An MIC Doppler Module with Output Radiation Normal to the Substrate Plane

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Abstract—**A flat Doppler module, only 18 mm thick, was fabricated. The module is based on a microwave integrated circuits (MIC) stabilized oscillator having a dipole antenna on a single substrate. It emits a microwave beam normal to the substrate plane whose radiation pattern is nearly symmetrical around the normal axis with a half-power-angle of about 60 .**

I. Introduction

MICROWAVE Doppler modules are used in various fields of application, such as speedometers and intrusion-detection systems. Usually, parabola antennas or horn antennas have been used so that the modules are inevitably long in the direction of the microwave radiation. On the other hand, there is a need for modules of much smaller size, especially for case of installation of intruder-detector systems. A microwave integrated circuits (MIC) module with a stripline dipole antenna [1] may considerably reduce the overall size, but the length of the module in the direction of radiation will still be long, because a reflector is usually constructed in the direction normal to the MIC substrate plane and the microwave beam is emitted in the direction parallel to the substrate plane. Moreover, a large reflector is required to eliminate side-lobes and backward radiation.

The present paper reports a miniature Doppler module with a stripline dipole antenna and built-in reflectors, reflecting the output beam in the direction normal to the MIC substrate.

II. Construction of the MIC Module

The structure of the module is shown in Fig. 1, where (a) and (b) show the circuit layout and the cross-sectional view of the module, respectively. The right-hand part is the stabilized oscillator [2], [3], and the left-hand side is the dipole antenna with reflectors. Both parts are constructed on one alumina substrate 0.65 mm thick.

III. The Oscillator

The oscillator cavity A is driven by a germanium avalanche diode, and the transmission cavity B is needed for frequency stabilization and mechanical tuning. The detection cavity C, which employs a Schottky-barrier diode, is also used to suppress unwanted-mode oscillation inherent in

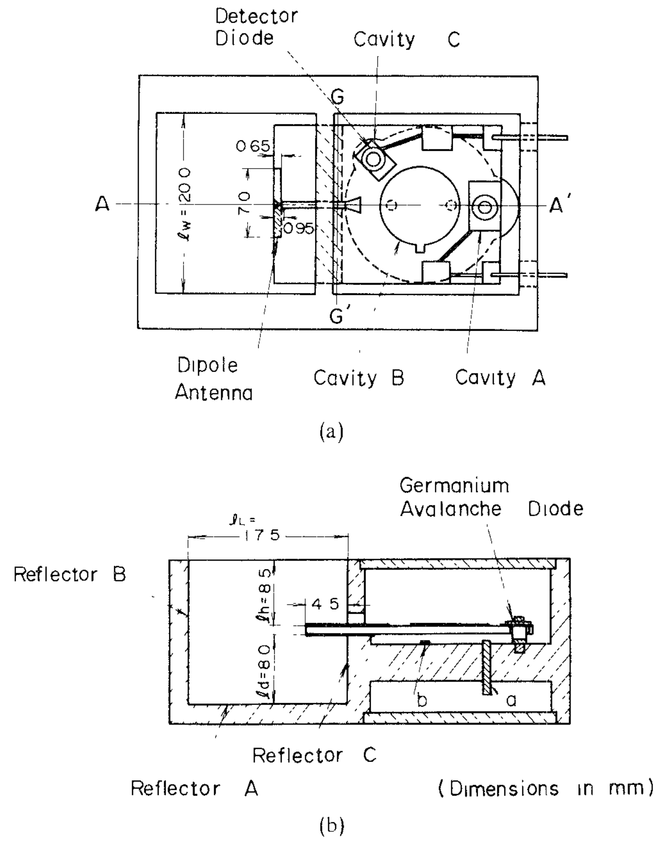

Fig 1 The structure of the module (a) The circuit layout (b) The cross-sectional view of A-A'. a: Tuning screw. b: TiO_2.

the coupled-cavity oscillator by increasing circuit conductance near the unwanted-mode frequency, as reported previously [2]. The oscillation frequency was tuned to 10.525 GHz ± 10 MHz by the tuning screw.

The characteristics of the oscillator part were measured separately by means of a waveguide measurement system. A rotary fan was used for the measurement of the Doppler effect. The result is shown in Table I. High stability of the Doppler signal output level [3] is evident.

IV. Dipole Antenna with Reflectors

The dimension of the dipole antenna was designed to minimize the input VSWR without reflectors in the vicinity of 10.52 GHz. The actual dimensions are indicated in Fig. 1(a). An input VSWR less than 1.2 was obtained over the frequency range from 10.3 to 11.8 GHz.

The reflectors, which mechanically support the substrate,

Manuscript received March 30, 1977, revised May 27, 1977
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0018-9480/78/0100-0003$00.75

TABLE I
THE CHARACTERISTICS OF THE DOPPLER MODULE

Characteristics	
Transmitter Power	10 - 13 dBm
Minimum Detectable Signal Level*	-100 dBm
Temperature Stability (-20°C ∿ 60°C)	
Frequency	10 ppm/°C
Transmitter Power	0.05 mW/°C
Doppler Output Signal Level*	0.01 dB/°C

* Measurement condition: Input signal power/transmitter power = −30 dB; detector load = 100 Ω; transmitter power = 10 dBm; amplifier bandwidth = 10–10 000 Hz.

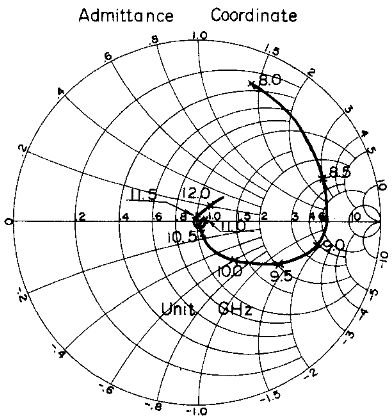

Fig. 2. Input admittance of the antenna with reflector looking to the left from GG' (DSC plane of the oscillator).

are shown in Fig. 1. The optimum dimensions of reflectors A, B, and C were again determined to minimize the input VSWR looking to the left from GG', which is a detuned short-circuit (DSC) plane of the oscillator part. The dimensions l_d and l_L strongly influence the characteristics of the antenna; optimum values were found near a quarter wavelength and a half wavelength, respectively. On the other hand, the lengths l_w and l_h affect the input admittance of the antenna only slightly, so they can be determined from the design of the oscillator. Reduction of the separation l_h between the substrate and the metal cover of the oscillator may increase the resonant frequency of the suspended stripline resonator, causing parasitic oscillation. The smallest value of l_h allowable was 8.5 mm.

Fig. 2 shows the input admittance of the antenna with reflectors of optimum dimensions looking to the left from GG'. The change in admittance by the attachment of the reflectors was little.

The radiation pattern of the antenna, measured separately, was symmetrical around an axis normal to the substrate plane, with a half-power-angle of about 60°. The antenna gain calculated from the radiation pattern [4] was about 10 dB. No backward radiation was observed.

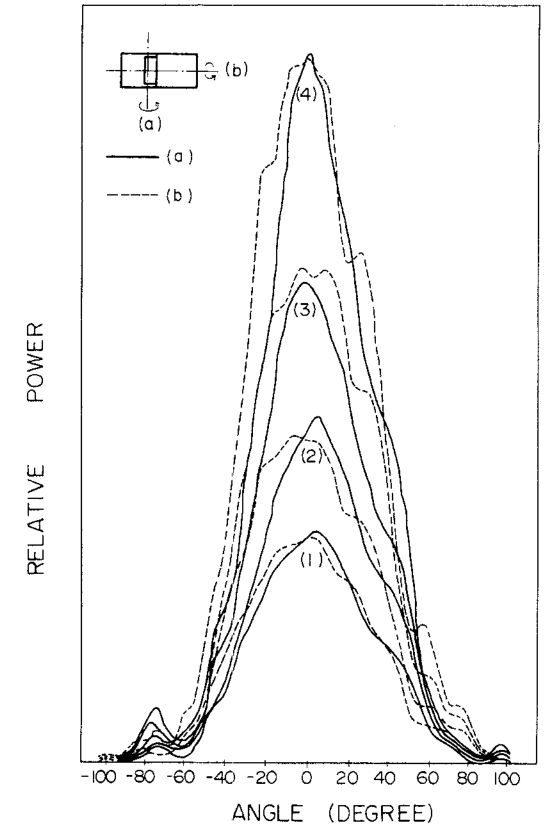

Fig. 3. Radiation pattern. Bias currents of the oscillator diode = (1) 35 mA, (2) 39 mA, (3) 43 mA, and (4) 48 mA. Bias voltage = 34 V.

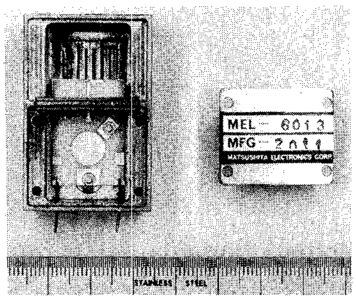

Fig. 4. Photograph of the module.

V. THE MIC DOPPLER MODULE

Fig. 3 shows the radiation pattern of the module for various bias currents of a germanium avalanche diode, which is almost the same as that of the antenna itself. The overall thickness of the module is only 18 mm along the direction of radiation. A photograph of the module is shown in Fig. 4.

Knowing the required input signal level, the range of the present module can be calculated [4], [5]. Assume that a signal level 10 dB above the noise level is needed, that the frequency range of interest is 10–10 000 Hz, that the transmitter power is 12 dBm, and that the target is a walking man of the equivalent target gain 41 dB. Then the allowable two-way free-space path loss at 10.525 GHz and the range of the module are calculated to be about 163 dB and 25 m, respectively.

VI. Conclusion

Because of compact size, thin structure, and low cost, the present module is useful as sensors not only for intrusion-detection systems, but also for other wide applications. As the range is stable because of the high stability of the Doppler signal output level, high reliability will also be achieved in such applications.

Acknowledgment

The author wishes to thank Dr. H. Mizuno for encouragement and guidance, and Dr. T. Tanaka, Dr. I. Teramoto, and Dr. M. Takeshima for valuable discussions. He also wishes to thank Mr. Yoshioka and his colleagues for many kinds of support.

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Improving the Isolation of 3-dB Couplers in Microstrip-Slotline Technique

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Abstract—**The isolation of an experimental 3-dB strip–slot coupler has been improved by capacitive loading at the ends of the coupled region, accomplished by a lengthening of the slotline. In practice, the isolation has been improved by 5–10 dB, as compared to the uncompensated structure in C band.**

WITH the growing complexity of microwave integrated circuitry, and the quality requirements of basic components, e.g., VSWR and isolation of directional couplers, increase.

Microstrip directional couplers made of parallel-coupled transmission-lines exhibit a reduced directivity due to the difference in the phase velocity of the odd and even mode. To improve directivity, velocity equalization has been introduced [1]–[3], e.g., by a capacitive loading of the odd mode, using lumped capacitors at the ends of the coupled region (Fig. 1).

It is the purpose of this paper to point out that a very similar technique can also be successfully applied to improve the directivity of planar 3-dB couplers, realized with a slotline in the groundplane of the substrate [3]–[5]. In this case, the length of the slotline between the two slot open circuits should be increased by a certain amount (Fig. 2), such that the additional length of slotline l_2 gives the

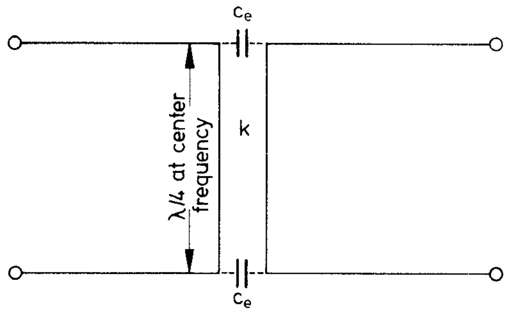

Fig. 1. Proximity coupler with capacitive loading at the ends of the coupled region.

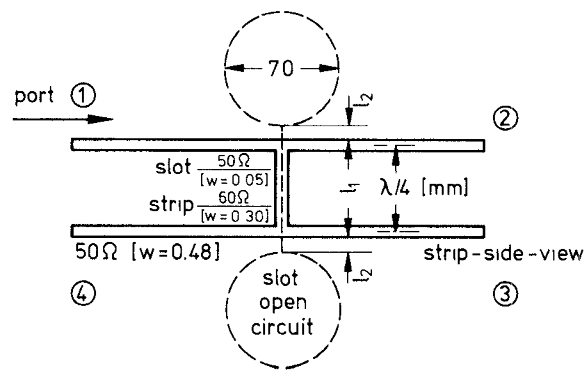

Fig 2. Layout of the experimental 3-dB strip–slot coupler. Center frequency 6 GHz; Al_2O_3 substrate 0.51 mm thick; $l_1 = 5.5$ mm, $l_2 = 0.55$ mm.

Manuscript received January 31, 1977, revised May 18, 1977.

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0018-9480/78/0100-0005$00.75