

# Keysight Technologies

## Noise and Noise Figure: Improving and Simplifying Measurements

Application Brief

Noise is present in every electronic circuit, and it can disturb the signals sent from a transmitter to a receiver. Because these disturbances can limit the overall performance of any wireless system, noise is a fundamental parameter to be tested in all transmitter and receiver components. To ensure meaningful results, the signal analyzers used to make the measurements must have better performance than the devices being characterized. As these measurements have become increasingly complex, signal analyzers have evolved to support easy-to-use measurement applications that help reduce complexity while instilling confidence that the results are accurate. Today, the touch-enhanced UI technology widely used in smartphones, tablets and PCs has been adapted to the large displays that are increasingly common in signal analyzers. Consequently, analyzers now provide new levels of interaction that enable intuitive connections between cause and effect during development, debugging and troubleshooting.



Unlocking Measurement Insights

## Improving Signal Analyzer Sensitivity

When testing devices with signal amplitudes near or below the observed noise floor of the signal analyzer, optimizing the tradeoffs between analyzer sensitivity and sweep speed will make it easier to see and compare the differences between signals. You can optimize a variety of parameters to improve the sensitivity of the signal analyzer and bring the noise floor to acceptable levels using any of the following techniques individually or in combination:

- Reduce signal analyzer attenuation to a level closer to that of the largest spurious signal
- Reduce resolution bandwidth to a narrower setting that balances the reduction in noise floor with the increase in measurement time
- Use a preamplifier to lift the noise floor of the incoming signal above that of the analyzer
- Use Keysight's Noise Floor Extension feature to subtract the analyzer's own noise power from the measurement

In Figure 1, traces 1 through 4 show how the signal analyzer's noise floor can be lowered by reducing attenuation and resolution bandwidth (traces 1 and 2) and by using the internal preamplifier along with Noise Floor Extension (traces 3 and 4). Trace 4 shows a low-level signal appearing as the noise floor is reduced.

### Frequently Used Settings Available on Touchscreen

The Keysight Technologies, Inc. N9010B EXA signal analyzer, multi-multi-touch, provides a touchscreen UI that includes features such as drop down menus and customizable user menus. Rather than navigating through hardkeys, softkeys and long menus, most of the capabilities can be accessed with the tap of a finger. In addition, many frequently used display settings can be modified in the menu bar, measurement bar and annotation hotspot areas. It's as easy as tapping the settings tables and diagrams, or you can interact with the selected trace by stretching, pinching, dragging or tapping.

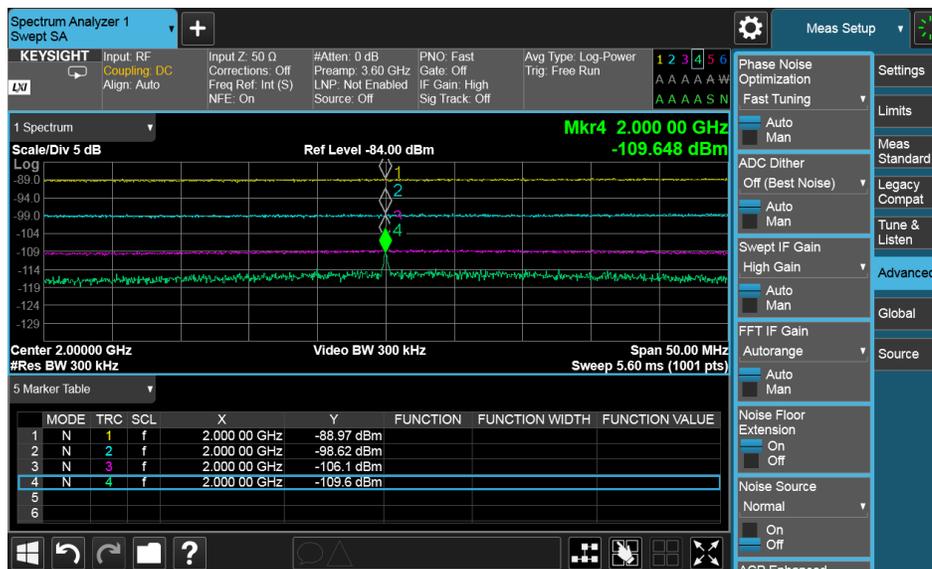


Figure 1. The succession of color-coded traces shows an improvement of more than 20 dBm in noise floor using the techniques described here.

User-interface (UI) features such as the trace settings table and marker settings diagram help make noise (sensitivity) measurements faster and easier to implement, especially when accessed through the multi-touch UI of the X-Series signal analyzers. For additional information about noise reduction techniques, please refer to the application briefs, *Five Hints for Successful Measurements in Noise*, literature number 5992-0932EN and *Three Hints for Better Noise Figure Measurements*, literature number 5992-1153EN.

## Accessing Multiple Traces Simultaneously

The trace settings table is a feature of the EXA's multi-touch UI, designed to provide quick access to as many as six traces. With the table, you can access parameters such as trace type, trace view, detector type, and math functions such as power difference and log offset. The trace parameter settings – Trace Type = Trace Average, ViewBlank = Active and Detector = Average (Log/RMS/V) – are quickly enabled on traces 1 through 4 using the touchscreen interface (Figure 2).

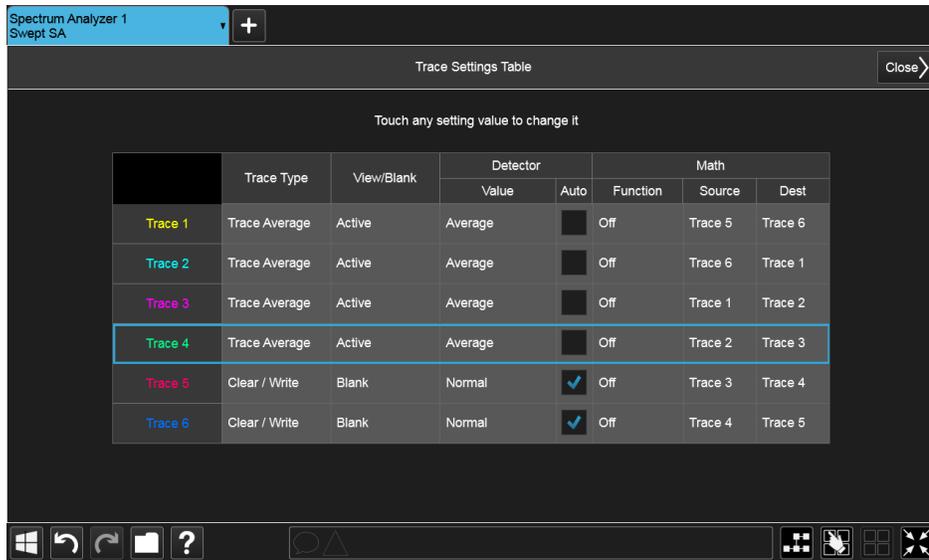
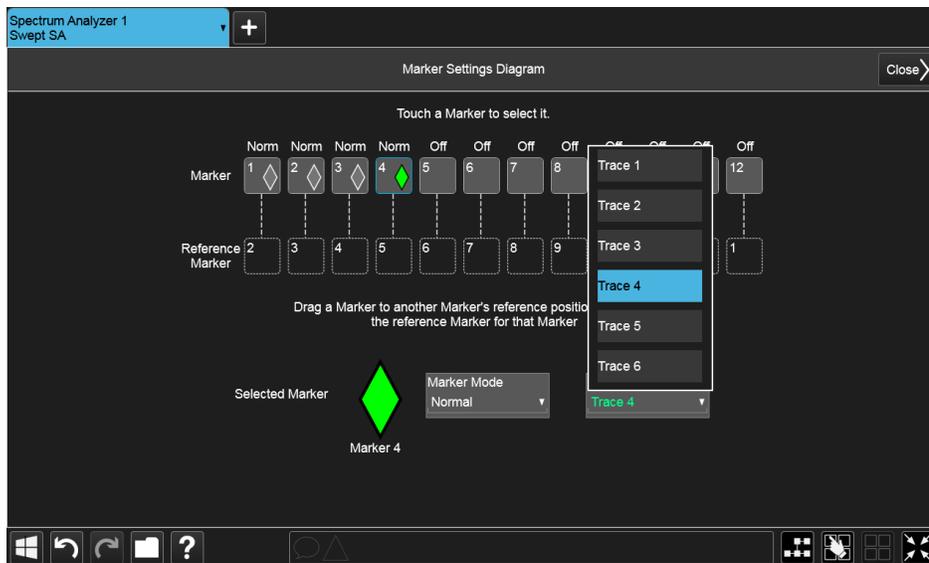
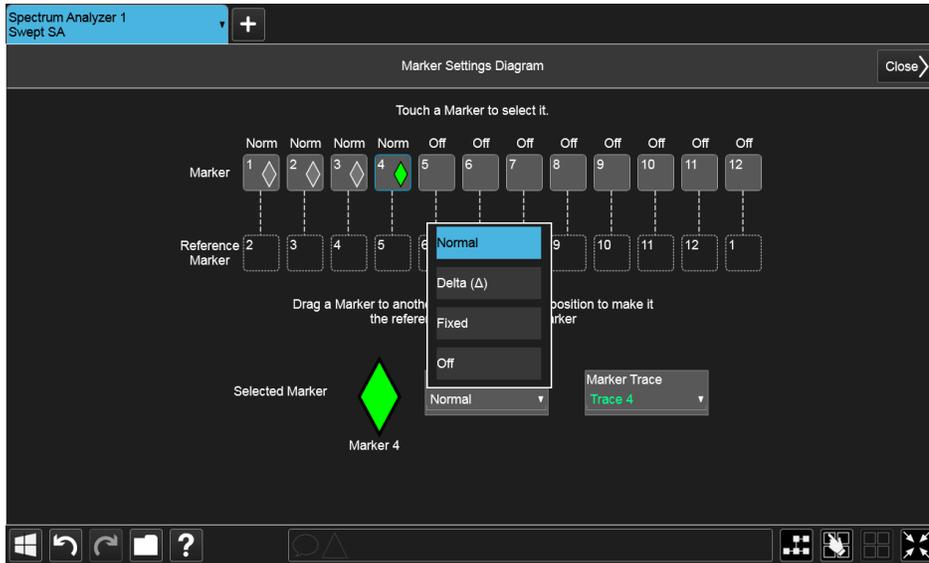


Figure 2. You can quickly and easily configure up to six traces using the trace settings table feature.

## Configuring multiple markers

The marker settings diagram enables quick and easy configuration of up to 12 markers. The diagram provides a visual relationship between different markers and reference markers. Using the touchscreen, you can activate marker modes such as normal, delta and fixed (Figure 3a) and assign markers to selected traces (Figure 3b).



Figures 3a and 3b. The ability to configure up to 12 markers and assign them to specific traces makes it easier to keep track of signal characteristics.

In Figures 3a and 3b, markers 1 through 4 were set to normal mode and assigned to traces 1-4, respectively. The marker table was turned on for easy viewing of each marker value as we changed parameters.

## Simplifying Noise Figure Measurements

In the multi-touch EXA, the Mode/Measurement/View Selector provides quick access to a suite of measurement applications ranging from parametric—phase noise, noise figure, analog demodulation—to the latest standards-compliant wireless measurements including LTE and WLAN (Figure 4).

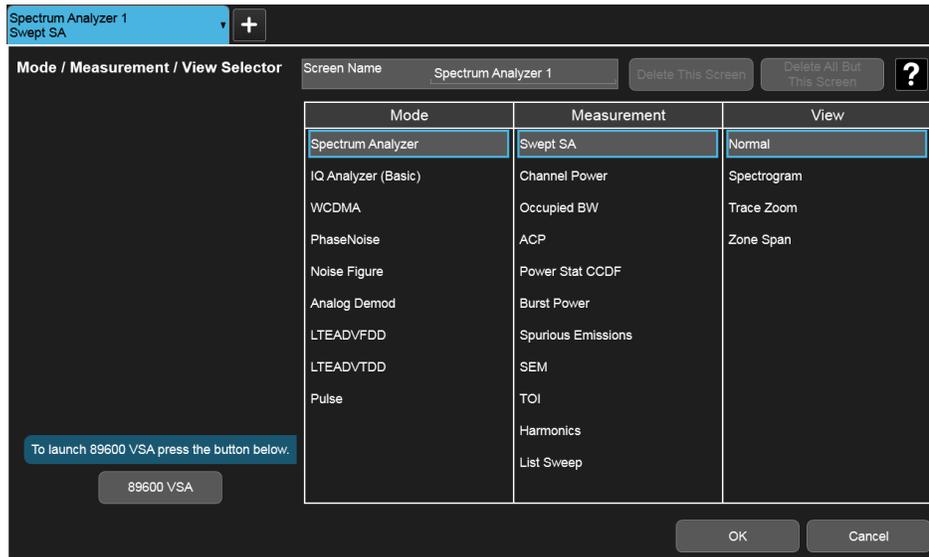


Figure 4. Mode/Measurement/View Selector lets you quickly change from spectrum analyzer mode to noise figure mode.

Noise figure measurements are typically required in an R&D lab during product design and optimization; some manufacturers also test noise figure on the production line to verify device performance is meeting specification with adequate margin. The multi-touch X-Series measurement application for noise figure makes DUT set up and calibration easier and more efficient.

The DUT measurement set-up diagram shows you how to connect the noise source, DUT, and analyzer when making noise figure measurements on amplifiers, downconverters and upconverters (Figure 5). With the touchscreen interface, the diagram gives you quick access to parameter settings for your measurement.

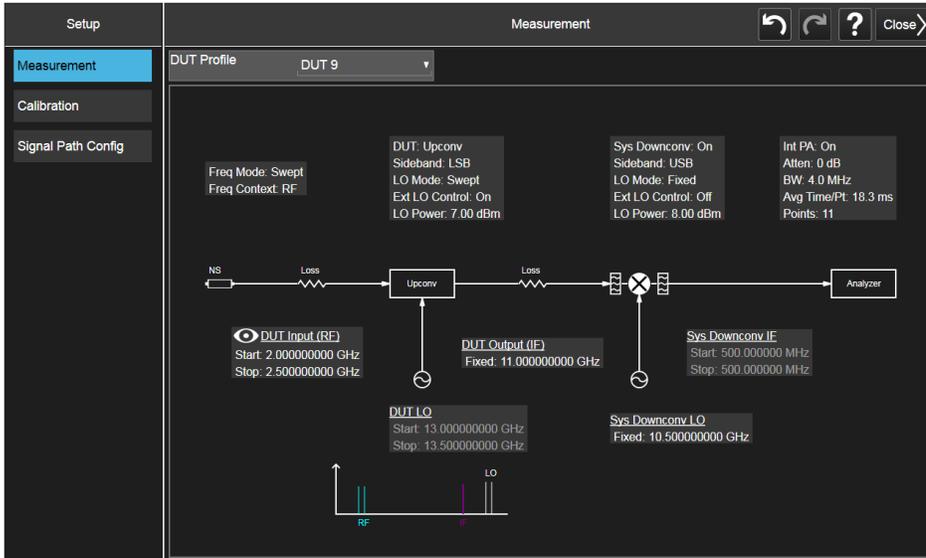


Figure 5. Whether you're a new user, an infrequent user, or an expert in need of a refresher, the on-screen diagram will guide you through the set-up process.

Y-factor noise figure measurements are the most common and these require two connections: a user calibration and the DUT noise figure measurement. The multi-touch noise figure measurement application speeds up this process by allowing you to calibrate up to 12 DUT profiles in a single step (Figure 6).

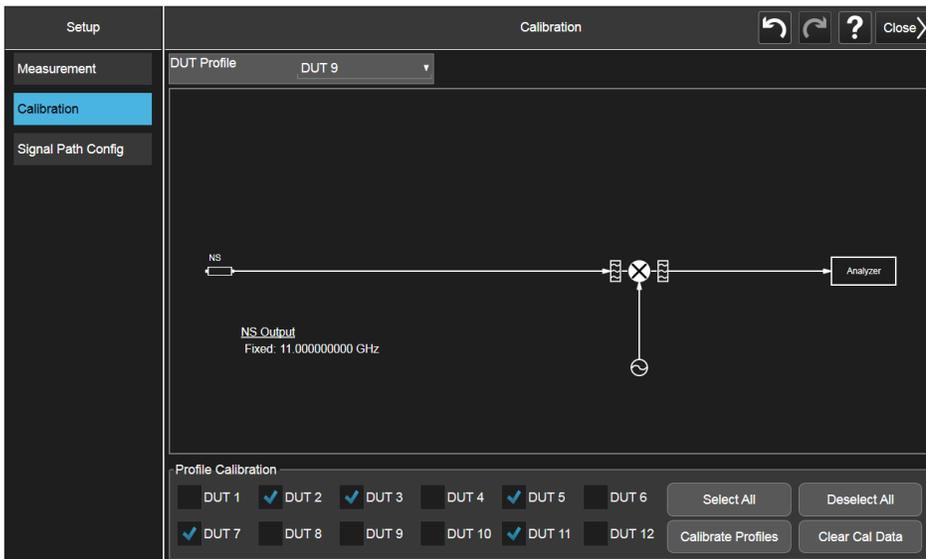


Figure 6. The ability to pre-define and calibrate up to 12 DUT profiles can save significant time during future measurements.

Additionally, the internal calibration feature allows you to bypass the second-stage noise source user calibration and go directly to the DUT measurement. This saves time without significantly affecting measurement uncertainty, which is the key to successful noise figure measurements.

## Getting Dependable Uncertainty Readings – Built-in

The EXA comes with a built-in noise figure uncertainty calculator, which gives you a dependable uncertainty reading for a specified setup. A typical measurement configuration includes a signal analyzer, a preamplifier (internal or external), and an external noise source. Once the accessories have been connected, the calculator is pre-populated with data from, for example, an external USB preamplifier, a smart noise source, and the instrument itself. The calculator also offers flexibility in choosing distribution and specification style for DUT characteristics. With the noise figure uncertainty calculator, you will know your measurement uncertainty and how to reduce it.

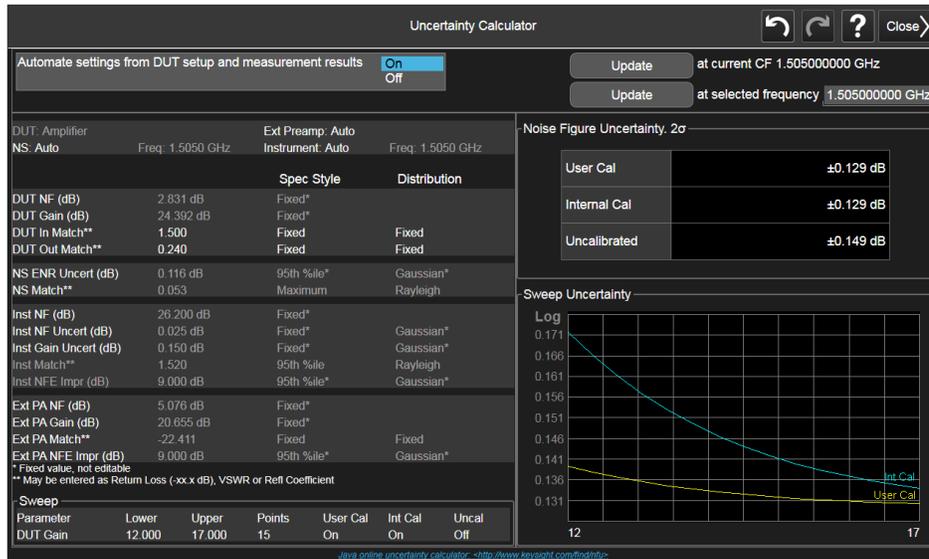


Figure 7. The built-in noise figure uncertainty calculator provides fast DUT measurement uncertainty readings.

## Conclusion

Each of the ideas presented here will help you improve noise figure and noise figure measurements. All can be implemented using a compact system based on a Keysight X-Series signal analyzer, an internal or external preamplifier, and an external noise source. Adding the noise figure measurement application (N9069C) provides one-touch convenience and ensures accurate results across the analyzer’s full frequency range.

One suggested solution is the midrange N9010B EXA X-Series signal analyzer with multi-touch. It provides excellent noise figure results when equipped with the noise figure measurement application.

For more information, please visit [www.keysight.com/find/switch2exa](http://www.keysight.com/find/switch2exa).

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