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Fast switching keeps Avantek's DRO on track

GaAs technology:
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Cover Feature

SINGLE DRO RAPIDLY SWITCHES THREE FREQUENCIES

A unique design selects multiple frequencies with less than 2-μs settling time.

FREQUENCY-agile radars and electronic defense systems require fast-switching, fast-settling signal sources for maximum effectiveness. Fast signal switching is critical to system accuracy and probability-of-intercept performance: an oscillator's failure to provide the proper LO signal can allow a threat to go undetected.

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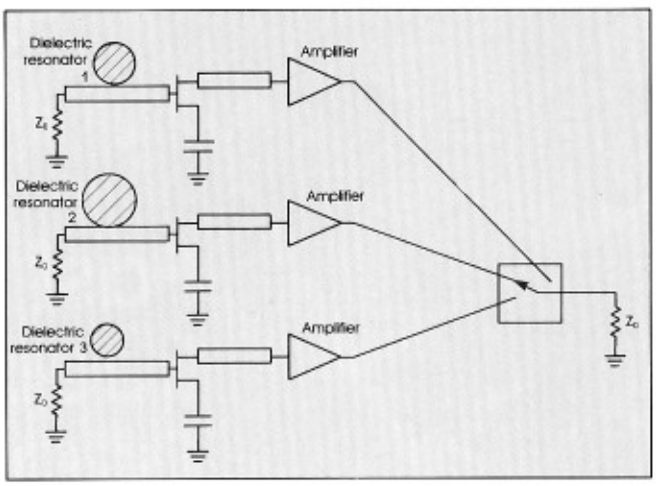
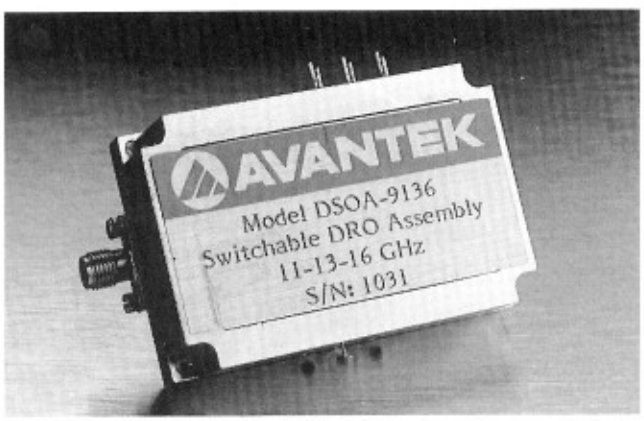


2. This multifrequency DRO design powers the oscillator circuitry at all times, relying on switch rejection to suppress unwanted outputs.

In response to this need for agile, accurate oscillators, Avantek has developed a series of multifrequency dielectric resonator oscillators that provide three discrete operating frequencies from a single housing. These oscillators, which are available with operating frequencies from 8 to 18 GHz, switch rapidly, settling to a new frequency in less than 2 μs.



1. Model DSOA-9136 is an example of the three-frequency oscillators in the DSOA-9000 family. The source provides output signals at 11, 13, and 16 GHz with at least +10 dBm output power.

A typical source in the DSOA-9000 series of multifrequency DROs is model DSOA-9136 (Fig. 1), which operates at 11, 13, and 16 GHz. The output power at each frequency is +10 dBm. The typical settling time—the amount of time before a selected frequency is available at full output power and final operating frequency—is 2 μs. In this time, the source draws within ±100 kHz of the final operating frequency. Output signals are relatively free of single-sideband (SSB) phase noise, with less than -80 dBc/Hz noise offset 10 kHz from the operating frequency.

An important specification that is unique to these multifrequency DROs, nonselected frequency

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Summarizing the DSOA-9000 series

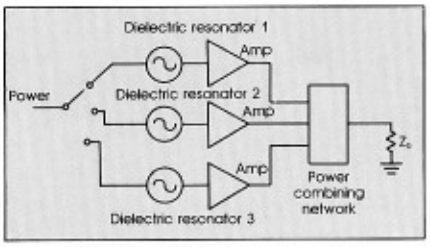
Frequency range	8 to 18 GHz
Output power	+10 dBm
Phase noise	−80 dBc at 10 kHz offset from 12 GHz
Nonselected frequency feedthrough	−90 dBc (min.)
Settling time	2 ms to within 100 kHz of final frequency
Power requirements:	+15 VDC (5 percent) at 300 mA −15 VDC (5 percent) at 75 mA
Size	0.75 /1.6 /2.4 in.
Weight	80 g
Operating temperature range	−54 to +85°C

feedthrough, is a figure of merit that describes the signal leakage from the unused DRO circuits. In the DSOA-9136, the specification is better than -90 dBc.

DESIGNING FOR SPEED

There are several ways to derive ultiple frequencies from a single DRO housing. In one approach, several separate DRO circuits, each with its own active oscillator transistor, are incorporated into a common package. The circuits are always biased on; a desired output signal is selected by means of high-isolation PIN diode switches (Fig. 2). This approach offers very fast settling time (on the order of 1 μs), outputs that remain stable despite the differing loads of switches in their on and off positions, and, with the addition of buffer amplifiers, isolation from frequency pulling.

For all of its benefits, however, the approach requires very well matched, high-isolation PIN diode switches that must terminate signals from the unselected DRO circuits. With practical circuits and presently available diodes, these unwanted output signals are only 40 to 60 dB less than the desired output signal. (Compare this to the -90 dBc achieved in the DSOA-9136.) In a sensitive receiver design, excessive feedthrough from the unselected resonators can obscure low-level input signals.



3. This DRO design only powers the appropriate DRO circuitry when the associated frequency is desired.

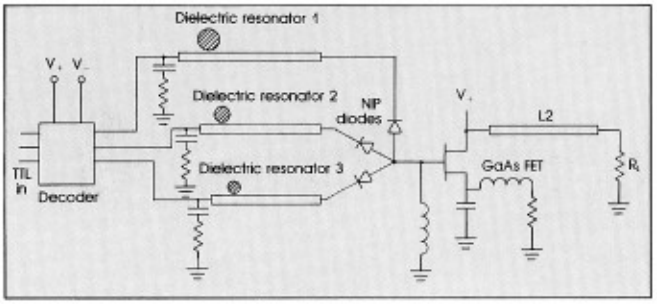
Another approach to a multifrequency DRO design applies power to the individual oscillator circuits only when needed. The output of the oscillators is combined with or without switching (Fig. 3). This approach eliminates spurious outputs from the unused oscillator circuits, but suffers relatively slow switching time, generally on the order of milliseconds.

The unique design employed in the DSOA-9000 series oscillators (protected by U.S. Patent No. 4,649,354) strives for speed and efficiency (Fig. 4). The configuration can rapidly switch among three very stable signals at widely different frequencies, without generating outputs from the unused resonators. The approach features a single oscillator transistor and simple multithrow switch to select the desired dielectric resonator at the transistor's gate terminal.

By using the DSOA-9000 configuration, output signals from the unselected resonators are totally eliminated. Since oscillation conditions are satisfied only at the desired frequency, only one frequency can be generated at any one time. This design is ideal for high-sensitivity, octave-band receiving systems, where internally generated spurious signals reduce both the probability of intercept and, in many cases, the dynamic range.

The DSOA-9000 design also provides very fast settling time. Since the GaAs FET is always biased on, and since precautions are taken in the design to keep the RF power output and DC-to-RF conversion efficiency the same at each frequency, thermal changes in the FET are minimized. Such thermal changes are a major contributor to settling time.

Compared to oscillators that switch among separate, independent DRO circuits, the number of transistors in a DSOA-9000 oscillator is reduced by at least 1/n, where n is the number of frequencies generated. In fact, in many multi-oscillator applications, one or two buffer transistors are used for each oscillator circuit to reduce frequency pulling and permit more stable, low-power operation of the main oscillator transistor. DSOA-9000 sources require a single, broadband buffer amplifier to serve all three output frequencies. DSOA-9000 oscillators



4. The DSOA-9000 series oscillators employ separate resonators but only one oscillator transistor to produce three separate frequencies.

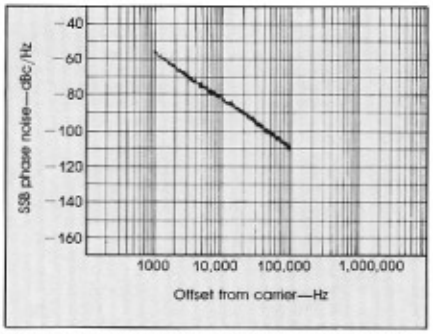
MULTIFREQUENCY DRO

also employ very simple diode switches compared to the complex, matched PIN-diode switching necessary in multiple-oscillator assemblies. This overall saving in components in the DSOA-9000 oscillators translates into lower cost, higher efficiency, and improved reliabilty.

DSOA-9000 oscillators are generally custom products because of the specialized applications that they serve. In addition to a specifier's choice of frequencies, the source can be supplied with several different output power levels, with more than one isolated output port, with a sampled output (via a coupler) in addition to the main output(s), and in a variety of package configurations.

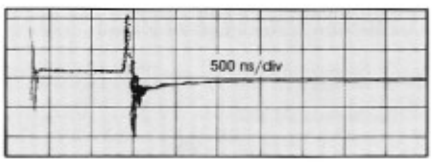
SAMPLING THE SERIES

Model DSOA-9136 is one of the most basic configurations in the DSOA-9000 series. The three-frequency oscillator has a single RF output and one stage of RF amplification. It is packaged in a $0.75 \times 1.6 \times 2.4$ in. hermetic package that weighs about 80 g. The oscillator is powered from a dual-polarity source of +15 VDC at 300 mA nominal current. An additional -15 VDC at 75 mA nominal current is used to provide the negative bias for the diode switches and power some of the driver circuitry (both voltage lines incorporate regulators). In the actual switch circuitry, NIP rather than PIN diodes are used in the switches, so a negative voltage forward biases the diodes, while a positive voltage applied to the unselected diodes assures that they are in a nonconducting state, even with the application of power and changes in temperature.

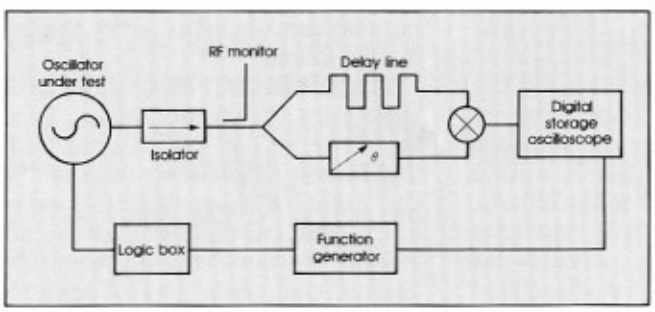


5. The SSB phase noise performance of the DSOA-9000 series oscillators is on a par with that of most single-frequency DROs.

The output of the oscillator alone is +7 dBm, but this is raised to +10 dBm with a single buffer amplifier stage, a distributed GaAs MMIC amplifier. The buffer also serves to isolate the oscillator circuitry from frequency pulling caused by load variations. The design goal for the DSOA-9000 oscillators was to provide a multifrequency oscillator with performance at any frequency equal to that of a single-frequency DRO. As the table and Fig. 5 attest, the designers were successful.



6. Fast settling time of better than 2μs is achieved in the DSOA-9000 series oscillator. The scale here is 500 ns/div.



7. This test system was used to measure the rapid settling time of the DSOA-9000 series dielectric resonator oscillators.

In switched operation, the switching times, which are controlled by the carrier lifetimes of the PIN diodes and the inductance in the switching circuitry, are in the 100-ns range. Settling time, which is governed by the Q of the resonator and the slight changes in thermal conditions within the oscillator circuitry, ranges between 1.4 and 1.8 μs (Fig. 6). Settling time was measured with a basic test system (Fig. 7) that includes a digital storage oscilloscope, a function generator, and a delay line.

The DSOA-9000 oscillator circuitry is based on a series-feedback, drain-output design. The single active device is a proprietary high-gain, low-current, 0.5-μm-gate-length GaAs FET. The GaAs FET is characterized using two-port common-source S-parameters, with the source impedance mapped in the S11 plane by using the converted three-port S-parameters at different frequencies.[1-3]

Each of the three DRO frequencies is selected by a multithrow PIN diode switch. The switch is set at the gate terminal of the GaAs FET to choose a dielectric resonator corresponding to a particular frequency. Each of the resonators is positioned within a transmission line to satisfy the oscillation conditions at its resonant frequency when its corresponding in-line PIN diode is biased into conduction, and the other three diodes are biased off. In this state, the unused resonators act as passive elements connected to the FET gate through the high impedance of the off-state PIN diodes.

Three-frequency oscillators in the DSOA-9000 series are available with a wide range of options, including dual outputs and additional output power. A multipin input is used for bias and TTL frequency control signals. The output connector is SMA. P&A: 6 months. **Avantek, Inc., Oscillator and Filter Product Marketing, 3175 Bowers Ave., Santa Clara, CA 95054; (408) 970-2529.**

REFERENCES

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2. D. Kajfez & P. Guillon, *Dielectric Resonators* (Artech House, Boston, 1986), Chap. 10.
3. A.P.S. Khanna & R. Soohoo, "Fast Switching X- and Ku-Band Multifrequency Dielectric Resonator Oscillator Using a Single GaAs FET," 1987 MTT-S International Microwave Symposium Digest, Las Vegas, NV, June 10-12, 1987.