R&S®FSW-K96
OFDM Vector Signal Analysis Application
User Manual

1179384402
Version 06

ROHDE&SCHWARZ
Make ideas real

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

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

The following software options are described:

- R&S®FSW-K96 (1313.1539.02)

Muehldorfstr. 15, 81671 Muenchen, Germany
Phone: +49 89 41 29 - 0
Email: info@rohde-schwarz.com
Internet: www.rohde-schwarz.com

1179.3844.02 | Version 06 | R&S®FSW-K96

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

Contents

1 Welcome to the OFDM vector signal analysis (VSA) application

The R&S FSW OFDM VSA application performs vector and scalar measurements on digitally modulated OFDM signals. To perform the measurements it converts RF signals into the complex baseband.

The R&S FSW OFDM VSA application features:

- Analysis of non-standard and standard-conform OFDM systems
- I/Q-based measurement results such as EVM, constellation diagrams, power spectrum

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

Functions that are not discussed in this manual are the same as in the Spectrum application and are described in the FSW base unit user manual.

The latest version is available for download at the product homepage http://www.rohde-schwarz.com/product/FSW.

1.1 Introduction to vector signal analysis

The goal of vector signal analysis is to determine the quality of the signal that is transmitted by the device under test (DUT) by comparing it against an ideal signal. The DUT is usually connected with the analyzer via a cable. The key task of the analyzer is to determine the ideal signal. Hence, the analyzer aims to reconstruct the ideal signal from the measured signal that is transmitted by the DUT. This ideal signal is commonly referred to as the *reference signal*, while the signal from the DUT is called the *measurement signal*.

After extracting the reference signal, the R&S FSW OFDM VSA application compares the measurement signal and the reference signal, and the results of this comparison are displayed.

Example:

The most common vector signal analysis measurement is the EVM ("Error Vector Magnitude") measurement. Here, the complex baseband reference signal is subtracted from the complex baseband measurement signal. The magnitude of this error vector represents the EVM value. The EVM has the advantage that it "summarizes" all potential errors and distortions in one single value. If the EVM value is low, the signal quality of the DUT is high.

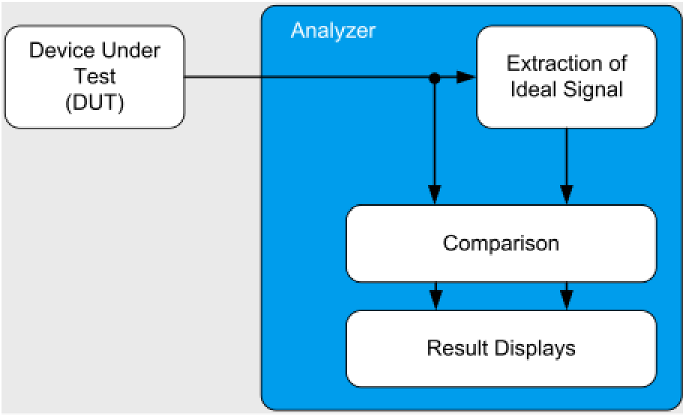


Figure 1-1: Simplified schema of vector signal analysis

1.2 Starting the R&S FSW OFDM VSA application

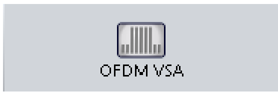
The R&S FSW OFDM VSA application adds a new application to the FSW.

To activate the R&S FSW OFDM VSA application

1. Select [MODE].

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

2. Select the "OFDM VSA" item.

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

Multiple Measurement Channels and Sequencer Function

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

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

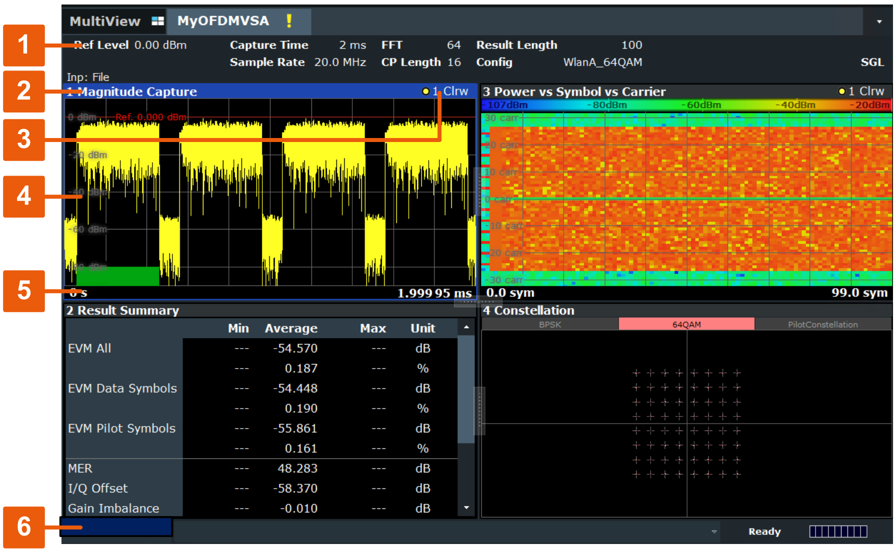
Only one measurement can be performed at any time, namely the one in the currently active channel. However, in order to perform the configured measurements consecutively, a Sequencer function is provided.

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

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

1.3 Understanding the display information

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



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

Channel bar information

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

Table 1-1: Information displayed in the channel bar in R&S FSW OFDM VSA application

Label	Description
Ref Level	Reference level
Att	Mechanical and electronic RF attenuation
Input	Input type of the signal source
Offset	Reference level offset
Freq	Center frequency for the RF signal
Capture Time	How long data was captured in current sweep
Sample Rate	Sample rate

Label	Description
FFT	FFT size
CP Length	Cyclic prefix length
Res Len	Result length
Config	Currently loaded configuration file

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 FSW base unit user manual.

Window title bar information

For each diagram, the header provides the following information:

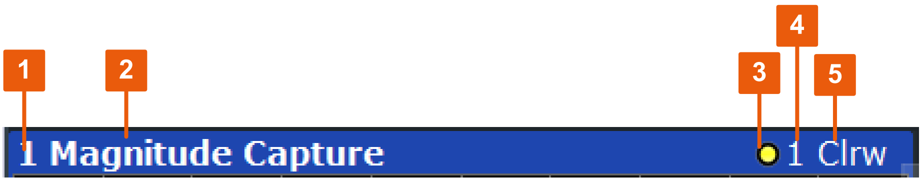


Figure 1-2: Window title bar information in R&S FSW OFDM VSA application

1 = Window name
2 = Result type
3 = Trace color
4 = Trace number
5 = Trace mode

Diagram area

The diagram area displays the results according to the selected result displays (see Chapter 2.2, "Evaluation methods for OFDM VSA measurements", on page 11).

Diagram footer information

The diagram footer (beneath the diagram) contains the start and stop symbols or time of the evaluation range.

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 FSW window.

2 OFDM VSA measurement and results

Access: "Overview" > "Display Config"

Or: [MEAS] > "Display Config"

The R&S FSW OFDM VSA application provides various different result displays for OFDM VSA measurements.

2.1 OFDM VSA parameters

Several signal parameters are determined during vector signal analysis and displayed in the Result Summary.

For details concerning the calculation of individual parameters, see Chapter A, "Formulae", on page 329.

Evaluated cells for EVM and MER results

For the numerical EVM and MER results described in Table 2-1, only the symbols in the specified result length are evaluated. The following cells and carriers are ignored:

- All "don't care" cells in all carriers
- All zero cells in all carriers
- All guard carriers, which consist of zero cells or "don't care" cells only
- DC carriers, which consist of zero cells only

Note that for the "EVM vs Carrier", "EVM vs Symbol" and "EVM vs Symbol vs Carrier" results, the traces include the zero cells and DC carriers to avoid gaps.

Table 2-1: OFDM VSA parameters

Parameter	Description	SCPI parameter *)
EVM All [%/dB]	Error Vector Magnitude of all pilot and data cells of the analyzed frames	EVM[:ALL]
EVM Data Symbols [%/dB]	Error Vector Magnitude of all data cells of the analyzed frames. All pilot cells are ignored.	EVM:DATA
EVM Pilot Symbols [%/dB]	Error Vector Magnitude of all pilot cells of the analyzed frames. All data cells are ignored.	EVM:PILot
**)	Maximum EVM of each carrier (frequency domain) and in each symbol (time domain) for each analyzed signal frame. The results are provided in dB or percent. Corresponds to the maximum of the peaks for each frame in the EVM vs Symbol vs Carrier display.	EVMPeak[:ALL]
*) Required to retrieve the parameter result, see Chapter 8.8.1, "Retrieving numerical results", on page 295 **) not included in Result Summary, remote query only		

Parameter	Description	SCPI parameter *)
**)	Maximum EVM of each carrier (frequency domain) and in each data symbol (time domain) for each analyzed signal frame. The results are provided in dB or percent.	`EVMPeak:DATA`
**)	Maximum EVM of each carrier (frequency domain) and in each pilot symbol (time domain) for each analyzed signal frame. The results are provided in dB or percent.	`EVMPeak:PILot`
MER [dB]	Average Modulation Error Ratio (MER) for all data and all pilot cells of the analyzed frames. If more than one frame is evaluated, mean square averaging is used. The MER is the ratio of the RMS power of the ideal reference signal to the RMS power of the error vector. For the average MER, the ratio of (power of the error vector) to (power of the ideal reference signal) is averaged.	`MER[:ALL]`
I/Q offset [dB]	Transmitter center frequency leakage relative to the total Tx channel power	`IQOFset`
Gain imbalance [dB]	Amplification of the quadrature phase component of the signal relative to the amplification of the in-phase component	`GIMBalance`
Quadrature error [°]	Phase angle between Q-channel and I-channel deviating from the ideal 90 degrees; measure for crosstalk from the Q-branch into the I-branch	`QUADerror`
Frequency Error [Hz]	Frequency error between the signal and the currently defined center frequency The absolute frequency error includes the frequency error of the FSW and that of the DUT. If possible, the transmitter FSW and the DUT should be synchronized (using an external reference).	`FERRor`
Sample Clock Error	Clock error between the signal and the sample clock of the FSW in parts per million (ppm), i.e. the symbol timing error Requires at least two OFDM symbols containing pilots for pilot-aided demodulation. If possible, the transmitter FSW and the DUT should be synchronized (using an external reference).	`SERRor`
Frame Power	Average time domain power of the analyzed signal frame	`POWer`
Crest factor [dB]	The ratio of the peak power to the mean power of the analyzed signal frame	`CRESt`

*) Required to retrieve the parameter result, see Chapter 8.8.1, "Retrieving numerical results", on page 295

**) not included in Result Summary, remote query only

The R&S FSW OFDM VSA application also performs statistical evaluation over several frames and displays the following results:

Table 2-2: Calculated summary results

Result type	Description
Min	Minimum measured value
Average	Average measured value
Max	Maximum measured value

2.2 Evaluation methods for OFDM VSA measurements

The data that was measured by the FSW can be evaluated using various different methods without having to start a new measurement. Which results are displayed depends on the selected evaluation.

The R&S FSW OFDM VSA application provides the following evaluation methods:

Allocation Matrix

The Allocation Matrix display is a graphical representation of the OFDM cell structure defined in the currently loaded configuration file.

Use markers to get more detailed information on the individual cells.

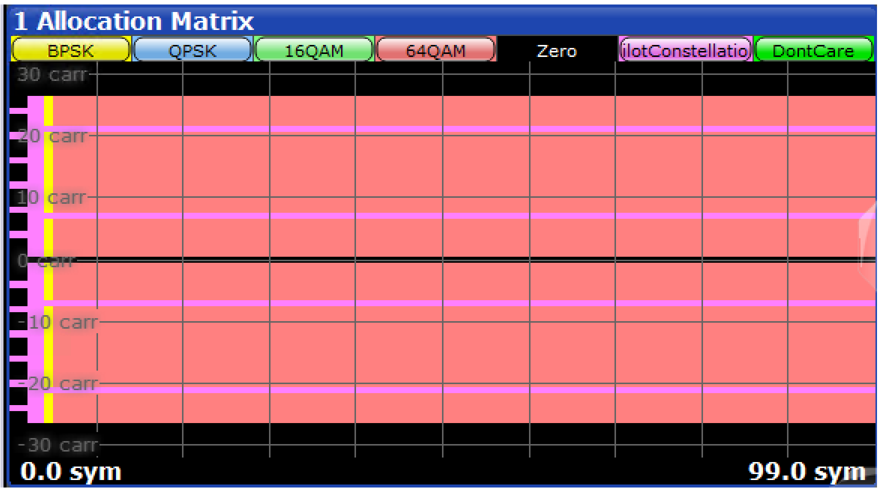


Figure 2-1: Allocation Matrix

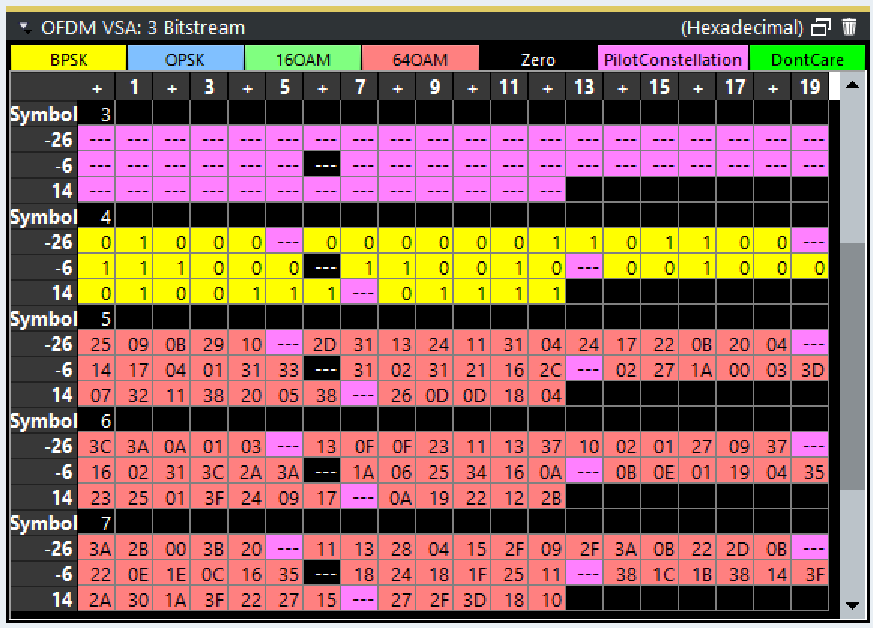
The legend for the color coding is displayed at the top of the matrix.

Note: Markers in the Allocation Matrix. Using markers you can detect individual allocation points for a specific symbol or carrier. When you activate a marker in the Allocation Matrix, its position is defined by the symbol and carrier number the point belongs to. The marker result indicates the I and Q values of the point.
See also "Markers in the Constellation View and Allocation Matrix" on page 136.

Remote command:
`LAY:ADD? '1',RIGH,AMATrix`, see `LAYout:ADD[:WINDow]?` on page 288
`TRACe<n>[:DATA]?` on page 310, see Chapter 8.8.4.1, "Allocation matrix", on page 314
`TRACe<n>[:DATA]:X?` on page 310
`TRACe<n>[:DATA]:Y?` on page 311
Symbol unit: `UNIT:SAXes` on page 269

Bitstream

This result display shows a demodulated data stream for the symbols in the currently analyzed result ranges. The different modulation types are indicated by color, as shown in the legend at the top of the window. Guard carriers are not included in the display, but are returned as non-data cells ("---") in trace export files.



OFDM VSA: 3 Bitstream (Hexadecimal)

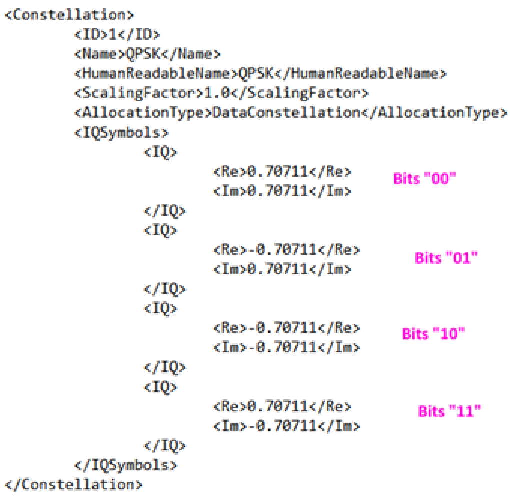
BPSK | QPSK | 16QAM | 64QAM | Zero | PilotConstellation | DontCare

	+	1	+	3	+	5	+	7	+	9	+	11	+	13	+	15	+	17	+	19
Symbol	3																			
-26	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
-6	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
14	---	---	---	---	---	---	---	---	---	---	---	---	---							
Symbol	4																			
-26	0	1	0	0	0	---	0	0	0	0	0	0	1	1	0	1	1	0	0	---
-6	1	1	1	0	0	0	---	1	1	0	0	1	0	---	0	0	1	0	0	0
14	0	1	0	0	1	1	1	---	0	1	1	1	1							
Symbol	5																			
-26	25	09	0B	29	10	---	2D	31	13	24	11	31	04	24	17	22	0B	20	04	---
-6	14	17	04	01	31	33	---	31	02	31	21	16	2C	---	02	27	1A	00	03	3D
14	07	32	11	38	20	05	38	---	26	0D	0D	18	04							
Symbol	6																			
-26	3C	3A	0A	01	03	---	13	0F	0F	23	11	13	37	10	02	01	27	09	37	---
-6	16	02	31	3C	2A	3A	---	1A	06	25	34	16	0A	---	0B	0E	01	19	04	35
14	23	25	01	3F	24	09	17	---	0A	19	22	12	2B							
Symbol	7																			
-26	3A	2B	00	3B	20	---	11	13	28	04	15	2F	09	2F	3A	0B	22	2D	0B	---
-6	22	0E	1E	0C	16	35	---	18	24	18	1F	25	11	---	38	1C	1B	38	14	3F
14	2A	30	1A	3F	22	27	15	---	27	2F	3D	18	10							

The bitstream is derived from the order of the constellation points in the configuration file.

Example:

For QPSK, the value that is in the first position defines "00", the value that is in the second position defines "01", the value that is in the third position "10" and the last value "11".



```
<Constellation>
        <ID>1</ID>
        <Name>QPSK</Name>
        <HumanReadableName>QPSK</HumanReadableName>
        <ScalingFactor>1.0</ScalingFactor>
        <AllocationType>DataConstellation</AllocationType>
        <IQSymbols>
                <IQ>
                        <Re>0.70711</Re>        Bits "00"
                        <Im>0.70711</Im>
                </IQ>
                <IQ>
                        <Re>-0.70711</Re>       Bits "01"
                        <Im>0.70711</Im>
                </IQ>
                <IQ>
                        <Re>-0.70711</Re>       Bits "10"
                        <Im>-0.70711</Im>
                </IQ>
                <IQ>
                        <Re>0.70711</Re>        Bits "11"
                        <Im>-0.70711</Im>
                </IQ>
        </IQSymbols>
</Constellation>
```

Figure 2-2: Extract from configuration file defining the constellation points

Remote command:
`LAY:ADD? '1',RIGH,BITS`, see `LAYout:ADD[:WINDow]?` on page 288
`TRACe:DATA?`, see Chapter 8.8.4.2, "Bitstream", on page 314

CCDF

The CCDF results display shows the probability of an amplitude exceeding the mean power. The x-axis displays power relative to the measured mean power.

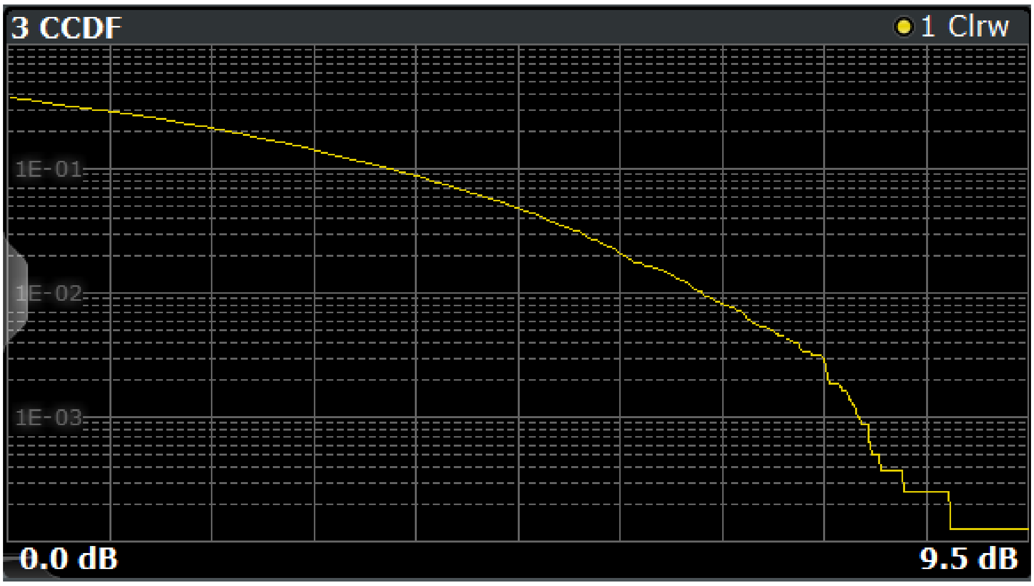


Figure 2-3: CCDF display

Remote command:

LAY:ADD? '1',RIGH,CCDF, see LAYout:ADD[:WINDow]? on page 288

TRACe:DATA?, see Chapter 8.8.4.3, "CCDF", on page 315

TRACe<n>[:DATA]:X? on page 310

Channel Flatness

The Channel Flatness display shows the amplitude of the channel transfer function vs. carrier.

The statistic is performed over all analyzed frames.

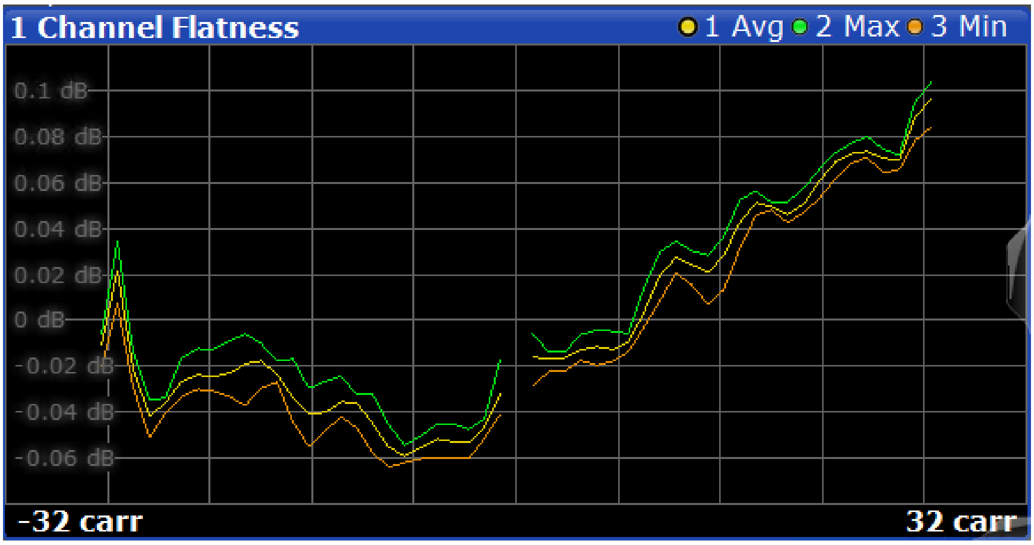


Figure 2-4: Channel Flatness Display

Remote command:
`LAY:ADD? '1',RIGH,CHFL`, see `LAYout:ADD[:WINDow]?` on page 288
`TRACe:DATA?`, see Chapter 8.8.4.4, "Channel flatness", on page 315
`TRACe<n>[:DATA]:X?` on page 310
Carrier unit: `UNIT:CAXes` on page 268

Constellation Diagram

The Constellation Diagram shows the inphase and quadrature results for the analyzed input data. The ideal points for the selected cell types are displayed for reference purposes.

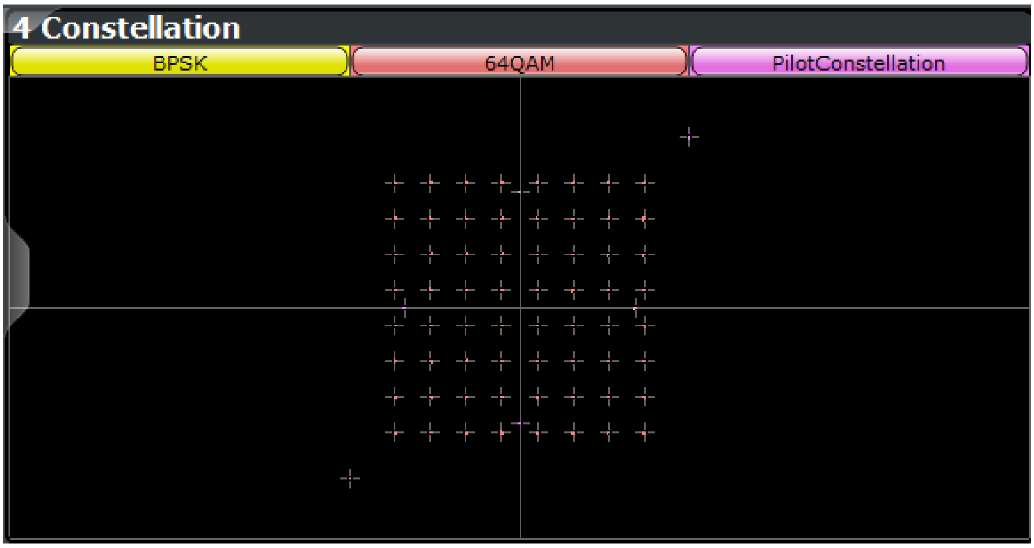


Figure 2-5: Constellation diagram

The legend for the color coding is displayed at the top of the matrix. If you click on one of the codes, only the selected constellation points are displayed. Click again, and all constellation points are displayed again (according to the constellation filter).

See Chapter 6.1, "Result configuration", on page 130.

Note: Markers in the Constellation diagram. Using markers you can detect individual constellation points for a specific symbol or carrier. When you activate a marker in the Constellation diagram, its position is defined by the symbol and carrier number the point belongs to. The marker result indicates the I and Q values of the point.

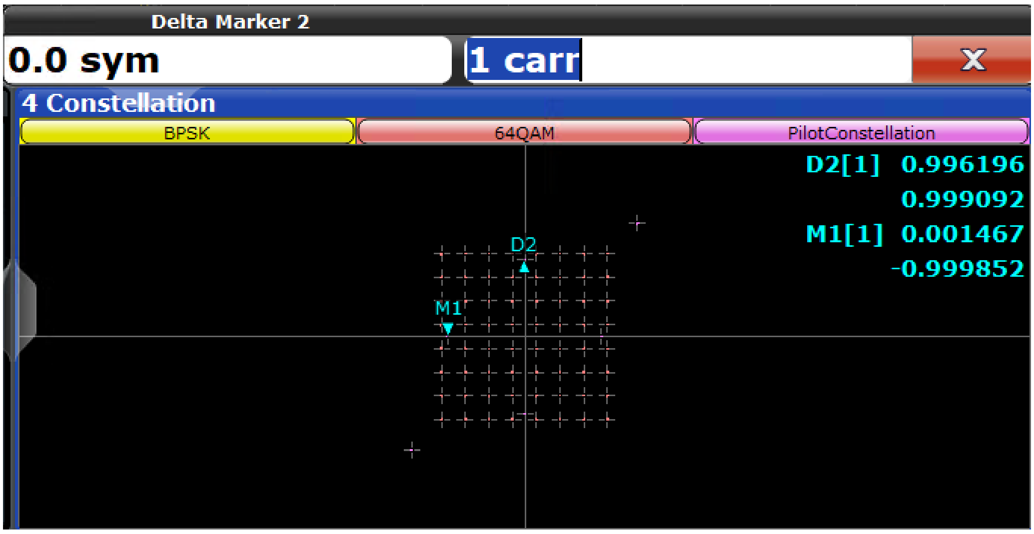


Figure 2-6: Marker in a Constellation diagram

See also "Markers in the Constellation View and Allocation Matrix" on page 136.

Remote command:
`LAY:ADD? '1',RIGH,CONS`, see `LAYout:ADD[:WINDow]?` on page 288
`TRACe:DATA?`, see Chapter 8.8.4.5, "Constellation diagram", on page 315
Marker I/Q values:
`CALCulate<n>:MARKer<m>:Z` on page 306

Constellation vs Carrier

The Constellation vs. Carrier display shows the inphase and quadrature magnitude results of all analyzed symbols over the corresponding carriers. The inphase values are displayed as yellow dots; the quadrature-values are displayed as blue dots.

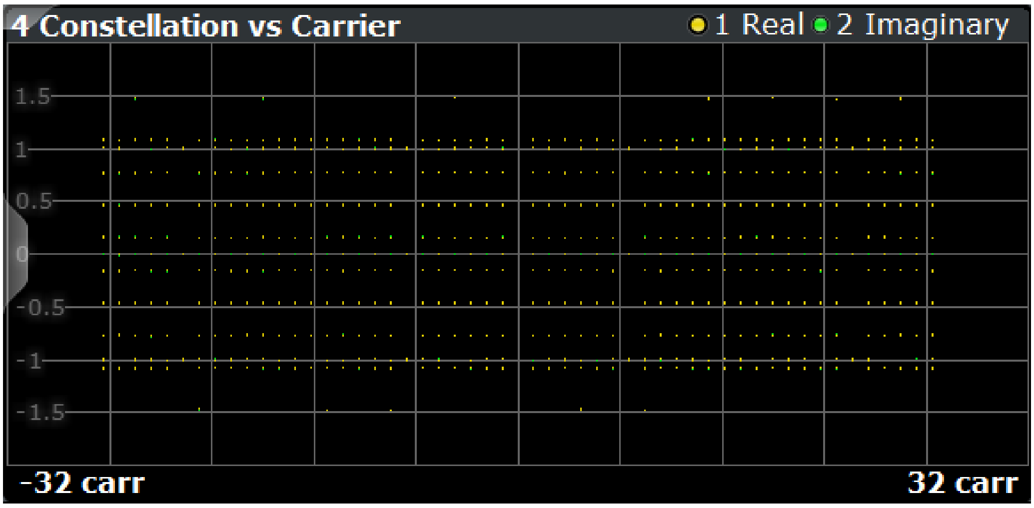


Figure 2-7: Constellation vs Carrier display

Note: This result display is only available if synchronization is successful.

Remote command:
`LAY:ADD? '1',RIGH,CCAR`, see `LAYout:ADD[:WINDow]?` on page 288
`TRACe:DATA?`, see Chapter 8.8.4, "Using the TRACe[:DATA] command", on page 313
Carrier unit: `UNIT:CAXes` on page 268
Symbol selection for marker: `CALCulate<n>:MARKer<m>:Z` on page 306

Constellation vs Symbol

The Constellation vs. Symbol display shows the inphase and quadrature magnitude results of all analyzed carriers over the corresponding symbols. The inphase values are displayed as yellow dots; the quadrature-values are displayed as blue dots.

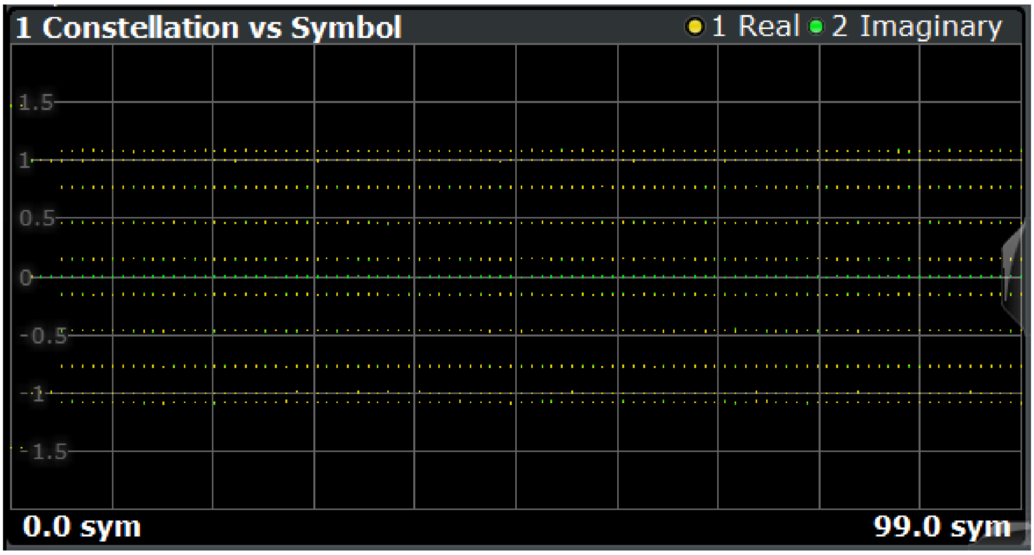


Figure 2-8: Constellation vs Symbol display

Note: This result display is only available if synchronization is successful.

Remote command:
`LAY:ADD? '1',RIGH,CSYM`, see `LAYout:ADD[:WINDow]?` on page 288
`TRACe:DATA?`, see Chapter 8.8.4, "Using the TRACe[:DATA] command", on page 313
Symbol unit: `UNIT:SAXes` on page 269
Carrier selection for marker: `CALCulate<n>:MARKer<m>:Z` on page 306

EVM vs Carrier

The EVM vs Carrier display shows the EVM of each carrier of the analyzed signal frame in the frequency domain. The results are provided in dB. Multiple traces display statistical evaluations over carriers.

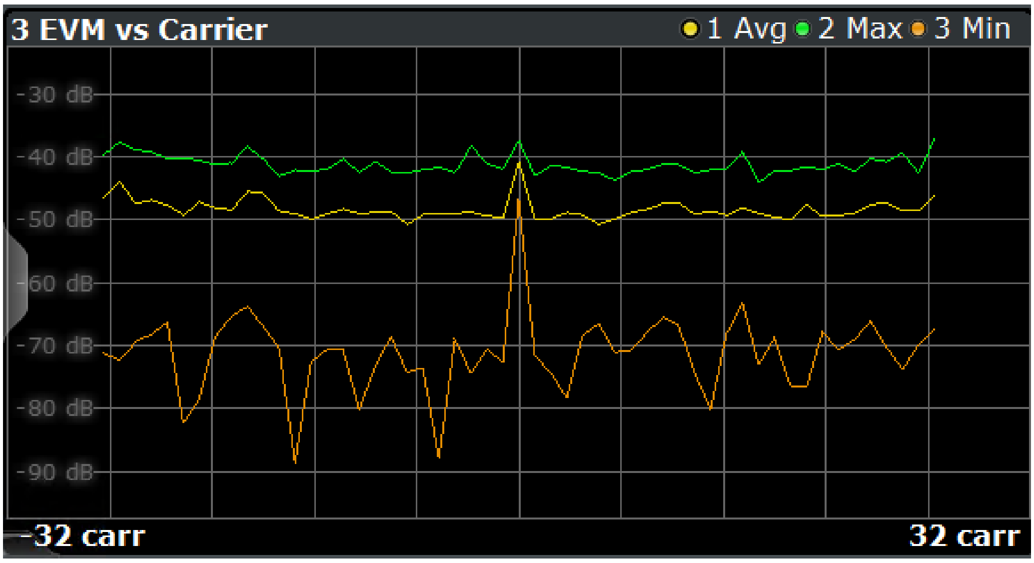


Figure 2-9: EVM vs Carrier display

Note: This result display is only available if synchronization is successful.
Guard carriers to the left and right of the spectrum are not included in the EVM calculation. However, zero cells and the DC carrier are included.

Remote command:
`LAY:ADD? '1',RIGH,EVC`, see `LAYout:ADD[:WINDow]?` on page 288
`TRACe:DATA?`, see Chapter 8.8.4.8, "EVM vs carrier", on page 318
`TRACe<n>[:DATA]:X?` on page 310
Carrier unit: `UNIT:CAXes` on page 268
EVM unit: `UNIT:EVM` on page 268

EVM vs Symbol

The EVM vs. Symbol display shows the EVM of each symbol of the analyzed signal frame in the time domain. The results are provided in dB. Multiple traces display statistical evaluations over symbols.

Blue lines indicate the border between different OFDM frames if more than one frame is analyzed.

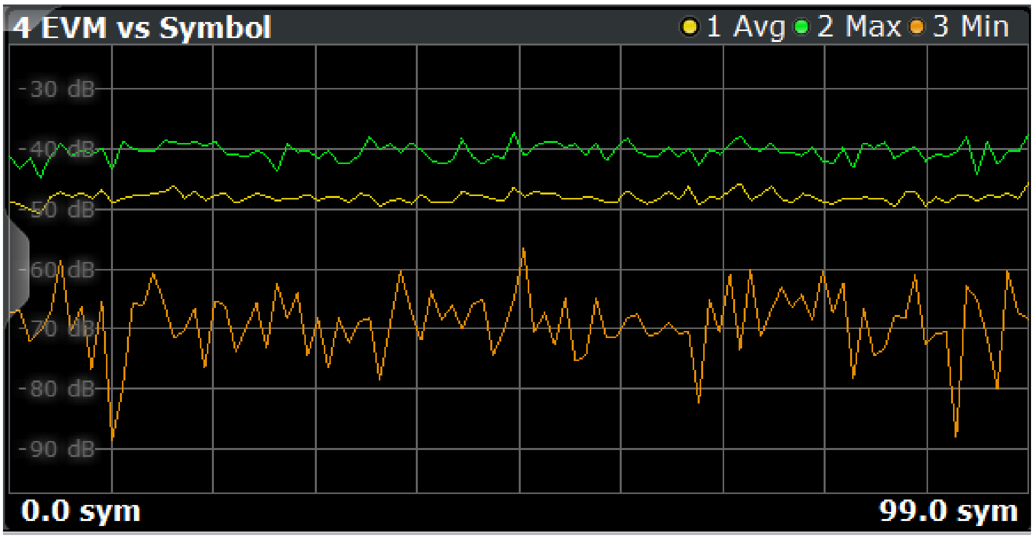


Figure 2-10: EVM vs Symbol display

Note: This result display is only available if synchronization is successful.
Guard carriers to the left and right of the spectrum are not included in the EVM calculation. However, zero cells and the DC carrier are included.

Remote command:
`LAY:ADD? '1',RIGH,EVSY`, see `LAYout:ADD[:WINDow]?` on page 288
`TRACe:DATA?`, see Chapter 8.8.4.9, "EVM vs symbol", on page 318
`TRACe<n>[:DATA]:X?` on page 310
Symbol unit: `UNIT:SAXes` on page 269
EVM unit: `UNIT:EVM` on page 268

EVM vs Symbol vs Carrier
The EVM vs Symbol vs Carrier display shows the EVM of each carrier (frequency domain) and in each symbol (time domain) of the analyzed signal frame.

The results are provided in dB or percent, depending on the unit settings.

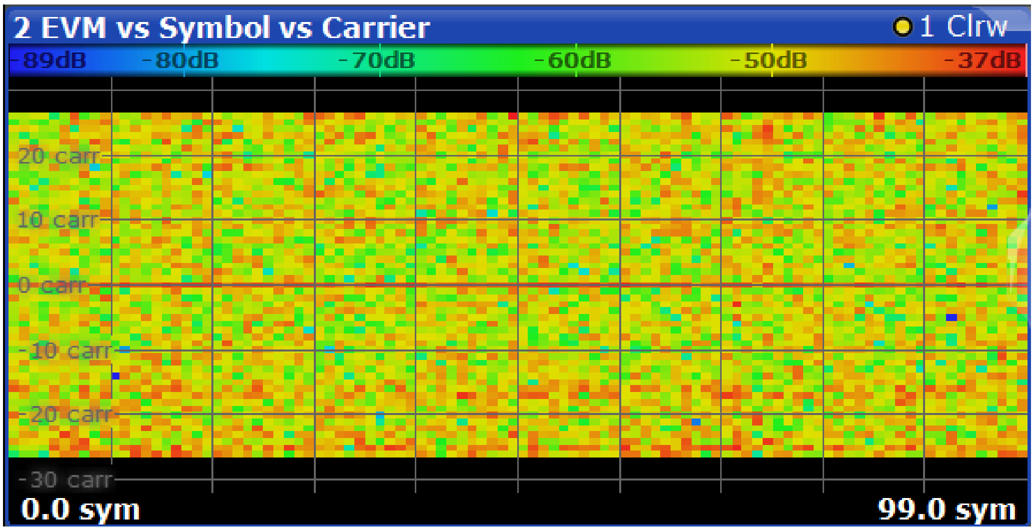


Figure 2-11: EVM vs Symbol vs Carrier display

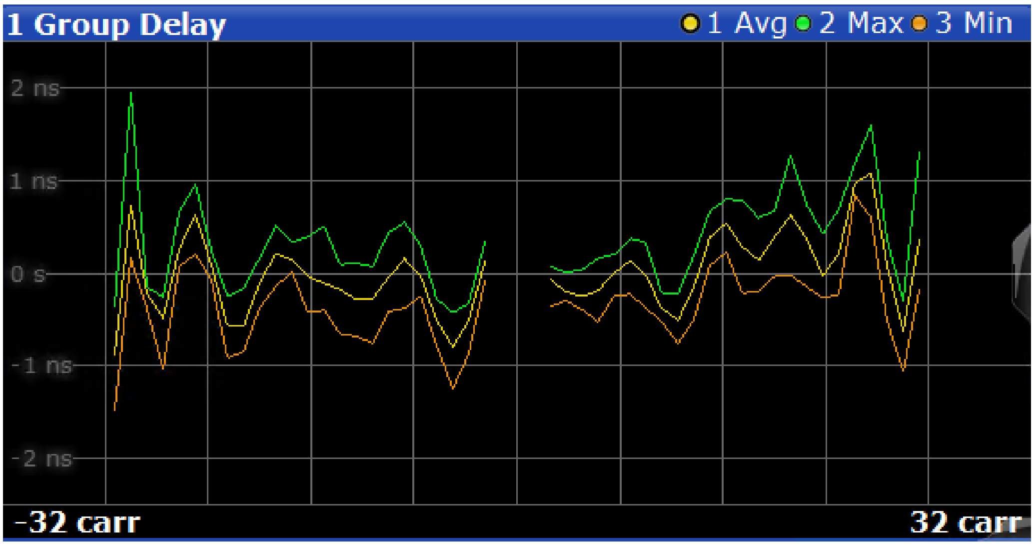
The EVM values are represented by colors. The corresponding color map is displayed at the top of the result display.

Note: This result display is only available if synchronization is successful.

Remote command:
`LAY:ADD? '1',RIGH,EVSC`, see `LAYout:ADD[:WINDow]?` on page 288
`TRACe:DATA?`, see Chapter 8.8.4.10, "EVM vs symbol vs carrier", on page 318
`TRACe<n>[:DATA]:X?` on page 310
`TRACe<n>[:DATA]:Y?` on page 311
Carrier unit: `UNIT:CAXes` on page 268
Symbol unit: `UNIT:SAXes` on page 269
EVM unit: `UNIT:EVM` on page 268
Carrier selection for marker: `CALCulate<n>:MARKer<m>:Z` on page 306

Group Delay
The Group Delay display shows the relative group delay of the transmission channel per carrier.

Multiple traces display statistical evaluations over all analyzed frames.



Remote command:
`LAY:ADD? '1',RIGH,GDEL`, see `LAYout:ADD[:WINDow]?` on page 288
`TRACe:DATA?`, see Chapter 8.8.4.11, "Group delay", on page 319
`TRACe<n>[:DATA]:X?` on page 310
Carrier unit: `UNIT:CAXes` on page 268

Impulse Response

The "Channel Impulse Response" display shows the impulse response of the channel and its position within the guard interval. The start and the end of the cyclic prefix are marked with blue lines.

Multiple traces display statistical evaluations over all analyzed frames.

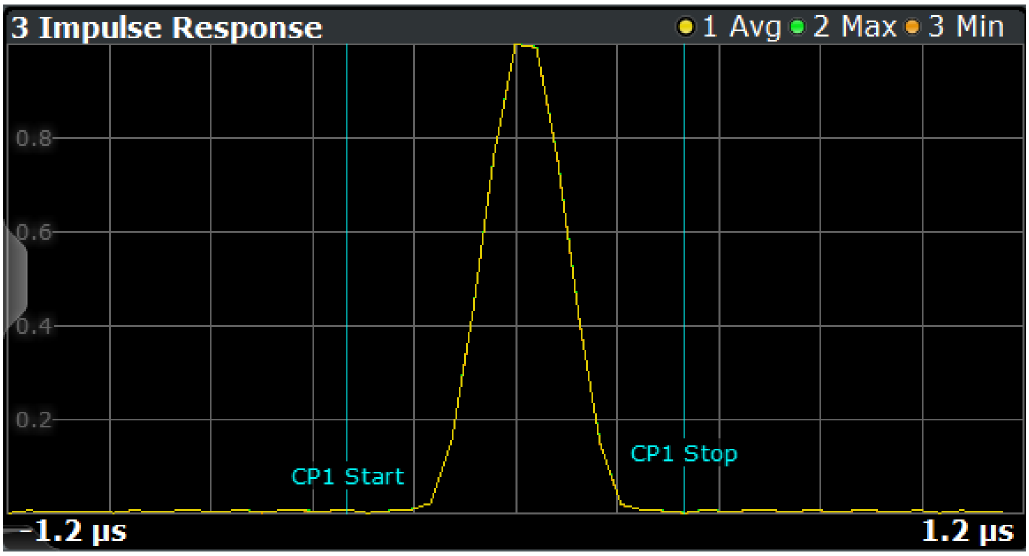


Figure 2-12: Channel Impulse Response Display

Remote command:
LAY:ADD? '1',RIGH,IRES, see LAYout:ADD[:WINDow]? on page 288
TRACe:DATA?, see Chapter 8.8.4.12, "Impulse response", on page 319
TRACe<n>[:DATA]:X? on page 310
Linear/ logarithmic scaling: UNIT:IRESponse on page 269

Magnitude Capture

The capture buffer contains the complete range of captured data for the last sweep. The "Magnitude Capture" display shows the power of the captured I/Q data in dBm versus time. The analyzed frames are identified with a green bar at the bottom of the "Magnitude Capture" display.

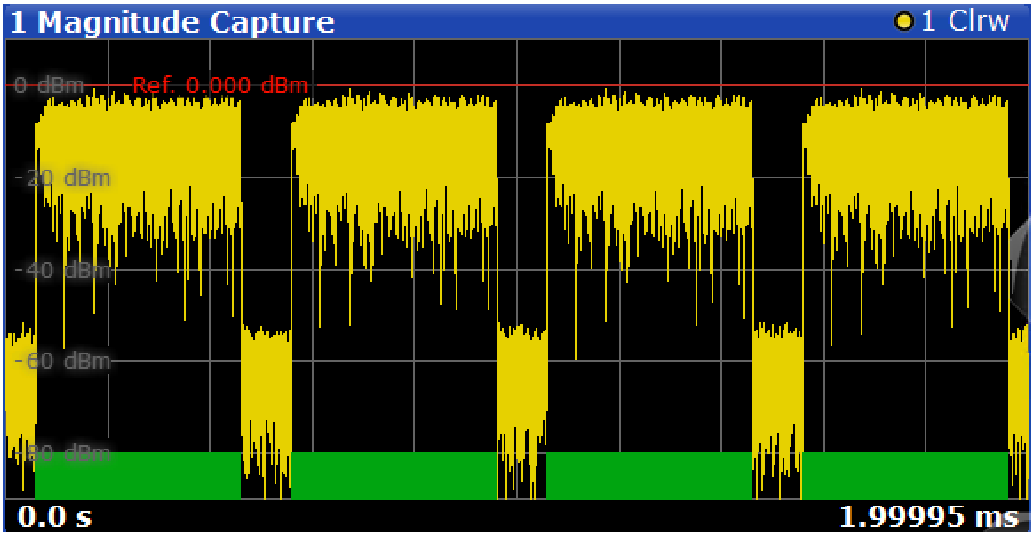


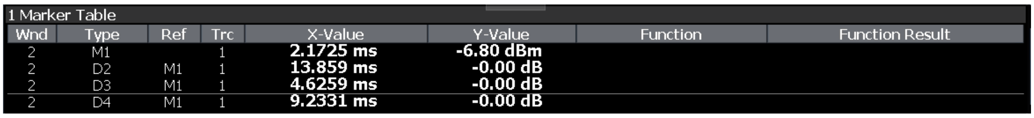
Figure 2-13: Magnitude Capture display

Remote command:
LAY:ADD? '1',RIGH,MCAP, see LAYout:ADD[:WINDow]? on page 288
TRACe:DATA?, see Chapter 8.8.4.13, "Magnitude capture", on page 319
TRACe<n>[:DATA]:X? on page 310
Time unit: UNIT:TAXes on page 270

Marker Table

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

This table is displayed automatically if configured accordingly.


1 Marker Table

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

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

Remote command:
LAY:ADD? '1',RIGH, MTAB, see LAYout:ADD[:WINDow]? on page 288
Results:

CALCulate<n>:MARKer<m>:X on page 272
CALCulate<n>:MARKer<m>:Y? on page 306

Notes

Allows you to add comments or explanations to the current measurement. The content of the Notes display can also be included in test reports.

For details, see the FSW base unit user manual.

Remote command:
LAY:ADD? '1',RIGH,NOT, see LAYout:ADD[:WINDow]? on page 288

Power Spectrum

The Power Spectrum display shows the power in dBm/Hz vs frequency results of the complete capture buffer. This display is always available.

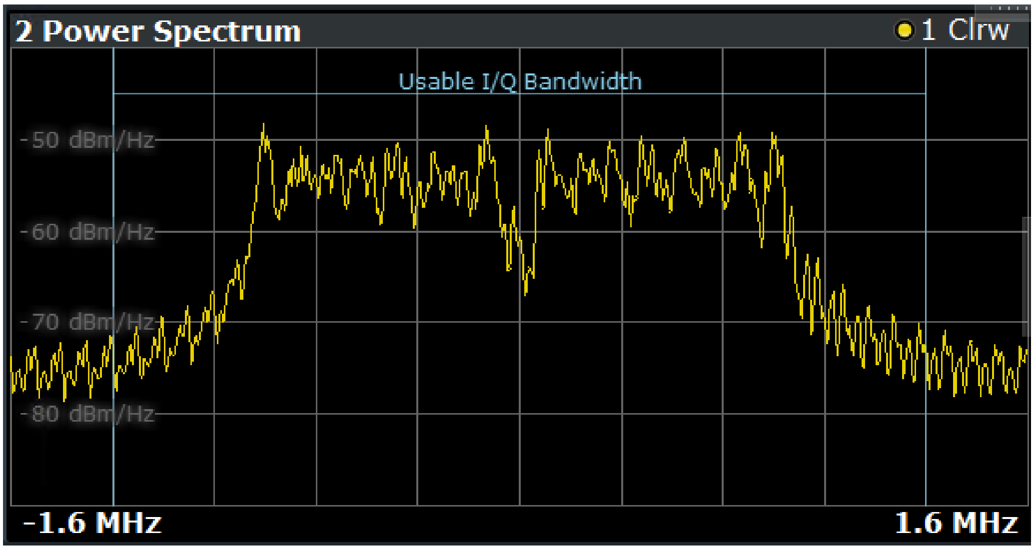


Figure 2-14: Power Spectrum display

The usable I/Q bandwidth is indicated for reference. If a channel filter is active, the 6-dB-bandwidth of the filter is indicated instead.

See Chapter 4.5, "Data acquisition", on page 90.

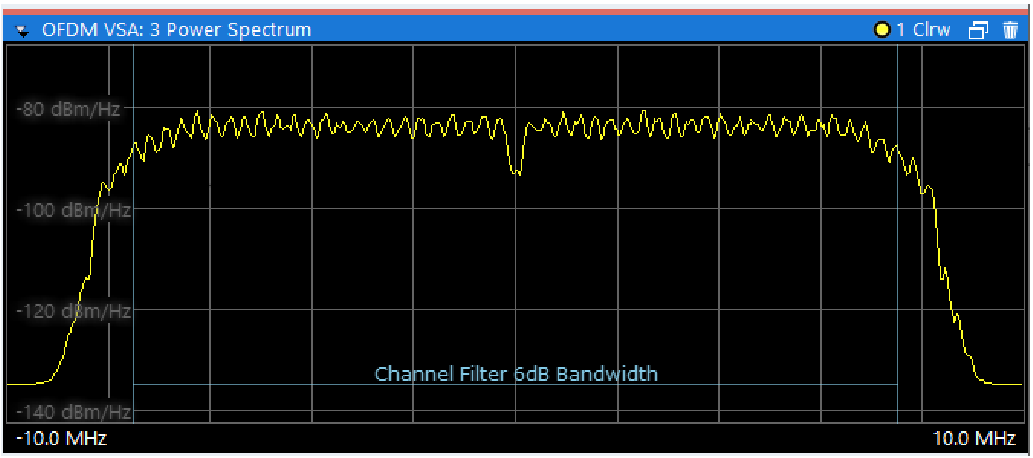


Figure 2-15: Power spectrum with active channel filter

Remote command:
LAY:ADD? '1',RIGH,PSP, see LAYout:ADD[:WINDow]? on page 288
TRACe:DATA?, see Chapter 8.8.4.17, "Power spectrum", on page 321
Frequency unit: UNIT:FAXes on page 269

Power vs Carrier

The Power vs. Carrier display shows the power of all OFDM symbols in the analyzed signal frames for each carrier. The power is measured with a resolution bandwidth equal to the carrier spacing.

Multiple traces display statistical evaluations over all analyzed frames.

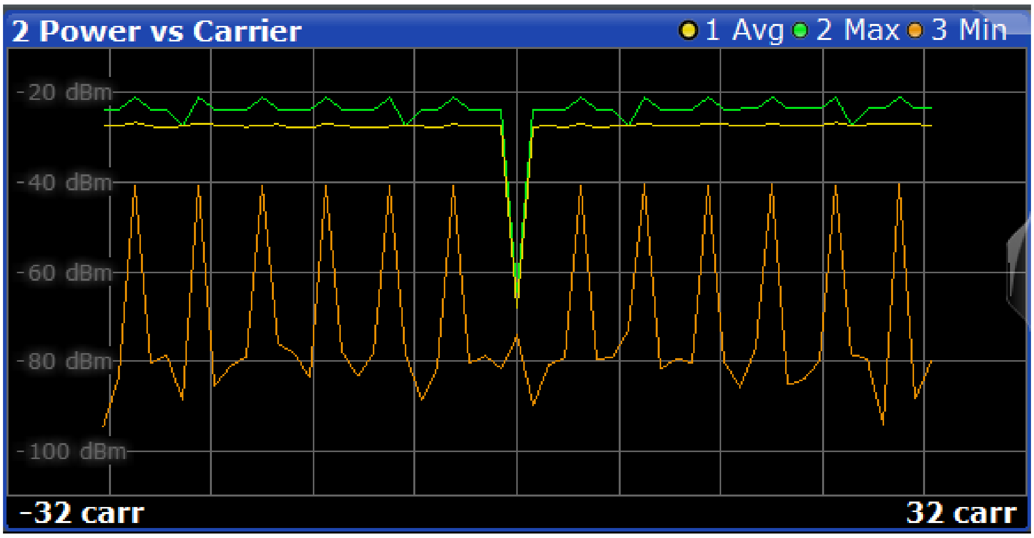


Figure 2-16: Power vs Carrier display

Note: This result display is only available if synchronization is successful.

Remote command:
LAY:ADD? '1',RIGH,PCAR, see LAYout:ADD[:WINDow]? on page 288
TRACe:DATA?, see Chapter 8.8.4.14, "Power vs carrier", on page 320

TRACe<n>[:DATA]:X? on page 310
Carrier unit: UNIT:CAXes on page 268

Power vs Symbol

The Power vs Symbol display shows the power of all OFDM carriers in the analyzed signal frames for each symbol. The power is measured with a resolution bandwidth equal to the carrier spacing. Carriers which contain 'Zero'-cells over the complete symbol range (e.g. guard carriers or DC carrier) are excluded.

Multiple traces display statistical evaluations over all analyzed frames.

Vertical blue lines indicate the borders between frames.

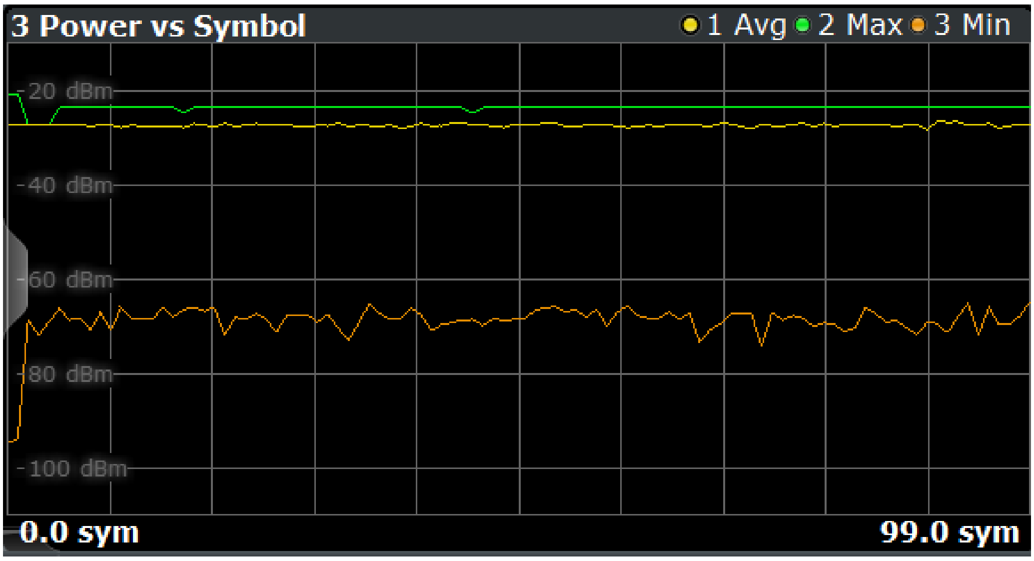


Figure 2-17: Power vs Symbol display

Note: This result display is only available if synchronization is successful.

Remote command:

`LAY:ADD? '1',RIGH,PSYM`, see `LAYout:ADD[:WINDow]?` on page 288

`TRACe:DATA?`, see Chapter 8.8.4.15, "Power vs symbol", on page 320

`TRACe<n>[:DATA]:X?` on page 310

Symbol unit: `UNIT:SAXes` on page 269

Power vs Symbol vs Carrier

The Power vs Carrier vs Symbol display shows the power of each carrier (= frequency domain) in each symbol (= time domain) of the analyzed signal frames in dBm. The power is measured with a resolution bandwidth that equals the carrier spacing.

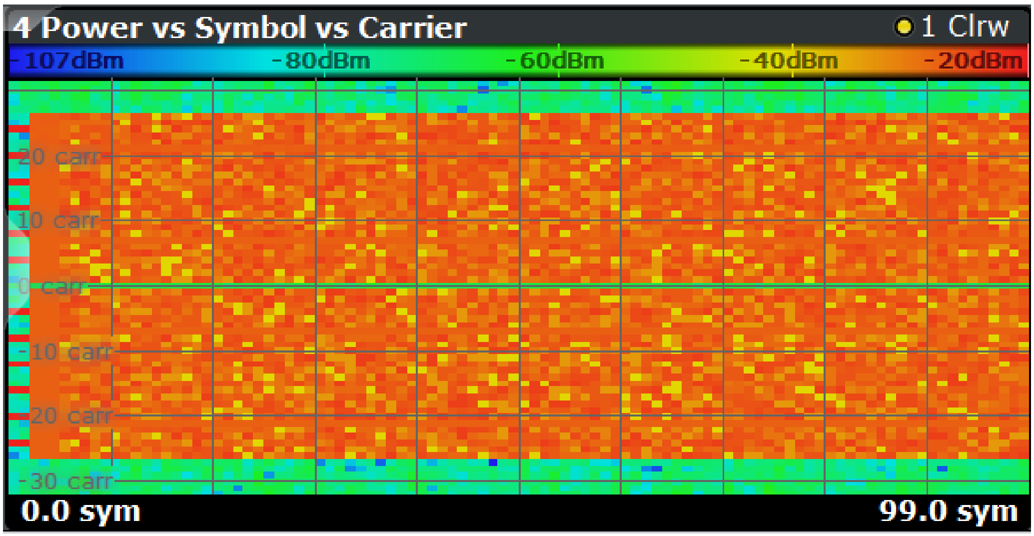


Figure 2-18: Power vs Symbol vs Carrier display

The power levels are represented by colors. The corresponding color map is displayed at the top of the result display.

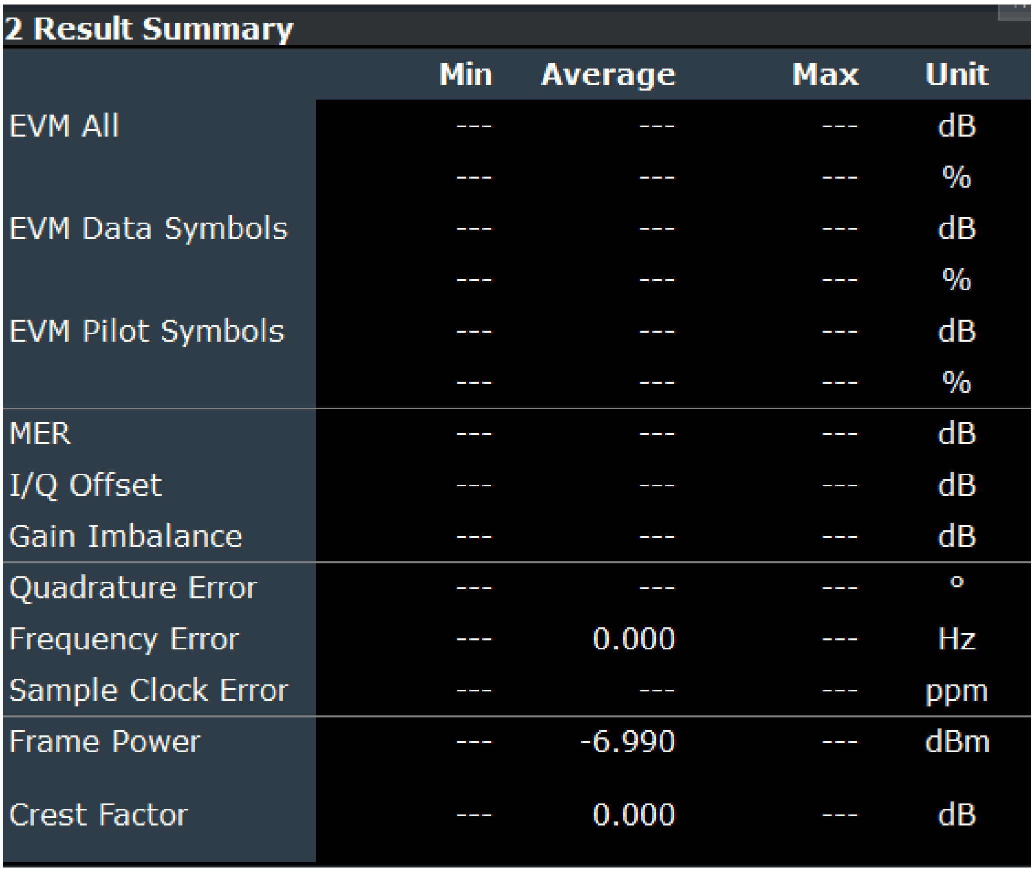
Note: This result display is only available if synchronization is successful.

Remote command:
`LAY:ADD? '1',RIGH,PSC`, see `LAYout:ADD[:WINDow]?` on page 288
`TRACe:DATA?`, see Chapter 8.8.4.16, "Power vs symbol vs carrier", on page 320
`TRACe<n>[:DATA]:X?` on page 310
`TRACe<n>[:DATA]:Y?` on page 311
Carrier unit: `UNIT:CAXes` on page 268
Symbol unit: `UNIT:SAXes` on page 269
Carrier selection for marker: `CALCulate<n>:MARKer<m>:Z` on page 306

Result Summary

The Result Summary table provides numerical measurement results.

Statistical evaluation is performed over all analyzed frames within the capture buffer.



2 Result Summary

	Min	Average	Max	Unit
EVM All	---	---	---	dB
	---	---	---	%
EVM Data Symbols	---	---	---	dB
	---	---	---	%
EVM Pilot Symbols	---	---	---	dB
	---	---	---	%
MER	---	---	---	dB
I/Q Offset	---	---	---	dB
Gain Imbalance	---	---	---	dB
Quadrature Error	---	---	---	°
Frequency Error	---	0.000	---	Hz
Sample Clock Error	---	---	---	ppm
Frame Power	---	-6.990	---	dBm
Crest Factor	---	0.000	---	dB

Figure 2-19: Result Summary display

Note: If only one frame is available for analysis, the minimum and maximum values are not displayed, as they are identical to the average value.

For details on the individual results, see Chapter 2.1, "OFDM VSA parameters", on page 9.

Remote command:
`LAY:ADD? '1',RIGH,RSUM`, see `LAYout:ADD[:WINDow]?` on page 288
Results:
`FETCh:SUMMary[:ALL]?` on page 297

Signal Flow
The Signal Flow display shows a detailed description of the current measurement status. If demodulation is not successful, it provides useful hints on possible reasons. Unused blocks are shown in gray.

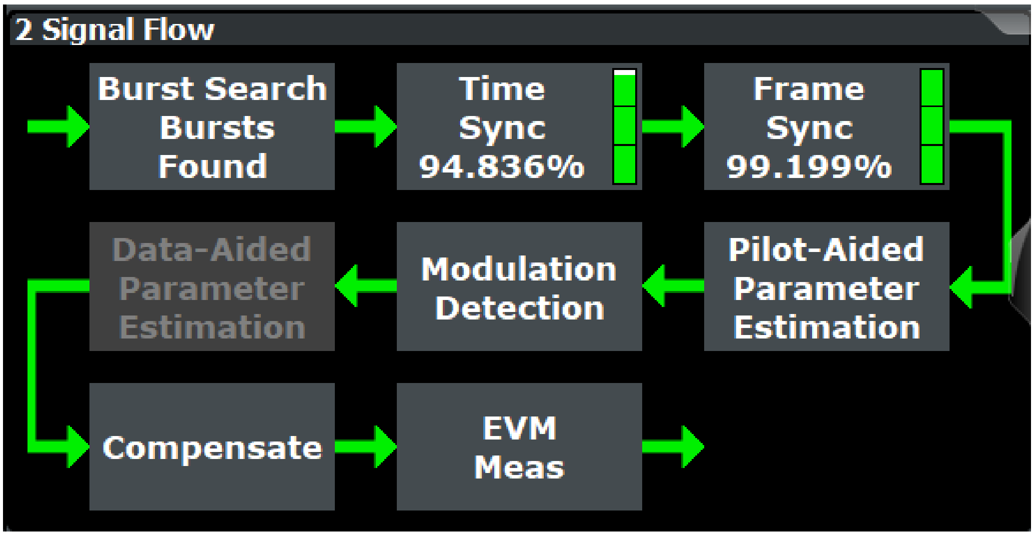


Figure 2-20: Signal Flow display

For the synchronization blocks, a colored bar provides information about the reliability of the synchronization result. If the level in the bar falls below the thresholds indicated by the horizontal line, the color of the bar changes from green to yellow and finally to red. If the synchronization of the block fails, all succeeding arrows change their color, too.

For detailed information about the complete synchronization process, refer to Chapter 3.4.1, "Synchronization block", on page 38.

Remote command:
`LAY:ADD? '1',RIGH,SFL`, see `LAYout:ADD[:WINDow]?` on page 288
Retrieving results:
Chapter 8.8.2, "Retrieving signal flow results", on page 300

Trigger to Sync
Indicates the time offset between the trigger event and the start of the first OFDM frame. One value per capture is displayed.

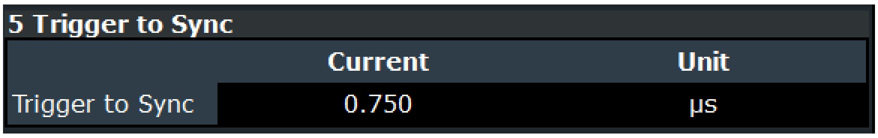


Figure 2-21: Trigger to Sync display

Remote command:
`LAY:ADD? '1',RIGH,TRIG`, see `LAYout:ADD[:WINDow]?` on page 288
Retrieving results:
`FETCh:TTFRame?` on page 299

3 Measurement basics

Some background knowledge on basic terms and principles used in OFDM vector signal analysis is provided here for a better understanding of the required configuration settings.

3.1 OFDMA

In an OFDM system, the available spectrum is divided into multiple carriers, called subcarriers, which are orthogonal to each other. Each of these subcarriers is independently modulated by a low rate data stream.

OFDM is used as well in WLAN, WiMAX and broadcast technologies like DVB. OFDM has several benefits including its robustness against multipath fading and its efficient receiver architecture.

Figure 3-1 shows a representation of an OFDM signal taken from 3GPP TR 25.892. Data symbols are independently modulated and transmitted over a high number of closely spaced orthogonal subcarriers. In the OFDM-VSA common modulation schemes as QPSK, 16QAM, and 64QAM can be defined as well as arbitrarily distributed constellation points.

In the time domain, a guard interval can be added to each symbol to combat inter-OFDM-symbol-interference due to channel delay spread. In EUTRA, the guard interval is a cyclic prefix which is inserted before each OFDM symbol.

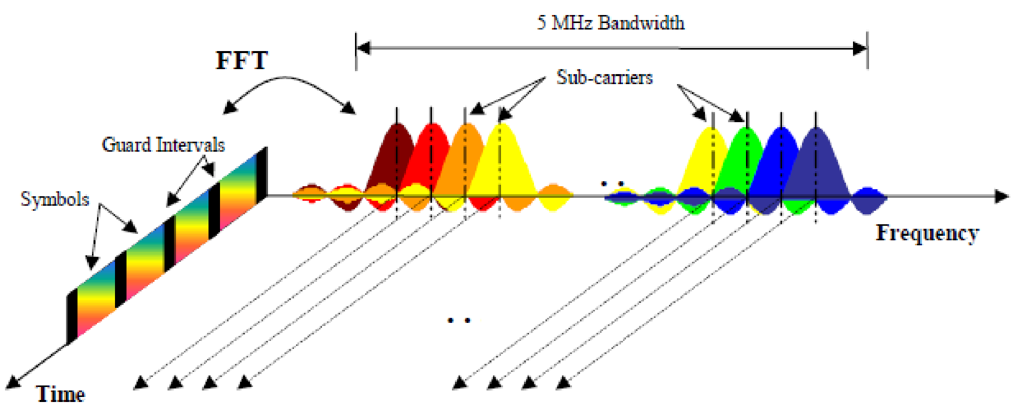


Figure 3-1: Frequency-time representation of an OFDM signal

In practice, the OFDM signal can be generated using the inverse fast Fourier transform (IFFT) digital signal processing. The IFFT converts a number N of complex data symbols used as frequency domain bins into the time domain signal. Such an N-point IFFT is illustrated in Figure 3-2, where a(mN+n) refers to the n^{th} subchannel modulated data symbol, during the time period $mT_u < t \leq (m+1)T_u$.

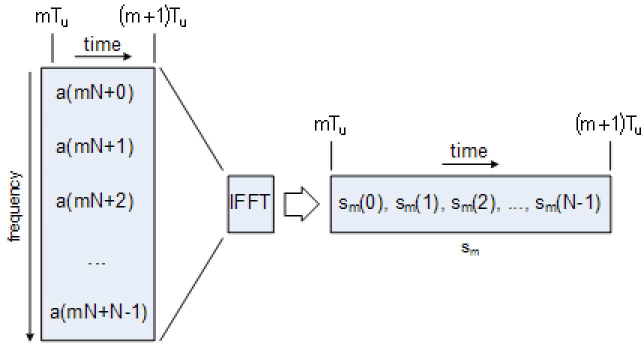


Figure 3-2: OFDM useful symbol generation using an IFFT

The vector s_m is defined as the useful OFDM symbol. It is the time superposition of the N narrowband modulated subcarriers. Therefore, from a parallel stream of N sources of data, each one independently modulated, a waveform composed of N orthogonal subcarriers is obtained. Each subcarrier has the shape of a frequency sinc function (see Figure 3-1).

Figure 3-3 illustrates the mapping from a serial stream of QAM symbols to N parallel streams, used as frequency domain bins for the IFFT. The N-point time domain blocks obtained from the IFFT are then serialized to create a time domain signal. Not shown in Figure 3-3 is the process of cyclic prefix insertion.

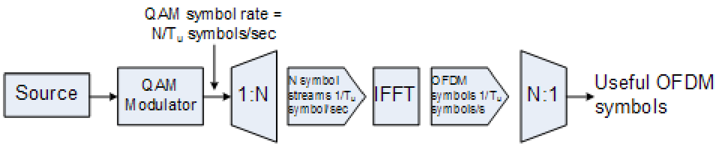


Figure 3-3: OFDM signal generation chain

3.2 OFDM parameterization

A generic OFDM analyzer supports various OFDM standards. Therefore a common parameterization of OFDM systems has to be defined.

3.2.1 Time domain description

The fundamental unit of an OFDM signal in the time domain is a *sample*.

An *OFDM symbol* with a length of N_S samples consists of:

- A *guard interval* of length N_G
- An *FFT interval* of length N_{FFT}

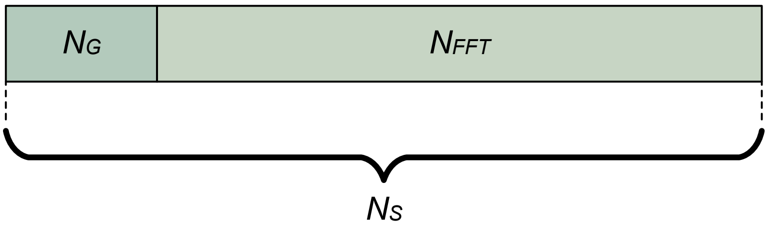


Figure 3-4: OFDM symbol in time domain

Cyclic suffix

In addition to the guard interval at the beginning of an OFDM symbol, some symbols also contain a cyclic suffix. See "Cyclic Suffix Length" on page 65.

3.2.2 Frequency domain description

The FFT intervals of the OFDM symbols are transformed into the frequency domain using a discrete Fourier transformation. The successive symbols of the OFDM signal are displayed in time-frequency matrices. The fundamental unit of an OFDM signal in the frequency domain is a *cell*.

The total area of a time-frequency matrix is called *frame*. A frame is the highest level unit used in OFDM VSA.

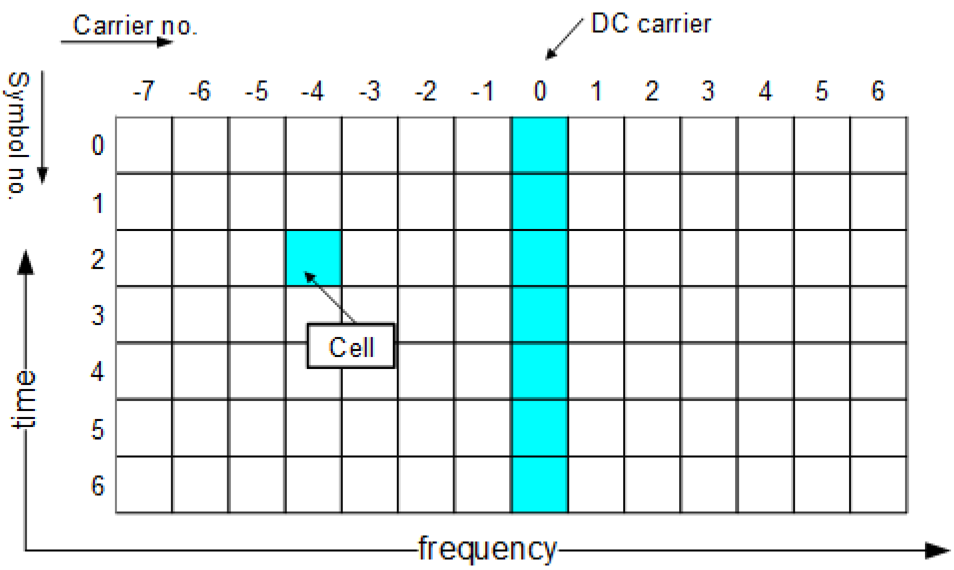


Figure 3-5: Time-Frequency matrix

Carriers

A column of cells at the same frequency is called *carrier*.

The carrier number is the column index of a time-frequency matrix. The number '0' is assigned to the *DC-carrier*, which lies at the transmitter center frequency. The total number of subcarriers is N_{FFT}. The *DC-carrier offset* determines the position of the DC carrier relative to the lowermost subcarrier. The offset is an inherent attribute of the FFT algorithm.

Table 3-1: Relationship between FFT length and subcarrier range

FFT length N_{FFT}	DC-Carrier offset	Range
even	$\frac{N_{FFT}}{2}$	$\left[-\frac{N_{FFT}}{2}, \frac{N_{FFT}}{2}-1\right]$
odd	$\frac{N_{FFT}-1}{2}$	$\left[-\frac{N_{FFT}-1}{2}, \frac{N_{FFT}-1}{2}\right]$

OFDM system sample rate

In an OFDM system, an FFT (with the length N_{FFT}) is performed for each symbol. Each FFT bin corresponds to one subcarrier. For each FFT bin, one sample must be captured in the time domain for each OFDM symbol. The minimum number of samples required for the measurement is thus the number of subcarriers (or the number of FFT bins), multiplied by the number of symbols to measure. To avoid intersymbol interference, the cyclic prefix is added as the guard interval.

No_samples$_{min}$ = *(<FFT_size> + <CyclicPrefixLength> + <CyclicSuffixLength>) * <No_symbols_to_measure>*

Generally, the number of samples acquired per second is referred to as the sample rate. The sample rate required by a specific OFDM system is referred to as the *OFDM system sample rate*. It depends on parameters that characterize the OFDM system and is defined by the following equation:

SR$_{OFDM}$ = *<carrier_spacing>* <FFT_size>*

For the R&S FSW OFDM VSA application to demodulate OFDM symbols, it is important that the number of acquired samples in the application corresponds to the OFDM system sample rate.

Symbols

A row of cells at the same time is called *symbol*.

The symbol number is the row index of a time frequency matrix. The first symbol gets the number '0'.

3.2.2.1 Allocation matrix

The allocation matrix defines the complete frame and subdivides the OFDM system into the following cell types:

- **Pilot cells**: Contain known values and are used for various synchronization and parameter estimation purposes.
- **Data cells**: Contain the user data or *payload* of the transmission. The modulation format of the data cells must be known or can be estimated in a modulation estimation block.
- **"Don't Care" cells**: Cells that are not evaluated for EVM measurement, but contain signal power.
- **Zero cells**: Contain no signal power at all; Typically, guard carriers around DC or at the edges of the carrier axis.

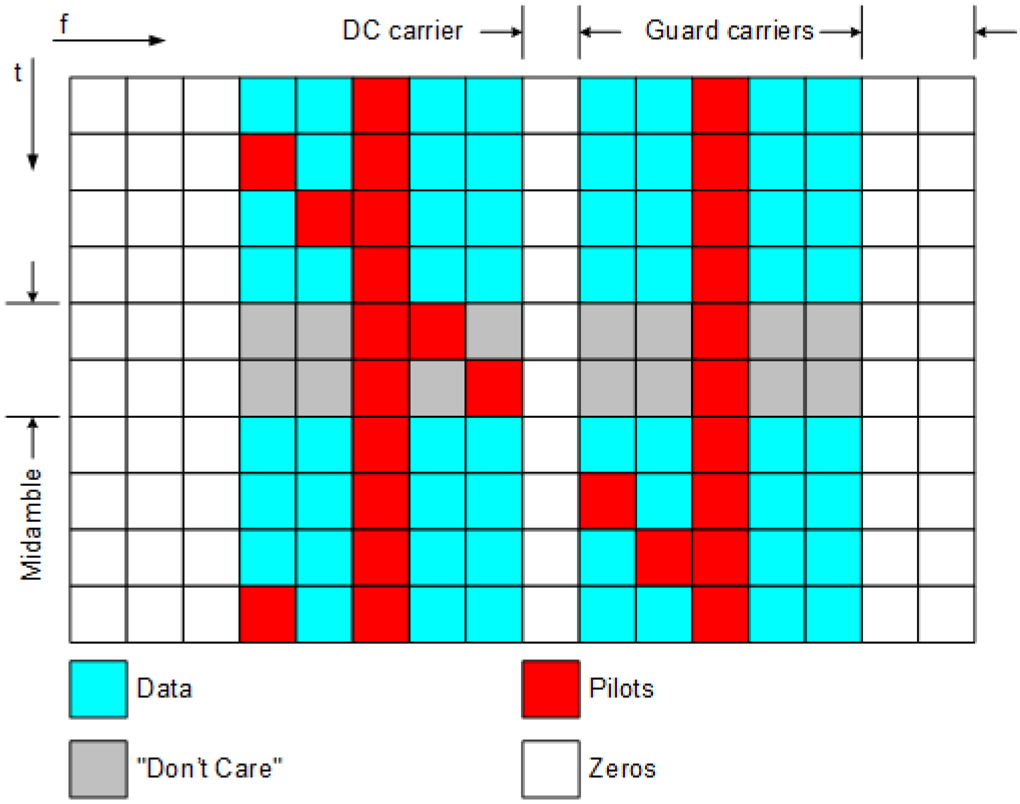


Figure 3-6: Allocation matrix

3.2.2.2 Pilot matrix

A pilot matrix contains known complex numbers in the matrix cells, which are defined as pilot cells in the allocation matrix. Within the analyzer, the pilot matrix is correlated with the received time frequency matrix. Thus, it obtains the frame start and the frequency offset of the received signal relative to the given allocation matrix.

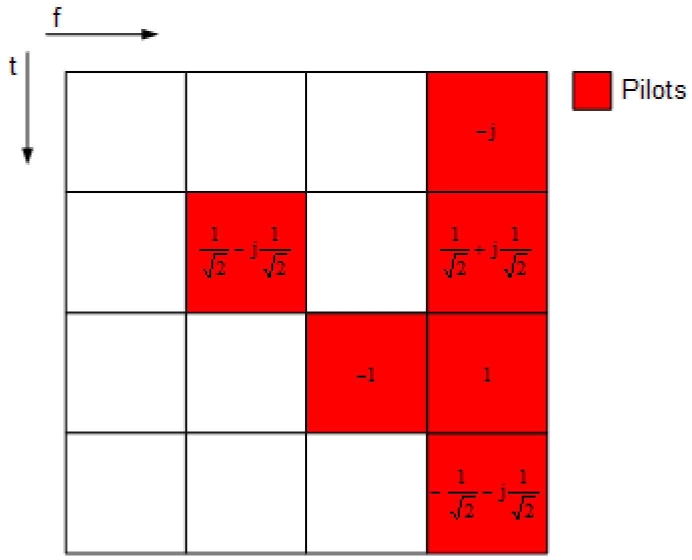


Figure 3-7: Pilot matrix

3.2.2.3 Constellation vector

A constellation vector contains all possible numbers in the complex plane that belong to a specific modulation format. Constellation vectors must be defined for each possible data modulation format. The magnitude within the constellation vectors must be scaled according to the pilot matrix. One entry in the constellation vector is called *constellation point'*.

Differential modulation is not supported. The respective absolute modulation scheme must be used instead (e.g. QPSK instead of DQPSK). Periodically rotated constellations are not supported. The set union of all constellations must be used instead (e.g. 8PSK instead of PI/4-DQPSK).

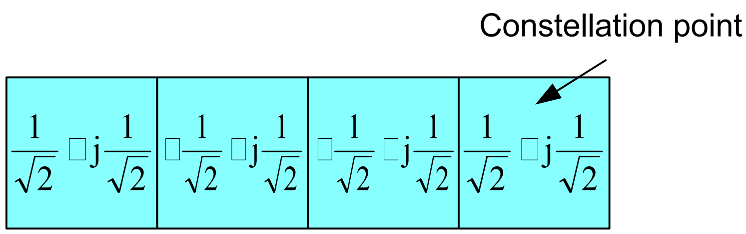


Figure 3-8: QPSK constellation vector

3.2.2.4 Modulation matrix

A modulation matrix contains numbers to the underlying constellation vector for each cell, which is defined as data cell in the allocation matrix. Clusters of data cells with the same modulation therefore share the same number. A data cell can also contain an unused number, that is a number for which no constellation vector is defined. In this case, all data cells sharing that number are assumed to use only one of the valid constellation vectors. This method can be used within the R&S FSW OFDM VSA application to allow for automatic modulation detection.

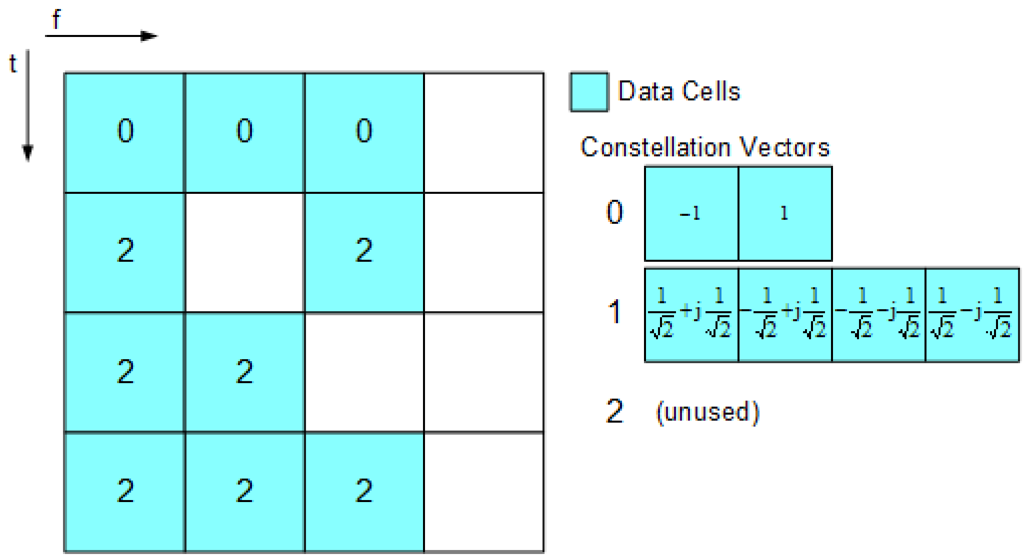


Figure 3-9: Modulation matrix

3.2.3 Preamble description

The OFDM demodulator must support synchronization on repetitive preamble symbols. A repetitive preamble contains several repetitions of one time domain block. The Figure 3-10 shows exemplarily the parameterization of a repetitive preamble symbol, which contains a five times repetition of block T. The allocation matrix can have an arbitrary offset to the beginning of the preamble symbol. If the offset is zero or negative, the preamble is also contained within the frame and is used for further estimation processes.

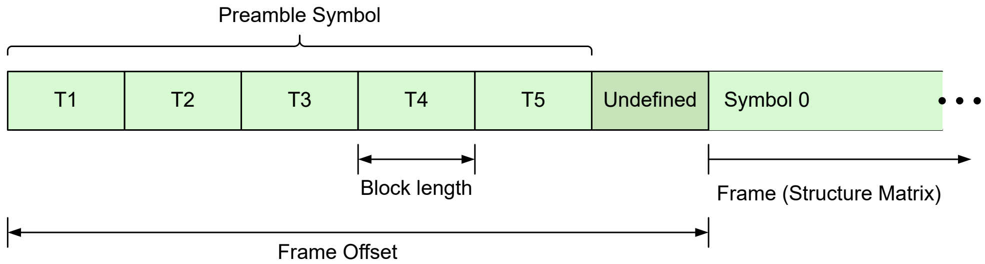


Figure 3-10: Description of a repetitive preamble symbol

3.3 Channel filter

The R&S FSW OFDM VSA application can use the internal channel filter of the instrument or apply an adjustable channel filter. The filter bandwidth of the internal channel filter is fully equalized within the digital hardware.

Alternatively to the internal filters, you can apply a channel filter with adjustable bandwidth and slope characteristics to the input signal. The R&S FSW OFDM VSA application then designs a window-based finite impulse response filter. The bandwidth is defined as two times the 6-dB cutoff frequency. The 50-dB cutoff frequency determines the slope characteristics.

Choosing the correct filter settings is a trade-off between selectivity and filter impulse response length. A steep filter leads to superior selectivity between adjacent channels. On the other hand, such a filter has a long channel impulse response, which can produce intersymbol interference if used in systems with small guard intervals. Flat filters require a higher distance between channels and possibly attenuate the outer carriers of the signal. In contrast, the channel impulse response is short and suited for systems with short guard intervals.

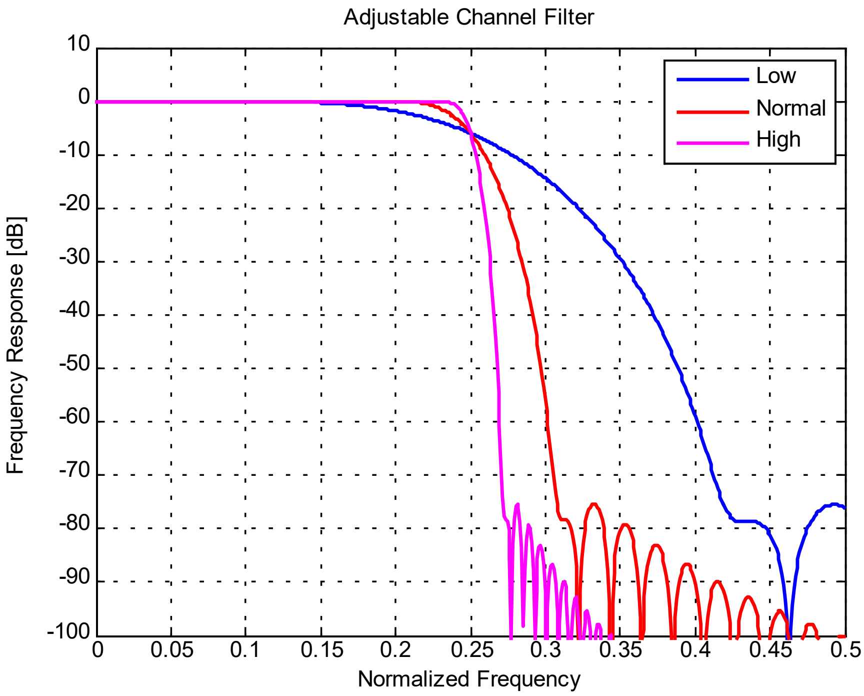


Figure 3-11: Slope characteristics for different channel filters (with low, normal, high steepness)

The adjustable channel filter performs a decimation at its output. Thus, the user-definable maximum output sample rate is reduced compared to the internal filter setting. Therefore, data is captured by the FSW with an oversampling factor before the adjustable channel filter is applied.

Example:

Assume you want to analyze a 20-MHz WLAN-A signal. The specified (demodulation) sample rate is 20 MHz.

If the adjustable channel filter is disabled, the FSW captures I/Q data and resamples it to 20 MHz. The instrument's hardware defines the flat bandwidth, filter slope and stop-band frequency of the used filter. The R&S FSW OFDM VSA application receives the data with the required sample rate of 20 MHz.

If the adjustable channel filter is enabled, the FSW captures I/Q data using a doubled sample rate of 40 MHz, that is: an oversampling factor of 2 is applied. The R&S FSW OFDM VSA application then applies the adjustable channel filter. The user-defined 6-dB bandwidth defines the overall bandwidth of the filter. The distance between the 6-dB bandwidth and the user-defined 50-dB bandwidth defines the filter slope (see Figure 3-11). The 20-MHz region of interest in the middle of the signal is not affected by the filter. Finally, the R&S FSW OFDM VSA application decimates the filtered data from 40 MHz to the required sample rate of 20 MHz.

3.4 OFDM measurement

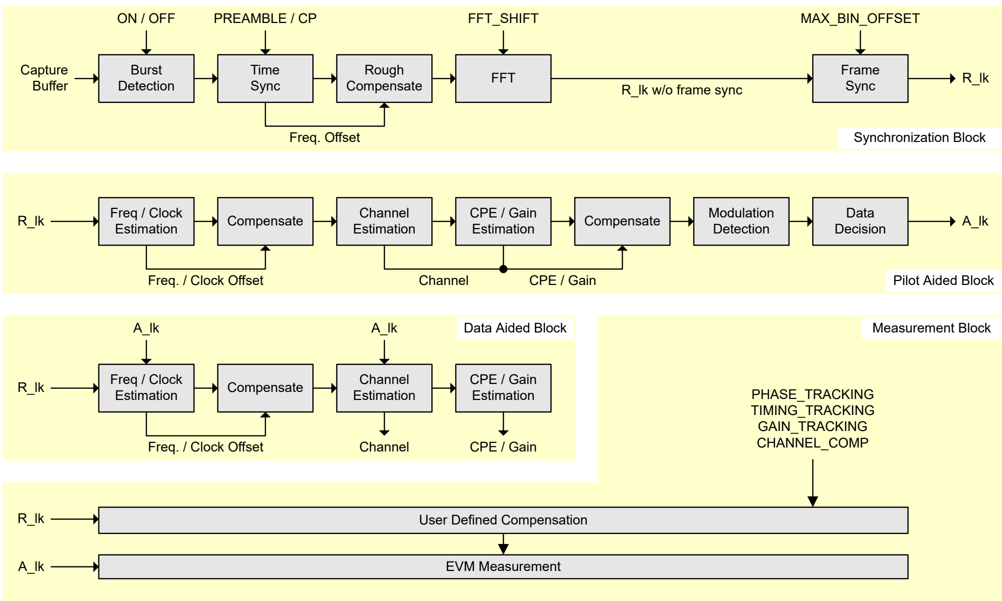


Figure 3-12: Block diagram of the R&S FSW OFDM VSA application

The block diagram in Figure 3-12 shows the R&S FSW OFDM VSA application process from the capture buffer containing the I/Q data to the actual analysis block. The signal processing chain can be divided in four major blocks:

3.4.1 Synchronization block

The synchronization starts with a burst detection that extracts transmission areas within a burst signal by a power threshold. For seamless transmission, as is the case in most broadcast systems, it is possible to bypass this block. The following time synchronization uses either the preamble or the cyclic prefix of each OFDM symbol to find the optimum starting point for the FFT by a correlation metric. If preamble synchronization is selected, the correlation is done between successive blocks of a repetitive preamble structure. Alternatively, the cyclic prefix synchronization correlates the guard interval of each symbol with the end of the FFT part. In addition, both methods return an estimation of the fractional frequency offset by evaluating the phase of the correlation maximum. This frequency offset has to be compensated before the FFT to avoid intercarrier interference.

By default, the FFT starting point is put in the center of the guard interval assuming a symmetric impulse response, but it can optionally be shifted within the guard interval. After performing the FFT for each available OFDM symbol, a time-frequency matrix $R_{l,k}$ with symbol index l and subcarrier index k is available.

The subsequent frame synchronization determines the frame start within this matrix and the integer carrier frequency offset. It is determined by a two-dimensional correlation of $R_{l,k}$ with the known pilot matrix from the configuration file. To avoid unnecessary computing time for signals with low frequency offset, the search length in the frequency direction can be limited by a control parameter.

Furthermore, a threshold for the reliability of time and frame synchronization can be defined to ensure that only correct frames are evaluated. A threshold is particularly useful for 5G signals, for example. In this case, the pilot structure in the second half of the frame is similar, but not identical to the first half. Thus, frame synchronization can be off by half a frame, but since the pilots do not match completely, the reliability is poor. The EVM results are also poor. By defining a threshold, only the correctly synchronized frames are evaluated.

3.4.2 Pilot-aided block

The pilot-aided block within the signal processing chain uses the predefined pilot cells to estimate the parameters and compensate the signal impairments. It starts with maximum likelihood estimation of the remaining frequency error and sample clock offset. While a frequency error leads to a phase offset that increases linearly in time, the clock offset introduces an additional phase error that increases linearly with frequency. The estimator determines the most probable parameters that lead to the phase offsets observed on the pilot cells. The resulting offset values are compensated in the frequency domain by rerotating the phase of the $R_{l,k}$ matrix. However, for severe clock offsets it can be necessary to resample the received signal in the time domain and repeat the FFT stage.

The subsequent channel estimator determines the channel transfer function at the known pilot positions and uses interpolation to get a complete frequency response vector for all subcarriers. It does not extrapolate the channel transfer function for the guard carriers (which are defined by zero or "don't care" cell types). Since the presented measurement system is intended for stationary channels, the interpolation is performed along the frequency direction only. The node values on the frequency axis are determined by averaging all available pilots of each subcarrier over time. Depending on the layout of the pilots on the frequency axis, an interpolation filter bank with optimum Wiener filter coefficients is calculated in advance. The Wiener filter is designed under the assumption that the maximum impulse response length does not exceed the cyclic prefix length.

Although the channel is assumed to be stationary, common phase error and power level variations are estimated symbol by symbol over the complete frame. The estimation takes settling effects of oscillators and power amplifiers into account. All estimated impairments are fully compensated to get an optimum signal for the subsequent modulation-detection and data decision stage.

The modulation-detection block determines the modulation type of the data cells. Either each carrier or each symbol can be assigned to one specific constellation. Alternatively, the modulation information provided in the configuration file is evaluated to extract clusters of data cells with consistent modulation. The estimator uses a maximum likelihood approach. Each cluster of data cells is compared with all possible modulation hypotheses and the most probable constellation for each cluster is used for the subsequent data decision. The data decision block finally outputs a reference signal matrix $A_{l,k}$ which is an optimum estimate of the actual transmitted OFDM frame.

Note that the pilot-aided block requires at least 2 OFDM symbols containing pilots to:

- Estimate the sample clock error
- Demodulate the signal correctly
- Compensate phase, timing or level offsets

3.4.3 Data aided block

The data aided block can be activated optionally to refine the parameter estimations with the help of the reference signal. Whereas the previous stages could only include pilot cells for the estimation algorithms, the data aided part can treat data cells as additional pilots. Thus, the accuracy of the estimates increases in good signal to noise environments without data decision errors. However, if the reference signal matrix $A_{l,k}$ contains falsely decided data cells, the data aided estimation part can corrupt the results and should be omitted.

3.4.4 Measurement block

The last part of the signal processing chain comprises the user-defined compensation and the measurement of modulation quality. The measurement block takes the received OFDM symbols $R_{l,k}$ and the previously determined reference OFDM symbols $A_{l,k}$ to calculate the error vector magnitude (EVM). The received OFDM symbols can optionally be compensated using phase, timing and level deviations and the channel transfer function.

3.5 Sample rate and maximum usable I/Q bandwidth for RF input

Definitions

- **Input sample rate (ISR)**: the sample rate of the useful data provided by the device connected to the input of the FSW
- (User, Output) **Sample rate (SR)**: the user-defined sample rate (e.g. in the "Data Acquisition" dialog box in the "I/Q Analyzer" application) which is used as the basis for analysis or output
- **Usable I/Q (analysis) bandwidth**: the bandwidth range in which the signal remains undistorted in regard to amplitude characteristic and group delay; this range can be used for accurate analysis by the FSW
- **Record length**: the number of I/Q samples to capture during the specified measurement time; calculated as the measurement time multiplied by the sample rate

For the I/Q data acquisition, digital decimation filters are used internally in the FSW. The passband of these digital filters determines the *maximum usable I/Q bandwidth*. In consequence, signals within the usable I/Q bandwidth (passband) remain unchanged, while signals outside the usable I/Q bandwidth (passband) are suppressed. Usually, the suppressed signals are noise, artifacts, and the second IF sideband. If frequencies of interest to you are also suppressed, try to increase the output sample rate, which increases the maximum usable I/Q bandwidth.

Bandwidth extension options

You can extend the maximum usable I/Q bandwidth provided by the FSW in the basic installation by adding options. These options can either be included in the initial installation (B-options) or updated later (U-options). The maximum bandwidth provided by the individual option is indicated by its number, for example, B40 extends the bandwidth to 40 MHz.

Note that the U-options as of U40 always require all lower-bandwidth options as a prerequisite, while the B-options already include them.

As a rule, the usable I/Q bandwidth is proportional to the output sample rate. Yet, when the I/Q bandwidth reaches the bandwidth of the analog IF filter (at very high output sample rates), the curve breaks.

3.5.1 Available bandwidth extension options

Table 3-2: Available bandwidth extension options

Max. usable I/Q bandwidth	Required B-option	Required U-options
28 MHz	-	-
40 MHz	B40	U40
80 MHz	B80	U40+U80 **or** B40+U80
160 MHz	B160	U40+U80+U160 **or** B40+U80+U160 **or** B80+U160
320 MHz	B320	U40+U80+U160+U320 **or** B40+U80+U160+U320 **or** B80+U160+U320 **or** B160+U320
512 MHz	B512	U40+U80+U512 **or** B40+U80+U512 **or** B80+U512 **or**
1200 MHz	B1200	B40 + U80 + U1200 **or** B80 + U1200
2000 MHz	B2000	U2000
2000 MHz	B2001	U2001
4000 MHz	B4001	U4001
5000 MHz	B5000	U5000
6000 MHz	B6001	U6001
8000 MHz	B8001	U8001

3.5.2 Relationship between sample rate, record length and usable I/Q bandwidth

Up to the maximum bandwidth, the following rule applies:

*Usable I/Q bandwidth = 0.8 * Output sample rate*

Regarding the record length, the following rule applies:

*Record length = Measurement time * sample rate*

Maximum record length for RF input

The maximum record length, that is, the maximum number of samples that can be captured, depends on the sample rate.

For activated option B1200, see Table 3-14.

For activated option B2001, see Chapter 3.5.10, "FSW with activated I/Q bandwidth extension option B2001", on page 50.

For activated option B2000, see Chapter 3.5.11, "FSW with activated I/Q bandwidth extension option B2000", on page 52.

For activated option B5000, see Chapter 3.5.12, "FSW with activated I/Q bandwidth extension option B5000", on page 53.

For activated option B4001/B6001/B8001, see Chapter 3.5.13, "FSW with activated I/Q bandwidth extension option B4001/B6001/B8001", on page 54.

Table 3-3: Maximum record length (without I/Q bandwidth extension options FSW-B160/-B320/-B512/-B1200/-B2001/-B4001/-B6001/-B8001)

Sample rate	Maximum record length
100 Hz to 200 MHz	440 Msamples
200 MHz to 20 GHz (upsampling)	220 Msamples

The Figure 3-13 shows the maximum usable I/Q bandwidths depending on the output sample rates.

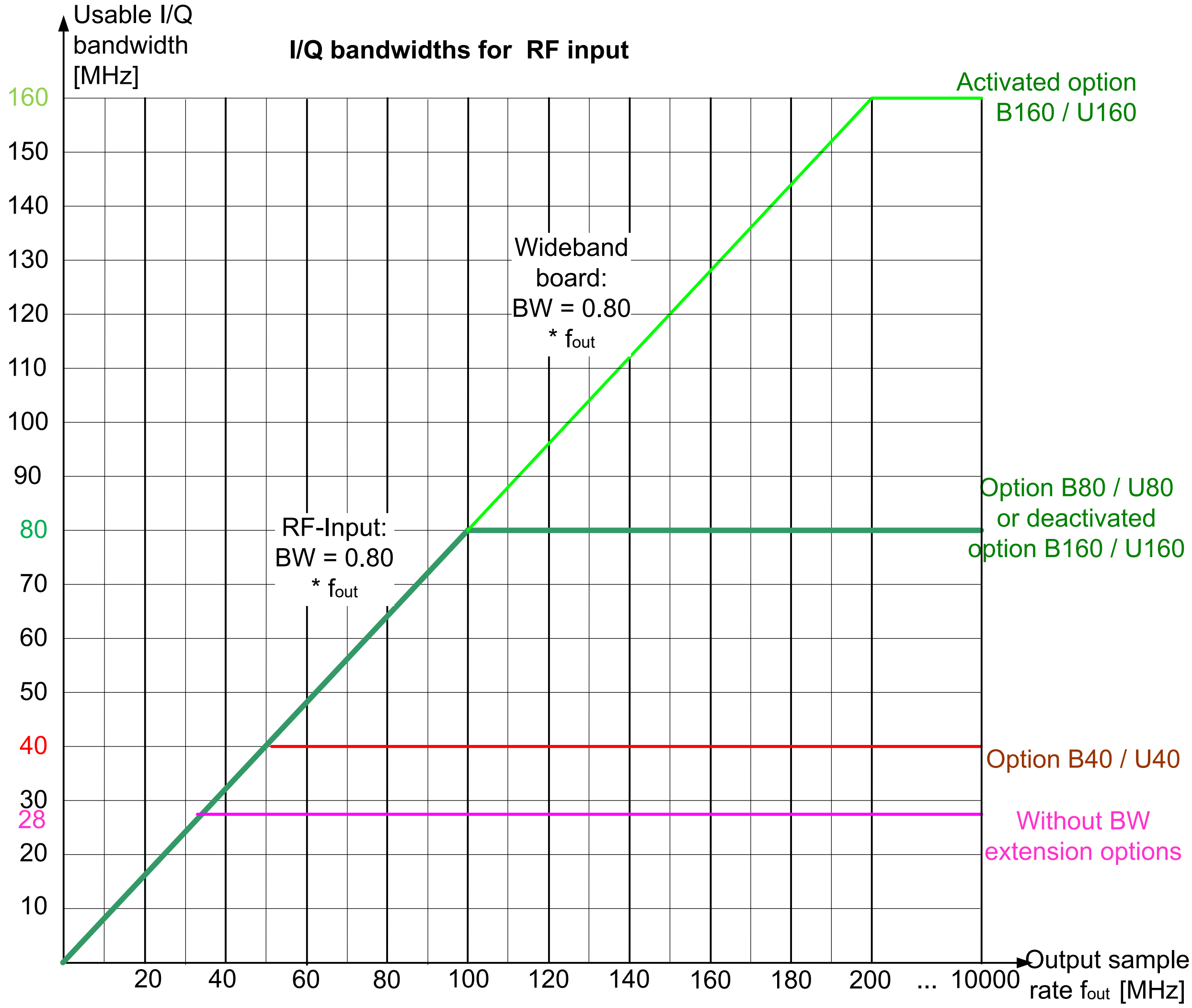


Figure 3-13: Relationship between maximum usable I/Q bandwidth and output sample rate with and without bandwidth extensions

Restricting the maximum bandwidth manually

By default, all installed bandwidth extension options are activated, allowing for the maximum bandwidth for measurements on the FSW. However, sometimes the maximum bandwidth is not necessary. For example, due to the correlation of both parameters, high sample rates automatically lead to an extended analysis bandwidth. However, while a high sample rate can be necessary (for example due to postprocessing in an OFDM system), the wide bandwidth is not necessarily required.

On the other hand, low sample rates lead to small usable I/Q bandwidths. To ensure the availability of the required bandwidth, the minimum required bandwidth for the specified sample rate can be selected (via remote command only).

Thus, if one of the bandwidth extension options is installed, the maximum bandwidth can be restricted manually to a value that can improve the measurement (see "Maximum Bandwidth" on page 92). In this case, the hardware of the "regular" RF path is used, rather than the hardware required by the bandwidth extension options.

The following improvements can be achieved:

- Longer measurement time for sample rates under 300 MHz
- Data processing becomes up to 10 times faster.
- Digital baseband output becomes available (with bandwidth extension options that do not support output).

General notes and restrictions

- The memory extension option FSW-B106 is only available together with the R&S FSW-B160 or B320 bandwidth extension options.
- The memory extension option FSW-B108 is only available together with the FSW-B1200/-B2001/-B800R options.
- The memory extension option FSW-B124 is only available together with the FSW-B4001/B6001/B8001 options.
- In MSRA operating mode, the MSRA primary is restricted to a sample rate of 600 MHz.

3.5.3 FSW without additional bandwidth extension options

Sample rate: 100 Hz - 20 GHz

Maximum I/Q bandwidth: 28 MHz

Table 3-4: Maximum I/Q bandwidth

Sample rate	Maximum I/Q bandwidth
100 Hz to 28 MHz	Proportional up to maximum 28 MHz
28 MHz to 20 GHz	28 MHz

MSRA operating mode

In MSRA operating mode, the MSRA primary is restricted to a sample rate of 600 MHz.

3.5.4 FSW with I/Q bandwidth extension option B40 or U40

Sample rate: 100 Hz - 20 GHz

Maximum bandwidth: 40 MHz

Table 3-5: Maximum I/Q bandwidth

Sample rate	Maximum I/Q bandwidth
100 Hz to 50 MHz	Proportional up to maximum 40 MHz
50 MHz to 20 GHz	40 MHz

MSRA operating mode
In MSRA operating mode, the MSRA primary is restricted to a sample rate of 600 MHz.

3.5.5 FSW with I/Q bandwidth extension option B80 or U80

Sample rate: 100 Hz - 20 GHz

Maximum bandwidth: 80 MHz

Table 3-6: Maximum I/Q bandwidth

Sample rate	Maximum I/Q bandwidth
100 Hz to 100 MHz	Proportional up to maximum 80 MHz
100 MHz to 20 GHz	80 MHz

MSRA operating mode
In MSRA operating mode, the MSRA primary is restricted to a sample rate of 600 MHz.

3.5.6 FSW with activated I/Q bandwidth extension option B160 or U160

Sample rate: 100 Hz - 20 GHz

Maximum bandwidth: 160 MHz

Table 3-7: Maximum I/Q bandwidth

Sample rate	Maximum I/Q bandwidth
100 Hz to 200 MHz	Proportional up to maximum 160 MHz
200 MHz to 20 GHz	160 MHz

Table 3-8: Maximum record length with activated I/Q bandwidth extension option B160 or U160

Sample rate	Maximum record length
100 Hz to 200 MHz	440 Msamples
	220 Msamples

Notes and restrictions for FSW-B160 or U160
- In MSRA operating mode, the MSRA primary is restricted to a sample rate of 600 MHz.

3.5.7 FSW with activated I/Q bandwidth extension option B320/U320

Table 3-9: Maximum I/Q bandwidth

Sample rate	Maximum I/Q bandwidth
100 Hz to 400 MHz	Proportional up to maximum 320 MHz
400 MHz to 20 GHz	320 MHz

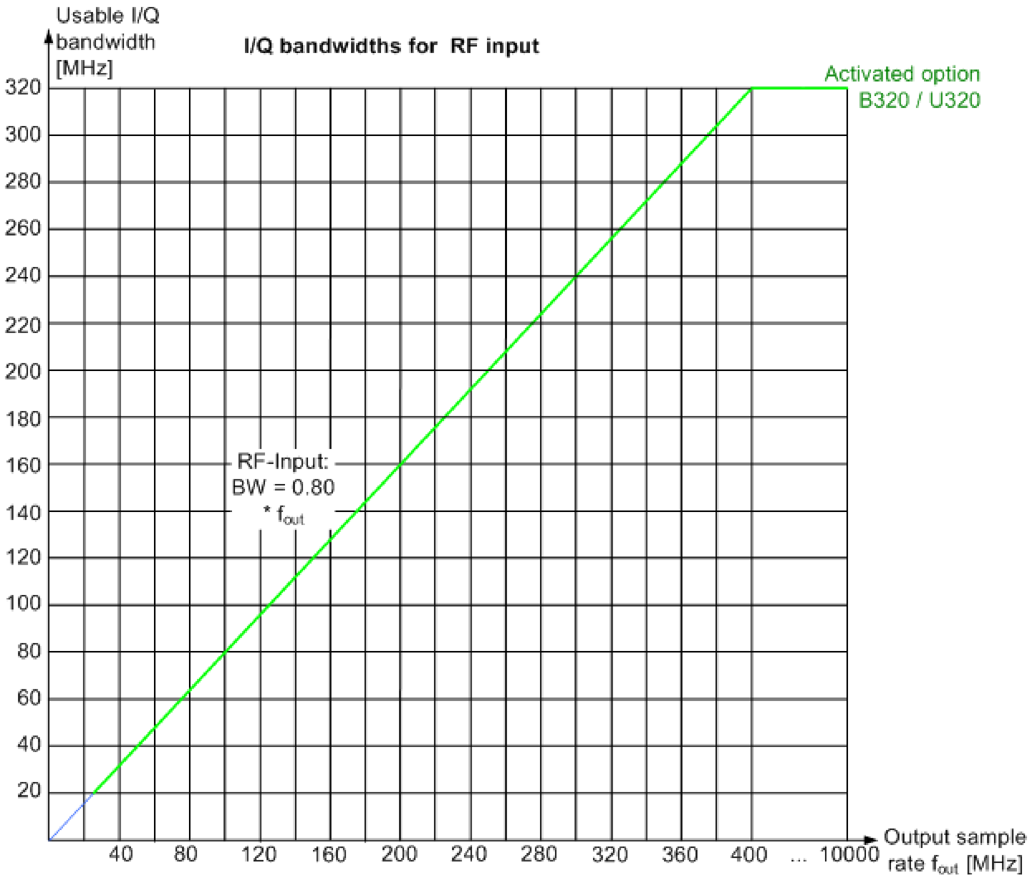


Figure 3-14: Relationship between maximum usable I/Q bandwidth and output sample rate for active FSW-B320

Table 3-10: Maximum record length with activated I/Q bandwidth extension option B320 or U320

Sample rate	Maximum record length
100 Hz to 200 MHz*)	440 Msamples With FSW-B106 option: 1400 Msamples
200 MHz to 468 MHz	470 Msamples * sample rate / 1GHz With FSW-B106 option: 1400 Msamples * sample rate / 1GHz
468 MHz to 20 GHz	220 Msamples With FSW-B106 option: 700 Msamples
*) for sample rates up to 200 MHz the I/Q bandwidth extension B320 is not used	

Notes and restrictions for FSW-B320

- In MSRA operating mode, the MSRA primary is restricted to a sample rate of 600 MHz.

3.5.8 FSW with activated I/Q bandwidth extension option B512

The bandwidth extension option FSW-B512 provides measurement bandwidths up to 512 MHz.

Table 3-11: Maximum I/Q bandwidth

Sample rate	Maximum I/Q bandwidth
100 Hz to 600 MHz	0.8 * sample rate (up to maximum 512 MHz)
600 MHz to 20 GHz	512 MHz

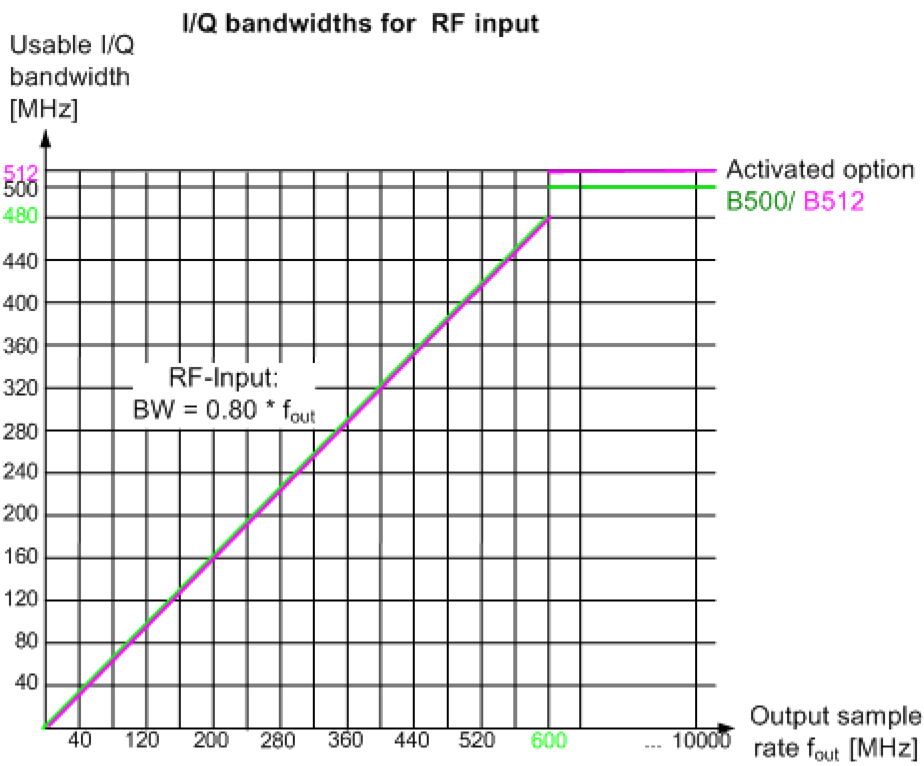


Figure 3-15: Relationship between maximum usable I/Q bandwidth and output sample rate for active FSW-B512

Table 3-12: Maximum record length with activated I/Q bandwidth extension option FSW-B512

Sample rate	Maximum record length
100 Hz to 20 GHz	440 Msamples

Notes and restrictions for FSW-B512

- In MSRA operating mode, the MSRA primary is restricted to a sample rate of 600 MHz and a maximum record length of 220 Msamples.
- The memory extension options FSW-B106/-B108/-B124 are not available together with the -B512 option.

Bandwidths between 480 MHz and 512 MHz with FSW-B512 option

Note the irregular behavior of the relationshipt between the sample rate and the usable I/Q bandwidth for bandwidths between 480 MHz and 512 MHz with the -B512 options, depending on which setting you change.

For compatibility reasons, the common relationship is maintained for bandwidths ≤ 480 MHz:

*Usable I/Q bandwidth = 0.8 * output sample rate*

However, to make use of the maximum sample rate of 600 MHz at the maximum bandwidth of 512 MHz, there is an exception. If you **change the bandwidth** between 480 MHz and 500 MHz, the sample rate is adapted according to the relationship:

Output sample rate = usable I/Q bandwidth / (500/600)

Or

Output sample rate = usable I/Q bandwidth / 0.8333

When using option R&S FSW-**B512R**, if you **change the bandwidth** between 500 MHz and 512 MHz, the sample rate is adapted according to the relationship:

Output sample rate = usable I/Q bandwidth / (512/600)

Or

Output sample rate = usable I/Q bandwidth / 0.8533

On the other hand, if you **decrease the sample rate** under 600 MHz, the I/Q bandwidth is adapted according to the common relationship:

*Usable I/Q bandwidth = 0.8 * output sample rate*.

3.5.9 FSW with activated I/Q bandwidth extension option B1200

The bandwidth extension option FSW-B1200 provides measurement bandwidths up to 1200 MHz.

Table 3-13: Maximum I/Q bandwidth

Sample rate	Maximum I/Q bandwidth
100 Hz to 600 MHz	0.8 * sample rate
600 MHz	0.8533 * sample rate (=512 MHz)
600 MHz to 1500 MHz	0.8 * sample rate ***)**
1500 MHz to 20 GHz	1200 MHz
***)** Exception: for active digital I/Q 40G streaming output, a sample rate of 1200 MHz provides a maximum I/Q bandwidth of 1000 MHz	

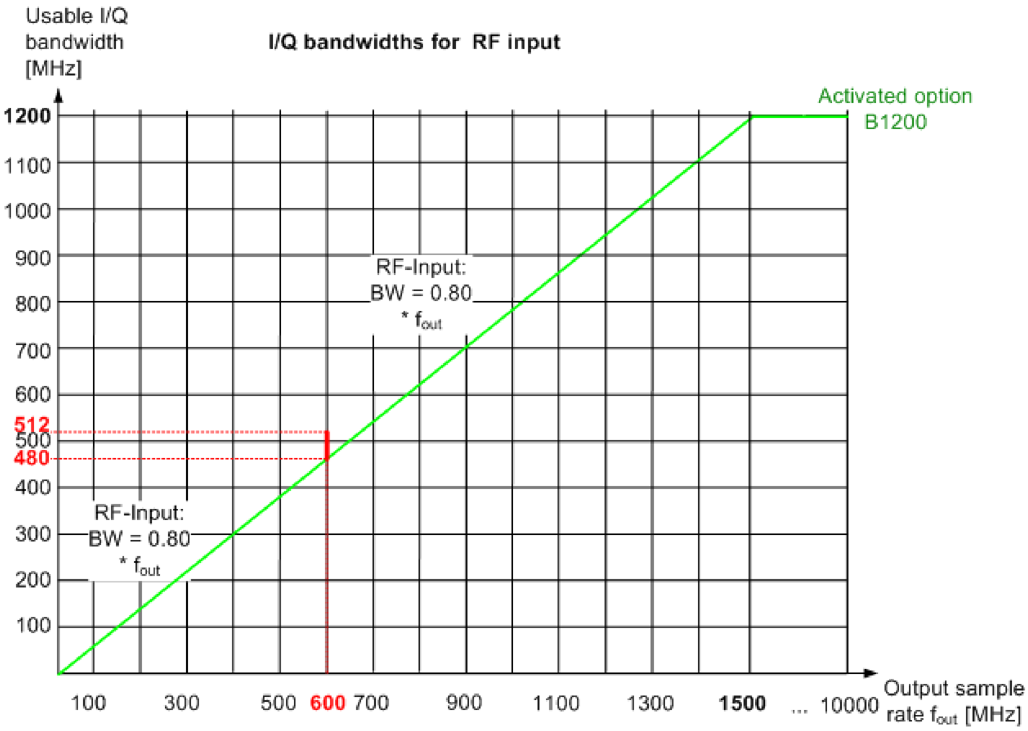


Figure 3-16: Relationship between maximum usable I/Q bandwidth and output sample rate for active FSW-B1200

Table 3-14: Maximum record length with activated I/Q bandwidth extension option FSW-B1200

Sample rate	Maximum record length
100 Hz to 600 MHz	440 Msamples With FSW-B108 option: max. 1800 Msamples
600 MHz to 1250 MHz	480 Msamples * (sample rate / 1250 MHz); max. 440 Msamples With FSW-B108 option: 990 Msamples * (sample rate / 1250 MHz); max. 900 Msamples
1250 MHz to 20 GHz	max. 440 Msamples With FSW-B108 option: 900 Msamples * (sample rate / 1250 MHz); max. 900 Msamples

Notes and restrictions for FSW-B1200

- The memory extension option FSW-B106 is not available together with the B1200 option.
- When the FSW-B1200 option is active, only an external trigger (or no trigger) is available.

Irregular behavior in bandwidths between 480 MHz and R&S FSW512 MHz with FSW-B1200 option

Note that the B1200 bandwidth extension option has the same irregular behavior of the relationship between the sample rate and the usable I/Q bandwidth for bandwidths between 480 MHz and 512 MHz as the B512 option. The FSW uses the same hardware for both options up to 512 MHz.

For compatibility reasons, the common relationship is maintained for bandwidths ≤ 480 MHz:

Output sample rate = usable I/Q bandwidth / 0.8

However, to make use of the maximum sample rate of 600 MHz at the maximum bandwidth of 500 MHz, there is an exception. If you **change the bandwidth** between 480 MHz and 500 MHz, the sample rate is adapted according to the relationship:

Output sample rate = usable I/Q bandwidth / (500/600)

Or

Output sample rate = usable I/Q bandwidth / 0.8333

If you **change the bandwidth** between 500 MHz and 512 MHz, the sample rate is adapted according to the relationship:

Output sample rate = usable I/Q bandwidth / (512/600)

Or

Output sample rate = usable I/Q bandwidth / 0.8533

If you increase the bandwidth above 512 MHz, the common relationship is maintained again:

Output sample rate = usable I/Q bandwidth / 0.8

On the other hand, if you **set the sample rate** to **600 MHz**, the I/Q bandwidth is set to:

*Output sample rate * 0.8533 = **512 MHz***

However, if you **decrease the sample rate** under 600 MHz or **increase the sample rate** above 600 MHz, the I/Q bandwidth is adapted according to the common relationship:

*Usable I/Q bandwidth = 0.8 * output sample rate*.

3.5.10 FSW with activated I/Q bandwidth extension option B2001

The (internal) bandwidth extension option FSW-B2001 provides measurement bandwidths up to 2 GHz, with no additional devices required.

Table 3-15: Maximum I/Q bandwidth

Sample rate	Maximum I/Q bandwidth
100 Hz to 600 MHz	0.8 * sample rate
600 MHz	0.8533 * sample rate (=512 MHz)
***)** Exception: for active digital I/Q 40G streaming output, a sample rate of 1200 MHz provides a maximum I/Q bandwidth of 1000 MHz	

Sample rate	Maximum I/Q bandwidth
600 MHz to 2500 MHz	0.8 * sample rate ***)**
2500 MHz to 20 GHz	2000 MHz
***)** Exception: for active digital I/Q 40G streaming output, a sample rate of 1200 MHz provides a maximum I/Q bandwidth of 1000 MHz	

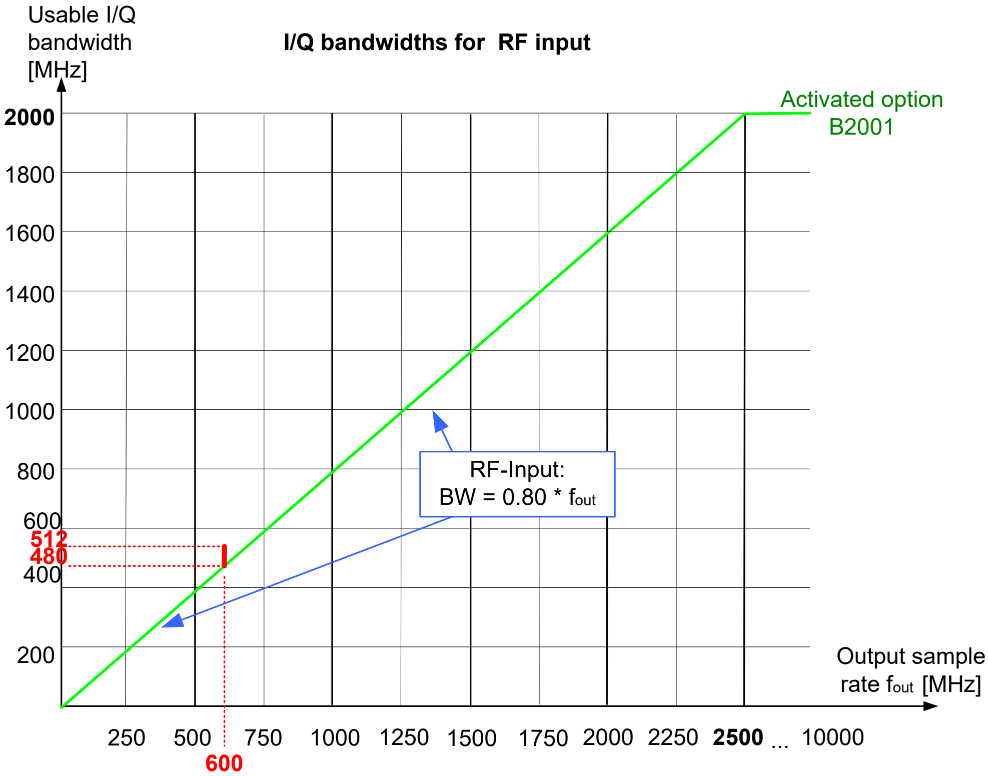


Figure 3-17: Relationship between maximum usable I/Q bandwidth and output sample rate for active FSW-B2001

Table 3-16: Maximum record length with activated I/Q bandwidth extension option FSW-B2001

Sample rate	Maximum record length
100 Hz to 600 MHz	440 Msamples With FSW-B108 option: max. 1800 Msamples
600 MHz to 1250 MHz	440 Msamples * (sample rate / 1250 MHz); max. 900 Msamples With FSW-B108 option: 900 Msamples * (sample rate / 1250 MHz); max. 900 Msamples
1250 MHz to 20 GHz	440 Msamples * (sample rate / 2500 MHz); max. 900 Msamples With FSW-B108 option: 900 Msamples * (sample rate / 1250 MHz); max. 900 Msamples

Notes and restrictions for FSW-B2001

- The memory extension option FSW-B106 is not available together with the B2001 option.
- When the FSW-B2001 option is active, only an external trigger (or no trigger) is available.

Irregular behavior in bandwidths between 480 MHz and 512 MHz with FSW-B2001 option

Note that the B2001 bandwidth extension option has the same irregular behavior of the relationship between the sample rate and the usable I/Q bandwidth for bandwidths between 480 MHz and 512 MHz as the -B512 options. The FSW uses the same hardware for both options up to 512 MHz.

For compatibility reasons, the common relationship is maintained for bandwidths ≤ 480 MHz:

Output sample rate = usable I/Q bandwidth / 0.8

However, to make use of the maximum sample rate of 600 MHz at the maximum bandwidth of 500 MHz, there is an exception. If you **change the bandwidth** between 480 MHz and 500 MHz, the sample rate is adapted according to the relationship:

Output sample rate = usable I/Q bandwidth / (500/600)

Or

Output sample rate = usable I/Q bandwidth / 0.8333

If you **change the bandwidth** between 500 MHz and 512 MHz, the sample rate is adapted according to the relationship:

Output sample rate = usable I/Q bandwidth / (512/600)

Or

Output sample rate = usable I/Q bandwidth / 0.8533

If you increase the bandwidth above 512 MHz, the common relationship is maintained again:

Output sample rate = usable I/Q bandwidth / 0.8

On the other hand, if you **set the sample rate** to **600 MHz**, the I/Q bandwidth is set to:

*Output sample rate * 0.8533 =* ***512 MHz***

However, if you **decrease the sample rate** under 600 MHz or **increase the sample rate** above 600 MHz, the I/Q bandwidth is adapted according to the common relationship:

*Usable I/Q bandwidth = 0.8 * output sample rate*.

3.5.11 FSW with activated I/Q bandwidth extension option B2000

The bandwidth extension option FSW-B2000 provides measurement bandwidths up to 2 GHz.

Table 3-17: Maximum I/Q bandwidth

Sample rate	Maximum I/Q bandwidth
10 kHz to 20 GHz	Proportional up to maximum 2 GHz

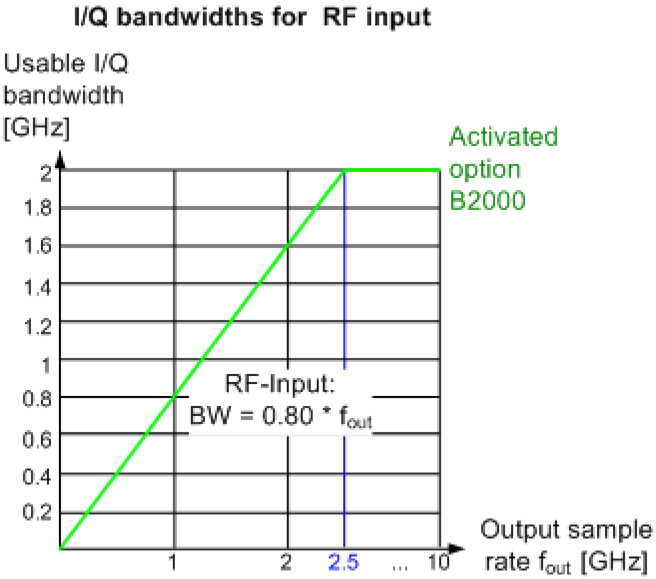


Figure 3-18: Relationship between maximum usable I/Q bandwidth and output sample rate for active FSW-B2000

Notes and restrictions for FSW-B2000

- The memory extension options FSW-B106/-B108/-B124 are not available together with the B2000 option.
- If the FSW-B2000 bandwidth extension option is active, MSRA operating mode is not available.
- The maximum memory size, and thus record length, available for a single input channel can be reduced by half in the following cases:
  - When using an external trigger in common B2000 mode, which uses another channel on the oscilloscope.
  - In power splitter mode, which uses two input channels on the oscilloscope.

  For details, see the oscilloscope's specifications document and documentation. For details on the power splitter mode, see the FSW I/Q Analyzer and I/Q Input user manual.

3.5.12 FSW with activated I/Q bandwidth extension option B5000

The bandwidth extension option FSW-B5000 provides measurement bandwidths up to 5 GHz.

Table 3-18: Maximum I/Q bandwidth

Sample rate	Maximum I/Q bandwidth
10 kHz to 20 GHz	Proportional up to maximum 5 GHz

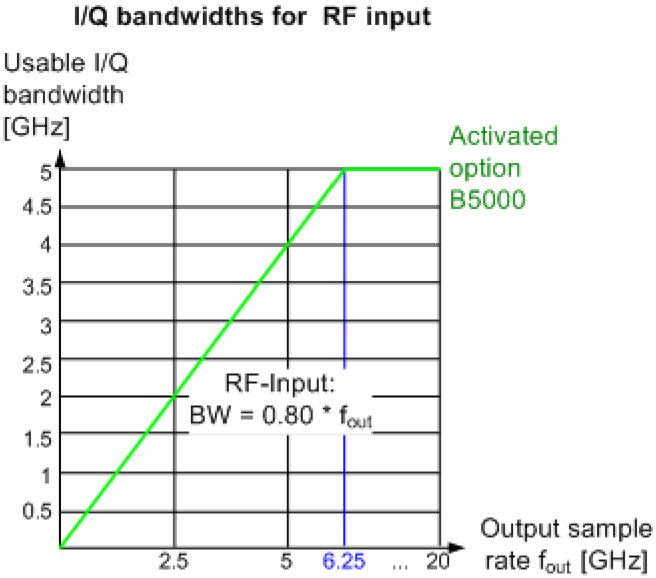


Figure 3-19: Relationship between maximum usable I/Q bandwidth and output sample rate for active FSW-B5000

Notes and restrictions for FSW-B5000

- The memory extension options FSW-B106/-B108/-B124 are not available together with the B5000 option.
- If the FSW-B5000 bandwidth extension option is active, MSRA operating mode is not available.
- The maximum memory size, and thus record length, available for a single input channel can be reduced by half in the following cases:
  - When using an external trigger in common B5000 mode, which uses another channel on the oscilloscope.
  - In power splitter mode, which uses two input channels on the oscilloscope.

  For details, see the oscilloscope's specifications document and documentation. For details on the power splitter mode, see the FSW I/Q Analyzer and I/Q Input user manual.

3.5.13 FSW with activated I/Q bandwidth extension option B4001/B6001/B8001

The (internal) bandwidth extension options FSW-B4001/B6001/B8001 provide measurement bandwidths up to 4 GHz, 6 GHz or 8 GHz, respectively, with no additional devices required. The B4001 option is activated automatically for bandwidths larger than 80 MHz, if installed. The B6001 and B8001 options are activated automatically for bandwidths larger than 80 MHz and center frequencies above 18 GHz, if installed.

The memory extension options FSW-B106/-B108 are not available together with the B4001/B6001/B8001 options.

Table 3-19: Maximum I/Q bandwidth

Option	Sample rate	Maximum I/Q bandwidth
B4001	100 Hz to 5500 MHz	0.8 * sample rate
	5500 MHz to 20 GHz	4400 MHz
B6001	100 Hz to 8000 MHz	0.8 * sample rate
	8000 MHz to 20 GHz	6400 MHz
B8001	100 Hz to 10390 MHz	0.8 * sample rate
	10390 MHz to 20 GHz	8312 MHz

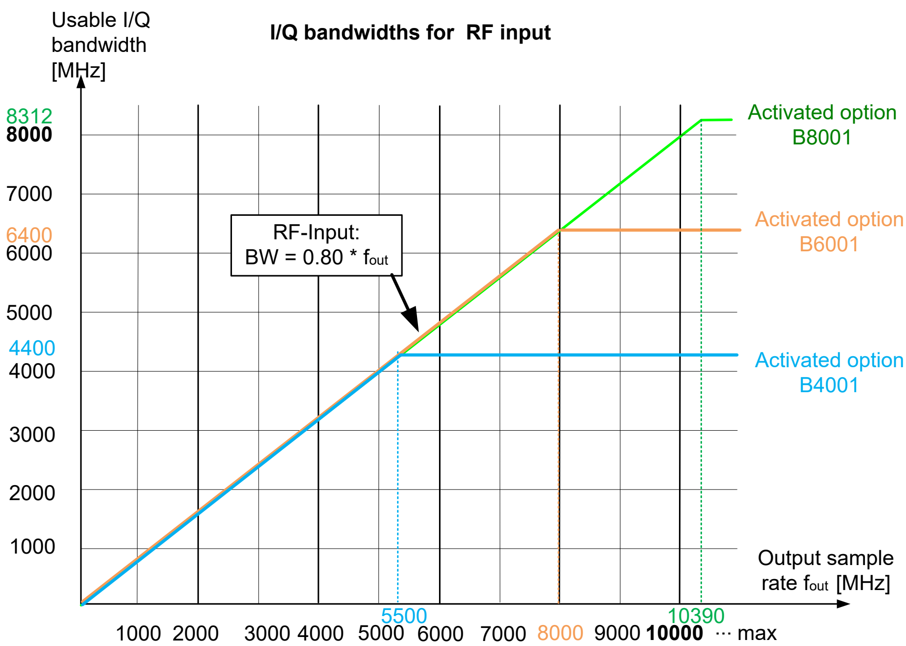


Figure 3-20: Relationship between maximum usable I/Q bandwidth and output sample rate for active FSW-B4001/B6001/B8001

Table 3-20: Maximum record length with activated I/Q bandwidth extension option FSW-B4001/B6001/B8001

Sample rate	Maximum record length
100 Hz to 100 MHz	440 Msamples
100 MHz to 20 GHz	1039 Msamples
100 MHz to 5.32 GHz	1039 Msamples With FSW-B124 option: max. 5600 Msamples

Sample rate	Maximum record length
5.32 GHz to 10.64 GHz	1039 Msamples With FSW-B124 option: max. 6440 Msamples
10.64 GHz to 20 GHz	1039 Msamples With FSW-B124 option: max. 2800 Msamples

Notes and restrictions for FSW-B4001/B6001/B8001

- In MSRA operating mode, the MSRA primary is restricted to a sample rate of 200 MHz and a maximum bandwidth of 80 MHz.
- If a FSW-B4001/B6001/B8001 option is active, only an external trigger (or no trigger) is available.

3.6 DFT-S precoding

DFT-s-OFDM and SC-FDMA are different names for a method that can be applied to lower the crest factor of the RF signal.

For DFT-s-OFDM, an additional digital Fourier transformation (DFT) is included in the transmitter's signal processing stage, referred to as *precoding*. If this method is used by the input signal, enable the "Transform Precoding" option to decode the precoding transformation using an iDFT. The R&S FSW OFDM VSA application tries to detect contiguous groups of data cells for each OFDM symbol and decode them using an inverse DFT. Zero cells are ignored.

If "Transform Precoding" is enabled, you can define how to process OFDM symbols that contain "Don't Care" and pilot cells:

- OFDM symbols that contain pilot or "Don't Care" cells are decoded, but these cells are ignored.
- OFDM symbols that contain a pilot or a "Don't Care" cell are skipped and not decoded.

The "Ignore pilot/don't care" setting has no effect if the signal generator does not use interspersed pilots in any OFDM symbol that uses DFT-S precoding on DATA cells. In this case, either there are DATA-only symbols with DFT-S, or PILOT-only symbols without DFT-s.

Configuration files for precoded signals

If precoding is enabled, take special care when editing the configuration file. Make sure that all cells are allocated correctly, that is:

- No cell is falsely allocated as a data cell.
- All data cells are allocated as data cells.

Otherwise, the iDFT parameters (length, start, stop) are not correct and *all* data cells in that OFDM symbol are demodulated inaccurately.

Example: Processing a precoded DFT-S signal

The following example demonstrates how a precoded DFT-S signal is processed for analysis.

On the signal generator:

Assume that the signal generator uses DFT-S precoding and interspersed pilots in a certain OFDM symbol. Before encoding, this OFDM symbol consists of the following cells:

D1 D2 P1 D3 D4 P2 D5 D6

with D = Data cells, P = Pilots cells

Encoding is performed on data cells only, omitting the pilots:

[D1’ D2’ D3’ D4’ D5’ D6’] = FFT([D1 D2 D3 D4 D5 D6])

Then the encoded data cells are sorted back into correct positions:

D1’ D2’ P1 D3’ D4’ P2 D5’ D6’

These encoded I/Q symbols are used for further OFDM modulation and then transmitted.

In the R&S FSW OFDM VSA application:

For this OFDM symbol, the received I/Q symbols are in an early stage:

D1’ D2’ P1 D3’ D4’ P2 D5’ D6’

Since we know that DFT-S was used, we select "Signal description" > "Transform precoding" : "on". The R&S FSW OFDM VSA application tries to revert the DFT-S precoding, but it detects the disturbing pilots. Now there are two ways to deal with this OFDM symbol:

- "Ignore pilot/don't care" enabled:
  The R&S FSW OFDM VSA application is told to ignore the disturbing pilots. The resulting IFFT ignores the pilot cells in the input buffer:
  [D1 D2 D3 D4 D5 D6] = IFFT ([D1’ D2’ D3’ D4’ D5’ D6’])
  The cells are sorted back into their correct position:
  D1 D2 P1 D3 D4 P2 D5 D6
  The result is identical to what was sent, so the EVM in this OFDM symbol is OK.
- "Ignore pilot/don't care" disabled:
  The R&S FSW OFDM VSA application is not told to just ignore those disturbing pilots. The R&S FSW OFDM VSA application only performs the IFFT for data-only OFDM symbols. Since the planned IFFT cannot be performed, it is skipped entirely for this OFDM symbol.
  The received I/Q symbols remain unchanged:
  D1’ D2’ P1 D3’ D4’ P2 D5’ D6’
  This result is not identical to the sent I/Q symbols D1 D2 P1 D3 D4 P2 D5 D6. The EVM in this symbol is high.

3.7 OFDM VSA in MSRA operating mode

The R&S FSW OFDM VSA application can also be used to analyze data in MSRA operating mode.

In MSRA operating mode, only the MSRA primary actually captures data; the MSRA applications receive an extract of the captured data for analysis, referred to as the **application data**. For the R&S FSW OFDM VSA application in MSRA operating mode, the application data range is defined by the same settings used to define the signal capture in Signal and Spectrum Analyzer mode. In addition, a capture offset can be defined, i.e. an offset from the start of the captured data to the start of the application data for vector signal analysis. The "Capture Buffer" displays show the application data of the R&S FSW OFDM VSA application in MSRA mode.

Data coverage for each active application

Generally, if a signal contains multiple data channels for multiple standards, separate applications are used to analyze each data channel. Thus, it is of interest to know which application is analyzing which data channel. The MSRA primary display indicates the data covered by each application, restricted to the channel bandwidth used by the corresponding standard, by vertical blue lines labeled with the application name. The R&S FSW OFDM VSA application supports several standards, but the standard used by the currently analyzed data is not known. Thus, the "Symbol Rate" defined in the "Signal Description" settings is used to approximate the channel bandwidth.

Analysis interval

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

In the R&S FSW OFDM VSA application, the analysis interval is automatically determined according to the evaluation range or result range settings, as in Signal and Spectrum Analyzer mode. The currently used analysis interval (in seconds, related to capture buffer start) is indicated in the window header for each result display.

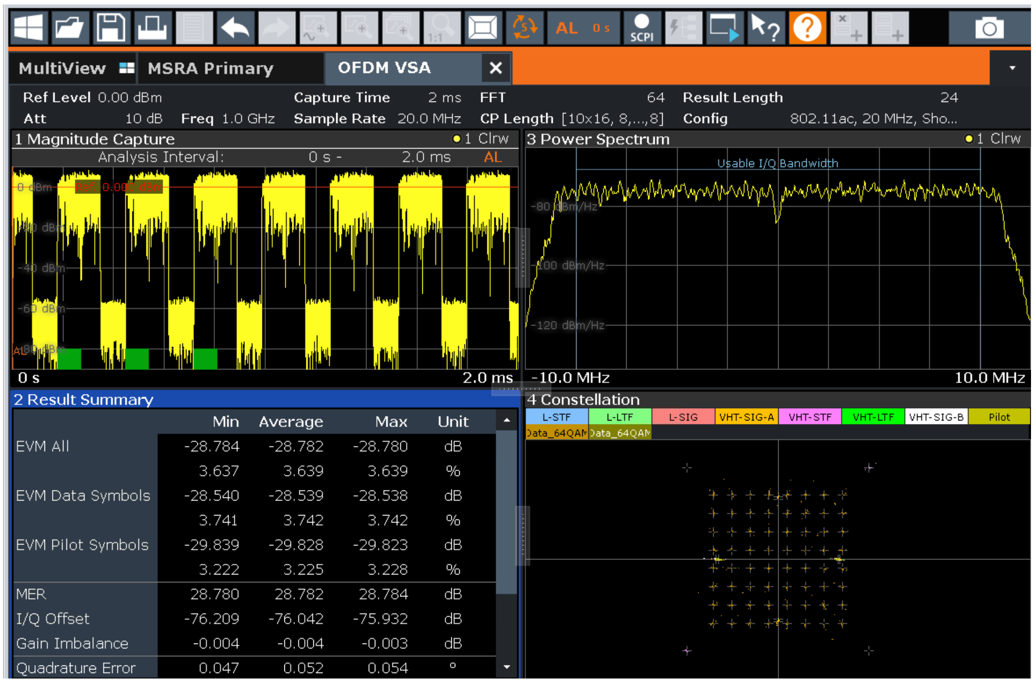
Analysis line

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

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

- **orange "AL"**: the line lies within the interval

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



For details on the MSRA operating mode, see the FSW MSRA User Manual.

4 Configuring OFDM VSA measurements

When you activate a measurement channel for the R&S FSW OFDM VSA application, a OFDM VSA measurement for the input signal is started automatically with the default configuration. The "OFDM VSA" menu is displayed and provides access to the most important configuration functions.

General FSW functions

The application-independent functions for general tasks on the FSW are also available for the R&S FSW OFDM VSA application and are described in the FSW user manual. In particular, the application supports the following functionality:

- Data management
- Test report functionality
- General software preferences and information
- Fast access panel

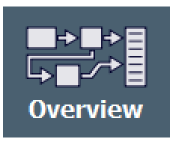
Importing and exporting I/Q data

The I/Q data to be evaluated in the R&S FSW OFDM VSA application cannot only be measured by the R&S FSW OFDM VSA application itself, it can also be imported to the application, provided it has the correct format. Furthermore, the evaluated I/Q data from the R&S FSW OFDM VSA application can be exported for further analysis in external applications.

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

For details on importing and exporting I/Q data, see the FSW base unit user manual.

4.1 Configuration overview



Access: [Meas Config] > "Overview"

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

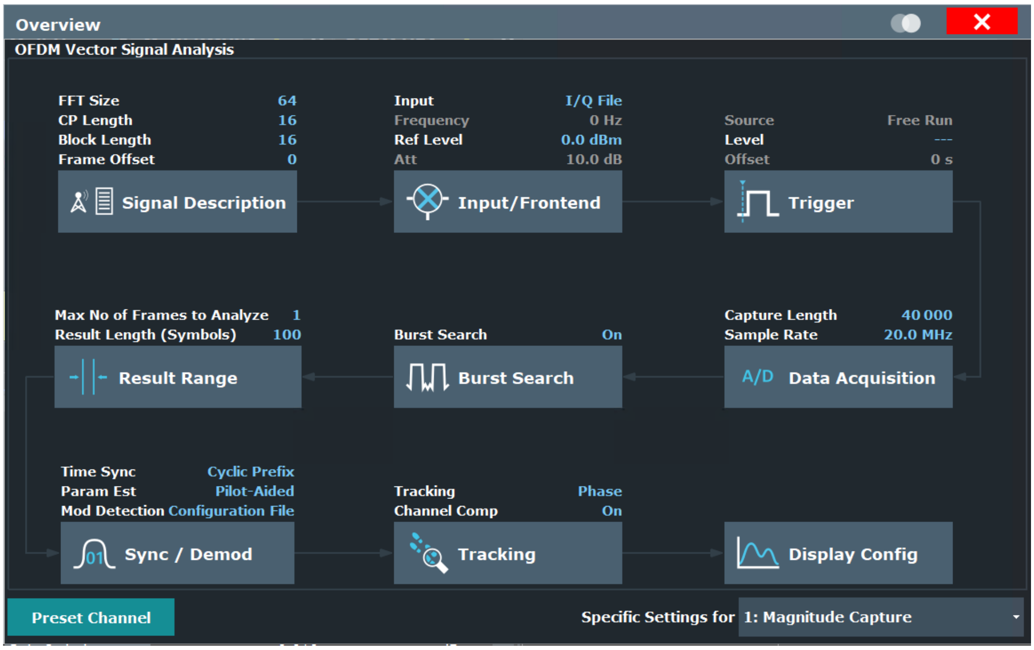


Figure 4-1: Configuration "Overview" for the R&S FSW OFDM VSA application

In addition to the main measurement settings, the "Overview" provides quick access to the main settings dialog boxes. Thus, you can easily configure an entire measurement channel from input over processing to evaluation by stepping through the dialog boxes as indicated in the "Overview".

In particular, 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 62
2. Input/Frontend
   See Chapter 4.3, "Input, output and frontend settings", on page 68
3. Trigger
   See Chapter 4.4, "Trigger settings", on page 84
4. Data acquisition
   See Chapter 4.5, "Data acquisition", on page 90
5. Burst search
   See Chapter 4.7, "Burst search", on page 95
6. Result range
   See Chapter 4.8, "Result ranges", on page 96
7. Synchronization and demodulation settings
   See Chapter 4.9, "Synchronization, demodulation and tracking", on page 97
8. Tracking
   See Chapter 4.9, "Synchronization, demodulation and tracking", on page 97

9. Result configuration
   See Chapter 6.1, "Result configuration", on page 130

To configure settings

► Select any button in the "Overview" to open the corresponding dialog box.
  Select a setting in the channel bar (at the top of the measurement channel tab) to change a specific setting.

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

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

Remote command:
`SYSTem:PRESet:CHANnel[:EXEC]` on page 157

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.

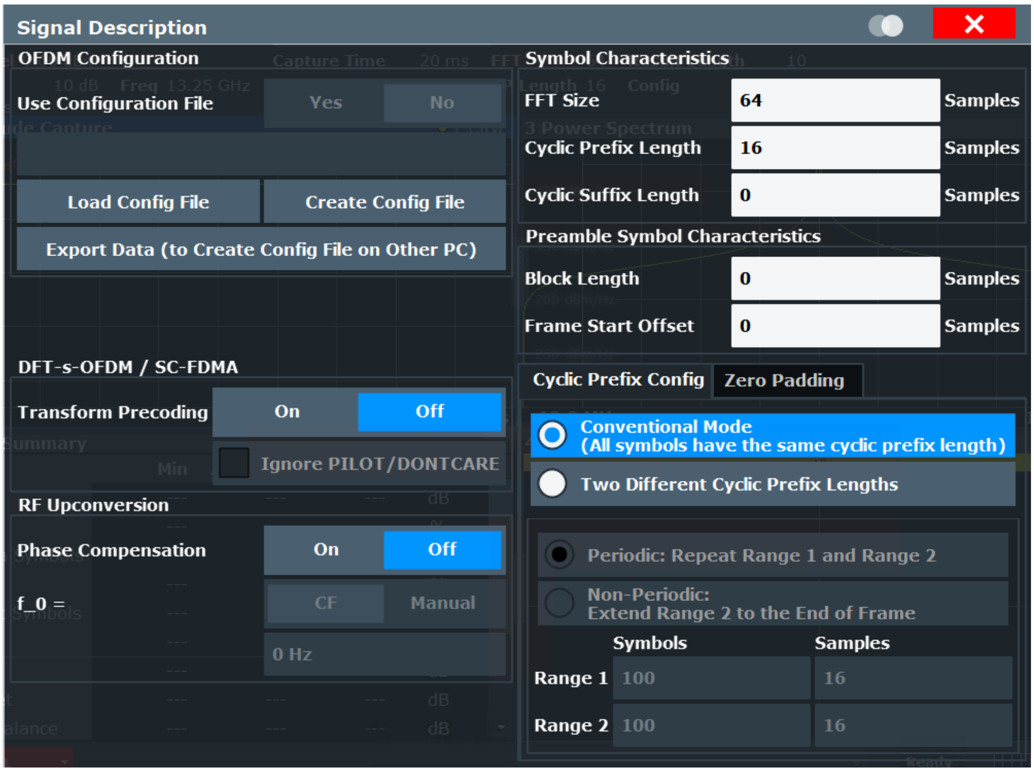
The "Overview" and dialog boxes are updated to indicate the settings for the selected window.

4.2 Signal description

Access: "Overview" > "Signal Description"

You must describe the expected input signal so that the R&S FSW OFDM VSA application can compare the measured signal to the expected reference signal. You can load an existing configuration file, or create one interactively using a wizard for the current input signal (see Chapter 5, "Creating a configuration file using the wizard", on page 102).

The R&S FSW OFDM VSA application provides some sample files for I/Q input data and configuration files in the `C:\R_S\INSTR\USER\demo\OFDM-VSA` directory.



Use Configuration File

Determines whether the configuration from the currently loaded file is used for the measurement. Alternatively, you can configure the OFDM signal manually.

The currently loaded configuration file is indicated for reference.

Remote command:

`CONFigure:SYSTem:CFILe` on page 162

Load Configuration File
Opens a file selection dialog box to select the configuration (`.XML`) file for the measurement.

Note: Configuration files with more than 100 different modulation types cannot be loaded.

Remote command:
`MMEMory:LOAD:CFGFile` on page 164

Create Configuration File
Opens a wizard that helps you create a new configuration file interactively. See Chapter 5, "Creating a configuration file using the wizard", on page 102.

Export Data (to Create Config File on Other PC)
Exports the current settings to a `.K96_wizv` file. Use this input file to create a configuration file using the wizard on another PC.

DFT-s-OFDM / SC-FDMA:Transform Precoding
DFT-s-OFDM and SC-FDMA are different names for a method that can be applied to lower the crest factor of the RF signal.

For DFT-s-OFDM, an additional digital Fourier transformation (DFT) is included in the transmitter's signal processing stage, referred to as *precoding*. If this method is used by the input signal, enable the "Transform Precoding" option to decode the precoding transformation using an iDFT. The R&S FSW OFDM VSA application tries to detect contiguous groups of data cells for each OFDM symbol and decode them using an inverse DFT. Zero cells are ignored.

For details, see Chapter 3.6, "DFT-S precoding", on page 56.

Remote command:
`CONFigure:TPRecoding` on page 164

Ignore PILOT/DONTCARE ← DFT-s-OFDM / SC-FDMA:Transform Precoding
If "Transform Precoding" is enabled, define how to process OFDM symbols that contain "Don't Care" and pilot cells:

"Ignore pilot/don't care" enabled:
OFDM symbols that contain pilot or "Don't Care" cells are decoded, but these cells are ignored.

"Ignore pilot/don't care" disabled:
OFDM symbols that contain a pilot or a "Don't Care" cell are skipped and not decoded.

Remote command:
`CONFigure:TPRecoding:IGNore` on page 164

RF Upconversion: Phase Compensation
For example, in 5G uplink signals, the phase shifts from one OFDM symbol to the next. In this case, the R&S FSW OFDM VSA application must revert the phase compensation that is applied to the signal during RF upconversion. The phase compensation is based on a fixed frequency, which can either be the center frequency, or you can define the frequency for the shift manually.

Remote command:
`CONFigure:RFUC:STATe` on page 159
`CONFigure:RFUC:FZERo:MODE` on page 159
`CONFigure:RFUC:FZERo:FREQuency` on page 158

FFT Size
Defines the useful length of an OFDM symbol in the time domain as the number of samples. This setting determines the number of samples used as input for each FFT calculation.

This setting is not available if a configuration file is active (see "Use Configuration File" on page 63). In this case, the FFT length defined in the file is displayed for reference only.

Remote command:
`CONFigure[:SYMBol]:NFFT` on page 161

Cyclic Prefix Length
Defines the length of the cyclic prefix (CP) area between two OFDM symbols in samples. The cyclic prefix area defines the guard interval and is expected to contain a copy of the samples at the end of the OFDM symbol.

The cyclic prefix length must be smaller than or equal to the "FFT Size" on page 65.

Remote command:
`CONFigure[:SYMBol]:NGUard<cp>` on page 161

Cyclic Suffix Length
Defines the length of the cyclic suffix between two OFDM symbols in samples. The cyclic suffix is expected to contain a copy of the first N samples at the beginning of the OFDM symbol.

Figure 4-2 shows how the complete OFDM symbol is retrieved for an FFT length of 8 and a cyclic prefix and suffix length of 2.

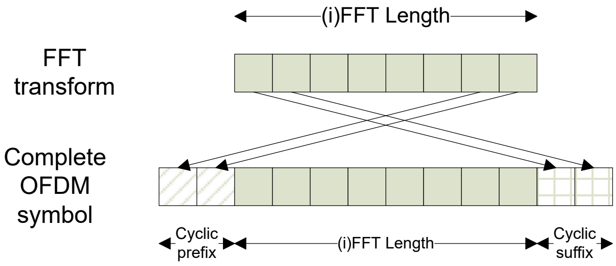


Figure 4-2: OFDM symbol with cyclic prefix and suffix

The cyclic suffix length must be smaller than or equal to the "FFT Size" on page 65.

Remote command:
`CONFigure[:SYMBol]:NSUFfix` on page 162

Preamble Symbol Characteristics: Block Length
Instead of using the cyclic prefix for the time synchronization, the R&S FSW OFDM VSA application can also use a preamble that contains repetitive blocks of samples (if available in the signal). This setting specifies the length of one data block within the repetitive preamble as a number of samples.

Remote command:
`CONFigure:PREamble:BLENgth` on page 158

Frame Start Offset
Specifies the time offset from the preamble start to the actual frame start as a number of samples.

Remote command:
`CONFigure:PREamble:FOFFset` on page 158

Cyclic Prefix Configuration
By default, the application assumes that each OFDM symbol has the same cyclic prefix length ("Conventional Mode"). If the symbols have two different cyclic prefix lengths, additional settings are available.

Remote command:
`CONFigure[:SYMBol]:GUARd:MODE` on page 159

Different cyclic prefix lengths
Some OFDM signals change their cyclic prefix over time (e.g. 802.11ac). This setting defines the behavior in such a case.

"Periodic" One "slot" that consists of the two defined ranges is repeated over and over until the number of symbols specified by the result range parameter is reached. The ranges are repeated periodically, first range 1, then range 2, then range 1, etc.

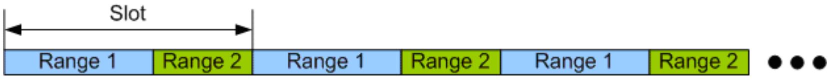


Figure 4-3: Non-Conventional cyclic prefix case: Periodic mode

"Non-Periodic" A fixed preamble has a different cyclic prefix length than the rest of the frame (e.g. WLAN 802.11ac signals). In this case, the length of the second range is extended until the end of the demodulated frame. Therefore, the length of the second range cannot be specified in this case.

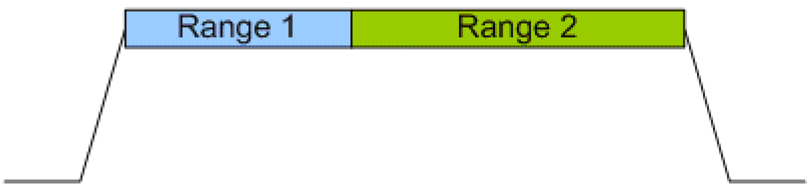


Figure 4-4: Non-Conventional cyclic prefix case: Non-Periodic mode

Remote command:
`CONFigure[:SYMBol]:GUARd:PERiodic` on page 160

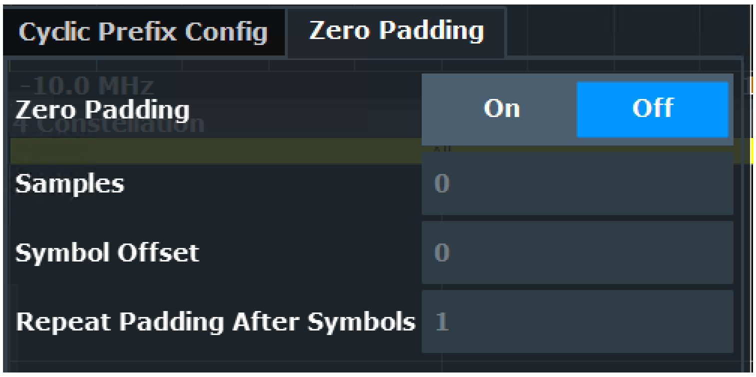
Cyclic prefix definition per range (Symbols / Samples) ← Different cyclic prefix lengths
For each range, configure the number of symbols the cyclic prefix length is applied to, and the length of the cyclic prefix as a number of samples.

For non-periodic cyclic prefixes, the length of the second range cannot be specified. It is extended to the end of the demodulated frame.

Remote command:
`CONFigure[:SYMBol]:GUARd:NSYMbols<cp>` on page 160
`CONFigure[:SYMBol]:NGUard<cp>` on page 161

Zero Padding
Enables or disables zero padding.

If enabled, "zero" samples are inserted before the cyclic prefix of specific OFDM symbols to allow for correct demodulation.



Remote command:
`CONFigure[:SYMBol]:ZPADding:STATe` on page 163

Samples ← Zero Padding
Defines the number of samples inserted for zero padding.

Remote command:
`CONFigure[:SYMBol]:ZPADding:LENGth` on page 162

Symbol Offset ← Zero Padding
Defines a number of symbols from the signal start for which no zero padding is inserted.

Remote command:
`CONFigure[:SYMBol]:ZPADding:OFFSet` on page 163

Repeat Padding After Symbols ← Zero Padding
Defines an interval of symbols (starting after the "Symbol Offset"), after which zero padding is repeated. For a repetition rate of 1, each symbol has zero padding.

Remote command:
`CONFigure[:SYMBol]:ZPADding:REPetition` on page 163

4.3 Input, output and frontend settings

Access: "Overview" > "Input/Frontend"

Or: [INPUT/OUTPUT]

The FSW can evaluate signals from different input sources.

The frequency and amplitude settings represent the frontend of the measurement setup.

4.3.1 Input settings

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

Or: [INPUT/OUTPUT]

Some settings are also available in the "Amplitude" tab of the "Amplitude" dialog box, see "Input Settings" on page 80.

Input from other sources

The R&S FSW OFDM VSA application can also process input from the following optional sources:

- I/Q input files
- External mixer
- External frontend
- Digital Baseband (I/Q) Interface (FSW-B17)
- Analog Baseband Interface (FSW-B71)
- Baseband oscilloscope input (FSW-B2071)
- 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000)
- Probes

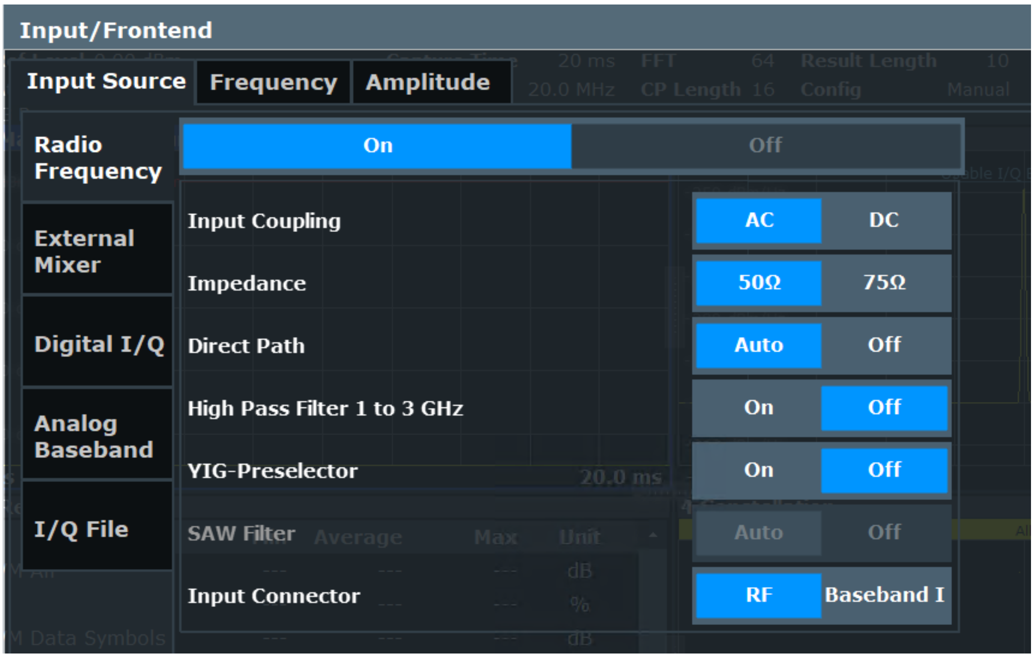
For details, see the FSW I/Q Analyzer and I/Q Input user manual.

4.3.1.1 Radio frequency input

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

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

The default input source for the FSW is the radio frequency.



RF input protection

The RF input connector of the FSW must be protected against signal levels that exceed the ranges specified in the specifications document. Therefore, the FSW is equipped with an overload protection mechanism for DC and signal frequencies up to 30 MHz. This mechanism becomes active as soon as the power at the input mixer exceeds the specified limit. It ensures that the connection between RF input and input mixer is cut off.

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

Radio Frequency State

Activates input from the "RF Input" connector.

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

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

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

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

Remote command:
`INPut:SELect` on page 168
`INPut:TYPE` on page 169

Input Coupling

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

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

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

Not available for input from the optional "Digital 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 specifications document.

Remote command:
`INPut:COUPling` on page 166

Impedance

The FSW has an internal impedance of 50 Ω. However, some applications use other impedance values. To match the impedance of an external application to the impedance of the FSW, an *impedance matching pad* can be inserted at the input. If the type and impedance value of the used matching pad is known to the FSW, it can convert the measured units accordingly so that the results are calculated correctly.

For an active external frontend, impedance is always 50 Ω.

This function is not available for input from the optional "Digital Baseband" interface. Not all settings are supported by all FSW applications.

The impedance conversion does not affect the level of the output signals (such as IF, video, demod, digital I/Q output).

"50Ω" (Default:) no conversion takes place

"75Ω" The 50 Ω input impedance is transformed to a higher impedance using a 75 Ω adapter of the selected "Pad Type": "Series-R" (default) or "MLP" (Minimum Loss Pad)

"User" The 50 Ω input impedance is transformed to a user-defined impedance value according to the selected "Pad Type": "Series-R" (default) or "MLP" (Minimum Loss Pad)

Remote command:
`INPut:IMPedance` on page 167
`INPut:IMPedance:PTYPe` on page 168
For Analog Baseband input:
`INPut:IQ:IMPedance` on page 211
`INPut:IQ:IMPedance:PTYPe` on page 211

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.

For an active external frontend, the direct path is always used automatically for frequencies close to zero.

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

"Off" The analog mixer path is always used.

Remote command:
`INPut:DPATh` on page 166

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.

This function requires an additional hardware option.

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

Remote command:
`INPut:FILTer:HPASs[:STATe]` on page 167

YIG-Preselector
Enables or disables the YIG-preselector.

This setting requires an additional option on the FSW.

Remote command:
`INPut:FILTer:YIG[:STATe]` on page 167

Input Connector
Determines which connector the input data for the measurement is taken from.

For more information on the optional "Analog Baseband" interface, see the FSW I/Q Analyzer and I/Q Input user manual.

"RF" (Default:) The "RF Input" connector

"RF Probe" The "RF Input" connector with an adapter for a modular probe
This setting is only available if a probe is connected to the "RF Input" connector.
It is not available for an active external frontend.

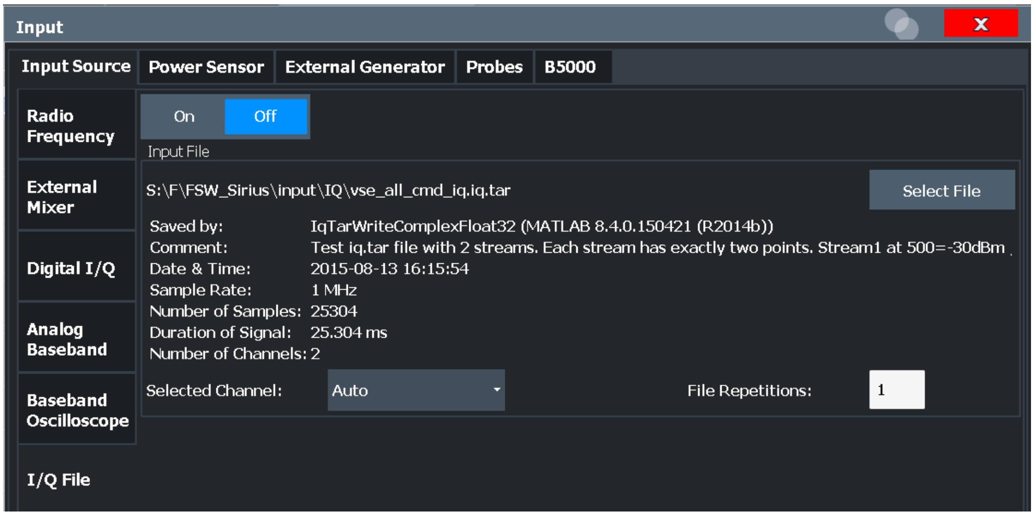
"Baseband Input I" The optional "Baseband Input I" connector
This setting is only available if the optional "Analog Baseband" interface is installed and active for input.
It is not available for the FSW67. For FSW85 models with two input connectors, this setting is only available for "Input 1".

Remote command:
`INPut:CONNector` on page 165

4.3.1.2 Settings for input from I/Q data files

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

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



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

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

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

Remote command:
`INPut:SELect` on page 168

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

The I/Q data file must be in one of the following supported formats:
- `.iq.tar`
- `.iqw`
- `.csv`
- `.mat`
- `.wv`
- `.aid`

For details on formats, see the FSW I/Q Analyzer and I/Q Input user manual.

The file type is determined by the file extension. If no file extension is provided, the file type is assumed to be `.iq.tar`. For `.mat` files, Matlab® v4 is assumed.

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

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

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

Remote command:
`INPut:FILE:PATH` on page 169

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

Remote command:
`TRACe:IQ:FILE:REPetition:COUNt` on page 171

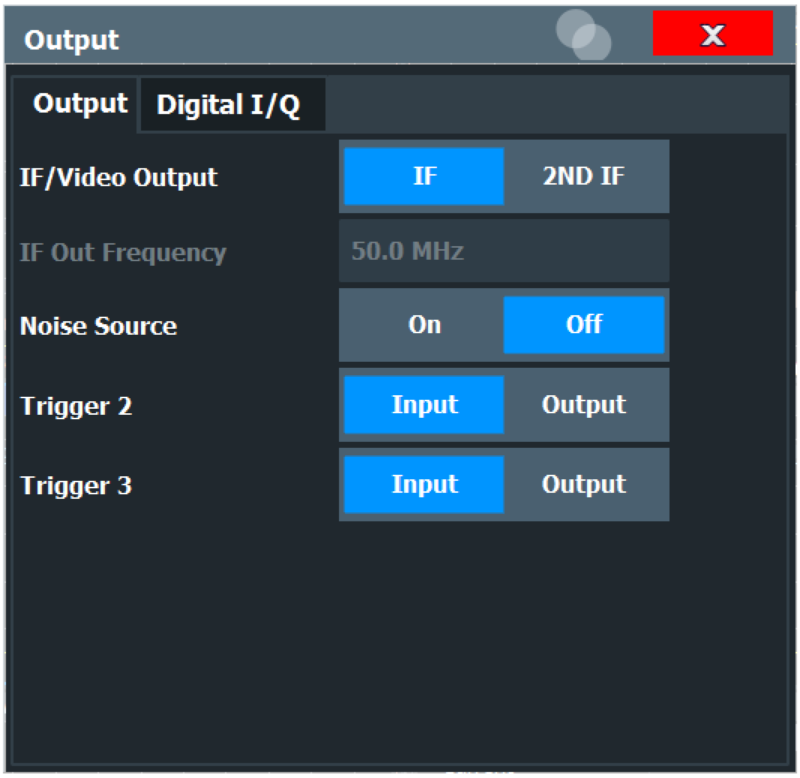
4.3.2 Output settings

Access: [INPUT/OUTPUT] > "OUTPUT Config"

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

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

Output settings can be configured via [Input/Output] or in the "Output" dialog box.



Data Output

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

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

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

Remote command:
`OUTPut:IF[:SOURce]` on page 255

Noise Source Control

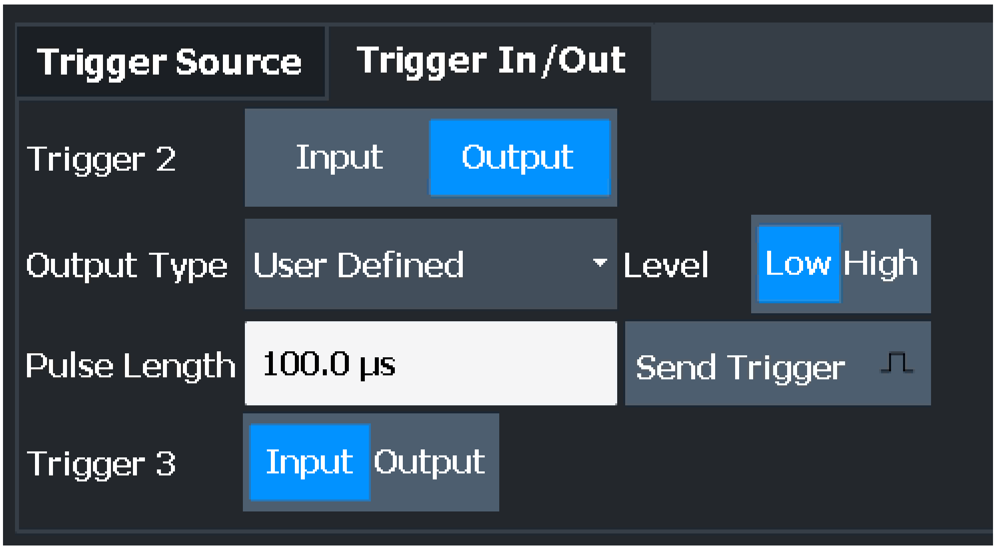
Enables or disables the 28 V voltage supply for an external noise source connected to the "Noise source control / Power sensor") connector. By switching the supply voltage for an external noise source on or off in the firmware, you can enable or disable the device as required.

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

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

Remote command:
`DIAGnostic:SERVice:NSOurce` on page 254

Trigger 2/3



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

"Trigger 1" "Trigger 1" is input only.

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

Remote command:
`OUTPut:TRIGger<tp>:DIRection` on page 255

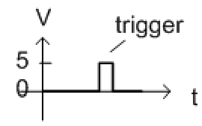
Output Type ← Trigger 2/3
Type of signal to be sent to the output

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

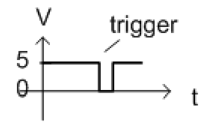
Remote command:
`OUTPut:TRIGger<tp>:OTYPe` on page 256

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

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



low-level constant, high-level trigger



high-level constant, low-level trigger

Remote command:
`OUTPut:TRIGger<tp>:LEVel` on page 256

Pulse Length ← Output Type ← Trigger 2/3
Defines the duration of the pulse (pulse width) sent as a trigger to the output connector.

Remote command:
`OUTPut:TRIGger<tp>:PULSe:LENGth` on page 257

Send Trigger ← Output Type ← Trigger 2/3
Sends a user-defined trigger to the output connector immediately.

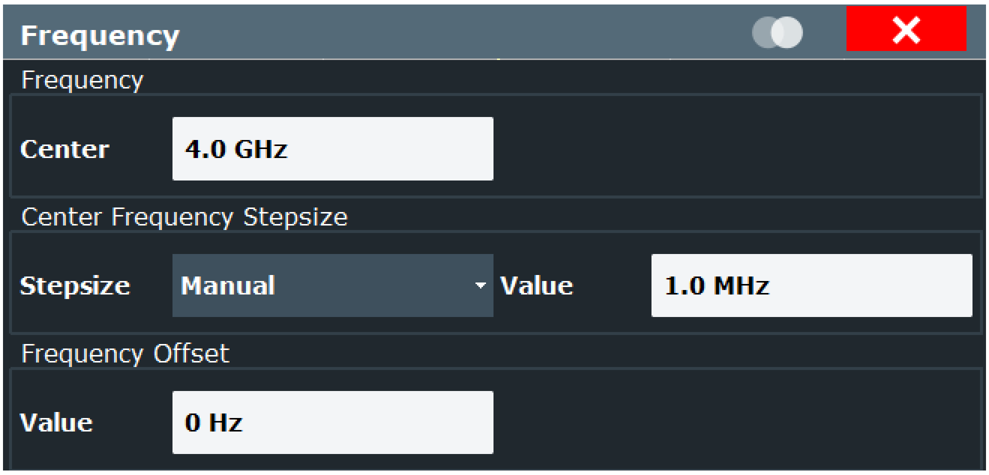
Note that the trigger pulse level is always opposite to the constant signal level defined by the output Level setting. For example, for "Level" = "High", a constant high signal is output to the connector until you select the "Send Trigger" function. Then, a low pulse is sent.

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

Remote command:
`OUTPut:TRIGger<tp>:PULSe:IMMediate` on page 257

4.3.3 Frequency settings

Access: [FREQ] > "Frequency Config"



Center Frequency
Defines the center frequency of the signal in Hertz.

f_{max} and $span_{min}$ depend on the instrument and are specified in the specifications document.

Remote command:
`[SENSe:]FREQuency:CENTer` on page 229

Center Frequency Stepsize
Defines the step size when scrolling through center frequency values. The step size can be set to a predefined value, or it can be manually set to a user-defined value.

"Auto" The step size is set to the default value:
- using the rotary knob: 100 kHz
- using the arrow keys: 1 MHz

"Manual" Defines a user-defined step size for the center frequency. Enter the step size in the "Value" field.

Remote command:
[SENSe:]FREQuency:CENTer:STEP:AUTO on page 230
[SENSe:]FREQuency:CENTer:STEP on page 230

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.

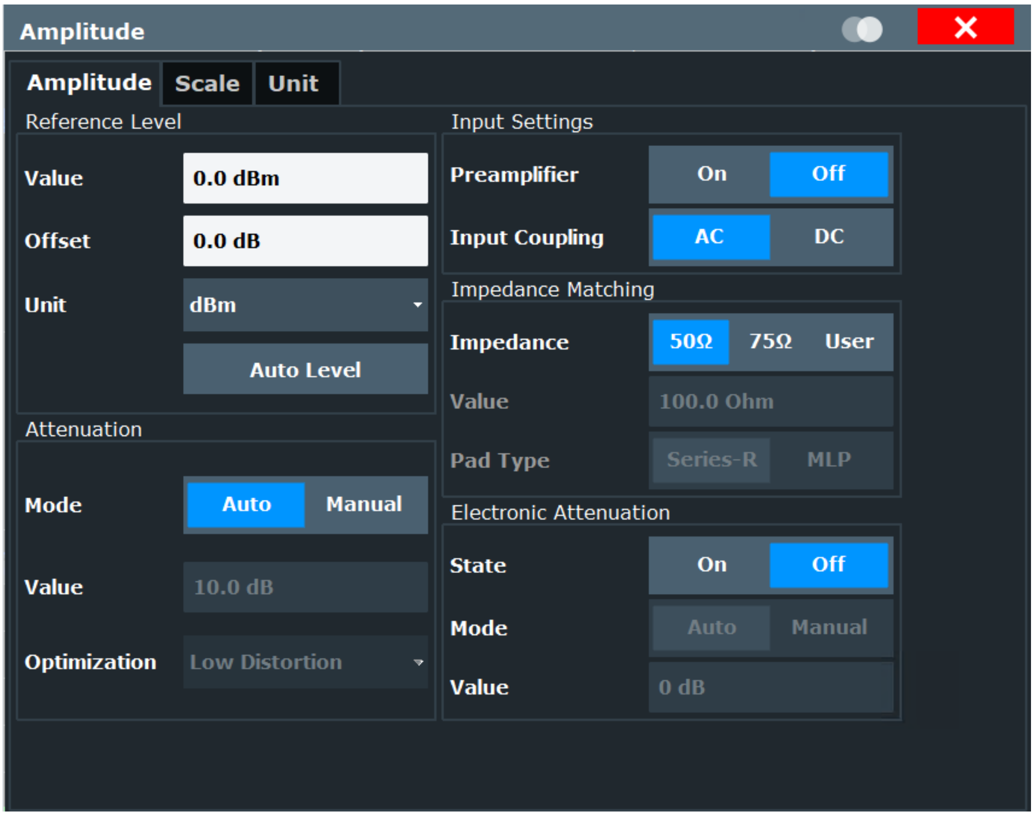
Note: In MSRA mode, this function is only available for the MSRA primary.

Remote command:
[SENSe:]FREQuency:OFFSet on page 230

4.3.4 Amplitude settings

Access: [AMPT] > "Amplitude Config"

Amplitude settings affect the signal power or error levels.



Note that amplitude settings are not window-specific, as opposed to the scaling and unit settings.

Reference Level

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

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

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

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

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

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel` on page 231

Shifting the Display (Offset) ← Reference Level
Defines an arithmetic level offset. This offset is added to the measured level. In some result displays, the scaling of the y-axis is changed accordingly.

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

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

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

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel:OFFSet` on page 231

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

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

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

Remote command:
`[SENSe:]ADJust:LEVel` on page 232

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

For information on other input settings, see Chapter 4.3.1, "Input settings", on page 68.

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

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

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

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

This function is not available for input from the (optional) "Digital Baseband" interface.

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

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

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

For FSW85 models, no preamplifier is available.

Remote command:
`INPut:GAIN:STATe` on page 236
`INPut:GAIN[:VALue]` on page 236

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

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

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

Not available for input from the optional "Digital 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 specifications document.

Remote command:
`INPut:COUPling` on page 166

Impedance
The FSW has an internal impedance of 50 Ω. However, some applications use other impedance values. To match the impedance of an external application to the impedance of the FSW, an *impedance matching pad* can be inserted at the input. If the type and impedance value of the used matching pad is known to the FSW, it can convert the measured units accordingly so that the results are calculated correctly.

For an active external frontend, impedance is always 50 Ω.

This function is not available for input from the optional "Digital Baseband" interface. Not all settings are supported by all FSW applications.

The impedance conversion does not affect the level of the output signals (such as IF, video, demod, digital I/Q output).

"50Ω"	(Default:) no conversion takes place
"75Ω"	The 50 Ω input impedance is transformed to a higher impedance using a 75 Ω adapter of the selected "Pad Type": "Series-R" (default) or "MLP" (Minimum Loss Pad)
"User"	The 50 Ω input impedance is transformed to a user-defined impedance value according to the selected "Pad Type": "Series-R" (default) or "MLP" (Minimum Loss Pad)

Remote command:
`INPut:IMPedance` on page 167
`INPut:IMPedance:PTYPe` on page 168
For Analog Baseband input:
`INPut:IQ:IMPedance` on page 211
`INPut:IQ:IMPedance:PTYPe` on page 211

RF Attenuation
Defines the mechanical attenuation for RF input.

This function is not available for input from the optional R&S Digital Baseband Interface.

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

This function is not available for input from the optional "Digital Baseband" interface.

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

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

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

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

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

Remote command:
INPut:ATTenuation on page 232
INPut:ATTenuation:AUTO on page 233
Defining attenuation for the analyzer when using an external frontend:
INPut:SANalyzer:ATTenuation:AUTO on page 235
INPut:SANalyzer:ATTenuation on page 234

Optimization
Selects the priority for signal processing *after* the RF attenuation has been applied.

This function is only available under the following conditions:
- One of the following options that provide a separate wideband processing path in the FSW is installed:
  - Bandwidth extension R&S FSW-B160/-B320 Extension Board 1, Revision 2 or higher
  - Bandwidth extension R&S FSW-B512, B1200, B2001, B4001, B6001, or B8001
  - Real-time option R&S FSW-B160R
    (Currently not supported for K161R, B512R and B800R/K800RE)
- An I/Q bandwidth that requires the wideband path is used.
- The optional "Digital Baseband" interface is not active.

"Low distortion"
(Default:) Optimized for low distortion by avoiding intermodulation

"Low noise" Optimized for high sensitivity and low noise levels
If this setting is selected, "Low noise" is indicated in the channel information bar.

Remote command:
INPut:ATTenuation:AUTO:MODE on page 233

Signal Path
Selects the signal path for signal processing.

"Narrowband" (Default:) The narrowband signal path is used.

"Wideband" The wideband signal path is used. With this setting, the dynamic range for EVM measurements is increased.

This function is only available under the following conditions:
- Instrument models FSW50/67/85
- One of the following bandwidth extension options is installed:
  - R&S FSW-B1200
  - R&S FSW-B2001
  - R&S FSW-B800R
- An I/Q bandwidth between 80 MHz and 512 MHz is used.
- The center frequency is higher than 43.5 GHz.
- The optional "Digital Baseband" interface is not active.

Remote command:
[SENSe:]IQ:WBANd on page 235

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

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

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

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

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

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

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

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

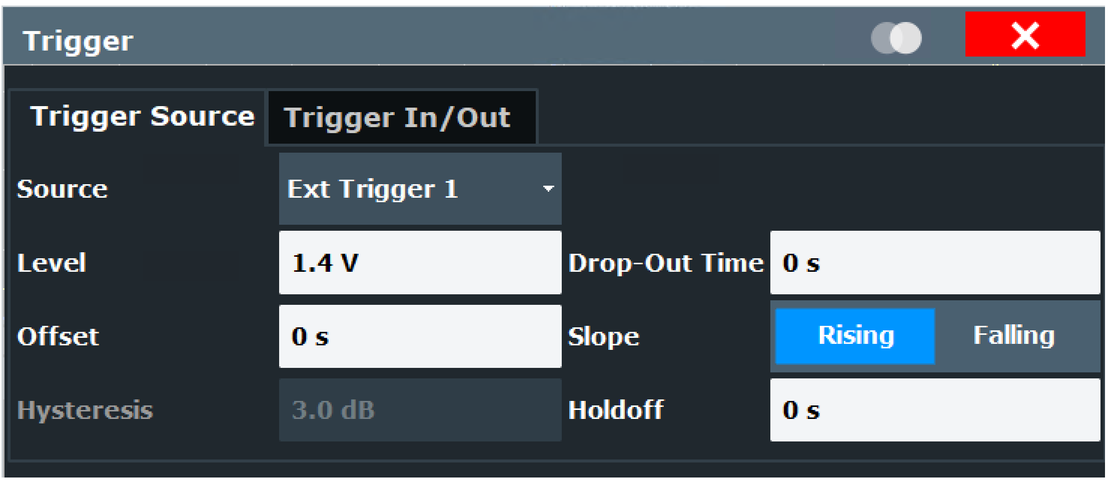
Remote command:
`INPut:EATT:STATe` on page 234
`INPut:EATT:AUTO` on page 234
`INPut:EATT` on page 233

4.4 Trigger settings

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

Or: [TRIG] > "Trigger Config"

The trigger settings define the beginning of a measurement.



For step-by-step instructions on configuring triggered measurements, see the FSW user manual.

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 240

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 240

External Trigger 1/2/3 ← Trigger Source

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

(See "Trigger Level" on page 88).

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

For details, see the "Instrument Tour" chapter in the FSW Getting Started manual.

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

"External Trigger 2"
Trigger signal from the "TRIGGER 2 INPUT / OUTPUT" connector.
For FSW85 models, "Trigger 2" is not available due to the second RF input connector on the front panel.

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

Remote command:
`TRIG:SOUR EXT`, `TRIG:SOUR EXT2`
`TRIG:SOUR EXT3`
See `TRIGger[:SEQuence]:SOURce` on page 240

External Channel 3 ← Trigger Source
Data acquisition starts when the signal fed into the "Ch3" input connector on the oscilloscope meets or exceeds the specified trigger level.

Note: In previous firmware versions, the external trigger was connected to the *"Ch2"* input on the oscilloscope. As of firmware version FSW 2.30, the *"Ch3"* input on the oscilloscope must be used!

This trigger source is only available if the optional 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000) is active (see FSW I/Q Analyzer and I/Q Input User Manual).

Note: Since the external trigger uses a second channel on the oscilloscope, the maximum memory size, and thus record length, available for the input channel 1 may be reduced by half. For details, see the oscilloscope's specifications document and documentation.

Remote command:
`TRIG:SOUR EXT`
See `TRIGger[:SEQuence]:SOURce` on page 240

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

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

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

This trigger source is only available for RF input.

Available for input from the optional "Analog Baseband" interface.

Available for input from the optional "Digital Baseband" interface.

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

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

Remote command:
`TRIG:SOUR IFP`, see `TRIGger[:SEQuence]:SOURce` on page 240

Baseband Power ← Trigger Source
Defines triggering on the baseband power for baseband input.

Available for input from the optional "Analog Baseband" interface.

Available for input from the optional "Digital Baseband" interface.

Remote command:
`TRIG:SOUR BBP`, see `TRIGger[:SEQuence]:SOURce` on page 240

I/Q Power ← Trigger Source
Not available for the optional "Digital Baseband" interface.

Triggers the measurement when the magnitude of the sampled I/Q data exceeds the trigger threshold.

Remote command:
`TRIG:SOUR IQP`, see `TRIGger[:SEQuence]:SOURce` on page 240

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

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

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

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

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

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

Not available for input from the optional "Digital 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 240

Time ← Trigger Source
Triggers in a specified repetition interval.

See "Repetition Interval" on page 88.

Remote command:
`TRIG:SOUR TIME`, see `TRIGger[:SEQuence]:SOURce` on page 240

Digital I/Q ← Trigger Source
For applications that process I/Q data, such as the I/Q Analyzer or optional applications, and only if the optional "Digital Baseband" interface is available:

Defines triggering of the measurement directly via the "LVDS" connector. In the selection list, specify which general-purpose bit ("GP0" to "GP5") provides the trigger data.

Note: If the Digital I/Q enhanced mode is used, i.e. the connected device supports transfer rates up to 200 Msps, only the general-purpose bits "GP0" and "GP1" are available as a Digital I/Q trigger source.

The following table describes the assignment of the general-purpose bits to the LVDS connector pins.

Table 4-1: Assignment of general-purpose bits to LVDS connector pins

Bit	LVDS pin
GP0	SDATA4_P - Trigger1
GP1	SDATA4_P - Trigger2
GP2 *)	SDATA0_P - Reserve1
GP3 *)	SDATA4_P - Reserve2
GP4 *)	SDATA0_P - Marker1
GP5 *)	SDATA4_P - Marker2
*): not available for Digital I/Q enhanced mode	

Remote command:
`TRIG:SOUR GP0`, see `TRIGger[:SEQuence]:SOURce` on page 240

Trigger Level

Defines the trigger level for the specified trigger source.

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

Remote command:
`TRIGger[:SEQuence]:LEVel[:EXTernal<port>]` on page 239
For baseband input only:
`TRIGger[:SEQuence]:LEVel:BBPower` on page 239

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 241

Trigger Offset

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

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

Remote command:
`TRIGger[:SEQuence]:HOLDoff[:TIME]` on page 238

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" trigger sources. The range of the value is between 3 dB and 50 dB with a step width of 1 dB.

Remote command:
`TRIGger[:SEQuence]:IFPower:HYSTeresis` on page 238

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

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 238

Coupling
If the selected trigger source is "IF Power" or "External Channel 3", you can configure the coupling of the external trigger to the oscilloscope.

This setting is only available if the optional 2 GHz bandwidth extension is active.

"DC 50Ω"	Direct connection with 50 Ω termination, passes both DC and AC components of the trigger signal.
"DC 1 MΩ"	Direct connection with 1 MΩ termination, passes both DC and AC components of the trigger signal.
"AC"	Connection through capacitor, removes unwanted DC and very low-frequency components.

Remote command:
`TRIGger[:SEQuence]:OSCilloscope:COUPling` on page 223

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.

When using the optional 2 GHz / 5 GHz bandwidth extension (R&S FSW-B2000/B5000) with an IF power trigger, only rising slopes can be detected.

Remote command:
`TRIGger[:SEQuence]:SLOPe` on page 240

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.

Remote command:
`TRIGger[:SEQuence]:IFPower:HOLDoff` on page 238

Capture Offset
This setting is only available for secondary applications in **MSRA operating mode**. It has a similar effect as the trigger offset in other measurements: it defines the time offset between the capture buffer start and the start of the extracted secondary application data.

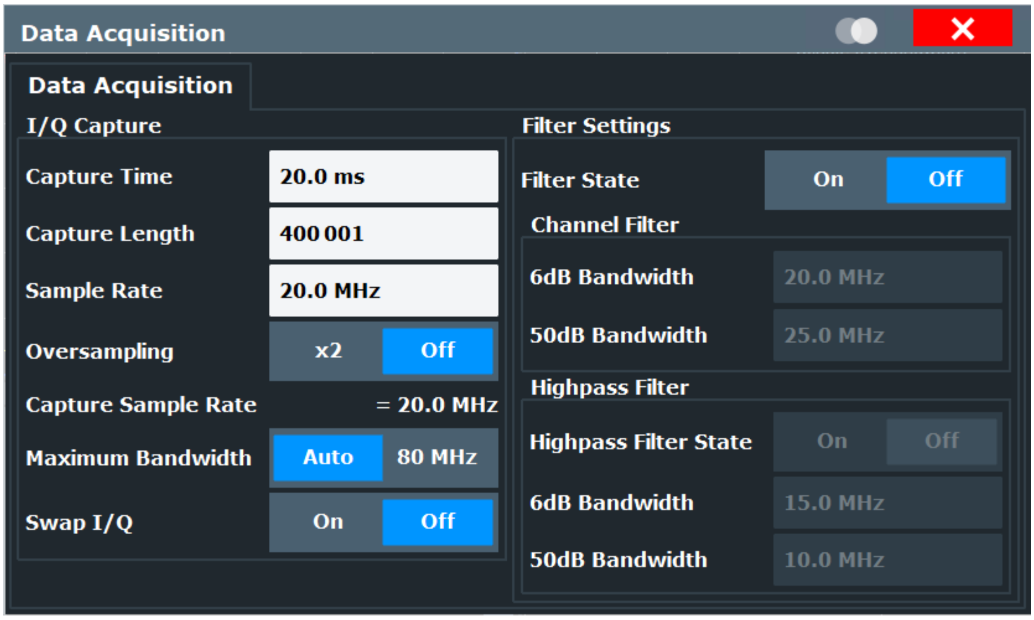
In MSRA mode, the offset must be a positive value, as the capture buffer starts at the trigger time = 0.

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

Remote command:
`[SENSe:]MSRA:CAPTure:OFFSet` on page 286

4.5 Data acquisition

Configure how data is to be acquired in the "Data Acquisition" dialog box.



MSRA operating mode

In MSRA operating mode, only the MSRA primary channel actually captures data from the input signal. The data acquisition settings for the OFDM VSA application in MSRA mode define the **application data extract** and **analysis interval**.

For details on the MSRA operating mode, see the FSW MSRA User Manual.

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 245

Capture Length
Defines the number of samples to be captured during each measurement. The required Capture Time is adapted accordingly.

A maximum of 8 000 000 samples can be captured.

Remote command:
`[SENSe:]SWEep:LENGth` on page 245

Sample Rate
Defines the I/Q data sample rate of the R&S FSW OFDM VSA application used for demodulation.

Note that the sample rate in the R&S FSW OFDM VSA application must correspond to the OFDM system sample rate, otherwise demodulation can fail.

Remote command:
`TRACe:IQ:SRATe` on page 246

Oversampling / Capture Sample Rate
By default, the R&S FSW OFDM VSA application captures data with a usable I/Q bandwidth that is 0.8 * sample rate.

(See Chapter 3.5, "Sample rate and maximum usable I/Q bandwidth for RF input", on page 40)

However, for some signals and measurements, a higher bandwidth is required. In this case, you can force the R&S FSW OFDM VSA application to capture with twice the sample rate, which is referred to as *capture oversampling*.

Oversampling is not available in the following cases:
- A channel filter is enabled (see "Filter State" on page 93).
  In this case, an oversampling factor of 2 is applied automatically.

- The defined Sample Rate is higher than half the maximum sample rate the FSW supports.

The actual "Capture Sample Rate", that is: the rate with which the R&S FSW OFDM VSA application samples data, is calculated as:

Sample Rate * Oversampling factor

If you are analyzing data from an input file, the "Capture Sample Rate" indicates the rate with which the R&S FSW OFDM VSA application initially processes the data in the file.

In MSRA operating mode, only the MSRA primary channel actually captures data from the input signal. In this case, the "Capture Sample Rate" indicates the rate with which the R&S FSW OFDM VSA application receives data from the primary application.

"2x"	An oversampling of 2 is applied. The sample rate with which the R&S FSW OFDM VSA application captures data is twice the system sample rate.
"Off"	No oversampling is applied, the capture sample rate of the R&S FSW OFDM VSA application and the system sample rate are identical.

Remote command:
`[SENSe:]CAPTure:OVERsampling` on page 244

Maximum Bandwidth

Defines the maximum bandwidth to be used by the FSW for I/Q data acquisition. Which options are available depends on which bandwidth extension options are installed.

This setting is only available if a bandwidth extension option greater than 160 MHz is installed on the FSW. Otherwise the maximum bandwidth is determined automatically.

"Auto"	(Default:) All installed bandwidth extension options are enabled. The currently available maximum bandwidth is allowed. Note that using bandwidth extension options greater than 160 MHz may cause more spurious effects.
"80 MHz"	Restricts the analysis bandwidth to a maximum of 80 MHz. The bandwidth extension options greater than 160 MHz are disabled.
"160 MHz"	Restricts the analysis bandwidth to a maximum of 160 MHz. The bandwidth extension option for 320 MHz is disabled. (Not available or required if other bandwidth extension options larger than 320 MHz are installed.)
"512 MHz"	Restricts the analysis bandwidth to a maximum of 512 MHz. Larger bandwidth extension options are disabled.
"1200 MHz"	Restricts the analysis bandwidth to a maximum of 1200 MHz. Larger bandwidth extension options are disabled.

Remote command:
`TRACe:IQ:WBANd[:STATe]` on page 246
`TRACe:IQ:WBANd:MBWidth` on page 246

Swap I/Q

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

On	I and Q signals are interchanged Inverted sideband, Q+j*I
Off	I and Q signals are not interchanged Normal sideband, I+j*Q

Remote command:
[SENSe:]SWAPiq on page 244

Filter State

Defines whether a channel filter - and a highpass filter, if active - is applied to the I/Q data before OFDM demodulation.

Remote command:
INPut:FILTer:CHANnel[:LPASs][:STATe] on page 243

6-dB Bandwidth

Configures the bandwidth of the channel filter at which an attenuation of 6 dB is reached (see Figure 4-5). The filter bandwidth cannot be higher than the current Sample Rate. If necessary, the filter bandwidth is adapted to the current sample rate.

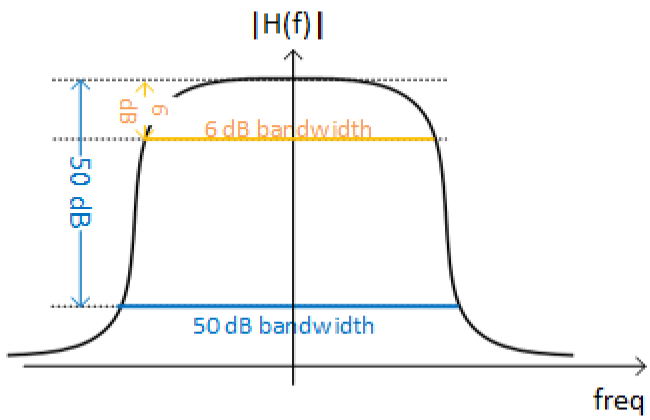


Figure 4-5: Definition of filter bandwidths

Remote command:
INPut:FILTer:CHANnel[:LPASs]:SDBBw on page 243

50-dB Bandwidth

Configures the 50-dB bandwidth of the channel filter. The 50-dB bandwidth is the bandwidth at which the filter reaches an attenuation of 50 dB (see Figure 4-5). This bandwidth must always be larger than the "6-dB Bandwidth" on page 93. If necessary, the 50-dB bandwidth is adapted to the current 6-dB bandwidth.

Remote command:
INPut:FILTer:CHANnel[:LPASs]:FDBBw on page 243

Highpass Filter State
Activates or deactivates an additional internal highpass filter.

Remote command:
`INPut:FILTer:CHANnel:HPASs[:STATe]` on page 243

6-dB Bandwidth
Configures the bandwidth of the high pass filter at which an attenuation of 6 dB is reached (see Figure 4-5). The filter bandwidth cannot be higher than the current 6-dB Bandwidth of the channel filter. If necessary, the filter bandwidth is adapted to the same value.

Remote command:
`INPut:FILTer:CHANnel:HPASs:SDBBw` on page 242

50-dB Bandwidth
Indicates the 50-dB bandwidth of the high pass filter. The 50-dB bandwidth is the bandwidth at which the filter reaches an attenuation of 50 dB (see Figure 4-5). This bandwidth must always be smaller than the 6-dB Bandwidth of the high pass filter.

The 50-dB bandwidth cannot be defined manually. It is automatically determined according to the relation between the 6-dB bandwidth and the 50-dB bandwidth of the channel filter (see 6-dB Bandwidth and 50-dB Bandwidth).

Remote command:
`INPut:FILTer:CHANnel:HPASs:FDBBw?` on page 242

4.6 Sweep settings

Access: [Sweep]

The sweep settings define how often data from the input signal is acquired and then evaluated.

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

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

Note: Sequencer. If the Sequencer is active, "Continuous Sweep" only controls the sweep mode for the currently selected channel. However, the sweep mode only takes effect the next time the Sequencer activates that channel, and only for a channel-defined sequence. In this case, a channel in continuous sweep mode is swept repeatedly.

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

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

Remote command:
`INITiate<n>:CONTinuous` on page 259

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

Note: Sequencer. If the Sequencer is active, "Single Sweep" only controls the sweep mode for the currently selected channel. However, the sweep mode only takes effect the next time the Sequencer activates that channel, and only for a channel-defined sequence. In this case, the Sequencer sweeps a channel in single sweep mode only once.
Furthermore, [RUN SINGLE] controls the Sequencer, not individual sweeps. [RUN SINGLE] starts the Sequencer in single mode.

If the Sequencer is off, only the evaluation for the currently displayed channel is updated.

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

Remote command:
`INITiate<n>[:IMMediate]` on page 259

Refresh
Repeats the evaluation of the data currently in the capture buffer without capturing new data.

Remote command:
`INITiate<n>:REFResh` on page 259

Statistic Config / Max No of Frames to Analyze
Defines the maximum number of OFDM frames from the current capture buffer to be included in analysis.

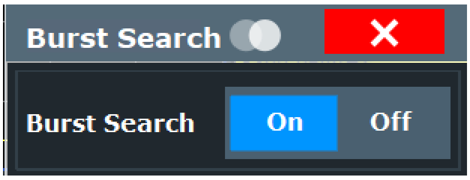
If a configuration file is available, the contents of the file determine the frame. If no file is available, a single result range is considered a frame.

Remote command:
`[SENSe:]DEMod:FORMat:MAXFrames` on page 247

4.7 Burst search

Access: "Overview" > "Burst Search"

Or: "Meas Setup" > "Burst Search"



During a burst search, the capture buffer is searched for bursts that comply with the signal description. If no bursts are detected, the entire capture buffer is considered to be a single burst. A list of the detected bursts is passed on to the next processing stage.

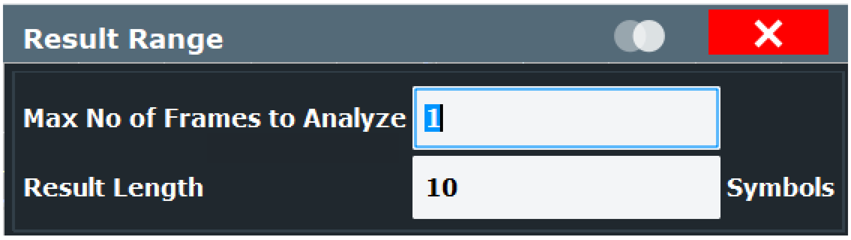
See also Chapter 3.4, "OFDM measurement", on page 37.

Burst Search State
Activates or deactivates a burst search.

Remote command:
`[SENSe:]DEMod:FORMat:BURSt` on page 247

4.8 Result ranges

The result range is an extract from the capture buffer and defines the data basis used for further analysis.



Statistic Config / Max No of Frames to Analyze
Defines the maximum number of OFDM frames from the current capture buffer to be included in analysis.

If a configuration file is available, the contents of the file determine the frame. If no file is available, a single result range is considered a frame.

Remote command:
`[SENSe:]DEMod:FORMat:MAXFrames` on page 247

Result Length
Configures the number of OFDM symbols per frame to be analyzed. Note that this is not the maximum, but a precise number. If this number is higher than the actual number of symbols found in the signal, the result is not considered a frame, and not analyzed.

Note: If a loaded configuration file contains a `<DefaultResultLength>` entry, the specified value is used as the default result length for the current measurement setup.

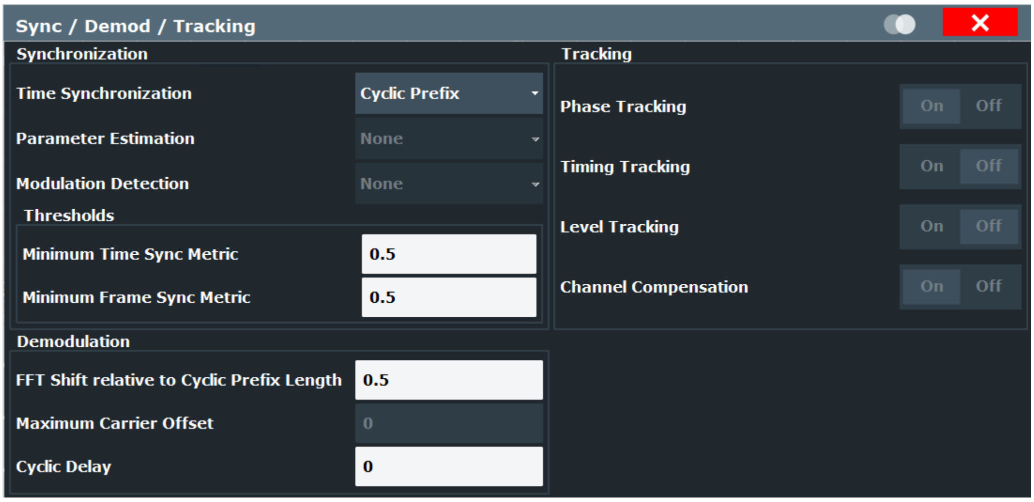
Remote command:
`[SENSe:]DEMod:FORMat:NOFSymbols` on page 248

4.9 Synchronization, demodulation and tracking

Access: "Overview" > "Sync / Demod"/"Tracking"

Or: "Meas Setup" > "Sync / Demod"/"Tracking"

The following settings determine how the input signal is synchronized, demodulated, and tracked.



Time Synchronization

Specifies the synchronization method in the time domain.

"Cyclic Prefix" The cyclic prefix method performs a correlation of the cyclic prefix with the end of the FFT interval.

"Preamble" The preamble method searches for the repetitive preamble blocks.

Remote command:
[SENSe:]DEMod:TSYNc on page 251

Parameter Estimation

Defines which parts of the OFDM signal are used for the parameter estimation.

This setting is only available if a configuration file is loaded and active (see "Use Configuration File" on page 63). In manual configuration mode without a configuration file, no parameter estimation is performed.

"Pilot-Aided" Uses only the predefined pilot cells for parameter estimation.
Requires at least 1 OFDM symbol containing pilot cells (in previous versions: 2 symbols). For sample clock error estimation and tracking functions, at least 2 OFDM symbols with pilots are required.
See also Chapter 3.4.2, "Pilot-aided block", on page 38.

"Pilot And Data-Aided"
Uses both pilots and detected data cells for an additional synchronization step.

Remote command:
[SENSe:]DEMod:FSYNc on page 249

Modulation Detection

Specifies how the modulation of the data cells is detected.

The R&S FSW OFDM VSA application can use the modulation configured in the configuration file for each cell.

Alternatively, the R&S FSW OFDM VSA application tries to detect the used modulation automatically based on the available modulation types (which are also defined in the configuration file). For automatic detection, the R&S FSW OFDM VSA application analyzes the modulation type per carrier or per symbol.

This setting is only available if a configuration file is loaded and active (see "Use Configuration File" on page 63).

"Configuration File" The modulation format configured for the cell is used.
Note that if the actual modulation of a constellation point differs from the configured modulation for the cell, the EVM is increased.

"Symbolwise" A common modulation format for all data cells within one OFDM symbol is determined.

"Carrierwise" A common modulation format for all data cells within one OFDM carrier is determined.

Remote command:
[SENSe:]DEMod:MDETect on page 250

Synchronization Thresholds

If you require particular reliability in synchronization results, define thresholds for the success of synchronization required to calculate results. The current reliability is indicated in the Signal Flow.

High thresholds are useful if several similar, but not identical frames, must be distinguished. In this case, it is important that the application synchronizes only to the correct frame to obtain correct results.

On the other hand, if the signal quality is poor, only a low level of reliability in synchronization can be achieved. In this case, high thresholds can prevent the application from evaluating any frames at all.

For details, see Chapter 3.4.1, "Synchronization block", on page 38.

Minimum Time Sync Metric ← Synchronization Thresholds
Defines the minimum reliability required for time synchronization.

Values between 0 and 1 are allowed, where:

- 0: low threshold, very poor reliability is sufficient to synchronize successfully (always fulfilled)
- 1: high threshold, time synchronization must be absolutely reliable to be successful (only possible for ideal signal).

The default value is 0.5, that means: for reliability of 50 %, time synchronization is successful.

Remote command:
`[SENSe:]DEMod:THReshold:TIME` on page 250

Minimum Frame Sync Metric ← Synchronization Thresholds
Defines the minimum correlation rate of the CP or preamble for frame synchronization to be successful.

Values between 0 and 1 are allowed, where:

- 0: low threshold, a very poor correlation is sufficient to synchronize successfully (always fulfilled)
- 1: high threshold, correlation must be very precise for frame synchronization to be successful (only possible for ideal signal).

The default value is 0.5, that means: for a correlation of 50 %, frame synchronization is successful.

Remote command:
`[SENSe:]DEMod:THReshold:FRAMe` on page 251

Phase Tracking
Defines whether phase tracking is used to improve the signal quality. The compensation is done on a per-symbol basis. Requires at least two OFDM symbols containing pilots for pilot-aided demodulation.

This setting is only available if a configuration file is loaded and active (see "Use Configuration File" on page 63).

Remote command:
`SENSe:TRACking:PHASe` on page 252

Timing Tracking
Defines whether timing tracking is used to improve the signal quality (for sample clock deviations). The compensation is done on a per-symbol basis. Requires at least two OFDM symbols containing pilots for pilot-aided demodulation.

This setting is only available if a configuration file is loaded and active (see "Use Configuration File" on page 63).

Remote command:
SENSe:TRACking:TIME on page 252

Level Tracking
Defines whether level tracking is used to improve the signal quality (for power level deviations). The compensation is done on a per-symbol basis. Requires at least two OFDM symbols containing pilots for pilot-aided demodulation.

This setting is only available if a configuration file is loaded and active (see "Use Configuration File" on page 63).

Remote command:
SENSe:TRACking:LEVel on page 251

Channel Compensation
Defines whether channel tracking is used to improve the signal quality (for the channel transfer function). The compensation is done on a per-carrier basis.

This setting is only available if a configuration file is loaded and active (see "Use Configuration File" on page 63).

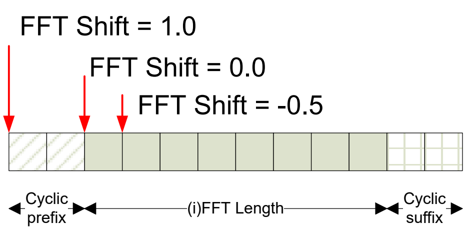
Remote command:
[SENSe:]COMPensate:CHANnel on page 248

FFT Shift relative to Cyclic Prefix Length
Defines the starting point of the FFT relative to the cyclic prefix length. Thus, you can shift the FFT start sample within the guard interval. Shifting is useful if relevant parts of the channel impulse response fall outside the cyclic prefix interval.

A value of 1 is the first sample of the cyclic prefix; a value of 0 is after the last sample of the prefix. A negative value includes part of the cyclic suffix in the FFT.

Note: If a cyclic suffix is used, the FFT shift can be a negative value, down to
-1 (cyclic suffix length / cyclic prefix length)*

(See "Cyclic Suffix Length" on page 65)



Remote command:
[SENSe:]DEMod:FFTShift on page 249

Maximum Carrier Offset
The R&S FSW OFDM VSA application can compensate for possible carrier offsets. However, searching for offsets slows down the measurement. This setting defines the range of carriers in which the R&S FSW OFDM VSA application searches for an offset.

To eliminate the search for carrier offset altogether, set the number of carriers to 0. In this case, the center frequency offset must be less than half the carrier distance to obtain useful results.

This setting is only available if a configuration file is loaded and active (see "Use Configuration File" on page 63).

Remote command:
[SENSe:]DEMod:COFFset on page 249

Cyclic Delay
Defines a cyclic shift of the FFT values for each OFDM symbol on the transmitter end before adding the cyclic prefix. This known shift should be compensated in the receiver to get a correct channel phase response.

Remote command:
[SENSe:]DEMod:CDD on page 248

4.10 Adjusting settings automatically

Access: "Auto Set"

Depending on the FSW, some settings can be adjusted by the instrument automatically according to the current measurement settings. To do so, a measurement is performed.

To activate the automatic adjustment of a setting from the FSW, select the corresponding function in the "Auto Set" menu or in the configuration dialog box for the setting, where available.

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

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

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

Remote command:
[SENSe:]ADJust:LEVel on page 232

5 Creating a configuration file using the wizard

The R&S FSW-K96 Configuration File Wizard (referred to as *wizard* here) is a tool that supports you in defining the configuration of your OFDM signal directly in the R&S FSW OFDM VSA application.

The R&S FSW OFDM VSA application has to know the configuration of the OFDM system to be able to demodulate an OFDM signal correctly. By *configuration*, we refer to the complete description of the OFDM system:

- The number of subcarriers (i.e. the FFT size)
- The number of symbols
- The number of samples in the cyclic prefix (also referred to as guard length)
- The position (carrier number, symbol number) of the:
  - Pilot symbols
  - Data symbols
  - Zero symbols
  - "Do not care" symbols
- The modulation format of the data symbols (e.g. QPSK, 16QAM etc.)
- The I/Q values of the pilot symbols
- Optional: the definition of the preamble

This section describes how to generate the OFDM system configuration file in the R&S FSW OFDM VSA application for the current input signal.

The R&S FSW OFDM VSA application provides some sample files for I/Q input data and configuration files in the `C:\R_S\INSTR\USER\demo\OFDM-VSA` directory.

The R&S FSW-K96 Configuration File Wizard is provided with the R&S FSW OFDM VSA application firmware and stored on the instrument.

It is available from the Windows "Start" menu.

5.1 Understanding the R&S FSW-K96 Configuration File Wizard display

The following figure shows the R&S FSW-K96 Configuration File Wizard user interface. All different areas are labeled. They are explained in more detail in the following sections.

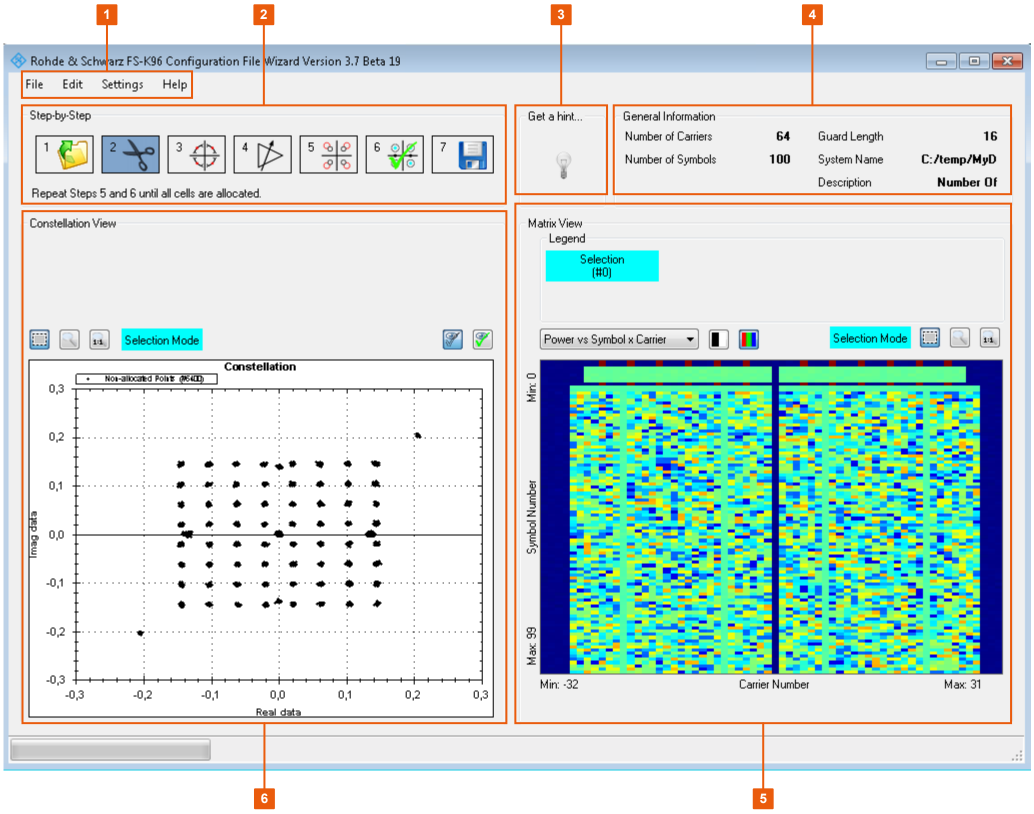
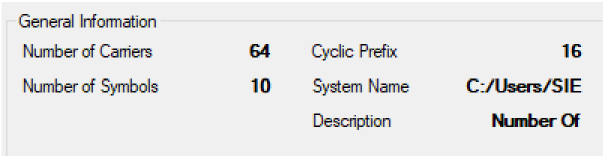


Figure 5-1: Elements of the wizard user interface

1 = Menu functions (see Chapter 5.3, "Reference of wizard menu functions", on page 117)
2 = Progress indicator (see Chapter 5.2, "Configuration steps", on page 109)
3 = Constellation view
4 = Access to wizard help (see Chapter 5.3.4, "Help", on page 122)
5 = General signal information
6 = Matrix view

5.1.1 General signal information

General information on the configured signal is provided here for reference. Some values are derived from the configuration settings in the R&S FSW OFDM VSA application, others are generated by the wizard. The values displayed here are also included in the generated configuration file. If specified in the description, some values are shown in the "Signal Description" dialog box when you load the file in the R&S FSW OFDM VSA application.



Number of Carriers

Indicates the number of subcarriers used by the signal. This value corresponds to the "FFT Size" on page 65.

Number of Symbols

The number of OFDM symbols corresponds to the result length configured in the "Result Range" settings in the R&S FSW OFDM VSA application (see "Result Length" on page 96).

Cyclic Prefix Length

Defines the length of the cyclic prefix (CP) area between two OFDM symbols in samples. The cyclic prefix area defines the guard interval and is expected to contain a copy of the samples at the end of the OFDM symbol.

The cyclic prefix length must be smaller than or equal to the "FFT Size" on page 65.

Remote command:
CONFigure[:SYMBol]:NGUard<cp> on page 161

System Name

Defines the name of the stored configuration file. The default name is MyData. You can change the name in the "Settings" (see Chapter 5.3.3, "Settings", on page 118).

System Description

Provides a description of the signal configured in the file.

By default, the following main characteristics are included:

- Number of Carriers
- Number of Symbols
- Cyclic Prefix Length

If you deactivate the "Default" setting, you can overwrite the text with any other.

5.1.2 Constellation view

The "Constellation View" shows the constellation points (= I/Q values) for the OFDM cells in the defined result range. Using this view, you can assign the measured constellation points to specific cell types for the allocation matrix in the configuration file.

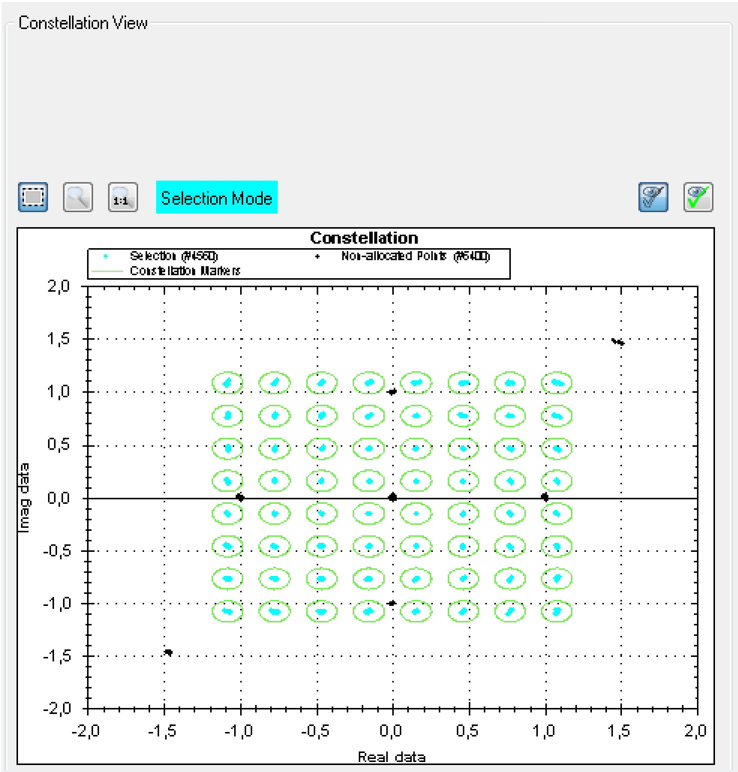
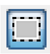


Figure 5-2: Constellation View



Selection tool

Sets the cursor action to selection mode. All cells in the selection area are highlighted in color. The Selection Mode / Zoom Mode indicator shows which color is used. Any subsequent functions are applied to the selected cells.

Click in the diagram and move the cursor, holding the mouse button, to display a dotted rectangle and define the selection area.

Press [Shift] and click in the diagram to extend the selection to neighboring symbols.

Press [CTRL] and click in the diagram to add further (non-neighboring) points to the existing selection. Click the same points again to deselect them.

Zoom

Sets the cursor action to zoom mode. Click in the diagram and move the cursor, holding the mouse button, to display a rectangle and define the zoom area. The zoomed area is enlarged in the display. Repeat the action to zoom in further.

The Selection Mode / Zoom Mode indicator above the diagram shows that zoom mode is active.

To change the cursor function and stop zooming, select Selection tool.

Zoom Off

Displays the diagram in its original size.

Note that this function does not change the cursor function. To change the cursor function and stop zooming, select Selection tool.

The Selection Mode / Zoom Mode indicator above the diagram shows that zoom mode is active.

Selection Mode / Zoom Mode indicator
Indicates whether the current cursor action is to select cells (selection mode), or to define the zoom area. In selection mode, the color used to highlight selected cells is indicated.

Show non-allocated constellation points
Displays or hides the constellation points not yet allocated to a cell type in the "Constellation View".

Show allocated constellation points
Displays or hides the constellation points already allocated to a cell type in the "Constellation View".

5.1.3 Matrix view

The "Matrix View" displays two different diagrams of the measured symbols (y-axis) vs carriers (x-axis).

- "Power vs Symbol x Carrier" diagram
  Shows a colored rectangle (= OFDM cell) for each symbol and carrier, with a different color for each measured power range. Thus, you can easily identify symbols with a similar power value, which therefore most likely belong to the same cell type.

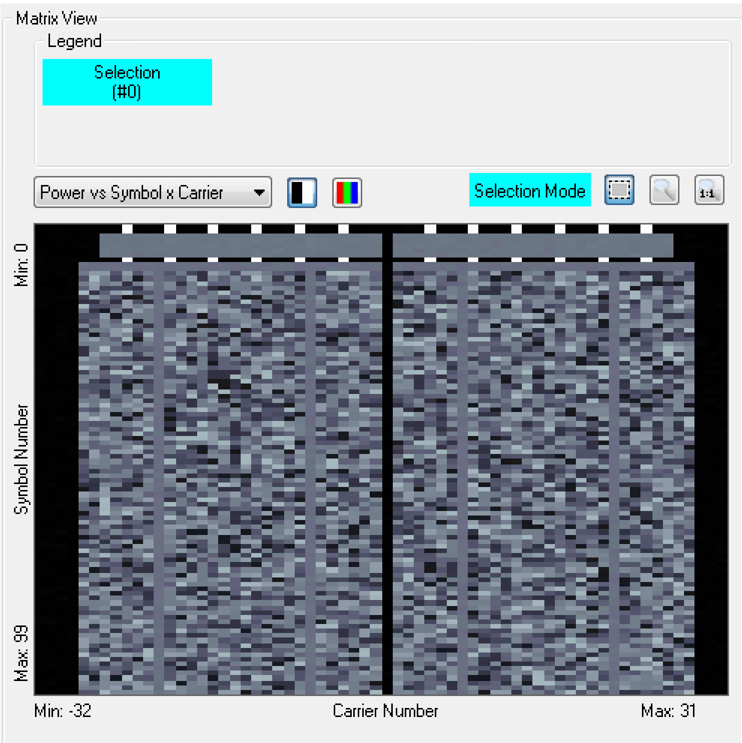


Figure 5-3: Matrix View with Power vs Symbol x Carrier diagram

Either a colored or a black-and-white (gray shades) power indication is available (see Black and white color map / Colored color map). The darker the color, the lower the power of the corresponding OFDM cell.

- "Allocation Matrix"
Shows a colored point for each allocated symbol and carrier, with a different color for each cell type.

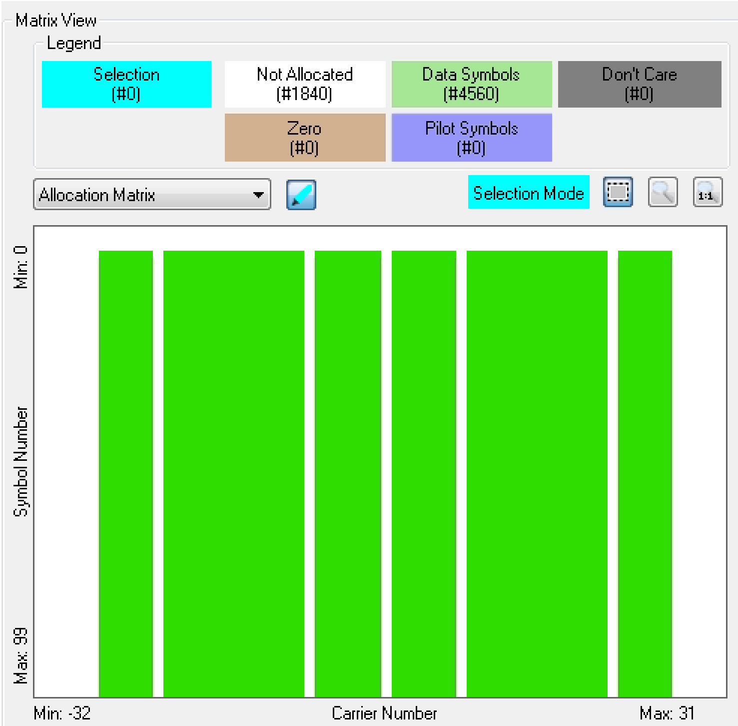
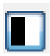


Figure 5-4: Matrix View with Allocation Matrix

Optionally, the selected symbols can be highlighted in the matrix.

Similarly to the "Constellation View", you can also select cells in the "Matrix View" to assign them to specific cell types.

Further zoom and selection functions are provided in the context menu for the diagram (right-click in the diagram).

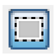


Black and white color map
The different modulation types in the "Power vs Symbol x Carrier" diagram are displayed in different shades of black, white, and gray. The lighter the shade of gray, the higher the power level in the OFDM cell.

Colored color map
The different modulation types in the "Power vs Symbol x Carrier" diagram are displayed in different colors. The used colors are indicated in the legend above the diagram.

Highlight selected cells
The cells in the area selected by the Selection tool are highlighted in the "Allocation Matrix".

Selection Mode / Zoom Mode indicator
Indicates whether the current cursor action is to select cells (selection mode), or to define the zoom area. In selection mode, the color used to highlight selected cells is indicated.



Selection tool
Sets the cursor action to selection mode. All cells in the selection area are highlighted in color. The Selection Mode / Zoom Mode indicator shows which color is used. Any subsequent functions are applied to the selected cells.

Click in the diagram and move the cursor, holding the mouse button, to display a dotted rectangle and define the selection area.

Press [Shift] and click in the diagram to extend the selection to neighboring symbols.

Press [CTRL] and click in the diagram to add further (non-neighboring) points to the existing selection. Click the same points again to deselect them.

Deselect All (context-menu)
Deselects all currently selected symbols or carriers.

Zoom
Sets the cursor action to zoom mode. Click in the diagram and move the cursor, holding the mouse button, to display a rectangle and define the zoom area. The zoomed area is enlarged in the display. Repeat the action to zoom in further.

The Selection Mode / Zoom Mode indicator above the diagram shows that zoom mode is active.

To change the cursor function and stop zooming, select Selection tool.

Zoom Off
Displays the diagram in its original size.

Note that this function does not change the cursor function. To change the cursor function and stop zooming, select Selection tool.

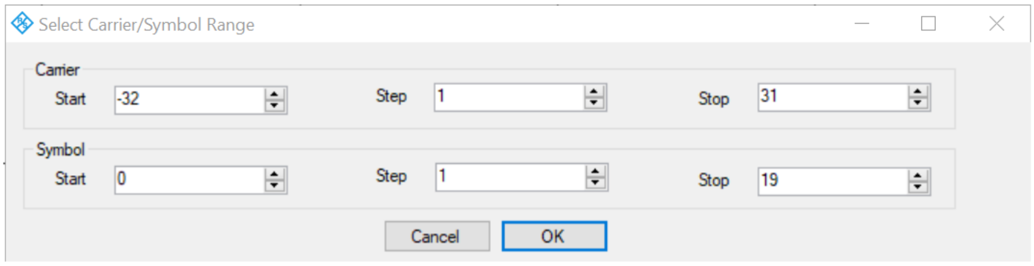
The Selection Mode / Zoom Mode indicator above the diagram shows that zoom mode is active.

Select Symbol / Select Carrier (context-menu)
Selects the symbol or carrier at the current cursor position.

Select Specific Symbol / Select Specific Carrier (context-menu)
Opens an input field to enter a specific symbol or carrier number for selection.

Select Symbol/Carrier Range (context-menu)
Opens a dialog box to define a range of symbols or carriers for selection.

Note that when you accept a range using "OK", it is added to the current selection, instead of replacing it. Thus, you can add a sequence of symbols or carriers before allocating the entire selection in one step. If necessary, use the Deselect All (context-menu) function to empty the selection first.



Start ← Select Symbol/Carrier Range (context-menu)
Selects the first carrier or symbol of a range.

Step ← Select Symbol/Carrier Range (context-menu)
Selects the steps between individual carriers or symbols of a range, for example to select every second one.

Stop ← Select Symbol/Carrier Range (context-menu)
Selects the last carrier or symbol of a range.

Deselect All (context-menu)
Deselects all currently selected symbols or carriers.

Extract Symbols (context-menu)
Extracts a range of symbols from the imported signal for further analysis.

Note: To restore discarded symbols for analysis, you must re-import the signal.

This function is identical to Chapter 5.2.3, "Step 2: (Optional:) Adjusting the analysis region", on page 112.

5.2 Configuration steps

The wizard guides you through the process of creating a configuration file. The progress bar (see Figure 5-1) indicates which step you are currently working on. After you complete all required steps, you have created a configuration file that you can import to the R&S FSW OFDM VSA application for signal analysis.

5.2.1 Starting the R&S FSW-K96 Configuration File Wizard

To start the R&S FSW-K96 Configuration File Wizard within the FSW

1. Configure the required input signal in the R&S FSW OFDM VSA application, either from a connected instrument or from an input file.
2. Configure the basic OFDM settings:
   a) In the "Signal Description" settings:
      - "FFT size", that is: the number of subcarriers
      - "Cyclic prefix length"
      - "Cyclic suffix length"
      - If a preamble exists and is used for synchronization: "Preamble Symbol Characteristics":
        – "Block Length"
        – "Frame Start Offset"

   b) "Burst search", if the signal is bursted
   c) In the "Sync/Demod/Tracking" settings:
      - "FFT Shift relative to Cyclic Prefix Length"
      - "Cyclic delay"
      - If a preamble is configured: "Time Synchronization": "Preamble"
3. Open a "Signal Flow" and a "Constellation" result display.
4. Select [RUN SINGLE].
5. The initial coarse time synchronization must be sufficiently reliable to ensure that demodulation is successful before you can start the R&S FSW-K96 Configuration File Wizard. Note that the signal need not be perfectly synchronized in this step. The wizard provides means to compensate for remaining small frequency, phase or timing errors.
   Check the "Signal Flow" result display to ensure the time synchronization meets the Minimum Time Sync Metric. Define the threshold in the "Sync/Demod/Tracking" settings (see "Minimum Time Sync Metric" on page 99).

   Note: Without a configuration file, only the timing synchronization metric, which is based on cyclic prefix or preamble, is relevant. The frame synchronization metric, which is based on pilots, is only useful in the next analysis stage that uses the configuration file.

6. Check the "Constellation" result display to ensure that the signal is as expected, e.g. the constellation points do not show a severe rotation.

   Note: If the data cells use DFT-S precoding, the R&S FSW OFDM VSA application cannot demodulate the transformed data cells correctly without a configuration file (see also "DFT-s-OFDM / SC-FDMA:Transform Precoding" on page 64). Since the R&S FSW OFDM VSA application does not know which cells are data cells, the I/Q symbols of the data cells look like noise. Nevertheless, synchronization using the cyclic prefix is still successful. The pilot cells are not affected, and are demodulated correctly.

7. Select "Overview" > "Signal Description" > "Create New Configuration File".

   The R&S FSW-K96 Configuration File Wizard starts.

To start the R&S FSW-K96 Configuration File Wizard on a separate PC

For very large frames, using the R&S FSW-K96 Configuration File Wizard on a separate PC with a higher display resolution and a mouse can be more convenient.

1. Configure the signal input and characteristics as described in "To start the R&S FSW-K96 Configuration File Wizard within the FSW" on page 110.

2. Instead of creating a new configuration file directly on the instrument, save the demodulated data to a file.
   Select "Overview" > "Signal Description" > "Export data".

3. Save the data to a `*.k96_wizv` file on a USB storage device connected to the instrument.

4. Copy the `K96_ConfigurationFileWizard.exe` and the `ZedGraph.dll` files from the instrument to a folder on the PC.

5. Start the `K96_ConfigurationFileWizard.exe` file on the PC.

   The R&S FSW-K96 Configuration File Wizard starts.
   Continue with Chapter 5.2.2, "Step 1: (Optional:) Importing existing files", on page 111 and select the `*.k96_wizv` file from the USB storage device.

5.2.2 Step 1: (Optional:) Importing existing files

The wizard requires demodulated data as input. When you open the wizard directly from the R&S FSW OFDM VSA application, the demodulated data from the input signal is stored in a `.K96_wizv` file internally. The wizard automatically loads this file when it is started and you start with step 2.

If a configuration file already exists, you can load it to the wizard and use it to create a new one.

To import an existing configuration file

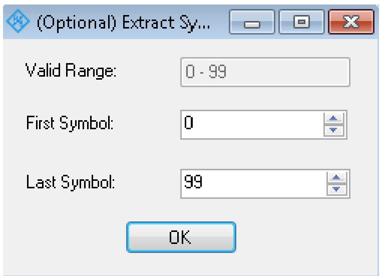
1. Select "Step 1" in the progress bar ("Step-by-Step").
2. Select the `.K96_wizv` file to load.

   The constellation diagram and "Allocation Matrix" are updated according to the stored data.

5.2.3 Step 2: (Optional:) Adjusting the analysis region

By default, the result range configured in the R&S FSW OFDM VSA application defines the number of symbols displayed in the "Constellation View". If the result range was correctly configured to comprise exactly one frame, you do not need to adjust the analysis region.

If necessary, you can restrict the analysis region.



Example:

The result range in Figure 5-5 contains 4 bursts, indicated by green bars. To configure the configuration file using the wizard, only one burst is required. Thus, you can extract the symbols for one burst to be used as the analysis region.

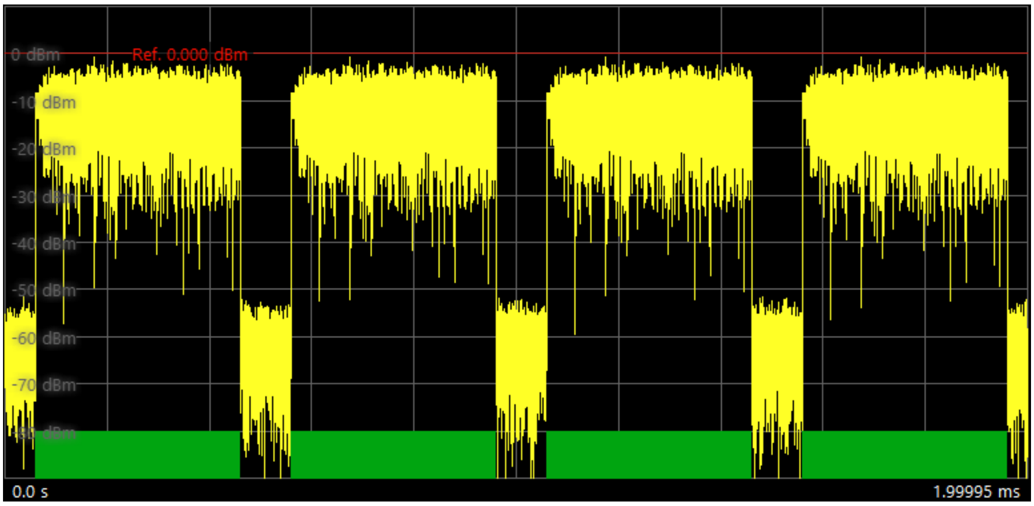


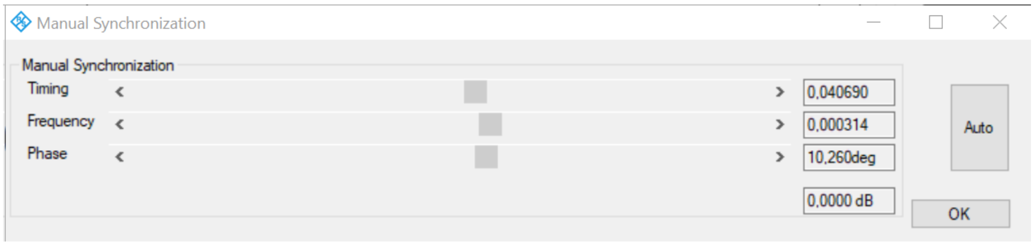
Figure 5-5: Sample result range with multiple bursts

To restrict the analysis region

1. Select "Step 2" in the progress bar ("Step-by-Step").
2. Define the first and last symbols of the result range to analyze.

5.2.4 Step 3: Synchronizing the measured data

The wizard can synchronize the measured data in terms of time, frequency, and phase, automatically. If necessary, improve the synchronization manually.



To synchronize the measured data

1. Select "Step 3" in the progress bar ("Step-by-Step").
2. Select "Auto" to perform automatic synchronization.
3. If necessary, move the sliders for timing, frequency, or phase until the constellation diagram shows an optimal display.

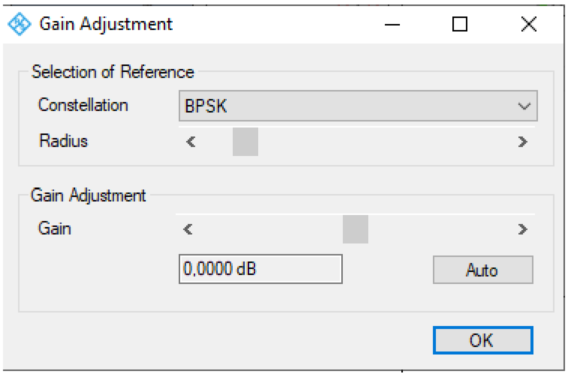
   Tip: Click directly on the "Phase" slider to rotate the constellation in 45° steps. Click the arrows of the slider or move the slider handle to rotate the constellation by smaller degrees.

   The currently selected values are indicated for reference. You can also enter a value directly.

5.2.5 Step 4: Adjusting the gain

The power gain for individual OFDM cells is determined in reference to the power measured for a specific constellation. It is recommended that you define a reference constellation that comprises many cells with similar power. Usually, the data cells of the OFDM signal are a good selection to be used as a reference.

The reference can be defined automatically or manually.



To select the reference for the gain

1. Select "Step 4" in the progress bar ("Step-by-Step").
2. Select the constellation type to use as a reference.
3. The "Radius" defines the area around the constellation point used to detect the symbol and calculate the power of the symbol. As a rule, define the radius such that neighboring constellation markers do not overlap.

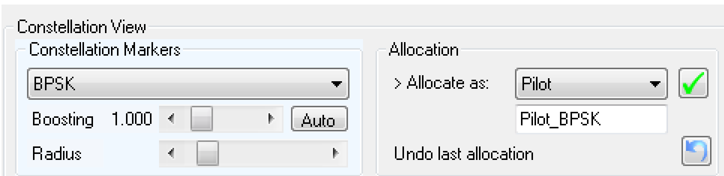
   The currently used radius is indicated by a circle around the ideal constellation points in the "Constellation View".

To adjust the gain

1. Select "Auto" to perform a gain estimation based on the power measured in the selected constellation type.
2. To increase the reference gain, move the slider to the right.
   To reduce the reference gain, move the slider to the left.
   The currently selected value is indicated for reference. You can also enter a value directly.
3. Select "OK" to define the measured power of the selected cells as the reference power for gain settings of other cells.

5.2.6 Steps 5 + 6: Allocating signal components

In this step, you configure the main characteristics of each OFDM cell. To do so, you select the OFDM cells that belong to a specific cell type, configure their characteristics, and then allocate them. The result is an "Allocation Matrix" that contains information for each OFDM cell of the current OFDM frame.



How to allocate the individual signal components

The characteristics that cells of the same type have in common are referred to as "Constellation Markers".

Select constellation markers that match your demodulated constellation, or a subset of your demodulated constellation. If you cannot see a clear constellation, improve the synchronization as described in Chapter 5.2.4, "Step 3: Synchronizing the measured data", on page 113.

1. Select "Step 5" in the progress bar ("Step-by-Step").

   Note: Steps 5 and 6 use the same display, therefore it is not necessary to switch from step 5 to 6.

2. The selection from Step 4: Adjusting the gain is maintained, so you can allocate the cell type used for gain adjustment first.
   a) Optionally, edit the name of the cell type, which is used for the legend of the "Allocation Matrix". By default, the name consists of the cell type and modulation.
   b) Select the ✓ checkmark and confirm the message to allocate the selected cells to the selected cell type.

3. For all other cell types, in the "Constellation View", select the modulation type.
   a) For pilot cells, you can select:
      - "Pilot as received": the received (demodulated and synchronized) I/Q symbol is stored. Thus, you do not require the ideal constellation value. However, during demodulation, the application cannot correct minor symbol errors. Use this setting only if the signal and synchronization are of high quality, e.g. from a file import.
      - Any other modulation type: the received I/Q symbol is demodulated and synchronized, and if necessary, mapped to the closest ideal I/Q constellation point. The ideal value is stored.
   b) For a user-specific, unusual constellation of a signal component, you can configure the constellation in an IQW file in advance. Then load the file to the wizard instead of selecting a predefined modulation for a specific signal component. For details see Chapter B, "Reference: IQW format specification for user-defined constellation points", on page 331.

   The symbols with the selected modulation are highlighted.

4. For "Don't care" cells, for which no characteristic modulation applies, define or edit the selection manually using the Selection tool.

5. Another characteristic stored for each cell is the gain value. By default, the reference power defined in Step 4: Adjusting the gain is assumed. Thus, a "Boosting" factor of 1.000 - relative to the reference power - is defined. For cells with different gain values, define a different boosting factor to apply to the reference power.
   - To determine the required boosting automatically from the constellation points, select "Auto".

- If you know the required factor, click the boosting value and enter the value directly.

  Note: The more accurate the boosting is defined, the more accurate the EVM results in the R&S FSW OFDM VSA application.

6. The "Radius" defines the area around the ideal constellation point used to detect the measured constellation points that correspond to the currently selected constellation type. As a rule, select the radius such that the circles around the ideal constellation points do not overlap.
   If necessary, adapt the radius around the ideal constellation points to include all and only constellation points that belong to the selected constellation type.
7. In the "Constellation View", in the "Allocation" area, select the cell type of the selected OFDM cells, for example "Pilot" or "Data".
8. Optionally, edit the name of the cell type, which is used for the legend of the "Allocation Matrix". By default, the name consists of the cell type and modulation.

9. Select the checkmark and confirm the message to allocate the selected cells to the selected cell type.

   The cells are indicated in the color shown in the legend above the "Allocation Matrix". The cells are no longer displayed if you selected only Show non-allocated constellation points in the "Constellation View".

10. If necessary, you can revert the last allocation.

    The allocated OFDM cells are indicated as non-allocated (but still selected).
11. Repeat these steps until all OFDM cells are allocated. When the last cell type is allocated, a message prompts you to store the results.

    Tip: In the "Constellation View", select Show non-allocated constellation points and deselect "Show allocated constellation points" on page 106 to see which cells are still missing in the "Allocation Matrix".

5.2.7 Step 7: Storing results

When you have allocated all constellation points in the "Constellation View" to a cell type and configured all other settings as required, store the results to a file. The resulting configuration file can then be used for analysis in the R&S FSW OFDM VSA application.

To store a configuration file

1. At the end of Steps 5 + 6: Allocating signal components, when all OFDM cells are allocated, the wizard prompts you to store the configuration file.
   At any other point in the configuration process, select "Step 7" in the progress bar ("Step-by-Step"), or select the "File" > "Save Configuration File" menu item.
2. Select a filename and storage location for the configuration file.

3. Select "Save".

5.3 Reference of wizard menu functions

The following functions are provided in the menus of the configuration file wizard.

5.3.1 File functions

New
Creates a new, empty configuration file. This function is similar to a preset function. Any information from the input signal in the R&S FSW OFDM VSA application is no longer available in the wizard. Load existing signal or configuration data to continue.

See "Import Data from R&S OFDM VSA" on page 117 and "Load Configuration File" on page 117.

Import Data from R&S OFDM VSA
Opens a file selection dialog box to import I/Q data from an existing `.K96_wizv` file (created by the R&S FSW OFDM VSA application).

Load Configuration File
Opens a file selection dialog box to load an existing `.xml` configuration file, for example as the basis for a similar configuration.

Save Configuration File
Opens a file selection dialog box to save the current configuration to an `.xml` file.

This function is identical to Chapter 5.2.7, "Step 7: Storing results", on page 116.

Note: At the end of Steps 5 + 6: Allocating signal components, when all symbols have been allocated, you are automatically asked if you want to store the configuration file.

Exit
Closes the wizard without a confirmation. Use Save Configuration File to store your current configuration before exiting.

5.3.2 Edit functions

Reset All Allocations
Removes all applied allocations. All cells are indicated as non-allocated.

Undo Last Allocation
Reverts the most recently applied allocation. The allocated cells are indicated as non-allocated (but still selected).

This function is identical to using the icon in the "Constellation View".

Extract Symbols (context-menu)
Extracts a range of symbols from the imported signal for further analysis.

Note: To restore discarded symbols for analysis, you must re-import the signal.

This function is identical to Chapter 5.2.3, "Step 2: (Optional:) Adjusting the analysis region", on page 112.

Shift Left by 1 Carrier / Shift Right by 1 Carrier
Shifts the carrier information for all symbols by one carrier. Shifting is useful to compensate for a frequency offset that could not be corrected by the automatic synchronization function.

5.3.3 Settings

System Name
Defines the name of the stored configuration file. The default name is `MyData`. You can change the name in the "Settings" (see Chapter 5.3.3, "Settings", on page 118).

System Description
Provides a description of the signal configured in the file.

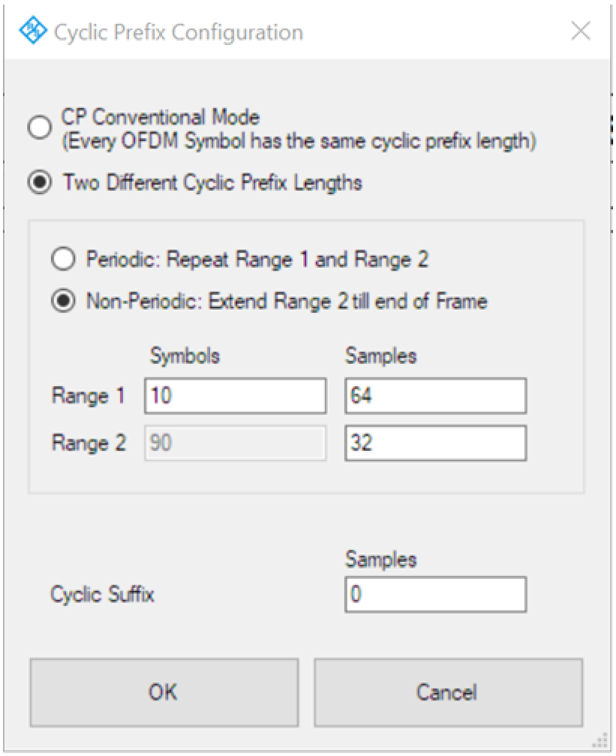
By default, the following main characteristics are included:

- Number of Carriers
- Number of Symbols
- Cyclic Prefix Length

If you deactivate the "Default" setting, you can overwrite the text with any other.

Cyclic Prefix / Suffix

Configures the cyclic prefix and suffix, if applicable.



Cyclic Prefix Length ← Cyclic Prefix / Suffix

Defines the length of the cyclic prefix (CP) area between two OFDM symbols in samples. The cyclic prefix area defines the guard interval and is expected to contain a copy of the samples at the end of the OFDM symbol.

The cyclic prefix length must be smaller than or equal to the "FFT Size" on page 65.

Remote command:
`CONFigure[:SYMBol]:NGUard<cp>` on page 161

Cyclic prefix mode ← Cyclic Prefix / Suffix

Determines how the cyclic prefix is configured.

By default, "Conventional Mode" is assumed, that is: each OFDM symbol has the same cyclic prefix length.

Remote command:
`CONFigure[:SYMBol]:GUARd:MODE` on page 159

Different cyclic prefix lengths ← Cyclic Prefix / Suffix
Some OFDM signals change their cyclic prefix over time (e.g. 802.11ac). This setting defines the behavior in such a case.

"Periodic" One "slot" that consists of the two defined ranges is repeated over and over until the number of symbols specified by the result range parameter is reached. The ranges are repeated periodically, first range 1, then range 2, then range 1, etc.

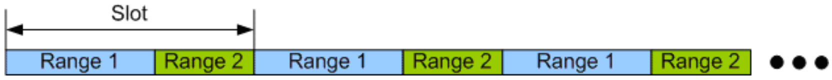


Figure 5-6: Non-Conventional cyclic prefix case: Periodic mode

"Non-Periodic" A fixed preamble has a different cyclic prefix length than the rest of the frame (e.g. WLAN 802.11ac signals). In this case, the length of the second range is extended until the end of the demodulated frame. Therefore, the length of the second range cannot be specified in this case.

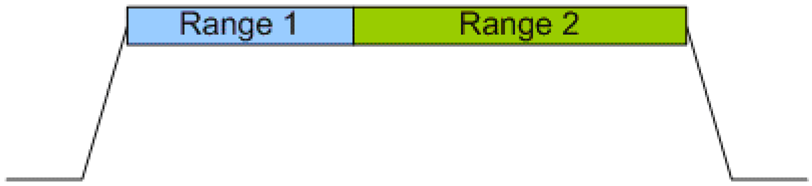


Figure 5-7: Non-Conventional cyclic prefix case: Non-Periodic mode

Remote command:
`CONFigure[:SYMBol]:GUARd:PERiodic` on page 160

Cyclic prefix definition per range (Symbols / Samples) ← Different cyclic prefix lengths ← Cyclic Prefix / Suffix
For each range, configure the number of symbols the cyclic prefix length is applied to, and the length of the cyclic prefix as a number of samples.

For non-periodic cyclic prefixes, the length of the second range cannot be specified. It is extended to the end of the demodulated frame.

Remote command:
`CONFigure[:SYMBol]:GUARd:NSYMbols<cp>` on page 160
`CONFigure[:SYMBol]:NGUard<cp>` on page 161

Cyclic Suffix Length ← Cyclic Prefix / Suffix
Defines the length of the cyclic suffix between two OFDM symbols in samples. The cyclic suffix is expected to contain a copy of the first N samples at the beginning of the OFDM symbol.

Figure 4-2 shows how the complete OFDM symbol is retrieved for an FFT length of 8 and a cyclic prefix and suffix length of 2.

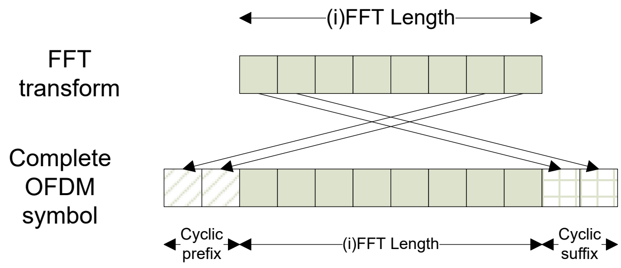
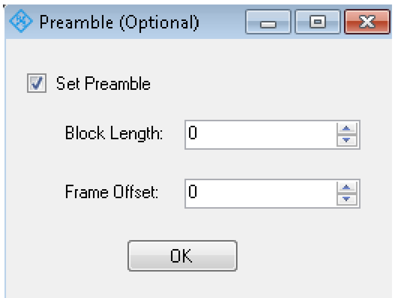


Figure 5-8: OFDM symbol with cyclic prefix and suffix

The cyclic suffix length must be smaller than or equal to the "FFT Size" on page 65.

Remote command:
`CONFigure[:SYMBol]:NSUFfix` on page 162

Preamble
Preamble symbol characteristics can be stored in the configuration file. These settings correspond to the settings in the "Signal Description" dialog in the R&S FSW OFDM VSA application (see Chapter 4.2, "Signal description", on page 62). The information can be used by the R&S FSW OFDM VSA application, for example for synchronization.



Set Preamble ← Preamble
If activated, the defined preamble symbol characteristics are stored in the configuration file.

Block Length ← Preamble
Specifies the length of one data block within the repetitive preamble as a number of samples.

Frame Start Offset ← Preamble
Specifies the time offset from the preamble start to the actual frame start as a number of samples.

Cyclic Delay Diversity
Defines a cyclic shift of the FFT values for each OFDM symbol before adding the cyclic prefix.

5.3.4 Help

Provides context-sensitive help on the configuration process, according to the currently selected process step.

5.4 Example: creating a configuration file from an input signal

The wizard requires demodulated data as input for the configuration file. You can configure a basic measurement for the input signal in the R&S FSW OFDM VSA application as described in Chapter 7, "How to perform measurements in the R&S FSW OFDM VSA application", on page 145, or load existing I/Q data to the application.

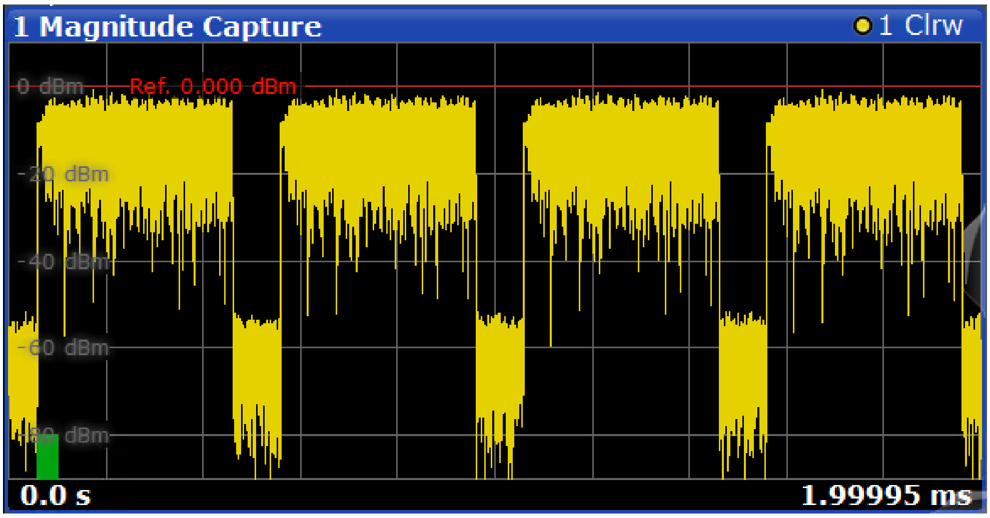
For this example, we use the I/Q data in the demo file `C:\R_S\INSTR\USER\demo\OFDM-VSA\WlanA_64QAM.iq.tar` provided with the FSW software.

The following signal parameters are already known:

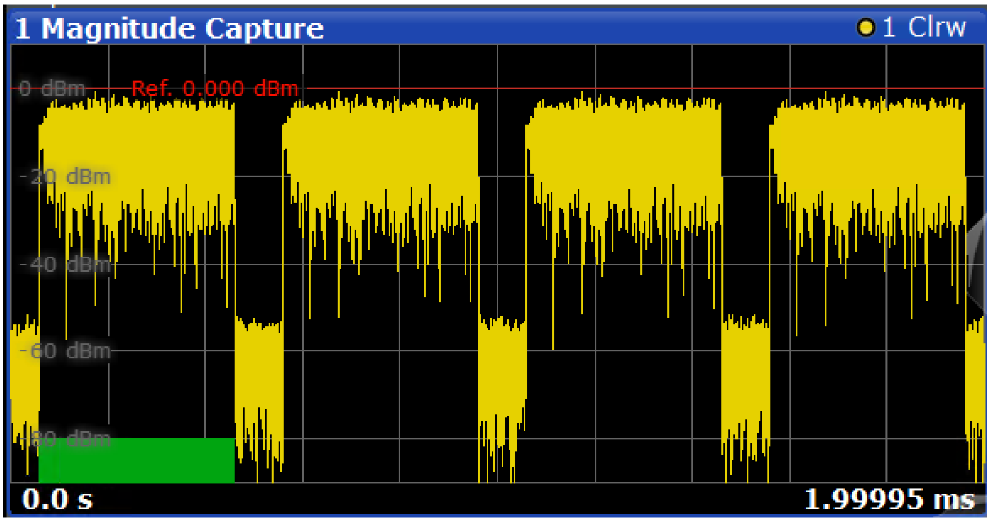
- FFT size (= number of subcarriers): 64 samples
- Cyclic prefix length: 16 samples
- OFDM system sample rate: 20 MHz
- Pilot modulation: QPSK + 45°QPSK
- Data modulation: 64QAM + BPSK

1. Define the basic signal parameters so the R&S FSW OFDM VSA application can demodulate the data.
   a) Select the "Meas Setup > Signal Description" menu item.
      - Set "FFT Size" = *64*.
      - Set "Cyclic Prefix Length" = *16*.
   b) Select the "Meas Setup > Data Acquisition" menu item.
      - Set "Sample Rate" = *20 MHz*.
2. Select the I/Q data file to use as input:
   a) Select "Input/Frontend" > "Input Source" > "I/Q file" > "Select file".
   b) Select `C:\R_S\INSTR\USER\demo\OFDM-VSA\WlanA_64QAM.iq.tar`.
   c) Set the state of the I/Q file input to "On".

   The Magnitude Capture display shows the bursted signal.



3. The green bar in the Magnitude Capture diagram does not cover an entire frame. Increase the result range to include all symbols of a frame.
   a) Select the "Meas Setup > Result Range" menu item.
      - Set "Result Length" = *100*.



   The data is now demodulated correctly and can be used as input for a new configuration file.
4. In the "Signal Description" dialog box, select "Create New Configuration File".
5. Since it is a bursted signal and the result range is large enough, the analysis range corresponds to exactly one frame. We can start directly with step 3, synchronization.
   Our constellation diagram is slightly rotated and generally does not show an ideal constellation, so we must improve the synchronization settings.

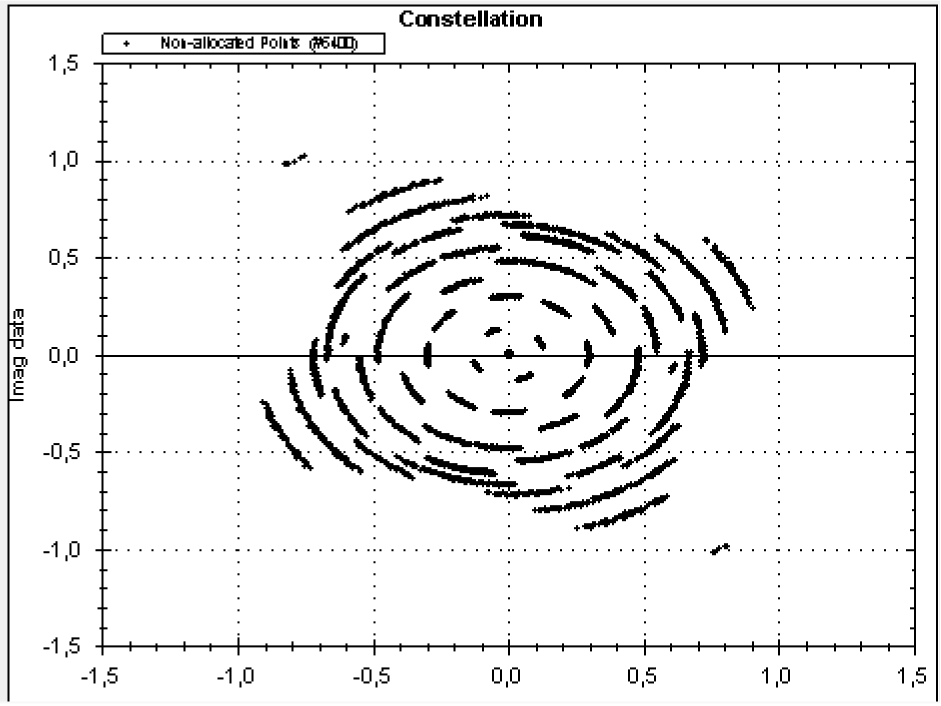


Figure 5-9: Constellation diagram for loaded WLAN signal data

Select "Step 3" in the progress bar.

a) Select "Auto" to perform automatic synchronization.

b) If necessary, move the sliders for timing, frequency, or phase until the constellation diagram shows an optimal display.

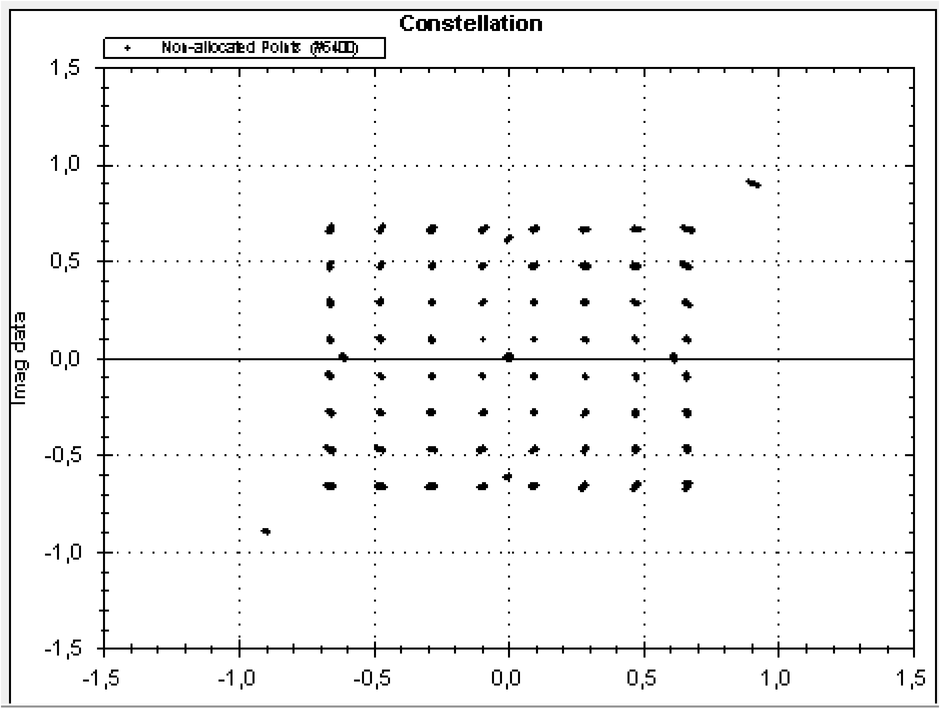


Figure 5-10: Constellation diagram after automatic synchronization

6. The reference constellation for the gain calculation is best defined by the data cells in this signal, which use a 64QAM modulation.
   Select "Step 4" in the progress bar.
   a) In the "Gain Adjustment" dialog box, select "Constellation" = "64QAM".

b) Select "Gain Adjustment" > "Auto".
The data cells which use this modulation are highlighted both in the "Constellation View" and the "Matrix View".

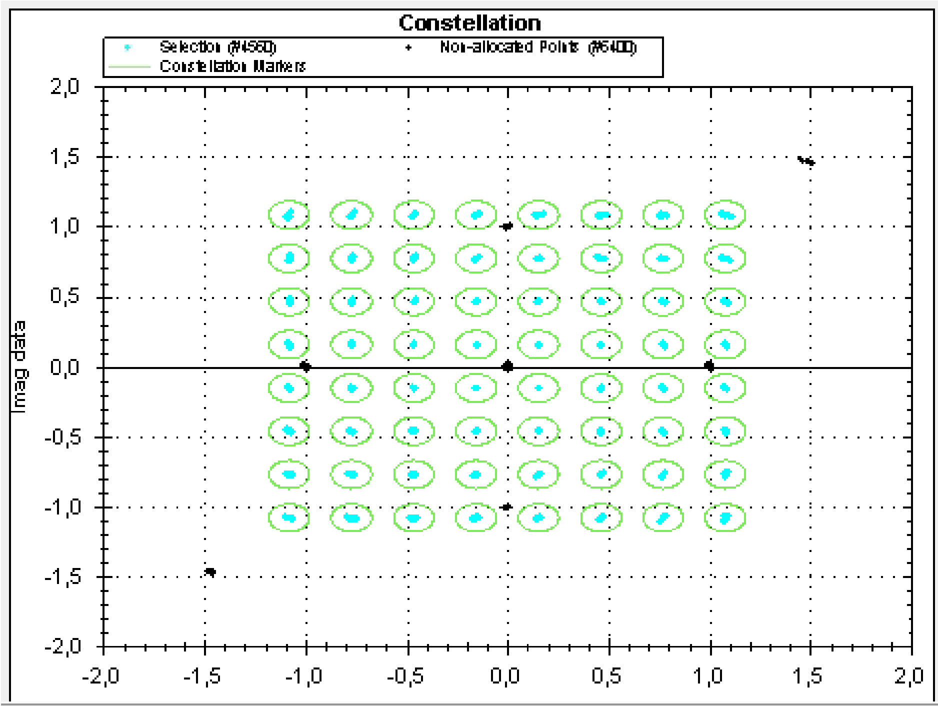


Figure 5-11: Highlighted data points in 64QAM constellation

The power for the highlighted constellation points is stored as the reference power, that is: as the boosting factor "1.0".

7. Since the data cells are already selected, we allocate those cells in the matrix first.
   a) Select "Step 5" in the progress bar.
   b) In the "Constellation View", "Allocation" area, select "Allocate as:" "Data"
   c) Select the ✅ green checkmark icon.

   The data cells in the "Allocation Matrix" are indicated in the specified color for data symbols.
8. Next we allocate the symbols with a power level of 0 V - the "Zero" cells.
   a) In the "Constellation View", select the modulation type "Zero" as a constellation marker.
   b) In the "Constellation View", "Allocation" area, select "Allocate as:" = "Zero".
   c) Select the ✅ green checkmark icon.

   The zero cells in the "Allocation Matrix" are indicated in the specified color for "Zero" symbols.
9. Allocate the "Pilot" cells.

a) In the "Constellation View", select the modulation type "QPSK" as a constellation marker.

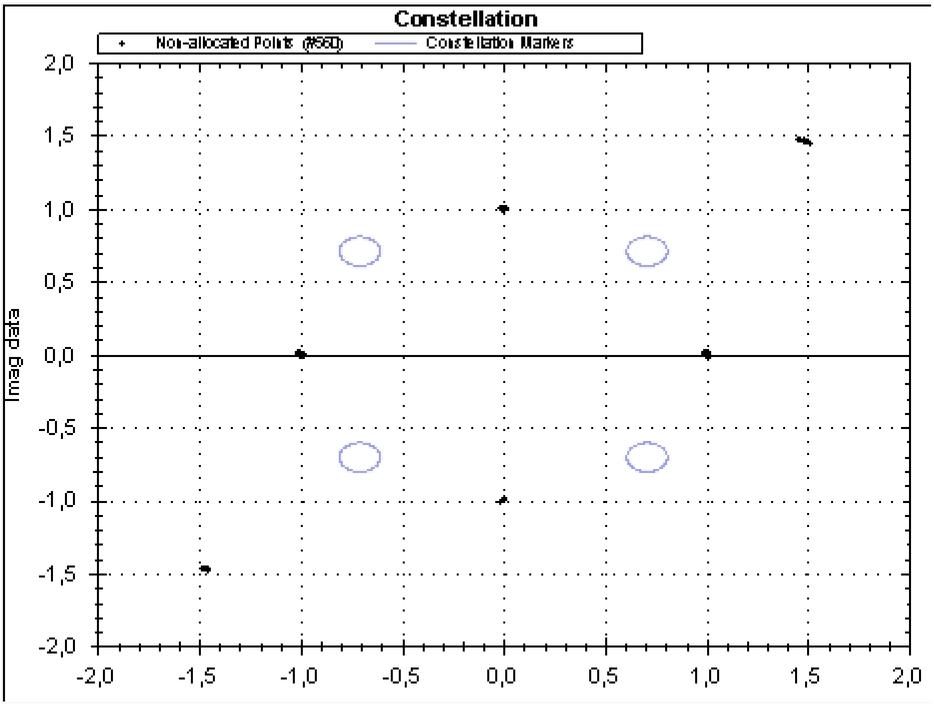


Figure 5-12: Symbols with QPSK constellation

Although we know some of the pilots use QPSK modulation, none of the symbols are highlighted. Possibly a boosting factor was applied.

b) Select the "Boosting" - "Auto" function.
A boosting of 2.079 is detected and applied to the symbols. Now some of the symbols are highlighted.

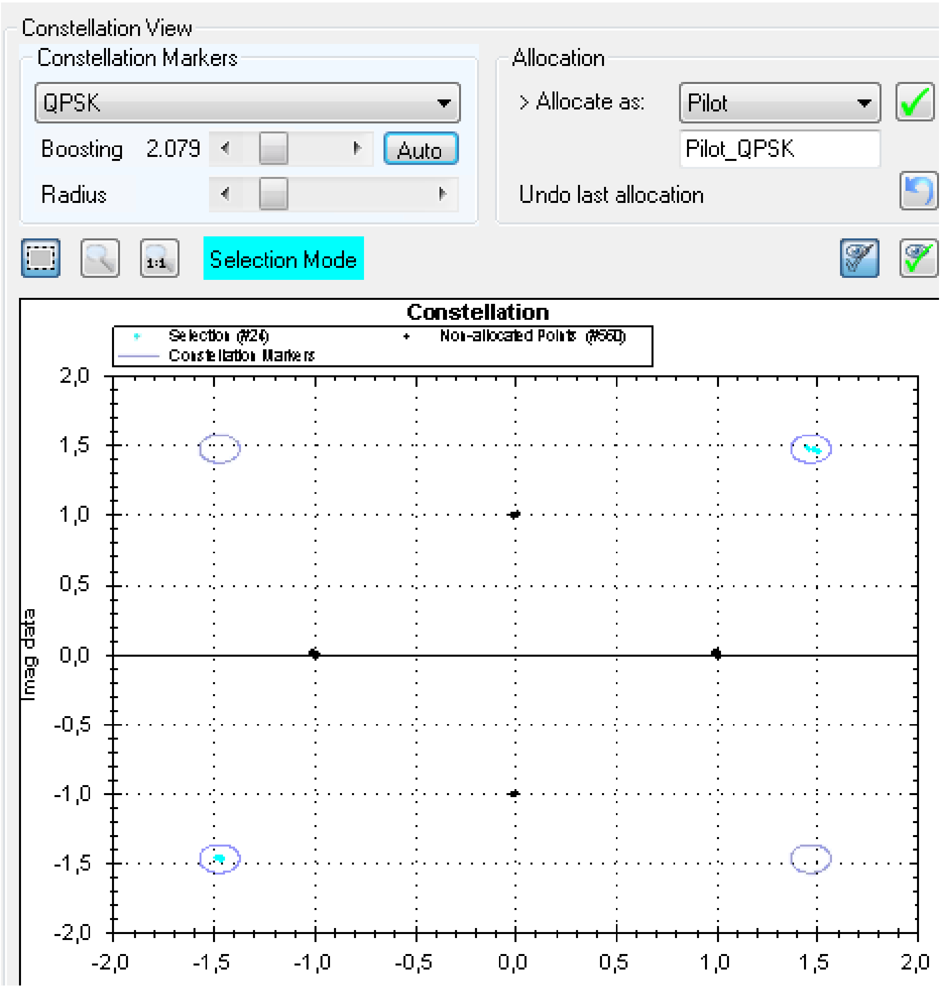


Figure 5-13: Symbols with QPSK modulation and applied boosting

c) In the "Constellation View", "Allocation" area, select "Allocate as:" "Pilots".
d) Select the ☑ green checkmark icon.

The pilot cells in the "Allocation Matrix" are indicated in the specified color for "Pilot" symbols, and the selected cells are stored with a boosting factor of 2.079.

10. Some of the remaining cells are data cells with a BPSK modulation.
    a) In the "Constellation View", select the modulation type "BPSK" as a constellation marker.
    b) In the "Constellation View", "Allocation" area, select "Allocate as:" = "Data".
    c) Select the ☑ green checkmark icon.
11. The last remaining cells are pilot cells with a 45°QPSK modulation.
    a) In the "Constellation View", select the modulation type "45°QPSK" as a constellation marker.

b) In the "Constellation View", "Allocation" area, select "Allocate as:" = "Pilot".
c) Select the ☑ green checkmark icon.

A message is displayed informing you that all symbols are allocated.

12. Store the configuration file.
    Select "Step 7" in the progress bar.
    a) Enter the filename and storage location for the configuration file:
       `C:\R_S\INSTR\USER\demo\OFDM-VSA\MyWlanA_64QAM.xml`
13. Close the wizard.

    Now you can load the configuration file in the R&S FSW OFDM VSA application.
    See step 5

6 Analyzing OFDM VSA vector signals

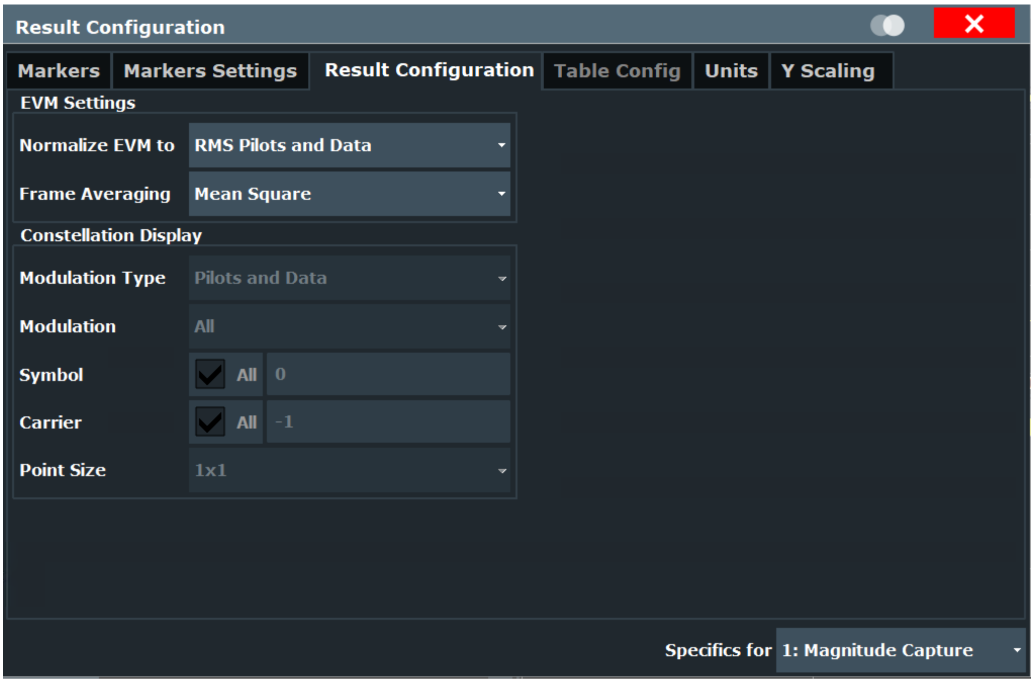
Access: "Meas Config" > "Result Config"

General result analysis settings concerning the trace, markers, windows etc. can be configured. They are identical to the analysis functions in the base unit except for the special window functions.

6.1 Result configuration

Access: "Meas Config" > "Result Config" > "Result Configuration" tab

Some result displays provide further settings.



Normalize EVM to

Specifies the OFDM cells which are averaged to get the reference magnitude for EVM normalization.

(See Chapter A.1, "Error vector magnitude (EVM)", on page 329 for details.)

"RMS Pilots & Data"	RMS value of the pilot and data cells
"RMS Data"	RMS value of the data cells
"RMS Pilots"	RMS value of the pilot cells
"Peak Pilots & Data"	Peak value of the pilot and data cells
"Peak Data"	Peak value of the data cells
"Peak Pilots"	Peak value of the pilot cells
"None"	Normalization is turned off

Remote command:
[SENSe:]DEMod:EVMCalc:NORMalize on page 263

Frame Averaging

Specifies the method of averaging over multiple OFDM frames in one capture buffer used to get the mean EVM values in the result list.

Frame averaging	Averaged EVM over N frames
Mean square	$\sqrt{\frac{1}{N}\sum_{i=0}^{N-1} EVM_i^2}$
RMS	$\frac{1}{N}\sum_{i=0}^{N-1} EVM_i$

Mean square averaging is consistent with the EVM calculation within one frame. However, some standards, e.g. 802.11a, require RMS averaging.

Remote command:
[SENSe:]DEMod:EVMCalc:FAVerage on page 262

Constellation Display - Modulation Type

The constellation diagram includes only symbols for the selected modulation types.

The selected modulation types are indicated in the constellation diagram for reference.

Remote command:
CONFigure:FILTer<n>:MODulation:TYPE on page 264

Constellation Display - Modulation

The constellation diagram includes only symbols with the selected modulation.

Remote command:
CONFigure:FILTer<n>:MODulation on page 264

Constellation Display - Symbol
The constellation diagram includes all or only the specified symbol number. The first symbol number is 0.

Remote command:
CONFigure:FILTer<n>:SYMBol on page 264

Constellation Display - Carrier
The constellation diagram includes symbols for all or only for the specified carrier number.

The range of valid carrier numbers is:

[- FFT Size/2, +FFT Size/2]

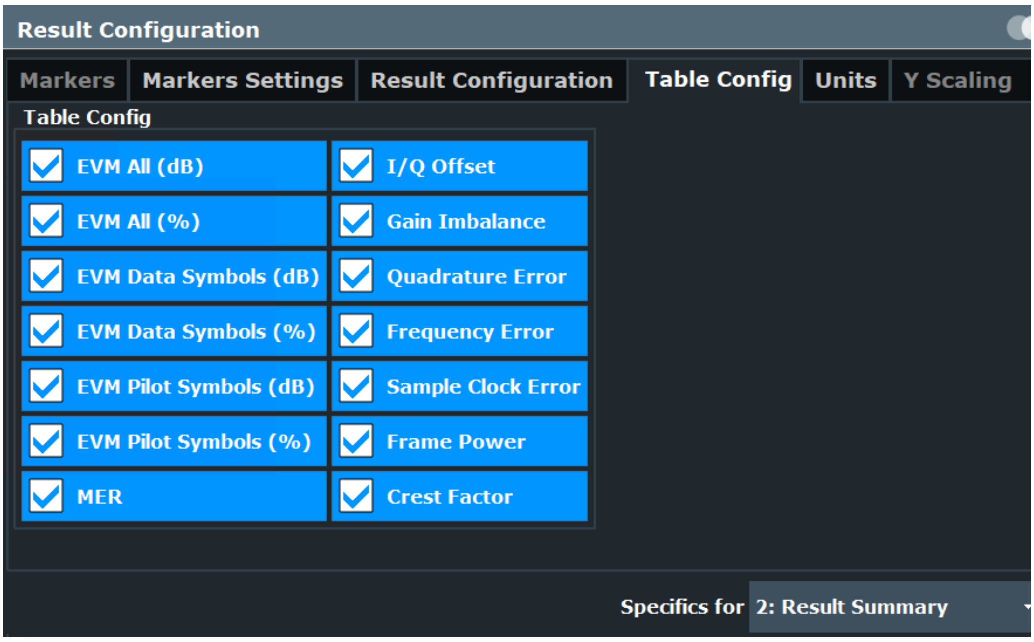
Remote command:
CONFigure:FILTer<n>:CARRier on page 263

Constellation Display - Point Size
Defines the size of the individual points in a constellation diagram.

6.2 Table configuration

Access: "Meas Config" > "Result Config" > "Table Config"

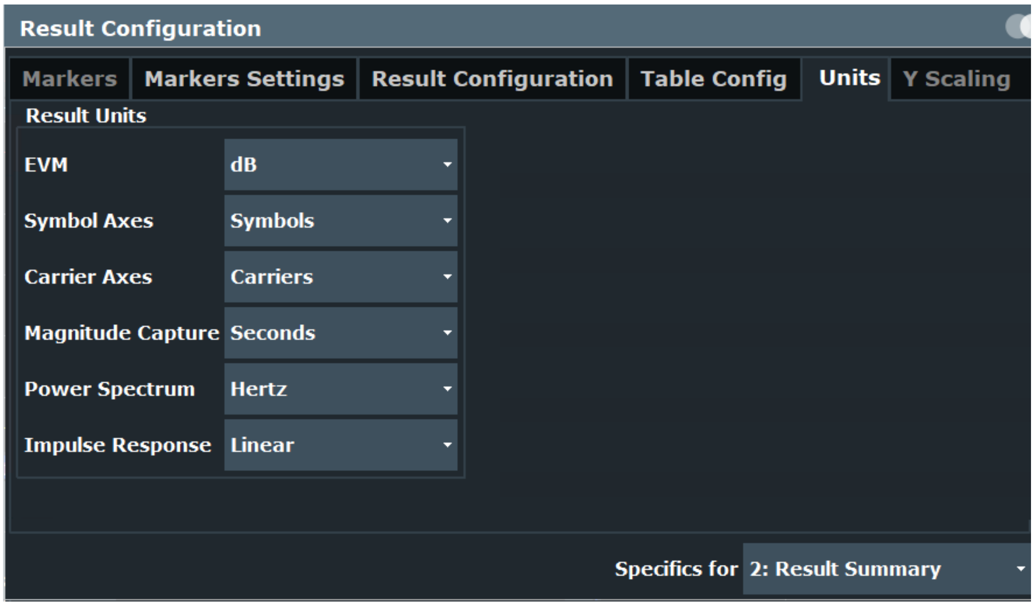
During each measurement, many characteristic signal parameters are determined. Select the parameters to be included in the table. For a description of the individual parameters, see Chapter 2.1, "OFDM VSA parameters", on page 9.



6.3 Units

Access: "Meas Config" > "Result Config" > "Units" tab

For some result configurations, the unit of the displayed values can be configured.



Remote command:

EVM: UNIT:EVM on page 268

Symbol axes: UNIT:SAXes on page 269

Carrier axes: UNIT:CAXes on page 268

Magnitude Capture: UNIT:TAXes on page 270

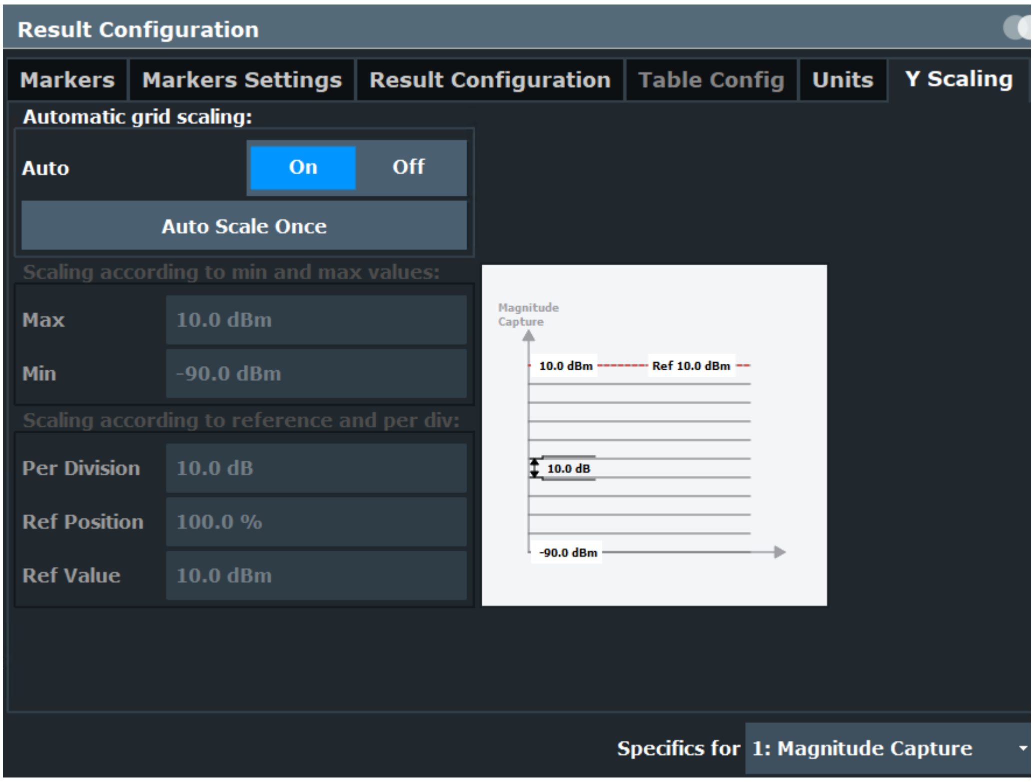
Power Spectrum: UNIT:FAXes on page 269

Impulse Response: UNIT:IRESponse on page 269

6.4 Y-scaling

Access: "Meas Config" > "Result Config" > "Y Scaling" tab

The scaling for the vertical axis is highly configurable, using either absolute or relative values. Note that scaling settings are window-specific and not available for all result displays.



Automatic Grid Scaling

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

Tip: To update the scaling automatically *once* when this setting for continuous scaling is off, use the Auto Scale Once function.

Remote command:

`DISPlay[:WINDow<n>][:SUBWindow<n>]:TRACe<t>:Y[:SCALe]:AUTO` on page 265

Auto Scale Once

If enabled, both the x-axis and y-axis are automatically adapted to the current measurement results (only once, not dynamically) in the selected window.

Remote command:

`DISPlay[:WINDow<n>][:SUBWindow<n>]:TRACe<t>:Y[:SCALe]:AUTO` on page 265

Absolute Scaling (Min/Max Values)
Define the scaling using absolute minimum and maximum values.

Remote command:
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MAXimum` on page 267
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MINimum` on page 267

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

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

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

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:PDIVision` on page 266

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

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RPOSition` on page 266

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

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RVALue` on page 267

6.5 Markers

Access: "Meas Config" > "Result Config" > "Markers" tab

Or: "Marker"

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

Markers in 3-dimensional diagrams

Some diagrams have a third dimension - in addition to the x-axis and y-axis they show a third dimension (z-dimension) of results using different colors. For such diagrams, you must define the position of the marker both in the x-dimension and in the y-dimension to obtain the results in the z-dimension.

Markers in the Constellation View and Allocation Matrix

Using markers in a Constellation View you can detect individual constellation points for a specific symbol or carrier. When you activate a marker in the Constellation View, its position is defined by the symbol and carrier number the point belongs to. However, the marker result indicates the I and Q values of the point.

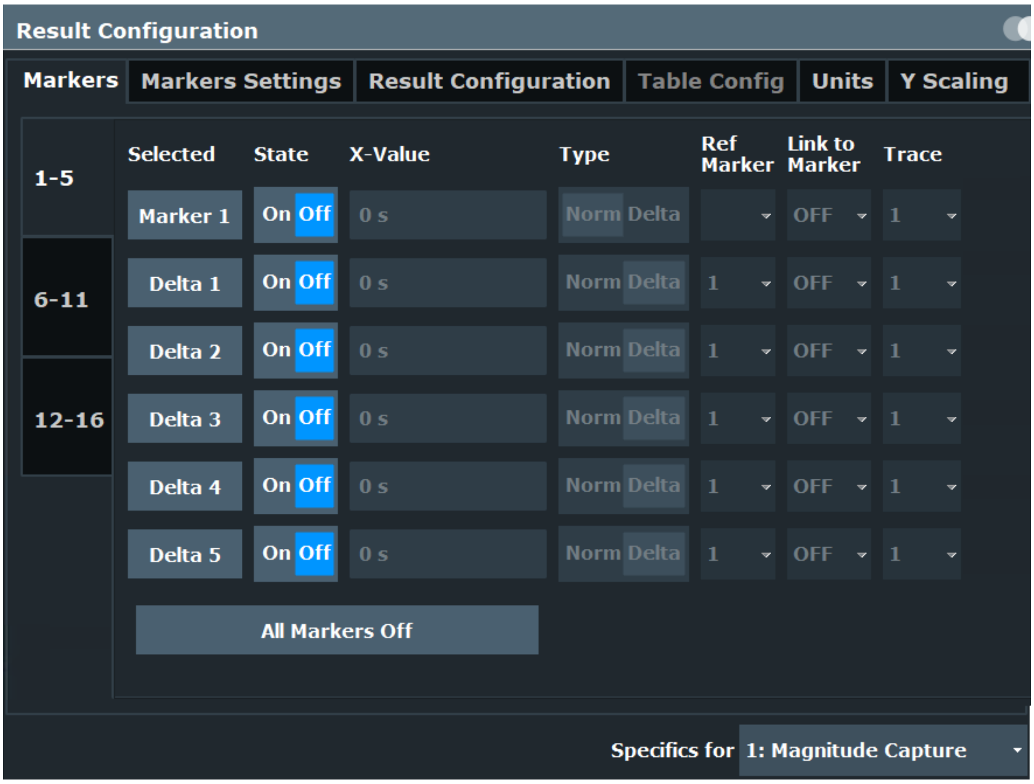
Similarly, you can define markers in an Allocation Matrix by selecting the symbol and carrier number.

Using markers in the Constellation View and Allocation Matrix, you can scroll through the points for a specific carrier, for example. Activate a marker, then use the rotary knob or mouse wheel to move the marker from one symbol to the next.

6.5.1 Individual marker settings

Access: "Meas Config" > "Result Config" > "Markers" tab

In OFDM VSA evaluations, up to 16 markers can be activated in each diagram at any time.



Selected Marker

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

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

Select Marker

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

Remote command:
CALCulate<n>:MARKer<m>[:STATe] on page 272
CALCulate<n>:DELTamarker<m>[:STATe] on page 274

Marker State
Activates or deactivates the marker in the diagram.

Remote command:
CALCulate<n>:MARKer<m>[:STATe] on page 272
CALCulate<n>:DELTamarker<m>[:STATe] on page 274

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

For the Constellation View, the position is defined by a symbol number.

Remote command:
CALCulate<n>:DELTamarker<m>:X on page 275
CALCulate<n>:MARKer<m>:X on page 272

Y-Value
Defines the position of the marker on the y-axis for 3-dimensional diagrams.

For the Constellation View, the position is defined by a carrier number.

Remote command:
CALCulate<n>:DELTamarker<m>:Y? on page 304
CALCulate<n>:MARKer<m>:Y? on page 306

Marker Type
Toggles the marker type.

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

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

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

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

Remote command:
`CALCulate<n>:MARKer<m>[:STATe]` on page 272
`CALCulate<n>:DELTamarker<m>[:STATe]` on page 274

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

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

Remote command:
`CALCulate<n>:DELTamarker<m>:MREFerence` on page 274

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

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

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

Remote command:
`CALCulate<n>:MARKer<ms>:LINK:TO:MARKer<md>` on page 271
`CALCulate<n>:DELTamarker<ms>:LINK:TO:MARKer<md>` on page 273
`CALCulate<n>:DELTamarker<m>:LINK` on page 273

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

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

Remote command:
`CALCulate<n>:MARKer<m>:TRACe` on page 272

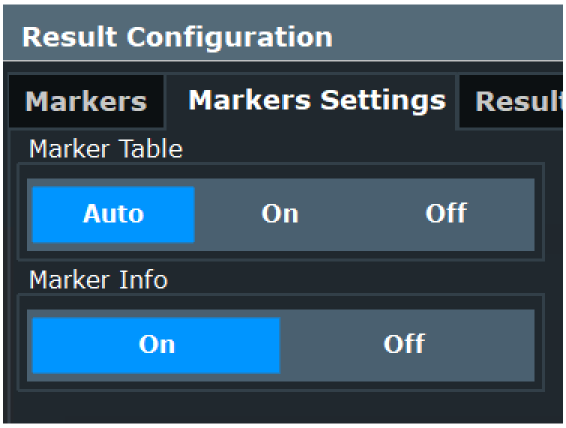
All Markers Off
Deactivates all markers in one step.

Remote command:
`CALCulate<n>:MARKer<m>:AOFF` on page 271

6.5.2 General marker settings

Access: "Meas Config" > "Result Config" > "Marker Settings" tab

Or: "Marker" > "Marker Settings"



Marker Table Display
Defines how the marker information is displayed.

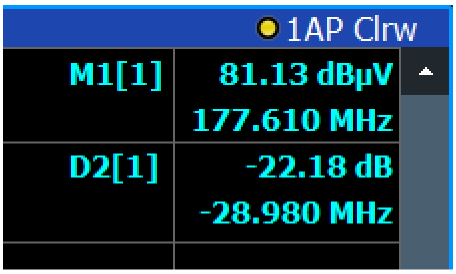
"On" Displays the marker information in a table in a separate area beneath the diagram.

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

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

Remote command:
`DISPlay[:WINDow<n>]:MTABle` on page 276

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



Remote command:
DISPlay[:WINDow<n>]:MINFo[:STATe] on page 275

6.5.3 Marker positioning functions

The following functions set the currently selected marker to the result of a peak search.

Access: [Marker ->]

Peak Search

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

Remote command:
CALCulate<n>:MARKer<m>:MAXimum[:PEAK] on page 280
CALCulate<n>:DELTamarker<m>:MAXimum[:PEAK] on page 278

Search Next Peak

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

Remote command:
CALCulate<n>:MARKer<m>:MAXimum:NEXT on page 279
CALCulate<n>:MARKer<m>:MAXimum:RIGHt on page 280
CALCulate<n>:MARKer<m>:MAXimum:LEFT on page 279
CALCulate<n>:DELTamarker<m>:MAXimum:NEXT on page 277
CALCulate<n>:DELTamarker<m>:MAXimum:RIGHt on page 278
CALCulate<n>:DELTamarker<m>:MAXimum:LEFT on page 277

Search Minimum

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

Remote command:
CALCulate<n>:MARKer<m>:MINimum[:PEAK] on page 281
CALCulate<n>:DELTamarker<m>:MINimum[:PEAK] on page 278

Search Next Minimum

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

Remote command:
CALCulate<n>:MARKer<m>:MINimum:NEXT on page 280
CALCulate<n>:MARKer<m>:MINimum:LEFT on page 280
CALCulate<n>:MARKer<m>:MINimum:RIGHt on page 281
CALCulate<n>:DELTamarker<m>:MINimum:NEXT on page 278

CALCulate<n>:DELTamarker<m>:MINimum:LEFT on page 278
CALCulate<n>:DELTamarker<m>:MINimum:RIGHt on page 279

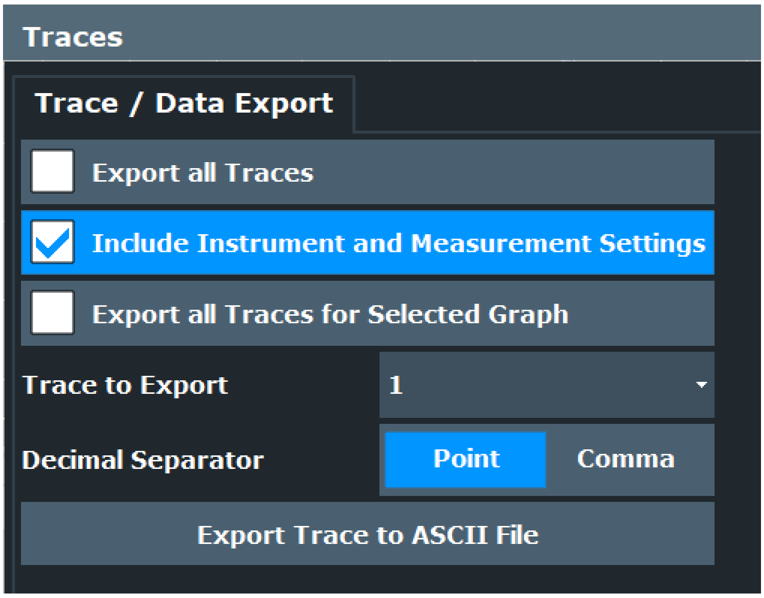
6.6 Trace / data export configuration

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

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

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

See the FSW base unit user manual for a description of the standard functions.



Export all Traces and all Table Results

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

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

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

Remote command:
`FORMat:DEXPort:TRACes` on page 309

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

Remote command:
`FORMat:DEXPort:HEADer` on page 308

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

Remote command:
`FORMat:DEXPort:GRAPh` on page 308

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

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

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

Remote command:
`FORMat:DEXPort:DSEParator` on page 308

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

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

Note: Secure user mode.
In secure user mode, settings that are stored on the instrument are stored to volatile memory, which is restricted to 256 MB. Thus, a "memory limit reached" error can occur although the hard disk indicates that storage space is still available.

To store data permanently, select an external storage location such as a USB memory device.

For details, see "Protecting Data Using the Secure User Mode" in the "Data Management" section of the FSW base unit user manual.

Remote command:
`MMEMory:STORe<n>:TRACe` on page 309

6.7 Analysis in MSRA mode

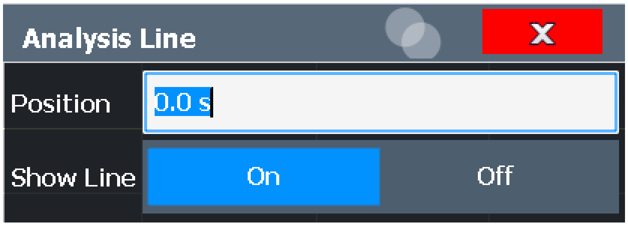
The data that was captured by the MSRA primary can be analyzed in the OFDM VSA application.

The analysis settings and functions available in MSRA mode are those described for common Signal and Spectrum Analyzer mode.

Analysis line settings

In addition, an analysis line can be positioned. The analysis line is a common time marker for all MSRA applications.

To hide or show and position the analysis line, a dialog box is available. To display the "Analysis Line" dialog box, tap the "AL" icon in the toolbar (only available in MSRA mode). The current position of the analysis line is indicated on the icon.



Position

Defines the position of the analysis line in the time domain. The position must lie within the measurement time of the multistandard measurement.

Remote command:
`CALCulate<n>:MSRA:ALINe[:VALue]` on page 285

Show Line

Hides or displays the analysis line in the time-based windows. By default, the line is displayed.

Note: The window title bar always shows whether the currently defined line position lies within the analysis interval of the active secondary application, even if the analysis line display is disabled.

Remote command:
`CALCulate<n>:MSRA:ALINe:SHOW` on page 285

7 How to perform measurements in the R&S FSW OFDM VSA application

The following step-by-step instructions demonstrate how to perform measurements with the R&S FSW OFDM VSA application.

The R&S FSW OFDM VSA application provides sample data and sample configuration files in the `C:\R_S\INSTR\USER\demo\OFDM-VSA` directory.

To perform an OFDM VSA measurement

1. Open a new channel or replace an existing one and select the R&S FSW OFDM VSA application.
2. Configure the input source to be used.
3. Select "Overview" to display the "Overview" for an OFDM VSA measurement.
4. Select "Signal Description" and configure the expected signal characteristics either manually or using a configuration file.
5. To use a configuration file:
   a) If no configuration file is available yet, create one from the input signal as described in Chapter 5, "Creating a configuration file using the wizard", on page 102.
   b) Select "Load Config. File".
   c) Select the configuration file to use.

   The file is loaded and "Use Configuration File" is automatically set to "Yes".
6. Select "Input/Frontend" to define the input signal's center frequency, amplitude and other basic settings.
7. Select "Data Acquisition" and define how much and which data to capture:
   (In MSRA mode, define the application data instead, see Chapter 3.7, "OFDM VSA in MSRA operating mode", on page 58).
   - "Capture Time" or "Capture length": the duration or number of samples to be captured
     For non-triggered ("Free run") measurements, be sure to capture at least twice the number of samples per frame so you are sure to capture at least one entire frame.
   - "Sample rate": the rate at which I/Q data is acquired (analysis bandwidth / 0.8); must also correspond to the OFDM system sample rate (<subcarrier_spacing> * <FFT_size>, see also "OFDM system sample rate" on page 32)
8. Optionally, select "Trigger" and define a trigger for data acquisition, for example an external trigger to start capturing data only when a useful signal is transmitted.
   (In MSRA mode, define a "Capture Offset" instead, see Chapter 3.7, "OFDM VSA in MSRA operating mode", on page 58).

9. For bursted signals, select "Burst Search" and activate a burst search.
10. Select "Result Range" and define how many OFDM symbols are to be interpreted as one frame.
11. To optimize the synchronization process, if necessary, select "Sync/Demod" and configure the synchronization and demodulation parameters.
    Which compensation and synchronization functions are allowed depends on the standard defining the tests.
12. Select the "Configure Display" icon from the toolbar to add further result displays for the R&S FSW OFDM VSA application.

    The measured data is stored in the capture buffer and can be analyzed.

8 Remote commands for the R&S FSW OFDM VSA application

The following commands are required to perform measurements in the R&S FSW OFDM VSA application in a remote environment.

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

General FSW Remote Commands

The application-independent remote commands for general tasks on the FSW are also available for R&S FSW OFDM VSA application and are described in the FSW Base Software User Manual. In particular, this comprises the following functionality:

- Managing Settings and Results
- Setting Up the Instrument
- Using the Status Register

SCPI Recorder - automating tasks with remote command scripts

The R&S FSW OFDM VSA application also supports the SCPI Recorder functionality.

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

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

8.1 Introduction

Commands are program messages that a controller (e.g. a PC) sends to the instrument or software. They operate its functions ('setting commands' or 'events') and request information ('query commands'). Some commands can only be used in one way, others work in two ways (setting and query). If not indicated otherwise, the commands can be used for settings and queries.

The syntax of a SCPI command consists of a header and, usually, one or more parameters. To use a command as a query, you have to append a question mark after the last header element, even if the command contains a parameter.

A header contains one or more keywords, separated by a colon. Header and parameters are separated by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank). If there is more than one parameter for a command, they are separated by a comma from one another.

Only the most important characteristics that you need to know when working with SCPI commands are described here. For a more complete description, refer to the user manual of the FSW.

Remote command examples

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

8.1.1 Conventions used in descriptions

The following conventions are used in the remote command descriptions:

- *Command usage*
  If not specified otherwise, commands can be used both for setting and for querying parameters.
  If a command can be used for setting or querying only, or if it initiates an event, the usage is stated explicitly.
- *Parameter usage*
  If not specified otherwise, a parameter can be used to set a value, and it is the result of a query.
  Parameters required only for setting are indicated as "Setting parameters".
  Parameters required only to refine a query are indicated as "Query parameters".
  Parameters that are only returned as the result of a query are indicated as "Return values".
- *Conformity*
  Commands that are taken from the SCPI standard are indicated as "SCPI confirmed". All commands used by the FSW follow the SCPI syntax rules.
- *Asynchronous commands*
  A command which does not automatically finish executing before the next command starts executing (overlapping command) is indicated as an "Asynchronous command".
- *Reset values (*RST)*
  Default parameter values that are used directly after resetting the instrument (`*RST` command) are indicated as "*RST" values, if available.
- *Default unit*
  The default unit is used for numeric values if no other unit is provided with the parameter.

- *Manual operation*
  If the result of a remote command can also be achieved in manual operation, a link to the description is inserted.

8.1.2 Long and short form

The keywords have a long and a short form. You can use either the long or the short form, but no other abbreviations of the keywords.

The short form is emphasized in uppercase letters. Note however, that this emphasis only serves the purpose to distinguish the short from the long form in the manual. For the instrument, the case does not matter.

Example:

`SENSe:FREQuency:CENTer` is the same as `SENS:FREQ:CENT`.

8.1.3 Numeric suffixes

Some keywords have a numeric suffix if the command can be applied to multiple instances of an object. In that case, the suffix selects a particular instance (e.g. a measurement window).

Numeric suffixes are indicated by angular brackets (<n>) next to the keyword.

If you do not quote a suffix for keywords that support one, a 1 is assumed.

Example:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe` enables the zoom in a particular measurement window, selected by the suffix at `WINDow`.

`DISPlay:WINDow4:ZOOM:STATe ON` refers to window 4.

8.1.4 Optional keywords

Some keywords are optional and are only part of the syntax because of SCPI compliance. You can include them in the header or not.

If an optional keyword has a numeric suffix and you need to use the suffix, you have to include the optional keyword. Otherwise, the suffix of the missing keyword is assumed to be the value 1.

Optional keywords are emphasized with square brackets.

Example:

Without a numeric suffix in the optional keyword:

`[SENSe:]FREQuency:CENTer` is the same as `FREQuency:CENTer`

With a numeric suffix in the optional keyword:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe`

`DISPlay:ZOOM:STATe ON` enables the zoom in window 1 (no suffix).

`DISPlay:WINDow4:ZOOM:STATe ON` enables the zoom in window 4.

8.1.5 Alternative keywords

A vertical stroke indicates alternatives for a specific keyword. You can use both keywords to the same effect.

Example:

`[SENSe:]BANDwidth|BWIDth[:RESolution]`

In the short form without optional keywords, `BAND 1MHZ` would have the same effect as `BWID 1MHZ`.

8.1.6 SCPI parameters

Many commands feature one or more parameters.

If a command supports more than one parameter, they are separated by a comma.

Example:

`LAYout:ADD:WINDow Spectrum,LEFT,MTABle`

Parameters can have different forms of values.

8.1.6.1 Numeric values

Numeric values can be entered in any form, i.e. with sign, decimal point or exponent. For physical quantities, you can also add the unit. If the unit is missing, the command uses the basic unit.

Example:

With unit: `SENSe:FREQuency:CENTer 1GHZ`

Without unit: `SENSe:FREQuency:CENTer 1E9` would also set a frequency of 1 GHz.

Values exceeding the resolution of the instrument are rounded up or down.

If the number you have entered is not supported (e.g. for discrete steps), the command returns an error.

Instead of a number, you can also set numeric values with a text parameter in special cases.

- MIN/MAX
  Defines the minimum or maximum numeric value that is supported.
- DEF
  Defines the default value.
- UP/DOWN
  Increases or decreases the numeric value by one step. The step size depends on the setting. Sometimes, you can customize the step size with a corresponding command.

Querying numeric values

When you query numeric values, the system returns a number. For physical quantities, it applies the basic unit (e.g. Hz for frequencies). The number of digits after the decimal point depends on the type of numeric value.

Example:

Setting: `SENSe:FREQuency:CENTer 1GHZ`

Query: `SENSe:FREQuency:CENTer?` would return `1E9`

Sometimes, numeric values are returned as text.

- INF/NINF
  Infinity or negative infinity. Represents the numeric values 9.9E37 or -9.9E37.
- NAN
  Not a number. Represents the numeric value 9.91E37. NAN is returned if errors occur.

8.1.6.2 Boolean

Boolean parameters represent two states. The "on" state (logically true) is represented by "`ON`" or the numeric value 1. The "off" state (logically untrue) is represented by "`OFF`" or the numeric value 0.

Querying Boolean parameters

When you query Boolean parameters, the system returns either the value 1 ("`ON`") or the value 0 ("`OFF`").

Example:

Setting: `DISPlay:WINDow:ZOOM:STATe ON`

Query: `DISPlay:WINDow:ZOOM:STATe?` would return `1`

8.1.6.3 Character data

Character data follows the syntactic rules of keywords. You can enter text using a short or a long form. For more information, see Chapter 8.1.2, "Long and short form", on page 149.

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`

8.1.6.4 Character strings

Strings are alphanumeric characters. They have to be in straight quotation marks. You can use a single quotation mark (') or a double quotation mark (").

Example:

`INSTRument:DELete 'Spectrum'`

8.1.6.5 Block data

Block data is a format which is suitable for the transmission of large amounts of data.

The ASCII character # introduces the data block. The next number indicates how many of the following digits describe the length of the data block. The data bytes follow. During the transmission of these data bytes, all end or other control signs are ignored until all bytes are transmitted. #0 specifies a data block of indefinite length. The use of the indefinite format requires an `NL^END` message to terminate the data block. This format is useful when the length of the transmission is not known or if speed or other considerations prevent segmentation of the data into blocks of definite length.

8.2 Common suffixes

In the R&S FSW OFDM VSA application, the following common suffixes are used in remote commands:

Table 8-1: Common suffixes used in remote commands in the R&S FSW OFDM VSA application

Suffix	Value range	Description
<m>	1 to 4	Marker
<n>	1 to x	Window (**in the currently selected channel**)

Suffix	Value range	Description
<t>	1 to 6	Trace
	1 to 8	Limit line

8.3 Activating the R&S FSW OFDM VSA application

INSTrument:CREate:DUPLicate

Duplicates the currently selected channel, i.e creates a new channel of the same type and with the identical measurement settings. The name of the new channel is the same as the copied channel, extended by a consecutive number (e.g. "IQAnalyzer" -> "IQAnalyzer 2").

The channel to be duplicated must be selected first using the `INST:SEL` command.

Is not available if the MSRA primary channel is selected.

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

Usage: Event

INSTrument:CREate[:NEW] <ChannelType>, <ChannelName>

Adds a measurement channel. You can configure up to 10 measurement channels at the same time (depending on available memory).

Parameters:

<ChannelType> Channel type of the new channel.
For a list of available channel types, see `INSTrument:LIST?` on page 154.

<ChannelName> String containing the name of the channel.
Note that you cannot assign an existing channel name to a new channel. If you do, an error occurs.

Example:
```
INST:CRE SAN, 'Spectrum 2'
```
Adds a spectrum display named "Spectrum 2".

INSTrument:CREate:REPLace <ChannelName1>, <ChannelType>, <ChannelName2>

Replaces a channel with another one.

Setting parameters:

<ChannelName1> String containing the name of the channel you want to replace.

<ChannelType> Channel type of the new channel.
For a list of available channel types, see INSTrument:LIST? on page 154.

<ChannelName2> String containing the name of the new channel.
Note: If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel (see INSTrument:LIST? on page 154).
Channel names can have a maximum of 31 characters, and must be compatible with the Windows conventions for file names. In particular, they must not contain special characters such as ":", "*", "?".

Example: `INST:CRE:REPL 'IQAnalyzer2',IQ,'IQAnalyzer'`
Replaces the channel named "IQAnalyzer2" by a new channel of type "IQ Analyzer" named "IQAnalyzer".

Usage: Setting only

INSTrument:DELete <ChannelName>

Deletes a channel.

If you delete the last channel, the default "Spectrum" channel is activated.

Setting parameters:

<ChannelName> String containing the name of the channel you want to delete.
A channel must exist to delete it.

Example: `INST:DEL 'IQAnalyzer4'`
Deletes the channel with the name 'IQAnalyzer4'.

Usage: Setting only

INSTrument:LIST?

Queries all active channels. The query is useful to obtain the names of the existing channels, which are required to replace or delete the channels.

Return values:

<ChannelType>, <ChannelName> For each channel, the command returns the channel type and channel name (see tables below).
Tip: to change the channel name, use the `INSTrument:REName` command.

Example:
```
INST:LIST?
```
Result for 3 channels:
```
'ADEM','Analog Demod','IQ','IQ
Analyzer','IQ','IQ Analyzer2'
```

Usage: Query only

Table 8-2: Available channel types and default channel names in Signal and Spectrum Analyzer mode

Application	<ChannelType> parameter	Default Channel name*)
Spectrum	SANALYZER	Spectrum
1xEV-DO BTS (R&S FSW-K84)	BDO	1xEV-DO BTS
1xEV-DO MS (R&S FSW-K85)	MDO	1xEV-DO MS
3GPP FDD BTS (R&S FSW-K72)	BWCD	3G FDD BTS
3GPP FDD UE (R&S FSW-K73)	MWCD	3G FDD UE
802.11ad (R&S FSW-K95)	WIGIG	802.11ad
802.11ay (R&S FSW-K97)	EDMG	802.11ay EDMG
Amplifier Measurements (R&S FSW-K18)	AMPLifier	Amplifier
AM/FM/PM Modulation Analysis (R&S FSW-K7)	ADEM	Analog Demod
Avionics (R&S FSW-K15)	AVIonics	Avionics
Bluetooth (R&S FSW-K8)	BTO	Bluetooth
cdma2000 BTS (R&S FSW-K82)	BC2K	CDMA2000 BTS
cdma2000 MS (R&S FSW-K83)	MC2K	CDMA2000 MS
DOCSIS 3.1 (R&S FSW-K192/193)	DOCSis	DOCSIS 3.1
Fast Spur Search (R&S FSW-K50)	SPUR	Spurious
GSM (R&S FSW-K10)	GSM	GSM
HRP UWB (R&S FSW-K149)	UWB	HRP UWB
I/Q Analyzer	IQ	IQ Analyzer
LTE (R&S FSW-K10x)	LTE	LTE
Multi-Carrier "Group Delay" (R&S FSW-K17)	MCGD	MC "Group Delay"
NB-IoT (R&S FSW-K106)	NIOT	NB-IoT
Noise (R&S FSW-K30)	NOISE	Noise
5G NR (R&S FSW-K144)	NR5G	5G NR
OFDM VSA (R&S FSW-K96)	OFDMVSA	OFDM VSA
OneWeb (R&S FSW-K201)	OWEB	OneWeb
Phase Noise (R&S FSW-K40)	PNOISE	Phase Noise
*) If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel.		

Application	<ChannelType> parameter	Default Channel name*)
Pulse (R&S FSW-K6)	PULSE	Pulse
"Real-Time Spectrum"	RTIM	"Real-Time Spectrum"
TD-SCDMA BTS (R&S FSW-K76)	BTDS	TD-SCDMA BTS
TD-SCDMA UE (R&S FSW-K77)	MTDS	TD-SCDMA UE
Transient Analysis (R&S FSW-K60)	TA	Transient Analysis
Verizon 5GTF Measurement Application (V5GTF, R&S FSW-K118)	V5GT	V5GT
VSA (R&S FSW-K70)	DDEM	VSA
WLAN (R&S FSW-K91)	WLAN	WLAN
*) If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel.		

INSTrument:REName <ChannelName1>, <ChannelName2>

Renames a channel.

Setting parameters:

<ChannelName1> String containing the name of the channel you want to rename.

<ChannelName2> String containing the new channel name.
Note that you cannot assign an existing channel name to a new channel. If you do, an error occurs.
Channel names can have a maximum of 31 characters, and must be compatible with the Windows conventions for file names. In particular, they must not contain special characters such as ":", "*", "?".

Example:
```
INST:REN 'IQAnalyzer2','IQAnalyzer3'
```
Renames the channel with the name 'IQAnalyzer2' to 'IQAnalyzer3'.

Usage: Setting only

8.4 Configuring the R&S FSW OFDM VSA application

8.4.1 Restoring the default configuration (Preset)

SYSTem:PRESet:CHANnel[:EXEC]

Restores the default instrument settings in the current channel.

Use `INST:SEL` to select the channel.

Example:

`INST:SEL 'Spectrum2'`
Selects the channel for "Spectrum2".
`SYST:PRES:CHAN:EXEC`
Restores the factory default settings to the "Spectrum2" channel.

Usage: Event

Manual operation: See "Preset Channel" on page 62

8.4.2 Signal description

The signal description provides information on the expected input signal, which optimizes pattern and burst detection and the calculation of the ideal reference signal.

CONFigure:PREamble:BLENgth <BlockLength>

Defines the length of a block of repeating samples within a preamble symbol.

Parameters:

<BlockLength> Range: 0 to 65536
*RST: 0
Default unit: samples

Example: `CONF:PRE:BLEN 32`
Defines a block length of 32 samples.

Manual operation: See "Preamble Symbol Characteristics: Block Length" on page 66

CONFigure:PREamble:FOFFset <FrameOffset>

Defines the frame offset, that is the start of the actual OFDM frame relative to the start of the first detected preamble block.

Parameters:

<FrameOffset> Distance from the first preamble sample to the first sample of the frame.
Range: - <capture_length> to +<capture_length>
*RST: 0

Example: `CONF:PRE:FOFF 0`
Defines a frame offset of 0 samples. Thus, the frame starts with the first sample of the preamble.

Manual operation: See "Frame Start Offset" on page 66

CONFigure:RFUC:FZERo:FREQuency <Frequency>

If phase compensation is enabled (see `CONFigure:RFUC:STATe` on page 159) and the phase shift frequency is defined manually (see `CONFigure:RFUC:FZERo:MODE` on page 159), this command defines the frequency for phase shift.

Parameters:

<Frequency> numeric value
Default unit: HZ

Example:
```
CONF:RFUC:STAT ON
CONF:RFUC:FZER:MODE MAN
CONF:RFUC:FZER:FREQ 10MHz
```

Manual operation: See "RF Upconversion: Phase Compensation" on page 64

CONFigure:RFUC:FZERo:MODE <Mode>

If phase compensation is enabled (see CONFigure:RFUC:STATe on page 159), this command defines the frequency for phase shift.

Parameters:

<Mode> CF | MANual

CF
The phase shift frequency corresponds to the current center frequency.

MANual
The phase shift frequency is defined manually by the CONFigure:RFUC:FZERo:FREQuency command.

Example:
```
CONF:RFUC:STAT ON
CONF:RFUC:FZER:MODE MAN
CONF:RFUC:FZER:FREQ 10MHz
```

Manual operation: See "RF Upconversion: Phase Compensation" on page 64

CONFigure:RFUC:STATe <State>

Enables or disables phase compensation during the upconversion of the baseband signal to the radio frequency.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off. The R&S FSW OFDM VSA application assumes that the input signal is not phase-compensated.

ON | 1
Switches the function on. The R&S FSW OFDM VSA application assumes the input signal is phase-compensated for a specific frequency. Define the frequency using the CONFigure:RFUC:FZERo:MODE and CONFigure:RFUC:FZERo:FREQuency commands.

*RST: 0

Example:
```
CONF:RFUC:STAT ON
CONF:RFUC:FZER:MODE MAN
CONF:RFUC:FZER:FREQ 10MHz
```

Manual operation: See "RF Upconversion: Phase Compensation" on page 64

CONFigure[:SYMBol]:GUARd:MODE <GuardMode>

Selects the type of cyclic prefix.

Parameters:

<GuardMode> **CONV**
Conventional cyclic prefix mode.

GU2
Cyclic prefix with two different lengths.

*RST: CONV

Example:
`CONF:GUAR:MODE GU2`
Selects a cyclic prefix with two different lengths.
`CONF:GUAR:PER ON`
Activates periodic cyclic prefix ranges.
`CONF:GUAR1:NSYM 5`
`CONF:GUAR2:NSYM 10`
Defines the number of symbols for both cyclic prefixes (5 and 10).

Manual operation: See "Cyclic Prefix Configuration" on page 66
See "Cyclic prefix mode" on page 119

CONFigure[:SYMBol]:GUARd:NSYMbols<cp> <Symbols>

Defines the number of symbols for which the first and second non-conventional cyclic prefix is used.

For more information see:

- `CONFigure[:SYMBol]:GUARd:MODE`
- `CONFigure[:SYMBol]:GUARd:PERiodic` on page 160

Suffix:
<cp> 1 | 2
Selects the cyclic prefix for non-conventional, periodic cyclic prefix lengths.
For non-periodic non-conventional cyclic prefix lengths, the suffix must be 1 (range 2 is variable, till the end of the frame).

Parameters:
<Symbols> unsigned integer
Number of symbols

Range: 1 to 1000
*RST: 100

Example: See `CONFigure[:SYMBol]:GUARd:MODE` on page 159.

Manual operation: See "Cyclic prefix definition per range (Symbols / Samples)" on page 67

CONFigure[:SYMBol]:GUARd:PERiodic <State>

Turns periodic cyclic prefix ranges on and off.

The command is available for non-conventional cyclic prefixes.

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

OFF | 0
The cyclic prefix changes at a certain point in time and then stays constant till the end of the OFDM frame.

ON | 1
The cyclic prefix toggles between two different values periodically.

*RST: 0

Example: See CONFigure[:SYMBol]:GUARd:MODE on page 159.

Manual operation: See "Different cyclic prefix lengths" on page 66

CONFigure[:SYMBol]:NFFT <NFFT>

Defines the FFT length of an OFDM symbol. This command is only available if no configuration file has been loaded.

Parameters:

<NFFT> FFT length in samples.

Range: 8 to 65535
*RST: 64

Example: `CONF:SYMB:NFFT 1024`
Defines an FFT length of 1024 samples.

Manual operation: See "FFT Size" on page 65

CONFigure[:SYMBol]:NGUard<cp> <NGuard>

Defines the cyclic prefix length.

Suffix:

<cp> 1 | 2
Selects the cyclic prefix for non-conventional, periodic cyclic prefix lengths.
For non-periodic non-conventional cyclic prefix lengths, the suffix must be 1 (range 2 is variable, till the end of the frame).
For conventional cyclic prefix lengths, the suffix is irrelevant.

Parameters:

<NGuard> unsigned integer

Length of the cyclic prefix in samples.

Range: 4 to 65535
*RST: 16

Example: `CONF:SYMB:NGU 128`
Defines a guard length of 128 samples.

Manual operation: See "Cyclic Prefix Length" on page 65
See "Cyclic prefix definition per range (Symbols / Samples)" on page 67

CONFigure[:SYMBol]:NSUFfix <NSuffix>

Defines the length of the cyclic suffix.

The cyclic suffix length must be smaller than or equal to the "FFT Size" on page 65.

Parameters:

<NSuffix> unsigned integer

Length of the cyclic suffix in samples.

Range: 0 to FFT size
*RST: 0

Example: `CONF:NSUF 16`

Manual operation: See "Cyclic Suffix Length" on page 65

CONFigure:SYSTem:CFILe <State>

Determines whether the configuration from the currently loaded file is used for the measurement. Alternatively, you can configure the OFDM signal manually.

Note: when you load a configuration file using the `MMEMory:LOAD:CFGFile` command, the use of the file is automatically set to ON.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example:

`MMEM:LOAD:CFGF 'C:\TEMP\K96Test.xml'`
Loads the configuration stored in the file `K96Test.xml`.
`CONF:SYST:MAN`
Switches to manual configuration.
`CONF:SYST:CFIL ON`
Uses the configuration in the loaded file.

Manual operation: See "Use Configuration File" on page 63

CONFigure[:SYMBol]:ZPADding:LENGth <Samples>

Defines the number of samples used for zero padding.

Parameters:

<Samples> unsigned integer

Range: 0 to <FFTSize>-1
*RST: 0

Example:

```
CONF:ZPAD ON
CONF:ZPAD:LEN 20
```

Manual operation: See "Samples" on page 67

CONFigure[:SYMBol]:ZPADding:OFFSet <Symbols>

Defines a number of symbols from the start for which no zero padding is inserted.

Parameters:

<Symbols> unsigned integer

Range: 0 to 65536
*RST: 0

Example:

```
CONF:ZPAD ON
CONF:SYMB:ZPAD:SOFF 20
```

Manual operation: See "Symbol Offset" on page 67

CONFigure[:SYMBol]:ZPADding:REPetition <Symbols>

Defines an interval of symbols (starting after the "Symbol Offset"), after which zero padding is repeated. For a repetition rate of 1, each symbol has zero padding.

Parameters:

<Symbols> unsigned integer

Range: 1 to 65536
*RST: 1

Example:

```
CONF:ZPAD ON
CONF:ZPAD:REP 6
```

Manual operation: See "Repeat Padding After Symbols" on page 67

CONFigure[:SYMBol]:ZPADding:STATe <State>

Enables or disables zero padding.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example:

Insert a zero padding consisting of 10 samples, for every 4th symbol, starting at symbol 2.

```
CONF:ZPAD ON
CONF:ZPAD:LEN 10
CONF:ZPAD:REP 4
CONF:SYMB:ZPAD:SOFF 2
```

Result: symbols 2 (offset), 6 (2+4), 10 (6+4) etc. contain 10 samples of value "0".

Manual operation: See "Zero Padding" on page 67

CONFigure:TPRecoding <State>

Enables or disables transform precoding. See "DFT-s-OFDM / SC-FDMA:Transform Precoding" on page 64.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example: `CONF:TPR ON`

Manual operation: See "DFT-s-OFDM / SC-FDMA:Transform Precoding" on page 64

CONFigure:TPRecoding:IGNore <State>

For `CONFigure:TPRecoding ON`, defines how to process OFDM symbols that contain "Don't Care" and pilot cells.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
OFDM symbols that contain a pilot or a "Don't Care" cell are skipped and not decoded.

ON | 1
OFDM symbols that contain pilot or "Don't Care" cells are decoded, but these cells are ignored.

*RST: 0

Example: Decode precoding for all symbols, even if they contain pilot or "Don't Care" cells.

```
CONF:TPR ON
CONF:TPR:IGN 1
```

Manual operation: See "Ignore PILOT/DONTCARE" on page 64

MMEMory:LOAD:CFGFile <Filename>

Loads an OFDM configuration file and activates its use.

Parameters:

<Filename> String containing the path and name of the `.xml` file.

Example: `MMEM:LOAD:CFGF 'C:\TEMP\K96Test.xml'`
Loads the configuration stored in the file `K96Test.xml`.

Manual operation: See "Load Configuration File" on page 64

8.4.3 Input, output and frontend settings

The FSW can analyze signals from different input sources. The frequency and amplitude settings represent the "frontend" of the measurement setup.

Manual configuration of the input and frontend is described in Chapter 4.3, "Input, output and frontend settings", on page 68.

8.4.3.1 RF input

INPut:ATTenuation:PROTection:RESet

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

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

Example: `INP:ATT:PROT:RES`

INPut:CONNector <ConnType>

Determines which connector the input for the measurement is taken from.

If an external frontend is active, the connector is automatically set to `RF`.

Parameters:

<ConnType>

RF
RF input connector

RFPRobe
Active RF probe

*RST: RF

Example: `INP:CONN RF`
Selects input from the RF input connector.

Manual operation: See "Input Connector" on page 72

INPut:COUPling <CouplingType>

Selects the coupling type of the RF input.

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

Parameters:

<CouplingType> AC | DC

AC
AC coupling

DC
DC coupling

*RST: AC

Example: `INP:COUP DC`

Manual operation: See "Input Coupling" on page 70

INPut:DPATh <DirectPath>

Enables or disables the use of the direct path for frequencies close to 0 Hz.

If an external frontend is active, the direct path is always used.

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 71

INPut:FILTer:HPASs[:STATe] <State>

Activates an additional internal high-pass filter for RF input signals from 1 GHz to 3 GHz. This filter is used to remove the harmonics of the FSW 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.)

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 71

INPut:FILTer:YIG[:STATe] <State>

Enables or disables the YIG filter.

Parameters:

<State> ON | OFF | 0 | 1

Example: `INP:FILT:YIG OFF`
Deactivates the YIG-preselector.

Manual operation: See "YIG-Preselector" on page 71

INPut:IMPedance <Impedance>

Selects the nominal input impedance of the RF input. In some applications, only 50 Ω are supported.

Parameters:

<Impedance> 50 | 75

numeric value
User-defined impedance from 50 Ohm to 100000000 Ohm (=100 MOhm)
User-defined values are only available for the Spectrum application, the I/Q Analyzer, and some optional applications.
(In MSRA mode, primary only)

*RST: 50 Ω
Default unit: OHM

Example: `INP:IMP 75`

Manual operation: See "Impedance" on page 70

INPut:IMPedance:PTYPe <PadType>

Defines the type of matching pad used for impedance conversion for RF input.

Parameters:

<PadType> SRESistor | MLPad

SRESistor
Series-R

MLPad
Minimum Loss Pad

*RST: SRESistor

Example:
```
INP:IMP 100
INP:IMP:PTYP MLP
```

Manual operation: See "Impedance" on page 70

INPut:SELect <Source>

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

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

Parameters:

<Source>

RF
Radio Frequency ("RF INPUT" connector)

FIQ
I/Q data file
Not available for Input2.

AIQ
Analog Baseband signal (only available with optional "Analog Baseband" interface)
Not available for Input2.

*RST: RF

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

Manual operation: See "Radio Frequency State" on page 69
See "I/Q Input File State" on page 72

INPut:TYPE <Input>

The command selects the input path.

Parameters:

<Input>

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

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

*RST: INPUT1

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

Manual operation: See "Radio Frequency State" on page 69

8.4.3.2 Configuring file input

The following commands are required to define input from a file.

Useful commands for configuring file input described elsewhere:

- `INPut:SELect` on page 168

Remote commands exclusive to configuring input from files:

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

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

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

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

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

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

Parameters:

<FileName> String containing the path and name of the source file.
The file type is determined by the file extension. If no file extension is provided, the file type is assumed to be `.iq.tar`.
For `.mat` files, Matlab® v4 is assumed.

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

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

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

Manual operation: See "Select I/Q data file" on page 73

MMEMory:LOAD:IQ:STReam <Channel>

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

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

Parameters:

<Channel> String containing the channel name.

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

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

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

Parameters:

<State> ON | OFF | 0 | 1

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

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

*RST: 1

MMEMory:LOAD:IQ:STReam:LIST?

Returns the available channels in the currently loaded input file.

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

Usage: Query only

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

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

Parameters:
<RepetitionCount> integer

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

Manual operation: See "File Repetitions" on page 73

8.4.3.3 Using external mixers

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

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 172).

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 172).

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`

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 172).

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 172).

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 8-3: Frequency ranges for pre-defined bands

Band	Frequency start [GHz]	Frequency stop [GHz]
KA (A) *)	26.5	40.0
Q	33.0	50.0
U	40.0	60.0
V	50.0	75.0
E	60.0	90.0
W	75.0	110.0
F	90.0	140.0
D	110.0	170.0
G	140.0	220.0
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

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

*RST: 2 (for band F)

Example: `MIX:HARM 3`

[SENSe:]MIXer<x>:IF?

Queries the intermediate frequency currently used by the external mixer.

Suffix:
<x> 1..n
irrelevant

Example: `MIX:IF?`

Example: See "Programming example: working with an external mixer" on page 182.

Usage: Query only

[SENSe:]MIXer<x>:LOSS:HIGH <Average>

Defines the average conversion loss to be used for the entire high (second) range.

Suffix:
<x> 1..n
irrelevant

Parameters:

<Average>
Range: 0 to 100
*RST: 24.0 dB
Default unit: dB

Example:
```
MIX:LOSS:HIGH 20dB
```

[SENSe:]MIXer<x>:LOSS:TABLe:HIGH <FileName>

Defines the conversion loss table to be used for the high (second) range.

Suffix:

<x>
1..n
irrelevant

Parameters:

<FileName>
String containing the path and name of the file, or the serial number of the external mixer whose file is required. The FSW automatically selects the correct cvl file for the current IF. As an alternative, you can also select a user-defined conversion loss table (`.acl` file).

Example:
```
MIX:LOSS:TABL:HIGH '101567'
MIX:LOSS:TABL:HIGH?
//Result for installed B5000, bw<= 4.4 GHz: 101567_B5000_2G8.B5G:
//'101567_MAG_6_B5000_2G8.B5G'
//Result for installed B5000, bw> 4.4 GHz: 101567_B5000_2G8.B5G:
//'101567_MAG_6_B5000_3G5.B5G'
//Result for installed B2001 and bw> 80 MHz:
//'101567_MAG_6_B1200_B2001.B2G'
//Result for installed B2001 and bw<= 80 MHz:
//'101567_MAG_6.ACL'
```

[SENSe:]MIXer<x>:LOSS:TABLe[:LOW] <FileName>

Defines the file name of the conversion loss table to be used for the low (first) range.

Suffix:

<x>
1..n
irrelevant

Parameters:

<FileName>
String containing the path and name of the file, or the serial number of the external mixer whose file is required. The FSW automatically selects the correct cvl file for the current IF. As an alternative, you can also select a user-defined conversion loss table (`.acl` file).

Example:
```
MIX:LOSS:TABL '101567'
MIX:LOSS:TABL?
//Result:
'101567_MAG_6_B5000_3G5.B5G'
```

[SENSe:]MIXer<x>:LOSS[:LOW] <Average>

Defines the average conversion loss to be used for the entire low (first) range.

Suffix:
<x> 1..n
irrelevant

Parameters:
<Average> Range: 0 to 100
*RST: 24.0 dB
Default unit: dB

Example: `MIX:LOSS 20dB`

[SENSe:]MIXer<x>:PORTs <PortType>

Selects the mixer type.

Suffix:
<x> 1..n
irrelevant

Parameters:
<PortType> **2 | 3**

2
Two-port mixer.

3
Three-port mixer.

*RST: 2

Example: `MIX:PORT 3`

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

If enabled, the band limits are extended beyond "RF Start" and "RF Stop" due to the capabilities of the used harmonics.

Suffix:
<x> 1..n
irrelevant

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

Conversion loss table settings

The following settings are required to configure and manage conversion loss tables.

[SENSe:]CORRection:CVL:BAND <Band>

Defines the waveguide band for which the conversion loss table is to be used. This setting is checked against the current mixer setting before the table can be assigned to the range.

Before this command can be performed, the conversion loss table must be selected (see `[SENSe:]CORRection:CVL:SELect` on page 182).

Is only available with option B21 (External Mixer) installed.

Parameters:

<Band>
: K | KA | Q | U | V | E | W | F | D | G | Y | J | USER
Standard waveguide band or user-defined band.
For a definition of the frequency range for the pre-defined bands, see Table 8-3).
*RST: F (90 GHz - 140 GHz)

Example:
`CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:BAND KA`
Sets the band to KA (26.5 GHz - 40 GHz).

[SENSe:]CORRection:CVL:BIAS <BiasSetting>

Defines the bias setting to be used with the conversion loss table.

Before this command can be performed, the conversion loss table must be selected (see `[SENSe:]CORRection:CVL:SELect` on page 182.

Is only available with option B21 (External Mixer) installed.

Parameters:

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

Example:
`CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:BIAS 3A`

[SENSe:]CORRection:CVL:CATalog?

Queries all available conversion loss tables saved in the `C:\R_S\INSTR\USER\cvl\` directory on the instrument.

Is only available with option B21 (External Mixer) installed.

Return values:

<Files> 'string'

Comma-separated list of strings containing the file names.

Example: CORR:CVL:CAT?

Usage: Query only

[SENSe:]CORRection:CVL:CLEar

Deletes the selected conversion loss table. Before this command can be performed, the conversion loss table must be selected (see `[SENSe:]CORRection:CVL:SELect` on page 182).

Is only available with option B21 (External Mixer) installed.

Example: `CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:CLE`

[SENSe:]CORRection:CVL:COMMent <Text>

Defines a comment for the conversion loss table. Before this command can be performed, the conversion loss table must be selected (see `[SENSe:]CORRection:CVL:SELect` on page 182).

Is only available with option B21 (External Mixer) installed.

Parameters:

<Text>

Example: `CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:COMM 'Conversion loss table for FS_Z60'`

[SENSe:]CORRection:CVL:DATA {<Freq>, <Level>}...

Defines the reference values of the selected conversion loss tables. The values are entered as a set of frequency/level pairs. You can define a maximum of 500 frequency/level pairs. Before this command can be performed, you must select the conversion loss table (see `[SENSe:]CORRection:CVL:SELect` on page 182).

Is only available with option B21 (External Mixer) installed.

Parameters:

<Freq>	The frequencies have to be sent in ascending order. Default unit: HZ
<Level>	Default unit: DB

Example: `CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:DATA 1MHZ,-30DB,2MHZ,-40DB`

[SENSe:]CORRection:CVL:HARMonic <HarmOrder>

Defines the harmonic order for which the conversion loss table is to be used. This setting is checked against the current mixer setting before the table can be assigned to the range.

Before this command can be performed, the conversion loss table must be selected (see [SENSe:]CORRection:CVL:SELect on page 182.

Is only available with option B21 (External Mixer) installed.

Parameters:

<HarmOrder> Range: 2 to 65

Example: `CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:HARM 3`

[SENSe:]CORRection:CVL:MIXer <Type>

Defines the mixer name in the conversion loss table. This setting is checked against the current mixer setting before the table can be assigned to the range.

Before this command can be performed, the conversion loss table must be selected (see [SENSe:]CORRection:CVL:SELect on page 182).

Is only available with option B21 (External Mixer) installed.

Parameters:

<Type>	string Name of mixer with a maximum of 16 characters

Example: `CORR:CVL:SEL 'LOSS_TAB_4'`
Selects the conversion loss table.
`CORR:CVL:MIX 'FS_Z60'`

[SENSe:]CORRection:CVL:PORTs <PortType>

Defines the mixer type in the conversion loss table. This setting is checked against the current mixer setting before the table can be assigned to the range.

Before this command can be performed, the conversion loss table must be selected (see [SENSe:]CORRection:CVL:SELect on page 182).

Is only available with option B21 (External Mixer) installed.

Parameters:

<PortType> 2 | 3

*RST: 2

Example:
```
CORR:CVL:SEL 'LOSS_TAB_4'
```
Selects the conversion loss table.
```
CORR:CVL:PORT 3
```

[SENSe:]CORRection:CVL:SELect <FileName>

Selects the conversion loss table with the specified file name. If <file_name> is not available, a new conversion loss table is created.

Is only available with option B21 (External Mixer) installed.

Parameters:

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

Example:
```
CORR:CVL:SEL 'LOSS_TAB_4'
```

[SENSe:]CORRection:CVL:SNUMber <SerialNo>

Defines the serial number of the mixer for which the conversion loss table is to be used. This setting is checked against the current mixer setting before the table can be assigned to the range.

Before this command can be performed, the conversion loss table must be selected (see [SENSe:]CORRection:CVL:SELect on page 182).

Is only available with option B21 (External Mixer) installed.

Parameters:

<SerialNo> Serial number with a maximum of 16 characters

Example:
```
CORR:CVL:SEL 'LOSS_TAB_4'
```
Selects the conversion loss table.
```
CORR:CVL:MIX '123.4567'
```

Programming example: working with an external mixer

This example demonstrates how to work with an external mixer in a remote environment. It is performed in the Spectrum application in the default layout configuration. Note that without a real input signal and connected mixer, this measurement will not return useful results.

```
//--------------Preparing the instrument -----------
//Reset the instrument
*RST
//Activate the use of the connected external mixer.
SENS:MIX ON
//----------- Configuring basic mixer behavior -------------
//Set the LO level of the mixer's LO port to 15 dBm.
```

```
SENS:MIX:LOP 15dBm
//Set the bias current to -1 mA .
SENS:MIX:BIAS:LOW -1mA
//----------- Configuring the mixer and band settings -------------
//Use band "V" to full possible range extent for assigned harmonic (6).
SENS:MIX:HARM:BAND V
SENS:MIX:RFOV ON
//Query the possible range
SENS:MIX:FREQ:STAR?
//Result: 47480000000 (47.48 GHz)
SENS:MIX:FREQ:STOP?
//Result: 138020000000 (138.02 GHz)
//Use a 3-port mixer type
SENS:MIX:PORT 3
//Split the frequency range into two ranges;
//range 1 covers 47.48 GHz GHz to 80 GHz; harmonic 6, average conv. loss of 20 dB
//range 2 covers 80 GHz to 138.02 GHz; harmonic 8, average conv.loss of 30 dB
SENS:MIX:HARM:TYPE EVEN
SENS:MIX:HARM:HIGH:STAT ON
SENS:MIX:FREQ:HAND 80GHz
SENS:MIX:HARM:LOW 6
SENS:MIX:LOSS:LOW  20dB
SENS:MIX:HARM:HIGH 8
SENS:MIX:LOSS:HIGH 30dB
//--------- Activating automatic signal identification functions -----------
//Activate both automatic signal identification functions.
SENS:MIX:SIGN ALL
//Use auto ID threshold of 8 dB.
SENS:MIX:THR 8dB

//--------------Performing the Measurement-----
//Select single sweep mode.
INIT:CONT OFF
//Initiate a basic frequency sweep and wait until the sweep has finished.
INIT;*WAI
//---------------Retrieving Results-------------
//Return the trace data for the input signal without distortions
//(default screen configuration)
TRAC:DATA? TRACE3
```

Configuring a conversion loss table for a user-defined band

```
//--------------Preparing the instrument -----------
//Reset the instrument
*RST
//Activate the use of the connected external mixer.
SENS:MIX ON
//--------------Configuring a new conversion loss table --------------
//Define cvl table for range 1 of band as described in previous example
```

```
// (extended V band)
SENS:CORR:CVL:SEL 'UserTable'
SENS:CORR:CVL:COMM 'User-defined conversion loss table for USER band'
SENS:CORR:CVL:BAND USER
SENS:CORR:CVL:HARM 6
SENS:CORR:CVL:BIAS -1mA
SENS:CORR:CVL:MIX 'FS_Z60'
SENS:CORR:CVL:SNUM '123.4567'
SENS:CORR:CVL:PORT 3
//Conversion loss is linear from 55 GHz to 75 GHz
SENS:CORR:CVL:DATA 55GHZ,-20DB,75GHZ,-30DB
//----------- Configuring the mixer and band settings -------------
//Use user-defined band and assign new cvl table.
SENS:MIX:HARM:BAND USER
//Define band by two ranges;
//range 1 covers 47.48 GHz to 80 GHz; harmonic 6, cvl table 'UserTable'
//range 2 covers 80 GHz to 138.02 GHz; harmonic 8, average conv.loss of 30 dB
SENS:MIX:HARM:TYPE EVEN
SENS:MIX:HARM:HIGH:STAT ON
SENS:MIX:FREQ:HAND 80GHz
SENS:MIX:HARM:LOW 6
SENS:MIX:LOSS:TABL:LOW 'UserTable'
SENS:MIX:HARM:HIGH 8

SENS:MIX:LOSS:HIGH 30dB
//Query the possible range
SENS:MIX:FREQ:STAR?
//Result: 47480000000 (47.48 GHz)
SENS:MIX:FREQ:STOP?
//Result: 138020000000 (138.02 GHz)

//--------------Performing the Measurement-----
//Select single sweep mode.
INIT:CONT OFF
//Initiate a basic frequency sweep and wait until the sweep has finished.
INIT;*WAI
//---------------Retrieving Results-------------
//Return the trace data (default screen configuration)
TRAC:DATA? TRACe1
```

8.4.3.4 Remote commands for external frontend control

The following commands are available and required only if the external frontend control option (R&S FSW-K553) is installed.

Further commands for external frontend control described elsewhere:

- `INPut:SELect RF`; see `INPut:SELect` on page 168
- `[SENSe:]FREQuency:CENTer` on page 229

- DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel on page 231
- INPut:ATTenuation:AUTO on page 233
- INPut:ATTenuation on page 232
- INPut:SANalyzer:ATTenuation:AUTO on page 235

Commands for initial configuration

The following commands are required when you initially set up an external frontend.

[SENSe:]EFRontend:CONNection[:STATe] <State>

Queries the external frontend connection state in the firmware.

Note: to query the physical connection state of the external frontend, use [SENSe:]EFRontend:CONNection:CSTate? on page 187.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
The connection to the frontend is deactivated temporarily. The frontend is thus available for use elsewhere, for example by a signal generator. The measurement settings on the FSW remain untouched.

ON | 1
Frontend connection enabled.
The frontend is reserved for exclusive use by the FSW.

*RST: 0

Example:

```
//Global activation of external frontend
EFR ON
//Configure frontend
EFR:CONN:CONF "FE44S","123.456.789"
//Activate exclusive use of frontend by FSW.
EFR:CONN ON
```

[SENSe:]EFRontend:CONNection:CONFig <Type>, <IPAddress>[, <DeviceID>, <SymbolicName>]

Configures the connection to the external frontend.

Parameters:

<Type> | "FE44S" | "FE50DTR" | "FE170SR" | "FE110SR"
String in double quotes containing the type of frontend to be connected.

<IPAddress> string in double quotes
The IP address or computer name of the frontend connected to the FSW via LAN. The IP address and computer name are indicated on the electronic ink display on the side panel of the frontend.

<DeviceID> string in double quotes
Unique device ID consisting of <type>-<serialnumber>
Not required or relevant for the FSW.

<SymbolicName> string in double quotes
Symbolic name of the external frontend.
Not required or relevant for the FSW.

Example:

```
//Global activation of external frontend
EFR ON
//Configure frontend
EFR:CONN:CONF "FE44S","123.456.789"
//Activate exclusive use of frontend by FSW.
EFR:CONN ON
```

[SENSe:]EFRontend:CONNection:CSTate?

Queries the status of the physical connection to the external frontend.

Return values:

<State> ON | OFF | 0 | 1

OFF | 0
Frontend not connected; connection error

ON | 1
Frontend connected

Usage: Query only

[SENSe:]EFRontend:FREQuency:BAND:COUNt?

Queries the number of frequency bands provided by the selected frontend.

Return values:

<NoBands> integer

Number of frequency bands

Example:

```
//Query number of frequency bands
EFR:FREQ:BAND:COUN?
//Result: 2
```

Usage: Query only

[SENSe:]EFRontend:FREQuency:BAND<b>:LOWer?

Queries the start of the frequency range supported by the selected frontend frequency band.

Suffix:

<b> 1..n
Band for multi-band frontends
Use [SENSe:]EFRontend:FREQuency:BAND:COUNt? on page 187 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 187 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 189.

ON | 1
Configures the frequency band automatically
Currently, auto mode always applies the "IF Low" range.

*RST: 1

Example:

//Configures the use of the IF high band manually.

```
EFR:FREQ:BCON:AUTO 0
EFR:FREQ:BCON:SEL "IF HIGH"
```

[SENSe:]EFRontend:FREQuency:BCONfig:LIST?

Returns the intermediate frequency (output) range of the external frontend.

Return values:

<BandConfigs> string

"IF LOW"
(Not for R&S FE170SR/R&S FE110SR frontends.)
A higher intermediate frequency is used on the external frontend, resulting in a higher input frequency at the FSW.

"IF HIGH"
(Not for R&S FE170SR/R&S FE110SR frontends.)
A lower intermediate frequency is used on the external frontend, resulting in a lower input frequency at the FSW.

"Spur Optimized"
The selected IF range avoids unwanted spurious effects.

"EVM Optimized"
The selected IF range provides an optimal EVM result.

Example:
```
EFR:FREQ:BCON:LIST?
//Result: "IF HIGH", "IF LOW"
EFR:FREQ:BCON:SEL "IF HIGH"
```

Usage: Query only

[SENSe:]EFRontend:FREQuency:BCONfig:SELect <BandConfig>

Defines the intermediate frequency (output) range of the external frontend.

Parameters:

<BandConfig>

"IF HIGH"
(R&S FE44S/ R&S FE50DTR)
A higher intermediate frequency is used on the external frontend, resulting in a higher input frequency at the FSW.

"IF LOW"
(R&S FE44S/ R&S FE50DTR)
A lower intermediate frequency is used on the external frontend, resulting in a lower input frequency at the FSW.

"Spur Optimized"
(R&S FE170SR/R&S FE110SR only)
The selected IF range avoids unwanted spurious effects.

"EVM Optimized"
(R&S FE170SR/R&S FE110SR only)
The selected IF range provides an optimal EVM result.

"Shared LO"
(R&S FE170SR/R&S FE110SR only)
Ensures that multiple external frontends (R&S FE170SR/R&S FE170ST or R&S FE110SR/R&S FE110ST) use the same LO frequencies for upconversion and downconversion.

Example:
```
EFR:FREQ:BCON:LIST?
//Result: "IF HIGH", "IF LOW"
EFR:FREQ:BCON:SEL "IF HIGH"
```

[SENSe:]EFRontend:FREQuency:IFRequency:MAXimum?

Queries the maximum used intermediate frequency (IF) for frequency conversion for a frequency span.

Return values:

<IFFrequency> numeric

Example:
```
EFR:FREQ:IFR:MAX?
```

Usage: Query only

[SENSe:]EFRontend:FREQuency:IFRequency:MINimum?

Queries the minimum used intermediate frequency (IF) for frequency conversion for a frequency span.

Return values:
<IFFrequency> numeric

Example: `EFR:FREQ:IFR:MIN?`

Usage: Query only

[SENSe:]EFRontend:FREQuency:IFRequency:SIDeband?

Queries the currently used sideband for frequency conversion.

Return values:
<Sideband> "USB" | "LSB"

"USB"
Upper sideband

"LSB"
Lower sideband

Example: `EFR:FREQ:IFR?`
`EFR:FREQ:IFR:SID?`

Usage: Query only

[SENSe:]EFRontend:FREQuency:IFRequency[:VALue]?

Queries the currently used intermediate frequency (IF) for frequency conversion.

To query the maximum and minimum IF for the selected frequency range, use `[SENSe:]EFRontend:FREQuency:IFRequency:MAXimum?` on page 189 and `[SENSe:]EFRontend:FREQuency:IFRequency:MINimum?` on page 190.

Return values:
<IFFrequency> numeric

Example: `EFR:FREQ:IFR?`

Usage: Query only

[SENSe:]EFRontend:FREQuency:LOSCillator:INPut:FREQuency?

Queries the frequency of the LO input for `[SENSe:]EFRontend:FREQuency:LOSCillator:MODE EXT`.

Return values:
<LOInFreq> Default unit: Hz

Example: The external frontend uses the external LO provided at the "LO IN" connector.
`EFR:FREQ:LOSC:MODE EXT`
Query the frequency that the external LO must be provided at.
`EFR:FREQ:LOSC:INP:FREQ?`
`//Result: 10615000000`

Usage: Query only

[SENSe:]EFRontend:FREQuency:LOSCillator:MODE <Type>

Determines whether the external frontend uses its internal LO or an external LO.

Parameters:

<Type> EXTernal | INTernal

EXTernal
Uses the external LO provided at the LO input connector of the external frontend. Query the frequency at which the LO must be input to the external frontend using `[SENSe:]EFRontend:FREQuency:LOSCillator:INPut:FREQuency?` on page 190.

INTernal
Uses the internal LO.

*RST: EXTernal

Example:
```
EFR:FREQ:LOSC:MODE EXT
EFR:FREQ:LOSC:INP:FREQ?
//Result: 10615000000
```

[SENSe:]EFRontend:FREQuency:LOSCillator:OUTPut:FREQuency?

Queries the frequency of the LO output for `[SENSe:]EFRontend:FREQuency:LOSCillator:OUTPut:STATe` ON.

Return values:

<LOOutFreq> Default unit: Hz

Example: The external frontend uses the internal LO and provides it as output to the "LO OUT" connector.
`EFR:FREQ:LOSC:MODE INT`
`EFR:FREQ:LOSC:OUTP:STAT ON`
Query the frequency of the LO output.
`EFR:FREQ:LOSC:OUTP:FREQ?`
`//Result: 10615000000`

Usage: Query only

[SENSe:]EFRontend:FREQuency:LOSCillator:OUTPut:STATe <State>

Enables or disables output of the LO by the external frontend. The output frequency is returned by `[SENSe:]EFRontend:FREQuency:LOSCillator:OUTPut:FREQuency?` on page 191.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example: The external frontend provides the LO as output at the "LO OUT" connector.

```
EFR:FREQ:LOSC:OUTP:STAT ON
```

Query the frequency of the LO output.

```
EFR:FREQ:LOSC:OUTP:FREQ?
//Result: 10615000000
```

[SENSe:]EFRontend:FREQuency:REFerence <Frequency>

Sets the reference frequency that is used for frequency conversion on the frontend. Depending on the connected type of frontend, different values are available. To determine which reference levels are available, use `[SENSe:]EFRontend:FREQuency:REFerence:LIST?` on page 192.

Parameters:

<Frequency> Default unit: HZ

Example:

```
//Query the available reference levels
EFR:FREQ:REF:LIST?
//Result: 10000000,640000000,1000000000
//Use 640 MHz reference
EFR:FREQ:REF 640000000
```

[SENSe:]EFRontend:FREQuency:REFerence:LIST?

Queries the available reference signals for the connected frontend type.

Return values:

<References> 10000000 | 640000000 | 1000000000

Example:

```
//Query the available reference levels
EFR:FREQ:REF:LIST?
//Result: 10000000,640000000,1000000000
//Use 640 MHz reference
EFR:FREQ:REF 640000000
```

Usage: Query only

[SENSe:]EFRontend:IDN?

Queries the device identifcation information (`*IDN?`) of the frontend.

Return values:

<DevInfo> string without quotes

Rohde&Schwarz,<device type>,<part number>/<serial number>,<firmware version>

Example:
```
EFR:IDN?
//Result: Rohde&Schwarz,FE44S,
1234.5678K00/123456,0.8.0
```

Usage: Query only

[SENSe:]EFRontend:NETWork <IPAddress>, <Subnet>, <DHCP State>

Sets or queries the network information for the frontend.

This information is also indicated on the electronic paper display on the side panel of the device.

Beware that if you change the network setting to DHCP = ON, the connection is aborted and you must re-establish a connection to the frontend (see [SENSe:]EFRontend:CONNection[:STATe] on page 185).

Parameters:

<IPAddress> string in double quotes

IP address of the frontend

<Subnet> string in double quotes

Subnet mask of the frontend

<DHCP State> ON | OFF | 0 | 1

Indicates whether a DHCP server is used.

OFF | 0
DHCP off

ON | 1
DHCP on

*RST: 0

Example:
```
EFR:NETW?
//Result: "123.456.78.90","255.255.255.0",ON
```

[SENSe:]EFRontend[:STATe] <State>

Enables or disables the general use of an external frontend for the application.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
The frontend is disconnected. The application adapts the measurement settings to the common settings supported by the FSW.

ON | 1
The FSW allows you to configure and connect an external frontend for the application. The application adapts the available measurement settings to the connected frontend.
The channel bar indicates "Inp: ExtFe".

*RST: 0

Example: `EFR ON`

Commands for test, alignment, and diagnosis

The following commands are required to test and optimize the connection after it has initially been set up.

[SENSe:]EFRontend:ALIGnment<ch>:FILE <File>

Selects or queries the touchstone file that contains correction data to compensate for signal losses in the cable occurring at different IF signal frequencies.

Suffix:
<ch> 1..n
Currently irrelevant

Parameters:
<File> string in double quotes

Path and file name of the correction data file. The file must be in `s2p` format.
If the specified file is not found or does not have the correct format, an error message is returned (`-256, "File name not found"`, `-150, "String data error"`).

Example: `EFR:ALIG:FILE "FE44S.s2p"`

[SENSe:]EFRontend:ALIGnment<ch>:STATe <State>

Activates correction of the IF signal due to cable loss from the frontend to the analyzer. Specify the file with correction data using `[SENSe:]EFRontend:ALIGnment<ch>:FILE` on page 194.

Suffix:
<ch> 1..n
Currently irrelevant

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

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

[SENSe:]EFRontend:FWUPdate

Updates the firmware on the external frontend. Note that this process can take some time.

Usage: Event

[SENSe:]EFRontend<fe>:SELFtest?

Performs a selftest on the frontend to compare the current performance and characteristic values with the specified values for the frontend.

As a result, the success is returned.

Suffix:
<fe> 1
Connected frontend

Return values:
<Result> **0**
No error

>0
Error

*RST: 0

Example:
```
EFR:SELF?
//Result: 0
```

Usage: Query only

[SENSe:]EFRontend<fe>:SELFtest:RESult?

Queries the results of the selftest on the frontend.

Suffix:
<fe> 1
Connected frontend

Return values:
<Result> string containing xml data in double quotes

Example: `EFR:SELF:RES?`

Usage: Query only

Commands for external devices

You can insert additional external devices in the signal path between the DUT and the external frontend, such as preamplifiers or filters. The external frontend must then consider the additional gain or correction values.

[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:CORRection:FILE <File>

Defines the correction file to compensate for signal losses by the external devices occurring at different IF signal frequencies.

To query whether the loaded file is valid or not, use `[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:CORRection:VALid?` on page 197.

Suffix:

<ch> 1..n
For future use.

<di> 1..n
irrelevant

Parameters:

<File>

Example:
```
SENS:EFR:CHAN:EXTD:CORR:FILE 'ExtDev_Corr.s2p'
SENS:EFR:CHAN:EXTD:CORR:STAT ON
SENS:EFR:CHAN:EXTD:CORR:FILE:VAL?
```

[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:CORRection:STATe <State>

Enables or disables the use of a correction file for the connected external devices. The file is defined by `[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:CORRection:FILE` on page 196.

Suffix:

<ch> 1..n
For future use.

<di> 1..n
irrelevant

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example:
```
SENS:EFR:CHAN:EXTD:CORR:FILE 'ExtDev_Corr.s2p'
SENS:EFR:CHAN:EXTD:CORR:STAT ON
```

[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:CORRection:VALid?

Queries whether the loaded correction file for an external device is valid or not.

Suffix:

<ch> 1..n
For future use.

<di> 1..n
irrelevant

Return values:

<Result> ON | OFF | 0 | 1

OFF | 0
File is valid.

ON | 1
File is not valid.

Example:
```
SENS:EFR:CHAN:EXTD:CORR:STAT ON
SENS:EFR:CHAN:EXTD:CORR:FILE 'ExtDev_Corr.s2p'
SENS:EFR:CHAN:EXTD:CORR:VAL?
```

Usage: Query only

[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:LIST?

Queries the names of all detected connected devices at the external frontend.

Suffix:

<ch> 1..n
For future use.

<di> 1..n
irrelevant

Return values:

<Devices> Comma-separated list of the names of the devices.

Example: `:SENSe1:EFRontend1:CHANnel1:EXTDevice1:LIST?`
`//Result:`
`//"fe170_z50","fe170_z01"`

Usage: Query only

[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:REFResh

Scans the ports of the external frontend and refreshes the display with detected information on connected devices. This function is useful after connecting a new device to the frontend.

Suffix:

<ch> 1..n
For future use.

<di> 1..n
irrelevant

Example: `SENSe1:EFRontend1:CHANnel:EXTDevice1:REFResh`

Usage: Event

[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:FREQuency:MAXimum?

Queries the upper limit of the supported frequency range of the connected device.

Suffix:

<ch> 1..n
For future use.

<di> 1..n
Connected external device

Return values:

<RFFrequency> numeric value

Maximum frequency

Default unit: Hz

Example: `SENS:EFR:EXTD1:FREQ:MAX?`
`//Result:`
`170000000000`

Usage: Query only

[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:FREQuency:MINimum?

Queries the lower limit of the supported frequency range of the connected device.

Suffix:

<ch> 1..n
For future use.

<di> 1..n
Connected external device

Return values:

<RFFrequency> numeric value

Minimum frequency

Default unit: Hz

Example:
```
SENS:EFR:EXTD1:FREQ:MIN?
//Result:
110000000000
```

Usage: Query only

[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:GAIN?

Queries the gain provided by a connected external amplifier.

Suffix:

<ch> 1..n
For future use.

<di> 1..n
Connected external device

Return values:

<Gain> numeric value

Default unit: dB

Example:
```
SENSe1:EFRontend1:CHANnel1:EXTDevice1:GAIN?
//Result:
//10
```

Usage: Query only

[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:NAME?

Queries the name of the external device for reference.

Suffix:

<ch> 1..n
For future use.

<di> 1..n
Connected external device

Return values:

<Type> string

Example:
```
SENS:EFR:CHAN:EXTD1:NAME?
//Result:
//'fe170_z50'
```

Usage: Query only

[SENSe:]EFRontend[:CHANnel<ch>]:EXTDevice<di>:TYPE?

Queries the type of the detected device for reference.

Suffix:

<ch> 1..n
For future use.

<di> 1..n
Connected external device

Return values:

<Type> 'Amplifier' | 'Filter'

Example:
```
SENSe1:EFRontend1:CHANnel1:EXTDevice1:TYPE?
//Result:
//'Filter'
```

Usage: Query only

Format of selftest result file

As a result of the selftest, an XML file with test details is created. It contains the following information in the specified order. Mandatory elements and attributes are indicated in bold font.

Element	Attributes	Description
<Sequence>		Main element
	Name	="Selftest"
	Description	Optional description of the test process
	FirmwareVersion	Firmware version of the controlling instrument (FSW)
	FrontendLibrary-Version	Version of the `control.dll` with the format `x.y.z`
	FrontendServerVer-sion	Version of the RRH server with the format `x.y.z` (FE44A only)
	Date	Date the selftest was performed, with the format `dd/mm/yyyy`
	Time	Time the selftest was performed, with the format `hh:mm:ss`
	State	Test result state, combined result of all <SequenceCate-gory>s: "`PASSED`"/ "`FAILED`"
	Version	For internal use.
	Comment	Optional comment on the test process
<SequenceCate-gory>		Set of test steps
	Name	Name of the test sequence, e.g. "Frontend voltages"
	Description	Optional description of the test sequence
	State	Test sequence result state, combined result of all <Sequence-Step>s: "`PASSED`"/ "`FAILED`"

Element	Attributes	Description
	Version	For internal use.
	Comment	Optional comment on the test sequence
<SequenceStep>		Subelement of **<SequenceCategory>** for an individual test step
	Name	Name of the individual test step, e.g. FE1_3V3
	Description	Optional description of the test step
	LimitLow	Optional: lower limit to be checked
	LimitHigh	Optional: upper limit to be checked
	MeasValue	Optional: measured value
	Unit	Optional: unit of the measured value
	State	Test step result state:"PASSED"/ "FAILED"
	Version	For internal use.
	Comment	Optional comment on the test step

Example for selftest result xml file

```
<?xml version="1.0" encoding="UTF-8"?>
<Sequence xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
          xsi:noNamespaceSchemaLocation="SelfTest_Schema.xsd">
 <Name>DeviceCheck</Name>
 <FirmwareVersion>1.50-21.1.1.0 Beta</FirmwareVersion>
 <FrontendLibraryVersion>0.8.0</FrontendLibraryVersion>
 <Date>15/01/2021</Date>
 <Time>08:51:35</Time>
 <State>FAILED</State>
 <Version>1.0.0</Version>
 <SequenceCategory>
  <Name>Frontend Voltages</Name>
  <Description>test description</Description>
  <State>FAILED</State>
  <Version>1.0.0</Version>
  <Type>Diagnose</Type>
  <SequenceStep>
   <Name>FE1_3V3</Name>
   <LimitLow>3.000</LimitLow>
   <LimitHigh>3.600</LimitHigh>
   <MeasValue>3.311</MeasValue>
   <State>PASSED</State>
   <Version>1.0.0</Version>
  </SequenceStep>
  <SequenceStep>
   <Name>FE1_5V</Name>
   <LimitLow>4.250</LimitLow>
   <LimitHigh>5.750</LimitHigh>
```

```
   <MeasValue>5.027</MeasValue>
   <State>PASSED</State>
   <Version>1.0.0</Version>
  </SequenceStep>
  <SequenceStep>
   <Name>FE1_6V5</Name>
   <LimitLow>6.000</LimitLow>
   <LimitHigh>7.000</LimitHigh>
   <MeasValue>5.893</MeasValue>
   <State>FAILED</State>
   <Version>1.0.0</Version>
  </SequenceStep>
  <SequenceStep>
   <Name>FE1_M3V3</Name>
   <LimitLow>-3.600</LimitLow>
   <LimitHigh>-3.000</LimitHigh>
   <MeasValue>3.347</MeasValue>
   <State>FAILED</State>
   <Version>1.0.0</Version>
  </SequenceStep>
 </SequenceCategory>
 <SequenceCategory>
  <Name>Frontend Temperature</Name>
  <Description>test description</Description>
  <State>PASSED</State>
  <Version>1.0.0</Version>
  <Type>Diagnose</Type>
  <SequenceStep>
   <Name>TEMP_FE1</Name>
   <LimitLow>0.000</LimitLow>
   <LimitHigh>60.000</LimitHigh>
   <MeasValue>39.300</MeasValue>
   <State>PASSED</State>
   <Version>1.0.0</Version>
  </SequenceStep>
 </SequenceCategory>
 <SequenceCategory>
  <Name>Synthesizer Voltage</Name>
  <Description>test description</Description>
  <State>PASSED</State>
  <Version>1.0.0</Version>
  <Type>Diagnose</Type>
  <SequenceStep>
   <Name>SYNTH_3V4</Name>
   <LimitLow>3.200</LimitLow>
   <LimitHigh>3.910</LimitHigh>
   <MeasValue>3.576</MeasValue>
   <State>PASSED</State>
   <Version>1.0.0</Version>
  </SequenceStep>
```

```
    <SequenceStep>
     <Name>SYNTH_5V4_SYN</Name>
     <LimitLow>4.860</LimitLow>
     <LimitHigh>5.940</LimitHigh>
     <MeasValue>5.405</MeasValue>
     <State>PASSED</State>
     <Version>1.0.0</Version>
    </SequenceStep>
    <SequenceStep>
     <Name>SYNTH_5V4_YIG</Name>
     <LimitLow>4.860</LimitLow>
     <LimitHigh>5.940</LimitHigh>
     <MeasValue>5.438</MeasValue>
     <State>PASSED</State>
     <Version>1.0.0</Version>
    </SequenceStep>
    <SequenceStep>
     <Name>SYNTH_M5V</Name>
     <LimitLow>-5.500</LimitLow>
     <LimitHigh>-4.500</LimitHigh>
     <MeasValue>-4.948</MeasValue>
     <State>PASSED</State>
     <Version>1.0.0</Version>
    </SequenceStep>
    <SequenceStep>
     <Name>SYNTH_REF5V</Name>
     <LimitLow>4.500</LimitLow>
     <LimitHigh>5.500</LimitHigh>
     <MeasValue>5.031</MeasValue>
     <State>PASSED</State>
     <Version>1.0.0</Version>
    </SequenceStep>
   </SequenceCategory>
   <SequenceCategory>
    <Name>Supply Voltage</Name>
    <Description>test description</Description>
    <State>PASSED</State>
    <Version>1.0.0</Version>
    <Type>Diagnose</Type>
    <SequenceStep>
     <Name>SUPPLY_12V</Name>
     <LimitLow>10.800</LimitLow>
     <LimitHigh>13.200</LimitHigh>
     <MeasValue>11.909</MeasValue>
     <State>PASSED</State>
     <Version>1.0.0</Version>
    </SequenceStep>
    <SequenceStep>
     <Name>SUPPLY_3V3D</Name>
     <LimitLow>2.970</LimitLow>
```

```
   <LimitHigh>3.630</LimitHigh>
   <MeasValue>3.318</MeasValue>
   <State>PASSED</State>
   <Version>1.0.0</Version>
  </SequenceStep>
  <SequenceStep>
   <Name>SUPPLY_4V</Name>
   <LimitLow>3.650</LimitLow>
   <LimitHigh>4.460</LimitHigh>
   <MeasValue>4.053</MeasValue>
   <State>PASSED</State>
   <Version>1.0.0</Version>
  </SequenceStep>
  <SequenceStep>
   <Name>SUPPLY_6V</Name>
   <LimitLow>5.400</LimitLow>
   <LimitHigh>6.600</LimitHigh>
   <MeasValue>6.076</MeasValue>
   <State>PASSED</State>
   <Version>1.0.0</Version>
  </SequenceStep>
  <SequenceStep>
   <Name>SUPPLY_M5V</Name>
   <LimitLow>-6.050</LimitLow>
   <LimitHigh>-4.950</LimitHigh>
   <MeasValue>-5.507</MeasValue>
   <State>PASSED</State>
   <Version>1.0.0</Version>
  </SequenceStep>
 </SequenceCategory>
</Sequence>
```


Programming example: Configuring an external frontend

The following example describes how to configure RF frontend settings in remote operation.

```
// Prepare the instrument
// Preset
*RST
// Create new IQ-Analyzer channel
:INST:SEL IQ
// Enable 640MHz Reference
:ROSC:O640 ON

//Enable general use of external frontend
SENSe:EFRontend:STATe ON
//Configure connection to ext. FE named "FE44S-1000826"
SENSe:EFRontend:CONNection:CONFig "FE44S","FE44S-1000826"
//Activate exclusive use of frontend by FSW.
SENSe:EFRontend:CONNection:STATe ON
```

```
//For demonstration purposes only: assign a static IP address
SENSe:EFRontend:NETWork "123.456.7.8", "255.255.255.00", OFF

// Query information about the connected RF frontend.
SENSe:EFRontend:CONNection:CSTAte?
// Response: 1 (connected)
SENSe:EFRontend:IDN?
////Result: Rohde&Schwarz,FE44S,1234.5678K00/123456,0.8.0

// Specify frontend settings
//Query available intermediate frequency bands
SENSe:EFRontend:FREQuency:BCONfig:LIST?
//Result: "IF HIGH", "IF LOW"
//Use high IF
SENSe:EFRontend:FREQuency:BCONfig:SELect "IF HIGH"
//Query used intermediate frequency
SENSe:EFRontend:FREQuency:IFRequency?
//Result: 8.595000000

//Query available reference frequencies
SENSe:EFRontend:FREQuency:REFerence:LIST?
//Result: 10000000,640000000,1000000000
//Use 640 MHz reference
SENSe:EFRontend:FREQuency:REFerence 640000000

// Query ranges of the operating frequency band.
SENSe:EFRontend:FREQuency:BAND1:LOWer?
// Response in Hz: "24000000000" (= 24 GHz)
SENSe:EFRontend:FREQuency:BAND1:UPPer?
// Response in Hz: "44000000000" (= 44 GHz)

// Add cable correction data by loading an *.s2p file.
SENSe:EFRontend:ALIGnment:FILE "C:\R_S\Instr\user\external_frontends\FE44S\
touchstonefiles\if_default_cable_1347_7552_00.s2p"
SENSe:EFRontend:ALIGnment:STATe ON

//Update FW version on frontend (only available if external frontend firmware
//is incompatible to FSW firmware)
SENSe:EFRontend:FWUPdate
//Perform a selftest on the frontend and query results
SENSe:EFRontend:SELFtest?
//Result: 0 (no errors)
SENSe:EFRontend:SELFtest:RESult?
//Result: "<?xml version="1.0" encoding="UTF-8"?>
//<Sequence xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
//xsi:noNamespaceSchemaLocation="
//<Name>DeviceCheck</Name>
//<FirmwareVersion>1.50-21.1.1.0 Beta</FirmwareVersion>
//..."
```

Programming example 2: Configuring an external frontend with a connected amplifier

The following example demonstrates how to configure an R&S FE170SR external frontend with a connected amplifier.

Some commands may not be necessary as they reflect the default settings; however, they are included to demonstrate the command usage.

```
// Prepare the instrument
// Preset
*RST
// Create new IQ-Analyzer channel
:INST:SEL IQ
// Enable 640MHz Reference
:ROSC:O640 ON

//Enable general use of external frontend
SENSe:EFRontend:STATe ON
//Configure connection to ext. FE named "FE170SR-123456"
SENSe:EFRontend:CONNection:CONFig "FE170SR","FE170SR-123456"
//Activate exclusive use of frontend by FSW.
SENSe:EFRontend:CONNection:STATe ON

// Query information about the connected RF frontend.
SENSe:EFRontend:CONNection:CSTAte?
// Response: 1 (connected)
SENSe:EFRontend:IDN?
////Result: Rohde&Schwarz,FE170SR,1234.5678K00/123456,0.8.0

// Specify frontend settings
//Query available intermediate frequency bands
SENSe:EFRontend:FREQuency:BCONfig:LIST?
//Result: "Spur Optimized","EVM Optimized"
//Use spur optimized
SENSe:EFRontend:FREQuency:BCONfig:SELect "Spur Optimized"
//Query used intermediate frequency
SENSe:EFRontend:FREQuency:IFRequency?
//Result: 9940000000

//Query available reference frequencies
SENSe:EFRontend:FREQuency:REFerence:LIST?
//Result: 10000000,640000000,1000000000
//Use 1 GHz reference
SENSe:EFRontend:FREQuency:REFerence 1000000000

// Query ranges of the operating frequency band.
SENSe:EFRontend:FREQuency:BAND1:LOWer?
// Response in Hz: "110000000000" (= 110 GHz)
SENSe:EFRontend:FREQuency:BAND1:UPPer?
// Response in Hz: "170000000000" (= 170 GHz)
```

```
// Add cable correction data by loading an *.s2p file.
SENSe:EFRontend:ALIGnment:FILE "C:\R_S\Instr\user\external_frontends\FE170SR\
touchstonefiles\if_default_cable_1348_3850_00.s2p"
SENSe:EFRontend:ALIGnment:STATe ON

//Configure external amplifier named "fe170_z50" connected to frontend
//Refresh and query the list of detected external devices
SENSe:EFRontend:EXTDevice:REFResh
SENSe:EFRontend:EXTDevice:LIST?
//Result:
//"fe170_z50"
//Query the type of the external device
SENSe:EFRontend:EXTDevice:TYPE?
//Result:
//'Amplifier'
//Query the supported frequency range of the amplifier
SENSe:EFRontend:EXTDevice1:FREQuency:MINimum?
//Result:
//110000000000
SENSe:EFRontend:EXTDevice1:FREQuency:MAXimum?
//Result:
//170000000000
//Query the gain of the amplifier
SENSe:EFRontend:EXTDevice1:GAIN?
//Result:
//10
//Only for demonstration purposes:
//Load and enable a correction file for the amplifier.
//The correction file is automatically considered if the IX cable is used to connect
//the external device to the frontend.
SENSe:EFRontend:EXTDevice1:CORRection:FILE 'C:\temp\ExtDev_Corr.s2p'
SENSe:EFRontend:EXTDevice1:CORRection:STATe ON
//Check if the loaded file is valid
SENSe:EFRontend:EXTDevice1:CORRection:VALid?
```

8.4.3.5 Configuring digital I/Q input and output

Remote commands exclusive to digital I/Q data input and output

INPut:DIQ:CDEVice

Queries the current configuration and the status of the digital I/Q input from the optional "Digital Baseband" interface.

For details see the section "Interface Status Information" for the optional "Digital Baseband" interface in the FSW I/Q Analyzer User Manual.

Return values:
<Value>

Example:
`INP:DIQ:CDEV?`
Result:
`1,SMW200A,101190,BBMM 1 OUT,`
`100000000,200000000,Passed,Passed,1,1.#QNAN`

INPut:DIQ:RANGe:COUPling <State>

If enabled, the reference level for digital input is adjusted to the full scale level automatically if the full scale level changes.

Is only available if the optional "Digital Baseband" interface is installed.

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

INPut:DIQ:RANGe[:UPPer] <Level>

Defines or queries the "Full Scale Level", i.e. the level that corresponds to an I/Q sample with the magnitude "1".

Is only available if the optional "Digital Baseband" interface is installed.

Parameters:
<Level> Range: 1 µV to 7.071 V
*RST: 1 V
Default unit: DBM

INPut:DIQ:RANGe[:UPPer]:AUTO <State>

If enabled, the digital input full scale level is automatically set to the value provided by the connected device (if available).

Is only available if the optional "Digital Baseband" interface is installed.

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

INPut:DIQ:RANGe[:UPPer]:UNIT <Level>

Defines the unit of the full scale level. The availability of units depends on the measurement application you are using.

Is only available if the optional "Digital Baseband" interface is installed.

Parameters:

<Level>	DBM | DBPW | WATT | DBUV | DBMV | VOLT | DBUA | AMPere *RST: Volt

INPut:DIQ:SRATe <SampleRate>

Specifies or queries the sample rate of the input signal from the optional "Digital Baseband" interface.

Parameters:

<SampleRate>	Range: 1 Hz to 20 GHz *RST: 32 MHz Default unit: HZ

Example: `INP:DIQ:SRAT 200 MHz`

INPut:DIQ:SRATe:AUTO <State>

If enabled, the sample rate of the digital I/Q input signal is set automatically by the connected device.

Is only available if the optional "Digital Baseband" interface is installed.

Parameters:

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

8.4.3.6 Configuring input via the optional Analog Baseband interface

The following commands are required to control the optional "Analog Baseband" interface in a remote environment. They are only available if this option is installed.

Useful commands for Analog Baseband data described elsewhere:

- `INP:SEL AIQ` (see `INPut:SELect` on page 168)
- `[SENSe:]FREQuency:CENTer` on page 229

Commands for the Analog Baseband calibration signal are described in the FSW User Manual.

Remote commands exclusive to Analog Baseband data input and output

---

INPut:IQ:BALanced[:STATe] <State>

Defines whether the input is provided as a differential signal via all 4 Analog Baseband connectors or as a plain I/Q signal via 2 single-ended lines.

Parameters:

<State> ON | OFF | 1 | 0

ON | 1
Differential

OFF | 0
Single ended

*RST: 1

Example: `INP:IQ:BAL OFF`

INPut:IQ:FULLscale:AUTO <State>

Defines whether the full scale level (i.e. the maximum input power on the Baseband Input connector) is defined automatically according to the reference level, or manually.

Parameters:

<State>

ON | 1
Automatic definition

OFF | 0
Manual definition according to `INPut:IQ:FULLscale[:LEVel]` on page 210

*RST: 1

Example: `INP:IQ:FULL:AUTO OFF`

INPut:IQ:FULLscale[:LEVel] <PeakVoltage>

Defines the peak voltage at the Baseband Input connector if the full scale level is set to manual mode (see `INPut:IQ:FULLscale:AUTO` on page 210).

Parameters:

<PeakVoltage> 0.25 V | 0.5 V | 1 V | 2 V

Peak voltage level at the connector.
For probes, the possible full scale values are adapted according to the probe's attenuation and maximum allowed power.

*RST: 1V
Default unit: V

Example: `INP:IQ:FULL 0.5V`

INPut:IQ:IMPedance <Impedance>

Selects the nominal input impedance of the analog baseband input.

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

For input from the RF input, use the `INPut:IMPedance` command.

Parameters:

<Impedance> 50 | 75

numeric value
User-defined impedance from 50 Ohm to 100000000 Ohm (=100 MOhm)
User-defined values are only available for:
Spectrum application
I/Q Analyzer

*RST: 50
Default unit: OHM

Example: `INP:IQ:IMP 75`

Manual operation: See "Impedance" on page 70

INPut:IQ:IMPedance:PTYPe <PadType>

Defines the type of matching pad used for impedance conversion for analog baseband input.

For RF input, use the `INPut:IMPedance:PTYPe` command.

Parameters:

<PadType> SRESistor | MLPad

SRESistor
Series-R

MLPad
Minimum Loss Pad

*RST: SRESistor

Example:

```
INP:IQ:IMP 100
INP:IQ:IMP:PTYP MLP
```

Manual operation: See "Impedance" on page 70

INPut:IQ:TYPE <DataType>

Defines the format of the input signal.

Parameters:

<DataType> IQ | I | Q

IQ
The input signal is filtered and resampled to the sample rate of the application.
Two input channels are required for each input signal, one for the in-phase component, and one for the quadrature component.

I
The in-phase component of the input signal is filtered and resampled to the sample rate of the application. If the center frequency is not 0, the in-phase component of the input signal is down-converted first (Low IF I).

Q
The quadrature component of the input signal is filtered and resampled to the sample rate of the application. If the center frequency is not 0, the quadrature component of the input signal is down-converted first (Low IF Q).

*RST: IQ

Example: `INP:IQ:TYPE Q`

CALibration:AIQ:HATiming[:STATe] <State>

Activates a mode with enhanced timing accuracy between analog baseband, RF and external trigger signals.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CAL:AIQ:HAT:STAT ON`

8.4.3.7 Setting up probes

Modular probes can be connected to the RF input connector of the FSW.

For details see the FSW User Manual.

Probes can also be connected to the optional "Baseband Input" connectors, if the "Analog Baseband" interface (option FSW-B71) is installed.

[SENSe:]PROBe<pb>:ID:PARTnumber?

Queries the R&S part number of the probe.

Suffix:
<pb> 1..n
Selects the connector:
1 = Baseband Input I
2 = Baseband Input Q
3 = RF

Return values:
<PartNumber>

Example: //Query part number
`PROB3:ID:PART?`

Usage: Query only

[SENSe:]PROBe<pb>:ID:SRNumber?

Queries the serial number of the probe.

Suffix:
<pb> 1..n
Selects the connector:
1 = Baseband Input I
2 = Baseband Input Q
3 = RF

Return values:
<SerialNo>

Example: //Query serial number
`PROB3:ID:SRN?`

Usage: Query only

[SENSe:]PROBe<pb>:SETup:ATTRatio <AttenuationRatio>

Defines the attenuation applied to the input at the probe. This setting is only available for modular probes.

Suffix:

<pb> 1..n
Selects the connector:
1 = Baseband Input I
2 = Baseband Input Q
3 = RF

Parameters:

<AttenuationRatio> **10**
Attenuation by 20 dB (ratio= 10:1)

2
Attenuation by 6 dB (ratio= 2:1)

*RST: 10
Default unit: DB

[SENSe:]PROBe<pb>:SETup:CMOFfset <CMOffset>

Sets the common mode offset. The setting is only available if a differential probe in CM-mode is connected to the FSW.

If the probe is disconnected, the common mode offset of the probe is reset to 0.0 V.

Note that if the offset for DM-mode or CM-mode is changed, the offsets for the P-mode and N-mode are adapted accordingly, and vice versa.

For details see the FSW User Manual.

Suffix:

<pb> 1..n
Selects the connector:
1 = Baseband Input I
2 = Baseband Input Q
3 = RF

Parameters:

<CMOffset> Offset of the mean voltage between the positive and negative input terminal vs. ground

Range: -16 V to +16 V
Default unit: V

[SENSe:]PROBe<pb>:SETup:DMOFfset <DMOffset>

Sets the DM-mode offset. The setting is only available if a modular probe in DM-mode is connected to the FSW.

If the probe is disconnected, the DM-mode offset of the probe is reset to 0.0 V.

Note that if the offset for DM-mode or CM-mode is changed, the offsets for the P-mode and N-mode are adapted accordingly, and vice versa.

For details see the FSW User Manual.

Suffix:
<pb> 1..n
Selects the connector:
1 = Baseband Input I
2 = Baseband Input Q
3 = RF

Parameters:
<DMOffset> Voltage offset between the positive and negative input terminal
Default unit: V

[SENSe:]PROBe<pb>:SETup:MODE <Mode>

Suffix:
<pb> 1..n
Selects the connector:
1 = Baseband Input I
2 = Baseband Input Q
3 = RF

Parameters:
<Mode> RSINgle | NOACtion

RSINgle
Run single: starts one data acquisition.

NOACtion
Nothing is started on pressing the micro button.

[SENSe:]PROBe<pb>:SETup:NAME?

Queries the name of the probe.

Suffix:
<pb> 1..n
Selects the connector:
1 = Baseband Input I
2 = Baseband Input Q
3 = RF

Return values:
<Name> String containing the name of the probe.

Example: //Query name of the probe
`PROB3:SET:NAME?`

Usage: Query only

[SENSe:]PROBe<pb>:SETup:NMOFfset <NMOffset>

Sets the N-mode offset. The setting is only available if a modular probe in N-mode is connected to the FSW. The maximum voltage difference between the positive and negative input terminals is 16 V.

If the probe is disconnected, the N-mode offset of the probe is reset to 0.0 V.

Note that if the offset for DM-mode or CM-mode is changed, the offsets for the P-mode and N-mode are adapted accordingly, and vice versa.

For details see the FSW User Manual.

Suffix:
<pb> 1..n
Selects the connector:
1 = Baseband Input I
2 = Baseband Input Q
3 = RF

Parameters:
<NMOffset> The voltage offset between the negative input terminal and ground.
Default unit: V

[SENSe:]PROBe<pb>:SETup:PMODe <Mode>

Determines the mode of a multi-mode modular probe.

For details see the FSW User Manual.

Suffix:
<pb> 1..n
Selects the connector:
1 = Baseband Input I
2 = Baseband Input Q
3 = RF

Parameters:
<Mode> CM | DM | PM | NM

DM
Voltage between the positive and negative input terminal

CM
Mean voltage between the positive and negative input terminal vs. ground

PM
Voltage between the positive input terminal and ground

NM
Voltage between the negative input terminal and ground

Example: `SENS:PROB:SETU:PMOD PM`
Sets the probe to P-mode.

[SENSe:]PROBe<pb>:SETup:PMOFfset <PMOffset>

Sets the P-mode offset. The setting is only available if a modular probe in P-mode is connected to the FSW. The maximum voltage difference between the positive and negative input terminals is 16 V.

If the probe is disconnected, the P-mode offset of the probe is reset to 0.0 V.

Note that if the offset for DM-mode or CM-mode is changed, the offsets for the P-mode and N-mode are adapted accordingly, and vice versa.

For details see the FSW User Manual.

Suffix:
<pb> 1..n
Selects the connector:
1 = Baseband Input I
2 = Baseband Input Q
3 = RF

Parameters:
<PMOffset> The voltage offset between the positive input terminal and ground.
Default unit: V

[SENSe:]PROBe<pb>:SETup:STATe?

Queries if the probe at the specified connector is active (detected) or not active (not detected).

To switch the probe on, i.e. activate input from the connector, use `INP:SEL:AIQ` (see `INPut:SELect` on page 168).

Suffix:
<pb> 1..n
Selects the connector:
1 = Baseband Input I
2 = Baseband Input Q
3 = RF

Return values:
<State> DETected | NDETected

Example: //Query connector state
`PROB3:SET:STAT?`

Usage: Query only

[SENSe:]PROBe<pb>:SETup:TYPE?

Queries the type of the probe.

Suffix:

<pb> 1..n
Selects the connector:
1 = Baseband Input I
2 = Baseband Input Q
3 = RF

Return values:

<Type> String containing one of the following values:
–"None" (no probe detected)
–"active differential"
–"active single-ended"
–"active modular"

Example: //Query probe type
`PROB3:SET:TYPE?`

Usage: Query only

8.4.3.8 Configuring the 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000)

The following commands are required to use the optional 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000).

Remote commands exclusive to configuring the 2 GHz / 5 GHz bandwidth extensions:

EXPort:WAVeform:DISPlayoff <FastExport>

Enables or disables the display update on the oscilloscope during data acquisition with the optional 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000).

Note that this command is **only executable by the oscilloscope**, not by the FSW.

As soon as the FSW-B2000/B5000 is activated, the display on the oscilloscope is turned off to improve performance during data export. As soon as the FSW closes the connection to the oscilloscope, the display is reactivated and the oscilloscope can be operated as usual. However, if the LAN connection is lost for any reason, the display of the oscilloscope remains deactivated. Use this command to re-activate it.

For details on the optional 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000), see FSW I/Q Analyzer and I/Q Input User Manual.

Parameters:

<FastExport> ON | OFF | 1 | 0

ON | 1: Disables the display update for maximum export speed.
OFF | 0: Enables the display update. The export is slower.

*RST: 1

SYSTem:COMMunicate:RDEVice:OSCilloscope[:STATe] <State>

Activates the optional 2 GHz / 5 GHz bandwidth extension (R&S FSW-B2000/B5000).

Note: Manual operation on the connected oscilloscope, or remote operation other than by the FSW, is not possible while the B2000/B5000 option is active.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `SYST:COMM:RDEV:OSC ON`

SYSTem:COMMunicate:RDEVice:OSCilloscope:ALIGnment:STEP<st>[:STATe] <State>

Performs the alignment of the oscilloscope itself and the oscilloscope ADC for the optional 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000). The correction data for the oscilloscope (including the connection cable between the FSW and the oscilloscope) is recorded. As a result, the state of the alignment is returned.

Alignment is required only once after setup. If alignment was performed successfully, the alignment data is stored on the oscilloscope.

Thus, alignment need only be repeated if one of the following applies:

- A new oscilloscope is connected to the "IF OUT 2 GHz/ IF OUT 5 GHz" connector of the FSW
- A new cable is used between the "IF OUT 2 GHz/ IF OUT 5 GHz" connector of the FSW and the oscilloscope
- A power splitter is inserted between the "IF OUT 2 GHz/ IF OUT 5 GHz" connector of the FSW and the oscilloscope
- New firmware is installed on the oscilloscope or the FSW

Suffix:
<st> 1..n

Parameters:
<State> Returns the state of the second alignment step.

ON | 1
Alignment was successful.

OFF | 0
Alignment was not yet performed (successfully).

Example:
```
SYST:COMM:RDEV:OSC:ALIG:STEP?
//Result: 1
```

SYSTem:COMMunicate:RDEVice:OSCilloscope:ALIGnment:DATE <Date>

Returns the date of alignment of the "IF OUT 2 GHz/ IF OUT 5 GHz" to the oscilloscope for the optional 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000).

Parameters:
<Date> Returns the date of alignment.

Example:
```
SYST:COMM:RDEV:OSC:ALIG:DATE?
//Result: 2014-02-28
```

SYSTem:COMMunicate:RDEVice:OSCilloscope:ALIGnment:FALignment <State>

Performs a self-alignment on the oscilloscope before the B2000/B5000 alignment on the FSW.

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

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example:
```
SYST:COMM:RDEV:OSC:ALIG:FAL ON
```

SYSTem:COMMunicate:RDEVice:OSCilloscope:IDN <IDString>

Returns the identification string of the oscilloscope connected to the FSW.

Parameters:
<IDString>

Example:
```
SYST:COMM:RDEV:OSC:IDN?
//Result: Rohde&Schwarz,RTO,
1316.1000k14/200153,2.45.1.1
```

SYSTem:COMMunicate:RDEVice:OSCilloscope:LEDState <Color>

Returns the state of the LAN connection to the oscilloscope for the optional 2 GHz / 5 GHz bandwidth extension (FSW-B2000/B5000).

Parameters:

<Color> OFF | SUCCessful | ERRor

SUCCessful
Connection to the instrument has been established successfully.

OFF
No instrument configured.

ERRor
Connection to the instrument could not be established.
Check the connection between the FSW and the oscilloscope, and make sure the IP address of the oscilloscope has been defined (see SYSTem:COMMunicate:RDEVice:OSCilloscope:TCPip on page 222).

Example:

```
SYST:COMM:RDEV:OSC:LEDS?
//Result: 'SUCC'
```

SYSTem:COMMunicate:RDEVice:OSCilloscope:PSMode[:STATe] <State>

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

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

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example:

```
SYST:COMM:RDEV:OSC:PSM ON
```

SYSTem:COMMunicate:RDEVice:OSCilloscope:SRATe <Rate>

Determines whether the 10 GHz mode (default) or 20 GHz mode of the connected oscilloscope is used. The 20 GHZ mode achieves a higher decimation gain, but reduces the record length by half.

Parameters:

<Rate> 10 GHz | 20 GHz

No other sample rate values are allowed.

*RST: 10 GHz
Default unit: HZ

Example:
```
TRAC:IQ:SRAT?
//Result: 100000000
TRAC:IQ:RLEN?
//Result: 3128
SYST:COMM:RDEV:OSC:SRAT 20GHZ
TRAC:IQ:SRAT?
//Result: 200000000
TRAC:IQ:RLEN?
//Result: 1564
```

SYSTem:COMMunicate:RDEVice:OSCilloscope:TCPip <Address>

Defines the TCPIP address or computer name of the oscilloscope connected to the FSW via LAN.

Note: The IP address is maintained after a [PRESET], and is transferred between applications.

Parameters:

<Address> computer name or IP address

Example: `SYST:COMM:RDEV:OSC:TCP '192.0.2.0'`

Example: `SYST:COMM:RDEV:OSC:TCP 'FSW43-12345'`

SYSTem:COMMunicate:RDEVice:OSCilloscope:VDEVice?

Queries whether the connected instrument is supported by the 2 GHz / 5 GHz bandwidth extension option(B2000/B5000).

Return values:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `SYST:COMM:RDEV:OSC:VDEV?`

Usage: Query only

SYSTem:COMMunicate:RDEVice:OSCilloscope:VFIRmware?

Queries whether the firmware on the connected oscilloscope is supported by the 2 GHz / 5 GHz bandwidth extension (B2000/B5000) option.

Return values:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `SYST:COMM:RDEV:OSC:VFIR?`

Usage: Query only

TRIGger[:SEQuence]:OSCilloscope:COUPling <CoupType>

Configures the coupling of the external trigger to the oscilloscope.

Parameters:

<CoupType> Coupling type

DC
Direct connection with 50 Ω termination, passes both DC and AC components of the trigger signal.

CDLimit
Direct connection with 1 MΩ termination, passes both DC and AC components of the trigger signal.

AC
Connection through capacitor, removes unwanted DC and very low-frequency components.

*RST: DC

Manual operation: See "Coupling" on page 89

8.4.3.9 Configuring Oscilloscope Baseband Input

The following commands define settings for analog baseband input from an oscilloscope.

The commands for analog baseband input from an oscilloscope are similar, but *not identical* to those used for analog baseband using the optional "Analog Baseband" interface on the FSW.

INPut:IQ:OSC:BALanced[:STATe] <State>

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Single ended

ON | 1
Differential

*RST: 1

Example: `INP:IQ:OSC:BAL OFF`

INPut:IQ:OSC:CONState?

Returns the state of the LAN connection to the oscilloscope for the optional Oscilloscope Baseband Input.

Return values:

<ConnectionState> CONNECTED | NOT_CONNECTED | ESTABLISHING_CONNECTION

CONNECTED
Connection to the instrument has been established successfully.

ESTABLISHING_CONNECTION
Connection is currently being established.

NOT_CONNECTED
Connection to the instrument could not be established.
Check the connection between the FSW and the oscilloscope, and make sure the IP address of the oscilloscope has been defined (see `INPut:IQ:OSC:TCPip` on page 228).

Usage: Query only

INPut:IQ:OSC:COUPling <Coupling>

Determines the coupling of the oscilloscope to the FSW.

Parameters:

<Coupling> DC | DCLimit | AC

DC
DC coupling shows all parts of an input signal. DC 50 Ω coupling is the default for 50Ω input impedance to connect, for example, active probes.

DCLimit
DC coupling with 1 M Ω input impedance to connect standard passive probes.

AC
AC coupling is useful if the DC component of a signal is of no interest. AC coupling blocks the DC component of the signal so that the waveform is centered on zero volts.

INPut:IQ:OSC:FULLscale[:LEVel] <Level>

The full scale level defines the maximum power for baseband input possible without clipping the signal.

For manual input, this setting corresponds to the setting on the oscilloscope. Thus, possible scaling values of the oscilloscope are allowed.

Parameters:

<Level>	Default unit: V
Example:	`INP:IQ:OSC:FULL:AUTO OFF`
Example:	`INP:IQ:OSC:FULL:LEV 1.0`

INPut:IQ:OSC:IDN?

Returns the identification string of the oscilloscope connected to the FSW.

Return values:

<IDN>	string

Example:	`INP:IQ:OSC:IDN?`
	`//Result: Rohde&Schwarz,RTO,`
	`1316.1000k14/200153,2.45.1.1`

Usage:	Query only

INPut:IQ:OSC:IMPedance <Impedance>

Selects the nominal input impedance of the analog baseband input.

The command is not available for measurements with the optional "Digital Baseband" interface.

For input from the RF input, use the `INPut:IMPedance` command.

For analog baseband input without an oscilloscope, use the `INPut:IQ:IMPedance` command.

Parameters:

<Impedance> 50 | 75

numeric value
User-defined impedance from 50 Ohm to 100000000 Ohm (=100 MOhm)
User-defined values are only available for the Spectrum application, the I/Q Analyzer (and thus MSRA mode, primary application only) and the optional Docsis 3.1 application.

*RST: 50
Default unit: Ohm

Example: `INP:IQ:OSC:IMP 75`

INPut:IQ:OSC:IMPedance:PTYPe <PadType>

Defines the type of matching pad used for impedance conversion for analog baseband input.

For RF input, use the `INPut:IMPedance:PTYPe` command.

For analog baseband input without an oscilloscope, use the `INPut:IQ:IMPedance:PTYPe` command.

Parameters:

<PadType> SRESistor | MLPad

SRESistor
Series-R

MLPad
Minimum Loss Pad

*RST: SRESistor

Example:
```
INP:IQ:OSC:IMP 100
INP:IQ:OSC:IMP:PTYP MLP
```

INPut:IQ:OSC:SKEW:I <Value>

Compensates for skewed values in the positive I path, e.g. due to different input cables.

Parameters:

<Value> Default unit: S

Example: `INP:IQ:OSC:SKEW:I 0.2`

INPut:IQ:OSC:SKEW:I:INVerted <Value>

Compensates for skewed values in the negative I path, e.g. due to different input cables.

Parameters:

<Value> Default unit: S

Example: `INP:IQ:OSC:SKEW:I:INV 0.2`

INPut:IQ:OSC:SKEW:Q <Value>

Compensates for skewed values in the positive Q path, e.g. due to different input cables.

Parameters:
<Value> Default unit: S

Example: `INP:IQ:OSC:SKEW:Q 0.2`

INPut:IQ:OSC:SKEW:Q:INVerted <Value>

Compensates for skewed values in the negative Q path, e.g. due to different input cables.

Parameters:
<Value> Default unit: S

Example: `INP:IQ:OSC:SKEW:Q:INV 0.2`

INPut:IQ:OSC:SRATe <SampleRate>

Returns the used oscilloscope acquisition sample rate, which depends on the used I/Q mode (see `INPut:IQ:OSC:TYPE` on page 228).

Parameters:
<SampleRate> 10 GHz | 20 GHz

10 GHz
differential mode

20 GHz
single-ended mode

Default unit: Hz

Example: `INP:IQ:OSC:SRAT?`

INPut:IQ:OSC[:STATe] <State>

Activates or deactivates Oscilloscope Baseband Input from a connected oscilloscope. This input requires optional firmware.

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

OFF | 0
Oscilloscope Baseband Input not active

ON | 1
Oscilloscope Baseband Input active

*RST: 0

Example: `INP:IQ:OSC:STAT ON`
This command has the same effect as `INP:SEL OBB`, see `INPut:SELect` on page 168.

INPut:IQ:OSC:TCPip <Tcpip>

Defines the TCPIP address or computer name of the oscilloscope connected to the FSW via LAN.

Note: The IP address is maintained after a [PRESET], and is transferred between applications.

Parameters:
<Tcpip> computer name or IP address

Example: `INP:IQ:OSC:TCP '192.0.2.0'`

Example: `INP:IQ:OSC:TCP 'FSW43-12345'`

INPut:IQ:OSC:TYPE <Type>

Defines the format of the input signal.

Parameters:
<Type> IQ | I

IQ
Both components of the complex input signal (in-phase component, quadrature component) are filtered and resampled to the sample rate of the application.
The input signal is down-converted with the center frequency (**Low IF I**).

I
The input signal at the channel providing I data is resampled to the sample rate of the application.
The input signal is down-converted with the center frequency (**Low IF I**).

Example: `INP:IQ:OSC:TYPE I`

INPut:IQ:OSC:VDEVice?

Queries whether the connected instrument is supported for Oscilloscope Baseband Input.

For details see the specifications document.

Return values:
<Device> ON | OFF | 0 | 1

OFF | 0
Instrument is not supported.

ON | 1
Instrument is supported

Example: `INP:IQ:OSC:VDEV?`

Usage: Query only

INPut:IQ:OSC:VFIRmware?

Queries whether the firmware on the connected oscilloscope is supported for Oscilloscope Baseband Input.

For details see the specifications document.

Return values:

<FirmwareState> ON | OFF | 0 | 1

OFF | 0
Firmware is not supported

ON | 1
Firmware is supported

Example: `INP:IQ:OSC:VFIR?`

Usage: Query only

8.4.3.10 Frontend settings

The frequency and amplitude settings represent the "frontend" of the measurement setup.

Frequency

[SENSe:]FREQuency:CENTer <Frequency>

Defines the center frequency.

Parameters:

<Frequency> For the allowed range and f_{max}, refer to the specifications document.

*RST: fmax/2
Default unit: Hz

Example:
```
FREQ:CENT 100 MHz
FREQ:CENT:STEP 10 MHz
FREQ:CENT UP
```
Sets the center frequency to 110 MHz.

Manual operation: See "Center Frequency" on page 77

[SENSe:]FREQuency:CENTer:STEP <StepSize>

Defines the center frequency step size.

Parameters:

<StepSize> For f_{max}, refer to the specifications document.

Range: 1 to fMAX
*RST: 0.1 x span
Default unit: Hz

Example: //Set the center frequency to 110 MHz.
```
FREQ:CENT 100 MHz
FREQ:CENT:STEP 10 MHz
FREQ:CENT UP
```

Manual operation: See "Center Frequency Stepsize" on page 77

[SENSe:]FREQuency:CENTer:STEP:AUTO <State>

Defines the step width of the center frequency.

Parameters:

<State>

ON | 1
Links the step width to the current standard (currently 1 MHz for all standards)

OFF | 0
Sets the step width as defined using the `FREQ:CENT:STEP` command (see `[SENSe:]FREQuency:CENTer:STEP` on page 230).

Manual operation: See "Center Frequency Stepsize" on page 77

[SENSe:]FREQuency:OFFSet <Offset>

Defines a frequency offset.

If this value is not 0 Hz, the application assumes that the input signal was frequency shifted outside the application. All results of type "frequency" will be corrected for this shift numerically by the application.

Parameters:

<Offset> Range: -1 THz to 1 THz
*RST: 0 Hz
Default unit: HZ

Example: `FREQ:OFFS 1GHZ`

Manual operation: See "Frequency Offset" on page 78

Reference level

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel <ReferenceLevel>

Defines the reference level (for all traces in all windows).

With a reference level offset ≠ 0, the value range of the reference level is modified by the offset.

Suffix:

<n> irrelevant

<w> subwindow
Not supported by all applications

<t> irrelevant

Parameters:

<ReferenceLevel> The unit is variable.

Range: see specifications document
*RST: 0 dBm
Default unit: DBM

Example: `DISP:TRAC:Y:RLEV -60dBm`

Manual operation: See "Reference Level" on page 79

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel:OFFSet <Offset>

Defines a reference level offset (for all traces in all windows).

Suffix:

<n> irrelevant

<w> subwindow
Not supported by all applications

<t> irrelevant

Parameters:

<Offset> Range: -200 dB to 200 dB
*RST: 0dB
Default unit: DB

Example: `DISP:TRAC:Y:RLEV:OFFS -10dB`

Manual operation: See "Shifting the Display (Offset)" on page 80

[SENSe:]ADJust:LEVel

Initiates a single (internal) measurement that evaluates and sets the ideal reference level for the current input data and measurement settings. Thus, the settings of the RF attenuation and the reference level are optimized for the signal level. The FSW is not overloaded and the dynamic range is not limited by an S/N ratio that is too small.

Example: `ADJ:LEV`

Manual operation: See "Setting the Reference Level Automatically (Auto Level)" on page 80

Attenuation

INPut:ATTenuation <Attenuation>

Defines the total attenuation for RF input.

If you set the attenuation manually, it is no longer coupled to the reference level, but the reference level is coupled to the attenuation. Thus, if the current reference level is not compatible with an attenuation that has been set manually, the command also adjusts the reference level.

If an external frontend is active (see `[SENSe:]EFRontend[:STATe]` on page 193), you can configure the attenuation of the external frontend and the analyzer separately. See also `INPut:SANalyzer:ATTenuation:AUTO` on page 235 and `INPut:SANalyzer:ATTenuation` on page 234.

Parameters:

<Attenuation>
Range: see specifications document
Increment: 5 dB (with optional electr. attenuator: 1 dB)
*RST: 10 dB (AUTO is set to ON)
Default unit: DB

Example: `INP:ATT 30dB`
Defines a 30 dB attenuation and decouples the attenuation from the reference level.

Manual operation: See "Attenuation Mode / Value" on page 82

INPut:ATTenuation:AUTO <State>

Couples or decouples the attenuation to the reference level. Thus, when the reference level is changed, the FSW determines the signal level for optimal internal data processing and sets the required attenuation accordingly.

If an external frontend is active (see `[SENSe:]EFRontend[:STATe]` on page 193), you can configure the attenuation of the external frontend and the analyzer separately. See also `INPut:SANalyzer:ATTenuation:AUTO` on page 235 and `INPut:SANalyzer:ATTenuation` on page 234.

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 82

INPut:ATTenuation:AUTO:MODE <OptMode>

Selects the priority for signal processing *after* the RF attenuation has been applied.

Parameters:

<OptMode> LNOise | LDIStortion

LNOise

Optimized for high sensitivity and low noise levels

LDIStortion

Optimized for low distortion by avoiding intermodulation

*RST: LDIStortion (WLAN application: LNOise)

Example: `INP:ATT:AUTO:MODE LNO`

Manual operation: See "Optimization" on page 83

INPut:EATT <Attenuation>

Defines an electronic attenuation manually. Automatic mode must be switched off (`INP:EATT:AUTO OFF`, see `INPut:EATT:AUTO` on page 234).

If the current reference level is not compatible with an attenuation that has been set manually, the command also adjusts the reference level.

Parameters:

<Attenuation> attenuation in dB

Range: see specifications document
Increment: 1 dB
*RST: 0 dB (OFF)
Default unit: DB

Example: `INP:EATT:AUTO OFF`
`INP:EATT 10 dB`

Manual operation: See "Using Electronic Attenuation" on page 83

INPut:EATT:AUTO <State>

Turns automatic selection of the electronic attenuation on and off.

If on, electronic attenuation reduces the mechanical attenuation whenever possible.

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

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 1

Example: `INP:EATT:AUTO OFF`

Manual operation: See "Using Electronic Attenuation" on page 83

INPut:EATT:STATe <State>

Turns the electronic attenuator on and off.

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

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example: `INP:EATT:STAT ON`
Switches the electronic attenuator into the signal path.

Manual operation: See "Using Electronic Attenuation" on page 83

INPut:SANalyzer:ATTenuation <Attenuation>

Configures attenuation at the analyzer input for an active external frontend manually.

Parameters:
<Attenuation> Range: see specifications document
Increment: 1 dB
Default unit: DB

Manual operation: See "Attenuation Mode / Value" on page 82

INPut:SANalyzer:ATTenuation:AUTO <State>

Enables or disables automatic configuration of attenuation at the analyzer input for an active external frontend.

By default, the attenuation settings are applied at the input of the external frontend.

See `INPut:ATTenuation:AUTO` on page 233 and `INPut:ATTenuation` on page 232.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Auto mode for analyzer attenuation is disabled. Allows you to configure attenuation at the analyzer using `INPut:SANalyzer:ATTenuation` on page 234.

ON | 1
Auto mode for analyzer attenuation is enabled. No attenuation is configured at the analyzer.

*RST: 0

Example:

```
//Enable external frontend
EFR ON
//Query the currently configured RF attenuation
INP:ATT?
//Result: 10 dB
//Disable auto mode for analyzer attenuation
INP:SAN:ATT:AUTO OFF
//Configure 10 dB attenuation at the analyzer
INP:SAN:ATT 10
//Query the currently configured RF attenuation at the ext. FE
INP:ATT?
//Result: 0 dB
```

Manual operation: See "Attenuation Mode / Value" on page 82

[SENSe:]IQ:WBANd <State>

Selects the signal path for signal processing.

For details and restrictions, see "Signal Path" on page 83.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
The narrowband signal path is used.

ON | 1
The wideband signal path is used.

*RST: 0

Example:

```
SENS:IQ:WBAN ON
```

Manual operation: See "Signal Path" on page 83

Configuring a preamplifier

INPut:GAIN:STATe <State>

Turns the internal preamplifier on and off. It requires the optional preamplifier hardware.

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

Is not available for input from the optional "Digital Baseband" interface.

For FSW85 models, no preamplifier is available.

If option R&S FSW-B22 is installed, the preamplifier is only active below 7 GHz.

If option R&S FSW-B24 is installed, the preamplifier is active for all frequencies.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example:

```
INP:GAIN:STAT ON
INP:GAIN:VAL 15
```

Switches on 15 dB preamplification.

Manual operation: See "Preamplifier" on page 81

INPut:GAIN[:VALue] <Gain>

Selects the "gain" if the preamplifier is activated (`INP:GAIN:STAT ON`, see `INPut:GAIN:STATe` on page 236).

The command requires the additional preamplifier hardware option.

Parameters:

<Gain> For all FSW models except for FSW85, the following settings are available:
15 dB and 30 dB
All other values are rounded to the nearest of these two.
30 dB
For older FSW43/FSW50/FSW67 models, the input signal is always ampilfied by about 30 dB when the preamplifier is active.
For FSW85 models, no preamplifier is available.

Default unit: DB

Example:
`INP:GAIN:STAT ON`
`INP:GAIN:VAL 30`
Switches on 30 dB preamplification.

Manual operation: See "Preamplifier" on page 81

8.4.4 Triggering measurements

The trigger commands define the beginning of a measurement.

Useful commands for retrieving results described elsewhere:

- `TRIGger[:SEQuence]:OSCilloscope:COUPling` on page 223

Remote commands exclusive to triggering measurements:

TRIGger[:SEQuence]:BBPower:HOLDoff <Period>

Defines the holding time before the baseband power trigger event.

The command requires the optional "Digital Baseband" interface or the optional "Analog Baseband" interface.

Note that this command is maintained for compatibility reasons only. Use the `TRIGger[:SEQuence]:IFPower:HOLDoff` on page 238 command for new remote control programs.

Parameters:

<Period>
Range: 150 ns to 1000 s
*RST: 150 ns
Default unit: S

Example:
`TRIG:SOUR BBP`
Sets the baseband power trigger source.
`TRIG:BBP:HOLD 200 ns`
Sets the holding time to 200 ns.

TRIGger[:SEQuence]:DTIMe <DropoutTime>

Defines the time the input signal must stay below the trigger level before a trigger is detected again.

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 89

TRIGger[:SEQuence]:IFPower:HOLDoff <Period>

Defines the holding time before the next trigger event.

Note that this command can be used for **any trigger source**, not just IF Power (despite the legacy keyword).

Parameters:

<Period> Range: 0 s to 10 s
*RST: 0 s
Default unit: S

Example: `TRIG:SOUR EXT`
Sets an external trigger source.
`TRIG:IFP:HOLD 200 ns`
Sets the holding time to 200 ns.

Manual operation: See "Trigger Holdoff" on page 89

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 88

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 89

TRIGger[:SEQuence]:LEVel:BBPower <Level>

Sets the level of the baseband power trigger.

Is available for the optional "Digital Baseband" interface.

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 88

TRIGger[:SEQuence]:LEVel[:EXTernal<port>] <TriggerLevel>

Defines the level the external signal must exceed to cause a trigger event.

Suffix:

<port> Selects the trigger port.
1 = trigger port 1 (TRIGGER INPUT connector on front panel)
2 = trigger port 2 (TRIGGER INPUT/OUTPUT connector on front panel)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (TRIGGER3 INPUT/OUTPUT connector on rear panel)

Parameters:

<TriggerLevel> Range: 0.5 V to 3.5 V
*RST: 1.4 V
Default unit: V

Example: `TRIG:LEV 2V`

Manual operation: See "Trigger Level" on page 88

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.

Parameters:

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

*RST: -20 dBm
Default unit: DBM

Example: `TRIG:LEV:IFP -30DBM`

TRIGger[:SEQuence]:LEVel:IQPower <TriggerLevel>

Defines the magnitude the I/Q data must exceed to cause a trigger event.

Note that any RF attenuation or preamplification is considered when the trigger level is analyzed. If defined, a reference level offset is also considered.

Parameters:

<TriggerLevel> Range: -130 dBm to 30 dBm
*RST: -20 dBm
Default unit: DBM

Example: `TRIG:LEV:IQP -30DBM`

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 89

TRIGger[:SEQuence]:SOURce <Source>

Selects the trigger source.

Note on external triggers:

If a measurement is configured to wait for an external trigger signal in a remote control program, remote control is blocked until the trigger is received and the program can continue. Make sure that this situation is avoided in your remote control programs.

Parameters:

<Source>

IMMediate
Free Run

EXTernal
Trigger signal from the "Trigger Input" connector.
If power splitter mode is active, this parameter activates the "EXT TRIGGER INPUT" connector on the oscilloscope. Then the FSW triggers when the signal fed into the "EXT TRIGGER INPUT" connector on the oscilloscope meets or exceeds the specified trigger level.

EXT2
Trigger signal from the "Trigger Input/Output" connector.
For FSW85 models, Trigger 2 is not available due to the second RF input connector on the front panel. The trigger signal is taken from the "Trigger Input/Output" connector on the rear panel.
Note: Connector must be configured for "Input".

EXT3
Trigger signal from the "TRIGGER 3 INPUT/ OUTPUT" connector.
Note: Connector must be configured for "Input".

BBPower
Baseband power
For input from the optional "Analog Baseband" interface.
For input from the optional "Digital Baseband" interface.

*RST: IMMediate

Example:

`TRIG:SOUR EXT`
Selects the external trigger input as source of the trigger signal

Manual operation:

See "Trigger Source" on page 85
See "Free Run" on page 85
See "External Trigger 1/2/3" on page 85
See "External Channel 3" on page 86
See "IF Power" on page 86
See "Baseband Power" on page 86
See "I/Q Power" on page 87
See "RF Power" on page 87
See "Time" on page 87
See "Digital I/Q" on page 87

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 88

8.4.5 Configuring data acquisition

INPut:FILTer:CHANnel:HPASs:FDBBw?

Return values:

<Frequency>	Default unit: HZ

Usage: Query only

Manual operation: See "50-dB Bandwidth" on page 94

INPut:FILTer:CHANnel:HPASs:SDBBw <Frequency>

Configures the bandwidth of the high pass filter at which an attenuation of 6 dB is reached. The filter bandwidth cannot be higher than the current sample rate. If necessary, the filter bandwidth is adapted to the current sample rate.

Parameters:

<Frequency>	Default unit: HZ

Example: `INPU:FILT:CHAN:HPAS:SDBB 30 MHZ`

Manual operation: See "6-dB Bandwidth" on page 94

INPut:FILTer:CHANnel:HPASs[:STATe] <State>

Activates an additional internal highpass filter.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the filter off.

ON | 1
Switches the filter on

*RST: 0

Example: `INP:FILT:CHAN:HPAS ON`

Manual operation: See "Highpass Filter State" on page 94

INPut:FILTer:CHANnel[:LPASs]:FDBBw <Frequency>

Configures the 50-dB frequency of the channel filter. The 50-dB frequency is the distance from the center of the filter to the point at which the filter reaches an attenuation of 50 dB. This frequency must always be larger than the 6-dB passband (see `INPut:FILTer:CHANnel[:LPASs]:SDBBw` on page 243).

Parameters:

<Frequency> Default unit: HZ

Example: `INP:FILT:CHAN:FDBB 40MHZ`

Manual operation: See "50-dB Bandwidth" on page 93

INPut:FILTer:CHANnel[:LPASs]:SDBBw <Frequency>

Configures the 6-dB bandwidth of the channel filter. The filter bandwidth cannot be higher than the current 50-dB frequency (see `INPut:FILTer:CHANnel[:LPASs]:FDBBw` on page 243).

Parameters:

<Frequency> Default unit: HZ

Example: `INP:FILT:CHAN:SDBB 30MHZ`

Manual operation: See "6-dB Bandwidth" on page 93

INPut:FILTer:CHANnel[:LPASs][:STATe] <State>

Turns an adjustable (lowpass) channel filter in the signal path on and off.

You can define its characteristics with

- `INPut:FILTer:CHANnel[:LPASs]:SDBBw` on page 243
- `INPut:FILTer:CHANnel[:LPASs]:FDBBw` on page 243

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

Example:
```
INP:FILT:CHAN ON
```
Turns on the adjustable channel filter.

Manual operation: See "Filter State" on page 93

[SENSe:]CAPTure:OVERsampling <OversamplingValue>
[SENSe:]CAPTure:OVERsampling? <OversamplingValue>

Enables or disables a capture oversampling factor.

Parameters for setting and query:
<OversamplingValue> 1 | 2

1
Capture oversampling is disabled (capture sample rate = system sample rate)

2
Oversampling factor 2 is enabled (capture sampling rate = 2*system sample rate)

Example:
```
TRACe:IQ:SRATe 2 MHz
SENSe:CAPTure:OVERsampling 2
```
Capture sample rate = 4 MHz

Manual operation: See "Oversampling / Capture Sample Rate" on page 91

[SENSe:]SWAPiq <State>

Defines whether or not the recorded I/Q pairs should be swapped (I<->Q) before being processed. Swapping I and Q inverts the sideband.

This is useful if the DUT interchanged the I and Q parts of the signal; then the FSW can do the same to compensate for it.

Parameters:
<State>

ON | 1
I and Q signals are interchanged
Inverted sideband, Q+j*I

OFF | 0
I and Q signals are not interchanged
Normal sideband, I+j*Q

*RST: 0

Manual operation: See "Swap I/Q" on page 93

[SENSe:]SWEep:COUNt <SweepCount>

This command defines the number of measurements that the application uses to average traces.

In case of continuous measurement mode, the application calculates the moving average over the average count.

In case of single measurement mode, the application stops the measurement and calculates the average after the average count has been reached.

Suffix:
<n> Window

Example:
`SWE:COUN 64`
Sets the number of measurements to 64.
`INIT:CONT OFF`
Switches to single measurement mode.
`INIT;*WAI`
Starts a measurement and waits for its end.

[SENSe:]SWEep:LENGth <Length>

Defines the number of samples to be captured during each measurement.

Parameters:
<Length> integer
Range: 1 to 8 000 000

Example: `SENSe:SWEep:LENGth 1001`

Manual operation: See "Capture Length" on page 91

[SENSe:]SWEep:TIME <Time>

Defines the measurement time. It automatically decouples the time from any other settings.

Parameters:
<Time> refer to specifications document
*RST: depends on current settings (determined automatically)
Default unit: S

Manual operation: See "Capture Time" on page 91

TRACe:IQ:BWIDth <Bandwidth>

Queries the bandwidth in Hz of the resampling filter ("Usable I/Q Bandwidth").

Parameters:
<Bandwidth> Usable I/Q bandwidth
Default unit: Hz

Example: `TRAC1:IQ:BWID?`

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 FSW.

Parameters:

<SampleRate> The valid sample rates are described in Chapter 3.5, "Sample rate and maximum usable I/Q bandwidth for RF input", on page 40.

*RST: 32 MHz

Default unit: HZ

Manual operation: See "Sample Rate" on page 91

TRACe:IQ:WBANd[:STATe] <State>

Determines whether the wideband provided by bandwidth extension options is used or not (if installed).

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Manual operation: See "Maximum Bandwidth" on page 92

TRACe:IQ:WBANd:MBWidth <Limit>

Defines the maximum analysis bandwidth. Any value can be specified; the next higher fixed bandwidth is used.

Defining a value other than "MAX" is useful if you want to specify the sample rate directly and at the same time, ensure a minimum bandwidth is available.

Parameters:

<Limit>

80 MHz
Restricts the analysis bandwidth to a maximum of 80 MHz.
The bandwidth extension options greater than 160 MHz are disabled.
`TRACe:IQ:WBANd[:STATe]` is set to OFF.

160 MHz
Restricts the analysis bandwidth to a maximum of 160 MHz. The bandwidth extension option R&S FSW-B320 is deactivated.
(Not available or required if other bandwidth extension options larger than 320 MHz are installed.)
`TRACe:IQ:WBANd[:STATe]` is set to ON.

1200 MHz | 500 MHz | 320 MHz | MAX
All installed bandwidth extension options are activated. The currently available maximum bandwidth is allowed.
`TRACe:IQ:WBANd[:STATe]` is set to ON.

*RST: maximum available
Default unit: Hz

Example:
```
TRAC:IQ:WBAN:MBW 82 MHZ
TRAC:IQ:WBAN:MBW?
```
Result if R&S FSW-B160/-B320 is active:
`160000000`

Example:
```
TRAC:IQ:WBAN:MBW 82 MHZ
TRAC:IQ:WBAN:MBW?
```
Result if R&S FSW-B512 is active:
`512000000`

Manual operation: See "Maximum Bandwidth" on page 92

8.4.6 Enabling a burst search

[SENSe:]DEMod:FORMat:BURSt <State>

Turns a search for bursted OFDM signals on and off.

Parameters:
<State> ON | OFF

*RST: ON

Example:
`DEM:FORM:BURS ON`
Turns on the burst search.

Manual operation: See "Burst Search State" on page 96

8.4.7 Defining the result range

The result range determines which part of the capture buffer or burst is displayed.

[SENSe:]DEMod:FORMat:MAXFrames <NFrames>

Defines the maximum number of frames to be demodulated.

Parameters:
<NFrames> Numeric value.

*RST: 1

Example:
`DEM:FORM:MAXF 10`
Defines a maximum of 10 frames to be demodulated.

Manual operation: See "Statistic Config / Max No of Frames to Analyze" on page 95

[SENSe:]DEMod:FORMat:NOFSymbols <NSymbols>

Defines the number of symbols in a frame.

Note that frames with fewer symbols are not analyzed.

Parameters:

<NSymbols> Range: 4 to 2000
*RST: 10

Example: `DEM:FORM:NOFS 44`
Defines 44 symbols per frame.

Manual operation: See "Result Length" on page 96

8.4.8 Synchronization, tracking and demodulation

[SENSe:]COMPensate:CHANnel <State>

Turns compensation for the estimated channel transfer function on and off.

Parameters:

<State> ON | OFF
*RST: ON

Example: `COMP:CHAN ON`
Turns on channel compensation.

Manual operation: See "Channel Compensation" on page 100

[SENSe:]DEMod:CDD <Delay>

Defines the cyclic delay.

Parameters:

<Delay> Cyclic delay in samples.

Range: –<FFT size> to +<FFT size>
*RST: 0

Example:
`DEM:CDD 5`
Defines a cyclic delay of 5 samples.

Manual operation: See "Cyclic Delay" on page 101

[SENSe:]DEMod:COFFset <Offset>

Defines the maximum allowed carrier offset for frame synchronization.

Parameters:

<Offset> Frequency offset in terms of (sub)carriers.

Range: 0 to 16
*RST: 0

Example:
`SENS:DEM:COFF 2`
Frame synchronization can cope with a signal frequency offset of up to two subcarrier spacings.

Manual operation: See "Maximum Carrier Offset" on page 100

[SENSe:]DEMod:FFTShift <IQSamplingRate>

Defines an offset for the FFT start sample in the guard interval.

Parameters:

<IQSamplingRate> Numeric value that defines the FFT shift.
The value is normalized to the length of the guard interval.
If a cyclic suffix is used, the FFT shift can be a negative value, down to
-1 (cyclic suffix length / cyclic prefix length)*

*RST: 0.5

Example:
`DEM:FFTS 0.6`
Defines an FFT shift of 0.6.

Manual operation: See "FFT Shift relative to Cyclic Prefix Length" on page 100

[SENSe:]DEMod:FSYNc <Mode>

Selects the parameter estimation mode.

Parameters:

<Mode>

DATA
Demodulator uses pilot and data cells for synchronization.

PIL
Demodulator uses only pilot cells for synchronization.

NONE
Return value only.
The software returns `NONE` if no configuration file has been loaded.

*RST: PIL

Example: `DEM:FSYN PIL`
Selects synchronization based on the pilot cells.

Manual operation: See "Parameter Estimation" on page 98

[SENSe:]DEMod:MDETect <Mode>

Selects the auto demodulation mode.

Parameters:

<Mode>

CARR
Assumes one constellation for all data cells in the carriers.

CFG
Evaluates the modulation matrix within the configuration file.

SYMB
Assigns the data cells of each symbol to one constellation.

*RST: CFG

Example: `DEM:MDET CFG`
Selects evaluation of the modulation matrix in the configuration file.

Manual operation: See "Modulation Detection" on page 98

[SENSe:]DEMod:THReshold:TIME <Reliability>

Sets and queries the reliability threshold for time synchronisation.

Values between 0 and 1 are allowed, where:

- 0: low threshold, a very poor reliability is sufficient to synchronize successfully (always fulfilled)
- 1: high threshold, time synchronization must be absolutely reliable to be successful (only possible for ideal signal).

The default value is 0.5, that means: for a reliability of 50 %, time synchronization is successful.

Parameters:

<Reliability>

Range: 0 to 1
*RST: 0.5

Example: `SENS:DEM:THR:TIME 0.5`

Manual operation: See "Minimum Time Sync Metric" on page 99

[SENSe:]DEMod:THReshold:FRAMe <Reliability>

Sets and queries the reliability threshold for frame synchronisation.

Values between 0 and 1 are allowed, where:

- 0: low threshold, a very poor correlation is sufficient to synchronize successfully (always fulfilled)
- 1: high threshold, correlation must be very precise for frame synchronization to be successful (only possible for ideal signal).

The default value is 0.5, that means: for a correlation of 50 %, frame synchronization is successful.

Parameters:

<Reliability> Range: 0 to 1
*RST: 0.5

Example: `SENS:DEM:THR:FRAM 0.5`

Manual operation: See "Minimum Frame Sync Metric" on page 99

[SENSe:]DEMod:TSYNc <Mode>

Selects the time synchronization mode.

Parameters:

<Mode> **CP**
Performs time synchronization by correlating the cyclic prefix.

PREamble
Performs time synchronization by correlating the recurring preamble structure.

*RST: CP

Example: `DEM:TSYN CP`
Selects time synchronization based on the cyclic prefix.

Manual operation: See "Time Synchronization" on page 97

SENSe:TRACking:LEVel <State>

Turns tracking of the power level on and off.

Note

The syntax element `[SENSe]` is not optional for this command.

Parameters:

<State> ON | OFF
*RST: OFF

Example: `SENS:TRAC:LEV ON`
Turns on power level tracking.

Manual operation: See "Level Tracking" on page 100

SENSe:TRACking:PHASe <State>

Turns phase tracking on and off.

Note

The syntax element `[SENSe]` is not optional for this command.

Parameters:

<State>	ON | OFF *RST: ON
Example:	`SENS:TRAC:PHAS ON` Turns on phase tracking.
Manual operation:	See "Phase Tracking" on page 99

SENSe:TRACking:TIME <State>

Turns tracking of the sample clock deviation on and off.

Note

The syntax element `[SENSe]` is not optional for this command.

Parameters:

<State>	ON | OFF *RST: OFF
Example:	`SENS:TRAC:TIME ON` Turns on tracking of sample clock deviations.
Manual operation:	See "Timing Tracking" on page 99

8.4.9 Adjusting settings automatically

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

Useful commands for adjusting settings automatically described elsewhere:

- `[SENSe:]ADJust:LEVel` on page 232

Remote commands exclusive to adjusting settings automatically:

[SENSe:]ADJust:CONFigure:LEVel:DURation <Duration>

To determine the ideal reference level, the FSW performs a measurement on the current input data. This command defines the length of the measurement if `[SENSe:]ADJust:CONFigure:LEVel:DURation:MODE` is set to `MANual`.

Parameters:

<Duration> Numeric value in seconds

Range: 0.001 to 16000.0
*RST: 0.001
Default unit: s

Example:
`ADJ:CONF:DUR:MODE MAN`
Selects manual definition of the measurement length.
`ADJ:CONF:LEV:DUR 5ms`
Length of the measurement is 5 ms.

[SENSe:]ADJust:CONFigure:LEVel:DURation:MODE <Mode>

To determine the ideal reference level, the FSW performs a measurement on the current input data. This command selects the way the FSW determines the length of the measurement .

Parameters:

<Mode>

AUTO
The FSW determines the measurement length automatically according to the current input data.

MANual
The FSW uses the measurement length defined by `[SENSe:]ADJust:CONFigure:LEVel:DURation` on page 253.

*RST: AUTO

[SENSe:]ADJust:CONFigure:HYSTeresis:LOWer <Threshold>

When the reference level is adjusted automatically using the `[SENSe:]ADJust:LEVel` on page 232 command, the internal attenuators and the preamplifier are also adjusted. To avoid frequent adaptation due to small changes in the input signal, you can define a hysteresis. This setting defines a lower threshold the signal must fall below (compared to the last measurement) before the reference level is adapted automatically.

Parameters:

<Threshold>

Range: 0 dB to 200 dB
*RST: +1 dB
Default unit: dB

Example:
`SENS:ADJ:CONF:HYST:LOW 2`
For an input signal level of currently 20 dBm, the reference level is only adjusted when the signal level falls below 18 dBm.

[SENSe:]ADJust:CONFigure:HYSTeresis:UPPer <Threshold>

When the reference level is adjusted automatically using the `[SENSe:]ADJust:LEVel` on page 232 command, the internal attenuators and the preamplifier are also adjusted. To avoid frequent adaptation due to small changes in the input signal, you can define a hysteresis. This setting defines an upper threshold the signal must exceed (compared to the last measurement) before the reference level is adapted automatically.

Parameters:

<Threshold> Range: 0 dB to 200 dB
*RST: +1 dB
Default unit: dB

Example: `SENS:ADJ:CONF:HYST:UPP 2`

Example: For an input signal level of currently 20 dBm, the reference level is only adjusted when the signal level rises above 22 dBm.

8.4.10 Output settings

The following commands are required to query or provide output at the FSW connectors.

DIAGnostic:SERVice:NSOurce <State>

Turns the 28 V supply of the BNC connector labeled [noise source control] on the FSW on and off.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `DIAG:SERV:NSO ON`

Manual operation: See "Noise Source Control" on page 75

OUTPut:IF:SBANd?

Queries the sideband provided at the "IF OUT 2 GHz" connector compared to the sideband of the RF signal. The sideband depends on the current center frequency.

Return values:

<SideBand> **NORMal**
The sideband at the output is identical to the RF signal.

INVerted
The sideband at the output is the inverted RF signal sideband.

Example: `OUTP:IF IF2`
Activates output at the IF OUTPUT (2 GHZ) connector.
`OUTP:IF:SBAN?`
Queries the sideband provided at the connector.

Usage: Query only

OUTPut:IF[:SOURce] <Source>

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

Parameters:
<Source>
IF
The measured IF value is available at the IF/VIDEO/DEMOD output connector.
*RST: IF

Example: `OUTP:IF VID`
Selects the video signal for the IF/VIDEO/DEMOD output connector.

Manual operation: See "Data Output" on page 74

8.4.11 Configuring the trigger output

The following commands are required to send the trigger signal to one of the variable "TRIGGER INPUT/OUTPUT" connectors on the FSW.

OUTPut:TRIGger<tp>:DIRection <Direction>

Selects the trigger direction for trigger ports that serve as an input as well as an output.

Suffix:
<tp>
Selects the used trigger port.
2 = trigger port 2 (front)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (rear panel)

Parameters:
<Direction>
INPut | OUTPut
INPut
Port works as an input.
OUTPut
Port works as an output.
*RST: INPut

Manual operation: See "Trigger 2/3" on page 75

OUTPut:TRIGger<tp>:LEVel <Level>

Defines the level of the (TTL compatible) signal generated at the trigger output.

Works only if you have selected a user-defined output with `OUTPut:TRIGger<tp>:OTYPe`.

Suffix:

<tp> 1..n
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (rear)

Parameters:

<Level>

HIGH
5 V

LOW
0 V

*RST: LOW

Example: `OUTP:TRIG2:LEV HIGH`

Manual operation: See "Level" on page 76

OUTPut:TRIGger<tp>:OTYPe <OutputType>

Selects the type of signal generated at the trigger output.

Suffix:

<tp> 1..n
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (rear)

Parameters:

<OutputType>

DEVice
Sends a trigger signal when the FSW has triggered internally.

TARMed
Sends a trigger signal when the trigger is armed and ready for an external trigger event.

UDEFined
Sends a user-defined trigger signal. For more information, see `OUTPut:TRIGger<tp>:LEVel`.

*RST: DEVice

Manual operation: See "Output Type" on page 76

OUTPut:TRIGger<tp>:PULSe:IMMediate

Generates a pulse at the trigger output.

Suffix:

<tp> 1..n
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (rear)

Manual operation: See "Send Trigger" on page 77

OUTPut:TRIGger<tp>:PULSe:LENGth <Length>

Defines the length of the pulse generated at the trigger output.

Suffix:

<tp> Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (rear)

Parameters:

<Length> Pulse length in seconds.
Default unit: S

Example: `OUTP:TRIG2:PULS:LENG 0.02`

Manual operation: See "Pulse Length" on page 76

8.5 Performing a measurement

When the VSA application is activated, a continuous sweep is performed automatically. However, you can stop and start a new measurement any time.

Furthermore, you can perform a sequence of measurements using the Sequencer (see "Multiple Measurement Channels and Sequencer Function" on page 6).

ABORt

Aborts the measurement in the current channel and resets the trigger system.

To prevent overlapping execution of the subsequent command before the measurement has been aborted successfully, use the `*OPC?` or `*WAI` command after `ABOR` and before the next command.

For details on overlapping execution see Remote control via SCPI.

Note on blocked remote control programs:

If a sequential command cannot be completed, for example because a triggered sweep never receives a trigger, the remote control program will never finish and the remote channel to the FSW is blocked for further commands. In this case, you must interrupt processing on the remote channel first in order to abort the measurement.

To do so, send a "Device Clear" command from the control instrument to the FSW on a parallel channel to clear all currently active remote channels. Depending on the used interface and protocol, send the following commands:

- **Visa**: `viClear()`
- **GPIB**: `ibclr()`
- **RSIB**: `RSDLLibclr()`

Now you can send the `ABORt` command on the remote channel performing the measurement.

Example: `ABOR;:INIT:IMM`
Aborts the current measurement and immediately starts a new one.

Example: `ABOR;*WAI`
`INIT:IMM`
Aborts the current measurement and starts a new one once abortion has been completed.

Usage: Event

INITiate<n>:CONMeas

Restarts a (single) measurement that has been stopped (using `ABORt`) or finished in single measurement mode.

The measurement is restarted at the beginning, not where the previous measurement was stopped.

As opposed to `INITiate<n>[:IMMediate]`, this command does not reset traces in maxhold, minhold or average mode. Therefore it can be used to continue measurements using maxhold or averaging functions.

Suffix:
<n> irrelevant

Usage: Asynchronous command

INITiate<n>:CONTinuous <State>

Controls the measurement mode for an individual channel.

Note that in single measurement mode, you can synchronize to the end of the measurement with *OPC, *OPC? or *WAI. In continuous measurement mode, synchronization to the end of the measurement is not possible. Thus, it is not recommended that you use continuous measurement mode in remote control, as results like trace data or markers are only valid after a single measurement end synchronization.

For details on synchronization see Remote control via SCPI.

Suffix:
<n> irrelevant

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

ON | 1
Continuous measurement

OFF | 0
Single measurement

*RST: 1 (some applications can differ)

Example:
`INIT:CONT OFF`
Switches the measurement mode to single measurement.
`INIT:CONT ON`
Switches the measurement mode to continuous measurement.

Manual operation: See "Continuous Sweep / Run Cont" on page 94

INITiate<n>[:IMMediate]

Starts a (single) new measurement.

You can synchronize to the end of the measurement with *OPC, *OPC? or *WAI.

For details on synchronization see Remote control via SCPI.

Suffix:
<n> irrelevant

Usage: Asynchronous command

Manual operation: See "Single Sweep / Run Single" on page 95

INITiate<n>:REFResh

Updates the current measurement results to reflect the current measurement settings.

No new I/Q data is captured. Thus, measurement settings apply to the I/Q data currently in the capture buffer.

The command applies exclusively to I/Q measurements. It requires I/Q data.

Suffix:
<n> irrelevant

Example: `INIT:REFR`
Updates the IQ measurement results.

Usage: Asynchronous command

Manual operation: See "Refresh" on page 95

INITiate:SEQuencer:ABORt

Stops the currently active sequence of measurements.

You can start a new sequence any time using `INITiate:SEQuencer:IMMediate` on page 260.

Usage: Event

INITiate:SEQuencer:IMMediate

Starts a new sequence of measurements by the Sequencer.

Its effect is similar to the `INITiate<n>[:IMMediate]` command used for a single measurement.

Before this command can be executed, the Sequencer must be activated (see `SYSTem:SEQuencer` on page 261).

Example: `SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single sequence mode so each active measurement is performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.

INITiate:SEQuencer:REFResh[:ALL]

Is only available if the Sequencer is deactivated (`SYSTem:SEQuencer SYST:SEQ:OFF`) and only in MSRA mode.

The data in the capture buffer is re-evaluated by all active MSRA secondary applications.

Example:

`SYST:SEQ:OFF`
Deactivates the scheduler
`INIT:CONT OFF`
Switches to single sweep mode.
`INIT;*WAI`
Starts a new data measurement and waits for the end of the sweep.
`INIT:SEQ:REFR`
Refreshes the display for all channels.

INITiate:SEQuencer:MODE <Mode>

Defines the capture mode for the entire measurement sequence and all measurement groups and channels it contains.

Note: To synchronize to the end of a measurement sequence using `*OPC`, `*OPC?` or `*WAI`, use `SINGle` Sequencer mode.

Parameters:

<Mode>

SINGle
Each measurement group is started one after the other in the order of definition. All measurement channels in a group are started simultaneously and performed once. After *all* measurements are completed, the next group is started. After the last group, the measurement sequence is finished.

CONTinuous
Each measurement group is started one after the other in the order of definition. All measurement channels in a group are started simultaneously and performed once. After *all* measurements are completed, the next group is started. After the last group, the measurement sequence restarts with the first one and continues until it is stopped explicitly.

*RST: CONTinuous

SYSTem:SEQuencer <State>

Turns the Sequencer on and off. The Sequencer must be active before any other Sequencer commands (`INIT:SEQ...`) are executed, otherwise an error occurs.

Parameters:

<State>

ON | OFF | 0 | 1

ON | 1
The Sequencer is activated and a sequential measurement is started immediately.

OFF | 0
The Sequencer is deactivated. Any running sequential measurements are stopped. Further Sequencer commands (`INIT:SEQ...`) are not available.

*RST: 0

Example: `SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single Sequencer mode so each active measurement is performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.
`SYST:SEQ OFF`

8.6 Analysis

General result analysis settings concerning the trace, markers, windows etc. can be configured.

8.6.1 Result configuration

[SENSe:]DEMod:EVMCalc:FAVerage <Type>

Selects the averaging method for the mean EVM over multiple frames.

Parameters:

<Type> **MSQ**
Mean EVM is based on squared EVM values.
RMS
Mean EVM is directly based on the EVM values.
*RST: MS

Example: `DEM:EVMC:FAV MS`
Selects EVM averaging based on squared EVM values.

Manual operation: See "Frame Averaging" on page 131

[SENSe:]DEMod:EVMCalc:NORMalize <Method>

Selects the normalization method for EVM results.

Parameters:

<Method>

NONE
Normalization is turned off.

PDAT
EVM normalized to the peak value of the data cells.

PPD
EVM normalized to the peak value of the pilot and data cells.

PPIL
EVM normalized to the peak value of the pilot cells.

RMSD
EVM values normalized to the RMS value of the data cells.

RPD
EVM values normalized to the RMS value of the pilot and data cells.

RMSP
EVM values normalized to the RMS value of the pilot cells.

*RST: RPD

Example: `DEM:EVMC:NORM RMSD`
Selects normalization to the RMS value of the data cells.

Manual operation: See "Normalize EVM to" on page 131

CALCulate<n>:BITStream:FORMat <Mode>

Defines the format of the symbols for the Bitstream display.

Suffix:

<n> 1..n

Parameters:

<Mode> BINary | OCTal | DECimal | HEXadecimal

*RST: HEXadecimal

Example: `CALC2:BITS:FORM DEC`
Sets the bitstream display on window 2 to use decimal format.

CONFigure:FILTer<n>:CARRier <CarrierNo>

The constellation diagram includes symbols for all or only for the specified carrier number.

The range of valid carrier numbers is:

[- FFT Size/2, +FFT Size/2]

Suffix:
<n> 1..n
Window

Parameters:
<CarrierNo> ALL | integer

Example: `CONF:FILT:CARR -2`

Manual operation: See "Constellation Display - Carrier" on page 132

CONFigure:FILTer<n>:MODulation <Modulation>

The constellation diagram includes only symbols for the selected modulation.

Suffix:
<n> 1..n
Window

Parameters:
<Modulation> ALL | 'string'
Modulation as defined in the configuration file.

Example: `CONF:FILT:MOD 'Zero'`

Manual operation: See "Constellation Display - Modulation" on page 131

CONFigure:FILTer<n>:MODulation:TYPE <ModType>

The constellation diagram includes only cells for the selected modulation type.

Suffix:
<n> 1..n
Window

Parameters:
<ModType> PDATa | PILots | DATA

PDATa
Pilot and data cells

PILots
Pilot cells only

DATA
Data cells only

Example: `CONF:FILT:MOD:TYPE DATA`
Only data cells are displayed.

Manual operation: See "Constellation Display - Modulation Type" on page 131

CONFigure:FILTer<n>:SYMBol <SymbolNo>

The constellation diagram includes all or only the specified symbol number. The first symbol is 0.

Suffix:
<n> 1..n
Window

Parameters:
<SymbolNo> ALL | integer

Example: `CONF:FILT:SYMB 2`

Manual operation: See "Constellation Display - Symbol" on page 132

8.6.2 Scaling

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:AUTO ONCE

Automatic scaling of the y-axis is performed once, then switched off again (for all traces).

Suffix:
<n> Window

<t> irrelevant

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

*RST: ON

Manual operation: See "Automatic Grid Scaling" on page 134
See "Auto Scale Once" on page 134

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`

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:PDIVision <Value>

This remote command determines the grid spacing on the Y-axis for all diagrams, where possible.

In spectrum displays, for example, this command is not available.

Suffix:

<n>	Window
<w>	subwindow Not supported by all applications
<t>	irrelevant

Parameters:

<Value> numeric value WITHOUT UNIT (unit according to the result display)

Defines the range per division (total range = 10*<Value>)

*RST: depends on the result display
Default unit: DBM

Example: `DISP:TRAC:Y:PDIV 10`
Sets the grid spacing to 10 units (e.g. dB) per division

Manual operation: See "Per Division" on page 135

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RPOSition <Position>

Defines the vertical position of the reference level on the display grid (for all traces).

The FSW adjusts the scaling of the y-axis accordingly.

Suffix:

<n>	Window
<w>	subwindow Not supported by all applications
<t>	irrelevant

Example: `DISP:TRAC:Y:RPOS 50PCT`

Manual operation: See "Ref Position" on page 135

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RVALue <Value>

Defines the reference value assigned to the reference position in the specified window. Separate reference values are maintained for the various displays.

Suffix:

<n> Window

<w> subwindow

<t> irrelevant

Parameters:

<Value> Default unit: DB

Example: `DISP:TRAC:Y:RVAL 0`
Sets the value assigned to the reference position to 0 Hz

Manual operation: See "Ref Value" on page 135

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MAXimum <Value>

Defines the maximum value on the y-axis in the specified window.

Suffix:

<n> Window

<t> irrelevant

Parameters:

<Max> numeric value

Example: `DISP:WIND2:TRAC:Y:SCAL:MAX 10`

Manual operation: See "Absolute Scaling (Min/Max Values)" on page 135

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MINimum <Value>

Defines the minimum value on the y-axis in the specified window.

Suffix:

<n> Window

<t> irrelevant

Parameters:

<Min> numeric value

Example: `DISP:WIND2:TRAC:Y:SCAL:MIN -90`

Manual operation: See "Absolute Scaling (Min/Max Values)" on page 135

8.6.3 Units for results

UNIT:CAXes <Unit>

Selects the unit for result displays that show results on carrier level, for example the EVM vs Carrier.

Parameters:

<Unit>

CARR
Carrier axis represents the subcarriers.

HZ
Carrier axis represents the frequency (Hz).

*RST: CARR

Example:
`UNIT:CAX CARR`
Selects 'subcarriers' as the unit of the carrier axis.

Manual operation:
See "Channel Flatness" on page 14
See "Constellation vs Carrier" on page 16
See "EVM vs Carrier" on page 18
See "EVM vs Symbol vs Carrier" on page 19
See "Group Delay" on page 20
See "Power vs Carrier" on page 24
See "Power vs Symbol vs Carrier" on page 25

UNIT:EVM <Unit>

Selects the unit for EVM results.

Parameters:

<Unit>

DB
Returns EVM results in dB.

PCT
Returns EVM results in %.

*RST: dB

Example:
`UNIT:EVM PCT`
Selects '%' as the unit of EVM results.

Manual operation:
See "EVM vs Carrier" on page 18
See "EVM vs Symbol" on page 18
See "EVM vs Symbol vs Carrier" on page 19

UNIT:FAXes <Unit>

Selects the unit for result displays that show results over the frequency, for example the Power Spectrum.

Parameters:

<Unit>

HZ
Frequency axis represents Hz.

CARRier
Frequency axis represents carrier number.

*RST: Hz

Example: `UNIT:FAX HZ`
Selects 'Hz' as the unit of the frequency axis.

Manual operation: See "Power Spectrum" on page 23

UNIT:IRESponse <Unit>

Selects the unit for impulse response results.

Parameters:

<Unit>

DB
Returns impulse response results in dB.

LIN
Returns impulse response results normalized to 1.

*RST: LIN

Example: `UNIT:IRES DB`
Selects 'dB' as the unit for impulse response results.

Manual operation: See "Impulse Response" on page 21

UNIT:SAXes <Unit>

Selects the unit for result displays that show results on symbol level, for example the EVM vs Symbol.

Parameters:

<Unit> SYMBol | SECond

SYMBol
Symbol axis represents symbols.

SECond
Symbol axis represents seconds.

*RST: SYM

Example: `UNIT:SAX SYM`
Selects 'symbols' as the unit of the symbol axis.

Manual operation: See "Allocation Matrix" on page 11
See "Constellation vs Symbol" on page 17
See "EVM vs Symbol" on page 18
See "EVM vs Symbol vs Carrier" on page 19
See "Power vs Symbol" on page 25
See "Power vs Symbol vs Carrier" on page 25

UNIT:TAXes <Unit>

Selects the unit for result displays that show results over time, for example the Magnitude Capture display.

Parameters:

<Unit>

SECond
Time axis represents seconds.

SAMPle
Time axis represents samples.

SYMBol
Time axis represents symbols.
This setting is not available if 2 different cyclic prefix lengths are used (see `CONFigure[:SYMBol]:GUARd:MODE` on page 159).

*RST: SEC

Example: `UNIT:TAX SEC`
Selects 'seconds' as the unit of the time axis.

Manual operation: See "Magnitude Capture" on page 22

8.6.4 Working with markers

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

8.6.4.1 Individual marker settings

In OFDM VSA evaluations, up to 5 markers can be activated in each diagram at any time.

Useful commands for configuring markers described elsewhere:

- `CALCulate<n>:MARKer<m>:Y?` on page 306
- `CALCulate<n>:DELTamarker<m>:Y?` on page 304

Remote commands exclusive to individual 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 139

CALCulate<n>:MARKer<ms>:LINK:TO:MARKer<md> <State>

Links the normal source marker <ms> to any active destination marker <md> (normal or delta marker).

If you change the horizontal position of marker <md>, marker <ms> changes its horizontal position to the same value.

Suffix:

<n>	Window
<ms>	source marker, see Marker
<md>	destination marker, see Marker

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:MARK4:LINK:TO:MARK2 ON`
Links marker 4 to marker 2.

Manual operation: See "Linking to Another Marker" on page 139

CALCulate<n>:MARKer<m>[:STATe] <State>

Turns markers on and off. If the corresponding marker number is currently active as a delta marker, it is turned into a normal marker.

Suffix:

<n> Window

<m> Marker

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:MARK3 ON`
Switches on marker 3.

Manual operation: See "Select Marker" on page 137
See "Marker State" on page 138
See "Marker Type" on page 138

CALCulate<n>:MARKer<m>:TRACe <Trace>

Selects the trace the marker is positioned on.

Note that the corresponding trace must have a trace mode other than "Blank".

If necessary, the command activates the marker first.

Suffix:

<n> Window

<m> Marker

Parameters:

<Trace>

Example: //Assign marker to trace 1
`CALC:MARK3:TRAC 2`

Manual operation: See "Assigning the Marker to a Trace" on page 139

CALCulate<n>:MARKer<m>:X <Position>

Moves a marker to a specific coordinate on the x-axis.

If necessary, the command activates the marker.

If the marker has been used as a delta marker, the command turns it into a normal marker.

Suffix:

<n> Window

<m> Marker

Parameters:
<Position> Numeric value that defines the marker position on the x-axis. The unit depends on the result display.
Range: The range depends on the current x-axis range.
Default unit: Hz

Example: `CALC:MARK2:X 1.7MHz`
Positions marker 2 to frequency 1.7 MHz.

Manual operation: See "Marker Table" on page 22
See "X-Value" on page 138

CALCulate<n>:DELTamarker<m>:AOFF

Turns off *all* delta markers.

Suffix:
<n> Window

<m> irrelevant

Example: `CALC:DELT:AOFF`
Turns off all delta markers.

CALCulate<n>:DELTamarker<m>:LINK <State>

Links delta marker <m> to marker 1.

If you change the horizontal position (x-value) of marker 1, delta marker <m> changes its horizontal position to the same value.

Suffix:
<n> Window

<m> Marker

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

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:DELT2:LINK ON`

Manual operation: See "Linking to Another Marker" on page 139

CALCulate<n>:DELTamarker<ms>:LINK:TO:MARKer<md> <State>

Links the delta source marker <ms> to any active destination marker <md> (normal or delta marker).

Suffix:

<n> Window

<ms> source marker, see Marker

<md> destination marker, see Marker

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:DELT4:LINK:TO:MARK2 ON`
Links the delta marker 4 to the marker 2.

Manual operation: See "Linking to Another Marker" on page 139

CALCulate<n>:DELTamarker<m>:MREFerence <Reference>

Selects a reference marker for a delta marker other than marker 1.

Suffix:

<n> Window

<m> Marker

Parameters:

<Reference> **D1**
Selects the deltamarker 1 as the reference.

Example: `CALC:DELT3:MREF 2`
Specifies that the values of delta marker 3 are relative to marker 2.

Manual operation: See "Reference Marker" on page 139

CALCulate<n>:DELTamarker<m>[:STATe] <State>

Turns delta markers on and off.

If necessary, the command activates the delta marker first.

No suffix at DELTamarker turns on delta marker 1.

Suffix:

<n> Window

<m> Marker

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:DELT2 ON`
Turns on delta marker 2.

Manual operation: See "Select Marker" on page 137
See "Marker State" on page 138
See "Marker Type" on page 138

CALCulate<n>:DELTamarker<m>:TRACe <Trace>

Selects the trace a delta marker is positioned on.

Note that the corresponding trace must have a trace mode other than "Blank".

If necessary, the command activates the marker first.

Suffix:
<n> Window

<m> Marker

Parameters:
<Trace> Trace number the marker is assigned to.

Example: `CALC:DELT2:TRAC 2`
Positions delta marker 2 on trace 2.

CALCulate<n>:DELTamarker<m>:X <Position>

Moves a delta marker to a particular coordinate on the x-axis.

If necessary, the command activates the delta marker and positions a reference marker to the peak power.

Suffix:
<n> Window

<m> Marker

Example: `CALC:DELT:X?`
Outputs the absolute x-value of delta marker 1.

Manual operation: See "X-Value" on page 138

8.6.4.2 General marker settings

DISPlay[:WINDow<n>]:MINFo[:STATe] <State>

Turns the marker information in all diagrams on and off.

Suffix:
<n> irrelevant

Parameters:
<State> **ON | 1**
Displays the marker information in the diagrams.
OFF | 0
Hides the marker information in the diagrams.
*RST: 1

Example: `DISP:MINF OFF`
Hides the marker information.

Manual operation: See "Marker Info" on page 140

DISPlay[:WINDow<n>]:MTABle <DisplayMode>

Turns the marker table on and off.

Suffix:
<n> irrelevant

Parameters:
<DisplayMode> **ON | 1**
Turns on the marker table.
OFF | 0
Turns off the marker table.
*RST: AUTO

Example: `DISP:MTAB ON`
Activates the marker table.

Manual operation: See "Marker Table Display" on page 140

8.6.4.3 Marker positioning settings

Several functions are available to set the marker to a specific position very quickly and easily.

Useful commands for positioning markers described elsewhere:

- `CALCulate<n>:MARKer<m>:TRACe` on page 272
- `CALCulate<n>:DELTamarker<m>:TRACe` on page 275

Remote commands exclusive to positioning markers:

CALCulate<n>:DELTamarker<m>:MAXimum:APEak

Positions the active marker or delta marker on the largest absolute peak value (maximum or minimum) of the selected trace.

Suffix:

<n> Window

<m> Marker

Usage: Event

CALCulate<n>:DELTamarker<m>:MAXimum:LEFT

Moves a delta marker to the next positive peak value.

The search includes only measurement values to the left of the current marker position.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Next Peak" on page 141

CALCulate<n>:DELTamarker<m>:MAXimum:NEXT

Moves a marker to the next positive peak value.

Suffix:

<n> 1..n
Window

<m> 1..n
Marker

Manual operation: See "Search Next Peak" on page 141

CALCulate<n>:DELTamarker<m>:MAXimum[:PEAK]

Moves a delta marker to the highest level.

If the marker is not yet active, the command first activates the marker.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Peak Search" on page 141

CALCulate<n>:DELTamarker<m>:MAXimum:RIGHt

Moves a delta marker to the next positive peak value on the trace.

The search includes only measurement values to the right of the current marker position.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Search Next Peak" on page 141

CALCulate<n>:DELTamarker<m>:MINimum:LEFT

Moves a delta marker to the next minimum peak value.

The search includes only measurement values to the right of the current marker position.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Search Next Minimum" on page 141

CALCulate<n>:DELTamarker<m>:MINimum:NEXT

Moves a marker to the next minimum peak value.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Search Next Minimum" on page 141

CALCulate<n>:DELTamarker<m>:MINimum[:PEAK]

Moves a delta marker to the minimum level.

If the marker is not yet active, the command first activates the marker.

Suffix:
<n> Window

<m> Marker

Manual operation: See "Search Minimum" on page 141

CALCulate<n>:DELTamarker<m>:MINimum:RIGHt

Moves a delta marker to the next minimum peak value.

The search includes only measurement values to the right of the current marker position.

Suffix:
<n> Window

<m> Marker

Manual operation: See "Search Next Minimum" on page 141

CALCulate<n>:MARKer<m>:MAXimum:APEak

sets the marker to the largest absolute peak value (maximum or minimum) of the selected trace.

Suffix:
<n> Window

<m> Marker

Usage: Event

CALCulate<n>:MARKer<m>:MAXimum:LEFT

Moves a marker to the next positive peak.

The search includes only measurement values to the left of the current marker position.

Suffix:
<n> Window

<m> Marker

Manual operation: See "Search Next Peak" on page 141

CALCulate<n>:MARKer<m>:MAXimum:NEXT

Moves a marker to the next positive peak.

Suffix:
<n> Window

<m> Marker

Manual operation: See "Search Next Peak" on page 141

CALCulate<n>:MARKer<m>:MAXimum:RIGHt

Moves a marker to the next positive peak.

The search includes only measurement values to the right of the current marker position.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Next Peak" on page 141

CALCulate<n>:MARKer<m>:MAXimum[:PEAK]

Moves a marker to the highest level.

If the marker is not yet active, the command first activates the marker.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Peak Search" on page 141

CALCulate<n>:MARKer<m>:MINimum:LEFT

Moves a marker to the next minimum peak value.

The search includes only measurement values to the right of the current marker position.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Next Minimum" on page 141

CALCulate<n>:MARKer<m>:MINimum:NEXT

Moves a marker to the next minimum peak value.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Next Minimum" on page 141

CALCulate<n>:MARKer<m>:MINimum:RIGHt

Moves a marker to the next minimum peak value.

The search includes only measurement values to the right of the current marker position.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Next Minimum" on page 141

CALCulate<n>:MARKer<m>:MINimum[:PEAK]

Moves a marker to the minimum level.

If the marker is not yet active, the command first activates the marker.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Minimum" on page 141

CALCulate<n>:MARKer<m>:SEARch <MarkRealImag>

Specifies whether the marker search works on the real or the imag trace (for all markers).

Suffix:

<n> 1..n
Window

<m> 1..4
Marker

Parameters:

<MarkRealImag> REAL | IMAG
*RST: REAL

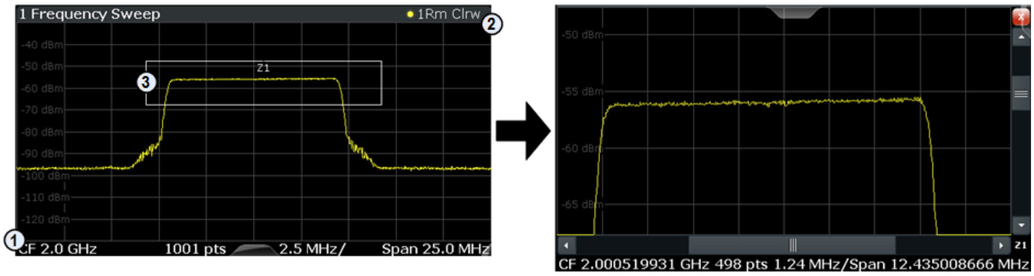
8.6.5 Zooming into the display

8.6.5.1 Using the single zoom

DISPlay[:WINDow<n>][:SUBWindow<w>]:ZOOM:AREA <x1>,<y1>,<x2>,<y2>

Defines the zoom area.

To define a zoom area, you first have to turn the zoom on.



1 = origin of coordinate system (x1 = 0, y1 = 0)
2 = end point of system (x2 = 100, y2= 100)
3 = zoom area (e.g. x1 = 60, y1 = 30, x2 = 80, y2 = 75)

Suffix:

<n> Window

<w> subwindow
Not supported by all applications

Parameters:

<x1> Diagram coordinates in % of the complete diagram that define the zoom area.
The lower left corner is the origin of coordinate system. The upper right corner is the end point of the system.
Range: 0 to 100
Default unit: PCT

<y1> Diagram coordinates in % of the complete diagram that define the zoom area.
The lower left corner is the origin of coordinate system. The upper right corner is the end point of the system.
Range: 0 to 100
Default unit: PCT

<x2> Diagram coordinates in % of the complete diagram that define the zoom area.
The lower left corner is the origin of coordinate system. The upper right corner is the end point of the system.
Range: 0 to 100
Default unit: PCT

<y2> Diagram coordinates in % of the complete diagram that define the zoom area.
The lower left corner is the origin of coordinate system. The upper right corner is the end point of the system.
Range: 0 to 100
Default unit: PCT

DISPlay[:WINDow<n>][:SUBWindow<w>]:ZOOM[:STATe] <State>

Turns the zoom on and off.

Suffix:

<n> Window

<w> subwindow
Not supported by all applications

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

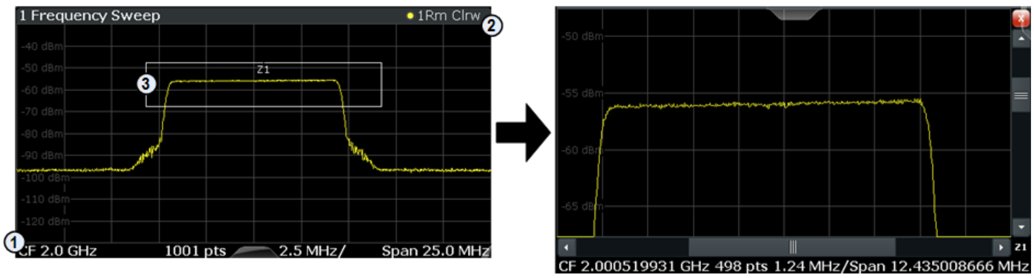
Example: `DISP:ZOOM ON`
Activates the zoom mode.

8.6.5.2 Using the multiple zoom

DISPlay[:WINDow<n>][:SUBWindow<w>]:ZOOM:MULTiple<zn>:AREA
<x1>,<y1>,<x2>,<y2>

Defines the zoom area for a multiple zoom.

To define a zoom area, you first have to turn the zoom on.



1 = origin of coordinate system (x1 = 0, y1 = 0)
2 = end point of system (x2 = 100, y2= 100)
3 = zoom area (e.g. x1 = 60, y1 = 30, x2 = 80, y2 = 75)

Suffix:

<n> Window

<w> subwindow
Not supported by all applications

<zn> Selects the zoom window.

Parameters:

<x1> Diagram coordinates in % of the complete diagram that define the zoom area.
The lower left corner is the origin of coordinate system. The upper right corner is the end point of the system.

Range: 0 to 100
Default unit: PCT

<y1> Diagram coordinates in % of the complete diagram that define the zoom area.
The lower left corner is the origin of coordinate system. The upper right corner is the end point of the system.

Range: 0 to 100
Default unit: PCT

<x2> Diagram coordinates in % of the complete diagram that define the zoom area.
The lower left corner is the origin of coordinate system. The upper right corner is the end point of the system.

Range: 0 to 100
Default unit: PCT

<y2> Diagram coordinates in % of the complete diagram that define the zoom area.
The lower left corner is the origin of coordinate system. The upper right corner is the end point of the system.

Range: 0 to 100
Default unit: PCT

DISPlay[:WINDow<n>][:SUBWindow<w>]:ZOOM:MULTiple<zn>[:STATe] <State>

Turns the multiple zoom on and off.

Suffix:

<n> Window

<w> subwindow
Not supported by all applications

<zn> Selects the zoom window.
If you turn off one of the zoom windows, all subsequent zoom windows move up one position.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

8.6.6 Configuring an analysis interval and line (MSRA mode only)

In MSRA operating mode, only the MSRA primary actually captures data; the MSRA secondary applications define an extract of the captured data for analysis, referred to as the **analysis interval**. The **analysis line** is a common time marker for all MSRA secondary applications.

For the OFDM VSA secondary application, the commands to define the analysis interval are the same as those used to define the actual data acquisition (see Chapter 4.5, "Data acquisition", on page 90. Be sure to select the correct measurement channel before executing these commands.

Useful commands related to MSRA mode described elsewhere:

- `INITiate<n>:REFResh` on page 259
- `INITiate:SEQuencer:REFResh[:ALL]` on page 260

Remote commands exclusive to MSRA secondary applications

The following commands are only available for MSRA secondary application channels:

CALCulate<n>:MSRA:ALINe:SHOW

Defines whether or not the analysis line is displayed in all time-based windows in all MSRA secondary applications and the MSRA primary application.

Note: even if the analysis line display is off, the indication whether or not the currently defined line position lies within the analysis interval of the active secondary application remains in the window title bars.

Suffix:
<n> irrelevant

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

OFF | 0
Switches the function off

ON | 1
Switches the function on

Manual operation: See "Show Line" on page 144

CALCulate<n>:MSRA:ALINe[:VALue] <Position>

Defines the position of the analysis line for all time-based windows in all MSRA secondary applications and the MSRA primary application.

Suffix:
<n> irrelevant

Parameters:

<Position> Position of the analysis line in seconds. The position must lie within the measurement time of the MSRA measurement.

Default unit: s

Manual operation: See "Position" on page 144

CALCulate<n>:MSRA:WINDow<n>:IVAL

Returns the current analysis interval for applications in MSRA operating mode.

Suffix:

<n> irrelevant

<n> 1..n
Window

Return values:

<IntStart> Analysis start = Capture offset time

Default unit: s

<IntStop> Analysis end = capture offset + capture time

Default unit: s

[SENSe:]MSRA:CAPTure:OFFSet <Offset>

This setting is only available for secondary applications in MSRA mode, not for the MSRA primary application. It has a similar effect as the trigger offset in other measurements.

Parameters:

<Offset> This parameter defines the time offset between the capture buffer start and the start of the extracted secondary application data. The offset must be a positive value, as the secondary application can only analyze data that is contained in the capture buffer.

Range: 0 to <Record length>
*RST: 0
Default unit: S

Manual operation: See "Capture Offset" on page 90

8.7 Configuring the result display

The following commands are required to configure the result display in a remote environment.

8.7.1 General window commands

The following commands are required to configure general window layout, independent of the application.

DISPlay:FORMat <Format>

Determines which tab is displayed.

Parameters:

<Format>

SPLit
Displays the MultiView tab with an overview of all active channels

SINGle
Displays the measurement channel that was previously focused.

*RST: SING

Example: `DISP:FORM SPL`

DISPlay[:WINDow<n>]:SIZE <Size>

Maximizes the size of the selected result display window *temporarily*. To change the size of several windows on the screen permanently, use the `LAY:SPL` command (see `LAYout:SPLitter` on page 292).

Suffix:

<n> Window

Parameters:

<Size>

LARGe
Maximizes the selected window to full screen.
Other windows are still active in the background.

SMALl
Reduces the size of the selected window to its original size.
If more than one measurement window was displayed originally, these are visible again.

*RST: SMALl

Example: `DISP:WIND2:SIZE LARG`

8.7.2 Working with windows in the display

The following commands are required to change the evaluation type and rearrange the screen layout for a channel as you do using the SmartGrid in manual operation. Since the available evaluation types depend on the selected application, some parameters for the following commands also depend on the selected channel.

Note that the suffix <n> always refers to the window *in the currently selected channel*.

LAYout:ADD[:WINDow]? <WindowName>, <Direction>, <WindowType>

Adds a window to the display in the active channel.

Is always used as a query so that you immediately obtain the name of the new window as a result.

To replace an existing window, use the `LAYout:REPLace[:WINDow]` command.

Query parameters:

<WindowName>	String containing the name of the existing window the new window is inserted next to. By default, the name of a window is the same as its index. To determine the name and index of all active windows, use the `LAYout:CATalog[:WINDow]?` query.
<Direction>	LEFT | RIGHt | ABOVe | BELow Direction the new window is added relative to the existing window.
<WindowType>	text value Type of result display (evaluation method) you want to add. See the table below for available parameter values.

Return values:

<NewWindowName>	When adding a new window, the command returns its name (by default the same as its number) as a result.

Usage: Query only

Manual operation:
See "Allocation Matrix" on page 11
See "Bitstream" on page 12
See "CCDF" on page 14
See "Channel Flatness" on page 14
See "Constellation Diagram" on page 15
See "Constellation vs Carrier" on page 16
See "Constellation vs Symbol" on page 17
See "EVM vs Carrier" on page 18
See "EVM vs Symbol" on page 18
See "EVM vs Symbol vs Carrier" on page 19
See "Group Delay" on page 20
See "Impulse Response" on page 21
See "Magnitude Capture" on page 22
See "Marker Table" on page 22
See "Notes" on page 23
See "Power Spectrum" on page 23
See "Power vs Carrier" on page 24
See "Power vs Symbol" on page 25
See "Power vs Symbol vs Carrier" on page 25
See "Result Summary" on page 26
See "Signal Flow" on page 27
See "Trigger to Sync" on page 28

Table 8-4: <WindowType> parameter values for OFDM VSA application

Parameter value	Window type
AMATrix	"Allocation Matrix"
BITStream	"Bitstream"
CCARrier	"Constellation vs Carrier"
CCDF	"CCDF"
CHFLatness	"Channel Flatness"
CONStell	"Constellation Diagram"
CSYMbol	"Constellation vs Symbol"
EVCarrier	"EVM vs Carrier"
EVSYmbol	"EVM vs Symbol"
EVSC	"EVM vs Symbol vs Carrier"
GDELay	"Group Delay"
IRESponse	"Impulse Response"
MCAPture	"Magnitude Capture"
MTABle	"Marker Table"
PCARrier	"Power vs Carrier"
PSC	"Power vs Symbol vs Carrier"
PSPectrum	"Power Spectrum"

Parameter value	Window type
PSYMbol	"Power vs Symbol"
RSUMmary	"Result Summary"
SFLow	"Signal Flow"
TRIGger	"Trigger to Sync"

LAYout:CATalog[:WINDow]?

Queries the name and index of all active windows in the active channel from top left to bottom right. The result is a comma-separated list of values for each window, with the syntax:

<WindowName_1>,<WindowIndex_1>..<WindowName_n>,<WindowIndex_n>

Return values:

<WindowName> string

Name of the window.
In the default state, the name of the window is its index.

<WindowIndex> **numeric value**
Index of the window.

Example: `LAY:CAT?`
Result:
`'2',2,'1',1`
Two windows are displayed, named '2' (at the top or left), and '1' (at the bottom or right).

Usage: Query only

LAYout:IDENtify[:WINDow]? <WindowName>

Queries the **index** of a particular display window in the active channel.

Note: to query the **name** of a particular window, use the `LAYout:WINDow<n>:IDENtify?` query.

Query parameters:

<WindowName> String containing the name of a window.

Return values:

<WindowIndex> Index number of the window.

Example: `LAY:IDEN:WIND? '2'`
Queries the index of the result display named '2'.
Response:
`2`

Usage: Query only

LAYout:MOVE[:WINDow] <WindowName>, <WindowName>, <Direction>

Setting parameters:

<WindowName> String containing the name of an existing window that is to be moved.
By default, the name of a window is the same as its index. To determine the name and index of all active windows in the active channel, use the `LAYout:CATalog[:WINDow]?` query.

<WindowName> String containing the name of an existing window the selected window is placed next to or replaces.
By default, the name of a window is the same as its index. To determine the name and index of all active windows in the active channel, use the `LAYout:CATalog[:WINDow]?` query.

<Direction> LEFT | RIGHt | ABOVe | BELow | REPLace
Destination the selected window is moved to, relative to the reference window.

Example: `LAY:MOVE '4','1',LEFT`
Moves the window named '4' to the left of window 1.

Example: `LAY:MOVE '1','3',REPL`
Replaces the window named '3' by window 1. Window 3 is deleted.

Usage: Setting only

LAYout:REMove[:WINDow] <WindowName>

Removes a window from the display in the active channel.

Setting parameters:

<WindowName> String containing the name of the window. In the default state, the name of the window is its index.

Example: `LAY:REM '2'`
Removes the result display in the window named '2'.

Usage: Setting only

LAYout:REPLace[:WINDow] <WindowName>,<WindowType>

Replaces the window type (for example from "Diagram" to "Result Summary") of an already existing window in the active channel while keeping its position, index and window name.

To add a new window, use the `LAYout:ADD[:WINDow]?` command.

Setting parameters:

<WindowName> String containing the name of the existing window.
By default, the name of a window is the same as its index. To determine the name and index of all active windows in the active channel, use the `LAYout:CATalog[:WINDow]?` query.

<WindowType>	Type of result display you want to use in the existing window. See `LAYout:ADD[:WINDow]?` on page 288 for a list of available window types.
Example:	`LAY:REPL:WIND '1',MTAB` Replaces the result display in window 1 with a marker table.
Usage:	Setting only

LAYout:SPLitter <Index1>, <Index2>, <Position>

Changes the position of a splitter and thus controls the size of the windows on each side of the splitter.

Compared to the `DISPlay[:WINDow<n>]:SIZE` on page 287 command, the `LAYout:SPLitter` changes the size of all windows to either side of the splitter permanently, it does not just maximize a single window temporarily.

Note that windows must have a certain minimum size. If the position you define conflicts with the minimum size of any of the affected windows, the command does not work, but does not return an error.

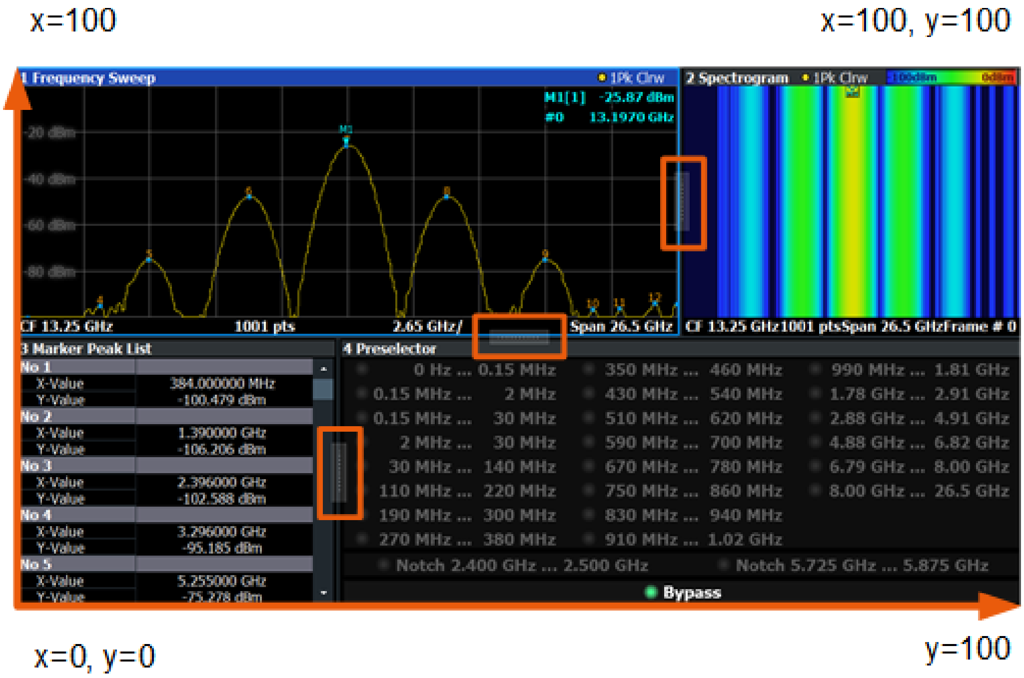


Figure 8-1: SmartGrid coordinates for remote control of the splitters

Setting parameters:

<Index1>	The index of one window the splitter controls.
<Index2>	The index of a window on the other side of the splitter.

<Position> New vertical or horizontal position of the splitter as a fraction of the screen area (without channel and status bar and softkey menu).
The point of origin (x = 0, y = 0) is in the lower left corner of the screen. The end point (x = 100, y = 100) is in the upper right corner of the screen. (See Figure 8-1.)
The direction in which the splitter is moved depends on the screen layout. If the windows are positioned horizontally, the splitter also moves horizontally. If the windows are positioned vertically, the splitter also moves vertically.
Range: 0 to 100

Example: `LAY:SPL 1,3,50`
Moves the splitter between window 1 ('Frequency Sweep') and 3 ('"Marker Table"') to the center (50%) of the screen, i.e. in the figure above, to the left.

Example: `LAY:SPL 1,4,70`
Moves the splitter between window 1 ('Frequency Sweep') and 3 ('"Marker Peak List"') towards the top (70%) of the screen.
The following commands have the exact same effect, as any combination of windows above and below the splitter moves the splitter vertically.
```
LAY:SPL 3,2,70
LAY:SPL 4,1,70
LAY:SPL 2,1,70
```

Usage: Setting only

LAYout:WINDow<n>:ADD? <Direction>,<WindowType>

Adds a measurement window to the display. Note that with this command, the suffix <n> determines the existing window next to which the new window is added. Unlike `LAYout:ADD[:WINDow]?`, for which the existing window is defined by a parameter.

To replace an existing window, use the `LAYout:WINDow<n>:REPLace` command.

Is always used as a query so that you immediately obtain the name of the new window as a result.

Suffix:
<n> Window

Query parameters:
<Direction> LEFT | RIGHt | ABOVe | BELow

<WindowType> Type of measurement window you want to add.
See `LAYout:ADD[:WINDow]?` on page 288 for a list of available window types.

Return values:
<NewWindowName> When adding a new window, the command returns its name (by default the same as its number) as a result.

Example: `LAY:WIND1:ADD? LEFT,MTAB`
Result:
`'2'`
Adds a new window named '2' with a marker table to the left of window 1.

Usage: Query only

LAYout:WINDow<n>:IDENtify?

Queries the **name** of a particular display window (indicated by the <n> suffix) in the active channel.

Note: to query the **index** of a particular window, use the `LAYout:IDENtify[:WINDow]?` command.

Suffix:
<n> Window

Return values:
<WindowName> String containing the name of a window.
In the default state, the name of the window is its index.

Example: `LAY:WIND2:IDEN?`
Queries the name of the result display in window 2.
Response:
`'2'`

Usage: Query only

LAYout:WINDow<n>:REMove

Removes the window specified by the suffix <n> from the display in the active channel.

The result of this command is identical to the `LAYout:REMove[:WINDow]` command.

Suffix:
<n> Window

Example: `LAY:WIND2:REM`
Removes the result display in window 2.

Usage: Event

LAYout:WINDow<n>:REPLace <WindowType>

Changes the window type of an existing window (specified by the suffix <n>) in the active channel.

The effect of this command is identical to the `LAYout:REPLace[:WINDow]` command.

To add a new window, use the `LAYout:WINDow<n>:ADD?` command.

Suffix:
<n> Window

Setting parameters:
<WindowType> Type of measurement window you want to replace another one with.
See LAYout:ADD[:WINDow]? on page 288 for a list of available window types.

Example: `LAY:WIND2:REPL MTAB`
Replaces the result display in window 2 with a marker table.

Usage: Setting only

LAYout:WINDow<n>:TYPE <WindowType>

Queries or defines the window type of the window specified by the index <n>. The window type determines which results are displayed. For a list of possible window types, see LAYout:ADD[:WINDow]? on page 288.

Note that this command is not available in all applications and measurements.

Suffix:
<n> 1..n
Window

Parameters:
<WindowType>

Example: `LAY:WIND2:TYPE?`

8.8 Retrieving results

The following commands are required to retrieve the calculated OFDM VSA parameters.

8.8.1 Retrieving numerical results

These commands return the average, maximum or minimum result of the specified parameter. For details and an assignment of the parameters to the keywords see

FETCh:BURSt:COUNt?

Returns the number of analyzed bursts from the current capture buffer.

Return values:
<Value>

Usage: Query only

FETCh:BURSt:LENGths?

Returns the length of the analyzed bursts from the current measurement.

The result is a comma-separated list of lengths, one for each burst.

Return values:
<Value> Default unit: s

Usage: Query only

FETCh:BURSt:STARts?

Returns the start position of each analyzed burst in the current capture buffer.

Return values:
<Value> Offset of the burst start from the beginning of the capture buffer.
Default unit: s

Example:
```
FETC:BURS:STAR?
//Result:
//6.04e-05
```

Usage: Query only

FETCh:SUMMary[:ALL]?

Returns all values in the result summary, in the same order as in the display

(See "Result Summary" on page 26.)

Return values:

<Result> <EVMAll_dB_Min>,<EVMAll_dB_Avg>,<EVMAll_dB_Max>, <EVMAll_PCT_Min>,<EVMAll_PCT_Avg>,<EVMAll_PCT_Max> , <EVMData_dB_Min>,<EVMData_dB_Avg>,<EVMData_dB_Max>, <EVMData_PCT_Min>,<EVMData_PCT_Avg>,<EVMData_PCT_Max>, <EVMPilot_dB_Min>,<EVMPilot_dB_Avg>,<EVMPilot_dB_Max>, <EVMPilot_PCT_Min>,<EVMPilot_PCT_Avg>,<EVMPilot_PCT_Max>, <MER_Min>,<MER_Avg>,<MER_Max>, <I/QOffset_Min>,<I/QOffset_Avg>,<I/QOffset_Max>, <GainImbalance_Min>,<GainImbalance_Avg>,<GainImbalance_Max>, <QuadError_Min>,<QuadError_Avg>,<QuadError_Max>, <FreqErr_Min>,<FreqErr_Avg>,<FreqErr_Max>, <SampleClockErr_Min>,<SampleClockErr_Avg>,<SampleClockErr_Max>, <FramePower_Min>,<FramePower_Avg>,<FramePower_Max>, <CrestFactor_Min>,<CrestFactor_Avg>,<CrestFactor_Max>,

Comma-separated list with 3 statistical values for each result.

Example:

```
FETC:SUMM:ALL?
//-34.6742,-34.6742,-34.6742,
//1.84624,1.84624,1.84624,
//-34.5875,-34.5875,-34.5875,
//1.86477,1.86477,1.86477,
//-35.5229,-35.5229,-35.5229,
//1.67439,1.67439,1.67439,
//34.6742,34.6742,34.6742,
//-75.106,-75.106,-75.106,
//0.00573547,0.00573547,0.00573547,
//-0.0159425,-0.0159425,-0.0159425,
//0.272241,0.272241,0.272241,
//0.219516,0.219516,0.219516,
//-23.1036,-23.1036,-23.1036,
//9.84252,9.84252,9.84252
```

Usage: Query only

Manual operation: See "Result Summary" on page 26

FETCh:SUMMary:CRESt:MAXimum?
FETCh:SUMMary:CRESt:MINimum?
FETCh:SUMMary:CRESt[:AVERage]?
FETCh:SUMMary:EVM:DATA:MAXimum?
FETCh:SUMMary:EVM:DATA:MINimum?
FETCh:SUMMary:EVM:DATA[:AVERage]?
FETCh:SUMMary:EVMPeak:DATA:MAXimum*?
FETCh:SUMMary:EVMPeak:DATA:PCT:MAXimum*?
FETCh:SUMMary:EVMPeak:PILot:MAXimum*?
FETCh:SUMMary:EVMPeak:PILot:PCT:MAXimum*?
FETCh:SUMMary:EVMPeak[:ALL]:MAXimum*?
FETCh:SUMMary:EVMPeak[:ALL]:PCT:MAXimum*?

FETCh:SUMMary:EVM:PILot:MAXimum?
FETCh:SUMMary:EVM:PILot:MINimum?
FETCh:SUMMary:EVM:PILot[:AVERage]?
FETCh:SUMMary:EVM:PILot:PCT[:AVERage]?
FETCh:SUMMary:EVM[:ALL]:MAXimum?
FETCh:SUMMary:EVM[:ALL]:MINimum?
FETCh:SUMMary:EVM[:ALL][:AVERage]?
FETCh:SUMMary:EVM[:ALL]:PCT:MAXimum?
FETCh:SUMMary:EVM[:ALL]:PCT:MINimum?
FETCh:SUMMary:EVM[:ALL]:PCT[:AVERage]?
FETCh:SUMMary:FERRor:MAXimum?
FETCh:SUMMary:FERRor:MINimum?
FETCh:SUMMary:FERRor[:AVERage]?
FETCh:SUMMary:GIMBalance:MAXimum?
FETCh:SUMMary:GIMBalance:MINimum?
FETCh:SUMMary:GIMBalance[:AVERage]?
FETCh:SUMMary:IQOFfset:MAXimum?
FETCh:SUMMary:IQOFfset:MINimum?
FETCh:SUMMary:IQOFfset[:AVERage]?
FETCh:SUMMary:MER[:ALL]:MAXimum?
FETCh:SUMMary:MER[:ALL]:MINimum?
FETCh:SUMMary:MER[:ALL][:AVERage]?
FETCh:SUMMary:POWer:MAXimum?
FETCh:SUMMary:POWer:MINimum?
FETCh:SUMMary:POWer[:AVERage]?
FETCh:SUMMary:QUADerror:MAXimum?
FETCh:SUMMary:QUADerror:MINimum?
FETCh:SUMMary:QUADerror[:AVERage]?
FETCh:SUMMary:SERRor:MAXimum?
FETCh:SUMMary:SERRor:MINimum?
FETCh:SUMMary:SERRor[:AVERage]?
FETCh:SUMM:<parameter>:<statistic>

These commands return the average, maximum or minimum result of the specified parameter. For details and an assignment of the parameters to the keywords see Table 2-1.

*) These results are not included in the Result Summary display, nor in the `FETCh:SUMMary[:ALL]?` results.

FETCh:TTFRame?

Retrieves the time offset between the trigger event and the start of the first OFDM frame.

Return values:
<Time>

Example: `FETC:TTFR?`

Usage: Query only

Manual operation: See "Trigger to Sync" on page 28

8.8.2 Retrieving signal flow results

The following commands are required to retrieve the results of the signal flow stages. See also "Signal Flow" on page 27.

FETCh:SFLow:FSYNc?

Returns the Frame Synchronisation value.

Return values:
<Value>

Example: `FETC:SFL:FSYN?`

Usage: Query only

FETCh:SFLow:STATe:ALL?

Returns the state of the individual stages of the signal flow. The result is a comma-separated list of states, one for each stage. The stages are in the following order:

- Burst Detection
- Time Sync
- Frame Sync
- Data-Aided Parameter estimation
- Modulation detection
- Pilot-aided parameter estimation
- Compensate
- EVM meas

Return values:
<Value>
FAIL
Not successful
PASS
Successful

WARN
Warning occurred

DISabled
Inactive

Example: `FETC:SFL:STAT:ALL?`

Usage: Query only

FETCh:SFLow:STATe:BDETection?

Returns the state of the burst detection stage of the signal flow.

Return values:

<Value>

FAIL
Not successful

PASS
Successful

WARN
Warning occurred

DISabled
Inactive

Example: `FETC:SFL:STAT:BDET?`

Usage: Query only

FETCh:SFLow:STATe:COMPensate?

Returns the state of the compensation stage of the signal flow.

Return values:

<Value>

FAIL
Not successful

PASS
Successful

WARN
Warning occurred

DISabled
Inactive

Example: `FETC:SFL:STAT:COMP?`

Usage: Query only

FETCh:SFLow:STATe:DESTimation?

Returns the state of the data-aided parameter estimation stage of the signal flow.

Return values:

<Value>

FAIL
Not successful

PASS
Successful

WARN
Warning occurred

DISabled
Inactive

Example: `FETC:SFL:STAT:DEST?`

Usage: Query only

FETCh:SFLow:STATe:EVMMeas?

Returns the state of the EVM measurement stage of the signal flow.

Return values:

<Value>

FAIL
Not successful

PASS
Successful

WARN
Warning occurred

DISabled
Inactive

Example: `FETC:SFL:STAT:EVMM?`

Usage: Query only

FETCh:SFLow:STATe:FSYNc?

Returns the state of the frame synchronization stage of the signal flow.

Return values:

<Value>

FAIL
Not successful

PASS
Successful

WARN
Warning occurred

DISabled
Inactive

Example: `FETC:SFL:STAT:FSYN?`

Usage: Query only

FETCh:SFLow:STATe:MDETection?

Returns the state of the modulation detection stage of the signal flow.

Return values:
<Value>
FAIL
Not successful
PASS
Successful
WARN
Warning occurred
DISabled
Inactive

Example: `FETC:SFL:STAT:MDET?`

Usage: Query only

FETCh:SFLow:STATe:PESTimation?

Returns the state of the pilot-aided parameter estimation stage of the signal flow.

Return values:
<Value>
FAIL
Not successful
PASS
Successful
WARN
Warning occurred
DISabled
Inactive

Example: `FETC:SFL:STAT:PEST?`

Usage: Query only

FETCh:SFLow:STATe:TSYNc?

Returns the state of the time synchronization stage of the signal flow.

Return values:
<Value>
FAIL
Not successful
PASS
Successful
WARN
Warning occurred
DISabled
Inactive

Example: `FETC:SFL:STAT:TSYN?`

Usage: Query only

FETCh:SFLow:TSYNc?

Returns the Time Synchronisation value.

Return values:
<Value>

Example: `FETC:SFL:TSYN?`

Usage: Query only

8.8.3 Retrieving trace data and marker values

In order to retrieve the trace and marker results in a remote environment, use the following commands:

Useful commands for retrieving results described elsewhere:

- `CALCulate<n>:MARKer<m>:X` on page 272

Remote commands exclusive to retrieving trace data and marker values:

CALCulate<n>:DELTamarker<m>:Y?

Queries the result at the position of the specified delta marker.

Suffix:

<n>	1..n
<m>	1..n

Return values:

<Result> Result at the position of the delta marker.
The unit is variable and depends on the one you have currently set.

Default unit: DBM

Usage: Query only

Manual operation: See "Y-Value" on page 138

CALCulate<n>:DELTamarker<m>:Y:RELative?

Queries the relative position of a delta marker of a 3D trace on the y-axis. If necessary, the command activates the delta marker first.

Suffix:

<n> 1..n
Window

<m> 1..n
Marker

Return values:

<XValue> Default unit: HZ

Example:
```
CALC:DELT3:Y:REL?
```

Usage: Query only

CALCulate<n>:DELTamarker<m>:Z <Result>

Sets a delta marker's current position on the z-axis or queries its result in a 3-dimensional diagram.

Suffix:

<n> 1..n
Window

<m> 1..n
Marker

Parameters:

<Result> Result at the position of the delta marker.
For 3-dimensional constellation diagrams (Constellation vs carrier/symbol), this parameter defines the carrier or symbol, respectively, to place the marker at.
The unit depends on the type of data displayed on the z-axis.

Example:
```
//Define a power vs. symbol vs. carrier display
LAY:ADD? '1',RIGH,PSC
//Set delta marker 2 at carrier 2
CALC2:DELT2:Y 2
//Query the delta marker result for carrier 2
CALC2:DELT2:Z?
```

Example:

```
//Define constellation vs. symbol display
LAY:ADD? '1',RIGH,CSYM
//Set delta marker 2 at carrier 1
CALC2:DELT2:Z 1
//Query the delta marker result for carrier 1.
CAL2:DELT2:Y?
```

CALCulate<n>:MARKer<m>:Y?

Queries the result at the position of the specified marker.

Suffix:

<n> 1..n

<m> 1..n

Return values:

<Result> Default unit: DBM

Usage: Query only

Manual operation: See "Marker Table" on page 22
See "Y-Value" on page 138

CALCulate<n>:MARKer<m>:Z <Result>

Sets a marker's current position on the z-axis or queries its result in a 3-dimensional diagram.

Suffix:

<n> 1..n
Window

<m> 1..n
Marker

Parameters:

<Result> Result at the position of the marker.
For 3-dimensional constellation diagrams (Constellation vs carrier/symbol), this parameter defines the carrier or symbol, respectively, to place the marker at.
The unit depends on the type of data displayed on the z-axis.

Example:

```
//Define a power vs. symbol vs. carrier display
LAY:ADD? '1',RIGH,PSC
//Set marker 2 at carrier 2
CALC2:MARK2:Y 2
//Query the marker result for carrier 2
CALC2:MARK2:Z?
```

Example:

```
//Define constellation vs. carrier display
LAY:ADD? '1',RIGH,CCAR
//Set marker 2 at symbol 3
CALC2:MARK2:Z 3
//Query the marker result for symbol 3.
CAL2:MARK2:Y?
```

Manual operation:
See "Constellation Diagram" on page 15
See "Constellation vs Carrier" on page 16
See "Constellation vs Symbol" on page 17
See "EVM vs Symbol vs Carrier" on page 19
See "Power vs Symbol vs Carrier" on page 25

FORMat[:DATA] <Format>[, <BitLength>]

Selects the data format that is used for transmission of trace data from the FSW to the controlling computer.

Note that the command has no effect for data that you send to the FSW. The FSW automatically recognizes the data it receives, regardless of the format.

Parameters:

<Format>

ASCii
ASCii format, separated by commas.
This format is almost always suitable, regardless of the actual data format. However, the data is not as compact as other formats can be.

REAL
Floating-point numbers (according to IEEE 754) in the "definite length block format".
In the Spectrum application, the format setting `REAL` is used for the binary transmission of trace data.

<BitLength>

Length in bits for floating-point results

16
16-bit floating-point numbers.
Compared to `REAL,32` format, half as many numbers are returned.

32
32-bit floating-point numbers
For I/Q data, 8 bytes per sample are returned for this format setting.

64
64-bit floating-point numbers
Compared to `REAL,32` format, twice as many numbers are returned.

Example: `FORM REAL,32`

FORMat:DEXPort:DSEParator <Separator>

Selects the decimal separator for data exported in ASCII format.

Parameters:

<Separator> POINt | COMMa

COMMa
Uses a comma as decimal separator, e.g. *4,05*.

POINt
Uses a point as decimal separator, e.g. *4.05*.

*RST: *RST has no effect on the decimal separator. Default is POINt.

Example: `FORM:DEXP:DSEP POIN`
Sets the decimal point as separator.

Manual operation: See "Decimal Separator" on page 143

FORMat:DEXPort:GRAPh <State>

If enabled, all traces for the currently selected graphical result display are included in the export file.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Manual operation: See "Export All Traces for Selected Graph" on page 143

FORMat:DEXPort:HEADer <State>

If enabled, additional instrument and measurement settings are included in the header of the export file for result data. If disabled, only the pure result data from the selected traces and tables is exported.

Parameters:

<State> ON | OFF | 0 | 1

*RST: 1

Manual operation: See "Include Instrument & Measurement Settings" on page 143

FORMat:DEXPort:TRACes <Selection>

Selects the data to be included in a data export file (see `MMEMory:STORe<n>:TRACe` on page 309).

Parameters:

<Selection> SINGle | ALL

SINGle
Only a single trace is selected for export, namely the one specified by the `MMEMory:STORe<n>:TRACe` command.

ALL
Selects all active traces and result tables (e.g. "Result Summary", marker peak list etc.) in the current application for export to an ASCII file.
The <trace> parameter for the `MMEMory:STORe<n>:TRACe` command is ignored.

*RST: SINGle

Manual operation: See "Export all Traces and all Table Results" on page 142

FORMat:DEXPort:XDIStrib <XDistribution>

Defines how the x-values of the trace are determined in the frequency domain.

Parameters:

<XDistribution> STARtstop | BINCentered

BINCentered
The full measurement span is divided by the number of measurement points to obtain *bin*s. The x-value of the measurement point is defined as the x-value at the center of the bin (bin/2).

STARtstop
(Default): The x-value of the first measurement point corresponds to the starting point of the full measurement span. The x-value of the last measurement point corresponds to the end point of the full measurement span. All other measurement points are divided evenly between the first and last points.

Example: `FORM:DEXP:XDIS BINC`

MMEMory:STORe<n>:TRACe <Trace>, <FileName>

Exports trace data from the specified window to an ASCII file.

For details on the order of the trace results depending on the display type, see Chapter 8.8.4, "Using the TRACe[:DATA] command", on page 313.

Secure User Mode

In secure user mode, settings that are stored on the instrument are stored to volatile memory, which is restricted to 256 MB. Thus, a "memory limit reached" error can occur although the hard disk indicates that storage space is still available.

To store data permanently, select an external storage location such as a USB memory device.

For details, see "Protecting Data Using the Secure User Mode" in the "Data Management" section of the FSW base unit user manual.

Suffix:
<n> Window

Parameters:
<Trace> Number of the trace to be stored

<FileName> String containing the path and name of the target file.

Example: `MMEM:STOR1:TRAC 1,'C:\TEST.ASC'`
Stores trace 1 from window 1 in the file `TEST.ASC`.

Manual operation: See "Export Trace to ASCII File" on page 143

TRACe<n>[:DATA]? <Trace>

Returns the y-values of the trace data for the current measurement or result display.

For 3-dimensional displays, such as the Allocation Matrix, this command returns the data values for the third (z-) dimension.

For more information see Chapter 8.8.4, "Using the TRACe[:DATA] command", on page 313.

Suffix:
<n> 1..n
Window

Query parameters:
<Trace> TRACE1 | TRACE2 | TRACE3 | TRACE4 | TRACE5 | TRACE6

Usage: Query only

Manual operation: See "Allocation Matrix" on page 11

TRACe<n>[:DATA]:X? [<Trace>]

Returns the x-values for the trace data in the selected result display.

For information on how many values are returned see Chapter 8.8.4, "Using the TRACe[:DATA] command", on page 313.

Suffix:
<n> 1..n
Window

Query parameters:
<Trace> TRACE1 | TRACE2 | TRACE3 | TRACE4 | TRACE5 | TRACE6

Example: `TRAC2:DATA:X?`

Usage: Query only

Manual operation: See "Allocation Matrix" on page 11
See "CCDF" on page 14
See "Channel Flatness" on page 14
See "EVM vs Carrier" on page 18
See "EVM vs Symbol" on page 18
See "EVM vs Symbol vs Carrier" on page 19
See "Group Delay" on page 20
See "Impulse Response" on page 21
See "Magnitude Capture" on page 22
See "Power vs Carrier" on page 24
See "Power vs Symbol" on page 25
See "Power vs Symbol vs Carrier" on page 25

TRACe<n>[:DATA]:Y? [<Trace>]

Returns the y-values for 3-dimensional trace data in the selected result display.

For information on how many values are returned see Chapter 8.8.4, "Using the TRACe[:DATA] command", on page 313.

Suffix:

<n> 1..n
Window

Query parameters:

<Trace>

Example: `TRAC2:DATA:Y?`

Usage: Query only

Manual operation: See "Allocation Matrix" on page 11
See "EVM vs Symbol vs Carrier" on page 19
See "Power vs Symbol vs Carrier" on page 25

TRACe:IQ:DATA?

Initiates a measurement with the current settings and returns the captured data from I/Q measurements.

Corresponds to:

`INIT:IMM;*WAI;:TRACe:IQ:DATA:MEMory?`

However, the `TRACe:IQ:DATA?` command is quicker in comparison.

Return values:

<Results> Measured voltage for I and Q component for each sample that has been captured during the measurement.
Default unit: V

Example: `TRAC:IQ:STAT ON`
Enables acquisition of I/Q data
`TRAC:IQ:SET NORM,10MHz,32MHz,EXT,POS,0,4096`
Measurement configuration:
Sample Rate = 32 MHz
Trigger Source = External
Trigger Slope = Positive
Pretrigger Samples = 0
Number of Samples = 4096
`FORMat REAL,32`
Selects format of response data
`TRAC:IQ:DATA?`
Starts measurement and reads results

Usage: Query only

TRACe:IQ:DATA:FORMat <Format>

Selects the order of the I/Q data.

Parameters:

<Format> COMPatible | IQBLock | IQPair

COMPatible
I and Q values are separated and collected in blocks: A block (512k) of I values is followed by a block (512k) of Q values, followed by a block of I values, followed by a block of Q values etc. (I,I,I,I,Q,Q,Q,Q,I,I,I,I,Q,Q,Q,Q...)

IQBLock
First all I-values are listed, then the Q-values (I,I,I,I,I,I,...Q,Q,Q,Q,Q,Q)

IQPair
One pair of I/Q values after the other is listed (I,Q,I,Q,I,Q...).

*RST: IQBL

TRACe:IQ:DATA:MEMory? [<OffsetSamples>,<NoOfSamples>]

Queries the I/Q data currently stored in the capture buffer of the FSW.

By default, the command returns all I/Q data in the memory. You can, however, narrow down the amount of data that the command returns using the optional parameters.

If no parameters are specified with the command, the entire trace data is retrieved.

In this case, the command returns the same results as `TRACe:IQ:DATA?`. (Note, however, that the `TRAC:IQ:DATA?` command initiates a new measurement before returning the captured values, rather than returning the existing data in the memory.)

The command returns a comma-separated list of the measured values in floating point format (comma-separated values = CSV). The number of values returned is 2 * the number of complex samples.

The total number of complex samples is displayed in the channel bar in manual operation and can be calculated as:

<SampleRate> * <CaptureTime>

Query parameters:

<OffsetSamples> Selects an offset at which the output of data should start in relation to the first data. If omitted, all captured samples are output, starting with the first sample.

Range: 0 to <# of samples> – 1, with <# of samples> being the maximum number of captured values
*RST: 0

<NoOfSamples> Number of samples you want to query, beginning at the offset you have defined. If omitted, all captured samples (starting at offset) are output.

Range: 1 to <# of samples> - <offset samples> with <# of samples> maximum number of captured values
*RST: <# of samples>

Return values:

<IQData> Measured value pair (I,Q) for each sample that has been recorded.
The data format of the individual values depends on `FORMat[:DATA]` on page 307.

Default unit: V

Example:

```
// Perform a single I/Q capture.
INIT;*WAI
// Determine output format (binary float32)
FORMat REAL,32
// Read 1024 I/Q samples starting at sample 2048.
TRAC:IQ:DATA:MEM? 2048,1024
```

Usage: Query only

8.8.4 Using the TRACe[:DATA] command

This chapter contains information on the TRACe:DATA command and a detailed description of the characteristics of that command.

The `TRACe<n>[:DATA]?` command queries the trace data or results of the currently active measurement or result display. The type, number and structure of the return values are specific for each result display. For results that have any kind of unit, the command returns the results in the unit you have currently set for that result display.

For several result displays, the command also supports various SCPI parameters in combination with the query. If available, each SCPI parameter returns a different aspect of the results. If SCPI parameters are supported, you have to specify them in the query.

Example:

`TRAC:DATA? TRACE1`

The format of the return values is either in ASCII or binary characters and depends on the format you set with FORMat[:DATA] on page 307.

Following this detailed description, you find a short summary of the most important functions of the TRACe<n>[:DATA]? command.

8.8.4.1 Allocation matrix

The values in the allocation matrix represent the modulation type for that symbol and carrier. Depending on the parameter, the modulation is provided in different formats.

`TRACe<n>:DATA? TRACe1` returns the modulation indexes used for each symbol (column-wise from the matrix).

`TRACe<n>:DATA? TRACe2` returns the modulation names used for each symbol (column-wise from the matrix).

To obtain a list of the symbols (corresponding to the x-axis in the matrix), use `TRACe<n>:DATA:X? TRACe1`, see TRACe<n>[:DATA]:X? on page 310.

To obtain a list of the subcarriers (corresponding to the y-axis in the matrix), use `TRACe<n>:DATA:Y? TRACe1`, see TRACe<n>[:DATA]:Y? on page 311.

8.8.4.2 Bitstream

The command returns a demodulated data stream for the symbols in the currently analyzed result ranges in decimal format. Non-data cells, including the guard carriers, are indicated as "-1".

8.8.4.3 CCDF

The command returns the complementary cumulative probability distribution for each sample in the capture buffer, relative to the average power.

To obtain a list of the average power per sample, use `TRACe<n>:DATA:X? TRACe1`, see `TRACe<n>[:DATA]:X?` on page 310.

8.8.4.4 Channel flatness

The command returns the spectrum flatness as a list over all subcarriers. The list consists of one value for each trace point.

```
<relative power>, ...
```

The unit is always dB.

The following parameters are supported.

- TRACE1
  Returns the average power over all frames.
- TRACE2
  Returns the minimum power found over all frames.
- TRACE3
  Returns the maximum power found over all frames.

8.8.4.5 Constellation diagram

The command returns two values (I/Q) for each constellation point, for each carrier, in each symbol, in each frame, as defined in the Allocation matrix.

<I[F_0][Sym_0][$Carr_0$]>, <Q[F_0][Sym_0][$Carr_0$]>, ..., <I[F_0][Sym_0][$Carr_n$]>, <Q[F_0][Sym_0][$Carr_n$]>,

<I[F_0][Sym_1][$Carr_0$]>, <Q[F_0][Sym_1][$Carr_0$]>, ..., <I[F_0][Sym_1][$Carr_n$]>, <Q[F_0][Sym_1][$Carr_n$]>,

...

<I[F_0][Sym_n][$Carr_0$]>, <Q[F_0][Sym_n][$Carr_0$]>, ..., <I[F_0][Sym_n][$Carr_n$]>, <Q[F_0][Sym_n][$Carr_n$]>,

<I[F_1][Sym_0][$Carr_0$]>, <Q[F_1][Sym_0][$Carr_0$]>, ..., <I[F_1][Sym_0][$Carr_n$]>, <Q[F_1][Sym_0][$Carr_n$]>,

<I[F_1][Sym_1][$Carr_0$]>, <Q[F_1][Sym_1][$Carr_0$]>, ..., <I[F_1][Sym_1][$Carr_n$]>, <Q[F_1][Sym_1][$Carr_n$]>,

...

<I[F_n][Sym_n][$Carr_0$]>, <Q[F_n][Sym_n][$Carr_0$]>, ..., <I[F_n][Sym_n][$Carr_n$]>, <Q[F_n][Sym_n][$Carr_n$]>

Where:

- F = frame
- Sym = symbol of that subframe
- Carr = subcarrier in that symbol

The I and Q values have no unit.

The TRACe<n>[:DATA]? command evaluates *all* cells in the Constellation diagram, including non-allocated cells, for example in guard carriers. Any specific selection by CONFigure:FILTer<n>:MODulation or CONFigure:FILTer<n>:MODulation:TYPE is ignored.

Results for trace export (MMEM:STOR:TRAC)

Note that for the trace export feature, the results are different to the TRACe<n>[:DATA]? results (see MMEMory:STORe<n>:TRACe on page 309):

- Only the constellation activated in the Constellation diagram is exported (see CONFigure:FILTer<n>:MODulation and CONFigure:FILTer<n>:MODulation:TYPE). Non-allocated cells are not included.
- The order of the trace data is as follows:
  – One modulation type after the next (see CONFigure:FILTer<n>:MODulation:TYPE on page 264)
  – Within one modulation type: carriers in ascending order of their number (from negative to positive)
  – For each carrier: measured symbols in ascending order, starting with 0
  – For each symbol: First Q, then I

Example: Trace export results

Assume you measure 2 frames with 4 carriers and 4 symbols each.

Frame 0				**Frame 1**				**Carrier number**
Symbol								
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
U	U	U	U	U	U	U	U	+1
P1	B1	Q1	Q3	P3	B3	Q5	Q7	0
P0	B0	Q0	Q2	P2	B2	Q4	Q6	-1
U	U	U	U	U	U	U	U	-2

Where:

- P: pilots
- B: BPSK data cells
- Q: QAM data cells
- U: unallocated guard carriers

Then the trace export results for MMEM:STOR:TRAC? depending on the constellation is:

- For all modulation types:
  P0 P2 P1 P3 B0 B2 B1 B3 Q0 Q2 Q4 Q6 Q1 Q3 Q5 Q7
- For pilots only:
  P0 P2 P1 P3
- For QAM modulation only:

Q0 Q2 Q4 Q6 Q1 Q3 Q5 Q7

8.8.4.6 Constellation vs carrier

The command returns one value (I or Q) for each constellation point, for each symbol, for each carrier, in each frame. Whether the I or Q values are returned depends on the parameter:

`TRACe1:DATA? TRACe1` returns I values

`TRACe1:DATA? TRACe2` returns Q values

Table 8-5: Results for TRACe1:DATA? TRACe1

$<I[F_0][Carr_0][Sym_0]>,<I[F_0][Carr_0][Sym_1]>, ..., <I[F_0][Carr_0][Sym_n]>,$

$<I[F_0][Carr_1[Sym_0]]>,<I[F_0][Carr_1[Sym_1]]> , ..., <I[F_0][Carr_1][Sym_n]>,$

...

$<I[F_0][Carr_n][Sym_0]>,<I[F_0][Carr_n][Sym_1]> , ..., <I[F_0][Carr_n][Sym_n]>,$

$<I[F_1][Carr_0][Sym_0]>,<I[F_1][Carr_0][Sym_1]> , ..., <I[F_1][Carr_0][Sym_n]>,$

$<I[F_1][Carr_1][Sym_0]>,<I[F_1][Carr_1][Sym_1]> , ..., <I[F_1][Carr_1][Sym_n]>,$

...

$<I[F_n][Carr_n][Sym_0]>,<I[F_n][Carr_n][Sym_1]> , ..., <I[F_n][Carr_n][Sym_n]>$

Where:

- F = frame
- Carr = subcarrier in that frame
- Sym = symbol of that subcarrier

The I and Q values have no unit.

To obtain a list of the subcarriers (corresponding to the x-axis in the matrix), use `TRACe<n>:DATA:X? TRACe1`, see `TRACe<n>[:DATA]:X?` on page 310.

Example for a result length of 4, FFT size = 64:

-32,-32,-32-,32,-31,-31,-31,-31,-30,-30,-30,-30, ... ,+30,+30,+30,+30,+31,+31,+31,+31

8.8.4.7 Constellation vs symbol

The command returns one value (I or Q) for each constellation point, for each carrier, in each symbol, in each frame, in the same order as for the Constellation vs. Carrier diagram. Whether the I or Q values are returned depends on the parameter:

`TRACe1:DATA? TRACe1` returns I values

`TRACe1:DATA? TRACe2` returns Q values

The I and Q values have no unit.

To obtain a list of the symbols (corresponding to the x-axis in the matrix), use `TRACe<n>:DATA:X? TRACe1`, see `TRACe<n>[:DATA]:X?` on page 310.

Example for a result length of 4:

0,0,0,0, ... ,0,1,1,1,1, ... , 1,2,2,2,2, ... ,2,3,3,3,3 ... , 3

8.8.4.8 EVM vs carrier

The command returns one value for each carrier that has been analyzed.

The following parameters are supported.

- TRACE1
  Returns the average EVM over all symbols.
- TRACE2
  Returns the minimum EVM found over all symbols.
- TRACE3
  Returns the maximum EVM found over all symbols.

8.8.4.9 EVM vs symbol

The command returns one value for each OFDM symbol that has been analyzed.

The following parameters are supported.

- TRACE1
  Returns the average EVM over all carriers.
- TRACE2
  Returns the minimum EVM found over all carriers.
- TRACE3
  Returns the maximum EVM found over all carriers.

8.8.4.10 EVM vs symbol vs carrier

The command returns one value for each OFDM cell.

<[F0][Symb0][Carrier1]>, ..., <[F0][Symb0][Carrier(n)]>,
<[F0][Symb1][Carrier1]>, ..., <[F0][Symb1][Carrier(n)]>,
<[F0][Symb(n)][Carrier1]>, ..., <[F0][Symb(n)][Carrier(n)]>,
<[F1][Symb0][Carrier1]>, ..., <[F1][Symb0][Carrier(n)]>,
<[F1][Symb1][Carrier1]>, ..., <[F1][Symb1][Carrier(n)]>,
<[F(n)][Symb(n)][Carrier1]>, ..., <[F(n)][Symb(n)][Carrier(n)]>

With F = frame and Symb = symbol of that subframe.

The following parameters are supported.

- TRACE1
  Returns the EVM over all carriers.

To obtain a list of the symbols (corresponding to the x-axis in the matrix), use `TRACe<n>:DATA:X? TRACe1`, see `TRACe<n>[:DATA]:X?` on page 310.

To obtain a list of the subcarriers (corresponding to the y-axis in the matrix), use `TRACe<n>:DATA:Y? TRACe1`, see `TRACe<n>[:DATA]:Y?` on page 311.

8.8.4.11 Group delay

The command returns one value for each trace point.

```
<group delay>, ...
```

The unit is always ns.

The following parameters are supported.

- TRACE1
  Returns the average group delay over all frames.
- TRACE2
  Returns the minimum group delay found over all frames.
- TRACE3
  Returns the maximum group delay found over all frames.

8.8.4.12 Impulse response

The command returns one value for each trace point.

```
<impulse response>, ...
```

The channel impulse response is the inverse FFT of the estimated channel transfer function. The time axis spans one FFT interval.

The following parameters are supported.

- TRACE1
  Returns the average impulse response over all frames.
- TRACE2
  Returns the minimum impulse response found over all frames.
- TRACE3
  Returns the maximum impulse response found over all frames.

8.8.4.13 Magnitude capture

The command returns one value for each I/Q sample in the capture buffer.

```
<absolute power>, ...
```

The unit is always dBm.

The following parameters are supported.

- TRACE1

8.8.4.14 Power vs carrier

The command returns one value for each carrier that has been analyzed.

`<power>,...`

The unit is always dBm.

The following parameters are supported.

- TRACE1
  Returns the average power over all symbols.
- TRACE2
  Returns the minimum power found over all symbols.
- TRACE3
  Returns the maximum power found over all symbols.

8.8.4.15 Power vs symbol

The command returns one value for each OFDM symbol that has been analyzed.

`<power>,...`

The unit is always dBm.

The following parameters are supported.

- TRACE1
  Returns the average power over all carriers.
- TRACE2
  Returns the minimum power found over all carriers.
- TRACE3
  Returns the maximum power found over all carriers.

8.8.4.16 Power vs symbol vs carrier

The command returns one value for each OFDM cell.

<[F0][Symb0][Carrier1]>, ..., <[F0][Symb0][Carrier(n)]>,
<[F0][Symb1][Carrier1]>, ..., <[F0][Symb1][Carrier(n)]>,
<[F0][Symb(n)][Carrier1]>, ..., <[F0][Symb(n)][Carrier(n)]>,
<[F1][Symb0][Carrier1]>, ..., <[F1][Symb0][Carrier(n)]>,
<[F1][Symb1][Carrier1]>, ..., <[F1][Symb1][Carrier(n)]>,
<[F(n)][Symb(n)][Carrier1]>, ..., <[F(n)][Symb(n)][Carrier(n)]>

With F = frame and Symb = symbol of that subframe.

The unit depends on is always dBm.

The following parameters are supported.

- TRACE1
  Returns the power over all carriers.

To obtain a list of the symbols (corresponding to the x-axis in the matrix), use `TRACe<n>:DATA:X? TRACe1`, see `TRACe<n>[:DATA]:X?` on page 310.

To obtain a list of the subcarriers (corresponding to the y-axis in the matrix), use `TRACe<n>:DATA:Y? TRACe1`, see `TRACe<n>[:DATA]:Y?` on page 311.

8.8.4.17 Power spectrum

The command returns one value for each trace point.

`<power>,...`

The unit is always dBm/Hz.

The following parameters are supported.

- TRACE1

8.9 Status reporting system

The status reporting system stores all information on the current operating state of the instrument, e.g. information on errors or limit violations which have occurred. This information is stored in the status registers and in the error queue. The status registers and the error queue can be queried via IEC bus.

In this section, only the status registers/bits specific to the R&S FSW OFDM VSA application are described.

For details on the common FSW status registers refer to the description of remote control basics in the FSW User Manual.

*RST does not influence the status registers.

Description of the Status Registers

In addition to the registers provided by the base system, the following register is used in the R&S FSW OFDM VSA application.

The `STATus:QUEStionable` register "sums up" the information from all subregisters (e.g. bit 11 sums up the information for all `STATus:QUEStionable:SYNC` registers). For some subregisters, there may be separate registers for each active channel. Thus, if a status bit in the `STATus:QUEStionable` register indicates an error, the error may have occurred in any of the channel-specific subregisters. In this case, you must check the subregister of each channel to determine which channel caused the error. By default, querying the status of a subregister always returns the result for the currently selected channel.

This register contains application-specific information about synchronization errors or errors during burst detection for each window in each OFDM VSA channel. It can be queried with commands `STATus:QUEStionable:SYNC:CONDition?` on page 322 and `STATus:QUEStionable:SYNC[:EVENt]?` on page 322.

Table 8-6: Status error bits in STATus:QUEStionable:SYNC register for the R&S FSW OFDM VSA application

Bit	Definition
0	Not used.
1	Sync not found This bit is set if synchronization failed.
2 to 14	Not used.
15	This bit is always 0.

The following commands query the contents of the individual status registers.

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

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

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.

STATus:QUEStionable:SYNC:NTRansition <BitDefinition>[,<ChannelName>]

Controls the Negative TRansition part of a register.

Setting a bit causes a 1 to 0 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding EVENt register.

Parameters:

<BitDefinition> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

STATus:QUEStionable:SYNC:PTRansition <BitDefinition>[,<ChannelName>]

These commands control the Positive TRansition part of a register.

Setting a bit causes a 0 to 1 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding EVENt register.

Parameters:

<BitDefinition> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

8.10 Deprecated commands

Note that the following commands are maintained for compatibility reasons only. Use the specified alternative commands for new remote control programs.

CALCulate<n>:FEED <ResultDisplay>

This command selects the result display.

Note that this command is maintained for compatibility reasons only. Use the `LAYout` commands for new remote control programs (see Chapter 8.7.2, "Working with windows in the display", on page 287).

Suffix:

<n>	Window

Parameters for setting and query:

<ResultDisplay> String containing a short form of the result display.

'POW:PVSC'
(Power vs Symbol X Carrier)

'POW:PVCA'
(Power vs Carrier)

'POW:PVSY'
(Power vs Symbol)

'POW:CBUF'
(Capture Buffer)

'POW:PSPE'
(Power Spectrum)

'EVM:EVSC'
(EVM vs Symbol X Carrier)

'EVM:EVCA'
(EVM vs Carrier)

'EVM:EVSY'
(EVM vs Symbol)

'EVM:FERR'
(Frequency Error)

'EVM:PERR'
(Phase Error)

'CHAN:FLAT'
(Channel Flatness)

'CHAN:GDEL'
(Group Delay)

'CHAN:IRES'
(Impulse Response)

'CONS:CONS'
(Constellation Diagram)

'CONS:CVCA'
(Constellation vs Carrier)

'CONS:CVSY'
(Constellation vs Symbol)

'STAT:CCDF'
(CCDF)

'STAT:SFLO'
(Signal Flow)

Example: `CALC2:FEED 'POW:CBUF'`
Selects the Capture Buffer result display for screen B.

DISPlay[:WINDow<n>]:TYPE <WindowType>

Selects the results displayed in a measurement window.

Note that this command is maintained for compatibility reasons only. Use the `LAYout` commands for new remote control programs (see Chapter 8.7.2, "Working with windows in the display", on page 287).

Suffix:
<n> Window

Parameters:
<WindowType> The parameter values are the same as for `LAYout:ADD[:WINDow]?` on page 288.

8.11 Programming examples: OFDM vector signal analysis

The following examples demonstrate how to perform OFDM vector signal analysis in a remote environment. They use I/Q data from the demo files provided with the FSW software as input.

Note that some of the used commands may not be necessary as they define default values, but are included to demonstrate their use.

8.11.1 Example 1: analysis using a predefined configuration file

This example uses input from the demo file `WlanA_64QAM.iq.tar` and the configuration file `WlanA_64QAM.xml`, which are both provided in the directory: `C:\R_S\INSTR\USER\demo\OFDM-VSA\`.

Note: You must insert the correct path for your installation before executing this script.

```
//-----------Preparing the measurement channel ------------
//Reset the instrument
*RST

//Create OFDM VSA channel as replacement for default Receiver channel
INST:CRE:REPL 'Receiver',OFDMVSA,'MyOFDMVSA'

//Load I/Q data file for input

//Select file to load - insert correct path! Analysis bandwidth = 16 MHz
INP:FILE:PATH 'WlanA_64QAM.iq.tar', 16000000
//Assign the file as input source
INP:SEL FIQ
```

```
//--------------Configuring the OFDM signal --------------
//Use the provided sample file - insert correct path!
MMEM:LOAD:CFGF 'WlanA_64QAM.xml'

//--------------Configuring data acquisition--------------
//Capture 40000 samples with a sample rate of 20 MHz
SWE:LENG 40000
TRAC:IQ:SRAT 20000000

//Enable burst search
DEM:FORM:BURS ON
//Max 1 frame to be demodulated, result length = 100 symbols per frame
DEM:FORM:MAXF 1
DEM:FORM:NOFS 100

//--------------Configuring synchronization, tracking, demodulation
//Time synchronization using cp
DEM:TSYN CP
//Enable phase tracking and channel comp., disable timing and level tracking
SENS:TRAC:TIME OFF
SENS:TRAC:PHAS ON
SENS:TRAC:LEV OFF
SENS:COMP:CHAN ON
//FFT shift relative to cp length: 0.5
DEM:FFTS 0.5

//---------------Configuring Results
// Default displays:
//1: Magnitude Capture 3: Power Spectrum
//2: Result Summary    4: Constellation

//Replace power spectrum by Power vs. symbol vs. carrier
LAY:REPL:WIND '3',PSC

//Normalize EVM to Peak Pilots and Data
DEM:EVMC:NORM PPD

//Filter constellation - show only data symbols with 64QAM mod.
CONF:FILT4:MOD:TYPE DATA
CONF:FILT4:MOD '64QAM'

//--------------Performing the Measurement-----
//Select single sweep mode.
INIT:CONT OFF

//Initiate a new measurement and wait until the sweep has finished.
INIT:IMM;*OPC?

//---------------Retrieving Results-------------
//Query frame burst count and length (1 frame, 40 symbols)
```

```
FETC:BURS:COUN?
FETC:BURS:LENG?

//Query max. EVM of data symbols
FETC:SUMM:EVM:DATA:MAX?

//Query the state of the individual signal flow stages
FETC:SFL:STAT:ALL?

//Retrieve trace data for power vs symbol vs carrier diagram
TRAC3:DATA:X? TRACe1
TRAC3:DATA:Y? TRACe1
TRAC3:DATA? TRACe1

//Retrieve trace data for filtered constellation diagram
TRAC4:DATA? TRACE1
```

8.11.2 Example 2: analysis with manual signal description

This signal uses input from the demo file `WLANac_64QAM_20MHz_ShortCP.iq.tar`.

Note: You must insert the correct path for your installation before executing this script.

```
//-----------Preparing the measurement channel ------------
//Reset the instrument
*RST

//Create a second OFDM VSA channel
INST:CRE:NEW OFDMVSA,'ManualOFDMVSA'

//Load I/Q data file for input

//Select file to load - insert correct path! Analysis bandwidth = 16 MHz
INP:FILE:PATH 'WLANac_64QAM_20MHz_ShortCP.iq.tar', 16000000
//Assign the file as input source
INP:SEL FIQ

//--------------Configuring the OFDM signal --------------
//Define 64 subcarriers
CONF:SYMB:NFFT 64
//Non-conventional, non-periodic cyclic prefixes;
//Range 1 (10 symbols): 16 samples
//Range 2 (all other symbols): 8 samples
CONF:GUAR:MODE GU2
CONF:GUAR:PER OFF
CONF:GUAR1:NSYM 10
CONF:SYMB:NGU1 16
CONF:SYMB:NGU2 8
//Preamble of 16 samples; frame starts at -560 samples
CONF:PRE:BLEN 16
```

```
CONF:PRE:FOFF -560

//--------------Configuring data acquisition--------------
//Capture 43680 samples with a sample rate of 20 MHz
SWE:LENG 43680
TRAC:IQ:SRAT 20000000

//Enable burst search
DEM:FORM:BURS ON
//Max 1 frame to be demodulated, result length = 100 symbols per frame
DEM:FORM:MAXF 1
DEM:FORM:NOFS 100

//---------------Configuring Results
// Default displays:
//1: Magnitude Capture 3: Power Spectrum
//2: Result Summary    4: Constellation

//--------------Performing the Measurement-----
//Select single sweep mode.
INIT:CONT OFF

//Initiate a new measurement and wait until the sweep has finished.
INIT:IMM;*OPC?

//---------------Retrieving Results-------------
//Query frame burst count and length (1 frame, 40 symbols)
FETC:BURS:COUN?
FETC:BURS:LENG?

//Query the state of the individual signal flow stages
FETC:SFL:STAT:ALL?

//Retrieve trace data for capture buffer
TRAC1:DATA:X? TRACe1
TRAC1:DATA? TRACe1
```

After the signal has been demodulated correctly, you can use the configuration to create a new configuration file with the interactive wizard. See Chapter 5, "Creating a configuration file using the wizard", on page 102.

Annex

A Formulae

A.1 Error vector magnitude (EVM)

The EVM of a cell (symbol number l, carrier number k) is defined as

$$EVM_{l,k} = \sqrt{\frac{\left|r_{l,k} - a_{l,k}\right|^2}{P_{norm}}}$$

where

- $r_{l,k}$ is the received symbol point in the complex plane of symbol number l and carrier number k.
  The received symbol point is compensated by phase and clock errors as well as channel transfer function according to the user settings.
- $a_{l,k}$ is the ideal symbol point in the complex plane of symbol number l and carrier number k.
  P_{norm} is a normalization value that can be set in four different ways

Normalize EVM to	P_{norm}
RMS Pilots & Data	$\frac{1}{N_{pilot} + N_{data}} \sum_{l,k \in Pilot,Data} \left|a_{l,k}\right|^2$
RMS Data	$\frac{1}{N_{data}} \sum_{l,k \in Data} \left|a_{l,k}\right|^2$
RMS Pilots	$\frac{1}{N_{pilot}} \sum_{l,k \in Pilot} \left|a_{l,k}\right|^2$
Peak Pilots & Data	$\max_{l,k \in Pilot,Data} \left|a_{l,k}\right|^2$
Peak Data	$\max_{l,k \in Data} \left|a_{l,k}\right|^2$
Peak Pilots	$\max_{l,k \in Pilot} \left|a_{l,k}\right|^2$
None	1.0

- N_{pilot} is the number of pilot cells

- N_{data} is the number of data cells

A.2 I/Q impairments

The I/Q imbalance can be written as

$$r(t) = G_I \cdot \Re\{s(t)\} + j \cdot G_Q \cdot \Im\{s(t)\}$$

where s(t) is the transmit signal, r(t) is the received signal, and G_I and G_Q are the weighting factors.

Variable	Meaning	Definition from Transmitter Model
G_I	Gain I-branch	1
G_Q	Gain Q-branch	$1 + \Delta Q$ (complex)

$$\text{Gain-Imbalance} = 20\log\left(\frac{|G_Q|}{|G_I|}\right)\text{dB}$$

$$\text{Quadrature-Error} = \arctan\left(\frac{\text{Im}\{G_Q\}}{\text{Re}\{G_Q\}}\right).180^{\circ}/\pi$$

B Reference: IQW format specification for user-defined constellation points

For a user-specific, unusual constellation of a signal component, you can configure the constellation in an IQW file in advance. Then load the file to the wizard instead of selecting a predefined modulation for a specific signal component. See Step 3: Synchronizing the measured data, step 3.

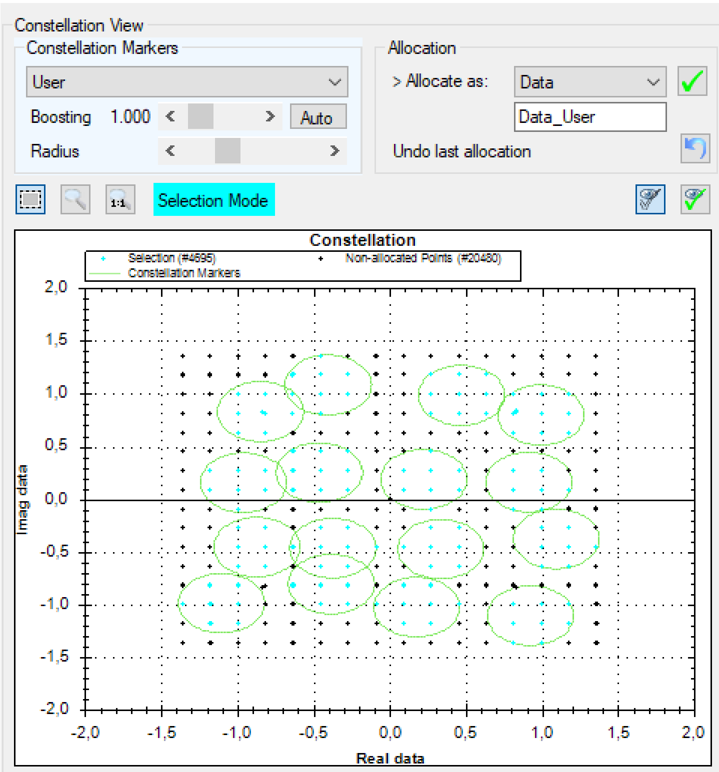


Figure B-1: Example for user-defined constellation points

Create the constellation file using a python or Matlab script, for example.

Consider the following prerequisites:

- The file must contain the ideal complex values for the N constellation points.
- Define the symbols in the correct order (symbol number 0, 1, 2, 3.. , N-1). Otherwise, the bitstream results are incorrect.
- The number of points must be between 2 and 64*1024.
- For each constellation point, define the real component first, than the imaginary component. One point after the next. (Re_0, Im_0, Re_1, Im_1, ..., Re_n, Im_N)
- Define each value in binary, single-precision float format.
- Do not include any header or length information, only the values themselves.

Sample script to configure 16 constellation points in Matlab

The following script can be used to configure the 16 points on the unit circle (16-PSK) as shown in Figure B-2.

```
sFilename = '16PSK.iqw';
iN = 16
vfcVector = exp(1j*2*pi/iN*[0:iN-1])

fileID = fopen(sFilename, 'w');
if -1==fileID
    error('file open failed')
end
for iK = 1:length(vfcVector)
    fwrite(fileID, real(vfcVector(iK)) ,'single', 'ieee-le');
    fwrite(fileID, imag(vfcVector(iK)) ,'single', 'ieee-le');
end
fclose(fileID);
```

As a result, the following constellation points are configured:

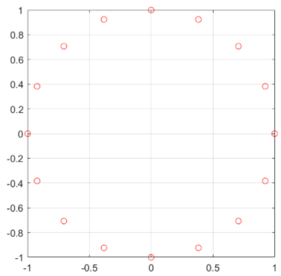


Figure B-2: 16-PSK ideal constellation points

```
1.00 +j*0.00  //corresponds to symbol number 0
0.92 +j*0.38
0.71 +j*0.71
0.38 +j*0.92
0.00 +j*1.00
-0.38 +j*0.92
-0.71 +j*0.71
-0.92 +j*0.38
-1.00 +j*0.00
-0.92 +j*-0.38
-0.71 +j*-0.71
-0.38 +j*-0.92
-0.00 +j*-1.00
0.38 +j*-0.92
0.71 +j*-0.71
0.92 +j*-0.38     //corresponds to symbol number 15
```

List of commands (OFDM VSA)

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