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2015

Chen, Z., & Shen, Z. (2015). Broadband and low-profile H-plane ridged horn antenna. 2015 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting, 2319-2320.

<https://hdl.handle.net/10356/82898>

<https://doi.org/10.1109/APS.2015.7305548>

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Broadband and Low-Profile H-Plane Ridged Horn Antenna

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Abstract—This paper presents a broadband and low-profile H-plane horn antenna mounted on a large ground plane. By employing stepped ridges and an ellipse-shaped copper taper extended along the horn aperture, the proposed antenna achieves a wide bandwidth from 4.2 GHz to 18 GHz for $VSWR \leq 2$ while retaining the antenna height of only 5.508 mm. Acceptable gain values with nearly end-fire radiation beams are obtained over the entire frequency band.

I. INTRODUCTION

H-plane horn antennas are widely used in wireless communications due to their vertical polarization, end-fire radiation patterns, and low profile [1]. However, simultaneously retaining a small thickness and achieving a wide bandwidth remain a challenging task because a poor impedance matching will be introduced when the antenna height is much smaller than the free-space wavelength [2]. By extending the dielectric slab and printing some grated transition after the horn aperture can help to improve the matching condition [2], [3]. In addition, ridged waveguides are often employed to further increase the bandwidth [4], [5]. In [5], a tapered ridged waveguide was utilized by an H-plane horn antenna, achieving end-fire radiations over a bandwidth of 76% with a substrate thickness of $0.25\lambda_0$ at the center frequency.

In this paper, we propose a wideband and low-profile H-plane horn antenna. The antenna utilizes an ellipse-shaped copper taper to improve the matching condition from the horn aperture to free space, and employs stepped ridges to increase the bandwidth. The antenna is mounted on a large conducting plane, which is suitable to be flush-mounted for aircraft, missile, and unmanned aerial vehicle (UAV) applications.

II. ANTENNA CONFIGURATION

The configuration of the proposed antenna is shown in Fig. 1, which consists of a coaxial-to-ridged waveguide transition, an H-plane horn with ellipse-shaped copper taper, and a large conducting ground plane. Two substrate layers, Duroid RT 5880 with permittivity of ϵ_{r1} and thickness of h_1 , and Teflon with permittivity of ϵ_{r2} and thickness of h_2 , are used in this structure. W and L are the width and length of the substrate, respectively. W_g and L_g are the width and length of the ground plane, respectively. A four-step ridge is employed in the transition part, the length and height of each step are denoted by a_i and b_i ($i = 1, 2, 3, 4$), respectively. W_r is the width of the ridge, which is uniform for all four sections. W_a represents the

width of the horn aperture. An ellipse-shaped copper taper is printed on the top layer of the Rogers 5880 substrate and extended along the horn aperture. The center point of the ellipse is O' . d_1 and d_2 represent the half minor and major axes of the ellipse, respectively.

Fig. 1. Configuration of the proposed wideband and low-profile H-plane horn antenna. (a) Top view. (b) c-c' cut plane.

III. ANTENNA DESIGN

A. Coaxial-to-Ridged Waveguide Transition

The coaxial-to-waveguide transition is critical to realize the wideband and low-profile H-plane horn antenna. As shown in Fig. 2, the shape of the reflecting wall can be expressed as $|x| = (4py)^n$. The distance between the coaxial probe and the reflecting wall is p . In order to widen the bandwidth and improve the impedance matching, a tapered probe and a ridge are employed. The upper and lower diameters of the tapered probe are d_t and d_b , respectively. A cylindrical air cavity is perforated in the dielectric to support the probe for the ease of actual implementation.

Fig. 3 shows the simulated VSWR of the proposed coaxial-to-ridged waveguide transition. It is seen that the VSWR of the transition is less than 2 from 4 GHz to 18 GHz with the height of only 5.508 mm.

Fig. 2. Geometry of the coaxial-to-ridged waveguide transition. (a) Top view. (b) c-c' cut plane.

Fig. 3. Simulated VSWR of the coaxial-to-ridged waveguide transition. ($\epsilon_{r1} = 2.2$, $h_1 = 0.508$ mm, $\epsilon_{r2} = 2.1$, $h_2 = 5$ mm, $n = 0.55$, $p = 6.5$ mm, $W_r = 36.3$ mm, $W_r = 3.5$ mm, $b_1 = 4.4$ mm, $d_r = 2.8$ mm, $d_b = 1.3$ mm.).

B. H-plane Horn Antenna

A four-step ridge is employed to obtain a better transition from the waveguide to the flare part of the horn antenna. In order to smoothen the transition from the horn aperture to free space, an ellipse-shaped copper taper is used to extend along the horn aperture [4]. Fig. 4 shows the VSWR and gain values of the proposed H-plan horn antenna. Fig. 5 shows the radiation patterns at different frequencies. It is seen that the simulated VSWR of the antenna is less than 2 from 4.2 GHz to 18 GHz. Acceptable gain values with nearly end-fire radiations are obtained over the frequency band. It should be mentioned that a larger D can tilt the radiation beam closer to the end-fire direction.

Fig. 4. Simulated VSWR and gain of the proposed H-plane horn antenna. ($\epsilon_{r1} = 2.2$, $h_1 = 0.508$ mm, $\epsilon_{r2} = 2.1$, $h_2 = 5$ mm, $L = 46$ mm, $W = 57$ mm, $W_g = 75$ mm, $L_g = 110$ mm, $D = 40$ mm, $W_a = 43$ mm, $n = 0.55$, $p = 6.5$ mm, $W_r = 3.5$ mm, $a_1 = 3.8$ mm, $a_2 = 5$ mm, $a_3 = 5$ mm, $a_4 = 5$ mm, $b_1 = 4.06$ mm, $b_2 = 3.16$ mm, $b_3 = 2$ mm, $b_4 = 0.9$ mm, $d_r = 2.8$ mm, $d_b = 1.3$ mm, $d_1 = 22.6$ mm, $d_2 = 31.8$ mm.).

IV. CONCLUSION

In this paper, a wideband and low-profile H-plane horn antenna has been presented. With a tapered probe, a ridged waveguide transition, and an ellipse-shaped copper taper extended along the horn aperture, the antenna has achieved a wide bandwidth while retaining a very low profile. It is worth mentioning that the proposed antenna is a very promising candidate for wideband and conformal applications.

Fig. 5. Simulated normalized radiation patterns of the H-plane antenna at different frequencies.

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