R&S®FSWP PHASE NOISE ANALYZER AND VCO TESTER

High-end analysis of signal sources and components

Product Brochure
Version 02.00

ROHDE&SCHWARZ

Make ideas real

AT A GLANCE

The R&S®FSWP phase noise analyzer and VCO tester features very high sensitivity thanks to extremely low-noise internal sources and cross-correlation. It can measure phase noise on highly stable sources such as those found in radar applications in just seconds. Additional options such as pulsed signal measurements, residual phase noise (including pulsed) characterization and integrated high-end signal and spectrum analysis make the R&S®FSWP a unique test instrument. A multitouch display ensures straightforward and intuitive operation. The embedded SCPI recorder enables easy creation of executable scripts.

The R&S®FSWP phase noise analyzer and VCO tester is the optimal test solution for radar applications and when developing and manufacturing synthesizers, OCXOs, DROs and VCOs. It can be easily configured to meet different application requirements. Thanks to its low-noise internal local oscillator, it is capable of measuring most commercially available synthesizers and oscillators without any additional options.

For high-end applications, the R&S®FSWP is equipped with a second receive path, which enables cross-correlation and increases sensitivity by up to 25 dB, depending on the number of correlations used. The analyzer's excellent internal sources and largely digital architecture make it faster than test systems that digitize the signal after the phase detector.

The R&S®FSWP measures the phase noise of pulsed sources and the residual phase noise of individual (also pulsed) components at the push of a button. For residual phase noise measurements, the internal source or an external source can be used if, for example, users have their own high-quality oscillator. In the past, costly and complex systems using external sources, splitters and phase shifters were necessary for this measurement.

The R&S®FSWP not only measures phase noise, it is also a full-featured signal and spectrum analyzer that helps users determine if the wanted signal is available, for example.

The R&S®FSWP is an all-in-one solution that allows users to easily switch between various measurement channels. A glance at the spectrum and then on to phase noise measurements – no problem.

KEY FACTS

- Frequency range from 1 MHz to 8/26.5/50 GHz, up to 325 GHz with external harmonic mixers
- High sensitivity for phase noise measurements thanks to cross-correlation and extremely low-noise internal reference sources
  - Typ. –174 dBc (1 Hz) at 1 GHz carrier frequency and 10 kHz offset
  - Typ. –158 dBc (1 Hz) at 10 GHz carrier frequency and 10 kHz offset
- Simultaneous measurement of amplitude noise and phase noise
- Measurement of phase noise on pulsed sources at the push of a button
- Internal source for measuring residual phase noise, including on pulsed signals
- High measurement speed due to its digital architecture
- Low-noise internal DC sources for VCO characterization
- Automatic VCO characterization
- Analysis of up to 8 GHz wide frequency hops (transients) and automatic settling time measurement
- Measurement of Allan variance
- SCPI recorder simplifies code generation
- Signal and spectrum analyzer and phase noise analyzer in a single box
  - High-end signal and spectrum analyzer, 10 Hz to 8/26.5/50 GHz
  - Wide dynamic range thanks to low displayed average noise level (DANL) of –156 dBm (1 Hz) (without noise cancellation) and high TOI of typ. 25 dBm
  - 320 MHz signal analysis bandwidth
  - Total measurement uncertainty: < 0.3 dB up to 3.6 GHz, < 0.4 dB up to 8 GHz

BENEFITS AND KEY FEATURES

High measurement speed

- Perfect for production applications
- Faster development

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Measuring phase and amplitude noise with high sensitivity

- Extremely low phase noise from internal sources
- Cross-correlation to improve phase noise sensitivity
- Accuracy of amplitude noise measurements significantly higher than with diode detectors
- Display of improvement in sensitivity through cross-correlation
- Frequency offset up to maximum input frequency
- Measurement of Allan deviation and Allan variance

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Phase noise measurements on pulsed sources at the push of a button

- Simple test setup
- High sensitivity despite desensitization
- Automatic pulse parameter measurement

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Internal source for measuring residual phase noise, also on pulsed signals

- Simple and fast measurement
- Higher sensitivity through cross-correlation
- Residual phase noise on pulsed signals
- Measuring the phase and amplitude stability of pulsed signals

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Signal and spectrum analyzer and phase noise analyzer up to 50 GHz in a single box

- Simple, cost-optimized test setup
- A worthwhile investment
- High-end signal and spectrum analyzer

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Low-noise internal DC sources for VCO characterization

- Complete VCO characterization
- Measuring higher harmonics
- Phase noise relative to the tuning voltage

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Measuring transients or frequency hops (transient analysis)

- Up to 8 GHz bandwidth for frequency and phase analysis
- Triggering on phase or frequency deviation
- Analysis linearity of FMCW chirps
- Automatic settling time measurement

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Analyzing the random jitter and periodic jitter of clock-like signals in high speed digital applications

- Jitter measurement of reference clocks
- Jitter measurements on high speed data lanes using clock pattern on the lane under test (LUT)

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HIGH MEASUREMENT SPEED

Perfect for production applications

The combination of a fast processor and FPGAs in the R&S®FSWP phase noise analyzer and VCO tester enables immediate data processing. Measurement time is determined solely by the physically required time (data recording). Signal demodulation and correlation of the various measurement sequences take no additional time.

Speed is a vital factor, especially in manufacturing applications. High-quality internal sources mean fewer correlations are needed for phase noise measurements, effectively reducing data recording time, e.g. with a sensitivity more than 10 dB better than similar systems. The internal sources of the R&S®FSWP require a hundred times fewer correlations to measure highly sensitive oscillators such as DROs and OCXOs. This multiplies the measurement throughput, especially when working close to the carrier where data recording is the determining factor for the measurement time.

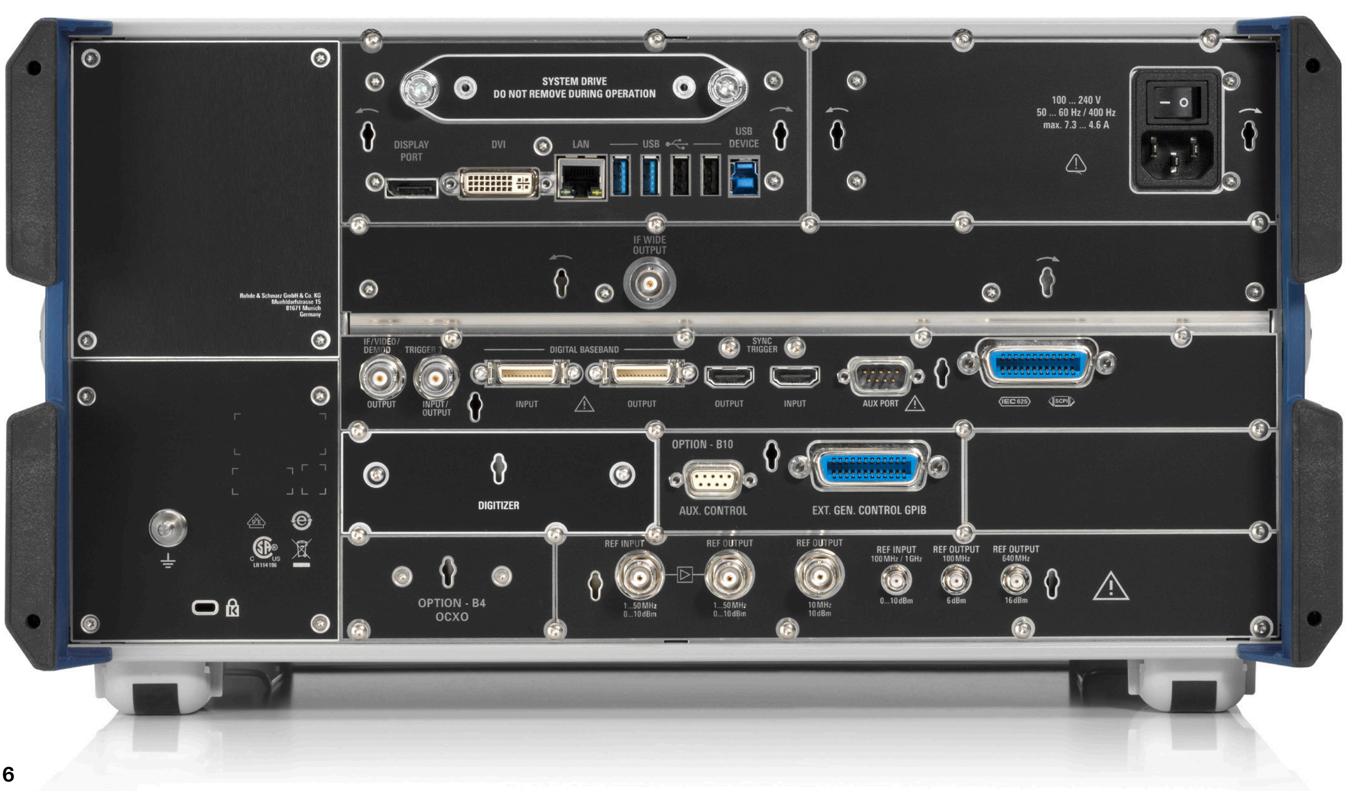
In addition, an embedded SCPI recorder for easy creation of executable scripts saves time during the setup for automated measurements in production.

Faster development

Short measurement times also speed up the development process. The R&S®FSWP takes just minutes to display the phase noise trace of high-end oscillators – a measurement that often took several hours in the past.

Developing and optimizing signal sources becomes substantially simpler and faster, as it only takes a few minutes to measure the influence of circuit modifications such as the addition of new capacitors or resistors (e.g. on an OCXO).

Rear view



MEASURING PHASE AND AMPLITUDE NOISE WITH HIGH SENSITIVITY

Extremely low phase noise from internal sources

Until now, high-end phase noise measurement systems required costly external signal generators as reference sources. The quality of these generators or external sources limited the sensitivity of phase noise measurements. The R&S®FSWP does not require external reference sources. Its internal local oscillator surpasses almost any generator available on the market when it comes to phase noise performance. The table shows typical values for the internal source at 1 GHz. If even better sensitivity is required, cross-correlation can improve the sensitivity by up to 25 dB.

Cross-correlation to improve phase noise sensitivity

To measure sources that have extremely low phase noise, the R&S®FSWP is equipped with a second local oscillator (R&S®FSWP-B60 or R&S®FSWP-B61 option) for cross-correlation. This improves the sensitivity by as much as 25 dB, depending on the number of correlations used. The improvement that can be expected is as follows:

$$\Delta L = 5 \cdot log(n)$$

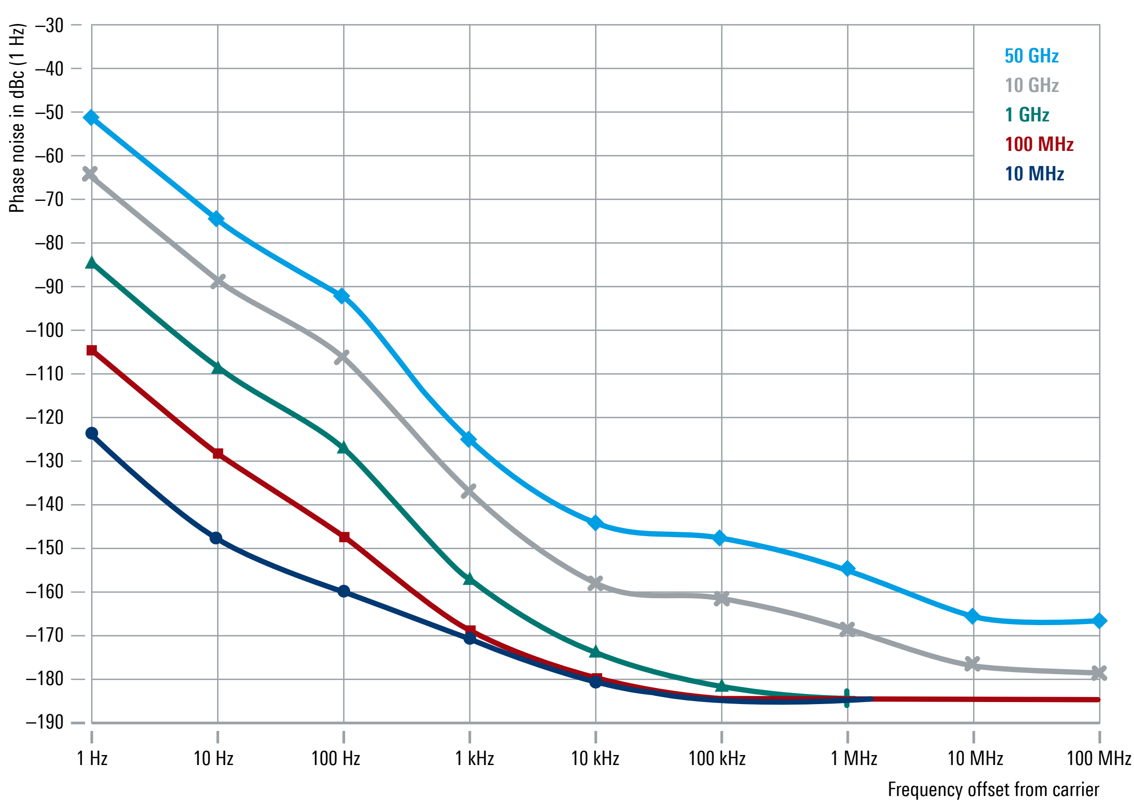
ΔL: improvement in phase noise sensitivity through cross-correlation (in dB)
n: number of correlations/averages

Increasing the number of correlations by a factor of 10 lowers the phase noise of the R&S®FSWP by 5 dB. Thanks to the analyzer's low-noise internal sources, often only a few correlations are needed to measure a high-quality oscillator. Users receive reliable results faster, which shortens development and manufacturing times.

Typical sensitivity at 1 GHz input frequency with R&S®FSWP-B61 option (start offset 1 Hz)

	1 Hz	10 Hz	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz	10 MHz
1 GHz	–84 dBc	–108 dBc	–127 dBc	–157 dBc	–174 dBc	–182 dBc	–185 dBc	–185 dBc

Typical sensitivity at various frequencies with R&S®FSWP-B61 option (start offset 1 Hz)

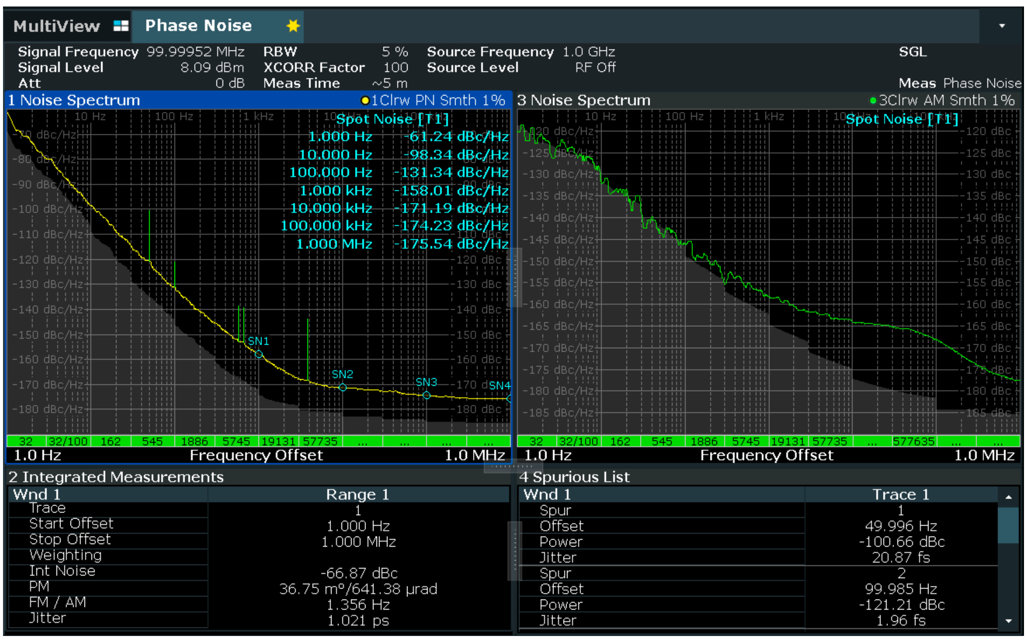


Accuracy of amplitude noise measurements significantly higher than with diode detectors

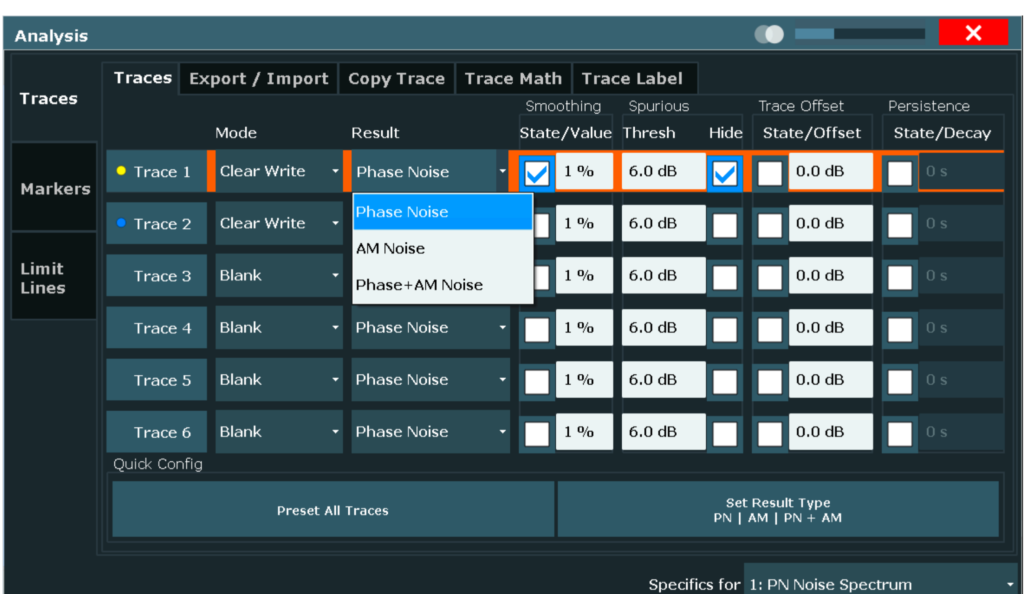
The R&S®FSWP measures amplitude noise as well as phase noise. The results of both measurements can be simultaneously displayed in a diagram or in separate windows. The R&S®FSWP high-precision sources, in combination with cross-correlation, surpass the accuracy of diode detector based measurements, with a sensitivity up to 20 dB better.

Display of improvement in sensitivity through cross-correlation

Users often do not know how many correlations are needed to measure a signal source. A gray area below the trace therefore shows the achievable level of sensitivity for a particular measurement for the selected number of correlations. The correlation process can be aborted automatically if adding more correlations fails to improve the sensitivity.



The R&S®FSWP can measure phase noise and amplitude noise simultaneously. The results can be displayed in separate windows or together in one window (gray area: correlation gain of the R&S®FSWP, green trace: amplitude noise, yellow trace: phase noise).



In the trace menu, users can assign traces to phase noise and/or amplitude noise measurements. They can also select whether they want spurious removed or traces smoothed or whether the traces should be displayed in the persistence mode.

Users can easily adapt the instrument to their specific requirements. Many applications (e.g. manufacturing) do not require high sensitivity. A second local oscillator or the signal and spectrum analyzer functionality are not always required. These functions can easily be added whenever measurement requirements increase, e.g. to measure highly accurate crystal oscillators.

Frequency offset up to maximum input frequency

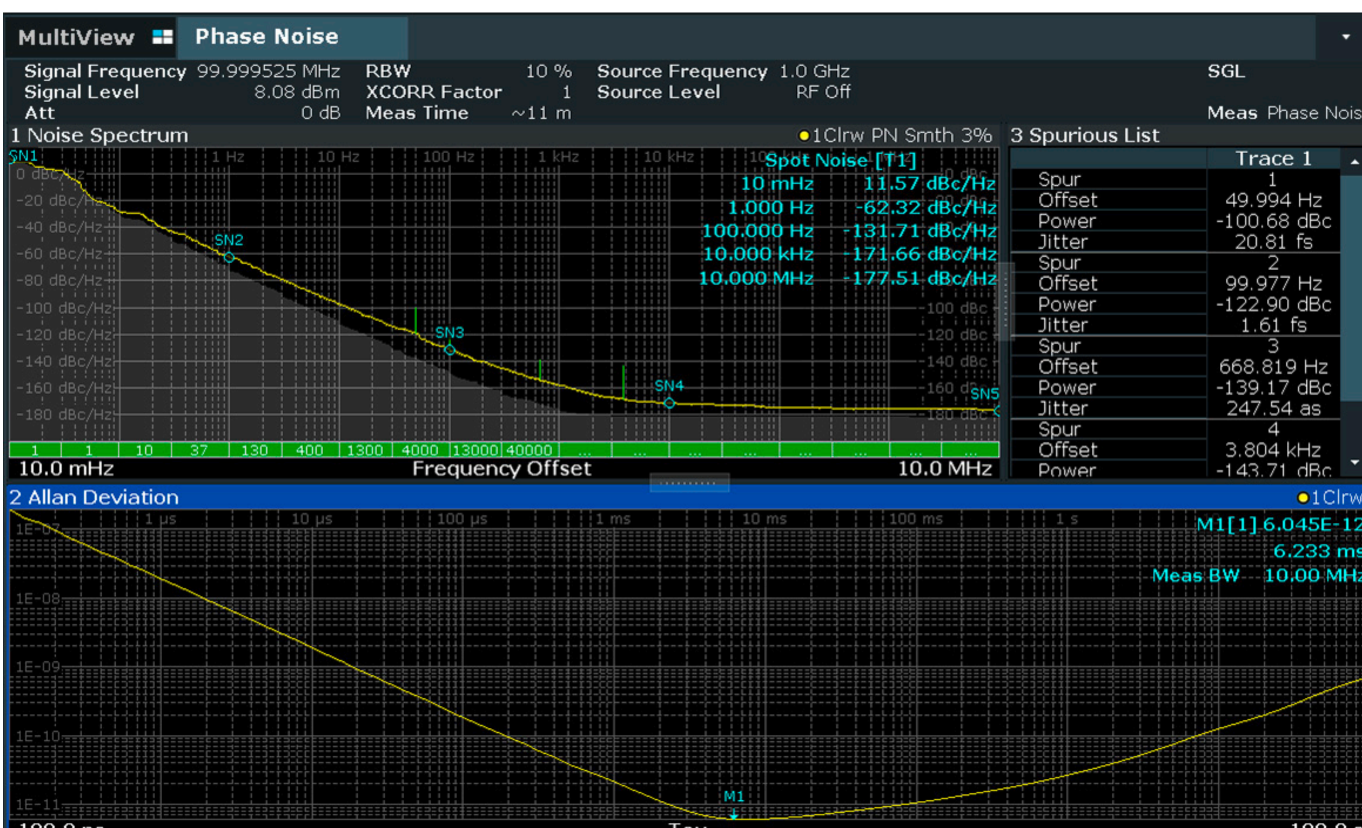
The R&S®FSWP can measure phase noise for offset frequencies starting at 1 µHz. The maximum offset is limited only by the input frequency of the R&S®FSWP, with parallel display of AM noise and phase noise up to an offset of 30 MHz. Despite this large bandwidth, there are no dynamic range restrictions since the R&S®FSWP features fast frequency processing and covers the measurement range incrementally.

Measurement of Allan deviation and Allan variance

To characterize the frequency stability of oscillators, the frequency is measured in the time domain at fixed time intervals and the deviation/variance of the measurement is determined. Instead of being output as a single value, this parameter is typically plotted over time, which is especially important for characterizing highly stable sources such as those used in satellite navigation systems.

The long-term frequency stability over several thousand seconds can also be calculated from the close-in phase noise. The R&S®FSWP displays the Allan deviation and Allan variance for up to 1 million seconds (minimum offset: 1 µHz). Unlike the previous method, this method makes it easy to suppress undesired side effects that appear as spurious emissions in the phase noise spectrum. Even short-term disturbances due to the phase noise of the instrument's internal sources can be easily suppressed.

The R&S®FSWP calculates the Allan deviation based on the phase noise measurement (upper window).
For example, an offset range of 10 mHz to 10 MHz corresponds to a time domain display of 100 ns to 100 s.



PHASE NOISE MEASUREMENTS ON PULSED SOURCES AT THE PUSH OF A BUTTON

Simple test setup

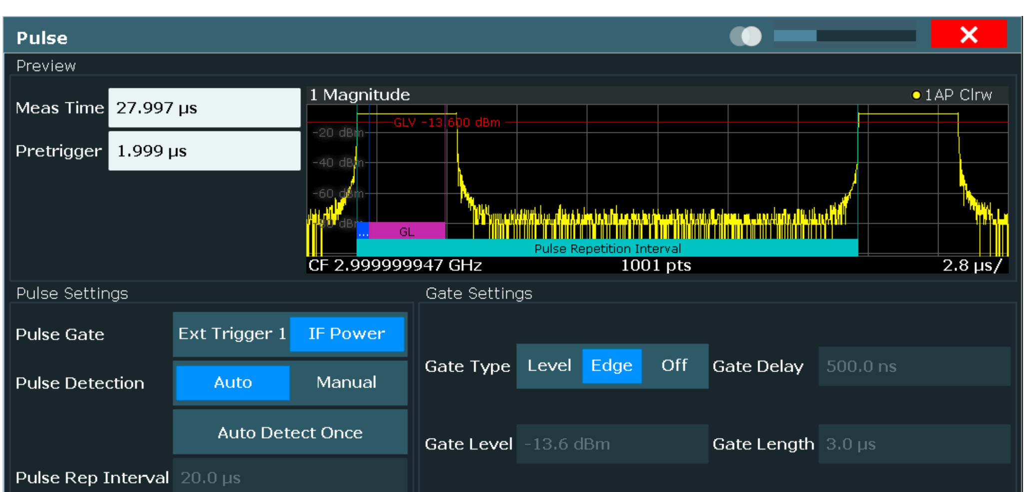
Until now, measuring the phase noise of pulsed sources such as used in radar applications required extremely costly and complex systems. Accurate pulse parameter information and a great deal of patience were needed to achieve stable measurements.

When equipped with the R&S®FSWP-K4 option, the R&S®FSWP carries out these measurements at the push of a button. The R&S®FSWP records the signal and calculates all pulse parameters. It then demodulates the signal and displays the phase noise and amplitude noise. Stable measurements take almost no time.

All results are available at the push of a button, enabling users to focus on optimizing their circuit design.

High sensitivity despite desensitization

The R&S®FSWP offers cross-correlation and the option to define a test port (gating) for pulsed source measurements, thereby compensating for desensitization caused by lower average signal power due to long pulse off times. This enables the R&S®FSWP to achieve a large dynamic range even for phase noise measurements on pulsed signals.

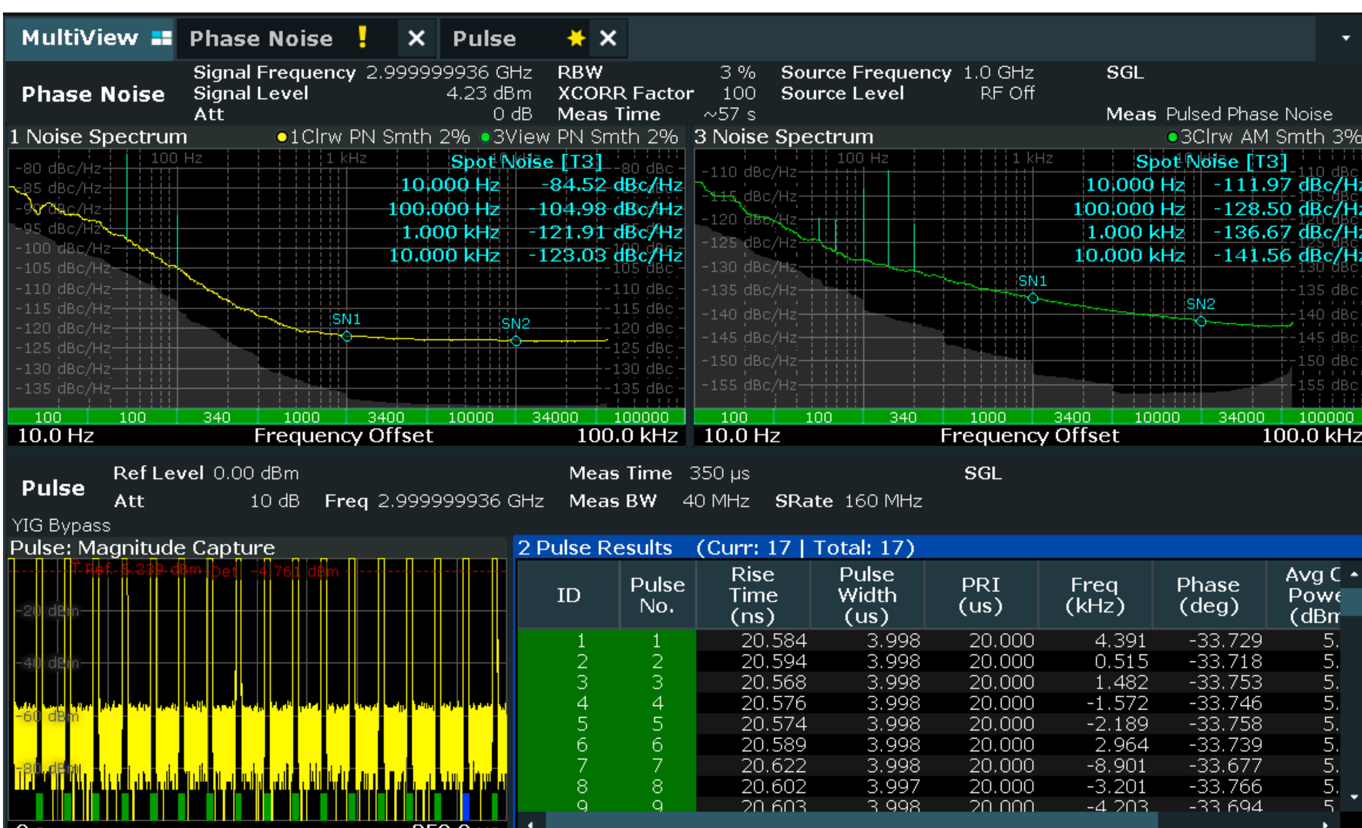


The instrument measures pulse parameters automatically; the user can define the gate.

Automatic pulse parameter measurement

Similar to a dedicated pulse measurement application (R&S®FSW-K6/R&S®FSWP-K6), the R&S®FSWP with R&S®FSW-K4 automatically determines all pulse parameters (e.g. pulse repetition rate and pulse width) that are relevant to measuring the phase noise of pulsed sources. Users do not have to worry about correctly setting these parameters. However, they can define a gate, for example to suppress transients. It is no longer necessary to carry out subsequent corrections, shift the trace or manually limit the available offset range.

Pulsed signal measurement: the upper left window shows the phase noise of the pulsed source up to an offset equal to one half of the pulse repetition rate. The amplitude noise can be seen in the upper right window. The table below shows the results of the pulse analysis along with all important pulse parameters.



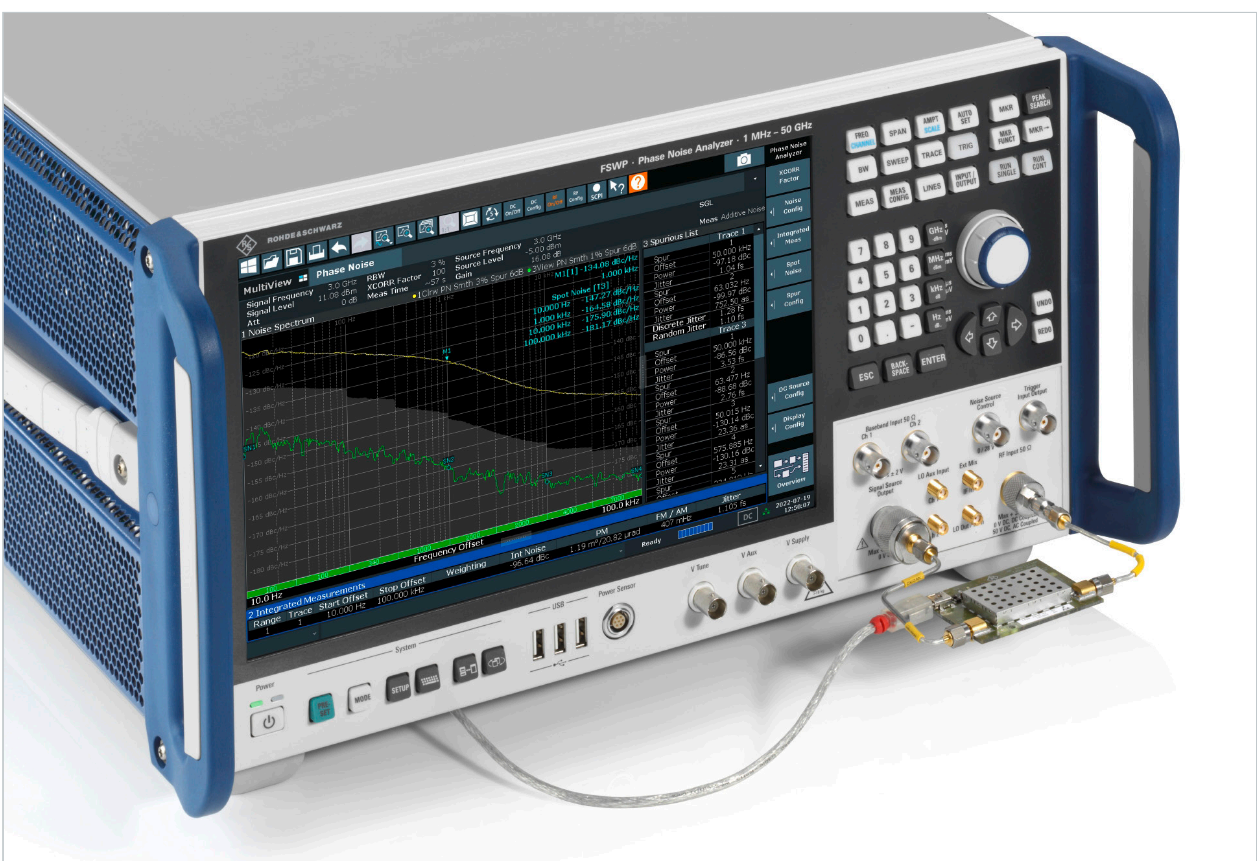
INTERNAL SOURCE FOR MEASURING RESIDUAL PHASE NOISE, ALSO ON PULSED SIGNALS

Simple and fast measurement

The R&S®FSWP offers an internal signal source (R&S®FSW-B64 option) for measuring residual phase noise. In addition, this option provides users with local oscillator inputs if they want to perform this measurement using their own external sources, for example to compare the results with those of other test setups. Amplifiers, doublers, splitters and other two-port components cause residual phase noise even though they do not generate a signal. When developing high-end radar applications, for instance, it is necessary to know how much phase noise these individual components as well as the local oscillator are adding to the signal path. Only then is it possible to develop extremely low-noise transmitters.

Previously, complex setups with a high-quality external signal source, splitters and the appropriate phase shifters were required to measure this parameter. The measurement was highly vulnerable to electromagnetic disturbances and vibration. With the R&S®FSWP, users simply connect the internal signal source to the DUT input and the DUT output back to the R&S®FSWP. The residual phase noise of the DUT is then available at the push of a button.

Typical setup for measuring the residual phase noise of an amplifier and displaying the resulting trace. The green trace shows the sensitivity without the DUT.



Higher sensitivity through cross-correlation

The R&S®FSWP uses cross-correlation for this operating mode as well to suppress the residual phase noise of the internal components. This enables the analyzer to deliver significantly better sensitivity than PLL based measurements and allows users to develop low-noise transmitters, for example to improve the location and time resolution of radar systems.

Residual phase noise on pulsed signals

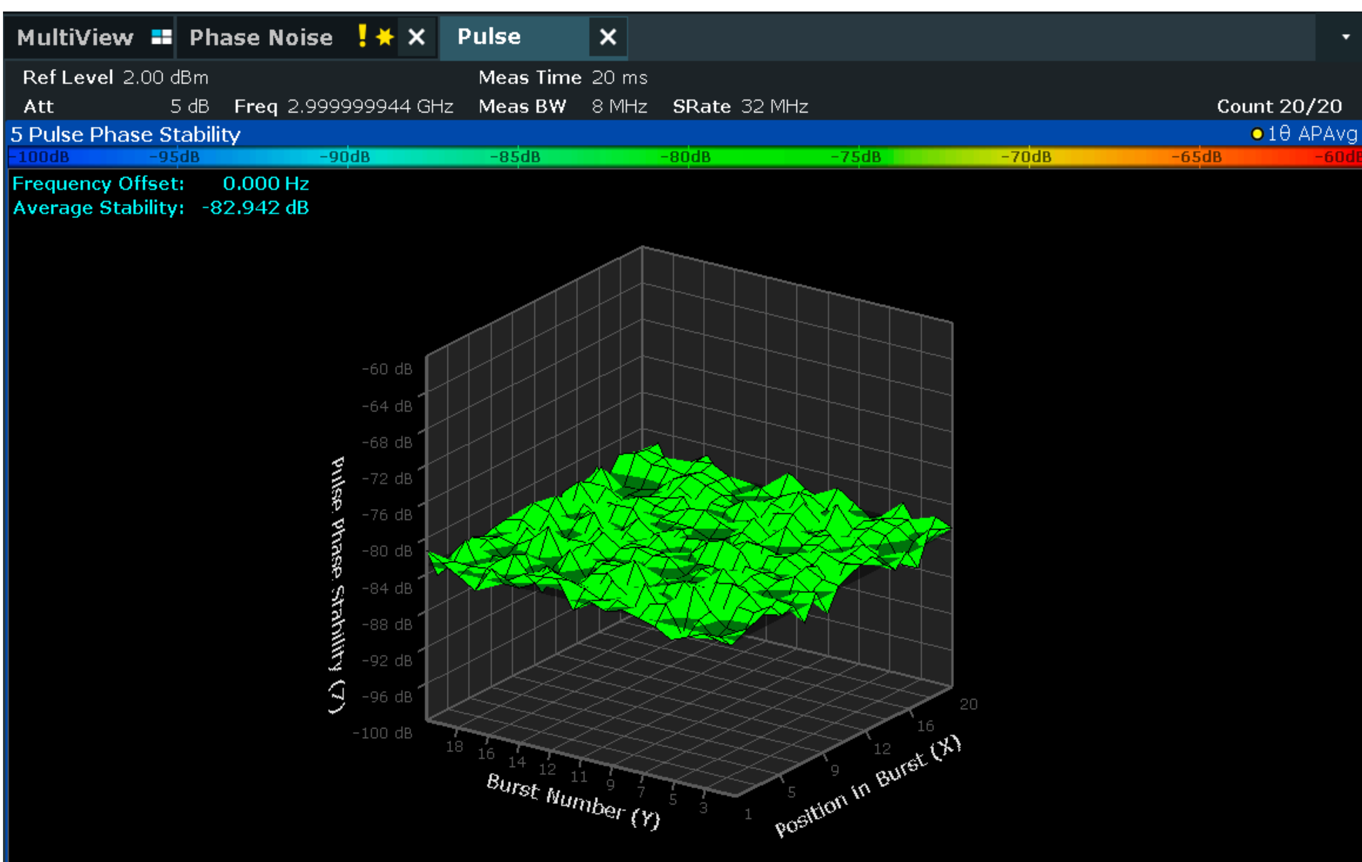
Equipped with the R&S®FSWP-K4 option, the R&S®FSWP can measure residual phase noise on pulsed signals.

To characterize and optimize components for a radar transmitter, for example, these components have to be tested using pulsed signals under real-world conditions. Amplifiers operating in pulsed mode can behave much differently than in continuous wave mode. This measurement was previously possible only with extremely complex test setups, but the R&S®FSWP performs it at the push of a button.

Measuring the phase and amplitude stability of pulsed signals

In radar applications for detecting moving objects, the phase and amplitude of the pulses must be very stable. This is the only way to clearly distinguish objects from unwanted reflections. Oscillators and amplifiers are the main causes of unstable signals. An R&S®FSWP equipped with the R&S®FSWP-K6 and R&S®FSWP-K6P options can measure and display these instabilities. When fitted with the internal source (R&S®FSWP-B64), the instrument can even perform residual measurements of the pulse stability on amplifiers, cables and other two-port components. The R&S®FSWP achieves a level of sensitivity previously attained by only a few very costly and complex measuring systems. A 3D plot shows the phase and amplitude stability of the single pulses and the various pulse sequences (bursts) and provides an even more precise overview.

3D plot of the phase stability of pulses in various pulse sequences (bursts).



SIGNAL AND SPECTRUM ANALYZER AND PHASE NOISE ANALYZER UP TO 50 GHz IN A SINGLE BOX

Simple, cost-optimized test setup

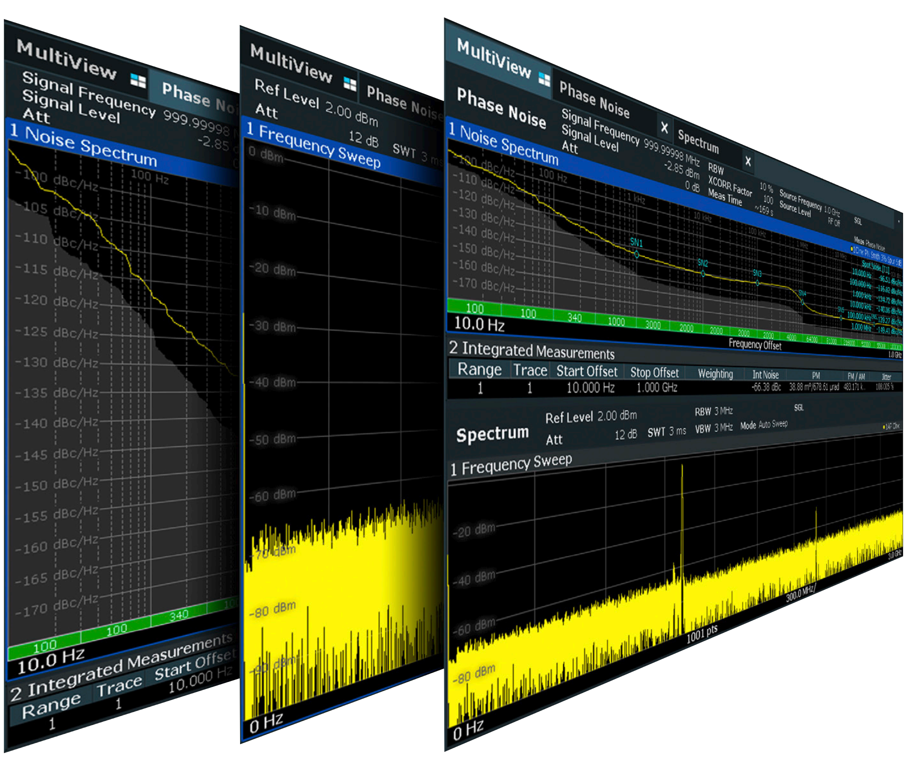
Most phase noise analyzers record noise after the phase detector and then convert it to the frequency domain. The carrier of the signal under test is no longer visible. Users do not know if they are measuring on the right frequency or on an unwanted spurious signal. They do not know if the measurement result is incorrect because the carrier is unstable or drifting too fast or if the difference between the measured signal and the reference source has grown too large. A spectrum analyzer is needed to determine this and also to examine harmonics and spurious emissions.

The R&S®FSWP phase noise analyzer and VCO tester can easily be upgraded to include signal and spectrum analyzer functionality by adding the R&S®FSWP-B1 option. Users can monitor the signal in a different measurement channel and quickly and effectively optimize and start their measurements without additional complicated cabling. This feature is also beneficial in automated test systems.

A worthwhile investment

Often, there are not enough lab applications to justify purchasing just a phase noise analyzer. Adding signal and spectrum analyzer functionality to the instrument ensures exceptionally good utilization, as it can be used for all the spectral measurements that are performed much more frequently in the lab. Instrument downtime is practically eliminated – a safe investment.

Manufacturers of automatic test systems also save space and money since they do not have to purchase an additional spectrum analyzer.



Users can switch between the spectrum analyzer and phase noise analyzer measurement channels or view both simultaneously

High-end signal and spectrum analyzer

The signal and spectrum analyzer is based on the R&S®FSW with its unique RF performance and high sensitivity. The analyzer's low phase noise enables users to precisely analyze modulation, measure the power of adjacent channels with high dynamic range and measure spurious emissions, even very close to the carrier. The internal preamplifier lowers the displayed average noise level (DANL) to below –165 dBm (1 Hz). Additional noise cancellation brings the DANL close to the theoretical limit of –174 dBm (1 Hz). Spurious emission measurement in particular is extremely fast, since the R&S®FSWP measures with a higher resolution bandwidth than less sensitive spectrum analyzers.

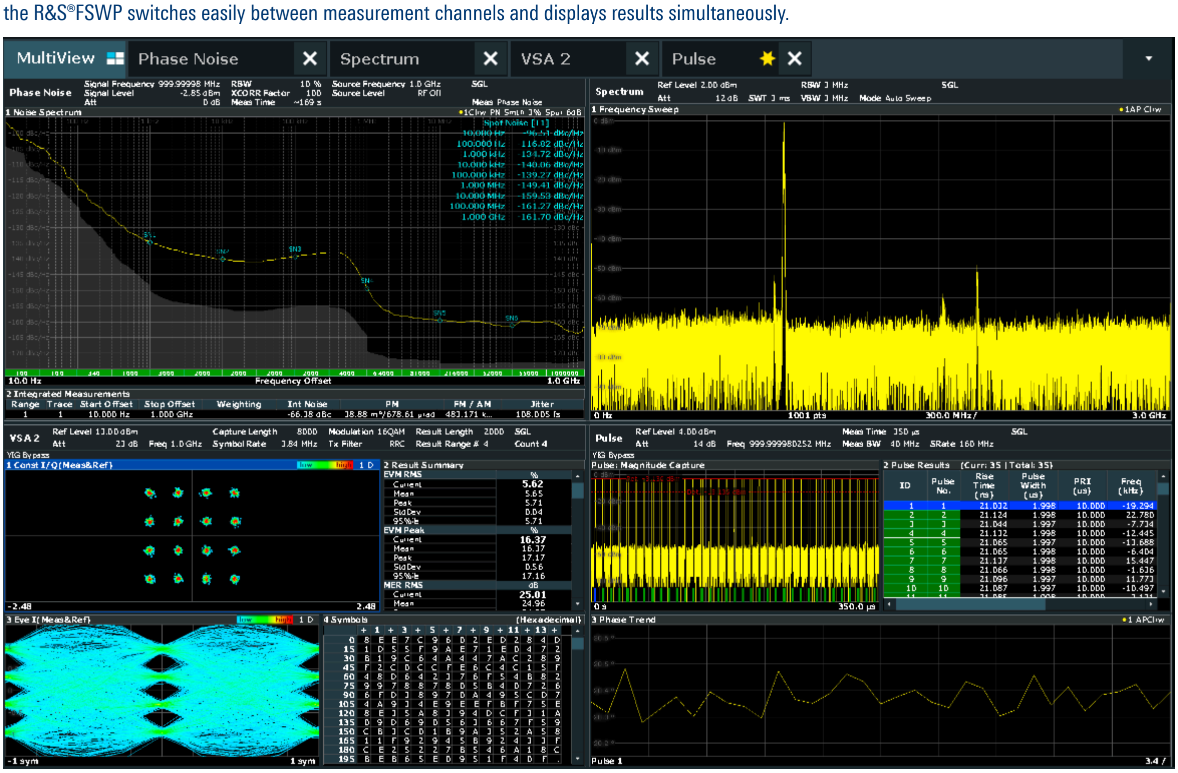
A high third-order intercept (TOI) of typically 25 dBm provides a wide dynamic range, allowing users to measure small input signals in the presence of large input signals and to determine adjacent channel rejection for wideband modulated signals.

When used as a signal analyzer (R&S®FSWP-B1 option), the R&S®FSWP uses an analysis bandwidth of up to 320 MHz (R&S®FSWP-B320 option) and offers internal, I/Q data based options for signal analysis. This makes it possible, for example, to analyze pulses automatically (R&S®FSWP-K6 option). The R&S®FSWP records the data across a wide band and calculates all important pulse parameters such as pulse width, rise times and pulse repetition rate at the push of a button. Digitally modulated signals can be evaluated using the internal vector signal analysis function (R&S®FSWP-K70 option). The R&S®FSWP-K7 option is available for analog-modulated signals. Users can also upload the I/Q data to a computer and perform their own analyses.

Key features

- ▶ Wide dynamic range thanks to a low noise level of –156 dBm (1 Hz) (without noise cancellation and preamplifier) and high TOI of typ. 25 dBm
- ▶ Total measurement uncertainty of < 0.2 dB up to 3.6 GHz, < 0.3 dB up to 8 GHz
- ▶ Phase noise of –140 dBc (1 Hz) at 1 GHz (100 kHz offset)
- ▶ 320 MHz signal analysis bandwidth
- ▶ Optional internal measurement applications for
  - – Pulse measurements (R&S®FSWP-K6/K6S/K6P)
  - – Vector signal analysis, for analyzing digitally modulated single carriers (R&S®FSWP-K70)
  - – Modulation analysis of analog-modulated (AM, FM, PM) single carriers (R&S®FSWP-K7)
  - – Noise figure measurements (R&S®FSWP-K30)
  - – Detection and display of low level spurious signals (R&S®FSWP-K50)
  - – Analysis of hopped signals and frequency chirps (R&S®FSWP-K60/-K60C/-K60H/-K60P)

Sensitive phase noise measurements, spectrum analysis, vector signal analysis and pulsed signal analysis: the R&S®FSWP switches easily between measurement channels and displays results simultaneously.



LOW-NOISE INTERNAL DC SOURCES FOR VCO CHARACTERIZATION

The R&S®FSWP features extremely low-noise internal DC sources to supply and control voltage-controlled oscillators (VCO) and other components, making it easy to measure VCOs. Creating VCO data sheets is likewise very easy, since the R&S®FSWP can measure the phase noise at various tuning and supply voltages, delivering the parameter values typically listed in the specifications.

Specifications for internal DC source	
Supply voltage	0 V to 16 V
Maximum current load	2000 mA
Tuning voltage	–10 V to +28 V
Maximum current load	20 mA

Complete VCO characterization

At the press of a button, the R&S®FSWP measures all the parameters needed to characterize a VCO:

- Frequency versus voltage
- Tuning slope versus voltage
- Output power versus voltage
- Current drain versus voltage
- Output power versus frequency

The user can decide whether to vary the tuning voltage or supply voltage and whether the current should be measured at the tuning voltage or supply voltage input.

Measuring higher harmonics

The R&S®FSWP can measure not only the fundamental but also the power of the VCO's higher harmonics relative to the tuning voltage.

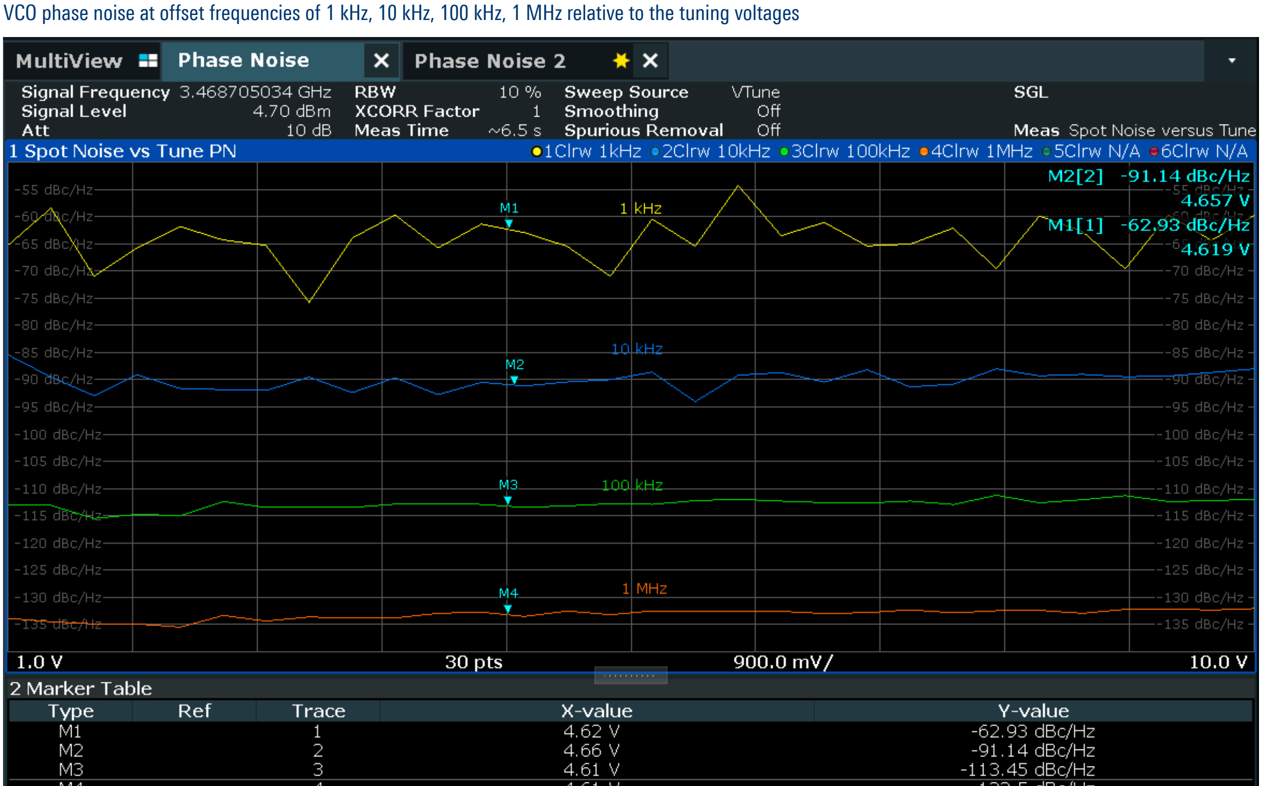
This is particularly important, since an effort is made to suppress harmonics because they can cause interference in the overall system. Higher harmonic suppression is a parameter that VCO users expect to see in the specifications.

A typical VCO measurement. Key parameters such as frequency, power, sensitivity (tuning slope) and current consumption are measured relative to the tuning voltage. Markers can be coupled across windows and displayed in a table. In addition, the power of higher harmonics can be measured.

Phase noise relative to the tuning voltage

Due to the high measurement speed of the R&S®FSWP, it can display the phase noise at various offset frequencies relative to the tuning voltage even without long measurement times. This allows the user to verify whether the VCO's phase noise depends on the frequency as expected, or whether additional noise caused by interference or parasitic oscillations can be seen at certain tuning voltages.

VCO phase noise at offset frequencies of 1 kHz, 10 kHz, 100 kHz, 1 MHz relative to the tuning voltages



MEASURING TRANSIENTS OR FREQUENCY HOPS (TRANSIENT ANALYSIS)

Up to 8 GHz bandwidth for frequency and phase analysis

The R&S®FSWP offers up to 8 GHz bandwidth for analyzing the frequency or phase characteristic versus time for detailed characterization of switched sources, synthesizer frequency hops and frequency ramps.

Are the required frequencies met? How long are the switching times? At what point is the frequency in a targeted tolerance range? The user gets answers to such questions at the press of a button.

Besides this wideband analysis, the R&S®FSWP offers narrowband analysis down to 40 MHz to examine, for example, the transient response of PLLs in detail.

For characterizing and optimizing the overall performance of signal sources, these narrowband and wideband frequency and phase measurements in the time domain (transient analysis) are of immense value, primarily for designers of synthesizers or frequency agile systems. A persistent display of all traces makes it possible to estimate how strongly these parameters scatter or whether there are any outliers.

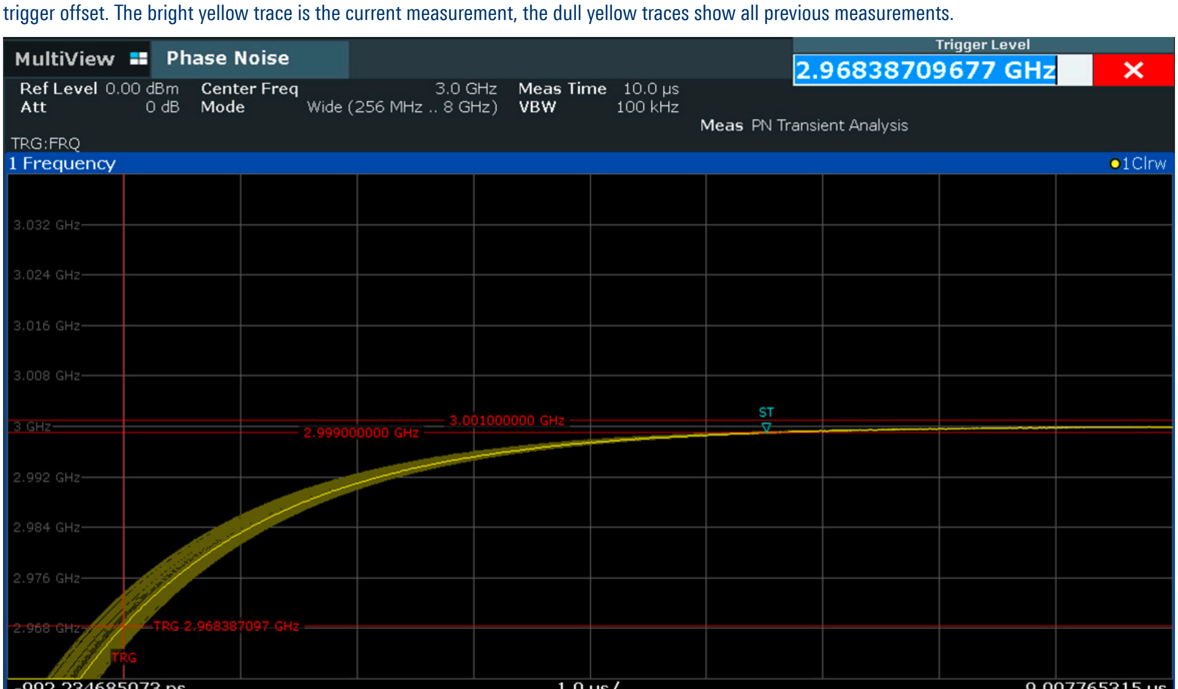
Triggering on phase or frequency deviation

For a detailed examination of a synthesizer's transient response, it is advisable to use a trigger to obtain comparable and reproducible measurement results. Besides utilizing an external trigger or power trigger, in the transient analysis the user can also trigger on the frequency or phase deviation. This is made possible by the input signal's real-time demodulation.

The user can define a frequency threshold so that the signal is displayed only when it is above or below a specified frequency.

For error analysis or to optimize the synthesizer, this makes it easy to selectively trigger on specific frequency hops.

Transient response of a synthesizer in persistence mode. The horizontal red line shows the frequency trigger threshold, the vertical line the trigger offset. The bright yellow trace is the current measurement, the dull yellow traces show all previous measurements.



Type	Ref	Trace	X-value	Y-value
ST		1	5.5 µs	2.998992432 GHz

Analysis linearity of FMCW chirps

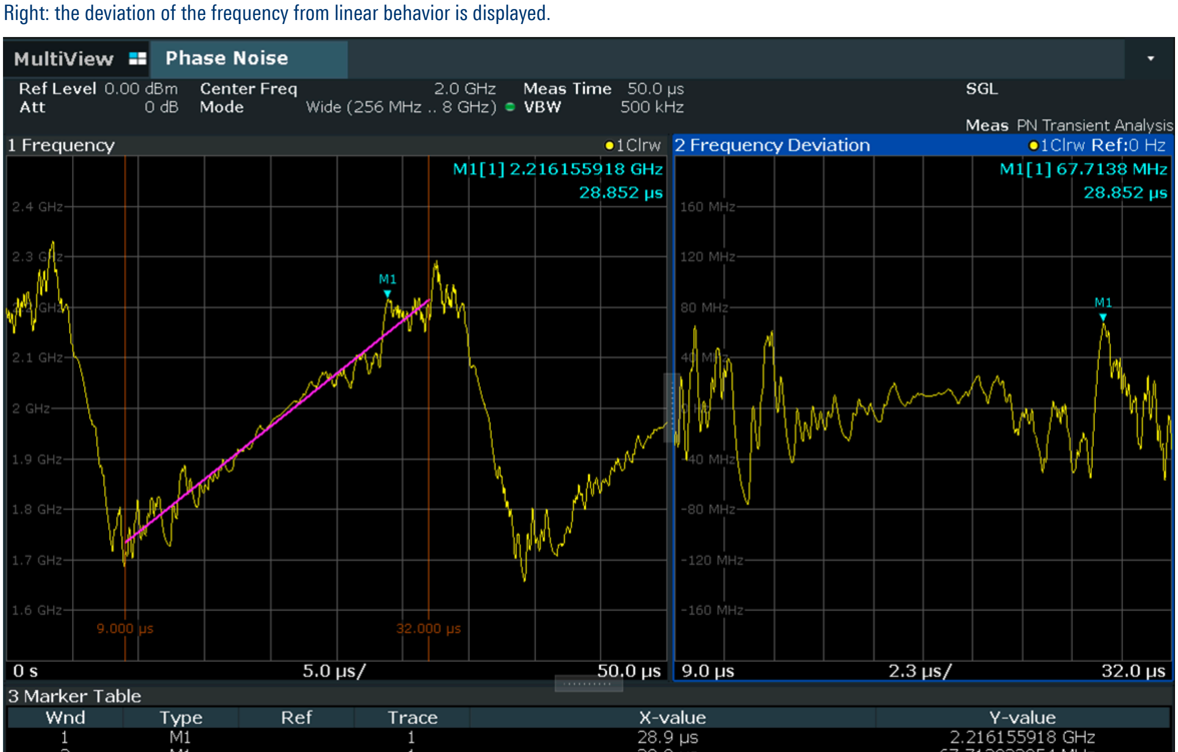
Deviations from the linear behavior of e.g. radar chirp signals in the frequency domain have a crucial influence on system performance and have to be analyzed in detail. The R&S®FSWP inserts a reference line, which is the calculated regression slope of the signal between two evaluation lines that can easily be adapted by the user via the touchscreen. In a new window, the deviation of the frequency from the reference line is displayed, as can be seen below.

Automatic settling time measurement

After a trigger event, the R&S®FSWP automatically measures the time, until the frequency of the synthesizer stays in between a certain tolerance range for the frequency. Users can define this tolerance range according to their requirements and the result is displayed on the screen. No complex configuration with limit lines and delta marker function is needed.

Automatic settling time measurement: after defining the tolerance frequency range the settling time is displayed in the result summary.

Analysis of linearity of FMCW chirps. Left: the pink reference line can be seen between the evaluation lines.
Right: the deviation of the frequency from linear behavior is displayed.



ANALYZING THE RANDOM JITTER AND PERIODIC JITTER OF CLOCK-LIKE SIGNALS IN HIGH SPEED DIGITAL APPLICATIONS

Jitter measurement of reference clocks

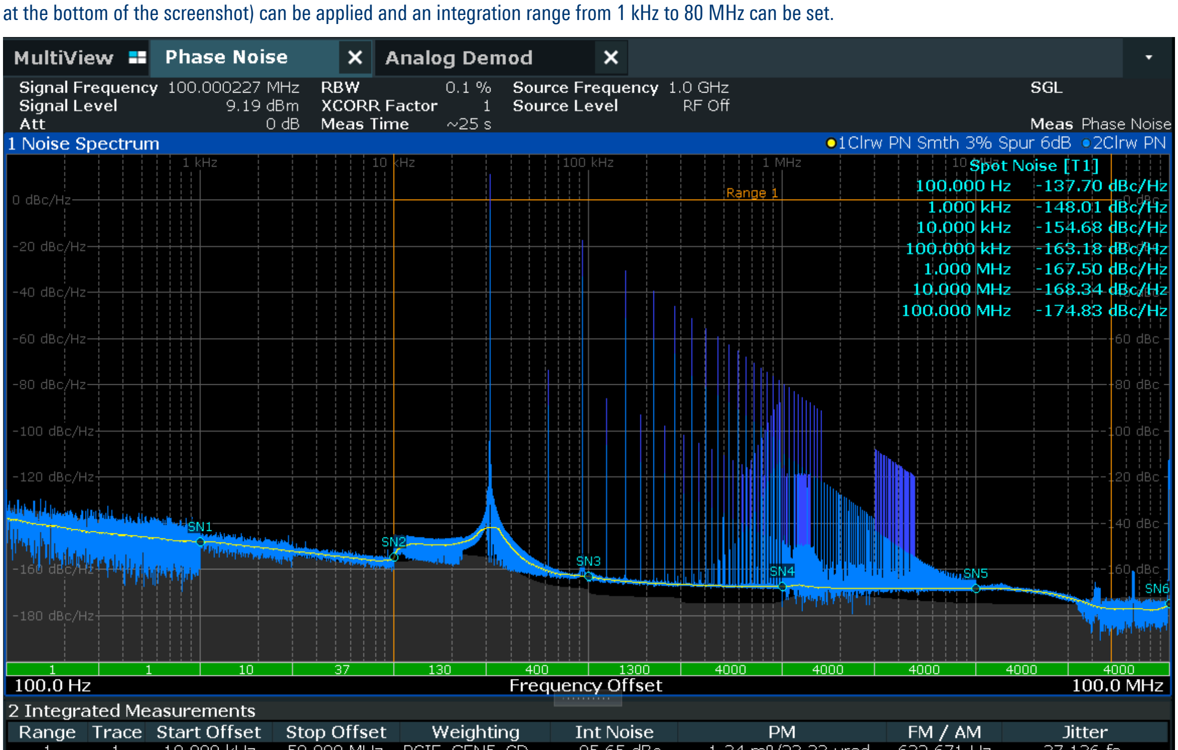
High speed digital interfaces like PCIe 6.0, IEEE 802.3ck and others require oscillators and reference clocks (RefClk) with ultra-low jitter (e.g. 100 fs or better). To measure the jitter performance of the device, the R&S®FSWP is the instrument of choice. Due to its industry-leading jitter and phase noise sensitivity, it shows the true jitter performance of the device under test. Based on a digital demodulation architecture, it can also measure RefClks with spread spectrum clocking (SSC). The R&S®FSWP displays random jitter (RJ) and periodic jitter (PJ) and offers weighting filters, so that the jitter can be weighted in line with TX, RX and clock data recovery (CDR) transfer functions.

Jitter measurements on high speed data lanes using clock pattern on the lane under test (LUT)

The data lanes in high speed interfaces also require a very low RJ. Key contributors are the jitter of the reference clock and the jitter of the phase-locked loop (PLL), converting the reference clock into the symbol clock.

With a clock pattern on the data lane, the R&S®FSWP measures the true RJ and PJ of the signal. By substituting the reference clock with a quasi-ideal signal source with negligible jitter (e.g. with the R&S®FSWP-B64 option or an R&S®SMA100B RF and microwave signal generator), the R&S®FSWP even measures the specific jitter contribution of the PLL. The digital demodulation architecture supports measurements using SSC with a down-spread of up to 80 MHz, as used in PCIe 6.0. Jitter, for example, can be weighted with a behavioral CDR filter to model the behavior of a receiver's CDR.

Measurement of a reference clock at 100 MHz with spread spectrum clocking (SSC). A weighting filter (see "PCIE_GEN5_CDR_100MHz" at the bottom of the screenshot) can be applied and an integration range from 1 kHz to 80 MHz can be set.



SPECIFICATIONS IN BRIEF

Base unit		
Frequency		
Frequency range, RF input		
Phase noise, amplitude noise measurement	R&S®FSWP8	1 MHz to 8 GHz
	R&S®FSWP26	1 MHz to 26.5 GHz
	R&S®FSWP50	1 MHz to 50 GHz
Phase noise measurement		
Measurement results		SSB phase noise, spurious signals, integrated RMS phase deviation, residual FM, time jitter

Phase noise sensitivity with R&S®FSWP-B60 option (correlations = 1, start offset = 1 Hz)[1]									
RF input frequency	Offset from carrier								
	1 Hz	10 Hz	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz	10 MHz	30 MHz
1 MHz	–118	–136	–148	–166	–176	–176			
10 MHz	–106	–130	–140	–158	–170	–170	–170		
100 MHz	–86	–116	–136	–163	–170	–173	–175	–175	–175
1 GHz	–66	–96	–116	–143	–166	–173	–173	–173	–173
3 GHz	–56	–86	–106	–133	–160	–164	–170	–173	–173
7 GHz	–49	–79	–99	–130	–153	–157	–163	–173	–173
10 GHz	–46	–76	–96	–128	–147	–150	–155	–173	–173
16 GHz	–42	–64	–92	–124	–143	–146	–151	–170	–170
26 GHz	–38	–60	–88	–120	–139	–142	–147	–166	–166
50 GHz	–32	–54	–82	–114	–133	–136	–141	–160	–160

Phase noise sensitivity with R&S®FSWP-B61 option (correlations = 1, start offset = 1 Hz)[1]											
RF input frequency	Offset from carrier										
	0.01 Hz	0.1 Hz	1 Hz	10 Hz	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz	10 MHz	30 MHz
1 MHz	–60	–105	–118	–136	–148	–166	–176	–176			
10 MHz	–40	–86	–115	–132	–142	–160	–170	–170	–170		
100 MHz	–20	–66	–95	–117	–140	–166	–170	–173	–175	–175	–175
1 GHz	0	–46	–75	–97	–120	–150	–166	–173	–173	–173	–173
3 GHz	+10	–36	–65	–87	–110	–140	–160	–164	–170	–173	–173
7 GHz	+17	–29	–58	–80	–103	–133	–153	–157	–163	–173	–173
10 GHz	+20	–26	–55	–77	–100	–133	–152	–153	–157	–173	–175
16 GHz	+24	–22	–51	–73	–96	–129	–148	–149	–153	–170	–171
26 GHz	+28	–18	–47	–69	–92	–125	–144	–145	–149	–166	–167
50 GHz	+34	–12	–41	–63	–86	–119	–138	–139	–143	–160	–161

Amplitude noise measurement		
Offset frequency range	input signal ≤ 100 MHz	10 mHz to 30% of carrier frequency
	input signal > 100 MHz	10 mHz to 30 MHz

AM noise sensitivity[1]

RF input frequency	Offset from carrier								
	1 Hz	10 Hz	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz	10 MHz	≥ 30 MHz
1 GHz	–105	–120	–135	–150	–158	–165	–165	–165	–165
10 GHz	–90	–105	–120	–135	–150	–160	–165	–165	–165

Residual phase noise measurement (R&S®FSWP-B64 option), internal source		
Signal source		
Frequency range	R&S®FSWP8	10 MHz to 8 GHz
	R&S®FSWP26	10 MHz to 18 GHz
	R&S®FSWP50	10 MHz to 18 GHz
Residual phase noise measurement		
Offset frequency range	input signal ≤ 100 MHz	10 mHz to 30% of carrier frequency
	input signal > 100 MHz	10 mHz to 30 MHz

Sensitivity [1]

RF input frequency	Offset from carrier							
	1 Hz	10 Hz	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz	3 MHz
1 GHz	–115	–123	–137	–147	–160	–165	–165	–161
10 GHz	–85	–104	–120	–138	–148	–154	–164	–160

[1] Values in dBc (1 Hz).

R&S®FSWP-B1 signal and spectrum analyzer option		
Frequency range	R&S®FSWP8	10 Hz to 8 GHz
	R&S®FSWP26	10 Hz to 26.5 GHz
	R&S®FSWP50	10 Hz to 50 GHz
Aging per year		1×10^{-7}/year
	with R&S®FSWP-B4 option	3×10^{-8}/year
Resolution bandwidths	standard filter	1 Hz to 10 MHz with R&S®FSWP-B8 option additionally: 20 MHz, 50 MHz, 80 MHz
	RRC filter	18 kHz (NADC), 24.3 kHz (TETRA), 3.84 MHz (3GPP)
	channel filter	100 Hz to 5 MHz
	video filter	1 Hz to 10 MHz
I/Q demodulation bandwidths		10 MHz
	with R&S®FSWP-B80 option	80 MHz
	with R&S®FSWP-B320 option	320 MHz
Displayed average noise level (DANL)	2 GHz	–150 dBm (1 Hz)
	8 GHz	–150 dBm (1 Hz)
	20 GHz	–145 dBm (1 Hz)
	40 GHz	–137 dBm (1 Hz)
DANL with preamplifier	8 GHz	–162 dBm (1 Hz)
	20 GHz	–160 dBm (1 Hz)
	40 GHz	–156 dBm (1 Hz)
Phase noise	1 GHz carrier frequency, 10 kHz offset	typ. –138 dBc (1 Hz)
Total measurement uncertainty	< 8 GHz	< 0.4 dB

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The analyzer firmware can be updated using a USB storage device or via the LAN port.
Free firmware updates can be downloaded from the Rohde&Schwarz website: www.rohde-schwarz.com.

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For detailed specifications and ordering information, see R&S®FSWP specifications (PD 3683.7719.22).

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