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AN MMIC/MIC-TO-WAVEGUIDE TRANSITION FOR SINGLE- AND DUAL-POLARIZATION SYSTEMS*

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ABSTRACT

A simple, low-cost, 20-GHz MMIC/MIC-to-waveguide septum-type transition is described for rectangular, square, or circular waveguides operating in single- or dual-polarization modes. The MMIC is attached to a dielectric substrate surface with a circuit that transforms the waveguide impedance to that of the MMIC. Good insertion loss, return loss,and cross polarization are measured.

INTRODUCTION

The application of monolithic microwave integrated circuits (MMIC) to future communication systems will require the integration of these devices with other functional blocks and different transmission media. Two techniques for effecting direct MIC-to-waveguide transitions exist in the literature: one is a ridged waveguide transformer (1); the other is an antipodal finline transition (2). Both have the drawback of allowing transmission in only one of the two possible orthogonal modes.

The septum-type transition from MMIC to waveguide at 20 GHz is polarization-selective, broadband, low-loss, and simple to fabricate. The transition circuit, printed on a dielectric substrate, is designed to be easily removed from its waveguide structure for adjustment or repair. Its one-piece structure allows reproducible and noninvasive measurement of fragile MMIC chips. Two versions of the transitions are shown in Figure 1, a single-polarization version in rectangular waveguide and a dual-polarization version in square waveguide.

DESCRIPTION AND DESIGN PROCEDURE OF TRANSITION

Figure 2 shows the details of the circuit that constitute the transition. The MMIC circuit is mounted directly on the metallized surface of a dielectric substrate, which in turn is mounted along the electric field and centered in a rectangular, square, or cylindrical waveguide. The substrate is metallized on one surface only. On that one side, the structure can be divided into three subcircuits: a stepped $\lambda/4$ unilateral finline transformer transitioning from waveguide to slotline; a balun to convert the balanced slotline mode to the unbalanced microstrip or coplanar waveguide (CPW) on the MMIC; and the MMIC circuit, either soldered or epoxied onto the surface of the substrate.

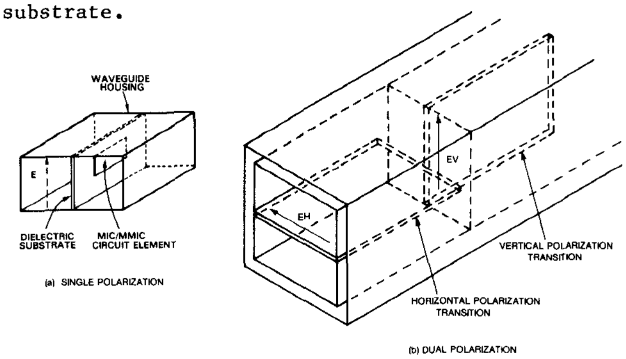

Figure 1. Single- and Dual-Polarization Transition Assemblies

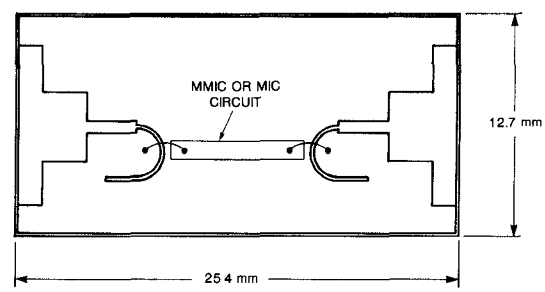

Figure 2. Circuit for MMIC-to-Square Waveguide Transition

The design began with a calculation of the propagation characteristics and characteristic impedances of the chosen geometries and dielectrics. Although some design information on finlines is available in the literature, much of it is restricted to special waveguide geometries or dielectrics. The requirement for nonstandard waveguide sizes and a previously unanalyzed dielectric--the 0.635 mm (0.025 in.) beryllia--made it necessary to calculate the required parameters.

These calculations were performed using a spectral domain analysis technique (3). The balun used was a modified version of one described by Cohn (4) that is based on an orthogonal junction of a balanced and unbalanced line.

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SINGLE POLARIZATION TRANSITION

The single-polarization transition is housed in a WR-42 rectangular waveguide. Figure 3 shows the disassembled transition. The circuit shown is actually two back-to-back waveguide-to-MMIC transitions with a 0.5-in. length of 50-Ω microstrip on 0.012-in.-thick GaAs in between. The septum on which the MMIC is attached divides the waveguide into two sections of waveguide below cutoff. To avoid problems with passband ripples or instabilities, the attenuation of this section should be large compared to the gain of the MMIC circuit.

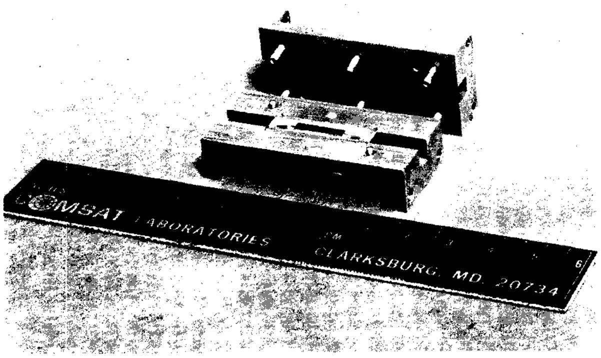

Figure 3. Rectangular Waveguide Transition (Disassembled)

Figure 4 is the measured performance of the same circuit. The overall insertion loss, in the range of 18.5 to 19.5 GHz, is approximately 1 dB. The return loss over this same range is better than 15 dB, reaching about 25 dB at 19 GHz. Subtracting 0.4 dB for the microstrip section, which is inserted to simulate an MMIC module, a loss of 0.3 dB per transition is obtained. Isolation between input and output was measured by removing the input and output ribbons. The resulting coupling of -30 dB is caused primarily by leakage through the waveguide beyond cutoff, in the vicinity of the 50-Ω microstrip.

DUAL POLARIZATION TRANSITION

In square or circular waveguides, two orthogonally polarized signals may exist in the same waveguide. To produce a waveguide-to-MMIC transition for each polarization, two orthogonal dielectric septums of the kind described above can be used, as shown in Figure 1b. Each septum will act as a transition for the polarization parallel to its plane and will be almost transparent to the orthogonal polarization. The measured insertion and return losses for this transition in a 0.42-in. square waveguide are shown in Figure 5. Of special importance in this case is the vertical-to-horizontal mode conversion, measured to be about 30 dB over the operating band.

CONCLUSIONS

The septum-type transition couples energy with very low loss over a broad bandwidth from waveguide into an MMIC or MIC circuit. The virtually coplanar circuit makes possible dual-mode structures in square or circular waveguides. It provides a single-piece, rugged, easily reproduced module that can be inexpensively produced. The use of beryllia for the substrate material allows for a low thermal resistance structure.

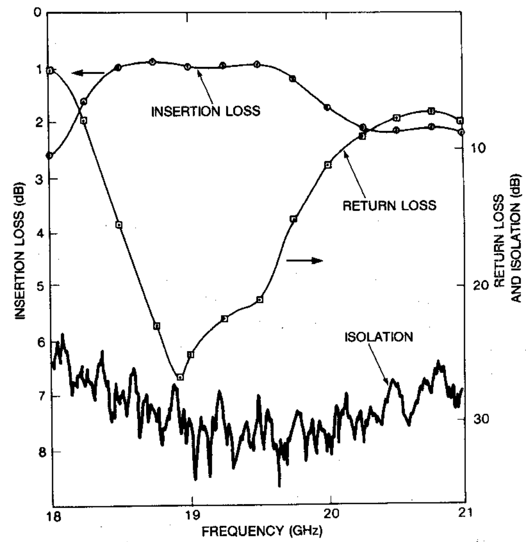

Figure 4. Measured Performance of Rectangular Waveguide Transition

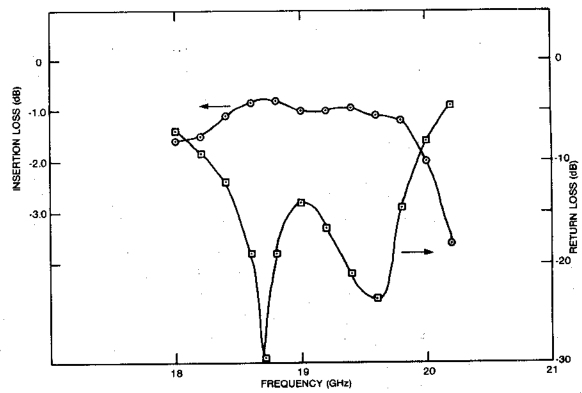

Figure 5. Insertion Loss and Return Loss of Square Waveguide Transition

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