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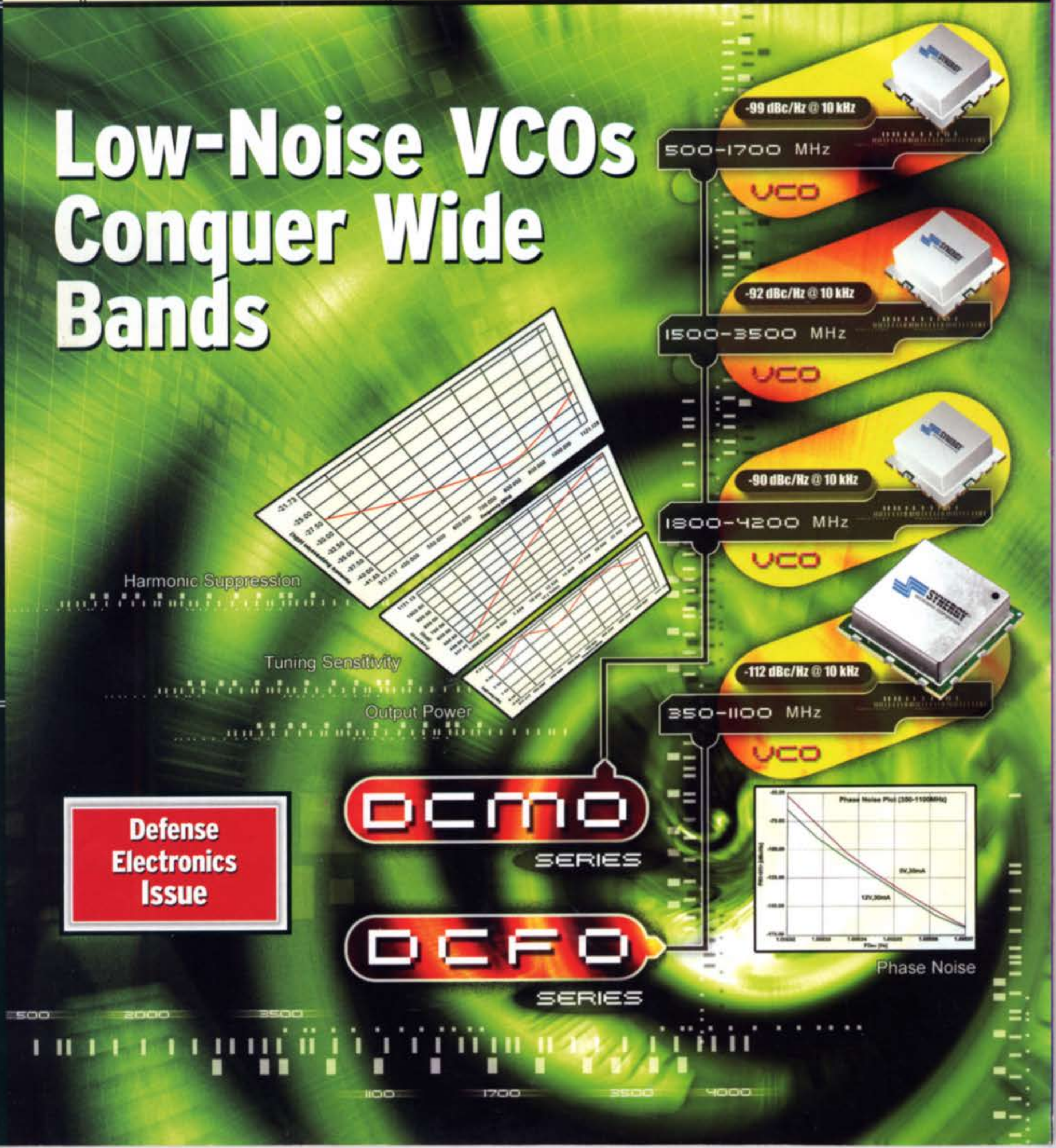


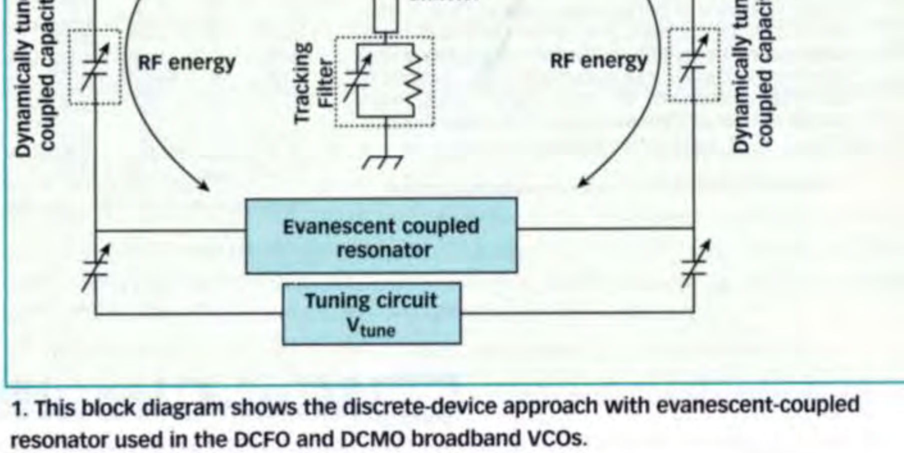
cover story

Low-Noise VCOs Conquer Wide Bands

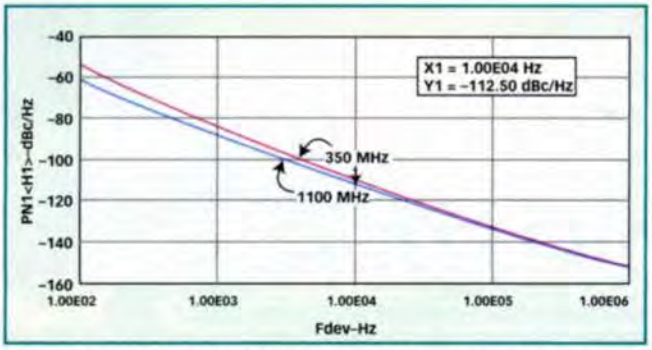
These low-cost, surface-mount sources offer better than octave tuning ranges and low phase noise while consuming minimal power through 4200 MHz.

ULRICH L. ROHDE
K. JUERGEN SCHOEPF
AJAY KUMAR PODDAR
Synergy Microwave Corp., 201 McLean Blvd., Paterson, NJ 07504; (973) 881-8800, FAX: (973) 881-8361, e-mail: sales@synergymwave.com, Internet: www.synergymwave.com.

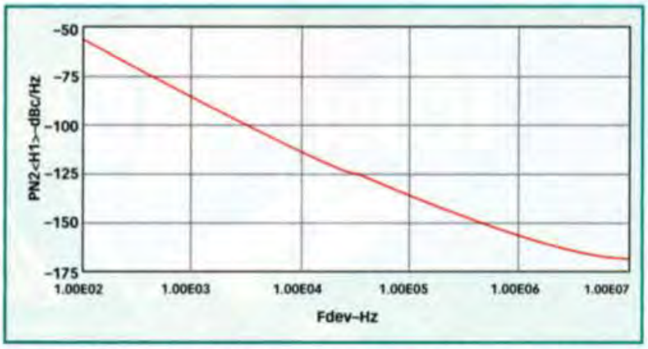
Bandwidth and phase noise are two of the leading requirements for signal-generating components in modern communications equipment. Voltage-controlled oscillators (VCOs) have been the frequency source of choice for many wired-, wireless-, and optical-communications systems, even though traditionally limited to less than an octave tuning range to maintain low phase noise. Fortunately, the new DCFO and DCMO series of VCOs from Synergy Microwave Corp. (Paterson, NJ) break with tradition and overcome the long-time hurdle of achieving very low phase noise while also delivering broadband frequency coverage. The low-cost, surface-mountable VCOs are currently available in bands from 350 to 4200 MHz.



1. This block diagram shows the discrete-device approach with evanescent-coupled resonator used in the DCFO and DCMO broadband VCOs.



2. This phase-noise plot shows the performance of a DCFO oscillator for two carrier frequencies at the edges of the full bandwidth with bias of 28 mA at +5 VDC.

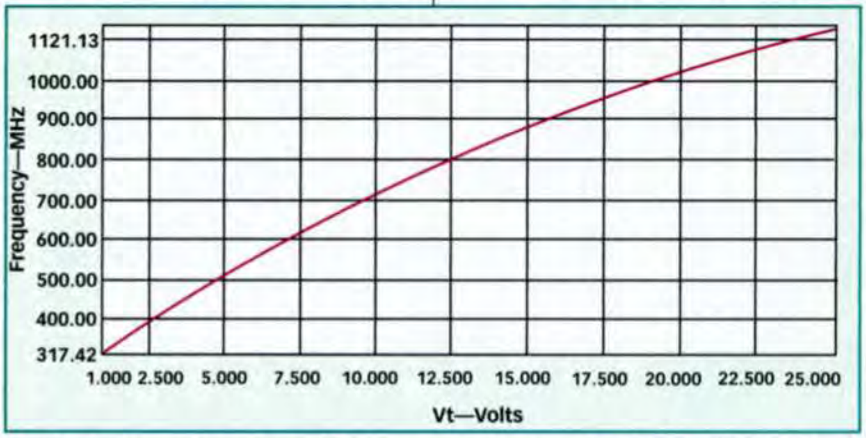


3. This phase-noise plot shows how the performance of a DCFO oscillator improves with a +12-VDC (28-mA) supply.

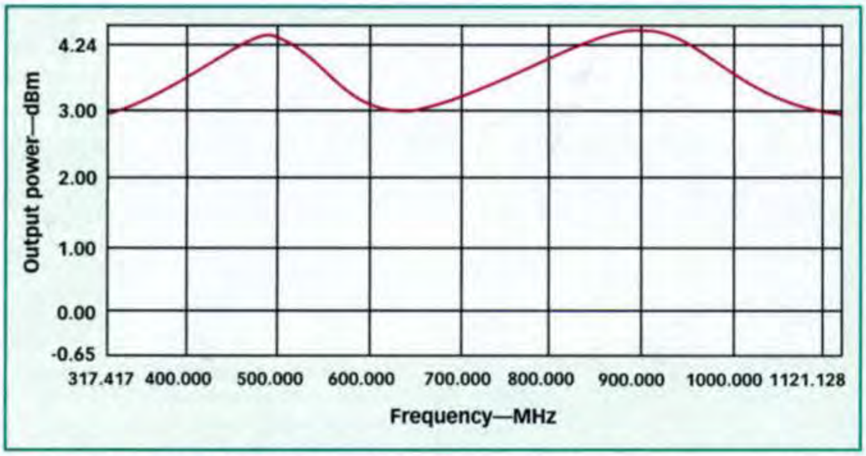
The new VCOs are particularly well suited for the new families of cellular handsets and base stations with Universal Mobile Telephone Systems (UMTS) requirements. Increased-bandwidth coverage is needed in support of combined voice, data, and wireless Internet services, yet the frequency source must also deliver very low levels of single-sideband (SSB) phase noise in order to reliably handle the complex digital modulation employed in these systems while also stably operating within tightly spaced communications channels. In a digital wireless-communications system, excessive phase noise can cause degradation in the effective system bit-error rate (BER), resulting in a loss of transmitted/received data and a loss of voice and data performance as perceived by the wireless customer.

Wideband tuning and low phase noise have long been assumed as opposing design targets. A decrease in VCO phase noise generally meant a decrease in tuning bandwidth, due to the problem of simultaneously controlling the loop parameters and optimizing the time average loaded quality factor (Q) of the VCO resonator over the tuning range. The tuning range of the oscillator generally influences the phase noise and typically there is a trade-off between the continuous tuning range of VCOs and the amount of phase noise generated by the varactor capacitance modulation.[1] On the other hand, the requirements for low-noise performance over a broad (more than an octave) frequency range are typically demanding. Thus, there exists a need for method and circuitry for improving the phase-noise performance over a wide tuning frequency range, typically more than an octave-band tuning range.

Although a great deal of progress has been made in recent years in monolithic, integrated-circuit (IC) VCOs, with a desire to fabricate completely integrated radio front-end circuitry for large-volume communications applications (such as cellular handsets), the best performance levels are still the domain of discrete-device VCOs. In



4. This plot shows the extremely linear tuning response of a DCFO oscillator with tuning voltages from 1 to 25 V.



5. Although specified for +1 dBm and ±3.5 dB flatness, the output power of a typical DCFO oscillator is much higher and flatter over frequency.

addition to high performance, discrete VCOs offer advantages such as superior performance, tremendous design flexibility and versatility, faster time-to-market, low cost, and reduced risk.

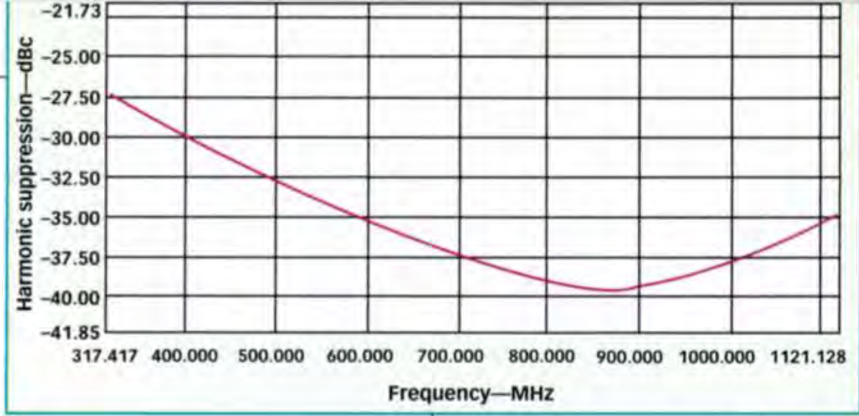
The discrete-device approach was used in the development of the DCFO and DCMO series oscillators. The sources employ a novel oscillator topology (for which a patent has been applied) based on an evanescent-mode dynamic coupled resonator **(Fig. 1).**[2] The design approach has resulted in wideband VCOs capable of delivering stable, low-noise output signals **(Figs. 2 and 3)** over temperature ranges as wide as –40 to +85°C with extremely linear tuning response **(Fig. 4).** The **table** offers a brief overview of some of the new VCOs. As the table shows, the new VCOs offer tuning ranges as wide as 2400 MHz, but without sacrificing phase-noise performance. Using a dynamic tracking filter at the output, harmonics can be suppressed by better than –30 dBc.

The wideband VCOs at a glance

SERIES/SIZE	FREQUENCY RANGE (MHz)	TYPICAL PHASE NOISE OFFSET 10 kHz FROM CARRIER	TYPICAL PHASE NOISE OFFSET 100 kHz FROM CARRIER
DCFO	350 to 1100	-112 dBc/Hz	-132dBc/Hz
DCMO	500 to 1700	-99 dBc/Hz	-120dBc/Hz
DCMO	1500 to 3500	-92 dBc/Hz	-112 dBc/Hz
DCMODCFO	1500 to 3500	-90 dBc/Hz	-110 dBc/Hz

As an example of the DCFO series, model DCFO-35105 accepts tuning voltages from 0 to +25 VDC to cover a total range of 350 to 1050 MHz (700 MHz). The bias requirements are no more than 35 mA at +5 VDC. The tuning sensitivity is typically 20 to 48 MHz/V. With output power of +1 dBm **(Fig. 5),** the VCO exhibits typical phase noise of –112 dBc/Hz offset 10 kHz from the carrier and –132 dBc/Hz offset 100 kHz from the carrier. Harmonic suppression for this model is specified at –10 dBc, although typical performance is much better **(Fig. 6).** Maximum frequency pulling is 4 MHz for a 1.75:1 VSWR load while maximum frequency pushing is 2 MHz/V. The VCO is supplied in a surface-mount package with slotted metal cover measuring just 0.91 × 0.91 × 0.305 in.

As an example of the higher-frequency DCMO series VCOs, the model DCMO-190410 covers a tuning range of 1900 to 4100 MHz by means of tuning voltages from 0.5 to 20.0 V. The typical bias requirements are 35 mA (maximum) and +5 VDC, and the typical tuning sensitivity is 100 to 200 MHz/V. With minimum output power of +3 dBm across this wide tuning range, the VCO delivers typical phase noise of –90 dBc/Hz offset 10 kHz from the carrier and –110 dBc/Hz offset 100 kHz from the carrier. Maximum frequency pulling is 14 MHz for a 1.75:1 VSWR load while maximum frequency pushing is 7 MHz/V. The VCO is supplied in a surface-mount package with slotted metal cover measuring just 0.50



6. Harmonic suppression in a DCFO oscillator is specified as –10 dBc, although measured performance clearly exceeds the specification.

× 0.50 × 0.25 in. Both the DCFO-35015 and the DCMO-190410 have an operating temperature range of –30 to +75°C.

In between, the model DCMO-150320 tunes from 1500 to 3200 MHz via tuning voltages of 0.5 to 20.0 V and tuning sensitivity of 100 to 200 MHz/V. The oscillator delivers at least –2 dBm output power with typical phase noise of –92 dBc/Hz offset 10 kHz from the carrier and –112 dBc/Hz offset 100 kHz from the carrier. With a 1.75:1 VSWR load, frequency pulling is a maximum of 12 MHz; the maximum frequency pushing is 6 MHz/V. The company also offers model DCMO-60170 with minimum output power of +3 dBm from 600 to 1700 MHz and phase noise of –99 dBc/Hz offset 10 kHz from the carrier and –120 dBc/Hz offset 100 kHz from the carrier.

In short, these VCOs combine the much desired wide tuning ranges required for multimode operation in next-generation cellular-communications handsets and infrastructure equipment with the low phase noise of much narrower-band sources. The combination should allow designers to make use of a single VCO where two or more were used in the past. **Synergy Microwave Corp., 201 McLean Blvd., Paterson, NJ 07504; (973) 881-8800, FAX: (973) 881-8361, e-mail: sales@synergymwave.com, Internet: www.synergymwave.com.** MRF

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2. A.K. Poddar, S.K. Koul, and B. Bhat, "Millimeter Wave Evanescent Mode Gunn Diode Oscillator in Suspended Stripline Configuration," 22nd International Conference on Infrared and Millimeter Waves, pp. 265-266, July 1997.