Microwave Power Divider with Arbitrary Distribution Ratio

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Abstract As is well known, the EM field of TE11 mode at the wall of the circular waveguide changes as sine (or cosine) function azimuthally. So when we attach two perpendicular waveguides to the wall of the circular waveguide and rotate them around the axis of the waveguide, we can distribute the input power between the two waveguides with arbitrary distribution proportion. We have designed a new power divider following this idea. The 3D electromagnetic simulation software HFSS is used in the design. And a new type circular TE11 mode launcher is developed.

Key words microwave power divider, circular TE11 mode launcher, microwave components design

1 Introduction

The distribution ratio of power dividers is usually fixed. If the distribution ratio can be adjusted, the system will be more flexible. We have observed that the electric field of TE11 mode at the wall of the circular waveguide changes as the sine (or cosine) function azimuthally. This character can be used to design an adjustable power divider. We have explored this intuitive idea using the 3D electromagnetic simulation software HFSS and developed a 30GHz power divider successfully.

We also have developed a new type circular TE11 mode launcher, which is very useful to many microwave devices.

2 Power divider design

The model of the power divider is shown in Fig. 1. It consists of a circular TE11 mode launcher, a straight circular waveguide, two short circuit waveguides for matching and two output waveguides. As the circular waveguide rotates around its axis, the power distributions in the two output rectangle waveguides change accordingly.

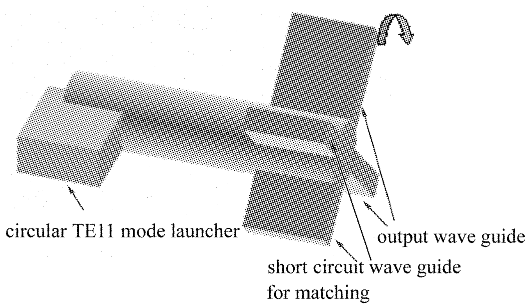

Fig. 1. The model of the power divider

2.1 Circular TE11 mode launcher[1]

The circular TE11 mode launcher can be used in many kinds of devices such as rotary variable attenuator, phase shifter and many ferrite devices. Traditionally it is made by tapering the rectangle waveguide to the circular waveguide. We have developed a new type circular TE11 mode launcher. It is made by simply connecting a standard rectangle waveguide to the sidewall of a circular waveguide. The model and its electric field are shown in Fig. 2. Matching can be met by adjusting the depth and width of the connection. Its band-

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width can be better than 20% . The new mode launcher is very simple and much easier to be fabricated than the traditional one.

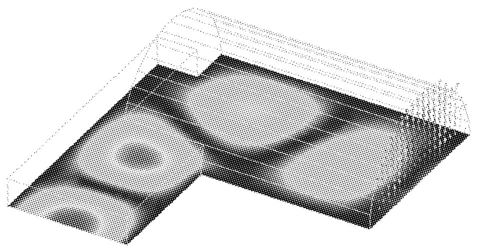

Fig. 2. Circular TE11 mode launcher

2.2 The Power Divider

The electric field at the wall of the circular waveguide[2] can be written as

$$E_r = -\sigma_0 H_0 \frac{\beta}{\beta_c^2 \cdot a} \sin\theta. \tag{1}$$

The plots of the electric field at different angles are shown in Fig.3. At 0 degree, there is no power flow to port 1. All the power goes to port 2. As the waveguide rotates, the power distribution between the two output ports changes. At 45 degree, the power divides equally between the two outputs. At 90 degree, all power goes to port 1 and no power flows to port 2. The change of the magnitude of the electric field in the two output waveguides as the waveguide rotates is shown in Fig.4. It can be seen that the change of the electric field magnitude in the two output ports coincides very well with sine and cosine functions. The output powers from port 1 and port 2 are

$$\begin{aligned} P_1 &= P_{\text{input}} \sin^2\theta \\ P_2 &= P_{\text{input}} \cos^2\theta \end{aligned} \tag{2}$$

The reflection at different angles is shown in Fig. 5. It

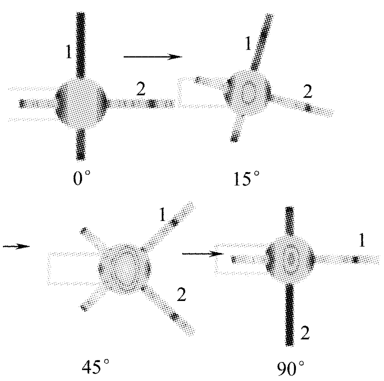

Fig. 3. Electric field at different angles

can be seen that the matching is very good in the full range. The bandwidth (S11 under −20dB) at different angles is shown in Fig. 6.

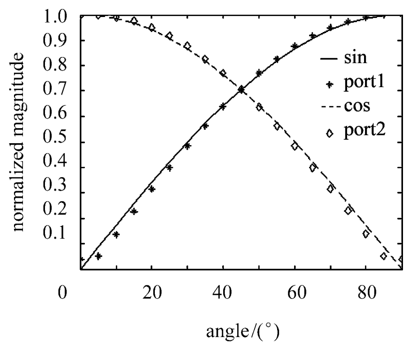

Fig. 4. Magnitude of the electric field in the two output waveguides at different angles

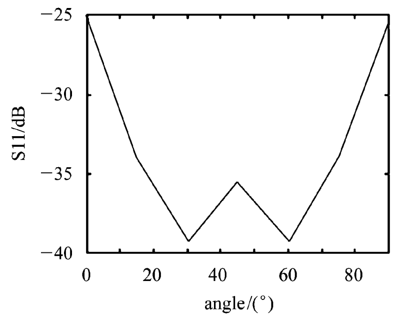

Fig. 5. change of S11 with rotation

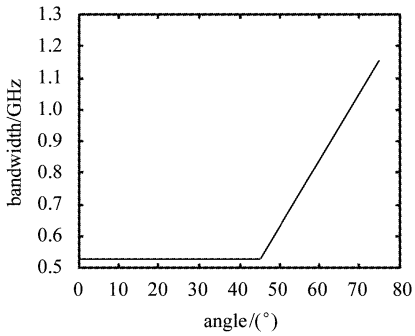

Fig. 6. Change of bandwidth with rotation

3 Conclusion

The concept to design a power divider with arbitrary distribution ratio has been fully tested. A new 30GHz power divider has been designed using HFSS. The design concept can be easily adapted to other working frequencies. The new circular TE11 mode launcher is also very useful in many microwave devices.

References

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任意分配比的微波功率分配器

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摘要　圆波导中 TE11 模式波的电场在波导壁上随角度按正弦(或余弦)变化.如果在其侧壁上沿径向接两根互相垂直的波导,波导绕轴转动时两根波导中所分配的功率将随旋转角度而变化.这样就可以设计出任意分配比的微波功率分配器.通过 HFSS 的模拟计算完成了该功分器的设计,同时设计了一个新型的圆波导 TE11 模式转换器.

关键词　微波功率分配器　圆波导 TE11 模式转换器　微波器件设计

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