Automated Pulsed Phase Noise Measurements

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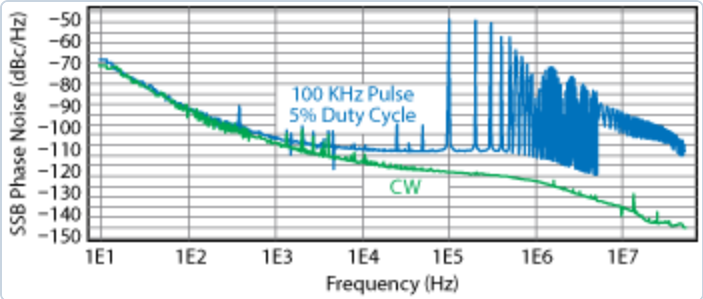
1 Automated Pulsed Phase Noise Measurements

The Berkeley Nucleonics 7000 Series signal source analyzers measure absolute and residual phase noise on CW and pulsed signals to 40 GHz (Model 7340), with transient analysis and VCO characterization, under full remote control. This note summarizes the measurement capabilities that make the 7000 Series one analyzer for R&D and production testing.

Overview

The 7000 Series measures absolute phase noise on CW sources at offsets from 0.01 Hz to 100 MHz (to 25 percent of the carrier below 150 MHz), residual (additive) phase noise of two-port devices (Option APN), phase noise on pulsed carriers (Options PULSE and NPS), frequency and phase transients (Option TRAN) and VCO characteristics (Option VCO). High-speed measurement modes serve automated testing. Three models share one chassis, GUI and option set and differ only in top frequency: the Model 7070 covers 1 MHz to 7 GHz, the Model 7300 1 MHz to 26 GHz and the Model 7340 1 MHz to 40 GHz with the internal references; with external references the range is 5 MHz to 7 GHz on the 7070 and 5 MHz to 18 GHz on the 7300 and 7340. The instruments are controlled over Ethernet, USB or GPIB (Option GPIB) from a standard computer and ship as a 3U half-rack unit weighing no more than 10 kg.

The instrument runs from 24 V DC at under 70 W, which allows an external battery pack (option) for use away from AC power. Two programmable low-noise supplies (0 to 15 V, 550 mA each) and three tuning voltages (-5 to +20 V) power and tune the device under test. 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. A PC, laptop or tablet serves as the control unit through the GUI, the API library or SCPI.



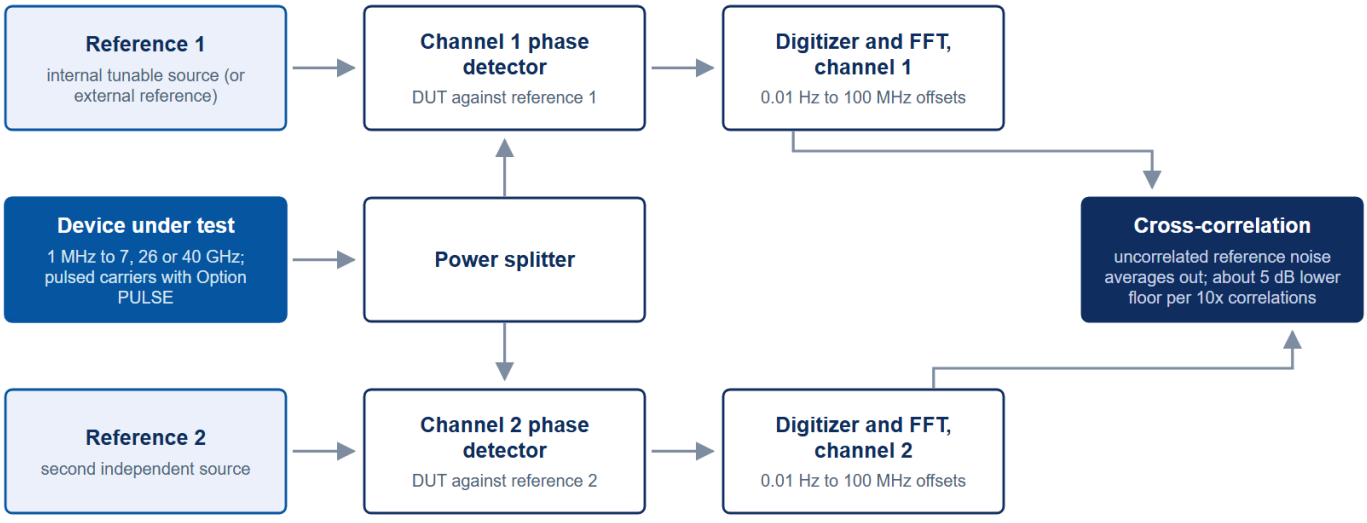
MEASURED **Figure 1.** SSB phase noise of a 2.5 GHz carrier pulsed at 100 kHz with 5 percent duty cycle (blue) against the same carrier in CW (green). The lines at multiples of 100 kHz are the pulse spectrum.

Special Capabilities

ATE Measurement: In addition to benchtop use, the 7000 Series supports automatic test equipment (ATE) use, with phase noise measurements below 200 milliseconds per device under test (DUT) in a production environment. The unit is controlled and triggered by SCPI commands over USB, GPIB or Ethernet. The measurement runs without operator action once a short

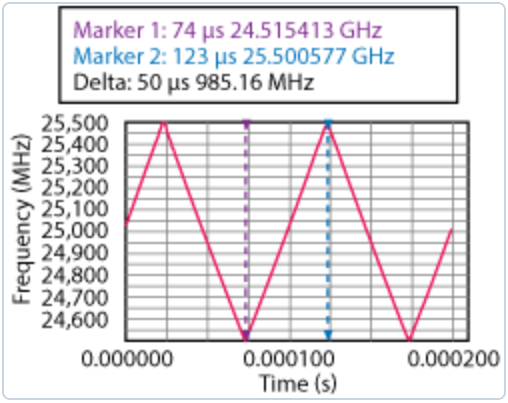
SCPI sequence has set it up, and example programs are available in VBA, Java, C, MATLAB and LabVIEW. The ATE SCPI command set allows for phase noise plots, spot phase noise values, spurious extraction, and calculation of RMS jitter and integral phase noise.

Pulsed Phase Noise: A pulsed carrier carries spectral lines at multiples of the pulse repetition frequency, and the analyzer measures the phase noise between them, so the offset range runs from 0.01 Hz up to the PRF. By detecting the pulses, or from an external trigger, the hardware sets its parameters for the pulse train. With Option PULSE the 7000 Series handles pulse repetition frequencies from 300 Hz to 2 MHz, pulse widths from 1 µs to 2 ms and duty cycles from 2 to 60 percent; Option NPS extends this to pulse widths down to 50 ns and duty cycles down to 0.1 percent, and Option BURST measures single bursts as short as 10 µs. Figure 1 shows the measurement of a 2.5 GHz signal at a 100 kHz pulse rate and 5 percent duty cycle, a 500 ns pulse width that calls for Option NPS.



SCHEMATIC **Figure 3.** Two-channel cross-correlation. The device under test is measured against two independent references; averaging the two channels cancels the analyzer's own uncorrelated noise, about 5 dB per tenfold correlations.

Frequency Transients



MEASURED **Figure 2.** Transient analysis of a triangular 1 GHz chirp between 24.5 and 25.5 GHz with a 50 µs chirp time; the markers read 24.515 GHz at 74 µs and 25.501 GHz at 123 µs, a delta of 985 MHz.

The 7000 Series also works as a modulation domain analyzer, showing frequency and phase against time, so frequency switching, jitter or modulation can be viewed directly. In effect, the 7000 Series becomes a frequency oscilloscope, measuring carrier frequency against time up to 40 GHz (Model 7340) with 16 ns time resolution. Figure 2 shows a 1 GHz

chirp between 24.5 and 25.5 GHz with a 50 µs chirp time. Wideband mode covers six bands from 5 MHz to the top frequency, the widest being 5.2 to 40 GHz on the Model 7340, and narrowband mode resolves frequency, power and phase in spans of 200 kHz, 1.25 MHz and 80 MHz. With a time resolution of 16 ns and time spans from 10 µs to 1 minute (Option TRAN), the mode covers:

- **Frequency hopping systems** measuring the frequency droop on individual channels
- **Chirp radar** analyzing chirp radar performance
- **Pulse jitter** measuring pulse jitter and viewing the distribution histogram
- **Frequency sweep calibration** calibrating frequency sweep signals
- **Intentional modulation** calibrating intentional modulation (FM or FSK)
- **PLL and FLL analysis** analyzing phase-locked loops (PLL) and frequency-locked loops
- **Synchronization clocks** discovering phase jumps in synchronization clocks
- **Rotational encoders** detecting missing periods from rotational encoders
- **VCO settling** measuring VCO frequency settling times
- **Oscillator start-up** characterizing the start-up/warm-up of oscillators

Automatic VCO Characterization

Characterizing a VCO takes at least two low-noise DC sources and one analyzer to measure power, frequency and phase noise. With two programmable supplies and three tuning voltages to power and control the device under test, the 7000 Series with Option VCO characterizes a VCO against tuning voltage for frequency, tuning sensitivity, output power, supply current, supply pushing and SSB phase noise, and captures them in a single sweep at 70 ms per point.

Summary

The 7000 Series signal source analyzer measures CW and pulsed phase noise, absolute and residual, and adds transient analysis in the time domain, FFT analysis and VCO characterization, each from one tab of a single graphical user interface. For production testing, the same measurements run from SCPI commands with measurement times set for throughput.

Talk to an application engineer

Berkeley Nucleonics application engineers can help you match the Model 7070, 7300 or 7340 to your pulsed, CW, transient or VCO measurement needs. Request a quote or demo to discuss your test setup. You can also reach us at info@berkeleynucleonics.com or 800-234-7858.

Ask now → Chat with our assistant and get an answer in seconds.