POS1-15

Design of Modified Dual Mode Horn Antenna to Improve E/H-plane Radiation Pattern Symmetry

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1. Introduction

Dual mode horn antenna is widely used in reflector antenna systems to illuminate symmetric E/H-plane radiation patterns to a reflector surface. Symmetric E/H-plane radiation pattern can improve the total gain of the reflector antenna system and allows a design of a reflector to be symmetric [1]. Dual mode horn antenna was developed by Potter [2] and many designs have been proposed to have symmetric E/H-plane radiation pattern [3]-[7]. The mode at the aperture of the dual mode horn antenna is hybrid mode (HE_{11} mode) which consists of approximately 85% of TE_{11} mode and 15% of TM_{11} mode [8] and the antenna radiates gaussian-like beam pattern, and therefore the E/H-plane radiation patterns are symmetric ideally. However, if the aperture size of a dual mode horn antenna is increased to attain the desired gain or beamwidth for the reflector antenna system, ideal HE_{11} mode is difficult to be attained at the aperture because undesired high order modes which lead asymmetric E/H-plane radiation patterns are generated. In this paper, modified dual mode horn antenna with rectangular aperture is proposed to improve the E/H-plane radiation pattern symmetry in oversized aperture horn. Simulation and experimental results show that the proposed dual mode horn antenna has the improved E/H-plane radiation pattern symmetry compared to a conventional circular dual mode horn antenna.

2. Design of dual mode horn antennas

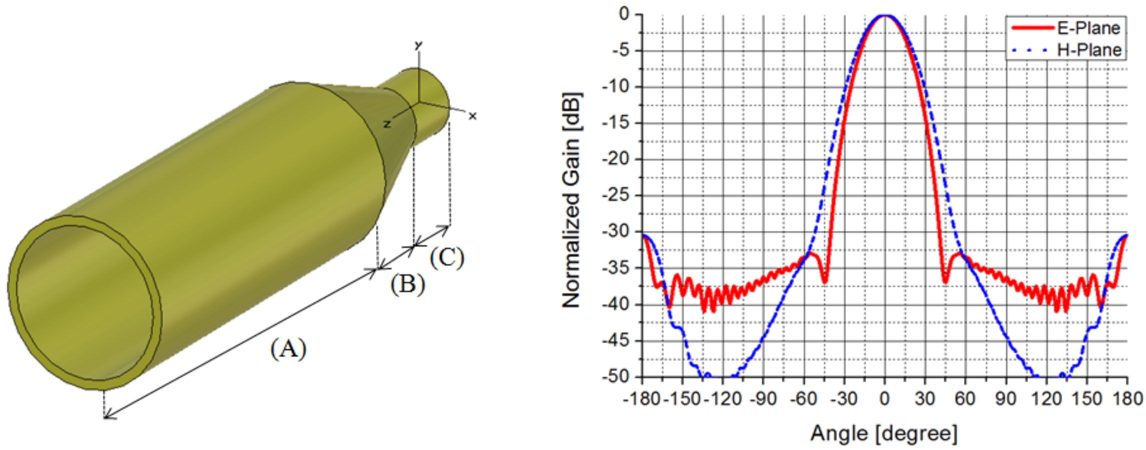
To verify compatibility, the conventional and proposed dual mode horn antenna are designed and simulated at 15 GHz.

2.1 Conventional circular dual mode horn antenna design

A conventional circular dual mode horn antenna is designed for the reflector antenna system with f/d ratio = 1 where the half of the subtend angle from the feed to the reflector aperture is 26.5°. Edge illumination = -11 dB is selected for the maximum reflector antenna aperture efficiency [9], Therefore -11 dB beamwidth can be set as 53° (-26.5° ~ 26.5°). To satisfy this condition, aperture diameter of the horn is selected as 46.87 mm (≈ 2.34 λ) and tapering angle and the length of the phase matching section are calculated as 19.03° and 131.3 mm respectively [10]. Fig. 1(a) shows the structure of the conventional circular dual mode horn antenna where (A) is phase matching section, (B) is tapering section and (C) is feeding section. The excitation mode is TE_{11} mode and the length of the feeding section is 20 mm. Fig. 1(b) depicts the simulated normalized radiation patterns of the conventional circular dual mode horn antenna. It shows that there are differences between E and H-plane radiation pattern within the desired beamwidth because undesired high order modes are generated in oversized structure. The detailed values of the differences between the E/H-plane radiation pattern within desired -11 dB beamwidth are presented in Table Ⅰ.

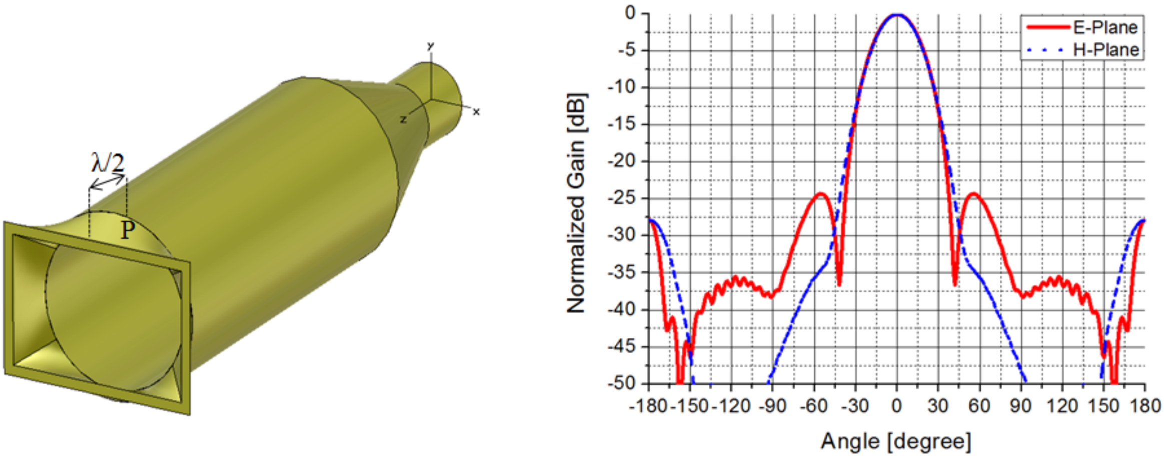
2.2 Proposed dual mode horn antenna design

As shown in previous section, E/H-plane radiation pattern symmetry is difficult to be obtained with a oversized conventional circular dual mode horn antenna due to undesired high order modes. To improve E/H-plane radiation pattern symmetry in a oversized circular dual mode horn



(a) (b)

Figure 1: The conventional circular dual mode horn antenna (a) designed structure and (b) normalized E/H-plane radiation patterns(Simulated)



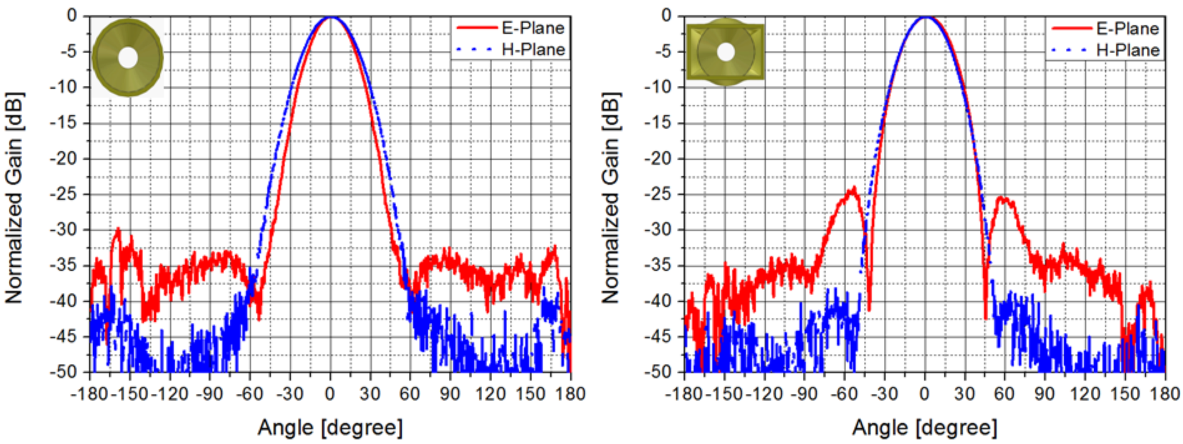
(a) (b)

Figure 2: The proposed dual mode horn antenna (a) designed structure and (b) normalized E/H-plane radiation patterns(Simulated)

antenna, a dual mode horn antenna with modified aperture is proposed. From the fact that a large aperture antenna has narrow radiation beam pattern compared to a small aperture antenna, the horizontal length (x-axis direction) of the circular aperture of the conventional circular dual mode horn antenna is increased to narrow the H-plane beamwidth. Otherwise the vertical length (y-direction) is reduced to broaden the E-plane beamwidth compared to the conventional circular dual mode horn antenna. For a simple fabrication process, rectangular aperture shape is selected to satisfy the above procedure. Fig. 2(a) shows the proposed dual mode horn antenna structure. Every dimension is the same as the conventional circular dual mode horn antenna except the aperture dimension. The aperture shape transition start point (P) is decided experimentally which started 10 mm (= $\lambda/2$) back from the aperture. The horizontal and the vertical length of the rectangular aperture are increased by 10 mm and reduced by 10 mm respectively compared with the diameter of the conventional circular dual mode horn antenna. Fig. 2(b) illustrates the simulated normalized radiation patterns of the proposed dual mode horn antenna. It shows that the E/H-plane radiation pattern symmetry is improved compared to the conventional circular dual mode horn antenna within desired -11 dB beamwidth (-26.5° ~ 26.5°). On the other hand, the side lobe level on the E-plane is increased because the reduced vertical length of the aperture leads stronger electric field on upper and lower boundary surfaces. However, if the desired beamwidth is selected within an angle where an sidelobe arises, the problem can be disregarded.

(a) (b) (c)

Figure 3: Fabricated structures of (a) the conventional circular dual mode horn antenna, (b) the proposed dual mode horn antenna and (c) measurement environment



(a) (b)

Figure 4: Normalized E/H-plane radiation patterns(Measured) of (a) the conventional circular dual mode horn antenna and (b) the proposed dual mode horn antenna

3. Fabrication and measurement

The fabricated conventional circular dual mode horn antenna and the proposed dual mode horn antenna are shown in Fig. 3(a) and (b) . Both antennas are fabricated by milling machine process which is ordinary fabrication method of a horn antenna. Fig. 3(c) shows that far-field measurement system environment. Fig. 4 illustrates the measured E/H-plane radiation patterns of the each antenna. The measured result shows very good agreement with the simulation results. It shows that the proposed dual mode horn antenna has improved the E/H-plane radiation pattern symmetry compared to the conventional circular dual mode horn antenna within desired -11 dB beamwidth. Table Ⅰ illustrates the detailed values of the E/H-plane radiation pattern differences. For the conventional circular dual mode horn antenna, when the angle is increased 0 to 26.5°, the E/H-plane radiation pattern differences increase from 0 to 3.394 dB. On the other hand, the radiation pattern differences of the proposed dual mode horn antenna is varied only from 0 to 0.5398 dB within the desired beamwidth.

4. Conclusion

A modified dual mode horn antenna with rectangular aperture is proposed to improve the E/H-plane radiation pattern symmetry compared to the oversized conventional dual mode horn

Table 1: E/H-plane Radiation Pattern Differences.

Angle [degree]	Conventional circular dual mode horn [dB]		Proposed dual mode horn [dB]	
	Simulate	Measure	Simulate	Measure
0	0	0	0	0
5	0.078	0.1758	0.025	0.0504
10	0.32	0.5641	0.09	0.0123
15	0.75	1.2082	0.17	0.0733
20	1.42	1.4577	0.2	0.0966
25	2.39	1.9447	0.08	0.1680
26.5	2.77	3.3940	0.01	0.5398

antenna. To verify compatibility, the conventional and the proposed dual mode horn antenna are fabricated and investigated at 15 GHz. The proposed antenna can improve the E/H-plane radiation pattern symmetry, therefore the total gain of the reflector antenna systems can be enhanced compared to a reflector antenna system with a conventional circular dual mode horn antenna.

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