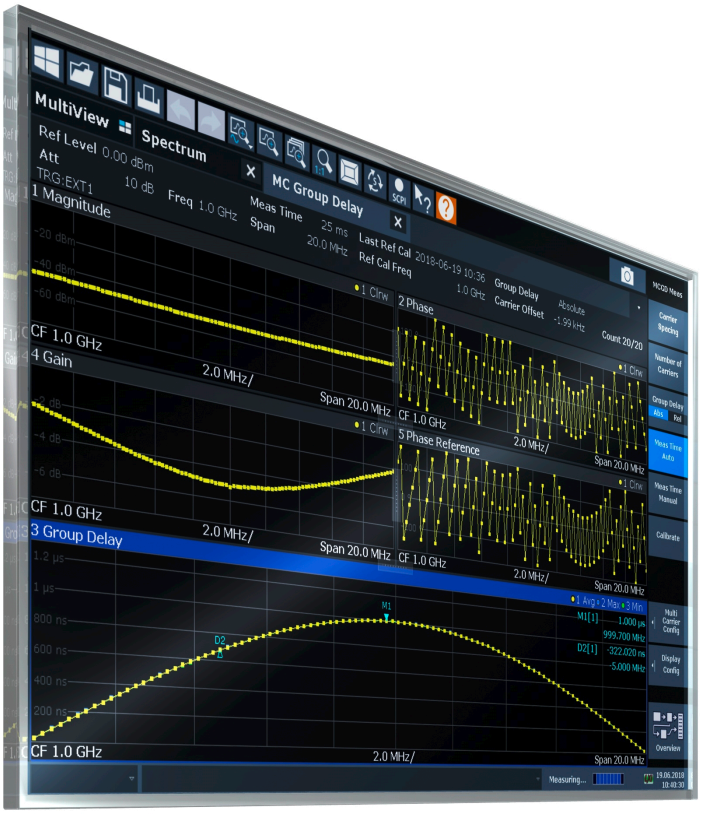
R&S®FSW-K17
Multi-Carrier Group Delay Measurement
User Manual



1173940502
Version 33

ROHDE&SCHWARZ
Make ideas real

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

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

The following firmware options are described:

- FSW-K17 (1313.4150.02)
- FSW-K17S (1338.5896.02)

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1173.9405.02 | Version 33 | R&S®FSW-K17

The following abbreviations are used throughout this manual: R&S®FSW is abbreviated as R&S FSW. Products of the R&S®SMW family, e.g. R&S®SMW200A, are abbreviated as R&S SMW.

Contents

1 Preface

This chapter provides safety-related information, an overview of the user documentation and the conventions used in the documentation.

1.1 Documentation overview

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

www.rohde-schwarz.com/manual/FSW

Further documents are available at:

www.rohde-schwarz.com/product/FSW

1.1.1 Getting started manual

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

A printed version is delivered with the instrument. A PDF version is available for download on the Internet.

1.1.2 User manuals and help

Separate user manuals are provided for the base unit and the firmware applications:

- Base unit manual
  Contains the description of all instrument modes and functions. It also provides an introduction to remote control, a complete description of the remote control commands with programming examples, and information on maintenance, instrument interfaces and error messages. Includes the contents of the getting started manual.
- Firmware application manual
  Contains the description of the specific functions of a firmware application, including remote control commands. Basic information on operating the FSW is not included.

The contents of the user manuals are available as help in the FSW. The help offers quick, context-sensitive access to the complete information for the base unit and the firmware applications.

All user manuals are also available for download or for immediate display on the Internet.

1.1.3 Service manual

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

The service manual is available for registered users on the global Rohde & Schwarz information system (GLORIS):

https://gloris.rohde-schwarz.com

1.1.4 Instrument security procedures

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

1.1.5 Printed safety instructions

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

1.1.6 Specifications and brochures

The specifications document, also known as the data sheet, contains the technical specifications of the FSW. It also lists the firmware applications and their order numbers, and optional accessories.

The brochure provides an overview of the instrument and deals with the specific characteristics.

See www.rohde-schwarz.com/brochure-datasheet/FSW

1.1.7 Release notes and open-source acknowledgment (OSA)

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

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

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

1.1.8 Application notes, application cards, white papers, etc.

These documents deal with special applications or background information on particular topics.

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

1.1.9 Videos

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

1.2 About this manual

This Multi-Carrier "Group Delay" 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 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 Multi-Carrier Group Delay Application**
  Introduction to and getting familiar with the application
- **About the measurement**
  General concept of the MCGD measurement and typical applications
- **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 Multi-Carrier Group Delay Application**
  Step-by-step instructions to perform a basic MCGD measurement
- **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 Multi-Carrier Group Delay Measurements**
  Remote commands required to configure and perform Multi-Carrier "Group Delay" 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 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**

1.3 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 and knob names are enclosed by square brackets.
`Filenames, commands, program code`	Filenames, commands, coding samples and screen output are distinguished by their font.
Input	Input to be entered by the user is displayed in italics.
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 operating 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 many as possible of the provided functions and possible interdependencies between parameters. The shown values may not represent realistic usage scenarios.

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 multi-carrier group delay application

The FSW-K17 option is a firmware application that adds functionality to perform Multi-Carrier "Group Delay" measurements to the FSW.

The Multi-Carrier "Group Delay" (*MCGD*) application features:

- Highly accurate group delay measurement for large spans
- Orthogonal measurement method
- Frequency converted group delay measurement
- Storage and loading functions for reference data
- Storage functions for measurement settings and results
- Graphical display of:
  - "Group delay"
  - "Gain"
  - "Magnitude" and "phase" at carrier frequency points in measurement or reference signal
  - "Phase difference" between measurement and reference signal
- Interactive or remote measurement control

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

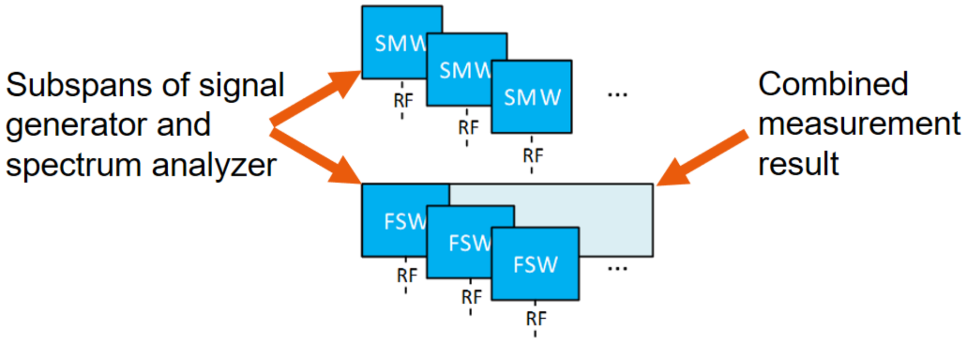
Functions that are not discussed in this manual are the same as in the Spectrum application and are described in the FSW User Manual. The latest version is available for download at the product homepage.

Subspan measurements application FSW-K17S

The frequency subspan measurements application FSW-K17S is an extension of the Multi-Carrier "Group Delay" (*MCGD*) application. A minimum internal analysis bandwidth of 512 MHz (FSW-B512) and a connection to an R&S SMW signal generator equipped with option R&S SMW-K61 (MCCW) is needed to run the FSW-K17S application.

It provides functionality to execute measurements on signal bandwidths that are larger than the analysis bandwidth of the instrument itself or to analyze large spans in a number of smaller subspans with improved signal-to-noise ratio. With option FSW-K17S, the measurement span is only limited by the frequency limit of the instrument.

To achieve this functionality, the FSW-K17S application and also the connected signal generator are working with multiple stepped subspans until the whole frequency span is covered. These small subspans are then combined and the measurement result for the whole bandwidth is calculated and displayed.



Installation

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

2.1 Starting the multi-carrier group delay application

The Multi-Carrier "Group Delay" application adds a new measurement to the FSW.

To activate the Multi-Carrier "Group Delay" application

1. Press [MODE] on the front panel of the FSW.

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

2. Select the "MC Group Delay" item.

   The FSW opens a new measurement channel for the Multi-Carrier "Group Delay" application.

The measurement is started immediately with the default settings. It can be configured in the Multi-Carrier "Group Delay" "Overview" dialog box, which is displayed when you select "Overview" from any menu (see Chapter 6.1, "Configuration overview", on page 32).

Multiple Measurement Channels and Sequencer Function

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

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

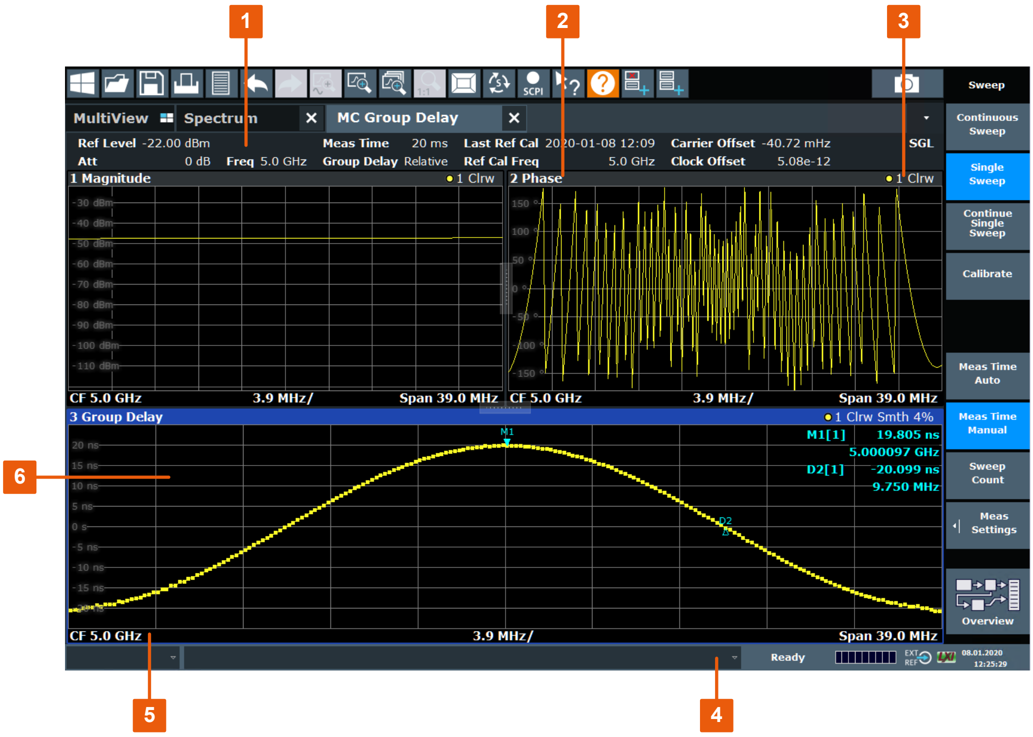
Only one measurement can be performed at any time, namely the one in the currently active channel. However, to perform the configured measurements consecutively, a Sequencer function is provided.

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

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

2.2 Understanding the display information

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



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

Channel bar information

In the Multi-Carrier "Group Delay" application, the FSW shows the following settings:

Table 2-1: Information displayed in the channel bar in the Multi-Carrier Group Delay application

"Ref Level"	Reference level
"Att"	Mechanical and electronic RF attenuation
"Freq"	Center frequency for the RF signal
"Meas Time"	Measurement time
"Last Ref Cal"	Timestamp of most recently performed reference calibration (if it has already been performed)
"Ref Cal Freq"	Frequency used for reference calibration
"Group Delay"	Mode of group delay result display (absolute or relative)
"Carrier Offset"	Frequency offset of the captured multi-carrier signal compared to the setting given by multi-carrier signal description. This frequency offset is estimated and compensated when using carrier estimation modes "Offset" or "All Carriers".
"Clock Offset"	Frequency spread of the captured multi-carrier signal compared to the setting given by multi-carrier signal description. This frequency spread is estimated and compensated when using carrier estimation mode "All Carriers". The clock offset reading shows the influence of Doppler shift in satellite communication measurements.

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

Window title bar information

For each diagram, the header provides the following information:

Figure 2-1: Window title bar information in Multi-Carrier Group Delay 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 center frequency and span and the range displayed per division.

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 About the measurement

Frequency delay in transmitted signals

All frequency components of a signal are delayed when passed through a device such as an amplifier, a loudspeaker, or propagated through space or a medium, such as air. This signal delay will be different for the various frequencies unless the device has the property of being linear phase. The delay variation means that signals consisting of multiple frequency components will suffer distortion because these components are not delayed by the same amount of time at the output of the device. This changes the shape of the signal in addition to any constant delay, which can result in a signal that no longer matches the receiver filter, which in turn results in degraded Signal to Noise Ratio (SNR) or Bit Error Rate (BER).

Group delay as a characterization of transmission components

The delay of all frequencies together is referred to as the group delay and can be used to characterize the quality of transmission for such components. Group delay is also a measure of how long it takes for a signal's information to propagate through a channel or device under test.

Since digital modulation schemes in which the frequency plays an important role are very common, the group delay is of special interest to all manufacturers or testers of transmission components, as well as frequency converters. Satellite transponders, for example, need to be characterized by the phase transmission in addition to the amplitude transmission. Both values can be determined precisely and easily with the FSW Multi-Carrier "Group Delay" application.

The Multi-Carrier Group Delay measurement method

The FSW Multi-Carrier "Group Delay" application evaluates an input signal provided by a signal generator. After a preliminary reference measurement of this signal without the device under test, the same signal is evaluated with the device subsequently. Instead of evaluating the timing of the signals, the phase shift and "magnitude" response of multiple carriers across frequency is measured. A baseband signal consisting of several unmodulated carriers with a fixed step size is used as an input signal, allowing for a very quick wideband measurement. By measuring the "phase differences" between the two signals at the input and at the output, the application calculates the relative phase between output and input.

However, the phase of the carriers at the input to the DUT does not actually have to be measured. Instead, the results are normalized. That way, no reference path or connection is needed between the input and the output of the DUT. A reference mixer in the signal generator provides a "phase reference" at the IF frequency. Thus, a constant delay factor is eliminated and the group delay is calculated relative to the reference signal.

If an external trigger is used, the absolute group delay can also be calculated. Absolute group delay is of interest for instance to equalize the delay of two channels, characterize cables and design quadrature FM demodulators.

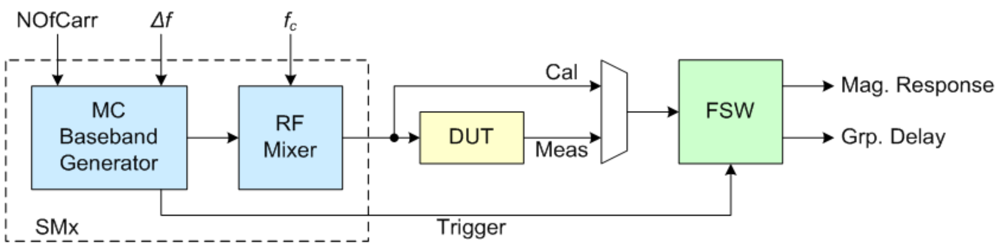


Figure 3-1: Multi-Carrier Group Delay Measurement Setup

4 Measurements and result displays

The data that was measured by the FSW can be evaluated using various different methods. In the Multi-Carrier "Group Delay" application, up to 6 evaluation methods can be displayed simultaneously in separate windows.

All results are determined from the I/Q data set captured for the measurement.

Storing Results

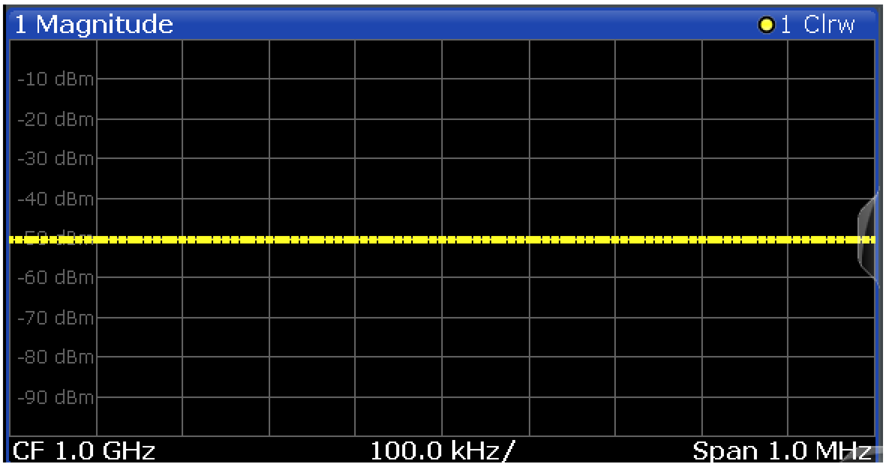
The results of the Multi-Carrier "Group Delay" measurement can be stored to a file, either in CSV or ASCII format. The results of the calibration (reference) measurement can also be stored in CSV format.

4.1 Evaluation methods for multi-carrier group delay

The following evaluation methods can be selected for Multi-Carrier "Group Delay" measurements.

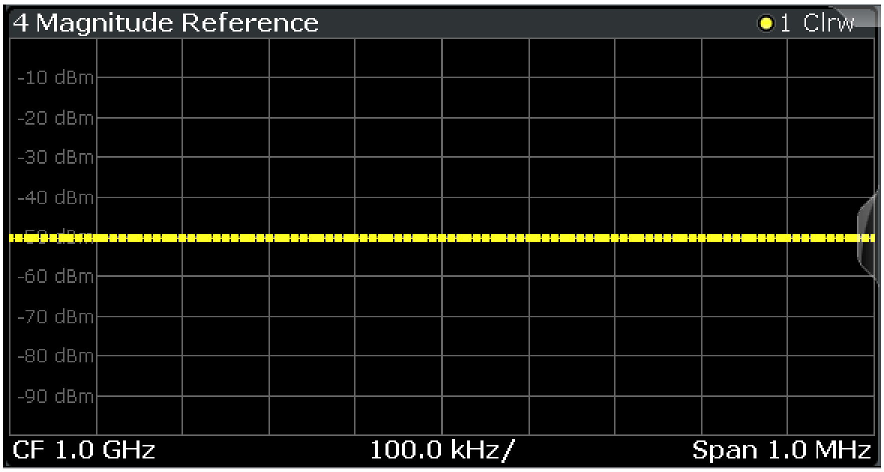
Magnitude

Displays the spectrum of the input signal. In contrast to the Spectrum application, the frequency values are determined using an *Discrete frequency transformation* (DFT) from the recorded I/Q data set.



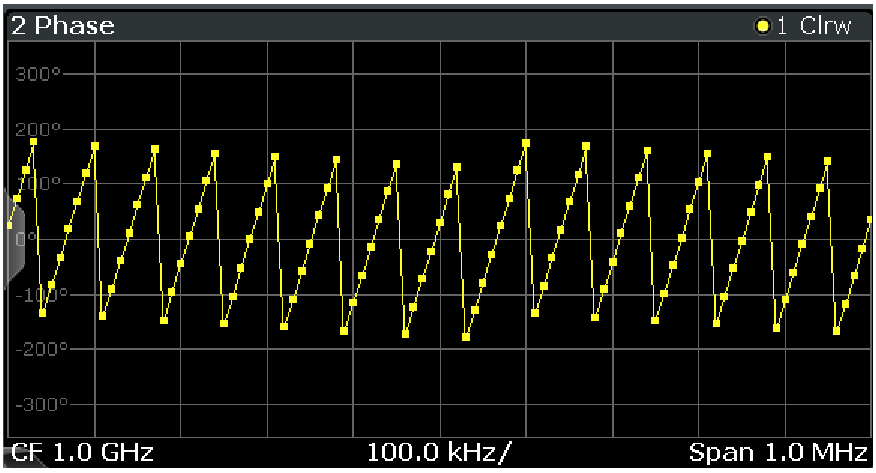
Remote command:
`LAY:ADD? '1',RIGH,MAGN`
(see LAYout:ADD[:WINDow]? on page 168)

Magnitude Reference
Displays the spectrum of the reference signal. In contrast to the Spectrum application, the frequency values are determined using DFT from the recorded I/Q data set.



Remote command:
`LAY:ADD? '1',RIGH,RMAG`
(see LAYout:ADD[:WINDow]? on page 168)

Phase
Displays the "phase" deviations of the measured signal (in rad or °) versus frequency.

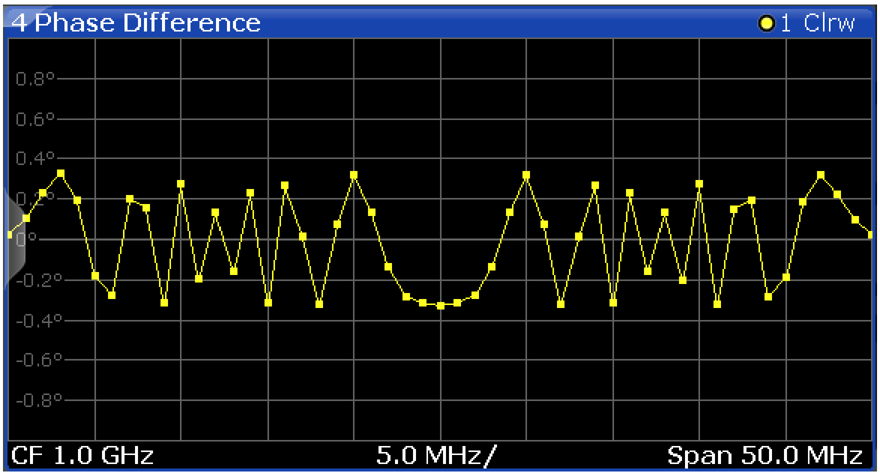


Remote command:
`LAY:ADD? '1',RIGH,PHAS`
(see LAYout:ADD[:WINDow]? on page 168)
To display raw phase data: `[SENSe:]RAWPhase[:STATe]` on page 149

Phase Difference
Displays the "phase difference" (in rad or °) between the measured signal and the calibration (reference) signal vs frequency.

For absolute group delay measurement (see "Group Delay Mode" on page 60), the "phase difference" also includes the linear "phase" trend related to the absolute group delay.

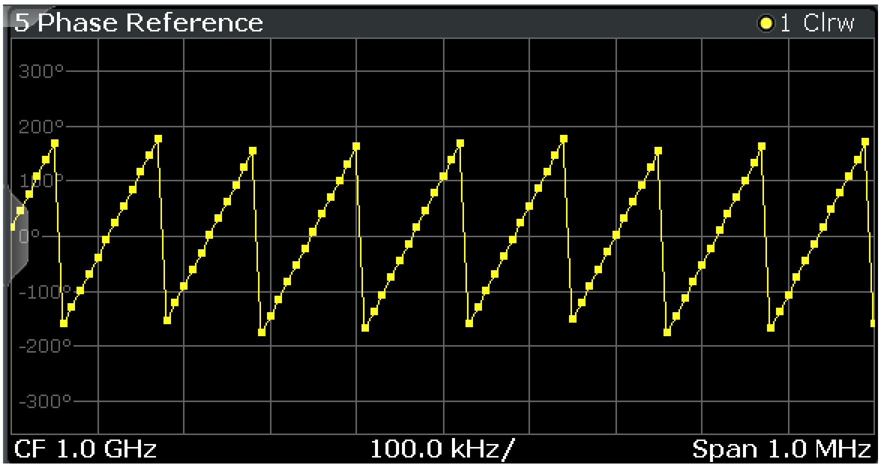
For group delay measurements relative to the average group delay (see "Reference for Relative Calculation/ Reference Frequency" on page 60), the linear trend is removed from the "phase difference" results.



Note: This result display requires a calibration measurement (see "Calibrate (Execute Reference Calibration)" on page 64).

Remote command:
`LAY:ADD? '1',RIGH,DPHase`
(see `LAYout:ADD[:WINDow]?` on page 168)
To display raw phase data: `[SENSe:]RAWPhase[:STATe]` on page 149

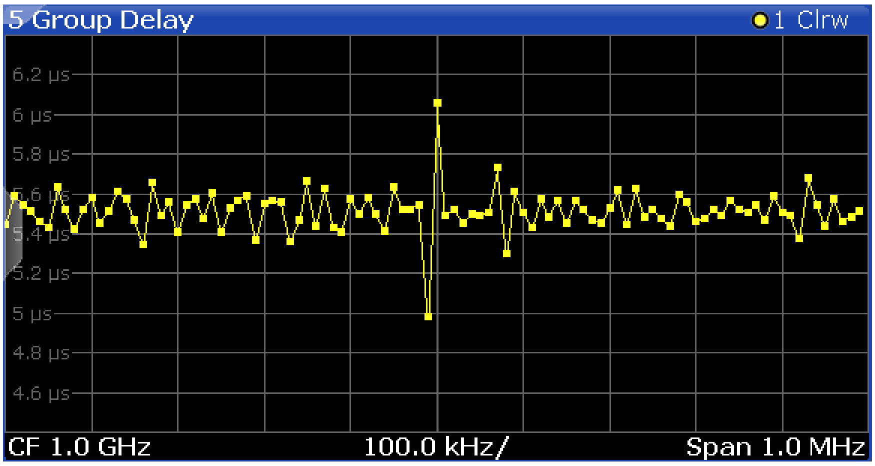
Phase Reference
Displays the "phase" deviations of the reference signal (in rad or °) versus frequency.



Remote command:
`LAY:ADD? '1',RIGH,RPH`
(see `LAYout:ADD[:WINDow]?` on page 168)

Group Delay
Displays the time deviations of the signal versus frequency.

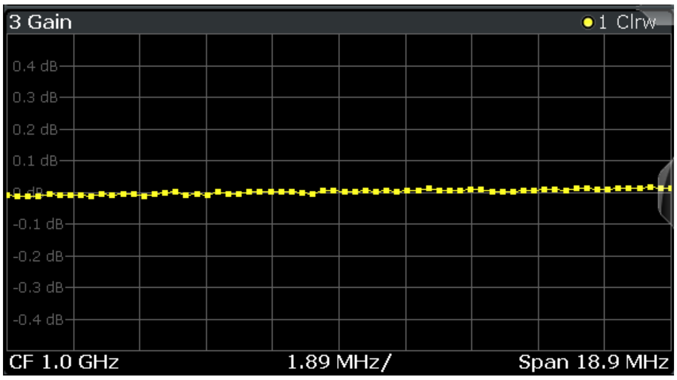
Note: This result display requires a calibration measurement (see "Calibrate (Execute Reference Calibration)" on page 64).



Remote command:
`LAY:ADD? '1',RIGH,GDEL`
(see `LAYout:ADD[:WINDow]?` on page 168)

Gain
Displays the "gain" in "magnitude" from the reference trace to the measurement trace in dB or percent. This diagram characterizes the transmission behavior of the DUT.

Note: This result display requires a calibration measurement (see "Calibrate (Execute Reference Calibration)" on page 64).



Remote command:
`LAY:ADD? '1',RIGH,GAIN`
(see `LAYout:ADD[:WINDow]?` on page 168)

Marker Table

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

This table is displayed automatically if configured accordingly.

(See "Marker Table Display" on page 92).

1 Marker Table

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

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

Remote command:

`LAY:ADD? '1',RIGH, MTAB`, see `LAYout:ADD[:WINDow]?` on page 168

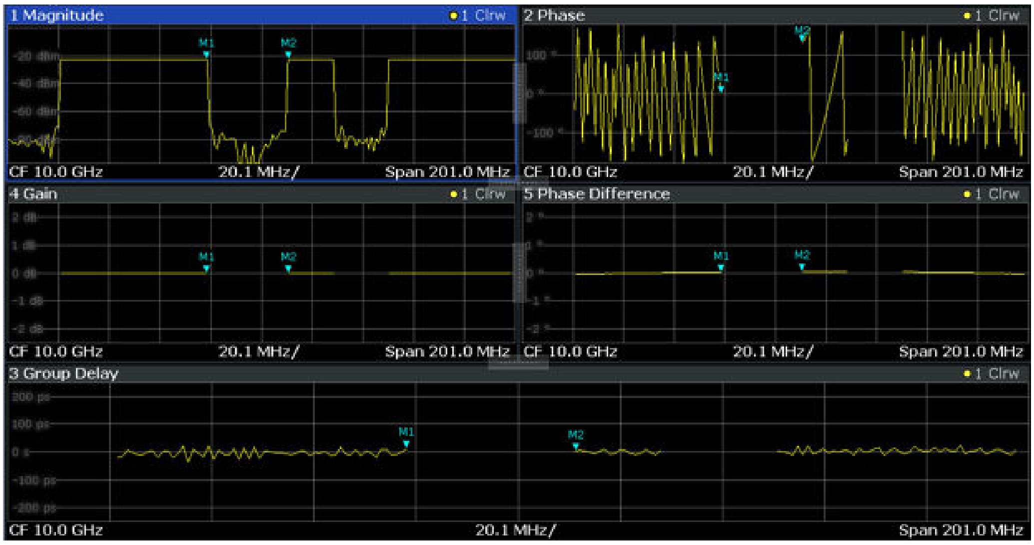
Results:

`CALCulate<n>:MARKer<m>:X` on page 197

`CALCulate<n>:MARKer<m>:Y?` on page 181

Carrier Table

When the carrier table is active, the "magnitude" display shows the complete signal in order to give an appropriate overview of the signal. Other result displays "(phase", "gain", "phase difference", group delay) show gaps for areas that are defined in the "carrier table" as having state = off (or having state = on, but a "magnitude" value that is smaller than the specified carrier threshold).



5 Measurement basics

Some background knowledge on basic terms and principles used in Multi-Carrier "Group Delay" measurements is provided here for a better understanding of the required configuration settings.

5.1 Definitions

Group delay

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

$$\tau(f) = -\frac{1}{2\pi} \cdot \frac{d\varphi_{delta}(f)}{df} \quad with \quad \varphi_{delta}(f) = \mathrm{unwrap}\left(\varphi_{meas}(f) - \varphi_{cal}(f)\right)$$

Gain (Magnitude flatness)

The *"gain"* (also referred to as the "magnitude" flatness or amplitude flatness) is defined as the relation between the measured "magnitud"e and the reference (calibration) "magnitude":

$$Gain(f) = \frac{M_{meas}(f)}{M_{cal}(f)}$$

The "gain" describes the transmission behavior of the DUT.

5.2 The multi-carrier measurement

The FSW Multi-Carrier "Group Delay" application evaluates an input signal provided by a signal generator. A signal consisting of several unmodulated carriers with a fixed step size is used as an input signal.

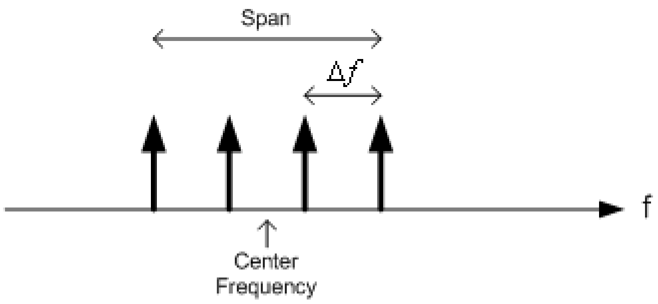
Dependency of the span on the number of carriers

The frequency **span** to be swept during the measurement is determined by the number of carriers in the input signal and the spacing between them. It is recommended that you set the span according to the following equation:

*Span = (Number of carriers -1) * carrier spacing (Δf)*

Example:

A span ≥ 3 * carrier spacing (Δf) is required to measure a signal with four carriers.



As a rule, the span can only be defined as a multiple of the carrier spacing.

Carrier estimation

If the carrier frequencies are distorted, for example due to the Doppler-effect, the frequencies for each carrier can be estimated in order to improve the calculation of measurement results like the group delay.

For more a more detailed description of the carrier estimation, see "Carrier Estimation Mode" on page 70.

Carrier offset

If the carriers of the captured multi-carrier signal are not aligned with the defined multi-carrier signal description in terms of showing a constant frequency shift for all carriers, the corresponding frequency offset can be estimated and compensated automatically. This is done when using carrier estimation mode "Offset" or "All Carriers".

The estimated carrier offset is displayed in the channel info bar.

The carrier offset can be queried using `[SENSe:]CARRier:OFFSet?` on page 146.

Clock Offset

If the carriers of the captured multi-carrier signal are not aligned with the defined multi-carrier signal description in terms of showing a frequency spread, the corresponding clock offset can be estimated and compensated automatically. This is done when using carrier estimation mode "All Carriers".

The estimated clock offset is displayed in the channel info bar and shows the influence of Doppler shift in satellite communication measurements. The actual Doppler factor can be calculated from the clock offset value be using formula:

- $k_{Doppler} = (ClockOffset) + 1$
- For a transmission Sat -> Earth, this corresponds to:

  $$k_{Doppler,S \rightarrow E} = (1 + \frac{v_{rel}}{c})$$

- For a transmission Earth -> Sat -> Earth, this corresponds to:

  $$k_{Doppler,E \rightarrow S \rightarrow E} = (1 + \frac{v_{rel}}{c})^2$$

The clock offset can be queried using [SENSe:]CLOCk:OFFSet? on page 146.

Demodulation bandwidth

The bandwidth to be demodulated during the measurement is determined automatically by the application from the defined span and carrier spacing.

Measurement time

The required duration of the measurement can be determined automatically by the application according to the defined carrier spacing and span, or it can be configured manually.

Averaging results

The calculated values can be averaged over several sweeps to obtain more reliable results.

Orthogonal calculation method

The orthogonal calculation method aligns the trace points in the result display to the carrier frequencies of the input signal. To do so, a DFT window length equaling 1/Δf is used.

Absolute vs relative group delay

By default, the group delay is calculated relative to the reference signal, eliminating any constant delay factors. Optionally, the reference carrier frequency for relative measurements can be defined manually.

Alternatively, if an external trigger is used, the absolute group delay can also be calculated. In this case, the trigger uncertainty for the current measurement bandwidth is indicated and considered as an additional error in the group delay calculation.

Unambiguous group delay results

In the time domain, a multi-carrier signal with a group delay of 1/<CarrierSpacing> simply repeats itself. The result is the same as a signal with a group delay of 0. The R&S FSW MCGD application cannot distinguish the two signals. Therefore, any group delays larger than 1/<CarrierSpacing> are no longer unambiguous.

The range in which unambiguous group delay results can be measured is defined by the following equation:

$$UnambiguousRange = \pm \frac{1}{2 * CarrierSpacing}$$

Equation 5-1: Range in which unambiguous group delay results can be measured

Any group delay that exceeds this range is wrapped back into the unambiguous range. To avoid ambiguous results, define the carrier spacing such that the expected group delay does not exceed the unambiguous range.

5.3 The calibration (reference) measurement

The Multi-Carrier "Group Delay" measurement method requires a preliminary reference measurement of the input signal *without the device under test* before the actual group delay measurement. This reference measurement is also referred to as the **calibration measurement**. The results of this measurement are stored internally in the FSW to be used as a reference for the group delay calculation in the subsequent measurement *with* the DUT.

The results of the calibration measurement can be stored to a file and loaded as reference data for future measurements with the same setup.

The date and time of the most recently performed or loaded calibration measurement is indicated in the channel bar.

5.4 Measurement setup

Before a Multi-Carrier "Group Delay" measurement can be performed, the FSW must be set up in a test environment. This section describes the required settings of the FSW. Before starting the measurements, the FSW has to be configured correctly and supplied with power as described in the FSW Getting Started manual, "Preparing For Use". Furthermore, the application firmware FSW-K17 must be enabled. Installation and enabling of the application firmware are described in the FSW Getting Started manual or in the Release Notes.

A Multi-Carrier "Group Delay" measurement requires the following devices:

- A baseband signal generator, e.g. a Vector Signal Generator R&S SMW
- The FSW with application firmware FSW-K17: Multi-Carrier "Group Delay"
- The device under test to be analyzed

► Connect the signal generator output to the [RF Input] connector of the FSW - first without the DUT, then with the DUT in-between.

For absolute group delay measurement, connect the trigger output of the signal generator to one of the trigger inputs ([TRIGGER INPUT]) of the FSW (see "Trigger 2/3" on page 54).

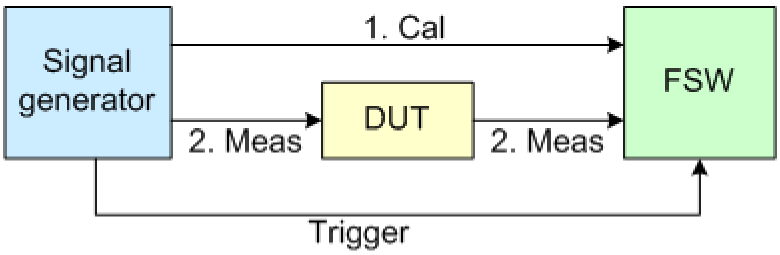


Figure 5-1: Multi-Carrier Group Delay test setup

It is recommended that you use an input signal with a low crest factor to get the "phase" response of the DUT. Furthermore, an external frequency reference is recommended for high accuracy measurements.

The following list summarizes the necessary measurement and calculation steps:

1. Calibration measurement without DUT:
   $\varphi_{cal}(f)$
2. Measurement with DUT:
   $\varphi_{meas}(f)$
3. Evaluate group delay:

$$\tau(f) = -\frac{1}{2\pi} \cdot \frac{d\varphi_{delta}(f)}{df} \quad with \quad \varphi_{delta}(f) = \text{unwrap}\left(\varphi_{meas}(f) - \varphi_{cal}(f)\right)$$

5.5 Group delay measurements with generator control

Since the group delay measurement requires a signal generator to provide the signal to the DUT, you must configure the same settings on the analyzer and on the generator. Alternatively, the FSW can take control of the connected generator, so that you only need to configure the measurement once. The analyzer then automatically sets the generator to the same settings.

Generator control is only available for R&S SMW signal generators with the Multicarrier CW option (R&S SMW-K61) installed.

Automated Frequency Translating Measurements

For DUTs with a frequency translating characteristic, configuring and reconfiguring first the analyzer and then the generator for several center frequencies can become tedious. Therefore, an automated measurement is now provided in which the analyzer takes control of the generator. The center frequencies of both the analyzer and the generator are configured according to the frequency translation characteristics of the DUT. This is done for both the calibration and the group delay measurement.

5.6 Trace smoothing

(Software-based) **smoothing** is a way to remove anomalies visually in the trace that can distort the results. The smoothing process is based on a moving average over the complete measurement range. The number of samples included in the averaging process (the *aperture* size) is variable and is a percentage of all samples that the trace consists of.

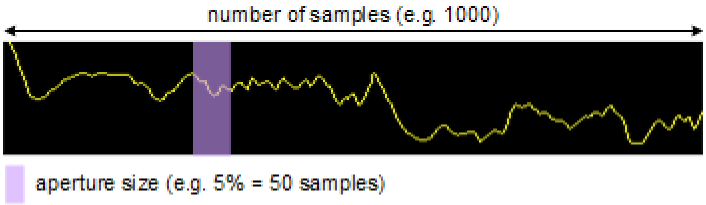


Figure 5-2: Sample size included in trace smoothing

The application smoothes the trace only after the measurement has been finished and the data has been analyzed and written to a trace. Thus, smoothing is just an enhancement of the trace display, not of the data itself. This also means that smoothing is always applied after any other trace averagings have been done, as these happen during the measurement itself.

You can turn trace smoothing on and off for all traces individually and compare, for example, the raw and the smooth trace.

Linear smoothing is based on the following algorithm:

$$y'(s) = \frac{1}{n}\left(\sum_{x=s-\frac{n-1}{2}}^{x=s+\frac{n-1}{2}} y(x)\right)$$

Equation 5-2: Linear trace smoothing

With:

s = sample number

y(s) = group delay, "magnitude" or "gain"

x = sample offset from s

n = aperture size

6 Configuration

Multi-Carrier Group Delay Application

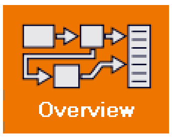
Access: [MODE]"MC Group Delay"

Multi-Carrier "Group Delay" measurements require a special application on the FSW.

When you switch the application of a measurement channel to Multi-Carrier "Group Delay" application the first time, a set of parameters is passed on from the currently active application. After initial setup, the parameters for the measurement channel are stored upon exiting and restored upon re-entering the channel. Thus, you can switch between applications quickly and easily.

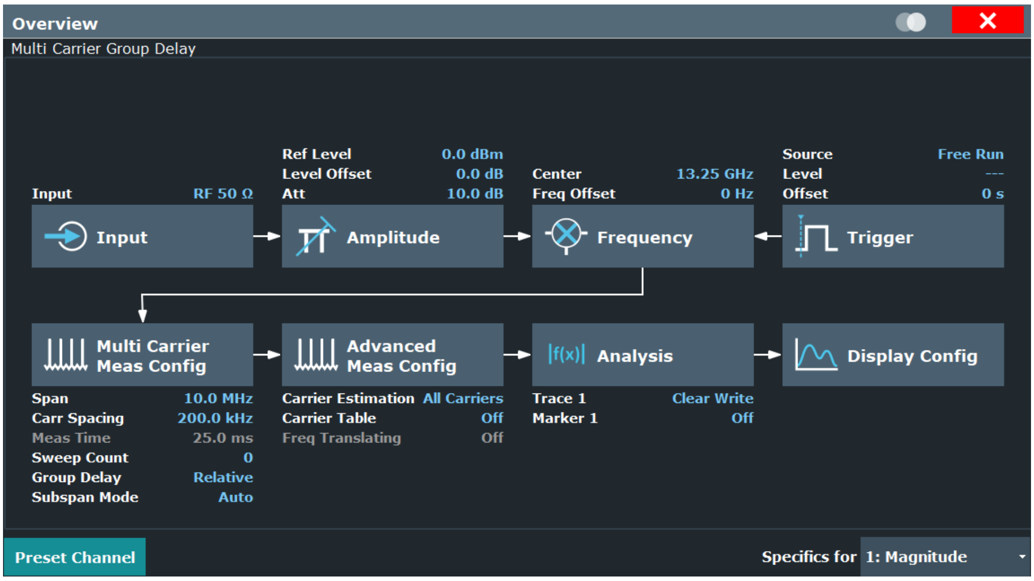
When you enable a measurement channel in Multi-Carrier "Group Delay" application, a Multi-Carrier "Group Delay" measurement for the input signal is started automatically with the default configuration. The "MCGD Meas" menu is displayed and provides access to the most important configuration functions.

6.1 Configuration overview



Access: all menus

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



In addition to the main measurement settings, the "Overview" provides quick access to the main settings dialog boxes. The individual configuration steps are displayed in the order of the data flow. 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".

In particular, the "Overview" provides quick access to the following configuration dialog boxes (listed in the recommended order of processing):

1. Input Settings
   See Chapter 6.2.1, "RF input settings", on page 35
2. Amplitude Settings
   See Chapter 6.3, "Amplitude and Y-Axis scaling", on page 39
3. Frequency Settings
   See Chapter 6.4, "Frequency settings", on page 47
4. Trigger Settings
   See Chapter 6.5, "Trigger settings", on page 49
5. Multi-Carrier Measurement Configuration
   See Chapter 6.6, "Multi-carrier configuration", on page 55
6. Advanced Measurement Configuration
   See Chapter 6.7, "Advanced measurement configuration", on page 69
7. Analysis
   See Chapter 7, "Analysis", on page 82
8. Display Configuration
   See Chapter 7.4, "Display configuration", on page 96

The main configuration settings and dialog boxes are also available via the "MCGD Meas" menu which is displayed when you press [MEAS CONFIG].

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

To configure settings

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

For step-by-step instructions on configuring Multi-Carrier "Group Delay" measurements, see Chapter 9, "How to perform measurements in the multi-carrier group delay application", on page 100.

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

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

Remote command:
`SYSTem:PRESet:CHANnel[:EXEC]` on page 119

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

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

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

6.2 Input source settings

Access: "Overview" > "Input" > "Input Source"

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

The input source determines which data the FSW will analyze.

Further input sources

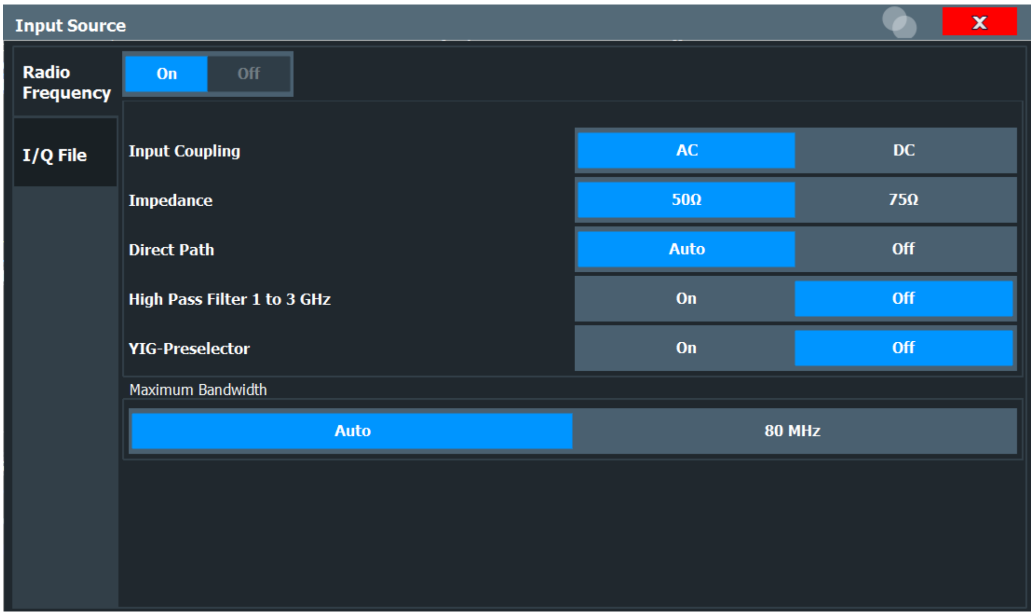
The R&S FSW MCGD application application can also process input from the following sources:

- I/Q Input files
- Active modular probes

6.2.1 RF input settings

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

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



Radio Frequency State

Activates input from the "RF Input" connector.

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

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

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

Remote command:
`INPut:SELect` on page 122
`INPut:TYPE` on page 122

Input Coupling

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

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

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

Remote command:
`INPut:COUPling` on page 120

Impedance

For some measurements, the reference impedance for the measured levels of the 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 121

Direct Path

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

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

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

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

"Off" The analog mixer path is always used.

Remote command:
`INPut:DPATh` on page 120

High Pass Filter 1 to 3 GHz

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

This function requires an additional hardware option.

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

Remote command:
`INPut:FILTer:HPASs[:STATe]` on page 121

YIG-Preselector

Enables or disables the YIG-preselector.

This setting requires an additional option on the FSW.

An internal YIG-preselector at the input of the FSW ensures that image frequencies are rejected. However, image rejection is only possible for a restricted bandwidth. To use the maximum bandwidth for signal analysis you can disable the YIG-preselector at the input of the FSW, which can lead to image-frequency display.

Remote command:
`INPut:FILTer:YIG[:STATe]` on page 121

Maximum Bandwidth

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

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

"Auto" (Default:) All installed bandwidth extension options are enabled. The currently available maximum bandwidth is allowed.
Note that using bandwidth extension options greater than 160 MHz may cause more spurious effects.

"80 MHz" Restricts the analysis bandwidth to a maximum of 80 MHz.
The bandwidth extension options greater than 160 MHz are disabled.

"160 MHz" Restricts the analysis bandwidth to a maximum of 160 MHz. The bandwidth extension option for 320 MHz is disabled.
(Not available or required if other bandwidth extension options larger than 320 MHz are installed.)

"512 MHz" Restricts the analysis bandwidth to a maximum of 512 MHz. Larger bandwidth extension options are disabled.

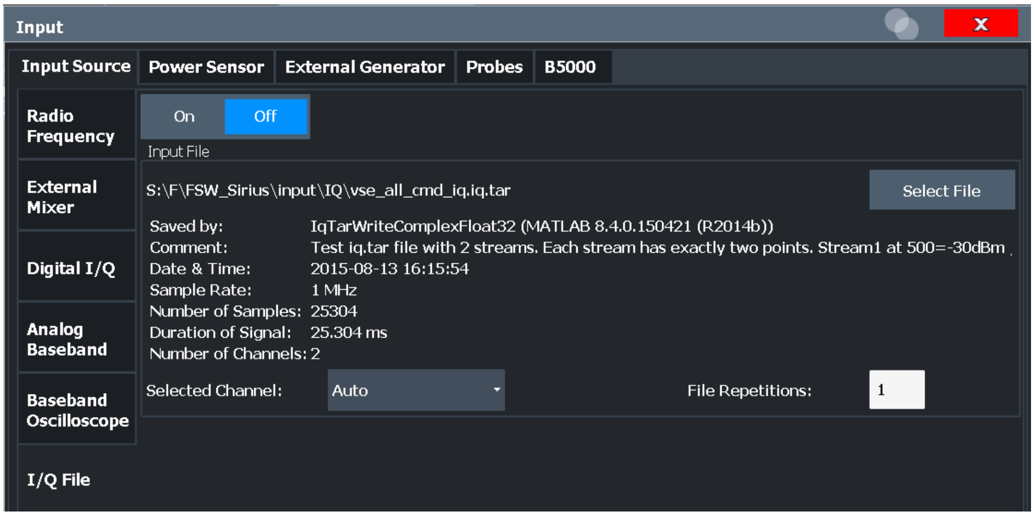
"1200 MHz" Restricts the analysis bandwidth to a maximum of 1200 MHz. Larger bandwidth extension options are disabled.

Remote command:
`TRACe:IQ:WBANd[:STATe]` on page 123
`TRACe:IQ:WBANd:MBWidth` on page 123

6.2.2 Settings for input from I/Q data files

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

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



I/Q Input File State

Enables input from the selected I/Q input file.

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

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

Remote command:
`INPut:SELect` on page 122

Select I/Q data file

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

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

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

- `.wv`
- `.aid`

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

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

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

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

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

Remote command:
`INPut:FILE:PATH` on page 124

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

Remote command:
`TRACe:IQ:FILE:REPetition:COUNt` on page 126

6.3 Amplitude and Y-Axis scaling

Access: "Overview" > "Amplitude"

Amplitude settings are identical to the base unit.

For background information on amplitude settings see the FSW User Manual.

6.3.1 Amplitude settings

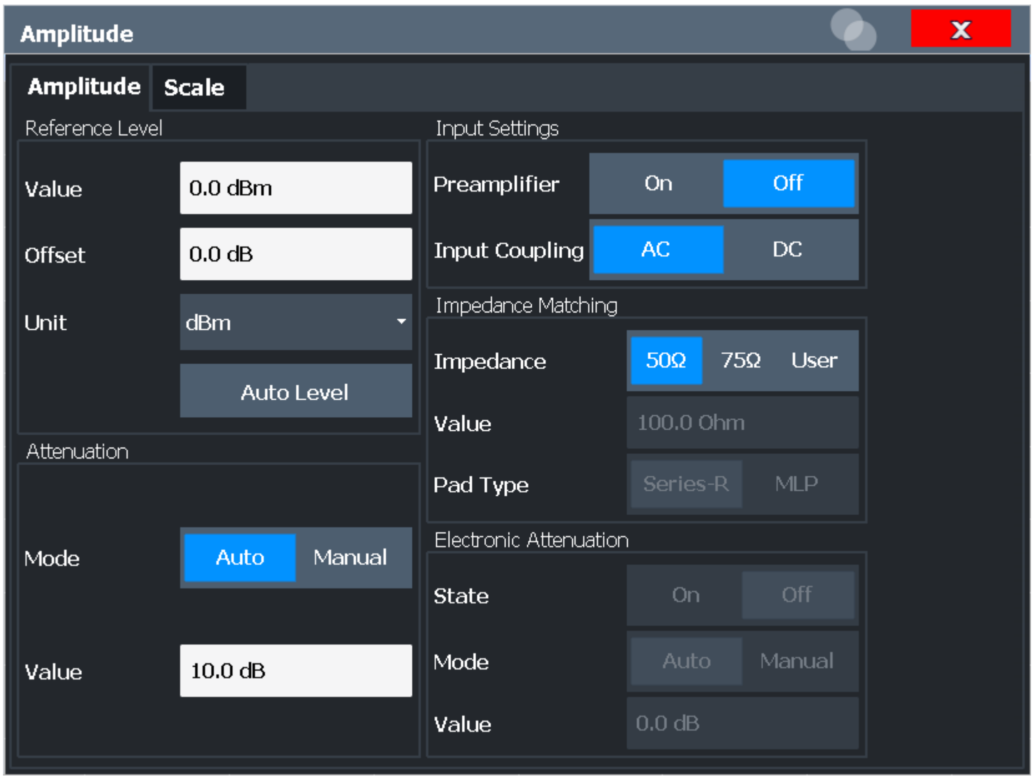
Access: "Overview" > "Amplitude"

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

Configuring amplitude settings allows you to:

- Adapt the instrument hardware to the expected maximum signal level by setting the Reference Level to this maximum
- Consider an external attenuator or preamplifier (using the "Offset").

- Optimize the SNR of the measurement for low signal levels by configuring the Reference Level as high as possible without introducing compression, clipping or overload. Use early amplification by the preamplifier and a low attenuation.
- Optimize the SNR for high signal levels and ensure that the instrument hardware is not damaged, using high attenuation and AC coupling (for DC input voltage).
- Adapt the reference impedance for power results when measuring in a 75-Ohm system by connecting an external matching pad to the RF input.



Reference Level

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

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

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

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel` on page 126

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

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

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

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

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel:OFFSet` on page 127

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

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

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

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

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

Remote command:
`INPut:ATTenuation` on page 127
`INPut:ATTenuation:AUTO` on page 128

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

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

Note: Electronic attenuation is not available for stop frequencies (or center frequencies in zero span) above 15 GHz.

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

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

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

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

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

Remote command:
`INPut:EATT:STATe` on page 129
`INPut:EATT:AUTO` on page 128
`INPut:EATT` on page 128

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.

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

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

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

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

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

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

For FSW85 models, no preamplifier is available.

Remote command:
`INPut:GAIN:STATe` on page 130
`INPut:GAIN[:VALue]` on page 130

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

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

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

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

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

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

Remote command:
`INPut:EGAin[:STATe]` on page 129

6.3.2 Scaling the Y-Axis

Access: "Overview" > "Amplitude" > "Scaling" tab

The individual scaling settings that affect the vertical axis are described here.

ⓘ Note that scaling settings are window-specific, as opposed to the amplitude settings. Depending on the result display, different methods of defining the scaling are available.

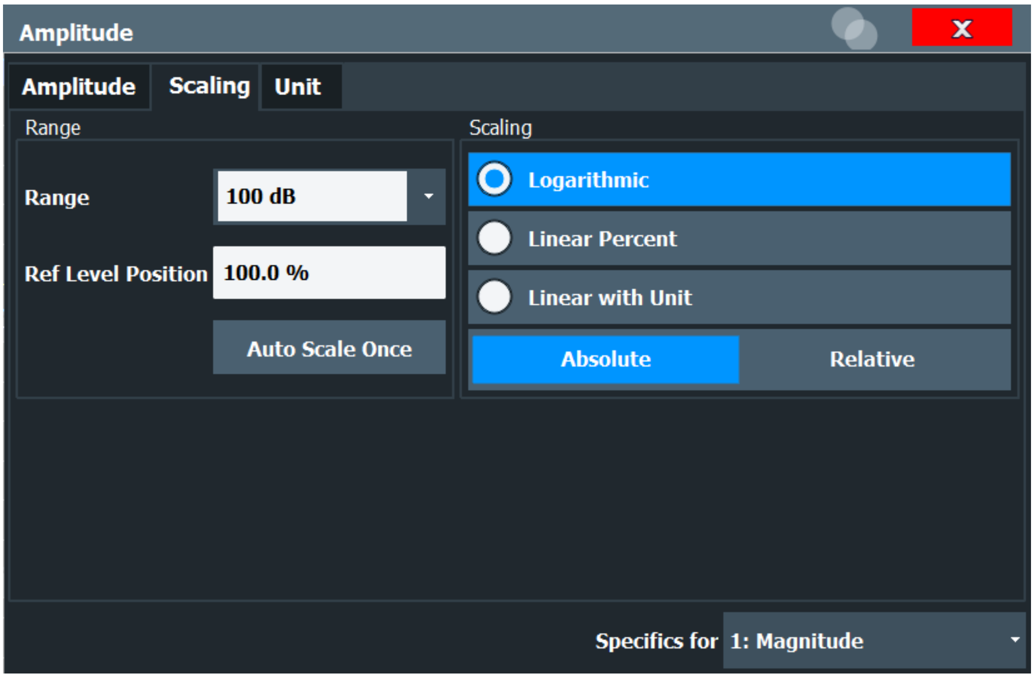


Figure 6-1: Scaling settings for Magnitude display

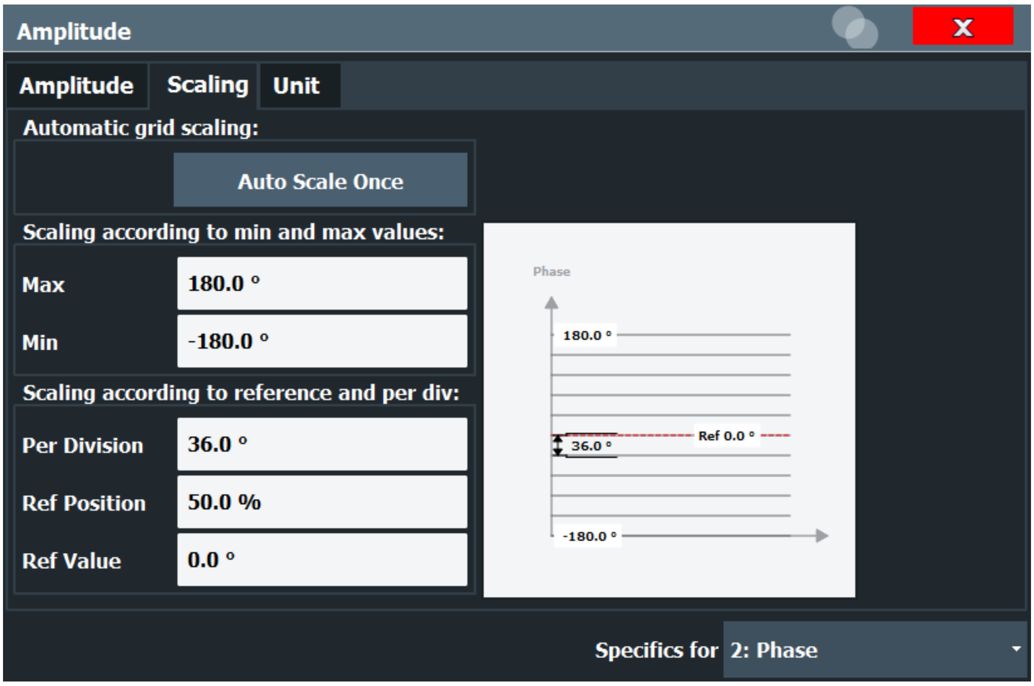


Figure 6-2: Scaling settings for Phase and Group Delay display

Auto Scale Once

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

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

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:AUTO ONCE` on page 131

Defining a Range and the Reference Level Position

For "Magnitude" displays, you can define the position of the reference level (for linear scaling), or define the range in dB and the position of the reference level.

Range ← Defining a Range and the Reference Level Position

Defines the displayed y-axis range in dB.

The default value is 100 dB.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]` on page 131

Ref Level Position ← Defining a Range and the Reference Level Position

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

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

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

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

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RPOSition` on page 133

Scaling ← Defining a Range and the Reference Level Position

Defines the scaling method for the y-axis.

"Logarithmic"	Logarithmic scaling (only available for logarithmic units - dB..., and A, V, Watt)
"Linear with Unit"	Linear scaling in the unit of the measured signal
"Linear Percent"	Linear scaling in percentages from 0 to 100

"Absolute" The labeling of the level lines refers to the absolute value of the reference level (not available for "Linear Percent")

"Relative" The scaling is in dB, relative to the reference level (only available for logarithmic units - dB...). The upper line of the grid (reference level) is always at 0 dB.

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y:SPACing on page 134
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:MODE
on page 132

Configuring a Reference Point and Divisions
Defines the displayed range using a reference point and the size of the divisions.

Y-Axis Reference Value ← Configuring a Reference Point and Divisions
Defines a reference value for the y-axis in the current unit. The y-axis is adapted so that the reference value is displayed at the Y-Axis Reference Position.

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RVALue
on page 134

Y-Axis Reference Position ← Configuring a Reference Point and Divisions
Defines the position of the Y-Axis Reference Value on the y-axis. The position is defined as a percentage value, where 0 % refers to the bottom edge, 100 % refers to the top edge of the screen. The y-axis is adapted so that the reference value is displayed at the reference position.

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RPOSition
on page 133

Range per Division ← Configuring a Reference Point and Divisions
Defines the value range to be displayed per division. Since the display consists of 10 divisions by default, the displayed range is:

*Range = 10 * <Range per Division>*

Note: If fewer divisions are displayed (e.g. because the window is reduced in height), the range per division is increased. Thus, the same result range is displayed in the smaller window. In this case, the range per division does not correspond to the actual display.

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:PDIVision
on page 133

Defining Min and Max Values
Defines the displayed range using minimum and maximum values.

Remote command:
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MINimum on page 132
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MAXimum on page 132

Scale Mode
For "Gain" display only: Defines the scaling method for the y-axis.

"Logarithmic" Logarithmic scaling (only available for logarithmic units - dB...)

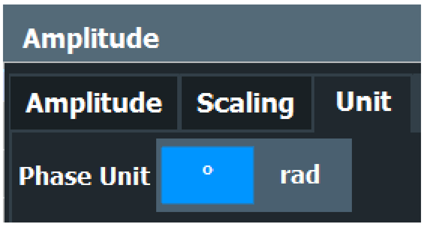
"Linear" Linear scaling in percentages from 0 to 100

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:MODE` on page 132

6.3.3 Unit

Access: "Overview" > "Amplitude" > "Unit" tab

The unit defines how the measured data is displayed.

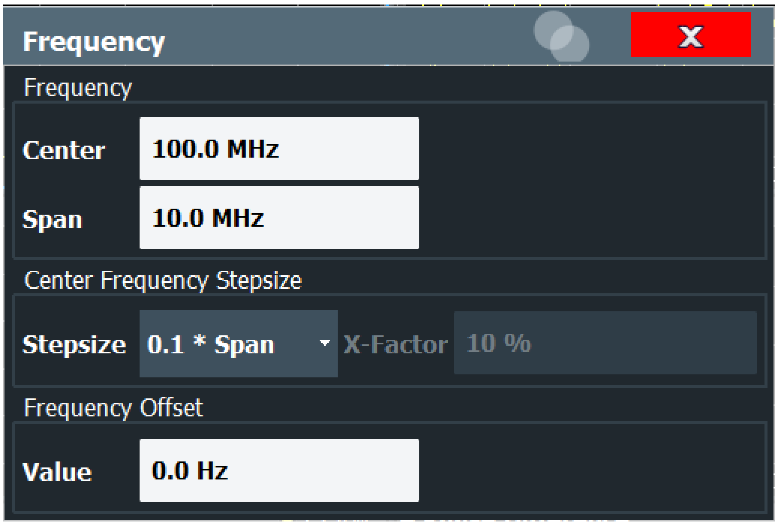


Phase Unit (Rad/Deg)
Sets the phase unit to rad or deg for displaying phase signals.

Remote command:
`UNIT:ANGLe` on page 135

6.4 Frequency settings

Access: "Overview" > "Frequency"



Center Frequency

Defines the center frequency of the signal in Hertz.

Remote command:

`[SENSe:]FREQuency:CENTer` on page 135

Span

Defines the frequency span to be measured. Only a multiple of the carrier spacing can be defined. The Number of Carriers is adapted accordingly (see "Dependency of the span on the number of carriers" on page 26).

Remote command:

`[SENSe<ip>:]FREQuency:SPAN` on page 147

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.

"X * Span" Sets the step size for the center frequency to a defined factor of the span. The "X-Factor" defines the percentage of the span.
Values between 1 % and 100 % in steps of 1 % are allowed. The default setting is 10 %.

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

"= Marker" This setting is only available if a marker is active.
Sets the step size to the value of the current marker and removes the coupling of the step size to span. 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 135

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

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

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

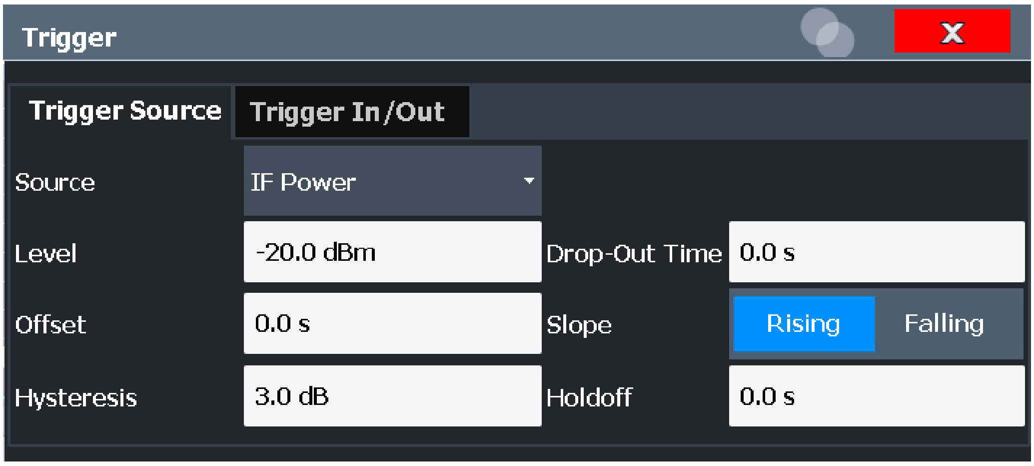
The allowed values range from -1 THz to 1 THz. The default setting is 0 Hz.

Remote command:
[SENSe:]FREQuency:OFFSet on page 136

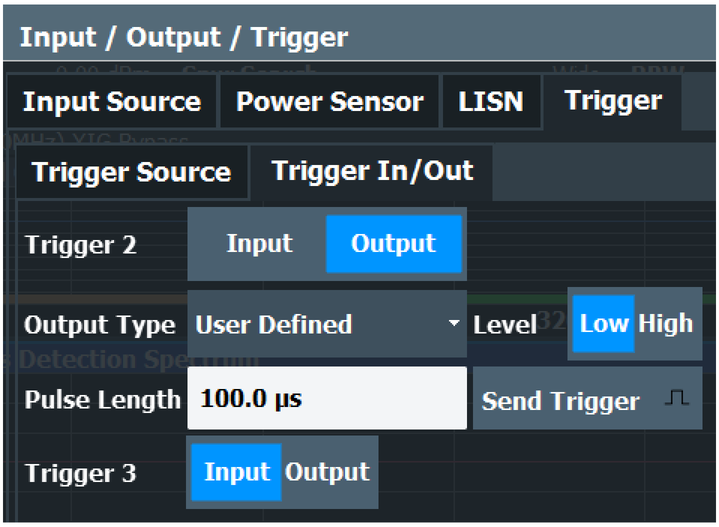
6.5 Trigger settings

Access: "Overview" > "Trigger"

Trigger settings determine when the input signal is measured.



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



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

Trigger Source

The trigger settings define the beginning of a measurement.

Trigger Source ← Trigger Source

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

Remote command:

`TRIGger[:SEQuence]:SOURce` on page 140

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

Remote command:
`TRIG:SOUR IMM`, see `TRIGger[:SEQuence]:SOURce` on page 140

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

(See "Trigger Level" on page 52).

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

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

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

"External Trigger 2"
Trigger signal from the "TRIGGER 2 INPUT / OUTPUT" connector.
Note: Connector must be configured for "Input" in the "Output" configuration
For FSW85 models, "Trigger 2" is not available due to the second RF input connector on the front panel.
(See the FSW base unit user manual).

"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 "Output" configuration.
(See FSW base unit user manual).

Remote command:
`TRIG:SOUR EXT`, `TRIG:SOUR EXT2`
`TRIG:SOUR EXT3`
See `TRIGger[:SEQuence]:SOURce` on page 140

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

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

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

This trigger source is only available for RF input.

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

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

Note: Be aware that in auto sweep type mode, due to a possible change in sweep types, the trigger bandwidth can vary considerably for the same RBW setting.

Remote command:
`TRIG:SOUR IFP`, see `TRIGger[:SEQuence]:SOURce` on page 140

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

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

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

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

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

Remote command:
`TRIG:SOUR RFP`, see `TRIGger[:SEQuence]:SOURce` on page 140

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

Remote command:
`TRIG:SOUR IQP`, see `TRIGger[:SEQuence]:SOURce` on page 140

Time ← Trigger Source ← Trigger Source
Triggers in a specified repetition interval.

See "Repetition Interval" on page 53.

Remote command:
`TRIG:SOUR TIME`, see `TRIGger[:SEQuence]:SOURce` on page 140

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

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

Remote command:
`TRIGger[:SEQuence]:LEVel:IFPower` on page 139
`TRIGger[:SEQuence]:LEVel:IQPower` on page 139
`TRIGger[:SEQuence]:LEVel[:EXTernal<port>]` on page 138

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

Remote command:
TRIGger[:SEQuence]:DTIMe on page 137

Trigger Offset ← Trigger Source

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

Offset > 0:	Start of the sweep is delayed
Offset < 0:	Sweep starts earlier (pretrigger)

Remote command:
TRIGger[:SEQuence]:HOLDoff[:TIME] on page 138

Hysteresis ← Trigger Source

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

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

Remote command:
TRIGger[:SEQuence]:IFPower:HYSTeresis on page 138

Trigger Holdoff ← Trigger Source

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

Remote command:
TRIGger[:SEQuence]:IFPower:HOLDoff on page 138

Slope ← Trigger Source

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

Remote command:
TRIGger[:SEQuence]:SLOPe on page 140

Repetition Interval

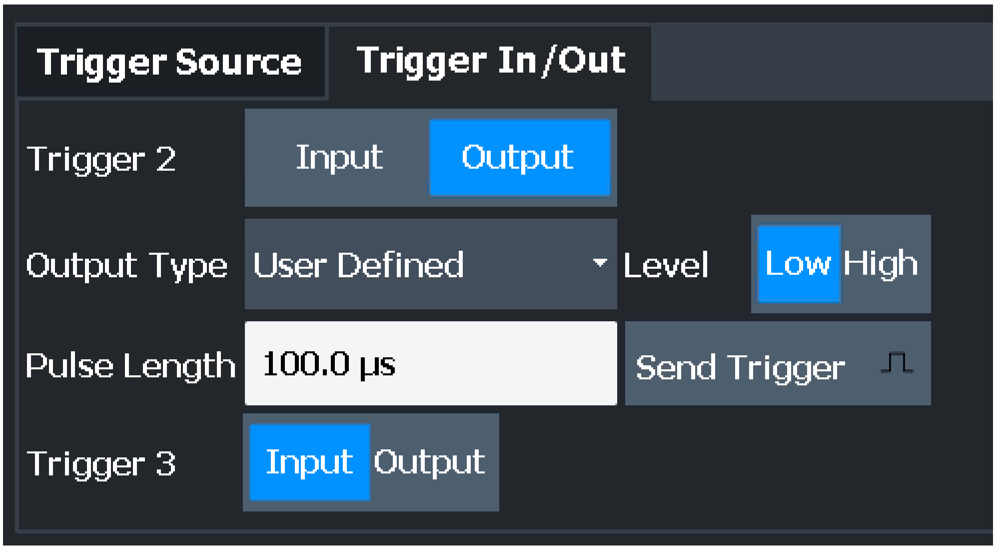
Defines the repetition interval for a time trigger.

The shortest interval is 2 ms.

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

Remote command:
TRIGger[:SEQuence]:TIME:RINTerval on page 141

Trigger 2/3



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

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

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

Remote command:
`OUTPut:TRIGger<tp>:DIRection` on page 142

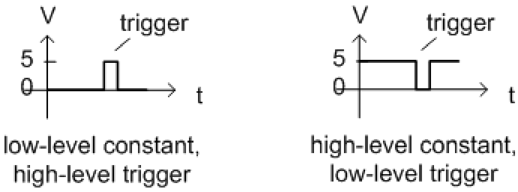
Output Type ← Trigger 2/3
Type of signal to be sent to the output

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

Remote command:
`OUTPut:TRIGger<tp>:OTYPe` on page 143

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

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



Remote command:
`OUTPut:TRIGger<tp>:LEVel` on page 142

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

Remote command:
`OUTPut:TRIGger<tp>:PULSe:LENGth` on page 143

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

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

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

Remote command:
`OUTPut:TRIGger<tp>:PULSe:IMMediate` on page 143

6.6 Multi-carrier configuration

Access: "Overview" > "Multi Carrier Meas Config"

Or: [MEAS CONFIG] > "Multi Carrier Description"

6.6.1 Multi-carrier description

The multiple carriers are configured in the "Multi-Carrier Description" tab.

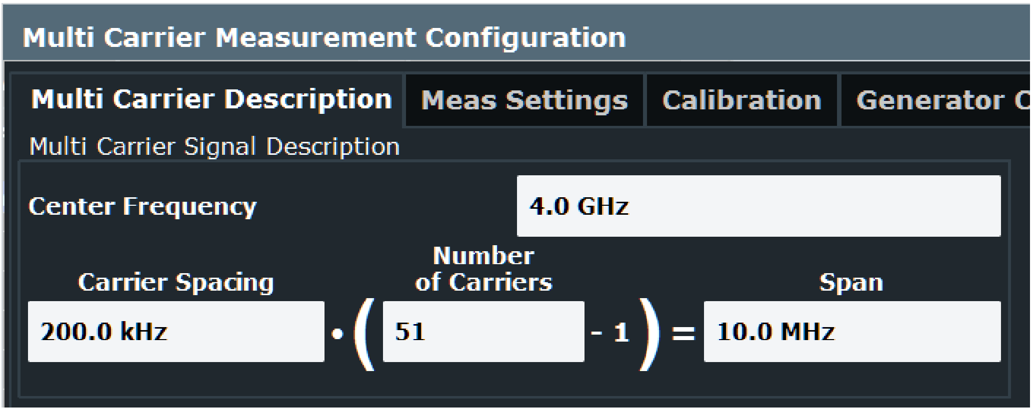


Figure 6-3: Multi Carrier Description dialog in FSW-K17 application.

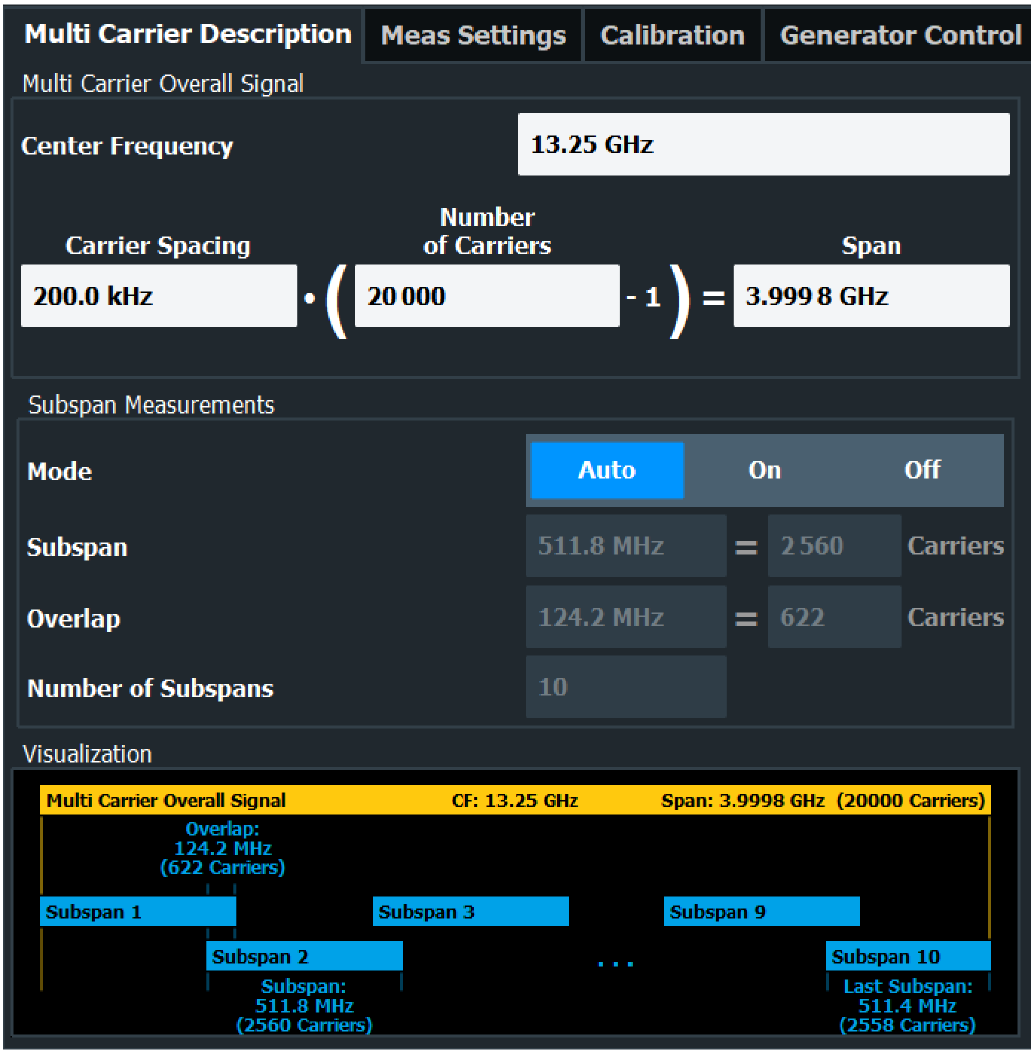


Figure 6-4: Multi Carrier Description dialog with FSW-K17S application installed.

Center Frequency

Defines the center frequency of the signal in Hertz.

Remote command:

`[SENSe:]FREQuency:CENTer` on page 135

Carrier Spacing

Defines the spacing between two carriers. The Number of Carriers and the Number of Carriers are adapted accordingly (see "Dependency of the span on the number of carriers" on page 26).

To avoid ambiguous results, define the carrier spacing such that the expected group delay does not exceed the unambiguous range:

$$UnambiguousRange = \pm \frac{1}{2 * CarrierSpacing}$$

For details, see "Unambiguous group delay results" on page 28.

Remote command:
[SENSe:]CARRier:SPACing on page 146

Number of Carriers
Defines the number of carriers in the signal. The "Span" on page 48 and Carrier Spacing are adapted according to the following formula:

Number of carriers -1 = Span / Carrier spacing

For details, see "Dependency of the span on the number of carriers" on page 26.

Remote command:
[SENSe:]CARRier:COUNt on page 146

Span
Defines the frequency span to be measured. Only a multiple of the carrier spacing can be defined. The Number of Carriers is adapted accordingly (see "Dependency of the span on the number of carriers" on page 26).

Remote command:
[SENSe<ip>:]FREQuency:SPAN on page 147

Mode (FSW-K17S)
Sets the status of the "Frequency Subspan Measurements" mode.

- **Auto**
  The FSW-K17S application selects automatically if subspan measurements are activated. If the defined span is smaller than the maximum available bandwidth of signal generator and spectrum analyzer, subspan measurements stay inactive. If subspan measurements are needed to cover the defined span, the parameters in the "Subspan Measurements" dialog are set automatically.
- **On**
  Subspan measurements are active. The parameters in the "Subspan Measurements" dialog can be set manually.
- **Off**
  Subspan measurements are deactivated. The maximum available bandwidth for measurements is equal to the maximum analysis bandwidth of the instrument.

Remote command:
[SENSe:]SUBSpan:MODE on page 150

Subspan (FSW-K17S)
Defines the bandwidth of a subspan. It can be defined as a bandwidth in Hz or as the corresponding number of carriers.

It is recommended to use an even number of subspan carriers in order to avoid generator center frequency bleed through.

Remote command:
[SENSe:]SUBSpan[:BANDwidth] on page 150
[SENSe:]SUBSpan:CARRier:COUNt on page 150

Overlap (FSW-K17S)
Defines the overlap of one subspan to the next subspan. It can be defined as an overlap in Hz or as the corresponding number of carriers.

It is recommended to use an overlap of at least 2 carriers in order to obtain a continuous group delay trace result.

Remote command:
[SENSe:]SUBSpan:OVERlap on page 151
[SENSe:]SUBSpan:OVERlap:CARRier:COUNt on page 151

Number of Subspans (FSW-K17S)
Defines the number of subspans that are analyzed.

Remote command:
[SENSe:]SUBSpan:COUNt on page 150

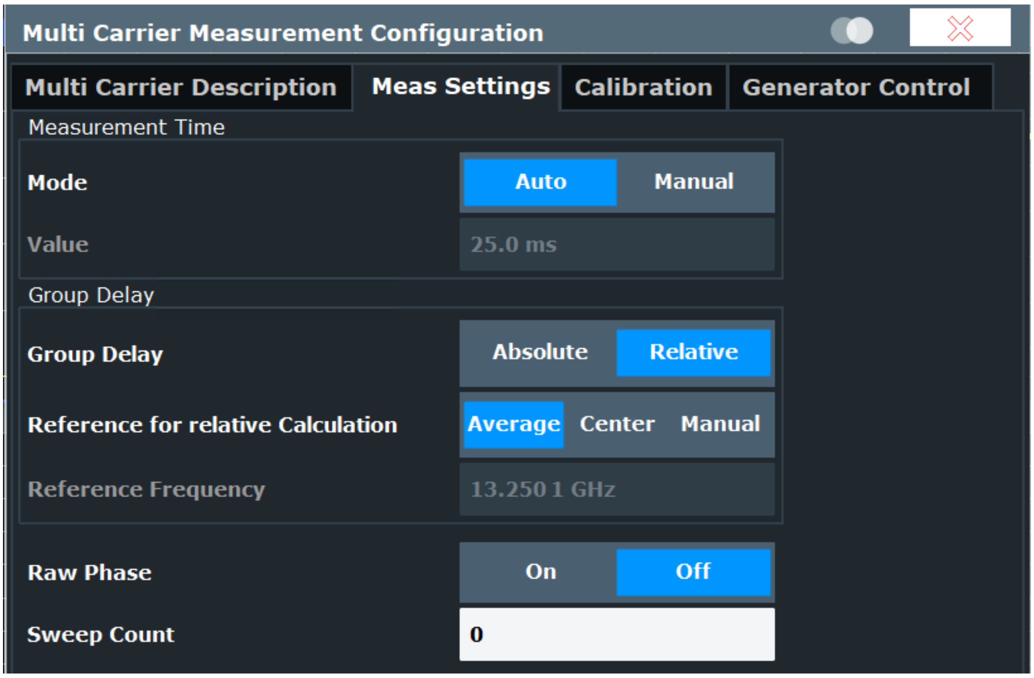
Visualization (FSW-K17S)
The visualization graphic shows the correlation between overall signal and subspan measurement settings. Sometimes it can also be visible that the last subspan is smaller than the selected subspan bandwidth.

6.6.2 Measurement settings

Access: "Overview" > "Multi Carrier Meas Config" > "Meas Settings" tab

Or: [MEAS CONFIG] > "Meas Settings" tab

Depending on the group delay mode, the measurement parameters for group delay calculation vary slightly. You must specify the configuration of multiple carriers for the measurement.



Measurement Time

Defines the duration of data acquisition

With option FSW-K17S installed and subspan measurements active, the measurement time refers to a single subspan and not the overall span.

"Auto" (Default:) In automatic mode the required time is determined according to carrier spacing and span; the currently used measurement time is indicated for reference only

"Manual" The measurement time is defined manually; enter the measurement time in seconds

Remote command:

`[SENSe:]MTIMe` on page 151

`[SENSe:]MTIMe:AUTO` on page 151

Group Delay Mode

Defines how the group delay is calculated. Note that this setting also affects the "phase difference" results (see "Phase Difference" on page 23).

"Absolute" Calculates the absolute group delay; requires an external trigger

"Relative" Calculates the relative group delay; the reference is configurable (see Reference for Relative Calculation/ Reference Frequency)

Remote command:

`CALCulate<n>:GRPDelay:MODE` on page 144

Reference for Relative Calculation/ Reference Frequency

Determines the reference used for relative group delay measurement.

"Average" (Default:) The average group delay is used as a reference

"Center" The group delay measured for the center frequency is used as a reference

"Manual" The group delay measured at the user-defined "Reference Frequency" is used as a reference

Remote command:

`CALCulate:GRPDelay:REFerence` on page 145

`CALCulate:GRPDelay:REFerence:FREQuency` on page 145

Trigger Source

The trigger source used for the group delay measurement; the trigger specified here is the same as in the Chapter 6.5, "Trigger settings", on page 49). It is provided here for convenience as absolute group delay measurement requires an external trigger.

Remote command:

`TRIGger[:SEQuence]:SOURce` on page 140

Trigger Uncertainty
For absolute group delay measurement using an external trigger, the trigger uncertainty for the current bandwidth (=Span) is indicated. This value is considered as an additional error in the group delay calculation.

Raw Phase
Normally, the FSW-K17 application compensates measurements for an (arbitrary) phase offset before displaying the results in the "Phase" result display. This is done for each capture to get a stable phase display. In order to deactivate this behavior (i.e. no compensation), the "Raw Phase" feature can be activated. The "Raw Phase" allows to relate the phase plot from measurement 1 to the phase plot of measurement 2, etc. This can be useful e.g. for phased array measurements.

When using an even number of carriers and having applied no trigger ("Free Run"), the raw phase arbitrarily can change between +/- 180°. This is no measurement error but an effect resulting in the mathematical definition of the raw phase.

The "Raw Phase" cannot be used in combination with subspan measurements.

Remote command:
`[SENSe:]RAWPhase[:STATe]` on page 149

Sweep Count
Defines the number of sweeps to be performed in the single sweep mode. Values from 0 to 32767 are allowed. If the values 0 or 1 are set, one sweep is performed. The sweep count is applied to all the traces in all diagrams.

During calibration measurements, the phase and amplitude values are averaged over the defined number of sweeps.

If the trace configurations "Average", "Max Hold" or "Min Hold" are set, this value also determines the number of averaging or maximum search procedures.

In continuous sweep mode, if sweep count = 0 (default), averaging is performed over 10 sweeps. For sweep count =1, no averaging, Max Hold or Min Hold operations are performed.

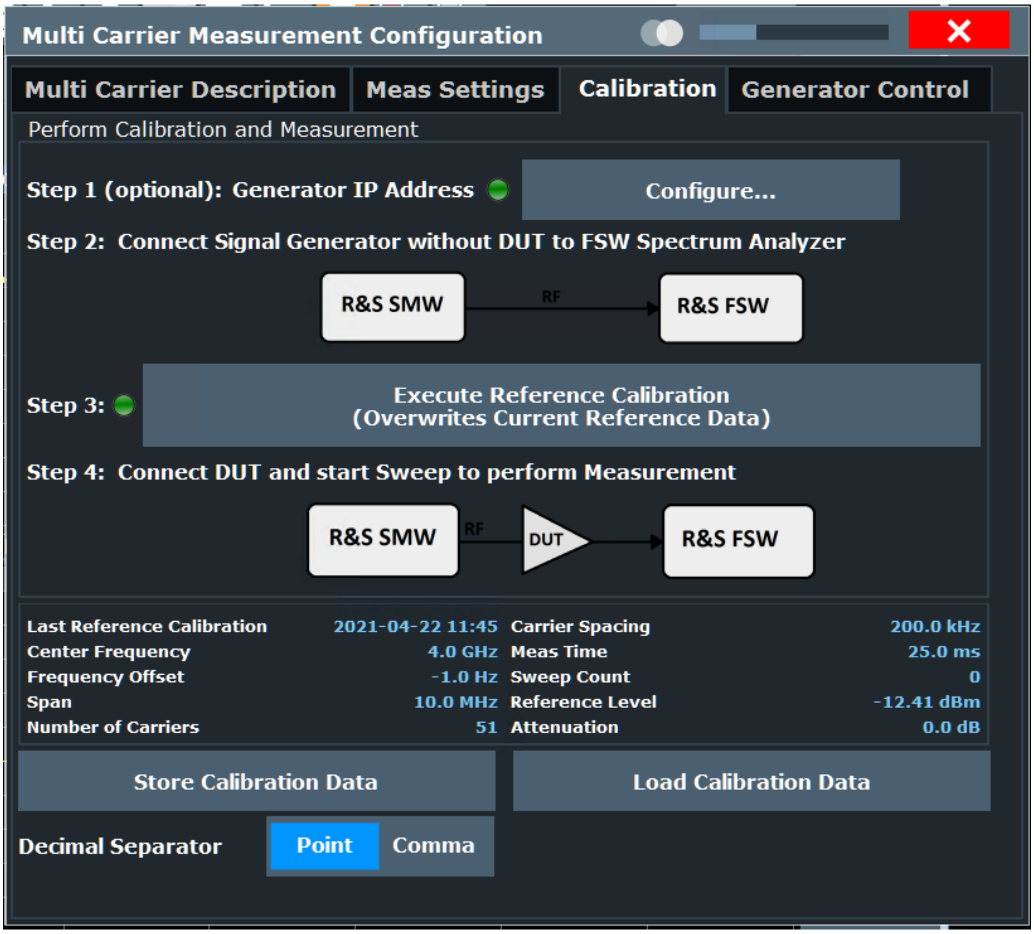
Remote command:
`[SENSe:]SWEep:COUNt` on page 179

6.6.3 Calibration

Access: "Overview" > "Multi-Carrier Config" > "Calibration" tab

Or: [MEAS CONFIG] > "Multi-Carrier Config" > "Calibration" tab

The calibration measurement is the first measurement required to determine the group delay. Optionally, a connected signal generator can be controlled directly from the FSW to configure the calibration measurement.



The values defined by the most recently performed or loaded calibration measurement are displayed at the bottom of the dialog box.

The overall status of the calibration measurement is indicated by an LED on the dialog tab. Thus, you can quickly detect the cause of possible errors.

The LED indicates the following states:

- **green:** connection established and all settings valid
- **red:** control error, for example because a specified value cannot be applied on the signal generator
- **gray:** signal generator control off

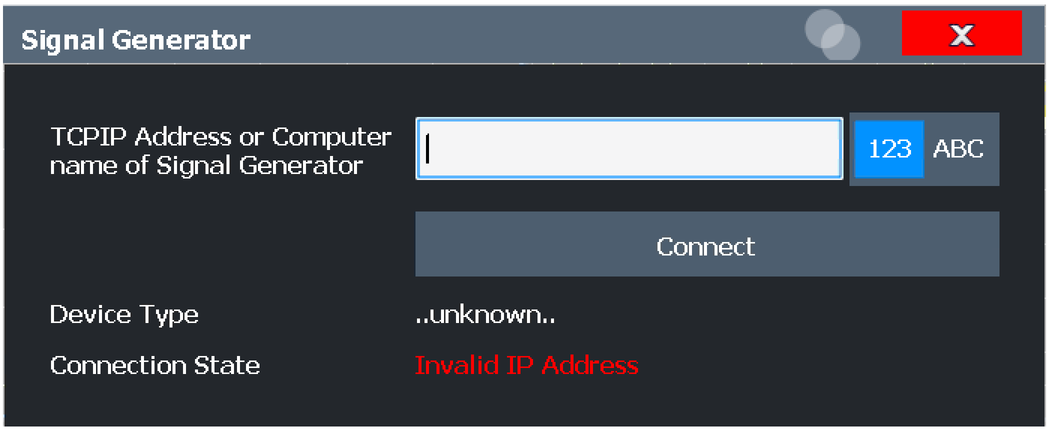
IP Address

Indicates the state and address of a connected signal generator.

The LED indicates the following connection states:

- **green:** connection established to compatible generator
- **red:** connection could not be established, possibly due to an incompatible instrument
- **gray:** no signal generator connected

Select the TCPIP address or "Configure" to define the connection information for the connected signal generator.



Remote command:
CONFigure:GENerator:CONNection:CSTate? on page 152
CONFigure:GENerator:MCGD:CONNection:CSTate? on page 154

IP Address / Computer Name ← IP Address

The IP address or computer name of the signal generator connected to the FSW via LAN.

By default, the IP address is expected. To enter the computer name, toggle the "123"/"ABC" button to "ABC".

Select Connect/Disconnect to establish a connection from the FSW to the specified signal generator.

Note: While a connection to a signal generator is established, you cannot change the connection information.
The IP address / computer name is maintained after a [PRESET], and is transferred between applications. However, when you switch applications, the control is disabled in the other applications. Only one application can control a generator at any time.

Remote command:
CONFigure:GENerator:IPConnection:ADDRess on page 153

Connect/Disconnect ← IP Address

The FSW attempts to establish a connection to the signal generator, or disconnects it.

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

- Device type
- Name and serial number
- Connection state

Remote command:
CONFigure:GENerator:CONNection[:STATe] on page 153
CONFigure:GENerator:CONNection:CSTate? on page 152
CONFigure:GENerator:MCGD:CONNection:CSTate? on page 154

Calibrate (Execute Reference Calibration)
Starts a new sweep to perform a calibration measurement. The status of the running measurement is indicated in a dialog box. During this time, no other actions can be performed on the FSW. The results are used as reference data for the group delay and gain calculation.

The date and time of the most recently performed or loaded calibration measurement is indicated in the channel bar and at the bottom of the dialog box.

The values defined by the most recently performed or loaded calibration measurement are displayed at the bottom of the dialog box.

The status of the calibration measurement is also indicated by an LED next to the "Execute Reference Calibration" button in the dialog box. Thus, you can quickly detect the cause of possible errors.

The LED indicates the following states:

- **green:** reference calibration available and valid
- **red:** reference calibration available, but not compatible to the currently defined multi-carrier measurement configuration
- **gray:** no reference data available

Remote command:
CALibration:MCGD on page 165

Storing Calibration Data
Stores the calibration data (reference data) to the selected file (**.csv** format)

Remote command:
MMEMory:STORe<n>:MCGD:RCALibration on page 166

Loading Calibration Data
Loads the calibration data (reference data) from the selected file (.csv format) to the instrument. The current reference data in the MCGD application is overwritten; the loaded data is used for the group delay calculation.

Remote command:
MMEMory:LOAD:MCGD:RCALibration on page 166

Decimal Separator
Defines the decimal separator for floating-point numerals for the data export/import files. Evaluation programs require different separators in different languages.

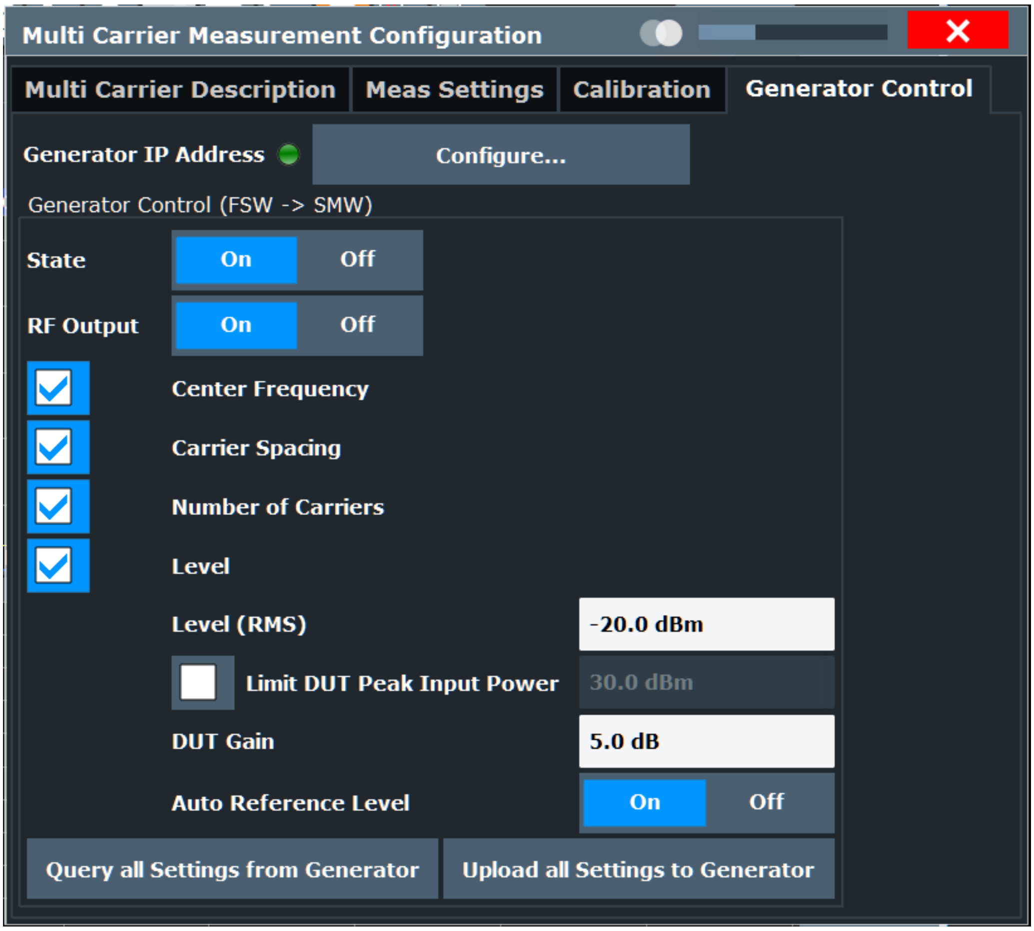
Remote command:
FORMat:DEXPort:DSEParator on page 184

6.6.4 Generator control

Access: "Overview" > "Multi-Carrier Config" > "Generator Control" tab

Or: [MEAS CONFIG] > "Multi-Carrier Config" > "Generator Control" tab

The general settings required to control a connected signal generator by the FSW are defined here. The control settings are only available if a connection to a signal generator has been established.



Remote command:

`CONFigure:GENerator:MCGD:OSTate?` on page 157

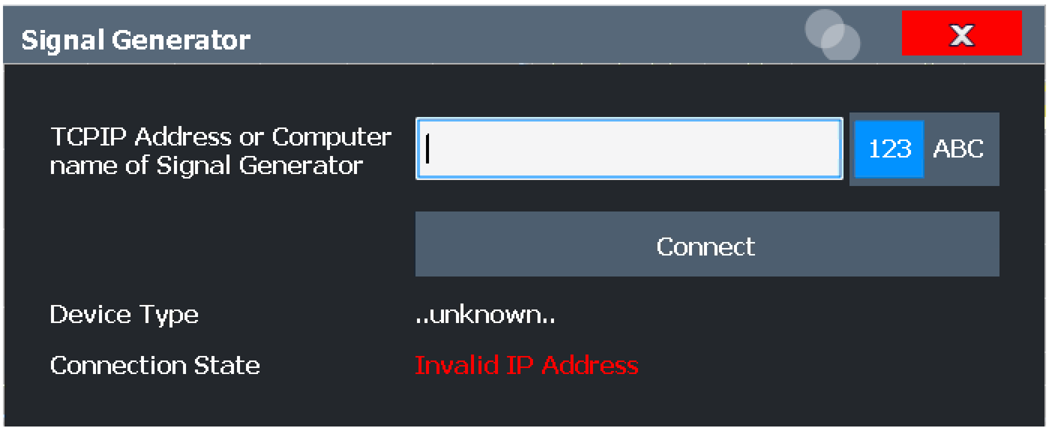
IP Address

Indicates the state and address of a connected signal generator.

The LED indicates the following connection states:

- **green:** connection established to compatible generator
- **red:** connection could not be established, possibly due to an incompatible instrument
- **gray:** no signal generator connected

Select the TCPIP address or "Configure" to define the connection information for the connected signal generator.



Remote command:
`CONFigure:GENerator:CONNection:CSTate?` on page 152
`CONFigure:GENerator:MCGD:CONNection:CSTate?` on page 154

IP Address / Computer Name ← IP Address

The IP address or computer name of the signal generator connected to the FSW via LAN.

By default, the IP address is expected. To enter the computer name, toggle the "123"/"ABC" button to "ABC".

Select Connect/Disconnect to establish a connection from the FSW to the specified signal generator.

Note: While a connection to a signal generator is established, you cannot change the connection information.
The IP address / computer name is maintained after a [PRESET], and is transferred between applications. However, when you switch applications, the control is disabled in the other applications. Only one application can control a generator at any time.

Remote command:
`CONFigure:GENerator:IPConnection:ADDRess` on page 153

Connect/Disconnect ← IP Address

The FSW attempts to establish a connection to the signal generator, or disconnects it.

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

- Device type
- Name and serial number
- Connection state

Remote command:
CONFigure:GENerator:CONNection[:STATe] on page 153
CONFigure:GENerator:CONNection:CSTate? on page 152
CONFigure:GENerator:MCGD:CONNection:CSTate? on page 154

Generator Control State

Activates or disables control of the signal generator by the FSW.

If a connection was defined in another measurement channel, the connection is maintained when you switch to the R&S FSW MCGD application. However, generator control is disabled to protect the DUT from possibly erroneous or damaging settings. Check the settings, then enable the control state.

Note: While generator control is active, you cannot change the connection information. Only one channel can control a generator at any time. If you switch on generator control while it is still active in another channel, for example for parameter coupling with a generator, the control is disabled in the other channel.

Exception: The SCPI Recorder maintains control of the generator even if you switch channels.

Remote command:
CONFigure:GENerator:MCGD:CONTrol[:STATe] on page 154

RF Output State

To protect the instrument from possibly erroneous or damaging settings, you must manually activate the RF output on the signal generator to start providing a signal. Check all settings on the signal generator, in particular the level settings, before activating the RF output.

A red LED on the "Generator Control" tab indicates a setting error on the generator.

Remote command:
CONFigure:GENerator:RFOutput[:STATe] on page 157

Center Frequency Control State

If enabled, any changes to the center frequency on the FSW are automatically also applied to the connected signal generator. Initially, the value defined in the Measurement settings is applied. If Automated Frequency Translating Measurement State is active, the center frequency is set according to the Frequency translating measurement configuration.

Remote command:
CONFigure:GENerator:MCGD:FREQuency:CENTer:STATe on page 155

Carrier Spacing Control State

If enabled, any changes to the carrier spacing on the FSW are automatically also applied to the connected signal generator. Initially, the value defined in the Measurement settings is applied.

Remote command:
CONFigure:GENerator:MCGD:CARRier:SPACing:STATe on page 154

Number of Carriers Control State
If enabled, any changes to the number of carriers on the FSW are automatically also applied to the connected signal generator. Initially, the value defined in the Measurement settings is applied.

Remote command:
CONFigure:GENerator:MCGD:CARRier:COUNt:STATe on page 153

Level Control State
If enabled, the FSW automatically controls the signal level provided by the signal generator as input to the FSW. Initially, the Level (RMS)value is applied. Note that the reference level on the FSW is also affected by the signal level:

$Ref\_level_{Analyzer}$= <Peak envelope power DUT> + DUT Gain

Where the current peak envelope power (PEP) value of the DUT is determined from the generator.

To protect the signal generator from possibly excess power levels, the level setting control is disabled by default.

With option FSW-K17S installed and subspan measurements active, the value of "Level (RMS)" refers to the generator output level for each single subspan measurement and not to the overall span.

Remote command:
CONFigure:GENerator:MCGD:LEVel:STATe on page 157

Level (RMS) ← Level Control State
(Default:) The specified power level is used for the output power by the connected signal generator.

With option R&S FSW-K17S installed and subspan measurements active, the value of "Level (RMS)" refers to the generator output level for each single subspan measurement and not to the overall span.

Remote command:
CONFigure:GENerator:MCGD:LEVel on page 155

Limit DUT Peak Input Power ← Level Control State
If enabled, the generator does not exceed the maximum input power (peak envelope power, "PEP") that is currently allowed by the DUT and that is specified on the generator. The defined "PEP" value is indicated.

Remote command:
CONFigure:GENerator:MCGD:LEVel:DUTLimit:STATe on page 156
CONFigure:GENerator:MCGD:LEVel:DUTLimit on page 156

DUT Gain ← Level Control State
The FSW considers a gain due to the DUT when determining the reference level.

During the reference calibration measurement, in which the DUT is removed from the signal path, the generator level is also adjusted according to the DUT gain value.

Remote command:
CONFigure:GENerator:MCGD:LEVel:DUTGain on page 156

Auto Reference Level ← Level Control State
If active, the FSW automatically adapts the reference level if Level (RMS) or the DUT Gain is changed.

If you change the reference level on the FSW manually, "Auto Reference Level" is automatically deactivated.

Remote command:
CONFigure:GENerator:MCGD:LEVel:ARLevel[:STATe] on page 155

Upload all Settings to Generator
Applies all generator setup settings defined on this tab to the connected signal generator once.

This is useful directly after activating generator control, for example, or when you change settings on the generator. As soon as generator control is active, any changes to the general settings on the FSW are immediately applied to the generator automatically.

Remote command:
CONFigure:GENerator:MCGD:SETTings:UPDate on page 157

Query all Settings from Generator
Queries all currently defined generator setup settings on the connected signal generator and applies the settings to the FSW.

This is useful directly after activating generator control, for example, or when you change settings on the generator. The FSW does *not* automatically adapt its settings when you make changes on the generator.

Remote command:
CONFigure:SETTings:MCGD on page 158

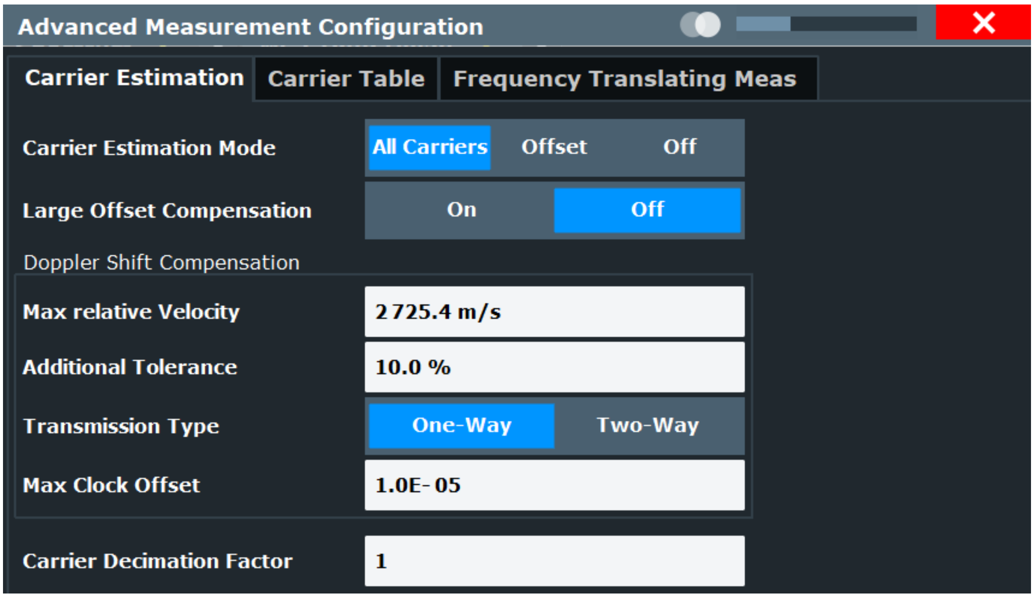
6.7 Advanced measurement configuration

Access: "Overview" > "Advanced Meas Config"

Or: [MEAS CONFIG] > "Advanced Meas Config"

6.7.1 Carrier estimation

The carriers estimation parameters are configured in the "Carrier Estimation" tab.



Carrier Estimation Mode

Defines whether the carrier frequencies of the captured multi-carrier signal are estimated and then compensated for.

"All Carriers" Estimates the frequency for each carrier and uses the determined frequencies when calculating measurement results.
This estimation is useful for in-orbit measurements of satellites for which the group delay can be distorted due to the Doppler effect.

"Offset" The frequency offset is assumed to be identical for all carriers. It is estimated and the determined frequencies are then used for calculation of measurement results.

"Off" The carrier frequencies as defined in the multi-carrier signal description are used. Possible offsets are not compensated.

Remote command:
`[SENSe:]CESTimation:MODE` on page 147
`[SENSe:]CARRier:OFFSet?` on page 146
`[SENSe:]CLOCk:OFFSet?` on page 146
`[SENSe:]CARRier:OFFSet:MODE` on page 209 (deprecated)

Large Offset Compensation

- **On**
  Large offset compensation enables the R&S FSW MCGD application to handle frequency offsets in the captured multi-carrier signal, larger than half the carrier spac-

ing. This can be necessary in order to compensate for a frequency offset resulting from large Doppler shift. The multi-carrier spectrum is centered according to the spectral power of the individual carriers to compensate for the frequency offset. The signal generator has to be configured to output a multi-carrier signal that corresponds to the multi-carrier signal description including providing exactly the same amount of defined number of carriers.

- **Off**
  Only frequency offsets smaller than half the carrier spacing can be compensated. This setting provides functionality to handle a measurement tasks where the span is set to only analyze a sub part of a broader multi-carrier signal. In this case, an activated large offset compensation could misinterpret the carriers outside the span as a Doppler shift.

Remote command:
`[SENSe:]CEStimation:LOComp` on page 147

Max relative Velocity
Defines the relative velocity between ground station and satellite in m/s. This information is used to calculate the Max Clock Offset.

Remote command:
`[SENSe:]CEStimation:MVELocity` on page 148

Additional Tolerance
Defines an additional tolerance to the Max relative Satellite Velocity in %. This information is used to calculate the Max Clock Offset.

Remote command:
`[SENSe:]CEStimation:VTOLerance` on page 149

Transmission Type
Defines the satellite transmission type. This information is necessary to correctly calculate the Max Clock Offset.

Remote command:
`[SENSe:]CEStimation:TRANsmission` on page 149

Max Clock Offset
Defines the maximum clock offset the frequency estimation algorithm of the FSW-K17 application is able to handle. Larger values for this parameter result in slower measurement speed.

This parameter is automatically calculated using the other three "Doppler Shift Compensation" parameter settings. For the calculation, speed of light in medium vacuum (cvac) is used.

This parameter is calculated according to the maximum relative velocity v_{rel} for satellite in-orbit measurements:

- For a one-way transmission Sat -> Earth:

$$MaxClockOffset = \frac{vrel,max \cdot (1 + AdditionalTolerance/100)}{c}$$

- For a two-way transmission Earth -> Sat -> Earth:

$$MaxClockOffset = (1 + \frac{vrel,max \cdot (1 + AdditionalTolerance/100)}{c})^2 - 1$$

If a value for max clock offset is entered manually, the Max relative Velocity is adjusted accordingly.

Remote command:
[SENSe:]CESTimation:MCOFfset on page 148

Carrier Decimation Factor
Improves the measurement speed by decimating the number of carriers used for the frequency estimation synchronization as a speed vs accuracy tradeoff in carrier estimation mode "All Carriers". For example, a value of "1000" configures the synchronization to only use each 1000th carrier for frequency estimation and significantly speeds up the measurement for scenarios with large number of carriers (100k carriers scenarios) while still providing good measurement accuracy. A value of "1" provides the best possible measurement accuracy. The value is clipped internally to 2 carriers if set larger then the available number of carriers configured in the multi-carrier signal description.

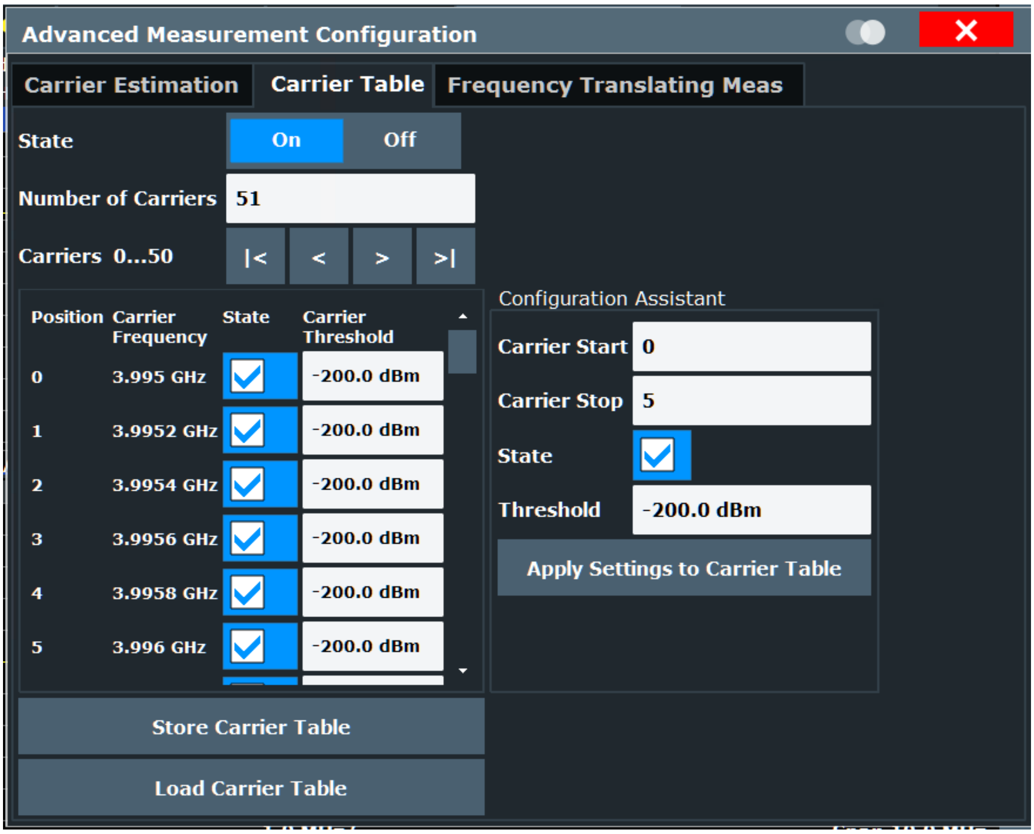
Remote command:
[SENSe:]CESTimation:CDECimation on page 148

6.7.2 Carrier table

Access: "Overview" > "Multi-Carrier Config" > "Carrier Table" tab

Or: [MEAS CONFIG] > "Multi-Carrier Config" > "Carrier Table" tab

The "carrier table" provides functionality to define the state of multiple carriers and set their respective threshold in the Multi-Carrier "Group Delay" measurements application.



Carrier Table State

Activates or deactivates the "carrier table" for signal processing and result display.

Remote command:

`CONFigure:CTABle:STATe` on page 158

Number of Carriers

Defines the number of carriers in the signal. The "Span" on page 48 and Carrier Spacing are adapted according to the following formula:

Number of carriers -1 = Span / Carrier spacing

For details, see "Dependency of the span on the number of carriers" on page 26.

Remote command:

`[SENSe:]CARRier:COUNt` on page 146

Carrier State

Defines if the carrier is taken into account for signal estimation and result display.

Remote command:
CONFigure:CTABle:CARRier:STATe on page 158

Carrier Threshold
Defines a minimum value for the carrier to be part of the result display visualization.

Remote command:
CONFigure:CTABle:CARRier:THReshold on page 159

Store / Load Carrier Table
Stores or loads a "carrier table" to or from a .csv file.

Remote command:
MMEMory:LOAD:MCGD:CTABle on page 160
MMEMory:STORe<n>:MCGD:CTABle on page 160

Configuration Assistant
The configuration assistant provides functionality for quick configuration of multiple positions of the "carrier table". Carrier start and carrier stop define the postions of the "carrier table" that are set. Apply settings to "carrier table" sets the selected carrier state and carrier threshold for the selected range at once.

Remote command:
CONFigure:CTABle:EDIT:CARRier:STARt on page 159
CONFigure:CTABle:EDIT:CARRier:STOP on page 159
CONFigure:CTABle:EDIT:CARRier:STATe on page 159
CONFigure:CTABle:EDIT:CARRier:THReshold on page 159
CONFigure:CTABle:EDIT:CARRier:EXECute on page 159

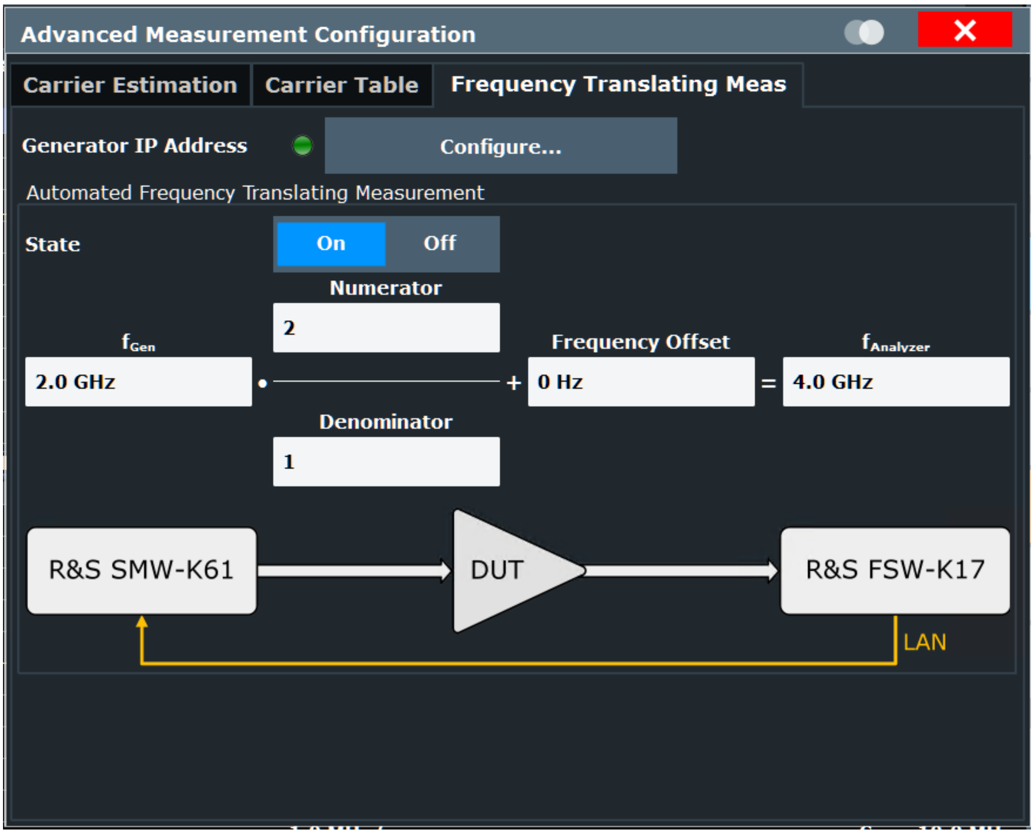
6.7.3 Frequency translating measurement configuration

Access: "Overview" > "Multi-Carrier Config" > "Freq Translating Meas" tab

Or: [MEAS CONFIG] > "Multi-Carrier Config" > "Freq Translating Meas" tab

You can configure the frequency translating characteristics of the DUT in order to perform an automatic measurement. In this case, the FSW controls the center frequency for both the connected generator and the R&S FSW MCGD application, during the calibration and the group delay measurement.

The frequency translation settings are only available if a connection to a signal generator has been established.



Remote command:

CONFigure:GENerator:MCGD:AFTM:OSTate? on page 162

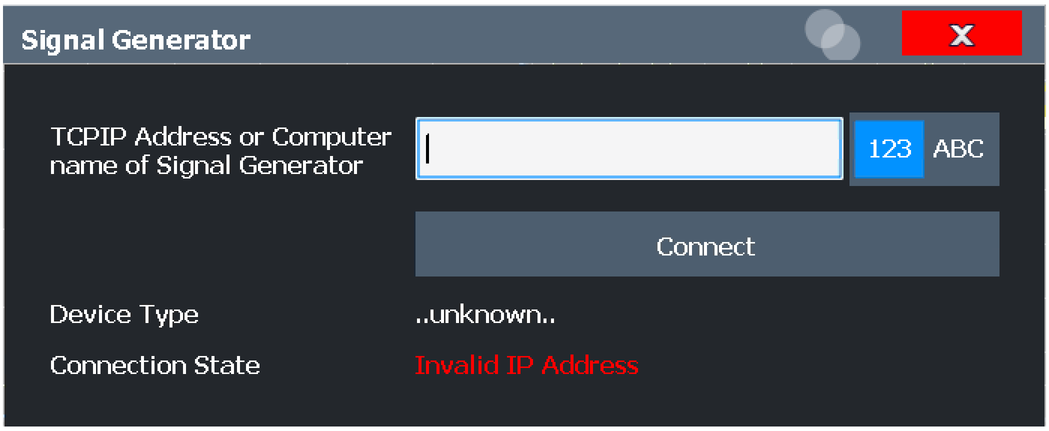
IP Address

Indicates the state and address of a connected signal generator.

The LED indicates the following connection states:

- **green:** connection established to compatible generator
- **red:** connection could not be established, possibly due to an incompatible instrument
- **gray:** no signal generator connected

Select the TCPIP address or "Configure" to define the connection information for the connected signal generator.



Remote command:
CONFigure:GENerator:CONNection:CSTate? on page 152
CONFigure:GENerator:MCGD:CONNection:CSTate? on page 154

IP Address / Computer Name ← IP Address
The IP address or computer name of the signal generator connected to the FSW via LAN.

By default, the IP address is expected. To enter the computer name, toggle the "123"/"ABC" button to "ABC".

Select Connect/Disconnect to establish a connection from the FSW to the specified signal generator.

Note: While a connection to a signal generator is established, you cannot change the connection information.
The IP address / computer name is maintained after a [PRESET], and is transferred between applications. However, when you switch applications, the control is disabled in the other applications. Only one application can control a generator at any time.

Remote command:
CONFigure:GENerator:IPConnection:ADDRess on page 153

Connect/Disconnect ← IP Address
The FSW attempts to establish a connection to the signal generator, or disconnects it.

If an instrument is connected, the following information is displayed:
- Device type
- Name and serial number
- Connection state

Remote command:
CONFigure:GENerator:CONNection[:STATe] on page 153
CONFigure:GENerator:CONNection:CSTate? on page 152
CONFigure:GENerator:MCGD:CONNection:CSTate? on page 154

Automated Frequency Translating Measurement State
Enables or disables automated measurement of a frequency translating DUT using generator control by the FSW.

If enabled, the Generator Control State is also enabled.

If Generator Control State is disabled, Automated Frequency Translating Measurement State is also disabled.

Remote command:
`CONFigure:GENerator:MCGD:AFTM[:STATe]` on page 162

f_{Gen}
Determines the signal generator frequency. By default, the current Center Frequency in the Measurement settings is used. Any changes here are automatically applied to the connected generator.

Remote command:
`CONFigure:GENerator:MCGD:AFTM:FREQuency:GENerator` on page 161

Numerator
Defines the numerator of the frequency translating factor of the DUT.

Remote command:
`CONFigure:GENerator:MCGD:AFTM:FREQuency[:FACTor]:NUMerator` on page 162

Denominator
Defines the denominator of the frequency translating factor of the DUT.

Remote command:
`CONFigure:GENerator:MCGD:AFTM:FREQuency[:FACTor]:DENominator` on page 162

Frequency Offset
Defines a fixed offset caused by the DUT.

Remote command:
`CONFigure:GENerator:MCGD:AFTM:FREQuency:OFFSet` on page 161

$f_{Analyzer}$
Sets or indicates the analyzer frequency. By default (not during calibration), the current Center Frequency in the Measurement settings is used.

The analyzer frequency is defined as:

f_{Ana} = [f_{Gen}* Numerator / Denominator] + Frequency Offset

Remote command:
`CONFigure:GENerator:MCGD:AFTM:FREQuency:ANALyzer` on page 161

6.8 Sweep settings

Access: [SWEEP] menu

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

Continuous Sweep / Run Cont

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

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

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

Remote command:
`INITiate<n>:CONTinuous` on page 176

Single Sweep / Run Single

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

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

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

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

Remote command:
`INITiate<n>[:IMMediate]` on page 177

Continue Single Sweep

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

Remote command:
`INITiate<n>:CONMeas` on page 176

Sweep Count

Defines the number of sweeps to be performed in the single sweep mode. Values from 0 to 32767 are allowed. If the values 0 or 1 are set, one sweep is performed. The sweep count is applied to all the traces in all diagrams.

During calibration measurements, the phase and amplitude values are averaged over the defined number of sweeps.

If the trace configurations "Average", "Max Hold" or "Min Hold" are set, this value also determines the number of averaging or maximum search procedures.

In continuous sweep mode, if sweep count = 0 (default), averaging is performed over 10 sweeps. For sweep count =1, no averaging, Max Hold or Min Hold operations are performed.

Remote command:
`[SENSe:]SWEep:COUNt` on page 179

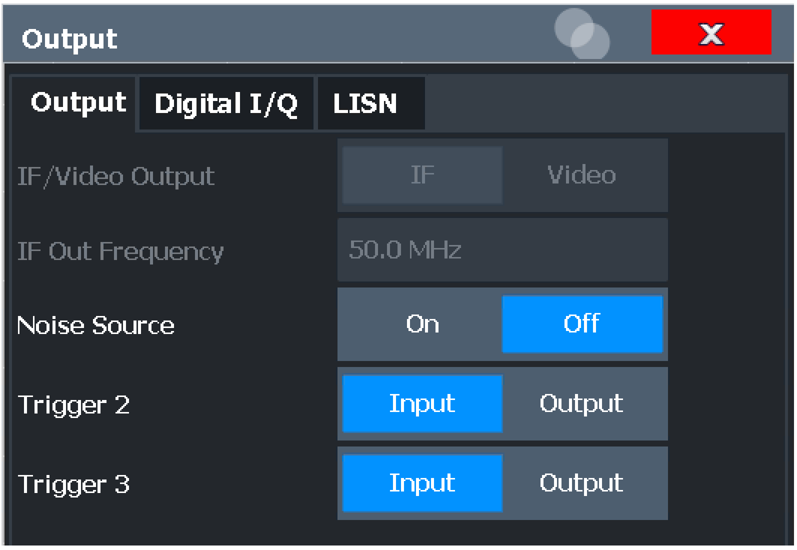
6.9 Output settings

Access: [Input/Output] > "Output"

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

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

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



Noise Source Control

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

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

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

Remote command:
`DIAGnostic:SERVice:NSOurce` on page 163

6.10 Automatic settings

Access: [AUTO SET] menu

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

Setting the Reference Level Automatically (Auto Level)

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

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

You can change the measurement time for the level measurement if necessary (see "Changing the Automatic Measurement Time (Meas Time Manual)" on page 81).

Remote command:
`[SENSe:]ADJust:LEVel` on page 165

Resetting the Automatic Measurement Time (Meas Time Auto)

Resets the measurement duration for automatic settings to the default value.

Remote command:
`[SENSe:]ADJust:CONFigure:LEVel:DURation:MODE` on page 164

Changing the Automatic Measurement Time (Meas Time Manual)
This function allows you to change the measurement duration for automatic setting adjustments. Enter the value in seconds.

Note: The maximum measurement duration depends on the currently selected measurement and the installed (optional) hardware. Thus, the measurement duration actually used to determine the automatic settings can be shorter than the value you define here.

Remote command:
`[SENSe:]ADJust:CONFigure:LEVel:DURation:MODE` on page 164
`[SENSe:]ADJust:CONFigure:LEVel:DURation` on page 163

Upper Level Hysteresis
When the reference level is adjusted automatically using the Auto Level function, the internal attenuators and the preamplifier are also adjusted. To avoid frequent adaptation due to small changes in the input signal, you can define a hysteresis. This setting defines an upper threshold that the signal must exceed (compared to the last measurement) before the reference level is adapted automatically.

Remote command:
`[SENSe:]ADJust:CONFigure:HYSTeresis:UPPer` on page 165

Lower Level Hysteresis
When the reference level is adjusted automatically using the Auto Level function, the internal attenuators and the preamplifier are also adjusted. To avoid frequent adaptation due to small changes in the input signal, you can define a hysteresis. This setting defines a lower threshold that the signal must fall below (compared to the last measurement) before the reference level is adapted automatically.

Remote command:
`[SENSe:]ADJust:CONFigure:HYSTeresis:LOWer` on page 164

7 Analysis

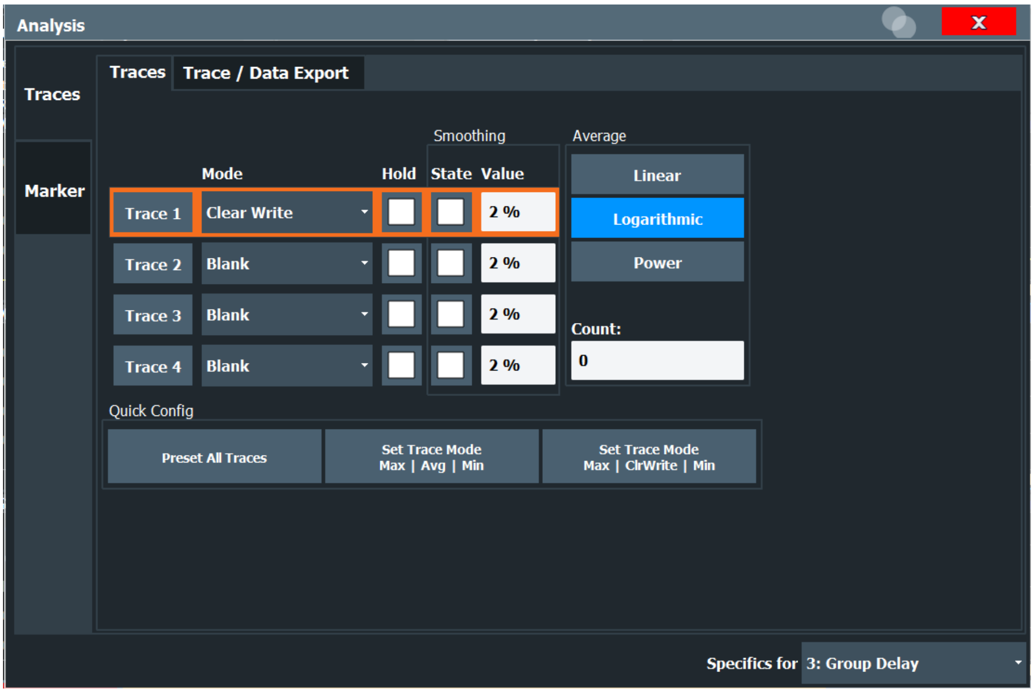
General result analysis settings concerning the trace, markers, windows etc. can be configured via the "Analysis" button in the "Overview". They are identical to the analysis functions in the base unit except for the special window functions.

7.1 Trace settings

Access: "Overview" > "Analysis" > "Traces"

The trace settings determine how the measured data is analyzed and displayed in the window. Depending on the result display, between 1 and 4 traces can be displayed.

Trace data can also be exported to an ASCII file for further analysis. For details, see Chapter 7.2, "Trace / data export configuration", on page 85.



Trace 1/Trace 2/Trace 3/Trace 4

Selects the corresponding trace for configuration. The currently selected trace is highlighted orange.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>[:STATe]` on page 189
Selected via numeric suffix of `TRACe<t>` commands

Mode

Defines the update mode for subsequent traces.

"Clear Write"	Overwrite mode: the trace is overwritten by each sweep (default)
"Max Hold"	The maximum value is determined over several sweeps and displayed. The FSW saves the sweep result in the trace memory only if the new value is greater than the previous one.
"Min Hold"	The minimum value is determined from several measurements and displayed. The FSW saves the sweep result in the trace memory only if the new value is lower than the previous one.
"Average"	The average is formed over several sweeps. The "Average Count" on page 84 determines the number of averaging procedures.
"View"	The current contents of the trace memory are frozen and displayed.
"Blank"	Removes the selected trace from the display.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MODE` on page 186

Hold

If activated, traces in "Min Hold", "Max Hold" and "Average" mode are not reset after specific parameter changes have been made.

Normally, the measurement is started again after parameter changes, before the measurement results are analyzed (e.g. using a marker). In all cases that require a new measurement after parameter changes, the trace is reset automatically to avoid false results (e.g. with span changes). For applications that require no reset after parameter changes, the automatic reset can be switched off.

The default setting is off.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MODE:HCONtinuous`
on page 187

Smoothing

If enabled, the "Group Delay" trace is smoothed by the specified value (between 1 % and 50 %). The smoothing value is defined as a percentage of the display width. The larger the smoothing value, the greater the smoothing effect.

This setting is not available for "Phase", "Phase Reference", and "Magnitude Reference" (vs Frequency) results.

For more information, see Chapter 5.6, "Trace smoothing", on page 30.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:SMOothing[:STATe]` on page 188
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:SMOothing:APERture` on page 188

Average Mode

Defines the mode with which the trace is averaged over several sweeps.

This setting is generally applicable if trace mode "Average" is selected.

For FFT sweeps, the setting also affects the VBW (regardless of whether the trace is averaged).

(See the chapter on ACLR power measurements in the FSW User Manual.)

How many sweeps are averaged is defined by the "Average Count" on page 84.

"Linear"	The power level values are converted into linear units before averaging. After the averaging, the data is converted back into its original unit.
"Logarithmic"	For logarithmic scaling, the values are averaged in dBm. For linear scaling, the behavior is the same as with linear averaging.
"Power"	Activates linear power averaging. The power level values are converted into unit Watt before averaging. After the averaging, the data is converted back into its original unit. Use this mode to average power values in Volts or Amperes correctly. In particular, for small VBW values (smaller than the RBW), use power averaging mode for correct power measurements in FFT sweep mode.

Remote command:
`[SENSe:]AVERage<n>:TYPE` on page 190

Average Count

Determines the number of averaging or maximum search procedures If the trace modes "Average", "Max Hold" or "Min Hold" are set.

In continuous sweep mode, if sweep count = 0 (default), averaging is performed over 10 sweeps. For sweep count =1, no averaging, Max Hold or Min Hold operations are performed.

This value is identical to the Sweep Count setting in the "Sweep" and "Multi-carrier" configuration.

Remote command:
`[SENSe:]AVERage<n>:COUNt` on page 190

Predefined Trace Settings - Quick Config

Commonly required trace settings have been predefined and can be applied very quickly by selecting the appropriate button.

Function	Trace Settings	
Preset All Traces	Trace 1:	Clear Write
	Traces 2-4:	Blank
Set Trace Mode Max | Avg | Min	Trace 1:	Max Hold
	Trace 2:	Average
	Trace 3:	Min Hold
	Trace 4:	Blank
Set Trace Mode Max | ClrWrite | Min	Trace 1:	Max Hold
	Trace 2:	Clear Write
	Trace 3:	Min Hold
	Trace 4:	Blank

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:PRESet` on page 189

Trace 1/ Trace 2/ Trace 3/ Trace 4 (Softkeys)
Displays the "Traces" settings and focuses the "Mode" list for the selected trace.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>[:STATe]` on page 189

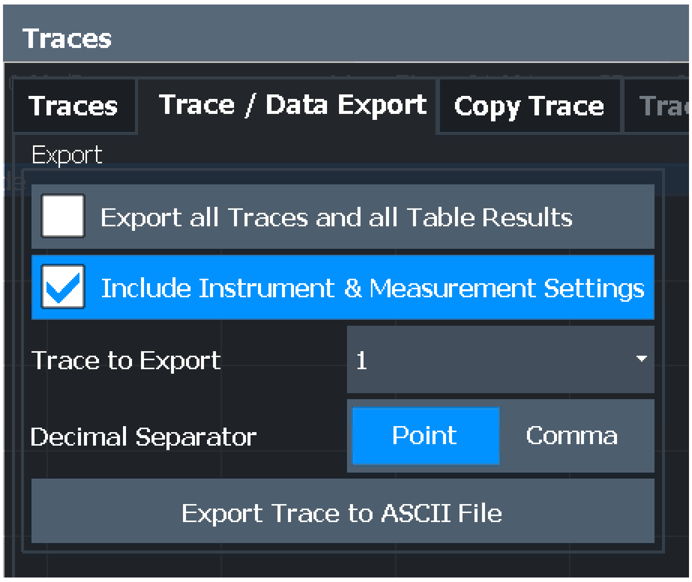
7.2 Trace / data export configuration

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

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

The FSW provides various evaluation methods for the results of the performed measurements. However, if you want to evaluate the data with other, external applications, you can export the measurement data to a standard format file (ASCII or CSV).

The standard data management functions (e.g. saving or loading instrument settings) that are available for all FSW applications are not described here.
See the FSW base unit user manual for a description of the standard functions.



Export all Traces and all Table Results

Selects all displayed traces and result tables (e.g. "Result Summary", marker table etc.) in the current application for export to an ASCII file.

Alternatively, you can select one specific trace only for export (see Trace to Export).

The results are output in the same order as they are displayed on the screen: window by window, trace by trace, and table row by table row.

Remote command:

`FORMat:DEXPort:TRACes` on page 185

Include Instrument & Measurement Settings

Includes additional instrument and measurement settings in the header of the export file for result data.

See Chapter 12.2, "Reference: ASCII file export format", on page 214 for details.

Remote command:

`FORMat:DEXPort:HEADer` on page 185

Trace to Export

Defines an individual trace to be exported to a file.

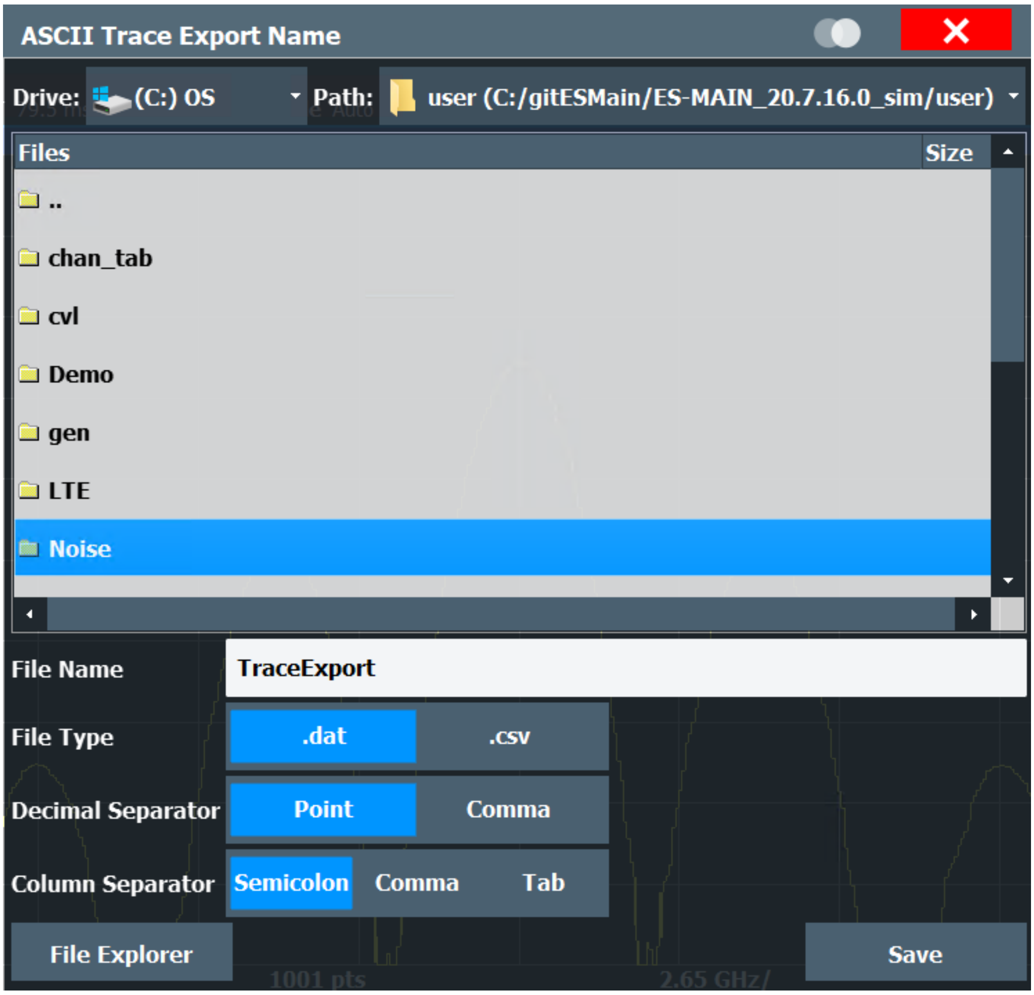
This setting is not available if Export all Traces and all Table Results is selected.

Decimal Separator
Defines the decimal separator for floating-point numerals for the data export/import files. Evaluation programs require different separators in different languages.

Remote command:
`FORMat:DEXPort:DSEParator` on page 184

Export Trace to ASCII File
Saves the selected trace or all traces in the currently active result display to the specified file and directory in the selected ASCII format.

"File Explorer": Instead of using the file manager of the FSW firmware, you can also use the Microsoft Windows File Explorer to manage files.



Note: Secure user mode.
In secure user mode, settings that are stored on the instrument are stored to volatile memory, which is restricted to 256 MB. Thus, a "memory limit reached" error can occur although the hard disk indicates that storage space is still available.

To store data permanently, select an external storage location such as a USB memory device.

For details, see "Protecting Data Using the Secure User Mode" in the "Data Management" section of the FSW base unit user manual.

Remote command:
`MMEMory:STORe<n>:TRACe` on page 184

File Type ← Export Trace to ASCII File
Determines the format of the ASCII file to be imported or exported.

Depending on the external program in which the data file was created or is evaluated, a comma-separated list (`CSV`) or a plain data format (`DAT`) file is required.

Remote command:
`FORMat:DEXPort:FORMat` on page 185

Decimal Separator ← Export Trace to ASCII File
Defines the decimal separator for floating-point numerals for the data export/import files. Evaluation programs require different separators in different languages.

Remote command:
`FORMat:DEXPort:DSEParator` on page 184

File Explorer ← Export Trace to ASCII File
Opens the Microsoft Windows File Explorer.

Remote command:
not supported

7.3 Markers

Access: "Overview" > "Analysis" > "Marker"

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

7.3.1 Marker settings

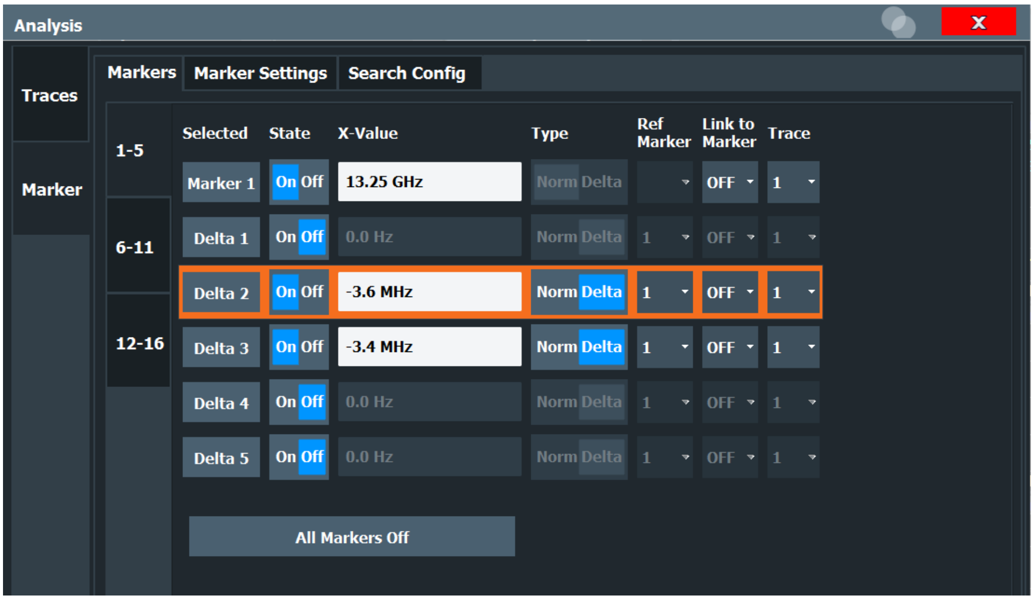
Marker settings can be configured via [Marker] or in the "Marker" dialog box. To display the "Marker" dialog box, do one of the following:

- Press [MKR], then select "Marker Config".
- In the "Overview", select "Analysis", and switch to the vertical "Marker" tab.

The remote commands required to define these settings are described in Chapter 11.9.3, "General marker settings", on page 197.

7.3.1.1 Individual marker setup

In the R&S FSW MCGD application, up to 17 markers or delta markers can be activated for each window simultaneously. Initial marker setup is performed using the "Marker" dialog box.



The markers are distributed among 3 tabs for a better overview. By default, the first marker is defined as a normal marker, whereas all others are defined as delta markers with reference to the first marker. All markers are assigned to trace 1, but only the first marker is active.

Select Marker

The "Select Marker" function opens a dialog box to select and activate or deactivate one or more markers quickly.

Remote command:
`CALCulate<n>:MARKer<m>[:STATe]` on page 196
`CALCulate<n>:DELTamarker<m>[:STATe]` on page 194

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 196
`CALCulate<n>:DELTamarker<m>[:STATe]` on page 194

Marker Position X-value
Defines the position (x-value) of the marker in the diagram. For normal markers, the absolute position is indicated. For delta markers, the position relative to the reference marker is provided.

Remote command:
`CALCulate<n>:MARKer<m>:X` on page 197
`CALCulate<n>:DELTamarker<m>:X` on page 194

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 196
CALCulate<n>:DELTamarker<m>[:STATe] on page 194

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.

If the reference marker is deactivated, a different reference marker is automatically selected; the delta marker remains active.

Remote command:
CALCulate<n>:DELTamarker<m>:MREFerence on page 193

Linking to Another Marker

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

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

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

Remote command:
CALCulate<n>:MARKer<ms>:LINK:TO:MARKer<md> on page 196
CALCulate<n>:DELTamarker<ms>:LINK:TO:MARKer<md> on page 192
CALCulate<n>:DELTamarker<m>:LINK on page 192

Assigning the Marker to a Trace

The "Trace" setting assigns the selected marker to an active trace. The trace determines which value the marker shows at the marker position. If the marker was previously assigned to a different trace, the marker remains on the previous frequency or time, but indicates the value of the new trace.

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

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

All Markers Off

Deactivates all markers in one step.

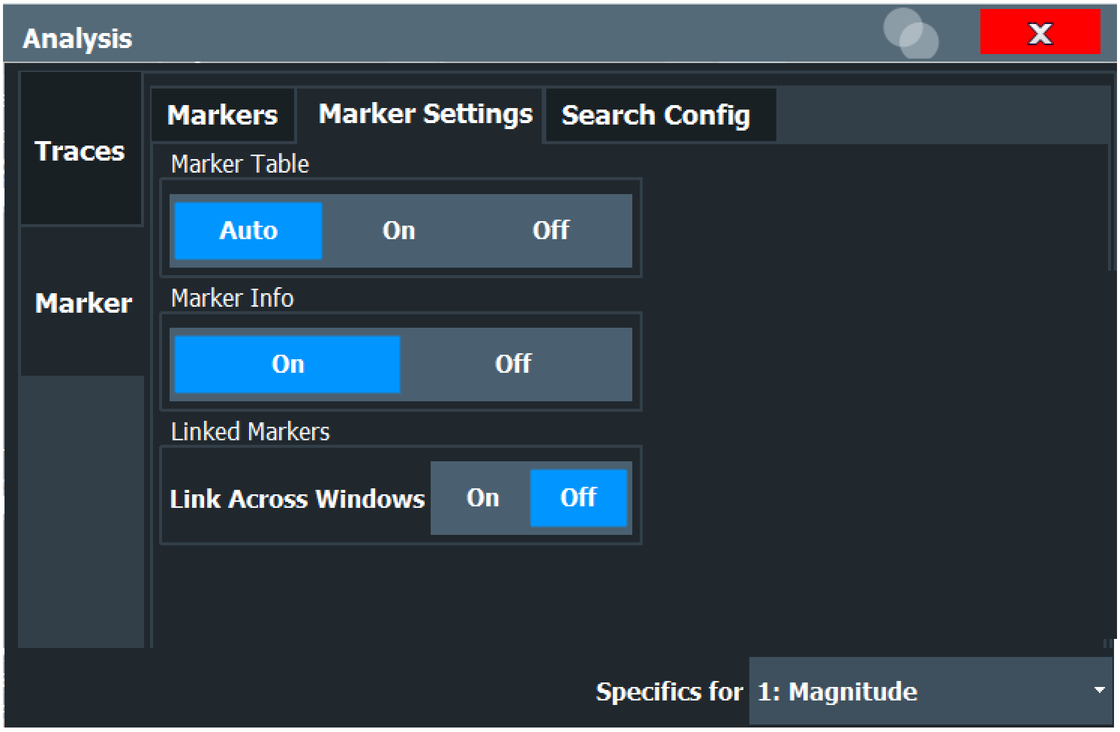
Remote command:
`CALCulate<n>:MARKer<m>:AOFF` on page 195

7.3.1.2 General marker settings

Some general marker settings allow you to influence the marker behavior for all markers.

These settings are located in the "Marker Settings" tab of the "Marker" dialog box. To display this tab, do one of the following:

- Press [MKR], then select "Marker Config".
- In the "Overview", select "Analysis", and switch to the vertical "Marker" tab. Then select the horizontal "Marker Settings" tab.



Marker Table Display
Defines how the marker information is displayed.

"On" Displays the marker information in a table in a separate area beneath the diagram.

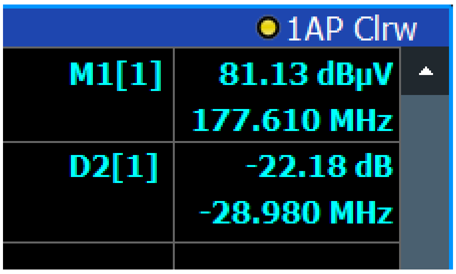
"Off" No separate marker table is displayed.
If Marker Info is active, the marker information is displayed within the diagram area.

"Auto" (Default) If more than two markers are active, the marker table is displayed automatically.
If Marker Info is active, the marker information for up to two markers is displayed in the diagram area.

Remote command:
`DISPlay[:WINDow<n>]:MTABle` on page 198

Marker Info

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



Remote command:
`DISPlay[:WINDow<n>]:MINFo[:STATe]` on page 198

Linked Markers

If enabled, the markers in all diagrams are linked, i.e. when you move a marker in one window, the markers in all other windows are moved to the same x-value.

Note: The group delay display uses a frequency grid with an offset of (<carrier_spacing>/2). Thus, the x-value of a linked marker on the group delay trace is always half the carrier spacing higher than in other result displays.

Linking markers is only possible if compatible reference data is available, or no reference data at all. Compatible reference data means the settings used to perform calibration were the same as the currently active measurement settings. If measurement settings are changed that do not match the reference data, linking markers is no longer possible and the function is automatically deactivated.

An exception to this rule is the center frequency. If a different center frequency was used for calibration, the markers can still be linked. However, in this case the markers are not moved to a specific x-value, but to the same horizontal position relative to the diagram edge.

Remote command:
`CALCulate<n>:MARKer<m>:LINK` on page 197

7.3.2 Marker search settings and positioning functions

Several functions are available to set the marker to a specific position quickly and easily, or to use the current marker position to define another characteristic value. To determine the required marker position, searches can be performed. The search results can be influenced by special settings.

Most marker positioning functions and the search settings are available in the [MKR ->] menu.

Search settings are also available via [Marker] or in the vertical "Marker Config" tab of the "Analysis" dialog box (horizontal "Search Settings" tab).

The remote commands required to define these settings are described in Chapter 11.9.4, "Searching for peaks and positioning the marker", on page 198.

7.3.2.1 Marker search settings

Markers are commonly used to determine peak values, i.e. maximum or minimum values, in the measured signal. Configuration settings allow you to influence the peak search results.

These settings are available as softkeys in the Marker To menu, or in the "Search Settings" tab of the "Marker" dialog box. To display this tab, do one of the following:

- Press [MKR], then select "Marker Config". Then select the horizontal "Search Settings" tab.
- In the "Overview", select "Analysis", and switch to the vertical "Marker Config" tab. Then select the horizontal "Search Settings" tab.

Search Mode for Next Peak
Selects the search mode for the next peak search.

"Left"	Determines the next maximum/minimum to the left of the current peak.
"Absolute"	Determines the next maximum/minimum to either side of the current peak.
"Right"	Determines the next maximum/minimum to the right of the current peak.

Remote command:
Chapter 11.9.4, "Searching for peaks and positioning the marker", on page 198

Peak Excursion
Defines the minimum level value by which a signal must rise or fall so that it is identified as a maximum or a minimum by the search functions.

Remote command:
`CALCulate<n>:MARKer<m>:PEXCursion` on page 199

7.3.2.2 Positioning functions

Access: [MKR ->]

The following functions set the currently selected marker to the result of a peak search or set other characteristic values to the current marker value.

Select Marker

The "Select Marker" function opens a dialog box to select and activate or deactivate one or more markers quickly.

Remote command:

CALCulate<n>:MARKer<m>[:STATe] on page 196

CALCulate<n>:DELTamarker<m>[:STATe] on page 194

Peak Search

Sets the selected marker/delta marker to the maximum of the trace. If no marker is active, marker 1 is activated.

Remote command:

CALCulate<n>:MARKer<m>:MAXimum[:PEAK] on page 200

CALCulate<n>:DELTamarker<m>:MAXimum[:PEAK] on page 202

Search Next Peak

Sets the selected marker/delta marker to the next (lower) maximum of the assigned trace. If no marker is active, marker 1 is activated.

Remote command:

CALCulate<n>:MARKer<m>:MAXimum:NEXT on page 200

CALCulate<n>:MARKer<m>:MAXimum:RIGHt on page 200

CALCulate<n>:MARKer<m>:MAXimum:LEFT on page 200

CALCulate<n>:DELTamarker<m>:MAXimum:NEXT on page 202

CALCulate<n>:DELTamarker<m>:MAXimum:RIGHt on page 202

CALCulate<n>:DELTamarker<m>:MAXimum:LEFT on page 202

Search Minimum

Sets the selected marker/delta marker to the minimum of the trace. If no marker is active, marker 1 is activated.

Remote command:
CALCulate<n>:MARKer<m>:MINimum[:PEAK] on page 201
CALCulate<n>:DELTamarker<m>:MINimum[:PEAK] on page 203

Search Next Minimum

Sets the selected marker/delta marker to the next (higher) minimum of the selected trace. If no marker is active, marker 1 is activated.

Remote command:
CALCulate<n>:MARKer<m>:MINimum:NEXT on page 201
CALCulate<n>:MARKer<m>:MINimum:LEFT on page 200
CALCulate<n>:MARKer<m>:MINimum:RIGHt on page 201
CALCulate<n>:DELTamarker<m>:MINimum:NEXT on page 203
CALCulate<n>:DELTamarker<m>:MINimum:LEFT on page 203
CALCulate<n>:DELTamarker<m>:MINimum:RIGHt on page 203

7.4 Display configuration

The captured signal can be displayed using various evaluation methods. All evaluation methods available for the Multi-Carrier "Group Delay" application are displayed in the evaluation bar in SmartGrid mode when you do one of the following:

- Select the "SmartGrid" icon from the toolbar.
- Select "Display Config" in the "Overview".
- Press [MEAS].
- Select "Display Config" in any Multi-Carrier "Group Delay" menu.

Up to 6 evaluation methods can be displayed simultaneously in separate windows. The Multi-Carrier "Group Delay" evaluation methods are described in Chapter 4.1, "Evaluation methods for multi-carrier group delay", on page 21.

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

8 Importing and exporting results

The FSW provides various evaluation methods for the results of the performed measurements. However, you may want to evaluate the data with other, external applications. In this case, you can export the measurement data to a standard format file (ASCII or CSV). The results from the calibration measurements can also be be re-imported to the FSW MCGD application as reference data for further measurements.

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

See the FSW User Manual for a description of the standard functions.

8.1 Export functions

The following export functions are available via softkeys in the "Save/Recall" menu which is displayed when you select the "Save" or "Open" icon in the toolbar. Some functions are also available via softkeys or dialog boxes in the corresponding menus, e.g. trace data or calibration data.

Storing Calibration Data

Stores the calibration data (reference data) to the selected file (`.csv` format)

Remote command:

`MMEMory:STORe<n>:MCGD:RCALibration` on page 166

Storing Measurement Results

Stores the currently displayed measurement results (i.e. all traces in all windows) to the selected file (in `.csv` format).

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.

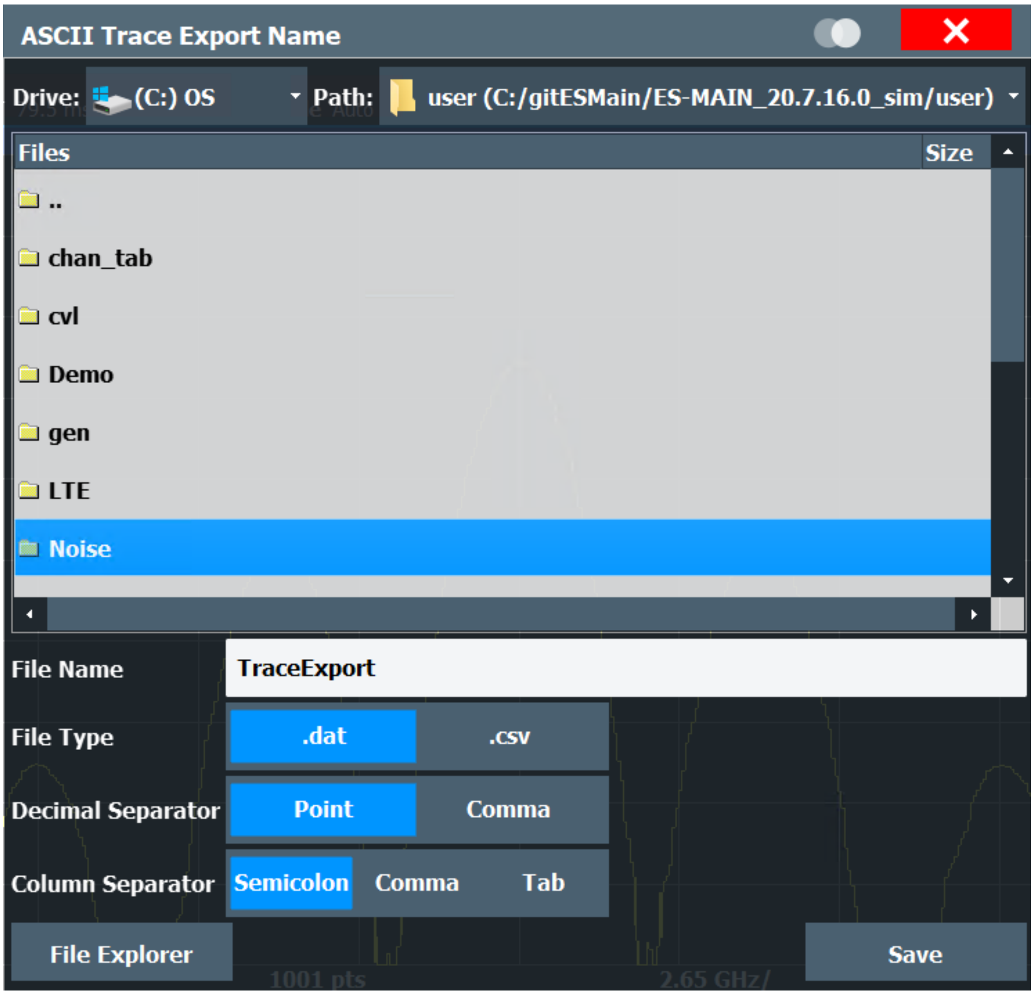
Note: To store the results of an individual trace or all traces in ASCII format, use the Export Trace to ASCII File function.

Remote command:

`MMEMory:STORe<n>:MCGD:MEAS` on page 182

Export Trace to ASCII File
Saves the selected trace or all traces in the currently active result display to the specified file and directory in the selected ASCII format.

"File Explorer": Instead of using the file manager of the FSW firmware, you can also use the Microsoft Windows File Explorer to manage files.



Note: Secure user mode.
In secure user mode, settings that are stored on the instrument are stored to volatile memory, which is restricted to 256 MB. Thus, a "memory limit reached" error can occur although the hard disk indicates that storage space is still available.

To store data permanently, select an external storage location such as a USB memory device.

For details, see "Protecting Data Using the Secure User Mode" in the "Data Management" section of the FSW base unit user manual.

Remote command:
`MMEMory:STORe<n>:TRACe` on page 184

File Type ← Export Trace to ASCII File
Determines the format of the ASCII file to be imported or exported.

Depending on the external program in which the data file was created or is evaluated, a comma-separated list (CSV) or a plain data format (DAT) file is required.

Remote command:
FORMat:DEXPort:FORMat on page 185

Decimal Separator ← Export Trace to ASCII File
Defines the decimal separator for floating-point numerals for the data export/import files. Evaluation programs require different separators in different languages.

Remote command:
FORMat:DEXPort:DSEParator on page 184

File Explorer ← Export Trace to ASCII File
Opens the Microsoft Windows File Explorer.

Remote command:
not supported

8.2 Import functions

The following import functions are available via softkeys in the "Save/Recall" menu which is displayed when you select the "Save" or "Open" icon in the toolbar. Calibration data can also be imported from the "Calibration" configuration dialog box.

Loading Calibration Data
Loads the calibration data (reference data) from the selected file (.csv format) to the instrument. The current reference data in the MCGD application is overwritten; the loaded data is used for the group delay calculation.

Remote command:
MMEMory:LOAD:MCGD:RCALibration on page 166

Decimal Separator
Defines the decimal separator for floating-point numerals for the data export/import files. Evaluation programs require different separators in different languages.

Remote command:
FORMat:DEXPort:DSEParator on page 184

9 How to perform measurements in the multi-carrier group delay application

The following step-by-step instructions demonstrate how to perform a multi-carrier group delay measurement with the FSW-K17 option. For details on the individual functions and settings, see Chapter 6, "Configuration", on page 32.

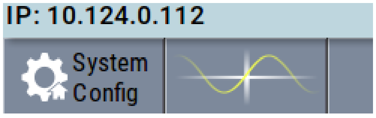
9.1 Performing an automated frequency translating measurement

Using the signal generator control function in the R&S FSW MCGD application, performing a multi-carrier group delay measurement for a frequency-translating DUT can be automated. In this case, you need not configure and re-configure the generator and the R&S FSW MCGD application. Instead, the FSW controls the generator and automatically configures the required signal settings according to the configuration in the R&S FSW MCGD application. This saves time and efforts and speeds up the measurement immensely.

To perform the multi-carrier group delay measurement on the FSW, controlling the generator automatically

1. To use the trigger from the signal generator on the FSW, for example to calculate an absolute group delay, connect the trigger output of the signal generator to the trigger input of the FSW.
2. To synchronize the reference frequencies used by the signal generator and the FSW, use an external reference frequency:
   a) Connect the external reference output of the signal generator ([Ref Out]) to the external reference input on the rear panel of the FSW ([Ref input] 1..20 MHz).
   b) On the FSW, press [SETUP], then select "Reference".
   c) In the "Reference Frequency Input" area, select the used external reference.
3. Connect the signal generator and the FSW using a LAN cable so the FSW can take control of the generator.
4. Connect the RF A output of the signal generator to the [RF Input] connector on the front panel of the FSW **without the DUT**.
5. Press [MODE] on the front panel of the FSW and select the "MC Group Delay" application.
6. Select "Overview" to display the "Overview" for a Multi-Carrier "Group Delay" measurement.
7. Select "Frequency" to define the input signal's center frequency.

8. To measure the absolute group delay, select "Trigger" and select the trigger source "External Trigger1".
9. Select "Multi-Carrier Config" to describe the signal and define measurement settings:
    a) Define the carrier spacing.
    b) Define the number of carriers (tones) or the frequency span of the input signal.
    c) If the measurement time determined automatically is not adequate, define it manually.
    d) To average the results over several sweeps, increase the sweep count.
    e) To calculate an absolute group delay, select "Absolute" mode for the group delay result.
10. Set up the generator for automatic control by the FSW.
    a) In the "Multi-Carrier Config" dialog box, switch to the "Generator Control" tab.
    b) If no generator is configured yet, select "Invalid IP Address".
    c) In the "Signal Generator" dialog box, enter the TCP/IP address or the computer name of the connected generator.
    Tip: When connected, the R&S SMW displays the address information on the screen.



    d) Select "Connect" to establish a connection to the generator.
    e) Close the "Signal Generator" dialog box.
    A green light indicates a successful connection.
    f) If not yet activated, activate the "Generator Control" > "State".
    g) Activate the "Level" control state.
    h) Configure the generator's output level by adjusting the Level (RMS) and the DUT Gain
    i) Activate the "RF Output".
11. Set up the frequency translating characteristics of the DUT, which determine the required signal settings on the generator during the measurement.
    a) In the "Multi-Carrier Config" dialog box, switch to the "Freq Translating Meas" tab.
    b) Activate the "Automated Frequency Translating Measurement" > "State".
    c) Define a factor to be applied to the input frequency of the DUT as a "Numerator" and "Denominator".
    d) Define a "frequency offset" that is caused by the DUT.
    During the reference calibration and the group delay measurement, the signal generator and the FSW are set to the correct center frequencies automatically.
12. Press [Run SINGLE] to stop the continuous sweep mode.
13. Select "Multi-Carrier Config" to re-open the "Multi-Carrier Config" dialog box and switch to the "Calibration" tab.

14. Select "Calibrate" to perform a calibration measurement.

    The center frequency for the R&S FSW MCGD application is automatically set to the signal generator's center frequency. The signal level of the generator is adjusted to provide an appropriate input power for the FSW. The calibration measurement is performed. The status of the running measurement is indicated in a dialog box. During this time, no other actions can be performed on the FSW.

15. Optionally, to store the results from the performed calibration measurement to a CSV file for later use, select "Store Calibration Data".

16. Once the reference data is available in the Multi-Carrier "Group Delay" application, connect the DUT between the signal generator and the FSW.

17. On the FSW, select "Display Config" to enter the SmartGrid mode and select the displays that are of interest to you (up to 6).
    Arrange them on the display to suit your preferences, then exit the SmartGrid mode.

18. Press [Run Single] to start a new measurement.

    The group delay is calculated and the selected results are displayed.

19. To store the displayed results in a CSV file:
    a) Select the "Save" icon in the toolbar.
    b) Select "Export".
    c) If necessary, change the decimal separator to be used for the export file.
    d) Select "Store Measurement Data".
    e) Define a file name and storage location for the results file.

20. To make use of the advanced analysis functions in the displays, select "Analysis" in the "Overview".
    - Configure a trace to display the average over a series of sweeps (on the "Trace" tab; if necessary, increase the "Sweep Count" in the "Multi-Carrier Config" settings).
      For absolute group delay trace results, we recommend you average the results.
    - Configure markers and delta markers to determine deviations and offsets within the signal (on the "Marker" tab).

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

9.2 Performing a manual MCGD measurement

The following step-by-step instructions demonstrate how to perform a multi-carrier group delay measurement without automatic signal generator control.

The procedure to generate the multi-carrier signal for the frequency range to be analyzed on a signal generator is described using the R&S SMW as an example. For details on configuring the signal generator, see the R&S SMW User Manual.

To generate a multi-carrier signal for the frequency range of the DUT on an R&S SMW

1. Preset the signal generator.
2. In the "Baseband A" menu, select "Multicarrier CW". (Alternatively, the R&S SMW can produce multi-carrier signals using the "ARB" option.)
3. In the "General" tab, define the "No of Carriers" and "Carrier Spacing" such that the generated signal covers the frequency range in which the DUT is to be analyzed.
4. In the "Optimize Crest Factor Mode" field, select "Chirp" to improve the SNR in the MC "Group Delay" measurement.
5. To improve measurement accuracy, send a trigger signal to the FSW:
   a) Select the "Trigger In" tab.
   b) For "Mode", select "Auto".
   c) Select the "Marker" tab.
   d) For "Marker 1", select "Restart".
6. In the "General" tab, activate the multi-carrier signal by switching the state to "ON".
7. Close the "Multi Carrier CW A" menu.
8. Set "RF A" to "ON" to activate the RF modulation.
9. Select [Freq] to define the center frequency of the test signal.
10. Select [Level] to define the generator's output power.

To perform the MC "Group Delay" measurement on the FSW

1. To use the trigger from the signal generator on the FSW, for example to calculate an absolute group delay, connect the trigger output of the signal generator to the trigger input of the FSW.
2. To synchronize the reference frequencies used by the signal generator and the FSW, use an external reference frequency:
   a) Connect the external reference output of the signal generator ([Ref Out]) to the external reference input on the rear panel of the FSW ([Ref input] 1..20 MHz).
   b) On the FSW, press [SETUP], then select "Reference".
   c) In the "Reference Frequency Input" area, select the used external reference.

3. Connect the RF A output of the signal generator to the [RF Input] connector on the front panel of the FSW **without the DUT**.
4. Configure the signal generator to output a multi-carrier signal in the frequency range in which the DUT is to be analyzed (as described in "To generate a multi-carrier signal for the frequency range of the DUT on an R&S SMW" on page 103).
5. Press [MODE] on the front panel of the FSW and select the "MC Group Delay" application.
6. Select "Overview" to display the "Overview" for a Multi-Carrier "Group Delay" measurement.
7. Select "Amplitude" and define the required attenuation and reference level for the generated input signal.

   Note: Correct attenuation and reference level settings are an important factor for accurate group delay measurement results. You can also use the auto leveling function in the FSW Spectrum application before starting the MCGD application. The attenuation and reference level values are then passed on to the new MCGD measurement channel.
8. Select "Frequency" to define the input signal's center frequency.
9. To measure the absolute group delay, select "Trigger" and select the trigger source "External Trigger1".
10. Select "Multi-Carrier Config" to describe the signal and define measurement settings:
    a) Define the carrier spacing.
    b) Define the number of carriers (tones) or the frequency span according to the settings on the generator.
    c) If the measurement time determined automatically is not adequate, define it manually.
    d) To average the results over several sweeps, increase the sweep count.
    e) To calculate an absolute group delay, select "Absolute" mode for the group delay result.

    Check the displayed results to ensure that the measurement configuration is adequate.
11. Press [Run SINGLE] to stop the continuous sweep mode.
12. Select "Multi-Carrier Config" to re-open the "Multi-Carrier Config" dialog box and switch to the "Calibration" tab.
13. Select "Calibrate" to perform a calibration measurement.
    Alternatively, if a calibration measurement has already been performed with the same measurement setup, select "Load Calibration Data" to load stored reference data.

    The calibration measurement is performed. The status of the running measurement is indicated in a dialog box. During this time, no other actions can be performed on the FSW.

The "Calibration" tab displays date and time, center frequency, reference level and further parameters of the most recently performed or loaded calibration measurement.

14. Optionally, to store the results from the performed calibration measurement to a CSV file for later use, select "Store Calibration Data".
15. Once the reference data is available in the Multi-Carrier "Group Delay" application, connect the DUT between the signal generator and the FSW.
16. On the FSW, select "Display Config" to enter the SmartGrid mode and select the displays that are of interest to you (up to 6).
    Arrange them on the display to suit your preferences, then exit the SmartGrid mode.
17. Press [Run Single] to start a new measurement.

    The group delay is calculated and the selected results are displayed.
18. To store the displayed results in a CSV file:
    a) Select the "Save" icon in the toolbar.
    b) Select "Export".
    c) If necessary, change the decimal separator to be used for the export file.
    d) Select "Store Measurement Data".
    e) Define a file name and storage location for the results file.
19. To make use of the advanced analysis functions in the displays, select "Analysis" in the "Overview".
    - Configure a trace to display the average over a series of sweeps (on the "Trace" tab; if necessary, increase the "Sweep Count" in the "Multi-Carrier Config" settings).
      For absolute group delay trace results, we recommend you average the results.
    - Configure markers and delta markers to determine deviations and offsets within the signal (on the "Marker" tab).
20. Optionally, export the trace data of the demodulated signal to a file.
    a) In the "Traces" tab of the "Analysis" dialog box, switch to the "Trace Export" tab.
    b) Select "Export Trace to ASCII File".
    c) Define a file name and storage location and select "OK".

10 Troubleshooting the measurement

If the results do not meet your expectations, try the following methods to correct the measurement:

Calibration fails

- Check the connection from the signal generator to the FSW.
- Check the settings on the signal generator.
- Check the input signal at the FSW.

No trace visible in "Magnitude Reference" and "Phase Reference" windows

- No calibration data is available, perform a calibration measurement (without the DUT) or load stored calibration data.

No trace visible in "Group Delay" window

- No calibration data is available, perform a calibration measurement (without the DUT) or load stored calibration data.
- MCGD configuration is not compatible to the current calibration (reference) data. Perform a new calibration or adjust measurement settings to fit the calibration data (see Chapter 6.6.3, "Calibration", on page 61).

Group delay results are not calculated correctly

- Check the connections from the DUT to the FSW and to the signal generator.
- Repeat the calibration measurement (without the DUT) or load stored calibration data from the same measurement setup.
- Check if the MCGD configuration on the FSW fits to the signal sent by the generator.
- Connect an external reference to the FSW to improve accuracy (see the FSW User Manual).
- Check level settings on both the signal generator in use and the FSW MCGD application. Increase the generator's output level and adjust the reference level of the MCGD application accordingly.
- Check the measurement time. Longer measurement times result in better signal to noise ratios in the group delay calculation. The "Meas Time Auto" mode usually provides a suitable value (see "Measurement Time" on page 60).
- For absolute group delay calculation an external trigger has to be used. Check whether an external trigger is connected and is being sent to the FSW. The trigger periodicity has to be an integer multiple of the signal's periodicity, which is 1/carrier spacing.
- Increase the sweep count for absolute group delay calculation (for example 100 sweeps) to improve the measurement result. Use the sweep count for calibration and for group delay measurement (trace averaging) to compensate for trigger inaccuracies.
- Increase the carrier spacing on the used multi-carrier signal to reduce noise in the group delay calculation. Reducing the carrier spacing for multi-carrier signals leads to a better frequency resolution, but also causes more noise in the calculated group delay.

- For very low signal levels and short measurement times, intercarrier interference may remain uncompensated. In this case, the frequency estimation used by the R&S FSW MCGD application to determine the exact position of the carriers can degrade the measurement result. Increase the signal generator's output level.

10.1 Error and status messages

Error messages are entered in the error/event queue of the status reporting system in the remote control mode and can be queried with the command `SYSTem:ERRor?`.

Warnings are not indicated in the status reporting system, but are displayed in the status bar. A short explanation of the warning messages for the FSW MCGD application is given below.

Table 10-1: Status messages for the FSW MCGD application

Status bar message	Description
"No Calibration Data"	The calibration measurement has not yet been performed, nor have stored settings been loaded.
"Measurement Configuration not compatible to Calibration Data"	MCGD configuration contains a setting that is not compatible to the current calibration (reference) data. **Solution:** Repeat the calibration measurement (without the DUT) or change the measurement settings.
"Activate external Trigger to measure absolute Group Delay"	The R&S FSW MCGD application is configured to measure the absolute group delay, but no trigger is used. **Solution:** Activate an external trigger for absolute group delay measurements.
"This instrument supports datasheet versions up to 1.01"	The used FSW does not comply with the specifications stated in the R&S FSW MCGD application specifications document version (≥ 2.00) for frequency converting group delay measurements. To improve instrument accuracy, contact the central Rohde & Schwarz service.
"Connected Generator is not supported for Generator Control. Use R&S SMW." "Multicarrier CW Option (SMW-K61) missing on connected Generator"	Generator control is only available for R&S SMW signal generators with the Multicarrier CW option (R&S SMW-K61) installed.
"Lost connection to Generator"	The connection to the generator was lost during operation. Check the connection cables.
[XXX] "exceeds limits of Generator"	The specified parameter is controlled by the FSW, but cannot be set on the connected signal generator. Correct the parameter value in the R&S FSW MCGD application or disable control by the FSW (see Chapter 6.6.4, "Generator control", on page 64).
"Generator Frequency exceeds Analyzer Frequency Range during Calibration"	During calibration in an automated frequency translating measurement: the generator has a larger center frequency than the analyzer; the calibration frequency cannot be set on the analyzer. Reduce the output frequency on the generator, or disable the automated measurement.

Status bar message	Description
FSW-K17S: "Connect to Generator and activate Generator Control in order to use Subspan Measurements."	FSW-K17S Frequency Subspan Measurements cannot be performed. Connect to generator and activate Generator Control in order to use Frequency Subspan Measurements.
FSW-K17S: "Activate Generator RF Output in order to use Frequency Measurements."	FSW-K17S Frequency Subspan Measurements cannot be performed. Activate the Generator Control Generator RF Output in order to use Frequency Subspan Measurements.

11 Remote commands to perform multi-carrier group delay measurements

The following commands are required to perform measurements in the Multi-Carrier "Group Delay" application in a remote environment. It is assumed that the FSW has already been set up for remote operation in a network as described in the FSW User Manual.

Note that basic tasks that are also performed in the base unit in the same way are not described here. For a description of such tasks, see the FSW User Manual.

In particular, this includes:

- Managing Settings and Results, i.e. storing and loading settings and result data
- Basic instrument configuration, e.g. checking the system configuration, customizing the screen layout, or configuring networks and remote operation
- Using the common status registers

SCPI Recorder - automating tasks with remote command scripts

The R&S FSW MCGD application also supports the SCPI Recorder functionality.

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

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

The following topics specific to Multi-Carrier "Group Delay" application are described here:

11.1 Introduction

Commands are program messages that a controller (e.g. a PC) sends to the instrument or software. They operate its functions ('setting commands' or 'events') and request information ('query commands'). Some commands can only be used in one way, others work in two ways (setting and query). If not indicated otherwise, the commands can be used for settings and queries.

The syntax of a SCPI command consists of a header and, usually, one or more parameters. To use a command as a query, you have to append a question mark after the last header element, even if the command contains a parameter.

A header contains one or more keywords, separated by a colon. Header and parameters are separated by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank). If there is more than one parameter for a command, they are separated by a comma from one another.

Only the most important characteristics that you need to know when working with SCPI commands are described here. For a more complete description, refer to the user manual of the FSW.

Remote command examples

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

11.1.1 Conventions used in descriptions

The following conventions are used in the remote command descriptions:

- *Command usage*
  If not specified otherwise, commands can be used both for setting and for querying parameters.
  If a command can be used for setting or querying only, or if it initiates an event, the usage is stated explicitly.
- *Parameter usage*
  If not specified otherwise, a parameter can be used to set a value, and it is the result of a query.
  Parameters required only for setting are indicated as "Setting parameters".
  Parameters required only to refine a query are indicated as "Query parameters".
  Parameters that are only returned as the result of a query are indicated as "Return values".
- *Conformity*
  Commands that are taken from the SCPI standard are indicated as "SCPI confirmed". All commands used by the FSW follow the SCPI syntax rules.
- *Asynchronous commands*
  A command which does not automatically finish executing before the next command starts executing (overlapping command) is indicated as an "Asynchronous command".
- *Reset values (*RST)*

Default parameter values that are used directly after resetting the instrument (`*RST` command) are indicated as "*RST" values, if available.

- *Default unit*
  The default unit is used for numeric values if no other unit is provided with the parameter.
- *Manual operation*
  If the result of a remote command can also be achieved in manual operation, a link to the description is inserted.

11.1.2 Long and short form

The keywords have a long and a short form. You can use either the long or the short form, but no other abbreviations of the keywords.

The short form is emphasized in uppercase letters. Note however, that this emphasis only serves the purpose to distinguish the short from the long form in the manual. For the instrument, the case does not matter.

Example:

`SENSe:FREQuency:CENTer` is the same as `SENS:FREQ:CENT`.

11.1.3 Numeric suffixes

Some keywords have a numeric suffix if the command can be applied to multiple instances of an object. In that case, the suffix selects a particular instance (e.g. a measurement window).

Numeric suffixes are indicated by angular brackets (<n>) next to the keyword.

If you do not quote a suffix for keywords that support one, a 1 is assumed.

Example:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe` enables the zoom in a particular measurement window, selected by the suffix at `WINDow`.

`DISPlay:WINDow4:ZOOM:STATe ON` refers to window 4.

11.1.4 Optional keywords

Some keywords are optional and are only part of the syntax because of SCPI compliance. You can include them in the header or not.

If an optional keyword has a numeric suffix and you need to use the suffix, you have to include the optional keyword. Otherwise, the suffix of the missing keyword is assumed to be the value 1.

Optional keywords are emphasized with square brackets.

Example:

Without a numeric suffix in the optional keyword:

`[SENSe:]FREQuency:CENTer` is the same as `FREQuency:CENTer`

With a numeric suffix in the optional keyword:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe`

`DISPlay:ZOOM:STATe ON` enables the zoom in window 1 (no suffix).

`DISPlay:WINDow4:ZOOM:STATe ON` enables the zoom in window 4.

11.1.5 Alternative keywords

A vertical stroke indicates alternatives for a specific keyword. You can use both keywords to the same effect.

Example:

`[SENSe:]BANDwidth|BWIDth[:RESolution]`

In the short form without optional keywords, `BAND 1MHZ` would have the same effect as `BWID 1MHZ`.

11.1.6 SCPI parameters

Many commands feature one or more parameters.

If a command supports more than one parameter, they are separated by a comma.

Example:

`LAYout:ADD:WINDow Spectrum,LEFT,MTABle`

Parameters can have different forms of values.

11.1.6.1 Numeric values

Numeric values can be entered in any form, i.e. with sign, decimal point or exponent. For physical quantities, you can also add the unit. If the unit is missing, the command uses the basic unit.

Example:

With unit: `SENSe:FREQuency:CENTer 1GHZ`

Without unit: `SENSe:FREQuency:CENTer 1E9` would also set a frequency of 1 GHz.

Values exceeding the resolution of the instrument are rounded up or down.

If the number you have entered is not supported (e.g. for discrete steps), the command returns an error.

Instead of a number, you can also set numeric values with a text parameter in special cases.

- MIN/MAX
  Defines the minimum or maximum numeric value that is supported.
- DEF
  Defines the default value.
- UP/DOWN
  Increases or decreases the numeric value by one step. The step size depends on the setting. Sometimes, you can customize the step size with a corresponding command.

Querying numeric values

When you query numeric values, the system returns a number. For physical quantities, it applies the basic unit (e.g. Hz for frequencies). The number of digits after the decimal point depends on the type of numeric value.

Example:

Setting: `SENSe:FREQuency:CENTer 1GHZ`

Query: `SENSe:FREQuency:CENTer?` would return `1E9`

Sometimes, numeric values are returned as text.

- INF/NINF
  Infinity or negative infinity. Represents the numeric values 9.9E37 or -9.9E37.
- NAN
  Not a number. Represents the numeric value 9.91E37. NAN is returned if errors occur.

11.1.6.2 Boolean

Boolean parameters represent two states. The "on" state (logically true) is represented by "`ON`" or the numeric value 1. The "off" state (logically untrue) is represented by "`OFF`" or the numeric value 0.

Querying Boolean parameters

When you query Boolean parameters, the system returns either the value 1 ("`ON`") or the value 0 ("`OFF`").

Example:

Setting: `DISPlay:WINDow:ZOOM:STATe ON`

Query: `DISPlay:WINDow:ZOOM:STATe?` would return `1`

11.1.6.3 Character data

Character data follows the syntactic rules of keywords. You can enter text using a short or a long form. For more information, see Chapter 11.1.2, "Long and short form", on page 111.

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`

11.1.6.4 Character strings

Strings are alphanumeric characters. They have to be in straight quotation marks. You can use a single quotation mark (') or a double quotation mark (").

Example:

`INSTRument:DELete 'Spectrum'`

11.1.6.5 Block data

Block data is a format which is suitable for the transmission of large amounts of data.

The ASCII character # introduces the data block. The next number indicates how many of the following digits describe the length of the data block. The data bytes follow. During the transmission of these data bytes, all end or other control signs are ignored until all bytes are transmitted. #0 specifies a data block of indefinite length. The use of the indefinite format requires an `NL^END` message to terminate the data block. This format is useful when the length of the transmission is not known or if speed or other considerations prevent segmentation of the data into blocks of definite length.

11.2 Common suffixes

In the R&S FSW MCGD application, the following common suffixes are used in remote commands:

Table 11-1: Common suffixes used in remote commands in the R&S FSW MCGD application

Suffix	Value range	Description
<m>	1 to 16	Marker
<n>	1 to 6	Window (**in the currently selected channel**)

Suffix	Value range	Description
<t>	1 to 4	Trace
	1 to 8	Limit line

11.3 Activating multi-carrier group delay measurements

Multi-Carrier "Group Delay" measurements requires a special application on the FSW. A measurement is started immediately with the default settings.

INSTrument:CREate:DUPLicate

Duplicates the currently selected channel, i.e creates a new channel of the same type and with the identical measurement settings. The name of the new channel is the same as the copied channel, extended by a consecutive number (e.g. "IQAnalyzer" -> "IQAnalyzer 2").

The channel to be duplicated must be selected first using the `INST:SEL` command.

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

Usage: Event

INSTrument:CREate[:NEW] <ChannelType>, <ChannelName>

Adds a measurement channel. You can configure up to 10 measurement channels at the same time (depending on available memory).

Parameters:

<ChannelType> Channel type of the new channel.
For a list of available channel types, see `INSTrument:LIST?` on page 116.

<ChannelName> String containing the name of the channel.
Note that you cannot assign an existing channel name to a new channel. If you do, an error occurs.

Example:
`INST:CRE SAN, 'Spectrum 2'`
Adds a spectrum display named "Spectrum 2".

INSTrument:CREate:REPLace <ChannelName1>, <ChannelType>, <ChannelName2>

Replaces a channel with another one.

Setting parameters:

<ChannelName1> String containing the name of the channel you want to replace.

<ChannelType> Channel type of the new channel.
For a list of available channel types, see `INSTrument:LIST?` on page 116.

<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 116).
Channel names can have a maximum of 31 characters, and must be compatible with the Windows conventions for file names. In particular, they must not contain special characters such as ":", "*", "?".

Example: `INST:CRE:REPL 'IQAnalyzer2',IQ,'IQAnalyzer'`
Replaces the channel named "IQAnalyzer2" by a new channel of type "IQ Analyzer" named "IQAnalyzer".

Usage: Setting only

INSTrument:DELete <ChannelName>

Deletes a channel.

If you delete the last channel, the default "Spectrum" channel is activated.

Setting parameters:

<ChannelName> String containing the name of the channel you want to delete.
A channel must exist to delete it.

Example: `INST:DEL 'IQAnalyzer4'`
Deletes the channel with the name 'IQAnalyzer4'.

Usage: Setting only

INSTrument:LIST?

Queries all active channels. The query is useful to obtain the names of the existing channels, which are required to replace or delete the channels.

Return values:

<ChannelType>, <ChannelName> For each channel, the command returns the channel type and channel name (see tables below).
Tip: to change the channel name, use the `INSTrument:REName` command.

Example:
```
INST:LIST?
```
Result for 3 channels:
```
'ADEM','Analog Demod','IQ','IQ
Analyzer','IQ','IQ Analyzer2'
```

Usage: Query only

Table 11-2: Available channel types and default channel names in Signal and Spectrum Analyzer mode

Application	<ChannelType> parameter	Default Channel name*)
Spectrum	SANALYZER	Spectrum
1xEV-DO BTS (R&S FSW-K84)	BDO	1xEV-DO BTS
1xEV-DO MS (R&S FSW-K85)	MDO	1xEV-DO MS
3GPP FDD BTS (R&S FSW-K72)	BWCD	3G FDD BTS
3GPP FDD UE (R&S FSW-K73)	MWCD	3G FDD UE
802.11ad (R&S FSW-K95)	WIGIG	802.11ad
802.11ay (R&S FSW-K97)	EDMG	802.11ay EDMG
Amplifier Measurements (R&S FSW-K18)	AMPLifier	Amplifier
AM/FM/PM Modulation Analysis (R&S FSW-K7)	ADEM	Analog Demod
Avionics (R&S FSW-K15)	AVIonics	Avionics
Bluetooth (R&S FSW-K8)	BTO	Bluetooth
cdma2000 BTS (R&S FSW-K82)	BC2K	CDMA2000 BTS
cdma2000 MS (R&S FSW-K83)	MC2K	CDMA2000 MS
DOCSIS 3.1 (R&S FSW-K192/193)	DOCSis	DOCSIS 3.1
Fast Spur Search (R&S FSW-K50)	SPUR	Spurious
GSM (R&S FSW-K10)	GSM	GSM
HRP UWB (R&S FSW-K149)	UWB	HRP UWB
I/Q Analyzer	IQ	IQ Analyzer
LTE (R&S FSW-K10x)	LTE	LTE
Multi-Carrier "Group Delay" (R&S FSW-K17)	MCGD	MC "Group Delay"
NB-IoT (R&S FSW-K106)	NIOT	NB-IoT
Noise (R&S FSW-K30)	NOISE	Noise
5G NR (R&S FSW-K144)	NR5G	5G NR
OFDM VSA (R&S FSW-K96)	OFDMVSA	OFDM VSA
OneWeb (R&S FSW-K201)	OWEB	OneWeb
Phase Noise (R&S FSW-K40)	PNOISE	Phase Noise
*) If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel.		

Application	<ChannelType> parameter	Default Channel name*)
Pulse (R&S FSW-K6)	PULSE	Pulse
"Real-Time Spectrum"	RTIM	"Real-Time Spectrum"
TD-SCDMA BTS (R&S FSW-K76)	BTDS	TD-SCDMA BTS
TD-SCDMA UE (R&S FSW-K77)	MTDS	TD-SCDMA UE
Transient Analysis (R&S FSW-K60)	TA	Transient Analysis
Verizon 5GTF Measurement Application (V5GTF, R&S FSW-K118)	V5GT	V5GT
VSA (R&S FSW-K70)	DDEM	VSA
WLAN (R&S FSW-K91)	WLAN	WLAN
*) If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel.		

INSTrument:REName <ChannelName1>, <ChannelName2>

Renames a channel.

Setting parameters:

<ChannelName1> String containing the name of the channel you want to rename.

<ChannelName2> String containing the new channel name.
Note that you cannot assign an existing channel name to a new channel. If you do, an error occurs.
Channel names can have a maximum of 31 characters, and must be compatible with the Windows conventions for file names. In particular, they must not contain special characters such as ":", "*", "?".

Example: `INST:REN 'IQAnalyzer2','IQAnalyzer3'`
Renames the channel with the name 'IQAnalyzer2' to 'IQAnalyzer3'.

Usage: Setting only

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 115.

Parameters:

<ChannelType> **MCGD**
Multi-Carrier "Group Delay" application, FSW-K17
For a list of available channel types see `INSTrument:LIST?` on page 116.

<ChannelName> String containing the name of the channel.

SYSTem:PRESet:CHANnel[:EXEC]

Restores the default instrument settings in the current channel.

Use `INST:SEL` to select the channel.

Example: `INST:SEL 'Spectrum2'`
Selects the channel for "Spectrum2".
`SYST:PRES:CHAN:EXEC`
Restores the factory default settings to the "Spectrum2" channel.

Usage: Event

Manual operation: See "Preset Channel" on page 34

11.4 Configuring multi-carrier group delay measurements

The commands required to configure a Multi-Carrier "Group Delay" measurement in a remote environment are described here.

11.4.1 RF input

INPut:ATTenuation:PROTection:RESet

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

(For details on the status register see the FSW base unit user manual).

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

Example: `INP:ATT:PROT:RES`

INPut:CONNector <ConnType>

Determines which connector the input for the measurement is taken from.

Parameters:

<ConnType>

RF
RF input connector

RFPRobe
Active RF probe

*RST: RF

Example: `INP:CONN RF`
Selects input from the RF input connector.

INPut:COUPling <CouplingType>

Selects the coupling type of the RF input.

Parameters:

<CouplingType> AC | DC

AC
AC coupling

DC
DC coupling

*RST: AC

Example: `INP:COUP DC`

Manual operation: See "Input Coupling" on page 36

INPut:DPATh <DirectPath>

Enables or disables the use of the direct path for frequencies close to 0 Hz.

Parameters:

<DirectPath> AUTO | OFF

AUTO | 1
(Default) the direct path is used automatically for frequencies close to 0 Hz.

OFF | 0
The analog mixer path is always used.

Example: `INP:DPAT OFF`

Manual operation: See "Direct Path" on page 36

INPut:FILTer:HPASs[:STATe] <State>

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

Requires an additional high-pass filter hardware option.

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

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

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example: `INP:FILT:HPAS ON`
Turns on the filter.

Manual operation: See "High Pass Filter 1 to 3 GHz" on page 37

INPut:FILTer:YIG[:STATe] <State>

Enables or disables the YIG filter.

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

Example: `INP:FILT:YIG OFF`
Deactivates the YIG-preselector.

Manual operation: See "YIG-Preselector" on page 37

INPut:IMPedance <Impedance>

Selects the nominal input impedance of the RF input. In some applications, only 50 Ω are supported.

Parameters:
<Impedance> 50 | 75

*RST: 50 Ω
Default unit: OHM

Example: `INP:IMP 75`

Manual operation: See "Impedance" on page 36

INPut:SELect <Source>

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

If no additional input options are installed, only RF input is supported.

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

Parameters:
<Source>

RF
Radio Frequency ("RF INPUT" connector)

FIQ
I/Q data file
Not available for Input2.

*RST: RF

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

Manual operation: See "Radio Frequency State" on page 35
See "I/Q Input File State" on page 38

INPut:TYPE <Input>

The command selects the input path.

Parameters:
<Input>

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

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

*RST: INPUT1

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

Manual operation: See "Radio Frequency State" on page 35

TRACe:IQ:WBANd:MBWidth <Limit>

Defines the maximum analysis bandwidth. Any value can be specified; the next higher fixed bandwidth is used.

Defining a value other than "MAX" is useful if you want to specify the sample rate directly and at the same time, ensure a minimum bandwidth is available.

Parameters:

<Limit>

80 MHz
Restricts the analysis bandwidth to a maximum of 80 MHz.
The bandwidth extension options greater than 160 MHz are disabled.
`TRACe:IQ:WBANd[:STATe]` is set to OFF.

160 MHz
Restricts the analysis bandwidth to a maximum of 160 MHz. The bandwidth extension option R&S FSW-B320 is deactivated.
(Not available or required if other bandwidth extension options larger than 320 MHz are installed.)
`TRACe:IQ:WBANd[:STATe]` is set to ON.

1200 MHz | 500 MHz | 320 MHz | MAX
All installed bandwidth extension options are activated. The currently available maximum bandwidth is allowed.
`TRACe:IQ:WBANd[:STATe]` is set to ON.

*RST: maximum available
Default unit: Hz

Example:
```
TRAC:IQ:WBAN:MBW 82 MHZ
TRAC:IQ:WBAN:MBW?
```
Result if R&S FSW-B160/-B320 is active:
```
160000000
```

Example:
```
TRAC:IQ:WBAN:MBW 82 MHZ
TRAC:IQ:WBAN:MBW?
```
Result if R&S FSW-B512 is active:
```
512000000
```

Manual operation: See "Maximum Bandwidth" on page 37

TRACe:IQ:WBANd[:STATe] <State>

Determines whether the wideband provided by bandwidth extension options is used or not (if installed).

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Manual operation: See "Maximum Bandwidth" on page 37

11.4.2 Input from I/Q data files

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

Useful commands for retrieving results described elsewhere:

- `INPut:SELect` on page 122

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

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

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

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

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

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

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

Parameters:

<FileName> String containing the path and name of the source file.
The file type is determined by the file extension. If no file extension is provided, the file type is assumed to be `.iq.tar`.
For `.mat` files, Matlab® v4 is assumed.

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

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

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

Manual operation: See "Select I/Q data file" on page 38

MMEMory:LOAD:IQ:STReam <Channel>

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

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

Parameters:
<Channel> String containing the channel name.

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

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

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

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

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

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

*RST: 1

MMEMory:LOAD:IQ:STReam:LIST?

Returns the available channels in the currently loaded input file.

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

Usage: Query only

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

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

Parameters:
<RepetitionCount> integer

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

Manual operation: See "File Repetitions" on page 39

11.4.3 Configuring the vertical axis (amplitude, scaling)

The following commands are required to configure the amplitude and vertical axis settings in a remote environment.

11.4.3.1 Amplitude settings

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel <ReferenceLevel>

Defines the reference level (for all traces in all windows).

With a reference level offset ≠ 0, the value range of the reference level is modified by the offset.

Suffix:

<n> irrelevant

<w> subwindow
Not supported by all applications

<t> irrelevant

Parameters:

<ReferenceLevel> The unit is variable.

Range: see specifications document
*RST: 0 dBm
Default unit: DBM

Example: `DISP:TRAC:Y:RLEV -60dBm`

Manual operation: See "Reference Level" on page 40

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel:OFFSet <Offset>

Defines a reference level offset (for all traces in all windows).

Suffix:

<n> irrelevant

<w> subwindow
Not supported by all applications

<t> irrelevant

Parameters:

<Offset> Range: -200 dB to 200 dB
*RST: 0dB
Default unit: DB

Example: `DISP:TRAC:Y:RLEV:OFFS -10dB`

Manual operation: See "Shifting the Display (Offset)" on page 41

11.4.3.2 Attenuation

INPut:ATTenuation <Attenuation>

Defines the total attenuation for RF input.

If an electronic attenuator is available and active, the command defines a mechanical attenuation (see `INPut:EATT:STATe` on page 129).

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 specifications document
Increment: 5 dB (with optional electr. attenuator: 1 dB)
*RST: 10 dB (AUTO is set to ON)
Default unit: DB

Example:
`INP:ATT 30dB`
Defines a 30 dB attenuation and decouples the attenuation from the reference level.

Manual operation: See "Attenuation Mode / Value" on page 41

INPut:ATTenuation:AUTO <State>

Couples or decouples the attenuation to the reference level. Thus, when the reference level is changed, the FSW determines the signal level for optimal internal data processing and sets the required attenuation accordingly.

Parameters:

<State>

ON | OFF | 0 | 1
*RST: 1

Example:
`INP:ATT:AUTO ON`
Couples the attenuation to the reference level.

Manual operation: See "Attenuation Mode / Value" on page 41

INPut:EATT <Attenuation>

Defines an electronic attenuation manually. Automatic mode must be switched off (`INP:EATT:AUTO OFF`, see `INPut:EATT:AUTO` on page 128).

If the current reference level is not compatible with an attenuation that has been set manually, the command also adjusts the reference level.

Parameters:

<Attenuation>

attenuation in dB
Range: see specifications document
Increment: 1 dB
*RST: 0 dB (OFF)
Default unit: DB

Example:
```
INP:EATT:AUTO OFF
INP:EATT 10 dB
```

Manual operation: See "Using Electronic Attenuation" on page 41

INPut:EATT:AUTO <State>

Turns automatic selection of the electronic attenuation on and off.

If on, electronic attenuation reduces the mechanical attenuation whenever possible.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 1

Example: `INP:EATT:AUTO OFF`

Manual operation: See "Using Electronic Attenuation" on page 41

INPut:EATT:STATe <State>

Turns the electronic attenuator on and off.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example: `INP:EATT:STAT ON`
Switches the electronic attenuator into the signal path.

Manual operation: See "Using Electronic Attenuation" on page 41

11.4.3.3 Configuring a preamplifier

INPut:EGAin[:STATe] <State>

Before this command can be used, the external preamplifier must be connected to the FSW. See the preamplifier's documentation for details.

When activated, the FSW automatically compensates the magnitude and phase characteristics of the external preamplifier in the measurement results.

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

For FSW85 models with two RF inputs, you must enable correction from the external preamplifier for each input individually. Correction cannot be enabled for both inputs at the same time.

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

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

OFF | 0
No data correction is performed based on the external preamplifier

ON | 1
Performs data corrections based on the external preamplifier

*RST: 0

Example: `INP:EGA ON`

Manual operation: See "Ext. PA Correction" on page 42

INPut:GAIN:STATe <State>

Turns the internal preamplifier on and off. It requires the optional preamplifier hardware.

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

For FSW85 models, no preamplifier is available.

If option R&S FSW-B22 is installed, the preamplifier is only active below 7 GHz.

If option R&S FSW-B24 is installed, the preamplifier is active for all frequencies.

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

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example:
```
INP:GAIN:STAT ON
INP:GAIN:VAL 15
```
Switches on 15 dB preamplification.

Manual operation: See "Preamplifier" on page 42

INPut:GAIN[:VALue] <Gain>

Selects the "gain" if the preamplifier is activated (`INP:GAIN:STAT ON`, see `INPut:GAIN:STATe` on page 130).

The command requires the additional preamplifier hardware option.

Parameters:

<Gain> For all FSW models except for FSW85, the following settings are available:
15 dB and 30 dB
All other values are rounded to the nearest of these two.
30 dB
For older FSW43/FSW50/FSW67 models, the input signal is always ampilfied by about 30 dB when the preamplifier is active.
For FSW85 models, no preamplifier is available.
Default unit: DB

Example:
```
INP:GAIN:STAT ON
INP:GAIN:VAL 30
```
Switches on 30 dB preamplification.

Manual operation: See "Preamplifier" on page 42

11.4.3.4 Scaling the Y-Axis (+units)

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:AUTO ONCE

Automatic scaling of the y-axis is performed once, then switched off again (for all traces).

Suffix:

<n> Window

<t> irrelevant

Manual operation: See "Auto Scale Once" on page 45

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe] <Range>

Defines the display range of the y-axis (for all traces).

Suffix:

<n> Window

<w> subwindow
Not supported by all applications

<t> irrelevant

Example: `DISP:TRAC:Y 110dB`

Manual operation: See "Range" on page 45

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MAXimum <Value>

Defines the maximum value on the y-axis in the specified window.

Suffix:
<n> Window

<t> irrelevant

Parameters:
<Max> numeric value

Example: `DISP:WIND2:TRAC:Y:SCAL:MAX 10`

Manual operation: See "Defining Min and Max Values" on page 46

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MINimum <Value>

Defines the minimum value on the y-axis in the specified window.

Suffix:
<n> Window

<t> irrelevant

Parameters:
<Min> numeric value

Example: `DISP:WIND2:TRAC:Y:SCAL:MIN -90`

Manual operation: See "Defining Min and Max Values" on page 46

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:MODE <Mode>

Selects the type of scaling of the y-axis (for all traces).

When the display update during remote control is off, this command has no immediate effect.

Suffix:
<n> Window

<w> subwindow

<t> irrelevant

Parameters:
<Mode> **ABSolute**
absolute scaling of the y-axis
RELative
relative scaling of the y-axis

*RST: ABSolute

Example: `DISP:TRAC:Y:MODE REL`

Manual operation: See "Scaling" on page 45
See "Scale Mode" on page 47

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:PDIVision <Value>

This remote command determines the grid spacing on the Y-axis for all diagrams, where possible.

In spectrum displays, for example, this command is not available.

Suffix:

<n> Window

<w> subwindow
Not supported by all applications

<t> irrelevant

Parameters:

<Value> numeric value WITHOUT UNIT (unit according to the result display)

Defines the range per division (total range = 10*<Value>)

*RST: depends on the result display
Default unit: DBM

Example: `DISP:TRAC:Y:PDIV 10`
Sets the grid spacing to 10 units (e.g. dB) per division

Manual operation: See "Range per Division" on page 46

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RPOSition <Position>

Defines the vertical position of the reference level on the display grid (for all traces).

The FSW adjusts the scaling of the y-axis accordingly.

Suffix:

<n> Window

<w> subwindow
Not supported by all applications

<t> irrelevant

Parameters:
<Position> 0 PCT corresponds to the lower display border, 100% corresponds to the upper display border.
*RST: 100 PCT = frequency display; 50 PCT = time display
Default unit: PCT

Example: `DISP:TRAC:Y:RPOS 50PCT`

Manual operation: See "Ref Level Position" on page 45
See "Y-Axis Reference Position" on page 46

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RVALue <Value>

Defines the reference value assigned to the reference position in the specified window. Separate reference values are maintained for the various displays.

Suffix:
<n> Window
<w> subwindow
<t> irrelevant

Parameters:
<Value> Default unit: DB

Example: `DISP:TRAC:Y:RVAL 0`
Sets the value assigned to the reference position to 0 Hz

Manual operation: See "Y-Axis Reference Value" on page 46

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y:SPACing <ScalingType>

Selects the scaling of the y-axis (for all traces, <t> is irrelevant).

Suffix:
<n> Window
<w> subwindow
<t> Trace

Parameters:
<ScalingType> **LOGarithmic**
Logarithmic scaling.
LINear
Linear scaling in %.
LDB
Linear scaling in the specified unit.
PERCent
Linear scaling in %.
*RST: LOGarithmic

Example: `DISP:TRAC:Y:SPAC LIN`
Selects linear scaling in %.

Manual operation: See "Scaling" on page 45

UNIT:ANGLe <Unit>

Selects the unit for angles (for phase displays).

Parameters:
<Unit> DEG | RAD
*RST: DEG

Example: `UNIT:ANGL DEG`

Manual operation: See "Phase Unit (Rad/Deg)" on page 47

11.4.4 Frequency

[SENSe:]FREQuency:CENTer <Frequency>

Defines the center frequency.

Parameters:
<Frequency> For the allowed range and f_{max}, refer to the specifications document.
*RST: fmax/2
Default unit: Hz

Example:
```
FREQ:CENT 100 MHz
FREQ:CENT:STEP 10 MHz
FREQ:CENT UP
```
Sets the center frequency to 110 MHz.

Manual operation: See "Center Frequency" on page 48

[SENSe:]FREQuency:CENTer:STEP <StepSize>

Defines the center frequency step size.

You can increase or decrease the center frequency quickly in fixed steps using the `SENS:FREQ UP` AND `SENS:FREQ DOWN` commands, see `[SENSe:]FREQuency:CENTer` on page 135.

Parameters:

<StepSize> For f_{max}, refer to the specifications document.

Range: 1 to fMAX
*RST: 0.1 x span
Default unit: Hz

Example: //Set the center frequency to 110 MHz.
```
FREQ:CENT 100 MHz
FREQ:CENT:STEP 10 MHz
FREQ:CENT UP
```

Manual operation: See "Center Frequency Stepsize" on page 48

[SENSe:]FREQuency:CENTer:STEP:LINK <CouplingType>

Couples and decouples the center frequency step size to the span or the resolution bandwidth.

Parameters:

<CouplingType> SPAN | RBW | OFF

SPAN
Couples the step size to the span. Available for measurements in the frequency domain.

OFF
Decouples the step size.

*RST: SPAN

Example: //Couple step size to span
```
FREQ:CENT:STEP:LINK SPAN
```

[SENSe:]FREQuency:CENTer:STEP:LINK:FACTor <Factor>

Defines a step size factor if the center frequency step size is coupled to the span.

Parameters:

<Factor> 1 to 100 PCT

*RST: 10
Default unit: PCT

Example: //Couple frequency step size to span and define a step size factor
```
FREQ:CENT:STEP:LINK SPAN
FREQ:CENT:STEP:LINK:FACT 20PCT
```

[SENSe:]FREQuency:OFFSet <Offset>

Defines a frequency offset.

If this value is not 0 Hz, the application assumes that the input signal was frequency shifted outside the application. All results of type "frequency" will be corrected for this shift numerically by the application.

See also "Frequency Offset" on page 49.

Parameters:

<Offset>
Range: -1 THz to 1 THz
*RST: 0 Hz
Default unit: HZ

Example: `FREQ:OFFS 1GHZ`

Manual operation: See "Frequency Offset" on page 49

11.4.5 Triggering measurements

Useful commands for triggering described elsewhere:

- `[SENSe:]FREQuency:CENTer` on page 135

Remote commands exclusive to triggering:

11.4.5.1 Configuring the triggering conditions

TRIGger[:SEQuence]:DTIMe <DropoutTime>

Defines the time the input signal must stay below the trigger level before a trigger is detected again.

Parameters:

<DropoutTime> Dropout time of the trigger.
Range: 0 s to 10.0 s
*RST: 0 s
Default unit: S

Manual operation: See "Drop-Out Time" on page 52

TRIGger[:SEQuence]:HOLDoff[:TIME] <Offset>

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

Parameters:

<Offset> *RST: 0 s
Default unit: S

Example: `TRIG:HOLD 500us`

Manual operation: See "Trigger Offset" on page 53

TRIGger[:SEQuence]:IFPower:HOLDoff <Period>

Defines the holding time before the next trigger event.

Note that this command can be used for **any trigger source**, not just IF Power (despite the legacy keyword).

Parameters:

<Period> Range: 0 s to 10 s
*RST: 0 s
Default unit: S

Example: `TRIG:SOUR EXT`
Sets an external trigger source.
`TRIG:IFP:HOLD 200 ns`
Sets the holding time to 200 ns.

Manual operation: See "Trigger Holdoff" on page 53

TRIGger[:SEQuence]:IFPower:HYSTeresis <Hysteresis>

Defines the trigger hysteresis, which is only available for "IF Power" trigger sources.

Parameters:

<Hysteresis> Range: 3 dB to 50 dB
*RST: 3 dB
Default unit: DB

Example: `TRIG:SOUR IFP`
Sets the IF power trigger source.
`TRIG:IFP:HYST 10DB`
Sets the hysteresis limit value.

Manual operation: See "Hysteresis" on page 53

TRIGger[:SEQuence]:LEVel[:EXTernal<port>] <TriggerLevel>

Defines the level the external signal must exceed to cause a trigger event.

Note that the variable "Input/Output" connectors (ports 2+3) must be set for use as input using the `OUTPut:TRIGger<tp>:DIRection` command.

Suffix:
<port> Selects the trigger port.
1 = trigger port 1 (TRIGGER INPUT connector on front panel)
2 = trigger port 2 (TRIGGER INPUT/OUTPUT connector on front panel)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (TRIGGER3 INPUT/OUTPUT connector on rear panel)

Parameters:
<TriggerLevel> Range: 0.5 V to 3.5 V
*RST: 1.4 V
Default unit: V

Example: `TRIG:LEV 2V`

Manual operation: See "Trigger Level" on page 52

TRIGger[:SEQuence]:LEVel:IFPower <TriggerLevel>

Defines the power level at the third intermediate frequency that must be exceeded to cause a trigger event.

Note that any RF attenuation or preamplification is considered when the trigger level is analyzed. If defined, a reference level offset is also considered.

Parameters:
<TriggerLevel> For details on available trigger levels and trigger bandwidths, see the specifications document.
*RST: -20 dBm
Default unit: DBM

Example: `TRIG:LEV:IFP -30DBM`

Manual operation: See "Trigger Level" on page 52

TRIGger[:SEQuence]:LEVel:IQPower <TriggerLevel>

Defines the magnitude the I/Q data must exceed to cause a trigger event.

Note that any RF attenuation or preamplification is considered when the trigger level is analyzed. If defined, a reference level offset is also considered.

Parameters:
<TriggerLevel> Range: -130 dBm to 30 dBm
*RST: -20 dBm
Default unit: DBM

Example: `TRIG:LEV:IQP -30DBM`

Manual operation: See "Trigger Level" on page 52

TRIGger[:SEQuence]:LEVel:RFPower <TriggerLevel>

Defines the power level the RF input must exceed to cause a trigger event. Note that any RF attenuation or preamplification is considered when the trigger level is analyzed. If defined, a reference level offset is also considered.

The input signal must be between 500 MHz and 8 GHz.

Parameters:

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

*RST: -20 dBm
Default unit: DBM

Example: `TRIG:LEV:RFP -30dBm`

TRIGger[:SEQuence]:RFPower:HOLDoff <Time>

Parameters:

<Time> Default unit: S

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 53

TRIGger[:SEQuence]:SOURce <Source>

Selects the trigger source.

Note on external triggers:

If a measurement is configured to wait for an external trigger signal in a remote control program, remote control is blocked until the trigger is received and the program can continue. Make sure that this situation is avoided in your remote control programs.

Parameters:

<Source>

IMMediate
Free Run

EXTernal
Trigger signal from the "Trigger Input" connector.

EXT2
Trigger signal from the "Trigger Input/Output" connector.
For FSW85 models, Trigger 2 is not available due to the second RF input connector on the front panel. The trigger signal is taken from the "Trigger Input/Output" connector on the rear panel.
Note: Connector must be configured for "Input".

EXT3
Trigger signal from the "TRIGGER 3 INPUT/ OUTPUT" connector.
Note: Connector must be configured for "Input".

RFPower
First intermediate frequency
(Frequency and time domain measurements only.)

IFPower
Second intermediate frequency

IQPower
Magnitude of sampled I/Q data
For applications that process I/Q data, such as the I/Q Analyzer or optional applications.

*RST: IMMediate

Example: `TRIG:SOUR EXT`
Selects the external trigger input as source of the trigger signal

Manual operation:
See "Trigger Source" on page 50
See "Free Run" on page 51
See "External Trigger 1/2/3" on page 51
See "IF Power" on page 51
See "RF Power" on page 52
See "I/Q Power" on page 52
See "Time" on page 52
See "Trigger Source" on page 60

TRIGger[:SEQuence]:TIME:RINTerval <Interval>

Defines the repetition interval for the time trigger.

Parameters:
<Interval> numeric value

Range: 2 ms to 5000 s
*RST: 1.0 s
Default unit: S

Example: `TRIG:SOUR TIME`
Selects the time trigger input for triggering.
`TRIG:TIME:RINT 5`
The sweep starts every 5 s.

Manual operation: See "Repetition Interval" on page 53

11.4.5.2 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 FSW.

OUTPut:TRIGger<tp>:DIRection <Direction>

Selects the trigger direction for trigger ports that serve as an input as well as an output.

Suffix:

<tp> Selects the used trigger port.
2 = trigger port 2 (front)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (rear panel)

Parameters:

<Direction> INPut | OUTPut

INPut
Port works as an input.

OUTPut
Port works as an output.

*RST: INPut

Manual operation: See "Trigger 2/3" on page 54

OUTPut:TRIGger<tp>:LEVel <Level>

Defines the level of the (TTL compatible) signal generated at the trigger output.

Works only if you have selected a user-defined output with `OUTPut:TRIGger<tp>:OTYPe`.

Suffix:

<tp> 1..n
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (rear)

Parameters:

<Level> **HIGH**
5 V

LOW
0 V

*RST: LOW

Example: `OUTP:TRIG2:LEV HIGH`

Manual operation: See "Level" on page 55

OUTPut:TRIGger<tp>:OTYPe <OutputType>

Selects the type of signal generated at the trigger output.

Suffix:

<tp>
1..n
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (rear)

Parameters:

<OutputType>

DEVice
Sends a trigger signal when the FSW has triggered internally.

TARMed
Sends a trigger signal when the trigger is armed and ready for an external trigger event.

UDEFined
Sends a user-defined trigger signal. For more information, see `OUTPut:TRIGger<tp>:LEVel`.

*RST: DEVice

Manual operation: See "Output Type" on page 54

OUTPut:TRIGger<tp>:PULSe:IMMediate

Generates a pulse at the trigger output.

Suffix:

<tp>
1..n
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (rear)

Manual operation: See "Send Trigger" on page 55

OUTPut:TRIGger<tp>:PULSe:LENGth <Length>

Defines the length of the pulse generated at the trigger output.

Suffix:

<tp>
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
(Not available for FSW85 models with two RF input connectors.)
3 = trigger port 3 (rear)

Parameters:

<Length> Pulse length in seconds.
Default unit: S

Example: `OUTP:TRIG2:PULS:LENG 0.02`

Manual operation: See "Pulse Length" on page 55

11.4.6 Multi-carrier configuration

The following commands are required to configure the multi-carrier measurement.

CALCulate<n>:GRPDelay:MODE <Mode>

Sets the group delay mode for multi carriers or queries its current state.

Suffix:

<n> 1..n

Parameters:

<Mode> ABSolute | RELative

ABSolute
Calculates the absolute group delay; requires an external trigger

RELative
Calculates the relative group delay; the reference is configured by `CALCulate:GRPDelay:REFerence`.

*RST: RELative

Example: `CALC:GRPD:MODE ABS`

Manual operation: See "Group Delay Mode" on page 60

CALCulate:GRPDelay:REFerence <RefType>

Determines the reference used for relative group delay measurement.

Parameters:

<RefType>

AVERage
(Default:) The average group delay is used as a reference

CENTer
The group delay measured for the center frequency is used as a reference

MANual
The group delay measured at the user-defined reference frequency is used as a reference (see `CALCulate:GRPDelay:REFerence:FREQuency` on page 145)

*RST: AVERage

Example:
```
CALC:GRPD:MODE REL
CALC:GRPD:REF MAN
CALC:GRPD:REF:FREQ 5GHZ
```

Manual operation: See "Reference for Relative Calculation/ Reference Frequency" on page 60

CALCulate:GRPDelay:REFerence:FREQuency <RefCarrFreq>

Determines the frequency of the reference carrier used for relative group delay calculation. The group delay measured at this frequency is used as a reference.

Parameters:

<RefCarrFreq> <numeric value>

Example:
```
CALC:GRPD:MODE REL
CALC:GRPD:REF MAN
CALC:GRPD:REF:FREQ 5GHZ
```

Manual operation: See "Reference for Relative Calculation/ Reference Frequency" on page 60

[SENSe<ip>:]BANDwidth:DEMod <Bandwidth>
[SENSe<ip>:]BWIDth:DEMod <Bandwidth>

Suffix:

<ip> 1..n

Parameters:

<Bandwidth> Default unit: HZ

[SENSe:]CARRier:COUNt <Count>

Sets/queries the number of carriers.

Parameters:

<Count> integer

Example: `SENS:CARR:COUN 100`

Manual operation: See "Number of Carriers" on page 58

[SENSe:]CARRier:SPACing <CarrierSpacing>

Sets/queries the carrier spacing in Hz between the multiple carriers.

Parameters:

<CarrierSpacing> Default unit: HZ

Manual operation: See "Carrier Spacing" on page 57

[SENSe:]CARRier:OFFSet?

Frequency offset of the captured multi-carrier signal compared to the setting given by multi-carrier signal description. This frequency offset is estimated and compensated when using carrier estimation modes "Offset" or "All Carriers".

Return values:

<CarrierOffset> Default unit: Hz

Usage: Query only

Manual operation: See "Carrier Estimation Mode" on page 70

[SENSe:]CLOCk:OFFSet?

Frequency spread of the captured multi-carrier signal compared to the setting given by multi-carrier signal description. This frequency spread is estimated and compensated when using carrier estimation mode "All Carriers". The clock offset reading shows the influence of Doppler shift in satellite communication measurements.

Return values:

<ClockOffset> Default unit: Hz

Example: `SENSe:CLOCk:OFFSet?`

Usage: Query only

Manual operation: See "Carrier Estimation Mode" on page 70

[SENSe<ip>:]FREQuency:SPAN <Frequency>

Suffix:
<ip> 1..n

Parameters:
<Frequency> Default unit: HZ

Manual operation: See "Span" on page 48

[SENSe:]CESTimation:MODE <Mode>

Sets/queries the carrier estimation mode. This defines how the carrier frequencies of the captured multi-carrier signal are estimated and how differences compared to the multi-carrier signal description are being compensated.

Parameters:
<Mode> CARRiers | OFFSet | OFF

CARRiers
Estimates the frequency for each carrier and uses the determined frequencies when calculating measurement results. This estimation is useful for in-orbit measurements of satellites for which the group delay can be distorted due to the Doppler effect. (Corresponds to the manual setting "All Carriers")

OFFSet
The frequency offset is assumed to be identical for all carriers. It is estimated and the determined frequencies are then used for calculation of measurement results.

OFF
No estimation is performed. The carrier frequencies as defined in the multi-carrier signal description are used. Possible frequency offsets or Doppler-effects are not compensated.

Manual operation: See "Carrier Estimation Mode" on page 70

[SENSe:]CESTimation:LOComp <LOCState>

Enables or disables the Large Offset Compensation.

Parameters:
<LOCState> ON | OFF | 0 | 1

Example: `SENS:CEST:LOC ON`

Manual operation: See "Large Offset Compensation" on page 70

[SENSe:]CESTimation:MCOFfset <MaxClockOffset>

Defines the maximum clock offset the frequency estimation algorithm of the R&S FSW MCGD application is able to handle. Larger values for this parameter result in slower measurement speed.

This parameter is automatically calculated using the other three "Doppler Shift Compensation" parameter settings. For the calculation, speed of light in medium vacuum (cvac) is used.

Parameters:
<MaxClockOffset> numeric value

Example: `SENSe:CEST:MCOF 1e-5`

Manual operation: See "Max Clock Offset" on page 71

[SENSe:]CESTimation:CDECimation <Value>

Improves the measurement speed by decimating the number of carriers used for the frequency estimation synchronization as a speed vs accuracy tradeoff in carrier estimation mode "All Carriers". For example, a value of "1000" configures the synchronization to only use each 1000th carrier for frequency estimation and significantly speeds up the measurement for scenarios with large number of carriers (100k carriers scenarios) while still providing good measurement accuracy. A value of "1" provides the best possible measurement accuracy. The value is clipped internally to 2 carriers if set larger then the available number of carriers configured in the multi-carrier signal description.

Parameters:
<Value> numeric value

Example: `SENS:CEST:CDEC 1000`

Manual operation: See "Carrier Decimation Factor" on page 72

[SENSe:]CESTimation:MVELocity <MaxRelVelocity>

Defines the relative velocity between ground station and satellite in m/s. This information is used to calculate the Max Clock Offset.

Parameters:
<MaxRelVelocity> <numeric value>
Default unit: m/s

Example: `SENSe:CEST:MVEL 1e3`

Manual operation: See "Max relative Velocity" on page 71

[SENSe:]CESTimation:TRANsmission <TransmissionType>

Defines the satellite transmission type. This information is necessary to correctly calculate the Max Clock Offset.

Parameters:

<TransmissionType> **OWAY**
One-Way Transmission

TWAY
Two-Way Transmission

Manual operation: See "Transmission Type" on page 71

[SENSe:]CESTimation:VTOLerance <Tolerance>

Defines an additional tolerance to the Max relative Satellite Velocity in %. This information is used to calculate the Max Clock Offset.

Parameters:

<Tolerance> <numeric value>

Default unit: %

Example: `SENS:CEST:VTOL 10`

Manual operation: See "Additional Tolerance" on page 71

[SENSe:]RAWPhase[:STATe] <State>

If enabled, the raw, unprocessed phase data is displayed in the "Phase" and "Phase Difference" result displays.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example:
```
LAY:ADD? '1',RIGH,DPHase
SENS:RAWP ON
```

Manual operation: See "Phase" on page 22
See "Phase Difference" on page 23
See "Raw Phase" on page 61

[SENSe:]SUBSpan:STATe?

Queries the state of the frequency subspan measurements. This can be helpful when using subspan mode "Auto" where the FSW-K17S decides automatically if subspan measurements are active (query state "ON") or inactive (query state "OFF").

Parameters:
<State> ON | OFF

Example: `SENS:SUBS:STAT?`

Usage: Query only

[SENSe:]SUBSpan:MODE <State>

Defines the frequency subspan mode.

Parameters:
<State> ON | OFF | AUTO

Example: `SENS:SUBS:MODE ON`

Manual operation: See "Mode (FSW-K17S)" on page 58

[SENSe:]SUBSpan[:BANDwidth] <SubSpanFrequency>

Defines the bandwidth of the subspans for active frequency subspan measurements.

Parameters:
<SubSpanFrequency>Default unit: Hz

Example: `SENS:SUBS 10 MHz`

Manual operation: See "Subspan (FSW-K17S)" on page 58

[SENSe:]SUBSpan:COUNt <SubspanCount>

Defines the number of subspans for active frequency subspan measurements.

Parameters:
<SubspanCount> <numeric value>

Example: `SENS:SUBS:COUN 2`

Manual operation: See "Number of Subspans (FSW-K17S)" on page 59

[SENSe:]SUBSpan:CARRier:COUNt <CarrCount>

Defines the bandwidth of the subspans in number of carriers for active frequency sub-span measurements.

Parameters:
<CarrCount> <numeric value>

Example: `SENS:SUBS:CARR:COUN 2`

Manual operation: See "Subspan (FSW-K17S)" on page 58

[SENSe:]SUBSpan:OVERlap <OverlapFrequency>

Defines the frequency overlap of subspans for active frequency subspan measurements.

Parameters:

<OverlapFrequency> <numeric value>

Default unit: Hz

Manual operation: See "Overlap (FSW-K17S)" on page 58

[SENSe:]SUBSpan:OVERlap:CARRier:COUNt <OverlapCount>

Defines the overlap of subspans in carriers for active frequency subspan measurements.

Parameters:

<CarrCount> <numeric value>

Example:

```
SENS:SUBS:OVER:CARR:COUN 2
```

Manual operation: See "Overlap (FSW-K17S)" on page 58

[SENSe:]MTIMe:AUTO <State>

Enables or disables automatic measurement time selection.

Parameters:

<State>

ON | 1
Enables automatic measurement time selection.

OFF | 0
Measurement time is defined manually.

*RST: 1

Example:

```
SENS:MTIM:AUTO ON
```

Manual operation: See "Measurement Time" on page 60

[SENSe:]MTIMe <MeasTime>

Queries or sets the measurement time.

Parameters:

<MeasTime> The measurement time.

*RST: 25 ms
Default unit: S

Manual operation: See "Measurement Time" on page 60

[SENSe:]RLENgth?

Returns the record length determined by the current measurement settings.

Return values:

<SampleCount> Number of samples captured in one sweep.

Usage: Query only

[SENSe:]SRATe?

Returns the sample rate set up for current measurement settings.

Return values:

<SampleRate> Current sample rate used by the application.

Usage: Query only

11.4.7 Configuring generator control

CONFigure:GENerator:CONNection:CSTate?

Queries the state of the connected signal generator.

Return values:

<ConnectionState>

UNKNown
no signal generator connected

CONNected
connection established

NCONnected
connection could not be established, possibly due to an incompatible instrument or invalid IP address

Example: `CONFigure:GENerator:CONNection:CSTate?`

Usage: Query only

Manual operation: See "IP Address" on page 63
See "Connect/Disconnect" on page 63

CONFigure:GENerator:CONNection[:STATe] <State>

Connects or disconnects the signal generator specified by `CONFigure:GENerator:IPConnection:ADDRess` on page 153. The IP address must be specified before you use this command.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Disconnects the generator.

ON | 1
Connects the generator.

*RST: 0

Example:
```
CONF:GEN:IPC:ADDR '192.168.114.90'
CONF:GEN:CONN:STAT ON
```

Usage: Asynchronous command

Manual operation: See "Connect/Disconnect" on page 63

CONFigure:GENerator:IPConnection:ADDRess <IPAddress>

The TCPIP address or computer name of the signal generator connected to the FSW via LAN.

The IP address / computer name is maintained after a [PRESET], and is transferred between applications.

Parameters:

<IPAddress> IP address or computer name

Example:
```
CONF:GEN:IPC:ADDR '192.168.114.90'
```

Manual operation: See "IP Address / Computer Name" on page 63

CONFigure:GENerator:MCGD:CARRier:COUNt:STATe <State>

If activated, any changes to the number of carriers on the FSW are automatically also applied to the connected signal generator. Initially, the value defined by `[SENSe:]CARRier:COUNt` is applied.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 1

Example: `CONF:GEN:MCGD:CARR:COUN:STAT OFF`

Manual operation: See "Number of Carriers Control State" on page 68

CONFigure:GENerator:MCGD:CARRier:SPACing:STATe <State>

If activated, any changes to the carrier spacing on the FSW are automatically also applied to the connected signal generator. Initially, the value defined by `[SENSe:]CARRier:SPACing` is applied.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 1

Example: `CONF:GEN:MCGD:CARR:SPAC:STAT OFF`

Manual operation: See "Carrier Spacing Control State" on page 67

CONFigure:GENerator:MCGD:CONNection:CSTate?

Queries the state of the connected signal generator and its availability for the R&S FSW MCGD application.

Return values:

<State> OFF | SUCCessful | ERRor

OFF
No signal generator defined

SUCCessful
Connection established to compatible generator

ERRor
Connection error, for example due to an incompatible generator

Example: `CONF:GEN:MCGD:CONN:CST?`

Usage: Query only

Manual operation: See "IP Address" on page 63
See "Connect/Disconnect" on page 63

CONFigure:GENerator:MCGD:CONTrol[:STATe] <State>

Activates or deactivates control of the signal generator by the FSW.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example: `CONF:GEN:MCGD:CONT:STAT ON`

Manual operation: See "Generator Control State" on page 67

CONFigure:GENerator:MCGD:FREQuency:CENTer:STATe <State>

If activated, any changes to the center frequency on the FSW are automatically also applied to the connected signal generator. Initially, the value defined by `[SENSe:]FREQuency:CENTer` is applied.

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

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 1

Example: `CONF:GEN:MCGD:FREQ:CENT:STAT OFF`

Manual operation: See "Center Frequency Control State" on page 67

CONFigure:GENerator:MCGD:LEVel:ARLevel[:STATe] <State>

Determines the behavior of the reference level.

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

ON | 1
The FSW automatically adapts the reference level if Level (RMS) or the DUT Gain is changed.

OFF | 0
The reference level is not automatically adapted.

*RST: 1

Example: `CONF:GEN:MCGD:LEV:ARL ON`

Manual operation: See "Auto Reference Level" on page 69

CONFigure:GENerator:MCGD:LEVel <Level>

Sets the specified value on the connected signal generator or queries which value is used.

Parameters:
<Level> Default unit: dBm

Example: `CONF:GEN:MCGD:LEV 0`

Manual operation: See "Level (RMS)" on page 68

CONFigure:GENerator:MCGD:LEVel:DUTGain <Level>

A gain due to the DUT is taken into consideration when determining the reference level on the FSW and the signal level on the generator during the reference calibration.

Parameters:
<Level> Default unit: dB

Example: `CONF:GEN:MCGD:LEV:DUTG 0`

Manual operation: See "DUT Gain" on page 68

CONFigure:GENerator:MCGD:LEVel:DUTLimit <Level>

Sets or queries the maximum input power (peak envelope power, "PEP") that is currently allowed by the DUT and that is specified on the generator. The generator output does not exceed this value.

Parameters:
<Level> Default unit: dBm

Example: `CONF:GEN:MCGD:LEV:DUTL?`

Manual operation: See "Limit DUT Peak Input Power" on page 68

CONFigure:GENerator:MCGD:LEVel:DUTLimit:STATe <State>

If activated, the generator does not exceed the maximum input power (peak envelope power, "PEP") that is currently allowed by the DUT. To query or define the current PEP limit value, use `CONFigure:GENerator:MCGD:LEVel:DUTLimit` on page 156.

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

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example:
```
CONF:GEN:MCGD:LEV:DUTL:STAT ON
CONF:GEN:MCGD:LEV:DUTL?
```

Manual operation: See "Limit DUT Peak Input Power" on page 68

CONFigure:GENerator:MCGD:LEVel:STATe <State>

If enabled, the FSW automatically controls the signal level provided by the signal generator as input to the FSW. Initially,the value defined by `CONFigure:GENerator:MCGD:LEVel` is applied. Note that the reference level on the FSW is also affected by the signal level.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example: `CONF:GEN:MCGD:LEVE:STAT ON`

Manual operation: See "Level Control State" on page 68

CONFigure:GENerator:MCGD:OSTate?

Queries the overall status of the generator control settings.

Return values:

<State> OFF | SUCCessful | ERRor

OFF
Signal generator control off

SUCCessful
Connection established and all settings valid

ERRor
Control error, for example because a specified value cannot be applied on the signal generator

Example: `CONF:GEN:MCGD:OST?`

Usage: Query only

CONFigure:GENerator:MCGD:SETTings:UPDate

Applies all generator setup settings to the connected signal generator once.

Usage: Event

Manual operation: See "Upload all Settings to Generator" on page 69

CONFigure:GENerator:RFOutput[:STATe] <State>

Enables or disables RF output on the connected generator.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example: `CONF:GEN:RFO:STAT ON`

Manual operation: See "RF Output State" on page 67

CONFigure:SETTings:MCGD

Queries all currently defined generator setup settings on the connected signal generator and applies the settings to the FSW.

Usage: Event

Manual operation: See "Query all Settings from Generator" on page 69

11.4.8 Configuring carrier table

CONFigure:CTABle:STATe <TableState>

Sets the state of the carrier table.

Parameters:
<TableState> ON | OFF

Manual operation: See "Carrier Table State" on page 73

CONFigure:CTABle:CARRier:STATe <Index>, <CarrierState>

Sets the state of a specific carrier of the carrier table.

Parameters:
<Index> Carrier position

<CarrierState> ON | OFF

Manual operation: See "Carrier State" on page 73

CONFigure:CTABle:CARRier:THReshold <Index>, <CarrierThreshold>

Sets the threshold of a specific carrier of the carrier table.

Parameters:

<Index> Carrier position

<CarrierThreshold> <numeric value>
Default unit: dBm

Manual operation: See "Carrier Threshold" on page 74

CONFigure:CTABle:EDIT:CARRier:EXECute

Transfers configuration assistant settings to the carrier table.

Example: `CONF:CTAB:EDIT:CARR:EXEC`

Usage: Event

Manual operation: See "Configuration Assistant" on page 74

CONFigure:CTABle:EDIT:CARRier:STARt <AssistantStart>

Sets the first selected carrier in the configuration assistant.

Parameters:

<AssistantStart> Carrier position

Manual operation: See "Configuration Assistant" on page 74

CONFigure:CTABle:EDIT:CARRier:STATe <AssistantState>

Sets the state of the selected carriers in the configuration assistant.

Parameters:

<AssistantState> ON | OFF

Manual operation: See "Configuration Assistant" on page 74

CONFigure:CTABle:EDIT:CARRier:STOP <AssistantStop>

Sets the last selected carrier in the configuration assistant.

Parameters:

<AssistantStop> Carrier position

Manual operation: See "Configuration Assistant" on page 74

CONFigure:CTABle:EDIT:CARRier:THReshold <SelectedCarrierThreshold>

Sets the threshold of the selected carriers in the configuration assistant.

Parameters:

<SelectedCarrierThreshold> <numeric value>

Default unit: dBm

Manual operation: See "Configuration Assistant" on page 74

MMEMory:STORe<n>:MCGD:CTABle <File>

Stores the carrier table to a `.csv` file.

The `.csv` file has the following structure:

- Column 1: Carrier position index
- Column 2: Carrier frequency
- Column 3: Carrier state (0|1|on|off)
- Column 4: Carrier Threshold (in dBm)

Suffix:

<n> 1..n

Setting parameters:

<File>

Example:

```
MMEM:STOR:MCGD:CTAB 'C:
\R_S\userdata\MyCarrierTable.csv'
```

Usage: Setting only

Manual operation: See "Store / Load Carrier Table" on page 74

MMEMory:LOAD:MCGD:CTABle <File>

Loads a carrier table from a `.csv` file.

Make sure the multi carrier signal description (center frequency, carrier spacing, number of carriers) is set appropriate before loading the carrier table. If you have defined a smaller number of carriers in the signal description than in the stored `.csv` file, carrier table information is getting truncated when loading the `.csv` file.

Setting parameters:

<File>

Example:

```
MMEM:LOAD:MCGD:CTAB 'C:
\R_S\userdata\MyCarrierTable.csv'
```

Usage: Setting only

Manual operation: See "Store / Load Carrier Table" on page 74

11.4.9 Configuring automatic frequency translating measurements

CONFigure:GENerator:MCGD:AFTM:FREQuency:ANALyzer <Frequency>

Sets or queries the analyzer frequency for the frequency translating measurement. During the group delay measurement, this value corresponds to the center frequency of the R&S FSW MCGD application.

Parameters:

<Frequency> Default unit: HZ

Example:

```
CONF:GEN:MCGD:AFTM:FREQ:ANAL 1000005
CONF:GEN:MCGD:AFTM:FREQ:FACT:NUM 1
CONF:GEN:MCGD:AFTM:FREQ:FACT:DEN 2
CONF:GEN:MCGD:AFTM:FREQ:OFFS 5
CONF:GEN:MCGD:AFTM:FREQ:GEN?
```

// Result:
// f_{Gen} = [1000005 - 5] /2 = 500000 Hz

Manual operation: See "$f_{Analyzer}$" on page 77

CONFigure:GENerator:MCGD:AFTM:FREQuency:GENerator <Frequency>

Determines the signal generator frequency. Any changes here are automatically applied to the connected generator.

Parameters:

<Frequency> Default unit: HZ

Example:

```
CONF:GEN:MCGD:AFTM:FREQ:GEN 1000000
```

Manual operation: See "f_{Gen}" on page 77

CONFigure:GENerator:MCGD:AFTM:FREQuency:OFFSet <Frequency>

Defines a fixed offset to be applied to the generator frequency as an effect of the DUT.

Parameters:

<Frequency> Default unit: HZ

Example:

```
CONF:GEN:MCGD:AFTM:FREQ:OFFS 5
```

Manual operation: See "Frequency Offset" on page 77

CONFigure:GENerator:MCGD:AFTM:FREQuency[:FACTor]:DENominator <Denominator>

Defines the denominator of the frequency translating factor of the DUT.

Parameters:
<Denominator>

Example: `CONF:GEN:MCGD:AFTM:FREQ:FACT:DEN 2`

Manual operation: See "Denominator" on page 77

CONFigure:GENerator:MCGD:AFTM:FREQuency[:FACTor]:NUMerator <Numerator>

Defines the numerator of the frequency translating factor of the DUT.

Parameters:
<Numerator>

Example: `CONF:GEN:MCGD:AFTM:FREQ:FACT:NUM 1`

Manual operation: See "Numerator" on page 77

CONFigure:GENerator:MCGD:AFTM:OSTate?

Queries the overall status of the automated frequency translating measurement.

Return values:
<State> OFF | SUCCessful | ERRor

OFF
Automated frequency translating measurement off

SUCCessful
Automated frequency translating measurement on and all settings valid

ERRor
Control error, for example because a specified value cannot be applied on the signal generator

Example: `CONF:GEN:MCGD:AFTM:OST?`

Usage: Query only

CONFigure:GENerator:MCGD:AFTM[:STATe] <State>

Activates or deactivates automated measurement of a frequency translating DUT using generator control by the FSW.

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

OFF | 0
Switches the function off

ON | 1
Switches the function on
*RST: 1

Example: `CONF:GEN:MCGD:AFTM:STAT ON`

Manual operation: See "Automated Frequency Translating Measurement State" on page 76

11.4.10 Configuring the outputs

Configuring trigger input/output is described in Chapter 11.4.5.2, "Configuring the trigger output", on page 142.

DIAGnostic:SERVice:NSOurce <State>

Turns the 28 V supply of the BNC connector labeled [noise source control] on the FSW on and off.

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

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `DIAG:SERV:NSO ON`

Manual operation: See "Noise Source Control" on page 80

11.4.11 Automatic settings

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

[SENSe:]ADJust:CONFigure:LEVel:DURation <Duration>

To determine the ideal reference level, the FSW performs a measurement on the current input data. This command defines the length of the measurement if `[SENSe:]ADJust:CONFigure:LEVel:DURation:MODE` is set to `MANual`.

Parameters:
<Duration> Numeric value in seconds

Range: 0.001 to 16000.0
*RST: 0.001
Default unit: s

Example: `ADJ:CONF:DUR:MODE MAN`
Selects manual definition of the measurement length.
`ADJ:CONF:LEV:DUR 5ms`
Length of the measurement is 5 ms.

Manual operation: See "Changing the Automatic Measurement Time (Meas Time Manual)" on page 81

[SENSe:]ADJust:CONFigure:LEVel:DURation:MODE <Mode>

To determine the ideal reference level, the FSW performs a measurement on the current input data. This command selects the way the FSW determines the length of the measurement .

Parameters:
<Mode>

AUTO
The FSW determines the measurement length automatically according to the current input data.

MANual
The FSW uses the measurement length defined by `[SENSe:]ADJust:CONFigure:LEVel:DURation` on page 163.

*RST: AUTO

Manual operation: See "Resetting the Automatic Measurement Time (Meas Time Auto)" on page 80
See "Changing the Automatic Measurement Time (Meas Time Manual)" on page 81

[SENSe:]ADJust:CONFigure:HYSTeresis:LOWer <Threshold>

When the reference level is adjusted automatically using the `[SENSe:]ADJust:LEVel` on page 165 command, the internal attenuators and the preamplifier are also adjusted. To avoid frequent adaptation due to small changes in the input signal, you can define a hysteresis. This setting defines a lower threshold the signal must fall below (compared to the last measurement) before the reference level is adapted automatically.

Parameters:
<Threshold> Range: 0 dB to 200 dB
*RST: +1 dB
Default unit: dB

Example: `SENS:ADJ:CONF:HYST:LOW 2`
For an input signal level of currently 20 dBm, the reference level is only adjusted when the signal level falls below 18 dBm.

Manual operation: See "Lower Level Hysteresis" on page 81

[SENSe:]ADJust:CONFigure:HYSTeresis:UPPer <Threshold>

When the reference level is adjusted automatically using the `[SENSe:]ADJust:LEVel` on page 165 command, the internal attenuators and the preamplifier are also adjusted. To avoid frequent adaptation due to small changes in the input signal, you can define a hysteresis. This setting defines an upper threshold the signal must exceed (compared to the last measurement) before the reference level is adapted automatically.

Parameters:

<Threshold> Range: 0 dB to 200 dB
*RST: +1 dB
Default unit: dB

Example: `SENS:ADJ:CONF:HYST:UPP 2`

Example: For an input signal level of currently 20 dBm, the reference level is only adjusted when the signal level rises above 22 dBm.

Manual operation: See "Upper Level Hysteresis" on page 81

[SENSe:]ADJust:LEVel

Initiates a single (internal) measurement that evaluates and sets the ideal reference level for the current input data and measurement settings. Thus, the settings of the RF attenuation and the reference level are optimized for the signal level. The FSW is not overloaded and the dynamic range is not limited by an S/N ratio that is too small.

Example: `ADJ:LEV`

Manual operation: See "Setting the Reference Level Automatically (Auto Level)" on page 80

11.5 Measuring, loading and storing calibration data

The folowing commands are required to perform the calibration measurement and load and store the calibration data.

CALibration:MCGD

Initiates a new calibration. You can synchronize to the end of the measurement as usual with *OPC, *OPC? or *WAI.

You can execute this command in two different modes: synchronous and asynchronous.

In asynchronous mode, the command starts a new calibration and immediately continues processing subsequent commands while calibration is performed in the background.

In synchronous mode, further processing only continues when the calibration is finished. For synchronous mode, add `;*WAI` to the end of the `CALibration:MCGD` command. This is useful, for example, if you want to run a script file which does not know when the calibration finishes.

Example: `CAL:MCGD;*WAI`
Performs a calibration measurement and waits for the results.

Usage: Event

Manual operation: See "Calibrate (Execute Reference Calibration)" on page 64

CALibration:MCGD:STATe?

Queries the calibration status of the Multi-Carrier "Group Delay" application.

Return values:

<State>

ON | 1
Calibration has been performed, reference data is available.

OFF | 0
Calibration has not yet been performed or is currently running, reference data is not yet available.

Usage: Query only

MMEMory:LOAD:MCGD:RCALibration <File>

Loads the calibration data stored in the selected file and replaces the current data.

Setting parameters:

<File> path and file name of the `.csv` file that contains the calibration data

Usage: Setting only

Manual operation: See "Loading Calibration Data" on page 64

MMEMory:STORe<n>:MCGD:RCALibration <File>

Stores the current calibration data to the selected file.

Suffix:

<n> 1..n

Setting parameters:

<File> path and file name of the `.csv` file that will contain the calibration data

Usage: Setting only

Manual operation: See "Storing Calibration Data" on page 64

11.6 Configuring the result display

The commands required to configure the screen display in a remote environment are described here.

11.6.1 General window commands

The following commands are required to configure general window layout, independent of the application.

Note that the suffix <n> always refers to the window *in the currently selected channel* (see `INSTrument[:SELect]` on page 118).

DISPlay:FORMat <Format>

Determines which tab is displayed.

Parameters:

<Format>

SPLit
Displays the MultiView tab with an overview of all active channels

SINGle
Displays the measurement channel that was previously focused.

*RST: SING

Example: `DISP:FORM SPL`

DISPlay[:WINDow<n>]:SIZE <Size>

Maximizes the size of the selected result display window *temporarily*. To change the size of several windows on the screen permanently, use the `LAY:SPL` command (see `LAYout:SPLitter` on page 171).

Suffix:

<n> Window

Parameters:

<Size>

LARGe
Maximizes the selected window to full screen.
Other windows are still active in the background.

SMALI
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: SMALI

Example: `DISP:WIND2:SIZE LARG`

11.6.2 Working with windows in the display

The following commands are required to change the evaluation type and rearrange the screen layout for a channel as you do using the SmartGrid in manual operation. Since the available evaluation types depend on the selected application, some parameters for the following commands also depend on the selected channel.

Note that the suffix <n> always refers to the window *in the currently selected channel*.

(See `INSTrument[:SELect]` on page 118).

LAYout:ADD[:WINDow]? <WindowName>, <Direction>, <WindowType>

Adds a window to the display in the active channel.

Is always used as a query so that you immediately obtain the name of the new window as a result.

To replace an existing window, use the `LAYout:REPLace[:WINDow]` command.

Query parameters:

<WindowName> String containing the name of the existing window the new window is inserted next to.
By default, the name of a window is the same as its index. To determine the name and index of all active windows, use the `LAYout:CATalog[:WINDow]?` query.

<Direction> LEFT | RIGHt | ABOVe | BELow
Direction the new window is added relative to the existing window.

<WindowType> text value

Type of result display (evaluation method) you want to add.
See the table below for available parameter values.

Return values:
<NewWindowName> When adding a new window, the command returns its name (by default the same as its number) as a result.

Example: `LAY:ADD? '1',LEFT,MTAB`
Result:
`'2'`
Adds a new window named '2' with a marker table to the left of window 1.

Usage: Query only

Manual operation: See "Magnitude" on page 21
See "Magnitude Reference" on page 22
See "Phase" on page 22
See "Phase Difference" on page 23
See "Phase Reference" on page 23
See "Group Delay" on page 24
See "Gain" on page 24
See "Marker Table" on page 25

Table 11-3: <WindowType> parameter values for Multi-Carrier Group Delay (K17) application

Parameter value	Window type
DPHase	"Phase Difference" vs. frequency
GAIN	"Gain"
GDELay	"Group Delay" vs. frequency
MAGNitude	"Magnitude" vs. frequency (Measurement data)
MTABle	"Marker Table"
PHASe	"Phase" vs. frequency (Measurement data)
RMAGnitude	"Magnitude" vs. frequency (Reference data)
RPHase	"Phase" vs. frequency (Reference data)

LAYout:CATalog[:WINDow]?

Queries the name and index of all active windows in the active channel from top left to bottom right. The result is a comma-separated list of values for each window, with the syntax:

<WindowName_1>,<WindowIndex_1>..<WindowName_n>,<WindowIndex_n>

Return values:
<WindowName> string

Name of the window.
In the default state, the name of the window is its index.

<WindowIndex> **numeric value**
Index of the window.

Example: `LAY:CAT?`
Result:
`'2',2,'1',1`
Two windows are displayed, named '2' (at the top or left), and '1' (at the bottom or right).

Usage: Query only

LAYout:IDENtify[:WINDow]? <WindowName>

Queries the **index** of a particular display window in the active channel.

Note: to query the **name** of a particular window, use the `LAYout:WINDow<n>:IDENtify?` query.

Query parameters:
<WindowName> String containing the name of a window.

Return values:
<WindowIndex> Index number of the window.

Example: `LAY:IDEN:WIND? '2'`
Queries the index of the result display named '2'.
Response:
`2`

Usage: Query only

LAYout:MOVE[:WINDow] <WindowName>, <WindowName>, <Direction>

Setting parameters:
<WindowName> String containing the name of an existing window that is to be moved.
By default, the name of a window is the same as its index. To determine the name and index of all active windows in the active channel, use the `LAYout:CATalog[:WINDow]?` query.

<WindowName> String containing the name of an existing window the selected window is placed next to or replaces.
By default, the name of a window is the same as its index. To determine the name and index of all active windows in the active channel, use the `LAYout:CATalog[:WINDow]?` query.

<Direction> LEFT | RIGHt | ABOVe | BELow | REPLace
Destination the selected window is moved to, relative to the reference window.

Example: `LAY:MOVE '4','1',LEFT`
Moves the window named '4' to the left of window 1.

Example: `LAY:MOVE '1','3',REPL`
Replaces the window named '3' by window 1. Window 3 is deleted.

Usage: Setting only

LAYout:REMove[:WINDow] <WindowName>

Removes a window from the display in the active channel.

Setting parameters:
<WindowName> String containing the name of the window. In the default state, the name of the window is its index.

Example: `LAY:REM '2'`
Removes the result display in the window named '2'.

Usage: Setting only

LAYout:REPLace[:WINDow] <WindowName>,<WindowType>

Replaces the window type (for example from "Diagram" to "Result Summary") of an already existing window in the active channel while keeping its position, index and window name.

To add a new window, use the `LAYout:ADD[:WINDow]?` command.

Setting parameters:
<WindowName> String containing the name of the existing window.
By default, the name of a window is the same as its index. To determine the name and index of all active windows in the active channel, use the `LAYout:CATalog[:WINDow]?` query.

<WindowType> Type of result display you want to use in the existing window.
See `LAYout:ADD[:WINDow]?` on page 168 for a list of available window types.

Example: `LAY:REPL:WIND '1',MTAB`
Replaces the result display in window 1 with a marker table.

Usage: Setting only

LAYout:SPLitter <Index1>, <Index2>, <Position>

Changes the position of a splitter and thus controls the size of the windows on each side of the splitter.

Compared to the `DISPlay[:WINDow<n>]:SIZE` on page 167 command, the `LAYout:SPLitter` changes the size of all windows to either side of the splitter permanently, it does not just maximize a single window temporarily.

Note that windows must have a certain minimum size. If the position you define conflicts with the minimum size of any of the affected windows, the command does not work, but does not return an error.

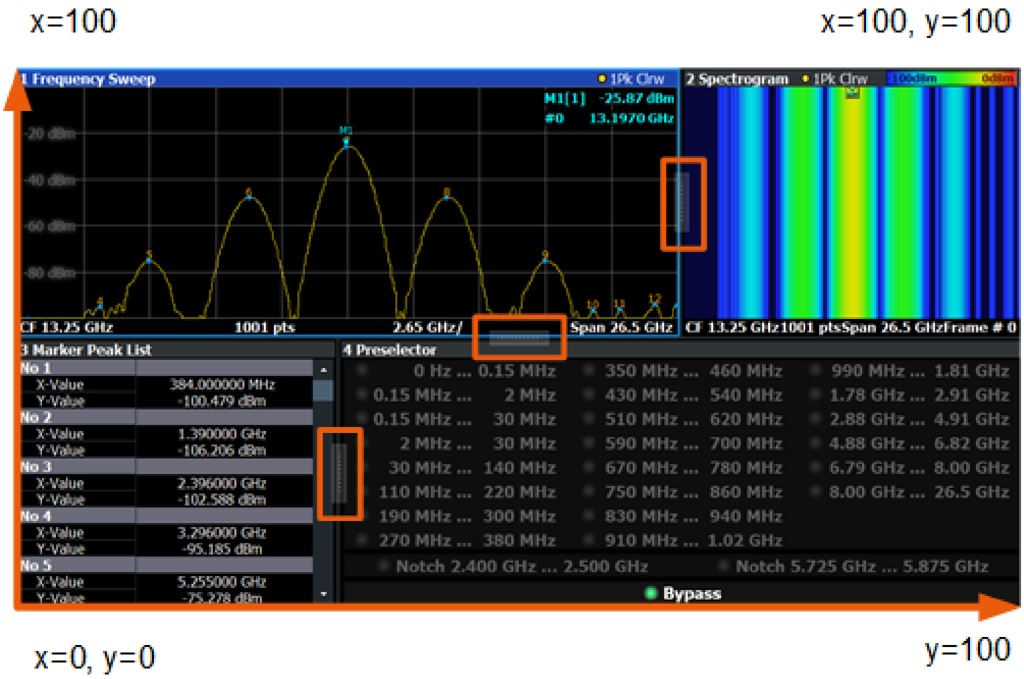


Figure 11-1: SmartGrid coordinates for remote control of the splitters

Setting parameters:

<Index1> The index of one window the splitter controls.

<Index2> The index of a window on the other side of the splitter.

<Position> New vertical or horizontal position of the splitter as a fraction of the screen area (without channel and status bar and softkey menu).
The point of origin (x = 0, y = 0) is in the lower left corner of the screen. The end point (x = 100, y = 100) is in the upper right corner of the screen. (See Figure 11-1.)
The direction in which the splitter is moved depends on the screen layout. If the windows are positioned horizontally, the splitter also moves horizontally. If the windows are positioned vertically, the splitter also moves vertically.

Range: 0 to 100

Example:

```
LAY:SPL 1,3,50
```

Moves the splitter between window 1 ('Frequency Sweep') and 3 ('"Marker Table"') to the center (50%) of the screen, i.e. in the figure above, to the left.

Example:
`LAY:SPL 1,4,70`
Moves the splitter between window 1 ('Frequency Sweep') and 3 ('"Marker Peak List"') towards the top (70%) of the screen.
The following commands have the exact same effect, as any combination of windows above and below the splitter moves the splitter vertically.
`LAY:SPL 3,2,70`
`LAY:SPL 4,1,70`
`LAY:SPL 2,1,70`

Usage: Setting only

LAYout:WINDow<n>:ADD? <Direction>,<WindowType>

Adds a measurement window to the display. Note that with this command, the suffix <n> determines the existing window next to which the new window is added. Unlike `LAYout:ADD[:WINDow]?`, for which the existing window is defined by a parameter.

To replace an existing window, use the `LAYout:WINDow<n>:REPLace` command.

Is always used as a query so that you immediately obtain the name of the new window as a result.

Suffix:
<n> Window

Query parameters:
<Direction> LEFT | RIGHt | ABOVe | BELow

<WindowType> Type of measurement window you want to add.
See `LAYout:ADD[:WINDow]?` on page 168 for a list of available window types.

Return values:
<NewWindowName> When adding a new window, the command returns its name (by default the same as its number) as a result.

Example:
`LAY:WIND1:ADD? LEFT,MTAB`
Result:
`'2'`
Adds a new window named '2' with a marker table to the left of window 1.

Usage: Query only

LAYout:WINDow<n>:IDENtify?

Queries the **name** of a particular display window (indicated by the <n> suffix) in the active channel.

Note: to query the **index** of a particular window, use the `LAYout:IDENtify[:WINDow]?` command.

Suffix:
<n> Window

Return values:
<WindowName> String containing the name of a window.
In the default state, the name of the window is its index.

Example: `LAY:WIND2:IDEN?`
Queries the name of the result display in window 2.
Response:
`'2'`

Usage: Query only

LAYout:WINDow<n>:REMove

Removes the window specified by the suffix <n> from the display in the active channel.

The result of this command is identical to the `LAYout:REMove[:WINDow]` command.

Suffix:
<n> Window

Example: `LAY:WIND2:REM`
Removes the result display in window 2.

Usage: Event

LAYout:WINDow<n>:REPLace <WindowType>

Changes the window type of an existing window (specified by the suffix <n>) in the active channel.

The effect of this command is identical to the `LAYout:REPLace[:WINDow]` command.

To add a new window, use the `LAYout:WINDow<n>:ADD?` command.

Suffix:
<n> Window

Setting parameters:
<WindowType> Type of measurement window you want to replace another one with.
See `LAYout:ADD[:WINDow]?` on page 168 for a list of available window types.

Example: `LAY:WIND2:REPL MTAB`
Replaces the result display in window 2 with a marker table.

Usage: Setting only

11.7 Configuring and performing sweeps

When the MCGD application is activated, a continuous sweep is performed automatically. However, you can stop and start a new measurement any time.

Furthermore, you can perform a sequence of measurements using the Sequencer (see "Multiple Measurement Channels and Sequencer Function" on page 15).

Useful commands for configuring sweeps described elsewhere:

- `[SENSe:]AVERage<n>:COUNt` on page 190

Remote commands exclusive to

ABORt

Aborts the measurement in the current channel and resets the trigger system.

To prevent overlapping execution of the subsequent command before the measurement has been aborted successfully, use the `*OPC?` or `*WAI` command after `ABOR` and before the next command.

For details on overlapping execution see Remote control via SCPI.

To abort a sequence of measurements by the Sequencer, use the `INITiate:SEQuencer:ABORt` command.

Note on blocked remote control programs:

If a sequential command cannot be completed, for example because a triggered sweep never receives a trigger, the remote control program will never finish and the remote channel to the FSW is blocked for further commands. In this case, you must interrupt processing on the remote channel first in order to abort the measurement.

To do so, send a "Device Clear" command from the control instrument to the FSW on a parallel channel to clear all currently active remote channels. Depending on the used interface and protocol, send the following commands:

- **Visa**: `viClear()`
- **GPIB**: `ibclr()`
- **RSIB**: `RSDLLibclr()`

Now you can send the `ABORt` command on the remote channel performing the measurement.

Example: `ABOR;:INIT:IMM`
Aborts the current measurement and immediately starts a new one.

Example: `ABOR;*WAI`
`INIT:IMM`
Aborts the current measurement and starts a new one once abortion has been completed.

Usage: Event

INITiate<n>:CONMeas

Restarts a (single) measurement that has been stopped (using `ABORt`) or finished in single sweep mode.

The measurement is restarted at the beginning, not where the previous measurement was stopped.

As opposed to `INITiate<n>[:IMMediate]`, this command does not reset traces in maxhold, minhold or average mode. Therefore it can be used to continue measurements using maxhold or averaging functions.

Suffix:
<n> irrelevant

Usage: Asynchronous command

Manual operation: See "Continue Single Sweep" on page 78

INITiate<n>:CONTinuous <State>

Controls the sweep mode for an individual channel.

Note that in single sweep mode, you can synchronize to the end of the measurement with *OPC, *OPC? or *WAI. In continuous sweep mode, synchronization to the end of the measurement is not possible. Thus, it is not recommended that you use continuous sweep mode in remote control, as results like trace data or markers are only valid after a single sweep end synchronization.

For details on synchronization see Remote control via SCPI.

If the sweep mode is changed for a channel while the Sequencer is active (see `INITiate:SEQuencer:IMMediate` on page 177), the mode is only considered the next time the measurement in that channel is activated by the Sequencer.

Suffix:
<n> irrelevant

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

ON | 1
Continuous sweep

OFF | 0
Single sweep
*RST: 1 (some applications can differ)

Example: `INIT:CONT OFF`
Switches the sweep mode to single sweep.
`INIT:CONT ON`
Switches the sweep mode to continuous sweep.

Manual operation: See "Continuous Sweep / Run Cont" on page 78

INITiate<n>[:IMMediate]

Starts a (single) new measurement.

With sweep count or average count > 0, this means a restart of the corresponding number of measurements. With trace mode MAXHold, MINHold and AVERage, the previous results are reset on restarting the measurement.

You can synchronize to the end of the measurement with *OPC, *OPC? or *WAI.

For details on synchronization see Remote control via SCPI.

Suffix:
<n> irrelevant

Usage: Asynchronous command

Manual operation: See "Single Sweep / Run Single" on page 78

INITiate:SEQuencer:ABORt

Stops the currently active sequence of measurements.

You can start a new sequence any time using `INITiate:SEQuencer:IMMediate` on page 177.

Usage: Event

INITiate:SEQuencer:IMMediate

Starts a new sequence of measurements by the Sequencer.

Its effect is similar to the `INITiate<n>[:IMMediate]` command used for a single measurement.

Before this command can be executed, the Sequencer must be activated (see `SYSTem:SEQuencer` on page 178).

Example:

`SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single sequence mode so each active measurement is performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.

INITiate:SEQuencer:MODE <Mode>

Defines the capture mode for the entire measurement sequence and all measurement groups and channels it contains.

Note: To synchronize to the end of a measurement sequence using `*OPC`, `*OPC?` or `*WAI`, use `SINGle` Sequencer mode.

Parameters:

<Mode>

SINGle
Each measurement group is started one after the other in the order of definition. All measurement channels in a group are started simultaneously and performed once. After *all* measurements are completed, the next group is started. After the last group, the measurement sequence is finished.

CONTinuous
Each measurement group is started one after the other in the order of definition. All measurement channels in a group are started simultaneously and performed once. After *all* measurements are completed, the next group is started. After the last group, the measurement sequence restarts with the first one and continues until it is stopped explicitly.

*RST: CONTinuous

SYSTem:SEQuencer <State>

Turns the Sequencer on and off. The Sequencer must be active before any other Sequencer commands (`INIT:SEQ...`) are executed, otherwise an error occurs.

A detailed programming example is provided in the "Operating Modes" chapter in the 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 is performed once.
INIT:SEQ:IMM
Starts the sequential measurements.
SYST:SEQ OFF

[SENSe:]SWEep:COUNt <SweepCount>

Defines the number of sweeps that the application uses to average traces.

During calibration measurements, the phase and amplitude values are averaged over the defined number of sweeps.

In continuous sweep mode, the application calculates the moving average over the average count.

In single sweep mode, the application stops the measurement and calculates the average after the average count has been reached.

Parameters:
<SweepCount> If you set a sweep count of 0 or 1, the application performs one single sweep in single sweep mode.
In continuous sweep mode, if the average count is set to 0, a moving average over 10 sweeps is performed.
Range: 0 to 32767
*RST: 0

Example:
SWE:COUN 64
Sets the number of sweeps to 64.
INIT:CONT OFF
Switches to single sweep mode.
INIT;*WAI
Starts a sweep and waits for its end.

Manual operation: See "Sweep Count" on page 61

[SENSe:]SWEep:COUNt:CURRent?

This query returns the current number of started sweeps or measurements. This command is only available if a sweep count value is defined and the instrument is in single sweep mode.

Return values:
<CurrentCount>

Example:
`SWE:COUNt 64`
Sets sweep count to 64
`INIT:CONT OFF`
Switches to single sweep mode
`INIT`
Starts a sweep (without waiting for the sweep end!)
`SWE:COUN:CURR?`
Queries the number of started sweeps

Usage: Query only

11.8 Retrieving results

The following commands are required to retrieve the results in a remote environment.

11.8.1 Retrieving marker results

Useful commands for retrieving results described elsewhere:

- `CALCulate<n>:DELTamarker<m>:X` on page 194
- `CALCulate<n>:MARKer<m>:X` on page 197

Remote commands exclusive to retrieving marker results:

CALCulate<n>:DELTamarker<m>:X:RELative?

Queries the relative position of a delta marker on the x-axis.

If necessary, the command activates the delta marker first.

Suffix:
<n> Window

<m> Marker

Return values:
<Position> Position of the delta marker in relation to the reference marker.

Example:
`CALC:DELT3:X:REL?`
Outputs the frequency of delta marker 3 relative to marker 1 or relative to the reference position.

Usage: Query only

CALCulate<n>:DELTamarker<m>:Y?

Queries the result at the position of the specified delta marker.

Suffix:

<n>	1..n
<m>	1..n

Return values:

<Result>	Result at the position of the delta marker. The unit is variable and depends on the one you have currently set. Default unit: DBM

Usage: Query only

CALCulate<n>:MARKer<m>:Y?

Queries the result at the position of the specified marker.

Suffix:

<n>	1..n
<m>	1..n

Return values:

<Result>	Default unit: DBM

Usage: Query only

Manual operation: See "Marker Table" on page 25

11.8.2 Retrieving trace results

The following remote commands are required to retrieve the trace results in a remote environment.

DISPlay[:WINDow<n>]:TRACe<t>:LENGth?

Queries the trace length.

Suffix:

<n>	1..n
<t>	1..n

Return values:

<TraceLength>	Number of trace points

Usage: Query only

FORMat[:DATA] <Format>[, <BitLength>]

Selects the data format that is used for transmission of trace data from the FSW to the controlling computer.

Note that the command has no effect for data that you send to the FSW. The FSW automatically recognizes the data it receives, regardless of the format.

Parameters:

<Format>

ASCii
ASCii format, separated by commas.
This format is almost always suitable, regardless of the actual data format. However, the data is not as compact as other formats can be.

REAL
Floating-point numbers (according to IEEE 754) in the "definite length block format".
In the Spectrum application, the format setting `REAL` is used for the binary transmission of trace data.

<BitLength>

Length in bits for floating-point results

16
16-bit floating-point numbers.
Compared to `REAL,32` format, half as many numbers are returned.

32
32-bit floating-point numbers
For I/Q data, 8 bytes per sample are returned for this format setting.

64
64-bit floating-point numbers
Compared to `REAL,32` format, twice as many numbers are returned.

Example: `FORM REAL,32`

MMEMory:STORe<n>:MCGD:MEAS <File>

Stores the current measurement results (all active traces in all windows, including calibration traces) to the selected file.

Suffix:

<n> 1..n

Setting parameters:

<File> path and file name of the `.csv` file that contains the measured data

Usage: Setting only

Manual operation: See "Storing Measurement Results" on page 97

TRACe<n>[:DATA]? <Trace>

Queries current trace data and measurement results for the specified window. For each of the measurement points (number is determined by record length, see `[SENSe:]RLENgth?` on page 151) the power level, phase or group delay value is returned.

Suffix:

<n> Window

Query parameters:

<Trace> TRACE1 | TRACE2 | TRACE3 | TRACE4

Defines the trace whose data is returned.

Example: TRAC3:DATA? TRACE1

Returns the measured values for trace 1 in window 3.

Usage: Query only

TRACe<n>[:DATA]:X? <TraceNumber>

Queries the horizontal trace data for each sweep point in the specified window, for example the frequency in frequency domain or the time in time domain measurements.

Suffix:

<n> Window

Query parameters:

<TraceNumber> Trace number.

TRACE1 | TRACE2 | TRACE3 | TRACE4

Return values:

<X-Values>

Example: `TRAC3:X? TRACE1`

Returns the x-values for trace 1 in window 3.

Usage: Query only

11.8.3 Exporting trace results

Trace results can be exported to a file.

For more commands concerning data and results storage see the FSW User Manual.

MMEMory:STORe<n>:TRACe <Trace>, <FileName>

Exports trace data from the specified window to an ASCII file.

For details on the file format, see Chapter 12.2, "Reference: ASCII file export format", on page 214.

Secure User Mode

In secure user mode, settings that are stored on the instrument are stored to volatile memory, which is restricted to 256 MB. Thus, a "memory limit reached" error can occur although the hard disk indicates that storage space is still available.

To store data permanently, select an external storage location such as a USB memory device.

For details, see "Protecting Data Using the Secure User Mode" in the "Data Management" section of the FSW base unit user manual.

Suffix:

<n> Window

Parameters:

<Trace> Number of the trace to be stored
(This parameter is ignored if the option "Export all Traces and all Table Results" is activated in the Export configuration settings, see `FORMat:DEXPort:TRACes` on page 185).

<FileName> String containing the path and name of the target file.

Example: `MMEM:STOR1:TRAC 1,'C:\TEST.ASC'`
Stores trace 1 from window 1 in the file `TEST.ASC`.

Manual operation: See "Export Trace to ASCII File" on page 87

FORMat:DEXPort:DSEParator <Separator>

Selects the decimal separator for data exported in ASCII format.

Parameters:

<Separator> POINt | COMMa

COMMa
Uses a comma as decimal separator, e.g. *4,05*.

POINt
Uses a point as decimal separator, e.g. *4.05*.

*RST: *RST has no effect on the decimal separator. Default is POINt.

Example: `FORM:DEXP:DSEP POIN`
Sets the decimal point as separator.

Manual operation: See "Decimal Separator" on page 64

FORMat:DEXPort:FORMat <FileFormat>

Determines the format of the ASCII file to be imported or exported. Depending on the external program that creates the data file or evaluates it, a comma-separated list (CSV) or a plain data format (DAT) file is required.

Parameters:
<FileFormat> CSV | DAT
*RST: DAT

Example: `FORM:DEXP:FORM CSV`

Manual operation: See "File Type" on page 88

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.

See Chapter 12.2, "Reference: ASCII file export format", on page 214 for details.

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

Manual operation: See "Include Instrument & Measurement Settings" on page 86

FORMat:DEXPort:TRACes <Selection>

Selects the data to be included in a data export file (see `MMEMory:STORe<n>:TRACe` on page 184).

Parameters:
<Selection> SINGle | ALL

SINGle
Only a single trace is selected for export, namely the one specified by the `MMEMory:STORe<n>:TRACe` command.

ALL
Selects all active traces and result tables (e.g. "Result Summary", marker peak list etc.) in the current application for export to an ASCII file.
The <trace> parameter for the `MMEMory:STORe<n>:TRACe` command is ignored.
*RST: SINGle

Manual operation: See "Export all Traces and all Table Results" on page 86

11.9 Analyzing multi-carrier group delay measurements

The following commands are required to analyze MCGD measurements in a remote environment.

11.9.1 Configuring standard traces

Useful commands for trace configuration described elsewhere

- DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y:SPACing on page 134
- DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe] on page 131

Remote commands exclusive to trace configuration

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MODE <Mode>

Selects the trace mode. If necessary, the selected trace is also activated.

For max hold, min hold or average trace mode, you can set the number of single measurements with Sweep Count. Note that synchronization to the end of the measurement is possible only in single sweep mode.

Suffix:

<n>	Window
<w>	subwindow Not supported by all applications
<t>	Trace

Parameters:

<Mode>	**WRITe** (default:) Overwrite mode: the trace is overwritten by each sweep.

AVERage
The average is formed over several sweeps. The "Sweep/Average Count" determines the number of averaging procedures.

MAXHold
The maximum value is determined over several sweeps and displayed. The FSW saves the sweep result in the trace memory only if the new value is greater than the previous one.

MINHold
The minimum value is determined from several measurements and displayed. The FSW saves the sweep result in the trace memory only if the new value is lower than the previous one.

VIEW
The current contents of the trace memory are frozen and displayed.

BLANk
Hides the selected trace.

*RST: Trace 1: WRITe, Trace 2-6: BLANk

Example:

`INIT:CONT OFF`
Switching to single sweep mode.
`SWE:COUN 16`
Sets the number of measurements to 16.
`DISP:TRAC3:MODE WRIT`
Selects clear/write mode for trace 3.
`INIT;*WAI`
Starts the measurement and waits for the end of the measurement.

Manual operation: See "Mode" on page 83

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MODE:HCONtinuous <State>

Turns an automatic reset of a trace on and off after a parameter has changed.

The reset works for trace modes min hold, max hold and average.

Note that the command has no effect if critical parameters like the span have been changed to avoid invalid measurement results

Suffix:

<n>	Window
<w>	subwindow
<t>	Trace

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `DISP:WIND:TRAC3:MODE:HCON ON`
Switches off the reset function.

Manual operation: See "Hold" on page 83

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:SMOothing:APERture <Aperture>

Defines the degree (aperture) of the trace smoothing, if `DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:SMOothing[:STATe]` `TRUE`.

This setting is not available for Phase and "Phase Reference" vs. frequency results.

Suffix:

<n> — Window

<w> — subwindow

<t> — Trace

Parameters:

<Aperture> — Range: 1 to 50
*RST: 2
Default unit: PCT

Example: `DISP3:TRAC2:SMO:APER 5`
Defines an aperture of 5% for trace 2 in window 3 (assuming this is not a Phase, "Phase Reference", or "Magnitude Reference" vs. frequency result display).

Manual operation: See "Smoothing" on page 83

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:SMOothing[:STATe] <State>

Turns trace smoothing for a particular trace on and off.

If enabled, the trace is smoothed by the value specified using `DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:SMOothing:APERture` on page 188.

This setting is not available for Phase, "Phase Reference", and "Magnitude Reference" (vs Frequency) results.

Suffix:

<n> — Window

<w> — subwindow

<t> — Trace

Parameters:

<State> — ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `DISP3:TRAC2:SMO ON`
Turns on trace smoothing for trace 2 in window 3 (assuming this is a "Group Delay" result display).

Manual operation: See "Smoothing" on page 83

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:PRESet <ResultType>

Applies predefined, commonly required trace settings to the selected window.

Suffix:

<n> 1..n
Window

<w> 1..n
subwindow

<t> 1..n
Trace

Parameters:

<ResultType>

ALL
Preset All Traces

MAM
Max | Avg | Min

MCM
Max | ClrWrite | Min

Example: `DISP:WIND3:TRAC:PRES MCM`
In window 3, the traces are set to the following modes:
Trace 1: Max Hold
Trace 2: Clear Write
Trace 3: Min Hold

Manual operation: See "Predefined Trace Settings - Quick Config" on page 84

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>[:STATe] <State>

Turns a trace on and off.

The measurement continues in the background.

Suffix:

<n> Window

<w> subwindow
Not supported by all applications

<t> Trace

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `DISP:TRAC3 ON`

Manual operation: See "Trace 1/Trace 2/Trace 3/Trace 4" on page 83
See "Trace 1/ Trace 2/ Trace 3/ Trace 4 (Softkeys)" on page 85

[SENSe:]AVERage<n>:COUNt <AverageCount>

Defines the number of sweeps that the application uses to average traces.

During calibration measurements, the phase and amplitude values are averaged over the defined number of sweeps.

In case of continuous sweep mode, the application calculates the moving average over the average count.

In case of single sweep mode, the application stops the measurement and calculates the average after the average count has been reached.

Suffix:
<n> irrelevant

Parameters:
<AverageCount> If you set an average count of 0 or 1, the application performs one single sweep in single sweep mode.
In continuous sweep mode, if the average count is set to 0, a moving average over 10 sweeps is performed.
Range: 0 to 32767
*RST: 0

Manual operation: See "Average Count" on page 84

[SENSe:]AVERage<n>[:STATe<t>] <State>

Turns averaging for a particular trace in a particular window on and off.

Suffix:
<n> Window

<t> Trace

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

[SENSe:]AVERage<n>:TYPE <Mode>

Selects the trace averaging mode.

Suffix:

<n> 1..n
Window

Parameters:

<Mode> **LOGarithmic**
The logarithmic power values are averaged.

LINear
The power values are averaged before they are converted to logarithmic values.

POWer
The power level values are converted into unit Watt prior to averaging. After the averaging, the data is converted back into its original unit.

Example: `AVER:TYPE LIN`
Switches to linear average calculation.

Manual operation: See "Average Mode" on page 84

11.9.2 Setting up individual markers

The following commands define the position of markers in the diagram.

CALCulate<n>:DELTamarker<m>:AOFF

Turns off *all* delta markers.

Suffix:

<n> Window

<m> irrelevant

Example: `CALC:DELT:AOFF`
Turns off all delta markers.

CALCulate<n>:DELTamarker<m>:LINK <State>

Links delta marker <m> to marker 1.

If you change the horizontal position (x-value) of marker 1, delta marker <m> changes its horizontal position to the same value.

Suffix:

<n> Window

<m> Marker

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:DELT2:LINK ON`

Manual operation: See "Linking to Another Marker" on page 91

CALCulate<n>:DELTamarker<ms>:LINK:TO:DELTa<md> <State>

Links the delta source marker <ms> to any active destination delta marker <md>.

If you change the horizontal position of marker <md>, marker <ms> changes its horizontal position to the same value.

Suffix:

<n> Window

<ms> source marker, see Marker

<md> destination marker, see Marker

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:DELT2:LINK:TO:DELT3 ON`
Links D2 and D3.

CALCulate<n>:DELTamarker<ms>:LINK:TO:MARKer<md> <State>

Links the delta source marker <ms> to any active destination marker <md> (normal or delta marker).

Suffix:

<n> Window

<ms>	source marker, see Marker
<md>	destination marker, see Marker

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:DELT4:LINK:TO:MARK2 ON`
Links the delta marker 4 to the marker 2.

Manual operation: See "Linking to Another Marker" on page 91

CALCulate<n>:DELTamarker<m>:MODE <Mode>

Defines whether the position of a delta marker is provided as an absolute value or relative to a reference marker. Note that this setting applies to *all* windows.

Note that when the position of a delta marker is *queried*, the result is always an absolute value (see `CALCulate<n>:DELTamarker<m>:X` on page 194)!

Suffix:

<n>	irrelevant
<m>	irrelevant

Parameters:

<Mode> **ABSolute**
Delta marker position in absolute terms.

RELative
Delta marker position in relation to a reference marker.

*RST: RELative

Example: `CALC:DELT:MODE ABS`
Absolute delta marker position.

CALCulate<n>:DELTamarker<m>:MREFerence <Reference>

Selects a reference marker for a delta marker other than marker 1.

Suffix:

<n>	Window
<m>	Marker

Parameters:

<Reference> **D1**
Selects the deltamarker 1 as the reference.

Example: `CALC:DELT3:MREF 2`
Specifies that the values of delta marker 3 are relative to marker 2.

Manual operation: See "Reference Marker" on page 91

CALCulate<n>:DELTamarker<m>[:STATe] <State>

Turns delta markers on and off.

If necessary, the command activates the delta marker first.

No suffix at DELTamarker turns on delta marker 1.

Suffix:

<n> Window

<m> Marker

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:DELT2 ON`
Turns on delta marker 2.

Manual operation: See "Select Marker" on page 89
See "Marker State" on page 90
See "Marker Type" on page 90

CALCulate<n>:DELTamarker<m>:TRACe <Trace>

Selects the trace a delta marker is positioned on.

Note that the corresponding trace must have a trace mode other than "Blank".

If necessary, the command activates the marker first.

Suffix:

<n> Window

<m> Marker

Parameters:

<Trace> Trace number the marker is assigned to.

Example: `CALC:DELT2:TRAC 2`
Positions delta marker 2 on trace 2.

CALCulate<n>:DELTamarker<m>:X <Position>

Moves a delta marker to a particular coordinate on the x-axis.

If necessary, the command activates the delta marker and positions a reference marker to the peak power.

Suffix:

<n>	Window
<m>	Marker

Parameters:

<Position>	Numeric value that defines the marker position on the x-axis. The unit is s.

Example: `CALC:DELT:X?`
Outputs the absolute x-value of delta marker 1.

Manual operation: See "Marker Position X-value" on page 90

CALCulate<n>:MARKer<m>:AOFF

Turns off all markers.

Suffix:

<n>	Window
<m>	Marker

Example: `CALC:MARK:AOFF`
Switches off all markers.

Manual operation: See "All Markers Off" on page 91

CALCulate<n>:MARKer<ms>:LINK:TO:DELTa<md> <State>

Links the normal source marker <ms> to any active delta destination marker <md>.

If you change the horizontal position of marker <md>, marker <ms> changes its horizontal position to the same value.

Suffix:

<n>	Window
<ms>	source marker, see Marker
<md>	destination marker, see Marker

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:MARK4:LINK:TO:DELT2 ON`
Links marker 4 to delta marker 2.

CALCulate<n>:MARKer<ms>:LINK:TO:MARKer<md> <State>

Links the normal source marker <ms> to any active destination marker <md> (normal or delta marker).

If you change the horizontal position of marker <md>, marker <ms> changes its horizontal position to the same value.

Suffix:

<n> Window

<ms> source marker, see Marker

<md> destination marker, see Marker

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:MARK4:LINK:TO:MARK2 ON`
Links marker 4 to marker 2.

Manual operation: See "Linking to Another Marker" on page 91

CALCulate<n>:MARKer<m>[:STATe] <State>

Turns markers on and off. If the corresponding marker number is currently active as a delta marker, it is turned into a normal marker.

Suffix:

<n> Window

<m> Marker

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CALC:MARK3 ON`
Switches on marker 3.

Manual operation: See "Select Marker" on page 89
See "Marker State" on page 90
See "Marker Type" on page 90

CALCulate<n>:MARKer<m>:TRACe <Trace>

Selects the trace the marker is positioned on.

Note that the corresponding trace must have a trace mode other than "Blank".

If necessary, the command activates the marker first.

Suffix:
<n> Window

<m> Marker

Parameters:
<Trace>

Example: //Assign marker to trace 1
`CALC:MARK3:TRAC 2`

Manual operation: See "Assigning the Marker to a Trace" on page 91

CALCulate<n>:MARKer<m>:X <Position>

Moves a marker to a specific coordinate on the x-axis.

If necessary, the command activates the marker.

If the marker has been used as a delta marker, the command turns it into a normal marker.

Suffix:
<n> Window

<m> Marker

Parameters:
<Position> Numeric value that defines the marker position on the x-axis.
The unit depends on the result display.

Range: The range depends on the current x-axis range.
Default unit: Hz

Example: `CALC:MARK2:X 1.7MHz`
Positions marker 2 to frequency 1.7 MHz.

Manual operation: See "Marker Table" on page 25
See "Marker Position X-value" on page 90

11.9.3 General marker settings

The following commands control general marker functionality.

CALCulate<n>:MARKer<m>:LINK <State>

This command sets whether all markers will be linked across all display windows or queries the current setting.

Parameters:
<State>

Manual operation: See "Linked Markers" on page 93

DISPlay[:WINDow<n>]:MINFo[:STATe] <State>

Turns the marker information in all diagrams on and off.

Suffix:
<n> irrelevant

Parameters:
<State>

ON | 1
Displays the marker information in the diagrams.

OFF | 0
Hides the marker information in the diagrams.

*RST: 1

Example: `DISP:MINF OFF`
Hides the marker information.

Manual operation: See "Marker Info" on page 93

DISPlay[:WINDow<n>]:MTABle <DisplayMode>

Turns the marker table on and off.

Suffix:
<n> irrelevant

Parameters:
<DisplayMode>

ON | 1
Turns on the marker table.

OFF | 0
Turns off the marker table.

AUTO
Turns on the marker table if 3 or more markers are active.

*RST: AUTO

Example: `DISP:MTAB ON`
Activates the marker table.

Manual operation: See "Marker Table Display" on page 92

11.9.4 Searching for peaks and positioning the marker

The following remote commands are required to search for peaks and position the marker on a trace.

11.9.4.1 Searching for peaks

CALCulate<n>:MARKer<m>:PEXCursion <Excursion>

Defines the peak excursion (for *all* markers in *all* windows).

The peak excursion sets the requirements for a peak to be detected during a peak search.

The unit depends on the measurement.

Application/Result display	Unit
Spectrum	dB
MCGD	dBm, DEG, RAD, S, MS, US, NS, PS, SC

Suffix:

<n> irrelevant

<m> irrelevant

Parameters:

<Excursion> The excursion is the distance to a trace maximum that must be attained before a new maximum is recognized, or the distance to a trace minimum that must be attained before a new minimum is recognized

Range: 0 to 80 dB (MCGD: 60 dBm)
*RST: 6.0

Manual operation: See "Peak Excursion" on page 94

11.9.4.2 Positioning markers

The following commands position markers on the trace.

Useful commands for positioning markers described elsewhere:

- `CALCulate<n>:DELTamarker<m>:X` on page 194

Remote commands exclusive to positioning markers

CALCulate<n>:MARKer<m>:MAXimum:LEFT

Moves a marker to the next positive peak.

The search includes only measurement values to the left of the current marker position.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Search Next Peak" on page 95

CALCulate<n>:MARKer<m>:MAXimum:NEXT

Moves a marker to the next positive peak.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Search Next Peak" on page 95

CALCulate<n>:MARKer<m>:MAXimum[:PEAK]

Moves a marker to the highest level.

If the marker is not yet active, the command first activates the marker.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Peak Search" on page 95

CALCulate<n>:MARKer<m>:MAXimum:RIGHt

Moves a marker to the next positive peak.

The search includes only measurement values to the right of the current marker position.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Search Next Peak" on page 95

CALCulate<n>:MARKer<m>:MINimum:LEFT

Moves a marker to the next minimum peak value.

The search includes only measurement values to the right of the current marker position.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Next Minimum" on page 96

CALCulate<n>:MARKer<m>:MINimum:NEXT

Moves a marker to the next minimum peak value.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Next Minimum" on page 96

CALCulate<n>:MARKer<m>:MINimum[:PEAK]

Moves a marker to the minimum level.

If the marker is not yet active, the command first activates the marker.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Minimum" on page 96

CALCulate<n>:MARKer<m>:MINimum:RIGHt

Moves a marker to the next minimum peak value.

The search includes only measurement values to the right of the current marker position.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Next Minimum" on page 96

11.9.4.3 Positioning delta markers

The following commands position delta markers on the trace.

Useful commands for positioning delta markers described elsewhere:

- `CALCulate<n>:MARKer<m>:X` on page 197

Remote commands exclusive to positioning delta markers

CALCulate<n>:DELTamarker<m>:MAXimum:LEFT

Moves a delta marker to the next positive peak value.

The search includes only measurement values to the left of the current marker position.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Search Next Peak" on page 95

CALCulate<n>:DELTamarker<m>:MAXimum:NEXT

Moves a marker to the next positive peak value.

Suffix:

<n>	1..n Window
<m>	1..n Marker

Manual operation: See "Search Next Peak" on page 95

CALCulate<n>:DELTamarker<m>:MAXimum[:PEAK]

Moves a delta marker to the highest level.

If the marker is not yet active, the command first activates the marker.

Suffix:

<n>	Window
<m>	Marker

Manual operation: See "Peak Search" on page 95

CALCulate<n>:DELTamarker<m>:MAXimum:RIGHt

Moves a delta marker to the next positive peak value on the trace.

The search includes only measurement values to the right of the current marker position.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Next Peak" on page 95

CALCulate<n>:DELTamarker<m>:MINimum:LEFT

Moves a delta marker to the next minimum peak value.

The search includes only measurement values to the right of the current marker position.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Next Minimum" on page 96

CALCulate<n>:DELTamarker<m>:MINimum:NEXT

Moves a marker to the next minimum peak value.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Next Minimum" on page 96

CALCulate<n>:DELTamarker<m>:MINimum[:PEAK]

Moves a delta marker to the minimum level.

If the marker is not yet active, the command first activates the marker.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Minimum" on page 96

CALCulate<n>:DELTamarker<m>:MINimum:RIGHt

Moves a delta marker to the next minimum peak value.

The search includes only measurement values to the right of the current marker position.

Suffix:

<n> Window

<m> Marker

Manual operation: See "Search Next Minimum" on page 96

11.10 Deprecated commands

The following commands are provided for compatibility to other signal analyzers only. For new remote control programs use the specified alternative commands.

To set the FSW to compatible mode for previous signal analyzers, use the `SYST:LANG` command.

For details see the FSW User Manual.

CALCulate<n>:FEED <WindowType>

Selects the evaluation method of the measured data that is to be displayed in the specified window.

Queries or sets the diagram type (for magnitude or for phase).

Note that this command is maintained for compatibility reasons only. Use the `LAYout` commands for new remote control programs (see Chapter 11.6.2, "Working with windows in the display", on page 168).

Suffix:
<n> Window

Setting parameters:
<WindowType> **'XFRequency:SPECtrum[:MAGNitude]'**
Magnitude diagram
'XFRequency:SPECtrum:PHASe'
Phase diagram

Usage: Setting only

DISPlay[:WINDow<n>]:TYPE <ResultType>

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 11.6.2, "Working with windows in the display", on page 168).

Suffix:
<n> 1..n

Parameters:
<ResultType>

Table 11-4: <WindowType> parameter values for Multi-Carrier Group Delay (K17) mode

Parameter value	Window type
DPHase	"Phase Difference"
GAIN	Gain
GDELay	"Group Delay"
MAGNitude	Magnitude (Measurement data)
MTABle	Marker table
PHASe	Phase (Measurement data)
RMAGnitude	Magnitude (Reference data)
RPHase	Phase vs frequency (Reference data)

[SENSe:]ADEMod:BANDwidth:DEModulation?
[SENSe:]ADEMod:BWIDth:DEModulation?

Queries the measurement bandwidth.

Note that this command is maintained for compatibility reasons only. Use `[SENSe<ip>:]BANDwidth:DEMod` on page 146 for new remote control programs.

Return values:
<Span> Default unit: HZ

Usage: Query only

[SENSe:]ADEMod:MCPHase:METHod <Method>

Selects the method used for group delay measurements. This command is maintained for compatibility reasons only.

As the FSW MCGD application only supports orthogonal measurements, this command returns an error if the FLATtop parameter is used.

Parameters:

<Method> ORTHogonal | FLATtop

[SENSe:]ADEMod:MCPHase:SPACing <CarrierSpacing>

Sets/queries the carrier spacing in Hz between the multiple carriers.

Note that this command is maintained for compatibility reasons only. Use [SENSe:]CARRier:SPACing on page 146 for new remote control programs.

Parameters:

<CarrierSpacing> Default unit: HZ

[SENSe:]ADEMod:MCPHase[:STATe] <State>

Switches to the Multi-Carrier "Group Delay" application of the instrument or disables it.

Note that this command is maintained for compatibility reasons only. Use the INST:SEL MCGD command for new remote control programs (see INSTrument[:SELect] on page 118).

Parameters:

<State>

[SENSe:]ADEMod:SPECtrum:PHASe:RESult? <WindowType>

Returns the trace data of the first trace of the given type within the phase window.

Note that this command is maintained for compatibility reasons only. Use TRACe<n>[:DATA]? on page 183 for new remote control programs.

Query parameters:

<WindowType> WRITe | AVERage | MINHold | MAXHold

Usage: Query only

[SENSe:]ADEMod:SPECtrum:PHASe:TYPE <Trace1>, <Trace2>, <Trace3>

Sets the modes of the first three traces of phase windows.

Note that this command is maintained for compatibility reasons only. Use DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MODE on page 186 for new remote control programs.

Parameters:

<Trace1> WRITe | AVERage | MINHold | MAXHold | VIEW | OFF

<Trace2> WRITe | AVERage | MINHold | MAXHold | VIEW | OFF

<Trace3> WRITe | AVERage | MINHold | MAXHold | VIEW | OFF

[SENSe:]ADEMod:SPECtrum:SPAN <Frequency>

Sets/queries the frequency span in Hz.

Note that this command is maintained for compatibility reasons only. Use the `[SENSe<ip>:]FREQuency:SPAN` on page 147 command for new remote control programs.

Parameters:

<Frequency> Default unit: HZ

[SENSe:]ADEMod:SPECtrum:SPAN:ZOOM <Value>

Sets the span.

Note that this command is maintained for compatibility reasons only. Use `[SENSe<ip>:]FREQuency:SPAN` on page 147 for new remote control programs.

Parameters:

<Value> Default unit: HZ

[SENSe:]ADEMod:SPECtrum:SPAN[:MAXimum] <Value>

Sets the span.

Note that this command is maintained for compatibility reasons only. Use `[SENSe<ip>:]FREQuency:SPAN` on page 147 for new remote control programs.

Parameters:

<Value> Default unit: HZ

[SENSe:]ADEMod:SPECtrum[:MAGNitude]:RESult? <WindowType>

Returns the trace data of the first trace of the given type within the magnitude window.

Note that this command is maintained for compatibility reasons only. Use `TRACe<n>[:DATA]?` on page 183 for new remote control programs.

Query parameters:

<WindowType> WRITe | AVERage | MINHold | MAXHold

Usage: Query only

[SENSe:]ADEMod:SPECtrum[:MAGNitude][:TYPE] <Trace1>, <Trace2>, <Trace3>

Sets the modes of the first three traces of magnitude windows.

Note that this command is maintained for compatibility reasons only. Use DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:MODE on page 186 for new remote control programs.

Parameters:

<Trace1>	WRITe | AVERage | MINHold | MAXHold | VIEW | OFF
<Trace2>	WRITe | AVERage | MINHold | MAXHold | VIEW | OFF
<Trace3>	WRITe | AVERage | MINHold | MAXHold | VIEW | OFF

[SENSe:]ADEMod:MTIMe <MeasTime>

Queries or sets the measurement time.

Note that this command is maintained for compatibility reasons only. Use [SENSe:]MTIMe on page 151 for new remote control programs.

Parameters:

<MeasTime> Default unit: S

[SENSe:]ADEMod:MTIMe:AUTO <State>

Enables or disables automatic measurement time selection.

Note that this command is maintained for compatibility reasons only. Use [SENSe:]MTIMe:AUTO on page 151 for new remote control programs.

Parameters:

<State>

[SENSe:]ADEMod:RLENgth?

Returns the record length set up for current measurement settings.

Note that this command is maintained for compatibility reasons only. Use the [SENSe:]RLENgth? on page 151 command for new remote control programs.

Return values:

<SampleCount>

Usage: Query only

[SENSe:]ADEMod:SRATe?

Returns the sample rate set up for current measurement settings.

Note that this command is maintained for compatibility reasons only. Use [SENSe:]SRATe? on page 152 for new remote control programs.

Return values:

<SampleRate>

Usage: Query only

[SENSe:]ADEMod[:STATe] <State>

Switches to the Analog Demodulation application or disables it.

Note that this command is maintained for compatibility reasons only. Use the `INST:SEL ADEM` command for new remote control programs.

Parameters:
<State>

[SENSe:]CARRier:OFFSet:MODE <Mode>

Is maintained for compatibility reasons only. Use `[SENSe:]CESTimation:MODE` on page 147 instead.

Parameters:

<Mode> ESTimate | FIXed | CARRiers

FIXed
No estimation is performed. The carrier frequencies as defined in the configuration are used; possible offsets or Doppler-effects are not compensated.
(Corresponds to the manual setting "OFF")

CARRiers
The frequency offset of each carrier is estimated and compensated when calculating the group delay.
(Corresponds to the manual setting "All Carriers")

ESTimate
A fixed offset is estimated and used for all carriers.
(Corresponds to the manual setting "Offset")

Manual operation: See "Carrier Estimation Mode" on page 70

11.11 Programming examples

The following examples demonstrate how to perform a multi-carrier group delay measurement in a remote environment.

11.11.1 Programming example: measuring multi-carrier group delay

This example assumes a multi-carrier signal is being input, for example by a connected signal generator. Furthermore, it assumes an external trigger and an external reference frequency are being provided by a connected signal generator. The commands to set up the signal generator are not provided in this example.

```
//----------- Preparing the measurement ------------
//Reset the instrument
```

```
*RST
//Configure the use of an external reference frequency at 10 MHz
SENS:ROSC:SOUR EXT
SOUR:EXT:ROSC:EXT:FREQ 10MHZ

//Activate the MCGD measurement application
INST:SEL 'MCGD'

// -----------Configuring the measurement ------------
//Configure the use of an external trigger at 1.5V
TRIG:SOUR EXT
TRIG:LEV:EXT 1.5V

//Set the center frequency to 100 MHz
FREQ:CENT 100MHZ
//Set the carrier spacing to 200 kHz for 50 carriers
SENS:CARR:SPAC 200 kHz
SENS:CARR:COUN 51
//Query the resulting span (10 MHZ)
SENS:FREQ:SPAN?
//Set the attenuation and reference level automatically
SENS:ADJ:LEV
//Set a sweep count of 100
SENS:SWE:COUN 100
//Configure absolute group delay
CALC:GRPD:MODE ABS
//Activate carrier estimation for each carrier
SENS:CARR:OFFS:MODE CARR
//Query the record length and sample rate determined by the meas settings
SENS:RLEN?
SENS:SRAT?

//---------------Configuring the calibration measurement---------------------
//Perform new calibration measurement and wait for completion
CAL:MCGD;*WAI
//Query the state of the calibration measurement
CAL:MCGD:STAT?
//Store the resulting calibration data to a file
MMEM:STOR:MCGD:RCAL 'C:\TESTS\CalData.csv'

//----------------Configuring the result displays-----------------------------
//Add a Magnitude Reference and replace the Phase by a Gain display:
//Top row: 1) Magnitude (default) 2) Magnitude Reference
//Bottom row: 3) Group Delay (default) 4) Gain
LAY:REPL '2',RMAG
LAY:ADD:WIND? '3',RIGH,GAIN

//--------------Performing the Measurement-----
//Switch to single mode, initiate a new measurement and wait
//until the sweep has finished.
```

```
INIT:CONT OFF
INIT;*WAI

//---------------Retrieving Results-------------
//Store the results of the multi-carrier measurement to a file
MMEM:STOR:MCGD:MEAS 'C:\TESTS\MeasResults.csv'
```

11.11.2 Programming example: measuring multi-carrier group delay

This example demonstrates how to perform an automated multi-carrier group delay measurement with a connected signal generator in a remote environment. It assumes the analyzer and the generator have already been physically connected and set up.

```
//----------- Preparing the measurement ------------
//Reset the instrument
*RST
//Configure the use of an external reference frequency at 10 MHz
SENS:ROSC:SOUR EXT
SOUR:EXT:ROSC:EXT:FREQ 10MHZ

//Activate the MCGD measurement application
INST:SEL 'MCGD'

// -----------Configuring the measurement ------------
//Configure the use of an external trigger at 1.5V
TRIG:SOUR EXT
TRIG:LEV:EXT 1.5V

//Set the center frequency to 100 MHz
FREQ:CENT 100MHZ
//Set the carrier spacing to 200 kHz for 50 carriers
SENS:CARR:SPAC 200 kHz
SENS:CARR:COUN 51
//Query the resulting span (10 MHZ)
SENS:FREQ:SPAN?
//Set the attenuation and reference level automatically
SENS:ADJ:LEV
//Set a sweep count of 100
SENS:SWE:COUN 100
//Configure absolute group delay
CALC:GRPD:MODE ABS
//Activate carrier estimation for each carrier
SENS:CARR:OFFS:MODE CARR
//Query the record length and sample rate determined by the meas settings
SENS:RLEN?
SENS:SRAT?

// -----------Configuring generator control ------------
//Define the generator IP address
```

```
CONF:GEN:IPC:ADDR '192.168.114.90'
//Query the connection state of the connected generator
CONF:GEN:MCGD:CONN:CST?
//Activate control of all settings
CONF:GEN:MCGD:FREQ:CENT:STAT ON
CONF:GEN:MCGD:CARR:COUN:STAT ON
CONF:GEN:MCGD:CARR:SPAC:STAT ON
//Activate control of level, using PEP and applying gain
CONF:GEN:MCGD:LEV:DUTL?
CONF:GEN:MCGD:LEV:DUTL:STAT ON
CONF:GEN:MCGD:LEV:DUTG 10
CONF:GEN:MCGD:LEVE:STAT ON

//Activate control of the generator by the analyzer
CONF:GEN:MCGD:CONT:STAT ON

//Query overall status of generator control settings
CONF:GEN:MCGD:OST?

// -----------Configuring automated frequency translation measurement ------------
CONF:GEN:MCGD:AFTM:FREQ:ANAL 1000005
CONF:GEN:MCGD:AFTM:FREQ:FACT:NUM 1
CONF:GEN:MCGD:AFTM:FREQ:FACT:DEN 2
CONF:GEN:MCGD:AFTM:FREQ:OFFS 5
CONF:GEN:MCGD:AFTM:FREQ:GEN?
CONF:GEN:MCGD:AFTM:STAT ON
//Query overall state of automated measurement
CONF:GEN:MCGD:AFTM:OST?

//---------------Configuring the calibration measurement---------------------
//Perform new calibration measurement and wait for completion
CAL:MCGD;*WAI
//Query the state of the calibration measurement
CAL:MCGD:STAT?

//--------------Performing the Measurement-----
//Switch to single mode, initiate a new measurement and wait
//until the sweep has finished.
INIT:CONT OFF
INIT;*WAI

//---------------Retrieving Results-------------
//Store the results of the multi-carrier measurement to a file
MMEM:STOR:MCGD:MEAS 'C:\TESTS\MeasResults.csv'
```

12 Annex

12.1 Formats for returned values: ASCII format and binary format

When trace data is retrieved using the `TRAC:DATA` or `TRAC:IQ:DATA` command, the data is returned in the format defined using the `FORMat[:DATA]` on page 182. The possible formats are described here.

- ASCII Format (FORMat ASCII):
  The data is stored as a list of comma-separated values (CSV) of the measured values in floating point format.
- Binary Format (FORMat REAL,16/32/64):
  The data is stored as binary data (definite length block data according to IEEE 488.2), each measurement value being formatted in 16-bit/32-bit/64-bit IEEE 754 floating-point-format.
  The schema of the result string is as follows:
  `#<Length of length><Length of data><value1><value2>…<value n>`
  with:

<Length of length>	Number of digits of the following number of data bytes
<Length of data>	Number of following data bytes
<Value>	2-byte/4-byte/8-byte floating point value

Example: `#41024`<Data>... contains 1024 data bytes

Data blocks larger than 999,999,999 bytes

According to SCPI, the header of the block data format allows for a maximum of 9 characters to describe the data length. Thus, the maximum REAL 32 data that can be represented is 999,999,999 bytes. However, the FSW is able to send larger data blocks. In this case, the length of the data block is placed in brackets, e.g. `#(1234567890)`<value1><value2>…

Reading out data in binary format is quicker than in ASCII format. Thus, binary format is recommended for large amounts of data.

12.2 Reference: ASCII file export format

Trace data (both measurement and reference traces) can be exported to a file in ASCII format for further evaluation in other applications

The file consists of the header containing important scaling parameters and a data section containing the trace data.

Generally, the format of this ASCII file can be processed by spreadsheet calculation programs, e.g. MS-Excel. Different language versions of evaluation programs may require a different handling of the decimal point. Thus you can define the decimal separator to be used (decimal point or comma, see "Decimal Separator" on page 64).

The data of the file header consist of two columns, separated by a semicolon: parameter name; numeric value. The data section contains the measured data in two columns, which are also separated by a semicolon.

Table 12-1: ASCII file format for trace export

File contents	Description
Header data	
Type;FSW;	Instrument model
Version;1.30;	Firmware version
Date;20.Jan 2012;	Date of data set storage
Mode;MCGD	Channel type
Ref Level;0;	Reference level
Level offset;0;	Reference level offset
Rf Att;10;	Input attenuation
El Att;0;	Electronic attentuation
Center Freq;10000000;Hz	Center frequency
Freq Offset;0;Hz	Frequency offset
Span;10000000;Hz	Frequency range
Carrier Spacing,10000000;Hz	Distance between two carriers
Meas Time;0.00003128125;s	Measurement time
"Group Delay";Absolute;	Value type for group delay
Carrier Offset;AUTO;	Auto mode for carrier offset
Carrier Offset;0;Hz	Carrier offset value
Sweep Count;0;	Number of sweeps set
Preamplifier;OFF	Preamplifier status
Window;1 Magnitude;	Window name containing trace
Trace 1:;;	Selected trace

File contents	Description
Trace Mode;Clear Write	Display mode of trace: CLR/WRITE,AVER-AGE,MAXHOLD,MINHOLD
x-Axis;Linear;	Scaling of x-axis linear (LIN) or logarithmic (LOG)
Start;95000000;Hz Stop;105000000;Hz	Start/stop value of the display range
x-Unit;Hz;	Unit of x values: Hz with span > 0; s with span = 0; dBm/dB with statistics measurements
y-Axis;Linear;	Scaling of y-axis linear (LIN) or logarithmic (LOG)
Level Range;100;dB	Display range in y direction. Unit: dB with x-axis LOG, % with x-axis LIN
Ref Position;100; %	Position of reference value referred to diagram limits (0 % = lower edge)
Ref Value;0.0;dBm	Reference value
y-Unit;dBm;	Unit of y values: dB*/V/A/W depending on the selected unit with y-axis LOG or % with y-axis LIN
Data section	
Values; 1001;	Number of measurement points
95000000;-20.5 96000000;-20.3 97000000;-24.2 ...;...;	Measured values: <x value>, <y value>

12.3 Reference: CSV file export format

Measurement results and calibration data can be exported to a file in CSV format for further evaluation in other applications. Note that as opposed to the Export Trace to ASCII File, storing the measurement results in `.csv` format includes all traces in all windows, not just one single trace.

The file consists of the header containing important parameters and a data section containing the measurement data.

Generally, the format of this CSV file can be processed by spreadsheet calculation programs, e.g. MS-Excel. Different language versions of evaluation programs may require a different handling of the decimal point. Thus you can define the decimal separator to be used (decimal point or comma; see "Decimal Separator" on page 64).

The data of the file header consist of three columns; each separated by a semicolon: parameter name; numeric value; basic unit. The data section contains the measured data in two columns, which are also separated by a semicolon.

Table 12-2: CSV file format for calibration data export

File contents	Description
Header data	
Type;FSW-K17 Reference Calibration;	Type of data
Version;1.40;	Firmware version
Date;20.Jan 2012;	Date of data set storage
Mode;MCGD	Channel type
Center Freq;10000000;Hz	Center frequency
Freq Offset;0;Hz	Frequency offset
Span;10000000;Hz	Frequency range
Number of Carriers;51;	Number of carriers
Carrier Spacing;10000000;Hz	Distance between two carriers
Meas Time;0.00003128125;s	Measurement time
Sweep Count;0	Sweep count
Trace type;Amplitude Reference Calibration	Data source and result display ("Magnitude Reference")
x-Unit;Hz;	Unit of x values
y-Unit;V;	Unit of y values
Data section	
Values; 51;	Number of measurement points
95000000;-20.5 96000000;-20.3 97000000;-24.2 ...;...;	Measured values: <x value>; <y value>

Table 12-3: CSV file format for measurement data export

File contents	Description
Header data	
Type;FSW;	Instrument model
Version;1.30;	Firmware version
Date;20.Jan 2012;	Date of data set storage
Mode;MCGD;DB1.00	Channel type; database version
Ref Level;0;	Reference level
Level offset;0;	Reference level offset
Rf Att;10;	Input attenuation
El Att;0;	Electronic attentuation
Center Freq;10000000;Hz	Center frequency

File contents	Description
Freq Offset;0;Hz	Frequency offset
Span;10000000;Hz	Frequency range
Number of Carriers;51;	Number of carriers
Carrier Spacing;10000000;Hz	Distance between two carriers
Meas Time;0.00003128125;s	Measurement time
"Group Delay";Absolute;	Value type for group delay
Carrier Offset;AUTO;	Auto mode for carrier offset
Carrier Offset;0;Hz	Carrier offset value
Sweep Count;0;	Number of sweeps set
Preamplifier;OFF	Preamplifier status
Number of windows	Number of windows included in export
Data section for individual window	
Window;1 Magnitude	Name of first window (= result display)
Data section for individual trace	
Trace 1;;	First trace
Trace Mode;Clear Write;	Display mode of trace: CLR/WRITE;AVER-AGE;MAXHOLD;MINHOLD
x-Axis;Linear;	Scaling of x-axis: linear (LIN) or logarithmic (LOG)
Start;95000000;Hz Stop;105000000;Hz	Start/stop value of the display range
x-Unit;Hz;	Unit of x values: Hz with span > 0; s with span = 0; dBm/dB with statistics measurements
y-Axis;Linear;	Scaling of y-axis linear (LIN) or logarithmic (LOG)
Level Range;100;dB	Display range in y direction. Unit: dB with x-axis LOG; % with x-axis LIN
Ref Position;100; %	Position of reference value referred to diagram limits (0 % = lower edge)
Ref Value;0.0;dBm	Reference value
y-Unit;dBm;	Unit of y values: dB*/V/A/W depending on the selected unit with y-axis LOG or % with y-axis LIN
Values; 1001;	Number of measurement points
95000000;-20.5 96000000;-20.3 97000000;-24.2 ...;...;	Measured values: <x value>; <y value>
Data section for individual trace	
Trace 2;;	Next trace in same window

File contents	Description
...	
Data section for individual window	
Window;2 Phase;	Name of next window
Data section for individual trace	
Trace 1;;	First trace
...	

List of Commands (MC Group Delay)

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