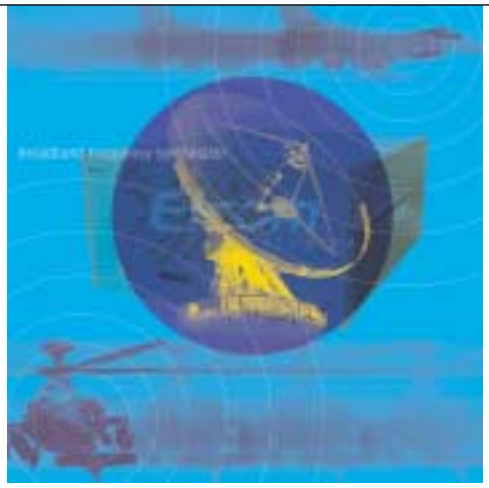


Synthesizers Offer Submicrosecond Switching

A series of broadband frequency synthesizers provides very low phase noise with submicrosecond switching time for military applications.

PETER STAVENICK
Managing Editor

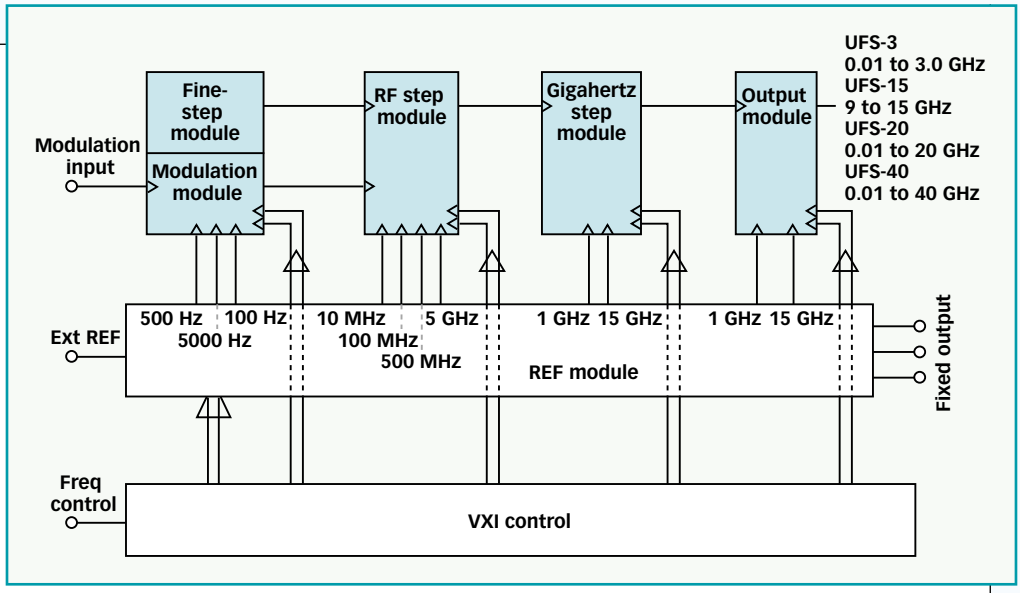
Military systems require low-noise synthesizers with fast switching for radar, electronic-warfare (EW), and surveillance applications. Elcom Technologies' (Rockleigh, NJ) UFS series of modular synthesizers addresses these applications with submicrosecond switching speed and phase noise that represents up to a 30-dB improvement over existing products. The UFS series also covers a wide bandwidth, ranging from 0.01 to 40 GHz.

Broadband synthesizers are divided into two groups (techniques)—yttrium iron garnet (YIG) and direct analog. The YIG group is based on YIG oscillators that are phase locked to a low-phase-noise reference. This technique provides a very-low-phase-noise floor –160 dBc) across the 0.01-to-40-GHz frequency range, switching speed limited by the inductance of the YIG tuning coil. As a result, the switching speed is limited to approximately 1 μs. Also, due to the division ratios inside the phase-locked loop (PLL), the phase noise at 10 kHz from the carrier is higher than the noise floor (–117 dBc at 10 kHz offset from the 10-GHz carrier compared to –160 dBc offset 10 MHz from the carrier).

The second group is based on direct-analog techniques (arithmetic operations on main and auxiliary frequencies) combined with digital direct synthesis (DDS) for fine-step resolution. Although this method is more complex, it enables fast switching speeds (0.2 ms) with low phase noise. The switching speed is controlled

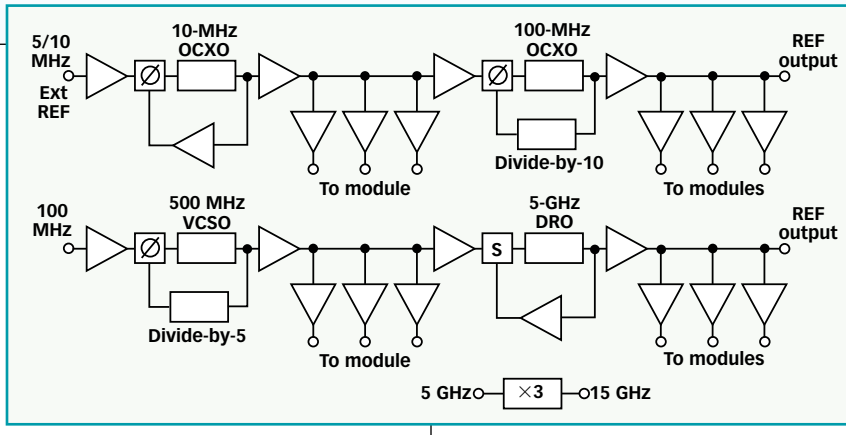
by the propagation delay through bandpass filters and switches inside the synthesizer. Phase noise is limited by internal-source phase noise. In the UFS series of synthesizers, a proprietary phase-locked direct resonator oscillator (DRO) features a noise floor of –165 dBc at 500 kHz offset from a 10-GHz signal.

The series of synthesizers provides 100-MHz modulation with a switch-speed range of 150 to 200 ns. Harmonics range from –50 to –60 dBc with frequency resolution of less than 0.1 Hz for the UFS-3, UFS-20, and UFS-40. For the UFS-15, the switching speed is 150 ns. The frequency modulation is 100-MHz peak-to-peak deviation for all synthesizers, while phase noise is –95 dBc offset 100 Hz from the carrier for the UFS-3 and UFS-15. For the UFS-20 and UFS-40, phase noise is –90 dBc offset 100 Hz from the carrier and –84 dBc offset 100 Hz from the carrier, respectively. With the UFS-3, phase noise is –155 dBc offset 100 kHz from the carrier. For the UFS-15, it is –152 dBc offset 100 kHz from the carrier, the UFS-20's phase noise is –150 dBc offset 100 kHz from the carrier, and the UFS-40's phase noise at 100 kHz is –144 dBc offset from the carrier **(see table).**



1. The six basic modules of a synthesizer are the VXI interface and control, REF module, fine step and modulation, and RF step, as well as Gigahertz step and output module.

Controlled through a special parallel interface with a VXI control bus,



2. The REF module combines several ultra-low noise sources.

the UFS series employs existing mainframes, such as VXI, for control power supply and packaging. Custom packages are optional.

Basic modules are used for several possible frequency ranges and step sizes. As a result, units can be customized for various requirements. The UFS-3, for example, requires a simple output module while the UFS-15 requires only four slots (no need for modulation and output module).

The overall block diagram of the UFS series synthesizer in **Fig. 1** shows the basic six modules of the synthesizer. They consist of VXI interface and control, reference (REF) module, fine-step and modulation module, RF-step module, gigahertz-step module, and output-step module.

In **Fig. 2**, the REF module, which combines several ultra-low noise sources, can be seen. They consist of a 10-MHz oven-controlled crystal oscillator (OCXO), 500-MHz voltage-controlled surface-acoustic-wave oscillator (VCSO), and 5-GHz voltage-controlled dielectric resonator oscillator (VCDRO). Every source has optimal phase noise at differential offset. If all of the phase noises are translated to 5 GHz, then 10 MHz has the best phase noise for the offset ranging from 1 to 100 Hz. The 100-MHz OCXO offers the best phase noise from 100 Hz to 2 kHz. The 500-MHz VCSO source excels to 10 kHz and the 5-GHz DRO provides the best noise floor. To optimize performance, the sources are phase locked in series with the loop bandwidth for phase-noise offset purposes.

With the wide-modulation module, the modulation signal is applied to fixed-frequency voltage-controlled-oscillator (VCO)-based PLL. The arrangement keeps modulation constant over the full synthesizer bandwidth. A two-point modulation method supports wide frequency-modulation (FM) bandwidths from DC to 200 MHz, even with a loop bandwidth of 100 kHz. This reduces

UFS synthesizer data

SPECIFICATION	UNITS	UFS-3	UFS-15	UFS-20	UFS-40
Frequency range	GHz	0.01 to 3.0	9 to 15	0.01 to 20	0.01 to 40
Frequency resolution	Hz	<0.1 Hz	5 MHz	<0.1 Hz	<0.1 Hz
Switching speed	ns	200	150	200	200
Spurious	dBc	–80	–80	–70	–64
Harmonics	dBc	–50	–60	–50	–50
Output power	dBm	10 ± 2	10 ± 2	10 ± 2	10 min.
Phase noise					
Offset 100 Hz		–95	–95	–90	–84
1 kHz		–112	–110	–108	–102
10 kHz		–132	–129	–125	–119
100 kHz		–155	–152	–150	–144
1 MHz		–160	–157	–154	–148
Modulation					
FM	Peak-to-peak deviation	100 MHz	100 MHz	100 MHz	100 MHz
QAM		TBD	TBD	TBD	TBD
Size	C size VXI slots	5 single	4 single	6 single	6 single

the noise floor of the modulation PLL. For continuous wave (CW), amplitude modulation (AM), and quadrature amplitude modulation (QAM), the FM PLL is disabled. The modulation signals are directed to an ultra-low phase-noise CW source, deriving from the 500-MHz VCSO. AM, phase, and QAM [using in-phase/quadrature (I/Q)] modulation can be set according to customer requirements (DC to 200 MHz).

The fine-step module has several options. A DDS section provides steps of less than 250 kHz. DDS spurious are reduced by the mixer and divide modules. Coherent operation to the external REF is maintained by using proprietary technology.

The RF step uses mix and divide techniques. The basic block could repeat itself until the bandwidth and step resolution are being met. Also, every block improves the spurious from the previous block by a factor of 20logN due to the divide-by-N stage. This supports the use of DDS stages with relatively high spurious in the front blocks. The most hardware-efficient N was found to be 4, reducing the number of required frequencies to 4. Also single-pole, four-throw (SP4T) switches and divide-by-4 prescalers are common and easy-to-find components.The gigahertz-step module employs a base 12 synthesizer stage for high-speed switching.

The output-step converts the basic 10-to-20-GHz octave to the required range. For the full 40-GHz band, the module uses a doubler with a switchable filter bank to screen unwanted subharmonics. A switchable lowpass filter cleans the harmonics after mixing in the low-frequency band. Some models use a simpler output section. UFS-3 only uses a mixing and switchable lowpass filter. For UFS-15, the output directly derives from the gigahertz step module, eliminating the section.

The synthesizers can be customized to many frequency ranges, including 2 to 20 GHz, 8 to 12 GHz, and 12 to 18 GHz. Step sizes include less than 0.1 Hz, 250 kHz, 5 MHz, and 50 MHz, while modulation includes FM, AM, QAM, and PM. Elcom Technologies, 11 Volvo Dr., Rockleigh, NJ 07647; (201) 767-8030 ext. 230, FAX: (201) 767-6266, e-mail: info@elcom-tech.com, Internet: www.elcom-tech.com.

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