FREQUENCY MODULATION OF CAVITY STABILIZED SOLID STATE DIODE OSCILLATORS

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Abstract

A coupled cavity technique for frequency modulation of cavity stabilized solid state diode sources is described. This technique provides FM deviations suitable for communications system applications while still retaining low FM noise.

Introduction

Solid state diode oscillators which utilize high Q cavities for stabilization have not been useful as frequency modulated sources. The rf energy storage in the high Q cavity prevents deviation of the carrier frequency. Previous attempts at frequency modulation of such oscillators by coupling tuning varactors to the stabilizing cavity fields have only resulted in a drastic lowering of their Q and thus unacceptably degrading their FM noise and temperature stability. This paper will describe a new coupled cavity technique for frequency modulation of cavity stabilized solid state diode sources which provides useful modulation bandwidth with minimum degradation of FM noise.

Circuit Description

Figure 1 shows the configuration of the frequency modulated cavity stabilized oscillator and its equivalent circuit. The solid state diode oscillator (Impatt or Gunn device) is reaction cavity stabilized by a high Q TE_{01m} cylindrical resonator. The diode oscillator is constructed in rectangular waveguide and iris coupled both to the load and to the stabilizing cavity. Invar cavity and waveguide structures must be used for high frequency stability with temperature.

The stabilizing cavity is located $n\lambda g/2$ from the oscillator cavity in a manner similar to that described by Ito, et al.[1] A third cavity containing a post mounted tuning varactor is iris coupled to the stabilizing cavity. When this cavity is tuned to the vicinity of the stabilizing cavity frequency it tends to "push" or modulate the stabilizing cavity frequency which in turn modulates the oscillator frequency. The Q of the modulating cavity is relatively high which results in a small decrease in stabilizing cavity Q and consequently a small increase in FM noise. Linear FM characteristics can be achieved by operating the tuning varactor at higher voltages where its capacitance change with voltage is most linear. The modulation bandwidth may be controlled by adjusting the degree of coupling between the modulating cavity and the stabilizing cavity.

Employing the stabilization and modulation cavities in a reaction rather than a transmission mode results in a very small sacrifice of available oscillator power. Reaction cavity stabilization results in a reduction of output power of approximately 1 dB whereas transmission cavity stabilization results in a decrease of approximately 10 dB, for the same stabilization factor.

Test Results

A frequency modulated cavity stabilized Impatt diode oscillator was constructed according to Fig. 1. The oscillator utilized a TE_{012} mode stabilizing cavity with a Q_o of 23,000. The coupling of the modulating cavity was adjusted for a frequency deviation of 20 MHz at 12.3 GHz with a 40 volt swing on the varactor. Figure 2 shows the modulation and output power characteristics of this source. Linear FM was achieved over a 10 MHz range with a modulation sensitivity of 835 kHz/volt. The output power was 115 mW with a total incidental AM of 0.23 dB resulting from the FM.

In order to determine the effect of the cavity modulation technique on FM noise, measurements were made on the oscillator with and without the modulating cavity coupled to the stabilizing cavity. The FM noise in a 1 kHz bandwidth from 10 kHz to 500 kHz away from the carrier was less than 2 Hz rms with the stabilizing cavity alone. With the modulating cavity coupled for 10 MHz of linear frequency modulation the FM noise was less than 6.3 Hz rms. Figure 3 shows the results of the FM noise measurements. The rising FM noise near the carrier was probably due to pickup on the varactor lead and its bias supply.

Temperature stability measurements were not performed on the source which has been described; however, similar sources stabilized by Invar reaction cavities have demonstrated temperature coefficients of -30 kHz/°C in X-band.

Modulation linearity in the 10 MHz bandwidth was measured to be within ±1 percent from a best straight line. These measurements were performed by the carrier null vs tuning voltage technique and were limited in their accuracy.

Conclusion

By using the coupled cavity technique described in this paper, cavity stabilized solid state diode oscillators can now be frequency modulated over bandwidths suitable for communications system applications while still retaining low FM noise.

Reference

(1) Y. Ito, H. Komizo and S. Sawagawa, "Cavity Stabilized X-Band Gunn Oscillator", IEEE Trans. Microwave Theory and Tech., Vol. MTT-18, pp. 890-897, November 1970.

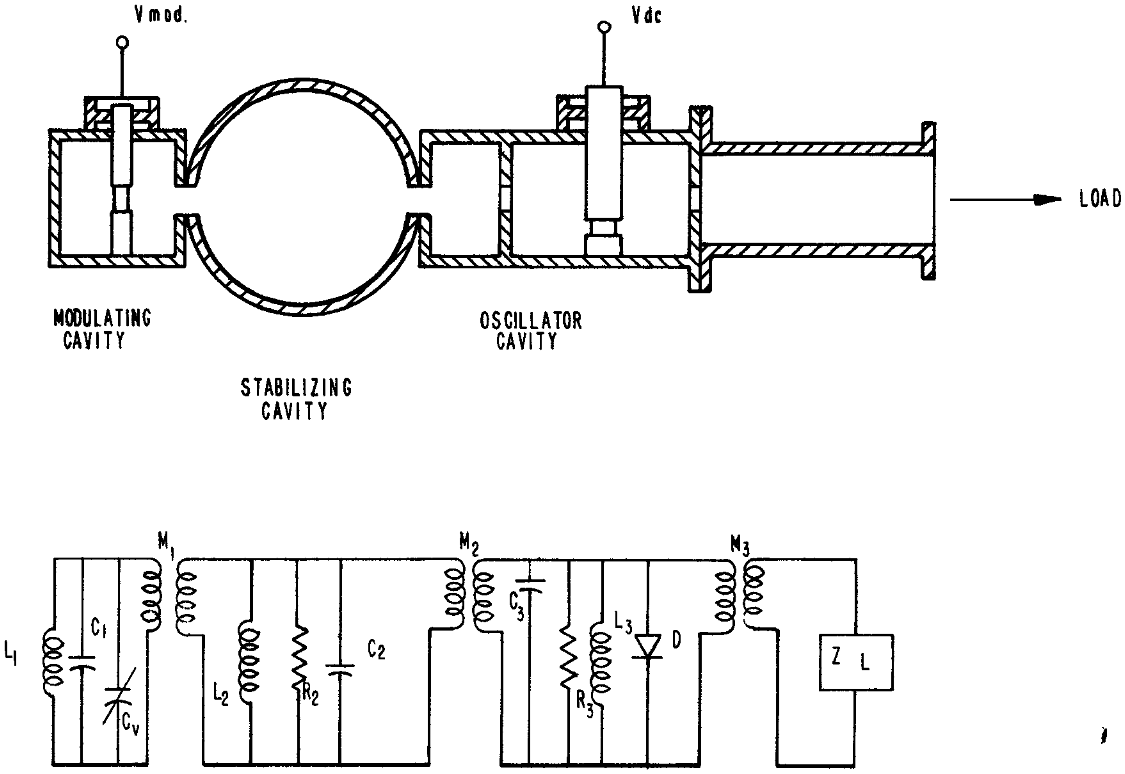

Fig. 1 Frequency Modulated Cavity Stabilized Solid State Diode Oscillator and Equivalent Circuit

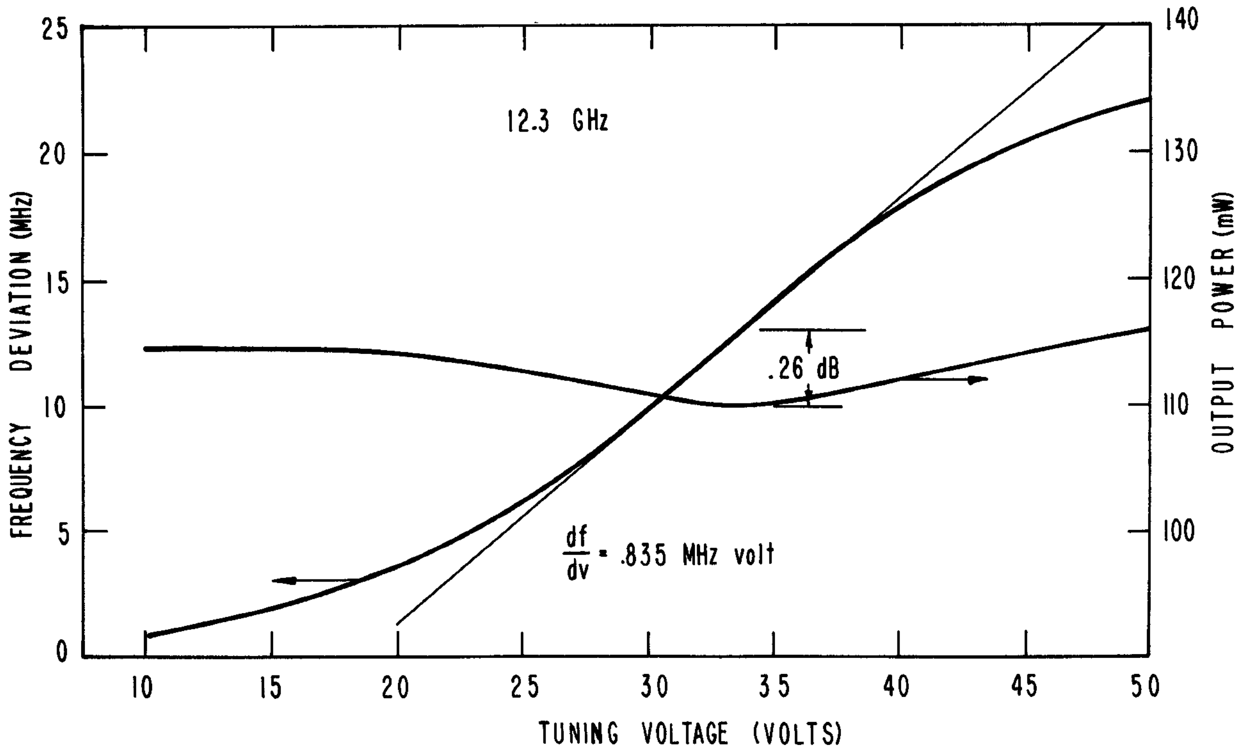

Fig. 2 Frequency Deviation and Output Power vs Tuning Voltage

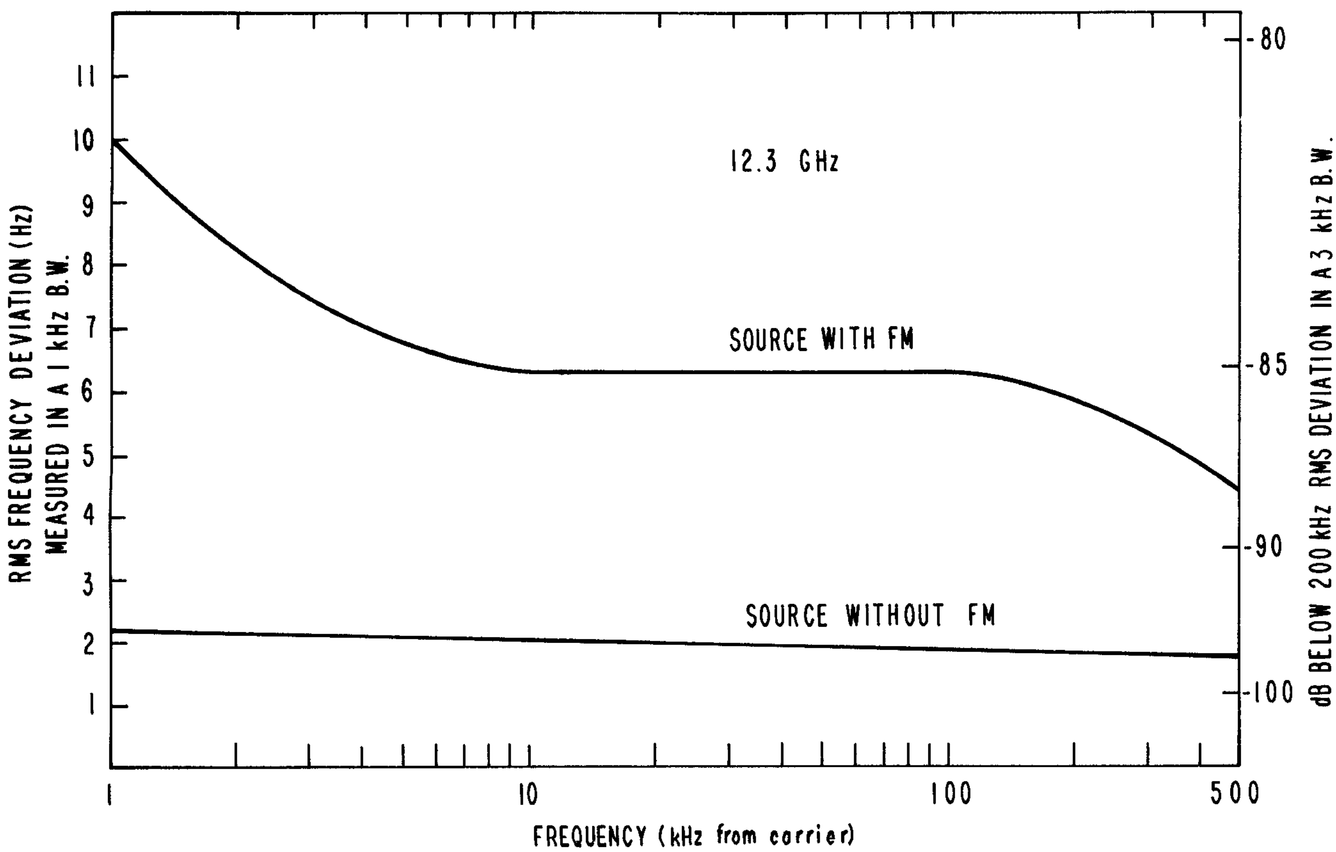

Fig. 3 FM Noise With and Without Modulation Cavity