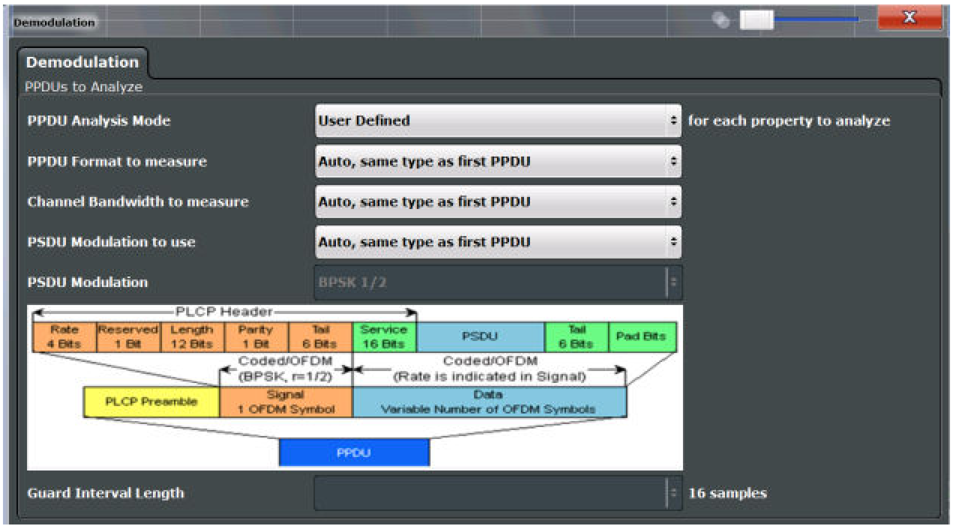


Figure 5-2: Demodulation settings for IEEE 802.11a, g (OFDM), j, or p standard

PPDU Analysis Mode

Defines whether all or only specific PPDUs are to be analyzed.

"Auto, same type as first PPDU"
: The signal symbol field, i.e. the PLCP header field, of the first recognized PPDU is analyzed to determine the details of the PPDU. All PPDUs identical to the first recognized PPDU are analyzed.
All subsequent settings are set to "Auto" mode.

"Auto, individually for each PPDU"
: All PPDUs are analyzed

"User-defined"
: User-defined settings define which PPDUs are analyzed. This setting is automatically selected when any of the subsequent settings are changed to a value other than "Auto".

Remote command:
`[SENSe:]DEMod:FORMat[:BCONtent]:AUTO` on page 275

PPDU Format to measure

Defines which PPDU formats are to be included in the analysis. Depending on which standards the communicating devices are using, different formats of PPDUs are available. Thus you can restrict analysis to the supported formats.

Note: The PPDU format determines the available channel bandwidths.

For details on supported PPDU formats and channel bandwidths depending on the standard see Table 4-1.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("Format" column, see "Signal Field" on page 46).

"Auto, same type as first PPDU(A1st)"
The format of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same format.

"Auto, individually for each PPDU(AI)"
All PPDUs are analyzed regardless of their format

"Meas only ...(M ...)"
Only PPDUs with the specified format are analyzed

"Demod all as ...(D ...)"
All PPDUs are assumed to have the specified PPDU format

Remote command:
`[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE` on page 273
`[SENSe:]DEMod:FORMat:BANalyze` on page 271

Channel Bandwidth to measure (CBW)
Defines the channel bandwidth of the PPDUs taking part in the analysis. Depending on which standards the communicating devices are using, different PPDU formats and channel bandwidths are supported.

For details on supported PPDU formats and channel bandwidths depending on the standard see Table 4-1.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("Format" column, see "Signal Field" on page 46).

"Auto, same type as first PPDU""(A1st)"
The channel bandwidth of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same channel bandwidth.

"Auto, individually for each PPDU""(AI)"
All PPDUs are analyzed regardless of their channel bandwidth

"Meas only ... signal""(M ...)"
Only PPDUs with the specified channel bandwidth are analyzed

"Demod all as ... signal""(D ...)"
All PPDUs are assumed to have the specified channel bandwidth

Remote command:
`[SENSe:]BANDwidth:CHANnel:AUTO:TYPE` on page 269

PSDU Modulation to use
Specifies which PSDUs are to be analyzed depending on their modulation. Only PSDUs using the selected modulation are considered in measurement analysis.

For details on supported modulation depending on the standard see Table 4-1.

"Auto, same type as first PPDU""(A1st)"
All PSDUs using the same modulation as the first recognized PPDU are analyzed.

"Auto, individually for each PPDU""(AI)"
All PSDUs are analyzed

"Meas only the specified PSDU Modulation""(M ...)"
Only PSDUs with the modulation specified by the PSDU Modulation setting are analyzed

"Demod all with specified PSDU modulation""(D ...)"
The PSDU modulation of the PSDU Modulation setting is used for all PSDUs.

Remote command:
`[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE` on page 273
`[SENSe:]DEMod:FORMat:BANalyze` on page 271

PSDU Modulation
If analysis is restricted to PSDU with a particular modulation type, this setting defines which type.

For details on supported modulation depending on the standard see Table 4-1.

Remote command:
`[SENSe:]DEMod:FORMat:BANalyze` on page 271

5.3.8.2 Demodulation - IEEE 802.11ac

Access: "Overview" > "Demodulation"

Or: MEAS CONFIG > "Demod."

The following settings are available for demodulation of IEEE 802.11ac signals.

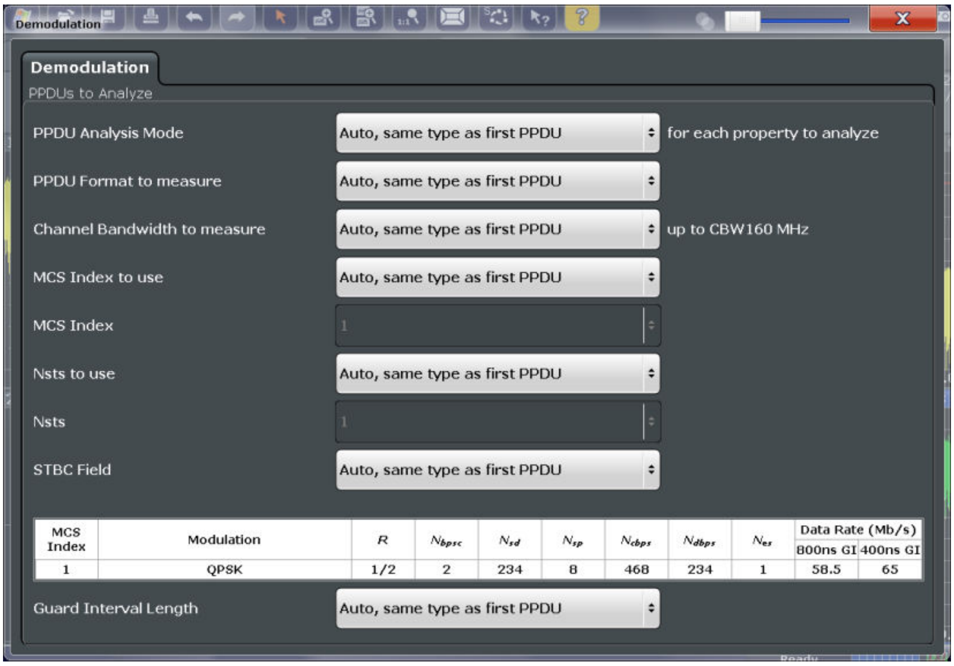


Figure 5-3: Demodulation settings for IEEE 802.11ac standard

PPDU Analysis Mode

Defines whether all or only specific PPDUs are to be analyzed.

"Auto, same type as first PPDU"
: The signal symbol field, i.e. the PLCP header field, of the first recognized PPDU is analyzed to determine the details of the PPDU. All PPDUs identical to the first recognized PPDU are analyzed.
All subsequent settings are set to "Auto" mode.

"Auto, individually for each PPDU"
: All PPDUs are analyzed

"User-defined"
: User-defined settings define which PPDUs are analyzed. This setting is automatically selected when any of the subsequent settings are changed to a value other than "Auto".

Remote command:
`[SENSe:]DEMod:FORMat[:BCONtent]:AUTO` on page 275

PPDU Format to measure
Defines which PPDU formats are to be included in the analysis. Depending on which standards the communicating devices are using, different formats of PPDUs are available. Thus you can restrict analysis to the supported formats.

Note: The PPDU format determines the available channel bandwidths.

For details on supported PPDU formats and channel bandwidths depending on the standard see Table 4-1.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("Format" column, see "Signal Field" on page 46).

"Auto, same type as first PPDU(A1st)"
The format of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same format.

"Auto, individually for each PPDU(AI)"
All PPDUs are analyzed regardless of their format

"Meas only ...(M ...)"
Only PPDUs with the specified format are analyzed

"Demod all as ...(D ...)"
All PPDUs are assumed to have the specified PPDU format

Remote command:
`[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE` on page 273
`[SENSe:]DEMod:FORMat:BANalyze` on page 271

Channel Bandwidth to measure (CBW)
Defines the channel bandwidth of the PPDUs taking part in the analysis. Depending on which standards the communicating devices are using, different PPDU formats and channel bandwidths are supported.

For details on supported PPDU formats and channel bandwidths depending on the standard see Table 4-1.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("Format" column, see "Signal Field" on page 46).

"Auto, same type as first PPDU""(A1st)"
The channel bandwidth of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same channel bandwidth.

"Auto, individually for each PPDU""(AI)"
All PPDUs are analyzed regardless of their channel bandwidth

"Meas only ... signal""(M ...)"
Only PPDUs with the specified channel bandwidth are analyzed

"Demod all as ... signal""(D ...)"
All PPDUs are assumed to have the specified channel bandwidth

Remote command:
`[SENSe:]BANDwidth:CHANnel:AUTO:TYPE` on page 269

MCS Index to use

Defines the PPDUs taking part in the analysis depending on their Modulation and Coding Scheme (MCS) index.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("Format" column, see "Signal Field" on page 46).

"Auto, same type as first PPDU:""(A1st)"
: All PPDUs using the MCS index identical to the first recognized PPDU are analyzed.

" Auto, individually for each PPDU""(AI)"
: All PPDUs are analyzed

"Meas only the specified MCS""(M ...)"
: Only PPDUs with the MCS index specified for the MCS Index setting are analyzed

"Demod all with specified MCS""(D ...)"
: The MCS Index setting is used for all PPDUs.

Remote command:
`[SENSe:]DEMod:FORMat:MCSindex:MODE` on page 275

MCS Index

Defines the MCS index of the PPDUs taking part in the analysis manually. This field is enabled for "MCS index to use" = "Meas only the specified MCS" or "Demod all with specified MCS".

Remote command:
`[SENSe:]DEMod:FORMat:MCSindex` on page 275

Nsts to use

Defines the the PPDUs taking part in the analysis depending on their Nsts.

Note: The terms in brackets in the following description indicate how the setting is referred to in the "Signal Field" result display ("NSTS" column, see "Signal Field" on page 46).

"Auto, same type as first PPDU:""(A1st)"
: All PPDUs using the Nsts identical to the first recognized PPDU are analyzed.

" Auto, individually for each PPDU""(AI)"
: All PPDUs are analyzed

"Meas only the specified Nsts""(M ...)"
: Only PPDUs with the Nsts specified for the "Nsts" on page 150 setting are analyzed

"Demod all with specified Nsts""(D ...)"
: The "Nsts" on page 150 setting is used for all PPDUs.

Remote command:
`[SENSe:]DEMod:FORMat:NSTSindex:MODE` on page 276

Nsts

Defines the Nsts of the PPDUs taking part in the analysis. This field is enabled for Nsts to use = "Meas only the specified Nsts" or "Demod all with specified Nsts".

Remote command:
`[SENSe:]DEMod:FORMat:NSTSindex` on page 276

STBC Field

Defines the PPDUs taking part in the analysis according to the Space-Time Block Coding (STBC) field content.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("Format" column, see "Signal Field" on page 46).

"Auto, same type as first PPDU""(A1st)"
All PPDUs using a STBC field content identical to the first recognized PPDU are analyzed.

"Auto, individually for each PPDU""(AI)"
All PPDUs are analyzed.

"Meas only if STBC field = 1 (+1 Stream)""(M1)"(IEEE 802.11N)
Only PPDUs with the specified STBC field content are analyzed.

"Meas only if STBC field = 2 (+2 Stream)""(M2)"(IEEE 802.11N)
Only PPDUs with the specified STBC field content are analyzed.

"Demod all as STBC field = 1""(D1)"(IEEE 802.11N)
All PPDUs are analyzed assuming the specified STBC field content.

"Demod all as STBC field = 2""(D2)"(IEEE 802.11N)
All PPDUs are analyzed assuming the specified STBC field content.

"Meas only if STBC = 1 (Nsts = 2Nss)""(M1)"(IEEE 802.11AC)
Only PPDUs with the specified STBC field content are analyzed.

"Demod all as STBC = 1 (Nsts = 2Nss)""(D1)"(IEEE 802.11AC)
All PPDUs are analyzed assuming the specified STBC field content.

Remote command:
`CONFigure:WLAN:STBC:AUTO:TYPE` on page 268

Table info overview

Depending on the selected channel bandwidth, MCS index or NSS (STBC), the relevant information from the modulation and coding scheme (MCS) as defined in the WLAN 802.11 standard is displayed here. This information is for reference only, for example so you can determine the required data rate.

Guard Interval Length

Defines the PPDUs taking part in the analysis depending on the guard interval length.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("Format" column, see "Signal Field" on page 46).

"Auto, same type as first PPDU""(A1st)"
All PPDUs using the guard interval length identical to the first recognized PPDU are analyzed.

"Auto, individually for each PPDU""(AI)"
All PPDUs are analyzed.

"Meas only Short""(MS)"
Only PPDUs with short guard interval length are analyzed.

"Meas only Long""(ML)"
Only PPDUs with long guard interval length are analyzed.

"Demod all as short""(DS)"
All PPDUs are demodulated assuming short guard interval length.

"Demod all as long ""(DL)"
All PPDUs are demodulated assuming long guard interval length.

Remote command:
`CONFigure:WLAN:GTIMe:AUTO` on page 265
`CONFigure:WLAN:GTIMe:AUTO:TYPE` on page 265
`CONFigure:WLAN:GTIMe:SELect` on page 266

5.3.8.3 Demodulation - IEEE 802.11b, g (DSSS)

Access: "Overview" > "Demodulation"

Or: MEAS CONFIG > "Demod."

The following settings are available for demodulation of IEEE 802.11b or g (DSSS) signals.

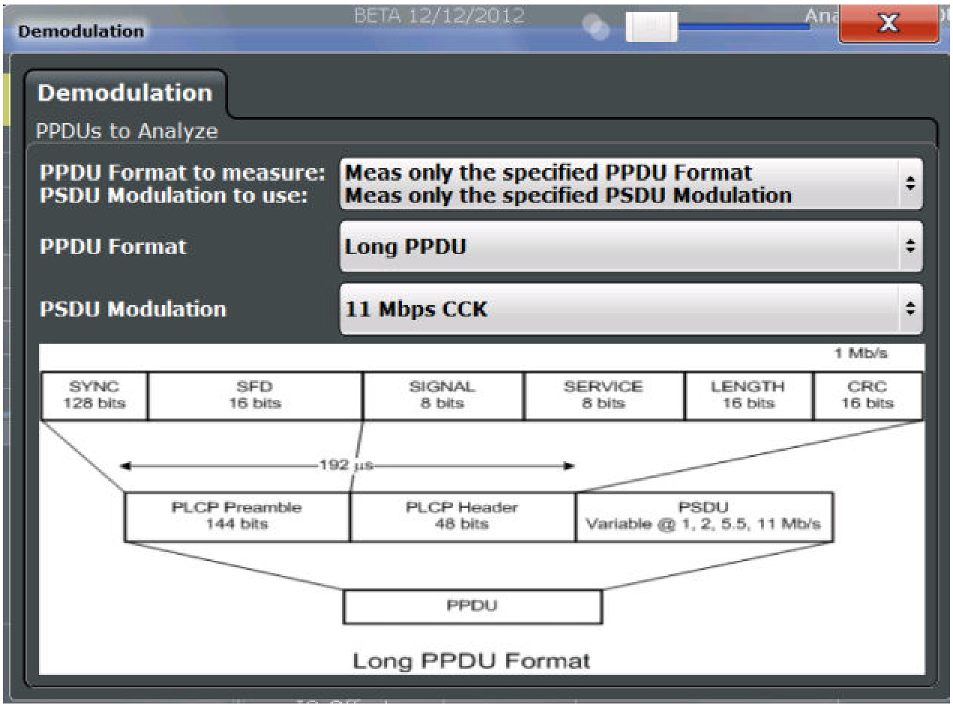


Figure 5-4: Demodulation settings for IEEE 802.11b, g (DSSS) signals

PPDU Format to measure / PSDU Modulation to use

Defines which PPDU formats/modulations are to be included in the analysis. Depending on which standards the communicating devices are using, different formats of PPDUs are available. Thus you can restrict analysis to the supported formats.

Note: The PPDU format determines the available channel bandwidths.

For details on supported PPDU formats, modulations, and channel bandwidths depending on the standard see Table 4-1.

"Auto, same type as first PPDU"
: The format/modulation of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same format.

"Auto, individually for each PPDU"
: All PPDUs are analyzed regardless of their format/modulation

"Meas only ..."
: Only PPDUs with the specified format or PSDUs with the specified modulation are analyzed

"Demod all as ..."
: All PPDUs are assumed to have the specified PPDU format/ PSDU modulation

Remote command:
[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE on page 273
[SENSe:]DEMod:FORMat:BANalyze on page 271
[SENSe:]DEMod:FORMat:SIGSymbol on page 277

PPDU Format

If analysis is restricted to PPDUs with a particular format (see PPDU Format to measure / PSDU Modulation to use), this setting defines which type.

For details on supported modulation depending on the standard see Table 4-1.

Remote command:
[SENSe:]DEMod:FORMat:BANalyze on page 271
[SENSe:]DEMod:FORMat:BANalyze:BTYPe on page 272

PSDU Modulation

If analysis is restricted to PSDU with a particular modulation type, this setting defines which type.

For details on supported modulation depending on the standard see Table 4-1.

Remote command:
[SENSe:]DEMod:FORMat:BANalyze on page 271

5.3.8.4 Demodulation - IEEE 802.11n

Access: "Overview" > "Demodulation"

Or: MEAS CONFIG > "Demod."

The following settings are available for demodulation of IEEE 802.11n signals.

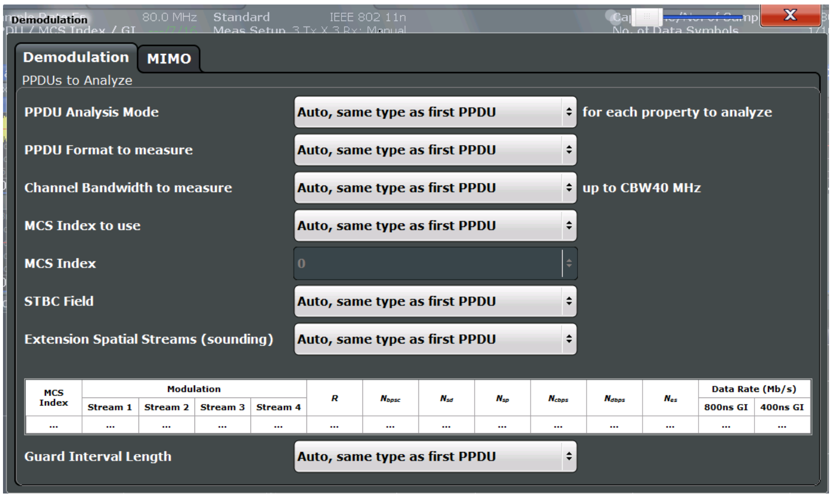


Figure 5-5: Demodulation settings for IEEE 802.11n standard

PPDU Analysis Mode

Defines whether all or only specific PPDUs are to be analyzed.

"Auto, same type as first PPDU"
: The signal symbol field, i.e. the PLCP header field, of the first recognized PPDU is analyzed to determine the details of the PPDU. All PPDUs identical to the first recognized PPDU are analyzed.
All subsequent settings are set to "Auto" mode.

"Auto, individually for each PPDU"
: All PPDUs are analyzed

"User-defined"
: User-defined settings define which PPDUs are analyzed. This setting is automatically selected when any of the subsequent settings are changed to a value other than "Auto".

Remote command:
`[SENSe:]DEMod:FORMat[:BCONtent]:AUTO` on page 275

PPDU Format to measure
Defines which PPDU formats are to be included in the analysis. Depending on which standards the communicating devices are using, different formats of PPDUs are available. Thus you can restrict analysis to the supported formats.

Note: The PPDU format determines the available channel bandwidths.

For details on supported PPDU formats and channel bandwidths depending on the standard see Table 4-1.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("Format" column, see "Signal Field" on page 46).

"Auto, same type as first PPDU(A1st)"
The format of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same format.

"Auto, individually for each PPDU(AI)"
All PPDUs are analyzed regardless of their format

"Meas only ...(M ...)"
Only PPDUs with the specified format are analyzed

"Demod all as ...(D ...)"
All PPDUs are assumed to have the specified PPDU format

Remote command:
`[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE` on page 273
`[SENSe:]DEMod:FORMat:BANalyze` on page 271

Channel Bandwidth to measure (CBW)
Defines the channel bandwidth of the PPDUs taking part in the analysis. Depending on which standards the communicating devices are using, different PPDU formats and channel bandwidths are supported.

For details on supported PPDU formats and channel bandwidths depending on the standard see Table 4-1.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("Format" column, see "Signal Field" on page 46).

"Auto, same type as first PPDU""(A1st)"
The channel bandwidth of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same channel bandwidth.

"Auto, individually for each PPDU""(AI)"
All PPDUs are analyzed regardless of their channel bandwidth

"Meas only ... signal""(M ...)"
Only PPDUs with the specified channel bandwidth are analyzed

"Demod all as ... signal""(D ...)"
All PPDUs are assumed to have the specified channel bandwidth

Remote command:
`[SENSe:]BANDwidth:CHANnel:AUTO:TYPE` on page 269

MCS Index to use

Defines the PPDUs taking part in the analysis depending on their Modulation and Coding Scheme (MCS) index.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("Format" column, see "Signal Field" on page 46).

"Auto, same type as first PPDU:""(A1st)"
: All PPDUs using the MCS index identical to the first recognized PPDU are analyzed.

" Auto, individually for each PPDU""(AI)"
: All PPDUs are analyzed

"Meas only the specified MCS""(M ...)"
: Only PPDUs with the MCS index specified for the MCS Index setting are analyzed

"Demod all with specified MCS""(D ...)"
: The MCS Index setting is used for all PPDUs.

Remote command:
`[SENSe:]DEMod:FORMat:MCSindex:MODE` on page 275

MCS Index

Defines the MCS index of the PPDUs taking part in the analysis manually. This field is enabled for "MCS index to use" = "Meas only the specified MCS" or "Demod all with specified MCS".

Remote command:
`[SENSe:]DEMod:FORMat:MCSindex` on page 275

STBC Field

Defines the PPDUs taking part in the analysis according to the Space-Time Block Coding (STBC) field content.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("Format" column, see "Signal Field" on page 46).

"Auto, same type as first PPDU""(A1st)"
: All PPDUs using a STBC field content identical to the first recognized PPDU are analyzed.

"Auto, individually for each PPDU""(AI)"
: All PPDUs are analyzed.

"Meas only if STBC field = 1 (+1 Stream)""(M1)"(IEEE 802.11N)
: Only PPDUs with the specified STBC field content are analyzed.

"Meas only if STBC field = 2 (+2 Stream)""(M2)"(IEEE 802.11N)
: Only PPDUs with the specified STBC field content are analyzed.

"Demod all as STBC field = 1""(D1)"(IEEE 802.11N)
: All PPDUs are analyzed assuming the specified STBC field content.

"Demod all as STBC field = 2""(D2)"(IEEE 802.11N)
: All PPDUs are analyzed assuming the specified STBC field content.

"Meas only if STBC = 1 (Nsts = 2Nss)""(M1)"(IEEE 802.11AC)
Only PPDUs with the specified STBC field content are analyzed.

"Demod all as STBC = 1 (Nsts = 2Nss)""(D1)"(IEEE 802.11AC)
All PPDUs are analyzed assuming the specified STBC field content.

Remote command:
CONFigure:WLAN:STBC:AUTO:TYPE on page 268

Extension Spatial Streams (sounding)
Defines the PPDUs taking part in the analysis according to the Ness field content.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("NESS" column, see "Signal Field" on page 46).

"Auto, same type as first PPDU""(A1st)"
All PPDUs using a Ness value identical to the first recognized PPDU are analyzed.

"Auto, individually for each PPDU""(AI)"
All PPDUs are analyzed.

"Meas only if Ness = <x>""(M ...)"
Only PPDUs with the specified Ness value are analyzed.

"Demod all as Ness = <x>"
All PPDUs are analyzed assuming the specified Ness value.

Remote command:
CONFigure:WLAN:EXTension:AUTO:TYPE on page 264

Table info overview
Depending on the selected channel bandwidth, MCS index or NSS (STBC), the relevant information from the modulation and coding scheme (MCS) as defined in the WLAN 802.11 standard is displayed here. This information is for reference only, for example so you can determine the required data rate.

Guard Interval Length
Defines the PPDUs taking part in the analysis depending on the guard interval length.

Note: The terms in brackets in the following description indicate how the setting is referred to in the Signal Field result display ("Format" column, see "Signal Field" on page 46).

"Auto, same type as first PPDU""(A1st)"
All PPDUs using the guard interval length identical to the first recognized PPDU are analyzed.

"Auto, individually for each PPDU""(AI)"
All PPDUs are analyzed.

"Meas only Short""(MS)"
Only PPDUs with short guard interval length are analyzed.

"Meas only Long""(ML)"
Only PPDUs with long guard interval length are analyzed.

"Demod all as short""(DS)"

All PPDUs are demodulated assuming short guard interval length.

"Demod all as long ""(DL)"

All PPDUs are demodulated assuming long guard interval length.

Remote command:

`CONFigure:WLAN:GTIMe:AUTO` on page 265

`CONFigure:WLAN:GTIMe:AUTO:TYPE` on page 265

`CONFigure:WLAN:GTIMe:SELect` on page 266

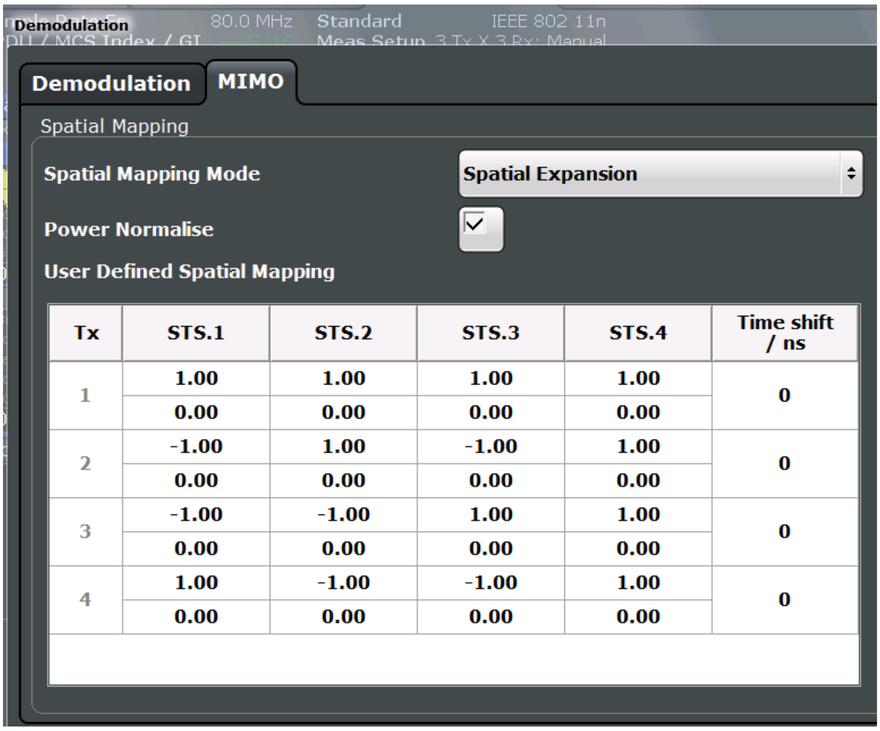
5.3.8.5 Demodulation - MIMO (IEEE 802.11ac, n)

Access: "Overview" > "Demodulation" > "MIMO" tab

Or: MEAS CONFIG > "Demod." > "MIMO" tab

The MIMO settings define the mapping between streams and antennas.

This tab is **only available for the standard IEEE 802.11ac or n (MIMO)**.



Spatial Mapping Mode

Defines the mapping between streams and antennas.

For details see Chapter 4.3.2, "Spatial Mapping", on page 72.

"Direct"	The mapping between streams and antennas is the identity matrix. See also section "20.3.11.10.1 Spatial Mapping" of the IEEE 802.11n WLAN standard.
"Spatial Expansion:"	For this mode all streams contribute to all antennas. See also section "20.3.11.10.1 Spatial Mapping" of the IEEE 802.11n WLAN standard.
"User defined"	The mapping between streams and antennas is defined by the User Defined Spatial Mapping table.

Remote command:
`CONFigure:WLAN:SMAPping:MODE` on page 267

Power Normalise
Specifies whether an amplification of the signal power due to the spatial mapping is performed according to the matrix entries.

"On"	Spatial mapping matrix is scaled by a constant factor to obtain a passive spatial mapping matrix which does not increase the total transmitted power.
"Off"	Normalization step is omitted

Remote command:
`CONFigure:WLAN:SMAPping:NORMalise` on page 267

User Defined Spatial Mapping
Define your own spatial mapping between streams and antennas.

For each antenna (Tx1..4), the complex element of each STS-Stream is defined. The upper value is the real part of the complex element. The lower value is the imaginary part of the complex element.

Additionally, a "Time Shift" can be defined for cyclic delay diversity (CSD).

Remote command:
`CONFigure:WLAN:SMAPping:TX<ch>` on page 267
`CONFigure:WLAN:SMAPping:TX<ch>:STReam<stream>` on page 268
`CONFigure:WLAN:SMAPping:TX<ch>:TIMeshift` on page 268

5.3.9 Evaluation Range

The evaluation range defines which objects the result displays are based on. The available settings depend on the selected standard.

5.3.9.1 Evaluation Range Settings for IEEE IEEE 802.11a, ac, g (OFDM), j, n, p

Access: "Overview" > "Evaluation Range"

Or: MEAS CONFIG > "Evaluation Range"

The following settings are available to configure the evaluation range for standards IEEE IEEE 802.11a, ac, g (OFDM), j, n, p.

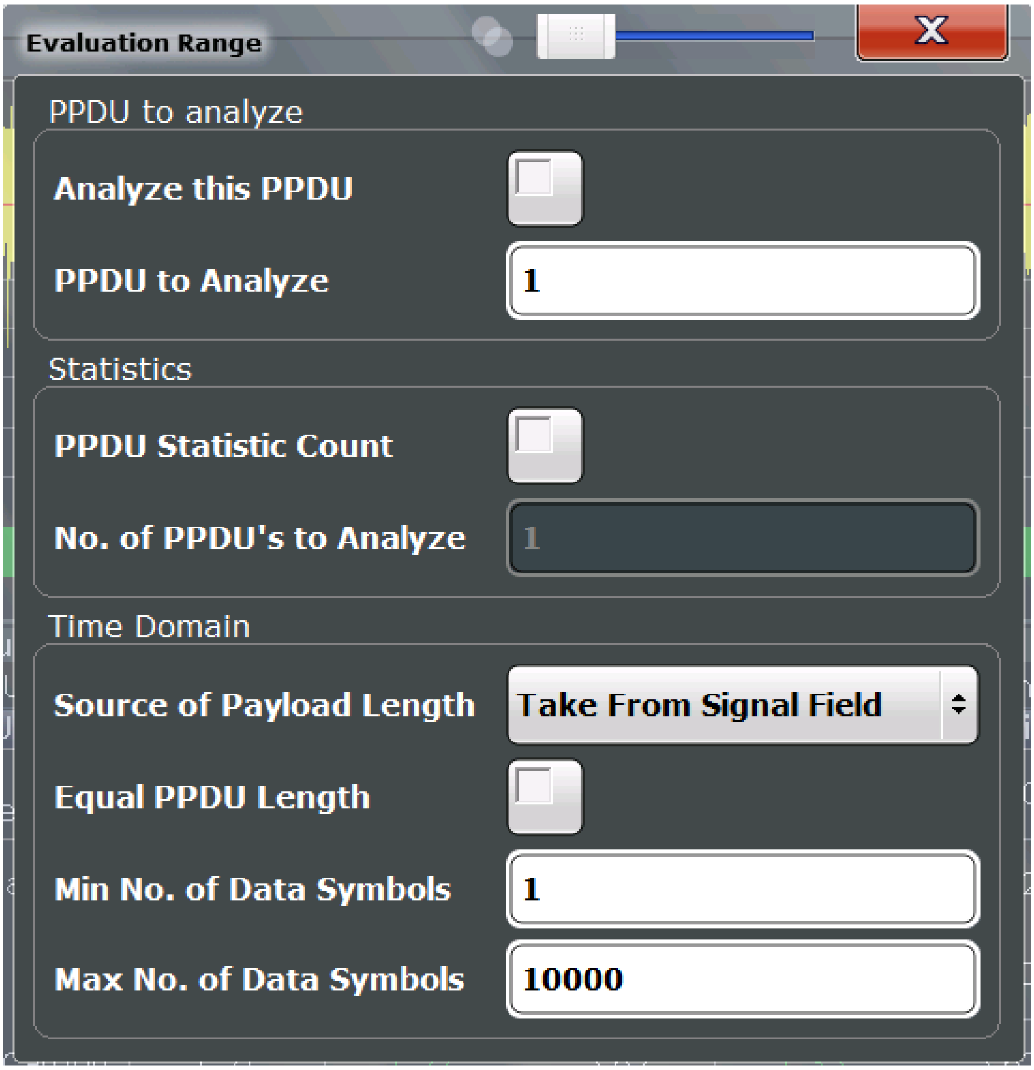


Figure 5-6: Evaluation range settings for IEEE 802.11a, ac, g (OFDM), j, n, p standards

Analyze this PPDU / PPDU to Analyze

If enabled, the WLAN I/Q results are based on one individual PPDU only, namely the defined "PPDU to Analyze". 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 36).

Note: AM/AM, AM/EVM and AM/PM results are not updated when single PPDU analysis is selected.
In MSRA mode, single PPDU analysis is not available.

Remote command:
[SENSe:]BURSt:SELect:STATe on page 280
[SENSe:]BURSt:SELect on page 280

PPDU Statistic Count / No of PPDUs to Analyze
If the statistic count is enabled, the specified number of PPDUs is taken into consideration for the statistical evaluation. Sweeps are performed continuously until the required number of PPDUs are available. The number of captured and required PPDUs, as well as the number of PPDUs detected in the current sweep, are indicated as "Analyzed PPDUs" in the channel bar.

(See "Channel bar information" on page 11).

If disabled, all valid PPDUs in the current capture buffer are considered. Note that in this case, the number of PPDUs contributing to the current results may vary extremely.

Remote command:
[SENSe:]BURSt:COUNt:STATe on page 280
[SENSe:]BURSt:COUNt on page 279

Source of Payload Length
Defines which signal source is used to determine the payload length of a PPDU.

"Take from Signal Field" (IEEE 802.11 A, J, P)
Uses the length defined by the signal field

"L-Signal" (IEEE 802.11 AC)
Determines the length of the L signal

"HT-Signal" (IEEE 802.11 N)
Determines the length of the HT signal

"Estimate from signal"
Uses an estimated length

Remote command:
CONFigure:WLAN:PAYLoad:LENGth:SRC on page 278

Equal PPDU Length
If enabled, only PPDUs with the specified (Min./Max.) Payload Length are considered for measurement analysis.

If disabled, a maximum and minimum (Min./Max.) Payload Length can be defined and all PPDUs whose length is within this range are considered.

Remote command:
IEEE 802.11a, ac, g (OFDM), j, n, p
[SENSe:]DEMod:FORMat:BANalyze:SYMBols:EQUal on page 283
IEEE 802.11 b, g (DSSS):
[SENSe:]DEMod:FORMat:BANalyze:DURation:EQUal on page 282
[SENSe:]DEMod:FORMat:BANalyze:DBYTes:EQUal on page 281

(Min./Max.) No. of Data Symbols
If the Equal PPDU Length setting is enabled, the number of data symbols defines the exact length a PPDU must have to be considered for analysis.

If the Equal PPDU Length setting is disabled, you can define the minimum and maximum number of data symbols a PPDU must contain to be considered in measurement analysis.

Remote command:
`[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MIN` on page 284
`[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MAX` on page 283

5.3.9.2 Evaluation Range Settings for IEEE 802.11b, g (DSSS)

Access: "Overview" > "Evaluation Range"

Or: MEAS CONFIG > "Evaluation Range"

The following settings are available to configure the evaluation range for standards IEEE 802.11b, g (DSSS).

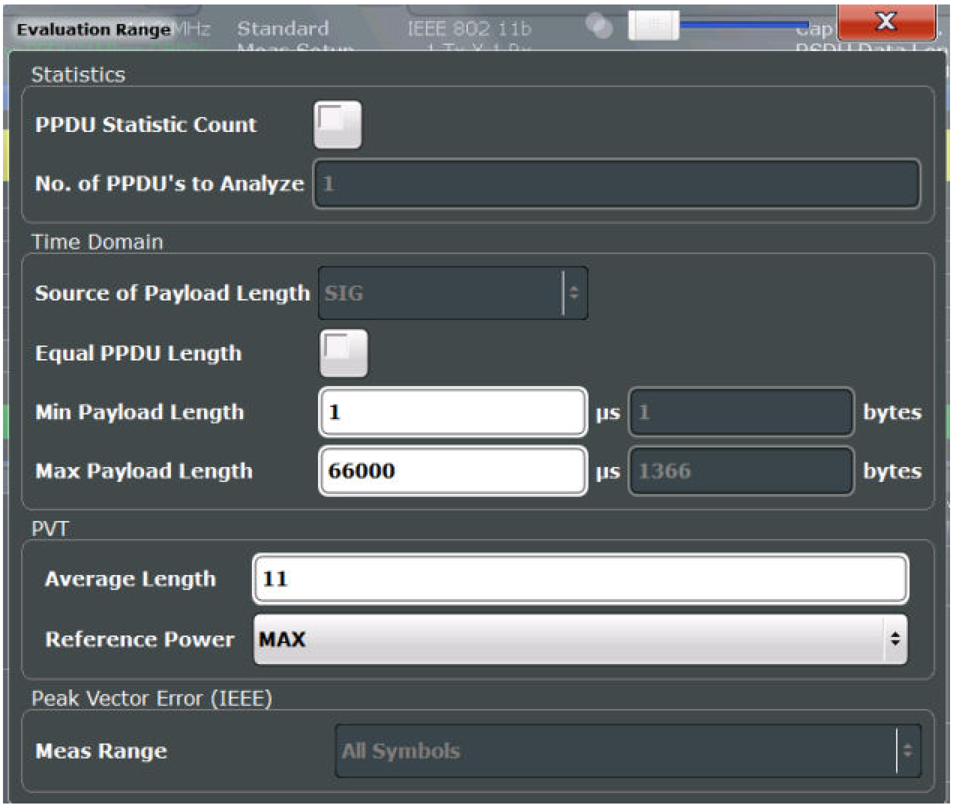


Figure 5-7: Evaluation range settings for IEEE 802.11b and g (DSSS) standards

PPDU Statistic Count / No of PPDUs to Analyze
If the statistic count is enabled, the specified number of PPDUs is taken into consideration for the statistical evaluation. Sweeps are performed continuously until the required number of PPDUs are available. The number of captured and required PPDUs, as well as the number of PPDUs detected in the current sweep, are indicated as "Analyzed PPDUs" in the channel bar.

(See "Channel bar information" on page 11).

If disabled, all valid PPDUs in the current capture buffer are considered. Note that in this case, the number of PPDUs contributing to the current results may vary extremely.

Remote command:
`[SENSe:]BURSt:COUNt:STATe` on page 280
`[SENSe:]BURSt:COUNt` on page 279

Equal PPDU Length
If enabled, only PPDUs with the specified (Min./Max.) Payload Length are considered for measurement analysis.

If disabled, a maximum and minimum (Min./Max.) Payload Length can be defined and all PPDUs whose length is within this range are considered.

Remote command:
IEEE 802.11a, ac, g (OFDM), j, n, p
`[SENSe:]DEMod:FORMat:BANalyze:SYMBols:EQUal` on page 283
IEEE 802.11 b, g (DSSS):
`[SENSe:]DEMod:FORMat:BANalyze:DURation:EQUal` on page 282
`[SENSe:]DEMod:FORMat:BANalyze:DBYTes:EQUal` on page 281

(Min./Max.) Payload Length
If the Equal PPDU Length setting is enabled, the payload length defines the exact length a PPDU must have to be considered for analysis.

If the Equal PPDU Length setting is disabled, you can define the minimum and maximum payload length a PPDU must contain to be considered in measurement analysis.

The payload length can be defined as a duration in µs or a number of bytes (only if specific PPDU modulation and format are defined for analysis, see "PPDU Format to measure" on page 144).

Remote command:
`[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MIN` on page 281
`[SENSe:]DEMod:FORMat:BANalyze:DURation:MIN` on page 282
`[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MAX` on page 281
`[SENSe:]DEMod:FORMat:BANalyze:DURation:MAX` on page 282

PVT : Average Length
Defines the number of samples used to adjust the length of the smoothing filter for PVT measurement.

For details see "PvT Full PPDU" on page 39.

Remote command:
`CONFigure:BURSt:PVT:AVERage` on page 278

PVT : Reference Power

Sets the reference for the rise and fall time in PVT calculation to the maximum or mean PPDU power.

For details see "PvT Full PPDU" on page 39.

Remote command:
`CONFigure:BURSt:PVT:RPOWer` on page 278

Peak Vector Error : Meas Range

Displays the used measurement range for peak vector error measurement (for reference only).

"All Symbols" Peak Vector Error results are calculated over the complete PPDU

"PSDU only" Peak Vector Error results are calculated over the PSDU only

Remote command:
`CONFigure:WLAN:PVERror:MRANge?` on page 279

5.3.10 Result Configuration

Access: MEAS CONFIG > "Result Config"

For some result displays, additional settings are available.

(The softkey is only available if a window with additional settings is currently selected.)

Depending on the selected result display, different settings are available.

5.3.10.1 Result Summary Configuration

Access: MEAS CONFIG > "Result Config"

You can configure which results are displayed in Result Summary displays (see "Result Summary Detailed" on page 42 and "Result Summary Global" on page 44). However, the results are always *calculated*, regardless of their visibility on the screen.

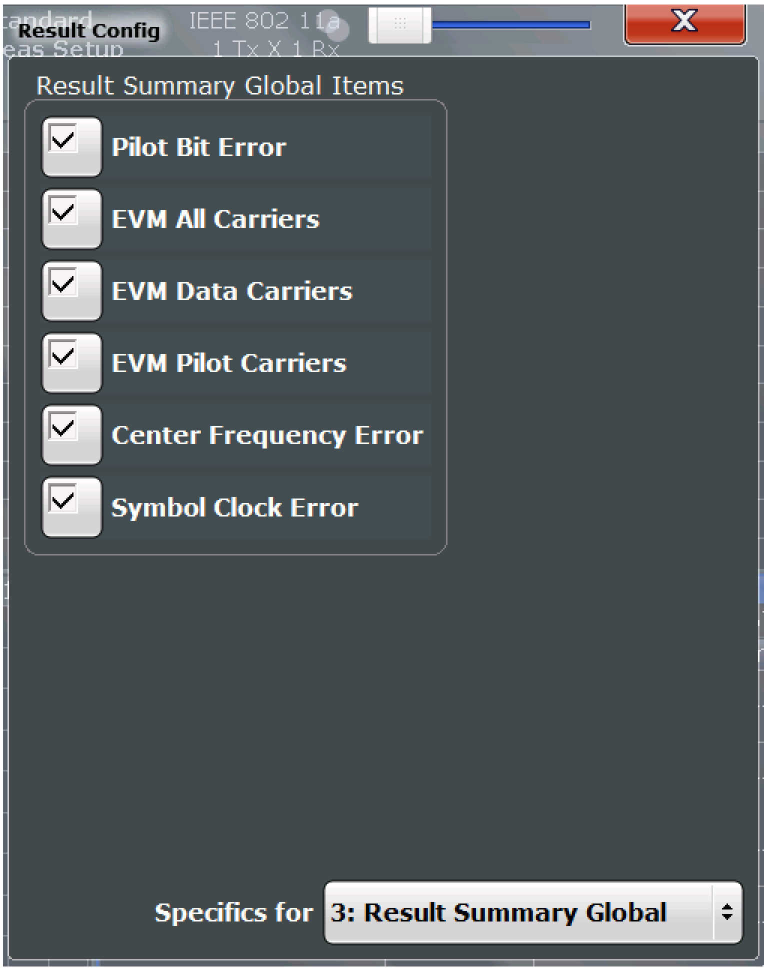


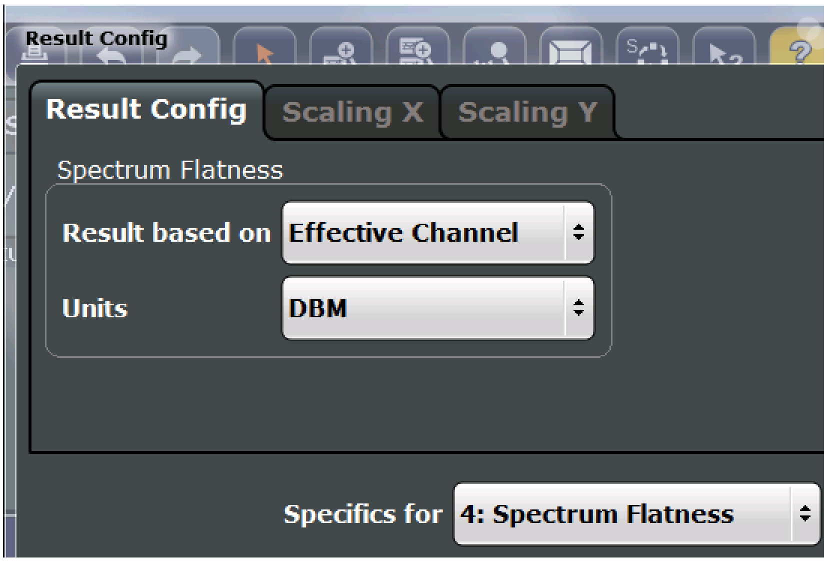
Figure 5-8: Result Summary Global configuration for IEEE 802.11a, ac, g (OFDM), j, n, p standards

Remote command:

DISPlay[:WINDow<n>]:TABLe:ITEM on page 301

5.3.10.2 Spectrum Flatness and Group Delay Configuration

Access: MEAS CONFIG > "Result Config"



Result based on

For MIMO measurements, Spectrum Flatness and Group Delay results can be based on either the effective channels or the physical channels.

While the physical channels cannot always be determined, the effective channel can always be estimated from the known training fields. Thus, for some PPDUs or measurement scenarios, only the results based on the mapping of the space-time stream to the Rx antenna (effective channel) are available, as the mapping of the Rx antennas to the Tx antennas (physical channel) could not be determined.

For more information see Chapter 4.3.3, "Physical vs Effective Channels", on page 73.

Remote command:

`CONFigure:BURSt:SPECtrum:FLATness:CSELect` on page 302

Units

Switches between relative (dB) and absolute (dBm) results.

Remote command:

`UNIT:SFLatness` on page 302

5.3.10.3 AM/AM Configuration

Access: MEAS CONFIG > "Result Config"

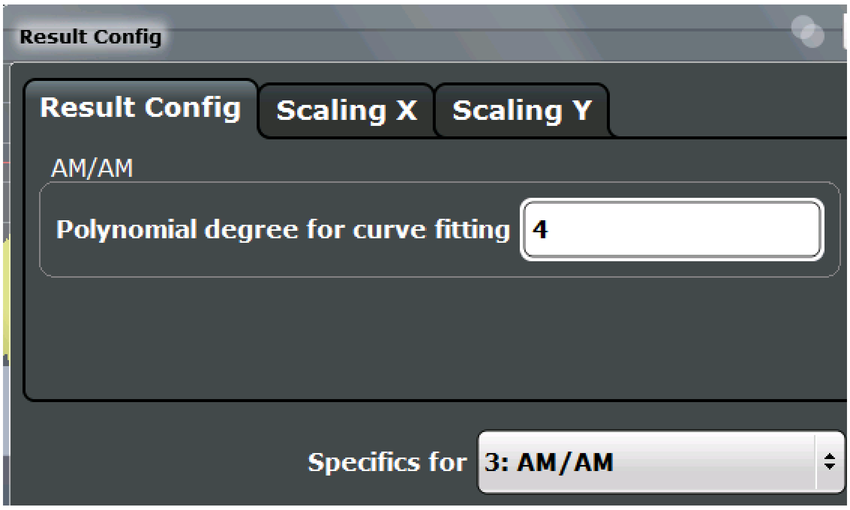
For AM result displays some additional configuration settings are available.

General AM/AM Settings

Access: MEAS CONFIG > "Result Config" > "Result Config" tab

Polynomial degree for curve fitting

For AM/AM result displays, the trace is determined by calculating a polynomial regression model for the scattered measurement vs. reference signal data (see "AM/AM" on page 23). The degree of this model can be specified in the "Result Config" dialog box for this result display.



The resulting regression polynomial is indicated in the window title of the result display.

Remote command:

`CONFigure:BURSt:AM:AM:POLYnomial` on page 303

Resulting coefficients:

`FETCh:BURSt:AM:AM:COEFficients?` on page 319

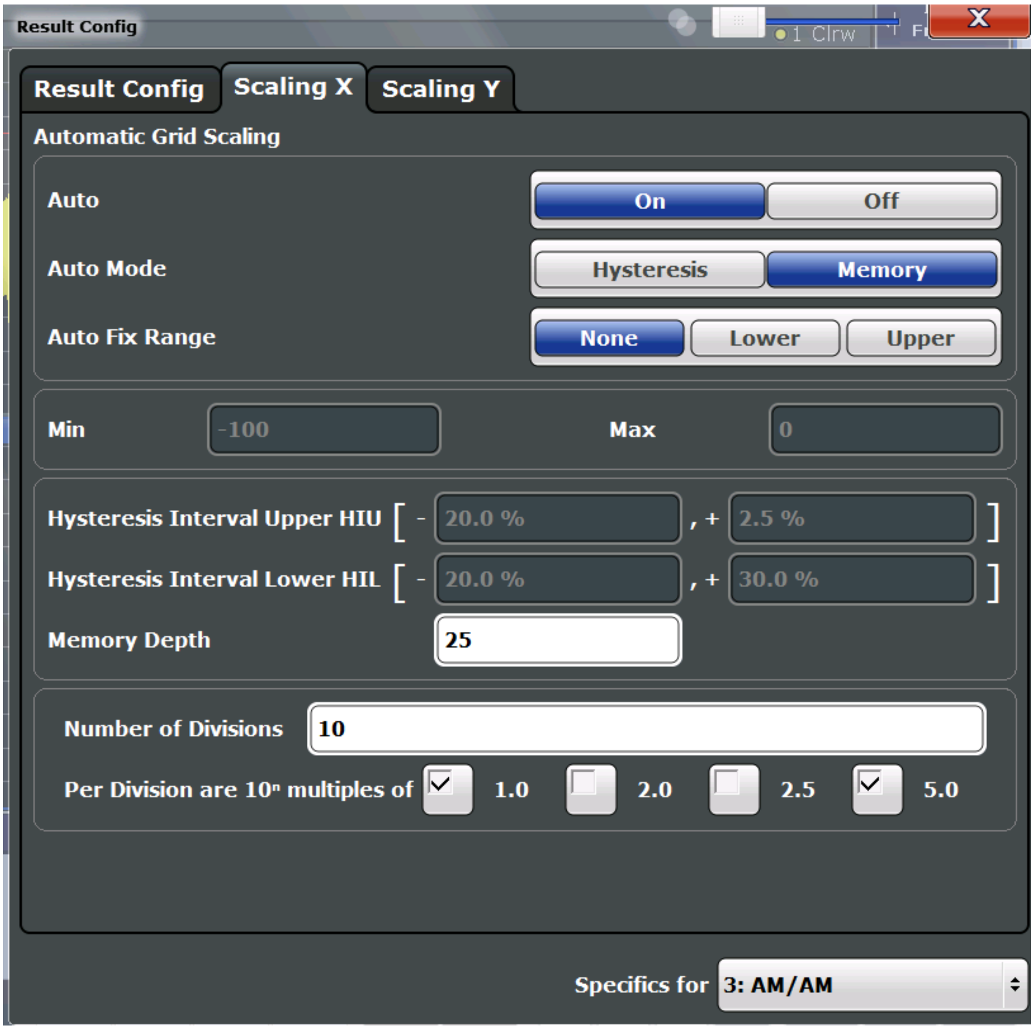
Scaling AM Result Displays

Access: MEAS CONFIG > "Result Config" > "Scaling X"/"Scaling Y" tab

Scaling settings are available for the x-axis or y-axis of the following result displays:

- AM/AM
- AM/PM
- AM/EVM

The available scaling settings and functions are identical for both axes, but can be configured separately.



Automatic Grid Scaling

Activates or deactivates automatic scaling of the x-axis or y-axis for the specified trace display. If enabled, the R&S FSW WLAN application automatically scales the x-axis or y-axis to best fit the measurement results.

If disabled, the x-axis or y-axis is scaled according to the specified Minimum / Maximum and Number of Divisions.

Remote command:
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO` on page 303

Auto Mode

Determines which algorithm is used to determine whether the x-axis or y-axis requires automatic rescaling.

"Hysteresis" If the minimum and/or maximum values of the current measurement exceed a specific value range (hysteresis interval), the axis is rescaled. The hysteresis interval is defined as a percentage of the currently displayed value range on the x-axis or y-axis. An upper hysteresis interval is defined for the maximum value, a lower hysteresis interval is defined for the minimum value.
(See Hysteresis Interval Upper/Lower)

"Memory" If the minimum or maximum values of the current measurement exceed the minimum or maximum of the <x> previous results, respectively, the axis is rescaled.
The minimum and maximum value of each measurement is added to the memory. After <x> measurements, the oldest results in the memory are overwritten by each new measurement.
The number <x> of results in the memory to be considered is configurable (see Memory Depth).

Remote command:
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:MODE` on page 306

Auto Fix Range

This command defines the use of fixed value limits.

"None" Both the upper and lower limits are determined by automatic scaling of the x-axis or y-axis.

"Lower" The lower limit is fixed (defined by the Minimum / Maximum settings), while the upper limit is determined by automatic scaling of the x-axis or y-axis.

"Upper" The upper limit is fixed (defined by the Minimum / Maximum settings), while the lower limit is determined by automatic scaling of the x-axis or y-axis.

Remote command:
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:FIXed:RANGe`
on page 304

Hysteresis Interval Upper/Lower

For automatic scaling based on hysteresis, the hysteresis intervals are defined here. Depending on whether either of the limits are fixed or not (see Auto Fix Range), one or both limits are defined by a hysteresis value range.

The hysteresis range is defined as a percentage of the currently displayed value range on the x-axis or y-axis.

Example:

The currently displayed value range on the y-axis is 0 to 100. The upper limit is fixed by a maximum of 100. The lower hysteresis range is defined as -10% to +10%. If the minimum value in the current measurement drops below -10 or exceeds +10, the y-axis will be rescaled automatically, for example to [-10..+100] or [+10..+100], respectively.

"Upper"(HIU) If the maximum value in the current measurement exceeds the specified range, the x-axis or y-axis is rescaled automatically.

"Lower"(HIL) If the minimum value in the current measurement exceeds the specified range, the x-axis or y-axis is rescaled automatically.

Remote command:
`DISPlay[:WINDow<N>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:LOWer:UPPer` on page 304
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:LOWer:LOWer` on page 305
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:UPPer:LOWer` on page 305
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:UPPer:UPPer` on page 306

Minimum / Maximum

Defines the minimum and maximum value to be displayed on the x-axis or y-axis of the specified evaluation diagram.

For automatic scaling with a fixed range (see Auto Fix Range), the minimum defines the fixed lower limit, the maximum defines the fixed upper limit.

Remote command:
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MAXimum` on page 308
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MINimum` on page 308

Memory Depth

For automatic scaling based on memory (see "Auto Mode" on page 168), this value defines the number <x> of previous results to be considered when determining if rescaling is required.

The minimum and maximum value of each measurement are added to the memory. After <x> measurements, the oldest results in the memory are overwritten by each new measurement.

If the maximum value in the current measurement exceeds the maximum of the <x>previous results, and the upper limit is not fixed, the x-axis or y-axis is rescaled.

If the minimum value in the current measurement drops below the minimum of the <x>previous results, and the lower limit is not fixed, the x-axis or y-axis is rescaled.

Remote command:
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:MEMory:DEPTh`
on page 306

Number of Divisions
Defines the number of divisions to be used for the x-axis or y-axis. By default, the x-axis or y-axis is divided into 10 divisions.

Remote command:
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:DIVisions` on page 307

Scaling per division
Determines the values shown for each division on the x-axis or y-axis.

One or more multiples of 10^n can be selected. The R&S FSW WLAN application then selects the optimal scaling from the selected values.

Example:

- Multiples of "2.0" and **"2.5"** selected; division range = [-80..-130]; number of divisions: 10;
  Possible scaling (n=1):
  [-80;-85;-90;-95;-100;-105;-110;-115;-130;]
- Multiples of **"2.0"** selected; division range = [-80..-130]; number of divisions: 10;
  Possible scaling (n=1):
  [0;-20;-40;-60;-80;-100;-120;-140;-160;-180;]

"1.0"	Each division on the x-axis or y-axis displays multiples of $1*10^n$: For example for n= -1; division range = [0..1]; number of divisions: 10; [0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0]
"2.0"	Each division on the x-axis or y-axis displays multiples of $2*10^n$: For example for n= -1;division range = [0..1]; number of divisions: 5; [0, 0.2, 0.4, 0.6, 0.8, 1.0]
"2.5"	Each division on the x-axis or y-axis displays multiples of $2.5*10^n$: For example for n= -1; division range = [0..1]; number of divisions: 5; [0, 0.25, 0.5, 0.75, 1.0]
"5.0"	Each division on the x-axis or y-axis displays multiples of $5*10^n$: For example for n= -1; division range = [0..1]; number of divisions: 5, [-0.5, 0, 0.5, 1.0, 1.5]

Remote command:
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:PDIVision` on page 308

5.3.11 Automatic Settings

Access: AUTO SET menu

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

MSRA operating mode

In MSRA operating mode, the following automatic settings are not available, as they require a new data acquisition. However, the R&S FSW WLAN application cannot perform data acquisition in MSRA operating mode.

Setting the Reference Level Automatically (Auto Level)

Automatically determines a reference level which ensures that no overload occurs at the R&S FSW for the current input data. At the same time, the internal attenuators and the preamplifier (for analog baseband input: the full scale level) are adjusted so the signal-to-noise ratio is optimized, while signal compression and clipping are minimized.

To determine the required reference level, a level measurement is performed on the R&S 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 287

5.3.12 Sweep Settings

Access: SWEEP menu

The sweep settings define how the data is measured.

Continuous Sweep/RUN CONT

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

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

Remote command:
`INITiate<n>:CONTinuous` on page 310

Single Sweep/ RUN SINGLE

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

Note: Sequencer. If the Sequencer is active, the "Single Sweep" softkey 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, the RUN SINGLE key 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 measurement channel is updated.

Remote command:
`INITiate<n>[:IMMediate]` on page 311

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

Refresh (MSRA only)
This function is only available if the Sequencer is deactivated and only for **MSRA slave applications**.

The data in the capture buffer is re-evaluated by the currently active slave application only. The results for any other slave applications remain unchanged.

This is useful, for example, after evaluation changes have been made or if a new sweep was performed from another slave application; in this case, only that slave application is updated automatically after data acquisition.

Note: To update all active slave applications at once, use the "Refresh all" function in the "Sequencer" menu.

Remote command:
`INITiate<n>:REFResh` on page 289

5.4 Frequency Sweep Measurements

When you activate a measurement channel in WLAN mode, an IQ measurement of the input signal is started automatically (see Chapter 3.1, "WLAN I/Q Measurement (Modulation Accuracy, Flatness and Tolerance)", on page 13). However, some parameters specified in the WLAN 802.11 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, "Frequency Sweep Measurements", on page 50). In these measurements, demodulation is not performed.

Selecting the measurement type

WLAN measurements require a special operating mode on the R&S FSW, which you activate using the MODE key.

► To select a frequency sweep measurement type, do one of the following:

- Select the "Overview" softkey. In the "Overview", select the "Select Measurement" button. Select the required measurement.
- Press the MEAS key. In the "Select Measurement" dialog box, select the required measurement.

The R&S FSW WLAN application uses the functionality of the R&S FSW base system (Spectrum application) to perform the WLAN frequency sweep measurements. Some parameters are set automatically according to the WLAN 802.11 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 WLAN frequency sweep measurements are identical to the Spectrum application.

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

The measurement-specific settings for the following measurements are available via the "Overview".

5.4.1 Channel Power (ACLR) Measurements

The Adjacent Channel Power measurement analyzes the power of the TX channel and the power of adjacent and alternate channels on the left and right side of the TX channel. The number of TX channels and adjacent channels can be modified as well as the band class. The bandwidth and power of the TX channel and the bandwidth, spacing and power of the adjacent and alternate channels are displayed in the Result Summary.

Channel Power ACLR measurements are performed as in the Spectrum application with the following predefined settings according to WLAN specifications (adjacent channel leakage ratio).

Table 5-3: Predefined settings for WLAN ACLR Channel Power measurements

Setting	Default value
ACLR Standard	same as defined in WLAN signal description (see "Standard" on page 95)
Number of adjacent channels	3
Reference channel	Max power Tx channel
Channel bandwidth	20 MHz

For further details about the ACLR measurements refer to "Measuring Channel Power and Adjacent-Channel Power" in the R&S 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
- RBW, VBW
- Sweep time
- Span
- Number of adjacent channels
- Fast ACLR mode

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

5.4.2 Spectrum Emission Mask

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 WLAN 802.11 specifications. The limits depend on the selected power class. Thus, the performance of the DUT can be tested and the emissions and their distance to the limit are identified.

Note that the WLAN 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 WLAN application performs the SEM measurement as in the Spectrum application with the following settings:

Table 5-4: Predefined settings for WLAN SEM measurements

Setting	Default value
Number of ranges	3
Frequency Span	+/- 12.75 MHz
Fast SEM	OFF
Sweep time	140 µs
RBW	30 kHz
Power reference type	Channel Power
Tx Bandwidth	3.84 MHz
Number of power classes	1

You must select the SEM file with the pre-defined settings required by the standard manually (using the "Standard Files" softkey in the main "SEMask" menu). The subdirectory displayed in the SEM standard file selection dialog box depends on the standard you selected previously for the WLAN Modulation Accuracy, Flatness,... measurement (see "Standard" on page 95).

For further details about the Spectrum Emission Mask measurements refer to "Spectrum Emission Mask Measurement" in the R&S 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 frequency sweep measurements are identical to the Spectrum application.

5.4.3 Occupied Bandwidth

Access: "Overview" > "Select Measurement" > "OBW"

or: MEAS > "Select Measurement" > "OBW"

The Occupied Bandwidth measurement is performed as in the Spectrum application with default settings.

Table 5-5: Predefined settings for WLAN 802.11 OBW measurements

Setting	Default value
% Power Bandwidth	99 %
Channel bandwidth	3.84 MHz

The Occupied Bandwidth measurement determines the bandwidth that the signal occupies. The occupied bandwidth is defined as the bandwidth in which – in default settings - 99 % of the total signal power is to be found. The percentage of the signal power to be included in the bandwidth measurement can be changed.

For further details about the Occupied Bandwidth measurements refer to "Measuring the Occupied Bandwidth" in the R&S 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
- RBW, VBW
- Sweep time
- Span

5.4.4 CCDF

Access: "Overview" > "Select Measurement" > "CCDF"

or: MEAS > "Select Measurement" > "CCDF"

The CCDF measurement determines the distribution of the signal amplitudes (complementary cumulative distribution function). The CCDF and the Crest factor are displayed. For the purposes of this measurement, a signal section of user-definable length is recorded continuously in zero span, and the distribution of the signal amplitudes is evaluated.

The measurement is useful to determine errors of linear amplifiers. The crest factor is defined as the ratio of the peak power and the mean power. The Result Summary displays the number of included samples, the mean and peak power and the crest factor.

The CCDF measurement is performed as in the Spectrum application with the following settings:

Table 5-6: Predefined settings for WLAN 802.11 CCDF measurements

Setting	Default value
CCDF	Active on trace 1
Analysis bandwidth	10 MHz
Number of samples	62500
Detector	Sample

For further details about the CCDF measurements refer to "Statistical Measurements" in the R&S 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
- Analysis bandwidth
- Number of samples

6 Analysis

General result analysis settings concerning the trace and markers etc. are currently not available for the standard WLAN measurements. Only one (Clear/Write) trace and one marker are available for these measurements.

Analysis of frequency sweep 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 WLAN application.

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

The remote commands required to perform these tasks are described in Chapter 10.10, "Analysis", on page 350.

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 in phase (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 R&S FSW later
- Capturing and saving I/Q signals with an RF or baseband signal analyzer to analyze them with the R&S FSW or an external software tool later

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 WLAN application.

As opposed to storing trace data, which may be averaged or restricted to peak values, I/Q data is stored as it was captured, without further processing. The data is stored as complex values in 32-bit floating-point format. Multi-channel data is not supported. The I/Q data is stored in a format with the file extension `.iq.tar`.

For a detailed description see the R&S FSW I/Q Analyzer and I/Q Input User Manual.

Export only in MSRA mode

In MSRA mode, I/Q data can only be exported to other applications; I/Q data cannot be imported to the MSRA Master or any MSRA applications.

7.1 Import/Export Functions

Access: "Save"/ "Open" icon in the toolbar > "Import" / "Export"

These functions are only available if no measurement is running.

In particular, if Continuous Sweep/RUN CONT is active, the import/export functions are not available.

For a description of the other functions in the "Save/Recall" menu, see the R&S FSW User Manual.

Import
Access: "Save/Recall" > Import

Provides functions to import data.

I/Q Import ← Import
Opens a file selection dialog box to select an import file that contains I/Q data. This function is only available in single sweep mode and only in applications that process I/Q data, such as the I/Q Analyzer or optional applications.

Note that the I/Q data must have a specific format as described in the R&S FSW I/Q Analyzer and I/Q Input User Manual.

Remote command:
`MMEMory:LOAD:IQ:STATe` on page 349

Export
Access: "Save/Recall" > Export

Opens a submenu to configure data export.

I/Q Export ← Export
Opens a file selection dialog box to define an export file name to which the I/Q data is stored. This function is only available in single sweep mode.

Note: Storing large amounts of I/Q data (several Gigabytes) can exceed the available (internal) storage space on the R&S FSW. In this case, it can be necessary to use an external storage medium.

Note: Secure user mode.
In secure user mode, settings that are stored on the instrument are stored to volatile memory, which is restricted to 256 MB. Thus, a "Memory full" error can occur although the hard disk indicates that storage space is still available.

To store data permanently, select an external storage location such as a USB memory device.

For details, see "Protecting Data Using the Secure User Mode" in the "Data Management" section of the R&S FSW User Manual.

Remote command:
`MMEMory:STORe<n>:IQ:STATe` on page 350

7.2 How to Export and Import I/Q Data

I/Q data can only be exported in applications that process I/Q data, such as the I/Q Analyzer or optional applications.

Capturing and exporting I/Q data

1. Press the PRESET key.
2. Press the MODE key and select the R&S FSW WLAN application or any other application that supports I/Q data.
3. Configure the data acquisition.
4. Press the RUN SINGLE key to perform a single sweep measurement.
5. Select the "Save" icon in the toolbar.
6. Select the "I/Q Export" softkey.
7. In the file selection dialog box, select a storage location and enter a file name.
8. Select "Save".

   The captured data is stored to a file with the extension `.iq.tar`.

Importing I/Q data

1. Press the MODE key and select the "I/Q Analyzer" or any other application that supports I/Q data.
2. If necessary, switch to single sweep mode by pressing the RUN SINGLE key.
3. Select the "Open" icon in the toolbar.
4. Select the "I/Q Import" softkey.
5. Select the storage location and the file name with the `.iq.tar` file extension.
6. Select "Open".

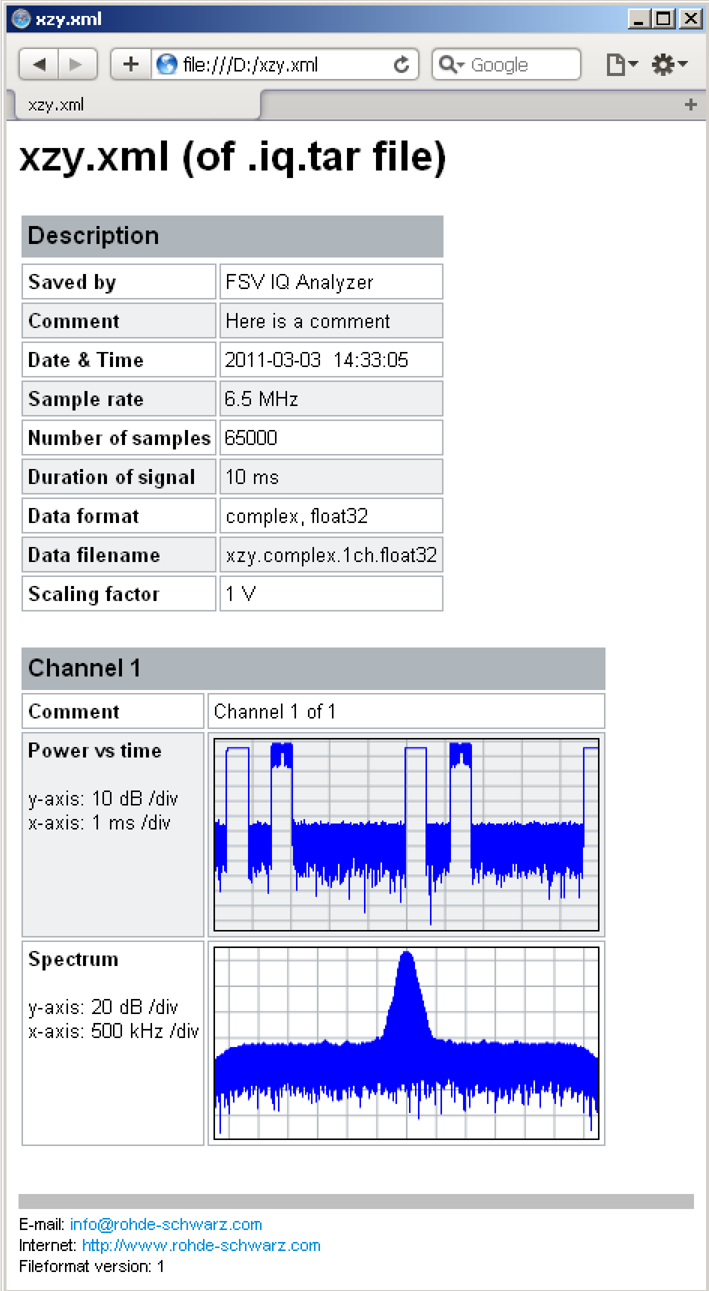
   The stored data is loaded from the file and displayed in the current application.

Previewing the I/Q data in a web browser

The `iq-tar` file format allows you to preview the I/Q data in a web browser.

1. Use an archive tool (e.g. WinZip® or PowerArchiver®) to unpack the `iq-tar` file into a folder.
2. Locate the folder using Windows Explorer.
3. Open your web browser.

4. Drag the I/Q parameter XML file, e.g. `example.xml`, into your web browser.



xzy.xml

file:///D:/xzy.xml

xzy.xml (of .iq.tar file)

Description	
Saved by	FSV IQ Analyzer
Comment	Here is a comment
Date & Time	2011-03-03 14:33:05
Sample rate	6.5 MHz
Number of samples	65000
Duration of signal	10 ms
Data format	complex, float32
Data filename	xzy.complex.1ch.float32
Scaling factor	1 V

Channel 1	
Comment	Channel 1 of 1
Power vs time y-axis: 10 dB /div x-axis: 1 ms /div	
Spectrum y-axis: 20 dB /div x-axis: 500 kHz /div	

E-mail: info@rohde-schwarz.com
Internet: http://www.rohde-schwarz.com
Fileformat version: 1

8 How to Perform Measurements in the WLAN Application

The following step-by-step instructions demonstrate how to perform measurements in the R&S FSW WLAN application. The following tasks are described:

8.1 How to Determine Modulation Accuracy, Flatness and Tolerance Parameters for WLAN Signals

1. Press the MODE key.

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

2. Select the "WLAN" item.

   The R&S FSW opens a new measurement channel for the WLAN application.

3. Select the "Overview" softkey to display the "Overview" for a WLAN measurement.
4. Select the "Signal Description" button to define the digital standard to be used.
5. Select the "Input/Frontend" button and then the "Frequency" tab to define the input signal's center frequency.
6. Select the "Signal Capture" button to define how much and which data to capture from the input signal.
7. To define a particular starting point for the FFT or to improve the measurement speed for signals with a low duty cycle, select the "Synchronization/OFDM-Demod." button and set the required parameters.
8. Select the "Tracking/Channel Estimation" button to define how the data channels are to be estimated and which distortions will be compensated for.
9. Select the "Demod" button to provide information on the modulated signal and how the PPDUs detected in the capture buffer are to be demodulated.
10. Select the "Evaluation Range" button to define which data in the capture buffer you want to analyze.

11. Select the "Display Config" button and select the displays that are of interest to you (up to 16).
    Arrange them on the display to suit your preferences.
12. Exit the SmartGrid mode.
13. Start a new sweep with the defined settings.
    - To perform a single sweep measurement, press the RUN SINGLE hardkey.
    - To perform a continuous sweep measurement, press the RUN CONT hardkey.

    In MSRA mode you may want to stop the continuous measurement mode by the Sequencer and perform a single data acquisition:

    a) Select the Sequencer icon ( ) from the toolbar.
    b) Set the Sequencer state to "OFF".
    c) Press the RUN SINGLE key.

    Measurement results are updated once the measurement has completed.

To select the application data for MSRA measurements

In multi-standard radio analysis you can analyze the data captured by the MSRA Master in the R&S FSW WLAN application. Assuming you have detected a suspect area of the captured data in another application, you would now like to analyze the same data in the R&S FSW WLAN application.

1. Select the "Overview" softkey to display the "Overview" for WLAN I/Q measurements.
2. Select the "Signal Capture" button.
3. Define the application data range as the "Capture Time".
4. Define the starting point of the application data as the "Capture offset". The offset is calculated according to the following formula:
   <capture offset> = <starting point for application> - <starting point in capture buffer>
5. The analysis interval is automatically determined according to the selected channel, carrier or PPDU to analyze (defined for the evaluation range), depending on the result display. Note that the channel/carrier/PPDU is analyzed *within the application data*. If the analysis interval does not yet show the required area of the capture buffer, move through the channels/carriers/PPDUs in the evaluation range or correct the application data range.
6. If the Sequencer is off, select the "Refresh" softkey in the "Sweep" menu to update the result displays for the changed application data.

8.2 How to Analyze WLAN Signals in a MIMO Measurement Setup

MIMO measurements are only available for IEEE 802.11ac, n standards. They can be performed automatically or manually (see Chapter 4.3.4, "Capturing Data from MIMO Antennas", on page 74).

To perform a manual sequential measurement

1. Press the MODE key.
2. Select the "WLAN" item.

   The R&S FSW opens a new measurement channel for the WLAN application.
3. Select the "Overview" softkey to display the "Overview" for a WLAN measurement.
4. Select the "Signal Description" button to select the digital standard *IEEE 802.11ac* or *IEEE 802.11n*.
5. Select the "Input/Frontend" button and then the "Frequency" tab to define the input signal's center frequency.
6. Select the "Signal Capture" button to define how much and which data to capture from the input signal.
7. Select the "MIMO Capture" tab to define how the data from the MIMO antennas is to be captured.
   a) For the "DUT MIMO Config." select the number of TX antennas data will be transmitted from.
   b) Under "MIMO antenna Signal Capture Setup" select "Sequential Manual".
8. To define a particular starting point for the FFT or to improve the measurement speed for signals with a low duty cycle, select the "Synchronization/OFDM-Demod." button and set the required parameters.
9. Select the "Tracking/Channel Estimation" button to define how the data channels are to be estimated and which distortions will be compensated for, e.g. crosstalk between the MIMO antennas at the DUT.
10. Select the "Demod" button and then the "Demod" tab to provide information on the modulated signal and how the PPDUs detected in the capture buffer are to be demodulated.
11. In the "Demodulation" dialog box, select the "MIMO" tab to define which spatial mapping mode is used, that is, how the space-time streams are mapped to the antennas.
    a) If necessary, include a time shift for the individual antennas.

b) If the signal power is amplified according to the maxtrix entries so that the total transmitted power is not increased, the measured powers can be normalised to consider this effect in demodulation.

12. Select the "Evaluation Range" button to define which data in the capture buffer you want to analyze.
13. Select the "Display Config" button and select the displays that are of interest to you (up to 16).
    Arrange them on the display to suit your preferences.
14. Exit the SmartGrid mode.
15. Return to the "Signal Capture" > "MIMO Capture" dialog box tab to perform the measurement.
    a) Connect the input for the first Tx antenna to the RF input of the R&S FSW.
    b) Select the "Single" or "Cont." button for the RX 1 capture buffer to perform a single or continuous measurement for that antenna. For a continuous measurement, select the "Cont." button again to stop the measurement.
    c) Connect the input for the second Tx antenna to the RF input of the R&S FSW.
    d) Select the "Single" / "Cont." button for the RX 2 capture buffer.
    e) If necessary, repeat these steps for the third and fourth antennas.
    f) Select "Calc Results" to determine the results for each individual data stream in the selected result displays.

    Note: Instead of selecting the "Single" / "Cont." button in the "Signal Capture" dialog box for each individual antenna capture, which requires keeping the dialog box open, you can press the RUN SINGLE or RUN CONT key to perform the measurements. The data is evaluated and the result displays are updated when the measurement is stopped.
    However, in this case the data is written to the same capture buffer for all antennas (namely the one selected for "<RUNS SINGLE> or <RUN CONT> updates" in the "MIMO Capture" tab). Thus, the assignment of the individual data streams to antennas is no longer visible in the result displays.

To perform an automated sequential measurement (with an OSP switch box)

This measurement setup requires an additional R&S OSP switch box. For details on setting up and using this instrument, see the corresponding documentation!

1. Press the MODE key.
2. Select the "WLAN" item.

   The R&S FSW opens a new measurement channel for the WLAN application.
3. Select the "Overview" softkey to display the "Overview" for a WLAN measurement.
4. Select the "Signal Description" button to select the digital standard *IEEE 802.11ac* or *IEEE 802.11n*.

5. Select the "Input/Frontend" button and then the "Frequency" tab to define the input signal's center frequency.
6. Select the "Signal Capture" button to define how much and which data to capture from the input signal.
7. Select the "MIMO Capture" tab to define how the data from the MIMO antennas is to be captured.
   a) For the "DUT MIMO Config." select the number of TX antennas data will be transmitted from.
   b) Under "MIMO antenna Signal Capture Setup" select "Sequential using OSP switch box".
   c) Enter the IP address of the connected OSP switch box.
   d) For the "OSP Switch Bank Configuration" select the module used to connect the OSP switch box to the R&S FSW.
   e) Connect the antennas and the R&S FSW to the OSP switch box as indicated in the dialog box.
   f) Configure the OSP switch box to switch between the antenna input as required.
8. To define a particular starting point for the FFT or to improve the measurement speed for signals with a low duty cycle, select the "Synchronization/OFDM-Demod." button and set the required parameters.
9. Select the "Tracking/Channel Estimation" button to define how the data channels are to be estimated and which distortions will be compensated for, e.g. crosstalk between the MIMO antennas at the DUT.
10. Select the "Demod" button to provide information on the modulated signal and how the PPDUs detected in the capture buffer are to be demodulated.
11. Select the "MIMO" tab in the "Demodulation" dialog box to define which spatial mapping mode is used, that is, how the space-time streams are mapped to the antennas.
    a) If necessary, include a time shift for the individual antennas.
    b) If the signal power is amplified according to the maxtrix entries so that the total transmitted power is not increased, the measured powers can be normalised to consider this effect in demodulation.
12. Select the "Evaluation Range" button to define which data in the capture buffer you want to analyze.
13. Select the "Display Config" button and select the displays that are of interest to you (up to 16).
    Arrange them on the display to suit your preferences.
14. Exit the SmartGrid mode.
15. Start the measurement via the OSP switch box. The data is captured from all antennas automatically. The data is evaluated and the result displays are updated for the individual data streams when the measurement is stopped.

To perform a simultaneous measurement (with multiple R&S FSWs and an R&S FS-Z11 Trigger Unit)

This measurement setup requires as many R&S FSWs as Tx antennas are used! They must all be connected via LAN. Select one R&S FSW as a master. It is assumed the R&S FS-Z11 Trigger Unit is set up according to the following illustration:

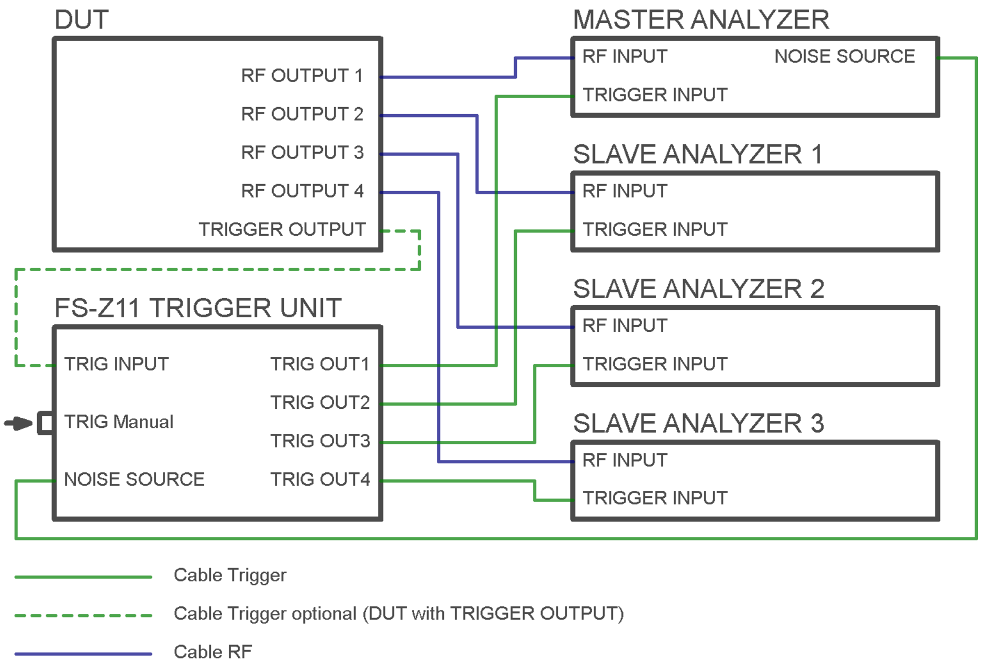


Figure 8-1: R&S FS-Z11 Trigger Unit connections

Perform the following configuration **on all R&S FSWs**, except for the MIMO capture settings (step 7). These settings are only required for the master analyzer.

1. Press the MODE key.
2. Select the "WLAN" item.

The R&S FSW opens a new measurement channel for the WLAN application.

3. Select the "Overview" softkey to display the "Overview" for a WLAN measurement.
4. Select the "Signal Description" button to select the digital standard *IEEE 802.11ac* or *IEEE 802.11n*.
5. Select the "Input/Frontend" button and then the "Frequency" tab to define the input signal's center frequency.
6. Select the "Signal Capture" button to define how much and which data to capture from the input signal.
7. **For the master analyzer only:**

Select the "MIMO Capture" tab to define how the data from the MIMO antennas is to be captured.

a) For the "DUT MIMO Config." select the number of TX antennas data will be transmitted from.
b) Under "MIMO antenna Signal Capture Setup" select "Simultaneous".
c) For each connected R&S FSW, enter the IP address and assign an antenna that this analyzer slave will capture data from.
d) Ensure that the "State" of each analyzer is "On" and the connection is established (the lights should be green in the dialog box).
e) Connect the assigned antenna to each R&S FSW.

8. To define a particular starting point for the FFT or to improve the measurement speed for signals with a low duty cycle, select the "Synchronization/OFDM-Demod." button and set the required parameters.
9. Select the "Tracking/Channel Estimation" button to define how the data channels are to be estimated and which distortions will be compensated for, e.g. crosstalk between the MIMO antennas at the DUT.
10. Select the "Demod" button to provide information on the modulated signal and how the PPDUs detected in the capture buffer are to be demodulated.
11. Select the "MIMO" tab in the "Demodulation" dialog box to define which spatial mapping mode is used, that is, how the space-time streams are mapped to the antennas.
    a) If necessary, include a time shift for the individual antennas.
    b) If the signal power is amplified according to the maxtrix entries so that the total transmitted power is not increased, the measured powers can be normalised to consider this effect in demodulation.
12. Select the "Evaluation Range" button to define which data in the capture buffer you want to analyze.
13. Select the "Display Config" button and select the displays that are of interest to you (up to 16).
    Arrange them on the display to suit your preferences.
14. Exit the SmartGrid mode.
15. **For the master analyzer only:**
    Activate the NOISE SOURCE output for the connection to the R&S FS-Z11 Trigger Unit.
    For an R&S FSW as a master analyzer:
    a) Press the INPUT/OUTPUT key.
    b) Select "Output Config".
    c) Select "Noise Source": "On".

16. Trigger a new sweep by pressing the TRIG MANUAL button on the Trigger Unit.

    The data is captured from all antennas automatically. The data is collected by the master R&S FSW, which evaluates the entire data and updates the result displays for the individual data streams when the measurement is stopped.

8.3 How to Determine the OBW, SEM, ACLR or CCDF for WLAN Signals

1. Press the MODE key and select the "WLAN" application.

   The R&S FSW opens a new measurement channel for the WLAN application. I/Q data acquisition is performed by default.

2. Select the "Signal Description" button to define the digital standard to be used.

3. Select the required measurement:

   a) Press the MEAS key.
   b) In the "Select Measurement" dialog box, select the required measurement.

   The selected measurement is activated with the default settings for WLAN immediately.

4. For SEM measurements, select the required standard settings file:

   a) In the SEMask menu, select the "Standard Files" softkey.
   b) Select the required settings file. The subdirectory displayed in the file selection dialog box depends on the standard you selected in step step 2.

5. If necessary, adapt the settings as described for the individual measurements in the R&S FSW User Manual.

6. Select the "Display Config" button and select the evaluation methods that are of interest to you.
   Arrange them on the display to suit your preferences.

7. Exit the SmartGrid mode and select the "Overview" softkey to display the "Overview" again.

8. Select the "Analysis" button 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.

9. 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 Optimizing and Troubleshooting the Measurement

9.1 Optimizing the Measurement Results

If the results do not meet your expectations, try the following methods to optimize the measurement.

9.1.1 Improving Performance

Performing a coarse burst search

For signals with **low duty cycle rates**, enable the "Power Interval Search" for synchronization (see "Power Interval Search" on page 139). In this case, the R&S FSW WLAN application initially performs a coarse burst search on the input signal in which increases in the power vs time trace are detected. Further time-consuming processing is then only performed where bursts are assumed. This improves the measurement speed.

However, for signals in which the PPDU power levels differ significantly, this option should be disabled as otherwise some PPDUs may not be detected.

9.1.2 Improving Channel Estimation and EVM Accuracy

The channels in the WLAN signal are estimated based on the expected input signal description and the information provided by the PPDUs themselves. The more accurate the channel estimation, the more accurate the EVM based on these channels can be calculated.

Increasing the basis for channel estimation

The more information that can be used to estimate the channels, the more accurate the results. For measurements that need not be performed strictly according to the WLAN 802.11 standard, set the "Channel Estimation Range" to "Payload" (see "Channel Estimation Range" on page 141).

The channel estimation is performed in the preamble and the payload. The EVM results can be calculated more accurately.

Accounting for phase drift in the EVM

According to the WLAN 802.11 standards, the common phase drift must be estimated and compensated from the pilots. Thus, these deviations are not included in the EVM. To include the phase drift, disable "Phase Tracking" (see "Phase Tracking" on page 142).

Analyzing time jitter

Normally, a symbol-wise timing jitter is negligible and not required by the IEEE 802.11a measurement standard [6], and thus not considered in channel estimation. However, there may be situations where the timing drift has to be taken into account.

However, to analyze the time jitter per symbol, enable "Timing Tracking" (see "Timing Error Tracking" on page 142).

Compensating for non-standard-conform pilot sequences

In case the pilot generation algorithm of the device under test (DUT) has a problem, the non-standard-conform pilot sequence might affect the measurement results, or the WLAN application might not synchronize at all onto the signal generated by the DUT.

In this case, set the "Pilots for Tracking" to "Detected" (see "Pilots for Tracking" on page 142), so that the pilot sequence detected in the signal is used instead of the sequence defined by the standard.

However, if the pilot sequence generated by the DUT is correct, it is recommended that you use the "According to Standard" setting because it generates more accurate measurement results.

9.2 Error Messages and Warnings

The following messages are displayed in the status bar in case of errors.

Results contribute to overall results despite inconsistencies:

"Info: Comparison between HT-SIG Payload Length and Estimated Payload Length not performed due to insufficient SNR"

The R&S FSW WLAN application compares the HT-SIG length against the length estimated from the PPDU power profile. If the two values do not match, the corresponding entry is highlighted orange. If the signal quality is very bad, this comparison is suppressed and the message above is shown.

"Warning: HT-SIG of PPDU was not evaluated"

Decoding of the HT-SIG was not possible because there was to not enough data in the Capture Memory (potential PPDU truncation).

"Warning: Mismatch between HT-SIG and estimated (SNR+Power) PPDU length"

The HT-SIG length and the length estimated by the R&S FSW WLAN application (from the PPDU power profile) are different.

"Warning: Physical Channel estimation impossible / Phy Chan results not available Possible reasons: channel matrix not square or singular to working precision"

The Physical Channel results could not be calculated for one or both of the following reasons:

- The spatial mapping can not be applied due to a rectangular mapping matrix (the number of space time streams is not equal to the number of transmit antennas).
- The spatial mapping matrices are singular to working precision.

PPDUs are dismissed due to inconsistencies

"Hint: PPDU requires at least one payload symbol"

Currently at least one payload symbol is required in order to successfully analyze the PPDU. Null data packet (NDP) sounding PPDUs will generate this message.

"Hint: PPDU dismissed due to a mismatch with the PPDU format to be analyzed"

The properties causing the mismatches for this PPDU are highlighted.

"Hint: PPDU dismissed due to truncation"

The first or the last PPDU was truncated during the signal capture process, for example.

"Hint: PPDU dismissed due to HT-SIG inconsistencies"

One or more of the following HT-SIG decoding results are outside of specified range: MCS index, Number of additional STBC streams, Number of space time streams (derived from MCS and STBC), CRC Check failed, Non zero tail bits.

"Hint: PPDU dismissed because payload channel estimation was not possible"

The payload based channel estimation was not possible because the channel matrix is singular to working precision.

"Hint: Channel matrix singular to working precision"

Channel equalizing (for PPDU Length Detection, fully and user compensated measurement signal) is not possible because the estimated channel matrix is singular to working precision.

10 Remote Commands for WLAN 802.11 Measurements

The following commands are required to perform measurements in the R&S FSW WLAN application in a remote environment.

It is assumed that the R&S FSW has already been set up for remote control in a network as described in the R&S 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 R&S 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

After an introduction to SCPI commands, the following tasks specific to the R&S FSW WLAN application are described here:

10.1 Common Suffixes

In the R&S FSW WLAN application, the following common suffixes are used in remote commands:

Table 10-1: Common suffixes used in remote commands in the R&S FSW WLAN application

Suffix	Value range	Description
<m>	1 to 4 (RF: 1 to 16)	Marker
<n>	1 to 16	Window (**in the currently selected measurement channel**)

Suffix	Value range	Description
<t>	irrelevant (RF: 1 to 6)	Trace
<k>	1 to 8	Limit line

10.2 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, in most cases, 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, these are separated by a comma from one another.

Only the most important characteristics that you need to know when working with SCPI commands are described here. For a more complete description, refer to the User Manual of the R&S FSW.

Remote command examples

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

10.2.1 Conventions used in Descriptions

Note the following conventions used in the remote command descriptions:

- **Command usage**
  If not specified otherwise, commands can be used both for setting and for querying parameters.
  If a command can be used for setting or querying only, or if it initiates an event, the usage is stated explicitly.
- **Parameter usage**
  If not specified otherwise, a parameter can be used to set a value and it is the result of a query.
  Parameters required only for setting are indicated as **Setting parameters**.
  Parameters required only to refine a query are indicated as **Query parameters**.
  Parameters that are only returned as the result of a query are indicated as **Return values**.
- **Conformity**

Commands that are taken from the SCPI standard are indicated as **SCPI confirmed**. All commands used by the R&S 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**
  This is the unit used for numeric values if no other unit is provided with the parameter.
- **Manual operation**
  If the result of a remote command can also be achieved in manual operation, a link to the description is inserted.

10.2.2 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 upper case letters. Note however, that this emphasis only serves the purpose to distinguish the short from the long form in the manual. For the instrument, the case does not matter.

Example:

`SENSe:FREQuency:CENTer` is the same as `SENS:FREQ:CENT`.

10.2.3 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 don't quote a suffix for keywords that support one, a 1 is assumed.

Example:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe` enables the zoom in a particular measurement window, selected by the suffix at `WINDow`.

`DISPlay:WINDow4:ZOOM:STATe ON` refers to window 4.

10.2.4 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.

Note that if an optional keyword has a numeric suffix and you need to use the suffix, you have to include the optional keyword. Otherwise, the suffix of the missing keyword is assumed to be the value 1.

Optional keywords are emphasized with square brackets.

Example:

Without a numeric suffix in the optional keyword:

`[SENSe:]FREQuency:CENTer` is the same as `FREQuency:CENTer`

With a numeric suffix in the optional keyword:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe`

`DISPlay:ZOOM:STATe ON` enables the zoom in window 1 (no suffix).

`DISPlay:WINDow4:ZOOM:STATe ON` enables the zoom in window 4.

10.2.5 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`.

10.2.6 SCPI Parameters

Many commands feature one or more parameters.

If a command supports more than one parameter, these are separated by a comma.

Example:

`LAYout:ADD:WINDow Spectrum,LEFT,MTABle`

Parameters may have different forms of values.

10.2.6.1 Numeric Values

Numeric values can be entered in any form, i.e. with sign, decimal point or exponent. In case of 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. in case of 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. In some cases you can customize the step size with a corresponding command.

Querying numeric values

When you query numeric values, the system returns a number. In case of physical quantities, it applies the basic unit (e.g. Hz in case of 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`

In some cases, numeric values may be 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 in case of errors.

10.2.6.2 Boolean

Boolean parameters represent two states. The "ON" state (logically true) is represented by "ON" or a numeric value 1. The "OFF" state (logically untrue) is represented by "OFF" or the numeric value 0.

Querying boolean parameters

When you query boolean parameters, the system returns either the value 1 ("ON") or the value 0 ("OFF").

Example:

Setting: `DISPlay:WINDow:ZOOM:STATe ON`

Query: `DISPlay:WINDow:ZOOM:STATe?` would return `1`

10.2.6.3 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 10.2.2, "Long and Short Form", on page 196.

Querying text parameters

When you query text parameters, the system returns its short form.

Example:

Setting: `SENSe:BANDwidth:RESolution:TYPE NORMal`

Query: `SENSe:BANDwidth:RESolution:TYPE?` would return `NORM`

10.2.6.4 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'`

10.2.6.5 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. In the example the 4 following digits indicate the length to be 5168 bytes. The data bytes follow. During the transmission of these data bytes all end or other control signs are ignored until all bytes are transmitted. #0 specifies a data block of indefinite length. The use of the indefinite format requires an `NL^END` message to terminate the data block. This format is useful when the length of the transmission is not known or if speed or other considerations prevent segmentation of the data into blocks of definite length.

10.3 Activating WLAN 802.11 Measurements

WLAN 802.11 measurements require a special application on the R&S FSW (R&S FSW-K91). The measurement is started immediately with the default settings.

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

INSTrument:CREate:DUPLicate

This command duplicates the currently selected measurement channel, i.e creates a new measurement 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" -> "IQAnalyzer2").

The channel to be duplicated must be selected first using the `INST:SEL` command.

This command is not available if the MSRA Master channel is selected.

Example:

```
INST:SEL 'IQAnalyzer'
INST:CRE:DUPL
```

Duplicates the channel named 'IQAnalyzer' and creates a new measurement channel named 'IQAnalyzer2'.

Usage: Event

INSTrument:CREate[:NEW] <ChannelType>, <ChannelName>

This command adds an additional measurement channel.

The number of measurement channels you can configure at the same time depends on available memory.

Parameters:

<ChannelType> Channel type of the new channel.
For a list of available channel types see `INSTrument:LIST?` on page 201.

<ChannelName> String containing the name of the channel. The channel name is displayed as the tab label for the measurement 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 201).

Example: `INST:CRE IQ, 'IQAnalyzer2'`
Adds an additional I/Q Analyzer channel named "IQAnalyzer2".

INSTrument:CREate:REPLace <ChannelName1>,<ChannelType>,<ChannelName2>

This command replaces a measurement channel with another one.

Setting parameters:

<ChannelName1> String containing the name of the measurement channel you want to replace.

<ChannelType> Channel type of the new channel.
For a list of available channel types see INSTrument:LIST? on page 201.

<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 201).

Example: `INST:CRE:REPL 'IQAnalyzer2',IQ,'IQAnalyzer'`
Replaces the channel named 'IQAnalyzer2' by a new measurement channel of type 'IQ Analyzer' named 'IQAnalyzer'.

Usage: Setting only

INSTrument:DELete <ChannelName>

This command deletes a measurement channel.

If you delete the last measurement channel, the default "Spectrum" channel is activated.

Parameters:

<ChannelName> String containing the name of the channel you want to delete.
A measurement channel must exist in order to be able delete it.

Example: `INST:DEL 'IQAnalyzer4'`
Deletes the channel with the name 'IQAnalyzer4'.

Usage: Event

INSTrument:LIST?

This command queries all active measurement channels. This is useful in order to obtain the names of the existing measurement channels, which are required in order 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 measurement channels:
`'ADEM','Analog Demod','IQ','IQ Analyzer','IQ','IQ Analyzer2'`

Usage: Query only

Table 10-2: Available measurement 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
Amplifier Measurements (R&S FSW-K18)	AMPLifier	Amplifier
Analog Demodulation (R&S FSW-K7)	ADEM	Analog Demod
Avionics (R&S FSW-K15)	AVIonics	Avionics
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
GSM (R&S FSW-K10)	GSM	GSM
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
Noise (R&S FSW-K30)	NOISE	Noise
Phase Noise (R&S FSW-K40)	PNOISE	Phase Noise
Pulse (R&S FSW-K6)	PULSE	Pulse
Real-Time Spectrum (R&S FSW-B160R/-K160RE)	RTIM	Real-Time Spectrum
Spurious Measurements (R&S FSW-K50)	SPUR	Spurious
*) the default channel name is also listed in the table. If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel.		

Application	<ChannelType> Parameter	Default Channel Name*)
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
VSA (R&S FSW-K70)	DDEM	VSA
WLAN (R&S FSW-K91)	WLAN	WLAN
*) the default channel name is also listed in the table. If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel.		

INSTrument:REName <ChannelName1>, <ChannelName2>

This command renames a measurement channel.

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; this will cause an error.

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 200.

For a list of available channel types see `INSTrument:LIST?` on page 201.

Parameters:

<ChannelType> Channel type of the new channel.
For a list of available channel types see Table 10-2.

WLAN
WLAN option, R&S FSW–K91

<ChannelName> String containing the name of the channel.

Example: `INST WLAN`
Activates a measurement channel for the WLAN application.
`INST 'WLAN'`
Selects the measurement channel named 'WLAN' (for example before executing further commands for that channel).

SYSTem:PRESet:CHANnel[:EXECute]

This command 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 94

10.4 Selecting a Measurement

The following commands are required to define the measurement type in a remote environment. The selected measurement must be started explicitely (see Chapter 10.8, "Starting a Measurement", on page 309)!

For details on available measurements see Chapter 3, "Measurements and Result Displays", on page 13.

The WLAN IQ measurement captures the I/Q data from the WLAN signal using a (nearly rectangular) filter with a relatively large bandwidth. This measurement is selected when the WLAN measurement channel is activated. The commands to select a different measurement or return to the WLAN IQ 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 10.7, "Configuring the Result Display", on page 292).

10.4.1 Selecting the WLAN IQ Measurement (Modulation Accuracy, Flatness and Tolerance)

Any of the following commands can be used to return to the WLAN IQ measurement. Each of these results are automatically determined when the WLAN IQ measurement is performed.

The selected measurement must be started explicitly (see Chapter 10.8, "Starting a Measurement", on page 309)!

CONFigure:BURSt:AM:AM[:IMMediate]

This remote control command configures the result display type of window 2 to be AM vs AM. Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Usage: Event

Manual operation: See "AM/AM" on page 23

CONFigure:BURSt:AM:EVM[:IMMediate]

This remote control command configures the result display type of window 2 to be AM vs. EVM. Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Usage: Event

Manual operation: See "AM/EVM" on page 24

CONFigure:BURSt:AM:PM[:IMMediate]

This remote control command configures the result display type of window 2 to be AM vs PM. Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Usage: Event

Manual operation: See "AM/PM" on page 24

CONFigure:BURSt:CONSt:CCARrier[:IMMediate]

This remote control command configures the result display type of window 2 to be Constellation vs Carrier.

Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Usage: Event

Manual operation: See "Constellation vs Carrier" on page 29

CONFigure:BURSt:CONSt:CSYMbol[:IMMediate]

This remote control command configures the result display type of window 2 to be Constellation (vs Symbol).

Results are only displayed after a measurement has been executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Usage: Event

Manual operation: See "Constellation" on page 27

CONFigure:BURSt:EVM:ECARrier[:IMMediate]

This remote control command configures the result display type of window 2 to be EVM vs Carrier.

Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Usage: Event

Manual operation: See "EVM vs Carrier" on page 30

CONFigure:BURSt:EVM:ESYMbol[:IMMediate] (IEEE 802.11b and g (DSSS))
CONFigure:BURSt:EVM:ECHip[:IMMediate]

Both of these commands configure the measurement type to be EVM vs Chip for **IEEE 802.11b and g (DSSS)** standards. For compatibility reasons, the `CONFigure:BURSt:EVM:ESYMbol[:IMMediate]` command is also supported for the IEEE 802.11b and g (DSSS) standards. However, for new remote control programs use the `LAYout` commands (see Chapter 10.7.2, "Working with Windows in the Display", on page 293).

Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Manual operation: See "EVM vs Chip" on page 31

CONFigure:BURSt:EVM:ESYMbol[:IMMediate]

This remote control command configures the measurement type to be EVM vs Symbol.

For **IEEE 802.11b and g (DSSS)** standards, this command selects the EVM vs Chip result display.

Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Usage: Event

Manual operation: See "EVM vs Chip" on page 31
See "EVM vs Symbol" on page 31

CONFigure:BURSt:GAIN:GCARrier[:IMMediate]

This remote control command configures the result display type of window 2 to be Gain Imbalance vs Carrier. Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Usage: Event

Manual operation: See "Gain Imbalance vs Carrier" on page 34

CONFigure:BURSt:PREamble[:IMMediate]

This remote control command configures the measurement type to be Frequency Error vs Preamble or Phase Error vs Preamble. Which of the two is determined by `CONFigure:BURSt:PREamble:SELect`.

Manual operation: See "Freq. Error vs Preamble" on page 34
See "Phase Error vs Preamble" on page 37

CONFigure:BURSt:PREamble:SELect <ErrType>

This remote control command specifies whether frequency or phase results are displayed when the measurement type is set to Error Vs Preamble (`CONFigure:BURSt:PREamble[:IMMediate]` on page 207).

Parameters:

<ErrType>

FREQuency
Displays frequency error results for the preamble of the measured PPDUs only

PHASe
Displays phase error results for the preamble of the measured PPDUs only

Example: `CONF:BURS:PRE:SEL PHAS`

Manual operation: See "Freq. Error vs Preamble" on page 34
See "Phase Error vs Preamble" on page 37

CONFigure:BURSt:PTRacking[:IMMediate]

This remote control command configures the measurement type to be Phase Tracking vs Symbol.

Manual operation: See "Phase Tracking" on page 38

CONFigure:BURSt:PVT[:IMMediate]

This remote control command configures the measurement type to be Power vs Time.

Manual operation: See "PvT Full PPDU" on page 39
See "PvT Rising Edge" on page 40
See "PvT Falling Edge" on page 41

CONFigure:BURSt:PVT:SELect <Mode>

This remote command determines how to interpret the Power vs Time measurement results.

Parameters:

<Mode>

EDGE
Displays rising and falling edges only

FALL
Displays falling edge only

FULL
Displays the full PPDU

RISE
Displays the rising edge only

Example: `CONF:BURS:PVT:SEL FULL`
Interprets the measurement results as full PPDU

Manual operation: See "PvT Full PPDU" on page 39
See "PvT Rising Edge" on page 40
See "PvT Falling Edge" on page 41

CONFigure:BURSt:QUAD:QCARrier[:IMMediate]

This remote control command configures the result display type in window 2 to be Quadrature Error vs Carrier. Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Usage: Event

Manual operation: See "Quad Error vs Carrier" on page 42

CONFigure:BURSt:SPECtrum:FFT[:IMMediate]

This remote control command configures the result display type of window 2 to be FFT Spectrum.

Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Usage: Event

Manual operation: See "FFT Spectrum" on page 32

CONFigure:BURSt:SPECtrum:FLATness:SELect <MeasType>

This remote control command configures result display type of window 2 to be either Spectrum Flatness or Group Delay.

Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Parameters:
<MeasType> FLATness | GRDelay

Example: `CONF:BURS:SPEC:FLAT:SEL FLAT`
Configures the result display of window 2 to be Spectrum Flatness.
`CONF:BURS:SPEC:FLAT:IMM`
Performs a default WLAN measurement. When the measurement is completed, the Spectrum Flatness results are displayed.

Usage: Event

Manual operation: See "Group Delay" on page 35
See "Spectrum Flatness" on page 49

CONFigure:BURSt:SPECtrum:FLATness[:IMMediate]

This remote control command configures the result display in window 2 to be Spectrum Flatness or Group Delay, depending on which result display was selected last using `CONFigure:BURSt:SPECtrum:FLATness:SELect` on page 209.

Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Example: `CONF:BURS:SPEC:FLAT:SEL FLAT`
Configures the result display of window 2 to be Spectrum Flatness.
`CONF:BURS:SPEC:FLAT:IMM`
Performs a default WLAN measurement. When the measurement is completed, the Spectrum Flatness results are displayed.

Usage: Event

Manual operation: See "Group Delay" on page 35
See "Spectrum Flatness" on page 49

CONFigure:BURSt:STATistics:BSTReam[:IMMediate]

This remote control command configures the result display type of window 2 to be Bitstream.

Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Usage: Event

Manual operation: See "Bitstream" on page 25

CONFigure:BURSt:STATistics:SFIeld[:IMMediate]

This remote control command configures the result display type of window 2 to be Signal Field.

Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Usage: Event

Manual operation: See "PLCP Header (IEEE 802.11b, g (DSSS)" on page 38
See "Signal Field" on page 46

DISPlay[:WINDow<n>]:SELect

This command sets the focus on the selected result display window.

This window is then the active window.

Suffix:
<n> Window

Example: `DISP:WIND1:SEL`
Sets the window 1 active.

Usage: Setting only

10.4.2 Selecting a Common RF Measurement for WLAN Signals

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

For details on available measurements see Chapter 3.2, "Frequency Sweep Measurements", on page 50.

The selected measurement must be started explicitely (see Chapter 10.8, "Starting a Measurement", on page 309)!

CONFigure:BURSt:SPECtrum:ACPR[:IMMediate]

This remote control command configures the result display in window 2 to be ACPR (adjacent channel power relative). Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Usage: Event

Manual operation: See "Channel Power ACLR" on page 51

CONFigure:BURSt:SPECtrum:MASK[:IMMediate]

This remote control command configures the result display in window 2 to be Spectrum Mask. Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command

Usage: Event

Manual operation: See "Spectrum Emission Mask" on page 52

CONFigure:BURSt:SPECtrum:OBWidth[:IMMediate]

This remote control command configures the result display in window 2 to be ACPR (adjacent channel power relative). Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Usage: Event

Manual operation: See "Occupied Bandwidth" on page 53

CONFigure:BURSt:STATistics:CCDF[:IMMediate]

This remote control command configures the result display in window 2 to be CCDF (conditional cumulative distribution function). Results are only displayed after a measurement is executed, e.g. using the `INITiate<n>[:IMMediate]` command.

Usage: Event

Manual operation: See "CCDF" on page 54

10.5 Configuring the WLAN IQ Measurement (Modulation Accuracy, Flatness and Tolerance)

The following commands are required to configure the WLAN IQ measurement described in Chapter 3.1, "WLAN I/Q Measurement (Modulation Accuracy, Flatness and Tolerance)", on page 13.

10.5.1 Signal Description

The signal description provides information on the expected input signal.

Useful commands for describing the WLAN signal described elsewhere:

- `[SENSe:]FREQuency:CENTer` on page 237

Remote commands exclusive to describing the WLAN signal:

CONFigure:STANdard <Standard>

This remote control command specifies which WLAN standard the option is configured to measure.

The availability of many commands depends on the selected standard!

Parameters:

<Standard>

0
IEEE 802.11a

1
IEEE 802.11b

2
IEEE 802.11j (10 MHz)

3
IEEE 802.11j (20 MHz)

4
IEEE 802.11g
To distinguish between OFDM and DSSS use the command `[SENSe:]DEMod:FORMat:BANalyze:BTYPe` on page 272.
By default, the R&S FSW WLAN application selects the most recently defined PPDU type.

6
IEEE 802.11n

7
IEEE 802.11n (MIMO)

8
IEEE 802.11ac

9
IEEE 802.11p

*RST: 0

Example: Select IEEE 802.11g OFDM standard:
```
CONF:STAN 4
SENS:DEM:FORM:BAN:BTYP 'OFDM'
```

Manual operation: See "Standard" on page 95

CALCulate:LIMit:TOLerance <Limit>

This command defines or queries the tolerance limit to be used for the measurement. The required tolerance limit depends on the used standard.

Parameters:

<Limit> PRIOR11_2012 | STD11_2012 | P11ACD5_1

PRIOR11_2012
Tolerance limits are based on the IEEE 802.11 specification **prior to 2012**.
Default for OFDM standards (except 802.11ac).

STD11_2012
Tolerance limits are based on the IEEE 802.11 specification from **2012.**
Required for DSSS standards. Also possible for OFDM standards (except 802.11ac).

P11ACD5_1
Tolerance limits are based on the **IEEE 802.11ac** specification.
Required by IEEE 802.11ac standard.

*RST: STD11_2012

Manual operation: See "Tolerance Limit" on page 95

10.5.2 Configuring the Data Input and Output

10.5.2.1 RF Input

INPut:ATTenuation:PROTection:RESet

This command resets the attenuator and reconnects the RF input with the input mixer 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.

For details on the protection mechanism see Chapter 4.7.1, "RF Input Protection", on page 81.

Usage: Event

INPut:CONNector <ConnType>

Determines whether the RF input data is taken from the RF input connector or the optional Analog Baseband I connector. This command is only available if the Analog Baseband interface (R&S FSW-B71) is installed and active for input. It is not available for the R&S FSW67 or R&S FSW85.

For more information on the Analog Baseband Interface (R&S FSW-B71) see the R&S FSW I/Q Analyzer and I/Q Input User Manual.

Parameters:

<ConnType>

RF
RF input connector

AIQI
Analog Baseband I connector

*RST: RF

Example: `INP:CONN:AIQI`
Selects input from the analog baseband I connector.

Usage: SCPI confirmed

Manual operation: See "Input Connector" on page 99

INPut:COUPling <CouplingType>

This command selects the coupling type of the RF input.

Parameters:

<CouplingType>

AC
AC coupling

DC
DC coupling

*RST: AC

Example: `INP:COUP DC`

Usage: SCPI confirmed

Manual operation: See "Input Coupling" on page 98

INPut:DPATh <State>

Enables or disables the use of the direct path for frequencies close to 0 Hz.

Parameters:
<State>

AUTO | 1
(Default) the direct path is used automatically for frequencies close to 0 Hz.

OFF | 0
The analog mixer path is always used.

*RST: 1

Example: `INP:DPAT OFF`

Usage: SCPI confirmed

Manual operation: See "Direct Path" on page 98

INPut:FILTer:HPASs[:STATe] <State>

Activates an additional internal high-pass filter for RF input signals from 1 GHz to 3 GHz. This filter is used to remove the harmonics of the R&S FSW in order to measure the harmonics for a DUT, for example.

This function requires an additional high-pass filter hardware option.

(Note: for RF input signals outside the specified range, the high-pass filter has no effect. For signals with a frequency of approximately 4 GHz upwards, the harmonics are suppressed sufficiently by the YIG-preselector, if available.)

Parameters:
<State> ON | OFF

*RST: OFF

Example: `INP:FILT:HPAS ON`
Turns on the filter.

Usage: SCPI confirmed

Manual operation: See "High-Pass Filter 1...3 GHz" on page 99

INPut:FILTer:YIG[:STATe] <State>

This command turns the YIG-preselector on and off.

Note the special conditions and restrictions for the YIG-preselector described in "YIG-Preselector" on page 99.

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

*RST: 1 (0 for I/Q Analyzer, GSM, VSA, Pulse, Amplifier, Transient Analysis, DOCSIS and MC Group Delay measurements)

Example: `INP:FILT:YIG OFF`
Deactivates the YIG-preselector.

Manual operation: See "YIG-Preselector" on page 99

INPut:IMPedance <Impedance>

This command selects the nominal input impedance of the RF input. In some applications, only 50 Ω are supported.

75 Ω should be selected if the 50 Ω input impedance is transformed to a higher impedance using a matching pad of the RAZ type (= 25 Ω in series to the input impedance of the instrument). The power loss correction value in this case is 1.76 dB = 10 log (75Ω/50Ω).

Parameters:

<Impedance> 50 | 75

*RST: 50 Ω

Example: `INP:IMP 75`

Usage: SCPI confirmed

Manual operation: See "Impedance" on page 98

INPut:SELect <Source>

This command selects the signal source for measurements, i.e. it defines which connector is used to input data to the R&S FSW.

If no additional input options are installed, only RF input is supported.

Tip: The I/Q data to be analyzed for WLAN 802.11 can not only be measured by the WLAN application itself, it can also be imported to the application, provided it has the correct format. Furthermore, the analyzed I/Q data from the WLAN application can be exported for further analysis in external applications. See Chapter 7.1, "Import/Export Functions", on page 178.

Parameters:

<Source> **RF**

Radio Frequency ("RF INPUT" connector)

*RST: RF

Manual operation: See "Radio Frequency State" on page 97
See "Digital I/Q Input State" on page 110
See "Analog Baseband Input State" on page 112

10.5.2.2 Using External Mixers

The commands required to work with external mixers in a remote environment are described here. Note that these commands require the R&S FSW-B21 option to be installed and an external mixer to be connected to the front panel of the R&S FSW.

In MSRA mode, external mixers are not supported.

Basic Settings

The basic settings concern general usage of an external mixer.

[SENSe:]MIXer[: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.

Parameters:

<State> ON | OFF

*RST: OFF

Example: `MIX ON`

Manual operation: See "External Mixer State" on page 100

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

This command defines the bias current for the high (second) range.

This command is only available if the external mixer is active (see `[SENSe:]MIXer[:STATe]` on page 218).

Parameters:

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

Manual operation: See "Bias Settings" on page 104

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

This command defines the bias current for the low (first) range.

This command is only available if the external mixer is active (see `[SENSe:]MIXer[:STATe]` on page 218).

Parameters:

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

Manual operation: See "Bias Settings" on page 104

[SENSe:]MIXer:LOPower <Level>

This command specifies the LO level of the external mixer's LO port.

Parameters:

<Level> numeric value

Range: 13.0 dBm to 17.0 dBm
Increment: 0.1 dB
*RST: 15.5 dBm

Example: `MIX:LOP 16.0dBm`

Manual operation: See "LO Level" on page 103

[SENSe:]MIXer:SIGNal <State>

This command 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).

Parameters:

<State> **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

Manual operation: See "Signal ID" on page 104
See "Auto ID" on page 104

[SENSe:]MIXer:THReshold <Value>

This command defines the maximum permissible level difference between test sweep and reference sweep to be corrected during automatic comparison (see `[SENSe:]MIXer:SIGNal` on page 219).

Parameters:

<Value> <numeric value>

Range: 0.1 dB to 100 dB
*RST: 10 dB

Example: `MIX:PORT 3`

Manual operation: See "Auto ID Threshold" on page 104

Mixer Settings

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

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

This command 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.

This command is only available if the external mixer is active (see `[SENSe:]MIXer[:STATe]` on page 218).

Parameters:
<Frequency> numeric value

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

Manual operation: See "Handover Freq." on page 101

[SENSe:]MIXer:FREQuency:STARt?

This command queries the frequency at which the external mixer band starts.

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

Usage: Query only

Manual operation: See "RF Start / RF Stop" on page 100

[SENSe:]MIXer:FREQuency:STOP?

This command queries the frequency at which the external mixer band stops.

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

Usage: Query only

Manual operation: See "RF Start / RF Stop" on page 100

[SENSe:]MIXer:HARMonic:BAND:PRESet

This command 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.

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

Usage: Event

Manual operation: See "Preset Band" on page 101

[SENSe:]MIXer:HARMonic:BAND[:VALue] <Band>

This command selects the external mixer band. The query returns the currently selected band.

This command is only available if the external mixer is active (see `[SENSe:]MIXer[:STATe]` on page 218).

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

Manual operation: See "Band" on page 101

Table 10-3: 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
*) The band formerly referred to as "A" is now named "KA".		

Band	Frequency start [GHz]	Frequency stop [GHz]
D	110.0	170.0
G	140.0	220.0
J	220.0	325.0
Y	325.0	500.0
USER	32.18 (default)	68.22 (default)
***)** The band formerly referred to as "A" is now named "KA".		

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

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

Parameters:

<State> ON | OFF

*RST: OFF

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

Manual operation: See "Range 1/2" on page 102

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

This command specifies the harmonic order to be used for the high (second) range.

Parameters:

<HarmOrder numeric value

Range: 2 to 61 (USER band); for other bands: see band definition

Example: `MIX:HARM:HIGH 2`

Manual operation: See "Harmonic Order" on page 102

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

This command specifies whether the harmonic order to be used should be odd, even, or both.

Which harmonics are supported depends on the mixer type.

Parameters:

<OddEven> **ODD | EVEN | EODD**

*RST: EVEN

Example: `MIX:HARM:TYPE ODD`

Manual operation: See "Harmonic Type" on page 102

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

This command specifies the harmonic order to be used for the low (first) range.

Parameters:
<HarmOrder> numeric value

Range: 2 to 61 (USER band); for other bands: see band definition
*RST: 2 (for band F)

Example: `MIX:HARM 3`

Manual operation: See "Harmonic Order" on page 102

[SENSe:]MIXer:LOSS:HIGH <Average>

This command defines the average conversion loss to be used for the entire high (second) range.

Parameters:
<Average> numeric value

Range: 0 to 100
*RST: 24.0 dB
Default unit: dB

Example: `MIX:LOSS:HIGH 20dB`

Manual operation: See "Conversion loss" on page 102

[SENSe:]MIXer:LOSS:TABLe:HIGH <FileName>

This command defines the file name of the conversion loss table to be used for the high (second) range.

Parameters:
<FileName> String containing the path and name of the file.

Example: `MIX:LOSS:TABL:HIGH 'MyCVLTable'`

Manual operation: See "Conversion loss" on page 102

[SENSe:]MIXer:LOSS:TABLe[:LOW] <FileName>

This command defines the file name of the conversion loss table to be used for the low (first) range.

Parameters:
<FileName> String containing the path and name of the file.

Example: `MIX:LOSS:TABL 'mix_1_4'`
Specifies the conversion loss table *mix_1_4*.

Manual operation: See "Conversion loss" on page 102

[SENSe:]MIXer:LOSS[:LOW] <Average>

This command defines the average conversion loss to be used for the entire low (first) range.

Parameters:

<Average> numeric value

Range: 0 to 100
*RST: 24.0 dB
Default unit: dB

Example: `MIX:LOSS 20dB`

Manual operation: See "Conversion loss" on page 102

[SENSe:]MIXer:PORTs <PortType>

This command specifies whether the mixer is a 2-port or 3-port type.

Parameters:

<PortType> **2 | 3**

*RST: 2

Example: `MIX:PORT 3`

Manual operation: See "Mixer Type" on page 101

[SENSe:]MIXer:RFOVerrange[:STATe] <State>

If enabled, the band limits are extended beyond "RF Start" and "RF Stop" due to the capabilities of the used harmonics.

Parameters:

<State> ON | OFF

*RST: OFF

Manual operation: See "RF Overrange" on page 101

Conversion Loss Table Settings

The following settings are required to configure and manage conversion loss tables.

[SENSe:]CORRection:CVL:BAND <Type>

This command 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 228).

This command is only available with option B21 (External Mixer) installed.

Parameters:

<Band> K | A | KA | Q | U | V | E | W | F | D | G | Y | J | USER

Standard waveguide band or user-defined band.
Note: The band formerly referred to as "A" is now named "KA"; the input parameter "A" is still available and refers to the same band as "KA".
For a definition of the frequency range for the pre-defined bands, see Table 10-3).

*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).

Manual operation: See "Band" on page 108

[SENSe:]CORRection:CVL:BIAS <BiasSetting>

This command 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 228.

This command is only available with option B21 (External Mixer) installed.

Parameters:

<BiasSetting> numeric value

*RST: 0.0 A
Default unit: A

Example:
`CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:BIAS 3A`

Manual operation: See "Write to <CVL table name>" on page 105
See "Bias" on page 108

[SENSe:]CORRection:CVL:CATAlog?

This command queries all available conversion loss tables saved in the `C:\r_s\instr\user\cvl\` directory on the instrument.

This command is only available with option B21 (External Mixer) installed.

Usage: Query only

[SENSe:]CORRection:CVL:CLEAr

This command 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 228).

This command is only available with option B21 (External Mixer) installed.

Example: `CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:CLE`

Usage: Event

Manual operation: See "Delete Table" on page 106

[SENSe:]CORRection:CVL:COMMent <Text>

This command 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 228).

This command 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'`

Manual operation: See "Comment" on page 108

[SENSe:]CORRection:CVL:DATA <Freq>,<Level>

This command defines the reference values of the selected conversion loss tables. The values are entered as a set of frequency/level pairs. A maximum of 50 frequency/level pairs may be entered. Before this command can be performed, the conversion loss table must be selected (see [SENSe:]CORRection:CVL:SELect on page 228).

This command is only available with option B21 (External Mixer) installed.

Parameters:

<Freq> numeric value

The frequencies have to be sent in ascending order.

<Level>

Example: `CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:DATA 1MHZ,-30DB,2MHZ,-40DB`

Manual operation: See "Position/Value" on page 109

[SENSe:]CORRection:CVL:HARMonic <HarmOrder>

This command 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 228.

This command is only available with option B21 (External Mixer) installed.

Parameters:
<HarmOrder> numeric value

Range: 2 to 65

Example: `CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:HARM 3`

Manual operation: See "Harmonic Order" on page 108

[SENSe:]CORRection:CVL:MIXer <Type>

This command 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 228).

This command 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'`

Manual operation: See "Mixer Name" on page 108

[SENSe:]CORRection:CVL:PORTs <PortNo>

This command 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 228).

This command 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`

Manual operation: See "Mixer Type" on page 109

[SENSe:]CORRection:CVL:SELect <FileName>

This command selects the conversion loss table with the specified file name. If <file_name> is not available, a new conversion loss table is created.

This command 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'`

Manual operation: See "New Table" on page 105
See "Edit Table" on page 106
See "File Name" on page 107

[SENSe:]CORRection:CVL:SNUMber <SerialNo>

This command 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 228).

This command 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'`

Manual operation: See "Mixer S/N" on page 108

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
```

10.5.2.3 Configuring Digital I/Q Input and Output

Useful commands for digital I/Q data described elsewhere:

- `INP:SEL DIQ` (see `INPut:SELect` on page 217)
- `TRIGger[:SEQuence]:LEVel:BBPower` on page 249

Remote commands for the R&S DigIConf software

Remote commands for the R&S DigIConf software always begin with `SOURce:EBOX`. Such commands are passed on from the R&S FSW to the R&S DigIConf automatically which then configures the R&S EX-IQ-BOX via the USB connection.

All remote commands available for configuration via the R&S DigIConf software are described in the "R&S®EX-IQ-BOX Digital Interface Module R&S®DigIConf Software Operating Manual".

Example 1:

`SOURce:EBOX:*RST`

`SOURce:EBOX:*IDN?`

Result:

"Rohde&Schwarz,DigIConf,02.05.436 Build 47"

Example 2:

`SOURce:EBOX:USER:CLOCk:REFerence:FREQuency 5MHZ`

Defines the frequency value of the reference clock.

Remote commands exclusive to digital I/Q data input and output

INPut:DIQ:CDEVice

This command queries the current configuration and the status of the digital I/Q input from the optional Digital Baseband Interface.

For details see the section "Interface Status Information" for the optional Digital Baseband Interface in the R&S FSW I/Q Analyzer User Manual.

Return values:

<ConnState> Defines whether a device is connected or not.

0
No device is connected.

1
A device is connected.

<DeviceName>	Device ID of the connected device
<SerialNumber>	Serial number of the connected device
<PortName>	Port name used by the connected device
<SampleRate>	Maximum or currently used sample rate of the connected device in Hz (depends on the used connection protocol version; indicated by <SampleRateType> parameter)
<MaxTransferRate>	Maximum data transfer rate of the connected device in Hz
<ConnProtState>	State of the connection protocol which is used to identify the connected device. **Not Started** **Has to be Started** **Started** **Passed** **Failed** **Done**
<PRBSTestState>	State of the PRBS test. **Not Started** **Has to be Started** **Started** **Passed** **Failed** **Done**
<SampleRateType>	**0** Maximum sample rate is displayed **1** Current sample rate is displayed
<FullScaleLevel>	The level (in dBm) that should correspond to an I/Q sample with the magnitude "1" (if transferred from connected device); If not available, `1.#QNAN` (not a number) is returned

Example:	`INP:DIQ:CDEV?`
	Result:
	`1,SMW200A,101190,BBMM 1 OUT,`
	`100000000,200000000,Passed,Passed,1,1.#QNAN`

Manual operation:	See "Connected Instrument" on page 111

INPut:DIQ:RANGe[:UPPer]:AUTO <State>

If enabled, the digital input full scale level is automatically set to the value provided by the connected device (if available).

This command is only available if the optional Digital Baseband interface is installed.

Parameters:

<State> ON | OFF

*RST: OFF

Manual operation: See "Full Scale Level" on page 111

INPut:DIQ:RANGe:COUPling <State>

If enabled, the reference level for digital input is adjusted to the full scale level automatically if the full scale level changes.

This command is only available if the optional Digital Baseband Interface is installed.

Parameters:

<State> ON | OFF

*RST: OFF

Manual operation: See "Adjust Reference Level to Full Scale Level" on page 111

INPut:DIQ:RANGe[:UPPer] <Level>

Defines or queries the "Full Scale Level", i.e. the level that corresponds to an I/Q sample with the magnitude "1".

This command is only available if the optional Digital Baseband Interface is installed.

Parameters:

<Level> <numeric value>

Range: 1 µV to 7.071 V

*RST: 1 V

Manual operation: See "Full Scale Level" on page 111

INPut:DIQ:RANGe[:UPPer]:UNIT <Unit>

Defines the unit of the full scale level (see "Full Scale Level" on page 111). The availability of units depends on the measurement application you are using.

This command is only available if the optional Digital Baseband Interface is installed.

Parameters:

<Level> VOLT | DBM | DBPW | WATT | DBMV | DBUV | DBUA | AMPere

*RST: Volt

Manual operation: See "Full Scale Level" on page 111

INPut:DIQ:SRATe <SampleRate>

This command specifies or queries the sample rate of the input signal from the optional Digital Baseband Interface (see "Input Sample Rate" on page 110).

Parameters:

<SampleRate>	Range:	1 Hz to 10 GHz
	*RST:	32 MHz

Example: INP:DIQ:SRAT 200 MHz

Manual operation: See "Input Sample Rate" on page 110

INPut:DIQ:SRATe:AUTO <State>

If enabled, the sample rate of the digital I/Q input signal is set automatically by the connected device.

This command is only available if the optional Digital Baseband Interface is installed.

Parameters:

<State> ON | OFF

*RST: OFF

Manual operation: See "Input Sample Rate" on page 110

10.5.2.4 Configuring Input via the Optional Analog Baseband Interface

The following commands are required to control the optional Analog Baseband Interface in a remote environment. They are only available if this option is installed.

Useful commands for Analog Baseband data described elsewhere:

- `INP:SEL AIQ` (see `INPut:SELect` on page 217)
- `[SENSe:]FREQuency:CENTer` on page 237

Commands for the Analog Baseband calibration signal are described in the R&S FSW User Manual.

Remote commands exclusive to Analog Baseband data input and output

---

INPut:IQ:BALanced[:STATe] <State>

This command defines whether the input is provided as a differential signal via all 4 Analog Baseband connectors or as a plain I/Q signal via 2 single-ended lines.

Parameters:

<State>

ON
Differential

OFF
Single ended

*RST: ON

Example: `INP:IQ:BAL OFF`

Manual operation: See "Input Configuration" on page 113

INPut:IQ:FULLscale:AUTO <State>

This command defines whether the full scale level (i.e. the maximum input power on the Baseband Input connector) is defined automatically according to the reference level, or manually.

Parameters:

<State>

ON
Automatic definition

OFF
Manual definition according to `INPut:IQ:FULLscale[:LEVel]` on page 235

*RST: ON

Example: `INP:IQ:FULL:AUTO OFF`

INPut:IQ:FULLscale[:LEVel] <PeakVoltage>

This command defines the peak voltage at the Baseband Input connector if the full scale level is set to manual mode (see `INPut:IQ:FULLscale:AUTO` on page 235).

Parameters:

<PeakVoltage> 0.25 V | 0.5 V | 1 V | 2 V

Peak voltage level at the connector.
For probes, the possible full scale values are adapted according to the probe's attenuation and maximum allowed power.

*RST: 1V

Example: `INP:IQ:FULL 0.5V`

INPut:IQ:TYPE <DataType>

This command defines the format of the input signal.

Parameters:

<DataType> IQ | I | Q

IQ
The input signal is filtered and resampled to the sample rate of the application.
Two input channels are required for each input signal, one for the in-phase component, and one for the quadrature component.

I
The in-phase component of the input signal is filtered and resampled to the sample rate of the application. If the center frequency is not 0, the in-phase component of the input signal is down-converted first (Low IF I).

Q
The quadrature component of the input signal is filtered and resampled to the sample rate of the application. If the center frequency is not 0, the quadrature component of the input signal is down-converted first (Low IF Q).

*RST: IQ

Example: `INP:IQ:TYPE Q`

Manual operation: See "I/Q Mode" on page 112

CALibration:AIQ:HATiming[:STATe] <State>

Activates a mode with enhanced timing accuracy between analog baseband, RF and external trigger signals.

For more information see the R&S FSW I/Q Analyzer and I/Q Input User Manual.

Parameters:

<State> ON | OFF | 1 | 0

ON | 1
The high accuracy timing function is switched on.
The cable for high accuracy timing must be connected to trigger ports 1 and 2.

OFF | 0
The high accuracy timing function is switched off.

*RST: OFF

Example: `CAL:AIQ:HAT:STAT ON`

Manual operation: See "High Accuracy Timing Trigger - Baseband - RF" on page 113

10.5.2.5 Configuring the Outputs

Configuring trigger input/output is described in "Configuring the Trigger Output" on page 253.

DIAGnostic:SERVice:NSOurce <State>

This command turns the 28 V supply of the BNC connector labeled NOISE SOURCE CONTROL on the R&S FSW on and off.

For details see Chapter 4.7.2, "Input from Noise Sources", on page 81.

Suffix:

<n> Window

Parameters:

<State> ON | OFF

*RST: OFF

Example: `DIAG:SERV:NSO ON`

Manual operation: See "Noise Source" on page 114

10.5.3 Frontend Configuration

The following commands configure frequency, amplitude and y-axis scaling settings, which represent the "frontend" of the measurement setup.

10.5.3.1 Frequency

[SENSe:]FREQuency:CENTer <Frequency>

This command defines the center frequency.

Parameters:

<Frequency> The allowed range and f_{max} is specified in the data sheet.

UP
Increases the center frequency by the step defined using the `[SENSe:]FREQuency:CENTer:STEP` command.

DOWN
Decreases the center frequency by the step defined using the `[SENSe:]FREQuency:CENTer:STEP` command.

*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.

Usage: SCPI confirmed

Manual operation: See "Frequency" on page 95
See "Center Frequency" on page 113
See "Center frequency" on page 117

[SENSe:]FREQuency:CENTer:STEP <StepSize>

This command defines the center frequency step size.

You can increase or decrease the center frequency quickly in fixed steps using the `SENS:FREQ UP` AND `SENS:FREQ DOWN` commands, see `[SENSe:]FREQuency:CENTer` on page 237.

Parameters:

<StepSize> f_{max} is specified in the data sheet.

Range: 1 to fMAX
*RST: 0.1 x span
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 Stepsize" on page 117

[SENSe:]FREQuency:CENTer:STEP:AUTO <State>

This command couples or decouples the center frequency step size to the span.

In time domain (zero span) measurements, the center frequency is coupled to the RBW.

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

Example: `FREQ:CENT:STEP:AUTO ON`
Activates the coupling of the step size to the span.

[SENSe:]FREQuency:OFFSet <Offset>

This command 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.

See also "Frequency Offset" on page 117.

Note: In MSRA mode, the setting command is only available for the MSRA Master. For MSRA slave applications, only the query command is available.

Parameters:
<Offset> Range: -100 GHz to 100 GHz
*RST: 0 Hz

Example: `FREQ:OFFS 1GHZ`

Usage: SCPI confirmed

Manual operation: See "Frequency Offset" on page 117

10.5.3.2 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 215
- `INPut:IMPedance` on page 217
- `[SENSe:]ADJust:LEVel` on page 287

Remote commands exclusive to amplitude settings:

CALCulate<n>:UNIT:POWer <Unit>

This command selects the unit of the y-axis.

The unit applies to all power-based measurement windows with absolute values.

Suffix:
<n> irrelevant

Parameters:
<Unit> *RST: dBm

Example: `CALC:UNIT:POW DBM`
Sets the power unit to dBm.

Manual operation: See "Unit" on page 120

CONFigure:POWer:AUTO <Mode>

This command is used to switch on or off automatic power level detection.

Parameters for setting and query:
<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>]:TRACe<t>:Y[:SCALe]:RLEVel` on page 241)

ONCE
Automatic power level detection is performed once at the start of the next measurement sweep, and the reference level is adapted accordingly.

*RST: ON

Manual operation: See "Reference Level Mode" on page 119
See "Setting the Reference Level Automatically (Auto Level)" on page 120

CONFigure:POWer:AUTO:SWEep:TIME <Value>

This command is used to specify the auto track time, i.e. the sweep time for auto level detection.

This setting can currently only be defined in remote control, not in manual operation.

Parameters for setting and query:

<Value> numeric value

Auto level measurement sweep time

Range: 0.01 to 1
*RST: 0.1 s
Default unit: S

Example: `CONF:POW:AUTO:SWE:TIME 0.01 MS`

CONFigure:POWer:EXPected:RF <Value>

This command specifies the mean power level of the source signal as supplied to the instrument's RF input. This value is overwritten if "Auto Level" mode is turned on.

Parameters:

<Value> Default unit: DBM

Manual operation: See "Signal Level (RMS)" on page 119

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel <ReferenceLevel>

This command defines the reference level (for all traces in all windows).

Suffix:

<n>, <t> irrelevant

Example: `DISP:TRAC:Y:RLEV -60dBm`

Usage: SCPI confirmed

Manual operation: See "Reference Level" on page 119

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel:OFFSet <Offset>

This command defines a reference level offset (for all traces in all windows).

Suffix:

<n>, <t> irrelevant

Parameters:

<Offset> Range: -200 dB to 200 dB
*RST: 0dB

Example: `DISP:TRAC:Y:RLEV:OFFS -10dB`

Manual operation: See "Shifting the Display (Offset)" on page 119

INPut:ATTenuation <Attenuation>

This command defines the total attenuation for RF input.

If an electronic attenuator is available and active, the command defines a mechanical attenuation (see `INPut:EATT:STATe` on page 243).

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.

This function is not available if the optional Digital Baseband Interface is active.

Parameters:

<Attenuation>

Range: see data sheet
Increment: 5 dB
*RST: 10 dB (AUTO is set to ON)

Example: `INP:ATT 30dB`
Defines a 30 dB attenuation and decouples the attenuation from the reference level.

Usage: SCPI confirmed

Manual operation: See "Attenuation Mode / Value" on page 120

INPut:ATTenuation:AUTO <State>

This command couples or decouples the attenuation to the reference level. Thus, when the reference level is changed, the R&S FSW determines the signal level for optimal internal data processing and sets the required attenuation accordingly.

This function is not available if the optional Digital Baseband Interface is active.

Parameters:

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

Example: `INP:ATT:AUTO ON`
Couples the attenuation to the reference level.

Usage: SCPI confirmed

Manual operation: See "Attenuation Mode / Value" on page 120

INPut:EATT <Attenuation>

This command defines an electronic attenuation manually. Automatic mode must be switched off (`INP:EATT:AUTO OFF`, see `INPut:EATT:AUTO` on page 243).

If the current reference level is not compatible with an attenuation that has been set manually, the command also adjusts the reference level.

This command requires the electronic attenuation hardware option.

This function is not available if the optional Digital Baseband Interface is active.

Parameters:

<Attenuation> attenuation in dB

Range: see data sheet
Increment: 1 dB
*RST: 0 dB (OFF)

Example:
```
INP:EATT:AUTO OFF
INP:EATT 10 dB
```

Manual operation: See "Using Electronic Attenuation" on page 121

INPut:EATT:AUTO <State>

This command turns automatic selection of the electronic attenuation on and off.

If on, electronic attenuation reduces the mechanical attenuation whenever possible.

This command requires the electronic attenuation hardware option.

This function is not available if the optional Digital Baseband Interface is active.

Parameters:

<State> 1 | 0 | ON | OFF

1 | ON

0 | OFF

*RST: 1

Example:
```
INP:EATT:AUTO OFF
```

Manual operation: See "Using Electronic Attenuation" on page 121

INPut:EATT:STATe <State>

This command turns the electronic attenuator on and off.

This command requires the electronic attenuation hardware option.

This function is not available if the optional Digital Baseband Interface is active.

Parameters:

<State> 1 | 0 | ON | OFF

1 | ON

0 | OFF

*RST: 0

Example:
```
INP:EATT:STAT ON
```
Switches the electronic attenuator into the signal path.

Manual operation: See "Using Electronic Attenuation" on page 121

INPut:GAIN[:VALue] <Gain>

This command selects the gain if the preamplifier is activated (`INP:GAIN:STAT ON`, see `INPut:GAIN:STATe` on page 244).

The command requires the additional preamplifier hardware option.

Parameters:

<Gain> 15 dB | 30 dB

The availability of gain levels depends on the model of the R&S FSW.
R&S FSW8/13: 15dB and 30 dB
R&S FSW26 or higher: 30 dB
All other values are rounded to the nearest of these two.

*RST: OFF

Example: `INP:GAIN:STAT ON`
`INP:GAIN:VAL 30`
Switches on 30 dB preamplification.

Usage: SCPI confirmed

Manual operation: See "Preamplifier" on page 121

INPut:GAIN:STATe <State>

This command turns the preamplifier on and off. It requires the optional preamplifier hardware.

This function is not available if the optional Digital Baseband Interface is active.

Parameters:

<State> ON | OFF

*RST: OFF

Example: `INP:GAIN:STAT ON`
Switches on 30 dB preamplification.

Usage: SCPI confirmed

Manual operation: See "Preamplifier" on page 121

10.5.4 Signal Capturing

The following commands are required to configure how much and how data is captured from the input signal.

MSRA operating mode

In MSRA operating mode, only the MSRA Master channel actually captures data from the input signal. The data acquisition settings for the WLAN 802.11 slave application in MSRA mode define the **slave application data extract**.

For details on the MSRA operating mode see the R&S FSW MSRA User Manual.

10.5.4.1 General Capture Settings

[SENSe:]BANDwidth[:RESolution]:FILTer[:STATe] <State>

This remote control command enables or disables use of the adjacent channel filter.

If activated, only the useful signal is analyzed, all signal data in adjacent channels is removed by the filter. This setting improves the signal to noise ratio and thus the EVM results for signals with strong or a large number of adjacent channels. However, for some measurements information on the effects of adjacent channels on the measured signal may be of interest.

Parameters:

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

Manual operation: See "Suppressing (Filter out) Adjacent Channels (IEEE 802.11a, g (OFDM), ac, j, n, p)" on page 124

[SENSe:]SWAPiq <State>

This command 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 R&S FSW can do the same to compensate for it.

Parameters:
<State>

ON
I and Q signals are interchanged
Inverted sideband, Q+j*I

OFF
I and Q signals are not interchanged
Normal sideband, I+j*Q

*RST: OFF

Manual operation: See "Swap I/Q" on page 124

[SENSe:]SWEep:TIME <Time>

This command defines the measurement time.

Parameters:
<Time> refer to data sheet

*RST: depends on current settings (determined automatically)

Example: `SWE:TIME 10s`

Usage: SCPI confirmed

Manual operation: See "Capture Time" on page 123

TRACe:IQ:SRATe <SampleRate>

This command sets the final user sample rate for the acquired I/Q data. Thus, the user sample rate can be modified without affecting the actual data capturing settings on the R&S FSW.

Parameters:
<SampleRate> The valid sample rates are described in Chapter A.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 366.

*RST: 32 MHz

Manual operation: See "Input Sample Rate" on page 123

10.5.4.2 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 5.3.4.2, "Trigger Settings", on page 124.

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]:BBPower:HOLDoff <Period>

This command defines the holding time before the baseband power trigger event.

The command requires the optional Digital Baseband Interface or the optional Analog Baseband Interface.

Note that this command is maintained for compatibility reasons only. Use the TRIGger[:SEQuence]:IFPower:HOLDoff on page 248 command for new remote control programs.

Parameters:

<Period>	Range:	150 ns to 1000 s
	*RST:	150 ns

Example:
TRIG:SOUR BBP
Sets the baseband power trigger source.
TRIG:BBP:HOLD 200 ns
Sets the holding time to 200 ns.

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

Manual operation: See "Drop-Out Time" on page 129

TRIGger[:SEQuence]:HOLDoff[:TIME] <Offset>

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

Parameters:

<Offset>	*RST: 0 s

Example: `TRIG:HOLD 500us`

Manual operation: See "Trigger Offset" on page 129

TRIGger[:SEQuence]:IFPower:HOLDoff <Period>

This command 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

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 129

TRIGger[:SEQuence]:IFPower:HYSTeresis <Hysteresis>

This command defines the trigger hysteresis, which is only available for "IF Power" trigger sources.

Parameters:

<Hysteresis>	Range: 3 dB to 50 dB *RST: 3 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 129

TRIGger[:SEQuence]:LEVel:BBPower <Level>

This command sets the level of the baseband power trigger.

This command is available for the optional Digital Baseband Interface and the optional Analog Baseband Interface.

Parameters:

<Level>	Range:	-50 dBm to +20 dBm
	*RST:	-20 dBm

Example: `TRIG:LEV:BBP -30DBM`

Manual operation: See "Trigger Level" on page 128

TRIGger[:SEQuence]:LEVel[:EXTernal<port>] <TriggerLevel>

This command defines the level the external signal must exceed to cause a trigger event.

Note that the variable INPUT/OUTPUT connectors (ports 2+3) must be set for use as input using the `OUTPut:TRIGger<port>:DIRection` command.

For details on the trigger source see "Trigger Source Settings" on page 125.

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)
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

Example: `TRIG:LEV 2V`

Manual operation: See "Trigger Level" on page 128

TRIGger[:SEQuence]:LEVel:IFPower <TriggerLevel>

This command 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.

For details on the trigger settings see "Trigger Source Settings" on page 125.

Parameters:

<TriggerLevel>

For details on available trigger levels and trigger bandwidths see the data sheet.

*RST: -10 dBm

Example: `TRIG:LEV:IFP -30DBM`

Manual operation: See "Trigger Level" on page 128

TRIGger[:SEQuence]:LEVel:IQPower <TriggerLevel>

This command 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.

For details on the trigger source see "Trigger Source Settings" on page 125.

Parameters:

<TriggerLevel> Range: -130 dBm to 30 dBm
*RST: -20 dBm

Example: `TRIG:LEV:IQP -30DBM`

Manual operation: See "Trigger Level" on page 128

TRIGger:SEQuence:LEVel:POWer:AUTO <State>

By default, the optimum trigger level for power triggers is automatically measured and determined at the start of each sweep (for Modulation Accuracy, Flatness, Tolerance... measurements).

This function is only considered for `TRIG:SEQ:SOUR IFP` and `TRIG:SEQ:SOUR RFP`, see `TRIGger[:SEQuence]:SOURce` on page 251

In order to define the trigger level manually, switch this function off and define the level using `TRIGger[:SEQuence]:LEVel:IFPower` on page 249 or `TRIGger[:SEQuence]:LEVel:RFPower` on page 250.

Parameters for setting and query:

<State> **OFF**
Switches the auto level detection function off

ON
Switches the auto level detection function on

*RST: ON

Manual operation: See "Trigger Level Mode" on page 128

TRIGger[:SEQuence]:LEVel:RFPower <TriggerLevel>

This command 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.

For details on the trigger source see "Trigger Source Settings" on page 125.

Parameters:

<TriggerLevel> For details on available trigger levels and trigger bandwidths see the data sheet.

*RST: -20 dBm

Example: `TRIG:LEV:RFP -30dBm`

Manual operation: See "Trigger Level" on page 128

TRIGger[:SEQuence]:SLOPe <Type>

For external and time domain trigger sources you can define whether triggering occurs when the signal rises to the trigger level or falls down to it.

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 130

TRIGger[:SEQuence]:SOURce <Source>

This command selects the trigger source.

For details on the available trigger sources see "Trigger Source Settings" on page 125.

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 this situation is avoided in your remote control programs.

Parameters:

<Source>

IMMediate
Free Run

EXTernal
Trigger signal from the TRIGGER INPUT connector.

EXT2
Trigger signal from the TRIGGER INPUT/OUTPUT connector.
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
Not available for input from the optional Digital Baseband Interface or the optional Analog Baseband Interface.

IFPower
Second intermediate frequency
Not available for input from the optional Digital Baseband Interface. For input from the optional Analog Baseband Interface, this parameter is interpreted as `BBPower` for compatibility reasons.

IQPower
Magnitude of sampled I/Q data
For applications that process I/Q data, such as the I/Q Analyzer or optional applications.
Not available for input from the optional Digital Baseband Interface or the optional Analog Baseband Interface.

TIME
Time interval

BBPower
Baseband power (for digital input via the optional Digital Baseband Interface
Baseband power (for digital input via the optional Digital Baseband Interface or the optional Analog Baseband interface

PSEN
External power sensor

GP0 | GP1 | GP2 | GP3 | GP4 | GP5
For applications that process I/Q data, such as the I/Q Analyzer or optional applications, and only if the optional Digital Baseband Interface is available.
Defines triggering of the measurement directly via the LVDS connector. The parameter specifies which general purpose bit (0 to 5) will provide the trigger data.
The assignment of the general purpose bits used by the Digital IQ trigger to the LVDS connector pins is provided in "Digital I/Q" on page 127.

TUNit

If activated, the measurement is triggered by a connected R&S FS-Z11 trigger unit, simultaneously for all connected analyzers.

For details see Chapter 4.9.6, "Trigger Synchronization Using an R&S FS-Z11 Trigger Unit", on page 87.

*RST: IMMediate

Example: `TRIG:SOUR EXT`

Selects the external trigger input as source of the trigger signal

Manual operation:
See "Trigger Source" on page 126
See "Free Run" on page 126
See "External Trigger 1/2/3" on page 126
See "Baseband Power" on page 126
See "Digital I/Q" on page 127
See "RF Power" on page 127
See "I/Q Power" on page 128
See "Power Sensor" on page 128
See "Time" on page 128
See "FS-Z11 Trigger" on page 130

TRIGger[:SEQuence]:TIME:RINTerval <Interval>

This command defines the repetition interval for the time trigger.

Parameters:

<Interval> 2.0 ms to 5000

Range: 2 ms to 5000 s
*RST: 1.0 s

Example: `TRIG:SOUR TIME`

Selects the time trigger input for triggering.

`TRIG:TIME:RINT 50`

The measurement starts every 50 s.

Manual operation: See "Repetition Interval" on page 129

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 R&S FSW.

OUTPut:TRIGger<port>:DIRection <Direction>

This command selects the trigger direction for trigger ports that serve as an input as well as an output.

Suffix:
<port> Selects the used trigger port.
2 = trigger port 2 (front panel)
3 = trigger port 3 (rear panel)

Parameters:
<Direction> **INPut**
Port works as an input.

OUTPut
Port works as an output.

*RST: INPut

Manual operation: See "Trigger 2/3" on page 115

OUTPut:TRIGger<port>:LEVel <Level>

This command defines the level of the (TTL compatible) signal generated at the trigger output.

This command works only if you have selected a user defined output with `OUTPut:TRIGger<port>:OTYPe`.

Suffix:
<port> Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Parameters:
<Level> **HIGH**
5 V

LOW
0 V

*RST: LOW

Example: `OUTP:TRIG2:LEV HIGH`

Manual operation: See "Level" on page 116

OUTPut:TRIGger<port>:OTYPe <OutputType>

This command selects the type of signal generated at the trigger output.

Suffix:
<port> Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Parameters:
<OutputType>

DEVice
Sends a trigger signal when the R&S 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<port>:LEVel`.

*RST: DEVice

Manual operation: See "Output Type" on page 115

OUTPut:TRIGger<port>:PULSe:IMMediate

This command generates a pulse at the trigger output.

Suffix:
<port>
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Usage: Event

Manual operation: See "Send Trigger" on page 116

OUTPut:TRIGger<port>:PULSe:LENGth <Length>

This command defines the length of the pulse generated at the trigger output.

Suffix:
<port>
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Parameters:
<Length> Pulse length in seconds.

Example: `OUTP:TRIG2:PULS:LENG 0.02`

Manual operation: See "Pulse Length" on page 116

10.5.4.3 MIMO Capture Settings

The following commands are **only available for IEEE 802.11ac, n standards**.

Useful commands for defining MIMO capture settings described elsewhere:

- `CALCulate<n>:BURSt[:IMMediate]` on page 310

Remote commands exclusive to defining MIMO capture settings:

CONFigure:WLAN:ANTMatrix:ADDRess<add> <Address>

This remote control command specifies the TCP/IP address for each receiver path in IPV4 format. Note, it is not possible to set the IP address of ANTMatrix1 (Master)

Parameters:

<Address> TCP/IP address in IPV4 format

Manual operation: See "Analyzer IP Address" on page 134

CONFigure:WLAN:ANTMatrix:ANTenna<Analyzer> <Antenna>

This remote control command specifies the antenna assignment of the receive path.

Parameters:

<Antenna> ANTenna1 | ANTenna2 | ANTenna3 | ANTenna4

Antenna assignment of the receiver path

Example:

```
CONF:WLAN:ANTM:ANT2 ANT1
```

Analyzer number 2 measures antenna no. 1

```
CONF:WLAN:ANTM;ANT4 ANT2
```

Analyzer number 42 measures antenna no. 2

Manual operation: See "Assignment" on page 135

CONFigure:WLAN:ANTMatrix:SOURce:ROSCillator:SOURce <Coupling>

This remote control command determines whether the reference frequency for the master and slave devices in a simultaneous MIMO setup are coupled or not.

Parameters:

<Coupling> Coupling mode

AUTO
Slaves set to the same external reference source as master.
Use an R&S Z11 trigger box to send to the same trigger to all devices (see TRIG:SEQ:SOUR TUN.

EXTernal
Slaves' reference source is set to external.
Configure a trigger output from the master (see `OUTPut:TRIGger<port>:OTYPe` on page 254).

OFF
Slaves' reference source is set to internal.

*RST: EXT

Example: `CONF:WLAN:ANTM:SOUR:ROSC:SOUR AUTO`

Manual operation: See "Reference Frequency Coupling" on page 135

CONFigure:WLAN:ANTMatrix:STATe<antenna> <State>

This remote control command specifies the state of the specified antenna. Note, it is not possible to change the state of the first antenna (Master).

Parameters:

<State> ON | OFF

State of the antenna

Manual operation: See "State" on page 134

CONFigure:WLAN:DUTConfig <NoOfAnt>

This remote control command specifies the number of antennas used for MIMO measurement.

Parameters:

<NoOfAnt> TX1 | TX2 | TX3 | TX4 | TX5 | TX6 | TX7 | TX8

TX1: one antenna,
TX2: two antennas etc.

*RST: TX1

Example: `CONF:WLAN:DUTC TX1`

Manual operation: See "DUT MIMO Configuration" on page 133

CONFigure:WLAN:MIMO:CAPTure <SignalPath>

Specifies the signal path to be captured in MIMO sequential manual measurements. Subsequently, use the `INITiate<n>[:IMMediate]` command to start capturing data.

Parameters:

<SignalPath> RX1 | RX2 | RX3 | RX4 | RX5 | RX6 | RX7 | RX8

For details see "Manual Sequential MIMO Data Capture" on page 137.

*RST: RX1

Example:

```
CONFigure:WLAN:MIMO:CAPTure RX2
INIT:IMM
```

Starts capturing data from the receive antenna number 2.

Manual operation: See "Single / Cont." on page 138

CONFigure:WLAN:MIMO:CAPTure:BUFFer <SignalPath>

Specifies the signal path to be captured in MIMO sequential manual measurements and immediately starts capturing data.

Parameters:

<SignalPath> RX1 | RX2 | RX3 | RX4 | RX5 | RX6 | RX7 | RX8

For details see "Manual Sequential MIMO Data Capture" on page 137.

*RST: RX1

Example:

```
CONFigure:WLAN:MIMO:CAPTure:BUFFer RX2
```

Starts capturing data from the receive antenna number 2.

CONFigure:WLAN:MIMO:CAPTure:TYPE <Method>

Specifies the method used to analyze MIMO signals.

Parameters:

<Method> SIMultaneous | OSP | MANual

SIMultaneous
Simultaneous normal MIMO operation

OSP
Sequential using open switch platform

MANual
Sequential using manual operation

*RST: SIM

Manual operation: See "MIMO Antenna Signal Capture Setup" on page 134
See "Manual Sequential MIMO Data Capture" on page 137

CONFigure:WLAN:MIMO:OSP:ADDRess <Address>

Specifies the TCP/IP address of the switch unit to be used for automated sequential MIMO measurements. The supported unit is Rohde & Schwarz OSP 1505.3009.03 with module option 1505.5101.02

Parameters:
<Address>

Manual operation: See "OSP IP Address" on page 136

CONFigure:WLAN:MIMO:OSP:MODule <ID>

Specifies the module of the switch unit to be used for automated sequential MIMO measurements. The supported unit is Rohde & Schwarz OSP 1505.3009.03 with module option 1505.5101.02

Parameters:
<ID> A11 | A12 | A13

Manual operation: See "OSP Switch Bank Configuration" on page 137

CONFigure:WLAN:RSYNc:JOINed <State>

This command configures how PPDU synchronization and tracking is performed for multiple antennas.

Parameters:
<State> ON | OFF

ON
RX antennas are synchronized and tracked together.

OFF
RX antennas are synchronized and tracked separately.

*RST: OFF

Manual operation: See "Joined RX Sync and Tracking" on page 135

10.5.5 Synchronization and OFDM Demodulation

[SENSe:]DEMod:FFT:OFFSet <Mode>

This command specifies the start offset of the FFT for OFDM demodulation (not for the FFT Spectrum display).

Parameters:

<Mode> AUTO | GICenter | PEAK

AUTO
The FFT start offset is automatically chosen to minimize the intersymbol interference.

GICenter
Guard Interval Center: The FFT start offset is placed to the center of the guard interval.

PEAK
The peak of the fine timing metric is used to determine the FFT start offset.

*RST: AUTO

Manual operation: See "FFT Start Offset" on page 140

[SENSe:]DEMod:TXARea <State>

If enabled, the R&S FSW WLAN application initially performs a coarse burst search on the input signal in which increases in the power vs time trace are detected. Further time-consuming processing is then only performed where bursts are assumed. This improves the measurement speed for signals with low duty cycle rates.

However, for signals in which the PPDU power levels differ significantly, this option should be disabled as otherwise some PPDUs may not be detected.

Parameters:

<State> ON | OFF | 0 | 1

ON | 1
A coarse burst search is performed based on the power levels of the input signal.

OFF | 0
No pre-evaluation is performed, the entire signal is processed.

*RST: 1

Manual operation: See "Power Interval Search" on page 139

10.5.6 Tracking and Channel Estimation

[SENSe:]DEMod:CESTimation <State>

This command defines whether channel estimation will be done in preamble and payload or only in preamble. The effect of this is most noticeable for the EVM measurement results, where the results will be improved when this feature is enabled.

However, this functionality is not supported by the IEEE 802.11 standard and must be disabled if the results are to be measured strictly according to the standard.

Parameters:

<State> ON | OFF

ON
The channel estimation is performed in the preamble and the payload. The EVM results can be calculated more accurately.

OFF
The channel estimation is performed in the preamble as required in the standard.

*RST: OFF

Manual operation: See "Channel Estimation Range" on page 141

SENSe:TRACking:CROSstalk <State>

Activates or deactivates the compensation for crosstalk between MIMO carriers.

This command is **only available for standard IEEE 802.11ac or n (MIMO)**.

Parameters:

<State> ON | OFF

*RST: OFF

Example: `SENS:TRAC:CROS ON`

Manual operation: See "Compensate Crosstalk (MIMO only)" on page 143

SENSe:TRACking:IQMComp <State>

Activates or deactivates the compensation for I/Q mismatch (gain imbalance, quadrature offset, I/Q skew, see Chapter 3.1.1.5, "I/Q Mismatch", on page 19).

This setting is **not available for standards IEEE 802.11b and g (DSSS)**.

Parameters:

<State> ON | OFF

ON
Compensation for gain imbalance, quadrature offset, and I/Q skew impairments is applied.

OFF
Compensation is not applied; this setting is required for measurements strictly according to the IEEE 802.11-2012, IEEE 802.11ac-2013 WLAN standard

*RST: OFF

Example: `SENS:TRAC:IQMC ON`

Manual operation: See "I/Q Mismatch Compensation" on page 142

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

*RST: OFF

Example: `SENS:TRAC:LEV ON`

Manual operation: See "Level Error (Gain) Tracking" on page 142

SENSe:TRACking:PHASe <State>

Activates or deactivates the compensation for phase drifts. If activated, the measurement results are compensated for phase drifts on a per-symbol basis.

Parameters:

<State> ON | OFF | 0 | 1

*RST: 1

Example: `SENS:TRAC:PHAS ON`

Manual operation: See "Phase Tracking" on page 142

SENSe:TRACking:PILots <Mode>

In case tracking is used, the used pilot sequence has an effect on the measurement results.

Parameters:

<Mode> STANdard | DETected

STANdard
The pilot sequence is determined according to the corresponding WLAN standard. In case the pilot generation algorithm of the device under test (DUT) has a problem, the non-standard-conform pilot sequence might affect the measurement results, or the WLAN application might not synchronize at all onto the signal generated by the DUT.

DETected
The pilot sequence detected in the WLAN signal to be analyzed is used by the WLAN application. In case the pilot generation algorithm of the device under test (DUT) has a problem, the non-standard-conform pilot sequence will not affect the measurement results. In case the pilot sequence generated by the DUT is correct, it is recommended that you use the "According to Standard" setting because it generates more accurate measurement results.

*RST: STANdard

Example: `SENS:TRAC:PIL DET`

Manual operation: See "Pilots for Tracking" on page 142

SENSe:TRACking:TIME <State>

Activates or deactivates the compensation for timing drift. If activated, the measurement results are compensated for timing error on a per-symbol basis.

Parameters:

<State> ON | OFF | 0 | 1

*RST: 0

Example: `SENS:TRAC:TIME ON`

Manual operation: See "Timing Error Tracking" on page 142

[SENSe] (see also SENSe: commands!)

10.5.7 Demodulation

The demodulation settings define which PPDUs are to be analyzed, thus they define a *logical filter*.

The available demodulation settings vary depending on the selected digital standard (see `CONFigure:STANdard` on page 212).

Manual configuration is described in Chapter 5.3.8, "Demodulation", on page 143.

CONFigure:WLAN:EXTension:AUTO:TYPE <PPDUType>

Defines the PPDUs taking part in the analysis according to the Ness (Extension Spatial Streams) field content (for **IEEE 802.11n** standard only).

Parameters:

<PPDUType> FBURst | ALL | M0 | M1 | M2 | M3 | D0 | D1 | D2 | D3

The first PPDU is analyzed and subsequent PPDUs are analyzed only if they match

FBURst
The Ness field contents of the first PPDU is detected and subsequent PPDUs are analyzed only if they have the same Ness field contents (corresponds to "Auto, same type as first PPDU")

ALL
All recognized PPDUs are analyzed according to their individual Ness field contents (corresponds to "Auto, individually for each PPDU")

M0 | M1 | M2 | M3
Only PPDUs with the specified Ness value are analyzed.

D0 | D1 | D2| D3
All PPDUs are analyzed assuming the specified Ness value.

*RST: FBURst

Example: `CONF:WLAN:EXT:AUTO:TYPE M0`

Manual operation: See "Extension Spatial Streams (sounding)" on page 156

CONFigure:WLAN:GTIMe:AUTO <State>

This remote control command specifies whether the guard time of the input signal is automatically detected or specified manually (**IEEE 802.11n or ac** only).

Parameters:

<State>

ON
The guard time is detected automatically according to `CONFigure:WLAN:GTIMe:AUTO:TYPE` on page 265.

OFF
The guard time is defined by the `CONFigure:WLAN:GTIMe:SELect` command.

*RST: ON

Manual operation: See "Guard Interval Length" on page 150

CONFigure:WLAN:GTIMe:AUTO:TYPE <Type>

This remote control command specifies which PPDUs are analyzed depending on their guard length if automatic detection is used (`CONF:WLAN:GTIM:AUTO ON`, see `CONFigure:WLAN:GTIMe:AUTO` on page 265).

This command is available for **IEEE 802.11 n, ac** standards only.

Note: On previous Rohde & Schwarz signal and spectrum analyzers, this command configured both the guard interval type and the channel bandwidth. On the R&S FSW, this command only configures the guard type. The channel bandwidth of the PPDU to be measured must be configured separately using the `[SENSe:]BANDwidth:CHANnel:AUTO:TYPE` command.

Parameters:

<Type>

FBURst
The Gurad interval length of the first PPDU is detected and subsequent PPDUs are analyzed only if they have the same length (corresponds to "Auto, same type as first PPDU")

ALL
All PPDUs are analyzed regardless of their guard length (corresponds to "Auto, individually for each PPDU").

MS
Only PPDUs with short guard interval length are analyzed. (corresponds to "Meas only Short" in manual operation; MN8 | MN16 parameters in previous Rohde & Schwarz signal and spectrum analyzers)

ML
Only PPDUs with long guard interval length are analyzed. (corresponds to "Meas only Long" in manual operation; ML16 | ML32 parameters in previous Rohde & Schwarz signal and spectrum analyzers)

DS
All PPDUs are demodulated assuming short guard interval length.
(corresponds to "Demod all as short" in manual operation; DN8 | DN16 parameters in previous Rohde & Schwarz signal and spectrum analyzers)

DL
All PPDUs are demodulated assuming long guard interval length.
(corresponds to "Demod all as long" in manual operation; DL16 | DL32 parameters in previous Rohde & Schwarz signal and spectrum analyzers)

*RST: 'ALL'

Example: `CONF:WLAN:GTIM:AUTO:TYPE DL`

Manual operation: See "Guard Interval Length" on page 150

CONFigure:WLAN:GTIMe:SELect <GuardTime>

This remote control command specifies the guard time the PPDUs in the **IEEE 802.11n or ac** input signal should have. If the guard time is specified to be detected from the input signal using the `CONFigure:WLAN:GTIMe:AUTO` command then this command is query only and allows the detected guard time to be obtained.

Parameters:

<GuardTime> SHORt | NORMal

SHORt
Only the PPDUs with short guard interval are analyzed.

NORMal
Only the PPDUs with long guard interval are analyzed.
("Long" in manual operation)

*RST: NORMal

Example: `CONF:WLAN:GTIM:SEL SHOR`

Manual operation: See "Guard Interval Length" on page 150

CONFigure:WLAN:SMAPping:MODE <Mode>

This remote control command specifies the special mapping mode.

Parameters:

<Mode> DIRect | SEXPansion | USER

DIRect
direct

SEXPansion
expansion

USER
user defined

Manual operation: See "Spatial Mapping Mode" on page 157

CONFigure:WLAN:SMAPping:NORMalise <State>

This remote control command specifies whether an amplification of the signal power due to the spatial mapping is performed according to the matrix entries. If this command it set to ON then the spatial mapping matrix is scaled by a constant factor to obtain a passive spatial mapping matrix which does not increase the total transmitted power. If this command is set to OFF the normalization step is omitted.

Parameters:

<State>

Manual operation: See "Power Normalise" on page 158

CONFigure:WLAN:SMAPping:TX<ch> <STS I>, <STS Q>{<STS I>,<STS Q>},<TimeShift>

This remote control command specifies the mapping for all streams (real & imaginary data pairs) and timeshift for a specified antenna.

Parameters:

<STS I> Imag part of the complex element of the STS-Stream

<STS Q> Real part of the complex element of the STS-Stream

<TimeShift> Time shift for specification of user defined CSD (cyclic delay diversity) for the Spatial Mapping.

Range: -32 ns to 32 ns
Default unit: ns

Example: `CONF:WLAN:SMAP:TX 1.0,1.0,2.0,2.0,3.0,3.0,4.0,4.0,1e-9`

Manual operation: See "User Defined Spatial Mapping" on page 158

CONFigure:WLAN:SMAPping:TX<ch>:STReam<stream> <STS I>, <STS Q>

This remote control command specifies the mapping for a specific stream and antenna.

Parameters:

<STS I> Imag part of the complex element of the STS-Stream

<STS Q> Real part of the complex element of the STS-Stream

Example: `CONF:WLAN:SMAP:TX4:STR1 1.0,1.0`

Manual operation: See "User Defined Spatial Mapping" on page 158

CONFigure:WLAN:SMAPping:TX<ch>:TIMeshift <TimeShift>

This remote control command specifies the timeshift for a specific antenna.

Parameters:

<TimeShift> Time shift (in s) for specification of user defined CSD (cyclic delay diversity) for the Spatial Mapping.

Range: -32 ns to 32 ns

Manual operation: See "User Defined Spatial Mapping" on page 158

CONFigure:WLAN:STBC:AUTO:TYPE <PPDUType>

This remote control command specifies which PPDUs are analyzed according to STBC streams (for **IEEE 802.11n, ac** standards only).

Parameters:

<PPDUType> FBURst | ALL | M0 | M1 | M2 | D0 | D1 | D2

FBURst
The STBC of the first PPDU is detected and subsequent PPDUs are analyzed only if they have the same STBC (corresponds to "Auto, same type as first PPDU")

ALL
All recognized PPDUs are analyzed according to their individual STBC (corresponds to "Auto, individually for each PPDU")

M0 | M1 | M2
Measure only if STBC field = 0 | 1 | 2
For details see "STBC Field" on page 150

D0 | D1 | D2
Demod all as STBC field = 0 | 1 | 2
For details see "STBC Field" on page 150

Example: `CONF:WLAN:STBC:AUTO:TYPE M0`

Manual operation: See "STBC Field" on page 150

[SENSe:]BANDwidth:CHANnel:AUTO:TYPE <Bandwidth>

This remote control command specifies the bandwidth in which the PPDUs are analyzed.

This command is only available for standards **IEEE 802.11a, ac, n**.

Note that channel bandwidths larger than 10 MHz require a bandwidth extension option on the R&S FSW, see Chapter A.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 366.

Parameters:

<Bandwidth> FBURst | ALL | MB5 | MB10 | MB20 | MB40 | MB80 | MB160 | DB5 | DB10 | DB20 | DB40 | DB80 | DB160

FBURSt
The channel bandwidth of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same channel bandwidth (corresponds to "Auto, same type as first PPDU")

ALL
All PPDUs are analyzed regardless of the channel bandwidth (corresponds to "Auto, individually for each PPDU")

MB5
Only PPDUs within a channel bandwidth of 5MHz are analyzed (**IEEE 802.11 a, p only**)

MB10
Only PPDUs within a channel bandwidth of 10MHz are analyzed (**IEEE 802.11 a, p only**)

MB20
Only PPDUs within a channel bandwidth of 20MHz are analyzed

MB40
Only PPDUs within a channel bandwidth of 40MHz are analyzed (**IEEE 802.11 n, ac only**)

MB80
Only PPDUs within a channel bandwidth of 80MHz are analyzed (**IEEE 802.11 ac only**)

MB160
Only PPDUs within a channel bandwidth of 160MHz are analyzed
(**IEEE 802.11 ac only**)

DB5
All PPDUs are analyzed within a channel bandwidth of 5MHz (**IEEE 802.11 a, p only**)

DB10
All PPDUs are analyzed within a channel bandwidth of 10MHz (**IEEE 802.11 a, p only**)

DB20
All PPDUs are analyzed within a channel bandwidth of 20MHz

DB40
All PPDUs are analyzed within a channel bandwidth of 40MHz (**IEEE 802.11 n, ac only**)

DB80
All PPDUs are analyzed within a channel bandwidth of 80MHz (**IEEE 802.11 n, ac only**)

DB160
All PPDUs are analyzed within a channel bandwidth of 160MHz

(**IEEE 802.11 n, ac only**)

*RST: FBURst

Example: `SENS:BAND:CHAN:AUTO:TYPE MB20`

Manual operation: See "Channel Bandwidth to measure (CBW)" on page 145

[SENSe:]DEMod:FORMat:BANalyze <Format>

Specifies which PSDUs are to be analyzed depending on their modulation. Only PSDUs using the selected modulation are considered in result analysis.

Note: to analyze all PPDUs that are identical to the first detected PPDU (corresponds to "Auto, same type as first PPDU"), use the command:
`SENS:DEMO:FORM:BANA:BTYP:AUTO:TYPE FBUR`.

To analyze all PPDUs regardless of their format and modulation (corresponds to "Auto, individually for each PPDU") , use the command:
`SENS:DEMO:FORM:BANA:BTYP:AUTO:TYPE ALL`.

See `[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE` on page 273.

Parameters:

<Format> *RST: QAM64

Example: `SENS:DEMO:FORM:BAN 'BPSK6'`

Manual operation: See "PPDU Format to measure" on page 144
See "PSDU Modulation to use" on page 145
See "PSDU Modulation" on page 146
See "PPDU Format to measure / PSDU Modulation to use" on page 152
See "PPDU Format" on page 152

Table 10-4: Modulation format parameters for IEEE 802.11a, g (OFDM), j, p standard

SCPI parameter	Dialog parameter
BPSK6	BPSK 1/2
BPSK9	BPSK 3/4
QPSK12	QPSK 1/2
QPSK18	QPSK 3/4
QAM1624	16-QAM 1/2
QAM1636	16-QAM 3/4
QAM6448	64-QAM 2/3
QAM6454	64-QAM 3/4

Table 10-5: Modulation format parameters for IEEE 802.11b or g (DSSS) standard

SCPI parameter	Dialog parameter
CCK11	Complementary Code Keying at 11 Mbps
CCK55	Complementary Code Keying at 5.5 Mbps
DBPSK1	Differential BI-Phase shift keying
DQPSK2	Differential Quadrature phase shift keying
PBCC11	PBCC at 11 Mbps
PBCC22	PBCC at 11 Mbps
PBCC55	PBCC at 5.5 Mbps

Table 10-6: Modulation format parameters for IEEE 802.11n standard

SCPI parameter	Dialog parameter
BPSK65	BI-Phase shift keying at 6.5 Mbps
BPSK72	BI-Phase shift keying at 7.2 Mbps
QAM1626	Quadrature Amplitude Modulation at 26 Mbps
QAM1639	Quadrature Amplitude Modulation at 39 Mbps
QAM16289	Quadrature Amplitude Modulation at 28.9 Mbps
QAM16433	Quadrature Amplitude Modulation at 43.3 Mbps
QAM6452	Quadrature Amplitude Modulation at 52 Mbps
QAM6465	Quadrature Amplitude Modulation at 65 Mbps
QAM16289	Quadrature Amplitude Modulation at 28.9 Mbps
QAM16433	Quadrature Amplitude Modulation at 43.3 Mbps
QAM64578	Quadrature Amplitude Modulation at 57.8 Mbps
QAM64585	Quadrature Amplitude Modulation at 58.5 Mbps
QAM64722	Quadrature Amplitude Modulation at 72.2 Mbps
QPSK13	Quadrature phase shift keying at 13 Mbps
QPSK144	Quadrature phase shift keying at 14.4 Mbps
QPSK195	Quadrature phase shift keying at 19.5 Mbps
QPSK217	Quadrature phase shift keying at 21.7 Mbps

[SENSe:]DEMod:FORMat:BANalyze:BTYPe <PPDUType>

This remote control command specifies the type of PPDU to be analyzed. Only PPDUs of the specified type take part in measurement analysis.

Parameters:

<PPDUType>

'LONG'
Only long (DSSS) PLCP PPDUs are analyzed.
Available for IEEE 802.11b, g.

'SHORT'
Only short (DSSS) PLCP PPDUs are analyzed.
Available for IEEE 802.11b, g.

'OFDM'
Only OFDM PPDUs are analyzed.
Available for IEEE 802.11g.

'MM20'
IEEE 802.11n, Mixed Mode, 20 MHz sample rate
Note that this setting is maintained for compatibility reasons only. Use the specified commands for new remote control programs (see [SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE on page 273 and [SENSe:]BANDwidth:CHANnel:AUTO:TYPE on page 269).
For new programs use:
`[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE MMIX`
`[SENSe:]BANDwidth:CHANnel:AUTO:TYPE MB20`

'GFM20'
IEEE 802.11n Green Field Mode, 20 MHz sample rate
Note that this setting is maintained for compatibility reasons only. Use the specified commands for new remote control programs (see [SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE on page 273 and [SENSe:]BANDwidth:CHANnel:AUTO:TYPE on page 269).
For new programs use:
`[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE MGRF`
`[SENSe:]BANDwidth:CHANnel:AUTO:TYPE MB20`

Example: Select IEEE 802.11g OFDM standard:

```
CONF:STAN 4
SENS:DEM:FORM:BAN:BTYP 'OFDM'
```

Manual operation: See "PPDU Format" on page 152

[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE <Analysis>

This remote control command specifies how signals are analyzed.

Parameters:

<Analysis>

FBURst | ALL | MMIX | MGRF | DMIX | DGRF | MVHT | DVHT | MNHT | DNHT

FBURst
The format of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same format (corresponds to "Auto, same type as first PPDU")

ALL
All PPDUs are analyzed regardless of their format (corresponds to "Auto, individually for each PPDU")

MNHT
Only PPDUs with format "Non-HT" are analyzed
IEEE 802.11a, g (OFDM), p

DNHT
All PPDUs are assumed to have the PPDU format "Non-HT"
IEEE 802.11a, g (OFDM), p

MMIX
Only PPDUs with format "HT-MF" (Mixed) are analyzed
(IEEE 802.11 n)

MGRF
Only PPDUs with format "HT-GF" (Greenfield) are analyzed
(IEEE 802.11 n)

DMIX
All PPDUs are assumed to have the PPDU format "HT-MF"
(IEEE 802.11 n)

DGRF
All PPDUs are assumed to have the PPDU format "HT-GF"
(IEEE 802.11 n)

MVHT
Only PPDUs with format "VHT" are analyzed
(IEEE 802.11 ac)

DVHT
All PPDUs are assumed to have the PPDU format "VHT"
(IEEE 802.11 ac)

FMMM
Only PPDUs with specified format are analyzed (see `[SENSe:]DEMod:FORMat:BANalyze` on page 271)
(IEEE 802.11 b, g (DSSS))

FMMD
All PPDUs are assumed to have the specified PPDU format (see `[SENSe:]DEMod:FORMat:BANalyze` on page 271)
(IEEE 802.11 b, g (DSSS))

*RST: FBURst

Example: `SENS:DEM:FORM:BAN:BTYP:AUTO:TYPE FBUR`

Manual operation: See "PPDU Format to measure" on page 144
See "PSDU Modulation to use" on page 145
See "PPDU Format to measure / PSDU Modulation to use" on page 152

[SENSe:]DEMod:FORMat[:BCONtent]:AUTO <State>

This command determines whether the PPDUs to be analyzed are determined automatically or by the user.

Parameters:

<State>

ON
The signal field, i.e. the PLCP header field, of the first recognized PPDU is analyzed to determine the details of the PPDU. All PPDUs identical to the first recognized PPDU are analyzed.

OFF
Only PPDUs that match the user-defined PPDU type and modulation are considered in results analysis (see `[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE` on page 273 and `[SENSe:]DEMod:FORMat:BANalyze` on page 271).

Manual operation: See "PPDU Analysis Mode" on page 144

[SENSe:]DEMod:FORMat:MCSindex <Index>

This command specifies the MCS index which controls the data rate, modulation and streams (for **IEEE 802.11n, ac** standards only, see document: IEEE 802.11n/D11.0 June 2009).

This command is required if `[SENSe:]DEMod:FORMat:MCSindex:MODE` is set to `MEAS` or `DEM`.

Parameters:

<Index> *RST: 1

Example:

```
SENS:DEM:FORM:MCS:MODE MEAS
SENS:DEM:FORM:MCS 1
```

Manual operation: See "MCS Index" on page 149

[SENSe:]DEMod:FORMat:MCSindex:MODE <Mode>

This command defines the PPDUs taking part in the analysis depending on their Modulation and Coding Scheme (MCS) index (for **IEEE 802.11n, ac** standards only).

Parameters:
<Mode> FBURst | ALL | MEASure | DEMod

FBURst
The MCS index of the first PPDU is detected and subsequent PPDUs are analyzed only if they have the same MCS index (corresponds to "Auto, same type as first PPDU")

ALL
All recognized PPDUs are analyzed according to their individual MCS indexes (corresponds to "Auto, individually for each PPDU")

MEASure
Only PPDUs with an MCS index which matches that specified by `[SENSe:]DEMod:FORMat:MCSindex` are analyzed

DEMod
All PPDUs will be analyzed according to the MCS index specified by `[SENSe:]DEMod:FORMat:MCSindex`.

*RST: FBURst

Example:
```
SENS:DEM:FORM:MCS:MODE MEAS
SENS:DEM:FORM:MCS 1
```

Manual operation: See "MCS Index to use" on page 149

[SENSe:]DEMod:FORMat:NSTSindex <Index>

Defines the PPDUs taking part in the analysis depending on their Nsts.

This command is only available for the **IEEE 802.11 ac** standard.

This command is available for `DEM:FORM:NSTS:MODE MEAS` or `DEM:FORM:NSTS:MODE DEM` (see `[SENSe:]DEMod:FORMat:NSTSindex:MODE` on page 276).

Parameters:
<Index>

Example:
```
SENS:DEM:FORM:NSTS:MODE MEAS
SENS:DEM:FORM:NSTS 1
```

Manual operation: See "Nsts" on page 150

[SENSe:]DEMod:FORMat:NSTSindex:MODE <Mode>

Defines the PPDUs taking part in the analysis depending on their Nsts.

This command is only available for the **IEEE 802.11 ac** standard.

Parameters:

<Mode> FBURst | ALL | MEASure | DEMod

FBURst
The Nsts of the first PPDU is detected and subsequent PPDUs are analyzed only if they have the same Nsts (corresponds to "Auto, same type as first PPDU")

ALL
All recognized PPDUs are analyzed according to their individual Nsts (corresponds to "Auto, individually for each PPDU")

MEASure
Only PPDUs with the Nsts specified by `[SENSe:]DEMod:FORMat:NSTSindex` are analyzed

DEMod
The "Nsts" index specified by `[SENSe:]DEMod:FORMat:NSTSindex`is used for all PPDUs.

*RST: FBURst

Example:
```
SENS:DEM:FORM:NSTS:MODE MEAS
SENS:DEM:FORM:NSTS 1
```

Manual operation: See "Nsts to use" on page 149

[SENSe:]DEMod:FORMat:SIGSymbol <State>

Activates and deactivates signal symbol field decoding.

For IEEE 802.11b this command can only be queried as the decoding of the signal field is always performed for this standard.

Parameters for setting and query:

<State> **OFF**
Deactivates signal symbol field decoding. All PPDUs are assumed to have the specified PPDU format / PSDU modulation, regardless of the actual format or modulation.

ON
If activated, the signal symbol field of the PPDU is analyzed to determine the details of the PPDU. Only PPDUs which match the PPDU type/ PSDU modulation defined by `[SENSe:]DEMod:FORMat:BANalyze` and `[SENSe:]DEMod:FORMat:BANalyze:BTYPe` are considered in results analysis.

*RST: OFF

Example:
```
DEM:FORM:SIGS ON
```

Manual operation: See "PPDU Format to measure / PSDU Modulation to use" on page 152

10.5.8 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.

CONFigure:BURSt:PVT:AVERage <Value>

Defines the number of samples used to adjust the length of the smoothing filter for PVT measurement.

This command is **only** available for **IEEE 802.11b, g (DSSS)** standards.

Parameters:
<Value>

Manual operation: See "PVT : Average Length" on page 162

CONFigure:BURSt:PVT:RPOWer <Mode>

This remote control command configures the use of either mean or maximum PPDU power as a reference power for the 802.11b, g (DSSS) PVT measurement.

Parameters:
<Mode> MEAN | MAXimum

Manual operation: See "PVT : Reference Power" on page 163

CONFigure:WLAN:PAYLoad:LENGth:SRC <Source>

Defines which payload length is used to determine the minimum or maximum number of required data symbols (**IEEE 802.11n, ac**).

Parameters:
<Source> ESTimate | HTSignal

ESTimate
Uses a length estimated from the input signal

HTSignal
(**IEEE811.02 n**)
Determines the length of the HT signal (from the signal field)

LSIGnal
(**IEEE811.02 ac**)
Determines the length of the L signal (from the signal field)

Manual operation: See "Source of Payload Length" on page 160

CONFigure:WLAN:PVERror:MRANge? <Range>

This remote control command queries whether the Peak Vector Error results are calculated over the complete PPDU or just over the PSDU.

This command is supported for **802.11b and 802.11g (DSSS)** only.

Return values:
<Range> ALL | PSDU

ALL
Peak Vector Error results are calculated over the complete PPDU

PSDU
Peak Vector Error results are calculated over the PSDU only

Usage: Query only

Manual operation: See "Peak Vector Error : Meas Range" on page 163

[SENSe:]BURSt:COUNt <Value>

If the statistic count is enabled (see `[SENSe:]BURSt:COUNt:STATe` on page 280), 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> *RST: 1

Example:
```
SENS:BURS:COUN:STAT ON
SENS:BURS:COUN 10
```

Manual operation: See "PPDU Statistic Count / No of PPDUs to Analyze" on page 160

[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

*RST: OFF

Example:
```
SENS:BURS:COUN:STAT ON
SENS:BURS:COUN 10
```

Manual operation: See "PPDU Statistic Count / No of PPDUs to Analyze" on page 160

[SENSe:]BURSt:SELect <Value>

If single PPDU analysis is enabled (see [SENSe:]BURSt:SELect:STATe on page 280), the WLAN 802.11 I/Q results are based on the specified PPDU.

If disabled, all detected PPDUs in the current capture buffer are evaluated.

Parameters:

<Value> *RST: 1

Example:
```
SENS:BURS:SEL:STAT ON
SENS:BURS:SEL 2
```
Results are based on the PPDU number 2 only.

Manual operation: See "Analyze this PPDU / PPDU to Analyze" on page 159

[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 WLAN 802.11 I/Q results are based on one individual PPDU only, namely the defined using [SENSe:]BURSt:SELect on page 280. 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 "Analyze this PPDU / PPDU to Analyze" on page 159

[SENSe:]DEMod:FORMat:BANalyze:DBYTes:EQUal <State>

For **IEEE 802.11b and g (DSSS)** signals only:

If **enabled**, only PPDUs with a **specific** payload length are considered for measurement analysis.

If **disabled**, only PPDUs whose length is within a specified **range** are considered.

The payload length is specified by the `[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MIN` command.

A payload length **range** is defined as a minimum and maximum number of symbols the payload may contain (see `[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MAX` on page 281 and `[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MIN`).

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

Manual operation: See "Equal PPDU Length" on page 160

[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MAX <NumDataBytes>

If the `[SENSe:]DEMod:FORMat:BANalyze:DBYTes:EQUal` command is set to **false**, this command specifies the maximum number of data bytes allowed for a PPDU to take part in measurement analysis.

If the `[SENSe:]DEMod:FORMat:BANalyze:DBYTes:EQUal` command is set to **true**, then this command has no effect.

Parameters:
<NumDataBytes> *RST: 64
Default unit: bytes

Manual operation: See "(Min./Max.) Payload Length" on page 162

[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MIN <NumDataBytes>

For **IEEE 802.11b and g (DSSS)** signals only:

If the `[SENSe:]DEMod:FORMat:BANalyze:DBYTes:EQUal` command is set to **true**, then this command specifies the exact number of data bytes a PPDU must have to take part in measurement analysis.

If the `[SENSe:]DEMod:FORMat:BANalyze:DBYTes:EQUal` command is set to **false**, this command specifies the minimum number of data bytes required for a PPDU to take part in measurement analysis.

Parameters:
<NumDataBytes> *RST: 1
Default unit: bytes

Manual operation: See "(Min./Max.) Payload Length" on page 162

[SENSe:]DEMod:FORMat:BANalyze:DURation:EQUal <State>

For **IEEE 802.11b and g (DSSS)** signals only:

If **enabled**, only PPDUs with a **specific** duration are considered for measurement analysis.

If **disabled**, only PPDUs whose duration is within a specified **range** are considered.

The duration is specified by the `[SENSe:]DEMod:FORMat:BANalyze:DURation:MIN` command.

A duration **range** is defined as a minimum and maximum duration the PPDU may have (see `[SENSe:]DEMod:FORMat:BANalyze:DURation:MAX` and `[SENSe:]DEMod:FORMat:BANalyze:DURation:MIN`).

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

Manual operation: See "Equal PPDU Length" on page 160

[SENSe:]DEMod:FORMat:BANalyze:DURation:MAX <Duration>

For **IEEE 802.11b and g (DSSS)** signals only:

If the `[SENSe:]DEMod:FORMat:BANalyze:DURation:EQUal` command is set to **false**, this command specifies the maximum number of symbols allowed for a PPDU to take part in measurement analysis.

If the `[SENSe:]DEMod:FORMat:BANalyze:DURation:EQUal` command is set to **true**, then this command has no effect.

Parameters:
<Duration> *RST: 5464
Default unit: us

Manual operation: See "(Min./Max.) Payload Length" on page 162

[SENSe:]DEMod:FORMat:BANalyze:DURation:MIN <Duration>

For **IEEE 802.11b and g (DSSS)** signals only:

If the `[SENSe:]DEMod:FORMat:BANalyze:DURation:EQUal` command is set to **true** then this command specifies the **exact** duration required for a PPDU to take part in measurement analysis.

If the [SENSe:]DEMod:FORMat:BANalyze:DURation:EQUal command is set to **false** this command specifies the **minimum** duration required for a PPDU to take part in measurement analysis.

Parameters:

<Duration>	*RST: 1 Default unit: us

Manual operation: See "(Min./Max.) Payload Length" on page 162

[SENSe:]DEMod:FORMat:BANalyze:SYMBols:EQUal <State>

For **IEEE 802.11a, ac, g (OFDM), j, n, p** signals only:

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 283 and [SENSe:]DEMod:FORMat:BANalyze:SYMBols:MIN on page 284).

Parameters:

<State>	ON | OFF *RST: OFF

Manual operation: See "Equal PPDU Length" on page 160

[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MAX <NumDataSymbols>

For **IEEE 802.11a, ac, g (OFDM), j, n, p** signals only:

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>	*RST: 64

Manual operation: See "(Min./Max.) No. of Data Symbols" on page 160

[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MIN <NumDataSymbols>

For **IEEE 802.11a, ac, g (OFDM), j, n, p** signals only:

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> *RST: 1

Example:
```
SENS:DEM:FORM:BAN:SYMB:EQU ON
SENS:DEMO:FORM:BANA:SYMB:MIN
```

Manual operation: See "(Min./Max.) No. of Data Symbols" on page 160

10.5.9 Limits

The following commands are required to define the limits against which the individual parameter results are checked. Principally, the limits are defined in the WLAN 802.11 standards. However, you can change the limits for your own test cases and reset the limits to the standard values later. Note that changing limits is currently only possible via remote control, not manually via the user interface.

The commands required to retrieve the limit check results are described in Chapter 10.9.1.3, "Limit Check Results", on page 326.

Useful commands for defining limits described elsewhere:

- `UNIT:EVM` on page 325
- `UNIT:GIMBalance` on page 326

Remote commands exclusive to defining limits:

CALCulate:LIMit:BURSt:ALL <Limits>

This command sets or returns the limit values for the parameters determined by the default WLAN measurement all in one step.

(see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13).

To define individual limit values use the individual `CALCulate<n>:LIMit<k>:BURSt...` commands.

Note that the units for the EVM and gain imbalance parameters must be defined in advance using the following commands:

- `UNIT:EVM` on page 325
- `UNIT:GIMBalance` on page 326

Parameters:

<Limits> The parameters are input or output as a list of (ASCII) values separated by ',' in the following order:
<average CF error>, <max CF error>, <average symbol clock error>, <max symbol clock error>, <average I/Q offset>, <maximum I/Q offset>, <average EVM all carriers>, <max EVM all carriers>, <average EVM data carriers>, <max EVM data carriers> <average EVM pilots>, <max EVM pilots>

CALCulate:LIMit:BURSt:EVM:ALL[:AVERage] <Limit>
CALCulate:LIMit:BURSt:EVM:ALL:MAXimum <Limit>

This command sets or queries the average or maximum error vector magnitude limit for all carriers as determined by the default WLAN measurement.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Parameters:

<Limit> numeric value in dB
The unit for the EVM parameters can be changed in advance using `UNIT:EVM` on page 325.
Default unit: DB

CALCulate:LIMit:BURSt:EVM:DATA[:AVERage] <Limit>
CALCulate:LIMit:BURSt:EVM:DATA:MAXimum <Limit>

This command sets or queries the average or maximum error vector magnitude limit for the data carrier determined by the default WLAN measurement.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Parameters:

<Limit> numeric value in dB
The unit for the EVM parameters can be changed in advance using `UNIT:EVM` on page 325.
Default unit: DB

CALCulate:LIMit:BURSt:EVM:PILot[:AVERage] <Limit>
CALCulate:LIMit:BURSt:EVM:PILot:MAXimum <Limit>

This command sets or queries the average or maximum error vector magnitude limit for the pilot carriers determined by the default WLAN measurement.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Parameters:

<Limit> numeric value in dB
The unit for the EVM parameters can be changed in advance using `UNIT:EVM` on page 325.
Default unit: DB

CALCulate:LIMit:BURSt:FERRor[:AVERage] <Limit>
CALCulate:LIMit:BURSt:FERRor:MAXimum <Limit>

This command sets or queries the average or maximum center frequency error limit determined by the default WLAN measurement.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Parameters:

<Limit> numeric value in Hertz
Default unit: HZ

CALCulate:LIMit:BURSt:IQOFfset[:AVERage] <Limit>
CALCulate:LIMit:BURSt:IQOFfset:MAXimum <Limit>

This command sets or queries the average or maximum I/Q offset error limit determined by the default WLAN measurement..

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Parameters:

<Limit> Range: -1000000 to 1000000
Default unit: DB

CALCulate:LIMit:BURSt:SYMBolerror[:AVERage] <Limit>
CALCulate:LIMit:BURSt:SYMBolerror:MAXimum <Limit>

This command sets or queries the average or maximum symbol clock error limit determined by the default WLAN measurement.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Parameters:

<Limit> numeric value in parts per million

Default unit: PPM

10.5.10 Automatic Settings

MSRA operating mode

In MSRA operating mode, the following commands are not available, as they require a new data acquisition. However, WLAN 802.11 slave applications cannot perform data acquisition in MSRA operating mode.

Useful commands for automatic configuration described elsewhere:

- `CONFigure:POWer:AUTO` on page 240
- `CONFigure:POWer:AUTO:SWEep:TIME` on page 240

Remote commands exclusive to automatic configuration:

[SENSe:]ADJust:LEVel

This command initiates a single (internal) measurement that evaluates and sets the ideal reference level for the current input data and measurement settings. This ensures that the settings of the RF attenuation and the reference level are optimally adjusted to the signal level without overloading the R&S FSW or limiting the dynamic range by an S/N ratio that is too small.

Example: `ADJ:LEV`

Usage: Event

Manual operation: See "Setting the Reference Level Automatically (Auto Level)" on page 171

10.5.11 Configuring the Slave Application Data Range (MSRA mode only)

In MSRA operating mode, only the MSRA Master actually captures data; the MSRA slave applications define an extract of the captured data for analysis, referred to as the **slave application data**.

For the R&S FSW WLAN application, the slave application data range is defined by the same commands used to define the signal capture in Signal and Spectrum Analyzer mode (see Chapter 10.5.4, "Signal Capturing", on page 244). Be sure to select the correct measurement channel before executing this command.

In addition, a capture offset can be defined, i.e. an offset from the start of the captured data to the start of the slave application data for the WLAN I/Q measurement.

The **analysis interval** used by the individual result displays cannot be edited, but is determined automatically. However, you can query the currently used analysis interval for a specific window.

The **analysis line** is displayed by default but can be hidden or re-positioned.

Remote commands exclusive to MSRA slave applications

The following commands are only available for MSRA slave application channels:

CALCulate<n>:MSRA:ALINe:SHOW

This command defines whether or not the analysis line is displayed in all time-based windows in all MSRA slave applications and the MSRA Master.

Note: even if the analysis line display is off, the indication whether or not the currently defined line position lies within the analysis interval of the active slave application remains in the window title bars.

Suffix:

<n>	irrelevant

Parameters:

<State>	ON | OFF
	*RST: ON

CALCulate<n>:MSRA:ALINe[:VALue] <Position>

This command defines the position of the analysis line for all time-based windows in all MSRA slave applications and the MSRA Master.

Suffix:

<n>	irrelevant

Parameters:

<Position>	Position of the analysis line in seconds. The position must lie within the measurement time of the MSRA measurement.
	Default unit: s

CALCulate<n>:MSRA:WINDow<n>:IVAL?

This command queries the analysis interval for the window specified by the WINDow suffix <n> (the CALC suffix is irrelevant). This command is only available in slave application measurement channels, not the MSRA View or MSRA Master.

Suffix:

<n> Window

Return values:

<IntStart> Start value of the analysis interval in seconds
Default unit: s

<IntStop> Stop value of the analysis interval in seconds

Usage: Query only

INITiate<n>:REFResh

This function is only available if the Sequencer is deactivated (`SYSTem:SEQuencer` SYST:SEQ:OFF) and only for slave applications in MSRA mode, not the MSRA Master.

The data in the capture buffer is re-evaluated by the currently active slave application only. The results for any other slave applications remain unchanged.

Suffix:

<n> irrelevant

Example:
`SYST:SEQ:OFF`
Deactivates the scheduler
`INIT:CONT OFF`
Switches to single sweep mode.
`INIT;*WAI`
Starts a new data measurement and waits for the end of the sweep.
`INST:SEL 'IQ ANALYZER'`
Selects the IQ Analyzer channel.
`INIT:REFR`
Refreshes the display for the I/Q Analyzer channel.

Usage: Event

Manual operation: See "Refresh (MSRA only)" on page 172

[SENSe:]MSRA:CAPTure:OFFSet <Offset>

This setting is only available for slave applications in MSRA mode, not for the MSRA Master. It has a similar effect as the trigger offset in other measurements.

Parameters:

<Offset> This parameter defines the time offset between the capture buffer start and the start of the extracted slave application data. The offset must be a positive value, as the slave application can only analyze data that is contained in the capture buffer.

Range: 0 to <Record length>
*RST: 0

Manual operation: See "Capture Offset" on page 123

10.6 Configuring Frequency Sweep Measurements on WLAN 802.11 Signals

The R&S FSW WLAN application uses the functionality of the R&S FSW base system (Spectrum application, see the R&S FSW User Manual) to perform the WLAN frequency sweep measurements. The R&S FSW WLAN application automatically sets the parameters to predefined settings as described in Chapter 5.4, "Frequency Sweep Measurements", on page 172.

The WLAN RF measurements must be activated for a measurement channel in the R&S FSW WLAN application, see Chapter 10.3, "Activating WLAN 802.11 Measurements", on page 200.

For details on configuring these RF measurements in a remote environment, see the Remote Commands chapter of the R&S FSW User Manual.

Remote commands exclusive to SEM measurements in the R&S FSW WLAN application:

[SENSe:]POWer:SEM <Type>

This command sets the Spectrum Emission Mask (SEM) measurement type.

Parameters:

<Type> 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 360.

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 10-7: 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 Figure 20-17—Transmit spectral mask for 20 MHz transmission	IEEE or 'IEEE_2009_20_2_4'
IEEE 802.11n-2009 40M@2.4G	IEEE Std 802.11n™-2009 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 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 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 Figure 20-17—Transmit spectral mask for 20 MHz transmission IEEE Draft P802.11-REVmb™/D8.0, March 2011 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 Figure 20-18—Transmit spectral mask for a 40 MHz channel IEEE Draft P802.11-REVmb™/D8.0, March 2011 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 Figure 19-19—Transmit spectral mask for 20 MHz transmission in the 5 GHz band	'IEEE_D08_20_5'

Manual operation	The spectrum emission mask measurement is performed according to the standard	Parameter value
IEEE 802.11mb/D08 40M@5G	IEEE Draft P802.11-REVmb™/D8.0, March 2011 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 Figure 22-17—Transmit spectral mask for a 20 MHz channel	'IEEE_AC_D1_1_20_5'
IEEE 802.11ac/D1.1 40M@5G	IEEE P802.11ac™/D1.1, August 2011 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 Figure 22-19—Transmit spectral mask for a 80 MHz channel	'IEEE_AC_D1_1_80_5'

[SENSe:]POWer:SEM:CLASs <Index>

This command 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 combo box, within the SEM settings configuration page.

Parameters:
<Index> *RST: 0

10.7 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 5.2, "Display Configuration", on page 92.

The suffix <n> in the following remote commands represents the window (1..16) in the currently selected measurement channel.

10.7.1 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 measurement channel* (see `INSTrument[:SELect]` on page 203).

DISPlay:FORMat <Format>

This command 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>

This command 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 298).

Suffix:

<n> Window

Parameters:

<Size>

LARGe
Maximizes the selected window to full screen.
Other windows are still active in the background.

SMALl
Reduces the size of the selected window to its original size.
If more than one measurement window was displayed originally, these are visible again.

*RST: SMALl

Example: `DISP:WIND2:SIZE LARG`

10.7.2 Working with Windows in the Display

The following commands are required to change the evaluation type and rearrange the screen layout for a measurement 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 measurement channel.

Note that the suffix <n> always refers to the window *in the currently selected measurement channel* (see `INSTrument[:SELect]` on page 203).

LAYout:ADD[:WINDow]? <WindowName>,<Direction>,<WindowType>

This command adds a window to the display in the active measurement channel.

This command 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.

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 "AM/AM" on page 23
See "AM/PM" on page 24
See "AM/EVM" on page 24
See "Bitstream" on page 25
See "Constellation" on page 27
See "Constellation vs Carrier" on page 29
See "EVM vs Carrier" on page 30
See "EVM vs Chip" on page 31
See "EVM vs Symbol" on page 31
See "FFT Spectrum" on page 32
See "Freq. Error vs Preamble" on page 34
See "Gain Imbalance vs Carrier" on page 34
See "Group Delay" on page 35
See "Magnitude Capture" on page 36
See "Phase Error vs Preamble" on page 37
See "Phase Tracking" on page 38
See "PLCP Header (IEEE 802.11b, g (DSSS)" on page 38
See "PvT Full PPDU" on page 39
See "PvT Rising Edge" on page 40
See "PvT Falling Edge" on page 41
See "Quad Error vs Carrier" on page 42
See "Result Summary Detailed" on page 42
See "Result Summary Global" on page 44
See "Signal Field" on page 46
See "Spectrum Flatness" on page 49
See "Diagram" on page 55
See "Result Summary" on page 55
See "Marker Table" on page 55
See "Marker Peak List" on page 56

Table 10-8: <WindowType> parameter values for WLAN application

Parameter value	Window type
Window types for I/Q data	
AMAM	AM/AM (**IEEE 802.11a, g (OFDM), ac, n, p** only)
AMEV	AM/EVM (**IEEE 802.11a, g (OFDM), ac, n, p** only)
AMPM	AM/PM (**IEEE 802.11a, g (OFDM), ac, n, p** only)
BITStream	Bitstream
CMEMory	Magnitude Capture
CONStellation	Constellation
CVCarrier	Constellation vs. Carrier (**IEEE 802.11a, ac, g (OFDM), j, n, p** only)
EVCarrier	EVM vs. Carrier (**IEEE 802.11a, ac, g (OFDM), j, n, p** only)
EVCHip	EVM vs. Chip (**IEEE 802.11b and g (DSSS)** only)
EVSYmbol	EVM vs. Symbol (**IEEE 802.11a, ac, g (OFDM), j, n, p** only)
FEVPreamble	Frequency Error vs. Preamble

Parameter value	Window type
FSPectrum	FFT Spectrum
GAIN	Gain Imbalance vs. carrier
GDELay	Group Delay (**IEEE 802.11a, ac, g (OFDM), j, n, p** only)
PEVPreamble	Phase Error vs. Preamble
PFALling	PvT Falling Edge
PFPPdu	PvT Full PPDU
PRISing	PvT Rising Edge
PTRacking	Phase tracking vs. symbol
QUAD	Quadrature error vs. carrier
RSDetailed	Result Summary Detailed (**IEEE 802.11a, ac, g (OFDM), j, n, p** only)
RSGLobal	Result Summary Global
SFIeld	Signal Field (**IEEE 802.11a, ac, g (OFDM), j, n, p**) PLCP Header (**IEEE 802.11b and g (DSSS)**)
SFLatness	Spectrum Flatness (**IEEE 802.11a, ac, g (OFDM), j, n, p** only)
Window types for RF data	
DIAGram	Diagram (SEM, ACLR)
MTABle	Marker table (SEM, ACLR)
PEAKlist	Marker peak list (SEM, ACLR)
RSUMmary	Result summary (SEM, ACLR)

LAYout:CATalog[:WINDow]?

This command queries the name and index of all active windows in the active measurement 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>

This command queries the **index** of a particular display window in the active measurement 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:WIND:IDEN? '2'`
Queries the index of the result display named '2'.
Response:
`2`

Usage: Query only

LAYout:REMove[:WINDow] <WindowName>

This command removes a window from the display in the active measurement channel.

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: Event

LAYout:REPLace[:WINDow] <WindowName>,<WindowType>

This command replaces the window type (for example from "Diagram" to "Result Summary") of an already existing window in the active measurement channel while keeping its position, index and window name.

To add a new window, use the `LAYout:ADD[:WINDow]?` command.

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 measurement 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 294 for a list of available window types.

Example: `LAY:REPL:WIND '1',MTAB`
Replaces the result display in window 1 with a marker table.

LAYout:SPLitter <Index1>,<Index2>,<Position>

This command 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 293 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 will not work, but does not return an error.

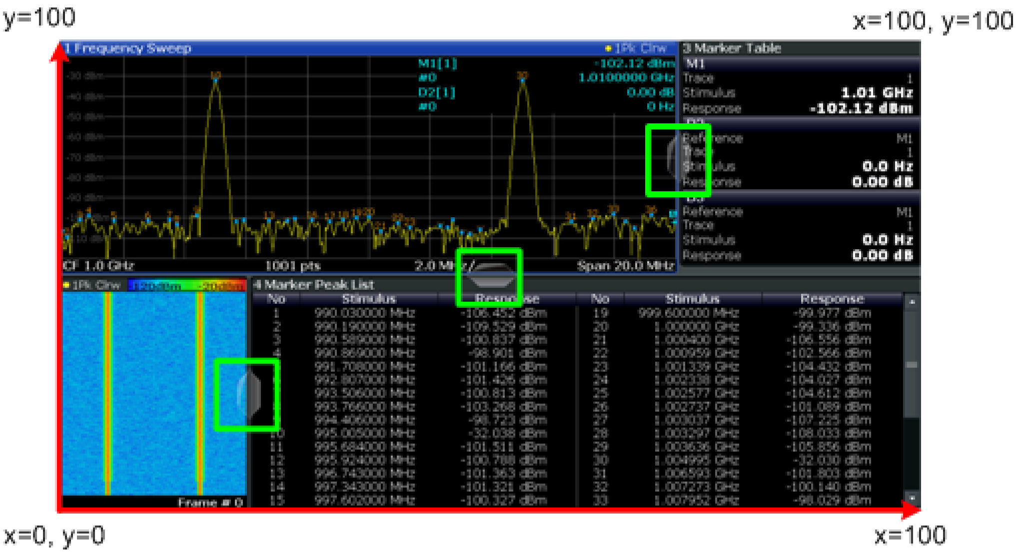


Figure 10-1: SmartGrid coordinates for remote control of the splitters

Parameters:

<Index1> The index of one window the splitter controls.

<Index2> The index of a window on the other side of the splitter.

<Position> New vertical or horizontal position of the splitter as a fraction of the screen area (without channel and status bar and softkey menu).
The point of origin (x = 0, y = 0) is in the lower left corner of the screen. The end point (x = 100, y = 100) is in the upper right corner of the screen. (See Figure 10-1.)
The direction in which the splitter is moved depends on the screen layout. If the windows are positioned horizontally, the splitter also moves horizontally. If the windows are positioned vertically, the splitter also moves vertically.

Range: 0 to 100

Example: `LAY:SPL 1,3,50`
Moves the splitter between window 1 ('Frequency Sweep') and 3 ('Marker Table') to the center (50%) of the screen, i.e. in the figure above, to the left.

Example: `LAY:SPL 1,4,70`
Moves the splitter between window 1 ('Frequency Sweep') and 3 ('Marker Peak List') towards the top (70%) of the screen.
The following commands have the exact same effect, as any combination of windows above and below the splitter moves the splitter vertically.
`LAY:SPL 3,2,70`
`LAY:SPL 4,1,70`
`LAY:SPL 2,1,70`

LAYout:WINDow<n>:ADD? <Direction>,<WindowType>

This command 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, as opposed to `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.

This command is always used as a query so that you immediately obtain the name of the new window as a result.

Suffix:
<n> Window

Parameters:
<Direction> LEFT | RIGHt | ABOVe | BELow

<WindowType> Type of measurement window you want to add.
See `LAYout:ADD[:WINDow]?` on page 294 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?

This command queries the **name** of a particular display window (indicated by the <n> suffix) in the active measurement 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

This command removes the window specified by the suffix <n> from the display in the active measurement 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>

This command changes the window type of an existing window (specified by the suffix <n>) in the active measurement channel.

The result 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

Parameters:
<WindowType> Type of measurement window you want to replace another one with.
See LAYout:ADD[:WINDow]? on page 294 for a list of available window types.

Example: LAY:WIND2:REPL MTAB
Replaces the result display in window 2 with a marker table.

10.7.3 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 Detailed" on page 42 and "Result Summary Global" on page 44).

Note that the results are always *calculated*, regardless of their visibility in the Result Summary.

Suffix:

<n> Window

Parameters:

<Item> Item to be included in Result Summary. For an overview of possible results and the required parameters see the tables below.

<State> ON | OFF

ON
Item is displayed in Result Summary.

OFF
Item is not displayed in Result Summary.

*RST: ON

Table 10-9: Parameters for the items of the "Result Summary Detailed"

Result in table	SCPI parameter
TX channel ("Tx All")	TALL
I/Q offset	IOFSset
Gain imbalance	GIMBalance
Quadrature offset	QOFFset
I/Q skew	IQSKew
PPDU power	TPPower
Crest factor	TCFactor
Receive channel ("Rx All")	RALL
PPDU power	RPPower
Crest factor	RCFactor
Bitstream ("Stream All")	SALL
Pilot bit error rate	BPILot
EVM all carriers	SEACarriers
EVM data carriers	SEDCarriers
EVM pilot carriers	SEPCarriers

Table 10-10: Parameters for the items of the "Result Summary Global"

Result in table	SCPI parameter
Pilot bit error rate	PBERate
EVM all carriers	EACarriers
EVM data carriers	EDCarriers
EVM pilot carriers	EPCarriers
Center frequency error	CFERror
Symbol clock error	SCERror

10.7.4 Configuring the Spectrum Flatness and Group Delay Result Displays

The following command is only relevant for the Spectrum Flatness and Group Delay result displays.

CONFigure:BURSt:SPECtrum:FLATness:CSELect <ChannelType>

This remote control command configures the Spectrum Flatness and Group Delay results to be based on either effective or physical channels. This command is only valid for IEEE 802.11n and IEEE 802.11ac standards.

While the physical channels cannot always be determined, the effective channel can always be estimated from the known training fields. Thus, for some PPDUs or measurement scenarios, only the results based on the mapping of the space-time stream to the Rx antenna (effective channel) are available, as the mapping of the Rx antennas to the Tx antennas (physical channel) could not be determined.

For more information see Chapter 4.3.3, "Physical vs Effective Channels", on page 73.

Parameters:
<ChannelType> EFFective | PHYSical
*RST: EFF

Example: `CONF:BURS:SPEC:FLAT:CSEL PHYS`
Configures the Spectrum Flatness and Group Delay result displays to calculate the results based on the physical channel.

Usage: Event

Manual operation: See "Result based on" on page 165

UNIT:SFLatness <Unit>

This command switches between relative (dB) and absolute (dBm) results for Spectrum Flatness results (see "Spectrum Flatness" on page 49).

Parameters:
<Unit> DB | DBM
*RST: DBM

Example: `UNIT:SFL DBM`

Manual operation: See "Units" on page 165

10.7.5 Configuring the AM/AM Result Display

The following commands are only relevant for the AM/AM result display.

CONFigure:BURSt:AM:AM:POLYnomial <Degree>

This remote control command specifies the degree of the polynomial regression model used to determine the AM/AM result display.

The resulting coefficients of the regression polynomial can be queried using the `FETCh:BURSt:AM:AM:COEFficients?` command.

Parameters:

<Degree> integer

Range: 1 to 20
*RST: 4

Example: `CONF:BURS:AM:AM:POLY 3`

Manual operation: See "AM/AM" on page 23
See "Polynomial degree for curve fitting" on page 166

DISPlay[:WINDow<n>]:TRACe<t>:X[:SCALe]:AUTO <State>
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO <State>

This command activates or deactivates automatic scaling of the x-axis or y-axis for the specified trace display. If enabled, the R&S FSW WLAN application automatically scales the x-axis or y-axis to best fit the measurement results.

If disabled, the x-axis or y-axis is scaled according to the specified minimum/maximum values (see `DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MINimum`/ `DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MAXimum`) and number of divisions (see `DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:DIVisions`).

Suffix:

<n> Window

<t> Trace

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 1

Example: `DISP:WIND2:TRAC:Y:SCAL:AUTO ON`

Manual operation: See "Automatic Grid Scaling" on page 167

DISPlay[:WINDow<n>]:TRACe<t>:X[:SCALe]:AUTO:FIXed:RANGe <AutoFixRange>
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:FIXed:RANGe <AutoFixRange>

This command defines the use of fixed value limits.

Suffix:

<n> Window

<t> Trace

Parameters:

<AutoFixRange> NONE | LOWer | UPPer

NONE
Both the upper and lower limits are determined by automatic scaling of the x-axis or y-axis.

LOWer
The lower limit is fixed (defined by `DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MINimum`/`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MAXimum`), while the upper limit is determined by automatic scaling of the x-axis or y-axis.

UPPer
The upper limit is fixed, while the lower limit is determined by automatic scaling of the x-axis or y-axis.

Example:
```
DISP:WIND1:TRAC:Y:AUTO:FIX:RANG LOW
DISP:WIND1:TRAC:Y:MIN 0dBm
```
Sets the lower limit of the y-axis to a fixed value of 0 dBm.

Manual operation: See "Auto Fix Range" on page 168

DISPlay[:WINDow<N>]:TRACe<t>:X[:SCALe]:AUTO:HYSTeresis:LOWer:UPPer <Value>
DISPlay[:WINDow<N>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:LOWer:UPPer <Value>

For automatic scaling based on hysteresis, this command defines the upper limit of the lower hysteresis interval.

If the minimum value in the current measurement exceeds this limit, the x-axis or y-axis is rescaled automatically.

For details see "Hysteresis Interval Upper/Lower" on page 168.

Suffix:

<n> Window

<t> Trace

Parameters:

<Value> Percentage of the currently displayed value range on the x-axis or y-axis.

Example: DISP:WIND2:TRAC:Y:SCAL:AUTO:HYST:LOW:UPP 5

Manual operation: See "Hysteresis Interval Upper/Lower" on page 168

DISPlay[:WINDow<N>]:TRACe<t>:X[:SCALe]:AUTO:HYSTeresis:LOWer:LOWer <Value>
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:LOWer:LOWer <Value>

For automatic scaling based on hysteresis, this command defines the lower limit of the lower hysteresis interval.

If the minimum value in the current measurement drops below this limit, the x-axis or y-axis is rescaled automatically.

For details see "Hysteresis Interval Upper/Lower" on page 168.

Suffix:

<n>	Window
<t>	Trace

Parameters:

<Value>	Percentage of the currently displayed value range on the x-axis or y-axis.

Example: DISP:WIND2:TRAC:Y:SCAL:AUTO:HYST:LOW:LOW 5

Manual operation: See "Hysteresis Interval Upper/Lower" on page 168

DISPlay[:WINDow<N>]:TRACe<t>:X[:SCALe]:AUTO:HYSTeresis:UPPer:LOWer <Value>
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:UPPer:LOWer <Value>

For automatic scaling based on hysteresis, this command defines the lower limit of the upper hysteresis interval.

If the maximum value in the current measurement drops below this limit, the x-axis or y-axis is rescaled automatically.

For details see "Hysteresis Interval Upper/Lower" on page 168.

Suffix:

<n>	Window
<t>	Trace

Parameters:

<Value>	Percentage of the currently displayed value range on the x-axis or y-axis.

Example: DISP:WIND2:TRAC:Y:AUTO:HYST:UPP:LOW 25

Manual operation: See "Hysteresis Interval Upper/Lower" on page 168

DISPlay[:WINDow<N>]:TRACe<t>:X[:SCALe]:AUTO:HYSTeresis:UPPer:UPPer <Value>
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:UPPer:UPPer <Value>

For automatic scaling based on hysteresis, this command defines the upper limit of the upper hysteresis interval.

If the maximum value in the current measurement exceeds this limit, the x-axis or y-axis is rescaled automatically.

For details see "Hysteresis Interval Upper/Lower" on page 168.

Suffix:

<n>	Window
<t>	Trace

Parameters:

<Value>	Percentage of the currently displayed value range on the x-axis or y-axis.

Example: `DISP:WIND2:TRAC:Y:AUTO:HYST:UPP:UPP 20`

Manual operation: See "Hysteresis Interval Upper/Lower" on page 168

DISPlay[:WINDow<n>]:TRACe<t>:X[:SCALe]:AUTO:MEMory:DEPTh <NoMeas>
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:MEMory:DEPTh <NoMeas>

For automatic scaling based on memory, this value defines the number <x> of previous results to be considered when determining if rescaling is required.

The minimum and maximum value of each measurement are added to the memory. After <x> measurements, the oldest results in the memory are overwritten by each new measurement.

For details see "Auto Mode" on page 168.

Suffix:

<n>	Window
<t>	Trace

Parameters:

<NoMeas>	integer value Number of measurement results to be stored for autoscaling

Example: `DISP:WIND2:TRAC:Y:AUTO:MEM:DEPT 16`

Manual operation: See "Memory Depth" on page 169

DISPlay[:WINDow<n>]:TRACe<t>:X[:SCALe]:AUTO:MODE <AutoMode>
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:MODE <AutoMode>

This command determines which algorithm is used to determine whether the x-axis or y-axis requires automatic rescaling.

Suffix:

<n> Window

<t> Trace

Parameters:

<AutoMode> **HYSTeresis**

If the minimum and/or maximum values of the current measurement exceed a specific value range (hysteresis interval), the axis is rescaled. The hysteresis interval is defined as a percentage of the currently displayed value range on the x-axis or y-axis. An upper hysteresis interval is defined for the maximum value, a lower hysteresis interval is defined for the minimum value.

MEMory

If the minimum and/or maximum values of the current measurement exceed the minimum and/or maximum of the <x> previous results, the axis is rescaled.

The minimum and maximum value of each measurement are added to the memory. After <x> measurements, the oldest results in the memory are overwritten by each new measurement.

The number of results in the memory to be considered is configurable (see `DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:MEMory:DEPTh`).

*RST: HYSTeresis

Example: `DISP:WIND2:TRAC:Y:AUTO:MODE MEM`

Manual operation: See "Auto Mode" on page 168

DISPlay[:WINDow<n>]:TRACe<t>:X[:SCALe]:DIVisions <NoDivisions>
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:DIVisions <NoDivisions>

Defines the number of divisions to be used for the x-axis or y-axis in the specified window.

Separate division settings can be configured for individual result displays.

Suffix:

<n> Window

<t> Trace

Parameters:

<NoDivisions>

Example: `DISP:WIND2:TRAC:Y:SCAL:DIV 10`

Manual operation: See "Number of Divisions" on page 170

DISPlay[:WINDow<n>]:TRACe<t>:X[:SCALe]:MAXimum <Max>
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MAXimum <Max>

Defines the maximum value to be displayed on the x-axis or y-axis of the specified evaluation diagram.

For automatic scaling with a fixed range (see `DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:FIXed:RANGe` on page 304), the maximum defines the fixed upper limit.

Suffix:

<n>	Window
<t>	Trace

Parameters:

<Max>

Example: `DISP:WIND2:TRAC:Y:SCAL:MAX 100`

Manual operation: See "Minimum / Maximum" on page 169

DISPlay[:WINDow<n>]:TRACe<t>:X[:SCALe]:MINimum <Min>
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MINimum <Min>

Defines the minimum value to be displayed on the x-axis or y-axis of the specified evaluation diagram.

For automatic scaling with a fixed range (see `DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:FIXed:RANGe` on page 304), the minimum defines the fixed lower limit.

Suffix:

<n>	Window
<t>	Trace

Parameters:

<Min>

Example: `DISP:WIND2:TRAC:Y:SCAL:MIN -20`

Manual operation: See "Minimum / Maximum" on page 169

DISPlay[:WINDow<n>]:TRACe<t>:X[:SCALe]:PDIVision <State_1>,<State_2>,<State_2_5>, <State_5>
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:PDIVision <Multiple>[,<Multiple>]

Determines the values shown for each division on the x-axis or y-axis in the specified window.

One or more multiples of 10^n can be selected. The R&S FSW WLAN application then selects the optimal scaling from the selected values.

For details see "Scaling per division" on page 170.

Suffix:
<n> Window

<t> Trace

Parameters:
<Multiple> 1.0 | 2.0 | 2.5 | 5.0

If enabled, each division on the x-axis or y-axis displays the selected multiple of 10^n.

*RST: 1.0,5.0

Example: `DISP:WIND:TRAC:Y:SCAL:PDIV 2.0,2.5`

Multiples of 2.0*10^n or multiples of 2.5*10^n are displayed on the x-axis or y-axis.

Manual operation: See "Scaling per division" on page 170

10.8 Starting a Measurement

When a WLAN measurement channel is activated on the R&S FSW, a WLAN IQ measurement (Modulation Accuracy, Flatness and Tolerance, see Chapter 3.1, "WLAN I/Q Measurement (Modulation Accuracy, Flatness and Tolerance)", 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 Chapter 5.1, "Multiple Measurement Channels and Sequencer Function", on page 90).

ABORt

This command aborts the measurement in the current measurement channel and resets the trigger system.

To prevent overlapping execution of the subsequent command before the measurement has been aborted successfully, use the `*OPC?` or `*WAI` command after `ABOR` and before the next command.

For details see the "Remote Basics" chapter in the R&S FSW User Manual.

To abort a sequence of measurements by the Sequencer, use the `INITiate<n>:SEQuencer:ABORt` command.

Note on blocked remote control programs:

If a sequential command cannot be completed, for example because a triggered sweep never receives a trigger, the remote control program will never finish and the remote channel to the R&S 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 R&S 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
SCPI confirmed

CALCulate<n>:BURSt[:IMMediate]

This command forces the IQ measurement results to be recalculated according to the current settings.

Suffix:
<n> Window

Manual operation: See "Calc Results" on page 138

INITiate<n>:CONTinuous <State>

This command controls the measurement mode for an individual measurement 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 the "Remote Basics" chapter in the R&S FSW User Manual.

If the measurement mode is changed for a measurement channel while the Sequencer is active (see INITiate<n>:SEQuencer:IMMediate on page 312) the mode is only considered the next time the measurement in that channel is activated by the Sequencer.

Suffix:

<n> irrelevant

Parameters:

<State> ON | OFF | 0 | 1

ON | 1
Continuous measurement

OFF | 0
Single measurement

*RST: 1

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 171

INITiate<n>[:IMMediate]

This command starts a (single) new measurement.

You can synchronize to the end of the measurement with *OPC, *OPC? or *WAI.

For details on synchronization see the "Remote Basics" chapter in the R&S FSW User Manual.

Suffix:

<n> irrelevant

Usage: Event

Manual operation: See "Single / Cont." on page 138
See "Single Sweep/ RUN SINGLE" on page 171

INITiate<n>:SEQuencer:ABORt

This command stops the currently active sequence of measurements. The Sequencer itself is not deactivated, so you can start a new sequence immediately using INITiate<n>:SEQuencer:IMMediate on page 312.

To deactivate the Sequencer use SYSTem:SEQuencer on page 314.

Suffix:

<n> irrelevant

Usage: Event

Manual operation: See "Sequencer State" on page 91

INITiate<n>:SEQuencer:IMMediate

This command 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 314).

Suffix:

<n> irrelevant

Example: `SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single sequence mode so each active measurement will be performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.

Usage: Event

Manual operation: See "Sequencer State" on page 91

INITiate<n>:SEQuencer:MODE <Mode>

This command selects the way the R&S FSW application performs measurements sequentially.

Before this command can be executed, the Sequencer must be activated (see `SYSTem:SEQuencer` on page 314).

A detailed programming example is provided in the "Operating Modes" chapter in the R&S FSW User Manual.

Note: In order to synchronize to the end of a sequential measurement using *OPC, *OPC? or *WAI you must use `SINGle` Sequence mode.

For details on synchronization see the "Remote Basics" chapter in the R&S FSW User Manual.

Suffix:

<n> irrelevant

Parameters:

<Mode>	**SINGle** Each measurement is performed once (regardless of the channel's sweep mode), considering each channels' sweep count, until all measurements in all active channels have been performed. **CONTinuous** The measurements in each active channel are performed one after the other, repeatedly (regardless of the channel's sweep mode), in the same order, until the Sequencer is stopped. **CDEFined** First, a single sequence is performed. Then, only those channels in continuous sweep mode (`INIT:CONT ON`) are repeated. *RST: CONTinuous

Example:

`SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single sequence mode so each active measurement will be performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.

Manual operation: See "Sequencer Mode" on page 91

INITiate<n>:SEQuencer:REFResh[:ALL]

This function is only available if the Sequencer is deactivated (`SYSTem:SEQuencer` SYST:SEQ:OFF) and only in MSRA mode.

The data in the capture buffer is re-evaluated by all active MSRA slave applications.

Suffix:

<n> irrelevant

Example:

`SYST:SEQ:OFF`
Deactivates the scheduler
`INIT:CONT OFF`
Switches to single sweep mode.
`INIT;*WAI`
Starts a new data measurement and waits for the end of the sweep.
`INIT:SEQ:REFR`
Refreshes the display for all channels.

Usage: Event

SYSTem:SEQuencer <State>

This command turns the Sequencer on and off. The Sequencer must be active before any other Sequencer commands (`INIT:SEQ...`) are executed, otherwise an error will occur.

A detailed programming example is provided in the "Operating Modes" chapter in the R&S FSW User Manual.

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 will be performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.
`SYST:SEQ OFF`

Manual operation: See "Sequencer State" on page 91

10.9 Retrieving Results

The following commands are required to retrieve the results from a WLAN measurement in a remote environment.

Before retrieving measurement results, check if PPDU synchronization was successful or not by checking the status register (see Chapter 10.11.1, "The STATus:QUEStionable:SYNC Register", on page 352). If no PPDUs were found, `STAT:QUES:SYNC:COND?` returns 0 (see `STATus:QUEStionable:SYNC:CONDition?` on page 358).

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.

10.9.1 Numeric Modulation Accuracy, Flatness and Tolerance Results

The following commands describe how to retrieve the numeric results from the standard WLAN measurements.

The commands to retrieve results from frequency sweep measurements for WLAN signals are described in Chapter 10.9.2, "Numeric Results for Frequency Sweep Measurements", on page 329.

10.9.1.1 PPDU and Symbol Count Results

The following commands are required to retrieve PPDU and symbol count results from the WLAN IQ measurement on the captured I/Q data (see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13).

FETCh:BURSt:COUNt?

This command returns the number of analyzed PPDUs from the current capture buffer. If multiple measurements are required because the number of PPDUs to analyze is greater than the number of PPDUs that can be captured in one buffer, this command only returns the number of captured PPDUs *in the current capture buffer* (as opposed to `FETCh:BURSt:COUNt:ALL?`).

Usage: Query only

FETCh:BURSt:COUNt:ALL?

This command returns the number of analyzed PPDUs for the entire measurement. If multiple measurements are required because the number of PPDUs to analyze is greater than the number of PPDUs that can be captured in one buffer, this command returns the number of analyzed PPDUs in *all* measurements (as opposed to `FETCh:BURSt:COUNt?`.

Usage: Query only

FETCh:SYMBol:COUNt?

This command returns the number of symbols in each analyzed PPDU as a comma separated list. The length of the list corresponds to the number of PPDUs, i.e. the result of `FETCh:BURSt:COUNt:ALL?`.

Usage: Query only

FETCh:BURSt:LENGths?

This command returns the length of the analyzed PPDUs from the current measurement. If the number of PPDUs to analyze is greater than the number of PPDUs that can be captured in one buffer, this command only returns the lengths of the PPDUs *in the current capture buffer*.

The result is a comma-separated list of lengths, one for each PPDU.

Return values:

<PPDULength> Length of the PPDU in the unit specified by the `UNIT:BURSt` command.

Usage: Query only

FETCh:BURSt:STARts?

This command returns the start position of each analyzed PPDU in the current capture buffer.

Return values:

<Position> Comma-separated list of samples or symbols (depending on the `UNIT:BURSt` command) indicating the start position of each PPDU.

Usage: Query only

UNIT:BURSt <Unit>

This command specifies the units for PPDU length results (see `FETCh:BURSt:LENGths?` on page 316).

Parameters:

<Unit>	SYMBol | SAMPle	
	*RST:	SYMBol

10.9.1.2 Error Parameter Results

The following commands are required to retrieve individual results from the WLAN IQ measurement on the captured I/Q data (see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13).

FETCh:BURSt:ALL

This command returns all results from the default WLAN measurement (Modulation Accuracy, Flatness and Tolerance

(see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13).

The results are output as a list of result strings separated by commas in ASCII format. The results are output in the following order:

<Global Result>, <Stream 1 result> ... <Stream n result>

Return values:

<Global Result> <preamble power>, <payload power>, <peak power>,
<min rms power>, <avg rms power>, <max rms power>,
'nan','nan','nan',
<min freq error>,<avg freq error>, <max freq error>,
<min symbol error>, <avg symbol error>, <max symbol error>,
'nan','nan','nan',
'nan','nan','nan',
'nan','nan','nan',
<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>
'nan','nan','nan',
'nan','nan','nan',
'nan','nan','nan',
'nan','nan','nan',

<Stream Results> 'nan','nan','nan',
'nan','nan','nan',
<peak power>,
<min rms power>, <avg rms power>, <max rms power>,
<min crest factor>,<avg crest factor>,<max crest factor>,
<min freq error>,<avg freq error>, <max freq error>,
<min symbol error>, <avg symbol error>, <max symbol error>,
<min IQ offset>, <avg IQ offset>, <max IQ offset>,
<min gain imb>, <avg gain imb>, <max gain imb>,
<min quad offset>, <avg quad offset>, <max quad offset>,
<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 BER>, <avg BER >, <max BER>
<min IQ skew>, <avg IQ skew>, <max IQ skew>
<min MIMO CP>, <avg MIMO CP>, <max MIMO CP>
<min CPE>, <avg CPE>, <max CPE>

Manual operation: See "Result Summary Detailed" on page 42
See "Result Summary Global" on page 44

FETCh:BURSt:AM:AM:COEFficients?

This remote control returns the coefficients of the polynomial regression model used to determine the AM/AM result display.

See "AM/AM" on page 23 for details.

Return values:

<Coefficients> comma-separated list of numeric values

The coefficients are listed in ascending order of degree (as displayed in the result display title bar).

Example: `FETC:BURS:AM:AM:COEF?`

Usage: Query only

Manual operation: See "Polynomial degree for curve fitting" on page 166

FETCh:BURSt:BERPilot:AVERage?
FETCh:BURSt:BERPilot:MAXimum?
FETCh:BURSt:BERPilot:MINimum?

This command returns the Bit Error Rate (BER) for Pilots (average, maximum or minimum value) in % for the IEEE 802.11n (MIMO) standard. For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Return values:

<Result> <Global Result>, <Stream 1 result> ... <Stream n result>

Usage: Query only

FETCh:BURSt:CPERror:AVERage
FETCh:BURSt:CPERror:MAXimum
FETCh:BURSt:CPERror:MINimum

This command returns the common phase error (average, maximum or minimum value) in degrees for the IEEE 802.11n (MIMO) standard. For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Parameters:

<Result> <Stream 1 result> ... <Stream n result>

FETCh:BURSt:CRESt[:AVERage]?
FETCh:BURSt:CRESt:MAXimum?
FETCh:BURSt:CRESt:MINimum?

This command returns the average, maximum or minimum determined CREST factor (= ratio of peak power to average power) in dB.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Usage: Query only

FETCh:BURSt:ECMGain?

This command returns the effective channel gain result which is used as the reference for the Spectrum Flatness limits when Spectrum Flatness results are based on effective channels (see `CONFigure:BURSt:SPECtrum:FLATness:CSELect` on page 302).

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Return values:

<Result>	comma-separated list of values; one value for each RX stream Default unit: dBm
Example:	`FETC:BURS:ECMG?`
Usage:	Query only

FETCh:BURSt:PCMGain?

This command returns the physical channel gain result which is used as the reference for the Spectrum Flatness limits when Spectrum Flatness results are based on physical channels (see `CONFigure:BURSt:SPECtrum:FLATness:CSELect` on page 302).

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Return values:

<Result>	comma-separated list of values; one value for each RX stream Default unit: dBm
Example:	`FETC:BURS:PCMG?`
Usage:	Query only

FETCh:BURSt:EVM:ALL:AVERage?
FETCh:BURSt:EVM:ALL:MAXimum?
FETCh:BURSt:EVM:ALL:MINimum?

This command returns the average, maximum or minimum EVM in dB. This is a combined figure that represents the pilot, data and the free carrier.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Return values:

<Result>	<Global Result>, <Stream 1 result> ... <Stream n result>
Usage:	Query only

FETCh:BURSt:EVM:DATA:AVERage?
FETCh:BURSt:EVM:DATA:MAXimum?
FETCh:BURSt:EVM:DATA:MINimum?

This command returns the average, maximum or minimum EVM for the data carrier in dB.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Return values:

<Result>	<Global Result>, <Stream 1 result> ... <Stream n result>
Usage:	Query only

FETCh:BURSt:EVM:DIRect:AVERage?
FETCh:BURSt:EVM:DIRect:MAXimum?
FETCh:BURSt:EVM:DIRect:MINimum?

This command returns the average, maximum or minimum EVM in dB for the IEEE 802.11b standard. This result is the value after filtering.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Usage: Query only

FETCh:BURSt:EVM:PILot:AVERage?
FETCh:BURSt:EVM:PILot:MAXimum?
FETCh:BURSt:EVM:PILot:MINimum?

This command returns the average, maximum or minimum EVM in dB for the pilot carrier.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Return values:
<Result> <Global Result>, <Stream 1 result> ... <Stream n result>

Usage: Query only

FETCh:BURSt:EVM[:IEEE]:AVERage?
FETCh:BURSt:EVM[:IEEE]:MAXimum?
FETCh:BURSt:EVM[:IEEE]:MINimum?

This command returns the average, maximum or minimum EVM in dB for the IEEE 802.11b standard. This result is the value before filtering.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Usage: Query only

FETCh:BURSt:CFERror:AVERage
FETCh:BURSt:CFERror:MAXimum
FETCh:BURSt:CFERror:MINimum
FETCh:BURSt:FERRor:AVERage?
FETCh:BURSt:FERRor:MAXimum?
FETCh:BURSt:FERRor:MINimum?

This command returns the average, maximum or minimum center frequency errors in Hertz.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Return values:
<Result> <Global Result>, <Stream 1 result> ... <Stream n result>

Usage: Query only

FETCh:BURSt:GIMBalance:AVERage?
FETCh:BURSt:GIMBalance:MAXimum?
FETCh:BURSt:GIMBalance:MINimum?

This command returns the average, maximum or minimum I/Q imbalance in dB.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Usage: Query only

FETCh:BURSt:IQOFfset:AVERage?
FETCh:BURSt:IQOFfset:MAXimum?
FETCh:BURSt:IQOFfset:MINimum?

This command returns the average, maximum or minimum I/Q offset in dB.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Usage: Query only

FETCh:BURSt:EVM:ALL:AVERage?
FETCh:BURSt:EVM:ALL:MAXimum?
FETCh:BURSt:EVM:ALL:MINimum?

This command returns the average, maximum or minimum I/Q skew in picoseconds.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Usage: Query only

FETCh:BURSt:MCPower:AVERage
FETCh:BURSt:MCPower:MAXimum
FETCh:BURSt:MCPower:MINimum

This command returns the MIMO cross power (average, maximum or minimum value) in dB for the IEEE 802.11n (MIMO) standard. For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Parameters:
<Result> <Stream 1 result> ... <Stream n result>

FETCh:BURSt:PAYLoad[:AVERage]?
FETCh:BURSt:PAYLoad:MINimum?
FETCh:BURSt:PAYLoad:MAXimum?

This command returns the average, maximum or minimum of the "Payload Power per PPDU" (in dBm). All analyzed PPDUs, up to the statistic length, take part in the statistical evaluation.

Usage: Query only

FETCh:BURSt:PEAK[:AVERage]?
FETCh:BURSt:PEAK:MINimum?
FETCh:BURSt:PEAK:MAXimum?

This command returns the average, maximum or minimum of the "Peak Power per PPDU" (in dBm). All analyzed PPDUs, up to the statistic length, take part in the statistical evaluation.

Usage: Query only

FETCh:BURSt:PREamble[:AVERage]?
FETCh:BURSt:PREamble:MINimum?
FETCh:BURSt:PREamble:MAXimum?

This command returns the average, maximum or minimum of the "Preamble Power per PPDU" (in dBm). All analyzed PPDUs, up to the statistic length, take part in the statistical evaluation.

Usage: Query only

FETCh:BURSt:QUADoffset:AVERage?
FETCh:BURSt:QUADoffset:MAXimum?
FETCh:BURSt:QUADoffset:MINimum?

This command returns the average, maximum or minimum quadrature offset of symbols within a PPDU. This value indicates the phase accuracy.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Usage: Query only

FETCh:BURSt:RMS[:AVERage]?
FETCh:BURSt:RMS:MAXimum?
FETCh:BURSt:RMS:MINimum?

This command returns the average, maximum or minimum RMS power in dBm for all analyzed PPDUs.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Return values:

<Result> <Global Result>, <Stream 1 result> ... <Stream n result>

Usage: Query only

FETCh:BURSt:SYMBolerror:AVERage?
FETCh:BURSt:SYMBolerror:MAXimum?
FETCh:BURSt:SYMBolerror:MINimum?

This command returns the average, maximum or minimum percentage of symbols that were outside the allowed demodulation range within a PPDU (as defined by the standard).

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Return values:

<Result> <Global Result>, <Stream 1 result> ... <Stream n result>

Usage: Query only

FETCh:BURSt:TFALl:AVERage?
FETCh:BURSt:TFALl:MAXimum?
FETCh:BURSt:TFALl:MINimum?

This command returns the average, maximum or minimum PPDU fall time in seconds.

This command is only applicable to IEEE802.11b & IEEE802.11g (DSSS) signals.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Usage: Query only

FETCh:BURSt:TRISe:AVERage?
FETCh:BURSt:TRISe:MAXimum?
FETCh:BURSt:TRISe:MINimum?

This command returns the average, maximum or minimum burst rise time in seconds.

This command is only applicable to IEEE802.11b & IEEE802.11g (DSSS) signals.

For details see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13.

Usage: Query only

UNIT:EVM <Unit>

This command specifies the units for EVM limits and results

(see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13).

Parameters:

<Unit>	DB | PCT	
	*RST:	DB

UNIT:GIMBalance <Unit>

This command specifies the units for gain imbalance results

(see Chapter 3.1.1, "Modulation Accuracy, Flatness and Tolerance Parameters", on page 13).

Parameters:

<Unit>	DB | PCT	
	*RST:	DB

UNIT:PREamble <Unit>

This command specifies the units for preamble error results.

Parameters:

<Unit>	HZ | PCT

10.9.1.3 Limit Check Results

The following commands are required to query the results of the limit checks.

Useful commands for retrieving results described elsewhere:

- UNIT:EVM on page 325
- UNIT:GIMBalance on page 326

Remote commands exclusive to retrieving limit check results

CALCulate:LIMit:BURSt:ALL:RESult?

This command returns the result of the EVM limit check for all carriers. The limit value is defined by the standard or the user (see CALCulate:LIMit:BURSt:ALL on page 285).

Return values:

<LimitCheck> **PASS**
The defined limit for the parameter was not exceeded.
FAILED
The defined limit for the parameter was exceeded.

Usage: Query only

CALCulate:LIMit:BURSt:EVM:ALL[:AVERage]:RESult?
CALCulate:LIMit:BURSt:EVM:ALL:MAXimum:RESult?

This command returns the result of the average or maximum EVM limit check. The limit value is defined by the standard or the user (see CALCulate:LIMit:BURSt:EVM:ALL:MAXimum on page 285).

Return values:

<LimitCheck> **PASS**
The defined limit for the parameter was not exceeded.
FAILED
The defined limit for the parameter was exceeded.

Usage: Query only

CALCulate:LIMit:BURSt:EVM:DATA[:AVERage]:RESult?
CALCulate:LIMit:BURSt:EVM:DATA:MAXimum:RESult?

This command returns the result of the average or maximum EVM limit check for data carriers. The limit value is defined by the standard or the user (see CALCulate:LIMit:BURSt:EVM:DATA:MAXimum on page 285).

Return values:

<LimitCheck> **PASS**
The defined limit for the parameter was not exceeded.
FAILED
The defined limit for the parameter was exceeded.

Usage: Query only

CALCulate:LIMit:BURSt:EVM:PILot[:AVERage]:RESult?
CALCulate:LIMit:BURSt:EVM:PILot:MAXimum:RESult?

This command returns the result of the average or maximum EVM limit check for pilot carriers. The limit value is defined by the standard or the user (see CALCulate:LIMit:BURSt:EVM:PILot:MAXimum on page 286).

Return values:
<LimitCheck> **PASS**
The defined limit for the parameter was not exceeded.
FAILED
The defined limit for the parameter was exceeded.

Usage: Query only

CALCulate:LIMit:BURSt:FERRor[:AVERage]:RESult?
CALCulate:LIMit:BURSt:FERRor:MAXimum:RESult?

This command returns the result of the average or maximum center frequency error limit check. The limit value is defined by the standard or the user (see `CALCulate:LIMit:BURSt:FERRor:MAXimum` on page 286).

Return values:
<LimitCheck> **PASS**
The defined limit for the parameter was not exceeded.
FAILED
The defined limit for the parameter was exceeded.

Usage: Query only

CALCulate:LIMit:BURSt:IQOFfset[:AVERage]:RESult?
CALCulate:LIMit:BURSt:IQOFfset:MAXimum:RESult?

This command returns the result of the average or maximum I/Q offset limit check. The limit value is defined by the standard or the user (see `CALCulate:LIMit:BURSt:IQOFfset:MAXimum` on page 286).

Return values:
<LimitCheck> **PASS**
The defined limit for the parameter was not exceeded.
FAILED
The defined limit for the parameter was exceeded.

Usage: Query only

CALCulate:LIMit:BURSt:SYMBolerror[:AVERage]:RESult?
CALCulate:LIMit:BURSt:SYMBolerror:MAXimum:RESult?

This command returns the result of the average or maximum symbol clock error limit check. The limit value is defined by the standard or the user (see `CALCulate:LIMit:BURSt:SYMBolerror:MAXimum` on page 287).

Return values:
<LimitCheck> **PASS**
The defined limit for the parameter was not exceeded.
FAILED
The defined limit for the parameter was exceeded.

Usage: Query only

CALCulate<n>:LIMit<k>:LOWer:FULL

CALCulate<n>:LIMit<k>:UPPer:FULL?

This command queries the limit line y-values as defined by the standard for the specified window.

Tip: to query the corresponding x-values, use the `TRACe<n>[:DATA]:X?` command.

Note: both commands have the same effect; the suffix determines whether the upper or lower limit is returned. For compatibility reasons, both commands are maintained.

Suffix:

<n> Window

<k> 4 | 5
The limit line to query
4: Spectrum Flatness **upper** limit line
5: Spectrum Flatness **lower** limit line

Return values:

<Result> One y-value for each trace point; value depends on the type of result display (see Chapter 10.9.4, "Measurement Results for TRACe<n>[:DATA]? TRACE<n>", on page 339)

Example: `CALC2:LIM4:UPP:FULL?`

Usage: Query only

10.9.2 Numeric Results for Frequency Sweep Measurements

The following commands are required to retrieve the numeric results of the WLAN frequency sweep measurements (see Chapter 3.2, "Frequency Sweep Measurements", on page 50).

In the following commands used to retrieve the numeric results for RF data, the suffixes <n> for CALCulate and <k> for LIMit are irrelevant.

CALCulate<n>:LIMit<k>:ACPower:ACHannel:RESult?
CALCulate<n>:LIMit<k>:ACPower:ALTernate<ch>:RESult?

This command queries the state of the limit check for the adjacent or alternate channels in an ACLR measurement.

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 310.

Suffix:

<n>, <k>	irrelevant
<ch>	1 to 11 Alternate channel number

Return values:

<LowerChan>, <UpperChan>	text value The command returns two results. The first is the result for the lower, the second for the upper adjacent or alternate channel. **PASSED** Limit check has passed. **FAIL** Limit check has failed.

Example:

```
INIT:IMM;*WAI;
CALC:LIM:ACP:ACH:RES?
PASSED,PASSED
```

Usage: Query only

CALCulate<n>:LIMit<k>:FAIL?

This command queries the result of a limit check in the specified window.

For measurements in the R&S FSW WLAN application, the numeric suffix <k> specifies the limit line according to Table 10-11.

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 310.

Suffix:

<n>	Window
<k>	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

SCPI confirmed

Manual operation: See "Spectrum Emission Mask" on page 52

Table 10-11: Limit line suffix <k> for WLAN application

Suffix	Limit
1 to 2	These indexes are not used
3	Limit line for Spectrum Emission Mask as defined by ETSI
4	Spectrum Flatness (Upper) limit line
5	Spectrum Flatness (Lower) limit line
6	Limit line for Spectrum Emission Mask as defined by IEEE
7	PVT Rising Edge max limit
8	PVT Rising Edge mean limit
9	PVT Falling Edge max limit
10	PVT Falling Edge mean limit

CALCulate<n>:MARKer<m>:FUNCtion:POWer<sb>:RESult? <Measurement>

This command queries the results of power measurements.

This command is only available for measurements on RF data (see Chapter 3.2, "Frequency Sweep Measurements", on page 50).

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 310.

Suffix:

<n>, <m>

irrelevant

<sb>

1 | 2 | 3 (4 | 5)

Sub block in a Multi-standard radio measurement;

MSR ACLR: 1 to 5

Multi-SEM: 1 to 3

for all other measurements: irrelevant

Query parameters:

<Measurement>

ACPower | MCACpower
ACLR measurements (also known as adjacent channel power or multicarrier adjacent channel measurements).
Returns the power for every active transmission and adjacent channel. The order is:
• power of the transmission channels
• power of adjacent channel (lower,upper)
• power of alternate channels (lower,upper)
MSR ACLR results:
For MSR ACLR measurements, the order of the returned results is slightly different:
• power of the transmission channels
• total power of the transmission channels for each sub block
• power of adjacent channels (lower, upper)
• power of alternate channels (lower, upper)
• power of gap channels (lower1, upper1, lower2, upper2)
The unit of the return values depends on the scaling of the y-axis:
• logarithmic scaling returns the power in the current unit
• linear scaling returns the power in W

GACLr
For MSR ACLR measurements only: returns a list of ACLR values for each gap channel (lower1, upper1, lower2, upper2)

MACM
For MSR ACLR measurements only: returns a list of CACLR values for each gap channel (lower1, upper1, lower2, upper2)

CN
Carrier-to-noise measurements.
Returns the C/N ratio in dB.

CN0
Carrier-to-noise measurements.
Returns the C/N ratio referenced to a 1 Hz bandwidth in dBm/Hz.

CPOWer
Channel power measurements.
Returns the channel power. The unit of the return values depends on the scaling of the y-axis:
• logarithmic scaling returns the power in the current unit
• linear scaling returns the power in W
For SEM measurements, the return value is the channel power of the reference range (in the specified sub block).

PPOWer
Peak power measurements.
Returns the peak power. The unit of the return values depends on the scaling of the y-axis:
• logarithmic scaling returns the power in the current unit
• linear scaling returns the power in W

For SEM measurements, the return value is the peak power of the reference range (in the specified sub block).

OBANdwidth | OBWidth
Occupied bandwidth.
Returns the occupied bandwidth in Hz.

Usage: Query only

Manual operation: See "Channel Power ACLR" on page 51
See "Occupied Bandwidth" on page 53

CALCulate<n>:MARKer<m>:X <Position>

This command moves a marker to a particular 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:

<m> Marker (query: 1 to 16)

<n> Window

Parameters:

<Position> Numeric value that defines the marker position on the x-axis.
Range: The range depends on the current x-axis range.

Example: `CALC:MARK2:X 1.7MHz`
Positions marker 2 to frequency 1.7 MHz.

Manual operation: See "Marker Table" on page 55
See "Marker Peak List" on page 56

CALCulate<n>:STATistics:RESult<t>? <ResultType>

This command queries the results of a CCDF or ADP measurement for a specific trace.

Suffix:

<n> irrelevant

<t> Trace

Parameters:

<ResultType>

MEAN
Average (=RMS) power in dBm measured during the measurement time.

PEAK
Peak power in dBm measured during the measurement time.

CFACtor
Determined crest factor (= ratio of peak power to average power) in dB.

ALL
Results of all three measurements mentioned before, separated by commas: <mean power>,<peak power>,<crest factor>

Example: `CALC:STAT:RES2? ALL`
Reads out the three measurement results of trace 2. Example of answer string: 5.56,19.25,13.69 i.e. mean power: 5.56 dBm, peak power 19.25 dBm, crest factor 13.69 dB

Usage: Query only

Manual operation: See "CCDF" on page 54

10.9.3 Retrieving Trace Results

The following commands describe how to retrieve the trace data from the WLAN IQ measurement (Modulation Accuracy, Flatness and Tolerance). Note that for these measurements, only 1 trace per window can be configured.

The traces for frequency sweep measurements are identical to those in the Spectrum application.

Useful commands for retrieving results described elsewhere:

- `DISPlay[:WINDow<n>]:SELect` on page 210

Remote commands exclusive to retrieving trace results:

FORMat[:DATA] <Format>

This command selects the data format that is used for transmission of trace data from the R&S FSW to the controlling computer.

Note that the command has no effect for data that you send to the R&S FSW. The R&S 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 may be.

REAL,32
32-bit IEEE 754 floating-point numbers in the "definite length block format".
In the Spectrum application, the format setting `REAL` is used for the binary transmission of trace data.
For I/Q data, 8 bytes per sample are returned for this format setting.

UINT
In the R&S FSW WLAN application, bitstream data can be sent as unsigned integers format to improve the data transfer speed (compared to ASCII format).

*RST: ASCII

Example: `FORM REAL,32`

Usage: SCPI confirmed

[SENSe:]BURSt:SELect <Value>

This command selects the PPDU for which the trace data is queried (using `TRACe<n>[:DATA]`) for the "EVM vs Symbol" and "EVM vs Carrier" result displays if `[SENSe:]BURSt:SELect:STATe` is `ON`.

The selected PPDU does not affect the corresponding graphical trace displays.

Parameters:

<Value> Range: 1 to <statistic count>
*RST: 1

Example:
```
LAY:WIND2:REPL EVSY
SENS:BURS:SEL:STAT ON
SENS:BURS:SEL 10
TRAC2:DATA? TRACE1
```
Returns the trace results for the PPDU number 10 in window 2 ("EVM vs Symbol").

[SENSe:]BURSt:SELect:STATe <State>

Determines whether a selected PPDU (using `[SENSe:]BURSt:SELect`) is considered or ignored.

Parameters:

<State> ON | OFF

ON
Only the results for the selected PPDU are considered by a subsequent TRACe<n>[:DATA] query for "EVM vs Symbol" and "EVM vs Carrier" result displays.

OFF
"EVM vs Symbol" result display: query returns all detected PPDUs in the current capture buffer
"EVM vs Carrier" result display: query returns the statistical results for all analyzed PPDUs

*RST: OFF

Example:

```
LAY:WIND2:REPL EVSY
SENS:BURS:SEL:STAT ON
SENS:BURS:SEL 10
TRAC2:DATA? TRACE1
```

Returns the trace results for the PPDU number 10 in window 2 ("EVM vs Symbol").

TRACe<n>[:DATA] <ResultType>

This command queries current trace data and measurement results from the window previously selected using DISPlay[:WINDow<n>]:SELect.

As opposed to the R&S FSW base unit, the window suffix <n> is not considered in the R&S FSW WLAN application! Use the DISPlay[:WINDow<n>]:SELect to select the window before you query trace results!

For details see Chapter 10.9.4, "Measurement Results for TRACe<n>[:DATA]? TRACE<n>", on page 339.

Suffix:

<n> irrelevant

Parameters:

<ResultType> Selects the type of result to be returned.

TRACE1 | ... | TRACE6
Returns the trace data for the corresponding trace.
Note that for the default WLAN I/Q measurement (Modulation Accuracy, Flatness and Tolerance), only 1 trace per window (TRACE1) is available.

LIST
Returns the results of the peak list evaluation for Spectrum Emission Mask measurements.

Return values:

<TraceData> For more information see tables below.

Example:
```
DISP:WIND2:SEL
TRAC? TRACE3
```
Queries the data of trace 3 in window 2.

Manual operation:
See "AM/AM" on page 23
See "AM/PM" on page 24
See "AM/EVM" on page 24
See "Bitstream" on page 25
See "Constellation" on page 27
See "Constellation vs Carrier" on page 29
See "EVM vs Carrier" on page 30
See "EVM vs Chip" on page 31
See "EVM vs Symbol" on page 31
See "FFT Spectrum" on page 32
See "Freq. Error vs Preamble" on page 34
See "Gain Imbalance vs Carrier" on page 34
See "Group Delay" on page 35
See "Magnitude Capture" on page 36
See "Phase Error vs Preamble" on page 37
See "Phase Tracking" on page 38
See "PLCP Header (IEEE 802.11b, g (DSSS)" on page 38
See "PvT Full PPDU" on page 39
See "PvT Rising Edge" on page 40
See "PvT Falling Edge" on page 41
See "Quad Error vs Carrier" on page 42
See "Signal Field" on page 46
See "Spectrum Flatness" on page 49
See "Spectrum Emission Mask" on page 52

Table 10-12: Return values for TRACE1 to TRACE6 parameter

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 294. The results for the various window types are described in Chapter 10.9.4, "Measurement Results for TRACe<n>[:DATA]? TRACE<n>", on page 339. For RF data traces, the trace data consists of a list of 1001 power levels that have been measured. The unit depends on the measurement and on the unit you have currently set. For SEM measurements, the x-values should be queried as well, as they are not equi-distant (see `TRACe<n>[:DATA]:X?` on page 338).

Table 10-13: Return values for LIST parameter

This parameter is only available for SEM measurements. For each sweep list range you have defined (range 1...n), the command returns eight values in the following order. <No>,<StartFreq>,<StopFreq>,<RBW>,<PeakFreq>,<PowerAbs>,<PowerRel>,<PowerDelta>,<LimitCheck>,<Unused1>,<Unused2> ● <No>: range number ● <StartFreq>,<StopFreq>: start and stop frequency of the range ● <RBW>: resolution bandwidth ● <PeakFreq>: frequency of the peak in a range ● <PowerAbs>: absolute power of the peak in dBm ● <PowerRel>: power of the peak in relation to the channel power in dBc ● <PowerDelta>: distance from the peak to the limit line in dB, positive values indicate a failed limit check ● <LimitCheck>: state of the limit check (0 = PASS, 1 = FAIL) ● <Unused1>,<Unused2>: reserved (0.0)

TRACe<n>[:DATA]:X? <TraceNumber>

This command 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 | ... | TRACE6

Example: `TRAC3:X? TRACE1`

Returns the x-values for trace 1 in window 3.

Usage: Query only

TRACe:IQ:DATA:MEMory <OffsetSamp>, <NumSamples>

Returns all the I/Q trace data in the capture buffer. The result values are scaled in Volts. The command returns a comma-separated list of the measured voltage values in floating point format (Comma Separated Values = CSV). The number of values returned is 2 * the number of complex samples, the first half being the I values, the second half the Q values.

Parameters:

<OffsetSamp> Offset of the values to be read related to the start of the capture buffer.

Range: 0 to (<NumSamples>-1)

<NumSamples> Number of measurement values to be read.

Range: 1 to (<NumSamples>-<OffsetSa>)

10.9.4 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)

As opposed to the R&S FSW base unit, the window suffix <n> is not considered in the R&S FSW WLAN application! Use the `DISPlay[:WINDow<n>]:SELect` to select the window before you query trace results!

For details on the graphical results of these evaluation methods, see Chapter 3.1.2, "Evaluation Methods for WLAN IQ Measurements", on page 22.

The following table provides an overview of the main characteristics of the WLAN OFDM symbol structure in the frequency domain for various standards. The description of the TRACe results refers to these values to simplify the description.

Table 10-14: WLAN OFDM symbol structure in the frequency domain

Stan dard	CBW / MHz	N_{FFT}	N_{SD} No. of data sc	N_{SP} No. of pilot sc	Pilot subcarrier (sc)	N_{ST} No. of sc total : $=N_{SD}$ $+N_{SP}$	N_{Null} No. of DC/ Null sc	DC / Null subcar-rier	N_{used} No. of used sc := N_{ST} + N_{Null}	N_{guard} :=N_{FFT} - N_{used}	Comment
IEEE 802.11 a, j, p	5	64	48	4	{-21,-7,7,21}	52	1	{0}	53	11	IEEE Std 802.11-2012 Tab Table 18-5—Timing-related parameters
	10	64	48	4	{-21,-7,7,21}	52	1	{0}	53	11	IEEE Std 802.11-2012 Tab Table 18-5—Timing-related parameters
	20	64	48	4	{-21,-7,7,21}	52	1	{0}	53	11	IEEE Std 802.11-2012 Tab Table 18-5—Timing-related parameters
11n	20	64	52	4	{-21,-7,7,21}[1)]	56	1	{0}	57	7	IEEE Std 802.11-2012 Tab Table 20-6—Timing-related constants
	40	128	108	6	{-53, -25, -11, 11, 25, 53}[1)]	114	3	{-1,0,1}[3)]	117	11	IEEE Std 802.11-2012 Tab Table 20-6—Timing-related constants
11ac	20	64	52	4	{-21,-7,7,21}2	56	1	{0}	57	7	IEEE P802.11ac/D2.1, March 2012 Table 22-5—Timing-related con-stants
	40	128	108	6	{-53, -25, -11, 11, 25, 53}[2)]	114	3	{-1,0,1}[4)]	117	11	IEEE P802.11ac/D2.1, March 2012 Table 22-5—Timing-related con-stants

1) IEEE Std 802.11-2012 Section 20.3.11.10 Pilot subcarriers

2) IEEE P802.11ac/D2.1, March 2012 Section 22.3.10.10 Pilot subcarriers

3) IEEE Std 802.11-2012 equation (20-59)

4) IEEE P802.11ac/D2.1, March 2012 equation (22-94)

5) IEEE P802.11ac/D2.1, March 2012 equation (22-95)

6) IEEE P802.11ac/D2.1, March 2012 equation (22-96)

Stan dard	CBW / MHz	N_{FFT}	N_{SD} No. of data sc	N_{SP} No. of pilot sc	Pilot subcarrier (sc)	N_{ST} No. of sc total : $=N_{SD}+N_{SP}$	N_{Null} No. of DC/ Null sc	DC / Null subcar- rier	N_{used} No. of used sc := N_{ST} + N_{Null}	N_{guard} :=N_{FFT} - N_{used}	Comment
	80	256	234	8	{–103, –75, –39, –11, 11, 39, 75,103}[2)]	242	3	{-1,0,1}[5)]	245	11	IEEE P802.11ac/D2.1, March 2012 Table 22-5—Timing-related con- stants
	160	512	468	16	{ -231, -203, -167, -139, -117, -89, -53, -25, 25, 53, 89, 117, 139, 167, 203, 231}[2)]	484	17	{-129, -128, -127, -5:1:5, 127, 128, 129}[6)]	501	11	IEEE P802.11ac/D2.1, March 2012 Table 22-5—Timing-related con- stants

1) IEEE Std 802.11-2012 Section 20.3.11.10 Pilot subcarriers
2) IEEE P802.11ac/D2.1, March 2012 Section 22.3.10.10 Pilot subcarriers
3) IEEE Std 802.11-2012 equation (20-59)
4) IEEE P802.11ac/D2.1, March 2012 equation (22-94)
5) IEEE P802.11ac/D2.1, March 2012 equation (22-95)
6) IEEE P802.11ac/D2.1, March 2012 equation (22-96)

10.9.4.1 AM/AM

For each sample, the x-axis value represents the amplitude of the reference-signal and the y-axis value represents the amplitude of the measured-signal.

Note: The measured signal and reference signal are complex signals.

10.9.4.2 AM/PM

For each sample, the x-axis value represents the amplitude of the reference signal. The y-axis value represents the angle difference of the measured signal minus the reference signal.

Note: The measured signal and reference signal are complex signals.

10.9.4.3 AM/EVM

For each sample, the x-axis value represents the amplitude of the reference-signal. The y-axis value represents the length of the error vector between the measured signal and the reference signal.

Note: The measured signal and reference signal are complex signals.

10.9.4.4 Bitstream

Data is returned depending on the selected standard for which the measurement was executed (see `CONFigure:STANdard` on page 212):

IEEE 802.11a, ac, g (OFDM), j, n, p standard (OFDM physical layers)

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.

Standard	CBW in MHz	N_{SD} (Number of data subcarriers)	N_{SP} (Number of pilot subcarriers)	N_{ST} (Total number of subcarriers: N_{SD}+N_{SP})
IEEE 802.11 a, p	5	48	4	**52**
IEEE 802.11 a, j, p	10	48	4	**52**
IEEE 802.11 a, j, p	20	48	4	**52**
IEEE 802.11n	20	52	4	**56**
IEEE 802.11n	40	108	6	**114**
IEEE 802.11ac	20	52	4	**56**
IEEE 802.11ac	40	108	6	**114**
IEEE 802.11ac	80	234	8	**242**
IEEE 802.11ac	160	468	16	**484**

IEEE 802.11b and g (DSSS) standard (DSSS physical layers)

For the IEEE 802.11b and g (DSSS) standard, the data is returned in PPDU order. Each PPDU is represented as a series of bytes. For each PPDU, the first 9 or 18 bytes represent the PLCP preamble for short and long PPDU types, respectively. The next 6 bytes represent the PLCP header. The remaining bytes represent the PSDU. Data is returned in ASCII printable hexadecimal character format.

TRACE1 is used for these measurement results.

10.9.4.5 CCDF – Complementary Cumulative Distribution Function

The length of the results varies; up to a maximum of 201 data points is returned, following a data count value. The first value in the return data represents the quantity of probability values that follow. Each of the potential 201 data points is returned as a probability value and represents the total number of samples that are equal to or exceed the current mean power level.

Probability data is returned up to the power level that contains at least one sample. It is highly unlikely that the full 201 data values will ever be returned.

Each probability value is returned as a floating point number, with a value between 0 and 1.

The syntax of the result is thus:

N, CCDF(0), CCDF(1/10), CCDF(2/10), …, CCDF((N-1)/10)

10.9.4.6 Constellation

This measurement represents the complex constellation points as I and Q data. See for example IEEE Std. 802.11-2012 'Fig. 18-10 BPSK, QPSK, 16-QAM and 64-QAM constellation bit encoding'. Each I and Q point is returned in floating point format.

Data is returned as a repeating array of interleaved I and Q data in groups of selected carriers per OFDM-Symbol, until all the I and Q data for the analyzed OFDM-Symbols is exhausted.

The following carrier selections are possible:

- "All Carriers": `CONFigure:BURSt:CONStellation:CARRier:SELect ALL`
  N_{ST} pairs of I and Q data per OFDM-Symbol
  OFDM-Symbol 1: $(I_{1,1}, Q_{1,1}), (I_{1,2},Q_{1,2}), \ldots,(I_{1,Nst}, Q_{1,Nst})$
  OFDM-Symbol 2: $(I_{2,1}, Q_{2,1}), (I_{2,2},Q_{2,2}),\ldots,(I_{2,Nst}, Q_{2,Nst})$
  …
  OFDM-Symbol N:
  $(I_{N,1}, Q_{N,1}), (I_{N,2},Q_{N,2}),\ldots,(I_{N,Nst}, Q_{N,Nst})$
- "Pilots Only": `CONFigure:BURSt:CONStellation:CARRier:SELect PILOTS`
  N_{SP} pairs of I and Q data per OFDM-Symbol in the natural number order.
  OFDM-Symbol 1: $(I_{1,1}, Q_{1,1}), (I_{1,2},Q_{1,2}), \ldots,(I_{1,Nsp}, Q_{1,Nsp})$
  OFDM-Symbol 2: $(I_{2,1}, Q_{2,1}), (I_{2,2},Q_{2,2}),\ldots,(I_{2,Nsp}, Q_{2,Nsp})$
  …
  OFDM-Symbol N:
  $(I_{N,1}, Q_{N,1}), (I_{N,2},Q_{N,2}),\ldots,(I_{N,Nsp}, Q_{N,Nsp})$
- Single carrier:
  1 pair of I and Q data per OFDM-Symbol for the selected carrier
  `CONFigure:BURSt:CONStellation:CARRier:SELect k`
  with

  $$\boldsymbol{k} \in \left\{- (\boldsymbol{N_{used}} - 1)/2\,, -(\boldsymbol{N_{used}} - 1)/2 + 1, \ldots, (\boldsymbol{N_{used}} - 1)/2\right\}$$

  OFDM-Symbol 1: $(I_{1,1}, Q_{1,1})$
  OFDM-Symbol 2: $(I_{2,1}, Q_{2,1})$
  …
  OFDM-Symbol N: $(I_{N,1}, Q_{N,1})$

10.9.4.7 Constellation vs Carrier

This measurement represents the complex constellation points as I and Q data. See for example IEEE Std. 802.11-2012 'Fig. 18-10 BPSK, QPSK, 16-QAM and 64-QAM constellation bit encoding'. Each I and Q point is returned in floating point format. Data is returned as a repeating array of interleaved I and Q data in groups of N_{used} subcarriers per OFDM-Symbol, until all the I and Q data for the analyzed OFDM-Symbols is exhausted.

Note that as opposed to the Constellation results, the DC/null subcarriers are included as NaNs.

N_{used} pairs of I and Q data per OFDM-Symbol

OFDM-Symbol 1: $(I_{1,1}, Q_{1,1})$, $(I_{1,2},Q_{1,2})$, …,($I_{1,Nused}$, $Q_{1,Nused}$)

OFDM-Symbol 2: $(I_{2,1}, Q_{2,1})$, $(I_{2,2},Q_{2,2})$,…,($I_{2,Nused}$, $Q_{2,Nused}$)

…

OFDM-Symbol N:

$(I_{N,1}, Q_{N,1})$, $(I_{N,2},Q_{N,2})$,…,($I_{N,Nused}$, $Q_{N,Nused}$)

10.9.4.8 Error vs Carrier

Three trace types are provided for gain imbalance/quadrature error evaluation:

TRACE1	The minimum gain imbalance/quadrature error value - over the analyzed PPDUs - for each of the N_{used} subcarriers
TRACE2	The average gain imbalance/quadrature error value - over the analyzed PPDUs - for each of the N_{used} subcarriers
TRACE3	The maximum gain imbalance/quadrature error value - over the analyzed PPDUs - for each of the N_{used} subcarriers

Each gain imbalance/quadrature error value is returned as a floating point number, expressed in units of dB.

Supported data formats (see `FORMat[:DATA]` on page 334): `ASCii|UINT`

10.9.4.9 Error vs Preamble

Three traces types are available for frequency or phase error measurement. The basic trace types show either the minimum, mean or maximum frequency or phase value as measured over the preamble part of the PPDU.

Supported data formats (see `FORMat[:DATA]` on page 334): `ASCii|REAL`

10.9.4.10 EVM vs Carrier

Three trace types are provided for this evaluation:

Table 10-15: Query parameter and results for EVM vs Carrier

TRACE1	The minimum EVM value - over the analyzed PPDUs - for each of the N_{used} subcarriers
TRACE2	The average EVM value - over the analyzed PPDUs - for each of the N_{used} subcarriers
TRACE3	The maximum EVM value - over the analyzed PPDUs - for each of the N_{used} subcarriers

Each EVM value is returned as a floating point number, expressed in units of dB.

Supported data formats (see `FORMat[:DATA]` on page 334): `ASCii|UINT`

Example:

For $EVM_{m,n}$: the EVM of the m-th analyzed PPDU for the subcarrier n = {1,2,…, N_{used} }

TRACE1: Minimum EVM value per subcarrier

Minimum($EVM_{1,1}$, $EVM_{2,1}$,…. $EVM_{Statistic\ Length,1}$),

//Minimum EVM value for subcarrier –(N_{used}-1)/2

Minimum($EVM_{1,2}$, $EVM_{2,2}$,…. $EVM_{Statistic\ Length,2}$),

// Minimum EVM value for subcarrier –(N_{used}-1)/2 + 1

…,

Minimum($EVM_{1,Nused}$,$EVM_{2,Nused}$,…. $EVM_{Statistic\ Length,Nused}$)

// Minimum EVM value for subcarrier +(N_{used}-1)/2

10.9.4.11 EVM vs Chip

These results are **only** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).

Since the R&S FSW WLAN application provides two different methods to calculate the EVM, two traces are available:

TRACE1	EVM IEEE values
TRACE2	EVM Direct values

Each trace shows the EVM value as measured over the complete capture period.

The number of repeating groups that are returned is equal to the number of measured chips.

Each EVM value is returned as a floating point number, expressed in units of dBm.

Supported data formats (see `FORMat[:DATA]` on page 334): `ASCii|REAL`

10.9.4.12 EVM vs Symbol

Three traces types are available with this measurement. The basic trace types show either the minimum, mean or maximum EVM value, as measured over the complete capture period.

The number of repeating groups that are returned is equal to the number of measured symbols.

Each EVM value is returned as a floating point number, expressed in units of dBm.

Supported data formats (see `FORMat[:DATA]` on page 334): `ASCii|REAL`

TRACE1	Minimum EVM values
TRACE2	Mean EVM values
TRACE3	Maximum EVM values

These results are **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).

10.9.4.13 FFT 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.

10.9.4.14 Group Delay

Currently the following trace types are provided with this measurement:

- `TRACE1`
  A repeating list of group delay values for each subcarrier. The number of repeating lists corresponds to the number of fully analyzed PPDUs as displayed in the current Magnitude Capture. Each group delay value is returned as a floating point number, expressed in units of seconds.
- `TRACE`
  All group delay values per subcarrier for each analyzed PPDU of the capture period

Example:

For $GD_{m,n}$: the group delay of the m-th analyzed PPDU for the subcarrier corresponding to n = {1,2,…, N_{used} };

`TRACE:DATA? TRACE2`

Analyzed PPDU 1:

$GD_{1,1}$, $GD_{1,2}$, …,

Analyzed PPDU 2:

$GD_{2,1}$, $GD_{2,2}$, …,

…

Analyzed PPDU N :

$GD_{N,1}$, $GD_{N,2}$, …,

10.9.4.15 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 "Input Sample Rate" on page 123 and "Capture Time" on page 123).

10.9.4.16 Phase Tracking

Returns the average phase tracking result per symbol (in Radians).

These results are **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).

10.9.4.17 Power vs Time (PVT)

All complete PPDUs within the capture time are analyzed in three master PPDUs. The three master 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 334): `ASCii|REAL`

10.9.4.18 Signal Field

The bits are returned as read from the corresponding signal field parts in transmit order. I.e. the first transmitted bit has the highest significance and the last transmitted bit has the lowest significance.

See also "Signal Field" on page 46.

The `TRAC:DATA?` command returns the information as read from the signal field for each analyzed PPDU. The signal field bit sequence is converted to an equivalent sequence of hexadecimal digits for each analyzed PPDU in transmit order.

10.9.4.19 Spectrum Flatness

The spectrum flatness evaluation returns absolute power values per carrier (in dBm).

Two trace types are provided for this evaluation:

Table 10-16: Query parameter and results for Spectrum Flatness

TRACE1	An average spectrum flatness value for each of the 53 (or 57/117 within the IEEE 802.11 n standard) carriers
TRACE2	All spectrum flatness values per channel

Supported data formats (FORMat:DATA): ASCii|REAL

10.9.5 Importing and Exporting I/Q Data and Results

The I/Q data to be evaluated in the R&S FSW WLAN application can not only be measured by the R&S FSW WLAN application 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 WLAN application can be exported for further analysis in external applications.

For details on importing and exporting I/Q data see the R&S FSW User Manual.

MMEMory:LOAD:IQ:STATe 1,<FileName>

This command restores I/Q data from a file.

The file extension is *.iqw.

Parameters:

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

Example: `MMEM:LOAD:IQ:STAT 1, 'C:\R_S\Instr\user\data.iqw'`
Loads IQ data from the specified file.

Usage: Setting only

Manual operation: See "I/Q Import" on page 179

MMEMory:STORe<n>:IQ:STATe 1, <FileName>

This command writes the captured I/Q data to a file.

The file extension is *.iq.tar. By default, the contents of the file are in 32-bit floating point format.

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 full" error can occur although the hard disk indicates that storage space is still available.

To store data permanently, select an external storage location such as a USB memory device.

For details, see "Protecting Data Using the Secure User Mode" in the "Data Management" section of the R&S FSW User Manual.

Suffix:
<n> irrelevant

Parameters:
1

<FileName> String containing the path and name of the target file.

Example: `MMEM:STOR:IQ:STAT 1, 'C:\R_S\Instr\user\data.iq.tar'`
Stores the captured I/Q data to the specified file.

Manual operation: See "I/Q Export" on page 179

10.10 Analysis

The following commands define general result analysis settings concerning the traces and markers in standard WLAN measurements. Currently, only one (Clear/Write) trace and one marker are available for standard WLAN 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 WLAN application.

For details see the "General Measurement Analysis and Display" chapter in the R&S FSW User Manual.

10.10.1 Markers

Markers help you analyze your measurement results by determining particular values in the diagram. Currently, only 1 marker per window can be configured for standard WLAN measurements.

CALCulate<n>:MARKer<m>[:STATe] <State>

This command turns markers on and off. If the corresponding marker number is currently active as a deltamarker, it is turned into a normal marker.

Suffix:

<n>	Window
<m>	Marker

Parameters:

<State>	ON | OFF *RST: OFF

Example: `CALC:MARK3 ON`
Switches on marker 3.

CALCulate<n>:MARKer<m>:Y?

This command queries the position of a marker on the y-axis.

If necessary, the command activates the marker first.

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 310.

Suffix:

<n>	Window
<m>	Marker

Return values:

<Result>	Result at the marker position.

Example:
`INIT:CONT OFF`
Switches to single measurement mode.
`CALC:MARK2 ON`
Switches marker 2.
`INIT;*WAI`
Starts a measurement and waits for the end.
`CALC:MARK2:Y?`
Outputs the measured value of marker 2.

Usage: Query only

Manual operation: See "CCDF" on page 54
See "Marker Table" on page 55
See "Marker Peak List" on page 56

10.11 Status Registers

The R&S FSW WLAN application uses the standard status registers of the R&S 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 R&S FSW status registers refer to the description of remote control basics in the R&S FSW User Manual.

*RST does not influence the status registers.

10.11.1 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 10-17: Meaning of the bits used in the STATus:QUEStionable:SYNC register

Bit No.	Meaning
0	PPDU not found This bit is set if an IQ measurement is performed and no PPDUs are detected
1	This bit is not used
2	No PPDUs of REQuired type This bit is set if an IQ measurement is performed and no PPDUs of the specified type are detected

Bit No.	Meaning
3	GATE length too small This bit is set if gating is used in a measurement and the gate length is not set sufficiently large enough
4	PPDU count too small This bit is set if a PVT measurement is performed with gating active and there is not at least 1 PPDU within the gate lines
5	Auto level OVERload This bit is set if a signal overload is detected when an auto-level measurement is performed
6	Auto level NoSIGnal This bit is set if no signal is detected by the auto-level measurement
7 - 14	These bits are not used.
15	This bit is always 0.

10.11.2 STATus:QUEStionable:DIQ Register

This register contains information about the state of the digital I/Q input and output. This register is used by the optional Digital Baseband Interface.

The status of the `STATus:QUEStionable:DIQ` register is indicated in bit 14 of the `STATus:QUEStionable` register.

You can read out the state of the register with `STATus:QUEStionable:DIQ:CONDition?` on page 354 and `STATus:QUEStionable:DIQ[:EVENt]?` on page 356.

Bit No.	Meaning
0	**Digital I/Q Input Device connected** This bit is set if a device is recognized and connected to the Digital Baseband Interface of the analyzer.
1	**Digital I/Q Input Connection Protocol in progress** This bit is set while the connection between analyzer and digital baseband data signal source (e.g. R&S SMW, R&S Ex-I/Q-Box) is established.
2	**Digital I/Q Input Connection Protocol error** This bit is set if an error occurred during establishing of the connect between analyzer and digital I/Q data signal source (e.g. R&S SMW, R&S Ex-I/Q-Box) is established.
3	**Digital I/Q Input PLL unlocked** This bit is set if the PLL of the Digital I/Q input is out of lock due to missing or unstable clock provided by the connected Digital I/Q TX device. To solve the problem the Digital I/Q connection has to be newly initialized after the clock has been restored.

Bit No.	Meaning
4	**Digital I/Q Input DATA Error** This bit is set if the data from the Digital I/Q input module is erroneous. Possible reasons: ● Bit errors in the data transmission. The bit will only be set if an error occurred at the current measurement. ● Protocol or data header errors. May occur due to data synchronization problems or vast transmission errors. The bit will be set constantly and all data will be erroneous. To solve the problem the Digital I/Q connection has to be newly initialized. NOTE: If this error is indicated repeatedly either the Digital I/Q LVDS connection cable or the receiving or transmitting device might be defect.
5	Not used
6	**Digital I/Q Input FIFO Overload** This bit is set if the sample rate on the connected instrument is higher than the input sample rate setting on the R&S FSW. Possible solution: ● Reduce the sample rate on the connected instrument ● Increase the input sample rate setting on the R&S FSW
7	Not used
8	**Digital I/Q Output Device connected** This bit is set if a device is recognized and connected to the Digital I/Q Output.
9	**Digital I/Q Output Connection Protocol in progress** This bit is set while the connection between analyzer and digital I/Q data signal source (e.g. R&S SMW, R&S Ex-I/Q-Box) is established.
10	**Digital I/Q Output Connection Protocol error** This bit is set if an error occurred while the connection between analyzer and digital I/Q data signal source (e.g. R&S SMW, R&S Ex-I/Q-Box) is established.
11	**Digital I/Q Output FIFO Overload** This bit is set if an overload of the Digital I/Q Output FIFO occurred. This happens if the output data rate is higher than the maximal data rate of the connected instrument. Reduce the sample rate to solve the problem.
12-14	Not used
15	This bit is always set to 0.

STATus:QUEStionable:DIQ:CONDition? <ChannelName>

This command reads out the CONDition section of the `STATus:QUEStionable:DIQ:CONDition` status register.

The command does not delete the contents of the EVENt section.

Query parameters:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Example: `STAT:QUES:DIQ:COND?`

Usage: Query only

STATus:QUEStionable:DIQ:ENABle <BitDefinition>, <ChannelName>

This command 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:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Setting parameters:

<SumBit> Range: 0 to 65535

Usage: SCPI confirmed

STATus:QUEStionable:DIQ:NTRansition <BitDefinition>,<ChannelName>

This command 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:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Setting parameters:

<BitDefinition> Range: 0 to 65535

STATus:QUEStionable:DIQ:PTRansition <BitDefinition>,<ChannelName>

This command controls 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:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Setting parameters:

<BitDefinition> Range: 0 to 65535

STATus:QUEStionable:DIQ[:EVENt]? <ChannelName>

This command queries the contents of the "EVENt" section of the `STATus:QUEStionable:DIQ` register for IQ measurements.

Readout 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.

Example: `STAT:QUES:DIQ?`

Usage: Query only

10.11.3 Querying the Status Registers

The following commands are required to query the status of the R&S FSW and the R&S FSW WLAN application.

For details on the common R&S FSW status registers refer to the description of remote control basics in the R&S FSW User Manual.

10.11.3.1 General Status Register Commands

STATus:PRESet

This command 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]?

This command 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

10.11.3.2 Reading Out the EVENt Part

STATus:OPERation[:EVENt]?
STATus:QUEStionable[:EVENt]?
STATus:QUEStionable:ACPLimit[:EVENt]? <ChannelName>
STATus:QUEStionable:LIMit<n>[:EVENt]? <ChannelName>
STATus:QUEStionable:SYNC[:EVENt]? <ChannelName>

This command reads out the EVENt section of the status register.

The command also deletes the contents of the EVENt section.

Suffix:
<n> Window

<m> Marker

Query parameters:
<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

10.11.3.3 Reading Out the CONDition Part

STATus:OPERation:CONDition?
STATus:QUEStionable:CONDition?
STATus:QUEStionable:ACPLimit:CONDition? <ChannelName>

STATus:QUEStionable:LIMit<n>:CONDition? <ChannelName>
STATus:QUEStionable:SYNC:CONDition? <ChannelName>

This command reads out the CONDition section of the status register.

The command does not delete the contents of the EVENt section.

Suffix:

<n> Window

<m> Marker

Query parameters:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

10.11.3.4 Controlling the ENABle Part

STATus:OPERation:ENABle <SumBit>
STATus:QUEStionable:ENABle <SumBit>
STATus:QUEStionable:ACPLimit:ENABle <SumBit>,<ChannelName>
STATus:QUEStionable:LIMit<n>:ENABle <SumBit>,<ChannelName>
STATus:QUEStionable:SYNC:ENABle <BitDefinition>, <ChannelName>

This command 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.

Suffix:

<n> Window

<m> Marker

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.

10.11.3.5 Controlling the Negative Transition Part

STATus:OPERation:NTRansition <SumBit>
STATus:QUEStionable:NTRansition <SumBit>
STATus:QUEStionable:ACPLimit:NTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:LIMit<n>:NTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:SYNC:NTRansition <BitDefinition>,<ChannelName>

This command 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.

Suffix:

<n>	Window
<m>	Marker

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.

10.11.3.6 Controlling the Positive Transition Part

STATus:OPERation:PTRansition <SumBit>
STATus:QUEStionable:PTRansition <SumBit>
STATus:QUEStionable:ACPLimit:PTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:LIMit<n>:PTRansition <SumBit>,<ChannelName>
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.

Suffix:

<n>	Window
<m>	Marker

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.

10.12 Deprecated Commands

The following commands are provided only for compatibility to remote control programs from R&S FSW WLAN applications on previous signal analyzers. For new remote control programs use the specified alternative commands.

The `CONF:BURS:<ResultType>:IMM` commands used in former R&S Signal and Spectrum Analyzers to change the result display are still supported for compatibility reasons; however they have been replaced by the `LAY:ADD:WIND` commands in the R&S FSW (see Chapter 10.7, "Configuring the Result Display", on page 292). 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.

MMEMory:LOAD:SEM:STATe <1>, <Filename>

This command 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 R&S 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'
```

TRIGger[:SEQuence]:MODE <Source>

Defines the trigger source.

Note that this command is maintained for compatibility reasons only. Use the `TRIGger[:SEQuence]:SOURce` on page 251 commands for new remote control programs.

This command configures how triggering is to be performed.

Parameters:
<Source> IMMediate | EXTernal | VIDeo | RFPower | IFPower | TV | AF | AM | FM | PM | AMRelative | LXI | TIME | SLEFt | SRIGht | SMPX | SMONo | SSTereo | SRDS | SPILot | BBPower | MASK | PSENsor | TDTRigger | IQPower | EXT2 | EXT3

10.13 Programming Examples (R&S FSW WLAN application)

This example demonstrates how to configure a WLAN 802.11 measurement in a remote environment.

10.13.1 Measurement 1: Measuring Modulation Accuracy for WLAN 802.11n Standard

This example demonstrates how to configure a WLAN IQ measurement for a signal according to WLAN 802.11n standard in a remote environment.

```
//---------- Preparing the application ------------
// Preset the instrument
*RST
// Enter the WLAN option K91n
INSTrument:SELect WLAN
// Switch to single sweep mode and stop sweep
INITiate:CONTinuous OFF;:ABORt

//---------- Configuring the result display ------------
// Activate following result displays:
// 1: Magnitude Capture (default, upper left)
// 2: Result Summary Detailed (below Mag Capt)
// 3: Result Summary Global (default, lower right)
// 4: EVM vs Carrier (next to Mag Capt)

LAY:REPL '2',RSD
LAY:ADD:WIND? '1',RIGH,EVC
//Result: '4'

//---------- Signal description ------------
//Use measurement standard IEEE 802 11n
CONF:STAN 6
//Center frequency is 13.25 GHz
FREQ:CENT 13.25GHZ

//---------- Configuring Data Acquisition ---------------------
//Each measurement captures data for 10 ms.
SWE:TIME 10ms
//Set the input sample rate for the captured I/Q data to 20MHz
TRAC:IQ:SRAT 20MHZ
// Number of samples captured per measurement: 0.01s * 20e6 samples per second
// = 200 000 samples
//Include effects from adjacent channels - switch off filter
BAND:FILT OFF
```

```
//---------- Synchronization -----------------
//Improve performance - perform coarse burst search initially
SENS:DEM:TXAR ON
//Minimize the intersymbol interference - FFT start offset determined automatically
SENS:DEM:FFT:OFFS AUTO

//---------- Tracking and channel estimation -----------------
//Improve EVM accuracy - estimate channel from preamble and payload
SENS:DEM:CEST ON
//Use pilot sequence as defined in standard
SENS:TRAC:PIL STAN
//Disable all tracking and compensation functions
SENS:TRAC:LEV OFF
SENS:TRAC:PHAS OFF
SENS:TRAC:TIME OFF

//---------- Demodulation ------------
//Define a user-defined logical filter to analyze:
SENS:DEM:FORM:BCON:AUTO OFF
//all PPDU formats
SENS:DEM:FORM:BAN:BTYP:AUTO:TYPE ALL
//20MHZ channel bandwidth
SENS:BAND:CHAN:AUTO:TYPE MB20
//an MCS Index '1'
SENS:DEM:FORM:MCS:MODE MEAS
SENS:DEM:FORM:MCS 1
//STBC field = '1'
CONF:WLAN:STBC:AUTO:TYPE M1
//Ness = 1
CONF:WLAN:EXT:AUTO:TYPE M1
//short guard interval length (8 samples)
CONF:WLAN:GTIM:AUTO ON
CONF:WLAN:GTIM:AUTO:TYPE MS

//---------- Evaluation range settings -----------------
//Calculate statistics over 10 PPDUs
SENS:BURS:COUN:STAT ON
SENS:BURS:COUN 10
//Determine payload length from HT signal
CONF:WLAN:PAYL:LENG:SRC HTS
//Payload length: 8-16 symbols
SENS:DEM:FORM:BAN:SYMB:EQU OFF
SENS:DEM:FORM:BAN:SYMB:MIN 8
SENS:DEM:FORM:BAN:SYMB:MAX 16

//---------- Measurement settings --------------------
//Define units for EVM and Gain imbalance results
UNIT:EVM PCT
UNIT:GIMB PCT
```

```
//---------- Defining Limits -----------------------
//Define non-standard limits for demonstration purposes
//and return to standard limits later.
//Query current limit settings:
CALC:LIM:BURS:ALL?
//Set new limits:
//Average CF error: 5HZ
//max CF error: 10HZ
//average symbol clock error: 5
//max symbol clock error: 10
//average I/Q offset: 5
//maximum I/Q offset: 10
//average EVM all carriers: 0.1%
//max EVM all carriers: 0.5%
//average EVM data carriers: 0.1%
//max EVM data carriers: 0.5%
//average EVM pilots: 0.1%
//max EVM pilots: 0.5%
CALC:LIM:BURS:ALL 5,10,5,10,5,10,0.1,0.5,0.1,0.5,0.1,0.5

//---------- Performing the Measurements -----
// Run 10 (blocking) single measurements
INITiate:IMMediate;*WAI

//---------- Retrieving Results -------------
//Query the I/Q data from magnitude capture buffer for first ms
// 200 000 samples per second -> 200 samples
TRACe1:IQ:DATA:MEMory? 0,200
//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? 201,400
//Note: result will be too long to display in IECWIN, but is stored in log file


//Select window 4 (EVM vs carrier)
DISP:WIND4:SEL
//Query the current EVM vs carrier trace
TRAC: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 carriers
FETC:BURS:EVM:ALL:AVER?
//Query the result of the EVM limit check for all carriers
CALC:LIM:BURS:ALL:RES?

//Return to standard-defined limits
CALC:LIM:BURS:ALL
//Query the result of the EVM limit check for all carriers again
CALC:LIM:BURS:ALL:RES?
```

```
//---------- 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'
```

10.13.2 Measurement 2: Determining the Spectrum Emission Mask

```
//---------- Preparing the application ------------
*RST
//Reset the instrument
INST:CRE:NEW WLAN,'SEMMeasurement'
//Activate a WLAN 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
CONF:BURS:SPEC:MASK
//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 10-18: 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 Annex: Reference

A.1 Sample Rate and Maximum Usable I/Q Bandwidth for RF Input

Definitions

- **Input sample rate (ISR)**: the sample rate of the useful data provided by the device connected to the input of the R&S FSW
- (User, Output) **Sample rate (SR)**: the user-defined sample rate (e.g. in the "Data Aquisition" dialog box in the "I/Q Analyzer" application) which is used as the basis for analysis or output
- **Usable I/Q (Analysis) bandwidth**: the bandwidth range in which the signal remains undistorted in regard to amplitude characteristic and group delay; this range can be used for accurate analysis by the R&S FSW
- **Record length**: Number of I/Q samples to capture during the specified measurement time; calculated as the measurement time multiplied by the sample rate

For the I/Q data acquisition, digital decimation filters are used internally in the R&S FSW. The passband of these digital filters determines the *maximum usable I/Q bandwidth*. In consequence, signals within the usable I/Q bandwidth (passband) remain unchanged, while signals outside the usable I/Q bandwidth (passband) are suppressed. Usually, the suppressed signals are noise, artifacts, and the second IF side band. If frequencies of interest to you are also suppressed, try to increase the output sample rate, which increases the maximum usable I/Q bandwidth.

Bandwidth extension options

You can extend the maximum usable I/Q bandwidth provided by the R&S FSW in the basic installation by adding options. These options can either be included in the initial installation (B-options) or updated later (U-options). The maximum bandwidth provided by the individual option is indicated by its number, for example, B40 extends the bandwidth to 40 MHz.

Note that the U-options as of U40 always require all lower-bandwidth options as a prerequisite, while the B-options already include them.

As a rule, the usable I/Q bandwidth is proportional to the output sample rate. Yet, when the I/Q bandwidth reaches the bandwidth of the analog IF filter (at very high output sample rates), the curve breaks.

A.1.1 Bandwidth Extension Options

Max. usable I/Q BW	Required B-option	Required U-option(s)
10 MHz	-	-
28 MHz	B28	U28
40 MHz	B40	U28+U40 **or** B28+U40
80 MHz	B80	U28+U40+U80 **or** B28+U40+U80 **or** B40+U80
160 MHz	B160	U28+U40+U80+U160 **or** B28+U40+U80+U160 **or** B40+U80+U160 **or** B80+U160
320 MHz	B320	U28+U40+U80+U160+U320 **or** B28+U40+U80+U160+U320 **or** B40+U80+U160+U320 **or** B80+U160+U320 **or** B160+U320
500 MHz	B500	See data sheet
512 MHz	B512	U28+U40+U80+U512 **or** B28+U40+U80+U512 **or** B40+U80+U512 **or** B80+U512**or** B500+U512A

A.1.2 Relationship Between Sample Rate and Usable I/Q Bandwidth

Up to the maximum bandwidth, the following rule applies:

*Usable I/Q bandwidth = 0.8 * Output sample rate*

MSRA operating mode

In MSRA operating mode, the MSRA Master is restricted to a sample rate of 600 MHz.

The Figure A-1 shows the maximum usable I/Q bandwidths depending on the output sample rates.

A.1.3 Relationship Between Sample Rate, Record Length and Usable I/Q Bandwidth

Up to the maximum bandwidth, the following rule applies:

*Usable I/Q bandwidth = 0.8 * Output sample rate*

Regarding the record length, the following rule applies:

*Record length = Measurement time * sample rate*

Maximum record length for RF input

The maximum record length, that is, the maximum number of samples that can be captured, depends on the sample rate.

Table A-1: Maximum record length (without I/Q bandwidth extension options R&S FSW-B160/-B320/-B500/-B512)

Sample rate	Maximum record length
100 Hz to 200 MHz	440 MSamples (precisely: 461373440 (= 440*1024*1024) samples)
200 MHz to 10 GHz (upsampling) MSRA master: 200 MHz to 600 MHz	220 MSamples

The Figure A-1 shows the maximum usable I/Q bandwidths depending on the output sample rates.

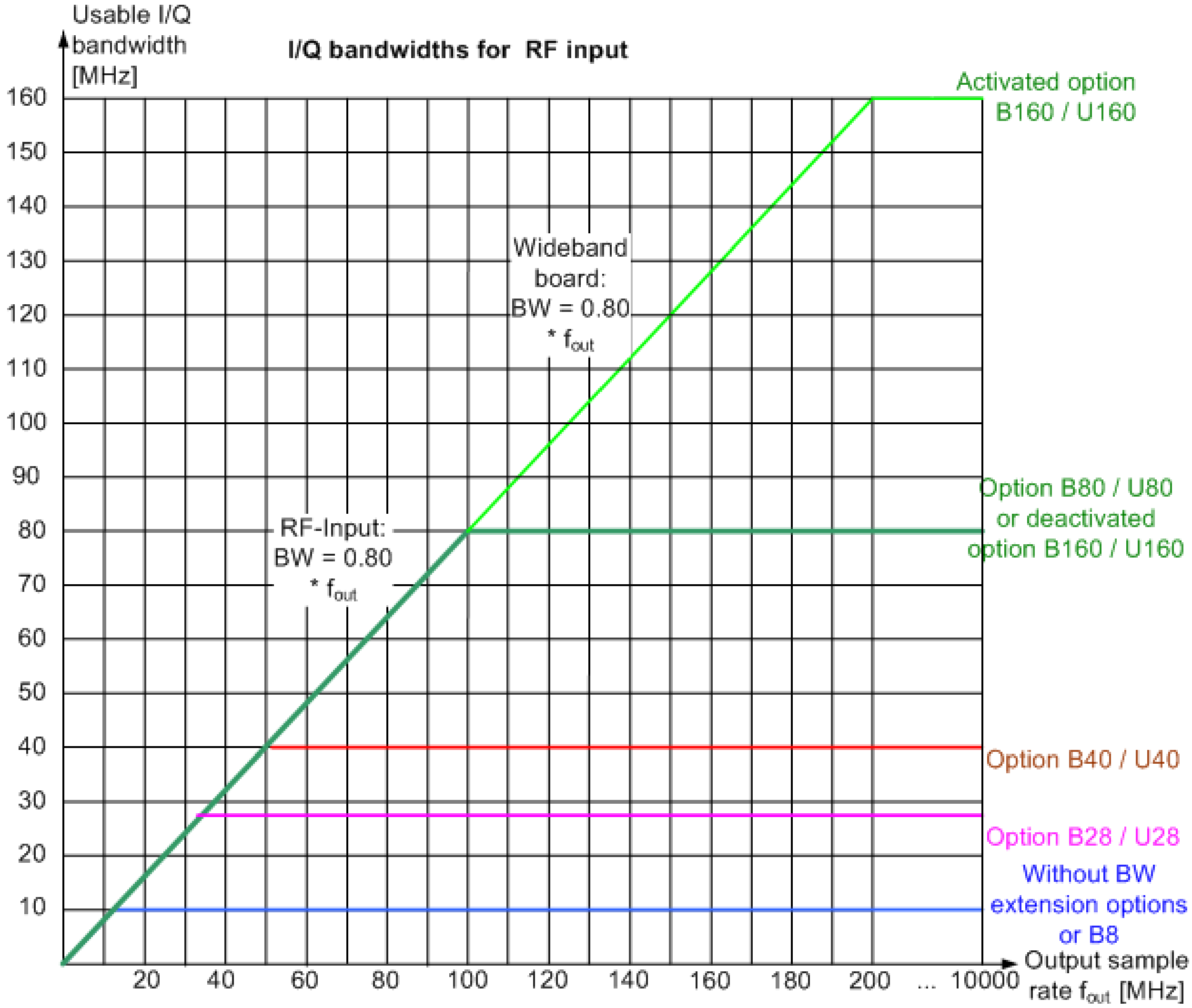


Figure A-1: Relationship between maximum usable I/Q bandwidth and output sample rate with and without bandwidth extensions

A.1.4 R&S FSW Without Additional Bandwidth Extension Options

Sample rate: 100 Hz - 10 GHz

Maximum I/Q bandwidth: 10 MHz

MSRA operating mode

In MSRA operating mode, the MSRA Master is restricted to a sample rate of 600 MHz.

Table A-2: Maximum I/Q bandwidth

Sample rate	Maximum I/Q bandwidth
100 Hz to 10 MHz	Proportional up to maximum 10 MHz
10 MHz to 10 GHz MSRA master: 10 MHz to 600 MHz	10 MHz

A.1.5 R&S FSW with Options B28 or U28 (I/Q Bandwidth Extension):

Sample rate: 100 Hz - 10 GHz

Maximum bandwidth: 28 MHz

MSRA operating mode

In MSRA operating mode, the MSRA Master is restricted to a sample rate of 600 MHz.

Sample rate	Maximum I/Q bandwidth
100 Hz to 35 MHz	Proportional up to maximum 28 MHz
35 MHz to 10 GHz MSRA master: 35 MHz to 600 MHz	28 MHz

A.1.6 R&S FSW with Option B40 or U40 (I/Q Bandwidth Extension):

Sample rate: 100 Hz - 10 GHz

Maximum bandwidth: 40 MHz

MSRA operating mode

In MSRA operating mode, the MSRA Master is restricted to a sample rate of 600 MHz.

Sample rate	Maximum I/Q bandwidth
100 Hz to 50 MHz	Proportional up to maximum 40 MHz
50 MHz to 10 GHz MSRA master: 50 MHz to 600 MHz	40 MHz

A.1.7 R&S FSW with Option B80 or U80 (I/Q Bandwidth Extension):

Sample rate: 100 Hz - 10 GHz

Maximum bandwidth: 80 MHz

MSRA operating mode

In MSRA operating mode, the MSRA Master is restricted to a sample rate of 600 MHz.

Sample rate	Maximum I/Q bandwidth
100 Hz to 100 MHz	Proportional up to maximum 80 MHz
100 MHz to 10 GHz MSRA master: 100 MHz to 600 MHz	80 MHz

A.1.8 R&S FSW with Activated Option B160 or U160 (I/Q Bandwidth Extension):

Sample rate: 100 Hz - 10 GHz

Maximum bandwidth: 160 MHz

MSRA operating mode

In MSRA operating mode, the MSRA Master is restricted to a sample rate of 600 MHz.

Sample rate	Maximum I/Q bandwidth
100 Hz to 200 MHz	Proportional up to maximum 160 MHz
200 MHz to 10 GHz MSRA master: 200 MHz to 600 MHz	160 MHz

A.1.9 Max. Sample Rate and Bandwidth with Activated I/Q Bandwidth Extension Option B320/U320

Sample rate	Maximum I/Q bandwidth
100 Hz to 400 MHz	Proportional up to maximum 320 MHz
400 MHz to 10 GHz MSRA master: 400 MHz to 600 MHz	320 MHz

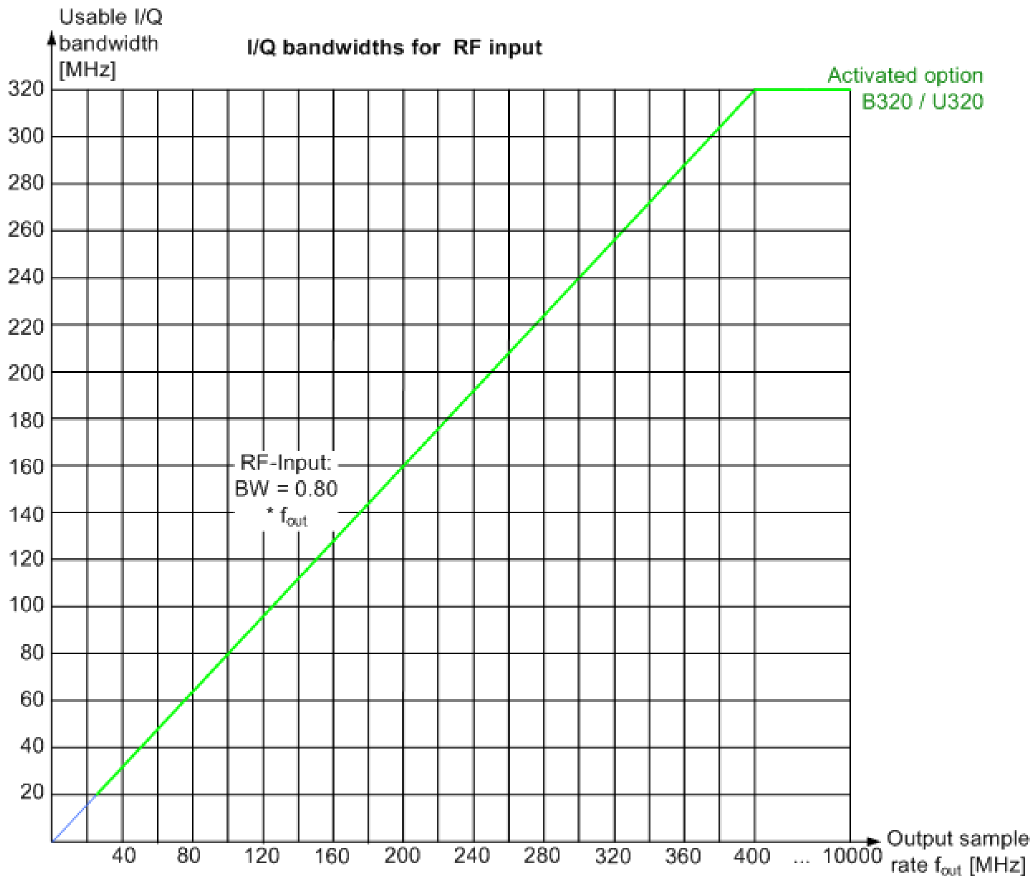


Figure A-2: Relationship between maximum usable I/Q bandwidth and output sample rate for active R&S FSW-B320

A.1.10 Max. Sample Rate and Bandwidth with Activated I/Q Bandwidth Extension Options B500/B512

The bandwidth extension options R&S FSW-B500/ -B512 provide measurement bandwidths up to 500 MHz/ 512 MHz, respectively.

Sample rate	Maximum I/Q bandwidth
100 Hz to 600 MHz	0.8 * sample rate (up to maximum 500 MHz/ 512 MHz)
600 MHz to 10 GHz (not MSRA master)	500 MHz/ 512 MHz

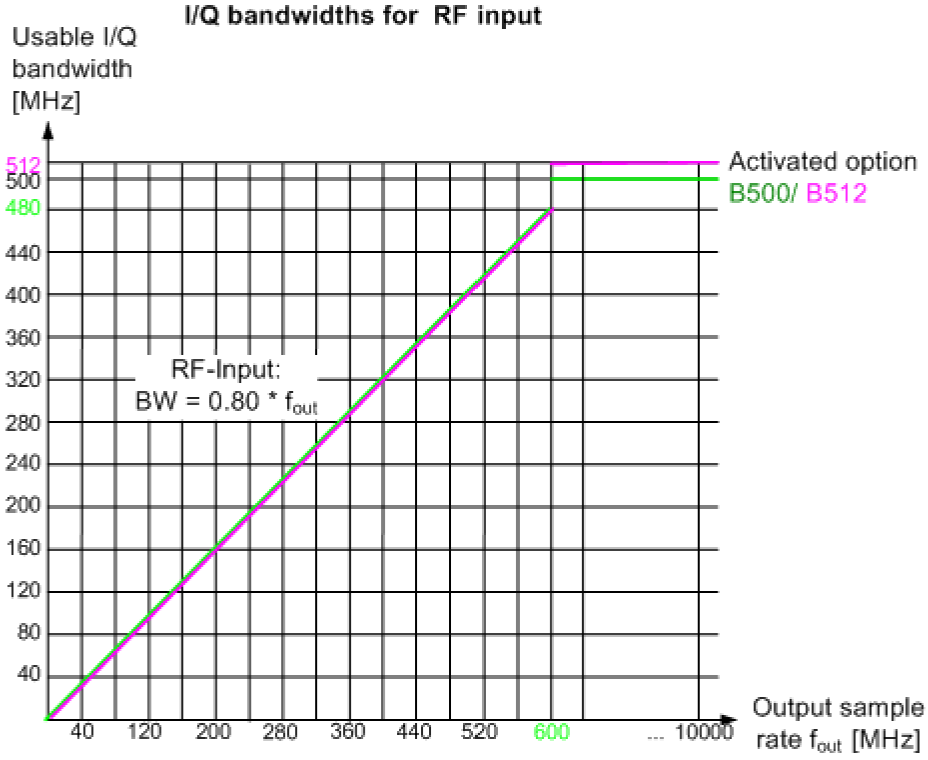


Figure A-3: Relationship between maximum usable I/Q bandwidth and output sample rate for active R&S FSW-B500/ -B512

A.2 I/Q Data File Format (iq-tar)

I/Q data is packed in a file with the extension `.iq.tar`. An iq-tar file contains I/Q data in binary format together with meta information that describes the nature and the source of data, e.g. the sample rate. The objective of the iq-tar file format is to separate I/Q data from the meta information while still having both inside one file. In addition, the file format allows you to preview the I/Q data in a web browser, and allows you to include user-specific data.

The iq-tar container packs several files into a single `.tar` archive file. Files in `.tar` format can be unpacked using standard archive tools (see http://en.wikipedia.org/wiki/Comparison_of_file_archivers) available for most operating systems. The advantage of `.tar` files is that the archived files inside the `.tar` file are not changed (not compressed) and thus it is possible to read the I/Q data directly within the archive without the need to unpack (untar) the `.tar` file first.

Sample iq-tar files

If you have the optional R&S 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 R&S FSW.

Contained files

An iq-tar file must contain the following files:

- **I/Q parameter XML file**, e.g. `xyz.xml`
  Contains meta information about the I/Q data (e.g. sample rate). The filename can be defined freely, but there must be only one single I/Q parameter XML file inside an iq-tar file.
- **I/Q data binary file**, e.g. `xyz.complex.float32`
  Contains the binary I/Q data of all channels. There must be only one single I/Q data binary file inside an iq-tar file.

Optionally, an iq-tar file can contain the following file:

- **I/Q preview XSLT file**, e.g. `open_IqTar_xml_file_in_web_browser.xslt`
  Contains a stylesheet to display the I/Q parameter XML file and a preview of the I/Q data in a web browser.
  A sample stylesheet is available at http://www.rohde-schwarz.com/file/open_IqTar_xml_file_in_web_browser.xslt.

A.2.1 I/Q Parameter XML File Specification

The content of the I/Q parameter XML file must comply with the XML schema `RsIqTar.xsd` available at: http://www.rohde-schwarz.com/file/RsIqTar.xsd.

In particular, the order of the XML elements must be respected, i.e. iq-tar uses an "ordered XML schema". For your own implementation of the iq-tar file format make sure to validate your XML file against the given schema.

The following example shows an I/Q parameter XML file. The XML elements and attributes are explained in the following sections.

Sample I/Q parameter XML file: xyz.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet type="text/xsl"
href="open_IqTar_xml_file_in_web_browser.xslt"?>
<RS_IQ_TAR_FileFormat fileFormatVersion="1"
xsi:noNamespaceSchemaLocation="RsIqTar.xsd"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <Name>R&S FSW</Name>
  <Comment>Here is a comment</Comment>
  <DateTime>2011-01-24T14:02:49</DateTime>
  <Samples>68751</Samples>
  <Clock unit="Hz">6.5e+006</Clock>
  <Format>complex</Format>
  <DataType>float32</DataType>
  <ScalingFactor unit="V">1</ScalingFactor>
  <NumberOfChannels>1</NumberOfChannels>
<DataFilename>xyz.complex.float32</DataFilename>
<UserData>
```

```
  <UserDefinedElement>Example</UserDefinedElement>
</UserData>
  <PreviewData>...</PreviewData>
</RS_IQ_TAR_FileFormat>
```

Element	Description
RS_IQ_TAR_File-Format	The root element of the XML file. It must contain the attribute `fileFormatVersion` that contains the number of the file format definition. Currently, `fileFormatVersion` "2" is used.
Name	Optional: describes the device or application that created the file.
Comment	Optional: contains text that further describes the contents of the file.
DateTime	Contains the date and time of the creation of the file. Its type is `xs:dateTime` (see `RsIqTar.xsd`).
Samples	Contains the number of samples of the I/Q data. For multi-channel signals all channels have the same number of samples. One sample can be: ● A complex number represented as a pair of I and Q values ● A complex number represented as a pair of magnitude and phase values ● A real number represented as a single real value See also `Format` element.
Clock	Contains the clock frequency in Hz, i.e. the sample rate of the I/Q data. A signal generator typically outputs the I/Q data at a rate that equals the clock frequency. If the I/Q data was captured with a signal analyzer, the signal analyzer used the clock frequency as the sample rate. The attribute `unit` must be set to "Hz".
Format	Specifies how the binary data is saved in the I/Q data binary file (see `DataFilename` element). Every sample must be in the same format. The format can be one of the following: ● `complex`: Complex number in cartesian format, i.e. I and Q values interleaved. I and Q are unitless ● `real`: Real number (unitless) ● `polar`: Complex number in polar format, i.e. magnitude (unitless) and phase (rad) values interleaved. Requires `DataType` = `float32` or `float64`
DataType	Specifies the binary format used for samples in the I/Q data binary file (see `DataFilename` element and Chapter A.2.2, "I/Q Data Binary File", on page 377). The following data types are allowed: ● `int8`: 8 bit signed integer data ● `int16`: 16 bit signed integer data ● `int32`: 32 bit signed integer data ● `float32`: 32 bit floating point data (IEEE 754) ● `float64`: 64 bit floating point data (IEEE 754)
ScalingFactor	Optional: describes how the binary data can be transformed into values in the unit Volt. The binary I/Q data itself has no unit. To get an I/Q sample in the unit Volt the saved samples have to be multiplied by the value of the `ScalingFactor`. For polar data only the magnitude value has to be multiplied. For multi-channel signals the `ScalingFactor` must be applied to all channels. The attribute `unit` must be set to "`V`". The `ScalingFactor` must be > 0. If the `ScalingFactor` element is not defined, a value of 1 V is assumed.

Element	Description
NumberOfChannels	Optional: specifies the number of channels, e.g. of a MIMO signal, contained in the I/Q data binary file. For multi-channels, the I/Q samples of the channels are expected to be interleaved within the I/Q data file (see Chapter A.2.2, "I/Q Data Binary File", on page 377). If the `NumberOfChannels` element is not defined, one channel is assumed.
DataFilename	Contains the filename of the I/Q data binary file that is part of the iq-tar file. It is recommended that the filename uses the following convention: <xyz>.<Format>.<Channels>ch.<Type> ● <xyz> = a valid Windows file name ● <Format> = complex, polar or real (see `Format` element) ● <Channels> = Number of channels (see `NumberOfChannels` element) ● <Type> = float32, float64, int8, int16, int32 or int64 (see `DataType` element) Examples: ● xyz.complex.1ch.float32 ● xyz.polar.1ch.float64 ● xyz.real.1ch.int16 ● xyz.complex.16ch.int8
UserData	Optional: contains user, application or device-specific XML data which is not part of the iq-tar specification. This element can be used to store additional information, e.g. the hardware configuration. User data must be valid XML content.
PreviewData	Optional: contains further XML elements that provide a preview of the I/Q data. The preview data is determined by the routine that saves an iq-tar file (e.g. R&S FSW). For the definition of this element refer to the `RsIqTar.xsd` schema. Note that the preview can be only displayed by current web browsers that have JavaScript enabled and if the XSLT stylesheet `open_IqTar_xml_file_in_web_browser.xslt` is available.

Example: ScalingFactor

Data stored as `int16` and a desired full scale voltage of 1 V

`ScalingFactor` = 1 V / maximum int16 value = 1 V / 2^{15} = 3.0517578125e-5 V

Scaling Factor	Numerical value	Numerical value x ScalingFactor
Minimum (negative) int16 value	$- 2^{15} = - 32768$	-1 V
Maximum (positive) int16 value	$2^{15}-1= 32767$	0.999969482421875 V

Example: PreviewData in XML

```
<PreviewData>
    <ArrayOfChannel length="1">
      <Channel>
        <PowerVsTime>
          <Min>
            <ArrayOfFloat length="256">
              <float>-134</float>
              <float>-142</float>
              ...
              <float>-140</float>
            </ArrayOfFloat>
          </Min>
```

```
          <Max>
            <ArrayOfFloat length="256">
              <float>-70</float>
              <float>-71</float>
              ...
              <float>-69</float>
            </ArrayOfFloat>
          </Max>
        </PowerVsTime>
        <Spectrum>
          <Min>
            <ArrayOfFloat length="256">
              <float>-133</float>
              <float>-111</float>
              ...
              <float>-111</float>
            </ArrayOfFloat>
          </Min>
          <Max>
            <ArrayOfFloat length="256">
              <float>-67</float>
              <float>-69</float>
              ...
              <float>-70</float>
              <float>-69</float>
            </ArrayOfFloat>
          </Max>
        </Spectrum>
        <IQ>
          <Histogram width="64" height="64">0123456789...0</Histogram>
        </IQ>
      </Channel>
    </ArrayOfChannel>
  </PreviewData>
```

A.2.2 I/Q Data Binary File

The I/Q data is saved in binary format according to the format and data type specified in the XML file (see `Format` element and `DataType` element). To allow reading and writing of streamed I/Q data, all data is interleaved, i.e. complex values are interleaved pairs of I and Q values and multi-channel signals contain interleaved (complex) samples for channel 0, channel 1, channel 2 etc. If the `NumberOfChannels` element is not defined, one channel is presumed.

Example: Element order for real data (1 channel)

```
I[0],                          // Real sample 0
I[1],                          // Real sample 1
```

```
I[2],                        // Real sample 2
...
```

Example: Element order for complex cartesian data (1 channel)

```
I[0], Q[0],                  // Real and imaginary part of complex sample 0
I[1], Q[1],                  // Real and imaginary part of complex sample 1
I[2], Q[2],                  // Real and imaginary part of complex sample 2
...
```

Example: Element order for complex polar data (1 channel)

```
Mag[0], Phi[0],              // Magnitude and phase part of complex sample 0
Mag[1], Phi[1],              // Magnitude and phase part of complex sample 1
Mag[2], Phi[2],              // Magnitude and phase part of complex sample 2
...
```

Example: Element order for complex cartesian data (3 channels)

Complex data: I[channel no][time index], Q[channel no][time index]

```
I[0][0], Q[0][0],           // Channel 0, Complex sample 0
I[1][0], Q[1][0],           // Channel 1, Complex sample 0
I[2][0], Q[2][0],           // Channel 2, Complex sample 0

I[0][1], Q[0][1],           // Channel 0, Complex sample 1
I[1][1], Q[1][1],           // Channel 1, Complex sample 1
I[2][1], Q[2][1],           // Channel 2, Complex sample 1

I[0][2], Q[0][2],           // Channel 0, Complex sample 2
I[1][2], Q[1][2],           // Channel 1, Complex sample 2
I[2][2], Q[2][2],           // Channel 2, Complex sample 2
...
```

Example: Element order for complex cartesian data (1 channel)

This example demonstrates how to store complex cartesian data in float32 format using MATLAB®.

```
% Save vector of complex cartesian I/Q data, i.e. iqiqiq...
N = 100
iq = randn(1,N)+1j*randn(1,N)
fid = fopen('xyz.complex.float32','w');
for k=1:length(iq)
  fwrite(fid,single(real(iq(k))),'float32');
  fwrite(fid,single(imag(iq(k))),'float32');
end
fclose(fid)
```

List of Remote Commands (WLAN)

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