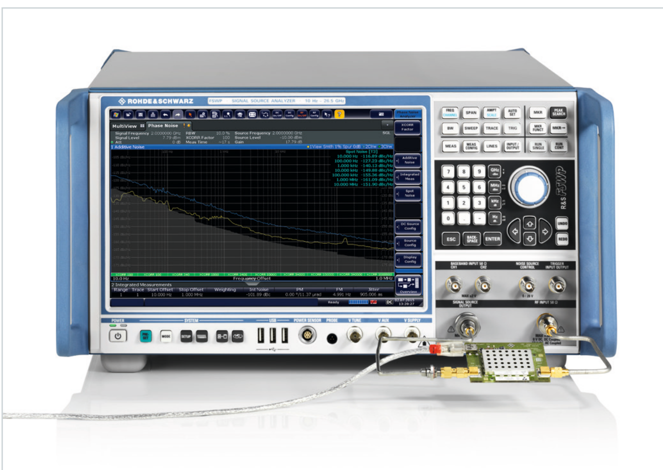
Dynamic noise figure measurements

The R&S®FSWP phase noise analyzer is a high-end instrument designed to accurately analyze noise performance of key components in radar and communications systems. Using phase noise measurements, a device's large-signal noise figure can be derived under real-world operating conditions.



Your task

Measuring the noise figure is commonly used to characterize the performance of e.g. amplifiers, frequency converters and other devices placed in the signal path.

The noise figure (measured or specified for a device) is a key parameter used by system designers as part of their link budget calculations for uplink and downlink transmission systems.

The traditional noise figure method uses the common Y factor method (for details, see application note 1MA178: The Y Factor Technique for Noise Figure Measurements). This measurement is traditionally performed with a spectrum analyzer and a noise source. It measures the additive noise produced by a device during stimulation with a wideband calibrated noise source.

The power levels that are produced during this measurement are described as small signal. Therefore, they produce noise figure results that do not relate directly to the operating conditions. These device conditions depend heavily on the device's input power.

Amplifiers used in transmitters are usually not used in their small-signal state. The small-signal noise figure is much more important for receivers. Typical operating conditions of an amplifier used in a transmitter of a mobile base station or even a radar tend to be driven in a very specific operating range to maximize linearity and efficiency. Often that range can be around the 1 dB compression point of the device.

The Y factor method can produce noise figures that are not representative of the device under realistic operating conditions.

T&M solution

The phase noise of a device is very closely related to its noise figure. Noise contributors for an amplifier can broadly be stated as the 1/f flicker noise along with its wideband noise operating beyond the flicker knee. Given that a noise figure is basically an indication of the wideband noise generated by a device, it is reasonable to use a wideband phase noise measurement to calculate the noise figure of a device. The R&S®FSWP signal source analyzer makes it possible to vary drive levels to the DUT in order to clearly understand the additive/residual phase noise and noise figure performance of a device under varying operating conditions.

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The noise figure can be calculated from a phase noise result using the following equation:

$$NF = L(f) - N_{th} + P_{in}$$

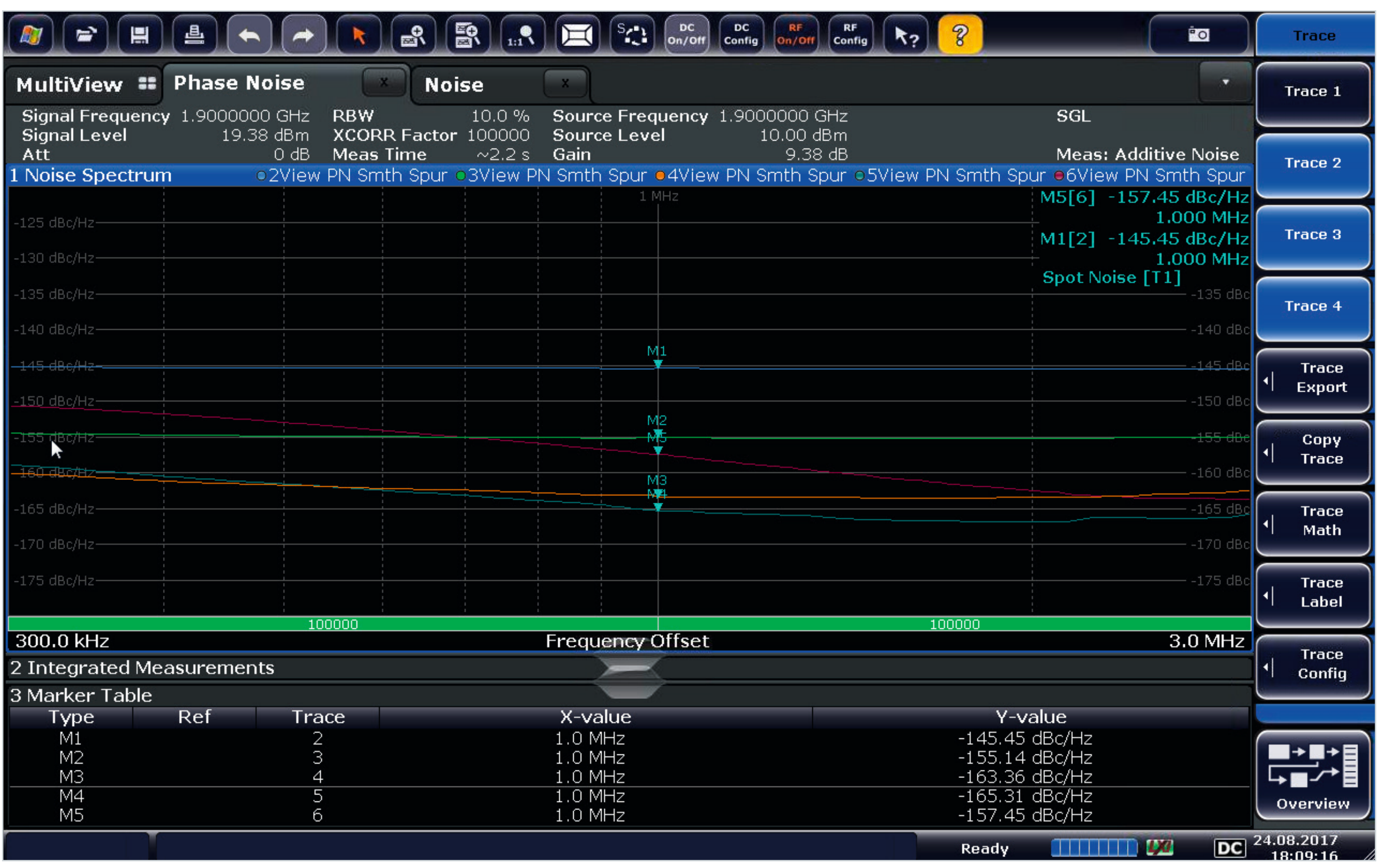
Where:
$L(f)$ = phase noise measured at a specified offset in dBm/Hz
N_{th} = thermal phase noise (–177 dBm (1 Hz))
P_{in} = calibrated signal level applied to DUT

Example

An amplifier whose small-signal noise figure has been measured using the Y factor method at 1.9 dB at 1900 MHz. Use the phase noise method to calculate the amplifier's noise figure over a varying input level.

DUT drive level in dBm	Phase noise in dBm (1 Hz)	Noise figure in dB
–30	–145.45	1.55
–20	–155.14	1.86
–10	–163.36	3.64
0	–165.31	11.69
10	–157.45	29.55

Additive phase noise of a device with varying drive level.



Summary

It is clear to see that as the DUT is driven close to and beyond its 1 dB compression (0 dBm drive level), the additive phase noise and the noise figure calculated from the same result become significantly worse. This example shows that, under real-world operating conditions, the large-signal noise figure derived from phase noise measurements is a more reliable method for calculating the link budget of a transmission system.

See also

www.rohde-schwarz.com/product/FSWP

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