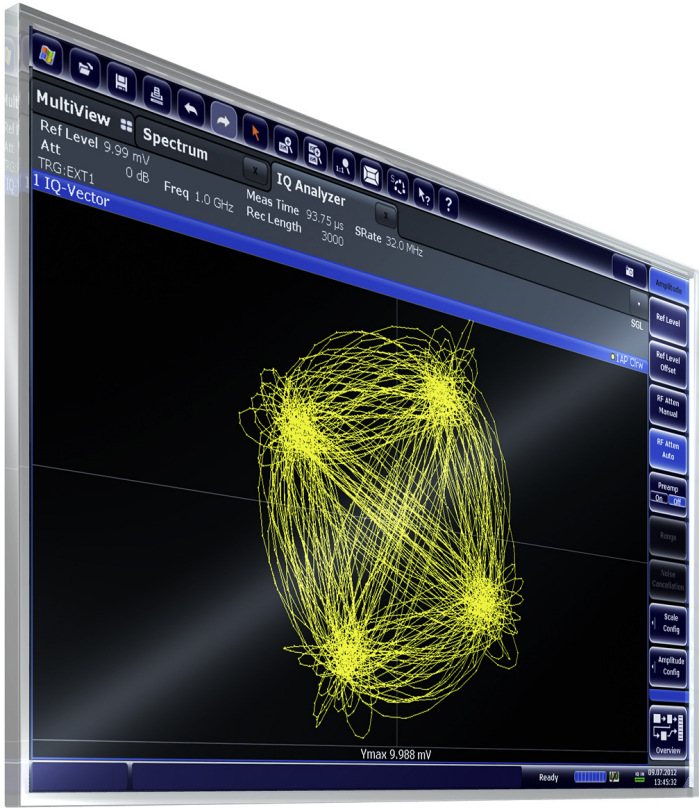# R&S®ESW
I/Q Analyzer
User Manual

ROHDE&SCHWARZ

This manual describes the following R&S®ESW models:

- R&S®ESW8 (1328.4100K08)
- R&S®ESW26 (1328.4100K26)
- R&S®ESW44 (1328.4100K44)

The I/Q Analyzer application is integral part of the R&S®ESW.

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

Contents

1 Welcome to the I/Q Analyzer Application

The R&S ESW I/Q Analyzer is a firmware application that adds functionality to perform I/Q data acquisition and analysis to the R&S ESW.

The R&S ESW-I/Q Analyzer features:

- Acquisition of analog I/Q data
- Import of stored I/Q data from other applications
- Spectrum, magnitude, I/Q vector and separate I and Q component analysis of any I/Q data on the instrument
- Export of I/Q data to other applications

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

All functions not discussed in this manual are the same as in the base unit and are described in the R&S ESW User Manual. The latest version is available for download at the product homepage

http://www2.rohde-schwarz.com/product/ESW.html.

Installation

The R&S ESW I/Q Analyzer application is part of the standard base unit and requires no further installation.

1.1 Starting the I/Q Analyzer Application

The I/Q Analyzer is an application on the R&S ESW.

To activate the I/Q Analyzer application

1. Select the MODE key.

   A dialog box opens that contains all applications currently available on your R&S ESW.

2. Select the "I/Q Analyzer" item.
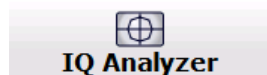
   The R&S ESW opens a new measurement channel for the I/Q Analyzer application.

The measurement is started immediately with the default settings.

It can be configured in the I/Q Analyzer "Overview" dialog box, which is displayed when you select the "Overview" softkey from any menu (see Chapter 4, "Configuration", on page 26).

Multiple Measurement Channels and Sequencer Function

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

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

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

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

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

1.2 Understanding the Display Information

The following figure shows a measurement diagram during I/Q Analyzer operation. All different information areas are labeled. They are explained in more detail in the following sections.
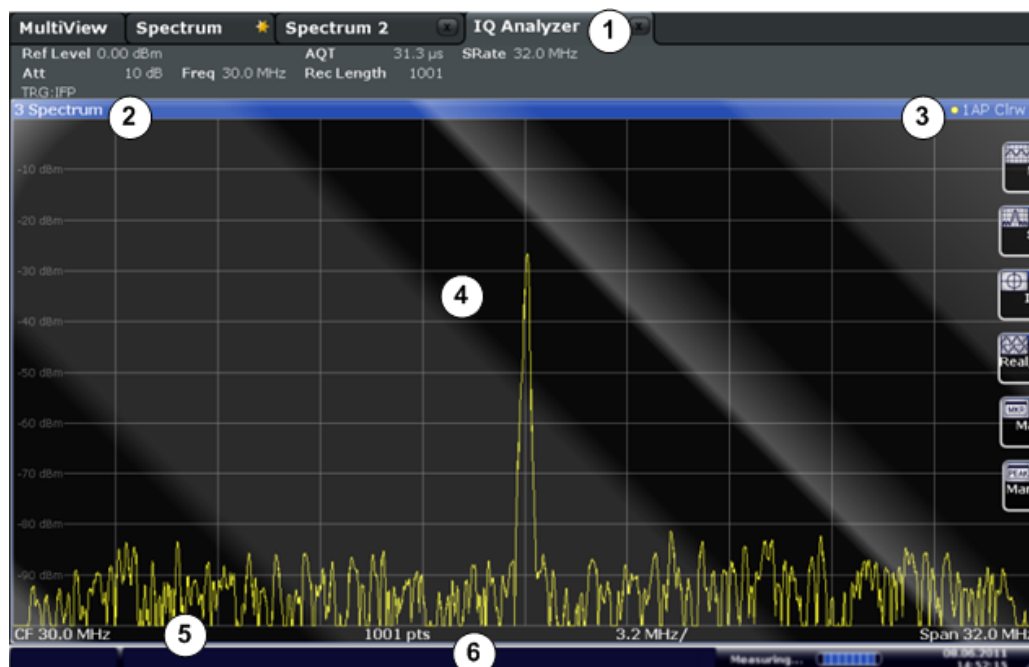
Figure 1-1: Screen elements in the I/Q Analyzer application

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

Channel bar information

In the I/Q Analyzer application, the R&S ESW shows the following settings:

Table 1-1: Information displayed in the channel bar for the I/Q Analyzer application

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

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

Window title bar information

For each diagram, the header provides the following information:

Figure 1-2: Window title bar information in the I/Q Analyzer application

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

Diagram footer information

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

- Center frequency
- Number of sweep points

- Range per division (x-axis)
- Span (Spectrum)

Status bar information

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

2 Measurement and Result Displays

The I/Q Analyzer can capture I/Q data. The I/Q data that was captured by or imported to the R&S ESW can then be evaluated in various different result displays. Select the result displays using the SmartGrid functions.

Up to 6 evaluations can be displayed in the I/Q Analyzer at any time, including several graphical diagrams, marker tables or peak lists.

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

Result displays for I/Q data:

Magnitude
Shows the level values in time domain.
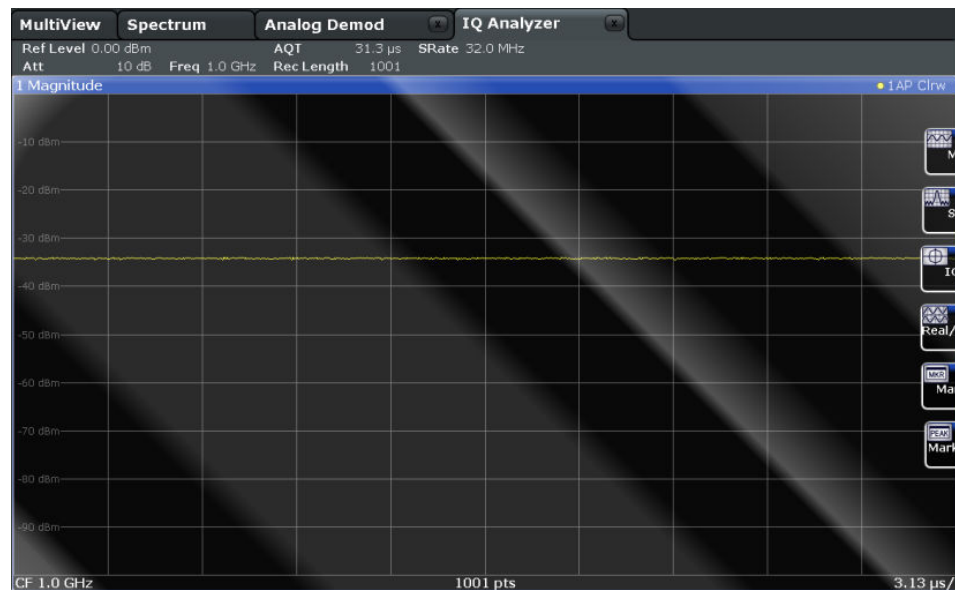
Remote command:
LAY:ADD:WIND? '1',RIGH,MAGN, see LAYout:ADD[:WINDow]? on page 115
Results:
TRACe<n>[:DATA] on page 81

Spectrum
Displays the frequency spectrum of the captured I/Q samples.
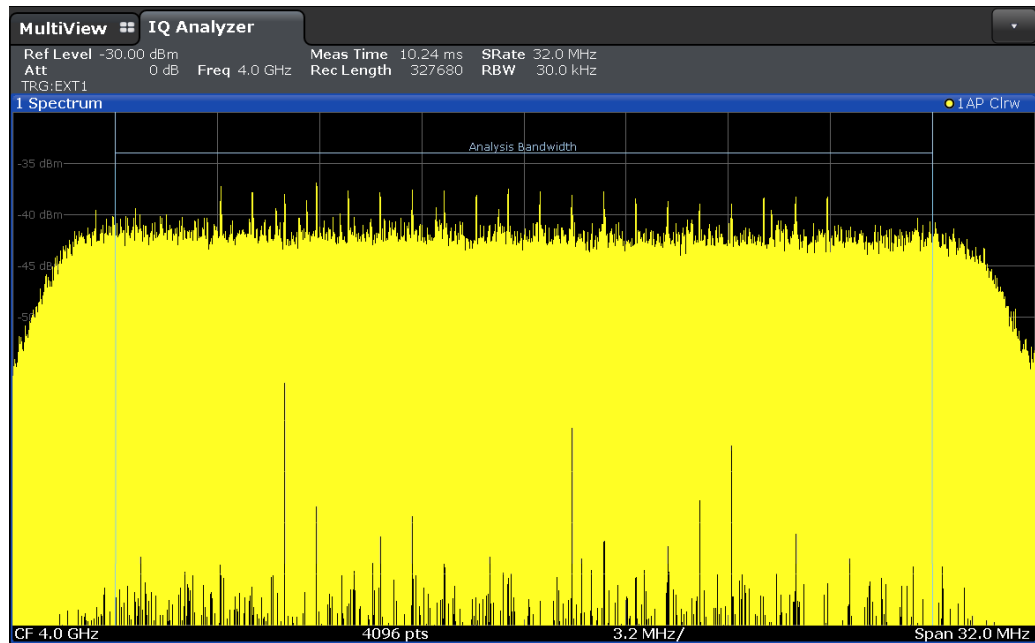
Remote command:
LAY:ADD:WIND? '1',RIGH,FREQ, see LAYout:ADD[:WINDow]? on page 115
Results:
TRACe<n>[:DATA] on page 81

I/Q-Vector

Displays the captured samples in an I/Q-plot. The samples are connected by a line.
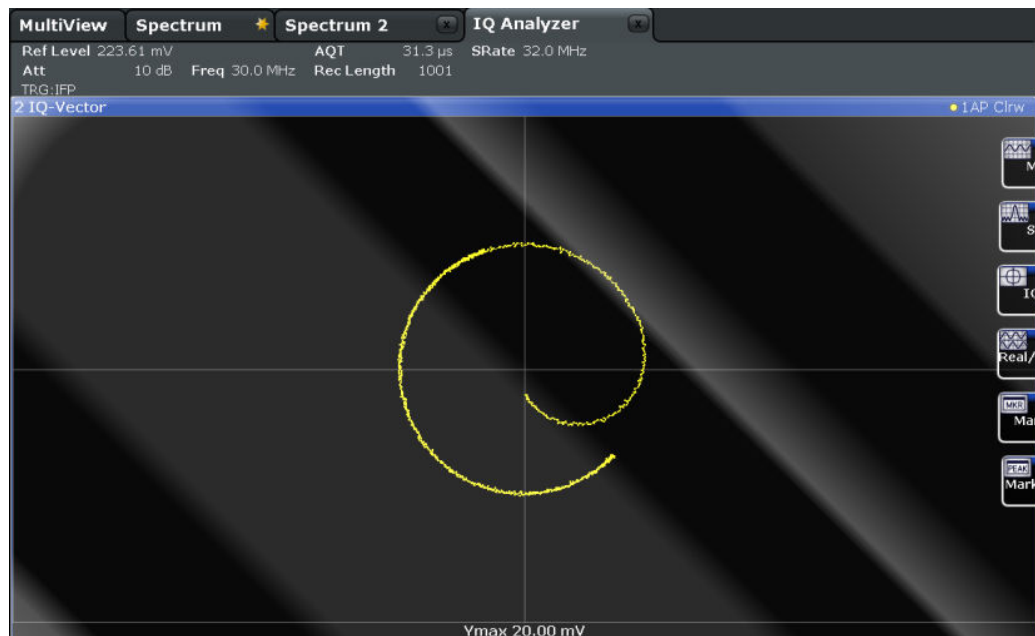
Note: For the I/Q vector result display, the number of I/Q samples to record ("Record Length") must be identical to the number of trace points to be displayed ("Sweep

Points"; for I/Q Analyzer: 1001). For record lengths outside the valid range of sweep points the diagram does not show valid results.

Remote command:
LAY:ADD:WIND? '1',RIGH,VECT, see LAYout:ADD[:WINDow]? on page 115
Results:
TRACe<n>[:DATA] on page 81

Real/Imag (I/Q)
Displays the I and Q values in separate diagrams.
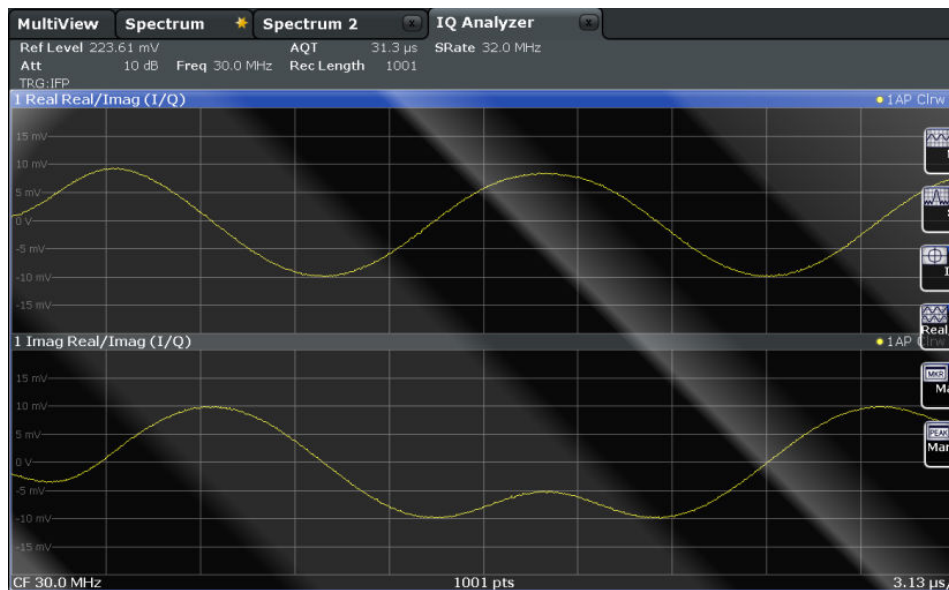
Remote command:
LAY:ADD:WIND? '1',RIGH,RIM, see LAYout:ADD[:WINDow]? on page 115
Results:
TRACe<n>[:DATA] on page 81

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

This table may be displayed automatically if configured accordingly.

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 115
Results:
CALCulate<n>:MARKer<m>:X on page 84
CALCulate<n>:MARKer<m>:Y? on page 85

Marker Peak List

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

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

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

Remote command:

LAY:ADD? '1',RIGH, PEAK, see LAYout:ADD[:WINDow]? on page 115
Results:

CALCulate<n>:MARKer<m>:X on page 84

CALCulate<n>:MARKer<m>:Y? on page 85

3 Basics on I/Q Data Acquisition and Processing

Some background knowledge on basic terms and principles used when describing I/Q data acquisition on the R&S ESW in general, and in the I/Q Analyzer application in particular, is provided here for a better understanding of the required configuration settings.

The I/Q Analyzer provides various possibilities to acquire the I/Q data to be analyzed:

- Capturing analog I/Q data from the RF INPUT connector
- Importing I/Q data from a file

Background information for all these scenarios and more is provided in the following sections.

3.1 Increasing Measurement Sensitivity (or Avoiding an Input Mixer Overload)

Measurements often confront you with unknown or unintentional signals with unknown signal levels (and often with pulse characteristics). Such signals can either have very weak signal levels, in which case you might miss them during the measurement. Or they can have very strong signal levels, in which case they might damage the input mixer.

> **NOTICE**
>
> **Risk of damage to the input mixer**
>
> Do not overload the input mixer.
>
> Overloading the input mixer can damage it. The following topics contain advice on how to avoid an overload of the input mixer. Read them carefully before applying a signal.

Protecting the input mixer

Protecting the input mixer from damage should always be considered first when setting up a measurement.

The input mixer of the R&S ESW is equipped with an overload protection mechanism. If you apply a signal whose power exceeds the specified limit (see datasheet), the connection between the RF input and the input mixer is cut off and the R&S ESW displays a corresponding message in the status display.

Note that pulses have different level characteristics. Refer to the data sheet for more information on the allowed maximum pulse energy.

The signal level at the input mixer is calculated as follows.

Mixer Level = Input Level - attenuation + gain

RF input protection

The R&S ESW is equipped with an overload protection mechanism. This mechanism becomes active as soon as the signal level at the input mixer exceeds the specified limit. It ensures that the connection between RF input and input mixer is cut off.

In this case you must decrease the level at the RF input connector and then close the message box. Then measurements are possible again.

3.1.1 Using the RF Attenuator

The first tool provided by the R&S ESW to control measurement sensitivity is the RF attenuator.

The RF attenuator is available in all hardware configurations of the R&S ESW.

Attenuation has the following effects on the measurement:

- High attenuation protects the input mixer: the main purpose of the attenuator is to protect the input mixer.
- High attenuation makes sure that the measurement results are reliable (signals that are stronger than allowed might distort the results)
- High attenuation helps you to avoid intermodulation
- High attenuation increases inherent noise (i.e. the noise floor) and thus decreases measurement sensitivity: if you increase attenuation by 10 dB, the sensitivity is reduced by 10 dB (in other words: the displayed noise increases by 10 dB)

Depending on the required test setup, a compromise must be found between a high sensitivity, low intermodulation and input mixer protection. This is best done by letting the R&S ESW determine the ideal attenuation automatically.

You can determine the attenuation automatically with the auto ranging feature in the Receiver application and the auto attenuation feature in the other applications. Determining the attenuation automatically might not necessarily utilize the maximum dynamic range, but still yields valid and reliable results.

When you select the attenuation manually and are measuring unknown signals, especially DUTs with a high RFI voltage, always select the highest possible attenuation level before you apply the signal.

If you need a better sensitivity or signal-to-noise ratio, make sure that the applied signal does not exceed the specified limits, before you lower the attenuation.

For further protection of the input mixer, the R&S ESW does not allow you to select attenuation levels of less than 10 dB unless you explicitly turn this feature on ("10 dB Minimum Attenuation").

NOTICE

Risk of damage to the input mixer

- Do not apply a 0 dB attenuation when you measure unknown signals or RFI voltage in combination with an artificial network (LISN).
  During phase switching, such test setups generate very strong pulses which can damage the input mixer.
- When you allow attenuation of less than 10 dB in combination with auto ranging, make sure that the signal level at the RF input does not exceed the allowed limits. Exceeding the limits can damage the input mixer.

3.1.2 Using the Preamplifier

The second tool that allows you to control measurement sensitivity is the preamplifier.

In addition to the standard preamplifier available in every R&S ESW, an additional Low Noise amplifier is available as an optional component (R&S ESW-B24).

Signal gain has the following effects on the measurement:

- The preamplifier allows you to detect even weak signals.
- The preamplifier reduces the noise figure of the R&S ESW and thus increases its sensitivity. Thus, it is recommended to use the preamplifier for measurements that require maximum sensitivity.
- The preamplifier reduces the dynamic range. If a measurement should be performed at maximum dynamic range, you should turn off the preamplifier.
- The preamplifier is located after the preselection filters; this reduces the risk of overloading the input mixer by strong out-of-band signals.
- The optional Low Noise amplifier is located in front of the preselection filters which increases the measurement sensitivity.

The gain of the preamplifier is automatically considered in the level display. The disadvantage of a poorer large-signal immunity (intermodulation) is reduced by the preselector.

3.1.3 Using the Preselector

The third tool that allows you to control measurement sensitivity is the preselector.

Preselection has the following effects on the measurement:

- Preselection rejects most of the spectrumsl energy which helps to protect the input mixer and thus makes sure that the measurement results are valid and reliable.

- Preselection filters out signals that you do not want to be displayed (selectivity) and thus allows you to analyze only the frequency range you are interested in.

The preselector of the R&S ESW consists of several filters which are automatically applied during measurements. The filter that is currently used depends on the frequency that is currently measured. You can see the list of filters and the progress in the "Preselector" result display (the currently applied filter is indicated by a green LED, filters that are outside the scan range are ignored).

Figure 3-1: Preselector result display. The green LED indicates the currently applied filter.

In the frequency range from 150 kHz to 30 MHz, you can select whether to preselect in a single stage (150 kHz to 30 MHz), or split the preselection into two stages, each of which applies a separate filter: one from 150 kHz to 2 MHz, and another from 2 MHz to 30 MHz.

In addition, the R&S ESW provides several notch filters to suppress certain frequency ranges completely.

Using the preselector

Switching the filters is a mechanical process. Avoid excessive filters switches, because the hardware may wear out.

Note that results in a frequency band are only displayed if there is at least one valid measurement point in the corresponding range. If a particular measurement point is captured by more than one filter, the R&S ESW displays the combined results.

Notch filter

The R&S ESW provides additional notch filters that suppress signals in the frequency bands from 2.4 GHz to 2.5 GHz and 5.725 GHz to 5.875 GHz.

3.2 Processing Analog I/Q Data from RF Input

Complex baseband data

In the telephone systems of the past, baseband data was transmitted unchanged as an analog signal. In modern phone systems and in radio communication, however, the baseband data is modulated on a carrier frequency, which is then transmitted. The receiver must demodulate the data based on the carrier frequency. When using modern modulation methods (e.g. QPSK, QAM etc.), the baseband signal becomes com-

plex. Complex data (or: *I/Q data*) consists of an imaginary (I) and a real (Q) component.

I/Q Analyzer - processing complex data from RF input

The I/Q Analyzer is a standard application used to capture and analyze I/Q data on the R&S ESW. By default, it assumes the I/Q data is modulated on a carrier frequency and input via the RF INPUT connector on the R&S ESW.

The A/D converter samples the IF signal at a rate of 200 MHz. The digital signal is down-converted to the complex baseband, lowpass-filtered, and the sample rate is reduced. The analog filter stages in the analyzer cause a frequency response which adds to the modulation errors. An **equalizer filter** before the **resampler** compensates for this frequency response. The continuously adjustable sample rates are realized using an optimal decimation filter and subsequent resampling on the set sample rate.

A special memory (**capture buffer**) is available in the R&S ESW for a maximum of 400 Ms (400*1024*1024) of complex samples (pairs of I and Q data). The number of complex samples to be captured can be defined (for restrictions refer to Chapter 3.2.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 17).

The block diagram in Figure 3-2 shows the analyzer hardware from the IF section to the processor.
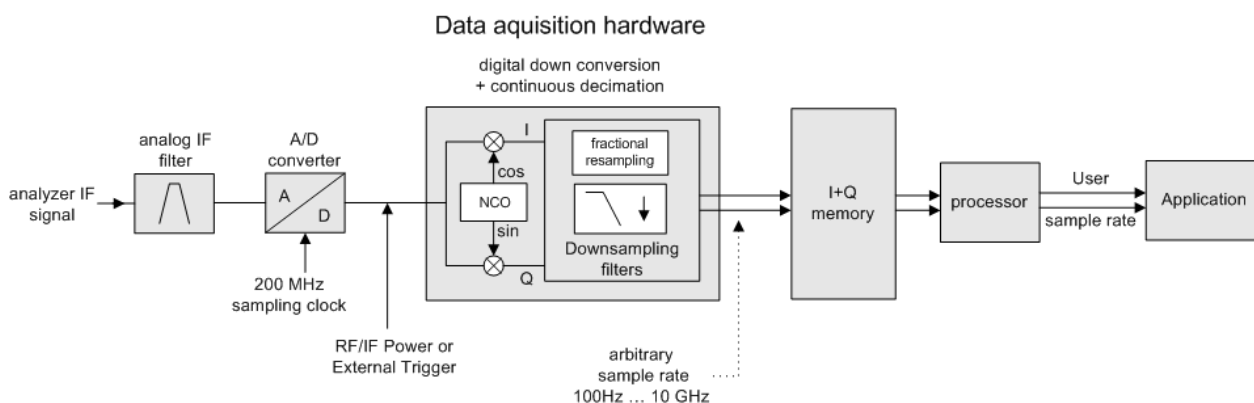
Figure 3-2: Block diagram illustrating the R&S ESW signal processing for analog I/Q data

3.2.1   Sample Rate and Maximum Usable I/Q Bandwidth for RF Input

Definitions

- **Input sample rate (ISR)**: the sample rate of the useful data provided by the device connected to the input of the R&S ESW
- (User, Output) **Sample rate (SR)**: the user-defined sample rate (e.g. in the "Data Aquisition" dialog box in the "I/Q Analyzer" application) which is used as the basis for analysis or output

- **Usable I/Q (Analysis) bandwidth**: the bandwidth range in which the signal remains undistorted in regard to amplitude characteristic and group delay; this range can be used for accurate analysis by the R&S ESW
- **Record length**: Number of I/Q samples to capture during the specified measurement time; calculated as the measurement time multiplied by the sample rate

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

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

- Relationship Between Sample Rate, Record Length and Usable I/Q Bandwidth... 18

3.2.1.1 Relationship Between Sample Rate, Record Length and Usable I/Q Bandwidth

Up to the maximum bandwidth, the following rule applies:

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

Regarding the record length, the following rule applies:

*Record length = Measurement time * sample rate*

Maximum record length for RF input

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

Table 3-1: Maximum record length

Sample rate	Maximum record length
100 Hz to 200 MHz	440 MSamples (precisely: 461373440 (= 440*1024*1024) samples)
200 MHz to 10 GHz (upsampling)	220 MSamples
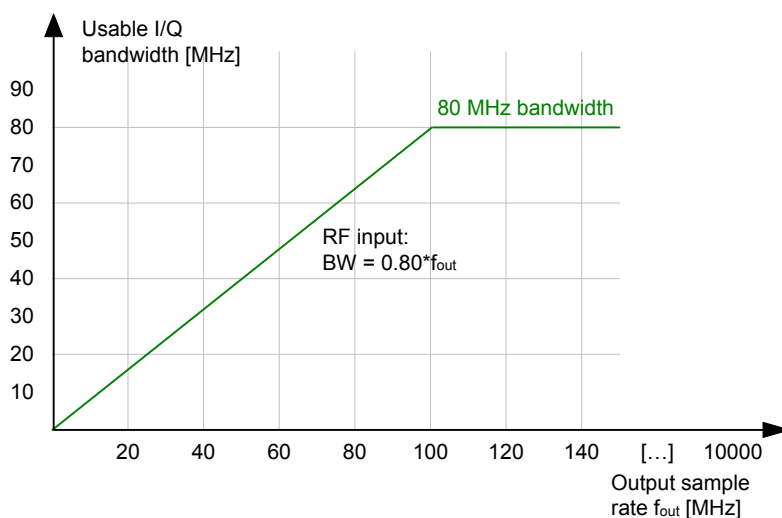
Figure 3-3: Relationship between maximum usable I/Q bandwidth and output sample rate

3.3 I/Q Data Import and Export

Baseband signals mostly occur as so-called complex baseband signals, i.e. a signal representation that consists of two channels; the in phase (I) and the quadrature (Q) channel. Such signals are referred to as I/Q signals. The complete modulation information and even distortion that originates from the RF, IF or baseband domains can be analyzed in the I/Q baseband.

Importing and exporting I/Q signals is useful for various applications:

- Generating and saving I/Q signals in an RF or baseband signal generator or in external software tools to analyze them with the R&S ESW later
- Capturing and saving I/Q signals with an RF or baseband signal analyzer to analyze them with the R&S ESW or an external software tool later

As opposed to storing trace data, which may be averaged or restricted to peak values, I/Q data is stored as it was captured, without further processing. The data is stored as complex values in 32-bit floating-point format. Multi-channel data is not supported. The I/Q data is stored in a format with the file extension `.iq.tar`.

For a detailed description see the R&S ESW I/Q Analyzer and I/Q Input User Manual.

The import and export functions are available in the "Save/Recall" menu which is displayed when you select the ▣ "Save" or ▣ "Open" icon in the toolbar (see Chapter 4.2, "Import/Export Functions", on page 28).

3.4 Basics on FFT

The I/Q Analyzer measures the power of the signal input over time. To convert the time domain signal to a frequency spectrum, an FFT (Fast Fourier Transformation) is performed which converts a vector of input values into a discrete spectrum of frequencies.
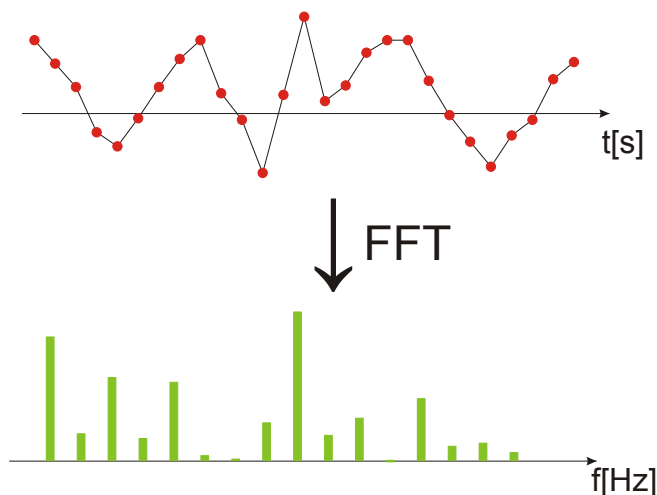
3.4.1 Window Functions

The Fourier transformation is not performed on the entire captured data in one step. Only a limited number of samples is used to calculate an individual result. This process is called windowing.

After sampling in the time domain, each window is multiplied with a specific window function. Windowing helps minimize the discontinuities at the end of the measured signal interval and thus reduces the effect of spectral leakage, increasing the frequency resolution.

Various different window functions are provided in the R&S ESW to suit different input signals. Each of the window functions has specific characteristics, including some advantages and some trade-offs. Consider these characteristics to find the optimum solution for the measurement task.

Ignoring the window function - rectangular window

The rectangular window function is in effect not a function at all, it maintains the original sampled data. This may be useful to minimize the required bandwidth. However, be aware that if the window does not contain exactly one period of your signal, heavy sidelobes may occur, which do not exist in the original signal.

Table 3-2: Characteristics of typical FFT window functions

Window type	Frequency resolution	Magnitude resolution	Sidelobe suppression	Measurement recommendation
Rectangular	Best	Worst	Worst	No function applied. Separation of two tones with almost equal amplitudes and a small frequency distance
Blackman-Harris (default)	Good	Good	Good	Harmonic detection and spurious emission detection
Gauss (Alpha = 0.4)	Good	Good	Good	Weak signals and short duration
Flattop	Worst	Best	Good	Accurate single tone measurements
5-Term	Good	Good	Best	Measurements with very high dynamic range

3.4.2 Overlapping

The I/Q Analyzer calculates multiple FFTs per measurement by dividing one captured record into several windows. Furthermore, the I/Q Analyzer allows consecutive windows to overlap. Overlapping "reuses" samples that were already used to calculate the preceding FFT result.
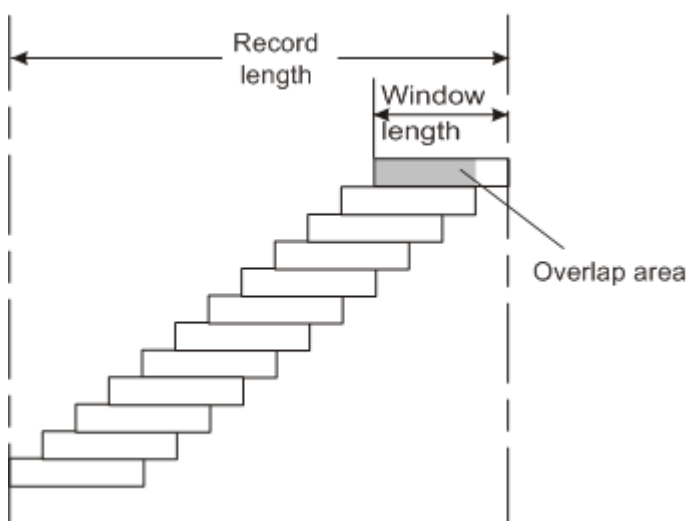
In advanced FFT mode with averaging, the overlapping factor can be set freely. The higher the overlap factor, the more windows are used. This leads to more individual results and improves detection of transient signal effects. However, it also extends the duration of the calculation. The size of the window can be defined manually according to the record length, the overlap factor, and the FFT length.

An FFT overlap of 67%, for example, means the second FFT calculation uses the last 67% of the data of the first FFT. It uses only 33% new data. The third FFT still covers 33% of the first FFT and 67% of the second FFT, and so on.
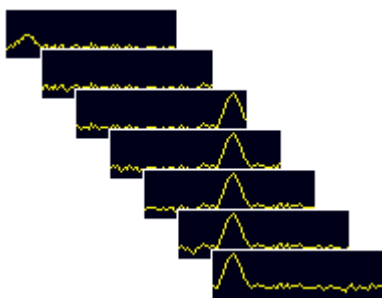
Figure 3-4: Overlapping FFTs

In "Manual" or "Auto" FFT mode, an FFT length of 4096 and a window length of 4096 (or the record length, if shorter) is used to calculate the spectrum.

Combining results - trace detector

If the record length permits, multiple overlapping windows are calculated and combined to create the final spectrum using the selected trace detector. If necessary, the trace detector is also used to reduce the number of calculated frequency points (defined by the FFT length) to the defined number of sweep points. By default, the Autopeak trace detector is used.

> Since the frequency points are reduced to the number of sweep points, using a detector other than "Auto Peak" and fewer than 4096 sweep points can lead to false level results.
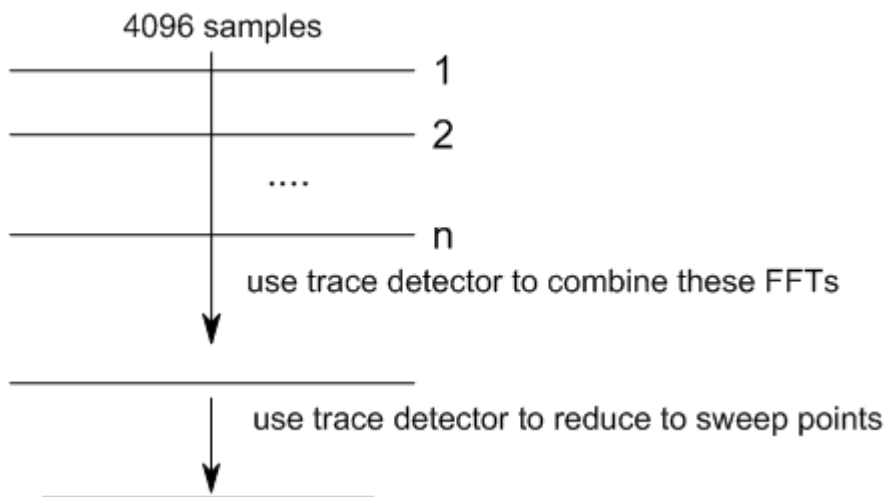
3.4.3 Dependencies Between FFT Parameters

FFT analysis in the R&S ESW is highly configurable. Several parameters, including the resolution bandwidth, record length, and FFT length, are user-definable. Note, however, that several parameters are correlated and not all can be configured independently of the others.

Record Length

Defines the number of I/Q samples to capture. By default, the number of sweep points is used. The record length is calculated as the measurement time multiplied by the sample rate.

If you change the record length, the Meas Time is automatically changed, as well.

For FFTs using only a single window ("Single" mode), the record length (which is then identical to the FFT length) must not exceed 512k.

FFT Length

Defines the number of frequency points determined by each FFT calculation. The more points are used, the higher the resolution in the spectrum becomes, but the longer the calculation takes.

In "Auto" or "Manual" mode, an FFT length of 4096 is used.

If the FFT length is longer than the Window Length the sample data is filled up with zeros up to the FFT length. The FFT is then performed using interpolated frequency points.

For an FFT length that is not a power of 2, a DFT (discrete Fourier transform) is performed, which requires more time for calculation, but avoids the effects of interpolation.

To display all calculated frequency points (defined by the FFT length), the number of sweep points is set to the FFT length automatically in advanced FFT mode.

Window Length

Defines the number of samples to be included in a single window in averaging mode. (In single mode, the window length corresponds to the "Record Length" on page 45.)

Values from 3 to 4096 are available in "Manual" mode; in "Advanced" FFT mode, values from 3 to 524288 are available. However, the window length must not be longer than the FFT Length.

If the window length is shorter than the FFT Length, the sample data is filled up with zeros up to the FFT length.

If the window length is longer than the Record Length (that is, not enough samples are available), a window length the size of the Record Length is used for calculation.

The window length and the Window Overlap determine how many FFT calculations must be performed for each record in averaging mode (see "Transformation Algorithm" on page 46).

3.4.4   Frequency Resolution of FFT Results - RBW

The **resolution bandwidth** defines the minimum frequency separation at which the individual components of a spectrum can be distinguished. Small values result in high precision, as the distance between two distinguishable frequencies is small. Higher values decrease the precision, but increase measurement speed.

The RBW is determined by the following equation:

$$RBW = Normalized\,Bandwidth * \frac{Sample\ Rate}{Window\ Length}$$

Equation 3-1: Definition of RBW

(Note: The normalized bandwidth is a fixed value that takes the noise bandwidth of the window function into consideration.)

The maximum RBW is restricted by the Analysis Bandwidth, or by the following equation, whichever is higher:

$$RBW_{max} = \frac{Normalized\,Bandwidth * Sample\ Rate}{3}$$

If a higher spectral resolution is required, the number of samples must be increased by using a higher sample rate or longer record length.

The minimum achievable RBW depends on the sample rate and record length, according to the following equation:

$$RBW_{min} = \frac{Normalized\,Bandwidth * Sample\ Rate}{min(4096,\,Re\,cord\ Length)}$$

To simplify operation, some parameters are coupled and automatically calculated, such as record length and RBW.

RBW mode

Depending on the selected RBW mode, the resolution bandwidth is either determined automatically or can be defined manually.

Auto mode:

This is the default mode in the I/Q Analyzer. The RBW is determined automatically depending on the Sample Rate and Window Length, where the window length corresponds to the Record Length, or a maximum of 4096.

If the record length is larger than the window length, multiple windows are combined; the FFT length is 4096.

A Flatop window function is used.

Manual mode:

The RBW is user-definable.

The Window Length is adapted to comply with Equation 3-1. Since only window lengths with integer values can be employed, the Sample Rate is adapted, if necessary, to obtain an integer window length value.

If the record length is larger than the window length, multiple windows are combined; the FFT length is 4096.

A Flatop window function is used.

Advanced FFT mode

The RBW is determined by the advanced FFT parameters, depending on the selected FFT Calculation Methods method.

3.4.5 FFT Calculation Methods

FFT calculation can be performed using different methods.

Single

In single mode, one FFT is calculated for the entire record length, that means the window length is identical to the record length.

If the defined FFT Length is larger than the record length, zeros are appended to the captured data to reach the FFT length.

Figure 3-5: FFT parameters for single FFT calculation

Averaging

In averaging mode, several overlapping FFTs are calculated for each record; the results are combined to determine the final FFT result for the record.

The number of FFTs to be combined is determined by the Window Overlap and the Window Length.
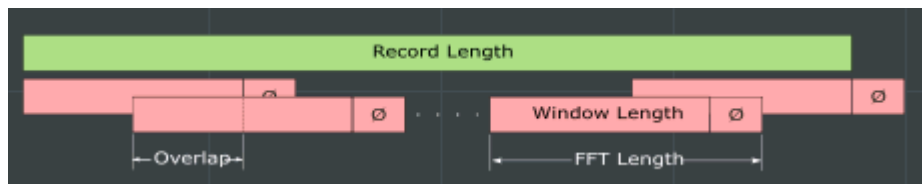

Figure 3-6: FFT parameters for averaged FFT calculation

4 Configuration

The I/Q Analyzer is a special application on the R&S ESW, which you activate using the MODE key on the front panel.

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

When you activate a measurement channel for the I/Q Analyzer application, data acquisition from the input signal is started automatically with the default configuration. It can be configured in the I/Q Analyzer "Overview" dialog box, which is displayed when you select the "Overview" softkey from any menu.

The main configuration settings and dialog boxes are also available via the "I/Q Analyzer" menu which is displayed when you press the MEAS CONFIG key.

The remote commands required to perform these tasks are described in Chapter 7, "Remote Commands for the I/Q Analyzer", on page 59.

Importing and Exporting I/Q Data

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

For details see Chapter 3.3, "I/Q Data Import and Export", on page 19.

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" icon, which is available at the bottom of all softkey menus.

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

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

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

1. Configuring the input
   See Chapter 4.3, "Configuring Data Input and Output", on page 29

2. Configuring level characteristics
   See Chapter 4.4, "Configuring the Amplitude", on page 33

3. Configuring Frequency Characteristics
   See Chapter 4.5, "Configuring Frequency Characteristics", on page 38

4. Configuring triggered and gated measurements
   See Chapter 4.6, "Configuring Triggered Measurements", on page 39

5. Configuring the output
   See Chapter 4.3, "Configuring Data Input and Output", on page 29

6. Configuring the bandwidth
   See Chapter 4.7, "Data Acquisition and Bandwidth Settings", on page 44

7. Analyzing results
   See the User Manual of the R&S ESW

8. Configuring the display
   See Chapter 4.8, "Display Configuration", on page 50

To configure settings

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

For step-by-step instructions on configuring I/Q Analyzer measurements, see Chapter 6.1, "How to Perform Measurements in the I/Q Analyzer Application", on page 55.

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

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

Remote command:
SYSTem:PRESet:CHANnel[:EXECute] on page 68

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

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

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

4.2 Import/Export Functions

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

These functions are only available if no measurement is running.

In particular, if a continuous measurement is running, the import/export functions are not available.

Some functions for particular data types are (also) available via softkeys or dialog boxes in the corresponding menus, e.g. trace data or marker peak lists.

For a description of the other functions in the "Save/Recall" menu see the R&S ESW User Manual.

Import
Provides functions to import data.

I/Q Import ← **Import**
Opens a file selection dialog box to select an import file that contains I/Q data. This function is only available in single sweep mode and only in applications that process I/Q data, such as the I/Q Analyzer or optional applications.

Note that the I/Q data must have a specific format as described in the R&S ESW I/Q Analyzer and I/Q Input User Manual.

Remote command:
MMEMory:LOAD:IQ:STATe on page 123

Export
Opens a submenu to configure data export.

I/Q Export ← **Export**
Opens a file selection dialog box to define an export file name to which the I/Q data will be stored. This function is only available in single sweep mode.

Note: Storing large amounts of I/Q data (several Gigabytes) may exceed the available (internal) storage space on the R&S ESW. In this case, it may be necessary to use an external storage medium.

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

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

For details, see "Protecting Data Using the Secure User Mode" in the "Data Management" section of the R&S ESW User Manual.

Remote command:
MMEMory:STORe<n>:IQ:STATe on page 123
MMEMory:STORe<n>:IQ:COMMent on page 123

4.3 Configuring Data Input and Output

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

► To display this dialog box, do one of the following:
  ● Select the "Input" button in the "Overview".

● Select the INPUT/OUTPUT key.

4.3.1 Configuring the RF Input

The default input source for the R&S ESW is "Radio Frequency", i.e. the signal at the RF INPUT connector on the front panel of the R&S ESW.
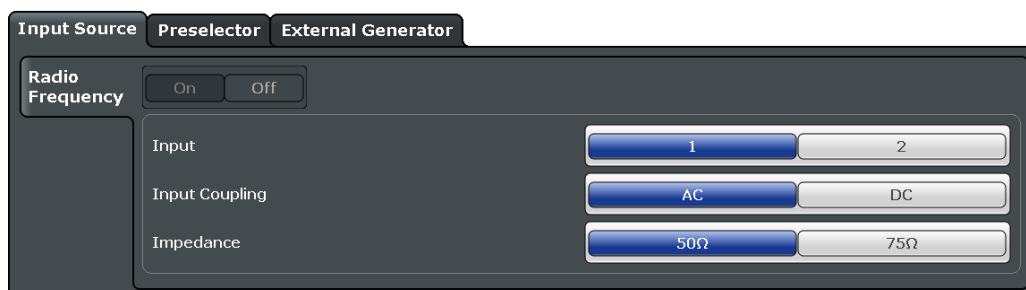
The remote commands required to configure the RF input are described in Chapter 7.6.1, "Configuring Inputs", on page 86.

Input Selection
Selects the RF input you would like to use for a measurement.

Note that you cannot use both RF inputs simultaneously.

Remote command:
Global: `INPut<n>:TYPE` on page 88

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

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

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

Remote command:
`INPut:COUPling` on page 87

Impedance

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

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

This value also affects the unit conversion.

Remote command:
INPut:IMPedance on page 87

4.3.2 Configuring the Preselector

The preselector works the same as in the Receiver.

For more information refer to the R&S ESW User Manual.

4.3.3 Configuring External Generators

External Generator Control is available as an option.

For more information about using external generators, refer to the User Manual of the R&S ESW.

4.3.4 Configuring Outputs (IF / Video / Demodulation)

The R&S ESW provides several outputs that you can use to transfer a signal to other devices. The R&S ESW allows you to configure the output as required.

The output functionality is similar to that in Receiver application.

For more information refer to the R&S ESW User Manual.

4.3.5 Configuring Line Impedance Stabilization Networks (LISN)

The R&S ESW supports several LISN models and provides functionality to control these devices. The functionality is the same as in the Receiver application.

For more information refer to the R&S ESW User Manual.
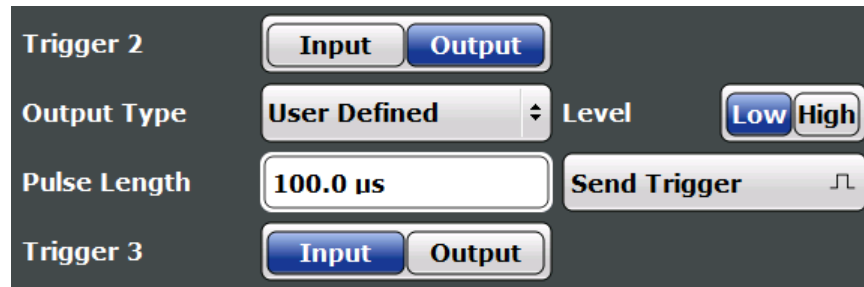
4.3.6 Configuring Additional Outputs

The R&S ESW provides additional outputs that you can use for various tasks. The functionality is the same as in the Receiver application.

For more information refer to the R&S ESW User Manual.

Trigger 2/3

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

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

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

(Trigger 1 is INPUT only.)

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

"Input"	The signal at the connector is used as an external trigger source by the R&S ESW. Trigger input parameters are available in the "Trigger" dialog box.
"Output"	The R&S ESW sends a trigger signal to the output connector to be used by connected devices. Further trigger parameters are available for the connector.

Remote command:
OUTPut:TRIGger<port>:DIRection on page 101

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

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

Remote command:
OUTPut:TRIGger<port>:OTYPe on page 102

Level ← Output Type ← Trigger 2/3

Defines whether a high (1) or low (0) constant signal is sent to the trigger output connector.

The trigger pulse level is always opposite to the constant signal level defined here, e.g. for "Level = High", a constant high signal is output to the connector until the Send Trigger function is selected. Then, a low pulse is provided.
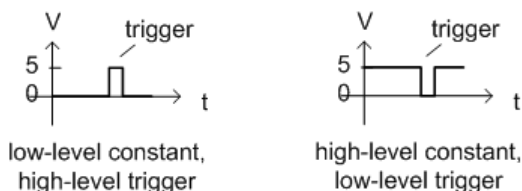
low-level constant,
high-level trigger

high-level constant,
low-level trigger

Remote command:
OUTPut:TRIGger<port>:LEVel on page 101

Pulse Length ← Output Type ← Trigger 2/3

Defines the duration of the pulse (pulse width) sent as a trigger to the output connector.

Remote command:
OUTPut:TRIGger<port>:PULSe:LENGth on page 102

Send Trigger ← Output Type ← Trigger 2/3

Sends a user-defined trigger to the output connector immediately.

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

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

Remote command:
OUTPut:TRIGger<port>:PULSe:IMMediate on page 102

4.4 Configuring the Amplitude

The amplitude is configured in the "Amplitude" dialog box. Amplitude settings are similar to those of the Spectrum application, except for a few functions

4.4.1 Configuring Level Characteristics

To configure the amplitude settings

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

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

● Select "Amplitude" from the "Overview".
● Select the AMPT key and then the "Amplitude Config" softkey.
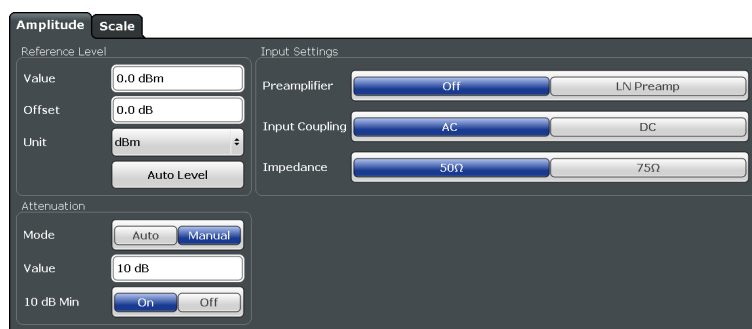
Functions to configure amplitude characteristics described elsewhere:

● "Input Coupling" on page 30
● "Impedance" on page 31
● Scaling settings are described in Chapter 4.4.2, "Scaling the Level Axis", on page 37.
● The preselector settings are described in the R&S ESW User Manual.

The remote commands required to configure amplitude characteristics are described in Chapter 7.6.3, "Configuring Level Characteristics", on page 88, Chapter 7.6.4, "Configuring the Attenuator", on page 90 and Chapter 7.6.5, "Configuring the Preamplifier", on page 91.

Reference Level

Defines the expected maximum reference level. Signal levels above this value may not be measured correctly. This is indicated by an "IF OVLD" or "OVLD" status display.

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

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

Remote command:
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel on page 89

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

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

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

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

Remote command:
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel:OFFSet on page 89

Unit ← Reference Level
The R&S ESW measures the signal voltage at the RF input.

In the default state, the level is displayed at a power of 1 mW (= dBm). Via the known input impedance (50 Ω or 75 Ω, see "Impedance" on page 31), conversion to other units is possible.

The following units are available and directly convertible:
- dBm
- dBmV
- dBµV
- dBµA
- dBpW
- Volt
- Ampere
- Watt

Remote command:
INPut:IMPedance on page 87
CALCulate<n>:UNIT:POWer on page 89

Attenuation
Defines the attenuation of the signal.

You can attenuate the signal in 1 dB steps. The range is specified in the datasheet. Attenuation of less than 10 dB is only possible if you turn off 10 dB Minimum Attenuation.

If you are using the preamplifier in frequency ranges above 8 GHz, the available attenuation may be reduced. For more information see Chapter 3.1.2, "Using the Preamplifier", on page 15.

Notice: For more information see Chapter 3.1, "Increasing Measurement Sensitivity (or Avoiding an Input Mixer Overload)", on page 13.

The R&S ESW also allows you to determine the best attenuation automatically.
- In the Receiver application, turn on the "Auto Ranging" feature.
- In the other applications, select attenuation "Mode" ➙ "Auto"

Remote command:

Global: `INPut<n>:ATTenuation` on page 90

Attenuation mode: `INPut<n>:ATTenuation:AUTO` on page 90

10 dB Minimum Attenuation

Turns the availability of attenuation levels of less than 10 dB on and off.

When you turn the feature on, the attenuation level is always at least 10 dB to protect the input mixer and avoid accidental setting of 0 dB, especially if you measure DUTs with high RFI voltage.

When you turn it off, you can also select attenuation levels of less than 10 dB.

The setting applies to a manual selection of the attenuation as well as the automatic selection of the attenuation.

Remote command:
`INPut<n>:ATTenuation:PROTection[:STATe]` on page 90

Preamplifier

Configures the preamplifier.

In addition to the standard preamplifer, a low noise amplifier is available as an optional hardware component.

- **Off**
  Turns the preamplifier off.
- **LN Amplifier**
  Turns the optional low noise amplifier on.
- **Auto Preamp**
  Turns the preamplifier on (only possible when the preselector is "On").
  Using both preamplifiers at the same time is not possible.

Note that if you want to use the standard preamplifer, you have to route the signal through the preselector.

More information.

Remote command:
Preamplifier:
State (global): `INPut<n>:GAIN:STATe` on page 91
Low Noise preamplifier:
State (global): `INPut<n>:GAIN:LNA:STATe` on page 91

4.4.2 Scaling the Level Axis

To configure the y-axis scaling settings

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

► To display the "Amplitude" dialog box, do one of the following:
- Select "Amplitude" from the "Overview".
- Select the AMPT key and then the "Scale Config" softkey.
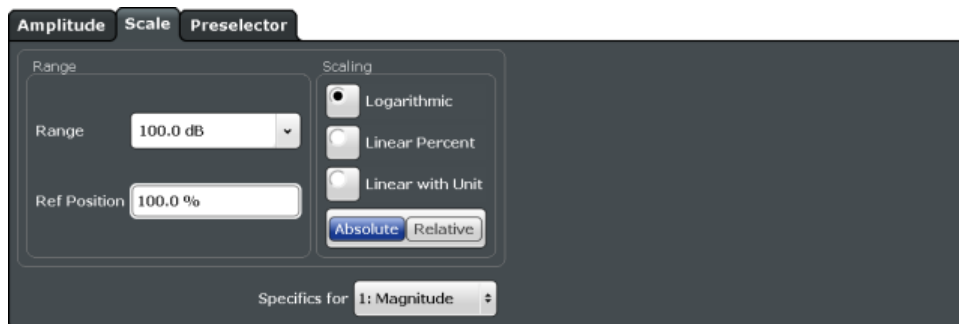
The remote commands required to scale the y-axis are described in Chapter 7.6.6, "Scaling the Y-Axis", on page 92.

Range
Defines the displayed y-axis range in dB.

The default value is 100 dB.

Remote command:
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe] on page 92

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

Remote command:
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RPOSition on page 93

Scaling
Defines the scaling method for the y-axis.

"Logarithmic"   Logarithmic scaling (only available for logarithmic units - dB..., and A, V, Watt)

"Linear Unit"   Linear scaling in the unit of the measured signal

"Linear Percent"   Linear scaling in percentages from 0 to 100

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

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

Remote command:
DISPlay[:WINDow<n>]:TRACe<t>:Y:SPACing on page 93
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:MODE on page 92

Y-Axis Max
Defines the maximum value of the y-axis in the currently selected diagram in either direction (in Volts). Thus, the y-axis scale starts at -<Y-Axis Max> and ends at +<Y-Axis Max>.

The maximum y-axis value depends on the current reference level. If the reference level is changed, the "Y-Axis Max" value is automatically set to the new reference level (in V).

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

Remote command:
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe] on page 92

4.4.3 Configuring the Preselector

For more information refer to the R&S ESW User Manual.

4.5 Configuring Frequency Characteristics

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

● Select the FREQ key and then the "Frequency Config" softkey.
● Select "Frequency" from the "Overview".
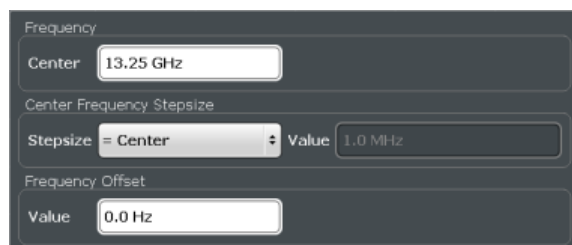
The remote commands required to configure the frequency are described in Chapter 7.6.7, "Configuring the Frequency", on page 94.

Center frequency

Defines the center frequency of the signal in Hertz.

The allowed range of values for the center frequency depends on the frequency span.

span > 0: $span_{min}/2 \le f_{center} \le f_{max} - span_{min}/2$

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

Remote command:
[SENSe:]FREQuency:CENTer on page 94

Center Frequency Stepsize

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

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

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

"= Center"	Sets the step size to the value of the center frequency. The used value is indicated in the "Value" field.
"Manual"	Defines a fixed step size for the center frequency. Enter the step size in the "Value" field.

Remote command:
[SENSe:]FREQuency:CENTer:STEP on page 95

Frequency Offset

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

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

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

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

Remote command:
[SENSe:]FREQuency:OFFSet on page 96

4.6 Configuring Triggered Measurements

Trigger settings determine when the input signal is measured.

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

External triggers from one of the TRIGGER INPUT/OUTPUT connectors on the R&S ESW are configured in a separate tab of the dialog box.
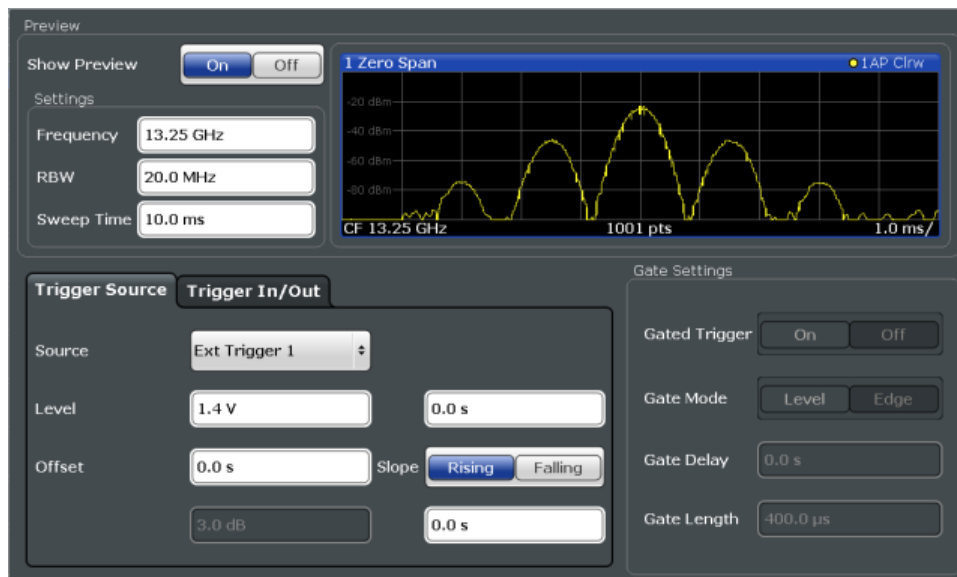
> Conventional gating as in the Spectrum application is not available for the I/Q Analyzer; however, a special gating mode is available in remote control, see Chapter 7.6.10, "Configuring Gated Measurements", on page 103.

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

Functionality to configure trigger output is the same as in the Receiver and Spectrum applications. For more information refer to the corresponding User Manuals.

The remote commands required to configure triggered measurements are described in Chapter 7.6.8, "Configuring Trigger", on page 96.

Trigger Source

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

For gated measurements, this setting also selects the gating source.

Remote command:
TRIGger<n>[:SEQuence]:SOURce on page 99

Free Run ← Trigger Source

No trigger source is considered. Data acquisition is started manually or automatically and continues until stopped explicitly.

In its default state, the R&S ESW performs free run measurements.

Remote command:
TRIGger<n>[:SEQuence]:SOURce on page 99

Ext. Trigger 1/2 ← Trigger Source

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

Note: The "External Trigger 1" softkey automatically selects the trigger signal from the TRIGGER 1 INPUT connector on the front panel.
In the I/Q Analyzer application only "External Trigger 1" is supported.

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

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

"External Trigger 2"
    Trigger signal from the TRIGGER 2 INPUT / OUTPUT connector.
    Note: Connector must be configured for "Input" in the "Outputs" configuration (see "Trigger 2/3" on page 32).

"External Trigger 3"
    Trigger signal from the TRIGGER 3 INPUT/ OUTPUT connector on the rear panel.
    Note: Connector must be configured for "Input" in the "Outputs" configuration (see "Trigger 2/3" on page 32).

Remote command:
TRIGger<n>[:SEQuence]:SOURce on page 99

IF Power ← Trigger Source

The R&S ESW starts capturing data as soon as the trigger level is exceeded around the third intermediate frequency.

This trigger source is only available for RF input.

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

For details on available trigger levels and trigger bandwidths see the data sheet.

Remote command:
TRIGger<n>[:SEQuence]:SOURce on page 99

I/Q Power ← Trigger Source
This trigger source is only available in the I/Q Analyzer application and in applications that process I/Q data.

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

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

Remote command:
TRIGger<n>[:SEQuence]:SOURce on page 99

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

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

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

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

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

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

Remote command:
TRIGger<n>[:SEQuence]:SOURce on page 99

Time ← Trigger Source
Triggers in a specified repetition interval.

Remote command:
TRIGger<n>[:SEQuence]:SOURce on page 99

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

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

Remote command:
TRIGger[:SEQuence]:LEVel:IFPower on page 98
TRIGger[:SEQuence]:LEVel:IQPower on page 99
TRIGger<n>[:SEQuence]:LEVel[:EXTernal<port>] on page 98
TRIGger[:SEQuence]:LEVel:RFPower on page 99

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

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

Remote command:
TRIGger[:SEQuence]:TIME:RINTerval on page 100

Trigger Offset

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

offset > 0:	Start of the sweep is delayed
offset < 0:	Sweep starts earlier (pretrigger)
	Only possible for zero span (e.g. I/Q Analyzer application) and gated trigger switched off
	Maximum allowed range limited by the sweep time:
	$pretrigger_{max} = sweep\ time_{max}$

Tip: To determine the trigger point in the sample (for "External" or "IF Power" trigger source), use the `TRACe:IQ:TPISample?` command.

Remote command:

`TRIGger<n>[:SEQuence]:HOLDoff[:TIME]` on page 97

Hysteresis

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

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

Remote command:

`TRIGger[:SEQuence]:IFPower:HYSTeresis` on page 97

Drop-Out Time

Defines the time the input signal must stay below the trigger level before triggering again.

Remote command:

`TRIGger[:SEQuence]:DTIMe` on page 96

Trigger Holdoff

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

Remote command:

`TRIGger[:SEQuence]:IFPower:HOLDoff` on page 97

Slope

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

Remote command:

`TRIGger<n>[:SEQuence]:SLOPe` on page 99

4.7 Data Acquisition and Bandwidth Settings

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

4.7.1 Data Acquisition

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

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

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

The remote commands required to perform these tasks are described in Chapter 7.6.11, "Configuring Data Acquisition", on page 105.

Sample Rate
Defines the I/Q data sample rate of the R&S ESW. This value is dependent on the defined Analysis Bandwidth and the defined signal source.

The following rule applies:

sample rate = analysis bandwidth / 0.8

For details on the dependencies see Chapter 3.2.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 17.

Remote command:
TRACe:IQ:SRATe on page 111

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

The following rule applies:

*analysis bandwidth = 0.8 * sample rate*

Remote command:
TRACe:IQ:BWIDth on page 109

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

For details on the maximum number of samples see also Chapter 3.2.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 17.

Remote command:
[SENSe:]SWEep:TIME on page 75

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

Note: For the I/Q vector result display, the number of I/Q samples to record ("Record Length") must be identical to the number of trace points to be displayed ("Sweep Points"). Thus, the sweep points are not editable for this result display. If the "Record Length" is edited, the sweep points are adapted automatically.
For record lengths outside the valid range of sweep points, i.e. fewer than 101 points or more than 100001 points, the diagram does not show valid results.

Remote command:
TRACe:IQ:RLENgth on page 109
TRACe:IQ:SET on page 109

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

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

Remote command:
[SENSe:]SWAPiq on page 108

RBW
Defines the resolution bandwidth for Spectrum results. The available RBW values depend on the sample rate and record length.

(See Chapter 3.4.4, "Frequency Resolution of FFT Results - RBW", on page 23).

Depending on the selected RBW mode, the value is either determined automatically or can be defined manually. As soon as you enter a value in the input field, the RBW mode is changed to "Manual".

This setting is only available if a Spectrum window is active.

If the "Advanced Fourier Transformation Params" option is enabled, advanced FFT mode is selected and the RBW cannot be defined directly.

Note that the RBW is correlated with the Sample Rate and Record Length (and possibly the Window Function and Window Length). Changing any one of these parameters may cause a change to one or more of the other parameters. For more information see Chapter 3.4, "Basics on FFT", on page 20.

"Auto mode"	(Default) The RBW is determined automatically depending on the Sample Rate and Record Length.
"Manual mode"	The RBW can be defined by the user. The user-defined RBW is used and the Window Length (and possibly Sample Rate) are adapted accordingly.
"Advanced FFT mode"	This mode is used if the "Advanced Fourier Transformation Params" option is enabled. The RBW is determined by the advanced FFT parameters.

Remote command:
[SENSe:]IQ:BANDwidth|BWIDth:MODE on page 105
[SENSe:]IQ:BANDwidth|BWIDth:RESolution on page 106

Advanced FFT mode / Basic settings
Shows or hides the "Advanced Fourier Transformation" parameters in the "Data Acquisition" dialog box.

These parameters are only available and required for the advanced FFT mode.

Note that if the advanced FFT mode is used, the RBW settings are not available.

For more information see Chapter 3.4.4, "Frequency Resolution of FFT Results - RBW", on page 23.

Transformation Algorithm ← Advanced FFT mode / Basic settings
Defines the FFT calculation method.

"Single"	One FFT is calculated for the entire record length; if the FFT Length is larger than the record length, zeros are appended to the captured data.
"Averaging"	Several overlapping FFTs are calculated for each record; the results are combined to determine the final FFT result for the record. The number of FFTs to be averaged is determined by the Window Overlap and the Window Length.

Remote command:
[SENSe:]IQ:FFT:ALGorithm on page 106

FFT Length ← Advanced FFT mode / Basic settings
Defines the number of frequency points determined by each FFT calculation. The more points are used, the higher the resolution in the spectrum becomes, but the longer the calculation takes.

In advanced FFT mode, the number of sweep points is set to the FFT length automatically.

Note: If you use the arrow keys or the rotary knob to change the FFT length, the value is incremented or decremented by powers of 2.
If you enter the value manually, any integer value from 3 to 524288 is available.

Remote command:
[SENSe:]IQ:FFT:LENGth on page 107

Window Function ← Advanced FFT mode / Basic settings
In the I/Q analyzer you can select one of several FFT window types.

The following window types are available:
- Blackman-Harris
- Flattop
- Gauss
- Rectangular
- 5-Term

Remote command:
[SENSe:]IQ:FFT:WINDow:TYPE on page 108

Window Overlap ← Advanced FFT mode / Basic settings
Defines the part of a single FFT window that is re-calculated by the next FFT calculation when using multiple FFT windows.

Remote command:
[SENSe:]IQ:FFT:WINDow:OVERlap on page 108

Window Length ← Advanced FFT mode / Basic settings
Defines the number of samples to be included in a single FFT window in averaging mode. (In single mode, the window length corresponds to the "Record Length" on page 45.)

Values from 3 to 4096 are available in "Manual" mode; in "Advanced" FFT mode, values from 3 to 524288 are available.

However, the window length may not be longer than the FFT Length.

Remote command:
[SENSe:]IQ:FFT:WINDow:LENGth on page 107

4.7.2 Sweep Settings

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

► To display this dialog box, do one of the following:
- Select the "Bandwidth" button in the configuration "Overview" and switch to the "Sweep" tab.
- Select the SWEEP key and then the "Sweep Config" softkey.

Sweep Points

In the I/Q Analyzer application, a specific frequency bandwidth is swept for a specified measurement time. During this time, a defined number of samples (= "Record Length") are captured. These samples are then evaluated by the applications. Therefore, in this case the number of sweep points does not define the amount of data to be acquired, but rather the number of trace points that are evaluated and displayed in the result diagrams.

Note: As opposed to previous versions of the I/Q Analyzer, the sweep settings are now window-specific. For some result displays, the sweep points may not be editable as they are determined automatically, or restrictions may apply.
For the I/Q vector result display, the number of I/Q samples to record ("Record Length") must be identical to the number of trace points to be displayed ("Sweep Points"). Thus, the sweep points are not editable for this result display. If the "Record Length" is edited, the sweep points are adapted automatically. For record lengths outside the valid range of sweep points, i.e. less than 101 points or more than 32001 points, the diagram does not show valid results.

Using fewer than 4096 sweep points with a detector other than Auto Peak may lead to wrong level results. For details see "Combining results - trace detector" on page 22.

Remote command:
[SENSe:]SWEep:POINts on page 75

Sweep / Average Count

Defines the number of sweeps to be performed in the single sweep mode. Values from 0 to 200000 are allowed. If the values 0 or 1 are set, one sweep is performed.

The sweep count is applied to all the traces in all diagrams.

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

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

Remote command:
[SENSe:]SWEep:COUNt on page 74
[SENSe:]AVERage:COUNt on page 73

Continuous Sweep/RUN CONT

After triggering, starts the sweep and repeats it continuously until stopped. This is the default setting.

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

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

Remote command:
INITiate<n>:CONTinuous on page 71
Measurement mode: INITiate<n>:CONTinuous on page 71
Run measurement: INITiate<n>[:IMMediate] on page 71

Single Sweep/ RUN SINGLE
After triggering, starts the number of sweeps set in "Sweep Count". The measurement stops after the defined number of sweeps has been performed.

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

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

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

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

Remote command:
Measurement mode: INITiate<n>:CONTinuous on page 71
Run measurement: INITiate<n>[:IMMediate] on page 71

Continue Single Sweep
After triggering, repeats the number of sweeps set in "Sweep Count", without deleting the trace of the last measurement.

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

Remote command:
INITiate<n>:CONMeas on page 70

4.8 Display Configuration

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

● Select the ▣ "SmartGrid" icon from the toolbar.
● Select the "Display Config" button in the "Overview".
● Select the "Display Config" softkey in the main application menu.

For a description of the available evaluation methods see Chapter 2, "Measurement and Result Displays", on page 9.

4.9 Adjusting Settings Automatically

Some settings can be adjusted by the R&S ESW automatically according to the current measurement settings. In order to do so, a measurement is performed. The duration of this measurement can be defined automatically or manually.

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

Adjusting settings automatically during triggered measurements

When you select an auto adjust function a measurement is performed to determine the optimal settings. If you select an auto adjust function for a triggered measurement, you are asked how the R&S ESW should behave:

● (default:) The measurement for adjustment waits for the next trigger
● The measurement for adjustment is performed without waiting for a trigger.
  The trigger source is temporarily set to "Free Run". After the measurement is completed, the original trigger source is restored. The trigger level is adjusted as follows:
  – For IF Power and RF Power triggers:
    Trigger Level = Reference Level - 15 dB
  – For Video trigger:
    Trigger Level = 85 %

Remote command:

[SENSe:]ADJust:CONFigure:TRIG on page 114

Adjusting all Determinable Settings Automatically (Auto All)

Activates all automatic adjustment functions for the current measurement settings.

This includes:

- Auto Frequency
- Auto Level

Remote command:

[SENSe:]ADJust:ALL on page 112

Adjusting the Center Frequency Automatically (Auto Freq)

The R&S ESW adjusts the center frequency automatically.

The optimum center frequency is the frequency with the highest S/N ratio in the frequency span. As this function uses the signal counter, it is intended for use with sinusoidal signals.

Remote command:

[SENSe:]ADJust:FREQuency on page 114

Setting the Reference Level Automatically (Auto Level)

Automatically determines a reference level which ensures that no overload occurs at the R&S ESW for the current input data. At the same time, the internal attenuators are adjusted so the signal-to-noise ratio is optimized, while signal compression and clipping are minimized.

To determine the required reference level, a level measurement is performed on the R&S ESW.

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

You can change the measurement time for the level measurement if necessary (see "Changing the Automatic Measurement Time (Meastime Manual)" on page 51).

Remote command:

[SENSe:]ADJust:LEVel on page 114

Resetting the Automatic Measurement Time (Meastime Auto)

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

Remote command:

[SENSe:]ADJust:CONFigure:DURation:MODE on page 112

Changing the Automatic Measurement Time (Meastime Manual)

This function allows you to change the measurement duration for automatic setting adjustments. Enter the value in seconds.

Remote command:

[SENSe:]ADJust:CONFigure:DURation:MODE on page 112
[SENSe:]ADJust:CONFigure:DURation on page 112

Upper Level Hysteresis

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

Remote command:
[SENSe:]ADJust:CONFigure:HYSTeresis:UPPer on page 113

Lower Level Hysteresis

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

Remote command:
[SENSe:]ADJust:CONFigure:HYSTeresis:LOWer on page 113

5 Analysis

Access

● "Overview" > "Analysis"

General result analysis settings concerning the trace, markers, lines etc. are similar to the analysis functions in the Spectrum application, except for the features described here.

For more information, refer to the R&S ESW User Manual.

5.1 Trace Configuration

Access

● "Overview" > "Analysis" > "Trace"

For more information, refer to the R&S ESW User Manual.

Spectrograms in the I/Q Analyzer application

Basically, spectrograms work the same as in the Receiver application.

However, in the I/Q Analyzer application, they have the following distinctive features.

● Not all result displays support spectrograms.

● Compared to the Receiver or Spectrum application, a spectrogram can not be added as an independent result display. Instead, spectrograms relate to a certain measurement window (or result display). Result diagram and spectrogram are a single entity in that case and can not be divided.

To view results in a spectrogram, select a window (indicated by a blue frame), then select TRACE > "Spectrogram Config".

Spectrograms are either displayed in "Split" mode (spectrogram is displayed below the trace diagram), in "Full" mode (trace diagram is not displayed), or not displayed at all ("Off)".

When the "Spectrogram Config"softkey is greyed out, spectrograms are not supported by the selected result display.

State
Activates and deactivates a Spectrogram subwindow.

"Split"   Displays the Spectrogram as a subwindow in the original result display.

"Full"   Displays the Spectrogram in a subwindow in the full size of the original result display.

"Off"   Closes the Spectrogram subwindow.

Remote command:
CALCulate<n>:SPECtrogram:LAYout on page 122

5.2 Marker Settings

Access

● "Overview" > "Analysis" > "Marker"

● "Overview" > "Analysis" > "Marker Function"

For more information, refer to the R&S ESW User Manual.

Branch for Peak Search
Defines which data is used for marker search functions in I/Q data.

This function is only available for the display configuration "Real/Imag (I/Q)" (see "Real/Imag (I/Q)" on page 11).

Note: The search settings apply to all markers, not only the currently selected one.

"Real"
                  Marker search functions are performed on the real trace of the I/Q
                  measurement.

"Imag"
                  Marker search functions are performed on the imaginary trace of the
                  I/Q measurement.

"Magnitude"
                  Marker search functions are performed on the magnitude of the I and
                  Q data.

Remote command:
CALCulate<n>:MARKer<m>:SEARch on page 121

6 How to Work with I/Q Data

The following step-by-step procedures demonstrate in detail how to perform various tasks when working with I/Q data.

6.1 How to Perform Measurements in the I/Q Analyzer Application

The following step-by-step instructions demonstrate how to capture I/Q data on the R&S ESW and how to analyze data in the I/Q Analyzer application.

6.1.1 How to Capture Baseband (I/Q) Data as RF Input

By default, the I/Q Analyzer assumes the I/Q data is modulated on a carrier frequency and input via the RF INPUT connector on the R&S ESW.

1. Select the MODE key and select the "I/Q Analyzer" application.

2. Select the "Overview" softkey to display the "Overview" for an I/Q Analyzer measurement.

3. Select the "Input" button to select and configure the "RF Input" signal source.

4. Select the "Amplitude" button to define the attenuation, reference level or other settings that affect the input signal's amplitude and scaling.

5. Select the "Frequency" button to define the input signal's center frequency.

6. Optionally, select the "Trigger" button and define a trigger for data acquisition, for example an I/Q Power trigger to start capturing data only when a specific power is exceeded.

7. Select the "Bandwidth" button and define the bandwidth parameters for data acquisition:

   - "Sample rate" or "Analysis Bandwidth:" the span of the input signal to be captured for analysis, or the rate at which samples are captured (both values are correlated)
   - "Measurement Time:" how long the data is to be captured
   - "Record Length": the number of samples to be captured (also defined by sample rate and measurement time)

8. Select the "Display Config" button and select up to six displays that are of interest to you.
    Arrange them on the display to suit your preferences.

9. Exit the SmartGrid mode.

10. Start a new sweep with the defined settings.

    a) Select the Sequencer icon (⊞) from the toolbar.
    b) Set the Sequencer state to "OFF".
    c) Select the RUN SINGLE key.

6.1.2 How to Analyze Data in the I/Q Analyzer

1. Select the MODE key and select the "I/Q Analyzer" application.

2. Select the "Overview" softkey to display the "Overview" for an I/Q Analyzer measurement.

3. Select the "Display Config" button and select up to six displays that are of interest to you.
    Arrange them on the display to suit your preferences.

4. Exit the SmartGrid mode and select the "Overview" softkey to display the "Overview" again.

5. Select the "Analysis" button in the "Overview" to make use of the advanced analysis functions in the displays.

    ● Configure a trace to display the average over a series of sweeps (on the "Trace" tab; if necessary, increase the "Average Count").
    ● Configure markers and delta markers to determine deviations and offsets within the signal (on the "Marker" tab).

6.2 How to Export and Import I/Q Data

ⓘ I/Q data can only be exported in applications that process I/Q data, such as the I/Q Analyzer or optional applications.

Capturing and exporting I/Q data

1. Press the PRESET key.

2. Press the MODE key and select the I/Q Analyzer application or any other application that supports I/Q data.

3. Configure the data acquisition.

4. Press the RUN SINGLE key to perform a single sweep measurement.

5. Select the ▣ "Save" icon in the toolbar.

6. Select the "I/Q Export" softkey.

7. In the file selection dialog box, select a storage location and enter a file name.

8. Select "Save".

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

Importing I/Q data

1. Press the MODE key and select the "I/Q Analyzer" or any other application that supports I/Q data.

2. If necessary, switch to single sweep mode by pressing the RUN SINGLE key.

3. Select the ▣ "Open" icon in the toolbar.

4. Select the "I/Q Import" softkey.

5. Select the storage location and the file name with the `.iq.tar` file extension.
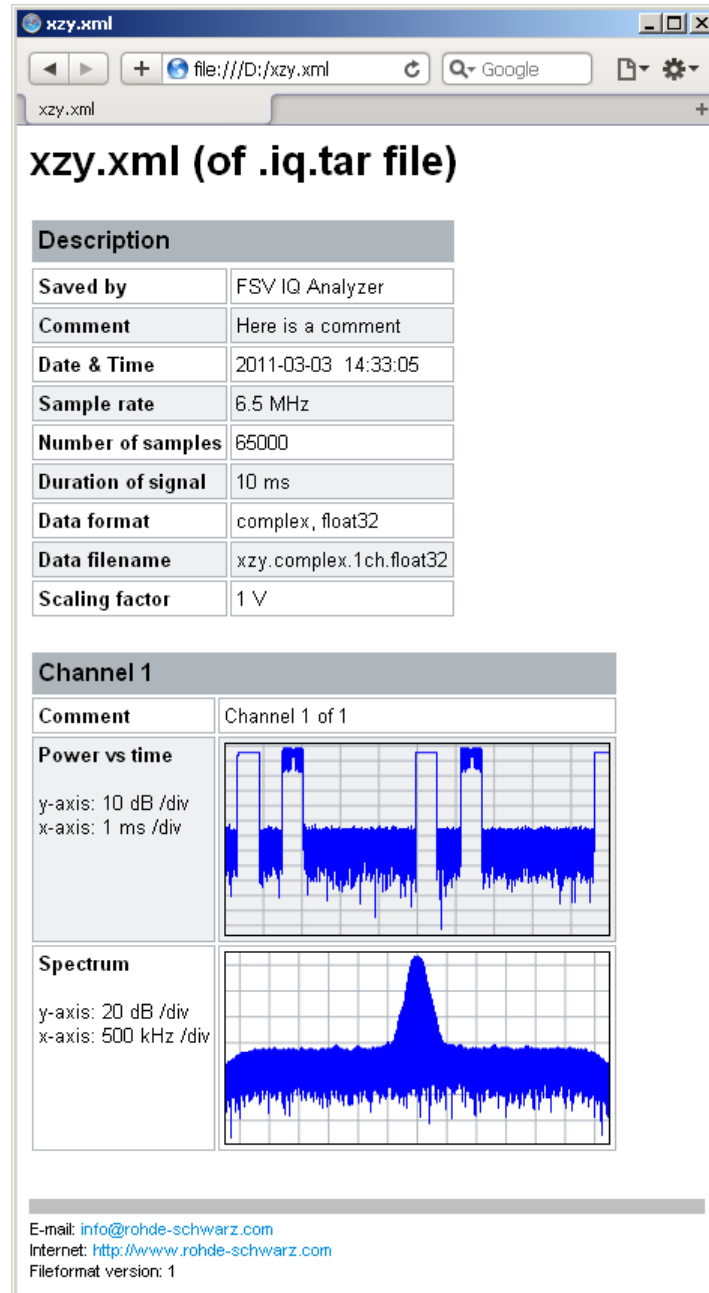
6. Select "Open".

    The stored data is loaded from the file and displayed in the current application.

Previewing the I/Q data in a web browser

The `iq-tar` file format allows you to preview the I/Q data in a web browser.

1. Use an archive tool (e.g. WinZip® or PowerArchiver®) to unpack the `iq-tar` file into a folder.

2. Locate the folder using Windows Explorer.

3. Open your web browser.

4. Drag the I/Q parameter XML file, e.g. `example.xml`, into your web browser.
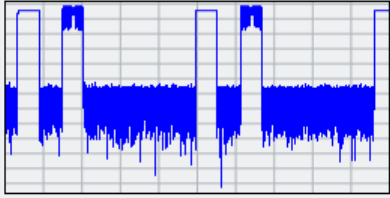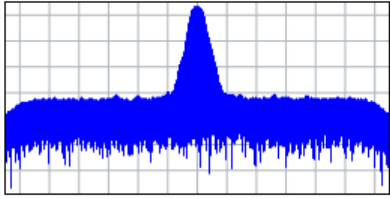
7 Remote Commands for the I/Q Analyzer

The following commands are specific to performing measurements in the I/Q Analyzer application or using the optional Digital Baseband Interface in a remote environment. The R&S ESW must already be set up for remote operation in a network as described in the base unit manual.

7.1 Introduction

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

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

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

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

Remote command examples

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

7.1.1 Conventions used in Descriptions

Note the following conventions used in the remote command descriptions:

- **Command usage**

If not specified otherwise, commands can be used both for setting and for querying parameters.

If a command can be used for setting or querying only, or if it initiates an event, the usage is stated explicitly.

- **Parameter usage**

  If not specified otherwise, a parameter can be used to set a value and it is the result of a query.

  Parameters required only for setting are indicated as **Setting parameters**.

  Parameters required only to refine a query are indicated as **Query parameters**.

  Parameters that are only returned as the result of a query are indicated as **Return values**.

- **Conformity**

  Commands that are taken from the SCPI standard are indicated as **SCPI confirmed**. All commands used by the R&S ESW follow the SCPI syntax rules.

- **Asynchronous commands**

  A command which does not automatically finish executing before the next command starts executing (overlapping command) is indicated as an **Asynchronous command**.

- **Reset values (*RST)**

  Default parameter values that are used directly after resetting the instrument (`*RST` command) are indicated as ***RST** values, if available.

- **Default unit**

  This is the unit used for numeric values if no other unit is provided with the parameter.

- **Manual operation**

  If the result of a remote command can also be achieved in manual operation, a link to the description is inserted.

7.1.2 Long and Short Form

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

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

Example:

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

7.1.3 Numeric Suffixes

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

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

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

Example:

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

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

7.1.4 Optional Keywords

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

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

Optional keywords are emphasized with square brackets.

Example:

Without a numeric suffix in the optional keyword:

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

With a numeric suffix in the optional keyword:

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

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

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

7.1.5 Alternative Keywords

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

Example:

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

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

7.1.6 SCPI Parameters

Many commands feature one or more parameters.

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

Example:

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

Parameters may have different forms of values.

7.1.6.1 Numeric Values

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

Example:

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

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

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

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

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

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

Querying numeric values

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

Example:

Setting: `SENSe:FREQuency:CENTer 1GHZ`

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

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

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

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

7.1.6.2 Boolean

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

Querying boolean parameters

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

Example:

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

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

7.1.6.3 Character Data

Character data follows the syntactic rules of keywords. You can enter text using a short or a long form. For more information see Chapter 7.1.2, "Long and Short Form", on page 60.

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`

7.1.6.4 Character Strings

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

Example:

`INSTRument:DELete 'Spectrum'`

7.1.6.5 Block Data

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

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

transmitted. #0 specifies a data block of indefinite length. The use of the indefinite format requires an `NL^END` message to terminate the data block. This format is useful when the length of the transmission is not known or if speed or other considerations prevent segmentation of the data into blocks of definite length.

7.2 Common Suffixes

In the I/Q Analyzer application, the following common suffixes are used in remote commands:

Table 7-1: Common suffixes used in remote commands in the I/Q Analyzer application

Suffix	Value range	Description
<m>	1..16	Marker
<n>	1..16	Window (**in the currently selected measurement channel**)
<t>	1..6	Trace
<k>	irrelevant	Limit line
<i>	1..3	Output (1, 2 or Phones)
<k>	1..8 (Limit line) 1 | 2 (Display line)	Line

Selecting windows in multiple measurement channels

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

7.3 Activating I/Q Analyzer Measurements

I/Q Analyzer measurements require a special measurement channel on the R&S ESW. It can be activated using the common `INSTrument:CREate[:NEW]` or `INSTrument:CREate:REPLace` commands. In this case, some - but not all - parameters from the previously selected application are passed on to the I/Q Analyzer channel. In order to retain *all* relevant parameters from the current application for the I/Q measurement, use the `TRACe:IQ[:STATe]` command to change the application of the current channel.

A measurement is started immediately with the default settings when the channel is activated.

Different remote modes available

In remote control, two different modes for the I/Q Analyzer measurements are available:

- A quick mode for pure data acquisition
  This mode is activated by default with the `TRACe:IQ[:STATe]` command. The evaluation functions are not available; however, performance is slightly improved.

- A more sophisticated mode for acquisition and analysis.
  This mode is activated when a new channel is opened for the I/Q Analyzer application (INST:CRE:NEW/ INST:CRE:REPL) or by an additional command (see `TRACe:IQ:EVAL` on page 68).

INSTrument:CREate:DUPLicate

This command duplicates the currently selected measurement channel, i.e creates a new measurement channel of the same type and with the identical measurement settings. The name of the new channel is the same as the copied channel, extended by a consecutive number (e.g. "IQAnalyzer" -> "IQAnalyzer2").

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

Example:	`INST:SEL 'Receiver'`
	`INST:CRE:DUPL`
	Duplicates the channel named 'Receiver' and creates a new measurement channel named 'Receiver 2'.
Usage:	Event

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

This command adds an additional measurement channel.

The number of measurement channels you can configure at the same time depends on available memory.

Parameters:

<ChannelType>   Channel type of the new channel.
                  For a list of available channel types see `INSTrument:LIST?` on page 66.

<ChannelName>	String containing the name of the channel. The channel name is displayed as the tab label for the measurement channel. Note: If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel (see `INSTrument:LIST?` on page 66).
Example:	`INST:CRE REC, 'Receiver 2'` Adds an additional Receiver channel named "Receiver 2".

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

This command replaces a measurement channel with another one.

Setting parameters:

<ChannelName1>	String containing the name of the measurement channel you want to replace.
<ChannelType>	Channel type of the new channel. For a list of available channel types see `INSTrument:LIST?` on page 66.
<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 66).
Example:	`INST:CRE:REPL 'Receiver',REC,'REC2'` Replaces the channel named 'Receiver' by a new measurement channel of type 'Receiver' named 'REC2'.
Usage:	Setting only

INSTrument:DELete <ChannelName>

This command deletes a measurement channel.

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

Parameters:

<ChannelName>	String containing the name of the channel you want to delete. A measurement channel must exist in order to be able delete it.
Example:	`INST:DEL 'Receiver'` Deletes the channel with the name 'Receiver'.
Usage:	Event

INSTrument:LIST?

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

Return values:

<ChannelType>, <ChannelName>	For each channel, the command returns the channel type and channel name (see tables below). Tip: to change the channel name, use the `INSTrument: REName` command.
Example:	`INST:LIST?` Result for 2 measurement channels: `'REC','Receiver','REC','Receiver2'`
Usage:	Query only

Table 7-2: Available measurement channel types and default channel names

Application	<ChannelType> Parameter	Default Channel Name*)
Receiver	RECEIVER	Receiver
CISPR APD	n/a Use `CALCulate:STATistics: CAPD[:STATe]`	CISPR APD
Spectrum	SANALYZER	Spectrum
I/Q Analyzer	IQ	IQ Analyzer
Real-Time Spectrum	RTIM	Real-Time Spectrum

Note: the default channel name is also listed in the table. If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel.

INSTrument:REName <ChannelName1>, <ChannelName2>

This command renames a measurement channel.

Parameters:

<ChannelName1>	String containing the name of the channel you want to rename.
<ChannelName2>	String containing the new channel name. Note that you cannot assign an existing channel name to a new channel; this will cause an error.
Example:	`INST:REN 'Receiver','REC'` Renames the channel with the name 'Receiver' to 'REC'.
Usage:	Setting only

INSTrument[:SELect] <ChannelType> | <ChannelName>

This command activates a new measurement channel with the defined channel type, or selects an existing measurement channel with the specified name.

Also see

-

Parameters:

<ChannelType>	Channel type of the new channel.
	For a list of available channel types see `INSTrument:LIST?` on page 66.
<ChannelName>	String containing the name of the channel.
Example:	`INST IQ`
	Activates a measurement channel for the I/Q Analyzer application (evaluation mode).
	`INST 'MyIQSpectrum'`
	Selects the measurement channel named 'MyIQSpectrum' (for example before executing further commands for that channel).
Usage:	SCPI confirmed

SYSTem:PRESet:CHANnel[:EXECute]

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

Use `INST:SEL` to select the channel.

Example:	`INST:SEL 'Spectrum2'`
	Selects the channel for "Spectrum2".
	`SYST:PRES:CHAN:EXEC`
	Restores the factory default settings to the "Spectrum2" channel.
Usage:	Event
Manual operation:	See "Preset Channel" on page 28

TRACe:IQ:EVAL <State>

This command turns I/Q data analysis on and off.

Before you can use this command, you have to turn on the I/Q data acquisition using `INST:CRE:NEW IQ` or `INST:CRE:REPL`, or using the `TRACe:IQ[:STATe]` command to replace the current measurement channel while retaining the settings.

Parameters:

<State>	ON | OFF
	*RST: OFF
Example:	`TRAC:IQ ON`
	Enables I/Q data acquisition
	`TRAC:IQ:EVAL ON`
	Enables the I/Q data analysis mode.

TRACe:IQ[:STATe] <State>

Executing this command also has the following effects:

- The sweep, amplitude, input and trigger settings from the previous application are retained

- All measurements from the previous application (e.g. Spectrum) are turned off
- All traces are set to "Blank" mode
- The I/Q data analysis mode is turned off (`TRAC:IQ:EVAL OFF`, if previous application was also I/Q Analyzer)

Note: To turn trace display back on or to enable the evaluation functions of the I/Q Analyzer, execute the `TRAC:IQ:EVAL ON` command (see `TRACe:IQ:EVAL` on page 68).

Parameters:

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

| **Example:** | `TRAC:IQ ON` |
| | Switches on I/Q data acquisition |

7.4 Performing Measurements

Different measurement procedures

Two different procedures to capture I/Q data remotely are available:

- Measurement and result query with one command (see `TRACe:IQ:DATA?` on page 77)
  This method causes the least delay between measurement and output of the result data, but it requires the control computer to wait actively for the response data.
- Setting up the instrument, starting the measurement via `INIT` and querying the result list at the end of the measurement (see `TRACe:IQ:DATA:MEMory?` on page 78)
  With this method, the control computer can be used for other activities during the measurement. However, the additional time needed for synchronization via service request must be taken into account.

ABORt

This command aborts the measurement in the current measurement channel and resets the trigger system.

To prevent overlapping execution of the subsequent command before the measurement has been aborted successfully, use the `*OPC?` or `*WAI` command after ABOR and before the next command.

Note on blocked remote control programs:

If a sequential command cannot be completed, for example because a triggered sweep never receives a trigger, the remote control program will never finish and the remote channel to the R&S ESW is blocked for further commands. In this case, you must interrupt processing on the remote channel first in order to abort the measurement.

To do so, send a "Device Clear" command from the control instrument to the R&S ESW on a parallel channel to clear all currently active remote channels. Depending on the used interface and protocol, send the following commands:

● **Visa**: `viClear()`

Now you can send the ABORt command on the remote channel performing the measurement.

Example:	`ABOR;:INIT:IMM` Aborts the current measurement and immediately starts a new one.

Example:	`ABOR;*WAI`
	`INIT:IMM`
	Aborts the current measurement and starts a new one once abortion has been completed.

Usage:	Event SCPI confirmed

INITiate<n>:CONMeas

This command restarts a (single) measurement that has been stopped (using ABORt) or finished in single sweep mode.

The measurement is restarted at the beginning, not where the previous measurement was stopped.

Suffix:	
<n>	irrelevant
Usage:	Event
Manual operation:	See "Continue Single Sweep" on page 49

INITiate<n>:CONTinuous <State>

This command controls the sweep mode for an individual measurement channel.

Note that in single sweep mode, you can synchronize to the end of the measurement with *OPC, *OPC? or *WAI. In continuous sweep mode, synchronization to the end of the measurement is not possible. Thus, it is not recommended that you use continuous sweep mode in remote control, as results like trace data or markers are only valid after a single sweep end synchronization.

For details on synchronization refer to the R&S ESW User Manual, chapter "Command Sequence and Synchronization".

If the sweep mode is changed for a measurement channel while the Sequencer is active the mode is only considered the next time the measurement in that channel is activated by the Sequencer.

Suffix:

<n>	1 | 2
	INITiate1 selects single or continuous bargraph measurements.
	INITiate2 selects single or continuous scans.

Parameters:

<State>	ON | OFF | 0 | 1
	ON | 1
	Continuous sweep
	OFF | 0
	Single sweep
	*RST: 1

Example:	`INIT:CONT OFF`
	Switches the sweep mode to single sweep.
	`INIT:CONT ON`
	Switches the sweep mode to continuous sweep.

Manual operation:	See "Continuous Sweep/RUN CONT" on page 48
	See "Single Sweep/ RUN SINGLE" on page 49

INITiate<n>[:IMMediate]

The command initiates a new sweep.

In case of a single sweep, the R&S ESW stops measuring when it has reached the end frequency. When you start a continuous measurement, it stops only if you abort it deliberately.

If you are using trace modes MAXHold, MINHold and AVERage, previous results are reset when you restart the measurement.

- **Single measurements**
  Synchronization to the end of the measurement is possible with `*OPC`, `*OPC?` or `*WAI`.

- **Continuous measurements**

Synchronization to the end of the measurement is not possible.
It is thus recommended to use a single measurement for remote controlled measurements, because results like trace data or markers are only valid after synchronization.

Suffix:

<n>	1 | 2
	INITiate1 initiates a bargraph measurement.
	INITiate2 initiates a scan.

Example: `INIT2:CONT OFF`
`SWE:COUN 20`
`INIT2;*WAI`
Starts a single scan (with a scan count = 20), and waits until the measurement is done.

Usage: Event

Manual operation: See "Continuous Sweep/RUN CONT" on page 48
See "Single Sweep/ RUN SINGLE" on page 49

INITiate<n>:SEQuencer:ABORt

This command stops the currently active sequence of measurements. The Sequencer itself is not deactivated, so you can start a new sequence immediately using `INITiate<n>:SEQuencer:IMMediate` on page 72.

To deactivate the Sequencer use `SYSTem:SEQuencer` on page 76.

Suffix:

<n>	irrelevant

Usage: Event

INITiate<n>:SEQuencer:IMMediate

This command starts a new sequence of measurements by the Sequencer.

Before this command can be executed, the Sequencer must be activated (see `SYSTem:SEQuencer` on page 76).

Suffix:

<n>	irrelevant

Example: `SYST:SEQ ON`
Activates the Sequencer.
`INIT:SEQ:MODE SING`
Sets single sequence mode so each active measurement will be performed once.
`INIT:SEQ:IMM`
Starts the sequential measurements.

Usage: Event

INITiate<n>:SEQuencer:MODE <Mode>

This command selects the way the R&S ESW application performs measurements sequentially.

Before this command can be executed, the Sequencer must be activated (see SYSTem:SEQuencer on page 76).

A detailed programming example is provided in the "Operating Modes" chapter in the R&S ESW User Manual.

Note: In order to synchronize to the end of a sequential measurement using *OPC, *OPC? or *WAI you must use SINGle Sequence mode.

For details on synchronization see the "Remote Basics" chapter in the R&S ESW User Manual.

Suffix:

<n>   irrelevant

Parameters:

<Mode>   **SINGle**
                             Each measurement is performed once (regardless of the chan-
                             nel's sweep mode), considering each channels' sweep count,
                             until all measurements in all active channels have been per-
                             formed.

                             CONTinuous
                             The measurements in each active channel are performed one
                             after the other, repeatedly (regardless of the channel's sweep
                             mode), in the same order, until the Sequencer is stopped.

                             CDEFined
                             First, a single sequence is performed. Then, only those channels
                             in continuous sweep mode (INIT:CONT ON) are repeated.

                             *RST: CONTinuous

Example: SYST:SEQ ON
                             Activates the Sequencer.
                             INIT:SEQ:MODE SING
                             Sets single sequence mode so each active measurement will be
                             performed once.
                             INIT:SEQ:IMM
                             Starts the sequential measurements.

[SENSe:]AVERage:COUNt <AverageCount>
TRACe:IQ:AVERage:COUNt <NumberSets>

This command defines the number of I/Q data sets that the averaging is based on.

Parameters:

<NumberSets>   Range: 0 to 32767
                             *RST: 0

Example: TRAC:IQ ON
                      Switches on acquisition of I/Q data.
                      TRAC:IQ:AVER ON
                      Enables averaging of the I/Q measurement data
                      TRAC:IQ:AVER:COUN 10
                      Selects averaging over 10 data sets
                      TRAC:IQ:DATA?
                      Starts the measurement and reads out the averaged data.

[SENSe:]AVERage<n>[:STATe<t>] <State>
TRACe:IQ:AVERage[:STATe] <State>

This command turns averaging of the I/Q data on and off.

Before you can use the command you have to turn the I/Q data acquisition on with
TRACe:IQ[:STATe].

If averaging is on, the maximum amount of I/Q data that can be recorded is 512kS
(524288 samples).

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

Example: TRAC:IQ ON
                      Switches on acquisition of I/Q data.
                      TRAC:IQ:AVER ON
                      Enables averaging of the I/Q measurement data.
                      TRAC:IQ:AVER:COUN 10
                      Selects averaging over 10 data sets.
                      TRAC:IQ:DATA?
                      Starts the measurement and reads out the averaged data.

[SENSe:]SWEep:COUNt <SweepCount>

This command defines the number of sweeps that the application uses to average
traces.

In case of continuous sweep mode, the application calculates the moving average over
the average count.

In case of single sweep mode, the application stops the measurement and calculates
the average after the average count has been reached.

Suffix:
<n>   Window

Example: SWE:COUN 64
                      Sets the number of sweeps to 64.
                      INIT:CONT OFF
                      Switches to single sweep mode.
                      INIT;*WAI
                      Starts a sweep and waits for its end.

Usage:	SCPI confirmed
Manual operation:	See "Sweep / Average Count" on page 48

[SENSe:]SWEep:COUNt:CURRent?

This query returns the current number of started sweeps or measurements. This command is only available if a sweep count value is defined and the instrument is in single sweep mode.

Example:	SWE:COUNt 64
	Sets sweep count to 64
	INIT:CONT OFF
	Switches to single sweep mode
	INIT
	Starts a sweep (without waiting for the sweep end!)
	SWE:COUN:CURR?
	Queries the number of started sweeps
Usage:	Query only

[SENSe:]SWEep:POINts <SweepPoints>

This command defines the number of sweep points to analyze after a sweep.

Parameters:

<SweepPoints>	Range:	101 to 100001
	*RST:	1001

Example:	SWE:POIN 251
Usage:	SCPI confirmed
Manual operation:	See "Sweep Points" on page 48

[SENSe:]SWEep:TIME <Time>

This command defines the sweep time.

Parameters:

<Time>	refer to data sheet
	*RST:	depends on current settings (determined automatically)

Example:	SWE:TIME 10s
Usage:	SCPI confirmed
Manual operation:	See "Meas Time" on page 45

SYSTem:SEQuencer <State>

This command turns the Sequencer on and off. The Sequencer must be active before any other Sequencer commands (INIT:SEQ...) are executed, otherwise an error will occur.

A detailed programming example is provided in the "Operating Modes" chapter in the R&S ESW User Manual.

Parameters:

<State>   ON | OFF | 0 | 1

                           ON | 1
                           The Sequencer is activated and a sequential measurement is started immediately.

                           OFF | 0
                           The Sequencer is deactivated. Any running sequential measurements are stopped. Further Sequencer commands (INIT: SEQ...) are not available.

                           *RST: 0

Example: SYST:SEQ ON
                           Activates the Sequencer.
                           INIT:SEQ:MODE SING
                           Sets single Sequencer mode so each active measurement will be performed once.
                           INIT:SEQ:IMM
                           Starts the sequential measurements.
                           SYST:SEQ OFF

7.5 Retrieving Results

The following commands can be used to retrieve the results of the I/Q Analyzer measurement.

> **Storing large amounts of I/Q data**
>
> When storing large amounts of I/Q data to a file, consider the following tips to improve performance:
>
> - If capturing and storing the I/Q data is the main goal of the measurement and evaluation functions are not required, use the basic I/Q data acquisition mode (see `TRACe:IQ[:STATe]` on page 68).
> - Use a HiSlip or raw socket connection to export the data from the R&S ESW to a PC.
> - Export the data in binary format rather than ASCII format (see Chapter A.1, "Formats for Returned Values: ASCII Format and Binary Format", on page 127).
> - Use the "Compatible" or "IQPair" data mode (see Chapter A.2, "Reference: Format Description for I/Q Data Files", on page 127).
> - If only an extract of the available data is relevant, use the `TRACe<n>[:DATA]:MEMory?` command to store only the required section of data.

7.5.1 Retrieving Captured I/Q Data

The captured I/Q data is output in the form of a list, three different formats can be selected for this list (see `TRACe:IQ:DATA:FORMat` on page 78).

For details on formats refer to Chapter A.2, "Reference: Format Description for I/Q Data Files", on page 127.

TRACe:IQ:DATA?

This command queries the captured data from measurements with the I/Q Analyzer.

To get the results, the command also initiates a measurement with the current settings of the R&S ESW.

Note: Using the command with the *RST values for the `TRACe:IQ:SET` command, the following minimum buffer sizes for the response data are recommended: ASCII format 10 kBytes, binary format: 2 kBytes

Return values:

<Results>   Measured voltage for I and Q component for each sample that
                   has been captured during the measurement.
                   The number of samples depends on `TRACe:IQ:SET`. In ASCII
                   format, the number of results is 2* the number of samples.
                   The data format depends on `TRACe:IQ:DATA:FORMat`
                   on page 78.
                   Default unit: V

Example: `TRAC:IQ:STAT ON`
                   Enables acquisition of I/Q data
                   `TRAC:IQ:SET NORM,10MHz,32MHz,EXT,POS,0,4096`
                   Measurement configuration:
                   Sample Rate = 32 MHz
                   Trigger Source = External
                   Trigger Slope = Positive
                   Pretrigger Samples = 0
                   Number of Samples = 4096
                   `FORMat REAL,32`
                   Selects format of response data
                   `TRAC:IQ:DATA?`
                   Starts measurement and reads results

Usage: Query only

TRACe:IQ:DATA:FORMat <Format>

This command selects the order of the I/Q data.

For details see Chapter A.2, "Reference: Format Description for I/Q Data Files",
on page 127.

Parameters:

<Format>   COMPatible | IQBLock | IQPair

                   COMPatible
                   I and Q values are separated and collected in blocks: A block
                   (512k) of I values is followed by a block (512k) of Q values, fol-
                   lowed by a block of I values, followed by a block of Q values etc.
                   (I,I,I,I,Q,Q,Q,Q,I,I,I,I,Q,Q,Q,Q...)
                   IQBLock
                   First all I-values are listed, then the Q-values
                   (I,I,I,I,I,I,...Q,Q,Q,Q,Q,Q)
                   IQPair
                   One pair of I/Q values after the other is listed
                   (I,Q,I,Q,I,Q...).
                   *RST: IQBL

TRACe:IQ:DATA:MEMory? [<OffsetSamples>,<NoOfSamples>]

This command queries the I/Q data currently stored in the memory of the R&S ESW.

By default, the command returns all I/Q data in the memory. You can, however, narrow down the amount of data that the command returns using the optional parameters.

By default, the amount of available data depends on `TRACe:IQ:SET`.

Parameters:

<OffsetSamples> Selects an offset at which the output of data should start in relation to the first data. If omitted, all captured samples are output, starting with the first sample.

Range: 0 to <# of samples> – 1, with <# of samples> being the maximum number of captured values

*RST: 0

<NoOfSamples> Number of samples you want to query, beginning at the offset you have defined. If omitted, all captured samples (starting at offset) are output.

Range: 1 to <# of samples> - <offset samples> with <# of samples> maximum number of captured values

*RST: <# of samples>

Return values:

<IQData> Measured value pair (I,Q) for each sample that has been recorded.
The data format depends on `FORMat[:DATA]`.

Default unit: V

Example: `TRAC:IQ:STAT ON`
Enables acquisition of I/Q data
`TRAC:IQ:SET NORM,10MHz,32MHz,EXT,POS,100,4096`
Measurement configuration:
Sample Rate = 32 MHz
Trigger Source = External
Trigger Slope = Positive
Pretrigger Samples = 100
Number of Samples = 4096
`INIT;*WAI`
Starts measurement and wait for sync
`FORMat REAL,32`
Determines output format
To read the results:
`TRAC:IQ:DATA:MEM?`
Reads all 4096 I/Q data
`TRAC:IQ:DATA:MEM? 0,2048`
Reads 2048 I/Q data starting at the beginning of data acquisition
`TRAC:IQ:DATA:MEM? 2048,1024`
Reads 1024 I/Q data from half of the recorded data
`TRAC:IQ:DATA:MEM? 100,512`
Reads 512 I/Q data starting at the trigger point (<Pretrigger Samples> was 100)

Usage: Query only

7.5.2 Retrieving I/Q Trace Data

FORMat[:DATA] <Format>

This command selects the data format that is used for transmission of trace data from the R&S ESW to the controlling computer.

Note that the command has no effect for data that you send to the R&S ESW. The R&S ESW automatically recognizes the data it receives, regardless of the format.

Parameters:

<Format>   **ASCii**
                    ASCii format, separated by commas.
                    This format is almost always suitable, regardless of the actual data format. However, the data is not as compact as other formats may be.

                    REAL,32
                    32-bit IEEE 754 floating-point numbers in the "definite length block format".
                    The format setting REAL is used for the binary transmission of trace data.
                    For I/Q data, 8 bytes per sample are returned for this format setting.
                    *RST: ASCII

Example: FORM REAL,32

Usage: SCPI confirmed

FORMat:DEXPort:DSEParator <Separator>

This command selects the decimal separator for data exported in ASCII format.

Parameters:

<Separator>   **COMMa**
                    Uses a comma as decimal separator, e.g. *4,05*.

                    POINt
                    Uses a point as decimal separator, e.g. *4.05*.

                    *RST: *RST has no effect on the decimal separator.
                                 Default is POINt.

Example: FORM:DEXP:DSEP POIN
                       Sets the decimal point as separator.

TRACe<n>[:DATA]

This command queries current trace data and measurement results.

The data format depends on FORMat[:DATA].

Suffix:

<n>   Window

Query parameters:

<ResultType>   Selects the type of result to be returned.

                       TRACE1 | ... | TRACE6
                       Returns the trace data for the corresponding trace.

Return values:

<TraceData>   Returns the sweep point values as shown in the result display.
                       If you are measuring with the auto peak detector, the command
                       returns positive peak values only. (To retrieve negative peak val-
                       ues, define a second trace with a negative peak detector.)
                       For the Magnitude and Spectrum result displays in the I/Q Ana-
                       lyzer application, this command returns the magnitude of the I
                       and Q values (I+jQ) for each sweep point (=1001 values).
                       For the Real/Imag (I/Q) result display, the command returns first
                       the real parts for each trace point, then the imaginary parts
                       (I_1,...,I_{1001}, Q_1,...,Q_{1001}).
                       For the I/Q Vector result display, the I and Q values for each
                       trace point are returned (1001 pairs of I and Q values).

Example: TRAC? TRACE3
                       Queries the data of trace 3.

Usage: SCPI confirmed

Manual operation: See "Magnitude" on page 9
                       See "Spectrum" on page 9
                       See "I/Q-Vector" on page 10
                       See "Real/Imag (I/Q)" on page 11

TRACe<n>[:DATA]:MEMory? <Trace>,<OffsSwPoint>,<NoOfSwPoints>

This command queries the previously captured trace data for the specified trace from
the memory. As an offset and number of sweep points to be retrieved can be specified,
the trace data can be retrieved in smaller portions, making the command faster than
the TRAC:DATA? command. This is useful if only specific parts of the trace data are of
interest.

If no parameters are specified with the command, the entire trace data is retrieved; in
this case, the command is identical to TRAC:DATA? TRACE1

Suffix:

<n>   Window

Query parameters:

<Trace>   TRACE1 | TRACE2 | TRACE3 | TRACE4 | TRACE5 | TRACE6

<OffsSwPoint>	The offset in sweep points related to the start of the measurement at which data retrieval is to start.
<NoOfSwPoints>	Number of sweep points to be retrieved from the trace.
Example:	`TRAC:DATA:MEM? TRACE1,25,100` Retrieves 100 sweep points from trace 1, starting at sweep point 25.
Usage:	Query only

TRACe<n>[:DATA]:X? <TraceNumber>

This command queries the horizontal trace data for each sweep point in the specified window, for example the frequency in frequency domain or the time in time domain measurements.

Suffix:

<n>	Window

Query parameters:

<TraceNumber>	Trace number.
	**TRACE1	...	TRACE6**

Example:	`TRAC3:X? TRACE1` Returns the x-values for trace 1 in window 3.
Usage:	Query only

7.5.3 Retrieving Marker and Peak Search Results

CALCulate<n>:MARKer<m>:FUNCtion:FPEaks:SORT <SortMode>

This command selects the order in which the results of a peak search are returned.

Suffix:

<n>	Window
<m>	Marker

Parameters:

<SortMode>	**X**
	Sorts the peaks according to increasing position on the x-axis.
	Y
	Sorts the peaks according to decreasing position on the y-axis.
	*RST: X

Example:	CALC:MARK:FUNC:FPE:SORT Y
	Sets the sort mode to decreasing y values

CALCulate<n>:MARKer<m>:FUNCtion:FPEeaks:X?

This command queries the position of the peaks on the x-axis.

The order depends on the sort order that has been set with CALCulate<n>: MARKer<m>:FUNCtion:FPEaks:SORT.

Suffix:

<n>, <m>	irrelevant

Return values:

<PeakPosition>	Position of the peaks on the x-axis. The unit depends on the measurement.

Usage:	Query only

CALCulate<n>:MARKer<m>:FUNCtion:FPEeaks:Y?

This command queries the position of the peaks on the y-axis.

The order depends on the sort order that has been set with CALCulate<n>: MARKer<m>:FUNCtion:FPEaks:SORT.

Suffix:

<n>, <m>	irrelevant

Return values:

<PeakPosition>	Position of the peaks on the y-axis. The unit depends on the measurement.

Usage:	Query only

CALCulate<n>:DELTamarker<m>:X <Position>

This command moves a delta marker to a particular coordinate on the x-axis.

If necessary, the command activates the delta marker and positions a reference marker to the peak power.

Suffix:

<m>	Marker
<n>	Window

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?

This command queries the relative position of a delta marker on the y-axis.

If necessary, the command activates the delta 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 sweep mode.

The unit depends on the application of the command.

Suffix:

<m>	Marker
<n>	Window

Return values:

<Position>	Position of the delta marker in relation to the reference marker or the fixed reference.

Example: INIT:CONT OFF

Switches to single sweep mode.

INIT;*WAI

Starts a sweep and waits for its end.

CALC:DELT2 ON

Switches on delta marker 2.

CALC:DELT2:Y?

Outputs measurement value of delta marker 2.

Usage: Query only

CALCulate<n>:MARKer<m>:X <Position>

This command moves a marker to a particular coordinate on the x-axis.

If necessary, the command activates the marker.

If the marker has been used as a delta marker, the command turns it into a normal marker.

Suffix:

<m>	Marker (query: 1 to 16)
<n>	Window

Parameters:

<Position>   Numeric value that defines the marker position on the x-axis.
                    The unit depends on the result display.

                    Range: The range depends on the current x-axis range.

Example: `CALC:MARK2:X 1.7MHz`
                    Positions marker 2 to frequency 1.7 MHz.

Manual operation: See "Marker Table" on page 11
                    See "Marker Peak List" on page 12

CALCulate<n>:MARKer<m>:Y?

This command queries the position of a marker on the y-axis.

If necessary, the command activates the marker first.

To get a valid result, you have to perform a complete measurement with synchroniza-
tion to the end of the measurement before reading out the result. This is only possible
for single sweep mode.

Suffix:

<n>   Window

<m>   Marker

Return values:

<Result>   Result at the marker position.
                    The unit is variable and depends on the one you have currently
                    set.
                    In the Real/Imag (I/Q) result display of the I/Q Analyzer, the
                    command returns the real part first, then the imaginary part.

Example: `INIT:CONT OFF`
                    Switches to single measurement mode.
                    `CALC:MARK2 ON`
                    Switches marker 2.
                    `INIT;*WAI`
                    Starts a measurement and waits for the end.
                    `CALC:MARK2:Y?`
                    Outputs the measured value of marker 2.
                    In I/Q Analyzer application, for "Real/Imag (I/Q)", for example:
                    `1.852719887E-011,0`

Usage: Query only

Manual operation: See "Marker Table" on page 11
                    See "Marker Peak List" on page 12

MMEMory:STORe<n>:LIST <FileName>

This command exports the SEM and spurious emission list evaluation to a file.

The file format is *.dat.

Secure User Mode

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

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

For details, see "Protecting Data Using the Secure User Mode" in the "Data Management" section of the R&S ESW User Manual.

Suffix:

<n>   Window

Parameters:

<FileName>   String containing the path and name of the target file.

Example: MMEM:STOR:LIST 'test'

Stores the current list evaluation results in the test.dat file.

7.6   Configuring I/Q Analyzer Measurements

7.6.1   Configuring Inputs

7.6.1.1   Configuring the RF Input

INPut:ATTenuation:PROTection:RESet

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

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

For more information see Chapter 3.1, "Increasing Measurement Sensitivity (or Avoiding an Input Mixer Overload)", on page 13.

Usage:	Event

INPut:COUPling <CouplingType>

This command selects the coupling type of the RF input.

Parameters:

<CouplingType>	**AC**
	AC coupling
	DC
	DC coupling
	*RST: AC
Example:	INP:COUP DC
Usage:	SCPI confirmed
Manual operation:	See "Input Coupling" on page 30

INPut:IMPedance <Impedance>

This command selects the nominal input impedance of the RF input. In some applications, only 50 Ω are supported.

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

Parameters:

<Impedance>	50 | 75
	*RST: 50 Ω
Example:	INP:IMP 75
Usage:	SCPI confirmed
Manual operation:	See "Impedance" on page 31
	See "Unit" on page 35

INPut<n>:TYPE <Input>

The command selects the signal source.

Suffix:

<n>   irrelevant

Parameters:

<Input>   **INPUT1**
                           Selects RF input 1.

                           INPUT2
                           Selects RF input 2.

                           *RST: INPUT1

Example: INP:TYPE INPUT1
                           Selects RF input 1.

Manual operation: See "Input Selection" on page 30

7.6.2 Configuring External Generators

Refer to the R&S ESW User Manual for a comprehensive description of the remote commands required to configure external generators.

7.6.3 Configuring Level Characteristics

Commands useful to configure level characteristics described elsewhere:

- [SENSe:]ADJust:LEVel on page 114

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

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

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

Suffix:

<n>   Window

<m>   Marker

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

Usage: Event

CALCulate<n>:UNIT:POWer <Unit>

This command selects the unit of the y-axis.

The unit applies to all power-based measurement windows with absolute values.

Suffix:

<n>   irrelevant

Parameters:

<Unit>   DBM | V | A | W | DBPW | WATT | DBUV | DBMV | VOLT |
                         DBUA | AMPere
                         *RST: dBm

Example: CALC:UNIT:POW DBM
                         Sets the power unit to dBm.

Manual operation: See "Unit" on page 35

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

This command 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>, <t>   irrelevant

Parameters:

<ReferenceLevel>   The unit is variable.

                         Range: see datasheet
                         *RST: 0 dBm

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

Usage: SCPI confirmed

Manual operation: See "Reference Level" on page 34

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

This command defines a reference level offset (for all traces in all windows).

Suffix:

<n>, <t>   irrelevant

Parameters:

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

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

Manual operation: See "Shifting the Display (Offset)" on page 35

7.6.4 Configuring the Attenuator

INPut<n>:ATTenuation:AUTO <State>

This command turns automatic determination of the attenuation level on and off.

When you turn it on, the R&S ESW selects an attenuation that results in a good signal-to-noise ratio without overloading the RF input.

Suffix:
<n>   irrelevant

Parameters:
<State>   ON | OFF

                       ON
                       Selects automatic attenuation mode.
                       ON
                       Selects manual attenuation mode.
                       *RST: ON

Example: INP:ATT:AUTO ON
                       Turns the auto ranging function on.

Manual operation: See "Attenuation" on page 35

INPut<n>:ATTenuation:PROTection[:STATe] <State>

This command turns the availability of attenuation levels of 10 dB or less on and off.

Suffix:
<n>   irrelevant

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

Example: INP:ATT:PROT ON

Manual operation: See "10 dB Minimum Attenuation" on page 36

INPut<n>:ATTenuation <Attenuation>

This command defines the attenuation at the RF input.

To protect the input mixer, attenuation levels of 10 dB or less are possible only if you have turned the input protection off with INPut<n>:ATTenuation:PROTection[: STATe] on page 90.

Suffix:

<n>	irrelevant

Parameters:

<Attenuation>	numeric value
	Range: 0 dB to 79 dB
	*RST: 10 dB
	Default unit: dB

Example: INP:ATT 40dB

Defines an attenuation level of 40 dB.

Manual operation: See "Attenuation" on page 35

7.6.5 Configuring the Preamplifier

INPut<n>:GAIN:LNA:STATe <State>

This command turns the optional low noise amplifier on and off.

Note that it is not possible to use the low noise amplifier and the preamplifier at the same time.

Suffix:

<n>	irrelevant

Parameters:

<State>	ON	OFF
	*RST: OFF

Example: INP:GAIN:LNA:STAT ON

Turns on the low noise amplifier.

Usage: SCPI confirmed

Manual operation: See "Preamplifier" on page 36

INPut<n>:GAIN:STATe <State>

This command turns the preamplifier on and off.

Suffix:

<n>	irrelevant

Parameters:

<State>	ON	OFF
	*RST: OFF

Example: INP:GAIN:STAT ON

Turns on the preamplifier.

Manual operation: See "Preamplifier" on page 36

7.6.6 Scaling the Y-Axis

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

This command defines the display range of the y-axis (for all traces).

Suffix:

<n>   Window

<t>   irrelevant

Parameters:

<Range>   Range: 1 dB to 200 dB
                       *RST: 100 dB

Example: DISP:TRAC:Y 110dB

Usage: SCPI confirmed

Manual operation: See "Range" on page 37
                      See "Y-Axis Max" on page 38

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

Automatic scaling of the y-axis is performed once, then switched off again (for all traces).

Suffix:

<n>   Window

<t>   irrelevant

Usage: SCPI confirmed

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

This command selects the type of scaling of the y-axis (for all traces).

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

Suffix:

<n>   Window

<t>   irrelevant

Parameters:

<Mode>	**ABSolute**
	absolute scaling of the y-axis
	RELative
	relative scaling of the y-axis
	*RST: ABSolute

Example:	DISP:TRAC:Y:MODE REL
Manual operation:	See "Scaling" on page 37

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

This command defines the vertical position of the reference level on the display grid (for all traces).

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

For measurements with the optional external generator control, the command defines the position of the reference value.

Suffix:

<n>	Window
<t>	irrelevant

Parameters:

<Position>	0 PCT corresponds to the lower display border, 100% corresponds to the upper display border.
	*RST: 100 PCT = frequency display; 50 PCT = time display

Example:	DISP:TRAC:Y:RPOS 50PCT
Usage:	SCPI confirmed
Manual operation:	See "Ref Level Position" on page 37

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

This command selects the scaling of the y-axis (for all traces, <t> is irrelevant).

Suffix:

<n>	Window
<t>	Trace

Parameters:

<ScalingType>   **LOGarithmic**
                        Logarithmic scaling.

                        LINear
                        Linear scaling in %.

                        LDB
                        Linear scaling in the specified unit.

                        PERCent
                        Linear scaling in %.

                        *RST: LOGarithmic

Example: DISP:TRAC:Y:SPAC LIN
                        Selects linear scaling in %.

Usage: SCPI confirmed

Manual operation: See "Scaling" on page 37

7.6.7 Configuring the Frequency

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

This command matches the center frequency to the frequency of a marker.

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

Suffix:

<n>   Window

<m>   Marker

Example: CALC:MARK2:FUNC:CENT
                        Sets the center frequency to the frequency of marker 2.

Usage: Event

[SENSe:]FREQuency:CENTer <Frequency>

This command defines the center frequency.

Parameters:

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

UP

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

DOWN

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

*RST: fmax/2
Default unit: Hz

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

Usage: SCPI confirmed

Manual operation: See "Center frequency" on page 39

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

This command defines the center frequency step size.

You can increase or decrease the center frequency quickly in fixed steps using the SENS:FREQ UP AND SENS:FREQ DOWN commands, see [SENSe:]FREQuency:CENTer on page 94.

Parameters:

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

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

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

Manual operation: See "Center Frequency Stepsize" on page 39

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

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

In time domain (zero span) measurements, the center frequency is coupled to the RBW.

Parameters:

<State>   ON | OFF | 0 | 1

*RST: 1

Example: `FREQ:CENT:STEP:AUTO ON`

Activates the coupling of the step size to the span.

[SENSe:]FREQuency:OFFSet <Offset>

This command defines a frequency offset.

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

See also "Frequency Offset" on page 39.

Parameters:

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

Example: `FREQ:OFFS 1GHZ`

Usage: SCPI confirmed

Manual operation: See "Frequency Offset" on page 39

7.6.8 Configuring Trigger

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

TRIGger[:SEQuence]:DTIMe <DropoutTime>

Defines the time the input signal must stay below the trigger level before a trigger is detected again.

Parameters:

<DropoutTime>	Dropout time of the trigger.	
	Range:	0 s to 10.0 s
	*RST:	0 s

Manual operation: See "Drop-Out Time" on page 43

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

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

A negative offset is possible for time domain measurements.

For the trigger sources "External" or "IF Power", a common input signal is used for both trigger and gate. Therefore, changes to the gate delay will affect the trigger offset as well.

Suffix:

<n>   irrelevant

Parameters:

<Offset>   For measurements in the frequency domain, the range is 0 s to 30 s.
                         For measurements in the time domain, the range is the negative sweep time to 30 s.

                         *RST: 0 s

Example: TRIG:HOLD 500us
                         Defines a trigger offset of 500 µs.

Manual operation: See "Trigger Offset" on page 43

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

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

Note that this command can be used for **any trigger source**, not just IF Power (despite the legacy keyword).

Note: If you perform gated measurements in combination with the IF Power trigger, the R&S ESW ignores the holding time for frequency sweep, FFT sweep, zero span and I/Q data measurements.

Parameters:

<Period>   Range: 0 s to 10 s
                         *RST: 0 s

Example: TRIG:SOUR EXT
                         Sets an external trigger source.
                         TRIG:IFP:HOLD 200 ns
                         Sets the holding time to 200 ns.

Manual operation: See "Trigger Holdoff" on page 43

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

This command defines the trigger hysteresis, which is only available for "IF Power" trigger sources.

Parameters:

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

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

Manual operation: See "Hysteresis" on page 43

TRIGger<n>[:SEQuence]:LEVel[:EXTernal<port>] <Level>

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

Note that the variable INPUT/OUTPUT connectors must be set for use as input using the `OUTPut:TRIGger<port>:DIRection` command.

In the I/Q Analyzer application only `EXTernal1` is supported.

Suffix:

<n>	irrelevant
<port>	Selects the trigger port.
1 = trigger port 1 (TRIGGER INPUT connector on front panel)
2 = trigger port 2 (TRIGGER INPUT/OUTPUT connector on front panel)

Parameters:

<Level>	Numeric value in V.

Example: `TRIG:SOUR EXT`
`TRIG:LEV 2V`
Defines a trigger level of 2 V for an external trigger source.

Manual operation: See "Trigger Level" on page 42

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

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

Parameters:

<TriggerLevel>	For details on available trigger levels and trigger bandwidths see the data sheet.
	*RST: -10 dBm

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

Manual operation: See "Trigger Level" on page 42

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

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

Parameters:

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

Example:	TRIG:LEV:IQP -30DBM
Manual operation:	See "Trigger Level" on page 42

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

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

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

Parameters:

<TriggerLevel>	For details on available trigger levels and trigger bandwidths see the data sheet.
	*RST: -20 dBm

Example:	TRIG:LEV:RFP -30dBm
Manual operation:	See "Trigger Level" on page 42

TRIGger<n>[:SEQuence]:SLOPe <Type>

This command selects the trigger slope.

Suffix:

<n>	irrelevant

Parameters:

<Type>	**POSitive**
	Triggers when the signal rises to the trigger level (rising edge).
	NEGative
	Triggers when the signal drops to the trigger level (falling edge).
	*RST: POSitive

Example:	TRIG:SLOP NEG
Manual operation:	See "Slope" on page 43

TRIGger<n>[:SEQuence]:SOURce <Source>

This command selects the trigger source.

Note on external triggers:

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

Suffix:

<n>   irrelevant

Parameters:

<Source>   See table below.

                                *RST: IMMediate

Example: TRIG:SOUR EXT

Selects the external trigger input as source of the trigger signal

Manual operation: See "Trigger Source" on page 41
See "Free Run" on page 41
See "Ext. Trigger 1/2" on page 41
See "IF Power" on page 41
See "I/Q Power" on page 42
See "RF Power" on page 42
See "Time" on page 42

Table 7-3: Available trigger sources

SCPI parameter	Trigger source
EXTernal	Trigger signal from the TRIGGER INPUT connector.
EXT2 | EXT3	Trigger signal from the TRIGGER INPUT/OUTPUT connector. Note: Connector must be configured for "Input".
IFPower	Second intermediate frequency.
IMMediate	Free Run trigger.
IQPower	Magnitude of sampled I/Q data. For applications that process I/Q data, such as the I/Q Analyzer or optional applications.
RFPower	First intermediate frequency.
TIME	Time interval
VIDeo	Trigger source is the video signal.

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

This command defines the repetition interval for the time trigger.

Parameters:

<Interval>   2.0 ms to 5000

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

Example: TRIG:SOUR TIME

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

Manual operation: See "Repetition Interval" on page 42

7.6.9 Configuring Trigger Output

OUTPut:TRIGger<port>:DIRection <Direction>

This command selects the trigger direction for trigger ports that serve as an input as well as an output.

Suffix:

<port>   Selects the used trigger port.
                          2 = trigger port 2 (front panel)
                          3 = trigger port 3 (rear panel)

Parameters:

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

                          OUTPut
                          Port works as an output.

                          *RST: INPut

Manual operation: See "Trigger 2/3" on page 32

OUTPut:TRIGger<port>:LEVel <Level>

This command defines the level of the (TTL compatible) signal generated at the trigger output.

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

Suffix:

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

Parameters:

<Level>   **HIGH**
                          5 V

                          LOW
                          0 V

                          *RST: LOW

Example: OUTP:TRIG2:LEV HIGH

Manual operation: See "Level" on page 33

OUTPut:TRIGger\<port\>:OTYPe \<OutputType\>

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

Suffix:

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

Parameters:

\<OutputType\>   **DEVice**
                            Sends a trigger signal when the R&S ESW has triggered inter-nally.

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

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

                            *RST: DEVice

Manual operation: See "Output Type" on page 32

OUTPut:TRIGger\<port\>:PULSe:IMMediate

This command generates a pulse at the trigger output.

Suffix:

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

Usage: Event

Manual operation: See "Send Trigger" on page 33

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

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

Suffix:

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

Parameters:

\<Length\>   Pulse length in seconds.

Example: `OUTP:TRIG2:PULS:LENG 0.02`

Manual operation: See "Pulse Length" on page 33

7.6.10   Configuring Gated Measurements

Usually in spectrum analysis, measurements are based on a certain length of time called the gate area. With I/Q gating, you can define the gate area using the gate length, the distance between the capture periods and the number of periods. The gate length and the distance between the capture periods are specified in samples.

I/Q gating is only available using remote commands; manual configuration is not possible.

Using I/Q gating, the gate area can be defined using the following methods:

- Edge triggered capturing
  After a trigger signal, the gate period is defined by a gate length and a gate distance. All data in the gate period is captured until the required number of samples has been captured.
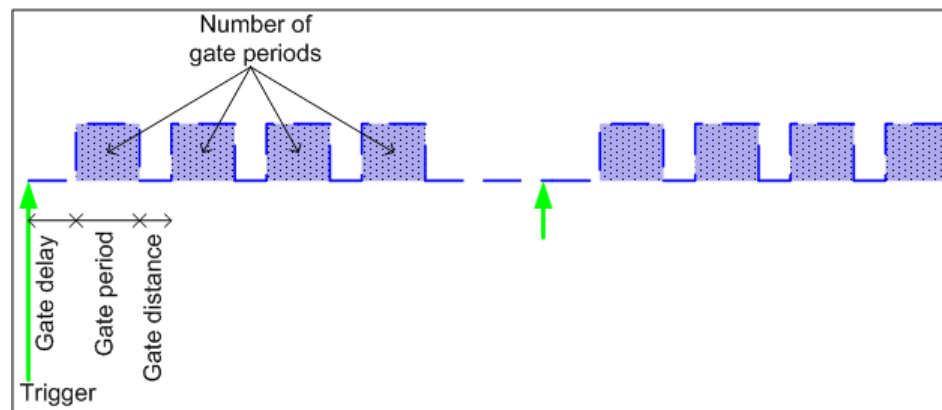
- Level triggered capturing
  After a trigger signal, all data is captured in which the gate signal is set to 1, which means it has exceeded a level. In this case, the gate signal can be generated by the IFP trigger, for example: each time the IFP level is exceeded, the IFP trigger signal is set to 1 and the samples in this area are captured as gate samples.
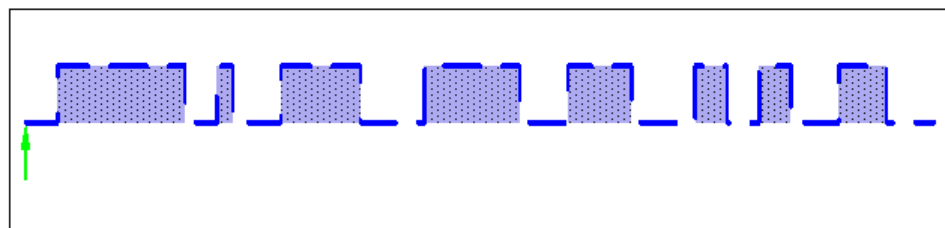
The number of complex samples to be captured prior to the trigger event can be selected (see `TRACe:IQ:SET` on page 109) for all available trigger sources, except for "Free Run".

TRACe:IQ:EGATe <State>

This command turns gated measurements with the I/Q analyzer on and off.

Before you can use the command you have to turn on the I/Q analyzer and select an external or IF power trigger source.

Parameters:

<State>   ON | OFF

                       *RST: OFF

Example: TRAC:IQ:EGAT ON

TRACe:IQ:EGATe:GAP <Samples>

This command defines the interval between several gate periods for gated measurements with the I/Q analyzer.

Parameters:

<Samples>   <numeric value>

                       Max = (440 MS * sample rate/200MHz) -1
                       pretrigger samples defined by TRACe:IQ:SET;
                       sample rate defined by TRACe:IQ:SRATe)

                       Range: 1…Max (samples)
                       *RST: 1

Example: TRAC:IQ:EGAT:GAP 2

TRACe:IQ:EGATe:LENGth <GateLength>

This command defines the gate length for gated measurements with the I/Q analyzer.

Parameters:

<GateLength>   <numeric value>

                       Max = (440 MS * sample rate/200MHz) -1
                       pretrigger samples defined by TRACe:IQ:SET;
                       sample rate defined by TRACe:IQ:SRATe)

                       Range: 1…Max (samples)
                       *RST: 100

Example: TRAC:IQ:EGAT:LENG 2000

TRACe:IQ:EGATe:NOFgateperiods <Number>

This command defines the number of gate periods after the trigger signal for gated measurements with the I/Q analyzer.

Parameters:

<Number>   Range: 1 to 1023
                       *RST: 1

Example: TRAC:IQ:EGAT:NOF 2

TRACe:IQ:EGATe:TYPE <Type>

This command selects the gate mode for gated measurements with the I/Q analyzer.

Note: The IF power trigger holdoff time is ignored if you are using the "Level" gate mode in combination with an IF Power trigger.

Parameters:

<Type>	**LEVel**
	EDGE
	*RST: EDGE

Example: `TRAC:IQ:EGAT:TYPE LEV`

7.6.11 Configuring Data Acquisition

Useful commands for I/Q data acquisition described elsewhere

- `[SENSe:]SWEep:COUNt` on page 74
- `[SENSe:]SWEep:POINts` on page 75
- `[SENSe:]SWEep:TIME` on page 75

[SENSe:]IQ:BANDwidth|BWIDth:MODE <Mode>

This command defines how the resolution bandwidth is determined.

Parameters:

<Mode>   AUTO | MANual | FFT

AUTO
(Default) The RBW is determined automatically depending on
the sample rate and record length.

MANual
The user-defined RBW is used and the (FFT) window length
(and possibly the sample rate) are adapted accordingly. The
RBW is defined using the `[SENSe:]IQ:BANDwidth|BWIDth:`
`RESolution` command.

FFT
The RBW is determined by the FFT parameters.

*RST: AUTO

Example: `IQ:BAND:MODE MAN`
Switches to manual RBW mode.
`IQ:BAND:RES 120000`
Sets the RBW to 120 kHz.

Usage: SCPI confirmed

Manual operation: See "RBW" on page 45

[SENSe:]IQ:BANDwidth|BWIDth:RESolution <Bandwidth>

This command defines the resolution bandwidth manually if `[SENSe:]IQ:`
`BANDwidth|BWIDth:MODE` is set to `MAN`.

Defines the resolution bandwidth. The available RBW values depend on the sample
rate and record length.

For details see Chapter 3.4.4, "Frequency Resolution of FFT Results - RBW",
on page 23.

Parameters:

<Bandwidth>   refer to data sheet

*RST: RBW: AUTO mode is used

Example: `IQ:BAND:MODE MAN`
Switches to manual RBW mode.
`IQ:BAND:RES 120000`
Sets the RBW to 120 kHz.

Usage: SCPI confirmed

Manual operation: See "RBW" on page 45

[SENSe:]IQ:FFT:ALGorithm <Method>

Defines the FFT calculation method.

Parameters:

<Method>   **SINGle**
One FFT is calculated for the entire record length; if the FFT length is larger than the record length (see `[SENSe:]IQ:FFT:LENGth` and `TRACe:IQ:RLENgth`), zeros are appended to the captured data.

AVERage
Several overlapping FFTs are calculated for each record; the results are averaged to determine the final FFT result for the record.
The user-defined window length and window overlap are used (see `[SENSe:]IQ:FFT:WINDow:LENGth` and `[SENSe:]IQ:FFT:WINDow:OVERlap`).

*RST: AVER

Example: `IQ:FFT:ALG SING`

Usage: SCPI confirmed

Manual operation: See "Transformation Algorithm" on page 46

[SENSe:]IQ:FFT:LENGth <NoOfBins>

Defines the number of frequency points determined by each FFT calculation. The more points are used, the higher the resolution in the spectrum becomes, but the longer the calculation takes.

Parameters:

<NoOfBins>   integer value

Range: 3 to 524288
*RST: 4096

Example: `IQ:FFT:LENG 2048`

Usage: SCPI confirmed

Manual operation: See "FFT Length" on page 46

[SENSe:]IQ:FFT:WINDow:LENGth <NoOfFFT>

Defines the number of samples to be included in a single FFT window when multiple FFT windows are used.

Parameters:

<NoOfFFT>   integer value

Range: 3 to 1001
*RST: 1001

Example: `IQ:FFT:WIND:LENG 500`

Usage: SCPI confirmed

Manual operation: See "Window Length" on page 47

[SENSe:]IQ:FFT:WINDow:OVERlap <Rate>

Defines the part of a single FFT window that is re-calculated by the next FFT calculation.

Parameters:

<Rate>	double value
	Percentage rate
	Range: 0 to 1
	*RST: 0.75
Example:	IQ:FFT:WIND:OVER 0.5
	Half of each window overlaps the previous window in FFT calculation.
Usage:	SCPI confirmed
Manual operation:	See "Window Overlap" on page 47

[SENSe:]IQ:FFT:WINDow:TYPE <Function>

In the I/Q Analyzer you can select one of several FFT window types.

Parameters:

<Function>	**BLACkharris**
	Blackman-Harris
	FLATtop
	Flattop
	GAUSsian
	Gauss
	RECTangular
	Rectangular
	P5
	5-Term
	*RST: FLAT
Example:	IQ:FFT:WIND:TYPE GAUS
Usage:	SCPI confirmed
Manual operation:	See "Window Function" on page 47

[SENSe:]SWAPiq <State>

This command defines whether or not the recorded I/Q pairs should be swapped (I<->Q) before being processed. Swapping I and Q inverts the sideband.

This is useful if the DUT interchanged the I and Q parts of the signal; then the R&S ESW can do the same to compensate for it.

Parameters:

<State> **ON**

I and Q signals are interchanged

Inverted sideband, Q+j*I

OFF

I and Q signals are not interchanged

Normal sideband, I+j*Q

*RST: OFF

Manual operation: See "Swap I/Q" on page 45

TRACe:IQ:BWIDth

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

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

Parameters:

<Bandwidth> For details on the maximum bandwidth see Chapter 3.2.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 17.

Manual operation: See "Analysis Bandwidth" on page 44

TRACe:IQ:RLENgth <NoOfSamples>

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

Increasing the record length also increases the measurement time.

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

Parameters:

<NoOfSamples> Number of samples to record.

See Chapter 3.2.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 17.

*RST: 1001

Example: `TRAC:IQ:RLEN 256`

Manual operation: See "Record Length" on page 45

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

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

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

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

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

ASCII format: 10 kBytes

4

Binary format: 2 kBytes

Parameters:

NORM	This value is always `NORM`.
0	This value is always `0`.
\<SampleRate\>	Sample rate for the data acquisition.
	Range: 100 Hz to 10 GHz, continuously adjustable *RST: 32000000
\<TriggerMode\>	Selection of the trigger source used for the measurement.
	IMMediate | EXTernal | EXT2 | EXT3 | IFPower For IMM mode, gating is automatically deactivated.
	*RST: IMM
\<TriggerSlope\>	Used trigger slope.
	POSitive | NEGative
	*RST: POS
\<PretriggerSamp\>	Defines the trigger offset in terms of pretrigger samples. Negative values correspond to a trigger delay. This value also defines the interval between the trigger signal and the gate edge in samples.
	Range: -461373339 to 461373339 *RST: 0
\<NumberSamples\>	Number of measurement values to record (including the pretrigger samples). See Chapter 3.2.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 17.
	*RST: 1001

Example:	`TRAC:IQ:SET NORM,0,32MHz,EXT,POS,0,2048`
	 Reads 2048 I/Q-values starting at the trigger point.
	 sample rate = 32 MHz
	 trigger = External
	 slope = Positive
	 `TRAC:IQ:SET NORM,0,4 MHz,EXT,POS,1024,512`
	 Reads 512 I/Q-values from 1024 measurement points before the trigger point.
	 filter type = NORMAL
	 sample rate = 4 MHz
	 trigger = External
	 slope = Positive

Manual operation:	See "Record Length" on page 45

TRACe:IQ:SRATe <SampleRate>

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

Note: The smaller the user sample rate, the smaller the usable I/Q bandwidth, see Chapter 3.2.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 17.

Parameters:

<SampleRate>   The valid sample rates are described in Chapter 3.2.1, "Sample Rate and Maximum Usable I/Q Bandwidth for RF Input", on page 17.

*RST: 32 MHz

Manual operation: See "Sample Rate" on page 44

TRACe:IQ:TPISample?

This command queries the time offset between the sample start and the trigger event (trigger point in sample = TPIS). Since the R&S ESW usually samples with a much higher sample rate than the specific application actually requires, the trigger point determined internally is much more precise than the one determined from the (down-sampled) data in the application. Thus, the TPIS indicates the offset between the sample start and the actual trigger event.
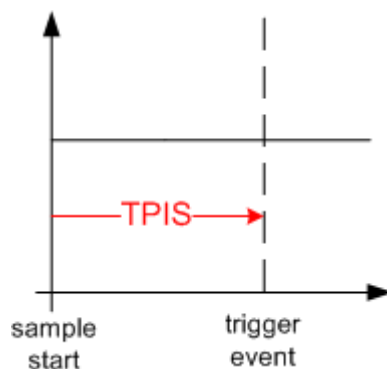
This value can only be determined in triggered measurements using external or IFPower triggers, otherwise the value is 0.

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

Usage: Query only

Manual operation: See "Trigger Offset" on page 43

7.6.12 Automatic Configuration

[SENSe:]ADJust:ALL

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

This includes:

- Reference level

Example:	ADJ:ALL
Usage:	Event
Manual operation:	See "Adjusting all Determinable Settings Automatically (Auto All)" on page 51

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

In order to determine the ideal reference level, the R&S ESW performs a measurement on the current input data. This command defines the length of the measurement if [SENSe:]ADJust:CONFigure:DURation:MODE is set to MANual.

Parameters:

<Duration>	Numeric value in seconds
	Range: 0.001 to 16000.0
	*RST: 0.001
	Default unit: s
Example:	ADJ:CONF:DUR:MODE MAN
	Selects manual definition of the measurement length.
	ADJ:CONF:LEV:DUR 5ms
	Length of the measurement is 5 ms.
Manual operation:	See "Changing the Automatic Measurement Time (Meastime Manual)" on page 51

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

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

Parameters:

<Mode>   **AUTO**

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

MANual

The R&S ESW uses the measurement length defined by
[SENSe:]ADJust:CONFigure:DURation on page 112.

*RST: AUTO

Manual operation: See "Resetting the Automatic Measurement Time (Meastime Auto)" on page 51
See "Changing the Automatic Measurement Time (Meastime Manual)" on page 51

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

When the reference level is adjusted automatically using the [SENSe:]ADJust: LEVel on page 114 command, the internal attenuators and the preamplifier are also adjusted. In order to avoid frequent adaptation due to small changes in the input signal, you can define a hysteresis. This setting defines a lower threshold the signal must fall below (compared to the last measurement) before the reference level is adapted automatically.

Parameters:

<Threshold>   Range: 0 dB to 200 dB
                     *RST: +1 dB
                     Default unit: dB

Example: SENS:ADJ:CONF:HYST:LOW 2
                     For an input signal level of currently 20 dBm, the reference level will only be adjusted when the signal level falls below 18 dBm.

Manual operation: See "Lower Level Hysteresis" on page 52

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

When the reference level is adjusted automatically using the [SENSe:]ADJust: LEVel on page 114 command, the internal attenuators and the preamplifier are also adjusted. In order to avoid frequent adaptation due to small changes in the input signal, you can define a hysteresis. This setting defines an upper threshold the signal must exceed (compared to the last measurement) before the reference level is adapted automatically.

Parameters:

<Threshold>   Range: 0 dB to 200 dB
                     *RST: +1 dB
                     Default unit: dB

Example: SENS:ADJ:CONF:HYST:UPP 2

Example: For an input signal level of currently 20 dBm, the reference level will only be adjusted when the signal level rises above 22 dBm.

Manual operation: See "Upper Level Hysteresis" on page 52

[SENSe:]ADJust:CONFigure:TRIG <State>

Defines the behavior of the measurement when adjusting a setting automatically (using `SENS:ADJ:LEV ON`, for example).

Parameters:

<State>
            ON | 1
            The measurement for automatic adjustment waits for the trigger.
            OFF | 0
            The measurement for automatic adjustment is performed immediately, without waiting for a trigger.
            *RST: 1

[SENSe:]ADJust:FREQuency

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

Example: `ADJ:FREQ`

Usage: Event

Manual operation: See "Adjusting the Center Frequency Automatically (Auto Freq)" on page 51

[SENSe:]ADJust:LEVel

This command initiates a single (internal) measurement that evaluates and sets the ideal reference level for the current input data and measurement settings. This ensures that the settings of the RF attenuation and the reference level are optimally adjusted to the signal level without overloading the R&S ESW or limiting the dynamic range by an S/N ratio that is too small.

Example: `ADJ:LEV`

Usage: Event

Manual operation: See "Setting the Reference Level Automatically (Auto Level)" on page 51

7.6.13 Configuring the Result Display

DISPlay:FORMat <Format>

This command determines which tab is displayed.

Parameters:

<Format>   **SPLit**

Displays the MultiView tab with an overview of all active chan-
nels

SINGle

Displays the measurement channel that was previously focused.

*RST: SING

Example: DISP:FORM SPL

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

This command maximizes the size of the selected result display window *temporarily*.
To change the size of several windows on the screen permanently, use the LAY:SPL
command (see LAYout:SPLitter on page 118).

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

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

This command adds a window to the display in the active measurement channel.

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

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

Parameters:

<WindowName>   String containing the name of the existing window the new win-
                     dow 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 win-
                     dow.

<WindowType>   text value

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

Return values:

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

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

Usage: Query only

Manual operation: See "Magnitude" on page 9
                     See "Spectrum" on page 9
                     See "I/Q-Vector" on page 10
                     See "Real/Imag (I/Q)" on page 11
                     See "Marker Table" on page 11
                     See "Marker Peak List" on page 12

Table 7-4: <WindowType> parameter values for IQ Analyzer application

Parameter value	Window type
FREQ	Spectrum
MAGN	Magnitude
MTABle	Marker table
PEAKlist	Marker peak list
RIMAG	Real/Imag (I/Q)
VECT	I/Q Vector

LAYout:CATalog[:WINDow]?

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

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

Return values:

<WindowName>	string
	Name of the window.
	In the default state, the name of the window is its index.
<WindowIndex>	**numeric value**
	Index of the window.
Example:	LAY:CAT?
	Result:
	'2',2,'1',1
	Two windows are displayed, named '2' (at the top or left), and '1' (at the bottom or right).
Usage:	Query only

LAYout:IDENtify[:WINDow]? <WindowName>

This command queries the **index** of a particular display window in the active measurement channel.

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

Query parameters:

<WindowName>	String containing the name of a window.

Return values:

<WindowIndex>	Index number of the window.
Example:	LAY:WIND:IDEN? '2'
	Queries the index of the result display named '2'.
	Response:
	2
Usage:	Query only

LAYout:REMove[:WINDow] <WindowName>

This command removes a window from the display in the active measurement channel.

Parameters:

<WindowName>	String containing the name of the window.
	In the default state, the name of the window is its index.
Example:	LAY:REM '2'
	Removes the result display in the window named '2'.
Usage:	Event

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

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

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

Parameters:

<WindowName>	String containing the name of the existing window. By default, the name of a window is the same as its index. To determine the name and index of all active windows in the active measurement channel, use the `LAYout:CATalog[:WINDow]?` query.
<WindowType>	Type of result display you want to use in the existing window. See `LAYout:ADD[:WINDow]?` on page 115 for a list of available window types.
Example:	`LAY:REPL:WIND '1',MTAB` Replaces the result display in window 1 with a marker table.

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

This command changes the position of a splitter and thus controls the size of the windows on each side of the splitter.

Compared to the `DISPlay[:WINDow<n>]:SIZE` on page 115 command, the `LAYout:SPLitter` changes the size of all windows to either side of the splitter permanently, it does not just maximize a single window temporarily.

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

y=100   x=100, y=100

x=0, y=0   x=100
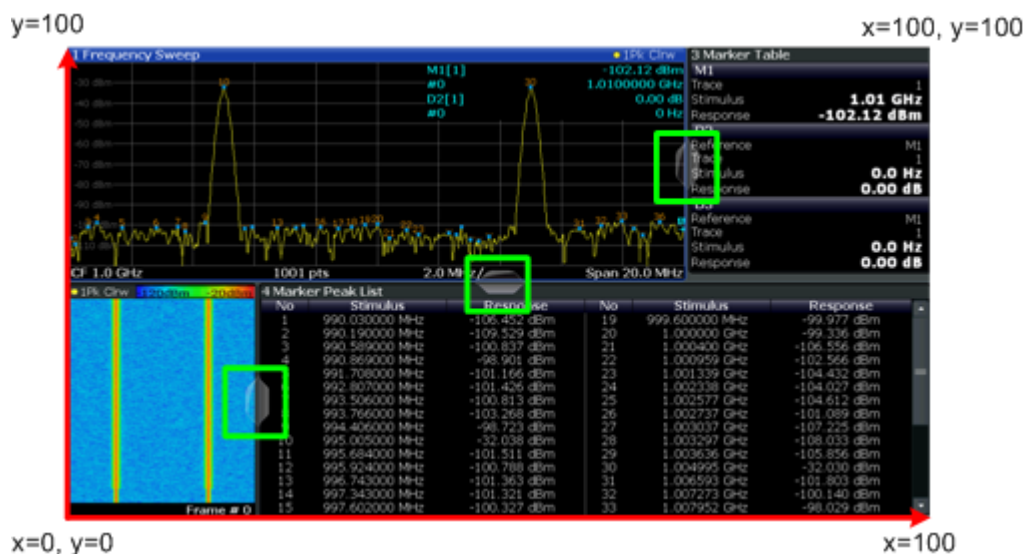
Figure 7-1: SmartGrid coordinates for remote control of the splitters

Parameters:

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

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

<Position>   New vertical or horizontal position of the splitter as a fraction of
                            the screen area (without channel and status bar and softkey
                            menu).
                            The point of origin (x = 0, y = 0) is in the lower left corner of the
                            screen. The end point (x = 100, y = 100) is in the upper right cor-
                            ner of the screen. (See Figure 7-1.)
                            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 fig-
                            ure above, to the left.

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

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

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

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

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

Suffix:

<n>	Window

Parameters:

<Direction>	LEFT | RIGHt | ABOVe | BELow
<WindowType>	Type of measurement window you want to add. See `LAYout:ADD[:WINDow]?` on page 115 for a list of available window types.

Return values:

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

Example:

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

Usage: Query only

LAYout:WINDow<n>:IDENtify?

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

Note: to query the **index** of a particular window, use the `LAYout:IDENtify[:WINDow]?` command.

Suffix:

<n>	Window

Return values:

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

Example:

	`LAY:WIND2:IDEN?`
	Queries the name of the result display in window 2.
	Response:
	`'2'`

Usage: Query only

LAYout:WINDow<n>:REMove

This command removes the window specified by the suffix <n> from the display in the active measurement channel.

The result of this command is identical to the LAYout:REMove[:WINDow] command.

Suffix:

<n>   Window

Example: LAY:WIND2:REM
                         Removes the result display in window 2.

Usage: Event

LAYout:WINDow<n>:REPLace <WindowType>

This command changes the window type of an existing window (specified by the suffix <n>) in the active measurement channel.

The result of this command is identical to the LAYout:REPLace[:WINDow] command.

To add a new window, use the LAYout:WINDow<n>:ADD? command.

Suffix:

<n>   Window

Parameters:

<WindowType>   Type of measurement window you want to replace another one with.
                         See LAYout:ADD[:WINDow]? on page 115 for a list of available window types.

Example: LAY:WIND2:REPL MTAB
                         Replaces the result display in window 2 with a marker table.

7.7 Analyzing Results

For a comprehensive description of the commands required to analyze results (trace and marker functionality), please refer to the R&S ESW User Manual.

CALCulate<n>:MARKer<m>:SEARch <MarkRealImag>

This command selects the trace type a marker search is performed on.

Suffix:

<m>   irrelevant

Parameters:

<MarkRealImag>   **REAL**
Marker search functions are performed on the real trace of the "I/Q" measurement.
IMAG
Marker search functions are performed on the imaginary trace of the "I/Q" measurement.
MAGN
Marker search functions are performed on the magnitude of the I and Q data.
*RST: REAL

Example: CALC4:MARK:SEAR IMAG

Manual operation: See "Branch for Peak Search" on page 54

CALCulate<n>:SPECtrogram:LAYout <State>

This command selects the state and size of spectrograms.

The command is available for result displays that support spectrograms.

Suffix:
<n>   Window

Parameters:
<State>   **FULL**
Only the spectrogram is displayed, the trace diagram is not.
OFF
Only the trace diagram is displayed, the spectrogram is not.
SPLIT
Spectrogram and trace diagram share a window.
*RST: OFF

Example: CALC4:SPEC:LAY FULL
Shows the spectrogram in window 4. The corresponding trace diagram is hidden.

Manual operation: See "State" on page 53

7.8 Importing and Exporting I/Q Data

Alternatively to capturing I/Q data by the I/Q Analyzer itself, stored I/Q data from previous measurements or other applications can be imported to the I/Q Analyzer. Furthermore, I/Q data processed in the I/Q Analyzer can be stored to a file for further evaluation in other applications.

For details on importing and exporting I/Q data see Chapter 3.3, "I/Q Data Import and Export", on page 19.

MMEMory:LOAD:IQ:STATe 1,<FileName>

This command restores I/Q data from a file.

The file extension is *.iq.tar.

Parameters:

<FileName>   String containing the path and name of the source file.

Example: `MMEM:LOAD:IQ:STAT 1, 'C:`
                       `\R_S\Instr\user\data.iq.tar'`
                       Loads IQ data from the specified file.

Usage: Setting only

Manual operation: See "I/Q Import" on page 29

MMEMory:STORe<n>:IQ:COMMent <Comment>

This command adds a comment to a file that contains I/Q data.

Suffix:

<n>   irrelevant

Parameters:

<Comment>   String containing the comment.

Example: `MMEM:STOR:IQ:COMM 'Device test 1b'`
                       Creates a description for the export file.
                       `MMEM:STOR:IQ:STAT 1, 'C:`
                       `\R_S\Instr\user\data.iq.tar'`
                       Stores I/Q data and the comment to the specified file.

Manual operation: See "I/Q Export" on page 29

MMEMory:STORe<n>:IQ:STATe 1, <FileName>

This command writes the captured I/Q data to a file.

The file extension is *.iq.tar. By default, the contents of the file are in 32-bit floating point format.

Secure User Mode

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

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

For details, see "Protecting Data Using the Secure User Mode" in the "Data Management" section of the R&S ESW User Manual.

Suffix:

<n>	irrelevant

Parameters:
1

<FileName>	String containing the path and name of the target file.

Example:	`MMEM:STOR:IQ:STAT 1, 'C:\R_S\Instr\user\data.iq.tar'` Stores the captured I/Q data to the specified file.

Manual operation:	See "I/Q Export" on page 29

7.9 Querying the Status Registers

The R&S ESW-I/Q Analyzer uses the standard status registers of the R&S ESW.

For details on the common R&S ESW status registers refer to the description of remote control basics in the R&S ESW User Manual.

*RST does not influence the status registers.

7.10 Programming Examples

The following programming examples demonstrate how to capture I/Q data and perform I/Q data analysis using the I/Q Analyzer in a remote environment.

7.10.1 I/Q Analysis with Graphical Evaluation

This example demonstrates how to configure and perform a basic I/Q data acquisition and analyze the data using the I/Q Analyzer in a remote environment.

```
//--------------Activating the I/Q Analyzer application --------------------
*RST
//Reset the instrument
INST:CRE IQ,'IQANALYZER'
//Creates a new measurement channel named 'IQANALYZER'.
INIT:CONT OFF
//Switches to single sweep mode
```

```
//--------------Configuring Data Acquisition-------------
TRAC:IQ:SRAT 32MHZ
//Defines the sample rate.
TRAC:IQ:RLEN 1000
//Sets the record length (number of samples to capture) to 1000 samples.
TRAC:IQ:BWID?
//Queries the bandwidth of the resampling filter, determined by the sample rate
FORM:DATA REAL,32
//Formats the data as 32-byte real values.
TRAC:IQ:DATA:FORM IQP
//Lists all I values first, then all Q values in the trace results.


//--------------Configuring the Trace--------------------
TRAC:IQ:AVER ON
//Defines averaging for the I/Q trace.
TRAC:IQ:AVER:COUN 10
//Defines an average over 10 sweeps.


DISP:TRAC1:MODE WRIT
DISP:TRAC2:MODE MAXH
DISP:TRAC3:MODE MINH
//Changes the trace modes.


//--------------Performing the Measurement---------------------
INIT;*WAI
//Initiates a new measurement and waits until the sweep has finished.


//--------------Retrieving Results---------------------------

TRAC:DATA? TRACE1
TRAC:DATA? TRACE2
TRAC:DATA? TRACE3
//Returns the magnitude for each sweep point


LAY:REPL:WIND '1',RIMAG
//Changes the result display to Real/Imag (I/Q)


CALC:MARK:SEAR MAGN
//Configures searches to search both I and Q branches.
CALC:MARK:Y?
//Queries the result of the peak search on both branches.


TRAC:IQ:DATA:MEM? 0,500
//Returns the first 500 samples of the stored I/Q data for the measurement.
//For each sample, first the I-value, then the Q-value is listed.


TRAC:IQ:DATA:MEM? 500,500
//Returns the second half of the 1000 captured sample values.
```

7.10.2 Basic I/Q Analysis with Improved Performance

This example demonstrates how to configure and perform a basic I/Q data acquisition and analyze the data using the I/Q Analyzer in a remote environment.

```
//--------------Activating the I/Q Analyzer application --------------------
*RST
//Reset the instrument

INIT:CONT OFF
//Switches to single sweep mode
TRACE:IQ ON
//Switches the operating mode of the current measurement channel to I/Q Analyzer
//while retaining the relevant parameters from the Spectrum mode.

//--------------Configuring Data Acquisition-------------
TRACE:IQ:SET NORM,0,32000000,IQP,POS,0,1000
//Configures the sample rate as 32 MHz, IQP trigger, positive trigger slope,
//no pretrigger samples, 1000 samples to capture
FORM REAL,32
//The data is formatted as real values.

//--------------Configuring I/Q Gating------------------------
TRAC:IQ:EGAT ON
//Turns on gated measurement.
TRAC:IQ:EGAT:TYPE LEV
//Select the level gate type.
TRAC:IQ:EGAT:LENG 20
//Sets the gate length to 20 samples.
TRAC:IQ:EGAT:GAP 20
//Sets the interval between gate periods to 20 samples.
TRAC:IQ:EGAT:NOF 2
//Sets the number of gate periods after the trigger signal to 2.
TRIG:SOUR IQP
//Defines the magnitude of the sampled I/Q data to be used as a trigger.
TRIG:LEV:IQP -30dbm
//Sets the trigger level.

//--------------Performing the Measurement and Retrieving Results-------------
TRAC:IQ:DATA?; *WAI;
//Performs a measurement and returns the RF input voltage at each sample point
//(first 1000 I-values, then 1000 Q-values).

TRAC:IQ:DATA:MEM? 0,500
//Returns the first 500 samples of the stored trace data for the measurement.
//For each sample, first the I-value, then the Q-value is listed.

TRAC:IQ:DATA:MEM? 500,500
//Returns the second half of the 1000 captured sample values.
```

Annex

A Annex: Reference

A.1 Formats for Returned Values: ASCII Format and Binary Format

When trace data is retrieved using the `TRAC:DATA` or `TRAC:IQ:DATA` command, the data is returned in the format defined using the `FORMat[:DATA]`. The possible formats are described here.

- ASCII Format (FORMat ASCII):
  The data is stored as a list of comma-separated values (CSV) of the measured values in floating point format.

- Binary Format (FORMat REAL,32):
  The data is stored as binary data (Definite Length Block Data according to IEEE 488.2), each measurement value being formatted in 32-Bit IEEE 754 Floating-Point-Format.
  The schema of the result string is as follows:
  `#41024<value1><value2>…<value n>` with

#4	Number of digits (= 4 in the example) of the following number of data bytes
1024	Number of following data bytes (= 1024 in the example)
<Value>	4-byte floating point value

Reading out data in binary format is quicker than in ASCII format. Thus, binary format is recommended for large amounts of data.

A.2 Reference: Format Description for I/Q Data Files

This section describes how I/Q data is transferred to the memory during remote control (see `TRACe:IQ:DATA:FORMat` on page 78 command).

For details on the format of the individual values, see Chapter A.1, "Formats for Returned Values: ASCII Format and Binary Format", on page 127.

For details on the format of I/Q export files (using the "I/Q Export" function), see the R&S ESW User Manual.
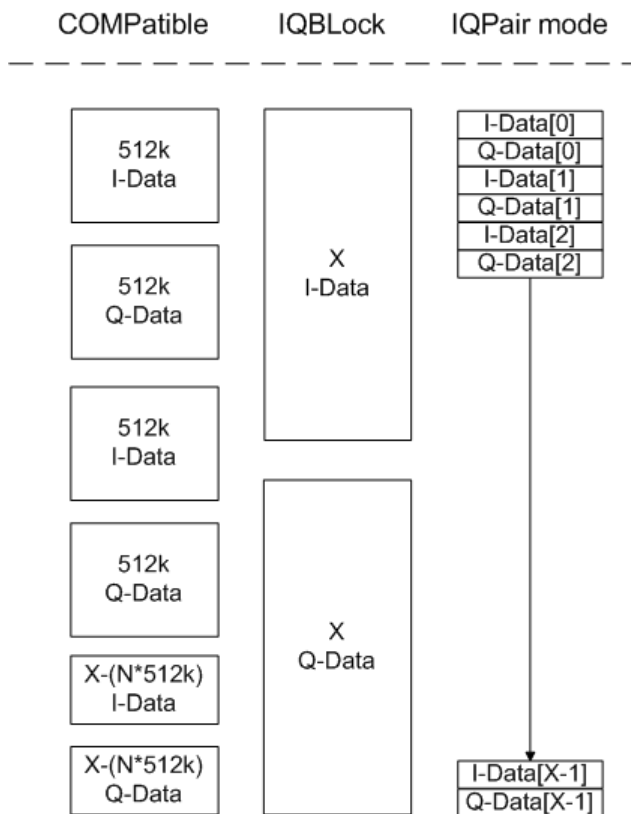
Figure A-1: I/Q data formats

Note: 512k corresponds to 524288 samples

For maximum performance, the formats "Compatible" or "IQPair" should be used. Furthermore, for large amounts of data, the data should be in binary format to improve performance.

In binary format, the number of I- and Q-data can be calculated as follows:

$$\# \, of \, I - Data \;\; = \;\; \# \, of \, Q - Data \;\; = \;\; \frac{\# \, of \, DataBytes}{8}$$

For the format "QBLock", the offset of Q-data in the output buffer can be calculated as follows:

$$Q - Data - Offset \;\; = \;\; \frac{(\# \, of \, DataBytes)}{2} + LengthIndicatorDigits$$

with "LengthIndicatorDigits" being the number of digits of the length indicator including the #. In the example above (#41024…), this results in a value of 6 for "LengthIndicatorDigits" and the offset for the Q-data results in 512 + 6 = 518.

A.3 I/Q Data File Format (iq-tar)

I/Q data is packed in a file with the extension `.iq.tar`. An iq-tar file contains I/Q data in binary format together with meta information that describes the nature and the source of data, e.g. the sample rate. The objective of the iq-tar file format is to separate I/Q data from the meta information while still having both inside one file. In addition, the file format allows you to preview the I/Q data in a web browser, and allows you to include user-specific data.

The iq-tar container packs several files into a single `.tar` archive file. Files in `.tar` format can be unpacked using standard archive tools (see http://en.wikipedia.org/wiki/Comparison_of_file_archivers) available for most operating systems. The advantage of `.tar` files is that the archived files inside the `.tar` file are not changed (not compressed) and thus it is possible to read the I/Q data directly within the archive without the need to unpack (untar) the `.tar` file first.

Contained files

An iq-tar file must contain the following files:

- **I/Q parameter XML file**, e.g. `xyz.xml`
  Contains meta information about the I/Q data (e.g. sample rate). The filename can be defined freely, but there must be only one single I/Q parameter XML file inside an iq-tar file.

- **I/Q data binary file**, e.g. `xyz.complex.float32`
  Contains the binary I/Q data of all channels. There must be only one single I/Q data binary file inside an iq-tar file.

Optionally, an iq-tar file can contain the following file:

- **I/Q preview XSLT file**, e.g. `open_IqTar_xml_file_in_web_browser.xslt`
  Contains a stylesheet to display the I/Q parameter XML file and a preview of the I/Q data in a web browser.
  A sample stylesheet is available at http://www.rohde-schwarz.com/file/open_IqTar_xml_file_in_web_browser.xslt.

A.3.1 I/Q Parameter XML File Specification

The content of the I/Q parameter XML file must comply with the XML schema `RsIqTar.xsd` available at: http://www.rohde-schwarz.com/file/RsIqTar.xsd.

In particular, the order of the XML elements must be respected, i.e. iq-tar uses an "ordered XML schema". For your own implementation of the iq-tar file format make sure to validate your XML file against the given schema.

The following example shows an I/Q parameter XML file. The XML elements and attributes are explained in the following sections.

Sample I/Q parameter XML file: xyz.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet type="text/xsl"
href="open_IqTar_xml_file_in_web_browser.xslt"?>
<RS_IQ_TAR_FileFormat fileFormatVersion="1"
xsi:noNamespaceSchemaLocation="RsIqTar.xsd"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <Name>FSV-K10</Name>
  <Comment>Here is a comment</Comment>
  <DateTime>2011-01-24T14:02:49</DateTime>
  <Samples>68751</Samples>
  <Clock unit="Hz">6.5e+006</Clock>
  <Format>complex</Format>
  <DataType>float32</DataType>
  <ScalingFactor unit="V">1</ScalingFactor>
  <NumberOfChannels>1</NumberOfChannels>
<DataFilename>xyz.complex.float32</DataFilename>
<UserData>
  <UserDefinedElement>Example</UserDefinedElement>
</UserData>
  <PreviewData>...</PreviewData>
</RS_IQ_TAR_FileFormat>
```

Element	Description
RS_IQ_TAR_File-Format	The root element of the XML file. It must contain the attribute `fileFormatVersion` that contains the number of the file format definition. Currently, `fileFormatVersion` "2" is used.
Name	Optional: describes the device or application that created the file.
Comment	Optional: contains text that further describes the contents of the file.
DateTime	Contains the date and time of the creation of the file. Its type is `xs:dateTime` (see `RsIqTar.xsd`).
Samples	Contains the number of samples of the I/Q data. For multi-channel signals all channels have the same number of samples. One sample can be: • A complex number represented as a pair of I and Q values • A complex number represented as a pair of magnitude and phase values • A real number represented as a single real value See also `Format` element.
Clock	Contains the clock frequency in Hz, i.e. the sample rate of the I/Q data. A signal generator typically outputs the I/Q data at a rate that equals the clock frequency. If the I/Q data was captured with a signal analyzer, the signal analyzer used the clock frequency as the sample rate. The attribute `unit` must be set to "Hz".
Format	Specifies how the binary data is saved in the I/Q data binary file (see `DataFilename` element). Every sample must be in the same format. The format can be one of the following: • `complex`: Complex number in cartesian format, i.e. I and Q values interleaved. I and Q are unitless • `real`: Real number (unitless) • `polar`: Complex number in polar format, i.e. magnitude (unitless) and phase (rad) values interleaved. Requires `DataType` = `float32` or `float64`

Element	Description
DataType	Specifies the binary format used for samples in the I/Q data binary file (see `DataFilename` element and Chapter A.3.2, "I/Q Data Binary File", on page 133). The following data types are allowed: • `int8`: 8 bit signed integer data • `int16`: 16 bit signed integer data • `int32`: 32 bit signed integer data • `float32`: 32 bit floating point data (IEEE 754) • `float64`: 64 bit floating point data (IEEE 754)
ScalingFactor	Optional: describes how the binary data can be transformed into values in the unit Volt. The binary I/Q data itself has no unit. To get an I/Q sample in the unit Volt the saved samples have to be multiplied by the value of the `ScalingFactor`. For polar data only the magnitude value has to be multiplied. For multi-channel signals the `ScalingFactor` must be applied to all channels. The attribute `unit` must be set to "`V`". The `ScalingFactor` must be > 0. If the `ScalingFactor` element is not defined, a value of 1 V is assumed.
NumberOfChan-nels	Optional: specifies the number of channels, e.g. of a MIMO signal, contained in the I/Q data binary file. For multi-channels, the I/Q samples of the channels are expected to be interleaved within the I/Q data file (see Chapter A.3.2, "I/Q Data Binary File", on page 133). If the `NumberOfChannels` element is not defined, one channel is assumed.
DataFilename	Contains the filename of the I/Q data binary file that is part of the iq-tar file. It is recommended that the filename uses the following convention: `<xyz>.<Format>.<Channels>ch.<Type>` • `<xyz>` = a valid Windows file name • `<Format>` = complex, polar or real (see `Format` element) • `<Channels>` = Number of channels (see `NumberOfChannels` element) • `<Type>` = float32, float64, int8, int16, int32 or int64 (see `DataType` element) Examples: • xyz.complex.1ch.float32 • xyz.polar.1ch.float64 • xyz.real.1ch.int16 • xyz.complex.16ch.int8
UserData	Optional: contains user, application or device-specific XML data which is not part of the iq-tar specification. This element can be used to store additional information, e.g. the hardware configuration. User data must be valid XML content.
PreviewData	Optional: contains further XML elements that provide a preview of the I/Q data. The preview data is determined by the routine that saves an iq-tar file (e.g. R&S ESW). For the definition of this element refer to the `RsIqTar.xsd` schema. Note that the preview can be only displayed by current web browsers that have JavaScript enabled and if the XSLT stylesheet `open_IqTar_xml_file_in_web_browser.xslt` is available.

Example: ScalingFactor

Data stored as `int16` and a desired full scale voltage of 1 V

`ScalingFactor` = 1 V / maximum int16 value = 1 V / 2^{15} = 3.0517578125e-5 V

Scaling Factor	Numerical value	Numerical value x ScalingFactor
Minimum (negative) int16 value	$- 2^{15}$ = - 32768	-1 V
Maximum (positive) int16 value	$2^{15}-1$= 32767	0.999969482421875 V

Example: PreviewData in XML

```
<PreviewData>
    <ArrayOfChannel length="1">
      <Channel>
        <PowerVsTime>
          <Min>
            <ArrayOfFloat length="256">
              <float>-134</float>
              <float>-142</float>
              ...
              <float>-140</float>
            </ArrayOfFloat>
          </Min>
          <Max>
            <ArrayOfFloat length="256">
              <float>-70</float>
              <float>-71</float>
              ...
              <float>-69</float>
            </ArrayOfFloat>
          </Max>
        </PowerVsTime>
        <Spectrum>
          <Min>
            <ArrayOfFloat length="256">
              <float>-133</float>
              <float>-111</float>
              ...
              <float>-111</float>
            </ArrayOfFloat>
          </Min>
          <Max>
            <ArrayOfFloat length="256">
              <float>-67</float>
              <float>-69</float>
              ...
              <float>-70</float>
              <float>-69</float>
            </ArrayOfFloat>
          </Max>
        </Spectrum>
        <IQ>
          <Histogram width="64" height="64">0123456789...0</Histogram>
        </IQ>
      </Channel>
    </ArrayOfChannel>
  </PreviewData>
```

A.3.2   I/Q Data Binary File

The I/Q data is saved in binary format according to the format and data type specified in the XML file (see `Format` element and `DataType` element). To allow reading and writing of streamed I/Q data, all data is interleaved, i.e. complex values are interleaved pairs of I and Q values and multi-channel signals contain interleaved (complex) samples for channel 0, channel 1, channel 2 etc. If the `NumberOfChannels` element is not defined, one channel is presumed.

Example: Element order for real data (1 channel)

```
I[0],                           // Real sample 0
I[1],                           // Real sample 1
I[2],                           // Real sample 2
...
```

Example: Element order for complex cartesian data (1 channel)

```
I[0], Q[0],                     // Real and imaginary part of complex sample 0
I[1], Q[1],                     // Real and imaginary part of complex sample 1
I[2], Q[2],                     // Real and imaginary part of complex sample 2
...
```

Example: Element order for complex polar data (1 channel)

```
Mag[0], Phi[0],                 // Magnitude and phase part of complex sample 0
Mag[1], Phi[1],                 // Magnitude and phase part of complex sample 1
Mag[2], Phi[2],                 // Magnitude and phase part of complex sample 2
...
```

Example: Element order for complex cartesian data (3 channels)
Complex data: I[channel no][time index], Q[channel no][time index]

```
I[0][0], Q[0][0],               // Channel 0, Complex sample 0
I[1][0], Q[1][0],               // Channel 1, Complex sample 0
I[2][0], Q[2][0],               // Channel 2, Complex sample 0

I[0][1], Q[0][1],               // Channel 0, Complex sample 1
I[1][1], Q[1][1],               // Channel 1, Complex sample 1
I[2][1], Q[2][1],               // Channel 2, Complex sample 1

I[0][2], Q[0][2],               // Channel 0, Complex sample 2
I[1][2], Q[1][2],               // Channel 1, Complex sample 2
I[2][2], Q[2][2],               // Channel 2, Complex sample 2
...
```

Example: Element order for complex cartesian data (1 channel)
This example demonstrates how to store complex cartesian data in float32 format using MATLAB®.

```
% Save vector of complex cartesian I/Q data, i.e. iqiqiq...
N = 100
iq = randn(1,N)+1j*randn(1,N)
fid = fopen('xyz.complex.float32','w');
for k=1:length(iq)
  fwrite(fid,single(real(iq(k))),'float32');
  fwrite(fid,single(imag(iq(k))),'float32');
end
fclose(fid)
```

List of Remote Commands (I/Q Analyzer)

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