R&S®FSW-K106
LTE NB-IoT Measurement Application (Downlink)
User Manual

1178593702
Version 16

ROHDE&SCHWARZ
Make ideas real

This manual applies to the following FSW models with firmware version 6.00 and later:

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

The following firmware options are described:

- R&S®FSW-K106 LTE NB-IoT Downlink Measurement Application (1331.6351.02)

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1178.5937.02 | Version 16 | R&S®FSW-K106

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

Contents

1 Documentation overview

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

www.rohde-schwarz.com/manual/FSW

Further documents are available at:

www.rohde-schwarz.com/product/FSW

1.1 Getting started manual

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

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

1.2 User manuals and help

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

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

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

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

1.3 Service manual

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

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

https://gloris.rohde-schwarz.com

1.4 Instrument security procedures

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

1.5 Printed safety instructions

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

1.6 Specifications and brochures

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

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

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

1.7 Release notes and open-source acknowledgment (OSA)

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

The firmware makes use of several valuable open source software packages. An open-source acknowledgment document provides verbatim license texts of the used open source software.

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

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

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

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

1.9 Videos

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

2 Welcome to the LTE NB-IoT measurement application

The LTE NB-IoT measurement application is a firmware application that adds functionality to measure on NB-IoT signals according to the 3GPP standard to the FSW.

This user manual contains a description of the functionality that the application provides, including remote control operation. Functions that are not discussed in this manual are the same as in the spectrum application and are described in the FSW user manual. The latest versions of the manuals are available for download at the product homepage.

https://www.rohde-schwarz.com/manual/fsw.

2.1 Installation

Find detailed installing instructions in the getting started or the release notes of the FSW.

2.2 Starting the LTE NB-IoT measurement application

The LTE NB-IoT measurement application adds a new application to the FSW.

Starting the NB-IoT application

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

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

2. Select the "NB-IoT" item.

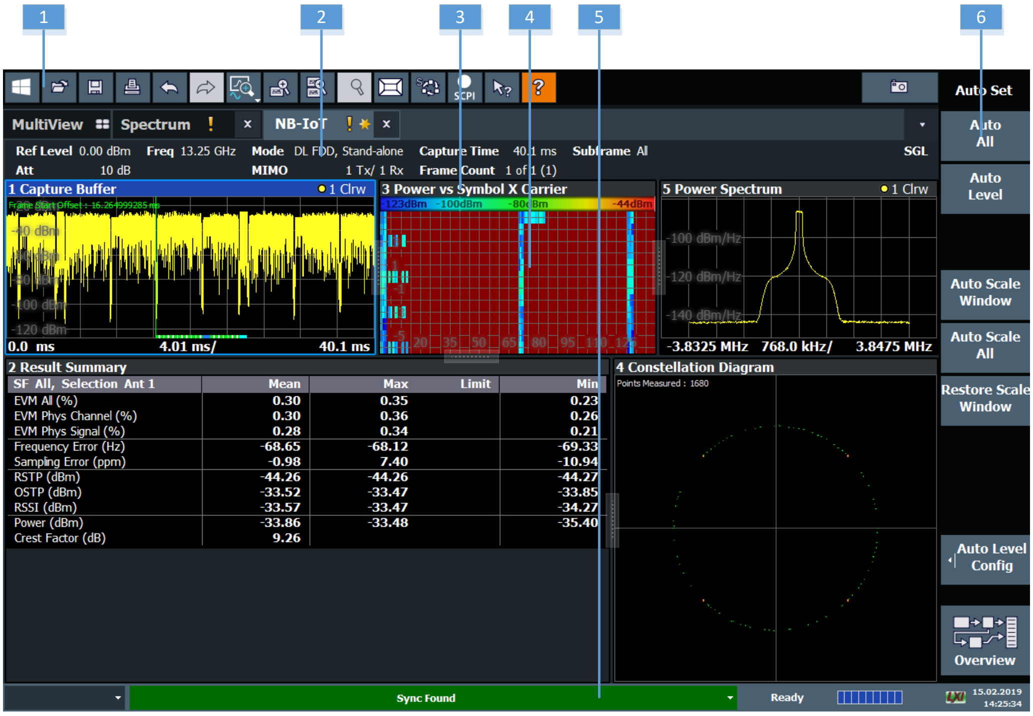
   The FSW opens a new measurement channel for the NB-IoT measurement application.

The application is started with the default settings. It can be configured in the "Overview" dialog box, which is displayed when you select the "Overview" softkey from the "Meas Setup" menu.

For more information, see Chapter 4, "Configuration", on page 35.

2.3 Understanding the display information

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



1 = Toolbar
2 = Channel bar
3 = Diagram header
4 = Result display
5 = Status bar
6 = Softkeys

Channel bar information

In the LTE NB-IoT measurement application, the FSW shows the following settings:

Table 2-1: Information displayed in the channel bar in the NB-IoT measurement application

Ref Level	Reference level
Att	Mechanical and electronic RF attenuation
Offset	Reference level offset
Freq	Frequency
E-UTRA Freq	Center frequency of the LTE channel (in-band deployment only)
Mode	NB-IoT standard
MIMO	Number of Tx and Rx antennas in the measurement setup
Capture Time	Length of the signal that has been captured

Frame Count	Number of frames that have been captured
Subframe	Subframe considered in the signal analysis

In addition, the channel bar displays information on instrument settings that affect the measurement results even though this is not immediately apparent from the display of the measured values (for example trigger settings). This information is displayed only when applicable for the current measurement. For details, see the FSW getting started manual.

Window title bar information

The information in the window title bar depends on the result display.

The "Constellation Diagram", for example, shows the number of points that have been measured.

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.

Regarding the synchronization state, the application shows the following labels.

- "Sync OK"
  The synchronization was successful. The status bar is green.
- "Sync Failed"
  The synchronization was not successful. The status bar is red.
  There can be three different synchronization errors.
  – "Sync Failed (Cyclic Prefix)": The cyclic prefix correlation failed.
  – "Sync Failed (NPSS)": The NPSS correlation failed.
  – "Sync Failed (NSSS)": The NSSS correlation failed.

3 Measurements and result displays

The LTE NB-IoT measurement application measures and analyzes various aspects of an NB-IoT signal.

It features several measurements and result displays. Measurements represent different ways of processing the captured data during the digital signal processing. Result displays are different representations of the measurement results. They can be diagrams that show the results as a graph or tables that show the results as numbers.

Remote command:

Measurement selection: `CONFigure[:LTE]:MEASurement` on page 120

Result display selection: `LAYout:ADD[:WINDow]?` on page 86

3.1 Selecting measurements

Access: "Overview" > "Select Measurement"

The "Select Measurement" dialog box contains several buttons. Each button represents a measurement. A measurement in turn is a set of result displays that thematically belong together and that have a particular display configuration. If these predefined display configurations do not suit your requirements, you can add or remove result displays as you like. For more information about selecting result displays, see Chapter 3.2, "Selecting result displays", on page 14.

Depending on the measurement, the FSW changes the way it captures and processes the raw signal data.

EVM

EVM measurements record, process and demodulate the signal's I/Q data. The result displays available for EVM measurements show various aspects of the NB-IoT signal quality.

For EVM measurements, you can combine the result displays in any way.

For more information on the result displays, see Chapter 3.5, "I/Q measurements", on page 16.

Remote command:
`CONFigure[:LTE]:MEASurement` on page 120

Time alignment error
Time alignment error (TAE) measurements record, process and demodulate the signal's I/Q data. The result displays available for TAE measurements indicate how well the antennas in a multi-antenna system are aligned.

For TAE measurements, you can combine the result displays in any way.

For more information on the result displays, see Chapter 3.6, "Time alignment error", on page 30.

Remote command:
`CONFigure[:LTE]:MEASurement` on page 120

Channel power ACLR
ACLR measurements sweep the frequency spectrum instead of processing I/Q data.

The ACLR measurements evaluates the leakage ratio of neighboring channels and evaluates if the signal is within the defined limits. The measurement provides several result displays. You can combine the result displays in any way.

For more information on the result displays, see Chapter 3.7, "Frequency sweep measurements", on page 31.

Remote command:
`CONFigure[:LTE]:MEASurement` on page 120

SEM
SEM measurements sweep the frequency spectrum instead of processing I/Q data.

The SEM measurements tests the signal against a spectrum emission mask and evaluates if the signal is within the defined limits. The measurement provides several result displays. You can combine the result displays in any way.

For more information on the result displays, see Chapter 3.7, "Frequency sweep measurements", on page 31.

Remote command:
`CONFigure[:LTE]:MEASurement` on page 120

3.2 Selecting result displays

Access: ⌧

The FSW opens a menu (the SmartGrid) to select result displays. For more information on the SmartGrid functionality, see the FSW Getting Started.

In the default state of the application, it shows several conventional result displays.

- Capture Buffer
- Power vs Symbol X Carrier
- Constellation Diagram
- Power Spectrum
- Result Summary

From that predefined state, add and remove result displays as you like from the Smart-Grid menu.

Remote command: `LAYout:ADD[:WINDow]?` on page 86

3.3 Performing measurements

By default, the application measures the signal continuously. In "Continuous Sweep" mode, the FSW captures and analyzes the data again and again.

- For I/Q measurements, the amount of captured data depends on the capture time.
- For frequency sweep measurement, the amount of captured data depends on the sweep time.

In "Single Sweep" mode, the FSW stops measuring after it has captured the data once. The amount of data again depends on the capture time.

Refreshing captured data

You can also repeat a measurement based on the data that has already been captured with the "Refresh" function. Repeating a measurement with the same data can be useful, for example, if you want to apply different modulation settings to the same I/Q data.

For more information, see the documentation of the FSW.

3.4 Selecting the operating mode

Access: [MODE] > "Multi-Standard Radio Analyzer Tab"

The NB-IoT application is supported by the Multi Standard Radio Analyzer (MSRA).

The MSRA mode supports all I/Q measurements and result displays available with the NB-IoT application, except the frequency sweep measurements (SEM and ACLR).

In MSRA operating mode, only the MSRA primary actually captures data. The application receives an extract of the captured data for analysis, referred to as the **application data**. The application data range is defined by the same settings used to define the signal capture in "Signal and Spectrum Analyzer" mode. In addition, a capture offset can be defined, i.e. an offset from the start of the captured data to the start of the analysis interval.

If a signal contains multiple data channels for multiple standards, separate applications are used to analyze each data channel. Thus, it is of interest to know which application is analyzing which data channel. The MSRA primary display indicates the data covered by each application by vertical blue lines labeled with the application name. The blue lines correspond to the channel bandwidth.

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

The analysis interval is automatically determined according to the Capture Time you have defined. The analysis interval cannot be edited directly in the NB-IoT application, but is changed automatically when you change the evaluation range. The currently used analysis interval (in seconds, related to capture buffer start) is indicated in the window header for each result display.

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

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

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

For details on the MSRA operating mode, see the FSW MSRA documentation.

3.5 I/Q measurements

Access: "Overview" > "Select Measurement" > "EVM/Frequency Err/Power"

You can select the result displays from the evaluation bar and arrange them as you like with the SmartGrid functionality.

Remote command:

Measurement selection: `CONFigure[:LTE]:MEASurement` on page 120

Result display selection: `LAYout:ADD[:WINDow]?` on page 86

Capture Buffer

The "Capture Buffer" shows the complete range of captured data for the last data capture.

The x-axis represents time. The maximum value of the x-axis is equal to the Capture Time.

The y-axis represents the amplitude of the captured I/Q data in dBm (for RF input).

The capture buffer uses the auto peak detector to evaluate the measurement data. The auto peak detector determines the maximum and the minimum value of the measured levels for each measurement point and combines both values in one sample point.

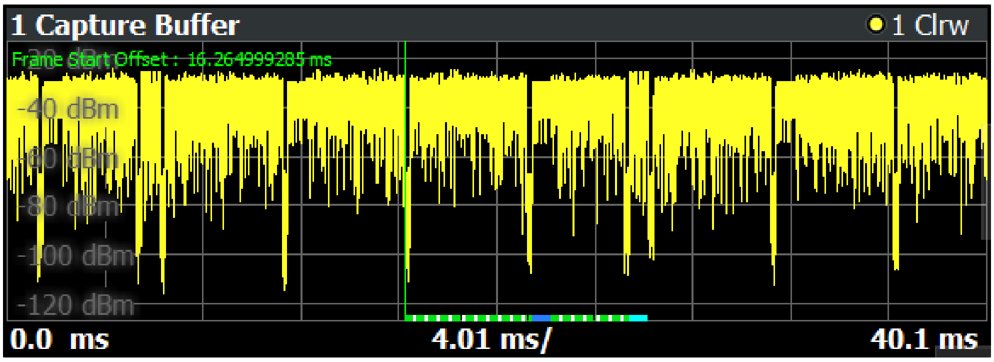


Figure 3-1: Capture buffer without zoom

A colored bar at the bottom of the diagram represents the frame that is currently analyzed. Different colors indicate the OFDM symbol type.

- Indicates the data stream.
- Indicates the reference signal and data.
- Indicates the NPSS and data.
- Indicates the NSSS and data.

A green vertical line at the beginning of the green bar in the capture buffer represents the subframe start. The diagram also contains the "Start Offset" value. This value is the time difference between the subframe start and capture buffer start.

When you zoom into the diagram, you will see that the bar is interrupted at certain positions. Each small bar indicates the useful parts of the OFDM symbol.

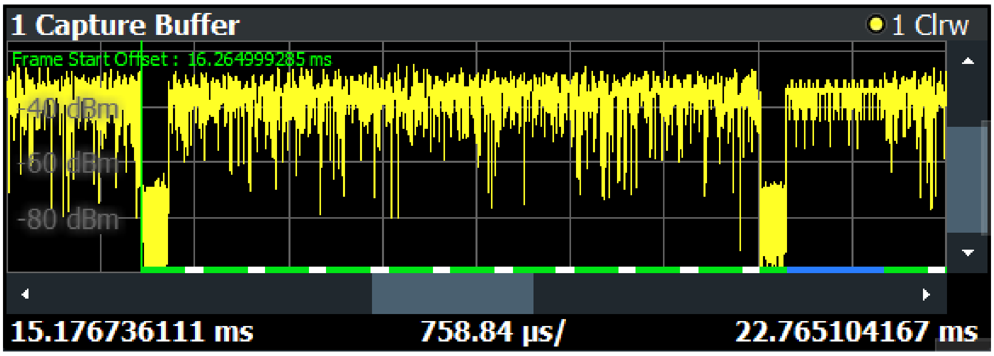


Figure 3-2: Capture buffer after a zoom has been applied

Remote command:
Selection: `LAY:ADD ? '1',LEFT,CBUF`
Query (y-axis): TRACe:DATA?
Query (x-axis): `TRACe<n>[:DATA]:X?` on page 107
Subframe start offset: `FETCh[:CC<cc>]:SUMMary:TFRame?` on page 114

EVM vs Carrier

The "EVM vs Carrier" result display shows the error vector magnitude (EVM) of the subcarriers. With the help of a marker, you can use it as a debugging technique to identify any subcarriers whose EVM is too high.

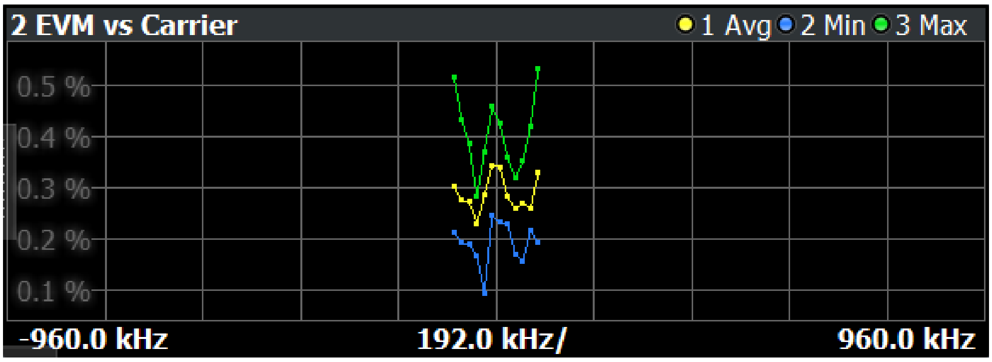
The results are based on an average EVM that is calculated over the resource elements for each subcarrier. This average subcarrier EVM is determined for each analyzed subframe in the capture buffer.

If you analyze all subframes, the result display contains three traces.

- Average EVM
  This trace shows the subcarrier EVM, averaged over all subframes.
- Minimum EVM
  This trace shows the lowest (average) subcarrier EVM that has been found over the analyzed subframes.
- Maximum EVM
  This trace shows the highest (average) subcarrier EVM that has been found over the analyzed subframes.

If you select and analyze one subframe only, the result display contains one trace that shows the subcarrier EVM for that subframe only. Average, minimum and maximum values in that case are the same. For more information, see "Subframe Selection" on page 69.

The x-axis represents the center frequencies of the subcarriers. The y-axis shows the EVM in % or in dB, depending on the EVM Unit.



Remote command:
Selection `LAY:ADD ? '1',LEFT,EVCA`
Query (y-axis): TRACe:DATA?
Query (x-axis): `TRACe<n>[:DATA]:X?` on page 107

EVM vs Symbol

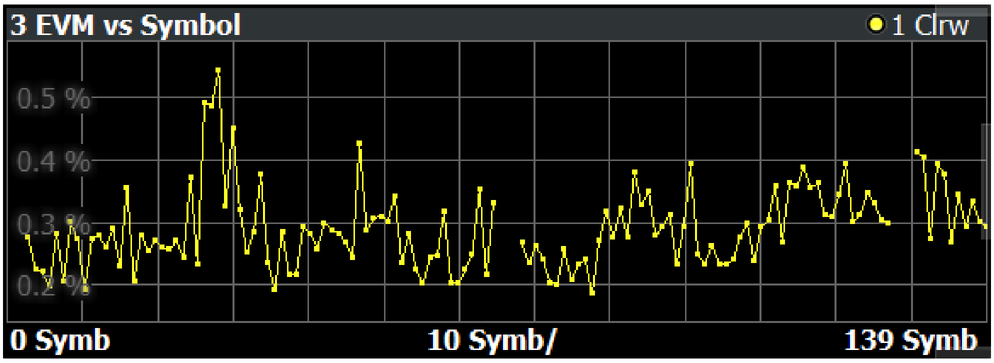
The "EVM vs Symbol" result display shows the error vector magnitude (EVM) of the OFDM symbols. You can use it as a debugging technique to identify any symbols whose EVM is too high.

The results are based on an average EVM that is calculated over all subcarriers that are part of a certain OFDM symbol. This average OFDM symbol EVM is determined for all OFDM symbols in each analyzed subframe.

The x-axis represents the OFDM symbols, with each symbol represented by a dot on the line. Any missing connections from one dot to another mean that the FSW could not determine the EVM for that symbol.

The number of displayed symbols depends on the subframe selection.

On the y-axis, the EVM is plotted either in % or in dB, depending on the EVM Unit.



Remote command:
Selection: `LAY:ADD ? '1',LEFT,EVSY`
Query (y-axis): TRACe:DATA?
Query (x-axis): `TRACe<n>[:DATA]:X?` on page 107

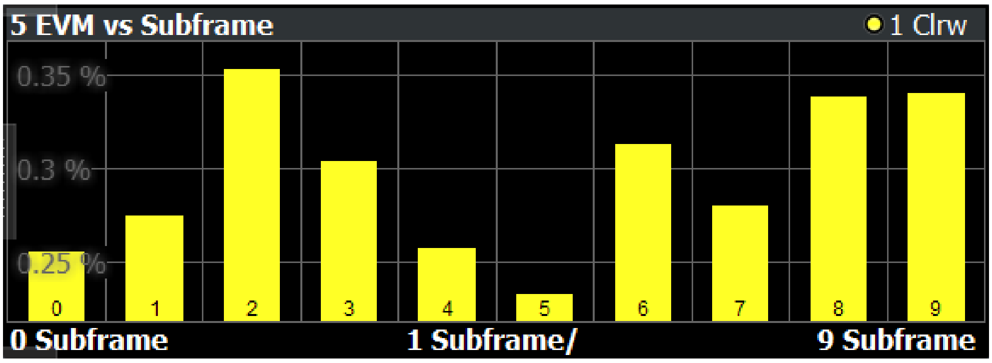
EVM vs Subframe

The "EVM vs Subframe" result display shows the Error Vector Magnitude (EVM) for each subframe. You can use it as a debugging technique to identify a subframe whose EVM is too high.

The result is an average over all subcarriers and symbols of a specific subframe.

The x-axis represents the subframes, with the number of displayed subframes being 10.

On the y-axis, the EVM is plotted either in % or in dB, depending on the EVM Unit.



Remote command:
Selection: `LAY:ADD ? '1',LEFT,EVSU`
Query (y-axis): TRACe:DATA?
Query (x-axis): `TRACe<n>[:DATA]:X?` on page 107

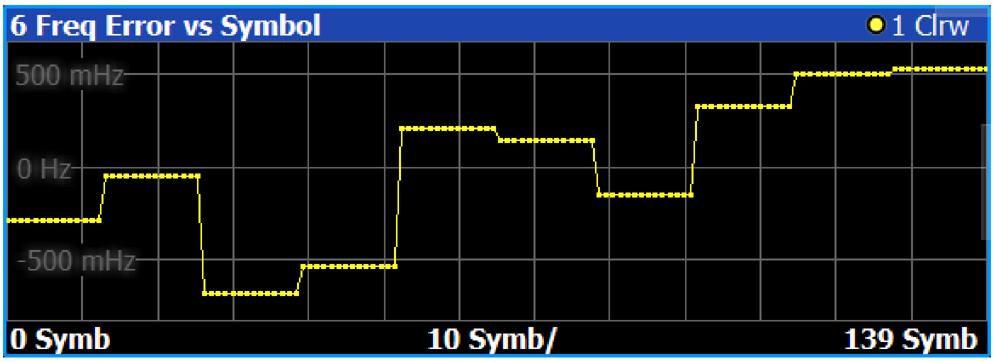
Frequency Error vs Symbol

Th e "Frequency Error vs Symbol" result display shows the frequency error of each symbol. You can use it as a debugging technique to identify any frequency errors within symbols.

The result is an average over all subcarriers in the symbol.

On the y-axis, the frequency error is plotted in Hz.

Note that the variance of the measurement results in this result display can be much higher compared to the frequency error display in the numerical result summary, depending on the NPDSCH and control channel configuration. The potential difference is caused by the number of available resource elements for the measurement on symbol level.



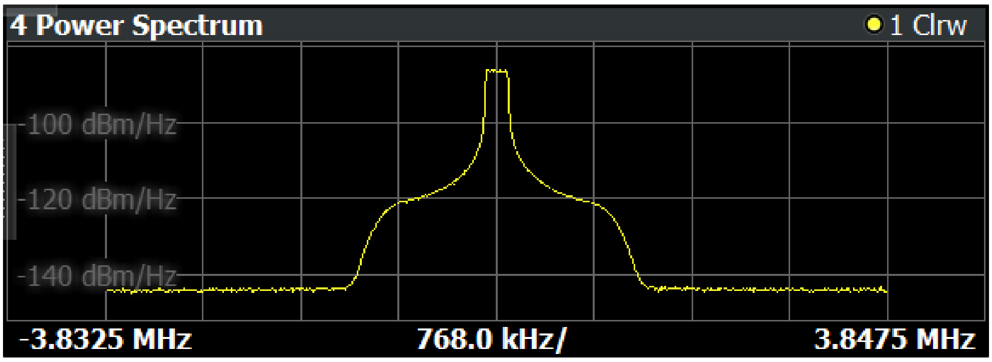
Remote command:
Selection: LAY:ADD ? '1',LEFT,FEVS
Query (y-axis): TRACe:DATA?
Query (x-axis): TRACe<n>[:DATA]:X? on page 107

Power Spectrum

The "Power Spectrum" shows the power density of the complete capture buffer in dBm/Hz.

The displayed bandwidth is always 7.68 MHz.

The x-axis represents the frequency. On the y-axis, the power level is plotted.



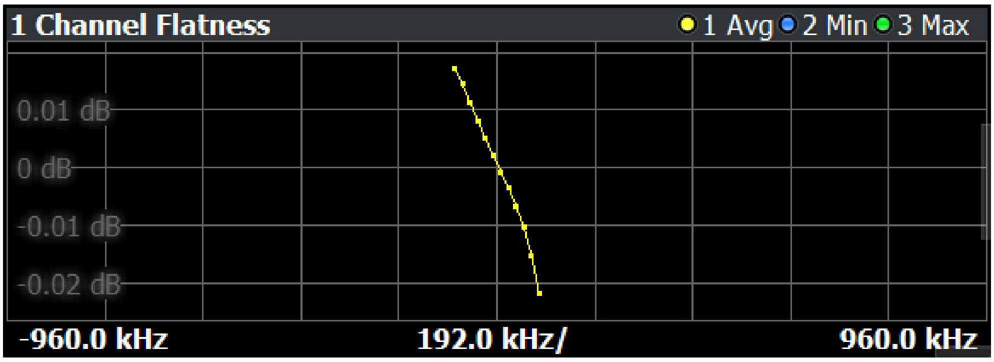
Remote command:
Selection: LAY:ADD ? '1',LEFT,PSPE
Query (y-axis): TRACe:DATA?
Query (x-axis): TRACe<n>[:DATA]:X? on page 107

Channel Flatness

The "Channel Flatness" shows the relative power offset caused by the transmit channel.

The currently selected subframe depends on your selection.

The x-axis represents the frequency. On the y-axis, the channel flatness is plotted in dB.



Remote command:
Selection: LAY:ADD ? '1',LEFT,FLAT
Query (y-axis): TRACe:DATA?
Query (x-axis): TRACe<n>[:DATA]:X? on page 107

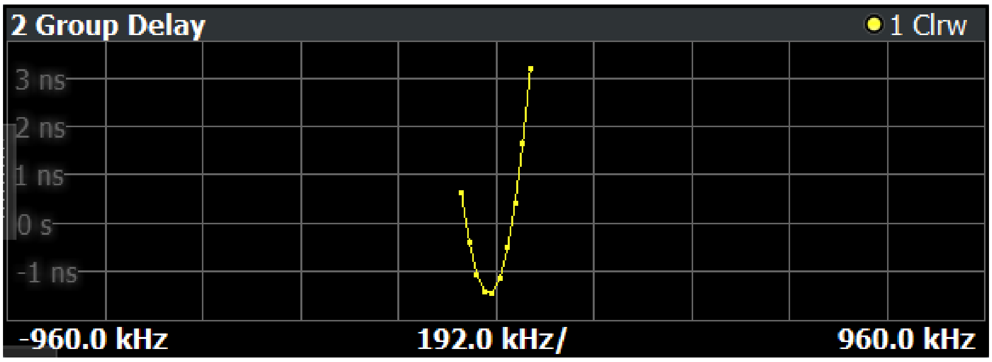
Group Delay

This "Group Delay" shows the group delay of each subcarrier.

The measurement is evaluated over the currently selected slot in the currently selected subframe.

The currently selected subframe depends on your selection.

The x-axis represents the frequency. On the y-axis, the group delay is plotted in ns.



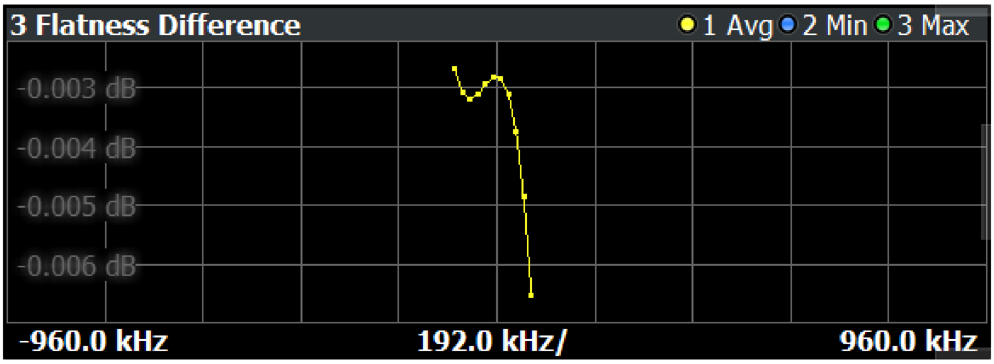
Remote command:
Selection: `LAY:ADD ? '1',LEFT,GDEL`
Query (y-axis): TRACe:DATA?
Query (x-axis): `TRACe<n>[:DATA]:X?` on page 107

Channel Flatness Difference

The "Channel Flatness Difference" shows the level difference in the spectrum flatness result between two adjacent physical subcarriers.

The currently selected subframe depends on your selection.

The x-axis represents the frequency. On the y-axis, the power is plotted in dB.



Remote command:
Selection: `LAY:ADD ? '1',LEFT,FDIF`
Query (y-axis): TRACe:DATA?
Query (x-axis): `TRACe<n>[:DATA]:X?` on page 107

Constellation Diagram

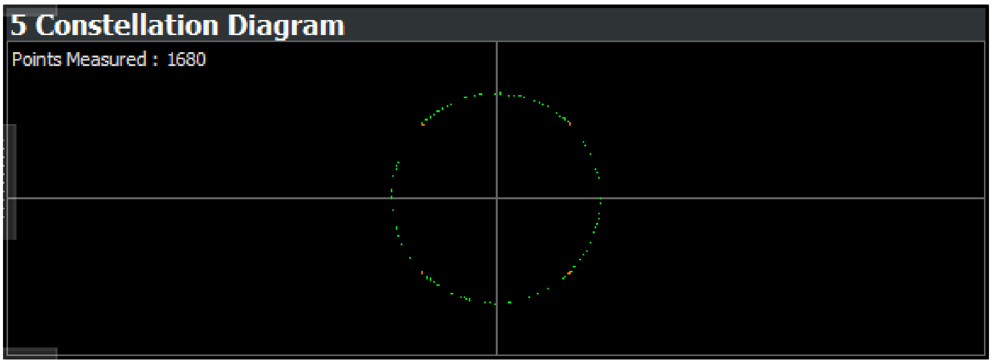
The "Constellation Diagram" shows the in-phase and quadrature phase results and is an indicator of the quality of the modulation of the signal.

In the default state, the result display evaluates the full range of the measured input data.

Each color represents a modulation type.

- : BPSK
- : RBPSK
- : MIXTURE
- : QPSK
- : PSK (CAZAC)

You can filter the results by changing the evaluation range.



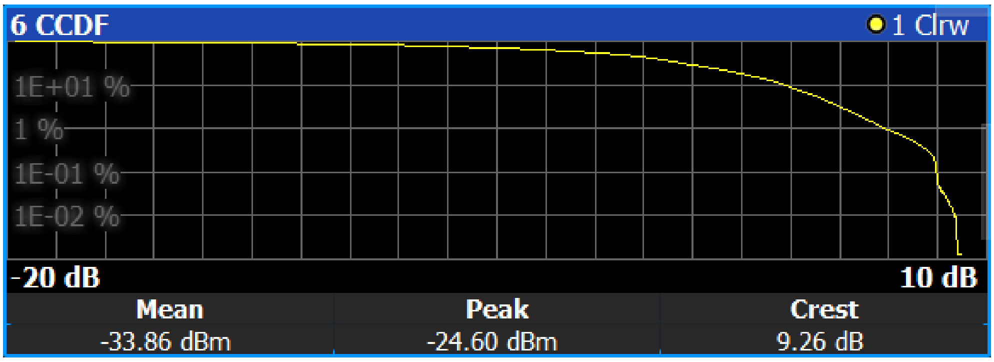
The constellation diagram also contains information about the current evaluation range, including the number of points that are displayed in the diagram.

Remote command:
Selection: `LAY:ADD ? '1',LEFT,CONS`
Query: TRACe:DATA?

CCDF

The "Complementary Cumulative Distribution Function (CCDF)" shows the probability of an amplitude exceeding the mean power. For the measurement, the complete capture buffer is used.

The x-axis represents the power relative to the measured mean power. On the y-axis, the probability is plotted in %.



In addition to the diagram, the results for the CCDF measurement are summarized in the CCDF table.

Mean	Mean power
Peak	Peak power
Crest	Crest factor (peak power – mean power)
10 %	10 % probability that the level exceeds mean power + [x] dB
1 %	1 % probability that the level exceeds mean power + [x] dB
0.1 %	0.1 % probability that the level exceeds mean power + [x] dB
0.01 %	0.01 % probability that the level exceeds mean power + [x] dB

Remote command:
Selection: LAY:ADD ? '1',LEFT,CCDF
Query (y-axis): TRACe:DATA?
Numerical results: CALCulate<n>:STATistics:CCDF:X<t>? on page 119
Numerical results: CALCulate<n>:STATistics:RESult<res>? on page 119

Allocation Summary
The "Allocation Summary" shows various parameters of the measured allocations in a table.

Each row in the allocation table corresponds to an allocation. A set of several allocations make up a subframe. A horizontal line indicates the beginning of a new subframe.

Special allocations summarize the characteristics of all allocations in a subframe ("ALL") and the complete frame (allocation "ALL" at the end of the table).

3 Allocation Summary

Sub-frame	Allocation ID	No of RBs	Rel Power [dB]	Modulation	Power per RE [dBm]	EVM [%]
0	NRS-Ant1		0.000	QPSK	-44.267	0.251
	NPBCH		-0.000	QPSK	-44.268	0.255
	ALL	0				0.255
1	NRS-Ant1		0.000	QPSK	-44.263	0.242
	NPDSCH/NPD...	1	-0.005	QPSK	-44.272	0.276
	ALL	1				0.274

The columns of the table show the following properties for each allocation.
- The location of the allocation (subframe number).
- The ID of the allocation (channel type).
- Number of resource blocks used by the allocation.
- The relative power of the allocation in dB.
- The modulation of the allocation.
- The power of each resource element in the allocation in dBm.
- The EVM of the allocation.
  The unit depends on the EVM unit
- The EVM over all codewords in a layer. The layer EVM is calculated for all data allocations, and not for the DMRS or other physical signals.
  The unit depends on the EVM unit

Remote command:
Selection: LAY:ADD ? '1',LEFT,ASUM
Query: TRACe:DATA?

Bitstream
The "Bitstream" shows the demodulated data stream for the data allocations.

At the end of the table is a summary of the bitstream for certain configurations.
- Total number of bits or symbols
- Total number of coded bits
- Total number of bit errors
- Bit error rate (BER) in percent
- Bits per second (= coded bits - bit errors)
  The totals are calculated over all NPDSCH allocations that contribute to the bit-stream. If the crc fails for one of the allocations, the FSW returns NAN for the total numbers.

The bitstream summary is displayed under the following conditions.
- Select NPDSCH reference data = "All 0".
- Turn off automatic demodulation of the NPDSCH to define the location of the NPDSCH (subframes and N_RNTI).

Depending on the bitstream format, the numbers represent either bits (bit order) or symbols (symbol order).

- For the bit format, each number represents one raw bit.
- For the symbol format, the bits that belong to one symbol are shown as hexadecimal numbers with two digits.

Resource elements that do not contain data or are not part of the transmission are represented by a "-".

n Table

Allocation ID	Code-word	Modulation	Symbol Index	Bitstream
NPBCH	1/1	QPSK	0	03 02 02 02 00 03 01 00 00 00 02 01 02 03 02 02
NPBCH	1/1	QPSK	16	03 01 02 00 02 03 01 03 00 01 03 00 02 01 03 00
NPBCH	1/1	QPSK	32	03 00 00 01 02 00 02 00 03 03 02 01 00 03 00 00
NPBCH	1/1	QPSK	48	01 01 03 03 01 01 03 03 03 00 00 02 03 01 03 02
NPBCH	1/1	QPSK	64	03 01 01 01 02 00 00 02 00 01 03 03 02 02 01 03
NPBCH	1/1	QPSK	80	03 03 01 03 01 00 00 00 01 01 00 00 00 03 03 02
NPBCH	1/1	QPSK	96	02 02 02 01

The table contains the following information:

- **Subframe**
  Number of the subframe the bits belong to.
- **Allocation ID**
  Channel the bits belong to.
- **Codeword**
  Code word of the allocation.
- **Modulation**
  Modulation type of the channels.
- **Symbol Index** or **Bit Index**

Indicates the position of the table row's first bit or symbol within the complete stream.

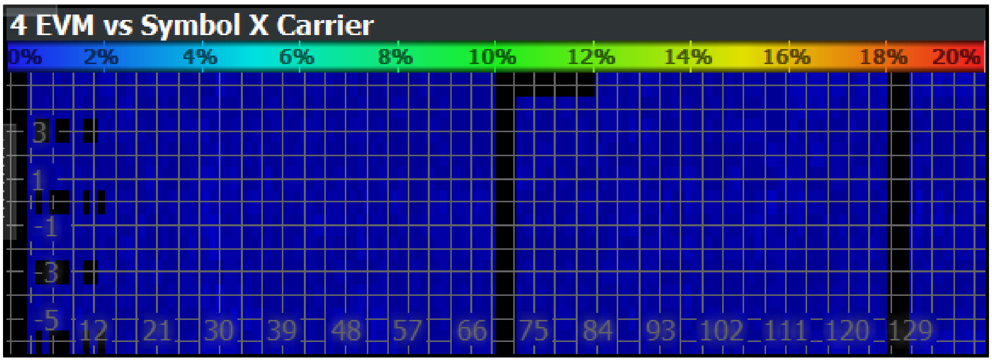
- **Bit Stream**
  The actual bit stream.

Remote command:
Selection: LAY:ADD ? '1',LEFT,BSTR

EVM vs Symbol x Carrier

The "EVM vs Symbol x Carrier" result display shows the EVM for each carrier in each symbol.

The x-axis represents the symbols. The y-axis represents the subcarriers. Different colors in the diagram area represent the EVM. A color map in the diagram header indicates the corresponding power levels.

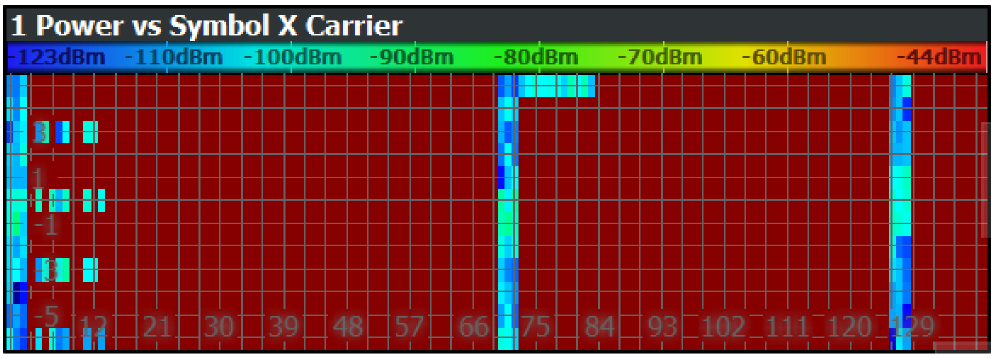


Remote command:
Selection: LAY:ADD ? '1',LEFT,EVSC
Query: TRACe:DATA?

Power vs Symbol x Carrier

The "Power vs Symbol x Carrier" result display shows the power for each carrier in each symbol.

The x-axis represents the symbols. The y-axis represents the subcarriers. Different colors in the diagram area represent the power. A color map in the diagram header indicates the corresponding power levels.



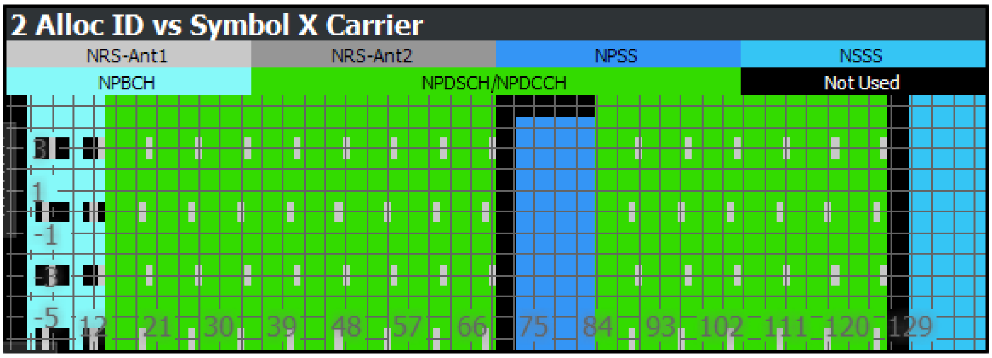
Remote command:
Selection: LAY:ADD ? '1',LEFT,PVSC
Query: TRACe:DATA?

Allocation ID vs Symbol x Carrier

The "Allocation ID vs Symbol x Carrier" result display is a graphical representation of the structure of the analyzed frame. It shows the allocation type of each subcarrier in each symbol of the received signal.

The x-axis represents the OFDM symbols. The y-axis represents the subcarriers.

Each type of allocation is represented by a different color. The legend above the diagram indicates the colors used for each allocation. You can also use a marker to get more information about the type of allocation.



Remote command:
Selection: `LAY:ADD ? '1',LEFT,AISC`
Query: TRACe:DATA?

Result Summary

The Result Summary shows all relevant measurement results in numerical form, combined in one table.

Remote command:

`LAY:ADD ? '1',LEFT,RSUM`

Contents of the result summary

6 Result Summary

SF All, Selection Ant 1	Mean	Max	Limit	Min
EVM All (%)	0.30	0.35		0.23
EVM Phys Channel (%)	0.30	0.36		0.26
EVM Phys Signal (%)	0.28	0.34		0.21
Frequency Error (Hz)	-68.65	-68.12		-69.33
Sampling Error (ppm)	-0.98	7.40		-10.94
RSTP (dBm)	-44.26	-44.26		-44.27
OSTP (dBm)	-33.52	-33.47		-33.85
RSSI (dBm)	-33.57	-33.47		-34.27
Power (dBm)	-33.86	-33.48		-35.40
Crest Factor (dB)	9.26			

The table shows results that refer to the complete frame. For each result, the minimum, mean and maximum values are displayed. It also indicates limit values as defined in the NB-IoT standard and limit check results where available. The font of 'Pass' results is green and that of 'Fail' results is red.

In addition to the red font, the application also puts a red star (* 25.60) in front of failed results.

By default, all EVM results are in %. To view the EVM results in dB, change the EVM Unit.

The second part of the table shows results that refer to a specific selection of the frame.

The statistic is always evaluated over the subframes.

The header row of the table contains information about the selection you have made (like the subframe).

EVM All

Shows the EVM for all resource elements in the analyzed frame.

`FETCh[:CC<cc>]:SUMMary:EVM[:ALL][:AVERage]?` on page 110

EVM Phys Channel

Shows the EVM for all physical channel resource elements in the analyzed frame.

A physical channel corresponds to a set of resource elements carrying information from higher layers. NPDSCH, NPBCH or NPDCCH, for example, are physical channels. For more information, see 3GPP 36.211.

`FETCh[:CC<cc>]:SUMMary:EVM:PCHannel[:AVERage]?` on page 111

EVM Phys Signal

Shows the EVM for all physical signal resource elements in the analyzed frame.

The reference signal, for example, is a physical signal. For more information, see 3GPP 36.211.

`FETCh[:CC<cc>]:SUMMary:EVM:PSIGnal[:AVERage]?` on page 111

Frequency Error

Shows the difference in the measured center frequency and the reference center frequency.

`FETCh[:CC<cc>]:SUMMary:FERRor[:AVERage]?` on page 111

Sampling Error

Shows the difference in measured symbol clock and reference symbol clock relative to the system sampling rate.

`FETCh[:CC<cc>]:SUMMary:SERRor[:AVERage]?` on page 114

RSTP

Shows the reference signal transmit power as defined in 3GPP TS 36.141. It is required for the "DL RS Power" test.

It is an average power and accumulates the powers of the reference symbols within a subframe divided by the number of reference symbols within a subframe.

`FETCh[:CC<cc>]:SUMMary:RSTP[:AVERage]?` on page 113

OSTP

Shows the OFDM symbol transmit power as defined in 3GPP TS 36.141.

It accumulates all subcarrier powers of the 4th OFDM symbol. The 4th (out of 14 OFDM symbols within a subframe (for frame type 1, normal CP length)) contains exclusively NPDSCH.

`FETCh[:CC<cc>]:SUMMary:OSTP[:AVERage]?` on page 112

RSSI

Shows the Received Signal Strength Indicator. The RSSI is the complete signal power of the channel that has been measured, regardless of the origin of the signal.

`FETCh[:CC<cc>]:SUMMary:RSSI[:AVERage]?` on page 113

Power

Shows the average time domain power of the analyzed signal.

`FETCh[:CC<cc>]:SUMMary:POWer[:AVERage]?` on page 112

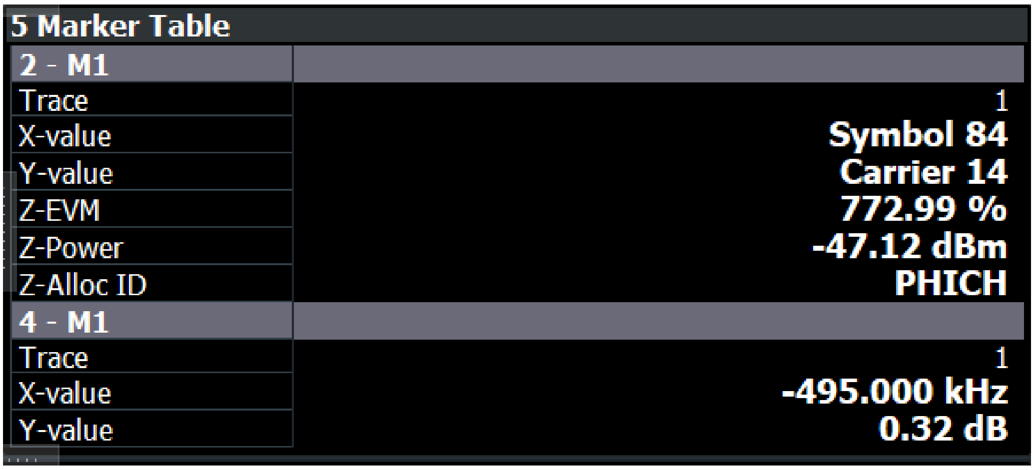
NB-IoT Power	Shows the power of all resource elements used by NB-IoT. FETCh[:CC<cc>]:SUMMary:NBPower[:AVERage]? on page 113
Crest Factor	Shows the peak-to-average power ratio of captured signal. FETCh[:CC<cc>]:SUMMary:CRESt[:AVERage]? on page 110

Marker Table

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

This table is displayed automatically if configured accordingly.

Wnd	Shows the window the marker is in.
Type	Shows the marker type and number ("M" for a normal marker, "D" for a delta marker).
Trc	Shows the trace that the marker is positioned on.
Ref	Shows the reference marker that a delta marker refers to.
X- / Y-Value	Shows the marker coordinates (usually frequency and level).
Z-EVM **Z-Power** **Z-Alloc ID**	Shows the "EVM", power and allocation type at the marker position. Only in 3D result displays (for example "EVM vs Symbol x Carrier").



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

Remote command:

`LAY:ADD? '1',RIGH, MTAB`, see LAYout:ADD[:WINDow]? on page 86

Results:

CALCulate<n>:MARKer<m>:X on page 116

CALCulate<n>:MARKer<m>:Y on page 117

CALCulate<n>:MARKer<m>:Z? on page 118

CALCulate<n>:MARKer<m>:Z:ALL? on page 118

3.6 Time alignment error

Access: "Overview" > "Select Measurement" > "Time Alignment"

The time alignment error measurement captures and analyzes new I/Q data when you select it.

The time alignment error measurement only works under the following conditions:

- It is only available in a MIMO setup (2 antennas).
  Therefore, you have to mix the signal of the antennas into one cable that you can connect to the FSW. For more information on configuring and performing a time alignment measurement, see Chapter A, "Performing time alignment measurements", on page 169.
- It is only available for the stand alone deployment.

In addition to the result displays mentioned in this section, the time alignment measurement also supports the following result displays described elsewhere.

- "Capture Buffer" on page 17
- "Power Spectrum" on page 21
- "Marker Table" on page 29

You can select the result displays from the evaluation bar and arrange them as you like with the SmartGrid functionality.

Remote command:

Measurement selection: `CONFigure[:LTE]:MEASurement` on page 120

Result display selection: `LAYout:ADD[:WINDow]?` on page 86

Time Alignment Error
The time alignment is an indicator of how well the transmission antennas in a MIMO system are synchronized. The time alignment error is the time delay between a reference antenna (for example antenna 1) and another antenna.

The application shows the results in a table.

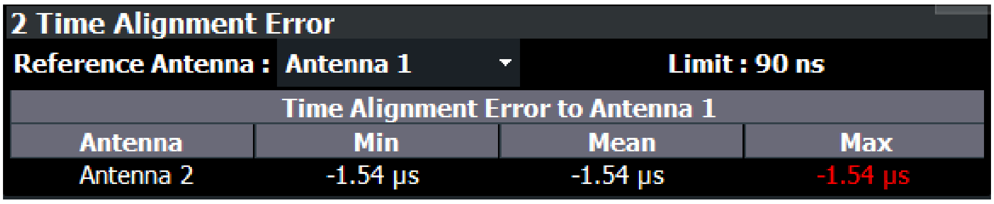
Each row in the table represents one antenna. The reference antenna is not shown.

For each antenna, the maximum, minimum and average time delay that has been measured is shown. The minimum and maximum results are calculated only if the measurement covers more than one subframe.

In any case, results are only displayed if the transmission power of both antennas is within 15 dB of each other. Likewise, if only one antenna transmits a signal, results will not be displayed (for example if the cabling on one antenna is faulty).

For more information on configuring this measurement, see Chapter 4.3, "Time alignment error measurements", on page 62.

The "Limit" value shown in the result display is the maximum time delay that may occur for each antenna (only displayed for systems without carrier aggregation).



You can select the reference antenna from the dropdown menu in the result display. You can also select the reference antenna in the MIMO Setup - if you change them in one place, they are also changed in the other.

In the default layout, the application also shows the "Capture Buffer" and "Power Spectrum" result displays for each component carrier.

Remote command:
Selection: `LAY:ADD ? '1',LEFT,TAL`
Query: `FETCh:TAERror[:CC<cc>]:ANTenna<ant>[:AVERage]?` on page 115
Reference antenna: `CONFigure[:LTE]:DL[:CC<cc>]:MIMO:ASELection` on page 129

3.7 Frequency sweep measurements

Access (ACLR): "Meas Setup" > "Select Measurement" > "Channel Power ACLR"

Access (SEM): "Meas Setup" > "Select Measurement" > "Spectrum Emission Mask"

The NB-IoT aplication supports the following frequency sweep measurements.

- Adjacent channel leakage ratio (ACLR)
- Spectrum emission mask (SEM)

Instead of using I/Q data, the frequency sweep measurements sweep the spectrum every time you run a new measurement. Therefore, it is mandatory to feed a signal into the RF input for these measurements. Using previously acquired I/Q data for the frequency sweep measurements is not possible (and vice-versa).

Because each of the frequency sweep measurements uses different settings to obtain signal data it is also not possible to run a frequency sweep measurement and view the results in another frequency sweep measurement.

Make sure to have sufficient bandwidth to be able to capture the whole signal, including neighboring channels.

Features of the frequency sweep measurements:

- Frequency sweep measurements are only available for the stand alone deployment.

In addition to the specific diagrams and table (see description below), frequency sweep measurements support the following result displays.

- "Marker Table" on page 29
- Marker peak list
  Both result displays have the same contents as the spectrum application.

Remote command:

Measurement selection: CONFigure[:LTE]:MEASurement on page 120

Result display selection: LAYout:ADD[:WINDow]? on page 86

Adjacent Channel Leakage Ratio (ACLR)

The adjacent channel leakage ratio (ACLR) measurement is designed to analyze signals that contain multiple signals for different radio standards. Using the ACLR measurement, you can determine the power of the transmit (Tx) channel and the power of the neighboring (adjacent) channels to the left and right of the Tx channel. Thus, the ACLR measurement provides information about the power in the adjacent channels as well as the leakage into these adjacent channels.

When you measure the ACLR in the NB-IoT application, the FSW automatically selects appropriate ACLR settings based on the selected channel bandwidth.

For a comprehensive description of the ACLR measurement, refer to the user manual of the FSW.

Remote command:
Selection: CONF:MEAS ACLR

Result diagram ← Adjacent Channel Leakage Ratio (ACLR)

The result diagram is a graphic representation of the signals with a trace that shows the measured signal. Individual channels (Tx and adjacent channels) are indicated by vertical lines and corresponding labels.

In addition, the FSW highlights the channels (blue: Tx channel, green: adjacent channels).

The x-axis represents the frequency with a frequency span that relates to the specified NB-IoT channel and adjacent channel bandwidths. On the y-axis, the power is plotted in dBm.

The power for the Tx channel is an absolute value in dBm. The power of the adjacent channels is relative to the power of the Tx channel.

In addition, the FSW tests the ACLR measurement results against the limits defined by 3GPP.

Remote command:
Result query: TRACe:DATA?

Result summary ← Adjacent Channel Leakage Ratio (ACLR)

The result summary shows the signal characteristics in numerical form. Each row in the table corresponds to a certain channel type (Tx, adjacent channel). The columns contain the channel characteristics.

- **Channel**
  Shows the channel type (Tx, adjacent or alternate channel).
- **Bandwidth**
  Shows the channel bandwidth.
- **Offset**
  Shows the channel spacing.
- **Power**
  Shows the power of the Tx channel.
- **Lower / Upper**
  Shows the relative power of the lower and upper adjacent and alternate channels. The values turn red if the power violates the limits.

Remote command:
Result query: `CALCulate<n>:MARKer<m>:FUNCtion:POWer<sb>:RESult[:CURRent]?`

Spectrum Emission Mask (SEM)
The "Spectrum Emission Mask" (SEM) measurement shows the quality of the measured signal by comparing the power values in the frequency range near the carrier against a spectral mask that is defined by the 3GPP specifications. In this way, you can test the performance of the DUT and identify the emissions and their distance to the limit.

For a comprehensive description of the SEM measurement, refer to the user manual of the FSW.

Remote command:
Selection (SEM): `CONF:MEAS ESP`

Result diagram ← Spectrum Emission Mask (SEM)
The result diagram is a graphic representation of the signal with a trace that shows the measured signal. The SEM is represented by a red line.

If any measured power levels are above that limit line, the test fails. If all power levels are inside the specified limits, the test passes. The application labels the limit line to indicate whether the limit check has passed or failed.

The x-axis represents the frequency with a frequency span that relates to the specified NB-IoT channel bandwidths. The y-axis shows the signal power in dBm.

Remote command:
Result query: TRACe:DATA?

Result summary ← Spectrum Emission Mask (SEM)
The result summary shows the signal characteristics in numerical form. Each row in the table corresponds to a certain SEM range. The columns contain the range characteristics. If a limit fails, the range characteristics turn red.

- **Start / Stop Freq Rel**
  Shows the start and stop frequency of each section of the spectrum emission mask relative to the center frequency.
- **RBW**
  Shows the resolution bandwidth of each section of the spectrum emission mask.
- **Freq at Δ to Limit**

Shows the absolute frequency whose power measurement being closest to the limit line for the corresponding frequency segment.

- **Power Abs**
  Shows the absolute measured power of the frequency whose power is closest to the limit. The application evaluates this value for each frequency segment.
- **Power Rel**
  Shows the distance from the measured power to the limit line at the frequency whose power is closest to the limit. The application evaluates this value for each frequency segment.
- **Δ to Limit**
  Shows the minimal distance of the tolerance limit to the SEM trace for the corresponding frequency segment. Negative distances indicate that the trace is below the tolerance limit, positive distances indicate that the trace is above the tolerance limit.

Marker Peak List

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

3 Marker Peak List

Wnd	No	X-Value	Y-Value
2	1	1.086245 ms	-75.810 dBm
2	2	2.172490 ms	-6.797 dBm
2	3	3.258736 ms	-76.448 dBm
2	4	4.831918 ms	-76.676 dBm
2	5	6.255274 ms	-76.482 dBm
2	6	6.798397 ms	-6.800 dBm
2	7	9.233084 ms	-76.519 dBm
2	8	10.075861 ms	-76.172 dBm
2	9	11.405574 ms	-6.801 dBm

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

Remote command:
`LAY:ADD? '1',RIGH, PEAK`, see `LAYout:ADD[:WINDow]?` on page 86
Results:
`CALCulate<n>:MARKer<m>:X` on page 116
`CALCulate<n>:MARKer<m>:Y` on page 117

4 Configuration

LTE NB-IoT measurements require a special application on the FSW, which you can select by adding a new measurement channel or replacing an existing one.

When you start the LTE NB-IoT application, the FSW starts to measure the input signal with the default configuration or the configuration of the last measurement (if you haven't performed a preset since then).

Automatic refresh of preview and visualization in dialog boxes after configuration changes

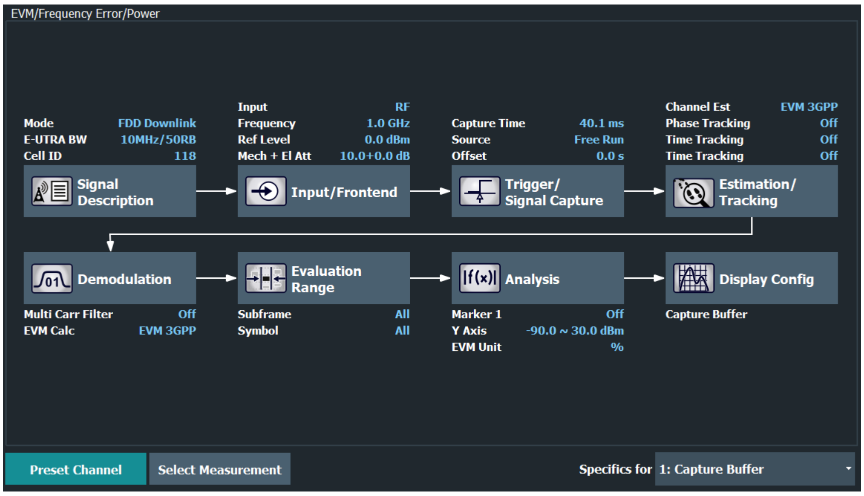
The FSW supports you in finding the correct measurement settings quickly and easily - after each change in settings in dialog boxes, the preview and visualization areas are updated immediately and automatically to reflect the changes. Thus, you can see if the setting is appropriate or not before accepting the changes.

Unavailable hardkeys

Note that the [SPAN], [BW], [TRACE], [LINES] and [MKR FUNC] keys have no contents and no function in the NB-IoT application.

4.1 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" menu item from the "Meas Setup" menu.



In addition to the main measurement settings, the "Overview" provides quick access to the main settings dialog boxes. The individual configuration steps are displayed in the order of the data flow. Thus, you can easily configure an entire measurement channel from input over processing to output and analysis by stepping through the dialog boxes as indicated in the "Overview".

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

1. Signal Description
   See Chapter 4.2.1, "Defining signal characteristics", on page 37.
2. Input / Frontend
   See Chapter 4.2.6, "Input source configuration", on page 44.
3. Trigger / Signal Capture
   See Chapter 4.2.10, "Trigger configuration", on page 57.
   See Chapter 4.2.9, "Configuring the data capture", on page 55
4. Estimation / Tracking
   See Chapter 4.2.11, "Parameter estimation and tracking", on page 58.
5. Demodulation
   See Chapter 4.2.12, "Configuring demodulation parameters", on page 60.
6. Evaluation Range
   See Chapter 5.2.2, "Evaluation range", on page 69.
7. Analysis
   See Chapter 5, "Analysis", on page 65.
8. Display Configuration
   See Chapter 3, "Measurements and result displays", on page 13.

In addition, the dialog box provides the "Select Measurement" button that serves as a shortcut to select the measurement type.

To configure settings

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

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

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

Remote command:
`SYSTem:PRESet:CHANnel[:EXEC]` on page 121

Select Measurement
Opens a dialog box to select the type of measurement.

For more information about selecting measurements, see Chapter 3.1, "Selecting measurements", on page 13.

Remote command:
`CONFigure[:LTE]:MEASurement` on page 120

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

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

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

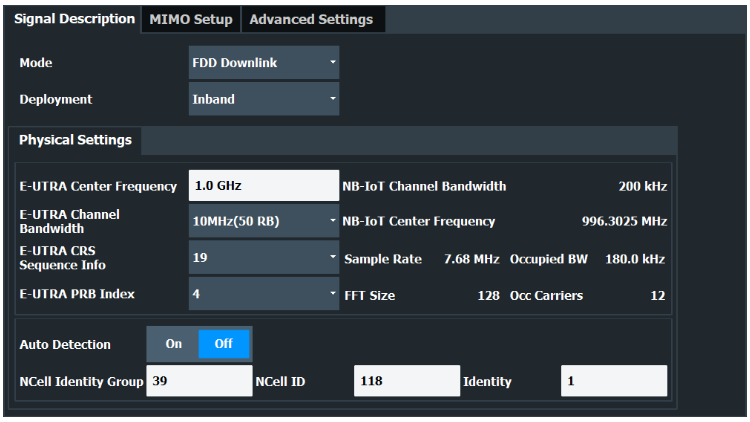
4.2 I/Q measurements

4.2.1 Defining signal characteristics

Access: "Overview" > "Signal Description" > "Signal Description"

The general signal characteristics contain settings to describe the general physical attributes of the signal. They are part of the "Signal Description" tab of the "Signal Description" dialog box.

The contents of the "Signal Description" dialog box depend on the deployment you have selected.



The remote commands required to configure the physical signal characteristics are described in "Physical settings" on page 122.

Selecting the NB-IoT mode

The "Mode" selects the NB-IoT link direction you are testing.

Note that the FSW only supports measurements on FDD downlink (DL) signals.

FDD and TDD are **duplexing** methods.

- FDD mode uses different frequencies for the uplink and the downlink.
- TDD mode uses the same frequency for the uplink and the downlink.
  Note that the NB-IoT standard only supports FDD mode.

Downlink (DL) and Uplink (UL) describe the **transmission path**.

- Downlink is the transmission path from the base station to the user equipment.
  The physical layer mode for the downlink is always OFDMA.
- Uplink is the transmission path from the user equipment to the base station.

The application shows the currently selected NB-IoT mode (including the bandwidth) in the channel bar.

Remote command:
not supported

Deployment

The 3GPP standard specifies several operating modes, or deployment. The deployment specifies where the NB-IoT signal is located in the frequency spectrum.

You can select the deployment of the signal you are testing from the "Deployment" dropdown menu.

The application supports the following deployments.
- "Stand Alone"
  The NB-IoT signal uses a dedicated spectrum outside of an LTE band, for example a frequency band currently used by GSM. With a carrier bandwidth of 200 kHz in GSM, there is enough room for an NB-IoT carrier (180 kHz), including a guard interval of 10 kHz on both sides of the carrier.
- "In Band"
  The NB-IoT signal uses resource blocks within an LTE carrier.
- "Guard Band"
  The NB-IoT signal uses the resource blocks of the guard band of an LTE carrier.

Remote command:
`CONFigure[:LTE]:DEPLoyment` on page 122

Carrier Type
Selects the NB-IoT carrier type. 3GPP defines different carrier types for NB-IoT signals.

"Anchor"	The UE assumes a carrier that transmits NPSS, NSSS, NPBCH and SIB-NB.
"Non-Anchor"	The UE assumes a carrier that does not transmit NPSS, NSSS, NPBCH and SIB-NB.

Remote command:
`CONFigure[:LTE]:TYPE` on page 127

Defining physical settings for NB-IoT stand alone deployment
The physical properties of the NB-IoT signal depend on the channel bandwidth.

Currently, the 3GPP standard specifies a 200 kHz bandwidth for an NB-IoT carrier. This bandwidth corresponds to one LTE resource block (RB).

The application derives various other physical properties of the measured signal from the bandwidth.

- "Number of Resource Blocks" (NB_1RB)
- "FFT Size"
- "Sample Rate"
- "Occupied Bandwidth"
- "Occupied Carriers"

All values are read only.

Remote command:
not supported

Defining physical settings for NB-IoT inband deployment
When you use the in band deployment, you have to specify the characteristics of the LTE (E-UTRA) channel that the NB-IoT channel is located in.

Define the following E-UTRA properties:
- "E-UTRA Center Frequency"
  Center frequency of the LTE channel.
- "E-UTRA Channel Bandwidth"
  Channel bandwidth of the LTE channel (3 MHz, 5 MHz, 10 MHz, 15 MHz or 20 MHz).

Note that the 1.4 MHz bandwidth is not supported for in band transmission of NB-IoT signals.

- "E-UTRA CRS Sequence Info"
  Cell-specific reference signal sequence. The sequence defines the assignment of resources between LTE and NB-IoT. These sequences are defined in 3GPP 36.213, chapter 16.8.
- "E-UTRA PRB Index"
  For inband deployment, the physical resource block (PRB) index is derived from the E-UTRA CRS sequence info. It defines the location of the NB-IoT carriers in the E-UTRA signal.

In addition, the application shows various physical properties of the NB-IoT signal.

- "NB-IoT Channel Bandwidth", which is currently always 200 kHz.
- "NB-IoT Center Frequency", which is calculated from the E-UTRA channel characteristics.
- "FFT Size"
- "Sample Rate"
- "Occupied Bandwidth"
- "Occupied Carriers"

Remote command:
E-UTRA center frequency: `CONFigure[:LTE]:EUTRa:FREQuency` on page 123
E-UTRA channel bandwidth: `CONFigure[:LTE]:DL[:CC<cc>]:BW` on page 125
E-UTRA CRS sequence: `CONFigure[:LTE]:DL:SINFo` on page 124
E-UTRA PRB index: `CONFigure[:LTE]:DL:PINDex` on page 124
Query NB-IoT center frequency: `[SENSe:]FREQuency:CENTer[:CC<cc>]` on page 139

Defining physical settings for NB-IoT guardband deployment

When you use the guard band deployment, you have to specify the characteristics of the LTE (E-UTRA) channel that the NB-IoT channel is located in.

Define the following E-UTRA properties:

- "E-UTRA Center Frequency"
  Center frequency of the LTE channel.
- "E-UTRA Channel Bandwidth"
  Channel bandwidth of the LTE channel (3 MHz, 5 MHz, 10 MHz, 15 MHz or 20 MHz).
  Note that the 1.4 MHz bandwidth is not supported for guard band transmission of NB-IoT signals.
- "Δf to DC"
  Location of the center frequency of the NB-IoT carrier relative to center frequency of the E-UTRA carrier (DC).
  The location of the NB-IoT carrier in the guard band must fulfill several requirements, so possible frequencies are predefined. Available values depend on the "E-UTRA Channel Bandwidth".
  If you select the "User Defined" menu item, you can also define locations that do not fulfill the requirements specified by 3GPP in the "User Value" field.
  Positive values correspond to a location in the upper guard band, negative values to a location in the lower guard band.

In addition, the application shows various physical properties of the NB-IoT signal.

- "NB-IoT Channel Bandwidth", which is currently always 200 kHz.
- "NB-IoT Center Frequency", which is calculated from the E-UTRA channel characteristics.
- "FFT Size"
- "Sample Rate"
- "Occupied Bandwidth"
- "Occupied Carriers"

Remote command:
E-UTRA center frequency: `CONFigure[:LTE]:EUTRa:FREQuency` on page 123
E-UTRA channel bandwidth: `CONFigure[:LTE]:DL[:CC<cc>]:BW` on page 125
Location: `CONFigure[:LTE]:DL:FREQuency:GINDex` on page 123
Custom location: `CONFigure[:LTE]:DL:FREQuency:OFFSet` on page 124
Query NB-IoT center frequency: `[SENSe:]FREQuency:CENTer[:CC<cc>]` on page 139

Configuring the Physical Layer Cell Identity

The "NCell ID", "NCell Identity Group" and physical layer "Identity" are interdependent parameters. In combination, they are responsible for synchronization between network and user equipment.

The physical layer cell ID identifies a particular radio cell in the NB-IoT network. The cell identities are divided into 168 unique cell identity groups. Each group consists of 3 physical layer identities. According to:

$$N_{ID}^{cell} = 3 \cdot N_{ID}^{(1)} + N_{ID}^{(2)}$$

$N^{(1)}$ = cell identity group, {0...167}
$N^{(2)}$ = physical layer identity, {0...2}

there is a total of 504 different cell IDs.

If you change one of these three parameters, the application automatically updates the other two.

For automatic detection of the cell ID, turn on the "Auto" function.

Before it can establish a connection, the user equipment must synchronize to the radio cell it is in. For this purpose, two synchronization signals are transmitted on the downlink. These two signals are reference signals whose content is defined by the "Physical Layer Identity" and the "Cell Identity Group".

Remote command:
Cell ID: `CONFigure[:LTE]:DL[:CC<cc>]:PLC:CID` on page 125
Cell Identity Group (setting): `CONFigure[:LTE]:DL[:CC<cc>]:PLC:CIDGroup` on page 126
Cell Identity Group (query): `FETCh[:CC<cc>]:PLC:CIDGroup?` on page 127
Identity (setting): `CONFigure[:LTE]:DL[:CC<cc>]:PLC:PLID` on page 126
Identity (query): `FETCh[:CC<cc>]:PLC:PLID?` on page 127

4.2.2 Test scenarios

Access: "Overview" > "Signal Description" > "Test Models"

Test scenarios are descriptions of specific NB-IoT signals for standardized testing of DUTs. These test scenarios are stored in .allocation files. You can select, manage and create test scenarios in the "Test Models" dialog box.

3GPP test models
Test models are certain signal descriptions defined by 3GPP for various test scenarios. 3GPP calls them N-TM. These N-TM are defined in 3GPP 36.141.

There are three main test model groups, one for guardband operation, one for inband operation and one for standalone operation. Each of these main groups in turn contain signal descriptions for specific signal configurations (different transmission type, different bandwidth etc.).

Remote command:
MMEMory:LOAD[:CC<cc>]:TMOD:DL on page 128

User defined test scenarios
User defined test scenarios are custom signal descriptions for standardized measurements that you can save and restore as you like. To create a custom test scenario, describe a signal as required and then save it with the corresponding button. The FSW stores custom scenarios in .allocation files.

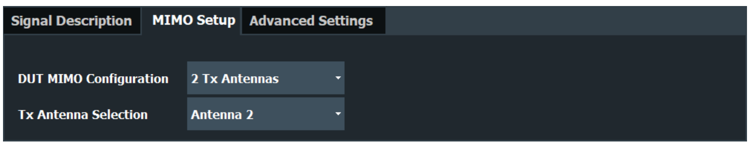
If you do not need test scenarios any longer, you can also delete them.

Remote command:
Save: MMEMory:STORe<n>[:CC<cc>]:DEModsetting on page 128
Restore: MMEMory:LOAD[:CC<cc>]:DEModsetting on page 128

4.2.3 Configuring MIMO setups

Access: "Overview" > "Signal Description" > "MIMO Setup"

MIMO measurements need a special setup that you can configure with the settings available in the MIMO configuration dialog box.



DUT MIMO Configuration
The "DUT MIMO Configuration" selects the number of antennas in the system you are analyzing.

The FSW supports measurements on one and two antennas.

Remote command:
CONFigure[:LTE]:DL[:CC<cc>]:MIMO:CONFig on page 129

Tx Antenna Selection
The "Tx Antenna Selection" selects the antenna(s) you want to analyze. The number of menu items depends on the number of antennas in the system.

Each antenna corresponds to a cell-specific reference signal.

Antenna 1	Tests antenna 1 only.
Antenna 2	Tests antenna 2 only.
Auto	Automatically selects the antenna to test.

The antenna you have selected is also the reference antenna for time alignment measurements.

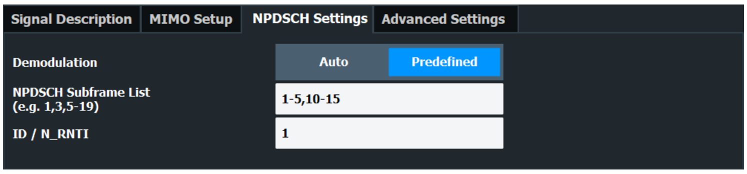
Remote command:
CONFigure[:LTE]:DL[:CC<cc>]:MIMO:ASELection on page 129

4.2.4 NPDSCH settings

Access: "Overview" > "Signal Description" > "NPDSCH Settings"

The NPDSCH settings contain settings to configure the parts of the NPDSCH that are evaluated.

The Narrowband Physical Downlink Shared Channel (NPDSCH) is the traffic channel and carries SIBs, upper layer data, and RAR messages. The application allows you to automatically demodulate the channel of the signal you are testing.



The remote commands required to configure the NPDSCH are described in "NPDSCH settings" on page 130.

NPDSCH Demodulation
Turns automatic demodulation of the NPDSCH on and off.

When you turn on this feature, the application automatically detects and demodulates both NPDSCH and NPDCCH subframes (NPDSCH and NPDCCH subframes are not distinguished by the application).

When you turn off automatic demodulation, you can specify in which subframes and in which N_RNTI (user equipment) the NPDSCH information is located in the signal. You can specify subframe numbers as a comma-separated list (1,2,6,7), a certain range with a dash (1-3), or a combination of both (1-3,5,6). The N_RNTI is a value between 0 and 65535.

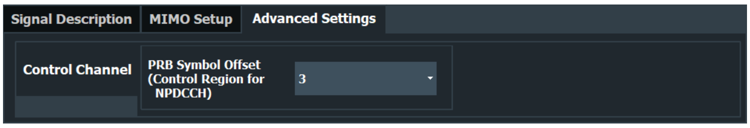
This information about the NPDSCH is required to distinguish between NPDSCH and NPDCCH information, which in turn is required to calculate bit error information in the bitstream result display.

Remote command:
State: CONFigure[:LTE]:DL:NPDSch:DMODulation on page 130
Subframes: CONFigure[:LTE]:DL:NPDSch:SFList on page 130
ID: CONFigure[:LTE]:DL:NPDSch:UEID on page 130

4.2.5 Configuring the control channel

Access: "Overview" > "Signal Description" > "Advanced Settings" > "Control Channel"

The NPDSCH resource block symbol offset is part of the "Advanced Settings" tab of the "Signal Description" dialog box.



PRB Symbol Offset
PRB Symbol Offset specifies the symbol offset of the NPDSCH allocations relative to the subframe start. This setting applies to all subframes in a frame.

Only available for the in band deployment.

Remote command:
CONFigure[:LTE]:DL[:CC<cc>]:PSOFfset on page 131

4.2.6 Input source configuration

The FSW supports several input sources and outputs.

For a comprehensive description of the supported inputs and outputs, refer to the FSW user manual.

4.2.6.1 RF input

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

Functions to configure the RF input described elsewhere:

- "Input Coupling" on page 54

- "Impedance" on page 55

Direct Path

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

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

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

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

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

Remote command:
`INPut:DPATh` on page 134

High Pass Filter 1 to 3 GHz

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

This function requires an additional hardware option.

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

Remote command:
`INPut:FILTer:HPASs[:STATe]` on page 136

YIG-Preselector

Enables or disables the YIG-preselector.

This setting requires an additional option on the FSW.

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

Note: 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.

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

The YIG-"Preselector" is off by default.

Remote command:
`INPut:FILTer:YIG[:STATe]` on page 136

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

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

"RF"	(Default:) The "RF Input" connector
"RF Probe"	The "RF Input" connector with an adapter for a modular probe This setting is only available if a probe is connected to the "RF Input" connector. It is not available for an active external frontend.
"Baseband Input I"	The optional "Baseband Input I" connector This setting is only available if the optional "Analog Baseband" interface is installed and active for input. It is not available for the FSW67. For FSW85 models with two input connectors, this setting is only available for "Input 1".

Remote command:
`INPut:CONNector` on page 132

4.2.6.2 External mixer

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

Controlling external generators is available with the optional external generator control. The functionality is the same as in the spectrum application.

For more information about using external generators, refer to the FSW user manual.

4.2.6.3 Digital I/Q input

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

Digital I/Q Input State
Enables or disable the use of the "Digital I/Q" input source for measurements.

"Digital I/Q" is only available if the optional "Digital Baseband" is installed.

Remote command:
`INPut:SELect` on page 137

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 20 GHz.

Remote command:
`INPut:DIQ:SRATe` on page 134
`INPut:DIQ:SRATe:AUTO` on page 134

Full Scale Level

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

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

Remote command:
`INPut:DIQ:RANGe[:UPPer]` on page 133
`INPut:DIQ:RANGe[:UPPer]:UNIT` on page 134
`INPut:DIQ:RANGe[:UPPer]:AUTO` on page 133

Adjust Reference Level to Full Scale Level

If enabled, the reference level is adjusted to the full scale level automatically if any change occurs.

Remote command:
`INPut:DIQ:RANGe:COUPling` on page 133

Connected Instrument

Displays the status of the "Digital Baseband" interface connection.

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

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

Remote command:
`INPut:DIQ:CDEVice` on page 132

4.2.6.4 Analog baseband

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

Analog Baseband Input State

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

Remote command:
`INPut:SELect` on page 137

I/Q Mode

Defines the format of the input signal.

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

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

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

Remote command:
`INPut:IQ:TYPE` on page 137

Input Configuration

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

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

"Single-ended" I, Q data only

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

Remote command:
`INPut:IQ:BALanced[:STATe]` on page 136

High Accuracy Timing Trigger - Baseband - RF
Activates a mode with enhanced timing accuracy between analog baseband, RF and external trigger signals.

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

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

Remote command:
`CALibration:AIQ:HATiming[:STATe]` on page 132

4.2.6.5 Baseband oscilloscope

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

Capturing I/Q data with an oscilloscope is available with the optional baseband oscilloscope inputs. The functionality is the same as in the spectrum application.

For details, see the user manual of the I/Q analyzer.

4.2.6.6 I/Q file

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

As an alternative to capturing the measurement (I/Q) data live, you can also load previously recorded I/Q data stored in an `iq.tar` file. The file is then used as the input source for the application.

Available for I/Q based measurements.

For details, see the user manual of the I/Q analyzer.

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

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

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

Remote command:
`INPut:SELect` on page 137

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

The I/Q data must have a specific format (`.iq.tar`) as described in FSW I/Q Analyzer and I/Q Input user manual.

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

Remote command:
`INPut:FILE:PATH` on page 135

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

Remote command:
`TRACe:IQ:FILE:REPetition:COUNt` on page 139

Selected Channel
Only available for files that contain more than one data stream from multiple channels: selects the data stream to be used as input for the currently selected channel.

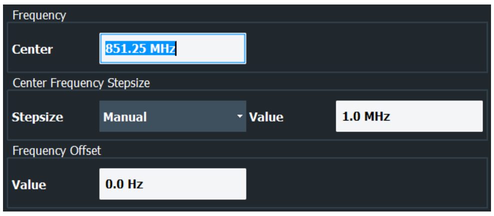
In "Auto" mode (default), the first data stream in the file is used as input for the channel. Applications that support multiple data streams use the first data stream in the file for the first input stream, the second for the second stream etc.

Remote command:
`MMEMory:LOAD:IQ:STReam` on page 138
`MMEMory:LOAD:IQ:STReam:AUTO` on page 139
`MMEMory:LOAD:IQ:STReam:LIST?` on page 139

4.2.7 Frequency configuration

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

Frequency settings define the frequency characteristics of the signal at the RF input. They are part of the "Frequency" tab of the "Signal Characteristics" dialog box.



The remote commands required to configure the frequency are described in Chapter 6.9.2.3, "Frequency configuration", on page 139.

Signal Frequency
For measurements with an RF input source, you have to match the **center frequency** of the analyzer to the frequency of the signal.

Center Frequency ← Signal Frequency
Defines the center frequency of the signal and thus the frequency the FSW tunes to.

The frequency range depends on the hardware configuration of the analyzer you are using.

Note that the center frequency for the in-band deployment is the center frequency of the used LTE channel (E-UTRA frequency).

Remote command:
Center frequency: `[SENSe:]FREQuency:CENTer[:CC<cc>]` on page 139
Frequency offset: `[SENSe:]FREQuency:CENTer[:CC<cc>]:OFFSet` on page 140

Frequency Stepsize ← Signal Frequency
In addition to the frequency itself, you can also define a frequency stepsize. The frequency stepsize defines the extent of a frequency change if you change it, for example with the rotary knob.

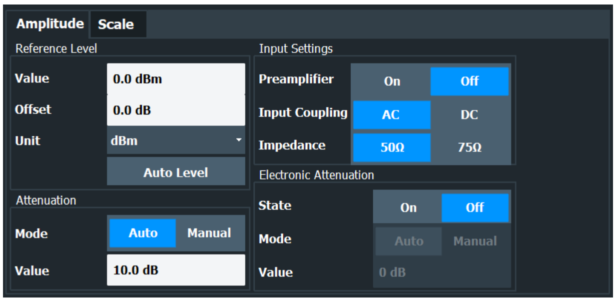
You can define the stepsize in two ways.
- = Center
  One frequency step corresponds to the current center frequency.
- Manual
  Define any stepsize you need.

Remote command:
Frequency stepsize: `[SENSe:]FREQuency:CENTer:STEP` on page 140

4.2.8 Amplitude configuration

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

Amplitude settings define the expected level characteristics of the signal at the RF input.



The remote commands required to configure the amplitude are described in Chapter 6.9.2.4, "Amplitude configuration", on page 141.

Reference Level

The reference level is the power level the analyzer expects at the RF input. Keep in mind that the power level at the RF input is the peak envelope power for signals with a high crest factor like NB-IoT.

To get the best dynamic range, you have to set the reference level as low as possible. At the same time, make sure that the maximum signal level does not exceed the reference level. If it does, it will overload the A/D converter, regardless of the signal power. Measurement results can deteriorate (e.g. EVM), especially for measurements with more than one active channel near the one you are trying to measure (± 6 MHz).

Note that the signal level at the A/D converter can be stronger than the level the application displays, depending on the current resolution bandwidth. This is because the resolution bandwidths are implemented digitally after the A/D converter.

The reference level is a value in dBm.

Remote command:
Reference level: `DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel` on page 141

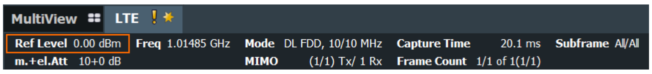
Auto Level ← Reference Level

Automatically determines the ideal reference level. The automatic leveling process measures the signal and defines the ideal reference signal for the measured signal.

Automatic level detection also optimizes RF attenuation.

Auto leveling slightly increases the measurement time, because of the extra leveling measurement prior to each sweep. By default, the FSW automatically defines the time for auto leveling, but you can also define it manually ([Auto Set] > "Auto Level Config" > "Meas Time").

The application shows the current reference level (including RF and external attenuation) in the channel bar.



Remote command:
Automatic: [SENSe:]ADJust:LEVel<ant> on page 156
Auto level mode: [SENSe:]ADJust:CONFigure:LEVel:DURation:MODE on page 156
Auto level time: [SENSe:]ADJust:CONFigure:LEVel:DURation on page 155

Reference Level Offset ← Reference Level
The reference level offset is an arithmetic level offset. A level offset is useful if the signal is attenuated or amplified before it is fed into the analyzer. All displayed power level results are shifted by this value. Note however, that the reference value ignores the level offset. Thus, it is still mandatory to define the actual power level that the analyzer has to handle as the reference level.

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:RLEVel:OFFSet on page 141

Attenuating the Signal
Attenuation of the signal becomes necessary if you have to reduce the power of the signal that you have applied. Power reduction is necessary, for example, to prevent an overload of the input mixer.

For a comprehensive information about signal attenuation, refer to the user manual of the FSW.

The NB-IoT measurement application provides several attenuation modes.

RF Attenuation ← Attenuating the Signal
Controls the RF (or mechanical) attenuator at the RF input.

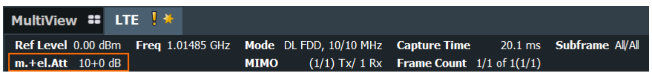
If you select automatic signal attenuation, the attenuation level is coupled to the reference level.

If you select manual signal attenuation, you can define an arbitrary attenuation (within the supported value range).

Positive values correspond to signal attenuation and negative values correspond to signal gain.

Note that when you are using an external frontend, you can define attenuation for the analyzer and the external frontend separately. For more information about external frontends, refer to the user manual of the I/Q analyzer.

The application shows the attenuation level (mechanical and electronic) in the channel bar.



Remote command:
State: INPut:ATTenuation<ant>:AUTO on page 142
Level: INPut:ATTenuation<ant> on page 142

Electronic Attenuation ← Attenuating the Signal
Controls the optional electronic attenuator.

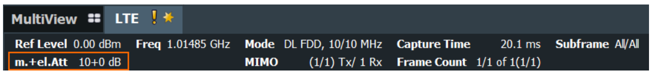
If you select automatic signal attenuation, the attenuation level is coupled to the reference level.

If you select manual signal attenuation, you can define an arbitrary attenuation (within the supported value range).

Positive values correspond to signal attenuation and negative values correspond to signal gain.

Note that the frequency range must not exceed the specification of the electronic attenuator for it to work.

The application shows the attenuation level (mechanical and electronic) in the channel bar.



Remote command:
Electronic attenuation: INPut:EATT<ant>:STATe on page 145
Electronic attenuation: INPut:EATT<ant>:AUTO on page 145
Electronic attenuation: INPut:EATT<ant> on page 144

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

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

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

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

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

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

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

For FSW85 models, the input signal is amplified by 30 dB if the preamplifier is activated.

Remote command:
INPut:GAIN:STATe on page 143
INPut:GAIN[:VALue] on page 143

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

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

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

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

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

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

Remote command:
`INPut:COUPling` on page 143

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

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

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

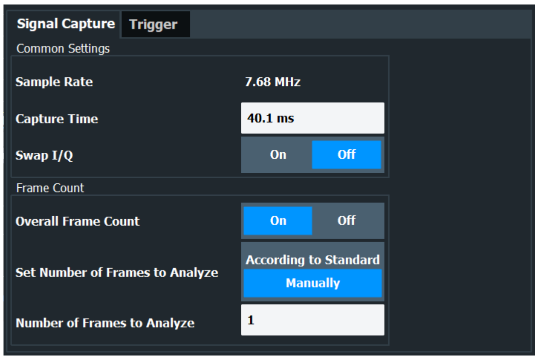
Not available for input from the optional "Digital Baseband" interface.

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

Remote command:
`INPut:IMPedance` on page 144

4.2.9 Configuring the data capture

Access: "Overview" > "Trig / Sig Capture" > "Signal Capture"



Capture Time
The "Capture Time" corresponds to the time of one measurement. Therefore, it defines the amount of data the application captures during a single measurement (or sweep).

By default, the application captures 20.1 ms of data to make sure that at least one complete NB-IoT frame is captured in the measurement.

The application shows the current capture time in the channel bar.

Note that if you are using the multi-standard radio analyzer, only the MSRA primary channel actually captures the data. The capture time only defines the NB-IoT analysis interval.

Remote command:
`[SENSe:]SWEep:TIME` on page 147

Swap I/Q
Swaps the real (I branch) and the imaginary (Q branch) parts of the signal.

Remote command:
`[SENSe:]SWAPiq` on page 146

Overall Frame Count
The "Overall Frame Count" turns the manual selection of the number of frames to capture (and analyze) on and off.

When you turn on the overall frame count, you can define the number of frames to capture and analyze. The measurement runs until all frames have been analyzed, even if it takes more than one capture.

The results are an average of the captured frames.

When you turn off the overall frame count, the application analyzes all NB-IoT frames found in one capture buffer.

The application shows the current frame count in the channel bar.

Remote command:
`[SENSe:][LTE:]FRAMe:COUNt:STATe` on page 146

Auto According to Standard
Turns automatic selection of the number of frames to capture and analyze on and off.

When you turn on this feature, the FSW captures and evaluates a number of frames the 3GPP standard specifies for EVM tests.

If you want to analyze an arbitrary number of frames, turn off the feature.

This parameter is not available when the overall frame count is inactive.

Remote command:
`[SENSe:][LTE:]FRAMe:COUNt:AUTO` on page 146

Number of Frames to Analyze
Defines the number of frames you want to capture and analyze.

If the number of frames you have set last longer than a single measurement, the application continues the measurement until all frames have been captured.

The parameter is read only in the following cases:
- If you turn off the overall frame count.

- If you capture the data according to the standard.

Remote command:
`[SENSe:][LTE:]FRAMe:COUNt` on page 145

4.2.10 Trigger configuration

Access: "Overview" > "Trig / Sig Capture" > "Trigger"

A trigger allows you to capture those parts of the signal that you are really interested in.

While the application runs freely and analyzes all signal data in its default state, no matter if the signal contains information or not, a trigger initiates a measurement only under certain circumstances (the trigger event).

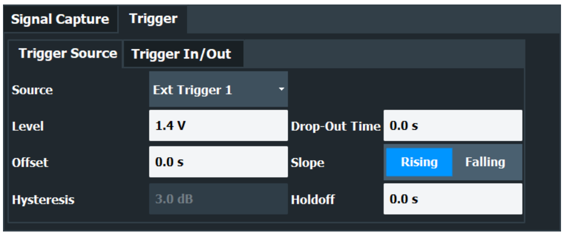
Except for the available trigger sources, the functionality is the same as that of the FSW base system.

For a comprehensive description of the available trigger settings not described here, refer to the documentation of the FSW.

Gated measurements

In addition to the general trigger functions, the frequency sweep measurements (for example ACLR) also support gated measurements.

The functionality is basically the same as in the spectrum application. However, the NB-IoT application automatically selects the correct gate settings (delay and length) according to the current signal description.



Trigger Source

The application supports several trigger modes or sources.

- **Free Run**
  Starts the measurement immediately and measures continuously.
- **External <x>**
  The trigger event is the level of an external trigger signal. The measurement starts when this signal meets or exceeds a specified trigger level at the trigger input.
  Some measurement devices have several trigger ports. When you use one of these, several external trigger sources are available.
- **I/Q Power**
  The trigger event is the magnitude of the sampled I/Q data. The measurement starts when the magnitude of the I/Q data meets or exceeds the trigger level.

- **IF Power**
  The trigger event is the level of the intermediate frequency (IF). The measurement starts when the level of the IF meets or exceeds the trigger level.
- **RF Power**
  The trigger event is the level measured at the RF input. The measurement starts when the level of the signal meets or exceeds the trigger level.

For all trigger sources, except "Free Run", you can define several trigger characteristics.

- The trigger "Level" defines the signal level that initiates the measurement.
- The trigger "Offset" is the time that must pass between the trigger event and the start of the measurement. This can be a negative value (a pretrigger).
- The trigger "Drop-out Time" defines the time the input signal must stay below the trigger level before triggering again.
- The trigger "Slope" defines whether triggering occurs when the signal rises to the trigger level or falls down to it.
- The trigger "Holdoff" defines a time period that must at least pass between one trigger event and the next.
- The trigger "Hysteresis" is available for the IF power trigger. It defines a distance to the trigger level that the input signal must stay below to fulfill the trigger condition.

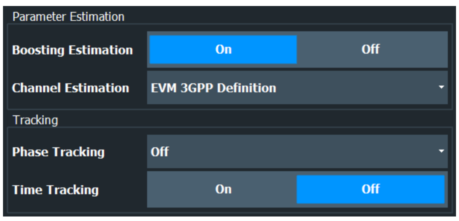
For a detailed description of the trigger parameters, see the user manual of the I/Q analyzer.

Remote command:
Source: `TRIGger[:SEQuence]:SOURce<ant>` on page 151
Level (external): `TRIGger[:SEQuence]:LEVel<ant>[:EXTernal<tp>]` on page 149
Level (I/Q power): `TRIGger[:SEQuence]:LEVel<ant>:IQPower` on page 149
Level (IF power): `TRIGger[:SEQuence]:LEVel<ant>:IFPower` on page 149
Level (RF power): `TRIGger[:SEQuence]:LEVel<ant>:RFPower` on page 150
Offset: `TRIGger[:SEQuence]:HOLDoff<ant>[:TIME]` on page 148
Hysteresis: `TRIGger[:SEQuence]:IFPower:HYSTeresis` on page 148
Drop-out time: `TRIGger[:SEQuence]:DTIMe` on page 147
Slope: `TRIGger[:SEQuence]:SLOPe` on page 151
Holdoff: `TRIGger[:SEQuence]:IFPower:HOLDoff` on page 148

4.2.11 Parameter estimation and tracking

Access: "Overview" > "Estimation / Tracking"

Parameter estimation and tracking provides functionality to estimate various settings based on the measured signal and functionality to compensate for errors in the signal.



Boosting Estimation

Turns boosting estimation on and off.

Boosting estimation, when you turn it on, automatically sets the relative power settings of all physical channels, the NPSS and NSSS by analyzing the signal.

Boosting estimation is always active.

Remote command:
`[SENSe:][LTE:]DL:DEMod:BESTimation` on page 154

Channel Estimation

Selects the method of channel estimation.

- **EVM 3GPP Definition**
  Channel estimation according to 3GPP TS 36.141. This method is based on averaging in frequency direction and linear interpolation. Examines the reference signal only.
- **Optimal, Pilot only**
  Optimal channel estimation method. Examines the reference signal only.
- **Optimal, Pilot and Payload**
  Optimal channel estimation method. Examines both the reference signal and the payload resource elements.

Remote command:
`[SENSe:][LTE:]DL:DEMod:CESTimation` on page 154

Phase

Turns phase tracking on and off.

When you turn on phase tracking, the application compensates the measurement results for the phase error on a symbol level.

"Off"	Phase tracking is not applied.
"Pilot Only"	Only the reference signal is used for the estimation of the phase error.
"Pilot and Payload"	Both reference signal and payload resource elements are used for the estimation of the phase error.

Remote command:
`[SENSe:][LTE:]DL:TRACking:PHASe` on page 155

Time Tracking

Turns time tracking on and off.

Clock deviations (slower or faster sampling time) lead to a drift of the ideal sampling instant over time, causing a rotating constellation diagram.

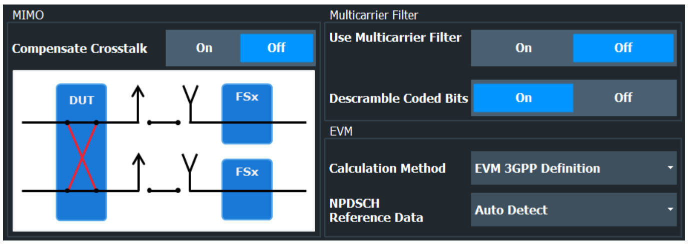
When you turn on time tracking, the application compensates the measurement results for timing errors on a symbol level.

Remote command:
[SENSe:][LTE:]DL:TRACking:TIME on page 155

4.2.12 Configuring demodulation parameters

Access: "Overview" > "Demodulation"

Demodulation settings contain settings that describe signal processing and the way the signal is measured.



The remote commands required to configure the demodulation are described in Chapter 6.9.2.7, "Demodulation", on page 152.

Multicarrier Filter
Turns the suppression of interference of neighboring carriers for tests on multiradio base stations on and off (e.g. LTE, WCDMA, GSM etc.).

The FSW automatically selects the multicarrier filter when you analyze more than 1 component carrier.

Remote command:
[SENSe:][LTE:]DL:DEMod:MCFilter on page 153

Scrambling of Coded Bits
Turns the scrambling of coded bits for all physical channels like NPDSCH on and off.

The scrambling of coded bits affects the bitstream results.

Remote command:
[SENSe:][LTE:]DL:DEMod:CBSCrambling on page 153

EVM Calculation Method
Selects the way the EVM is calculated.

"EVM 3GPP Definition"	Calculates the EVM according to 3GPP TS 36.141. Evaluates the EVM at two trial timing positions and then uses the higher EVM of the two.

"At Optimal Timing Position" Calculates the EVM using the optimal timing position.

Remote command:
[SENSe:][LTE:]DL:DEMod:EVMCalc on page 153

NPDSCH Reference Data
Selects the type of reference data to calculate the EVM for the NPDSCH.

By default, the FSW automatically detects the NPDSCH reference values and maps the measured values to the nearest reference point.

"Auto Detect" Automatically detects the NPDSCH reference values.

"All 0" Assumes the NPDSCH to be all 0's, according to test model definitions.

Remote command:
[SENSe:][LTE:]DL:DEMod:PRData on page 153

Compensate Crosstalk
Turns compensation of crosstalk produced by one of the components in the test setup on and off.

Turn on this feature, if you expect crosstalk from the DUT or another component in the test setup. This can become necessary, for example, for over-the-air measurements.

If you connect the DUT to the analyzer by cable, turn off crosstalk compensation. In that case, the only crosstalk results from the DUT itself and contributes as distortion to the measurement results.

Crosstalk compensation must be activated for Time Alignment Error measurements. For more information, see Chapter A, "Performing time alignment measurements", on page 169.

Remote command:
CONFigure[:LTE]:DL[:CC<cc>]:MIMO:CROSstalk on page 152

4.2.13 Automatic configuration

Access: [AUTO SET]

The FSW features several automatic configuration routines. When you use one of those, the FSW configures different parameters based on the signal that you are measuring.

Auto leveling
You can use the auto leveling routine for a quick determination of preliminary amplitude settings for the current NB-IoT input signal.

Remote command:
[SENSe:]ADJust:LEVel<ant> on page 156

Auto Scaling
Scales the y-axis for best viewing results. Also see "Automatic scaling of the y-axis" on page 67.

Remote command:
`DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:AUTO` on page 164

4.3 Time alignment error measurements

Several settings supported by time alignment error measurements are the same as those for I/Q measurements. For a comprehensive description, refer to the following chapters.

- Chapter 4.2.1, "Defining signal characteristics", on page 37
- Chapter 4.2.5, "Configuring the control channel", on page 44
- Chapter 4.2.6, "Input source configuration", on page 44
- Chapter 4.2.7, "Frequency configuration", on page 50
- Chapter 4.2.8, "Amplitude configuration", on page 51
- Chapter 4.2.9, "Configuring the data capture", on page 55
- Chapter 4.2.10, "Trigger configuration", on page 57
- Chapter 4.2.12, "Configuring demodulation parameters", on page 60

4.4 Frequency sweep measurements

After starting one of the frequency sweep measurements, the application automatically loads the configuration required by measurements according to the 3GPP standard.

- The channel configuration defined in the standard for the ACLR measurement.
- The spectral mask as defined in the 3GPP standard for SEM measurements.

If you need a different measurement configuration, you can change all parameters as required. Except for the dialog box described below, the measurement configuration menus for the frequency sweep measurements are the same as in the Spectrum application.

Refer to the User Manual of the FSW for a detailed description on how to configure ACLR and SEM measurements.

4.4.1 ACLR signal description

Access: "Overview"

Access: "Meas Config" > "CP / ACLR Config"

The SEM measurement and its settings are basically the same as in the spectrum application of the FSW. For a comprehensive description, see the FSW user manual.

In addition, the ACLR measurement in the NB-IoT application has several exclusive settings not available in the spectrum application.

The signal description for ACLR measurements contains settings to describe general physical characteristics of the signal you are measuring.

Access: "Meas Setup" > "Signal Description"

- NB-IoT "Mode": The NB-IoT mode is always "FDD Downlink".
- "Deployment": The SEM measurement only supports measurements on stand-alone deployment.
- "Channel Bandwidth": The channel bandwidth for the stand-alone deployment is a fix value of 200 kHz.
- "Adjacent Channels": Selects the adjacent channel configuration for the "Stand Alone" deployment as specified by 3GPP 36.104 chapter 6.6.2.

4.4.2 SEM signal description

Access: "Overview"

The SEM measurement and its settings are basically the same as in the spectrum application of the FSW. For a comprehensive description, see the FSW user manual.

In addition, the SEM measurement in the NB-IoT application has several exclusive settings not available in the spectrum application.

The signal description for SEM measurements contains settings to describe general physical characteristics of the signal you are measuring.

Access: "Meas Setup" > "Signal Description"

- NB-IoT "Mode": The NB-IoT mode is always "FDD Downlink".
- "Deployment": The SEM measurement only supports measurements on stand-alone deployment.
- "Channel Bandwidth": The channel bandwidth for the stand-alone deployment is a fix value of 200 kHz.

Category
Selects the baste station category to test. The base station category defines the shape of the SEM limit line.

You can select one of the following categories.
- Wide areas base stations
- Local area base stations
- Home base stations
- Medium range base stations

In addition to the base station category, the shape of the limit line depends on the power of the NB-IoT carrier.

For medium range base stations, the shape of the limit line also depends on the power of the transmission channel.

Remote command:
`[SENSe:]POWer:SEM:CATegory` on page 157

Tx Power
Defines the Tx channel power for medium range base stations. The selected channel power has an effect on the shape of the SEM limit line.

You can define the channel power either manually or automatically. For automatic detection, the FSW measures the power of the transmission channel.

Remote command:
State: `[SENSe:]POWer:SEM:CHBS:AMPower:AUTO` on page 158
Power: `[SENSe:]POWer:SEM:CHBS:AMPower` on page 157

Power NB-IoT Carrier
Defines the power of the NB-IoT carrier. The selected power has an effect on the shape of the SEM limit line.

You can define the channel power either manually or automatically.

For automatic detection, the FSW measures the power of the NB-IoT carrier. The limit values are relative values based on the power of the NB-IoT carrier measured in the reference range.

For manual definition of the power, the limit values are absolute values based on the power of the NB-IoT carrier.

Remote command:
Mode: `[SENSe:]POWer:SEM:PIOM` on page 158
Power: `[SENSe:]POWer:SEM:PIOV` on page 159

5 Analysis

The FSW provides various tools to analyze the measurement results.

5.1 General analysis tools

The general analysis tools are tools available for all measurements.

5.1.1 Data export

Access: [TRACE] > "Trace Export Config"

You can export the measurement results to an ASCII file, for example to backup the results or analyze the results with external applications (for example in a Microsoft Excel spreadsheet).

You can also export the I/Q data itself, for example if you want to keep it for later reevaluation.

The data export is available for:

- I/Q measurements
- Time alignment error measurements

Exporting trace data

1. Select [TRACE] > "Trace Export Config".
2. Select the data you would like to export.
3. Select the results you would like to export from the "Specifics For" dropdown menu.
4. Export the data with the "Export Trace to ASCII File" feature.
5. Select the location where you would like to save the data (as a `.dat` file).

   Note that the measurement data stored in the file depend on the selected result display ("Specifics For" selection).

Exporting I/Q data

1. Select the disk icon in the toolbar.

2. Select "Export" > "I/Q Export".
3. Define a file name and location for the I/Q data.
   The default file type is `iq.tar`.
4. Later on, you can import the I/Q data using the I/Q file input source.

Data import and export
The basic principle for both trace export and I/Q data export and import is the same as in the spectrum application. For a comprehensive description, refer to the FSW user manual.

Remote command:
Trace export: `TRACe<n>[:DATA]?` on page 106
I/Q export: `MMEMory:STORe<n>:IQ:STATe` on page 121
I/Q import: `INPut:FILE:PATH` on page 135

5.1.2 Microservice export

Access: / > "Export" > "Microservice Export"

You can export the signal configuration in a file format compatible to the cloud-based microservice (`.m5g` file extension).

For a comprehensive description of the microservice, refer to the microservice user manual.

Remote command:

`MMEMory:STORe<n>:MSERvice` on page 161

5.1.3 Diagram scale

Access: "Overview" > "Analysis" > "Scale"

You can change the scale of the y-axis in various diagrams. The y-axis scale determines the vertical resolution of the measurement results.

The scale of the x-axis in the diagrams is fix. If you want to get a better resolution of the x-axis, you have to zoom into the diagram.

The remote commands required to configure the y-axis scale are described in Chapter 6.10.4, "Y-axis scale", on page 163.

Manual scaling of the y-axis
The "Y Minimum" and "Y Maximum" properties define a custom scale of the y-axis.

The "Y Minimum" corresponds to the value at the origin. The "Y Maximum" corresponds to the last value on the y-axis. The scale you select applies to the currently active window.

You can restore the original scale anytime with "Restore Scale".

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:MAXimum on page 164
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:MINimum on page 164

Automatic scaling of the y-axis
Usually, the best way to view the results is if they fit ideally in the diagram area and display the complete trace. The "Auto Scale Once" automatically determines the scale of the y-axis that fits this criteria in the currently active window.

Tip: You can also scale the windows in the "Auto Set" menu. In addition to scaling the selected window ("Auto Scale Window"), you can change the scale of all windows at the same time ("Auto Scale All").

You can restore the original scale anytime with "Restore Scale".

Remote command:
DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:AUTO on page 164

5.1.4 Zoom

The zoom feature allows you to zoom into any graphical result display. This can be a useful tool if you want to analyze certain parts of a diagram in more detail.

The zoom functionality is the same as in the spectrum application.

The following zoom functions are supported.

- : Magnifies the selected diagram area.
- : Magnifies the selected diagram area, but keeps the original diagram in a separate window.
- : Restores the original diagram.

Note that the zoom is a graphical feature that magnifies the data in the capture buffer. Zooming into the diagram does not reevaluate the I/Q data.

For a comprehensive description of the zoom, refer to the FSW user manual.

5.1.5 Markers

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

Markers are a tool that help you to identify measurement results at specific trace points. When you turn on a marker, it gives you the coordinates of its position, for example the frequency and its level value or the symbol and its EVM value.

In general, the marker functionality of setting and positioning markers is similar to the spectrum application.

For I/Q measurement, the FSW supports up to four markers, for frequency sweep measurements there are more. Markers give either absolute values (normal markers) or values relative to the first marker (deltamarkers). If a result display has more than one trace, for example the "EVM vs Symbol" result display, you can position the marker on either trace. By default, all markers are positioned on trace 1.

Note that if you analyze more than one bandwidth part, each bandwidth part is represented by a different trace.

The FSW also supports several automatic positioning mechanisms that allow you to move the marker to the maximum trace value (peak), the minimum trace value or move it from peak to subsequent peak.

The marker table summarizes the marker characteristics.

For a comprehensive description, refer to the FSW user manual.

Markers in result displays with a third quantity

In result displays that show a third quantity, for example the "EVM vs Symbol x Carrier" result, the FSW provides an extended marker functionality.

You can position the marker on a specific resource element, whose position is defined by the following coordinates:

- The "Symbol" input field selects the symbol.
- The "Carrier" input field selects the carrier.

Alternatively, you can define the marker position in the "Marker Configuration" dialog box, which is expanded accordingly.

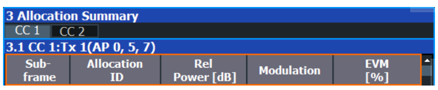
The marker information shows the EVM, the power and the allocation ID of the resource element you have selected as the marker position.

5.2 Analysis tools for I/Q measurements

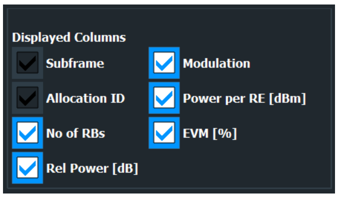
5.2.1 Layout of numerical results

You can customize the displayed information of some numerical result displays or tables, for example the allocation summary.

► Select some point in the header row of the table.



The application opens a dialog box to add or remove columns.

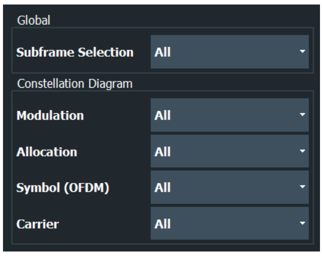


Add and remove columns as required.

5.2.2 Evaluation range

Access: "Overview" > "Evaluation Range"

The evaluation range defines the signal parts that are considered during signal analysis.



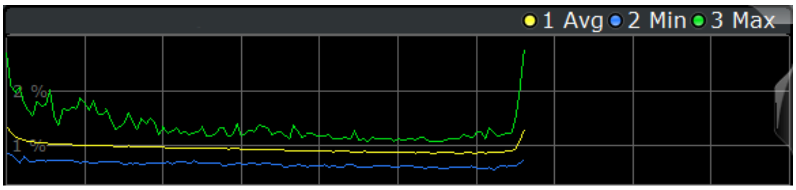
Subframe Selection

The "Subframe" selection filters the results by a specific subframe number.

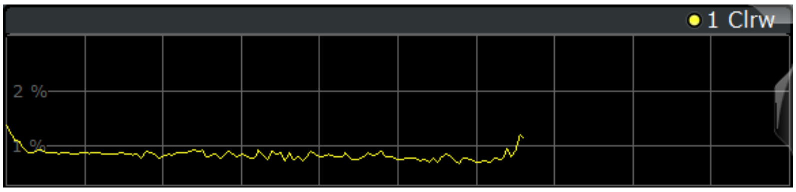
If you apply the filter, only the results for the subframe you have selected are displayed. Otherwise, the FSW shows the results for all subframes that have been analyzed.

The FSW shows three traces if you display the results for all subframes.

- One trace ("Min") shows the minimum values measured over all analyzed subframes.
- One trace ("Max") shows the maximum values measured over all analyzed subframes.
- One trace ("Avg") shows the average values measured over all subframes.



If you filter by a single subframe, the FSW shows one trace that represents the values measured for that subframe only.



You can apply the filter to the following result displays.

- Result Summary
- EVM vs Carrier / EVM vs Symbol / EVM vs Symbol X Carrier
- Group Delay
- Power vs Symbol X Carrier
- Constellation Diagram
- Allocation Summary
- Time Alignment Error

Remote command:
[SENSe:][LTE:][CC<cc>:]SUBFrame:SELect on page 163

Evaluation range for the constellation diagram

The "Evaluation Range" for the constellation diagram selects the information displayed in the constellation diagram.

By default, the constellation diagram contains the constellation points of the complete data that has been analyzed. However, you can filter the results by several aspects.

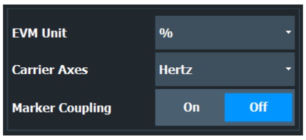
- Modulation
  Filters the results by the selected type of modulation.
- Allocation
  Filters the results by a certain type of allocation.
- Symbol (OFDM)
  Filters the results by a certain OFDM symbol.
- Carrier
  Filters the results by a certain subcarrier.
- Location
  Selects the point in the signal processing at which the constellation diagram is created, before or after the MIMO encoding.
  For spatial multiplexing, symbols of different encoding schemes are merged in the MIMO encoder. Thus you get a mix of different modulation alphabets. When you filter these symbols to show a modulation "MIXTURE", you get the mixed symbols only if you have selected the "Before MIMO/CDMA Decoder" option.
  Note that the PHICH is CDMA encoded. Thus, the constellation points for the PHICH are either created before or after CDMA encoding.
  If you have selected "After MIMO/CDMA Decoder", filtering by "Symbol" and "Carrier" is not available. Instead, you can filter by "Symbol" and "Codeword".

Remote command:
Modulation: [SENSe:][LTE:][CC<cc>:]MODulation:SELect on page 162
Allocation: [SENSe:][LTE:][CC<cc>:]ALLocation:SELect on page 161
Symbol: [SENSe:][LTE:][CC<cc>:]SYMBol:SELect on page 163
Carrier: [SENSe:][LTE:][CC<cc>:]CARRier:SELect on page 162
Location: [SENSe:][LTE:][CC<cc>:]LOCation:SELect on page 162

5.2.3 Result settings

Access: "Overview" > "Analysis" > "Result Settings"

Result settings define the way certain measurement results are displayed.



EVM Unit

The "EVM Unit" selects the unit for the EVM measurement results in diagrams and numerical result displays.

Possible units are dB and %.

Remote command:
`UNIT:EVM` on page 166

Bit Stream Format

Selects the way the bit stream is displayed.

The bit stream is either a stream of raw bits or of symbols. In case of the symbol format, the bits that belong to a symbol are shown as hexadecimal numbers with two digits.

Example:

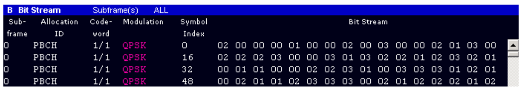


Figure 5-1: Bit stream display in downlink application if the bit stream format is set to "symbols"

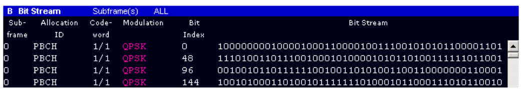


Figure 5-2: Bit stream display in downlink application if the bit stream format is set to "bits"

Remote command:
`UNIT:BSTR` on page 165

Carrier Axes

The "Carrier Axes" selects the unit of the x-axis in result displays that show results over the subcarriers.

- "Hertz"
  X-axis shows the results in terms of the subcarrier frequency.
- "Subcarrier Number"

X-axis shows the results in terms of the subcarrier number.

Remote command:
`UNIT:CAXes` on page 166

Marker Coupling
Couples or decouples markers that are active in multiple result displays.

When you turn on this feature, the application moves the marker to its new position in all active result displays.

When you turn it off, you can move the markers in different result displays independent from each other.

Remote command:
`CALCulate<n>:MARKer<m>:COUPling` on page 165

5.3 Analysis tools for frequency sweep measurements

Access: "Overview" > "Analysis"

Access: "Overview" > "Analysis"

The analysis tools available for the frequency sweep measurements are the same as in the spectrum analyzer.

For more information, refer to the FSW user manual.

6 Remote control

The following remote control commands are required to configure and perform LTE NB-IoT measurements in a remote environment. The FSW must already be set up for remote operation in a network as described in the base unit manual.

Universal functionality

Note that basic tasks that are also performed in the base unit in the same way are not described here. For a description of such tasks, see the FSW user manual. In particular, this includes:

- Managing Settings and Results, i.e. storing and loading settings and result data.
- Basic instrument configuration, e.g. checking the system configuration, customizing the screen layout, or configuring networks and remote operation.
- Using the common status registers (specific status registers for Pulse measurements are not used).

SCPI Recorder - automating tasks with remote command scripts

The LTE NB-IoT measurement application also supports the SCPI Recorder functionality.

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

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

6.1 Common suffixes

In the LTE NB-IoT measurement application, the following common suffixes are used in remote commands:

Table 6-1: Common suffixes used in remote commands in the LTE NB-IoT measurement application

Suffix	Value range	Description
<m>	1..4	Marker
<n>	1..16	Window (**in the currently selected channel**)
<t>	1..6	Trace
	1 to 8	Limit line
<ant>	1..2	Selects an antenna for MIMO measurements.
<cc>	1..5	Selects a component carrier. Irrelevant for the NB-IoT application.
<k>	---	Selects a limit line. Irrelevant for the NB-IoT application.
<np>	0...20	Selects a NPUSCH (NB-IoT uplink only)

6.2 Introduction

Commands are program messages that a controller (e.g. a PC) sends to the instrument or software. They operate its functions ('setting commands' or 'events') and request information ('query commands'). Some commands can only be used in one way, others work in two ways (setting and query). If not indicated otherwise, the commands can be used for settings and queries.

The syntax of a SCPI command consists of a header and, usually, one or more parameters. To use a command as a query, you have to append a question mark after the last header element, even if the command contains a parameter.

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

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

Remote command examples

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

6.2.1 Conventions used in descriptions

The following conventions are used in the remote command descriptions:

- **Command usage**

If not specified otherwise, commands can be used both for setting and for querying parameters.
If a command can be used for setting or querying only, or if it initiates an event, the usage is stated explicitly.

- **Parameter usage**
  If not specified otherwise, a parameter can be used to set a value, and it is the result of a query.
  Parameters required only for setting are indicated as **Setting parameters**.
  Parameters required only to refine a query are indicated as **Query parameters**.
  Parameters that are only returned as the result of a query are indicated as **Return values**.
- **Conformity**
  Commands that are taken from the SCPI standard are indicated as **SCPI confirmed**. All commands used by the FSW follow the SCPI syntax rules.
- **Asynchronous commands**
  A command which does not automatically finish executing before the next command starts executing (overlapping command) is indicated as an **Asynchronous command**.
- **Reset values (*RST)**
  Default parameter values that are used directly after resetting the instrument (`*RST` command) are indicated as ***RST** values, if available.
- **Default unit**
  The default unit is used for numeric values if no other unit is provided with the parameter.
- **Manual operation**
  If the result of a remote command can also be achieved in manual operation, a link to the description is inserted.

6.2.2 Long and short form

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

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

Example:

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

6.2.3 Numeric suffixes

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

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

If you do not quote a suffix for keywords that support one, a 1 is assumed.

Example:

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

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

6.2.4 Optional keywords

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

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

Optional keywords are emphasized with square brackets.

Example:

Without a numeric suffix in the optional keyword:

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

With a numeric suffix in the optional keyword:

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

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

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

6.2.5 Alternative keywords

A vertical stroke indicates alternatives for a specific keyword. You can use both keywords to the same effect.

Example:

`[SENSe:]BANDwidth|BWIDth[:RESolution]`

In the short form without optional keywords, `BAND 1MHZ` would have the same effect as `BWID 1MHZ`.

6.2.6 SCPI parameters

Many commands feature one or more parameters.

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

Example:

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

Parameters can have different forms of values.

6.2.6.1 Numeric values

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

Example:

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

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

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

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

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

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

Querying numeric values

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

Example:

Setting: `SENSe:FREQuency:CENTer 1GHZ`

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

Sometimes, numeric values are returned as text.

- INF/NINF
  Infinity or negative infinity. Represents the numeric values 9.9E37 or -9.9E37.
- NAN
  Not a number. Represents the numeric value 9.91E37. NAN is returned if errors occur.

6.2.6.2 Boolean

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

Querying Boolean parameters

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

Example:

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

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

6.2.6.3 Character data

Character data follows the syntactic rules of keywords. You can enter text using a short or a long form. For more information, see Chapter 6.2.2, "Long and short form", on page 75.

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`

6.2.6.4 Character strings

Strings are alphanumeric characters. They have to be in straight quotation marks. You can use a single quotation mark (') or a double quotation mark (").

Example:

`INSTRument:DELete 'Spectrum'`

6.2.6.5 Block data

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

The ASCII character # introduces the data block. The next number indicates how many of the following digits describe the length of the data block. The data bytes follow. During the transmission of these data bytes, all end or other control signs are ignored until all bytes are transmitted. #0 specifies a data block of indefinite length. The use of the indefinite format requires an `NL^END` message to terminate the data block. This format is useful when the length of the transmission is not known or if speed or other considerations prevent segmentation of the data into blocks of definite length.

6.3 Status register

The LTE NB-IoT measurement application uses the standard status registers of the FSW (depending on the measurement type). However, some registers are used differently. Only those differences are described in the following sections.

For details on the common FSW status registers refer to the description of remote control basics in the FSW user manual.

*RST does not influence the status registers.

STATus:QUEStionable:SYNC register

The `STATus:QUEStionable:SYNC` register contains application-specific information. If any errors occur in this register, the status bit #11 in the `STATus:QUEStionable` register is set to 1.

Each active channel uses a separate `STATus:QUEStionable:SYNC` register. Thus, if the status bit #11 in the `STATus:QUEStionable` register indicates an error, the error may have occurred in any of the channel-specific `STATus:QUEStionable:SYNC` registers. In this case, you must check the register of each channel to determine which channel caused the error. By default, querying the status of a register always returns the result for the currently selected channel. However, you can specify any other channel name as a query parameter.

Table 6-2: Meaning of the bits used in the STATus:QUEStionable:SYNC register

Bit No.	Meaning
0	Configured frame not found
1	Sync not found
2 to 5	Unused
6	Auto level no signal
7	Setting mismatch
8	Signal analysis error

Bit No.	Meaning
9 to 14	Unused
15	This bit is always 0

6.4 NB-IoT application selection

INSTrument:CREate:DUPLicate

Duplicates the currently selected channel, i.e creates a new channel of the same type and with the identical measurement settings. The name of the new channel is the same as the copied channel, extended by a consecutive number (e.g. "IQAnalyzer" -> "IQAnalyzer 2").

The channel to be duplicated must be selected first using the `INST:SEL` command.

Example:
`INST:SEL 'IQAnalyzer'`
`INST:CRE:DUPL`
Duplicates the channel named 'IQAnalyzer' and creates a new channel named 'IQAnalyzer2'.

Usage: Event

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

Adds a measurement channel. You can configure up to 10 measurement channels at the same time (depending on available memory).

Parameters:

<ChannelType> Channel type of the new channel.
For a list of available channel types, see `INSTrument:LIST?` on page 81.

<ChannelName> String containing the name of the channel.
Note that you cannot assign an existing channel name to a new channel. If you do, an error occurs.

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

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

Replaces a channel with another one.

Setting parameters:

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

<ChannelType> Channel type of the new channel.
For a list of available channel types, see `INSTrument:LIST?` on page 81.

<ChannelName2> String containing the name of the new channel.
Note: If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel (see `INSTrument:LIST?` on page 81).
Channel names can have a maximum of 31 characters, and must be compatible with the Windows conventions for file names. In particular, they must not contain special characters such as ":", "*", "?".

Example: `INST:CRE:REPL 'IQAnalyzer2',IQ,'IQAnalyzer'`
Replaces the channel named "IQAnalyzer2" by a new channel of type "IQ Analyzer" named "IQAnalyzer".

Usage: Setting only

INSTrument:DELete <ChannelName>

Deletes a channel.

If you delete the last channel, the default "Spectrum" channel is activated.

Setting parameters:

<ChannelName> String containing the name of the channel you want to delete.
A channel must exist to delete it.

Example: `INST:DEL 'IQAnalyzer4'`
Deletes the channel with the name 'IQAnalyzer4'.

Usage: Setting only

INSTrument:LIST?

Queries all active channels. The query is useful to obtain the names of the existing channels, which are required to replace or delete the channels.

Return values:

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

Example: `INST:LIST?`
Result for 3 channels:
`'ADEM','Analog Demod','IQ','IQ Analyzer','IQ','IQ Analyzer2'`

Usage: Query only

Table 6-3: Available channel types and default channel names in Signal and Spectrum Analyzer mode

Application	<ChannelType> parameter	Default Channel name*)
Spectrum	SANALYZER	Spectrum
1xEV-DO BTS (FSW-K84)	BDO	1xEV-DO BTS
1xEV-DO MS (FSW-K85)	MDO	1xEV-DO MS
3GPP FDD BTS (FSW-K72)	BWCD	3G FDD BTS
3GPP FDD UE (FSW-K73)	MWCD	3G FDD UE
802.11ad (FSW-K95)	WIGIG	802.11ad
802.11ay (FSW-K97)	EDMG	802.11ay EDMG
Amplifier Measurements (FSW-K18)	AMPLifier	Amplifier
AM/FM/PM Modulation Analysis (FSW-K7)	ADEM	Analog Demod
Avionics (FSW-K15)	AVIonics	Avionics
Bluetooth (FSW-K8)	BTO	Bluetooth
cdma2000 BTS (FSW-K82)	BC2K	CDMA2000 BTS
cdma2000 MS (FSW-K83)	MC2K	CDMA2000 MS
DOCSIS 3.1 (FSW-K192/193)	DOCSis	DOCSIS 3.1
Fast Spur Search (FSW-K50)	SPUR	Spurious
GSM (FSW-K10)	GSM	GSM
HRP UWB (FSW-K149)	UWB	HRP UWB
I/Q Analyzer	IQ	IQ Analyzer
LTE (FSW-K10x)	LTE	LTE
Multi-Carrier "Group Delay" (FSW-K17)	MCGD	MC "Group Delay"
NB-IoT (FSW-K106)	NIOT	NB-IoT
Noise (FSW-K30)	NOISE	Noise
5G NR (FSW-K144)	NR5G	5G NR
OFDM VSA (FSW-K96)	OFDMVSA	OFDM VSA
OneWeb (FSW-K201)	OWEB	OneWeb
Phase Noise (FSW-K40)	PNOISE	Phase Noise
*) If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel.		

Application	<ChannelType> parameter	Default Channel name*)
Pulse (FSW-K6)	PULSE	Pulse
"Real-Time Spectrum"	RTIM	"Real-Time Spectrum"
TD-SCDMA BTS (FSW-K76)	BTDS	TD-SCDMA BTS
TD-SCDMA UE (FSW-K77)	MTDS	TD-SCDMA UE
Transient Analysis (FSW-K60)	TA	Transient Analysis
Verizon 5GTF Measurement Application (V5GTF, FSW-K118)	V5GT	V5GT
VSA (FSW-K70)	DDEM	VSA
WLAN (FSW-K91)	WLAN	WLAN
*) If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel.		

INSTrument:REName <ChannelName1>, <ChannelName2>

Renames a channel.

Setting parameters:

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

<ChannelName2> String containing the new channel name.
Note that you cannot assign an existing channel name to a new channel. If you do, an error occurs.
Channel names can have a maximum of 31 characters, and must be compatible with the Windows conventions for file names. In particular, they must not contain special characters such as ":", "*", "?".

Example: `INST:REN 'IQAnalyzer2','IQAnalyzer3'`
Renames the channel with the name 'IQAnalyzer2' to 'IQAnalyzer3'.

Usage: Setting only

INSTrument[:SELect] <ChannelType>

Selects a new measurement channel with the defined channel type.

Parameters:

<ChannelType> **NIOT**
LTE NB-IoT measurement channel

Example: //Select LTE NB-IoT application
`INST NIOT`

6.5 Screen layout

6.5.1 General layout

The following commands are required to configure general window layout, independent of the application.

Note that the suffix <n> always refers to the window *in the currently selected measurement channel*.

DISPlay:FORMat <Format>

Determines which tab is displayed.

Parameters:

<Format>

SPLit
Displays the MultiView tab with an overview of all active channels

SINGle
Displays the measurement channel that was previously focused.

*RST: SING

Example: `DISP:FORM SPL`

DISPlay[:WINDow<n>]:SIZE <Size>

Maximizes the size of the selected result display window *temporarily*. To change the size of several windows on the screen permanently, use the `LAY:SPL` command (see `LAYout:SPLitter` on page 89).

Suffix:

<n> Window

Parameters:

<Size>

LARGe
Maximizes the selected window to full screen.
Other windows are still active in the background.

SMALl
Reduces the size of the selected window to its original size.
If more than one measurement window was displayed originally, these are visible again.

*RST: SMALl

Example: `DISP:WIND2:SIZE LARG`

DISPlay[:WINDow<n>][:SUBWindow<w>]:SELect

Sets the focus on the selected result display window.

This window is then the active window.

For measurements with multiple results in subwindows, the command also selects the subwindow. Use this command to select the (sub)window before querying trace data.

Suffix:

<n> Window

<w> subwindow
Not supported by all applications

Example: //Put the focus on window 1
`DISP:WIND1:SEL`

Example: //Put the focus on subwindow 2 in window 1
`DISP:WIND1:SUBW2:SEL`

DISPlay[:WINDow<n>]:TAB<tab>:SELect

Selects a tab in diagrams with multiple subwindows (or views).

Note that selecting a tab does not actually select a subwindow. To select a subwindow, for example to query the results of a subwindow, use `DISPlay[:WINDow<n>][:SUBWindow<w>]:SELect`.

Suffix:

<n> Window

<tab> 1..n
Tab

Example: //Select a tab
`DISP:WIND2:TAB2:SEL`

6.5.2 Layout of a single channel

The following commands are required to change the evaluation type and rearrange the screen layout for a measurement channel as you do using the SmartGrid in manual operation. Since the available evaluation types depend on the selected application, some parameters for the following commands also depend on the selected measurement channel.

Note that the suffix <n> always refers to the window *in the currently selected measurement channel*.

LAYout:ADD[:WINDow]? <WindowName>, <Direction>, <WindowType>

Adds a window to the display in the active channel.

Is always used as a query so that you immediately obtain the name of the new window as a result.

To replace an existing window, use the `LAYout:REPLace[:WINDow]` command.

Query parameters:

<WindowName> String containing the name of the existing window the new window is inserted next to.
By default, the name of a window is the same as its index. To determine the name and index of all active windows, use the `LAYout:CATalog[:WINDow]?` query.

<Direction> LEFT | RIGHt | ABOVe | BELow
Direction the new window is added relative to the existing window.

<WindowType> text value
Type of result display (evaluation method) you want to add.
See the table below for available parameter values.

Return values:

<NewWindowName> When adding a new window, the command returns its name (by default the same as its number) as a result.

Example: `LAY:ADD? '1',LEFT,MTAB`
Result:
`'2'`
Adds a new window named '2' with a marker table to the left of window 1.

Usage: Query only

Manual operation:
See "Capture Buffer" on page 17
See "EVM vs Carrier" on page 18
See "EVM vs Symbol" on page 19
See "EVM vs Subframe" on page 20
See "Frequency Error vs Symbol" on page 20
See "Power Spectrum" on page 21
See "Channel Flatness" on page 21
See "Group Delay" on page 22
See "Channel Flatness Difference" on page 22
See "Constellation Diagram" on page 22
See "CCDF" on page 23
See "Allocation Summary" on page 24
See "Bitstream" on page 25
See "EVM vs Symbol x Carrier" on page 26
See "Power vs Symbol x Carrier" on page 26
See "Allocation ID vs Symbol x Carrier" on page 27
See "Marker Table" on page 29
See "Time Alignment Error" on page 30
See "Marker Peak List" on page 34

Table 6-4: <WindowType> parameter values for NB-IoT downlink measurement application

Parameter value	Window type
I/Q measurements	
AISC	"Allocation ID vs. Symbol X Carrier"
ASUM	"Allocation Summary"
BSTR	"Bitstream"
CBUF	"Capture Buffer"
CCDF	"CCDF"
FLAT	"Channel Flatness"
CONS	"Constellation Diagram"
EVCA	"EVM vs. Carrier"
EVSC	"EVM vs. Symbol X Carrier"
EVSU	"EVM vs. Subframe"
EVSY	"EVM vs. Symbol"
FEVS	"Frequency Error vs. Symbol"
GDEL	"Group Delay"
MTAB	"Marker Table"
PSPE	"Power Spectrum"
PVSC	"Power vs. Symbol X Carrier"
RSUM	"Result Summary"
Time alignment error	

Parameter value	Window type
CBUF	"Capture Buffer"
MTAB	"Marker Table"
PSPE	"Power Spectrum"
TAL	"Time Alignment Error"
ACLR and SEM measurements	
DIAG	"Diagram"
PEAK	"Peak List"
MTAB	"Marker Table"
RSUM	"Result Summary"

LAYout:CATalog[:WINDow]?

Queries the name and index of all active windows in the active channel from top left to bottom right. The result is a comma-separated list of values for each window, with the syntax:

<WindowName_1>,<WindowIndex_1>..<WindowName_n>,<WindowIndex_n>

Return values:

<WindowName> string

Name of the window.
In the default state, the name of the window is its index.

<WindowIndex> **numeric value**
Index of the window.

Example: `LAY:CAT?`
Result:
`'2',2,'1',1`
Two windows are displayed, named '2' (at the top or left), and '1' (at the bottom or right).

Usage: Query only

LAYout:IDENtify[:WINDow]? <WindowName>

Queries the **index** of a particular display window in the active channel.

Note: to query the **name** of a particular window, use the `LAYout:WINDow<n>:IDENtify?` query.

Query parameters:

<WindowName> String containing the name of a window.

Return values:

<WindowIndex> Index number of the window.

Example:
`LAY:IDEN:WIND? '2'`
Queries the index of the result display named '2'.
Response:
`2`

Usage: Query only

LAYout:REMove[:WINDow] <WindowName>

Removes a window from the display in the active channel.

Setting parameters:

<WindowName> String containing the name of the window. In the default state, the name of the window is its index.

Example:
`LAY:REM '2'`
Removes the result display in the window named '2'.

Usage: Setting only

LAYout:REPLace[:WINDow] <WindowName>,<WindowType>

Replaces the window type (for example from "Diagram" to "Result Summary") of an already existing window in the active channel while keeping its position, index and window name.

To add a new window, use the `LAYout:ADD[:WINDow]?` command.

Setting parameters:

<WindowName> String containing the name of the existing window.
By default, the name of a window is the same as its index. To determine the name and index of all active windows in the active channel, use the `LAYout:CATalog[:WINDow]?` query.

<WindowType> Type of result display you want to use in the existing window.
See `LAYout:ADD[:WINDow]?` on page 86 for a list of available window types.

Example:
`LAY:REPL:WIND '1',MTAB`
Replaces the result display in window 1 with a marker table.

Usage: Setting only

LAYout:SPLitter <Index1>, <Index2>, <Position>

Changes the position of a splitter and thus controls the size of the windows on each side of the splitter.

Compared to the `DISPlay[:WINDow<n>]:SIZE` on page 84 command, the `LAYout:SPLitter` changes the size of all windows to either side of the splitter permanently, it does not just maximize a single window temporarily.

Note that windows must have a certain minimum size. If the position you define conflicts with the minimum size of any of the affected windows, the command does not work, but does not return an error.

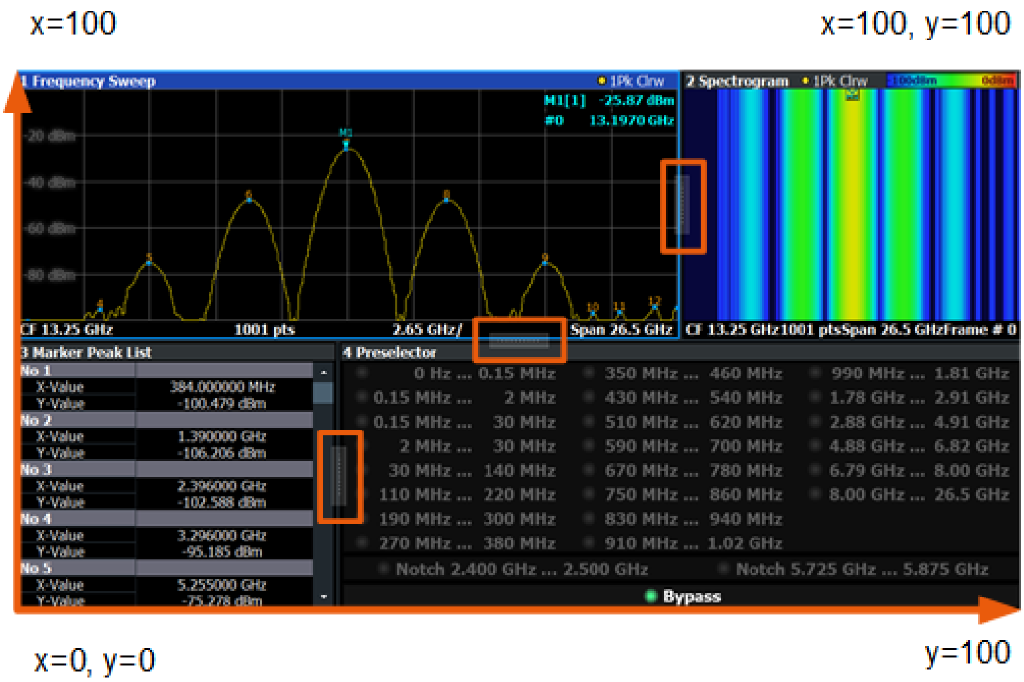


Figure 6-1: SmartGrid coordinates for remote control of the splitters

Setting parameters:

<Index1> The index of one window the splitter controls.

<Index2> The index of a window on the other side of the splitter.

<Position> New vertical or horizontal position of the splitter as a fraction of the screen area (without channel and status bar and softkey menu).
The point of origin (x = 0, y = 0) is in the lower left corner of the screen. The end point (x = 100, y = 100) is in the upper right corner of the screen. (See Figure 6-1.)
The direction in which the splitter is moved depends on the screen layout. If the windows are positioned horizontally, the splitter also moves horizontally. If the windows are positioned vertically, the splitter also moves vertically.

Range: 0 to 100

Example:

```
LAY:SPL 1,3,50
```

Moves the splitter between window 1 ('Frequency Sweep') and 3 ('"Marker Table"') to the center (50%) of the screen, i.e. in the figure above, to the left.

Example: `LAY:SPL 1,4,70`
Moves the splitter between window 1 ('Frequency Sweep') and 3 ('"Marker Peak List"') towards the top (70%) of the screen.
The following commands have the exact same effect, as any combination of windows above and below the splitter moves the splitter vertically.
`LAY:SPL 3,2,70`
`LAY:SPL 4,1,70`
`LAY:SPL 2,1,70`

Usage: Setting only

LAYout:WINDow<n>:ADD? <Direction>,<WindowType>

Adds a measurement window to the display. Note that with this command, the suffix <n> determines the existing window next to which the new window is added. Unlike `LAYout:ADD[:WINDow]?`, for which the existing window is defined by a parameter.

To replace an existing window, use the `LAYout:WINDow<n>:REPLace` command.

Is always used as a query so that you immediately obtain the name of the new window as a result.

Suffix:
<n> Window

Query parameters:
<Direction> LEFT | RIGHt | ABOVe | BELow

<WindowType> Type of measurement window you want to add.
See `LAYout:ADD[:WINDow]?` on page 86 for a list of available window types.

Return values:
<NewWindowName> When adding a new window, the command returns its name (by default the same as its number) as a result.

Example: `LAY:WIND1:ADD? LEFT,MTAB`
Result:
`'2'`
Adds a new window named '2' with a marker table to the left of window 1.

Usage: Query only

LAYout:WINDow<n>:IDENtify?

Queries the **name** of a particular display window (indicated by the <n> suffix) in the active channel.

Note: to query the **index** of a particular window, use the `LAYout:IDENtify[:WINDow]?` command.

Suffix:
<n> Window

Return values:
<WindowName> String containing the name of a window.
In the default state, the name of the window is its index.

Example: `LAY:WIND2:IDEN?`
Queries the name of the result display in window 2.
Response:
`'2'`

Usage: Query only

LAYout:WINDow<n>:REMove

Removes the window specified by the suffix <n> from the display in the active channel.

The result of this command is identical to the `LAYout:REMove[:WINDow]` command.

Suffix:
<n> Window

Example: `LAY:WIND2:REM`
Removes the result display in window 2.

Usage: Event

LAYout:WINDow<n>:REPLace <WindowType>

Changes the window type of an existing window (specified by the suffix <n>) in the active channel.

The effect of this command is identical to the `LAYout:REPLace[:WINDow]` command.

To add a new window, use the `LAYout:WINDow<n>:ADD?` command.

Suffix:
<n> Window

Setting parameters:
<WindowType> Type of measurement window you want to replace another one with.
See `LAYout:ADD[:WINDow]?` on page 86 for a list of available window types.

Example: `LAY:WIND2:REPL MTAB`
Replaces the result display in window 2 with a marker table.

Usage: Setting only

LAYout:WINDow<n>:TYPE <WindowType>

Queries or defines the window type of the window specified by the index <n>. The window type determines which results are displayed. For a list of possible window types, see `LAYout:ADD[:WINDow]?` on page 86.

Note that this command is not available in all applications and measurements.

Suffix:

<n> 1..n
Window

Parameters:

<WindowType>

Example: `LAY:WIND2:TYPE?`

6.6 Measurement control

6.6.1 Measurements

ABORt

Aborts the measurement in the current channel and resets the trigger system.

To prevent overlapping execution of the subsequent command before the measurement has been aborted successfully, use the `*OPC?` or `*WAI` command after `ABOR` and before the next command.

For details on overlapping execution see Remote control via SCPI.

Note on blocked remote control programs:

If a sequential command cannot be completed, for example because a triggered sweep never receives a trigger, the remote control program will never finish and the remote channel to the FSW is blocked for further commands. In this case, you must interrupt processing on the remote channel first in order to abort the measurement.

To do so, send a "Device Clear" command from the control instrument to the FSW on a parallel channel to clear all currently active remote channels. Depending on the used interface and protocol, send the following commands:

- **Visa**: `viClear()`
- **GPIB**: `ibclr()`
- **RSIB**: `RSDLLibclr()`

Now you can send the ABORt command on the remote channel performing the measurement.

Example: ABOR;:INIT:IMM
Aborts the current measurement and immediately starts a new one.

Example: ABOR;*WAI
INIT:IMM
Aborts the current measurement and starts a new one once abortion has been completed.

Usage: Event

INITiate<n>:CONTinuous <State>

Controls the measurement mode for an individual channel.

Note that in single measurement mode, you can synchronize to the end of the measurement with *OPC, *OPC? or *WAI. In continuous measurement mode, synchronization to the end of the measurement is not possible. Thus, it is not recommended that you use continuous measurement mode in remote control, as results like trace data or markers are only valid after a single measurement end synchronization.

For details on synchronization see Remote control via SCPI.

Suffix:
<n> irrelevant

Parameters:
<State> ON | OFF | 0 | 1

ON | 1
Continuous measurement

OFF | 0
Single measurement

*RST: 1 (some applications can differ)

Example: INIT:CONT OFF
Switches the measurement mode to single measurement.
INIT:CONT ON
Switches the measurement mode to continuous measurement.

INITiate<n>[:IMMediate]

Starts a (single) new measurement.

You can synchronize to the end of the measurement with *OPC, *OPC? or *WAI.

For details on synchronization see Remote control via SCPI.

Suffix:
<n> irrelevant

Usage: Asynchronous command

[SENSe:]SYNC[:CC<cc>][:STATe]?

Queries the current synchronization state.

Suffix:
<cc> irrelevant

Return values:
<State> The string contains the following information:
A zero represents a failure and a one represents a successful synchronization.

Example: //Query synchronization state
`SYNC:STAT?`
Would return, e.g. '1' for successful synchronization.

Usage: Query only

6.6.2 Measurement sequences

INITiate:SEQuencer:ABORt

Stops the currently active sequence of measurements.

You can start a new sequence any time using `INITiate:SEQuencer:IMMediate` on page 95.

Usage: Event

INITiate:SEQuencer:IMMediate

Starts a new sequence of measurements by the Sequencer.

Its effect is similar to the `INITiate<n>[:IMMediate]` command used for a single measurement.

Before this command can be executed, the Sequencer must be activated (see `SYSTem:SEQuencer` on page 96).

Example: `SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single sequence mode so each active measurement is performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.

INITiate:SEQuencer:MODE <Mode>

Defines the capture mode for the entire measurement sequence and all measurement groups and channels it contains.

Note: To synchronize to the end of a measurement sequence using `*OPC`, `*OPC?` or `*WAI`, use `SINGle` Sequencer mode.

Parameters:

<Mode>

SINGle
Each measurement group is started one after the other in the order of definition. All measurement channels in a group are started simultaneously and performed once. After *all* measurements are completed, the next group is started. After the last group, the measurement sequence is finished.

CONTinuous
Each measurement group is started one after the other in the order of definition. All measurement channels in a group are started simultaneously and performed once. After *all* measurements are completed, the next group is started. After the last group, the measurement sequence restarts with the first one and continues until it is stopped explicitly.

*RST: CONTinuous

SYSTem:SEQuencer <State>

Turns the Sequencer on and off. The Sequencer must be active before any other Sequencer commands (`INIT:SEQ...`) are executed, otherwise an error occurs.

Parameters:

<State> ON | OFF | 0 | 1

ON | 1
The Sequencer is activated and a sequential measurement is started immediately.

OFF | 0
The Sequencer is deactivated. Any running sequential measurements are stopped. Further Sequencer commands (`INIT:SEQ...`) are not available.

*RST: 0

Example:

`SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single Sequencer mode so each active measurement is performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.
`SYST:SEQ OFF`

6.7 Trace data readout

6.7.1 The TRACe[:DATA] command

This chapter contains information on the `TRACe:DATA` command and a detailed description of the characteristics of that command.

The `TRACe:DATA` command queries the trace data or results of the currently active measurement or result display. The type, number and structure of the return values are specific for each result display. In case of results that have any kind of unit, the command returns the results in the unit you have currently set for that result display.

Note also that return values for results that are available for both downlink and uplink may be different.

For several result displays, the command also supports various SCPI parameters in combination with the query. If available, each SCPI parameter returns a different aspect of the results. If SCPI parameters are supported, you have to quote one in the query.

Example:

```
TRAC2:DATA? TRACE1
```

The format of the return values is either in ASCII or binary characters and depends on the format you have set with `FORMat[:DATA]`.

Following this detailed description, you will find a short summary of the most important functions of the command (`TRACe<n>[:DATA]?`).

Selecting a measurement window

Before querying results, you have to select the measurement window with the suffix <n> at `TRACe`. The range of <n> depends on the number of active measurement windows.

6.7.1.1 Adjacent channel leakage ratio

For the ACLR result display, the number and type of returns values depend on the parameter.

- `TRAC:DATA TRACE1`
  Returns one value for each trace point.

6.7.1.2 Allocation ID vs symbol x carrier

For the allocation ID vs symbol x carrier, the command returns one value for each resource element.

```
<ID[Symbol(0),Carrier(1)]>, ..., <ID[Symbol(0),Carrier(n)]>,
<ID[Symbol(1),Carrier(1)]>, ..., <ID[Symbol(1),Carrier(n)]>,
...
<ID[Symbol(n),Carrier(1)]>, ..., <ID[Symbol(n),Carrier(n)]>,
```

The `<allocation ID>` is encoded.

For the code assignment, see Chapter 6.7.1.19, "Return value codes", on page 105.

The following parameters are supported.

- `TRAC:DATA TRACE1`

6.7.1.3 Allocation summary

For the allocation summary, the command returns several values for each line of the table.

- `<subframe>`
- `<allocation ID>`
- `<number of RB>`
- `<relative power>`
- `<modulation>`
- `<absolute power>`
- `<EVM>`
- `<LayerEVM>`

The data format of the return values is always ASCII.

The return values have the following characteristics.

- The `<allocation ID` is encoded.
  For the code assignment, see Chapter 6.7.1.19, "Return value codes", on page 105.
- The unit for `<relative power>` is always dB.
- The `<modulation>` is encoded.
  For the code assignment, see Chapter 6.7.1.19, "Return value codes", on page 105.
- The unit for `<absolute power>` is always dBm.
- The unit for `<EVM>` depends on `UNIT:EVM`.
- The unit for `<LayerEVM>` depends on `UNIT:EVM`.

Example:

Allocation Summary Selection Antenna: 1

Sub-frame	Alloc. ID	Number of RB	Rel. Power/dB	Modulation	Power per RE/dBm	EVM/%
0	RS Ant1		0,000	QPSK	-45,546	0,733
	P-SYNC		-0,007	CAZAC	-42,558	0,254
	S-SYNC		0,005	RBPSK	-42,546	0,251

`TRAC:DATA? TRACE1` would return:

```
0, -5, 0, 0.0000000000000, 2, -45.5463829153428, 7.33728660354122E-05, 8.2587600145187E-05
0, -3, 0, 0.0073997452251, 6, -42.5581007463452, 2.54197349219455E-05, 2.9270188222955E-05
0, -4, 0, 0.0052647197362, 1, -42.5464220485716, 2.51485275782241E-05, 2.5002471912438E-05
...
```

Additional information "ALL"

The allocation summary contains additional lines "ALL" that summarize the number of RB analyzed in each subframe and the average EVM measured in that subframe. This information is added to the return values after all allocations of the subframe have been returned. The "ALL" information has the allocation ID code "-2".

In addition, there is a line at the end of the allocation summary that shows the average EVM over all analyzed subframes. This information is also added as the last return values. The "ALL" information has the subframe ID and allocation ID code "-2".

A query result would thus look like this, for example:

```
//For subframe 0:
0, -40, 10, 2, 2, -84.7431947342849, 2.68723483754626E-06,
0, -41, 0, 0, 6, -84.7431432845264, 2.37549449584568E-06,
(...)
//ALL for subframe 0:
0,-2,20,,,,2.45581475911678E-06
//For subframe 1:
1, -40, 10, 2, 2, -84.7431947342849, 2.68723483754626E-06,
1, -41, 0, 0, 6, -84.7431432845264, 2.37549449584568E-06,
(...)
//ALL for subframe 1:
1,-2,20,,,,2.45581475911678E-06
```

```
(...)
//ALL for all subframes
-2,-2,,,,,2.13196434228374E-06
```

6.7.1.4 Bit stream

For the bitstream result display, the number of return values depends on the parameter.

- `TRACE:DATA TRACE1`
  Returns several values and the bitstream for each line of the table.
  `<subframe>, <allocation ID>, <codeword>, <modulation>, <# of symbols/bits>, <hexadecimal/binary numbers>,...`
- `TRACE:DATA TRACE2`
  Returns all informative values of an allocation, including the totals over all NPDSCH allocations that contribute to the bitstream, but not the bitstream itself.
  `<subframe>, <allocation ID>, <codeword>, <modulation>, <# of symbols/bits>, <hexadecimal/binary numbers>,...,<total # bits>, <total # bit errors>, <total # decoded bits>, <total bit error rate>`
- `TRACE:DATA TRACE3`
  Returns all informative values of an allocation, including the totals over all NPDSCH allocations that contribute to the bitstream, but not the bitstream itself. The difference to `TRACE2` is that this query also includes the Bit/s result.
  `<subframe>, <allocation ID>, <codeword>, <modulation>, <# of symbols/bits>, <hexadecimal/binary numbers>,...,<total # bits>, <total # bit errors>, <total # decoded bits>, <total bit error rate>, <bits/second>`

All values have no unit. The format of the bit stream depends on Bit Stream Format.

For symbols or bits that are not transmitted, the command returns

- "FFF" if the bit stream format is "Symbols"
- "9" if the bit stream format is "Bits".

For symbols or bits that could not be decoded because the number of layer exceeds the number of receive antennas, the command returns

- "FFE" if the bit stream format is "Symbols"
- "8" if the bit stream format is "Bits".

Note that the data format of the return values is always ASCII.

6.7.1.5 Capture buffer

For the capture buffer result display, the command returns one value for each I/Q sample in the capture buffer.

`<absolute power>, ...`

The unit is always dBm.

The following parameters are supported.

- `TRAC:DATA TRACE1`

Note that the command returns positive peak values only.

6.7.1.6 CCDF

For the CCDF result display, the type of return values depends on the parameter.

- `TRAC:DATA TRACE1`
  Returns the probability values (y-axis).
  `<# of values>, <probability>, ...`
  The unit is always %.
  The first value that is returned is the number of the following values.
- `TRAC:DATA TRACE2`
  Returns the corresponding power levels (x-axis).
  `<# of values>, <relative power>, ...`
  The unit is always dB.
  The first value that is returned is the number of the following values.

6.7.1.7 Channel and spectrum flatness

For the channel flatness result display, the command returns one value for each trace point.

`<relative power>, ...`

The unit is always dB.

The following parameters are supported.

- `TRAC:DATA TRACE1`
  Returns the average power over all subframes.
- `TRAC:DATA TRACE2`
  Returns the minimum power found over all subframes. If you are analyzing a particular subframe, it returns nothing.
- `TRAC:DATA TRACE3`
  Returns the maximum power found over all subframes. If you are analyzing a particular subframe, it returns nothing.

6.7.1.8 Channel and spectrum flatness difference

For the channel flatness difference result display, the command returns one value for each trace point.

`<relative power>, ...`

The unit is always dB. The number of values depends on the selected NB-IoT bandwidth.

The following parameters are supported.

- `TRAC:DATA TRACE1`

Returns the average power over all subframes.

- TRAC:DATA TRACE2
  Returns the minimum power found over all subframes. If you are analyzing a particular subframe, it returns nothing.
- TRAC:DATA TRACE3
  Returns the maximum power found over all subframes. If you are analyzing a particular subframe, it returns nothing.

6.7.1.9 Group delay

For the group delay result display, the command returns one value for each trace point.

<group delay>, ...

The unit is always ns. The number of values depends on the selected NB-IoT bandwidth.

The following parameters are supported.

- TRAC:DATA TRACE1
  Returns the group delay.

6.7.1.10 Constellation diagram

For the constellation diagram, the command returns two values for each constellation point.

<I[SF0][Sym0][Carrier1]>, <Q[SF0][Sym0][Carrier1]>, ..., <I[SF0][Sym0][Carrier(n)]>, <Q[SF0][Sym0][Carrier(n)]>,

<I[SF0][Sym1][Carrier1]>, <Q[SF0][Sym1][Carrier1]>, ..., <I[SF0][Sym1][Carrier(n)]>, <Q[SF0][Sym1][Carrier(n)]>,

<I[SF0][Sym(n)][Carrier1]>, <Q[SF0][Sym(n)][Carrier1]>, ..., <I[SF0][Sym(n)][Carrier(n)]>, <Q[SF0][Sym(n)][Carrier(n)]>,

<I[SF1][Sym0][Carrier1]>, <Q[SF1][Sym0][Carrier1]>, ..., <I[SF1][Sym0][Carrier(n)]>, <Q[SF1][Sym0][Carrier(n)]>,

<I[SF1][Sym1][Carrier1]>, <Q[SF1][Sym1][Carrier1]>, ..., <I[SF1][Sym1][Carrier(n)]>, <Q[SF1][Sym1][Carrier(n)]>,

<I[SF(n)][Sym(n)][Carrier1]>, <Q[SF(n)][Sym(n)][Carrier1]>, ..., <I[SF(n)][Sym(n)][Carrier(n)]>, <Q[SF(n)][Sym(n)][Carrier(n)]>

With SF = subframe and Sym = symbol of that subframe.

The I and Q values have no unit.

The number of return values depends on the constellation selection. By default, it returns all resource elements including the DC carrier.

The following parameters are supported.

- TRAC:DATA TRACE1
  Returns all constellation points included in the selection.

6.7.1.11 EVM vs carrier

For the EVM vs carrier result display, the command returns one value for each subcarrier that has been analyzed.

`<EVM>, ...`

The unit depends on `UNIT:EVM`.

The following parameters are supported.

- `TRAC:DATA TRACE1`
  Returns the average EVM over all subframes
- `TRAC:DATA TRACE2`
  Returns the minimum EVM found over all subframes. If you are analyzing a particular subframe, it returns nothing.
- `TRAC:DATA TRACE3`
  Returns the maximum EVM found over all subframes. If you are analyzing a particular subframe, it returns nothing.

6.7.1.12 EVM vs subframe

For the EVM vs subframe result display, the command returns one value for each subframe that has been analyzed.

`<EVM>, ...`

The unit depends on `UNIT:EVM`.

The following parameters are supported.

- `TRAC:DATA TRACE1`

6.7.1.13 EVM vs symbol

For the EVM vs symbol result display, the command returns one value for each OFDM symbol that has been analyzed.

`<EVM>, ...`

For measurements on a single subframe, the command returns the symbols of that subframe only.

The unit depends on `UNIT:EVM`.

The following parameters are supported.

- `TRAC:DATA TRACE1`

6.7.1.14 EVM vs symbol x carrier

For the EVM vs symbol x carrier, the command returns one value for each resource element.

`<EVM[Symbol(0),Carrier(1)]>, ..., <EVM[Symbol(0),Carrier(n)]>,`

```
<EVM[Symbol(1),Carrier(1)]>, ..., <EVM[Symbol(1),Carrier(n)]>,
...
<EVM[Symbol(n),Carrier(1)]>, ..., <EVM[Symbol(n),Carrier(n)]>,
```

The unit depends on `UNIT:EVM`.

Resource elements that are unused return `NAN`.

The following parameters are supported.

- `TRAC:DATA TRACE1`

6.7.1.15 Frequency error vs symbol

For the frequency error vs symbol result display, the command returns one value for each OFDM symbol that has been analyzed.

```
<frequency error>,...
```

The unit is always Hz.

The following parameters are supported.

- `TRAC:DATA TRACE1`

6.7.1.16 Power spectrum

For the power spectrum result display, the command returns one value for each trace point.

```
<power>,...
```

The unit is always dBm/Hz.

The following parameters are supported.

- `TRAC:DATA TRACE1`

6.7.1.17 Power vs symbol x carrier

For the power vs symbol x carrier, the command returns one value for each resource element.

```
<P[Symbol(0),Carrier(1)]>, ..., <P[Symbol(0),Carrier(n)]>,
<P[Symbol(1),Carrier(1)]>, ..., <P[Symbol(1),Carrier(n)]>,
...
<P[Symbol(n),Carrier(1)]>, ..., <P[Symbol(n),Carrier(n)]>,
```

with P = Power of a resource element.

The unit is always dBm.

Resource elements that are unused return `NAN`.

The following parameters are supported.

- `TRAC:DATA TRACE1`

6.7.1.18 Spectrum emission mask

For the SEM measurement, the number and type of returns values depend on the parameter.

- `TRAC:DATA TRACE1`
  Returns one value for each trace point.
  `<absolute power>, ...`
  The unit is always dBm.
- `TRAC:DATA LIST`
  Returns the contents of the SEM table. For every frequency in the spectrum emission mask, it returns 11 values.
  `<index>, <start frequency in Hz>, <stop frequency in Hz>, <RBW in Hz>, <limit fail frequency in Hz>, <absolute power in dBm>, <relative power in dBc>, <limit distance in dB>, <limit check result>, <reserved>, <reserved>...`
  The `<limit check result>` is either a 0 (for PASS) or a 1 (for FAIL).

6.7.1.19 Return value codes

<number of symbols or bits>

In hexadecimal mode, this represents the number of symbols to be transmitted. In binary mode, it represents the number of bits to be transmitted.

<allocation ID>

Represents the allocation ID. The range is as follows.

- **0** = NPDSCH
- **-1** = Invalid / not used
- **-2** = All
- **-3** = NPSS
- **-4** = NSSS
- **-5** = Reference Signal (Antenna 1)
- **-6** = Reference Signal (Antenna 2)
- **-10** = NPHICH
- **-11** = NPDCCH
- **-12** = NPCH

<channel type>

- **0** = TX channel
- **1** = adjacent channel

- **2** = alternate channel

<codeword>

Represents the codeword of an allocation. The range is {0...6}.

- **0** = 1/1
- **1** = 1/2
- **2** = 2/2
- **3** = 1/4
- **4** = 2/4
- **5** = 3/4
- **6** = 4/4

<modulation>

Represents the modulation scheme.

- **0** = unrecognized
- **1** = RBPSK
- **2** = QPSK
- **7** = mixed modulation
- **8** = BPSK

FORMat[:DATA] <Format>

Selects the data format for the data transmission between the FSW and the remote client.

Parameters:

<Format> ASCii | REAL

*RST: ASCii

Example: //Select data format
`FORM REAL`

TRACe<n>[:DATA]? <Result>

This command queries the trace data for each measurement point (y-axis values).

In combination with `TRACe<n>[:DATA]:X?`, you can thus query the coordinates of each measurement point.

Suffix:

<n> Window

Query parameters:

<TraceNumber> **TRACE1 | TRACE2 | TRACE3**
Queries the trace data of the corresponding trace.

LIST Queries the results for the SEM measurement.

Return values:

<TraceData> For more information about the type of return values in the different result displays, see Chapter 6.7.1, "The TRACe[:DATA] command", on page 97.

Example: //Query results of the second measurement window. The type of data that is returned by the parameter (`TRACE1`) depends on the result display shown in measurement window 2.
`TRAC2? TRACE1`

Usage: Query only

Manual operation: See "Data import and export" on page 66

TRACe<n>[:DATA]:X? <Result>

Queries the horizontal trace data for each measurement point (x-axis values).

In combination with `TRACe<n>[:DATA]?`, you can thus query the coordinates of each measurement point.

Suffix:

<n> Window

Query parameters:

<TraceNumber> TRACe1 | TRACe2 | TRACe3 | TRACe4 | TRACe5 | TRACe6

Return values:

<TraceData> The type of value depends on the information displayed on the x-axis of the result display whose contents you query.

Example: //Query trace data of trace 1 in window 2
`TRAC2? TRACE1`
`TRAC2:X? TRACE1`

Usage: Query only

Manual operation: See "Capture Buffer" on page 17
See "EVM vs Carrier" on page 18
See "EVM vs Symbol" on page 19
See "EVM vs Subframe" on page 20
See "Frequency Error vs Symbol" on page 20
See "Power Spectrum" on page 21
See "Channel Flatness" on page 21
See "Group Delay" on page 22
See "Channel Flatness Difference" on page 22

6.7.2 Result readout

CALCulate<n>:MARKer<m>:FUNCtion:POWer<sb>:RESult[:CURRent]? [<Measurement>]

Queries the results of the ACLR measurement or the total signal power level of the SEM measurement.

To get a valid result, you have to perform a complete measurement with synchronization to the end of the measurement before reading out the result. This is only possible for single sweeps.

Suffix:

<n> Window

<m> Marker

<sb> irrelevant

Query parameters:

<Measurement>

CPOW
This parameter queries the channel power of the reference range.

MCAC
Queries the channel powers of the ACLR measurements as shown in the ACLR table.
Where available, this parameter also queries the power of the adjacent channels (for example in the ACLR measurement).

Return values:

<Result>

Results for the Spectrum Emission Mask measurement:
Power level in dBm.

Results for the ACLR measurements:
Relative power levels of the ACLR channels. The number of return values depends on the number of transmission and adjacent channels. The order of return values is:
• <TXChannelPower> is the power of the transmission channel in dBm
• <LowerAdjChannelPower> is the relative power of the lower adjacent channel in dB
• <UpperAdjChannelPower> is the relative power of the upper adjacent channel in dB
• <1stLowerAltChannelPower> is the relative power of the first lower alternate channel in dB
• <1stUpperAltChannelPower> is the relative power of the first lower alternate channel in dB
(...)
• <nthLowerAltChannelPower> is the relative power of a subsequent lower alternate channel in dB
• <nthUpperAltChannelPower> is the relative power of a subsequent lower alternate channel in dB

Example: `CALC1:MARK:FUNC:POW:RES? MCAC`
Returns the current ACLR measurement results.

Usage: Query only

Manual operation: See "Result summary" on page 32

6.8 Numeric result readout

6.8.1 Result for selection

FETCh[:CC<cc>]:SUMMary:CRESt[:AVERage]?

Queries the average crest factor as shown in the result summary.

Suffix:

<cc> Component Carrier

Return values:

<CrestFactor> <numeric value>

Crest Factor in dB.

Example: //Query crest factor
`FETC:SUMM:CRES?`

Usage: Query only

FETCh[:CC<cc>]:SUMMary:EVM[:ALL]:MAXimum?
FETCh[:CC<cc>]:SUMMary:EVM[:ALL]:MINimum?
FETCh[:CC<cc>]:SUMMary:EVM[:ALL][:AVERage]?

Queries the EVM of all resource elements.

Suffix:

<cc> Component Carrier

Return values:

<EVM> <numeric value>

Minimum, maximum or average EVM, depending on the last command syntax element.
The unit is % or dB, depending on your selection.

Example: //Query EVM
`FETC:SUMM:EVM?`

Usage: Query only

FETCh[:CC<cc>]:SUMMary:EVM:PCHannel:MAXimum?
FETCh[:CC<cc>]:SUMMary:EVM:PCHannel:MINimum?
FETCh[:CC<cc>]:SUMMary:EVM:PCHannel[:AVERage]?

Queries the EVM of all physical channel resource elements.

Suffix:
<cc> Component Carrier

Return values:
<EVM> <numeric value>
EVM in % or dB, depending on the unit you have set.

Example: //Query EVM
`FETC:SUMM:EVM:PCH?`

Usage: Query only

FETCh[:CC<cc>]:SUMMary:EVM:PSIGnal:MAXimum?
FETCh[:CC<cc>]:SUMMary:EVM:PSIGnal:MINimum?
FETCh[:CC<cc>]:SUMMary:EVM:PSIGnal[:AVERage]?

Queries the EVM of all physical signal resource elements.

Suffix:
<cc> Component Carrier

Return values:
<EVM> <numeric value>
Minimum, maximum or average EVM, depending on the last command syntax element.
The unit is % or dB, depending on your selection.

Example: //Query EVM
`FETC:SUMM:EVM:PSIG?`

Usage: Query only

FETCh[:CC<cc>]:SUMMary:FERRor:MAXimum?
FETCh[:CC<cc>]:SUMMary:FERRor:MINimum?
FETCh[:CC<cc>]:SUMMary:FERRor[:AVERage]?

Queries the frequency error.

Suffix:
<cc> Component Carrier

Return values:

<FrequencyError> <numeric value>

Minimum, maximum or average frequency error, depending on the last command syntax element.

Default unit: Hz

Example: //Query average frequency error
`FETC:SUMM:FERR?`

Usage: Query only

FETCh[:CC<cc>]:SUMMary:OSTP:MAXimum?
FETCh[:CC<cc>]:SUMMary:OSTP:MINimum?
FETCh[:CC<cc>]:SUMMary:OSTP[:AVERage]?

Queries the OSTP.

Suffix:

<cc> Component Carrier

Return values:

<OSTP> <numeric value>

Minimum, maximum or average OSTP, depending on the last command syntax element.

Default unit: dBm

Example: //Query average OSTP
`FETC:SUMM:OSTP?`

Usage: Query only

FETCh[:CC<cc>]:SUMMary:POWer:MAXimum?
FETCh[:CC<cc>]:SUMMary:POWer:MINimum?
FETCh[:CC<cc>]:SUMMary:POWer[:AVERage]?

Queries the total power.

Suffix:

<cc> Component Carrier

Return values:

<Power> <numeric value>

Minimum, maximum or average power, depending on the last command syntax element.

Default unit: dBm

Example: //Query average total power
`FETC:SUMM:POW?`

Usage: Query only

FETCh[:CC<cc>]:SUMMary:NBP:MAXimum?
FETCh[:CC<cc>]:SUMMary:NBP:MINimum?
FETCh[:CC<cc>]:SUMMary:NBPower[:AVERage]?

Queries the NB-IoT power.

Suffix:

<cc>	irrelevant

Return values:

<Power>	<numeric value> Minimum, maximum or average power, depending on the last command syntax element. Default unit: dBm

Example:	//Query NB-IoT power `FETC:SUMM:NBP?`
Usage:	Query only

FETCh[:CC<cc>]:SUMMary:RSSI:MAXimum?
FETCh[:CC<cc>]:SUMMary:RSSI:MINimum?
FETCh[:CC<cc>]:SUMMary:RSSI[:AVERage]?

Queries the RSSI.

Suffix:

<cc>	Component Carrier

Return values:

<RSSI>	<numeric value> Minimum, maximum or average sampling error, depending on the last command syntax element. Default unit: dBm

Example:	//Query average RSSI `FETC:SUMM:RSSI?`
Usage:	Query only

FETCh[:CC<cc>]:SUMMary:RSTP:MAXimum?
FETCh[:CC<cc>]:SUMMary:RSTP:MINimum?
FETCh[:CC<cc>]:SUMMary:RSTP[:AVERage]?

Queries the RSTP.

Suffix:

<cc>	Component Carrier

Return values:

<RSTP>	<numeric value> Default unit: dBm

Example: //Query RSTP
`FETC:SUMM:RSTP?`

Usage: Query only

FETCh[:CC<cc>]:SUMMary:SERRor:MAXimum?
FETCh[:CC<cc>]:SUMMary:SERRor:MINimum?
FETCh[:CC<cc>]:SUMMary:SERRor[:AVERage]?

Queries the sampling error.

Suffix:
<cc> Component Carrier

Return values:
<SamplingError> <numeric value>

Minimum, maximum or average sampling error, depending on the last command syntax element.

Default unit: ppm

Example: //Query average sampling error
`FETC:SUMM:SERR?`

Usage: Query only

FETCh[:CC<cc>]:SUMMary:TFRame?

Queries the (sub)frame start offset as shown in the capture buffer.

Suffix:
<cc> Component Carrier

Return values:
<Offset> Time difference between the (sub)frame start and capture buffer start.

Default unit: s

Example: //Query subframe start offset
`FETC:SUMM:TFR?`

Usage: Query only

Manual operation: See "Capture Buffer" on page 17

6.8.2 Time alignment error

FETCh:FERRor[:CC<cc>][:AVERage]?

Queries the carrier frequency error.

Suffix:

<cc> Component Carrier

Return values:

<FrequencyError> <numeric value>

Average, minimum or maximum frequency error, depending on the command syntax.

Default unit: Hz

Example: //Query frequency error.
`FETC:FERR?`

Usage: Query only

FETCh:TAERror[:CC<cc>]:ANTenna<ant>:MAXimum
FETCh:TAERror[:CC<cc>]:ANTenna<ant>:MINimum
FETCh:TAERror[:CC<cc>]:ANTenna<ant>[:AVERage]?

Queries the time alignment error.

Suffix:

<cc> Component Carrier

<ant> Antenna

Return values:

<TAE> Minimum, maximum or average time alignment error, depending on the last command syntax element.

Default unit: s

Example: //Query average TAE between reference antenna and antenna 2
`FETC:TAER:ANT2?`

Usage: Query only

Manual operation: See "Time Alignment Error" on page 30

6.8.3 Marker table

CALCulate<n>:DELTamarker<m>:X <Position>

Moves a delta marker to a particular coordinate on the x-axis.

If necessary, the command activates the delta marker and positions a reference marker to the peak power.

Suffix:

<n> Window

<m> Marker

Parameters:

<Position> Numeric value that defines the marker position on the x-axis.

Range: The value range and unit depend on the measurement and scale of the x-axis.

Example: `CALC:DELT:X?`
Outputs the absolute x-value of delta marker 1.

CALCulate<n>:DELTamarker<m>:Y?

Queries the position of a deltamarker on the y-axis.

If necessary, the command activates the deltamarker first.

To get a valid result, you have to perform a complete measurement with synchronization to the end of the measurement before reading out the result. This is only possible for single measurement mode.

See also `INITiate<n>:CONTinuous` on page 94.

Note that result displays with a third aspect (for example "EVM vs Symbol x Carrier") do not support deltamarkers.

Suffix:

<n> Window

<m> Marker

Return values:

<Result> <numeric value>

Result at the deltamarker position. The return value is a value relative to the position of marker 1.
The type of value and its unit depend on the selected result display.

Example: //Query coordinates of deltamarker 2 in window 4
`CALC4:DELT2:X?`
`CALC4:DELT2:Y?`

Usage: Query only

CALCulate<n>:MARKer<m>:X <Position>

Moves a marker to a specific coordinate on the x-axis.

If necessary, the command activates the marker.

If the marker has been used as a delta marker, the command turns it into a normal marker.

Suffix:

<n> Window

<m> Marker
Note that 3D diagrams only support one marker.

Parameters:

<Position> Numeric value that defines the marker position on the x-axis.
The unit depends on the result display.
Range: The range depends on the current x-axis range.
Default unit: Hz

Example: `CALC:MARK2:X 1.7MHz`
Positions marker 2 to frequency 1.7 MHz.

Manual operation: See "Marker Table" on page 29
See "Marker Peak List" on page 34

CALCulate<n>:MARKer<m>:Y <Result>

Queries the position of a marker on the y-axis.

In result displays with a third aspect (for example "EVM vs Symbol x Carrier"), you can also use the command to define the position of the marker on the y-axis.

If necessary, the command activates the marker first.

To get a valid result, you have to perform a complete measurement with synchronization to the end of the measurement before reading out the result. This is only possible for single measurement mode.

See also `INITiate<n>:CONTinuous` on page 94.

Suffix:

<n> Window

<m> Marker
Note that 3D diagrams only support one marker.

Parameters:

<Result> <numeric value>
Result at the marker position.
The type of value and its unit depend on the selected result display.

Example: //Query coordinates of marker 2 in window 4
```
CALC4:MARK2:X?
CALC4:MARK2:Y?
```

Example: //Define position of marker in 3D diagram
```
CALC:MARK:X 16
CALC:MARK:Y 6
```

Manual operation: See "Marker Table" on page 29
See "Marker Peak List" on page 34

CALCulate<n>:MARKer<m>:Z?

Queries the marker position on the z-axis of three-dimensional result displays.

Returns the type of value displayed in the selected result display (EVM, Power or Allocation ID).

Suffix:

<n> Window

<m> Marker

Return values:

<Position> <numeric value>

Default unit: Depends on result display

Example: //Query marker position
```
CALC:MARK:Z?
```

Usage: Query only

Manual operation: See "Marker Table" on page 29

CALCulate<n>:MARKer<m>:Z:ALL?

Queries the marker position on the z-axis of three-dimensional result displays.

Instead of returning a certain type of value (EVM, Power **or** Allocation ID), which is possible with `CALCulate<n>:MARKer<m>:Z?`, this command returns all types of values (EVM, Power **and** Allocation ID), regardless of the result display type.

Suffix:

<n> Window

<m> irrelevant

Return values:

<Position> <numeric value>

EVM
EVM at the marker position.

Power
Power at the marker position.

Allocation ID
Allocation ID at the marker position.

Modulation
Modulation type at the marker position.

Example: //Query EVM, Power and Allocation ID at the marker position.
```
CALC:MARK:Z:ALL?
```

Usage: Query only

Manual operation: See "Marker Table" on page 29

6.8.4 CCDF table

CALCulate<n>:STATistics:CCDF:X<t>? <Probability>

Queries the results of the CCDF.

Suffix:

<n> Window

<t> Trace

Query parameters:

<Probability>

P0_01
Level value for 0.01 % probability

P0_1
Level value for 0.1 % probability

P1
P1: Level value for 1 % probability

P10
Level value for 10 % probability

Return values:

<CCDF Result>

Example: `CALC:STAT:CCDF:X1? P10`
Returns the level values that are over 10 % above the mean value.

Usage: Query only

Manual operation: See "CCDF" on page 23

CALCulate<n>:STATistics:RESult<res>? <ResultType>

Queries the results of a measurement for a specific trace.

Suffix:

<n> Window

<res> Trace

Query parameters:

<ResultType>

MEAN
Average (=RMS) power in dBm measured during the measurement time.

PEAK
Peak power in dBm measured during the measurement time.

CFACtor
Determined crest factor (= ratio of peak power to average power) in dB.

ALL
Results of all three measurements mentioned before, separated by commas: <mean power>,<peak power>,<crest factor>

Example: `CALC:STAT:RES2? ALL`
Reads out the three measurement results of trace 2. Example of answer string: 5.56,19.25,13.69 i.e. mean power: 5.56 dBm, peak power 19.25 dBm, crest factor 13.69 dB

Usage: Query only

Manual operation: See "CCDF" on page 23

6.9 Configuration

6.9.1 General configuration

The following remote control command control general configuration of the application.

The remote control commands to select the result displays for I/Q measurements are described in Chapter 6.5, "Screen layout", on page 84.

CONFigure[:LTE]:MEASurement <Measurement>

Selects the measurement.

Parameters:

<Measurement>

ACLR
Selects the Adjacent Channel Leakage Ratio measurement.

ESPectrum
Selects the Spectrum Emission Mask measurement.

EVM
Selects I/Q measurements.

TAERor
Selects the Time Alignment Error measurement.

*RST: EVM

Example: //Select measurement
CONF:MEAS EVM

Manual operation: See "EVM" on page 13
See "Time alignment error" on page 14
See "Channel power ACLR" on page 14
See "SEM" on page 14
See "Adjacent Channel Leakage Ratio (ACLR)" on page 32
See "Spectrum Emission Mask (SEM)" on page 33
See "Select Measurement" on page 37

MMEMory:STORe<n>:IQ:STATe <Value>,<FileName>

Saves I/Q data to a file.

Suffix:
<n> irrelevant

Parameters:
<Value> 1

<FileName> String containing the path and name of the target file.

Example: MMEM:STOR:IQ:STAT 'C:
\R_S\Instr\user\data.iq.tar'
Saves I/Q data to the specified file.

Manual operation: See "Data import and export" on page 66

SYSTem:PRESet:CHANnel[:EXEC]

Restores the default instrument settings in the current channel.

Use INST:SEL to select the channel.

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

Usage: Event

Manual operation: See "Preset Channel" on page 36

6.9.2 I/Q measurements

6.9.2.1 Signal characteristics

Physical settings

Commands to configure physical settings described elsewhere.

- [SENSe:]FREQuency:CENTer[:CC<cc>]

CONFigure[:LTE]:DEPLoyment <Deployment>

Selects the deployment of the NB-IoT carrier.

Parameters:

<Deployment>

GBANd
NB-IoT uses resource blocks of the guard band of an LTE carrier.

INBand
NB-IoT uses resource blocks within an LTE carrier.

SALone
NB-IoT uses a frequency band outside of an LTE carrier.

*RST: SALone

Example:
//Select NB-IoT deployment
`CONF:DEPL INB`

Manual operation: See "Deployment" on page 38

CONFigure[:LTE]:EUTRa:FREQuency <Frequency>

Defines the center frequency of an E-UTRA channel.

Prerequisites for this command

- Select in band deployment of an NB-IoT carrier (`CONFigure[:LTE]:DEPLoyment`).

Parameters:

<Frequency> <numeric value>

Default unit: Hz

Example: //Define E-UTRA channel center frequency

```
CONF:DEPL INB
CONF:EUTR:FREQ 1GHZ
```

Manual operation: See "Defining physical settings for NB-IoT inband deployment" on page 39

See "Defining physical settings for NB-IoT guardband deployment" on page 40

CONFigure[:LTE]:DL:FREQuency:GINDex <Index>

Defines the location of the NB-IoT carrier in the E-UTRA guard band.

Prerequisites for this command

- Select guard band deployment of an NB-IoT carrier (`CONFigure[:LTE]:DEPLoyment`).

Parameters:

<Index> **<numeric value> (integer only)**

Index number that represents the frequency band in the E-UTRA guard band that the NB-IoT carrier uses. The value range depends on the E-UTRA bandwidth.

For example, for a E-UTRA bandwidth of 10 MHz, the value "+1" corresponds to the first possible location of the NB-IoT carrier in the upper guard band at an offset of 4.4975 MHz. A value of "-2" corresponds to a location in the lower guard band at an offset of -4.7025 MHz.

USER

Custom location of the NB-IoT carrier. Define the location with `CONFigure[:LTE]:DL:FREQuency:OFFSet`.

Example: //Define location of NB-IoT carrier

```
CONF:DEPL GBAN
CONF:DL:GIND -4
```

Manual operation: See "Defining physical settings for NB-IoT guardband deployment" on page 40

CONFigure[:LTE]:DL:FREQuency:OFFSet <Frequency>

Defines the location of the NB-IoT carrier in the E-UTRA guard band.

Prerequisites for this command

- Select guard band deployment of an NB-IoT carrier (`CONFigure[:LTE]:DEPLoyment`).
- Select user defined location (`CONFigure[:LTE]:DL:FREQuency:GINDex`).

Parameters:

<Frequency> <numeric value>

Frequency relative to the center frequency of the E-UTRA carrier.

Default unit: Hz

Example: //Define location of carrier in guard band

```
CONF:DEPL GBAN
CONF:DL:FREQ:GIND USER
CONF:DL:FREQ:OFFS -2.5MHZ
```

Manual operation: See "Defining physical settings for NB-IoT guardband deployment" on page 40

CONFigure[:LTE]:DL:PINDex <Index>

Defines the PRB index of the E-UTRA channel.

Prerequisites for this command

- Select in band deployment of an NB-IoT carrier (`CONFigure[:LTE]:DEPLoyment`).

Parameters:

<Index> <numeric value> (integer only)

*RST: depends on the E-UTRA channel bandwidth

Example: //Define E-UTRA PRB index

```
CONF:DEPL INB
CONF:DL:BW BW10_00
CONF:DL:PIND 9
```

Manual operation: See "Defining physical settings for NB-IoT inband deployment" on page 39

CONFigure[:LTE]:DL:SINFo <Sequence>

Defines the CRS sequence info of the E-UTRA channel.

Prerequisites for this command

- Select in band deployment of an NB-IoT carrier (`CONFigure[:LTE]:DEPLoyment`).

Parameters:

<Sequence> <numeric value> (integer only)

*RST: depends on the E-UTRA channel bandwidth

Example: //Define E-UTRA CRS sequence

```
CONF:DEPL INB
CONF:DL:BW BW10_00
CONF:DL:SINF 20
```

Manual operation: See "Defining physical settings for NB-IoT inband deployment" on page 39

CONFigure[:LTE]:DL[:CC<cc>]:BW <Bandwidth>

Selects the E-UTRA channel bandwidth.

Prerequisites for this command

- Select inband or guard band deployment (CONFigure[:LTE]:DEPLoyment).

Suffix:

<cc> Component Carrier

Parameters:

<Bandwidth> BW1_40 | BW3_00 | BW5_00 | BW10_00 | BW15_00 | BW20_00 | NB_1rb | NB_6rb

*RST: BW10_00

Example: //Single carrier measurement:
//Define channel bandwidth

```
CONF:DL:BW BW1_40
```

Example: //Aggregated carrier measurement:
//Selects two carriers, one with a bandwidth of 5 MHz, the other with 10 MHz.

```
CONF:NOCC 2
CONF:DL:CC1:BW BW10_00
CONF:DL:CC2:BW BW5_00
```

Manual operation: See "Defining physical settings for NB-IoT inband deployment" on page 39
See "Defining physical settings for NB-IoT guardband deployment" on page 40

CONFigure[:LTE]:DL[:CC<cc>]:PLC:CID <CellID>

Defines the cell ID.

Suffix:

<cc> Component Carrier

Parameters:

<CellID> **AUTO**
Automatically defines the cell ID.

<numeric value> (integer only)
Number of the cell ID.

Range: 0 to 503

Example:
//Select cell ID
`CONF:DL:PLC:CID 15`

Manual operation: See "Configuring the Physical Layer Cell Identity" on page 41

CONFigure[:LTE]:DL[:CC<cc>]:PLC:CIDGroup <GroupNumber>

Selects the cell ID group.

Suffix:
<cc> Component Carrier

Parameters:
<GroupNumber>

AUTO
Automatic selection

0...167 (integer only)
Manual selection

*RST: AUTO

Example:
//Select cell identity group
`CONF:DL:PLC:CIDG 134`
//Turn on automatic cell identity group detection
`CONF:DL:PLC:CIDG AUTO`

Manual operation: See "Configuring the Physical Layer Cell Identity" on page 41

CONFigure[:LTE]:DL[:CC<cc>]:PLC:PLID <Identity>

Defines the physical layer cell identity for downlink signals.

Suffix:
<cc> Component Carrier

Parameters:
<Identity>

AUTO
Automatic selection

0...2 (integer only)
Manual selection

*RST: AUTO

Example:
//Select physical layer cell identity
`CONF:DL:PLC:PLID 1`

Manual operation: See "Configuring the Physical Layer Cell Identity" on page 41

CONFigure[:LTE]:TYPE <Type>

Selects the NB-IoT carrier type.

Parameters:

<Type>
: **ANCHor**
NPSS, NSSS, NPBCH and SIB-NB transmission assumed.
NANChor
NPSS, NSSS, NPBCH and SIB-NB transmission not assumed.
*RST: ANCHor

Example: //Select carrier type
`CONF:TYPE ANCH`

Manual operation: See "Carrier Type" on page 39

FETCh[:CC<cc>]:PLC:CIDGroup?

Queries the cell identity group that has been detected.

Suffix:

<cc>
: Component Carrier

Return values:

<CIDGroup>
: The command returns -1 if no valid result has been detected yet.
Range: 0 to 167

Example: //Query the current cell identity group
`FETC:PLC:CIDG?`

Usage: Query only

Manual operation: See "Configuring the Physical Layer Cell Identity" on page 41

FETCh[:CC<cc>]:PLC:PLID?

Queries the cell identity that has been detected.

Suffix:

<cc>
: Component Carrier

Return values:

<Identity>
: The command returns -1 if no valid result has been detected yet.
Range: 0 to 2

Example: //Query the current cell identity
`FETC:PLC:PLID?`

Usage: Query only

Manual operation: See "Configuring the Physical Layer Cell Identity" on page 41

MMEMory:LOAD[:CC<cc>]:DEModsetting <File>

Restores previously saved demodulation settings.

The file must be of type `.allocation` and depends on the link direction that was currently selected when the file was saved. You can load only files with correct link directions.

Suffix:
<cc> Component Carrier

Parameters:
<File> String containing the path and name of the file.

Example: //Load allocation file
`MMEM:LOAD:DEM 'D:\USER\Settingsfile.allocation'`

Manual operation: See "User defined test scenarios" on page 42

MMEMory:LOAD[:CC<cc>]:TMOD:DL <TestModel>

Loads an EUTRA test model (N-TM).

The EUTRA test models are in accordance with 3GPP 36.141.

You can also select an O-RAN test case with the command.

Suffix:
<cc> Component Carrier

Setting parameters:
<TestModel> **<string>**
String that contains the name of the test model, e.g. `'N-TM_Guardband'`.

Example: //Select test model for guardband operation.
`MMEM:LOAD:TMOD:DL 'N-TM_Guardband'`

Usage: Setting only

Manual operation: See "3GPP test models" on page 42

MMEMory:STORe<n>[:CC<cc>]:DEModsetting <FileName>

Saves the signal description.

Suffix:
<n> irrelevant

<cc> irrelevant

Parameters:
<FileName> String containing the path and name of the file.
The file extension is `.allocation`.

Example: //Save signal description
`MMEM:STOR:DEM 'c:\TestSignal.allocation'`

Manual operation: See "User defined test scenarios" on page 42

MIMO configuration

CONFigure[:LTE]:DL[:CC<cc>]:MIMO:ASELection <Antenna>

Selects the antenna for measurements with MIMO setups.

For time alignment error measurements, the command selects the reference antenna.

Suffix:
<cc> Component Carrier

Parameters:
<Antenna>

ANT1 | ANT2
Select a single antenna to be analyzed

ALL
Select all antennas to be analyzed

AUTO
Automatically selects the antenna(s) to be analyzed.

*RST: ANT1

Example: //Select a MIMO setup with two antennas and test antenna number two

```
CONF:DL:MIMO:CONF TX2
CONF:DL:MIMO:ASEL ANT2
```

Manual operation: See "Time Alignment Error" on page 30
See "Tx Antenna Selection" on page 43

CONFigure[:LTE]:DL[:CC<cc>]:MIMO:CONFig <NoOfAntennas>

Sets the number of antennas in the MIMO setup.

Suffix:
<cc> Component Carrier

Parameters:
<NoOfAntennas>

TX1
Use one Tx-antenna

TX2
Use two Tx-antennas

*RST: TX1

Example: //Select MIMO configuration with two antennas

```
CONF:DL:MIMO:CONF TX2
```

Manual operation: See "DUT MIMO Configuration" on page 42

NPDSCH settings

CONFigure[:LTE]:DL:NPDSch:DMODulation <State>

Turns automatic NPDSCH and NPDCCH demodulation on and off.

Parameters:

<State> ON | OFF | 1 | 0

*RST: ON

Example: //Turn on automatic demodulation
`CONF:DL:NPDS:DMOD ON`

Manual operation: See "NPDSCH Demodulation" on page 43

CONFigure[:LTE]:DL:NPDSch:SFList <Subframes>

Defines the subframes that contain the NPDSCH.

Prerequisites for this command

- Turn off automatic NPDSCH demodulation (`CONFigure[:LTE]:DL:NPDSch:DMODulation`).

Parameters:

<Subframes> String that contains the subframes as a comma-separated list (1,2,5,6), a certain range with a dash (1-3) or a combination of both (1-3,5,6).

*RST: ---

Example: // Select NPDSCH subframes
`CONF:DL:NPDS:DMOD OFF`
`CONF:DL:NPDS:SFL "1-3,5,6"`

Manual operation: See "NPDSCH Demodulation" on page 43

CONFigure[:LTE]:DL:NPDSch:UEID <ID>

Defines the N_RNTI (user equipment ID) that contain the NPDSCH.

Prerequisites for this command

- Turn off automatic NPDSCH demodulation (`CONFigure[:LTE]:DL:NPDSch:DMODulation`).

Parameters:

<ID> Range: 0 to 65535
*RST: 0

Example: // Select NPDSCH N_RNTI
`CONF:DL:NPDS:DMOD OFF`
`CONF:DL:NPDS:UEID 16`

Manual operation: See "NPDSCH Demodulation" on page 43

Control channel

CONFigure[:LTE]:DL[:CC<cc>]:PSOFfset <Offset>

Defines the symbol offset for NPDSCH allocations relative to the start of the subframe.

The offset applies to all subframes.

Suffix:
<cc> Component Carrier

Parameters:
<Offset> **AUTO**
Automatically determines the symbol offset.

<numeric value>
Manual selection of the symbol offset.

Range: 0 to 4
*RST: AUTO

Example: //Define PRB symbol offset
`CONF:DL:PSOF 2`

Manual operation: See "PRB Symbol Offset" on page 44

6.9.2.2 Input configuration

Remote commands to configure the input described elsewhere:

- `INPut:COUPling` on page 143
- `INPut:IMPedance` on page 144
- `[SENSe:]SWAPiq` on page 146

CALibration:AIQ:HATiming[:STATe] <State>

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

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

Example: `CAL:AIQ:HAT:STAT ON`

Manual operation: See "High Accuracy Timing Trigger - Baseband - RF" on page 49

INPut:CONNector <ConnType>

Determines which connector the input for the measurement is taken from.

If an external frontend is active, the connector is automatically set to `RF`.

Parameters:

<ConnType> **RF**
RF input connector

RFPRobe
Active RF probe

*RST: RF

Example: `INP:CONN RF`
Selects input from the RF input connector.

Manual operation: See "Input Connector" on page 46

INPut:DIQ:CDEVice

Queries the current configuration and the status of the digital I/Q input from the optional "Digital Baseband" interface.

For details see the section "Interface Status Information" for the optional "Digital Baseband" interface in the FSW I/Q Analyzer User Manual.

Return values:
<Value>

Example: `INP:DIQ:CDEV?`
Result:
`1,SMW200A,101190,BBMM 1 OUT,`
`100000000,200000000,Passed,Passed,1,1.#QNAN`

Manual operation: See "Connected Instrument" on page 47

INPut:DIQ:RANGe:COUPling <State>

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

Is only available if the optional "Digital Baseband" interface is installed.

Parameters:
<State> ON | OFF | 1 | 0
*RST: 0

Manual operation: See "Adjust Reference Level to Full Scale Level" on page 47

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

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

Is only available if the optional "Digital Baseband" interface is installed.

Parameters:
<Level> Range: 1 µV to 7.071 V
*RST: 1 V
Default unit: DBM

Manual operation: See "Full Scale Level" on page 47

INPut:DIQ:RANGe[:UPPer]:AUTO <State>

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

Is only available if the optional "Digital Baseband" interface is installed.

Parameters:
<State> ON | OFF | 1 | 0
*RST: 0

Manual operation: See "Full Scale Level" on page 47

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

Defines the unit of the full scale level. The availability of units depends on the measurement application you are using.

Is only available if the optional "Digital Baseband" interface is installed.

Parameters:

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

*RST: Volt

Manual operation: See "Full Scale Level" on page 47

INPut:DIQ:SRATe <SampleRate>

Specifies or queries the sample rate of the input signal from the optional "Digital Baseband" interface.

Parameters:

<SampleRate> Range: 1 Hz to 20 GHz

*RST: 32 MHz

Default unit: HZ

Example: `INP:DIQ:SRAT 200 MHz`

Manual operation: See "Input Sample Rate" on page 47

INPut:DIQ:SRATe:AUTO <State>

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

Is only available if the optional "Digital Baseband" interface is installed.

Parameters:

<State> ON | OFF | 1 | 0

*RST: 0

Manual operation: See "Input Sample Rate" on page 47

INPut:DPATh <DirectPath>

Enables or disables the use of the direct path for frequencies close to 0 Hz.

If an external frontend is active, the direct path is always used.

Parameters:

<DirectPath> AUTO | OFF

AUTO | 1
(Default) the direct path is used automatically for frequencies close to 0 Hz.

OFF | 0
The analog mixer path is always used.

Example: `INP:DPAT OFF`

Manual operation: See "Direct Path" on page 45

INPut:FILE:PATH <FileName>[, <AnalysisBW>]

Selects the I/Q data file to be used as input for further measurements.

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

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

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

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

Parameters:

<FileName> String containing the path and name of the source file.
The file type is determined by the file extension. If no file extension is provided, the file type is assumed to be `.iq.tar`.
For `.mat` files, Matlab® v4 is assumed.

<AnalysisBW> Optionally: The analysis bandwidth to be used by the measurement. The bandwidth must be smaller than or equal to the bandwidth of the data that was stored in the file.

Default unit: HZ

Example: `INP:FILE:PATH 'C:\R_S\Instr\user\data.iq.tar'`
Uses I/Q data from the specified file as input.

Example:

```
//Load an IQW file
INP:SEL:FIQ
INP:FILE:PATH 'C:\R_S\Instr\user\data.iqw'
//Define the sample rate
TRAC:IQ:SRAT 10MHz
//Define the measurement time
SENSe:SWEep:TIME  0.001001
//Start the measurement
INIT:IMM
```

Manual operation: See "Select I/Q data file" on page 50
See "Data import and export" on page 66

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

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

Requires an additional high-pass filter hardware option.

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

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example: `INP:FILT:HPAS ON`
Turns on the filter.

Manual operation: See "High Pass Filter 1 to 3 GHz" on page 45

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

Enables or disables the YIG filter.

Parameters:

<State> ON | OFF | 0 | 1

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

Manual operation: See "YIG-Preselector" on page 45

INPut:IQ:BALanced[:STATe] <State>

Defines whether the input is provided as a differential signal via all 4 Analog Baseband connectors or as a plain I/Q signal via 2 single-ended lines.

Parameters:

<State> ON | OFF | 1 | 0

ON | 1
Differential

OFF | 0
Single ended

*RST: 1

Example: `INP:IQ:BAL OFF`

Manual operation: See "Input Configuration" on page 48

INPut:IQ:TYPE <DataType>

Defines the format of the input signal.

Parameters:

<DataType> IQ | I | Q

IQ
The input signal is filtered and resampled to the sample rate of the application.
Two input channels are required for each input signal, one for the in-phase component, and one for the quadrature component.

I
The in-phase component of the input signal is filtered and resampled to the sample rate of the application. If the center frequency is not 0, the in-phase component of the input signal is down-converted first (Low IF I).

Q
The quadrature component of the input signal is filtered and resampled to the sample rate of the application. If the center frequency is not 0, the quadrature component of the input signal is down-converted first (Low IF Q).

*RST: IQ

Example: `INP:IQ:TYPE Q`

Manual operation: See "I/Q Mode" on page 48

INPut:SELect <Source>

Selects the signal source for measurements, i.e. it defines which connector is used to input data to the FSW.

If no additional input options are installed, only RF input or file input is supported.

For FSW85 models with two RF input connectors, you must select the input connector to configure first using `INPut:TYPE`.

Parameters:

<Source>

RF
Radio Frequency ("RF INPUT" connector)

FIQ
I/Q data file
(selected by `INPut:FILE:PATH` on page 135)
Not available for Input2.

DIQ
Digital IQ data (only available with optional "Digital Baseband" interface)
For details on I/Q input see the FSW I/Q Analyzer User Manual.
Not available for Input2.

AIQ
Analog Baseband signal (only available with optional "Analog Baseband" interface)
Not available for Input2.

*RST: RF

Example:
`INP:TYPE INP1`
For FSW85 models with two RF input connectors: selects the 1.00 mm RF input connector for configuration.
`INP:SEL RF`

Manual operation:
See "Digital I/Q Input State" on page 46
See "Analog Baseband Input State" on page 48
See "I/Q Input File State" on page 50

INPut:TYPE <Input>

The command selects the input path.

Parameters:

<Input>

INPUT1
Selects RF input 1.
1 mm [RF Input] connector

INPUT2
Selects RF input 2.
For FSW85 models with two RF input connectors:
1.85 mm [RF2 Input] connector
For all other models: not available

*RST: INPUT1

Example:
//Select input path
`INP:TYPE INPUT1`

MMEMory:LOAD:IQ:STReam <Channel>

Only available for files that contain more than one data stream from multiple channels: selects the data stream to be used as input for the currently selected channel.

Automatic mode (`MMEMory:LOAD:IQ:STReam:AUTO`) is set to OFF.

Parameters:

<Channel> String containing the channel name.

Example:
```
MMEM:LOAD:IQ:STR?
//Result: 'Channel1','Channel2'
MMEM:LOAD:IQ:STR 'Channel2'
```

Manual operation:
See "Selected Channel" on page 50

MMEMory:LOAD:IQ:STReam:AUTO <State>

Only available for files that contain more than one data stream from multiple channels: automatically defines which data stream in the file is used as input for the channel.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
The data stream specified by `MMEMory:LOAD:IQ:STReam` is used as input for the channel.

ON | 1
The first data stream in the file is used as input for the channel. Applications that support multiple data streams use the first data stream in the file for the first input stream, the second for the second stream etc.

*RST: 1

Manual operation: See "Selected Channel" on page 50

MMEMory:LOAD:IQ:STReam:LIST?

Returns the available channels in the currently loaded input file.

Example:
```
MMEM:LOAD:IQ:STR?
//Result: 'Channel1','Channel2'
```

Usage: Query only

Manual operation: See "Selected Channel" on page 50

TRACe:IQ:FILE:REPetition:COUNt <RepetitionCount>

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

Parameters:

<RepetitionCount> integer

Example: `TRAC:IQ:FILE:REP:COUN 3`

Manual operation: See "File Repetitions" on page 50

6.9.2.3 Frequency configuration

[SENSe:]FREQuency:CENTer[:CC<cc>] <Frequency>

Sets the center frequency for RF measurements.

Note that the [:CC<cc>] part of the syntax is not supported.

Suffix:
<cc> Component Carrier

Parameters:
<Frequency> <numeric value>

Range: fmin to fmax
*RST: 1 GHz
Default unit: Hz

Example: //Define frequency for measurement on one carrier:
`FREQ:CENT 1GHZ`

Manual operation: See "Defining physical settings for NB-IoT inband deployment" on page 39
See "Defining physical settings for NB-IoT guardband deployment" on page 40
See "Center Frequency" on page 51

[SENSe:]FREQuency:CENTer[:CC<cc>]:OFFSet <Offset>

Defines the general frequency offset.

Suffix:
<cc> Component Carrier

Parameters:
<Offset> <numeric value>

- General frequency offset: frequency offset in Hz.

Default unit: Hz

Example: //Add a frequency offset of 50 Hz to the measurement frequency.
`FREQ:CENT:OFFS 50HZ`

Manual operation: See "Center Frequency" on page 51

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

Defines the center frequency step size.

You can increase or decrease the center frequency quickly in fixed steps using the `SENS:FREQ UP` and `SENS:FREQ DOWN` commands, see `[SENSe:]FREQuency:CENTer[:CC<cc>]` on page 139.

Parameters:
<StepSize> For f_{max}, refer to the specifications document.

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

Example: //Set the center frequency to 110 MHz.

```
FREQ:CENT 100 MHz
FREQ:CENT:STEP 10 MHz
FREQ:CENT UP
```

Manual operation: See "Frequency Stepsize" on page 51

6.9.2.4 Amplitude configuration

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

Defines the reference level (for all traces in all windows).

With a reference level offset ≠ 0, the value range of the reference level is modified by the offset.

Suffix:

<n> irrelevant

<w> subwindow
Not supported by all applications

<t> irrelevant

Parameters:

<ReferenceLevel> The unit is variable.

Range: see specifications document
*RST: 0 dBm
Default unit: DBM

Example:

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

Manual operation: See "Reference Level" on page 52

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

Defines a reference level offset (for all traces in all windows).

Suffix:

<n> irrelevant

<w> subwindow
Not supported by all applications

<t> irrelevant

Parameters:

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

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

Manual operation: See "Reference Level Offset" on page 53

INPut:ATTenuation<ant> <Attenuation>

Defines the RF attenuation level.

Prerequisites for this command

- Decouple attenuation from reference level (`INPut:ATTenuation<ant>:AUTO`).

Suffix:

<ant> irrelevant

Parameters:

<Attenuation> *RST: 10 dB
Default unit: dB

Example: //Define RF attenuation
```
INP:ATT:AUTO OFF
INP:ATT 10
```

Manual operation: See "RF Attenuation" on page 53

INPut:ATTenuation<ant>:AUTO <State>

Couples and decouples the RF attenuation to the reference level.

Suffix:

<ant> irrelevant

Parameters:

<State> ON | OFF | 1 | 0
*RST: ON

Example: //Couple attenuation to reference level (auto attenuation)
```
INP:ATT:AUTO ON
```

Manual operation: See "RF Attenuation" on page 53

INPut:COUPling <CouplingType>

Selects the coupling type of the RF input.

If an external frontend is active, the coupling is automatically set to `AC`.

Parameters:

<CouplingType> AC | DC

AC
AC coupling

DC
DC coupling

*RST: AC

Example: `INP:COUP DC`

Manual operation: See "Input Coupling" on page 54

INPut:GAIN:STATe <State>

Turns the internal preamplifier on and off. It requires the optional preamplifier hardware.

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

If option R&S FSW-B22 is installed, the preamplifier is only active below 7 GHz.

If option R&S FSW-B24 is installed, the preamplifier is active for all frequencies.

Parameters:

<State> ON | OFF | 0 | 1

OFF | 0
Switches the function off

ON | 1
Switches the function on

*RST: 0

Example:

```
INP:GAIN:STAT ON
INP:GAIN:VAL 15
```

Switches on 15 dB preamplification.

Manual operation: See "Preamplifier" on page 54

INPut:GAIN[:VALue] <Gain>

Selects the "gain" if the preamplifier is activated (`INP:GAIN:STAT ON`, see `INPut:GAIN:STATe` on page 143).

The command requires the additional preamplifier hardware option.

Parameters:

<Gain> For all FSW models except for FSW85, the following settings are available:
15 dB and 30 dB
All other values are rounded to the nearest of these two.
For FSW85 models:
FSW43 or higher:
30 dB

Default unit: DB

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

Manual operation: See "Preamplifier" on page 54

INPut:IMPedance <Impedance>

Selects the nominal input impedance of the RF input. In some applications, only 50 Ω are supported.

Parameters:

<Impedance> 50 | 75

*RST: 50 Ω
Default unit: OHM

Example: `INP:IMP 75`

Manual operation: See "Impedance" on page 55

INPut:EATT<ant> <Attenuation>

Defines the electronic attenuation level.

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

Is available with the optional electronic attenuator, but not if you are using the optional digital baseband input.

Suffix:

<ant> Connected instrument

Parameters:

<Attenuation> Attenuation level in dB.

Default unit: dB

Example: //Define signal attenuation
`INP:EATT 10`

Manual operation: See "Electronic Attenuation" on page 54

INPut:EATT<ant>:AUTO <State>

Turns automatic selection of the electronic attenuation on and off.

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

Is available with the optional electronic attenuator, but not if you are using the optional digital baseband Input.

Suffix:
<ant> 1...4
Connected instrument

Parameters:
<State> ON | OFF | 1 | 0
*RST: OFF

Example: //Turn on automatic selection of electronic attenuation
`INP:EATT:AUTO ON`

Manual operation: See "Electronic Attenuation" on page 54

INPut:EATT<ant>:STATe <State>

Turns the electronic attenuator on and off.

Is available with the optional electronic attenuator, but not if you are using the optional digital baseband input.

Suffix:
<ant> 1...4
Connected instrument

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

Example: //Turn on electronic attenuation
`INP:EATT:STAT ON`

Manual operation: See "Electronic Attenuation" on page 54

6.9.2.5 Signal capture

[SENSe:][LTE:]FRAMe:COUNt <Subframes>

Defines the number of frames you want to analyze.

Prerequisites for this command

- Turn on overall frame count ([SENSe:][LTE:]FRAMe:COUNt:STATe).
- Turn on manual selection of frames to analyze ([SENSe:][LTE:]FRAMe:COUNt:AUTO).

Parameters:

<Subframes> <numeric value> (integer only)

*RST: 1

Example: //Define number of frames to analyze manually

```
FRAM:COUN:STAT ON
FRAM:COUN:AUTO OFF
FRAM:COUN 20
```

Manual operation: See "Number of Frames to Analyze" on page 56

[SENSe:][LTE:]FRAMe:COUNt:AUTO <State>

Turns automatic selection of the number of frames to analyze on and off.

Parameters:

<State>

ON | 1
Selects the analyzed number of frames according to the NB-IoT standard.

OFF | 0
Turns on manual selection of the number of frames.

Example: //Turn on automatic selection of analyzed frames

```
FRAM:COUN:AUTO ON
```

Manual operation: See "Auto According to Standard" on page 56

[SENSe:][LTE:]FRAMe:COUNt:STATe <State>

Turns manual selection of the number of frames you want to analyze on and off.

Parameters:

<State>

ON | 1
You can set the number of frames to analyze.

OFF | 0
The FSW analyzes the frames captured in a single sweep.

*RST: ON

Example: //Turn on manual selection of number of frames

```
FRAM:COUN:STAT ON
```

Manual operation: See "Overall Frame Count" on page 56

[SENSe:]SWAPiq <State>

Turns a swap of the I and Q branches on and off.

Parameters:

<State> ON | OFF | 1 | 0

*RST: OFF

Example: //Swap I and Q branches

```
SWAP ON
```

Manual operation: See "Swap I/Q" on page 56

[SENSe:]SWEep:TIME <CaptureLength>

Defines the capture time.

Parameters:

<CaptureLength> <numeric value>

*RST: 20.1 ms

Default unit: s

Example: //Define capture time

```
SWE:TIME 40ms
```

Manual operation: See "Capture Time" on page 56

6.9.2.6 Trigger

The trigger functionality of the NB-IoT measurement application is the same as that of the FSW.

For a comprehensive description of the available remote control commands for trigger configuration, see the documentation of the FSW.

TRIGger[:SEQuence]:DTIMe <DropoutTime>

Defines the time the input signal must stay below the trigger level before a trigger is detected again.

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

Parameters:

<DropoutTime> Dropout time of the trigger.

Range: 0 s to 10.0 s
*RST: 0 s
Default unit: S

Manual operation: See "Trigger Source" on page 57

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

Defines the trigger offset.

Suffix:

<ant> Instrument

Parameters:

<Offset> <numeric value>

*RST: 0 s
Default unit: s

Example: //Define trigger offset
`TRIG:HOLD 5MS`

Manual operation: See "Trigger Source" on page 57

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

Defines the holding time before the next trigger event.

Note that this command can be used for **any trigger source**, not just IF Power (despite the legacy keyword).

Parameters:

<Period> Range: 0 s to 10 s
*RST: 0 s
Default unit: S

Example: `TRIG:SOUR EXT`
Sets an external trigger source.
`TRIG:IFP:HOLD 200 ns`
Sets the holding time to 200 ns.

Manual operation: See "Trigger Source" on page 57

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

Defines the trigger hysteresis, which is only available for "IF Power" trigger sources.

Parameters:

<Hysteresis> Range: 3 dB to 50 dB
*RST: 3 dB
Default unit: DB

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

Manual operation: See "Trigger Source" on page 57

TRIGger[:SEQuence]:LEVel<ant>[:EXTernal<tp>] <Level>

Defines the level for an external trigger.

Suffix:
<ant> Instrument

<tp> Trigger port

Parameters:
<Level> Range: 0.5 V to 3.5 V
*RST: 1.4 V
Default unit: V

Example: //Define trigger level
`TRIG:LEV 2V`

Manual operation: See "Trigger Source" on page 57

TRIGger[:SEQuence]:LEVel<ant>:IFPower <Level>

Defines the power level at the third intermediate frequency that must be exceeded to cause a trigger event.

Note that any RF attenuation or preamplification is considered when the trigger level is analyzed. If defined, a reference level offset is also considered.

Suffix:
<ant> Instrument

Parameters:
<Level> <numeric value>

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

*RST: -10 dBm
Default unit: dBm

Example: //Define trigger level
`TRIG:SOUR IFP`
`TRIG:LEV:IFP -30dBm`

Manual operation: See "Trigger Source" on page 57

TRIGger[:SEQuence]:LEVel<ant>:IQPower <Level>

Defines the magnitude the I/Q data must exceed to cause a trigger event.

Note that any RF attenuation or preamplification is considered when the trigger level is analyzed. If defined, a reference level offset is also considered.

Suffix:
<ant> Instrument

Parameters:
<Level> <numeric value>

Range: -130 dBm to 30 dBm
*RST: -20 dBm
Default unit: dBm

Example: //Define trigger level

```
TRIG:SOUR IQP
TRIG:LEV:IQP -30dBm
```

Manual operation: See "Trigger Source" on page 57

TRIGger[:SEQuence]:LEVel<ant>:RFPower <Level>

Defines the power level the RF input must exceed to cause a trigger event. Note that any RF attenuation or preamplification is considered when the trigger level is analyzed. If defined, a reference level offset is also considered.

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

Suffix:
<ant> Instrument

Parameters:
<Level> <numeric value>

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

*RST: -20 dBm
Default unit: dBm

Example: //Define trigger level

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

Manual operation: See "Trigger Source" on page 57

TRIGger[:SEQuence]:PORT<ant> <port>

Selects the trigger port for measurements with devices that have several trigger ports.

Suffix:
<ant> Analyzer

Parameters:
<port> **PORT1**

PORT2

PORT3

Example: //Select trigger port 1
`TRIG:PORT PORT1`

TRIGger[:SEQuence]:SLOPe <Type>

Selects the trigger slope.

Parameters:

<Type> POSitive | NEGative

POSitive
Triggers when the signal rises to the trigger level (rising edge).

NEGative
Triggers when the signal drops to the trigger level (falling edge).

*RST: POSitive

Example: `TRIG:SLOP NEG`

Manual operation: See "Trigger Source" on page 57

TRIGger[:SEQuence]:SOURce<ant> <Source>

Selects the trigger source.

Note on external triggers:

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

Suffix:

<ant> Analyzer

Parameters:

<Source>

IMMediate
Free run (no trigger event to start a measurement).

EXTernal
Measurement starts when the external trigger signal exceeds a certain level.
Trigger signal from the "Trigger In" connector.

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

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

RFPower
Measurement starts when the first intermediate frequency exceeds a certain level.
(Frequency and time domain measurements only.)
Not available for input from the optional Digital Baseband Interface or the optional analog baseband Interface.

IFPower
Measurement starts when the second intermediate frequency exceeds a certain level.
Not available for input from the optional digital baseband interface. For input from the optional analog baseband interface, this parameter is interpreted as `BBPower` for compatibility reasons.

IQPower
Measurement starts when the sampled I/Q data exceeds a certain magnitude.
For applications that process I/Q data, such as the I/Q analyzer or optional applications.

BBPower
Measurement starts when the baseband power exceeds a certain level.
For digital input via the optional digital baseband interface or the optional analog baseband interface.

PSEN
External power sensor

GP0 | GP1 | GP2 | GP3 | GP4 | GP5
For applications that process I/Q data, such as the I/Q analyzer or optional applications, and only if the optional digital baseband interface is available.
Defines triggering of the measurement directly via the LVDS connector. The parameter specifies which general purpose bit (0 to 5) will provide the trigger data.

*RST: IMMediate

Manual operation: See "Trigger Source" on page 57

6.9.2.7 Demodulation

CONFigure[:LTE]:DL[:CC<cc>]:MIMO:CROSstalk <State>

Turns MIMO crosstalk compensation on and off.

Suffix:
<cc> Component Carrier

Parameters:
<State> ON | OFF | 1 | 0

*RST: OFF

Example: //Turn on crosstalk compensation
`CONF:DL:MIMO:CROS ON`

Manual operation: See "Compensate Crosstalk" on page 61

[SENSe:][LTE:]DL:DEMod:CBSCrambling <State>

Turns scrambling of coded bits on and off.

Parameters:

<State> ON | OFF | 1 | 0

*RST: ON

Example: //Descramble coded bits

`DL:DEM:CBSC ON`

Manual operation: See "Scrambling of Coded Bits" on page 60

[SENSe:][LTE:]DL:DEMod:MCFilter <State>

Turns suppression of interfering neighboring carriers on and off (e.g. LTE, WCDMA, GSM etc).

Parameters:

<State> ON | OFF | 1 | 0

*RST: OFF

Example: //Turn on interference suppression

`DL:DEM:MCF ON`

Manual operation: See "Multicarrier Filter" on page 60

[SENSe:][LTE:]DL:DEMod:EVMCalc <Calculation>

Selects the EVM calculation method.

Parameters:

<Calculation>

TGPP
3GPP definition

OTP
Optimal timing position

*RST: TGPP

Example: //Select EVM calculation method

`DL:DEM:EVMC TGPP`

Manual operation: See "EVM Calculation Method" on page 60

[SENSe:][LTE:]DL:DEMod:PRData <Reference>

Selects the type of reference data to calculate the EVM for the NPDSCH.

Parameters:

<Reference>

AUTO
Automatic identification of reference data.

ALL0
Reference data is 0, according to the test model definition.

Example: //Select reference data for NPDSCH demodulation
`DL:DEM:PRD ALL0`

Manual operation: See "NPDSCH Reference Data" on page 61

6.9.2.8 Estimation & compensation

Parameter estimation

[SENSe:][LTE:]DL:DEMod:BESTimation <State>

Turns boosting estimation on and off.

Note that boosting estimation is always active.

Parameters:
<State> ON | OFF | 1 | 0
*RST: ON

Example: //Turn on boosting estimation
`DL:DEM:BEST ON`

Manual operation: See "Boosting Estimation" on page 59

[SENSe:][LTE:]DL:DEMod:CESTimation <Type>

Selects the channel estimation type.

Parameters:
<Type>

PIL
Optimal, pilot only

PILP
Optimal, pilot and payload

TGPP
3GPP EVM definition

*RST: TGPP

Example: //Select channel estimation type
`DL:DEM:CEST TGPP`

Manual operation: See "Channel Estimation" on page 59

Error compensation

[SENSe:][LTE:]DL:TRACking:PHASe <Type>

Selects the phase tracking type.

Parameters:

<Type>

OFF
Deactivate phase tracking

PIL
Pilot only

PILP
Pilot and payload

*RST: OFF

Example: //Select phase tracking type
`DL:TRAC:PHAS PILPAY`

Manual operation: See "Phase" on page 59

[SENSe:][LTE:]DL:TRACking:TIME <State>

Turns timing tracking on and off.

Parameters:

<State> ON | OFF | 1 | 0

*RST: OFF

Example: //Turn on timing tracking
`DL:TRAC:TIME ON`

Manual operation: See "Time Tracking" on page 59

6.9.2.9 Automatic configuration

Commands to configure the application automatically described elsewhere.

- `DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:AUTO`

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

To determine the ideal reference level, the FSW performs a measurement on the current input data. This command defines the length of the measurement if `[SENSe:]ADJust:CONFigure:LEVel:DURation:MODE` is set to `MANual`.

Parameters:

<Duration> Numeric value in seconds

Range: 0.001 to 16000.0
*RST: 0.001
Default unit: s

Example: ADJ:CONF:DUR:MODE MAN
Selects manual definition of the measurement length.
ADJ:CONF:LEV:DUR 5ms
Length of the measurement is 5 ms.

Manual operation: See "Auto Level" on page 52

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

To determine the ideal reference level, the FSW performs a measurement on the current input data. This command selects the way the FSW determines the length of the measurement .

Parameters:

<Mode>

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

MANual
The FSW uses the measurement length defined by [SENSe:]ADJust:CONFigure:LEVel:DURation on page 155.

*RST: AUTO

Manual operation: See "Auto Level" on page 52

[SENSe:]ADJust:LEVel<ant>

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 FSW or limiting the dynamic range by an S/N ratio that is too small.

Suffix:

<ant> 1...4
Connected instrument

Example: //Auto level on one instrument
ADJ:LEV2

Usage: Event

Manual operation: See "Auto Level" on page 52
See "Auto leveling" on page 61

6.9.3 Time alignment error measurements

All commands specific to the time alignment measurement are listed below.

Commands to configure the time alignment measurement described elsewhere:

- Commands in "Physical settings" on page 122.
- Commands in "Control channel" on page 131.

- Commands in Chapter 6.9.2.7, "Demodulation", on page 152.
- Commands in Chapter 6.9.2.2, "Input configuration", on page 131.
- Commands in Chapter 6.9.2.3, "Frequency configuration", on page 139.
- Commands in Chapter 6.9.2.4, "Amplitude configuration", on page 141.
- Commands in Chapter 6.9.2.5, "Signal capture", on page 145.

6.9.4 Frequency sweep measurements

The remote commands required to configure frequency sweep measurements are the same as in the spectrum application.

Refer to the documentation of the FSW base unit for a comprehensive list and description of remote commands necessary to configure and perform frequency sweep measurements (ACLR and SEM).

All commands specific to the NB-IoT application are listed below.

[SENSe:]POWer:SEM:CATegory <Category>

Parameters:

<Category>

HOME
Home base station

LARE
Local area base station

MED
Medium range base station

WARE
Wide area base station

*RST: A

Example: //Select base station category
`POW:SEM:CAT MED`

Manual operation: See "Category" on page 63

[SENSe:]POWer:SEM:CHBS:AMPower <Power>

Defines the Tx power for medium range base stations.

Prerequisites for this command

- Select medium range base stations (`[SENSe:]POWer:SEM:CATegory`).
- Turn off automatic power determination (`[SENSe:]POWer:SEM:CHBS:AMPower:AUTO`).

Parameters:

<Power> <numeric value>

Default unit: dBm

Example: //Define base station power
```
POW:SEM:CAT MED
POW:SEM:CHBS:AMP:AUTO OFF
POW:SEM:CHBS:AMP 0
```

Manual operation: See "Tx Power" on page 64

[SENSe:]POWer:SEM:CHBS:AMPower:AUTO <State>

Turn automatic detection of the TX channel power on and off.

Prerequisites for this command

- Select medium range base stations ([SENSe:]POWer:SEM:CATegory).

When you turn off automatic detection, you can define the TX channel power manually with [SENSe:]POWer:SEM:CHBS:AMPower.

Parameters:

<State> ON | OFF | 1 | 0

*RST: OFF

Example: //Turn on automatic detection of the TX channel power
```
POW:SEM:CAT MED
POW:SEM:CHBS:AMP:AUTO ON
```

Manual operation: See "Tx Power" on page 64

[SENSe:]POWer:SEM:PIOM <Mode>

Selects the way that the limits of the spectrum emission mask are calculated.

Parameters:

<Mode>

AUTO
Automatically calculates the limits based on the NB-IoT power measured in the reference range.

MANual
Calculates the limits based on the power defined with [SENSe:]POWer:SEM:PIOV.

*RST: AUTO

Example: //Select calculation method for SEM limits
```
POW:SEM:PIOM AUTO
```

Manual operation: See "Power NB-IoT Carrier" on page 64

[SENSe:]POWer:SEM:PIOV <Power>

Defines the power of the NB-IoT carrier on which the calculation of the SEM limits is based.

Prerequisites for this command

- Select manual SEM limit calculation mode ([SENSe:]POWer:SEM:PIOM).

Parameters:

<Power> <numeric value>

*RST: 0

Example: //Define NB-IoT power manually

```
POW:SEM:PIOM MAN
POW:SEM:PIOV -43
```

Manual operation: See "Power NB-IoT Carrier" on page 64

6.10 Analysis

6.10.1 Trace export

FORMat:DEXPort:DSEParator <Separator>

Selects the decimal separator for data exported in ASCII format.

Parameters:

<Separator> POINt | COMMa

COMMa
Uses a comma as decimal separator, e.g. *4,05*.

POINt
Uses a point as decimal separator, e.g. *4.05*.

*RST: *RST has no effect on the decimal separator. Default is POINt.

Example:

```
FORM:DEXP:DSEP POIN
```

Sets the decimal point as separator.

FORMat:DEXPort:HEADer <State>

If enabled, additional instrument and measurement settings are included in the header of the export file for result data. If disabled, only the pure result data from the selected traces and tables is exported.

Parameters:

<State>	ON | OFF | 0 | 1 *RST: 1

FORMat:DEXPort:TRACes <Selection>

Selects the data to be included in a data export file (see MMEMory:STORe<n>:TRACe on page 160).

Parameters:

<Selection>	SINGle | ALL **SINGle** Only a single trace is selected for export, namely the one specified by the MMEMory:STORe<n>:TRACe command. **ALL** Selects all active traces and result tables (e.g. "Result Summary", marker peak list etc.) in the current application for export to an ASCII file. The <trace> parameter for the MMEMory:STORe<n>:TRACe command is ignored. *RST: SINGle

MMEMory:STORe<n>:TRACe <Trace>, <FileName>

Exports trace data from the specified window to an ASCII file.

Secure User Mode

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

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

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

Suffix:

<n>	Window

Parameters:

<Trace>	Number of the trace to be stored
<FileName>	String containing the path and name of the target file.

Example: `MMEM:STOR1:TRAC 1,'C:\TEST.ASC'`
Stores trace 1 from window 1 in the file `TEST.ASC`.

6.10.2 Microservice export

MMEMory:STORe<n>:MSERvice <FileName>

Exports the signal configuration to the microservice.

Suffix:
<n> irrelevant

Parameters:
<FileName> String containing the path and name of the file.
The file extension is `.m5g`.

Example: //Export to microservice
`MMEM:STOR:MSER 'signal.xxx'`

6.10.3 Evaluation range

[SENSe:][LTE:][CC<cc>:]ALLocation:SELect <Allocation>

Filters the displayed results in the constellation diagram by a certain type of allocation.

Suffix:
<cc> Component Carrier

Parameters:
<Allocation> **ALL**
Shows the results for all allocations.

<numeric_value> (integer only)
Shows the results for a single allocation type.
Allocation types are mapped to numeric values. For the code assignment, see Chapter 6.7.1.19, "Return value codes", on page 105.

*RST: ALL

Example: //Display results for NPDCCH
`ALL:SEL -11`

Manual operation: See "Evaluation range for the constellation diagram" on page 70

[SENSe:][LTE:][CC<cc>:]CARRier:SELect <Carrier>

Filters the results in the constellation diagram by a certain subcarrier.

Suffix:
<cc> Component Carrier

Parameters:
<Carrier>

ALL
Shows the results for all subcarriers.

<numeric_value> (integer only)
Shows the results for a single subcarrier.

*RST: ALL

Example: //Display results for subcarrier 1
`CARR:SEL 1`

Manual operation: See "Evaluation range for the constellation diagram" on page 70

[SENSe:][LTE:][CC<cc>:]LOCation:SELect <Location>

Selects the data source of the constellation diagram.

Suffix:
<cc> Component Carrier

Parameters:
<Location>

AMD
After the MIMO decoder

BMD
Before the MIMO decoder

*RST: BMD

Example: //Use data from after the MIMO decoder
`LOC:SEL AMD`

Manual operation: See "Evaluation range for the constellation diagram" on page 70

[SENSe:][LTE:][CC<cc>:]MODulation:SELect <Modulation>

Filters the results in the constellation diagram by a certain type of modulation.

Suffix:
<cc> Component Carrier

Parameters:
<Modulation>

ALL
Shows the results for all modulation types.

<numeric_value> (integer only)
Shows the results for a single modulation type.
Modulation types are mapped to numeric values. For the code assignment, see Chapter 6.7.1.19, "Return value codes", on page 105.

*RST: ALL

Example: //Display results for all elements with a QPSK modulation
`MOD:SEL 2`

Manual operation: See "Evaluation range for the constellation diagram" on page 70

[SENSe:][LTE:][CC<cc>:]SUBFrame:SELect <Subframe>

Selects the subframe to be analyzed.

Suffix:
<cc> Component Carrier

Parameters:
<Subframe> ALL | <numeric value>

ALL
Select all subframes

0...39
Select a single subframe

*RST: ALL

Example: //Display results for all subframes
`SUBF:SEL ALL`

Manual operation: See "Subframe Selection" on page 69

[SENSe:][LTE:][CC<cc>:]SYMBol:SELect <Symbol>

Filters the results in the constellation diagram by a certain OFDM symbol.

Suffix:
<cc> Component Carrier

Parameters:
<Symbol> **ALL**
Shows the results for all subcarriers.

<numeric_value> (integer only)
Shows the results for a single OFDM symbol.

*RST: ALL

Example: //Display result for OFDM symbol 2
`SYMB:SEL 2`

Manual operation: See "Evaluation range for the constellation diagram" on page 70

6.10.4 Y-axis scale

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

Automatically scales the y-axis of a diagram based on the displayed results.

Suffix:

<n> Window

<w> Subwindow

<t> irrelevant

Setting parameters:

<ONCE> **ALL**
Scales the y-axis in all windows for an ideal viewing experience.
DEFault
Restores the default scale of the y-axis.
ONCE
Scales the y-axis in a specific window for an ideal viewing experience.

Example: //Automatically scale the y-axis in subwindow 2 of window 2
`DISP:WIND2:SUBW2:TRAC:Y:AUTO ONCE`

Usage: Setting only

Manual operation: See "Auto Scaling" on page 62
See "Automatic scaling of the y-axis" on page 67

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:MAXimum <Value>

Defines the maximum value displayed on the y-axis of a diagram.

Suffix:

<n> Window

<w> Subwindow

<t> irrelevant

Parameters:

<Value> Maximum displayed value. The unit and value range depend on the selected diagram.

Example: //Define maximum value on y-axis in subwindow 2 of window 2
`DISP:WIND2:SUBW2:TRAC:Y:MAX 0`

Manual operation: See "Manual scaling of the y-axis" on page 66

DISPlay[:WINDow<n>][:SUBWindow<w>]:TRACe<t>:Y[:SCALe]:MINimum <Value>

Defines the minimum value displayed on the vertical diagram axis.

Suffix:

<n> Window

<w> Subwindow

<t> irrelevant

Parameters:

<Value> Minimum displayed value. The unit and value range depend on the selected diagram.

Example: //Define minimum value on y-axis in subwindow 2 of window 2
`DISP:WIND2:SUBW2:TRAC:Y:MIN -50`

Manual operation: See "Manual scaling of the y-axis" on page 66

6.10.5 Result settings

CALCulate<n>:MARKer<m>:COUPling <State>

Couples or decouples markers in different result displays to each other.

Suffix:

<n> irrelevant

<m> irrelevant

Parameters:

<State> ON | OFF | 1 | 0

*RST: OFF

Example: //Couple markers to each other.
`CALC:MARK:COUP ON`

Manual operation: See "Marker Coupling" on page 72

UNIT:BSTR <Unit>

Selects the way the bit stream is displayed.

Parameters:

<Unit> **SYMbols**
Displays the bit stream using symbols

BITs
Displays the bit stream using bits

*RST: SYMbols

Example: //Display bit stream as bits
`UNIT:BSTR BIT`

Manual operation: See "Bit Stream Format" on page 71

UNIT:CAXes <Unit>

Selects the scale of the x-axis for result displays that show subcarrier results.

Parameters:

<Unit>

CARR
Shows the number of the subcarriers on the x-axis.

HZ
Shows the frequency of the subcarriers on the x-axis.

Example: //Display frequency on the x-axis
`UNIT:CAX HZ`

Manual operation: See "Carrier Axes" on page 71

UNIT:EVM <Unit>

Selects the EVM unit.

Parameters:

<Unit>

DB
EVM results returned in dB

PCT
EVM results returned in %

*RST: PCT

Example: //Display EVM results in %
`UNIT:EVM PCT`

Manual operation: See "EVM Unit" on page 71

6.11 Reading out status register

The following commands are required to read out the `STATus:QUEStionable:SYNC` status register.

For a full list of commands required to read out the status register, refer to the FSW user manual.

STATus:QUEStionable:SYNC[:EVENt]? <ChannelName>

Reads out the EVENt section of the status register.

The command also deletes the contents of the EVENt section.

Query parameters:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

STATus:QUEStionable:SYNC:CONDition? <ChannelName>

Reads out the CONDition section of the status register.

The command does not delete the contents of the EVENt section.

Query parameters:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

STATus:QUEStionable:SYNC:ENABle <BitDefinition>, <ChannelName>

Controls the ENABle part of a register.

The ENABle part allows true conditions in the EVENt part of the status register to be reported in the summary bit. If a bit is 1 in the enable register and its associated event bit transitions to true, a positive transition will occur in the summary bit reported to the next higher level.

Parameters:

<BitDefinition> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

STATus:QUEStionable:SYNC:NTRansition <BitDefinition>[,<ChannelName>]

Controls the Negative TRansition part of a register.

Setting a bit causes a 1 to 0 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding EVENt register.

Parameters:

<BitDefinition> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

STATus:QUEStionable:SYNC:PTRansition <BitDefinition>[,<ChannelName>]

These commands control the Positive TRansition part of a register.

Setting a bit causes a 0 to 1 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding EVENt register.

Parameters:

<BitDefinition>	Range: 0 to 65535
<ChannelName>	String containing the name of the channel. The parameter is optional. If you omit it, the command works for the currently active channel.

Annex

A Performing time alignment measurements

The measurement application allows you to perform time alignment measurements between different antennas.

The measurement supports setups of up to two Tx antennas.

The result of the measurement is the time alignment error. The time alignment error is the time offset between a reference antenna (for example antenna 1) and another antenna.

The time alignment error results are summarized in the corresponding result display.

A schematic description of the results is provided in Figure A-1.

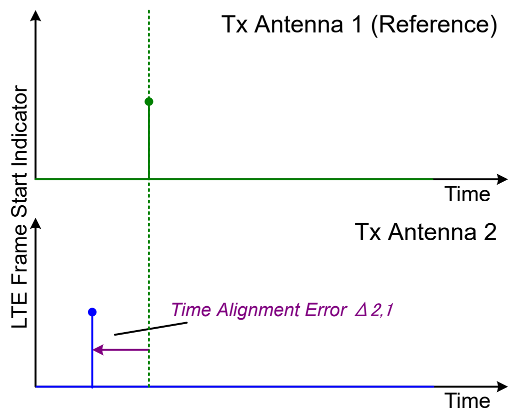


Figure A-1: Time Alignment Error (2 Tx antennas)

Test setup

Successful Time Alignment measurements require a correct test setup.

A typical test setup is shown in Figure A-2.

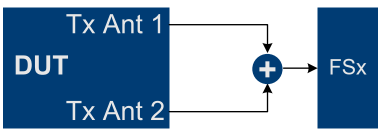


Figure A-2: Hardware setup

For best measurement result accuracy, it is recommended to use cables of the same length and identical combiners as adders.

List of commands (NB-IoT downlink)

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