cover story

SiGe Silences YIG Oscillator Phase Noise

Integrating SiGe transistor technology into high-frequency YIG oscillator structures results in new low levels of phase-noise performance at frequencies through 20 GHz.

RICH LEIER
Vice-President of Marketing
Micro Lambda Wireless, Inc.,
46515 Landing Pkwy., Fremont,
CA 94538; (510) 770-9221, FAX:
(510) 770-9213, Internet:
www.microlambdawireless.com.

Cutting phase noise from an oscillator can dramatically improve the performance of a microwave receiver or transmitter. Yttrium-iron-garnet (YIG) oscillators are usually the source of choice for designs requiring low phase noise, wide modulation bandwidths, and moderate tuning speed, and many refinements have been achieved in packaging the technology in recent years, but no true advances in lowering the phase noise. That is, until the engineers at Micro Lambda Wireless (Fremont, CA) blended their YIG technology with the latest low-noise silicon-germanium (SiGe) heterojunction-bipolar-transistor (HBT) active devices. The result is a dramatically drop in phase noise as embodied in several new lines of YIG-tuned oscillators with coverage from 6 to 20 GHz, with typical phase noise as good as –130 dBc/Hz offset 100 kHz from 8-to-18-GHz carriers.

1. The new MLXB-Extreme (left), MLXS-Extreme (center), and MLXM-Extreme YIG-tuned oscillators use SiGe technology to reach lower levels of phase noise than previous designs.

In the early 1990s, the firm (whose founders came from the legendary microwave technology company Avantek) set the standard for 8-to-20-GHz YIG-tuned oscillators with phase-noise performance of –108 dBc/Hz offset 100 kHz from the carrier. With the adoption of SiGe technology in their new YIGs, the firm shaved more noise from that

standard, with guaranteed phase-noise performance of –123 dBc/Hz offset 100 kHz from the carrier—a 15-dB noise improvement over earlier designs.

These new thin-film YIG oscillator circuits benefit from the latest SiGe HBT devices, replacing silicon bipolar active devices of earlier designs operating through 15 GHz and GaAs MESFET devices in oscillators at frequencies above about 15 GHz. SiGe HBT devices fabricated at IBM's facility in Hopewell Junction, NY, for example, have exhibited cutoff frequencies exceeding 120 GHz for robust 0.5-µm gate length.

The new product lines include the MLXB-Extreme 1.25-in. cube oscillators, the MLXS-Extreme 1.75-in. spherical oscillators, and the MLXM-Extreme 1-in. cube oscillators (**Fig. 1**). The first two series feature models covering 6 to 20 GHz while the MLXM line currently has two models operating from 6 to 18 GHz and from 8 to 18 GHz.

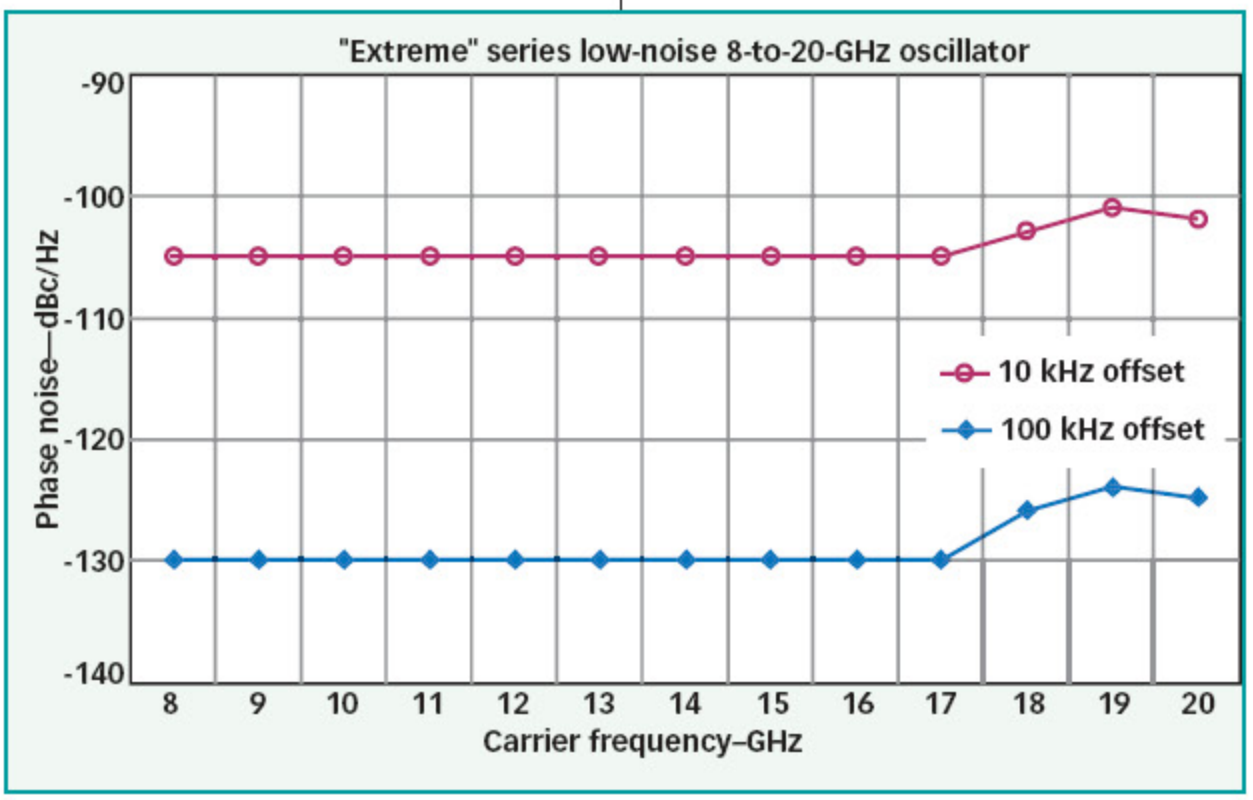
YIG oscillators are unique to microwave applications. They consist of a YIG with high unloaded quality factor (Q) set in a resonant cavity. The resonant frequency of the sphere and cavity are tuned according to the strength of a magnetic field, applied through the main tuning coil. When modulation is required, a second coil can be added to the design. Broadband oscillators can be built with this technology, with upper-frequency limits extending beyond 26.5 GHz. The bandwidth and phase noise are essentially limited by the circuit elements surrounding the sphere and resonant cavity, including the active device. Additionally, heater elements may be employed to stabilize the frequency of an oscillator over wide external operating temperatures.

Since SiGe HBTs exhibit higher electron mobility, lower device thermal noise, and lower device shot noise compared to traditional silicon bipolar transistors, YIG oscillator designers can take advantage of their wide potential bandwidths and low contributions to oscillator output noise. In the largest family of the new sources (supplied in 1.75-in.-diameter cylindrical housings), the

2. The MLXS-Extreme series of YIG-tuned oscillators operate from 6 to 20 GHz and are supplied in 1.75-in.-diameter cylindrical housings.

MLXS-Extreme line (**Fig. 2**), three models are available with frequency ranges of 6 to 18 GHz (model MLXS-0818), 8 to 18 GHz (MLXS-0618), and 8 to 20 GHz (MLXS-0820). Guaranteed phase noise for all three models is –100 dBc/Hz offset 10 kHz from the carrier and –123 dBc/Hz offset 100 kHz from the carrier, with typical performance of –128 dBc/Hz offset 100 kHz from the carrier (**Fig. 3**). The **table** provides a brief summary of performance for the MLXS-Extreme line of oscillators.

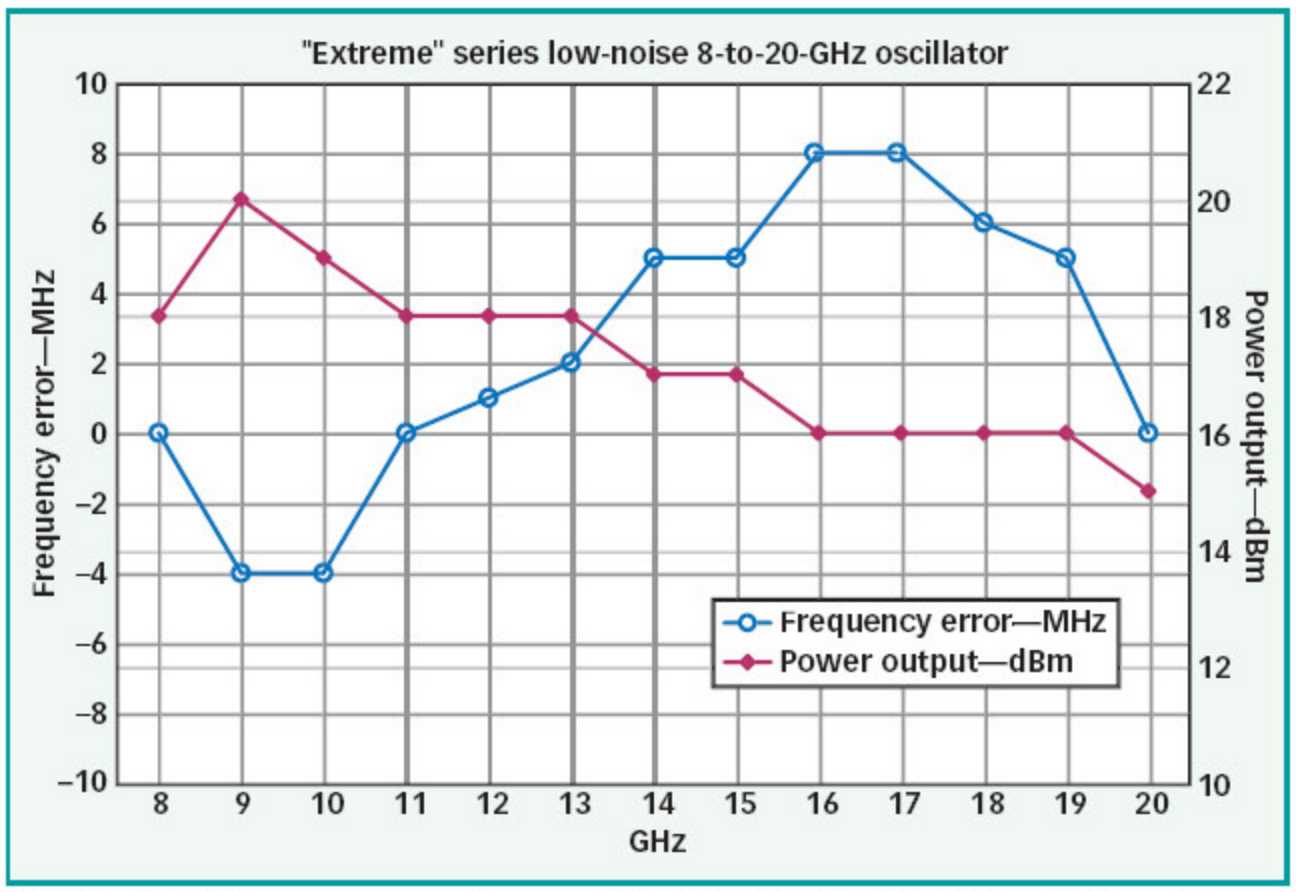
As with the other SiGe YIG oscillators, the MLXS-Extreme sources are designed to remain stable with tem-



3. The phase noise for the new YIG-tuned oscillators is typically as low as –130 dBc at 100-kHz offset from carriers below 17 GHz and below –100 dBc offset 10 kHz from all carriers.

The MLXS-Extreme Series YIG oscillators at a glance

PARAMETER	MLXS-0818	MLXS-0618	MLXS-0820
Frequency range	8 to 18 GHz	6 to 18 GHz	8 to 20 GHz
Output power	+15 dBm	+14 dBm	+14 dBm
Frequency drift with temperature	20 MHz	20 MHz	25 MHz
Harmonics	–15 dBc	–15 dBc	–15 dBc
Spurious	–60 dBc	–60 dBc	–60 dBc
Phase noise			
Offset 100 kHz, min.	–125 dBc/Hz	–123 dBc/Hz	–123 dBc/Hz
Offset 100 kHz, typ.	–130 dBc/Hz	–128 dBc/Hz	–128 dBc/Hz
Pulling	1 MHz	1 MHz	1 MHz
Pushing			
+12-VDC supply, typ.	0.1 MHz/V	0.1 MHz/V	0.1 MHz/V
–5 VDC supply, typ.	1 MHz/V	1 MHz/V	1 MHz/V



4. This plot of frequency error for one of the 8-to-20-GHz SiGe YIG oscillators shows the linearity of the tuning characteristic. The red trace shows the consistency of output power over the wide frequency tuning range.

perature, with no more than 20 MHz drift over the operating temperature range of 0 to +65°C (**Fig. 4**). All three families of YIG oscillators deliver minimum output levels of +14 dBm with maximum output-power variations of 5 dB. Harmonic levels are –15 dBc or better while spurious content does not exceed –60 dBc. The output signal occupies a typical 3-dB bandwidth of 5 kHz, tuned in frequency at a rate of 20 MHz/mA by current applied to the main tuning coil. The typical tuning linearity is ±6 MHz. Typical main coil tuning hysteresis is 12 MHz or less.

A secondary coil applies frequency modulation with applied current at a rate of 410 kHz/mA with typical 3-dB bandwidth of 400 kHz. The low-noise YIG oscillators provide minimum FM deviations as wide as 40 MHz to support a wide range of modulation schemes.

As far as power consumption, the YIG oscillators draw 200 mA current from a +12-VDC supply and 25 mA current from a –5-VDC supply. They also require a +12-VDC heater supply, which draws 150 mA maximum upon warmup and during surges but only 60 mA current during steady-state operation.

The new oscillators are available in standard 1.25-in. cube or 1.75-in. cylinder packages that operate over both commercial and military environments. Units up to 18 GHz are also available in 1-in. cube packages for commercial applications, making all the units in this new series mechanically interchangeable with existing designs. Versions are also available for the extended operating-temperature range of –40 to +85°C on special order. All units in the new series can be ordered with optional integrated or remote analog, 12-b TTL, or 16-b serial drivers. The largest of the new YIG oscillators weigh about 13 oz. The 1.25-in.-cube MLXB-Extreme Series oscillators weigh about 8 oz., while the smallest of the new sources, the 1-in.-cube MLXM-Extreme Series oscillators, weigh a mere 4 oz.

The new low-noise YIG oscillators are ideal for a wide range of commercial and military applications, including communications receivers, test equipment, electronic countermeasures (ECM) systems, and electronic-warfare (EW) systems. The sources feature pin connections for power supply, frequency tuning, modulation control, and power for the internal heater circuitry. P&A: 4 wks. **Micro Lambda Wireless, Inc., 46515 Landing Pkwy., Fremont, CA 94538; (510) 770-9221, FAX: (510) 770-9213, Internet: www.microlambdawireless.com.**