A HIGHLY STABILIZED GaAs FET OSCILLATOR USING A DIELECTRIC RESONATOR FEEDBACK CIRCUIT IN 9-14 GHz

T.Mori, O.Ishihara, M.Nakatani and T.Ishii

Semiconductor Laboratory, Mitsubishi Electric Corporation
4-1 Mizuhara, Itami, Hyogo, 664 Japan

ABSTRUCT

A new type of highly stabilized GaAs FET oscillator using a dielectric resonator and a stabilization resistor in the feedback circuit has been developed in 9-14 GHz. A small sized MIC oscillator has a frequency stability of ± 200 KHz (-20~+60 °C) at 11.6 GHz.

Introduction

In the field of space telecommunication and SHF TV broadcasting, microwave oscillator with a high frequency stability, mechanical tuning with ease, low FM noise and compact construction are required. The GaAs FET is a suitable device for oscillators because of high efficiency and low operation voltage. However, GaAs FET oscillators satisfying all the above requirements have not been reported.

Directing our attention to high quality factor, excellent temperature performance and wide frequency tuning range of a dielectric resonator, we have developed a new type of highly stabilized GaAs FET oscillator using a dielectric resonator feedback circuit with a stabilization resistor (DRF GaAs FET oscillator).

In this paper, we present this newly developed DRF GaAs FET oscillator and describe its performances based on experimental results.

Configuration

A block diagram of the DRF GaAs FET oscillator circuit is shown in Fig.1. This oscillator consists of a GaAs FET amplifier and a feedback circuit including a dielectric resonator and a stabilization resistor. The dielectric resonator, which has a dielectric constant of 37.6 and a frequency temperature coefficient of 4.1 PPM/°C, magnetically couples the two microstrip lines connected to the input and the output ports of the GaAs FET amplifier. The microstrip lines are arranged at a right angle in order to satisfy the phase condition of the feedback loop. The microstrip line connected to the input port is terminated with a resistor having characteristic impedance of the line to prevent mode jump or hysteresis phenomena.

Figure 2 shows a schematically drawn MIC pattern of the DRF GaAs FET oscillator in 11 GHz band. The output power is obtained from source terminal. The matching circuit between 50 ohm load and the GaAs FET is formed by DC block of coupled microstrip lines or a chip capacitor and a tapered strip line.

The oscillator circuit including a GaAs FET chip and a dielectric resonator is fabricated on an alumina substrate of 1.0 x 0.5 inches. The GaAs FET chip, commercially available MGF-C-1400, has a gate 0.8 um long and 400 um wide. Figure 3 shows photographs of the DRF GaAs FET oscillators with a BRJ-120 waveguide flange and a SMA-J coaxial connector. A bias network shown in Fig.4 is enclosed in the housing case of the oscillators and the oscillators are operated by a single positive DC power supply.

Performance

Figure 5 shows output power, oscillation frequency and efficiency as a function of bias voltage. An efficiency of 20 % was obtained at 11.85 GHz with 70 mW output power for external quality factor Qex more than 1000. Figure 6 shows oscillation frequency characteristics depending on thickness of the dielectric resonator in the same MIC pattern. The tuning range over 1000 MHz is obtained at any oscillation frequency from 9 to 14 GHz. Furthermore, no hysteresis phenomena attributable to a change of bias voltage or oscillation frequency were observed.

The output power and oscillation frequency measured in a temperature range from -20 to +60 °C are shown in Fig.7. Experimental results show that the frequency stability of ± 200 KHz and output power variation of ± 0.4 dB are obtained without difficulty. Reproducibility of the highly stabilized GaAs FET oscillator is also investigated. As is shown in Fig.8, all samples have a stability less than ± 500 KHz and 80 % of the samples have a stability less than ± 300 KHz.

The FM noise of 0.07 Hz/$\sqrt{Hz}$ at 100 KHz off-carrier frequency is obtained at 6.4 volt bias voltage as shown in Fig.9. This value is almost the same as that of a Gunn oscillator evaluated in the same noise mesurement system.

Conclusion

A new type of highly stabilized GaAs FET oscillator using a dielectric resonator and a stabilization resistor in the feedback circuit is reported.

Features and typical performances of this DRF GaAs FET oscillator are summarized in table 1.

Besides these superior characteristics, this oscillator is very compact and simple, therefore, suitable for low cost mass production. Since the circuit of the DRF GaAs FET oscillator is integrated on an alumina-ceramic substrate, it is easy to combine the oscillator with other microwave circuits such as mixer, amplifier or detector and construct a microwave equipment with MIC.

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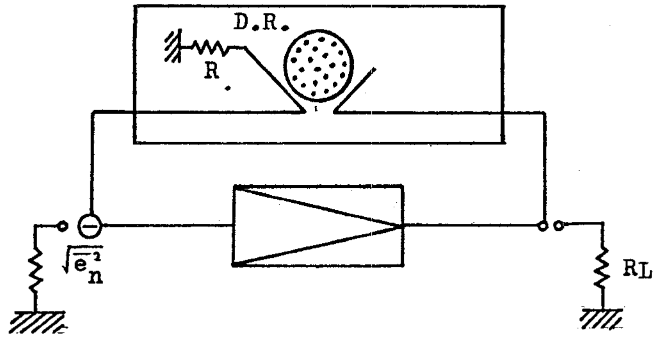
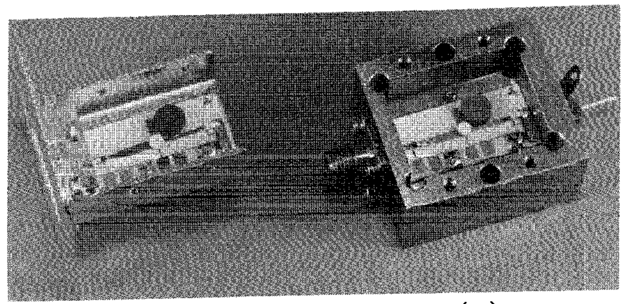


Fig.1 Block diagram of a DRF GaAs FET oscillator circuit



(a) (b)

Fig.3 DRF GaAs FET oscillators
(a); Waveguide type
(b); Coaxial type

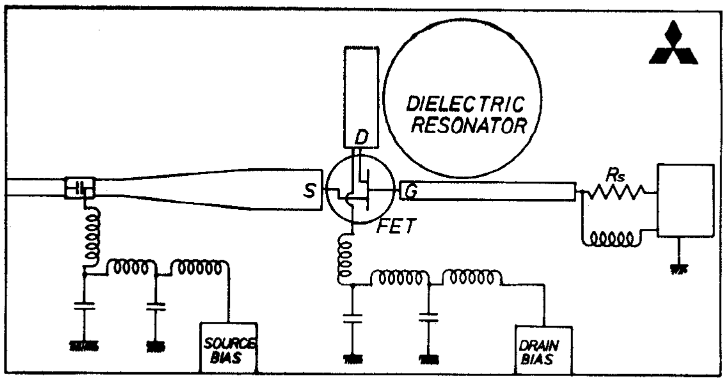


Fig.2 MIC pattern of the DRF GaAs FET oscillator

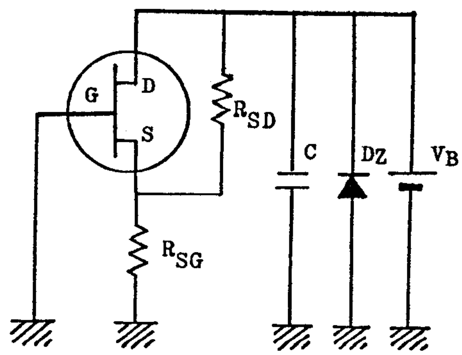


Fig.4 Bias circuit

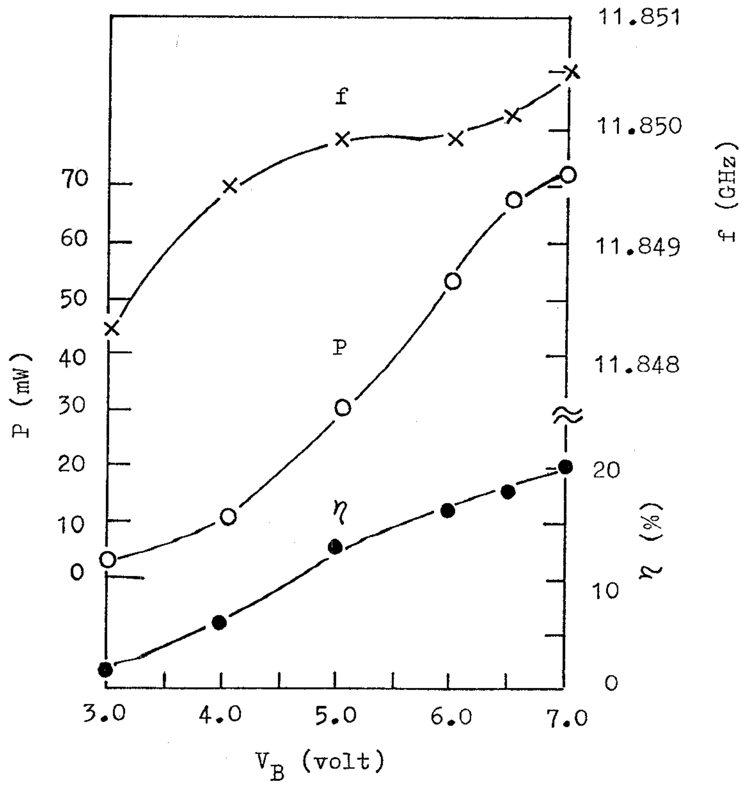


Fig.5 Oscillation characteristics as a function of bias voltage

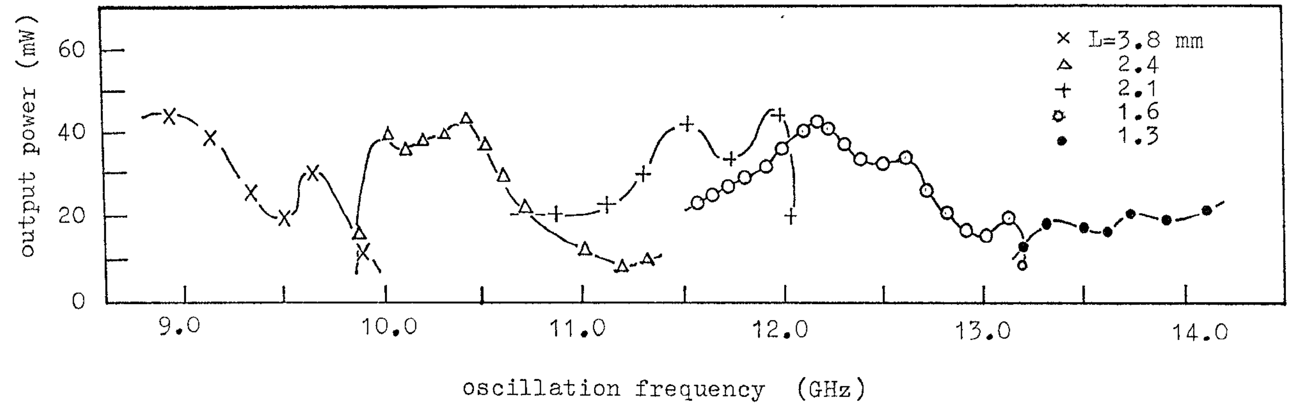


Fig.6 Mechanical tuning characteristics for the various thickness of the dielectric resonator

The diameter of the dielectric resonator is 5.5 mm.

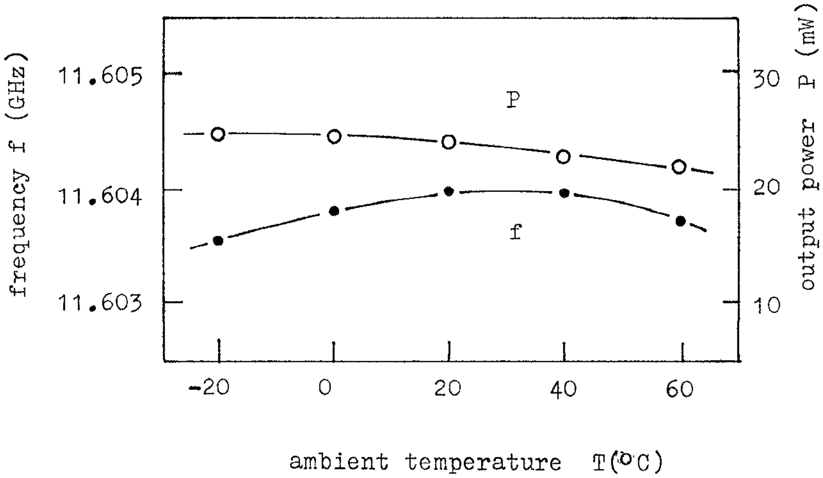


Fig.7 Temperature dependence of the oscillation frequency and the output power

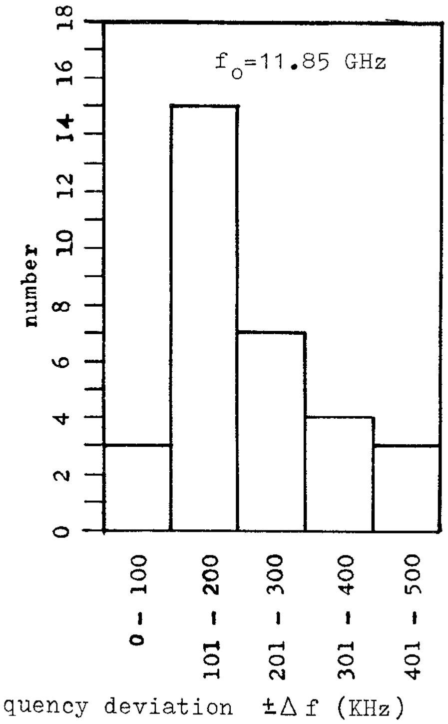


Fig.8 Distribution of frequency stability for 32 oscillators

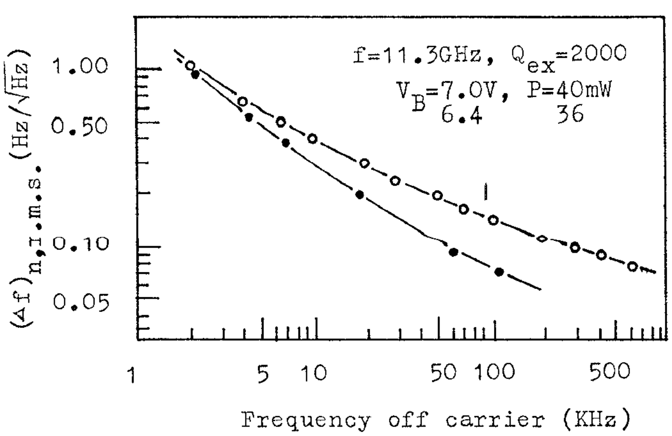


Fig.9 FM noise

Table 1 Features and typical characteristics

Feature	Characteristic
Low operation voltage	6 V
High efficiency	20 %
Wide oscillation frequency	9 - 14 GHz
Wide tuning range	1000 MHz
High external Q	1000
High frequency stability	± 200 KHz (-20~ +60°C)
Low FM noise	0.07 Hz/√Hz (100 KHz off-carrier)