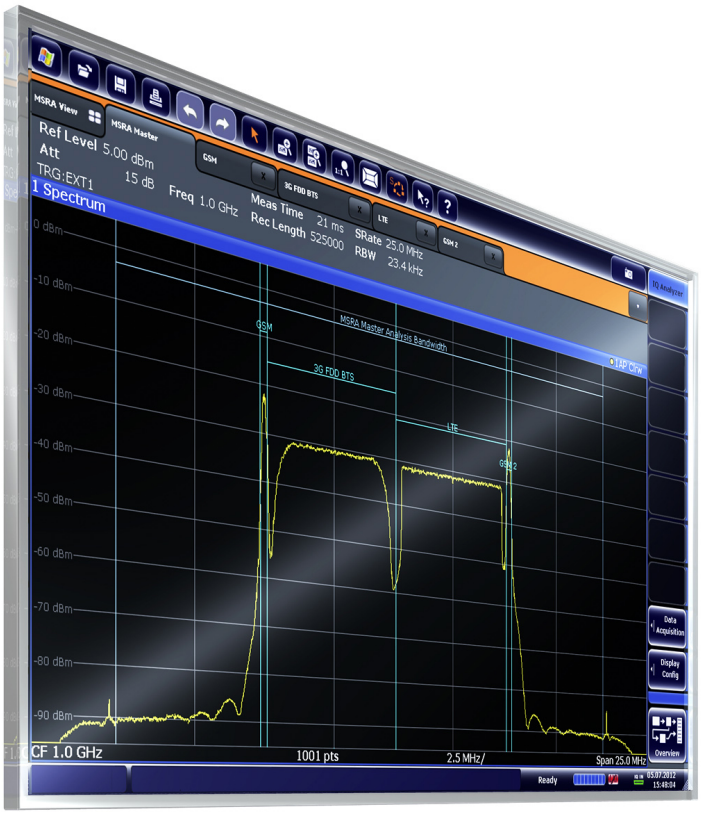
R&S®FSW MSRA
Multi-Standard Radio Analyzer
User Manual



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Test & Measurement

User Manual

ROHDE&SCHWARZ

This manual applies to the following R&S®FSW models with firmware version 1.51 and higher:

- R&S®FSW8 (1312.8000K08)
- R&S®FSW13 (1312.8000K13)
- R&S®FSW26 (1312.8000K26)

The firmware of the instrument makes use of several valuable open source software packages. For information, see the "Open Source Acknowledgement" on the user documentation CD-ROM (included in delivery).
Rohde & Schwarz would like to thank the open source community for their valuable contribution to embedded computing.

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The following abbreviations are used throughout this manual: R&S®FSW is abbreviated as R&S FSW. R&S®FSW Multi-Standard Radio Analyzer is abbreviated as R&S FSW MSRA.

Contents

1 Preface

1.1 About this Manual

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

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

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

1.2 Documentation Overview

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

- "Getting Started" printed manual
- Online Help system on the instrument
- Documentation CD-ROM with:
  - Getting Started
  - User Manuals for base unit and options
  - Service Manual
  - Release Notes
  - Data sheet and product brochures

Online Help

The Online Help is embedded in the instrument's firmware. It offers quick, context-sensitive access to the complete information needed for operation and programming. Online help is available using the icon on the toolbar of the R&S FSW.

Getting Started

This manual is delivered with the instrument in printed form and in PDF format on the CD. It provides the information needed to set up and start working with the instrument. Basic operations and handling are described. Safety information is also included.

The Getting Started manual in various languages is also available for download from the R&S website, on the R&S FSW product page at http://www2.rohde-schwarz.com/product/FSW.html.

User Manuals

User manuals are provided for the base unit and each additional (software) option.

The user manuals are available in PDF format - in printable form - on the Documentation CD-ROM delivered with the instrument. In the user manuals, all instrument functions are described in detail. Furthermore, they provide a complete description of the remote control commands with programming examples.

The user manual for the base unit provides basic information on operating the R&S FSW in general, and the Spectrum application in particular. Furthermore, the software functions that enhance the basic functionality for various applications are described here. An introduction to remote control is provided, as well as information on maintenance, instrument interfaces and troubleshooting.

In the individual application manuals, the specific instrument functions of the application are described in detail. For additional information on default settings and parameters, refer to the data sheets. Basic information on operating the R&S FSW is not included in the application manuals.

All user manuals are also available for download from the R&S website, on the R&S FSW product page at http://www2.rohde-schwarz.com/product/FSW.html.

Service Manual

This manual is available in PDF format on the CD delivered with the instrument. It describes how to check compliance with rated specifications, instrument function, repair, troubleshooting and fault elimination. It contains all information required for repairing the R&S FSW by replacing modules.

Release Notes

The release notes describe the installation of the firmware, new and modified functions, eliminated problems, and last minute changes to the documentation. The corresponding firmware version is indicated on the title page of the release notes.

The most recent release notes are also available for download from the R&S website, on the R&S FSW product page at http://www2.rohde-schwarz.com/product/FSW.html > Downloads > Firmware.

1.3 Conventions Used in the Documentation

1.3.1 Typographical Conventions

The following text markers are used throughout this documentation:

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

1.3.2 Conventions for Procedure Descriptions

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

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

2 Welcome to the MSRA Operating Mode

The MSRA operating mode is part of the standard R&S FSW firmware and adds functionality to perform multi-standard radio analysis.

The R&S FSW MSRA operating mode features:

- analysis of the same I/Q data in more than one application
- analysis of correlated effects due to multiple standards
- configuration of data acquisition settings only required once for all applications
- overview of all results in one screen in addition to large display of individual results

This user manual contains a description of the functionality specific to the MSRA operating mode, including remote control operation.

All functions not discussed in this manual are the same as in Signal and Spectrum Analyzer mode and are described in the R&S FSW User Manual. The latest version is available for download at the product homepage.

2.1 Starting the MSRA operating mode

MSRA is a new operating mode on the R&S FSW.

To activate the MSRA operating mode

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

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

2. Select the "Multi Standard Radio Analyzer" tab.

3. Confirm the message informing you that you are changing operating modes.

   The R&S FSW closes all active measurement channels in the current operating mode, then opens a new measurement channel for the MSRA operating mode.

   In addition to the "MSRA View" (the "Multiview" tab in MSRA mode), an "MSRA Master" tab is displayed.

The Sequencer is automatically activated in continuous mode (see chapter 5.3, "Using the Sequencer in MSRA Mode", on page 22), starting an I/Q Analyzer data acquisition with the default settings (but with a "Spectrum" result display). It can be configured in the MSRA "Overview" dialog box, which is displayed when you select the "Overview" softkey from any menu (see chapter 7, "Configuration", on page 28).

2.2 Understanding the Display Information

The following figure shows a screen display during MSRA operation. All different information areas are labeled. They are explained in more detail in the following sections.

- The colored background of the screen behind the measurement channel tabs indicates that you are in MSRA operating mode.
- The icon on the tab label indicates that the displayed trace (e.g. in an MSRA application) no longer matches the currently captured data. This may be the case, for example, if a data acquisition was performed in another application. As soon as the result display is refreshed, the icon disappears.
- The icon indicates that an error or warning is available for that measurement channel. This is particularly useful if the MSRA View tab is displayed.

1 = MSRA View (overview of all active channels in MSRA mode)
2 = MSRA Master (data acquisition channel with global configuration settings)
3 = Measurement channel tab for individual MSRA application
4 = Channel bar for firmware and measurement settings of current application
5+6 = Window title bar with diagram-specific (trace) information and analysis interval (applications)

7 = Diagram area
8 = Diagram footer with diagram-specific information, depending on evaluation
9 = Instrument status bar with error messages, progress bar and date/time display

The diagram area varies depending on the type of measurement channel, as described in detail in the following topics.

Window title bar information

For each diagram, the header provides the following information:

Fig. 2-1: Window title bar information in MSRA mode

1 = Window number
2 = Window type
3 = Trace color
4 = Trace number
5 = Detector
6 = Trace mode
7 = analysis interval

Diagram footer information

The information in the diagram footer (beneath the diagram) depends on the evaluation:

- Center frequency
- Number of sweep points
- Range per division (x-axis)
- Span (Spectrum)

Status bar information

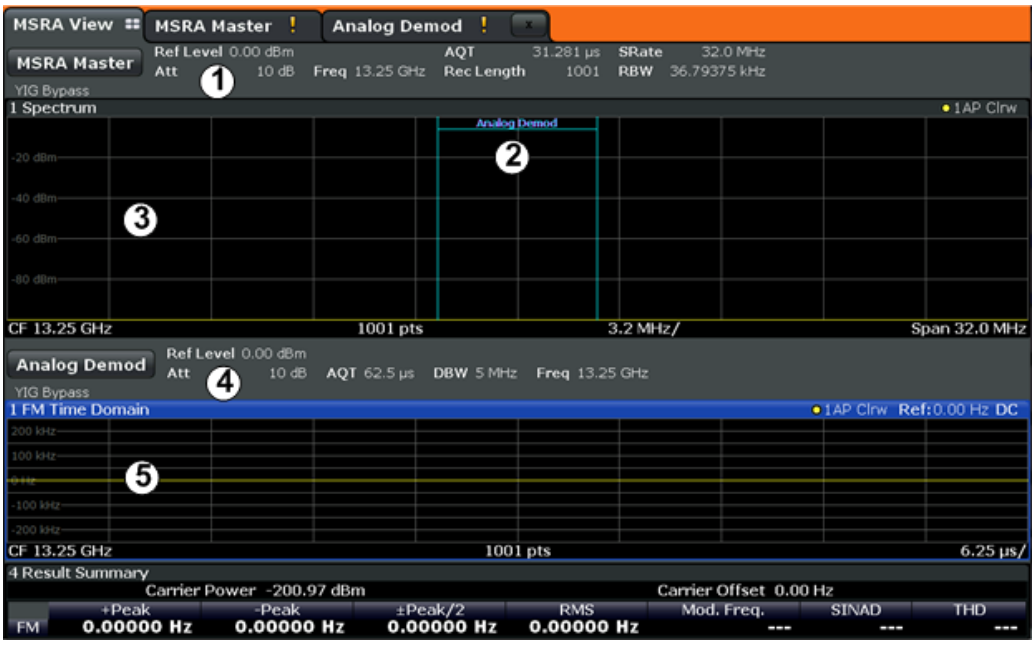
Global instrument settings, the instrument status and any irregularities are indicated in the status bar beneath the diagram. Furthermore, the progress of the current operation is displayed in the status bar.

If an error or warning is available for a measurement channel, the ! icon is displayed next to the tab label in the channel bar.

2.2.1 MSRA View

The MSRA View is an overview of all active channels in MSRA mode, similar to the MultiView tab in Signal and Spectrum Analyzer mode. At the top of the screen the MSRA Master is displayed, i.e. the application that captures data. Beneath the MSRA Master, all active applications are displayed in individual windows. Each application has its own channel bar with the current settings as well as a button in order to switch to that application tab directly.

The MSRA View displays the following basic elements:



1 = Channel information bar for the MSRA Master
2 = Application data coverage for each active application
3 = Result display for MSRA Master (for entire capture buffer)
4 = Channel information bar for application with button to switch to application tab
5 = Result display for application (for analysis interval)

2.2.2 MSRA Master

The MSRA Master is the only channel that captures data. It also controls global configuration settings for all applications. The MSRA Master channel itself is implemented as an I/Q Analyzer application. The MSRA Master measurement channel cannot be deleted or replaced.

The following figure shows the screen elements specific to the MSRA Master.

1 = Channel information bar for the MSRA Master
2 = Data coverage for each active application
3 = Result display for MSRA Master (for entire capture buffer)

Channel bar information

The channel bar shows the firmware and measurement information for data acquisition and global configuration.

Table 2-1: Information displayed in the channel bar for the MSRA Master

Ref Level	Reference level
(m.+el.)**Att**	(Mechanical and electronic) RF attenuation
Ref Offset	Reference level offset
Freq	Center frequency
AQT	Defined measurement time, i.e. the duration of data acquisition to the capture buffer
Rec Length	Defined record length (number of samples to capture)
SRate	Defined sample rate for data acquisition
RBW	(Spectrum evaluation only) Resolution bandwidth calculated from the sample rate and record length

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

Data coverage for each active application

Each application obtains an extract of the data captured by the MSRA Master (see also chapter 6.3, "Multi-Standard Analysis", on page 25). Generally, if a signal contains data channels for multiple standards, the individual applications are used to analyze the channel for the corresponding standard. Thus, it is of interest to know which application is analyzing which part of the captured data, or more precisely, which data channel. The MSRA Master display indicates the data covered by each application, restricted to the channel bandwidth used by the corresponding standard, by vertical blue lines labeled with the application name. For applications that support several standards (e.g. VSA, LTE) an estimated or user-defined bandwidth is indicated.

2.2.3 MSRA Applications

The data captured by the MSRA Master measurement (or only parts of it) can be evaluated by various applications. The measurement channel for each application contains the settings and results for the application data extract from the capture buffer.

The following figure shows the screen elements specific to the MSRA application tabs.

1 = Channel information bar for application
2 = Analysis interval for current evaluation
3 = Result display for analysis interval

The display for the individual MSRA applications is identical to the display in Signal and Spectrum Analyzer mode except for the following differences:

- The analysis interval indicates which part of the capture buffer is being evaluated and displayed in each window.
- The acquisition time indicated in the channel bar (AQT) indicates the *analyzed* measurement time, not the captured time.

- Any bandwidth or sample rate values refer to the application data, not to the actual data acquisition from the input signal.

For details on the individual application displays see the corresponding User Manuals for those applications.

3 Typical Applications

The technological advances made in the field of mobile radio have given rise to a wide variety of standards over the past several decades. These standards, which include those produced by the global cooperative for standardization – the 3rd Generation Partnership Project (3GPP) – are based on various transmission technologies. Network operators can deploy GSM/EDGE, WCDMA, TD-SCDMA and LTE or combinations of these four standards.

To handle these complex scenarios, the Multistandard Radio Base Station (MSR-BS) was developed. These can transmit and receive multiple standards simultaneously on various carriers. An MSR-BS combines at least two different radio access technologies (RAT).

Specifications and Tests

3GPP has published the specifications TS 37.141 and TS 37.104 for multistandard base stations. The latter describes the minimum requirements for multistandard base stations in terms of RF requirements for the downlink and uplink. TS 37.141 defines the tests and test requirements for the MSR-BS based on these RF requirements.

To allow for efficient MSR-BS testing, TS 37.141 includes test configurations. The goal of these test configurations is to significantly reduce the complexity of the many possible test scenarios. They are limited to the worst-case scenarios with the strictest criteria. Thus, for example, a test configuration is provided for receiver tests in which two signals – a GSM carrier and an LTE carrier with a $BW_{Channel}$ = 5 MHz – are positioned at the lower and upper edge of BW_{RF} while maintaining $F_{offset-RAT}$. This allows receiver tests to be performed with a configuration that fully utilizes the maximum bandwidth BW_{RF} of the MSR-BS.

MSR-BS Testing using R&S FSW Multi-Standard Radio Analysis

The newly introduced R&S FSW MSRA mode allows you to capture signals from a multistandard base station and analyze the same data in various standard applications.

4 Measurements and Result Displays

MSRA Measurement

The only true measurement in MSRA mode in which I/Q data from the input signal is captured and stored is performed by the MSRA Master. This data acquisition is performed as in the I/Q Analyzer application, i.e. a specified frequency span of the input signal is swept for a specified measurement time. The captured I/Q data can then be analyzed in various different applications.

Data Import

Alternatively to capturing I/Q data from an input signal, the data to be analyzed in MSRA mode can also be imported to the R&S FSW from a file.

See the R&S FSW I/Q Analyzer User Manual for details.

Result Displays

The data that was captured by the MSRA Master can be evaluated in various different applications. All evaluation modes available for the MSRA applications are displayed in the selection bar in SmartGrid mode.

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

The result displays available in MSRA mode are those described for the individual applications. The MSRA Master is implemented as an I/Q Analyzer application and has the same result displays.

See the R&S FSW I/Q Analyzer User Manual for a description of the result displays available for the I/Q Analyzer and thus the MSRA Master.

5 Applications and Operating Modes

The R&S FSW provides several applications for different analysis tasks and different types of signals, e.g. 3G FDD, Analog Demodulation, I/Q analysis or basic spectrum analysis. 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. Whenever you switch channels, the corresponding measurement settings are restored. Each channel is displayed in a separate tab on the screen.

The maximum number may be limited further by the available memory on the instrument.

Independant vs correlating measurements

With the **conventional R&S FSW Signal and Spectrum Analyzer** you can perform several different measurements almost simultaneously. However, the individual measurements are independant of each other - **each application captures and evaluates its own set of data**, regardless of what the other applications do.

In some cases it may be useful to **analyze the exact same input data using different applications**. For example, imagine capturing data from a base station and analyzing the RF spectrum in the Analog Demodulation application. If a spur or an unexpected peak occurs, you may want to analyze the same data in the I/Q Analyzer to see the real and imaginary components of the signal and thus detect the reason for the irregular signal. Normally when you switch to a different application, evaluation is performed on the data that was captured by that application, and not the previous one. In our example that would mean the irregular signal would be lost. Therefore, a new operating mode has been introduced to the R&S FSW: Multi-Standard Radio Analyzer (MSRA) mode.

In **Multi-Standard Radio Analyzer mode**, data acquisition is performed once and the captured data is then evaluated by any number of applications for different radio standards. Data acquisition and global configuration settings are controlled globally, while the evaluation and display settings can be configured individually for each application. Using the Multi-Standard Radio Analyzer, unwanted correlations between different signal components using different transmission standards can be detected. Thus, for example, an irregularity in a GSM burst can be examined closer in the WCDMA application to reveal dependencies like a change in the EVM value.

Currently, only applications for **base-station** tests and those that process I/Q data are supported in MSRA mode, in particular:

- I/Q Analyzer
- Analog Demodulation
- GSM
- 3G FDD BTS
- cdma2000 BTS
- 1xEV-DO BTS
- Vector Signal Analysis (VSA)

- LTE (Downlink)

The applications used in Multi-Standard Radio Analyzer mode are identical to those in the common Signal and Spectrum Analyzer mode, except that data acquisition is "outsourced" to a special measurement channel ("MSRA Master").

Distinct operating modes

Although the applications themselves are identical in either operating mode, the handling of the data between applications is not. Thus, the operating mode determines which applications are available and active. Whenever you change the operating mode, the currently active measurement channels are stored. The default operating mode is Signal and Spectrum Analyzer mode; however, the presetting can be changed.

SCPI command:

`INST:MODE MSR`, see `INSTrument:MODE` on page 75

5.1 Available Applications

The R&S FSW provides some applications in the base unit while others are available only if the corresponding firmware options are installed.

I/Q Analyzer
The I/Q Analyzer application provides measurement and display functions for digital I/Q signals.

For details see the R&S FSW I/Q Analyzer User Manual.

SCPI command:
`INST:SEL IQ`, see `INSTrument[:SELect]` on page 76

Analog Demodulation
The Analog Demodulation application requires an instrument equipped with the corresponding optional software. This application provides measurement functions for demodulating AM, FM, or PM signals.

For details see the R&S FSW Analog Demodulation User Manual.

SCPI command:
`INST:SEL ADEM`, see `INSTrument[:SELect]` on page 76

GSM
The GSM application requires an instrument equipped with the corresponding optional software. This application provides measurement functions for measuring GSM signals.

For details see the R&S FSW GSM User Manual.

SCPI command:
`INST:SEL GSM`, see `INSTrument[:SELect]` on page 76

Vector Signal Analysis (VSA)
The VSA application requires an instrument equipped with the Vector Signal Analysis option, R&S FSW-K70. This application provides measurements and evaluations for Vector Signal Analysis.

For details see the R&S FSW VSA User Manual.

SCPI command:
`INST:SEL DDEM`, see `INSTrument[:SELect]` on page 76

3G FDD BTS
The 3G FDD BTS application requires an instrument equipped with the 3GPP Base Station Measurements option, R&S FSW-K72. This application provides test measurements for WCDMA downlink signals (base station signals) according to the test specification.

RF measurements are not supported in MSRA mode.

For details see the R&S FSW 3G FDD User Manual.

SCPI command:
`INST:SEL BWCD`, see `INSTrument[:SELect]` on page 76

cdma2000 BTS
The cdma2000 BTS application requires an instrument equipped with the cdma2000 BTS Measurements option, R&S FSW-K82. This application provides test measurements for cdma2000 BTS downlink signals (base station signals) according to the test specification.

RF measurements are not supported in MSRA mode.

For details see the R&S FSW cdma2000 User Manual.

SCPI command:
`INST:SEL BC2K`, see `INSTrument[:SELect]` on page 76

1xEV-DO BTS
The 1xEV-DO BTS application requires an instrument equipped with the 1xEV-DO BTS Measurements option, R&S FSW-K84. This application provides test measurements for 1xEV-DO BTS downlink signals (base station signals) according to the test specification.

RF measurements are not supported in MSRA mode.

For details see the R&S FSW 1xEV-DO User Manual.

SCPI command:
`INST:SEL BDO`, see `INSTrument[:SELect]` on page 76

LTE DL
The LTE Downlink application requires an instrument equipped with the LTE Downlink option, R&S FSW-K100 or R&S FSW-K104. This application provides test measurements for LTE downlink signals (base station signals) according to the test specification.

Frequency sweep measurements are not supported in MSRA mode.

For details see the R&S FSW LTE DL User Manual.

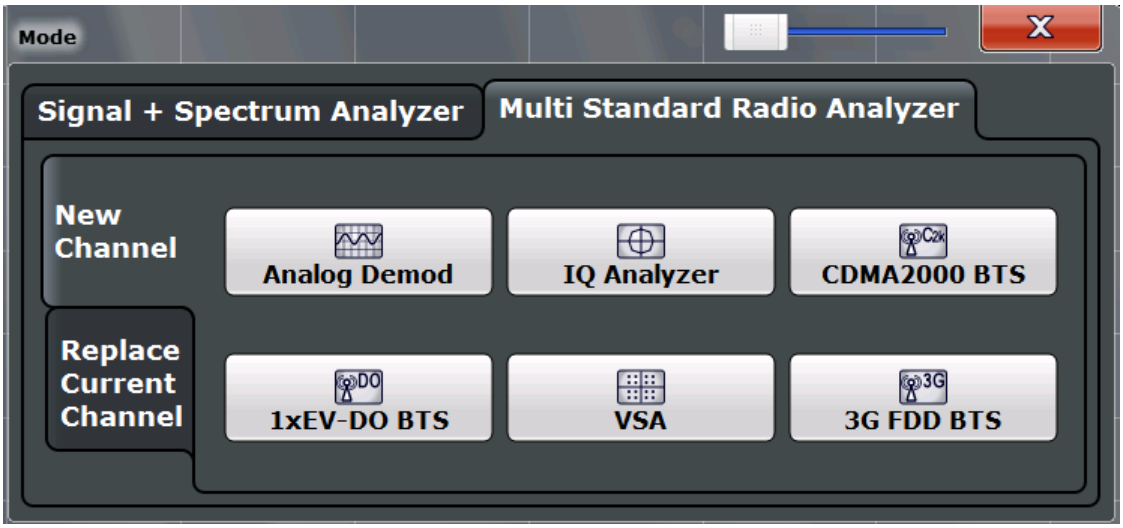
SCPI command:
`INST:SEL LTE`, see `INSTrument[:SELect]` on page 76

5.2 Selecting the Operating Mode and Application

The default operating mode is Signal and Spectrum Analyzer mode, however, the pre-setting can be changed.

(See the "Instrument Setup" chapter in the R&S FSW User Manual).

Both the operating mode and the application can be selected in the "Mode" dialog box which is displayed when you press the MODE key.



To switch the operating mode, select the corresponding tab (see chapter 2.1, "Starting the MSRA operating mode", on page 9).

To select an application, select the corresponding button.

To deactivate a channel, simply close the corresponding tab.

The remote commands required to perform these tasks are described in chapter 11.2, "Activating MSRA Measurements", on page 73.

New Channel
The applications selected on this tab are started in a new channel, i.e. a new tab in the display.

SCPI command:
`INSTrument:CREate[:NEW]` on page 73
`INSTrument[:SELect]` on page 76

Replace Current Channel
The applications selected on this tab are started in the currently displayed channel, replacing the current application.

SCPI command:
`INSTrument:CREate:REPLace` on page 73

5.3 Using the Sequencer in MSRA Mode

When you switch to MSRA mode, the Sequencer is automatically activated in continuous mode. Unless it is stopped or you select a different Sequencer mode, the R&S FSW will continuously perform a data acquisition (MSRA Master), then evaluate the data in the active applications one after the other, then repeat the data acquisition and evaluate the new data etc. The tabs are updated after each measurement or evaluation. This behaviour is identical to Signal and Spectrum Analyzer mode (also for Single Sequence or Channel-Defined Sequence modes).

However, if you switch the Sequencer off, the behaviour of the sweep functions is slightly different to Signal and Spectrum Analyzer mode (see also "Performing sweeps" on page 25):

- If continuous sweep is active (default) and you switch to a different application, continuous sweep is aborted. This is necessary in order to evaluate the same data in different applications without overwriting the data in the capture buffer. Continuous sweep can be started again as usual.
- Only the application that is currently displayed when a measurement is performed is updated automatically. A new "Refresh" function is available to update the display in one or all other applications.

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

The "Sequencer" menu is available from the toolbar.

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

SCPI command:
`SYSTem:SEQuencer` on page 109
`INITiate:SEQuencer:IMMediate` on page 107
`INITiate:SEQuencer:ABORt` on page 106

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

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

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

"Channel-defined Sequencer"
First, a single sequence is performed. Then, only channels in continuous sweep mode are repeated.

SCPI command:
`INITiate:SEQuencer:MODE` on page 107

Refresh All
This function is only available if the Sequencer is deactivated and only in MSRA mode.

The data in the capture buffer is re-evaluated by all active applications, for example after a new sweep was performed while the Sequencer was off.

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

SCPI command:
`INITiate:SEQuencer:REFResh[:ALL]` on page 108

6 MSRA Basics

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

6.1 Configuration

Master parameters

In MSRA mode, only the MSRA Master performs a data acquisition. Thus, all parameters that determine how the I/Q data is captured from the I/Q channel can only be configured in the MSRA Master tab. In all application tabs, these settings are deactivated (or have a different meaning).

Typical master parameters include:

- Sample rate
- Record length
- Bandwidth
- Center frequency
- Reference level
- Trigger settings
- External reference
- Impedance, preamplification, attenuation

Channel-specific parameters

Each application, however, can define all parameters concerning analysis individually.

Typical channel-specific parameters include:

- Center frequency, duration and number of trace points for the application data extract
- Offset of the application data extract from the trigger event
- Evaluation methods
- Range and scaling
- Trace mode
- Marker positions

Conflicting parameters

Master and channel-specific parameters can be configured independantly of one another, in any order that is convenient to you. However, there are dependencies between the parameters, as the applications can only evaluate data that has been captured by the MSRA Master previously. Thus, configuring parameters is not restricted, but you are informed about the violation of possible restrictions by error messages in the status bar of the applications where necessary.

6.2 Data Acquisition

As mentioned before, only the MSRA Master performs a data acquisition. Thus, the MSRA Master defines the center frequency, sample rate and record length of the captured I/Q data. It also defines the trigger event, thus all applications have the same trigger. However, an offset from the trigger can be defined by the individual applications (see "Trigger offset vs. capture offset" on page 27).

Performing sweeps

When you switch to MSRA mode, the Sequencer is automatically activated in continuous mode. The MSRA Master continuously performs a data acquisition. If any applications are activated, then after each measurement, the data in the active applications is evaluated one after the other. The MSRA Master will then repeat the data acquisition and evaluate the new data etc. The channel displays are updated after each measurement or evaluation.

Alternatively, you can perform measurements manually. You can start a single or continuous sweep from any application, which updates the data in the capture buffer and the results in the current application. The results in the other applications, however, remain unchanged. You must refresh them manually, either individually or all at once, using a **"Refresh"** function.

Note that in **continuous sweep mode**, sweeping is aborted when you switch to a different application. You can then continue sweeping from there. This is necessary in order to evaluate the same data in different applications without overwriting the data in the capture buffer.

In **single sweep mode**, only one sweep is performed; a sweep count is not available - neither for the MSRA Master, nor for the applications. However, depending on the application, a statistics count may be available for statistics based on a single data acquisition. Trace averaging is performed as usual for sweep count = 0, the current trace is averaged with the previously stored averaged trace.

Data availability

The applications can only receive data that is available in the capture buffer. As soon as data has been stored to the capture buffer successfully, a status bit (#9) in the `STAT:OPER` register is set. If the required application data is not available, an error message is displayed. Details on restrictions are described in chapter 6.4, "Restrictions for Applications", on page 27.

6.3 Multi-Standard Analysis

Application data

The applications receive data for analysis from the capture buffer, if necessary resampled or with filters applied. The applications can define their own center frequency, sample rate and record length for their **application data**, which is an **extract of the capture**

buffer data. The applications may not request more sample points than the captured data contains, or samples from a frequency outside the range of the capture buffer, for example.

Generally, if a signal contains data channels for multiple standards, the individual applications are used to analyze the channel for the corresponding standard. Thus, it is of interest to know which application is analyzing which part of the captured data, or more precisely, which data channel, and how each data channel is correlated (in time) to others.

The MSRA Master display indicates the data covered by each application, restricted to the channel bandwidth used by the corresponding standard, by vertical blue lines labeled with the application name. For applications that support several standards (e.g. VSA, LTE) an estimated or user-defined bandwidth is indicated.

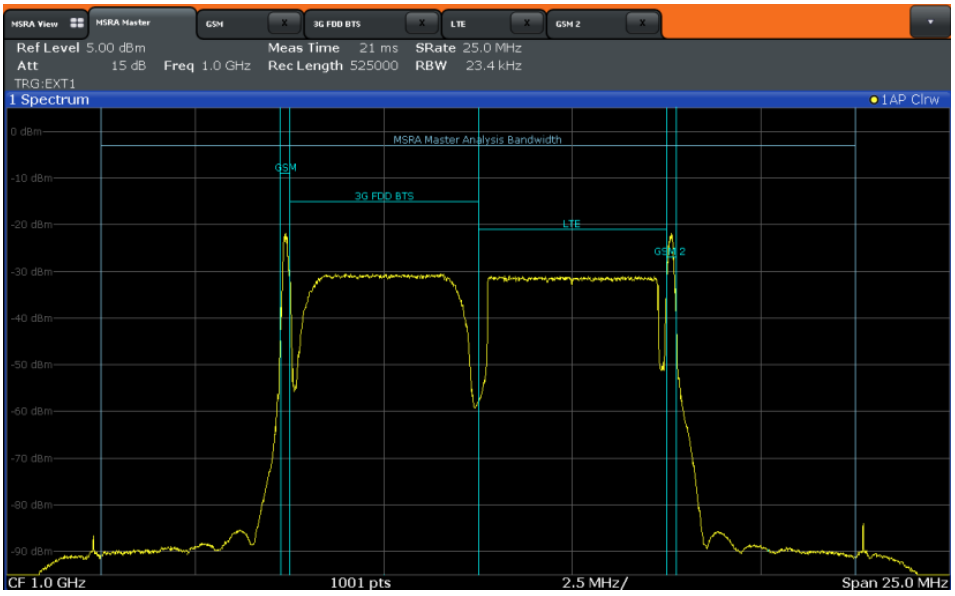


Fig. 6-1: MSRA Master indicating covered bandwidth for 4 applications

Analysis interval

Each application receives an extract of the data from the capture buffer. However, the individual evaluation methods of the application need not analyze the complete data range. Some applications allow you to select a specific part of the data for analysis, e.g. an individual frame, burst or pulse, or to use an offline trigger that defines an additional offset to the capture offset. The data range that is actually analyzed is referred to as the **analysis interval**.

The analysis interval is indicated in the window title bar for each evaluation, and can be queried via remote control.

For applications that do not allow you to restrict the evaluation range (e.g. I/Q Analyzer, Analog Demodulation), the analysis interval is identical to the application data extract.

Trigger offset vs. capture offset

The beginning of the capture buffer is defined by the trigger event and the trigger offset. The trigger source is defined by the MSRA Master, which means that all channels use the same trigger. However, each application might need a different trigger offset or a different number of pretrigger samples. Instead of a trigger offset, the applications define a **capture offset**. The capture offset is defined as an **offset to the beginning of the capture buffer**.

Thus, the beginning of the application data extract is calculated as:

[time of trigger event] + [trigger offset] + [capture offset]

Note that while the trigger offset value may be negative, thus starting before the trigger event, the capture offset may not. A negative capture offset would mean the application data would start before the first sample of the capture buffer. The (pre-)trigger offset in the MSRA Master must be configured such that the required number of pre-trigger samples for the applications are available.

6.4 Restrictions for Applications

As mentioned in various contexts before, the MSRA applications themselves are identical to Signal and Spectrum operating mode, however, the correlation between applications and the MSRA Master require some restrictions. Principally, you are not restricted in setting parameters. However, if any contradictions occur between the configured capture settings and the analysis settings, error messages are displayed in the status bar of the application and an icon (❗) is displayed next to the channel label. However, it does not matter in which order you configure the settings - you will not be prevented from doing so.

In particular, the following restrictions apply to applications in MSRA mode:

- **Data acquisition**: parameters related to data acquisition can only be configured by the MSRA Master
- **Application data**: only data contained in the capture buffer can be analyzed by the application; this implies the following restrictions:
  - **Center frequency**: must lie within the captured data bandwidth
  - **Measurement time/Record length**: must be smaller than or equal to the values of the MSRA Master
  - **Capture offset**: must be smaller than the record length of the MSRA Master
  - **Trace averaging**: only for sweep count = 0
- **AUTO SET functions**: in applications, only the frequency can be adjusted automatically; all other adjustment functions require a new data acquisition

General restrictions concerning sample rates and maximum usable I/Q bandwidths for I/Q data also apply in MSRA mode; see the R&S FSW I/Q Analyzer User Manual for details.

7 Configuration

MSRA is a special operating mode on the R&S FSW, which you activate using the MODE key on the front panel.

When you switch the operating mode of a measurement channel to MSRA mode the first time, the Sequencer is automatically activated in continuous mode (see chapter 5.3, "Using the Sequencer in MSRA Mode", on page 22), starting an I/Q Analyzer data acquisition with the default settings (but with a "Spectrum" result display). The "I/Q Analyzer" menu is displayed, providing access to the most important configuration functions.

Configuring the MSRA Master

The MSRA Master is the only channel that captures data. It also controls global configuration settings for all applications. Thus, all settings that refer to data acquisition can only be configured in the MSRA Master tab. These settings are deactivated in the configuration overviews and dialog boxes for all application channels. All other settings, e.g. concerning the evaluated data range, the display configuration or analysis, can be configured individually for each application and the Master.

Restrictions

Note that although some restrictions apply to parameters that affect both the MSRA Master and applications (see chapter 6.4, "Restrictions for Applications", on page 27), it does not matter in which order you configure them. If any contradictions occur between the captured data and the data to be evaluated, error messages are displayed in the status bar of the application and an icon (or) is displayed next to the channel label. However, you will not be prevented from configuring contradictory settings.

Importing and Exporting I/Q Data

The I/Q data to be evaluated in MSRA mode can not only be captured by the MSRA Master, it can also be imported to the R&S FSW, provided it has the correct format. Furthermore, the captured I/Q data from the MSRA Master can be exported for further analysis in external applications.

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

For details on importing and exporting I/Q data see the R&S FSW User Manual.

7.1 Default Settings for MSRA measurements

The following default settings are activated directly after the R&S FSW has been set to MSRA mode for the first time, or after presetting the instrument.

Table 7-1: Default settings for MSRA mode

Parameter	Value
Application	I/Q Analyzer (Master)
Sequencer mode	Continuous
Sweep mode	Continuous
Reference level	0 dBm
Attenuation	10 dB
Acquisition time	5 ms
Record length	1001 samples
Sample rate	100.0 MHz
Trigger settings	FREE RUN
Evaluation	Window 1: Spectrum

7.2 Configuration Overview

Throughout the measurement channel configuration, an overview of the most important currently defined settings is provided in the "Overview". The "Overview" is displayed when you select the "Overview" icon, which is available at the bottom of all softkey menus.

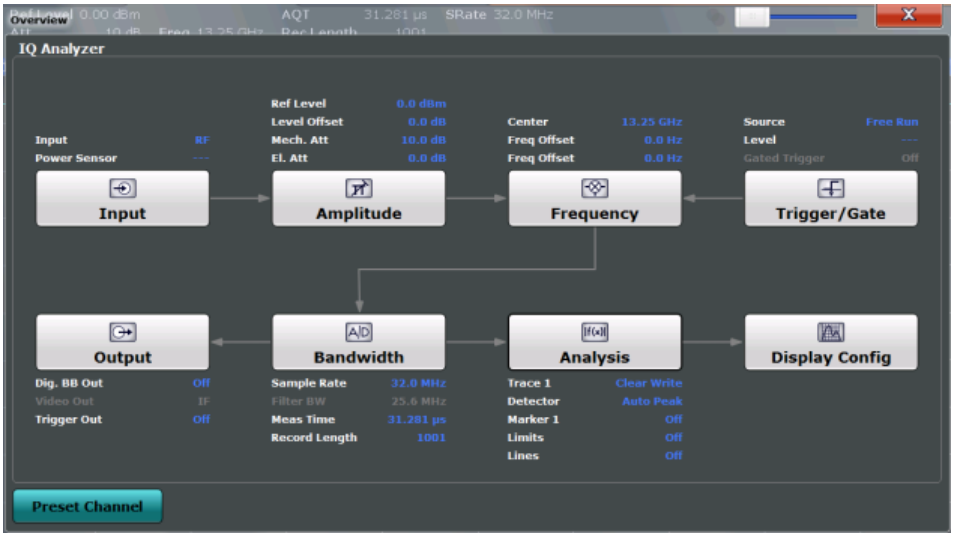


Fig. 7-1: Configuration Overview for MSRA Master

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".

The Overview varies depending on the application; for detailed descriptions see the corresponding application User Manual.

The "Overview" for the MSRA Master provides quick access to the following configuration dialog boxes (listed in the recommended order of processing):

1. Input settings
   See chapter 7.3, "Input Source", on page 31
2. Amplitude settings
   See chapter 7.4, "Amplitude", on page 36
3. Frequency settings
   See chapter 7.5, "Frequency Settings", on page 40
4. Optionally, trigger settings
   See chapter 7.6, "Trigger Settings", on page 41
5. Bandwidth settings
   See chapter 7.7, "Data Acquisition and Bandwidth Settings", on page 46
6. Optionally, output settings
   See chapter 7.8, "Data Output", on page 51
7. Analysis settings and functions
   See chapter 8, "Analysis", on page 56
8. Display configuration
   See chapter 7.9, "Display Configuration", on page 53

To configure settings

► Select any button to open the corresponding dialog box. To configure a particular setting displayed in the "Overview", simply select the setting on the touch screen. The corresponding dialog box is opened with the focus on the selected setting.

For step-by-step instructions on configuring MSRA measurements, see chapter 9, "How to Perform Measurements in MSRA Mode", on page 57.

7.3 Input Source

The R&S FSW can capture data from different input sources. The input source is configured in the "Input Source" tab of the "Input" dialog box. Input source settings are identical to Signal and Spectrum Analyzer mode.

For background information on input parameters, see the R&S FSW User Manual.

► To display this dialog box, do one of the following:

- Select the "Input" button in the "Overview".
- Select the INPUT/OUTPUT key and then the "Input Source Config" softkey.

7.3.1 Input Settings

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

Input settings can be configured via the INPUT/OUTPUT key, in the "Input" dialog box.

Some settings are also available in the "Amplitude" tab of the "Amplitude" dialog box.

7.3.1.1 Radio Frequency Input

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

Input Coupling

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

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

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

SCPI command:

`INPut:COUPling` on page 78

Impedance

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

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

This value also affects the unit conversion (see "Reference Level" on page 36).

SCPI command:

`INPut:IMPedance` on page 79

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

This function requires option R&S FSW-B13.

(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 filter.)

SCPI command:
`INPut:FILTer:HPASs[:STATe]` on page 78

YIG-Preselector
Activates or deactivates the YIG-preselector.

An internal YIG-preselector at the input of the R&S FSW ensures that image frequencies are rejected. However, this is only possible for a restricted bandwidth. In order to use the maximum bandwidth for signal analysis you can deactivate the YIG-preselector at the input of the R&S FSW, which may lead to image-frequency display.

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

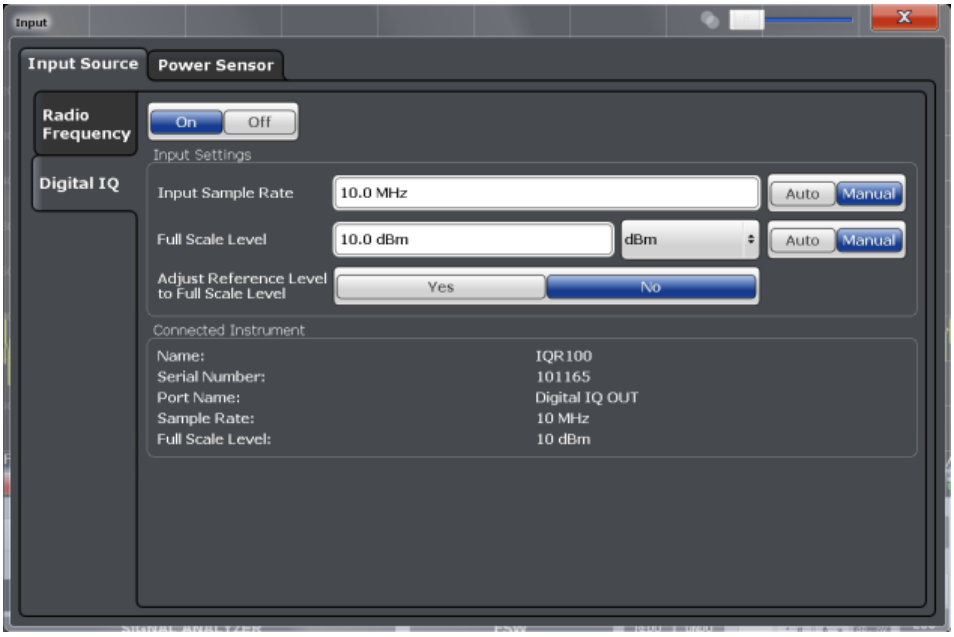
Note:
For the following measurements, the YIG-Preselector is off by default (if available).
- I/Q Analyzer (and thus in all applications in MSRA operating mode)
- Multi-Carrier Group Delay
- GSM

`INPut:FILTer:YIG[:STATe]` on page 79

7.3.1.2 Digital I/Q Input Settings

The following settings and functions are available to provide input via the Digital Baseband Interface (R&S FSW-B17) in the applications that support it.

They can be configured via the INPUT/OUTPUT key, in the "Input" dialog box.



Digital I/Q Input State
Enables or disable the use of the "Digital IQ" input source for measurements. "Digital IQ" is only available if the Digital Baseband Interface (R&S FSW-B17) is installed.

SCPI command:
`INPut:SELect` on page 79

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

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

The allowed range is from 100 Hz to 10 GHz.

SCPI command:
`INPut:DIQ:SRATe` on page 82
`INPut:DIQ:SRATe:AUTO` on page 83

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

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

SCPI command:
INPut:DIQ:RANGe[:UPPer] on page 82
INPut:DIQ:RANGe[:UPPer]:UNIT on page 82
INPut:DIQ:RANGe:AUTO on page 81

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

SCPI command:
INPut:DIQ:RANGe:COUPling on page 82

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

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

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

SCPI command:
INPut:DIQ:CDEVice on page 80

DigIConf
Starts the optional R&S DigIConf application. This softkey is available in the In-/Output menu, but only if the optional software is installed.

Note that R&S DigIConf requires a USB connection (not LAN!) from the R&S FSW to the R&S EX-IQ-BOX in addition to the Digital Baseband Interface (R&S FSW-B17) connection. R&S DigIConf version 2.20.360.86 Build 170 or higher is required.

To return to the R&S FSW application, press any key on the front panel. The R&S FSW application is displayed with the "Input/Output" menu, regardless of which key was pressed.

For details on the R&S DigIConf application, see the "R&S®EX-IQ-BOX Digital Interface Module R&S®DigIConf Software Operating Manual".

Note: If you close the R&S DigIConf window using the "Close" icon, the window is minimized, not closed.
If you select the "File > Exit" menu item in the R&S DigIConf window, the application is closed. Note that in this case the settings are lost and the EX-IQ-BOX functionality is no longer available until you restart the application using the "DigIConf" softkey in the R&S FSW once again.

7.4 Amplitude

The amplitude is configured in the "Amplitude" dialog box. Amplitude settings are identical to the Signal and Spectrum Analyzer mode.

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

7.4.1 Amplitude Settings

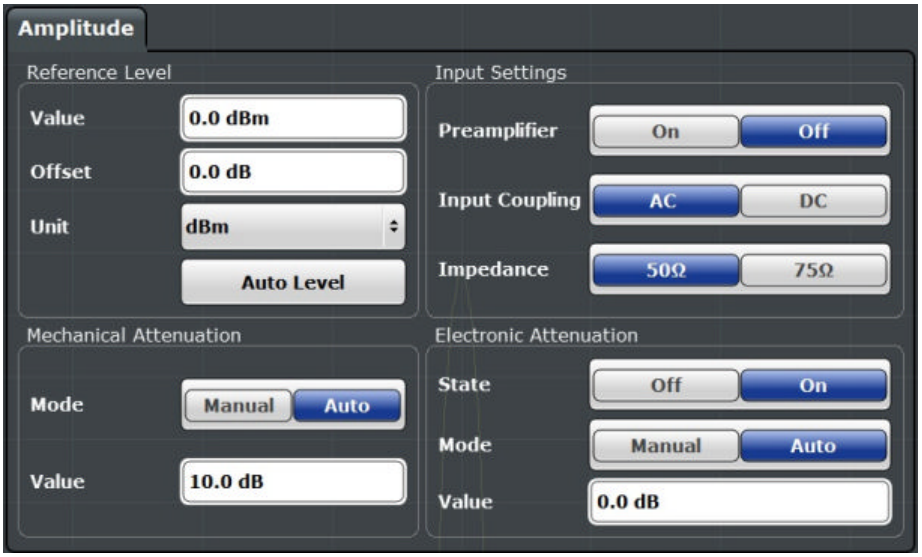
Amplitude settings determine how the R&S FSW must process or display the expected input power levels.

To configure the amplitude settings

Amplitude settings can be configured via the AMPT key or in the "Amplitude" dialog box.

► To display the "Amplitude" dialog box, do one of the following:

- Select "Input/Frontend" from the "Overview" and then switch to the "Amplitude" tab.
- Select the AMPT key and then the "Amplitude Config" softkey.



Reference Level
Defines the expected maximum reference level. Signal levels above this value may not be measured correctly, which is indicated by the "IFOVL" status display.

The reference level is also used to scale power diagrams; the reference level is then used as the maximum on the y-axis.

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

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

SCPI command:

`DISPlay[:WINDow<n>]:TRACe:Y[:SCALe]:RLEVel` on page 84

Shifting the Display (Offset) ← Reference Level

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

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

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

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

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

SCPI command:

`DISPlay[:WINDow<n>]:TRACe:Y[:SCALe]:RLEVel:OFFSet` on page 84

RF Attenuation

Defines the attenuation applied to the RF input.

Attenuation Mode / Value ← RF Attenuation

The RF attenuation can be set automatically as a function of the selected reference level (Auto mode). This ensures that the optimum RF attenuation is always used. It is the default setting. By default and when Using Electronic Attenuation (Option B25) is not available, mechanical attenuation is applied.

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

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

SCPI command:

`INPut:ATTenuation` on page 84

`INPut:ATTenuation:AUTO` on page 85

Using Electronic Attenuation (Option B25)
If option R&S FSW-B25 is installed, you can also activate an electronic attenuator.

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

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

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

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

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.

SCPI command:
`INPut:EATT:STATe` on page 86
`INPut:EATT:AUTO` on page 85
`INPut:EATT` on page 85

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

The parameters "Input Coupling" and "Impedance" are identical to those in the "Input" settings, see chapter 7.3.1, "Input Settings", on page 31.

Preamplifier (option B24) ← Input Settings
If option R&S FSW-B24 is installed, a preamplifier can be activated for the RF input signal.

For R&S FSW 26 models, the input signal is amplified by 30 dB if the preamplifier is activated.

For R&S FSW 8 or 13 models, the following settings are available:

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

SCPI command:
`INPut:GAIN:STATe` on page 86
`INPut:GAIN[:VALue]` on page 86

7.4.2 Scaling the Y-Axis

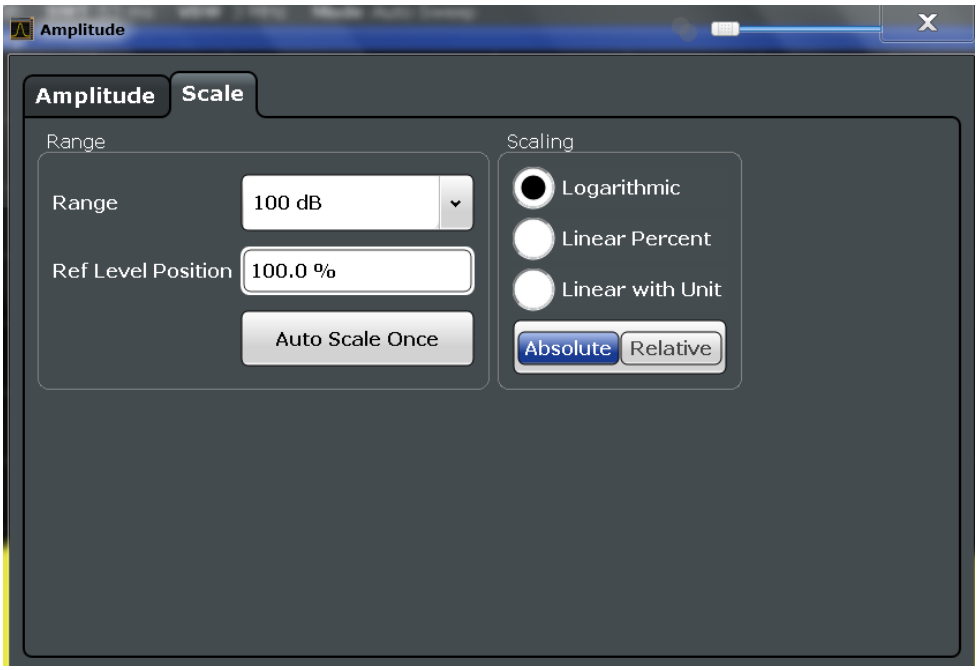
The individual scaling settings that affect the vertical axis are described here.

To configure the y-axis scaling settings

Vertical Axis settings can be configured via the AMPT key or in the "Amplitude" dialog box.

► To display the "Amplitude" dialog box, do one of the following:

- Select "Amplitude" from the "Overview".
- Select the AMPT key and then the "Scale Config" softkey.



Range
Defines the displayed y-axis range in dB (frequency domain) or Hz (time domain).

The default value is 100 dB or 500 kHz.

SCPI command:
`DISPlay[:WINDow<n>]:TRACe:Y[:SCALe]` on page 87

Ref Level Position
Defines the reference level position, i.e. the position of the maximum AD converter value on the level axis in %, where 0 % corresponds to the lower and 100 % to the upper limit of the diagram.

SCPI command:
`DISPlay[:WINDow<n>]:TRACe:Y[:SCALe]:RPOSition` on page 87

Scaling
Defines the scaling method for the y-axis.

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

SCPI command:

`DISPlay[:WINDow<n>]:TRACe:Y:SPACing` on page 88

`DISPlay[:WINDow<n>]:TRACe:Y[:SCALe]:MODE` on page 87

IQ Vector max

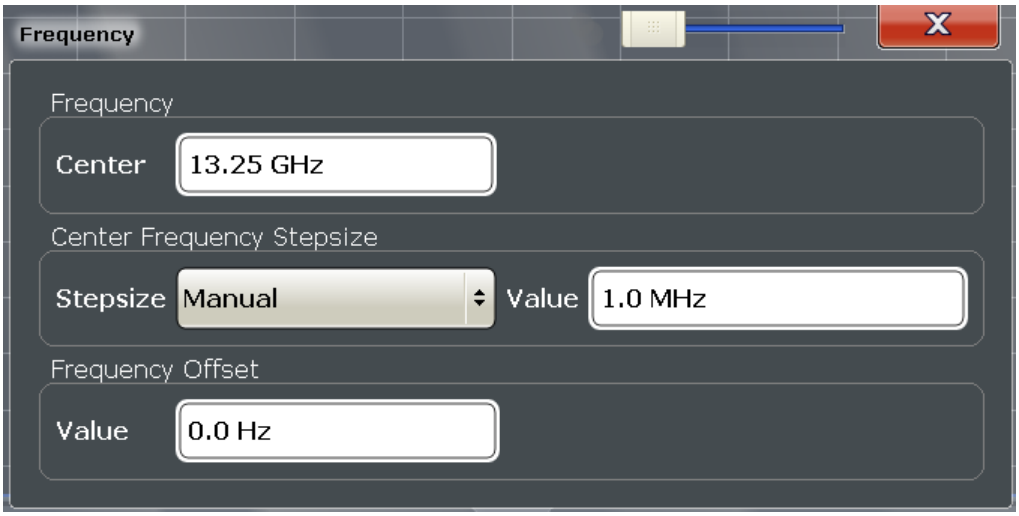
Defines the maximum value of the y-axis in either direction (in Volts). Thus, the y-axis scale starts at -<IqVectorMax> and ends at +<IqVectorMax>.

This command is only available if the evaluation mode for the I/Q Analyzer is set to "IQ Vector".

7.5 Frequency Settings

Frequency settings for the input signal can be configured via the "Frequency" dialog box, which is displayed when you do one of the following:

- Select the FREQ key and then the "Frequency Config" softkey.
- Select "Frequency" from the "Overview".



Center
Defines the normal center frequency of the signal. The allowed range of values for the center frequency depends on the frequency span.

f_{max} and $span_{min}$ are specified in the data sheet.

SCPI command:
`[SENSe:]FREQuency:CENTer` on page 88

Center Frequency Stepsize
Defines the step size by which the center frequency is increased or decreased when the arrow keys are pressed. When you use the rotary knob the center frequency changes in steps of only 1/10 of the "Center Frequency Stepsize".

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

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

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

SCPI command:
`[SENSe:]FREQuency:CENTer:STEP` on page 89

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

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

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

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

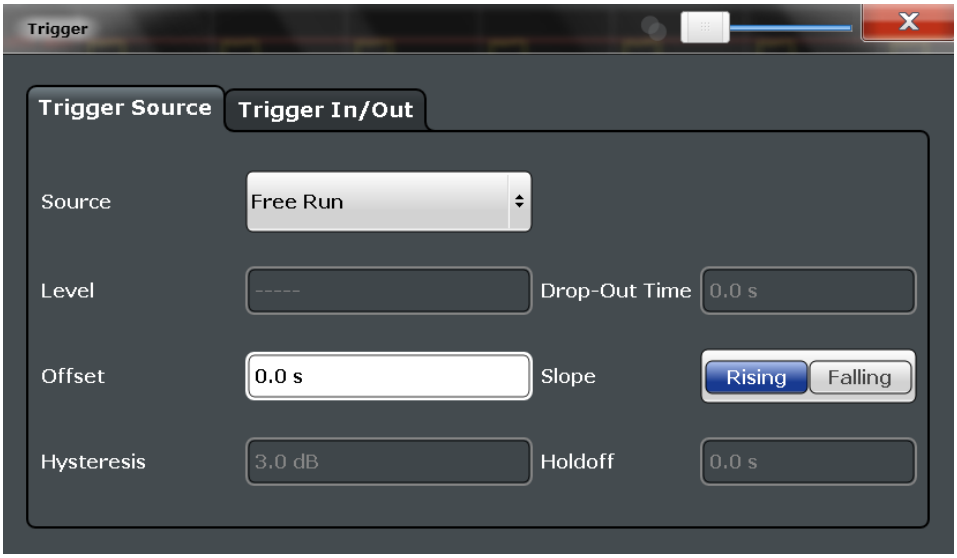
SCPI command:
`[SENSe:]FREQuency:OFFSet` on page 89

7.6 Trigger Settings

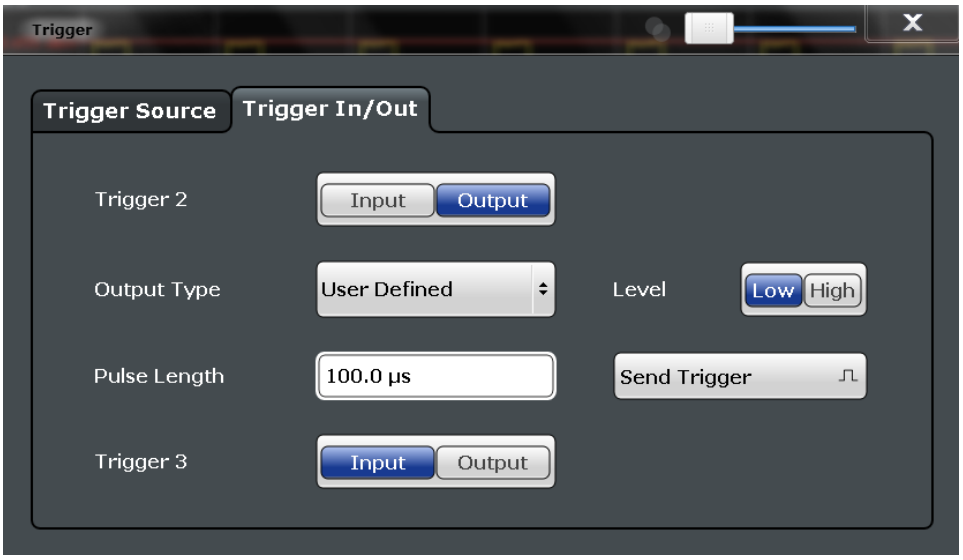
Trigger settings determine when the input signal is measured. These settings are only available for the MSRA Master.

The "Capture Offset", which has a similar function to the trigger offset but is available for MSRA applications only, is described in chapter 7.7, "Data Acquisition and Bandwidth Settings", on page 46.

Trigger settings can be configured via the TRIG key or in the "Trigger" dialog box, which is displayed when you select the "Trigger" button in the "Overview".



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



For step-by-step instructions on configuring triggered measurements, see the R&S 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.

SCPI command:
`TRIGger[:SEQuence]:SOURce` on page 94

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

SCPI command:
`TRIG:SOUR IMM`, see `TRIGger[:SEQuence]:SOURce` on page 94

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

(See "Trigger Level" on page 44).

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

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

"External Trigger 1"
Trigger signal from the TRIGGER INPUT connector on the front panel.

"External Trigger 2"
Trigger signal from the TRIGGER INPUT/OUTPUT connector on the front panel.
Note: Connector must be configured for "Input" in the "Outputs" configuration (see "Trigger 2/3" on page 45).

"External Trigger 3"
Trigger signal from the TRIGGER 3 INPUT/ OUTPUT connector on the rear panel.
Note: Connector must be configured for "Input" in the "Outputs" configuration (see "Trigger 2/3" on page 45).

SCPI command:
`TRIG:SOUR EXT`, `TRIG:SOUR EXT2`, `TRIG:SOUR EXT3`
See `TRIGger[:SEQuence]:SOURce` on page 94

Baseband Power ← Trigger Source ← Trigger Source
Defines triggering on the baseband power (for digital input via the Digital Baseband Interface R&S FSW-B17).

This trigger source is only available if "Digital IQ" is selected as the input source for the measurement (see "Digital I/Q Input State" on page 34).

SCPI command:
`TRIG:SOUR BBP`, see `TRIGger[:SEQuence]:SOURce` on page 94

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

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

SCPI command:
`TRIGger[:SEQuence]:LEVel[:EXTernal<port>]` on page 92

Repetition Interval ← Trigger Source
Defines the repetition interval for a time trigger. The shortest interval is 2 ms.

The repetition interval should be set to the exact pulse period, burst length, frame length or other repetitive signal characteristic.

SCPI command:
`TRIGger[:SEQuence]:TIME:RINTerval` on page 94

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

SCPI command:
`TRIGger[:SEQuence]:DTIMe` on page 91

Trigger Offset ← Trigger Source
Defines the time offset between the trigger event and the start of the sweep for the MSRA Master.

This setting is not available in MSRA application measurement channels. For applications, use the "Capture Offset" on page 48 instead.

offset > 0:	Start of the sweep is delayed
offset < 0:	Sweep starts earlier (pre-trigger) Maximum allowed range limited by the sweep time: $pretrigger_{max}$ = sweep time

SCPI command:
`TRIGger[:SEQuence]:HOLDoff[:TIME]` on page 91

Hysteresis ← Trigger Source
Defines the distance in dB to the trigger level that the trigger source must exceed before a trigger event occurs. Settting 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.

SCPI command:
TRIGger[:SEQuence]:IFPower:HYSTeresis on page 92

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.

SCPI command:
TRIGger[:SEQuence]:IFPower:HOLDoff on page 91

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.

SCPI command:
TRIGger[:SEQuence]:SLOPe on page 93

Trigger 2/3
Defines the usage of the variable TRIGGER INPUT/OUTPUT connectors, where:

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

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

(Trigger 1 is INPUT only.)

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

"Input"	The signal at the connector is used as an external trigger source by the R&S FSW. No further trigger parameters are available for the connector.
"Output"	The R&S FSW sends a trigger signal to the output connector to be used by connected devices. Further trigger parameters are available for the connector.

SCPI command:
OUTPut:TRIGger<port>:LEVel on page 95
OUTPut:TRIGger<port>:DIRection on page 95

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

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

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

SCPI command:
`OUTPut:TRIGger<port>:OTYPe` on page 96

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

SCPI command:
`OUTPut:TRIGger<port>:LEVel` on page 95

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

SCPI command:
`OUTPut:TRIGger<port>:PULSe:LENGth` on page 97

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, e.g. for "Level = High", a constant high signal is output to the connector until the "Send Trigger" button is selected. Then, a low pulse is sent.

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

SCPI command:
`OUTPut:TRIGger<port>:PULSe:IMMediate` on page 96

7.7 Data Acquisition and Bandwidth Settings

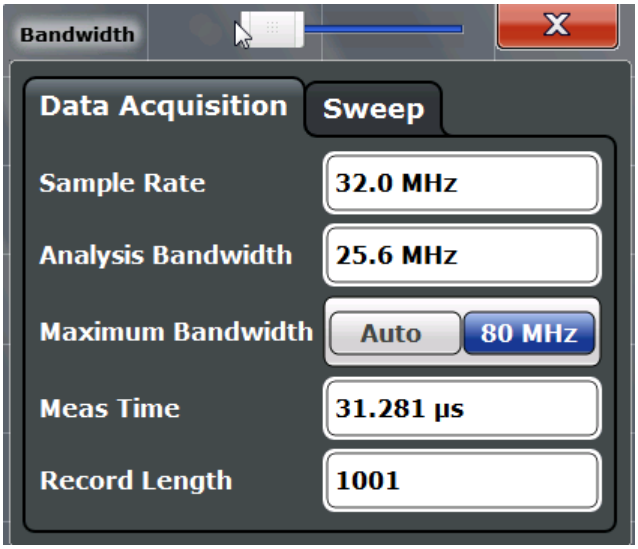
How data is to be acquired is configured in the "Bandwidth" dialog box.

7.7.1 Data Acquisition

The data acquisition settings define which parts of the input signal are captured for further evaluation in the applications. They are configured in the "Data Acquisition" tab of the "Bandwidth" dialog box.

► To display this dialog box, do one of the following:

- Select the "Bandwidth" button in the configuration "Overview"
- Select the BW key and then the "Data Acquisition" softkey.
- Select the "Data Acquisition" softkey in the "I/Q Analyzer" menu.



Configuring data acquisition is only possible for the MSRA Master channel. In I/Q Analyzer application channels, these settings define the analysis interval (see chapter 6.3, "Multi-Standard Analysis", on page 25). Be sure to select the correct measurement channel before changing these settings.

Sample Rate
Defines the I/Q data sample rate of the R&S FSW. This value is dependent on the defined Analysis Bandwidth and the defined signal source. Up to the Maximum Bandwidth, the following rule applies:

sample rate = analysis bandwidth / 0.8

For details on the dependencies see chapter A.3, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 121.

SCPI command:
`TRACe:IQ:SRATe` on page 99

Analysis Bandwidth
Defines the flat, usable bandwidth of the final I/Q data. This value is dependent on the defined Sample Rate and the defined signal source.

Up to the Maximum Bandwidth, the following rule applies:

*analysis bandwidth = 0.8 * sample rate*

SCPI command:
`TRACe:IQ:BWIDth` on page 97

Maximum Bandwidth
Defines the maximum bandwidth to be used by the R&S FSW for I/Q data acquisition. This setting is only available if the bandwidth extension option R&S FSW-B160 / U160 is installed. Otherwise the maximum bandwidth is determined automatically.

For details on the maximum bandwidth see chapter A.3, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 121.

"80 MHz" Restricts the analysis bandwidth to a maximum of 80 MHz. The bandwidth extension option R&S FSW-B160 / U160 is deactivated.

"Auto" (Default) Up to an analysis bandwidth of 80 MHz (or a sample rate of 100 MHz), the maximum bandwidth is set to 80 MHz. For larger bandwidths or sample rates, the bandwidth extension option R&S FSW-B160 / U160 is activated, thus allowing for a sample rate of up to 10 GHz. Note that using the bandwidth extension may cause more spurious effects.

SCPI command:
`TRACe:IQ:WBANd[:STATe]` on page 100

Meas Time
Defines the I/Q acquisition time. By default, the measurement time is calculated as the number of I/Q samples ("Record Length") divided by the sample rate. If you change the measurement time, the Record Length is automatically changed, as well.

For details on the maximum number of samples see also chapter A.3, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 121.

SCPI command:
`[SENSe:]SWEep:TIME` on page 108

Record Length
Defines the number of I/Q samples to record. By default, the number of sweep points is used. The record length is calculated as the measurement time multiplied by the sample rate. If you change the record length, the Meas Time is automatically changed, as well.

Note: For the I/Q vector result display, the number of I/Q samples to record ("Record Length") must be identical to the number of trace points to be displayed ("Sweep Points"). Thus, the sweep points are not editable for this result display. If the "Record Length" is edited, the sweep points are adapted automatically. For record lengths outside the valid range of sweep points, i.e. less than 101 points or more than 32001 points,the diagram does not show valid results .

SCPI command:
`TRACe:IQ:RLENgth` on page 97
`TRACe:IQ:SET` on page 98

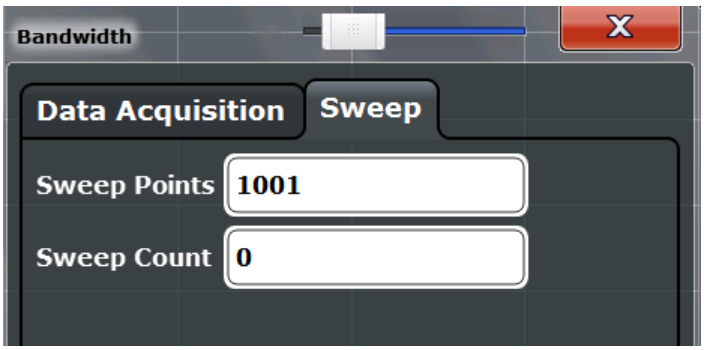
Capture Offset
This setting is only available for applications in **MSRA operating mode**. It has a similar effect as the trigger offset in other measurements: it defines the time offset between the capture buffer start and the start of the extracted application data. The offset must be a positive value, as the application can only analyze data that is contained in the capture buffer.

For more information see "Trigger offset vs. capture offset" on page 27.

SCPI command:
`[SENSe:]MSRA:CAPTure:OFFSet` on page 117

7.7.2 Sweep Settings

The sweep settings are configured via the SWEEP key or in the "Sweep" tab of the "Bandwidth" dialog box.



► To display this dialog box, do one of the following:

- Select the "Bandwidth" button in the configuration "Overview" and switch to the "Sweep" tab.
- Select the SWEEP key and then the "Sweep Config" softkey.

For background information on performing sweeps in MSRA mode see chapter 6.2, "Data Acquisition", on page 25.

Sweep Points
In MSRA mode, a specific frequency bandwidth is swept for a specified measurement time. During this time, a defined number of samples (= record length) are taken. These samples are then evaluated by the applications. Therefore, in this case the number of sweep points does not define the amount of data to be acquired, but rather the number of trace points that are evaluated and displayed in the result diagrams.

SCPI command:
`[SENSe:]SWEep:POINts` on page 108

Refresh
This function is only available if the Sequencer is deactivated and only for **MSRA applications**.

The data in the capture buffer is re-evaluated by the currently active application only. The results for any other applications remain unchanged.

This is useful, for example, after evaluation changes have been made or if a new sweep was performed from another application; in this case, only that application is updated automatically after data acquisition.

SCPI command:
INITiate:REFResh on page 116

Continuous Sweep/RUN CONT
After triggering, initiates data acquisition continuously until stopped. If the Sequencer is off, only the evaluation for the currently displayed measurement channel is updated.

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

Note: Sequencer. If the Sequencer is active, the "Continuous Sweep" softkey only controls the sweep mode for the currently selected channel; however, the sweep mode only has an 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, the RUN CONT key on the front panel controls the Sequencer, not individual sweeps. RUN CONT starts the Sequencer in continuous mode.

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

SCPI command:
INITiate:CONTinuous on page 105

Single Sweep/ RUN SINGLE
After triggering, starts a single data acquisition. If the Sequencer is off, only the evaluation for the currently displayed measurement channel is updated.

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

Note: Sequencer. If the Sequencer is active, the "Single Sweep" softkey only controls the sweep mode for the currently selected channel; however, the sweep mode only has an effect the next time the Sequencer activates that channel, and only for a channel-defined sequence. In this case, a channel in single sweep mode is swept only once by the Sequencer.
Furthermore, the RUN SINGLE key on the front panel controls the Sequencer, not individual sweeps. RUN SINGLE starts the Sequencer in single mode.

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

SCPI command:
INITiate[:IMMediate] on page 106

Continue Single Sweep
After triggering, repeats data acquisition without deleting the trace of the last measurement. If the Sequencer is off, only the evaluation for the currently displayed measurement channel is updated.

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

SCPI command:
`INITiate<n>:CONMeas` on page 105

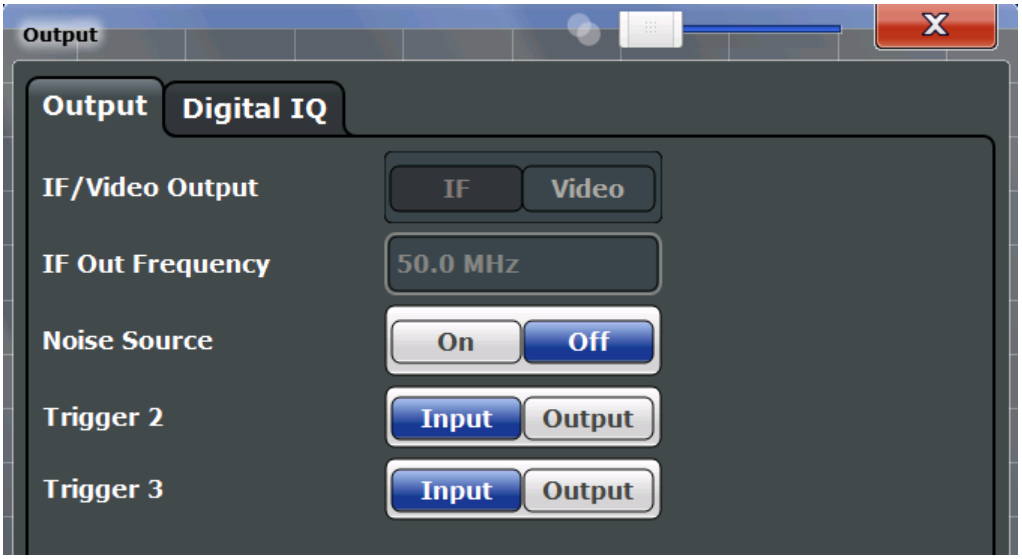
7.8 Data Output

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

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

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

Output settings can be configured via the INPUT/OUTPUT key or in the "Outputs" dialog box.



Noise Source
Switches the supply voltage for an external noise source on or off.

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

SCPI command:
DIAGnostic<n>:SERVice:NSOurce on page 90

Trigger 2/3
Defines the usage of the variable TRIGGER INPUT/OUTPUT connectors, where:

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

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

(Trigger 1 is INPUT only.)

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

"Input"	The signal at the connector is used as an external trigger source by the R&S FSW. No further trigger parameters are available for the connector.
"Output"	The R&S FSW sends a trigger signal to the output connector to be used by connected devices. Further trigger parameters are available for the connector.

SCPI command:
OUTPut:TRIGger<port>:LEVel on page 95
OUTPut:TRIGger<port>:DIRection on page 95

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

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

SCPI command:
OUTPut:TRIGger<port>:OTYPe on page 96

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

SCPI command:
OUTPut:TRIGger<port>:LEVel on page 95

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

SCPI command:
OUTPut:TRIGger<port>:PULSe:LENGth on page 97

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, e.g. for "Level = High", a constant high signal is output to the connector until the "Send Trigger" button is selected. Then, a low pulse is sent.

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

SCPI command:
`OUTPut:TRIGger<port>:PULSe:IMMediate` on page 96

7.9 Display Configuration

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

- Select the "SmartGrid" icon from the toolbar.
- Select the "Display Config" button in the "Overview".
- Press the MEAS key.
- Select the "Display Config" softkey in the main application menu.

For a description of the available evaluation methods see the "Measurements and Result Displays" topic of the corresponding application User Manual.

In the MSRA Master, up to six evaluation methods can be displayed simultaneously in separate windows. However, only one graphical display is available at a time.

7.10 Automatic Settings

Some settings can be adjusted by the R&S FSW automatically according to the current measurement settings.

To activate the automatic adjustment of a setting, select the corresponding function in the AUTO SET menu or in the configuration dialog box for the setting, where available.

Settings related to data acquisition (measurement time, hysteresis) can only be adjusted in the MSRA Master, not in the applications.

Adjusting all Determinable Settings Automatically (Auto All)
Activates all automatic adjustment functions for the current measurement settings.

This includes:

- "Setting the Reference Level Automatically (Auto Level)" on page 54

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

SCPI command:
`[SENSe:]ADJust:ALL` on page 101

Adjusting the Center Frequency Automatically (Auto Freq)
This function adjusts the center frequency automatically.

The optimum center frequency can be determined as the highest frequency level in the frequency span. As this function uses the signal counter, it is intended for use with sinusoidal signals.

SCPI command:
`[SENSe:]ADJust:FREQuency` on page 102

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

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

This setting can only be adjusted in the MSRA Master, not in the applications.

You can change the measurement time for the level measurement if necessary (see "Changing the Automatic Measurement Time (Meastime Manual)" on page 54).

SCPI command:
`[SENSe:]ADJust:LEVel` on page 103

Resetting the Automatic Measurement Time (Meastime Auto)
Resets the measurement duration for automatic settings to the default value.

This setting can only be adjusted in the MSRA Master, not in the applications.

SCPI command:
`[SENSe:]ADJust:CONFigure:DURation:MODE` on page 102

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

This setting can only be adjusted in the MSRA Master, not in the applications.

SCPI command:
`[SENSe:]ADJust:CONFigure:DURation:MODE` on page 102
`[SENSe:]ADJust:CONFigure:DURation` on page 101

Upper Level Hysteresis
When the reference level is adjusted automatically using the Setting the Reference Level Automatically (Auto Level) function, the internal attenuators and the preamplifier are also adjusted. In order 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.

This setting can only be adjusted in the MSRA Master, not in the applications.

SCPI command:
`[SENSe:]ADJust:CONFigure:HYSTeresis:UPPer` on page 103

Lower Level Hysteresis
When the reference level is adjusted automatically using the Setting the Reference Level Automatically (Auto Level) function, the internal attenuators and the preamplifier are also adjusted. In order 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.

This setting can only be adjusted in the MSRA Master, not in the applications.

SCPI command:
`[SENSe:]ADJust:CONFigure:HYSTeresis:LOWer` on page 102

8 Analysis

The data that was captured by the MSRA Master can be analyzed in various different applications.

The analysis settings and functions available in MSRA mode are those described for the individual applications. The MSRA Master is in effect an I/Q Analyzer application and has the same analysis functions and settings.

See the R&S FSW I/Q Analyzer User Manual for a description of the analysis functions and settings available for the I/Q Analyzer and thus the MSRA master.

Configuring the application data extract and analysis interval

The settings required to configure the application data extract or analysis intervals vary depending on the application. See the corresponding application manuals for details.

For the I/Q Analyzer, the settings are the same as those used to define the actual data acquisition (see chapter 7.7.1, "Data Acquisition", on page 46. In MSRA application channels, they define the analysis interval. Be sure to select the correct measurement channel before executing these commands.

9 How to Perform Measurements in MSRA Mode

The following step-by-step instructions demonstrate how to perform a measurement in MSRA mode.

How to capture I/Q data in MSRA mode

1. Press the MODE key on the front panel and select the "MSRA" operating mode. Confirm the message.
2. Select the "Overview" softkey to display the "Overview" for an MSRA measurement.
3. Select the "Input" button to select the input signal source.
4. Select the "Amplitude" button to define the attenuation, reference level or other settings that affect the input signal's amplitude and scaling.
5. Select the "Frequency" button to define the input signal's center frequency.
6. Optionally, select the "Trigger" button and define a trigger for data acquisition, for example an IQ Power trigger to start capturing data only when a specific power is exceeded.
7. Select the "Bandwidth" button and define the bandwidth parameters for data acquisition:
   - "Sample rate" or "Analysis Bandwidth:" the span of the input signal to be captured for analysis, or the rate at which samples are captured (both values are correlated)
   - Optionally, if R&S FSW-B160 is installed, the "Maximum Bandwidth", depending on whether you require a larger bandwidth or fewer spurious emissions.
   - "Measurement Time:" how long the data is to be captured
   - "Record Length": the number of samples to be captured (also defined by sample rate and measurement time)
8. If necessary, select the "Display Config" button and select other displays (up to a total of 6) required to control the acquired data.
   Arrange them on the display to suit your preferences.
9. Exit the SmartGrid mode.
10. Optionally, stop continuous measurement mode by the Sequencer and perform a single data acquisition:
    a) Select the Sequencer icon () from the toolbar.
    b) Set the Sequencer state to "OFF".
    c) Press the RUN SINGLE key.
11. Optionally, export the captured or analyzed I/Q data (depending on the active channel) to a file.

a) Select the "Save" icon in the toolbar.
b) Select the "I/Q Export" softkey.
c) Define a file name and storage location and select "Save".

The captured data is stored to a file with the extension `.iq.tar`.

Now you can analyze the captured I/Q data in various MSRA applications at the same time.

How to analyze the captured I/Q data in MSRA applications

1. Press the MODE key on the front panel and select an MSRA application.
2. Select the "Overview" softkey to display the "Overview" for the MSRA application.
3. Define the application data extract, i.e. the range of the capture buffer you want to analyze in this application.
4. Define the analysis interval, i.e. the frame number or similar within the application data you want to analyze in this application (not necessary for I/Q Analyzer or Analog Demodulation applications).
5. Select the "Frequency" button and define the center frequency for the analysis interval.
6. Select the "Display Config" button and select other displays (up to a total of 6) to analyze the data in the configured interval.
   Arrange them on the display to suit your preferences.
7. Exit the SmartGrid mode.

   Repeat these steps for any other applications.

How to perform multi-standard analysis of the I/Q data

1. Perform a single I/Q data aquisition measurement as described in "How to capture I/Q data in MSRA mode" on page 57.
2. Activate measurement channels for the MSRA applications you require as described in "How to analyze the captured I/Q data in MSRA applications" on page 58.
3. Select the MSRA View to get an overview of the captured data and the configured applications.
   Determine the individual data ranges that are relevant for a specific standard. If necessary, adapt the application data and analysis interval settings for the applications to reflect the relevant data ranges.
4. If the results indicate that dependencies between different standards in the signal may exist:
   a) Select the application in which unusual data occurs.
   b) If necessary, perform a new data acquisition.
   c) Determine the bandwidth or measurement time of the unusual data.

d) Select the MSRA View to compare the data with the other standard applications. If a specific event (e.g. a burst, spur etc.) occurs in another standard at the same time as the unusual data in the first application, the two effects may be correlated.
e) Select the possibly dependant standard application.
f) Define an analysis interval for the conspicuous data range (as described in "How to analyze the captured I/Q data in MSRA applications" on page 58).
g) Refresh the result display for the changed analysis interval ("Sweep" menu).

Now you can analyze the data in detail to determine the cause of the unusual signal behavior.

10 Measurement Example: Analyzing MSR Signals

Using the R&S FSW MSRA, you can examine crosstalk between different radio access technologies (RAT) sent out from a base station at the same time. Furthermore, you can determine any signal interference between two or more carriers due to time correlation, as you can analyze the same signal data (captured at exactly the same time) in various applications.

The following measurement example demonstrates how to capture data from a signal with 4 carriers using different standards (GSM, WCDMA, LTE, GSM) and then analyze the data in the MSRA operating mode using the I/Q Analyzer and the 3GPP FDD BTS application.

Measurement setup

The measurements are performed using the following instruments and accessories:

- The R&S FSW with application firmware R&S FSW-K72: 3GPP FDD BTS Measurements
- A Vector Signal Generator:
  R&S SMU (with options R&S SMU-K240 Dig. Std GSM/EDGE, SMU-K242 Dig. Std 3GPP FDD, SMU-K255 Dig. Std EUTRA)
  or
  R&S SMBV (with options R&S SMBV -K240 Dig. Std GSM/EDGE, SMBV-K242 Dig. Std 3GPP FDD, SMBV-K255 Dig. Std EUTRA)
  (The vector signal generator is referred to as *SMx* in the example.)
- 1 coaxial cable, 50Ω, approx. 1 m, N connector
- 1 coaxial cable, 50Ω, approx. 1 m, BNC connector

To set up the instruments

1. Connect the "RF output" of the SMx to the RF INPUT connector on the front panel of the R&S FSW (coaxial cable with an N connector).
2. Connect the "Marker1" output of the SMx to the TRIGGER INPUT connector on the front panel of the R&S FSW (coaxial cable with a BNC connector).

Preparation

The waveform of the described multi-standard signal is provided in the following file on the R&S FSW:

`C:\R_S\Instr\user\Waveforms\MSRA_GSM_WCDMA_LTE_GSM.wv`

The signal is described in the `Readme.txt` file in the same folder.

► Copy the file from the R&S FSW to the SMx using a USB stick, for example.

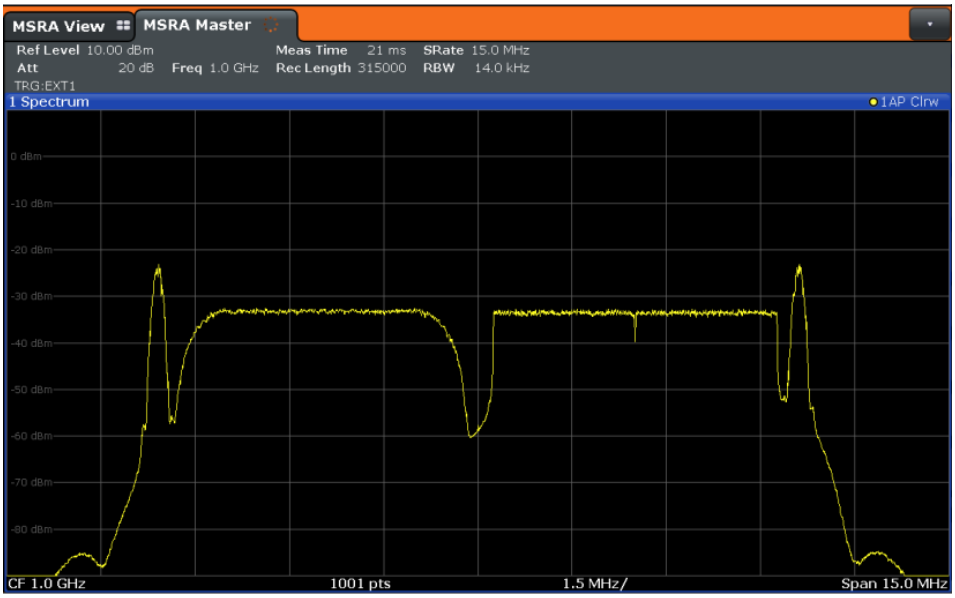
Settings on the R&S SMx

1. Press the PRESET key to reset the instrument.
2. Press the FREQ key and set the frequency to *1 GHz*.
3. Press the LEVEL key and set the level to *0 dBm*.
4. Press the RF ON/OFF key to switch the RF on.
5. Press the DIAGRAM key and then select "Load Waveform" to load the signal data from the provided file. From the drive for the USB stick, select the file `C:\R_S\Instr\user\Waveforms\MSRA_GSM_WCDMA_LTE_GSM.wv`.
6. Select the "Trigger/Marker" menu and set "Marker1" to "Restart".
   Press the ESC key to close the dialog box.
7. Switch the "State" button to "ON" to activate the waveform.

Settings on the R&S FSW

1. Press the PRESET key to preset the R&S FSW.
2. Press the MODE key and select the "Multi-Standard Radio Analyzer" tab. Confirm the message to switch to MSRA mode.
3. Press the FREQ key and set the "Center Frequency" to *1 GHz*.
4. Press the AMPT key and set the reference level to *10 dBm*.
5. Press the TRIG key and select "External Trigger 1" to use the external trigger from the SMU.
6. Press the MEAS CONFIG key, select the "Data Acquisition" softkey and set the "Sample Rate" to *15 MHz*.

   Since the R&S FSW is set to continuous sweep mode by default, data acquisition is started automatically. The spectrum of the stored MSR signal from the file is displayed in the "MSRA Master" tab.



To analyze the GSM signal

Activate an I/Q Analyzer to analyze the GSM signal in more detail. Only the area around the first burst is of interest, so the analysis interval should be the area approximately 4.5 to 6 MHz to the left of the measured center frequency.

1. Press the MODE key and select the "I/Q Analyzer" button.
2. Press the FREQ key and set the center frequency to *994.9 MHz*.
3. Press the MEAS CONFIG key, select the "Data Acquisition" softkey and set the "Sample Rate" to *1 MHz*.
4. Set the "Meas Time" to *5 ms*.

   The I/Q Analyzer obtains an extract of the data captured by the MSRA Master. Which spectrum of the captured data is analyzed is indicated by vertical blue lines in the MSRA Master window (see figure 10-1).

To analyze the WCDMA signal

Activate a measurement channel for the 3GPP FDD BTS application to analyze the WCDMA signal in more detail. Now the second burst is of interest, so the analysis interval should be the area approximately 0 to 5 MHz to the left of the measured center frequency.

1. Press the MODE key and select the "3GPP FDD BTS" button.
2. Press the FREQ key and set the center frequency to *997.5 MHz*.

   The 3GPP FDD BTS application obtains an extract of the data captured by the MSRA Master.
3. Select the "MSRA View" tab to see the captured data and the GSM and WCDMA results at once.

Which spectrum of the captured data is analyzed is indicated by vertical blue lines in the "MSRA Master" window.

Fig. 10-1: MSRA View for I/Q Analyzer and 3GPP FDD BTS applications

4. Tap the "3GPP FDD BTS" tab to return to the detailed WCDMA results.
5. Display the composite EVM of the WCDMA burst:
   a) Press the MEAS CONFIG key, then select the "Display Config" softkey.
   b) Scroll through the result display buttons until you see "Composite EVM", then drag the button to the diagram area of the display.
   The "Code Domain Power" display is replaced by the "Composite EVM" display.
   c) Tap the red cross at the top of the result display list (⌧) to close the SmartGrid mode.
6. To optimize the diagram display, press the AUTO SET key and select "Auto Scale Window".

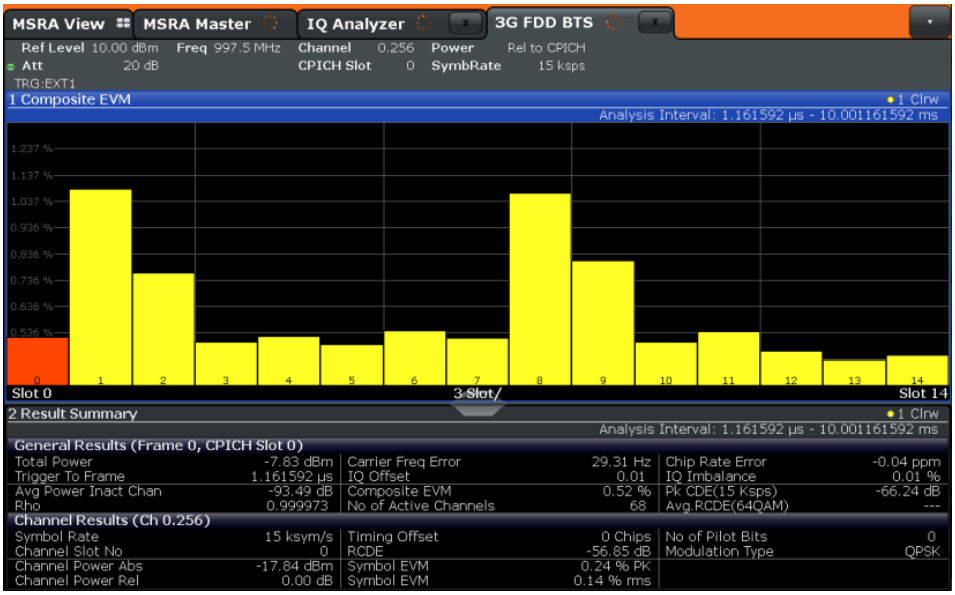


Fig. 10-2: Composite EVM of the WCDMA burst

The slots 1, 2, 8, and 9 show a much higher EVM than the other slots.

7. Analyze the EVM for the chips in these slots:
   a) Press the MEAS CONFIG key, then select the "Display Config" softkey.
   b) Drag the "EVM vs Chip" button over the "Result Summary" beneath the "Composite EVM" display to replace it.
   c) Tap the red cross at the top of the result display list (⌧) to close the SmartGrid mode.

   The EVM vs Chip results are displayed for slot 0.

8. Take a closer look at slot 1, which had a high EVM:
   a) Select the "Evaluation Range" softkey and set the "Slot" to *1*.
   Slot 1 is highlighted red in the Composite EVM display.
   b) Tap the "EVM vs Chip" window to set the focus on it.
   The EVM for the individual chips in slot 1 is displayed.
   Note the **analysis interval** displayed in the window title bar, which indicates that the data displayed in the "EVM vs Chip" window was captured in the time interval 667 µs to 1.3 ms (referred to the absolute time of the I/Q signal captured with the MSRA Master).
   c) Press the PEAK SEARCH key to place Marker1 on the chip with the highest EVM in slot 1.

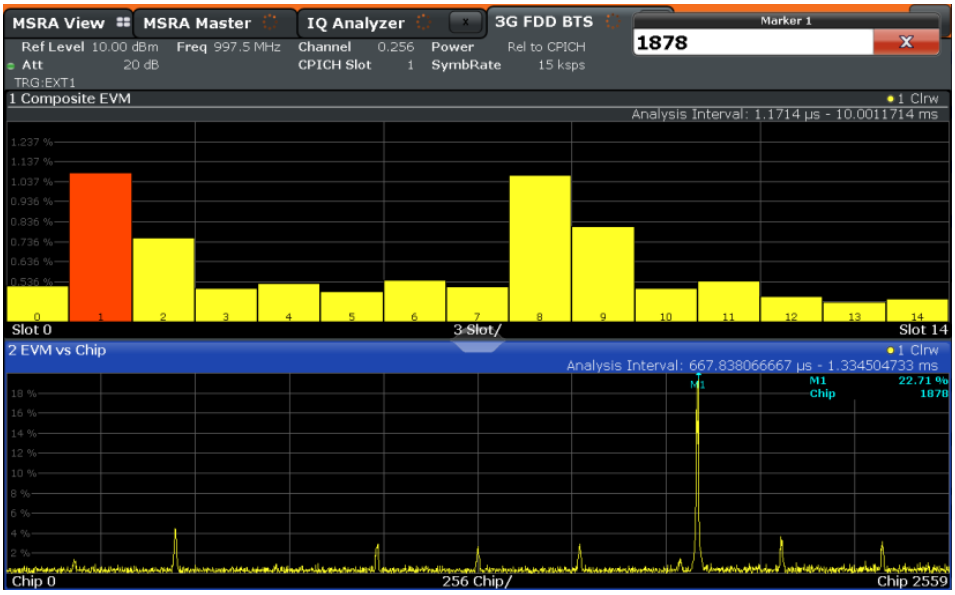


Fig. 10-3: Determining the chip with the highest EVM in a WCDMA slot

Marker1 indicates that chip number 1878 has the highest EVM.
The analysis interval for the EVM vs Chip result display indicates that this error occured between 667 µs and 1.3 ms. Each slot in a WCDMA signal is 667 µs long and contains 2560 chips.
Thus, the absolute point in time when the glitch occured can be calculated as:
*667µs (slot 0) + 1878/2560 * 667µs = 1.156ms*

To determine time correlations in the MSR signal

Now that you know the absolute time at which a particularly high error occured, you can analyze the MSR signal to find correlating events by other carriers at the same time. Start by analyzing the GSM signal at the known time.

1. Select the "I/Q Analyzer" tab.
2. Press the MKR key and set Marker1 to *1.156ms*.

   You see that this is the rising edge of the GSM burst.

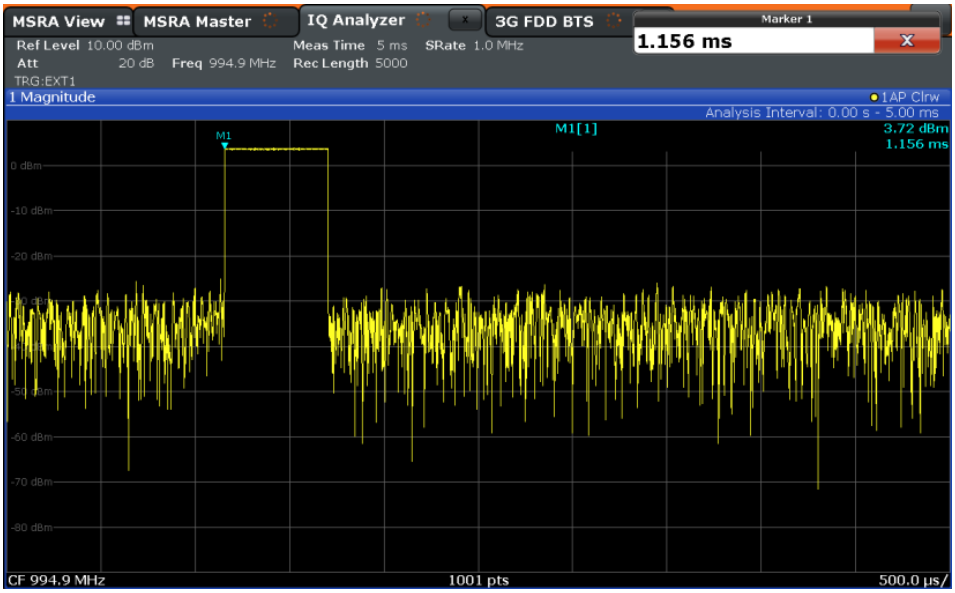


Fig. 10-4: Correlating events in an MSR signal

You can assume the GSM burst had an effect on the WCDMA burst, causing an error.

Conclusion of the measurement example

In R&S FSW MSRA mode it is very easy to find crosstalk between different carriers by detecting time correlations between different signals, since the analysis is performed on the same recorded I/Q data. This is especially easy to detect in the MSRA View, which displays the captured data and all individual application windows at once.

Fig. 10-5: MSRA View of MSR signal with time correlations

Capturing and analyzing long data sequences

The R&S FSW MSRA also allows you to capture very long data sequences. In order to examine particular areas of the large I/Q memory, each MSRA application supports a "Capture Offset" setting (TRIG menu, or "Data acquisition"/"Signal Capture" dialog box).

In the "MSRA Master" tab, the vertical blue lines in the "Magnitude" result display indicate which time interval of the I/Q data is analyzed by the individual applications. In this example, 40 ms are captured, the 3GPP FDD BTS application starts analysis at a Capture Offset of 20 ms (5 divisions with 4.0 ms/div), and the I/Q Analyzer starts with an offset of 31.5 ms.

11 Remote Commands to Perform Measurements in MSRA Mode

The following commands are specific to performing measurements in MSRA mode in a remote environment. Generally, the remote commands are identical to those used in Spectrum mode as described in the R&S FSW User Manual. However, some restrictions or conditions may apply to specific commands (see also chapter 6, "MSRA Basics", on page 24).

You must always switch to MSRA mode before executing any MSRA-specific commands (using `INST:MODE MSR`).

It is assumed that the R&S FSW has already been set up for remote control in a network as described in the R&S FSW User Manual.

Common Suffixes

The following common suffixes are used in remote commands specific to MSRA mode:

Suffix	Value range	Description
<m>	1..16	Marker
<n>	1..16	Window
<t>	1..6	Trace

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 R&S FSW User Manual.

In particular, this includes:

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

The following tasks specific to MSRA mode 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, in most cases, one or more parameters. To use a command as a query, you have to append a question mark after the last header element, even if the command contains a parameter.

A header contains one or more keywords, separated by a colon. Header and parameters are separated by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank). If there is more than one parameter for a command, these are separated by a comma from one another.

Only the most important characteristics that you need to know when working with SCPI commands are described here. For a more complete description, refer to the User Manual of the R&S FSW.

Remote command examples

Note that some remote command examples mentioned in this general introduction may not be supported by this particular application.

11.1.1 Long and Short Form

The keywords have a long and a short form. You can use either the long or the short form, but no other abbreviations of the keywords.

The short form is emphasized in upper case letters. Note however, that this emphasis only serves the purpose to distinguish the short from the long form in the manual. For the instrument, the case does not matter.

Example:

`SENSe:FREQuency:CENTer` is the same as `SENS:FREQ:CENT`.

11.1.2 Numeric Suffixes

Some keywords have a numeric suffix if the command can be applied to multiple instances of an object. In that case, the suffix selects a particular instance (e.g. a measurement window).

Numeric suffixes are indicated by angular brackets (<n>) next to the keyword.

If you don't quote a suffix for keywords that support one, a 1 is assumed.

Example:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe` enables the zoom in a particular measurement window, selected by the suffix at `WINDow`.

`DISPlay:WINDow4:ZOOM:STATe ON` refers to window 4.

11.1.3 Optional Keywords

Some keywords are optional and are only part of the syntax because of SCPI compliance. You can include them in the header or not.

Note that if an optional keyword has a numeric suffix and you need to use the suffix, you have to include the optional keyword. Otherwise, the suffix of the missing keyword is assumed to be the value 1.

Optional keywords are emphasized with square brackets.

Example:

Without a numeric suffix in the optional keyword:

`[SENSe:]FREQuency:CENTer` is the same as `FREQuency:CENTer`

With a numeric suffix in the optional keyword:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe`

`DISPlay:ZOOM:STATe ON` enables the zoom in window 1 (no suffix).

`DISPlay:WINDow4:ZOOM:STATe ON` enables the zoom in window 4.

11.1.4 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`.

11.1.5 SCPI Parameters

Many commands feature one or more parameters.

If a command supports more than one parameter, these are separated by a comma.

Example:

`LAYout:ADD:WINDow Spectrum,LEFT,MTABle`

Parameters may have different forms of values.

11.1.5.1 Numeric Values

Numeric values can be entered in any form, i.e. with sign, decimal point or exponent. In case of physical quantities, you can also add the unit. If the unit is missing, the command uses the basic unit.

Example:

with unit: `SENSe:FREQuency:CENTer 1GHZ`

without unit: `SENSe:FREQuency:CENTer 1E9` would also set a frequency of 1 GHz.

Values exceeding the resolution of the instrument are rounded up or down.

If the number you have entered is not supported (e.g. in case of discrete steps), the command returns an error.

Instead of a number, you can also set numeric values with a text parameter in special cases.

- MIN/MAX
  Defines the minimum or maximum numeric value that is supported.
- DEF
  Defines the default value.
- UP/DOWN
  Increases or decreases the numeric value by one step. The step size depends on the setting. In some cases you can customize the step size with a corresponding command.

Querying numeric values

When you query numeric values, the system returns a number. In case of physical quantities, it applies the basic unit (e.g. Hz in case of frequencies). The number of digits after the decimal point depends on the type of numeric value.

Example:

Setting: `SENSe:FREQuency:CENTer 1GHZ`

Query: `SENSe:FREQuency:CENTer?` would return `1E9`

In some cases, numeric values may be returned as text.

- INF/NINF
  Infinity or negative infinity. Represents the numeric values 9.9E37 or -9.9E37.
- NAN

Not a number. Represents the numeric value 9.91E37. NAN is returned in case of errors.

11.1.5.2 Boolean

Boolean parameters represent two states. The "ON" state (logically true) is represented by "ON" or a numeric value 1. The "OFF" state (logically untrue) is represented by "OFF" or the numeric value 0.

Querying boolean parameters

When you query boolean parameters, the system returns either the value 1 ("ON") or the value 0 ("OFF").

Example:

Setting: `DISPlay:WINDow:ZOOM:STATe ON`

Query: `DISPlay:WINDow:ZOOM:STATe?` would return `1`

11.1.5.3 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 11.1.1, "Long and Short Form", on page 69.

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`

11.1.5.4 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'
```

11.1.5.5 Block Data

Block data is a format which is suitable for the transmission of large amounts of data.

The ASCII character # introduces the data block. The next number indicates how many of the following digits describe the length of the data block. In the example the 4 following digits indicate the length to be 5168 bytes. The data bytes follow. During the transmission of these data bytes all end or other control signs are ignored until all bytes are transmitted.

#0 specifies a data block of indefinite length. The use of the indefinite format requires a 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 Activating MSRA Measurements

MSRA measurements requires a special operating mode on the R&S FSW. A measurement is started immediately with the default settings.

The special MSRA Master measurement channel is of the channel type "IQ" and is referred to by the channel name "MSRA Master". This channel cannot be replaced, deleted, or renamed.

INSTrument:CREate[:NEW] <ChannelType>, <ChannelName>

This command adds an additional measurement channel. The number of measurement channels you can configure at the same time depends on available memory.

Parameters:

<ChannelType> Channel type of the new channel.
For a list of available channel types see table 11-1.

<ChannelName> String containing the name of the channel. The channel name is displayed as the tab label for the measurement channel.
Note: If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel (see table 11-1).

Example: `INST:CRE SAN, 'Spectrum 2'`
Adds an additional spectrum display named "Spectrum 2".

Manual control: See "New Channel" on page 22

INSTrument:CREate:REPLace <ChannelName1>,<ChannelType>,<ChannelName2>

This command replaces a measurement channel with another one.

Parameters:

<ChannelName1> String containing the name of the measurement channel you want to replace.

<ChannelType> Channel type of the new channel.
For a list of available channel types see table 11-1.

<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 table 11-1).

Example: `INST:CRE:REPL 'Spectrum2',IQ,'IQAnalyzer'`
Replaces the channel named 'Spectrum2' by a new measurement channel of type 'IQ Analyzer' named 'IQAnalyzer'.

Manual control: See "Replace Current Channel" on page 22

INSTrument:DELete <ChannelName>

This command deletes a measurement channel. If you delete the last measurement channel, the default "Spectrum" channel is activated.

Parameters:

<ChannelName> String containing the name of the channel you want to delete.
A measurement channel must exist in order to be able delete it.

Example: `INST:DEL 'Spectrum4'`
Deletes the spectrum channel with the name 'Spectrum4'.

INSTrument:LIST?

This command queries all active measurement channels. This is useful in order to obtain the names of the existing measurement channels, which are required in order to replace or delete the channels.

Return values:

<ChannelType>, <ChannelName> For each channel, the command returns the channel type and channel name (see table 11-1).
Tip: to change the channel name, use the `INSTrument:REName` command.

Example: `INST:LIST?`
Result for 3 measurement channels:
`'ADEM','Analog Demod','IQ','IQ Analyzer','SANALYZER','Spectrum'`

Usage: Query only

Table 11-1: Available measurement channel types and default channel names

Application	<ChannelType> Parameter	Default Channel Name*)
Spectrum	SANALYZER	Spectrum
I/Q Analyzer	IQ	IQ Analyzer
Pulse (R&S FSW-K6)	PULSE	Pulse
Analog Demodulation (R&S FSW-K7)	ADEM	Analog Demod
GSM (R&S FSW-K10)	GSM	GSM
Multi-Carrier Group Delay (R&S FSW-K17)	MCGD	MC Group Delay
Noise (R&S FSW-K30)	NOISE	Noise
Phase Noise (R&S FSW-K40)	PNOISE	Phase Noise
VSA (R&S FSW-K70)	DDEM	VSA
3GPP FDD BTS (R&S FSW-K72)	BWCD	3G FDD BTS
3GPP FDD UE (R&S FSW-K73)	MWCD	3G FDD UE
cdma2000 BTS (R&S FSW-K82)	BC2K	CDMA2000 BTS
cdma2000 MS (R&S FSW-K83)	MC2K	CDMA2000 MS
1xEV-DO BTS (R&S FSW-K84)	BDO	1xEV-DO BTS
1xEV-DO MS (R&S FSW-K85)	MDO	1xEV-DO MS
WLAN (R&S FSW-K91)	WLAN	WLAN
LTE (R&S FSW-K10x)	LTE	LTE
Note: the default channel name is also listed in the table. If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel.		

INSTrument:MODE <OpMode>

The operating mode of the R&S FSW determines which applications are available and active. Whenever you change the operating mode, the currently active measurement channels are stored. The default operating mode is Signal and Spectrum Analyzer mode, however, the presetting can be changed.

Parameters:

<OpMode> SANalyzer | MSRanalyzer

Example: `INST:MODE MSR`
Switches to MSRA mode.

Usage: SCPI confirmed

INSTrument:REName <ChannelName1>, <ChannelName2>

This command renames a measurement channel.

Parameters:

<ChannelName1> String containing the name of the channel you want to rename.

<ChannelName2> String containing the new channel name.
Note that you can not assign an existing channel name to a new channel; this will cause an error.

Example: `INST:REN 'Spectrum2','Spectrum3'`
Renames the channel with the name 'Spectrum2' to 'Spectrum3'.

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.

Also see

- `INSTrument:CREate[:NEW]` on page 73

Parameters:

<ChannelType> Channel type of the new channel.
For a list of available channel types see table 11-1.

<ChannelName> String containing the name of the channel.

Example: `INST SAN`
Activates a measurement channel for the Spectrum application.
`INST 'MySpectrum'`
Selects the measurement channel named 'MySpectrum' (for example before executing further commands for that channel).

Usage: SCPI confirmed

Manual control: See "I/Q Analyzer" on page 19
See "Analog Demodulation" on page 19
See "GSM" on page 20
See "Vector Signal Analysis (VSA)" on page 20
See "3G FDD BTS" on page 20
See "cdma2000 BTS" on page 20
See "1xEV-DO BTS" on page 20
See "LTE DL" on page 21
See "New Channel" on page 22

SYSTem:PRESet:COMPatible <OpMode>

This command defines the operating mode that is activated when you switch on the R&S FSW or press the PRESET key.

For details on operating modes see chapter 5, "Applications and Operating Modes", on page 18.

Parameters:

<OpMode> **MSRA**
Defines MSRA as the default operating mode as the presetting.

SANalyzer
(Default:) Defines Signal and Spectrum Analyzer operating mode as the presetting.

*RST: SAN

Usage: Event

SYSTem:PRESet:CHANnel[:EXECute]

This command restores the default instrument settings in the current channel.

Use `INST:SEL` to select the channel.

Example:
```
INST 'Spectrum2'
```
Selects the channel for "Spectrum2".
```
SYST:PRES:CHAN:EXEC
```
Restores the factory default settings to the "Spectrum2" channel.

Usage: Event

11.3 Configuring MSRA Measurements

11.3.1 Configuring Input/Output and Frontend Settings

The following commands are required to define input, output and frontend settings. Any settings related to data acquisition or data output are only available for the MSRA Master.

11.3.1.1 RF Input

INPut:ATTenuation:PROTection:RESet

This command resets the attenuator and reconnects the RF input with the input mixer after an overload condition occured and the protection mechanism intervened.The error status bit (bit 3 in the `STAT:QUES:POW` status register) and the `INPUT OVLD` message in the status bar are cleared.

The command works only if the overload condition has been eliminated first.

Usage: Event

INPut:COUPling <CouplingType>

This command selects the coupling type of the RF input.

Parameters:

<CouplingType>
AC
AC coupling
DC
DC coupling
*RST: AC

Example: `INP:COUP:DC`

Usage: SCPI confirmed

Manual control: See "Input Coupling" on page 32

INPut:FILTer:HPASs[:STATe] <State>

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

This function requires option R&S FSW-B13.

(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 filter.)

Parameters:

<State> ON | OFF
*RST: OFF

Usage: SCPI confirmed

Manual control: See "High-Pass Filter 1...3 GHz" on page 33

INPut:FILTer:YIG[:STATe] <State>

This command turns the YIG-preselector on and off.

Note the special conditions and restrictions for the YIG filter described in "YIG-Preselector" on page 33.

Parameters:

<State> ON | OFF

*RST: ON (OFF for I/Q Analyzer, GSM and MC Group Delay measurements)

Example: `INP:FILT:YIG OFF`
Deactivates the YIG-preselector.

Manual control: See "YIG-Preselector" on page 33

INPut:IMPedance <Impedance>

This command selects the nominal input impedance of the RF input.

75 Ω should be selected if the 50 Ω input impedance is transformed to a higher impedance using a matching pad of the RAZ type (= 25 Ω in series to the input impedance of the instrument). The power loss correction value in this case is 1.76 dB = 10 log (75Ω/50Ω).

Parameters:

<Impedance> 50 | 75

*RST: 50 Ω

Example: `INP:IMP 75`

Usage: SCPI confirmed

Manual control: See "Impedance" on page 32

INPut:SELect <Source>

This command selects the signal source for measurements, i.e. it defines which connector is used to input data to the R&S FSW. If no additional options are installed, only RF input is supported.

Parameters:

<Source> **RF**
Radio Frequency ("RF INPUT" connector)

*RST: RF

Manual control: See "Digital I/Q Input State" on page 34

11.3.1.2 Configuring Digital I/Q Input and Output

Useful commands for digital I/Q data described elsewhere:

- `TRIG:SEQ:LEV:BBPTRIGger[:SEQuence]:LEVel:BBPower` on page 92

Remote commands for the R&S DigIConf software

Remote commands for the R&S DigIConf software always begin with `SOURce:EBOX`. Such commands are passed on from the R&S FSW to the R&S DigIConf automatically which then configures the R&S EX-IQ-BOX via the USB connection.

All remote commands available for configuration via the R&S DigIConf software are described in the "R&S®EX-IQ-BOX Digital Interface Module R&S®DigIConf Software Operating Manual".

Example 1:

```
SOURce:EBOX:*RST
SOURce:EBOX:*IDN?
```

Result:

"Rohde&Schwarz,DigIConf,02.05.436 Build 47"

Example 2:

```
SOURce:EBOX:USER:CLOCk:REFerence:FREQuency 5MHZ
```

Defines the frequency value of the reference clock.

Remote commands exclusive to digital I/Q data input and output

INPut:DIQ:CDEVice

This command queries the current configuration and the status of the digital I/Q input from the optional Digital Baseband Interface (R&S FSW-B17).

For details see the section "Interface Status Information" for the Digital Baseband Interface (R&S FSW-B17) in the R&S FSW I/Q Analyzer User Manual.

Return values:

<ConnState> Defines whether a device is connected or not.

0
No device is connected.

1
A device is connected.

<DeviceName> Device ID of the connected device

<SerialNumber> Serial number of the connected device

<PortName> Port name used by the connected device

<SampleRate> Maximum or currently used sample rate of the connected device in Hz (depends on the used connection protocol version; indicated by <SampleRateType> parameter)

<MaxTransferRate> Maximum data transfer rate of the connected device in Hz

<ConnProtState> State of the connection protocol which is used to identify the connected device.

Not Started

Has to be Started

Started

Passed

Failed

Done

<PRBSTestState> State of the PRBS test.

Not Started

Has to be Started

Started

Passed

Failed

Done

<SampleRateType> **0**
Maximum sampling rate is displayed

1
Current sampling rate is displayed

<FullScaleLevel> The level (in dBm) that should correspond to an I/Q sample with the magnitude "1" (if transferred from connected device);
If not available, `9.97e37` is returned

Example:
```
INP:DIQ:CDEV?
```
Result:
```
1,SMU200A,103634,Out
A,70000000,100000000,Passed,Not Started,0,0
```

Manual control: See "Connected Instrument" on page 35

INPut:DIQ:RANGe:AUTO <State>

If enabled, the digital input full scale level is automatically set to the value provided by the connected device (if available).

This command is only available if the optional Digital Baseband interface (option R&S FSW-B17) is installed.

Parameters:

<State> ON | OFF

*RST: OFF

Manual control: See "Full Scale Level" on page 34

INPut:DIQ:RANGe:COUPling <State>

If enabled, the reference level for digital input is adjusted to the full scale level automatically if the full scale level changes.

This command is only available if the optional Digital Baseband Interface (R&S FSW-B17) is installed.

Parameters:

<State> ON | OFF

*RST: OFF

Manual control: See "Adjust Reference Level to Full Scale Level" on page 35

INPut:DIQ:RANGe[:UPPer] <Level>

Defines or queries the "Full Scale Level", i.e. the level that corresponds to an I/Q sample with the magnitude "1".

This command is only available if the optional Digital Baseband Interface (R&S FSW-B17) is installed.

Parameters:

<Level> <numeric value>

Range: 1 µV to 7.071 V
*RST: 1 V

Manual control: See "Full Scale Level" on page 34

INPut:DIQ:RANGe[:UPPer]:UNIT <Unit>

Defines the unit of the full scale level (see "Full Scale Level" on page 34). The availability of units depends on the measurement application you are using.

This command is only available if the optional Digital Baseband Interface (R&S FSW-B17) is installed.

Parameters:

<Level> VOLT | DBM | DBPW | WATT | DBMV | DBUV | DBUA | AMPere

*RST: Volt

Manual control: See "Full Scale Level" on page 34

INPut:DIQ:SRATe <SampleRate>

This command specifies or queries the sample rate of the input signal from the Digital Baseband Interface (R&S FSW-B17, see "Input Sample Rate" on page 34).

Parameters:

<SampleRate> Range: 1 Hz to 10 GHz
*RST: 32 MHz

Example: INP:DIQ:SRAT 200 MHz

Manual control: See "Input Sample Rate" on page 34

INPut:DIQ:SRATe:AUTO <State>

If enabled, the sample rate of the digital I/Q input signal is set automatically by the connected device.

This command is only available if the optional Digital Baseband Interface (R&S FSW-B17) is installed.

Parameters:

<State> ON | OFF
*RST: OFF

Manual control: See "Input Sample Rate" on page 34

11.3.1.3 Configuring the Vertical Axis (Amplitude, Scaling)

The following commands are required to configure the amplitude and vertical axis settings in a remote environment.

Amplitude Settings

Useful commands for amplitude configuration described elsewhere:

- `[SENSe:]ADJust:LEVel` on page 103

Remote commands exclusive to amplitude configuration:

CALCulate<n>:MARKer<m>:FUNCtion:REFerence

This command matches the reference level to the power level of a marker.

If you use the command in combination with a delta marker, that delta marker is turned into a normal marker.

Example: `CALC:MARK2:FUNC:REF`
Sets the reference level to the level of marker 2.

Usage: Event

DISPlay[:WINDow<n>]:TRACe:Y[:SCALe]:RLEVel <ReferenceLevel>

This command defines the reference level.

Example: `DISP:TRAC:Y:RLEV -60dBm`

Usage: SCPI confirmed

Manual control: See "Reference Level" on page 36

DISPlay[:WINDow<n>]:TRACe:Y[:SCALe]:RLEVel:OFFSet <Offset>

This command defines a reference level offset.

Parameters:

<Offset> Range: -200 dB to 200 dB
*RST: 0dB

Example: `DISP:TRAC:Y:RLEV:OFFS -10dB`

Manual control: See "Reference Level" on page 36
See "Shifting the Display (Offset)" on page 37

Configuring the Attenuation

INPut:ATTenuation <Attenuation>

This command defines the total attenuation for RF input.

If you set the attenuation manually, it is no longer coupled to the reference level, but the reference level is coupled to the attenuation. Thus, if the current reference level is not compatible with an attenuation that has been set manually, the command also adjusts the reference level.

Parameters:

<Attenuation> Range: see data sheet
Increment: 5 dB
*RST: 10 dB (AUTO is set to ON)

Example: `INP:ATT 30dB`
Defines a 30 dB attenuation and decouples the attenuation from the reference level.

Usage: SCPI confirmed

Manual control: See "RF Attenuation" on page 37
See "Attenuation Mode / Value" on page 37

INPut:ATTenuation:AUTO <State>

This command couples or decouples the attenuation to the reference level. Thus, when the reference level is changed, the R&S FSW determines the signal level for optimal internal data processing and sets the required attenuation accordingly.

Parameters:
<State> ON | OFF
*RST: ON

Example: `INP:ATT:AUTO ON`
Couples the attenuation to the reference level.

Usage: SCPI confirmed

Manual control: See "RF Attenuation" on page 37
See "Attenuation Mode / Value" on page 37

INPut:EATT <Attenuation>

This command defines an electronic attenuation manually. Automatic mode must be switched off (`INP:EATT:AUTO OFF`, see `INPut:EATT:AUTO` on page 85).

If the current reference level is not compatible with an attenuation that has been set manually, the command also adjusts the reference level.

Parameters:
<Attenuation> attenuation in dB
Range: see data sheet
Increment: 1 dB
*RST: 0 dB (OFF)

Example:
```
INP:EATT:AUTO OFF
INP:EATT 10 dB
```

Manual control: See "Using Electronic Attenuation (Option B25)" on page 38

INPut:EATT:AUTO <State>

This command turns automatic selection of the electronic attenuation on and off.

If on, electronic attenuation reduces the mechanical attenuation whenever possible.

Parameters:
<State> ON | OFF
*RST: ON

Example: `INP:EATT:AUTO OFF`

Manual control: See "Using Electronic Attenuation (Option B25)" on page 38

INPut:EATT:STATe <State>

This command turns the electronic attenuator on and off.

Parameters:

<State> ON | OFF

*RST: OFF

Example: `INP:EATT:STAT ON`
Switches the electronic attenuator into the signal path.

Manual control: See "Using Electronic Attenuation (Option B25)" on page 38

Configuring a Preamplifier

INPut:GAIN:STATe <State>

This command turns the preamplifier on and off.

The command requires option R&S FSW-B24.

Parameters:

<State> ON | OFF

*RST: OFF

Example: `INP:GAIN:STAT ON`
Switches on 30 dB preamplification.

Usage: SCPI confirmed

Manual control: See "Input Settings" on page 38
See "Preamplifier (option B24)" on page 38

INPut:GAIN[:VALue] <Gain>

This command selects the preamplification level if the preamplifier is activated (`INP:GAIN:STAT ON`, see `INPut:GAIN:STATe` on page 86).

The command requires option R&S FSW-B24.

Parameters:

<Gain> 15 dB | 30 dB

The availability of preamplification levels depends on the R&S FSW model.
- R&S FSW8: 15dB and 30 dB
- R&S FSW13: 15dB and 30 dB
- R&S FSW26: 30 dB

All other values are rounded to the nearest of these two.

*RST: OFF

Example: INP:GAIN:VAL 30
Switches on 30 dB preamplification.

Usage: SCPI confirmed

Manual control: See "Input Settings" on page 38
See "Preamplifier (option B24)" on page 38

Scaling the Y-Axis

DISPlay[:WINDow<n>]:TRACe:Y[:SCALe] <Range>

This command defines the display range of the y-axis.

Example: DISP:TRAC:Y 110dB

Usage: SCPI confirmed

Manual control: See "Range" on page 39

DISPlay[:WINDow<n>]:TRACe:Y[:SCALe]:AUTO ONCE

Automatic scaling of the y-axis is performed once, then switched off again.

Usage: SCPI confirmed

DISPlay[:WINDow<n>]:TRACe:Y[:SCALe]:MODE <Mode>

This command selects the type of scaling of the y-axis.

When the display update during remote control is off, this command has no immediate effect.

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 control: See "Scaling" on page 39

DISPlay[:WINDow<n>]:TRACe:Y[:SCALe]:RPOSition <Position>

This command defines the vertical position of the reference level on the display grid.

The R&S FSW adjusts the scaling of the y-axis accordingly.

Example: `DISP:TRAC:Y:RPOS 50PCT`

Usage: SCPI confirmed

Manual control: See "Ref Level Position" on page 39

DISPlay[:WINDow<n>]:TRACe:Y:SPACing <ScalingType>

This command selects the scaling of the y-axis.

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 %.

Usage: SCPI confirmed

Manual control: See "Scaling" on page 39

11.3.1.4 Frequency

[SENSe:]FREQuency:CENTer <Frequency>

This command defines the center frequency.

Parameters:

<Frequency>

The allowed range and f_{max} is specified in the data sheet.

UP
Increases the center frequency by the step defined using the `[SENSe:]FREQuency:CENTer:STEP` command.

DOWN
Decreases the center frequency by the step defined using the `[SENSe:]FREQuency:CENTer:STEP` command.

*RST: fmax/2
Default unit: Hz

Example: FREQ:CENT 100 MHz
FREQ:CENT:STEP 10 MHz
FREQ:CENT UP
Sets the center frequency to 110 MHz.

Usage: SCPI confirmed

Manual control: See "Center" on page 41

[SENSe:]FREQuency:CENTer:STEP <StepSize>

This command defines the center frequency step size.

You can increase or decrease the center frequency quickly in fixed steps using the SENS:FREQ UP AND SENS:FREQ DOWN commands, see [SENSe:]FREQuency:CENTer on page 88.

Parameters:

<StepSize> f_{max} is specified in the data sheet.

Range: 1 to fMAX
*RST: 0.1 x span
Default unit: Hz

Example: FREQ:CENT 100 MHz
FREQ:CENT:STEP 10 MHz
FREQ:CENT UP
Sets the center frequency to 110 MHz.

Manual control: See "Center Frequency Stepsize" on page 41

[SENSe:]FREQuency:CENTer:STEP:AUTO <State>

This command couples or decouples the center frequency step size to the span.

Parameters:

<State> ON | OFF

*RST: ON

Example: FREQ:CENT:STEP:AUTO ON
Activates the coupling of the step size to the span.

[SENSe:]FREQuency:OFFSet <Offset>

This command defines a frequency offset.

If this value is not 0 Hz, the application assumes that the input signal was frequency shifted outside the application. All results of type "frequency" will be corrected for this shift numerically by the application.

See also "Frequency Offset" on page 41.

Parameters:

<Offset> Range: -100 GHz to 100 GHz
*RST: 0 Hz

Example: `FREQ:OFFS 1GHZ`

Usage: SCPI confirmed

Manual control: See "Frequency Offset" on page 41

11.3.1.5 Configuring the Outputs

Configuring trigger input/output is described in chapter 11.3.2.2, "Configuring the Trigger Output", on page 95.

DIAGnostic<n>:SERVice:NSOurce <State>

This command turns the 28 V supply of the BNC connector labeled NOISE SOURCE CONTROL on the front panel on and off.

Parameters:

<State> ON | OFF
*RST: OFF

Example: `DIAG:SERV:NSO ON`

Manual control: See "Noise Source" on page 51

11.3.2 Triggering

The following remote commands are required to configure a triggered measurement in a remote environment. These commands are only available for the MSRA Master channel. More details are described for manual operation in chapter 7.6, "Trigger Settings", on page 41.

*OPC should be used after requesting data. This will hold off any subsequent changes to the selected trigger source, until after the sweep is completed and the data is returned.

11.3.2.1 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

Manual control: See "Trigger Source" on page 43
See "Drop-Out Time" on page 44

TRIGger[:SEQuence]:HOLDoff[:TIME] <Offset>

Defines the time offset between the trigger event and the start of the sweep (data capturing).

Parameters:

<Offset> *RST: 0 s

Example: `TRIG:HOLD 500us`

Manual control: See "Trigger Source" on page 43
See "Trigger Offset" on page 44

TRIGger[:SEQuence]:IFPower:HOLDoff <Period>

This command defines the holding time before the next trigger event.

Note that this command is available for **any trigger source**, not just IF Power.

Parameters:

<Period> *RST: 150 ns

Example: `TRIG:SOUR IFP`
Sets the IF power trigger source.
`TRIG:IFP:HOLD 200 ns`
Sets the holding time to 200 ns.

Manual control: See "Trigger Source" on page 43
See "Trigger Holdoff" on page 45

TRIGger[:SEQuence]:IFPower:HYSTeresis <Hysteresis>

This command defines the trigger hysteresis.

Parameters:

<Hysteresis> Range: 3 dB to 50 dB
*RST: 3 dB

Example: `TRIG:SOUR IFP`
Sets the IF power trigger source.
`TRIG:IFP:HYST 10DB`
Sets the hysteresis limit value.

Manual control: See "Trigger Source" on page 43
See "Hysteresis" on page 44

TRIGger[:SEQuence]:LEVel:BBPower <Level>

This command sets the level of the baseband power trigger.

This command is available with the **Digital Baseband Interface (R&S FSW-B17)**.

Parameters:

<Level> Range: -50 dBm to +20 dBm
*RST: -20 DBM

Example: `TRIG:LEV:BB -30DBM`

TRIGger[:SEQuence]:LEVel[:EXTernal<port>] <TriggerLevel>

This command defines the level the external signal must exceed to cause a trigger event.

Suffix:

<port> 1 | 2 | 3
Selects the trigger port.
1 = trigger port 1 (TRIGGER INPUT connector on front panel)
2 = trigger port 2 (TRIGGER INPUT/OUTPUT connector on front panel)
3 = trigger port 3 (TRIGGER3 INPUT/OUTPUT connector on rear panel)

Parameters:

<TriggerLevel> Range: 0.5 V to 3.5 V
*RST: 1.4 V

Example: `TRIG:LEV 2V`

Manual control: See "Trigger Source" on page 43
See "Trigger Level" on page 44

TRIGger[:SEQuence]:LEVel:IFPower <TriggerLevel>

This command defines the power level at the third intermediate frequency that must be exceeded to cause a trigger event. Note that any RF attenuation or preamplification is considered when the trigger level is analyzed.

Parameters:

<TriggerLevel> Range: -50 dBm to 20 dBm
*RST: -20 dBm

Example: `TRIG:LEV:IFP -30DBM`

TRIGger[:SEQuence]:LEVel:IQPower <TriggerLevel>

This command defines the magnitude the I/Q data must exceed to cause a trigger event. Note that any RF attenuation or preamplification is considered when the trigger level is analyzed.

Parameters:

<TriggerLevel> Range: -130 dBm to 30 dBm
*RST: -20 dBm

Example: `TRIG:LEV:IQP -30DBM`

TRIGger[:SEQuence]:LEVel:RFPower <TriggerLevel>

This command defines the power level the RF input must exceed to cause a trigger event. Note that any RF attenuation or preamplification is considered when the trigger level is analyzed.

The input signal must be between 500 MHz and 8 GHz.

Parameters:

<TriggerLevel> Range: -50 dBm to -10 dBm
*RST: -20 dBm

Example: `TRIG:LEV:RFP -30dBm`

TRIGger[:SEQuence]:SLOPe <Type>

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.

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 control: See "Trigger Source" on page 43
See "Slope" on page 45

TRIGger[:SEQuence]:SOURce <Source>

This command selects the trigger source.

Note on external triggers:

If a measurement is configured to wait for an external trigger signal in a remote control program, remote control is blocked until the trigger is received and the program can continue. Make sure this situation is avoided in your remote control programs.

Parameters:

<Source>

IMMediate
Free Run

EXTern
Trigger signal from the TRIGGER INPUT connector.

EXT2
Trigger signal from the TRIGGER INPUT/OUTPUT connector.
Note: Connector must be configured for "Input".

EXT3
Trigger signal from the TRIGGER 3 INPUT/ OUTPUT connector.
Note: Connector must be configured for "Input".

IFPower
Second intermediate frequency

*RST: IMMediate

Example:
```
TRIG:SOUR EXT
```
Selects the external trigger input as source of the trigger signal

Manual control: See "Trigger Source" on page 43
See "Trigger Source" on page 43
See "Free Run" on page 43
See "External Trigger 1/2/3" on page 43
See "Baseband Power" on page 44

TRIGger[:SEQuence]:TIME:RINTerval <Interval>

This command defines the repetition interval for the time trigger.

Parameters:

<Interval>

2.0 ms to 5000

Range: 2 ms to 5000 s
*RST: 1.0 s

Example:
```
TRIG:SOUR TIME
```
Selects the time trigger input for triggering.
```
TRIG:TIME:RINT 50
```
The sweep starts every 50 s.

Manual control: See "Trigger Source" on page 43
See "Repetition Interval" on page 44

11.3.2.2 Configuring the Trigger Output

The following commands are required to send the trigger signal to one of the variable TRIGGER INPUT/OUTPUT connectors. The tasks for manual operation are described in "Trigger 2/3" on page 45.

OUTPut:TRIGger<port>:DIRection <Direction>

This command selects the trigger direction.

Suffix:
<port> 2 | 3
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Parameters:
<Direction> **INPut**
Port works as an input.

OUTPut
Port works as an output.

*RST: INPut

Manual control: See "Trigger 2/3" on page 45

OUTPut:TRIGger<port>:LEVel <Level>

This command defines the level of the signal generated at the trigger output.

This command works only if you have selected a user defined output with `OUTPut:TRIGger<port>:OTYPe`.

Suffix:
<port> 2 | 3
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Parameters:

<Level>

HIGH
TTL signal.

LOW
0 V

*RST: LOW

Manual control: See "Trigger 2/3" on page 45
See "Output Type" on page 45
See "Level" on page 46

OUTPut:TRIGger<port>:OTYPe <OutputType>

This command selects the type of signal generated at the trigger output.

Suffix:

<port>

2 | 3
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Parameters:

<OutputType>

DEVice
Sends a trigger signal when the R&S FSW has triggered internally.

TARMed
Sends a trigger signal when the trigger is armed and ready for an external trigger event.

UDEFined
Sends a user defined trigger signal. For more information see `OUTPut:TRIGger<port>:LEVel`.

*RST: DEVice

Manual control: See "Trigger 2/3" on page 45
See "Output Type" on page 45

OUTPut:TRIGger<port>:PULSe:IMMediate

This command generates a pulse at the trigger output.

Suffix:

<port>

2 | 3
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Usage: Event

Manual control: See "Trigger 2/3" on page 45
See "Output Type" on page 45
See "Send Trigger" on page 46

OUTPut:TRIGger<port>:PULSe:LENGth <Length>

This command defines the length of the pulse generated at the trigger output.

Suffix:
<port> 2 | 3
Selects the trigger port to which the output is sent.
2 = trigger port 2 (front)
3 = trigger port 3 (rear)

Parameters:
<Length> Pulse length in seconds.

Manual control: See "Trigger 2/3" on page 45
See "Output Type" on page 45
See "Pulse Length" on page 46

11.3.3 Configuring Data Acquisition

The following commands are required to configure the actual data acquisition.

Configuring data acquisition is only possible for the MSRA Master channel. In MSRA application channels, these commands define the analysis interval (see chapter 11.8, "Commands Specific to MSRA Applications", on page 116). Be sure to select the correct measurement channel before executing these commands.

TRACe:IQ:BWIDth

This command defines or queries the bandwidth of the resampling filter.

The bandwidth of the resampling filter depends on the sampling rate.

Parameters:
<Bandwidth> For details on the maximum bandwidth see chapter A.3, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 121.

Manual control: See "Analysis Bandwidth" on page 47

TRACe:IQ:RLENgth <NoOfSamples>

This command sets the record length for the acquired I/Q data.

Increasing the record length also increases the measurement time.

Note: Alternatively, you can define the measurement time using the `SENS:SWE:TIME` command.

Parameters:

<NoOfSamples> Number of samples values to record.
For digital input via the Digital Baseband Interface (R&S FSW-B17) the valid number of samples is described in chapter A.4, "Sample Rates and Bandwidths for Digital I/Q Data", on page 124.

Range: 1 ... 461373440 (= 4400*1024*1024);
*RST: 691

Example: `TRAC:IQ:RLEN 256`

Manual control: See "Record Length" on page 48

TRACe:IQ:SET NORM, 0, <SampleRate>, <TriggerMode>, <TriggerSlope>, <PretriggerSamp>, <NumberSamples>

This command sets up the R&S FSW for I/Q measurements.

If you do not use this command to set up I/Q measurements, the R&S FSW will use its current settings for I/Q measurements.

If the I/Q Analyzer has not been turned on previously, the command also switches to the I/Q Analyzer.

You can set the trigger level with `TRIGger[:SEQuence]:LEVel:IFPower`. For details on trigger parameters see chapter 7.6, "Trigger Settings", on page 41 and chapter 11.3.2, "Triggering", on page 90.

Note: If you use the default settings with `TRACe:IQ:DATA?`, the following minimum buffer sizes for the response data are recommended:

ASCII format: 10 kBytes

Binary format: 2 kBytes

Parameters:

NORM This value is always `NORM`.

0 This value is always `0`.

<SampleRate> Sample rate for the data acquisition.

Range: 100 Hz to 10 GHz, continuously adjustable
*RST: 32000000

<TriggerMode> Selection of the trigger source used for the measurement.

IMMediate | EXTernal | EXT2 | EXT3 | IFPower
For IMM mode, gating is automatically deactivated.

*RST: IMM

<TriggerSlope> Used trigger slope.

POSitive | NEGative

*RST: POS

<PretriggerSamp> Defines the trigger offset in terms of pretrigger samples. Negative values correspond to a trigger delay.

Range: -461373339 to 461373339
*RST: 0

<NumberSamples> Number of measurement values to record (including the pretrigger samples).

Range: 1 … 461373339 (= (440*1024*1024) -1)
*RST: 1001

Example:

```
TRAC:IQ:SET NORM,0,32MHz,EXT,POS,0,2048
```

Reads 2048 I/Q-values starting at the trigger point.
sample rate = 32 MHz
trigger = External
slope = Positive

```
TRAC:IQ:SET NORM,0,4 MHz,EXT,POS,1024,512
```

Reads 512 I/Q-values from 1024 measurement points before the trigger point.
filter type = NORMAL
sample rate = 4 MHz
trigger = External
slope = Positive

Manual control: See "Record Length" on page 48

TRACe:IQ:SRATe <SampleRate>

This command sets the final user sample rate for the acquired I/Q data. Thus, the user sample rate can be modified without affecting the actual data capturing settings on the R&S FSW.

Note: The smaller the user sample rate, the smaller the usable I/Q bandwidth, see chapter A.3, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 121.

Parameters:

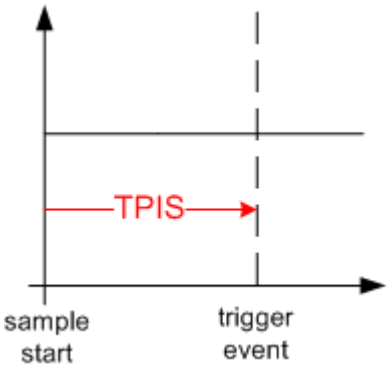
<SampleRate> The valid sample rates are described in chapter A.3, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 121.

Range: 100 Hz to 10 GHz continuously adjustable;
*RST: 32 MHz

Manual control: See "Sample Rate" on page 47

TRACe:IQ:TPISample?

This command queries the time offset between the sample start and the trigger event (trigger point in sample = TPIS). Since the R&S FSW usually samples with a much higher sample rate than the specific application actually requires, the trigger point determined internally is much more precise than the one determined from the (downsampled) data in the application. Thus, the TPIS indicates the offset between the sample start and the actual trigger event.



This value can only be determined in triggered measurements using external or IFPower triggers, otherwise the value is 0.

This command is not available if the Digital Baseband Interface (R&S FSW-B17) is active.

Example: `TRAC:IQ:TPIS?`
Result for a sample rate of 1 MHz: between 0 and 1/1 MHz, i.e. between 0 and 1 µs (the duration of 1 sample).

Usage: Query only

TRACe:IQ:WBANd[:STATe] <State>

Activates the bandwidth extension option R&S FSW-B160 / U160, if installed. Only if the extension is activated a bandwidth up to 160 MHz is available, which corresponds to a sample rate of 200 MHz. The extension must be activated for sample rates > 100 MHz.

Note: As opposed to manual operation, the bandwidth extension can also be activated for sample rates ≤ 100 MHz using this remote command. However, it is only actually employed when the sample rate exceeds 100 MHz. This simplifies creating remote programs as the sequence of activating the extension and controlling the sample rate is irrelevant.

Parameters:

<State> ON | OFF

*RST: OFF

Manual control: See "Maximum Bandwidth" on page 48

11.3.4 Adjusting Settings Automatically

The following remote commands are required to adjust settings automatically in a remote environment. These commands are only available for the MSRA Master channel. The tasks for manual operation are described in chapter 7.10, "Automatic Settings", on page 53.

Settings related to data acquisition (measurement time, hysteresis) can only be adjusted in the MSRA Master, not in the applications.

[SENSe:]ADJust:ALL

This command initiates a measurement to determine and set the ideal settings for the current task automatically (only once for the current measurement).

This includes:

- Reference level

Example: `ADJ:ALL`

Usage: Event

Manual control: See "Adjusting all Determinable Settings Automatically (Auto All)" on page 54

[SENSe:]ADJust:CONFigure:DURation <Duration>

In order to determine the ideal reference level, the R&S FSW performs a measurement on the current input data. This command defines the length of the measurement if `[SENSe:]ADJust:CONFigure: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 control: See "Changing the Automatic Measurement Time (Meastime Manual)" on page 54

[SENSe:]ADJust:CONFigure:DURation:MODE <Mode>

In order to determine the ideal reference level, the R&S FSW performs a measurement on the current input data. This command selects the way the R&S FSW determines the length of the measurement .

Parameters:

<Mode>

AUTO
The R&S FSW determines the measurement length automatically according to the current input data.

MANual
The R&S FSW uses the measurement length defined by `[SENSe:]ADJust:CONFigure:DURation` on page 101.

*RST: AUTO

Manual control: See "Resetting the Automatic Measurement Time (Meastime Auto)" on page 54
See "Changing the Automatic Measurement Time (Meastime Manual)" on page 54

[SENSe:]ADJust:FREQuency

This command sets the center frequency to the highest signal level in the current frequency range.

Example: `ADJ:FREQ`

Usage: Event

Manual control: See "Adjusting the Center Frequency Automatically (Auto Freq)" on page 54

[SENSe:]ADJust:CONFigure:HYSTeresis:LOWer <Threshold>

When the reference level is adjusted automatically using the `[SENSe:]ADJust:LEVel` on page 103 command, the internal attenuators and the preamplifier are also adjusted. In order 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.

This setting can only be adjusted in the MSRA Master, not in the applications.

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 will only be adjusted when the signal level falls below 18 dBm.

Manual control: See "Lower Level Hysteresis" on page 55

[SENSe:]ADJust:CONFigure:HYSTeresis:UPPer <Threshold>

When the reference level is adjusted automatically using the [SENSe:]ADJust:LEVel on page 103 command, the internal attenuators and the preamplifier are also adjusted. In order 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.

This setting can only be adjusted in the MSRA Master, not in the applications.

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 will only be adjusted when the signal level rises above 22 dBm.

Manual control: See "Upper Level Hysteresis" on page 55

[SENSe:]ADJust:LEVel

This command initiates a single (internal) measurement that evaluates and sets the ideal reference level for the current input data and measurement settings. This ensures that the settings of the RF attenuation and the reference level are optimally adjusted to the signal level without overloading the R&S FSW or limiting the dynamic range by an S/N ratio that is too small.

Example: ADJ:LEV

Usage: Event

Manual control: See "Setting the Reference Level Automatically (Auto Level)" on page 54

11.4 Capturing Data and Performing Sweeps

The only true measurement in MSRA mode in which I/Q data from the input signal is captured and stored is performed by the MSRA Master. This data acquisition is performed as in the I/Q Analyzer application, i.e. a specified frequency span of the input signal is swept for a specified measurement time.

As soon as data has been stored to the capture buffer successfully, a status bit (#9) in the STAT:OPER register is set (see chapter 11.6.1, "STATus:OPERation Register", on page 113. Once the bit has been set, the device under test can already be reconfigured while the R&S FSW performs analysis on the captured data. For measurements that require long measurement times and comprehensive analysis tasks, using the "capture finished" information can reduce the overall measurement time significantly.

See also:

- INITiate:REFResh on page 116

ABORt

This command aborts a current measurement and resets the trigger system.

To prevent overlapping execution of the subsequent command before the measurement has been aborted successfully, use the *OPC? or *WAI command after ABOR and before the next command.

For details see the "Remote Basics" chapter in the R&S FSW User Manual.

To abort a sequence of measurements by the Sequencer, use the INITiate:SEQuencer:ABORt on page 106 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 (GPIB, LAN or other interface) to the R&S FSW is blocked for further commands. In this case, you must interrupt processing on the remote channel first in order to abort the measurement.

To do so, send a "Device Clear" command from the control instrument to the R&S FSW on a parallel channel to clear all currently active remote channels. Depending on the used interface and protocol, send the following commands:

- **Visa**: viClear()
- **GPIB**: ibclr()
- **RSIB**: RSDLLibclr()

Now you can send the ABORt command on the remote channel performing the measurement.

Example: ABOR;:INIT:IMM
Aborts the current measurement and immediately starts a new one.

Example: ABOR;*WAI
INIT:IMM
Aborts the current measurement and starts a new one once abortion has been completed.

Usage: SCPI confirmed

INITiate<n>:CONMeas

This command restarts a measurement that has been stopped in single sweep mode.

The measurement is restarted at the first sweep point.

As opposed to INITiate[:IMMediate] on page 106, this command does not reset traces in maxhold, minhold or average mode. Therefore it can be used to continue measurements using max hold or averaging functions.

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.

Example: INIT:CONT OFF
Switches to single sweep mode.
INIT;*WAI
Starts the measurement and waits for the end of the sweep.
INIT:CONM;*WAI
Continues the measurement (next sweep) and waits for the end.

Manual control: See "Continue Single Sweep" on page 50

INITiate:CONTinuous <State>

This command controls the sweep mode.

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 the "Remote Basics" chapter in the R&S FSW User Manual.

If the sweep mode is changed for a measurement channel while the Sequencer is active (see INITiate:SEQuencer:IMMediate on page 107) the mode is only considered the next time the measurement in that channel is activated by the Sequencer.

Parameters:

<State> ON | OFF

ON
Continuous sweep

OFF
Single sweep

*RST: ON

Example:
```
INIT:CONT OFF
```
Switches the sweep mode to single sweep.
```
INIT:CONT ON
```
Switches the sweep mode to continuous sweep.

Manual control: See "Continuous Sweep/RUN CONT" on page 50

INITiate[:IMMediate]

This command starts a (single) new measurement.

You can synchronize to the end of the measurement with *OPC, *OPC? or *WAI.

For details on synchronization see the "Remote Basics" chapter in the R&S FSW User Manual.

Example: (For Spectrum application:)
```
INIT:CONT OFF
```
Switches to single sweep mode.
```
DISP:WIND:TRAC:MODE AVER
```
Switches on trace averaging.
```
SWE:COUN 20
```
Sets the sweep counter to 20 sweeps.
```
INIT;*WAI
```
Starts the measurement and waits for the end of the 20 sweeps.

Manual control: See "Single Sweep/ RUN SINGLE" on page 50

INITiate:SEQuencer:ABORt

This command stops the currently active sequence of measurements. The Sequencer itself is not deactivated, so you can start a new sequence immediately using INITiate:SEQuencer:IMMediate on page 107.

To deactivate the Sequencer use SYSTem:SEQuencer on page 109.

Usage: Event

Manual control: See "Sequencer State" on page 22

INITiate:SEQuencer:IMMediate

This command starts a new sequence of measurements by the Sequencer. Its effect is similar to the `INITiate[:IMMediate]` command used for a single measurement.

Before this command can be executed, the Sequencer must be activated (see `SYSTem:SEQuencer` on page 109).

Example:
`SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single Sequencer mode so each active measurement will be performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.

Usage: Event

Manual control: See "Sequencer State" on page 22

INITiate:SEQuencer:MODE <Mode>

This command selects the way the R&S FSW application performs measurements sequentially.

Before this command can be executed, the Sequencer must be activated (see `SYSTem:SEQuencer` on page 109).

A detailed programming example is provided in the "Operating Modes" chapter in the R&S FSW User Manual.

Note: In order to synchronize to the end of a sequential measurement using *OPC, *OPC? or *WAI you must use `SINGle` Sequencer mode.

For details on synchronization see the "Remote Basics" chapter in the R&S FSW User Manual.

Parameters:

<Mode>

SINGle
Each measurement is performed once (regardless of the channel's sweep mode), considering each channels' sweep count, until all measurements in all active channels have been performed.

CONTinuous
The measurements in each active channel are performed one after the other, repeatedly (regardless of the channel's sweep mode), in the same order, until the Sequencer is stopped.

CDEFined
First, a single sequence is performed. Then, only those channels in continuous sweep mode (`INIT:CONT ON`) are repeated.

*RST: CONTinuous

Example: `SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single Sequencer mode so each active measurement will be performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.

Manual control: See "Sequencer Mode" on page 23

INITiate:SEQuencer:REFResh[:ALL]

This function is only available if the Sequencer is deactivated (`SYSTem:SEQuencer SYST:SEQ:OFF`) and only in MSRA mode.

The data in the capture buffer is re-evaluated by all active MSRA applications.

Example: `SYST:SEQ:OFF`
Deactivates the scheduler
`INIT:CONT OFF`
Switches to single sweep mode.
`INIT;*WAI`
Starts a new data measurement and waits for the end of the sweep.
`INIT:SEQ:REFR`
Refreshes the display for all MSRA channels.

Usage: Event

Manual control: See "Refresh All" on page 23

[SENSe:]SWEep:POINts <SweepPoints>

This command defines the number of measurement points analyzed during a sweep.

Example: `SWE:POIN 251`

Usage: SCPI confirmed

Manual control: See "Sweep Points" on page 49

[SENSe:]SWEep:TIME <Time>

This command defines the sweep (or: data capture) time.

Parameters:
<Time> refer to data sheet
*RST: (AUTO is set to ON)

Example: `SWE:TIME 10s`

Usage: SCPI confirmed

Manual control: See "Meas Time" on page 48

SYSTem:SEQuencer <State>

This command turns the Sequencer on and off. The Sequencer must be active before any other Sequencer commands (`INIT:SEQ...`) are executed, otherwise an error will occur.

A detailed programming example is provided in the "Operating Modes" chapter in the R&S FSW User Manual.

Parameters:

<State> ON | OFF

ON
The Sequencer is activated and a sequential measurement is started immediately.

OFF
The Sequencer is deactivated. Any running sequential measurements are stopped. Further Sequencer commands (`INIT:SEQ...`) are not available.

*RST: OFF

Example:
`SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single Sequencer mode so each active measurement will be performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.
`SYST:SEQ OFF`

Manual control: See "Sequencer State" on page 22

11.5 Retrieving Results

The measurement results are output in the form of a list, three different formats can be selected for this list (see `TRACe:IQ:DATA:FORMat` on page 111).

For details on formats refer to chapter A.1, "Reference: Format Description for I/Q Data Files", on page 120.

The applications can only receive data that is available in the capture buffer. As soon as data has been stored to the capture buffer successfully, a status bit (#9) in the `STAT:OPER` register is set (see chapter 11.6.1, "STATus:OPERation Register", on page 113).

FORMat[:DATA] <Format>

This command selects the data format that is used for transmission of trace data from the R&S FSW to the controlling computer.

Note that the command has no effect for data that you send to the R&S FSW. The R&S FSW automatically recognizes the data it receives, regardless of the format.

Parameters:

<Format>

ASCii
ASCii format, separated by commas.
This format is almost always suitable, regardless of the actual data format. However, the data is not as compact as other formats may be.

REAL,32
32-bit IEEE 754 floating-point numbers in the "definite length block format".
In the Spectrum application, the format setting `REAL` is used for the binary transmission of trace data.

*RST: ASCII

Example: `FORM REAL,32`

Usage: SCPI confirmed

TRACe:IQ:DATA?

This command queries the measurement results for measurements with the I/Q analyzer.

To get the results, the command also initiates a measurement with the current settings of the R&S FSW.

Note: Using the command with the *RST values for the `TRACe:IQ:SET` command, the following minimum buffer sizes for the response data are recommended: ASCII format 10 kBytes, binary format: 2 kBytes

Return values:

<Results>

Voltage at the RF input for each sample that has been analyzed during the measurement.
The number of samples depends on `TRACe:IQ:SET`. In ASCII format, the number of results is 2* the number of samples.
The data format depends on `FORMat[:DATA]`.

Default unit: V

Example:
```
TRAC:IQ:STAT ON
```
Enables acquisition of I/Q data
```
TRAC:IQ:SET NORM,10MHz,32MHz,EXT,POS,0,4096
```
Measurement configuration:
Sample Rate = 32 MHz
Trigger Source = External
Trigger Slope = Positive
Pretrigger Samples = 0
Number of Samples = 4096
```
FORMat REAL,32
```
Selects format of response data
```
TRAC:IQ:DATA?
```
Starts measurement and reads results

Usage: Query only

TRACe:IQ:DATA:FORMat <Format>

This command selects the order of the I/Q data.

Parameters:

<Format> COMPatible | IQBLock | IQPair

COMPatible
I and Q values are separated and collected in blocks: A block of I values is followed by a block of Q values, followed by a block of I values, followed by a block of Q values etc.
(I,I,I,I,Q,Q,Q,Q,I,I,I,I,Q,Q,Q,Q...)

IQBLock
First all I-values are listed, then the Q-values
(I,I,I,I,I,I,...Q,Q,Q,Q,Q,Q)

IQPair
One pair of I/Q values after the other is listed
(I,Q,I,Q,I,Q...).

*RST: IQBL

TRACe:IQ:DATA:MEMory? <OffsetSamples>,<NoOfSamples>

This command queries the I/Q data currently stored in the memory of the R&S FSW.

By default, the command returns all I/Q data in the memory. You can, however, narrow down the amount of data that the command returns.

By default, the amount of available data depends on `TRACe:IQ:SET`.

Parameters:

<OffsetSamples> Selects an offset at which the output of data should start in relation to the first data.

Range: 0 to <# of samples> – 1, with <# of samples> being the maximum number of captured values

*RST: 0

<NoOfSamples> Number of samples you want to query, beginning at the offset you have defined.

Range: 1 to <# of samples> - <offset samples> with <# of samples> maximum number of captured values

*RST: <# of samples>

Return values:

<IQData> Measured value for each sample that has been recorded.
The data format depends on `FORMat[:DATA]`.

Default unit: V

Example: `TRAC:IQ:STAT ON`
Enables acquisition of I/Q data
`TRAC:IQ:SET NORM,10MHz,32MHz,EXT,POS,100,4096`
Measurement configuration:
Sample Rate = 32 MHz
Trigger Source = External
Trigger Slope = Positive
Pretrigger Samples = 100
Number of Samples = 4096
`INIT;*WAI`
Starts measurement and wait for sync
`FORMat REAL,32`
Determines output format
To read the results:
`TRAC:IQ:DATA:MEM?`
Reads all 4096 I/Q data
`TRAC:IQ:DATA:MEM? 0,2048`
Reads 2048 I/Q data starting at the beginning of data acquisition
`TRAC:IQ:DATA:MEM? 2048,1024`
Reads 1024 I/Q data from half of the recorded data
`TRAC:IQ:DATA:MEM? 100,512`
Reads 512 I/Q data starting at the trigger point (<Pretrigger Samples> was 100)

Usage: Query only

11.6 Querying the Status Registers

The R&S FSW-I/Q Analyzer uses the standard status registers of the R&S FSW.

The MSRA operating mode uses an additional bit in the `STATus:OPERation` register.

This register and the commands required to query its contents are described here.

For details on the common R&S FSW status registers refer to the description of remote control basics in the R&S FSW User Manual.

*RST does not influence the status registers.

11.6.1 STATus:OPERation Register

The `STATus:OPERation` register contains information on current activities of the R&S FSW. It also contains information on activities that have been executed since the last read out.

You can read out the register with `STATus:OPERation:CONDition?` on page 114 or `STATus:OPERation[:EVENt]?` on page 115.

Table 11-2: Meaning of the bits used in the STATus:OPERation register

Bit No.	Meaning
0	`CALibrating` This bit is set as long as the instrument is performing a calibration.
1-2	Not used
3	`SWEeping` Sweep is being performed in base unit (applications are not considered); identical to bit 4 In applications, this bit is not used.
4	`MEASuring` Measurement is being performed in base unit (applications are not considered); identical to bit 3 In applications, this bit is not used.
5	`Waiting for TRIgger` Instrument is ready to trigger and waiting for trigger signal
6-7	Not used
8	`HardCOPy` in progress This bit is set while the instrument is printing a hardcopy.
9	For data acquisition in MSRA mode only: `MSRA capture finish` This bit is set if a data acquisition measurement was completed successfully in MSRA operating mode and data is available for evaluation
10	`Range completed` This bit is set when a range in the sweep list has been completed if "Stop after Range" has been activated.
11-14	Not used
15	This bit is always 0.

11.6.2 Commands to Query the STATus:OPERation Register

The following commands are required to query the contents of the `STATus:OPERation` register.

STATus:OPERation:CONDition? <ChannelName>

This comand reads out the CONDition section of the status register.

The command does not delete the contents of the EVENt section.

Query parameters:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

STATus:OPERation:ENABle? <SumBit>,<ChannelName>

This command controls the ENABle part of the register.

The ENABle part allows true conditions in the EVENt part of the status register to bereported in the summary bit. If a bit is 1 in the enable register and its associated event bit transitions to true, a positive transition will occur in the summary bit reported to the next higher level.

Parameters:

<SumBit> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

STATus:OPERation:NTRansition? <SumBit>,<ChannelName>

This command controls the Negative TRansition part of a register.

Setting a bit causes a 1 to 0 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding EVENt register.

Parameters:

<SumBit> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

STATus:OPERation:PTRansition? <SumBit>,<ChannelName>

This command controls the Positive TRansition part of the register.

Setting a bit causes a 0 to 1 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding EVENt register.

Parameters:
<SumBit> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

STATus:OPERation[:EVENt]? <ChannelName>

This command queries the contents of the EVENt section of the status register.

A query deletes the contents of the EVENt section.

Query parameters:
<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Return values:
<RegisterContents> Range: 0 to 32767

Usage: Query only

11.7 Analyzing MSRA Measurements

The data that was captured by the MSRA Master can be analyzed in various different applications.

The analysis settings and functions available in MSRA mode are those described for the individual applications. The MSRA Master is in effect an I/Q Analyzer application and has the same analysis functions and settings.

See the R&S FSW I/Q Analyzer User Manual for a description of the analysis functions and settings available for the I/Q Analyzer and thus the MSRA Master.

11.8 Commands Specific to MSRA Applications

Most commands for the MSRA applications are identical to those described for the individual applications. However, some specific commands are available for the MSRA applications only.

Configuring the analysis interval

The commands required to configure the application data extracts and analysis intervals vary depending on the application. See the corresponding application manuals for details.

For the I/Q Analyzer, the commands are the same as those used to define the actual data acquisition (see chapter 11.3.3, "Configuring Data Acquisition", on page 97. In MSRA application channels, these commands define the analysis interval. Be sure to select the correct measurement channel before executing these commands.

Useful commands for configuring the analysis interval described elsewhere:

- `TRACe:IQ:SRATe` on page 99
- `TRACe:IQ:BWIDth` on page 97
- `TRACe:IQ:RLENgth` on page 97
- `[SENSe:]SWEep:TIME` on page 108

Remote commands exclusive to MSRA applications

The following commands are only available for MSRA application channels:

CALCulate:MSRA:WINDow<n>:IVAL?

This command queries the analysis interval for the current window. This command is only available in application measurement channels, not the MSRA View or MSRA Master.

Return values:

<IntStart> Start value of the analysis interval
Default unit: us

<IntStop> Stop value of the analysis interval
Default unit: us

Usage: Query only

INITiate:REFResh

This function is only available if the Sequencer is deactivated (`SYSTem:SEQuencer SYST:SEQ:OFF`) and only for applications in MSRA mode, not the MSRA Master.

The data in the capture buffer is re-evaluated by the currently active application only. The results for any other applications remain unchanged.

The application channel must be selected before this command can be executed (see INSTrument[:SELect] on page 76).

Example: SYST:SEQ:OFF
Deactivates the scheduler
INIT:CONT OFF
Switches to single sweep mode.
INIT;*WAI
Starts a new data measurement and waits for the end of the sweep.
INST:SEL 'IQ ANALYZER'
Selects the IQ Analyzer channel.
INIT:REFR
Refreshes the display for the I/Q Analyzer channel.

Usage: Event

Manual control: See "Refresh" on page 49

[SENSe:]MSRA:CAPTure:OFFSet <Offset>

This setting is only available for applications in MSRA mode, not for the MSRA Master. It has a similar effect as the trigger offset in other measurements.

Parameters:

<Offset> This parameter defines the time offset between the capture buffer start and the start of the extracted application data. The offset must be a positive value, as the application can only analyze data that is contained in the capture buffer.

Range: 0 to <Record length>
*RST: 0

Manual control: See "Capture Offset" on page 48

11.9 Programming Example: Analyzing MSR Signals

The following programming example demonstrates the use of the most important remote commands in MSRA mode. The example is based on the measurement example for manual operation described in chapter 10, "Measurement Example: Analyzing MSR Signals", on page 60.

```
//Preset
*RST

//Select Trace data output format: ASCII
FORM ASCII

//Switch to MSRA mode
INST:MODE MSR
```

```
//Set Sequencer in single mode
INIT:SEQ:MODE SING

//Preconfigure MSRA Master for general I/Q data acquisition

//Set initial center frequency
FREQ:CENT 1000MHz

//Set Level
DISP:WIND:TRAC:Y:SCAL:RLEV 10 dBm

//Set Trigger to External 1
:TRIG:SOUR EXT

//Set Sample Rate to 15MHz
:TRACe:IQ:SRATe 15E6

//Set Record Length to 1Msample -> AQT 21 ms
:TRACe:IQ:RLENgth 315000

//Create new measurement channel for I/Q Analyzer
INST:CRE IQ, 'IQ Analyzer'

//Set initial center frequency
FREQ:CENT 994.9 MHz

//Set Sample Rate to 1MHz
:TRACe:IQ:SRATe 1E6

//Set Record Length to 1Msample -> AQT 5 ms
:TRACe:IQ:RLENgth 5000

//Create measurement channel for 3GPP FDD BTS application
INST:CRE BWCD, '3GPP FDD BTS'

//Set initial center frequency
FREQ:CENT 997.5MHz

//Select Composite EVM vs slot in Window 1, EVM vs Chip in Window 3
//Result Summary remains in Window 2 as default
LAY:REPL:WIND '1',CEVM
LAY:ADD:WIND? '2',BEL,EVMC
//Result: new window is '5'

//Meas all tabs with synchronisation in MSRA mode
INIT:SEQ:IMM;*OPC?

//Retrieve Results of IQ Analyzer
INST:SEL 'IQ Analyzer'
```

```
//Check for Rising edge
:CALCulate:MARKer:X 1.14ms
:CALCulate:MARKer:Y?
:CALCulate:MARKer:X 1.156ms
:CALCulate:MARKer:Y?

//Retrieve Results from WCMDA
INST:SEL '3GPP FDD BTS'

//Retrieve Composite EVM results
TRAC1:DATA? TRACe1

//Select Slot No 1
CDP:SLOT 1

//Search Peak value of Marker in EVM vs Chip
:CALC5:MARK1 ON
:CALC5:MARK1:MAX:PEAK

//Retrieve Chip and max EVM value
:CALC5:MARK1:X?;Y?
```

A Annex

A.1 Reference: Format Description for I/Q Data Files

This section describes how I/Q data is transferred to the memory during remote control (see `TRACe:IQ:DATA:FORMat` on page 111 command).

For details on the format of the individual values, see chapter A.2, "Formats for Returned Values: ASCII Format and Binary Format", on page 121.

For details on the format of I/Q export files (using the "I/Q Export" function), see the R&S FSW User Manual.

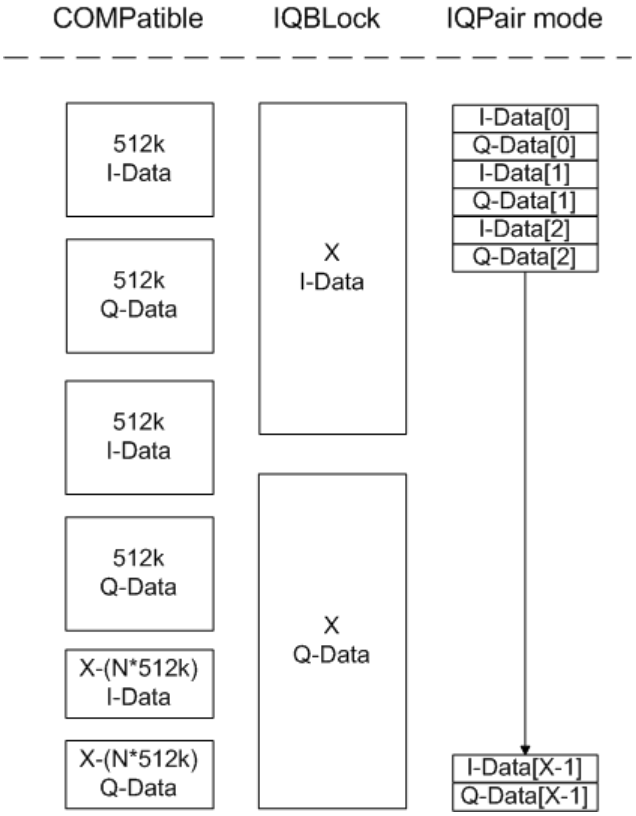


Fig. 1-1: I/Q data formats

Note: 512k corresponds to 524288 samples

For maximum performance, the formats "Compatible" or "IQPair" should be used. Furthermore, for large amounts of data, the data should be in binary format to improve performance.

In binary format, the number of I- and Q-data can be calculated as follows:

$$\#of\ I-Data\ =\ \#of\ Q-Data\ =\ \frac{\#of\ DataBytes}{8}$$

For the format "QBLock", the offset of Q-data in the output buffer can be calculated as follows:

$$Q - Data - Offset = \frac{(\#\ of\ DataBytes)}{2} + LengthIndicatorDigits$$

with "LengthIndicatorDigits" being the number of digits of the length indicator including the #. In the example above (#41024…), this results in a value of 6 for "LengthIndicator-Digits" and the offset for the Q-data results in 512 + 6 = 518.

A.2 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]`. 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,32):
  The data is stored as binary data (Definite Length Block Data according to IEEE 488.2), each measurement value being formatted in 32 Bit IEEE 754 Floating-Point-Format.
  The schema of the result string is as follows:
  `#41024<value1><value2>…<value n>` with

#4	number of digits (= 4 in the example) of the following number of data bytes
1024	number of following data bytes (= 1024 in the example)
<Value>	4-byte floating point value

Reading out data in binary format is quicker than in ASCII format. Thus, binary format is recommended for large amounts of data.

A.3 Sample Rate and Maximum Usable I/Q Bandwidth for RF Input

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

Bandwidth extension options

The maximum usable I/Q bandwidth provided by the R&S FSW in the basic installation can be extended by additional options. These options can either be included in the initial installation (B-options) or updated later (U-options). The maximum bandwidth provided by the individual option is indicated by its number, e.g. B80 extends the bandwidth to 80 MHz.

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

Max. usable I/Q BW	Required B-option	Required U-option(s)
10 MHz	-	-
28 MHz	B28	U28
40 MHz	B40	U28+U40 **or** B28+U40
80 MHz	B80	U28+U40+U80 **or** B28+U40+U80 **or** B40+U80
160 MHz	B160	U28+U40+U80+U160 **or** B28+U40+U80+U160 **or** B40+U80+U160 **or** B80+U160

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

Relationship between sample rate and usable I/Q bandwidth

Up to the maximum bandwidth, the following rule applies:

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

The figure 1-2 shows the maximum usable I/Q bandwidths depending on the output sample rates.

R&S FSW without additional bandwidth extension options

sample rate: 100 Hz - 10 GHz

maximum I/Q bandwidth: 10 MHz

Sample rate	Maximum I/Q bandwidth
100 Hz to 10 MHz	proportional up to maximum 10 MHz
10 MHz to 10 GHz	10 MHz

R&S FSW with options B28 or U28 (I/Q Bandwidth Extension):

sample rate: 100 Hz - 10 GHz

maximum bandwidth: 28 MHz

Sample rate	Maximum I/Q bandwidth
100 Hz to 35 MHz	proportional up to maximum 28 MHz
35 MHz to 10 GHz	28 MHz

R&S FSW with option B40 or U40 (I/Q Bandwidth Extension):

sample rate: 100 Hz - 10 GHz

maximum bandwidth: 40 MHz

Sample rate	Maximum I/Q bandwidth
100 Hz to 50 MHz	proportional up to maximum 40 MHz
50 MHz to 10 GHz	40 MHz

R&S FSW with option B80 or U80 (I/Q Bandwidth Extension):

sample rate: 100 Hz - 10 GHz

maximum bandwidth: 80 MHz

Sample rate	Maximum I/Q bandwidth
100 Hz to 100 MHz	proportional up to maximum 80 MHz
100 MHz to 10 GHz	80 MHz

R&S FSW with activated option B160 or U160 (I/Q Bandwidth Extension):

sample rate: 100 Hz - 10 GHz

maximum bandwidth: 160 MHz

Sample rate	Maximum I/Q bandwidth
100 Hz to 10 GHz	proportional up to maximum 1600 MHz

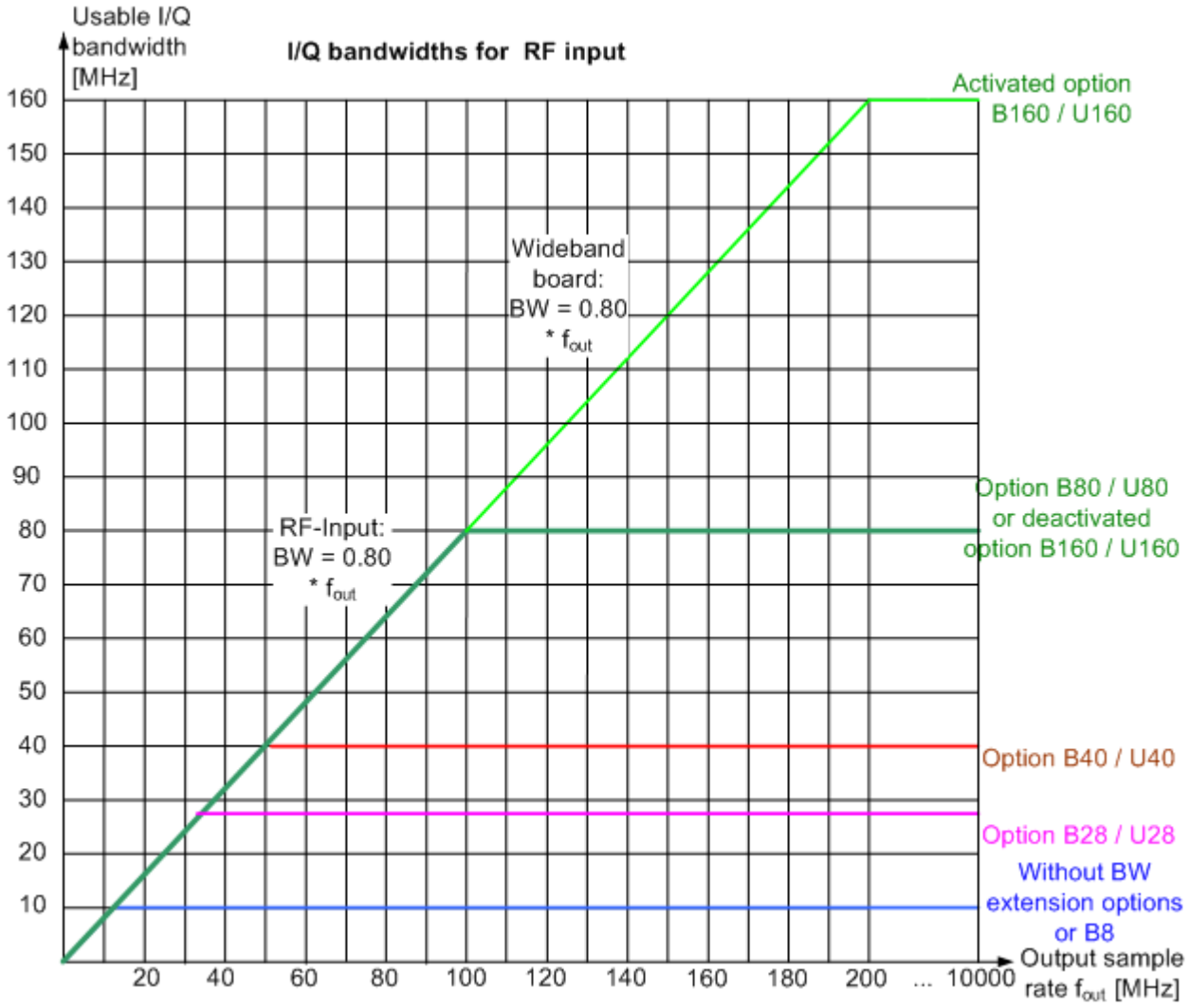


Fig. 1-2: Relationship between maximum usable I/Q bandwidth and output sample rate

A.4 Sample Rates and Bandwidths for Digital I/Q Data

Definitions

- **Clock rate**: the rate at which data is physically transmitted between the R&S FSW and the connected instrument; both instruments must be able to process data at this rate; the clock rate of the R&S FSW at the output connector is 100 MHz
- **Input sample rate (ISR)**: the sample rate of the useful data provided by the connected instrument to the digital input
- (User, Output) **Sample rate (SR)**: the sample rate that is defined by the user (e.g. in the "Data Aquisition" dialog box in the "I/Q Analyzer" application) and which is used as the basis for analysis or sent to the digital output

- **Usable I/Q (Analysis) bandwidth**: the bandwidth range in which the signal remains unchanged by the digital decimation filter and thus remains undistorted; this range can be used for accurate analysis by the R&S FSW

SlowI/Q measurements

"SlowI/Q" measurements are measurements where the user-defined sample rate exceeds the rate used to transfer valid samples. In the R&S FSW, the user-defined sample rate may exceed 10 GHz for "SlowI/Q" measurements. This happens, for example, when an analog signal is sampled by external hardware, e.g. an oscilloscope, with a sample rate larger than 10 GHz, is stored there in a memory temporarily and then read from the memory and transmitted to the R&S FSW at a slower rate than it was sampled. In this case, make sure the input sample rate is defined corrrespondingly for the connected instrument (see "Input Sample Rate" on page 34).

The following table describes the restrictions for digital in- and output:

Table 1-1: Restrictions for digital in- and output

Parameter	Minimum	Maximum
Record length	2 complex samples	220*1024*1024 complex samples
Input sample rate (ISR)	100 Hz	10 GHz
Sample Rate (SR) Digital input active: Digital output active:	 Max(100 Hz; ISR/8388608) 100 Hz	 Max[200 MHz; Min(10 GHz; 2*ISR)] 100 MHz
Usable I/Q bandwidth (Digital input and filter active)	Min(0.8*SR; 0.8*ISR)	

Bandwidths

Depending on the sample rate, the following bandwidths are available:

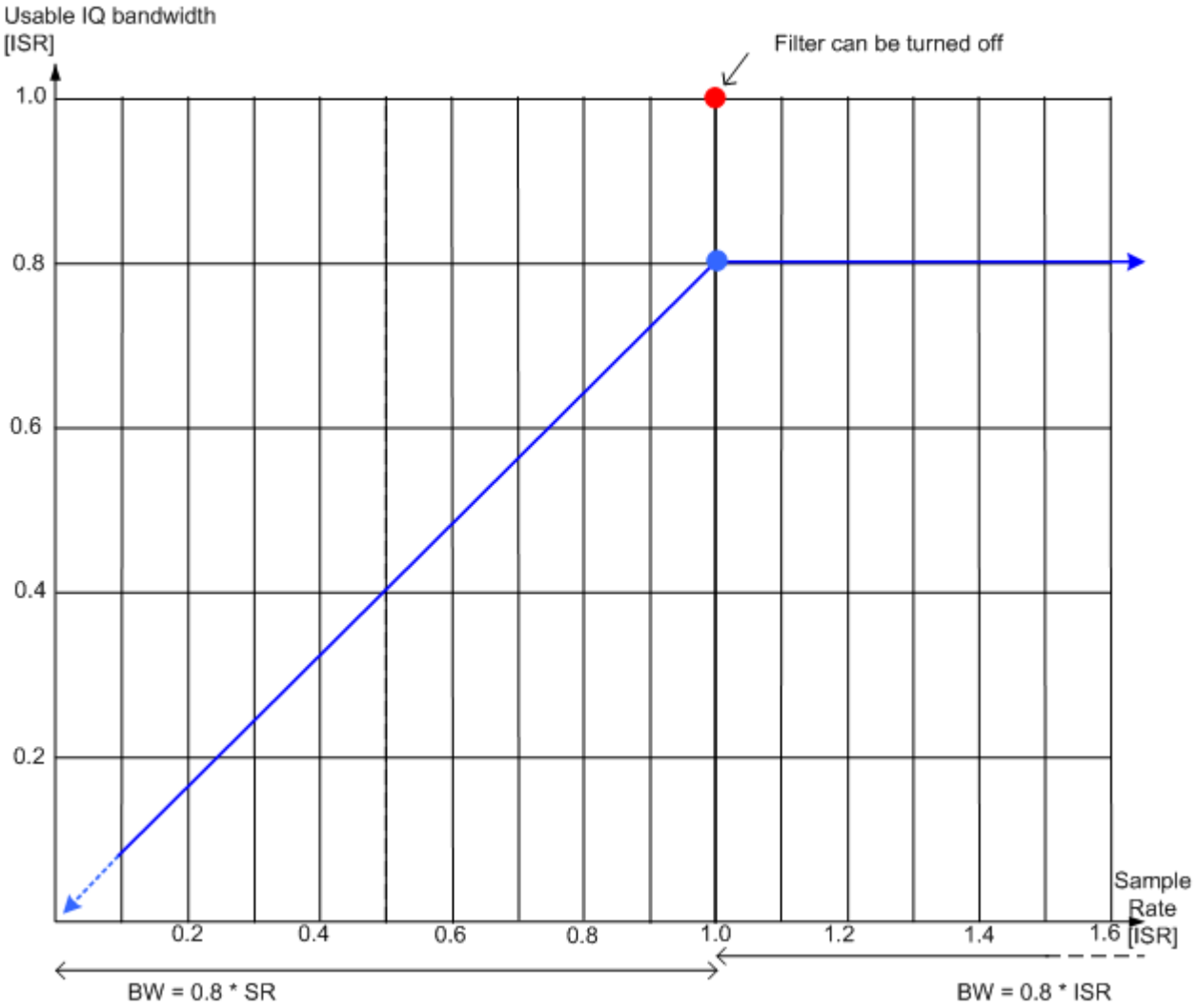


Fig. 1-3: Bandwidths depending on sample rate for active digital input

List of Remote Commands (MSRA)

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