R&S®FSW-K192/-K193
DOCSIS® 3.1 OFDM Measurements
User Manual

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Test & Measurement

User Manual

ROHDE&SCHWARZ

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

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

The following firmware options are described:

- R&S FSW-K192 DOCSIS 3.1 OFDM Downstream Measurements (1325.4138.02)
- R&S FSW-K193 DOCSIS 3.1 OFDM Upstream Measurements (1325.4144.02)

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

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1 Preface

1.1 About this Manual

This R&S FSW DOCSIS 3.1 application User Manual provides all the information **specific to the application**. All general instrument functions and settings common to all applications and operating modes are described in the main R&S FSW User Manual.

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

- **Welcome to the R&S FSW DOCSIS 3.1 application**
  Introduction to and getting familiar with the application
- **Typical applications**
  Example measurement scenarios in which the application is frequently used.
- **Measurements and Result Displays**
  Details on supported measurements and their result types
- **Measurement Basics**
  Background information on basic terms and principles in the context of the measurement
- **Configuration + Analysis**
  A concise description of all functions and settings available to configure measurements and analyze results with their corresponding remote control command
- **How to Perform Measurements in the R&S FSW DOCSIS 3.1 application**
  The basic procedure to perform each measurement and step-by-step instructions for more complex tasks or alternative methods
- **Measurement Examples**
  Detailed measurement examples to guide you through typical measurement scenarios and allow you to try out the application immediately
- **Optimizing and Troubleshooting the Measurement**
  Hints and tips on how to handle errors and optimize the test setup
- **Remote Commands for DOCSIS 3.1 Measurements**
  Remote commands required to configure and perform DOCSIS 3.1 measurements in a remote environment, sorted by tasks
  (Commands required to set up the environment or to perform common tasks on the instrument are provided in the main R&S FSW User Manual)
  Programming examples demonstrate the use of many commands and can usually be executed directly for test purposes
- **Annex**
  Reference material
- **List of remote commands**
  Alphabetical list of all remote commands described in the manual
- **Index**

1.2 Documentation Overview

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

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

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

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

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

Getting Started

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

Online Help

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

User Manuals and Online Manual

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

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

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

Service Manual

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

The service manual is available for **registered** users on the global Rohde & Schwarz information system (GLORIS, https://gloris.rohde-schwarz.com).

Instrument Security Procedures

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

Data Sheet and Brochures

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

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

Release Notes

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

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

Application Notes, Application Cards, White Papers, etc.

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

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

1.3 Conventions Used in the Documentation

1.3.1 Typographical Conventions

The following text markers are used throughout this documentation:

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

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

1.3.2 Conventions for Procedure Descriptions

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

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

1.3.3 Notes on Screenshots

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

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

2 Welcome to the R&S FSW DOCSIS 3.1 applications

The R&S FSW DOCSIS 3.1 applications (R&S FSW-K192/-K193) are firmware applications that add functionality to the R&S FSW to perform measurements according to the DOCSIS 3.1 standard.

R&S FSW-K192 performs measurements for DOCSIS 3.1 **downstream** signals.

R&S FSW-K193 performs measurements for DOCSIS 3.1 **upstream** signals.

Bandwidth extension option required

Both R&S FSW DOCSIS 3.1 applications require a bandwidth extension option for 320 MHz.

The R&S FSW-K193 option (for DOCSIS 3.1 **upstream** signals) requires the *new* bandwidth extension hardware R&S FSW-B320+ (11325.4867.04).

The R&S FSW-K192 option (for DOCSIS 3.1 **downstream** signals) requires either the option R&S FSW-B320 (1313.7172.02) *or* the new bandwidth extension hardware R&S FSW-B320+ (11325.4867.04).

If the required options are not installed, an error message is displayed and no measurements can be performed with the R&S FSW DOCSIS 3.1 applications.

The R&S FSW DOCSIS 3.1 applications feature:

- Modulation accuracy measurements
- Occupied bandwidth measurements
- Statistical measurements

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

All functions not discussed in this manual are the same as in the base unit and are described in the R&S FSW User Manual. The latest version is available for download at the http://www2.rohde-schwarz.com/product/FSW.html.

An application note discussing the fundamental technological advances of DOCSIS 3.1 and presenting measurement solutions from Rohde & Schwarz is available from the Rohde & Schwarz website: http://www.rohde-schwarz.com/appnote/7MH89.

Installation

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

2.1 Starting the R&S FSW DOCSIS 3.1 application

Both R&S FSW DOCSIS 3.1 application options add a new application to the R&S FSW.

To activate the R&S FSW DOCSIS 3.1 applications

1. Press the MODE key on the front panel of the R&S FSW.

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

2. Select the "DOCSIS 3.1" item.

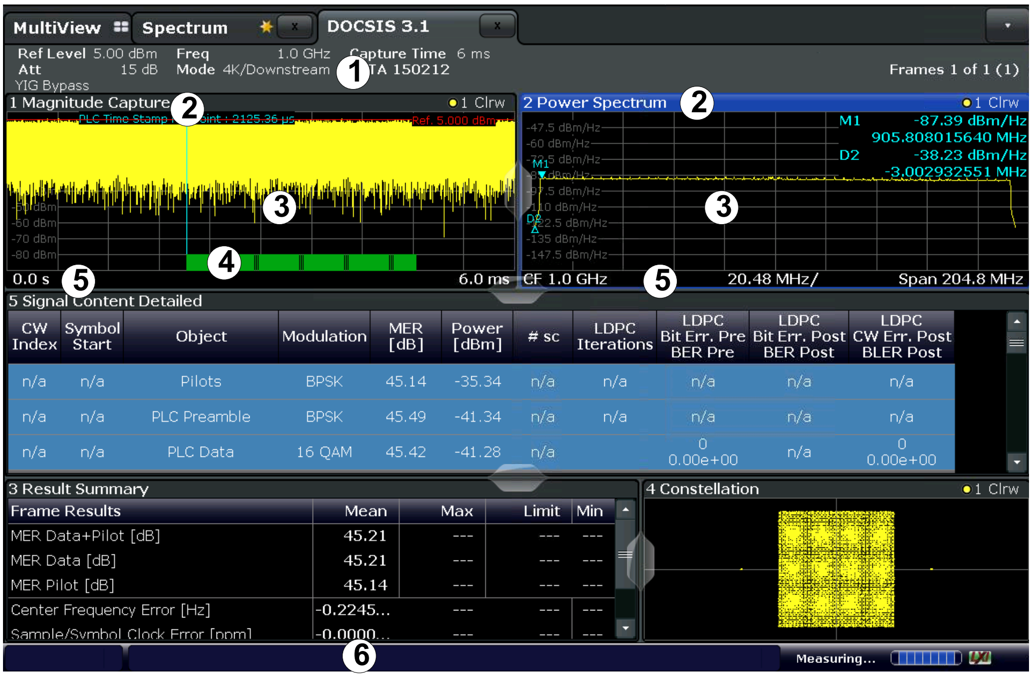
   The R&S FSW opens a new measurement channel for the DOCSIS 3.1 (downstream) application.
   The measurement is started immediately with the default settings. It can be configured in the DOCSIS 3.1 "Overview" dialog box, which is displayed when you select the "Overview" softkey from any menu (see Chapter 5.3.1, "Configuration Overview", on page 51).

3. To perform a measurement on a DOCSIS 3.1 uplink signal, select "Signal Description > Stream Direction: Upstream".

2.2 Understanding the Display Information

The following figure shows a measurement diagram during a DOCSIS 3.1 downlink measurement. All different information areas are labeled. They are explained in more detail in the following sections.

(The basic screen elements are identical for DOCSIS 3.1 uplink measurements.)



1 = Channel bar for firmware and measurement settings
2 = Window title bar with diagram-specific (trace) information
3 = Diagram area (with marker information)
4 = Detected symbols
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 DOCSIS 3.1 application, the R&S FSW shows the following settings:

Table 2-1: Information displayed in the channel bar in the R&S FSW DOCSIS 3.1 application

Ref Level	Reference level
Att	Mechanical and electronic RF attenuation
Freq	Center frequency for the RF signal
Mode	N_{FFT} mode: 4K - 8K / Downstream - Upstream
Capture Time	Measurement time for data acquisition.
SGL	The sweep is set to single sweep mode.
Frames x of y (z)	For statistical evaluation over frames: <x> frames of totally required <y> frames have been analyzed so far <z> frames were analyzed in the most recent measurement (= current capture buffer)

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. external mixer or trigger settings). This information is displayed only when applicable for the current measurement. For details see the R&S FSW Getting Started manual.

Window title bar information

For each diagram, the header provides the following information:

Figure 2-1: Window title bar information in the R&S FSW DOCSIS 3.1 application

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

Diagram footer information

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

Status bar information

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

3 Measurements and Result Display

The R&S FSW DOCSIS 3.1 application provides several different measurements to determine the parameters described by the DOCSIS 3.1 specifications.

- DOCSIS 3.1 I/Q Measurement.....13
- Frequency Sweep Measurements.....29

3.1 DOCSIS 3.1 I/Q Measurement

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

Or: MEAS > "Select Measurement" > "Modulation Accuracy"

The default DOCSIS 3.1 I/Q measurement captures the I/Q data from the DOCSIS 3.1 signal using a (nearly rectangular) filter with a relatively large bandwidth. The I/Q data captured with this filter includes magnitude and phase information. This information allows the R&S FSW DOCSIS 3.1 application to demodulate broadband signals and determine various characteristic signal parameters in just one measurement, including:

- Modulation accuracy
- Spectrum flatness
- Center frequency tolerance
- Symbol clock tolerance

Other parameters specified in the DOCSIS 3.1 standard require a better signal-to-noise level or a smaller bandwidth filter than the I/Q measurement provides and must be determined in separate measurements (see Chapter 3.2, "Frequency Sweep Measurements", on page 29).

- Modulation Accuracy Parameters.....13
- Signal Content Information.....15
- Evaluation Methods for DOCSIS 3.1 I/Q Measurements.....17

3.1.1 Modulation Accuracy Parameters

The default DOCSIS 3.1 I/Q measurement (Modulation Accuracy) captures the I/Q data from the DOCSIS 3.1 signal and determines all the following I/Q parameters in a single sweep.

Table 3-1: DOCSIS 3.1 Modulation Accuracy Parameters

Parameter	Keyword for remote command	Unit	Description
MER Data+Pilot	MER	dB	Modulation error ratio for data and pilot carriers
MER Data	MERD	dB	Modulation error ratio for data carriers only
MER Pilot	MERP	dB	Modulation error ratio for pilot carriers only

Parameter	Keyword for remote command	Unit	Description
Center Frequency Error	CERR	Hz	
Sample/Symbol Clock Error	FERR	ppm	
Trigger to PLC Time Stamp Ref point	TPLC	µs	Downstream only Time offset of the PLC Timestamp Reference Point (as defined in the standard in 7.5.13.10 "PLC Timestamp Reference Point") to the beginning of the capture buffer (Useful only with an (external) trigger at frame start; if no trigger is used, value is very unsteady)
Trigger to Frame	TFR	µs	Upstream only
Power	POW	dBm/ dBmV / dBuV	Absolute total power of OFDM channel (all subcarriers) Unit depends on Unit setting.
Power 6 MHz Channel containing PLC	POW:SPLC	dBm/ dBmV / dBuV	Absolute power in the 6-MHz channel containing the PLC Unit depends on Unit setting.
Power Data	POW:DATA	dB , dBm	Power in the data subcarriers Unit depends on Power Unit and Unit settings. For relative results, this value is always 0 (data power relative to itself).
Power Pilots	POW:PIL	dB , dBm	Power in all (normal and complementary) pilot channels (upstream only) Unit depends on Power Unit and Unit settings.
Power Scattered Pilots	POW:SPIL	dB , dBm	Power in the scattered pilot channels (downstream only) Unit depends on Power Unit and Unit settings.
Power Continuous Pilots	POW:CONP	dB , dBm	Power in the continuous pilot channels (downstream only) Unit depends on Power Unit and Unit settings.
Zero Bit Loaded Carrier Ratio	ZBIT	-	Downstream only Average ratio of the zero bit loaded subcarriers to the total number of carriers available for the codewords

Remote commands

When you query all results of the result summary using the `FETCh:SUMMary:ALL?` command, the values are returned in the order the parameters are described in table Table 3-1.

For each parameter, several evaluations are calculated for the entire input signal. The remote commands required to retrieve the results are indicated in the following table.

Table 3-2: Calculated summary results

Result type	Description	Remote command
Mean	Mean measured value	FETCh:SUMMary:<parameter>:AVERage
Max	Maximum measured value	FETCh:SUMMary:<parameter>:MAXimum
Min	Minimum measured value	FETCh:SUMMary:<parameter>:MINimum

3.1.2 Signal Content Information

In addition to the modulation accuracy parameters that are calculated from the input signal, detailed signal content information is available for analysis in the R&S FSW DOCSIS 3.1 application.

The Signal Content Detailed result display shows the serialized information from the list of NCPs and codewords (downstream) or minislot sets (upstream) contained in the input signal.

In the first rows, the information is provided for the following objects in the specified order:

Downstream:

- Scattered Pilots
- Continuous Pilots
- PLC preamble
- PLC data
- Excluded subcarriers

Upstream:

- Pilots
- Excluded subcarriers

Then, the information for each symbol in the order of the logical subcarriers is provided, with one row each for:

Downstream:

- NCPs
- Codewords

Upstream:

- Minislot sets

The Signal Content Summary result display shows the summarized information for the NCPs and codewords contained in the downstream input signal.

Table 3-3: DOCSIS 3.1 Signal Content Parameters

Column	Description
CW Index	Codeword index (0..1535) Not available for PLC, pilots and excluded subcarriers
Symbol Start	OFDM symbol (0..127) Not available for PLC, pilots and excluded subcarriers
Object	Information type: • Invalid data (-1) • Pilots (0) • PLC Preamble (1) • PLC Data (2) • Excluded subcarrier (3) • NCP CW (4) • NCP CRC-24 (5) • NCP Null (6) • Codeword / Minislot set (7) • NCP All (8) • Profile (9) • Compl. Pilots (10) • Scattered pilots (11) - downstream only • Continuous pilots (12) - downstream only (The value in parentheses is returned for `FETCh:SCDetailed:ALL?` on page 286)
Modulation	Modulation (see "Modulation" on page 65)
MER (dB)	Modulation error ratio in dB
Power	Power (unit depends on Power Unit setting.)
Upstream only:	
# Minislots	Number of minislots
Downstream only:	
# [count]	(Signal Content **Summary** only) For the PLC preamble and PLC data: the number of detected objects of this type (since one of these types is always in each frame, the count equals the number of analyzed frames) For the NCPs: the number of NCPs evaluated for the results For the profiles: the number of codewords of that profile
#sc	Number of subcarriers
LDPC Iterations	Low density parity check Number of iterations Note that PLC and NCP decoding may need up to 2 iterations even if no bit errors occurred since parts of the codewords are not transmitted (puncturing).
LDPC BitErr.Pre BER Pre	Low density parity check Absolute number of bit errors before decoding Bit error ratio before decoding (the ratio of errored bits to the total number of transmitted bits)

Column	Description
LDPC BitErr.Post BER Post	Low density parity check Absolute number of bit errors after decoding Bit error rate after decoding (the ratio of falsely decoded bits to the total number of transmitted bits)
LDPC CWErr.Post BLER Post	Low density parity check Absolute number of codeword errors after decoding Block error rate after decoding (the ratio of falsely decoded codewords to the total number of transmitted codewords)

3.1.3 Evaluation Methods for DOCSIS 3.1 I/Q Measurements

Access: "Overview" > "Display Config"

Or: MEAS > "Display Config"

The captured I/Q data from the DOCSIS 3.1 signal can be evaluated using various different methods without having to start a new measurement or sweep. Which results are displayed depends on the selected evaluation.

The following evaluation methods can be selected for the default DOCSIS 3.1 I/Q measurement.

Bitstream (downstream only).. 17
Constellation.. 19
Group Delay...20
Magnitude Capture..20
Marker Table...21
MER vs Carrier..21
MER vs Minislot (upstream only)... 22
MER vs Symbol...23
MER vs Symbol X Carrier... 23
Phase vs Carrier.. 24
Power vs Carrier (upstream only).. 24
Power vs Symbol X Carrier... 25
Power Spectrum..26
Result Summary..26
Signal Content Detailed.. 27
Signal Content Summary.. 28
Spectrum Flatness... 28

Bitstream (downstream only)

This result display shows the decoded data stream for each detected OFDM symbol in the currently Selected Frame as indicated in the "Magnitude Capture" display. Which bits exactly are decoded is configurable, for example the decoded payload data (default), the raw bits or the input or output bits of the parity check. By default, the byte values are displayed. Alternatively, the individual bit values can be displayed.

The bitstream can only be provided for downstream DOCSIS 3.1 signals.

The bitstream can be displayed in a compact or an expanded format. In the compact format, only the first (max.) 25 bytes are displayed for each codeword, so that one row per codeword is displayed in the table.

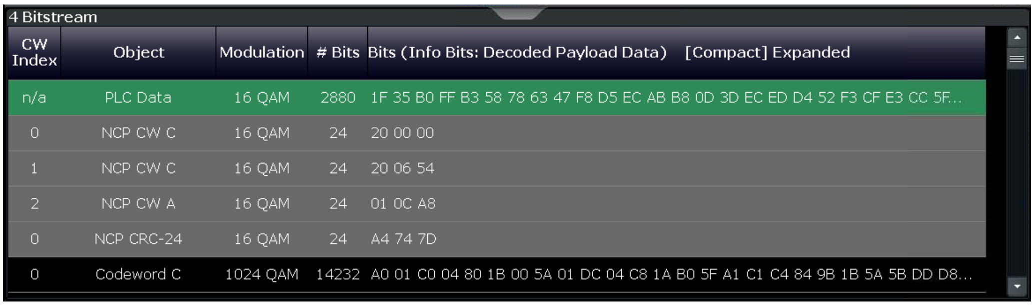


Figure 3-1: Bitstream result display for DOCSIS 3.1 standard (compact display)

In expanded format, all bytes for each codeword are displayed, where each row displays a maximum of 20 bytes. Thus, a single codeword can require multiple rows. In this case, the object for subsequent rows is indicated as "Codeword <X> Cont". A byte index indicates which bytes are displayed in each row.

Figure 3-2: Bitstream result display for DOCSIS 3.1 standard (expanded display)

Which information is displayed is configurable (see "Selected Frame" on page 110). If enabled, the Bitstream table includes the following information:

- Object
- Modulation
- Total number of bits in object
- Byte index (graphical display only, not in remote command output)
- Bit/byte values in hexadecimal format for max. 100 bytes

For details on individual parameters, see Chapter 3.1.2, "Signal Content Information", on page 15.

Remote command:
`LAY:ADD? '1',RIGH, BITS`, see `LAYout:ADD[:WINDow]?` on page 227
`UNIT:BITStream` on page 244
Querying results:
`FETCh:BITStream:ALL?` on page 253
`[SENSe:]FRAMe:SELect` on page 222

Constellation

This result display shows the in-phase and quadrature phase results for the currently Selected Frame as indicated in the "Magnitude Capture" display. The Tracking/Channel Estimation according to the user settings is applied.

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

The results can be restricted to the following:

- One or all information types
- One or more modulation types
- One or all symbols
- One or all subcarriers

Multiple (or all) modulations can be selected simultaneously. By default, all objects and all modulations are displayed (in yellow).

If a single modulation type is selected, the ideal constellation is also indicated in the display.

If multiple modulation types are selected, the constellation can be displayed in multiple colors, one for each modulation type, using the following color map:

All	BPSK	QPSK	16-QAM	64-QAM	128-QAM	256-QAM
512-QAM	1024-QAM	2048-QAM	4096-QAM	8192-QAM	16384-QAM	Ideal

Figure 3-3: Color map for constellation points for different modulations

Example:

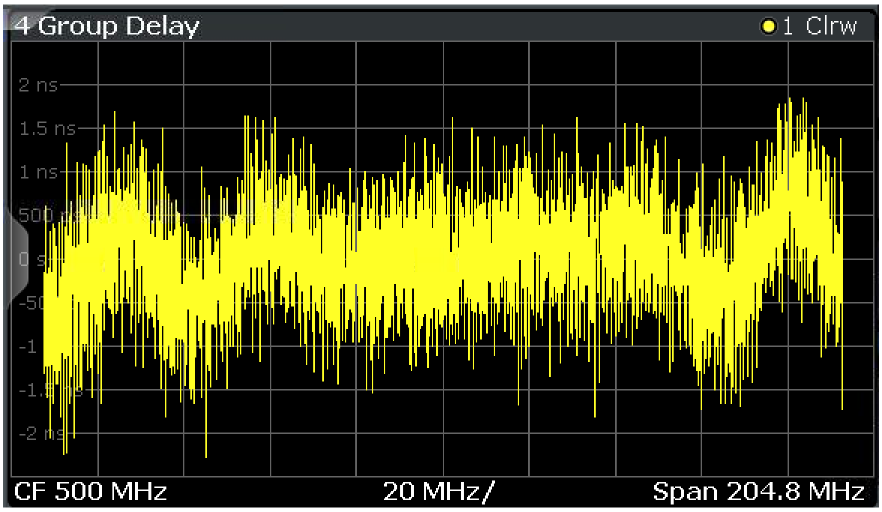
If the object is restricted to "Profile A" and all modulation types are selected, all modulation types found for profile A are displayed in multiple colors.

If the object is restricted to "Profile A" and the modulation is restricted to QPSK, any constellation points with QPSK modulation found for profile A are displayed in green. Additionally, the ideal QPSK constellation is displayed in gray in the same diagram.

To activate this color mapping, see "Fast Mode (Single Color)" on page 116.

Remote command:
LAY:ADD? '1',RIGH,CONS, see LAYout:ADD[:WINDow]? on page 227
[SENSe:]MODulation:SELect on page 235
[SENSe:]OBJect:SELect on page 235
[SENSe:]SUBCarrier:SELect on page 236
[SENSe:]SYMBol:SELect on page 236
[SENSe:]FRAMe:SELect on page 222
Results:
TRACe<n>[:DATA]? on page 269

Group Delay
Displays the time deviations of the signal versus carrier for the currently Selected Frame as indicated in the "Magnitude Capture" display.



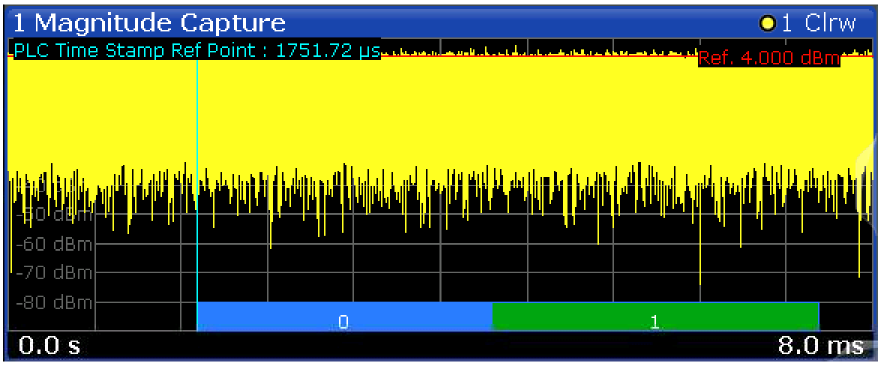
The carrier values can be provided as carrier numbers or carrier frequencies, see Selected Frame.

Remote command:
LAY:ADD? '1',RIGH,GDEL, see LAYout:ADD[:WINDow]? on page 227
Results:
[SENSe:]FRAMe:SELect on page 222
TRACe<n>[:DATA]? on page 269

Magnitude Capture
The Magnitude Capture display shows the magnitude vs time data captured in the last measurement. Green bars at the bottom of the Magnitude Capture display indicate the individual detected frames with their frame number. The blue bar indicates the currently Selected Frame which is evaluated for graphical result displays.

A vertical blue line indicates the frame start (upstream) or the position of the PLC timestamp reference point (downstream, see Table 3-1).

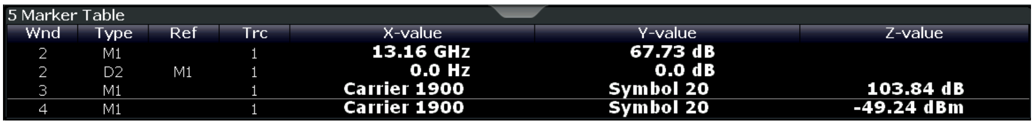
(The position of the PLC timestamp reference point moves frequently if no trigger is used; only with an (external) trigger at frame start it remains steady.)



Remote command:
`LAY:ADD? '1',RIGH,RFM`, see `LAYout:ADD[:WINDow]?` on page 227
Results:
`TRACe<n>[:DATA]?` on page 269

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

For 3-dimensional result displays (MER vs Symbol X Carrier, Power vs Symbol X Carrier), the value of a marker consists of the carrier (x), the symbol (y) and the parameter value (z).


5 Marker Table

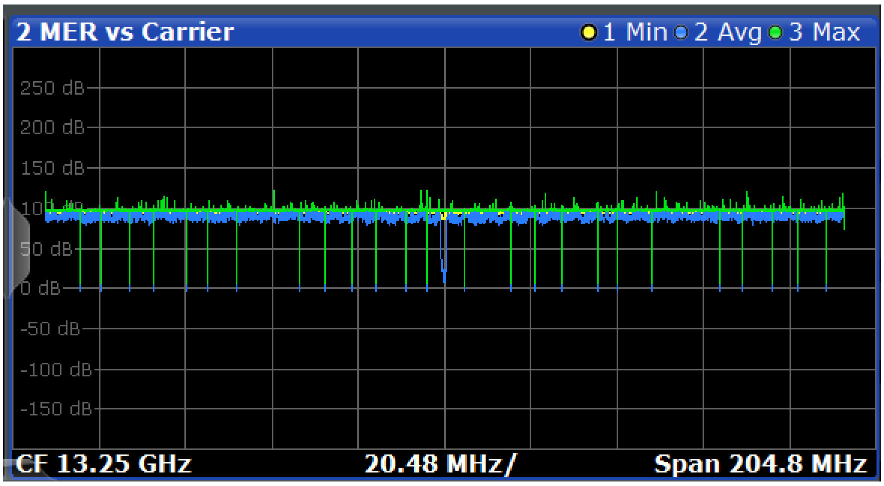
Wnd	Type	Ref	Trc	X-value	Y-value	Z-value
2	M1		1	13.16 GHz	67.73 dB	
2	D2	M1	1	0.0 Hz	0.0 dB	
3	M1		1	Carrier 1900	Symbol 20	103.84 dB
4	M1		1	Carrier 1900	Symbol 20	-49.24 dBm

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 227
Results:
`CALCulate<n>:MARKer<m>:X` on page 267
`CALCulate<n>:MARKer<m>:Y?` on page 278

MER vs Carrier
Displays the modulation error ratio per carrier for the currently Selected Frame as indicated in the "Magnitude Capture" display, or the statistical evaluation, if enabled (see "Frame Statistic Count / Number of Frames to Analyze" on page 111).

The Minhold, Average and Maxhold traces are displayed. Define the number of frames on which the statistical evaluation is based using "Evaluation Range" > Frame Statistic Count / Number of Frames to Analyze.



The carrier values can be provided as carrier numbers or carrier frequencies, see "Carrier Axes Unit" on page 117.

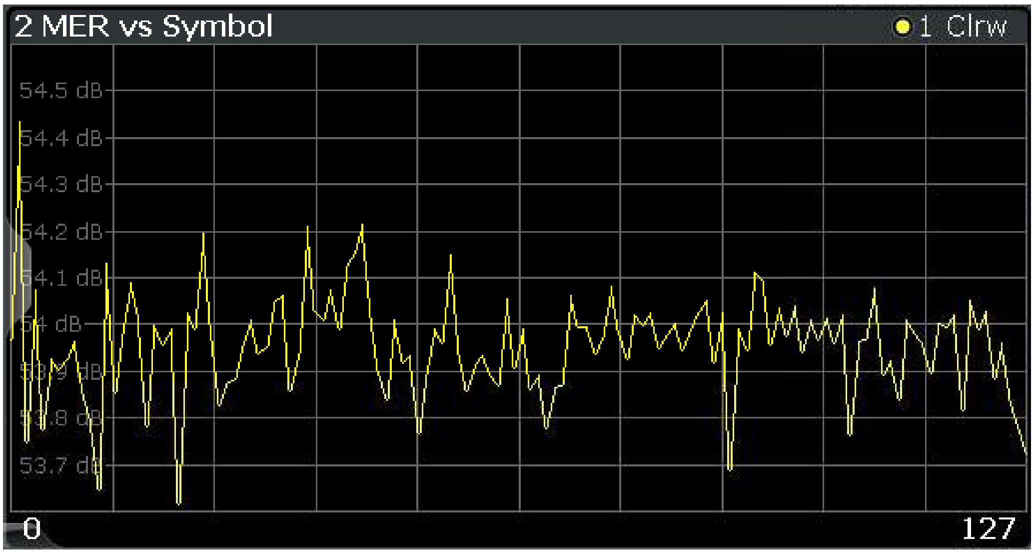
Remote command:
`LAY:ADD? '1',RIGH,MERC`, see `LAYout:ADD[:WINDow]?` on page 227
Results:
`[SENSe:]FRAMe:SELect` on page 222
`TRAC:DATA? <TRACEx>`, see `TRACe<n>[:DATA]?` on page 269

MER vs Minislot (upstream only)
Displays the modulation error ratio per minislot for the currently Selected Frame as indicated in the "Magnitude Capture" display. Values are only displayed for minislots that are configured for the upstream signal (see "Profile Configuration (Upstream)" on page 74).

Remote command:
`LAY:ADD? '1',RIGH,MERC`, see `LAYout:ADD[:WINDow]?` on page 227
Results:
`[SENSe:]FRAMe:SELect` on page 222
`TRACe<n>[:DATA]?` on page 269

MER vs Symbol

Displays the modulation error ratio per symbol for the currently Selected Frame as indicated in the "Magnitude Capture" display.

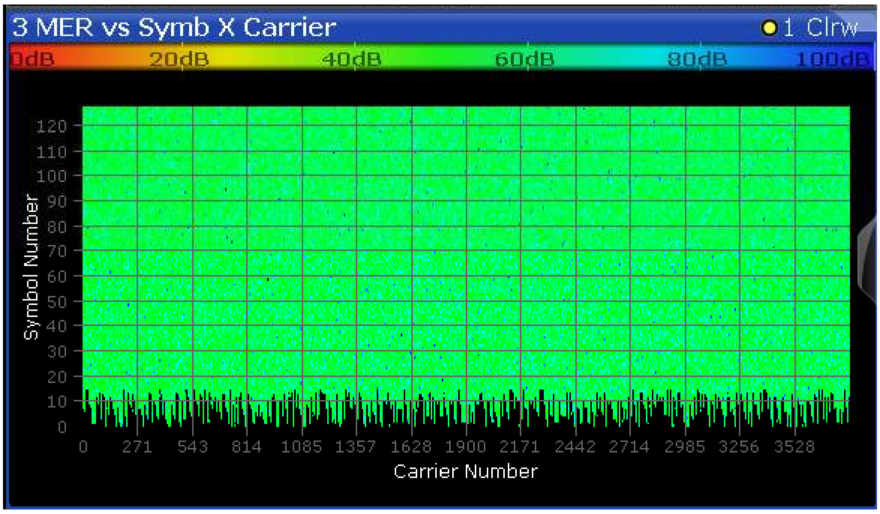


Remote command:
`LAY:ADD? '1',RIGH,MERS`, see `LAYout:ADD[:WINDow]?` on page 227

Results:
`TRACe<n>[:DATA]?` on page 269
`[SENSe:]FRAMe:SELect` on page 222

MER vs Symbol X Carrier

Displays the modulation error ratio per carrier and symbol for the currently Selected Frame as indicated in the "Magnitude Capture" display. The symbols are displayed on the x-axis, the carriers are displayed on the y-axis. The MER is color-coded according to its level and is indicated as a colored dot for each symbol and carrier. The legend for the color coding is provided by a color bar at the top of the diagram.



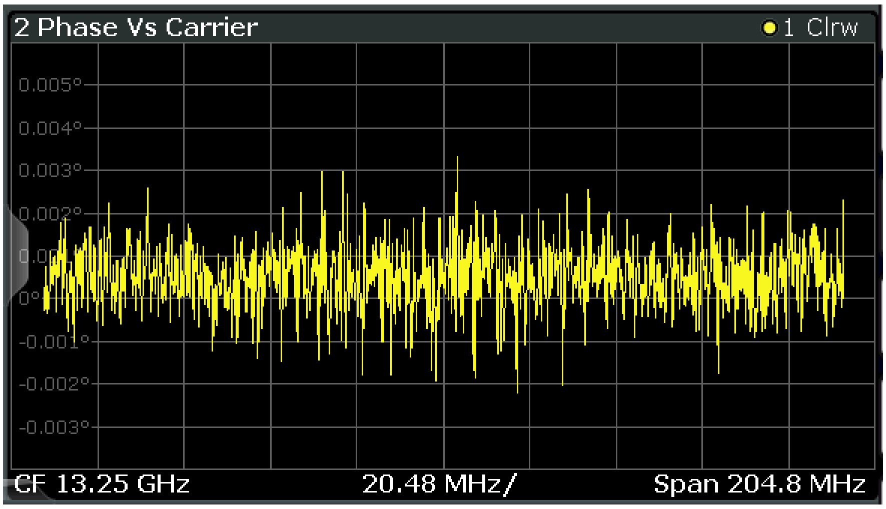
Note:

In 3-dimensional result displays the marker position is defined by its value on the x-axis (carrier) and y-axis (symbol). The parameter value (MER) is queried as the third dimension (z).

In this result display, only a single (normal) marker is available.

Remote command:
`LAY:ADD? '1',RIGH,MERSC`, see `LAYout:ADD[:WINDow]?` on page 227
Results:
`[SENSe:]FRAMe:SELect` on page 222
`TRACe<n>[:DATA]?` on page 269

Phase vs Carrier
Displays the phase per carrier for the currently Selected Frame as indicated in the "Magnitude Capture" display.



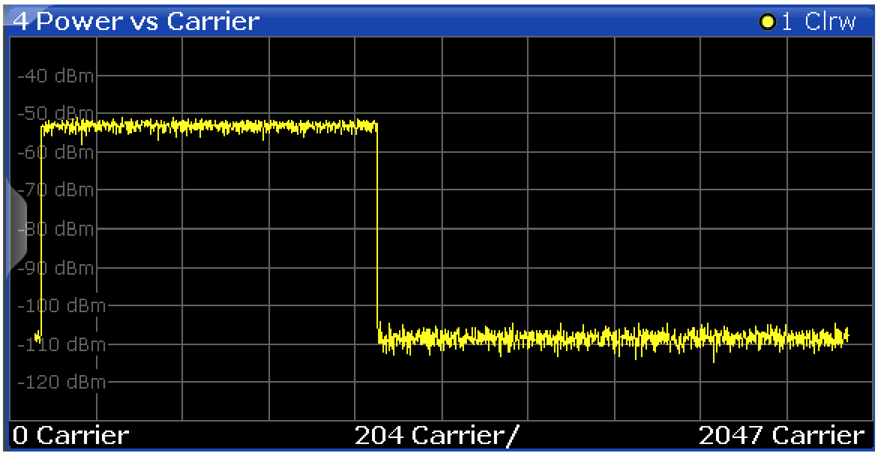
The carrier values can be provided as carrier numbers or carrier frequencies, see Selected Frame.

Remote command:
`LAY:ADD? '1',RIGH,PHAC`, see `LAYout:ADD[:WINDow]?` on page 227
Results:
`[SENSe:]FRAMe:SELect` on page 222
`TRACe<n>[:DATA]?` on page 269

Power vs Carrier (upstream only)
Displays the power level per carrier for the currently Selected Frame as indicated in the "Magnitude Capture" display. The carriers are displayed on the x-axis, the power is displayed on the y-axis.

The power unit depends on the Unit setting.

The carrier unit depends on the Carrier Axes Unit setting.



Remote command:

`LAY:ADD? '1',RIGH,PCAR`, see `LAYout:ADD[:WINDow]?` on page 227

Results:

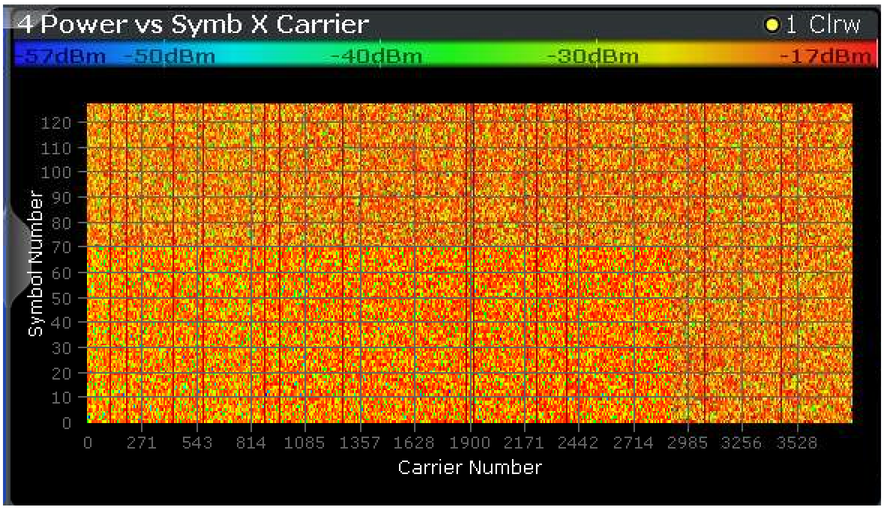
`[SENSe:]FRAMe:SELect` on page 222

`TRACe<n>[:DATA]?` on page 269

Power vs Symbol X Carrier

Displays the power level per carrier and symbol for the currently Selected Frame as indicated in the "Magnitude Capture" display. The symbols are displayed on the x-axis, the carriers are displayed on the y-axis. The power level is color-coded and is indicated as a colored dot for each symbol and carrier. The legend for the color coding is provided by a color bar at the top of the diagram.

The power unit depends on the Unit setting.



Note:

In 3-dimensional result displays the marker position is defined by its value on the x-axis (carrier) and y-axis (symbol). The parameter value (Power) is queried as the third dimension (z).

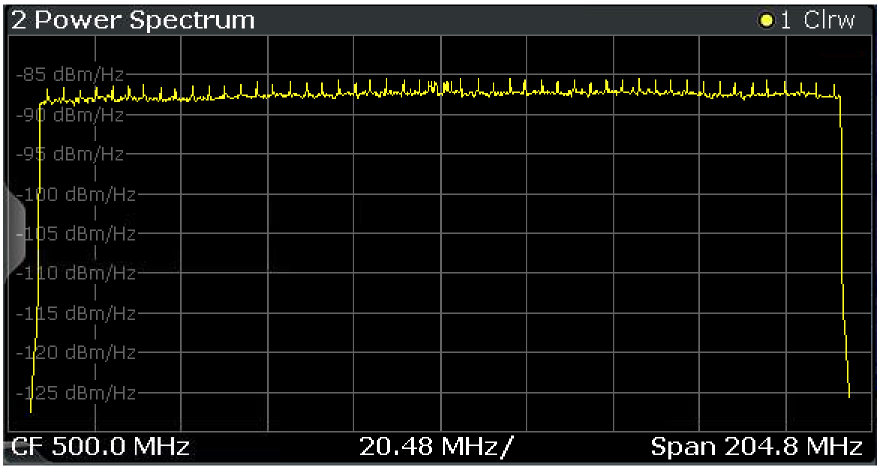
In this result display, only a single (normal) marker is available.

Remote command:
`LAY:ADD? '1',RIGH,PSC`, see `LAYout:ADD[:WINDow]?` on page 227
Results:
`[SENSe:]FRAMe:SELect` on page 222
`TRACe<n>[:DATA]?` on page 269

Power Spectrum

This result display shows the power density (power/Hz) vs frequency values obtained using an FFT. The evaluation is performed over the complete data in the current capture buffer, without any correction or compensation.

The power unit depends on the Unit setting.



Remote command:
`LAY:ADD? '1',RIGH,PSP`, see `LAYout:ADD[:WINDow]?` on page 227
Results:
`[SENSe:]FRAMe:SELect` on page 222
`TRACe<n>[:DATA]?` on page 269

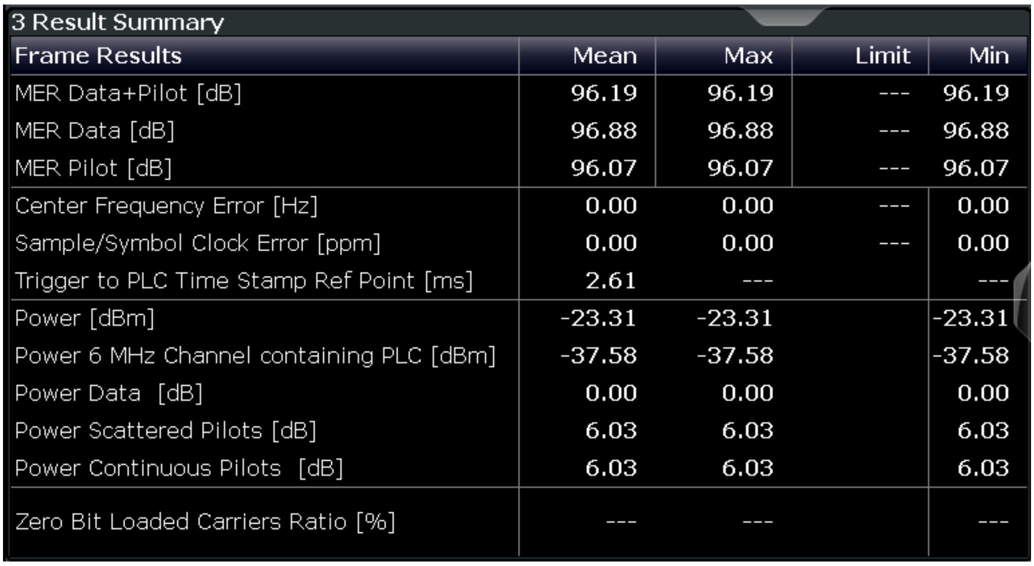
Result Summary

The result summary provides the numerical results for the main DOCSIS 3.1 parameters summarized over a specified number of frames or for a single frame. This is the currently Selected Frame as indicated in the "Magnitude Capture" display.

If more than one frame is evaluated (that is, Analyzing a single frame (Specified Frame) is not enabled), a statistical evaluation of the specified "Frame Statistic Count / Number of Frames to Analyze" on page 111 or for all detected frames in the capture buffer is also performed. In this case, the minimum, maximum and mean values are displayed, as well as the defined limit, if available.

For details on the evaluation basis, see "Basis of (Statistical) Evaluation" on page 39.

For details on individual parameters, see Chapter 3.1.1, "Modulation Accuracy Parameters", on page 13.



3 Result Summary

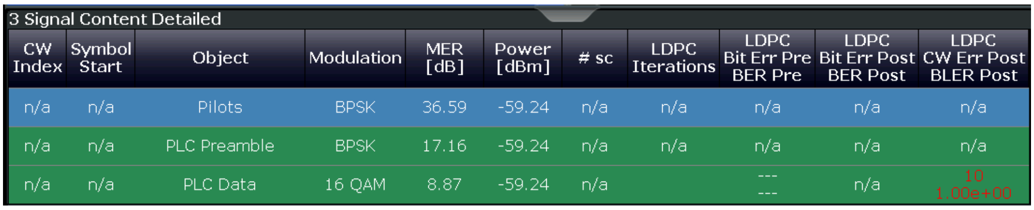
Frame Results	Mean	Max	Limit	Min
MER Data+Pilot [dB]	96.19	96.19	---	96.19
MER Data [dB]	96.88	96.88	---	96.88
MER Pilot [dB]	96.07	96.07	---	96.07
Center Frequency Error [Hz]	0.00	0.00	---	0.00
Sample/Symbol Clock Error [ppm]	0.00	0.00	---	0.00
Trigger to PLC Time Stamp Ref Point [ms]	2.61	---		---
Power [dBm]	-23.31	-23.31		-23.31
Power 6 MHz Channel containing PLC [dBm]	-37.58	-37.58		-37.58
Power Data [dB]	0.00	0.00		0.00
Power Scattered Pilots [dB]	6.03	6.03		6.03
Power Continuous Pilots [dB]	6.03	6.03		6.03
Zero Bit Loaded Carriers Ratio [%]	---	---		---

Remote command:
LAY:ADD? '1',RIGH,RSUM, see LAYout:ADD[:WINDow]? on page 227
Results:
FETCh:SUMMary:ALL? on page 261
FETCh:FRAMe:COUNt? on page 251
FETCh:FRAMe:COUNt:ALL? on page 251

Signal Content Detailed

This result display shows the serialized information from the list of NCPs and codewords (downstream) or minislot sets (upstream) for the currently Selected Frame as indicated in the "Magnitude Capture" display.

For details on individual entries, see Chapter 3.1.2, "Signal Content Information", on page 15.



3 Signal Content Detailed

CW Index	Symbol Start	Object	Modulation	MER [dB]	Power [dBm]	# sc	LDPC Iterations	LDPC Bit Err Pre BER Pre	LDPC Bit Err Post BER Post	LDPC CW Err Post BLER Post
n/a	n/a	Pilots	BPSK	36.59	-59.24	n/a	n/a	n/a	n/a	n/a
n/a	n/a	PLC Preamble	BPSK	17.16	-59.24	n/a	n/a	n/a	n/a	n/a
n/a	n/a	PLC Data	16 QAM	8.87	-59.24	n/a		--- ---	n/a	10 1.00e+00

Note: If the low density parity check (LDPC) results indicate no errors (= 0), the value is displayed green, otherwise the value is red. This allows you to detect errors at a glance.

Remote command:
LAY:ADD? '1',RIGH,SCD, see LAYout:ADD[:WINDow]? on page 227
Results:
FETCh:SCDetailed:ALL:FORMatted? on page 255
[SENSe:]FRAMe:SELect on page 222

Signal Content Summary

This result display shows the summarized information for the NCPs and codewords in a specified number of frames or for a single frame. This is the currently Selected Frame as indicated in the "Magnitude Capture" display.

Note: This result display is **not** available for **upstream** measurements!

If more than one frame is evaluated (that is, Analyzing a single frame (Specified Frame) is not enabled), a statistical evaluation of the specified Frame Statistic Count / Number of Frames to Analyze or for all detected frames in the capture buffer is also performed. In this case, the minimum, maximum and mean values are displayed, as well as the defined limit, if available.

For details on the evaluation basis, see "Basis of (Statistical) Evaluation" on page 39.

For details on individual entries, see Chapter 3.1.2, "Signal Content Information", on page 15.

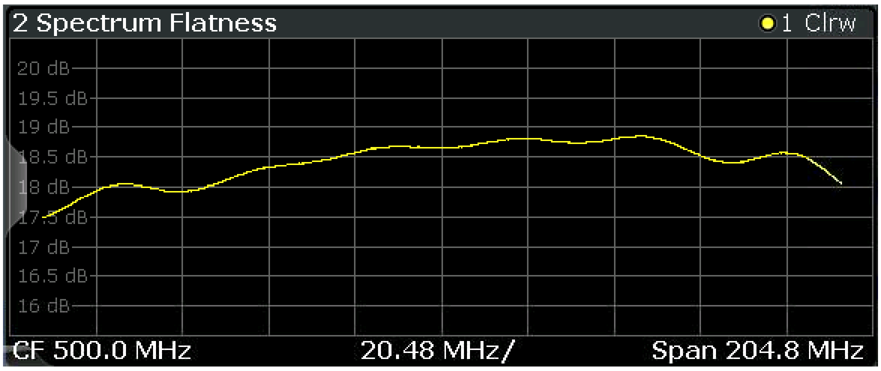
3 Signal Content Summary

Name	Modulation	MER [dB]	# [count]	LDPC Bit Err Pre BER Pre	LDPC Bit Err Post BER Post	LDPC CW Err Post BLER Post
Pilots	BPSK	84.07	n/a	n/a	n/a	n/a
PLC Preamble	BPSK	90.81	10	n/a	n/a	n/a
PLC Data	16 QAM	90.88	10	--- ---	n/a	100 1.00e+00
NCP All	None	---	0	--- ---	n/a	--- ---

Remote command:
`LAY:ADD? '1',RIGH,SCS`, see `LAYout:ADD[:WINDow]?` on page 227
Results:
`FETCh:SCSummary:ALL?` on page 259
`FETCh:FRAMe:COUNt?` on page 251
`FETCh:FRAMe:COUNt:ALL?` on page 251

Spectrum Flatness

This result display shows the relative power offset per carrier caused by the transmit channel for the currently Selected Frame as indicated in the "Magnitude Capture" display.



The carrier values can be provided as carrier numbers or carrier frequencies, see "Carrier Axes Unit" on page 117.

Remote command:
`LAY:ADD? '1',RIGH,SFL`, see `LAYout:ADD[:WINDow]?` on page 227
Results:
`[SENSe:]FRAMe:SELect` on page 222
`TRACe<n>[:DATA]?` on page 269

3.2 Frequency Sweep Measurements

Access: "Overview" > "Select Measurement"

Or: MEAS > "Select Meas"

Standard measurements that are common to several digital standards and are often required in signal and spectrum test scenarios are provided by the R&S FSW base unit (Spectrum application). These measurements capture only the power level (magnitude, which we refer to as *RF data*) of the signal, as opposed to the two components provided by I/Q data.

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

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

The frequency sweep measurements provided by the R&S FSW DOCSIS 3.1 application are identical to the corresponding measurements in the base unit, but are pre-configured according to the requirements of the selected DOCSIS 3.1 standard.

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

The R&S FSW DOCSIS 3.1 application provides the following frequency sweep measurements:

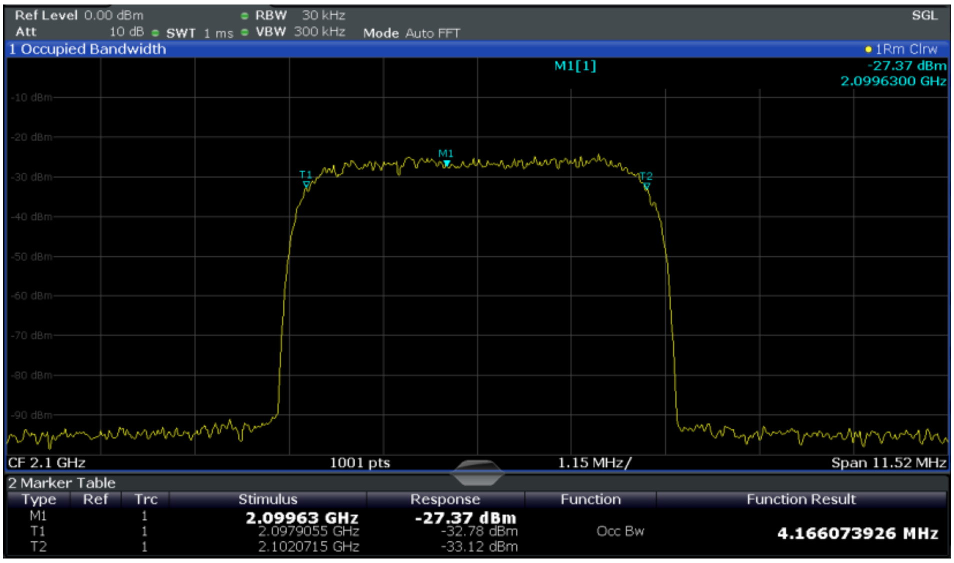
3.2.1 Measurement Types and Results for Frequency Sweep Measurements

The R&S FSW DOCSIS 3.1 application provides the following pre-configured frequency sweep measurements:

Occupied Bandwidth.. 29
CCDF... 30

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

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



For details, see Chapter 5.4.1, "Occupied Bandwidth", on page 125.

Remote command:
`CALC:MARK:FUNC:POW:SEL OBW`, see `CALCulate<n>:MARKer<m>:FUNCtion:POWer:SELect` on page 154
Querying results:
`CALC:MARK:FUNC:POW:RES? OBW`, see `CALCulate<n>:MARKer<m>:FUNCtion:POWer:RESult?` on page 267

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

For details see Chapter 5.4.2, "CCDF", on page 126.

Figure 3-4: CCDF measurement results

Remote command:
CALCulate<n>:STATistics:CCDF[:STATe] on page 154
Querying results:
CALCulate<n>:MARKer<m>:Y? on page 278
CALCulate<n>:STATistics:RESult<t>? on page 267

3.2.2 Evaluation Methods for Frequency Sweep Measurements

The evaluation methods for frequency sweep measurements in the R&S FSW DOCSIS 3.1 application are identical to those in the R&S FSW base unit (Spectrum application).

Diagram..........31
Result Summary..........31
Marker Table..........32
Marker Peak List..........32

Diagram

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

Remote command:
`LAY:ADD? '1',RIGH, DIAG`, see LAYout:ADD[:WINDow]? on page 227

Result Summary

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

2 Result Summary

Channel	Bandwidth	Offset	Power	
TX1 (Ref)	1.229 MHz		-0.86 dBm	
Tx Total			-0.86 dBm	
Channel	Bandwidth	Offset	Lower	Upper
Adj	30.000 kHz	750.000 kHz	-79.59 dB	-80.34 dB
Alt1	30.000 kHz	1.980 MHz	-85.04 dB	-83.85 dB

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

Remote command:

`LAY:ADD? '1',RIGH, RSUM`, see `LAYout:ADD[:WINDow]?` on page 227

Marker Table

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

For 3-dimensional result displays (MER vs Symbol X Carrier, Power vs Symbol X Carrier), the value of a marker consists of the carrier (x), the symbol (y) and the parameter value (z).

5 Marker Table

Wnd	Type	Ref	Trc	X-value	Y-value	Z-value
2	M1		1	13.16 GHz	67.73 dB	
2	D2	M1	1	0.0 Hz	0.0 dB	
3	M1		1	Carrier 1900	Symbol 20	103.84 dB
4	M1		1	Carrier 1900	Symbol 20	-49.24 dBm

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 227

Results:

`CALCulate<n>:MARKer<m>:X` on page 267
`CALCulate<n>:MARKer<m>:Y?` on page 278

Marker Peak List

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

2 Marker Peak List

No	Stimulus	Response
1	64.400000 MHz	-30.352 dBm
2	128.400000 MHz	-51.896 dBm
3	192.300000 MHz	-40.227 dBm
4	257.200000 MHz	-60.699 dBm
5	320.200000 MHz	-44.273 dBm
6	384.100000 MHz	-53.494 dBm
7	448.100000 MHz	-47.460 dBm
8	513.000000 MHz	-55.603 dBm

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

Remote command:

`LAY:ADD? '1',RIGH, PEAK`, see `LAYout:ADD[:WINDow]?` on page 227

Results:

`CALCulate<n>:MARKer<m>:X` on page 267
`CALCulate<n>:MARKer<m>:Y?` on page 278

4 Measurement Basics

Some background knowledge on basic terms and principles used in DOCSIS 3.1 measurements is provided here for a better understanding of the required configuration settings.

- DOCSIS 3.1 Characteristics.....33
- DOCSIS 3.1 Downstream Signal Processing.....33
- DOCSIS 3.1 Upstream Signal Processing.....39
- Receiving Data Input and Providing Data Output.....44
- Preparing the R&S FSW for the Expected Input Signal - Frontend Parameters.....46

4.1 DOCSIS 3.1 Characteristics

A cable network based on the Data-Over-Cable Service Interface Specifications (DOCSIS® 3.1, see References) allows for very high data rates due to its large number of carriers and very high modulation rates.

For *downstream* transmission based on DOCSIS 3.1, OFDM channels with a bandwidth of up to 192 MHz are used in a spectrum from 258 MHz to 1.2 GHz. Each OFDM channel in turn consists of 7600 (active) subcarriers with a spacing of 25 kHz, or 3800 (active) subcarriers with a spacing of 50 kHz. Data is transmitted with a fixed sample rate of 204.8 MHz.

For *upstream* transmission based on DOCSIS 3.1, OFDM channels with a bandwidth of up to 96 MHz are used in a spectrum from 5 MHz to 204 MHz. Each OFDM channel in turn consists of 3800 (active) subcarriers with a spacing of 25 kHz, or 1900 (active) subcarriers with a spacing of 50 kHz. Data is transmitted with a fixed sample rate of 102.4 MHz.

OFDM channels can be configured independantly, taking different channel conditions into account. Each subcarrier can use a different modulation, allowing for higher data rates where transmission conditions are good, and reliable data reception where they are poor. Time and frequency interleaving methods, as well as forward error correction (FEC) and cyclic redundancy correction bits ensure low error rates and high modulation accuracy.

Using DOCSIS 3.1, the same data is sent to multiple cable modems in data blocks containing information on which contents need to be decoded by the individual modems.

4.2 DOCSIS 3.1 Downstream Signal Processing

Downstream DOCSIS 3.1 signals are used to transmit data from the cable modem termination system (CMTS) to numerous individual cable modems in widely spread locations. The R&S FSW DOCSIS 3.1 applications analyze both types of signals based on DOCSIS 3.1.

The following graphic illustrates the basic signal processing performed by the application for downstream signals. The individual steps are then described in more detail.

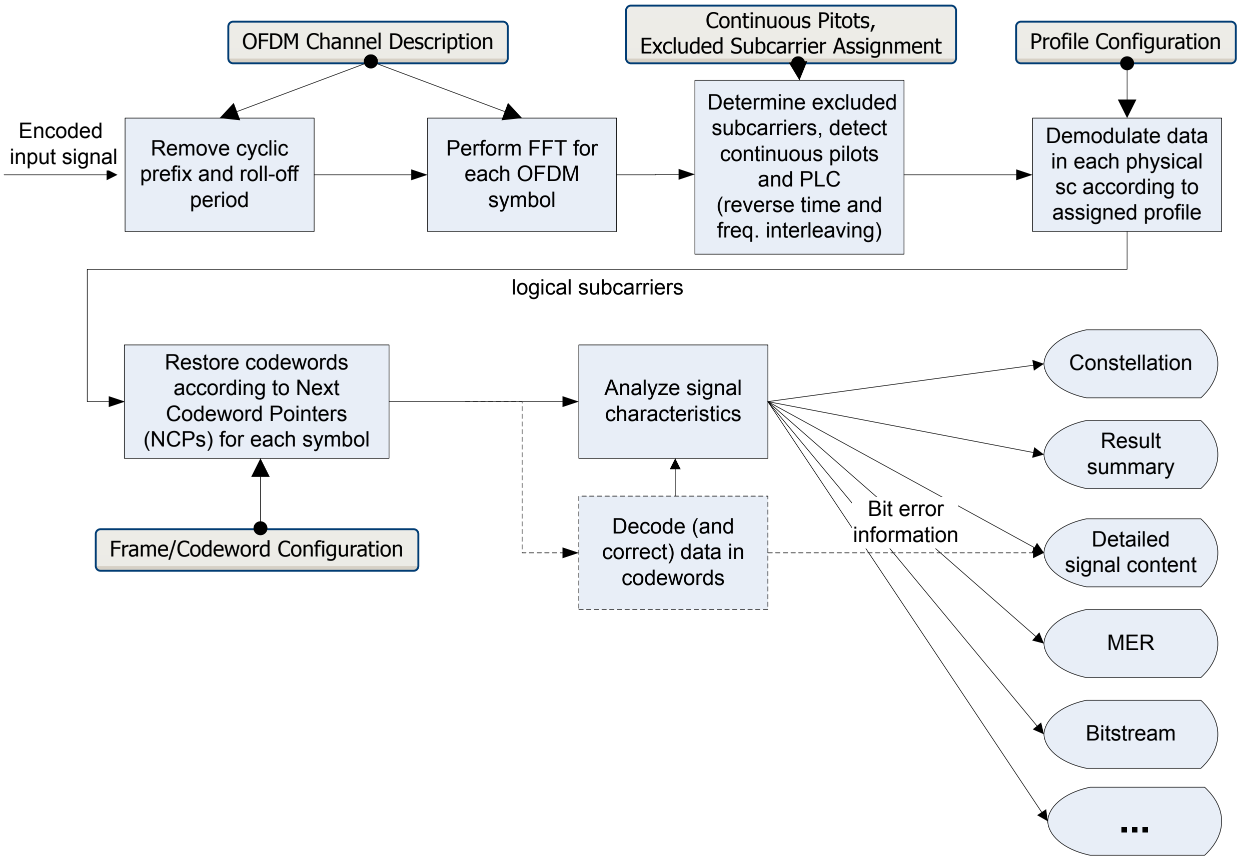


Figure 4-1: Signal processing in the R&S FSW DOCSIS 3.1 application

OFDM channel input

The encoded data input from an OFDM channel is a time domain discrete, complex-valued signal, which is sampled at a rate of 204.8 MSamples by the R&S FSW DOCSIS 3.1 application. It is then analyzed according to the configured signal description.

In the first step, the cyclic prefix and roll-off period are removed. While the cyclic prefix prevents intersymbol interference, the roll-off period determines how steep the spectrum rises and falls at its edges.

FFT

The initial data captured by the R&S FSW DOCSIS 3.1 application consists of measured values over time. In order to analyze the data for each OFDM symbol in the frequency domain, that is, the data in each subcarrier, an FFT must be performed on the captured data. Depending on the specified FFT length, which corresponds to the number of subcarriers, an FFT is performed on either 4096 samples (4K mode), or 8192 samples (8K mode) of the channel input, for each symbol.

Subcarriers and profiles

For each of the subcarriers, a different modulation may be used for transmission, depending on channel conditions.

The assignment is configured in *profiles*. For each set of modems with similar transmission conditions, a profile can then be assigned.

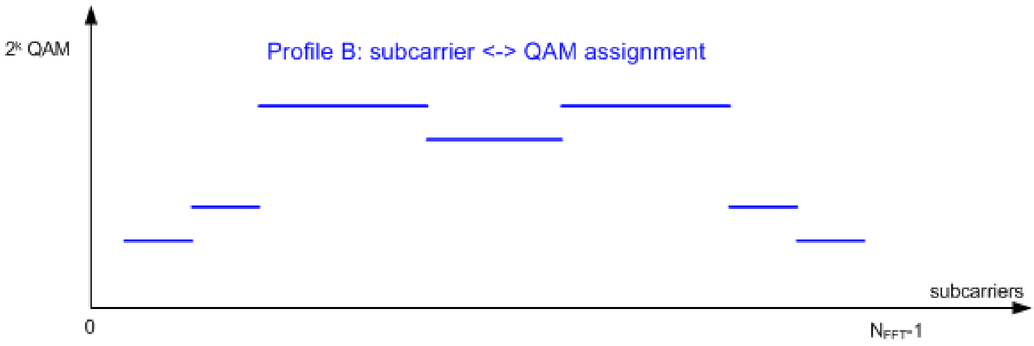


Figure 4-2: Profile: assignment of modulation to physical subcarriers

In order to demodulate the data in the subcarriers, the R&S FSW DOCSIS 3.1 application must determine the assignment of the modulation used by each subcarrier. This is configured in the signal description. Up to 16 different profiles can be configured and then assigned to each set of subcarriers sent to the same set of modems (see "Codewords, logical subcarriers, frames, and NCPs" on page 36).

Continuous pilots, excluded subcarriers, PLC

Some subcarriers have a specific function and are used identically for all symbols. Such fixed objects in the channel must be configured so that the R&S FSW DOCSIS 3.1 application can distinguish their contents from the useful data. Subcarriers with a special function are configured in the signal description in a continuous pilots and excluded subcarrier assignment table.

Continuous pilots are located at the same position in each OFDM channel and are used to synchronize time and phase information between symbols.

Excluded subcarriers are not used to transmit data in a DOCSIS 3.1 channel. This may be due to poor transmission conditions, use by other transmission channels, or for other reasons. Such carriers are blocked for all symbols of the channel.

The *Physical Link Channel (PLC)* is located at the same position in each OFDM symbol and consists of several consecutive subcarriers. It contains general transmission information, such as the FFT size, number of subcarriers, and spacing size used for transmission, as well as a preamble, which contains a defined pattern and is required to synchronize the symbols. The preamble of the PLC is BPSK-modulated, while the PLC data is always transmitted using 16-QAM modulation.

The information in the PLC can be used by the R&S FSW DOCSIS 3.1 application to determine several of the signal description parameters described above automatically. The position of the PLC itself can also be detected by the R&S FSW DOCSIS 3.1 application automatically.

Codewords, logical subcarriers, frames, and NCPs

The useful data that is to be transmitted to the same group of cable modems is summarized into blocks. The blocks are extended by additional bits for forword error correction, which allow transmission errors to be detected and corrected by the receiver. Such an encoded data block, which may vary in size, is referred to as a *codeword*.

The subcarriers for a single symbol in an OFDM channel that are available for useful data, that is to transmit the codewords, are called *logical subcarriers*. Logical subcarriers are combined in a *frame*.

The codewords are assigned to the next available symbol in the order they are sent. If more subcarriers are required than are still empty, subcarriers in the next symbol are assigned to the block as well. Up to four consecutive symbols can be used by any one codeword. Therefore it is necessary to document the assignment of codewords to symbols.

For each new codeword that starts in a symbol, the first subcarrier of the codeword is provided as a *Next Codeword Pointer (NCP)*. The NCPs are also included in the frame. NCPs are modulated using QPSK, 16-QAM or 64-QAM. Which modulation is used for the NCP is indicated by the PLC.

Finally, for error protection, each frame contains a *Cyclic Redundancy Check (CRC)* block, based on all NCPs in the frame.

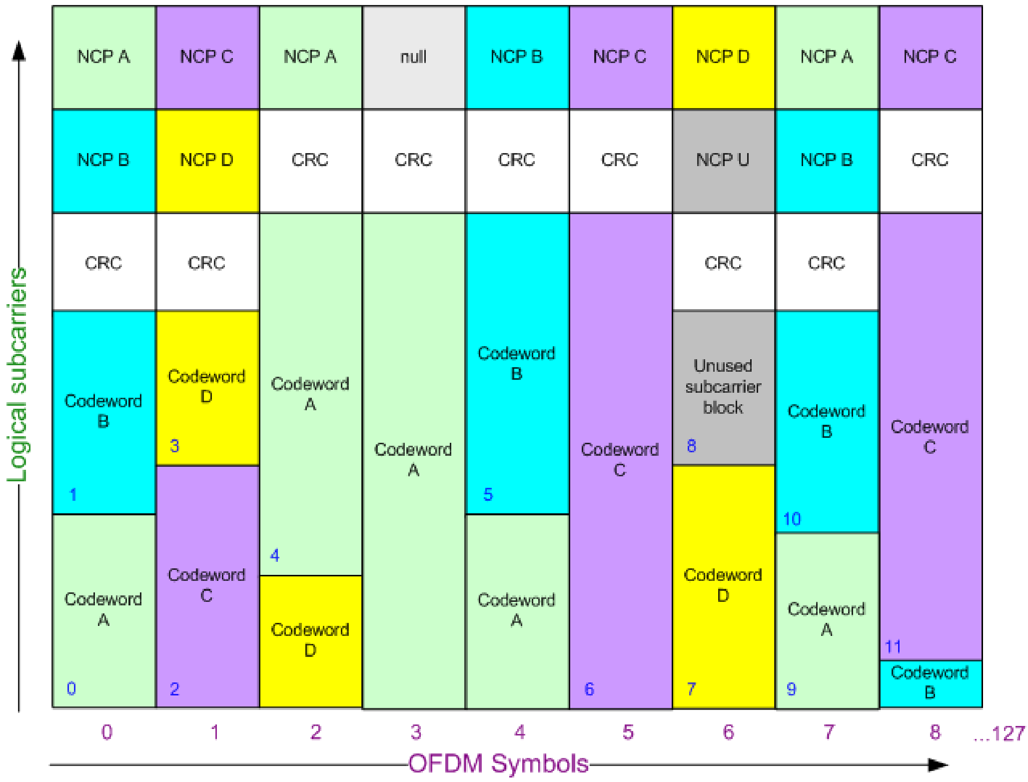


Figure 4-3: Frame/codeword configuration of the logical subcarriers

Frame configuration in the R&S FSW DOCSIS 3.1 application

In a realistic DOCSIS 3.1 transmission scenario, the transmitted data changes constantly. Thus, the frame configuration also changes accordingly. However, for analysis and test purposes, it is assumed that you use the same input signal to the R&S FSW DOCSIS 3.1 application for a specific test scenario, and thus the frame configuration need only be configured once for that signal.

The R&S FSW DOCSIS 3.1 application provides an auto-detection function to configure the frames automatically from the signal.

In the R&S FSW DOCSIS 3.1 application, you configure the assignment of codewords to symbols in a table. The codewords are numbered consecutively from the first to the last OFDM symbol, and from the first to last logical subcarrier (see Figure 4-3). For each codeword, an entry in the table is required, which assigns the (first and) total number of subcarriers per codeword, or alternatively the first and total number of OFDM symbols. Furthermore, the profile (that is: modulation) to be used for the codeword is defined. Note that since one OFDM symbol may contain more than one codeword, and each codeword may use a different modulation, the same OFDM symbol may have a "mixed modulation".

Physical vs. logical subcarriers

As described above, the physical subcarriers in a DOCSIS 3.1 channel may contain general signal information (PLC, pilots), useful data, or unspecified data (excluded carriers).

In order to improve modulation accuracy, the data is not transmitted in consecutive subcarriers, but scattered across all available subcarriers, by subjecting it to time and frequency interleaving. The time and frequency interleaved data, together with the NCPs and PLCs, are then distributed amoung all physical subcarriers, with exception of the excluded subcarriers, and modulated according to the assigned profiles.

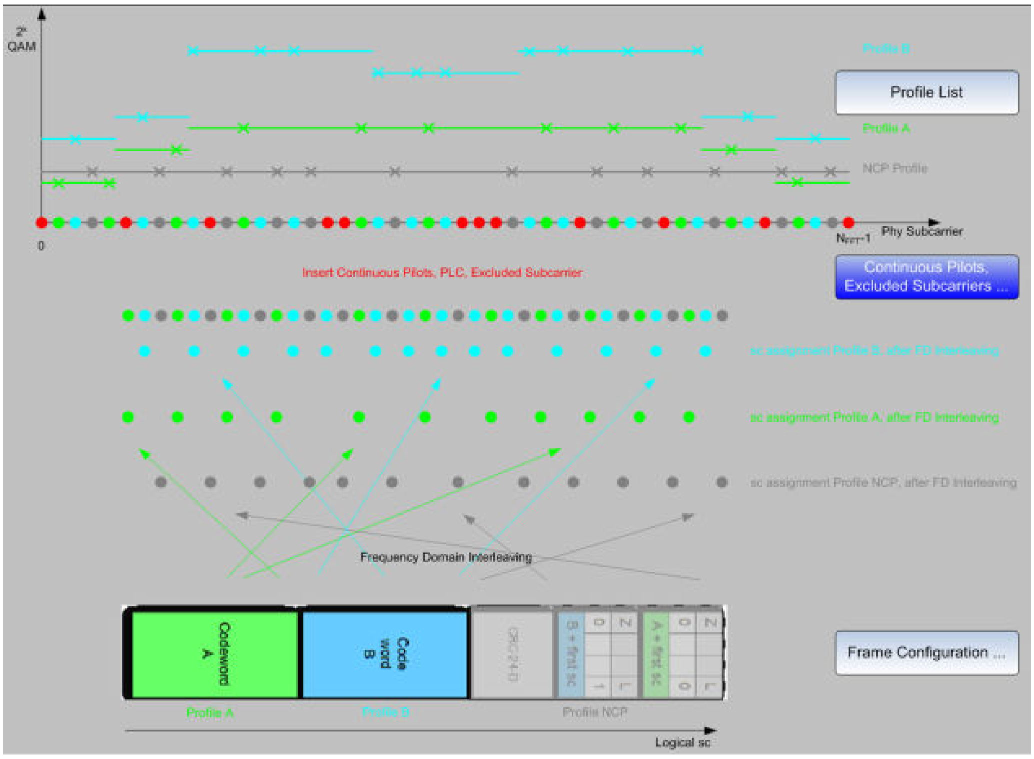


Figure 4-4: Relation between frames, logical subcarriers, profiles, and physical subcarriers

During demodulation, the R&S FSW DOCSIS 3.1 application must restore the original time and frequency order of the information, to form *logical subcarriers* with coherent data.

Demodulation and Analysis

When demodulating the DOCSIS 3.1 signal, the R&S FSW DOCSIS 3.1 application must restore the original correlation between the symbols in order to retrieve the blocks in the logical subcarriers, and thus the useful information. The continuous pilots and the PLC preamble help synchronize the time and phase information between symbols.

With the help of the frame/codeword configuration, the R&S FSW DOCSIS 3.1 application can demodulate the data in the logical subcarriers and restore the codewords. As a result, various signal characteristics, modulation accuracy parameters and constellation data are available.

The detailed signal content can also be output in a table. The order of entries in this table is similar to the frame configuration table: For each frame, the CRC and the codewords with the assigned NCP are listed in consecutive order of the codeword index. For each object in the table, modulation accuracy parameters, the measured power level and detected error bits are indicated.

Optionally, the codewords are not decoded to save calculation time; however, in this case codeword error bits are not evaluated.

Basis of (Statistical) Evaluation

Various modulation accuracy parameters as well as the symbol constellation can be displayed graphically. Graphical results are always based on a single frame. The Bitstream and detailed signal content is also always provided for a single frame. Which frame is to be evaluated is configurable (see Selected Frame). By default, it is always the first detected frame in the capture buffer (frame 0).

The numeric results in the Result Summary and Signal Content Summary, on the other hand, are summarized over all frames in the current capture buffer, by default. Optionally, they can be summarized over a specific number of frames (see "Frame Statistic Count / Number of Frames to Analyze" on page 111). In this case, multiple measurements are performed, if necessary, to obtain the required number of frames. Using a defined number of frames to base statistics on makes the results more consistent, as the number of frames detected in each measurement (and which are thus available in the capture buffer) may vary. If evaluation is restricted to a single frame, no statistics are calculated for the summarized results.

Note that frames from multiple measurements can be included in statistical evaluation; however, only frames in the current capture buffer can be analyzed and displayed individually.

4.3 DOCSIS 3.1 Upstream Signal Processing

Upstream DOCSIS 3.1 signals are used to transmit data from numerous individual cable modems (CMs) to the cable modem termination system (CMTS). Signal processing in the R&S FSW DOCSIS 3.1 application is similar to processing downstream signals, as described in Chapter 4.2, "DOCSIS 3.1 Downstream Signal Processing", on page 33. The main differences for upstream signals are described here.

Minislots and transmission profiles

According to the DOCSIS 3.1 specification [2], minislots are defined as follows:

"*The upstream spectrum is divided into groups of subcarriers called minislots. Minislots have dedicated subcarriers, of which all data subcarriers have the same modulation order ("bit loading"). A CM is allocated to transmit one or more minislots in a transmission burst. The modulation order of a minislot, as well as the pilot pattern to use, may change between different transmission bursts and are determined by a transmission profile.* [...]*This allows bit loading to vary across the spectrum.*"

Pilots, complementary pilots, data subcarriers

Each minislot is comprised of pilots, complementary pilots, and data subcarriers. Subcarriers that are not used for data or pilots are set to zero.

Pilots are subcarriers that do not carry data, but encode a pre-defined BPSK symbol known to the receiver. Pilot patterns differ by the number of pilots in a minislot, and by their arrangement within the minislot. The different pilot patterns enable the CMTS to optimize its performance according to different transmission conditions.

The DOCSIS 3.1 specification [2] also specifies complementary pilots:

"*Complementary pilots are subcarriers that carry data, but with a lower modulation order than other data subcarriers in the minislot. Complementary pilots allow phase tracking along the time axis for frequency offset and phase noise correction, and may be used by the CMTS upstream receiver to enhance signal processing, such as improving the accuracy of center frequency offset tracking.*"

Minislot structure

All data subcarriers in a minislot have the same QAM constellation. All complementary data subcarriers in a minislot also have the same QAM constellation, but lower in order than that of the data subcarriers in that minislot. QAM constellations of data and complementary pilots need not be the same for all minislots.

Minislots are defined by a fixed number (K) of symbols and a number (Q) of subcarriers. The number (K) of symbols per minislot is defined as a minimum of 6 and a maximum of 9 to 36, depending on the used bandwidth and FFT duration. The number (Q) of subcarriers per minislot is defined as 8 for 2K mode and 16 for 4K mode.

Between minislots, excluded subcarriers may exist.

In the R&S FSW DOCSIS 3.1 application, profiles for upstream signals contain the assignment of the pilot pattern and modulation per minislot or for a number of minislots (as opposed to the modulation-subcarrier assignment for downstream signals). Only a single profile is configurable for upstream signals in the R&S FSW DOCSIS 3.1 application.

Pilot patterns

As described above, pilot patterns differ by the number of pilots in a minislot, and by their arrangement within the minislot. Which patterns are available for a minislot depends on the number of subcarriers and thus the FFT mode.

For **2K mode** (=8 subcarriers per minislot), 8 different pilot patterns are available (defined in the DOCSIS 3.1 specification [2]):

In each figure, the horizontal axis represents OFDMA symbols, and the vertical axis represents the subcarriers. Each square in a figure represents a subcarrier at a specific symbol time. Pilots are designated by "P" and complementary pilots by "CP". All other subcarriers carry data with the modulation order of the minislot.

The figures show patterns for K between 6 and 16. For K>16 the complementary pilots are always located in the 14th and 16th symbols, all symbols from the 17th symbol to the end of the frame carry data only. Pilot locations are the same for any K.

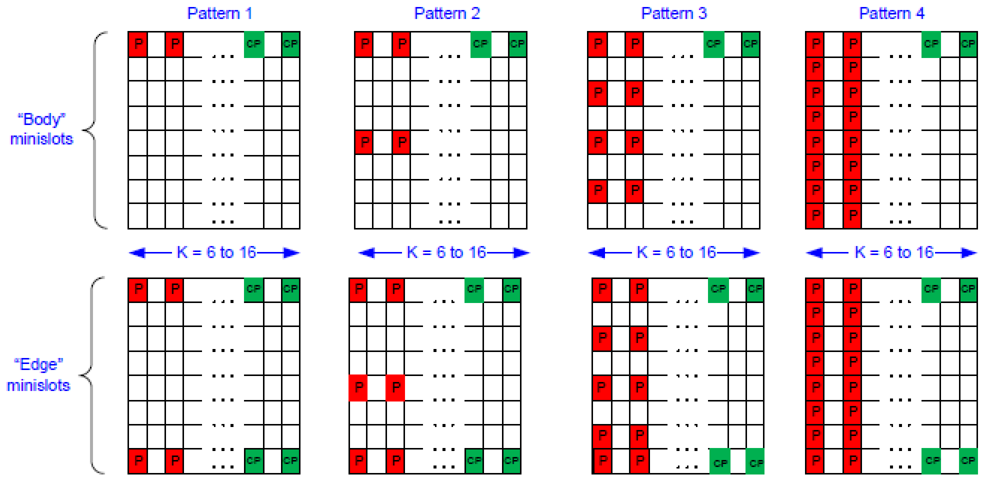


Figure 7-36 - Pilot Patterns 1-4 for Minislots with 8 Subcarriers

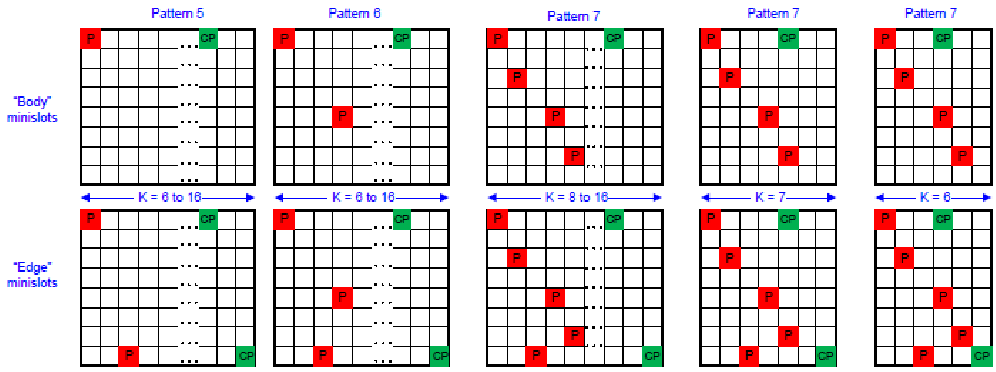


Figure 7-37 - Pilot Patterns 5 - 7 for Minislots with 8 Subcarriers

For **4K mode** (=16 subcarriers per minislot), 16 different pilot patterns are available (defined in the DOCSIS 3.1 specification [2]):

The figures show patterns for K between 6 and 9. For K>9, the complementary pilots are always located in the 7th and 9th symbols, all symbols from the 10th symbol to end of frame carry data only. Pilot locations are the same for any K.

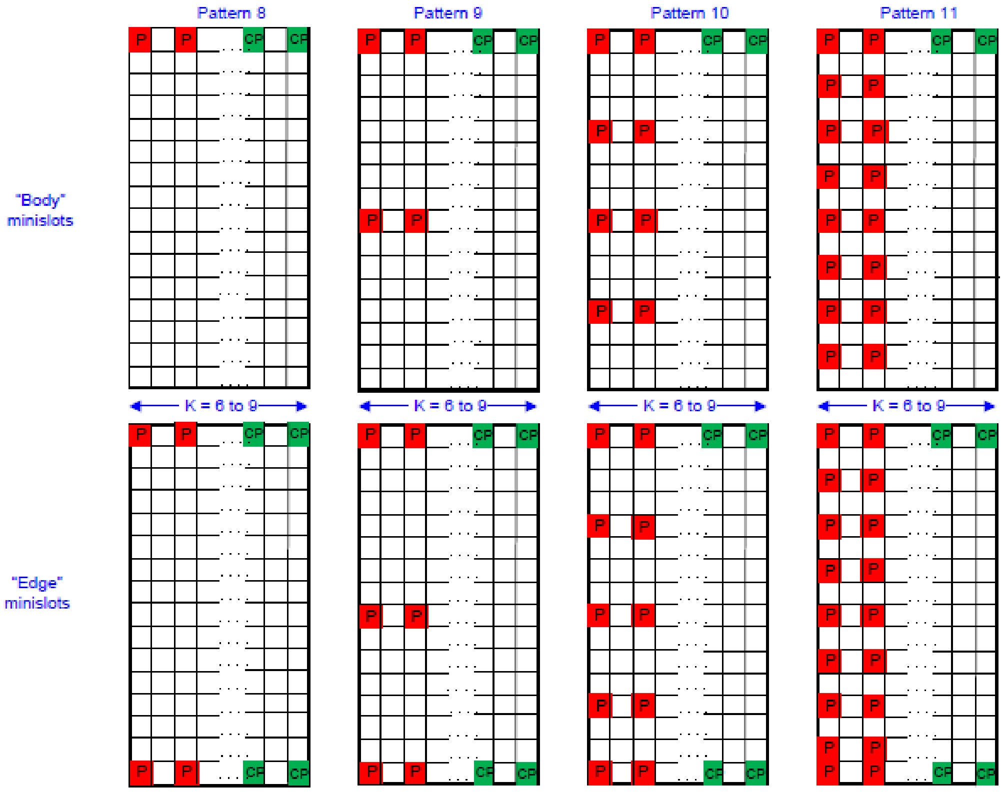


Figure 7-38 - Pilot Patterns 8-11 for Minislots with 16 Subcarriers

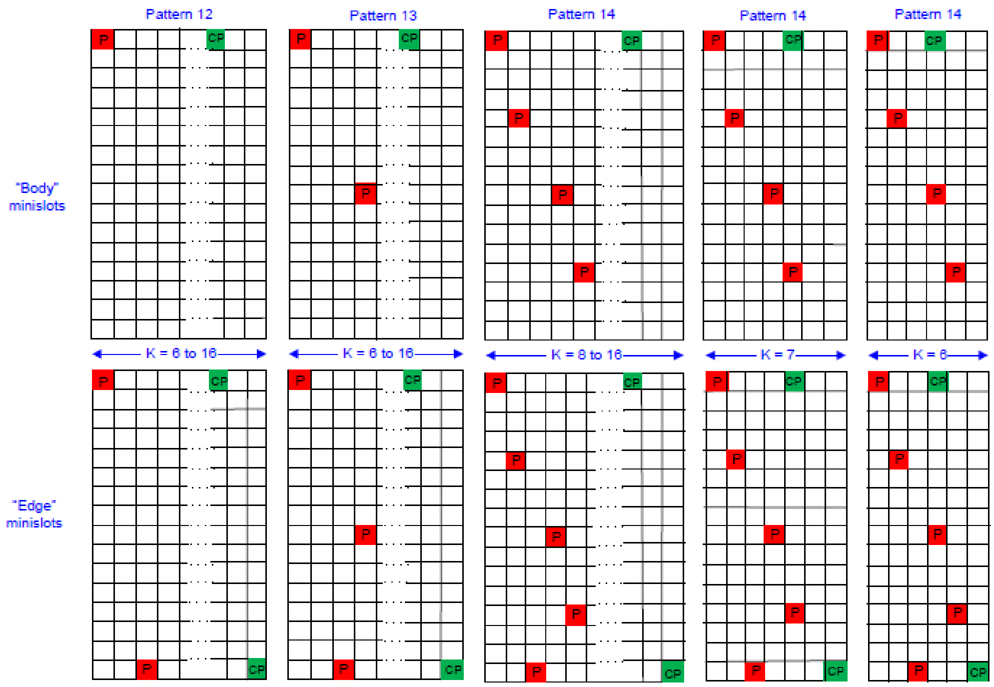


Figure 7-39 - Pilot Patterns 12 - 14 for Minislots with 16 Subcarriers

Frame structure

The DOCSIS 3.1 specification [2] defines frames as follows:

"*Upstream transmission uses OFDMA frames. Each OFDMA frame is comprised of a configurable number of OFDM symbols, K. Several transmitters may share the same OFDMA frame by transmitting data and pilots on allocated subcarriers of the OFDMA frame.*"

In upstream DOCSIS 3.1 signals, a frame comprises the minislots that use the same frequency range within the OFDMA channel spectrum.

The following figure illustrates the frame structure for upstream transmission.

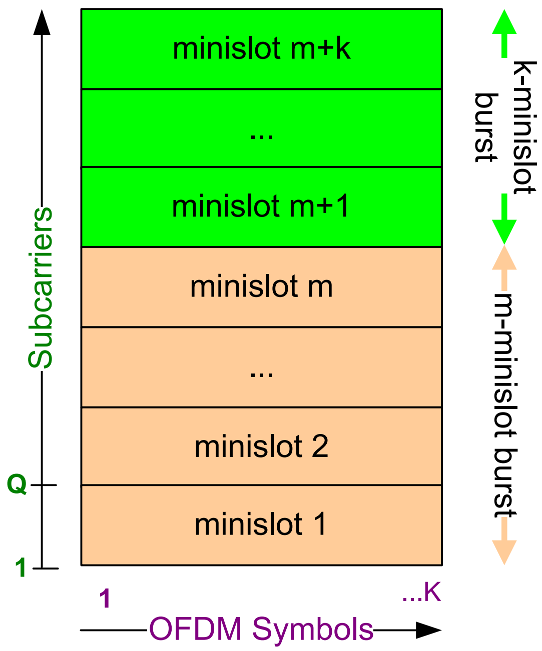


Figure 4-5: DOCSIS 3.1 OFDMA frame structure for upstream transmission

Mapping data and profiles to minislots

The order of data bits within a minislot is described in the DOCSIS 3.1 specification [2].

The useful data codewords are mapped into minislots, prior to time and frequency interleaving, using only contiguous subcarriers. There are no subcarrier exclusions or unused subcarriers within a minislot. "*The data is filled across all symbol periods, subcarrier by subcarrier, transmitted symbol period by symbol period, with complementary pilots filled inline.*" All data subcarriers within one minislot use the same modulation. Different minislots may use different modulation types.

4.4 Receiving Data Input and Providing Data Output

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

4.4.1 RF Input Protection

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

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

4.4.2 Input from Noise Sources

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

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

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

The noise source is controlled in the "Output" settings, see "Noise Source" on page 88

4.4.3 Receiving and Providing Trigger Signals

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

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

External trigger as input

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

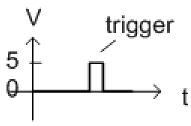
Trigger output

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

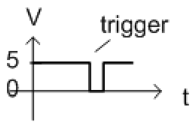
The trigger signal can be output by the R&S FSW automatically, or manually by the user. If it is provided automatically, a high signal is output when the R&S FSW has triggered due to a measurement start ("Device Triggered"), or when the R&S FSW is ready to receive a trigger signal after a measurement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

Manual triggering

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



low-level constant, high-level trigger



high-level constant, low-level trigger

4.4.4 IF and Video Signal Output

The measured IF signal or displayed video signal (i.e. the filtered and detected IF signal) can be provided at the IF/VIDEO/DEMOD or IF OUT 2 GHZ output connector.

The **video output** is a signal of 1 V. It can be used, for example, to control demodulated audio frequencies.

The **IF output** is a signal of the measured level at a specified frequency.

The IF OUT 2 GHZ output is a signal with a bandwidth of 2 GHz at the frequency 2 GHz. This output is only available if the IF OUT 2 GHZ output connector is installed (see Prerequisites below).

If the optional 2 GHz bandwidth extension (R&S FSW-B2000) is installed and active, this is the *only* setting available for IF output.

Restrictions

Note the following restrictions for IF output:

- IF and video output is only available in the time domain (zero span).
- For I/Q data, only IF output is available.

- IF output is not available if any of the following conditions apply:
  – The optional Digital Baseband Interface is active (for input or output)
  – MSRT operating mode is active
  – A wideband extension is used (hardware options R&S FSW-B160/-B320/-B500/-B512; used automatically for bandwidths > 80 MHz; in this case use the IF WIDE OUTPUT connector)
  – The sample rate is larger than 200 MHz (upsampling)

IF WIDE OUTPUT

If a hardware option R&S FSW-B160/-B320/-B500/-B512 for **bandwidth extension** is installed and activated (i.e. for bandwidths > 80 MHz), the IF output is not available at the IF/VIDEO/DEMOD output connector, but rather at the additional **IF WIDE OUTPUT** connector provided by the option.

In this case, the IF output frequency cannot be defined manually, but is determined automatically depending on the center frequency. For details on the used frequencies see the data sheet. The currently used output frequency is indicated in the field otherwise used to define the frequency manually (in the "Output" settings dialog box, see "IF (Wide) Out Frequency" on page 88).

IF 2 GHz Output

For instrument models R&S FSW26/43/50/67/85, the IF output can also be provided at the alternative IF OUT 2 GHZ output connector at a frequency of 2 GHz and **with a bandwidth of 2 GHz**. The IF output can then be analyzed by a different instrument, for example an R&S®RTO oscilloscope.

If IF OUT 2 GHZ output is activated, the measured values are no longer available on the display; thus, the trace data currently displayed on the R&S FSW becomes invalid. A message in the status bar indicates this situation. The message also indicates whether the sidebands of the IF spectrum output are in normal or inverted order compared to the RF signal, which depends on the used center frequency.

Prerequisites

Note the following prerequisites for output to the IF OUT 2 GHZ connector:

- Instrument model R&S FSW26/43/50/67/85; external mixers can be used
- Zero span mode, I/Q Analyzer, or VSA (R&S FSW-K70) application
- Center frequency ≥ 8 GHz

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

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

Reference level

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

Attenuation

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

Amplification

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

Impedance

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

5 Configuration

Access: MODE > "Docsis 3.1"

The default DOCSIS 3.1 I/Q measurement captures the I/Q data from the DOCSIS 3.1 signal and determines various characteristic signal parameters such as the modulation accuracy, spectrum flatness, center frequency tolerance and symbol clock tolerance in just one measurement (see Chapter 3, "Measurements and Result Display", on page 13).

Other parameters specified in the DOCSIS 3.1 standard must be determined in separate measurements (see Chapter 5.4, "Frequency Sweep Measurements", on page 124).

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

- Multiple Measurement Channels and Sequencer Function.................................. 48
- Display Configuration...49
- DOCSIS 3.1 I/Q Measurement (Modulation Accuracy)..50
- Frequency Sweep Measurements... 124

5.1 Multiple Measurement Channels and Sequencer Function

When you activate an application, a new measurement channel is created which determines the measurement settings for that application. These settings include the input source, the type of data to be processed (I/Q or RF data), frequency and level settings, measurement functions etc. If you want to perform the same measurement but with different center frequencies, for instance, or process the same input data with different measurement functions, there are two ways to do so:

- Change the settings in the measurement channel for each measurement scenario. In this case the results of each measurement are updated each time you change the settings and you cannot compare them or analyze them together without storing them on an external medium.
- Activate a new measurement channel for the same application.
  In the latter case, the two measurement scenarios with their different settings are displayed simultaneously in separate tabs, and you can switch between the tabs to compare the results.
  For example, you can activate one DOCSIS 3.1 measurement channel to perform a DOCSIS 3.1 modulation accuracy measurement, and a second channel to perform an OBW measurement using the same DOCSIS 3.1 input source. Then you can monitor all results at the same time in the "MultiView" tab.

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

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

However, you can enable a Sequencer function that automatically calls up each activated measurement channel in turn. This means the measurements configured in the channels are performed one after the other in the order of the tabs. The currently active measurement is indicated by a symbol in the tab label. The result displays of the individual channels are updated in the corresponding tab (as well as the "MultiView") as the measurements are performed. Sequencer operation is independent of the currently *displayed* tab; for example, you can analyze the OBW measurement while the modulation accuracy measurement is being performed by the Sequencer.

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

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

Sequencer State..49
Sequencer Mode..49

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

Remote command:
`SYSTem:SEQuencer` on page 249
`INITiate<n>:SEQuencer:IMMediate` on page 248
`INITiate<n>:SEQuencer:ABORt` on page 248

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

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

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

Remote command:
`INITiate<n>:SEQuencer:MODE` on page 248

5.2 Display Configuration

Access: "Overview" > "Display Config"

or: MEAS > "Display Config"

The measurement results can be displayed using various evaluation methods. All evaluation methods available for the R&S FSW DOCSIS 3.1 application are displayed in the evaluation bar in SmartGrid mode.

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

Up to 16 evaluation methods can be displayed simultaneously in separate windows. The DOCSIS 3.1 evaluation methods are described in Chapter 3, "Measurements and Result Display", on page 13.

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

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

5.3 DOCSIS 3.1 I/Q Measurement (Modulation Accuracy)

Access: MODE > "Docsis 3.1"

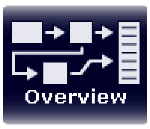
"Overview" > "Select Measurement" > "Modulation Accuracy"

When you activate the DOCSIS 3.1 application, an I/Q measurement of the input signal is started automatically with the default configuration. The "DOCSIS 3.1" menu is displayed and provides access to the most important configuration functions.

The "Span", "Bandwidth", "Lines", and "Marker Functions" menus are not available for DOCSIS 3.1 I/Q measurements.

Multiple access paths to functionality

The easiest way to configure a measurement channel is via the "Overview" dialog box, which is displayed when you select the "Overview" softkey from any DOCSIS 3.1 softkey menu.



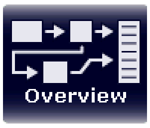
Alternatively, you can access the individual dialog boxes via softkeys from the corresponding menus, or via tools in the toolbars, if available.

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

- Configuration Overview....51
- Signal Description....53
- Input, Output, and Frontend Settings....75
- Trigger Settings....95

- Data Acquisition....102
- Sweep Settings....104
- Parameter Estimation and Tracking....105
- Demodulation (downstream only)....107
- Evaluation Range....109
- Result Configuration....112
- Automatic Settings....123

5.3.1 Configuration Overview



Access: all menus

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

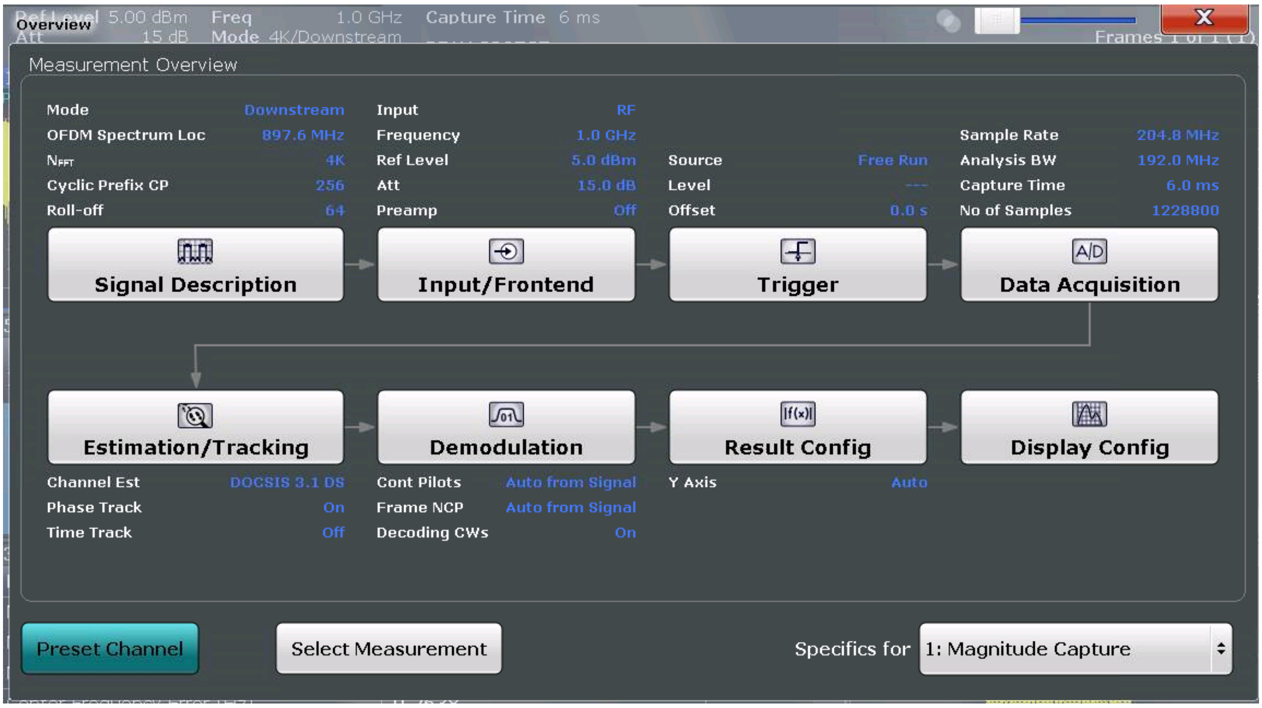


Figure 5-1: Documentation Overview for a DOCSIS 3.1 downstream measurement

The "Overview" not only shows the main measurement settings, it also provides quick access to the main settings dialog boxes. The indicated signal flow shows which parameters affect which processing stage in the measurement. Thus, you can easily configure an entire measurement channel from input over processing to output and analysis by stepping through the dialog boxes as indicated in the "Overview".

The available settings and functions in the "Overview" vary depending on the currently selected measurement. For frequency sweep measurements see Chapter 5.4, "Frequency Sweep Measurements", on page 124.

For the DOCSIS 3.1 I/Q measurement, the "Overview" provides quick access to the following configuration dialog boxes (listed in the recommended order of processing):

1. "Select Measurement"
   See "Select Measurement" on page 52
2. "Signal Description"
   See Chapter 5.3.2, "Signal Description", on page 53
3. "Input/ Frontend"
   See and Chapter 5.3.3, "Input, Output, and Frontend Settings", on page 75
4. "Trigger"
   See Chapter 5.3.4, "Trigger Settings", on page 95
5. "Data Acquisition"
   See Chapter 5.3.5, "Data Acquisition", on page 102
6. "Parameter Estimation and Tracking"
   See Chapter 5.3.7, "Parameter Estimation and Tracking", on page 105
7. "Demodulation" (downstream only)
   See Chapter 5.3.8, "Demodulation (downstream only)", on page 107
8. "Result Configuration"
   See Chapter 5.3.10, "Result Configuration", on page 112
9. "Display Configuration"
   See Chapter 5.2, "Display Configuration", on page 49

To configure settings

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

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

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

Remote command:
`SYSTem:PRESet:CHANnel[:EXECute]` on page 153

Select Measurement
Selects a measurement to be performed.

See Chapter 3, "Measurements and Result Display", on page 13.

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

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

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

5.3.2 Signal Description

Access: "Overview" > "Signal Description"

or: MEAS CONFIG > "Signal Description"

The signal description provides information on the expected input signal.

- Downstream Signal Description....................53
- Upstream Signal Description....................67

5.3.2.1 Downstream Signal Description

Access: "Overview" > "Signal Description" > "Stream Direction": "Downstream"

or: MEAS CONFIG > "Signal Description" > "Stream Direction": "Downstream"

- OFDM Channel Description (Downstream)....................53
- Continuous Pilots and Excluded Subcarrier Assignment....................57
- Codeword / Frame Configuration....................60
- Profile Configuration (Downstream)....................63

OFDM Channel Description (Downstream)

Access: "Overview" > "Signal Description" > "OFDM Channel Description"

or: MEAS CONFIG > "Signal Description" > "OFDM Channel Description": "Down- stream"

The general OFDM channel transmission settings are configured in the "Signal Description" dialog box.

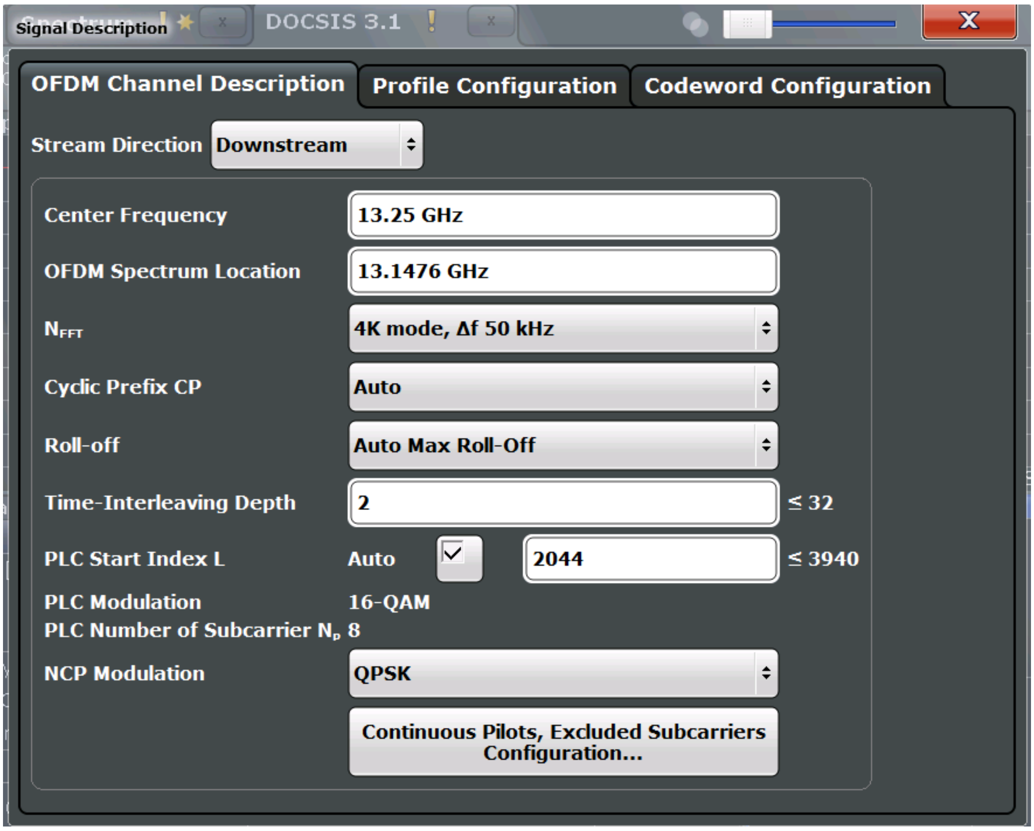


Figure 5-2: OFDM channel description for downstream DOCSIS 3.1 signals

Stream Direction 54
Center frequency 55
OFDM Spectrum Location 55
N_{FFT} (FFT length) 55
Cyclic Prefix CP 55
Roll-off 56
Time-Interleaving Depth 56
PLC Start Index L 56
PLC Modulation 57
PLC Number of Subcarriers (N_p) 57
NCP Modulation 57

Stream Direction

Defines the direction of the signal stream to be analyzed. Various configuration parameters for the DOCSIS 3.1 measurement depend on the stream direction.

"Downstream" (default) Downstream signal (from the CMTS to the cable modems). Requires R&S FSW-K192 option.

"Upstream" Upstream signal (from the cable modems to the CMTS). Requires R&S FSW-K193 option.

Remote command:

`CONFigure:SDIRection` on page 159

Center frequency

Defines the center frequency of the signal in Hertz.

The center frequency of the complete signal depends on the center frequency of the subcarrier 0 of the OFDM channel (f_{sc0}), which defines the beginning of the OFDM spectrum. If the OFDM Spectrum Location is changed, then the general center frequency is also changed, and vice versa.

Remote command:
`[SENSe:]FREQuency:CENTer` on page 200

OFDM Spectrum Location

Specifies the center frequency in Hz of the subcarrier 0 of the OFDM channel (f_{sc0}), which defines the beginning of the OFDM spectrum.

The default value for this setting is derived from the current Center frequency. If the spectrum location is changed, the center frequency is adapted accordingly, and vice versa.

Remote command:
`CONFigure:DS:CHANnel:SPECtrum:FREQuency` on page 159

N_{FFT} (FFT length)

Specifies the length of the FFT defining the OFDM transmission, which corresponds to the number of physical subcarriers.

"4K mode, Δf 50 kHz"
4096 subcarriers at = 50 kHz spacing; FFT length = 4096 samples

"8K mode, Δf 25 kHz"
8192 subcarriers at 25 kHz spacing; FFT length = 8192 samples

Remote command:
`CONFigure:CHANnel:NFFT` on page 156

Cyclic Prefix CP

Length of the configurable cyclic prefix.

The cyclic prefix determines where the useful data starts and prevents inter-symbol interference between multiple OFDM symbols during transmission.

Note: The cyclic prefix must be longer than the Roll-off period.

"AUTO" The length is determined automatically by the R&S FSW DOCSIS 3.1 application and indicated in the dialog box after the next measurement.
If the cyclic prefix is set to "AUTO", the Roll-off is also automatically set to "Auto Max Roll-Off" and cannot be edited.

"192 Samples, 0.9375µs" Useful symbol period starts after 192 samples or 0.9375µs.

"256 Samples, 1.25µs" Useful symbol period starts after 256 samples or 1.25µs.

"512 Samples, 2.5µs" Useful symbol period starts after 512 samples or 2.5µs.

"768 Samples, 3.75µs"	Useful symbol period starts after 768 samples or 3.75 s.
"1024 Samples, 5.0µs"	Useful symbol period starts after 1024 samples or 5.0µs.

Remote command:
`CONFigure:CHANnel:CP` on page 155

Roll-off

Defines the roll-off period for the Tukey raised-cosine window which is applied at the beginning (and end) of an OFDM symbol. The roll-off period defines the steepness of the filter.

The required period depends on the current transmission conditions. The roll-off period can be between 0 µs and 1.25 µs for the downstream.

Note: The roll-off period is integrated in the Cyclic Prefix CP and must be shorter than the Cyclic Prefix CP.
If the Cyclic Prefix CP is set to "AUTO", the roll-off is also automatically set to "Auto Max Roll-Off" and cannot be edited.

"Auto Max Roll-Off"	The maximum possible roll-off period is used automatically.
"0 Samples, 0.0 µs"	No samples in the roll-off period (for no transmit windowing)
"64 Samples, 0.3125 µs"	The roll-off period contains 64 samples and lasts 0.3125 µs.
"128 Samples, 0.625 µs"	The roll-off period contains 128 samples and lasts 0.625 µs.
"192 Samples, 0.9375 µs"	The roll-off period contains 192 samples and lasts 0.9375 µs.
"256 Samples, 1.25 µs"	The roll-off period contains 256 samples and lasts 1.25 µs.

Remote command:
`CONFigure:CHANnel:ROFF` on page 157

Time-Interleaving Depth

Defines the maximum number of delay lines used for time interleaving. The possible depth depends on the N_{FFT} (FFT length).

The maximum depth for 4K mode is 32; for 8K mode it is 16.

Remote command:
`CONFigure:DS:CHANnel:TIDepth` on page 159

PLC Start Index L

Defines the starting subcarrier index of the physical link channel (PLC).

The PLC is located at the same position in each OFDM symbol and consists of several consecutive subcarriers. The information in the PLC can be used by the R&S FSW DOCSIS 3.1 application to determine several of the signal description parameters automatically.

For more information see "Continuous pilots, excluded subcarriers, PLC" on page 35.

If "Auto" is enabled, the start index of the PLC is detected automatically. After successful detection, this field indicates the PLC start index L.

If "Auto" is disabled, the numeric value defined manually is used as the start index.

Note: If you enter a value manually, the "Auto" option is automatically disabled.

Remote command:
`CONFigure:DS:CHANnel:PLC:INDex:AUTO` on page 158
`CONFigure:DS:CHANnel:PLC:INDex` on page 158

PLC Modulation

Indicates the used PLC modulation (for reference only).

16QAM modulation is required by the DOCSIS 3.1 standard.

Remote command:
`CONFigure:DS:CHANnel:PLC:MODulation?` on page 159

PLC Number of Subcarriers (N_p)

Indicates the number of subcarriers used by the PLC (for reference only). The number of subcarriers depends on the N_{FFT} (FFT length) setting.

Remote command:
`CONFigure:DS:CHANnel:PLC:CARRiers?` on page 158

NCP Modulation

Defines the modulation used by the Next Codeword Pointer (NCP).

The following modulation types are supported:
- QPSK
- 16-QAM
- 64-QAM

Remote command:
`CONFigure:DS:CHANnel:NCP:MODulation` on page 157

Continuous Pilots and Excluded Subcarrier Assignment

Access: "Overview" > "Signal Description" > "OFDM Channel Description" > "Continuous Pilots, Excluded Subcarriers Configuration..."

or: MEAS CONFIG > "Signal Description" > "OFDM Channel Description" > "Continuous Pilots, Excluded Subcarriers Configuration..."

Some subcarriers have a specific function and are used identically for all symbols. Such fixed objects in the channel must be configured so that the R&S FSW DOCSIS 3.1 application can distinguish their contents from the useful data. Subcarriers with a special function are configured in the signal description in the "Continuous Pilots and Excluded Subcarrier Assignment" table.

For downstream signals, the first row contains the PLC and is configured automatically according to the PLC Start Index L, and "PLC Number of Subcarriers (N_p)" on page 57 from the Signal Description settings. Therefore the first row providing the PLC info is read only.

Below the table, a modulation vs. subcarrier diagram indicates which channels are defined for which function.

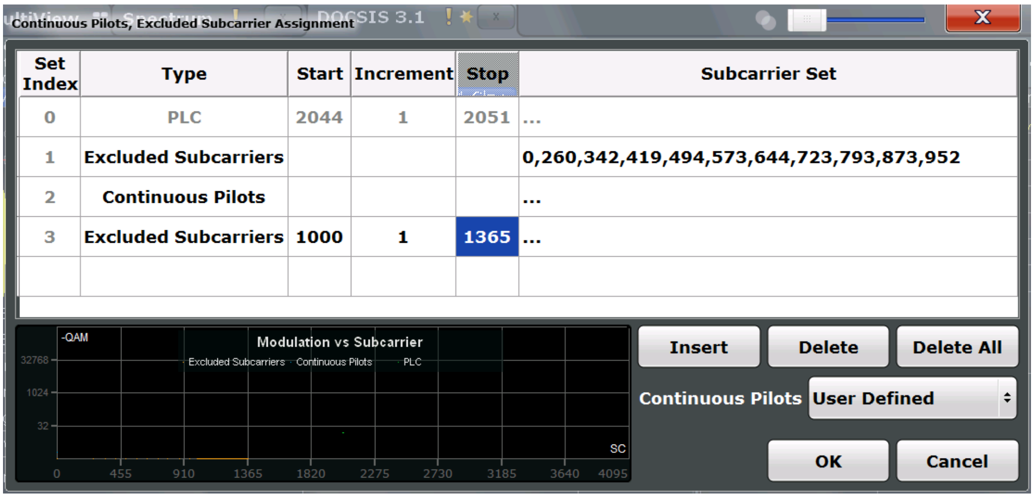


Figure 5-3: Continuous pilots and excluded subcarrier assignment for downstream DOCSIS 3.1 signals

Set Index..58
Type...58
Subcarrier Range (Start / Increment / Stop)..59
Subcarrier Set..59
└ Add...60
└ Remove...60
└ Remove All..60
Insert..60
Delete...60
Delete All..60
Auto Detection : Continuous Pilots (downstream only)..60
OK..60
Cancel...60

Set Index

Continuous line number in configuration table.

Remote command:

`CONFigure:DS:CHANnel:CPES<i>:COUNt?` on page 163

Type

Type of special subcarrier; for upstream signals, only excluded subcarriers are available

"PLC"	Physical link channel (First line only, default, always available)

"Cont. Pilot" Pilot that occurs at the same frequency location in every OFDM symbol, and which is used for frequency and phase synchronization.

Note: As soon as an entry in the table is defined using the "Type": "Continuous Pilots", Auto Detection : Continuous Pilots (downstream only) is automatically set to "User Defined".

"Excluded Subcarrier" Subcarrier that cannot be used because another type of service is using the subcarrier's frequency or a permanent interference is present on the frequency.

Remote command:
CONFigure:DS:CHANnel:CPES<n>:SUBCarrier:TYPE on page 165

Subcarrier Range (Start / Increment / Stop)
Defines a series of subcarriers to be configured identically.

The following restrictions apply:
- "Start" < "Stop"
- "Increment" ≥ 1

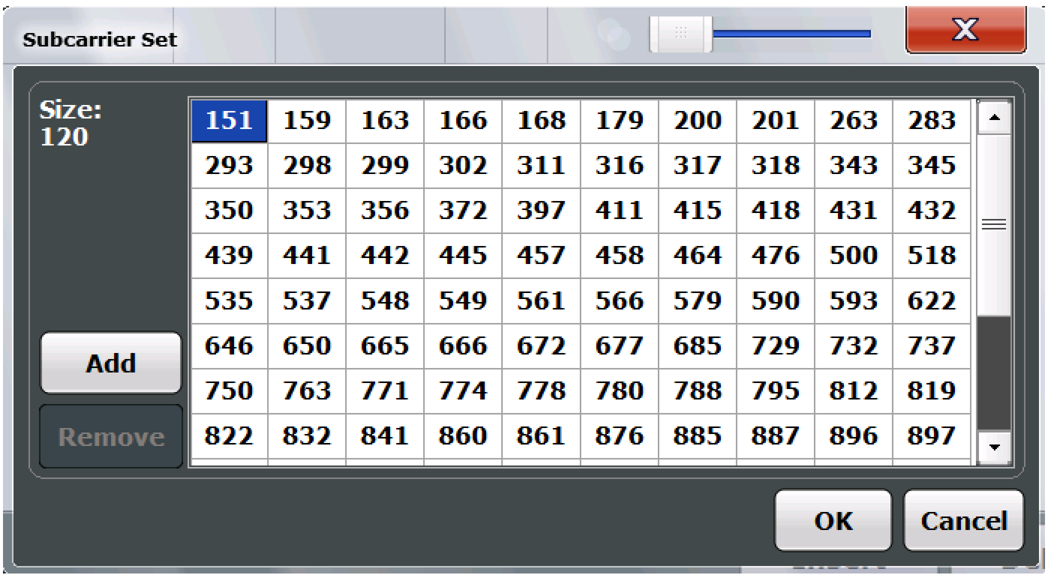
For example: to configure all 10 carriers between subcarriers 2044 and 2053, define:
- "Start" = *2044*
- "Increment" = *1*
- "Stop" = *2053*

Remote command:
CONFigure:DS:CHANnel:CPES<i>:SUBCarrier:STARt on page 164
CONFigure:DS:CHANnel:CPES<i>:SUBCarrier:INCRement on page 164
CONFigure:DS:CHANnel:CPES<i>:SUBCarrier:STOP on page 165

Subcarrier Set
Specifies the (discrete) subcarrier numbers to be configured in the same set.

When you select the input field, an edit dialog is displayed. Enter the individual subcarrier numbers in the dialog, selecting ENTER after each number.

To add further entry fields, select Add.



Tip: to configure a series of subcarriers identically, use the Subcarrier Range (Start / Increment / Stop) settings.

Remote command:
`CONFigure:DS:CHANnel:CPES<i>:SUBCarrier:SET` on page 164

Add ← Subcarrier Set
Adds a new entry to the left of the currently selected entry.

Remove ← Subcarrier Set
Removes the currently selected entry.

Remove All ← Subcarrier Set
Removes all entries in the list.

Insert
Inserts a new line in the table below the currently selected row.

Delete
Deletes the currently selected row.

Delete All
Deletes all lines in the table, except for the default PLC configuration.

Auto Detection : Continuous Pilots (downstream only)
Defines how continuous pilots are detected in the symbols.

If "Auto from Signal" is selected, continuous pilots are detected automatically during demodulation.

If "User Defined" is selected, the pilots must be configured manually in the Continuous Pilots and Excluded Subcarrier Assignment table, using the Type: "Continuous Pilots".

Note: As soon as an entry in the Continuous Pilots and Excluded Subcarrier Assignment table is defined or changed to the "Type": "Continuous Pilots", this setting is automatically set to "User Defined".

Remote command:
`[SENSe:]DEMod:CPILots:AUTO` on page 218

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

Cancel
Closes the dialog box without saving the changes.

Codeword / Frame Configuration

Access: "Overview" > "Signal Description" > "Codeword Configuration" > "Frame Configuration"

or: MEAS CONFIG > "Signal Description" > "Codeword Configuration" > "Frame Configuration"

The useful data that is to be transmitted to the same group of cable modems is summarized into codewords. Codewords are sequentially assigned to frames (subcarriers) and associated with a profile.

A codeword can either be defined by the first and total number of *subcarriers* it is assigned to, or by the first and total number of *symbols* it is assigned to.

For more information see also "Codewords, logical subcarriers, frames, and NCPs" on page 36.

Select the .

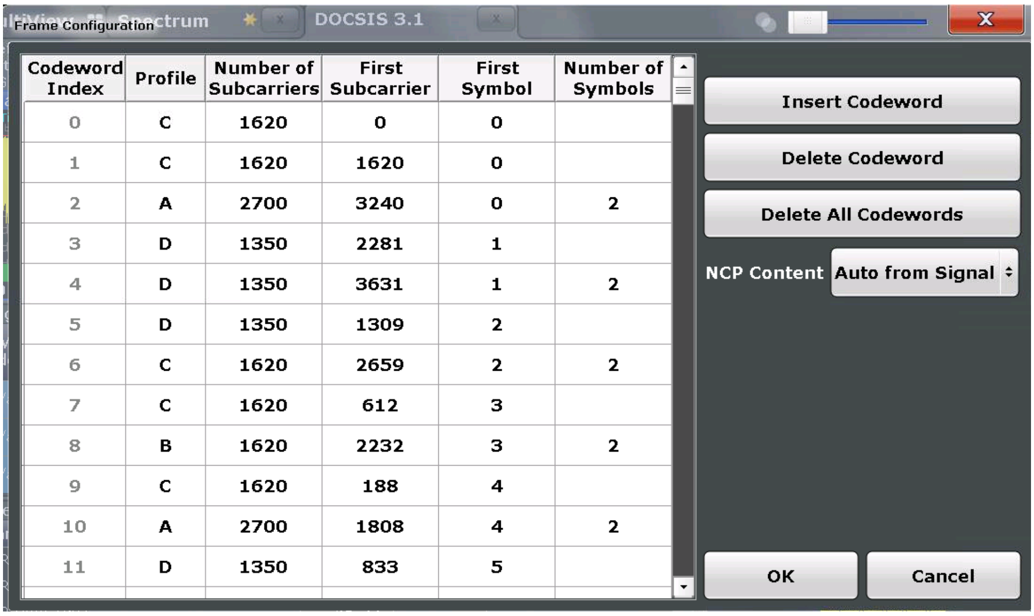


Figure 5-4: Frame/codeword configuration for downstream DOCSIS 3.1 signals

Codeword Index....61
Profile....62
First Subcarrier....62
Number of Subcarriers....62
First Symbol....62
Number of Symbols....62
Insert Codeword....62
Delete Codeword....62
Delete All Codewords....62
Auto Detection: NCP Content....62
OK....63
Cancel....63

Codeword Index

Continuous line number in configuration table.

Remote command:

`CONFigure:DS:CHANnel:FCONfig<i>:COUNt?` on page 176

Profile
One of the active profiles defined in the "Profile List" on page 64, which is assigned to the selected codeword.

For zero-bit loaded codewords, assign the profile "Unused".

Remote command:
`CONFigure:DS:CHANnel:FCONfig<i>:PROFile` on page 177

First Subcarrier
Defines the first logical subcarrier to which the selected codeword is assigned.

Remote command:
`CONFigure:DS:CHANnel:FCONfig<i>:SUBCarrier:STARt` on page 177

Number of Subcarriers
Defines the number of subcarriers to which the selected codeword is assigned.

Remote command:
`CONFigure:DS:CHANnel:FCONfig<i>:SUBCarrier:COUNt` on page 177

First Symbol
Defines the first symbol to which the selected codeword is assigned.

Remote command:
`CONFigure:DS:CHANnel:FCONfig<i>:SYMBol:STARt` on page 178

Number of Symbols
Defines the number of symbols to which the selected codeword is assigned.

Remote command:
`CONFigure:DS:CHANnel:FCONfig<i>:SYMBol:COUNt` on page 178

Insert Codeword
Inserts a new row in the table below the currently selected row.

Delete Codeword
Deletes the currently selected row.

Delete All Codewords
Deletes all rows in the table.

Auto Detection: NCP Content
For each new codeword that starts in a frame, the first subcarrier and the number of subcarriers in total for the codeword is provided as a *Next Codeword Pointer (NCP)*. The contents of the NCP can be configured manually or detected automatically by the R&S FSW DOCSIS 3.1 application.

If "Auto from Signal" is selected, the position of the codewords (NCP content) is detected in the signal automatically during demodulation. The entire table is filled automatically.

If "User Defined" is selected, the frames must be configured manually in the Codeword / Frame Configuration table.

Remote command:
`[SENSe:]DEMod:NCP:AUTO` on page 220

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

Cancel
Closes the dialog box without saving the changes.

Profile Configuration (Downstream)

Access: "Overview" > "Signal Description" > "Profile Configuration"

or: MEAS CONFIG > "Signal Description" > "Profile Configuration"

Profiles define the modulation used by each subcarrier. For each set of modems with similar transmission conditions, a profile can then be assigned (see "Codeword / Frame Configuration" on page 60).

For more information see also "Subcarriers and profiles" on page 35.

- Profile Management....................63
- Profile Settings: Modulation Subcarrier Assignment....................65
- NCP Profile....................67

Profile Management

Access: "Overview" > "Signal Description" > "Profile Configuration"

or: MEAS CONFIG > "Signal Description" > "Profile Configuration"

A profile is a set of parameters that defines how information is transmitted from a CMTS to a cable modem, or from a cable modem to a CMTS.

Up to 16 different profiles can be defined and assigned to a specific block of data. Profiles that contain a configuration for at least one subcarrier are considered to be active, indicated by black text. Empty profiles are inactive, indicated by gray text.

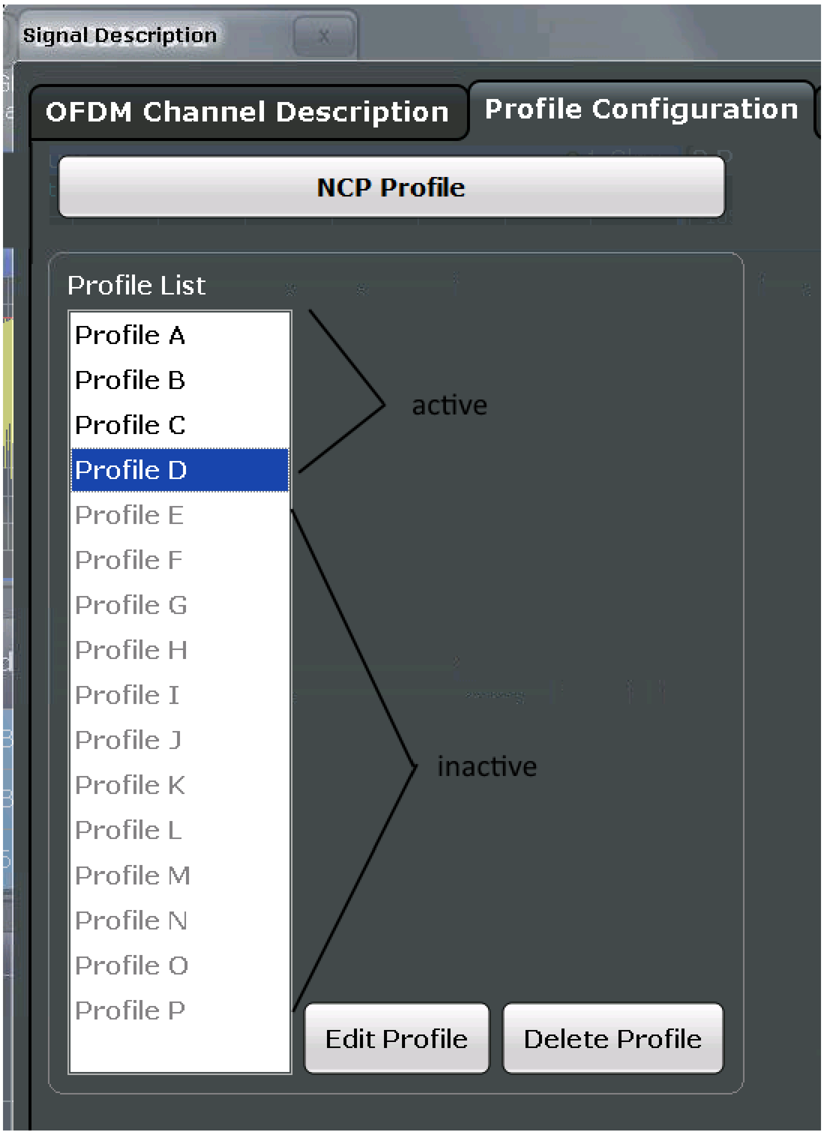


Figure 5-5: Profile configuration for downstream DOCSIS 3.1 signals

Profile List.. 64
Edit Profile..64
Delete Profile...65

Profile List

Up to 16 different profiles can be defined and assigned to a specific set of subcarriers. Profiles that contain a configuration for at least one subcarrier are considered to be active, indicated by black text. Empty profiles are inactive, indicated by gray text.

Remote command:

`CONFigure:DS:CHANnel:PCONfig<i>:SELect` on page 171

Edit Profile

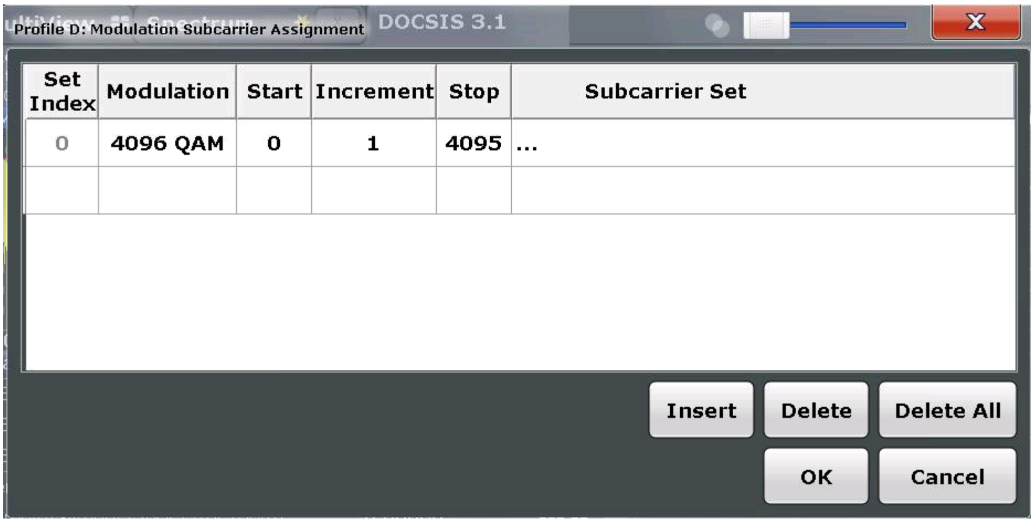
Displays the "Modulation Subcarrier Assignment" dialog box for the selected profile. For details see "Profile Settings: Modulation Subcarrier Assignment" on page 65.

Delete Profile
Deletes the currently selected profile in the "Modulation Subcarrier Assignment" list.

Profile Settings: Modulation Subcarrier Assignment

Access: "Overview" > "Signal Description" > "Profile Configuration" > "Edit Profile"

or: MEAS CONFIG > "Signal Description" > "Profile Configuration" > "Edit Profile"



Set Index....65
Modulation....65
Start / Increment / Stop....66
Subcarrier Set....66
└ Add....67
└ Remove....67
Insert....67
Delete....67
Delete All....67
OK....67
Cancel....67

Set Index
Continuous line number in configuration table.

Remote command:
`CONFigure:DS:CHANnel:PCONfig<i>:COUNt?` on page 171
`CONFigure:DS:CHANnel:NCP:PCONfig<i>:COUNt?` on page 168

Modulation
Defines the modulation used by the specified subcarriers.

For the NCP profile, zero bit modulation is used for all entries except the index 0, whose modulation depends on the NCP Modulation setting and cannot be edited here.

Remote command:
CONFigure:DS:CHANnel:PCONfig<i>:SUBCarrier:MODulation on page 173
CONFigure:DS:CHANnel:NCP:PCONfig<i>:SUBCarrier:MODulation
on page 169

Start / Increment / Stop

Defines a series of subcarriers to be configured identically.

The following restrictions apply:

- "Start" < "Stop"
- "Increment" ≥ 1

For example: to configure all 10 carriers between subcarriers 2044 and 2053, define:

- "Start" = *2044*
- "Increment" = *1*
- "Stop" = *2053*

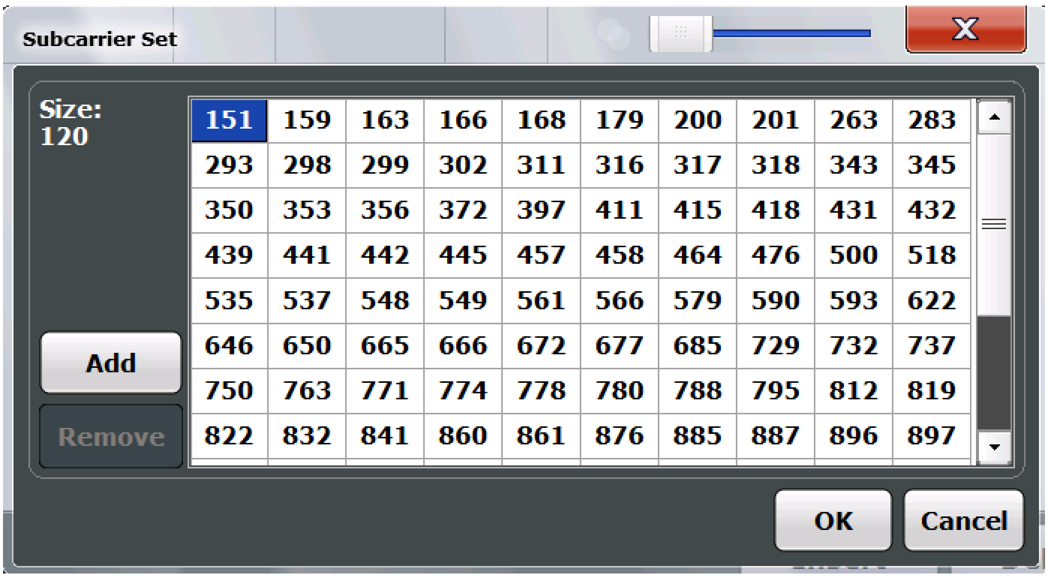
Remote command:
CONFigure:DS:CHANnel:PCONfig<i>:SUBCarrier:STARt on page 174
CONFigure:DS:CHANnel:PCONfig<i>:SUBCarrier:INCRement on page 172
CONFigure:DS:CHANnel:PCONfig<i>:SUBCarrier:STOP on page 174
CONFigure:DS:CHANnel:NCP:PCONfig<i>:SUBCarrier:STARt on page 170
CONFigure:DS:CHANnel:NCP:PCONfig<i>:SUBCarrier:INCRement
on page 169
CONFigure:DS:CHANnel:NCP:PCONfig<i>:SUBCarrier:STOP on page 170

Subcarrier Set

Specifies the (discrete) subcarrier numbers to be configured identically.

When you select the input field, an edit dialog is displayed. Enter the individual subcarrier numbers in the dialog, selecting ENTER after each number.

To add further entry fields, select Add .



Tip: to configure a series of subcarriers identically, use the Subcarrier Range (Start / Increment / Stop) settings.

Remote command:
`CONFigure:DS:CHANnel:PCONfig<i>:SUBCarrier:SET` on page 173
`CONFigure:DS:CHANnel:NCP:PCONfig<i>:SUBCarrier:SET` on page 170

Add ← Subcarrier Set
Adds a new entry to the left of the currently selected entry.

Remove ← Subcarrier Set
Removes the currently selected entry.

Insert
Inserts a new line in the table below the currently selected row.

Delete
Deletes the currently selected row.

Delete All
Deletes all lines in the table.

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

Cancel
Closes the dialog box without saving the changes.

NCP Profile

Access: "Overview" > "Signal Description" > "Profile Configuration" > "NCP Profile"

or: MEAS CONFIG > "Signal Description" > "Profile Configuration" > "NCP Profile"

The modulation used by the subcarriers for the NCP is defined in a separate profile, but in the same way as all other profiles (see "Profile Settings: Modulation Subcarrier Assignment" on page 65). However, the following restrictions apply:

- The entry with the index 0 is not editable. It is defined for the subcarriers from 0 to N_{FFT}-1, in steps of 1.
  The modulation depends on the NCP Modulation setting and cannot be edited in the "Profile" dialog box.
- For all other entries, zero bit modulation is used.

5.3.2.2 Upstream Signal Description

Access: "Overview" > "Signal Description" > "Stream Direction": "Upstream"

or: MEAS CONFIG > "Signal Description" > "Stream Direction"

- OFDM Channel Description (Upstream)....................68
- Excluded Subcarrier Assignment....................71
- Profile Configuration (Upstream)....................74

OFDM Channel Description (Upstream)

Access: "Overview" > "Signal Description" > "OFDM Channel Description"

or: MEAS CONFIG > "Signal Description" > "OFDM Channel Description"

The general OFDM channel transmission settings are configured in the "Signal Description" dialog box.

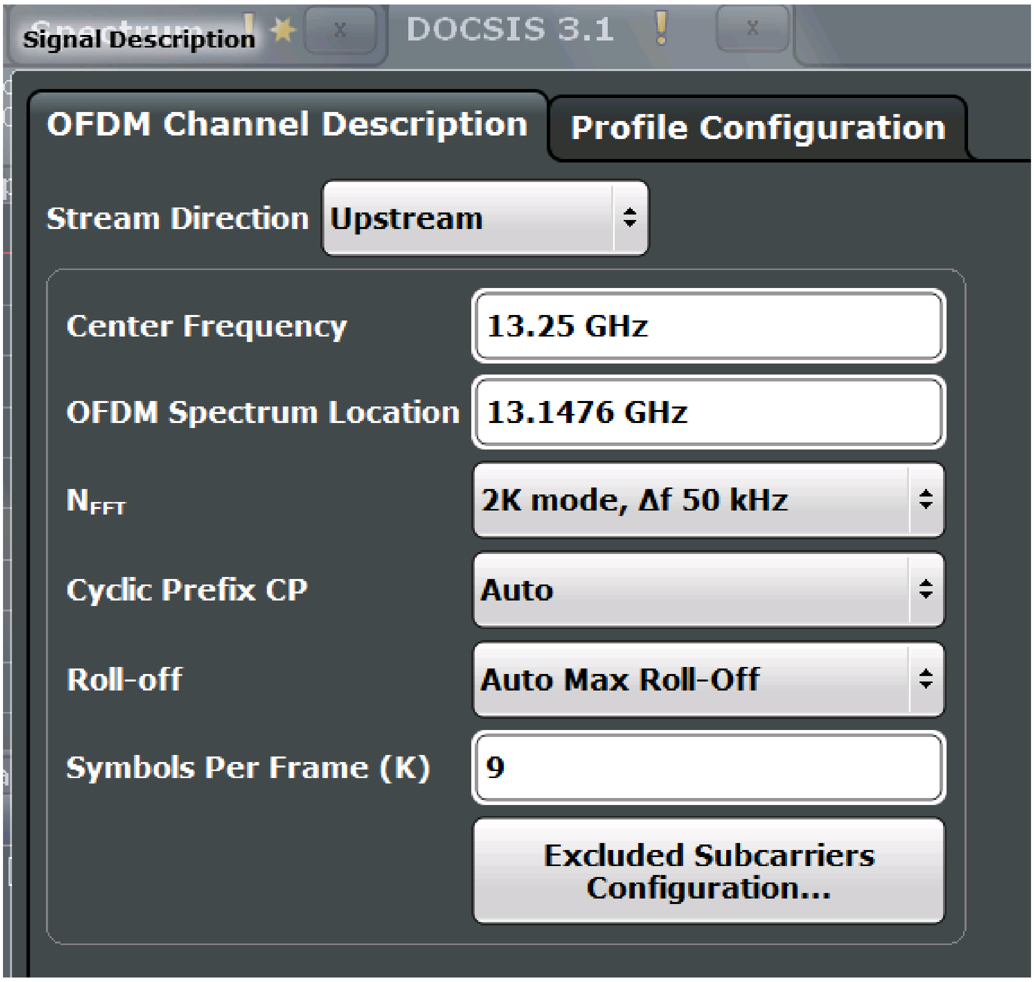


Figure 5-6: OFDM channel description for upstream DOCSIS 3.1 signals

Stream Direction....................68
Center frequency....................69
OFDM Spectrum Location....................69
N_{FFT} (FFT length)....................69
Cyclic Prefix CP....................69
Roll-off....................70
Symbols Per Frame (K)....................71

Stream Direction

Defines the direction of the signal stream to be analyzed. Various configuration parameters for the DOCSIS 3.1 measurement depend on the stream direction.

"Downstream" (default) Downstream signal (from the CMTS to the cable modems). Requires R&S FSW-K192 option.

"Upstream" Upstream signal (from the cable modems to the CMTS). Requires R&S FSW-K193 option.

Remote command:
CONFigure:SDIRection on page 159

Center frequency

Defines the center frequency of the signal in Hertz.

The center frequency of the complete signal depends on the center frequency of the subcarrier 0 of the OFDM channel (f_{sc0}), which defines the beginning of the OFDM spectrum. If the OFDM Spectrum Location is changed, then the general center frequency is also changed, and vice versa.

Remote command:
[SENSe:]FREQuency:CENTer on page 200

OFDM Spectrum Location

Specifies the center frequency in Hz of the subcarrier 0 of the OFDM channel (f_{sc0}), which defines the beginning of the OFDM spectrum.

The default value for this setting is derived from the current Center frequency. If the spectrum location is changed, the center frequency is adapted accordingly, and vice versa.

Remote command:
CONFigure:US:CHANnel:SPECtrum:FREQuency on page 162

N_{FFT} (FFT length)

Specifies the length of the FFT defining the OFDM transmission, which corresponds to the number of physical subcarriers.

"2K mode, Δf 50 kHz"
2048 subcarriers at = 50 kHz spacing; FFT length = 2048 samples

"4K mode, Δf 25 kHz"
4096 subcarriers at = 25 kHz spacing; FFT length = 4096 samples

Remote command:
CONFigure:CHANnel:NFFT on page 156

Cyclic Prefix CP

Length of the configurable cyclic prefix.

The cyclic prefix determines where the useful data starts and allows the application to detect delay spreads during transmission. The longer the delay spread, the longer the CP must be.

Note: The cyclic prefix must be longer than the Roll-off period.

"AUTO" The length is determined automatically by the R&S FSW DOCSIS 3.1 application and indicated in the dialog box after the next measurement.

"96 Samples, 0.9375µs"	Useful symbol period starts after 96 samples or 0.9375 µs.
"128 Samples, 1.25µs"	Useful symbol period starts after 128 samples or 1.25 µs.
"160 Samples, 1.5625µs"	Useful symbol period starts after 160 samples or 1.5625 µs.
"192 Samples, 1.875µs"	Useful symbol period starts after 192 samples or 1.875µs.
"224 Samples, 2.1875µs"	Useful symbol period starts after 224 samples or 2.1875 µs.
"256 Samples, 2.5µs"	Useful symbol period starts after 256 samples or 2.5µs.
"288 Samples, 2.8125µs"	Useful symbol period starts after 288 samples or 2.8125 µs.
"320 Samples, 3.125µs"	Useful symbol period starts after 320 samples or 3.125 µs.
"384 Samples, 3.75µs"	Useful symbol period starts after 384 samples or 3.75 µs.
"512 Samples, 5.0µs"	Useful symbol period starts after 512 samples or 5.0µs.
"640 Samples, 6.25µs "	Useful symbol period starts after 640 samples or 6.25 µs.

Remote command:
CONFigure:CHANnel:CP on page 160
FETCh:CP? on page 254

Roll-off

Defines the roll-off period for the Tukey raised-cosine window which is applied at the beginning (and end) of an OFDM symbol. The roll-off period defines the steepness of the filter.

The required period depends on the current transmission conditions. The roll-off period can be between 0 µs and 2.1875 µs for the upstream.

Note: The roll-off period is integrated in the Cyclic Prefix CP and must be shorter than the Cyclic Prefix CP.

"Auto Max Roll-Off"	The maximum possible roll-off period is used automatically.
"0 Samples, 0.0 µs"	No samples in the roll-off period (for no transmit windowing)
"32 Samples, 0.3125µs"	The roll-off period contains 64 samples and lasts 0.3125 µs.
"64 Samples, 0.625 µs"	The roll-off period contains 128 samples and lasts 0.625 µs.
"96 Samples, 0.9375 µs"	The roll-off period contains 192 samples and lasts 0.9375 µs.

"128 Samples, 1.25 µs"	The roll-off period contains 256 samples and lasts 1.25 µs.
"160 Samples, 1.5625 µs"	The roll-off period contains 256 samples and lasts 1.25 µs.
"192 Samples, 1.875 µs"	The roll-off period contains 256 samples and lasts 1.25 µs.
"224 Samples, 2.1875 µs"	The roll-off period contains 256 samples and lasts 1.25 µs.

Remote command:
`CONFigure:CHANnel:ROFF` on page 157

Symbols Per Frame (K)
Defines the number of symbols per frame to be expected. The available number of symbols per frame varies depending on the used bandwidth and N_{FFT} (FFT length).

Values between 6 and 18 are allowed for 4K mode, values between 6 and 36 for 2K mode.

Remote command:
`CONFigure:US:CHANnel:SYMBols` on page 162

Excluded Subcarrier Assignment

Access: "Overview" > "Signal Description" > "OFDM Channel Description" > "Excluded Subcarriers Configuration"

or: MEAS CONFIG > "Signal Description" > "OFDM Channel Description" > "Excluded Subcarriers Configuration"

Some subcarriers are excluded for transmission. Such subcarriers must be configured so that the R&S FSW DOCSIS 3.1 application can distinguish their contents from the useful data. Excluded subcarriers are configured in the signal description in the "Excluded Subcarrier Assignment" table.

Below the table, a modulation vs. subcarrier diagram indicates which channels are defined as excluded subcarriers.

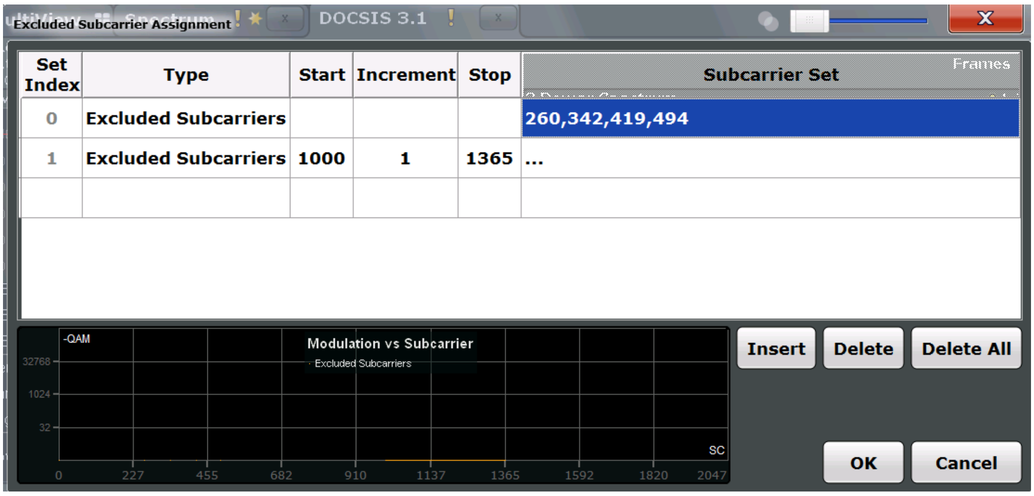


Figure 5-7: Excluded subcarrier assignment for upstream DOCSIS 3.1 signals

Set Index....72
Type....72
Subcarrier Range (Start / Increment / Stop)....72
Subcarrier Set....73
└ Add....73
└ Remove....73
Inserting a line....73
Deleting a line....73
Deleting the entire table....74
OK....74
Cancel....74

Set Index

Indicates the continuous line number in the configuration table.

Remote command:
`CONFigure:US:CHANnel:ESUB<i>:COUNt?` on page 166

Type

Defines the type of special subcarrier.

"Excluded Subcarrier" Subcarrier that cannot be used because another type of service is using the subcarrier's frequency or a permanent ingressor is present on the frequency.

Remote command:
`CONFigure:US:CHANnel:ESUB<i>:SUBCarrier:TYPE?` on page 168

Subcarrier Range (Start / Increment / Stop)

Defines a series of subcarriers to be configured identically.

The following restrictions apply:
- "Start" < "Stop"
- "Increment" ≥ 1

For example: to configure all 10 carriers between subcarriers 2044 and 2053, define:

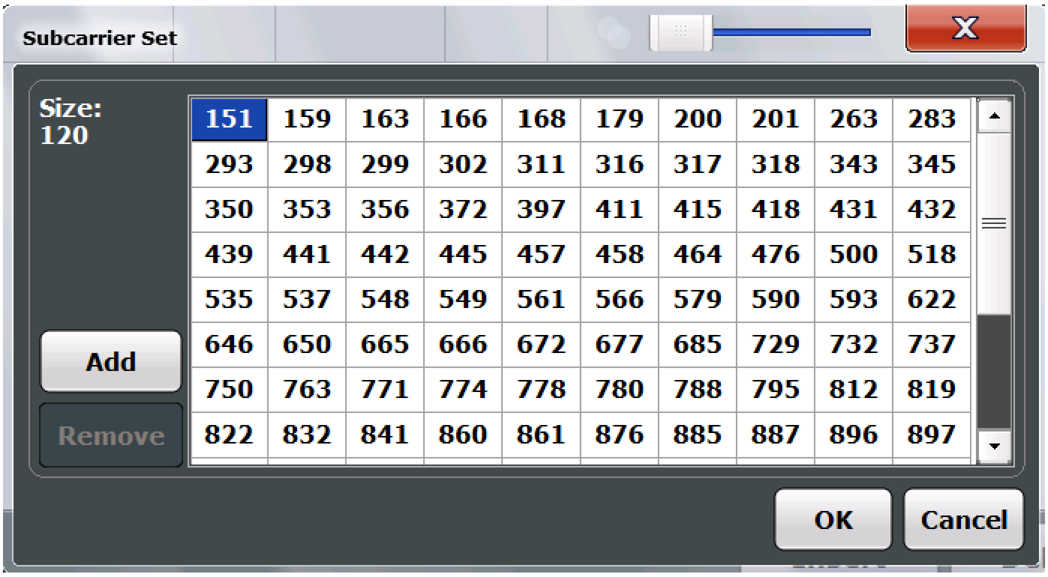
- "Start" = *2044*
- "Increment" = *1*
- "Stop" = *2053*

Remote command:
`CONFigure:US:CHANnel:ESUB<i>:SUBCarrier:STARt` on page 167
`CONFigure:US:CHANnel:ESUB<i>:SUBCarrier:INCRement` on page 166
`CONFigure:US:CHANnel:ESUB<i>:SUBCarrier:STOP` on page 167

Subcarrier Set
Specifies the (discrete) subcarrier numbers to be configured identically.

When you select the input field, an edit dialog is displayed. Enter the individual subcarrier numbers in the dialog, selecting ENTER after each number.

To add further entry fields, select Add.



Tip: to configure a series of subcarriers identically, use the Subcarrier Range (Start / Increment / Stop) settings.

Remote command:
`CONFigure:US:CHANnel:ESUB<i>:SUBCarrier:SET` on page 167

Add ← Subcarrier Set
Adds a new entry to the left of the currently selected entry.

Remove ← Subcarrier Set
Removes the currently selected entry.

Inserting a line
Inserts a new line in the table below the currently selected row.

Deleting a line
Deletes the currently selected row.

Deleting the entire table
Deletes all lines in the table, except for the default PLC configuration.

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

Cancel
Closes the dialog box without saving the changes.

Profile Configuration (Upstream)

Access: "Overview" > "Signal Description" > "Profile Configuration" > "Profile Configuration"

or: MEAS CONFIG > "Signal Description" > "Profile Configuration" > "Profile Configuration"

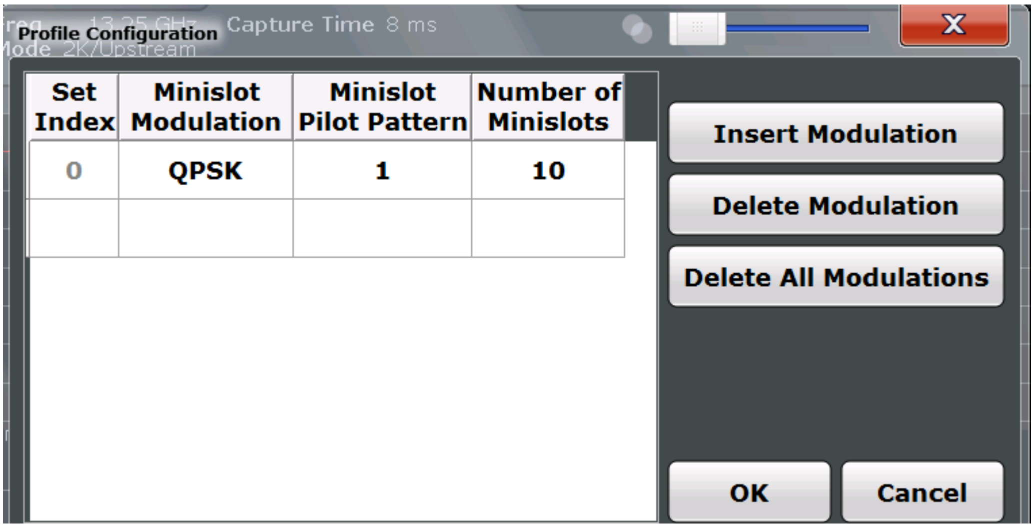


Figure 5-8: Profile configuration for upstream DOCSIS 3.1 signals

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Minislot Modulation......74
Minislot Pilot Pattern......75
Number of Minislots......75
Insert Modulation......75
Delete Modulation......75
Delete All Modulations......75
OK......75
Cancel......75

Set Index
Continuous line number in configuration table.

Minislot Modulation
Defines the modulation used by the specified minislots.

Remote command:
`CONFigure:US:CHANnel:PCONfig<i>:MINislot:MODulation` on page 175

Minislot Pilot Pattern
Defines the pilot pattern used by the specified minislots. Which patterns are available depends on the N_{FFT} (FFT length).

- **2K mode: 1 to 7**
- **4K mode: 8 to 14**

For more information, see "Pilot patterns" on page 40.

Remote command:
`CONFigure:US:CHANnel:PCONfig<i>:MINislot:PPATtern` on page 176

Number of Minislots
Defines the number of minislots for which the modulation is used.

Remote command:
`CONFigure:US:CHANnel:PCONfig<i>:MINislot:COUNt` on page 175

Insert Modulation
Inserts a new line in the table below the currently selected row.

Delete Modulation
Deletes the currently selected row.

Delete All Modulations
Deletes all lines in the table.

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

Cancel
Closes the dialog box without saving the changes.

5.3.3 Input, Output, and Frontend Settings

Access: "Overview" ≥ "Input/Frontend"

or: INPUT/OUTPUT

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

Importing and Exporting I/Q Data
The I/Q data to be analyzed for DOCSIS 3.1 cannot only be captured by the DOCSIS 3.1 application itself, it can also be imported to the application, provided it has the correct format. Furthermore, the analyzed I/Q data from the DOCSIS 3.1 application can be exported for further analysis in external applications.
See Chapter 7.1, "Import/Export Functions", on page 134.

Frequency and amplitude settings are available to configure the frontend of the R&S FSW.

For more information on the use and effects of these settings, see Chapter 4.5, "Preparing the R&S FSW for the Expected Input Signal - Frontend Parameters", on page 46.

- Input Source Settings.....76
- Power Sensor.....82
- Output Settings.....87
- Frequency Settings.....90
- Amplitude Settings.....91

5.3.3.1 Input Source Settings

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

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

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

- Radio Frequency Input.....76
- Digital I/Q Input Settings.....78
- Analog Baseband Input Settings.....80

Radio Frequency Input

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

Radio Frequency State.....77
Input Coupling.....77
Impedance.....77

Direct Path... 77
High-Pass Filter 1...3 GHz.. 78
YIG-Preselector...78

Radio Frequency State

Activates input from the RF INPUT connector.

Remote command:
`INPut:SELect` on page 181

Input Coupling

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

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

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

Remote command:
`INPut:COUPling` on page 179

Impedance

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

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

Remote command:
`INPut:IMPedance` on page 180

Direct Path

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

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

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

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

Remote command:
`INPut:DPATh` on page 179

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

This function requires an additional hardware option.

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

Remote command:
`INPut:FILTer:HPASs[:STATe]` on page 180

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

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

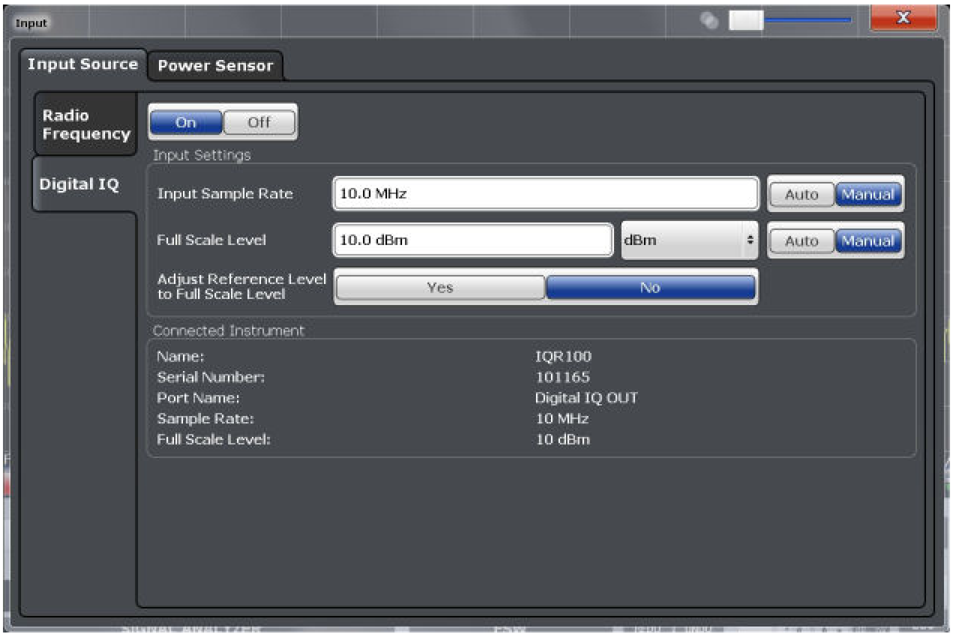
Remote command:
`INPut:FILTer:YIG[:STATe]` on page 180

Digital I/Q Input Settings

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

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

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



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

Digital I/Q Input State....79
Input Sample Rate....79
Full Scale Level....79
Adjust Reference Level to Full Scale Level....80
Connected Instrument....80

Digital I/Q Input State

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

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

Remote command:
`INPut:SELect` on page 181

Input Sample Rate

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

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

The allowed range is from 100 Hz to 10 GHz.

Remote command:
`INPut:DIQ:SRATe` on page 184
`INPut:DIQ:SRATe:AUTO` on page 184

Full Scale Level

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

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

Remote command:
`INPut:DIQ:RANGe[:UPPer]` on page 184
`INPut:DIQ:RANGe[:UPPer]:UNIT` on page 184
`INPut:DIQ:RANGe[:UPPer]:AUTO` on page 183

Adjust Reference Level to Full Scale Level
If enabled, the reference level is adjusted to the full scale level automatically if any change occurs.

Remote command:
`INPut:DIQ:RANGe:COUPling` on page 183

Connected Instrument
Displays the status of the Digital Baseband Interface connection.

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

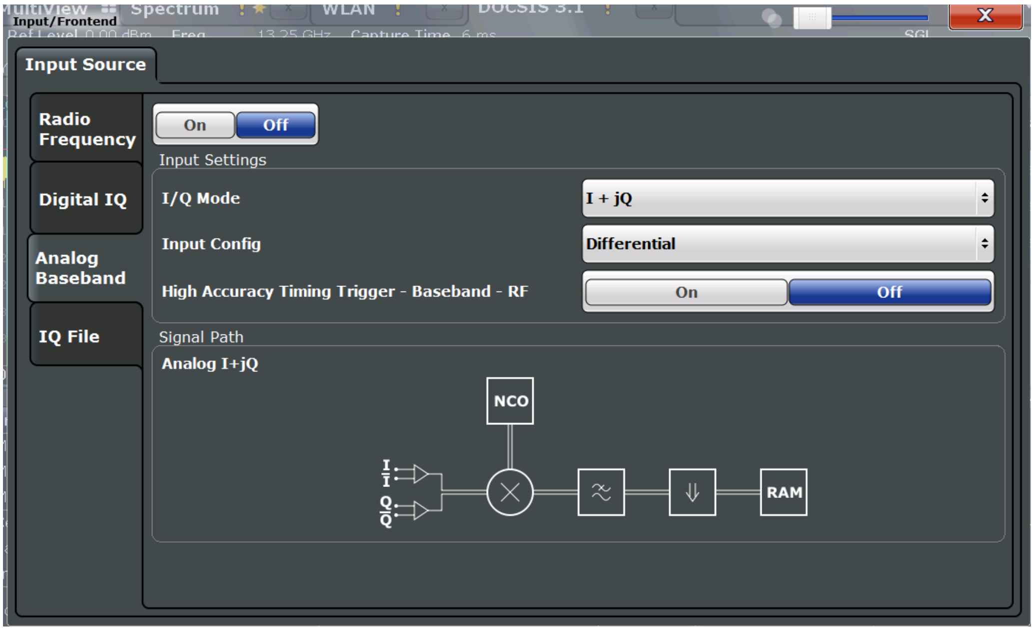
- Name and serial number of the instrument connected to the Digital Baseband Interface
- Used port
- Sample rate of the data currently being transferred via the Digital Baseband Interface
- Level and unit that corresponds to an I/Q sample with the magnitude "1" (Full Scale Level), if provided by connected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

Remote command:
`INPut:DIQ:CDEVice` on page 182

Analog Baseband Input Settings

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

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



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

Analog Baseband Input State..81
I/Q Mode..81
Input Configuration..81
High Accuracy Timing Trigger - Baseband - RF..82
Center Frequency..82

Analog Baseband Input State

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

Remote command:
`INPut:SELect` on page 181

I/Q Mode

Defines the format of the input signal.

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

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

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

Remote command:
`INPut:IQ:TYPE` on page 186

Input Configuration

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

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

"Single Ended" I, Q data only

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

Remote command:
`INPut:IQ:BALanced[:STATe]` on page 185

High Accuracy Timing Trigger - Baseband - RF

Activates a mode with enhanced timing accuracy between analog baseband, RF and external trigger signals.

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

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

Remote command:
`CALibration:AIQ:HATiming[:STATe]` on page 186

Center Frequency

Defines the center frequency for analog baseband input.

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

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

Remote command:
`[SENSe:]FREQuency:CENTer` on page 200

5.3.3.2 Power Sensor

Access: "Overview" ≥ "Input/Frontend" > "Power Sensor"

or: INPUT/OUTPUT > "Power Sensor Config"

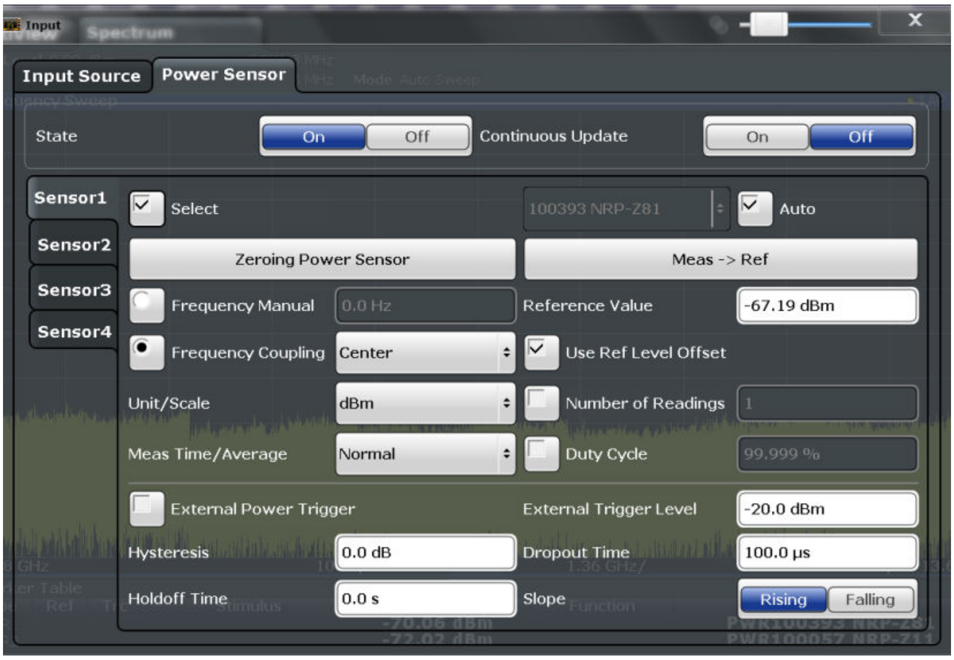
The R&S FSW can also analyze data from a connected power sensor.

For background information on working with power sensors see the R&S FSW User Manual.

Power Sensor Settings

Access: "Overview" > "Input" > "Power Sensor" tab

Each sensor is configured on a separate tab.



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Continuous Value Update......84
Select......84
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Frequency Manual......84
Frequency Coupling......84
Unit/Scale......85
Meas Time/Average......85
Setting the Reference Level from the Measurement (Meas->Ref)......85
Reference Value......85
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Average Count (Number of Readings)......86
Duty Cycle......86
Using the power sensor as an external trigger......86
└ External Trigger Level......86
└ Hysteresis......86
└ Trigger Holdoff......86
└ Drop-Out Time......87
└ Slope......87

State

Switches the power measurement for all power sensors on or off. Note that in addition to this general setting, each power sensor can be activated or deactivated individually by the Select setting on each tab. However, the general setting overrides the individual settings.

Remote command:

`[SENSe:]PMETer<p>[:STATe]` on page 194

Continuous Value Update
If activated, the power sensor data is updated continuously during a sweep with a long sweep time, and even after a single sweep has completed.

This function cannot be activated for individual sensors.

If the power sensor is being used as a trigger (see "Using the power sensor as an external trigger" on page 86), continuous update is not possible; this setting is ignored.

Remote command:
`[SENSe:]PMETer<p>:UPDate[:STATe]` on page 194

Select
Selects the individual power sensor for usage if power measurement is generally activated (State function).

The detected **serial numbers** of the power sensors connected to the instrument are provided in a selection list. For each of the four available power sensor indexes ("Power Sensor 1"..."Power Sensor 4"), which correspond to the tabs in the configuration dialog, one of the detected serial numbers can be assigned. The physical sensor is thus assigned to the configuration setting for the selected power sensor index.

By default, serial numbers not yet assigned are automatically assigned to the next free power sensor index for which "Auto Assignment" is selected.

Alternatively, you can assign the sensors manually by deactivating the "Auto" option and selecting a serial number from the list.

Remote command:
`[SENSe:]PMETer<p>[:STATe]` on page 194
`SYSTem:COMMunicate:RDEVice:PMETer<p>:DEFine` on page 188
`SYSTem:COMMunicate:RDEVice:PMETer<p>:CONFigure:AUTO[:STATe]`
on page 187
`SYSTem:COMMunicate:RDEVice:PMETer:COUNt?` on page 187

Zeroing Power Sensor
Starts zeroing of the power sensor.

Remote command:
`CALibration:PMETer<p>:ZERO:AUTO ONCE` on page 189

Frequency Manual
Defines the frequency of the signal to be measured. The power sensor has a memory with frequency-dependent correction factors. This allows extreme accuracy for signals of a known frequency.

Remote command:
`[SENSe:]PMETer<p>:FREQuency` on page 192

Frequency Coupling
Selects the coupling option. The frequency can be coupled automatically to the center frequency of the instrument or to the frequency of marker 1.

Remote command:
`[SENSe:]PMETer<p>:FREQuency:LINK` on page 192

Unit/Scale
Selects the unit with which the measured power is to be displayed. Available units are dBm, dB, W and %.

If dB or % is selected, the display is relative to the reference value that is defined with either the "Meas -> Ref" setting or the "Reference Value" setting.

Remote command:
`UNIT<n>:PMETer<p>:POWer` on page 195
`UNIT<n>:PMETer<p>:POWer:RATio` on page 195

Meas Time/Average
Selects the measurement time or switches to manual averaging mode. In general, results are more precise with longer measurement times. The following settings are recommended for different signal types to obtain stable and precise results:

"Short"	Stationary signals with high power (> -40dBm), because they require only a short measurement time and short measurement time provides the highest repetition rates.
"Normal"	Signals with lower power or modulated signals
"Long"	Signals at the lower end of the measurement range (<-50 dBm) or Signals with lower power to minimize the influence of noise
"Manual"	Manual averaging mode. The average count is set with the Average Count (Number of Readings) setting.

Remote command:
`[SENSe:]PMETer<p>:MTIMe` on page 192
`[SENSe:]PMETer<p>:MTIMe:AVERage[:STATe]` on page 193

Setting the Reference Level from the Measurement (Meas->Ref)
Sets the currently measured power as a reference value for the relative display. The reference value can also be set manually via the Reference Value setting.

Remote command:
`CALCulate<n>:PMETer<p>:RELative[:MAGNitude]:AUTO ONCE` on page 190

Reference Value
Defines the reference value for relative measurements in the unit dBm.

Remote command:
`CALCulate<n>:PMETer<p>:RELative[:MAGNitude]` on page 189

Use Ref Lev Offset
If activated, takes the reference level offset defined for the analyzer into account for the measured power.

If deactivated, takes no offset into account.

Remote command:
`[SENSe:]PMETer<p>:ROFFset[:STATe]` on page 194

Average Count (Number of Readings)
Defines the number of readings (averages) to be performed after a single sweep has been started. This setting is only available if manual averaging is selected (Meas Time/ Average setting).

The values for the average count range from 0 to 256 in binary steps (1, 2, 4, 8, …). For average count = 0 or 1, one reading is performed. The general averaging and sweep count for the trace are independent from this setting.

Results become more stable with extended average, particularly if signals with low power are measured. This setting can be used to minimize the influence of noise in the power sensor measurement.

Remote command:
`[SENSe:]PMETer<p>:MTIMe:AVERage:COUNt` on page 193

Duty Cycle
Sets the duty cycle to a percent value for the correction of pulse-modulated signals and activates the duty cycle correction. With the correction activated, the sensor calculates the signal pulse power from this value and the mean power.

Remote command:
`[SENSe:]PMETer<p>:DCYCle[:STATe]` on page 191
`[SENSe:]PMETer<p>:DCYCle:VALue` on page 191

Using the power sensor as an external trigger
If activated, the power sensor creates a trigger signal when a power higher than the defined "External Trigger Level" is measured. This trigger signal can be used as an external power trigger by the R&S FSW.

This setting is only available in conjunction with a compatible power sensor.

Remote command:
`[SENSe:]PMETer<p>:TRIGger[:STATe]` on page 197
`TRIG:SOUR PSE`, see `TRIGger[:SEQuence]:SOURce` on page 212

External Trigger Level ← Using the power sensor as an external trigger
Defines the trigger level for the power sensor trigger.

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

Remote command:
`[SENSe:]PMETer<p>:TRIGger:LEVel` on page 197

Hysteresis ← Using the power sensor as an external trigger
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.

Remote command:
`[SENSe:]PMETer<p>:TRIGger:HYSTeresis` on page 196

Trigger Holdoff ← Using the power sensor as an external trigger
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:
[SENSe:]PMETer<p>:TRIGger:HOLDoff on page 196

Drop-Out Time ← Using the power sensor as an external trigger
Defines the time the input signal must stay below the trigger level before triggering again.

Slope ← Using the power sensor as an external trigger
Defines whether triggering occurs when the signal rises to the trigger level or falls down to it.

Remote command:
[SENSe:]PMETer<p>:TRIGger:SLOPe on page 197

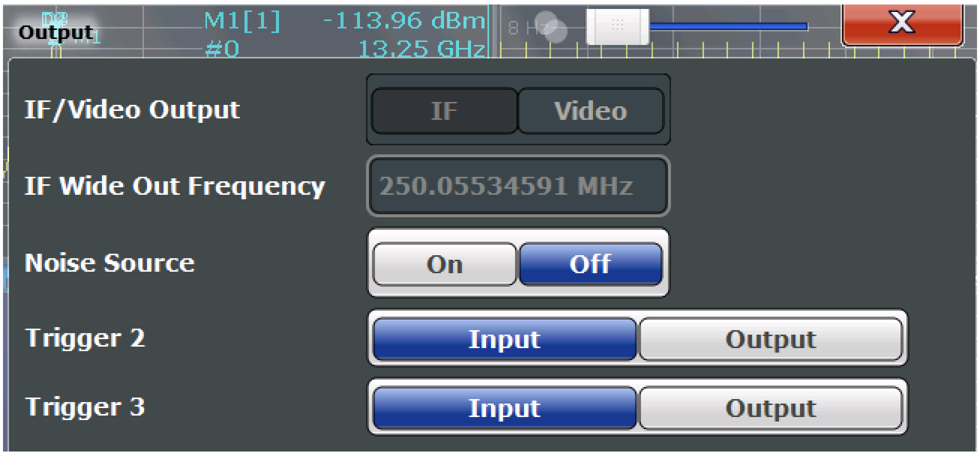
5.3.3.3 Output Settings

Access: INPUT/OUTPUT > "Output"

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

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

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



IF/Video Output......88
IF (Wide) Out Frequency......88
Noise Source......88
Trigger 2/3......88
└ Output Type......89
└ Level......89
└ Pulse Length......89
└ Send Trigger......89

IF/Video Output

Defines the type of signal available at the IF/VIDEO/DEMOD on the rear panel of the R&S FSW.

"IF" The measured IF value is available at the IF/VIDEO/DEMOD output connector.

Remote command:
`OUTPut:IF[:SOURce]` on page 198

IF (Wide) Out Frequency

Defines or indicates the frequency at which the IF signal level is provided at the IF/VIDEO/DEMOD connector if IF/Video Output is set to "IF".

Note: The IF output frequency of the **IF WIDE OUTPUT** connector cannot be defined manually, but is determined automatically depending on the center frequency. It is indicated in this field when the IF WIDE OUTPUT connector is used. For details on the used frequencies, see the data sheet.
The IF WIDE OUTPUT connector is used automatically instead of the IF/VIDEO/DEMOD connector if the bandwidth extension (hardware option R&S FSW-B160 / -U160) is activated (i.e. for bandwidths > 80 MHz).

Remote command:
`OUTPut:IF:IFFRequency` on page 199

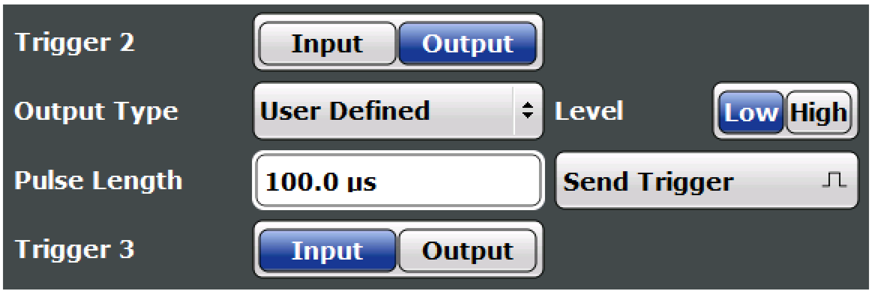
Noise Source

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

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

Remote command:
`DIAGnostic:SERVice:NSOurce` on page 198

Trigger 2/3



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

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

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

(Trigger 1 is INPUT only.)

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

"Input" The signal at the connector is used as an external trigger source by the R&S FSW. Trigger input parameters are available in the "Trigger" dialog box.

"Output" The R&S FSW sends a trigger signal to the output connector to be used by connected devices.
Further trigger parameters are available for the connector.

Remote command:
`OUTPut:TRIGger<port>:DIRection` on page 214

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

"Device Triggered" (Default) Sends a trigger when the R&S FSW triggers.

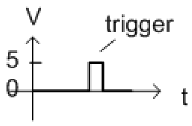
"Trigger Armed" Sends a (high level) trigger when the R&S FSW is in "Ready for trigger" state.
This state is indicated by a status bit in the `STATus:OPERation` register (bit 5), as well as by a low-level signal at the AUX port (pin 9).

"User Defined" Sends a trigger when you select the "Send Trigger" button.
In this case, further parameters are available for the output signal.

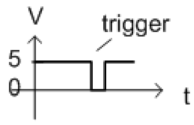
Remote command:
`OUTPut:TRIGger<port>:OTYPe` on page 215

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

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



low-level constant,
high-level trigger



high-level constant,
low-level trigger

Remote command:
`OUTPut:TRIGger<port>:LEVel` on page 214

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

Remote command:
`OUTPut:TRIGger<port>:PULSe:LENGth` on page 215

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

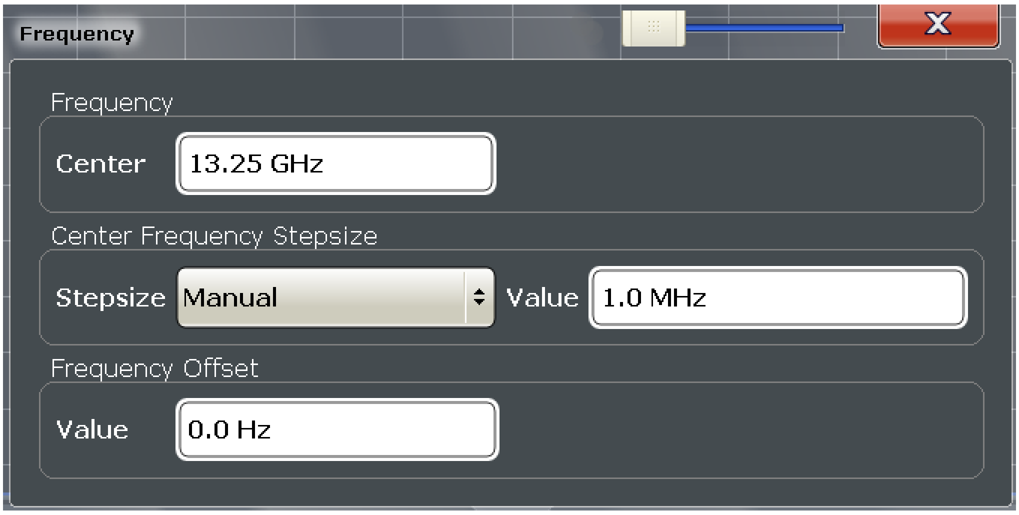
Note that the trigger pulse level is always opposite to the constant signal level defined by the output Level setting. For example, for "Level = High", a constant high signal is output to the connector until you select the "Send Trigger" function. Then, a low pulse is sent.

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

Remote command:
`OUTPut:TRIGger<port>:PULSe:IMMediate` on page 215

5.3.3.4 Frequency Settings

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



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

The center frequency of the complete signal depends on the center frequency of the subcarrier 0 of the OFDM channel (f_{sc0}), which defines the beginning of the OFDM spectrum. If the OFDM Spectrum Location is changed, then the general center frequency is also changed, and vice versa.

Remote command:
`[SENSe:]FREQuency:CENTer` on page 200

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

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

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

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

"Manual" Defines a fixed step size for the center frequency. Enter the step size in the "Value" field.

Remote command:
[SENSe:]FREQuency:CENTer:STEP on page 200

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

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

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

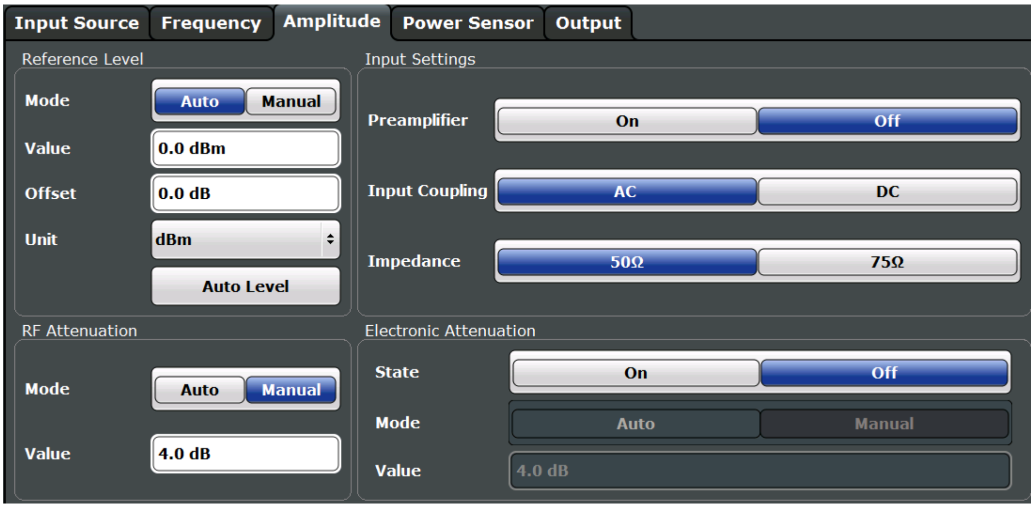
The allowed values range from -100 GHz to 100 GHz. The default setting is 0 Hz.

Remote command:
[SENSe:]FREQuency:OFFSet on page 201

5.3.3.5 Amplitude Settings

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

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



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Reference Level Settings

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

Reference Level Mode ← Reference Level Settings

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

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

Remote command:

`CONF:POW:AUTO ON`, see `CONFigure:POWer:AUTO` on page 202

Reference Level ← Reference Level Settings

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

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

Remote command:

`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel` on page 203

Shifting the Display (Offset) ← Reference Level Settings

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

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

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

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

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

Remote command:

`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel:OFFSet` on page 203

Unit ← Reference Level Settings

The R&S FSW measures the signal voltage at the RF input.

In the default state, the level is displayed at a power level of 1 mW (= dBm). Via the known input impedance (50 Ω or 75 Ω, see "Impedance" on page 77), conversion to other units is possible.

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

Remote command:
`INPut:IMPedance` on page 180
`CALCulate<n>:UNIT:POWer` on page 202

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

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

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

Remote command:
`CONFigure:POWer:AUTO` on page 202

RF Attenuation

Defines the attenuation applied to the RF input.

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

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

Attenuation Mode / Value ← RF Attenuation

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

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

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

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

Remote command:
`INPut:ATTenuation` on page 203
`INPut:ATTenuation:AUTO` on page 203

Using Electronic Attenuation

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

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

Note: Electronic attenuation is not available for stop frequencies (or center frequencies in zero span) > 13.6 GHz.
In "Auto" mode, RF attenuation is provided by the electronic attenuator as much as possible to reduce the amount of mechanical switching required. Mechanical attenuation may provide a better signal-to-noise ratio, however.

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

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

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

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

Remote command:
`INPut:EATT:STATe` on page 204
`INPut:EATT:AUTO` on page 204
`INPut:EATT` on page 204

Input Settings

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

The parameters "Input Coupling" and "Impedance" are identical to those in the "Input" settings, see Chapter 5.3.3.1, "Input Source Settings", on page 76.

Preamplifier ← Input Settings

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

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

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

For R&S FSW8 or 13 models, the following settings are available:

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

Remote command:
`INPut:GAIN:STATe` on page 205
`INPut:GAIN[:VALue]` on page 205

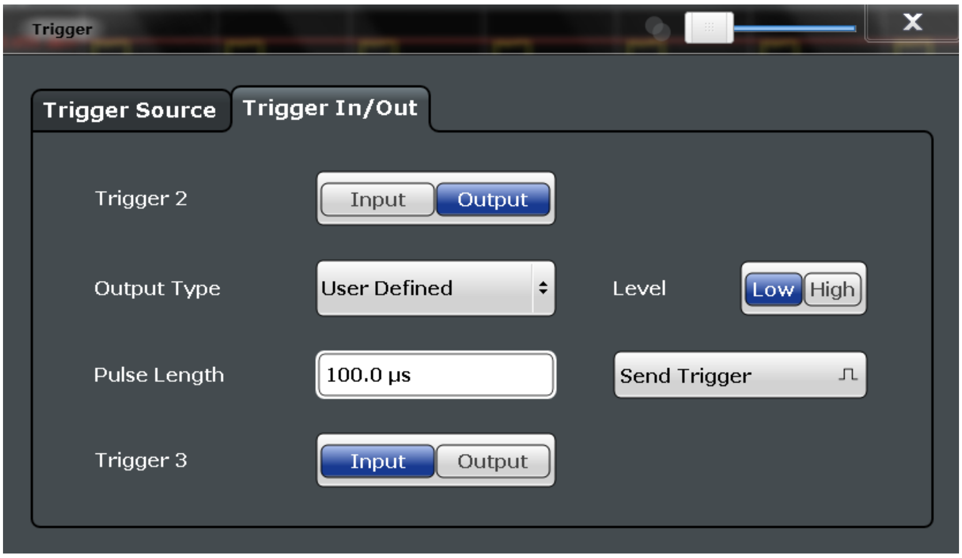
5.3.4 Trigger Settings

Access: "Overview" > "Trigger"

or: TRIG > "Trigger Config"

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

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



For more information on trigger settings and step-by-step instructions on configuring triggered measurements, see the R&S FSW User Manual.

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└ Time....99
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└ Trigger Offset....100
└ Hysteresis....100
└ Trigger Holdoff....100
└ Slope....100
Trigger 2/3....100
└ Output Type....101
└ Level....101
└ Pulse Length....101
└ Send Trigger....101

Trigger Source Settings
The Trigger Source settings define when data is captured.

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

Remote command:
`TRIGger[:SEQuence]:SOURce` on page 212

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

Remote command:
`TRIG:SOUR IMM`, see `TRIGger[:SEQuence]:SOURce` on page 212

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

(See "Trigger Level" on page 99).

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

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

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

"External Trigger 2"
Trigger signal from the TRIGGER 2 INPUT / OUTPUT connector.
Note: Connector must be configured for "Input" in the "Outputs" configuration (see "Trigger 2/3" on page 88).

"External Trigger 3"
Trigger signal from the TRIGGER 3 INPUT/ OUTPUT connector on the rear panel.
Note: Connector must be configured for "Input" in the "Outputs" configuration (see "Trigger 2/3" on page 88).

Remote command:
`TRIG:SOUR EXT`, `TRIG:SOUR EXT2`
`TRIG:SOUR EXT3`
See `TRIGger[:SEQuence]:SOURce` on page 212

Baseband Power ← Trigger Source ← Trigger Source Settings
Defines triggering on the baseband power (for baseband input via the optional Digital Baseband Interface or the optional Analog Baseband interface).

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

Remote command:
`TRIG:SOUR BBP`, see `TRIGger[:SEQuence]:SOURce` on page 212

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

Defines triggering of the measurement directly via the LVDS connector. In the selection list you must specify which general purpose bit (GP0 to GP5) will provide the trigger data.

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

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

(For details on the LVDS connector, see the R&S FSW I/Q Analyzer User Manual.)

Table 5-1: Assignment of general purpose bits to LVDS connector pins

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

Remote command:
`TRIG:SOUR GP0`, see `TRIGger[:SEQuence]:SOURce` on page 212

IF Power ← Trigger Source ← Trigger Source Settings
The R&S 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 bandwidth at the third IF depends on the RBW and sweep type.

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.

It is not available for input from the optional Digital Baseband Interface or the optional Analog 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 data sheet.

Remote command:
`TRIG:SOUR IFP`, see `TRIGger[:SEQuence]:SOURce` on page 212

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

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

The input signal must be in the frequency range between 500 MHz and 8 GHz.

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

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

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

This trigger source is not available for input from the optional Digital Baseband Interface or the optional Analog Baseband Interface . If the trigger source "RF Power" is selected and digital I/Q or analog baseband input is activated, the trigger source is automatically switched to "Free Run".

Remote command:
`TRIG:SOUR RFP`, see `TRIGger[:SEQuence]:SOURce` on page 212

I/Q Power ← Trigger Source ← Trigger Source Settings
This trigger source is not available if the optional Digital Baseband Interface or optional Analog Baseband Interface is used for input. It is also not available for analysis bandwidths ≥ 160 MHz.

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

The trigger bandwidth corresponds to the bandwidth setting for I/Q data acquisition.

Remote command:
`TRIG:SOUR IQP`, see `TRIGger[:SEQuence]:SOURce` on page 212

Power Sensor ← Trigger Source ← Trigger Source Settings
Uses an external power sensor as a trigger source. This option is only available if a power sensor is connected and configured.

Note: For R&S power sensors, the "Gate Mode" *Lvl* is not supported. The signal sent by these sensors merely reflects the instant the level is first exceeded, rather than a time period. However, only time periods can be used for gating in level mode. Thus, the trigger impulse from the sensors is not long enough for a fully gated measurement; the measurement cannot be completed.

Remote command:
`TRIG:SOUR PSE`, see `TRIGger[:SEQuence]:SOURce` on page 212

Time ← Trigger Source ← Trigger Source Settings
Triggers in a specified repetition interval.

Remote command:
`TRIG:SOUR TIME`, see `TRIGger[:SEQuence]:SOURce` on page 212

Trigger Level Mode ← Trigger Source Settings
By default, the optimum trigger level for power triggers is automatically measured and determined at the start of each sweep (for Modulation Accuracy measurements).

In order to define the trigger level manually, switch to "Manual" mode.

Remote command:
`TRIG:SEQ:LEV:POW:AUTO ON`, see `TRIGger:SEQuence:LEVel:POWer:AUTO` on page 211

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

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

Remote command:
`TRIGger[:SEQuence]:LEVel[:EXTernal<port>]` on page 210

Repetition Interval ← Trigger Source Settings
Defines the repetition interval for a time trigger. The shortest interval is 2 ms.

The repetition interval should be set to the exact pulse period, burst length, frame length or other repetitive signal characteristic.

Remote command:
`TRIGger[:SEQuence]:TIME:RINTerval` on page 213

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

Remote command:
`TRIGger[:SEQuence]:DTIMe` on page 209

Trigger Offset ← Trigger Source Settings
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 209

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

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

Remote command:
`TRIGger[:SEQuence]:IFPower:HYSTeresis` on page 210

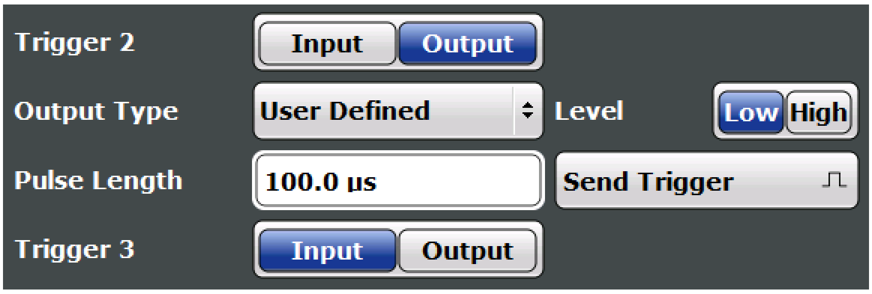
Trigger Holdoff ← Trigger Source Settings
Defines the minimum time (in seconds) that must pass between two trigger events. Trigger events that occur during the holdoff time are ignored.

Remote command:
`TRIGger[:SEQuence]:IFPower:HOLDoff` on page 209

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

Remote command:
`TRIGger[:SEQuence]:SLOPe` on page 212

Trigger 2/3



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

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

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

(Trigger 1 is INPUT only.)

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

"Input"	The signal at the connector is used as an external trigger source by the R&S FSW. Trigger input parameters are available in the "Trigger" dialog box.
"Output"	The R&S FSW sends a trigger signal to the output connector to be used by connected devices. Further trigger parameters are available for the connector.

Remote command:
`OUTPut:TRIGger<port>:DIRection` on page 214

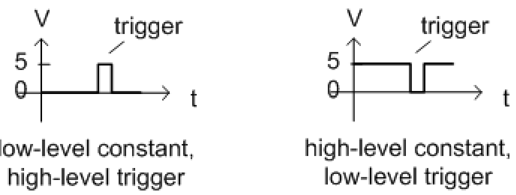
Output Type ← Trigger 2/3
Type of signal to be sent to the output

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

Remote command:
`OUTPut:TRIGger<port>:OTYPe` on page 215

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

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



Remote command:
`OUTPut:TRIGger<port>:LEVel` on page 214

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

Remote command:
`OUTPut:TRIGger<port>:PULSe:LENGth` on page 215

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

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

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

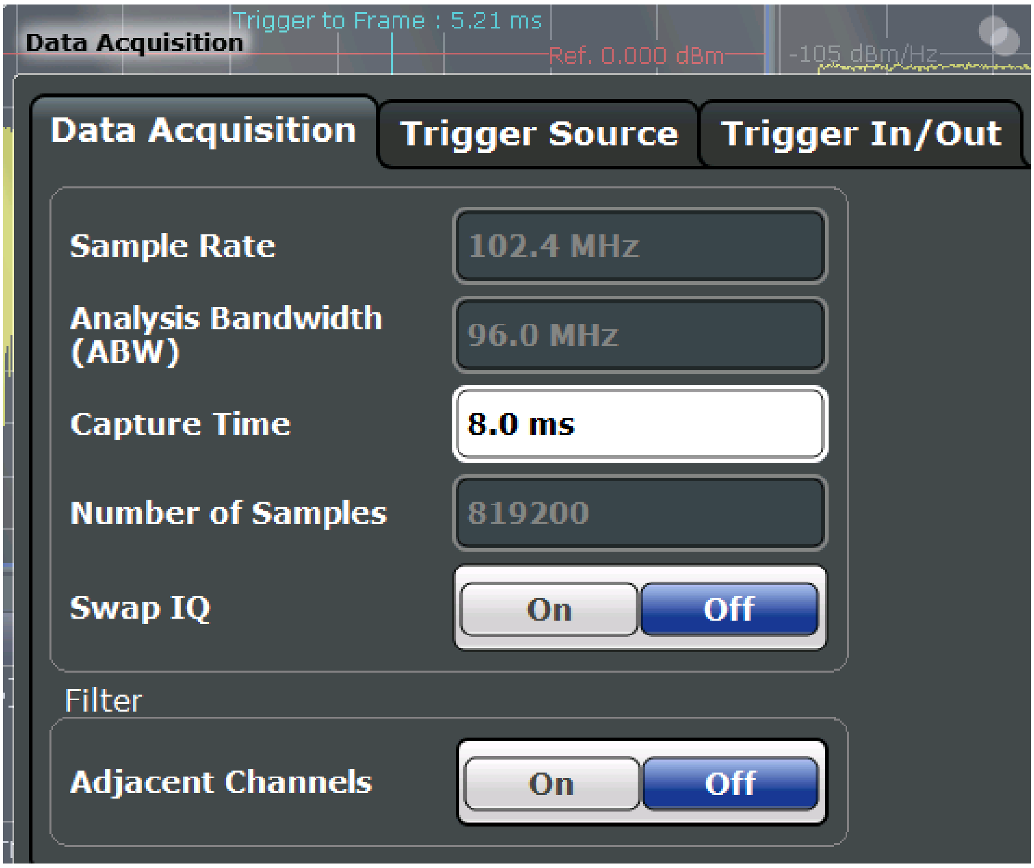
Remote command:
`OUTPut:TRIGger<port>:PULSe:IMMediate` on page 215

5.3.5 Data Acquisition

Access: "Overview" > "Data Acquisition"

or: MEAS CONFIG > "Data Acquisition"

You can define how much and how data is captured from the input signal. For DOCSIS 3.1 measurements, data is always captured with a fixed bandwidth of 192.00 MHz and a fixed sample rate of 204.80 MHz (downstream) or 102.4 MHz (upstream).



Sample Rate.. 103
Analysis Bandwidth (ABW)... 103
Capture Time.. 103

Number of Samples.......... 103
Swap I/Q.......... 103
Filter Adjacent Channels.......... 104

Sample Rate
Specifies the amount of data that is analyzed within the specified Capture Time.

For DOCSIS 3.1 downstream measurements, a fixed sample rate of 204.8 MHz is used.

For DOCSIS 3.1 upstream measurements, a fixed sample rate of 102.4 MHz is used.

Remote command:
`TRACe:IQ:SRATe?` on page 207

Analysis Bandwidth (ABW)
The bandwidth of the signal which is analyzed for the modulation accuracy measurement.

For DOCSIS 3.1 downstream measurements, a fixed bandwidth of 192.0 MHz is used.

For DOCSIS 3.1 upstream measurements, a fixed bandwidth of 96.0 MHz is used.

Remote command:
`TRACe:IQ:BWIDth?` on page 207

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. The capture time may not exceed 470 ms.

If the capture time is changed, the Number of Samples is adapted according to the following equation:

*Number of samples = capture time * sample rate*

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

Number of Samples
The number of samples is indicated for reference only. It is calculated from the Capture Time and the Sample Rate according to the following equation:

*Number of samples = capture time * sample rate*

The maximum number of samples for downstream is thus 96,256,000.

The maximum number of samples for upstream is thus 48,128,000.

Remote command:
`[SENSe:]SWEep:LENGth?` on page 207

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

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

Remote command:
[SENSe:]SWAPiq on page 206

Filter Adjacent Channels
If activated, only the useful signal is analyzed, signal data in adjacent channels is filtered out as much as possible.

This setting improves the signal to noise ratio and thus the MER results for signals with strong or a large number of adjacent channels. In particular, the filter is required for MER tests according to the DOCSIS 3.1 Physical Layer Acceptance Test Plan (see [3]).

However, for some measurements, information on the effects of adjacent channels on the measured signal may be of interest.

Remote command:
INPut:FILTer:ACHannels:STATe on page 206

5.3.6 Sweep Settings

Access: SWEEP

The sweep settings define how the data is measured.

Continuous Sweep/RUN CONT....104
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Continue Single Sweep....105

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

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

Remote command:
INITiate<n>:CONTinuous on page 246

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

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

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

Remote command:
`INITiate<n>[:IMMediate]` on page 247

Refresh

This function is only available if the Sequencer is deactivated and only in single sweep mode.

The data in the capture buffer is re-evaluated by the R&S FSW DOCSIS 3.1 application. This is useful, for example, after evaluation changes have been made.

Remote command:
`INITiate<n>:REFResh` on page 247

Continue Single Sweep

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

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

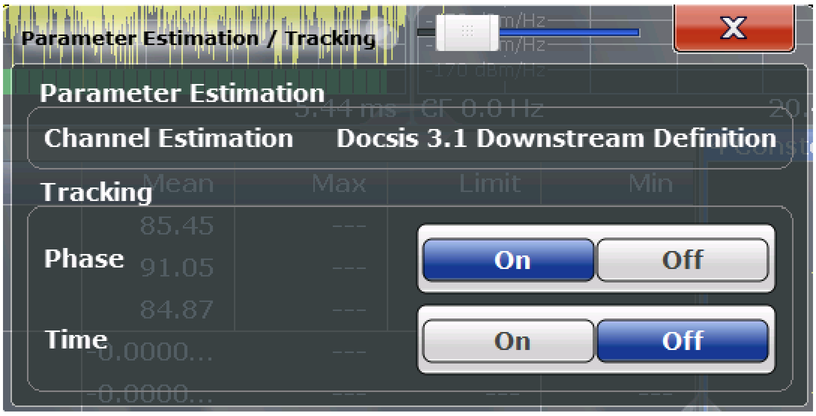
Remote command:
`INITiate<n>:CONMeas` on page 246

5.3.7 Parameter Estimation and Tracking

Access: "Overview" > "Estimation/Tracking"

or: MEAS CONFIG > "Parameter Estimation Tracking"

The channel estimation settings determine which channels are assumed in the input signal. Tracking settings allow for compensation of some transmission effects in the signal.



Channel Estimation....106
Phase Tracking (downstream only)....107
Timing Error Tracking....107

Channel Estimation

The channel estimation settings determine how channels are detected and compensated for in the input signal.

"Pilots only " (Downstream only, default:) An optimal channel estimation using all available pilots is performed, as defined in the DOCSIS 3.1 downstream standard.

"Pilots and Data"
(Downstream only:) An optimal channel estimation using all available pilots and data is performed.

"Off" (Downstream only:) The channel transfer function is not compensated for in the measurement results.

"Minimal Test Receiver Equalization"
(Downstream only:) Minimal test receiver equalization according to the definition in the physical layer standardization document in section 7.5.9.1. The estimated channel impulse response used by the test receiver is limited to half the length of the smallest transmit cyclic prefix.

"Equalized MER"
(Upstream only, default:) Measurements with linear distortions are equalized by the R&S FSW DOCSIS 3.1 application equalizer.

"Unequalized MER"
(Upstream only:) Measurements with linear distortions are not equalized by the R&S FSW DOCSIS 3.1 application equalizer.
Only one carrier amplitude adjustment common for all subcarriers and OFDM symbols in the burst is performed.
Only one timing adjustment is performed, resulting in phase ramp across subcarriers.

"Partial Equalization"

(Upstream only:) Partial equalization according to the definition in the standardization document *ATP TC1409.4 Procedure 3.1*. The partial equalizer is configured such that it does not correct components of the cable modem's impulse response that are longer than +/-200 ns.

Remote command:
`[SENSe:]CHANnel:ESTimation` on page 216

Phase Tracking (downstream only)
Activates or deactivates the compensation for phase drifts. If activated, the measurement results are compensated for phase drifts on a per-symbol basis.

Remote command:
`SENSe:TRACking:PHASe` on page 218

Timing Error Tracking
Activates or deactivates the compensation for timing drift. If activated, the measurement results are compensated for timing error on a per-symbol basis.

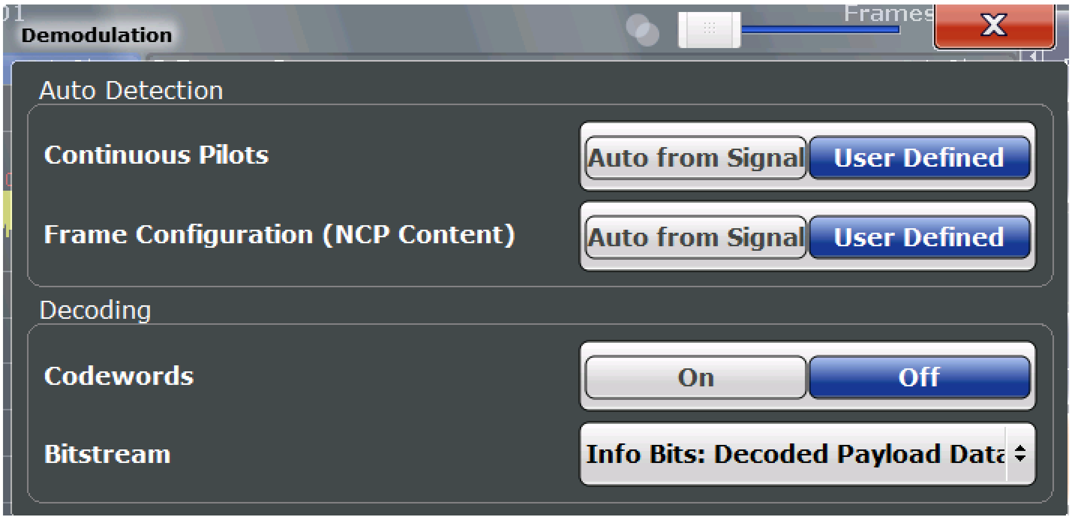
Remote command:
`SENSe:TRACking:TIME` on page 218

5.3.8 Demodulation (downstream only)

Access: "Overview" > "Demodulation"

or: MEAS CONFIG > "Demod"

The demodulation settings define which functions are performed during demodulation (for downstream signals only).



Auto Detection : Continuous Pilots (downstream only)....... 108
Auto Detection: NCP Content....... 108
Codewords....... 108
Bitstream....... 108

Auto Detection : Continuous Pilots (downstream only)
Defines how continuous pilots are detected in the symbols.

If "Auto from Signal" is selected, continuous pilots are detected automatically during demodulation.

If "User Defined" is selected, the pilots must be configured manually in the Continuous Pilots and Excluded Subcarrier Assignment table, using the Type: "Continuous Pilots".

Note: As soon as an entry in the Continuous Pilots and Excluded Subcarrier Assignment table is defined or changed to the "Type": "Continuous Pilots", this setting is automatically set to "User Defined".

Remote command:
`[SENSe:]DEMod:CPILots:AUTO` on page 218

Auto Detection: NCP Content
For each new codeword that starts in a frame, the first subcarrier and the number of subcarriers in total for the codeword is provided as a *Next Codeword Pointer (NCP)*. The contents of the NCP can be configured manually or detected automatically by the R&S FSW DOCSIS 3.1 application.

If "Auto from Signal" is selected, the position of the codewords (NCP content) is detected in the signal automatically during demodulation. The entire table is filled automatically.

If "User Defined" is selected, the frames must be configured manually in the Codeword / Frame Configuration table.

Remote command:
`[SENSe:]DEMod:NCP:AUTO` on page 220

Codewords
Determines whether codewords are decoded or not.

If the codewords are not decoded, calculation time decreases; however, in this case codeword error bits are not evaluated (in the "Signal Content Detailed" on page 27 display).

Remote command:
`[SENSe:]DEMod:DECode:CODewords` on page 220

Bitstream
Determines which bits of the data stream are decoded and then displayed in a Bitstream result display, if activated (see "Bitstream (downstream only)" on page 17).

"Info Bits: Decoded Payload Data"
(Default) Only the bits containing the actual information (the payload bits) are decoded and displayed

"Raw Bits"
Bits mapped to QAM constellation points, undecoded

"Raw Bits Descrambled"
Bits mapped to QAM constellation points, randomization undone, undecoded

"Input Bits LDPC"
Undecoded hard-decisions of the log-likelihood ratio values seen by the LDPC decoder, whole FEC codeword (16200 bits)

"Output Bits LDPC"
Decoded LDPC decoder output, whole FEC codeword (16200 bits)

Remote command:
`[SENSe:]DEMod:DECode:BITStream` on page 219

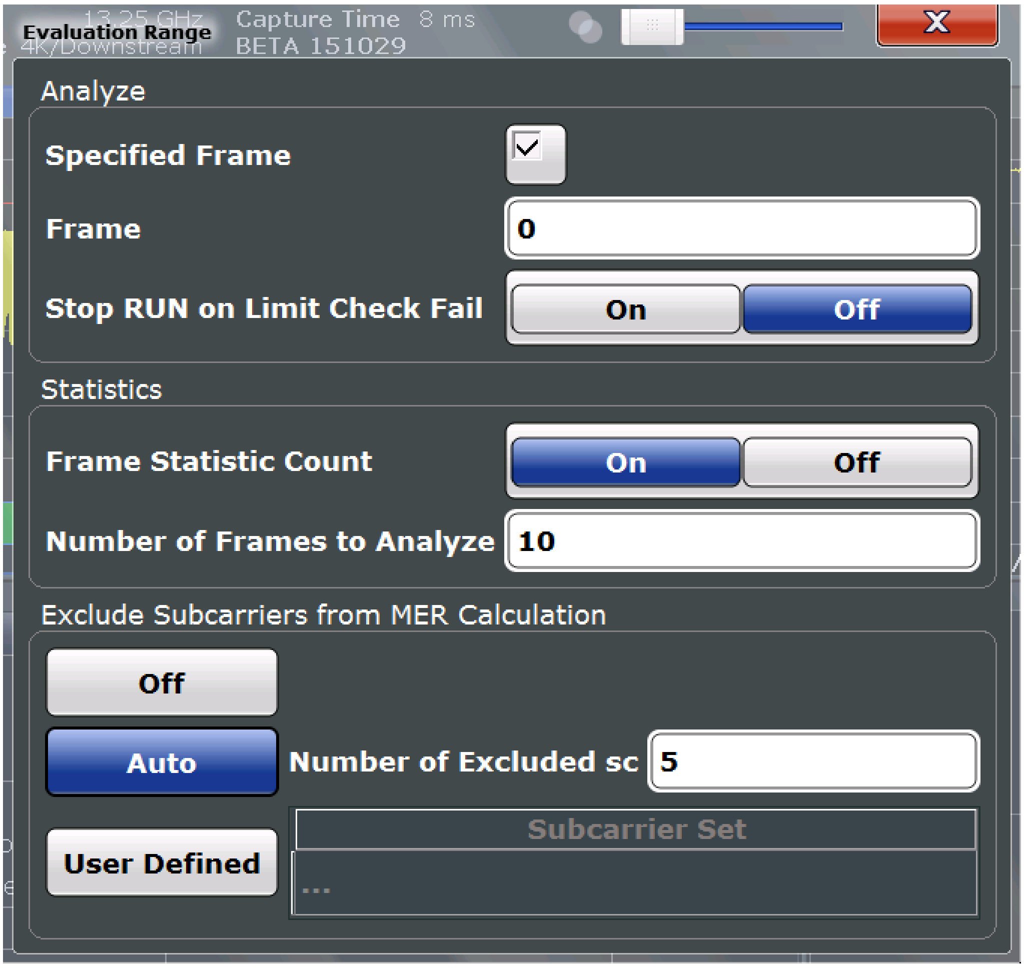
5.3.9 Evaluation Range

Access: MEAS CONFIG > "Evaluation Range"

The evaluation range defines which objects the result evaluation is based on.

As a rule, graphical result displays are always based on a single frame, while the numeric results may include statistical evaluation over several frames.

For more information see "Basis of (Statistical) Evaluation" on page 39.



Evaluation range settings are only available when no measurement is being performed, that is, after a single sweep has finished or when a continuous sweep has been interrupted.

Analyzing a single frame (Specified Frame).......... 110
Selected Frame.......... 110
Stop RUN on Limit Check Fail.......... 110
Frame Statistic Count / Number of Frames to Analyze.......... 111
Excluding Subcarriers from MER Calculation.......... 111
└ Subcarrier Set.......... 111
└ Add.......... 112
└ Remove.......... 112
└ OK.......... 112
└ Cancel.......... 112

Analyzing a single frame (Specified Frame)

If "Specified Frame" is enabled, the DOCSIS 3.1 I/Q results are based on one individual frame only, namely the one defined in Selected Frame. Statistic evaluation for numeric results is not performed, as only one result is available for each frame parameter.

If disabled, all detected frames in the capture buffer (or the Frame Statistic Count / Number of Frames to Analyze, if enabled) are evaluated for numeric results. For graphical results, the first frame to be detected in the capture buffer (frame 0) is automatically selected for evaluation.

Remote command:
`[SENSe:]FRAMe:SELect:STATe` on page 223

Selected Frame

If single frame evaluation is enabled (see Analyzing a single frame (Specified Frame)), the specified frame number is evaluated in all graphical and numeric result displays.

If single frame evaluation is disabled, the first frame to be detected in the capture buffer (frame 0) is automatically selected for evaluation.

Note that only frames in the current capture buffer can be analyzed and displayed individually, even if frames from multiple measurements were captured for statistical evaluation (see "Frame Statistic Count / Number of Frames to Analyze" on page 111).

When you select a new frame, the result displays are updated to show the results for the new evaluation range. The selected frame is marked by a blue bar in the capture buffer display (see "Magnitude Capture" on page 20).

Remote command:
`[SENSe:]FRAMe:SELect` on page 222

Stop RUN on Limit Check Fail

This function is only available for Signal Content Detailed and Signal Content Summary result displays.

If enabled, the measurement is stopped if the limit check fails at any time during the measurement.

The limit check fails if the bit or block error rate after decoding (BER Pre, BER Post, BLER Post, see Table 3-3) is not zero. An error message in the status bar and a status bit in the SYNC register (bit 3) indicate the failure.

Remote command:
`[SENSe:]SWEep:LIMit:ABORt:STATe?` on page 223

Frame Statistic Count / Number of Frames to Analyze
Measurements are performed continuously until the required number of frames are available. The number of captured and required frames in the current measurement are indicated as "Analyzed Frames" in the channel bar. The number in parenthesis indicates the number of frames detected in the current capture buffer. (See "Channel bar information" on page 11).

If the frame statistic count is enabled (and single frame evaluation is disabled, see Analyzing a single frame (Specified Frame)), the specified number of frames is taken into consideration for the statistical evaluation in numeric results. (For graphical results, even if frames from multiple measurements were captured for statistical evaluation, only frames in the current capture buffer can be analyzed and displayed individually).

If disabled, all detected frames in the current capture buffer are evaluated for statistics. Note that in this case, the number of frames contributing to the current results may vary extremely.

Remote command:
`[SENSe:]FRAMe:COUNt:STATe` on page 222
`[SENSe:]FRAMe:COUNt` on page 222

Excluding Subcarriers from MER Calculation
Up to five specific subcarriers can be excluded from modulation error ratio (MER) calculation.

"Off" (Default:) All subcarriers are included in MER calculation.

"Auto" The specified "Number of Excluded sc" with the worst MER are automatically excluded from MER calculation. Up to five subcarriers can be eliminated automatically.
Note: if you enter a value in "Number of Excluded sc", the setting is automatically set to "Auto".

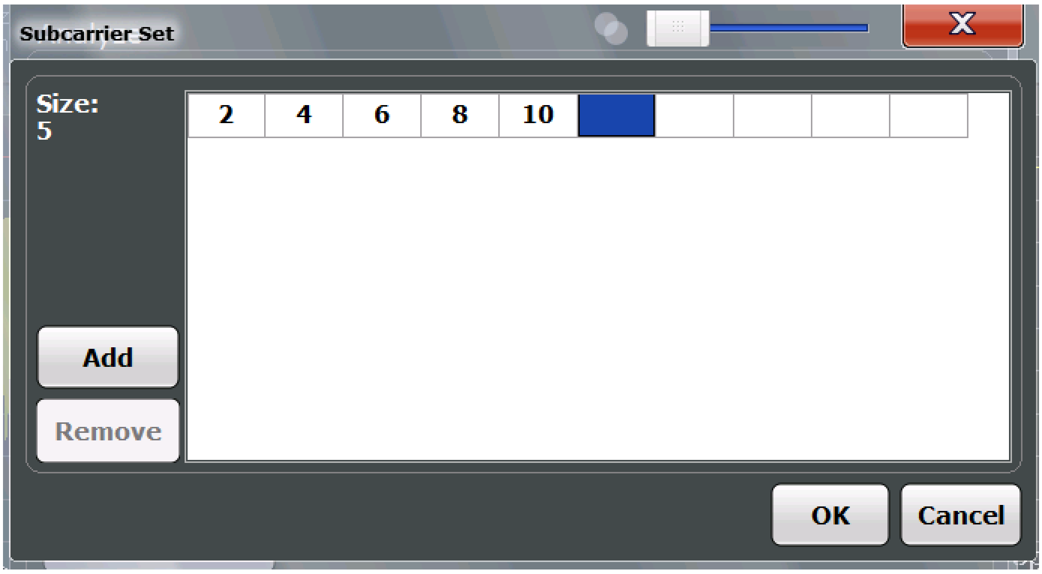
"User Defined" Up to five subcarriers defined in the set are excluded.
Note: if you enter a value in the set of excluded subcarriers, the setting is automatically changed to "User Defined".

Remote command:
`CONFigure:MEXC:STATe` on page 221
`CONFigure:MEXC:SUBCarrier:COUNt` on page 221

Subcarrier Set ← Excluding Subcarriers from MER Calculation
Specifies up to five subcarrier numbers to be excluded.

When you select the input field, an edit dialog is displayed. Enter the individual subcarrier numbers in the dialog, selecting ENTER after each number.

To add further entry fields, select "Add" on page 60.



Remote command:
`CONFigure:MEXC:SUBCarrier:SET` on page 221

Add ← Subcarrier Set ← Excluding Subcarriers from MER Calculation
Adds a new entry to the left of the currently selected entry.

Remove ← Subcarrier Set ← Excluding Subcarriers from MER Calculation
Removes the currently selected entry.

OK ← Subcarrier Set ← Excluding Subcarriers from MER Calculation
Saves the changes to the table and closes the dialog box.

Cancel ← Subcarrier Set ← Excluding Subcarriers from MER Calculation
Closes the dialog box without saving the changes.

5.3.10 Result Configuration

Access: "Overview" ≥ "Result Config"

or: MEAS CONFIG > "Result Config"

Some evaluation methods require or allow for additional settings to configure the result display. Note that the available settings depend on the selected window (see "Specifics for" on page 52).

Marker settings are described in Chapter 6.2, "Markers", on page 129.

● Table Configuration....113
● Display Settings....114
● Y-Scaling Settings....119

5.3.10.1 Table Configuration

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

or: MEAS CONFIG > "Result Config" > "Table Config"

You can configure which results are displayed in table results (see "Result Summary" on page 26, "Signal Content Detailed" on page 27, "Signal Content Summary" on page 28, and "Bitstream (downstream only)" on page 17). However, the results are always *calculated*, regardless of their visibility on the screen.

They are configured in the "Table Configuration" tab of the "Result Configuration" dialog box, which is displayed when you do one of the following:

- Select the "Result Configuration" softkey in the main DOCSIS 3.1 menu. This softkey is only available if a table result window is currently selected.
- In the "Overview", select a table result window from the "Specifics for" selection list, then select the "Result Configuration" button.

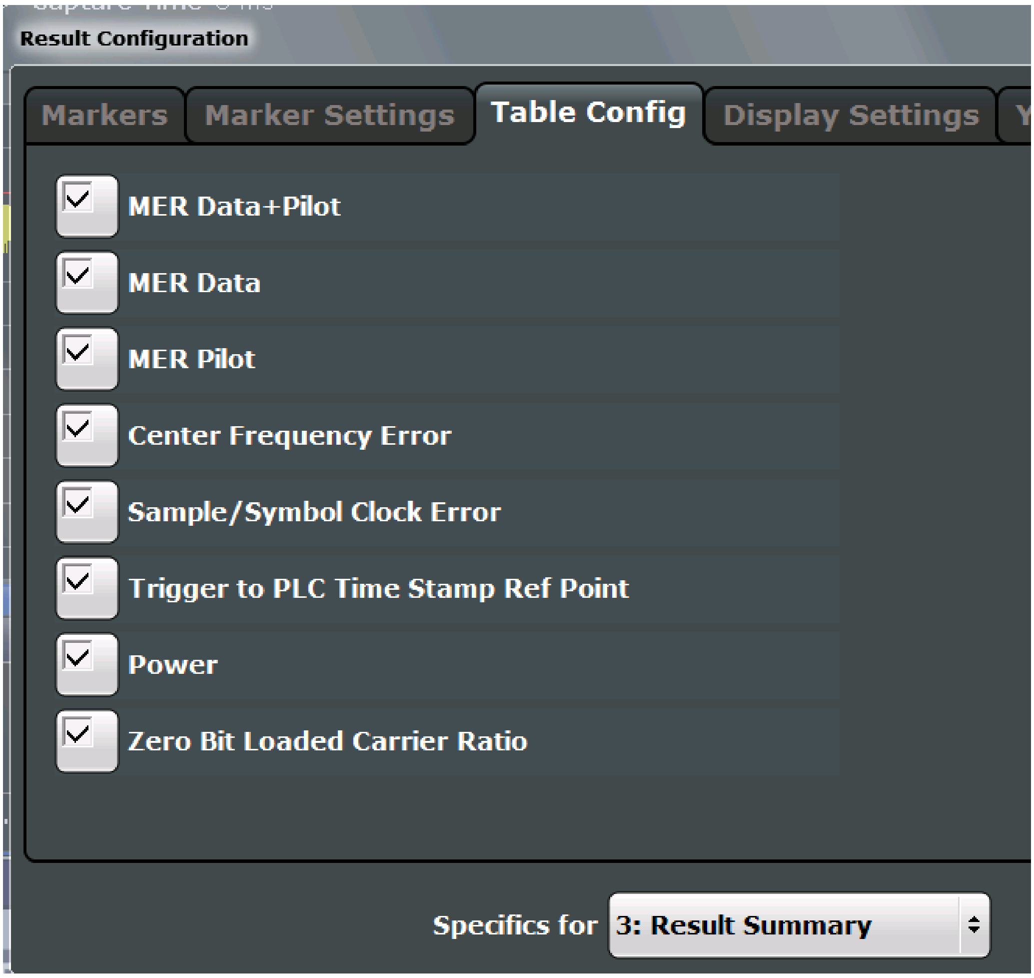


Figure 5-9: Result summary configuration

For details on individual parameters see Chapter 3.1.1, "Modulation Accuracy Parameters", on page 13.

Remote command:

Result Summary only:

`DISPlay[:WINDow<n>]:TABLe:ITEM` on page 234

Signal Content and Bitstream: not available

5.3.10.2 Display Settings

Access: "Overview" ≥ "Result Config" > "Display Settings"

or: MEAS CONFIG > "Result Config" > "Display Settings"

Display settings are available for specific graphical result displays.

They are configured in the "Display Settings" tab of the "Result Configuration" dialog box, which is displayed when you do one of the following:

- Select the "Result Configuration" softkey in the main DOCSIS 3.1 menu. This softkey is only available if a window with additional settings is currently selected.
- In the "Overview", select a window with a graphical result from the "Specifics for" selection list, then select the "Result Configuration" button.

- Display Settings for Constellation Results.. 114
- Display Settings for Carrier-Based Results...116
- Display Settings for Bitstream Results...117
- Display Settings for Result Summary and Signal Content Detailed Tables..........118

Display Settings for Constellation Results

Access: "Overview" ≥ "Result Config" > "Display Settings"

or: MEAS CONFIG > "Result Config" > "Display Settings"

The following settings are available for Constellation result displays.

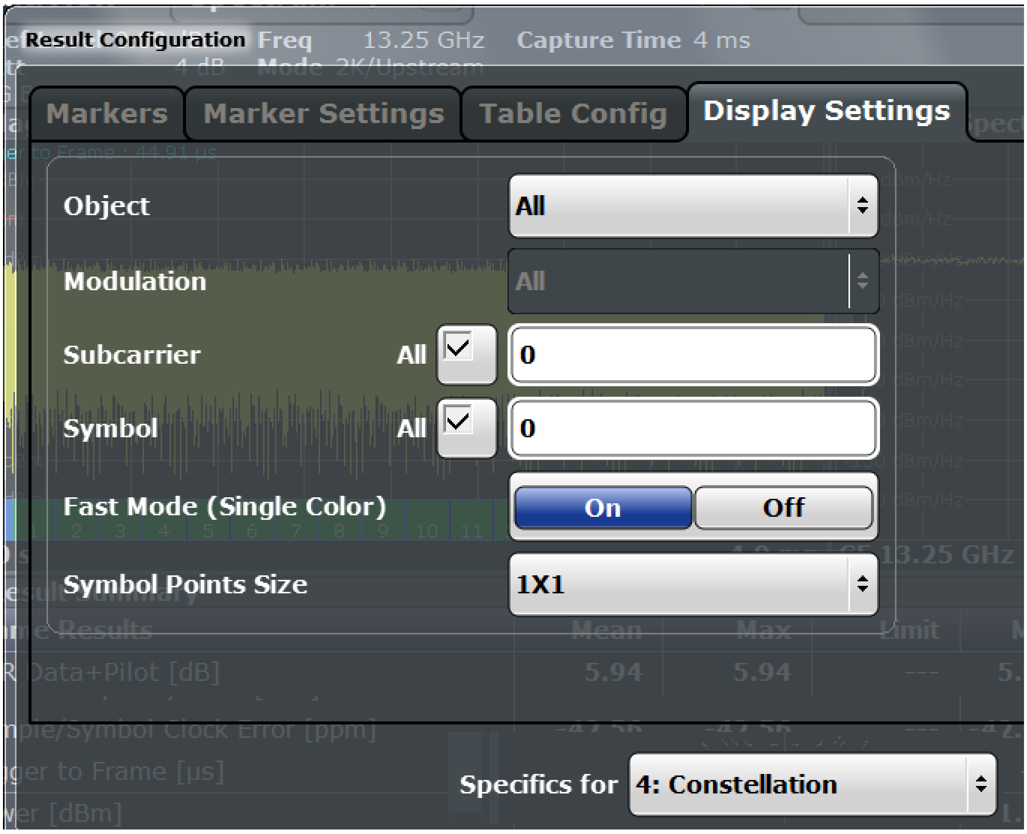


Figure 5-10: Result configuration settings for Constellation results

Object.......115
Modulation.......116
Subcarrier.......116
Symbol.......116
Fast Mode (Single Color).......116
Symbol Points Size.......116

Object

The constellation diagram is restricted to the specified object.

If "All" is selected (default), the Constellation diagram is displayed for the following objects:

- Pilots
- Complementary Pilots (upstream only)
- PLC preamble (downstream only)
- PLC data (downstream only)
- NCP all (downstream only)
- Individual profile (A to P) (downstream) / current profile (upstream)
- Scattered pilots (downstream only)
- Continuous pilots (downstream only)

Remote command:

`[SENSe:]OBJect:SELect` on page 235

Modulation
The constellation diagram is restricted to the specified modulation type(s) of the selected Object.

A specific modulation cannot be selected if Object is set to "All" and Fast Mode (Single Color) is "ON" (default).

Optionally, the points for each modulation can be displayed by a different color, see "Fast Mode (Single Color)" on page 116 and "Constellation" on page 19.

Remote command:
`[SENSe:]MODulation:SELect` on page 235

Subcarrier
The constellation diagram is restricted to the specified subcarrier.

If "All" is selected, the Constellation diagram is displayed for all detected subcarriers.

Remote command:
`[SENSe:]SUBCarrier:SELect` on page 236

Symbol
The constellation diagram is restricted to the specified symbol.

If "All" is selected, the Constellation diagram is displayed for all symbols.

Remote command:
`[SENSe:]SYMBol:SELect` on page 236

Fast Mode (Single Color)
If enabled, the constellation uses a single color for all modulations, which improves performance. However, individual Modulation types cannot be selected.

If disabled, different colors are used for different modulation types (see "Constellation" on page 19). Which Modulation types are displayed (depending on the selected Object) is configurable.

Remote command:
`[SENSe:]FMODE:STATe` on page 234

Symbol Points Size
Defines the size of the individual symbol points in the Constellation diagram.

"1X1"	One symbol point is displayed by 1 pixel on the x-axis and 1 pixel on the y-axis
"2X2"	One symbol point is displayed by 2 pixels on the x-axis and 2 pixels on the y-axis
"3X3"	One symbol point is displayed by 3 pixels on the x-axis and 3 pixels on the y-axis

Remote command:
`[SENSe:]SYMBol:SIZE` on page 236

Display Settings for Carrier-Based Results

Access: "Overview" ≥ "Result Config" > "Display Settings"

or: MEAS CONFIG > "Result Config" > "Display Settings"

The following settings are available for carrier-based result displays, such as MER vs. Carrier.

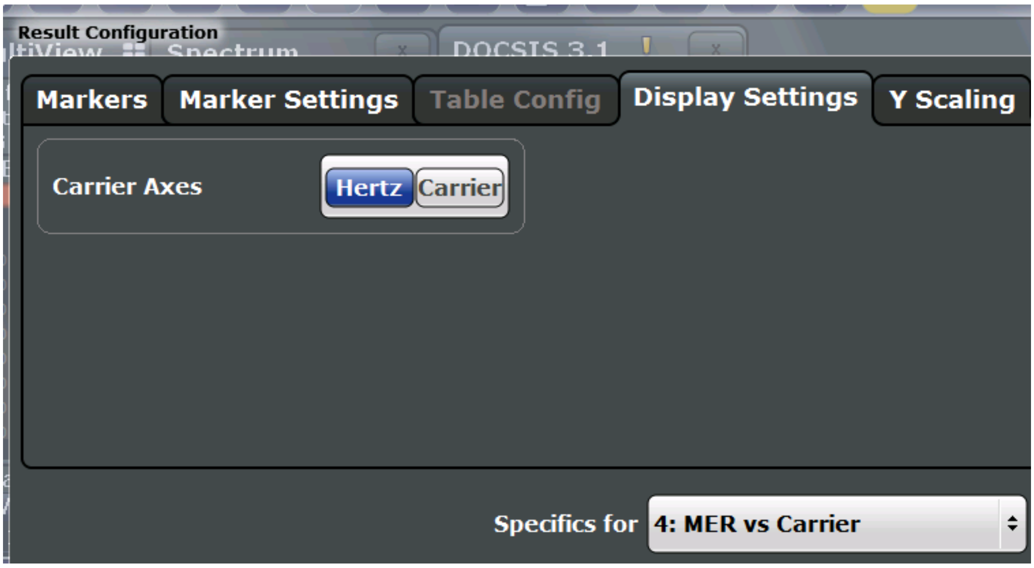


Figure 5-11: Result configuration settings for carrier-based results

Carrier Axes Unit..117

Carrier Axes Unit

For result displays that evaluate a parameter per carrier (e.g. MER vs Carrier, Group Delay, or Spectrum Flatness), you can define whether the carrier number or the carrier frequency (in Hz) is displayed on the x-axis. Note, however, that this setting applies to *ALL* result displays based on carriers.

Remote command:
`UNIT:CAXes` on page 244

Display Settings for Bitstream Results

Access: "Overview" ≥ "Result Config" > "Display Settings"

or: MEAS CONFIG > "Result Config" > "Display Settings"

The following settings are available for Bitstream result displays.

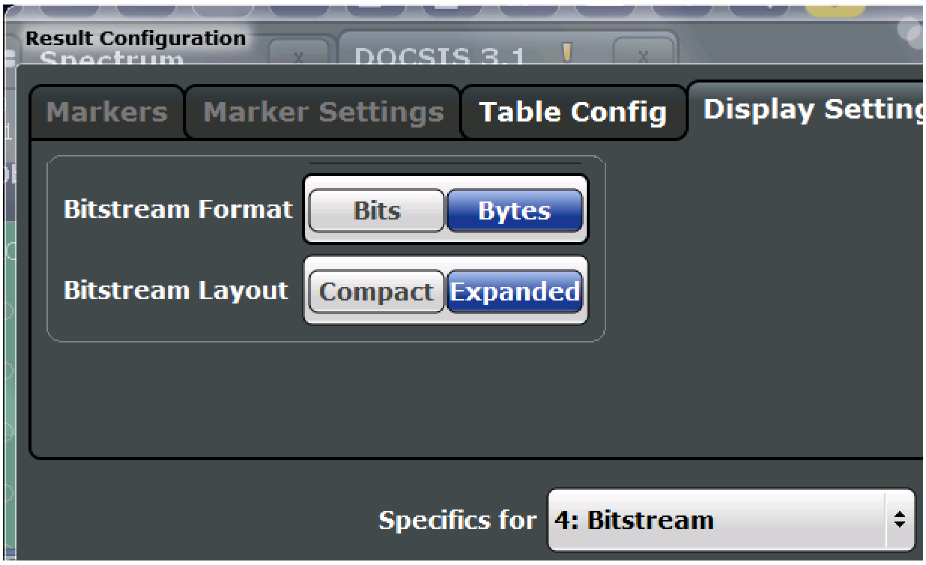


Figure 5-12: Result configuration settings for Bitstream results

Bitstream Format....118
Bitstream Layout....118

Bitstream Format

Determines whether the data is displayed as bits or bytes (default) in a Bitstream result display, if activated (see "Bitstream (downstream only)" on page 17).

Remote command:
`UNIT:BITStream` on page 244

Bitstream Layout

Determines whether a compact or expanded view of the bits is displayed in the Bitstream result display, if activated (see "Bitstream (downstream only)" on page 17).

Remote command:
`DISPlay[:WINDow<n>]:BITStream:LAYout` on page 234

Display Settings for Result Summary and Signal Content Detailed Tables

Access: "Overview" ≥ "Result Config" > "Display Settings"

or: MEAS CONFIG > "Result Config" > "Display Settings"

The following settings are available for Result Summary and Signal Content Detailed result displays.

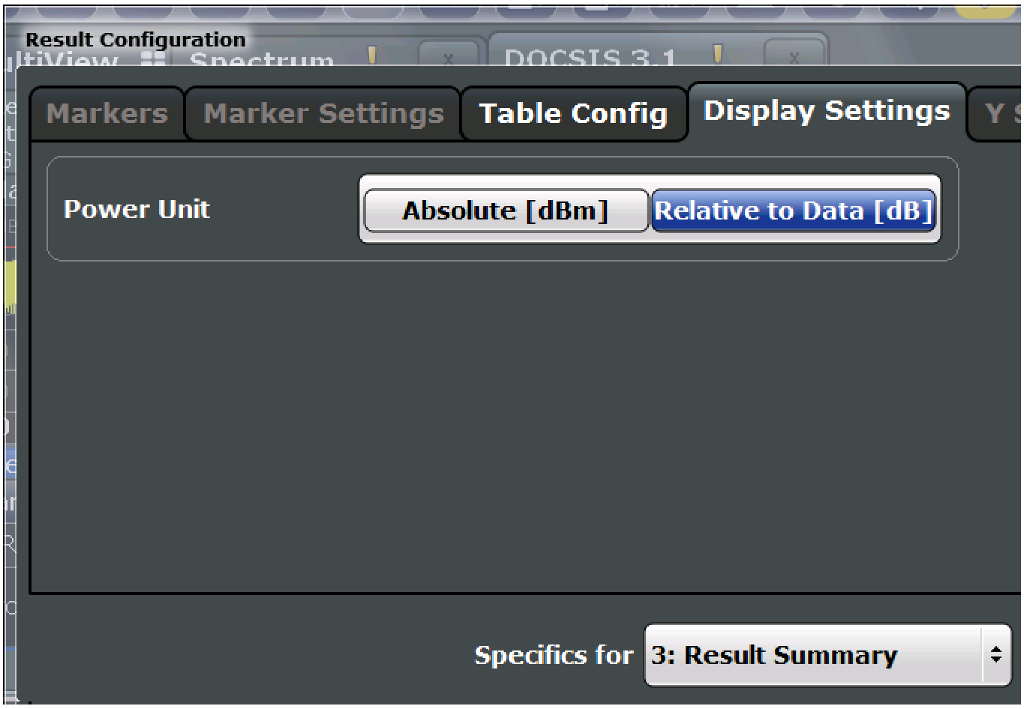


Figure 5-13: Result configuration settings for Result Summary results

Power Unit

Determines whether the power results in the Result Summary and Signal Content Detailed are calculated as absolute values or relative to the power measured in the data subcarriers.

For absolute values, the unit depends on the Unit setting in the amplitude settings.

Note that in the Signal Content Detailed table, all power values use the same unit (as defined here), whereas in the Result Summary, the total power of the OFDM channel and the power measured in the 6-MHz channel containing the PLC are always provided as absolute values, regardless of the "Power Unit" setting.

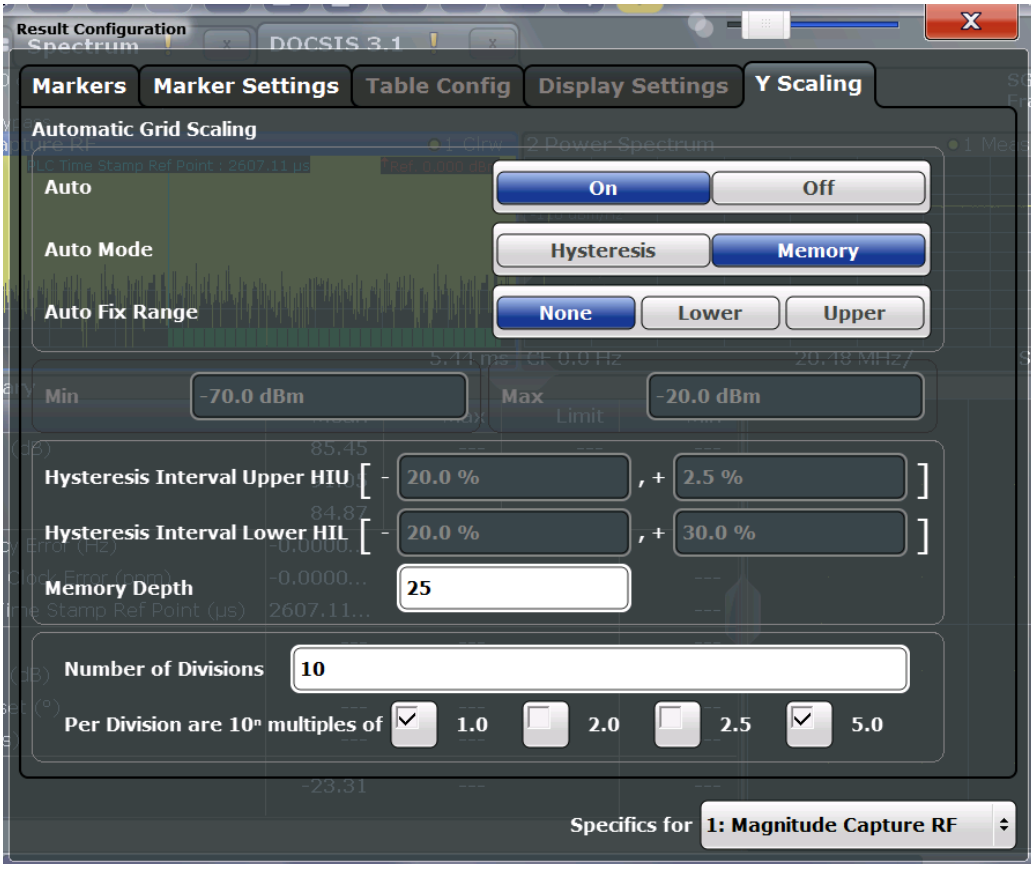
Remote command:
`UNIT:POWer` on page 237

5.3.10.3 Y-Scaling Settings

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

or: MEAS CONFIG > "Result Config" > "Y Scaling"

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



Automatic Grid Scaling....120
Auto Mode....120
Auto Fix Range....121
Hysteresis Interval Upper/Lower....121
Minimum / Maximum....122
Memory Depth....122
Number of Divisions....122
Scaling per division....122

Automatic Grid Scaling

Activates or deactivates automatic scaling of the y-axis for the specified trace display. If enabled, the R&S FSW DOCSIS 3.1 application automatically scales the y-axis to best fit the measurement results.

If disabled, the y-axis is scaled according to the specified Minimum / Maximum and Number of Divisions.

Remote command:
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO` on page 238

Auto Mode

Determines which algorithm is used to determine whether the y-axis requires automatic rescaling.

"Hysteresis"	If the minimum and/or maximum values of the current measurement exceed a specific value range (hysteresis interval), the axis is rescaled. The hysteresis interval is defined as a percentage of the currently displayed value range on the y-axis. An upper hysteresis interval is defined for the maximum value, a lower hysteresis interval is defined for the minimum value. (See Hysteresis Interval Upper/Lower)
"Memory"	If the minimum or maximum values of the current measurement exceed the minimum or maximum of the <x> previous results, respectively, the axis is rescaled. The minimum and maximum value of each measurement is added to the memory. After <x> measurements, the oldest results in the memory are overwritten by each new measurement. The number <x> of results in the memory to be considered is configurable (see Memory Depth).

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

Auto Fix Range

This command defines the use of fixed value limits.

"None"	Both the upper and lower limits are determined by automatic scaling of the y-axis.
"Lower"	The lower limit is fixed (defined by the Minimum / Maximum settings), while the upper limit is determined by automatic scaling of the y-axis.
"Upper"	The upper limit is fixed (defined by the Minimum / Maximum settings), while the lower limit is determined by automatic scaling of the y-axis.

Remote command:
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:FIXed:RANGe`
on page 238

Hysteresis Interval Upper/Lower

For automatic scaling based on hysteresis, the hysteresis intervals are defined here. Depending on whether either of the limits are fixed or not (see Auto Fix Range), one or both limits are defined by a hysteresis value range.

The hysteresis range is defined as a percentage of the currently displayed value range on the y-axis.

Example:

The currently displayed value range on the y-axis is 0 to 100. The upper limit is fixed by a maximum of 100. The lower hysteresis range is defined as -10% to +10%. If the minimum value in the current measurement drops below -10 or exceeds +10, the y-axis will be rescaled automatically, for example to [-10..+100] or [+10..+100], respectively.

"Upper"(HIU)	If the maximum value in the current measurement exceeds the specified range, the y-axis is rescaled automatically.

"Lower"(HIL) If the minimum value in the current measurement exceeds the specified range, the y-axis is rescaled automatically.

Remote command:
DISPlay[:WINDow<N>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:LOWer:UPPer on page 239
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:LOWer:LOWer on page 239
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:UPPer:LOWer on page 240
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:UPPer:UPPer on page 240

Minimum / Maximum

Defines the minimum and maximum value to be displayed on the y-axis of the specified evaluation diagram.

For automatic scaling with a fixed range (see Auto Fix Range), the minimum defines the fixed lower limit, the maximum defines the fixed upper limit.

Remote command:
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MAXimum on page 242
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MINimum on page 243

Memory Depth

For automatic scaling based on memory (see "Auto Mode" on page 120), this value defines the number <x> of previous results to be considered when determining if rescaling is required.

The minimum and maximum value of each measurement are added to the memory. After <x> measurements, the oldest results in the memory are overwritten by each new measurement.

If the maximum value in the current measurement exceeds the maximum of the <x>previous results, and the upper limit is not fixed, the y-axis is rescaled.

If the minimum value in the current measurement drops below the minimum of the <x>previous results, and the lower limit is not fixed, the y-axis is rescaled.

Remote command:
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:MEMory:DEPTh on page 241

Number of Divisions

Defines the number of divisions to be used for the y-axis. By default, the y-axis is divided into 10 divisions.

Remote command:
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:DIVisions on page 242

Scaling per division

Determines the values shown for each division on the y-axis.

One or more multiples of 10^n can be selected. The R&S FSW DOCSIS 3.1 application then selects the optimal scaling from the selected values.

Example:

- Multiples of "2.0" and **"2.5"** selected; division range = [-80..-130]; number of divisions: 10;
  Possible scaling (n=1):
  [-80;-85;-90;-95;-100;-105;-110;-115;-130;]
- Multiples of **"2.0"** selected; division range = [-80..-130]; number of divisions: 10;
  Possible scaling (n=1):
  [0;-20;-40;-60;-80;-100;-120;-140;-160;-180;]

"1.0" Each division on the y-axis displays multiples of $1*10^n$:
For example for n= -1; division range = [0..1]; number of divisions: 10;
[0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0]

"2.0" Each division on the y-axis displays multiples of $2*10^n$:
For example for n= -1;division range = [0..1]; number of divisions: 5;
[0, 0.2, 0.4, 0.6, 0.8, 1.0]

"2.5" Each division on the y-axis displays multiples of $2.5*10^n$:
For example for n= -1; division range = [0..1]; number of divisions: 5;
[0, 0.25, 0.5, 0.75, 1.0]

"5.0" Each division on the y-axis displays multiples of $5*10^n$:
For example for n= -1; division range = [0..1]; number of divisions: 5,
[-0.5, 0, 0.5, 1.0, 1.5]

Remote command:
`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:PDIVision` on page 243

5.3.11 Automatic Settings

Access: AUTO SET

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

Setting the Reference Level Automatically (Auto Level)..123
Auto Set from PLC & Run (downstream only)..124
Auto Detection & Run (upstream only)...124

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

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

Remote command:
`CONFigure:POWer:AUTO` on page 202

Auto Set from PLC & Run (downstream only)
Performs an initial measurement in order to determine the required signal description settings automatically from the detected PLC before starting (or continuing) the actual Modulation Accuracy measurement.

This function is **only** available for **downstream** DOCSIS 3.1 signals.

The center frequency need not be defined beforehand; however, the PLC must be located inside the captured signal bandwidth.

Note that if auto detection is not possible, the initial measurement will continue endlessly while trying to synchronize to the input signal. In this case, abort the detection process by selecting Single Sweep/ RUN SINGLE or Continuous Sweep/RUN CONT, or Auto Set from PLC & Run (downstream only) again.

The following parameters are determined automatically:

- Center frequency
- OFDM Spectrum Location
- N_{FFT} (FFT length)
- Cyclic Prefix CP
- Roll-off
- Time-Interleaving Depth
- PLC Start Index L
- Continuous Pilots
- Excluded Subcarriers
- Profile A (only)

Remote command:
`CONFigure:DS:PLC:AUTO` on page 224

Auto Detection & Run (upstream only)
Performs an initial measurement in order to determine the required signal description settings automatically from the detected signal characteristics before starting (or continuing) the actual Modulation Accuracy measurement.

This function is **only** available for **upstream** DOCSIS 3.1 signals.

The following parameters are determined automatically:

- "N_{FFT} (FFT length)" on page 69
- "Cyclic Prefix CP" on page 69
- "Symbols Per Frame (K)" on page 71
- "Excluded Subcarrier Assignment" on page 71
- "Profile Configuration (Upstream)" on page 74

The Center frequency and therefore OFDM Spectrum Location are corrected.

Remote command:
`CONFigure:US:AUTO ONCE` on page 225

5.4 Frequency Sweep Measurements

Access: MODE > "Docsis 3.1"

"Overview" > "Select Measurement"

When you activate a measurement channel in DOCSIS 3.1 mode, an I/Q measurement of the input signal is started automatically (see Chapter 3, "Measurements and Result Display", on page 13). However, some parameters specified in the DOCSIS 3.1 standard require a better signal-to-noise level or a smaller bandwidth filter than the default measurement on I/Q data provides and must be determined in separate measurements based on RF data (see Chapter 3.2, "Frequency Sweep Measurements", on page 29). In these measurements, demodulation is not performed.

The R&S FSW DOCSIS 3.1 application uses the functionality of the R&S FSW base system (Spectrum application) to perform the DOCSIS 3.1 frequency sweep measurements. Some parameters are set automatically according to the DOCSIS 3.1 standard the first time a measurement is selected (since the last PRESET operation). These parameters can be changed, but are not reset automatically the next time you re-enter the measurement. Refer to the description of each measurement type for details.

The main measurement configuration menus for the DOCSIS 3.1 frequency sweep measurements are identical to the Spectrum application.

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

- Occupied Bandwidth.. 125
- CCDF.. 126

5.4.1 Occupied Bandwidth

Access: "Overview" > "Select Measurement" > "OBW"

or: MEAS > "Select Measurement" > "OBW"

The Occupied Bandwidth measurement is performed as in the Spectrum application with default settings.

Table 5-2: Predefined settings for DOCSIS 3.1 OBW measurements

Setting	Default value
% Power Bandwidth	99 %
Channel bandwidth	3.84 MHz

The Occupied Bandwidth measurement determines the bandwidth that the signal occupies. The occupied bandwidth is defined as the bandwidth in which – in default settings - 99 % of the total signal power is to be found. The percentage of the signal power to be included in the bandwidth measurement can be changed.

For further details about the Occupied Bandwidth measurements refer to "Measuring the Occupied Bandwidth" in the R&S FSW User Manual.

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

- Reference level and reference level offset
- RBW, VBW
- Sweep time

- Span

5.4.2 CCDF

Access: "Overview" > "Select Measurement" > "CCDF"

or: MEAS > "Select Measurement" > "CCDF"

The CCDF measurement determines the distribution of the signal amplitudes (complementary cumulative distribution function). The CCDF and the Crest factor are displayed. For the purposes of this measurement, a signal section of user-definable length is recorded continuously in zero span, and the distribution of the signal amplitudes is evaluated.

The measurement is useful to determine errors of linear amplifiers. The crest factor is defined as the ratio of the peak power and the mean power. The Result Summary displays the number of included samples, the mean and peak power and the crest factor.

The CCDF measurement is performed as in the Spectrum application with the following settings:

Table 5-3: Predefined settings for DOCSIS 3.1 CCDF measurements

Setting	Default value
CCDF	Active on trace 1
Analysis bandwidth	10 MHz
Number of samples	62500
Detector	Sample

For further details about the CCDF measurements refer to "Statistical Measurements" in the R&S FSW User Manual.

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

- Reference level and reference level offset
- Analysis bandwidth
- Number of samples

6 Analysis

General result analysis settings concerning the trace and markers etc. are currently not available for the standard DOCSIS 3.1 measurements. Only one marker is available for these measurements.

Analysis of frequency sweep measurements

General result analysis settings concerning the trace, markers, lines etc. for RF measurements are identical to the analysis functions in the Spectrum application except for some special marker functions and spectrograms, which are not available in the DOCSIS 3.1 application.

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

The remote commands required to perform these tasks are described in Chapter 10.10, "Analysis", on page 275.

● Traces....127
● Markers....129

6.1 Traces

Access: TRACE > "Trace Config"

For I/Q measurements in the R&S FSW DOCSIS 3.1 application, the displayed traces are not configurable. However, the traces can be exported to an ASCII file.

For RF measurements, see the R&S FSW User Manual.

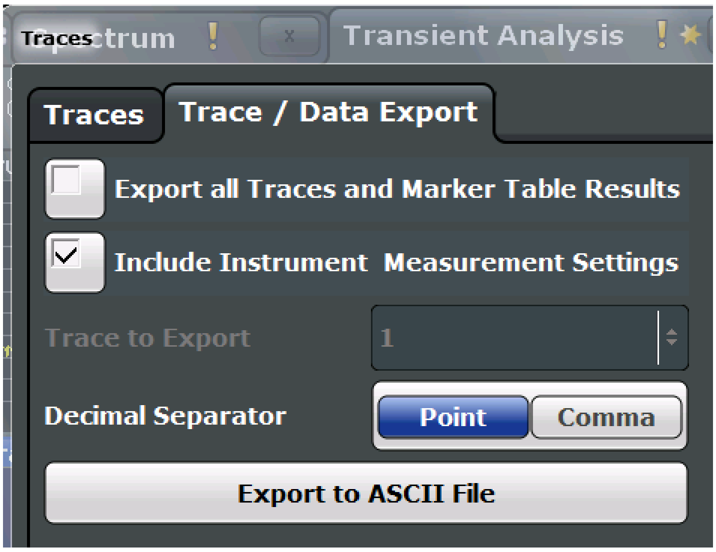
● Trace / Data Export Configuration....127

6.1.1 Trace / Data Export Configuration

Access: "Save" > "Export" > "(Trace) Export Config"

Or: TRACE > "Trace Config" > "Trace/Data Export"

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



Export all Traces and all Table Results....128
Include Instrument Measurement Settings....128
Trace to Export....128
Decimal Separator....128
Export Trace to ASCII File....129

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 281

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 280

Trace to Export

Defines an individual trace that will 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 files. Evaluation programs require different separators in different languages.

Remote command:

`FORMat:DEXPort:DSEParator` on page 280

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 full" error can occur although the hard disk indicates that storage space is still available.

To store data permanently, select an external storage location such as a USB memory device.

For details, see "Protecting Data Using the Secure User Mode" in the "Data Management" section of the R&S FSW User Manual.

Remote command:
`MMEMory:STORe<n>:TRACe` on page 281

6.2 Markers

Access: "Overview" > "Result Configuration" > "Markers"

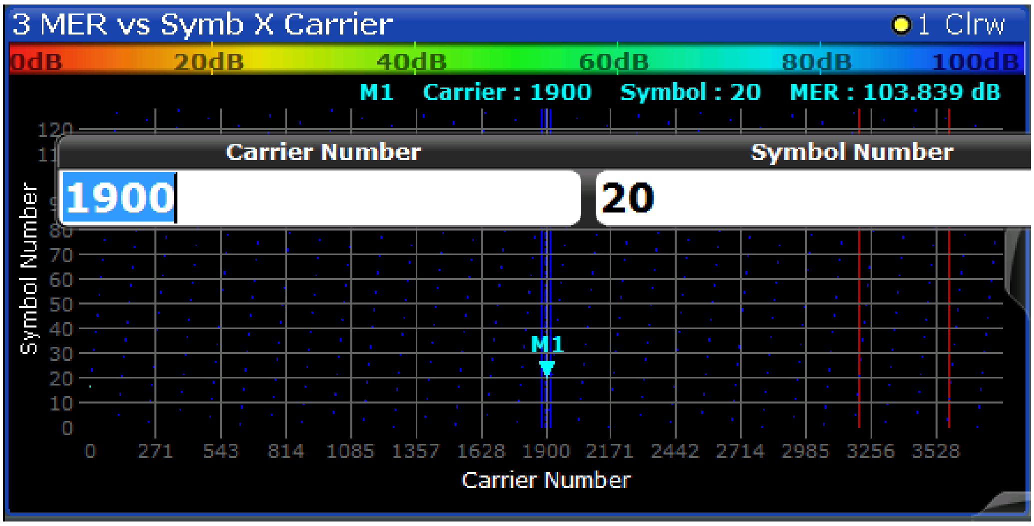
Or: MKR

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

Markers in 3-dimensional result displays

Common markers are defined by their value on the x-axis. In 3-dimensional result displays, where a parameter value is indicated by color for all carriers and symbols, the marker position must be defined by its value on the x-axis (carrier) and y-axis (symbol). The third dimension is the parameter value (MER or power).

In these result displays, only a single (normal) marker is available.



- Individual Marker Settings....................130
- General Marker Settings....................132

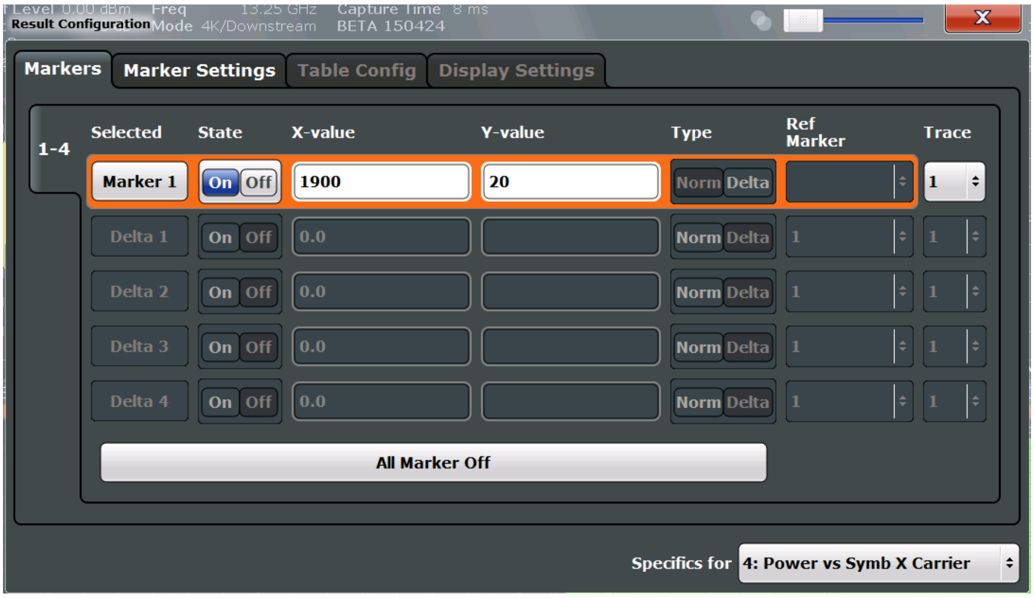
6.2.1 Individual Marker Settings

Access: "Overview" > "Result Configuration" > "Markers"

Or: MKR > "Marker Config"

In DOCSIS 3.1 evaluations, up to 4 markers can be activated in each diagram at any time.

In 3-dimensional result displays, only a single (normal) marker is available (see "Markers in 3-dimensional result displays" on page 130).



Selected Marker......131
Marker State......131
X-value......131
Y-value......131
Marker Type......132
Reference Marker......132
Assigning the Marker to a Trace......132
All Markers Off......132

Selected Marker

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

Remote command:

Marker selected via suffix <m> in remote commands.

Marker State

Activates or deactivates the marker in the diagram.

Remote command:

`CALCulate<n>:MARKer<m>[:STATe]` on page 277

`CALCulate<n>:DELTamarker<m>[:STATe]` on page 276

X-value

Defines the position of the marker on the x-axis (frequency, carrier, symbol, depending on evaluation).

Remote command:

`CALCulate<n>:DELTamarker<m>:X` on page 277

`CALCulate<n>:MARKer<m>:X` on page 267

Y-value

Defines the position of the marker on the y-axis (symbol) for 3-dimensional result displays (MER vs Symbol X Carrier, Power vs Symbol X Carrier).

Remote command:
CALCulate<n>:MARKer<m>:Y on page 279
CALCulate<n>:MARKer<m>:Y? on page 278

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 277
CALCulate<n>:DELTamarker<m>[:STATe] on page 276

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>:MREF on page 276

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 278

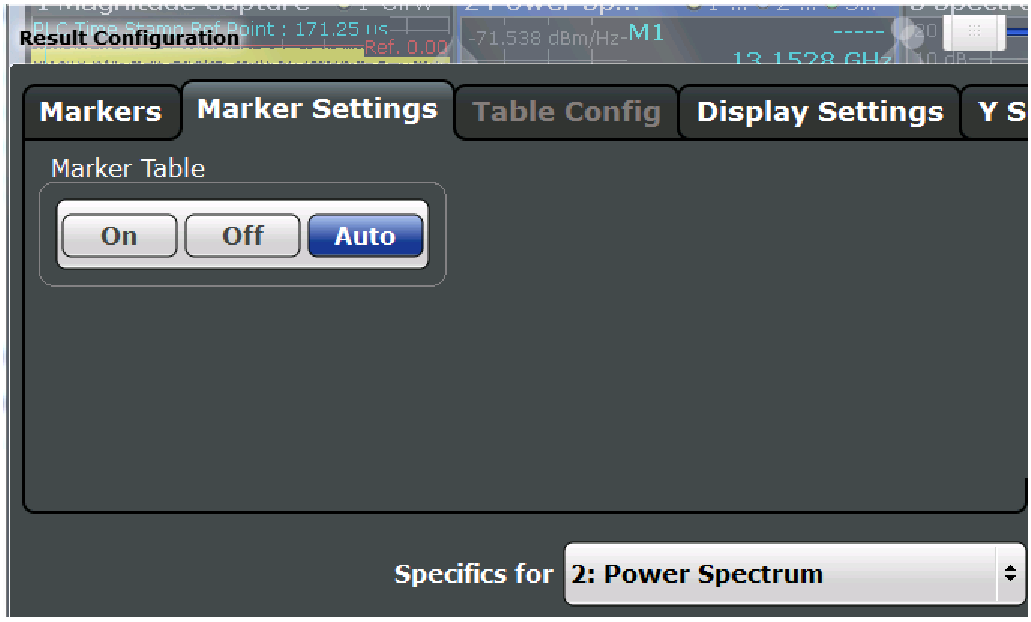
All Markers Off
Deactivates all markers in one step.

Remote command:
CALCulate<n>:MARKer<m>:AOFF on page 277

6.2.2 General Marker Settings

Access: "Overview" > "Result Configuration" > "Marker Settings"

Or: MKR > "Marker Config" > "Marker Settings"



Marker Table Display

Defines how the marker information is displayed.

"On"	Displays the marker information in a table in a separate area beneath the diagram.
"Off"	Displays the marker information within the diagram area. No separate marker table is displayed.
"Auto"	(Default) Up to two markers are displayed in the diagram area. If more markers are active, the marker table is displayed automatically.

Remote command:

`DISPlay:MTABle` on page 280

7 I/Q Data Import and Export

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

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

- Generating and saving I/Q signals in an RF or baseband signal generator or in external software tools to analyze them with the R&S FSW later
- Capturing and saving I/Q signals with an RF or baseband signal analyzer to analyze them with the R&S FSW or an external software tool later

For example, you can capture I/Q data using the I/Q Analyzer application, if available, and then analyze that data later using the R&S FSW DOCSIS 3.1 application.

As opposed to storing trace data, which may be averaged or restricted to peak values, I/Q data is stored as it was captured, without further processing. The data is stored as complex values in 32-bit floating-point format. Multi-channel data is not supported. The I/Q data is stored in a format with the file extension `.iq.tar`.

For a detailed description see the R&S FSW I/Q Analyzer and I/Q Input User Manual.

- Import/Export Functions....................134

7.1 Import/Export Functions

Access: "Save"/ "Open" icon in the toolbar > "Import" / "Export"

These functions are only available if no measurement is running.

In particular, if Continuous Sweep/RUN CONT is active, the import/export functions are not available.

For a description of the other functions in the "Save/Recall" menu, see the R&S FSW User Manual.

Export....................134
└ I/Q Export....................134

Export
Access: "Save/Recall" > Export

Opens a submenu to configure data export.

I/Q Export ← Export
Opens a file selection dialog box to define an export file name to which the I/Q data is stored. This function is only available in single sweep mode.

Note: Storing large amounts of I/Q data (several Gigabytes) can exceed the available (internal) storage space on the R&S FSW. In this case, it can be necessary to use an external storage medium.

Note: Secure user mode.
In secure user mode, settings that are stored on the instrument are stored to volatile memory, which is restricted to 256 MB. Thus, a "Memory full" error can occur although the hard disk indicates that storage space is still available.

To store data permanently, select an external storage location such as a USB memory device.

For details, see "Protecting Data Using the Secure User Mode" in the "Data Management" section of the R&S FSW User Manual.

8 How to Perform Measurements in the R&S FSW DOCSIS 3.1 application

The following step-by-step instructions demonstrate how to perform a measurement with the R&S FSW DOCSIS 3.1 application. The following tasks are described:

- How to Analyze Modulation Accuracy and Signal Contents for DOCSIS 3.1 Downstream Signals....... 136
- How to Analyze Modulation Accuracy and Signal Contents for DOCSIS 3.1 Upstream Signals.......138
- How to Evaluate the OBW or CCDF for DOCSIS 3.1 Signals....... 140

8.1 How to Analyze Modulation Accuracy and Signal Contents for DOCSIS 3.1 Downstream Signals

1. Press the MODE key.

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

2. Select the "DOCSIS 3.1" item.

   The R&S FSW opens a new measurement channel for the DOCSIS 3.1 application.

3. Select the "Overview" softkey to display the "Overview" for a DOCSIS 3.1 measurement.

4. Select the "Signal Description" button to describe the expected input signal.

5. In the "OFDM Channel Description" tab, define the general OFDM channel transmission settings, including:

   - Stream direction (*Downstream*)
   - the OFDM spectrum location
   - the PLC location
   - the NCP modulation
   - the FFT length

6. Select "Continuous Pilots, Excluded Subcarriers Configuration...".
   (Note: continuous pilots can also be detected automatically, see step 16.)
   For each set of continuous pilots and excluded subcarriers:

   a) Insert a new line.

   b) Assign the subcarriers either by entering a discrete set of numbers or by defining a series with a fixed start, stop and increment value.
   c) Select "OK" and close the "Continuous Pilots, Excluded Subcarriers Configuration..." dialog box.

7. In the "Signal Description" dialog box, select the "Profile Configuration" tab.
8. For each set of modems with similar transmission conditions, configure a profile that defines the modulation to be used by which subcarrier.
   a) Select a profile from the list and then "Edit profile".
   b) Insert a new line.
   c) Select the subcarriers either by entering a discrete set of numbers or by defining a series with a fixed start, stop and increment value.
   d) Select the modulation these subcarriers use for transmission.
   e) Select "OK" and close the "Profile: Modulation Subcarrier Assignment" dialog box.
9. In the "Signal Description" dialog box, select the "Codeword Configuration" tab.
10. Select "Frame Configuration".
11. To let the R&S FSW DOCSIS 3.1 application determine the frame configuration automatically from the input signal, set "NCP Content" to "Auto from Signal" and skip the next step.
    To configure the frames manually, set "NCP Content" to "User-Defined" and continue with the next step.
12. For each codeword in the signal, that is: the useful data transmitted to the same group of cable modems:
    a) Insert a new line.
    b) Assign a profile (which must have been configured, see step 8).
    c) Define either the first and total number of *subcarriers* the codeword is assigned to, or the first and total number of *symbols* it is assigned to.
    d) Select "OK" and close the "Frame Configuration" dialog box.
13. Select the "Input/Frontend" button and then the "Frequency" tab to define the input signal's center frequency.
14. Select the "Signal Capture" button to define how much and which data to capture from the input signal.
15. Select the "Estimation/Tracking" button to define how the data channels are to be estimated and which distortions will be compensated for.
16. Select the "Demodulation" button to activate automatic detection of continuous pilots and frames and to decode codewords during demodulation.
17. Select the "Evaluation Range" softkey to configure a specific number of frames as the basis for statistical evaluation in the Result Summary.
    Enable the "Frame Statistic Count" option and enter the "Number of Frames to Analyze".

18. Select the "Display Config" button and select the displays that are of interest to you (up to 16).
    Arrange them on the display to suit your preferences.
19. Exit the SmartGrid mode.
20. Start a new sweep with the defined settings.
    - To perform a single sweep measurement, press the RUN SINGLE hardkey.
    - To perform a continuous sweep measurement, press the RUN CONT hardkey.

    Measurement results are updated once the measurement has completed.
21. To restrict the number of numeric results displayed in the Result Summary or Signal Content Detailed tables, select the result display, then select "Result Config". In the "Table Config" tab, deactivate the information you want to hide in the tables.
22. To restrict constellation results to specific subcarriers or symbols, select the Constellation result display, then the "Result Config" button. In the "Display Settings"tab, define which data you want to analyze.
23. To scroll through the results for individual frames in graphical results, select the "Evaluation Range" softkey and change the Selected Frame number .
24. To configure the y-axis scaling for graphical results, select the result display, then select "Result Config".
    In the "Y Scaling" tab, do one of the following:
    - Set "Auto" to "Off", then configure the "Min" and "Max" values for the y-axis range.
    - Set the "Auto Mode" to "Memory" and select the number of results to consider for rescaling ("Memory Depth").
    - Set the "Auto Mode" to "Hysteresis" and define the percentage of the currently displayed value range to be used as "Hysteresis Intervals" for rescaling.

    Optionally, for automatic scaling, define a fixed upper or lower limit for the y-axis scale ("Auto Fix Range").
25. Press the SWEEP key, then select "Refresh" to update the result displays for the new settings without performing a new measurement.

8.2 How to Analyze Modulation Accuracy and Signal Contents for DOCSIS 3.1 Upstream Signals

1. Press the MODE key.
   A dialog box opens that contains all operating modes and applications currently available on your R&S FSW.
2. Select the "DOCSIS 3.1" item.

The R&S FSW opens a new measurement channel for the DOCSIS 3.1 application.

3. Select the "Overview" softkey to display the "Overview" for a DOCSIS 3.1 measurement.
4. Select the "Signal Description" button to describe the expected input signal.
5. In the "OFDM Channel Description" tab, define the general OFDM channel transmission settings, including:
   - Stream direction (*Upstream*)
   - OFDM spectrum location
   - FFT length
   - Cyclic prefix
   - Roll-off
   - Number of symbols per frame
6. Select "Excluded Subcarriers Configuration...".
   For each set of excluded subcarriers:
   a) Insert a new line.
   b) Assign the subcarriers either by entering a discrete set of numbers or by defining a series with a fixed start, stop and increment value.
   c) Select "OK" and close the "Excluded Subcarriers Configuration..." dialog box.
7. In the "Signal Description" dialog box, select the "Profile Configuration" tab.
8. Configure the transmission profile that defines the modulation and pilot pattern to be used by which minislot(s).
   a) Insert a new line.
   b) Select the number of minislots that use the same transmission configuration.
   c) Define the modulation and pilot pattern these minislots use for transmission.
   d) Select "OK" and close the "Profile Configuration" dialog box.
9. Select the "Input/Frontend" button and then the "Frequency" tab to define the input signal's center frequency.
10. Select the "Signal Capture" button to define how much and which data to capture from the input signal.
11. Select the "Estimation/Tracking" button to define which distortions will be compensated for.
12. Select the "Evaluation Range" softkey to configure a specific number of frames as the basis for statistical evaluation in the Result Summary.
    Enable the "Frame Statistic Count" option and enter the "Number of Frames to Analyze".

13. Select the "Display Config" button and select the displays that are of interest to you (up to 16).
    Arrange them on the display to suit your preferences.
14. Exit the SmartGrid mode.
15. Start a new sweep with the defined settings.
    - To perform a single sweep measurement, press the RUN SINGLE hardkey.
    - To perform a continuous sweep measurement, press the RUN CONT hardkey.

    Measurement results are updated once the measurement has completed.
16. To restrict the number of numeric results displayed in the Result Summary table, select the result display, then select "Result Config". In the "Table Config" tab, deactivate the information you want to hide in the tables.
17. To restrict constellation results to specific subcarriers or symbols, select the Constellation result display, then the "Result Config" button. In the "Display Settings" tab, define which data you want to analyze.
18. To scroll through the results for individual frames in graphical results, select the "Evaluation Range" softkey and change the Selected Frame number .
19. To configure the y-axis scaling for graphical results, select the result display, then select "Result Config".

    In the "Y Scaling" tab, do one of the following:
    - Set "Auto" to "Off", then configure the "Min" and "Max" values for the y-axis range.
    - Set the "Auto Mode" to "Memory" and select the number of results to consider for rescaling ("Memory Depth").
    - Set the "Auto Mode" to "Hysteresis" and define the percentage of the currently displayed value range to be used as "Hysteresis Intervals" for rescaling.

    Optionally, for automatic scaling, define a fixed upper or lower limit for the y-axis scale ("Auto Fix Range").
20. Press the SWEEP key, then select "Refresh" to update the result displays for the new settings without performing a new measurement.

8.3 How to Evaluate the OBW or CCDF for DOCSIS 3.1 Signals

1. Press the MODE key and select the "DOCSIS 3.1" application.

   The R&S FSW opens a new measurement channel for the DOCSIS 3.1 application. I/Q data acquisition is performed by default.
2. Select the "Signal Description" button to describe the expected input signal.
3. Select the required measurement:

a) Press the MEAS key.
b) In the "Select Measurement" dialog box, select the required measurement.

The selected measurement is activated with the default settings for DOCSIS 3.1 immediately.

4. If necessary, adapt the settings as described for the individual measurements in the R&S FSW User Manual.

9 Optimizing and Troubleshooting the Measurement

If the results do not meet your expectations, try the following methods to optimize the measurement:

Error Messages

Requires R&S®FSW-B320 320 MHz analysis bandwidth option................................142

Requires R&S®FSW-B320 320 MHz analysis bandwidth option.
Both R&S FSW DOCSIS 3.1 applications require a bandwidth extension option for 320 MHz.

The R&S FSW-K193 option (for DOCSIS 3.1 **upstream** signals) requires the *new* bandwidth extension hardware R&S FSW-B320+ (11325.4867.04).

The R&S FSW-K192 option (for DOCSIS 3.1 **downstream** signals) requires either the option R&S FSW-B320 (1313.7172.02) *or* the new bandwidth extension hardware R&S FSW-B320+ (11325.4867.04).

If the required options are not installed, an error message is displayed and no measurements can be performed with the R&S FSW DOCSIS 3.1 applications.

10 Remote Commands for DOCSIS 3.1 Measurements

The following commands are required to perform measurements in the R&S FSW DOCSIS 3.1 application in a remote environment.

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

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

In particular, this includes:

- Managing Settings and Results, i.e. storing and loading settings and result data
- Basic instrument configuration, e.g. checking the system configuration, customizing the screen layout, or configuring networks and remote operation
- Using the common status registers

After an introduction to SCPI commands, the following tasks specific to the R&S FSW DOCSIS 3.1 application are described here:

- Common Suffixes....143
- Introduction....144
- Activating DOCSIS 3.1 Measurements....149
- Selecting a Measurement....153
- Configuring the DOCSIS 3.1 I/Q Measurement (Modulation Accuracy)....155
- Configuring Frequency Sweep Measurements on DOCSIS 3.1 Signals....225
- Configuring the Result Display....225
- Starting a Measurement....245
- Retrieving Results....250
- Analysis....275
- Status Registers....282
- Deprecated Commands....286
- Programming Examples for DOCSIS 3.1 Measurements....286

10.1 Common Suffixes

In the R&S FSW DOCSIS 3.1 application, the following common suffixes are used in remote commands:

Table 10-1: Common suffixes used in remote commands in the R&S FSW DOCSIS 3.1 application

Suffix	Value range	Description
<m>	1 to 4 (RF: 1 to 16)	Marker
<n>	1 to 16	Window (**in the currently selected measurement channel**)

Suffix	Value range	Description
<t>	1 (RF: 1 to 6)	Trace
<k>	not applicable (RF: 1 to 8)	Limit line

10.2 Introduction

Commands are program messages that a controller (e.g. a PC) sends to the instrument or software. They operate its functions ('setting commands' or 'events') and request information ('query commands'). Some commands can only be used in one way, others work in two ways (setting and query). If not indicated otherwise, the commands can be used for settings and queries.

The syntax of a SCPI command consists of a header and, in most cases, one or more parameters. To use a command as a query, you have to append a question mark after the last header element, even if the command contains a parameter.

A header contains one or more keywords, separated by a colon. Header and parameters are separated by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank). If there is more than one parameter for a command, these are separated by a comma from one another.

Only the most important characteristics that you need to know when working with SCPI commands are described here. For a more complete description, refer to the User Manual of the R&S FSW.

Remote command examples

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

10.2.1 Conventions used in Descriptions

Note the following conventions used in the remote command descriptions:

- **Command usage**
  If not specified otherwise, commands can be used both for setting and for querying parameters.
  If a command can be used for setting or querying only, or if it initiates an event, the usage is stated explicitly.
- **Parameter usage**
  If not specified otherwise, a parameter can be used to set a value and it is the result of a query.
  Parameters required only for setting are indicated as **Setting parameters**.
  Parameters required only to refine a query are indicated as **Query parameters**.
  Parameters that are only returned as the result of a query are indicated as **Return values**.

- **Conformity**
  Commands that are taken from the SCPI standard are indicated as **SCPI confirmed**. All commands used by the R&S FSW follow the SCPI syntax rules.
- **Asynchronous commands**
  A command which does not automatically finish executing before the next command starts executing (overlapping command) is indicated as an **Asynchronous command**.
- **Reset values (*RST)**
  Default parameter values that are used directly after resetting the instrument (`*RST` command) are indicated as ***RST** values, if available.
- **Default unit**
  This is the unit used for numeric values if no other unit is provided with the parameter.
- **Manual operation**
  If the result of a remote command can also be achieved in manual operation, a link to the description is inserted.

10.2.2 Long and Short Form

The keywords have a long and a short form. You can use either the long or the short form, but no other abbreviations of the keywords.

The short form is emphasized in upper case letters. Note however, that this emphasis only serves the purpose to distinguish the short from the long form in the manual. For the instrument, the case does not matter.

Example:

`SENSe:FREQuency:CENTer` is the same as `SENS:FREQ:CENT`.

10.2.3 Numeric Suffixes

Some keywords have a numeric suffix if the command can be applied to multiple instances of an object. In that case, the suffix selects a particular instance (e.g. a measurement window).

Numeric suffixes are indicated by angular brackets (<n>) next to the keyword.

If you don't quote a suffix for keywords that support one, a 1 is assumed.

Example:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe` enables the zoom in a particular measurement window, selected by the suffix at `WINDow`.

`DISPlay:WINDow4:ZOOM:STATe ON` refers to window 4.

10.2.4 Optional Keywords

Some keywords are optional and are only part of the syntax because of SCPI compliance. You can include them in the header or not.

Note that if an optional keyword has a numeric suffix and you need to use the suffix, you have to include the optional keyword. Otherwise, the suffix of the missing keyword is assumed to be the value 1.

Optional keywords are emphasized with square brackets.

Example:
Without a numeric suffix in the optional keyword:
`[SENSe:]FREQuency:CENTer` is the same as `FREQuency:CENTer`
With a numeric suffix in the optional keyword:
`DISPlay[:WINDow<1...4>]:ZOOM:STATe`
`DISPlay:ZOOM:STATe ON` enables the zoom in window 1 (no suffix).
`DISPlay:WINDow4:ZOOM:STATe ON` enables the zoom in window 4.

10.2.5 Alternative Keywords

A vertical stroke indicates alternatives for a specific keyword. You can use both keywords to the same effect.

Example:
`[SENSe:]BANDwidth|BWIDth[:RESolution]`
In the short form without optional keywords, `BAND 1MHZ` would have the same effect as `BWID 1MHZ`.

10.2.6 SCPI Parameters

Many commands feature one or more parameters.

If a command supports more than one parameter, these are separated by a comma.

Example:
`LAYout:ADD:WINDow Spectrum,LEFT,MTABle`

Parameters may have different forms of values.

- Numeric Values.....147
- Boolean.....147
- Character Data.....148
- Character Strings.....148
- Block Data.....148

10.2.6.1 Numeric Values

Numeric values can be entered in any form, i.e. with sign, decimal point or exponent. In case of physical quantities, you can also add the unit. If the unit is missing, the command uses the basic unit.

Example:

with unit: `SENSe:FREQuency:CENTer 1GHZ`

without unit: `SENSe:FREQuency:CENTer 1E9` would also set a frequency of 1 GHz.

Values exceeding the resolution of the instrument are rounded up or down.

If the number you have entered is not supported (e.g. in case of discrete steps), the command returns an error.

Instead of a number, you can also set numeric values with a text parameter in special cases.

- MIN/MAX
  Defines the minimum or maximum numeric value that is supported.
- DEF
  Defines the default value.
- UP/DOWN
  Increases or decreases the numeric value by one step. The step size depends on the setting. In some cases you can customize the step size with a corresponding command.

Querying numeric values

When you query numeric values, the system returns a number. In case of physical quantities, it applies the basic unit (e.g. Hz in case of frequencies). The number of digits after the decimal point depends on the type of numeric value.

Example:

Setting: `SENSe:FREQuency:CENTer 1GHZ`

Query: `SENSe:FREQuency:CENTer?` would return `1E9`

In some cases, numeric values may be returned as text.

- INF/NINF
  Infinity or negative infinity. Represents the numeric values 9.9E37 or -9.9E37.
- NAN
  Not a number. Represents the numeric value 9.91E37. NAN is returned in case of errors.

10.2.6.2 Boolean

Boolean parameters represent two states. The "ON" state (logically true) is represented by "ON" or a numeric value 1. The "OFF" state (logically untrue) is represented by "OFF" or the numeric value 0.

Querying boolean parameters

When you query boolean parameters, the system returns either the value 1 ("ON") or the value 0 ("OFF").

Example:

Setting: `DISPlay:WINDow:ZOOM:STATe ON`

Query: `DISPlay:WINDow:ZOOM:STATe?` would return `1`

10.2.6.3 Character Data

Character data follows the syntactic rules of keywords. You can enter text using a short or a long form. For more information see Chapter 10.2.2, "Long and Short Form", on page 145.

Querying text parameters

When you query text parameters, the system returns its short form.

Example:

Setting: `SENSe:BANDwidth:RESolution:TYPE NORMal`

Query: `SENSe:BANDwidth:RESolution:TYPE?` would return `NORM`

10.2.6.4 Character Strings

Strings are alphanumeric characters. They have to be in straight quotation marks. You can use a single quotation mark (') or a double quotation mark (").

Example:

`INSTRument:DELete 'Spectrum'`

10.2.6.5 Block Data

Block data is a format which is suitable for the transmission of large amounts of data.

The ASCII character # introduces the data block. The next number indicates how many of the following digits describe the length of the data block. In the example the 4 following digits indicate the length to be 5168 bytes. The data bytes follow. During the transmission of these data bytes all end or other control signs are ignored until all bytes are transmitted. #0 specifies a data block of indefinite length. The use of the indefinite format requires an `NL^END` message to terminate the data block. This format is useful when the length of the transmission is not known or if speed or other considerations prevent segmentation of the data into blocks of definite length.

10.3 Activating DOCSIS 3.1 Measurements

DOCSIS 3.1 measurements require a special application on the R&S FSW (R&S FSW-K192). The measurement is started immediately with the default settings.

Bandwidth extension option required

Both R&S FSW DOCSIS 3.1 applications require a bandwidth extension option for 320 MHz.

The R&S FSW-K193 option (for DOCSIS 3.1 **upstream** signals) requires the *new* bandwidth extension hardware R&S FSW-B320+ (11325.4867.04).

The R&S FSW-K192 option (for DOCSIS 3.1 **downstream** signals) requires either the option R&S FSW-B320 (1313.7172.02) *or* the new bandwidth extension hardware R&S FSW-B320+ (11325.4867.04).

If the required options are not installed, an error message is displayed and no measurements can be performed with the R&S FSW DOCSIS 3.1 applications.

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

INSTrument:CREate:DUPLicate.................149
INSTrument:CREate[:NEW].................149
INSTrument:CREate:REPLace.................150
INSTrument:DELete.................150
INSTrument:LIST?.................151
INSTrument:REName.................152
INSTrument[:SELect].................152
SYSTem:PRESet:CHANnel[:EXECute].................153

INSTrument:CREate:DUPLicate

This command duplicates the currently selected measurement channel, i.e creates a new measurement channel of the same type and with the identical measurement settings. The name of the new channel is the same as the copied channel, extended by a consecutive number (e.g. "IQAnalyzer" -> "IQAnalyzer2").

The channel to be duplicated must be selected first using the `INST:SEL` command.

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

Usage: Event

INSTrument:CREate[:NEW] <ChannelType>, <ChannelName>

This command adds an additional measurement channel.

The number of measurement channels you can configure at the same time depends on available memory.

Parameters:

<ChannelType> Channel type of the new channel.
For a list of available channel types see INSTrument:LIST? on page 151.

<ChannelName> String containing the name of the channel. The channel name is displayed as the tab label for the measurement channel.
Note: If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel (see INSTrument:LIST? on page 151).

Example: `INST:CRE IQ, 'IQAnalyzer2'`
Adds an additional I/Q Analyzer channel named "IQAnalyzer2".

INSTrument:CREate:REPLace <ChannelName1>,<ChannelType>,<ChannelName2>

This command replaces a measurement channel with another one.

Setting parameters:

<ChannelName1> String containing the name of the measurement channel you want to replace.

<ChannelType> Channel type of the new channel.
For a list of available channel types see INSTrument:LIST? on page 151.

<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 151).

Example: `INST:CRE:REPL 'IQAnalyzer2',IQ,'IQAnalyzer'`
Replaces the channel named 'IQAnalyzer2' by a new measurement channel of type 'IQ Analyzer' named 'IQAnalyzer'.

Usage: Setting only

INSTrument:DELete <ChannelName>

This command deletes a measurement channel.

If you delete the last measurement channel, the default "Spectrum" channel is activated.

Parameters:

<ChannelName> String containing the name of the channel you want to delete.
A measurement channel must exist in order to be able delete it.

Example: `INST:DEL 'IQAnalyzer4'`
Deletes the channel with the name 'IQAnalyzer4'.

Usage: Event

INSTrument:LIST?

This command queries all active measurement channels. This is useful in order to obtain the names of the existing measurement channels, which are required in order to replace or delete the channels.

Return values:

<ChannelType>, <ChannelName>
: For each channel, the command returns the channel type and channel name (see tables below).
Tip: to change the channel name, use the `INSTrument:REName` command.

Example:
`INST:LIST?`
Result for 3 measurement channels:
`'ADEM','Analog Demod','IQ','IQ Analyzer','IQ','IQ Analyzer2'`

Usage: Query only

Table 10-2: Available measurement channel types and default channel names in Signal and Spectrum Analyzer mode

Application	<ChannelType> Parameter	Default Channel Name*)
Spectrum	SANALYZER	Spectrum
1xEV-DO BTS (R&S FSW-K84)	BDO	1xEV-DO BTS
1xEV-DO MS (R&S FSW-K85)	MDO	1xEV-DO MS
3GPP FDD BTS (R&S FSW-K72)	BWCD	3G FDD BTS
3GPP FDD UE (R&S FSW-K73)	MWCD	3G FDD UE
802.11ad (R&S FSW-K95)	WIGIG	802.11ad
Amplifier Measurements (R&S FSW-K18)	AMPLifier	Amplifier
Analog Demodulation (R&S FSW-K7)	ADEM	Analog Demod
Avionics (R&S FSW-K15)	AVIonics	Avionics
cdma2000 BTS (R&S FSW-K82)	BC2K	CDMA2000 BTS
cdma2000 MS (R&S FSW-K83)	MC2K	CDMA2000 MS
DOCSIS 3.1 (R&S FSW-K192/193)	DOCSis	DOCSIS 3.1
GSM (R&S FSW-K10)	GSM	GSM
I/Q Analyzer	IQ	IQ Analyzer
LTE (R&S FSW-K10x)	LTE	LTE
Multi-Carrier Group Delay (R&S FSW-K17)	MCGD	MC Group Delay
Noise (R&S FSW-K30)	NOISE	Noise
Phase Noise (R&S FSW-K40)	PNOISE	Phase Noise
*) the default channel name is also listed in the table. If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel.		

Application	<ChannelType> Parameter	Default Channel Name*)
Pulse (R&S FSW-K6)	PULSE	Pulse
Real-Time Spectrum (R&S FSW-B160R/-K160RE)	RTIM	Real-Time Spectrum
Spurious Measurements (R&S FSW-K50)	SPUR	Spurious
TD-SCDMA BTS (R&S FSW-K76)	BTDS	TD-SCDMA BTS
TD-SCDMA UE (R&S FSW-K77)	MTDS	TD-SCDMA UE
Transient Analysis (R&S FSW-K60)	TA	Transient Analysis
VSA (R&S FSW-K70)	DDEM	VSA
WLAN (R&S FSW-K91)	WLAN	WLAN
*) the default channel name is also listed in the table. If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel.		

INSTrument:REName <ChannelName1>, <ChannelName2>

This command renames a measurement channel.

Parameters:

<ChannelName1> String containing the name of the channel you want to rename.

<ChannelName2> String containing the new channel name.
Note that you cannot assign an existing channel name to a new channel; this will cause an error.

Example: `INST:REN 'IQAnalyzer2','IQAnalyzer3'`
Renames the channel with the name 'IQAnalyzer2' to 'IQAnalyzer3'.

Usage: Setting only

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

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

See also `INSTrument:CREate[:NEW]` on page 149.

For a list of available channel types see `INSTrument:LIST?` on page 151.

Parameters:

<ChannelType> Channel type of the new channel.
For a list of available channel types see Table 10-2.

DOCSis
DOCSIS 3.1 option, R&S FSW–K192

<ChannelName> String containing the name of the channel.

Example: `INST DOCS`
Activates a measurement channel for the R&S FSW DOCSIS 3.1 application.
`INST 'DOCSIS'`
Selects the measurement channel named 'DOCSIS' (for example before executing further commands for that channel).

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

SYSTem:PRESet:CHANnel[:EXECute]

This command restores the default instrument settings in the current channel.

Use `INST:SEL` to select the channel.

Example: `INST:SEL 'Spectrum2'`
Selects the channel for "Spectrum2".
`SYST:PRES:CHAN:EXEC`
Restores the factory default settings to the "Spectrum2" channel.

Usage: Event

Manual operation: See "Preset Channel" on page 52

10.4 Selecting a Measurement

The following commands are required to define the measurement type in a remote environment. The selected measurement must be started explicitely (see Chapter 10.8, "Starting a Measurement", on page 245)!

For details on available measurements see Chapter 3, "Measurements and Result Display", on page 13.

The DOCSIS 3.1 I/Q measurement captures the I/Q data from the DOCSIS 3.1 signal using a (nearly rectangular) filter with a relatively large bandwidth. This measurement is selected when the DOCSIS 3.1 measurement channel is activated. The commands to select a different measurement or return to the DOCSIS 3.1 I/Q measurement are described here.

Use the `LAYout` commands to change the display (see Chapter 10.7, "Configuring the Result Display", on page 225).

CALCulate<n>:MARKer<m>:FUNCtion:POWer:SELect.. 154
CALCulate<n>:MARKer<m>:FUNCtion:POWer[:STATe].. 154
CALCulate<n>:STATistics:CCDF[:STATe].. 154

CALCulate<n>:MARKer<m>:FUNCtion:POWer:SELect <MeasType>

This command selects the occupied bandwidth measurement and turns the measurement on.

Suffix:
<n>, <m> irrelevant

Parameters:
<MeasType> **OBANdwidth | OBWidth**
Occupied bandwidth measurement.

Example: For a detailed example see Chapter 10.13.2, "Measurement 2: Determining the Occupied Bandwidth", on page 291

Manual operation: See "Occupied Bandwidth" on page 29

CALCulate<n>:MARKer<m>:FUNCtion:POWer[:STATe] <State>

This command turns a power measurement on and off.

Suffix:
<n>, <m> irrelevant

Parameters:
<State> ON | OFF

ON | 1
The power measurement selected with `CALCulate<n>:MARKer<m>:FUNCtion:POWer:SELect` is activated.

OFF | 0
A standard DOCSIS 3.1 I/Q (Modulation Accuracy) measurement is activated.

*RST: OFF

Usage: Setting only

CALCulate<n>:STATistics:CCDF[:STATe] <State>

This command turns the CCDF on and off.

If the CCDF measurement is deactivated, a standard DOCSIS 3.1 I/Q (Modulation Accuracy) measurement is activated.

Suffix:
<n> irrelevant

Parameters:
<State> ON | OFF

*RST: OFF

Example: `CALC:STAT:CCDF ON`
Switches on the CCDF measurement.

Manual operation: See "CCDF" on page 30

10.5 Configuring the DOCSIS 3.1 I/Q Measurement (Modulation Accuracy)

The following commands are required to configure the DOCSIS 3.1 I/Q measurement described in Chapter 3.1, "DOCSIS 3.1 I/Q Measurement", on page 13.

- Signal Description.....155
- Configuring the Data Input and Output.....178
- Frontend Configuration.....199
- Signal Capturing.....206
- Configuring Triggered Measurements.....208
- Tracking and Channel Estimation.....216
- Demodulation.....218
- Evaluation Range.....220
- Automatic Settings.....224

10.5.1 Signal Description

The signal description provides information on the expected input signal.

- OFDM Downstream Channel Description.....155
- OFDM Upstream Channel Description.....160
- Continuous Pilots and Excluded Subcarrier Assignment.....163
- Profile Configuration and Modulation Subcarrier Assignment (Downstream).....168
- Profile Configuration (Upstream).....175
- Codeword/Frame Configuration.....176

10.5.1.1 OFDM Downstream Channel Description

CONFigure:CHANnel:CP.....155
CONFigure:CHANnel:NFFT.....156
CONFigure:CHANnel:ROFF.....157
CONFigure:DS:CHANnel:NCP:MODulation.....157
CONFigure:DS:CHANnel:PLC:CARRiers?.....158
CONFigure:DS:CHANnel:PLC:INDex.....158
CONFigure:DS:CHANnel:PLC:INDex:AUTO.....158
CONFigure:DS:CHANnel:PLC:MODulation?.....159
CONFigure:DS:CHANnel:SPECtrum:FREQuency.....159
CONFigure:DS:CHANnel:TIDepth.....159
CONFigure:SDIRection.....159

CONFigure:CHANnel:CP <CyclicPrefix> (downstream)

Defines the cyclic prefix, which determines where the useful data starts and allows the application to detect delay spreads during transmission. The longer the delay spread, the longer the CP must be.

This command describes the parameters for downstream signals. For upstream signals see `CONFigure:CHANnel:CP` on page 160.

Parameters:

<CyclicPrefix>

AUTO
The length is determined automatically by the R&S FSW DOCSIS 3.1 application and indicated in the dialog box after the next measurement.

S192
Useful symbol period starts after 192 samples or 0.9375µs.

S256
Useful symbol period starts after 256 samples or 1.25µs.

S512
Useful symbol period starts after 512 samples or 2.5µs.

S768
Useful symbol period starts after 768 samples or 3.75µs.

S1024
Useful symbol period starts after 1024 samples or 5.0µs.

*RST: AUTO

Example: `CONF:CHAN:CP S192`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Mode: downstream

Manual operation: See "Cyclic Prefix CP" on page 55

CONFigure:CHANnel:NFFT <NFFTsubcarriers>

Defines the length of the FFT duration, which corresponds to the number of phsyical subcarriers.

Parameters:

<NFFTsubcarriers> FFT2K | FFT4K | FFT8K

FFT2K
Upstream only:
2048 subcarriers at = 50 kHz spacing; FFT length = 2048 samples

FFT4K
Downstream: 4096 subcarriers at = 50 kHz spacing; FFT length = 4096 samples
Upstream: 4096 subcarriers at = 25 kHz spacing; FFT length = 4096 samples

FFT8K
Downstream only:
8192 subcarriers at 25 kHz spacing; FFT length = 2048 samples

*RST: FFT4K

Example: `CONF:CHAN:NFFT FFT8K`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "N_{FFT} (FFT length)" on page 55
See "N_{FFT} (FFT length)" on page 69

CONFigure:CHANnel:ROFF <RollOff> (downstream)

Defines the roll-off period for the Tukey raised-cosine window which is applied at the beginning (and end) of an OFDM symbol.

The required period depends on the channel bandwidth and the number of excluded carriers within the channel. The larger the roll-off period, the more time transmission takes; however, the more useful subcarriers are available in the frequency domain.

This command describes the parameters for downstream signals. For upstream signals see `CONFigure:CHANnel:ROFF` on page 161.

Parameters:

<RollOff> AMRO | S0 | S32 | S64 | S96 | S128 | S160 | S192 | S224 | S256

AMRO
The maximum possible roll-off period is used automatically.

S0
No samples in the roll-off period (for no transmit windowing)

S64
The roll-off period contains 64 samples and lasts 0.3125 μs.

S128
The roll-off period contains 128 samples and lasts 0.625 μs.

S192
The roll-off period contains 192 samples and lasts 0.9375 μs.

S256
The roll-off period contains 256 samples and lasts 1.25 μs.

*RST: AMRO

Example: `CONF:CHAN:ROFF S64`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Roll-off" on page 56
See "Roll-off" on page 70

CONFigure:DS:CHANnel:NCP:MODulation <NCPModulation>

Defines the modulation used by the Next Codeword Pointer (NCP).

Parameters:

<NCPModulation> QPSK | QAM16 | QAM64

*RST: QAM16

Example: `CONF:DS:CHAN:NCP:MOD QAM16`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "NCP Modulation" on page 57

CONFigure:DS:CHANnel:PLC:CARRiers?

Queries the number of subcarriers used by the PLC. The number of subcarriers depends on the FFT length setting (see `CONFigure:CHANnel:NFFT` on page 156).

Example: `CONF:DS:CHAN:PLC:CARR?`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Usage: Query only

Manual operation: See "PLC Number of Subcarriers (N_p)" on page 57

CONFigure:DS:CHANnel:PLC:INDex <PlcIndex>

Defines the start index of the physical link channel (PLC) if automatic detection is disabled (see `CONFigure:DS:CHANnel:PLC:INDex:AUTO` on page 158).

Setting parameters:
<PlcIndex> *RST: -1

Example: `CONF:DS:CHAN:PLC:IND 200`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "PLC Start Index L" on page 56

CONFigure:DS:CHANnel:PLC:INDex:AUTO <State>

If enabled, the start index of the physical link channel (PLC) is detected automatically.

If disabled, the numeric value defined by `CONFigure:DS:CHANnel:PLC:INDex` is used.

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

Example: `CONF:DS:CHAN:PLC:IND:AUTO ON`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "PLC Start Index L" on page 56

CONFigure:DS:CHANnel:PLC:MODulation?

Queries the currently used PLC modulation.

Return values:

<ModType>	Currently, only 16QAM modulation is supported.
Example:	`CONF:DS:CHAN:PLC:MOD?`
Example:	For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.
Usage:	Query only
Manual operation:	See "PLC Modulation" on page 57

CONFigure:DS:CHANnel:SPECtrum:FREQuency <Frequency>

Specifies the center frequency in Hz of the subcarrier 0 of the OFDM channel (f_{sc0}), which defines the beginning of the OFDM spectrum.

The default value is derived from the current center frequency. If the spectrum location is changed, the center frequency is adapted accordingly (see `[SENSe:]FREQuency:CENTer` on page 200).

Parameters:

<Frequency>	Default unit: Hz
Example:	`CONF:DS:CHAN:SPEC:FREQ 1285000`
Manual operation:	See "OFDM Spectrum Location" on page 55

CONFigure:DS:CHANnel:TIDepth <TimeInterDepth>

Defines the maximum number of delay lines used for time interleaving. The required depth depends on the symbol duration, that is the subcarrier spacing.

Setting parameters:

<TimeInterDepth>	Range:	1 to 16 (for NFFT = 8K mode); 32 (for NFFT = 4K mode)
	*RST:	16 (NFFT = 4K mode)
Example:	`CONF:DS:CHAN:TID 16`	
Example:	For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.	
Manual operation:	See "Time-Interleaving Depth" on page 56	

CONFigure:SDIRection <StreamDirection>

Defines the direction of the signal stream to be analyzed. Various configuration parameters for the DOCSIS 3.1 measurement depend on the stream direction.

Parameters:

<StreamDirection> US | DS

DS
Downstream signal (from the base station to the cable modems). Requires R&S FSW-K192 option.

US
Upstream signal (from the cable modems to the base station). Requires R&S FSW-K193 option.

*RST: DS

Manual operation: See "Stream Direction" on page 54

10.5.1.2 OFDM Upstream Channel Description

Useful commands for upstream channels described elsewhere:

- `CONFigure:SDIRection` on page 159
- `CONFigure:CHANnel:NFFT` on page 156

Remote commands exclusive to upstream channels

CONFigure:CHANnel:CP....................................160
CONFigure:CHANnel:ROFF....................................161
CONFigure:US:CHANnel:SPECtrum:FREQuency....................................162
CONFigure:US:CHANnel:SYMBols....................................162

CONFigure:CHANnel:CP <CyclicPrefix> (upstream)

Defines the cyclic prefix, which determines where the useful data starts and allows the application to detect delay spreads during transmission. The longer the delay spread, the longer the CP must be.

This command describes the parameters for upstream signals. For downstream signals see `CONFigure:CHANnel:CP` on page 155.

Parameters:
<CyclicPrefix>

AUTO
The length is determined automatically by the R&S FSW DOCSIS 3.1 application and indicated in the dialog box after the next measurement.

S96
Useful symbol period starts after 96 samples or 0.9375 µs.

S128
Useful symbol period starts after 128 samples or 1.25 µs.

S160
Useful symbol period starts after 160 samples or 1.5625 µs.

S192
Useful symbol period starts after 192 samples or 0.9375µs.

S224
Useful symbol period starts after 224 samples or 1.875 µs.

S256
Useful symbol period starts after 256 samples or 2.5µs.

S288
Useful symbol period starts after 288 samples or 2.8125 µs.

S320
Useful symbol period starts after 320 samples or 3.125 µs.

S384
Useful symbol period starts after 384 samples or 3.75 µs.

S512
Useful symbol period starts after 512 samples or 5.0µs.

S640
Useful symbol period starts after 640 samples or 6.25 µs.

*RST: AUTO

Example: `CONF:CHAN:CP S192`

Mode: upstream

Manual operation: See "Cyclic Prefix CP" on page 69

CONFigure:CHANnel:ROFF <RollOff> (upstream)

Defines the roll-off period for the Tukey raised-cosine window which is applied at the beginning (and end) of an OFDM symbol.

The required period depends on the channel bandwidth and the number of excluded carriers within the channel. The larger the roll-off period, the more time transmission takes; however, the more useful subcarriers are available in the frequency domain.

This command describes the parameters for upstream signals. For downstream signals see `CONFigure:CHANnel:ROFF` on page 157.

Parameters:
<RollOff>

AMRO
The maximum possible roll-off period is used automatically.

S0
No samples in the roll-off period (for no transmit windowing)

S32
The roll-off period contains 64 samples and lasts 0.3125 µs.

S64
The roll-off period contains 128 samples and lasts 0.625 µs.

S96
The roll-off period contains 192 samples and lasts 0.9375 µs.

S128
The roll-off period contains 256 samples and lasts 1.25 µs.

S160
The roll-off period contains 256 samples and lasts 1.25 µs.

S192
The roll-off period contains 256 samples and lasts 1.25 µs.

S224
The roll-off period contains 256 samples and lasts 1.25 µs.

*RST: AMRO

Example: `CONF:CHAN:ROFF S64`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

CONFigure:US:CHANnel:SPECtrum:FREQuency <StartFreq>

Specifies the center frequency in Hz of the subcarrier 0 of the OFDM channel (f_{sc0}), which defines the beginning of the OFDM spectrum.

The default value is derived from the current center frequency. If the spectrum location is changed, the center frequency is adapted accordingly (see `[SENSe:]FREQuency:CENTer` on page 200).

Parameters:
<StartFreq> Default unit: Hz

Example: `CONF:US:CHAN:SPEC:FREQ 1285000`

Manual operation: See "OFDM Spectrum Location" on page 69

CONFigure:US:CHANnel:SYMBols <SymbolsPerFrame>

Defines the number of symbols per frame to be expected.

Setting parameters:

<SymbolsPerFrame> The number of symbols per frame varies depending on the used bandwidth and N_{FFT} (FFT length).

Range: 2K mode: 6 to 36; 4K mode: 6 to 18;

Example: `CONF:US:CHAN:SYMB 8`

Manual operation: See "Symbols Per Frame (K)" on page 71

10.5.1.3 Continuous Pilots and Excluded Subcarrier Assignment

Useful commands for configuring continuous pilots described elsewhere:

- `[SENSe:]DEMod:CPILots:AUTO` on page 218

Remote commands exclusive to configuring continuous pilots and excluded subcarriers:

CONFigure:DS:CHANnel:CPES<i>:COUNt?....................163
CONFigure:DS:CHANnel:CPES<i>:SUBCarrier:INCRement....................164
CONFigure:DS:CHANnel:CPES<i>:SUBCarrier:SET....................164
CONFigure:DS:CHANnel:CPES<i>:SUBCarrier:STARt....................164
CONFigure:DS:CHANnel:CPES<i>:SUBCarrier:STOP....................165
CONFigure:DS:CHANnel:CPES<n>:SUBCarrier:TYPE....................165
CONFigure:US:CHANnel:ESUB<i>:COUNt?....................166
CONFigure:US:CHANnel:ESUB<i>:SUBCarrier:INCRement....................166
CONFigure:US:CHANnel:ESUB<i>:SUBCarrier:SET....................167
CONFigure:US:CHANnel:ESUB<i>:SUBCarrier:STARt....................167
CONFigure:US:CHANnel:ESUB<i>:SUBCarrier:STOP....................167
CONFigure:US:CHANnel:ESUB<i>:SUBCarrier:TYPE?....................168

CONFigure:DS:CHANnel:CPES<i>:COUNt?

Queries the number of entries in the Continuous Pilots and Excluded Subcarrier Assignment table.

Suffix:

<i> 1..200
irrelevant

Return values:

<Entries> integer

Range: 1 to 200

Example: `CONF:DS:CHAN:CPES:COUN?`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Usage: Query only

Manual operation: See "Set Index" on page 58

CONFigure:DS:CHANnel:CPES<i>:SUBCarrier:INCRement <Increment>

Defines the increment for a series of subcarriers to be configured identically in the Continuous Pilots and Excluded Subcarrier Assignment table.

Suffix:

<i> 1..200
index in the Continuous Pilots and Excluded Subcarrier Assignment table

Parameters:

<Increment> Range: 1 to 2K mode: 4095; 4K mode: 8191

Example: `CONF:DS:CHAN:CPES2:SUBC:INCR 10`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Subcarrier Range (Start / Increment / Stop)" on page 59

CONFigure:DS:CHANnel:CPES<i>:SUBCarrier:SET <Subcarrier>[, <Subcarrier>]

Defines a comma-separated list of (discrete) subcarriers to be configured identically in the Continuous Pilots and Excluded Subcarrier Assignment table.

Suffix:

<i> 1..200
index in the Continuous Pilots and Excluded Subcarrier Assignment table

Parameters:

<Subcarrier> integer
Subcarrier number
Range: 1 to 4095 (4k), 8191 (8k)

Example: `CONFigure:DS:CHANnel:CPES2:SUBCarrier:SET 301, 302`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Subcarrier Set" on page 59

CONFigure:DS:CHANnel:CPES<i>:SUBCarrier:STARt <SubcarrierStart>

Defines the first subcarrier in a series of subcarriers to be configured identically in the Continuous Pilots and Excluded Subcarrier Assignment table.

Suffix:

<i> 1..200
index in the Continuous Pilots and Excluded Subcarrier Assignment table

Parameters:

<SubcarrierStart> integer

Subcarrier number
Must be lower than the parameter used by `CONFigure:DS:CHANnel:CPES<i>:SUBCarrier:STOP` on page 165.

Range: 1 to 4094 (4k), 8190 (8k)

Example: `CONF:DS:CHAN:CPES2:SUBC:STAR 100`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Subcarrier Range (Start / Increment / Stop)" on page 59

CONFigure:DS:CHANnel:CPES<i>:SUBCarrier:STOP <SubcarrierStop>

Defines the last subcarrier in a series of subcarriers to be configured identically in the Continuous Pilots and Excluded Subcarrier Assignment table.

Suffix:

<i> 1..200
index in the Continuous Pilots and Excluded Subcarrier Assignment table

Parameters:

<SubcarrierStop> integer

Subcarrier number
Must be higher than the parameter used by `CONFigure:DS:CHANnel:CPES<i>:SUBCarrier:STARt` on page 164.

Range: 1 to 4095 (4k), 8191 (8k)

Example: `CONF:DS:CHAN:CPES2:SUBC:STOP 250`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Subcarrier Range (Start / Increment / Stop)" on page 59

CONFigure:DS:CHANnel:CPES<n>:SUBCarrier:TYPE <SubcarrierType>

Defines the type of configuration for the specified entry in the Continuous Pilots and Excluded Subcarrier Assignment table.

Suffix:

<n> 1..n
index in the Continuous Pilots and Excluded Subcarrier Assignment table

Parameters:
<SubcarrierType> CPIL | ESUB

PLC
Physical link channel
(Query only, always available as first entry.)

CPIL
Continuous pilot

ESUB
Excluded subcarrier

Example: `CONF:DS:CHAN:CPES2:SUBC:TYPE CPIL`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Type" on page 58

CONFigure:US:CHANnel:ESUB<i>:COUNt?

Queries the number of entries in the Excluded Subcarrier Assignment table.

Suffix:
<i> 1..200
irrelevant

Return values:
<Entries> integer
Range: 1 to 200

Example: `CONF:US:CHAN:ESUB:COUN?`

Usage: Query only

Manual operation: See "Set Index" on page 72

CONFigure:US:CHANnel:ESUB<i>:SUBCarrier:INCRement <SubcarrierIncrement>

Defines the increment for a series of subcarriers to be configured identically in the Excluded Subcarrier Assignment table.

Suffix:
<i> 1..200
index in the Excluded Subcarrier Assignment table

Parameters:
<Increment> Range: 1 to 2K mode: 2047; 4K mode: 4095

Example: `CONF:US:CHAN:ESUB2:SUBC:INCR 10`

Manual operation: See "Subcarrier Range (Start / Increment / Stop)" on page 72

CONFigure:US:CHANnel:ESUB<i>:SUBCarrier:SET <Subcarrier>[, <Subcarrier>]

Defines a comma-separated list of (discrete) subcarriers to be configured identically in the Excluded Subcarrier Assignment table.

Suffix:
<i> 1..200
index in the Excluded Subcarrier Assignment table

Parameters:
<Subcarrier> integer

Subcarrier number

Range: 1 to 2047 (2k), 4095 (4k)

Example: `CONFigure:US:CHANnel:ESUB2:SUBCarrier:SET 301, 302`

Manual operation: See "Subcarrier Set" on page 73

CONFigure:US:CHANnel:ESUB<i>:SUBCarrier:STARt <SubcarrierStart>

Defines the first excluded subcarrier in a series of subcarriers in the Excluded Subcarrier Assignment table.

Suffix:
<i> 1..200
index in the Excluded Subcarrier Assignment table

Parameters:
<SubcarrierStop> integer

Subcarrier number
Must be lower than the parameter used by `CONFigure:US:CHANnel:ESUB<i>:SUBCarrier:STOP` on page 167.

Range: 1 to 2047 (2k), 4094 (4k)

Manual operation: See "Subcarrier Range (Start / Increment / Stop)" on page 72

CONFigure:US:CHANnel:ESUB<i>:SUBCarrier:STOP <SubcarrierStop>

Defines the last excluded subcarrier in a series of subcarriers in the Excluded Subcarrier Assignment table.

Suffix:
<i> 1..200
index in the Excluded Subcarrier Assignment table

Parameters:
<SubcarrierStop> integer

Subcarrier number
Must be higher than the parameter used by `CONFigure:US:CHANnel:ESUB<i>:SUBCarrier:STARt` on page 167.

Range: 1 to 2047 (2k), 4095 (4k)

Manual operation: See "Subcarrier Range (Start / Increment / Stop)" on page 72

CONFigure:US:CHANnel:ESUB<i>:SUBCarrier:TYPE?

Queries the type of special subcarrier; for upstream signals, only excluded subcarriers are available

Suffix:
<i> 1..200
irrelevant

Return values:
<Type> **ESUB**
Subcarrier that cannot be used because another type of service is using the subcarrier's frequency or a permanent ingressor is present on the frequency.

Example: `CONF:US:CHAN:ESUB:SUBC:TYPE?`

Usage: Query only

Manual operation: See "Type" on page 72

10.5.1.4 Profile Configuration and Modulation Subcarrier Assignment (Downstream)

Useful commands for modulation subcarrier assignment described elsewhere:

- `CONFigure:DS:CHANnel:NCP:MODulation` on page 157

Remote commands exclusive to profile configuration and modulation subcarrier assignment

CONFigure:DS:CHANnel:NCP:PCONfig<i>:COUNt? 168
CONFigure:DS:CHANnel:NCP:PCONfig<i>:SUBCarrier:INCRement 169
CONFigure:DS:CHANnel:NCP:PCONfig<i>:SUBCarrier:MODulation 169
CONFigure:DS:CHANnel:NCP:PCONfig<i>:SUBCarrier:SET 170
CONFigure:DS:CHANnel:NCP:PCONfig<i>:SUBCarrier:STARt 170
CONFigure:DS:CHANnel:NCP:PCONfig<i>:SUBCarrier:STOP 170
CONFigure:DS:CHANnel:PCONfig<i>:COUNt? 171
CONFigure:DS:CHANnel:PCONfig<i>:DELete 171
CONFigure:DS:CHANnel:PCONfig<i>:SELect 171
CONFigure:DS:CHANnel:PCONfig<i>:STATe? 172
CONFigure:DS:CHANnel:PCONfig<i>:SUBCarrier:INCRement 172
CONFigure:DS:CHANnel:PCONfig<i>:SUBCarrier:MODulation 173
CONFigure:DS:CHANnel:PCONfig<i>:SUBCarrier:SET 173
CONFigure:DS:CHANnel:PCONfig<i>:SUBCarrier:STARt 174
CONFigure:DS:CHANnel:PCONfig<i>:SUBCarrier:STOP 174

CONFigure:DS:CHANnel:NCP:PCONfig<i>:COUNt?

Queries the number of entries in the modulation table for the NCP profile.

Suffix:
<i> 1..200
irrelevant

Return values:
<NoEntries> Number of entries
Range: 1 to 200

Example: `CONF:DS:CHAN:NCP:PCON:COUN?`

Usage: Query only

Manual operation: See "Set Index" on page 65

CONFigure:DS:CHANnel:NCP:PCONfig<i>:SUBCarrier:INCRement <Increment>

Defines the increment in a series of subcarriers in the selected row to be configured identically in the NCP profile.

Suffix:
<i> 1..200
index of the entry in the NCP profile (index 0: <i> = 1)
row 0 is not editable

Parameters:
<Increment> integer
Value between 1 and maximum number of subcarriers.

Example: `CONF:DS:CHAN:NCP:PCON2:SUBC:INCR 10`

Manual operation: See "Start / Increment / Stop" on page 66

CONFigure:DS:CHANnel:NCP:PCONfig<i>:SUBCarrier:MODulation <ModType_NCP>

Defines the modulation used by the specified row in the NCP profile. Note that the modulation for the row 0 is not editable, and for all other rows, the modulation is always zero bit.

Suffix:
<i> 1..200
index of the entry in the NCP profile (index 0: <i> = 1)
row 0 is not editable

Parameters:
<ModType_NCP> ZEROBIT

Manual operation: See "Modulation" on page 65

CONFigure:DS:CHANnel:NCP:PCONfig<i>:SUBCarrier:SET <Subcarrier>[, <Subcarrier>]

Defines a comma-separated list of (discrete) subcarriers to be configured identically in the selected row of the NCP profile.

Suffix:

<i> 1..200
index of the entry in the NCP profile (index 0: <i> = 1)
row 0 is not editable

Parameters:

<Subcarrier> Subcarrier number

Range: 1 to 2K mode: 2047; 4K mode: 4095

Example: `CONF:DS:CHAN:NCP:PCON2:SUBC:SET 100,101,102`

Manual operation: See "Subcarrier Set" on page 66

CONFigure:DS:CHANnel:NCP:PCONfig<i>:SUBCarrier:STARt <SubcarrierStart>

Defines the first subcarrier in a series of subcarriers in the selected row to be configured identically in the NCP profile.

Suffix:

<i> 1..200
index of the entry in the NCP profile (index 0: <i> = 1)
row 0 is not editable

Parameters:

<SubcarrierStart> Range: 1 to 2K mode: 2047; 4K mode: 4095
Must be lower than the parameter used by `CONFigure:DS:CHANnel:NCP:PCONfig<i>:SUBCarrier:STOP` on page 170.

Example: `CONF:DS:CHAN:NCP:PCON2:SUBC:STAR 100`

Manual operation: See "Start / Increment / Stop" on page 66

CONFigure:DS:CHANnel:NCP:PCONfig<i>:SUBCarrier:STOP <SubcarrierStop>

Defines the last subcarrier in a series of subcarriers in the selected row to be configured identically in the NCP profile.

Suffix:

<i> 1..200
index of the entry in the NCP profile (index 0: <i> = 1)
row 0 is not editable

Parameters:
<SubcarrierStop> Range: 1 to 2K mode: 2047; 4K mode: 4095
Must be higher than the parameter used by `CONFigure:DS:CHANnel:NCP:PCONfig<i>:SUBCarrier:STARt` on page 170.

Example: `CONF:DS:CHAN:NCP:PCON2:SUBC:STOP 100`

Manual operation: See "Start / Increment / Stop" on page 66

CONFigure:DS:CHANnel:PCONfig<i>:COUNt?

Queries the number of entries in the Modulation Subcarrier Assignment table for the selected profile.

Use the `CONFigure:DS:CHANnel:PCONfig<i>:SELect` command to select a profile.

Suffix:
<i> 1..200
irrelevant

Return values:
<NoEntries> Number of entries
Range: 0 to 200

Example: `CONF:DS:CHAN:PCON:COUN?`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Usage: Query only

Manual operation: See "Set Index" on page 65

CONFigure:DS:CHANnel:PCONfig<i>:DELete

This command deletes the currently selected profile.

Use the `CONFigure:DS:CHANnel:PCONfig<i>:SELect` command to select a profile.

Suffix:
<i> 1..200
irrelevant

Example: `CONF:DS:CHAN:PCON2:DEL`

Usage: Event

CONFigure:DS:CHANnel:PCONfig<i>:SELect <Profile>

This command selects the specified profile for further operation (e.g. configuration).

Suffix:
<i> 1..200
irrelevant

Parameters:
<Profile> A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | NONE

Example: `CONFigure:DS:CHANnel:PCONfig:SELect A`
`CONFigure:DS:CHANnel:PCONfig:COUNt?`
Returns the number of entries in the Modulation Subcarrier Assignment table for the profile A.

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Profile List" on page 64

CONFigure:DS:CHANnel:PCONfig<i>:STATe?

This command returns the state of the currently selected profile, that is: whether the profile contains configuration entries or not.

Use the `CONFigure:DS:CHANnel:PCONfig<i>:SELect` command to select a profile.

Suffix:
<i> 1..200
irrelevant

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

OFF | 0
The profile is empty.

ON | 1
The profile contains configuration entries for at least one subcarrier.

*RST: 0

Example: `CONFigure:DS:CHANnel:PCONfig:SELect A`
`CONFigure:DS:CHANnel:PCONfig:STATe?`
Returns the state of the Modulation Subcarrier Assignment table for the profile A.

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Usage: Query only

CONFigure:DS:CHANnel:PCONfig<i>:SUBCarrier:INCRement <Increment>

Defines the increment for a series of subcarriers to be configured identically in the Modulation Subcarrier Assignment table for the currently selected profile.

Use the `CONFigure:DS:CHANnel:PCONfig<i>:SELect` command to select a profile.

Suffix:
<i> 1..200
index in the Modulation Subcarrier Assignment table for the currently selected profile

Parameters:
<Increment> integer
Range: 1 to 4095 (4k), 8191 (8k)

Example: `CONF:DS:CHAN:PCON2:SUBC:INCR 10`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Start / Increment / Stop" on page 66

CONFigure:DS:CHANnel:PCONfig<i>:SUBCarrier:MODulation <ModType_DS>

Defines the modulation used by the specified subcarriers in the currently selected profile.

Use the `CONFigure:DS:CHANnel:PCONfig<i>:SELect` command to select a profile.

Suffix:
<i> 1..200
index in the Modulation Subcarrier Assignment table for the currently selected profile

Parameters:
<ModType_DS> ZEROBIT | QPSK | QAM16 | QAM64 | QAM128 | QAM256 | QAM512 | QAM1024 | QAM2048 | QAM4096 | QAM8192 | QAM16384

Example: `CONF:DS:CHAN:PCON2:SUBC:MOD QAM16`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Modulation" on page 65

CONFigure:DS:CHANnel:PCONfig<i>:SUBCarrier:SET <Subcarrier>[, <Subcarrier>]

Defines a comma-separated list of (discrete) subcarriers to be configured identically in the Modulation Subcarrier Assignment table for the currently selected profile.

Use the `CONFigure:DS:CHANnel:PCONfig<i>:SELect` command to select a profile.

Suffix:
<i> 1..200
index in the Modulation Subcarrier Assignment table for the currently selected profile

Parameters:
<Subcarrier> Subcarrier number

Range: 1 to 2K mode: 2047; 4K mode: 4095

Example: `CONF:DS:CHAN:PCON2:SUBC:SET 100,101,102`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Subcarrier Set" on page 66

CONFigure:DS:CHANnel:PCONfig<i>:SUBCarrier:STARt <SubcarrierStart>

Defines the first subcarrier in a series of subcarriers to be configured identically in the Modulation Subcarrier Assignment table for the currently selected profile.

Use the `CONFigure:DS:CHANnel:PCONfig<i>:SELect` command to select a profile.

Suffix:
<i> 1..200
index in the Modulation Subcarrier Assignment table for the currently selected profile

Parameters:
<SubcarrierStart> Range: 1 to 2K mode: 2047; 4K mode: 4095
Must be lower than the parameter used by `CONFigure:DS:CHANnel:PCONfig<i>:SUBCarrier:STOP` on page 174.

Example: `CONF:DS:CHAN:PCON2:SUBC:STAR 10`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Start / Increment / Stop" on page 66

CONFigure:DS:CHANnel:PCONfig<i>:SUBCarrier:STOP <SubcarrierStop>

Defines the last subcarrier in a series of subcarriers to be configured identically in the Modulation Subcarrier Assignment table for the currently selected profile.

Use the `CONFigure:DS:CHANnel:PCONfig<i>:SELect` command to select a profile.

Suffix:
<i> 1..200
index in the Modulation Subcarrier Assignment table for the currently selected profile

Parameters:
<SubcarrierStop> Range: 1 to 2K mode: 2047; 4K mode: 4095
Must be higher than the parameter used by `CONFigure:DS:CHANnel:PCONfig<i>:SUBCarrier:STARt` on page 174.

Example: `CONF:DS:CHAN:PCON2:SUBC:STOP 100`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Start / Increment / Stop" on page 66

10.5.1.5 Profile Configuration (Upstream)

The following commands require option R&S FSW-K193

CONFigure:US:CHANnel:PCONfig<i>:MINislot:COUNt..175
CONFigure:US:CHANnel:PCONfig<i>:MINislot:MODulation...175
CONFigure:US:CHANnel:PCONfig<i>:MINislot:PPATtern..176

CONFigure:US:CHANnel:PCONfig<i>:MINislot:COUNt <NoSlots>

Defines the number of minislots for which the specified configuration applies.

Suffix:
<i> 1..200
index in the Profile Configuration (Upstream) table

Parameters:
<NoSlots> Number of minislots
Range: 1 to 237
*RST: 10

Example: `CONF:US:CHAN:PCON2:MIN:COUN 4`

Manual operation: See "Number of Minislots" on page 75

CONFigure:US:CHANnel:PCONfig<i>:MINislot:MODulation <ModType_US>

Defines the modulation used by the specified subcarriers.

Suffix:
<i> 1..200
index in the Profile Configuration (Upstream) table

Parameters:
<ModType_US> ZEROVAL | BPSK | QPSK | QAM8 | QAM16 | QAM32 | QAM64 | QAM128 | QAM256 | QAM512 | QAM1024 | QAM2048 | QAM4096

Example: `CONF:US:CHAN:PCON:MIN:MOD QAM16`

Manual operation: See "Minislot Modulation" on page 74

CONFigure:US:CHANnel:PCONfig<i>:MINIslot:PPATtern <PilotPattern>

Defines the pilot pattern used by the specified minislots. Which patterns are available depends on the FFT mode.

For more information, see "Pilot patterns" on page 40.

Suffix:

<i> 1..200
index in the Profile Configuration (Upstream) table

Parameters:

<PilotPattern> integer

The pattern values depend on the selected N_{FFT} (FFT length).

Range: 2K mode: 1 to 7; 4K mode: 8 to 14

Manual operation: See "Minislot Pilot Pattern" on page 75

10.5.1.6 Codeword/Frame Configuration

Useful commands for codeword/frame configuration described elsewhere:

- `[SENSe:]DEMod:NCP:AUTO` on page 220

Remote commands exclusive to codeword/frame configuration:

CONFigure:DS:CHANnel:FCONfig<i>:COUNt?....176
CONFigure:DS:CHANnel:FCONfig<i>:PROFile....177
CONFigure:DS:CHANnel:FCONfig<i>:SUBCarrier:COUNt....177
CONFigure:DS:CHANnel:FCONfig<i>:SUBCarrier:STARt....177
CONFigure:DS:CHANnel:FCONfig<i>:SYMBol:COUNt....178
CONFigure:DS:CHANnel:FCONfig<i>:SYMBol:STARt....178

CONFigure:DS:CHANnel:FCONfig<i>:COUNt?

This command returns the number of codewords (rows) in the "Frame Configuration" table.

Suffix:

<i> irrelevant

Return values:

<Codewords> integer

Range: 1 to 200

Example: `CONF:DS:CHAN:FCON2:COUN?`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Usage: Query only

Manual operation: See "Codeword Index" on page 61

CONFigure:DS:CHANnel:FCONfig<i>:PROFile <ProfileType>

Assigns one of the active profiles defined in the "Profile List" on page 64 to the selected codeword.

To determine whether a profile is active or not, use the `CONFigure:DS:CHANnel:PCONfig<i>:STATe?` query.

Suffix:

<i>	1..1536 codeword index in the Codeword / Frame Configuration table

Parameters:

<ProfileType>	A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | NONE

Example: `CONF:DS:CHAN:FCON2:PROF A`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Profile" on page 62

CONFigure:DS:CHANnel:FCONfig<i>:SUBCarrier:COUNt <NoSubcarriers>

Defines the number of subcarriers to which the selected codeword is assigned.

Suffix:

<i>	1..1536 codeword index in the Codeword / Frame Configuration table

Parameters:

<NoSubcarriers>	Range: 1 to 3745 (4k), 7537 (8k)

Example: `CONF:DS:CHAN:FCON2:SUBC:COUN 200`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Number of Subcarriers" on page 62

CONFigure:DS:CHANnel:FCONfig<i>:SUBCarrier:STARt <SubcarrierStart>

Defines the first subcarrier to which the selected codeword is assigned.

Suffix:

<i>	1..1536 codeword index in the Codeword / Frame Configuration table

Parameters:

<SubcarrierStart>	integer Subcarrier number Range: 1 to 3745 (4k), 7537 (8k)

Example: `CONF:DS:CHAN:FCON2:SUBC:STAR 1`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "First Subcarrier" on page 62

CONFigure:DS:CHANnel:FCONfig<i>:SYMBol:COUNt <NoSymbols>

Defines the number of symbols to which the selected codeword is assigned.

Suffix:
<i> 1..1536
codeword index in the Codeword / Frame Configuration table

Parameters:
<NoSymbols> integer
Range: 1 to 4

Example: `CONF:DS:CHAN:FCON2:SYMB:COUN 3`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Number of Symbols" on page 62

CONFigure:DS:CHANnel:FCONfig<i>:SYMBol:STARt <SymbolStart>

Defines the first symbol to which the selected codeword is assigned.

Suffix:
<i> 1..1536
codeword index in the Codeword / Frame Configuration table

Parameters:
<SymbolStart> integer
Range: 0 to 127

Example: `CONF:DS:CHAN:FCON2:SYMB:STAR 1`

Manual operation: See "First Symbol" on page 62

10.5.2 Configuring the Data Input and Output

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- Configuring the Outputs 198

10.5.2.1 RF Input

INPut:ATTenuation:PROTection:RESet 179
INPut:COUPling 179
INPut:DPATh 179
INPut:FILTer:HPASs[:STATe] 180
INPut:FILTer:YIG[:STATe] 180
INPut:IMPedance 180
INPut:SELect 181

INPut:ATTenuation:PROTection:RESet

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

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

Usage: Event

INPut:COUPling <CouplingType>

This command selects the coupling type of the RF input.

Parameters:
<CouplingType>
AC
AC coupling
DC
DC coupling
*RST: AC

Example: `INP:COUP DC`

Usage: SCPI confirmed

Manual operation: See "Input Coupling" on page 77

INPut:DPATh <State>

Enables or disables the use of the direct path for frequencies close to 0 Hz.

Parameters:
<State>
AUTO | 1
(Default) the direct path is used automatically for frequencies close to 0 Hz.
OFF | 0
The analog mixer path is always used.
*RST: 1

Example: `INP:DPAT OFF`

Usage: SCPI confirmed

Manual operation: See "Direct Path" on page 77

INPut:FILTer:HPASs[:STATe] <State>

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

This function requires an additional high-pass filter hardware option.

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

Parameters:

<State> ON | OFF

*RST: OFF

Example: `INP:FILT:HPAS ON`
Turns on the filter.

Usage: SCPI confirmed

Manual operation: See "High-Pass Filter 1...3 GHz" on page 78

INPut:FILTer:YIG[:STATe] <State>

This command turns the YIG-preselector on and off.

Note the special conditions and restrictions for the YIG-preselector described in "YIG-Preselector" on page 78.

Parameters:

<State> ON | OFF | 0 | 1

*RST: 1 (0 for I/Q Analyzer, GSM, VSA, Pulse, Amplifier, Transient Analysis, DOCSIS and MC Group Delay measurements)

Example: `INP:FILT:YIG OFF`
Deactivates the YIG-preselector.

Manual operation: See "YIG-Preselector" on page 78

INPut:IMPedance <Impedance>

This command selects the nominal input impedance of the RF input. In some applications, only 50 Ω are supported.

75 Ω should be selected if the 50 Ω input impedance is transformed to a higher impedance using a matching pad of the RAZ type (= 25 Ω in series to the input impedance of the instrument). The power loss correction value in this case is 1.76 dB = 10 log (75Ω/50Ω).

Parameters:
<Impedance> 50 | 75
*RST: 50 Ω

Example: `INP:IMP 75`

Usage: SCPI confirmed

Manual operation: See "Impedance" on page 77
See "Unit" on page 92

INPut:SELect <Source>

This command selects the signal source for measurements, i.e. it defines which connector is used to input data to the R&S FSW.

If no additional input options are installed, only RF input is supported.

Parameters:
<Source> **RF**
Radio Frequency ("RF INPUT" connector)
*RST: RF

Manual operation: See "Radio Frequency State" on page 77
See "Digital I/Q Input State" on page 79
See "Analog Baseband Input State" on page 81

10.5.2.2 Configuring Digital I/Q Input and Output

Remote commands for the R&S DigIConf software

Remote commands for the R&S DigIConf software always begin with `SOURce:EBOX`. Such commands are passed on from the R&S FSW to the R&S DigIConf automatically which then configures the R&S EX-IQ-BOX via the USB connection.

All remote commands available for configuration via the R&S DigIConf software are described in the "R&S®EX-IQ-BOX Digital Interface Module R&S®DigIConf Software Operating Manual".

Example 1:

`SOURce:EBOX:*RST`

`SOURce:EBOX:*IDN?`

Result:

"Rohde&Schwarz,DigIConf,02.05.436 Build 47"

Example 2:

`SOURce:EBOX:USER:CLOCk:REFerence:FREQuency 5MHZ`

Defines the frequency value of the reference clock.

Remote commands exclusive to digital I/Q data input and output

INPut:DIQ:CDEVice 182
INPut:DIQ:RANGe[:UPPer]:AUTO 183
INPut:DIQ:RANGe:COUPling 183
INPut:DIQ:RANGe[:UPPer] 184
INPut:DIQ:RANGe[:UPPer]:UNIT 184
INPut:DIQ:SRATe 184
INPut:DIQ:SRATe:AUTO 184

INPut:DIQ:CDEVice

This command queries the current configuration and the status of the digital I/Q input from the optional Digital Baseband Interface.

For details see the section "Interface Status Information" for the optional Digital Baseband Interface in the R&S FSW I/Q Analyzer User Manual.

Return values:

<ConnState>	Defines whether a device is connected or not. **0** No device is connected. **1** A device is connected.
<DeviceName>	Device ID of the connected device
<SerialNumber>	Serial number of the connected device
<PortName>	Port name used by the connected device
<SampleRate>	Maximum or currently used sample rate of the connected device in Hz (depends on the used connection protocol version; indicated by <SampleRateType> parameter)
<MaxTransferRate>	Maximum data transfer rate of the connected device in Hz
<ConnProtState>	State of the connection protocol which is used to identify the connected device. **Not Started** **Has to be Started** **Started** **Passed** **Failed** **Done**

<PRBSTestState> State of the PRBS test.

Not Started

Has to be Started

Started

Passed

Failed

Done

<SampleRateType> **0**
Maximum sample rate is displayed

1
Current sample rate is displayed

<FullScaleLevel> The level (in dBm) that should correspond to an I/Q sample with the magnitude "1" (if transferred from connected device);
If not available, `1.#QNAN` (not a number) is returned

Example: `INP:DIQ:CDEV?`
Result:
`1,SMW200A,101190,BBMM 1 OUT,`
`100000000,200000000,Passed,Passed,1,1.#QNAN`

Manual operation: See "Connected Instrument" on page 80

INPut:DIQ:RANGe[:UPPer]:AUTO <State>

If enabled, the digital input full scale level is automatically set to the value provided by the connected device (if available).

This command is only available if the optional Digital Baseband interface is installed.

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

Manual operation: See "Full Scale Level" on page 79

INPut:DIQ:RANGe:COUPling <State>

If enabled, the reference level for digital input is adjusted to the full scale level automatically if the full scale level changes.

This command is only available if the optional Digital Baseband Interface is installed.

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

Manual operation: See "Adjust Reference Level to Full Scale Level" on page 80

INPut:DIQ:RANGe[:UPPer] <Level>

Defines or queries the "Full Scale Level", i.e. the level that corresponds to an I/Q sample with the magnitude "1".

This command is only available if the optional Digital Baseband Interface is installed.

Parameters:

<Level> <numeric value>

Range: 1 µV to 7.071 V
*RST: 1 V

Manual operation: See "Full Scale Level" on page 79

INPut:DIQ:RANGe[:UPPer]:UNIT <Unit>

Defines the unit of the full scale level (see "Full Scale Level" on page 79). The availability of units depends on the measurement application you are using.

This command is only available if the optional Digital Baseband Interface is installed.

Parameters:

<Level> VOLT | DBM | DBPW | WATT | DBMV | DBUV | DBUA | AMPere

*RST: Volt

Manual operation: See "Full Scale Level" on page 79

INPut:DIQ:SRATe <SampleRate>

This command specifies or queries the sample rate of the input signal from the optional Digital Baseband Interface (see "Input Sample Rate" on page 79).

Parameters:

<SampleRate> Range: 1 Hz to 10 GHz
*RST: 32 MHz

Example: INP:DIQ:SRAT 200 MHz

Manual operation: See "Input Sample Rate" on page 79

INPut:DIQ:SRATe:AUTO <State>

If enabled, the sample rate of the digital I/Q input signal is set automatically by the connected device.

This command is only available if the optional Digital Baseband Interface is installed.

Parameters:

<State> ON | OFF

*RST: OFF

Manual operation: See "Input Sample Rate" on page 79

10.5.2.3 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 181)
- `[SENSe:]FREQuency:CENTer` on page 200

Commands for the Analog Baseband calibration signal are described in the R&S FSW User Manual.

Remote commands exclusive to Analog Baseband data input and output

INPut:IQ:BALanced[:STATe]......185
INPut:IQ:FULLscale:AUTO......185
INPut:IQ:FULLscale[:LEVel]......186
INPut:IQ:TYPE......186
CALibration:AIQ:HATiming[:STATe]......186

INPut:IQ:BALanced[:STATe] <State>

This command defines whether the input is provided as a differential signal via all 4 Analog Baseband connectors or as a plain I/Q signal via 2 single-ended lines.

Parameters:

<State>

ON
Differential

OFF
Single ended

*RST: ON

Example: `INP:IQ:BAL OFF`

Manual operation: See "Input Configuration" on page 81

INPut:IQ:FULLscale:AUTO <State>

This command defines whether the full scale level (i.e. the maximum input power on the Baseband Input connector) is defined automatically according to the reference level, or manually.

Parameters:

<State>

ON
Automatic definition

OFF
Manual definition according to `INPut:IQ:FULLscale[:LEVel]` on page 186

*RST: ON

Example: `INP:IQ:FULL:AUTO OFF`

INPut:IQ:FULLscale[:LEVel] <PeakVoltage>

This command defines the peak voltage at the Baseband Input connector if the full scale level is set to manual mode (see `INPut:IQ:FULLscale:AUTO` on page 185).

Parameters:

<PeakVoltage> 0.25 V | 0.5 V | 1 V | 2 V

Peak voltage level at the connector.
For probes, the possible full scale values are adapted according to the probe's attenuation and maximum allowed power.

*RST: 1V

Example: `INP:IQ:FULL 0.5V`

INPut:IQ:TYPE <DataType>

This command defines the format of the input signal.

Parameters:

<DataType> IQ | I | Q

IQ
The input signal is filtered and resampled to the sample rate of the application.
Two input channels are required for each input signal, one for the in-phase component, and one for the quadrature component.

I
The in-phase component of the input signal is filtered and resampled to the sample rate of the application. If the center frequency is not 0, the in-phase component of the input signal is down-converted first (Low IF I).

Q
The quadrature component of the input signal is filtered and resampled to the sample rate of the application. If the center frequency is not 0, the quadrature component of the input signal is down-converted first (Low IF Q).

*RST: IQ

Example: `INP:IQ:TYPE Q`

Manual operation: See "I/Q Mode" on page 81

CALibration:AIQ:HATiming[:STATe] <State>

Activates a mode with enhanced timing accuracy between analog baseband, RF and external trigger signals.

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

ON | 1
The high accuracy timing function is switched on.
The cable for high accuracy timing must be connected to trigger ports 1 and 2.

OFF | 0
The high accuracy timing function is switched off.

*RST: OFF

Example: `CAL:AIQ:HAT:STAT ON`

Manual operation: See "High Accuracy Timing Trigger - Baseband - RF" on page 82

10.5.2.4 Working with Power Sensors

The following commands describe how to work with power sensors.

- Configuring Power Sensors 187
- Configuring Power Sensor Measurements 189
- Triggering with Power Sensors 195

Configuring Power Sensors

SYSTem:COMMunicate:RDEVice:PMETer<p>:CONFigure:AUTO[:STATe] 187
SYSTem:COMMunicate:RDEVice:PMETer:COUNt? 187
SYSTem:COMMunicate:RDEVice:PMETer<p>:DEFine 188

SYSTem:COMMunicate:RDEVice:PMETer<p>:CONFigure:AUTO[:STATe] <State>

This command turns automatic assignment of a power sensor to the power sensor index on and off.

Suffix:
<p> 1...4
Power sensor index

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

*RST: 1

Example: `SYST:COMM:RDEV:PMET:CONF:AUTO OFF`

Manual operation: See "Select" on page 84

SYSTem:COMMunicate:RDEVice:PMETer:COUNt?

This command queries the number of power sensors currently connected to the R&S FSW.

Parameters:
<NumberSensors> Number of connected power sensors.

Example: `SYST:COMM:RDEV:PMET:COUN?`

Usage: Query only

Manual operation: See "Select" on page 84

SYSTem:COMMunicate:RDEVice:PMETer<p>:DEFine <Placeholder>, <Type>, <Interface>, <SerialNo>

This command assigns the power sensor with the specified serial number to the selected power sensor index (configuration).

The query returns the power sensor type and serial number of the sensor assigned to the specified index.

Suffix:
<p> 1...4
Power sensor index

Setting parameters:
<Placeholder> Currently not evaluated

<SerialNo> Serial number of a connected power sensor

Query parameters:
<Type> The power sensor type, e.g. "NRP-Z81".

<Interface> Currently not evaluated

Return values:
<Placeholder> Currently not used

<Type> Detected power sensor type, e.g. "NRP-Z81".

<Interface> Interface the power sensor is connected to; always "USB"

<SerialNo> Serial number of the power sensor assigned to the specified index

Example: `SYST:COMM:RDEV:PMET2:DEF '','NRP-Z81','', '123456'`
Assigns the power sensor with the serial number '123456' to the configuration "Power Sensor 2".
`SYST:COMM:RDEV:PMET2:DEF?`
Queries the sensor assigned to "Power Sensor 2".
Result:
`'','NRP-Z81','USB','123456'`
The NRP-Z81 power sensor with the serial number '123456' is assigned to the "Power Sensor 2".

Manual operation: See "Select" on page 84

Configuring Power Sensor Measurements

CALibration:PMETer<p>:ZERO:AUTO ONCE 189
CALCulate<n>:PMETer<p>:RELative[:MAGNitude] 189
CALCulate<n>:PMETer<p>:RELative[:MAGNitude]:AUTO ONCE 190
CALCulate<n>:PMETer<p>:RELative:STATe 190
FETCh:PMETer<p>? 190
READ:PMETer<p>? 191
[SENSe:]PMETer<p>:DCYCle[:STATe] 191
[SENSe:]PMETer<p>:DCYCle:VALue 191
[SENSe:]PMETer<p>:FREQuency 192
[SENSe:]PMETer<p>:FREQuency:LINK 192
[SENSe:]PMETer<p>:MTIMe 192
[SENSe:]PMETer<p>:MTIMe:AVERage:COUNt 193
[SENSe:]PMETer<p>:MTIMe:AVERage[:STATe] 193
[SENSe:]PMETer<p>:ROFFset[:STATe] 194
[SENSe:]PMETer<p>[:STATe] 194
[SENSe:]PMETer<p>:UPDate[:STATe] 194
UNIT<n>:PMETer<p>:POWer 195
UNIT<n>:PMETer<p>:POWer:RATio 195

CALibration:PMETer<p>:ZERO:AUTO ONCE

This command zeroes the power sensor.

Note that you have to disconnect the signals from the power sensor input before you start to zero the power sensor. Otherwise, results are invalid.

Suffix:

<p> 1...4
Power sensor index

Parameters:

ONCE

Example: `CAL:PMET2:ZERO:AUTO ONCE;*WAI`
Starts zeroing the power sensor 2 and delays the execution of further commands until zeroing is concluded.

Usage: Event

Manual operation: See "Zeroing Power Sensor" on page 84

CALCulate<n>:PMETer<p>:RELative[:MAGNitude] <RefValue>

This command defines the reference value for relative measurements.

Suffix:

<n> Window

<p> 1...4
Power sensor index

Parameters:

<RefValue> Range: -200 dBm to 200 dBm
*RST: 0

Example: `CALC:PMET2:REL -30`
Sets the reference value for relative measurements to -30 dBm for power sensor 2.

Manual operation: See "Reference Value" on page 85

CALCulate<n>:PMETer<p>:RELative[:MAGNitude]:AUTO ONCE

This command sets the current measurement result as the reference level for relative measurements.

Suffix:

<n> Window

<p> 1...4
Power sensor index

Parameters:

ONCE

Example: `CALC:PMET2:REL:AUTO ONCE`
Takes the current measurement value as reference value for relative measurements for power sensor 2.

Usage: Event

Manual operation: See "Setting the Reference Level from the Measurement (Meas->Ref)" on page 85

CALCulate<n>:PMETer<p>:RELative:STATe <State>

This command turns relative power sensor measurements on and off.

Suffix:

<n> Window

<p> 1...4
Power sensor index

Parameters:

<State> ON | OFF
*RST: OFF

Example: `CALC:PMET2:REL:STAT ON`
Activates the relative display of the measured value for power sensor 2.

FETCh:PMETer<p>?

This command queries the results of power sensor measurements.

Suffix:

<p> 1...4
Power sensor index

Return values:

<Level> Power level that has been measured by a power sensor.
The unit is either dBm (absolute measurements) or dB (relative measurements).

Usage: Query only

READ:PMETer<p>?

This command initiates a power sensor measurement and queries the results.

Suffix:

<p> 1...4
Power sensor index

Usage: Query only

[SENSe:]PMETer<p>:DCYCle[:STATe] <State>

This command turns the duty cycle correction on and off.

Suffix:

<p> 1...4
Power sensor index

Parameters:

<State> ON | OFF
*RST: OFF

Example: `PMET2:DCYC:STAT ON`

Manual operation: See "Duty Cycle" on page 86

[SENSe:]PMETer<p>:DCYCle:VALue <Percentage>

This command defines the duty cycle for the correction of pulse signals.

The power sensor uses the duty cycle in combination with the mean power to calculate the power of the pulse.

Suffix:

<p> 1...4
Power sensor

Parameters:

<Percentage> Range: 0.001 to 99.999
*RST: 99.999
Default unit: %

Example: `PMET2:DCYC:STAT ON`
Activates the duty cycle correction.
`PMET2:DCYC:VAL 0.5`
Sets the correction value to 0.5%.

Manual operation: See "Duty Cycle" on page 86

[SENSe:]PMETer<p>:FREQuency <Frequency>

This command defines the frequency of the power sensor.

Suffix:
<p> 1...4
Power sensor index

Parameters:
<Frequency> The available value range is specified in the data sheet of the power sensor in use.
*RST: 50 MHz

Example: `PMET2:FREQ 1GHZ`
Sets the frequency of the power sensor to 1 GHz.

Manual operation: See "Frequency Manual" on page 84

[SENSe:]PMETer<p>:FREQuency:LINK <Coupling>

This command selects the frequency coupling for power sensor measurements.

Suffix:
<p> 1...4
Power sensor index

Parameters:
<Coupling>
CENTer
Couples the frequency to the center frequency of the analyzer
MARKer1
Couples the frequency to the position of marker 1
OFF
Switches the frequency coupling off
*RST: CENTer

Example: `PMET2:FREQ:LINK CENT`
Couples the frequency to the center frequency of the analyzer

Manual operation: See "Frequency Coupling" on page 84

[SENSe:]PMETer<p>:MTIMe <Duration>

This command selects the duration of power sensor measurements.

Suffix:

<p> 1...4
Power sensor index

Parameters:

<Duration> SHORt | NORMal | LONG

*RST: NORMal

Example: `PMET2:MTIM SHOR`
Sets a short measurement duration for measurements of stationary high power signals for the selected power sensor.

Manual operation: See "Meas Time/Average" on page 85

[SENSe:]PMETer<p>:MTIMe:AVERage:COUNt <NumberReadings>

This command sets the number of power readings included in the averaging process of power sensor measurements.

Extended averaging yields more stable results for power sensor measurements, especially for measurements on signals with a low power, because it minimizes the effects of noise.

Suffix:

<p> 1...4
Power sensor index

Parameters:

<NumberReadings> An average count of 0 or 1 performs one power reading.

Range: 0 to 256
Increment: binary steps (1, 2, 4, 8, ...)

Example: `PMET2:MTIM:AVER ON`
Activates manual averaging.
`PMET2:MTIM:AVER:COUN 8`
Sets the number of readings to 8.

Manual operation: See "Average Count (Number of Readings)" on page 86

[SENSe:]PMETer<p>:MTIMe:AVERage[:STATe] <State>

This command turns averaging for power sensor measurements on and off.

Suffix:

<p> 1...4
Power sensor index

Parameters:

<State> ON | OFF

*RST: OFF

Example: `PMET2:MTIM:AVER ON`
Activates manual averaging.

Manual operation: See "Meas Time/Average" on page 85

[SENSe:]PMETer<p>:ROFFset[:STATe] <State>

This command includes or excludes the reference level offset of the analyzer for power sensor measurements.

Suffix:

<p> 1...4
Power sensor index

Parameters:

<State> **ON | 1**
Includes the reference level offset in the results.
OFF | 0
Ignores the reference level offset.
*RST: 1

Example: `PMET2:ROFF OFF`
Takes no offset into account for the measured power.

Manual operation: See "Use Ref Lev Offset" on page 85

[SENSe:]PMETer<p>[:STATe] <State>

This command turns a power sensor on and off.

Suffix:

<p> 1...4
Power sensor index

Parameters:

<State> ON | OFF
*RST: OFF

Example: `PMET1 ON`
Switches the power sensor measurements on.

Manual operation: See "State" on page 83
See "Select" on page 84

[SENSe:]PMETer<p>:UPDate[:STATe] <State>

This command turns continuous update of power sensor measurements on and off.

If on, the results are update even if a single sweep is complete.

Suffix:

<p> 1...4
Power sensor index

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

Example: `PMET1:UPD ON`
The data from power sensor 1 is updated continuously.

Manual operation: See "Continuous Value Update" on page 84

UNIT<n>:PMETer<p>:POWer <Unit>

This command selects the unit for absolute power sensor measurements.

Suffix:
<n> irrelevant

<p> 1...4
Power sensor index

Parameters:
<Unit> DBM | WATT | W
*RST: DBM

Example: `UNIT:PMET:POW DBM`

Manual operation: See "Unit/Scale" on page 85

UNIT<n>:PMETer<p>:POWer:RATio <Unit>

This command selects the unit for relative power sensor measurements.

Suffix:
<n> irrelevant

<p> 1...4
Power sensor index

Parameters:
<Unit> DB | PCT
*RST: DB

Example: `UNIT:PMET:POW:RAT DB`

Manual operation: See "Unit/Scale" on page 85

Triggering with Power Sensors

[SENSe:]PMETer<p>:TRIGger:DTIMe....196
[SENSe:]PMETer<p>:TRIGger:HOLDoff....196
[SENSe:]PMETer<p>:TRIGger:HYSTeresis....196
[SENSe:]PMETer<p>:TRIGger:LEVel....197
[SENSe:]PMETer<p>:TRIGger:SLOPe....197
[SENSe:]PMETer<p>:TRIGger[:STATe]....197

[SENSe:]PMETer<p>:TRIGger:DTIMe <Time>

This command defines the time period that the input signal has to stay below the IF power trigger level before the measurement starts.

Suffix:
<p> 1...4
Power sensor index

Parameters:
<Time> Range: 0 s to 1 s
Increment: 100 ns
*RST: 100 µs

Example: `PMET2:TRIG:DTIMe 0.001`

[SENSe:]PMETer<p>:TRIGger:HOLDoff <Holdoff>

This command defines the trigger holdoff for external power triggers.

Suffix:
<p> 1...4
Power sensor index

Parameters:
<Holdoff> Time period that has to pass between the trigger event and the start of the measurement, in case another trigger event occurs.
Range: 0 s to 1 s
Increment: 100 ns
*RST: 0 s

Example: `PMET2:TRIG:HOLD 0.1`
Sets the holdoff time of the trigger to 100 ms

Manual operation: See "Trigger Holdoff" on page 86

[SENSe:]PMETer<p>:TRIGger:HYSTeresis <Hysteresis>

This command defines the trigger hysteresis for external power triggers.

The hysteresis in dB is the value the input signal must stay below the IF power trigger level in order to allow a trigger to start the measurement.

Suffix:
<p> 1...4
Power sensor index

Parameters:
<Hysteresis> Range: 3 dB to 50 dB
Increment: 1 dB
*RST: 0 dB

Example: `PMET2:TRIG:HYST 10`
Sets the hysteresis of the trigger to 10 dB.

Manual operation: See "Hysteresis" on page 86

[SENSe:]PMETer<p>:TRIGger:LEVel <Level>

This command defines the trigger level for external power triggers.

This command requires the use of an R&S NRP-Z81 power sensor.

Suffix:

<p> 1...4
Power sensor index

Parameters:

<Level> -20 to +20 dBm
Range: -20 dBm to 20 dBm
*RST: -10 dBm

Example: `PMET2:TRIG:LEV -10 dBm`
Sets the level of the trigger

Manual operation: See "External Trigger Level" on page 86

[SENSe:]PMETer<p>:TRIGger:SLOPe <Edge>

This command selects the trigger condition for external power triggers.

Suffix:

<p> 1...4
Power sensor index

Parameters:

<Edge> **POSitive**
The measurement starts in case the trigger signal shows a positive edge.
NEGative
The measurement starts in case the trigger signal shows a negative edge.
*RST: POSitive

Example: `PMET2:TRIG:SLOP NEG`

Manual operation: See "Slope" on page 87

[SENSe:]PMETer<p>:TRIGger[:STATe] <State>

This command turns the external power trigger on and off.

This command requires the use of an R&S NRP-Z81 power sensor.

Suffix:

<p> 1...4
Power sensor index

Parameters:

<State> ON | OFF

*RST: OFF

Example: `PMET2:TRIG ON`

Switches the external power trigger on

Manual operation: See "Using the power sensor as an external trigger" on page 86

10.5.2.5 Configuring the Outputs

Configuring trigger input/output is described in Chapter 10.5.5.2, "Configuring the Trigger Output", on page 214.

DIAGnostic:SERVice:NSOurce....198
OUTPut:IF[:SOURce]....198
OUTPut:IF:IFFRequency....199

DIAGnostic:SERVice:NSOurce <State>

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

Suffix:

<n> Window

Parameters:

<State> ON | OFF

*RST: OFF

Example: `DIAG:SERV:NSO ON`

Manual operation: See "Noise Source" on page 88

OUTPut:IF[:SOURce] <Source>

Defines the type of signal available at the IF/VIDEO/DEMOD or IF OUT 2 GHZ connector of the R&S FSW.

For restrictions and more information see Chapter 4.4.4, "IF and Video Signal Output", on page 45.

Parameters:

<Source>

IF
The measured IF value is available at the IF/VIDEO/DEMOD output connector.
The frequency at which the IF value is provided is defined using the `OUTPut:IF:IFFRequency` command.

IF2
The measured IF value is available at the IF OUT 2 GHZ output connector at a frequency of 2 GHz.
This setting is only available if the IF OUT 2 GHZ connector or the optional 2 GHz bandwidth extension (R&S FSW-B2000) is available.

VIDeo
The displayed video signal (i.e. the filtered and detected IF signal, 200mV) is available at the IF/VIDEO/DEMOD output connector.
This setting is required to provide demodulated audio frequencies at the output.

*RST: IF

Example: `OUTP:IF VID`
Selects the video signal for the IF/VIDEO/DEMOD output connector.

Manual operation: See "IF/Video Output" on page 88

OUTPut:IF:IFFRequency <Frequency>

This command defines the frequency for the IF output of the R&S FSW. The IF frequency of the signal is converted accordingly.

This command is available in the time domain and if the IF/VIDEO/DEMOD output is configured for IF.

Parameters:

<Frequency> *RST: 50.0 MHz

Manual operation: See "IF (Wide) Out Frequency" on page 88

10.5.3 Frontend Configuration

The following commands configure frequency, amplitude and y-axis scaling settings, which represent the "frontend" of the measurement setup.

- Frequency......200
- Amplitude Settings......201

10.5.3.1 Frequency

[SENSe:]FREQuency:CENTer....................200
[SENSe:]FREQuency:CENTer:STEP....................200
[SENSe:]FREQuency:CENTer:STEP:AUTO....................201
[SENSe:]FREQuency:OFFSet....................201

[SENSe:]FREQuency:CENTer <Frequency>

This command defines the center frequency.

Parameters:

<Frequency> The allowed range and f_{max} is specified in the data sheet.

UP
Increases the center frequency by the step defined using the `[SENSe:]FREQuency:CENTer:STEP` command.

DOWN
Decreases the center frequency by the step defined using the `[SENSe:]FREQuency:CENTer:STEP` command.

*RST: fmax/2
Default unit: Hz

Example:
```
FREQ:CENT 100 MHz
FREQ:CENT:STEP 10 MHz
FREQ:CENT UP
```
Sets the center frequency to 110 MHz.

Usage: SCPI confirmed

Manual operation: See "Center frequency" on page 55
See "Center Frequency" on page 82

[SENSe:]FREQuency:CENTer:STEP <StepSize>

This command defines the center frequency step size.

Parameters:

<StepSize> f_{max} is specified in the data sheet.

Range: 1 to fMAX
*RST: 0.1 x span
Default unit: Hz

Example:
```
FREQ:CENT 100 MHz
FREQ:CENT:STEP 10 MHz
FREQ:CENT UP
```
Sets the center frequency to 110 MHz.

Manual operation: See "Center Frequency Stepsize" on page 90

[SENSe:]FREQuency:CENTer:STEP:AUTO <State>

This command couples or decouples the center frequency step size to the span.

Parameters:

<State> ON | OFF | 0 | 1

*RST: 1

Example: `FREQ:CENT:STEP:AUTO ON`
Activates the coupling of the step size to the span.

[SENSe:]FREQuency:OFFSet <Offset>

This command defines a frequency offset.

If this value is not 0 Hz, the application assumes that the input signal was frequency shifted outside the application. All results of type "frequency" will be corrected for this shift numerically by the application.

Parameters:

<Offset> Range: -100 GHz to 100 GHz
*RST: 0 Hz

Example: `FREQ:OFFS 1GHZ`

Usage: SCPI confirmed

Manual operation: See "Frequency Offset" on page 91

10.5.3.2 Amplitude Settings

The following commands are required to configure the amplitude settings in a remote environment.

Useful commands for amplitude settings described elsewhere:

- `INPut:COUPling` on page 179
- `INPut:IMPedance` on page 180
- `[SENSe:]ADJust:LEVel` on page 224

Remote commands exclusive to amplitude settings:

CALCulate<n>:UNIT:POWer....................202
CONFigure:POWer:AUTO....................202
CONFigure:POWer:EXPected:RF....................202
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel....................203
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel:OFFSet....................203
INPut:ATTenuation....................203
INPut:ATTenuation:AUTO....................203
INPut:EATT....................204
INPut:EATT:AUTO....................204

INPut:EATT:STATe..204
INPut:GAIN[:VALue]..205
INPut:GAIN:STATe..205

CALCulate<n>:UNIT:POWer <Unit>

This command selects the unit of the y-axis.

The unit applies to all power-based measurement windows with absolute values.

Suffix:
<n> irrelevant

Parameters:
<Unit> DBM | DBMV | DBUV
*RST: dBm

Example: `CALC:UNIT:POW DBM`
Sets the power unit to dBm.

Manual operation: See "Unit" on page 92

CONFigure:POWer:AUTO <Mode>

This command is used to switch on or off automatic power level detection.

Parameters for setting and query:
<Mode> **ON**
Automatic power level detection is performed at the start of each measurement sweep, and the reference level is adapted accordingly.

OFF
The reference level must be defined manually (see `DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel` on page 203)

ONCE
Automatic power level detection is performed once at the start of the next measurement sweep, and the reference level is adapted accordingly.

*RST: ON

Manual operation: See "Reference Level Mode" on page 92
See "Setting the Reference Level Automatically (Auto Level)" on page 93

CONFigure:POWer:EXPected:RF <Value>

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

Parameters:
<Value> Default unit: DBM

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel <ReferenceLevel>

This command defines the reference level (for all traces in all windows).

Suffix:

<n>, <t>	irrelevant

Example: `DISP:TRAC:Y:RLEV -60dBm`

Usage: SCPI confirmed

Manual operation: See "Reference Level" on page 92

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel:OFFSet <Offset>

This command defines a reference level offset (for all traces in all windows).

Suffix:

<n>, <t>	irrelevant

Parameters:

<Offset>	Range:	-200 dB to 200 dB
	*RST:	0dB

Example: `DISP:TRAC:Y:RLEV:OFFS -10dB`

Manual operation: See "Shifting the Display (Offset)" on page 92

INPut:ATTenuation <Attenuation>

This command 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.

Parameters:

<Attenuation>	Range:	see data sheet
	Increment:	5 dB
	*RST:	10 dB (AUTO is set to ON)

Example: `INP:ATT 30dB`
Defines a 30 dB attenuation and decouples the attenuation from the reference level.

Usage: SCPI confirmed

Manual operation: See "Attenuation Mode / Value" on page 93

INPut:ATTenuation:AUTO <State>

This command couples or decouples the attenuation to the reference level. Thus, when the reference level is changed, the R&S FSW determines the signal level for optimal internal data processing and sets the required attenuation accordingly.

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

*RST: 1

Example: `INP:ATT:AUTO ON`
Couples the attenuation to the reference level.

Usage: SCPI confirmed

Manual operation: See "Attenuation Mode / Value" on page 93

INPut:EATT <Attenuation>

This command defines an electronic attenuation manually. Automatic mode must be switched off (`INP:EATT:AUTO OFF`, see `INPut:EATT:AUTO` on page 204).

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 data sheet
Increment: 1 dB
*RST: 0 dB (OFF)

Example: `INP:EATT:AUTO OFF`
`INP:EATT 10 dB`

Manual operation: See "Using Electronic Attenuation" on page 94

INPut:EATT:AUTO <State>

This command turns automatic selection of the electronic attenuation on and off.

If on, electronic attenuation reduces the mechanical attenuation whenever possible.

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

1 | ON

0 | OFF

*RST: 1

Example: `INP:EATT:AUTO OFF`

Manual operation: See "Using Electronic Attenuation" on page 94

INPut:EATT:STATe <State>

This command turns the electronic attenuator on and off.

Parameters:

<State> 1 | 0 | ON | OFF

1 | ON

0 | OFF

*RST: 0

Example: `INP:EATT:STAT ON`
Switches the electronic attenuator into the signal path.

Manual operation: See "Using Electronic Attenuation" on page 94

INPut:GAIN[:VALue] <Gain>

This command selects the gain if the preamplifier is activated (`INP:GAIN:STAT ON`, see `INPut:GAIN:STATe` on page 205).

The command requires the additional preamplifier hardware option.

Parameters:

<Gain> 15 dB | 30 dB

The availability of gain levels depends on the model of the R&S FSW.
R&S FSW8/13: 15dB and 30 dB
R&S FSW26 or higher: 30 dB
All other values are rounded to the nearest of these two.

*RST: OFF

Example: `INP:GAIN:STAT ON`
`INP:GAIN:VAL 30`
Switches on 30 dB preamplification.

Usage: SCPI confirmed

Manual operation: See "Preamplifier" on page 94

INPut:GAIN:STATe <State>

This command turns the preamplifier on and off. It requires the optional preamplifier hardware.

Parameters:

<State> ON | OFF

*RST: OFF

Example: `INP:GAIN:STAT ON`
Switches on 30 dB preamplification.

Usage: SCPI confirmed

Manual operation: See "Preamplifier" on page 94

10.5.4 Signal Capturing

The following commands are required to configure how much and how data is captured from the input signal.

INPut:FILTer:ACHannels:STATe.. 206
[SENSe:]SWAPiq.. 206
[SENSe:]SWEep:LENGth?.. 207
[SENSe:]SWEep:TIME.. 207
TRACe:IQ:BWIDth?.. 207
TRACe:IQ:SRATe?.. 207

INPut:FILTer:ACHannels:STATe <State>

This remote control command enables or disables use of the adjacent channel filter.

If activated, only the useful signal is analyzed, all signal data in adjacent channels is removed by the filter. This setting improves the signal to noise ratio and thus the MER results for signals with strong or a large number of adjacent channels. However, for some measurements information on the effects of adjacent channels on the measured signal may be of interest.

Parameters:

<State> ON | OFF | 0 | 1

ON | 1
Adjacent channels are filtered.

OFF | 0
Adjacent channels are not filtered.

*RST: 0

Manual operation: See "Filter Adjacent Channels" on page 104

[SENSe:]SWAPiq <State>

This command defines whether or not the recorded I/Q pairs should be swapped (I<->Q) before being processed. Swapping I and Q inverts the sideband.

This is useful if the DUT interchanged the I and Q parts of the signal; then the R&S FSW can do the same to compensate for it.

Parameters:

<State>

ON
I and Q signals are interchanged
Inverted sideband, Q+j*I

OFF
I and Q signals are not interchanged
Normal sideband, I+j*Q

*RST: OFF

Manual operation: See "Swap I/Q" on page 103

[SENSe:]SWEep:LENGth?

Queries the current record length, that is: the number of samples captured during the measurement. The maximum number of samples depends on the specified N_{FFT} (see CONFigure:CHANnel:NFFT on page 156).

Return values:

<Record Length> Range: 0 to 4K mode: 1228800000 samples; 8K mode: 2457600000 samples

Example: SWE:LENG?

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Usage: Query only

Manual operation: See "Number of Samples" on page 103

[SENSe:]SWEep:TIME <Time>

Defines or queries the duration (and therefore the amount of data) to be captured during one measurement. The maximum capture time depends on the specified N_{FFT} (see CONFigure:CHANnel:NFFT on page 156).

Parameters:

<Time> Range: 0 s to 4K mode: 6 ms; 8K mode: 12 ms
Default unit: S

Example: SWE:TIME 0.001

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Capture Time" on page 103

TRACe:IQ:BWIDth?

Queries the currently used analysis bandwidth.

For DOCSIS 3.1 downstream measurements, a fixed bandwidth of 192.0 MHz is used.

For DOCSIS 3.1 upstream measurements, a fixed bandwidth of 96.0 MHz is used.

Example: TRAC:IQ:BWID?

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Usage: Query only

Manual operation: See "Analysis Bandwidth (ABW)" on page 103

TRACe:IQ:SRATe?

Queries the currently used sample rate.

For DOCSIS 3.1 downstream measurements, a fixed sample rate of 204.8 MHz is used.

For DOCSIS 3.1 upstream measurements, a fixed sample rate of 102.4 MHz is used.

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Example: `TRAC:IQ:SRAT?`

Usage: Query only

Manual operation: See "Sample Rate" on page 103

10.5.5 Configuring Triggered Measurements

The following commands are required to configure a triggered measurement in a remote environment. The tasks for manual operation are described in Chapter 5.3.4, "Trigger Settings", on page 95.

The `*OPC` command should be used after commands that retrieve data so that subsequent commands to change the selected trigger source are held off until after the sweep is completed and the data has been returned.

● Configuring the Triggering Conditions....208
● Configuring the Trigger Output....214

10.5.5.1 Configuring the Triggering Conditions

The following commands are required to configure a triggered measurement.

TRIGger[:SEQuence]:BBPower:HOLDoff....208
TRIGger[:SEQuence]:DTIMe....209
TRIGger[:SEQuence]:HOLDoff[:TIME]....209
TRIGger[:SEQuence]:IFPower:HOLDoff....209
TRIGger[:SEQuence]:IFPower:HYSTeresis....210
TRIGger[:SEQuence]:LEVel:BBPower....210
TRIGger[:SEQuence]:LEVel[:EXTernal<port>]....210
TRIGger[:SEQuence]:LEVel:IFPower....211
TRIGger[:SEQuence]:LEVel:IQPower....211
TRIGger:SEQuence:LEVel:POWer:AUTO....211
TRIGger[:SEQuence]:LEVel:RFPower....212
TRIGger[:SEQuence]:SLOPe....212
TRIGger[:SEQuence]:SOURce....212
TRIGger[:SEQuence]:TIME:RINTerval....213

TRIGger[:SEQuence]:BBPower:HOLDoff <Period>

This command defines the holding time before the baseband power trigger event.

The command requires the optional Digital Baseband Interface or the optional Analog Baseband Interface.

Note that this command is maintained for compatibility reasons only. Use the `TRIGger[:SEQuence]:IFPower:HOLDoff` on page 209 command for new remote control programs.

Parameters:

<Period> Range: 150 ns to 1000 s
*RST: 150 ns

Example: `TRIG:SOUR BBP`
Sets the baseband power trigger source.
`TRIG:BBP:HOLD 200 ns`
Sets the holding time to 200 ns.

TRIGger[:SEQuence]:DTIMe <DropoutTime>

Defines the time the input signal must stay below the trigger level before a trigger is detected again.

Parameters:

<DropoutTime> Dropout time of the trigger.
Range: 0 s to 10.0 s
*RST: 0 s

Manual operation: See "Drop-Out Time" on page 99

TRIGger[:SEQuence]:HOLDoff[:TIME] <Offset>

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

Parameters:

<Offset> *RST: 0 s

Example: `TRIG:HOLD 500us`

Manual operation: See "Trigger Offset" on page 100

TRIGger[:SEQuence]:IFPower:HOLDoff <Period>

This command defines the holding time before the next trigger event.

Note that this command can be used for **any trigger source**, not just IF Power (despite the legacy keyword).

Parameters:

<Period> Range: 0 s to 10 s
*RST: 0 s

Example: `TRIG:SOUR EXT`
Sets an external trigger source.
`TRIG:IFP:HOLD 200 ns`
Sets the holding time to 200 ns.

Manual operation: See "Trigger Holdoff" on page 100

TRIGger[:SEQuence]:IFPower:HYSTeresis <Hysteresis>

This command defines the trigger hysteresis, which is only available for "IF Power" trigger sources.

Parameters:

<Hysteresis> Range: 3 dB to 50 dB
*RST: 3 dB

Example: `TRIG:SOUR IFP`
Sets the IF power trigger source.
`TRIG:IFP:HYST 10DB`
Sets the hysteresis limit value.

Manual operation: See "Hysteresis" on page 100

TRIGger[:SEQuence]:LEVel:BBPower <Level>

This command sets the level of the baseband power trigger.

This command is available for the optional Digital Baseband Interface and the optional Analog Baseband Interface.

Parameters:

<Level> Range: -50 dBm to +20 dBm
*RST: -20 dBm

Example: `TRIG:LEV:BBP -30DBM`

TRIGger[:SEQuence]:LEVel[:EXTernal<port>] <TriggerLevel>

This command 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)
3 = trigger port 3 (TRIGGER3 INPUT/OUTPUT connector on rear panel)

Parameters:

<TriggerLevel> Range: 0.5 V to 3.5 V
*RST: 1.4 V

Example: `TRIG:LEV 2V`

Manual operation: See "Trigger Level" on page 99

TRIGger[:SEQuence]:LEVel:IFPower <TriggerLevel>

This command defines the power level at the third intermediate frequency that must be exceeded to cause a trigger event. Note that any RF attenuation or preamplification is considered when the trigger level is analyzed. If defined, a reference level offset is also considered.

Parameters:

<TriggerLevel> For details on available trigger levels and trigger bandwidths see the data sheet.

*RST: -10 dBm

Example: `TRIG:LEV:IFP -30DBM`

TRIGger[:SEQuence]:LEVel:IQPower <TriggerLevel>

This command defines the magnitude the I/Q data must exceed to cause a trigger event. Note that any RF attenuation or preamplification is considered when the trigger level is analyzed.

Parameters:

<TriggerLevel> Range: -130 dBm to 30 dBm
*RST: -20 dBm

Example: `TRIG:LEV:IQP -30DBM`

TRIGger:SEQuence:LEVel:POWer:AUTO <State>

By default, the optimum trigger level for power triggers is automatically measured and determined at the start of each sweep (for Modulation Accuracy, Flatness, Tolerance... measurements).

This function is only considered for `TRIG:SEQ:SOUR IFP` and `TRIG:SEQ:SOUR RFP`, see `TRIGger[:SEQuence]:SOURce` on page 212

In order to define the trigger level manually, switch this function off and define the level using `TRIGger[:SEQuence]:LEVel:IFPower` on page 211 or `TRIGger[:SEQuence]:LEVel:RFPower` on page 212.

Parameters for setting and query:

<State> **OFF**
Switches the auto level detection function off

ON
Switches the auto level detection function on

*RST: ON

Manual operation: See "Trigger Level Mode" on page 99

TRIGger[:SEQuence]:LEVel:RFPower <TriggerLevel>

This command defines the power level the RF input must exceed to cause a trigger event. Note that any RF attenuation or preamplification is considered when the trigger level is analyzed. If defined, a reference level offset is also considered.

The input signal must be between 500 MHz and 8 GHz.

Parameters:

<TriggerLevel> For details on available trigger levels and trigger bandwidths see the data sheet.

*RST: -20 dBm

Example: `TRIG:LEV:RFP -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 100

TRIGger[:SEQuence]:SOURce <Source>

This command 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 this situation is avoided in your remote control programs.

Parameters:
<Source>

IMMediate
Free Run

EXTernal
Trigger signal from the TRIGGER INPUT connector.

EXT2
Trigger signal from the TRIGGER INPUT/OUTPUT connector.
Note: Connector must be configured for "Input".

EXT3
Trigger signal from the TRIGGER 3 INPUT/ OUTPUT connector.
Note: Connector must be configured for "Input".

RFPower
First intermediate frequency

IFPower
Second intermediate frequency

TIME
Time interval

*RST: IMMediate

Example:
`TRIG:SOUR EXT`
Selects the external trigger input as source of the trigger signal

Manual operation:
See "Using the power sensor as an external trigger" on page 86
See "Trigger Source" on page 96
See "Free Run" on page 96
See "External Trigger 1/2/3" on page 96
See "Baseband Power" on page 97
See "Digital I/Q" on page 97
See "IF Power" on page 98
See "RF Power" on page 98
See "I/Q Power" on page 98
See "Power Sensor" on page 99
See "Time" on page 99

TRIGger[:SEQuence]:TIME:RINTerval <Interval>

This command defines the repetition interval for the time trigger.

Parameters:
<Interval> 2.0 ms to 5000

Range: 2 ms to 5000 s
*RST: 1.0 s

Example:
`TRIG:SOUR TIME`
Selects the time trigger input for triggering.
`TRIG:TIME:RINT 50`
The measurement starts every 50 s.

Manual operation:
See "Repetition Interval" on page 99

10.5.5.2 Configuring the Trigger Output

The following commands are required to send the trigger signal to one of the variable TRIGGER INPUT/OUTPUT connectors on the R&S FSW.

OUTPut:TRIGger<port>:DIRection....214
OUTPut:TRIGger<port>:LEVel....214
OUTPut:TRIGger<port>:OTYPe....215
OUTPut:TRIGger<port>:PULSe:IMMediate....215
OUTPut:TRIGger<port>:PULSe:LENGth....215

OUTPut:TRIGger<port>:DIRection <Direction>

This command selects the trigger direction for trigger ports that serve as an input as well as an output.

Suffix:

<port> Selects the used trigger port.
2 = trigger port 2 (front panel)
3 = trigger port 3 (rear panel)

Parameters:

<Direction> **INPut**
Port works as an input.
OUTPut
Port works as an output.
*RST: INPut

Manual operation: See "Trigger 2/3" on page 88

OUTPut:TRIGger<port>:LEVel <Level>

This command defines the level of the (TTL compatible) signal generated at the trigger output.

This command works only if you have selected a user defined output with `OUTPut:TRIGger<port>:OTYPe`.

Suffix:

<port> Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Parameters:

<Level> **HIGH**
5 V
LOW
0 V
*RST: LOW

Example: `OUTP:TRIG2:LEV HIGH`

Manual operation: See "Level" on page 89

OUTPut:TRIGger<port>:OTYPe <OutputType>

This command selects the type of signal generated at the trigger output.

Suffix:

<port> Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Parameters:

<OutputType> **DEVice**
Sends a trigger signal when the R&S FSW has triggered internally.

TARMed
Sends a trigger signal when the trigger is armed and ready for an external trigger event.

UDEFined
Sends a user defined trigger signal. For more information see `OUTPut:TRIGger<port>:LEVel`.

*RST: DEVice

Manual operation: See "Output Type" on page 89

OUTPut:TRIGger<port>:PULSe:IMMediate

This command generates a pulse at the trigger output.

Suffix:

<port> Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Usage: Event

Manual operation: See "Send Trigger" on page 89

OUTPut:TRIGger<port>:PULSe:LENGth <Length>

This command defines the length of the pulse generated at the trigger output.

Suffix:

<port> Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Parameters:

<Length> Pulse length in seconds.

Example: `OUTP:TRIG2:PULS:LENG 0.02`

Manual operation: See "Pulse Length" on page 89

10.5.6 Tracking and Channel Estimation

[SENSe] (see also SENSe: commands!)....216
[SENSe:]CHANnel:ESTimation....216
SENSe:TRACking:PHASe....218
SENSe:TRACking:TIME....218

[SENSe] (see also SENSe: commands!)
[SENSe:]CHANnel:ESTimation <Mode>

This command determines how channels are detected and compensated for in the input signal.

Parameters:

<Mode>

PILots | DOCSis
(Downstream only:) An optimal channel estimation using all available pilots is performed, as defined in the DOCSIS 3.1 downstream standard.
Note: query returns `DOCS`

PDATa
(Downstream only:) An optimal channel estimation using all available pilots and data is performed.

OFF
(Downstream only:) The channel transfer function is not compensated for in the measurement results.

EMER
(Upstream only, default:) Equalized MER
Measurements with linear distortions are equalized by the R&S FSW DOCSIS 3.1 application equalizer.

UMER
(Upstream only:) Unequalized MER
Measurements with linear distortions are not equalized by the R&S FSW DOCSIS 3.1 application equalizer.
Only one carrier amplitude adjustment common for all subcarriers and OFDM symbols in the burst is performed.
Only one timing adjustment is performed, resulting in phase ramp across subcarriers.

PEQ
Partial Equalization
Upstream: Partial equalization according to the definition in the standardization document *ATP TC1409.4 Procedure 3.1*. The partial equalizer is configured such that it does not correct components of the cable modem's impulse response that are longer than +/-200 ns.
Downstream: Minimal test receiver equalization according to the definition in the physical layer standardization document in section 7.5.9.1. The estimated channel impulse response used by the test receiver is limited to half the length of the smallest transmit cyclic prefix.

*RST: PILots (downstream) / EMER (upstream)

Example:

```
CHAN:EST PIL
CHAN:EST?
//Result: DOCS
```

Query of the parameter PILots returns DOCS (for compatibility reasons).

Manual operation: See "Channel Estimation" on page 106

SENSe:TRACking:PHASe <State>

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

Parameters:

<State> ON | OFF | 0 | 1

*RST: 1

Example: `SENS:TRAC:PHAS ON`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Phase Tracking (downstream only)" on page 107

SENSe:TRACking:TIME <State>

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

Parameters:

<State> ON | OFF | 0 | 1

*RST: 0

Example: `SENS:TRAC:TIME ON`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Timing Error Tracking" on page 107

10.5.7 Demodulation

The demodulation settings define which PPDUs are to be analyzed, thus they define a *logical filter*.

Manual configuration is described in Chapter 5.3.8, "Demodulation (downstream only)", on page 107.

[SENSe:]DEMod:CPILots:AUTO....218
[SENSe:]DEMod:DECode:BITStream....219
[SENSe:]DEMod:DECode:CODewords....220
[SENSe:]DEMod:NCP:AUTO....220

[SENSe:]DEMod:CPILots:AUTO <ContinuousPilots>

Defines how continuous pilots are detected in the symbols.

Parameters:

<ContinuousPilots> SIGNAL | USER

SIGNAL
Continuous pilots are detected in the signal automatically during demodulation.

USER
The pilots must be configured manually using the `CONFigure:DS:CHANnel:CPES<n>:SUBCarrier:TYPE CPIL` command.

Example: `DEM:CPIL:AUTO SIGNAL`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Auto Detection : Continuous Pilots (downstream only)" on page 60

[SENSe:]DEMod:DECode:BITStream <Mode>

Determines which bits of the data stream are decoded and then displayed in a Bitstream result display, if activated (see "Bitstream (downstream only)" on page 17).

Parameters:

<Mode>

IBDPdata
"Info Bits: Decoded Payload Data"
Only the bits containing the actual information (the payload bits) are decoded and displayed

RBITs
"Raw Bits"
Bits mapped to QAM constellation points, undecoded

RBD
"Raw Bits Descrambled"
Bits mapped to QAM constellation points, randomization undone, undecoded

IBLDpc
"Input Bits LDPC"
Undecoded hard-decisions of the log-likelihood ratio values seen by the LDPC decoder, whole FEC codeword (16200 bits)

OBLDpc
"Output Bits LDPC"
Decoded LDPC decoder output, whole FEC codeword (16200 bits)

*RST: IBDP

Example: `DEM:DEC:BITS IBLD`

Manual operation: See "Bitstream" on page 108

[SENSe:]DEMod:DECode:CODewords <State>

This command determines whether codewords are decoded or not.

Parameters:

<State> ON | OFF

*RST: ON

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Codewords" on page 108

[SENSe:]DEMod:NCP:AUTO <FrameConfig>

This command determines how frames are configured.

Parameters:

<FrameConfig> SIGNAL | USER

SIGNAL
Frames (NCP content) are detected in the signal automatically during demodulation.

USER
Frames must be configured manually (see Chapter 10.5.1.6, "Codeword/Frame Configuration", on page 176).

Example: `DEM:NCP:AUTO SIGNAL`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Auto Detection: NCP Content" on page 62

10.5.8 Evaluation Range

The evaluation range defines which data is evaluated in the result display.

Note that, as opposed to manual operation, the PPDUs to be analyzed can be defined either by the number of data symbols, the number of data bytes, or the measurement duration.

CONFigure:MEXC:STATe....221
CONFigure:MEXC:SUBCarrier:COUNt....221
CONFigure:MEXC:SUBCarrier:SET....221
[SENSe:]FRAMe:COUNt....222
[SENSe:]FRAMe:COUNt:STATe....222
[SENSe:]FRAMe:SELect....222
[SENSe:]FRAMe:SELect:STATe....223
[SENSe:]SWEep:LIMit:ABORt:STATe?....223

CONFigure:MEXC:STATe <Mode>

Excludes specific subcarriers from modulation error ratio (MER) calculation.

Parameters:

<Mode>

OFF
All subcarriers are included in MER calculation.

AUTO
The number of excluded subcarriers specified by `CONFigure:MEXC:SUBCarrier:COUNt` with the worst MER are automatically excluded from MER calculation.

USER
The subcarriers specified by the `CONFigure:MEXC:SUBCarrier:SET` command are excluded.

*RST: OFF

Example:

```
CONF:MEXC:STAT USER
CONF:MEXC:SUBC:STAR 100
CONF:MEXC:SUBC:INCR 1
CONF:MEXC:SUBC:STOP 105
```

The subcarriers 100 to 105 are excluded from MER calculation.

Manual operation: See "Excluding Subcarriers from MER Calculation" on page 111

CONFigure:MEXC:SUBCarrier:COUNt <NoExclSC>

Defines the number of subcarriers to be excluded from MER calculation (for `CONFigure:MEXC:STATe` on page 221 `AUTO`). The subcarriers with the worst MER are automatically excluded from MER calculation.

Parameters:

<NoExclSC> integer

Range: 1 to 5
*RST: 5

Example:

```
CONF:MEXC:STAT AUTO
CONF:MEXC:SUBC:COUN 5
```

Manual operation: See "Excluding Subcarriers from MER Calculation" on page 111

CONFigure:MEXC:SUBCarrier:SET <Subcarrier>[, <Subcarrier>]

Defines a comma-separated list of (discrete) subcarriers to be excluded from MER calculation (for `CONFigure:MEXC:STATe` on page 221 `USER`).

Parameters:

<Subcarrier> Subcarrier number

Range: 1 to 8191

Example:

```
CONF:MEXC:STAT USER
CONF:MEXC:SUBC:SET 100,105,112,123,134,145
```

Manual operation: See "Subcarrier Set" on page 111

[SENSe:]FRAMe:COUNt <Value>

If the statistic count is enabled (see `[SENSe:]FRAMe:COUNt:STATe` on page 222), the specified number of frames is taken into consideration for the statistical evaluation (maximally the number of frames detected in the current capture buffer).

If disabled, all detected frames in the current capture buffer are considered.

Parameters:

<Value> *RST: 1

Example:
```
SENS:FRAM:COUN:STAT ON
SENS:FRAM:COUN 10
```

Manual operation: See "Frame Statistic Count / Number of Frames to Analyze" on page 111

[SENSe:]FRAMe:COUNt:STATe <State>

If the statistic count is enabled, the specified number of frames is taken into consideration for the statistical evaluation (maximally the number of frames detected in the current capture buffer).

If disabled, all detected frames in the current capture buffer are considered.

Parameters:

<State> ON | OFF

*RST: OFF

Example:
```
SENS:FRAM:COUN:STAT ON
SENS:FRAM:COUN 10
```

Manual operation: See "Frame Statistic Count / Number of Frames to Analyze" on page 111

[SENSe:]FRAMe:SELect <Value>

If single frame evaluation is enabled (see `[SENSe:]FRAMe:SELect:STATe` on page 223), the specified frame number is evaluated in all graphical and numeric result displays.

If single frame evaluation is disabled, the first frame to be detected in the capture buffer (frame 0) is automatically selected for evaluation.

The result displays are updated to show the results for the new evaluation range. The selected frame is marked by a blue bar in the capture buffer display (see "Magnitude Capture" on page 20).

Parameters:

<Value> integer

Range: 0 to max no. frames in capture buffer
*RST: 0

Example:
```
SENS:FRAM:SEL:STAT ON
SENS:FRAM:SEL 2
```

Manual operation: See "Bitstream (downstream only)" on page 17
See "Constellation" on page 19
See "Group Delay" on page 20
See "MER vs Carrier" on page 21
See "MER vs Minislot (upstream only)" on page 22
See "MER vs Symbol" on page 23
See "MER vs Symbol X Carrier" on page 23
See "Phase vs Carrier" on page 24
See "Power vs Carrier (upstream only)" on page 24
See "Power vs Symbol X Carrier" on page 25
See "Power Spectrum" on page 26
See "Signal Content Detailed" on page 27
See "Spectrum Flatness" on page 28
See "Selected Frame" on page 110

[SENSe:]FRAMe:SELect:STATe <State>

If enabled, only the frame specified by the `[SENSe:]FRAMe:SELect` command is evaluated. Statistic evaluation for numeric results is not performed, as only one result is available for each frame parameter.

If disabled, all detected frames in the current capture buffer are evaluated for numeric results. For graphical results, the first frame to be detected in the capture buffer (frame 0) is automatically selected for evaluation.

Parameters:

<State> ON | OFF

*RST: OFF

Example:
```
SENS:FRAM:SEL:STAT ON
SENS:FRAM:SEL 1
```

Manual operation: See "Analyzing a single frame (Specified Frame)" on page 110

[SENSe:]SWEep:LIMit:ABORt:STATe?

This command determines the behavior of the application after a limit check fails.

This function is only available for Signal Content Detailed and Signal Content Summary result displays.

The limit check fails if the bit or block error rate after decoding (BER Pre, BER Post, BLER Post, see Table 3-3) is not zero. An error message in the status bar and a status bit in the SYNC register (bit 3) indicate the failure (see Chapter 10.11.1, "The STATus:QUEStionable:SYNC Register", on page 282).

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
A limit check has no effects on the measurement.

ON | 1
The measurement is stopped if the limit check fails at any time during the measurement.

*RST: 0

Example: `SWE:LIM:ABOR:STAT ON`

Usage: Query only

Manual operation: See "Stop RUN on Limit Check Fail" on page 110

10.5.9 Automatic Settings

[SENSe:]ADJust:LEVel....224
CONFigure:DS:PLC:AUTO....224
CONFigure:US:AUTO ONCE....225

[SENSe:]ADJust:LEVel

This command initiates a single (internal) measurement that evaluates and sets the ideal reference level for the current input data and measurement settings. This ensures that the settings of the RF attenuation and the reference level are optimally adjusted to the signal level without overloading the R&S FSW or limiting the dynamic range by an S/N ratio that is too small.

Example: `ADJ:LEV`

Usage: Event

CONFigure:DS:PLC:AUTO <State>

Performs an initial measurement in order to determine the required signal description settings automatically from the detected PLC before starting (or continuing) the actual Modulation Accuracy measurement.

This function is **only** available for **downstream** DOCSIS 3.1 signals.

Parameters for setting and query:

<State>

OFF
Switches the function off

ON
Switches the function on

ONCE
Executes the function once

*RST: OFF

Example: `CONFigure:DS:PLC:AUTO ONCE`

Manual operation: See "Auto Set from PLC & Run (downstream only)" on page 124

CONFigure:US:AUTO ONCE

Performs an initial measurement in order to determine the required signal description settings automatically from the detected signal characteristics before starting (or continuing) the actual Modulation Accuracy measurement.

This function is **only** available for **upstream** DOCSIS 3.1 signals.

Example: `CONFigure:US:AUTO ONCE`

Usage: Event

Manual operation: See "Auto Detection & Run (upstream only)" on page 124

10.6 Configuring Frequency Sweep Measurements on DOCSIS 3.1 Signals

The R&S FSW DOCSIS 3.1 application uses the functionality of the R&S FSW base system (Spectrum application, see the R&S FSW User Manual) to perform the DOCSIS 3.1 frequency sweep measurements. The R&S FSW DOCSIS 3.1 application automatically sets the parameters to predefined settings as described in Chapter 10.6, "Configuring Frequency Sweep Measurements on DOCSIS 3.1 Signals", on page 225.

The DOCSIS 3.1 RF measurements must be activated for a measurement channel in the R&S FSW DOCSIS 3.1 application, see Chapter 10.3, "Activating DOCSIS 3.1 Measurements", on page 149.

For details on configuring these RF measurements in a remote environment, see the Remote Commands chapter of the R&S FSW User Manual.

10.7 Configuring the Result Display

The following commands are required to configure the screen display in DOCSIS 3.1 I/Q measurements in a remote environment. The corresponding tasks for manual operation are described in Chapter 5.2, "Display Configuration", on page 49.

The suffix <n> in the following remote commands represents the window (1..16) in the currently selected measurement channel.

- General Window Commands....................226
- Working with Windows in the Display....................227
- Configuring Specific Result Displays....................233
- Configuring Scaling and Units....................237

10.7.1 General Window Commands

The following commands are required to configure general window layout, independent of the application.

DISPlay:FORMat....................226
DISPlay[:WINDow<n>]:SIZE....................226

DISPlay:FORMat <Format>

This command determines which tab is displayed.

Parameters:

<Format>

SPLit
Displays the MultiView tab with an overview of all active channels

SINGle
Displays the measurement channel that was previously focused.

*RST: SING

Example: `DISP:FORM SPL`

DISPlay[:WINDow<n>]:SIZE <Size>

This command maximizes the size of the selected result display window *temporarily*. To change the size of several windows on the screen permanently, use the `LAY:SPL` command (see `LAYout:SPLitter` on page 230).

Suffix:

<n> Window

Parameters:

<Size>

LARGe
Maximizes the selected window to full screen.
Other windows are still active in the background.

SMALl
Reduces the size of the selected window to its original size.
If more than one measurement window was displayed originally, these are visible again.

*RST: SMALl

Example: `DISP:WIND2:SIZE LARG`

10.7.2 Working with Windows in the Display

The following commands are required to change the evaluation type and rearrange the screen layout for a measurement channel as you do using the SmartGrid in manual operation. Since the available evaluation types depend on the selected application, some parameters for the following commands also depend on the selected measurement channel.

LAYout:ADD[:WINDow]?....................227
LAYout:CATalog[:WINDow]?....................229
LAYout:IDENtify[:WINDow]?....................229
LAYout:REMove[:WINDow]....................229
LAYout:REPLace[:WINDow]....................230
LAYout:SPLitter....................230
LAYout:WINDow<n>:ADD?....................232
LAYout:WINDow<n>:IDENtify?....................232
LAYout:WINDow<n>:REMove....................233
LAYout:WINDow<n>:REPLace....................233

LAYout:ADD[:WINDow]? <WindowName>,<Direction>,<WindowType>

This command adds a window to the display in the active measurement channel.

This command is always used as a query so that you immediately obtain the name of the new window as a result.

To replace an existing window, use the `LAYout:REPLace[:WINDow]` command.

Parameters:

<WindowName> String containing the name of the existing window the new window is inserted next to.
By default, the name of a window is the same as its index. To determine the name and index of all active windows, use the `LAYout:CATalog[:WINDow]?` query.

<Direction> LEFT | RIGHt | ABOVe | BELow

Direction the new window is added relative to the existing window.

<WindowType> text value

Type of result display (evaluation method) you want to add.
See the table below for available parameter values.

Return values:

<NewWindowName> When adding a new window, the command returns its name (by default the same as its number) as a result.

Usage: Query only

Manual operation: See "Bitstream (downstream only)" on page 17
See "Constellation" on page 19
See "Group Delay" on page 20
See "Magnitude Capture" on page 20
See "Marker Table" on page 21
See "MER vs Carrier" on page 21
See "MER vs Minislot (upstream only)" on page 22
See "MER vs Symbol" on page 23
See "MER vs Symbol X Carrier" on page 23
See "Phase vs Carrier" on page 24
See "Power vs Carrier (upstream only)" on page 24
See "Power vs Symbol X Carrier" on page 25
See "Power Spectrum" on page 26
See "Result Summary" on page 26
See "Signal Content Detailed" on page 27
See "Signal Content Summary" on page 28
See "Spectrum Flatness" on page 28
See "Diagram" on page 31
See "Result Summary" on page 31
See "Marker Peak List" on page 32

For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Table 10-3: <WindowType> parameter values for DOCSIS application

Parameter value	Window type
BITStream	Bitstream
CONStellation	Constellation
GDELay	Group Delay
MERCarrier	MER vs. Carrier
MERM	MER vs. Minislot (upstream only)
MERSymbol	MER vs. Symbol
MERSC	MER vs. Symbol X Carrier
PCAR	Power vs. Carrier
PHAC	Phase vs. Carrier
PSC	Power vs. Symbol X Carrier
PSPectrum	Power Spectrum
RFMagnitude	Magnitude Capture RF
RSUMmary	Result Summary
SCDetailed	Signal Content Detailed
SCSummary	Signal Content Summary (downstream only)
SFLatness	Spectrum Flatness

LAYout:CATalog[:WINDow]?

This command queries the name and index of all active windows in the active measurement channel from top left to bottom right. The result is a comma-separated list of values for each window, with the syntax:

<WindowName_1>,<WindowIndex_1>..<WindowName_n>,<WindowIndex_n>

Return values:

<WindowName> string
Name of the window.
In the default state, the name of the window is its index.

<WindowIndex> **numeric value**
Index of the window.

Example: `LAY:CAT?`
Result:
`'2',2,'1',1`
Two windows are displayed, named '2' (at the top or left), and '1' (at the bottom or right).

Usage: Query only

LAYout:IDENtify[:WINDow]? <WindowName>

This command queries the **index** of a particular display window in the active measurement channel.

Note: to query the **name** of a particular window, use the `LAYout:WINDow<n>:IDENtify?` query.

Query parameters:

<WindowName> String containing the name of a window.

Return values:

<WindowIndex> Index number of the window.

Example: `LAY:WIND:IDEN? '2'`
Queries the index of the result display named '2'.
Response:
`2`

Usage: Query only

LAYout:REMove[:WINDow] <WindowName>

This command removes a window from the display in the active measurement channel.

Parameters:

<WindowName> String containing the name of the window.
In the default state, the name of the window is its index.

Example: `LAY:REM '2'`
Removes the result display in the window named '2'.

Usage: Event

LAYout:REPLace[:WINDow] <WindowName>,<WindowType>

This command replaces the window type (for example from "Diagram" to "Result Summary") of an already existing window in the active measurement channel while keeping its position, index and window name.

To add a new window, use the `LAYout:ADD[:WINDow]?` command.

Parameters:

<WindowName> String containing the name of the existing window.
By default, the name of a window is the same as its index. To determine the name and index of all active windows in the active measurement channel, use the `LAYout:CATalog[:WINDow]?` query.

<WindowType> Type of result display you want to use in the existing window.
See `LAYout:ADD[:WINDow]?` on page 227 for a list of available window types.

Example: `LAY:REPL:WIND '1',MTAB`
Replaces the result display in window 1 with a marker table.

LAYout:SPLitter <Index1>,<Index2>,<Position>

This command changes the position of a splitter and thus controls the size of the windows on each side of the splitter.

Compared to the `DISPlay[:WINDow<n>]:SIZE` on page 226 command, the `LAYout:SPLitter` changes the size of all windows to either side of the splitter permanently, it does not just maximize a single window temporarily.

Note that windows must have a certain minimum size. If the position you define conflicts with the minimum size of any of the affected windows, the command will not work, but does not return an error.

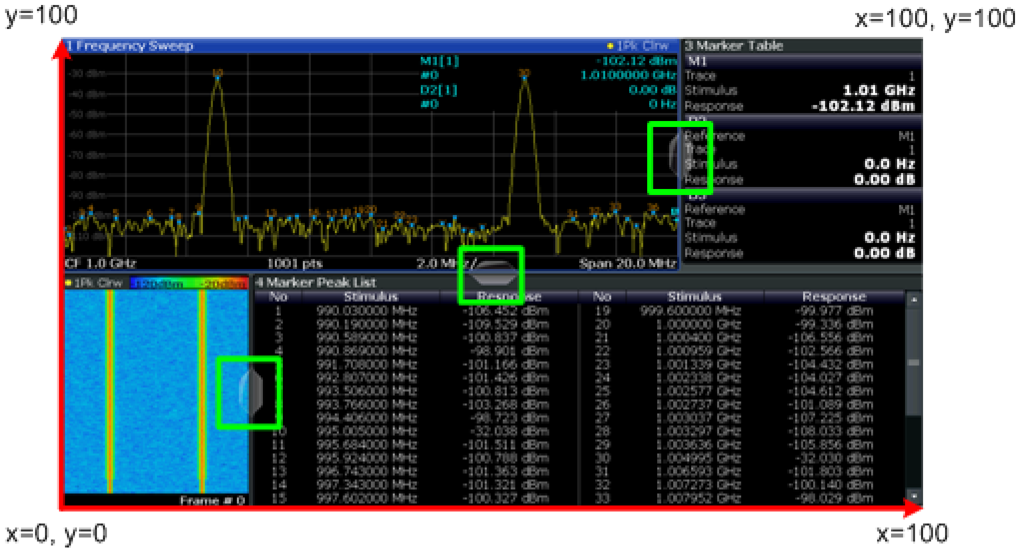

Figure 10-1: SmartGrid coordinates for remote control of the splitters

Parameters:

<Index1>	The index of one window the splitter controls.
<Index2>	The index of a window on the other side of the splitter.
<Position>	New vertical or horizontal position of the splitter as a fraction of the screen area (without channel and status bar and softkey menu). The point of origin (x = 0, y = 0) is in the lower left corner of the screen. The end point (x = 100, y = 100) is in the upper right corner of the screen. (See Figure 10-1.) The direction in which the splitter is moved depends on the screen layout. If the windows are positioned horizontally, the splitter also moves horizontally. If the windows are positioned vertically, the splitter also moves vertically. Range: 0 to 100

Example:

`LAY:SPL 1,3,50`

Moves the splitter between window 1 ('Frequency Sweep') and 3 ('Marker Table') to the center (50%) of the screen, i.e. in the figure above, to the left.

Example:

`LAY:SPL 1,4,70`

Moves the splitter between window 1 ('Frequency Sweep') and 3 ('Marker Peak List') towards the top (70%) of the screen.

The following commands have the exact same effect, as any combination of windows above and below the splitter moves the splitter vertically.

```
LAY:SPL 3,2,70
LAY:SPL 4,1,70
LAY:SPL 2,1,70
```

LAYout:WINDow<n>:ADD? <Direction>,<WindowType>

This command adds a measurement window to the display. Note that with this command, the suffix <n> determines the existing window next to which the new window is added, as opposed to `LAYout:ADD[:WINDow]?`, for which the existing window is defined by a parameter.

To replace an existing window, use the `LAYout:WINDow<n>:REPLace` command.

This command is always used as a query so that you immediately obtain the name of the new window as a result.

Suffix:

<n>	Window

Parameters:

<Direction>	LEFT | RIGHt | ABOVe | BELow
<WindowType>	Type of measurement window you want to add. See `LAYout:ADD[:WINDow]?` on page 227 for a list of available window types.

Return values:

<NewWindowName>	When adding a new window, the command returns its name (by default the same as its number) as a result.

Example:	`LAY:WIND1:ADD? LEFT,MTAB`
	Result:
	`'2'`
	Adds a new window named '2' with a marker table to the left of window 1.

Usage:	Query only

LAYout:WINDow<n>:IDENtify?

This command queries the **name** of a particular display window (indicated by the <n> suffix) in the active measurement channel.

Note: to query the **index** of a particular window, use the `LAYout:IDENtify[:WINDow]?` command.

Suffix:

<n>	Window

Return values:

<WindowName>	String containing the name of a window. In the default state, the name of the window is its index.

Example:	`LAY:WIND2:IDEN?`
	Queries the name of the result display in window 2.
	Response:
	`'2'`

Usage:	Query only

LAYout:WINDow<n>:REMove

This command removes the window specified by the suffix <n> from the display in the active measurement channel.

The result of this command is identical to the `LAYout:REMove[:WINDow]` command.

Suffix:

<n> Window

Example: `LAY:WIND2:REM`
Removes the result display in window 2.

Usage: Event

LAYout:WINDow<n>:REPLace <WindowType>

This command changes the window type of an existing window (specified by the suffix <n>) in the active measurement channel.

The result of this command is identical to the `LAYout:REPLace[:WINDow]` command.

To add a new window, use the `LAYout:WINDow<n>:ADD?` command.

Suffix:

<n> Window

Parameters:

<WindowType> Type of measurement window you want to replace another one with.
See `LAYout:ADD[:WINDow]?` on page 227 for a list of available window types.

Example: `LAY:WIND2:REPL MTAB`
Replaces the result display in window 2 with a marker table.

10.7.3 Configuring Specific Result Displays

The following command configure specific result displays.

DISPlay[:WINDow<n>]:BITStream:LAYout....234
DISPlay[:WINDow<n>]:TABLe:ITEM....234
[SENSe:]FMODE:STATe....234
[SENSe:]MODulation:SELect....235
[SENSe:]OBJect:SELect....235
[SENSe:]SUBCarrier:SELect....236
[SENSe:]SYMBol:SELect....236
[SENSe:]SYMBol:SIZE....236
UNIT:POWer....237

DISPlay[:WINDow<n>]:BITStream:LAYout <View>

Determines whether a compact or expanded view of the bits are displayed in the Bitstream result display, if activated (see "Bitstream (downstream only)" on page 17).

Suffix:

<n> Window

Parameters:

<View> COMPact | EXPanded

Manual operation: See "Bitstream Layout" on page 118

DISPlay[:WINDow<n>]:TABLe:ITEM <Item>, <State>
DISPlay[:WINDow<n>]:TABLe:ITEM? <Item>

This command specifies which parameters are displayed in the "Result Summary" display. Note that all parameters are calculated, regardless of their visibility.

Suffix:

<n> irrelevant

Parameters:

<State> ON | OFF

*RST: ON

Parameters for setting and query:

<Item> MER | MERData | MERPilot | FERRor | CERRor | TPLC | POWer | ZBIT

For details on the individual parameters and the assignment of the parameters to the keywords see Table 3-1.

Example: `DISP:WIND:TABL:ITEM MERD,ON`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

[SENSe:]FMODE:STATe <State>

If enabled, the constellation uses a single color for all modulations, which improves performance. However, individual modulation types cannot be selected.

If disabled, different colors are used for different modulation types (see "Constellation" on page 19). Which modulation types are displayed (depending on the selected object) is configurable.

Parameters:

<State> ON | OFF

*RST: ON

Example: `SENS:FMOD:STAT ON`

Manual operation: See "Fast Mode (Single Color)" on page 116

[SENSe:]MODulation:SELect <Modulation>

Defines the modulation for which the Constellation diagram is displayed.

Return values:

<Modulation> ALL | ZEROBIT | BPSK | QPSK | QAM16 | QAM64 | QAM128 | QAM256 | QAM512 | QAM1024 | QAM2048 | QAM4096 | QAM8192 | QAM16384

Example: `MOD:SEL QAM16`

Manual operation: See "Constellation" on page 19
See "Modulation" on page 116

[SENSe:]OBJect:SELect <EvalRange>

Defines the objects for which the Constellation diagram is displayed.

Return values:

<Object> ALL | ZEROBIT | BPSK | QPSK | QAM16 | QAM64 | QAM128 | QAM256 | QAM512 | QAM1024 | QAM2048 | QAM4096 | QAM8192 | QAM16384

Information type

ALL
All information types

PILots
Pilots

PLCData
(Downstream only:) PLC Data

PLCPreamble
(Downstream only:) PLC Preamble

NCPA
(Downstream only:) NCP All

A|B|C|D|E|F|G|H|I|J|K|L|M|N|O|P
(Downstream only:) Codeword A .. P

CPILots
(Upstream only:) Complementary Pilots

PROFile
(Upstream only:) Current profile

SPILots
(Downstream only:) Scattered pilots

CONPilots
(Downstream only:) Continuous pilots

Example: `OBJ:SEL B`

Manual operation: See "Constellation" on page 19
See "Object" on page 115

[SENSe:]SUBCarrier:SELect <EvalRange>

Defines the evaluation range for the Constellation diagram.

Parameters:

<EvalRange> **numeric value between 0 and 8191**
The constellation diagram is restricted to the specified subcarrier.

ALL
The Constellation diagram is displayed for all configured or detected subcarriers.

*RST: ALL

Example: `SUBC:SEL 7`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Constellation" on page 19
See "Subcarrier" on page 116

[SENSe:]SYMBol:SELect <EvalRange>

Defines the evaluation range for the Constellation diagram.

Parameters:

<EvalRange> **numeric value between 0 and 127**
The constellation diagram is restricted to the specified symbol.

ALL
The Constellation diagram is displayed for all symbols.

*RST: ALL

Example: `SYMB:SEL 7`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Constellation" on page 19
See "Symbol" on page 116

[SENSe:]SYMBol:SIZE <Size>

Defines the size of the individual symbol points in the Constellation diagram.

Parameters:
<Size> S1 | S2 | S3

S1
One symbol point is displayed by 1 pixel on the x-axis and 1 pixel on the y-axis

S2
One symbol point is displayed by 2 pixels on the x-axis and 2 pixels on the y-axis

S3
One symbol point is displayed by 3 pixels on the x-axis and 3 pixels on the y-axis

*RST: S1

Example: `SENS:SYMB:SIZE S2`

Manual operation: See "Symbol Points Size" on page 116

UNIT:POWer <Unit>

Determines whether the power results in the Result Summary are calculated as absolute values or relative to the power of the data subcarriers.

Parameters:
<Unit> **ABSolute**
Power results are provided as absolute values. The unit depends on the `CALCulate<n>:UNIT:POWer` command.

RELative
Power results are provided relative to the power measured in the data subcarriers.

*RST: REL

Example:
```
UNIT:POW ABS
CALC:UNIT:POW DBM
```
Sets the power unit to absolute values in dBm.

Manual operation: See "Power Unit" on page 119

10.7.4 Configuring Scaling and Units

The following commands are required to configure the scaling for DOCSIS 3.1 I/Q measurement results in a remote environment. The corresponding tasks for manual operation are described in Chapter 5.3.10.3, "Y-Scaling Settings", on page 119.

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO 238
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:FIXed:RANGe 238
DISPlay[:WINDow<N>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:LOWer:UPPer 239
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:LOWer:LOWer 239
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:UPPer:LOWer 240
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:UPPer:UPPer 240
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:MEMory:DEPTh 241

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:MODE....241
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:DIVisions....242
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MAXimum....242
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MINimum....243
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:PDIVision....243
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:UNIT?....244
UNIT:BITStream....244
UNIT:CAXes....244

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO <State>

This command activates or deactivates automatic scaling of the y-axis for the specified trace display. If enabled, the R&S FSW DOCSIS 3.1 application automatically scales the y-axis to best fit the measurement results.

If disabled, the y-axis is scaled according to the specified minimum/maximum values (see `DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MINimum`/`DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MAXimum`) and number of divisions (see `DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:DIVisions`).

Suffix:

<n> Window

<t> Trace

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 1

Example: `DISP:WIND2:TRAC:Y:SCAL:AUTO ON`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Automatic Grid Scaling" on page 120

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:FIXed:RANGe <AutoFixRange>

This command defines the use of fixed value limits.

Suffix:

<n> Window

<t> Trace

Parameters:

<AutoFixRange> NONE | LOWer | UPPer

NONE
Both the upper and lower limits are determined by automatic scaling of the y-axis.

LOWer
The lower limit is fixed (defined by DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MINimum/DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MAXimum), while the upper limit is determined by automatic scaling of the y-axis.

UPPer
The upper limit is fixed, while the lower limit is determined by automatic scaling of the y-axis.

Example:

```
DISP:WIND1:TRAC:Y:AUTO:FIX:RANG LOW
DISP:WIND1:TRAC:Y:MIN 0dBm
```

Sets the lower limit of the y-axis to a fixed value of 0 dBm.

Manual operation: See "Auto Fix Range" on page 121

DISPlay[:WINDow<N>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:LOWer:UPPer <Value>

For automatic scaling based on hysteresis, this command defines the upper limit of the lower hysteresis interval.

If the minimum value in the current measurement exceeds this limit, the y-axis is rescaled automatically.

For details see "Hysteresis Interval Upper/Lower" on page 121.

Suffix:

<n> Window

<t> Trace

Parameters:

<Value> Percentage of the currently displayed value range on the y-axis.

Example:

```
DISP:WIND2:TRAC:Y:SCAL:AUTO:HYST:LOW:UPP 5
```

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Hysteresis Interval Upper/Lower" on page 121

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:LOWer:LOWer <Value>

For automatic scaling based on hysteresis, this command defines the lower limit of the lower hysteresis interval.

If the minimum value in the current measurement drops below this limit, the y-axis is rescaled automatically.

For details see "Hysteresis Interval Upper/Lower" on page 121.

Suffix:

<n>	Window
<t>	Trace

Parameters:

<Value>	Percentage of the currently displayed value range on the y-axis.

Example: `DISP:WIND2:TRAC:Y:SCAL:AUTO:HYST:LOW:LOW 5`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Hysteresis Interval Upper/Lower" on page 121

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:UPPer:LOWer <Value>

For automatic scaling based on hysteresis, this command defines the lower limit of the upper hysteresis interval.

If the maximum value in the current measurement drops below this limit, the y-axis is rescaled automatically.

For details see "Hysteresis Interval Upper/Lower" on page 121.

Suffix:

<n>	Window
<t>	Trace

Parameters:

<Value>	Percentage of the currently displayed value range on the y-axis.

Example: `DISP:WIND2:TRAC:Y:AUTO:HYST:UPP:LOW 25`

Manual operation: See "Hysteresis Interval Upper/Lower" on page 121

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:HYSTeresis:UPPer:UPPer <Value>

For automatic scaling based on hysteresis, this command defines the upper limit of the upper hysteresis interval.

If the maximum value in the current measurement exceeds this limit, the y-axis is rescaled automatically.

For details see "Hysteresis Interval Upper/Lower" on page 121.

Suffix:

<n>	Window
<t>	Trace

Parameters:

<Value>	Percentage of the currently displayed value range on the y-axis.

Example: `DISP:WIND2:TRAC:Y:AUTO:HYST:UPP:UPP 20`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Hysteresis Interval Upper/Lower" on page 121

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:MEMory:DEPTh <NoMeas>

For automatic scaling based on memory, this value defines the number <x> of previous results to be considered when determining if rescaling is required.

The minimum and maximum value of each measurement are added to the memory. After <x> measurements, the oldest results in the memory are overwritten by each new measurement.

For details see "Auto Mode" on page 120.

Suffix:

<n> Window

<t> Trace

Parameters:

<NoMeas> integer value
Number of measurement results to be stored for autoscaling

Example: `DISP:WIND2:TRAC:Y:AUTO:MEM:DEPT 16`

Manual operation: See "Memory Depth" on page 122

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:MODE <AutoMode>

This command determines which algorithm is used to determine whether the y-axis requires automatic rescaling.

Suffix:

<n> Window

<t> Trace

Parameters:
<AutoMode>

HYSTeresis
If the minimum and/or maximum values of the current measurement exceed a specific value range (hysteresis interval), the axis is rescaled. The hysteresis interval is defined as a percentage of the currently displayed value range on the y-axis. An upper hysteresis interval is defined for the maximum value, a lower hysteresis interval is defined for the minimum value.

MEMory
If the minimum and/or maximum values of the current measurement exceed the minimum and/or maximum of the <x> previous results, the axis is rescaled.
The minimum and maximum value of each measurement are added to the memory. After <x> measurements, the oldest results in the memory are overwritten by each new measurement.
The number of results in the memory to be considered is configurable (see `DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:MEMory:DEPTh`).

*RST: HYSTeresis

Example: `DISP:WIND2:TRAC:Y:AUTO:MODE MEM`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Auto Mode" on page 120

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:DIVisions <NoDivisions>

Defines the number of divisions to be used for the y-axis in the specified window.

Separate division settings can be configured for individual result displays.

Suffix:
<n> Window

<t> Trace

Parameters:
<NoDivisions>

Example: `DISP:WIND2:TRAC:Y:SCAL:DIV 10`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Number of Divisions" on page 122

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MAXimum <Max>

Defines the maximum value to be displayed on the y-axis of the specified evaluation diagram.

For automatic scaling with a fixed range (see `DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:FIXed:RANGe` on page 238), the maximum defines the fixed upper limit.

Suffix:

<n>	Window
<t>	Trace

Parameters:
<Max>

Example: `DISP:WIND2:TRAC:Y:SCAL:MAX 100`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Minimum / Maximum" on page 122

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MINimum <Min>

Defines the minimum value to be displayed on the y-axis of the specified evaluation diagram.

For automatic scaling with a fixed range (see `DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:AUTO:FIXed:RANGe` on page 238), the minimum defines the fixed lower limit.

Suffix:

<n>	Window
<t>	Trace

Parameters:
<Min>

Example: `DISP:WIND2:TRAC:Y:SCAL:MIN -20`

Manual operation: See "Minimum / Maximum" on page 122

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:PDIVision <Multiple>[,<Multiple>]

Determines the values shown for each division on the y-axis in the specified window.

One or more multiples of 10^n can be selected. The R&S FSW DOCSIS 3.1 application then selects the optimal scaling from the selected values.

For details see "Scaling per division" on page 122.

Suffix:

<n>	Window
<t>	Trace

Parameters:

<Multiple> 1.0 | 2.0 | 2.5 | 5.0

If enabled, each division on the y-axis displays the selected multiple of 10^n.

*RST: 1.0,5.0

Example: `DISP:WIND:TRAC:Y:SCAL:PDIV 2.0,2.5`

Multiples of $2.0*10^n$ or multiples of $2.5*10^n$ are displayed on the y-axis.

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Manual operation: See "Scaling per division" on page 122

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:UNIT?

This command queries the unit currently configured for the y-axis in the specified window.

(The suffix <t> is ignored, as only one trace is available)

Suffix:

<n> Window

<t> irrelevant

Return values:

<Unit> Possible values depend on the type of result display.

Example: `DISP:WIND2:TRAC:Y:SCAL:UNIT?`

Usage: Query only

UNIT:BITStream <Unit>

Determines whether the data is displayed as bits or bytes (default) in a Bitstream result display, if activated (see "Bitstream (downstream only)" on page 17).

Parameters:

<Unit> BIT | BYTE

*RST: BYTE

Example: `UNIT:BITS BIT`

Manual operation: See "Bitstream (downstream only)" on page 17
See "Bitstream Format" on page 118

UNIT:CAXes <Unit>

For result displays that evaluate a parameter per carrier (e.g. MER vs Carrier), this command defines whether the carrier number or the carrier frequency (in Hz) is displayed on the x-axis. Note, however, that this setting applies to *ALL* result displays based on carriers.

Parameters:

<Unit> CARR | HZ

CARR
The carrier number is displayed on the x-axis of all carrier-based result displays.

HZ
The carrier frequency (in Hz) is displayed on the x-axis of all carrier-based result displays.

*RST: HZ

Example: `UNIT:CAX CARR`

Manual operation: See "Carrier Axes Unit" on page 117

10.8 Starting a Measurement

When a DOCSIS 3.1 measurement channel is activated on the R&S FSW, a DOCSIS 3.1 I/Q measurement (Modulation Accuracy, see Chapter 3.1, "DOCSIS 3.1 I/Q Measurement", on page 13), is started immediately. However, you can stop and start a new measurement any time.

Furthermore, you can perform a sequence of measurements using the Sequencer (see Chapter 5.1, "Multiple Measurement Channels and Sequencer Function", on page 48).

ABORt......245
INITiate<n>:CONMeas......246
INITiate<n>:CONTinuous......246
INITiate<n>[:IMMediate]......247
INITiate<n>:REFResh......247
INITiate<n>:SEQuencer:ABORt......248
INITiate<n>:SEQuencer:IMMediate......248
INITiate<n>:SEQuencer:MODE......248
SYSTem:SEQuencer......249

ABORt

This command aborts the measurement in the current measurement channel and resets the trigger system.

To prevent overlapping execution of the subsequent command before the measurement has been aborted successfully, use the `*OPC?` or `*WAI` command after `ABOR` and before the next command.

For details see the "Remote Basics" chapter in the R&S FSW User Manual.

Note on blocked remote control programs:

If a sequential command cannot be completed, for example because a triggered sweep never receives a trigger, the remote control program will never finish and the remote channel to the R&S FSW is blocked for further commands. In this case, you must interrupt processing on the remote channel first in order to abort the measurement.

To do so, send a "Device Clear" command from the control instrument to the R&S FSW on a parallel channel to clear all currently active remote channels. Depending on the used interface and protocol, send the following commands:

- **Visa**: `viClear()`
- **GPIB**: `ibclr()`
- **RSIB**: `RSDLLibclr()`

Now you can send the `ABORt` command on the remote channel performing the measurement.

Example: `ABOR;:INIT:IMM`
Aborts the current measurement and immediately starts a new one.

Example: `ABOR;*WAI`
`INIT:IMM`
Aborts the current measurement and starts a new one once abortion has been completed.

Usage: Event
SCPI confirmed

INITiate<n>:CONMeas

This command 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: Event

Manual operation: See "Continue Single Sweep" on page 105

INITiate<n>:CONTinuous <State>

This command controls the measurement mode for an individual measurement channel.

Note that in single measurement mode, you can synchronize to the end of the measurement with *OPC, *OPC? or *WAI. In continuous measurement mode, synchronization to the end of the measurement is not possible. Thus, it is not recommended that you use continuous measurement mode in remote control, as results like trace data or markers are only valid after a single measurement end synchronization.

Suffix:
<n> irrelevant

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

ON | 1
Continuous measurement

OFF | 0
Single measurement

*RST: 1

Example: `INIT:CONT OFF`
Switches the measurement mode to single measurement.
`INIT:CONT ON`
Switches the measurement mode to continuous measurement.

Manual operation: See "Continuous Sweep/RUN CONT" on page 104

INITiate<n>[:IMMediate]

This command starts a (single) new measurement.

You can synchronize to the end of the measurement with *OPC, *OPC? or *WAI.

For details on synchronization see the "Remote Basics" chapter in the R&S FSW User Manual.

Suffix:
<n> irrelevant

Usage: Event

Manual operation: See "Single Sweep/ RUN SINGLE" on page 104

INITiate<n>:REFResh

The data in the capture buffer is re-evaluated by the R&S FSW DOCSIS 3.1 application. This is useful, for example, after evaluation changes have been made.

This function is only available if the Sequencer is deactivated and only in single sweep mode.

Suffix:
<n> 1|2
irrelevant

Example: `INIT:REFR`

Usage: Event

Manual operation: See "Refresh" on page 105

INITiate<n>:SEQuencer:ABORt

This command stops the currently active sequence of measurements. The Sequencer itself is not deactivated, so you can start a new sequence immediately using INITiate<n>:SEQuencer:IMMediate on page 248.

To deactivate the Sequencer use SYSTem:SEQuencer on page 249.

Suffix:
<n> irrelevant

Usage: Event

Manual operation: See "Sequencer State" on page 49

INITiate<n>:SEQuencer:IMMediate

This command starts a new sequence of measurements by the Sequencer.

Its effect is similar to the INITiate<n>[:IMMediate] command used for a single measurement.

Before this command can be executed, the Sequencer must be activated (see SYSTem:SEQuencer on page 249).

Suffix:
<n> irrelevant

Example:
`SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single sequence mode so each active measurement will be performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.

Usage: Event

Manual operation: See "Sequencer State" on page 49

INITiate<n>:SEQuencer:MODE <Mode>

This command selects the way the R&S FSW application performs measurements sequentially.

Before this command can be executed, the Sequencer must be activated (see SYSTem:SEQuencer on page 249).

A detailed programming example is provided in the "Operating Modes" chapter in the R&S FSW User Manual.

Note: In order to synchronize to the end of a sequential measurement using *OPC, *OPC? or *WAI you must use `SINGle` Sequence mode.

For details on synchronization see the "Remote Basics" chapter in the R&S FSW User Manual.

Suffix:
<n> irrelevant

Parameters:
<Mode> **SINGle**
Each measurement is performed once (regardless of the channel's sweep mode), considering each channels' sweep count, until all measurements in all active channels have been performed.

CONTinuous
The measurements in each active channel are performed one after the other, repeatedly (regardless of the channel's sweep mode), in the same order, until the Sequencer is stopped.

CDEFined
First, a single sequence is performed. Then, only those channels in continuous sweep mode (`INIT:CONT ON`) are repeated.

*RST: CONTinuous

Example:
`SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single sequence mode so each active measurement will be performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.

Manual operation: See "Sequencer Mode" on page 49

SYSTem:SEQuencer <State>

This command turns the Sequencer on and off. The Sequencer must be active before any other Sequencer commands (`INIT:SEQ...`) are executed, otherwise an error will occur.

A detailed programming example is provided in the "Operating Modes" chapter in the R&S FSW User Manual.

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

ON | 1
The Sequencer is activated and a sequential measurement is started immediately.

OFF | 0
The Sequencer is deactivated. Any running sequential measurements are stopped. Further Sequencer commands (`INIT:SEQ...`) are not available.

*RST: 0

Example: `SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single Sequencer mode so each active measurement will be performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.
`SYST:SEQ OFF`

Manual operation: See "Sequencer State" on page 49

10.9 Retrieving Results

The following commands are required to retrieve the results from a DOCSIS 3.1 measurement in a remote environment.

The `*OPC` command should be used after commands that retrieve data so that subsequent commands to change the trigger or data capturing settings are held off until after the data capture is completed and the data has been returned.

- Numeric Modulation Accuracy Results.......... 250
- Numeric Results for Frequency Sweep Measurements.......... 266
- Retrieving Trace Results.......... 268
- Measurement Results for TRACe<n>[:DATA]? TRACE<n>.......... 271
- Importing and Exporting I/Q Data and Results.......... 274

10.9.1 Numeric Modulation Accuracy Results

The following commands describe how to retrieve the numeric results from the standard DOCSIS 3.1 measurements.

The commands to retrieve results from frequency sweep measurements for DOCSIS 3.1 signals are described in Chapter 10.9.2, "Numeric Results for Frequency Sweep Measurements", on page 266.

- Frame Statistic Results.......... 251
- Error Parameter and Detailed Signal Content Results.......... 251
- Querying Limits.......... 263
- Limit Check Results.......... 265

10.9.1.1 Frame Statistic Results

The following commands are required to determine the basis for statistical frame evaluation (see Table 3-2).

FETCh:FRAMe:COUNt?..251
FETCh:FRAMe:COUNt:ALL?...251

FETCh:FRAMe:COUNt?

This command returns the number of analyzed frames from the current capture buffer. If multiple measurements are required because the number of frames to analyze is greater than the number of frames that can be captured in one buffer, this command only returns the number of captured frames *in the current capture buffer* (as opposed to `FETCh:FRAMe:COUNt:ALL?`).

Return values:
<NoFrames> integer value

Example: `FETC:FRAM:COUN?`

Usage: Query only

Manual operation: See "Result Summary" on page 26
See "Signal Content Summary" on page 28

FETCh:FRAMe:COUNt:ALL?

This command returns the number of analyzed frames for the entire measurement. If multiple measurements are required because the number of frames to analyze is greater than the number of frames that can be captured in one buffer, this command returns the number of analyzed frames in *all* measurements (as opposed to `FETCh:FRAMe:COUNt?`).

Return values:
<NoFrames> integer value

Example: `FETC:FRAM:COUN:ALL?`

Usage: Query only

Manual operation: See "Result Summary" on page 26
See "Signal Content Summary" on page 28

10.9.1.2 Error Parameter and Detailed Signal Content Results

The following commands are required to retrieve individual results from the DOCSIS 3.1 I/Q measurement on the captured I/Q data (see Chapter 3.1.1, "Modulation Accuracy Parameters", on page 13).

FETCh:BITStream:ALL?..253
FETCh:CP?...254
FETCh:SCDetailed:ALL:FORMatted?...255
FETCh:SCSummary:ALL?...259

FETCh:SUMMary:ALL?....261
FETCh:SUMMary:CERRor[:AVERage]?....262
FETCh:SUMMary:CERRor:MAXimum?....262
FETCh:SUMMary:CERRor:MINimum?....262
FETCh:SUMMary:FERRor[:AVERage]?....262
FETCh:SUMMary:FERRor:MAXimum?....262
FETCh:SUMMary:FERRor:MINimum?....262
FETCh:SUMMary:MER[:AVERage]?....262
FETCh:SUMMary:MER:MAXimum?....262
FETCh:SUMMary:MER:MINimum?....262
FETCh:SUMMary:MERData[:AVERage]?....262
FETCh:SUMMary:MERData:MAXimum?....262
FETCh:SUMMary:MERData:MINimum?....262
FETCh:SUMMary:MERPilot[:AVERage]?....262
FETCh:SUMMary:MERPilot:MAXimum?....262
FETCh:SUMMary:MERPilot:MINimum?....262
FETCh:SUMMary:PERRor[:AVERage]?....262
FETCh:SUMMary:PERRor:MAXimum?....262
FETCh:SUMMary:PERRor:MINimum?....262
FETCh:SUMMary:POWer[:AVERage]?....262
FETCh:SUMMary:POWer:MAXimum?....263
FETCh:SUMMary:POWer:MINimum?....263
FETCh:SUMMary:POWer:CONPilots:MAXimum?....263
FETCh:SUMMary:POWer:CONPilots:MINimum?....263
FETCh:SUMMary:POWer:CONPilots[:AVERage]?....263
FETCh:SUMMary:POWer:DATA:MAXimum?....263
FETCh:SUMMary:POWer:DATA:MINimum?....263
FETCh:SUMMary:POWer:DATA[:AVERage]?....263
FETCh:SUMMary:POWer:PILots:MAXimum?....263
FETCh:SUMMary:POWer:PILots:MINimum?....263
FETCh:SUMMary:POWer:PILots[:AVERage]?....263
FETCh:SUMMary:POWer:SPILots:MAXimum?....263
FETCh:SUMMary:POWer:SPILots:MINimum?....263
FETCh:SUMMary:POWer:SPILots[:AVERage]?....263
FETCh:SUMMary:POWer:SPLC:MAXimum?....263
FETCh:SUMMary:POWer:SPLC:MINimum?....263
FETCh:SUMMary:POWer:SPLC[:AVERage]?....263
FETCh:SUMMary:TFRame[:AVERage]?....263
FETCh:SUMMary:TFRame:MAXimum?....263
FETCh:SUMMary:TFRame:MINimum?....263
FETCh:SUMMary:TPLC[:AVERage]?....263
FETCh:SUMMary:TPLC:MAXimum?....263
FETCh:SUMMary:TPLC:MINimum?....263
FETCh:SUMMary:ZBIT[:AVERage]?....263
FETCh:SUMMary:ZBIT:MAXimum?....263
FETCh:SUMMary:ZBIT:MINimum?....263
FETCh:SUMMary:<parameter>:AVERage|MAXimum|MINimum?....263

FETCh:BITStream:ALL?

This command returns the decoded payload data stream for each detected codeword in the currently captured I/Q data as a comma-separated list. For each codeword, the following information is displayed:

`<CW_Index>,<Object>,<Modulation>,<NoBits>,<NoEntries>,<Bits>,`

Note: Whether the result display is shown in compact or extended mode is irrelevant for the query results. However, the results do depend on whether bit or byte format is selected (see `UNIT:BITStream` on page 244).

For details see "Bitstream (downstream only)" on page 17.

Return values:

<CW_Index> integer (0..1535) | nan

Codeword index
Not available (nan) for PLC, pilots and excluded subcarriers

<Object> Information type

nan
Invalid data

PLCD
PLC Data

NCPCWA | ... | NCPCWP
NCP Codeword A...P

NCPC24
NCP CRC-24

NCPN
NCP Null

CWA | ... | CWP
Codeword A .. P

<Modulation> BPSK | QPSK | QAM16 | QAM64 | QAM128 | QAM256 | QAM512 | QAM1024 | QAM2048 | QAM4096 | QAM8192 | QAM16384 | NONE | MIXED

Modulation (see "Modulation" on page 65)

<NoBits> Total number of bits in object

<NoEntries> Number of decoded payload bits
For byte format (see `UNIT:BITStream`): <NoEntries> := <NoBits> / 8
For bit format: <NoEntries> := <NoBits>

<Bits> Decoded payload bits in hexadecimal format

Example:
UNIT:BITS BYTE
FETC:BITS:ALL?
Result (in byte format):

```
nan,PLCD,QAM16,2880,360,1F,35,B0,FF,B3,58,78,63,47,F8,...
0,NCPCWC,QAM16,24,3,20,00,00,
1,NCPCWC,QAM16,24,3,20,06,54,
2,NCPCWA,QAM16,24,3,01,0C,A8,
0,NCPC24,QAM16,24,3,A4,74,7D,
0,CWC,QAM1024,14232,1779,A0,01,C0,04,80,1B,00,5A,01,DC,...
1,CWC,QAM1024,14232,1779,A0,01,C0,04,80,1B,00,5A,01,DC,...
2,CWA,QAM64,14232,1779,80,01,00,06,00,14,00,78,01,10,...
3,NCPCWD,QAM16,24,3,30,08,E9,
4,NCPCWD,QAM16,24,3,31,0E,2F,
1,NCPC24,QAM16,24,3,7E,E4,A4,
3,CWD,QAM4096,14232,1779,E0,00,40,01,80,05,00,1E,00,44,...
4,CWD,QAM4096,14232,1779,E0,00,40,01,80,05,00,1E,00,44,...
5,NCPCWD,QAM16,24,3,30,05,1D,
6,NCPCWC,QAM16,24,3,21,0A,63,
2,NCPC24,QAM16,24,3,F3,28,22,
5,CWD,QAM4096,14232,1779,E0,00,40,01,80,05,00,1E,00,44,...
```

Usage: Query only

Manual operation: See "Bitstream (downstream only)" on page 17

FETCh:CP?

Queries the automatically determined or specified cyclic prefix for the signal description.

Parameters:
<CyclicPrefix> (downstream)

S192
Useful symbol period starts after 192 samples or 0.9375µs.

S256
Useful symbol period starts after 256 samples or 1.25µs.

S512
Useful symbol period starts after 512 samples or 2.5µs.

S768
Useful symbol period starts after 768 samples or 3.75µs.

S1024
Useful symbol period starts after 1024 samples or 5.0µs.

<CyclicPrefix> (upstream)

S96
Useful symbol period starts after 96 samples or 0.9375 µs.

S128
Useful symbol period starts after 128 samples or 1.25 µs.

S160
Useful symbol period starts after 160 samples or 1.5625 µs.

S192
Useful symbol period starts after 192 samples or 0.9375µs.

S224
Useful symbol period starts after 224 samples or 1.875 µs.

S256
Useful symbol period starts after 256 samples or 2.5µs.

S288
Useful symbol period starts after 288 samples or 2.8125 µs.

S320
Useful symbol period starts after 320 samples or 3.125 µs.

S384
Useful symbol period starts after 384 samples or 3.75 µs.

S512
Useful symbol period starts after 512 samples or 5.0µs.

S640
Useful symbol period starts after 640 samples or 6.25 µs.

Usage: Query only

Manual operation: See "Cyclic Prefix CP" on page 69

FETCh:SCDetailed:ALL:FORMatted?

This command returns the following detailed signal content values as a comma-separated list:

`<CW_INDEX>,<SYMBOL_START>,<OBJECT>,<MODULATION>,<MER>,<POWER>,<SUBCARRIERS>,<LDPC_ITER>,<BER_PRE>,<BER_PRE_N>,<BER_POST>,<BER_POST_N>,<CWERR_POST>,<CWERR_POST_N>,<RESERVED_1>,<RESERVED_2>,<RESERVED_3>,<RESERVED_4>,`

In the first rows, the information is provided for the following objects in the specified order:

Downstream:

- Scattered Pilots
- Continuous Pilots
- PLC preamble
- PLC data
- Excluded subcarriers

Upstream:

- Pilots
- Excluded subcarriers

Then, the information for each symbol in the order of the logical subcarriers is provided, with one row each for:

Downstream:

- NCPs
- Codewords

Upstream:

- Minislot sets

Tip: The `FETCh:SCSummary:ALL?` command returns the summarized information for the NCPs and codewords contained in the (downstream) input signal.

For details on individual parameters see Chapter 3.1.2, "Signal Content Information", on page 15.

Return values:

<CW_Index>	integer (0..1535) | nan Codeword index Not available (nan) for PLC, pilots and excluded subcarriers
<SymStart>	integer (0..127) | nan OFDM symbol Not available (nan) for PLC, pilots and excluded subcarriers

<Object>	Information type **nan** Invalid data **PIL** Pilots **PLCP** PLC Preamble (downstream only) **PLCD** PLC Data (downstream only) **EXCL** Excluded subcarrier **NCPCWA | ... | NCPCWP** NCP Codeword A...P (downstream only) **NCPC24** NCP CRC-24 (downstream only) **NCPN** NCP Null (downstream only) **CWA | ... | CWP** Codeword A .. P (downstream only) **CW** Codeword (upstream only) minislot set **CPIL** Compl. pilot (upstream only) **SPIL** Scattered pilots **CONP** Contiuous pilots
<Modulation>	BPSK | QPSK | QAM16 | QAM64 | QAM128 | QAM256 | QAM512 | QAM1024 | QAM2048 | QAM4096 | QAM8192 | QAM16384 | NONE | MIXED Modulation (see "Modulation" on page 65)
<MER>	Modulation error ratio in dB
<Power>	Power in dBm

<Subcarrier>	integer (0 .. 3800 | 0 .. 7600) Number of subcarrier (Not available (nan) for pilots and compl. pilots)
<LDPC_ITER>	Low density parity check - Number of iterations (Not available (nan) for upstream)
<BER_PRE>	Low density parity check - Absolute number of bit errors before decoding (Not available (nan) for upstream)
<BER_PRE_N>	Low density parity check - Bit error ratio before decoding (the ratio of errored bits to the total number of transmitted bits) (Not available (nan) for upstream)
<BER_POST>	Low density parity check - Absolute number of bit errors after decoding (Not available (nan) for upstream)
<BER_POST_N>	Low density parity check - Bit error rate after decoding (the ratio of falsely decoded bits to the total number of transmitted bits) (Not available (nan) for upstream)
<CWERR_POST>	Low density parity check - Absolute number of codeword errors after decoding (Not available (nan) for upstream)
<CWERR_POST_N>	Low density parity check - Block error rate after decoding (the ratio of falsely decoded codewords to the total number of transmitted codewords) (Not available (nan) for upstream)
<RESERVED_1> | <RESERVED_2> | <RESERVED_3> | <RESERVED_4>	nan Currently not used.

Example: `FETC:SCD:ALL:FORM?`
Result: see Table 10-4

Usage: Query only

Manual operation: See "Signal Content Detailed" on page 27

Table 10-4: Sample result for FETC:SCD:ALL:FORM? for downstream signal

nan,nan,PIL,BPSK,53.1588020325,-34.8106689453,nan,nan,nan,nan,nan,nan,nan,nan,nan,nan,nan,nan,
nan,nan,PLCP,BPSK,52.8738098145,-40.8754196167,nan,nan,nan,nan,nan,nan,nan,nan,nan,nan,nan,nan,
nan,nan,PLCD,QAM16,53.4272041321,-40.8166618347,nan,nan,0,0,nan,nan,0,0,nan,nan,nan,nan,
0,0,NCPCWC,QAM16,53.4041290283,-41.4880905151,12,1,0,0,nan,nan,0,0,nan,nan,nan,nan,
1,0,NCPCWC,QAM16,52.8550567627,-39.9809684753,12,2,0,0,nan,nan,0,0,nan,nan,nan,nan,
2,0,NCPCWA,QAM16,53.2005882263,-41.4098701477,12,2,0,0,nan,nan,0,0,nan,nan,nan,nan,
0,0,NCPC24,QAM16,52.7113189697,-40.9022140503,12,2,0,0,nan,nan,0,0,nan,nan,nan,nan,
0,0,CWC,QAM1024,53.3149108887,-40.9032096863,1620,0,0,0,0,0,0,0,nan,nan,nan,nan,
1,0,CWC,QAM1024,53.2711219788,-40.9649543762,1620,0,0,0,0,0,0,0,nan,nan,nan,nan,
2,0,CWA,QAM64,53.330871582,-40.7523536682,2700,0,0,0,0,0,0,0,nan,nan,nan,nan,
3,1,NCPCWD,QAM16,52.2366638184,-41.4213371277,12,2,0,0,nan,nan,0,0,nan,nan,nan,nan,
4,1,NCPCWD,QAM16,54.4256401062,-38.9862823486,12,2,0,0,nan,nan,0,0,nan,nan,nan,nan,
1,1,NCPC24,QAM16,51.8807907104,-40.8682556152,12,2,0,0,nan,nan,0,0,nan,nan,nan,nan,
3,1,CWD,QAM4096,53.1613197327,-41.0502662659,1350,0,0,0,0,0,0,0,nan,nan,nan,nan,
4,1,CWD,QAM4096,53.3801498413,-40.8685874939,1350,0,0,0,0,0,0,0,nan,nan,nan,nan,

Table 10-5: Sample result for FETC:SCD:ALL:FORM? for upstream signal

nan,nan,PIL,BPSK,32.7226867676,-53.2162704468,nan,nan,nan,nan,nan,nan,nan,nan,nan,nan,nan,nan,
0,0,CW,QPSK,5.97550678253,-53.2792778015,10,nan,nan,nan,nan,nan,nan,nan,nan,nan,nan,nan,
0,nan,CPIL,BPSK,2.58250331879,-53.2162590027,nan,nan,nan,nan,nan,nan,nan,nan,nan,nan,nan,nan

FETCh:SCSummary:ALL?

This command returns the following summarized signal content values for all codewords as a comma-separated list:

<OBJECT>,<MODULATION>,<MER>,<OBJECT_COUNT>,<BER_PRE>,
<BER_PRE_N>,<BER_POST>,<BER_POST_N>,<CWERR_POST>,<CWERR_POST_N>,

Note: this command is not available for upstream measurements!

For details on individual parameters see Chapter 3.1.2, "Signal Content Information", on page 15.

The information is provided for the following data elements in the stated order:

- Pilots
- PLC Preamble
- PLC Data
- NCPs (all)
- Profile A
- ...
- Profile P

Return values:

<Object> Information type

nan
Invalid data

PIL
Pilots

PLCP
PLC Preamble

PLCD
PLC Data

EXCL
Excluded subcarrier

NCPA
NCP All (all codewords)

PROFA | ... | PROFP
Profile A to P

<Modulation> BPSK | QPSK | QAM16 | QAM64 | QAM128 | QAM256 | QAM512 | QAM1024 | QAM2048 | QAM4096 | QAM8192 | QAM16384 | NONE | MIXED

Modulation (see "Modulation" on page 65)

<MER> Modulation error ratio in dB

<NoObject> Total number of data elements (PLC preambles, PLC data objects, NCPs, or codewords in the profile)

<LDPC_ITER> Low density parity check - Number of iterations

<BER_PRE> Low density parity check - Absolute number of bit errors before decoding

<BER_PRE_N> Low density parity check - Bit error ratio before decoding (the ratio of errored bits to the total number of transmitted bits)

<BER_POST> Low density parity check - Absolute number of bit errors after decoding

<BER_POST_N> Low density parity check - Bit error rate after decoding (the ratio of falsely decoded bits to the total number of transmitted bits)

<CWERR_POST> Low density parity check - Absolute number of codeword errors after decoding

<CWERR_POST_N> Low density parity check - Block error rate after decoding (the ratio of falsely decoded codewords to the total number of transmitted codewords)

Example: `FETC:SCS:ALL?`

Result:

```
PIL,BPSK,53.1570854187,nan,nan,nan,nan,nan,nan,nan,
PLCP,BPSK,52.8738098145,1,nan,nan,nan,nan,nan,nan,
PLCD,QAM16,53.4272041321,1,0,0,nan,nan,0,0,
NCPA,QAM16,53.28358078,387,0,0,nan,nan,0,0,
PROFA,QAM64,53.2824478149,67,0,0,0,0,0,0,
PROFB,QAM1024,53.3110733032,59,0,0,0,0,0,0,
PROFC,QAM1024,53.315738678,63,0,0,0,0,0,0,
PROFD,QAM4096,53.2790908813,64,0,0,0,0,0,0
```

Usage: Query only

Manual operation: See "Signal Content Summary" on page 28

FETCh:SUMMary:ALL?

This command returns all result summary values as a comma-separated list in the order they are displayed in the result display. For details see Chapter 3.1.1, "Modulation Accuracy Parameters", on page 13.

Return values:

<ResultDownstr>
<MER_DATA_+_Pilot_MEAN/MAX/LIM/MIN>,
<MER_DATA_MEAN/MAX/LIM/MIN>,
<MER_PILOT_MEAN/MAX/LIM/MIN>,
<CF_ERROR_MEAN/MAX/LIM/MIN>,
<SYM_CLOCK_ERR_MEAN/MAX/LIM/MIN>,
<TRIG_TO_PLC_TIMESTAMP_REF_MEAN/MAX/LIM/MIN>,
<POWER-ALL_MEAN/MAX/LIM/MIN>,
<POWER_PLC_MEAN/MAX/LIM/MIN>,
<POWER_DATA_MEAN/MAX/LIM/MIN>,
<POWER_SCAT_PIL_MEAN/MAX/LIM/MIN>,
<POWER_CONT_PIL_MEAN/MAX/LIM/MIN>,
<ZERO_BIT_CARR_RATIO_MEAN/MAX/LIM/MIN>

<ResultUpstr>
<MER_DATA_+_Pilot_MEAN/MAX/LIM/MIN>,
<MER_DATA_MEAN/MAX/LIM/MIN>,
<MER_PILOT_MEAN/MAX/LIM/MIN>,
<CF_ERROR_MEAN/MAX/LIM/MIN>,
<SYM_CLOCK_ERR_MEAN/MAX/LIM/MIN>,
<TRIG_TO_FRAME_MEAN/MAX/LIM/MIN>,
<POWER_ALL_MEAN/MAX/LIM/MIN>,
<POWER_PLC_MEAN/MAX/LIM/MIN>,
<POWER_DATA_MEAN/MAX/LIM/MIN>,
<POWER_PIL_MEAN/MAX/LIM/MIN>

Example:

```
FETC:SUMM:ALL?
//Result downstream:
96.1896514893,96.1896514893,nan,96.1896514893,
96.8796691895,96.8796691895,nan,96.8796691895,
96.0657196045,96.0657196045,nan,96.0657196045,
-0.00001588321,-0.00001588321,nan,-0.00001588321,
0.00000242496,0.00000242496,nan,0.00000242496,
0.00260711415,nan,nan,nan,
-23.3121681213,-23.3121681213,nan,-23.3121681213,
-37.5809326172,-37.5809326172,nan,-37.5809326172,
0,0,nan,0,
6.0314707756,6.0314707756,nan,6.0314707756,
6.0314707756,6.0314707756,nan,6.0314707756,
nan,nan,nan,nan
```

Example:

```
FETC:SUMM:ALL?
//Result upstream:
96.1896514893,96.1896514893,nan,96.1896514893,
96.8796691895,96.8796691895,nan,96.8796691895,
96.0657196045,96.0657196045,nan,96.0657196045,
-0.00001588321,-0.00001588321,nan,-0.00001588321,
0.00000242496,0.00000242496,nan,0.00000242496,
0.00260586431,nan,nan,nan,
-23.3121681213,-23.3121681213,nan,-23.3121681213,
0,0,nan,0,
6.0314707756,6.0314707756,nan,6.0314707756
```

Usage: Query only

Manual operation: See "Result Summary" on page 26

FETCh:SUMMary:CERRor[:AVERage]?
FETCh:SUMMary:CERRor:MAXimum?
FETCh:SUMMary:CERRor:MINimum?
FETCh:SUMMary:FERRor[:AVERage]?
FETCh:SUMMary:FERRor:MAXimum?
FETCh:SUMMary:FERRor:MINimum?
FETCh:SUMMary:MER[:AVERage]?
FETCh:SUMMary:MER:MAXimum?
FETCh:SUMMary:MER:MINimum?
FETCh:SUMMary:MERData[:AVERage]?
FETCh:SUMMary:MERData:MAXimum?
FETCh:SUMMary:MERData:MINimum?
FETCh:SUMMary:MERPilot[:AVERage]?
FETCh:SUMMary:MERPilot:MAXimum?
FETCh:SUMMary:MERPilot:MINimum?
FETCh:SUMMary:PERRor[:AVERage]?
FETCh:SUMMary:PERRor:MAXimum?
FETCh:SUMMary:PERRor:MINimum?
FETCh:SUMMary:POWer[:AVERage]?

FETCh:SUMMary:POWer:MAXimum?
FETCh:SUMMary:POWer:MINimum?
FETCh:SUMMary:POWer:CONPilots:MAXimum?
FETCh:SUMMary:POWer:CONPilots:MINimum?
FETCh:SUMMary:POWer:CONPilots[:AVERage]?
FETCh:SUMMary:POWer:DATA:MAXimum?
FETCh:SUMMary:POWer:DATA:MINimum?
FETCh:SUMMary:POWer:DATA[:AVERage]?
FETCh:SUMMary:POWer:PILots:MAXimum?
FETCh:SUMMary:POWer:PILots:MINimum?
FETCh:SUMMary:POWer:PILots[:AVERage]?
FETCh:SUMMary:POWer:SPILots:MAXimum?
FETCh:SUMMary:POWer:SPILots:MINimum?
FETCh:SUMMary:POWer:SPILots[:AVERage]?
FETCh:SUMMary:POWer:SPLC:MAXimum?
FETCh:SUMMary:POWer:SPLC:MINimum?
FETCh:SUMMary:POWer:SPLC[:AVERage]?
FETCh:SUMMary:TFRame[:AVERage]?
FETCh:SUMMary:TFRame:MAXimum?
FETCh:SUMMary:TFRame:MINimum?
FETCh:SUMMary:TPLC[:AVERage]?
FETCh:SUMMary:TPLC:MAXimum?
FETCh:SUMMary:TPLC:MINimum?
FETCh:SUMMary:ZBIT[:AVERage]?
FETCh:SUMMary:ZBIT:MAXimum?
FETCh:SUMMary:ZBIT:MINimum?
FETCh:SUMMary:<parameter>:AVERage|MAXimum|MINimum?

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 3-1.

Example: `FETC:SUMM:MER:MAX?`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Usage: Query only

10.9.1.3 Querying Limits

The following commands are required to query the limits against which the individual parameter results are checked. The limits are defined in the DOCSIS 3.1 standard.

CALCulate<n>:LIMit:SUMMary:CERRor[:AVERage]? 264
CALCulate<n>:LIMit:SUMMary:CERRor:MAXimum? 264
CALCulate<n>:LIMit:SUMMary:FERRor[:AVERage]? 264
CALCulate<n>:LIMit:SUMMary:FERRor:MAXimum? 264
CALCulate<n>:LIMit:SUMMary:MER[:MINimum]? 264
CALCulate<n>:LIMit:SUMMary:MERData[:MINimum]? 264
CALCulate<n>:LIMit:SUMMary:MERPilot[:MINimum]? 265

CALCulate<n>:LIMit:SUMMary:CERRor[:AVERage]?
CALCulate<n>:LIMit:SUMMary:CERRor:MAXimum?

This command queries the average or maximum sample/symbol clock error limit for all frames as determined by the default DOCSIS 3.1 measurement.

Suffix:
<n> irrelevant

Return values:
<Value> Default unit: ppm

Example: `CALC:LIM:SUMM:CERR:MAX?`

Usage: Query only

CALCulate<n>:LIMit:SUMMary:FERRor[:AVERage]?
CALCulate<n>:LIMit:SUMMary:FERRor:MAXimum?

This command queries the average or maximum center frequency error limit for all frames as determined by the default DOCSIS 3.1 measurement.

Suffix:
<n> irrelevant

Return values:
<Value> Default unit: Hz

Example: `CALC:LIM:SUMM:FERR:MAX?`

Usage: Query only

CALCulate<n>:LIMit:SUMMary:MER[:MINimum]?

This command queries the minimum modulation error ratio (MER) limit for all data + pilot carriers as determined by the default DOCSIS 3.1 measurement.

Suffix:
<n>, <k> irrelevant

Return values:
<Value> Default unit: dB

Example: `CALC:LIM:SUMM:MER:MIN?`

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Usage: Query only

CALCulate<n>:LIMit:SUMMary:MERData[:MINimum]?

This command queries the minimum modulation error ratio (MER) limit for all data carriers as determined by the default DOCSIS 3.1 measurement.

Suffix:

<n> irrelevant

Return values:

<Value> Default unit: dB

Example: `CALC:LIM:SUMM:MERD:MIN?`

Usage: Query only

CALCulate<n>:LIMit:SUMMary:MERPilot[:MINimum]?

This command queries the minimum modulation error ratio (MER) limit for all pilots as determined by the default DOCSIS 3.1 measurement.

Suffix:

<n> irrelevant

Return values:

<Value> Default unit: dB

Example: `CALC:LIM:SUMM:MERP:MIN?`

Usage: Query only

10.9.1.4 Limit Check Results

The following commands are required to query the results of the limit checks.

CALCulate<n>:LIMit:SUMMary:CERRor:MAXimum:RESult? ... 265
CALCulate<n>:LIMit:SUMMary:CERRor[:AVERage]:RESult? ... 265
CALCulate<n>:LIMit:SUMMary:FERRor:MAXimum:RESult? ... 265
CALCulate<n>:LIMit:SUMMary:FERRor[:AVERage]:RESult? ... 265
CALCulate<n>:LIMit:SUMMary:MER[:MINimum]:RESult? ... 265
CALCulate<n>:LIMit:SUMMary:MERData[:MINimum]:RESult? ... 265
CALCulate<n>:LIMit:SUMMary:MERPilot[:MINimum]:RESult? ... 265

CALCulate<n>:LIMit:SUMMary:CERRor:MAXimum:RESult?
CALCulate<n>:LIMit:SUMMary:CERRor[:AVERage]:RESult?
CALCulate<n>:LIMit:SUMMary:FERRor:MAXimum:RESult?
CALCulate<n>:LIMit:SUMMary:FERRor[:AVERage]:RESult?
CALCulate<n>:LIMit:SUMMary:MER[:MINimum]:RESult?
CALCulate<n>:LIMit:SUMMary:MERData[:MINimum]:RESult?
CALCulate<n>:LIMit:SUMMary:MERPilot[:MINimum]:RESult?

This command returns the result of the limit check for the specified parameter. The limit value is defined by the DOCSIS 3.1 standard (see Chapter 10.9.1.3, "Querying Limits", on page 263).

For details and an assignment of the parameters to the keywords see Table 3-1.

Suffix:

<n> irrelevant

Return values:

<LimitCheck>

PASS
The defined limit for the parameter was not exceeded.

FAILED
The defined limit for the parameter was exceeded.

Example: `CALC:LIM:SUMM:MERP:MIN:RES?`

Usage: Query only

10.9.2 Numeric Results for Frequency Sweep Measurements

The following commands are required to retrieve the numeric results of the DOCSIS 3.1 frequency sweep measurements (see Chapter 3.2, "Frequency Sweep Measurements", on page 29.

In the following commands used to retrieve the numeric results for RF data, the suffixes <n> for CALCulate and <k> for LIMit are irrelevant.

CALCulate<n>:LIMit<k>:FAIL?........266
CALCulate<n>:MARKer<m>:FUNCtion:POWer:RESult?........267
CALCulate<n>:MARKer<m>:X........267
CALCulate<n>:STATistics:RESult<t>?........267

CALCulate<n>:LIMit<k>:FAIL?

This command queries the result of a limit check in the specified window.

To get a valid result, you have to perform a complete measurement with synchronization to the end of the measurement before reading out the result. This is only possible for single measurement mode.

See also `INITiate<n>:CONTinuous` on page 246.

Suffix:

<n> Window

<k> Limit line

Return values:

<Result>

0
PASS

1
FAIL

Example: `INIT;*WAI`
Starts a new sweep and waits for its end.
`CALC2:LIM3:FAIL?`
Queries the result of the check for limit line 3 in window 2.

Usage: Query only
SCPI confirmed

CALCulate<n>:MARKer<m>:FUNCtion:POWer:RESult? <MeasType>

This command queries the results of power measurements.

Suffix:
<n>, <m> irrelevant

Query parameters:
<MeasType> **OBANdwidth | OBWidth**
Occupied bandwidth.
Returns the occupied bandwidth in Hz.

Example: `CALC:MARK:FUNC:POW:RES?`

Example: For a detailed example see Chapter 10.13.2, "Measurement 2: Determining the Occupied Bandwidth", on page 291

Usage: Query only

Manual operation: See "Occupied Bandwidth" on page 29

CALCulate<n>:MARKer<m>:X <Position>

This command moves a marker to a particular coordinate on the x-axis.

If necessary, the command activates the marker.

If the marker has been used as a delta marker, the command turns it into a normal marker.

Suffix:
<m> Marker (query: 1 to 16)

<n> Window

Parameters:
<Position> Numeric value that defines the marker position on the x-axis.
Range: The range depends on the current x-axis range.

Example: `CALC:MARK2:X 1.7MHz`
Positions marker 2 to frequency 1.7 MHz.

Manual operation: See "Marker Table" on page 21
See "Marker Peak List" on page 32
See "X-value" on page 131

CALCulate<n>:STATistics:RESult<t>? <ResultType>

This command queries the results of a CCDF or ADP measurement for a specific trace.

Suffix:
<n> irrelevant

<t> Trace

Parameters:

<ResultType>

MEAN
Average (=RMS) power in dBm measured during the measurement time.

PEAK
Peak power in dBm measured during the measurement time.

CFACtor
Determined crest factor (= ratio of peak power to average power) in dB.

ALL
Results of all three measurements mentioned before, separated by commas: <mean power>,<peak power>,<crest factor>

Example: `CALC:STAT:RES2? ALL`
Reads out the three measurement results of trace 2. Example of answer string: 5.56,19.25,13.69 i.e. mean power: 5.56 dBm, peak power 19.25 dBm, crest factor 13.69 dB

Usage: Query only

Manual operation: See "CCDF" on page 30

10.9.3 Retrieving Trace Results

The following commands describe how to retrieve the trace data from the DOCSIS 3.1 I/Q measurement (Modulation Accuracy).

The traces for frequency sweep measurements are identical to those in the Spectrum application.

FORMat[:DATA]......268
TRACe<n>[:DATA]?......269
TRACe<n>[:DATA]:X?......270
TRACe:IQ:DATA:MEMory......270

FORMat[:DATA] <Format>

This command selects the data format that is used for transmission of trace data from the R&S FSW to the controlling computer.

Note that the command has no effect for data that you send to the R&S FSW. The R&S FSW automatically recognizes the data it receives, regardless of the format.

Parameters:

<Format>

ASCii
ASCii format, separated by commas.
This format is almost always suitable, regardless of the actual data format. However, the data is not as compact as other formats may be.

REAL,32
32-bit IEEE 754 floating-point numbers in the "definite length block format".
In the Spectrum application, the format setting `REAL` is used for the binary transmission of trace data.
For I/Q data, 8 bytes per sample are returned for this format setting.

*RST: ASCII

Example: `FORM REAL,32`

Usage: SCPI confirmed

TRACe<n>[:DATA]? <ResultType>

This command queries current trace data and measurement results from the selected window.

For details see Chapter 10.9.4, "Measurement Results for TRACe<n>[:DATA]? TRACE<n>", on page 271.

Query parameters:

<ResultType> Selects the type of result to be returned.

TRACE1 | ... | TRACE6
Returns the trace data for the corresponding trace.
For most DOCSIS 3.1 I/Q measurements, only TRACE1 is available (unless specified otherwise in Chapter 10.9.4, "Measurement Results for TRACe<n>[:DATA]? TRACE<n>", on page 271).

Return values:

<TraceData> For I/Q data traces, the results depend on the evaluation method (window type) selected for the current window (see `LAYout:ADD[:WINDow]?` on page 227. The results for the various window types are described in Chapter 10.9.4, "Measurement Results for TRACe<n>[:DATA]? TRACE<n>", on page 271.
For RF data traces, the trace data consists of a list of 1001 power levels that have been measured. The unit depends on the measurement and on the unit you have currently set.

Example:
```
DISP:WIND2:SEL
TRAC? TRACE3
```
Queries the data of trace 3 in window 2.

Example: For a detailed example see Chapter 10.13.1, "Measurement 1: Measuring Modulation Accuracy", on page 287.

Usage: Query only

Manual operation: See "Constellation" on page 19
See "Group Delay" on page 20
See "Magnitude Capture" on page 20
See "MER vs Carrier" on page 21
See "MER vs Minislot (upstream only)" on page 22
See "MER vs Symbol" on page 23
See "MER vs Symbol X Carrier" on page 23
See "Phase vs Carrier" on page 24
See "Power vs Carrier (upstream only)" on page 24
See "Power vs Symbol X Carrier" on page 25
See "Power Spectrum" on page 26
See "Spectrum Flatness" on page 28

TRACe<n>[:DATA]:X? <TraceNumber>

This command queries the horizontal trace data for each sweep point in the specified window, for example the frequency in frequency domain or the time in time domain measurements.

Suffix:
<n> Window

Query parameters:
<TraceNumber> Trace number.

Example: `TRAC3:X? TRACE1`
Returns the x-values for trace 1 in window 3.

Usage: Query only

TRACe:IQ:DATA:MEMory <OffsetSamp>, <NumSamples>

Returns all the I/Q trace data in the capture buffer. The result values are scaled in Volts. The command returns a comma-separated list of the measured voltage values in floating point format (Comma Separated Values = CSV). The number of values returned is 2 * the number of complex samples, the first half being the I values, the second half the Q values.

Parameters:
<OffsetSamp> Offset of the values to be read related to the start of the capture buffer.
Range: 0 to (<NumSamples>-1)

<NumSamples> Number of measurement values to be read.
Range: 1 to (<NumSamples>-<OffsetSa>)

10.9.4 Measurement Results for TRACe<n>[:DATA]? TRACE<n>

The evaluation method selected by the LAY:ADD:WIND command also affects the results of the trace data query (see TRACe<n>[:DATA]? TRACE<n>).

Details on the returned trace data depending on the evaluation method are provided here.

All graphical results are based on a single frame only, namely the currently selected one (see [SENSe:]FRAMe:SELect on page 222).

No trace data is available for the following numeric evaluation methods:

- Bitstream
- Signal Content Detail
- Result Summary (Global/Detailed)

For details on the graphical results of these evaluation methods, see Chapter 3.1.3, "Evaluation Methods for DOCSIS 3.1 I/Q Measurements", on page 17.

- Constellation ... 271
- Group Delay ... 272
- Magnitude Capture ... 272
- MER vs Carrier ... 272
- MER vs Minislot (Upstream only) ... 273
- MER vs Symbol ... 273
- MER vs Symbol X Carrier ... 273
- Phase vs Carrier ... 273
- Power vs Carrier (Upstream only) ... 273
- Power vs Symbol X Carrier ... 273
- Power Spectrum ... 274
- Spectrum Flatness ... 274
- CCDF – Complementary Cumulative Distribution Function ... 274

10.9.4.1 Constellation

This measurement represents the complex constellation points *for the currently selected frame* as I and Q data. Each I and Q point is returned in floating point format.

Data is returned as a repeating array of interleaved I and Q data in groups of selected carriers per OFDM-Symbol, until all the I and Q data for the analyzed OFDM-Symbols is exhausted.

The following selections are possible:

- **All symbols** ([SENS:]SYMB:SELect ALL, see [SENSe:]SYMBol:SELect on page 236)**+ all subcarriers** ([SENS:]SUBC:SEL ALL[SENSe:]SUBCarrier:SELect on page 236
  Number of subcarriers (N_{FFT}) pairs of I and Q data per OFDM-Symbol:
  OFDM-Symbol 0: ($I_{0,0}$, $Q_{0,0}$), ($I_{0,1}$,$Q_{0,1}$),…,($I_{0,Nfft-1}$, $Q_{0,Nfft-1}$)
  OFDM-Symbol 1: ($I_{1,1}$, $Q_{1,1}$), ($I_{1,2}$,$Q_{1,2}$), …,($I_{1,Nfft-1}$, $Q_{1,Nfft-1}$)

…
OFDM-Symbol 127:
$(I_{127,0}, Q_{127,0}), (I_{127,1},Q_{127,1}),\ldots,(I_{127,Nfft-1}, Q_{127,Nfft-1})$

- **One symbol only** ([SENS:]SYMB:SEL <x>, see [SENSe:]SYMBol:SELect on page 236) **+ all subcarriers** ([SENS:]SUBC:SEL ALL [SENSe:]SUBCarrier:SELect on page 236
  Number of subcarriers (N_{FFT}) pairs of I and Q data for selected OFDM-Symbol x:
  $(I_{x,0}, Q_{x,0}), (I_{x,1},Q_{x,1}), \ldots,(I_{x,Nfft-1}, Q_{x,Nfft-1})$
- **All symbols** ([SENS:]SYMB:SELect ALL, see [SENSe:]SYMBol:SELect on page 236) **+ one subcarrier** ([SENS:]SUBC:SEL <y> [SENSe:]SUBCarrier:SELect on page 236
  One pair of I and Q data (for subcarrier y) per OFDM-Symbol:
  OFDM-Symbol 0: $(I_{0,y}, Q_{0,y})$
  OFDM-Symbol 1: $(I_{1,y}, Q_{1,y})$
  …
  OFDM-Symbol 127:
  $(I_{127,y}, Q_{127,y})$
- **One symbol only** ([SENS:]SYMB:SEL <x>, see [SENSe:]SYMBol:SELect on page 236) **+ one subcarrier** ([SENS:]SUBC:SEL <y> [SENSe:]SUBCarrier:SELect on page 236
  One pair of I and Q data for subcarrier y and selected OFDM-Symbol x:
  $(I_{x,y}, Q_{x,y})$

10.9.4.2 Group Delay

Returns one time deviation value per subcarrier (=N_{FFT} values) *for the currently selected frame*.

10.9.4.3 Magnitude Capture

Returns the magnitude for each measurement point in all measurements (not only the current capture buffer). The number of measurement points depends on the input sample rate and the capture time (see "Number of Samples" on page 103), as well as the Frame Statistic Count / Number of Frames to Analyze.

10.9.4.4 MER vs Carrier

Returns one modulation error ratio (in dB or %) per carrier (=N_{FFT} values), statistically evaluated over *the number of frames to anayze* (see [SENSe:]FRAMe:COUNt on page 222 and [SENSe:]FRAMe:COUNt:STATe on page 222).

Depending on the query parameter, following results are provided:

Query parameter	Result
<TRACe1>	Minimum
<TRACe2>	Average
<TRACe3>	Maximum

10.9.4.5 MER vs Minislot (Upstream only)

Returns one modulation error ratio (in dB or %) per minislot (= 237 values) *for the currently selected frame*.

Unconfigured minislots (for the upstream signal) return `NAN`.

10.9.4.6 MER vs Symbol

Returns one modulation error ratio (in dB or %) per symbol (=128 values) *for the currently selected frame*.

10.9.4.7 MER vs Symbol X Carrier

Returns the modulation error ratio (in dB or %) for each subcarrier for one symbol at a time (= 128 * N_{FFT} values) *for the currently selected frame*.

$MER_{(0,1)}$, $MER_{(0,2)}$, $MER_{(0,3)}$, ..., $MER_{(0,Nfft-1)}$,

...

$MER_{(127,1)}$, $MER_{(127,2)}$, $MER_{(127,3)}$, ..., $MER_{(127,Nfft-1)}$,

10.9.4.8 Phase vs Carrier

Returns one phase value (in ° or rad) per carrier (=N_{FFT} values) *for the currently selected frame*.

10.9.4.9 Power vs Carrier (Upstream only)

Returns one power value per carrier (=N_{FFT} values) *for the currently selected frame*.

The power unit depends on the `CALCulate<n>:UNIT:POWer` setting.

10.9.4.10 Power vs Symbol X Carrier

Returns the power value for each subcarrier for one symbol at a time (= 128 * N_{FFT} values) *for the currently selected frame*.

The power unit depends on the `CALCulate<n>:UNIT:POWer` setting.

$P_{(0,1)}$, $P_{(0,2)}$, $P_{(0,3)}$, ..., $P_{(0,Nfft-1)}$,

...

$P_{(127,1)}$, $P_{(127,2)}$, $P_{(127,3)}$, ..., $P_{(127,Nfft-1)}$,

10.9.4.11 Power Spectrum

Returns one power density value (in power/Hz) for each subcarrier (=N_{FFT} values) *for the currently selected frame*.

The power unit depends on the CALCulate<n>:UNIT:POWer setting.

10.9.4.12 Spectrum Flatness

The spectrum flatness evaluation returns one relative power value (in dB) per subcarrier (=N_{FFT} values) *for the currently selected frame*.

Supported data formats (FORMat:DATA): ASCii|REAL

10.9.4.13 CCDF – Complementary Cumulative Distribution Function

The length of the results varies; up to a maximum of 201 data points is returned, following a data count value. The first value in the return data represents the quantity of probability values that follow. Each of the potential 201 data points is returned as a probability value and represents the total number of samples that are equal to or exceed the current mean power level.

Probability data is returned up to the power level that contains at least one sample. It is highly unlikely that the full 201 data values will ever be returned.

Each probability value is returned as a floating point number, with a value between 0 and 1.

The syntax of the result is thus:

N, CCDF(0), CCDF(1/10), CCDF(2/10), …, CCDF((N-1)/10)

10.9.5 Importing and Exporting I/Q Data and Results

The I/Q data to be evaluated in the R&S FSW DOCSIS 3.1 application can not only be measured by the R&S FSW DOCSIS 3.1 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 DOCSIS 3.1 application can be exported for further analysis in external applications.

For details on importing and exporting I/Q data see the R&S FSW User Manual.

MMEMory:LOAD:IQ:STATe.. 275
MMEMory:STORe<n>:IQ:STATe...275

MMEMory:LOAD:IQ:STATe 1,<FileName>

This command restores I/Q data from a file.

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

Example: Loads IQ data from the specified file.

Usage: Setting only

MMEMory:STORe<n>:IQ:STATe 1, <FileName>

This command writes the captured I/Q data to a file.

The file extension is *.iq.tar. By default, the contents of the file are in 32-bit floating point format.

Secure User Mode

In secure user mode, settings that are stored on the instrument are stored to volatile memory, which is restricted to 256 MB. Thus, a "Memory full" error can occur although the hard disk indicates that storage space is still available.

To store data permanently, select an external storage location such as a USB memory device.

For details, see "Protecting Data Using the Secure User Mode" in the "Data Management" section of the R&S FSW User Manual.

Suffix:
<n> irrelevant

Parameters:
1

<FileName> String containing the path and name of the target file.

Example:
```
MMEM:STOR:IQ:STAT 1, 'C:
\R_S\Instr\user\data.iq.tar'
```
Stores the captured I/Q data to the specified file.

10.10 Analysis

The following commands define general result analysis settings concerning the traces and markers in standard DOCSIS 3.1 measurements. Currently, only one (Clear/Write) trace and one marker are available for standard DOCSIS 3.1 measurements.

Analysis for RF measurements

General result analysis settings concerning the trace, markers, lines etc. for RF measurements are identical to the analysis functions in the Spectrum application except for some special marker functions and spectrograms, which are not available in the R&S FSW DOCSIS 3.1 application.

For details see the "General Measurement Analysis and Display" chapter in the R&S FSW User Manual.

- Markers....................276
- Trace Export....................280

10.10.1 Markers

Markers help you analyze your measurement results by determining particular values in the diagram. Currently, only 1 marker per window can be configured for standard DOCSIS 3.1 measurements.

CALCulate<n>:DELTamarker<m>:MREF....................276
CALCulate<n>:DELTamarker<m>[:STATe]....................276
CALCulate<n>:DELTamarker<m>:X....................277
CALCulate<n>:MARKer<m>:AOFF....................277
CALCulate<n>:MARKer<m>[:STATe]....................277
CALCulate<n>:MARKer<m>:TRACe....................278
CALCulate<n>:MARKer<m>:Y?....................278
CALCulate<n>:MARKer<m>:Y....................279
CALCulate<n>:MARKer<m>:Z?....................279
DISPlay:MTABle....................280

CALCulate<n>:DELTamarker<m>:MREF <Reference>

This command selects a reference marker for a delta marker other than marker 1.

Suffix:

<n> Window

<m> Marker

Parameters:

<Reference> **1 to 4**
Selects markers 1 to 4 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 132

CALCulate<n>:DELTamarker<m>[:STATe] <State>

This command 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

*RST: OFF

Example: `CALC:DELT2 ON`
Turns on delta marker 2.

Manual operation: See "Marker State" on page 131
See "Marker Type" on page 132

CALCulate<n>:DELTamarker<m>:X <Position>

This command 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:

<m> Marker

<n> Window

Example: `CALC:DELT:X?`
Outputs the absolute x-value of delta marker 1.

Manual operation: See "X-value" on page 131

CALCulate<n>:MARKer<m>:AOFF

This command turns all markers off.

Suffix:

<n> Window

<m> Marker

Example: `CALC:MARK:AOFF`
Switches off all markers.

Usage: Event

Manual operation: See "All Markers Off" on page 132

CALCulate<n>:MARKer<m>[:STATe] <State>

This command turns markers on and off. If the corresponding marker number is currently active as a deltamarker, it is turned into a normal marker.

Suffix:

<n> Window

<m> Marker

Parameters:

<State> ON | OFF

*RST: OFF

Example: `CALC:MARK3 ON`
Switches on marker 3.

Manual operation: See "Marker State" on page 131
See "Marker Type" on page 132

CALCulate<n>:MARKer<m>:TRACe <Trace>

This command 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: `CALC:MARK3:TRAC 2`
Assigns marker 3 to trace 2.

Manual operation: See "Assigning the Marker to a Trace" on page 132

CALCulate<n>:MARKer<m>:Y?

This command queries the position of a marker on the y-axis.

If necessary, the command activates the marker first.

To get a valid result, you have to perform a complete measurement with synchronization to the end of the measurement before reading out the result. This is only possible for single measurement mode.

See also `INITiate<n>:CONTinuous` on page 246.

Suffix:

<n> Window

<m> Marker

Return values:

<Result> Result at the marker position.

Example:
`INIT:CONT OFF`
Switches to single measurement mode.
`CALC:MARK2 ON`
Switches marker 2.
`INIT;*WAI`
Starts a measurement and waits for the end.
`CALC:MARK2:Y?`
Outputs the measured value of marker 2.

Usage: Query only

Manual operation:
See "Marker Table" on page 21
See "CCDF" on page 30
See "Marker Peak List" on page 32
See "Y-value" on page 131

CALCulate<n>:MARKer<m>:Y <Symbol>

This command defines the position of a marker on the y-axis (symbol) for 3-dimensional result displays (MER vs Symbol X Carrier, Power vs Symbol X Carrier).

To get a valid result, you have to perform a complete measurement with synchronization to the end of the measurement before reading out the result. This is only possible for single measurement mode.

See also `INITiate<n>:CONTinuous` on page 246.

Parameters:
<Symbol> Symbol at which the marker is placed.

Example: `CALC:MARK2:Y 20`

Manual operation: See "Y-value" on page 131

CALCulate<n>:MARKer<m>:Z?

This command queries the value of a marker in 3-dimensional result displays (MER vs Symbol X Carrier, Power vs Symbol X Carrier).

To get a valid result, you have to perform a complete measurement with synchronization to the end of the measurement before reading out the result. This is only possible for single measurement mode.

See also `INITiate<n>:CONTinuous` on page 246.

Suffix:
<n> Window

<m> Marker

Return values:
<Result> Result at the marker position (symbol, carrier).
For MER vs Symbol X Carrier: modulation error ratio (in dB or %)
For Power vs Symbol X Carrier: power value (in dBm)

Example: `CALC:MARK2:Z?`
Outputs the measured value of marker 2.

Usage: Query only

DISPlay:MTABle <DisplayMode>

This command turns the marker table on and off.

Parameters:

<DisplayMode>

ON
Turns the marker table on.

OFF
Turns the marker table off.

*RST: AUTO

Example: `DISP:MTAB ON`
Activates the marker table.

Manual operation: See "Marker Table Display" on page 133

10.10.2 Trace Export

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FORMat:DEXPort:HEADer....280
FORMat:DEXPort:TRACes....281
MMEMory:STORe<n>:TRACe....281

FORMat:DEXPort:DSEParator <Separator>

This command selects the decimal separator for data exported in ASCII format.

Parameters:

<Separator>

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 128

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

Usage: SCPI confirmed

Manual operation: See "Include Instrument Measurement Settings" on page 128

FORMat:DEXPort:TRACes <Selection>

This command selects the data to be included in a data export file (see `MMEMory:STORe<n>:TRACe` on page 281).

Parameters:

<Selection>

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

Usage: SCPI confirmed

Manual operation: See "Export all Traces and all Table Results" on page 128

MMEMory:STORe<n>:TRACe <Trace>, <FileName>

This command exports trace data from the specified window to an ASCII file.

Secure User Mode

In secure user mode, settings that are stored on the instrument are stored to volatile memory, which is restricted to 256 MB. Thus, a "Memory full" error can occur although the hard disk indicates that storage space is still available.

To store data permanently, select an external storage location such as a USB memory device.

For details, see "Protecting Data Using the Secure User Mode" in the "Data Management" section of the R&S FSW User Manual.

Suffix:

<n> 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 3,'C:\TEST.ASC'`
Stores trace 3 from window 1 in the file `TEST.ASC`.

Usage: SCPI confirmed

Manual operation: See "Export Trace to ASCII File" on page 129

10.11 Status Registers

The R&S FSW DOCSIS 3.1 application uses the standard status registers of the R&S FSW (depending on the measurement type). However, some registers are used differently. Only those differences are described in the following sections.

For details on the common R&S FSW status registers refer to the description of remote control basics in the R&S FSW User Manual.

*RST does not influence the status registers.

- The STATus:QUEStionable:SYNC Register..282
- Querying the Status Registers...283

10.11.1 The STATus:QUEStionable:SYNC Register

The `STATus:QUEStionable:SYNC` register contains application-specific information about synchronization errors or errors during pilot symbol detection. If any errors occur in this register, the status bit #11 in the `STATus:QUEStionable` register is set to 1.

Each active channel uses a separate `STATus:QUEStionable:SYNC` register. Thus, if the status bit #11 in the `STATus:QUEStionable` register indicates an error, the error may have occurred in any of the channel-specific `STATus:QUEStionable:SYNC` registers. In this case, you must check the register of each channel to determine which channel caused the error. By default, querying the status of a register always returns the result for the currently selected channel. However, you can specify any other channel name as a query parameter.

Table 10-6: Meaning of the bits used in the STATus:QUEStionable:SYNC register

Bit No.	Meaning
0	This bit is not used
1	BIT_SYNC_NOT_FOUND No frames could be detected due to failed synchronization.
2	BIT_DSP_ERROR Signal analysis failed due to a DSP error
3	Limit check failed

Bit No.	Meaning
4 - 14	These bits are not used.
15	This bit is always 0.

10.11.2 Querying the Status Registers

The following commands are required to query the status of the R&S FSW and the R&S FSW DOCSIS 3.1 application.

For details on the common R&S FSW status registers refer to the description of remote control basics in the R&S FSW User Manual.

- Chapter 10.11.1, "The STATus:QUEStionable:SYNC Register", on page 282

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- Reading Out the EVENt Part....284
- Reading Out the CONDition Part....284
- Controlling the ENABle Part....284
- Controlling the Negative Transition Part....285
- Controlling the Positive Transition Part....285

10.11.2.1 General Status Register Commands

STATus:PRESet....283
STATus:QUEue[:NEXT]?....283

STATus:PRESet

This command resets the edge detectors and `ENABle` parts of all registers to a defined value. All `PTRansition` parts are set to `FFFFh`, i.e. all transitions from 0 to 1 are detected. All `NTRansition` parts are set to 0, i.e. a transition from 1 to 0 in a `CONDition` bit is not detected. The `ENABle` part of the `STATus:OPERation` and `STATus:QUEStionable` registers are set to 0, i.e. all events in these registers are not passed on.

Usage: Event

STATus:QUEue[:NEXT]?

This command queries the most recent error queue entry and deletes it.

Positive error numbers indicate device-specific errors, negative error numbers are error messages defined by SCPI. If the error queue is empty, the error number 0, "No error", is returned.

Usage: Query only

10.11.2.2 Reading Out the EVENt Part

STATus:OPERation[:EVENt]?
STATus:QUEStionable[:EVENt]?
STATus:QUEStionable:SYNC[:EVENt]? <ChannelName>

This command reads out the EVENt section of the status register.

The command also deletes the contents of the EVENt section.

Suffix:

<n>	Window
<m>	Marker

Query parameters:

<ChannelName>	String containing the name of the channel. The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

10.11.2.3 Reading Out the CONDition Part

STATus:OPERation:CONDition?
STATus:QUEStionable:CONDition?
STATus:QUEStionable:SYNC:CONDition? <ChannelName>

This command reads out the CONDition section of the status register.

The command does not delete the contents of the EVENt section.

Suffix:

<n>	Window
<m>	Marker

Query parameters:

<ChannelName>	String containing the name of the channel. The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

10.11.2.4 Controlling the ENABle Part

STATus:OPERation:ENABle <SumBit>
STATus:QUEStionable:ENABle <SumBit>
STATus:QUEStionable:SYNC:ENABle <BitDefinition>, <ChannelName>

This command controls the ENABle part of a register.

The ENABle part allows true conditions in the EVENt part of the status register to be reported in the summary bit. If a bit is 1 in the enable register and its associated event bit transitions to true, a positive transition will occur in the summary bit reported to the next higher level.

Suffix:

<n>	Window
<m>	Marker

Parameters:

<BitDefinition> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

10.11.2.5 Controlling the Negative Transition Part

STATus:OPERation:NTRansition <SumBit>
STATus:QUEStionable:NTRansition <SumBit>
STATus:QUEStionable:SYNC:NTRansition <BitDefinition>,<ChannelName>

This command controls the Negative TRansition part of a register.

Setting a bit causes a 1 to 0 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding EVENt register.

Suffix:

<n>	Window
<m>	Marker

Parameters:

<BitDefinition> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

10.11.2.6 Controlling the Positive Transition Part

STATus:OPERation:PTRansition <SumBit>
STATus:QUEStionable:PTRansition <SumBit>
STATus:QUEStionable:SYNC:PTRansition <BitDefinition>,<ChannelName>

These commands control the Positive TRansition part of a register.

Setting a bit causes a 0 to 1 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding EVENt register.

Suffix:

<n>	Window

<m> Marker

Parameters:

<BitDefinition> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

10.12 Deprecated Commands

The following commands are provided only for compatibility to remote control programs from R&S FSW DOCSIS 3.1 applications on previous signal analyzers. For new remote control programs use the specified alternative commands.

DISPlay[:WINDow<n>]:TYPE........286
FETCh:SCDetailed:ALL?........286

DISPlay[:WINDow<n>]:TYPE <WindowType>

This command 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 10.7.2, "Working with Windows in the Display", on page 227).

The parameter values are the same as for `LAYout:ADD[:WINDow]?` on page 227.

Suffix:

<n> Window

FETCh:SCDetailed:ALL?

This command returns all detailed signal content values as a comma-separated list.

Note this command is maintained for compatibility reasons only. For newer programs use the improved command `FETCh:SCDetailed:ALL:FORMatted?` on page 255.

Example: `FETC:SCD:ALL?`

Usage: Query only

10.13 Programming Examples for DOCSIS 3.1 Measurements

The following programming examples demonstrate how to configure basic DOCSIS measurements in a remote environment.

Note that some commands described in the examples may not actually be necessary, as the default settings are used; however, they are included to demonstrate the use of the commands.

- Measurement 1: Measuring Modulation Accuracy....................................287
- Measurement 2: Determining the Occupied Bandwidth...........................291

10.13.1 Measurement 1: Measuring Modulation Accuracy

This example demonstrates how to configure a modulation accuracy measurement in a remote environment.

```
//---------- Preparing the application ------------
// Preset the instrument
*RST
//Activate a DOCSIS measurement channel
INST:SEL DOCS

//-----------Configuring the measurement ------------
//Set the center frequency
FREQ:CENT 1.0GHZ

//---------- Signal description ------------
//Define the OFDM spectrum location (frequency of sc0) at 897.6 MHz
CONF:DS:CHAN:SPEC:FREQ 897600000
//Nfft mode is 4K
CONF:CHAN:NFFT FFT4K
//Configure the cyclic prefix to be 256 samples
CONF:CHAN:CP S256
//Configure roll-off factor of 64 samples
CONF:CHAN:ROFF S64
//Time-interleaving depth is 16
CONF:DS:CHAN:TID 16
//NCP uses 16-QAM modulation
CONF:DS:CHAN:NCP:MOD QAM16
//Set PLC start index to 2044 manually
CONF:DS:CHAN:PLC:IND:AUTO OFF
CONF:DS:CHAN:PLC:IND 2044
//Query the used PLC modulation
CONF:DS:CHAN:PLC:MOD?
//Result: 16-QAM
//Query the number of subcarriers used by the PLC
CONF:DS:CHAN:PLC:CARR?
//Result: 8

//Configure continuous pilots on every 50th subcarrier from 250 to 500
CONF:DS:CHAN:CPES2:SUBC:TYPE CPIL
CONF:DS:CHAN:CPES2:SUBC:STAR 250
CONF:DS:CHAN:CPES2:SUBC:STOP 500
CONF:DS:CHAN:CPES2:SUBC:INCR 50
```

```
//Exclude subcarriers 324 to 328 and 356 to 357
CONF:DS:CHAN:CPES3:SUBC:TYPE ESUB
CONF:DS:CHAN:CPES3:SUBC:SET 324,325,326,327,328,356,357

//Query the number of entries in the Continuous Pilots and Excluded
//Subcarrier Assignment table
CONF:DS:CHAN:CPES1:COUN?
//Result: 3 (PLC is default entry 1)

//Configure profile A:
//Assign 16-QAM modulation for excluded subcarriers and pilots
//Assign 4096-QAM for all other subcarriers
CONF:DS:CHAN:PCON:SEL A
CONF:DS:CHAN:PCON1:SUBC:STAR 0
CONF:DS:CHAN:PCON1:SUBC:STOP 8191
CONF:DS:CHAN:PCON1:SUBC:INCR 1
CONF:DS:CHAN:PCON1:SUBC:MOD QAM4096

CONF:DS:CHAN:PCON2:SUBC:SET 324,325,326,327,328,356,357
CONF:DS:CHAN:PCON2:SUBC:MOD QAM16

CONF:DS:CHAN:PCON3:SUBC:STAR 250
CONF:DS:CHAN:PCON3:SUBC:STOP 500
CONF:DS:CHAN:PCON3:SUBC:INCR 50
CONF:DS:CHAN:PCON3:SUBC:MOD QAM16

//Query the number of entries in the Profile configuration table
CONF:DS:CHAN:PCON:COUN?
//Result: 3
//Query the state of profile B
CONF:DS:CHAN:PCON:SEL B
CONF:DS:CHAN:PCON:STAT?
//Result: 0

//Query the number of entries in the Profile configuration table
CONF:DS:CHAN:FCON:COUN?
//Result: 1

//Configure the codewords in the frames:
// Profile A is used for the first 1620 carriers
CONF:DS:CHAN:FCON1:PROF A
CONF:DS:CHAN:FCON1:SUBC:STAR 0
CONF:DS:CHAN:FCON1:SUBC:COUN 1620
// Profile A is used for the next 2700 carriers (requires 2 symbols)
CONF:DS:CHAN:FCON2:PROF A
CONF:DS:CHAN:FCON2:SUBC:STAR 1620
CONF:DS:CHAN:FCON2:SUBC:COUN 2700
CONF:DS:CHAN:FCON2:SYMB:COUN?
//Result: 2
```

```
//---------- Configuring Data Acquisition ---------------------
//Each measurement captures data for 6 ms.
SWE:TIME 6ms
//Query the used sample rate
TRAC:IQ:SRAT?
//Result: 204.8 MHZ
//Query number of samples
SWE:LENG?
// Number of samples captured per measurement: 0.006s * 204.8e6 samples per second
// = 1228800 samples
//Query the analysis bandwidth
TRAC:IQ:BWID?
//Result: 192.0 MHz

//---------- Tracking and channel estimation -----------------
//Disable all tracking and compensation functions
SENS:TRAC:PHAS OFF
SENS:TRAC:TIME OFF

//---------- Demodulation ------------
//Activate codeword decoding
SENS:DEM:DEC:COD ON

//---------- Configuring the result displays ------------
// Activate following result displays:
// 1: Magnitude Capture (default, upper left)
// 2: Power Spectrum (default, upper right)
// 3: Result Summary (default, lower left)
// 4: Constellation (default, lower right)
// 5: Signal Content Detailed (bottom)
// 6: Bitstream (bottom right)

LAY:REPL '1',RFM
LAY:REPL '2',PSP
LAY:REPL '3',RSUM
LAY:REPL '4',CONS
LAY:ADD:WIND? '3',BEL,SCD
//Result: '5'
LAY:ADD:WIND? '5',RIGH,BITS
//Result: '6'

//Remove the individual MER data and MER Pilot results from the Result Summary table
DISP:WIND3:TABL:ITEM MERD,0
DISP:WIND3:TABL:ITEM MERP,0
//Query the display state of the combined pilot+data MER result
DISP:WIND3:TABL:ITEM? MER
//Result: 1

//Configure the y-axis scaling for the power spectrum:
```

```
// Minimum: Automatic scaling according to hyst. interval from -20% to +10%
// Maximum: fixed upper limit at -20dBm
//Display 10 divisions with multiples of 5E10
DISP:WIND2:TRAC:Y:SCAL:AUTO ON
DISP:WIND2:TRAC:Y:SCAL:AUTO:MODE HYST
DISP:WIND2:TRAC:Y:SCAL:AUTO:HYST:LOW:LOW 20
DISP:WIND2:TRAC:Y:SCAL:AUTO:HYST:LOW:UPP 10
DISP:WIND2:TRAC:Y:SCAL:AUTO:FIX:RANG UPP
DISP:WIND2:TRAC:Y:SCAL:MAX 20
DISP:WIND2:TRAC:Y:SCAL:DIV 10
DISP:WIND2:TRAC:Y:SCAL:PDIV 5.0

//Configure constellation for all subcarriers in symbol 1
SENS:SUBC:SEL ALL
SENS:SYMB:SEL 1

//---------- Evaluation range settings -----------------
//Configure statistical evaluation over 10 frames.
SENS:FRAM:COUN:STAT ON
SENS:FRAM:COUN 10

//---------- Performing the Measurements -----
//Select single sweep mode.
INIT:CONT OFF
//Initiate a new measurement and wait until the sweep has finished.
INIT;*WAI

//---------- Retrieving Results -------------

//Query the I/Q data from magnitude capture buffer for first ms
// 200 000 samples per second -> 200 samples
TRAC1:IQ:DATA:MEMory? 0,200
//Note: result will be too long to display in IECWIN, but is stored in log file
//Query the I/Q data from magnitude capture buffer for second ms
TRAC1:IQ:DATA:MEMory? 201,400
//Note: result will be too long to display in IECWIN, but is stored in log file

//Query the number of frames detected in the current capture buffer
FETC:FRAM:COUN?
//Query the number of frames detected in all measurements
FETC:FRAM:COUN:ALL?
//Select second frame (frame 1) to be evaluated in graphical results
SENS:FRAM:SEL:STAT ON
SENS:FRAM:SEL 1

//Query constellation data (window 4) in frame 1
TRAC4:DATA? TRACE1
//Note: result will be too long to display in IECWIN, but is stored in log file

//Query detailed signal content in frame 1
```

```
FETC:SCD:ALL?
//Note: result will be too long to display in IECWIN, but is stored in log file

//Query maximum MER for pilots and data in frame 1
FETC:SUMM:MER:MAX?

//Query the limit for minimum MER for pilots and data and the result of the limit check
CALC:LIM:SUMM:MER:MIN?
CALC:LIM:SUMM:MER:MIN:RES?

//Query the results for bitstream in byte format in frames 1 and 2
UNIT:BITS BYTE
FETC:BITS:ALL?
SENS:FRAM:SEL 2
FETC:BITS:ALL?


//---------- Exporting Captured I/Q Data-------------
//Store the captured I/Q data to a file.
MMEM:STOR:IQ:STAT 1, 'C:\R_S\Instr\user\data.iq.tar'
```

10.13.2 Measurement 2: Determining the Occupied Bandwidth

This example demonstrates how to determine the occupied bandwidth for the DOCSIS 3.1 channel.

```
//---------- Preparing the application ------------
//Reset the instrument
*RST
//Activate a DOCSIS measurement channel named "OBWMeasurement"
INST:CRE:NEW DOCS,'OBWMeasurement'

//---------- Configuring the measurement ------------

//Select the OBW measurement
CALC:MARK:FUNC:POW:SEL OBW

//---------- Performing the Measurement ----
//Stop continuous sweep
INIT:CONT OFF
//Set the number of sweeps to be performed to 100
SWE:COUN 100
//Start a new measurement with 100 sweeps and wait for the end
INIT;*WAI

//-------------- Retrieving Results ------------
//Query the occupied bandwidth.
CALC:MARK:FUNC:POW:RES? OBW
```

```
//-------------- Returning to DOCSIS I/Q measurement --------
//Stop power (OBW) measurement
CALC:MARK:FUNC:POW:STAT OFF
```

Annex

A References

The R&S FSW DOCSIS 3.1 application and User Manual refer to the following documents:

- **[1]:** Data-Over-Cable Service Interface Specifications DOCSIS® 3.1
  MAC and Upper Layer Protocols Interface Specification
  CM-SP-MULPIv3.1-I04-141218
  ©Cable Television Laboratories, Inc., 2013-2014
- **[2]:** Data-Over-Cable Service Interface Specifications DOCSIS® 3.1
  Physical Layer Specification
  CM-SP-PHYv3.1-I04-141218
  ©Cable Television Laboratories, Inc., 2013-2014
- **[3]:** Data-Over-Cable Service Interface Specifications DOCSIS® 3.1
  Physical Layer Acceptance Test Plan
  CM-TP-PHYv3.1-ATP-D04-150630 DRAFT
  ©Cable Television Laboratories, Inc., 2014-2015

The following application note discusses the fundamental technological advances of DOCSIS 3.1 and presents measurement solutions from Rohde & Schwarz: 7MH89: DOCSIS 3.1

B I/Q Data File Format (iq-tar)

I/Q data is packed in a file with the extension `.iq.tar`. An iq-tar file contains I/Q data in binary format together with meta information that describes the nature and the source of data, e.g. the sample rate. The objective of the iq-tar file format is to separate I/Q data from the meta information while still having both inside one file. In addition, the file format allows you to preview the I/Q data in a web browser, and allows you to include user-specific data.

The iq-tar container packs several files into a single `.tar` archive file. Files in `.tar` format can be unpacked using standard archive tools (see http://en.wikipedia.org/wiki/Comparison_of_file_archivers) available for most operating systems. The advantage of `.tar` files is that the archived files inside the `.tar` file are not changed (not compressed) and thus it is possible to read the I/Q data directly within the archive without the need to unpack (untar) the `.tar` file first.

Contained files

An iq-tar file must contain the following files:

- **I/Q parameter XML file**, e.g. `xyz.xml`
  Contains meta information about the I/Q data (e.g. sample rate). The filename can be defined freely, but there must be only one single I/Q parameter XML file inside an iq-tar file.
- **I/Q data binary file**, e.g. `xyz.complex.float32`
  Contains the binary I/Q data of all channels. There must be only one single I/Q data binary file inside an iq-tar file.

Optionally, an iq-tar file can contain the following file:

- **I/Q preview XSLT file**, e.g. `open_IqTar_xml_file_in_web_browser.xslt`
  Contains a stylesheet to display the I/Q parameter XML file and a preview of the I/Q data in a web browser.
  A sample stylesheet is available at http://www.rohde-schwarz.com/file/open_IqTar_xml_file_in_web_browser.xslt.

B.1 I/Q Parameter XML File Specification

The content of the I/Q parameter XML file must comply with the XML schema `RsIqTar.xsd` available at: http://www.rohde-schwarz.com/file/RsIqTar.xsd.

In particular, the order of the XML elements must be respected, i.e. iq-tar uses an "ordered XML schema". For your own implementation of the iq-tar file format make sure to validate your XML file against the given schema.

The following example shows an I/Q parameter XML file. The XML elements and attributes are explained in the following sections.

Sample I/Q parameter XML file: xyz.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet type="text/xsl"
href="open_IqTar_xml_file_in_web_browser.xslt"?>
<RS_IQ_TAR_FileFormat fileFormatVersion="1"
xsi:noNamespaceSchemaLocation="RsIqTar.xsd"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <Name>R&S FSW</Name>
  <Comment>Here is a comment</Comment>
  <DateTime>2011-01-24T14:02:49</DateTime>
  <Samples>68751</Samples>
  <Clock unit="Hz">6.5e+006</Clock>
  <Format>complex</Format>
  <DataType>float32</DataType>
  <ScalingFactor unit="V">1</ScalingFactor>
  <NumberOfChannels>1</NumberOfChannels>
<DataFilename>xyz.complex.float32</DataFilename>
<UserData>
  <UserDefinedElement>Example</UserDefinedElement>
</UserData>
  <PreviewData>...</PreviewData>
</RS_IQ_TAR_FileFormat>
```

Element	Description
RS_IQ_TAR_File-Format	The root element of the XML file. It must contain the attribute `fileFormatVersion` that contains the number of the file format definition. Currently, `fileFormatVersion` "2" is used.
Name	Optional: describes the device or application that created the file.
Comment	Optional: contains text that further describes the contents of the file.
DateTime	Contains the date and time of the creation of the file. Its type is `xs:dateTime` (see `RsIqTar.xsd`).
Samples	Contains the number of samples of the I/Q data. For multi-channel signals all channels have the same number of samples. One sample can be: • A complex number represented as a pair of I and Q values • A complex number represented as a pair of magnitude and phase values • A real number represented as a single real value See also `Format` element.
Clock	Contains the clock frequency in Hz, i.e. the sample rate of the I/Q data. A signal generator typically outputs the I/Q data at a rate that equals the clock frequency. If the I/Q data was captured with a signal analyzer, the signal analyzer used the clock frequency as the sample rate. The attribute `unit` must be set to "Hz".
Format	Specifies how the binary data is saved in the I/Q data binary file (see `DataFilename` element). Every sample must be in the same format. The format can be one of the following: • `complex`: Complex number in cartesian format, i.e. I and Q values interleaved. I and Q are unitless • `real`: Real number (unitless) • `polar`: Complex number in polar format, i.e. magnitude (unitless) and phase (rad) values interleaved. Requires `DataType` = `float32` or `float64`

Element	Description
DataType	Specifies the binary format used for samples in the I/Q data binary file (see `DataFilename` element and Chapter B.2, "I/Q Data Binary File", on page 298). The following data types are allowed: ● `int8`: 8 bit signed integer data ● `int16`: 16 bit signed integer data ● `int32`: 32 bit signed integer data ● `float32`: 32 bit floating point data (IEEE 754) ● `float64`: 64 bit floating point data (IEEE 754)
ScalingFactor	Optional: describes how the binary data can be transformed into values in the unit Volt. The binary I/Q data itself has no unit. To get an I/Q sample in the unit Volt the saved samples have to be multiplied by the value of the `ScalingFactor`. For polar data only the magnitude value has to be multiplied. For multi-channel signals the `ScalingFactor` must be applied to all channels. The attribute `unit` must be set to "`V`". The `ScalingFactor` must be > 0. If the `ScalingFactor` element is not defined, a value of 1 V is assumed.
NumberOfChan-nels	Optional: specifies the number of channels, e.g. of a MIMO signal, contained in the I/Q data binary file. For multi-channels, the I/Q samples of the channels are expected to be interleaved within the I/Q data file (see Chapter B.2, "I/Q Data Binary File", on page 298). If the `NumberOfChannels` element is not defined, one channel is assumed.
DataFilename	Contains the filename of the I/Q data binary file that is part of the iq-tar file. It is recommended that the filename uses the following convention: <xyz>.<Format>.<Channels>ch.<Type> ● <xyz> = a valid Windows file name ● <Format> = complex, polar or real (see `Format` element) ● <Channels> = Number of channels (see `NumberOfChannels` element) ● <Type> = float32, float64, int8, int16, int32 or int64 (see `DataType` element) Examples: ● xyz.complex.1ch.float32 ● xyz.polar.1ch.float64 ● xyz.real.1ch.int16 ● xyz.complex.16ch.int8
UserData	Optional: contains user, application or device-specific XML data which is not part of the iq-tar specification. This element can be used to store additional information, e.g. the hardware configuration. User data must be valid XML content.
PreviewData	Optional: contains further XML elements that provide a preview of the I/Q data. The preview data is determined by the routine that saves an iq-tar file (e.g. R&S FSW). For the definition of this element refer to the `RsIqTar.xsd` schema. Note that the preview can be only displayed by current web browsers that have JavaScript enabled and if the XSLT stylesheet `open_IqTar_xml_file_in_web_browser.xslt` is available.

Example: ScalingFactor

Data stored as `int16` and a desired full scale voltage of 1 V

`ScalingFactor` = 1 V / maximum int16 value = 1 V / 2^{15} = 3.0517578125e-5 V

Scaling Factor	Numerical value	Numerical value x ScalingFac-tor
Minimum (negative) int16 value	- 2^{15} = - 32768	-1 V
Maximum (positive) int16 value	2^{15}-1= 32767	0.999969482421875 V

Example: PreviewData in XML

```
<PreviewData>
    <ArrayOfChannel length="1">
      <Channel>
        <PowerVsTime>
          <Min>
            <ArrayOfFloat length="256">
              <float>-134</float>
              <float>-142</float>
              ...
              <float>-140</float>
            </ArrayOfFloat>
          </Min>
          <Max>
            <ArrayOfFloat length="256">
              <float>-70</float>
              <float>-71</float>
              ...
              <float>-69</float>
            </ArrayOfFloat>
          </Max>
        </PowerVsTime>
        <Spectrum>
          <Min>
            <ArrayOfFloat length="256">
              <float>-133</float>
              <float>-111</float>
              ...
              <float>-111</float>
            </ArrayOfFloat>
          </Min>
          <Max>
            <ArrayOfFloat length="256">
              <float>-67</float>
              <float>-69</float>
              ...
              <float>-70</float>
              <float>-69</float>
            </ArrayOfFloat>
          </Max>
        </Spectrum>
        <IQ>
          <Histogram width="64" height="64">0123456789...0</Histogram>
        </IQ>
      </Channel>
    </ArrayOfChannel>
  </PreviewData>
```

B.2 I/Q Data Binary File

The I/Q data is saved in binary format according to the format and data type specified in the XML file (see `Format` element and `DataType` element). To allow reading and writing of streamed I/Q data, all data is interleaved, i.e. complex values are interleaved pairs of I and Q values and multi-channel signals contain interleaved (complex) samples for channel 0, channel 1, channel 2 etc. If the `NumberOfChannels` element is not defined, one channel is presumed.

Example: Element order for real data (1 channel)

```
I[0],                    // Real sample 0
I[1],                    // Real sample 1
I[2],                    // Real sample 2
...
```

Example: Element order for complex cartesian data (1 channel)

```
I[0], Q[0],              // Real and imaginary part of complex sample 0
I[1], Q[1],              // Real and imaginary part of complex sample 1
I[2], Q[2],              // Real and imaginary part of complex sample 2
...
```

Example: Element order for complex polar data (1 channel)

```
Mag[0], Phi[0],          // Magnitude and phase part of complex sample 0
Mag[1], Phi[1],          // Magnitude and phase part of complex sample 1
Mag[2], Phi[2],          // Magnitude and phase part of complex sample 2
...
```

Example: Element order for complex cartesian data (3 channels)

Complex data: I[channel no][time index], Q[channel no][time index]

```
I[0][0], Q[0][0],        // Channel 0, Complex sample 0
I[1][0], Q[1][0],        // Channel 1, Complex sample 0
I[2][0], Q[2][0],        // Channel 2, Complex sample 0

I[0][1], Q[0][1],        // Channel 0, Complex sample 1
I[1][1], Q[1][1],        // Channel 1, Complex sample 1
I[2][1], Q[2][1],        // Channel 2, Complex sample 1

I[0][2], Q[0][2],        // Channel 0, Complex sample 2
I[1][2], Q[1][2],        // Channel 1, Complex sample 2
I[2][2], Q[2][2],        // Channel 2, Complex sample 2
...
```

Example: Element order for complex cartesian data (1 channel)

This example demonstrates how to store complex cartesian data in float32 format using MATLAB®.

```
% Save vector of complex cartesian I/Q data, i.e. iqiqiq...
N = 100
iq = randn(1,N)+1j*randn(1,N)
fid = fopen('xyz.complex.float32','w');
for k=1:length(iq)
  fwrite(fid,single(real(iq(k))),'float32');
  fwrite(fid,single(imag(iq(k))),'float32');
end
fclose(fid)
```

List of Remote Commands (Docsis 3.1)

[SENSe:]ADJust:LEVel....224
[SENSe:]CHANnel:ESTimation....216
[SENSe:]DEMod:CPILots:AUTO....218
[SENSe:]DEMod:DECode:BITStream....219
[SENSe:]DEMod:DECode:CODewords....220
[SENSe:]DEMod:NCP:AUTO....220
[SENSe:]FMODE:STATe....234
[SENSe:]FRAMe:COUNt....222
[SENSe:]FRAMe:COUNt:STATe....222
[SENSe:]FRAMe:SELect....222
[SENSe:]FRAMe:SELect:STATe....223
[SENSe:]FREQuency:CENTer....200
[SENSe:]FREQuency:CENTer:STEP....200
[SENSe:]FREQuency:CENTer:STEP:AUTO....201
[SENSe:]FREQuency:OFFSet....201
[SENSe:]MODulation:SELect....235
[SENSe:]OBJect:SELect....235
[SENSe:]PMETer<p>:DCYCle:VALue....191
[SENSe:]PMETer<p>:DCYCle[:STATe]....191
[SENSe:]PMETer<p>:FREQuency....192
[SENSe:]PMETer<p>:FREQuency:LINK....192
[SENSe:]PMETer<p>:MTIMe....192
[SENSe:]PMETer<p>:MTIMe:AVERage:COUNt....193
[SENSe:]PMETer<p>:MTIMe:AVERage[:STATe]....193
[SENSe:]PMETer<p>:ROFFset[:STATe]....194
[SENSe:]PMETer<p>:TRIGger:DTIMe....196
[SENSe:]PMETer<p>:TRIGger:HOLDoff....196
[SENSe:]PMETer<p>:TRIGger:HYSTeresis....196
[SENSe:]PMETer<p>:TRIGger:LEVel....197
[SENSe:]PMETer<p>:TRIGger:SLOPe....197
[SENSe:]PMETer<p>:TRIGger[:STATe]....197
[SENSe:]PMETer<p>:UPDate[:STATe]....194
[SENSe:]PMETer<p>[:STATe]....194
[SENSe:]SUBCarrier:SELect....236
[SENSe:]SWAPiq....206
[SENSe:]SWEep:LENGth?....207
[SENSe:]SWEep:LIMit:ABORt:STATe?....223
[SENSe:]SWEep:TIME....207
[SENSe:]SYMBol:SELect....236
[SENSe:]SYMBol:SIZE....236
[SENSe] (see also SENSe: commands!)....216
ABORt....245
CALCulate<n>:DELTamarker<m>:MREF....276
CALCulate<n>:DELTamarker<m>:X....277
CALCulate<n>:DELTamarker<m>[:STATe]....276
CALCulate<n>:LIMit:SUMMary:CERRor:MAXimum:RESult?....265
CALCulate<n>:LIMit:SUMMary:CERRor:MAXimum?....264

CALCulate<n>:LIMit:SUMMary:CERRor[:AVERage]:RESult?....265
CALCulate<n>:LIMit:SUMMary:CERRor[:AVERage]?....264
CALCulate<n>:LIMit:SUMMary:FERRor:MAXimum:RESult?....265
CALCulate<n>:LIMit:SUMMary:FERRor:MAXimum?....264
CALCulate<n>:LIMit:SUMMary:FERRor[:AVERage]:RESult?....265
CALCulate<n>:LIMit:SUMMary:FERRor[:AVERage]?....264
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