REDUCING COMPLEXITY IN CALIBRATION WITH THE R&S®FSMR3000 MEASURING RECEIVER

Application Brochure
Version 01.00

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REDUCING COMPLEXITY IN CALIBRATION

The R&S®FSMR3000 microwave measurement receiver calibrates signal generators and attenuators. Most important features provided are tuned RF level measurements, level measurements, analog modulation and spectrum analysis. Additionally, the R&S®FSMR3000 can be equipped with powerful hardware for high-end phase noise test, supplementary to the standard phase noise test with the spectrum analyzer. It offers also digital and analog modulation analysis, 80 MHz analysis bandwidth, analysis of pulses and VOR/ILS signals. The R&S®FSMR3000 as a single box instrument is designed to reduce the complexity in calibration capabilities.

Tuned RF level (TRFL) calibration and power measurement

The main application for the measuring receiver is to measure the power of a signal generator precisely and simple. Absolute power and reference power are measured with high accuracy using a power sensor. It is connected directly to the R&S®FSMR3000. The sensor input is either connected directly to the DUT (i.e. the generator output) or via a power splitter in parallel with the input of the R&S®FSMR3000. Power splitters simplify setup and testing since the DUT does not have to be repeatedly connected to the power sensor and the RF input of the R&S®FSMR3000. The R&S®FSMR3000 automatically corrects the power splitter's frequency response and insertion loss. Power sensors with a built-in power splitter like the R&S®NRP-Z27/-Z37 power sensor modules for the R&S®FSMR3000 additionally provide automatic VSWR correction as well as an attenuator in the signal path to the analyzer input for improved matching and accuracy.

To measure conventional RF generators over their full range, e.g. from –150 dBm to +20 dBm, which cannot be covered by a power sensor, the so called tuned RF level (TRFL) measurement is applied. To cover the full level range of a signal generator the input attenuation, preamplifier and IF gain of the R&S®FSMR3000 must be switched to get an optimized signal-to-noise ratio. The R&S®FSMR3000 eliminates potential level errors due to change of these parameters by using adjacent range calibration (Fig. 2). As a result, users benefit from the instrument's high linearity of ±(0.009 dB + 0.005/10 dB) across the entire level range. Optional, the R&S®FSMR3-B24 RF preamplifier extends the level range down to lower levels.

Fig. 1: R&S®NRP-Z27 power sensor module with built-in power splitter.

Only a few steps are required to perform the calibration for this wide dynamic range. The user begins with a reference measurement based on the power meter. This requires just one press of a key and prepares the R&S®FSMR3000 for the level calibration. The level of the device to be calibrated can now be reduced in the desired steps and verified. If the test signal is outside the usable measurement range and input attenuation, IF gain or preamplifier setting of the R&S®FSMR3000 need to be changed – the user is prompted to calibrate the adjacent range. The RECAL key initiates the adjacent range calibration and automatically switches the R&S®FSMR3000 measurement range. Fig. 3 shows the linearity, which can be reached, measured on devices during manufacturing.

Fig. 2: Adjacent range calibration for the TRFL measurement

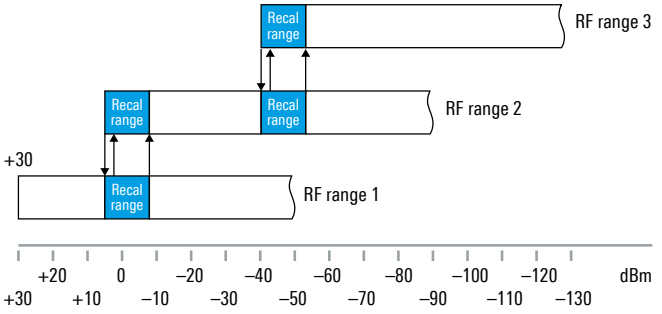


Fig. 3: Deviation of linearity of R&S®FSMR3000

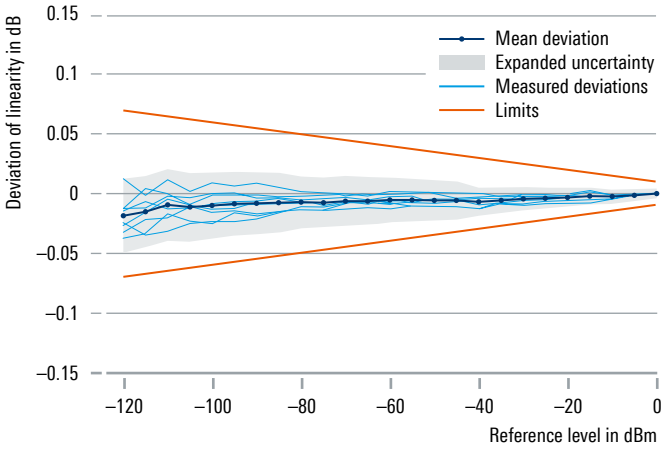
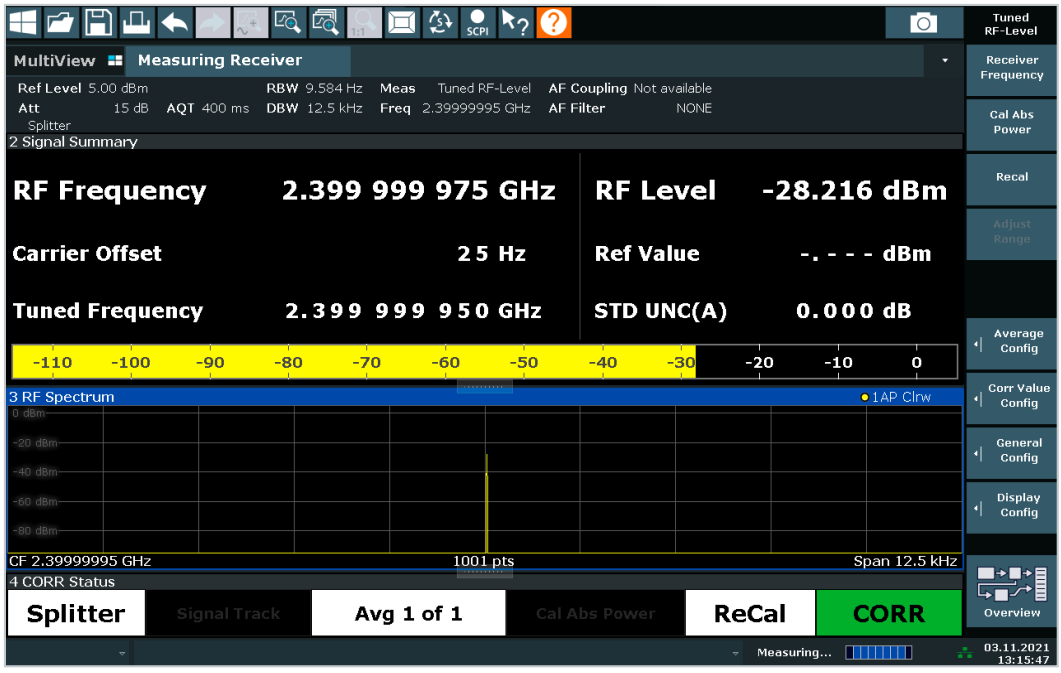


Fig. 4: Tuned RF level measurement (TRFL) at 2.4 GHz, entering the recalibration range at around –29 dBm input power.

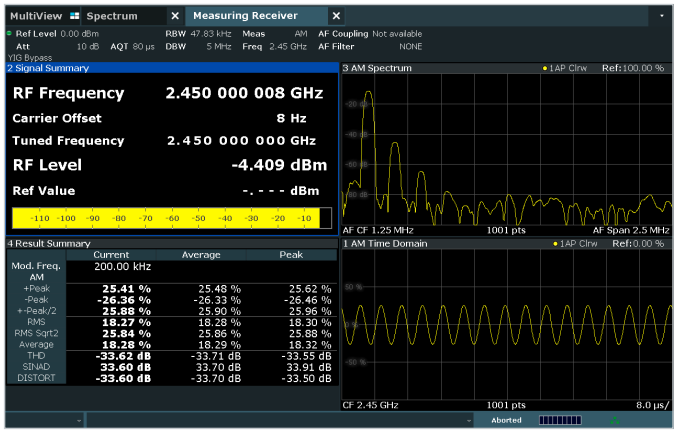


AM/FM/PM modulation analysis

The R&S®FSMR3000 features a complete, integrated modulation analyzer for the AM, FM and PM analog modulation modes. Audio parameters are measured on the demodulated signal. This means that no extra instrument is required for calibrating modulation settings and the modulation generator.

Various audio filters, deemphasis functions and detectors, which can be easily selected by clicking within large menus, are available for audio analysis. This makes it easy to perform residual FM measurements, for example. THD and SINAD are automatically calculated and displayed. The R&S®FSMR3000 displays all key results simultaneously. However, the user can choose certain results for detailed display or arrange the different windows as desired (Fig. 5). The presentation of the results can thus be optimized for the current application by suppressing unnecessary information. Since the user can see the most important parameters at a glance, pending measurements can be completed quickly and efficiently.

Fig. 5: Demodulation of an AM modulated signal in time domain and spectrum; only selected (right screen) parameters are listed in the result summary.



Full-featured signal and spectrum analyzer

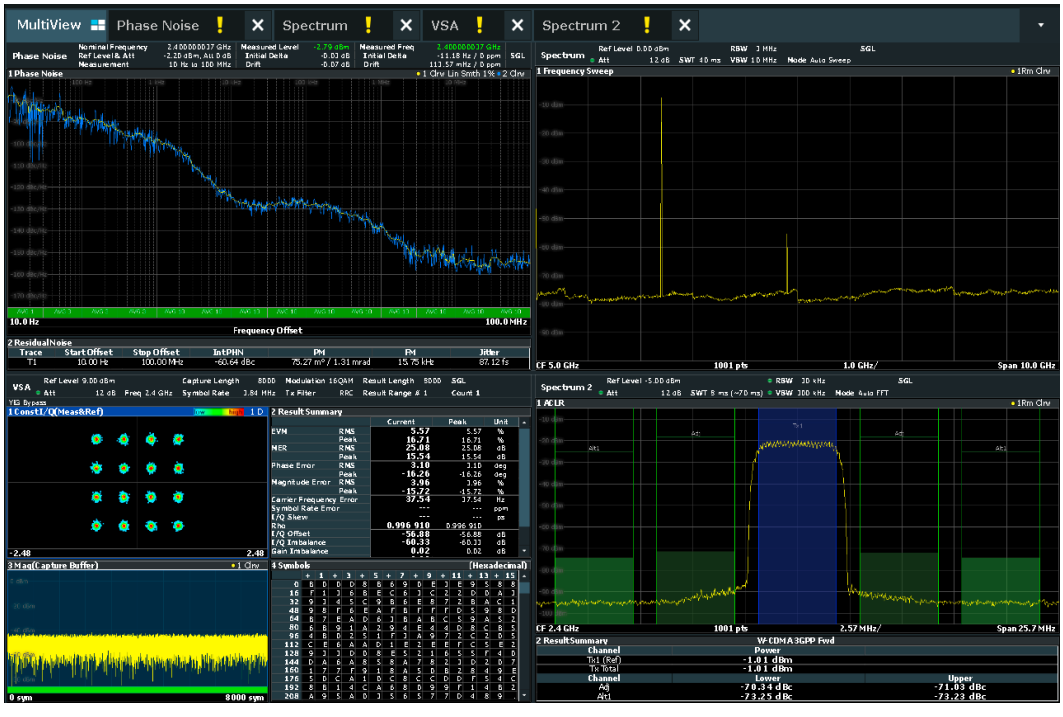
Calibration labs handle a variety of measurement tasks. These tasks often require a spectrum analyzer featuring a wide range of functions and excellent performance. This is possible with the R&S®FSMR3000 thanks to the R&S®FSMR3-B1 option which transforms the measuring receiver into a full-featured signal and spectrum analyzer. The functionality and performance are then equivalent to that of the R&S®FSW signal and spectrum analyzer. Along with unrivaled performance (e.g. phase noise, wide dynamic range due to very low intrinsic noise (DANL), high input TOI of up to +30 dBm), the instrument also offers a number of functions that are required for calibration and performance verification of generators as standard. For example, the instrument can measure a generator's higher-order harmonics at the press of a key. It also provides a routine for measuring TOI or adjacent channel power along with a wide array of marker functions.

Due to the extremely low inherent noise of the R&S®FSMR3000 the spectrum analyzer can be used for measuring the noise figure of components. The R&S®FSMR3-K30 option allows users to easily perform noise figure and gain measurements. An excess noise ratio (ENR) source is needed which is switched back and forth at the DUT input between normal (room temperature) and increased noise. Based on the noise measurements, the R&S®FSMR3-K30 option automatically calculates the gain or noise figure of the DUT vs. frequency. Any available noise diodes can be used as an ENR source. However, the relevant correction data must be taken into account for the frequency response of the ENR values as well as temperature and matching. The R&S®FS-SNS18/26/40/55/67 smart noise sources make this time-consuming and error-prone task unnecessary by providing all of the correction tables and measuring the ambient temperature. Using the combination of R&S®FSMR3-K30 and R&S®FS-SNSxx, it is possible to measure the gain and noise figure of components at the press of a key. The results are displayed along with the calculated measurement errors.

Phase noise is a key parameter for signal generators, because the lower the phase noise, the better the quality of signal and modulation. It can be measured with a spectrum analyzer as well. However, measuring this parameter requires an analyzer with even lower intrinsic phase noise. The R&S®FSMR3000 convinces with its outstanding dynamic range for phase noise measurements. At 10 kHz offset from the carrier, the analyzer achieves a phase noise of e.g. –133 dBc (1 Hz) for a 10 GHz carrier and the R&S®FSMR3-K40 option enables phase noise measurement at the press of a key.

In addition to spectral measurements, the R&S®FSMR3000 can also digitize and analyze signals. It can be equipped with a bandwidth of up to 80 MHz to handle signals with broadband modulation that are typical in advanced communications technology. The R&S®FSMR3-K70 option enables users to flexibly analyze digitally modulated single carriers down to the bit level. Measurements are simplified

Fig. 6: Signal and spectrum analysis in a single instrument. Right: typical spectral measurements such as adjacent channel power (ACP) or higher-order harmonics. Left (top): phase noise measurement. Left (bottom): vector signal analysis of a digitally modulated signal.



by the straightforward operating concept. For example, the different demodulation steps are visualized in a clear block diagram so that even inexperienced users can quickly find the optimum settings.

For characterizing pulse generators the R&S®FSMR3-K6 option measures – at the press of a key – all relevant parameters such as pulse duration, pulse period, pulse rise and fall times, power drop across a pulse and intrapulse phase modulation, and produces a trend analysis over many pulses. The user selects the results to be displayed simultaneously on the screen. A complete picture is available within seconds.

In addition, the R&S®FSMR3-K15 option extends the calibration capabilities of the R&S®FSMR3000 to cover VOR/ILS signal generators and navigation/ramp testers.

High-end phase noise analyzer

If the phase noise performance of the built in spectrum analyzer, even showing unrivalled performance, is not sensitive enough to calibrate high-end signal sources, the R&S®FSMR3-B60 option turns the R&S®FSMR3000 measuring receiver into a full-featured phase noise analyzer, which demodulates the signal in real-time measuring phase noise and amplitude noise in parallel.

Due to its excellent internal sources and largely digital architecture, the R&S®FSMR3000 equipped with the R&S®FSMR3-B60 option is faster than test systems that digitize the signal after the phase detector. In addition, the R&S®FSMR3000-B60 option equips the measuring receiver with a second RX path, thus allowing cross-correlation and increasing the sensitivity even more depending on the number of correlations.

Increasing the number of correlations by a factor of 10 lowers the intrinsic phase noise of the R&S®FSMR3000 by 5 dB.

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

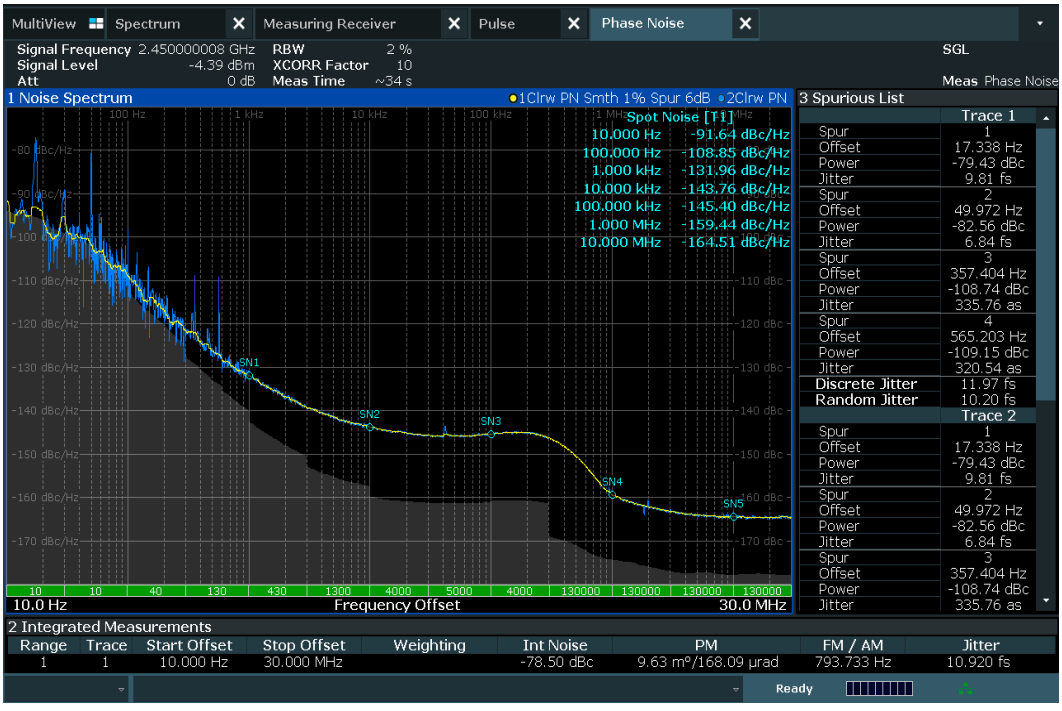
ΔL: improvement in phase noise sensitivity through cross-correlation (in dB)
n: number of correlations/averages

Thanks to the analyzer's low noise internal sources, often only a few correlations are needed to measure a high-quality generator. A gray area below the trace (x-corr gain) shows the expected sensitivity due to cross-correlation. This allows the user to accurately assess the measurement that is performed. If the gray area is well below the trace, the DUT can be precisely analyzed and errors due to insufficient sensitivity can be excluded (Fig. 7).

Summary

The new R&S®FSMR3000 is a new powerful tool to calibrate signal generators and characterize the modulation quality. Besides this functionality it optionally incorporates a modern high-end signal and spectrum analyzer and a high-end phase noise tester and becomes the only one box solution available on the market to cover the whole set of functions needed in a modern high-end calibration lab.

Fig. 7: Measurement of amplitude and phase noise with the R&S®FSMR3-B60 option.



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Reducing complexity in calibration with the R&S®FSMR3000 measuring receiver
Data without tolerance limits is not binding | Subject to change

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