FSWX
SIGNAL AND SPECTRUM ANALYZER

Measure the impossible

Product Brochure
Version 04.00

ROHDE&SCHWARZ

Make ideas real

AT A GLANCE

In today's fast-paced technological landscape, it is crucial to have a reliable and efficient signal analysis solution that can transcend limits and overcome the limitations of traditional measurement methods. The cutting-edge, two-path FSWX architecture makes a new level of performance and precision in signal analysis a reality.

The FSWX advanced signal analysis solution shows the real performance of a device under test (DUT) like never before. The FSWX introduces a groundbreaking concept in signal and spectrum analysis. Designed for wide bandwidths, it is not a classic heterodyne receiver. Signal and spectrum analysis use the same signal path and the same broadband A/D converter. The signal is downconverted via a maximum of one mixer stage and most of the analysis is performed in the powerful digital backend.

This innovative concept enables multichannel measurements, cross-correlation, high sweep speed and unrivalled precision. It is now possible to analyze signals at the lowest levels and capture critical details to ensure that no important information goes unnoticed.

Don't let unwanted signals distract you from your primary focus. The FSWX can filter out unwanted noise and interference, allowing you to concentrate solely on your signal of interest.

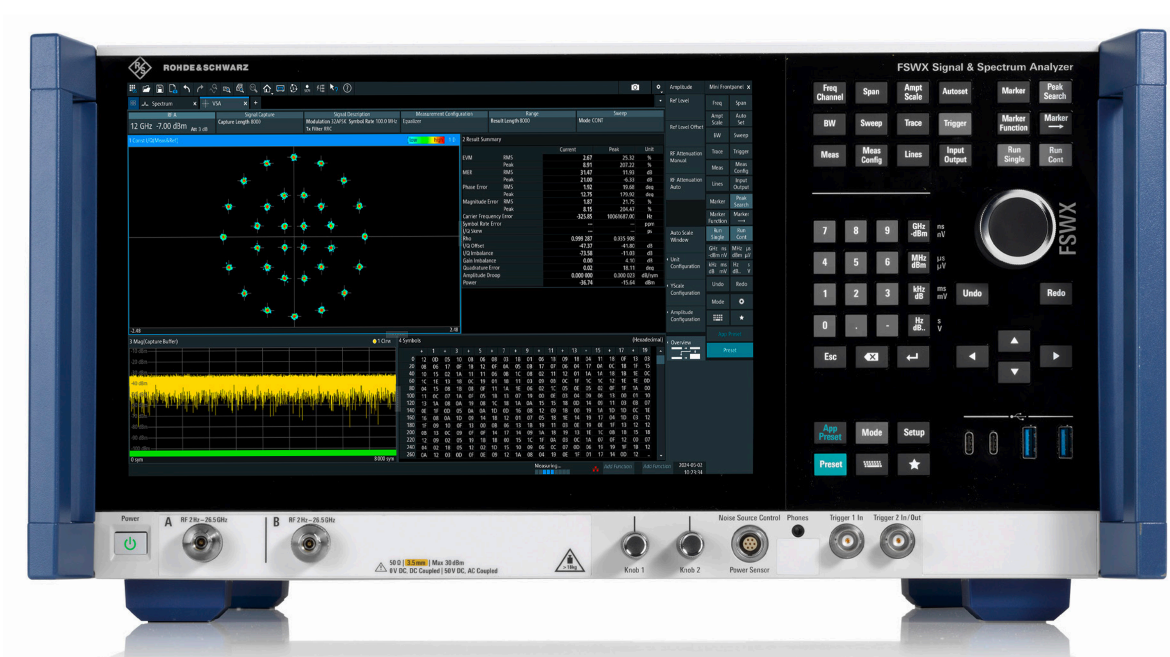
The FSWX signal analysis solution is designed to meet the need for speed. With its unprecedented speed and measurement capabilities, signals can be analyzed faster than ever before. This accelerated pace empowers the user to make quick decisions, troubleshoot issues promptly and stay ahead of the competition.

First multichannel spectrum analyzer in the market

- Phase coherent capturing at identical or different frequencies
- Simultaneous analysis of different frequencies
- Comparison of DUT input and output signals

Key features

- Extremely low phase noise: high signal purity and stability results in accurate and reliable measurements
- Spurious-free dynamic range: enables recognition of desired signals and unwanted spurious signals
- Advanced internal two-path architecture for cross-correlation: improves SNR by eliminating the analyzer's inherent noise
- 8 GHz bandwidth: for the demands of today's and tomorrow's mobile communications, wireless and radar technologies
- Outstanding EVM performance
- Preselected I/Q analysis over the full frequency range: innovative filter bank concept for preselection, enabling image rejection up to maximum available analysis bandwidth
- Level inaccuracy < 1 dB over the full frequency range



FSWX front view

BENEFITS

APPLICATIONS

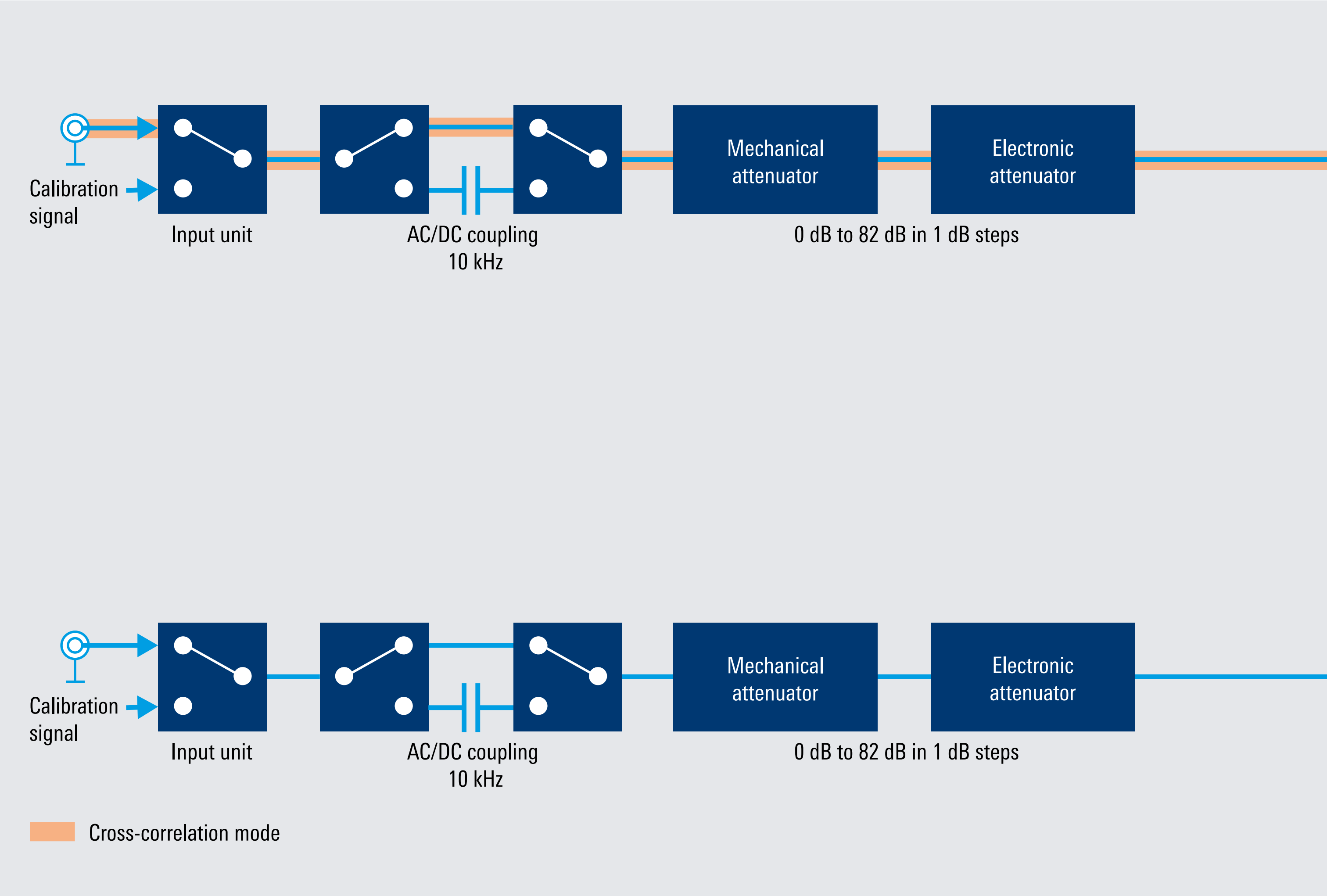
VERSATILE TWO-PATH ARCHITECTURE

Leveraging the powerful two-path architecture makes it possible to achieve high dynamic range measurements specifically for low phase noise and improved error vector magnitude (EVM) analysis. Even close to the physical noise limit, the FSWX excels at accurately quantifying phase noise and EVM, providing a comprehensive understanding of signal quality and performance.

The FSWX signal and spectrum analyzer boasts an extended spurious free dynamic range. By effectively suppressing inherent spurious signals and minimizing unwanted artifacts, the FSWX ensures that the true characteristics of the signal under test are faithfully captured and analyzed, even in the most demanding testing scenarios.

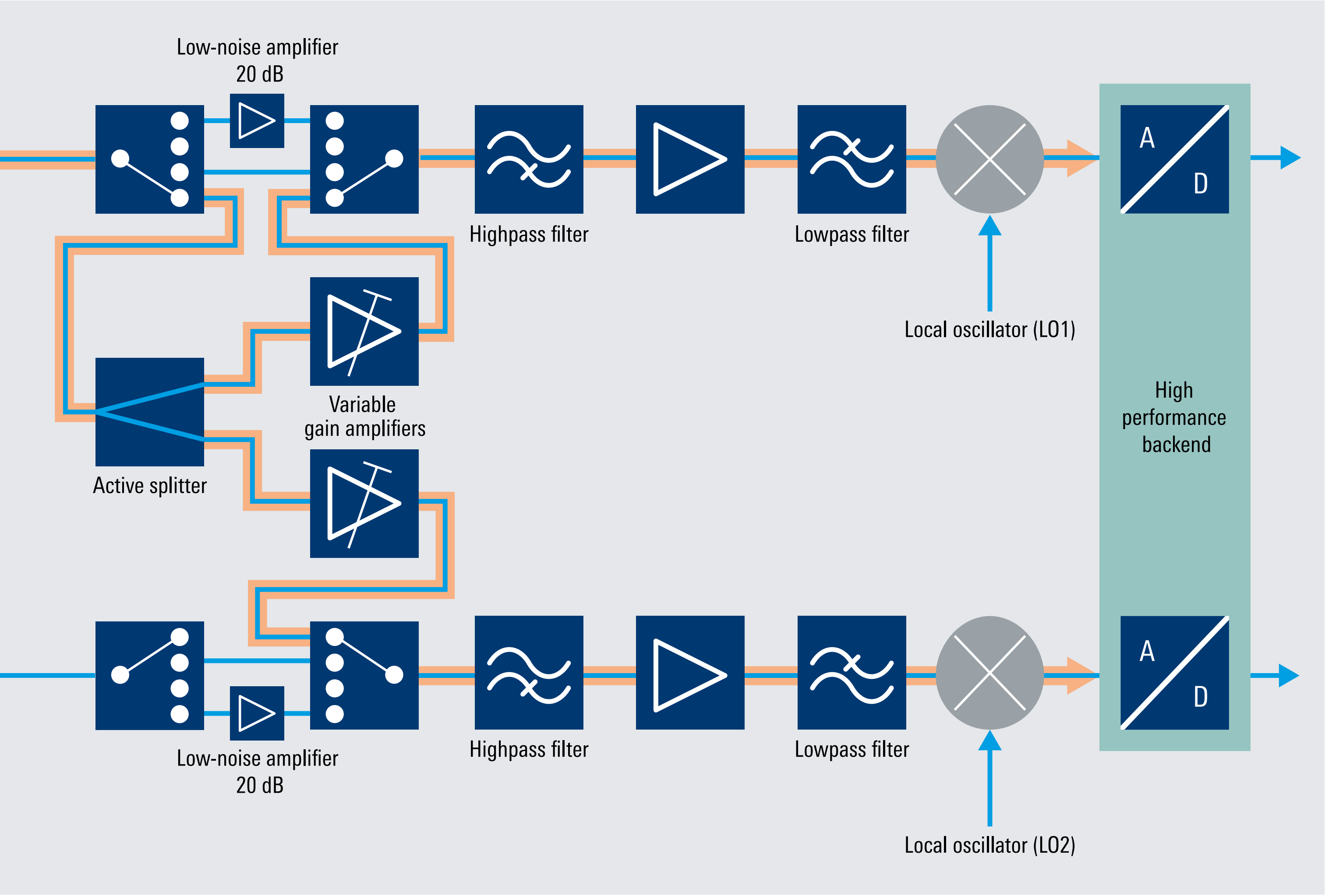
The FSWX adds the cross-correlation technique to improve phase noise sensitivity adding a second local oscillator. This is especially beneficial in order to measure sources that have extremely low phase noise. This technique significantly improves sensitivity for phase noise analysis.

Two-path architecture



Thanks to its advanced technology, the noise floor of the FSWX can be lowered to the thermal limit. This makes it possible to uncover hidden patterns, detect anomalies and identify previously overlooked correlations.

Even the dynamic range for EVM measurements can be expanded by increasing the signal-to-noise ratio (SNR) with the cross-correlation technique. The only limitation is the real performance of the device; added noise from the test instrument is no longer a limiting factor.



UNLEASHING THE POWER OF ADDITIONAL INPUT CHANNELS

The first multichannel signal and spectrum analyzer on the market revolutionizes the way data is collected and analyzed.

Analyzing multiple inputs time synchronously expands the scope of signal analysis and unlocks new possibilities for measurement setup and applications:

Measurement setup

▶ Reference signals, which represent the expected or desired waveform, can be compared in real time with the received waveform to evaluate the accuracy of the complete system

▶ The multichannel architecture enables simultaneous capture of multiple signals, and time synchronized channels allow fast correlation of the captured data

Applications

▶ Optimizing an antenna configuration for proper beamforming is possible by measuring and analyzing the phase relation between individual antennas

▶ To assess the performance of amplifiers, downconverters and upconverters, it is essential to compare the output signal with the reference signal at the input. This can be used to evaluate gain, linearity, noise figure and frequency conversion efficiency.

▶ For characterization of complex radar systems or jamming scenarios, the analysis of various input signals is required to accurately assess their performance

▶ MIMO measurements for mobile communications and WLAN applications

Multichannel approach: using the real-world signal at the input of the DUT as a reference signal for amplifier characterization measurements.

UNRIVALED RF PERFORMANCE FOR BEST EVM

New standards like the upcoming 6G wireless standard bring new challenges such as increased bandwidths or complex new modulation schemes. In order to measure real device performance, the instrument´s residual EVM noise floor needs to be as low as possible. The cross-correlation used in the FSWX reduces the noise contribution, enabling excellent EVM performance.

Because phase noise is a contributor to EVM degradation, having an instrument with low inherent phase noise is essential. With its groundbreaking architecture, the FSWX signal and spectrum analyzer sets a new standard in phase noise contribution. It offers exceptionally low phase noise, ensuring precise and accurate measurements of phase-related parameters. This is particularly important in applications where phase stability is critical, such as in wireless communications systems or radar applications.

The FSWX provides EVM measurements through a wide variety of options, enabling comprehensive analysis of signal quality such as amplifier measurements, vector signal analysis, wireless technology measurement options and more. With its advanced capabilities, the FSWX lets users assess signal performance and identify any potential issues or distortions.

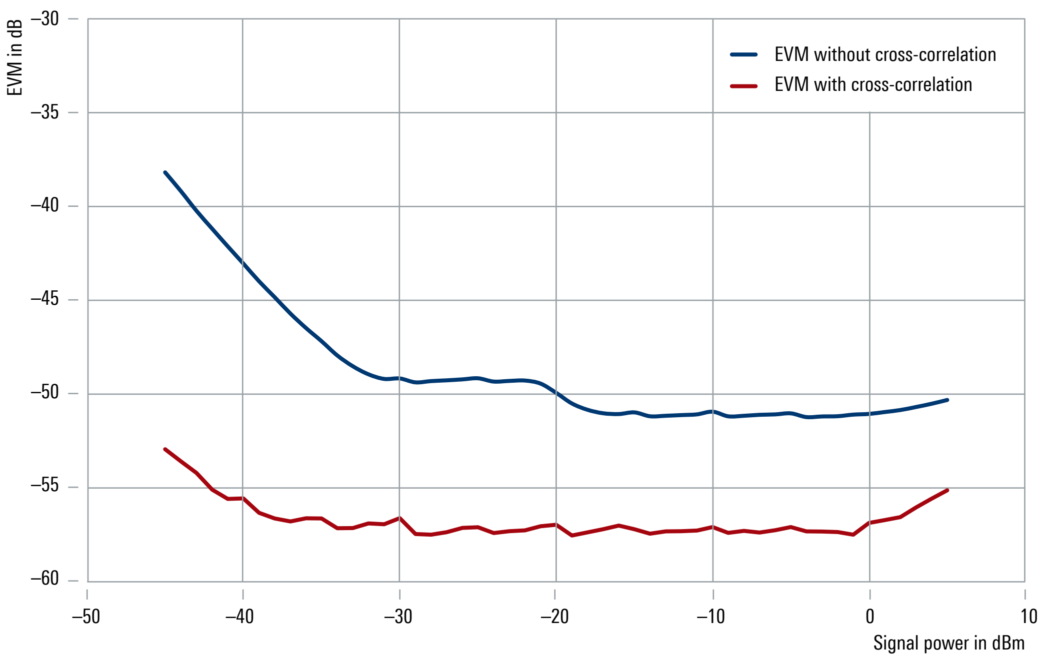
Outstanding EVM performance up to the millimeterwave range for wideband modulated signals

Thanks to its high dynamic range, the FSWX achieves very low EVM results across a wide range of input power, even at millimeterwave frequencies. For a 100 MHz wide 5G NR signal at 28 GHz, it achieves a residual EVM below –49 dB.

Its high-performance digitizer yields a low inherent error vector magnitude (EVM), providing new insight into designs.

Outstanding residual EVM

Bathtub curve comparison with and without cross-correlation activated for a 5G NR signal with 100 MHz bandwidth at a center frequency of 15 GHz. The EVM performance without cross-correlation is industry-leading. Applying cross-correlation leads to a significant EVM improvement and flattens the bathtub curve shape, especially for lower input power levels.



ANALYZING COMPLEX RADAR SCENARIOS

Next generation radar systems operate over a wide frequency range to account for atmospheric effects, jamming, interference and detection avoidance. To characterize these systems, multiple inputs and wide analysis bandwidth are needed to compare the transmitted or received waveform with a reference signal for characterization of pulse compression, radar cross sections or to measure the phase relation of individual antennas. For jamming applications, where the response to a radar signal has to be analyzed or how one radar transmission may interfere with another, multiple inputs are essential.

To increase the sensitivity of radar applications, the added wideband noise or phase noise of components or the whole system has to be minimized, which pushes measurement techniques needed for development to their limits. Techniques like cross-correlation provide a powerful tool for engineers to further improve their applications.

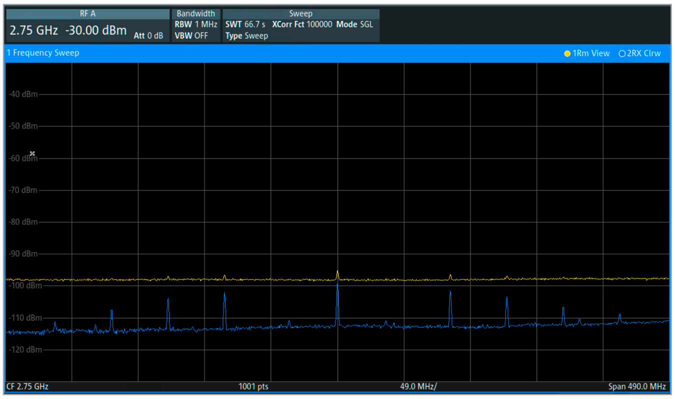
FSWX addresses all these needs. In addition, the FSWX is the first instrument to offer the cross-correlation detector to overcome the limitation of sensitivity for standard spectrum measurements. It is a powerful tool for detecting the smallest spurs and unwanted interference that reduce the performance of radar systems or communications applications, down to the physical limit of –174 dBm (1 Hz). Using the inherent cross-correlation technique increases the sensitivity for noise figure and phase noise measurements like never before in high-end signal and spectrum analyzers.

Powerful software applications are available to characterize pulses, pulse compression, frequency hopping and frequency modulated continuous wave (FMCW) signals. Group delay can be measured at the push of a button on multicarrier signals. Noise figure and phase noise measurement applications provide results with the highest accuracy thanks to cross-correlation.

The signal and spectrum analyzer analyzes modulation quality for radar and communications applications up to a signal bandwidth of 8 GHz.

Multichannel approach: monitoring changes over time of the output signal of a radar jammer (blue traces) in direct relation to the radar input signal (yellow traces).

The cross-correlation detector significantly enhances the instrument's sensitivity by removing the internal noise. This reveals signals and spurs that are below the instrument's noise floor and thus not detectable with conventional detection approaches (e.g. RMS detector, see the yellow trace).



LEADING MODERN SATELLITE TEST TECHNIQUES

To ensure reliable satellite communications, RF measurements are needed for monitoring data traffic in the channel, characterization of signal quality and spectral regrowth (noise power ratio, NPR). Besides spectral measurements, analysis of modulation quality and the bit error rate (BER) directly show data transmission performance. The group delay describes phase response over frequency, which has a crucial impact on the maximum data rate of the system. For these applications, a wide modulation or analysis bandwidth is needed because transmission channels for satellite communications can be up to several gigahertz wide.

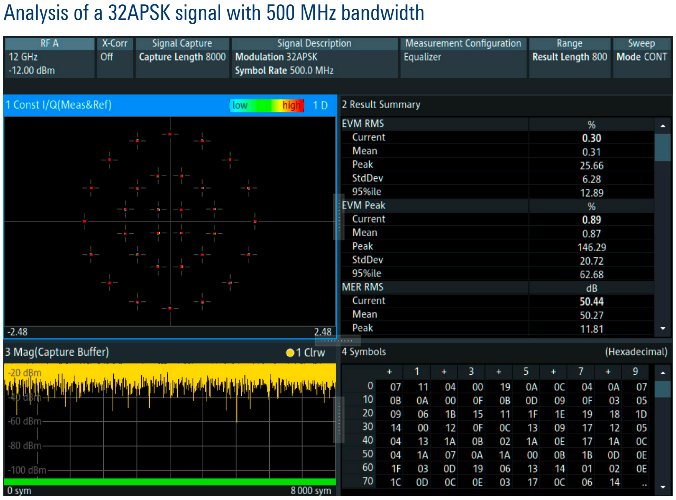
Spectral measurements
The FSWX supports dedicated measurement options for SNR or NPR analysis with unrivaled sensitivity using the cross-correlation detector. The inherent noise of the instrument has no influence on the measurements.

Modulation analysis
Thanks to up to 8 GHz wide analysis bandwidth combined with a powerful vector signal analysis option, the FSWX can measure modulation quality of transmission channels. The accuracy of such measurements can be significantly enhanced by applying cross-correlation. Predefined setups for DVB-S standards enable measurements at the push of a button.

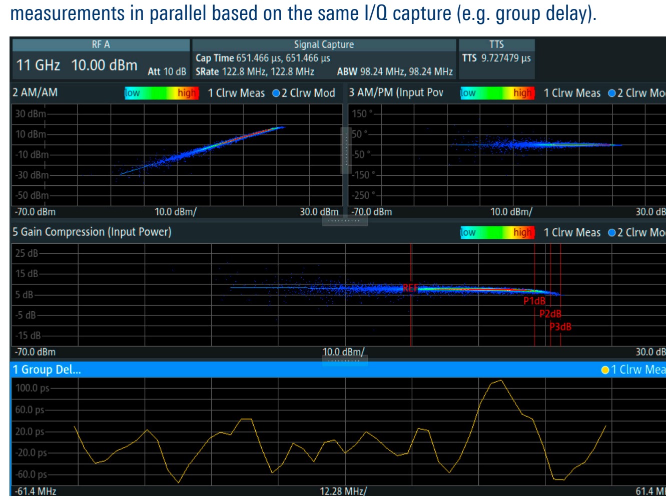
Group delay
A multicarrier signal covering the whole channel bandwidth measuring the amplitude and phase of the carrier enables group delay calculation. The two input channels show an instantaneous measurement with the reference signal on one channel and the group delay of the DUT on the other channel.

Characterization of amplifiers
Equipped with the R&S®FSW3-KM118 option, the FSWX is suitable for characterizing two-port devices such as satellite transponders, power amplifiers and converters. Typical measurements include gain compression, AM/AM, AM/PM, distortion, ACLR, frequency response and EVM. Direct digital predistortion can be applied to linearize the DUT. By using two channels, the input signal and the output signal of the DUT can be captured in parallel, providing instantaneous results.

Analysis of a 32APSK signal with 500 MHz bandwidth



Amplifier characterization using the signal at the input of the DUT as reference. The amplifier characterization measurement application allows for additional measurements in parallel based on the same I/Q capture (e.g. group delay).



STAYING AHEAD IN 5G AND BEYOND

The FSWX signal and spectrum analyzer provides insights into the signal quality at every step of your development process. From generic modulation analysis of single carrier and OFDM signals to standard compliant 5G measurements, the FSWX supports you on your path to innovation.

Measurement applications with auto sets and auto detection help users and give them time to focus on development. There are standard compliant limit lines, pre-defined test models as well as signal demodulation and conformance checks at a click. But the solution is not limited to existing standards. For early research on new numerologies or waveforms, the FSWX provides an extensive analysis toolbox.

Measurement applications

The FSWX provides measurement applications for all current cellular technologies, from GSM to 5G Advanced. With its high performance wideband capabilities, it is well suited to future standards.

The outstanding RF performance of the FSWX in combination with inherent cross-correlation allows seamless EVM and ACLR measuring of the most challenging signals with the highest dynamic range. For high modulation orders like 4096QAM, extremely precise measurement equipment is needed in order to measure the high signal quality of the DUTs without influencing the measurement.

Beamforming and MIMO

Get insights into the beam weights and phase differences on different antenna ports of your device with the independent RF inputs on the FSWX. Real 2x2 MIMO measurements are possible on the FSWX, which combines the highest RF performance with multichannel architecture.

Multistandard and multiband radios

The FSWX can perform time synchronized captures in different applications. For multistandard radios, time-aligned measurements – in GSM, LTE and 5G applications, for instance – can run simultaneously. This feature also enables time-aligned measurements of signals of the same standard in different applications. For multiband radios, different component carriers at frequencies far apart can be analyzed in parallel in different measurement tabs.

Cross-correlation significantly improves the EVM. In this example, approx. 5 dB EVM improvement can be achieved for a 5G NR signal with 100 MHz bandwidth at a center frequency of 5.9 GHz.

TOOLS TAILORED TO USER NEEDS

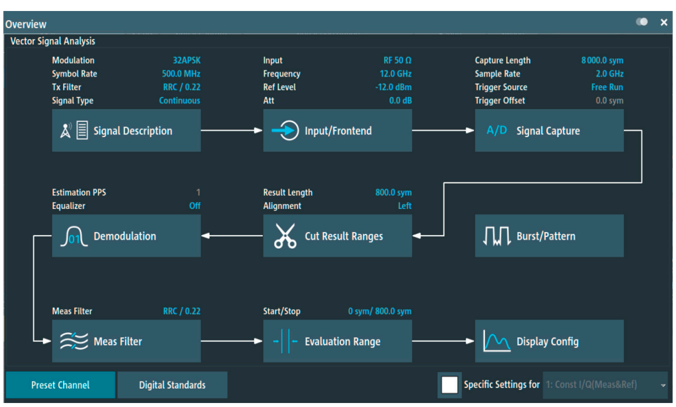
Research and pre-development experts are continuously exploring novel approaches to improving their systems and paving the way for next generation standards. The FSWX supports these activities with powerful generic signal analysis capabilities that allow them to flexibly customize their measurement configurations to best fit their signals of interest.

Vector signal analysis

The R&S®FSW3-KM101 vector signal analysis option lets users flexibly analyze digitally modulated single carriers down to the bit level. With an exhaustive selection of modulation formats and numerous user-definable constellations and mappings, this application offers unmatched versatility.

With its intuitive block diagram display, the R&S®FSW3-KM101 option helps users find useful settings automatically based on the description of the signal to be analyzed. The combination of the touchscreen and block diagram simplifies operation and readability.

Clearly structured block diagram display



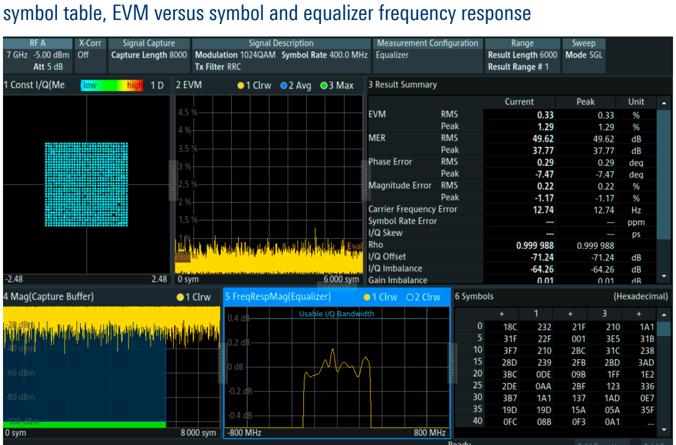
The R&S®FSW3-KM101 enables detailed signal analysis, significantly simplifying the process of troubleshooting. Among its diverse display options are amplitude, frequency and phase, eye diagrams and constellation or vector diagrams. The tools allow users to analyze RF signals as well as analog and digital baseband signals and offer statistical analysis in forms such as histogram representations. It also features an equalizer that helps users identify the optimum filter design.

Custom OFDM signal analysis

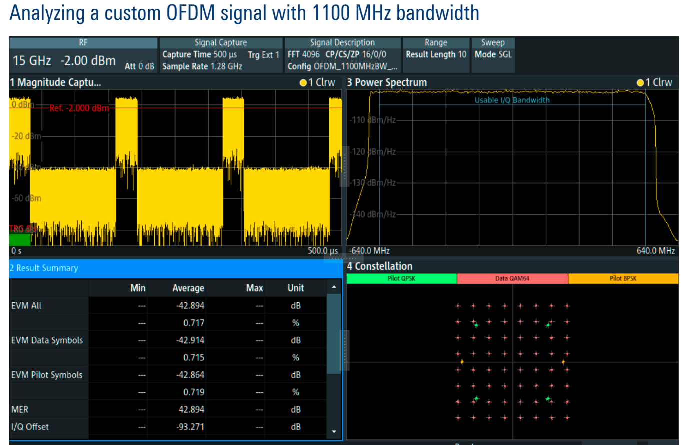
The R&S®FSW3-KM112 option provides the capability to analyze even the most complex orthogonal frequency division multiplexing (OFDM) based communications signals. This option lets users tailor the analysis to their precise requirements and tap the system's full potential. The R&S®FSW3-KM112 option features a built-in configuration file wizard that facilitates quick creation of a configuration file.

The R&S®FSW3-KM112 can demodulate and analyze custom OFDM, discrete Fourier transform spread OFDM (DFT-s-OFDM) and single carrier frequency division multiple access (SC-FDMA) signals with a known FFT size and cyclic prefix (CP). Moreover, it can analyze signals utilizing an configuration file automatically generated by the R&S®SMW200A vector signal generator with the R&S®SMW-K114 OFDM signal generation option.

Analysis of a 1024QAM modulated signal: constellation diagram, result table, symbol table, EVM versus symbol and equalizer frequency response



Analyzing a custom OFDM signal with 1100 MHz bandwidth



PUSHING THE LIMITS FOR ACTIVE RF COMPONENTS TESTING

Cross-correlation for spectral measurements

When cross-correlation is enabled in the FSWX, inherent noise is suppressed. The improvement in DANL is $5 \cdot log(N)$, where N is the number of correlations/averages.

Cross-correlation is activated in the FSWX when the cross-correlation detector is used. The only limit is the thermal noise floor of –174 dBm (1 Hz).

In addition, the two-path architecture suppresses inherent spurs without wasting time with a double sweep.

Noise figure and gain measurements

To perform noise figure and gain measurements on amplifiers or frequency converting devices, the Y-factor method is used. The higher the Y-factor, the lower the measurement error. Getting rid of the inherent noise of the instrument by applying cross-correlation enables an accuracy for noise figure and gain measurements never before available.

Use of the R&S®FS-SNS smart noise sources eliminates the need for time-consuming, error-prone entry of excess noise ratio (ENR) tables. Temperature, ENR and VSWR tables are loaded automatically. Users not only get the most accurate Y-factor measurement solution but the most convenient as well.

Phase noise measurement

Developers of oscillators and synthesizers benefit from the excellent RF performance of the FSWX for phase noise measurements. At 10 kHz offset from the carrier, the FSWX achieves a typical phase noise of –140 dBc (1 Hz) for a 1 GHz carrier. With cross-correlation implemented, sensitivity can even be increased by $5 \cdot log(N)$, with N the number of averages, achieving the performance of a high-end phase noise tester. AM noise can be suppressed as well, and a digital PLL can be implemented to follow drifting VCOs.

Amplifier measurements

A combination of a Rohde & Schwarz vector signal generator and the FSWX signal and spectrum analyzer equipped with the R&S®FSW3-KM118 option is suitable for characterizing two-port devices such as satellite transponders, power amplifiers and converters. A digitally modulated signal is used to determine how the DUT will perform under real-world conditions. Typical measurements include gain compression, AM/AM, AM/PM, distortion and ACLR. Direct digital predistortion (DPD) can be applied to linearize the DUT based on an iterative approach. It minimizes EVM and ACLR without being limited to a certain DPD algorithm. The solution measures frequency response of the DUT and can display magnitude, phase and group delay versus frequency. The two channel FSWX captures and displays the reference signal and measured signal, showing the results in real time.

Phase noise measurement with the R&S®FSW3-KM129 option with cross-correlation. The yellow trace shows the measurement with amplitude noise rejection; the green trace without amplitude noise suppression; the grey area shows the cross-correlation gain.

MASTERING THE MOST STRINGENT WLAN CHALLENGES

Follow the latest technology trends

Wireless local area networks (WLANs), categorized as IEEE 802.11, have become an integral part of today's business, educational and personal landscapes.

The WLAN IEEE 802.11 protocol has gone through several iterations – IEEE 802.11a/b/g/n/ac/ax/be and the latest IEEE 802.11bn also known as Wi-Fi 8. This technological evolution was driven by demands for higher data throughput, robustness and improved security. The latest developments are designed for economic use of the frequency spectrum, higher data rates, lower power consumption and lower latency in urban areas.

To achieve these aims, the latest IEEE 802.11 standards apply features such as 4096QAM modulation, multi-link operation (MLO), more spatial streams for multi-user MIMO (MU-MIMO) links and restricted target wake time (R-TWT).

With its WLAN analysis applications (R&S®FSW3-KM410, -KM411 and -KM412), the FSWX spectrum and signal analyzer enables extensive in-depth analysis of WLAN signals in line with legacy and current standards.

Unrivaled EVM performance

With its outstanding standard EVM performance, particularly in combination with the R&S®FSW3-KM417 cross-correlation option, the FSWX can discover details of WLAN signals that have been hidden up to now and offers new margins for optimization.

Ready for MIMO

Its multichannel architecture makes the FSWX well suited to analysis of complex MLO, MU-MIMO and R-TWT scenarios today and in the future.

Analysis of a 4096QAM modulated 320 MHz wide IEEE 802.11bn signal

COMBINING DIFFERENT MEASUREMENT SCENARIOS

Time-aligned multi-input analysis

With the cross-application control and triggering (CrossACT) functionality, multiple applications can measure concurrently, enabling time-aligned multi-input analysis. The applications are grouped into cross-application control and triggering groups. A group can consist of different applications or different instances of the same application. These applications can then capture multiple I/Q data streams from multiple sources in parallel: up to four I/Q data streams from RF, an arbitrary number of I/Q files and mixed scenarios of RF inputs and files.

CrossACT scenarios

The following scenarios illustrate how the new cross-application control and triggering option brings real benefits:

- Synchronous capture from different hardware paths
- Multiple carriers demodulated in two different applications
- Very high dynamic range measurement with external components such as filters e.g. for harmonic measurements with limited internal second harmonic intercept (SHI)
- Over-the-air (OTA) testing: parallel measurement of two polarizations of a single antenna
- Two different carriers, if more bandwidth is required
- Simultaneous evaluation of 5G interference and radar bands
- One single capture that must meet the bandwidth requirements of both applications, e.g. to simultaneously perform I/Q spectrum analysis measurements with different settings in the I/Q signal analyze; e.g., for simultaneous measurement of LTE and 5G

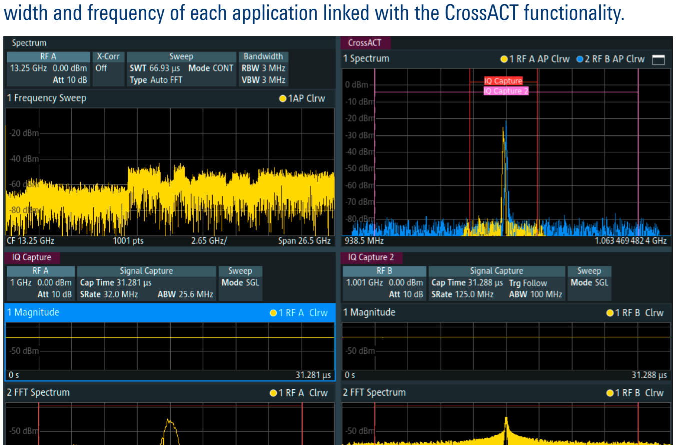
All running applications in the cross-application control and triggering group can start a capture simultaneously.

Parameter coupling

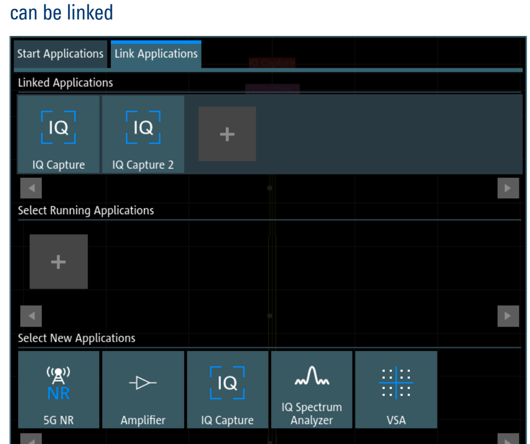
With parameter coupling, a parameter that occurs in different scenarios, e.g. in different applications, can be defined as coupled via the graphical user interface (GUI). For instance, if the parameter reference level is coupled between two applications, a change of the reference level in one application will lead to a change in the other application as well. This applies also to parameters like center frequency, trigger level or trigger offset.

This yields high accuracy while avoiding parameter mismatches when performing measurements in different applications.

The parameters in the scenarios "I/Q capture" and "I/Q capture 2" are coupled via CrossACT and measure exactly at the same time; "I/Q capture 2" follows the trigger defined in "I/Q capture". The CrossACT spectrum gives an overview of captured bandwidth and frequency of each application linked with the CrossACT functionality.



Applications can be linked in CrossACT by drag-and-drop from the tab bar or using a special menu showing all applications that can be linked



SPECIFICATIONS IN BRIEF

Specifications in brief		
Frequency		
Frequency range		2 Hz to 26 GHz/44 GHz
Aging of reference frequency		$\pm 1 \times 10^{-7}$/year
	with R&S®FSW3-B4 option	$\pm 3 \times 10^{-8}$/year
Bandwidths		
Resolution bandwidths (–3 dB)	sweep filters and FFT filters	1 Hz to 10 MHz
	RRC filter	18 kHz (NADC), 24.3 kHz (TETRA), 3.84 MHz (3GPP)
	channel filter	100 Hz to 10 MHz
	video filter	1 Hz to 10 MHz
I/Q demodulation bandwidth per channel	standard	40 MHz
	with R&S®FSW3x-B100	100 MHz
	with R&S®FSW3x-B320	320 MHz
	with R&S®FSW3x-B600	600 MHz
	with R&S®FSW3x-B1G2	1200 MHz
	with R&S®FSW3x-B2G	2000 MHz
	with R&S®FSW3x-B4G	
	f < 7.5 GHz	2000 MHz
	f ≥ 7.5 GHz	4000 MHz
Phase noise (without cross-correlation), 10 kHz from carrier	1 GHz carrier	–135 dBc/Hz, –139 dBc/Hz (typ.)
	10 GHz carrier	–132 dBc/Hz (typ.)
Detectors		auto peak, max. peak, min. peak, RMS, average, sample, RMS cross-correlation
Displayed average noise level (DANL)	10 GHz, preamplifier off, RMS	–154 dBm/Hz (typ.)
	10 GHz, preamplifier on, RMS	–166 dBm/Hz (typ.)
	10 GHz, preamplifier off, RMS cross-correlation	–154 dBm/Hz – 5 × log(FFT number), min. –174 dBm/Hz
Intermodulation		
Third order intercept (TOI)	10 MHz ≤ f ≤ 8 GHz	22 dBm (typ.)
Total measurement uncertainty	10 MHz ≤ f ≤ 3.6 GHz	±0.26 dB
	3.6 GHz < f ≤ 8 GHz	±0.37 dB
	8 GHz < f ≤ 22 GHz	±0.82 dB
	22 GHz < f ≤ 26.5 GHz	±1.01 dB
	26.5 GHz < f ≤ 44 GHz	±1.21 dB

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1) For extended periods, contact your Rohde & Schwarz sales office.

Instrument management made easy

The R&S®InstrumentManager makes it easy to register and manage your instruments. It lets you schedule calibration dates and book services.

Find out more about our service portfolio under:

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You're in great hands

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- ► Local and personalized
- ► Customized and flexible
- ► Uncompromising quality
- ► Long-term dependability

Rohde & Schwarz

The Rohde & Schwarz technology group is among the trailblazers when it comes to paving the way for a safer and connected world with its leading solutions in test & measurement, technology systems and networks & cybersecurity. Founded more than 90 years ago, the group is a reliable partner for industry and government customers around the globe. The independent company is headquartered in Munich, Germany and has an extensive sales and service network with locations in more than 70 countries.

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Sustainable product design

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- ▶ Energy efficiency and low emissions
- ▶ Longevity and optimized total cost of ownership

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PD 3684.1314.12 | Version 04.00 | November 2025 (jr)
FSWX Signal and Spectrum Analyzer
Data without tolerance limits is not binding | Subject to change