A Rectangular-to-Radial Waveguide Transformer through a Ring Slot for Excitation of a Rotating Mode

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1 Introduction

A radial line slot antenna (RLSA) is a high gain and high efficiency planar antenna proposed for DBS subscribes in 12GHz band [1]. In recent years, variety of radio systems have been developed in millimeter wave band [2].

In conventional RLSA, a radial waveguide is feeded by a coaxial feeder. In millimeter wave band, the fabrication of feeder is considerably difficult, since the volume of the feeder is small. High accuracy in manufacturing is necessary to realize excellent antenna efficiency [3]. We have proposed the planar feed circuit with the ring slot and the microstrip line [4]. The feed circuit can be integrated with RF planar circuit in the future. In these structure, however, the undesired radiation to the back of the antenna is significant and the antenna efficiency is degraded. In terms of efficiency in millimeter wave band, the rectangular waveguide is more attractive for feeding a radial waveguide.

In this presentation, a rectangular-to-radial waveguide transformer through a ring slot is proposed. This transformer is slightly bulky, however there is no leakage radiation. So, the efficiency of this feed system must be high. It is suitable for integrating with existing RF modules that have an interface to the rectangular waveguide.

The rectangular-to-radial waveguide transformer through a ring slot is designed and produced at 12GHz band and reasonable characteristic is realized.

2 Structure

Figure 1 shows the structure of the feed circuit. The rectangular waveguide is connected to the center of a lower plate of the radial waveguide. The radial waveguide is excited through the ring slot. This structure is very simple.

To obtain the rotating mode ($e^{j\phi}$:uniform in amplitude and linearly tapered in phase in ϕ-direction), I-slot is placed at the center of the ring. The rotating mode is used for obtaining a pencil beam in the broadside of a concentric array RLSA (CA-RLSA) [5].

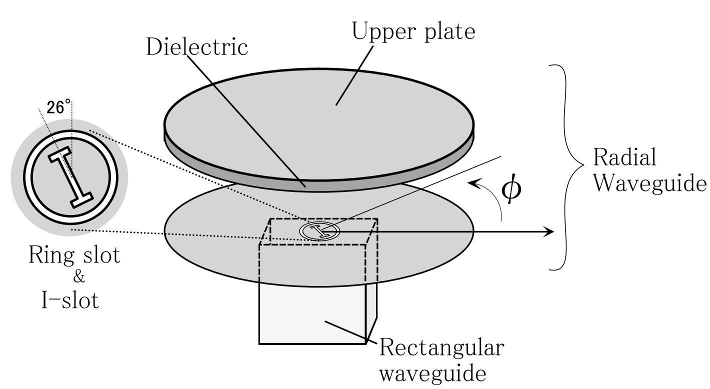

Figure 1: Structure of feed circuit with the rectangular waveguide

3 Design

The feed circuits are designed and fabricated for 12GHz band. The parameters of the feed circuit are optimized by using a simulation software (Ansoft HFSS). The parameters are shown in Table 1. The circumference of the ring slot is set to be about one wavelength. The size and the angle of the I-slot is decided to excite a reasonable rotating mode. The rectangular waveguide is WRJ120.

4 Experimental results

The inner field distribution in ϕ-direction at 11.5GHz is shown in Figure 4. This results are measured near the open-end by a probe like Figure 3. The ripple of the amplitude in ϕ-direction is 5.3dB,which is reasonably uniform. The phase is linearly tapered. The ripple of the phase is 23deg. These results show that rotating mode is excited in the radial waveguide.

Figure 5 shows the amplitude ripple as a function of the frequency. The aperture efficiency of the antenna is affected by a deviation of the amplitude distribution [6]. This effect is shown in Table 2. From Figure 5, the bandwidth which maintains the ripple of the amplitude below -6dB and -9dB is about 200MHz and 400MHz respectively. These results show that the bandwidth of the rotating mode excitation is almost equivalent to an electric-wall cavity resonator.

Figure 6 shows the reflection of the feed circuit. The measured result shows similar tendency to the prediction. The measured reflection at 11.5GHz is -16.8dB and reasonably suppressed. The bandwidth, which maintains the reflection below -15dB, is about 350MHz.

5 Conclusion

A rectangular-to-radial waveguide transformer through a ring slot is proposed. It is designed and fabricated for 12GHz. The measured ripple of the amplitude is 5.3dB and that of the phase is 23deg in ϕ-direction. These results show that the reasonable rotating mode is excited. To apply this transformer in millimeter wave band and to restrain the ripple of the amplitude are future study.

References

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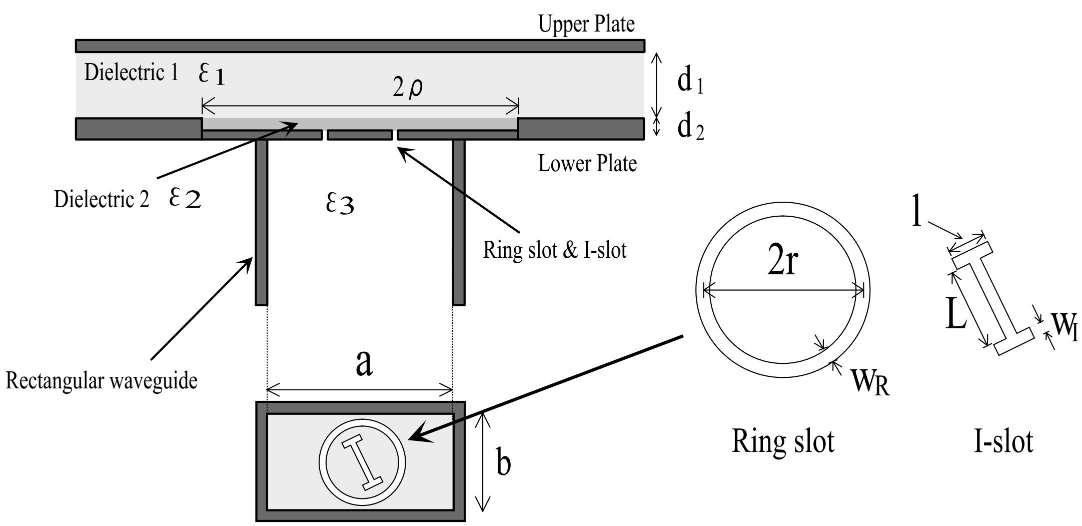


Figure 2: Feed circuit

Table 1: Parameter of feed circuit

Ring slot	Diameter: $2r$ [mm]	8.1
	Width: w_R [mm]	0.7
I-slot	Length of short slot: l [mm]	2.0
	Length of long slot: L [mm]	4.2
	Width: w_I [mm]	0.6
	Angle: θ [deg]	26
Rectangular waveguide	Width of broad wall: a [mm]	19.05
	Width of narrow wall: b [mm]	9.525
	Permittivity: ε_3	1.0
Radial waveguide	Height of dielectric1: d_1 [mm]	3.0
	Height of dielectric2: d_2 [mm]	0.5
	Diameter of dielectric2: 2ρ [mm]	70
	Permittivity: ε_1	1.17
	Permittivity: ε_2	2.17

Table 2: The effect of the amplitude ripple

Ripple of amplitude	Decline of aperture efficiency
-6 dB	10 %
-9 dB	20 %

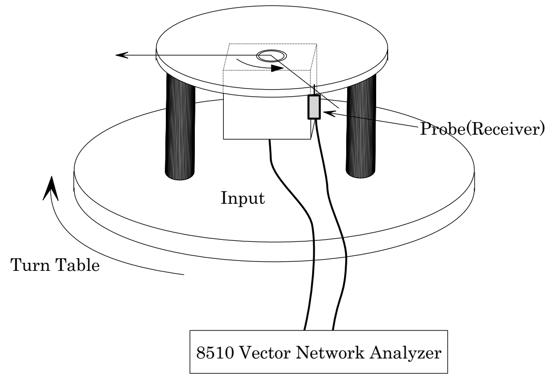
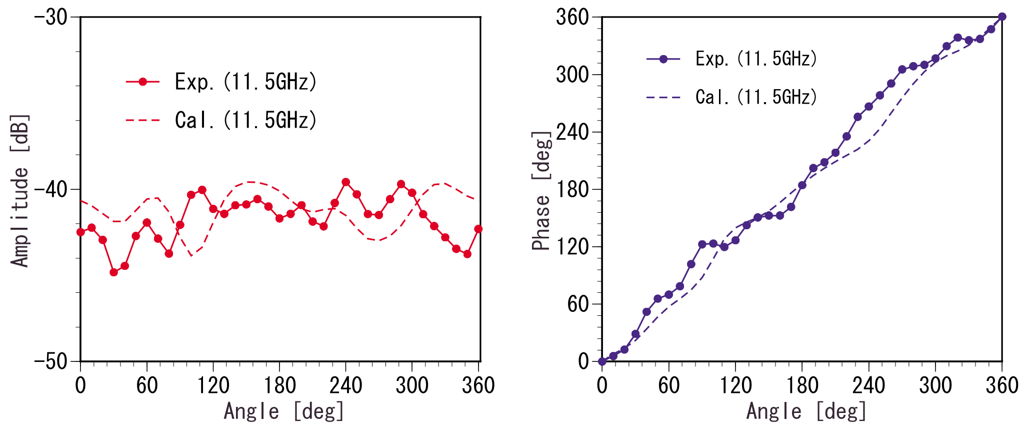


Figure 3: The way of the experiment



(a) Amplitude

(b) Phase

Figure 4: Field distribution in ϕ-direction

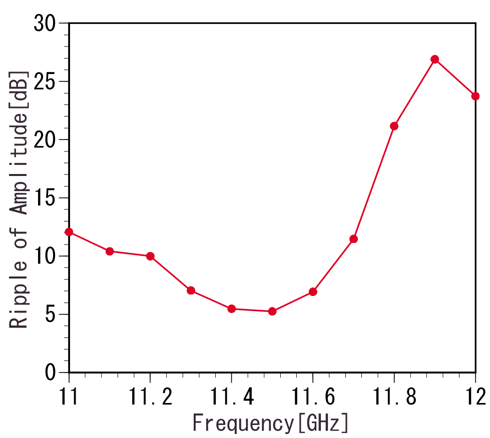


Figure 5: Ripple of amplitude

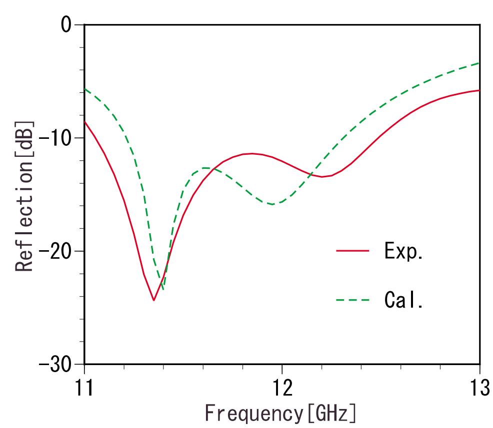


Figure 6: Reflection