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A WIDEBAND FINLINE POWER DIVIDER IN A METALLIZED PLASTIC HOUSING: DESIGN AND PERFORMANCE

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ABSTRACT

This paper describes the design and performance of a wideband power divider which utilizes finline technology and is housed in a metallized plastic housing. The power divider exhibits excellent performance across the entire waveguide band demonstrating its feasibility in the design of wideband millimeter wave feed networks. To the author's knowledge this is the first published report of an E-plane circuit housed in plastic.

INTRODUCTION

The power divider is an essential component in most microwave or millimeter wave systems. At lower frequencies the Wilkinson power divider [1] realized in microstrip or stripline is generally used. This configuration however becomes lossy at millimeter wave frequencies and is not readily combined with waveguide. A waveguide power divider recently reported in [2] produced excellent results, however over a narrower bandwidth than the one reported here and required much more complex machining. For millimeter wave application, Gajda and Verver [3] have published a finline power divider using a combination of unilateral finline and coplanar line. The attenuation of the undesired mode was achieved by placing an absorbing material along the center conductor of the coplanar line. However, this solution showed only a moderate bandwidth, and the output return loss was poor.

In this paper we propose a finline power divider which alleviates the disadvantages of the configuration in [3]. The new design is also a combination of unilateral finline and coplanar line but with an additional conductor placed opposite to the coplanar line (reversed side of the substrate). Both conductors are connected via a plated through hole and the undersired mode is attenuated by an absorbing material along the additional conductor. This solution provides a significantly improved bandwidth and a return loss at the output ports of 20 dB at center frequency. Even though this power divider was designed for the K-band, it is obvious that the configuration is potentially useful for millimeter wave frequencies.

HOUSING DESIGN AND FABRICATION

Before we describe the design of the power divider circuit, we like to emphasize the fact, that the component housing was fabricated from a lightweight carbon fiber loaded polyamide material. This material was metallized using BOLRIET TECHNOLOGIES unique quasi thin film metallization process (QTF method)[4]. In this process a thin layer of copper is deposited and then plated with gold or silver depending on the application. Modern plastics when used with fillers to alter its raw characteristics can be used for a variety of microwave applications in both ground and space based systems. Typical parameters for the plastic used in the construction of this housing are shown in Table 1. A photograph of the silver plated housing and circuit are shown in Fig. 1. Using plastic for the housing material as opposed to metal greatly reduces the weight of the component and reduces the cost since the parts can be injection moulded. As well, using injection moulding produces an even smoother surface than a machined surface which is important at millimeter wave frequencies.

Table 1

Tensile Strength	250 MPa
Specific Gravity	1.28
Coefficient of Linear Thermal Expansion	1.4 x 10 /m/OC
Thermal Conductivity	1.OW/km
Temperature Range	-55 - +250

CIRCUIT DESIGN AND FABRICATION

The circuit was fabricated on RT Duroid 5880 material. As in the case of the housing the circuit was metallized using the QTF method which allows the design of printed circuits with very fine lines and spaces.

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The power divider circuit is shown in Fig. 1. The circuit can be analysed using the even and odd mode concept [5]. The circuit operates in the odd mode when it is providing power division, and in the even mode when providing isolation between the two output ports. The odd mode circuit is shown in Fig. 2. As seen in the circuit the coupled finline section divides power equally into the two output arms. In order to match impedances the output arms must have an impedance equal to one half that of the input arm since these are effectively in series with the input port. For this design the input port has an impedance of 300 ohms which allows the output ports to have an easily realizable impedance of 150 ohms. To calculate the impedance of the input finline and the coupled finline section a spectral domain program has been used [6]. To calculate the impedance of the output finline a transverse resonance program which accounts for finite metallization thickness has been developed [7]. As shown in [7] the metallization thickness becomes an important consideration when the distance between the lines becomes small as in the case of the 150 ohm finline.

The even mode operation is shown in Fig. 3. With even mode excitation at output ports 1 and 2 and signals of equal amplitude a coplanar mode is excited in the coupled finline section. When this mode sees an open circuit at the input finline to coupled finline transition most of the energy is reflected back to a plated through hole which acts as a transition to a microstrip line printed on the opposite side of the substrate. The reflected energy is then absorbed in microwave absorber material which has been placed on the microstrip line.

As stated previously a transverse resonance program has been utilized to determine the gap width of the output finline section. The transverse resonance structure, which has been analyzed, is shown in Fig. 4. For the analysis electric walls are placed a distance of $\lambda g/2$ apart so as to form a dominant mode resonator. In Fig. 4 Y_0, Y_1, Y_2 and Y_3 are the TE_{10}-mode admittances for a transverse rectangular section which has an "a" dimension equal to $\lambda g/2$. The discontinuity susceptances at the metallization-dielectric and at the metallization-air interfaces respectively are represented by Bd and Ba. Expressions for these values have been derived from [8]. By applying the transverse resonance theory which states that the sum of the admittances at the plane of the dielectric-metallization interface must be zero one can determine ε_{eff}. Using Meiers' equivalent homogeneous model [9] one can then solve the Zo.

$$Zo = Zo_{\infty}/\varepsilon_{eff}$$

Where Zo_{∞} is the characteristic impedance at infinite frequency of a ridge loaded guide with the same dimensions as the finline.

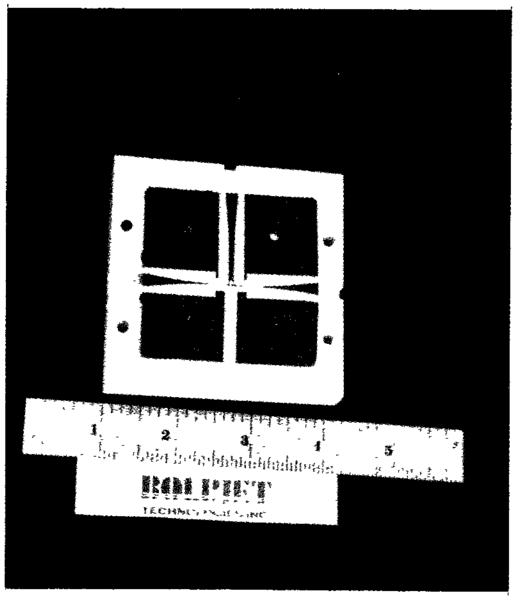

FIG. 1 Photograph of the power divider in a metallized plastic housing

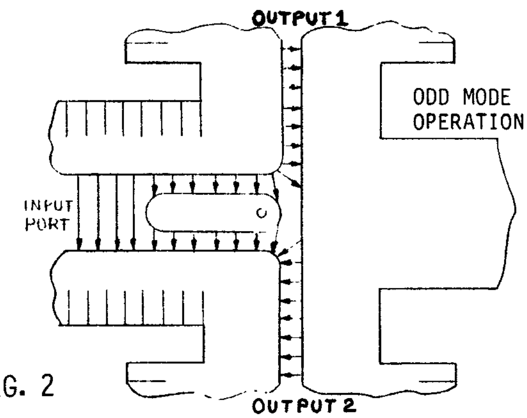

FIG. 2

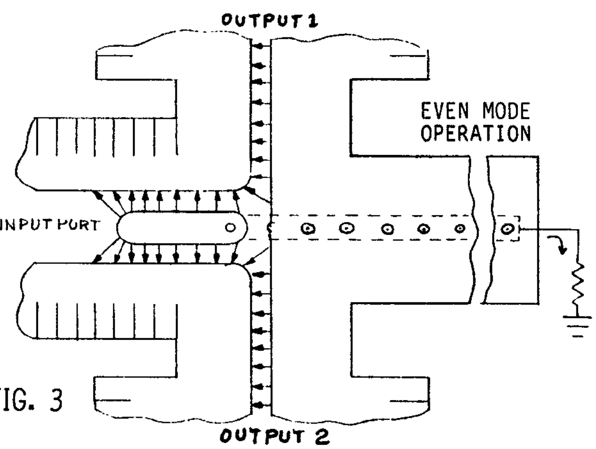

FIG. 3

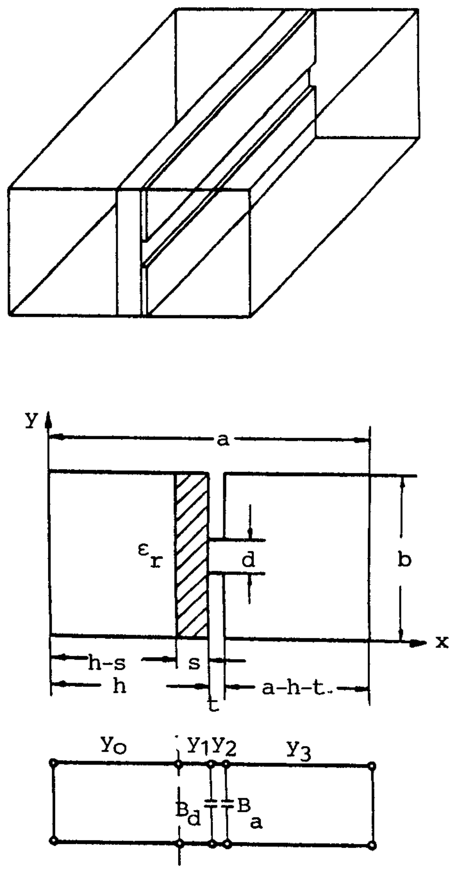

FIG. 4

RESULTS

The results which have been obtained for this circuit in a plastic housing are shown in Fig. 5, 6 and 7. Fig. 5 shows the output power in port 1 and the input return loss of the circuit. As seen in the figure the output power level remains at -4 ± .5 dB across most of the waveguide band. The input return loss is 14 dB at the center of the waveguide band and greater than 12 dB at the band edges. Fig. 6 shows the output power of port 2 which is constant to within .3 dB of port 1 up to 26 GHz. Also shown in this figure is the output return loss which is 20 dB at the center of the waveguide band and greater than 12 dB across the entire band.

Fig. 7 shows the isolation between output ports which is 18 dB at band center and greater than 15 dB at the band edges. Phase balance is maintained to within ± 2 degrees between the output ports.

CONCLUSION

This paper has described a novel finline power divider component which has been incorporated into a plastic housing. Inexpensive fabrication techniques and materials along with excellent performance make it an important component in the future designs of microwave and millimeter wave systems.

ACKNOWLEDGEMENT

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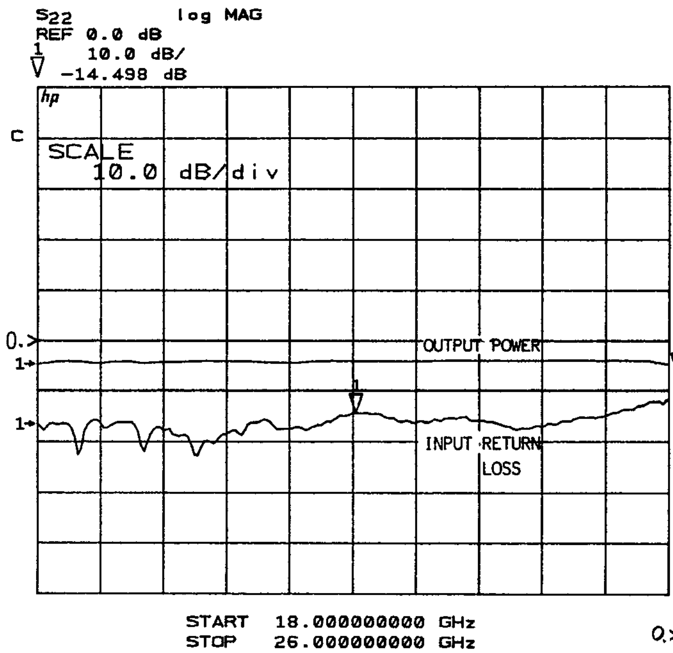

FIG.5 Output power at port 1 and input return loss

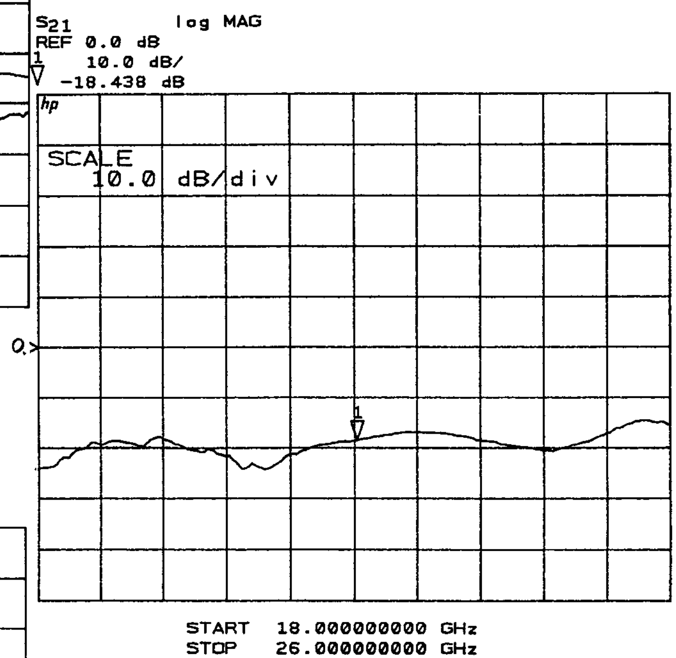

FIG.7 Isolation between both output ports

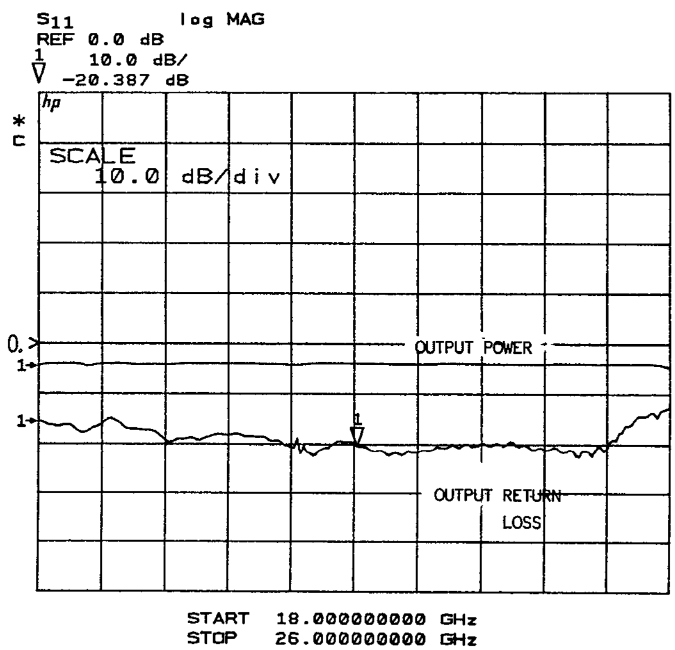

FIG.6 Output power at port 2 and output return loss