WAVEGUIDE POWER DIVIDER USING METALLIC SEPTUM
WITH RESISTIVE COUPLING SLOT

Z-4

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Summary

This paper describes a waveguide power divider using a metallic septum. In this divider, a high isolation and a low insertion loss were obtained by using a resistive coupling slot in the septum.

Introduction

A waveguide power divider using a metallic septum is useful for phased array antenna feeds, because of its simple structure and small size. In the conventional one, a card resistor has been attached at the edge of the septum. So it has been very difficult to obtain both a high isolation and a low insertion loss. In this paper we solved the problem by using a resistive coupling slot in the septum. The resistive coupling slot has a small resistor in the center of the slot. The slot becomes a magnetic wall for the even mode and an electric wall for the odd mode. So, the resistor does not affect the wave for the odd mode, and can be designed to absorb all the power for the even mode. The power divider with the resistive coupling slot was constructed, and a high isolation and a low insertion loss were obtained.

Structure

Figure 1 shows the construction of the 3 dB waveguide power divider using metallic septum. The septum divides the waveguide A into waveguides B and C of an equal cross section. The resistive coupling slot consists of a transverse slot and a small resistor in the septum.

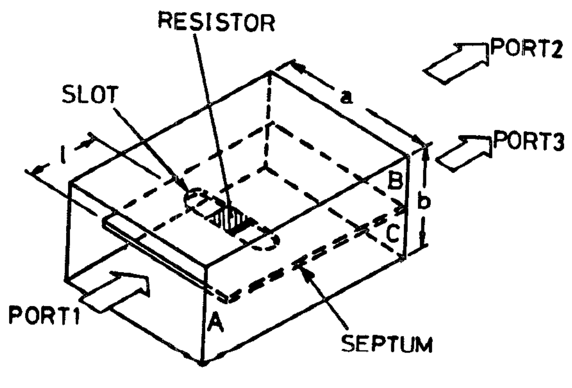

Figure 1. Structure of Power Divider

Design

To design the power divider shown in Figure 1, we used the even and odd mode concept.[1] The scattering parameters S_{11}, S_{21} and S_{31} are determined by the odd mode reflection and transmission coefficients, and S_{22}, S_{33}, S_{32} and S_{23} by the even and odd modes reflection coefficients.

For the odd mode the plane of symmetry is an electric wall. When the septum is thin enough, the slot and the resistor have no influence on the waves in the waveguides B and C. Moreover, the characteristic impedance of the waveguide A becomes the sum of those of the waveguides B and C. The equivalent circuit for the odd mode is shown in Figure 2(a). The odd mode reflection coefficient Γ_0 is approximately zero.

For the even mode the plane of symmetry is a magnetic wall. The equivalent circuit for the even mode is shown in Figure 2(b). The susceptance B_1 is caused by the slot, and R and L are the resistance and inductance of the resistor respectively. The waveguides B and C are connected with the susceptances B_2 which are caused by non-propagating LSE_{1n} (n=1, 3, --) modes of the waveguide A.

The susceptance B_2, as an approximation of the first degree, is given by the characteristic impedance of the LSE_{11} mode. Figure 3 shows the calculated and measured susceptances B_2 for the waveguide A with a/b = 2. The susceptances B_2 are capacitive and increase with frequency. The deviation is caused by neglecting the higher LSE_{1n} modes.

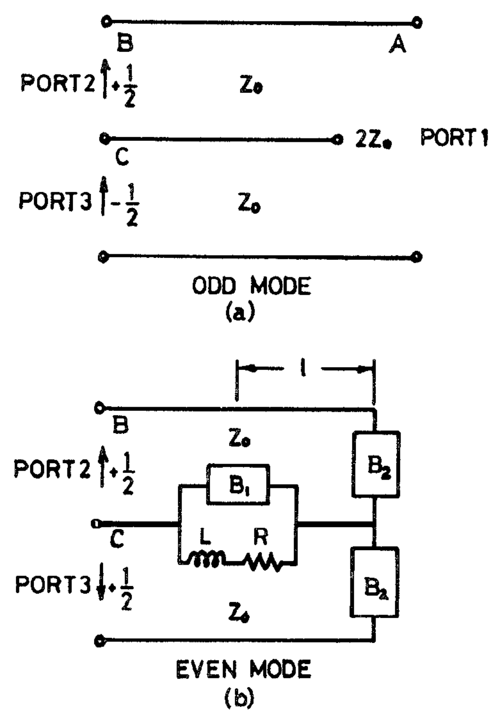

Figure 2. Equivalent Circuit of Power Divider

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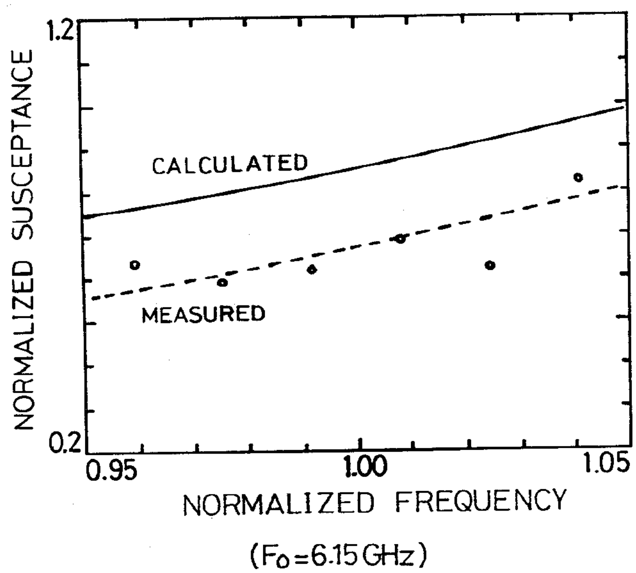

Figure 3. Susceptance B_2 due to LSE_{1n} Modes

Tó obtain an ideal 3 dB power divider, following conditions are required.

$$S_{22} = S_{33} = \frac{1}{2}(\Gamma_e + \Gamma_o) \simeq \frac{1}{2}\Gamma_e = 0 \qquad (1)$$

$$S_{32} = S_{23} = \frac{1}{2}(\Gamma_e - \Gamma_o) \simeq \frac{1}{2}\Gamma_e = 0 \qquad (2)$$

where Γ_e is the even mode reflection coefficient. The circuit parameters to satisfy the above condition are given by the following equations.

$$l = \frac{\lambda g}{4} - \frac{\lambda g}{2\pi}\tan^{-1}(Z_0 B_2) \qquad (3)$$

$$B_1 \simeq \omega L/R^2 \qquad (\omega L \ll R) \qquad (4)$$

$$R \simeq Z_0 \qquad (\omega L \ll R) \qquad (5)$$

where λ_g is the guide wavelength, and l is the distance from the slot to the edge of the septum, and Z_o is the characteristic impedance of the waveguides B and C.

As a result of the design, the distance l becomes approximately $\lambda_g/6$ for $a/b = 2$ from Figure 3 and equation (3). The length of the slot becomes slightly longer than half a wavelength to cancell out the inductance L of the resistor. The resistance R becomes equal to the characteristic impedance Z_0.

Experiment

A 6 GHz-band power divider was constructed. Figure 4 shows the photograph of the power divider. Resistance coated on a dielectric substrate was used as the isolation resistor. Figure 5 shows the measured performance. The VSWR is less than 1.12, and the insertion loss and amplitude unbalance are 0.15 dB and 0.02 dB respectively, and the isolation remains below 27 dB over the 10% frequency band.

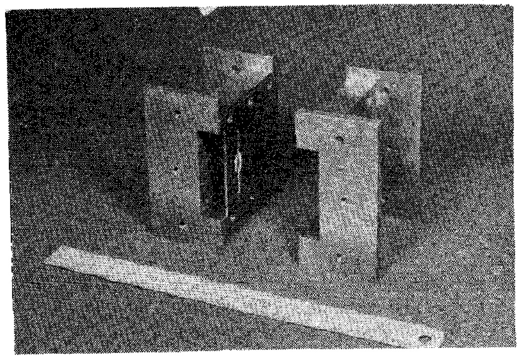

Figure 4. 6 GHz-Band 3 dB Power Divider

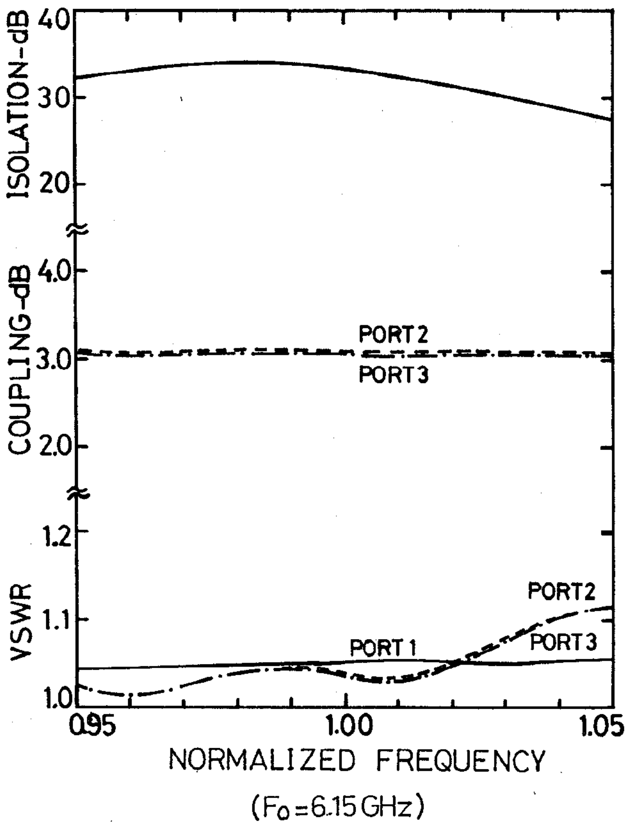

Figure 5. Measured Performance of Power Divider

Conclusion

A waveguide power divider using a metallic septum with a resistive coupling slot was presented. A high isolation and a low insertion loss were obtained in 6 GHz-band, and the above theory was experimentally verified.

References

1. Reed, J. and G. J. Wheeler, "A Method of Analysis of Symmetrical Four-Port Networks," IRE Trans. MTT, Vol. MTT-4, October 1956, pp. 246--252.