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Radiation Characteristics of a Square Pyramidal Horn Antenna with Tapered DielectricE-Plane Boundary Walls Loaded With Periodic Conducting Strips

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Abstract: *A rectangular pyramidal horn antenna fabricated with tapered dielectric E-plane boundary walls whose inner surface is periodically loaded with thin conducting strips is investigated. For better impedance matching, at the throat region of the horn antenna, 3 cm portion is metallised. The radiation characteristics of this horn antenna are compared with that of an identical conventional horn antenna with conducting E-plane boundary walls. Considerable improvement in the E-plane radiation characteristics is observed. As H-plane boundary walls are not modified, no change in the H-plane radiation characteristics is observed. However,the conventional horn antenna shows slightly better impedance matching than the test horn antenna.*
Keywords: *Antennas, Dielectric loaded horns, Electromagnetic waves, Feed horn antennas, Microwave antennas,*

I. Introduction

Metallic corrugated horns are superior as feed horns with their excellent radiation characteristics. However, these horns are difficult to manufacture and are heavy. Alternate feed horns with conical and square pyramidal profile with conducting strip loaded dielectric walls that simulates all the radiation characteristics of identical metallic corrugated horns are reported. In simulated feed horn antennas reported [5, 6, 7,10] the E-plane boundary walls were of uniform thickness after the tapered throat profile region used for impedance matching. Moreover, in these horns, at the throat region, immediately after the waveguide section only 1 cm portion of the throat is metallised.In the presentpaper,a square pyramidal horn with 3 cm metallisation at the throat region and tapered dielectric E-plane boundary walls that are loaded with periodic structure of conducting strips on inner sides is investigated. The radiation characteristics of the present test horn (TH antenna) antenna are compared with that of an identical conventional horn (CH antenna) antenna.

II. Fabrication Details

The TH antenna is a square pyramidal horn. The aperture dimensions are $a_1 = b_1 = 5.9$ cm and the E and H- plane slant lengths are $\rho_{E=}\rho_H= 12.8$ cm. The corresponding semi flare angles in the above planes are $\psi_{E=}\psi_H = 25^0$. At the throat region, 3 cm portion is metallised. After this metallised portion, the thickness of the dielectric plate is 0.75 cm .This is then gradually tapered to a thickness of 0.55 cm at the aperture of the horn so that the mean thickness of 0.65 cm satisfies balanced hybrid mode condition approximately at the frequency 9.2 GHz. The entire remaining inner surface of the E-plane walls are then periodically loaded with thin conducting strips at a period $d= 0.061\lambda$ and $a/d = 0.5$, where $\lambda$is the free space wavelength at the design frequency.

III. Experimental Results.

Typical return loss variation of the TH antenna with frequency is shown in figure 1. In the entire X-band frequency region the return loss is better than – 15.69 dB. For all the frequencies above this, in the entire X- band, the return loss is well within the tolerable limits.

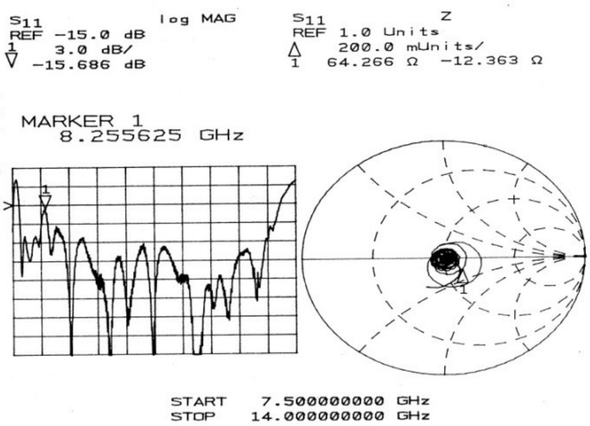

Figure 1.The return loss variation of the TH antenna with frequency

The typical E- plane radiation pattern of the TH antenna at the design frequency, 9.2 GHz, is presented in figure 2. For comparison, the E- plane radiation pattern of the identical CH antenna at 9.2 GHz is also plotted in the same graph. The radiation pattern of the new strip loaded TH antenna is narrow without any side lobes in the main beam. The H- plane radiation patterns of this horn are found to be identical to the H- plane radiation patterns of the identical CH antenna. Hence they are not presented here. It is also observed that the E-plane radiation patterns of this horn, in the entire X - band of frequency, are narrower than its H – plane radiation patterns.

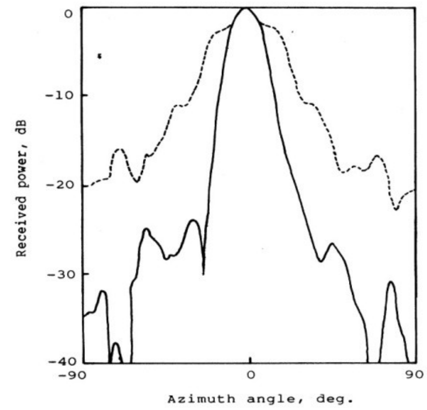

Figure 2. The E-plane radiation patterns of the TH antenna and the CH antenna

——— TH antenna -------- CH antenna

In figure 3, the variation of side lobe and back lobe levels of the present TH antenna and the conventional CH antenna is shown. Compared to the CH antenna, the side lobe and back lobe levels of the TH antenna are found to be considerably improved. The side lobe level of the TH antenna is found to be better than – 20 dB in the entire 8 GHz to 12 GHz frequency range. As shown in figure 4, the cross polarisation level of the TH antenna is better than -25 dB in the entire 8.5 GHz to 12 GHz frequency range. Moreover, its variation with frequency is also found to be smoother than that of the CH antenna.

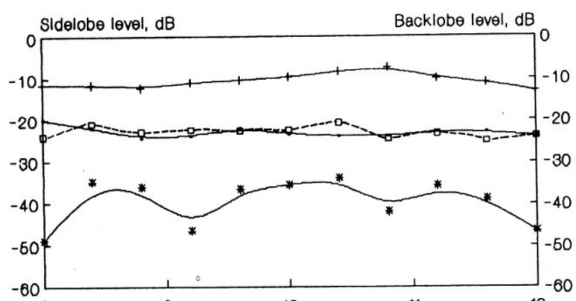

Figure3. Variation of side lobe and back lobe levels of TH antenna and CH antenna with frequency

—•— Side lobe level TH —+— Side lobe level CH

—✱—Back lobe levelTH—▫—   Back lobe level CH

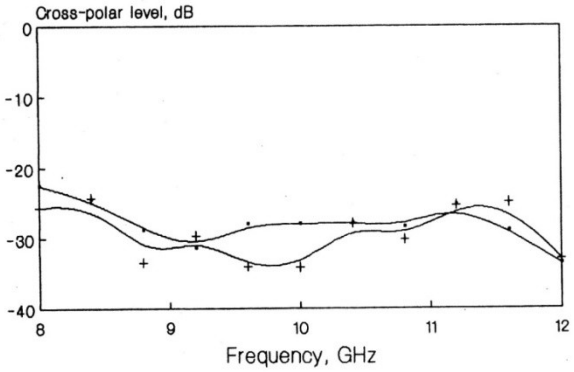

Figure 4. Variation of cross polarisation levels of TH antenna and CH antenna with frequency
—•—TH —+—   CH

Frequency response of the 3- dB and 10- dB beam widths of TH antenna compared with that of the CH antenna are shown in figure 4. In the entire X- band frequency region, the 3- dB beam width is found to be decreasing with increase of frequency. However, above 10.4 GHz, the 10- dB beam widths are found to be widened with increase of frequency.

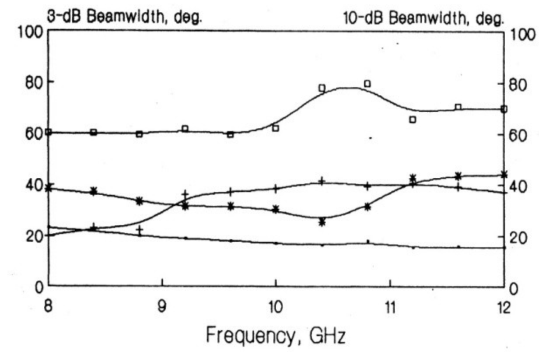

Figure 5. Frequency response of the 3- dB and 10 - dB beam widths of TH antenna and the CH antenna
—•—3- dB beam width TH   —+—3-dB beam width CH
—✱—10-dB beam width TH   —▫—10-dB beam width CH

The typical variation of gain with frequency of TH antenna and CH antenna are given in figure 6. In the entire frequency rangeof 8.5 GHz to 12 GHz, the gain of the present horn is better than that of the conventional CH antenna and it is found to be gradually increasing with frequency.

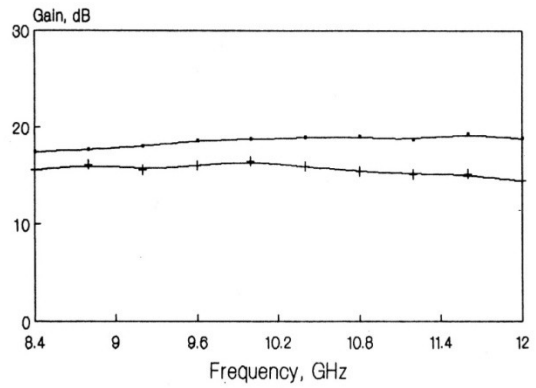

Figure 6. Variation of gain of horns TH and CH with frequency
—•—TH —+—   CH

IV. Conclusion

From the comparative study of the radiation characteristics of the new TH antenna and the identical CH antenna it is evident that the radiation characteristics of the present TH antenna fabricated with tapered dielectric E- plane walls, are much better than that of the CH antenna except the return loss characteristics. However, the return loss characteristics of the new TH antenna are well within the tolerable limits.

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