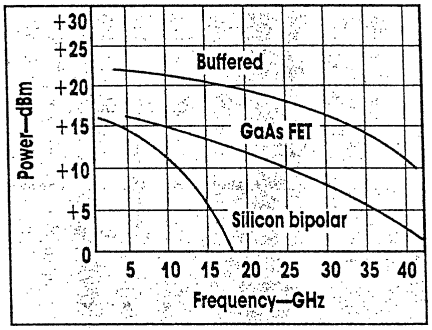
DROs, Part 2

PICKING DEVICES FOR OPTIMUM DRO PERFORMANCE

Different active devices ultimately determine the frequency range of noise performance for a microwave DRO.

DEPENDING on the active device, a dielectric resonator oscillator (DRO) can be made to operate beyond 50 GHz. And while most practical designs are at much lower frequencies, selection of an oscillator's active device is critical to reaching desired design goals.

Transistors are the most commonly-used active device for DROs operating to 40 GHz. Transistor DROs can be realized with either silicon bipolar or GaAs FET devices (Fig. 1).



1. These typical power levels are possible with bipolar and GaAs FET DROs with and without additional buffer amplification.

Other devices usable in DROs are Gunn and Impatt diodes. Gunn oscillators offer lower amplitude-modulation (AM) and frequency-modulation (FM) noise characteristics at the cost of poor DC-to-RF efficiency (less than 1 percent) and reliability problems over wide temperature ranges. Impatt oscillators have poor noise performance, but offer medium power levels at reasonable efficiencies (greater than 30 percent). Transistors offer medium noise performance with medium efficiencies (greater than 20 percent). Both Gunn and Impatt diode sources are more commonly used at millimeter frequencies (30 to 100 GHz).

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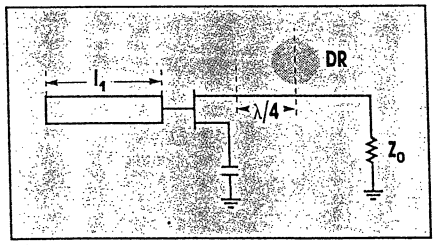
There are two means of incorporating a dielectric resonator in a microwave-integrated-circuit (MIC) oscillator: as a passive stabilization element (stabilized DRO) or as a circuit element in a frequency-determining network (stable DRO). A stabilized DRO is an oscillator which uses a dielectric resonator in the output plane of the circuit to stabilize an otherwise free-running oscillator (Fig. 2). This approach has disadvantages, including a tendency toward mode jumping, frequency hysteresis, and increased output-power variation.



2. A stabilized DRO incorporates the dielectric resonator in the output plane of the oscillator circuitry to stabilize the frequency.

The stable DRO, which uses the dielectric resonator as a feedback/frequency-determining element, is used most often. It provides greater efficiency, simpler construction, and more resistance to mode jumping and hysteresis effects than the passively-stabilized DRO.

To realize a stable DRO, the resonator may be used as either a series- or parallel-feedback element in the frequency-determining circuit (Fig. 3). Series-feedback configurations are based on the ability of the active device to produce a negative resistance (reflection coefficient greater than 1) at one of the three terminals in the frequency range of interest. The small-signal oscillation conditions in this case are reduced to:

$$|S'_{11}| \times |\Gamma_1| > 1 \qquad (1)$$

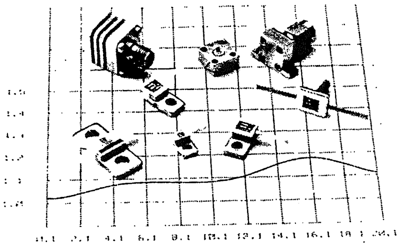
and

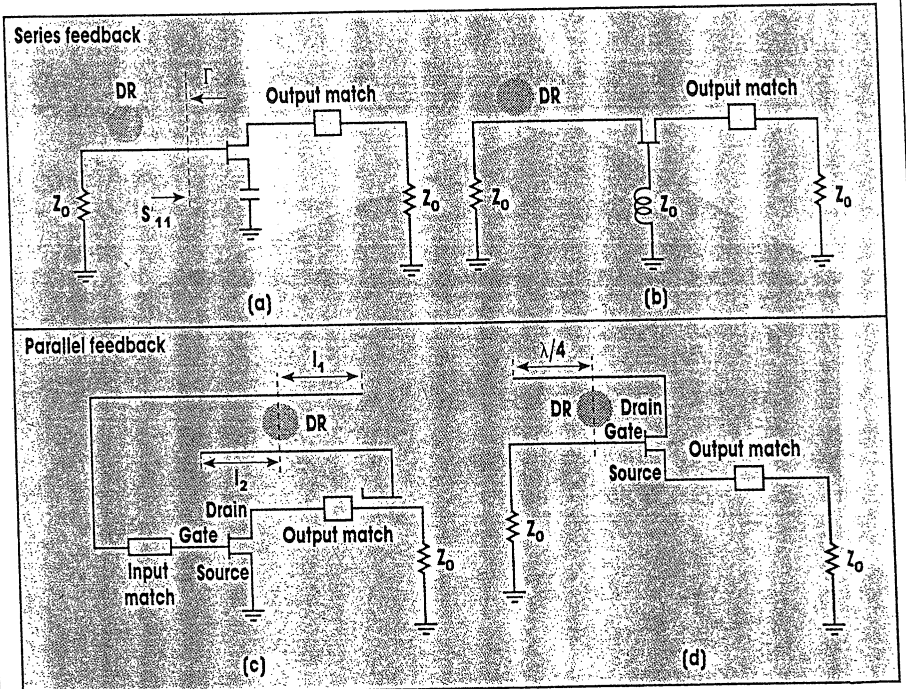
$$\leftarrow S'_{11} + \leftarrow \Gamma_1 = 2\pi n \text{ where } n = 0, 1, 2, \ldots$$

where:

S'_{11} = reflection coefficient of the transistor, and

Γ_1 = reflection coefficient of the resonator, with both reflection coefficients measured at any plane be-





3. These different DRO configurations show different resonator and transistor placements for series-feedback (a and b) and parallel-feedback (c and d) architectures.

tween the device and the resonator.

Since Γ_1 is always less than 1, this condition implies that $|S'_{11}|$ looking into the device should be greater than 1. A distributed capacitance in the source, in the case of a GaAs FET DRO, for a series-feedback configuration (Fig. 3a) and inductance in the gate for a modified series-feedback configuration (Fig. 3b) is commonly required to generate a high value (greater than 1) of $|S'_{11}|$. Position of the dielectric resonator with respect to the device must be determined to satisfy the oscillation condition completely.

The parallel-feedback configuration (Fig. 3c) is based on the use of the forward gain of a device (transmission coefficient greater than 1). In such a design, a dielectric resonator is used as a bandpass filter and connected across the two terminals of an active device possessing transmission gain greater than the insertion loss of the dielectric resonator. To oscillate, the electrical line length between the device input and output must provide a phase shift around the feedback loop equal to an integer multiple of 2π radians at the oscillation frequency.

An advantage of the series-feedback design is the relative ease of coupling to a single line, compared to the parallel circuit's requirement for coupling to two lines. In addition, the two coupling coefficients in the parallel case are not independent, increasing the difficulty of alignment. With the parallel-feedback circuit, however, the use of a high-gain amplifier can allow significant decoupling of the resonator from the microstrip lines, resulting in a higher, loaded quality factor (Q) with associated reduction in phase noise.

Next month, Part 3 of this series will examine salient DRO electrical parameters. The article will cover a DRO's phase noise, temperature stability, and tuning curves. ••

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