R&S® FSUP
Signal Source Analyzer
Phase noise tester, high-end spectrum and signal analyzer in a single box
The R&S®FSUP combines the functionality of a high-end spectrum and signal analyzer with the advantages of a pure phase noise tester. The instrument is a unique and easy-to-use single-box solution for measuring oscillators and synthesizers in development and production applications. In addition, it leads to enormous cost reductions.

One of the primary tasks in developing transmit and receive modules is to measure oscillator phase noise. This is necessary not only in the development and production of state-of-the-art communications and broadcast systems, but also in special high-tech applications such as radar. Apart from phase noise, other parameters that need to be measured when characterizing oscillators include tuning slope, transient response, power, harmonics and spurious emissions. Amplifier noise is of significant interest as well. All of these measurements can be carried out with the R&S®FSUP, the only signal source analyzer that covers the frequencies up to the microwave range in a single box. The R&S®FSUP also features very-low-noise DC sources to enable a wide range of measurements.

The unique combination of a phase noise tester with low-noise DC sources and a spectrum and signal analyzer in a single box enables simple, cost-optimized test setups for development and production.

**Key facts**
- Frequency range up to 8/26.5/50 GHz
- Up to 110 GHz with external mixers
- Low-noise DC outputs for supply and tuning voltages
- Maximum flexibility for phase noise measurements
- Noise figure and gain measurements
- Oscillator characterization
- Analysis of digital and analog modulated signals
R&S® FSUP
Signal Source Analyzer
Benefits and key features

Highly flexible phase noise tester with versatile measurement capabilities
- Phase detector method with internal/external reference
- Two-DUT method
- Exceptional sensitivity
- Automatic setting of all important parameters
- Easy operation
- Detection, suppression and listing of interference
- Measurement of reference points as a function of frequency
- Measurement of residual phase noise
- AM noise
▷ page 4

Maximum dynamic range through cross-correlation
- Dynamic range increased by up to 20 dB at 26 GHz
- Cross-correlation up to 50 GHz in a single box
▷ page 7

Unique combination of phase noise tester and spectrum analyzer
- Measurement of phase noise using the spectrum analyzer method
- Typical spectrum measurements such as ACP or interference search
- Measurement of noise figure using the R&S®FSUP
▷ page 8

Analysis in the time domain
- Transient response of oscillators
▷ page 9

Characteristics at the push of a button
- Low-noise voltage source for supply and tuning voltages
- Complete characterization of oscillators
▷ page 10

Analysis of digital and analog modulated signals
- General vector signal analysis of digitally modulated signals
- Special analysis options for digital communications standards
- Analysis of analog modulated signals (AM/FM/πM)
▷ page 11
Highly flexible phase noise tester with versatile measurement capabilities

Easy setting of test setup in configuration menu with display of recommended measurement range.

Phase detector method with internal/external reference
In this mode, the R&S®FSUP offers various settings for phase noise measurements. The most commonly used mode – measurement by means of an internal phase comparator using an internal reference – is predefined. Since many applications call for an extended test setup, the R&S®FSUP provides a straightforward menu for easily setting various measurement modes.

Two-DUT method
When using high-grade oscillators with very good phase noise characteristics, the oscillators are commonly measured against one another and the result is corrected by 3 dB – a measurement that can be carried out directly by means of the R&S®FSUP. Even if the application requires a complex test setup, such as using an external reference and external downconverter, such tasks are easy to accomplish with the R&S®FSUP because the user is supported through graphical tools.

Exceptional sensitivity
To ensure reliable oscillator measurements, the internal reference must exhibit negligible phase noise compared to the oscillator. For this purpose, the R&S®FSUP has an internal source with exceptionally low phase noise values, e.g. at an input frequency of 1 GHz with cross-correlation:
- $-143 \text{ dBc (1 Hz)}$ at 10 kHz frequency offset
- $-172 \text{ dBc (1 Hz)}$ at 10 MHz frequency offset

Automatic setting of all important parameters
All important oscillator parameters, such as power and tuning slope, are automatically measured in order to generate stable settings for the PLL loop. In addition, the loop bandwidth and IF gain are set automatically. All of the automatically set parameters can be modified and adapted to specific measurement tasks. The R&S®FSUP thus offers a solution for experts with special requirements, as well as for users who want to obtain measurement results quickly and easily.
Easy operation
Straightforward menus make it easy to perform all other settings and adapt them to the user’s requirements. Together with other measurement parameters such as bandwidth, filter type and number of averages, the offset frequency range for the phase noise measurement, for example, is conveniently configured by means of a straightforward menu. The menu layout is similar to that of the R&S®FS-K40 spectrum analyzer application firmware for phase noise measurements. This makes operation very easy, especially when switching between the various measurement modes. Predefined settings for fast or highly accurate measurements simplify operation even more.

After starting the phase noise measurement, LOCKED or UNLOCKED is displayed to indicate if the PLL is locked and whether a successful measurement can be started. The display shows the loop bandwidth used and the phase detector voltage during the measurement. In addition, limit lines can be activated. Integral parameters such as residual FM/φM or RMS jitter are displayed. The complete measurement range is used to perform the calculation. The integration limits are also user-definable.

Detection, suppression and listing of interference
Interference caused by AC hum or other sources in the test setup commonly occurs during phase noise measurements. The R&S®FSUP features the option of listing and suppressing all interference, or only clearly defined interference.

Instead of imaging the frequency response of the resolution filter being used for the phase noise measurement, interference can also be displayed in dBc by activating the “highlight spurs” function. This provides a clear and simple way to identify interference.

The interference level is output in either dBc or dBc (1 Hz). This also enables the definition of limit lines that not only represent a threshold for the maximum allowable phase noise, but especially apply to spurious emissions. For a VCO test for instance, the user can decide whether to check phase noise, spurious emissions or both.

Typical phase noise measurement with the phase detector method: Signal frequency, level and residual FM/φM are displayed.
Measurement of reference points as a function of frequency
For many applications, especially in the production of oscillators, phase noise is of interest only for certain offset frequencies (reference points referred to as spot noise) because these values are included in the data sheet. Furthermore, it is important to measure the phase noise over the entire tuning range of the oscillator at these reference points. Using the SPOT NOISE vs TUNING function, the R&S®FSUP performs exactly this measurement and makes it possible to measure all phase noise values that are listed in the oscillator data sheet at the push of a button.

The benefits are as follows:
- Substantially simpler programming for production applications
- Higher measurement speed

Measurement of residual phase noise
With RF transmitters, the oscillator is not the sole source of phase noise. Particularly in high-end applications, it is helpful to know which other components such as amplifiers and frequency dividers contribute to phase noise. The R&S®FSUP has the flexibility to carry out these complex measurements as well. The measurement can be performed by using an internal or an external phase shifter. The R&S®FSUP software guides the user through a wizard-like function to complete the calibration.

AM noise
Phase noise measurements with a spectrum analyzer always represent the sum of phase noise and amplitude noise. The phase detector method suppresses the amplitude noise. The amplitude noise can also be measured with the R&S®FSUP by means of an external diode.
Maximum dynamic range through cross-correlation

Improvement of phase noise sensitivity by means of cross-correlation. Measurement of the phase noise of a signal source at 25.8 GHz without cross-correlation (green trace) and with cross-correlation, 100 (violet) and 1000 (yellow) averages.

Dynamic range increased by up to 20 dB at 26 GHz
Cross-correlation significantly increases the dynamic range, which is no longer limited by the phase noise of the internal references. The degree of improvement, which can be up to 20 dB, depends on the number of averages. The R&S®FSUP thus enables users to measure phase noise in the microwave range. Previously, such tests were possible only with very expensive low-noise signal sources and required complex setups. High-end measurements in this range can now be carried out at the push of a button with a single instrument.

Cross-correlation up to 50 GHz in a single box
The R&S®FSUP-B60 and R&S®FSUP-B61 options expand the R&S®FSUP with two parallel receiver paths up to 50 GHz. The symmetrical structure enables cross-correlation to be carried out between the two paths, eliminating the uncorrelated inherent noise of the two reference sources. This method can be used with the R&S®FSUP-B60 option in the frequency range from 1 MHz to 8 GHz (all R&S®FSUP models) and with the R&S®FSUP-B60 and R&S®FSUP-B61 options in the frequency range from 1 MHz to 26/50 GHz (R&S®FSUP26 and R&S®FSUP50).

Cross-correlation: Two identical receiver paths minimize the influence of the internal reference. The additional microwave frequency converter enables measurements up to 50 GHz.
The R&S®FSUP is not only a very sensitive phase noise tester, but in addition a high-end spectrum analyzer. This combination simplifies the test setup for the analysis of signal sources because it eliminates the typical requirement for an additional spectrum analyzer.

**Measurement of phase noise using the spectrum analyzer method**

Using the R&S®FSUP, phase noise can also be measured directly in the spectrum. Although this measurement is more time-consuming and less sensitive, it allows the measurement of significantly higher frequency offsets up to 10 GHz. The system noise can be subtracted after a reference signal measurement.

**Typical spectrum measurements such as ACP or interference search**

Apart from the normal functions of a spectrum analyzer, which are essential for measuring harmonics, the R&S®FSUP also offers enhanced measurement capabilities for VCO characterization such as the spurious emissions measurement function. Various sweep ranges can be defined in a list to specify where the analyzer should automatically search for interference. Up to 100,000 measurement points are analyzed, and the result is displayed in a peak list. Unwanted interference located far from the carrier is quickly and easily detected.

Measuring adjacent channel power is another important function when characterizing signal sources. Here as well, the R&S®FSUP provides convenient measurement functions that make it possible to quickly determine the power of adjacent channels. Users can take advantage of predefined standard settings or define the channel width and spacing on their own with a high degree of flexibility. The unparalleled dynamic range of the R&S®FSUP sets new standards in the analysis of signal sources.

**Measurement of noise figure using the R&S®FSUP**

The R&S®FS-K30 application firmware provides the R&S®FSUP with features that are otherwise available only through special noise measurement systems. The following parameters can be measured at a specified frequency or in a selectable frequency range:

- Noise figure in dB
- Noise temperature in K
- Gain in dB
Analysis in the time domain

Transient response of oscillators

The R&S®FSUP can record the oscillator signal as a function of time and thus provide a wideband display of the settling or switching times for high-frequency sources. The following parameters can be analyzed in the time domain:
  - Power
  - Phase
  - Amplitude
  - Frequency

The resolution bandwidth, resolution filter and recording time can be varied as needed.
Characteristics at the push of a button

Specifications of the voltage sources

<table>
<thead>
<tr>
<th>DC outputs</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>0 V to 12 V</td>
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<tr>
<td>Measurement uncertainty</td>
<td>&lt;0.4%</td>
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<tr>
<td>Noise</td>
<td>10 Hz at 10 kHz</td>
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<tr>
<td>Max. current</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tuning outputs</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>–10 V to +28 V</td>
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</tr>
<tr>
<td>Measurement uncertainty</td>
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<td></td>
</tr>
<tr>
<td>Max. current</td>
<td>20 mA</td>
<td></td>
</tr>
<tr>
<td>Noise</td>
<td>1 Hz at 10 kHz</td>
<td></td>
</tr>
</tbody>
</table>

Menu for setting the DC ports for signal source analysis and additional port for negative supply voltage.

Low-noise voltage source for supply and tuning voltages

The R&S®FSUP has two separate, very-low-noise DC outputs for measuring the phase noise and for recording the characteristics. The supply and tuning voltages can be defined for each output. The voltages are entered by means of a straightforward menu. Depending on the application, the R&S®FSUP configures the values in line with the settings without falling below or exceeding the minimum and maximum values respectively. The user can define both the sequence in which the different voltages are switched on when the measurement starts and the port to be used for measuring the characteristics. The R&S®FSUP also has a negative voltage supply for special applications.

Complete characterization of oscillators

There are basically three types of measurements that can be carried out:

- Tuning characteristic: The tuning voltage is modified at a constant supply voltage
- DC dependencies: The supply voltage is modified at a constant tuning voltage
- The combination of both (pushing)

In addition, characteristic parameters can be measured not only for the fundamental, but also for the harmonics. For scaling the x-axis, the tuning voltage or the frequency is selectable. Settings such as the measurement procedure, trace display and order of harmonics are definable. In addition, all of the results can be summarized and displayed in a table.

Characteristics:

- Tuning range of the oscillator:
  - VCO tuning characteristic
- Other frequency dependencies:
  - VCO tuning sensitivity (tuning slope of oscillator)
  - VCO RF power characteristic (output power)
  - Harmonic power (power of upper harmonics)
- DC dependencies:
  - VCO DC characteristic (power and frequency of output signal)
  - DC dependencies in the tuning range
  - VCO pushing (tuning range at different input voltages)

The tuning voltage of the oscillator varies within the limits defined when the DC settings for the individual port were made. The result represents the settable frequency range and the tuning slope of the oscillator.
Analysis of digital and analog modulated signals

General vector signal analysis of digitally modulated signals
The R&S®FSQ-K70 vector signal analysis option expands the R&S®FSUP to support the universal demodulation and analysis of digital radio signals down to the bit stream level.

Supported wireless communications standards
- GSM and EDGE
- WCDMA-QPSK
- CDMA2000®-QPSK
- Bluetooth®
- TETRA
- PDC
- PHS
- DECT
- NADC

Supported digital modulation methods
- BPSK, QPSK, OQPSK
- π/4-DQPSK
- 8PSK, D8PSK, 3π/8-8PSK
- (G)MSK
- 2, 4, (G)FSK
- 16, 32, 64, 128, 256 (D)QAM

Optimal display of the results
- Inphase and quadrature signals versus time
- Magnitude and phase versus time
- Eye diagram
- Vector diagram
- Constellation diagram
- Table with modulation errors
- Demodulated bit stream
- Statistical evaluation of modulation parameters
- Amplifier distortion measurements

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Special analysis options for digital communications standards

From GSM ...

The R&S®FS-K5 GSM/EDGE application firmware provides the R&S®FSUP with all of the functions required to carry out RF and modulation measurements on GSM systems.

- Phase or frequency error for GSM
- Measurement of modulation quality for EDGE using EVM- and ETSI-compliant weighting filters
- OOS
- 95:th percentile
- Power versus time with synchronization to midamble
- Spectrum due to modulation
- Spectrum due to transients

... to UMTS

Modulation and code domain power measurements can be carried out on signals in line with the 3GPP standard using the R&S®FS-K7x application firmware.

- Additional functionalities for measuring 3GPP FDD and TDD LCR modes
- Fast measurement speed of 1 second/measurement for 3GPP base station signals
- Code domain, CPICH power and rho (CDMA2000®/3GPP2)
- EVM and PCDE
- Code domain power versus slot
- EVM/code channel
- HSPA
- Spectrum emission mask
- Constellation (symbol, composite)

Measuring the modulation spectrum of an EDGE burst.

WCDMA code domain power measurement by means of the R&S®FSUP and R&S®FS-K72/R&S®FS-K74 (HSDPA).
Analysis of analog modulated signals (AM/FM/φM)
The R&S®FS-K7 measurement demodulator for the R&S®FSUP enables the measurement of analog modulation parameters.

- Frequency modulation (FM)
- Amplitude modulation (AM)
- Phase modulation (φM)
- Table with numeric results
  - Peak and RMS deviation, modulation frequency
  - Carrier offset, carrier power
  - Carrier power versus time
  - RF spectrum (FFT spectrum analysis)
  - AF spectrum with SINAD and THD values

Various filters (highpass, lowpass, deemphasis) are available that can be used to simulate real receive-signal structures, thus enabling accurate characterization of analog transmit and receive systems. The capability to perform Fourier analysis on the RF signal combines the advantages of a high-end spectrum analyzer with those of an FFT analyzer in a single box. Spectrum analysis can also be carried out by first recording the complete signal and then representing it in the frequency domain.
Specifications in brief

### Condensed data

<table>
<thead>
<tr>
<th>Operating modes</th>
<th>signal source analyzer</th>
<th>1 MHz to 8/26.5/50 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>spectrum analyzer</td>
<td>20 Hz to 8/26.5/50 GHz</td>
</tr>
</tbody>
</table>

#### Signal source analyzer

- **Phase noise measurement**
  - with spectrum analyzer: 10 MHz to 8/26.5/50 GHz
  - with phase comparator: 1 MHz to 8/26.5/50 GHz
  - internal reference: 1 MHz to 8/26.5/50 GHz
  - external reference: 1 MHz to 8 GHz
- **Transients measurement**
  - min. frequency offset: 10 mHz
  - max. frequency offset: 30 mHz
- **Residual noise**
  - with phase comparator: 1 MHz to 8 GHz

#### AM noise

- See diode datasheet

### Sensitivity

Sensitivity with internal reference and internal phase detector.

Input level > +10 dBm, spurious and harmonics < -30 dBc, mode “averaged”, +20°C to +30°C. LNA gain 40 dB, loop bandwidth ≤ 10 × frequency offset, max. 1 kHz. With the R&S®FSUP-B60 low phase noise option and the R&S®FSUP-B61 correlation extension option.

#### Typical values

<table>
<thead>
<tr>
<th>Frequency offset</th>
<th>Input frequency values in dBc (1 Hz)</th>
<th>R&amp;S®FSUP8/26/50</th>
<th>R&amp;S®FSUP26/50</th>
<th>R&amp;S®FSUP50</th>
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<tbody>
<tr>
<td>5 MHz</td>
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<tr>
<td>1 Hz</td>
<td>-114</td>
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<td>10 Hz</td>
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<td>30 MHz</td>
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<td>-179</td>
<td>-172</td>
<td>-170</td>
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</table>

### VCO parameter characterization

#### Measurement parameters

- VCO tuning characteristic, VCO tuning slope, power, pushing on/off, harmonics measurement, VCO DC characteristic, summary

#### Frequency range

- R&S®FSUP8: 10 MHz to 8 GHz
- R&S®FSUP26: 10 MHz to 26.5 GHz
- R&S®FSUP50: 10 MHz to 50 GHz

#### Power supplies

- tuning ports: 2
- DC ports: 2
- additional ports: 1

---

1) If the internal phase detector is used.
## Ordering information

<table>
<thead>
<tr>
<th>Designation</th>
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<th>Retrofit</th>
<th>Remarks</th>
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<td>Signal Source Analyzer, 20 Hz to 8 GHz</td>
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<td>Signal Source Analyzer 20 Hz to 50 GHz</td>
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<td><strong>Accessories supplied:</strong></td>
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<td>RF cable, 1 m (1130.1725.00)</td>
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<td>R&amp;S®FSUP26: test port adapter with 3.5 mm female connector (1021.0512.00) and N female connector (1021.0535.00)</td>
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## Options

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<th>Remarks</th>
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<td>Low-Aging OXCO</td>
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<td>1303.0400.05</td>
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<td>requires R&amp;S®FSUP-B18</td>
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<td>LO/I/F Ports for External Mixers</td>
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<td>1157.1090.04</td>
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<td>20 dB Preamplifier, 3.6 GHz to 26.5 GHz, for R&amp;S®FSU26</td>
<td>R&amp;S®FSU-B23</td>
<td>1157.0907.02</td>
<td>no for R&amp;S®FSUP26, requires R&amp;S®FSU-B25</td>
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<td>Electronic Attenuator, 0 dB to 30 dB, and 20 dB Preamplifier (3.6 GHz)</td>
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<td>Trigger Port</td>
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<td>Low Phase Noise</td>
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<td>Correlation Extension for R&amp;S®FSUP26 (without R&amp;S®FSU-B23)</td>
<td>R&amp;S®FSUP-B61</td>
<td>1305.2500.26</td>
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<td>R&amp;S®FSUP-B61</td>
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<td>Correlation Extension for R&amp;S®FSUP50</td>
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<table>
<thead>
<tr>
<th>Firmware/software</th>
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<td>GSM/EDGE Application Firmware</td>
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<td>Power Sensor Measurements</td>
<td>R&amp;S®FS-K9</td>
<td>1157.3006.02</td>
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<tr>
<td>Application Firmware for Noise Figure and Gain Measurements</td>
<td>R&amp;S®FS-K30</td>
<td>1300.6508.02</td>
<td>preamplifier recommended (e.g. R&amp;S®FSU-B25)</td>
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