A 10.5 GHz MIC DIRECTION SENSITIVE DOPPLER MODULE USING A GaAs FET AND A Ag/Pd THICK FILM

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Abstract

A MIC direction sensitive doppler module with a GaAs FET oscillator stabilized by a dielectric resonator has been developed by means of a Ag/Pd thick film technique. A module with 17 mW output power at 10.5 GHz has about -90 dBm minimum detectable signal for the bandwidth of 1KHz at the bias condition of 6.5 V, 44 mA.

Introduction

A Direction sensitive doppler module with a Gunn diode and a waveguide cavity has been used such as a speedmeter and a intrusion alarm. The module has several disadvantages of the high input energy and the complicity assembly or adjustment. For improvement of the conventional doppler module, we have developed a new MIC direction sensitive doppler module with a GaAs FET oscillator stabilized by a dielectric resonator by means of a low cost Ag/Pd thick film technique.

In this paper, we present a doppler module having a simple MIC circuit and describe its performance based on experimental results.

Configuration

When the microwave integrated circuit is formed by thick film techniques for cost reduction and productivity improvement, it is important to consider the loss of microstrip line and the accuracy of screened pattern.

With regard to the loss, the Au thick film with the loss about 0.1 dB/cm in 10 GHz has a better performance than the Ag/Pd thick film with about 0.3 dB/cm(1). However, the Au thick film is expensive as compared with the Ag/Pd thick film and reduces the merit of the low cost. As the result considering the cost-performance trade-off, we use the Ag/Pd thick film which has not been reported in X-band MIC modules.

With regard to the pattern accuracy, we designed the module components of the oscillator(2) and the mixer with the simple circuit which consists of microstrip line having the more than 150 μ line width.

Figure 1 shows a schematically drawn MIC pattern of the direction sensitive doppler module formed by the GaAs FET oscillator and two mixer circuits.

The oscillator consists of a GaAs FET, a dielectric resonator and a stabilization resistor. The dielectric resonator magnetically couples the two microstrip lines connected to the drain and the gate. The microwave power is incident on the gate, and the amplified power out of the drain is fed back through the dielectric resonator. This feedback mechanism produces the microwave power. The oscillation frequency is decided by the resonant frequency of the dielectric resonator and can be easily changed by adjusting an air gap spacing between the dielectric resonator and the frequency tuning plate. The resistor connected to the gate microstrip line prevents mode jump or hysteresis phenomena.

The mixer circuits consist of two GaAs Schottky barrier diodes mounted on two T-type branches of the microstrip lines apparting 1/8 wavelength. The principle of the direction detection is similar to that of Kalmus(3), who used the waveguide. The two doppler signals from two Schottky barrier diodes are out of phase, ideally 90 degrees different, and the polarity of this phase different turns over according to the moving direction of the target. Therefore, the direction detection is possible by comparing phase of two doppler signals. Of cource, the velocity of a moving target can be found as a proportional function of doppler frequencies from two diodes.

The resistor of the thick film is placed between the part of the mixer and the oscillator and plays two important roles. One is the stabilization resistor to reduce variation of the output power and the oscillation frequency against the external load. The other is the bias resistor to operate the GaAs FET with single power supply, which is connected between source and gate.

The doppler module including a GaAs FET, Schottky diodes and a dielectric resonator is fabricated on an 96 % alumina substrate of 1 x 0.5 inches. The thick conductor film and the thick resistor film are made of Ag/Pd about 25 m$\Omega/\square$ and 10 $\Omega/\square$, respectivily. The GaAs FET chip, commercially available MGFC-1400, has a gate length of 0.8 μ and a width of 400 μ. The GaAs Schottky barrier diode is formed by Ni/Pd plating. The FET and diodes are bonded on the substrate using a Au/Sn solder and Au wire and are protected by epoxy resin. The cylindrical dielectric resonator of SnO_2-TiO_2-ZrO compound has a dielectric constant of 37.5.

Figure 2 shows a photograph of doppler modules installed in cavities with BRJ-10 waveguide flanges. A tapered ridge waveguide is used between the microstrip line and the WRJ-120 waveguide.

Performance

Figure 3 shows output power, oscillation frequency and bias current as a function of bias voltage. An output power of 17 mW was obtained at 10.5 GHz at the bias voltage of 6.5 V and the bias current of 44 mA. The efficiency of 5.[illegible] % is superior to the efficiency of a conventional doppler module with a Gunn diode for a same application.

Figure 4 shows oscillation frequency and output power characteristics depending on the

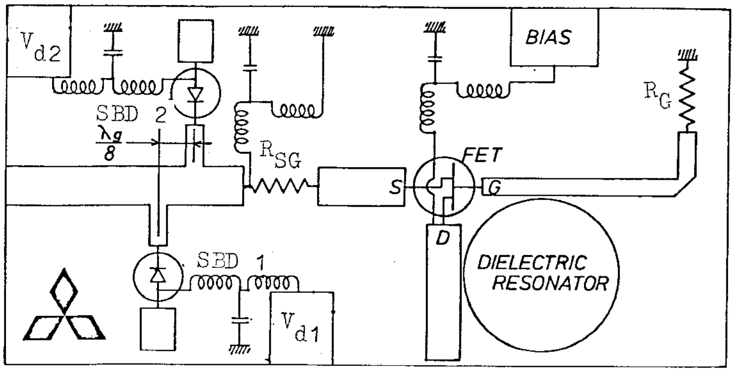

Fig. 1

Schematically drawn MIC patern of the direction sensitive doppler module

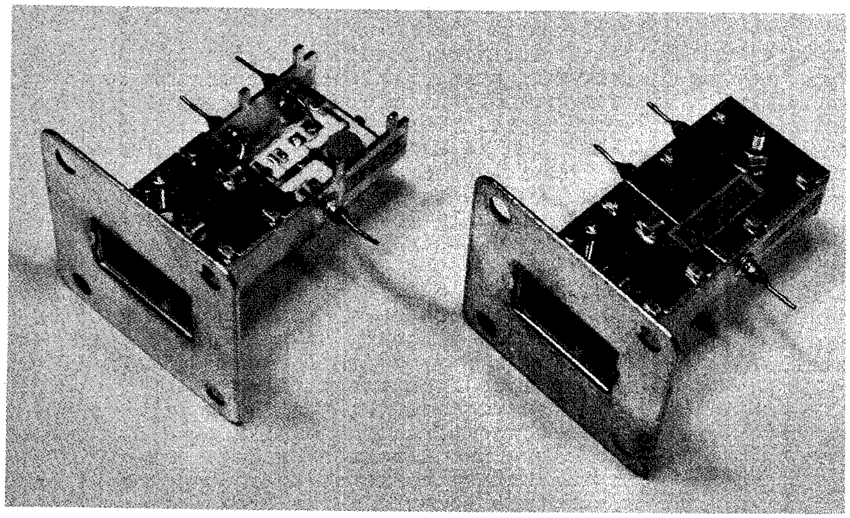

Fig. 2

Photographs of doppler modules with BRJ-1C flange

air gap spacing h between the dielectric resonator and the frequency tuning plate. The tuning range over 1000 MHz is obtained. Furthermore, no hysteresis phenomena attributabl to the change of bias voltage or oscillation frequency are shown in Fig. 3. and Fig. 4.

The Output power and oscillation frequency are measured in a temperature range from -40 to +80 °C as shown in Fig. 5. Experimental results show that frequency stability of -115 KHz/°C and output power variation of -0.01 dB/°C have been obtained without difficulty.

The doppler signal voltage from two GaAs Schottky barrier diodes are shown in Fig. 6 as a function of input power level. The test is accomplished by use of another oscillator in stead of a moving reflector. The doppler signal is mesured under the condition of the input frequency which is higher or lower than the oscillarion frequency by 1. MHz. Output voltage V_{d1} of 40 mVp-p and V_{d2} of 20 mV_{p-p} from two diodes shown in Fig. 1 are obtained when a input power is -20 dBm. The minimum detectable signal is -90 dBm for 1 KHz bandwidth at 3 KHz center frequency.

Figure 7 shows the oscilloscope photograph of the output voltage. A phase between two signals is about 70 degrees. The distribution of phase for 25 modules are shown in Fig. 4.

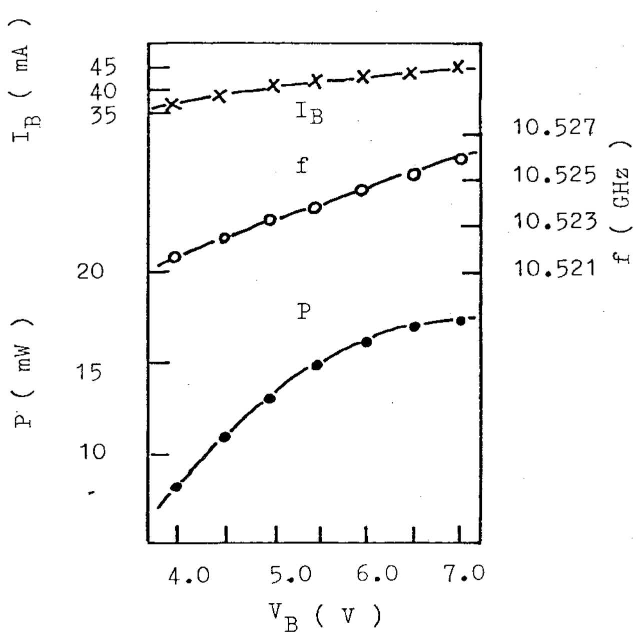

Fig. 3 Oscillation characteristics as a function of bias voltage

Conclusion

The high cost-performance microwave doppler module using the GaAs FET and the Ag/Pd thick film was developed. The microwave characterristics was excellent enough to be applied to the intrusion alarm or the automatic door.

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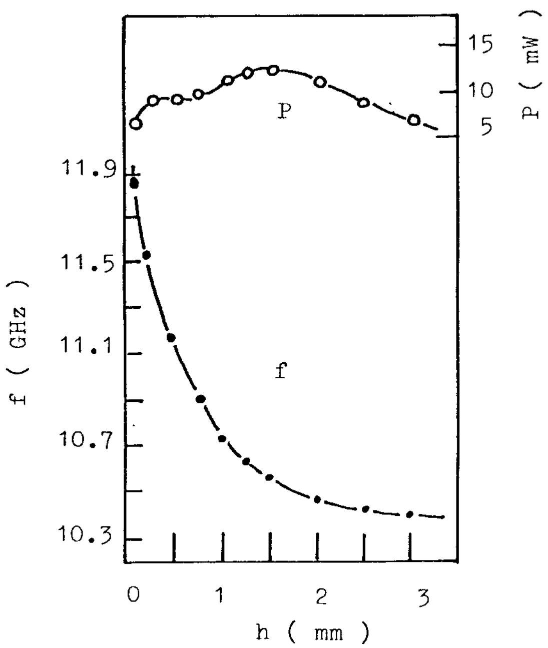

Fig. 4 Mechanical tuning characteristics as a function of air-gap spacing (h)

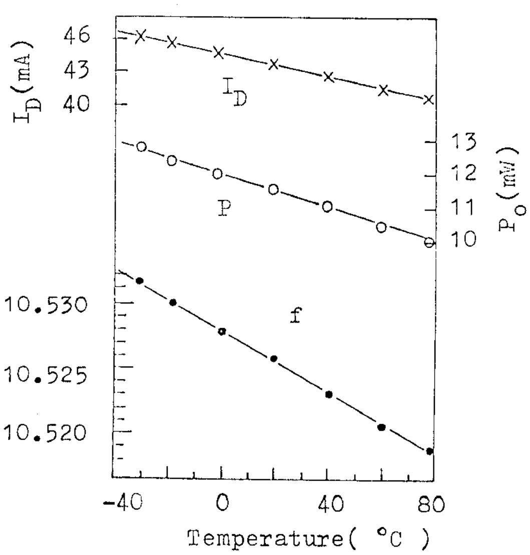

Fig. 5 Temperature dependence of the oscillation characteristics

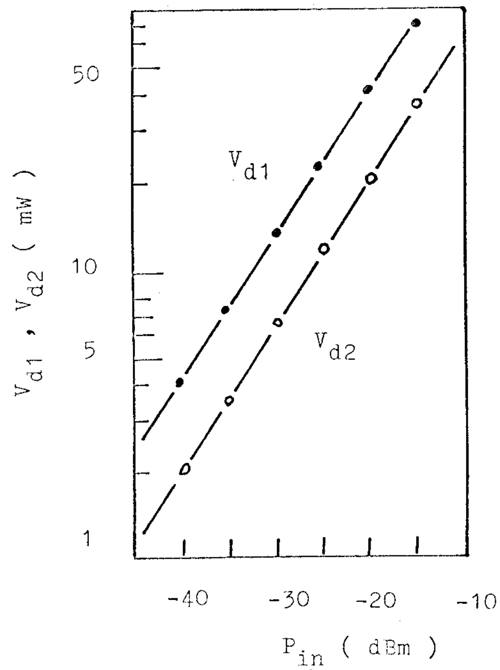

Fig. 6 Doppler signal voltage V_{d1} and V_{d2} as a function of input power

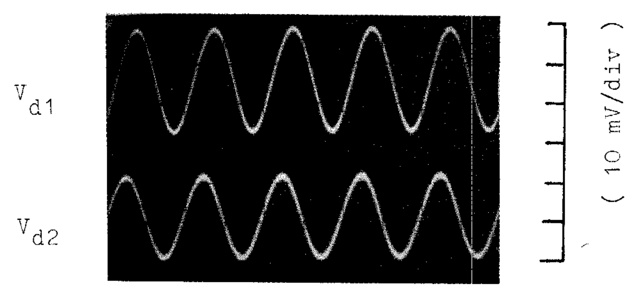

Fig. 7 Oscilloscope photograph of doppler signal voltage

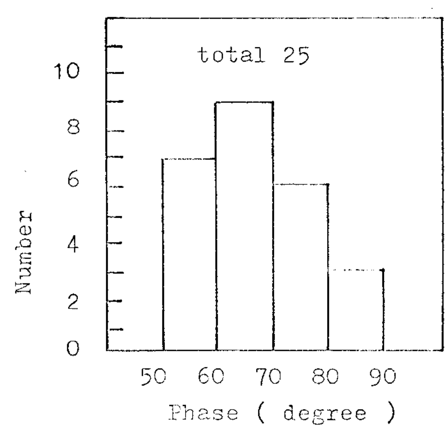

Fig. 8 Distribution of phase for two doppler signals