R&S®FSW-K40
Phase Noise Measurements
User Manual

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Test & Measurement

User Manual

ROHDE&SCHWARZ

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

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

The following firmware options are described:

- R&S FSW-K40 (1313.1397.02)

Muehldorfstr. 15, 81671 Munich, Germany
Phone: +49 89 41 29 - 0
Fax: +49 89 41 29 12 164
E-mail: info@rohde-schwarz.com
Internet: http://www.rohde-schwarz.com

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

Contents

1 Preface

1.1 About this Manual

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

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

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

1.2 Documentation Overview

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

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

Online Help

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

Getting Started

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

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

User Manuals

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

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

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

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

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

Service Manual

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

Release Notes

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

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

1.3 Conventions Used in the Documentation

1.3.1 Typographical Conventions

The following text markers are used throughout this documentation:

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

1.3.2 Conventions for Procedure Descriptions

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

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

2 Welcome to the Phase Noise Measurement Application

The R&S FSW-K40 is a firmware application that adds functionality to measure the phase noise characteristics of a device under test with the R&S FSW signal analyzer.

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

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

Installation

Find detailed installing instructions in the Getting Started or the release notes of the R&S FSW.

2.1 Starting the Application

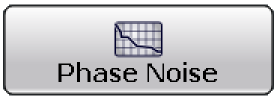
The phase noise measurement application adds a new type of measurement to the R&S FSW.

To activate the the Phase Noise application

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

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

2. Select the "Phase Noise" item.

   The R&S FSW opens a new measurement channel for the Phase Noise application. All settings specific to phase noise measurements are in their default state.

Multiple Measurement Channels and Sequencer Function

When you enter 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 (including the "MultiView") as the measurements are performed. Sequential operation itself is independant of the currently *displayed* tab.

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

2.2 Understanding the Display Information

The following figure shows the display as it looks for phase noise measurements. All different information areas are labeled. They are explained in more detail in the following sections.

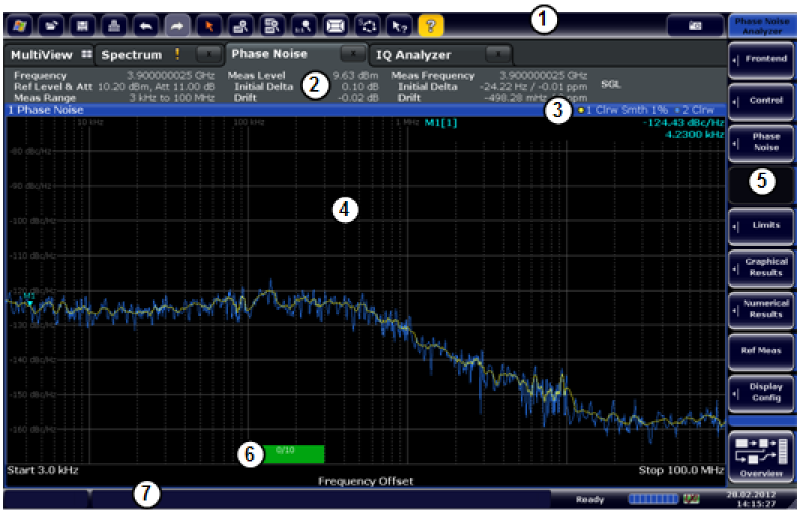


Fig. 2-1: Screen layout of the phase noise measurement application

1 = Toolbar
2 = Channel bar
3 = Diagram header
4 = Result display
5 = Softkey bar
6 = Measurement status
7 = Status bar

Measurement status

The measurement status is a green bar. The green bar indicates the half decade that the application currently measures.

The numbers within the green bar show the progress of the measurement(s) in the half decade the application currently works on. The first number is the current measurement, the second number the total number of measurements defined for that half decade.

For a description of the elements not described below, please refer to the Getting Started of the R&S FSW.

Channel bar information

The channel bar contains information about the current measurement setup, progress and results.

Fig. 2-2: Channel bar of the phase noise application

Frequency	Frequency the R&S FSW has been tuned to. The frontend frequency is the expected frequency of the carrier. When frequency tracking or verification is on, the application might adjust the frontend frequency.
Ref Level & Att	Reference level (first value) and attenuation (second value) of the R&S FSW. When level tracking or verification is on, the application might adjust the frontend level.
Meas Range	Complete phase noise measurement range. For more information see chapter 4.3, "Phase Noise Measurement Range", on page 20.
Meas(ured) Level	DUT level that has been actually measured. The measured level might differ from the frontend level, e.g. if you are using level verification.
Initial Delta	Difference between the nominal level and the first level that has been measured.
Drift	Difference between the 1st level that has been measured and the level that has been measured last. In continuous sweep mode, the drift is the difference between the 1st level that has been measured in the 1st sweep and the level that has been measured last.
Measured Frequency	DUT frequency that has been actually measured. The measured frequency might differ from the frontend frequency, e.g. if you are using level verification.
Initial Delta	Difference between the nominal frequency and the first frequency that has been measured.
Drift	Difference between the 1st frequency that has been measured and the frequency that has been measured last. In continuous sweep mode, the drift is the difference between the 1st frequency that has been measured in the 1st sweep and the frequency that has been measured last.
SGL [#/#]	Sweep mode (single or continuous). If you use trace averaging, it also shows the current measurement number out of the total number of measurements.

The following two figures show the relations between the frequency and level errors.

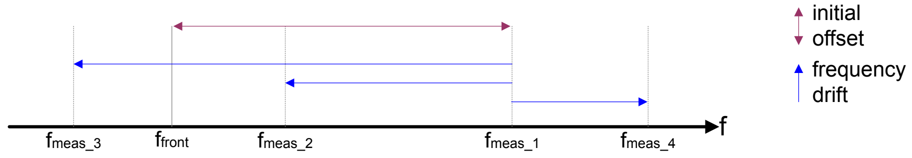


Fig. 2-3: Frequency errors

f_{front} = initial frequency set on the frontend
f_{meas_x} = actual frequency that has been measured

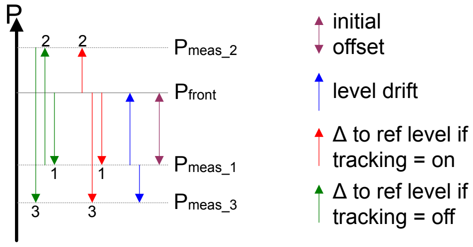


Fig. 2-4: Level errors

P_{front} = reference level if tracking = off
P_{front} = initial reference level if tracking = on
P_{meas_1} = becomes reference level after first sweep if tracking = on
P_{meas_2} = becomes reference level after second sweep if tracking = on
P_{meas_3} = becomes reference level after third sweep if tracking = on
1 = Δ to reference level after first sweep (red: tracking = on, green: tracking = off)
2 = Δ to reference level after second sweep (red: tracking = on, green: tracking = off)
3 = Δ to reference level after third sweep (red: tracking = on, green: tracking = off)

Window title bar information

For each diagram, the header provides the following information:

Fig. 2-5: Window title bar information of the phase noise application

1 = Window number
2 = Window type
3 = Trace color and number
4 = Trace mode
5 = Smoothing state and degree

Status bar information

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

3 Measurements and Result Displays

The R&S FSW-K40 measures the phase noise of a single sideband of a carrier.

It features several result displays. Result displays are different representations of the measurement results. They may be diagrams that show the results in a graphic way or tables that show the results in a numeric way.

► Select the icon in the toolbar or press the MEAS key.

  The application enters the SmartGrid configuration mode.
  For more information on the SmartGrid functionality see the R&S FSW Getting Started.

In the default state of the application, only the graphical display of phase noise results is active.

Phase Noise Diagram
The phase noise diagram shows the power level of the phase noise over a variable frequency offset from the carrier frequency.

Measurement range

The units of both axis in the diagram is fix. The x-axis always shows the offset frequencies in relation to the carrier frequency on a logarithmic scale in Hz. It always has a logarithmic scale to make sure of a equal representation of offsets near and far away from the carrier. The range of offsets that the x-axis shows is variable and depends on the measurement range you have defined and the scope of the x-axis that you have set.

For more information on the measurement range see chapter 4.3, "Phase Noise Measurement Range", on page 20.

If the measurement range you have set is necessary, but you need a better resolution of the results, you can limit the displayed result by changing the x-axis scope. The scope works like a zoom to get a better view of the trace at various points. It does not start a new measurement or alter the current measurements results in any way.

The y-axis always shows the phase noise power level contained in a 1 Hz bandwidth in relation to the level of the carrier. The unit for this information is dBc/Hz and is also fix.

Y-axis scale

The scale of the y-axis is variable. Usually it is best to use the automatic scaling that the application provides, because it makes sure that the whole trace is always visible. You can, however, also customize the range, the minimum and the maximum values on the y-axis by changing the y-axis scale.

The measurement results are displayed as traces in the diagram area. Up to six active traces at any time are possible. Each of those may have a different setup and thus show different aspects of the measurement results.

In the default state, the application shows two traces. A yellow one and a blue one. Both result from the same measurement data, but have been evaluated differently. On the first trace, smoothing has been applied, the second one shows the raw data.

For more information on trace smoothing see chapter 4.5, "Trace Averaging", on page 21.

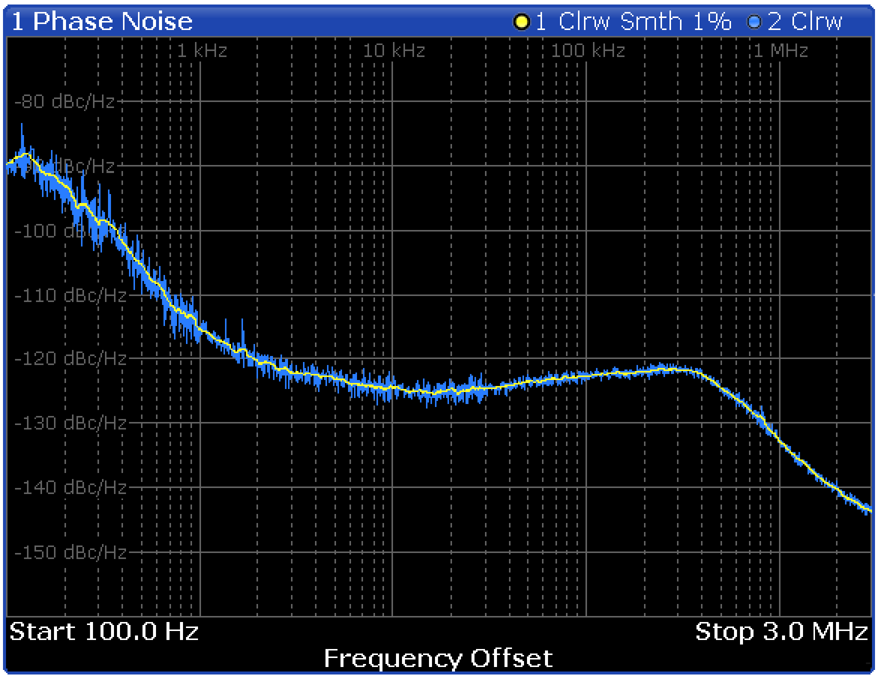


Fig. 3-1: Overview of the phase noise result display

The figure above shows a phase noise curve with typical characteristics. Frequency offsets near the carrier usually have higher phase noise levels than those further away from the carrier. The curve has a falling slope until the thermal noise of the DUT has been reached. From this point on, it is more or less a straight horizontal line.

SCPI command:

`TRACe[:DATA]?` on page 109

Residual Noise

The residual noise display summarizes the residual noise results in a table.

For more information on the residual noise results see chapter 4.2, "Residual Effects", on page 19.

The table consists of up to four rows with each row representing a different integration interval. Each row basically contains the same information with the exception that the first row always shows the results for the first trace and the other rows with custom integration ranges the results for any one trace.

1 Residual Noise

Type	Start	Stop	PM	FM	Jitter
Full, T2	100.00 Hz	3.00 MHz	0.06 °	320.1...	87.43 fs
User 1, T1	100.00 Hz	1.00 kHz	0.05 °	0.42 Hz	69.16 fs
User 2, T2	2.51 kHz	12.03 kHz	0.01 °	1.15 Hz	18.61 fs
User 3, T2	20.00 kHz	200.00 kHz	0.02 °	34.62 ...	22.19 fs

The residual noise information is made up out of several values.

Type
Shows the origin of the integration interval. Possible values are.
- Full
  for the integration of trace 1 over the complete measurement range.
- Eval
  for the integration of trace 1 over a customized range.
- User [x]
  for the integration of any trace over a customized range.

The information after the comma shows the trace that is integrated (T[x]).

Start / Stop
Shows the start and stop offset of the integration interval.

PM
Shows the residual PM result in degrees.

FM
Shows the residual FM results in Hz.

Jitter
Shows the jitter in seconds.

For more information on residual noise see chapter 4.2, "Residual Effects", on page 19.

SCPI command:
Querying residual PM:
FETCh:PNOise<t>:RPM? on page 113
Querying residual FM:
FETCh:PNOise<t>:RFM? on page 112
Querying jitter:
FETCh:PNOise<t>:RMS? on page 113
Querying user ranges:
FETCh:PNOise<t>:USER<range>:RFM? on page 113
FETCh:PNOise<t>:USER<range>:RMS? on page 113
FETCh:PNOise<t>:USER<range>:RPM? on page 114

Spot Noise

Spot noise is the phase noise at a particular frequency offset (or spot) that is part of the measurement range. It is thus like a fixed marker.

The unit of spot noise results is dBc/Hz. The application shows the results in a table.

2 Spot Noise

Type	Offset Frequency [T1]	Phase Noise [T1]
User 1	1.00 kHz	-115.33 dBc/Hz
User 2	10.00 kHz	-124.42 dBc/Hz
User 3	100.00 kHz	-122.67 dBc/Hz
User 4	1.00 MHz	-132.82 dBc/Hz
User 5	10.00 MHz	---

The table consists of a variable number of 10^x frequencies (depending on the measurement range), and a maximum of five user frequencies, with each row containing the spot noise information for a particular frequency offset.

The spot noise information is made up out of several variables.

Type Shows where the spot noise offset frequency comes from. By default, the application evaluates the spot noise for the first offset frequency of a decade only (10^x Hz, beginning at 1 kHz). However, you can add up to five customized offsets frequencies that you want to know the phase noise for. If you want to use more custom offsets, you can add another spot noise table.

The "User" label indicates a custom offset frequency.

Offset Frequency Shows the offset frequency the spot noise is evaluated for. You may add any offset that is part of the measurement range.

The number in brackets (T<x>) indicates the trace the result refers to.

Phase Noise Shows the phase noise for the corresponding offset frequency.

The number in brackets (T<x>) indicates the trace the result refers to.

SCPI command:
Querying spot noise results on 10^x offset frequencies:
CALCulate<n>:SNOise:DECades:X? on page 115
CALCulate<n>:SNOise:DECades:Y? on page 115
Querying custom spot noise results:
CALCulate<n>:SNOise<m>:Y? on page 116

Spur List
Spurs are peak levels at one or more offset frequencies and are caused mostly by interfering signals. The application shows the location of all detected spurs in a table.

4 Spur List

Number	Offset Frequency	Power
1	20.00 kHz	-60.94 dBc
2	40.00 kHz	-70.04 dBc
3	60.00 kHz	-79.74 dBc

The table consists of a variable number of rows. For each detected spur, the table shows several results.

Number Shows the spur number. Spurs are sorted by their frequency, beginning with the spur with the lowest frequency.

Offset Frequency Shows the position (offset frequency) of the spur.

Power Shows the power level of the spur in dBc.

For more information see chapter 4.1, "Spurs and Spur Removal", on page 18.

SCPI command:
FETCh:PNOise:SPURs? on page 117

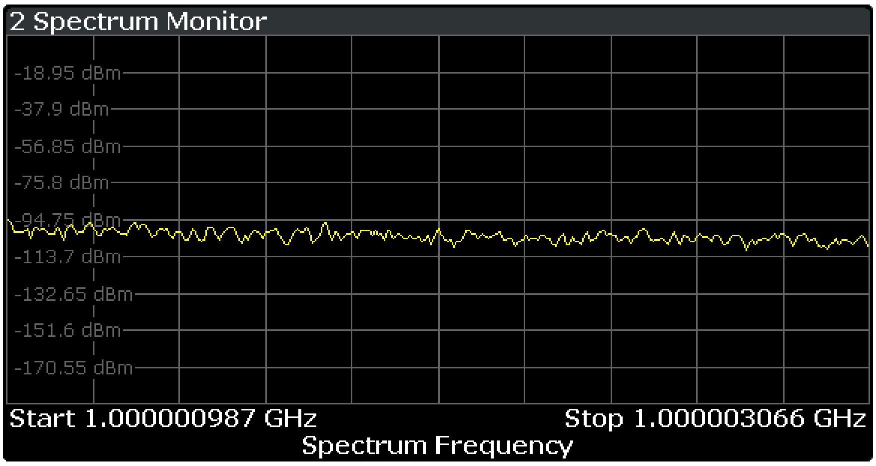
Spectrum Monitor
The spectrum monitor shows the spectrum for the half decade that is currently measured.

Span

The span on the x-axis is defined by the start and stop frequency of the half decade that is currently measured.

Y-axis scale

The scale of the y-axis is automatically determined according to the signal characteristics.



SCPI command:

`TRACe[:DATA]?` on page 109

Reference Measurement

The reference measurement measures the inherent phase noise of the R&S FSW.

To determine the inherent noise, the application performs a measurement without the signal at the input. The resulting trace shows the inherent noise of the R&S FSW only. When you substract that inherent noise from the phase noise of the measurement with trace mathematics, you get a trace that shows the phase noise of the DUT only.

SCPI command:

`CONFigure:REFMeas ONCE` on page 70

4 Measurement Basics

The measurement basics contain background information on the terminology and principles of phase noise measurements.

Phase noise measurements in general determine the single sideband phase noise characteristics of a device under test (DUT).

4.1 Spurs and Spur Removal

Most phase noise results contain spurs. Spurs are peak levels at one or more offset frequencies and are caused mostly by interfering signals. For some applications you may want to specifically indentify the location of spurs. However, for some applications, spurs do not matter in evaluating the results and you may want to remove them from the trace in order to get a "smooth" phase noise trace.

Spur removal

The application allows you to (visually) remove spurs from the trace. Spur removal is based on an algorithm that detects and completely removes the spurs from the trace and fills the gaps with data that has been determined mathematically.

The spur removal functionality separates the actual spur power from the underlying phase noise and displays the latter in a two-stage process. The first stage of spur detection is based on an eigenvalue decomposition during the signal processing.

Spur threshold

During the second stage, the application uses statistical methods to remove a spur. A spur is detected, if the level of the signal is above a certain threshold. The spur threshold is relative to an imaginary median trace that the application calculates.

If parts of the signal are identfied as spurs, the application removes all signal parts above that level and substitutes them with the median trace.

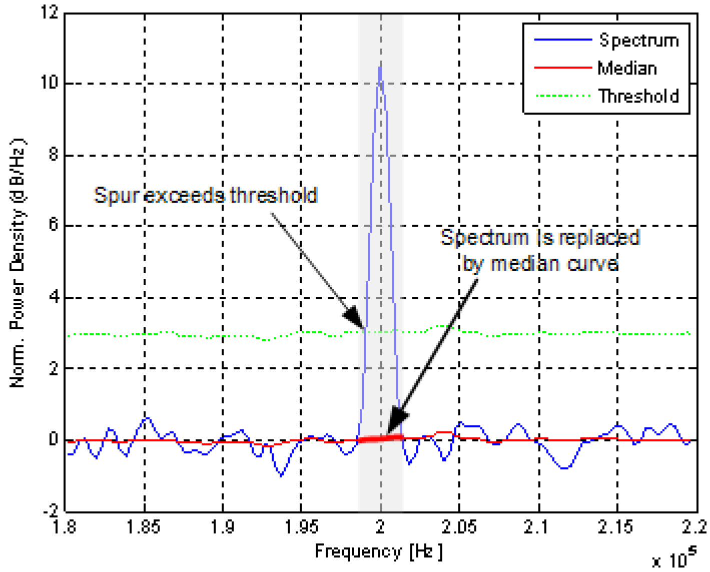


Fig. 4-1: Spur detection and removal principle

4.2 Residual Effects

Residual noise effects are modulation products that originate directly from the phase noise. It is possible deduct them mathematically from the phase noise of a DUT.

The application calculates three residual noise effects. All calculations are based on an integration of the phase noise over a particular offset frequency range.

Residual PM

The residual phase modulation is phase modulation whose origin is the phase noise.

$$\text{Residual PM} = \frac{360}{2\pi}\sqrt{\int_{f_{start}}^{f_{stop}} S_{\phi}(f)}\,[\deg]$$

Residual FM

The residual frequency modulation is noise that results from frequency fluctuation of the signal. Its unit is Hz.

$$\text{Residual FM} = \sqrt{\int_{f_{start}}^{f_{stop}} S_{v}(f)df}\,[Hz]$$

with $S_v(f) =$ Spectral Density of Frequency Fluctuations

Jitter

The jitter is noise that results from temporal fluctuations of the signal. Its unit is seconds.

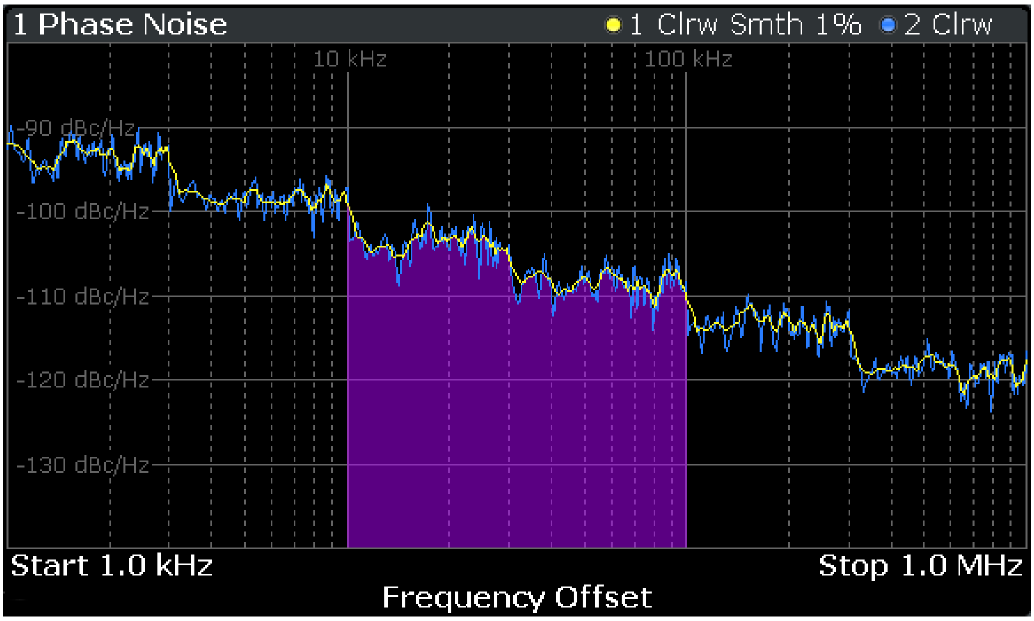


Fig. 4-2: Residual noise based on an integration between 10 kHz and 100 kHz offset

4.3 Phase Noise Measurement Range

Phase noise measurements determine the phase noise of a DUT over a particular measurement range. This **measurement range** is defined by two offset frequencies. The **frequency offsets** themselves are relative to the nominal frequency of the DUT.

The measurement range again is divided into several (logarithmic) decades, or, for configuration purposes, into **half decades**.

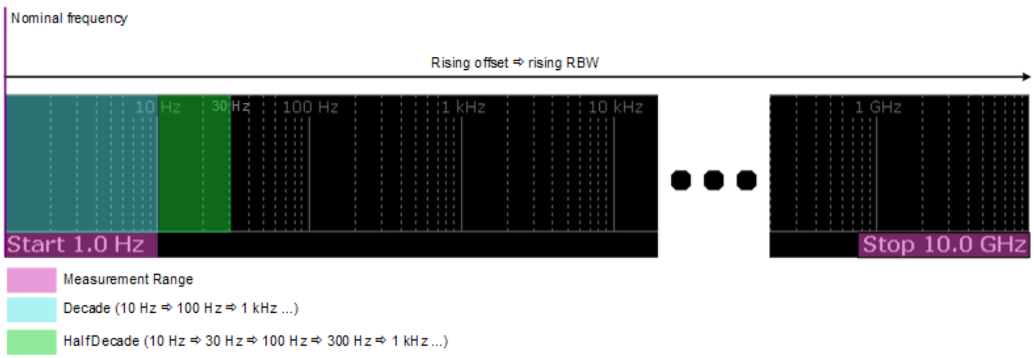


Fig. 4-3: Measurement range and half decades

This breakdown into several half decades is made to speed up measurements. You can configure each half decade separately in the "Half Decade Configuration Table". For quick, standardized measurements, the application provides several predefined sweep types or allows you to configure each half decade manually, but globally.

The main issue in this context is the **resolution bandwidth** (RBW) and its effect on the measurement time. In general, it is best to use a resolution bandwidth as small as possible for the most accurate measurement results. However, accuracy comes at the price of measurement speed.

To avoid very long measurement times, the application provides only a certain range of RBW that are available for each half decade.

4.4 Sweep Modes

Sweep modes define the data processing method.

Swept

The application performs a sweep of the frequency spectrum.

I/Q FFT

The application evaluates the I/Q data that has been collected and calculates the trace based on that data.

4.5 Trace Averaging

The application provides several modes of trace averaging that you can use separately or in any combination.

The order in which averaging is performed is as follows. For more details for each averaging mode see below.

1. Half decade averaging.
   The application measures each half decade a particualr number of times before measuring the next one.
2. Sweep Count.
   The application measures the complete measurement range a particular number of times. It again includes half decade averaging as defined.

   After the measurement over the sweep count is finished, the application displays the averaged results.
3. Trace smoothing.
   Calculates the moving average for the current trace.

4.5.1 Half Decade Averaging

Define the number of measurements that the application performs for each half decade before it displays the averaged results and measures the next half decade.

In combination with the RBW, this is the main factor that has an effect on the measurement time. Typically you will use a small number of averages for small RBWs because small RBWs already provide accurate results and a high number of averages for high RBWs to get more balanced results.

4.5.2 Sweep Count

The sweep count defines the number of sweeps that the application performs during a complete measurements.

A sweep in this context is the measurement over the complete measurement range (including half decade averaging) once. A complete measurement, however, can consists of more than one sweep. In that case the application measures until the number of sweeps that have been defined are done. The measurement configuration stays the same all the time.

In combination with the Average trace mode and half decade averaging, the sweep count averages the trace even more.

4.5.3 Trace Smoothing

Smoothing is a way to visually get rid of anomalies in the trace (like spurs) that may distort the results. The smoothing process is based on a moving average over the complete measurement range. The number of samples included in the averaging process (aperture size) is variable and is a percentage of all samples that the trace consists of.

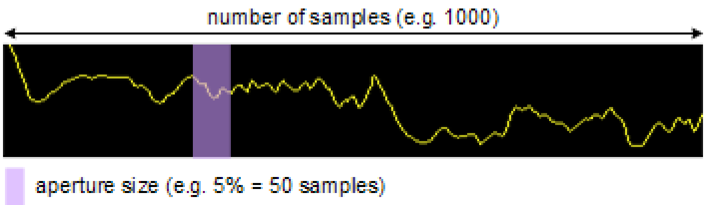


Fig. 4-4: Sample size included in trace smoothing

The application smoothes the trace only after the measurement has been finished and the data has been analyzed and written to a trace. Thus, smoothing is really just an enhancement of the trace display, not of the data itself. This also means that smoothing is applied always after any other trace averagings have been done, as these happen during the measurement itself. You can turn trace smoothing on and off for all traces individually and compare, for example, the raw and the smooth trace.

The smoothing is either linear or logarithmic and is based on the following algorithms.

$$y'(s) = 10 \cdot \log_{10}\left(\frac{1}{n}\left(\sum_{x=s-\frac{n-1}{2}}^{x=s+\frac{n-1}{2}} 10^{\left(\frac{y(x)}{10}\right)}\right)\right)$$

Logarithmic trace smoothing (4 - 1)

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

Linear trace smoothing (4 - 2)

with

s = sample number
$y(s)$ = logarithmic phase noise level
x = sample offset from s
n = aperture size

4.6 Frequency Determination

Nominal frequency

The nominal frequency is the output or center frequency of the DUT. To get correct and valid measurement results, the application needs to know the real frequency of the DUT.

Unverified signals

The R&S FSW tries to start the measurement as soon as you enter the phase noise application. If it cannot verify a signal, it will try to start the measurement over and over.

To stop the repeated (and probably unsuccessful) signal verification, stop the measurement on the first verification failure.

The available (nominal) frequency range depends on the hardware you are using. For more information see the datasheet of the R&S FSW.

If you are not sure about the nominal frequency, define a tolerance range to verify the frequency. For measurements on unstable or drifting DUTs, use the frequency tracking functionality.

Frequency verification

When you are using frequency verification, the application intiates a measurement that verifies that the frequency of the DUT is within a certain range of the nominal frequency. This measurement takes place before the actual phase noise measurement. Its purpose is to find strong signals within a frequency tolerance range and, if successful, to adjust the nominal frequency and lock onto that new frequency. The frequency tolerance is variable. You can define it in absolute or relative terms.

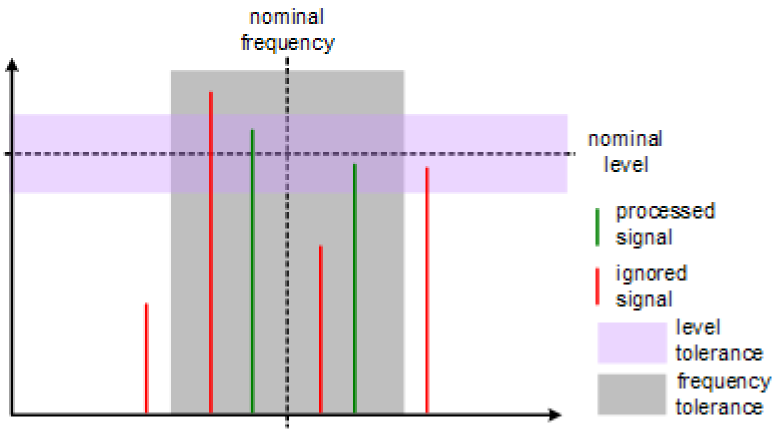


Fig. 4-5: Frequency and level tolerance

You can define both absolute and relative tolerances. In that case, the application uses the higher tolerance to determine the frequency.

If there is no signal within the tolerance range, the application aborts the phase noise measurement.

In the numerical results, the application always shows the frequency the measurement was actually performed on. If the measured frequency is not the same as the nominal frequency, the numerical results also show the deviation from the nominal frequency.

Frequency tracking

When you are using the frequency tracking, the application tracks drifting frequencies of unstable DUTs. It internally adjusts and keeps a lock on the nominal frequency of the DUT.

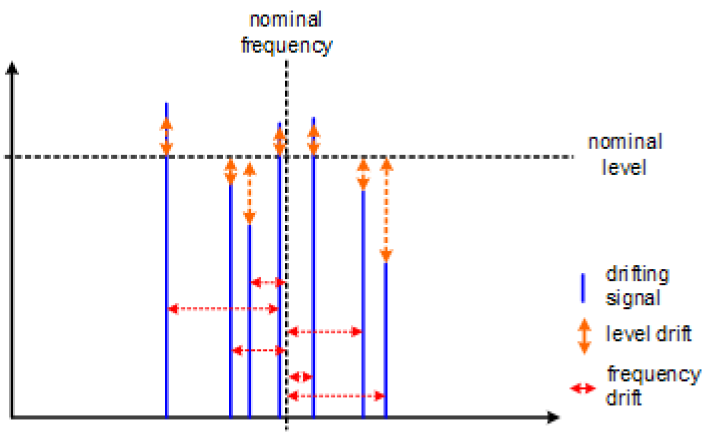


Fig. 4-6: Frequency and level tracking

Tracking bandwidth

The tracking bandwidth defines the bandwidth within which the application tracks the frequency.

Normally, the application adjusts the sample rate to the half decade it is currently measuring. For half decades that are near the carrier, the sample rate is small. Half decades far from the carrier use a higher sample rate. However, in case of drifting signals, this method may result in data loss because the default bandwidth for a half decade might be too small for the actual drift in the frequency. In that case, you can define the tracking bandwidth which increases the sample rate if necessary and thus increases the chance to capture the signal.

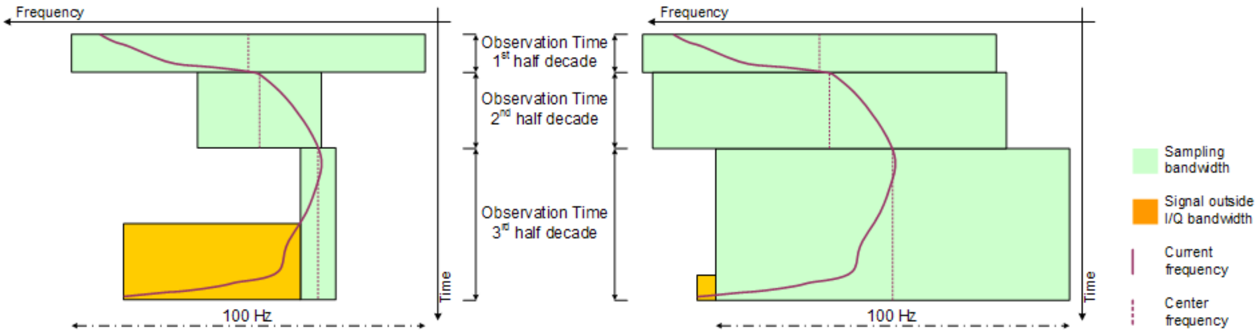


Fig. 4-7: Frequency tracking with tracking bandwidth turned off (left) and a tracking bandwidth of 100 Hz (right)

4.7 Level Determination

Nominal level

The nominal level in other terms is the reference level of the R&S FSW. This is the level that the analyzer expects at the RF input.

The available level range depends on the hardware. For more information see the datasheet of the R&S FSW.

Make sure to define a level that is as close to the level of the DUT to get the best dynamic range for the measurement. At the same time make sure that the signal level is not higher than the reference level to avoid an overload of the A/D converter and thus deteriorating measurement results.

If you are not sure about the power level of the DUT, but would still like to use the best dynamic range and get results that are as accurate as possible, you can verify or track the level.

Level verification

When you are using the level verification, the application initiates a measurement that determines the level of the DUT. If the level of the DUT is within a certain tolerance range, it will adjust the nominal level to that of the DUT. Else, it will abort the phase noise measurement.

Define a level tolerance in relation to the current nominal level. The tolerance range works for DUT levels that are above or below the current nominal level.

Level tracking

For tests on DUTs whose level varies, use level tracking. If active, the application keeps track of the DUTs level during the phase noise measurement and adjusts the nominal level accordingly.

For a graphical representation of level verification and level tracking see the figures in chapter 4.6, "Frequency Determination", on page 23.

4.8 Signal Attenuation

Attenuation of the signal may become necessary if you have to reduce the power of the signal that you have applied. Power reduction is necessary, for example, to prevent an overload of the input mixer. An overload of the input mixer may lead to incorrect measurement results or damage to the hardware if the signal power is too strong.

In the default state, the application automatically determines the attenuation according to the reference level. If necessary, you can also define the attenuation manually.

When you attenuate the signal, the application adjusts graphical and numerical results accordingly.

Because the reference level and attenuation are interdependent, changing the attenuation manually may also adjust the reference level.

RF attenuation

RF attenuation is always available. It is a combination of mechanical and IF attenuation.

The mechanical attenuator is located directly after the RF input of the R&S FSW. Its step size is 5 dB. IF attenuation is applied after the signal has been down-converted. Its step size is 1 dB.

Thus, the step size for RF attenuation as a whole is 1 dB. Mechanical attenuation is used whenever possible (attenuation levels that are divisible by 5). IF attenuation handles the 1 dB steps only.

Example:

If you set an attenuation level of 18 dB, 15 dB are mechanical attenuation and 3 dB are IF attenuation.

If you set an attenuation level 0f 6 dB, 5 dB are mechanical attenuation and 1 dB is IF attenuation.

Electronic attenuation

Electronic attenuation is available with R&S FSW-B25. You can use it in addition to mechanical attenuation. The step size of electronic attenuation is 1 dB with attenuation levels not divisible by 5 again handled by the IF attenuator. Compared to RF attenuation, you can define the amount of mechanical and electronic attenuation freely.

4.9 Using Limit Lines

Limit lines provide an easy way to verify if measurement results are within the limits you need them to be. As soon as you turn a limit line on, the application will indicate if the phase noise a trace displays is in line with the limits or if it violates the limits.

The application provides two kinds of limit lines. 'Normal' limit lines as you know them from the Spectrum application and special thermal limit lines for easy verification of thermal noise results.

Phase noise limit lines

Phase noise limit lines have been designed specifically for phase noise measurements. Their shape is based on the thermal noise floor of the DUT and the typical run of the phase noise curve.

The typical slope of the phase noise curve depends on the offset from the DUT frequency. In the white noise range (the noise floor), far away from the carrier, the slope is more or less 0 dB per frequency decade. In the colored noise segment, the slope is greater than 0 dB. The slope, however, is not constant in that segment, but again is typical for various carrier offset segments (or ranges).

The application supports the definition of up to five ranges, each with a different slope. The ranges themselves are defined by corner frequencies. Corner frequencies are those frequencies that mark the boundaries of typical curve slopes. If you use all five ranges, the result would be a limit line with six segments.

All segments have a slope of 10 dB per decade (f^{-1}) by default.

In most cases, these special limit lines will suffice for phase noise measurements as they represent the typical shape of a phase noise curve.

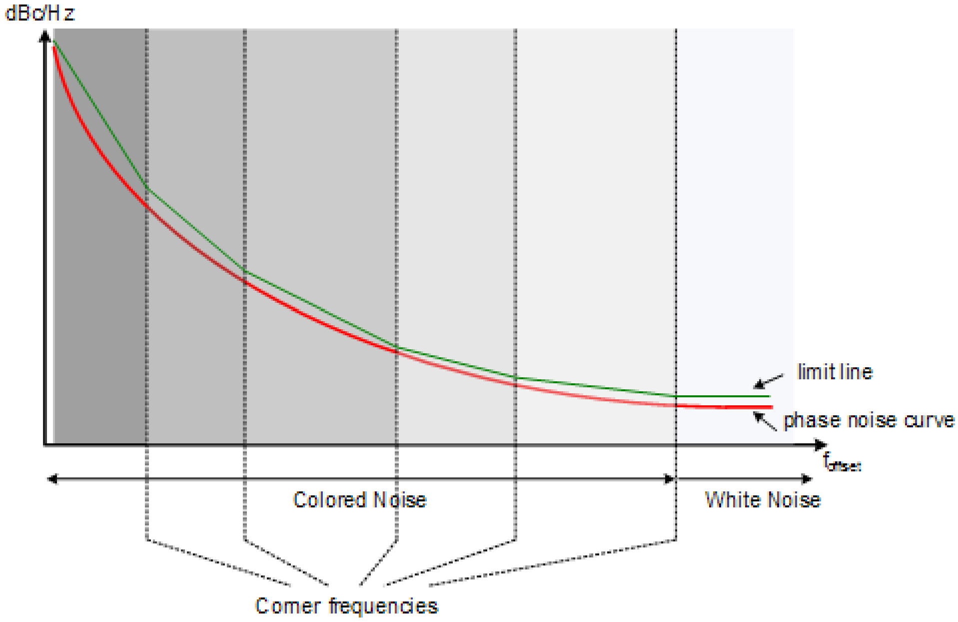


Fig. 4-8: Typical looks of a special limit line

Normal limit lines

Normal limit lines on the other hand may have any shape and may consist of up to 200 data points. You can turn on up to 8 normal limit lines at the same time. Each of those limit line can test one or several traces.

If you want to use them for phase noise measurements however, a limit line must be scaled in the unit dBc/Hz and must be defined on a logarithmic scale on the horizontal axis.

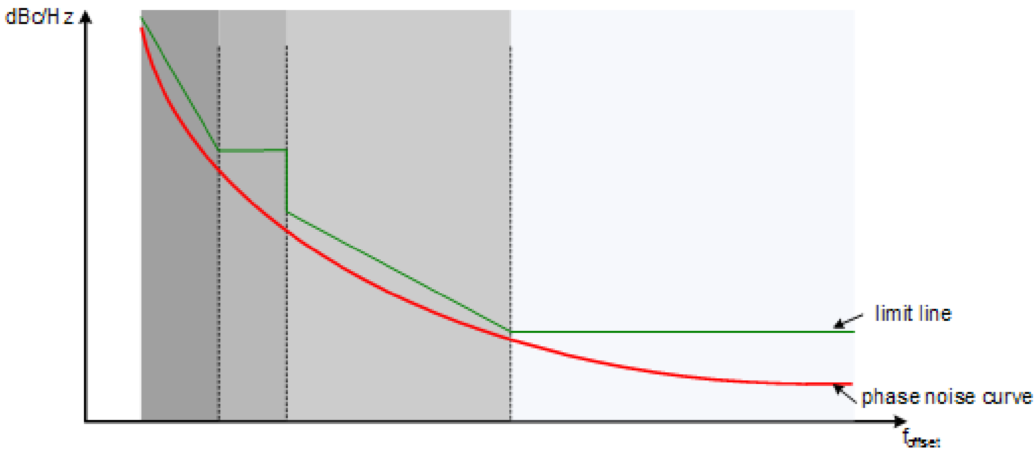


Fig. 4-9: Possible looks of a normal limit line

4.10 Analyzing Several Traces - Trace Mode

If several sweeps are performed one after the other, or continuous sweeps are performed, the trace mode determines how the data for subsequent traces is processed. After each sweep, the trace mode determines whether:

- the data is frozen (View)
- the data is hidden (Blank)
- the data is replaced by new values (Clear Write)
- the data is replaced selectively (Max Hold, Min Hold, Average)

Each time the trace mode is changed, the selected trace memory is cleared.

The R&S FSW provides the following trace modes:

Table 4-1: Overview of available trace modes

Trace Mode	Description
Blank	Hides the selected trace.
Clear Write	Overwrite mode: the trace is overwritten by each sweep. This is the default setting.
Max Hold	The maximum value is determined over several sweeps and displayed. The R&S FSW saves the sweep result in the trace memory only if the new value is greater than the previous one.
Min Hold	The minimum value is determined from several measurements and displayed. The R&S FSW saves the sweep result in the trace memory only if the new value is lower than the previous one.
Average	The average is formed over several sweeps. The sweep count determines the number of averaging procedures.
View	The current contents of the trace memory are frozen and displayed.

If a trace is frozen ("View" mode), the instrument settings, apart from level range and reference level, can be changed without impact on the displayed trace. The fact that the displayed trace no longer matches the current instrument setting is indicated by the icon on the tab label.

If the level range or reference level is changed, the R&S FSW automatically adapts the trace data to the changed display range. This allows an amplitude zoom to be made after the measurement in order to show details of the trace.

Trace averaging algorithm

In "Average" trace mode, the sweep count determines how many traces are averaged. The more traces are averaged, the smoother the trace is likely to become.

The algorithm for averaging traces depends on the sweep mode and sweep count.

- sweep count = 0 (default)

In continuous sweep mode, a continuous average is calculated for 10 sweeps, according to the following formula:

$$Trace = \frac{9 * Trace_{old} + MeasValue}{10}$$

Fig. 4-10: Equation 1

Due to the weighting between the current trace and the average trace, past values have practically no influence on the displayed trace after about ten sweeps. With this setting, signal noise is effectively reduced without need for restarting the averaging process after a change of the signal.

- sweep count = 1
  The currently measured trace is displayed and stored in the trace memory. No averaging is performed.
- sweep count > 1
  For both "Single Sweep" mode and "Continuous Sweep" mode, averaging takes place over the selected number of sweeps. In this case the displayed trace is determined during averaging according to the following formula:

$$Trace_n = \frac{1}{n} \cdot \left[\sum_{i=1}^{n-1} (T_i) + MeasValue_n \right]$$

Fig. 4-11: Equation 2

where n is the number of the current sweep (n = 2 ... Sweep Count).
No averaging is carried out for the first sweep but the measured value is stored in the trace memory. With increasing n, the displayed trace is increasingly smoothed since there are more individual sweeps for averaging.
After the selected number of sweeps the average trace is saved in the trace memory. Until this number of sweeps is reached, a preliminary average is displayed. When the averaging length defined by the "Sweep Count" is attained, averaging is continued in continuous sweep mode or for "Continue Single Sweep" according to the following formula:

$$Trace = \frac{(N-1) * Trace_{old} + MeasValue}{N}$$

where N is the sweep count

4.11 Using Markers

Markers are used to mark points on traces, to read out measurement results and to select a display section quickly. The application provides 4 markers.

By default, the application positions the marker on the lowest level of the trace.You can change a marker position in several ways.

- Enter a particular offset frequency in the input field that opens when you activate a marker.

- Move the marker around with the rotary knob or the cursor keys.
- Drag the marker around using the touchscreen.

4.11.1 Marker Types

All markers can be used either as normal markers or delta markers. A normal marker indicates the absolute signal value at the defined position in the diagram. A delta marker indicates the value of the marker relative to the specified reference marker (by default marker 1).

In addition, special functions can be assigned to the individual markers. The availability of special marker functions depends on whether the measurement is performed in the frequency or time domain.

4.11.2 Activating Markers

Only active markers are displayed in the diagram and in the marker table. Active markers are indicated by a highlighted softkey.

By default, marker 1 is active and positioned on the maximum value (peak) of trace 1 as a normal marker. If several traces are displayed, the marker is set to the maximum value of the trace which has the lowest number and is not frozen (View mode). The next marker to be activated is set to the frequency of the next lower level (next peak) as a delta marker; its value is indicated as an offset to marker 1.

A marker can only be activated when at least one trace in the corresponding window is visible. If a trace is switched off, the corresponding markers and marker functions are also deactivated. If the trace is switched on again, the markers along with coupled functions are restored to their original positions, provided the markers have not been used on another trace.

5 Configuration

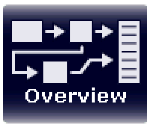
Phase noise measurements require a special application on the R&S FSW, which you activate using the MODE key on the front panel.

When you activate a measurement channel in the Phase Noise application, a measurement for the input signal is started automatically with the default configuration. The "Phase Noise" menu is displayed and provides access to the most important configuration functions.

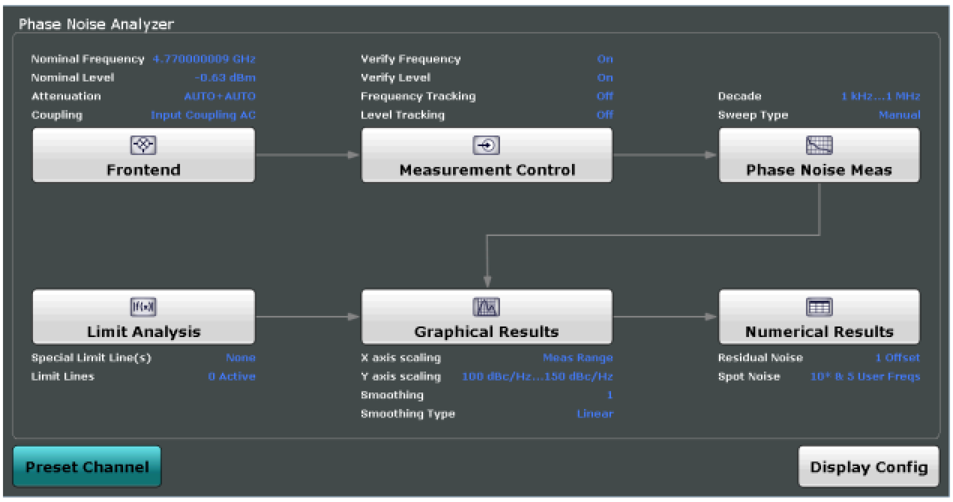
Automatic refresh of preview and visualization in dialog boxes after configuration changes

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

5.1 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".

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

1. Frontend
   See chapter 5.3, "Configuring the Frontend", on page 34.
2. Measurement Control
   See chapter 5.4, "Controlling the Measurement", on page 35.
3. Phase Noise Measurement
   See chapter 5.5, "Configuring the Measurement Range", on page 38.
4. Limit Analysis
   See chapter 6.3, "Using Limit Lines", on page 51.
5. Graphical Results
   See chapter 6.1, "Configuring Graphical Result Displays", on page 44.
6. Numerical Results
   See chapter 6.2, "Configure Numerical Result Displays", on page 49.

To configure settings

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

Preset Channel
Select 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 on the front panel restores all measurements **in all measurement channels** on the R&S FSW to their default values!

For details see chapter 5.2, "Default Settings for Phase Noise Measurements", on page 33.

SCPI command:
`SYSTem:PRESet:CHANnel[:EXECute]` on page 69

5.2 Default Settings for Phase Noise Measurements

When you enter the phase noise application for the first time, a set of parameters is passed on from the currently active application:

- nominal or center frequency

- nominal or reference level
- input coupling

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.

Apart from these settings, the following default settings are activated directly after a measurement channel has been set to the Phase Noise application, or after a channel preset:

Table 5-1: Default settings for phase noise measurement channels

Parameter	Value
Attenuation	Auto (0 dB)
Verify frequency & level	On
Frequency & level tracking	Off
Measurement range	1 kHz ... 1 MHz
Sweep type	Normal
X axis scaling	Measurement range
Y axis scaling	20 dBc/Hz ... 120 dBc/Hz
Smoothing	1%
Smoothing type	Linear

5.3 Configuring the Frontend

The "Frontend" tab of the "Measurement Settings" dialog box contains all funtions nec-essary to configure the frontend of the RF measurement hardware.

You can access this dialog box either via the "Phase Noise Analyzer" dialog box or the "Measurement Configuration" menu.

Nominal Frequency
Defines the nominal frequency of the measurement.

For more information see chapter 4.6, "Frequency Determination", on page 23.

SCPI command:
`[SENSe:]FREQuency:CENTer` on page 82

Nominal Level
Defines the nominal level of the R&S FSW.

For more informaation see .chapter 4.7, "Level Determination", on page 25

SCPI command:
`[SENSe:]POWer:RLEVel` on page 82

Mechanical Attenuator / Value
Turns mechanical attenuation on and off.

If on, you can define an attenuation level in 5 dB steps.

For more information see chapter 4.8, "Signal Attenuation", on page 26.

SCPI command:
Turning manual attenuation on and off:
`INPut:ATTenuation:AUTO` on page 83
Defining an attenuation level:
`INPut:ATTenuation` on page 82

Coupling
Selects the coupling method at the RF input.

AC coupling blocks any DC voltage from the input signal. DC coupling lets DC voltage through.

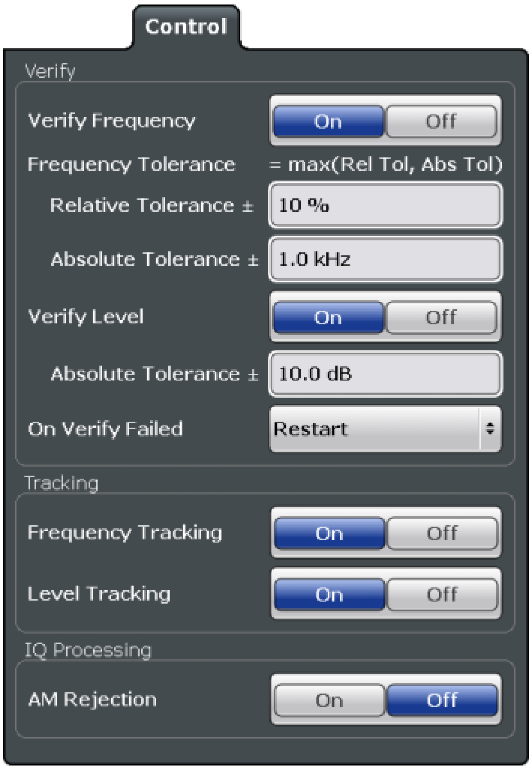
For more information refer to the data sheet.

SCPI command:
`INPut:COUPling` on page 83

5.4 Controlling the Measurement

The "Control" tab of the "Measurement Settings" dialog box contains all funtions necessary to control the sequence of the phase noise measurement.

You can access this dialog box either via the "Phase Noise Analyzer" dialog box or the "Measurement Configuration" menu.



Verify Frequency
Turns frequency verification on and off.

If frequency verification is on, the R&S FSW initiates the phase noise measurement only if the frequency of the DUT is within a certain frequency tolerance range. The tolerance range is either a percentage range of the nominal frequency or a absolute deviation from the nominal frequency.

If you define both an absolute and relative tolerance, the application uses the higher tolerance level.

For more information see chapter 4.6, "Frequency Determination", on page 23.

SCPI command:
Verify frequency:
`[SENSe:]FREQuency:VERify[:STATe]` on page 85
Relative tolerance:
`[SENSe:]FREQuency:VERify:TOLerance:RELative` on page 84
Absolute tolerance:
`[SENSe:]FREQuency:VERify:TOLerance:ABSolute` on page 84

Verify Level
Turns level verification on and off.

If level verification is on, the R&S FSW initiates the phase noise measurement only if the level of the DUT is within a certain level tolerance range. The tolerance range is a level range relative to the nominal level.

For more information see chapter 4.7, "Level Determination", on page 25.

SCPI command:
Verify level:
`[SENSe:]POWer:RLEVel:VERify[:STATe]` on page 85
Level tolerance:
`[SENSe:]POWer:RLEVel:VERify:TOLerance` on page 85

On Verify Failed
Selects the way the application reacts if signal verification fails.

Takes effect on both frequency and level verification.

"Restart"	Restarts the measurement if verification has failed.
"Stop"	Stops the measurement if verification has failed.
"Run Auto All"	Starts an automatic frequency and level detection routine if verification has failed. After the new frequency and level have been set, the measurement restarts. For more information see chapter 5.7, "Automatic Measurement Configuration", on page 42.

SCPI command:
`[SENSe:]SWEep:SVFailed` on page 86

Frequency Tracking
Turns frequency tracking on and off.

If on, the application tracks the frequency of the DUT during the phase noise measurement and adjusts the nominal frequency accordingly. The application adjusts the frequency after each half decade measurement.

For more information see chapter 4.6, "Frequency Determination", on page 23.

SCPI command:
`[SENSe:]FREQuency:TRACk` on page 84

Level Tracking
Turns level tracking on and off.

If on, the R&S FSW tracks the level of the DUT during phase noise measurements and adjusts the nominal level accordingly. The application adjusts the level after each half decade measurement.

For more information see chapter 4.7, "Level Determination", on page 25.

SCPI command:
`[SENSe:]POWer:TRACk` on page 86

AM Rejection
Turns the suppression of AM noise on and off.

If on, the application suppresses the AM noise that the signal contains in order to display phase noise as pure as possible.

AM rejection is available for the I/Q sweep mode.

SCPI command:
[SENSe:]REJect:AM on page 86

Tracking BW
Defines the minimum bandwidth or sample rate used in the signal processing to increase the probability of capture drifting signals.

The tracking bandwidth is valid for all half decades measured in I/Q mode.

SCPI command:
[SENSe:]IQ:TBW on page 85

5.5 Configuring the Measurement Range

The "Phase Noise" tab of the "Measurement Settings" dialog box contains all funtions necessary to configure the measurement range for phase noise measurements, including individual range settings.

You can access this dialog box either via the "Phase Noise Analyzer" dialog box or the "Measurement Configuration" menu.

Range Start / Stop

Defines the frequency offsets that make up the measurement range.

Note that the maximum offset you can select depends on the hardware you are using.

SCPI command:
Measurement Range Start
[SENSe:]FREQuency:STARt on page 88
Measurement Range Stop
[SENSe:]FREQuency:STOP on page 89

Sweep Forward

Selects the sweep direction. Forward and reverse sweep direction are available.

Forward sweep direction performs a measurement that begins at the smallest frequency offset you have defined. The measurement ends after the largest offset has been reached.

Reverse sweep direction performs a measurement that begins at the largest frequency offset you have defined. The measurement ends after the smallest offset has been reached. The reverse sweep is the default sweep direction because the application is able to lock on a drifting carrier frequency in that case.

SCPI command:
[SENSe:]SWEep:FORWard on page 92

Presets

Selects predefined measurement settings for each individual half decade that are used for the measurement.

"Fast" Fast measurements perform one measurement in each half decade. No averaging takes place.

"Normal" Normal measurements use averaging for some half decades, but with respect to measurement speed.

"Average" Average measurements use averaging for all half decades. However, you have to put up with slower measurement speed.

"Manual" Manual configuration of the measurement range.

SCPI command:
[SENSe:]SWEep:MODE on page 92

Global RBW

Defines the resolution bandwidth for all half decades globally.

The resulting RBW is a percentage of the start frequency of the corresponding half decade.

If the resulting RBW is not available, the application rounds to the next available band-width.

SCPI command:
[SENSe:]LIST:BWIDth[:RESolution]:RATio on page 88

Global Average Count
Defines the number of measurements that the application uses to calculate averaged results in each half decade.

The range is 1 to 10000.

If you turn on the "Multiplier", it defines the number of times the measurement is repeated for each half decade.

SCPI command:
[SENSe:]LIST:SWEep:COUNt on page 91

Global Sweep Mode
Selects the analysis mode for all half decades. The sweep mode defines the way the application processes the data.

For more information see chapter 4.4, "Sweep Modes", on page 21.

"Normal"	Uses spectrum analyzer data for the data analysis.
"I/Q / FFT"	Uses I/Q data for the data analysis.

SCPI command:
[SENSe:]LIST:BWIDth:RESolution:TYPE on page 89

Global I/Q Window
Selects the window function for all half decades.

The window function is available for I/Q analysis.

"Blackman Harris"	Blackman Harris window.
"Chebychev"	Chebychev window.
"Gaussian"	Gaussian window.
"Rectangular"	Rectangular window.

SCPI command:
[SENSe]:LIST:IQWindow:TYPE on page 89

Half Decades Configuration Table
Contains all functionality to configure the phase noise measurement range.

"Start"	Shows the offset frequency that the half decade starts with.
"Stop"	Shows the offset frequency that the half decade stops with.
"RBW"	Selects resolution bandwidth for the half decade. To avoid invalid measurements and long measurement times, the avail-ability of RBW for each half decade is limited.

"Sweep Mode" Selects the measurement mode. The measurement mode is the way the application analyzes the data.

- Swept
- I/Q / FFT

For more information see chapter 4.4, "Sweep Modes", on page 21.

"AVG" Defines the number of averagings that the application performs before the results for a half decade are displayed.

"Window" Selects the window type for a half decade.
Window functions are available for I/Q measurements.

"Meas Time" Shows an estimation of how long the measurement of a half decade lasts.

SCPI command:
RBW:
`[SENSe:]LIST:RANGe<range>:BWIDth[:RESolution]` on page 90
Sweep Mode
`[SENSe:]LIST:RANGe<range>:FILTer:TYPE` on page 90
Averages:
`[SENSe:]LIST:RANGe<range>:SWEep:COUNt` on page 91
Window:
`[SENSe:]LIST:RANGe<range>:IQWindow:TYPE` on page 91

5.6 Performing Measurements

The "Sweep" menu contains all functionality necessary to control and perform phase noise measurements.

You can access the "Sweep" menu with the SWEEP key.

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 on the front panel controls the Sequencer, not individual sweeps. RUN CONT starts the Sequencer in continuous mode.

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

SCPI command:
`INITiate:CONTinuous` on page 71

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

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

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

SCPI command:
`INITiate[:IMMediate]` on page 72

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.

SCPI command:
`INITiate:CONMeas` on page 71

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

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

SCPI command:
`[SENSe:]SWEep:COUNt` on page 74

5.7 Automatic Measurement Configuration

The "Auto Set" menu contains all functionality necessary to determine measurement parameters automatically.

You can access the "Auto Set" menu with the AUTO SET key.

Adjusting all Determinable Settings Automatically (Auto All)

Activates all automatic adjustment functions for the current measurement settings.

This includes:

- "Adjusting the Center Frequency Automatically (Auto Freq)" on page 43
- "Setting the Reference Level Automatically (Auto Level)" on page 43

SCPI command:

`[SENSe:]ADJust:ALL` on page 122

Adjusting the Center Frequency Automatically (Auto Freq)

This function adjusts the center frequency automatically.

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

SCPI command:

`[SENSe:]ADJust:FREQuency` on page 123

Setting the Reference Level Automatically (Auto Level)

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

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

SCPI command:

`[SENSe:]ADJust:LEVel` on page 123

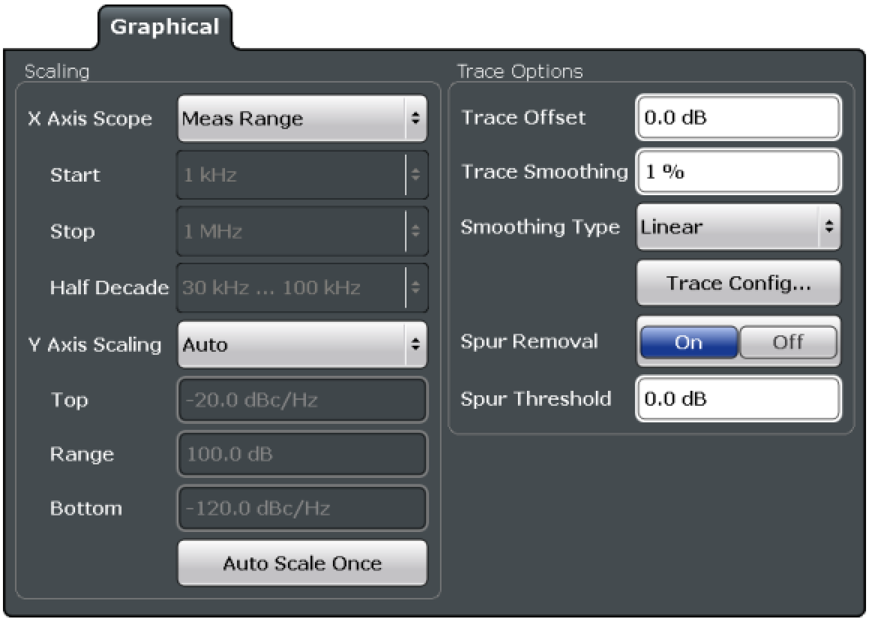
6 Analysis

The application provides various means and methods to analyze and evaluate measurement results.

6.1 Configuring Graphical Result Displays

The "Graphical" tab of the "Results" dialog box and the "Trace" menu contain all funtions necessary to set up and configure the graphical phase noise result displays.

You can access this dialog box either via the "Phase Noise Analyzer" dialog box or the "Measurement Configuration" menu. Access the "Trace" menu with the TRACE key.



6.1.1 Scaling the Diagram

X-Axis Scope

Selects the way the application scales the horizontal axis.

"Half Decade"	The horizontal axis shows one half decade that you can select.
"Manual"	The horizontal axis shows a detail of the measurement range that you can define freely.
"Meas Range"	The horizontal axis shows the complete measurement range.

SCPI command:
`DISPlay[:WINDow]:TRACe:X[:SCALe]:SCOPe` on page 105

X-Axis Start / Stop

Defines the start and stop frequency of the horizontal axis.

Note that the displayed frequency range is a detail of the measurement range. Regardless of the displayed frequency range, the application still performs all measurement over the measurement range you have defined.

The range depends on the measurement range. and possible increments correspond to the half decades.

Available for a manual "X Axis Scope".

SCPI command:
X-axis start:
`DISPlay[:WINDow]:TRACe:X[:SCALe]:STARt` on page 105
X-axis stop:
`DISPlay[:WINDow]:TRACe:X[:SCALe]:STOP` on page 106

Half Decade

Selects the half decade that is displayed.

Available if you have selected the half decade "X Axis Scope".

SCPI command:
`DISPlay[:WINDow]:TRACe:X[:SCALe]:HDECade` on page 104

Y Axis Scaling

Selects the type of scaling for the vertical axis.

"Auto"	Automatically scales the vertical axis.
"Top & Bottom"	Allows you to set the values at the top and bottom of the vertical axis.
"Top & Range"	Allows to set the value at the top of the vertical axis and its range.
"Bottom & Range"	Allows you to set the value at the bottom of the vertical axis and its range.

SCPI command:
Automatic scaling:
`DISPlay[:WINDow]:TRACe:Y[:SCALe]:AUTO` on page 106
Manual scaling:
`DISPlay[:WINDow]:TRACe:Y[:SCALe]:MANual` on page 107

Top / Range / Bottom

Define the top and bottom values or the range of the vertical axis.

Top defines the top values of the vertical axis. The unit is dBm/Hz.

Bottom defines the bottom value of the vertical axis. The unit is dBm/Hz.

Range defines the range of the vertical axis. The unit is dB.

The availability of the three fields depends on the type of manual "Y Axis Scaling" you have selected.

SCPI command:
Top:
DISPlay[:WINDow]:TRACe:Y[:SCALe]:RLEVel on page 107
Range:
DISPlay[:WINDow]:TRACe:Y:[:SCALe] on page 106
Bottom:
DISPlay[:WINDow]:TRACe:Y[:SCALe]:RLEVel:LOWer on page 107

Auto Scale Once
Automatically scales the vertical axis for ideal viewing.

6.1.2 Configuring Traces

Trace Offset
Defines a trace offset in dB.

The trace offset moves the trace vertically by the level you have defined.

The range is from -200 dB to 200 dB.

SCPI command:
DISPlay[:WINDow]:TRACe:Y[:SCALe]:RLEVel:OFFSet on page 108

Trace Smoothing
Defines the magnitude (or aperture) of trace smoothing in percent.

The range is from 1% to 20%. The aperture takes effect on all traces that you smooth.

For more information see chapter 4.5.3, "Trace Smoothing", on page 22.

SCPI command:
DISPlay[:WINDow]:TRACe:SMOothing:APERture on page 103

Smoothing Type
Selects the method that the application uses to smooth the trace.

For more information see chapter 4.5.3, "Trace Smoothing", on page 22.

"Linear" Converts the data to linear values before smoothing the trace.

"Logarithmic" Smoothes the (original) logarithmic data.

SCPI command:
DISPlay[:WINDow]:TRACe<t>:SMOothing:TYPE on page 104

Trace Config
Opens a dialog box to configure traces.

The application supports up to 6 traces with a different setup. In the diagram each trace has a different color.

The diagram header of the measurement window contains the trace information, including a color map, trace mode and smoothing percentage.

Traces ← Trace Config
The "Traces" tab contains functionality to configure a trace.

"Trace Selection" The "Trace 1" to "Trace 6" buttons select a trace. If a trace is selected, it is highlighted orange.
Note that you cannot select a trace if its trace mode is "Blank".

"Trace Mode" Selects the trace mode for the corresponding trace.
For more information see chapter 4.10, "Analyzing Several Traces - Trace Mode", on page 29.

"Smoothing" Turns trace smoothing for the corresponding trace on and off.
For more information see chapter 4.5.3, "Trace Smoothing", on page 22.

SCPI command:
Trace mode:
DISPlay[:WINDow]:TRACe<t>:MODE on page 103
Trace smoothing:
DISPlay[:WINDow]:TRACe<t>:SMOothing[:STATe] on page 104

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

Preset All Traces	Resets all traces to their default mode. Trace 1 - 2 mode = Clear Write; Trace 3 - 6 mode = Blank Trace 1 smoothing = On, Trace 2 - 6 smoothing = Off
Set Trace Mode Max | Avg | Min	Trace 1 mode: Max Hold Trace 2 mode: Average Trace 3 mode: Min Hold
Set Trace Mode Max | ClrWrite | Min	Trace 1 mode: Max Hold Trace 2 mode: Clear Write Trace 3 mode: Min Hold

Trace Export ← Trace Config

The "Trace Export" tab contains functionality to export trace data.

"Trace to Export"	Selects the trace that will be exported to a file.
"Decimal Separator"	Selects the decimal separator for floating-point numerals for the ASCII Trace export. Evaluation programs require different separators in different languages.
"Export Trace to ASCII File"	Opens a file selection dialog box and saves the selected trace in ASCII format to the specified file and directory.

SCPI command:
Decimal separator:
FORMat:DEXPort:DSEParator on page 108
Export trace to ASCII file:
MMEMory:STORe<n>:TRACe on page 108

Copy Trace ← Trace Config

The "Copy Trace" softkey opens the "Copy Trace" tab of the "Trace Configuration" dialog box.

The "Copy Trace" tab contains functionality to copy trace data to another trace.

The first group of buttons (labelled "Trace 1" to "Trace 6") select the source trace. The second group of buttons (labelled "Copy to Trace 1" to "Copy to Trace 6") select the destination.

SCPI command:
TRACe<n>:COPY on page 109

Trace Math ← Trace Config

The "Trace Math" tab contains functionality to control trace mathematics.

"State"	Turns trace mathematics on and off.
"Expression"	Selects the mathematical operation.

SCPI command:
State:
CALCulate<n>:MATH:STATe on page 103
Expression:
CALCulate<n>:MATH[:EXPression][:DEFine] on page 102

Spur Removal / Spur Threshold

Turns spur removal on and off and defines the threshold for spur removal.

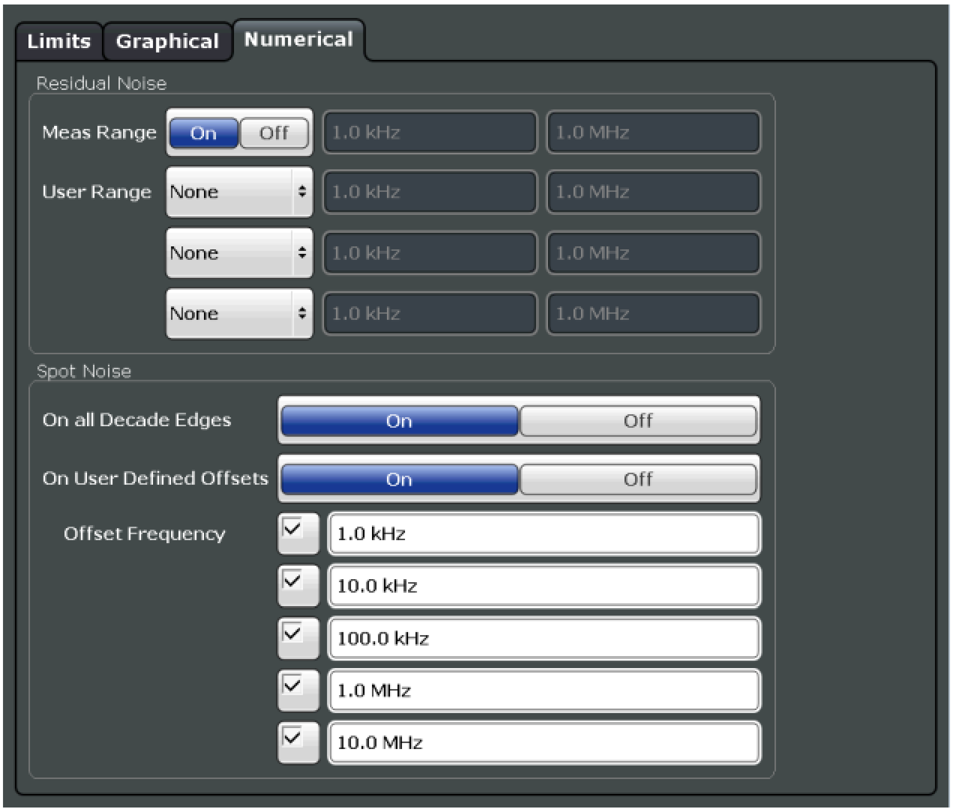
For more information see chapter 4.1, "Spurs and Spur Removal", on page 18.

SCPI command:
Turn spur suppression on and off:
[SENSe:]SPURs:SUPPression on page 109
Set the threshold:
[SENSe:]SPURs:THReshold on page 109

6.2 Configure Numerical Result Displays

The "Numerical" tab of the "Results" dialog box contains all funtions necessary to set up and configure the numerical phase noise result displays.

You can access this dialog box either via the "Phase Noise Analyzer" dialog box or the "Measurement Configuration" menu.



6.2.1 Configuring Residual Noise Measurements

Meas Range

Turns the integration of the entire measurement range for residual noise calculations on and off.

The range defined here is applied to all traces.

"On" The application calculates the residual noise over the entire measurement range.

"Off" The application calculates the residual noise over a customized range. The input fields next to the "On/Off" control become available to define a customized integration range.

SCPI command:
Turn customized range on and off:
CALCulate<n>:EVALuation[:STATe] on page 111
Define start point of custom range:
CALCulate<n>:EVALuation:STARt on page 110
Define end point of custom range:
CALCulate<n>:EVALuation:STOP on page 111

User Range
Defines a custom range for residual noise calculations. You have to assign a user range to a particular trace.

In the default state, user ranges are inactive. "None" is selected in the dropdown menu. If you assign the user range to a trace by selecting one of the traces from the dropdown menu, the input fields next to the trace selection become active. In these fields, you can define a start and stop offset frequency.

SCPI command:
Selecting a trace:
CALCulate<n>:EVALuation:USER<range>:TRACe on page 112
Define start frequency of user range:
CALCulate<n>:EVALuation:USER<range>:STARt on page 111
Define stop frequency of user range:
CALCulate<n>:EVALuation:USER<range>:STOP on page 112

6.2.2 Configuring Spot Noise Measurements

On All Decade Edges
Turns the calculation of spot noise on all 10^x offset frequencies on and off.

SCPI command:
Turn on and off spot noise calculation on 10^x offset frequencies:
CALCulate<n>:SNOise:DECades[:STATe] on page 114
Querying spot noise results on 10^x offset frequencies:
CALCulate<n>:SNOise:DECades:X? on page 115
CALCulate<n>:SNOise:DECades:Y? on page 115

On User Defined Offsets / Offset Frequency
Turns custom spot noise frequencies on and off.

If on, the "Offset Frequency" input fields become available. You can measure the spot noise for up to five custom offset frequencies. If active, the application adds those spots to the spot noise table.

SCPI command:

Turning spot noise marker on and off:
`CALCulate<n>:SNOise<m>:STATe` on page 115
`CALCulate<n>:SNOise:AOFF` on page 114
Positioning spot noise markers:
`CALCulate<n>:SNOise<m>:X` on page 116
Querying custom spot noise results:
`CALCulate<n>:SNOise<m>:Y?` on page 116

6.3 Using Limit Lines

The "Limits" tab of the "Results" dialog box contains all funtions necessary to set up and configure limit lines.

You can access this dialog box either via the "Phase Noise Analyzer" dialog box or the "Measurement Configuration" menu or the LINES key.

6.3.1 Using Phase Noise Limit Lines

Phase noise limit Line
Selects the shape of the phase noise limit line.

For more information see chapter 4.9, "Using Limit Lines", on page 27.

"None"	No limit line.
"Noise floor and x Ranges"	Limit line defined by the noise floor and x corner frequencies and slopes. The application supports up to 5 ranges.

SCPI command:
`CALCulate:PNLimit:TYPE` on page 94

Selected Traces
Selects the trace(s) to assign a phase noise limit line to.

For more information see chapter 4.9, "Using Limit Lines", on page 27.

SCPI command:
`CALCulate:PNLimit:TRACe` on page 94

Noise floor
Defines the noise floor level in dBm/Hz of the DUT.

For more information see chapter 4.9, "Using Limit Lines", on page 27.

SCPI command:
`CALCulate:PNLimit:NOISe` on page 94

Range x - Range y
Defines the corner frequencies and slope for a particular segment of phase noise limit lines.

The slope defines the slope of the limit line segment to the left of the corner frequency.

For more information see chapter 4.9, "Using Limit Lines", on page 27.

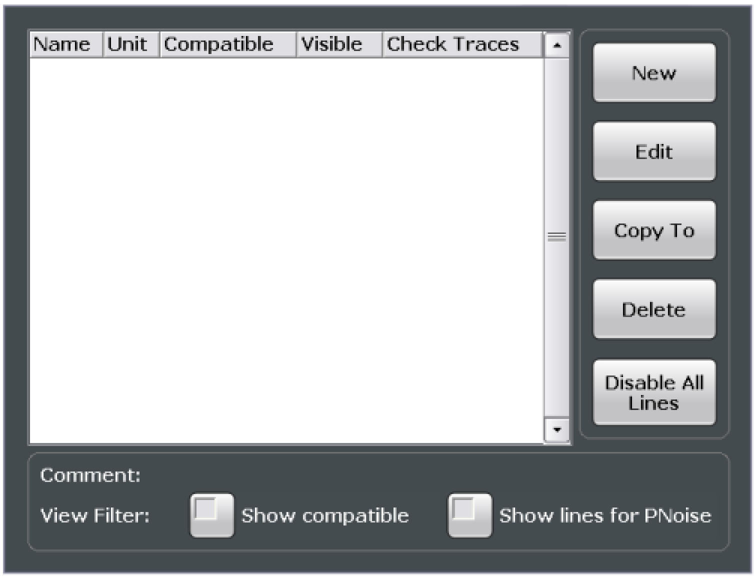
SCPI command:
Corner frequencies:
`CALCulate:PNLimit:FC5` on page 93
Slope:
CALCulate:PNLimit:SLOPe<segment> on page 95

6.3.2 Selecting Standard Limit Lines

Select Limit Line

The "Select Limit Line" dialog box contains functionality to include standard limit lines in the measurement.

The dialog box consists of a table that shows all available limit lines and their characteristics and a few buttons to manage individual limit lines.



Name ← Select Limit Line

Shows the name of the limit line.

Unit ← Select Limit Line

Shows the unit of the limit line.

Compatible ← Select Limit Line

Shows if the limit line is compatible to the current measurement setup or not.

"Yes"	You can use the limit line because it is compatible to the current measurement setup.
"No"	You cannot use the limit line because it is compatible to the current measurement setup.

Visible ← Select Limit Line

Displays a limit line in the diagram area.

You can display up to eight limit lines at the same time.

SCPI command:
Display a limit line:
Lower limit: `CALCulate:LIMit<k>:LOWer:STATe` on page 97
Upper limit: `CALCulate:LIMit<k>:UPPer:STATe` on page 98
Query all visible limit lines:
`CALCulate:LIMit:ACTive?` on page 96

Check Traces ← Select Limit Line
Turns the limit check for a particular trace on and off.

SCPI command:
Assign a limit line to a particular trace:
CALCulate:LIMit<k>:TRACe on page 98
Activate the limit check:
CALCulate:LIMit<k>:STATe on page 98
Querying limit check results:
CALCulate<n>:LIMit<k>:FAIL on page 97

Comment ← Select Limit Line
Shows the comment of the selected limit line. If the limit line has no comment, this field stays empty.

View Filter ← Select Limit Line
Turns filter for the list of limit lines on and off.

By default, the list includes all limit lines that are stored on the R&S FSW.

"Show Compatible"	Filters the list of limit lines by compatibility. If on, the list includes only those limit lines that are compatible to the current measurement setup.
"Show Lines For PNoise"	Filters the list of limit lines by compatibility to phase noise measurements. If on, the list includes only those limit lines that are compatible to phase noise measurements.

New / Edit / Copy To ← Select Limit Line
All three buttons open the "Edit Limit Line" dialog box to create or edit limit lines.

When you use the "New" button, the dialog box contains no data.

When you use the "Edit" button, the dialog box contains the data of the previously selected limit line.

When you use the "Copy To" button, the dialog box also contains a copy the data of the previously selected limit line.

SCPI command:
New:
CALCulate:LIMit<k>:NAME on page 97
Copy:
CALCulate:LIMit<k>:COPY on page 96

Delete ← Select Limit Line
Deletes the selected limit line.

SCPI command:
CALCulate:LIMit<k>:DELete on page 96

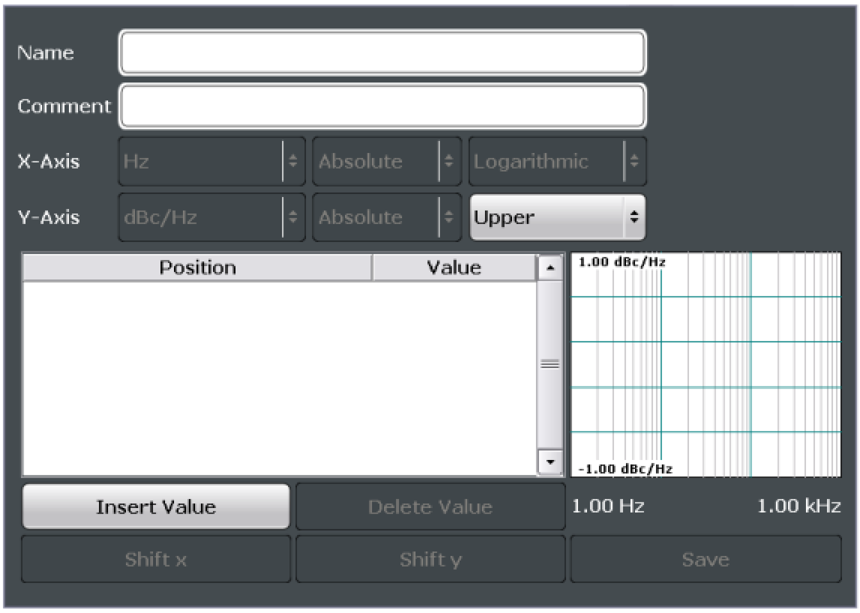
Disable All Lines ← Select Limit Line
Turns all active limit lines off.

6.3.3 Creating and Editing Standard Limit Lines

Edit Limit Line

The "Edit Limit Line" dialog box contains functionality to describe the shape of a limit line.

Because limit lines have to meet certain conditions for phase noise measurements, the availability of parameters is limited.



Name ← Edit Limit Line

Defines the name of a limit line.

SCPI command:

CALCulate:LIMit<k>:NAME on page 97

Comment ← Edit Limit Line

Defines a comment for the limit line.

A comment is not mandatory.

SCPI command:

CALCulate:LIMit:COMMent on page 99

X-Axis ← Edit Limit Line
Defines the characteristics of the horizontal axis.

The characteristics consist of the unit, the scaling and the type of values.

In the Phase Noise application, the unit for the horizontal axis is always Hz. The scaling can either be logarithmic or linear

"Unit"	In the Phase Noise application, the unit is always Hz.
"Scaling"	In the Phase Noise application, the scaling of the horizontal axis is always logarithmic.
"Type of Values"	The type of values can be absolute values or relative to the nominal frequency.

SCPI command:
Type of values:
`CALCulate:LIMit<k>:LOWer:MODE` on page 100
`CALCulate:LIMit<k>:UPPer:MODE` on page 100

Y-Axis ← Edit Limit Line
Defines the characteristics of the vertical axis.

The characteristics consist of the unit, the type of values and the usage of the line.

"Unit"	In the Phase Noise application, the unit is always dBc/Hz.
"Type of Values"	In the Phase Noise application, the type of values is always absolute.
"Line usage"	Selects if the limit line is used as an upper or lower limit line.

Data Points ← Edit Limit Line
The data points define the shape of the limit line. A limit line consists of at least 2 data points and a maximum of 200 data points.

A data point is defined by its position in horizontal ("Position" column) and vertical direction ("Value" column). The position of the data points have to be in ascending order.

SCPI command:
Horizontal data (position):
`CALCulate:LIMit<k>:CONTrol[:DATA]` on page 99
Vertical data (value):
Lower limit: `CALCulate:LIMit<k>:LOWer[:DATA]` on page 99
Upper limit: `CALCulate:LIMit<k>:UPPer[:DATA]` on page 101

Insert Value ← Edit Limit Line
Insert a new limit line data point below the selected data point.

Delete Value ← Edit Limit Line
Deletes the selected limit line data point.

Shift X ← Edit Limit Line
Shifts each data point horizontally by a particular amount.

SCPI command:
`CALCulate:LIMit<k>:CONTrol:SHIFt` on page 99

Shift Y ← Edit Limit Line
Shifts each data point vertically by a particular amount.

SCPI command:
Lower limit: `CALCulate:LIMit<k>:LOWer:SHIFt` on page 100
Upper limit: `CALCulate:LIMit<k>:UPPer:SHIFt` on page 101

Save ← Edit Limit Line
Saves the limit line or the changes you have made to a limit line.

6.4 Using Markers

The "Marker Configuration" dialog box and the "Marker" menu contain all functionality necessary to control markers.

You can access the "Marker" menu with the MKR key and the "Marker Configuration" dialog box with the "Marker Config" softkey.

Marker 1 ... Marker x
Selects and turns the corresponding marker on and off.

Turning on a marker also opens an input field to define the horizontal position of the marker.

In the "Marker Configuration" dialog box, the horizontal position of the marker corresponds to the stimulus.

By default, the first marker you turn on is a normal marker, all others are delta markers.

Marker Type

Toggles the marker type.

The type for marker 1 is always "Normal", the type for delta marker 1 is always "Delta". These types cannot be changed.

Note: If normal marker 1 is the active marker, switching the "Mkr Type" activates an additional delta marker 1. For any other marker, switching the marker type does not activate an additional marker, it only switches the type of the selected marker.

"Normal"	A normal marker indicates the absolute value at the defined position in the diagram.
"Delta"	A delta marker defines the value of the marker relative to the specified reference marker (marker 1 by default).

SCPI command:

`CALCulate<n>:MARKer<m>[:STATe]` on page 118

`CALCulate<n>:DELTamarker<m>[:STATe]` on page 120

Reference Marker

Defines a marker as the reference marker which is used to determine relative analysis results (delta marker values).

SCPI command:

`CALCulate<n>:DELTamarker<m>:MREF` on page 120

Assigning the Marker to a Trace

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

The marker can also be assigned to the currently active trace using the "Marker to Trace" softkey.

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

SCPI command:

`CALCulate<n>:MARKer<m>:TRACe` on page 118

Marker Zoom

Turns the marker zoom on and off.

The marker zoom magnifies the diagram area around marker 1 by a certain factor.

Turning on the zoom also opens an input field to define the zoom factor.

SCPI command:

Turning on the zoom:

`DISPlay[:WINDow:]ZOOM[:STATe]` on page 122

Defining the zoom factor:

`CALCulate:MARKer:FUNCtion:ZOOM` on page 122

All Markers Off

Deactivates all markers in one step.

SCPI command:

`CALCulate<n>:MARKer<m>:AOFF` on page 118

7 How to Configure Phase Noise Measurements

7.1 Performing a Basic Phase Noise Measurement

1. In the Spectrum application, define the center frequency of the DUT.
2. Enter the "Phase Noise" application.
   The R&S FSW-K40 starts the measurement with the default configuration. The default configuration defines most settings automatically.
   If you need any custom configuration, define them after entering the Phase Noise application.
3. Layout the display as required via the SmartGrid.
4. Open the "Overview" dialog box to configure the measurement.
5. Configure the frontend (frequency, level etc.) via the "Frontend" dialog box.
6. Define the measurement range via the "Phase Noise" dialog box.
7. Turn on frequency and level tracking via the "Control" dialog box.
8. Run a single sweep.
9. Turn on a marker and read out the results.
10. Read out the residual noise over the measurement range.
11. Customize a residual noise range and read out the results.
12. Freeze trace 1 and 2 (trace mode: View).
13. Turn on trace 3 and 4 (trace mode: Clear/Write).
14. Switch the measurement mode to "IQ FFT" in the "Phase Noise" dialog box.
15. Repeat the measurement.

7.2 Customizing the Measurement Range

The application provides several ways to customize. Each method features a different level of details you can define.

1. Open the "Phase Noise" configuration via the "Overview" dialog box or the "Meas Config" softkey menu.
2. Define the frequency offset range you'd like to measure in the corresponding fields.

3. Select the "Sweep Type".
   a) Select sweep types "Fast", "Normal" or "Averaged" for automatic measurement configuration.

   For a custom configuration, proceed to set up each measurement parameter separately.
4. Define the "RBW", number of "Averages", sweep "Mode" and "I/Q Window" function.
   a) Define the parameters globally for all (half) decades covered by the measurement range.
   b) Define the parameters for each individual (half) decade covered by the measurement range in the "Half Decade Configuration Table".

8 Remote Control Commands for Phase Noise Measurements

The following remote control commands are required to configure and perform phase noise measurements in a remote environment. The R&S FSW must already be set up for remote operation in a network as described in the base unit manual.

8.1 Introduction

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

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

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

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

Remote command examples

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

8.1.1 Long and Short Form

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

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

Example:

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

8.1.2 Numeric Suffixes

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

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

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

Example:

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

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

8.1.3 Optional Keywords

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

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

Optional keywords are emphasized with square brackets.

Example:

Without a numeric suffix in the optional keyword:

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

With a numeric suffix in the optional keyword:

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

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

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

8.1.4 Alternative Keywords

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

Example:

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

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

8.1.5 SCPI Parameters

Many commands feature one or more parameters.

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

Example:

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

Parameters may have different forms of values.

8.1.5.1 Numeric Values

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

Example:

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

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

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

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

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

- MIN/MAX
  Defines the minimum or maximum numeric value that is supported.
- DEF
  Defines the default value.

- UP/DOWN
  Increases or decreases the numeric value by one step. The step size depends on the setting. In some cases you can customize the step size with a corresponding command.

Querying numeric values

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

Example:

Setting: `SENSe:FREQuency:CENTer 1GHZ`

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

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

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

8.1.5.2 Boolean

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

Querying boolean parameters

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

Example:

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

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

8.1.5.3 Character Data

Character data follows the syntactic rules of keywords. You can enter text using a short or a long form. For more information see chapter 8.1.1, "Long and Short Form", on page 63.

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`

8.1.5.4 Character Strings

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

Example:

`INSTRument:DELete 'Spectrum'`

8.1.5.5 Block Data

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

The ASCII character # introduces the data block. The next number indicates how many of the following digits describe the length of the data block. In the example the 4 following digits indicate the length to be 5168 bytes. The data bytes follow. During the transmission of these data bytes all end or other control signs are ignored until all bytes are transmitted. #0 specifies a data block of indefinite length. The use of the indefinite format requires a NL^END message to terminate the data block. This format is useful when the length of the transmission is not known or if speed or other considerations prevent segmentation of the data into blocks of definite length.

8.2 Controlling the Phase Noise Measurement Channel

The following commands are necessary to control the measurement channel.

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

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

Parameters:

<ChannelType> Channel type of the new channel.
For a list of available channel types see table 8-1.

<ChannelName> String containing the name of the channel. The channel name is displayed as the tab label for the measurement channel.
Note: If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel (see table 8-1).

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

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

This command replaces a measurement channel with another one.

Parameters:

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

<ChannelType> Channel type of the new channel.
For a list of available channel types see table 8-1.

<ChannelName2> String containing the name of the new channel.
Note: If the specified name for a new channel already exists, the default name, extended by a sequential number, is used for the new channel (see table 8-1).

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

INSTrument:DELete <ChannelName>

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

Parameters:

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

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

INSTrument:LIST?

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

Return values:

<ChannelType>, <ChannelName> For each channel, the command returns the channel type and channel name (see table 8-1).
Tip: to change the channel name, use the `INSTrument:REName` command.

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

Usage: Query only

Table 8-1: Available measurement channel types and default channel names

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

INSTrument:REName <ChannelName1>, <ChannelName2>

This command renames a measurement channel.

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

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

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

INSTrument[:SELect] <Application>

Selects the measurement application (channel type) for the current channel.

See also `INSTrument:CREate[:NEW]` on page 66.

For a list of available channel types see table 8-1.

Parameters:
<Application> **PNOise**
Phase noise measurements, R&S FSW–K40

SYSTem:PRESet:CHANnel[:EXECute]

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

Use `INST:SEL` to select the channel.

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

Usage: Event

Manual control: See "Preset Channel" on page 33

8.3 Performing Measurements

The following commands are necessary to perform measurements.

You can also perform a sequence of measurements using the Sequencer (see "Multiple Measurement Channels and Sequencer Function" on page 9).

ABORt

This command aborts a current measurement and resets the trigger system.

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

For details see the "Remote Basics" chapter in the R&S FSW User Manual.

To abort a sequence of measurements by the Sequencer, use the `INITiate:SEQuencer:ABORt` on page 72 command.

Note on blocked remote control programs:

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

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

- **Visa**: `viClear()`
- **GPIB**: `ibclr()`
- **RSIB**: `RSDLLibclr()`

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

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

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

Usage: SCPI confirmed

CONFigure:REFMeas ONCE

This command initiates a reference measurement that determines the inherent phase noise of the R&S FSW.

Parameters:
ONCE

Example: `CONF:REFM ONCE`
Initiates a reference measurement

Manual control: See "Reference Measurement" on page 17

INITiate:CONMeas

This command restarts a (single) measurement that has been stopped (using `INIT:CONT OFF`) or finished in single sweep mode.

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

As opposed to `INITiate[:IMMediate]`, this command does not reset traces in max-hold, minhold or average mode. Therefore it can be used to continue measurements using maxhold or averaging functions.

Example: (for Spectrum application:)
`INIT:CONT OFF`
Switches to single sweep mode.
`DISP:WIND:TRAC:MODE AVER`
Switches on trace averaging.
`SWE:COUN 20`
Setting the sweep counter to 20 sweeps.
`INIT;*WAI`
Starts the measurement and waits for the end of the 20 sweeps.
`INIT:CONM;*WAI`
Continues the measurement (next 20 sweeps) and waits for the end.
Result: Averaging is performed over 40 sweeps.

Manual control: See "Continue Single Sweep" on page 42

INITiate:CONTinuous <State>

This command controls the sweep mode.

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

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

If the sweep mode is changed for a measurement channel while the Sequencer is active (see `INITiate:SEQuencer:IMMediate` on page 73) the mode is only considered the next time the measurement in that channel is activated by the Sequencer.

Parameters:
<State> ON | OFF

ON
Continuous sweep

OFF
Single sweep

*RST: ON

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

Manual control: See "Continuous Sweep/RUN CONT" on page 41

INITiate[:IMMediate]

This command starts a (single) new measurement.

With sweep count or average count > 0, this means a restart of the corresponding number of measurements. With trace mode MAXHold, MINHold and AVERage, the previous results are reset on restarting the measurement.

You can synchronize to the end of the measurement with *OPC, *OPC? or *WAI.

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

Example:
(For Spectrum application:)
`INIT:CONT OFF`
Switches to single sweep mode.
`DISP:WIND:TRAC:MODE AVER`
Switches on trace averaging.
`SWE:COUN 20`
Sets the sweep counter to 20 sweeps.
`INIT;*WAI`
Starts the measurement and waits for the end of the 20 sweeps.

Manual control: See "Single Sweep/ RUN SINGLE" on page 42

INITiate:SEQuencer:ABORt

This command stops the currently active sequence of measurements. The Sequencer itself is not deactivated, so you can start a new sequence immediately using `INITiate:SEQuencer:IMMediate` on page 73.

To deactivate the Sequencer use `SYSTem:SEQuencer` on page 74.

Usage: Event

INITiate:SEQuencer:IMMediate

This command starts a new sequence of measurements by the Sequencer. Its effect is similar to the INITiate[:IMMediate] command used for a single measurement.

Before this command can be executed, the Sequencer must be activated (see SYSTem:SEQuencer on page 74).

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

Usage: Event

INITiate:SEQuencer:MODE <Mode>

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

Before this command can be executed, the Sequencer must be activated (see SYSTem:SEQuencer on page 74).

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

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

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

Parameters:

<Mode>

SINGle
Each measurement is performed once (regardless of the channel's sweep mode), considering each channels' sweep count, until all measurements in all active channels have been performed.

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

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

*RST: CONTinuous

Example:

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

[SENSe:]SWEep:COUNt <SweepCount>

This command defines the number of sweeps the R&S FSW uses to average traces.

In case of continuous sweeps, the R&S FSW calculates the moving average over the average count.

In case of single sweep measurements, the R&S FSW stops the measurement and calculates the average after the average count has been reached.

Parameters:

<SweepCount> If you set a sweep count of 0 or 1, the R&S FSW performs one single sweep.

Range: 0 to 200000
*RST: 1

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 control: See "Sweep/Average Count" on page 42

SYSTem:SEQuencer <State>

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

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

Parameters:

<State> ON | OFF

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

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

*RST: OFF

Example:

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

8.4 Controlling the Screen Layout and Result Displays

The following commands are necessary to change the evaluation type and rearrange the screen layout as you do using the SmartGrid in manual operation.

DISPlay:MTABle <DisplayMode>

This command turns the marker table on and off.

Parameters:

<DisplayMode>

ON
Turns the marker table on.

OFF
Turns the marker table off.

AUTO
Turns the marker table on if 3 or more markers are active.

*RST: AUTO

Example: `DISP:MTAB ON`
Activates the marker table.

DISPlay[:WINDow<n>]:SELect

This command sets the focus on the selected result display window.

This window is then the active window.

Example: `DISP:WIND1:SEL`
Sets the window 1 active.

Usage: Setting only

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 79).

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:LARG`

DISPlay[:WINDow<n>]:STATe <State>

This command changes the display state of the selected measurement window.

Note that this command is maintained for compatibility reasons only. Use the `LAYout` commands for new remote control programs

(See chapter 8.4, "Controlling the Screen Layout and Result Displays", on page 75).

Parameters:

<State> ON | OFF

OFF

The window is closed.

*RST: OFF

Usage: SCPI confirmed

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

This command adds a window to the display.

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

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

Parameters:

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

<Direction> LEFT | RIGHt | ABOVe | BELow

Direction the new window is added relative to the existing window.

<WindowType> text value

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

Return values:

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

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

Table 8-2: <WindowType> parameter values for phase noise application

Parameter value	Window type
MTABle	Marker table
PNOise	Phase noise diagram
RNOise	Residual noise table
SNOise	Spot noise table

Parameter value	Window type
SPECtrum	Spectrum monitor
SPURs	Spur list

LAYout:CATalog[:WINDow]?

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

<WindowName_1>,<Index_1>..<WindowName_n>,<Index_n>

Return values:

<WindowName> string

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

<Index> **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.

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.

Usage: Query only

LAYout:REMove[:WINDow] <WindowName>

This command removes a window from the display.

Parameters:

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

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 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, 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 77 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.

As opposed to the `DISPlay[:WINDow<n>]:SIZE` on page 76 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.

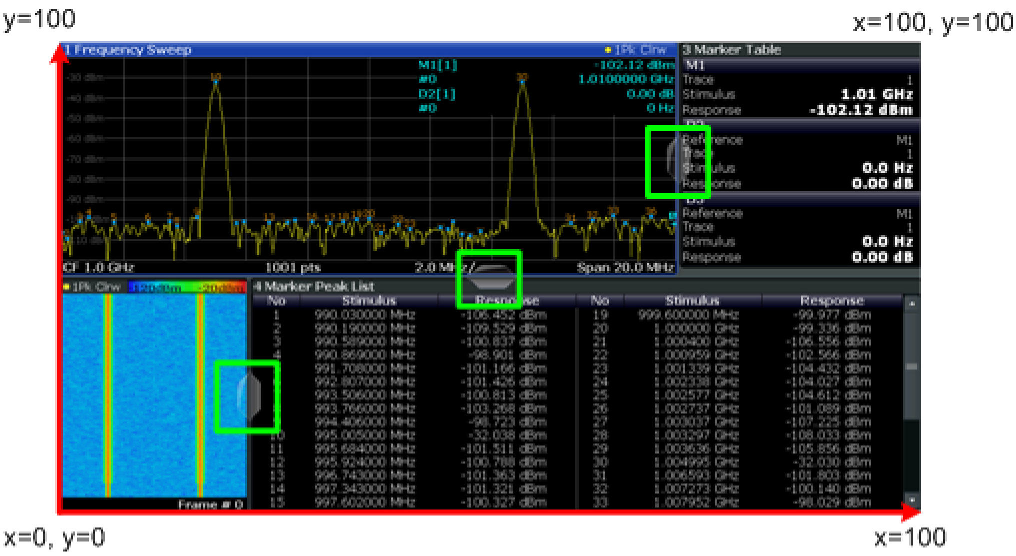


Fig. 8-1: SmartGrid coordinates for remote control of the splitters

Parameters:

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

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

<Position> New vertical or horizontal position of the splitter as a fraction of the screen area (without channel and status bar and softkey menu). The point of origin (x = 0, y = 0) is in the lower left corner of the screen. The end point (x = 100, y = 100) is in the upper right corner of the screen. (See figure 8-1.)
The direction in which the splitter is moved depends on the screen layout. If the windows are positioned horizontally, the splitter also moves horizontally. If the windows are positioned vertically, the splitter also moves vertically.
Range: 0 to 100

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

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

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

This command adds a measurement window to the display. Note that with this command, as opposed to `LAYout:ADD[:WINDow]?`, the suffix <n> determines the existing window next to which the new window is added.

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.

Parameters:

<Direction> LEFT | RIGHt | ABOVe | BELow

<WindowType> Type of measurement window you want to add.
See `LAYout:ADD[:WINDow]?` on page 77 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).

Note: to query the **index** of a particular window, use the `LAYout:IDENtify[:WINDow]?` command.

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

Usage: Query only

LAYout:WINDow<n>:REMove

This command removes the window specified by the suffix <n> from the display.

The result of this command is identical to the `LAYout:REMove[:WINDow]` command.

Usage: Event

LAYout:WINDow<n>:REPLace <WindowType>

This command changes the window type of an existing window (specified by the suffix <n>).

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.

Parameters:
<WindowType> Type of measurement window you want to replace another one with.
See `LAYout:ADD[:WINDow]?` on page 77 for a list of available window types.

8.5 Configuring the Frontend

The following commands are necessary to configure the frontend settings.

[SENSe:]FREQuency:CENTer <Frequency>

This command defines the nominal frequency.

Parameters:

<Frequency>
Range: 0 to fmax
*RST: fmax/2
Default unit: Hz
f_{max} is specified in the data sheet. min span is 10 Hz

Example: `FREQ:CENT 100 MHz`
Defines a nominal frequency of 100 MHz.

Usage: SCPI confirmed

Manual control: See "Nominal Frequency" on page 35

[SENSe:]POWer:RLEVel <Power>

This command defines the nominal level.

Parameters:

<Power>
Numeric value in dBm.
Range: -200 to 200
*RST: 0

Example: `POW:RLEV -20`
Defines a nominal level of -20 dBm.

Usage: SCPI confirmed

Manual control: See "Nominal Level" on page 35

INPut:ATTenuation <Attenuation>

This command defines the total attenuation for RF input.

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

Parameters:

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

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

Usage: SCPI confirmed

Manual control: See "Mechanical Attenuator / Value" on page 35

INPut:ATTenuation:AUTO <State>

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

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

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

Usage: SCPI confirmed

Manual control: See "Mechanical Attenuator / Value" on page 35

INPut:COUPling <CouplingType>

This command selects the coupling type of the RF input.

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

Example: `INP:COUP:DC`

Usage: SCPI confirmed

Manual control: See "Coupling" on page 35

8.6 Controlling the Measurement

The following commands are necessary to control the sequence of the phase noise measurement.

[SENSe:]FREQuency:TRACk <State>

This command turns frequency tracking on and off.

Parameters:

<State> ON | OFF

*RST: ON

Example: `FREQ:TRAC OFF`
Turns off frequency tracking.

Manual control: See "Frequency Tracking" on page 37

[SENSe:]FREQuency:VERify:TOLerance:ABSolute <Frequency>

This command defines an absolute frequency tolerance for frequency verification.

If you define both an absolute and relative tolerance, the application uses the higher tolerance level.

Parameters:

<Frequency> Numeric value in Hz.

*RST: 1 kHz

Example: `FREQ:VER:TOL:ABS 100kHz`
Defines a frequency tolerance range of 100 kHz.

Manual control: See "Verify Frequency" on page 36

[SENSe:]FREQuency:VERify:TOLerance:RELative <Percentage>

This command defines a relative frequency tolerance for frequency verification.

If you define both an absolute and relative tolerance, the application uses the higher tolerance level.

Parameters:

<Percentage> Numeric value in %, relative to the current nominal frequency.

Range: 1 to 100
*RST: 10
Default unit: PCT

Example: `FREQ:VER:TOL:REL 12`
Defines a frequency tolerance of 12% in relation to the nominal frequency.

Usage: SCPI confirmed

Manual control: See "Verify Frequency" on page 36

[SENSe:]FREQuency:VERify[:STATe] <State>

This command turns frequency verification on and off.

Parameters:

<State> ON | OFF

*RST: ON

Example: `FREQ:VER ON`
Turns on frequency verification.

Usage: SCPI confirmed

Manual control: See "Verify Frequency" on page 36

[SENSe:]IQ:TBW <Bandwidth>

This command defines the maximum tracking bandwidth (sample rate) for all half decades.

Parameters:

<Bandwidth> Range: 60 mHz to 65.28 MHz
Increment: 10 mHz
*RST: 60 mHz

Example: `IQ:TBW 100HZ`
Defines a tracking bandwidth of 100 Hz.

Manual control: See "Tracking BW" on page 38

[SENSe:]POWer:RLEVel:VERify:TOLerance <Level>

This command defines a relative level tolerance for level verification

Parameters:

<Level> Numeric value in dB, relative to the nominal level.

*RST: 10 dB

Example: `POW:RLEV:TOL 5`
Defines a level tolerance of 5 dB.

Usage: SCPI confirmed

Manual control: See "Verify Level" on page 37

[SENSe:]POWer:RLEVel:VERify[:STATe] <State>

This command turns level verification on and off.

Parameters:

<State> ON | OFF

*RST: ON

Example: `POW:RLEV:VER ON`
Turns on level verification.

Usage: SCPI confirmed

Manual control: See "Verify Level" on page 37

[SENSe:]POWer:TRACk <State>

This command turns level tracking on and off.

Parameters:

<State> ON | OFF

*RST: ON

Example: `POW:TRAC ON`
Turns on level tracking.

Usage: SCPI confirmed

Manual control: See "Level Tracking" on page 37

[SENSe:]REJect:AM <State>

This command turns the suppression of AM noise on and off.

Parameters:

<State> ON | OFF

Example: `REJ:AM ON`
Turns AM noise suppression on.

Manual control: See "AM Rejection" on page 37

[SENSe:]SWEep:SVFailed <State>

This command turns repeated tries to start the measurement if signal verification fails on and off.

Parameters:

<State> ON | OFF

If on, the application tries to verify the signal once and then aborts the measurement if verification has failed.

*RST: OFF

Example: `SWE:SVF ON`
Stops the measurement if signal verification has failed.

Manual control: See "On Verify Failed" on page 37

8.7 Configuring the Measurement Range

The following commands are necessary to configure the phase noise measurement range.

Table 8-3: <range> suffix assignment

Suffix	Half Decade
1	1 Hz ... 3 Hz
2	3 Hz ... 10 Hz
3	10 Hz ... 30 Hz
4	30 Hz ... 100 Hz
5	100 Hz ... 300 Hz
6	300 Hz ... 1 kHz
7	1 kHz ... 3 kHz
8	3 kHz ... 10 kHz
9	10 kHz ... 30 kHz
10	30 kHz ... 100 kHz
11	100 kHz ... 300 kHz
12	300 kHz ... 1 MHz
13	1 MHz ... 3 MHz
14	3 MHz ... 10 MHz
15	10 MHz ... 30 MHz
16	30 MHz ... 100 MHz
17	100 MHz ... 300 MHz
18	300 MHz ... 1 GHz
19	1 GHz ... 3 GHz
20	3 GHz ... 10 GHz

[SENSe:]LIST:BWIDth[:RESolution]:RATio <Ratio>

This command defines the resolution bandwidth over all half decades.

Parameters:

<Ratio> Numeric value in %.
The resulting RBW is the percentage of the start frequency of each half decade.
If the resulting RBW is not available, the application rounds to the next available bandwidth.

Range: 1 to 100
*RST: 10

Example: `LIST:BWID:RAT 20`
Defines a RBW of 20% of the start frequency of the corresponding half decade.

Manual control: See "Global RBW" on page 39

[SENSe:]BANDwidth|BWIDth[:RESolution]:TYPE <Mode>

This command selects the sweep mode for a all half decades globally.

Parameters:

<Mode>

IQ
Measurement based on I/Q data.

NORMal
Measurement based on spectrum analyzer data.

FFT
Measurement based on spectrum analyzer data. Kept for compatibility to R&S FSV.

*RST: Depends on half decade

Example: `BAND:TYPE FFT`
Selects FFT analysis for all half decades.

[SENSe:]FREQuency:STARt <Frequency>

This command defines the start frequency of the measurement range.

Parameters:

<Frequency> Offset frequencies in half decade steps.

Range: 1 Hz to 3 GHz
*RST: 1 kHz

Example: `FREQ:STAR 10kHz`
Defines a start frequency of 10 kHz.

Usage: SCPI confirmed

Manual control: See "Range Start / Stop" on page 39

[SENSe:]FREQuency:STOP <Frequency>

This command defines the stop frequency of the measurement range.

Parameters:

<Frequency> Offset frequencies in half decade steps.

Range: 3 Hz to 10 GHz
*RST: 1 MHz

Example: `FREQ:STOP 10MHz`
Defines a stop frequency of 10 MHz.

Usage: SCPI confirmed

Manual control: See "Range Start / Stop" on page 39

[SENSe:]LIST:BWIDth:RESolution:TYPE <Mode>

This command selects the sweep mode for all half decades.

Parameters:

<Mode>

IQFFt
Measurement based on I/Q data.

NORMal
Measurement based on spectrum analyzer data.

FFT
Measurement based on spectrum analyzer data. Kept for compatibility to R&S FSV.

*RST: Depends on half decade

Example: `LIST:BWID:RES:TYPE IQFF`
Selects I/Q analysis mode for all half decades.

Manual control: See "Global Sweep Mode" on page 40

[SENSe]:LIST:IQWindow:TYPE <WindowFunction>

This command selects the window function for all half decades.

Window functions are available for I/Q sweep mode.

Parameters:

<WindowFunction>

RECtangular

GAUSsian

CHEBychev

BHARris

*RST: Depends on the half decade

Example: `LIST:IQW:TYPE REC`
Selects a rectangular FFT window.

Manual control: See "Global I/Q Window" on page 40

[SENSe:]LIST:RANGe<range>:BWIDth[:RESolution] <RBW>

This command defines the resolution bandwidth for a particular half decade.

Suffix:
<range> 1...20
Selects the half decade.
For the suffix assignment see table 8-3.

Parameters:
<RBW> Numeric value in Hz.
Note that each half decade has a limited range of available bandwidths.
*RST: Depends on the half decade
Default unit: Hz

Example: `LIST:RANG9:BWID 100Hz`
Selects a RBW of 100 Hz for the half decade from 1 kHz to 3 kHz.

Manual control: See "Half Decades Configuration Table" on page 40

[SENSe:]LIST:RANGe<range>:FILTer:TYPE <Mode>

This command selects the sweep mode for a particular half decade.

Suffix:
<range> 1...20
Selects the half decade.
For the suffix assignment see table 8-3.

Parameters:
<Mode>
IQFFt
Measurement based on I/Q data.
NORMal
Measurement based on spectrum analyzer data.
FFT
Measurement based on spectrum analyzer data. Kept for compatibility to R&S FSV.
*RST: Depends on half decade

Example: `LIST:RANG9:FILT:TYPE FFT`
Selects FFT analysis for the ninth half decade.

Manual control: See "Half Decades Configuration Table" on page 40

[SENSe:]LIST:RANGe<range>:IQWindow:TYPE <WindowFunction>

This command selects the window function for a particular half decade.

Window functions are available for I/Q sweep mode.

Suffix:

<range> 1...20
Selects the half decade.
For the suffix assignment see table 8-3.

Parameters:

<WindowFunction>
RECtangular
GAUSsian
CHEBychev
BHARris
*RST: Depends on the half decade

Example: `LIST:RANG:IQW:TYPE BHAR`
Selects the Blackman Harris window function for the first half decade.

Manual control: See "Half Decades Configuration Table" on page 40

[SENSe:]LIST:RANGe<range>:SWEep:COUNt <Measurements>

This command defines the number of measurements included in the averaging for a half decade.

Suffix:

<range> 1...20
Selects the half decade.
For the suffix assignment see table 8-3.

Parameters:

<Measurements>
Range: 1 to 10000
*RST: Depends on the half decade

Example: `LIST:RANG9:SWE:COUN 15`
Includes 15 measurements in the averaging of the ninth half decade.

Usage: SCPI confirmed

Manual control: See "Half Decades Configuration Table" on page 40

[SENSe:]LIST:SWEep:COUNt <Averages>

This command defines the number of measurements to be included in the averaging for each and all half decades.

Parameters:

<Averages> Range: 1 to 10000
*RST: Depends on the half decade.

Example: `LIST:SWE:COUN 20`
Defines 20 averages for all half decades.

Manual control: See "Global Average Count" on page 40

[SENSe:]SWEep:FORWard <State>

This command selects the measurement direction.

Specifies the sweep direction. When switched on the sweep direction is from the start frequency to the stop frequency. When switched off the sweep direction is reversed

Parameters:

<State>

ON
Measurements in forward direction.
The measurements starts at the smallest offset frequency.

OFF
Measurement in reverse direction.
The measurement starts at the highest offset frequency.

*RST: OFF

Example: `SWE:FORW ON`
Selects forward measurements.

Usage: SCPI confirmed

Manual control: See "Sweep Forward" on page 39

[SENSe:]SWEep:MODE <Mode>

This command selects the type of measurement configuration.

Parameters:

<Mode>

AVERage
Selects a measurement configuration optimized for quality results.

FAST
Selects a measurement configuration optimized for speed.

MANual
Selects manual measurement configuration.

NORMal
Selects a balanced measurement configuration.

*RST: NORMal

Usage: SCPI confirmed

Manual control: See "Presets" on page 39

8.8 Using Limit Lines

The following commands are necessary to set up and configure limit lines.

8.8.1 Using Phase Noise Limit Lines

CALCulate:PNLimit:FC1 <Frequency>
CALCulate:PNLimit:FC2 <Frequency>
CALCulate:PNLimit:FC3 <Frequency>
CALCulate:PNLimit:FC4 <Frequency>
CALCulate:PNLimit:FC5 <Frequency>

This command defines the start frequency of a segment of a phase noise limit line.

CALCulate:PNLimit:FC1 is available for special phase noise limit lines with one segment or more.

CALCulate:PNLimit:FC2 is available for special phase noise limit lines with two segment or more.

CALCulate:PNLimit:FC3 is available for special phase noise limit lines with three segment or more.

CALCulate:PNLimit:FC4 is available for special phase noise limit lines with four segment or more.

CALCulate:PNLimit:FC5 is available for special phase noise limit lines with five segments.

Parameters:

<Frequency> Offset frequency relative to the carrier frequency.
The minimum offset is 1 Hz. The maximum offset depends on the hardware you are using.

*RST: 1 MHz

Example: `CALC:PNL:FC1 2MHZ`
Defines a corner frequency at 2 MHz offset.

Manual control: See "Range x - Range y" on page 52

CALCulate:PNLimit:NOISe <NoiseLevel>

This command defines the noise floor level of the DUT.

The noise floor level is necessary for the calculation of a phase noise limit line.

Parameters:

<NoiseLevel> Range: -200 to 200
*RST: 0
Default unit: dBm/Hz

Example:
```
CALC:PNL:NOIS -150
```
Defines a noise floor level of 150 dBm/Hz.

Manual control: See "Noise floor" on page 52

CALCulate:PNLimit:TRACe <Trace>

This command selects the trace to assign a phase noise limit line to.

Parameters:

<Trace> Range: 1 to 6
*RST: -

Example:
```
CALC:PNL:TRAC 1
```
Assigns the phase noise limit line to trace 1.

Manual control: See "Selected Traces" on page 52

CALCulate:PNLimit:TYPE <Shape>

This command selects the shape of a phase noise limit line.

Parameters:

<Shape>

FC1
Limit line defined by the noise floor and 1 corner frequency.

FC2
Limit line defined by the noise floor and 2 corner frequencies.

FC3
Limit line defined by the noise floor and 3 corner frequencies.

FC4
Limit line defined by the noise floor and 4 corner frequencies.

FC5
Limit line defined by the noise floor and 5 corner frequencies.

NONE
No limit line.

*RST: NONE

Example: `CALC:PNL:TYPE FC2`
Selects a limit line with 2 corner frequencies.

Manual control: See "Phase noise limit Line" on page 52

CALCulate:PNLimit:FAIL?

This command queries the limit check results for phase noise limit lines.

Return values:
<LimitCheck>

1
Limit check has passed.

0
Limit check has failed.

Example: `CALC:PNL:FAIL?`
Queries the limit check result.

Usage: Query only

CALCulate:PNLimit:SLOPe<segment> <Slope>

This command defines the slope for a phase noise limit line segment.

Suffix:
<segment>

1...5
Selects the limit line segment.

Parameters:
<Slope>

Level distance from the left border of the limit line segment to the previous one.

*RST: 10
Default unit: dB

Example: `CALC:PNL:SLOP2 20`
Defines a slope of 20 dB for the second limit line segment.

Manual control: See "Range x - Range y" on page 52

8.8.2 Using Standard Limit Lines

CALCulate:LIMit:ACTive?

This command queries the names of all active limit lines.

Return values:

<LimitLines> String containing the names of all active limit lines in alphabetical order.

Example: `CALC:LIM:ACT?`
Queries the names of all active limit lines.

Usage: Query only

Manual control: See "Select Limit Line" on page 53
See "Visible" on page 53

CALCulate:LIMit:CLEar[:IMMediate]

This command deletes the result of the current limit check.

The command works on all limit lines in all measurement windows at the same time.

Example: `CALC:LIM:CLE`
Deletes the result of the limit check.

Usage: SCPI confirmed

CALCulate:LIMit<k>:COPY <Line>

This command copies a limit line.

Parameters:

<Line> **1 to 8**
number of the new limit line

<name>
String containing the name of the limit line.

Example: `CALC:LIM1:COPY 2`
Copies limit line 1 to line 2.
`CALC:LIM1:COPY 'FM2'`
Copies limit line 1 to a new line named FM2.

Manual control: See "Select Limit Line" on page 53
See "New / Edit / Copy To" on page 54

CALCulate:LIMit<k>:DELete

This command deletes a limit line.

Usage: Event

Manual control: See "Select Limit Line" on page 53
See "Delete" on page 54

CALCulate<n>:LIMit<k>:FAIL

This command queries the result of a limit check.

To get a valid result, you have to perform a complete measurement with synchronization to the end of the measurement before reading out the result. This is only possible for single sweeps. See also `INITiate:CONTinuous` on page 71.

Return values:

<Result>
: **0**
PASS
: **1**
FAIL

Example:
`INIT;*WAI`
Starts a new sweep and waits for its end.
`CALC:LIM3:FAIL?`
Queries the result of the check for limit line 3.

Usage: SCPI confirmed

Manual control:
See "Select Limit Line" on page 53
See "Check Traces" on page 54

CALCulate:LIMit<k>:NAME <Name>

This command selects a limit line that already exists or defines a name for a new limit line.

Parameters:

<Name>
String containing the limit line name.
*RST: REM1 to REM8 for lines 1 to 8

Manual control:
See "Select Limit Line" on page 53
See "New / Edit / Copy To" on page 54
See "Edit Limit Line" on page 55
See "Name" on page 55

CALCulate:LIMit<k>:LOWer:STATe <State>

This command turns a lower limit line on and off.

Before you can use the command, you have to select a limit line with `CALCulate:LIMit<k>:NAME` on page 97.

Parameters:

<State>
ON | OFF
*RST: OFF

Usage: SCPI confirmed

Manual control:
See "Select Limit Line" on page 53
See "Visible" on page 53

CALCulate:LIMit<k>:STATe <State>

This command turns the limit check on and off.

To query the limit check result, use `CALCulate<n>:LIMit<k>:FAIL`.

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

Example: `CALC:LIM:STAT ON`
Switches on the limit check for limit line 1.

Usage: SCPI confirmed

Manual control: See "Select Limit Line" on page 53
See "Check Traces" on page 54

CALCulate:LIMit<k>:TRACe <TraceNumber>

This command links a limit line to one or more traces.

Example: `CALC:LIM2:TRAC 3`
Assigns limit line 2 to trace 3.

Manual control: See "Select Limit Line" on page 53
See "Check Traces" on page 54

CALCulate:LIMit<k>:UPPer:STATe <State>

This command turns an upper limit line on and off.

Before you can use the command, you have to select a limit line with `CALCulate:LIMit<k>:NAME` on page 97.

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

Usage: SCPI confirmed

Manual control: See "Select Limit Line" on page 53
See "Visible" on page 53

8.8.3 Creating and Editing Standard Limit Lines

CALCulate:LIMit:COMMent <Comment>

This command defines a comment for a limit line.

Parameters:

<Comment> String containing the description of the limit line. The comment may have up to 40 characters.

Manual control: See "Edit Limit Line" on page 55
See "Comment" on page 55

CALCulate:LIMit<k>:CONTrol[:DATA] <LimitLinePoints>

This command defines the horizontal definition points of a lower limit line.

Parameters:

<LimitLinePoints> Variable number of x-axis values.
Note that the number of horizontal values has to be the same as the number of vertical values set with `CALCulate:LIMit<k>:LOWer[:DATA]` or `CALCulate:LIMit<k>:UPPer[:DATA]`. If not, the R&S FSW either adds missing values or ignores surplus values.
The unit is Hz.
*RST: Limit line state is OFF

Usage: SCPI confirmed

Manual control: See "Edit Limit Line" on page 55
See "Data Points" on page 56

CALCulate:LIMit<k>:CONTrol:SHIFt <Distance>

This command moves a complete limit line horizontally.

Compared to defining an offset, this command actually changes the limit line definition points by the value you define.

Parameters:

<Distance> Numeric value.
The unit depends on the scale of the x-axis.

Manual control: See "Edit Limit Line" on page 55
See "Shift X" on page 56

CALCulate:LIMit<k>:LOWer[:DATA] <LimitLinePoints>

This command defines the vertical definition points of a lower limit line.

Parameters:

<LimitLinePoints> Variable number of level values.
Note that the number of vertical values has to be the same as the number of horizontal values set with `CALCulate:LIMit<k>:CONTrol[:DATA]`. If not, the R&S FSW either adds missing values or ignores surplus values.

*RST: Limit line state is OFF

Usage: SCPI confirmed

Manual control: See "Edit Limit Line" on page 55
See "Data Points" on page 56

CALCulate:LIMit<k>:LOWer:MODE <Mode>

This command selects the vertical limit line scaling.

Parameters:

<Mode>

ABSolute
Limit line is defined by absolute physical values.
The unit is variable.

RELative
Limit line is defined by relative values related to the reference level (dB).

*RST: ABSolute

Manual control: See "Edit Limit Line" on page 55
See "X-Axis" on page 56

CALCulate:LIMit<k>:LOWer:SHIFt <Distance>

This command moves a complete lower limit line vertically.

Compared to defining an offset, this command actually changes the limit line definition points by the value you define.

Parameters:

<Distance> Defines the distance that the limit line moves.

Manual control: See "Edit Limit Line" on page 55
See "Shift Y" on page 57

CALCulate:LIMit<k>:UPPer:MODE <Mode>

This command selects the vertical limit line scaling.

Parameters:

<Mode>

ABSolute
Limit line is defined by absolute physical values.
The unit is variable.

RELative
Limit line is defined by relative values related to the reference level (dB).

*RST: ABSolute

Manual control: See "Edit Limit Line" on page 55
See "X-Axis" on page 56

CALCulate:LIMit<k>:UPPer[:DATA] <LimitLinePoints>

This command defines the vertical definition points of an upper limit line.

Parameters:

<LimitLinePoints> Variable number of level values.
Note that the number of vertical values has to be the same as the number of horizontal values set with `CALCulate:LIMit<k>:CONTrol[:DATA]`. If not, the R&S FSW either adds missing values or ignores surplus values.

*RST: Limit line state is OFF

Usage: SCPI confirmed

Manual control: See "Edit Limit Line" on page 55
See "Data Points" on page 56

CALCulate:LIMit<k>:UPPer:SHIFt <Distance>

This command moves a complete upper limit line vertically.

Compared to defining an offset, this command actually changes the limit line definition points by the value you define.

Parameters:

<Distance> Defines the distance that the limit line moves.

Usage: Event

Manual control: See "Edit Limit Line" on page 55
See "Shift Y" on page 57

8.9 Graphical Display of Phase Noise Results

The following commands are necessary to set up and configure the graphical phase noise result displays.

CALCulate<n>:MATH[:EXPression][:DEFine] <Expression>

This command selects the mathematical expression for trace mathematics.

Before you can use the command, you have to turn trace mathematics on.

Parameters:

<Expression>

(TRACE1-TRACE2)
Subtracts trace 2 from trace 1.

(TRACE1-TRACE3)
Subtracts trace 3 from trace 1.

(TRACE1-TRACE4)
Subtracts trace 4 from trace 1.

(TRACE1-TRACE5)
Subtracts trace 5 from trace 1.

(TRACE1-TRACE6)
Subtracts trace 6 from trace 1.

Example:

`CALC:MATH:STAT ON`
Turns trace mathematics on.
`CALC:MATH:EXPR:DEF (TRACE1-TRACE3)`
Subtracts trace 3 from trace 1.

Usage: SCPI confirmed

Manual control: See "Trace Config" on page 47
See "Trace Math" on page 48

CALCulate<n>:MATH:STATe <State>

This command turns the trace mathematics on and off.

Parameters:

<State> ON | OFF

*RST: OFF

Example: `CALC:MATH:STAT ON`
Turns on trace mathematics.

Usage: SCPI confirmed

Manual control: See "Trace Config" on page 47
See "Trace Math" on page 48

DISPlay[:WINDow]:TRACe<t>:MODE <Mode>

This command selects the trace mode.

Suffix:

<t> 1...6
Selects the trace.

Parameters:

<Mode> WRITe | VIEW | AVERage | MAXHold | MINHold | BLANk

*RST: Trace 1/2: WRITe, Trace 3-6: BLANk

Example:
`INIT:CONT OFF`
`SWE:COUN 16`
Turns on single sweep mode and defines a count of 16 measurements.
`DISP:TRAC2:MODE AVER`
Select average trace mode for trace 2.
`INIT;*WAI`
Performs the measurement (16 sweeps) with synchronization to the end.

Manual control: See "Trace Config" on page 47
See "Traces" on page 47

DISPlay[:WINDow]:TRACe:SMOothing:APERture <Aperture>

This command defines the degree (aperture) of the trace smoothing.

A single aperture applies to all traces which require smoothing.

Parameters:

<Aperture> Range: 1 to 20
*RST: 0
Default unit: PCT

Example: `DISP:TRAC:SMO:APER 5`
Defines an aperture of 5%.

Usage: SCPI confirmed

Manual control: See "Trace Smoothing" on page 46

DISPlay[:WINDow]:TRACe<t>:SMOothing[:STATe] <State>

This command turns trace smoothing for a particular trace on and off.

Suffix:
<t> 1...6
Selects the trace.

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

Example: `DISP:TRAC2:SMO ON`
Turns on trace smoothing for trace 2.

Usage: SCPI confirmed

Manual control: See "Trace Config" on page 47
See "Traces" on page 47

DISPlay[:WINDow]:TRACe<t>:SMOothing:TYPE <Type>

This command selects the trace smoothing method.

Suffix:
<t> 1...6
Selects the trace.

Parameters:
<Type> **LINear**
Linear smoothing.
LOGarithmic
Logarithmic smoothing.
*RST: LIN

Example: `DISP:TRAC2:SMO:TYPE LIN`
Selects linear smoothing for trace 2.

Usage: SCPI confirmed

Manual control: See "Smoothing Type" on page 46

DISPlay[:WINDow]:TRACe:X[:SCALe]:HDECade <HalfDecade>

This command selects the half decade to be displayed.

Before you can use the command you have to select the half decade scope for the x-axis with `DISPlay[:WINDow]:TRACe:X[:SCALe]:SCOPe`.

Parameters:

<HalfDecade>

Start offset frequency of the half decade you want to display.
Note that the half decade you want to display has to be part of the current measurement range.

Range: 100 mHz...300 mHz to 3 GHz...10GHz
*RST: Half decade display is off.

Example:

`DISP:TRAC:X:HDEC 1KHZ`
Displays the half decade beginning with 1 kHz.

Manual control: See "Half Decade" on page 45

DISPlay[:WINDow]:TRACe:X[:SCALe]:SCOPe <Scope>

This command selects the way the application scales the horizontal axis.

Parameters:

<Scope>

HDECade
Shows a particular half decade only.
You can select a particular half decade with .

MANual
Shows a custom part of the measurement range.
You can select the start and stop offsets with .

MRANGe
Shows the complete measurement range.

*RST: MRANGe

Example:

`DISP:TRAC:X:SCOP MRAN`
Shows the complete measurement range on the x-axis.

Manual control: See "X-Axis Scope" on page 45

DISPlay[:WINDow]:TRACe:X[:SCALe]:STARt <StartFrequency>

This command selects the start frequency of the display range.

Before you can use the command you have to select a manual display range for the x-axis with `DISPlay[:WINDow]:TRACe:X[:SCALe]:SCOPe`.

Parameters:

<StartFrequency>

Start offset frequency of a half decade.
Note that the start offset you want to display has to be part of the current measurement range.

Range: 100 mHz to 3 GHz
*RST: Manual display range is OFF

Example:

`DISP:TRAC:X:STAR 100HZ`
Defines 100 Hz as the start of the display range.

Manual control: See "X-Axis Start / Stop" on page 45

DISPlay[:WINDow]:TRACe:X[:SCALe]:STOP <StopFrequency>

This command selects the stop frequency of the display range.

Before you can use the command you have to select a manual display range for the x-axis with `DISPlay[:WINDow]:TRACe:X[:SCALe]:SCOPe`.

Parameters:

<StopFrequency> Stop offset frequency of a half decade.
Note that the stop offset you want to display has to be part of the current measurement range.
Range: 300 mHz to 10 GHz
*RST: Manual display range is OFF

Example: `DISP:TRAC:X:STOP 3KHZ`
Defines 3 kHz as the end of the display range.

Manual control: See "X-Axis Start / Stop" on page 45

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

This command defines the display range.

Note that you have to select manual y-axis scaling before you can use the command.

Parameters:

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

Example: `DISP:TRAC:Y 80`
Defines a display range over 80 dB.

Manual control: See "Top / Range / Bottom" on page 45

DISPlay[:WINDow]:TRACe:Y[:SCALe]:AUTO <Mode>

This command turns automatic configuration of the vertical axis on and off.

Parameters:

<Mode> **ON**
Automatic scaling is on.

OFF
Automatic scaling is off.

ONCE
Automatic scaling is performed once, then turned off again.

*RST: ON

Example: `DISP:WIND2:TRAC:Y:SCAL:AUTO ONCE`
Scales the vertical axis once.

Manual control: See "Y Axis Scaling" on page 45

DISPlay[:WINDow]:TRACe:Y[:SCALe]:MANual <Mode>

This command selects the type of manual scaling of the vertical axis.

Parameters:

<Mode>

BRANge
Scaling based on the value at the bottom of the diagram and the axis range.

OFF
Turns manual scaling of the y-axis off.

TBOTtom
Scaling based on the values on the bottom and top of the diagram.

TRANge
Scaling based on the value at the top of the diagram and the axis range.

*RST: ON

Example: `DISP:WIND2:TRAC:Y:SCAL:MAN TRAN`
Scaling of the vertical axis based on the top and the range of the axis.

Manual control: See "Y Axis Scaling" on page 45

DISPlay[:WINDow]:TRACe:Y[:SCALe]:RLEVel <Reference>

This command defines the reference value or upper border of the diagram area.

Note that you have to select manual y-axis scaling before you can use the command.

Parameters:

<Reference>
Range: -200 to 0
*RST: -20
Default unit: dBc/Hz

Example: `DISP:TRAC:Y:RLEV -50`
Defines a reference value of -50 dBc/Hz.

Manual control: See "Top / Range / Bottom" on page 45

DISPlay[:WINDow]:TRACe:Y[:SCALe]:RLEVel:LOWer <LowerReference>

This command defines the reference value or upper border of the diagram area.

Note that you have to select manual y-axis scaling before you can use the command.

Parameters:

<LowerReference>
Range: -400 to 1
*RST: -120
Default unit: dBc/Hz

Example: `DISP:TRAC:Y:RLEV:LOW -100`
Sets the bottom of the diagram to .100 dBc/Hz.

Manual control: See "Top / Range / Bottom" on page 45

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

This command defines the trace offset.

Parameters:

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

Example: `DISP:TRAC:Y:RLEV:OFFS -10`
Defines a trace offset of -10 dB.

Manual control: See "Trace Offset" on page 46

FORMat:DEXPort:DSEParator <Separator>

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

Parameters:

<Separator>

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

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

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

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

Manual control: See "Trace Config" on page 47
See "Trace Export" on page 48

MMEMory:STORe<n>:TRACe <Trace>, <FileName>

This command exports trace data from the specified window to an ASCII file.

Parameters:

<Trace> Number of the trace to be stored

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

Example: `MMEM:STOR1:TRAC 3,'TEST.ASC'`
Stores trace 3 from window 1 in the file `TEST.ASC`.

Usage: SCPI confirmed

Manual control: See "Trace Config" on page 47
See "Trace Export" on page 48

[SENSe:]SPURs:SUPPression <State>

This command turns spur suppression on and off.

Parameters:

<State> ON | OFF

*RST: ON

Example: `SPUR:SUPP OFF`
Turns spur suppression off.

Manual control: See "Spur Removal / Spur Threshold" on page 48

[SENSe:]SPURs:THReshold <Threshold>

This command defines the level threshold for spur removal.

Parameters:

<Threshold> Range: 0 to 50
*RST: 0
Default unit: dB

Example: `SPUR:THR 10`
Defines a spur threshold of 50 dB.

Manual control: See "Spur Removal / Spur Threshold" on page 48

TRACe<n>:COPY <TraceNumber>, <TraceNumber>

This command copies data from one trace to another.

Parameters:

<TraceNumber>, <TraceNumber> **TRACE1 | TRACE2 | TRACE3 | TRACE4 | TRACE5 | TRACE6**
The first parameter is the destination trace, the second parameter is the source.

Example: `TRAC:COPY TRACe1,TRACe2`
Copies the data from trace 2 to trace 1.

Usage: SCPI confirmed

Manual control: See "Trace Config" on page 47
See "Copy Trace" on page 48

TRACe[:DATA]? <Trace>

This command queries the results of the graphical result displays.

Parameters:

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

Return values:

<Frequency>, <Level>	**Phase noise:** Coordinates of the phase noise trace as list of comma separated values, beginning at the nearest offset frequency. <OffsetFrequency1>,<Level1>,<OffsetFrequency2>,<Level2>,... **Spectrum monitor:** Coordinates of the spectrum trace as a list of comma separated values, beginning at the left border of the display. <Frequency1>,<Level1>,<Frequency2>,<Level2>,...

Example: `TRAC? TRACE1`
Queries the data of trace 1.

Usage: Query only

Manual control: See "Phase Noise Diagram" on page 13
See "Spectrum Monitor" on page 16

8.10 Configure Numerical Result Displays

The following commands are necessary to configure the numerical phase noise result displays.

8.10.1 Configuring Residual Noise Measurements

CALCulate<n>:EVALuation:STARt <OffsetFrequency>

This command defines the start point of the residual noise integration range.

Before you can use the command, you have to turn off the measurement range integration with `CALCulate<n>:EVALuation[:STATe]` on page 111.

Parameters:

<OffsetFrequency> The minimum offset is 1 Hz. The maximum offset depends on the hardware you are using.

*RST: 1 kHz

Example: `CALC:EVAL:STAR 1 kHz`
Defines an start point of 1 kHz for the residual noise range.

Manual control: See "Meas Range" on page 49

CALCulate<n>:EVALuation[:STATe] <State>

This command turn integration of the measurement range for residual noise calculation on and off.

Parameters:

<State>

ON
Calculates the residual noise over the entire measurement range.

OFF
Calculates the residual noise over a customized range.

*RST: ON

Example: `CALC:EVAL OFF`
Uses a customized offset range for residual noise calculation.

Manual control: See "Meas Range" on page 49

CALCulate<n>:EVALuation:STOP <OffsetFrequency>

This command defines the end point of the residual noise integration range.

Before you can use the command, you have to turn off the measurement range integration with `CALCulate<n>:EVALuation[:STATe]` on page 111.

Parameters:

<OffsetFrequency> The minimum offset is 1 Hz. The maximum offset depends on the hardware you are using.

*RST: 1 MHz

Example: `CALC:EVAL:STOP 1 MHZ`
Defines an end point of 1 MHz for the residual noise range.

Manual control: See "Meas Range" on page 49

CALCulate<n>:EVALuation:USER<range>:STARt <OffsetFrequency>

This command defines the start point of a custom residual noise calculation range.

Before you can use the command, you have to assign the user range to a trace with `CALCulate<n>:EVALuation:USER<range>:TRACe` on page 112.

Parameters:

<OffsetFrequency> The minimum offset is 1 Hz. The maximum offset depends on the hardware you are using.

*RST: 1 MHz

Example: `CALC:EVAL:USER2:STAR 1khz`
Defines a start point of 1 kHz for the second user range.

Manual control: See "User Range" on page 50

CALCulate<n>:EVALuation:USER<range>:STOP <OffsetFrequency>

This command defines the end point of a custom residual noise calculation range.

Before you can use the command, you have to assign the user range to a trace with `CALCulate<n>:EVALuation:USER<range>:TRACe` on page 112.

Parameters:

<OffsetFrequency> The minimum offset is 1 Hz. The maximum offset depends on the hardware you are using.

*RST: 1 MHz

Example: `CALC:EVAL:USER2:STOP 100kHz`
Defines an end point of 100 kHz for the second user range.

Manual control: See "User Range" on page 50

CALCulate<n>:EVALuation:USER<range>:TRACe <Trace>

This command selects the trace for a custom residual noise calculation range.

Suffix:

<range> 1...3
Selects the user range.

Parameters:

<Trace> **NONE**
Turns a user range off.

TRACE1 ... TRACE6
Trace to assign the user range to.

Example: `CALC:EVAL:USER2:TRAC TRACE2`
Assigns the second user range to trace 2.

Manual control: See "User Range" on page 50

8.10.2 Reading Out Residual Noise Results

FETCh:PNOise<t>:RFM?

This command queries the residual FM for the first trace.

Example: `FETC:PNO2:RFM?`
Queries the residual FM for the first trace in the diagram.

Usage: Query only

Manual control: See "Residual Noise" on page 14

FETCh:PNOise<t>:RMS?

This command queries the residual RMS jitter for the first trace.

Example: `FETC:PNO2:RMS?`
Queries the RMS jitter for the first trace in the diagram.

Usage: Query only

Manual control: See "Residual Noise" on page 14

FETCh:PNOise<t>:RPM?

This command queries the residual PM for the first trace.

Example: `FETC:PNO:RPM?`
Queries the residual PM for the first trace of the diagram.

Usage: Query only

Manual control: See "Residual Noise" on page 14

FETCh:PNOise<t>:USER<range>:RFM?

This command queries the residual FM for a particular user range.

The trace that is queried depends on `CALCulate<n>:EVALuation:USER<range>:TRACe`.

Suffix:
<range> 1...3
Selects the user range.

Example: `FETC:PNO:USER2:RFM?`
Queries the residual FM for user range 2.

Usage: Query only

Manual control: See "Residual Noise" on page 14

FETCh:PNOise<t>:USER<range>:RMS?

This command queries the residual RMS jitter for a particular user range.

The trace that is queried depends on `CALCulate<n>:EVALuation:USER<range>:TRACe`.

Suffix:

<range> 1...3
Selects the user range.

Example: `FETC:PNO:USER2:RMS?`
Queries the RMS jitter for user range 2.

Usage: Query only

Manual control: See "Residual Noise" on page 14

FETCh:PNOise<t>:USER<range>:RPM?

This command queries the residual PM for a particular user range.

The trace that is queried depends on `CALCulate<n>:EVALuation:USER<range>:TRACe`.

Suffix:

<range> 1...3
Selects the user range.

Example: `FETC:PNO:USER2:RPM?`
Queries the residual PM for user range 2.

Usage: Query only

Manual control: See "Residual Noise" on page 14

8.10.3 Configuring Spot Noise Measurements

CALCulate<n>:SNOise:AOFF

This command turns all spot noise markers off (custom and 10^x markers).

Example: `CALC:SNO:AOFF`
Turns all spot noise markers off.

Usage: Event

Manual control: See "On User Defined Offsets / Offset Frequency" on page 50

CALCulate<n>:SNOise:DECades[:STATe] <State>

This command turns the spot noise calculation on every 10^x offset frequency on and off.

Parameters:

<State> ON | OFF

*RST: ON

Example: `CALC:SNO:DEC ON`
Turns the spot noise calculation for each decade start on.

Manual control: See "On All Decade Edges" on page 50

CALCulate<n>:SNOise:DECades:X?

This command queries the horizontal poistion of the 10^x offset frequency spot noise markers.

Return values:

<OffsetFrequency> List of offset frequencies, one for each 10^x spot noise marker. The number of return values depends on the measurement range.

Default unit: Hz

Example: `CALC:SNO:DEC:X?`
Return values, e.g.:
`1000,10000,100000,1000000`

Usage: Query only

Manual control: See "Spot Noise" on page 15
See "On All Decade Edges" on page 50

CALCulate<n>:SNOise:DECades:Y?

This command queries the vertical poistion of the 10^x offset frequency spot noise markers.

Return values:

<Level> List of level values, one for each 10^x spot noise marker. The number of return values depends on the measurement range.

Default unit: dBc/Hz

Example: `CALC:SNO:DEC:Y?`
Return values, e.g.:
`-152.560974121094,-136.443389892578,`
`-145.932891845703,-152.560974121094`

Usage: Query only

Manual control: See "Spot Noise" on page 15
See "On All Decade Edges" on page 50

CALCulate<n>:SNOise<m>:STATe <State>

This command turns a custom spot noise marker on and off.

Suffix:

<m> 1...5
Selects the spot noise marker.

Parameters:

<State> ON | OFF
*RST: All ON

Example: `CALC:SNO3:STATE ON`
Turns spot noise marker 3 on.

Manual control: See "On User Defined Offsets / Offset Frequency" on page 50

CALCulate<n>:SNOise<m>:X <OffsetFrequency>

This command defines the horizontal position of a custom spot noise marker.

Suffix:

<m> 1...5
Selects the spot noise marker.

Parameters:

<OffsetFrequency> The minimum offset is 1 Hz. The maximum offset depends on the hardware you are using.
The default value varies for each of the five spot noise markers. For marker 1 it is 1 kHz, for marker 2 it is 10 kHz, for marker 3 it is 100 kHz, for marker 4 it is 1 MHz and for marker 5 it is 10 MHz

Example: `CALC:SNO3:X 2MHz`
Positions the third custom spot noise marker to an offset frequency of 2 MHz.

Manual control: See "On User Defined Offsets / Offset Frequency" on page 50

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

This command queries the vertical position of a custom spot noise marker.

Suffix:

<m> 1...5
Selects the spot noise marker

Return values:

<Level> <numeric value>
Phase noise level at the marker position.
Default unit: dBc/Hz

Example: `CALC:SNO3:Y?`
Queries the level of the third custom spot noise marker.

Usage: Query only

Manual control: See "Spot Noise" on page 15
See "On User Defined Offsets / Offset Frequency" on page 50

8.10.4 Reading Out the Spur List

FETCh:PNOise:SPURs?

This command queries the location and level of all spurs that have been detected.

Return values:

<Spurs> Returns two values (frequency and level) for each each spur that has been detected.

Example:
`FETC:PNO:SPUR?`
would return, e.g.
`1999.232666,-0.639974,6494.312500,-0.760579,`
`19992.324219,-0.639974`

Usage: Query only

Manual control: See "Spur List" on page 16

8.10.5 Reading Out Measured Values

FETCh:PNOise:MEASured:FREQuency?

This command queries the carrier frequency that has been actually measured.

The measured frequency is shown in the channel bar.

Return values:

<Frequency> Frequency in Hz.

Example:
`FETC:PNO:MEAS:FREQ?`
Queries the measured frequency.

Usage: Query only

FETCh:PNOise:MEASured:LEVel?

This command queries the level of the DUT that has been actually measured.

The measured level is shown in the channel bar.

Return values:

<Level> Level in dBm.

Example:
`FETC:PNO:MEAS:LEV?`
Queries the measured level.

Usage: Query only

8.11 Using Markers

The following commands are necessary to control markers.

8.11.1 Using Markers

CALCulate<n>:MARKer<m>:AOFF

This command turns all markers off.

Example: `CALC:MARK:AOFF`
Switches off all markers.

Usage: Event

Manual control: See "All Markers Off" on page 59

CALCulate<n>:MARKer<m>[:STATe] <State>

This command turns markers on and off. If the corresponding marker number is currently active as a deltamarker, it is turned into a normal marker.

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

Example: `CALC:MARK3 ON`
Switches on marker 3.

Manual control: See "Marker Type" on page 58

CALCulate<n>:MARKer<m>:TRACe <Trace>

This command selects the trace the marker is positioned on.

Note that the corresponding trace must have a trace mode other than "Blank".

If necessary, the command activates the marker first.

Parameters:
<Trace> **1 to 6**
Trace number the marker is assigned to.

Example: `CALC:MARK3:TRAC 2`
Assigns marker 3 to trace 2.

Manual control: See "Assigning the Marker to a Trace" on page 58

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.

Parameters:

<Position> Numeric value that defines the marker position on the x-axis.
Default unit: Hz

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

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

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

If necessary, the command activates the marker first.

To get a valid result, you have to perform a complete measurement with synchronization to the end of the measurement before reading out the result. This is only possible for single sweeps. See also `INITiate:CONTinuous` on page 71.

Return values:

<Level> Phase noise level of the marker.
Default unit: dBc/Hz

Example: `INIT:CONT OFF`
Switches to single measurement mode.
`CALC:MARK2 ON`
Switches marker 2.
`INIT;*WAI`
Starts a measurement and waits for the end.
`CALC:MARK2:Y?`
Outputs the measured value of marker 2.

Usage: Query only

8.11.2 Using Delta Markers

CALCulate<n>:DELTamarker:AOFF

This command turns all delta markers off.

Example: `CALC:DELT:AOFF`
Turns all delta markers off.

Usage: Event

CALCulate<n>:DELTamarker<m>:MREF <Reference>

This command selects a reference marker for a delta marker other than marker 1.

The reference may be another marker or the fixed reference.

Parameters:
<Reference> **1 to 16**
Selects markers 1 to 16 as the reference.

FIXed
Selects the fixed reference as the reference.

Example: `CALC:DELT3:MREF 2`
Specifies that the values of delta marker 3 are relative to marker 2.

Manual control: See "Reference Marker" on page 58

CALCulate<n>:DELTamarker<m>[:STATe] <State>

This command turns delta markers on and off.

If necessary, the command activates the delta marker first.

No suffix at DELTamarker turns on delta marker 1.

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

Example: `CALC:DELT2 ON`
Turns on delta marker 2.

Manual control: See "Marker Type" on page 58

CALCulate<n>:DELTamarker<m>:TRACe <Trace>

This command selects the trace a delta marker is positioned on.

Note that the corresponding trace must have a trace mode other than "Blank".

If necessary, the command activates the marker first.

Parameters:

<Trace> Trace number the marker is assigned to.

Example: `CALC:DELT2:TRAC 2`
Positions delta marker 2 on trace 2.

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

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.

Parameters:

<Position> The position is relative to the reference marker.
The unit is Hz (offset frequency).
A query returns the absolute position of the delta marker.

Range: The value range depends on the current measurement range.

Example: `CALC:DELT:X?`
Outputs the absolute frequency/time 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 sweeps. See also `INITiate:CONTinuous` on page 71.

Return values:

<Level> Phase noise level.

Default unit: dBc/Hz

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

8.11.3 Using the Marker Zoom

CALCulate:MARKer:FUNCtion:ZOOM <ZoomFactor>

This command defines the factor or magnitude of the marker zoom.

Parameters:

<ZoomFactor> Range: 1 to 20
*RST: Zoom OFF

Example: `CALC:MARK:FUNC:ZOOM 12`
Zooms into the diagram with a factor of 10 around marker 1.

Manual control: See "Marker Zoom" on page 58

DISPlay[:WINDow:]ZOOM[:STATe] <State>

This command turns the marker zoom for marker 1 on and off.

Parameters:

<State> ON | OFF
*RST: OFF

Example: `DISP:ZOOM ON`
Turns on the marker zoom.

Manual control: See "Marker Zoom" on page 58

8.12 Automatic Measurement Configuration

The following commands are necessary to determine measurement parameters automatically.

[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:

- Center frequency
- Reference level

Example: `ADJ:ALL`

Usage: Event

Manual control: See "Adjusting all Determinable Settings Automatically (Auto All)" on page 43

[SENSe:]ADJust:FREQuency

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

Example: `ADJ:FREQ`

Usage: Event

Manual control: See "Adjusting the Center Frequency Automatically (Auto Freq)" on page 43

[SENSe:]ADJust:LEVel

This command initiates a single (internal) measurement that evaluates and sets the ideal reference level for the current input data and measurement settings. This ensures that the settings of the RF attenuation and the reference level are optimally adjusted to the signal level without overloading the R&S FSW or limiting the dynamic range by an S/N ratio that is too small.

Example: `ADJ:LEV`

Usage: Event

Manual control: See "Setting the Reference Level Automatically (Auto Level)" on page 43

8.13 Using the Status Register

The status reporting system stores information about the current state of the R&S FSW. This includes, for example, information about errors during operation or information about limit checks. The R&S FSW stores this information in the status registers and in the error queue. You can query the status register and error queue via IEC bus.

The R&S FSW-K40 features several status registers that are specific to phase noise measurements. Here is a description of those, including the corresponding remote commands.

8.13.1 Status Registers for Phase Noise Measurements

The figure below shows the status registers of the phase noise application.

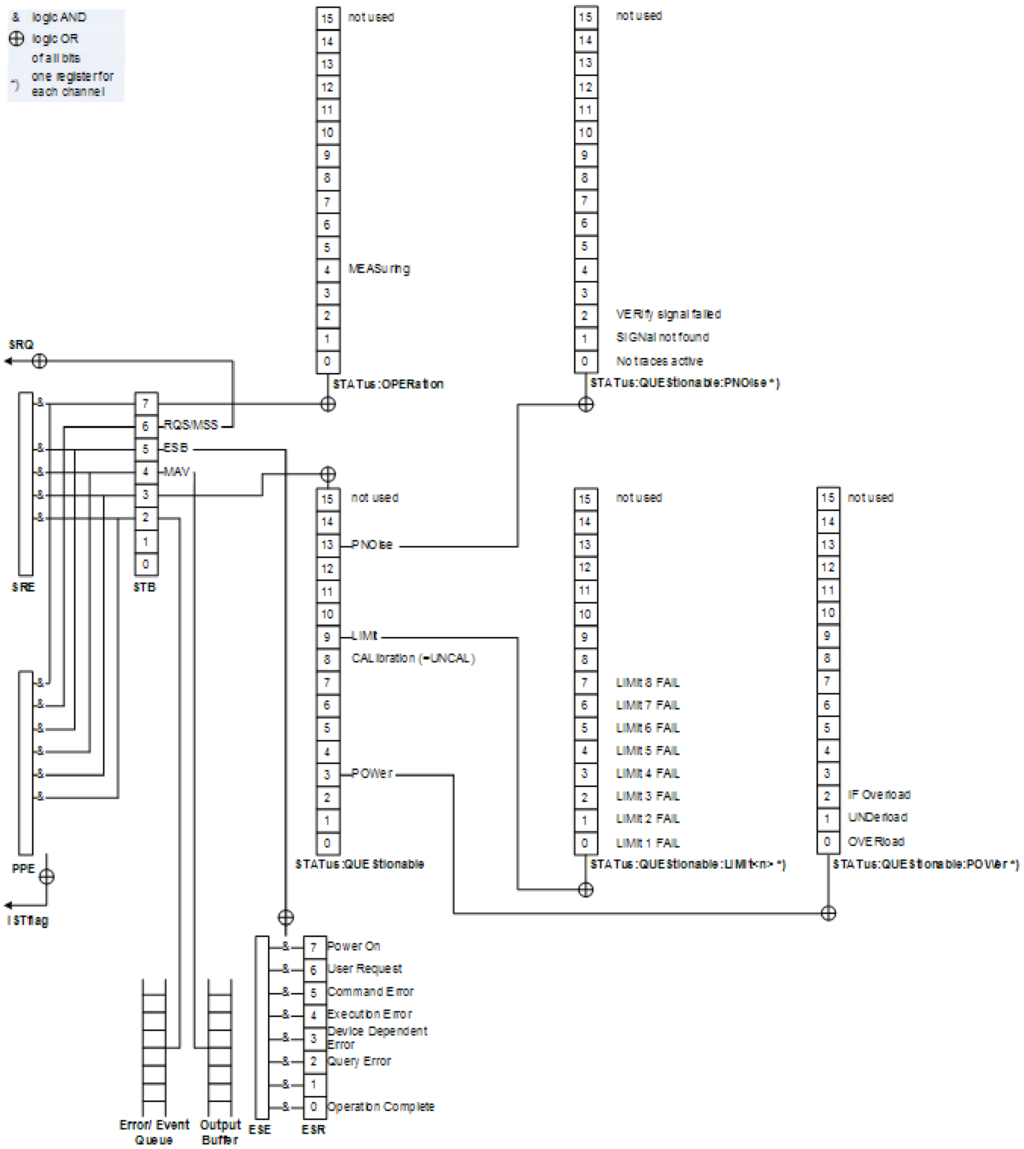


Fig. 8-2: Status registers for phase noise measurements

The R&S FSW structures the information hierarchically, with the Status Byte register (STB) and the Service Request Enable mask register (SRE) being on the highest level. The STB gets its information from the standard Event Status Register (ESR) and the Event Status Enable mask register (ESE). The STB and ESR are both defined by IEEE 488.2. In addition to the ESR, the STB also gets information from the STATus:OPERation and STATus:QUEStionable registers. These are the link to the lower levels of the status register and are defined by SCPI. They contain information about the state of the instrument.

For a more comprehensive description of the status registers not mentioned here and status register functionality in general see the manual of the base unit.

8.13.1.1 STATus:QUEStionable Register

The `STATus:QUEStionable` register contains information about indefinite states which may occur if the unit is operated without meeting the specifications.

Bit no	Meaning
0 to 2	Unavailable for phase noise measurements.
3	POWer This bit is set if a questionable power occurs.
5 to 7	Unavailable for phase noise measurements.
8	CALibration This bit is set if the R&S FSW is not calibrated.
9	LIMit This bit is set if a limit line is violated.
10-12	Unavailable for phase noise measurements.
13	PNOise This bit is set if the phase noise measurement is questionable.
14	Unavailable for phase noise measurements.
15	This bit is always 0.

8.13.1.2 STATus:QUEStionable:POWer Register

The `STATus:QUEStionable:POWer` register contains information about possible overload situations that may occur during operation of the R&S FSW.

Bit no	Meaning
0	OVERload This bit is set if an overload occurs at the RF input.
1	UNDerload This bit is set if an underload occurs at the RF input.
2	IF OVerload This bit is set if an overload occurs in the IF path.
3 to 14	Unavailable for phase noise measurements.
15	This bit is always 0.

8.13.1.3 STATus:QUEStionable:LIMit Register

The `STATus:QUEStionable:LIMit` register contains information about limit lines and the results of a limit checks.

The number of LIMit registers depends on the number of measurement windows available in any application.

Bit no	Meaning
0	LIMit 1 FAIL This bit is set if limit line 1 is violated.
1	LIMit 2 FAIL This bit is set if limit line 2 is violated.
2	LIMit 3 FAIL This bit is set if limit line 3 is violated.
3	LIMit 4 FAIL This bit is set if limit line 4 is violated.
4	LIMit 5 FAIL This bit is set if limit line 5 is violated.
5	LIMit 6 FAIL This bit is set if limit line 6 is violated.
6	LIMit 7 FAIL This bit is set if limit line 7 is violated.
7	LIMit 8 FAIL This bit is set if limit line 8 is violated.
8	Phase Noise LIMit FAIL This bit is set if a limit of the phase noise limit line is violated.
9 to 14	Unavailable for phase noise measurements.
15	This bit is always 0.

8.13.1.4 STATus:QUEStionable:PNOise Register

The `STATus:QUEStionable:PNOise` register contains information about the status of phase noise measurements.

Bit no	Meaning
0	No trace are active This bit is set if no trace is on.
1	SIGNal not found This bit is set if no valid signal could be found.
2	VERify This bit is set if signal verification has failed.

Bit no	Meaning
3 to 14	Unavailable for phase noise measurements.
15	This bit is always 0.

8.13.1.5 Status Register Remote Commands

STATus:OPERation[:EVENt]?
STATus:QUEStionable[:EVENt]?
STATus:QUEStionable:LIMit[:EVENt]? <ChannelName>
STATus:QUEStionable:PNOise[:EVENt]? <ChannelName>
STATus:QUEStionable:POWer[:EVENt]? <ChannelName>

These commands read out the EVENt section of the status register.

The commands at the same time delete the contents of the EVENt section.

Query parameters:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

STATus:OPERation:CONDition?
STATus:QUEStionable:CONDition?
STATus:QUEStionable:LIMit:CONDition? <ChannelName>
STATus:QUEStionable:PNOise:CONDition? <ChannelName>
STATus:QUEStionable:POWer:CONDition? <ChannelName>

These commands read out the CONDition section of the status register.

The commands do not delete the contents of the EVENt section.

Query parameters:

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

Usage: Query only

STATus:OPERation:ENABle <SumBit>,<ChannelName>
STATus:QUEStionable:ENABle <SumBit>,<ChannelName>
STATus:QUEStionable:LIMit:ENABle <SumBit>,<ChannelName>
STATus:QUEStionable:PNOise:ENABle <SumBit>,<ChannelName>
STATus:QUEStionable:POWer:ENABle <SumBit>,<ChannelName>

These commands control the ENABle part of a register.

The ENABle part allows true conditions in the EVENt part of the status register to bereported in the summary bit. If a bit is 1 in the enable register and its associated event bit transitions to true, a positive transition will occur in the summary bit reported to the next higher level.

Parameters:

<SumBit> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

STATus:OPERation:NTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:NTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:LIMit:NTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:PNOise:NTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:POWer:NTRansition <SumBit>,<ChannelName>

These commands control the Negative TRansition part of a register.

Setting a bit causes a 1 to 0 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding EVENt register.

Parameters:

<SumBit> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

STATus:OPERation:PTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:PTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:LIMit:PTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:PNOise:PTRansition <SumBit>,<ChannelName>
STATus:QUEStionable:POWer:PTRansition <SumBit>,<ChannelName>

These commands control the Positive TRansition part of a register.

Setting a bit causes a 0 to 1 transition in the corresponding bit of the associated register. The transition also writes a 1 into the associated bit of the corresponding EVENt register.

Parameters:

<SumBit> Range: 0 to 65535

<ChannelName> String containing the name of the channel.
The parameter is optional. If you omit it, the command works for the currently active channel.

8.14 Remote Control Example Scripts

This chapter contains a few remote control example scripts for particular phase noise measurement and configuration tasks.

The first chapter contains a short sequence of commands to perform a complete phase noise measurement. The subsequent chapters contain sequences of remote commands to perform special tasks for phase noise measurements like customizing the half decade configuration table.

All examples are based on a measurement range from 100 Hz to 1 MHz.

8.14.1 Performing a Basic Phase Noise Measurement

```
//Enter Phase Noise application
INST:SEL PNO
//Perform a preset of the channel
SYST:PRES:CHAN
//Customizing the screen layout.
//Add residual noise window:
LAY:ADD? '1',BEL,RNO
//Add spot noise window:
LAY:ADD? '2',RIGH,SNO
//Configure single sweep measurement.
INIT:CONT OFF
//Define the measurement range.
FREQ:STAR 100HZ
FREQ:STOP 1MHZ
//Select the sweep type.
SWE:MODE AVER
//Turn on frequency tracking.
FREQ:TRAC ON
```

```
//Turn on level tracking.
POW:TRAC ON
//Start the measurement with synchronization.
INIT;*WAI
//Set a marker on trace 1 and query its position.
CALC:MARK ON
CALC:MARK:X 1MHZ
CALC:MARK:Y?
//Query the residual noise results of trace 2 over the measurement range.
CALC:EVAL ON
//Residual FM:
FETC:PNO2:RFM?
//Residual PM:
FETC:PNO2:RPM?
//Residual RMS jitter:
FETC:PNO2:RMS?
//Freeze trace 1 and trace 2.
DISP:TRAC:MODE VIEW
DISP:TRAC2:MODE VIEW
//Activate trace 3 and trace 4.
DISP:TRAC3:MODE WRIT
DISP:TRAC4:MODE WRIT
//Activate linear trace smoothing for trace 4.
DISP:TRAC4:SMO ON
DISP:TRAC4:SMO:TYPE LIN
DISP:TRAC:SMO:APER 1
//Select IQ sweep mode.
SWE:MODE MAN
LIST:BWID:RES:TYPE IQFF
//Repeat the measurement.
INIT;*WAI
```

8.14.2 Configuring the Measurement Range

Performing a customized IQ FFT measurement over the whole measurement range

```
//Define the measurement range.
FREQ:STAR 100HZ
FREQ:STOP 1MHZ
//Define the measurement settings for all half decades in the measurement range.
SWE:MODE MAN
//Measurement bandwidth (in per cent of the decade frequency):
LIST:BWID:RAT 20
//Averages:
LIST:SWE:COUN 20
//Mode:
LIST:BWID:RES:TYPE IQFF
```

```
//Window function:
LIST:IQW:TYPE GAUS
```

Customizing a half decade configuration table

```
//Define the measurement range.
FREQ:STAR 100HZ
FREQ:STOP 1MHZ
//Define the contents of the table manually.
SWE:MODE MAN
//Customize the range from 100 Hz to 300 Hz.
//Measurement bandwidth:
LIST:RANG5:BWID 1HZ
//Sweep type:
LIST:RANG5:FILT:TYPE IQFF
//Window function:
LIST:RANG5:IQW:TYPE CHEB
//Averages:
LIST:RANG5:SWE:COUN 5
//Customize the range from 300 Hz to 1 kHz.
//Averages:
LIST:RANG6:SWE:COUN 5
```

8.14.3 Scaling the Display

Scaling the x-axis: displaying a half decade

```
//Select display of one half decade.
DISP:TRAC:X:SCOP HDEC
//Select the start frequency of the half decade.
DISP:TRAC:X:HDEC 1KHZ
//Display the full measurement range again.
DISP:TRAC:X:SCOP MRAN
```

Scaling the x-axis: customizing the x-axis range

```
//Select manual x-axis scaling.
DISP:TRAC:X:SCOP MAN
//Define the start frequency of the display range.
DISP:TRAC:X:STAR 30KHZ
//Define the stop frequency of the display range.
DISP:TRAC:X:STOP 300KHZ
```

Scaling the y-axis: scaling based on bottom value and range

```
//Select manual y-axis scaling.
DISP:TRAC:Y:MAN BRAN
//Define the bottom value.
DISP:TRAC:Y:RLEV:LOW -160
```

```
//Define the range.
DISP:TRAC:Y 60
```

Scaling the y-axis: scaling based on top value and range

```
//Select manual y-axis scaling.
DISP:TRAC:Y:MAN TRAN
//Define the top value.
DISP:TRAC:Y:RLEV -100
//Define the range.
DISP:TRAC:Y 60
```

Scaling the y-axis: scaling based on bottom and top value

```
//Select manual y-axis scaling.
DISP:TRAC:Y:MAN TBOT
//Define the bottom value.
DISP:TRAC:Y:RLEV:LOW -160
//Define the top value.
DISP:TRAC:Y:RLEV -100
```

8.14.4 Configuring Numerical Results

Defining a user range for residual noise results and query the results

```
//Select the trace for integration.
CALC:EVAL:USER2:TRAC TRACE1
//Define the start and stop frequencies of the integration range.
CALC:EVAL:USER2:STAR 100KHZ
CALC:EVAL:USER2:STOP 1MHZ
//Query the results.
//Residual FM:
FETC:PNO:USER2:RFM?
//Residual PM:
FETC:PNO:USER2:RPM?
//Residual RMS jitter:
FETC:PNO:USER2:RMS?
```

Working with spot noise results

```
//Turn on spot noise markers on every decade edge.
CALC:SNO:DEC ON
//Turn on spot noise markers at two additional offset frequencies.
CALC:SNO1:STAT ON
CALC:SNO1:X 50KHZ
CALC:SNO2:STAT ON
CALC:SNO2:X 500KHZ
//Read out spot noise marker results.
//Read out the decade edges:
```

```
CALC:SNO:DEC:X?
//Read out the marker positions on the decade edges:
CALC:SNO:DEC:Y?
//Read out customized spot noise marker results:
//At 50 kHz:
CALC:SNO1:Y?
//At 500 kHz:
CALC:SNO2:Y?
```

8.14.5 Using Limit Lines

Programming a phase noise limit line with three segments

```
//Define the level of the DUT's noise floor.
CALC:PNL:NOIS -134
//Select the number of line segments.
CALC:PNL:TYPE FC3
//Define the characteristics of the line segments.
CALC:PNL:FC1 300KHZ
CALC:PNL:SLOP1 10
CALC:PNL:FC2 30KHZ
CALC:PNL:SLOP2 20
CALC:PNL:FC3 3KHZ
CALC:PNL:SLOP3 30
//Assign the limit line to trace 1 and 2.
CALC:PNL:TRAC 1,2
//Query limit check results.
CALC:PNL:FAIL?
```

Programming a standard limit line

```
//Select or create the limit line by name.
CALC:LIM:NAME 'Phase Noise'
//Comment on the limit line.
CALC:LIM:COMM 'Limit line to test phase noise measurement'
//Define the horizontal data points of the limit line.
CALC:LIM:CONT 100HZ,1kHZ
//Define the vertical data points of an (upper) limit line.
//The unit is fix for phase noise measurements.
CALC:LIM:UPP -160,-170
//Shift the limit line 5 dBc/Hz down.
CALC:LIM:UPP:SHIF -5
//Turn the limit line on.
CALC:LIM:UPP:STAT ON
//Select the trace to check.
CALC:LIM:TRAC 3
//Turn on the limit check.
CALC:LIM:STAT ON
```

```
//Query the limit check results.
CALC:LIM:FAIL?
```

8.14.6 Using Markers

Using spot noise markers

See "Working with spot noise results" on page 132.

Using normal and delta markers

```
//Activate and position a normal marker (marker 1).
CALC:MARK ON
CALC:MARK:X 1MHZ
//Position marker 1 on trace 2.
CALC:MARK:TRAC 2
//Query the position of marker 1.
CALC:MARK:Y?
//Activate and position a delta marker (delta marker 1).
CALC:DELT ON
CALC:DELT:X -900KHZ
//Position the delta marker on trace 2.
CALC:DELT:TRAC 2
//Query the position of the delta marker.
CALC:DELT:Y?
//Turning all markers off
CALC:MARK:AOFF
CALC:DELT:AOFF
```

List of Remote Commands (Phase Noise)

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