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 ≤ 2 while retaining the antenna height of only 5.508mm. 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.

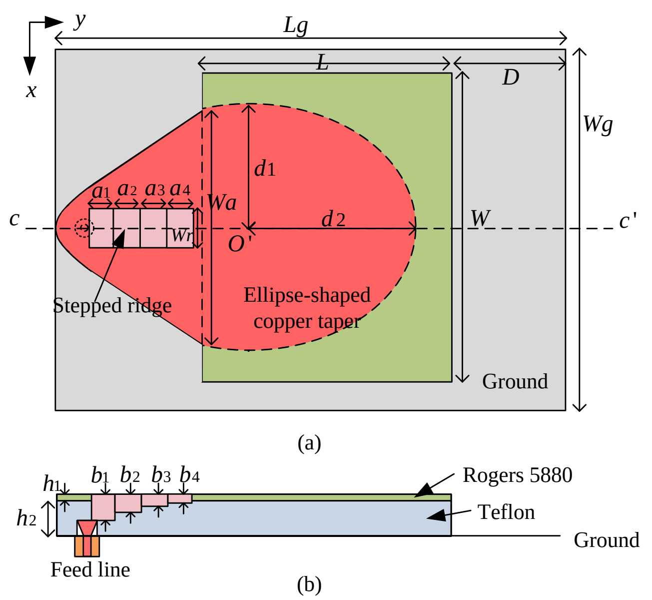


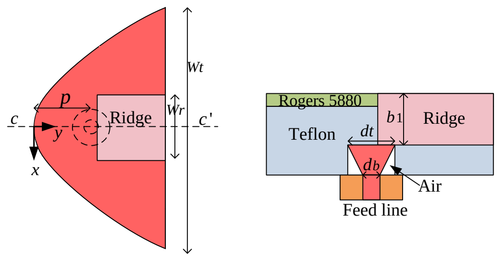
Fig. 1. Configuration of the proposed wideband and low-profile H-plane horn antenna. (a) Top view. (b) c-c' cut plane.

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.



(a) (b)

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

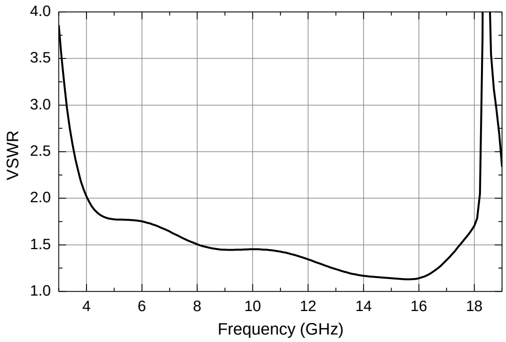


Fig. 3. Simulated VSWR of the coaxial-to-ridged waveguide transition. (ε_{r1} = 2.2, h_1 = 0.508 mm, ε_{r2} = 2.1, h_2 = 5 mm, n = 0.55, p = 6.5 mm, W_t = 36.3 mm, W_r = 3.5 mm, b_1 = 4.4 mm, d_t = 2.8 mm, d_b = 1.3 mm.).

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.

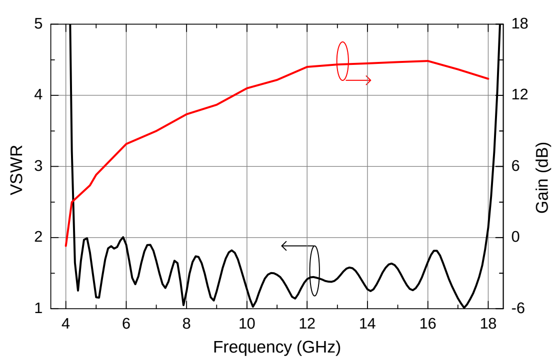


Fig. 4. Simulated VSWR and gain of the proposed H-plane horn antenna. (ε_{r1} = 2.2, h_1 = 0.508 mm, ε_{r2} = 2.1, h_2 = 5 mm, L = 46 mm, W = 57 mm, W_g = 75 mm, L_g = 110 mm, D = 40 mm, W_a = 43 mm, n = 0.55, p = 6.5 mm, W_r = 3.5 mm, a_1 = 3.8 mm, a_2 = 5 mm, a_3 = 5 mm, a_4 = 5 mm, b_1 = 4.06 mm,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

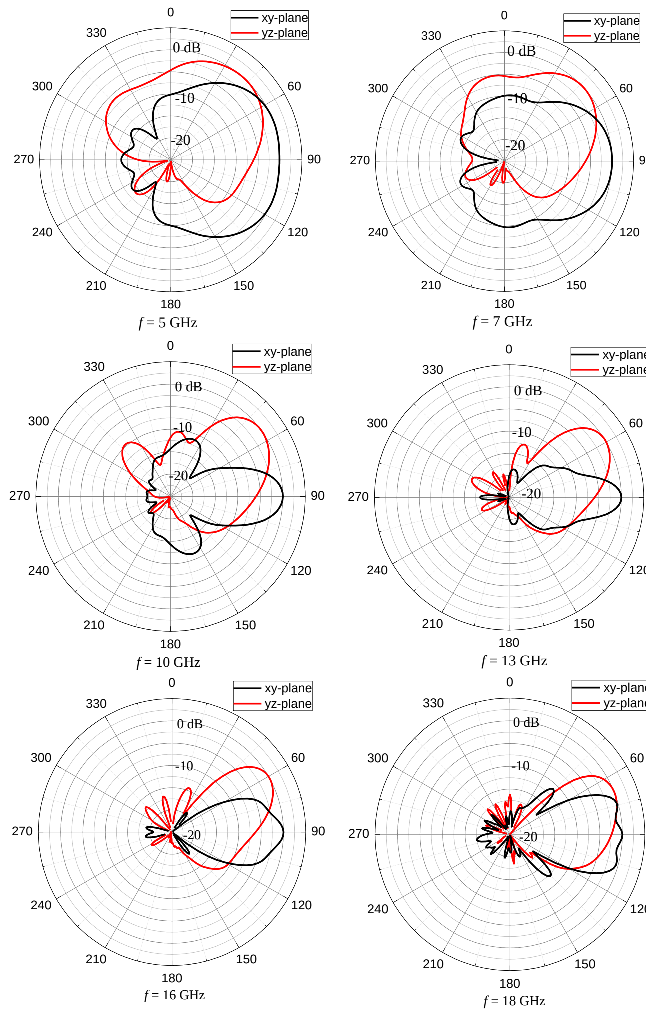


Fig. 5. Simulated normalized radiation patterns of the H-plane antenna at different frequencies.

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