Multistep rectangular horn loading grooves for orthogonally polarized elliptical beam

Naoki Kubo, Reiko Omi, Hiroyuki Deguchi, and Mikio Tsuji
Graduate School of Science and Engineering, Doshisha University
1-3 Tatara Miyakodani, Kyotanabe, Kyoto, 610-0321 Japan

***Abstract* – This paper proposes a new rectangular horn for orthogonal polarized elliptical beams. This consists of two sectoral horns, of which sidewalls have grooves its design is performed by optimization based on the mode-matching method. As a design example, we present a horn with -10 dB beam widths of 33° × 100° at 10 GHz. Effectiveness of the designed horn is verified numerically and experimentally.**

***Index Terms* — elliptical beam, orthogonal dual polarizations, groove, rectangular horn.**

1. Introduction

An elliptical-shaped beam antenna is required for efficient coverage of a specified region. The multimode rectangular horn was developed as a primary radiator of the elliptical-shaped reflectors [1]. It is constructed by arbitrary multistep rectangular taper and radiates an elliptical beam in orthogonal polarization. However its axial length is too long because multisteps are used in a stepwise sharp. Then we have realized the compact rectangular sector horn loading groove for the elliptical-shaped beam antenna [2]. In this paper, to make the elliptical-shaped beam antenna for orthogonal dual-polarization more compact, we propose a new rectangular horn, which consists of two orthogonal sidewalls loading grooves to generate the required higher-order modes. The proposed horn is designed by optimization technique based on the mode-matching method. The performance of the designed horn will be verified by numerical discussions and experiments.

2. Design Method

Fig.1 shows a horn structure having multistep sections with grooves in the *x* and the *y* directions. These sections allow controlling the required higher-order modes efficiently. The feeding section is a square waveguide in which only the orthogonal fundamental modes are supported.

The section #1 manly provides TE_{10}-to-TE_{30} and TE_{01}-to-TE_{21}/TM_{21} mode conversions and then the section #2 mainly provides TE_{10}-to-TE_{12}/TM_{12} mode conversions which are enough to shape the desired radiation patterns. In this case, we should just consider only the above-mentioned modes. Therefore, all the mode conversions can be analyzed by using the mode-matching method easily.

The design parameters $\mathbf{s}$ of the horn are determined by optimizing the following evaluation function

$$F(\mathbf{s}) = \sum_{freq.}\left[F_{peak}(\mathbf{s}) + \sum_{\substack{TE_{10}\\TE_{01}}} \left\{ F_x(\mathbf{s}) + F_y(\mathbf{s}) + F_{cross}(\mathbf{s}) + F_{return}(\mathbf{s}) \right\} \right] \quad ,(1)$$

where $F_{peak}(\mathbf{s})$ is the difference between the co-polar peak levels excited by the TE_{10} and the TE_{01} modes, $F_x(\mathbf{s})$ and $F_y(\mathbf{s})$ are the power level at the specified angles in the *x* and *y* directions corresponding to the edge levels of a reflector antenna, $F_{cross}(\mathbf{s})$ is the cross-polar peak level, and $F_{return}(\mathbf{s})$ is the return loss.

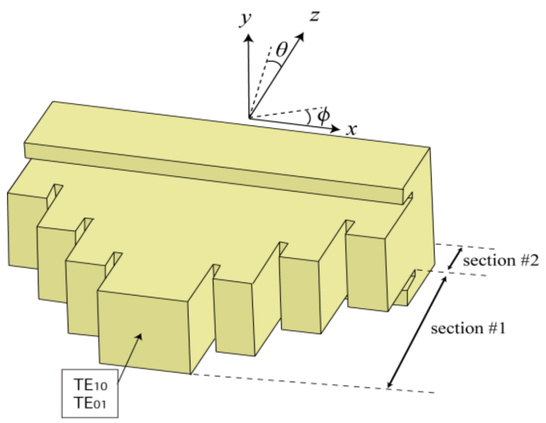

Fig. 1. Proposed horn.

3. Design Example and Evaluation

We design a horn with 10 dB beam widths of 33°×100° at 10GHz. The dimensions of the feeding section are 22.9×22.9 mm^2. The designed horn is shown in Fig. 2. The axial length is 64.8 mm and the aperture dimensions are 38.9×92.7 mm^2. In the mode matching analysis 80 rectangular-waveguide modes in each waveguide region are taken into consideration. Radiation patterns excited by the TE_{10} and TE_{01} modes at 10GHz are shown in Fig.3. This optimization result shows that 33° beam width of the design goal is achieved for the *x-z* plane($\phi = 0°$), whereas the beam width for the *y-z* plane ($\phi = 90°$) is a little bit narrower than 100° beam width. Then the cross-polar peak level at 10GHz is -34.5dB and -25.0dB for the TE_{10} mode and TE_{01} mode excitations, respectively.

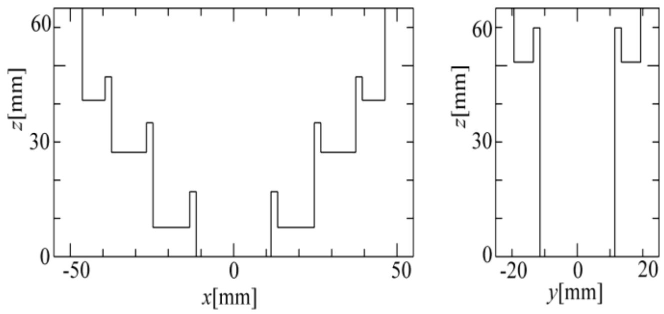

Fig. 2. Designed horn.

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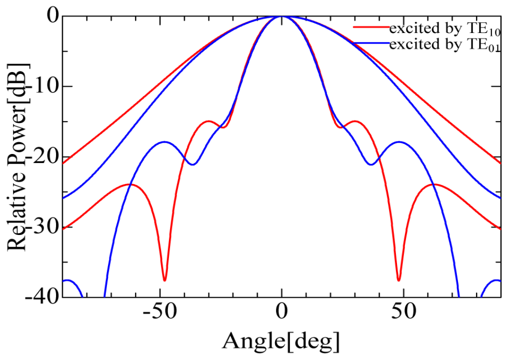


Fig. 3. Radiation patterns at 10.0GHz.

The VSWR for the TE_{10} is 1.23 but that for the TE_{01} mode is 1.64. So its value must be improved hereafter.

4, Experimental results

Photograph of the fabricated horn is shown in Fig 4, and the measured results of the designed horn are shown in Fig.5 (a) and (b) for the TE_{10} mode and TE_{01} mode excitation at 10GHz, respectively. We can see that the agreement between the calculated and measured radiation patterns are good in both excitation expect for $\theta = 0°$ for the cross polarization. In these figures, the simulated results by the HFSS are also designated for comparison. Fig.6 shows the beam widths for both the *x-z* plane and the *y-z* plane are almost agreement between dual polarization. So it is verified experimentally that the elliptical-shaped beam of orthogonal dual polarization is implemented by the horn consisting of two orthogonal sidewalls loading grooves.

5, Conclusion

This paper has proposed the multistep rectangular horn loading grooves designed by optimization based on the mode-matching analysis. The design example of the horn realizes elliptical beam for dual polarization use, of which radiation pattern has -10dB beam width of 33°×100°. Its effectiveness is verified numerically and experimentally.

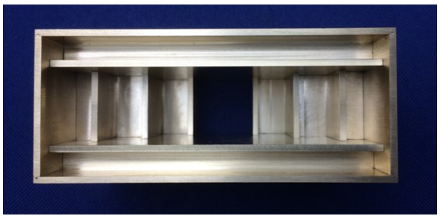
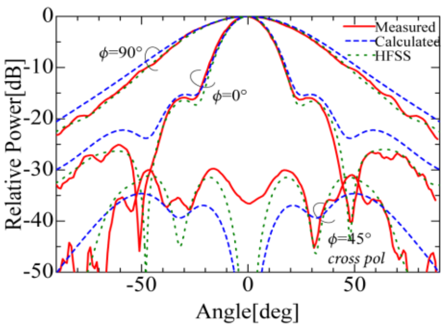
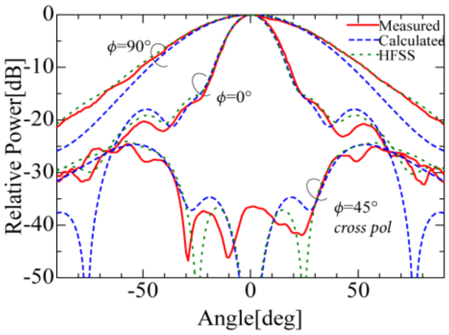


Fig.4. Photograph of fabricated horn (apeature side).



(a) TE_{10}-mode excitation.



(b) TE_{01}-mode excitation.
Fig.5. Radiation patterns excited at 10.0GHz.

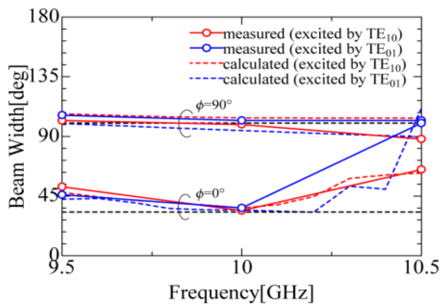


Fig.6. Frequency characteristics of beam width.

References

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