Microwave Journal

20 GHz Synthesizer Delivers Ultra-Low Phase Noise and Fast Switching

Trisynt Technology Inc.
Wilmington, Del.

Rapidly evolving microwave and mmWave technology is imposing more difficult requirements on the generation of microwave signals. The systems of tomorrow—from high speed analog-to-digital and digital-to-analog converters (ADC and DAC), to radar and fundamental research applications—all need signals with better frequency stability and spectral purity, as well as sub-microsecond frequency switching. The design of such systems can be simplified using a bench-top microwave frequency synthesizer capable of pushing conventional performance specifications close to theoretical limits. The new 100 kHz to 20 GHz frequency synthesizer developed by Trisynt Technology addresses this challenge, providing a unique combina-

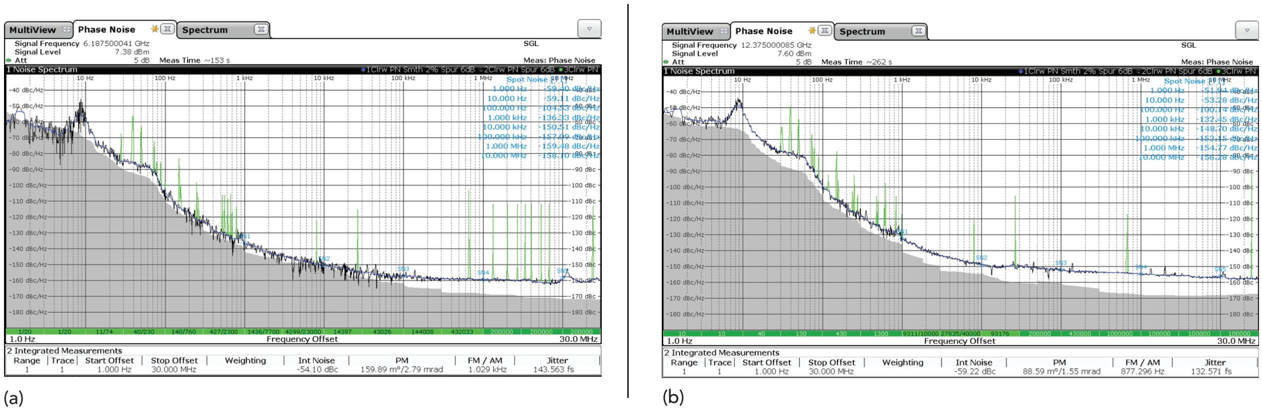

Fig. 1 Measured phase-noise at the ends of the main frequency band: 6.1875 GHz (a) and 12.375 GHz (b).

Reprinted with permission of MICROWAVE JOURNAL® from the March 2020 issue.
©2020 Horizon House Publications, Inc.

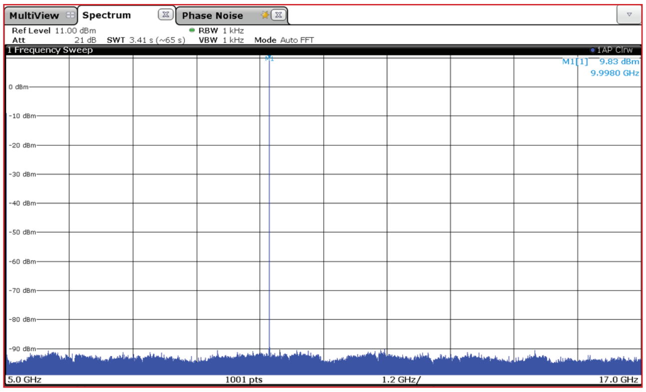

Fig. 2 Broadband spectrum around a 10 GHz synthesized signal, showing spurs below –90 dBm from 5 to 17 GHz.

tion of ultra-low phase noise, excellent spectral purity and ultimate frequency agility not previously available in a commercial instrument.

While the best available commercial synthesizers target -130 dBc/Hz at a 10 kHz offset from a 10 GHz carrier, Trisynt's SAPSYNT-200 provides 20 dB improvement compared to the industry standard, achieving an ultra-low -150 dBc/Hz at 10 kHz offset at 10 GHz. This dramatic advance in phase noise is possible using an X-Band frequency reference with a high Q sapphire resonator locked to a high stability 10 MHz OCXO, yielding a frequency stability better than $\pm 1 \times 10^{-11}$ over an operating temperature range from 0°C to 50°C. While the low noise characteristics of sapphire-based oscillators have been known for years, there were only a few systems which provided the frequency stabilization of sapphire oscillators with a low start-up time and without using cryogenic methods. The SAPSYNT-200 uses a novel approach where the sapphire oscillator frequency and phase are constantly measured by a high-resolution ADC and a dedicated FPGA, forming a corresponding linear FM signal to digitally phase-lock the sapphire to a 10 MHz reference. The system settles within just a couple of minutes after the instrument is switched on.

Engineers familiar with low noise frequency synthesis are aware that a low noise reference is not enough to build a synthesizer; a synthesis core broadband enough to be extended to a frequency octave is required. Transferring the reference characteristics without significant noise degradation to other frequencies is not trivial. Nevertheless, the SAPSYNT-200 accomplishes this, where all the frequencies in the main frequency band, from 6.1875 to 12.375 GHz, have consistently superb phase noise performance (see ***Figure 1***).

In addition to the frequency range available at the standard synthesizer output, the SAPSYNT-200 provides signal outputs derived from the combined 9.9 GHz reference: f/2 or 4.95 GHz, f/4 or 2.475 GHz, f/8 or 1.2375 GHz and f/16 or 618.75 MHz. These frequencies have enhanced phase noise comparable to "golden" phase noise standards and can be used for applications such as clocking an ADC or DAC.

ENHANCED SPUR PERFORMANCE

The SAPSYNT-200 carefully tackles unwanted synthesis spurs in the spectrum. A specialized DDS built as a combination of FPGA and high speed DAC has been developed to suppress non-harmonic spurs using both hardware and software, achieving levels well below -90 dBc. The SAPSYNT is a fully direct synthesizer with no VCOs, YTOs or PLLs—only direct frequency mixing, multiplication and division. All spur products from unwanted mixing, multiplication and division go through a multichannel switched filter bank, where they are rejected to very low levels. This is achieved using ninth-order hardware filters with very sharp skirts and by routing the signal through multiple switch isolations. Conceptually, low spurs within a 500 MHz band around the signal are achieved by DDS and outside this bandwidth by the switched filter bank. ***Figure 2*** shows the broadband spectrum around a 10 GHz CW at the output of the synthesizer.

FAST SWITCHING SPEED

The direct synthesis architecture of SAPSYNT-200 enables very low dwell time when switching between frequencies. The switching speed is only limited by the broadband switches and the data upload rates of the internal interfaces. The hardware filters are typically 500 MHz wide and contribute negligibly to the switching speed of the instrument. Within the main frequency octave, i.e., from 6.1875 to 12.375 GHz, the switching speed is within 200 ns for any two frequency points in the list mode, remaining in the sub-microsecond region across the specified frequency range from 100 kHz to 20 GHz. The synthesizer has a minimum frequency step of 1×10^{-6} Hz.

OPTIONS AND EVOLUTION

The architecture of the SAPSYNT-200 supports extension of the frequency range and adding functionality, as well as performance upgrades as microwave technology evolves. For example, the synthesizer can be modified to work from a photonic time-base of 9 to 10 GHz extracted from an optical frequency comb produced by mode-locked lasers. In this case, all the internal core frequencies including the DDS clock will be regenerated from a virtually noiseless reference, only limiting the synthesizer characteristics by the thermal noise of its active components.

The SAPSYNT-200 direct frequency synthesizer offers a new standard for phase noise and frequency agility, a safe investment since it will remain one of the lowest noise and fastest synthesizers for years to come.

Trisynt Technology Inc.
Wilmington, Del.
www.trisynttechnology.com
info@trisynt.com