VARACTOR TUNED DIELECTRIC RESONATOR GaAs FET OSCILLATOR IN X-BAND

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Abstract

A varactor tuned, dielectric resonator FET oscillator has been developed in X-band with an electronic tuning range of 0.2 percent to permit phase locking, AFC or FM. Performance data are presented from -54°C to +125°C.

Introduction

Previously reported dielectric resonator oscillators have exhibited excellent frequency stability with temperature.[1-4] Their application to a wide range of microwave systems has been limited by the lack of sufficient electronic tuning capability for phase locking, AFC or FM. This limitation has now been removed by the addition of varactor tuning.

This paper describes an X-band, dielectric resonator oscillator (DRO), using a GaAs FET, which is varactor tuned over a 0.2 percent bandwidth. Oscillator performance data are presented over a temperature range of -54°C to +125°C.

Oscillator Configuration

The rf circuit configuration of the varactor tuned DRO is shown in Figure 1. The dielectric resonator is placed in the feedback loop between the drain and gate of the FET. A stabilizing resistor is connected to the gate lead in order to suppress spurious oscillations. The tuning varactor is inductively coupled to the dielectric resonator. The range of electronic tuning obtained is dependent on the degree of coupling to the resonator and on the capacitance variation of the varactor diode. Tighter coupling between the varactor and the resonator results in greater electronic tuning range at the expense of loaded Q. Lower loaded Q causes degradation in frequency-temperature stability, FM noise, pulling figure and pushing figure.

The oscillator described in this paper was constructed on a 1.0 x 0.5 x 0.025 inch, Al_2O_3 substrate using standard MIC techniques. The dielectric resonator material was a barium tetratitanate-magnesium titanate composite. Mechanical tuning was achieved by adjusting the thickness of the air gap between the ground plane and the dielectric resonator. The varactor diode had a C_{jo} of 1.2 pf and a V_b of 65 volts.

In order to achieve high output power at high temperature (i.e., +125°C), two Varian VSF-9320, GaAs FETs were bonded in parallel. These devices have a 0.5 µm gate length and 240 µm gate width. The junction temperature was calculated to be 155°C for a 125°C base plate temperature.

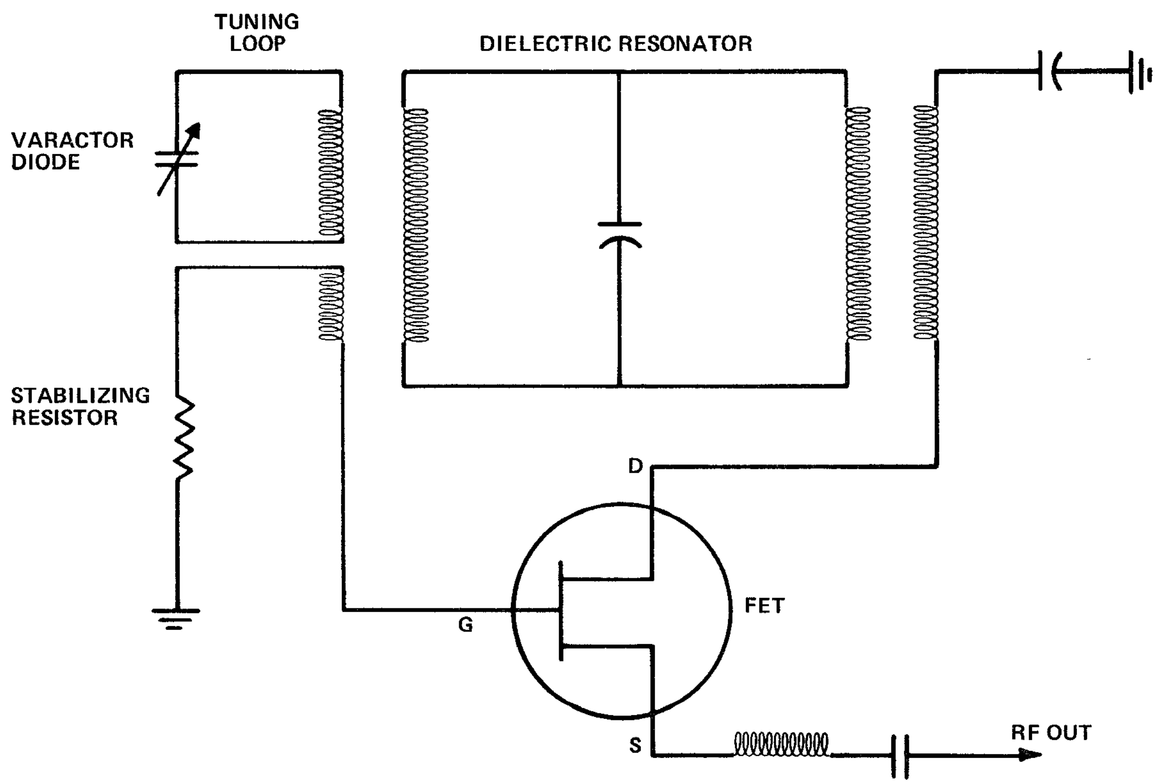

FIGURE 1. VARACTOR TUNED DIELECTRIC RESONATOR OSCILLATOR CIRCUIT

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Oscillator Performance

Figure 2 shows the temperature dependence of output power, frequency and efficiency of the oscillator with zero varactor voltage (worst case). The frequency drift is ±3.5 MHz and the output power variation is ±0.7 dB from 25°C to the extremes of the -54°C to 125°C range. The efficiency of the oscillator is the dc to rf conversion efficiency of the transistor excluding the power dissipation in a bias network. The mechanical tuning characteristics are shown in Figure 3 for zero varactor voltage. Less than 0.75 dB power variation over the mechanical tuning range is illustrated. Total power variation due to the temperature variation and the mechanical tuning is less than ± 1 dB.

Electronic tuning characteristics of the oscillator are shown in Figure 4. The tuning sensitivity variation with temperature appears to be negligible. Output power variation with tuning voltage is small which results from the relatively light coupling between the varactor and the dielectric resonator. Low output power at the low varactor tuning voltage is due to the higher series resistance of the undepleted region of varactor diode.

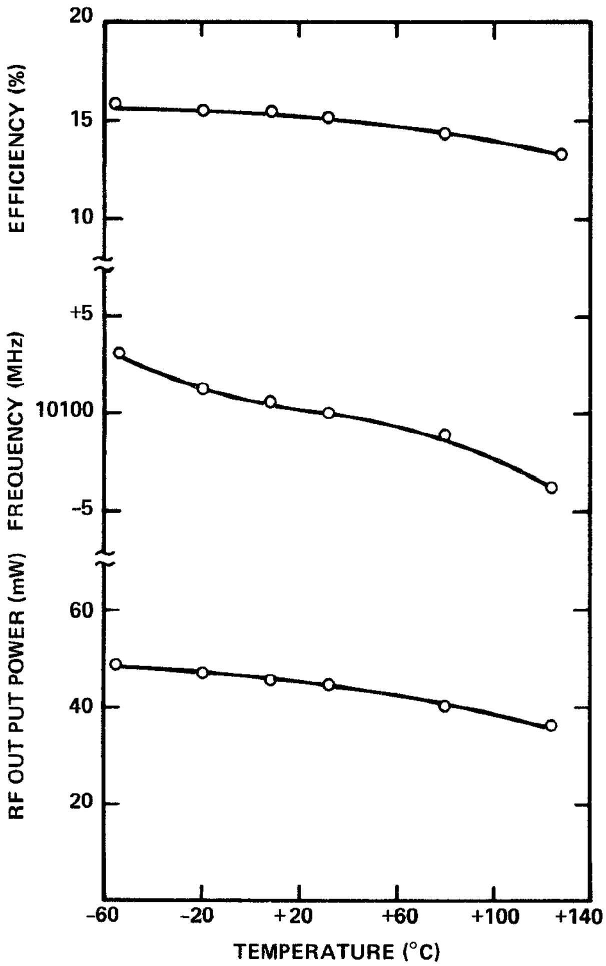

FIGURE 2. TEMPERATURE DEPENDENCE OF OSCILLATOR FREQUENCY, OUTPUT POWER AND EFFICIENCY

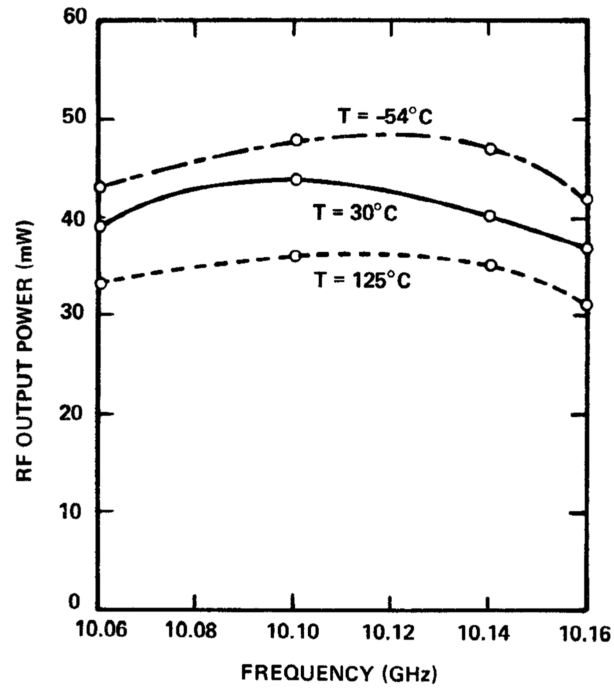

FIGURE 3. MECHANICAL TUNING CHARACTERISTICS VS TEMPERATURE

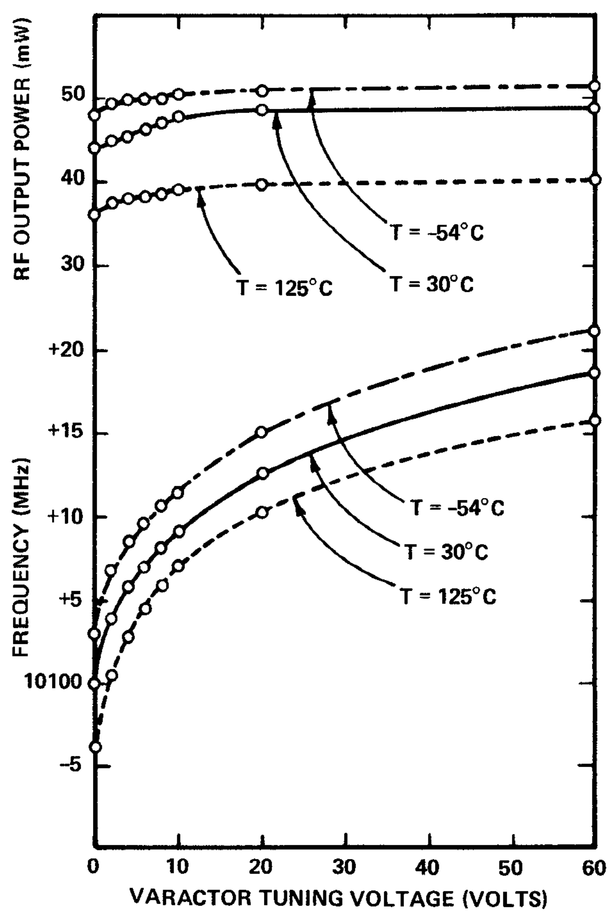

FIGURE 4. FREQUENCY AND OUTPUT POWER VS VARACTOR VOLTAGE AND TEMPERATURE

A 0.42 dB output power variation over the electronic tuning range is due to the series resistance variation of the diode. The higher series resistance of the varactor diode at the lower bias voltage affects the frequency stability of the oscillator. A total 7.0 MHz frequency drift over the temperature range of -54°C to +125°C at 0 volt varactor tuning voltage is improved to 5.5 MHz frequency drift over the same temperature range at 10 V varactor tuning voltage. The external Q of this type of oscillator typically ranges from 500 to 2000. Figure 5 shows the FM and AM noise measured on an oscillator having an external Q of 1600. The FM noise is -81 dBc/Hz at 10 kHz from the carrier, and the AM noise is -140 dBc/Hz at the same point. External Q of the oscillator was determined by measuring the injection locking bandwidth. The FM noise was measured by using a frequency discriminator and a wave analyzer calibrated by utilizing the frequency modulation capability of the oscillator. The AM noise was measured by using a crystal detector and a frequency selective voltmeter.

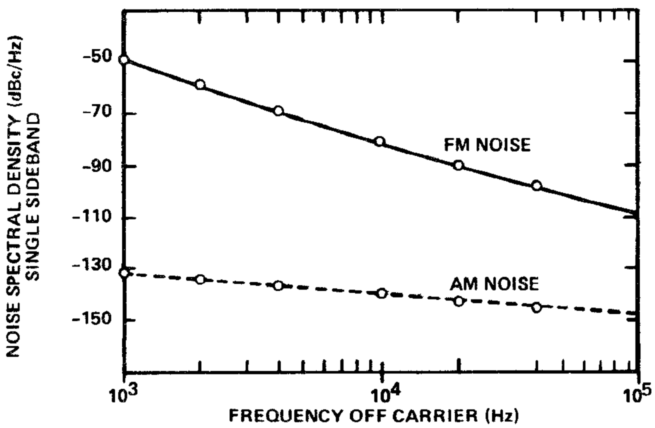

FIGURE 5. FM AND AM NOISE CHARACTERISTICS

Conclusion

A varactor tuned, X-band dielectric resonator FET oscillator has been developed which provides sufficient electronic tuning range for system applications requiring phase lock, AFC or FM capability. Furthermore, this electronic tuning capability can be utilized to compensate the frequency drift of the oscillator over temperature by programming the varactor tuning voltage at different ambient temperatures to achieve better frequency stability. Performance over a -54°C to +125°C temperature range has been reported herein. The addition of electronic tuning capability has had negligible effect on the excellent frequency-temperature stability, efficiency and noise performance of the DRO.

References

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