

# 7000 Series ATE Phase Noise Testing for Production Speed

How the 7000 Series signal source analyzer measures phase noise in under 200 ms per device, with the acquisition-time trade, twelve hours of repeatability data, automated VCO characterization and the analyzer's sensitivity from the current datasheet.

TECHNICAL NOTE · RF & MICROWAVE · dc-62022201

## 1 Measuring Phase Noise in Automated Production for Optimum Speed

The Berkeley Nucleonics 7000 Series signal source analyzer brings fully automated phase noise measurement to the production floor, with high-speed modes that trade acquisition time against accuracy on demand. This note walks through the ATE measurement capabilities, throughput, long-term repeatability and automated VCO characterization, and closes with the analyzer's sensitivity and measurement time from the current datasheet.

### The 7000 Series signal source analyzer

The 7000 Series signal source analyzers (Model 7070 to 7 GHz, Model 7300 to 26 GHz and Model 7340 to 40 GHz) carry high-speed measurement modes for automated testing alongside the full set of R&D measurements, so one instrument serves both the bench and the production line (Figure 1).



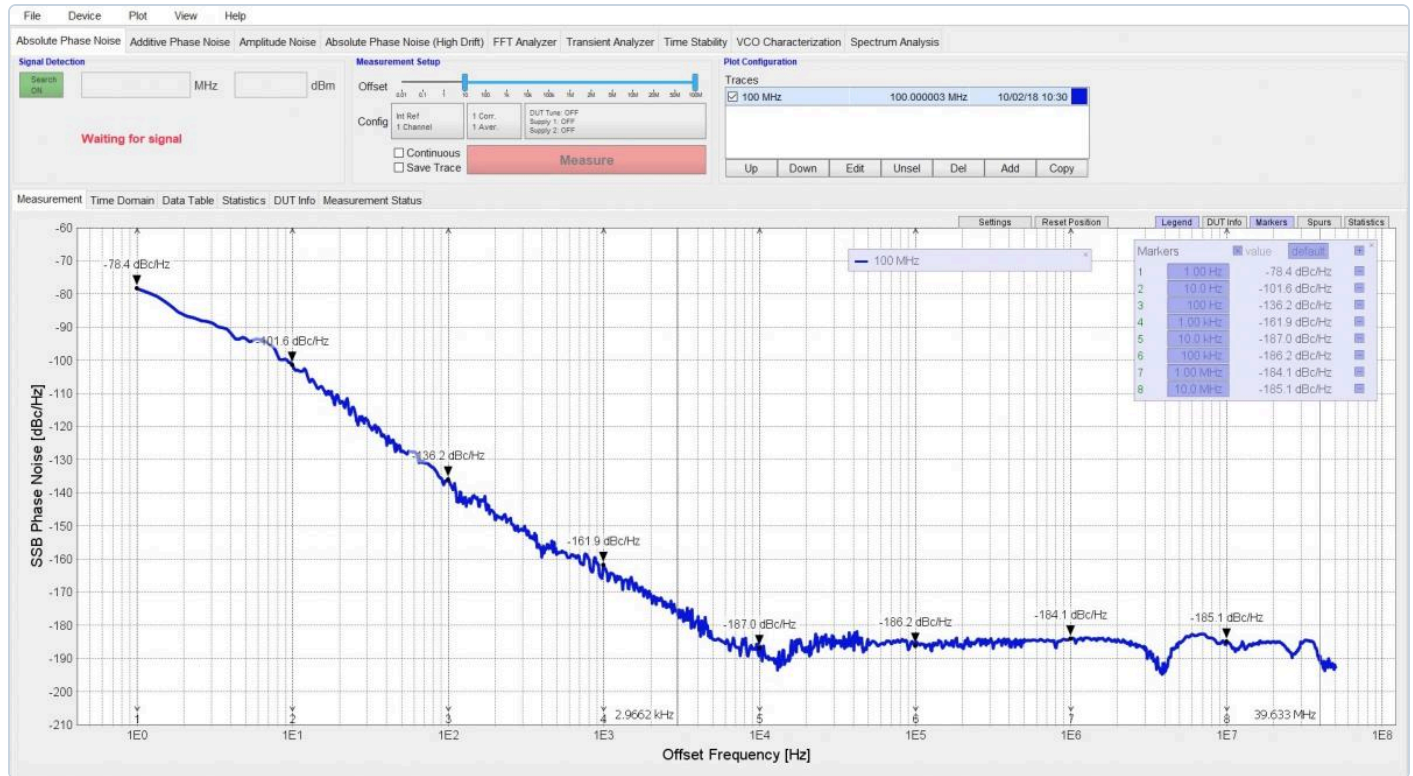
■ **PHOTO** Figure 1. 7000 Series signal source analyzer front panel, with the CH1 and CH2 reference inputs, the three TUNE outputs and the DUT input.

### R&D measurement capabilities

For R&D, the instrument is run from the desktop application (Figure 2) and offers these measurement modes:

- **Phase noise measurements**, absolute or residual, on CW or pulsed signals, with cross-correlation sensitivity to -190 dBc/Hz
- **Amplitude noise measurements**
- **Frequency & phase transient tests** (Transient Analyzer)
- **VCO Characterization** with low-noise internal DC sources
- **FFT analyzer**

The instrument is controlled over Ethernet, USB or GPIB (Option GPIB) from a standard computer. It is a 3U half-rack unit, 154 mm high by 467.5 mm wide by 342 mm deep, weighs no more than 10 kg (21 lb), and runs from 24 V DC at under 70 W; Option RM is the rack-mount chassis.



**MEASURED** Figure 2. The 7000 Series desktop application on an absolute phase noise measurement of a 100 MHz source, internal reference, one correlation; markers read -78.4 dBc/Hz at 1 Hz, -136.2 dBc/Hz at 100 Hz and -187.0 dBc/Hz at 10 kHz.

## ATE measurement capabilities

Besides benchtop use, the 7000 Series supports automated test (ATE). The unit is controlled and triggered by SCPI commands over USB, GPIB or Ethernet. The measurement runs without operator action once a short SCPI sequence has set it up, and example programs are available in VBA, Java, C, MATLAB and LabVIEW.

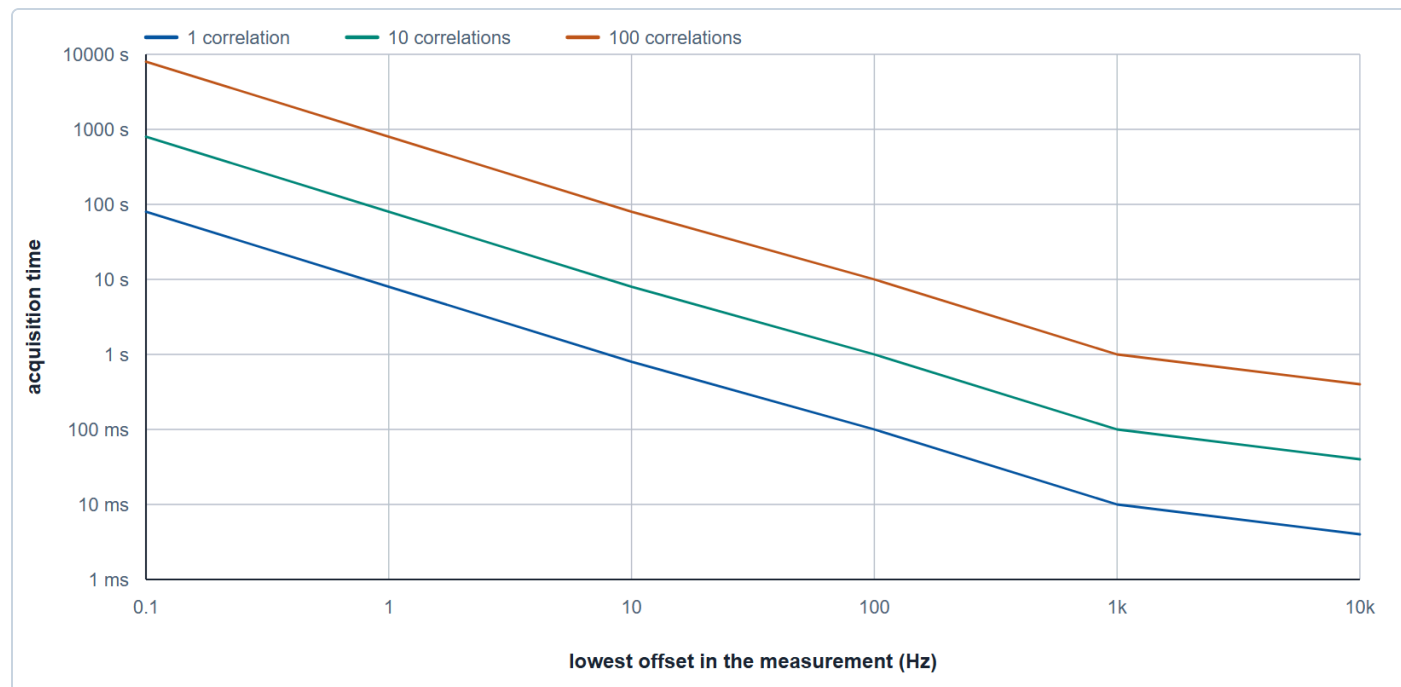
### Applications:

- **General purpose phase noise tests**
- **Crystal oscillator and VCO testing**
- **PLL synthesizer locking and characterization**
- **Supply noise verification**
- **Automated production testing**

## Automated phase noise measurement

The ATE SCPI command set returns phase noise plots, spot phase noise values, extracted spurious, and RMS jitter and integrated phase noise. In the phase noise mode a measurement completes in under 200 milliseconds per device under test when it starts at 1 kHz offset with one correlation. Measurement time is setup time plus acquisition time; the architecture keeps the setup time short, and the acquisition time is set by the user as a trade between accuracy and time, as Figure 3 shows.

The acquisition time follows from the tolerable uncertainty at a given offset and from the lowest offset of interest. As acquisition time rises, more correlations average down the uncertainty (the standard deviation curves in Figure 3), and lower offsets become available: the datasheet gives 10 ms per correlation for a measurement that starts at 1 kHz and 100 ms for one that starts at 100 Hz.



■ **DERIVED** Figure 3. Acquisition time against the lowest offset in the measurement for 1, 10 and 100 correlations, from the datasheet time-per-correlation table; a measurement that starts at 1 kHz costs 10 ms per correlation.

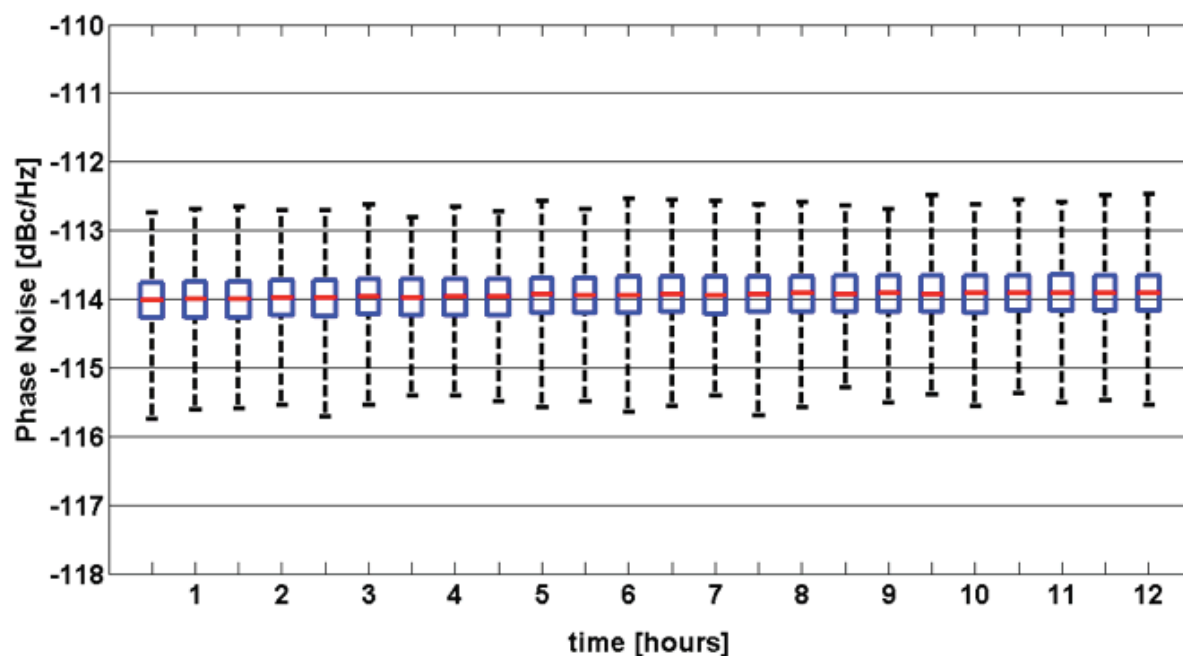
## Continuous, repeatable operation

### Options used in this note:

- **Option LN**, ultra-low-noise internal reference sources
- **Option VCO**, VCO characterization (the two programmable low-noise DC supplies and three tuning voltages are standard)
- **Option GPIB**

Figure 4 shows the result of 12 hours of continuous operation: the measured 100 kHz offset phase noise of a 5.4 GHz device over 12 hours: about 180,000 individual measurements, grouped into 30-minute windows.

The red line is the median of each group, the blue box holds the values between the 25th and 75th percentiles, and the whiskers mark the extremes. Over the 12 hours and an ambient variation of about 5 °C the median holds at about -114 dBc/Hz and the interquartile range stays within about 0.5 dB.



■ **MEASURED** **Figure 4.** Phase noise at 100 kHz offset over 12 hours, 5.4 GHz device at 0 dBm, about 180,000 measurements with about 7,450 per 30-minute column. The red line is the median, the blue box the 25th to 75th percentile, the whiskers the extremes.

## Automated VCO characterization

Characterizing a VCO takes at least two low-noise DC sources and one analyzer that measures frequency, power and the other parameters as a function of the control voltage. The 7000 Series carries two programmable low-noise supplies (0 to 15 V, 550 mA each) and three tuning voltages (-5 to +20 V), so with Option VCO it characterizes the device against tuning voltage for frequency, tuning sensitivity, output power, supply current, supply pushing and SSB phase noise at several offsets, from one instrument.

The parameters are captured in a single sweep. Measurement time per tuning-voltage point is 70 milliseconds for frequency, tuning slope, output power, supply current and supply pushing; adding SSB phase noise adds the acquisition time for the lowest offset requested, as Table 2 gives it. Figure 5 shows the full capture of a wideband VCO in the graphical user interface.



**MEASURED** Figure 5. GUI screen of a completed VCO characterization over 40 tuning points from 0 to 6 V, showing frequency, tuning sensitivity, supply current, output power, supply pushing and SSB phase noise at 1 MHz and 20 MHz offsets.

## Conclusion

The 7000 Series carries measurement modes written for automated testing with high throughput. VCO characterizations and phase noise measurements are triggered and read out remotely through SCPI over USB, GPIB or Ethernet, and a phase noise measurement completes in under 200 milliseconds per device with the repeatability shown in Figure 4.

The instrument is built on a fully integrated platform that runs from an external 24 V DC supply at under 70 W. It carries three tuning voltages and two programmable low-noise supplies of up to 15 V and 550 mA each. With one correlation at a 1 GHz carrier the internal references reach -140 dBc/Hz at 1 kHz offset and -160 dBc/Hz at 100 kHz, and external references lower the floor by 10 to 15 dB at offsets of 1 kHz and above, as Table 1 shows.

## Sensitivity and measurement time from the datasheet

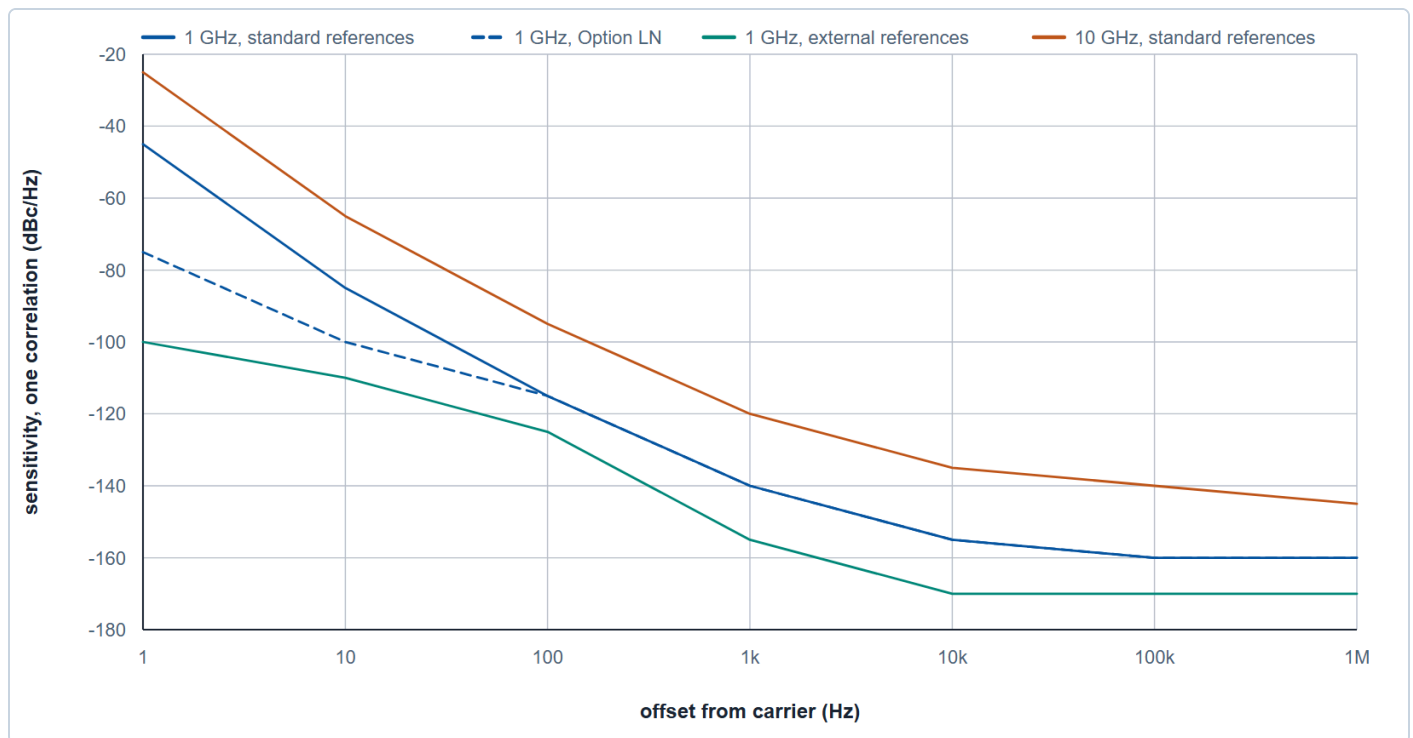
Table 1 gives the analyzer's phase noise sensitivity at a 1 GHz carrier after one correlation, with the standard internal references, with Option LN, and with external references, from the current 7000 Series datasheet. Each tenfold increase in the number of correlations lowers the displayed floor by about 5 dB. Table 2 gives the time one correlation takes as a function of the lowest offset in the measurement; a measurement that starts at 1 kHz costs 10 ms per correlation, one that starts at 1 Hz costs 8 s.

**Table 1.**

Table 1. Phase noise sensitivity at 1 GHz, dBc/Hz, after one correlation, carrier power 5 dBm or more

| Offset | Standard references | Option LN | External references |
|--------|---------------------|-----------|---------------------|
| 1 Hz   | -45                 | -75       | -100                |
| 10 Hz  | -85                 | -100      | -110                |

| Offset  | Standard references | Option LN | External references |
|---------|---------------------|-----------|---------------------|
| 100 Hz  | -115                | -115      | -125                |
| 1 kHz   | -140                | -140      | -155                |
| 10 kHz  | -155                | -155      | -170                |
| 100 kHz | -160                | -160      | -170                |
| 1 MHz   | -160                | -160      | -170                |



■ **DERIVED** Figure 6. 7000 Series phase noise sensitivity after one correlation at a 1 GHz carrier with standard, Option LN and external references, and at 10 GHz with standard references, from the datasheet sensitivity tables.

**Table 2.**

Table 2. Time per correlation against the lowest offset in the measurement, 250 points per decade

| Measurement range | Time per correlation |
|-------------------|----------------------|
| 0.1 Hz to 100 MHz | 80 s                 |
| 1 Hz to 100 MHz   | 8 s                  |
| 10 Hz to 100 MHz  | 0.8 s                |
| 100 Hz to 100 MHz | 0.1 s                |
| 1 kHz to 100 MHz  | 0.01 s               |
| 10 kHz to 100 MHz | under 0.004 s        |

### Reading the tables

Total measurement time is setup time plus transfer time plus the number of correlations times the time per correlation; the times in Table 2 are normalized to one correlation at the nominal resolution bandwidth. The sensitivity values in Table 1 are the analyzer's own floor, so at a 1 GHz carrier with the internal references a device measured at 1 kHz offset reads correctly only where its phase noise is well above -140 dBc/Hz with one correlation (-120 dBc/Hz at a 10 GHz carrier), or more correlations are taken.

### Talk to an application engineer

Deciding whether the 7000 Series fits your production line or R&D bench is easier with a specialist who knows the trade-offs. Request a quote or demo and we will help you match the analyzer, options, and throughput targets to your device under test. You can also reach us at [info@berkeleynucleonics.com](mailto:info@berkeleynucleonics.com) or 800-234-7858.

**Ask now** →

Chat with our assistant and get an answer in seconds.

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#### Technical Note

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