# A 19-WAY ISOLATED POWER DIVIDER VIA THE $TE_{01}$ CIRCULAR WAVEGUIDE MODE TRANSITION

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## ABSTRACT

A 19-way waveguide isolated power divider has been developed with broad bandwidth, low insertion loss and high isolation. Its design allows a flexible number of output ports and uneven power distribution. It can be used as a feed network for an antenna array and, due to this power divider's high isolation characteristics, it can be used as a power combiner for a high power amplifier.

## INTRODUCTION

Conventional power dividers are generally found in TEM line form, (1-4) i.e., coaxial radial line, strip line and microstrip line form. When in waveguide form, the number of output ports are limited to four (5,6) due to the complicated waveguide junction geometry. The TEM line power divider is lossy and difficult to fabricate at millimeter wave frequencies. Conventional waveguide power dividers are disadvantaged by the limited number of output ports.

This paper presents a waveguide power divider designed with a large number of output ports, such as 20 or 40. The number of output ports as well as the power division among the output ports is flexible. This flexibility provides a convenient feature for antenna array feed network application. Moreover, high isolation among the outputs can be attained by installing resistive slots and resistive cards at appropriate locations to absorb the unbalanced field. Therefore, the power divider can also be used as a power combiner for a high power amplifier. Since the power divider construction is in waveguide form, it is feasible to extend its application to higher frequencies, whereas microstrip power dividers might have fabrication difficulty.

## DEVICE DESCRIPTION

This power divider first converts the rectangular waveguide $TE_{10}$ mode to circular waveguide $TE_{01}$ mode, and then divides power from circular $TE_{01}$ mode to many rectangular waveguides with $TE_{10}$ mode along its circumference direction. Because of the large ratio of the circumferential distance of the circular waveguide for $TE_{01}$ mode to the linear distance of the narrow side of $TE_{10}$ rectangular waveguide, a power divider with a large number of output ports can be designed.

A mode transducer (7) with multisection design is used to convert the $TE_{10}$ rectangular waveguide mode to the $TE_{01}$ circular waveguide mode. Each transducer section is a waveguide taper with specially-designed cross-sections. These cross-sections are designed with dimensions according to mode symmetry which guide the wave to make the desired transformation without generating spurious modes. The cross-section geometry and mode patterns at various intermediate stages in the transducer are shown in Figure 1. After the $TE_{01}$ mode is launched in the circular waveguide, the wave is forced to make a $90^{\circ}$ turn toward its radial direction and consequently makes power division along its E-plane by a number of equally-spaced metallic septums (or nonequally spaced septums for a power divider with nonuniform power division). The divided power is transmitted to individual output ports.

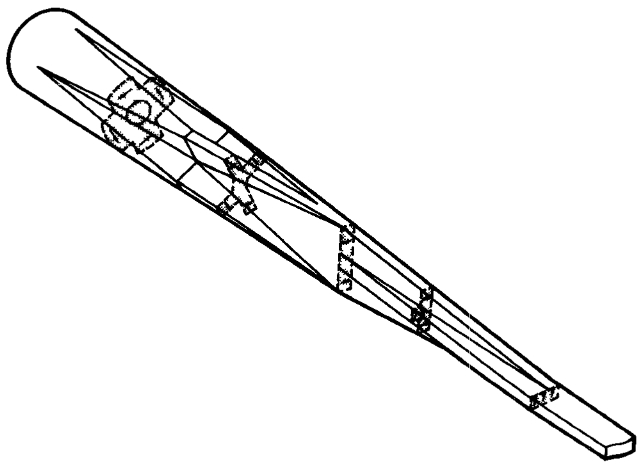

Figure 1. Mode Conversion Characteristics in a Mode Transducer from the Rectangular Waveguide $TE_{10}$ Mode to the Circular Waveguide $TE_{01}$ Mode

The septums used for power dividing do not disturb the model field due to the natural mode



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characteristics. Therefore, good broadband performance is obtainable. Moreover, a resistive slot (5) may be installed in the septum to absorb the unbalanced field and consequently to improve the output port matching and isolation. For further isolation, improvement resistive cards may be inserted radially. This would not disturb normal operation of the $TE_{01}$ mode, but would absorb other spurious modes generated.

EXPERIMENTAL MODEL OF A 19-WAY POWER DIVIDER

The 19-way power divider, Figure 2, is designed for equal power division among the output ports which feed a phased array antenna. Figure 3 reveals internal construction; indicating the resistive slots and the mode suppressing resistive cards. The spurious mode suppressing techniques used in the power divider design provide an average of 30 dB isolation (Figures 4 through 7) among the output ports, except for the adjacent port isolation of 20 dB. The typical output return loss of 15 dB is obtained as shown in Figure 8. The measured input return loss of 12 to 15 dB (see Figure 9) is contributed by using the short mode transducer. Better than 18 dB input return loss is feasible if a longer mode transducer is used. The typical insertion characteristics are measured as shown in Figure 10. The average value is 13.5 dB with a ripple of 0.5 dB. A perfect 19-way power divider has a signal level difference between the input port and the output port of 12.78 dB. Thus, the measured 13.5 dB loss is actually an insertion loss of only 0.72 dB. This 0.72 dB insertion loss seems high for a waveguide structure, but this is due to the poor contact among the joints of the metallic parts and the asymmetry of the resistive cards. With careful fabrication, the insertion loss could be below 0.4 dB.

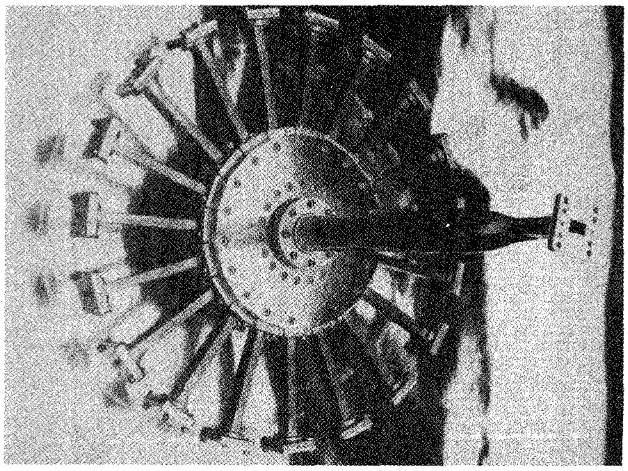

Figure 2. 19-Way Power Divider Prototype

CONCLUSION

A waveguide isolated power divider with many output ports has been developed. It exhibits broad bandwidth, low insertion loss and high isolation. The power divider high isolation feature allows it to be used as power combiner for a high power amplifier. Since the power divider is in waveguide form, its application may be exended to higher frequencies of over 100 GHz.

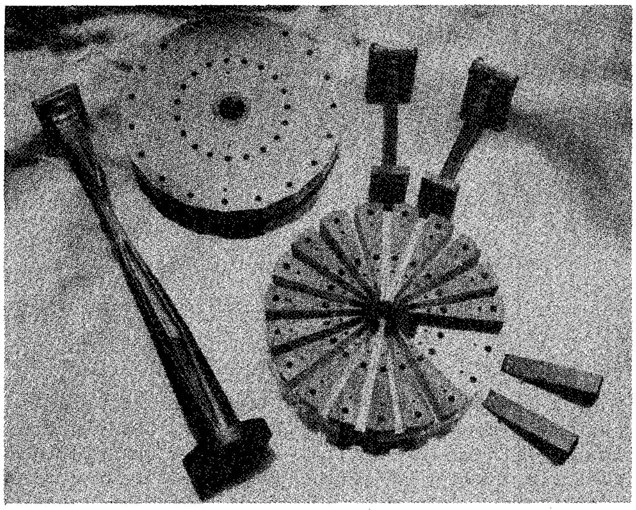

Figure 3. Disassembled Parts of a 19-Way Power Divider Prototype

This power divider allows variation in the number of output ports and in the amount of power divisions, and thus may be conveniently used to feed an antenna array. A tedious cascading feed network of two- and three-way power dividers would otherwise be required.

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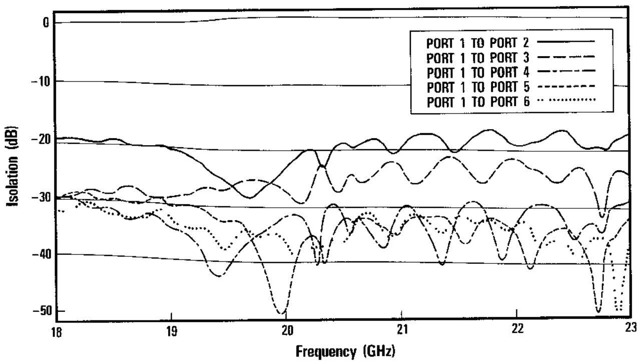


Figure 4. Output Port Isolation Characteristics-I

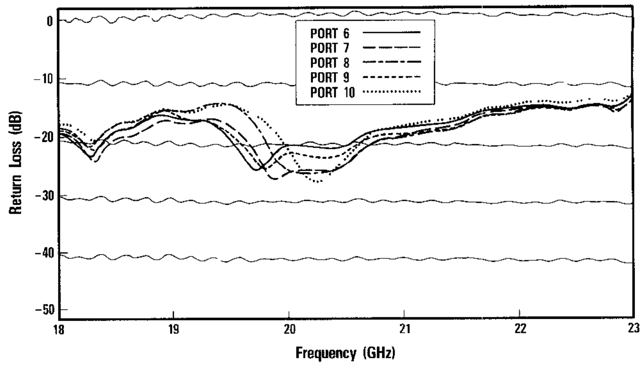


Figure 8. Typical Output Return Loss Characteristics

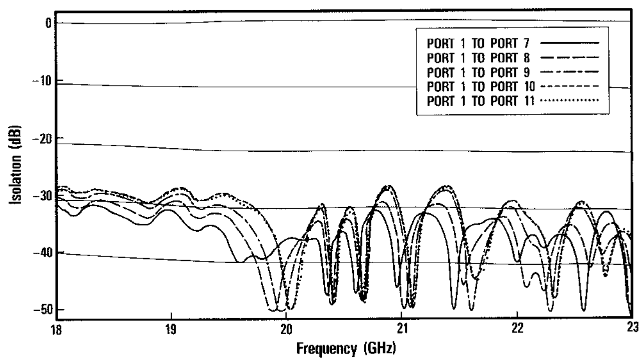


Figure 5. Output Port Isolation Characteristics-II

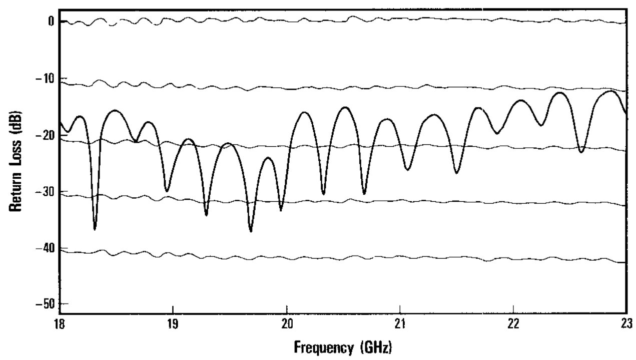


Figure 9. Input Return Loss Characteristics

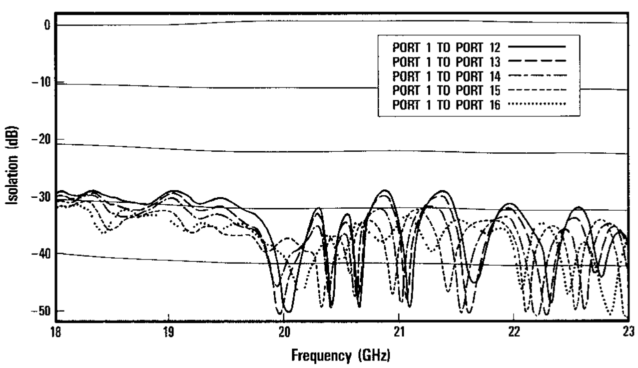


Figure 6. Output Port Isolation Characteristics-III

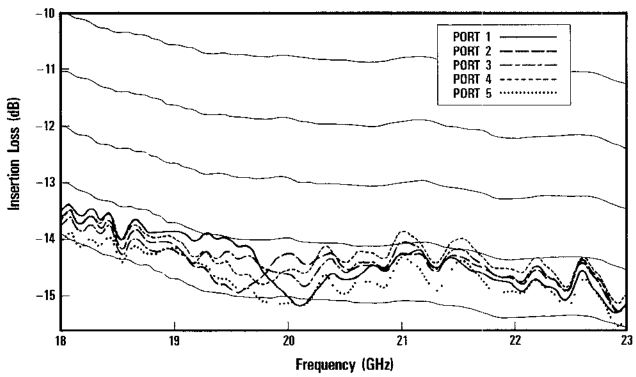


Figure 10. Typical Insertion Loss Characteristics

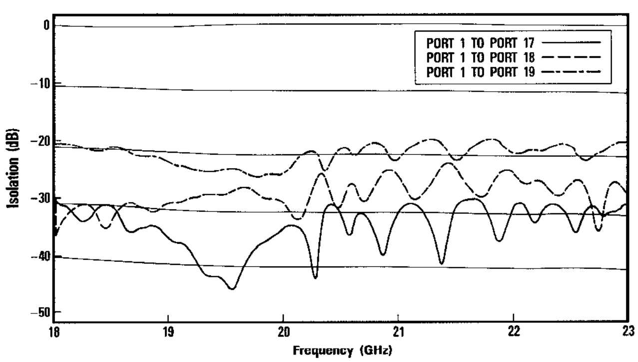


Figure 7. Output Port Isolation Characteristics-IV