Circular-to-Rectangular Waveguide Diplexers

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Abstract— **Design of circular-to-rectangular waveguide diplexers with circular waveguide as common port is presented. A ridged circular-to-rectangular waveguide T-junction is proposed as diplexing manifold. Full-wave optimization is used in the diplexer design. A Ka-band H-plane circular-to-rectangular waveguide diplexer is designed. Measured results are in good agreement with computed results.**

I. Introduction

The success of emerging Ka-band satellite systems for multimedia and broadband high-speed internet access is critically dependent on the availability of low-cost consumer terminals. Major cost drivers of these terminals are the RF/microwave subsystems and components. One of the most challenging components is the diplexer, which allows the use of a single antenna feed for both transmit and receive functions. The diplexer has stringent requirements on insertion loss, in-band flatness, selectivity, and rejection. For low-cost mass production, the diplexer must be designed to satisfy these stringent performance requirements and requires no manual tuning or adjustments. In [1], the design of a Ka-band H-plane rectangular waveguide diplexer is described. In some applications, the common port of the diplexer may interface with a circular waveguide to be used in linear- or circular-polarization feed systems.

In this paper, design of circular-to-rectangular waveguide diplexers with circular waveguide as common port is presented. Fig. 1 shows the diplexer configuration. A ridged circular-to-rectangular waveguide T-junction is proposed as diplexing manifold. A Ka-band H-plane circular-to-rectangular waveguide diplexer is designed. Measured results are in good agreement with computed results.

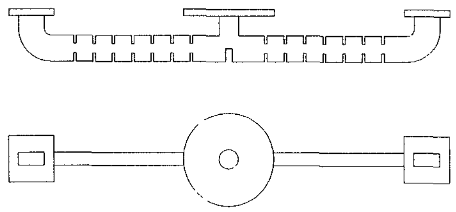


Fig. 1. Circular-to-rectangular waveguide diplexer.

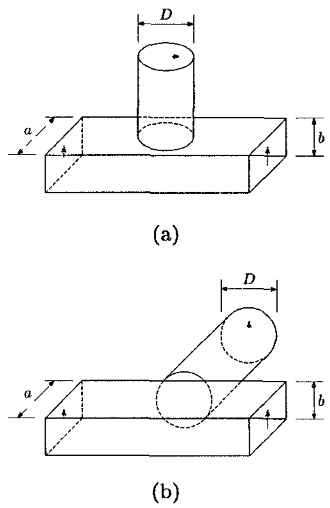


Fig. 2. Circular-to-rectangular waveguide T-junction. (a) E-plane. (b) H-plane.

II. Circular-to-Rectangular Waveguide T-Junction

The dominant mode of the circular waveguide is TE_{11} mode, having a cutoff wavelength $\lambda_c = 3.41D/2$ (D is the cross-section diameter of the circular waveguide.) The TE_{11} mode is degenerate: two polarizations which are orthogonal to each other can prop-

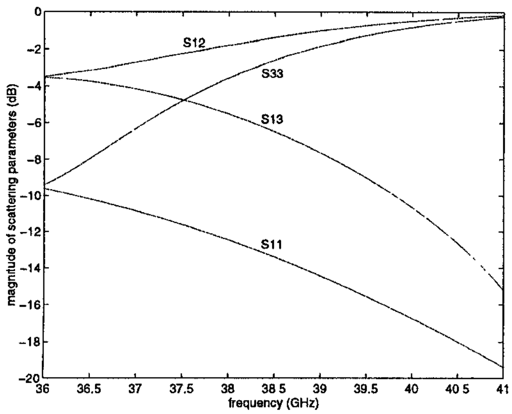


Fig. 3. Magnitude of scattering parameters of the H-plane T-junction of Fig. 2(b). Dimensions in inches are: $a = 0.28$, $b = 0.14$, and $D = 0.21$. Ports 1 and 2 are of the rectangular waveguides, and port 3 is of the circular waveguide.

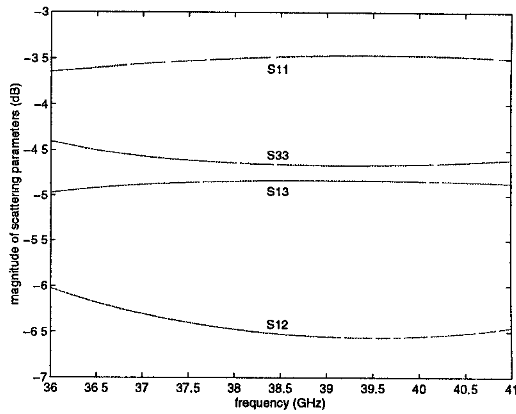


Fig. 5. Magnitude of scattering parameters of the ridged H-plane T-junction of Fig. 4. Dimensions in inches are: $a = 0.28$, $b = 0.14$, $D = 0.21$, $w = 0.14$, and $s = 0.08$. Ports 1 and 2 are of the rectangular waveguides, and port 3 is of the circular waveguide.

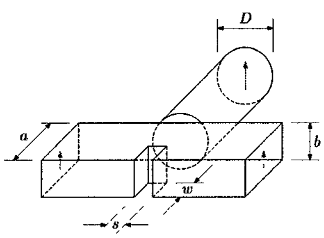


Fig. 4. Ridged H-plane circular-to-rectangular waveguide T-junction.

agate simultaneously. To ensure that only a single TE_{11} mode of the specified polarization can propagate, the circular-to-rectangular waveguide T-junction should be configured properly such that the other polarization cannot be supported by the boundary condition of the junction [2]. Such configuration is shown in Fig. 2. For the E-plane T-junction, the junction structure should be symmetric with respect to the half-a plane, which can be viewed as a perfect magnetic conductor (PMC). For the H-plane T-junction, the junction structure should be symmetric with respect to the half-b plane, which can be viewed as a perfect electric conductor (PEC).

Fig. 3 shows the magnitude of scattering parameters of the H-plane T-junction of Fig. 2(b) versus frequency. It has been proved [3] that the necessary conditions for an optimum three-port symmetric diplexing manifold are that the reflection coefficients of all three ports are approximately equal to or greater than 1/3, and their dispersion over the frequency band covering all channel filters is as small as possible. It is seen from Fig. 3 that the scattering parameters of the H-plane T-junction of Fig. 2(b) are highly frequency dependent, and the magnitude of S_{11} is less than 1/3 (-9.5 dB). Hence, the T-junction is not suitable to be used as diplexing manifold. Instead, a ridged H-plane circular-to-rectangular waveguide T-junction shown in Fig. 4 is proposed. By adjusting the ridge dimensions w and s, an optimum H-plane T-junction is obtained. Fig. 5 shows its magnitude of scattering parameters versus frequency. It is seen that all scattering parameters are nearly frequency independent, and the magnitudes of S_{11} and S_{33} are approximately equal to 0.67 (-3.5 dB) and 0.60 (-4.5 dB) over the whole frequency band. In next Section, a design example of a Ka-band H-plane diplexer using the ridged circular-to-rectangular waveguide T-junction as manifold is presented.

III. Diplexer

A Ka-band H-plane circular-to-rectangular waveguide diplexer using the ridged T-junction described in last Section is designed. Table I gives the design specification. Both channel filters are of six-section Tchebyscheff inductive-window type. In the modeling of the inductive-window channel filters, the rounded corner inherently introduced by the milling fabrication is taken into account using step approximation [1]. This is necessary since at Ka-band, the curvature radius of the rounded corner is in the order of the

TABLE I
SPECIFICATION OF THE DIPLEXER.

channel 1 passband	38.600 GHz – 38.950 GHz
channel 2 passband	39.300 GHz – 39.650 GHz
passband return loss	15 dB
passband insertion loss	2 dB
channel isolation	50 dB
channel 1 rejection	45 dB below 38.025 GHz
channel 2 rejection	45 dB above 40.225 GHz

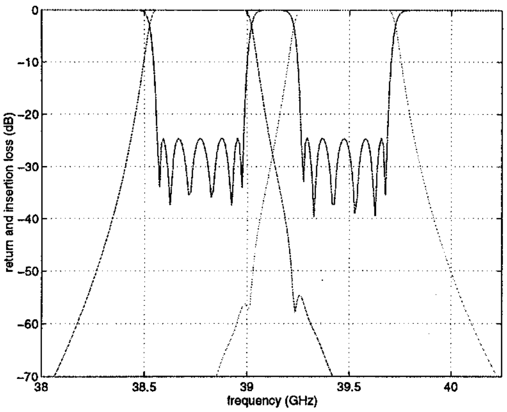
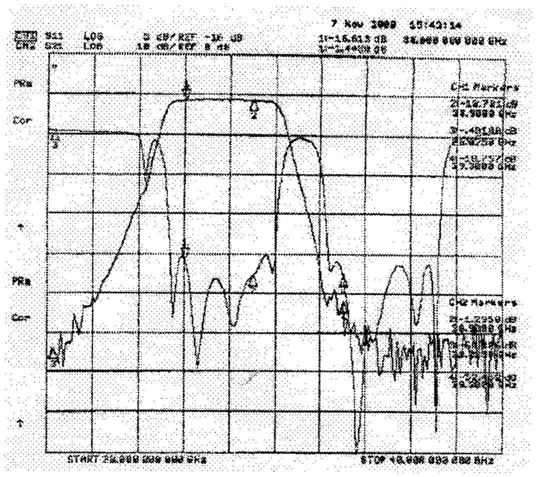
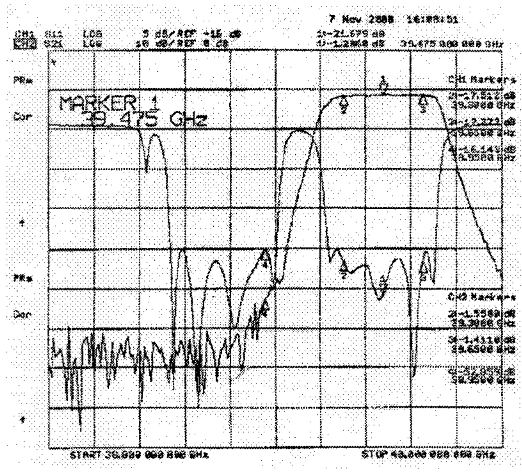


Fig. 6. Computed response of the diplexer.



(a)



(b)

Fig. 7. Measured response of the diplexer. (a) Channel 1. (b) Channel 2.

waveguide dimensions, and moreover, the size of the tuning screw is comparable with the waveguide size, which makes post-fabrication tuning difficult. In the diplexer design, a systematic optimization procedure is employed [1], [4].

Figs. 6 and 7 show the computed and measured responses of the diplexer, respectively. The measured results are in good agreement with the computed results, and the design specification is achieved. There is a dip next to the low-band channel approximately at 38.43 GHz. It is due to the imperfect transition between the circular waveguide and the rectangular waveguide test standard. The measurement of a back-to-back transition connection shows a dip at the same frequency.

IV. SUMMARY

Design of circular-to-rectangular waveguide diplexers with circular waveguide as common port is presented. A ridged circular-to-rectangular waveguide T-junction is proposed as diplexing manifold. Full-wave optimization is used in the diplexer design. A Ka-band H-plane circular-to-rectangular waveguide diplexer is designed. Measured results are in good agreement with computed results.

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