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News Report
Frequency synthesizers fit many modular formats

Design Feature
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Frequency Synthesizers Fit Many Modular Formats
Frequency synthesizers are used throughout RF/microwave applications in measurement labs; in commercial communications systems; in military avionics, electronic-warfare (EW), satellites, and other systems; and throughout industrial, automotive, and medical systems at every level from integrated circuits (ICs) to rack-mount subsystems in machined housings. Because the field of RF/microwave frequency synthesizers is so broad, this report will focus on modular, system-level frequency synthesizers.

In briefly categorizing frequency synthesizer types, they can be based on analog or digital circuitry, and can employ direct or indirect frequency-synthesis methods. Analog indirect synthesizers stabilize the phase of a tunable oscillator, such as a voltage-controlled oscillator (VCO), by comparing it to the phase of a more stable source, such as a crystal oscillator. Analog direct synthesizers generate all possible output signals via mixing, multiplication, and division, and then switch and filter specific desired output signals.

In contrast to an indirect analog synthesizer which requires tuning of a variable oscillator, the outputs of a direct analog synthesizer are always “on” and a particular signal can be selected essentially with the settling speed of a PIN diode. Direct digital synthesizers (DDSs) essentially convert digital representations of an analog signal to a desired output signal by means of a digital-to-analog converter (DAC). Depending on the bit resolution of the DAC and the bit resolutions of the phase and frequency accumulators in oscillator, such as a voltage-controlled oscillator (VCO), by comparing it to the phase of a more stable source, such as a crystal oscillator. Analog direct synthesizers generate all possible output signals via mixing, multiplication, and division, and then switch and filter specific desired output signals.

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the DDS, extremely small intervals of frequency and amplitude are possible with fast switching speeds. Analog synthesizers based on indirect signal generation and control via the use of a phase-locked loop (PLL) are still probably the most widespread form of RF/microwave frequency synthesizer, although sources using direct digital synthesis (DDS) are gaining ground with improvements in their spurious performance levels.

Frequency synthesizers are specified on the basis of a handful of performance specifications depending on an application. For some, phase noise and spurious performance may be most critical while, for others, it may be tuning resolution and switching speed. Every synthesizer model provides a different blend of the key performance parameters, with price, complexity, and reliability being other important factors in selecting a synthesizer.

Military applications, for example, tend to cover wide frequency bandwidths in contrast to the allocated frequency coverage of commercial communications requirements. Frequency synthesizers from Wide Band Systems (www.widebandsystems.com) were developing nominally for electronic-warfare (EW) applications calling for high-speed frequency tuning and broad frequency coverage. These modular synthesizers (Fig. 1) consume less than 16 W DC power in achieving better than 3 μs switching speed at frequencies from 2 to 18 GHz. Ideal also for automatic-test-equipment (ATE) applications, these synthesizers tune by means of 14-bit offset binary control words. Standard models tune in 1-MHz steps, although other tuning resolution is available in custom designs. The typical single-sideband (SSB) phase noise levels are –103 dBc/Hz offset 10 kHz from the carrier, –107 dBc/Hz offset 100 kHz from the carrier, and –121 dBc/Hz offset 1 MHz from the carrier.

Based on an internal oven-controlled-crystal-oscillator (OCXO) frequency reference, the frequency accuracy is 5 PPM, although a suitable external reference source can be connected to achieve even better accuracy. The synthesizers, which measure just 6.5 X 6.25 X 1.050 in., provide +10 dBm output power with ±1.5 dB flatness over temperature and frequency. Maximum spurious levels are –50 dBc and maximum harmonic levels are –20 dBc.

Not far from Wide Band Systems, also located in New Jersey, are several other suppliers of high-performance frequency synthesizers. Virtually just next door, Herley CTI (www.herley.com) has been one of the longest-running suppliers of frequency synthesizers in the industry. In addition to extensive lines of wideband synthesizers, the company also offers products, such as its BBS series of sources that aim at specific applications. The model BBS-600, for example, operates from 4400 to 6000 MHz and is well suited for C-band satellite communications systems. Other synthesizers in the series operate from 9 to 2200 MHz and 18 to 4400 MHz (through doubling). The phase noise is typically –87 to –91 dBc/Hz offset 100 Hz from a 1 GHz carrier, –129 to –136 dBc/Hz offset 100 kHz, with a noise floor of typically –153 dBc/Hz. The synthesizers are ideal as local oscillators (LOs) in a wide range of communications systems.

Just to the north, also in New Jersey, Elcom Technologies (www.elcomtech.com) offers all of the major frequency synthesizer technologies in both narrowband and broadband versions. The company’s UFS line of 19-in. rack-mount synthesizers includes one of the industry’s broadest-bandwidth standard models in the 0.1-to-40-GHz model UFS-40. Elcom even provides custom versions to 54 GHz. Other standard models in the UFS line (Fig. 2) cover 0.3 to 3 GHz (UFS-3), 0.5 to 18 GHz (UFS-18), and 0.1 to 20 GHz (UFS-20). The UFS-40 features 1-Hz frequency resolution with better than 250-ns switching speed. The output power is +10 dBm and flat within ±2 dB across the frequency range. Phase noise is –100 dBc/Hz offset 100 Hz from a 10-GHz carrier, –112 dBc/Hz offset 10 kHz, and –133 dBc/Hz offset 1 MHz from the same carrier. Spurious levels are typically –65 dBc while harmonics are –50 dBc.

In the same state, numerous other frequency synthesizer suppliers, including Advanced Control Components (www.advanced-control.com), Dbm Corp. (www.dbmcorp.com), offer standard and custom models for a wide range of applications. One of the smallest of frequency synthesizer hails from Synergy Microwave Corp. (www.synergymwave.com) in Paterson, NJ with their 3150-to-5550 MHz model FSFS315555-500 surface-mount frequency synthesizer (Fig. 3). It measures just 1.25 X 1.00 X 0.300 in., but delivers phase noise of –92.5 dBc/Hz offset 1 kHz from a 900-MHz carrier and –83.5 dBc/Hz offset 1 kHz from a 5.8-GHz carrier. It tunes in 5-MHz steps with typical spurious levels of –75 dBc. The switching speed is 50 microseconds or less to within 10 kHz of a new frequency. Another small synthesizer hails from EM Research (www.emresearch.com) and their LX-1450 synthesizer, which covers 950 to 1450 MHz in a surface-mount package measuring 0.75 X 0.75 X 0.15 in. Its phase noise is better than –80 dBc/Hz offset 10 kHz from the carrier.

Not far, in New York State, perhaps the best-known name in frequency synthesizers is Aeroflex...
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3. The model FSFS31555-500 surface-mount frequency synthesizer measures just 1.25 X 1.00 X 0.300 in. and tuned from 3150 to 5550 MHz. (Photo courtesy of Synergy Microwave Corp., www.synergymwave.com.)

(www.aeroflex.com) with its FS2000 and FS5000 lines of high-performance sources. The FS2000 family, for example, includes models operating from 1 MHz to 18.4 GHz with submicrosecond switching speed. The FS5000 line operates from 0.3 to 26.5 GHz with 1-MHz standard resolution and 200 ns switching speed. The line provides ±10 dBm output power across frequency with ±2 dB flatness. In addition to these rack-mount units, the company offers the model 3010 PXI synthesizer modules with coverage from 1.5 to 3.0 GHz and 1-Hz resolution. The module features 250-microsecond switching speed with typical phase noise of –116 dBc/Hz offset 20 kHz from the carrier. In the same area of New York State, Rodelco Electronics (www.rodelco-usa.com) designs and sells custom RF/microwave synthesizers for aerospace and military applications. Units range from 2.8 to 18.4 GHz.

ITT Microwave Systems (www.ittmicrowave.com) made one of the more recent product introductions based on DDS technology with their WaveCor Dual Synthesizers, in which two independent sources were housed in the same small enclosure (Fig.4). The rack-mountable dual synthesizers operate to 18 GHz with 300-ns switching speed. The product family includes a 0.3-to-18.0-GHz unit and a 0.3-to-2.5-GHz unit. Both are housed in 5U rack-mount enclosures measuring 8.75 X 18 X 18 in. The synthesizers employ separate 42-b binary-coded-decimal (BCD) interfaces to achieve 1-Hz frequency resolution for each independent source. The output power is at least +10 dBm and the phase noise is better than –125 dBc/Hz offset 10 kHz from a 9-GHz carrier with better than –65 dBc spurious performance. The lower-frequency unit cuts phase noise to –140 dBc/Hz offset 10 kHz from a 1.2-GHz carrier.

On the West Coast, Teledyne Microwave (www.teledynemicrowave.com) has developed a line of single-loop synthesizers for use from 0.7 to 40 GHz (minimum 10-percent bandwidths). The patent-pending design yields phase-noise performance of <–125 dBc/Hz at 100 kHz offset from the carrier. The firm’s series 9700 units feature low noise past 12.8 GHz with 1-kHz resolution and +12 dBm typical output power. The phase noise is –120 dBc/Hz offset 100 kHz from a 3.2-GHz carrier and –108 dBc/Hz offset 100 kHz from a 12.8-GHz carrier.

The MLSE series of wideband synthesizers from Micro Lambda Wireless (www.microlambdawireless.com) includes models covering 2 to 20 GHz and 1 to 22 GHz with output levels from +14 to +20 dBm. Leveraging the company’s proven tunable YIG oscillator technology, the MLSE models provide 31ms full-band tuning speed with 1-Hz resolution. Spurious content is –60 dBc. They offer options for multiple RF outputs and a second LO output. Measuring just 7 X 5 X 2 in., these miniature synthesizers consume just 43 W power.

Endwave Corp. (www.endwave.com) bases its synthesizers on both YIG and VCO technologies. Offering models through 18 GHz in single- and multiloop configurations and tuning ranges of ±1 GHz, the YIG models achieve phase noise of –100 dBc/Hz offset 10 kHz from any carrier and –128 dBc/Hz offset 100 kHz from any carrier. The company recently developed an X-band synthesizer for satellite-communications applications with tuning range of 6.410 to 7.545 GHz; it can be customized to meet step size requirements from 1 kHz down to 1 Hz. The phase noise is –77 dBc/Hz offset 100 Hz and –125 dBc/Hz offset 1 MHz from the carrier.

Phase Matrix (www.phasematrix.com) offers instrument-type and card-format synthesizers, including its 114XA family of VXI synthesizers. They provide 1 MHz resolution over bandwidths as wide as 10 MHz to 20 GHz and fit into three VXI slots. They feature output levels from +10 to +13 dBm with –30 dBc harmonics, –60 dBc spurious levels, and phase noise of –85 dBc/Hz offset 10 kHz from a 10-GHz carrier.

When a frequency synthesizer requirement calls for millimeter-wave signals, few firms can match the lineup offered by Insight Product Co. (www.insightproduct.com) with models spanning 36 to 1250 GHz. The company’s 120-to-180 GHz source, for example, provides more than 30 mW output power over that range and can be operated locally from the front-panel keypad or remotely under GPIB control. The company features three sources covering 370 to 535 GHz, 526 to 714 GHz, and 667 to 857 GHz with power levels from 4 to 15 mW.