R&S®VSE-K91
WLAN Measurements Application
User Manual

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Make ideas real

This manual applies to the following software, version 2.31 and later:

- R&S®VSE Enterprise Edition base software (1345.1105.06)
- R&S®VSE Basic Edition base software (1345.1011.06)

The following firmware options are described:

- R&S VSE-K91 WLAN 802.11a,b,g (1320.7597.02) / R&S VSE-KT91 (1345.1840.02)
- R&S VSE-K91ac WLAN 802.11ac (1320.7616.02) / R&S VSE-KT91ac (1345.1811.02)
- R&S VSE-K91ax WLAN 802.11ax (1345.1411.02) / R&S VSE-KT91ax (1345.1805.02)
- R&S VSE-K91be WLAN 802.11be (1345.1428.02) / R&S VSE-KT91be (1345.1986.02)
- R&S VSE-K91n WLAN 802.11n (1320.7600.02) / R&S VSE-KT91n (1345.1828.02)
- R&S VSE-K91p WLAN 802.11p (1320.7680.02) / R&S VSE-KT91p (1345.1692.02)

Contents

1 Welcome to the R&S VSE WLAN application

The R&S VSE WLAN application extends the functionality of the R&S VSE 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 option is installed):

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

The R&S VSE 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
- Transmit spectrum mask
- 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 I/Q Analyzer application and are described in the R&S VSE Base Software User Manual. The latest version is available for download at the product homepage http://www.rohde-schwarz.com/product/VSE.html.

1.1 Starting the R&S VSE WLAN application

The WLAN measurement requires a special application on the R&S VSE. It is activated by creating a new measurement channel in WLAN mode.

To activate the R&S VSE WLAN application

1.
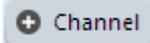
Select the "Add Channel" function in the Sequence tool window.

A dialog box opens that contains all operating modes and applications currently available in your R&S VSE.
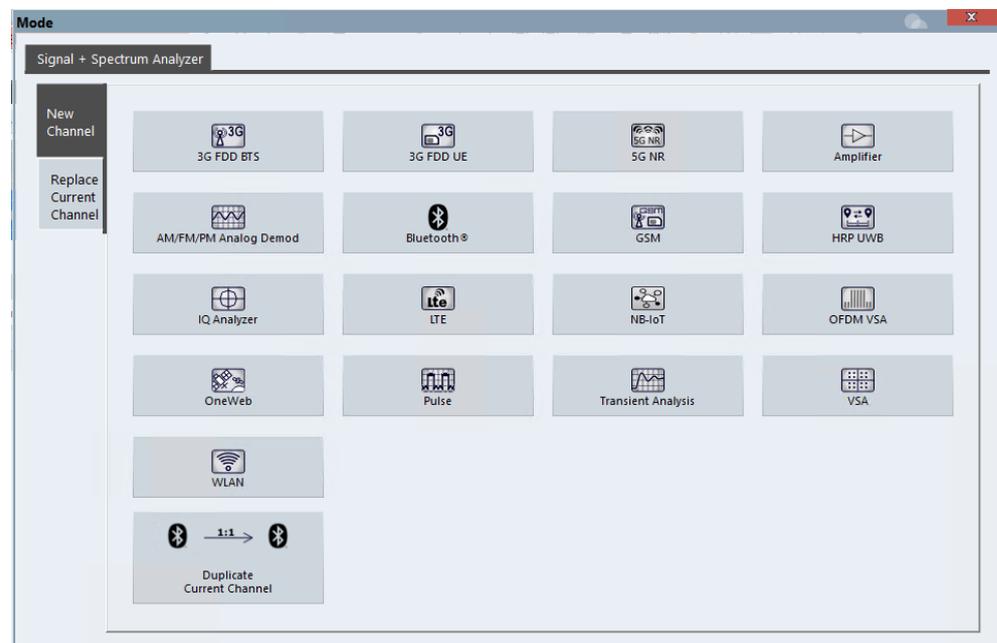
2.   Select the "WLAN" item.

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

1.2 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.
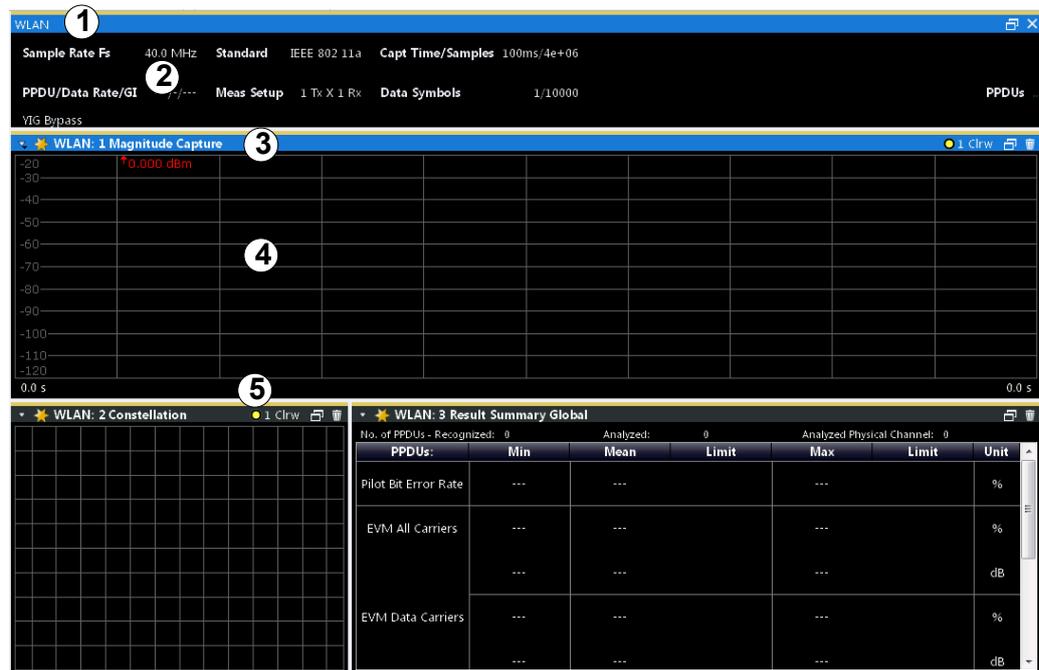
1 = Color coding for windows of same channel
2 = Channel bar with measurement settings
3 = Window title bar with diagram-specific (trace) information
4 = Diagram area
5 = Diagram footer with diagram-specific information, depending on result display

Channel bar information

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

Table 1-1: 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**: 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 / Samples	Duration of signal capture and number of samples captured

Label	Description
Data Symbols	The minimum and maximum number of data symbols that a PPDU may have if it is to be considered in results analysis.
PPDUs [x of y (z)]	For statistical evaluation over PPDUs (see "PPDU Statistic Count / No of PPDUs to Analyze" on page 159): <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 VSE Base Software User Manual.

Window title bar information

For each diagram, the header provides the following information:

Figure 1-1: Window title bar information in the WLAN application

0 = Color coding for windows of same channel
1 = Edit result display function
2 = Channel name
3 = Window number
4 = Window type
5 = Trace color, trace number, trace mode
6 = Dock/undock window function
7 = Close window function

Diagram footer information

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

Diagram area

The diagram area displays the results according to the selected result displays (see Chapter 2, "WLAN I/Q measurement (modulation accuracy, flatness and tolerance)", on page 9).

Status bar information

The software status, errors and warnings and any irregularities in the software are indicated in the status bar at the bottom of the R&S VSE window.

2 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. That allows the R&S VSE WLAN application to demodulate broadband signals and determine various characteristic signal parameters in just one measurement. Modulation accuracy, spectrum flatness, center frequency tolerance and symbol clock tolerance are only a few of the characteristic parameters.

2.1 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 2-1: WLAN I/Q parameters for IEEE 802.11a, ac, ax, g (OFDM), j, n, p, be

Parameter	Description	Keyword for remote query (`FETCh:BURSt:`)
General measurement parameters		
Sample Rate Fs	Input sample rate	
PPDU	Type of analyzed PPDUs	`PPDU:TYPE`
MCS Index	Modulation and Coding Scheme (MCS) index of the analyzed PPDUs	`MCSindex`
Data Rate	Data rate used for analysis of the signal (IEEE 802.11a only)	
GI / GI+HE-LTF / GI+EHT-LTF	Guard interval length for current measurement Guard interval and high-efficiency long training field length (IEEE 802.11ax only) Guard interval and length of EHT long training field (IEEE 802.11be only)	`GINTerval`
Meas Setup	Number of Transmitter (Tx) and Receiver (Rx) channels used in the measurement	
Capture time	Duration of signal capture	
Samples	Number of samples captured	
*) the limits can be changed via remote control (not manually, see Chapter 8.4.10, "Limits", on page 287); in this case, the currently defined limits are displayed here		

Parameter	Description	Keyword for remote query (`FETCh:BURSt:`)
Data Symbols	The minimum and maximum number of data symbols that a PPDU can have if it is to be considered in results analysis	
PPDU parameters		
Analyzed PPDUs	For statistical evaluation of PPDUs (see "PPDU Statistic Count / No of PPDUs to Analyze" on page 159): <x> PPDUs of the 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	COUNt
Number of analyzed PPDUs in physical channel	Number of PPDUs analyzed in entire signal (if available)	COUNt:ALL
TX and Rx carrier parameters		
I/Q offset [dB]	Transmitter center frequency leakage relative to the total Tx channel power (see Chapter 2.1.1, "I/Q offset", on page 14)	IQOFset
Gain imbalance [%/dB]	Amplification of the quadrature phase component of the signal relative to the amplification of the in-phase component (see Chapter 2.1.2, "Gain imbalance", on page 14)	GIMBalance
Quadrature offset [°]	Deviation of the quadrature phase angle from the ideal 90° (see Chapter 2.1.3, "Quadrature offset", on page 15).	QUADoffset
I/Q skew [s]	Delay of the transmission of the data on the I path compared to the Q path (see Chapter 2.1.4, "I/Q skew", on page 16)	IQSKew
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).	CRESt
MIMO Cross Power [dB]	Sum of RMS power from all cross streams	MCPower
MIMO Channel Power [dBm]	RMS power for each effective channel path from all active carriers.	MCHPower
*) the limits can be changed via remote control (not manually, see Chapter 8.4.10, "Limits", on page 287); in this case, the currently defined limits are displayed here		

Parameter	Description	Keyword for remote query (FETCh:BURSt:)
Center frequency error [Hz]	Frequency error between the signal and the current center frequency of the R&S VSE; the corresponding limits specified in the standard are also indicated***)** The absolute frequency error includes the frequency error of the R&S VSE and that of the DUT. If possible, synchronize the transmitter connected instrument and the DUT using an external reference. See R&S VSE base software user manual > Configuring Instruments	CFERror
Symbol clock error [ppm]	Clock error between the signal and the sample clock of the R&S VSE in parts per million (ppm), i.e. the symbol timing error; the corresponding limits specified in the standard are also indicated ***)** If possible, synchronize the transmitter connected instrument and the DUT using an external reference. See R&S VSE base software user manual > Configuring Instruments	
CPE	Common phase error	CPERror
Stream parameters		
BER Pilot [%]	Bit error rate (BER) of the pilot carriers	BERPilot
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:ALL
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:DATA
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***)**	EVM:PILot
*) the limits can be changed via remote control (not manually, see Chapter 8.4.10, "Limits", on page 287); in this case, the currently defined limits are displayed here		

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

Parameter	Description	Keyword for remote query (FETCh:BURSt:)
Sample Rate Fs	Input sample rate	
PPDU	Type of the analyzed PPDU	PPDU:TYPE
Data Rate	Data rate used for analysis of the signal	
Meas Setup	Number of Transmitter (Tx) and Receiver (Rx) channels used in the measurement	
Capture time	Duration of signal capture	
*) the limits can be changed via remote control (not manually, see Chapter 8.4.10, "Limits", on page 287); in this case, the currently defined limits are displayed here		

Parameter	Description	Keyword for remote query (`FETCh:BURSt:`)
No. of Samples	Number of samples captured (= sample rate * capture time)	
PSDU Data Length	The duration in seconds of the PSDU data	
PPDU parameters		
Analyzed PPDUs	For statistical evaluation of PPDUs (see "PPDU Statistic Count / No of PPDUs to Analyze" on page 159): <x> PPDUs of the 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	`COUNt`
Number of analyzed PPDUs in physical channel	Number of PPDUs analyzed in entire signal (if available)	`COUNt:ALL`
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 Chapter 2.1.7.2, "Peak vector error (IEEE method)", on page 18); The corresponding limits specified in the standard are also indicated ***)**	`EVM:DIRect`
PPDU EVM	EVM (Error Vector Magnitude) over the complete PPDU including the preamble in % and dB	`PPDU:EVM:ALL`
I/Q offset [dB]	Transmitter center frequency leakage relative to the total Tx channel power (see Chapter 2.1.1, "I/Q offset", on page 14)	`IQOFset`
Gain imbalance [%/dB]	Amplification of the quadrature phase component of the signal relative to the amplification of the in-phase component (see Chapter 2.1.2, "Gain imbalance", on page 14)	`GIMBalance`
Quadrature error [°]	Measure for the crosstalk of the Q-branch into the I-branch (see "Gain imbalance, I/Q offset, quadrature error" on page 63).	`QUADoffset`
*) the limits can be changed via remote control (not manually, see Chapter 8.4.10, "Limits", on page 287); in this case, the currently defined limits are displayed here		

Parameter	Description	Keyword for remote query (`FETCh:BURSt:`)
Center frequency error [Hz]	Frequency error between the signal and the current center frequency of the R&S VSE; the corresponding limits specified in the standard are also indicated ***)** The absolute frequency error includes the frequency error of the R&S VSE and that of the DUT. If possible, synchronize the transmitter connected instrument and the DUT using an external reference. See R&S VSE base software user manual > Configuring Instruments	`CFERror`
Chip clock error [ppm]	Clock error between the signal and the chip clock of the R&S VSE in parts per million (ppm), i.e. the chip timing error; the corresponding limits specified in the standard are also indicated ***)** If possible, synchronize the transmitter connected instrument and the DUT using an external reference. See R&S VSE base software user manual > Configuring Instruments	
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 ***)**	`TRISe`
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 ***)**	`TFALl`
Mean power [dBm]	Mean PPDU power	
Peak power [dBm]	Peak PPDU power	`PEAK`
Crest factor [dB]	The ratio of the peak power to the mean power of the PPDU (also called Peak to Average Power Ratio, PAPR).	`CRESt`
*) the limits can be changed via remote control (not manually, see Chapter 8.4.10, "Limits", on page 287); in this case, the currently defined limits are displayed here		

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

Table 2-3: 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

2.1.1 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.
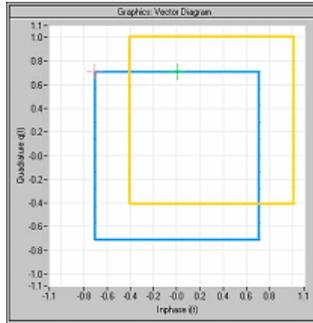
Figure 2-1: I/Q offset in a vector diagram

2.1.2 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:

$$Imbalance\ [dB] = 20\log(\frac{|Gain_Q|}{|Gain_I|})$$

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:

$$0.98 \approx 20\log_{10}(\frac{1.12}{1})$$
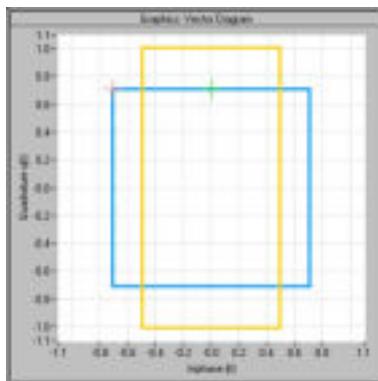
Figure 2-2: Positive gain imbalance

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:

$$-0.98 \approx 20 \log_{10}(\frac{1}{1.12})$$
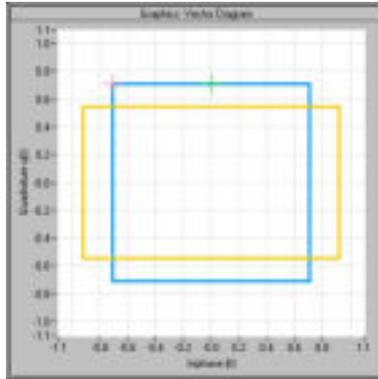
Figure 2-3: Negative gain imbalance

2.1.3 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:
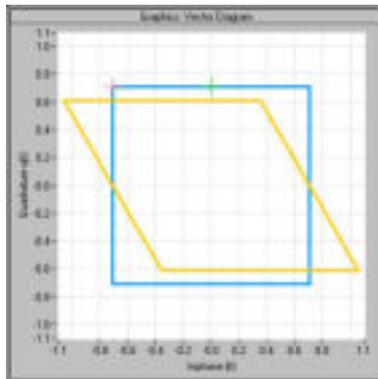
Figure 2-4: Positive quadrature offset

A negative quadrature offset means a phase angle less than 90 degrees:
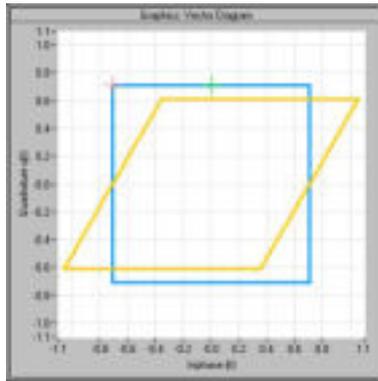
Figure 2-5: Negative quadrature offset

2.1.4　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 can be compensated for together with Gain imbalance and Quadrature offset (see "I/Q Mismatch Compensation" on page 125).

2.1.5　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 must not use compensation.

2.1.6　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 VSE WLAN application

The IQ offset measurement in the R&S VSE WLAN application returns the current carrier feedthrough normalized to the mean power at the symbol timings. This measure-

ment 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 VSE WLAN application. The difference (in dB) between the two values depends on the transmit filter shape. Determine it 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

2.1.7 EVM measurement

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

2.1.7.1 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:

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

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

The PPDU EVM is not part of the IEEE standard and no limit check is specified. Nevertheless, this commonly used EVM calculation can provide some insight in modulation quality and enables comparisons to other modulation standards.
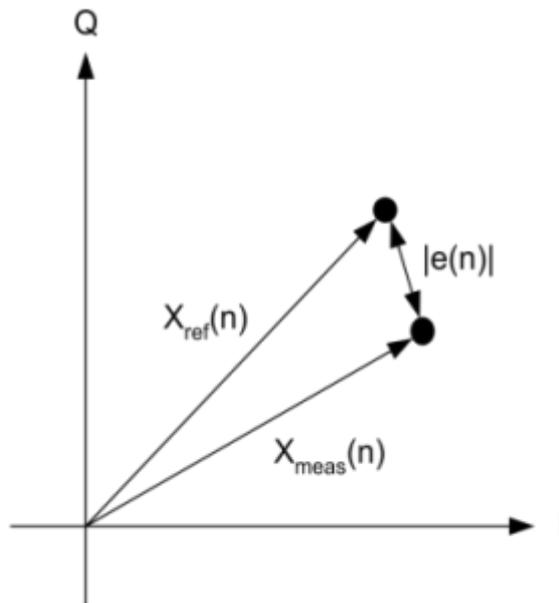
Figure 2-6: I/Q diagram for EVM calculation

2.1.7.2 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 VSE 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 the Min / Mean / Max columns show the minimum, mean or maximum Peak EVM of all analyzed PPDUs. This can be the case, for example, if several analyzed PPDUs are in the capture buffer or due to the PPDU Statistic Count / No of PPDUs to Analyze setting.

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 VSE WLAN application does not limit the measurement to 1000 chips length, but searches the maximum over the whole PPDU.

2.1.8 Unused tone error

Similarly to the adjacent channel power requirements for other WLAN standards, the IEEE 802.11ax standard specifies limits for power leakage into neighboring resource units (IEEE P802.11ax/D1.2, "Transmitter modulation accuracy (EVM) test" section). In high-efficiency wireless signals, the subcarriers or frequencies that are not used for active transmission are referred to as *unused tones*. Thus, the parameter that indicates

the power leakage into adjacent resource units is referred to as the *unused tone error*. The R&S VSE WLAN application provides a dedicated result display for the IEEE 802.11ax standard for HE trigger-based PPDUs.

The region in which the power leakage must be determined depends on the size and position within the channel of the resource unit being checked. Up to 3 times the number of subcarriers contained in the resource unit are checked on either side of it. Any remaining subcarriers are checked against the fixed limit of -35 dB. However, only sub-carriers in the same channel are evaluated. If the resource unit is at the edge of the channel, possibly no or not enough adjacent subcarriers are available in the channel. Assuming the resource unit contains n carriers, the adjacent n subcarriers are assigned a certain limit, the next n subcarriers have another limit, and the third n sub-carriers have yet another limit. All subcarriers beyond that have a fixed limit of -35 dB in relation to the EVM tolerance limit for the original resource unit (*"[IEEE P802.11ax/D1.2] Equation (28-123)"*).

Since the n subcarriers can be allocated to several different resource units, we refer to such a subset as an *RU group*. The RU group containing the resource unit to be checked is referred to as RU_{Idx}. The other subsets evaluated on either side of the RU_{Idx} are referred to as RU groups RU_{Idx-1}, RU_{Idx-2}, RU_{Idx-3}, and RU_{Idx+1}, RU_{Idx+2}, RU_{Idx+3}. The remaining subcarriers are referred to as the RU groups *-35 dB LHS* (left-hand side) and *-35 dB RHS* (right-hand side).

The size of the evaluated RU groups corresponds to the size of the RU_{Idx}, even if the actual resource unit allocation in the channel differs. However, the R&S VSE WLAN application measures one unused tone value for each set of 26 subcarriers. For each RU group, the mean, maximum, and minimum of these values is determined. In the Unused Tone Error Summary, the "RU Size [RU26]" is indicated as the quotient of the RU size divided by the RU26 size (see *"[IEEE P802.11ax/D1.2] Equation (28-123)"*). Thus, the "RU Size [RU26]" also indicates the number of measurement points deter-mined for each RU group.

Figure 2-7 illustrates the RU groups for which the unused tone error is determined for different RU indexes. The blue dots indicate individual power measurement points in the channel.
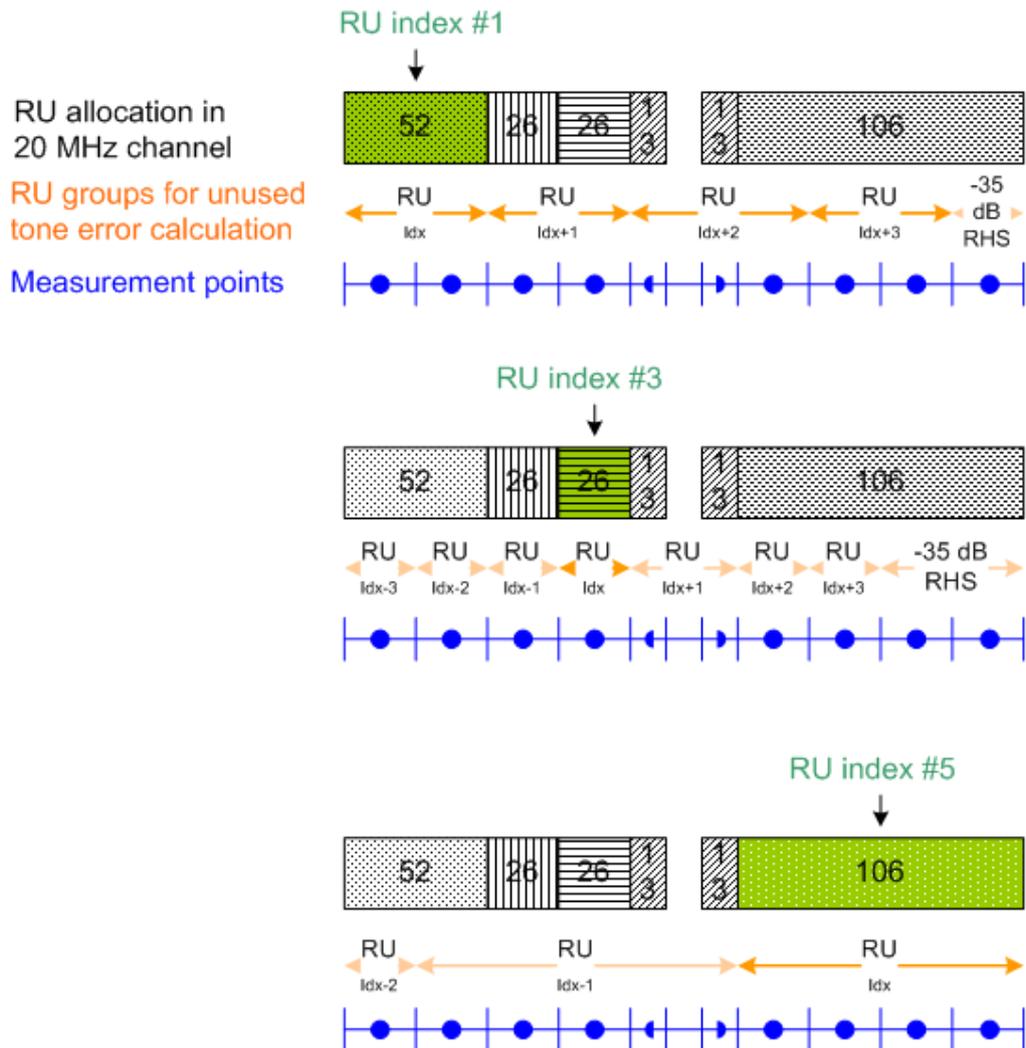
Figure 2-7: RU groups to be checked for unused tone error for different RU indexes

2.1.9 BER and CWER

The bit error rate (BER) and code word error rate (CWER) are displayed in the "Signal Content Detailed" result display. One value is determined for each resource unit (RU) data part.

If error correction corrects code words successfully, the BER is the ratio of the successfully corrected bits divided by the total number of bits.

The total number of bits contains:

● The code words that were corrected successfully.
● The code words without bit errors.
● No code words that could not be corrected.

The CWER is the ratio of the code words that could not be corrected divided by the total number of code words per resource unit (RU).

If no bit errors or code word errors are detected, the result is 0 %. If both results are 0 %, the results are highlighted green. Otherwise, the result is highlighted red.

The BER and CWER results are only available under the following conditions:

- IEEE 802.11 ax, be signals
- SISO (1 antenna)
- One user per resource unit
- Non-trigger-based PPDUs
- Low Density Parity Check (LDPC) encoding; BER also for Binary Convolutional Coding (BCC)

2.2 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.

Result display windows

For each measurement, a separate measurement channel is activated. Each measurement channel can provide multiple result displays, which are displayed in individual windows. The measurement windows can be rearranged and configured in the R&S VSE to meet your requirements. All windows that belong to the same measurement (including the channel bar) are indicated by a colored line at the top of the window title bar.

► To add further result displays for the WLAN 802.11 channel, select ⬚ "Add Window" from the toolbar, or select "Window > New Window".

For details on working with channels and windows, see the "Operating Basics" chapter in the R&S VSE base software user manual.

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[:DATA]?` on page 345).

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 were removed before demodulation.

The trace is determined by calculating a *polynomial regression model* of a specified degree (see "Polynomial degree for curve fitting" 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 298
Or:
CONFigure:BURSt:AM:AM[:IMMediate] on page 307
Polynomial degree:
CONFigure:BURSt:AM:AM:POLYnomial on page 314
Results:
TRACe[:DATA]?, see Chapter 8.6.3.1, "AM/AM", on page 350

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)**).
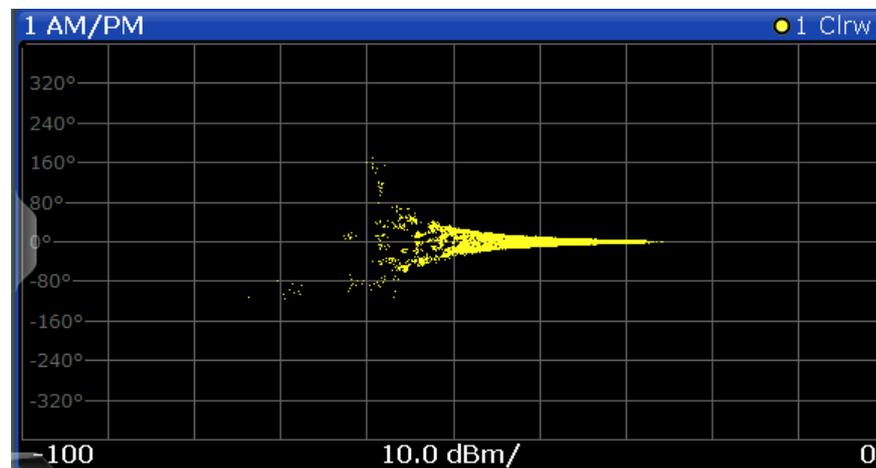
Remote command:
LAY:ADD? '1',RIGH,AMPM, see LAYout:ADD[:WINDow]? on page 298
Or:
CONFigure:BURSt:AM:PM[:IMMediate] on page 307
Querying results:
TRACe[:DATA]?, see Chapter 8.6.3.2, "AM/PM", on page 350

AM/EVM

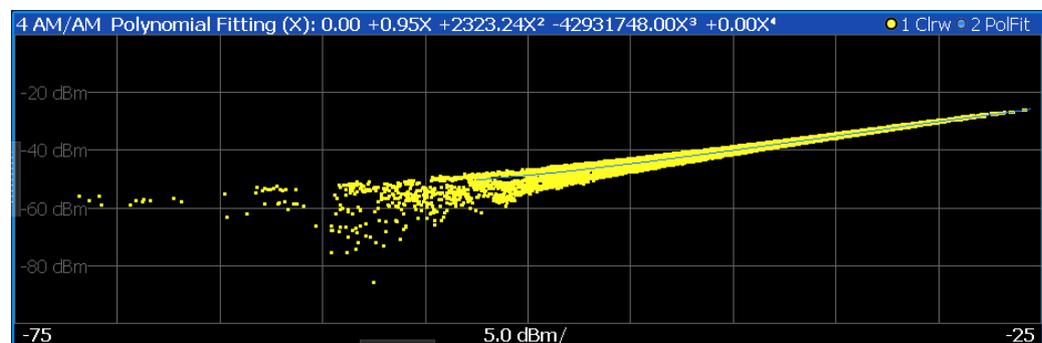This result display shows the measured and the reference signal in the time domain. For each sample, the x-axis value represents the amplitude of the reference signal. The y-axis value represents the length of the error vector between the measured signal and the reference signal.

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

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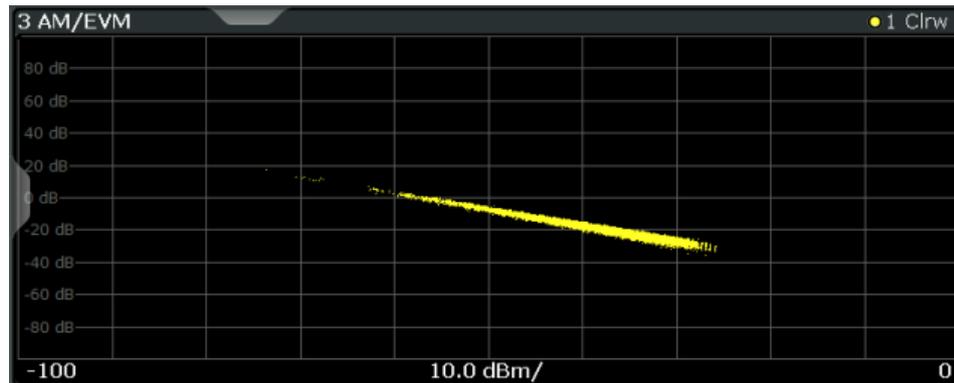
Remote command:

LAY:ADD? '1',RIGH,AMEV, see LAYout:ADD[:WINDow]? on page 298

Or:

CONFigure:BURSt:AM:EVM[:IMMediate] on page 307

Querying results:

TRACe[:DATA]?, see Chapter 8.6.3.3, "AM/EVM", on page 350

Amplitude Tracking

Displays the average amplitude tracking result per symbol (in dB).

For each OFDM-symbol N, the amplitude error (rel. to preamble) is averaged over the pilot subcarriers of the OFDM-symbol N.

For **IEEE 802.11ac, ax, n, be** only
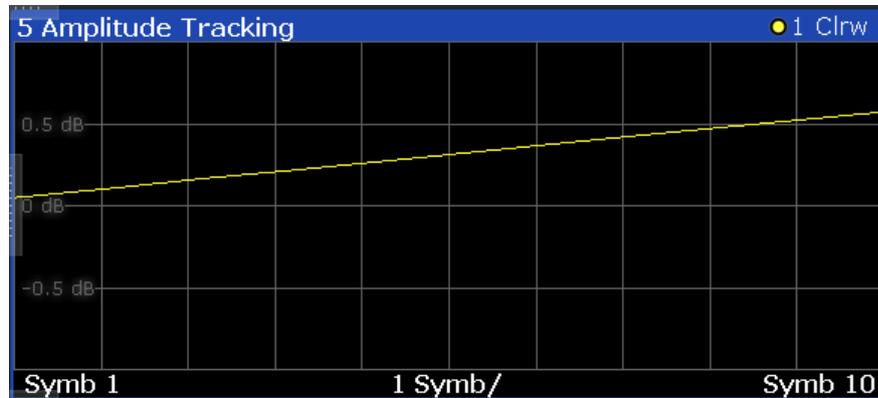
Remote command:

LAY:ADD? '1',RIGH,ATRacking, see LAYout:ADD[:WINDow]? on page 298

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, ac, g (OFDM), j, n, p**), the results are grouped by symbol and carrier.

Carrier	Symbol 1		
-26	000010	110111	111110
-23	000001	010100	0
-20	011001	101010	010101
-17	001010	011100	101010
-14	111100	001010	001101
-11	011011	111110	010010
-8	111100	0	001100
-5	001101	111100	101100
-2	101010	100011	NULL
1	101010	101101	101010
4	011010	000101	010001
7	0	101101	001011
10	000110	100100	100101
13	101001	111101	101011
16	011100	111001	010010
19	110100	111001	0
22	000011	101111	101111
25	001111	111100	

Carrier   Symbol 2

Figure 2-8: Bitstream result display for IEEE 802.11a, ac, g (OFDM), j, n, p standards

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

Figure 2-9: Bitstream result display for IEEE 802.11n MIMO measurements

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

```
4 Bitstream
PPDU 1
PLCP Preamble
0              11111111    11111111    11111111
24             11111111    11111111    11111111
48             11111111    11111111    11111111
72             11111111    11111111    11111111
96             11111111    11111111    11111111
120            11111111    00000101    11001111
PLCP Header
0              01010000    00100000    00000000
24             00000100    11001000    01000110
PSDU
0              10000000    01000010    00110000
24             10011100    10101011    00001101
48             11101001    10111001    00010100
```

Figure 2-10: Bitstream result display for IEEE 802.11b, g (DSSS) standards

The numeric trace results for this evaluation method are described in Chapter 8.6.3.4, "Bitstream", on page 350.

Remote command:
LAY:ADD? '1',RIGH, BITS, see LAYout:ADD[:WINDow]? on page 298
Or:
CONFigure:BURSt:STATistics:BSTReam[:IMMediate] on page 311
Querying results:
TRACe[:DATA]?, see Chapter 8.6.3.4, "Bitstream", on page 350

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 2-11: Constellation result display for IEEE 802.11n MIMO measurements

The numeric trace results for this evaluation method are described in Chapter 8.6.3.5, "Constellation", on page 351.

Remote command:
LAY:ADD? '1',RIGH, CONS, see LAYout:ADD[:WINDow]? on page 298
Or:
CONFigure:BURSt:CONSt:CSYMbol[:IMMediate] on page 308
Querying results:
TRACe[:DATA]?, see Chapter 8.6.3.5, "Constellation", on page 351

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).
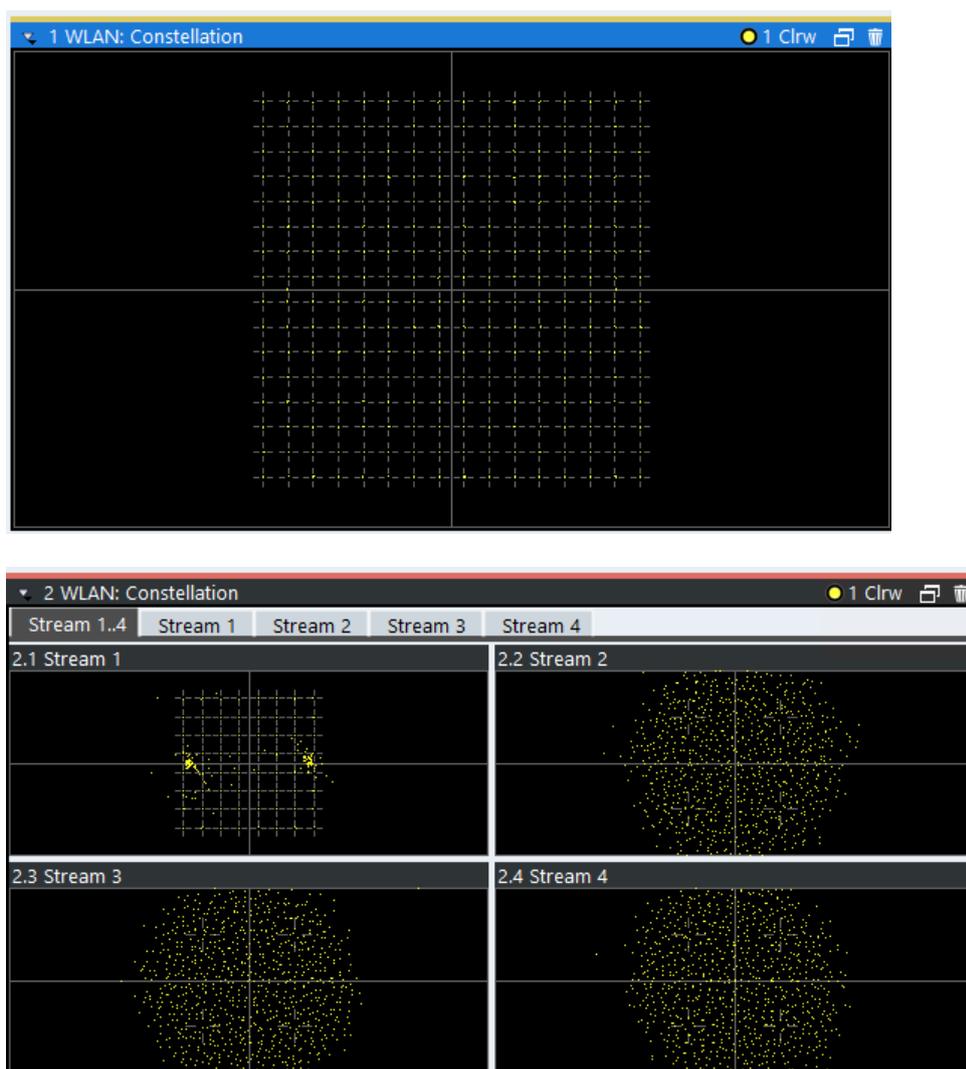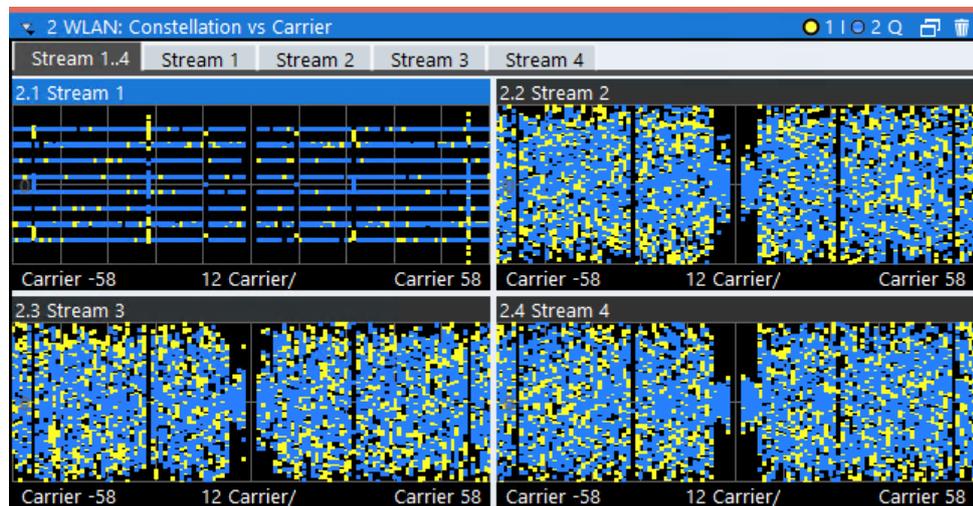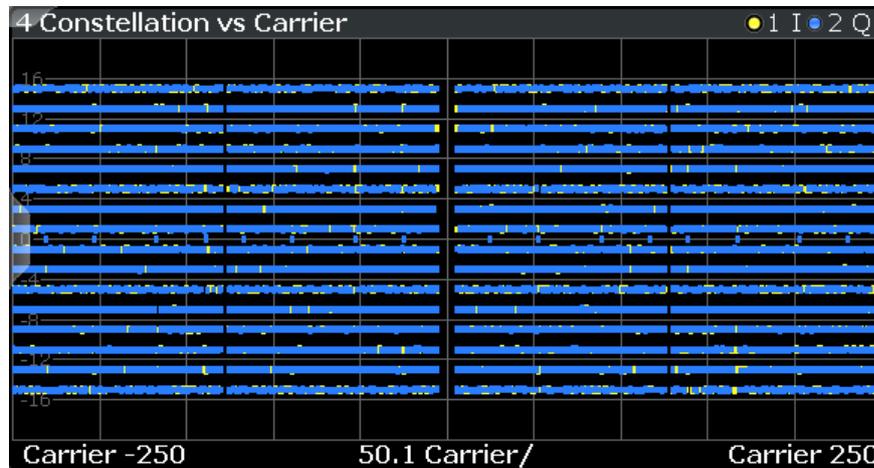

Figure 2-12: Constellation vs. carrier result display for IEEE 802.11n MIMO measurements

The numeric trace results for this evaluation method are described in Chapter 8.6.3.6, "Constellation vs carrier", on page 352.

Remote command:
LAY:ADD? '1',RIGH, CVC, see LAYout:ADD[:WINDow]? on page 298
Or:
CONFigure:BURSt:CONSt:CCARrier[:IMMediate] on page 307
Querying results:
TRACe[:DATA]?, see Chapter 8.6.3.6, "Constellation vs carrier", on page 352

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 4.6, "Tracking and channel estimation", on page 121). The minimum, average and maximum traces are displayed.

For **IEEE 802.11be** measurements, the results are displayed for the RUs selected in the PPDU configuration, see "Result displays for multi-user PPDUs" on page 144.

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

The numeric trace results for this evaluation method are described in Chapter 8.6.3.9, "EVM vs carrier", on page 353.

Remote command:
LAY:ADD? '1',RIGH, EVC, see LAYout:ADD[:WINDow]? on page 298
Or:
CONFigure:BURSt:EVM:ECARrier[:IMMediate] on page 308
Querying results:
TRACe[:DATA]?, see Chapter 8.6.3.9, "EVM vs carrier", on page 353

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 VSE WLAN application provides two different methods to calculate the EVM, two traces are displayed:
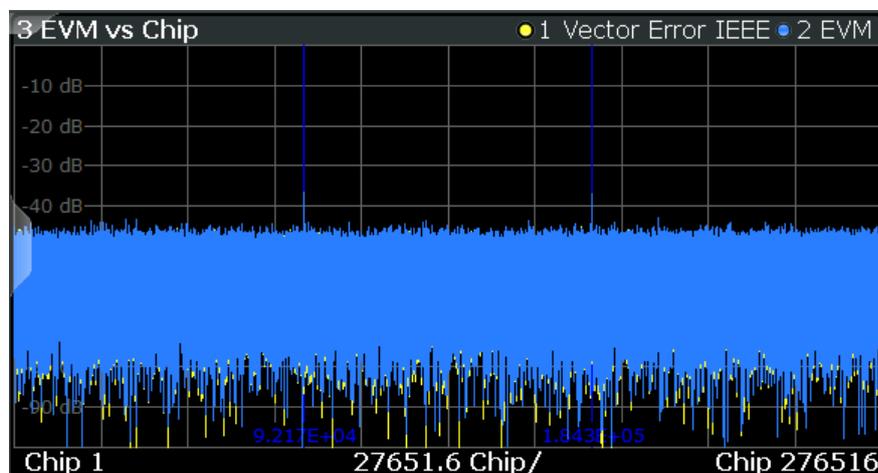
- "Vector Error IEEE" shows the error vector magnitude as defined in the IEEE 802.11b or g (DSSS) standards (see also "Error vector magnitude (EVM) - IEEE 802.11b or g (DSSS) method" on page 64)
- "EVM" shows the error vector magnitude calculated with an alternative method that provides higher accuracy of the estimations (see also "Error vector magnitude (EVM) - R&S VSE method" on page 64).

Remote command:

`LAY:ADD? '1',RIGH, EVCH,` see `LAYout:ADD[:WINDow]?` on page 298

Or:

`CONFigure:BURSt:EVM:EVCHip[:IMMediate]` on page 308

`CONFigure:BURSt:EVM:ESYMbol[:IMMediate]` on page 308

Querying results:

`TRACe[:DATA]?`, see Chapter 8.6.3.10, "EVM vs chip", on page 354

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 159). The "Tracking/Channel Estimation" according to the user settings is applied (see Chapter 4.6, "Tracking and channel estimation", on page 121). The minimum, average and maximum traces are displayed.
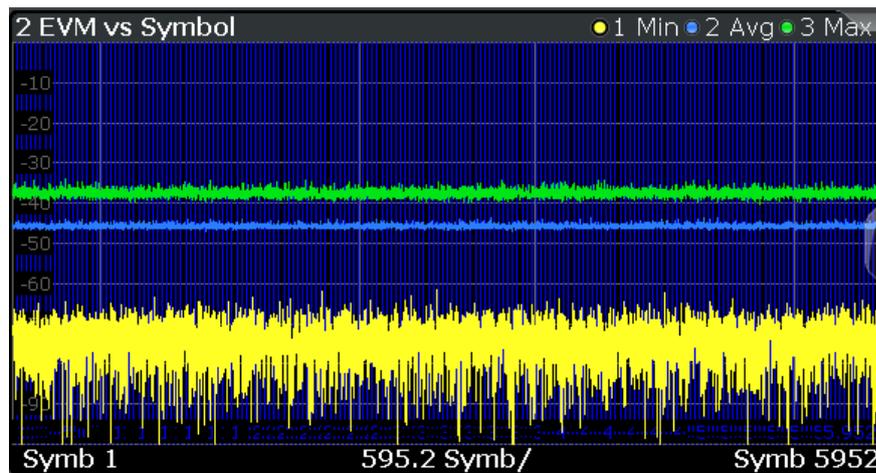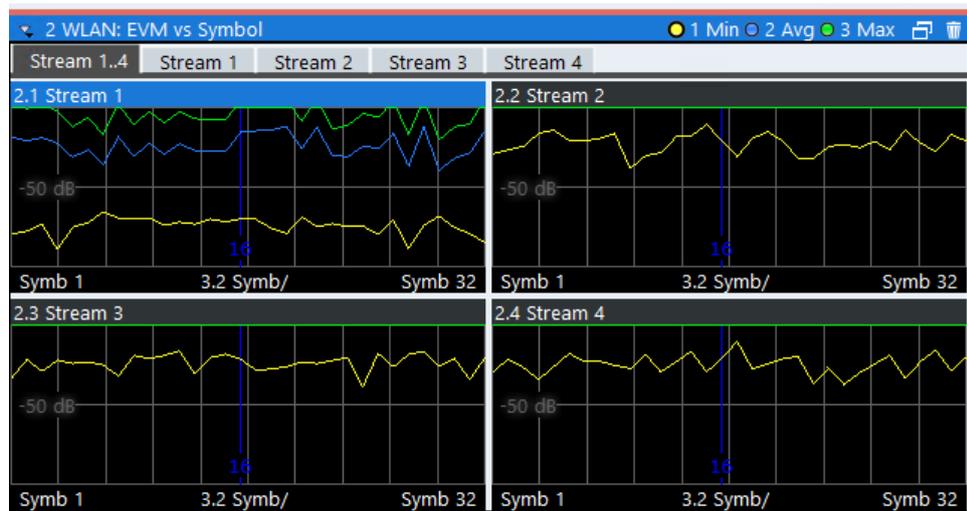
Figure 2-13: EVM vs symbol result display for IEEE 802.11n MIMO measurements

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 298
Or:
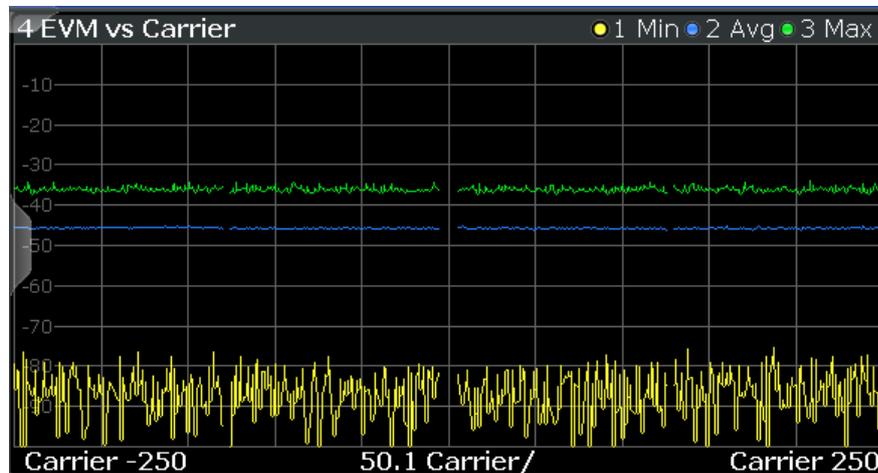CONFigure:BURSt:EVM:ESYMbol[:IMMediate] on page 308
Querying results:
TRACe[:DATA]?, see Chapter 8.6.3.11, "EVM vs symbol", on page 354

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.
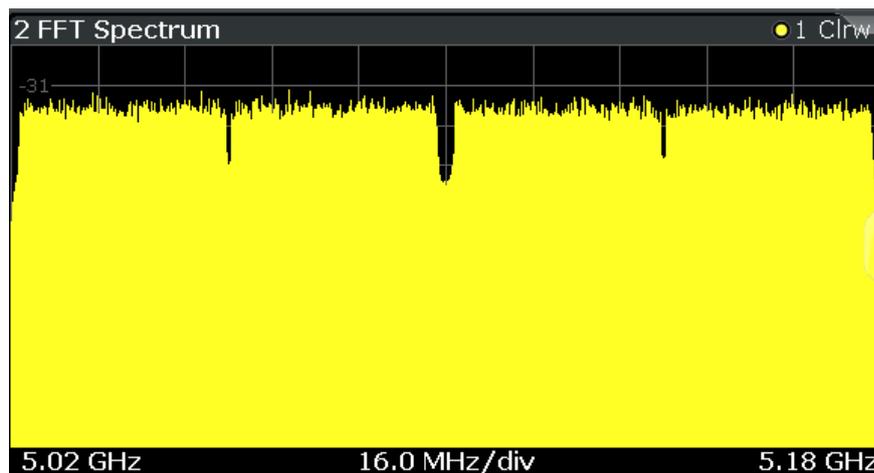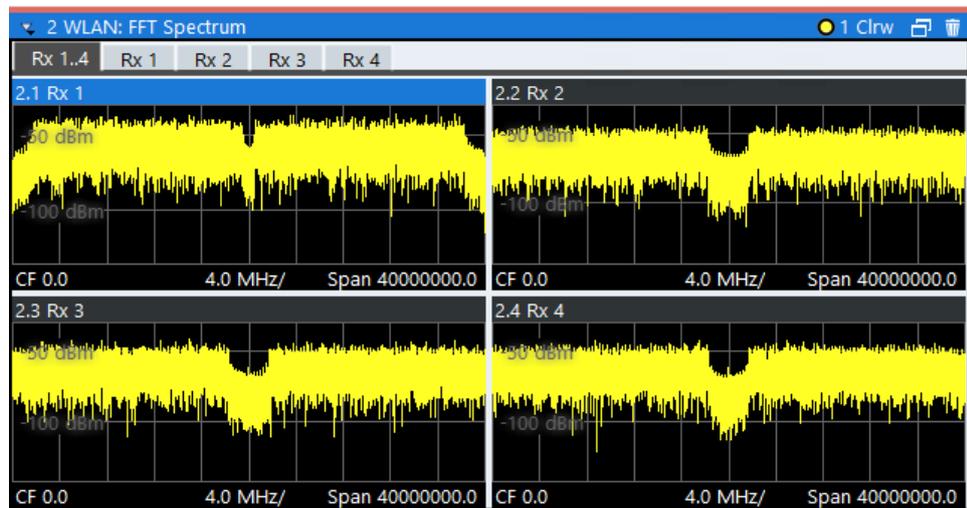
Figure 2-14: FFT spectrum result display for IEEE 802.11n MIMO measurements

The numeric trace results for this evaluation method are described in Chapter 8.6.3.12, "FFT spectrum", on page 355.

Remote command:
LAY:ADD? '1',RIGH, FSP, see LAYout:ADD[:WINDow]? on page 298
Or:
CONFigure:BURSt:SPECtrum:FFT[:IMMediate] on page 310
Querying results:
TRACe[:DATA]?, see Chapter 8.6.3.12, "FFT spectrum", on page 355

Freq. Error vs Preamble
Displays the frequency error values recorded over the preamble part of the PPDU. The minimum, average and maximum traces are displayed.
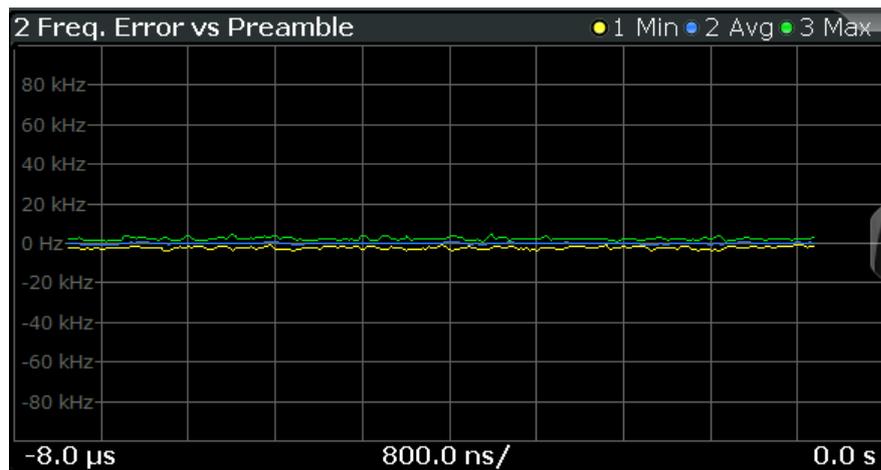
Remote command:
LAY:ADD? '1',RIGH,FEVP, see LAYout:ADD[:WINDow]? on page 298
Or:
CONFigure:BURSt:PREamble[:IMMediate] on page 308

CONFigure:BURSt:PREamble:SELect on page 309

Querying results:

TRACe[:DATA]?, see Chapter 8.6.3.8, "Error vs preamble", on page 353

Gain Imbalance vs Carrier

Displays the minimum, average and maximum gain imbalance versus carrier in individual traces. For details on gain imbalance, see Chapter 2.1.2, "Gain imbalance", on page 14.
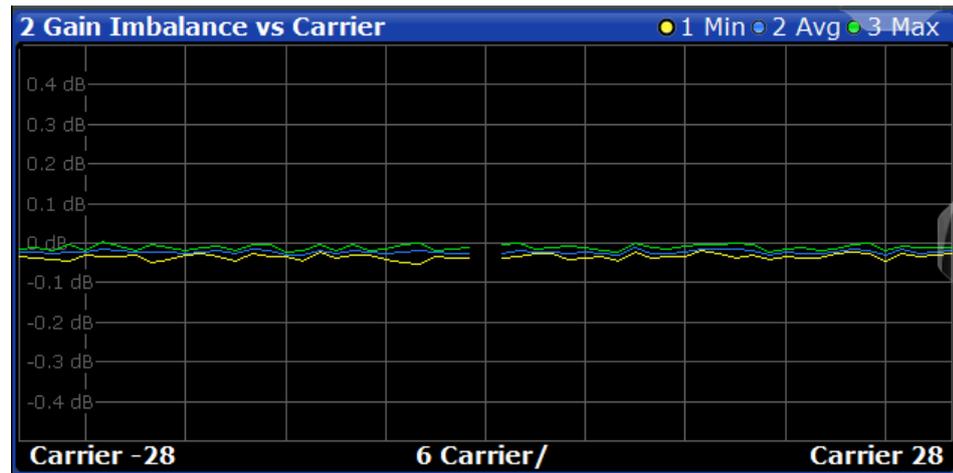
Remote command:

LAY:ADD? '1',RIGH,GAIN, see LAYout:ADD[:WINDow]? on page 298

Or:

CONFigure:BURSt:GAIN:GCARrier[:IMMediate] on page 308

Querying results:

TRACe[:DATA]?, see Chapter 8.6.3.7, "Error vs carrier", on page 353

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 159.

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)**).
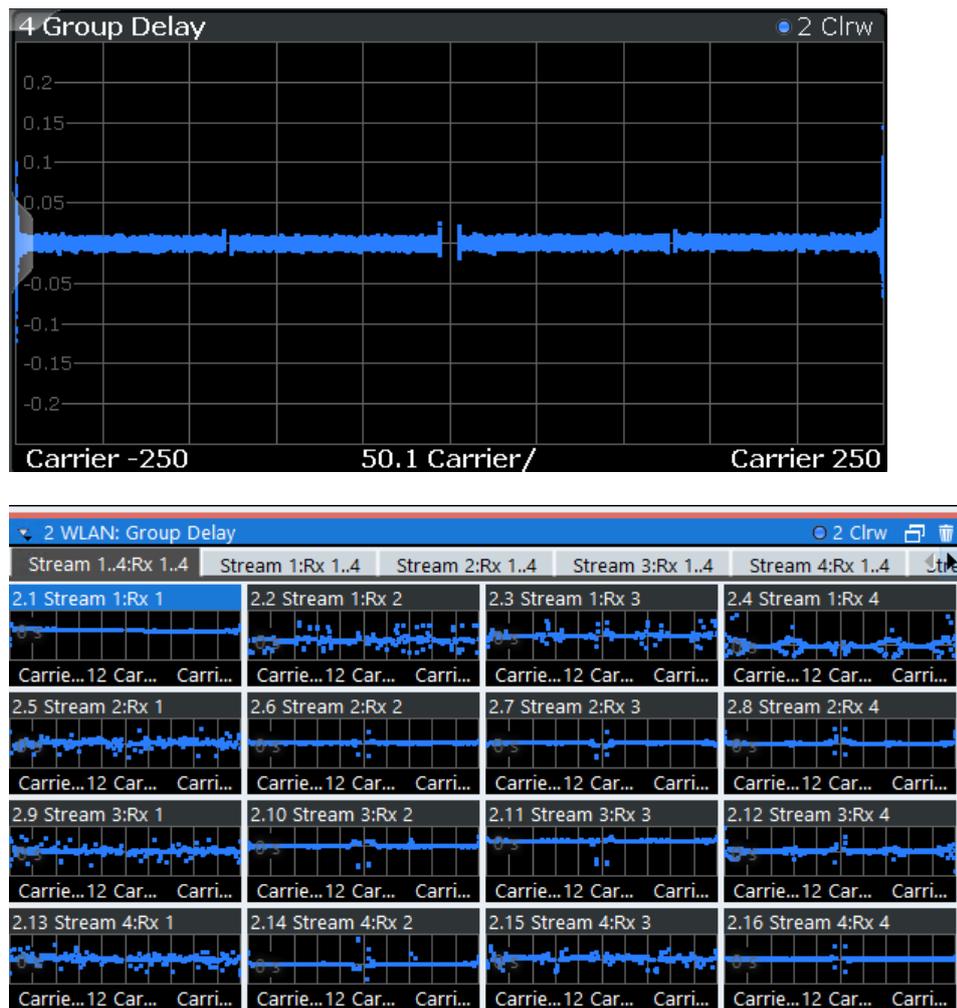
Figure 2-15: Group delay result display for IEEE 802.11n MIMO measurements

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 8.6.3.13, "Group delay", on page 355.

Remote command:
LAY:ADD? '1',RIGH, GDEL, see LAYout:ADD[:WINDow]? on page 298
Or:

`CONF:BURS:SPEC:FLAT:SEL GRD`, see `CONFigure:BURSt:SPECtrum:FLATness:SELect` on page 310 and `CONFigure:BURSt:SPECtrum:FLATness[:IMMediate]` on page 310

Querying results:

`TRACe[:DATA]?`, see Chapter 8.6.3.13, "Group delay", on page 355

Magnitude Capture

The "Magnitude Capture" display shows the complete range of captured data for the last sweep. Green bars at the bottom of the "Magnitude Capture" 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 158).
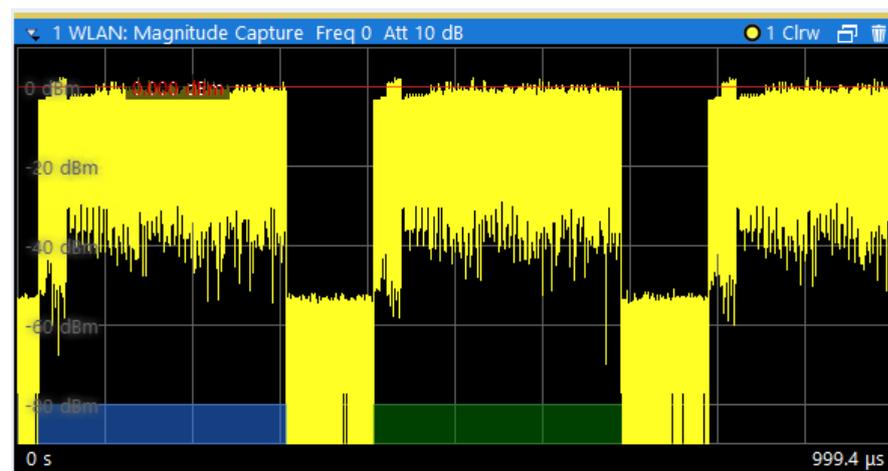
Figure 2-16: Magnitude capture display for single PPDU evaluation
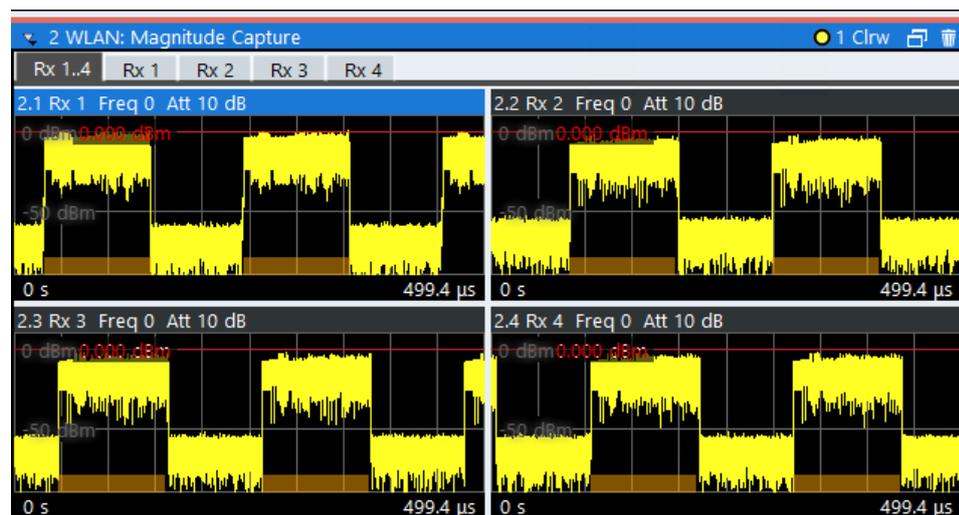
Figure 2-17: Magnitude capture result display for IEEE 802.11n MIMO measurements

Numeric trace results are not available for this evaluation method.

Remote command:
LAY:ADD? '1',RIGH, CMEM, see LAYout:ADD[:WINDow]? on page 298
Querying results:
TRACe[:DATA]?, see Chapter 8.6.3.14, "Magnitude capture", on page 355

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.
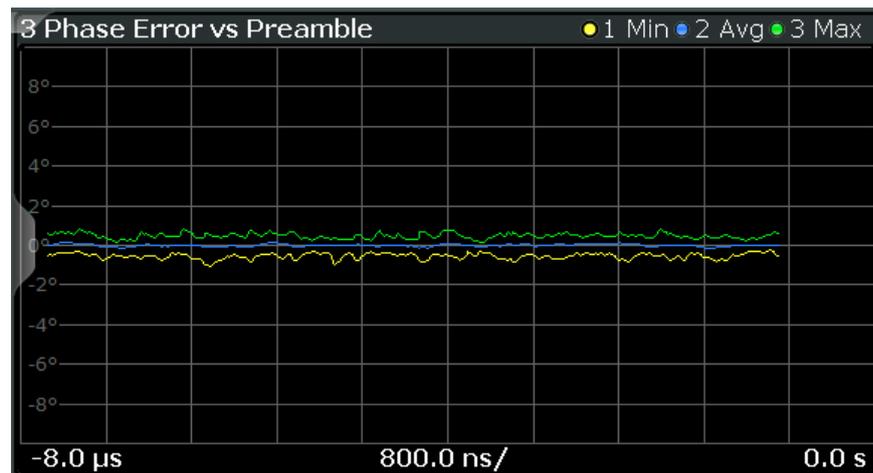
Remote command:
LAY:ADD? '1',RIGH,PEVP, see LAYout:ADD[:WINDow]? on page 298
Or:
CONFigure:BURSt:PREamble[:IMMediate] on page 308
CONFigure:BURSt:PREamble:SELect on page 309
Querying results:
TRACe[:DATA]?, see Chapter 8.6.3.8, "Error vs preamble", on page 353

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

For each OFDM-symbol N, the pilot phase error (rel. to preamble) is averaged over the pilot subcarriers of the OFDM-symbol N.

This result display is **not** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).
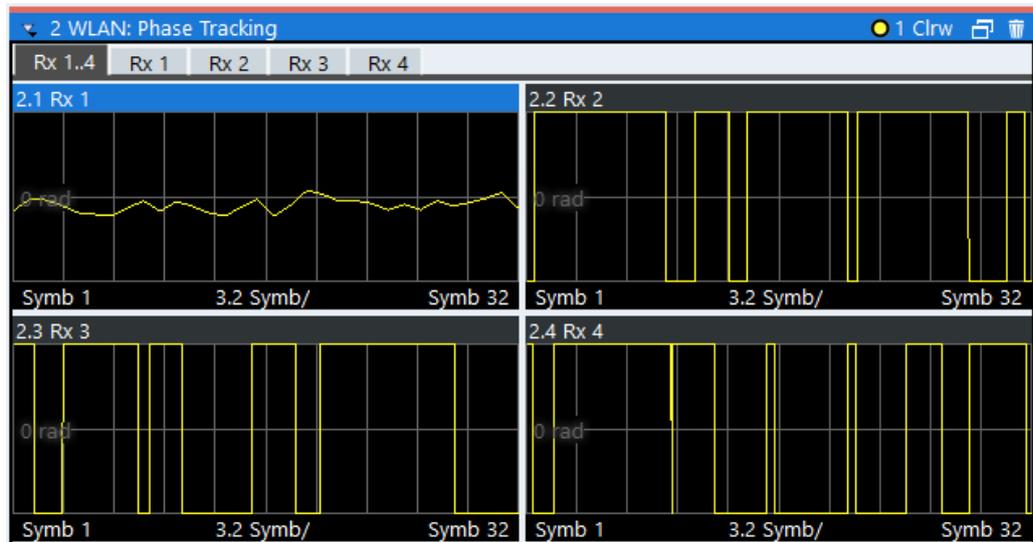
Figure 2-18: Phase tracking result display for IEEE 802.11n MIMO measurements

Remote command:
LAY:ADD? '1',RIGH,PTR, see LAYout:ADD[:WINDow]? on page 298
Or:
CONFigure:BURSt:PTRacking[:IMMediate] on page 309
Querying results:
TRACe[:DATA]?, see Chapter 8.6.3.15, "Phase tracking", on page 355

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.

Figure 2-19: PLCP Header result display for IEEE 802.11b, g (DSSS) standards

The following information is provided:

Note: 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 2-4: 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 decoded.	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 3-3 <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 298

Or:

`CONFigure:BURSt:STATistics:SFIeld[:IMMediate]` on page 311

Querying results:

`TRACe[:DATA]?,` see Chapter 8.6.3.17, "Signal field", on page 356

PvT Full PPDU

Displays the minimum, average and maximum power vs time diagram for all PPDUs.
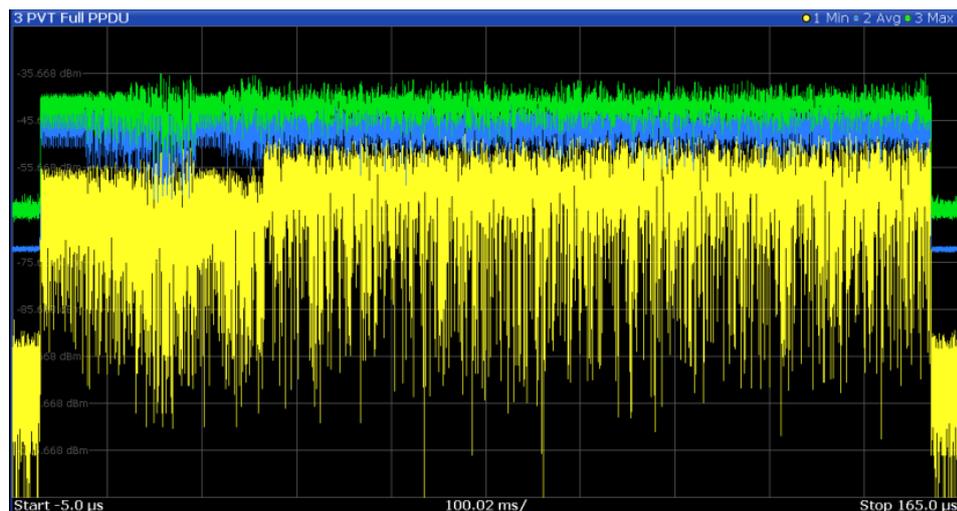
Figure 2-20: PvT Full PPDU result display for IEEE 802.11a, ac, g (OFDM), j, n, p standards
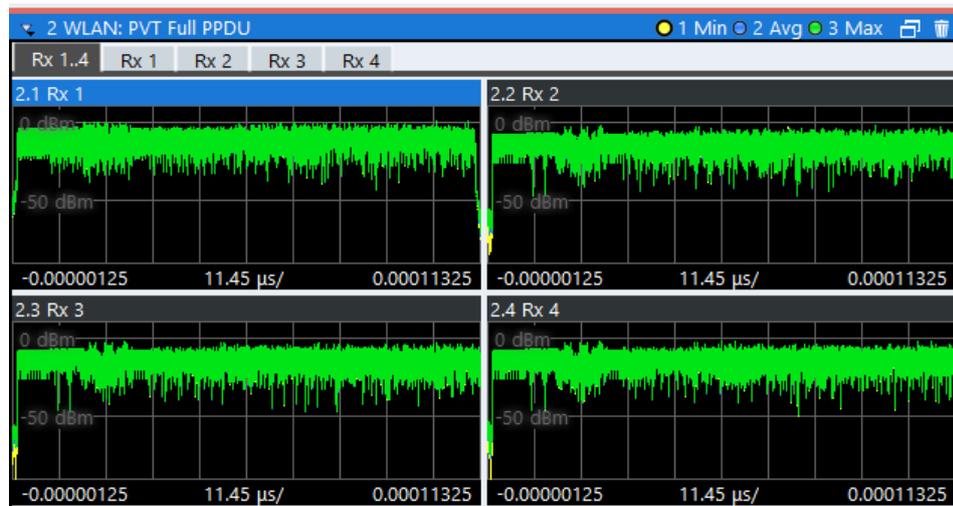
Figure 2-21: PvT Full PPDU result display for IEEE 802.11n MIMO measurements

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.
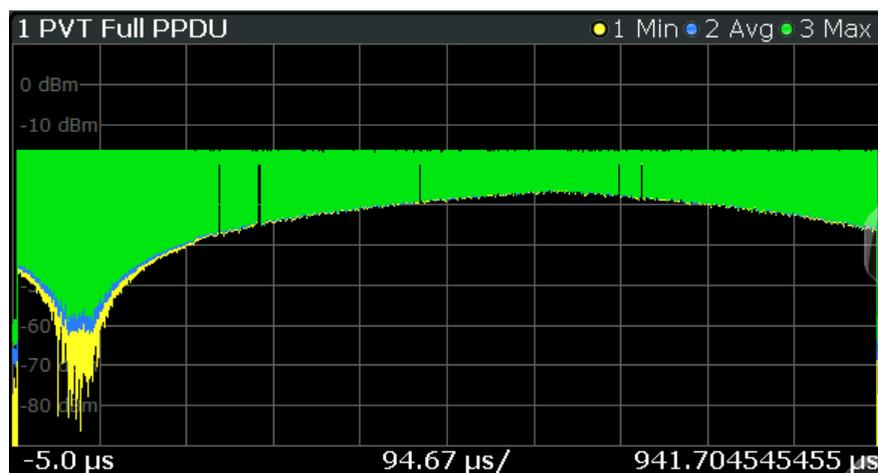
Figure 2-22: PvT Full PPDU result display for IEEE 802.11b, g (DSSS) standards

Remote command:
LAY:ADD:WIND '2',RIGH,PFPP see LAYout:ADD[:WINDow]? on page 298
Or:
CONFigure:BURSt:PVT:SELect on page 309
CONFigure:BURSt:PVT[:IMMediate] on page 309
Querying results:
TRACe[:DATA]?, see Chapter 8.6.3.16, "Power vs time (PVT)", on page 356

PvT Rising Edge
Displays the minimum, average and maximum power vs time diagram for the rising edge of all PPDUs.
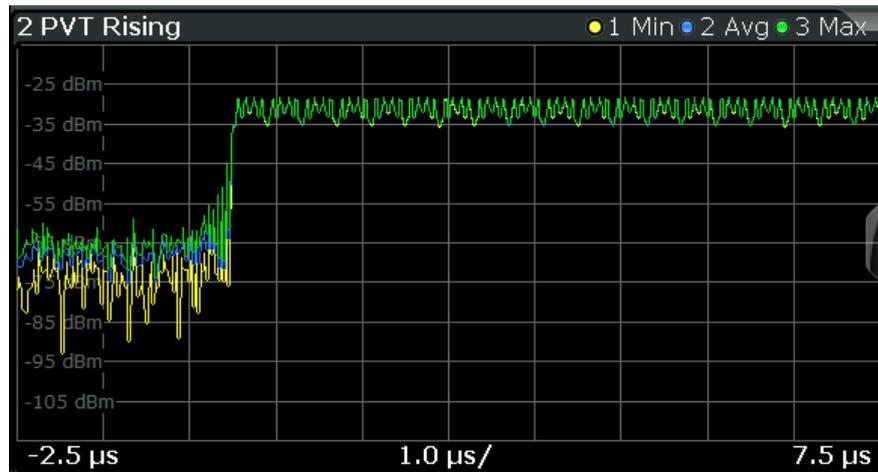
Figure 2-23: PvT Rising Edge result display

Remote command:
`LAY:ADD:WIND '2',RIGH,PRIS` see `LAYout:ADD[:WINDow]?` on page 298
Or:
`CONFigure:BURSt:PVT:SELect` on page 309
`CONFigure:BURSt:PVT[:IMMediate]` on page 309
Querying results:
`TRACe[:DATA]?`, see Chapter 8.6.3.16, "Power vs time (PVT)", on page 356

PvT Falling Edge
Displays the minimum, average and maximum power vs time diagram for the falling edge of all PPDUs.
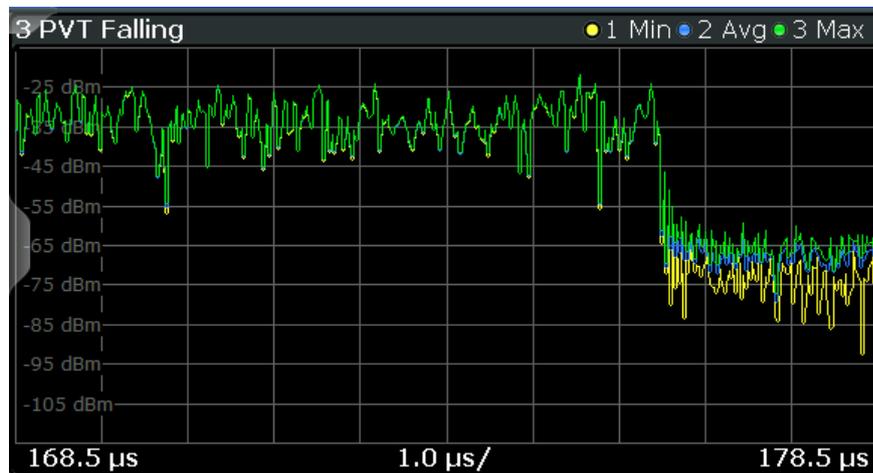
Figure 2-24: PvT Falling Edge result display

Remote command:
`LAY:ADD:WIND '2',RIGH,PFAL` see `LAYout:ADD[:WINDow]?` on page 298
Or:
`CONFigure:BURSt:PVT:SELect` on page 309
`CONFigure:BURSt:PVT[:IMMediate]` on page 309

Querying results:

`TRACe[:DATA]?`, see Chapter 8.6.3.16, "Power vs time (PVT)", on page 356

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 2.1.3, "Quadrature offset", on page 15.
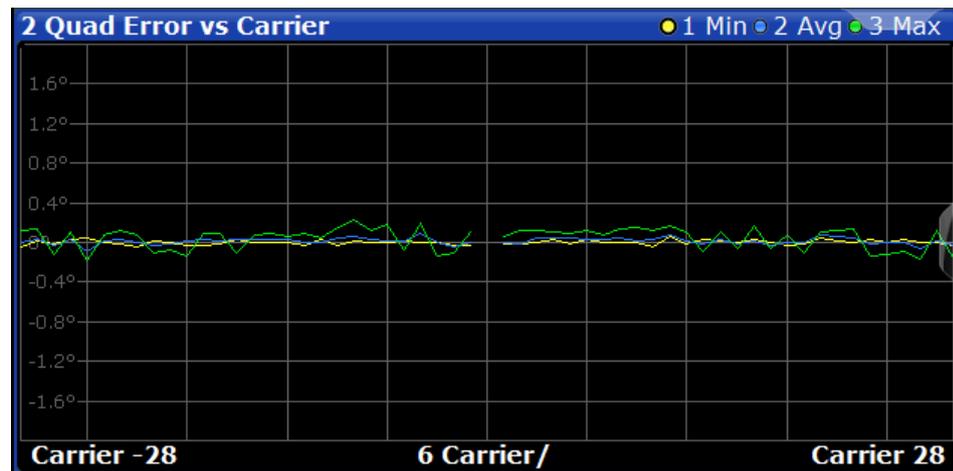
Remote command:

`LAY:ADD? '1',RIGH,QUAD`, see `LAYout:ADD[:WINDow]?` on page 298

Or:

`CONFigure:BURSt:QUAD:QCARrier[:IMMediate]` on page 310

Querying results:

`TRACe[:DATA]?`, see Chapter 8.6.3.7, "Error vs carrier", on page 353

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 2-25: 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 4.9, "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
- MIMO channel 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 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Remote command:

`LAY:ADD? '1',RIGH, RSD,` see `LAYout:ADD[:WINDow]?` on page 298

Querying results:

`FETCh:BURSt:ALL:FORMatted?` on page 320

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, ax, n, be), 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 2-26: Global result summary for IEEE 802.11a, ac, g (OFDM), j, 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 2-27: 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 4.9, "Result configuration", on page 163). However, the results are always calculated, regardless of their visibility.

(not for IEEE 802.11 be standard)
- Number of recognized PPDUs
- Number of analyzed PPDUs
- Number of analyzed PPDUs in entire physical channel, if available

IEEE 802.11 be standard: "PPDU / MCS / GI+EHT-LTF / RUS":
- PPDU type
- MCS index
- sum of guard interval (GI) length and extremely high throughput long training field (EHT-LTF) length
- RU size of the currently displayed resource unit (see also "Result displays for multi-user PPDUs" on page 79)

IEEE 802.11a, ac, ax, g (OFDM), j, n, p, be 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 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Remote command:
LAY:ADD? '1',RIGH, RSGL, see LAYout:ADD[:WINDow]? on page 298
Querying results:
All values in result summary table:
FETCh:BURSt:ALL:FORMatted? on page 320
EVM values only of all PPDUs:
FETCh:BURSt:PPDU:EVM:ALL:AVERage? on page 328

Signal Content Detailed (IEEE 802.11ax, be)
The Signal Content Detailed display contains information on the signal for *all* resource units.

This result display is only available for high-efficiency and extremely high throughput wireless signals (**IEEE 802.11ax, be**).

4 Signal Content Detailed							
PPDU Index	RU Index	RU Size	Object	EVM	Power	BER	CWER
1	---	---	L-LTF	---	-19.76 dBm	---	---
1	1	2x996	EHT-LTF	---	-55.47 dBm/SC	---	---
1	1	2x996	Data + Pilot	-89.72 dB	-55.47 dBm/SC	---	---
1	1	2x996	Data	-89.76 dB	---	0.00 %	0.00 %
1	1	2x996	Pilot	-87.96 dB	---	---	---
1	2	2x996	EHT-LTF	---	-55.47 dBm/SC	---	---
1	2	2x996	Data + Pilot	-88.10 dB	-53.88 dBm/SC	---	---
1	2	2x996	Data	-88.11 dB	---	0.00 %	0.00 %
1	2	2x996	Pilot	-87.96 dB	---	---	---

Figure 2-28: Signal Content Detailed result display for IEEE 802.11ax measurements

The "Signal Content Detailed" contains information for each decoded RU and for each object in the following order:
- (As of firmware version 3.20:) Legacy long training field (L-LTF)
- Long training field (HE-LTF)
- Data + Pilot
- Data only
- Pilot only

For each object, the following information is provided:
- PPDU index - sequential order of detected PPDU
- RU index - sequential order of resource unit
- RU size - size of the resource unit
- Object
- EVM in dB
- Power in dBm per subcarrier
- Bit error rate (BER)[*]
- Code word error rate (CWER)[*]

[*] Only if channel decoding is enabled in the Demodulation settings, see "Demodulation Data (Bitstream)" on page 141.

For details on the individual parameters and the summarized values, see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Remote command:
`LAY:ADD? '1',RIGH, SCD`, see `LAYout:ADD[:WINDow]?` on page 298
Querying results:
`FETCh:SCDetailed:ALL?` on page 329

Signal Field
This result display shows the decoded data from the signal fields of each recognized PPDU. These fields contain 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 2-29: 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 for each PPDU.

The currently applied user-defined demodulation settings are indicated in the table header for reference (e.g. "HT-MF20 PPDU [1]" in Figure 2-29). Since the demodulation settings define which PPDUs are to be analyzed, this *logical filter* can be the reason if the "Signal Field" display is not as expected.

The values for the individual demodulation parameters are described in Chapter 4.7, "Demodulation", on page 126.

The information differs for the different PPDU formats.

Table 2-5: Signal Field contents according to IEEE 802.11 standard

IEEE standard	PPDU format	"Signal Fields" contents	Standard reference
802.11a	Non-HT	L-SIG	[IEEE Std 802.11-2016] '17.3.4 SIG-NAL field'
802.11n	HT-mixed	L-SIG, HT-SIG	[IEEE Std 802.11-2016] '19.3.9.4.3 HT-SIG definition'
802.11n	HT-greenfield	HT-SIG	[IEEE Std 802.11-2016] '19.3.9.5.4 HT-greenfield format HT-SIG'
802.11ac	VHT	L-SIG, VHT-SIG-A	[IEEE Std 802.11-2016] '21.3.8.3.3 VHT-SIG-A definition'
802.11ax	HE SU, HE ER SU	L-SIG, SIG-A	[IEEE Std 802.11ax-2021] '27.3.11.5 L-SIG field'
802.11ax	HE MU	L-SIG, HE-SIG-A, HE-SIG-B	[IEEE Std 802.11ax-2021] '27.3.11.7 HE-SIG-A field'
802.11ax	HE TB	L-SIG, HE-SIG-A	[IEEE Std 802.11ax-2021] '27.3.11.8 HE-SIG-B field'

IEEE standard	PPDU format	"Signal Fields" contents	Standard reference
802.11be	EHT MU non-OFDMA	L-SIG, U-SIG, EHT-SIG common field	[IEEE P802.11be/D3.2, May 2023] '36.3.12.5 L-SIG'
802.11be	EHT MU	L-SIG, U-SIG, EHT-SIG common field	[IEEE P802.11be/D3.2, May 2023] '36.3.12.7 U-SIG'
802.11be	EHT TB	L-SIG, U-SIG	[IEEE P802.11be/D3.2, May 2023] '36.3.12.8 EHT-SIG'

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 8.6.3.17, "Signal field", on page 356.

Remote command:
LAY:ADD? '1',RIGH, SFI, see LAYout:ADD[:WINDow]? on page 298
Or:
CONFigure:BURSt:STATistics:SFIeld[:IMMediate] on page 311
Querying results:
Complete contents: FETCh:SFIeld:ALL? on page 333
(Decimal) Values: TRACe[:DATA]?, see Chapter 8.6.3.17, "Signal field", on page 356

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. We assume the cable connection between the DUT and the R&S VSE adds no residual channel distortion. Then 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 carriers.

In contrast to the SISO measurements in previous Rohde & Schwarz signal and spectrum analyzers, the trace is no longer normalized to 0 dB, that is: scaled by the mean gain of all carriers.
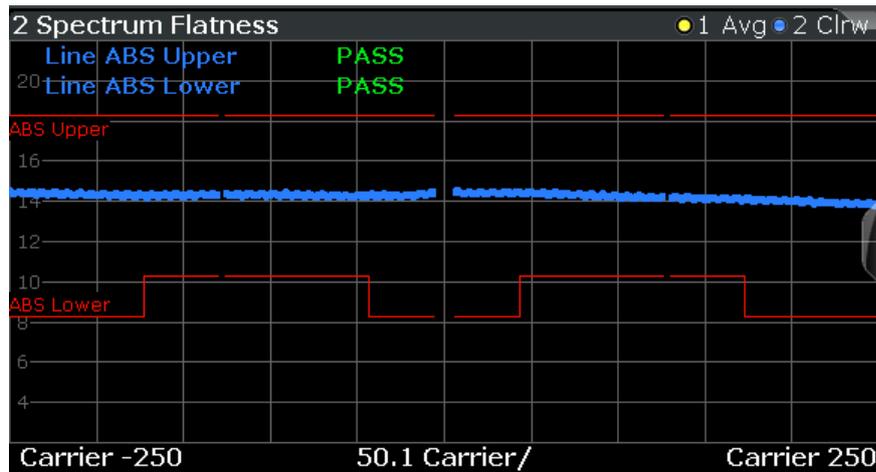
For more information, see Chapter 3.3.6, "Crosstalk and spectrum flatness", on page 74.
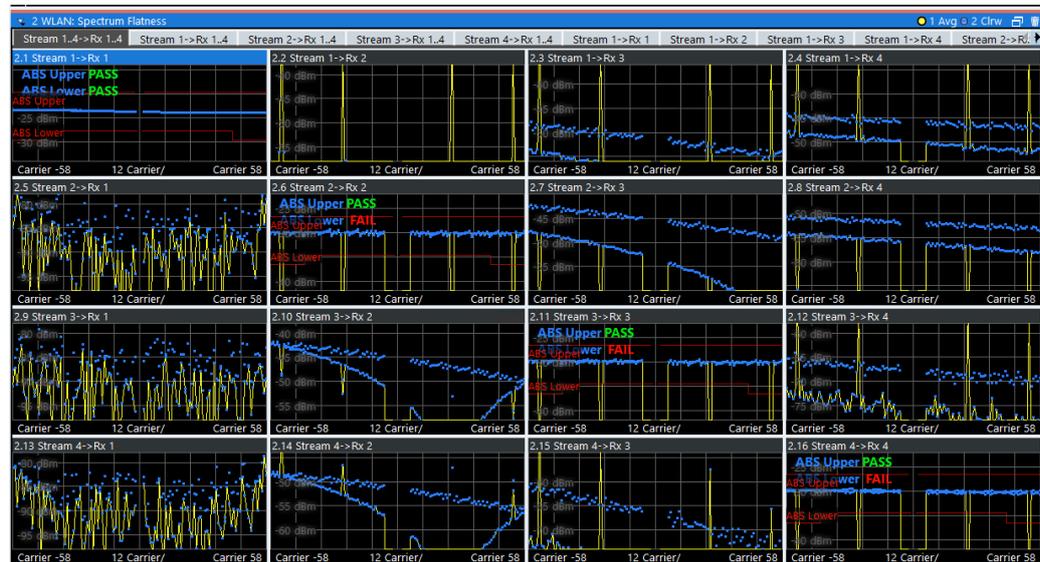
Figure 2-30: Spectrum flatness result display for IEEE 802.11n MIMO measurements

The numeric trace results for this evaluation method are described in Chapter 8.6.3.18, "Spectrum flatness", on page 356.

Remote command:
LAY:ADD? '1',RIGH, SFL, see LAYout:ADD[:WINDow]? on page 298
Or:
CONF:BURS:SPEC:FLAT:SEL FLAT (see CONFigure:BURSt:SPECtrum: FLATness:SELect on page 310) and CONFigure:BURSt:SPECtrum:FLATness[: IMMediate] on page 310
Querying results:
TRACe[:DATA]?, see Chapter 8.6.3.18, "Spectrum flatness", on page 356

Spectrum Flatness Result Summary

Provides numeric results for the Spectrum Flatness trace. This is useful to check the maximum transmit spectral deviations defined by the IEEE 802.11 ax and be standards.

3 Spectrum Flatness Result Summary					
Range Low /Subc.	Range Up /Subc.	Δ Lower Limit /dB	@Subcarrier	Δ Upper Limit /dB	@Subcarrier
-1012	1012	2.9906	166	3.1331	-826
-1012	-697	4.2194	-1012	3.1331	-826
-696	-515	4.2559	-533	3.3923	-696
-509	-166	4.1220	-167	3.5353	-292
-165	-12	5.3224	-13	3.8853	-165
12	165	4.9335	128	4.7902	12

Maximum deviations are bandwidth and subcarrier dependant. The overall subcarrier range is divided into subranges by the standard. For each subrange, the "Spectrum Flatness" "Result Summary" provides the following values:

(The **first row** indicates the results for the **entire subcarrier range**.)

Table 2-6: Spectrum Flatness deviation results

Result	Description
"Range Low/Subc."	Subcarrier number at start of subrange
"Range Up/Subc."	Subcarrier number at end of subrange
"Δ Lower Limit/dB"	The minimal distance from the subcarriers in the subrange to the lower tolerance limit (defined by standard)
"@Subcarrier"	Subcarrier number with the minimal distance to the lower limit
"Δ Upper Limit/dB"	The minimal distance from the subcarriers in the subrange to the upper tolerance limit (defined by standard)
"@Subcarrier"	Subcarrier number with the minimal distance to the upper limit

If the tolerance limit defined by the standard is exceeded, the values are indicated in red font.

Remote command:
LAY:ADD? '1',RIGH, SFL, see LAYout:ADD[:WINDow]? on page 298
Querying results:
FETCh:SFSummary:ALL? on page 333

Unused Tone Error

The unused tone error evaluation determines the error vector magnitude for unoccupied subcarriers, also referred to as *unused tones*. For details on this parameter, see Chapter 2.1.8, "Unused tone error", on page 18.

This result is required by the **IEEE 802.11ax** standard for HE trigger-based PPDUs with a maximum channel bandwidth of 80 MHz.
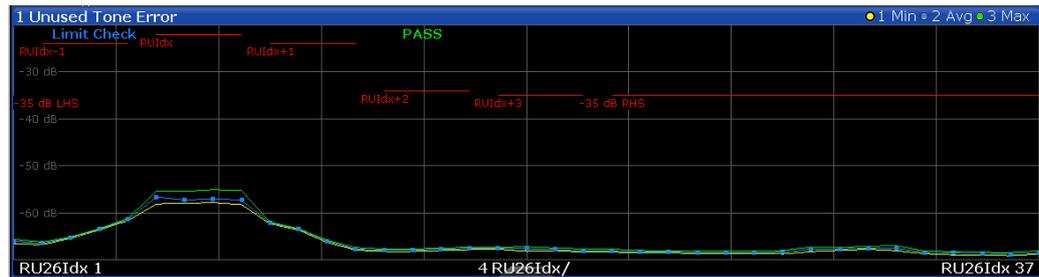
Figure 2-31: Unused tone error for an RU index of 2 and an RU size of 106

The minimum, average and maximum unused tone values are displayed. The x-axis displays the RU index based on an RU size of 26 subcarriers. The individual measurement points are indicated by blue dots. The error vector magnitude limit per RU group, relative to the original RU, as specified by the IEEE 802.11ax standard, is indicated by red lines in the diagram. The result of the overall limit check for the entire channel is indicated as "Pass" or "Fail".

The "Unused Tone Error" diagram provides an overview of the unused tone error results of an entire channel at a glance. For detailed numeric results for individual RU groups, use the Unused Tone Error Summary.

Remote command:
LAY:ADD? '1',RIGH,UTER, see LAYout:ADD[:WINDow]? on page 298
Querying results:
TRACe[:DATA]?, see Chapter 8.6.3.19, "Unused tone error", on page 357

Unused Tone Error Summary
The unused tone error summary determines the error vector magnitude, relative to the original RU, for unoccupied subcarriers, also referred to as *unused tones*. For details on this parameter, see Chapter 2.1.8, "Unused tone error", on page 18.

This result is required by the **IEEE 802.11ax** standard for HE trigger-based PPDUs with a maximum channel bandwidth of 80 MHz.

RU Group	RU Size	Min dB	Mean dB	Max dB	Limit dB	Delta dB	Max RU26Idx	Limit Check
-35 dB LHS	4	-66.01	-66.01	-66.01	-35.00	-31.01	1	PASS
RUIdx-3	---	---	---	---	---	---	---	---
RUIdx-2	---	---	---	---	---	---	---	---
RUIdx-1	4	-66.53	-64.16	-61.43	-24.00	-37.43	5	PASS
RUIdx	4	-57.29	-57.05	-56.63	-22.00	-34.63	6	PASS
RUIdx+1	4	-67.78	-64.86	-62.16	-24.00	-38.16	10	PASS
RUIdx+2	4	-67.97	-67.82	-67.62	-34.00	-33.62	17	PASS
RUIdx+3	4	-68.18	-67.78	-67.50	-35.00	-32.50	18	PASS

*Figure 2-32: Unused tone error summary for an RU index of 2 and an RU size of 106 (=4*26)*

Note: For an overview of the unused tone error results of an entire channel at a glance, use the Unused Tone Error diagram.

The "Unused Tone Error Summary" provides the following information for up to 9 RU groups. Which subcarriers are evaluated in which RU group depends on the size and index of the resource unit to be checked. For details, see Chapter 2.1.8, "Unused tone error", on page 18.

"RU group"	Set of subcarriers for which a limit is specified in the standard
"RU size"	Size of the RU, indicated as a factor of 26 (RU26 unit)
"Min"	Minimum unused tone error measured in the RU group
"Mean"	Mean unused tone error measured in the RU group
"Max"	Maximum unused tone error measured in the RU group
"Limit"	Limit for unused tone error, relative to the original RU, as specified by the IEEE 802.11ax standard
"Delta"	Limit - Max = distance of maximum value to limit for the RU group
"Max RU26 Idx"	Index of the subcarrier with the maximum value, based on an RU size of 26
"Limit check"	Result of the limit check for the individual RU group

Remote command:
LAY:ADD? '1',RIGH,UTES, see LAYout:ADD[:WINDow]? on page 298
Querying results:
FETCh:UTESummary:ALL? on page 334
Querying limit results:
CALCulate<n>:LIMit<li>:CONTrol[:DATA]? on page 340
CALCulate<n>:LIMit<li>:UPPer[:DATA]? on page 341
CALCulate<n>:LIMit<li>:FAIL? on page 340

3 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.

3.1 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 VSE 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

3.1.1 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 VSE WLAN application is shown in Figure 3-1.

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.
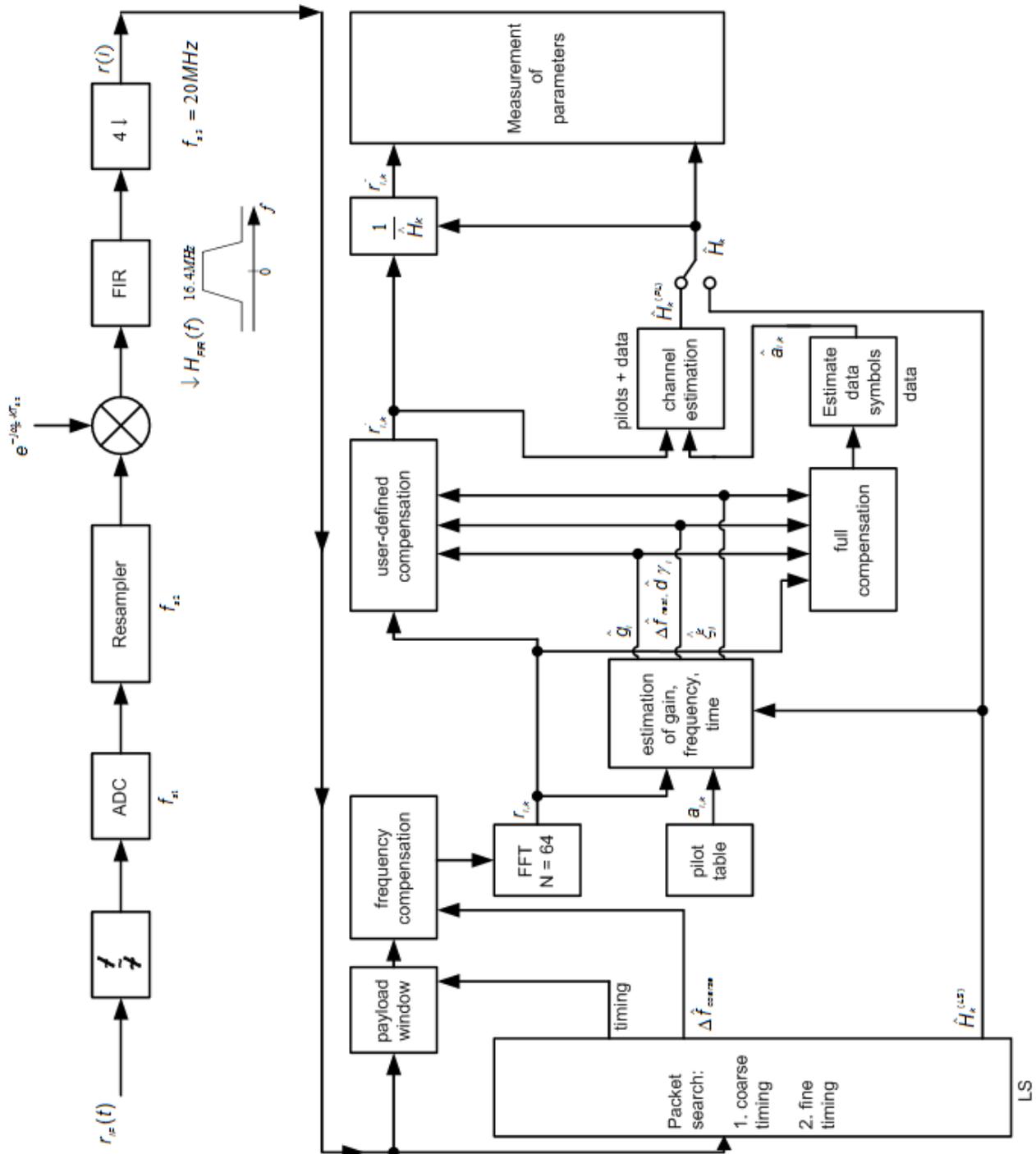
Figure 3-1: Block diagram for the R&S VSE WLAN application using the IEEE 802.11a, g (OFDM), j, p standard

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]

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

Equation 3-1: 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 3-2: 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 3-1) 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 VSE WLAN application (see "Phase Tracking" on page 124).

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 3-3: 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 VSE WLAN application (see "Timing Error Tracking" on page 124). 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 VSE WLAN application (see "Level Error (Gain) Tracking" on page 124).

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 $\tilde{\varepsilon}$. (The tilde generally describes a trial parameter. Example: $\tilde{x}$ is the trial parameter of x.)

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

Equation 3-4: Log likelihood function (step 1)

with:

$$\tilde{phase}_l^{(common)} = \frac{2\pi \times N_s}{N \times \Delta\tilde{f}_{rest} \times T \times l}$$

$$\tilde{phase}_{l,k}^{(timing)} = \frac{2\pi \times N_s}{N \times \tilde{\xi} \times k \times l}$$

The trial parameters leading to the minimum of the log likelihood function are used as estimates $\Delta\hat{f}_{rest}$ and $\hat{\varepsilon}$. 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 $d\tilde{\gamma}_l$:

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

Equation 3-5: Log likelihood function (step 2)

with:

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

$$\tilde{phase}_{l,k}^{(timing)} = \frac{2\pi \times N_s}{N \times \tilde{\xi} \times k \times l}$$

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

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 $\widehat{H}^{(LS)}{}_k$ 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 $\widehat{H}^{(PL)}{}_k$ 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 $\widehat{H}^{(LS)}{}_k$) leads to a nearly error-free channel estimate.

In the following equalizer block, $\widehat{H}^{(LS)}{}_k$ 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 $\widehat{H}^{(LS)}{}_k$ (from the long symbol) or the nearly error-free channel estimate $\widehat{H}^{(PL)}{}_k$ (from the payload) for equalization. If the improved estimate $\widehat{H}^{(LS)}{}_k$ 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 $\widehat{H}^{(LS)}{}_k$ (from the long symbol) has to be used for equalization. Therefore the default setting of the R&S VSE 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 3-6: 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:

$$EVM = \sqrt{\frac{1}{52} \sum_{k=-26(k\neq0)}^{26} EVM_k^2}$$

Equation 3-7: 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:

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

Equation 3-8: 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]).

3.1.2 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

3.2 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
Δf	frequency offset
ΔΦ	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

$\widehat{o}_Q$	estimate of the IQ-offset in the I-branch
r(v)	measurement signal
$\widehat{s}(v)$	estimate of the reference signal
$\widehat{s}_n(v)$	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

3.2.1 Block diagram for single-carrier measurements

A block diagram of the measurement application is shown below in Figure 3-2. 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.
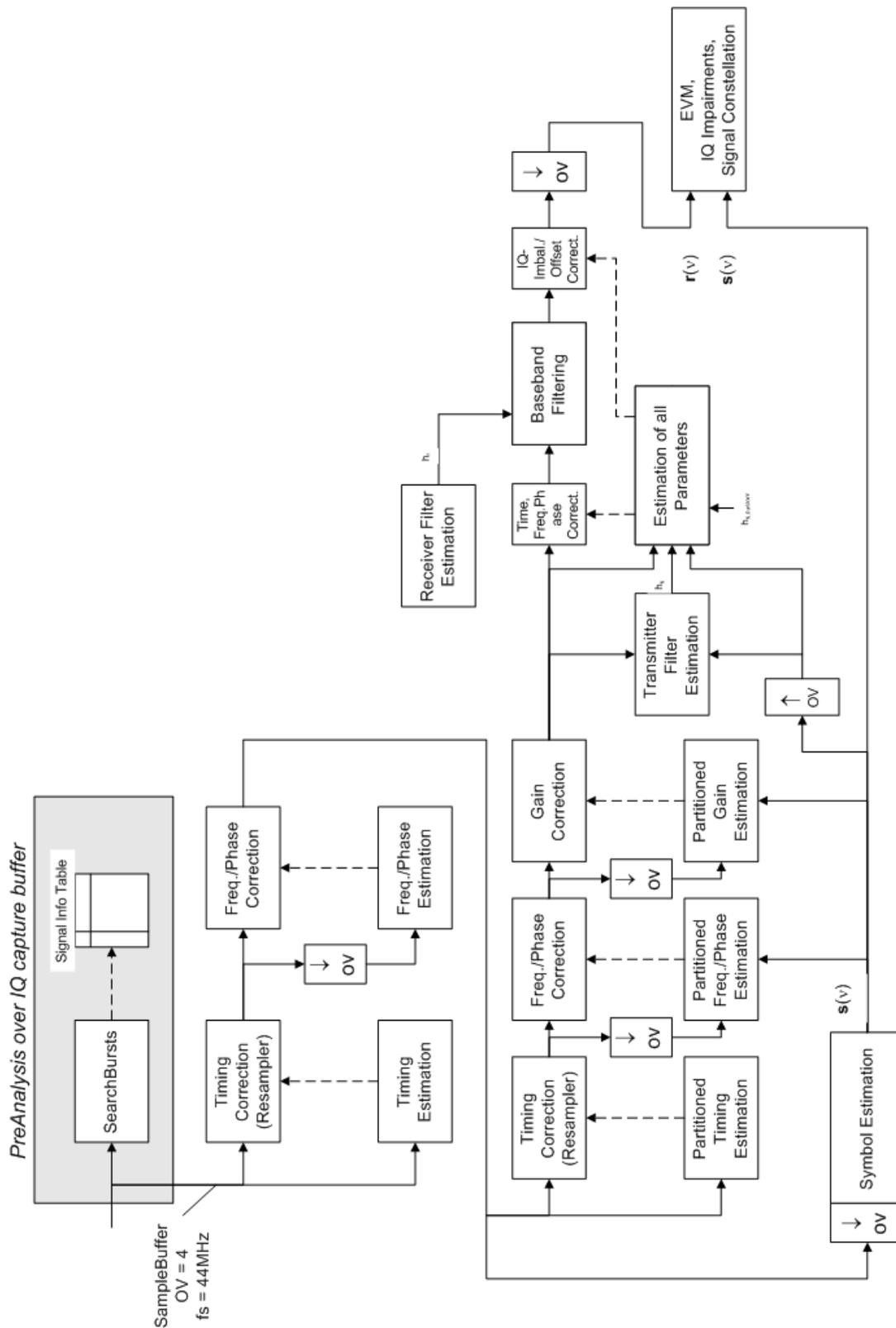
Figure 3-2: Signal processing for IEEE 802.11b or g (DSSS) signals

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:

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

Equation 3-9: Transmit antenna baseband filter (Tx filter) estimation

where:

r(v): the oversampled measurement signal

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

N: the observation length

L: the filter length

$\Delta\tilde{f}_v$: 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 I/Q offset

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

3.2.2   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:

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

Equation 3-10: 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(v) s_Q(v): 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:

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

Equation 3-11: Gain imbalance

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

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

Equation 3-12: 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 3-13: 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 VSE 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:

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

Equation 3-14: 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:

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

Equation 3-15: 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:

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

Equation 3-16: I/Q offset I-branch

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

Equation 3-17: 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:

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

Equation 3-18: Gain imbalance I-branch

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

Equation 3-19: Gain imbalance Q-branch

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

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

Equation 3-20: 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:

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

Equation 3-21: 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 30).

3.2.3 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.

3.3 Signal processing for MIMO measurements (IEEE IEEE 802.11ac, ax, n, be)

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 IEEE 802.11ac, ax, n, be standard, the R&S VSE 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 VSE 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 following application notes, available from the Rohde & Schwarz website:

1MA142: "Introduction to MIMO"

1MA192: 802.11ac Technology Introduction

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 3.3.2, "Spatial mapping", on page 68).

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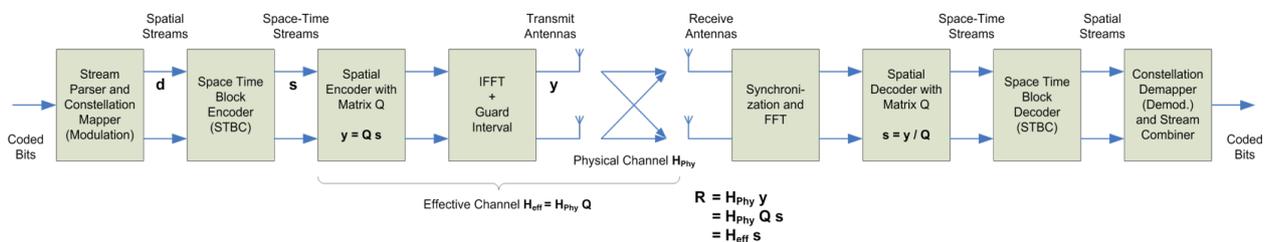
Figure 3-3: Data flow from the transmit antenna to the receive antenna

3.3.1 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 3-3).

The Space-Time Block Encoder (STBC) implements the transmit diversity technique (see "Basic technologies" on page 66). 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 3-6).

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.

3.3.2 Spatial mapping

The Spatial Encoder (see Figure 3-3) 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 VSE 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:

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

3.3.3 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 3-4). 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.
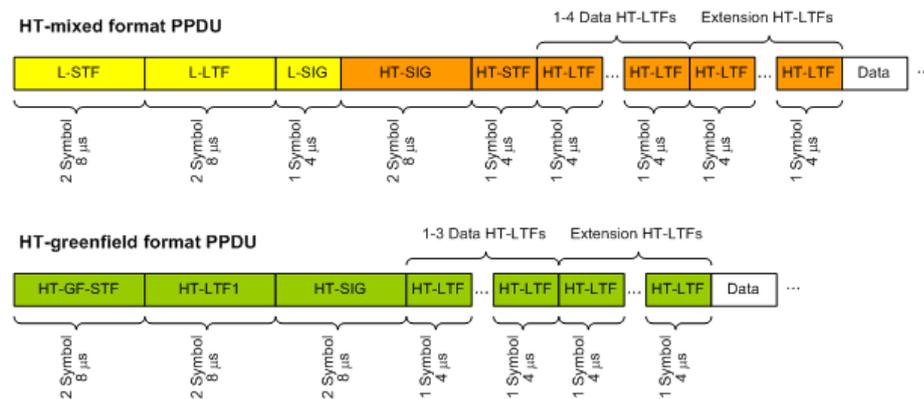
Figure 3-4: Training fields (TF) in the preamble of PPDUs in IEEE 802.11n standard

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 3.3.6, "Crosstalk and spectrum flatness", on page 74.

3.3.4 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 3.3.4.1, "Sequential MIMO measurement", on page 71). 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 VSE 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 *primary*, which receives the I/Q data from the other analyzers (the *secondaries*). The IP addresses of each secondary analyzer must be provided to the primary. The only function of the secondariess is to record the data that is then accumulated centrally by the primary.
  (Note that only the MIMO primary analyzer requires the R&S VSE-K91n or ac option. The secondary analyzers do not require a R&S VSE WLAN application.)
  The number of Tx antennas on the DUT defines the number of analyzers required for this measurement setup.
  Tip: Use the primary's trigger output (see Chapter 3.9.5, "Trigger synchronization using the primary's trigger output", on page 88) or an R&S Z11 trigger box (see Chapter 3.9.6, "Trigger synchronization using an R&S FS-Z11 trigger unit", on page 88) to send the same trigger signal to all devices.

The primary calculates the measurement results based on the I/Q data captured by *all* analyzers (primary and secondaries) 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 VSE 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 3.3.4.1, "Sequential MIMO measurement", on page 71.

- **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 VSE 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 3.3.4.1, "Sequential MIMO measurement", on page 71.

- **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").

3.3.4.1 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 3.3.4, "Capturing data from MIMO antennas", on page 70).

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!
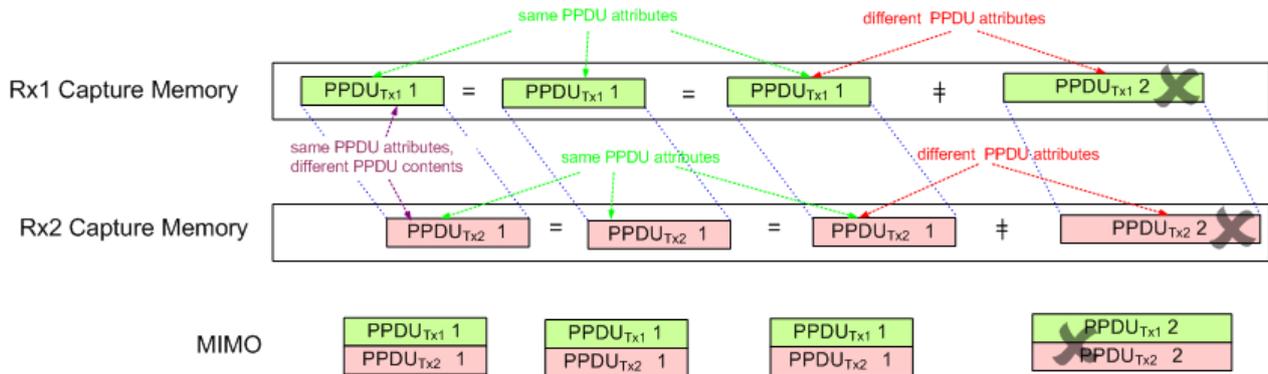
Figure 3-5: Basic principle of "Sequential MIMO Measurement" with 2 receive antennas

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.

3.3.5 Calculating results

When you analyze a WLAN signal in a MIMO setup, the R&S VSE acts as the receiving device. Since most measurement results have to be calculated at a particular stage in the processing chain, the R&S VSE 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.
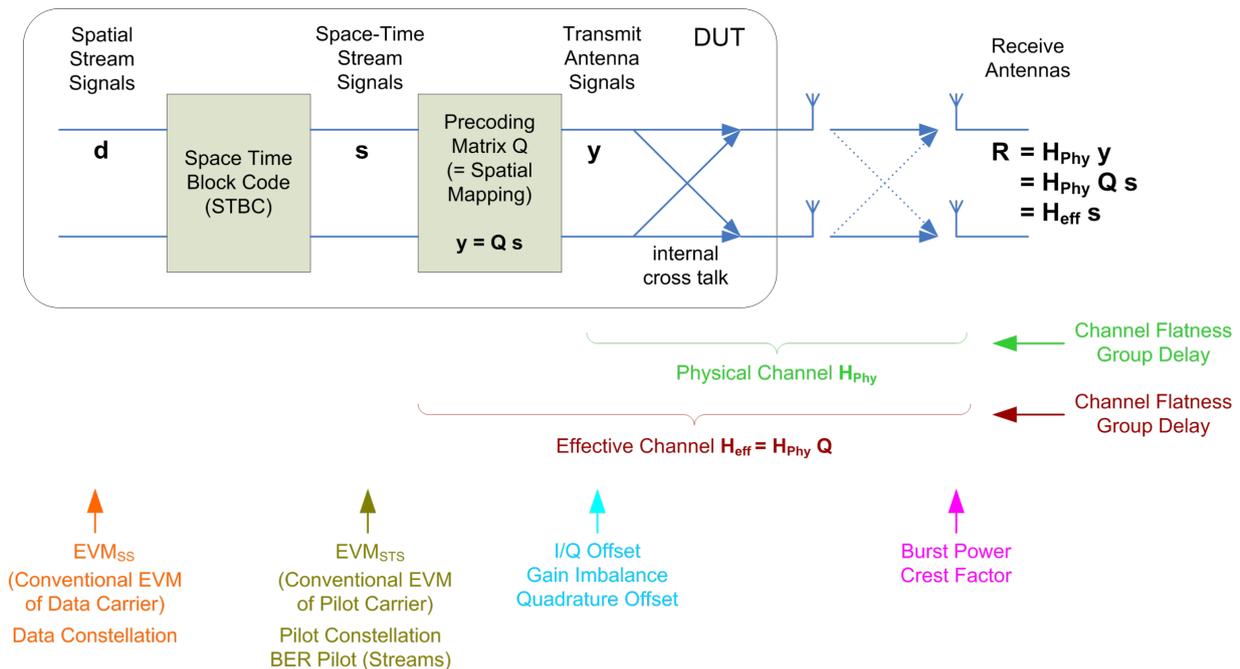
Figure 3-6: Results at individual processing stages

Receive antenna results

The R&S VSE 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 VSE 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 VSE WLAN application can determine the physical channel (see Chapter 3.3.3, "Physical vs effective channels", on page 68), 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 3.3.3, "Physical vs effective channels", on page 68), 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 3.3.1, "Space-time block coding (STBC)", on page 67). 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.

3.3.6 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 VSE WLAN application. However, you can deactivate compensation for crosstalk (see "Compensate Crosstalk(MIMO only)" on page 126). In this case, simple main path equalizing is performed only for direct connections between Tx and Rx antennas, disregarding ancillary trans-

mission between the main paths (crosstalk). This is useful to investigate the effects of crosstalk on results such as EVM.

3.4 Signal processing for high-efficiency wireless measurements (IEEE 802.11ax)

The IEEE 802.11ax standard, also known as High Efficiency Wireless (HEW), provides mechanisms to more efficiently utilize the unlicensed spectrum bands (2.4 GHz and 5 GHz) and improve user experience.

It is particularly meant for use in dense environments with large numbers of users (referred to as *stations*) and base stations (referred to as *access points*).

Currently, the specification for this standard is still under development by the IEEE organization. The basic features and processing methods described here and used by the R&S VSE WLAN application are based on the draft version 1.0 from December 2016.

For more information, see also the Rohde & Schwarz White Paper 1MA222: IEEE 802.11ax Technology Introduction.

3.4.1 Basic signal characteristics

PPDU formats

The new 802.11ax standard introduces four new PPDU (Packet Protocol Data Unit) formats:

- **HE SU (Single User) PPDU (HE_SU)**: used to transmit to a single user
- **HE Extended Range PPDU (HE_EXT_SU)**: used to transmit to a single user who is further away from the AP, such as in outdoor scenarios; Only available for 20 MHz channel bandwidths
- **HE MU (Multi-User) PPDU (HE-MU)**: carries one or more transmissions to one or more users
- **HE Trigger-Based PPDU (HE_Trig)**: carries a single transmission and is sent in response to a trigger frame; Used for OFDMA and/or MU MIMO uplink transmission

OFDMA

This new standard allows for the OFDMA method to be employed, where the available channel bandwidth (between 20 MHz and 160 MHz) is divided between multiple users. Each user is assigned a predefined number of subcarriers (also referred to as *tones*). This subset of subcarriers is referred to as a *resource unit (RU)*. RU sizes can vary between 26 subcarriers and (2x) 996 subcarriers. All users transmit their data simultaneously, and each data packet has the same length. However, the resource units used

by the individual users may have different lengths. In other words: each user can use a different number of subcarriers or channel bandwidth.
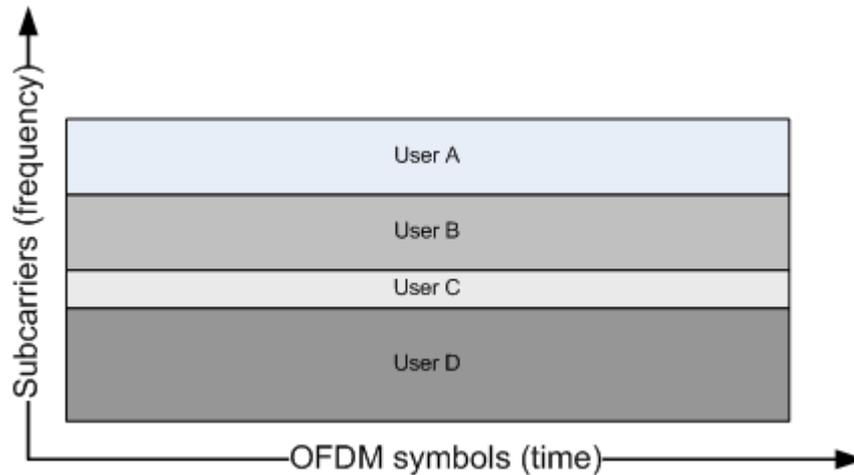

Figure 3-7: OFDMA frequency vs time usage

The OFDMA method provides several advantages versus the OFDM method:

- Flexible bandwidth allocation per user means each user blocks only the frequency range that they need
- Each station can use a different modulation according to the current SNR
- In the time range, less overhead is required

Resource units (RUs)

Depending on the available channel bandwidth and the size of the used RUs, the following number of resource units are available at the same time:

Table 3-1: Number of RUs depending on channel bandwidth and RU size

Channel band-width RU size (number of subcarriers)	20 MHz	40 MHz	80 MHz	160 MHz
26	9	18	37	74
52	4	8	16	32
106	2	4	8	16
242	1	2	4	8
484		1	2	4
996			1	2
2*996				1

Each RU in the channel is indexed. Depending on the size of the RU and the available channel bandwidth, the RU index refers to different subcarriers.
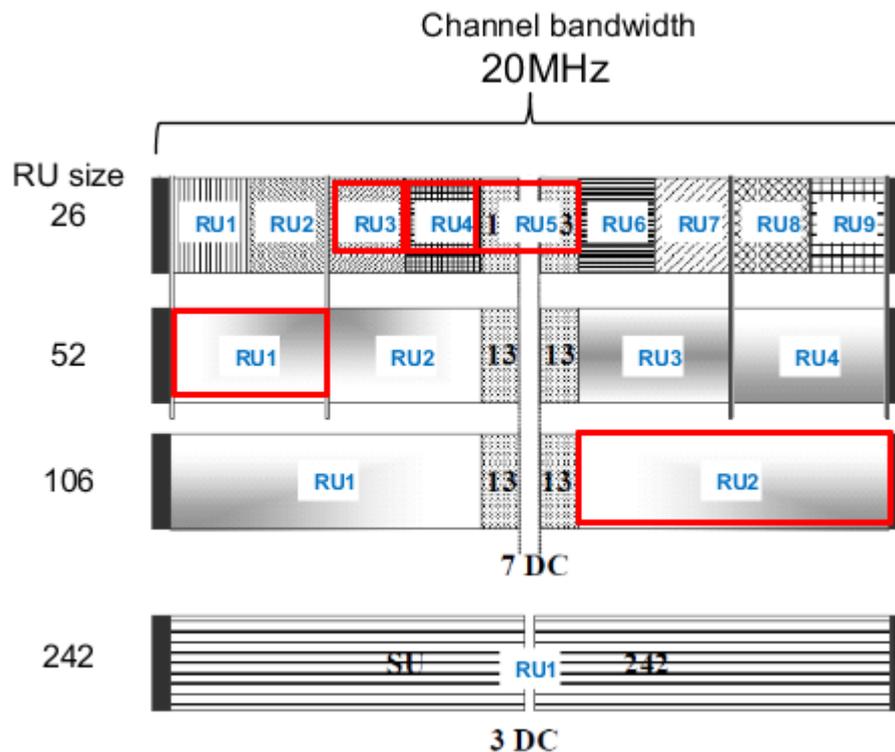
Figure 3-8: Example: RU indexing for 20 MHz channel bandwidth

The available RUs in a channel are assigned to the users sequentially according to the current transmission requirements. Generally, one user is assigned to one RU (for MIMO see "Multi-User (MU-)MIMO" on page 78). Although the RU sizes may vary per user, if both the RU index and the RU size is known, the position of a specific user's RU within the channel is uniquely identifiable.

In Example: RU indexing for 20 MHz channel bandwidth, the RUs indicated by the red boxes are uniquely identifiable by the following information:

Table 3-2: Unique identification of RUs in a channel

User	User 1	User 2	User 3	User 4	User 5
RU size	52	26	26	26 (13+13)	106
RU index	RU1	RU3	RU4	RU5	RU2

HE Signal fields and PPDU configuration

The combination of RU size and RU indexes for a channel are referred to as the RU allocation. Using 8 bits, each possible combination of RU sizes and positions for a 20 MHz channel (242 subcarriers) can be coded. These codes are defined in the 802.11ax specification.

As all WLAN signals, each HE PPDU contains a signal field (Sig-A) that defines the general PPDU configuration (see also "Signal Field" on page 46). In addition, multi-user PPDUs contain a second signal field (Sig-B) which defines the RU allocation and user assignment. The HE-Sig B field in turn consists of two parts:

- Common field: contains the RU allocation coding
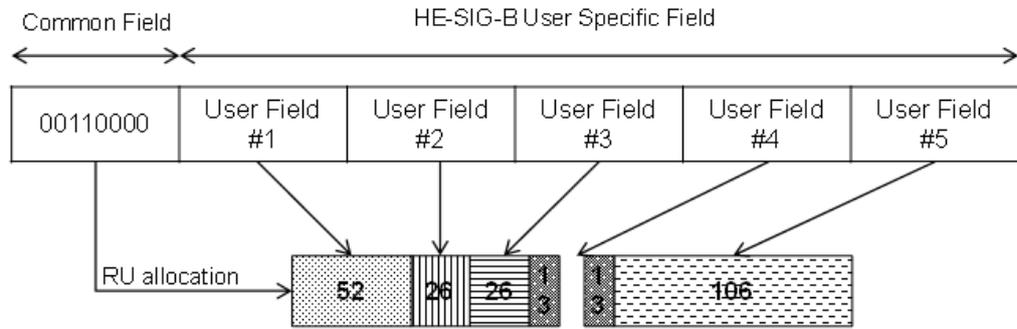- User specific field: contains the user ID, MIMO, MCS and coding information

Figure 3-9: HE Sig-B field structure

The HE Sig-B field is a 20 MHz channel that provides the RU allocation for users within a 20 MHz span (242 subcarriers) of the channel. For a 40 MHz channel, two SIG-B channels are required to code the RU allocation for the entire span. For an 80 MHz channel, the common field is extended to 2 x 8 bits, so that the RU allocation of 40 MHz can be coded in one common field (RU1+RU3 or RU2+RU4). Thus, two extended common fields are required to provide the RU allocation information for the entire 80 MHz signal. However, since the 80 MHz signal contains four 20 MHz SIG-B fields, the information in the first two fields is duplicated, and thus redundant:
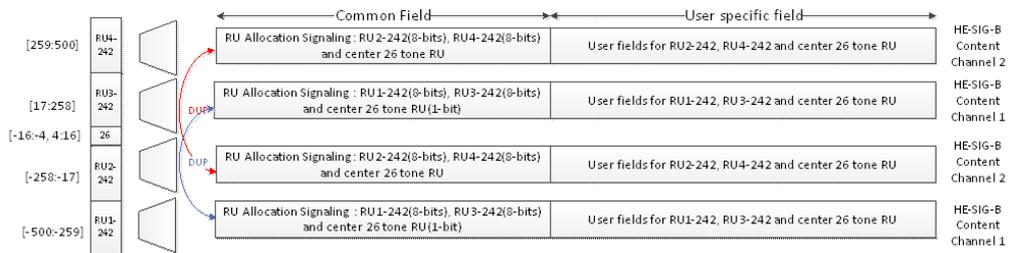

Figure 3-10: HE Sig-B field for 80 MHz channel bandwidth

This coding allows for the receiver to decode only 40 MHz bandwidth and still obtain the RU allocation information for the entire signal.

Multi-User (MU-)MIMO

As a rule, each resource unit is assigned to one user (see "Resource units (RUs)" on page 76). However, the 802.11ax standard also supports MIMO mode for HE multi-user PPDUs, both in uplink and downlink transmission. In MIMO mode, each resource unit with a size of 106 subcarriers or more can be assigned to multiple users (8, 16, or 32, depending on the channel bandwidth).

If MIMO is used with HE MU PPDUs, the location of the individual user's data is determined by the station (user) ID and spatial configuration provided in the HE-SIG-B field.

For more information on MIMO see also Chapter 3.3, "Signal processing for MIMO measurements (IEEE IEEE 802.11ac, ax, n, be)", on page 66.

HE Trigger-based PPDUs

In order for the access point (AP) to decode packets from multiple users, the uplink transmissions need to be synchronized when the AP receives them. After the users receive information from the AP to trigger the uplink transmissions (by a trigger frame), they transmit the HE_Trig PPDU at a specified time.

The number of users transmitting simultaneously is defined by the high efficiency long training field (HE-LTF). The length of the HE-LTF that the users should use for uplink transmission is defined in the trigger frame sent by the access point. The trigger frame also defines the length of the expected uplink packet.

3.4.2 Demodulating 802.11ax signals in the R&S VSE WLAN application

In order to demodulate high-efficiency PPDUs in the R&S VSE WLAN application, the application must have knowledge of the used PPDU format and the PPDU configuration. For multi-user PPDUs, the RU allocation and user assignment are also required.

Depending on the available channel bandwidth, the following multi-user configuration must be defined:

- For channels with 20 MHz bandwidth, only 1 configuration is required (RU1).
- For channels with 40 MHz bandwidth, 2 configurations are required in different tabs (RU1 and RU2).
- For channels with 80 MHz bandwidth, 4 configurations are required, in 4 different tabs (RU1 to RU4), where the contents of RU1 and RU3 are identical, and RU2 and RU4 are identical.
- For channels with 2x80 MHz or 160 MHz bandwidth, 4 configurations are required for each 80-MHz-segment of the channel (Segment 1 and Segment 2).

For single user (HE SU-PPDU) and trigger-based PPDUs (UL), the configuration is detected automatically by the R&S VSE WLAN application. For multi-user downlink PPDUs (HE MU_PPDU), you must define the configuration manually (see "HE PPDU Config" on page 136).

For trigger-based PPDUs, you must also define the length of the HE-LTF field in the PPDUs in the R&S VSE WLAN application.

Result displays for multi-user PPDUs

The result displays show the demodulated data for the selected RUs. The currently displayed RUs are highlighted green in the PPDU configuration table and the result displays. For multi-user configuration, the results cannot be displayed for an individual user. If you select an RU, the rows for all users of the RU are highlighted.

By default, the first RU is selected. To view the results of different RUs, select the RUs in the table by clicking in the first column ("#"), then Refresh.

3.5 Signal processing for extremely high throughput (EHT) wireless measurements (IEEE 802.11be)

The IEEE 802.11be standard, also known as extremely high throughput (EHT), provides mechanisms to process data rates over 30 Gbps. In addition, special attention is paid to keeping latency rates low (under 5 ms). It uses the unlicensed spectrum bands at 2.4 GHz, 5 GHz and 6 GHz. The standard aims at remaining compatible to previous standards in the same range. It is particularly meant for use in applications with high data volumes, such as virtual reality, gaming, or videos.

Currently, the specification for this standard is still under development by the IEEE organization. The basic features and processing methods described here and used by the R&S VSE WLAN application are based on the draft version 0.3 from January 2021.

3.5.1 Basic signal characteristics

PPDU formats

The new 802.11be standard introduces two new PPDU (PHY Protocol Data Unit) formats:

- **EHT MU PPDU**: extremely high throughput multi-user PPDU. This PPDU carries one or more transmissions to one or more users. Only the download PPDU is currently supported for demodulation by the R&S VSE WLAN application.

- **EHT Trigger-Based PPDU (UL)**: carries a single transmission and is sent in response to a trigger frame; Used for OFDMA and/or MU MIMO uplink transmission
  Measuring trigger-based PPDUs requires bandwidth information for the signal to be defined by the user.

The physical layer of the 802.11be standard uses some of the same methods as the 802.11ax standard, including OFDMA, resource units, and multi-user MIMO (see Chapter 3.4, "Signal processing for high-efficiency wireless measurements (IEEE 802.11ax)", on page 75). However, to improve the throughput, higher modulation methods are supported, such as 4096QAM. The number of spatial streams is increased to 16. And the channel bandwidth is increased to 320 MHz.

In addition, the 802.11be standard allows for multiple resource units to be assigned to a single user for high throughput requirements.

RU allocation

Similar to the 802.11ax standard, resource units are assigned to users in the RU allocation. However, as opposed to the 802.11ax standard, multiple resource units (MRUs) with up to 996 tones = 80 MHz can be assigned to a single user. The MRU allocation is defined in the signal field. To avoid a complex combination of RUs and users, the 802.11be standard defines the following restrictions for RU allocation:

- Large RUs with 242, 484, or 996 tones can only be combined with other RUs of these sizes.

- Smaller RUs with fewer than 242 tones can only be combined with other small RUs. Not all combinations of small RUs are allowed, see the specification for details.
- Each 80-MHz segment of the RU allocation that is used by a single user (without puncturing) is assigned a single 996-tone RU.
- For all other scenarios, RUs smaller than 996 tones are combined in compliance with the mentioned restrictions.

Segment puncturing

Sometimes other services use one or more subcarriers within the same range as a 802.11be standard signal. In this case, these subcarriers cannot be included in the RU allocation. The subcarriers are temporarily blocked in the 80-MHz-segment, which is thus referred to as "punctured". The subcarriers remain unused, while the remaining usable subcarriers are allocated to users as usual. The 802.11be standard defines 12 different configurations of ignored and usable carriers within an 80-MHz-segment. Only those configurations are supported. The used configuration (MRU index) must be defined in the PPDU configuration.

EHT signal fields

In addition to the common L-SIG field, the 802.11be standard introduces new signal fields named U-SIG and EHT-SIG to the EHT PPDU. They include version-specific information for the physical layer of the signal.

Multi-User (MU-)MIMO

The 802.11be standard also supports MIMO mode for EHT multi-user PPDUs, both in uplink and downlink transmission. In MIMO mode, each resource unit with a size of 106 subcarriers or more can be assigned to multiple users (8, 16, or 32, depending on the channel bandwidth).

If MIMO is used with EHT MU PPDUs, the location of the individual user's data is determined by the station (user) ID and spatial configuration provided in the EHT-SIG-B field.

For more information on MIMO see also Chapter 3.3, "Signal processing for MIMO measurements (IEEE IEEE 802.11ac, ax, n, be)", on page 66.

EHT Trigger-based PPDUs

In order for the access point (AP) to decode packets from multiple users, the uplink transmissions need to be synchronized when the AP receives them. After the users receive information from the AP to trigger the uplink transmissions (by a trigger frame), they transmit the EHT_Trig PPDU at a specified time.

The number of users transmitting simultaneously is defined by the EHT long training field (EHT-LTF). The length of the EHT-LTF that the users should use for uplink transmission is defined in the trigger frame sent by the access point. The trigger frame also defines the length of the expected uplink packet.

3.5.2 Demodulating 802.11be signals in the R&S VSE WLAN application

In order to demodulate extremely high throughput (EHT) PPDUs in the R&S VSE WLAN application, the application must have knowledge of the used PPDU configuration. The RU allocation and user assignment, as well as the MRU assignment, are also required.

Depending on the available channel bandwidth, the following multi-user configuration must be defined:

- For channels with 20 MHz bandwidth, only 1 configuration is required (RU1).
- For channels with 40 MHz bandwidth, 2 configurations are required in different tabs (RU1 and RU2).
- For channels with 80 MHz bandwidth, 4 configurations are required, in 4 different tabs (RU1 to RU4), where the contents of RU1 and RU3 are identical, and RU2 and RU4 are identical.
- For channels with 2x80 MHz or 160 MHz bandwidth, 4 configurations are required for each 80-MHz-segment of the channel (Segment 1 and Segment 2).
- For channels with 320 MHz bandwidth, 4 configurations are required for each 80-MHz-segment of the channel (Segment 1, 2, 3, 4)

For multi-user downlink PPDUs (EHT MU PPDU), you must define the configuration manually (see "EHT PPDU Config" on page 144).

For trigger-based PPDUs, you must also define the length of the EHT-LTF field in the PPDUs in the R&S VSE WLAN application.

Result displays for multi-user PPDUs

The result displays show the demodulated data for the selected RUs. The currently displayed RUs are highlighted green in the PPDU configuration table and the result displays. For multi-user configuration, the results cannot be displayed for an individual user. If you select an RU, the rows for all users of the RU are highlighted.

By default, the first RU is selected. To view the results of different RUs, select the RUs in the table by clicking in the first column ("#"), then Refresh.

3.6 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 3.8, "Demodulation parameters - logical filters", on page 83). 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.

3.7 Recognized vs. analyzed PPDUs

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

- **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 3.8, "Demodulation parameters - logical filters", on page 83). 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.

3.8 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 3-3: 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	2.5 MHz, 5 MHz, 10 MHz, 20 MHz[*)]
IEEE 802.11ac	16QAM 64QAM 256QAM 1024QAM	HT-MF (Mixed format) HT-GF (Greenfield format) VHT NON-HT<Channel Bandwidth>	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
IEEE 802.11n	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[*)]
IEEE 802.11ax	BPSK, QPSK, 16QAM, 64QAM, 256QAM, 1024QAM	HE<Channel Bandwidth>SU HE<Channel Bandwidth>MU HE<Channel Bandwidth>EXT HE<Channel Bandwidth>TB (Trigger-based)	20 MHz[*)], 40 MHz[*)], 80 MHz[*)], 160 MHz[*)]

[*)]: requires R&S VSE bandwidth extension option

See Chapter C, "Sample rate, record length and analysis bandwidth", on page 380.

Standard	Modulation formats	PPDU formats	Channel bandwidths
		HE Ext Range SU	20 MHz[*]
IEEE 802.11be	BPSK, QPSK, 16QAM, 64QAM, 256QAM, 1024QAM, 4096QAM	EHT MU EHT Trigger-Based (TB) EHT non-OFDMA Single User	20 MHz[*], 40 MHz[*], 80 MHz[*], 160 MHz[*], 320 MHz[*]

[*]: requires R&S VSE bandwidth extension option

See Chapter C, "Sample rate, record length and analysis bandwidth", on page 380.

3.9 Trigger basics

In a basic measurement with default settings, the measurement is started immediately when you select ▶"Capture". However, sometimes you want the measurement to start only when a specific condition is fulfilled on the connected instrument, for example a signal level is exceeded, or in certain time intervals. For these cases, you can define a trigger for the measurement.

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

For complex tasks, advanced trigger settings are available:

- Hysteresis to avoid unwanted trigger events caused by noise
- Holdoff to define exactly which trigger event causes the trigger in a jittering signal

3.9.1 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 VSE captures data continuously in the time domain, even before the trigger occurs.

See "Trigger Offset" on page 114.

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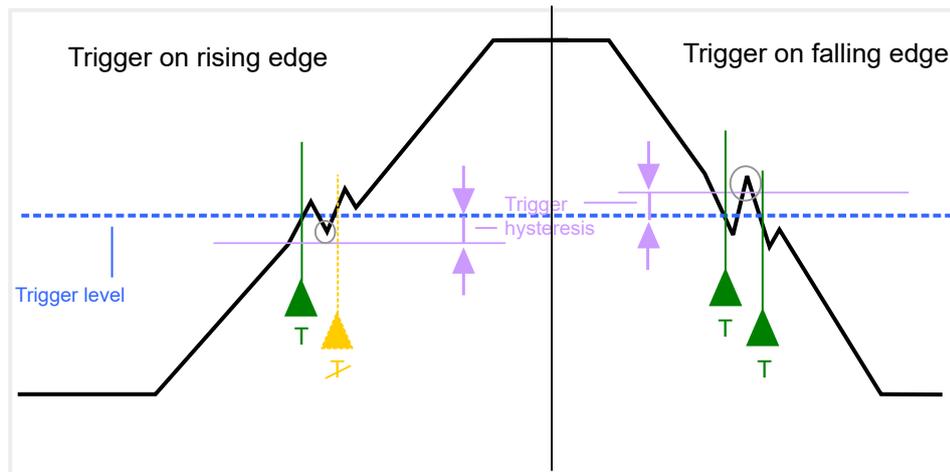

Figure 3-11: Effects of the trigger hysteresis

See "Hysteresis" on page 114

3.9.3 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.
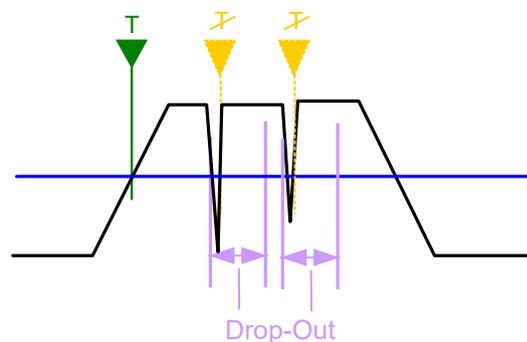

Figure 3-12: Effect of the trigger drop-out time

See "Drop-Out Time" on page 114.

Drop-out times for falling edge triggers

If a trigger is set to a falling edge ("Slope" = "Falling", see "Slope" on page 115) the measurement is to start when the power level falls below a certain level. This is useful, for example, to trigger at the end of a burst, similar to triggering on the rising edge for the beginning of a burst.

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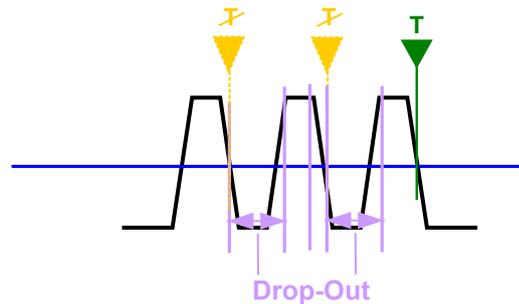

Figure 3-13: Trigger drop-out time for falling edge trigger

3.9.4 Trigger holdoff

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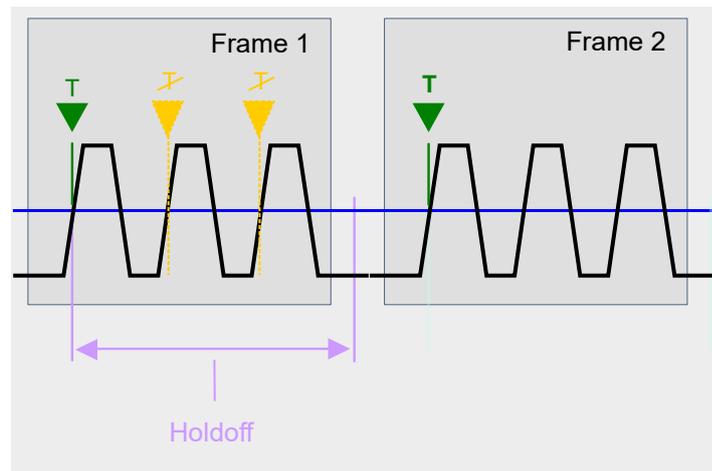

Figure 3-14: Effect of the trigger holdoff

See "Trigger Holdoff" on page 114.

3.9.5 Trigger synchronization using the primary'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 117, 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 primary's trigger output functionality.

The R&S VSE has variable input/output connectors for trigger signals. If you set the primary's Trigger 2 Input/output connector to "Device Triggered" output, and connect it to the secondarys' trigger input connectors, the primary R&S VSE sends its trigger event signal to any connected secondaries. The secondaries are automatically configured to use the trigger source "External". The primary itself can be configured to use any of the following trigger sources:

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

3.9.6 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 117, 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 primary's trigger out function, using the Trigger Unit provides a more accurate synchronization of the secondaries. 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 primary analyzer sends a trigger impulse to the Trigger Unit to start the measurement as soon as all secondary analyzers are ready to measure.
  The NOISE SOURCE output of the primary 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 primary 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) [TRIG MANUAL] on the Trigger unit.

Note: In manual mode you must *turn on the NOISE SOURCE output* of the primary analyzer manually (see the manual of the analyzer)!

A Trigger Unit is activated in the Trigger 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 primary 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 WLAN I/Q measurement configuration

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

Multiple access paths to functionality

The easiest way to configure a measurement channel is via the "Overview" dialog box, which is displayed when you select the 🖬 "Overview" icon from the main toolbar or the "Meas Setup" > "Overview" menu item.

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". For an overview of all available menu items and toolbar icons see Chapter A.2, "WLAN I/Q measurements menus", on page 373 and Chapter B, "Reference of toolbar functions", on page 376.

General R&S VSE functions

The application-independent functions for general tasks on the R&S VSE are also available for WLAN 802.11 measurements and are described in the R&S VSE Base Software User Manual. In particular, this comprises the following functionality:

- Controlling Instruments and Capturing I/Q Data
- Data Management
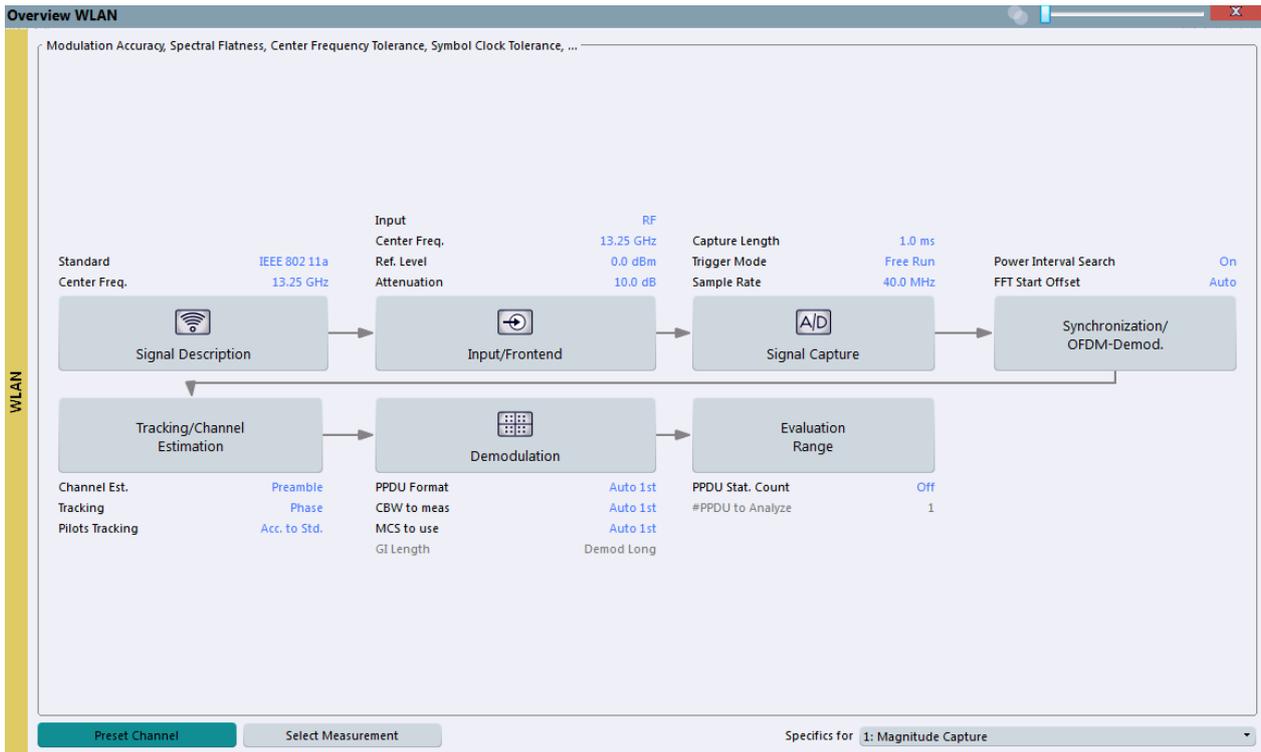- General Software Preferences and Information

4.1 Configuration overview

Access: "Meas Setup" > "Overview"

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".

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. "Signal Description"
   See Chapter 4.2, "Signal description", on page 92

2. "Input/ Frontend"
   See Chapter 4.3, "Input and frontend settings", on page 93

3. "Signal Capture"
   See Chapter 4.4, "Signal capture (data acquisition)", on page 109

4. "Synchronization / OFDM demodulation"
   See Chapter 4.5, "Synchronization and OFDM demodulation", on page 120

5. "Tracking / Channel Estimation"
   See Chapter 4.6, "Tracking and channel estimation", on page 121

6. "Demodulation"
   See Chapter 4.7, "Demodulation", on page 126

7. "Evaluation Range"
   See Chapter 4.8, "Evaluation range", on page 157

To configure settings

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

Preset Channel

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

Remote command:
SYSTem:PRESet:CHANnel[:EXEC] on page 181

Select Measurement

Currently only the WLAN I/Q measurement is available.

Specific Settings for

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

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

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

4.2 Signal description

Access: "Overview" > "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 3.8, "Demodulation parameters - logical filters", on page 83).

Remote command:
CONFigure:STANdard on page 182

Frequency

Specifies the center frequency of the signal to be measured.

Remote command:
[SENSe<ip>:]FREQuency:CENTer on page 219

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.

"In line with IEEE 802.11ax/D0.1"

Tolerance limits are based on the **IEEE 802.11ax** specification (draft).
Required by IEEE 802.11ax standard.

"In line with IEEE 802.11be/ D0.1"

Tolerance limits are based on the **IEEE 802.11be** specification (draft).
Required by IEEE 802.11be standard.

Remote command:
CALCulate<n>:LIMit<li>:TOLerance on page 183

4.3 Input and frontend settings

Access: "Overview" > "Input/Frontend"

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

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

ⓘ Output settings are described in the R&S VSE Base Software User Manual.

4.3.1 Input source settings

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

Or: "Input & Output" > "Input Source"

The R&S VSE can control the input sources of the connected instruments.

4.3.1.1 Radio frequency input

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

Or: "Input & Output" > "Input Source" > "Radio Frequency"

The default input source for the connected instrument is "Radio Frequency". Depending on the connected instrument, different input parameters are available.
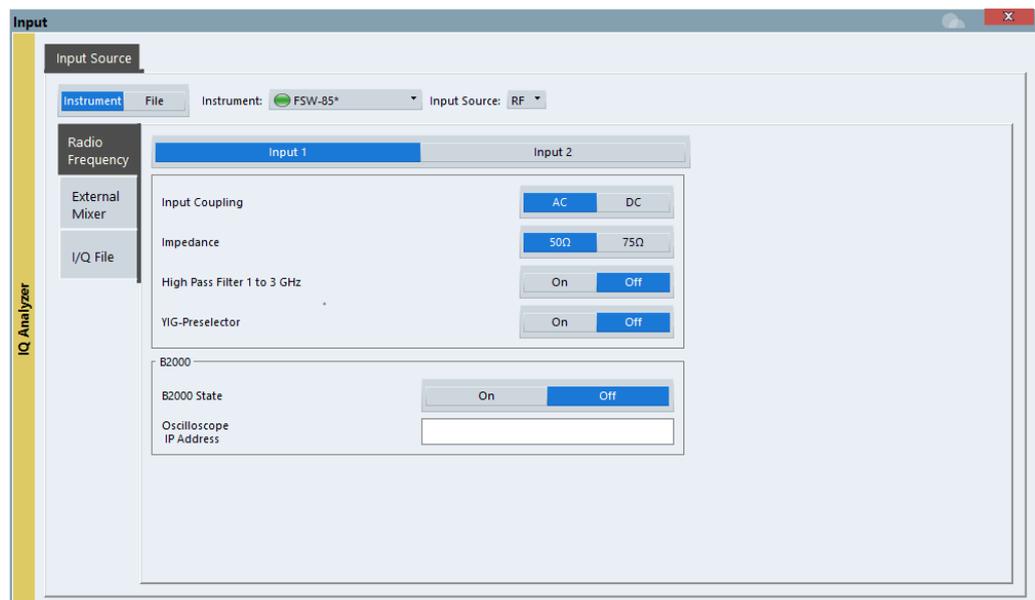

Figure 4-1: RF input source settings for an R&S FSW with B2000 option

If the Frequency Response Correction option (R&S VSE-K544) is installed, the R&S VSE WLAN application also supports frequency response correction using Touchstone (`.snp`) files or `.fres` files.

For details on user-defined frequency response correction, see the R&S VSE Base Software User Manual.

Input Type (Instrument / File)

Selects an instrument or a file as the type of input provided to the channel.

Note: External mixers are only available for input from a connected instrument.

Note: If the R&S VSE software is installed directly on an instrument, or integrated in Cadence®AWR®VSS, some restrictions apply on the available input type.

Remote command:
`INSTrument:BLOCk:CHANnel[:SETTings]:SOURce<si>` on page 191
`INPut:SELect` on page 190

Instrument

Specifies a configured instrument to be used for input.

Input 1 / Input 2

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

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

"Input 1"	R&S FSW85: 1.00 mm RF input connector for frequencies up to 85 GHz (90 GHz with option R&S FSW-B90G)
"Input2"	R&S FSW85: 1.85 mm RF input connector for frequencies up to 67 GHz

Remote command:
INPut:TYPE on page 190

Input Coupling

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

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

Not available for input from the optional "Analog Baseband" interface.

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

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

Remote command:
INPut<ip>:COUPling<ant> on page 185

Impedance

For some measurements, the reference impedance for the measured levels of the connected instrument 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).

Not available for input from the optional "Analog Baseband" interface. For analog baseband input, an impedance of 50 Ω is always used.

Remote command:
INPut<ip>:IMPedance<ant> on page 187

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 disabled. 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<ip>:DPATh on page 185

High Pass Filter 1 to 3 GHz

Activates an additional internal highpass 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.

For some connected instruments, this function requires an additional hardware option on the instrument.

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<ip>:FILTer:HPASs[:STATe] on page 186

YIG-Preselector

Enables or disables the YIG-preselector.

This setting requires an additional option on the connected instrument.

An internal YIG-preselector at the input of the connected instrument 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: Note that the YIG-preselector is active only higher frequencies, depending on the connected instrument. Therefore, switching the YIG-preselector on or off has no effect if the frequency is below that value.

To use the optional 90 GHz frequency extension (R&S FSW-B90G), the YIG-preselector must be disabled.

To use the optional 54 GHz frequency extension (R&S FSV3-B54G), the YIG-preselector must be disabled.

Remote command:
INPut<ip>:FILTer:YIG[:STATe] on page 187

Capture Mode

Determines how data from an oscilloscope is input to the R&S VSE software.

This function is only available for a connected R&S oscilloscope with a firmware version 3.0.1.1 or higher (for other versions and instruments the input is always I/Q data).

"I/Q"   The measured waveform is converted to I/Q data directly on the R&S oscilloscope (requires option K11), and input to the R&S VSE software as I/Q data.
For data imports with small bandwidths, importing data in this format is quicker. However, the maximum record length is restricted by the R&S oscilloscope. (Memory options on the R&S oscilloscope are not available for I/Q data.)

"Waveform"   The data is input in its original waveform format and converted to I/Q data in the R&S VSE software. No additional options are required on the R&S oscilloscope.
For data imports with large bandwidths, this format is more convenient as it allows for longer record lengths if appropriate memory options are available on the R&S oscilloscope.

"Auto"   Uses "I/Q" mode when possible, and "Waveform" only when required by the application (e.g. Pulse measurement, oscilloscope baseband input).

Remote command:
INPut<ip>:RF:CAPMode on page 188

B2000 State

Activates the optional 2 GHz bandwidth extension (R&S FSW-B2000).

Note: The R&S VSE software supports input from a connected R&S FSW with a B2000 option installed. However, the R&S FSW interface to the oscilloscope must be set up and aligned directly on the instrument before the R&S VSE software can start analyzing the input.
The analysis bandwidth is defined in the data acquisition settings of the application as usual. Note that the maximum bandwidth cannot be restricted manually as for other bandwidth extension options.

Manual operation on the connected oscilloscope, or remote operation other than by the R&S VSE, is not possible while the B2000 option is active.

Remote command:
SYSTem:COMMunicate:RDEVice:OSCilloscope[:STATe] on page 192

Oscilloscope Sample Rate

Determines the sample rate used by the connected oscilloscope.

This setting is only available if an R&S oscilloscope is used to obtain the input data, either directly or via the R&S FSW.

"10 GHz"   Default for waveform Capture Mode (not available for I/Q Capture Mode); provides maximum record length

"20 GHz"   Achieves a higher decimation gain, but reduces the record length by half.
Only available for R&S oscilloscope models that support a sample rate of 20 GHz (see data sheet).
For R&S oscilloscopes with an analysis bandwidth of 4 GHz or larger, a sample rate of 20 GHZ is always used in waveform Capture Mode

"40 GHz"   Provides a maximum sample rate.
Only available for I/Q Capture Mode, and only for R&S RTP13/RTP16 models that support a sample rate of 40 GHz (see data sheet)

Remote command:
Input source R&S FSW via oscilloscope:
SYSTem:COMMunicate:RDEVice:OSCilloscope:SRATe on page 193
Input source oscilloscope waveform mode:
INPut<ip>:RF:CAPMode:WAVeform:SRATe on page 189

Input source oscilloscope I/Q mode:
INPut<ip>:RF:CAPMode:IQ:SRATe on page 189

Oscilloscope Splitter Mode
Activates the use of the power splitter inserted between the "IF 2 GHZ OUT" connector of the R&S FSW and the "CH1" and "CH3" input connectors of the oscilloscope. Note that this mode requires an additional alignment with the power splitter.

For details see the R&S FSW I/Q Analyzer and I/Q Input user manual.

Remote command:
SYSTem:COMMunicate:RDEVice:OSCilloscope:PSMode[:STATe] on page 193

Oscilloscope IP Address
When using the optional 2 GHz bandwidth extension (R&S FSW-B2000) with an R&S FSW as the connected instrument, the entire measurement, as well as both instruments, are controlled by the R&S VSE software. Thus, the instruments must be connected via LAN, and the TCPIP address of the oscilloscope must be defined in the R&S VSE software.

For tips on how to determine the computer name or TCPIP address, see the oscilloscope's user documentation.

Remote command:
SYSTem:COMMunicate:RDEVice:OSCilloscope:TCPip on page 192

Preselector State
Turns the preselector on and off.

When you turn on the preselector, you can configure the characteristics of the preselector and add the preamplifier into the signal path.

When you turn off the preselector, the signal bypasses the preselector and the preamplifier, and is fed into the input mixer directly.

Remote command:
INPut<ip>:PRESelection[:STATe] on page 188

Preselector Mode
Selects the preselection filters to be applied to the measurement.

"Auto"   Automatically applies all available bandpass filters in a measurement. Available with the optional preamplifier.

"Auto Wide"   Automatically applies the wideband filters consecutively:

- Lowpass 40 MHz
- Bandpass 30 MHz to 2250 MHz
- Bandpass 2 GHz to 8 GHz
- Bandpass 8 GHz to 26.5 GHz

Available with the optional preselector.

"Auto Narrow"　　Automatically applies the most suitable narrowband preselection fil-
ters in a measurement, depending on the bandwidth you have
selected.
For measurement frequencies up to 30 MHz, the connected instru-
ment uses combinations of lowpass and highpass filters. For higher
frequencies, the connected instrument uses bandpass filters.
Available with the optional preselector.

"Manual"　　　　　Applies the filter settings you have defined manually.

Remote command:
INPut<ip>:PRESelection:SET on page 187

10 dB Minimum Attenuation

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

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

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

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

Remote command:
INPut:ATTenuation:PROTection:RESet on page 185

4.3.1.2　I/Q file input

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

Or: "Input & Output" > "Input Source" > "I/Q File"

Loading a file via drag&drop

You can load a file simply by selecting it in a file explorer and dragging it to the
R&S VSE software. Drop it into the "Measurement Group Setup" window or the chan-
nel bar for any channel. The channel is automatically configured for file input, if neces-
sary. If the file contains all essential information, the file input is immediately displayed
in the channel. Otherwise, the "Recall I/Q Recording" dialog box is opened for the
selected file so you can enter the missing information.

If the file contains data from multiple channels (e.g. from LTE measurements), it can be
loaded to individual input sources, if the application supports them.

For details see the R&S VSE Base Software User Manual.

The "Input Source" settings defined in the "Input" dialog box are identical to those con-
figured for a specific channel in the "Measurement Group Setup" window.
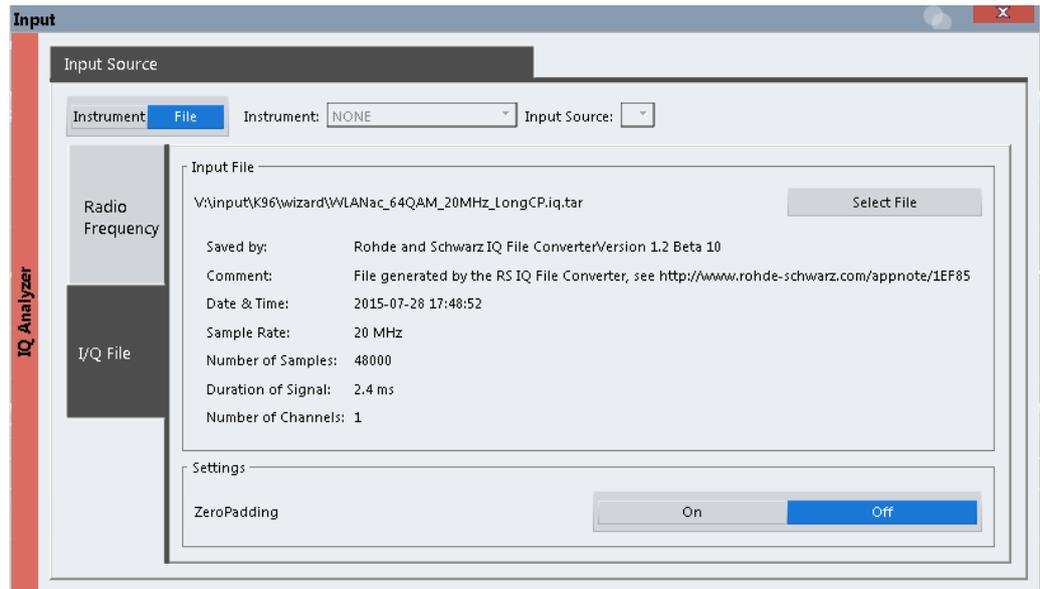
If the Frequency Response Correction option (R&S VSE-K544) is installed, the R&S VSE WLAN application also supports frequency response correction using Touchstone (`.snp`) files or `.fres` files.

For details on user-defined frequency response correction, see the R&S VSE Base Software User Manual.

Encrypted `.wv` files can also be imported. Note, however, that traces resulting from encrypted file input cannot be exported or stored in a saveset.

Input Type (Instrument / File)

Selects an instrument or a file as the type of input provided to the channel.

Note: External mixers are only available for input from a connected instrument.

Note: If the R&S VSE software is installed directly on an instrument, or integrated in Cadence®AWR®VSS, some restrictions apply on the available input type.

Remote command:
INSTrument:BLOCk:CHANnel[:SETTings]:SOURce<si> on page 191
INPut:SELect on page 190

Input File

Specifies the I/Q data file to be used for input.

Select "Select File" to open the "Load I/Q File" dialog box.

Zero Padding

Enables or disables zero padding for input from an I/Q data file that requires resampling. For resampling, a number of samples are required due to filter settling. These samples can either be taken from the provided I/Q data, or the software can add the required number of samples (zeros) at the beginning and end of the file.

If enabled, the required number of samples are inserted as zeros at the beginning and end of the file. The entire input data is analyzed. However, the additional zeros can effect the determined spectrum of the I/Q data. If zero padding is enabled, a status message is displayed.

If disabled (default), no zeros are added. The required samples for filter settling are taken from the provided I/Q data in the file. The start time in the R&S VSE Player is adapted to the actual start (after filter settling).

Note: You can activate zero padding directly when you load the file, or afterwards in the "Input Source" settings.
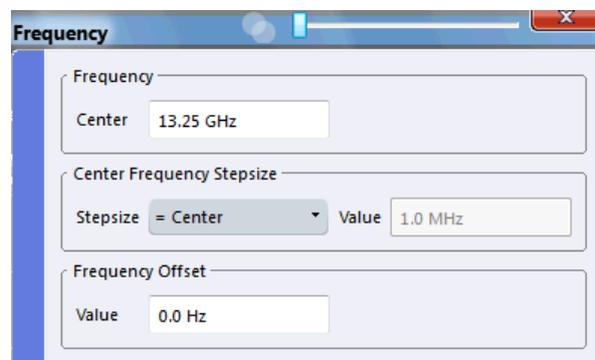
Remote command:
INPut<ip>:FILE:ZPADing on page 186

4.3.2 Frequency settings

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

Or: "Input & Output" > "Frequency"

Center Frequency

Defines the center frequency of the signal in Hertz.

$0 \text{ Hz} \le f_{center} \le f_{max}$

Note: For file input, you can shift the center frequency of the current measurement compared to the stored measurement data. The maximum shift depends on the sample rate of the file data.

$$CF_{shift_{max}} = CF_{file} \pm \frac{SR_{file}}{2}$$

If the file does not provide the center frequency, it is assumed to be 0 Hz.

To ensure that the input data remains within the valid analysis bandwidth, define the center frequency and the analysis bandwidth for the measurement such that the following applies:

$$CF + \frac{ABW_{channel}}{2} > CF_{file} + \frac{ABW_{file}}{2}$$

$$CF - \frac{ABW_{channel}}{2} > CF_{file} - \frac{ABW_{file}}{2}$$

Remote command:
[SENSe<ip>:]FREQuency:CENTer on page 219

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

When you use the mouse wheel, 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 219

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

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

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

The allowed values range from -1 THz to 1 THz. The default setting is 0 Hz.
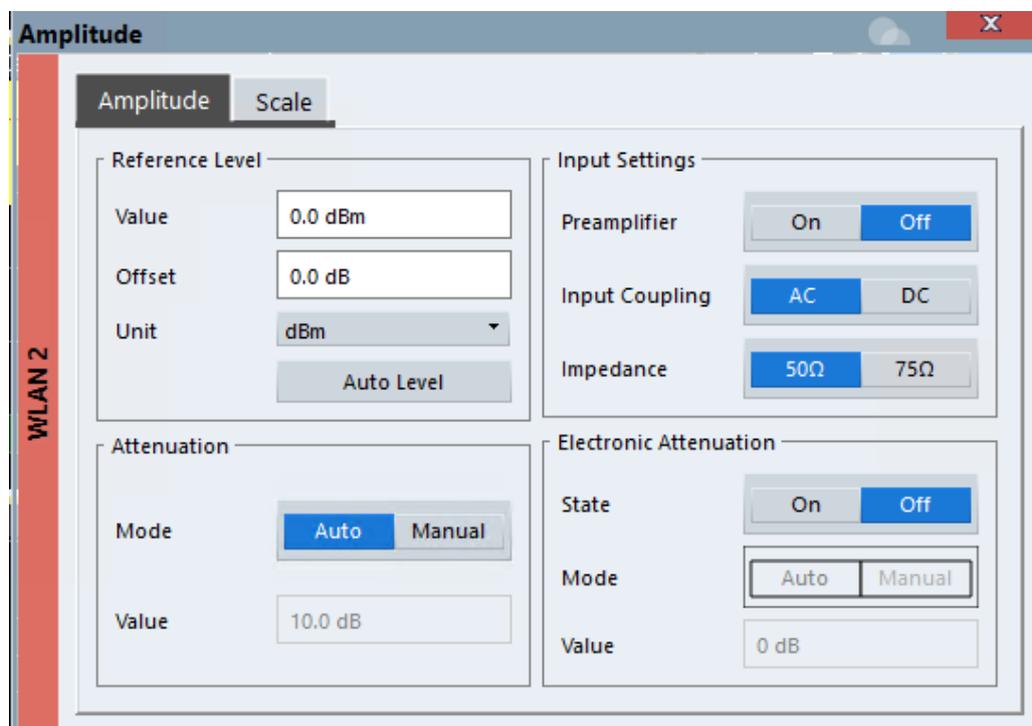
Remote command:
[SENSe<ip>:]FREQuency:OFFSet on page 220

4.3.3　Amplitude settings

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

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

For Analog Baseband input, see the slightly different amplitude settings described in the R&S VSE I/Q Analyzer and I/Q Input User Manual.

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 ← 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.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:`
`RLEVel<ant>` on page 222

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 VSE 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 VSE 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 VSE increases the displayed power values) , a negative value indicates an external gain (R&S VSE decreases the displayed power values).

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

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:
RLEVel<ant>:OFFSet on page 223

Unit ← Reference Level Settings
The connected instrument measures the signal voltage at the RF input.

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

Remote command:
INPut<ip>:IMPedance<ant> on page 187
CALCulate<n>:UNIT:POWer on page 221

RF Attenuation
Defines the attenuation applied to the RF input.

Attenuation Mode / Value ← RF Attenuation
Defines the attenuation applied to the RF input of the R&S VSE.

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

In "Manual" mode, you can set the RF attenuation in 1 dB steps (down to 0 dB). Other entries are rounded to the next integer value. The range is specified in the 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 can lead to hardware damage.

Remote command:
INPut<ip>:ATTenuation on page 223
INPut<ip>:ATTenuation:AUTO on page 224

Using Electronic Attenuation

If the (optional) Electronic Attenuation hardware is installed on the connected instrument, 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.

Note: Note that restrictions can apply concerning which frequencies electronic attenuation is available for, depending on which instrument is connected to the R&S VSE software. Check your instrument documentation for details.

In "Auto" mode, RF attenuation is provided by the electronic attenuator as much as possible to reduce the amount of mechanical switching required. Mechanical attenuation can provide a better signal-to-noise ratio, however.

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

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 225
INPut:EATT:AUTO on page 225
INPut:EATT on page 224

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 4.3.1.1, "Radio frequency input", on page 94.

Preamplifier ← Input Settings

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

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

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

"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.

Depending on the connected instrument, different settings are available. See the instrument's documentation for details.

Remote command:
INPut<ip>:GAIN<ant>:STATe on page 225
INPut<ip>:GAIN<ant>[:VALue] on page 226

Input Coupling ← Input Settings

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

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

Not available for input from the optional "Analog Baseband" interface.

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

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

Remote command:
INPut<ip>:COUPling<ant> on page 185

Impedance ← Input Settings
For some measurements, the reference impedance for the measured levels of the connected instrument 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).

Not available for input from the optional "Analog Baseband" interface. For analog baseband input, an impedance of 50 Ω is always used.
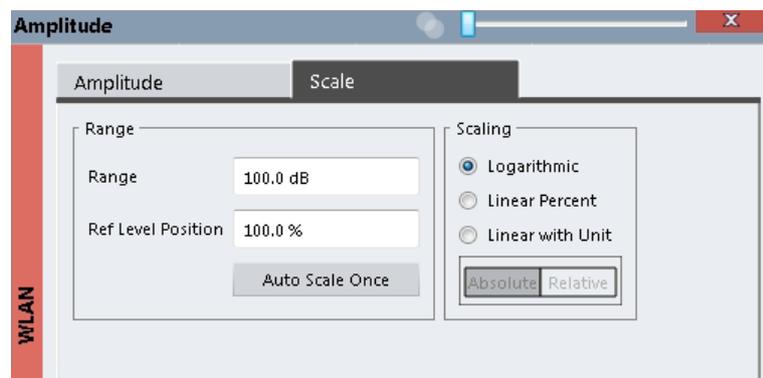
Remote command:
INPut<ip>:IMPedance<ant> on page 187

4.3.4 Y-axis scaling

Access: "Overview" > "Amplitude" > "Scale" tab

The individual scaling settings that affect the vertical axis are described here. These settings are window-specific.

Range

Defines the displayed y-axis range in dB.

The default value is 100 dB.

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe] on page 226

Ref Level Position

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

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

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

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

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RPOSition
on page 228

Auto Scale Once

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

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

This function is only available for RF measurements.

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<n>]:TRACe<t>:Y[:SCALe]:AUTO
on page 227

Scaling

Defines the scaling method for the y-axis.

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

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y:SPACing on page 228
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:MODE
on page 227

4.4   Signal capture (data acquisition)
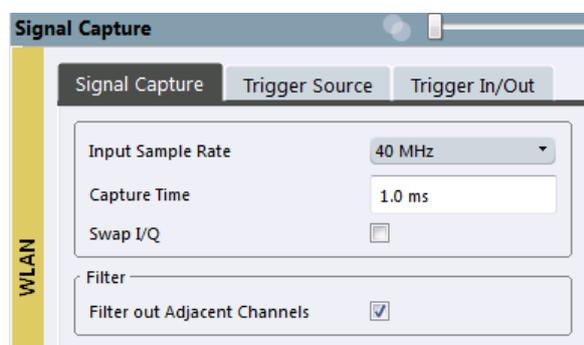
Access: "Overview" > "Signal Capture"

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

4.4.1   General capture settings

Access: "Overview" > "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 VSE WLAN application expects the I/Q input data to have. If necessary, the R&S VSE has to resample the data.

During data processing in the R&S VSE, the sample rate usually changes (decreases). The RF input is captured by the R&S VSE using a high sample rate, and is resampled before it is processed by the R&S VSE WLAN application.

Remote command:
TRACe:IQ:SRATe on page 231

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. In particular, if the result length does not fit in the capture buffer, demodulation will fail.

Remote command:
[SENSe:]SWEep:TIME on page 230

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 VSE 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 230

Suppressing (Filter out) Adjacent Channels (IEEE 802.11a, ac, ax, g (OFDM), j, n, p, be)
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 229

Transmit Filter(IEEE 802.11b, g (DSSS))
Indicates the used transmit filter setting (read-only)

See also Chapter 3.2.1, "Block diagram for single-carrier measurements", on page 61

"Auto"   default filter

Remote command:
[SENSe:]DEMod:FILTer:MODulation on page 230

Receive Filter (IEEE 802.11b, g (DSSS))
Indicates the used receive filter setting (read-only)

See also Chapter 3.2.1, "Block diagram for single-carrier measurements", on page 61

"Auto"   default filter

Remote command:
[SENSe:]DEMod:FILTer:MODulation on page 230

Equalizer Filter Length (IEEE 802.11b, g (DSSS))
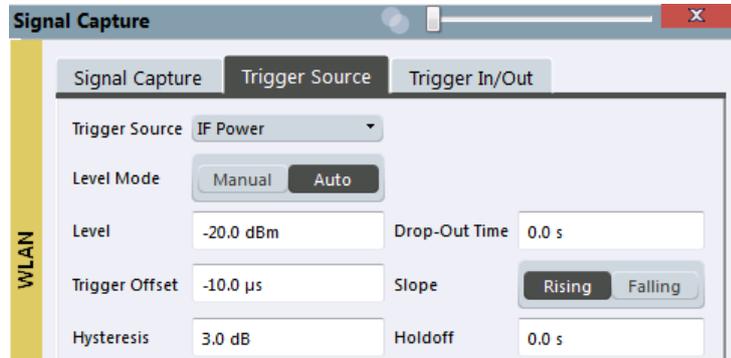Specifies the length of the equalizer filter in chips

Remote command:
[SENSe:]DEMod:FILTer:EFLength on page 230

4.4.2 Trigger settings

Access: "Overview" > "Signal Capture" > "Trigger Source"

Trigger settings determine when the R&S VSE starts to capture the input signal.

External triggers from one of the [TRIGGER INPUT/OUTPUT] connectors on the connected instrument are also available.

See the R&S VSE Base Software User Manual.

For more information on trigger settings see Chapter 3.9, "Trigger basics", on page 85.

Trigger Source...111
    └ Free Run..111
    └ External Trigger / Trigger Channel X...112
    └ RF Power...112
    └ I/Q Power..112
    └ Time..112
    └ Magnitude (Offline)..113
    └ Manual..113
Trigger Level Mode..113
Trigger Level..113
Repetition Interval..113
Drop-Out Time..114
Trigger Offset..114
Hysteresis...114
Trigger Holdoff..114
Slope...115

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

Remote command:
TRIGger[:SEQuence]:SOURce on page 236

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

Remote command:

TRIG:SOUR IMM, see TRIGger[:SEQuence]:SOURce on page 236

External Trigger / Trigger Channel X ← Trigger Source
Data acquisition starts when the signal fed into the specified input connector or input channel of the connected instrument meets or exceeds the specified trigger level.

Note: Which input and output connectors are available depends on the connected instrument. For details, see the instrument's documentation.
For a connected R&S oscilloscope, the following signals are used as trigger input:

- "External Trigger": EXT TRIGGER INPUT connector on rear panel of instrument
- "Trigger Channel 2"/"Trigger Channel 3"/"Trigger Channel 4": Input at channel connectors CH 2/3/4 on front panel of instrument - if not used as an input source

Remote command:

TRIG:SOUR EXT, TRIG:SOUR EXT2, TRIG:SOUR EXT3, TRIG:SOUR EXT4

See TRIGger[:SEQuence]:SOURce on page 236

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

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

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

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

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

Not available for input from the optional "Analog Baseband" interface.

If the trigger source "RF Power" is selected and you enable baseband input, the trigger source is automatically switched to "Free Run".

Remote command:

TRIG:SOUR RFP, see TRIGger[:SEQuence]:SOURce on page 236

I/Q Power ← Trigger Source
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 109 and

See Chapter C, "Sample rate, record length and analysis bandwidth", on page 380).

Remote command:

TRIG:SOUR IQP, see TRIGger[:SEQuence]:SOURce on page 236

Time ← Trigger Source
Triggers in a specified repetition interval.

See "Repetition Interval" on page 113.

For file input, data is taken from the file in the specified time interval. Overlap settings for the R&S VSE Player are ignored.

Remote command:
TRIG:SOUR TIME, see `TRIGger[:SEQuence]:SOURce` on page 236

Magnitude (Offline) ← Trigger Source
For (offline) input from a file, rather than an instrument. Triggers on a specified signal level.

Remote command:
TRIG:SOUR MAGN, see `TRIGger[:SEQuence]:SOURce` on page 236

Manual ← Trigger Source
Only available for a connected R&S RTP:

Any trigger settings in the R&S VSE software are ignored; only trigger settings defined on the connected instrument are considered. Thus, you can make use of the more complex trigger settings available on an R&S RTP.

Remote command:
TRIG:SOUR MAN, see `TRIGger[:SEQuence]:SOURce` on page 236

Trigger Level Mode
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 235

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

For details on supported trigger levels, see the instrument data sheet.

For time triggers, the repetition interval is defined. See "Repetition Interval" on page 113.

Remote command:
`TRIGger[:SEQuence]:LEVel:IFPower` on page 234
`TRIGger[:SEQuence]:LEVel:IQPower` on page 234
`TRIGger[:SEQuence]:LEVel[:EXTernal<port>]` on page 233
`TRIGger[:SEQuence]:LEVel:RFPower` on page 235
For baseband input only:
`TRIGger[:SEQuence]:LEVel:BBPower` on page 233
`TRIGger[:SEQuence]:LEVel:MAPower` on page 234

Repetition Interval
Defines the repetition interval for a time trigger.

The shortest interval is 2 ms.

Set the repetition interval to the exact pulse period, burst length, frame length or other repetitive signal characteristic. If the required interval cannot be set with the available granularity, configure a multiple of the interval that can be set. Thus, the trigger remains synchronized to the signal.

Remote command:
TRIGger[:SEQuence]:TIME:RINTerval on page 238

Drop-Out Time

Defines the time that the input signal must stay below the trigger level before triggering again.

For more information on the drop-out time, see Chapter 3.9.3, "Trigger drop-out time", on page 86.

Note: For input from the optional "Analog Baseband" interface using the baseband power trigger (BBP), the default drop out time is set to 100 ns. This avoids unintentional trigger events (as no hysteresis can be configured in this case).

Remote command:
TRIGger[:SEQuence]:DTIMe on page 232

Trigger Offset

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

For more information, see Chapter 3.9.1, "Trigger offset", on page 85.

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

(If supported by the connected instrument.)

Remote command:
TRIGger[:SEQuence]:HOLDoff[:TIME] on page 232

Hysteresis

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" or "Magnitude (Offline)" trigger sources.

The range of the value depends on the connected instrument.

For more information, see Chapter 3.9.2, "Trigger hysteresis", on page 85.

Remote command:
TRIGger[:SEQuence]:IFPower:HYSTeresis on page 233
TRIGger[:SEQuence]:MAPower:HYSTeresis on page 236

Trigger Holdoff

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 3.9.4, "Trigger holdoff", on page 87.

Remote command:
TRIGger[:SEQuence]:IFPower:HOLDoff on page 232
TRIGger[:SEQuence]:MAPower:HOLDoff on page 236

Slope
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 236

4.4.3 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, ax, n, be** 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 244

Time Sync.

Determines whether or not the cyclic shift delay (CSD) is used for timing synchronisation.

The R&S VSE WLAN application uses the preamble non-HT/non-VHT/non-HE cyclic shift delay to estimate the timing ofset.

For MIMO/Single Antenna MIMO signals, the applied antenna (and therefore the CSD) is detected automatically using the N_{STS} information from the "Signal Field" and the N_{VHTLTF} information counting the VHT-LTF preamble symbols. (See 802.11-2016 standard "Table 21-13—Number of VHT-LTFs required for different numbers of space-time streams". For 11n and 11ax the corresponding preamble symbols are used).

For a SISO Signal (N_{STS} = 1, N_{VHTLTF}= 1, see IEEE802.11-2016 Figure 19-2) the R&S VSE WLAN application assumes CSD=0 for the timing-offset estimation.

For antenna A0 this assumption matches with the applied signal and therefore the EVM is good.

However, for antennas A1, A2, A3, A4, if the applied signal contains a CSD other than 0, the wrong assumption leads to a wrong timing offset estimation. In this case, the CSD must be ignored to get the correct results.

"Apply CSD"   (Default:) The timing offset estimation result (assuming CSD=0) is used for the subsequent signal analysis.

"Ignore CSD"   The timing offset estimation result (assuming CSD=0) is ignored for the subsequent signal analysis.

Remote command:
CONFigure:WLAN:MIMO:CSD on page 246

MIMO Antenna Signal Capture Setup

Defines the MIMO method used by the R&S VSE(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   Sequential using open switch platform
using OSP   A single analyzer and the Rohde & Schwarz OSP Switch Platform
switch"   (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 245

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 primary):

Table 4-1: 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

Remote command:
CONFigure:WLAN:ANTMatrix:SOURce:ROSCillator:SOURce:STAT<ant>
on page 244

State ← Simultaneous Signal Capture Setup

Switches the corresponding secondary analyzer on or off. In "On" state the secondary analyzer captures data. This data is transferred via LAN to the primary for analysis of the MIMO system.

Remote command:
CONFigure:WLAN:ANTMatrix:STATe<ant> on page 244

Reference Status ← Simultaneous Signal Capture Setup

LEDs indicate the connection state of the device providing the individual reference frequency for each channel (for "Reference Frequency Coupling" on page 118).

Table 4-2: Meaning of LED colors

Color	State
gray	external reference off or IP address not available/valid
red	external reference on and IP address valid, but no external reference detected
green	external reference on and IP address accessible

Remote command:
CONFigure:WLAN:ANTMatrix:ADDRess<ant> on page 241

Analyzer IP Address ← Simultaneous Signal Capture Setup

Defines the IP addresses of the secondarys connected via LAN to the primary.

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<ant> on page 241

Reference Level Offset ← **Simultaneous Signal Capture Setup**

For simultaneous MIMO setups, you can set the reference level for all secondary devices to the same setting as the primary device, or define individual offsets.

"From primary"	The secondary analyzers' reference levels are set to match that of the primary.
"Manual"	The secondary analyzers' reference levels are specified individually and are not coupled to the reference level offset of the primary analyzer.

Remote command:
CONFigure:WLAN:ANTMatrix:SOURce:RLEVel:OFFSet on page 243
CONFigure:WLAN:ANTMatrix:RLEVel<ant>:OFFSet on page 241

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 246

Reference Frequency Coupling ← **Simultaneous Signal Capture Setup**

For simultaneous MIMO setups, you can set the reference frequency source for all secondary devices to the same setting as the primary device.

"Secondary reference same as primary setting"	Both the primary and all secondarys use the same reference, according to the setting at the primary.
"Secondary: External; primary: Internal"	The secondary devices are set to use the external reference from the primary. The primary device uses its internal reference. Configure the primary to send its reference frequency to all secondary devices via one of its [REF OUTPUT] connectors. (See the R&S VSE User Manual for details.)
"Off"	Both the primary and secondary devices use their own internal references; the frequencies are not coupled.

Remote command:
CONFigure:WLAN:ANTMatrix:SOURce:ROSCillator:SOURce on page 243

Amplitude Settings Coupling ← Simultaneous Signal Capture Setup

For simultaneous MIMO setups, you can set the amplitude settings for all secondary devices to the same setting as the primary device. Thus, for example, you can force the secondary devices to auto-level in order to achieve better results. This feature requires that the WLAN 802.11 application R&S VSE-K91 is installed on the secondary device.

"Secondary settings same as primary settings"	Both the primary and all secondarys use the same amplitude settings, according to the settings at the primary. All settings on the secondary are ignored (including "Reference Level Auto"). Note: if "Reference Level Auto" is set at the primary, the primary channel performs an auto-level measurement and the resulting amplitude settings are transferred to the secondarys.
"Secondary auto-level same as primary"	The secondary devices perform an auto-level at the same time as the primary. The amplitude settings are then determined automatically by each device according to the measured values. This feature requires that the WLAN 802.11 application R&S VSE-K91 (version 1.31 or higher) is installed on the secondary devices.
"Off"	Both the primary and secondary devices use their own amplitude settings as defined prior to the measurement; the settings are not coupled.

Remote command:
CONFigure:WLAN:ANTMatrix:SOURce:AMPLitude:SOURce on page 242

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 3.3.4.1, "Sequential MIMO measurement", on page 71.

For this MIMO method you must connect each Tx antenna of the WLAN DUT with the analyzer and start data capturing manually.

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.
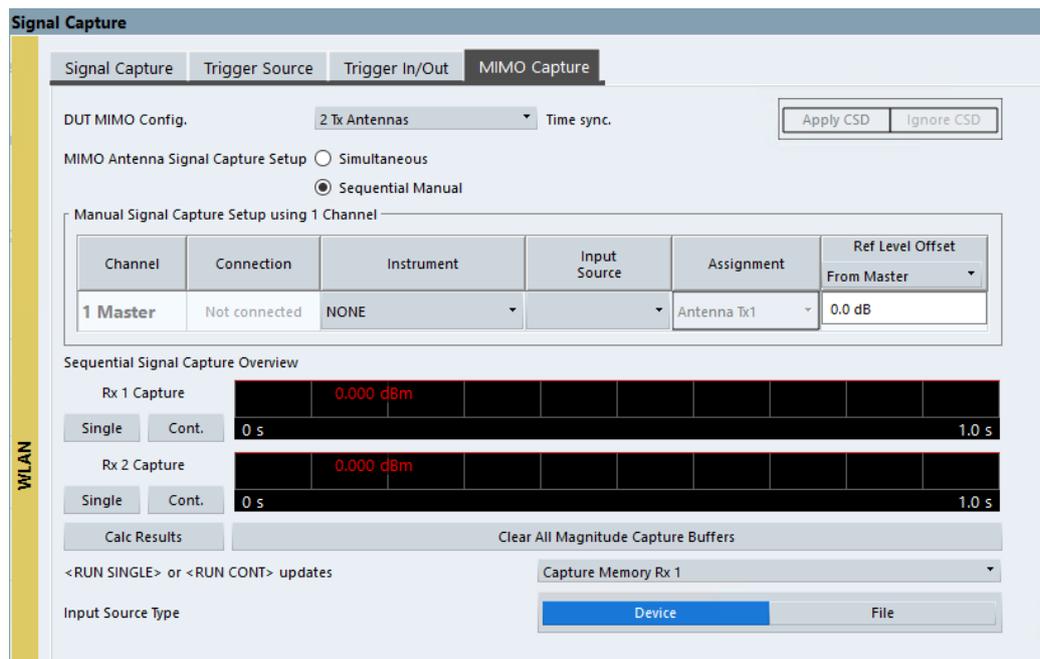
Remote command:
CONF:WLAN:MIMO:CAPT:TYP MAN, see CONFigure:WLAN:MIMO:CAPTure:TYPE on page 245

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 245
INITiate<n>[:IMMediate] on page 229

Calc Results ← **Manual Sequential MIMO Data Capture**
Calculates the results for the captured antenna signals.

Remote command:
CALCulate<n>:BURSt[:IMMediate] on page 240

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 global [RUN SGL] / [RUN CONT].

4.5 Synchronization and OFDM demodulation

Access: "Overview" > "Synchronization/ OFDM-Demod."

Synchronization settings have an effect on which parts of the input signal are processed during the WLAN 802.11 measurement.
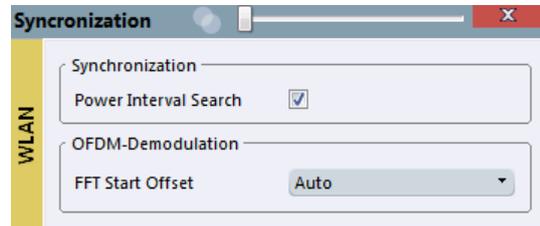
Power Interval Search

If enabled, the R&S VSE 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 247

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 247

4.6   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 57).
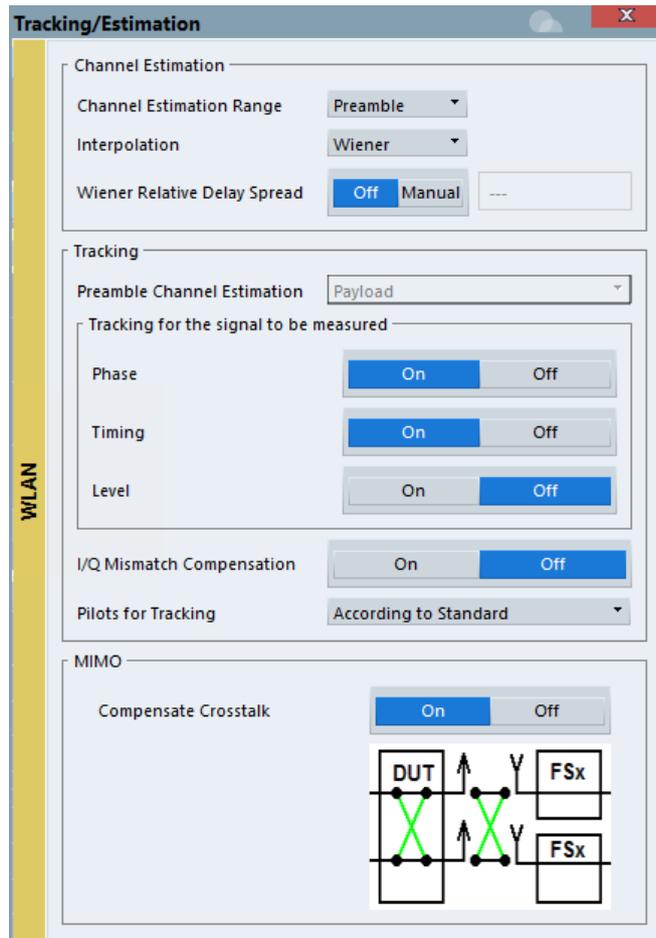
Channel Estimation Range

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 using the preamble of the HE/
(HE/EHT-LTF)"   EHT-LTF as required in the standard.

Remote command:
[SENSe:]DEMod:CESTimation:RANGe PRE1t

"Preamble (L-LTF + HE/EHT-LTF)"	The channel estimation is performed using the preamble of both training fields. Remote command: `[SENSe:]DEMod:CESTimation:RANGe PRE2t`
"Payload (Full tracking)"	The channel estimation is performed using the preamble and the payload. The EVM results can be calculated more accurately. All tracking options are applied to the payload symbols used for payload channel estimation. (Note: this setting corresponds to the simple "Payload" setting in previous firmware versions.) Remote command: `[SENSe:]DEMod:CESTimation:RANGe PFTRacking` (`[SENSe:]DEMod:CESTimation 1`)
"Payload (User tracking)"	The channel estimation is performed using the preamble and the payload. The EVM results can be calculated more accurately. The user-defined tracking settings as defined in the Tracking and channel estimation are applied to the payload symbols used for payload channel estimation. Remote command: `[SENSe:]DEMod:CESTimation:RANGe PUTRacking`

Remote command:
`[SENSe:]DEMod:CESTimation:RANGe` on page 248

Interpolation

Defines the type of interpolation and smoothing used during estimation.

In case all subcarriers are used (4xHE-LTF), sampling points for all subcarriers are available. In this case, the interpolation function smoothes the estimated channel.

This function is only available for standards **IEEE 802.11ax, be**.

"Wiener"	The unused subcarriers of the channel estimation fields (1xHE-LTF, 2xHE-LTF) are determined by Wiener interpolation. The estimated channel is smoothed. The Wiener interpolation overwrites the used subcarrier sampling points. In case all subcarriers are used (4xHE-LTF), sampling points for all subcarriers are available. The channel is smoothed.
"None/Linear"	The unused subcarriers of the channel estimation fields (1xHE-LTF, 2xHE-LTF) are determined by linear interpolation. Linear interpolation preserves the used subcarrier sampling points. In case all subcarriers are used (4xHE-LTF), the available sampling points for all subcarriers are preserved, and no interpolation is applied.

Remote command:
`[SENSe:]DEMod:INTerpolate` on page 249

Wiener Relative Delay Spread

Defines the filter for Wiener interpolation.

By default, the filter is defined automatically. You can define a value in percent man-ually, betwen 0.01 and 50. The value is relative to the DFT (discrete Fourier transform) period that is used for the Wiener filter design. Decrease this setting to finetune the EVM result if there is negligible delay spread, for example for a wired connection.

This function is only available for standards **IEEE 802.11ax, be** and only for Interpola-tion = "Wiener".

Remote command:
[SENSe:]DEMod:INTerpolate:WIENer:DSPRead:STATe on page 249
[SENSe:]DEMod:INTerpolate:WIENer:DSPRead on page 249

Preamble Channel Estimation

Defines which results are used for preamble tracking prior to the preamble channel estimation.

This function is only available for standards **WLAN 802.11ac and n**.

"Payload"   Prior to MIMO channel estimation, global center frequency error and symbol clock error estimates are calculated using known payload pilots. (V)HT-LTF symbols are then corrected using these estimates. Symbol-wise phase tracking over (V)HT-LTF symbols is not per-formed.

"(V)HT-LTF Symbols + Payload"   Prior to MIMO channel estimation, global center frequency error and symbol clock error estimates are calculated using known payload pilots. (V)HT-LTF symbols are then corrected using these estimates. In addition, a (V)HT-LTF symbol-wise phase estimation and correction (phase tracking) is performed. In case of strong phase drifts, this can help improve the channel estimate based on (V)HT-LTF symbols. However, (V)HT-LTF symbol phase tracking only makes sense if more than one (V)HT-LTF symbol is used for channel estimation. Oth-erwise, phase tracking is skipped.

Remote command:
SENSe:TRACking:PREamble on page 252

Phase Tracking

Activates or deactivates the compensation for phase drifts. If activated, the measure-ment results are compensated for phase drifts on a per-symbol basis.

Remote command:
SENSe:TRACking:PHASe on page 251

Timing Error Tracking

Activates or deactivates the compensation for timing drift. If activated, the measure-ment results are compensated for timing error on a per-symbol basis.

Remote command:
SENSe:TRACking:TIME on page 252

Level Error (Gain) Tracking

Activates or deactivates the compensation for level drifts within a single PPDU. If acti-vated, the measurement results are compensated for level error on a per-symbol basis.

Remote command:
SENSe:TRACking:LEVel on page 251

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.

This setting is **not available for standards IEEE 802.11b and g (DSSS)**.

For details see Chapter 2.1.5, "I/Q mismatch", on page 16.

Note: For EVM measurements according to the IEEE 802.11-2012, IEEE 802.11ac-2013 WLAN standard, I/Q mismatch compensation must be deactivated.

"Off"　　　　　　No compensation is applied.

"Average Subcarrier"

　　　　　　　　The I/Q mismatches (gain imbalance, quadrature offset, time skew) are averaged over the subcarriers. The scalar results are applied to the subcarriers and used for I/Q mismatch compensation. Note this setting corresponds to the previous "I/Q Mismatch Compensation: On" setting.

"Per Subcarrier"

　　　　　　　　The individual I/Q mismatches per subcarrier are used for I/Q mismatch compensation.

Remote command:
SENSe:TRACking:IQMComp on page 250

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 R&S VSE 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 R&S VSE 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 251

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, ax, n, be (MIMO)**.

By default, full MIMO equalizing is performed by the R&S VSE 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 3.3.6, "Crosstalk and spectrum flatness", on page 74.

Remote command:
SENSe:TRACking:CROSstalk on page 250

4.7 Demodulation

Access: "Overview" > "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 in the "Signal Description" (see "Standard" on page 93).

4.7.1 Demodulation - IEEE 802.11a, g (OFDM), j, p

Access: "Overview" > "Demodulation"

The following settings are available for demodulation of IEEE 802.11a, g (OFDM), j, p signals.
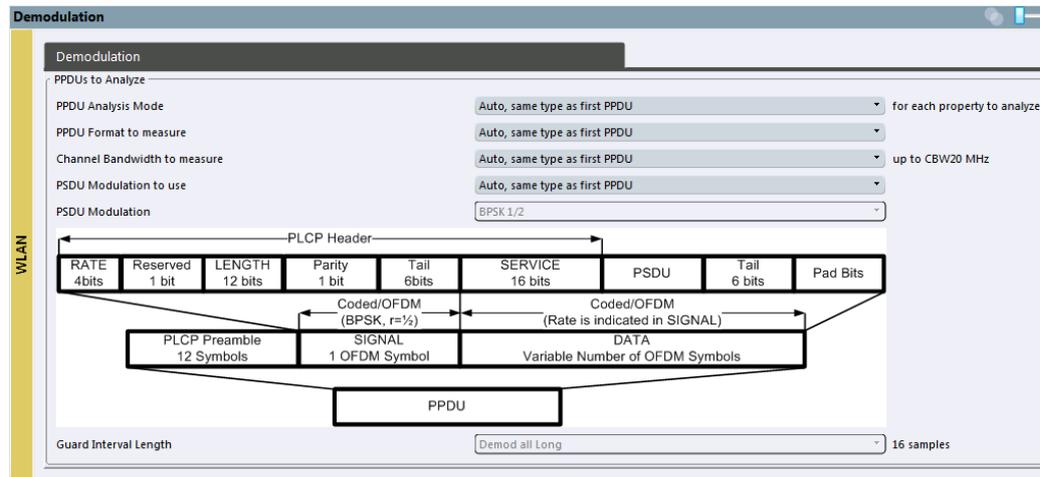
Figure 4-2: Demodulation settings for IEEE 802.11a, g (OFDM), j, p standard

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 262

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 3-3.

Note: The terms in brackets in the following description indicate how the setting is referred to in the "Signal Field" result display ("Format" column).

"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 260
[SENSe:]DEMod:FORMat:BANalyze on page 258

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 3-3.

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.

"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 256

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 3-3.

"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 260

[SENSe:]DEMod:FORMat:BANalyze on page 258

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 3-3.

Remote command:

[SENSe:]DEMod:FORMat:BANalyze on page 258

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 254

CONFigure:WLAN:GTIMe:AUTO:TYPE on page 364

CONFigure:WLAN:GTIMe:SELect on page 254

4.7.2 Demodulation - IEEE 802.11ac

Access: "Overview" > "Demodulation"

Or: [MEAS CONFIG] > "Demod."

The following settings are available for demodulation of IEEE 802.11ac signals.
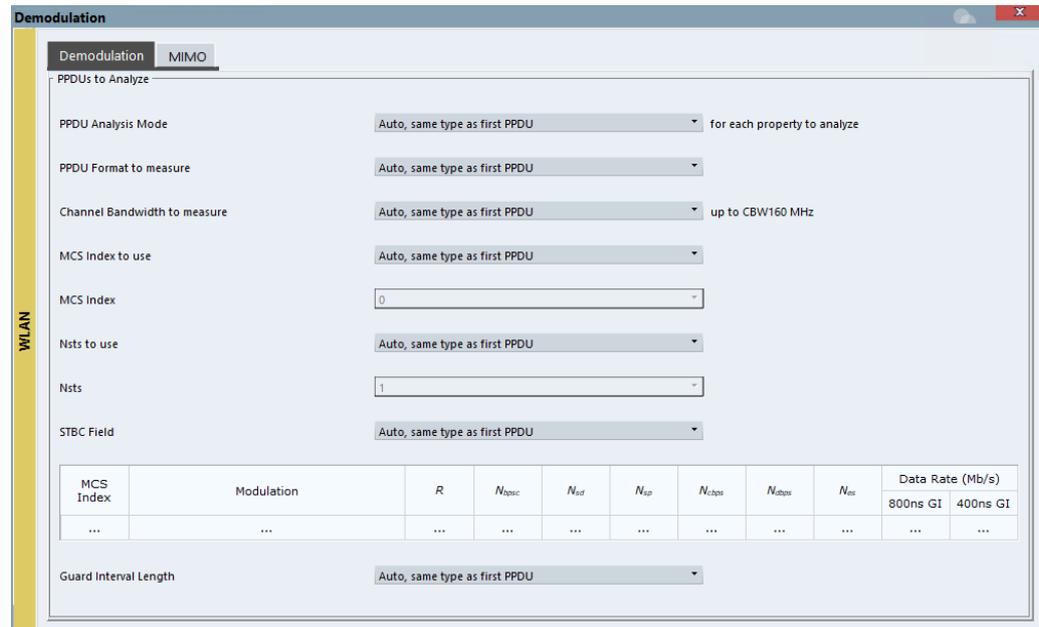
Figure 4-3: Demodulation settings for IEEE 802.11ac standard

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 262

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 3-3.

Note: The terms in brackets in the following description indicate how the setting is referred to in the "Signal Field" result display ("Format" column).

"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 260
[SENSe:]DEMod:FORMat:BANalyze on page 258

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 3-3.

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.

"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 256

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 263

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 263

Nsts to use

Defines 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 132 setting are analyzed

"Demod all with specified Nsts""(D ...)"

The "Nsts" on page 132 setting is used for all PPDUs.

Remote command:
[SENSe:]DEMod:FORMat:NSTSindex:MODE on page 264

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 264

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 255

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 254

CONFigure:WLAN:GTIMe:AUTO:TYPE on page 364

CONFigure:WLAN:GTIMe:SELect on page 254

4.7.3 Demodulation - IEEE 802.11ax

Access: "Overview" > "Demodulation"

Or: [MEAS CONFIG] > "Demod."

The following settings are available for demodulation of IEEE 802.11ax signals.

Figure 4-4: Demodulation settings for IEEE 802.11ax 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 262

PPDU Format to measure

Defines which PPDU formats are to be included in the analysis for standard **IEEE 802.11ax**.

Note: The PPDU format determines the available channel bandwidths.
In particular, extended range PPDUs can only be measured with a channel bandwidth of 20 MHz. If you increase the Channel Bandwidth to measure (CBW), the "PPDU Format to measure" is automatically set to "Auto individual for each HE SU-PPDU".

For details on supported PPDU formats and channel bandwidths depending on the standard see Table 3-3.

"Auto individual for each HE SU-PPDU/ HE MU-PPDU / HE Trigger-based PPDU / HE Ext. Range SU-PPDU"

Only PPDUs of the specified PPDU type are analyzed

"Demod all as specified HE PPDU"

All PPDUs are assumed to have HE PPDU format as defined in the HE PPDU Config settings

Remote command:

[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE on page 260

[SENSe:]DEMod:FORMat:BANalyze on page 258

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 3-3.

Note: The available channel bandwidths depends on the selected PPDU format. In particular, extended range PPDUs can only be measured with a channel bandwidth of 20 MHz. If you increase the "Channel Bandwidth to measure (CBW)", the HE PPDU Format is automatically set to "HE SU-PPDU".

"Auto, same type as first PPDU"

The channel bandwidth of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same channel bandwidth.

"Meas only ... signal"

Only PPDUs with the specified channel bandwidth are analyzed

"Demod all as ... signal"

All PPDUs are assumed to have the specified channel bandwidth

Remote command:
[SENSe:]BANDwidth:CHANnel:AUTO:TYPE on page 256

HE PPDU Config

Defines the PPDU configuration, which also contains the assignment of the stations (users) to the resource units (RUs), that is: the channels and subcarriers. For single user (HE SU-PPDU) and trigger-based PPDUs (UL), the configuration is detected automatically by the R&S VSE WLAN application. For multi-user downlink PPDUs (HE MU_PPDU), you must define the configuration manually.

For trigger-based PPDUs, you must also define the length of the HE-LTF field in the PPDUs in the R&S VSE WLAN application.

Note: Result displays for multi-user PPDUs. For multi-user PPDUs, the result displays show the demodulated data for an individual RU at a time. In continuous sweep measurements, the results for the first RU defined in the PPDU configuration table are displayed. In single sweep measurements, you can scroll through the RUs in the table to view the results. The currently displayed RU is highlighted green in the PPDU configuration table. To view the results of a different RU, select the RU in the table, then Refresh.

For details on PPDU configuration see also Chapter 3.4, "Signal processing for high-efficiency wireless measurements (IEEE 802.11ax)", on page 75.

HE PPDU Format ← HE PPDU Config

Defines the format of the HE PPDU. This format determines which other PPDU settings are available.

Note that the R&S VSE WLAN application performs plausibility checks concerning the number of RUs, RU sizes, and number of users over all segments and RU configuration tabs according to the 802.11ax standard.

"HE SU-PPDU (DL,UL)"	High-efficiency single user PPDU for uplink and downlink
"HE MU-PPDU (DL)"	High-efficiency multi-user PPDU for downlink to multiple users at the same time
"HE Trigger-based PPDU (UL)"	High-efficiency trigger-based PPDU for uplink from multiple users at the same time
"HE Ext Range SU-PPDU"	High-efficiency single-user PPDU for an extended range

Remote command:
CONFigure:WLAN:RUConfig:HEPPdu on page 266

N$_{HE-LTF}$ ← HE PPDU Config

Defines the length of the high-efficiency long training field (for **trigger-based uplink PPDUs only**). For more information see "HE Trigger-based PPDUs" on page 79.

"Auto"	The length is determined automatically by the application.
"As Configured STA"	The station configuration defines the used length.
"1 / 2 / 4 / 6 / 8 Symbols"	The LTF of the PPDUs have a fixed length.

Remote command:
CONFigure:WLAN:RUConfig:NHELtf on page 267

Segment 1/2 ← HE PPDU Config

For **160 MHz** channels and multi-user downlink PPDUs (**MU-PPDU (DL)) only**:
switches between the two possible 80-MHz-segments (242 tones) of the channel to be configured

RU1-242 / RU2-242 / RU3-242 / RU4-242 ← HE PPDU Config
Switches between the four possible RU allocation configuration tabs for channel band-
widths larger than 20 MHz. Each RU allocation tab configures the resource units for a
20 MHz channel.

A maximum of 9 resource units (with 26 subcarriers each) can be configured for any
20 MHz span.

RU Count ← HE PPDU Config
The number of used RUs for a single PPDU. Used to connect the results to the PPDU
configuration. Up to 9 resource units can be configured for each subchannel, depend-
ing on the RU Size.

RU26 Index ← HE PPDU Config
The index of the resource unit based on 26-subcarrier units. Values from 1 to 74 are
possible.

Remote command:
CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:
RU26index on page 269

RU Index ← HE PPDU Config
The index of the resource unit as defined by the 802.11ax standard. This value deter-
mines the position of the resource unit within the channel.

Remote command:
CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:
COUNt:HIGHest? on page 267

User Index ← HE PPDU Config
The index of the user assigned to the resource unit. In standard transmissions, only
one user is assigned to each RU. In MIMO transmissions, up to 8 users can be
assigned to one RU (depending on the size of the RU).

Remote command:
CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:
USER:COUNt? on page 271

RU Size ← HE PPDU Config
Size of the individual resource unit (= number of subcarriers or tones) for a single
transmission package.

Remote command:
CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:
RUSize on page 270

MCS Index ← HE PPDU Config
Modulation and Coding Scheme (MCS) index of the PPDU

- 0: BPSK 1/2
- 1: QPSK 1/2
- 2: QPSK 3/4
- 3: 16-QAM 1/2

- 4: 16-QAM 3/4
- 5: 64-QAM 2/3
- 6: 64-QAM 3/4
- 7: 64-QAM 5/6
- 8: 256-QAM 3/4
- 9: 256-QAM 5/6
- 10: 1024-QAM 3/4
- 11: 1024-QAM 5/6

Remote command:
CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:
USER<mu>:MCSindex on page 275

Nsts per User ← HE PPDU Config
For **MIMO** measurements only:

Number of space-time streams (NSTS) assigned to an individual user

Remote command:
CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:
USER<mu>:NSTS on page 276

TX Beamforming ← HE PPDU Config
Use of transmit beamforming

[1]   Beamforming is applied

[0]   No beamforming applied

Remote command:
CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:
USER<mu>:TBEamforming on page 276

DCM ← HE PPDU Config
Dual carrier modulation

[1]   DCM is used

[0]   DCM not used

Remote command:
CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:
USER<mu>:DCM on page 273

Coding ← HE PPDU Config
The type of coding used by the PPDU

[1]   LDPC is used

[0]   BCC is used

Remote command:
CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:
USER<mu>:CODing on page 272

Insert User ← HE PPDU Config
For **HE Multi-User Downlink PPDU**s that support **MIMO** only:

Adds another user (station) for the selected resource unit (RU) to the configuration table.

A maximum of 8 users can be assigned to a single resource unit in MIMO mode.

This function is only available for RU sizes of at least 106 subcarriers.

Remote command:
CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: USER<mu>:INSert on page 274

Delete User ← HE PPDU Config
Deletes the selected user (station) from the HE Multi-User Downlink PPDU configuration table (for **MIMO** configuration only).

Remote command:
CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: USER<mu>:DELete on page 273

Refresh ← HE PPDU Config
Updates the result displays for the currently selected RUs in the PPDU configuration table.

See "Result displays for multi-user PPDUs" on page 79.

Remote command:
CONFigure:WLAN:RUConfig:REFResh on page 267

OK ← HE PPDU Config
Saves the changes to the table and closes the dialog box.

Guard Interval (GI) + HE-LTF Size
Defines the PPDUs taking part in the analysis depending on the guard interval (GI) and HE long training field (LTF) length.

"Auto (HE-SIG-A), same type as first PPDU"
> All HE PPDUs using the guard interval length identical to the first recognized PPDU are analyzed.

"Auto (HE-SIG-A), individually for each PPDU"
> All HE PPDUs are analyzed.

"Meas only 4.0µs (1x HE-LTF + 1x GI1 = 3.2 + 0.8 µs)"
> Only HE PPDUs with one long training field (LTF) and one guard interval (GI) with the specified length are analyzed.
> Not available for HE trigger-based PPDUs.

"Meas only 4.8µs (1x HE-LTF + 2x GI1 = 3.2 + 1.6µs)"
> Only HE PPDUs with one long training field (LTF) and two guard intervals (GI) with the specified length are analyzed.
> For HE trigger-based PPDUs only.

"Meas only 7.2µs (2x HE-LTF + 1x GI1 = 6.4 + 0.8µs)"
> Only HE PPDUs with two long training field (LTF) and one guard interval (GI) with the specified length are analyzed.

"Meas only 8.0µs (2x HE-LTF + 2x GI1 = 6.4 + 1.6µs)"

Only HE PPDUs with two long training fields (LTF) and two guard intervals (GI) with the specified length are analyzed.

"Meas only 13.6µs (4x HE-LTF + 1x GI1 = 12.8 + 0.8µs)"

Only HE PPDUs with four long training fields (LTF) and one guard interval (GI) with the specified length are analyzed.

"Meas only 16.0µs (4x HE-LTF + 4x GI1 = 12.8 + 3.2µs)"

Only HE PPDUs with four long training fields (LTF) and four guard intervals (GI) with the specified length are analyzed.

Remote command:
CONFigure:WLAN:GTIMe:AUTO on page 254
CONFigure:WLAN:GTIMe:AUTO:TYPE on page 364
CONFigure:WLAN:GTIMe:SELect on page 254

Demodulation Data (Bitstream)
Defines when in the demodulation process the bitstream is determined and thus which results are available.

See also Chapter 2.1.9, "BER and CWER", on page 20.

"After Constellation Demapping (per Subcarrier)"

(Default:) No channel decoding is performed. Processing time is reduced, but BER and CWER results are not available.

"After LDPC/BCC Decoder"

Decoding is performed, providing BER and CWER results. Measurement time is increased compared to non-decoding process.

Remote command:
[SENSe:]DEMod:DATA on page 257

4.7.4 Demodulation - IEEE 802.11be

Access: "Overview" > "Demodulation"

Or: [MEAS CONFIG] > "Demod."

The following settings are available for demodulation of IEEE 802.11be signals.
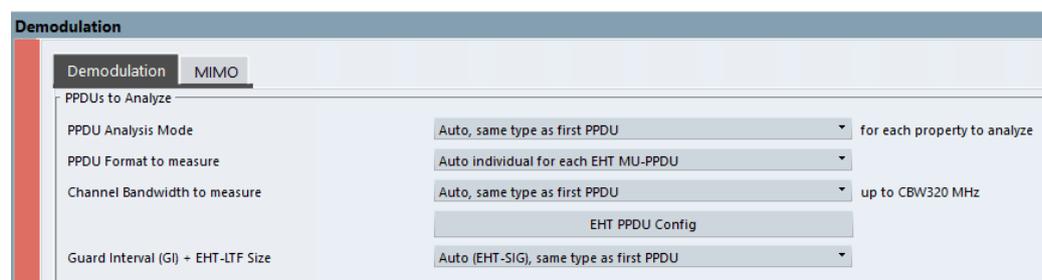
Figure 4-5: Demodulation settings for IEEE 802.11be standard

ⓘ **Result displays for multi-user PPDUs**

The result displays show the demodulated data for the selected RUs. The currently displayed RUs are highlighted green in the PPDU configuration table and the result displays. For multi-user configuration, the results cannot be displayed for an individual user. If you select an RU, the rows for all users of the RU are highlighted.

By default, the first RU is selected. To view the results of different RUs, select the RUs in the table by clicking in the first column ("#"), then Refresh.

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 262

PPDU Format to measure

Defines which PPDU formats are to be included in the analysis for standard **IEEE 802.11be**.

For details on supported PPDU formats and channel bandwidths depending on the standard see Table 3-3.

"Auto, same type as first PPDU"

> The format of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same format.

"Demod all as specified EHT PPDU"

> All PPDUs are assumed to have EHT PPDU format as defined in the EHT PPDU Config settings

"Auto individual for each EHT MU-PPDU"

> Signal is decoded and analyzed according to the U-SIG and EHT-SIG content. The decoded information is indicated in the EHT PPDU Config settings.

"Auto individual for each EHT Trigger-based PPDU"

> Signal is decoded and analyzed according to the U-SIG content. The decoded information is indicated in the EHT PPDU Config settings.

Remote command:

[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE on page 260
[SENSe:]DEMod:FORMat:BANalyze on page 258

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 3-3.

Note: The available channel bandwidths depend on the selected PPDU format.

"Auto, same type as first PPDU"

> The channel bandwidth of the first valid PPDU is detected and subsequent PPDUs are analyzed only if they have the same channel bandwidth.

"Meas only ... signal"

> Only PPDUs with the specified channel bandwidth are analyzed

"Demod all as ... signal"

> All PPDUs are assumed to have the specified channel bandwidth

Remote command:

[SENSe:]BANDwidth:CHANnel:AUTO:TYPE on page 256

EHT PPDU Config

Defines the PPDU configuration, which also contains the assignment of the stations (users) to the resource units (RUs), that is: the channels and subcarriers. For multi-user downlink PPDUs (EHT MU_PPDU), you must define the configuration manually.
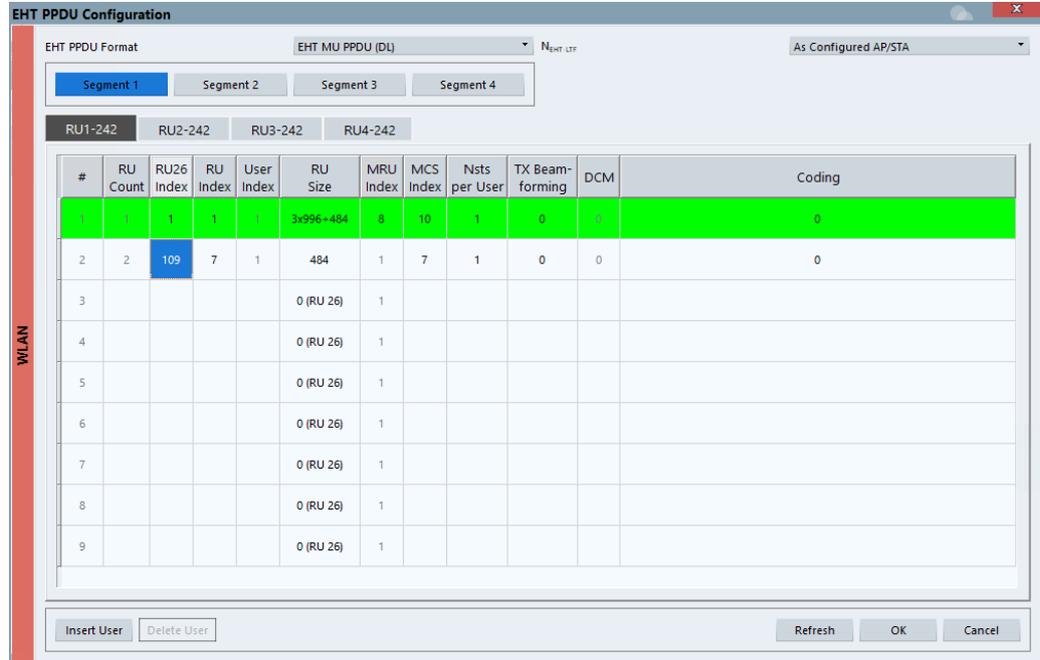
Note: Result displays for multi-user PPDUs.

The result displays show the demodulated data for the selected RUs. The currently displayed RUs are highlighted green in the PPDU configuration table and the result displays. For multi-user configuration, the results cannot be displayed for an individual user. If you select an RU, the rows for all users of the RU are highlighted.

By default, the first RU is selected. To view the results of different RUs, select the RUs in the table by clicking in the first column ("#"), then Refresh.
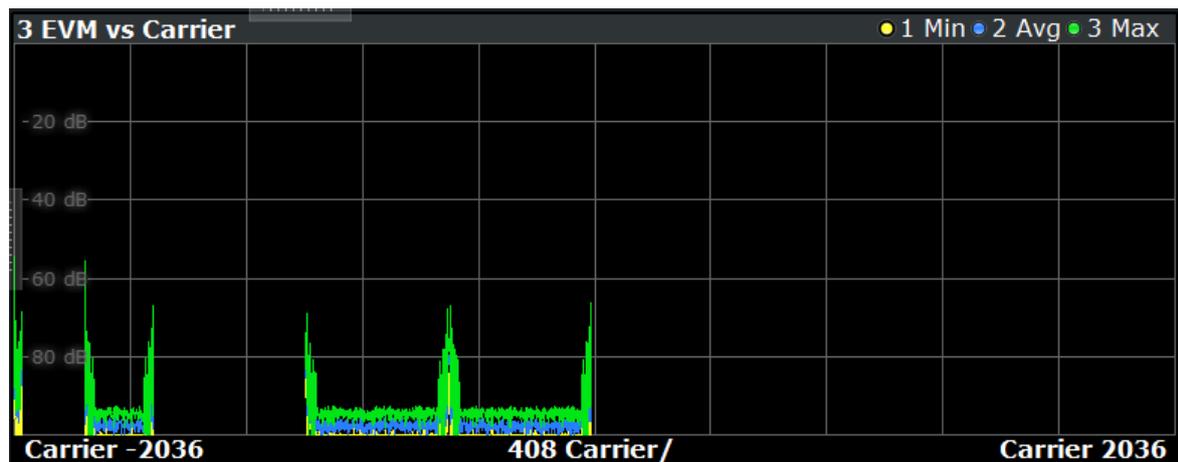
Figure 4-6: Result display for all RUs except 2 and 5

For details on PPDU configuration see also Chapter 3.5, "Signal processing for extremely high throughput (EHT) wireless measurements (IEEE 802.11be)", on page 80.

EHT PPDU Format ← EHT PPDU Config
Defines the format of the EHT PPDU. This format determines which other PPDU settings are available.

Note that the R&S VSE WLAN application does not perform plausibility checks concerning the number of RUs, RU sizes, and number of users over all segments and RU configuration tabs according to the 802.11be standard.

"EHT MU PPDU (DL)"
                    Extremely high throughput multi-user PPDU for downlink

"EHT Trigger-based PPDU (UL)"
                    Extremely high throughput trigger-based PPDU for uplink

Remote command:
CONFigure:WLAN:RUConfig:EHTPpdu on page 266

N$_{EHT-LTF}$ ← EHT PPDU Config
Defines the length of the high-efficiency long training field. For more information see "HE Trigger-based PPDUs" on page 79.

"Auto"   The length is determined automatically by the application.

"As Configured AP/STA"
                    The access point or station configuration defines the used length.

"1 / 2 / 4 / 6 / 8 Symbols"
                    The LTF of the PPDUs have a fixed length.

Remote command:
CONFigure:WLAN:RUConfig:NHELtf on page 267

Segment 1/2/3/4 ← EHT PPDU Config
For **160 MHz/320 MHz** channels only: switches between the four possible 80-MHz-segments (4*242 tones) of the channel to be configured.

RU1-242 / RU2-242 / RU3-242 / RU4-242 ← EHT PPDU Config
Switches between the four possible RU allocation configuration tabs for channel bandwidths larger than 20 MHz. Each RU allocation tab configures the resource units for a 20 MHz channel.

A maximum of 9 resource units (with 26 subcarriers each) can be configured for any 20 MHz span.

RU number ← EHT PPDU Config
Consecutive number of the RUs for a single user and PPDU. Select the number to toggle the selection of results to be displayed. Highlighted rows are selected.

Note: For multi-user configuration, the results cannot be displayed for an individual user. If you select an RU, the rows for all users of the RU are highlighted.

Remote command:
CONFigure:WLAN:RUConfig:COUNt:ACTive on page 266

RU Count ← EHT PPDU Config

The number of used RUs for a single PPDU. Used to connect the results to the PPDU configuration. Up to 9 resource units can be configured for each subchannel (=242 subcarriers). The RU Count for the 80-MHz-segments (RU1-242, RU2-242, RU3-242, RU4-242) is cumulative.

RU26 Index ← EHT PPDU Config

The index of the resource unit based on 26-subcarrier units. Values from 1 to 144 are possible.

Remote command:

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: RU26index on page 269

RU Index ← EHT PPDU Config

The index of the resource unit as defined by the 802.11be standard (based on resource units of the specified RU Size). This value determines the position of the resource unit within the channel. Values from 1 to 144 are possible, depending on the RU Size.

Remote command:

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: RUINdex on page 269
CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: COUNt:HIGHest? on page 267

User Index ← EHT PPDU Config

The index of the user assigned to the resource unit. In standard transmissions, only one user is assigned to each RU. In MIMO transmissions, up to 8 users can be assigned to one RU (depending on the size of the RU). MIMO is only supported for RUs with at least 242 subcarriers.

Remote command:

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: USER:COUNt? on page 271

RU Size ← EHT PPDU Config

Size of the individual resource unit (= number of subcarriers or tones) for a single transmission package.

Remote command:

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: RUSize on page 270

MRU Index ← EHT PPDU Config

Index of the subcarrier and resource allocation for multiple RUs (MRU) as defined by the 802.11be standard. This index determines the position of the ignored subcarriers and used RUs within the spectrum. Depending on the MRU size, values from 1 up to 12 are possible.

Remote command:

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: MRUindex on page 268

MCS Index ← EHT PPDU Config

Modulation and Coding Scheme (MCS) index of the PPDU

- 0: BPSK 1/2
- 1: QPSK 1/2
- 2: QPSK 3/4
- 3: 16-QAM 1/2
- 4: 16-QAM 3/4
- 5: 64-QAM 2/3
- 6: 64-QAM 3/4
- 7: 64-QAM 5/6
- 8: 256-QAM 3/4
- 9: 256-QAM 5/6
- 10: 1024-QAM 3/4
- 11: 1024-QAM 5/6
- 12: 4096-QAM 3/4
- 13: 4096-QAM 5/6

Remote command:

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: USER<mu>:MCSindex on page 275

Nsts per User ← EHT PPDU Config

For **MIMO** measurements only:

Number of space-time streams (NSTS) for each user

Remote command:

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: USER<mu>:NSTS on page 276

TX Beamforming ← EHT PPDU Config

Use of transmit beamforming

[1]   Beamforming is applied

[0]   No beamforming applied

Remote command:

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: USER<mu>:TBEamforming on page 276

DCM ← EHT PPDU Config

Dual carrier modulation

[1]   DCM is used

[0]   DCM not used

Remote command:

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: USER<mu>:DCM on page 273

Coding ← EHT PPDU Config

The type of coding used by the PPDU

[1]   LDPC is used

[0] BCC is used

Remote command:
CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:
USER<mu>:CODing on page 272

Insert User ← EHT PPDU Config

For PPDUs that support **MIMO** only:

Adds another user (station) for the selected resource unit (RU) to the configuration table.

A maximum of 8 users can be assigned to a single resource unit in MIMO mode.

This function is only available for RU sizes of at least 106 subcarriers.

Remote command:
CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:
USER<mu>:INSert on page 274

Delete User ← EHT PPDU Config

Deletes the selected user (station) from the HE Multi-User Downlink PPDU configuration table (for **MIMO** configuration only).

Remote command:
CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:
USER<mu>:DELete on page 273

Select All ← EHT PPDU Config

Selects all RUs for the result display. Selected RUs are highlighted green.

Deselect All ← EHT PPDU Config

Deselects all RUs excepts the first RU for the result display. Only the first RU is highlighted.

Refresh ← EHT PPDU Config

Updates the result displays for the currently selected RUs in the PPDU configuration table.

See "Result displays for multi-user PPDUs" on page 79.

Remote command:
CONFigure:WLAN:RUConfig:REFResh on page 267

OK ← EHT PPDU Config

Saves the changes to the table and closes the dialog box.

Guard Interval (GI) + EHT-LTF Size

Defines the PPDUs taking part in the analysis depending on the guard interval (GI) and the EHT long training field (LTF) length.

"Auto (EHT-SIG), same type as first PPDU"

All PPDUs using the guard interval length identical to the first recognized PPDU are analyzed.

"Auto (EHT-SIG), individually for each PPDU"
All PPDUs are analyzed.

"Meas only 4.0µs (1x EHT-LTF + 1x GI1 = 3.2 + 0.8 µs)"
Only EHT PPDUs with one long training field (LTF) and one guard
interval (GI) with the specified length are analyzed.
Not available for HE trigger-based PPDUs.

"Meas only 4.8µs (1x EHT-LTF + 2x GI1 = 3.2 + 1.6µs)"
Only EHT PPDUs with one long training field (LTF) and two guard
intervals (GI) with the specified length are analyzed.

"Meas only 7.2µs (2x EHT-LTF + 1x GI1 = 6.4 + 0.8µs)"
Only EHT PPDUs with two long training field (LTF) and one guard
interval (GI) with the specified length are analyzed.

"Meas only 8.0µs (2x EHT-LTF + 2x GI1 = 6.4 + 1.6µs)"
Only HEHTE PPDUs with two long training fields (LTF) and two guard
intervals (GI) with the specified length are analyzed.

"Meas only 13.6µs (4x EHT-LTF + 1x GI1 = 12.8 + 0.8µs)"
Only EHT PPDUs with four long training fields (LTF) and one guard
interval (GI) with the specified length are analyzed.

"Meas only 16.0µs (4x EHT-LTF + 4x GI1 = 12.8 + 3.2µs)"
Only EHT PPDUs with four long training fields (LTF) and four guard
intervals (GI) with the specified length are analyzed.

Remote command:
CONFigure:WLAN:GTIMe:AUTO on page 254
CONFigure:WLAN:GTIMe:AUTO:TYPE on page 364
CONFigure:WLAN:GTIMe:SELect on page 254

Demodulation Data (Bitstream)
Defines when in the demodulation process the bitstream is determined and thus which
results are available.

See also Chapter 2.1.9, "BER and CWER", on page 20.

"After Constellation Demapping (per Subcarrier)"	(Default:) No channel decoding is performed. Processing time is reduced, but BER and CWER results are not available.
"After LDPC/BCC Decoder"	Decoding is performed, providing BER and CWER results. Measurement time is increased compared to non-decoding process.

Remote command:
[SENSe:]DEMod:DATA on page 257

4.7.5 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.
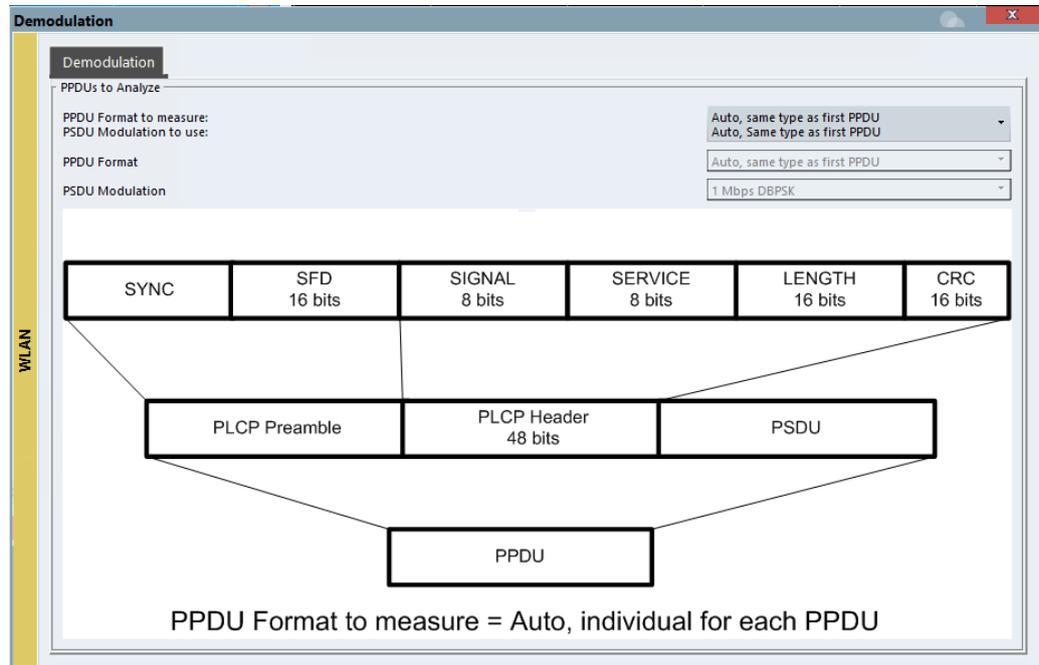
Figure 4-7: Demodulation settings for IEEE 802.11b, g (DSSS) signals

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 3-3.

"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 260

[SENSe:]DEMod:FORMat:BANalyze on page 258

[SENSe:]DEMod:FORMat:SIGSymbol on page 264

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 3-3.

Remote command:

[SENSe:]DEMod:FORMat:BANalyze on page 258

[SENSe:]DEMod:FORMat:BANalyze:BTYPe on page 259

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 3-3.

Remote command:

[SENSe:]DEMod:FORMat:BANalyze on page 258

4.7.6   Demodulation - IEEE 802.11n

Access: "Overview" > "Demodulation"

Or: [MEAS CONFIG] > "Demod."

The following settings are available for demodulation of IEEE 802.11n signals.
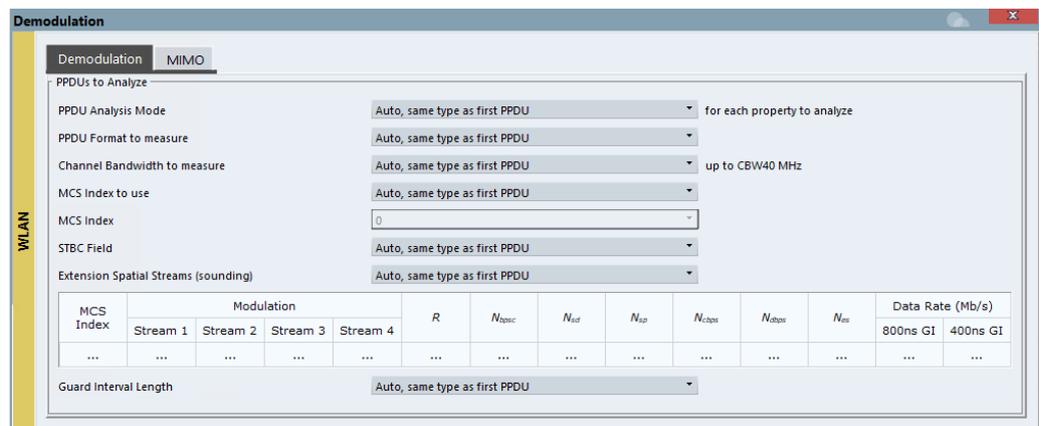
Figure 4-8: Demodulation settings for IEEE 802.11n standard

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 262

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 3-3.

Note: The terms in brackets in the following description indicate how the setting is referred to in the "Signal Field" result display ("Format" column).

"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 260
[SENSe:]DEMod:FORMat:BANalyze on page 258

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 3-3.

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.

"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 256

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 263

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 263

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 255

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 253

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 254
CONFigure:WLAN:GTIMe:AUTO:TYPE on page 364
CONFigure:WLAN:GTIMe:SELect on page 254

4.7.7 Demodulation - MIMO (IEEE 802.11ac, ax, n, be)

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, ax, n, be (MIMO)**.

Tx	STS.1	STS.2	STS.3	STS.4	STS.5	STS.6	STS.7	STS.8	Time shift (ns)
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2	-1.00	1.00	-1.00	1.00	-1.00	1.00	-1.00	1.00	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
3	-1.00	-1.00	1.00	1.00	-1.00	-1.00	1.00	1.00	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
4	1.00	-1.00	-1.00	1.00	1.00	-1.00	-1.00	1.00	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5	-1.00	-1.00	-1.00	-1.00	1.00	1.00	1.00	1.00	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
6	1.00	-1.00	1.00	-1.00	-1.00	1.00	-1.00	1.00	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
7	1.00	1.00	-1.00	-1.00	-1.00	-1.00	1.00	1.00	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8	-1.00	1.00	1.00	-1.00	1.00	-1.00	-1.00	1.00	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

Spatial Mapping Mode

Defines the mapping between streams and antennas.

For details see Chapter 3.3.2, "Spatial mapping", on page 68.

"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 277

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 278

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 278

CONFigure:WLAN:SMAPping:TX<ch>:STReam<ant> on page 278

CONFigure:WLAN:SMAPping:TX<ch>:TIMeshift on page 279

4.8　Evaluation range

Access: "Overview" > "Evaluation Range"

The evaluation range defines which objects the result displays are based on. The available settings depend on the selected standard.

4.8.1　Evaluation range settings for IEEE 802.11a, ac, ax, g (OFDM), j, n, p, be

Access: "Overview" > "Evaluation Range"

The following settings are available to configure the evaluation range for standards IEEE 802.11a, ac, ax, g (OFDM), j, n, p, be.
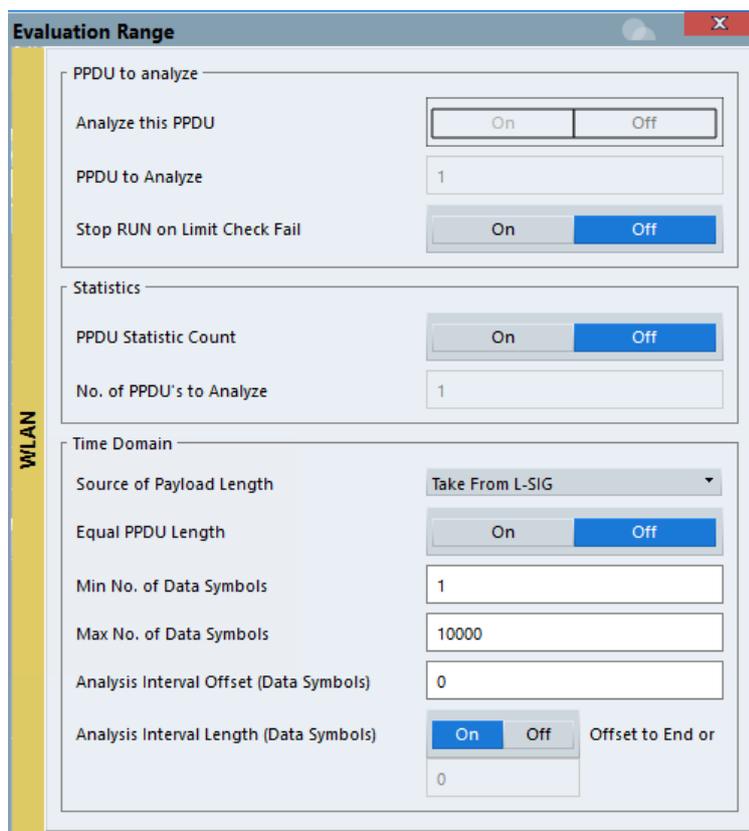
Figure 4-9: Evaluation range settings for IEEE 802.11a, ac, ax, g (OFDM), j, n, p, be standards

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 Chapter 2.2, "Evaluation methods for WLAN IQ measurements", on page 21).

Note: "AM/AM", "AM/EVM" and "AM/PM" results are not updated when single PPDU analysis is selected.

Remote command:
[SENSe:]BURSt:SELect:STATe on page 282
[SENSe:]BURSt:SELect on page 281

Stop RUN on Limit Check Fail

If enabled, the measurement is stopped if the limit check fails at any time during the measurement. This is particularly useful if statistical evaluation is performed. If a value exceeds the limit, the R&S VSE WLAN application stops acquiring data, thus allowing you to determine the cause of the limit violation.

If the limit check fails, an error message in the status bar and a status bit in the SYNC register (bit 3) indicate the failure.

Remote command:
[SENSe:]SWEep:LIMit:ABORt:STATe on page 287

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 7).

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 281
[SENSe:]BURSt:COUNt on page 281

Source of Payload Length

Defines which signal source is used to determine the payload length of a PPDU.

"Take from Signal Field" [(IEEE 802.11a, j, p)]
Uses the length defined by the signal field

"L-Signal" [(IEEE 802.11ac, ax)]
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 280

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, ax, g (OFDM), j, n, p, be
[SENSe:]DEMod:FORMat:BANalyze:SYMBols:EQUal on page 284
IEEE 802.11 b, g (DSSS):

`[SENSe:]DEMod:FORMat:BANalyze:DURation:EQUal` on page 283

`[SENSe:]DEMod:FORMat:BANalyze:DBYTes:EQUal` on page 282

(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 286

`[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MAX` on page 286

Analysis Interval Offset/Analysis Interval Length

The analysis interval defines the symbol range that is actually evaluated by the individual result display. By default it is defined as the length of the detected PPDU, possibly restricted by the minimum or maximum number of data symbols. However, it can be restricted further.

The "Analysis Interval Offset" specifies the number of data symbols from the start of each PPDU that are to be skipped before symbols take part in analysis.

If "Analysis Interval Length" is enabled, then the number of PPDU data symbols after the "Analysis Interval Offset" which are to be analyzed can be specified.

If "Analysis Interval Length" is disabled, then all PPDU data symbols after the "Analysis Interval Offset" are evaluated.

Remote command:

`[SENSe:]DEMod:FORMat:BANalyze:SYMBols:OFFSet` on page 287

`[SENSe:]DEMod:FORMat:BANalyze:SYMBols:LENGth:STATe` on page 285

`[SENSe:]DEMod:FORMat:BANalyze:SYMBols:LENGth` on page 285

4.8.2 Evaluation range settings for IEEE 802.11b, g (DSSS)

Access: "Overview" > "Evaluation Range"

The following settings are available to configure the evaluation range for standards IEEE 802.11b, g (DSSS).

Figure 4-10: 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 considera-
tion 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 7).

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 281
[SENSe:]BURSt:COUNt on page 281

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, ax, g (OFDM), j, n, p, be
`[SENSe:]DEMod:FORMat:BANalyze:SYMBols:EQUal` on page 284
IEEE 802.11 b, g (DSSS):
`[SENSe:]DEMod:FORMat:BANalyze:DURation:EQUal` on page 283
`[SENSe:]DEMod:FORMat:BANalyze:DBYTes:EQUal` on page 282

(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 127).

Remote command:
`[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MIN` on page 283
`[SENSe:]DEMod:FORMat:BANalyze:DURation:MIN` on page 284
`[SENSe:]DEMod:FORMat:BANalyze:DBYTes:MAX` on page 283
`[SENSe:]DEMod:FORMat:BANalyze:DURation:MAX` on page 284

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 38.

Remote command:
`CONFigure:BURSt:PVT:AVERage` on page 280

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 38.

Remote command:
`CONFigure:BURSt:PVT:RPOWer` on page 280

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 280

4.9   Result configuration

Access: "Meas Setup" > "Result Config"

This function is only available if a window with additional settings is currently selected.

Depending on the selected result display, different settings are available.

4.9.1   Result summary configuration

Access: "Meas Setup" > "Result Config"

You can configure which results are displayed in "Result Summary" displays (see "Result Summary Global" on page 43 and "Result Summary Detailed" on page 41). However, the results are always *calculated*, regardless of their visibility on the screen.
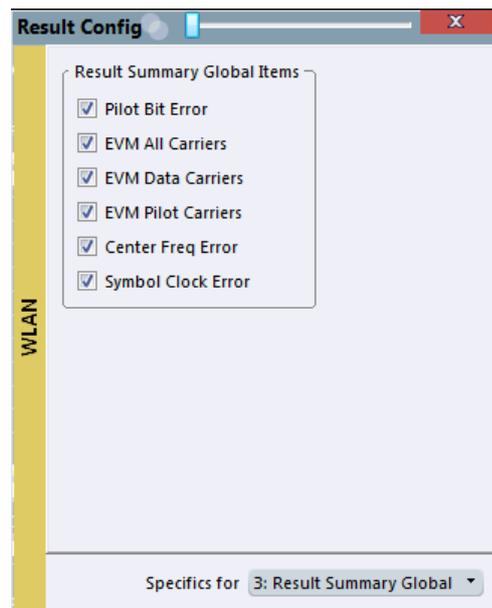
Figure 4-11: Result Summary Global configuration for IEEE 802.11a, ac, ax, g (OFDM), j, n, p, be standards

Remote command:

DISPlay[:WINDow<n>]:TABLe:ITEM on page 311

4.9.2   Spectrum flatness and group delay configuration

Access: "Meas Setup" > "Result Config"
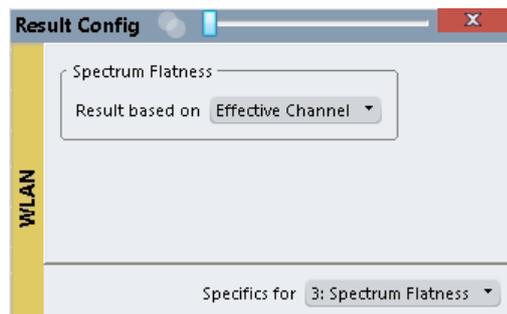
Result based on

"Spectrum Flatness" and "Group Delay" results can be based on either the effective channels or the physical channels.

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

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 3.3.3, "Physical vs effective channels", on page 68.

Remote command:
CONFigure:BURSt:SPECtrum:FLATness:CSELect on page 313

Units

Switches between relative (dB) and absolute (dBm) results.

Remote command:
UNIT:SFLatness on page 313

4.9.3 AM/AM configuration

Access: "Meas Setup" > "Result"

For AM result displays some additional configuration settings are available.

- General AM/AM settings.. 164

4.9.3.1 General AM/AM settings

Access: "Meas Setup" > "Result"
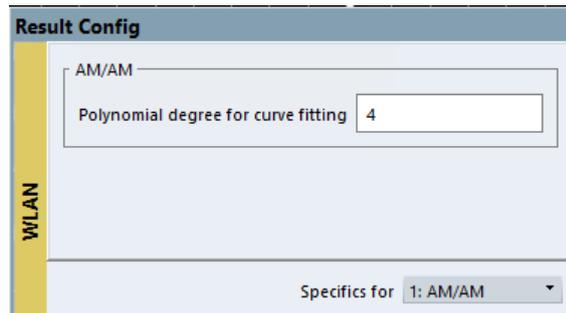
Polynomial degree for curve fitting

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 22). 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 314
Resulting coefficients:
FETCh:BURSt:AM:AM:COEFicients? on page 321

4.10 Automatic settings

Access: [AUTO SET] toolbar

Some settings can be adjusted by the R&S VSE automatically according to the current measurement settings and signal characteristics.

Setting the Reference Level Automatically (Auto Level)
The connected instrument 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. This function is not available on all supported instruments.

Remote command:
[SENSe<ip>:]ADJust:LEVel on page 292

Auto Settings Configuration
For some automatic settings, additional parameters can be configured. The "Auto Set Config" dialog box is available when you select the icon from the "Auto Set" toolbar.
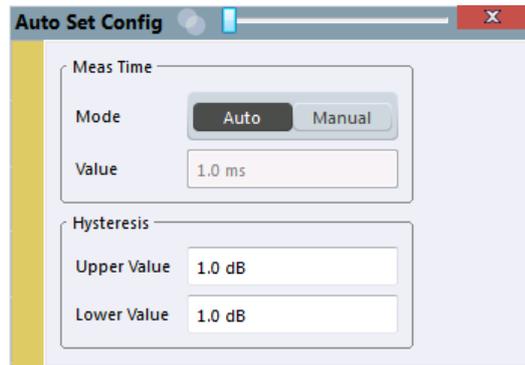
Automatic Measurement Time Mode and Value ← Auto Settings Configuration
To determine the optimal reference level automatically, a level measurement is performed on the connected instrument. You can define whether the duration of this measurement is determined automatically or manually.

To define the duration manually, enter a value in seconds.

Remote command:
[SENSe<ip>:]ADJust:CONFigure:LEVel:DURation:MODE on page 293
[SENSe<ip>:]ADJust:CONFigure:LEVel:DURation on page 292

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

Remote command:
[SENSe<ip>:]ADJust:CONFigure:HYSTeresis:UPPer on page 294

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

Remote command:
[SENSe<ip>:]ADJust:CONFigure:HYSTeresis:LOWer on page 293

5 Analysis

General result analysis settings concerning the trace and markers etc. are currently not available for the standard WLAN I/Q measurements. Only one (Clear/Write) trace and one marker are available for these measurements.

The remote commands required to perform these tasks are described in Chapter 8.7, "Analysis", on page 357.

Place New Marker
Activates the next currently unused marker and sets it to the peak value of the current trace in the current window.

All Markers Off

Deactivates all markers in one step.

Remote command:
CALCulate<n>:MARKer<m>:AOFF on page 358

6 How to perform measurements in the R&S VSE WLAN application

The following step-by-step instructions demonstrate how to perform measurements in the R&S VSE WLAN application.

6.1 How to determine modulation accuracy, flatness and tolerance parameters for WLAN signals

1. Open a new channel or replace an existing one and select the "WLAN 802.11" application.

2. Configure the input source to be used as described in the R&S VSE Base Software User Manual.

3. Select the "Meas Setup > Overview" menu item to display the "Overview" for a WLAN 802.11 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 🗗 "Add Window" icon from the toolbar to add further result displays for the WLAN 802.11 channel.

12. Select the ▶ "Capture" icon from the toolbar to start a new measurement with the defined settings.

Measurement results are updated once the measurement has completed.

6.2 How to analyze WLAN signals in a MIMO measurement setup

MIMO measurements are only available for IEEE IEEE 802.11ac, ax, n, be standards. They can be performed automatically or manually (see Chapter 3.3.4, "Capturing data from MIMO antennas", on page 70).

To perform a manual sequential measurement

1. Open a new channel or replace an existing one and select the "WLAN 802.11" application.

2. Configure the input source to be used as described in the R&S VSE Base Software User Manual.

3. Select the "Meas Setup > Overview" menu item to display the "Overview" for a WLAN 802.11 measurement.

4. Select the "Signal Description" button to select one of the following digital standards:

   - *IEEE 802.11ac*
   - *IEEE 802.11ax*
   - *IEEE 802.11be*
   - *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 VSE.
    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 VSE.
    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.

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. Open a new channel or replace an existing one and select the "WLAN 802.11" application.

2. Configure the input source to be used as described in the R&S VSE Base Software User Manual.

3. Select the "Meas Setup > Overview" menu item to display the "Overview" for a WLAN 802.11 measurement.

4. Select the "Signal Description" button to select one of the following digital standards:

   - *IEEE 802.11ac*
   - *IEEE 802.11ax*
   - *IEEE 802.11be*
   - *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 VSE.
   e) Connect the antennas and the R&S VSE 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.

7 Optimizing and troubleshooting the measurement

7.1 Optimizing the measurement results

If the results do not meet your expectations, try the following methods to optimize the measurement.

7.1.1 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 121). In this case, the R&S VSE 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.

7.1.2 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 122).

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 124).

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 124).

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 R&S VSE 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 125), 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.

7.2 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 VSE 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 VSE 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.

8 Remote commands for WLAN measurements

The following commands are required to perform measurements in the R&S VSE WLAN application in a remote environment.

It is assumed that the R&S VSE has already been set up for remote control in a network as described in the R&S VSE Base Software User Manual.

General R&S VSE Remote Commands

The application-independent remote commands for general tasks on the R&S VSE are also available for Analog Demodulation measurements and are described in the R&S VSE Base Software User Manual. In particular, this comprises the following functionality:

●   Controlling instruments and capturing data

●   Managing Settings and Results

●   Setting Up the Instrument

●   Using the Status Register

Channel-specific commands

Apart from a few general commands on the R&S VSE, most commands refer to the currently active channel. Thus, always remember to activate a WLAN 802.11 channel before starting a remote program for a WLAN 802.11 measurement.

8.1 Common suffixes

In the R&S VSE WLAN application, the following common suffixes are used in remote commands:

Table 8-1: Common suffixes used in remote commands in the R&S VSE WLAN application

Suffix	Value range	Description
<m>	1 to 4	Marker
<n>	1 to x	Window (**in the currently selected channel**)
<t>	1	Trace
	1 to 8	Limit line

8.2 Introduction

Commands are program messages that a controller (e.g. a PC) sends to the instrument or software. They operate its functions ('setting commands' or 'events') and request information ('query commands'). Some commands can only be used in one way, others work in two ways (setting and query). If not indicated otherwise, the commands can be used for settings and queries.

The syntax of a SCPI command consists of a header and, usually, one or more parameters. To use a command as a query, you have to append a question mark after the last header element, even if the command contains a parameter.

A header contains one or more keywords, separated by a colon. Header and parameters are separated by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank). If there is more than one parameter for a command, they are separated by a comma from one another.

Only the most important characteristics that you need to know when working with SCPI commands are described here. For a more complete description, refer to the user manual of the R&S VSE.

Remote command examples

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

8.2.1 Conventions used in descriptions

The following conventions are used in the remote command descriptions:

- **Command usage**
  If not specified otherwise, commands can be used both for setting and for querying parameters.
  If a command can be used for setting or querying only, or if it initiates an event, the usage is stated explicitly.

- **Parameter usage**
  If not specified otherwise, a parameter can be used to set a value and it is the result of a query.
  Parameters required only for setting are indicated as **Setting parameters**.
  Parameters required only to refine a query are indicated as **Query parameters**.

Parameters that are only returned as the result of a query are indicated as **Return values**.

- **Conformity**
  Commands that are taken from the SCPI standard are indicated as **SCPI confirmed**. All commands used by the R&S VSE follow the SCPI syntax rules.

- **Asynchronous commands**
  A command which does not automatically finish executing before the next command starts executing (overlapping command) is indicated as an **Asynchronous command**.

- **Reset values (*RST)**
  Default parameter values that are used directly after resetting the instrument (`*RST` command) are indicated as ***RST** values, if available.

- **Default unit**
  The default unit is used for numeric values if no other unit is provided with the parameter.

- **Manual operation**
  If the result of a remote command can also be achieved in manual operation, a link to the description is inserted.

8.2.2 Long and short form

The keywords have a long and a short form. You can use either the long or the short form, but no other abbreviations of the keywords.

The short form is emphasized in uppercase letters. Note however, that this emphasis only serves the purpose to distinguish the short from the long form in the manual. For the instrument, the case does not matter.

Example:

`SENSe:FREQuency:CENTer` is the same as `SENS:FREQ:CENT`.

8.2.3 Numeric suffixes

Some keywords have a numeric suffix if the command can be applied to multiple instances of an object. In that case, the suffix selects a particular instance (e.g. a measurement window).

Numeric suffixes are indicated by angular brackets (<n>) next to the keyword.

If you do not quote a suffix for keywords that support one, a 1 is assumed.

Example:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe` enables the zoom in a particular measurement window, selected by the suffix at `WINDow`.

`DISPlay:WINDow4:ZOOM:STATe ON` refers to window 4.

8.2.4 Optional keywords

Some keywords are optional and are only part of the syntax because of SCPI compliance. You can include them in the header or not.

ⓘ If an optional keyword has a numeric suffix and you need to use the suffix, you have to include the optional keyword. Otherwise, the suffix of the missing keyword is assumed to be the value 1.

Optional keywords are emphasized with square brackets.

Example:

Without a numeric suffix in the optional keyword:

`[SENSe:]FREQuency:CENTer` is the same as `FREQuency:CENTer`

With a numeric suffix in the optional keyword:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe`

`DISPlay:ZOOM:STATe ON` enables the zoom in window 1 (no suffix).

`DISPlay:WINDow4:ZOOM:STATe ON` enables the zoom in window 4.

8.2.5 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`.

8.2.6 SCPI parameters

Many commands feature one or more parameters.

If a command supports more than one parameter, they are separated by a comma.

Example:

`LAYout:ADD:WINDow Spectrum,LEFT,MTABle`

Parameters can have different forms of values.

8.2.6.1 Numeric values

Numeric values can be entered in any form, i.e. with sign, decimal point or exponent. For physical quantities, you can also add the unit. If the unit is missing, the command uses the basic unit.

Example:

With unit: `SENSe:FREQuency:CENTer 1GHZ`

Without unit: `SENSe:FREQuency:CENTer 1E9` would also set a frequency of 1 GHz.

Values exceeding the resolution of the instrument are rounded up or down.

If the number you have entered is not supported (e.g. for discrete steps), the command returns an error.

Instead of a number, you can also set numeric values with a text parameter in special cases.

- MIN/MAX
  Defines the minimum or maximum numeric value that is supported.
- DEF
  Defines the default value.
- UP/DOWN
  Increases or decreases the numeric value by one step. The step size depends on the setting. Sometimes, you can customize the step size with a corresponding command.

Querying numeric values

When you query numeric values, the system returns a number. For physical quantities, it applies the basic unit (e.g. Hz for frequencies). The number of digits after the decimal point depends on the type of numeric value.

Example:

Setting: `SENSe:FREQuency:CENTer 1GHZ`

Query: `SENSe:FREQuency:CENTer?` would return `1E9`

Sometimes, numeric values are returned as text.

- INF/NINF
  Infinity or negative infinity. Represents the numeric values 9.9E37 or -9.9E37.
- NAN
  Not a number. Represents the numeric value 9.91E37. NAN is returned if errors occur.

8.2.6.2 Boolean

Boolean parameters represent two states. The "on" state (logically true) is represented by "`ON`" or the numeric value 1. The "off" state (logically untrue) is represented by "`OFF`" or the numeric value 0.

Querying Boolean parameters

When you query Boolean parameters, the system returns either the value 1 ("ON") or the value 0 ("OFF").

Example:

Setting: `DISPlay:WINDow:ZOOM:STATe ON`

Query: `DISPlay:WINDow:ZOOM:STATe?` would return 1

8.2.6.3 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 8.2.2, "Long and short form", on page 177.

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`

8.2.6.4 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'`

8.2.6.5 Block data

Block data is a format which is suitable for the transmission of large amounts of data.

The ASCII character # introduces the data block. The next number indicates how many of the following digits describe the length of the data block. The data bytes follow. During the transmission of these data bytes, all end or other control signs are ignored until all bytes are transmitted. #0 specifies a data block of indefinite length. The use of the indefinite format requires an `NL^END` message to terminate the data block. This format is useful when the length of the transmission is not known or if speed or other considerations prevent segmentation of the data into blocks of definite length.

8.3 Activating WLAN 802.11 measurements

WLAN 802.11 measurements require a special application in the R&S VSE. The common commands for configuring and controlling measurement channels, as well as blocks and sequences, are also used in the R&S VSE WLAN application.

They are described in the R&S VSE base software user manual.

8.4 Configuring the WLAN I/Q measurement (Modulation accuracy, flatness and tolerance)

The following commands are required to configure the WLAN I/Q measurement described in Chapter 2, "WLAN I/Q measurement (modulation accuracy, flatness and tolerance)", on page 9.

8.4.1 Restoring the default configuration (Preset)

SYSTem:PRESet:CHANnel[:EXEC]

Restores the default software 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 92

8.4.2 Signal description

The signal description provides information on the expected input signal.

Useful commands for describing the WLAN signal described elsewhere:

- [SENSe<ip>:]FREQuency:CENTer on page 219

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
	4
	IEEE 802.11g
	To distinguish between OFDM and DSSS use the command [SENSe:]DEMod:FORMat:BANalyze:BTYPe on page 259. By default, the R&S VSE 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
	10
	IEEE 802.11ax
	11
	IEEE 802.11be
	*RST: 0
Example:	Select IEEE 802.11g OFDM standard: CONF:STAN 4 SENS:DEM:FORM:BAN:BTYP 'OFDM'
Manual operation:	See "Standard" on page 93

CALCulate\<n>:LIMit\<li>:TOLerance \<Limit>

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

Suffix:

\<n>	1..n irrelevant
\	1..n irrelevant

Parameters:

\<Limit>

     'Prior802_11_2012'
Tolerance limits are based on the IEEE 802.11 specification **prior to 2012**.
Default for OFDM standards (except 802.11ac).

     'Std802_11_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).

     'P802_11acD5_1'
Tolerance limits are based on the **IEEE 802.11ac** specification.
Required by IEEE 802.11ac standard.

     'P802_11axD0_1'
Tolerance limits are based on the **IEEE 802.11ax** specification.
Required by IEEE 802.11ax standard.

     'P802_11beD0_1'
Tolerance limits are based on the **IEEE 802.11be** specification.
Required by IEEE 802.11be standard.

     *RST: 'Std802_11_2012'

Example: CALC:LIM:TOL 'Std802_11_2012'

Manual operation: See "Tolerance Limit" on page 93

8.4.3 Configuring data input

The following commands are required to configure data input.

Data output is described in the R&S VSE Base Software User Manual.

8.4.3.1 RF input

Remote commands exclusive to configuring RF input:

INPut<ip>:ATTenuation:PROTection[:STATe] <State>

Turns the availability of attenuation levels of 10 dB or less on and off.

Suffix:

<ip>	1..n

Parameters:

<State>	ON | OFF | 1 | 0
	ON | 1
	Attenuation levels of 10 dB or less are not allowed to protect the RF input connector of the connected instrument.
	OFF | 0
	Attenuation levels of 10 dB or less are not blocked. Provide appropriate protection for the RF input connector of the connected instrument yourself.
	*RST: 1

Example:	`INP:ATT:PROT ON`
	Turns on the input protection.

INPut:ATTenuation:PROTection:RESet [<DeviceName>]

Resets the attenuator and reconnects the RF input with the input mixer for the connected instrument 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 the instrument's documentation.

Setting parameters:

<DeviceName>	string
	Name of the instrument for which the RF input protection is to be reset.

Example: `INP:ATT:PROT:RES 'MyDevice'`

Manual operation: See "10 dB Minimum Attenuation" on page 100

INPut<ip>:COUPling<ant> <CouplingType>

Selects the coupling type of the RF input.

Suffix:

<ip>	1 | 2
	irrelevant
<ant>	Input source (for MIMO measurements only)

Parameters:

<CouplingType>	AC | DC
	AC
	AC coupling
	DC
	DC coupling
	*RST: AC

Example: `INP:COUP DC`

Manual operation: See "Input Coupling" on page 96

INPut<ip>:DPATh <DirectPath>

Enables or disables the use of the direct path for frequencies close to 0 Hz.

Suffix:

<ip>	1..n

Parameters:

<DirectPath>	AUTO | OFF
	AUTO | 1
	(Default) the direct path is used automatically for frequencies close to 0 Hz.

OFF | 0
The analog mixer path is always used.

Example:	INP:DPAT OFF
Manual operation:	See "Direct Path" on page 96

INPut<ip>:FILE:ZPADing <State>

Enables or disables zeropadding for input from an I/Q data file that requires resampling. For resampling, a number of samples are required due to filter settling. These samples can either be taken from the provided I/Q data, or the software can add the required number of samples (zeros) at the beginning and end of the file.

Suffix:
<ip>   1..n

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

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example:	INP:FILE:ZPAD ON
Manual operation:	See "Zero Padding" on page 102

INPut<ip>: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 connected instrument to measure the harmonics for a DUT, for example.

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.)

Suffix:
<ip>   1..n

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

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example: INP:FILT:HPAS ON
                     Turns on the filter.

Manual operation: See "High Pass Filter 1 to 3 GHz" on page 97

INPut<ip>:FILTer:YIG[:STATe] <State>

Enables or disables the YIG filter.

Suffix:
<ip>   1 | 2
                     irrelevant

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

Example: INP:FILT:YIG OFF
                     Deactivates the YIG-preselector.

Manual operation: See "YIG-Preselector" on page 97

INPut<ip>:IMPedance<ant> <Impedance>

Selects the nominal input impedance of the RF input. In some applications, only 50 Ω
are supported.

Suffix:
<ip>   1 | 2
                     irrelevant

<ant>   Input source (for MIMO measurements only)

Parameters:
<Impedance>   50 | 75

                     *RST: 50 Ω
                     Default unit: OHM

Example: INP:IMP 75

Manual operation: See "Impedance" on page 96
                     See "Unit" on page 105

INPut<ip>:PRESelection:SET <Mode>

Selects the preselector mode.

The command is available with the optional preselector.

Suffix:

<ip>　　　　　　　　　1..n

Parameters:

<Mode>　　　　　　　　**NARRow**

Performs a measurement by automatically applying all available combinations of low and high pass filters consecutively. These combinations all have a narrow bandwidth.

WIDE

Performs a measurement by automatically applying all available bandpass filters consecutively. The bandpass filters have a wide bandwidth.

Manual operation:　　See "Preselector Mode" on page 99

INPut<ip>:PRESelection[:STATe] <State>

Turns the preselector on and off.

Suffix:

<ip>　　　　　　　　　1 | 2
　　　　　　　　　　　irrelevant

Manual operation:　　See "Preselector State" on page 99

INPut<ip>:RF:CAPMode <CAPMode>

Determines how data from an oscilloscope is input to the R&S VSE software.

Is only available for connected oscilloscopes.

Suffix:

<ip>　　　　　　　　　1..n

Parameters:

<CAPMode>　　　　　　AUTO | IQ | WAVeform

IQ

The measured waveform is converted to I/Q data directly on the R&S oscilloscope (requires option K11), and input to the R&S VSE software as I/Q data.

WAVeform

The data is input in its original waveform format and converted to I/Q data in the R&S VSE software. No additional options are required on the R&S oscilloscope.

AUTO

Uses "I/Q" mode when possible, and "Waveform" only when required by the application (e.g. Pulse measurement).

*RST:　　　　IQ

Example:　　　　　　`INP:RF:CAPM WAV`

Manual operation:　　See "Capture Mode" on page 97

INPut\<ip\>:RF:CAPMode:IQ:SRATe \<SamplingRate\>

Determines the sample rate used by the connected oscilloscope for I/Q capture mode (see `INPut<ip>:RF:CAPMode` on page 188).

This setting is only available if an R&S oscilloscope is used to obtain the input data.

Suffix:

\<ip\>   1..n

Parameters:

\<SamplingRate\>   20 GHz | 40 GHz

No other sample rate values are allowed.

20 GHz
Achieves a higher decimation gain, but reduces the record length by half.
Only available for R&S oscilloscope models that support a sample rate of 20 GHz (see data sheet).

40 GHz
Provides a maximum sample rate.
Only available for R&S RTP13/RTP16 models that support a sample rate of 40 GHz (see data sheet).

*RST: 20 GHz
Default unit: HZ

Example: `INP:RF:CAPM IQ`
`INP:RF:CAPM:IQ:SRAT 40 GHZ`

Manual operation: See "Oscilloscope Sample Rate" on page 98

INPut\<ip\>:RF:CAPMode:WAVeform:SRATe \<SamplingRate\>

Determines the sample rate used by the connected oscilloscope for waveform capture mode (see `INPut<ip>:RF:CAPMode` on page 188).

This setting is only available if an R&S oscilloscope is used to obtain the input data, either directly or via the R&S FSW.

Suffix:

\<ip\>   1..n

Parameters:

\<SamplingRate\>   10 GHz | 20 GHz

No other sample rate values are allowed.

10 GHz
Default ; provides maximum record length

20 GHz

Achieves a higher decimation gain, but reduces the record length by half.

Only available for R&S oscilloscope models that support a sample rate of 20 GHz (see data sheet).

For R&S oscilloscopes with an analysis bandwidth of 4 GHz or larger, a sample rate of 20 GHZ is always used.

*RST: 10 GHz
Default unit: HZ

| Example: | INP:RF:CAPM WAV |
| | INP:RF:CAPM:WAVE:SRAT 10000000 |

Manual operation: See "Oscilloscope Sample Rate" on page 98

INPut:SELect <Source>

Selects the signal source for measurements, i.e. it defines which connector is used to input data to the R&S VSE.

If no additional input options are installed, only RF input or file input is supported.

Tip: The I/Q data to be analyzed for WLAN 802.11 cannot only be measured by the R&S VSE 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 R&S VSE WLAN application can be exported for further analysis in external applications.

For details, see the R&S VSE I/Q Analyzer and I/Q Input User Manual.

Parameters:

<Source>   **RF**
                  Radio Frequency ("RF INPUT" connector)

                  FIQ
                  I/Q data file

                  AIQ
                  Analog Baseband signal (only available with optional "Analog Baseband" interface)

                  *RST: RF

Manual operation: See "Input Type (Instrument / File)" on page 95

INPut:TYPE <Input>

The command selects the input path for R&S FSW85 models.

Parameters:

<Input>   **INPUT1**
                 Selects RF input 1.

                 INPUT2
                 Selects RF input 2.

                 *RST: INPUT1

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

Manual operation: See "Input 1 / Input 2" on page 95

INSTrument:BLOCk:CHANnel[:SETTings]:SOURce<si> <Type>

Selects an instrument or a file as the source of input provided to the channel.

Suffix:
<si>   1 to 99
                     LTE-MIMO only: input source number

Parameters:
<Type>   FILE | DEVice | NONE

                     FILE
                     A loaded file is used for input.

                     DEVice
                     A configured device provides input for the measurement

                     NONE
                     No input source defined.

Manual operation: See "Input Type (Instrument / File)" on page 95

INSTrument:BLOCk:CHANnel[:SETTings]:SOURce<si>:CONFig <Port>

Configures the port to be used for input on the selected instrument.

Is only available if an oscilloscope is connected.

Suffix:
<si>   1 to 99
                     LTE-MIMO only: input source number

Parameters:
<Port>

INSTrument:BLOCk:CHANnel[:SETTings]:SOURce<si>:TYPE <Source>

Configures the source of input to be used from the selected instrument.

Not all input sources are supported by all R&S VSE applications.

Suffix:
<si>   1 to 99
                     LTE-MIMO only: input source number

Parameters:
<Source>   **RF**
                     Radio Frequency ("RF INPUT" connector)

                     'Channel 1' | 'Channel 2' | 'Channel 3' | 'Channel 4'
                     Oscilloscope input channel 1, 2, 3, or 4

'Channel 1,2 (I+Q)'

I/Q data provided by oscilloscope input channels 1 and 2 (for oscilloscopes with 2 channels only)

'Channel 1,3 (I+Q)' | 'Channel 2,4 (I+Q)'

I/Q data provided by oscilloscope input channels 1 and 3, or 2 and 4 (for oscilloscopes with 4 channels only)

'Channels 1-4 (diff. I+Q)'

Differential I/Q data provided by oscilloscope input channels (for oscilloscopes with 4 channels only):

Channel 1: I (pos.)

Channel 2: $\bar{I}$ (neg.)

Channel 3: Q (pos.)

Channel 4: $\bar{Q}$ (neg.)

'Channels 1,3 (Waveform)'

Waveform data provided by oscilloscope input channels 1 and 3 (for oscilloscopes with 2 channels only)

'Channels 2,4 (Waveform)'

Waveform data provided by oscilloscope input channels 2 and 4 (for oscilloscopes with 2 channels only)

'Channels 1-4 (Waveform)'

Waveform data provided by oscilloscope input channels 1 to 4 (for oscilloscopes with 4 channels only)

*RST: RF

Example: INST:BLOC:CHAN:SOUR:TYPE 'Channel 2,4 (I+Q)'

I/Q data is provided by oscilloscope input channels 2 and 4

SYSTem:COMMunicate:RDEVice:OSCilloscope[:STATe] <State>

Activates the optional 2 GHz bandwidth extension (R&S FSW-B2000).

Note: Manual operation on the connected oscilloscope, or remote operation other than by the R&S VSE, is not possible while the B2000 option is active.

Parameters:

<State>   ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: SYST:COMM:RDEV:OSC ON

Manual operation: See "B2000 State" on page 98

SYSTem:COMMunicate:RDEVice:OSCilloscope:TCPip <Address>

Defines the TCPIP address or computer name of the oscilloscope connected to the R&S VSE via LAN.

Note: The IP address is maintained after a [PRESET], and is transferred between applications.

Parameters:

<Address>   computer name or IP address

Example: SYST:COMM:RDEV:OSC:TCP '192.0.2.0'

Example: SYST:COMM:RDEV:OSC:TCP 'FSW43-12345'

Manual operation: See "Oscilloscope IP Address" on page 99

SYSTem:COMMunicate:RDEVice:OSCilloscope:PSMode[:STATe] <State>

Activates the use of the power splitter inserted between the "IF 2 GHZ OUT" connector of the R&S VSE and the "CH1" and "CH3" input connectors of the oscilloscope. Note that this mode requires an additional alignment with the power splitter.

For details see the R&S FSW I/Q Analyzer and I/Q Input User Manual

Parameters:

<State>   ON | OFF | 0 | 1

                         OFF | 0
                         Switches the function off

                         ON | 1
                         Switches the function on

Example: SYST:COMM:RDEV:OSC:PSM ON

Manual operation: See "Oscilloscope Splitter Mode" on page 99

SYSTem:COMMunicate:RDEVice:OSCilloscope:SRATe <Rate>

Determines whether the 10 GHz mode (default) or 20 GHz mode of the connected oscilloscope is used. The 20 GHZ mode achieves a higher decimation gain, but reduces the record length by half.

Parameters:

<Rate>   10 GHz | 20 GHz

                         No other sample rate values are allowed.

                         *RST: 10 GHz
                         Default unit: HZ

Example: TRAC:IQ:SRAT?
                         //Result: 100000000
                         TRAC:IQ:RLEN?
                         //Result: 3128
                         SYST:COMM:RDEV:OSC:SRAT 20GHZ
                         TRAC:IQ:SRAT?
                         //Result: 200000000
                         TRAC:IQ:RLEN?
                         //Result: 1564

Manual operation: See "Oscilloscope Sample Rate" on page 98

SYSTem:COMMunicate:RDEVice:OSCilloscope:VDEVice?

Queries whether the connected instrument is supported by the 2 GHz bandwidth extension option(B2000).

Return values:

<State>   ON | OFF | 0 | 1

                 OFF | 0
                 Switches the function off

                 ON | 1
                 Switches the function on

Example: `SYST:COMM:RDEV:OSC:VDEV?`

Usage: Query only

SYSTem:COMMunicate:RDEVice:OSCilloscope:VFIRmware?

Queries whether the firmware on the connected oscilloscope is supported by the 2 GHz bandwidth extension (B2000) option.

Return values:

<State>   ON | OFF | 0 | 1

                 OFF | 0
                 Switches the function off

                 ON | 1
                 Switches the function on

Example: `SYST:COMM:RDEV:OSC:VFIR?`

Usage: Query only

8.4.3.2 Using external mixers

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

Basic settings

The basic settings concern general usage of an external mixer.

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

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

Suffix:

<x>   1..n
                        irrelevant

Parameters:

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

Example: MIX ON

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

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

Is only available if the external mixer is active (see [SENSe:]MIXer<x>[:STATe] on page 195).

Suffix:

<x>   1..n
                        irrelevant

Parameters:

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

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

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

Is only available if the external mixer is active (see [SENSe:]MIXer<x>[:STATe] on page 195).

Suffix:

<x>   1..n
                        irrelevant

Parameters:

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

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

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

Suffix:

<x>   1..n
                         irrelevant

Parameters:

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

Example: `MIX:LOP 16.0dBm`

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

Specifies whether automatic signal detection is active or not.

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

Suffix:

<x>   1..n
                         irrelevant

Parameters:

<State>   OFF | ON | AUTO | ALL

                         OFF | ON | AUTO | ALL

                         OFF
                         No automatic signal detection is active.

                         ON
                         Automatic signal detection (Signal ID) is active.

                         AUTO
                         Automatic signal detection (Auto ID) is active.

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

                         *RST: OFF

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

Defines the maximum permissible level difference between test sweep and reference sweep to be corrected during automatic comparison (see `[SENSe:]MIXer<x>:SIGNal` on page 196).

Suffix:

<x>   1..n
                         irrelevant

Parameters:

<Value>   <numeric value>

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

Example: `MIX:PORT 3`

Mixer settings

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

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

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

Is only available if the external mixer is active (see `[SENSe:]MIXer<x>[:STATe]` on page 195).

Suffix:

<x>   1..n
                           irrelevant

Parameters:

<Frequency>   Default unit: HZ

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

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

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

Suffix:

<x>	1..n irrelevant

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

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

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

Suffix:

<x>	1..n irrelevant

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

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

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

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

Suffix:

<x>	1..n irrelevant

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

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

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

Is only available if the external mixer is active (see `[SENSe:]MIXer<x>[:STATe]` on page 195).

Suffix:

<x>	1..n irrelevant

Parameters:

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

Table 8-2: Frequency ranges for pre-defined bands

Band	Frequency start [GHz]	Frequency stop [GHz]
KA (A) *)	26.5	40.0
Q	33.0	50.0
U	40.0	60.0
V	50.0	75.0
E	60.0	90.0
W	75.0	110.0
F	90.0	140.0
D	110.0	170.0
G	140.0	220.0
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<x>:HARMonic:HIGH:STATe <State>

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

Suffix:

<x>　　　　　　　　　　1..n

Parameters:

<State>　　　　　　　　ON | OFF

　　　　　　　　　　　*RST:　　　　ON

Example:　　　　　　MIX:HARM:HIGH:STAT ON

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

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

Suffix:

<x>　　　　　　　　　　1..n
　　　　　　　　　　　irrelevant

Parameters:

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

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

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

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

Which harmonics are supported depends on the mixer type.

Suffix:

<x>　　　　　　　　1..n
　　　　　　　　　　irrelevant

Parameters:

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

Example:　　　　MIX:HARM:TYPE ODD

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

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

Suffix:

<x>　　　　　　　　1..n
　　　　　　　　　　irrelevant

Example:　　　　MIX:HARM 3

[SENSe:]MIXer<x>:IF?

Queries the intermediate frequency currently used by the external mixer.

Suffix:

<x>　　　　　　　　1..n
　　　　　　　　　　irrelevant

Example:　　　　MIX:IF?

Example:　　　　See "Programming example: working with an external mixer"
　　　　　　　　　　on page 202.

Usage:　　　　　Query only

[SENSe:]MIXer<x>:LOSS:HIGH <Average>

Defines the average conversion loss to be used for the entire high (second) range.

Suffix:

<x>　　　　　　　　1..n

Parameters:

<Average>　　　　Range:　　　0 to 100
　　　　　　　　　　*RST:　　　24.0 dB
　　　　　　　　　　Default unit: dB

Example:　　　　MIX:LOSS:HIGH 20dB

[SENSe:]MIXer<x>:LOSS:TABLe:HIGH <FileName>

Defines the conversion loss table to be used for the high (second) range.

Suffix:

<x>   1..n

Parameters:

<FileName>   String containing the path and name of the file, or the serial
                       number of the external mixer whose file is required. The
                       R&S VSE automatically selects the correct cvl file for the current
                       IF. As an alternative, you can also select a user-defined conver-
                       sion loss table (`.acl` file).

[SENSe:]MIXer<x>:LOSS:TABLe[:LOW] <FileName>

Defines the file name of the conversion loss table to be used for the low (first) range.

Suffix:

<x>   1..n

Parameters:

<FileName>   String containing the path and name of the file, or the serial
                       number of the external mixer whose file is required. The
                       R&S VSE automatically selects the correct cvl file for the current
                       IF. As an alternative, you can also select a user-defined conver-
                       sion loss table (`.acl` file).

Example: `MIX:LOSS:TABL '101567'`
                      `MIX:LOSS:TABL?`
                      `//Result:`
                      `'101567_MAG_6_B5000_3G5.B5G'`

[SENSe:]MIXer<x>:LOSS[:LOW] <Average>

Defines the average conversion loss to be used for the entire low (first) range.

Suffix:

<x>   1..n

Parameters:

<Average>   Range: 0 to 100
                       *RST: 24.0 dB
                       Default unit: dB

Example: `MIX:LOSS 20dB`

[SENSe:]MIXer<x>:PORTs <PortType>

Selects the mixer type.

Suffix:

<x>	1..n
	irrelevant

Parameters:

<PortType>	**2 | 3**
	2
	Two-port mixer.
	3
	Three-port mixer.
	*RST: 2

Example: MIX:PORT 3

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

If enabled, the band limits are extended beyond "RF Start" and "RF Stop" due to the capabilities of the used harmonics.

Suffix:

<x>	1..n
	irrelevant

Parameters:

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

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
```

8.4.3.3 Remote commands for external frontend control

The following commands are available and required only if the optional external frontend control is installed on the connected instrument.

Further commands for external frontend control described elsewhere:

Commands for initial configuration

The following commands are required when you initially set up a measurement with an external frontend on the connected instrument. Note that some commands are not available for all connected instruments, or only as queries.

[SENSe:]EFRontend:ALIGnment<ch>:FILE <File>

Selects or queries the touchstone file that contains correction data to compensate for signal losses in the cable occurring at different IF signal frequencies.

Suffix:

<ch>	1..n Currently irrelevant

Parameters:

<File>	string in double quotes
	Path and file name of the correction data file. The file must be in `s2p` format. If the specified file is not found or does not have the correct format, an error message is returned (`-256, "File name not found", -150, "String data error"`).

Example: `EFR:ALIG:FILE "FE44S.s2p"`

[SENSe:]EFRontend:ALIGnment<ch>:STATe <State>

Activates correction of the IF signal due to cable loss from the frontend to the analyzer. Specify the file with correction data using [SENSe:]EFRontend:ALIGnment<ch>:FILE on page 204.

Suffix:

<ch>   1..n
                            Currently irrelevant

Parameters:

<State>   ON | OFF | 0 | 1
                            OFF | 0
                            Switches the function off
                            ON | 1
                            Switches the function on
                            *RST: 0

[SENSe:]EFRontend:CONNection[:STATe] <State>

Queries the external frontend connection state in the firmware.

Note: to query the physical connection state of the external frontend, use [SENSe:
]EFRontend:CONNection:CSTate? on page 206.

Parameters:

<State>   ON | OFF | 0 | 1
                            OFF | 0
                            The connection to the frontend is deactivated temporarily. The
                            frontend is thus available for use elsewhere, for example by a
                            signal generator. The measurement settings on the R&S VSE
                            remain untouched.
                            ON | 1
                            Frontend connection enabled.
                            The frontend is reserved for exclusive use by the R&S VSE.
                            *RST: 0

Example: //Global activation of external frontend
                            EFR ON
                            //Configure frontend
                            EFR:CONN:CONF "FE44S","123.456.789"
                            //Activate exclusive use of frontend by
                            R&S VSE.
                            EFR:CONN ON

[SENSe:]EFRontend:CONNection:CONFig <Type>, <IPAddress>[, <DeviceID>,
      <SymbolicName>]

Configures the connection to the external frontend.

Parameters:

<Type>   String in double quotes containing the type of frontend to be
                            connected.

<IPAddress>	string in double quotes
	The IP address or computer name of the frontend connected to the R&S VSE via LAN. The IP address and computer name are indicated on the electronic ink display on the side panel of the frontend.
<DeviceID>	string in double quotes
	Unique device ID consisting of <type>-<serialnumber> Not required or relevant for the R&S VSE.
<SymbolicName>	string in double quotes
	Symbolic name of the external frontend. Not required or relevant for the R&S VSE.
Example:	//Global activation of external frontend EFR ON //Configure frontend EFR:CONN:CONF "FE44S","123.456.789" //Activate exclusive use of frontend by R&S VSE. EFR:CONN ON

[SENSe:]EFRontend:CONNection:CSTate?

Queries the status of the physical connection to the external frontend.

Return values:

<State>	ON	OFF	0	1
	**OFF	0** Frontend not connected; connection error
	**ON	1** Frontend connected
Usage:	Query only

[SENSe:]EFRontend:FREQuency:BAND:COUNt?

Queries the number of frequency bands provided by the selected frontend.

Return values:

<NoBands>	integer
	Number of frequency bands
Example:	//Query number of frequency bands EFR:FREQ:BAND:COUN? //Result: 2
Usage:	Query only

[SENSe:]EFRontend:FREQuency:BAND<b>:LOWer?

Queries the start of the frequency range supported by the selected frontend frequency band.

Suffix:

<b>   1..n
                            Band for multi-band frontends
                            Use [SENSe:]EFRontend:FREQuency:BAND:COUNt?
                            on page 206 to determine the number of available bands.

Return values:

<StartFreq>   Start frequency of the specified band

Example: //Query start frequency of second band
                            EFR:FREQ:BAND2:LOW?
                            //Result: 24000000000

Usage: Query only

[SENSe:]EFRontend:FREQuency:BAND<b>:UPPer?

Queries the end of the frequency range supported by the selected frontend frequency band.

Suffix:

<b>   1..n
                            Band for multi-band frontends
                            Use [SENSe:]EFRontend:FREQuency:BAND:COUNt?
                            on page 206 to determine the number of available bands.

Return values:

<StopFreq>   End frequency of the specified band

Example: //Query end frequency of second band
                            EFR:FREQ:BAND2:UPP?
                            //Result: 44000000000

Usage: Query only

[SENSe:]EFRontend:FREQuency:BCONfig:AUTO <State>

Determines whether the frequency band of the external frontend is configured automatically or manually.

Parameters:

<State>   ON | OFF | 0 | 1

                            OFF | 0
                            Uses the frequency band configured by [SENSe:]EFRontend:
                            FREQuency:BCONfig:SELect on page 208.

                            ON | 1
                            Configures the frequency band automatically

                            *RST: 1

Example: //Configures the use of the IF high band manually.
                      `EFR:FREQ:BCON:AUTO 0`
                      `EFR:FREQ:BCON:SEL "IF HIGH"`

[SENSe:]EFRontend:FREQuency:BCONfig:LIST?

Returns the intermediate frequency (output) range of the external frontend.

Return values:

<BandConfigs>   string

                      "IF LOW"
                      A higher intermediate frequency is used on the external fron-
                      tend, resulting in a higher input frequency at the R&S VSE.

                      "IF HIGH"
                      A lower intermediate frequency is used on the external frontend,
                      resulting in a lower input frequency at the R&S VSE.

Example: `EFR:FREQ:BCON:LIST?`
                      `//Result: "IF HIGH", "IF LOW"`
                      `EFR:FREQ:BCON:SEL "IF HIGH"`

Usage: Query only

[SENSe:]EFRontend:FREQuency:BCONfig:SELect <BandConfig>

Defines the intermediate frequency (output) range of the external frontend.

Parameters:

<BandConfig>   **"IF HIGH"**
                      (R&S FE44S/ R&S FE50DTR)
                      A higher intermediate frequency is used on the external fron-
                      tend, resulting in a higher input frequency at the connected
                      instrument.

                      "IF LOW"
                      (R&S FE44S/ R&S FE50DTR)
                      A lower intermediate frequency is used on the external frontend,
                      resulting in a lower input frequency at the connected instrument.

                      "Spur Optimized"
                      (R&S FE170SR/R&S FE110SR only)
                      The selected IF range avoids unwanted spurious effects.

                      "EVM Optimized"
                      (R&S FE170SR/R&S FE110SR only)
                      The selected IF range provides an optimal EVM result.

                      "Shared LO"
                      (R&S FE170SR/R&S FE110SR only)
                      Ensures that multiple external frontends (R&S FE170SR/
                      R&S FE170ST or R&S FE110SR/R&S FE110ST) use the same
                      LO frequencies for upconversion and downconversion.

Example: EFR:FREQ:BCON:LIST?
                     //Result: "IF HIGH", "IF LOW"
                     EFR:FREQ:BCON:SEL "IF HIGH"

[SENSe:]EFRontend:FREQuency:IFRequency:SIDeband?

Queries the currently used sideband for frequency conversion.

Return values:

<Sideband>   "USB" | "LSB"

                     "USB"
                     Upper sideband

                     "LSB"
                     Lower sideband

Example: EFR:FREQ:IFR?
                     EFR:FREQ:IFR:SID?

Usage: Query only

[SENSe:]EFRontend:FREQuency:IFRequency[:VALue]?

Queries the currently used intermediate frequency (IF) for frequency conversion.

Return values:

<IFFrequency>   numeric

Example: EFR:FREQ:IFR?

Usage: Query only

[SENSe:]EFRontend:FREQuency:REFerence <Frequency>

Sets the reference frequency that is used for frequency conversion on the frontend. Depending on the connected type of frontend, different values are available. To determine which reference levels are available, use [SENSe:]EFRontend:FREQuency:REFerence:LIST? on page 209.

Parameters:

<Frequency>   Default unit: HZ

Example: //Query the available reference levels
                     EFR:FREQ:REF:LIST?
                     //Result: 10000000,640000000,1000000000
                     //Use 640 MHz reference
                     EFR:FREQ:REF 640000000

[SENSe:]EFRontend:FREQuency:REFerence:LIST?

Queries the available reference signals for the connected frontend type.

Return values:

<References>	10000000 | 640000000 | 1000000000

Example:	//Query the available reference levels
	EFR:FREQ:REF:LIST?
	//Result: 10000000,640000000,1000000000
	//Use 640 MHz reference
	EFR:FREQ:REF 640000000

Usage:	Query only

[SENSe:]EFRontend:IDN?

Queries the device identifcation information (*IDN?) of the frontend.

Return values:

<DevInfo>	string without quotes
	Rohde&Schwarz,<device type>,<part number>/<serial number>,<firmware version>

Example:	EFR:IDN?
	//Result: Rohde&Schwarz,FE44S,
	1234.5678K00/123456,0.8.0

Usage:	Query only

[SENSe:]EFRontend[:STATe] <State>

Enables or disables the general use of an external frontend for the application.

Parameters:

<State>	ON | OFF | 0 | 1
	OFF | 0
	The frontend is disconnected. The application adapts the measurement settings to the common settings supported by the R&S VSE.
	ON | 1
	The R&S VSE allows you to configure and connect an external frontend for the application. The application adapts the available measurement settings to the connected frontend.
	The channel bar indicates "Inp: ExtFe".
	*RST: 0

Example:	EFR ON

8.4.3.4 Working with power sensors

The following commands describe how to work with power sensors.

These commands require the use of a Rohde & Schwarz power sensor. For a list of supported sensors, see the data sheet.

Configuring power sensors

SYSTem:COMMunicate:RDEVice:PMETer<p>:CONFigure:AUTO[:STATe] <State>

Turns automatic assignment of a power sensor to the power sensor index on and off.

Suffix:

<p>   Power sensor index

Parameters:

<State>   ON | OFF | 0 | 1

                          *RST: 1

Example: SYST:COMM:RDEV:PMET:CONF:AUTO OFF

SYSTem:COMMunicate:RDEVice:PMETer<p>:COUNt?

Queries the number of power sensors currently connected to the R&S VSE.

Suffix:

<p>   Power sensor index

Return values:

<NumberSensors>   Number of connected power sensors.

Example: SYST:COMM:RDEV:PMET:COUN?

Usage: Query only

SYSTem:COMMunicate:RDEVice:PMETer<p>:DEFine <Placeholder>, <Type>, <Interface>, <SerialNo>

Assigns the power sensor with the specified serial number to the selected power sensor index (configuration).

The query returns the power sensor type and serial number of the sensor assigned to the specified index.

Suffix:

<p>   Power sensor index

Parameters:

<Placeholder>   Currently not used

<Type>   Detected power sensor type, e.g. "NRP-Z81".

| <Interface> | Interface the power sensor is connected to; always "USB" |
| <SerialNo> | Serial number of the power sensor assigned to the specified index |

Example:	`SYST:COMM:RDEV:PMET2:DEF '','NRP-Z81','',` `'123456'`
	Assigns the power sensor with the serial number '123456' to the configuration "Power Sensor 2".
	`SYST:COMM:RDEV:PMET2:DEF?`
	Queries the sensor assigned to "Power Sensor 2".
	Result:
	`'','NRP-Z81','USB','123456'`
	The NRP-Z81 power sensor with the serial number '123456' is assigned to the "Power Sensor 2".

Configuring power sensor measurements

CALibration:PMETer<p>:ZERO:AUTO ONCE

Zeroes the power sensor.

Note that you have to disconnect the signals from the power sensor input before you start to zero the power sensor. Otherwise, results are invalid.

Suffix:

| <p> | Power sensor index |

| **Example:** | `CAL:PMET2:ZERO:AUTO ONCE;*WAI` |
| | Starts zeroing the power sensor 2 and delays the execution of further commands until zeroing is concluded. |

| **Usage:** | Event |

CALCulate<n>:PMETer<p>:RELative[:MAGNitude] <RefValue>

Defines the reference value for relative measurements.

Suffix:

<n>	Window
<p>	Power sensor index

Parameters:

<RefValue>	Range: -200 dBm to 200 dBm
	*RST: 0
	Default unit: DBM
Example:	CALC:PMET2:REL -30
	Sets the reference value for relative measurements to -30 dBm for power sensor 2.

CALCulate<n>:PMETer<p>:RELative[:MAGNitude]:AUTO ONCE

Sets the current measurement result as the reference level for relative measurements.

Suffix:

<n>	Window
<p>	Power sensor index
Example:	CALC:PMET2:REL:AUTO ONCE
	Takes the current measurement value as reference value for relative measurements for power sensor 2.
Usage:	Event

CALCulate<n>:PMETer<p>:RELative:STATe <State>

Turns relative power sensor measurements on and off.

Suffix:

<n>	Window
<p>	Power sensor index

Parameters:

<State>	ON | OFF | 0 | 1
	OFF | 0
	Switches the function off
	ON | 1
	Switches the function on
Example:	CALC:PMET2:REL:STAT ON
	Activates the relative display of the measured value for power sensor 2.

FETCh:PMETer<p>?

Queries the results of power sensor measurements.

Suffix:

<p>	Power sensor index

Usage: Query only

READ:PMETer<p>?

Initiates a power sensor measurement and queries the results.

Suffix:

<p>	Power sensor index

Usage: Query only

[SENSe:]PMETer<p>:DCYCle[:STATe] <State>

Turns the duty cycle correction on and off.

Suffix:

<p>	Power sensor index

Parameters:

<State>	ON | OFF | 0 | 1
	OFF | 0 Switches the function off
	ON | 1 Switches the function on

Example: `PMET2:DCYC:STAT ON`

[SENSe:]PMETer<p>:DCYCle:VALue <Percentage>

Defines the duty cycle for the correction of pulse signals.

The power sensor uses the duty cycle in combination with the mean power to calculate the power of the pulse.

Suffix:

<p>	Power sensor

Parameters:

<Percentage>	Range:	0.001 to 99.999
	*RST:	99.999
	Default unit: %	

Example: `PMET2:DCYC:STAT ON`
Activates the duty cycle correction.
`PMET2:DCYC:VAL 0.5`
Sets the correction value to 0.5%.

[SENSe:]PMETer<p>:FREQuency <Frequency>

Defines the frequency of the power sensor.

Suffix:

<p>   Power sensor index

Parameters:

<Frequency>   The available value range is specified in the data sheet of the power sensor in use.

                             *RST: 50 MHz

                             Default unit: HZ

Example: `PMET2:FREQ 1GHZ`

                             Sets the frequency of the power sensor to 1 GHz.

[SENSe:]PMETer<p>:FREQuency:LINK <Coupling>

Selects the frequency coupling for power sensor measurements.

Suffix:

<p>   Power sensor index

Parameters:

<Coupling>   **CENTer**

                             Couples the frequency to the center frequency of the analyzer

                             MARKer1

                             Couples the frequency to the position of marker 1

                             OFF

                             Switches the frequency coupling off

                             *RST: CENTer

Example: `PMET2:FREQ:LINK CENT`

                             Couples the frequency to the center frequency of the analyzer

---

[SENSe:]PMETer<p>:MTIMe <Duration>

Selects the duration of power sensor measurements.

Suffix:

<p>   Power sensor index

Parameters:

<Duration>   SHORt | NORMal | LONG

                             *RST: NORMal

Example: `PMET2:MTIM SHOR`

                             Sets a short measurement duration for measurements of stationary high power signals for the selected power sensor.

[SENSe:]PMETer<p>:MTIMe:AVERage:COUNt <NumberReadings>

Sets the number of power readings included in the averaging process of power sensor measurements.

Extended averaging yields more stable results for power sensor measurements, especially for measurements on signals with a low power, because it minimizes the effects of noise.

Suffix:

<p>   Power sensor index

Parameters:

<NumberReadings>   An average count of 0 or 1 performs one power reading.

Range: 0 to 256
Increment: binary steps (1, 2, 4, 8, ...)

Example: PMET2:MTIM:AVER ON
Activates manual averaging.
PMET2:MTIM:AVER:COUN 8
Sets the number of readings to 8.

[SENSe:]PMETer<p>:MTIMe:AVERage[:STATe] <State>

Turns averaging for power sensor measurements on and off.

Suffix:

<p>   Power sensor index

Parameters:

<State>   ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: PMET2:MTIM:AVER ON
Activates manual averaging.

[SENSe:]PMETer<p>:ROFFset[:STATe] <State>

Includes or excludes the reference level offset of the analyzer for power sensor measurements.

Suffix:

<p>   Power sensor index

Parameters:

<State>   ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: PMET2:ROFF OFF
Takes no offset into account for the measured power.

[SENSe:]PMETer<p>:SOFFset <SensorOffset>

Takes the specified offset into account for the measured power. Only available if
[SENSe:]PMETer<p>:ROFFset[:STATe] is disabled.

Suffix:
<p>   Power sensor index

Parameters:
<SensorOffset>   Default unit: DB

Example: PMET2:SOFF 0.001

[SENSe:]PMETer<p>[:STATe] <State>

Turns a power sensor on and off.

Suffix:
<p>   Power sensor index

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

                             OFF | 0
                             Switches the function off
                             ON | 1
                             Switches the function on

Example: PMET1 ON
Switches the power sensor measurements on.

[SENSe:]PMETer<p>:UPDate[:STATe] <State>

Turns continuous update of power sensor measurements on and off.

If on, the results are updated even if a single sweep is complete.

Suffix:
<p>   Power sensor index

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

                             OFF | 0
                             Switches the function off
                             ON | 1
                             Switches the function on

Example: `PMET1:UPD ON`
The data from power sensor 1 is updated continuously.

UNIT<n>:PMETer<p>:POWer <Unit>

Selects the unit for absolute power sensor measurements.

Suffix:

<n>   irrelevant

<p>   Power sensor index

Parameters:

<Unit>   DBM | WATT | W | DB | PCT

     *RST: DBM

Example: `UNIT:PMET:POW DBM`

UNIT<n>:PMETer<p>:POWer:RATio <Unit>

Selects the unit for relative power sensor measurements.

Suffix:

<n>   irrelevant

<p>   Power sensor index

Parameters:

<Unit>   DB | PCT

     *RST: DB

Example: `UNIT:PMET:POW:RAT DB`

8.4.4 Frontend configuration

The following commands configure frequency, amplitude and y-axis scaling settings, which represent the "frontend" of the measurement setup.

8.4.4.1 Frequency

[SENSe<ip>:]FREQuency:CENTer <Frequency>

Defines the center frequency.

Suffix:

<ip>   1..n

Parameters:

<Frequency>   The allowed range and f_{max} is specified in the data sheet.

                        *RST: fmax/2
                        Default unit: Hz

Example: FREQ:CENT 100 MHz
                        FREQ:CENT:STEP 10 MHz
                        FREQ:CENT UP
                        Sets the center frequency to 110 MHz.

Manual operation: See "Frequency" on page 93
                        See "Center Frequency" on page 102

[SENSe:]FREQuency:CENTer:STEP <StepSize>

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<ip>:
]FREQuency:CENTer on page 219.

Parameters:

<StepSize> f_{max} is specified in the data sheet.

                        Range: 1 to fMAX
                        *RST: 0.1 x span
                        Default unit: Hz

Example: //Set the center frequency to 110 MHz.
                        FREQ:CENT 100 MHz
                        FREQ:CENT:STEP 10 MHz
                        FREQ:CENT UP

Manual operation: See "Center Frequency Stepsize" on page 103

[SENSe:]FREQuency:CENTer:STEP:AUTO <State>

Couples or decouples the center frequency step size to the span.

In time domain (zero span) measurements, the center frequency is coupled to the
RBW.

Parameters:

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

Example: FREQ:CENT:STEP:AUTO ON

Activates the coupling of the step size to the span.

[SENSe<ip>:]FREQuency:OFFSet <Offset>

Defines a frequency offset.

If this value is not 0 Hz, the application assumes that the input signal was frequency shifted outside the application. All results of type "frequency" will be corrected for this shift numerically by the application.

See also "Frequency Offset" on page 103.

Suffix:

<ip>   1..n

Parameters:

<Offset>   Range: -1 THz to 1 THz
            *RST: 0 Hz
            Default unit: HZ

Example: FREQ:OFFS 1GHZ

Manual operation: See "Frequency Offset" on page 103

8.4.4.2 Amplitude settings

The following commands are required to configure the amplitude settings in a remote environment.

Useful commands for amplitude settings described elsewhere:

- INPut<ip>:COUPling<ant> on page 185
- INPut<ip>:IMPedance<ant> on page 187
- [SENSe<ip>:]ADJust:LEVel on page 292

Remote commands exclusive to amplitude settings:

CALCulate<n>:UNIT:POWer <Unit>

Selects the unit of the y-axis.

The unit applies to all power-based measurement windows with absolute values.

Suffix:

<n>   irrelevant

Parameters:

<Unit>   DBM | V | A | W | DBPW | WATT | DBUV | DBMV | VOLT |
                            DBUA | AMPere

                            *RST: dBm

Example: `CALC:UNIT:POW DBM`
                            Sets the power unit to dBm.

Manual operation: See "Unit" on page 105

CONFigure:POWer:AUTO <Mode>

Is used to switch on or off automatic power level detection.

Parameters:

<Mode>   **ON**
                            Automatic power level detection is performed at the start of each
                            measurement sweep, and the reference level is adapted accord-
                            ingly.
                            OFF
                            The reference level must be defined manually (see `DISPlay[:`
                            `WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:`
                            `RLEVel<ant>` on page 222)
                            ONCE
                            Automatic power level detection is performed once at the start of
                            the next measurement sweep, and the reference level is adap-
                            ted accordingly.
                            The command with this parameter corresponds to
                            `[SENSe<ip>:]ADJust:LEVel` on page 292.
                            *RST: ON

CONFigure:POWer:AUTO:OEVM <Optimisation>

Defines whether an optional iterative search is performed to determine the required
settings for minimum residual EVM. If enabled, the required reference level, preampli-
fier and, optionally, attenuation are configured. `CONFigure:POWer:AUTO` is set to
"OFF".

Parameters:

<Optimisation>   **OFF**
                            (Default): No optimization performed

FULL

An optional iterative search for minimum residual EVM is performed for the available preamplifier and attenuation settings. The optimal settings are configured.

PAONly

An optional iterative search for minimum residual EVM is performed, but only the available preamplifier settings are considered during the search. The optimal settings are configured.

*RST: OFF

Example: CONF:POW:AUTO:OEVM FULL

CONFigure:POWer:AUTO:SWEep:TIME <Value>

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:

<Value>   Auto level measurement sweep time

          Default unit: S

Example: CONF:POW:AUTO:SWE:TIME 0.01 MS

CONFigure:POWer:EXPected:RF <Value>

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

CONFigure:POWer:EXPected:IQ <Value>

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

Parameters:

<Value>   Default unit: V

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel<ant>
          <ReferenceLevel>

Defines the reference level (for all traces in all windows).

With a reference level offset ≠ 0, the value range of the reference level is modified by the offset.

Suffix:

<n>   irrelevant

<w>	subwindow
	Not supported by all applications
<t>	irrelevant
<ant>	Input source (for MIMO measurements only)

Parameters:

<ReferenceLevel>	The unit is variable.
	Range: see datasheet
	*RST: 0 dBm
	Default unit: DBM

Example:	`DISP:TRAC:Y:RLEV -60dBm`
Manual operation:	See "Reference Level" on page 104

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel<ant>: OFFSet <Offset>

Defines a reference level offset (for all traces in all windows).

Suffix:

<n>	irrelevant
<w>	subwindow
	Not supported by all applications
<t>	irrelevant
<ant>	Input source (for MIMO measurements only)

Parameters:

<Offset>	Range: -200 dB to 200 dB
	*RST: 0dB
	Default unit: DB

Example:	`DISP:TRAC:Y:RLEV:OFFS -10dB`
Manual operation:	See "Shifting the Display (Offset)" on page 105

INPut<ip>:ATTenuation <Attenuation>

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 225).

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.

Suffix:

<ip>	1..n

Parameters:

<Attenuation>	Range:	see data sheet
	Increment:	5 dB (with optional electr. attenuator: 1 dB)
	*RST:	10 dB (AUTO is set to ON)
	Default unit: DB	

Example:	INP:ATT 30dB
	Defines a 30 dB attenuation and decouples the attenuation from the reference level.
Manual operation:	See "Attenuation Mode / Value" on page 105

INPut<ip>:ATTenuation:AUTO <State>

Couples or decouples the attenuation to the reference level. Thus, when the reference level is changed, the R&S VSE determines the signal level for optimal internal data processing and sets the required attenuation accordingly.

Suffix:

<ip>	1..n

Parameters:

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

Example:	INP:ATT:AUTO ON
	Couples the attenuation to the reference level.
Manual operation:	See "Attenuation Mode / Value" on page 105

INPut:EATT <Attenuation>

Defines an electronic attenuation manually. Automatic mode must be switched off (INP:EATT:AUTO OFF, see INPut:EATT:AUTO on page 225).

If the current reference level is not compatible with an attenuation that has been set manually, the command also adjusts the reference level.

Requires the electronic attenuation hardware option.

Parameters:

<Attenuation>	attenuation in dB	
	Range:	see data sheet
	Increment:	1 dB
	*RST:	0 dB (OFF)
	Default unit: DB	

Example:	INP:EATT:AUTO OFF
	INP:EATT 10 dB
Manual operation:	See "Using Electronic Attenuation" on page 106

INPut:EATT:AUTO <State>

Turns automatic selection of the electronic attenuation on and off.

If on, electronic attenuation reduces the mechanical attenuation whenever possible.

Requires the electronic attenuation hardware option.

Parameters:

<State>	ON | OFF | 0 | 1
	OFF | 0 Switches the function off
	ON | 1 Switches the function on
	*RST: 1

Example: `INP:EATT:AUTO OFF`

Manual operation: See "Using Electronic Attenuation" on page 106

INPut:EATT:STATe <State>

Turns the electronic attenuator on and off.

Requires the electronic attenuation hardware option.

Parameters:

<State>	ON | OFF | 0 | 1
	OFF | 0 Switches the function off
	ON | 1 Switches the function on
	*RST: 0

Example: `INP:EATT:STAT ON`
Switches the electronic attenuator into the signal path.

Manual operation: See "Using Electronic Attenuation" on page 106

INPut<ip>:GAIN<ant>:STATe <State>

Turns the internal preamplifier on the connected instrument on and off. It requires the additional preamplifier hardware option on the connected instrument.

Suffix:

<ip>	1 | 2 irrelevant
<ant>	Input source (for MIMO measurements only)

Parameters:

<State>	ON | OFF | 0 | 1

OFF | 0

Switches the function off

ON | 1

Switches the function on

*RST: 0

Example: INP:GAIN:STAT ON

INP:GAIN:VAL 15

Switches on 15 dB preamplification.

Manual operation: See "Preamplifier" on page 106

INPut<ip>:GAIN<ant>[:VALue] <Gain>

Selects the "gain" if the preamplifier is activated (INP:GAIN:STAT ON, see
INPut<ip>:GAIN<ant>:STATe on page 225).

The command requires the additional preamplifier hardware option.

Suffix:

<ip>   1 | 2

irrelevant

<ant>   Input source (for MIMO measurements only)

Parameters:

<Gain>   15 dB and 30 dB

All other values are rounded to the nearest of these two.

30 dB

Default unit: DB

Example: INP:GAIN:STAT ON

INP:GAIN:VAL 30

Switches on 30 dB preamplification.

Manual operation: See "Preamplifier" on page 106

8.4.4.3 Y-axis scaling

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe] <Range>

Defines the display range of the y-axis (for all traces).

Suffix:

<n>   Window

<w>	subwindow
	Not supported by all applications
<t>	irrelevant
Example:	DISP:TRAC:Y 110dB
Manual operation:	See "Range" on page 108

DISPlay[:WINDow<n>][:SUBWindow<n>]:TRACe<t>:Y[:SCALe]:AUTO <State>

If enabled, the Y-axis is scaled automatically according to the current measurement.

Suffix:

<n>	Window
<w>	subwindow
	Not supported by all applications
<t>	irrelevant

Parameters for setting and query:

<State>	**OFF**
	Switch the function off
	ON
	Switch the function on
	ONCE
	Execute the function once
	*RST: ON
Manual operation:	See "Auto Scale Once" on page 108

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:MODE <Mode>

Selects the type of scaling of the y-axis (for all traces).

When the display update during remote control is off, this command has no immediate effect.

Suffix:

<n>	Window
<w>	subwindow
<t>	irrelevant

Parameters:

<Mode>	**ABSolute**
	absolute scaling of the y-axis
	RELative
	relative scaling of the y-axis
	*RST: ABSolute
Example:	DISP:TRAC:Y:MODE REL

Manual operation: See "Scaling" on page 108

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RPOSition
    <Position>

Defines the vertical position of the reference level on the display grid (for all traces).

The R&S VSE adjusts the scaling of the y-axis accordingly.

Suffix:

<n>   Window

<w>   subwindow
                        Not supported by all applications

<t>   irrelevant

Example: DISP:TRAC:Y:RPOS 50PCT

Manual operation: See "Ref Level Position" on page 108

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y:SPACing <ScalingType>

Selects the scaling of the y-axis (for all traces, <t> is irrelevant).

Suffix:

<n>   Window

<w>   subwindow

<t>   Trace

Parameters:
<ScalingType>   **LOGarithmic**
                        Logarithmic scaling.

                        LINear
                        Linear scaling in %.

                        LDB
                        Linear scaling in the specified unit.

                        PERCent
                        Linear scaling in %.

                        *RST: LOGarithmic

Example: DISP:TRAC:Y:SPAC LIN
                        Selects linear scaling in %.

Manual operation: See "Scaling" on page 108

8.4.5 Signal capturing

The following commands are required to configure how much and how data is captured from the input signal.

8.4.5.1　General capture settings

INITiate<n>[:IMMediate]

Starts a (single) new measurement.

You can synchronize to the end of the measurement with *OPC, *OPC? or *WAI.

For details on synchronization see Remote control via SCPI.

Suffix:

<n>　　　　　　　　　　irrelevant

Usage:　　　　　　　　Asynchronous command

Manual operation:　　See "Single / Cont." on page 120

[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, ac, ax, g (OFDM), j, n, p, be)" on page 110

[SENSe:]DEMod:FILTer:CATalog?

Reads the names of all available filters.

Return values:

<Filters>　　　　　　　　<list>

Usage: Query only

[SENSe:]DEMod:FILTer:EFLength <Length>

Specifies the equalizer filter length in chips.

Parameters:

<Length>   Range: 2 to 30
                     *RST: 10

Manual operation: See "Equalizer Filter Length (IEEE 802.11b, g (DSSS))" on page 110

[SENSe:]DEMod:FILTer:MODulation <TXFilter>, <RXFilter>

Selects the transmit (TX) and receive (RX) filters. The names of the filters correspond to the file names; a query of all available filters is possible by means of the [SENSe:]DEMod:FILTer:CATalog? on page 229 command.

Is only available for **IEEE 802.11b** measurements.

Parameters:

<TXFilter>   File name of the transmit filter

<RXFilter>   File name of the receive filter

Manual operation: See "Transmit Filter(IEEE 802.11b, g (DSSS))" on page 110
                          See "Receive Filter (IEEE 802.11b, g (DSSS))" on page 110

[SENSe:]SWAPiq <State>

Defines whether or not the recorded I/Q pairs should be swapped (I<->Q) before being processed. Swapping I and Q inverts the sideband.

This is useful if the DUT interchanged the I and Q parts of the signal; then the R&S VSE can do the same to compensate for it.

Parameters:

<State>   **ON | 1**
                     I and Q signals are interchanged
                     Inverted sideband, Q+j*I
                     OFF | 0
                     I and Q signals are not interchanged
                     Normal sideband, I+j*Q
                     *RST: 0

Manual operation: See "Swap I/Q" on page 110

[SENSe:]SWEep:TIME <Time>

Defines the measurement time. It automatically decouples the time from any other settings.

Parameters:

<Time>   refer to data sheet

                  *RST: depends on current settings (determined automatically)

                  Default unit: S

Manual operation: See "Capture Time" on page 109

TRACe:IQ:SRATe <SampleRate>

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 VSE.

Parameters:

<SampleRate>   The valid sample rates depend on the connected instrument. Refer to the instrument's documentation.

                  *RST: 32 MHz

                  Default unit: HZ

Manual operation: See "Input Sample Rate" on page 109

8.4.5.2 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 4.4.2, "Trigger settings", on page 111.

ⓘ   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.

Note that the availability of trigger sources depends on the connected instrument.

TRIGger[:SEQuence]:DTIMe <DropoutTime>

Defines the time the input signal must stay below the trigger level before a trigger is detected again.

For input from the "Analog Baseband" interface using the baseband power trigger (BBP), the default drop out time is set to 100 ns to avoid unintentional trigger events (as no hysteresis can be configured in this case).

Parameters:

<DropoutTime>   Dropout time of the trigger.

                        Range: 0 s to 10.0 s
                        *RST: 0 s
                        Default unit: S

Manual operation: See "Drop-Out Time" on page 114

TRIGger[:SEQuence]:HOLDoff[:TIME] <Offset>

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

Parameters:

<Offset>   *RST: 0 s
                        Default unit: S

Example: `TRIG:HOLD 500us`

Manual operation: See "Trigger Offset" on page 114

TRIGger[:SEQuence]:IFPower:HOLDoff <Period>

Defines the holding time before the next trigger event.

Note that this command can be used for **any trigger source**, not just IF Power (despite the legacy keyword).

For (offline) input from a file, this command does not apply. In this case, use `TRIGger[:SEQuence]:MAPower:HOLDoff` on page 236.

Parameters:

<Period>   Range: 0 s to 10 s
                        *RST: 0 s
                        Default unit: S

Example: `TRIG:SOUR EXT`
Sets an external trigger source.
`TRIG:IFP:HOLD 200 ns`
Sets the holding time to 200 ns.

Manual operation: See "Trigger Holdoff" on page 114

TRIGger[:SEQuence]:IFPower:HYSTeresis <Hysteresis>

Defines the trigger hysteresis, which is only available for "IF Power" trigger sources.

Parameters:

<Hysteresis>   Range: 3 dB to 50 dB
                         *RST: 3 dB
                         Default unit: DB

Example: `TRIG:SOUR IFP`
Sets the IF power trigger source.
`TRIG:IFP:HYST 10DB`
Sets the hysteresis limit value.

Manual operation: See "Hysteresis" on page 114

TRIGger[:SEQuence]:LEVel:BBPower <Level>

Sets the level of the baseband power trigger.

Is available for the optional "Analog Baseband" interface.

Parameters:

<Level>   Range: -50 dBm to +20 dBm
                         *RST: -20 dBm
                         Default unit: DBM

Example: `TRIG:LEV:BBP -30DBM`

Manual operation: See "Trigger Level" on page 113

TRIGger[:SEQuence]:LEVel[:EXTernal<port>] <TriggerLevel>

Defines the level the external signal must exceed to cause a trigger event.

For details on the trigger source see "Trigger Source" on page 111.

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
                        Default unit: V

Example: TRIG:LEV 2V

Manual operation: See "Trigger Level" on page 113

TRIGger[:SEQuence]:LEVel:IFPower <TriggerLevel>

Defines the power level at the third intermediate frequency that must be exceeded to cause a trigger event.

Note that any RF attenuation or preamplification is considered when the trigger level is analyzed. If defined, a reference level offset is also considered.

For compatibility reasons, this command is also available for the "Baseband Power" trigger source when using the "Analog Baseband" interface.

For details on the trigger settings, see "Trigger Source" on page 111.

Parameters:

<TriggerLevel>   For details on available trigger levels and trigger bandwidths, see the data sheet.

                        *RST: -20 dBm
                        Default unit: DBM

Example: TRIG:LEV:IFP -30DBM

Manual operation: See "Trigger Level" on page 113

TRIGger[:SEQuence]:LEVel:IQPower <TriggerLevel>

Defines the magnitude the I/Q data must exceed to cause a trigger event.

Note that any RF attenuation or preamplification is considered when the trigger level is analyzed. If defined, a reference level offset is also considered.

For details on the trigger source, see "Trigger Source" on page 111.

Parameters:

<TriggerLevel>   Range: -130 dBm to 30 dBm
                        *RST: -20 dBm
                        Default unit: DBM

Example: TRIG:LEV:IQP -30DBM

Manual operation: See "Trigger Level" on page 113

TRIGger[:SEQuence]:LEVel:MAPower <TriggerLevel>

Defines the power level that must be exceeded to cause a trigger event for (offline) input from a file.

Parameters:

\<TriggerLevel\>	For details on available trigger levels and trigger bandwidths, see the data sheet.
	Default unit: DBM

Example:	`TRIG:LEV:MAP -30DBM`
Manual operation:	See "Trigger Level" on page 113

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).

Is only considered for `TRIG:SEQ:SOUR IFP` and `TRIG:SEQ:SOUR RFP`, see `TRIGger[:SEQuence]:SOURce` on page 236

To define the trigger level manually, switch this function off and define the level using `TRIGger[:SEQuence]:LEVel:IFPower` on page 234 or `TRIGger[:SEQuence]:LEVel:RFPower` on page 235.

Parameters for setting and query:

\<State\>	**OFF | 0** Switches the auto level detection function off
	ON | 1 Switches the auto level detection function on
	*RST: 1

Manual operation:	See "Trigger Level Mode" on page 113

TRIGger[:SEQuence]:LEVel:RFPower \<TriggerLevel\>

Defines the power level the RF input must exceed to cause a trigger event. Note that any RF attenuation or preamplification is considered when the trigger level is analyzed. If defined, a reference level offset is also considered.

The input signal must be between 500 MHz and 8 GHz.

For details on the trigger source, see "Trigger Source" on page 111.

Parameters:

\<TriggerLevel\>	For details on available trigger levels and trigger bandwidths, see the data sheet.
	*RST: -20 dBm
	Default unit: DBM

Example:	`TRIG:LEV:RFP -30dBm`
Manual operation:	See "Trigger Level" on page 113

TRIGger[:SEQuence]:MAPower:HOLDoff <Period>

Defines the holding time before the next trigger event for (offline) input from a file.

Parameters:

<Period>   Range: 0 s to 10 s
                         *RST: 0 s
                         Default unit: S

Example: `TRIG:SOUR MAGN`
                        Sets an offline magnitude trigger source.
                        `TRIG:MAP:HOLD 200 ns`
                        Sets the holding time to 200 ns.

Manual operation: See "Trigger Holdoff" on page 114

TRIGger[:SEQuence]:MAPower:HYSTeresis <Hysteresis>

Defines the trigger hysteresis for the (offline) magnitude trigger source (used for input from a file).

Parameters:

<Hysteresis>   Range: 3 dB to 50 dB
                         *RST: 3 dB
                         Default unit: DB

Example: `TRIG:SOUR MAP`
                        Sets the (offline) magnitude trigger source.
                        `TRIG:MAP:HYST 10DB`
                        Sets the hysteresis limit value.

Manual operation: See "Hysteresis" on page 114

TRIGger[:SEQuence]:SLOPe <Type>

Parameters:

<Type>   POSitive | NEGative

                         POSitive
                         Triggers when the signal rises to the trigger level (rising edge).

                         NEGative
                         Triggers when the signal drops to the trigger level (falling edge).

                         *RST: POSitive

Example: `TRIG:SLOP NEG`

Manual operation: See "Slope" on page 115

TRIGger[:SEQuence]:SOURce <Source>

Selects the trigger source.

Note that the availability of trigger sources depends on the connected instrument.

For details on the available trigger sources, see "Trigger Source" on page 111.

Note on external triggers:

If a measurement is configured to wait for an external trigger signal in a remote control program, remote control is blocked until the trigger is received and the program can continue. Make sure that this situation is avoided in your remote control programs.

Parameters:

<Source>

IMMediate
Free Run

EXTernal
Trigger signal from the "Trigger Input" connector.

EXT | EXT2 | EXT3 | EXT4
Trigger signal from the corresponding "TRIGGER INPUT/ OUT-PUT" connector on the connected instrument, or the oscilloscope's corresponding input channel (if not used as an input source).
For details on the connectors see the instrument's Getting Started manual.

RFPower
First intermediate frequency
(Frequency and time domain measurements only.)
Not available for input from the optional "Analog Baseband" interface.

IFPower
Second intermediate frequency
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.

TIME
Time interval

BBPower
Baseband power
For input from the optional "Analog Baseband" interface.

MAGNitude
For (offline) input from a file, rather than an instrument.
The trigger level is specified by `TRIGger[:SEQuence]:LEVel:MAPower`.

MAIT
For trigger information stored as markers in an `.iqx` file.

MANual

Only available for a connected R&S RTP:

Any trigger settings in the R&S VSE software are ignored; only trigger settings defined on the connected instrument are considered. Thus, you can use the more complex trigger settings available on an R&S RTP.

*RST: IMMediate

Example: `TRIG:SOUR EXT`

Selects the external trigger input as source of the trigger signal

Manual operation: See "Trigger Source" on page 111

See "Free Run" on page 111

See "External Trigger / Trigger Channel X" on page 112

See "RF Power" on page 112

See "I/Q Power" on page 112

See "Time" on page 112

See "Magnitude (Offline)" on page 113

See "Manual" on page 113

TRIGger[:SEQuence]:TIME:RINTerval <Interval>

Defines the repetition interval for the time trigger.

Parameters:

<Interval>   numeric value

Range: 2 ms to 5000 s
*RST: 1.0 s
Default unit: S

Example: `TRIG:SOUR TIME`

Selects the time trigger input for triggering.

`TRIG:TIME:RINT 5`

The measurement starts every 5 s.

Manual operation: See "Repetition Interval" on page 113

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 connected instrument.

OUTPut:TRIGger<tp>:DIRection <Direction>

Selects the trigger direction for trigger ports that serve as an input as well as an output.

Suffix:

<Undefp>　　　　　　　　irrelevant

<tp>

Parameters:

<Direction>　　　　　　　INPut | OUTPut

INPut
Port works as an input.

OUTPut
Port works as an output.

*RST:　　　　　INPut

OUTPut:TRIGger<tp>:LEVel <Level>

Defines the level of the (TTL compatible) signal generated at the trigger output.

Works only if you have selected a user-defined output with `OUTPut:TRIGger<tp>:OTYPe`.

Suffix:

<tp>　　　　　　　　　　　1..n
Selects the trigger port to which the output is sent.

Parameters:

<Level>　　　　　　　　　**HIGH**
5 V

LOW
0 V

*RST:　　　　　LOW

Example:　　　　　　　`OUTP:TRIG2:LEV HIGH`

OUTPut:TRIGger<tp>:OTYPe <OutputType>

Selects the type of signal generated at the trigger output.

Suffix:

<tp>　　　　　　　　　　　1..n
Selects the trigger port to which the output is sent.

Parameters:

<OutputType>　　　　　　**DEVice**
Sends a trigger signal when the R&S VSE has triggered internally.

TARMed
Sends a trigger signal when the trigger is armed and ready for an external trigger event.

UDEFined
Sends a user-defined trigger signal. For more information, see `OUTPut:TRIGger<tp>:LEVel`.

*RST: DEVice

OUTPut:TRIGger<tp>:PULSe:IMMediate

Generates a pulse at the trigger output.

Suffix:

<tp>   1..n
                          Selects the trigger port to which the output is sent.

OUTPut:TRIGger<tp>:PULSe:LENGth <Length>

Defines the length of the pulse generated at the trigger output.

Suffix:

<tp>   Selects the trigger port to which the output is sent.

Parameters:

<Length>   Pulse length in seconds.
                          Default unit: S

Example: `OUTP:TRIG2:PULS:LENG 0.02`

8.4.5.3 MIMO capture settings

The following commands are **only available for IEEE 802.11ac, n standards**.

Remote commands exclusive to defining MIMO capture settings:

CALCulate<n>:BURSt[:IMMediate]

Forces the IQ measurement results to be recalculated according to the current settings.

Suffix:

<n>   1..n
                             Window

Manual operation: See "Calc Results" on page 120

CONFigure:WLAN:ANTMatrix:ADDRess<ant> <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 (primary)

Suffix:

<ant>   1..n

Parameters:

<Address>   TCP/IP address in IPV4 format

Manual operation: See "Reference Status" on page 117

CONFigure:WLAN:ANTMatrix:ANTenna<ant> <Antenna>

This remote control command specifies the antenna assignment of the receive path.

Suffix:

<ant>   1..n
                             Analyzer

Parameters:

<Antenna>   ANTenna1 | ANTenna2 | ANTenna3 | ANTenna4 | ANTenna5 |
                             ANTenna6 | ANTenna7 | ANTenna8 | ANT1 | ANT2 | ANT3 |
                             ANT4 | ANT5 | ANT6 | ANT7 | ANT8

                             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 118

CONFigure:WLAN:ANTMatrix:RLEVel<ant>:OFFSet <OffLevel>

This remote control command determines whether the reference value offset for the specified antenna if the primary and secondary devices in a simultaneous MIMO setup are not coupled (see `CONFigure:WLAN:ANTMatrix:SOURce:RLEVel:OFFSet` on page 243).

Suffix:

<ant>   1..n
                             antenna index as specified by `CONFigure:WLAN:ANTMatrix:STATe<ant>` on page 244

Parameters:

<OffLevel>
level offset in dB

*RST: 0
Default unit: DB

Example:
```
CONF:WLAN:ANTM:SOUR:RLEV:OFFS MAN
CONF:WLAN:ANTM:RLEV2:OFFS 10
```
Sets the reference level offset for the second antenna in the antenna matrix to 10 dB.

Manual operation:
See "Reference Level Offset" on page 118

CONFigure:WLAN:ANTMatrix:SOURce:AMPLitude:SOURce <Coupling>

This remote control command determines whether the amplitude settings for the primary and secondary devices in a simultaneous MIMO setup are coupled or not.

Parameters:

<Coupling>
PRIMary | AUTO | OFF

Coupling mode

AUTO
The secondary devices perform an auto-level at the same time as the primary. The amplitude settings are then determined automatically by each device according to the measured values. This feature requires that the WLAN 802.11 application R&S VSE-K91 (version 1.31 or higher) is installed on the secondary device.

PRIMary
Both the primary and all secondarys use the same amplitude settings, according to the settings at the primary. All settings on the secondary are ignored (including "Reference Level Auto"). Note: if "Reference Level Auto" is set at the primary, the primary channel performs an auto-level measurement and the resulting amplitude settings are transferred to the secondarys.

OFF
Both the primary and secondary devices use their own amplitude settings as defined prior to the measurement; the settings are not coupled.

*RST: PRIMary

Example:
```
CONF:WLAN:ANTM:SOUR:AMPL:SOUR AUTO
```

Manual operation:
See "Amplitude Settings Coupling" on page 119

CONFigure:WLAN:ANTMatrix:SOURce:RLEVel:OFFSet <Coupling>

This remote control command determines whether the reference level for the primary and secondary devices in a simultaneous MIMO setup are coupled or not.

Parameters:

<Coupling>　　　　　　PRIMary | MANual

　　　　　　　　　　　Coupling mode

　　　　　　　　　　　PRIMary
　　　　　　　　　　　The secondary analyzers' reference levels are set to match that of the primary.

　　　　　　　　　　　MANual
　　　　　　　　　　　The secondary analyzers' reference levels are specified individually (see CONFigure:WLAN:ANTMatrix:SOURce:RLEVel:OFFSet on page 243) and are not coupled to the reference level offset of the primary analyzer.

　　　　　　　　　　　*RST:　　　PRIMary

Example:　　　　　CONF:WLAN:ANTM:SOUR:RLEV:OFFS MAN
　　　　　　　　　　　CONF:WLAN:ANTM:RLEV2:OFFS 10
　　　　　　　　　　　Sets the reference level offset for the second antenna in the antenna matrix to 10 dB.

Manual operation:　See "Reference Level Offset" on page 118

CONFigure:WLAN:ANTMatrix:SOURce:ROSCillator:SOURce <Coupling>

This remote control command determines whether the reference frequency for the primary and secondary devices in a simultaneous MIMO setup are coupled or not.

Parameters:

<Coupling>　　　　　　AUTO | EXTernal | OFF

　　　　　　　　　　　Coupling mode

　　　　　　　　　　　AUTO
　　　　　　　　　　　Secondaries set to the same external reference source as primary.
　　　　　　　　　　　Use an R&S Z11 trigger box to send to the same trigger to all devices (see TRIG:SEQ:SOUR TUN.

　　　　　　　　　　　EXTernal
　　　　　　　　　　　Secondaries' reference source is set to external.
　　　　　　　　　　　Configure a trigger output from the primary (see OUTPut:TRIGger<tp>:OTYPe on page 239).

　　　　　　　　　　　OFF
　　　　　　　　　　　Secondaries' reference source is set to internal.

　　　　　　　　　　　*RST:　　　EXT

Example:　　　　　CONF:WLAN:ANTM:SOUR:ROSC:SOUR AUTO

Manual operation:　See "Reference Frequency Coupling" on page 118

CONFigure:WLAN:ANTMatrix:SOURce:ROSCillator:SOURce:STAT<ant> <State>

Queries the connection state of the external reference for each channel (see also CONFigure:WLAN:ANTMatrix:SOURce:ROSCillator:SOURce on page 243).

If the IP address of the antenna is not available or valid, or the selected antenna is not active, an error message is returned.

Suffix:

<ant>   1..n
                         antenna; 1 is primary

Parameters:

<State>   ON | OFF | 0 | 1

                         OFF | 0
                         External reference not available

                         ON | 1
                         External reference available

                         *RST: 0

Manual operation: See "LAN Status" on page 117

CONFigure:WLAN:ANTMatrix:STATe<ant> <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 (primary).

Suffix:

<ant>   1..n
                         antenna; 1 is primary

Parameters:

<State>   ON | OFF | 1 | 0

                         State of the antenna

Manual operation: See "State" on page 117

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 116

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 119.

*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 120

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 119.

*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 116
See "Manual Sequential MIMO Data Capture" on page 119

CONFigure:WLAN:MIMO:CSD <Method>

Determines whether or not the cyclic shift delay (CSD) is used for timing synchronisation.

Parameters:

<Method>   IGNore | APPLy

APPLy
(Default:) The timing offset estimation result (assuming CSD=0) is used for the subsequent signal analysis.

IGNore
The timing offset estimation result (assuming CSD=0) is ignored for the subsequent signal analysis.

*RST: APPLy

Example: CONF:WLAN:MIMO:CSD IGN
The timing offset estimation result is ignored for the subsequent signal analysis.

Manual operation: See "Time Sync." on page 116

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>

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

CONFigure:WLAN:RSYNc:JOINed <State>

Configures how PPDU synchronization and tracking is performed for multiple antennas.

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

ON | 1
RX antennas are synchronized and tracked together.

OFF | 0
RX antennas are synchronized and tracked separately.

*RST: 0

Manual operation: See "Joined RX Sync and Tracking" on page 118

8.4.6 Synchronization and OFDM demodulation

[SENSe:]DEMod:FFT:OFFSet <Mode>

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 121

[SENSe:]DEMod:TXARea <State>

If enabled, the R&S VSE 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 121

8.4.7   Tracking and channel estimation

[SENSe:]DEMod:CESTimation:RANGe <Range>

Parameters:

<Range>   PRE1t | PRE2t | PFTRacking | PUTRacking

PRE1t
The channel estimation is performed using the preamble of the HE/EHT-LTF as required in the standard.

PRE2t
The channel estimation is performed using the preamble of both training fields.

PFTRacking
The channel estimation is performed using the preamble and the payload. The EVM results can be calculated more accurately. (Note: this setting corresponds to the [SENSe:]DEMod:CESTimation 1 command in previous firmware versions.)

PUTRacking
The channel estimation is performed using the preamble and the payload. The EVM results can be calculated more accurately. The user-defined tracking settings are applied to the payload symbols used for payload channel estimation (see Chapter 8.4.7, "Tracking and channel estimation", on page 248).

Example: Channel estimation is performed using the preamble and payload, where only phase tracking is applied to the payload symbols used for payload channel estimation. The pilot sequence detected in the signal is used for tracking.
```
SENS:TRAC:PHAS ON
SENS:TRAC:PIL DET
SENS:TRAC:TIME OFF
SENS:TRAC:LEV OFF
[SENSe:]DEMod:CESTimation:RANGe PUTRacking
```

Manual operation: See "Channel Estimation Range" on page 122

[SENSe:]DEMod:INTerpolate <Interpolation>

Parameters:

<Interpolation>   WIENer | LINear

WIENer

The unused subcarriers of the channel estimation fields (1xHE-LTF, 2xHE-LTF) are determined by Wiener interpolation. The estimated channel is smoothed. The Wiener interpolation overwrites the used subcarrier sampling points.

In case all subcarriers are used (4xHE-LTF), sampling points for all subcarriers are available. The channel is smoothed.

LINear

The unused subcarriers of the channel estimation fields (1xHE-LTF, 2xHE-LTF) are determined by linear interpolation. Linear interpolation preserves the used subcarrier sampling points.

In case all subcarriers are used (4xHE-LTF), the available sampling points for all subcarriers are preserved, and no interpolation is applied.

*RST: WIENer

Example: DEM:INT:LIN

Manual operation: See "Interpolation" on page 123

[SENSe:]DEMod:INTerpolate:WIENer:DSPRead <Value>

Defines the value relative to the DFT period that is used for the Wiener filter design. Decrease this setting to finetune the EVM result if there is negligible delay spread, for example for a wired connection.

This setting is only available for [SENSe:]DEMod:INTerpolate:WIENer: DSPRead:STATe OFF.

Parameters:

<Value>   Range: 0.0001 to 0.5

Example: DEM:INT:WIEN
DEM:INT:WIEN:STAT OFF
DEM:INT:WIEN:DSPR 0.05

Manual operation: See "Wiener Relative Delay Spread" on page 123

[SENSe:]DEMod:INTerpolate:WIENer:DSPRead:STATe <State>

Defines whether the Wiener relative delay spread is disabled or defined manually.

Is only available for standards **IEEE 802.11ax, be** and only for [SENSe:]DEMod: INTerpolateWiener.

Parameters:

<State>   OFF | MANual

OFF
No delay spread is used.

MAN
The value is determined manually, using `[SENSe:]DEMod: INTerpolate:WIENer:DSPRead` on page 249.

*RST: OFF

Example: `DEM:INT:WIEN`
`DEM:INT:WIEN:DSPR:STAT MAN`
`DEM:INT:WIEN:DSPR 0.05`

Manual operation: See "Wiener Relative Delay Spread" on page 123

SENSe:TRACking:CROSstalk <State>

Activates or deactivates the compensation for crosstalk between MIMO carriers.

Is **only available for standard IEEE 802.11ac or n (MIMO)**.

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

*RST: 0

Example: `SENS:TRAC:CROS ON`

Manual operation: See "Compensate Crosstalk(MIMO only)" on page 126

SENSe:TRACking:IQMComp <State>

Activates or deactivates the compensation for I/Q mismatch (gain imbalance, quadrature offset, I/Q skew, see Chapter 2.1.5, "I/Q mismatch", on page 16).

This setting is **not available for standards IEEE 802.11b and g (DSSS)**.

Parameters:
<State>   **ON | 1 | AVGScarrier**
The I/Q mismatches (gain imbalance, quadrature offset, time skew) are averaged over the subcarriers. The scalar results are applied to the subcarriers and used for I/Q mismatch compensation.

PERScarrier
The individual I/Q mismatches per subcarrier are used for I/Q mismatch compensation.

OFF | 0
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: 0

Example: `SENS:TRAC:IQMC ON`
`//Applies I/Q mismatch based on average over subcarriers.`

Manual operation: See "I/Q Mismatch Compensation" on page 125

SENSe:TRACking:LEVel <State>

Activates or deactivates the compensation for level variations within a single PPDU. If activated, the measurement results are compensated for level error on a per-symbol basis.

Parameters:

<State>   ON | OFF | 1 | 0

                          *RST: 0

Example: SENS:TRAC:LEV ON

Manual operation: See "Level Error (Gain) Tracking" on page 124

SENSe:TRACking:PHASe <State>

Activates or deactivates the compensation for phase drifts.

Parameters:

<State>   ON | OFF | 0 | 1

                          OFF | 0
                          Switches the function off

                          ON | 1
                          Switches the function on. The measurement results are compensated for phase drifts on a per-symbol basis.

                          *RST: 1

Example: SENS:TRAC:PHAS ON

Manual operation: See "Phase Tracking" on page 124

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 R&S VSE 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 R&S VSE 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 125

SENSe:TRACking:PREamble <Mode>

Defines which results are used for preamble tracking prior to the preamble channel estimation.

Parameters:

<Mode>   **PAYLoad**

                  Payload tracking results are used for preamble tracking prior to the preamble channel estimation

                  VHT

                  (V)HT-LTF Symbols and Payload tracking results are used for preamble tracking prior to the preamble channel estimation.

                  *RST: PAYLoad

Example: SENS:TRAC:PRE VHT

Manual operation: See "Preamble Channel Estimation" on page 124

SENSe:TRACking:TIME <State>

Activates or deactivates the compensation for timing drift.

Parameters:

<State>   ON | OFF | 0 | 1

                  OFF | 0

                  Switches the function off

                  ON | 1

                  Switches the function on. The measurement results are compensated for timing error on a per-symbol basis.

                  *RST: 0

Example: SENS:TRAC:TIME ON

Manual operation: See "Timing Error Tracking" on page 124

[SENSe] (see also SENSe: commands!)

8.4.8 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 182).

Manual configuration is described in Chapter 4.7, "Demodulation", on page 126.

8.4.8.1 Common demodulation commands

The following commands are required for demodulation for several or all WLAN 802.11 standards.

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 154

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 | 1**

The guard time is detected automatically according to `CONFigure:WLAN:GTIMe:AUTO:TYPE` on page 364.

OFF | 0

The guard time is defined by the `CONFigure:WLAN:GTIMe:SELect` command.

*RST: 1

Manual operation: See "Guard Interval Length" on page 129
See "Guard Interval (GI) + HE-LTF Size" on page 140
See "Guard Interval (GI) + EHT-LTF Size" on page 148

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 129 See "Guard Interval (GI) + HE-LTF Size" on page 140 See "Guard Interval (GI) + EHT-LTF Size" on page 148

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 133

D0 | D1 | D2
Demod all as STBC field = 0 | 1 | 2
For details see "STBC Field" on page 133

Example:	`CONF:WLAN:STBC:AUTO:TYPE M0`
Manual operation:	See "STBC Field" on page 133

[SENSe:]BANDwidth:CHANnel:AUTO <State>

Defines whether the channel bandwidth to be analyzed is determined automatically.

Is only available for standards **IEEE 802.11a, ac, n**.

Parameters:

<State>   ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 1

[SENSe:]BANDwidth:CHANnel:AUTO:TYPE <Bandwidth>

This remote control command specifies the bandwidth in which the PPDUs are analyzed.

Note that channel bandwidths larger than 10 MHz require a bandwidth extension option on the connected instrument.

See Chapter C, "Sample rate, record length and analysis bandwidth", on page 380.

Parameters:

<Bandwidth>   FBURst | MB2_5 | MB5 | MB10 | MB20 | MB40 | MB80 | MB160 | MB320 | DB2_5 | DB5 | DB10 | DB20 | DB40 | DB80 | DB160 | DB320

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")

MB2_5
Only PPDUs with a channel bandwidth of 2.5 MHz are analyzed (**IEEE 802.11a, p only**)

MB5
Only PPDUs with a channel bandwidth of 5 MHz are analyzed (**IEEE 802.11a, p only**)

MB10
Only PPDUs with a channel bandwidth of 10 MHz are analyzed (**IEEE 802.11a, p only**)

MB20
Only PPDUs with a channel bandwidth of 20 MHz are analyzed

MB40
Only PPDUs with a channel bandwidth of 40 MHz are analyzed (**IEEE 802.11 n, ac only**)

MB80
Only PPDUs with a channel bandwidth of 80 MHz are analyzed (**IEEE 802.11 ac only**)

MB160
Only PPDUs with a channel bandwidth of 160 MHz are analyzed (**IEEE 802.11 ac only**)

DB2_5
The bandwidth indicated in the signal field of the PPDU is overwritten by a bandwidth of 2.5 MHz
(**IEEE 802.11a, p only**)

DB5
The bandwidth indicated in the signal field of the PPDU is overwritten by a bandwidth of 5 MHz
(**IEEE 802.11a, p only**)

DB10

The bandwidth indicated in the signal field of the PPDU is over-written by a bandwidth of 10 MHz

(**IEEE 802.11a, p only**)

DB20

The bandwidth indicated in the signal field of the PPDU is over-written by a bandwidth of 20 MHz

DB40

The bandwidth indicated in the signal field of the PPDU is over-written by a bandwidth of 40 MHz

(**IEEE 802.11ac, ax, n, be only**)

DB80

The bandwidth indicated in the signal field of the PPDU is over-written by a bandwidth of 80 MHz

(**IEEE 802.11ac, ax, n, be only**)

DB160

The bandwidth indicated in the signal field of the PPDU is over-written by a bandwidth of 160 MHz

(**IEEE 802.11ac, ax, n, be only**)

DB320

The bandwidth indicated in the signal field of the PPDU is over-written by a bandwidth of 320 MHz

(**IEEE 802.11be only**)

*RST: FBURst

Example:	SENS:BAND:CHAN:AUTO:TYPE MB20
Manual operation:	See "Channel Bandwidth to measure (CBW)" on page 128
	See "Channel Bandwidth to measure (CBW)" on page 135
	See "Channel Bandwidth to measure (CBW)" on page 143

[SENSe:]DEMod:DATA <Mode>

Defines when in the demodulation process the bitstream is determined and thus which results are available.

See also Chapter 2.1.9, "BER and CWER", on page 20.

Parameters:

<Mode>   ACDScarrier | ALBDecoder

       ACDScarrier

       (Default:) No channel decoding is performed. Processing time is reduced, but BER and CWER results are not available.

       ALBDecoder

       Decoding is performed, providing BER and CWER results. Measurement time is increased compared to non-decoding process.

       *RST: ACDScarrier

Example:	DEM:DATA ALBD

Manual operation: See "Demodulation Data (Bitstream)" on page 141

[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.

To analyze all PPDUs using the same modulation (corresponds to "Demod all as...", use the command: SENS:DEMO:FORM:BANA:BTYP:AUTO:TYPE ...

See [SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE on page 260.

Parameters:

<Format>   *RST: QAM64

Example: SENS:DEMO:FORM:BAN 'BPSK6'

Manual operation: See "PPDU Format to measure" on page 127
                         See "PSDU Modulation to use" on page 128
                         See "PSDU Modulation" on page 129
                         See "PPDU Format to measure" on page 135
                         See "PPDU Format to measure" on page 143
                         See "PPDU Format to measure[/] PSDU Modulation to use"
                         on page 150
                         See "PPDU Format" on page 151

Table 8-3: 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 8-4: 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 8-5: 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 260 and `[SENSe:]BANDwidth:CHANnel:AUTO:TYPE` on page 256).

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 260 and `[SENSe:]BANDwidth:CHANnel:AUTO:TYPE` on page 256).

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 151

[SENSe:]DEMod:FORMat:BANalyze:BTYPe:AUTO:TYPE <PPDUFormat>

This remote control command specifies how signals are analyzed.

Parameters:

<PPDUFormat>   **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)

AIHS

Only HE Single-User PPDUs are analyzed
(IEEE 802.11 ax)

AIHM

Only HE Multi-User PPDUs are analyzed
(IEEE 802.11 ax)

AIES

Only HE Extended Range PPDUs are analyzed
(IEEE 802.11 ax)

AIHT

Only HE Trigger-based PPDUs are analyzed
(IEEE 802.11 ax)

DHEP

All PPDUs are assumed to have HE PPDU format
(IEEE 802.11 ax)

FMMM

Only PPDUs with specified format are analyzed (see `[SENSe:
]DEMod:FORMat:BANalyze` on page 258)
(IEEE 802.11 b, g (DSSS))

FMMD

All PPDUs are assumed to have the specified PPDU format (see `[SENSe:]DEMod:FORMat:BANalyze` on page 258)

(IEEE 802.11 b, g (DSSS))

DEHP

All PPDUs are assumed to have EHT PPDU format

(IEEE 802.11 be)

AIEM

Only EHT MU PPDU are analyzed

(IEEE 802.11 be)

AIET

Only EHT trigger-based PPDU are analyzed

(IEEE 802.11 be)

DEHTppdu

All PPDUs are assumed to have EHT PPDU format

(IEEE 802.11 be)

*RST: FBURst

Example:	`SENS:DEM:FORM:BAN:BTYP:AUTO:TYPE FBUR`
Manual operation:	See "PPDU Format to measure" on page 127 See "PSDU Modulation to use" on page 128 See "PPDU Format to measure" on page 135 See "PPDU Format to measure" on page 143 See "PPDU Format to measure[/] PSDU Modulation to use" on page 150

[SENSe:]DEMod:FORMat[:BCONtent]:AUTO <State>

Determines whether the PPDUs to be analyzed are determined automatically or by the user.

Parameters:

<State>	**ON | 1** 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 | 0** 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 260 and `[SENSe:]DEMod:FORMat:BANalyze` on page 258).
Manual operation:	See "PPDU Analysis Mode" on page 127 See "PPDU Analysis Mode" on page 135

[SENSe:]DEMod:FORMat:BTRate <BitRate>

Parameters:
<BitRate>

[SENSe:]DEMod:FORMat:MCSindex <Index>

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).

Is required if `[SENSe:]DEMod:FORMat:MCSindex:MODE` is set to `MEAS` or `DEM`.

Parameters:
<Index>   Range: 0 to 11
                       *RST: 1

Example: SENS:DEM:FORM:MCS:MODE MEAS
                       SENS:DEM:FORM:MCS 1

Manual operation: See "MCS Index" on page 132

[SENSe:]DEMod:FORMat:MCSindex:MODE <Mode>

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 131

[SENSe:]DEMod:FORMat:NSTSindex <Index>

Defines the PPDUs taking part in the analysis depending on their Nsts.

Is only available for the **IEEE 802.11 ac** standard.

Is available for DEM:FORM:NSTS:MODE MEAS or DEM:FORM:NSTS:MODE DEM (see [SENSe:]DEMod:FORMat:NSTSindex:MODE on page 264).

Parameters:
<Index>

Example: SENS:DEM:FORM:NSTS:MODE MEAS
                      SENS:DEM:FORM:NSTS 1

Manual operation: See "Nsts" on page 132

[SENSe:]DEMod:FORMat:NSTSindex:MODE <Mode>

Defines the PPDUs taking part in the analysis depending on their Nsts.

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 132

[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:

<State>   **OFF | 0**
                           Deactivates signal symbol field decoding. All PPDUs are
                           assumed to have the specified PPDU format / PSDU modula-
                           tion, regardless of the actual format or modulation.

                           ON | 1
                           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: 0

Example: `DEM:FORM:SIGS ON`

Manual operation: See "PPDU Format to measure[/] PSDU Modulation to use"
                           on page 150

8.4.8.2 PPDU configuration

The following commands are required to configure PPDU resource units (IEEE
802.11ax, be standards).

CONFigure:WLAN:RUConfig:COUNt:ACTive <ActiveCount>...

Determines the RUs for which the results are evaluated.

Parameters:

<ActiveCount>	integer
	Comma-separated list of resource unit numbers from the PPDU configuration table.
Example:	`CONF:WLAN:RUC:COUN:ACT 1,5,7`
	Displays the results for the resource units in rows 1, 5, and 7 in the PPDU configuration table.
Manual operation:	See "RU number" on page 145

CONFigure:WLAN:RUConfig:COUNt:HIGHest?

Queries the highest configured RU index in the entire signal.

Return values:

<MaxIndex>	Range:	1 to 9
Example:	`CONF:WLAN:RUC:COUN:HIGH?`	
Usage:	Query only	

CONFigure:WLAN:RUConfig:EHTPpdu <RUConfig_PPDU>

Defines the format of the EHT PPDU. This format determines which other PPDU settings are available.

Parameters:

<RUConfig_PPDU>	**MU**
	High-efficiency multi-user PPDU for downlink to multiple users at the same time
	*RST: MU
Manual operation:	See "EHT PPDU Format" on page 145

CONFigure:WLAN:RUConfig:HEPPdu <RUConfig_PPDU>

Defines the format of the HE PPDU. This format determines which other PPDU settings are available.

Parameters:

<RUConfig_PPDU>	SU	MU	TRIG	ESU

SU

High-efficiency single user PPDU for uplink and downlink

MU

High-efficiency multi-user PPDU for downlink to multiple users at the same time

TRIG

High-efficiency trigger-based PPDU for uplink from multiple users at the same time

ESU

High-efficiency single-user PPDU for an extended range

*RST: SU

Manual operation: See "HE PPDU Format" on page 137

CONFigure:WLAN:RUConfig:NHELtf <RUConfig_N_HE_LTF>

Defines the length of the high-efficiency long training field (for **trigger-based uplink PPDUs only**). For more information see "HE Trigger-based PPDUs" on page 79.

Parameters:
<RUConfig_N_HE_LTF> AUTO | STA | S1 | S2 | S4 | S6 | S8

AUTO

The application determines the length automatically.

STA

The station configuration defines the used length.

S1 | S2 | S4 | S6 | S8

The LTF of the PPDUs have a fixed length (1 / 2 / 4 / 6 / 8 symbols).

*RST: STA

Manual operation: See "N_{HE-LTF}" on page 137

See "$N_{EHT-LTF}$" on page 145

CONFigure:WLAN:RUConfig:REFResh

Updates the result displays for the currently selected RUs in the PPDU configuration table.

Example: `CONF:WLAN:RUC:REFR`

Usage: Event

Manual operation: See "Refresh" on page 140

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:COUNt:HIGHest?

Queries the highest configured RU index in the specified RU allocation table.

Suffix:

<seg>	1 | 2 | 3 | 4
	80-MHz-segment to be configured
	Segment 1: first 80 MHz of the channel
	Segment 2: next 80 MHz of the channel (for **160 MHz** channels and **MU-PPDU (DL)** only)
	Segment 3 + 4: only for **320 MHz** channels and **EHT MU-PPDU (DL)**
<ch>	1 to 4
	20-MHz-subchannel (=242 subcarriers) that RU allocation applies to
<cf>	1..n
	irrelevant

Return values:

<MaxIndex>	Range:	1 to 9

Usage: Query only

Manual operation: See "RU Index" on page 138
                          See "RU Index" on page 146

**CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:
MRUindex** <MRUInd>

Sets or queries the index of the subcarrier and resource allocation for multiple RUs (MRU) as defined by the 802.11be standard. This index determines the position of the ignored subcarriers and used RUs within the spectrum.

Suffix:

<seg>	1 | 2 | 3 | 4
	80-MHz-segment to be configured
	Segment 1: first 80 MHz of the channel
	Segment 2: next 80 MHz of the channel (for **160 MHz** channels and **MU-PPDU (DL)** only)
	Segment 3 + 4: only for **320 MHz** channels and **EHT MU-PPDU (DL)**
<ch>	1 to 4
	20-MHz-subchannel (=242 subcarriers) that RU allocation applies to
<cf>	1 to 9
	Index of the entry in the RU allocation table

Parameters:

<MRUInd>	integer	
	Range:	1 to 12

Manual operation: See "MRU Index" on page 146

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: RU26index <Index>

Sets or queries the index of the resource unit based on 26-subcarrier units.

Suffix:

<seg>	1 | 2 | 3 | 4
	80-MHz-segment to be configured
	Segment 1: first 80 MHz of the channel
	Segment 2: next 80 MHz of the channel (for **160 MHz** channels and **MU-PPDU (DL)** only)
	Segment 3 + 4: only for **320 MHz** channels and **EHT MU-PPDU (DL)**
<ch>	1 to 4
	20-MHz-subchannel (=242 subcarriers) that RU allocation applies to
<cf>	1 to 9
	Index of the entry in the RU allocation table

Parameters:

<Index>	integer
	Range: 1 to 143

Manual operation: See "RU26 Index" on page 138
See "RU26 Index" on page 146

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: RUINdex <Index>

Sets or queries the index of the resource unit as defined by the IEEE 802.11ax, be standard (based on resource units of the specified RU size, see `CONFigure:WLAN: RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:RUSize`). This value determines the position of the resource unit within the channel.

Note that you can specify any possible RU index value for the entire channel, regardless of the specified segment and subchannel.

To determine the highest allocated RU index for a specific segment and subchannel, use `CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>: RULocation<cf>:COUNt:HIGHest?` on page 267. To determine the highest allocated RU index for the entire channel, see `CONFigure:WLAN:RUConfig:COUNt: HIGHest?` on page 266.

Suffix:

<seg>	1 | 2 | 3 | 4
	80-MHz-segment to be configured
	Segment 1: first 80 MHz of the channel
	Segment 2: next 80 MHz of the channel (for **160 MHz** channels and **MU-PPDU (DL)** only)

<ch>	1 to 4
	20-MHz-subchannel (=242 subcarriers) that RU allocation applies to
<cf>	1 to 9
	Index of the entry in the RU allocation table

Parameters:

<Index>	integer
	RU index
	Range: 1 to 144

| **Example:** | CONFigure:WLAN:RUConfig:SEGMent1:CHANnel1: RULocation2:RUINdex 2 |

Manual operation: See "RU Index" on page 146

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: RUSize <RUSize>

Defines the size of the individual resource unit (= number of subcarriers or tones) for a single transmission package.

Suffix:

<seg>	1 | 2 | 3 | 4
	80-MHz-segment to be configured
	Segment 1: first 80 MHz of the channel
	Segment 2: next 80 MHz of the channel (for **160 MHz** channels and **MU-PPDU (DL)** only)
	Segment 3 + 4: only for **320 MHz** channels and **EHT MU-PPDU (DL)**
<ch>	1 to 4
	20-MHz-subchannel (=242 subcarriers) that RU allocation applies to
<cf>	1 to 9
	Index of the entry in the RU allocation table

Parameters:

| <RUSize> | SU \| S0 \| S26 \| S52 \| S106 \| S242 \| S484 \| S996 \| S2X996 \| S4X996 \| S52S26 \| S106s26 \| S484s242 \| S996s484 \| S996s484s242 \| S2X996s484 \| S3X996 \| S3X996s484 |

| **Example:** | CONFigure:WLAN:RUConfig:SEGMent1:CHANnel1: RULocation2:RUSize? |
| | //Result: S106 |

Manual operation: See "RU Size" on page 138
See "RU Size" on page 146

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: RUTSix <Index>

Suffix:

<seg>	1 | 2 | 3 | 4 80-MHz-segment to be configured Segment 1: first 80 MHz of the channel Segment 2: next 80 MHz of the channel (for **160 MHz** channels and **MU-PPDU (DL)** only) Segment 3 + 4: only for **320 MHz** channels and **EHT MU-PPDU (DL)**
<ch>	1 to 4 20-MHz-subchannel (=242 subcarriers) that RU allocation applies to
<cf>	1 to 9 Index of the entry in the RU allocation table

Parameters:
<Index>

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: USER:COUNt?

Queries the number of users configured for the specified RU.

Suffix:

<seg>	1 | 2 | 3 | 4 80-MHz-segment to be configured Segment 1: first 80 MHz of the channel Segment 2: next 80 MHz of the channel (for **160 MHz** channels and **MU-PPDU (DL)** only) Segment 3 + 4: only for **320 MHz** channels and **EHT MU-PPDU (DL)**
<ch>	1 to 4 20-MHz-subchannel (=242 subcarriers) that RU allocation applies to
<cf>	1 to 9 Index of the entry in the RU allocation table

Return values:

<MaxUsers>	Range:	1 to 8

Example:	`CONFigure:WLAN:RUConfig:SEGMent1:CHANnel1:`
	`RULocation1:USER:INSert`
	Inserts a new user (User 1) under the default User 0 for the RU 1.
	`:CONFigure:WLAN:RUConfig:SEGMent1:CHANnel1:`
	`RULocation1:USER:COUNt?`
	Queries the number of users for RU 1.
	`//Result: 2`

Usage:	Query only
Manual operation:	See "User Index" on page 138 See "User Index" on page 146

CONFigure:WLAN:RUConfig:SEGMent\<seg>:CHANnel\<ch>:RULocation\<cf>: USER\<mu>:CODing \<Type>

The type of coding used by the PPDU

Suffix:

\<seg>	1 | 2 | 3 | 4 80-MHz-segment to be configured Segment 1: first 80 MHz of the channel Segment 2: next 80 MHz of the channel (for **160 MHz** channels and **MU-PPDU (DL)** only) Segment 3 + 4: only for **320 MHz** channels and **EHT MU-PPDU (DL)**
\<ch>	1 to 4 20-MHz-subchannel (=242 subcarriers) that RU allocation applies to
\<cf>	1 to 9 Index of the entry in the RU allocation table
\<mu>	1 to 8 User index for RU in MIMO mode

Parameters:

\<Type>	**1** LDPC is used **0** BCC is used

Example:	`:CONFigure:WLAN:RUConfig:SEGMent1:CHANnel1:`
	`RULocation1:USER1:CODing?`
	`//Result: 0`

Manual operation:	See "Coding" on page 139 See "Coding" on page 147

**CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:
USER<mu>:DCM** <Type>

Defines the use of dual carrier modulation for the specified user.

Suffix:

<seg>	1 | 2 | 3 | 4
	80-MHz-segment to be configured
	Segment 1: first 80 MHz of the channel
	Segment 2: next 80 MHz of the channel (for **160 MHz** channels and **MU-PPDU (DL)** only)
	Segment 3 + 4: only for **320 MHz** channels and **EHT MU-PPDU (DL)**
<ch>	1 to 4
	20-MHz-subchannel (=242 subcarriers) that RU allocation applies to
<cf>	1 to 9
	Index of the entry in the RU allocation table
<mu>	1 to 8
	User index for RU in MIMO mode

Parameters:

<Type>	ON | OFF | 0 | 1
	OFF | 0
	DCM not used
	ON | 1
	DCM is used
	*RST: 0

Example:	:CONFigure:WLAN:RUConfig:SEGMent1:CHANnel1:
	RULocation1:USER1:DCM?
	//Result: 0

Manual operation:	See "DCM" on page 139
	See "DCM" on page 147

**CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:
USER<mu>:DELete**

Deletes the selected user (station) from the HE Multi-User Downlink PPDU configuration table (for **MIMO** configuration only).

Suffix:

<seg>	1 | 2 | 3 | 4
	80-MHz-segment to be configured
	Segment 1: first 80 MHz of the channel
	Segment 2: next 80 MHz of the channel (for **160 MHz** channels and **MU-PPDU (DL)** only)
	Segment 3 + 4: only for **320 MHz** channels and **EHT MU-PPDU (DL)**

<ch>	1 to 4 20-MHz-subchannel (=242 subcarriers) that RU allocation applies to
<cf>	1 to 9 Index of the entry in the RU allocation table
<mu>	1 to 8 User index for RU in MIMO mode
Example:	CONFigure:WLAN:RUConfig:SEGMent1:CHANnel1: RULocation1:USER1:DELete Deletes User 1 for the RU 1.
Usage:	Event
Manual operation:	See "Delete User" on page 140 See "Delete User" on page 148

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: USER<mu>:INSert

For **HE Multi-User Downlink PPDU**s that support **MIMO** only:

Adds another user (station) for the selected resource unit (RU) to the configuration table.

A maximum of 8 users can be assigned to a single resource unit in MIMO mode.

Is only available for RU sizes of at least 106 subcarriers.

Suffix:

<seg>	1 | 2 | 3 | 4 80-MHz-segment to be configured Segment 1: first 80 MHz of the channel Segment 2: next 80 MHz of the channel (for **160 MHz** channels and **MU-PPDU (DL)** only) Segment 3 + 4: only for **320 MHz** channels and **EHT MU-PPDU (DL)**
<ch>	1 to 4 20-MHz-subchannel (=242 subcarriers) that RU allocation applies to
<cf>	1 to 9 Index of the entry in the RU allocation table
<mu>	1 to 8 User index for RU in MIMO mode
Example:	CONFigure:WLAN:RUConfig:SEGMent1:CHANnel1: RULocation1:USER1:INSert Inserts a new user (User 1) under the default User 0 for the RU 1.
Usage:	Event

Manual operation: See "Insert User" on page 139
See "Insert User" on page 148

**CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>:
USER<mu>:MCSindex** <ModCodInd>

Modulation and Coding Scheme (MCS) index of the PPDU

Suffix:

1 | 2 | 3 | 4
80-MHz-segment to be configured
Segment 1: first 80 MHz of the channel
Segment 2: next 80 MHz of the channel (for **160 MHz** channels
and **MU-PPDU (DL)** only)
Segment 3 + 4: only for **320 MHz** channels and **EHT MU-PPDU
(DL)**

<ch>
1 to 4
20-MHz-subchannel (=242 subcarriers) that RU allocation
applies to

<cf>
1 to 9
Index of the entry in the RU allocation table

<mu>
1 to 8
User index for RU in MIMO mode

Parameters:

<ModCodInd>
integer

Modulation and Coding Scheme (MCS) index of the PPDU

Range: 0 to 11

Example: `:CONFigure:WLAN:RUConfig:SEGMent1:CHANnel1:`
`RULocation1:USER1:MCSindex?`
`//Result: 0`

Manual operation: See "MCS Index" on page 138
See "MCS Index" on page 147

MCS index	Modulation and coding scheme
0	BPSK 1/2
1	QPSK 1/2
2	QPSK 3/4
3	16-QAM 1/2
4	16-QAM 3/4
5	64-QAM 2/3
6	64-QAM 3/4
7	64-QAM 5/6

MCS index	Modulation and coding scheme
8	256-QAM 3/4
9	256-QAM 5/6
10	1024-QAM 3/4
11	1024-QAM 5/6

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: USER<mu>:NSTS <NoStreams>

For **MIMO** measurements only:

Number of space-time streams (NSTS) for each user

Suffix:

1 | 2 | 3 | 4
80-MHz-segment to be configured
Segment 1: first 80 MHz of the channel
Segment 2: next 80 MHz of the channel (for **160 MHz** channels and **MU-PPDU (DL)** only)
Segment 3 + 4: only for **320 MHz** channels and **EHT MU-PPDU (DL)**

<ch>
1 to 4
20-MHz-subchannel (=242 subcarriers) that RU allocation applies to

<cf>
1 to 9
Index of the entry in the RU allocation table

<mu>
1 to 8
User index for RU in MIMO mode

Parameters:

<NoStreams>
Number of space-time streams (NSTS) for each user
Range: 1 to 8

Example:
CONFigure:WLAN:RUConfig:SEGMent1:CHANnel1:
RULocation1:USER1:NSTS?
//Result: 1

Manual operation:
See "Nsts per User" on page 139
See "Nsts per User" on page 147

CONFigure:WLAN:RUConfig:SEGMent<seg>:CHANnel<ch>:RULocation<cf>: USER<mu>:TBEamforming <State>

Defines whether transmit beamforming is used.

Suffix:

\<seg\>	1 | 2 | 3 | 4
	80-MHz-segment to be configured
	Segment 1: first 80 MHz of the channel
	Segment 2: next 80 MHz of the channel (for **160 MHz** channels and **MU-PPDU (DL)** only)
	Segment 3 + 4: only for **320 MHz** channels and **EHT MU-PPDU (DL)**
\<ch\>	1 to 4
	20-MHz-subchannel (=242 subcarriers) that RU allocation applies to
\<cf\>	1 to 9
	Index of the entry in the RU allocation table
\<mu\>	1 to 8
	User index for RU in MIMO mode

Parameters:

\<State\>	ON | OFF | 0 | 1
	OFF | 0
	No beamforming applied
	ON | 1
	Beamforming is applied
	*RST: 0

Example: `:CONFigure:WLAN:RUConfig:SEGMent1:CHANnel1:`
                            `RULocation1:USER1:TBEamforming?`
                            `//Result: 0`

Manual operation: See "TX Beamforming" on page 139
                           See "TX Beamforming" on page 147

8.4.8.3 MIMO demodulation commands

The following commands are required for WLAN 802.11 standards that support MIMO only.

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 156

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>   ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Manual operation: See "Power Normalise" on page 156

CONFigure:WLAN:SMAPping:TX<ch> <STSI>...

This remote control command specifies the mapping for all streams (real & imaginary data pairs) and timeshift for a specified antenna.

Suffix:

<ch>   1..n

Parameters:

<STSI>   Imag part of the complex element of the STS-Stream

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 157

CONFigure:WLAN:SMAPping:TX<ch>:STReam<ant> <STSI>, <STSQ>

This remote control command specifies the mapping for a specific stream and antenna.

Suffix:

<ch>   1..n

<ant>   1..n

Parameters:

<STSI>	Imag part of the complex element of the STS-Stream
<STSQ>	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 157

CONFigure:WLAN:SMAPping:TX<ch>:TIMeshift <TimeShift>

This remote control command specifies the timeshift for a specific antenna.

Suffix:

<ch>	1..n

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
	Default unit: S
Manual operation:	See "User Defined Spatial Mapping" on page 157

8.4.9 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.

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 162

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 | LSIGnal | SFIeld

                          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 159

CONFigure:WLAN:PVERror:MRANge <Range>

This remote control command defines or queries whether the Peak Vector Error results are calculated over the complete PPDU or just over the PSDU.

Is supported for **802.11b and 802.11g (DSSS)** only.

Parameters:

<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

Manual operation: See "Peak Vector Error : Meas Range" on page 162

[SENSe:]BURSt:COUNt <Value>

If the statistic count is enabled (see `[SENSe:]BURSt:COUNt:STATe` on page 281),
the specified number of PPDUs is taken into consideration for the statistical evaluation
(maximally the number of PPDUs detected in the current capture buffer).

If disabled, all detected PPDUs in the current capture buffer are considered.

Parameters:

<Value>   integer

                               *RST: 1

Example: `SENS:BURS:COUN:STAT ON`
                               `SENS:BURS:COUN 10`

Manual operation: See "PPDU Statistic Count / No of PPDUs to Analyze"
                               on page 159

[SENSe:]BURSt:COUNt:STATe <State>

If the statistic count is enabled, the specified number of PPDUs is taken into considera-
tion for the statistical evaluation (maximally the number of PPDUs detected in the cur-
rent capture buffer).

If disabled, all detected PPDUs in the current capture buffer are considered.

Parameters:

<State>   ON | OFF | 1 | 0

                               *RST: 0

Example: `SENS:BURS:COUN:STAT ON`
                               `SENS:BURS:COUN 10`

Manual operation: See "PPDU Statistic Count / No of PPDUs to Analyze"
                               on page 159

[SENSe:]BURSt:SELect <Value>

If single PPDU analysis is enabled (see `[SENSe:]BURSt:SELect:STATe`
on page 282), 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>   integer

                           *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 158

[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 281. As soon as a new measurement is started, the
                           evaluation range is reset to all PPDUs in the current capture buf-
                           fer.

                           *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 158

[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 measure-
ment 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 283 and [SENSe:]DEMod:FORMat:BANalyze:DBYTes:MIN).

Parameters:

<State>   ON | OFF | 1 | 0

                              *RST: 0

Manual operation: See "Equal PPDU Length" on page 159

[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 | 1 | 0

                          *RST: 0

Manual operation: See "Equal PPDU Length" on page 159

[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 286 and `[SENSe:]DEMod:FORMat:BANalyze:SYMBols:MIN` on page 286).

Parameters:

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

Manual operation: See "Equal PPDU Length" on page 159

[SENSe:]DEMod:FORMat:BANalyze:SYMBols:LENGth:STATe <State>

For **IEEE 802.11a, ac, g (OFDM), j, n, p** signals only:

If **enabled**, the number of PPDU data symbols after the "Analysis Interval Offset" which are to be analyzed can be specified (see `[SENSe:]DEMod:FORMat:BANalyze:SYMBols:LENGth` on page 285).

If **disabled**, all PPDU data symbols after the "Analysis Interval Offset" are evaluated.

Parameters:

<State>	ON | OFF | 0 | 1
	OFF | 0
	Switches the function off
	ON | 1
	Switches the function on
	*RST: 1

Example:	`SENS:DEM:FORM:BAN:SYMB:OFFS 10`
	PPDUs are analyzed after the 10th symbol in the PPDU.
	`SENS:DEM:FORM:BAN:SYMB:LENG:STAT OFF`
	PPDUs are analyzed after the symbol offset (10) until the end of each PPDU.
	`SENS:DEM:FORM:BAN:SYMB:LENG 100`
	100 symbols after the symbol offset (10-110) are analyzed in each PPDU.

Manual operation:	See "Analysis Interval Offset/Analysis Interval Length" on page 160

[SENSe:]DEMod:FORMat:BANalyze:SYMBols:LENGth <NumDataSymbols>

For **IEEE 802.11a, ac, g (OFDM), j, n, p** signals only:

If the `[SENSe:]DEMod:FORMat:BANalyze:SYMBols:LENGth:STATe` command is set to **false**, this command specifies the number of PPDU data symbols after the Analysis Interval Offset (see `[SENSe:]DEMod:FORMat:BANalyze:SYMBols:OFFSet` on page 287) which are to be analyzed.

If the `[SENSe:]DEMod:FORMat:BANalyze:SYMBols:LENGth:STATe` command is set to **true**, then this command has no effect.

Parameters:

<NumDataSymbols>   Range: 0 to 10000
                              *RST: 0

Example: SENS:DEM:FORM:BAN:SYMB:OFFS 10
                              SENS:DEM:FORM:BAN:SYMB:LENG:STAT OFF
                              SENS:DEM:FORM:BAN:SYMB:LENG 100

Manual operation: See "Analysis Interval Offset/Analysis Interval 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>   integer
                              *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>   integer
                              *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

[SENSe:]DEMod:FORMat:BANalyze:SYMBols:OFFSet <NumDataSymbols>

For **IEEE 802.11a, ac, g (OFDM), j, n, p** signals only:

Specifies the number of data symbols from the start of each PPDU that are to be skipped before symbols take part in analysis.

Parameters:

<NumDataSymbols> integer

                      Range: 0 to 10000
                      *RST: 0

Example: `SENS:DEM:FORM:BAN:SYMB:OFFS 10`
PPDUs are analyzed after the 10th symbol in the PPDU.
`SENS:DEM:FORM:BAN:SYMB:OFFS 0`
PPDUs are analyzed with a symbol offset of 0, i.e. starting with the first symbol

Manual operation: See "Analysis Interval Offset/Analysis Interval Length" on page 160

[SENSe:]SWEep:LIMit:ABORt:STATe <State>

Determines the behavior of the application after a limit check fails.

Parameters:

<State>   ON | OFF | 0 | 1

                      OFF | 0
A limit check has no effects on the measurement.
                      ON | 1
The measurement is stopped if the limit check fails at any time during the measurement.
                      *RST: 0

Example: `SWE:LIM:ABOR:STAT ON`

Manual operation: See "Stop RUN on Limit Check Fail" on page 159

8.4.10 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 8.6.1.3, "Limit check results", on page 335.

Useful commands for defining limits described elsewhere:

- `UNIT:EVM` on page 335

- UNIT:GIMBalance on page 335

Remote commands exclusive to defining limits:

CALCulate<n>:LIMit<li>:BURSt:ALL <Limits>...

Sets or returns the limit values for the parameters determined by the default WLAN measurement all in one step.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

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 335
- UNIT:GIMBalance on page 335

Suffix:

<n>   Window

   1..n

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<n>:LIMit<li>:BURSt:EVM:ALL[:AVERage] <Limit>
CALCulate<n>:LIMit<li>:BURSt:EVM:ALL:MAXimum <Limit>

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 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Suffix:

<n>	Window
	1..n

Parameters:

<Limit>	numeric value in dB
	The unit for the EVM parameters can be changed in advance using `UNIT:EVM` on page 335.
	Default unit: DB

CALCulate<n>:LIMit<li>:BURSt:EVM:DATA[:AVERage] <Limit>
CALCulate<n>:LIMit<li>:BURSt:EVM:DATA:MAXimum <Limit>

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 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Suffix:

<n>	Window
	1..n

Parameters:

<Limit>	numeric value in dB
	The unit for the EVM parameters can be changed in advance using `UNIT:EVM` on page 335.
	Default unit: DB

CALCulate<n>:LIMit<li>:BURSt:EVM:PILot[:AVERage] <Limit>
CALCulate<n>:LIMit<li>:BURSt:EVM:PILot:MAXimum <Limit>

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 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Suffix:

<n>   Window

   1..n

Parameters:

<Limit>   numeric value in dB
                                    The unit for the EVM parameters can be changed in advance
                                    using `UNIT:EVM` on page 335.

                                    Default unit: DB

CALCulate<n>:LIMit<li>:BURSt:EVM[:AVERage] <Limit>
CALCulate<n>:LIMit<li>:BURSt:EVM:MAXimum <Limit>

Sets or queries the average or maximum error vector magnitude limit determined by the default WLAN measurement.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Is only available for **IEEE 802.11b and g (DSSS)**.

Suffix:

<n>   Window

   1..n

Parameters:

<Limit>   numeric value in dB
                                    The unit for the EVM parameters can be changed in advance
                                    using `UNIT:EVM` on page 335.

                                    Default unit: PCT

CALCulate<n>:LIMit<li>:BURSt:FERRor[:AVERage] <Limit>
CALCulate<n>:LIMit<li>:BURSt:FERRor:MAXimum <Limit>

Sets or queries the average or maximum center frequency error limit determined by the default WLAN measurement.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Suffix:

<n>   Window

   1..n

Parameters:

<Limit>　　　　　　　　numeric value in Hertz

　　　　　　　　　　　　Default unit: HZ

CALCulate<n>:LIMit<li>:BURSt:IQOFfset[:AVERage] <Limit>
CALCulate<n>:LIMit<li>:BURSt:IQOFfset:MAXimum <Limit>

Sets or queries the average or maximum I/Q offset error limit determined by the default WLAN measurement..

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Suffix:

<n>　　　　　　　　　　Window

　　　　　　　　　　1..n

Parameters:

<Limit>　　　　　　　　Range:　　　-1000000　to　1000000
　　　　　　　　　　　　Default unit: DB

CALCulate<n>:LIMit<li>:BURSt:SYMBolerror[:AVERage] <Limit>
CALCulate<n>:LIMit<li>:BURSt:SYMBolerror:MAXimum <Limit>

Sets or queries the average or maximum symbol clock error limit determined by the default WLAN measurement.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Suffix:

<n>　　　　　　　　　　Window

　　　　　　　　　　1..n

Parameters:

<Limit>　　　　　　　　numeric value in parts per million

　　　　　　　　　　　　Default unit: PPM

CALCulate<n>:LIMit<li>:BURSt:TFALI[:AVERage] <Limit>
CALCulate<n>:LIMit<li>:BURSt:TFALI:MAXimum <Limit>

Sets or queries the average or maximum fall time limit for the data carrier determined by the default WLAN measurement.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Suffix:

<n>　　　　　　　　　　Window

　　　　　　　　　　1..n

Parameters:

<Limit>	Default unit: S

CALCulate<n>:LIMit<li>:BURSt:TRISe[:AVERage] <Limit>
CALCulate<n>:LIMit<li>:BURSt:TRISe:MAXimum <Limit>

Sets or queries the average or maximum rise time limit for the data carrier determined by the default WLAN measurement.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Suffix:

<n>	Window
	1..n

Parameters:

<Limit>	Default unit: S

8.4.11 Automatic settings

[SENSe<ip>:]ADJust:LEVel

Initiates a single (internal) measurement that evaluates and sets the ideal reference level for the current input data and measurement settings. Thus, the settings of the RF attenuation and the reference level are optimized for the signal level. The R&S VSE is not overloaded and the dynamic range is not limited by an S/N ratio that is too small.

Suffix:

<ip>	1..n

Example: ADJ:LEV

Manual operation: See "Setting the Reference Level Automatically (Auto Level)" on page 165

[SENSe<ip>:]ADJust:CONFigure:LEVel:DURation <Duration>

To determine the ideal reference level, the R&S VSE performs a measurement on the current input data. This command defines the length of the measurement if [SENSe<ip>:]ADJust:CONFigure:LEVel:DURation:MODE is set to MANual.

Suffix:

<ip>	1..n

Parameters:

<Duration>   Numeric value in seconds

Range: 0.001 to 16000.0
*RST: 0.001
Default unit: s

Example: `ADJ:CONF:DUR:MODE MAN`
Selects manual definition of the measurement length.
`ADJ:CONF:LEV:DUR 5ms`
Length of the measurement is 5 ms.

Manual operation: See "Automatic Measurement Time Mode and Value"
on page 166

[SENSe<ip>:]ADJust:CONFigure:LEVel:DURation:MODE <Mode>

To determine the ideal reference level, the R&S VSE performs a measurement on the
current input data. This command selects the way the R&S VSE determines the length
of the measurement .

Suffix:
<ip>   1..n

Parameters:
<Mode>   **AUTO**
The R&S VSE determines the measurement length automati-
cally according to the current input data.
MANual
The R&S VSE uses the measurement length defined by
`[SENSe<ip>:]ADJust:CONFigure:LEVel:DURation`
on page 292.
*RST: AUTO

Manual operation: See "Automatic Measurement Time Mode and Value"
on page 166

[SENSe<ip>:]ADJust:CONFigure:HYSTeresis:LOWer <Threshold>

Suffix:
<ip>   1..n

Parameters:
<Threshold>   Range: 0 dB to 200 dB
*RST: +1 dB
Default unit: dB

Example: `SENS:ADJ:CONF:HYST:LOW 2`
For an input signal level of currently 20 dBm, the reference level
is only adjusted when the signal level falls below 18 dBm.

Manual operation: See "Lower Level Hysteresis" on page 166

[SENSe<ip>:]ADJust:CONFigure:HYSTeresis:UPPer <Threshold>

Suffix:

<ip>   1..n

Parameters:

<Threshold>   Range: 0 dB to 200 dB
                             *RST: +1 dB
                             Default unit: dB

Example: SENS:ADJ:CONF:HYST:UPP 2

Example: For an input signal level of currently 20 dBm, the reference level
                             is only adjusted when the signal level rises above 22 dBm.

Manual operation: See "Upper Level Hysteresis" on page 166

8.5 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 the R&S VSE Base Software User Manual.

The suffix <n> in the following remote commands represents the window (1..x) in the currently selected measurement channel.

8.5.1 Configuring the result display

The commands required to configure the screen display in a remote environment are described here.

8.5.1.1 Global layout commands

The following commands are required to change the evaluation type and rearrange the screen layout across measurement channels as you do in manual operation.

ⓘ For compatibility with other Rohde & Schwarz Signal and Spectrum Analyzers, the layout commands described in Chapter 8.5.1.2, "Working with windows in the display", on page 298 are also supported. Note, however, that the commands described there only allow you to configure the layout within the *active* measurement channel.

LAYout:GLOBal:ADD[:WINDow]?
 <ExChanName>,<ExWinName>,<Direction>,<NewChanName>,<NewWinType>

Adds a window to the display next to an existing window. The new window may belong to a different channel than the existing window.

To replace an existing window, use the `LAYout:GLOBal:REPLace[:WINDow]` command.

Parameters:

<ExChanName> string

 Name of an existing channel

<ExWinName> string

 Name of the existing window within the <ExChanName> channel 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:GLOBal:IDENtify[:WINDow]?` query.

<Direction> LEFT | RIGHt | ABOVe | BELow | TAB

 Direction the new window is added relative to the existing window.

 TAB
 The new window is added as a new tab in the specified existing window.

<NewChanName> string

 Name of the channel for which a new window is to be added.

<NewWinType> string

 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: LAYout:GLOBal:ADD:WINDow? 'IQ
                     Analyzer','1',RIGH,'IQ Analyzer2','FREQ'
                     Adds a new window named 'Spectrum' with a Spectrum display
                     to the right of window 1 in the channel 'IQ Analyzer'.

Usage: Query only

Table 8-6: <WindowType> parameter values for WLAN application

Parameter value	Window type
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)
FSPectrum	FFT Spectrum
GDELay	Group Delay (**IEEE 802.11a, ac, g (OFDM), j, n, p** only)
PFPPdu	PvT Full PPDU
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)

LAYout:GLOBal:CATalog[:WINDow]?

Queries the name and index of all active windows from top left to bottom right for each active channel. The result is a comma-separated list of values for each window, with the syntax:

<ChannelName_1>: <WindowName_1>,<WindowIndex_1>..<WindowName_n>,<WindowIndex_n>

..

<ChannelName_m>: <WindowName_1>,<WindowIndex_1>..<WindowName_n>,<WindowIndex_n>

Return values:

<ChannelName>   String containing the name of the channel. The channel name is
                     displayed as the tab label for the measurement channel.

<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:GLOB:CAT?`
	Result:
	`IQ Analyzer: '1',1,'2',2`
	`Analog Demod: '1',1,'4',4`
	For the I/Q Analyzer channel, two windows are displayed, named '2' (at the top or left), and '1' (at the bottom or right). For the Analog Demodulation channel, two windows are displayed, named '1' (at the top or left), and '4' (at the bottom or right).
Usage:	Query only

LAYout:GLOBal:IDENtify[:WINDow]? <ChannelName>,<WindowName>

Queries the **index** of a particular display window in the specified channel.

Note: to query the **name** of a particular window, use the `LAYout:WINDow<n>:IDENtify?` query.

Parameters:

<ChannelName>	String containing the name of the channel. The channel name is displayed as the tab label for the measurement channel.

Query parameters:

<WindowName>	String containing the name of a window.

Return values:

<WindowIndex>	Index number of the window.

Example:	`LAYout:GLOBal:ADD:WINDow? IQ,'1',RIGH,`
	`'Spectrum',FREQ`
	Adds a new window named 'Spectrum' with a Spectrum display to the right of window 1.
Example:	`LAYout:GLOBal:IDENtify? 'IQ Analyzer',`
	`'Spectrum'`
	Result:
	2
	Window index is: 2.
Usage:	Query only

LAYout:GLOBal:REMove[:WINDow] <ChannelName>, <WindowName>

Setting parameters:
<ChannelName>

<WindowName>

Usage:	Setting only

LAYout:GLOBal:REPLace[:WINDow] <ExChannelName>, <WindowName>,
<NewChannelName>, <WindowType>

Setting parameters:
<ExChannelName>

<WindowName>

<NewChannelName>

<WindowType>

Usage: Setting only

8.5.1.2   Working with windows in the display

Note that the suffix <n> always refers to the window *in the currently selected channel*.

The following commands are required to change the evaluation type and rearrange the screen layout for a channel as you do in manual operation. Since the available evaluation types depend on the selected application, some parameters for the following commands also depend on the selected channel.

Note that the suffix <n> always refers to the window *in the currently selected channel*.

To configure the layout of windows across channels, use the Chapter 8.5.1.1, "Global layout commands", on page 294.

LAYout:ADD[:WINDow]? <WindowName>, <Direction>, <WindowType>

Adds a window to the display in the active channel.

Is always used as a query so that you immediately obtain the name of the new window as a result.

To replace an existing window, use the `LAYout:REPLace[:WINDow]` command.

Query parameters:
<WindowName>   String containing the name of the existing window the new window is inserted next to.
By default, the name of a window is the same as its index. To determine the name and index of all active windows, use the `LAYout:CATalog[:WINDow]?` query.

\<Direction\>	LEFT | RIGHt | ABOVe | BELow
	Direction the new window is added relative to the existing window.
\<WindowType\>	text value
	Type of result display (evaluation method) you want to add. See the table below for available parameter values. Note that the window type must be valid for the active channel. To create a window for a different channel, use the `LAYout:GLOBal:REPLace[:WINDow]` command.

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 22
	See "AM/PM" on page 23
	See "AM/EVM" on page 23
	See "Amplitude Tracking" on page 24
	See "Bitstream" on page 24
	See "Constellation" on page 26
	See "Constellation vs Carrier" on page 27
	See "EVM vs Carrier" on page 28
	See "EVM vs Chip" on page 29
	See "EVM vs Symbol" on page 30
	See "FFT Spectrum" on page 31
	See "Freq. Error vs Preamble" on page 32
	See "Gain Imbalance vs Carrier" on page 33
	See "Group Delay" on page 33
	See "Magnitude Capture" on page 35
	See "Phase Error vs Preamble" on page 36
	See "Phase Tracking" on page 36
	See "PLCP Header (IEEE 802.11b, g (DSSS)" on page 37
	See "PvT Full PPDU" on page 38
	See "PvT Rising Edge" on page 39
	See "PvT Falling Edge" on page 40
	See "Quad Error vs Carrier" on page 41
	See "Result Summary Detailed" on page 41
	See "Result Summary Global" on page 43
	See "Signal Content Detailed (IEEE 802.11ax, be)" on page 45
	See "Signal Field" on page 46
	See "Spectrum Flatness" on page 48
	See "Spectrum Flatness Result Summary" on page 50
	See "Unused Tone Error" on page 50
	See "Unused Tone Error Summary" on page 51

Table 8-7: <WindowType> parameter values for WLAN application

Parameter value	Window type
Window types for I/Q data	
AMAM	"AM/AM" (**IEEE 802.11a, ac, ax, g (OFDM), j, n, p, be** only)
AMEV	"AM/EVM" (**IEEE 802.11a, ac, ax, g (OFDM), j, n, p, be** only)
AMPM	"AM/PM" (**IEEE 802.11a, ac, ax, g (OFDM), j, n, p, be** only)
ATRacking	"Amplitude Tracking" (IEEE 802.11ac, ax, n, be 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)

Parameter value	Window type
FEVPreamble	"Frequency Error vs. Preamble"
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"
SCDetailed	"Signal Content Detailed"
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)
SFSummary	"Spectrum Flatness Result Summary" (**IEEE 802.11ax** only)""
UTERror	"Unused Tone Error" (**IEEE 802.11ax** only)
UTESummary	"Unused Tone Error" Summary (**IEEE 802.11ax** only)

LAYout:CATalog[:WINDow]?

Queries the name and index of all active windows in the active channel from top left to bottom right. The result is a comma-separated list of values for each window, with the syntax:

<WindowName_1>,<WindowIndex_1>..<WindowName_n>,<WindowIndex_n>

To query the name and index of all windows in all channels, use the `LAYout:GLOBal:CATalog[:WINDow]?` command.

Return values:

<WindowName>   string

Name of the window.
In the default state, the name of the window is its index.

<WindowIndex>   **numeric value**
Index of the window.

Example:	LAY:CAT? Result: '2',2,'1',1 Two windows are displayed, named '2' (at the top or left), and '1' (at the bottom or right).
Usage:	Query only

LAYout:IDENtify[:WINDow]? <WindowName>

Queries the **index** of a particular display window in the active channel.

Note: to query the **name** of a particular window, use the LAYout:WINDow<n>:IDENtify? query.

To query the index of a window in a different channel, use the LAYout:GLOBal:IDENtify[:WINDow]? command.

Query parameters:

<WindowName>   String containing the name of a window.

Return values:

<WindowIndex>   Index number of the window.

Example:	LAY:IDEN:WIND? '2' Queries the index of the result display named '2'. Response: 2
Usage:	Query only

LAYout:MOVE[:WINDow] <WindowName>, <WindowName>, <Direction>

Setting parameters:

<WindowName>   String containing the name of an existing window that is to be moved.
                     By default, the name of a window is the same as its index. To determine the name and index of all active windows in the active channel, use the LAYout:CATalog[:WINDow]? query.

<WindowName>   String containing the name of an existing window the selected window is placed next to or replaces.
                     By default, the name of a window is the same as its index. To determine the name and index of all active windows in the active channel, use the LAYout:CATalog[:WINDow]? query.

<Direction>   LEFT | RIGHt | ABOVe | BELow | REPLace

                     Destination the selected window is moved to, relative to the reference window.

Example:	LAY:MOVE '4','1',LEFT Moves the window named '4' to the left of window 1.

Example: LAY:MOVE '1','3',REPL
                     Replaces the window named '3' by window 1. Window 3 is
                     deleted.

Usage: Setting only

LAYout:REMove[:WINDow] <WindowName>

Removes a window from the display in the active channel.

Setting parameters:
<WindowName>   String containing the name of the window. In the default state,
                     the name of the window is its index.

Example: LAY:REM '2'
                     Removes the result display in the window named '2'.

Usage: Setting only

LAYout:REPLace[:WINDow] <WindowName>,<WindowType>

Replaces the window type (for example from "Diagram" to "Result Summary") of an
already existing window in the active channel while keeping its position, index and win-
dow name.

To add a new window, use the `LAYout:ADD[:WINDow]?` command.

Setting parameters:
<WindowName>   String containing the name of the existing window.
                     By default, the name of a window is the same as its index. To
                     determine the name and index of all active windows in the active
                     channel, use the `LAYout:CATalog[:WINDow]?` query.

<WindowType>   Type of result display you want to use in the existing window.
                     See `LAYout:ADD[:WINDow]?` on page 298 for a list of availa-
                     ble window types.
                     Note that the window type must be valid for the active channel.
                     To create a window for a different channel, use the `LAYout:`
                     `GLOBal:REPLace[:WINDow]` command.

Example: LAY:REPL:WIND '1',MTAB
                     Replaces the result display in window 1 with a marker table.

Usage: Setting only

LAYout:WINDow<n>:ADD? <Direction>,<WindowType>

Adds a measurement window to the display. Note that with this command, the suffix
<n> determines the existing window next to which the new window is added. Unlike
`LAYout:ADD[:WINDow]?`, for which the existing window is defined by a parameter.

To replace an existing window, use the `LAYout:WINDow<n>:REPLace` command.

Is always used as a query so that you immediately obtain the name of the new window as a result.

Suffix:

<n>	Window

Query parameters:

<Direction>	LEFT | RIGHt | ABOVe | BELow
<WindowType>	Type of measurement window you want to add. See `LAYout:ADD[:WINDow]?` on page 298 for a list of available window types. Note that the window type must be valid for the active channel. To create a window for a different channel, use the `LAYout:GLOBal:ADD[:WINDow]?` command.

Return values:

<NewWindowName>	When adding a new window, the command returns its name (by default the same as its number) as a result.

Example:

	`LAY:WIND1:ADD? LEFT,MTAB`
	Result:
	`'2'`
	Adds a new window named '2' with a marker table to the left of window 1.

Usage:

	Query only

LAYout:WINDow<n>:IDENtify?

Queries the **name** of a particular display window (indicated by the <n> suffix) in the active channel.

Note: to query the **index** of a particular window, use the `LAYout:IDENtify[:WINDow]?` command.

Suffix:

<n>	Window

Return values:

<WindowName>	String containing the name of a window. In the default state, the name of the window is its index.

Example:

	`LAY:WIND2:IDEN?`
	Queries the name of the result display in window 2.
	Response:
	`'2'`

Usage:

	Query only

LAYout:WINDow<n>:REMove

Removes the window specified by the suffix <n> from the display in the active channel.

The result of this command is identical to the `LAYout:REMove[:WINDow]` command.

To remove a window in a different channel, use the `LAYout:GLOBal:REMove[:WINDow]` command.

Suffix:

<n>   Window

Example: `LAY:WIND2:REM`
                             Removes the result display in window 2.

Usage: Event

LAYout:WINDow<n>:REPLace <WindowType>

Changes the window type of an existing window (specified by the suffix <n>) in the active channel.

The effect of this command is identical to the `LAYout:REPLace[:WINDow]` command.

To add a new window, use the `LAYout:WINDow<n>:ADD?` command.

Suffix:

<n>   Window

Setting parameters:

<WindowType>   Type of measurement window you want to replace another one with.
                             See `LAYout:ADD[:WINDow]?` on page 298 for a list of available window types.
                             Note that the window type must be valid for the active channel.
                             To create a window for a different channel, use the `LAYout:GLOBal:REPLace[:WINDow]` command.

Example: `LAY:WIND2:REPL MTAB`
                             Replaces the result display in window 2 with a marker table.

Usage: Setting only

8.5.1.3 General window commands

The following commands are required to work with windows, independently of the application.

Note that the suffix <n> always refers to the window *in the currently selected measurement channel*.

DISPlay:FORMat <Format>

Determines which tab is displayed.

Parameters:

<Format>   **SPLit**
                           Displays the MultiView tab with an overview of all active chan-
                           nels

                           SINGle
                           Displays the measurement channel that was previously focused.

                           *RST: SING

Example: DISP:FORM SPL

DISPlay[:WINDow<n>][:SUBWindow<w>]:SELect

Sets the focus on the selected result display window.

This window is then the active window.

For measurements with multiple results in subwindows, the command also selects the subwindow. Use this command to select the (sub)window before querying trace data.

Suffix:

<n>   Window

<w>   subwindow
                           Not supported by all applications

Example: //Put the focus on window 1
                           DISP:WIND1:SEL

Example: //Put the focus on subwindow 2 in window 1
                           DISP:WIND1:SUBW2:SEL

8.5.2 Result display deprecated commands

The following commands can also be used to change the type of result displays for the R&S VSE WLAN application. They are maintained for compatibility reasons, for example when re-using existing remote control programs for previous Rohde & Schwarz signal and spectrum analyzers. For new programs, use the LAYout commands to change the display (see Chapter 8.5.1, "Configuring the result display", on page 294.

Note that the CONF:BURS:<ResultType>:IMM commands change the screen layout to display the Magnitude Capture buffer in window 1 and the selected result type in window 2 for the WLAN 802.11 channel. Any other active windows are closed.

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.

Manual operation: See "AM/AM" on page 22

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.

Manual operation: See "AM/EVM" on page 23

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.

Manual operation: See "AM/PM" on page 23

CONFigure:BURSt:CONSt:CCARrier[:IMMediate]

This remote control command configures the result display type of window 2 to be "Constellation vs Carrier" .

Manual operation: See "Constellation vs Carrier" on page 27

CONFigure:BURSt:CONSt:CSYMbol[:IMMediate]

This remote control command configures the result display type of window 2 to be "Constellation vs Symbol".

Manual operation: See "Constellation" on page 26

CONFigure:BURSt:EVM:ECARrier[:IMMediate]

This remote control command configures the result display type of window 2 to be "EVM vs Carrier".

Manual operation: See "EVM vs Carrier" on page 28

CONFigure:BURSt:EVM:ESYMbol[:IMMediate] (IEEE 802.11b and g (DSSS))
CONFigure:BURSt:EVM:EVCHip[: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 8.5.1.2, "Working with windows in the display", on page 298).

Manual operation: See "EVM vs Chip" on page 29

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.

Manual operation: See "EVM vs Chip" on page 29
                         See "EVM vs Symbol" on page 30

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.

Manual operation: See "Gain Imbalance vs Carrier" on page 33

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 32
                         See "Phase Error vs Preamble" on page 36

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 308).

Parameters:
<ErrType>   FREQuency | PHASe

                         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 32
                         See "Phase Error vs Preamble" on page 36

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 36

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 38
                         See "PvT Rising Edge" on page 39
                         See "PvT Falling Edge" on page 40

CONFigure:BURSt:PVT:SELect <Mode>

This remote command determines how to interpret the "Power vs Time" measurement results.

Parameters:
<Mode>   EDGE | FULL | RISE | FALL

                         EDGE
                         Displays rising and falling edges only

                         FALL
                         Displays falling edge only

FULL
Displays the full PPDU

RISE
Displays the rising edge only

Manual operation: See "PvT Full PPDU" on page 38
See "PvT Rising Edge" on page 39
See "PvT Falling Edge" on page 40

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.

Manual operation: See "Quad Error vs Carrier" on page 41

CONFigure:BURSt:SPECtrum:FFT[:IMMediate]

This remote control command configures the result display type of window 2 to be "FFT Spectrum".

Manual operation: See "FFT Spectrum" on page 31

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".

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.

Manual operation: See "Group Delay" on page 33
See "Spectrum Flatness" on page 48

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 310.

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.
Manual operation:	See "Group Delay" on page 33
	See "Spectrum Flatness" on page 48

CONFigure:BURSt:STATistics:BSTReam[:IMMediate]

This remote control command configures the result display type of window 2 to be "Bitstream".

Manual operation:	See "Bitstream" on page 24

CONFigure:BURSt:STATistics:SFIeld[:IMMediate]

This remote control command configures the result display type of window 2 to be "Signal Field".

Manual operation:	See "PLCP Header (IEEE 802.11b, g (DSSS)" on page 37
	See "Signal Field" on page 46

8.5.3 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 41 and "Result Summary Global" on page 43).

Note that the results are always *calculated*, regardless of their visibility in the "Result Summary".

Suffix:

<n>	1..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 | 0 | 1
	OFF | 0
	Item is displayed in "Result Summary".

ON | 1
Item is not displayed in "Result Summary".

*RST: 1

Table 8-8: 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
PPDU power	TPPower
Crest factor	TCFactor
Receive channel ("Rx All")	RALL
PPDU power	RPPower
Crest factor	RCFactor
Center frequency error	RCFerror
Symbol clock error	RSCerror
Common phase error	RCPerror
MIMO cross power	RMCPower
MIMO channel power	RMCHpower
Bitstream ("Stream All")	SALL
Pilot bit error rate	BPILot
EVM all carriers	SEACarriers
EVM data carriers	SEDCarriers
EVM pilot carriers	SEPCarriers
Only available for **IEEE 802.11b and g**:	
Peak vector error	PVERror
PPDU EVM	PEVM
I/Q offset	GIOFfset
Gain imbalance	GGIMbalance
Quadrature error	QERRor
Center frequency error	GCFerror
Chip clock error	CCERror
Rise time	RTIMe
Fall time	FTIMe
Mean power	MPOWer

Result in table	SCPI parameter
Peak power	PPOWer
Crest factor	GCFactor

Table 8-9: 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

8.5.4 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.

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.

Manual operation: See "Result based on" on page 164

UNIT:SFLatness <Unit>

Switches between relative (dB) and absolute (dBm) results for "Spectrum Flatness" results (see "Spectrum Flatness" on page 48).

Parameters:

\<Unit>	DB | DBM
	*RST: DBM

Example: `UNIT:SFL DBM`

Manual operation: See "Units" on page 164

8.5.5 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:COEFicients?` command.

Parameters:

\<Degree>	integer
	Range: 1 to 20
	*RST: 4

Example: `CONF:BURS:AM:AM:POLY 3`

Manual operation: See "AM/AM" on page 22
                        See "Polynomial degree for curve fitting" on page 165

8.6 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 8.8.1, "The STATus:QUEStionable:SYNC register", on page 360). If no PPDUs were found, `STAT:QUES:SYNC:COND?` returns 0 (see `STATus:QUEStionable:SYNC:CONDition?` on page 362).

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.

8.6.1 Numeric modulation accuracy, flatness and tolerance results

The following commands describe how to retrieve the numeric results from the standard WLAN measurements.

8.6.1.1 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 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9).

FETCh:BURSt:COUNt?

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?).

Return values:
<PPDUCount>

Usage: Query only

FETCh:BURSt:COUNt:ALL?

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?.

Return values:
<PPDUCount>

Usage: Query only

FETCh:SYMBol:COUNt?

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?`.

Return values:

<Result>   <list>

Usage: Query only

FETCh:BURSt:GINTerval?

Queries the guard interval of the first analyzed PPDU.

Return values:

<GuardInterval>   Guard interval in microseconds.

Example: `FETC:BURS:GINT?`
                         `//Result: '24'`

Usage: Query only

FETCh:BURSt:LENGths?

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.
                        Tip: To obtain the result in seconds, divide the number of samples by the input sample rate. This value is indicated as "Sample Rate Fs" in the channel bar.

Example: `UNIT:BURS SAMP`
                         `FETC:BURS:LENG?`
                         `//Result: 39,39,39`
                         Result in seconds for an input sample rate of 40 MHz:
                         0.001 ms

Usage: Query only

FETCh:BURSt:MCSindex?

Queries the Modulation and Coding Scheme (MCS) index of the first analyzed PPDU.

Return values:

<MCSIndex>

Example:	SENS:DEM:FORM:MCS 1
	FETC:BURS:MCS?
	//Result: '1'

| **Usage:** | Query only |

FETCh:BURSt:PPDU:STATus?

Queries the status of the analyzed PPDUs in the current capture buffer (see `FETCh:BURSt:COUNt?` on page 315).

Return values:

<Result>	Comma-separated list of values; one value for each analyzed PPDU
	OK Analysis correct
	WARN Warning, an error occurred
	SEL Selected PPDU

Example:	FETC:BURS:COUN?
	//Result: 3
	FETCh:BURSt:PPDU:STATus?
	OK,OK,OK

| **Usage:** | Query only |

FETCh:BURSt:PPDU:TYPE?

Queries the type of the first analyzed PPDU in the current capture buffer.

Return values:

| <PPDUType> | See Table 3-3. |

Example:	SENS:DEM:FORM:BAN:BTYP 'OFDM'
	FETC:BURS:PPDU:TYPE?
	//Result: 'OFDM'

| **Usage:** | Query only |

FETCh:BURSt:STARts?

Returns the start position of each analyzed PPDU in the current capture buffer.

Return values:

<Position>	<list>
	Comma-separated list of sample numbers indicating the start position of each PPDU.
	Tip: To obtain the result in seconds, divide the sample number by the input sample rate. This value is indicated as "Sample Rate Fs" in the channel bar.

Example: FETC:BURS:STAR?

//Result: 6922,17962,29002

Result in seconds for an input sample rate of 40 MHz:

0.17 ms, 0.45 ms, 0.73 ms

Usage: Query only

UNIT:BURSt <Unit>

Specifies the units for PPDU length results (see `FETCh:BURSt:LENGths?` on page 316).

Parameters:

<Unit>	SYMBol | SAMPle

SYMBol

Number of OFDM data symbols for each analyzed PPDU. Preamble symbols are NOT included.

SAMPle

Number of samples each analyzed PPDU contains.

Tip: To obtain the result in seconds, divide the number of samples by the input sample rate. This value is indicated as "Sample Rate Fs" in the channel bar.

*RST: SYMBol

Example: UNIT:BURS SAMP

FETC:BURS:LENG?

//Result: 39,39,39

Result in seconds for an input sample rate of 40 MHz:

0.001 ms

8.6.1.2 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 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9).

FETCh:BURSt:ALL:FORMatted?

Returns all results from the default WLAN measurement (Modulation Accuracy, Flatness and Tolerance.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

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:

<GlobalResult>   <list>

                                    <preamble power>, <payload power>, <peak power>, 'nan','nan','nan', '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',

Example:	`FETC:BURS:ALL:FORM?`
	For sample results see "Example of results from a WLAN 802.11 MIMO measurement" on page 369.
Usage:	Query only
Manual operation:	See "Result Summary Detailed" on page 41 See "Result Summary Global" on page 43

FETCh:BURSt:AM:AM:COEFicients?

This remote control returns the coefficients of the polynomial regression model used to determine the "AM/AM" result display.

See "AM/AM" on page 22 for details.

Return values:
<Coefficients>

Example:	`FETC:BURS:AM:AM:COEF?`
Usage:	Query only
Manual operation:	See "Polynomial degree for curve fitting" on page 165

FETCh:BURSt:BERPilot:AVERage?
FETCh:BURSt:BERPilot:MAXimum?
FETCh:BURSt:BERPilot:MINimum?

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 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

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?

Returns the common phase error (average, maximum or minimum value) in degrees for the IEEE 802.11n (MIMO) standard. For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Return values:

<Result>   <Stream 1 result> ... <Stream n result>

Usage: Query only

FETCh:BURSt:CRESt[:AVERage]?
FETCh:BURSt:CRESt:MAXimum?
FETCh:BURSt:CRESt:MINimum?

Returns the average, maximum or minimum determined CREST factor (= ratio of peak power to average power) in dB.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Return values:

<Result>   <list>

Usage: Query only

FETCh:BURSt:ECMGain?

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 313).

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

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?

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 313).

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

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?

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 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

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?

Returns the average, maximum or minimum EVM for the data carrier in dB.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

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?

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 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Return values:

<Result>   <list>

Usage: Query only

FETCh:BURSt:EVM:PILot:AVERage?
FETCh:BURSt:EVM:PILot:MAXimum?
FETCh:BURSt:EVM:PILot:MINimum?

Returns the average, maximum or minimum EVM in dB for the pilot carrier.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

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?

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 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Return values:

<Result>   <list>

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?

Returns the average, maximum or minimum center frequency errors in Hertz.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

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?

Returns the average, maximum or minimum I/Q imbalance in dB.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Return values:

<Result>   <list>

Usage: Query only

FETCh:BURSt:IQOFfset:AVERage?
FETCh:BURSt:IQOFfset:MAXimum?
FETCh:BURSt:IQOFfset:MINimum?

Returns the average, maximum or minimum I/Q offset in dB.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Return values:

<Result>   <list>

Usage: Query only

FETCh:BURSt:IQSKew:AVERage?
FETCh:BURSt:IQSKew:MAXimum?
FETCh:BURSt:IQSKew:MINimum?

Returns the average, maximum or minimum I/Q skew in picoseconds.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Usage: Query only

FETCh:BURSt:MCPower:AVERage?
FETCh:BURSt:MCPower:MAXimum?
FETCh:BURSt:MCPower:MINimum?

Returns the MIMO cross power (average, maximum or minimum value) in dB for the IEEE 802.11n (MIMO) standard. For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Return values:

<Result>   <Stream 1 result> ... <Stream n result>

Usage: Query only

FETCh:BURSt:MCHPower:AVERage?
FETCh:BURSt:MCHPower:MAXimum?
FETCh:BURSt:MCHPower:MINimum?

Returns the MIMO channel power (average, maximum or minimum value) in dBm for the IEEE 802.11n (MIMO) standard. For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Return values:

<Result>   <Stream 1 result> ... <Stream n result>

Usage: Query only

FETCh:BURSt:PAYLoad[:AVERage]?
FETCh:BURSt:PAYLoad:MINimum?
FETCh:BURSt:PAYLoad:MAXimum?

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.

Return values:
<Result>   <list>

Usage: Query only

FETCh:BURSt:PEAK[:AVERage]?
FETCh:BURSt:PEAK:MINimum?
FETCh:BURSt:PEAK:MAXimum?

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.

Return values:
<Result>   <list>

Usage: Query only

FETCh:BURSt:PREamble[:AVERage]?
FETCh:BURSt:PREamble:MAXimum?
FETCh:BURSt:PREamble:MINimum?

Returns the average, maximum or minimum of the "Preamble Power per PPDU" (in dBm). All symbols prior to the first data symbol of the PPDU are used to calculate the preamble power.

All analyzed PPDUs, up to the statistic length, take part in the statistical evaluation.

Return values:
<Result>   <list>

Usage: Query only

FETCh:BURSt:QUADoffset:AVERage?
FETCh:BURSt:QUADoffset:MAXimum?
FETCh:BURSt:QUADoffset:MINimum?

Returns the average, maximum or minimum quadrature offset of symbols within a PPDU. This value indicates the phase accuracy.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Return values:

<Result>   <list>

Usage: Query only

FETCh:BURSt:RMS[:AVERage]?
FETCh:BURSt:RMS:MAXimum?
FETCh:BURSt:RMS:MINimum?

Returns the average, maximum or minimum RMS power in dBm for all analyzed PPDUs.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

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?

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 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

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?

Returns the average, maximum or minimum PPDU fall time in seconds.

Is only applicable to IEEE802.11b & IEEE802.11g (DSSS) signals.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Return values:

<Result>   <list>

Usage: Query only

FETCh:BURSt:TRISe:AVERage?
FETCh:BURSt:TRISe:MAXimum?
FETCh:BURSt:TRISe:MINimum?

Returns the average, maximum or minimum burst rise time in seconds.

Is only applicable to IEEE802.11b & IEEE802.11g (DSSS) signals.

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

Return values:

<Result>   <list>

Usage: Query only

FETCh:BURSt:PPDU:EVM:ALL:AVERage?

Returns the error vector magnitude results for each PPDU, averaged over all data and pilot subcarriers for all symbols and streams.

Return values:

<Result>   Comma-separated list of EVM values, one for each PPDU

                        Default unit: dB

Example: FETC:BURS:PPDU:EVM:ALL:AVER?
                        //Result:
                        -83.2953,-83.2953....

Usage: Query only

Manual operation: See "Result Summary Global" on page 43

FETCh:BURSt:PPDU:EVM:DATA:AVERage?

Returns the error vector magnitude results for each PPDU, averaged over all data sub-carriers for all symbols and streams.

Return values:

<Result>   Comma-separated list of EVM values, one for each PPDU

                        Default unit: dB

Example: FETC:BURS:PPDU:EVM:DATA:AVER?
                        //Result:
                        -83.2953,-83.2953....

Usage: Query only

FETCh:BURSt:PPDU:EVM:PILot:AVERage?

Returns the error vector magnitude results for each PPDU, averaged over all pilot sub-carriers for all symbols and streams.

Return values:

<Result>	Comma-separated list of EVM values, one for each PPDU
	Default unit: dB

Example: `FETC:BURS:PPDU:EVM:PIL:AVER?`
`//Result:`
`-83.2953,-83.2953....`

Usage: Query only

FETCh:SCDetailed:ALL?

Returns detailed signal information for each decoded RU and for each object. The result is a comma-separated list of values with 5 rows per RU, in the same order as the Signal Content Detailed result display (see "Signal Content Detailed (IEEE 802.11ax, be)" on page 45).

These results are only available if the Signal Content Detailed result display is currently active (see `LAYout:ADD[:WINDow]?` on page 298).

The information for each decoded RU is returned in the following object order:

- (As of firmware version 3.20:) Legacy long training field (L-LTF)
- Long training field (HE-LTF)
- Data + Pilot
- Data only
- Pilot only

Return values:

1:<PPDUIndex>	integer
	sequential order of detected PPDU
2:<RUIndex>	integer
	sequential order of resource unit
3:<RUSize>	integer
	size of the resource unit
	Range: 26 to 996
4:<Object>	L-LTF | HE-LTF | Data + Pilot | Data | Pilot
	Type of object
5: <EVM>	numeric value
	Default unit: dB
6:<Power>	numeric value
	Power per subcarrier
	Default unit: dBm
7:<BER>	numeric value
	Bit error rate

8:<BERCheck>	PASS	FAIL
	Check whether any bit errors occurred.
9:<CWER>	numeric value
	Code word error rate
10:<CWERCheck>	PASS	FAIL
	Check whether any code word errors occurred.

Example:

```
LAY:ADD:WIND? '1', RIGH, SCD
FETC:SCD:ALL?
//Result:
1,nan,nan,L-LTF,nan,0.5497,nan,PASS,nan,PASS,
1,1,S996S484,HE-LTF,nan,-30.8854,nan,PASS,nan,PASS,
1,1,S996S484,Data + Pilot,-88.6586,-30.9008,nan,PASS,nan,PASS,
1,1,S996S484,Data,-88.6741,nan,nan,PASS,nan,PASS,
1,1,S996S484,Pilot,-88.0084,nan,nan,PASS,nan,PASS
```

Usage: Query only

Manual operation: See "Signal Content Detailed (IEEE 802.11ax, be)" on page 45

FETCh:SCDetailed:EVM:ALL?

Returns the EVM for all data and pilot subcarriers. The result is a comma-separated list of values, one for each PPDU and each RU.

These results are only available if the Signal Content Detailed result display is currently active (see LAYout:ADD[:WINDow]? on page 298).

Return values:
<Result> Default unit: dB

Example:
```
LAY:ADD:WIND? '1', RIGH, SCD
FETC:SCD:EVM:ALL?
//Result:
//-45.3692,-40.0135,-36.0258,-37.8301,-37.1719
```

Usage: Query only

FETCh:SCDetailed:EVM:DATA?

Returns the EVM for all data subcarriers. The result is a comma-separated list of values, one for each PPDU and each RU.

These results are only available if the Signal Content Detailed result display is currently active (see LAYout:ADD[:WINDow]? on page 298).

Return values:
<Result> Default unit: dB

Example:	`LAY:ADD:WIND? '1', RIGH, SCD`
	`FETC:SCD:EVM:DATA?`
	`//Result:`
	`//-45.0616,-39.6757,-35.6879,-37.4979,-36.9032`
Usage:	Query only

FETCh:SCDetailed:EVM:PILot?

Returns the EVM for all pilot subcarriers. The result is a comma-separated list of values, one for each PPDU and each RU.

These results are only available if the Signal Content Detailed result display is currently active (see LAYout:ADD[:WINDow]? on page 298).

Return values:

<Result>	Default unit: dB
Example:	`LAY:ADD:WIND? '1', RIGH, SCD`
	`FETC:SCD:EVM:PIL?`
	`//Result:`
	`//-54.6124,-55.3704,-51.4149,-51.1958,-43.4808`
Usage:	Query only

FETCh:SCDetailed:POWer:PPDU? <SCDetailedObject>

Returns the power results for each PPDU for the selected subcarriers.

These results are only available if the Signal Content Detailed result display is currently active (see LAYout:ADD[:WINDow]? on page 298).

Query parameters:

<SCDetailedObject>	HELTf	EHTLtf	DPILot	LLTF
	HELTf
	Includes long training field (HE-LTF) subcarriers only
	DPILot
	Includes data and pilot subcarriers only
	LLTF
	Includes legacy long training field (L-LTF) subcarriers only
	Default unit: dBm
Example:	`LAY:ADD:WIND? '1', RIGH, SCD`
	`FETC:SCDE:POWE:PPDU? LLTF`
	`//Result for 3 PPDUs:`
	`//-11.1802, -11.1770, -11.1751`
Usage:	Query only

FETCh:SCDetailed:POWer:RU? <SCDetailedObject>

Returns the power in all PPDUs for each RU. The result is a comma-separated list of power values, one per RU.

These results are only available if the Signal Content Detailed result display is currently active (see `LAYout:ADD[:WINDow]?` on page 298).

Tip: to obtain the results for an individual subcarrier, use `FETCh:SCDetailed:POWer[:SC]?` on page 332.

Query parameters:

<SCDetailedObject>	HELTf | EHTLtf | DPILot | LLTF
	HELTf Includes long training field (HE-LTF) subcarriers only
	DPILot Includes data and pilot subcarriers only
	Default unit: dBm

Example: 　　　　　LAY:ADD:WIND? '1', RIGH, SCD
　　　　　　　　　　FETC:SCD:POW:RU?

Usage: 　　　　　Query only

FETCh:SCDetailed:POWer[:SC]? <SCDetailedObject>

Returns the power per subcarrier in all PPDUs and all RUs. The result is a comma-separated list of power values, one per subcarrier.

These results are only available if the Signal Content Detailed result display is currently active (see `LAYout:ADD[:WINDow]?` on page 298).

Tip: to obtain the results for an individual resource unit, use `FETCh:SCDetailed:POWer:RU?` on page 332.

Query parameters:

<SCDetailedObject>	HELTf | EHTLtf | DPILot | LLTF
	HELTf Includes long training field (HE-LTF) subcarriers only
	DPILot Includes data and pilot subcarriers only
	Default unit: dBm

Example: 　　　　　LAY:ADD:WIND? '1', RIGH, SCD
　　　　　　　　　　FETC:SCD:POW:SC?

Usage: 　　　　　Query only

FETCh:SFIeld:ALL?

Returns the results of the Signal Fields table, including column headers. The result is a comma-separated list of values for the selected PPDU. For details on the provided information see "Signal Field" on page 46

Is only available for the **IEEE 802.11ax, be** standards. For other standards, see TRACe[:DATA]? on page 345.

Return values:

<Result>   <Signal_field_type>[,<Occupied_bits>,<Field_name>,
                         <Binary_value>,<Human_readable_value>],...

Example: FETC:SFI:ALL?
                         // Result:
                         // **L-SIG**,
                         // B0-B3,Rate,0000,0,
                         // B4,Reserved,1,1,
                         // B5-B16,Length,000000000010,2,
                         // B17,Parity,0,0,
                         // B18-B23,Tail,010100,20,
                         // **HE-SIG-A1**,
                         // B0,Format,1,1,
                         // B1,Beam Change,1,1,
                         // B2,UL/DL,0,0,
                         // B3-B6,MCS,1010,10,B7,DCM,0,0,
                         // B8-B13,BSS Color,000000,0,
                         // B14,Reserved,0,0,
                         // B15-B18,Spatial Reuse,0000,0,
                         // B19-B20,Bandwidth,10,2,
                         // B21-B22,GI + LTF Size,010,2,
                         // B23-B25,Nsts,001,1,
                         // **HE-SIG-A2**
                         // B0-B6,TXOP Duration,0000000,0,
                         // B7,Coding,0,0,B8,LDPC Extra Symbol,0,0,
                         // B9,STBC,0,0,
                         // B10,TxBF,0,0,
                         // B11-B12,Pre-FEC Padding Factor,00,0,
                         // B13,PE Disambiguity,0,0,B14,Reserved,0,0,
                         // B15,Doppler,0,0,
                         // B16-B19,CRC,0000,0,
                         // B20-B25,Tail,000000,0

Usage: Query only

Manual operation: See "Signal Field" on page 46

FETCh:SFSummary:ALL?

Returns the numeric results of the "Spectrum Flatness" trace.

Is only available for the **IEEE 802.11ax, be** standards.

For details see "Spectrum Flatness Result Summary" on page 50.

Return values:

<Result>   <SC_Start_No>,<SC_End_No>,<MinDist_Low>,<SC_MinD-ist_Low>,<MinDist_Up>,<SC_MinDist_Up>,<LimitCheckRe-sult>,...

Comma-separated list of values for the overall subcarrier range and each subrange.

Example: ```
FETC:SFS:ALL?
//Result:
'-1012', '1012', '2.9906', '166', 'PASS',
'3.1331', '-826', 'PASS', '-1012', '-697',
'4.2194', '-1012', 'PASS', '3.1331', '-826',
'PASS', '-696', '-515', '4.2559', '-533',
'FAIL', '3.3923', '-696', 'PASS', '-509',
'-166', '4.1220', '-167', 'FAIL', '3.5353',
'-292', 'PASS', '-165', '-12', '5.3224', '-13',
'PASS', '3.8853', '-165', 'PASS', '12', '165',
'4.9335', '128', 'PASS', '4.7902', '12',
'PASS', '166', '509', '2.9906', '166', 'FAIL',
'3.9672', '508', 'PASS', '515', '696',
'3.7037', '695', 'FAIL', '3.9859', '519',
'PASS', '697', '1012', '3.6607', '1011',
'PASS', '4.1990', '953', 'PASS'
```

**Usage:**    Query only

**Manual operation:**    See "Spectrum Flatness Result Summary" on page 50

---

**FETCh:UTESummary:ALL?**

Returns the results of the "Unused Tone Error" Summary. The result is a comma-separated list of values for up to 37 measurement points in the channel. Which subcarriers are measured depends on the size and position of the RU being transmitted.

This result is required by the **IEEE 802.11ax** standard for HE trigger-based PPDUs with a maximum channel bandwidth of 80 MHz.

**Return values:**

<Result>    -35 dB LHS | RUIdx-3 | RUIdx-2 | RUIdx-1 | RUIdx | RUIdx+1 | RUIdx+2 | RUIdx+3 | -35 dB RHS

Set of n subcarriers, where n is the number of subcarriers in the resource unit to be checked.
For details see Chapter 2.1.8, "Unused tone error", on page 18
Default unit: -

**Example:**             FETC:UTES:ALL?
                         //Result:
                         //-35 dB LHS,-1,nan,nan,nan,nan,nan,-1,NONE,
                         //RUIdx-3,-1,nan,nan,nan,nan,nan,-1,NONE,
                         //RUIdx-2,-1,nan,nan,nan,nan,nan,-1,NONE,
                         //RUIdx-1,-1,nan,nan,nan,nan,nan,-1,NONE,
                         //RUIdx,4,-59.64,-58.80,-58.11,-30.00,-28.11,2,PASS,
                         //RUIdx+1,4,-68.39,-67.93,-67.28,-32.00,-35.28,7,PASS,
                         //RUIdx+2,4,-66.06,-65.14,-63.41,-35.00,-28.41,12,PASS,
                         //RUIdx+3,4,-68.06,-67.31,-65.97,-35.00,-30.97,13,PASS,
                          //-35 dB RHS,4,-73.80,-71.81,-69.82,-35.00,-34.82,17,PASS

**Usage:**               Query only

**Manual operation:**    See "Unused Tone Error Summary" on page 51

---

**UNIT:EVM** <Unit>

Specifies the units for EVM limits and results

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

**Parameters:**
<Unit>                   DB | PCT

                         *RST:        DB

---

**UNIT:GIMBalance** <Unit>

Specifies the units for gain imbalance results

For details see Chapter 2.1, "Modulation accuracy, flatness and tolerance parameters", on page 9.

**Parameters:**
<Unit>                   DB | PCT

                         *RST:        DB

---

**UNIT:PREamble** <Unit>

Specifies the units for preamble error results.

**Parameters:**
<Unit>                   HZ | PCT

### 8.6.1.3 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 335

- UNIT:GIMBalance on page 335

**Remote commands exclusive to retrieving limit check results**

**CALCulate<n>:LIMit<li>:BURSt:ALL:RESult?**

Returns the result of the EVM limit check for all carriers. The limit value is defined by the standard or the user (see CALCulate<n>:LIMit<li>:BURSt:ALL on page 288).

**Suffix:**

| | |
|---|---|
| <n> | Window |
| <li> | 1..n |

**Return values:**

| | |
|---|---|
| <LimitCheck> | PASS \| FAILed |
| | **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<li>:BURSt:EVM:ALL[:AVERage]:RESult?**
**CALCulate<n>:LIMit<li>:BURSt:EVM:ALL:MAXimum:RESult?**

Returns the result of the average or maximum EVM limit check. The limit value is defined by the standard or the user (see `CALCulate<n>:LIMit<li>:BURSt:EVM:ALL:MAXimum` on page 289).

**Suffix:**

| | |
|---|---|
| <n> | Window |
| <li> | 1..n |

**Return values:**

| | |
|---|---|
| <LimitCheck> | PASS \| FAILed |
| | **PASS**<br>The defined limit for the parameter was not exceeded. |
| | **FAILED**<br>The defined limit for the parameter was exceeded. |

**Usage:**          Query only

---

**CALCulate<n>:LIMit<li>:BURSt:EVM:DATA[:AVERage]:RESult?**
**CALCulate<n>:LIMit<li>:BURSt:EVM:DATA:MAXimum:RESult?**

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<n>:LIMit<li>:BURSt:EVM:DATA:MAXimum` on page 289).

**Suffix:**

| | |
|---|---|
| <n> | Window |
| <li> | 1..n |

**Return values:**

| | |
|---|---|
| <LimitCheck> | PASS \| FAILed |
| | **PASS**<br>The defined limit for the parameter was not exceeded. |
| | **FAILED**<br>The defined limit for the parameter was exceeded. |

**Usage:**          Query only

---

**CALCulate<n>:LIMit<li>:BURSt:EVM[:AVERage]:RESult?**
**CALCulate<n>:LIMit<li>:BURSt:EVM:MAXimum:RESult?**

Returns the result of the average or maximum EVM limit check. The limit value is defined by the standard or the user (see `CALCulate<n>:LIMit<li>:BURSt:EVM:MAXimum` on page 290).

Is only available for **IEEE 802.11b and g (DSSS)**.

**Suffix:**

| | |
|---|---|
| <n> | Window |

| <li> | 1..n |
|---|---|

**Usage:**　　　　　　　Query only

---

**CALCulate<n>:LIMit<li>:BURSt:EVM:PILot[:AVERage]:RESult?**
**CALCulate<n>:LIMit<li>:BURSt:EVM:PILot:MAXimum:RESult?**

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<n>:LIMit<li>:BURSt:EVM:PILot:MAXimum` on page 290).

**Suffix:**

| <n> | Window |
|---|---|
| <li> | 1..n |

**Return values:**

| <LimitCheck> | PASS \| FAILed |
|---|---|
| | **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<li>:BURSt:FERRor[:AVERage]:RESult?**
**CALCulate<n>:LIMit<li>:BURSt:FERRor:MAXimum:RESult?**

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<n>:LIMit<li>:BURSt:FERRor:MAXimum` on page 290).

**Suffix:**

| <n> | Window |
|---|---|
| <li> | 1..n |

**Return values:**

| <LimitCheck> | PASS \| FAILed |
|---|---|
| | **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<li>:BURSt:IQOFfset[:AVERage]:RESult?**
**CALCulate<n>:LIMit<li>:BURSt:IQOFfset:MAXimum:RESult?**

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<n>:LIMit<li>:BURSt:IQOFfset:MAXimum` on page 291).

**Suffix:**

| | |
|---|---|
| <n> | Window |
| <li> | 1..n |

**Return values:**

| | |
|---|---|
| <LimitCheck> | PASS \| FAILed |
| | **PASS**<br>The defined limit for the parameter was not exceeded. |
| | **FAILED**<br>The defined limit for the parameter was exceeded. |

**Usage:**         Query only

---

**CALCulate<n>:LIMit<li>:BURSt:SYMBolerror[:AVERage]:RESult?**
**CALCulate<n>:LIMit<li>:BURSt:SYMBolerror:MAXimum:RESult?**

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<n>:LIMit<li>:BURSt:SYMBolerror:MAXimum` on page 291).

**Suffix:**

| | |
|---|---|
| <n> | Window |
| <li> | 1..n |

**Return values:**

| | |
|---|---|
| <LimitCheck> | PASS \| FAILed |
| | **PASS**<br>The defined limit for the parameter was not exceeded. |
| | **FAILED**<br>The defined limit for the parameter was exceeded. |

**Usage:**         Query only

---

**CALCulate<n>:LIMit<li>:BURSt:TFALl[:AVERage]:RESult?**
**CALCulate<n>:LIMit<li>:BURSt:TFALl:MAXimum:RESult?**

Returns the result of the average or maximum fall time limit check. The limit value is defined by the standard or the user (see `CALCulate<n>:LIMit<li>:BURSt:TFALl:MAXimum` on page 291).

Is **only** available for **IEEE 802.11b**.

**Suffix:**

| | |
|---|---|
| <n> | Window |
| <li> | 1..n |

**Return values:**

| | |
|---|---|
| <LimitCheck> | PASS \| FAILed |

**Usage:**         Query only

**CALCulate<n>:LIMit<li>:BURSt:TRISe[:AVERage]:RESult?**
**CALCulate<n>:LIMit<li>:BURSt:TRISe:MAXimum:RESult?**

Returns the result of the average or maximum rise time limit check. The limit value is defined by the standard or the user (see `CALCulate<n>:LIMit<li>:BURSt:TRISe:MAXimum` on page 292).

Is **only** available for **IEEE 802.11b**.

**Suffix:**

| | |
|---|---|
| <n> | Window |
| <li> | 1..n |

**Usage:**          Query only

---

**CALCulate<n>:LIMit<li>:CONTrol[:DATA]?**

Queries the x-axis values for the specified limit line.

**Suffix:**

| | |
|---|---|
| <n> | 1..n |
| <li> | 1..n<br>Limit line for unused tone error RU group:<br>// 1 = -35dB LHS<br>// 2 = RUIdx-3<br>// 3 = RUIdx-2<br>// 4 = RUIdx-1<br>// 5 = RUIdx<br>// 6 = RUIdx+1<br>// 7 = RUIdx+2<br>// 8 = RUIdx+3<br>// 9 = -35dB RHS |

**Return values:**
<Result>

**Usage:**          Query only

**Manual operation:**    See "Unused Tone Error Summary" on page 51

---

**CALCulate<n>:LIMit<li>:FAIL?**

Queries the result of a limit check in the specified window.

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.

**Suffix:**

| | |
|---|---|
| <n> | 1..n<br>Window |

<li>                        1..n
                            SEM: Limit line according to Table 8-10

**Return values:**

<Result>                    **OFF | 0**
                            PASS

                            **ON | 1**
                            FAIL

**Example:**                INIT;*WAI
                            Starts a new sweep and waits for its end.
                            CALC2:LIM4:FAIL?
                            Queries the result of the check for spectrum flatness (upper)
                            limit line in window 2.

**Usage:**                  Query only

**Manual operation:**       See "Unused Tone Error Summary" on page 51

*Table 8-10: Limit line suffix <k> for SEM measurements in R&S VSE 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>:LIMit<li>:UPPer[:DATA]?**

Queries the y-axis values for the specified limit line.

**Suffix:**

<n>                         1..n

| <li> | 1..n |
|---|---|
| | Limit line for unused tone error RU group: |
| | // 1 = -35dB LHS |
| | // 2 = RUIdx-3 |
| | // 3 = RUIdx-2 |
| | // 4 = RUIdx-1 |
| | // 5 = RUIdx |
| | // 6 = RUIdx+1 |
| | // 7 = RUIdx+2 |
| | // 8 = RUIdx+3 |
| | // 9 = -35dB RHS |

**Return values:**

| <Result> | Default unit: DB |
|---|---|

| **Usage:** | Query only |
|---|---|

| **Manual operation:** | See "Unused Tone Error Summary" on page 51 |
|---|---|

---

**CALCulate<n>:LIMit<li>:LOWer:FULL?**
**CALCulate<n>:LIMit<li>:UPPer:FULL?**

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> | 1..n |
|---|---|
| | Window |

| <li> | 4 \| 5 |
|---|---|
| | The limit line to query |
| | **4**: "Spectrum Flatness" **upper** limit line |
| | **5**: "Spectrum Flatness" **lower** limit line |

| **Example:** | CALC2:LIM4:UPP:FULL? |
|---|---|

| **Usage:** | Query only |
|---|---|

---

**CALCulate<n>:LIMit<li>:ESPectrum:CHECk:X?**
**CALCulate<n>:LIMit<li>:SPECtrum:MASK:CHECk:X?**

Returns the highest frequency for which the SEM limit was exceeded. If no limit was exceeded, an error is returned.

**Suffix:**

| <n> | 1..n |
|---|---|
| | Window |

| <li> | 1..n |
|---|---|

| **Usage:** | Query only |
|---|---|

**CALCulate<n>:LIMit<li>:ESPectrum:CHECk:Y?**
**CALCulate<n>:LIMit<li>:SPECtrum:MASK:CHECk:Y?**

Returns the highest (absolute) power level that exceeds the SEM limit. If no limit was
exceeded, an error is returned.

**Suffix:**

| | |
|---|---|
| <n> | 1..n |
| | Window |
| <li> | 1..n |

**Usage:**          Query only

## 8.6.2 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 mea-
surements, only 1 trace per window can be configured.

&#9432;  **MIMO results in subwindows**

For MIMO measurements, 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. To query the trace data for a specific data stream, you
must select the subwindow first (see `DISPlay[:WINDow<n>][:SUBWindow<w>]:`
`SELect`).

Useful commands for retrieving trace results described elsewhere:

* The traces for frequency sweep measurements are identical to those in the Spec-
  trum application.
* `[SENSe:]BURSt:SELect` on page 281

**Remote commands exclusive to retrieving trace results:**

**DISPlay[:WINDow<n>]:FLAGs** <State>

Configures the output of bitstream data in ASCII format

**Suffix:**

| | |
|---|---|
| <n> | Window |

**Parameters:**

| | |
|---|---|
| <State> | 0 | 2 |

**0**

Switches the function off

**2**

In bitstream trace results, any DC (empty) carriers found in the bitstream are indicated by NULL in the bitstream, if the output format is ASCII.

*RST:          0

**Example:**          DISP:WIND3:FLAG 2

//Result:

//.....02,37,3E,01,**"NULL"**,01,19,2A.....

---

**FORMat[:DATA]** <Format>[, <BitLength>]

Selects the data format that is used for transmission of trace data from the R&S VSE to the controlling computer.

Note that the command has no effect for data that you send to the R&S VSE. The R&S VSE automatically recognizes the data it receives, regardless of the format.

**Parameters:**

<Format>          **ASCii**
                  ASCii format, separated by commas.
                  This format is almost always suitable, regardless of the actual data format. However, the data is not as compact as other formats can be.

                  **REAL**
                  Floating-point numbers (according to IEEE 754) in the "definite length block format".

                  **UINT**
                  In the R&S VSE WLAN application, bitstream data can be sent as unsigned integers format to improve the data transfer speed (compared to ASCII format).

<BitLength>       Length in bits for floating-point results

                  **16**
                  16-bit floating-point numbers.
                  Compared to REAL, 32 format, half as many numbers are returned.

                  **32**
                  32-bit floating-point numbers
                  For I/Q data, 8 bytes per sample are returned for this format setting.

                  **64**
                  64-bit floating-point numbers
                  Compared to REAL, 32 format, twice as many numbers are returned.

**Example:**          FORM REAL, 32

**[SENSe:]BURSt:COUNt:SELect:STATe** <State>

Determines whether a selected PPDU (using `[SENSe:]BURSt:SELect`) is considered or ignored.

**Parameters:**

<State>                ON | OFF | 1 | 0

**ON | 1**
Only the results for the selected PPDU are considered by a subsequent `TRACe[:DATA]?` query for "EVM vs Symbol" and "EVM vs Carrier" result displays.

**OFF | 0**
**"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:          0

**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[:DATA]?** <TraceNumber>

Queries current trace data and measurement results from the window previously selected using `DISPlay[:WINDow<n>][:SUBWindow<w>]:SELect`.

As opposed to the R&S VSE base unit, the window suffix <n> is not considered in the R&S VSE WLAN application! Use the `DISPlay[:WINDow<n>][:SUBWindow<w>]:SELect` to select the (sub)window before you query trace results!

For details see Chapter 8.6.3, "Measurement results for TRACe<n>[:DATA]? TRACE<n>", on page 347.

**Query parameters:**

<TraceNumber>          TRACE1 | ... | TRACE6
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.

**Example:**          `DISP:WIND2:SEL`
`TRAC? TRACE3`
Queries the data of trace 3 in window 2.

| **Manual operation:** | See "AM/AM" on page 22 |
|---|---|
| | See "AM/PM" on page 23 |
| | See "AM/EVM" on page 23 |
| | See "Bitstream" on page 24 |
| | See "Constellation" on page 26 |
| | See "Constellation vs Carrier" on page 27 |
| | See "EVM vs Carrier" on page 28 |
| | See "EVM vs Chip" on page 29 |
| | See "EVM vs Symbol" on page 30 |
| | See "FFT Spectrum" on page 31 |
| | See "Freq. Error vs Preamble" on page 32 |
| | See "Gain Imbalance vs Carrier" on page 33 |
| | See "Group Delay" on page 33 |
| | See "Magnitude Capture" on page 35 |
| | See "Phase Error vs Preamble" on page 36 |
| | See "Phase Tracking" on page 36 |
| | See "PLCP Header (IEEE 802.11b, g (DSSS)" on page 37 |
| | See "PvT Full PPDU" on page 38 |
| | See "PvT Rising Edge" on page 39 |
| | See "PvT Falling Edge" on page 40 |
| | See "Quad Error vs Carrier" on page 41 |
| | See "Signal Field" on page 46 |
| | See "Spectrum Flatness" on page 48 |
| | See "Unused Tone Error" on page 50 |

*Table 8-11: 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 298. The results for the various window types are described in Chapter 8.6.3, "Measurement results for TRACe<n>[:DATA]? TRACE<n>", on page 347.

---

**TRACe<n>[:DATA]:X?** <TraceNumber>

Queries the horizontal trace data for each sweep point in the specified window, for example the frequency in frequency domain or the time in time domain measurements.

This is especially useful for traces with non-equidistant x-values.

**Suffix:**
<n>                     Window

**Query parameters:**
<TraceNumber>           Trace number.
                        **TRACE1 | TRACE2 | TRACE3 | TRACE4 | TRACE5 | TRACE6**

**Return values:**
<X-Values>

**Example:**               `TRAC3:X? TRACE1`
                        Returns the x-values for trace 1 in window 3.

**Usage:**                 Query only

### 8.6.3   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 VSE base unit, the window suffix <n> is not considered in the R&S VSE WLAN application! Use the `DISPlay[:WINDow<n>][:SUBWindow<w>]:SELect` to select the window before you query trace results!

For details on the graphical results of these evaluation methods, see Chapter 2.2, "Evaluation methods for WLAN IQ measurements", on page 21.

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 8-12: WLAN OFDM symbol structure in the frequency domain*

| Standard | 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 subcarrier | $N_{used}$ No. of used sc := $N_{ST}$ + $N_{Null}$ | $N_{guard}$ := $N_{FT}$ - $N_{used}$ | 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 constants |
| | 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 constants |

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)

| Standard | 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 subcarrier | $N_{used}$ 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 constants |
| | 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 constants |

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)

### 8.6.3.1  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.

### 8.6.3.2  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.

### 8.6.3.3  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.

### 8.6.3.4  Bitstream

Data is returned depending on the selected standard for which the measurement was executed (see `CONFigure:STANdard` on page 182):

**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 802.11a, p | 5 | 48 | 4 | **52** |
| IEEE 802.11a, j, p | 10 | 48 | 4 | **52** |
| IEEE 802.11a, 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.

### 8.6.3.5 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

$$k \in \left\{ -(N_{used}-1)/2 , -(N_{used}-1)/2+1,...,(N_{used}-1)/2 \right\}$$

  OFDM-Symbol 1: $(I_{1,1}, Q_{1,1})$
  OFDM-Symbol 2: $(I_{2,1}, Q_{2,1})$
  …
  OFDM-Symbol N: $(I_{N,1}, Q_{N,1})$

### 8.6.3.6 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: $(I_{1,1}, Q_{1,1}), (I_{1,2},Q_{1,2}), \ldots,( I_{1,Nused}, Q_{1,Nused})$

OFDM-Symbol 2: $(I_{2,1}, Q_{2,1}), (I_{2,2},Q_{2,2}),\ldots,( I_{2,Nused}, Q_{2,Nused})$

…

OFDM-Symbol N:

$(I_{N,1}, Q_{N,1}), (I_{N,2},Q_{N,2}),\ldots,( I_{N,Nused}, Q_{N,Nused})$

#### 8.6.3.7 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 344): `ASCii|UINT`

#### 8.6.3.8 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 344): `ASCii|REAL`

#### 8.6.3.9 EVM vs carrier

Three trace types are provided for this evaluation:

*Table 8-13: 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 344): `ASCii|UINT`

**Example:**

For $EVM_{m,n}$: the EVM of the m-th analyzed PPDU for the subcarrier $n = \{1,2,\ldots, N_{used}\}$

TRACE1: Minimum EVM value per subcarrier

$Minimum(EVM_{1,1}, EVM_{2,1},\ldots EVM_{Statistic\ Length,1})$,

//Minimum EVM value for subcarrier $-(N_{used}-1)/2$

$Minimum(EVM_{1,2}, EVM_{2,2},\ldots EVM_{Statistic\ Length,2})$,

// Minimum EVM value for subcarrier $-(N_{used}-1)/2 + 1$

…,

$Minimum(EVM_{1,Nused}, EVM_{2,Nused},\ldots EVM_{Statistic\ Length,Nused})$

// Minimum EVM value for subcarrier $+(N_{used}-1)/2$

### 8.6.3.10 EVM vs chip

These results are **only** available for single-carrier measurements (**IEEE 802.11b, g (DSSS)**).

Since the R&S VSE 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 344): ASCii|REAL

### 8.6.3.11 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 344): 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)**).

### 8.6.3.12 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.

### 8.6.3.13 Group delay

Currently the following trace types are provided with this measurement:

* `TRACE2`
  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.

**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 :

$GD_{N,1}$, $GD_{N,2}$, …,

### 8.6.3.14 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 109 and "Capture Time" on page 109).

### 8.6.3.15 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)**).

### 8.6.3.16 Power vs time (PVT)

All complete PPDUs within the capture time are analyzed in three primary PPDUs. The three primary PPDUs relate to the minimum, maximum and average values across all complete PPDUs. This data is returned in dBm values on a per sample basis. Each sample relates to an analysis of each corresponding sample within each processed PPDU.

For PVT Rising and PVT Falling displays, the results are restricted to the rising or falling edge of the analyzed PPDUs.

The type of PVT data returned is determined by the TRACE number passed as an argument to the SCPI command:

| TRACE1 | minimum PPDU data values |
|---|---|
| TRACE2 | mean PPDU data values |
| TRACE3 | maximum PPDU data values |

Supported data formats (see `FORMat[:DATA]` on page 344): `ASCii|REAL`

### 8.6.3.17 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.

For **IEEE 802.11ax, be**, the data is displayed in the "Value" column of the Signal Fields table. To retrieve all values from the table in human-readable format, use `FETCh: SFIeld:ALL?` on page 333.

### 8.6.3.18 Spectrum flatness

The spectrum flatness evaluation returns absolute power values per carrier (in dBm).

Two trace types are provided for this evaluation:

*Table 8-14: 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 (see `FORMat[:DATA]` on page 344): `ASCii|REAL`

#### 8.6.3.19  Unused tone error

Returns a comma-separated list of EVM values in dB. One value is provided for each measurement point. The maximum number of measurement points is 37 (up to 37 RU26 groups in an 80 MHz channel).

The type of EVM data returned is determined by the TRACE number passed as an argument to the SCPI command:

| TRACE1 | Minimum EVM data values |
|--------|-------------------------|
| TRACE2 | Mean EVM data values    |
| TRACE3 | Maximum EVM data values |

Supported data formats (see `FORMat[:DATA]` on page 344): `ASCii|REAL`

# 8.7  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.

## 8.7.1  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>:DELTamarker<m>:AOFF**

Turns off *all* delta markers.

**Suffix:**

| <n> | Window |
|-----|--------|
| <m> | irrelevant |

**Example:**　　　　　　CALC:DELT:AOFF

Turns off all delta markers.

---

**CALCulate<n>:MARKer<m>:AOFF**

Turns off all markers.

**Suffix:**

<n>　　　　　　　　Window

<m>　　　　　　　　Marker

**Example:**　　　　　　CALC:MARK:AOFF

Switches off all markers.

**Manual operation:**　　See "All Markers Off" on page 167

---

**CALCulate<n>:MARKer<m>[:STATe]** <State>

Turns markers on and off. If the corresponding marker number is currently active as a delta marker, it is turned into a normal marker.

**Suffix:**

<n>　　　　　　　　Window

<m>　　　　　　　　Marker

**Parameters:**

<State>　　　　　　ON | OFF | 0 | 1

**OFF | 0**
Switches the function off
**ON | 1**
Switches the function on

**Example:**　　　　　　CALC:MARK3 ON

Switches on marker 3.

---

**CALCulate<n>:MARKer<m>:Y?**

Queries the result at the position of the specified marker.

**Suffix:**

<n>　　　　　　　　1..n

<m>　　　　　　　　1..n

**Return values:**

<Result>　　　　　　Default unit: DBM

**Usage:**　　　　　　Query only

**CALCulate\<n>:MARKer\<m>:BSYMbol** \<PPDU>, \<Symbol>

**Suffix:**

\<n>                          1..n

\<m>                          1..n

**Parameters:**
\<PPDU>

\<Symbol>

---

**CALCulate\<n>:MARKer\<m>:CARRier** \<CarrierNo>

Positions the selected marker to the indicated carrier.

Is query only for the following result displays:

* "Constellation" vs Symbol
* "Constellation" vs Carrier

**Suffix:**

\<n>                          1..n

\<m>                          1..n

**Parameters:**
\<CarrierNo>                  integer

---

**CALCulate\<n>:MARKer\<m>:SYMBol** \<Symbol>

Positions the selected marker to the indicated symbol.

Is query only for the following result displays:

* "Constellation" vs Symbol
* "Constellation" vs Carrier

**Suffix:**

\<n>                          1..n

\<m>                          1..n

**Parameters:**
\<Symbol>                     integer

## 8.8  Status registers

The R&S VSE WLAN application uses the standard status registers of the R&S VSE (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 VSE status registers refer to the description of remote control basics in the R&S VSE User Manual.

(i) *RST does not influence the status registers.

- The STATus:QUEStionable:SYNC register..........................................................360
- Querying the status registers.............................................................................360

## 8.8.1 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.

(i) 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 8-15: 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 |
| 3 | Limit check failed |
| 4 - 14 | These bits are not used. |
| 15 | This bit is always 0. |

## 8.8.2 Querying the status registers

The following commands are required to query the status of the R&S VSE and the R&S VSE WLAN application.

For details on the common R&S VSE status registers refer to the description of remote control basics in the R&S VSE User Manual.

### 8.8.2.1 General status register commands

#### STATus:PRESet

Resets the edge detectors and `ENABle` parts of all registers to a defined value. All `PTRansition` parts are set to `FFFFh`, i.e. all transitions from 0 to 1 are detected. All `NTRansition` parts are set to 0, i.e. a transition from 1 to 0 in a `CONDition` bit is not detected. The `ENABle` part of the `STATus:OPERation` and `STATus:QUEStionable` registers are set to 0, i.e. all events in these registers are not passed on.

**Usage:**            Event

#### STATus:QUEue[:NEXT]?

Queries the most recent error queue entry and deletes it.

Positive error numbers indicate device-specific errors, negative error numbers are error messages defined by SCPI. If the error queue is empty, the error number 0, "No error", is returned.

**Usage:**            Query only

### 8.8.2.2 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>

Reads out the EVENt section of the status register.

The command also deletes the contents of the EVENt section.

**Query parameters:**
<ChannelName>        String containing the name of the channel.
                     The parameter is optional. If you omit it, the command works for
                     the currently active channel.

**Usage:**            Query only

### 8.8.2.3 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>

Reads out the CONDition section of the status register.

The command does not delete the contents of the EVENt section.

**Query parameters:**
<ChannelName>          String containing the name of the channel.
                       The parameter is optional. If you omit it, the command works for
                       the currently active channel.

**Usage:**              Query only

### 8.8.2.4 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>

Controls the ENABle part of a register.

The ENABle part allows true conditions in the EVENt part of the status register to be
reported in the summary bit. If a bit is 1 in the enable register and its associated event
bit transitions to true, a positive transition will occur in the summary bit reported to the
next higher level.

**Parameters:**
<BitDefinition>        Range:     0  to  65535

<ChannelName>          String containing the name of the channel.
                       The parameter is optional. If you omit it, the command works for
                       the currently active channel.

### 8.8.2.5 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>]

Controls the Negative TRansition part of a register.

Setting a bit causes a 1 to 0 transition in the corresponding bit of the associated regis-
ter. The transition also writes a 1 into the associated bit of the corresponding EVENt
register.

**Parameters:**

| | |
|---|---|
| <BitDefinition> | Range: 0 to 65535 |
| <ChannelName> | String containing the name of the channel.<br>The parameter is optional. If you omit it, the command works for the currently active channel. |

### 8.8.2.6  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 regis-
ter. The transition also writes a 1 into the associated bit of the corresponding EVENt
register.

**Parameters:**

| | |
|---|---|
| <BitDefinition> | Range: 0 to 65535 |
| <ChannelName> | String containing the name of the channel.<br>The parameter is optional. If you omit it, the command works for the currently active channel. |

## 8.9  Deprecated commands

The following commands are provided only for compatibility to remote control programs
from WLAN applications on previous signal analyzers. For new remote control pro-
grams 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 VSE (see Chapter 8.5, "Configuring the result display", on page 294). 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.

**CONFigure:WLAN:GTIMe:AUTO:TYPE** <GuardInterval>

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 254).

Note that this command is maintained for compatibility reasons only. Use CONFigure:WLAN:GTIMe:SELect on page 254 for new remote control programs.

Is available for IEEE 802.11ac, ax, n, be 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 VSE, 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:**

<GuardInterval>        **FBURst**
The Guard 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)

**L1G1**

Only HE/EHT PPDUs with one guard interval (GI) and one long training field (LTF) with the specified length are analyzed.
Not available for HE trigger-based PPDUs.
(For IEEE 802.11ax, be only; corresponds to "Meas only 4.0µs (1x HE-LTF + 1x GI1 = 3.2 + 0.8 µs)" in manual operation.)

**L1G2**

Only HE/EHT PPDUs with one long training field (LTF) and two guard intervals (GI) with the specified length are analyzed.
For HE trigger-based PPDUs only.
(For IEEE 802.11ax, be only; corresponds to "Meas only 4.8µs (1x HE-LTF + 2x GI1 = 3.2 + 1.6µs)" in manual operation.)

**L2G1**

Only HE/EHT PPDUs with two long training field (LTF) and one guard interval (GI) with the specified length are analyzed.
(For IEEE 802.11ax, be only; corresponds to "Meas only 7.2µs (2x HE-LTF + 1x GI1 = 6.4 + 0.8µs)" in manual operation.)

**L2G2**

Only HE/EHT PPDUs with two long training fields (LTF) and two guard intervals (GI) with the specified length are analyzed.
(For IEEE 802.11ax,be only; corresponds to "Meas only 8.0µs (2x HE-LTF + 2x GI1 = 6.4 + 1.6µs)" in manual operation.)

**L4G1**

Only HE/EHT PPDUs with four long training fields (LTF) and one guard interval (GI) with the specified length are analyzed.
(For IEEE 802.11ax,be only; corresponds to "Meas only 13.6µs (4x HE-LTF + 1x GI1 = 12.8 + 0.8µs)" in manual operation.)

**L4G4**

Only HE/EHT PPDUs with four guard intervals (GI) and four long training fields (LTF) with the specified length are analyzed.
(For IEEE 802.11ax,be only; corresponds to "Meas only 16.0µs (4x HE-LTF + 4x GI1 = 12.8 + 3.2µs)" in manual operation.)

*RST:          'ALL'

| | |
|---|---|
| **Example:** | `CONF:WLAN:GTIM:AUTO:TYPE DL` |
| **Manual operation:** | See "Guard Interval Length" on page 129<br>See "Guard Interval (GI) + HE-LTF Size" on page 140<br>See "Guard Interval (GI) + EHT-LTF Size" on page 148 |

---

**FETCh:BURSt:ALL?**

Note that this command is maintained for compatibility reasons only. Use the `FETCh:BURSt:ALL:FORMatted?` command for new remote control programs.

Returns all results from the default WLAN measurement (Modulation Accuracy, Flatness and Tolerance). The results are output as a list of result strings separated by commas in ASCII format. The results are output in the following order:

**Return values:**

| | |
|---|---|
| <Result> | <list> |
| | <preamble power>, <payload power>, <min rms power>, <average rms power>, <max rms power>, <peak power>, <min crest factor>,<average crest factor>,<max crest factor>, <min frequency error>,<average frequency error>, <max frequency error>, <min symbol error>, <average symbol error>, <max symbol error>, <min IQ offset>, <average IQ offset>, <maximum IQ offset>, <min gain imbalance>, <average gain imbalance>, <max gain imbalance>, <min quadrature offset>, <average quadrature offset>, <max quadrature offset>, <min EVM all bursts>, <average EVM all bursts>, <max EVM all bursts>, <min EVM data carriers>, <average EVM data carriers >, <max EVM data carriers> <min EVM pilots>, <average EVM pilots >, <max EVM pilots> |

**Usage:**        Query only

---

**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 236 commands for new remote control programs.

Configures how triggering is to be performed.

**Parameters:**

| | |
|---|---|
| <Source> | MANual \| 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 \| TUNit |

## 8.10 Programming examples (R&S VSE WLAN application)

This example demonstrates how to configure a WLAN 802.11 measurement in a remote environment.

-

## 8.10.1　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'
```

Example of results from a WLAN 802.11 MIMO measurement

```
FETC:BURS:ALL:FORM?

//Global Results from "Result Summary Global" for 11n/11ac standard
-11.0804,-11.0921,-0.9189,    //<preamble power>, <payload power>, <peak power>,
```

```
nan,nan,nan,                    //<min rms power>, <avg rms power>, <max rms power>
nan,nan,nan,                    //<min crest factor>,<avg crest factor>,<max crest factor>,
199.0661,211.5656,222.7475,     //<min freq error>,<avg freq error>, <max freq error>,
-0.0281,0.1477,0.3204,          //<min symbol error>, <avg symbol error>, <max symbol error>,
nan,nan,nan,                    //<min IQ offset>, <avg IQ offset>, <max IQ offset>,
nan,nan,nan,                    //<min gain imb>, <avg gain imb>, <max gain imb>,
nan,nan,nan,                    //<min quad offset>, <avg quad offset>, <max quad offset>,
-43.8807,-43.4476,-43.0819,     //<min EVM all>, <avg EVM all>, <max EVM all>,
-43.9346,-43.4823,-43.1164,     //<min EVM data>, <avg EVM data >, <max EVM data>
-44.0135,-42.5833,-41.7621,     //<min EVM pilots>, <avg EVM pilots >, <max EVM pilots>
nan,nan,nan,                    //<min BER>, <avg BER >, <max BER>
nan,nan,nan,                    //<min IQ skew>, <avg IQ skew>, <max IQ skew>
nan,nan,nan,                    //<min MIMO CP>, <avg MIMO CP>, <max MIMO CP>
nan,nan,nan,                    //<min CPE>, <avg CPE>, <max CPE>

//MIMO Stream 1 Results from "Result Summary Detailed" for 11n/11ac standard
nan,nan,nan,                    //<preamble power>, <payload power>, <peak power>,
-11.0882,-11.0876,-11.0866,     //<min rms power>, <avg rms power>, <max rms power>
10.1580,10.1687,10.1756,        //<min crest factor>,<avg crest factor>,<max crest factor>,
199.0661,211.5656,222.7475,     //<min freq error>,<avg freq error>, <max freq error>,
-0.0281,0.1477,0.3204,          //<min symbol error>, <avg symbol error>, <max symbol error>,
-60.1847,-59.6930,-59.2831,     //<min IQ offset>, <avg IQ offset>, <max IQ offset>,
-0.0011,-0.0001,0.0010,         //<min gain imb>, <avg gain imb>, <max gain imb>,
-0.0377,-0.0394,-0.0409,        //<min quad offset>, <avg quad offset>, <max quad offset>,
-43.8807,-43.4476,-43.0819,     //<min EVM all>, <avg EVM all>, <max EVM all>,
-43.9346,-43.4823,-43.1164,     //<min EVM data>, <avg EVM data >, <max EVM data>
-44.0135,-42.5833,-41.7621,     //<min EVM pilots>, <avg EVM pilots >, <max EVM pilots>
nan,nan,nan,                    //<min BER>, <avg BER >, <max BER>
1.4105,2.0148,2.4481,           //<min IQ skew>, <avg IQ skew>, <max IQ skew>
nan,nan,nan,                    //<min MIMO CP>, <avg MIMO CP>, <max MIMO CP>
0.0026,-0.1309,-0.6969          //<min CPE>, <avg CPE>, <max CPE>
```

Annex

A   Menu reference

Most functions in the R&S VSE are available from the menus.

A.1   Common R&S VSE menus

The following menus provide **basic functions for all applications**:

A.1.1   File menu

The "File" menu includes all functionality directly related to any file operations, printing or setting up general parameters.

For a description of these functions see the "Data Management" chapter in the R&S VSE base software user manual.

Menu item	Correspond-ing icon in toolbar	Description
Save	💾	Saves the current software configuration to a file
Recall	📂	Recalls a saved software configuration from a file
Save IQ Recording	-	Saves the recorded I/Q data from a measurement channel to a file
Recall IQ Recording	-	Loads the recorded I/Q data from a file
Measurement Group >	-	Configures measurement channels and groups
> New Group	-	Inserts a new group in the measurement sequence
> Rename Group	-	Changes the name of the selected group
> New Measurement Channel	-	Inserts a new channel in the selected group
> Replace Measure-ment Channel	-	Replaces the currently selected channel by the selected applica-tion.
> Rename Measure-ment Channel	-	Changes the name of the selected channel.

Menu item	Corresponding icon in toolbar	Description
> Delete Current Measurement Channel	-	Deletes the currently selected channel.
> Measurement Group Setup	-	Displays the "Measurement Group Setup" tool window.
Instruments >	-	Configures instruments to be used for input to the R&S VSE software
> New	-	Creates a new instrument configuration
> Search	-	Searches for connected instruments in the network
> Delete All	-	Deletes all current instrument configurations
> Setup	-	Hides or displays the "Instrument" tool window
Preset >	-	Restores stored settings
> Selected Channel	-	Restores the default software configuration for an individual channel
> All	-	Restores the default software configuration globally for the entire software
> All & Delete Instruments		Restores the default software configuration globally for the entire software and deletes all instrument configurations
> Reset VSE Layout	-	Restores the default layout of windows, toolbars etc. in the R&S VSE
Preferences >	-	Configures global software settings
> General	-	
> Displayed Items	-	Hides or shows individual screen elements
> Theme & Color	-	Configures the style of individual screen elements
> Network & Remote	-	Configures the network settings and remote access to or from other devices
> Recording	-	Configures general recording parameters
Print	-	Opens "Print" dialog to print selected measurement results
Exit	-	Closes the R&S VSE

A.1.2 Window menu

The "Window" menu allows you to hide or show individual windows.

For a description of these functions see the "Controlling Instruments and Capturing Data" chapter in the R&S VSE base software user manual.

Menu item	Corresponding icon in toolbar	Description
Player	-	Displays the "Player" tool window to recall I/Q data recordings
Instruments	-	Displays the "Instruments" window to configure input instruments
Measurement Group Setup	-	Displays the "Measurement Group Setup" window to configure a measurement sequence
New Window >	⊡	Inserts a new result display window for the selected measurement channel
Channel Information >	-	Displays the channel bar with global channel information for the selected measurement channel
Active Windows >	-	Selects a result display as the active window; the corresponding channel is also activated

A.1.3 Help menu

The "Help" menu provides access to help, support and licensing functions.

For a description of these functions see the "Basic Operations" and "General Software Settings" chapters in the R&S VSE base software user manual.

Menu item	Corresponding icon in toolbar	Description
Help	?	Opens the Online help window
License	-	Licensing, version and options information
Support	-	Support functions
Register VSE	-	Opens the Rohde & Schwarz support page (http://www.rohde-schwarz.com/support) in a browser for registration.
Online Support	-	Opens the default web browser and attempts to establish an Internet connection to the Rohde & Schwarz product site.
About	-	Software version information

A.2 WLAN I/Q measurements menus

The following menus are only available if a WLAN I/Q measurement channel is selected.

A.2.1 Input & output menu

The "Input & Output" menu provides functions to configure the input source, frontend parameters and output settings for the measurement.

This menu is application-specific.

Table A-1: "Input" menu items for WLAN I/Q Measurements

Menu item	Description
Amplitude	Chapter 4.3.3, "Amplitude settings", on page 103
Scale	
Frequency	Chapter 4.3.2, "Frequency settings", on page 102
Trigger	Chapter 4.4.2, "Trigger settings", on page 111
Input Source	Chapter 4.3.1, "Input source settings", on page 94
Output Source	R&S VSE Base Software User Manual

A.2.2 Meas setup menu

The "Meas Setup" menu provides access to most measurement-specific settings, as well as bandwidth, sweep and auto configuration settings, and the configuration "Overview" window.

This menu is application-specific.

Table A-2: "Meas Setup" menu items for WLAN I/Q Measurements

Menu item	Description
Signal Description	Chapter 4.2, "Signal description", on page 92
Input/Frontend	Chapter 4.3.1, "Input source settings", on page 94
Signal Capture	Chapter 4.2, "Signal description", on page 92
Synch/OFDM-Demod	Chapter 4.5, "Synchronization and OFDM demodulation", on page 120
Tracking/Channel Estimation	Chapter 4.6, "Tracking and channel estimation", on page 121
Demod	Chapter 4.7, "Demodulation", on page 126
Evaluation Range	Chapter 4.8, "Evaluation range", on page 157
ResultConfig	Chapter 4.9, "Result configuration", on page 163
Meas Settings	Chapter 2, "WLAN I/Q measurement (modulation accuracy, flatness and tolerance)", on page 9
Expert mode	For Rohde & Schwarz oscilloscopes only: Configuration directly on the instrument, see the R&S VSE Base Software User Manual.

Menu item	Description
User Correction	User-defined frequency response correction, see the R&S VSE Base Software User Manual.
Overview	Chapter 4.1, "Configuration overview", on page 90

A.2.3 Trace menu

The "Trace" does not contain any functions for WLAN I/Q measurements, traces are generally not configurable.

A.2.4 Marker menu

The "Marker" menu provides access to marker-specific functions.

This menu is application-specific.

Table A-3: "Marker" menu items for WLAN I/Q Measurements

Menu item	Corresponding icon in toolbar	Description
Marker 1	-	
Marker to Trace	-	

A.2.5 Limits menu

The "Limits" menu does not contain any functions for WLAN I/Q measurements.

B Reference of toolbar functions

Common functions can be performed via the icons in the toolbars.

Individual toolbars can be hidden or displayed.

Hiding and displaying a toolbar

1. Right-click any toolbar or the menu bar.

   A context menu with a list of all available toolbars is displayed.

2. Select the toolbar you want to hide or display.

   A checkmark indicates that the toolbar is currently displayed.

   The toolbar is toggled on or off.

Note that some icons are only available for specific applications. Those functions are described in the individual application's User Manual.

General toolbars

The following functions are generally available for all applications:

"Main" toolbar

For a description of these functions see the R&S VSE base software user manual.

Table B-1: Functions in the "Main" toolbar

Icon	Description
	Overview: Displays the configuration overview for the current measurement channel
	Save: Saves the current software configuration to a file
	Recall: Recalls a saved software configuration from a file
	Save I/Q recording: Stores the recorded I/Q data to a file
	Recall I/Q recording: Loads recorded I/Q data from a file
	Print immediately: prints the current display (screenshot) as configured
	Add Window: Inserts a new result display window for the selected measurement channel
	MultiView mode: displays windows for all active measurement channels (disabled: only windows for currently selected channel are displayed)

"Control" toolbar

For a description of these functions see the R&S VSE base software user manual.

Table B-2: Functions in the "Control" toolbar

Icon	Description
IQ Analyzer ▼	Selects the currently active channel
▶	Capture: performs the selected measurement
⏸	Pause: temporarily stops the current measurement
↻	Continuous: toggles to continuous measurement mode for next capture
→|	Single: toggles to single measurement mode for next capture
●	Record: performs the selected measurement and records the captured data and results
↻	Refresh: Repeats the evaluation of the data currently in the capture buffer without capturing new data (VSA application only).

"Help" toolbar

For a description of these functions see the R&S VSE base software user manual.

Table B-3: Functions in the "Help" toolbar

Icon	Description
↖?	Help (+ Select): allows you to select an object for which context-specific help is displayed (not available in standard Windows dialog boxes or measurement result windows)
?	Help: displays context-sensitive help topic for currently selected element

Application-specific toolbars

The following toolbars are application-specific; not all functions shown here may be available in each application:

"Zoom" toolbar

For a description of these functions see the R&S VSE base software user manual.

Table B-4: Functions in the "Zoom" toolbar

Icon	Description
↖	Normal mouse mode: the cursor can be used to select (and move) markers in a zoomed display
🔍	Zoom mode: displays a dotted rectangle in the diagram that can be expanded to define the zoom area

Icon	Description
	Multiple zoom mode: multiple zoom areas can be defined for the same diagram
1:1	Zoom off: displays the diagram in its original size

Table B-5: Functions in the "Marker" toolbar

Icon	Description
	Place new marker
%	Percent Marker (CCDF only)
M1	Select marker
	Marker type "normal"
	Marker type "delta"
	Global peak
	Absolute peak (Currently only for GSM application)
	Next peak to the left
	Next peak to the right
	Next peak up (for spectrograms only: search in more recent frames)
	Next peak down (for spectrograms only: search in previous frames)
	Global minimum
	Next minimum left
	Next minimum right
	Next min up (for spectrograms only: search in more recent frames)
	Next min down (for spectrograms only: search in previous frames)
CF	Set marker value to center frequency
REF	Set reference level to marker value
	All markers off

Icon	Description
	Marker search configuration
	Marker configuration

Table B-6: Functions in the "AutoSet" toolbar

Icon	Description
	Refresh measurement results (R&S VSE VSA and OFDM VSA applications only)
AUTO LEVEL	Auto level
AUTO FREQ	Auto frequency
	Auto trigger (R&S VSE GSM application only)
	Auto frame (R&S VSE GSM application only)
	Auto search (R&S VSE 3GPP FDD application only)
	Auto scale (R&S VSE 3GPP FDD + Pulse applications only)
	Auto scale all (R&S VSE 3GPP FDD + Pulse applications only)
AUTO ALL	Auto all
	Configure auto settings

C Sample rate, record length and analysis bandwidth

Definitions

- **Input sample rate (ISR)**: the sample rate of the useful data provided by the device connected to the input of the connected instrument

- (User, Output) **Sample rate (SR)**: the sample rate that is defined by the user (e.g. in the "Data Aquisition" dialog box in the "I/Q Analyzer" application) and 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 VSE

- **Record length**: the number of I/Q samples the connected instrument captures during the specified measurement time; calculated as the measurement time multiplied by the sample rate. By default, the record length is set to the number of measurement points, and the measurement time and sample rate are adapted accordingly. The maximum record length is 524288, but must not exceed the number of samples provided by the connected instrument.

For the I/Q data acquisition, digital decimation filters are used internally in the connected instrument. 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 sideband. If frequencies of interest to you are also suppressed, try to increase the output sample rate to increase the maximum usable I/Q bandwidth.

As a rule, the usable I/Q bandwidth is proportional to the output sample rate. However, the bandwidth used by the R&S VSE software is restricted by the bandwidth provided by the connected instrument.

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