Application Note

CROSS CORRELATION PHASE NOISE MEASUREMENT USING THE FSMR3000

Products:

- R&S®FSMR3000
- R&S®SMA100B

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https://www.rohde-schwarz.com/appnote/1SL376

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Contents

1 Overview

The R&S® FSMR3000 (hereinafter FSMR) is a three-in-one instrument incorporating a Measurement Receiver, a Signal and Spectrum Analyser, and a Phase Noise Analyser.

This application note demonstrates the use of the FSMR, including the Cross-correlation option (R&S®FSMR3-B60), to measure the Phase Noise characteristics of a raw Signal Generator (R&S® SMA100B).

The Cross-correlation phase noise measurement improves sensitivity by $5 \cdot \log(n)$ dB, compared with measurements that do not use this option. For example, a measurement using 10 correlations, improves the phase noise floor by 5 dB.

For more information on the Cross-correlation implementation, the reader is referred to the IEEE paper [1] or its mirrored content [2] on the Rohde & Schwarz website. A video explainer is also provided in [3].

2 Apparatus and Method

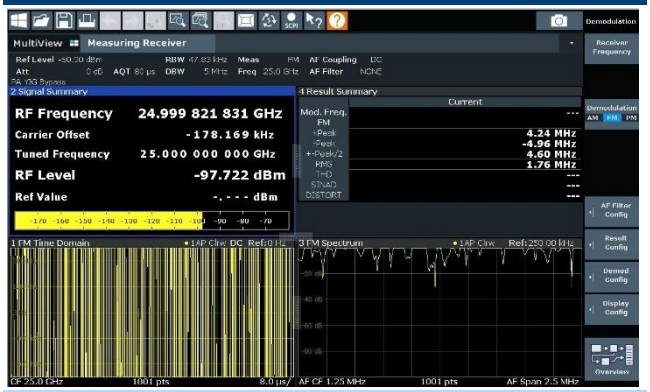
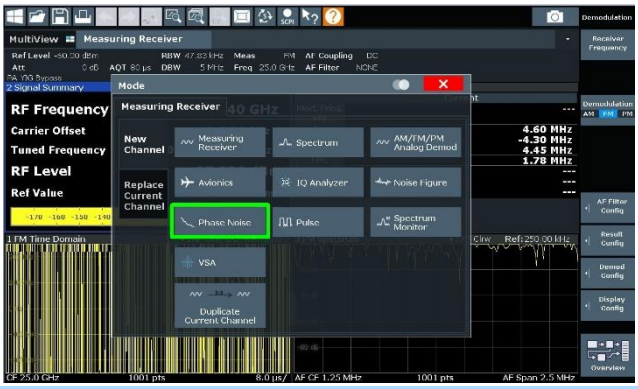
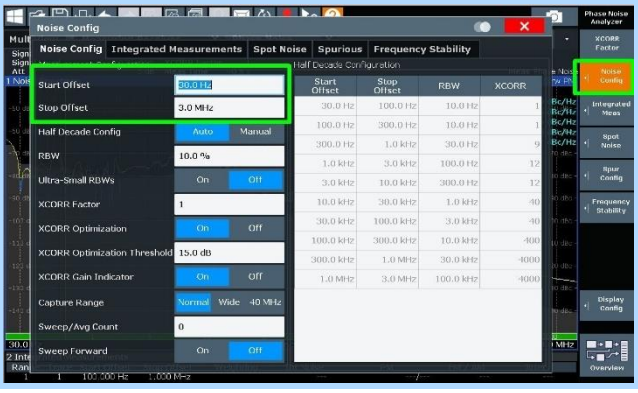
2.1 Apparatus

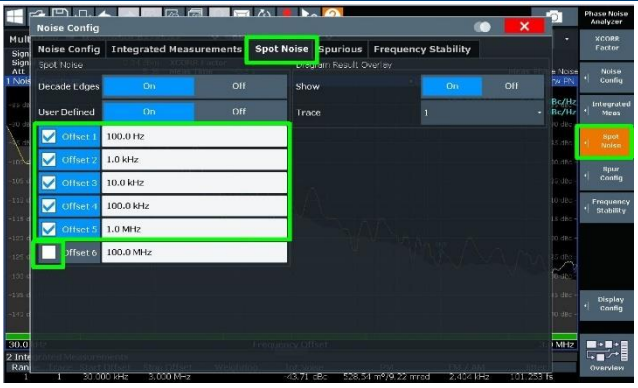
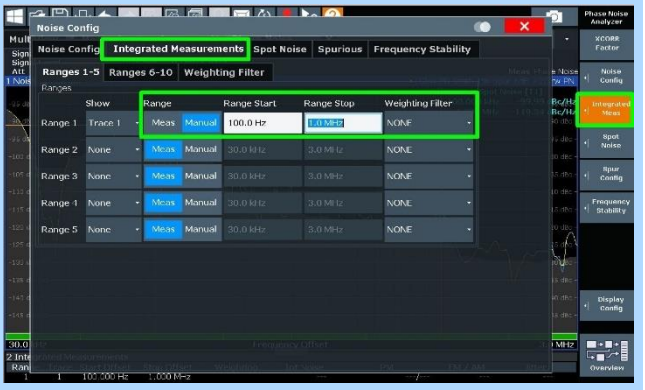
The following equipment was used in the creation of this Application Note

- ► FSMR3050 Measuring Receiver (to 50 GHz)
- ► SMA100B Signal Generator
- ► Suitable coaxial cable.

2.2 Method

The steps required in order to perform this measurement are tabulated.

Step	Action	
1	Preset the FSMR	
2	Connect the RF output of the Signal Generator to the RF input of the FSMR.	
3	Press "MODE" hardkey, and select the "Phase Noise" personality. By default, immediately, the FSMR will perform an automated search for a quasi-CW signal within its operating frequency range. Note: ► If the signal level input to the instrument is sufficiently high, it will be automatically found. ► If the auto-detect does not lock to a signal then select the "Spectrum" personality, in order to manually check for the presence of a signal. That frequency may then be manually specified	
4	In this example, the phase noise of the Signal Generator will be measured at 5 spot frequencies, from 100Hz to 1MHz. For this measurement, a noise offset range will be set from 30 Hz to 3 MHz. To set the frequency offset range; 1. Press the "Noise Config" softkey 2. Select the "Noise Config" tab 3. Enter the Start and Stop Offset values in the boxes.	

Step	Action	
5	Select either the "Spot Noise" tab, in case the dialog is still open, otherwise press the "Spot Noise" softkey. Piecewise, enter the (five) frequencies at which the DUT is to be tested, in the "User Defined" boxes (e.g. 100 Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz). The (sixth and) final Offset value is not needed, and it may be unchecked.	
6	The Phase Noise integrated across a bandwidth may also be specified and measured. Select the "Integrated Meas" softkey or tab. Enter the frequency range over which the Phase Noise shall be integrated. In this example, the noise will be integrated between the lowest (100 Hz) and highest (1 MHz) spot noise frequencies. Now, the dialog box may be closed to return to the measurements screen.	
7	The Signal Generator is now set to generate a 1 GHz CW tone at a nominal 15dBm. In this case, the Resolution Bandwidth (3%) is selected-on-test, to provide even better measurement granularity. A XCORR factor is selected-on-test (100), such that the grey curve ("XCORR Gain Indicator") is sufficiently different to the measured curve. This difference establishes that the measured phase noise is not limited by the FSMR. The measurement time (~ 22 seconds) is estimated before the measurement commences, and is dependent on these two parameters.	
8	The key measurement results are tabulated on the default screen layout, as shown. Spot Phase Noises are reported in the upper right, whilst the Integrated Measurements are shown at the bottom.	

Thus, the phase noise, present at the output of the Signal Generator has been measured.

3 Literature

[1] G. Feldhaus and A. Roth, "A 1 MHz to 50 GHz direct down-conversion phase noise analyzer with cross-correlation," in *European Frequency and Time Forum (EFTF)*, York, UK, 2016.

[2] "A 1 MHz to 50 GHz Direct Down-Conversion Phase Noise Analyzer with Cross-Correlation," [Online]. Available: https://www.rohde-schwarz.com/us/applications/a-1-mhz-to-50-ghz-direct-down-conversion-phase-noise-analyzer-with-cross-correlation-application-card_56279-231872.html. [Accessed 26 11 2021].

[3] P. Denisowski, "Understanding Phase Noise - the Cross Correlation Method," 15 11 2021. [Online]. Available: https://www.youtube.com/watch?v=Sf7qiysPFbQ. [Accessed 7 12 2021].

4 Ordering Information

Designation	Type	Order No.
Spectrum analyzer	R&S®FSMR3-B1	1345.3050.50
Phase noise analyzer with cross-correlation	R&S®FSMR3-B60	1345.3114.50

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Application Note | Cross Correlation Phase Noise Measurement using the FSMR3000
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