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A Small Square Aperture Simulated Corrugated Scalar Feed Horn with Beam Symmetry

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Abstract: *Radiation characteristics of a simulated scalar square pyramidal horn with small aperture is presented. The E-plane walls of this horn are made of tapered dielectric plates loaded with a periodic structure of thin metallic strips. In the central region of the 8 GHz to 12 GHz frequency band, around the design frequency of 10 GHz, the 3 dB and 10 dB E- plane and H-plane beam widths of the horn are found to be more or less the same. The analysis of the radiation characteristics of the horn antenna has shown that it is simulating almost identical radiation characteristics of a scalar feed horn antenna.*
Keywords: *Antennas, Electromagnetic waves, Feed horn antennas, Microwaves, Scalar feeds*

I. Introduction

Conical metallic corrugated horn antennas are widely used as feeds of large reflecting antennas used in radio astronomy, radar and communication purposes by virtue of their symmetrical radiation patterns in the two principal planes .However machining corrugations of desired precision is tedious and time consuming. A large amount of metal is also wasted in this process. Alternately, conical horns with conducting strips loaded on dielectric surface of uniform thickness as horn wall are also reported [1,2].Square pyramidal horns with metallic strip loaded dielectric plates as E-plane walls are also reported [3,4,5].However, the desired beam symmetry in the two principal planes are not obtained in the case of these feed horns. The large aperture of these horns may be the reason of unsymmetrical beam patterns in the two principal planes. The possibility of obtaining beam symmetry in the two principal planes is explored in the present investigation .For this, a square pyramidal horn with metallic strip loaded E-plane walls, with tapered throat profile, but of small aperture is fabricated.

II. Design details

The E-plane view of the horn investigated along with the design details are shown in figure. 1. The test horn is a square pyramidal horn with small aperture dimensions $a_1 = b_1 = 3.5$ cm.The E and H- plane slant lengths are $\rho_E = \rho_H = 20.3$ cm and the corresponding semi flare angles in the above planes are $\Psi_E = \Psi_H = 9.5^{\circ}$. The test horn is fabricated with dielectric E-plane boundary walls having an interior tapering profile structure at the vicinity of the throat region. After the 1 cm metalized portion at the throat region, the thickness of the dielectric substrate $h_1 = \lambda / 2 (\varepsilon_r - 1)^{112}$ where λ is the free space wavelength at the design frequency , 10 GHz , which is the centre frequency of the 8 GHZ to 12 GHz frequency range. This thickness is then gradually tapered to a thickness $h2 = \lambda / 4 (\varepsilon_r - 1)^{112}$ at the point P. From point P to the aperture of the horn, the thickness of the dielectric substrate is kept at $\lambda / 4 (\varepsilon_r - 1)^{112}$ so that the balanced hybrid mode condition is also satisfied at 10 GHz. The entire inner dielectric surface of the E-plane walls is then loaded with thin conducting strips at a period d = 0.133 λ and a / d = 0.5

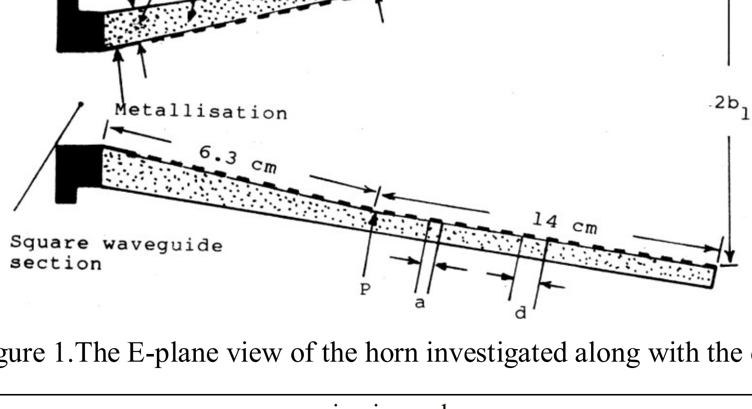

Figure 1.The E-plane view of the horn investigated along with the design details.

III. Experimental Results

The typical E and H - plane radiation patterns of the horn at the design frequency are given in figure 2. From the figure it is clear that the E and H plane radiation of the test horn are almost identical. The variation of the 3 dB and 10 dB beam widths of the E and H plane radiation patterns of the horn is presented in figure 3.In the central region of the 8 GHz to 12 GHz frequency band, the 3 dB and 10 dB E- plane and H-plane beam widths of the horn are found to be more or less the same. The deviation from the beam symmetry is observed to be more predominant in the lower edge of the frequency band than the upper band edge.

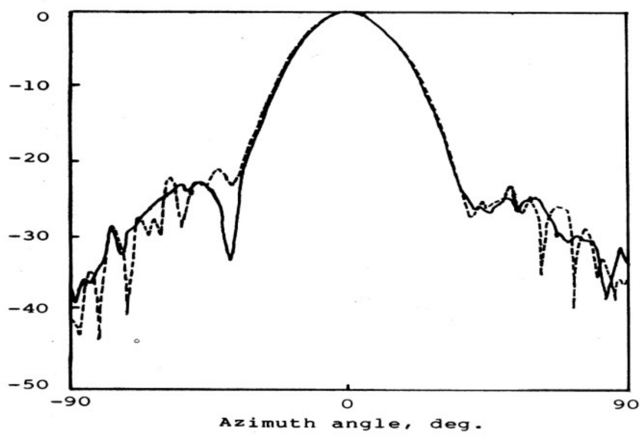

Fig. 2.The typical E and H - plane radiation patterns of the horn at the design frequency

The frequency response of the sidelobe, backlobe and cross-polar levels of E-plane radiation patterns of the horn antenna is shown in figure 4. As in the case of beamwidths, the horn antenna is found to be exhibiting better sidelobe and backlobe level characteristics in the central region of the 8 GHz to 12 GHz frequency band. However, in this region, the cross-polar level is found to be slightly high. In the entire 8 GHz to 12 GHz frequency band, the maximum sidelobe level exhibited by the horn is – 17. 5 dB. Though the horn is designed for 10 GHz, the minimum level of sidelobe is observed at 9.8 GHz. At the design frequency, the exhibited sidelobe level is – 22.5 dB. Since the H-plane walls of the horn are unmodified no effort is made to study the radiation characteristics of the H-plane except the beam widths.

The variation of the return loss of the horn with frequency is presented in figure 5. In the entire X-band of frequency, the maximum level of return loss is better than -19.75 dB.

The frequency response of gain of the horn is plotted in figure 6. As expected, the gain is found to be increasing with frequency. At the design frequency, the gain of the horn is 16.3 dB.

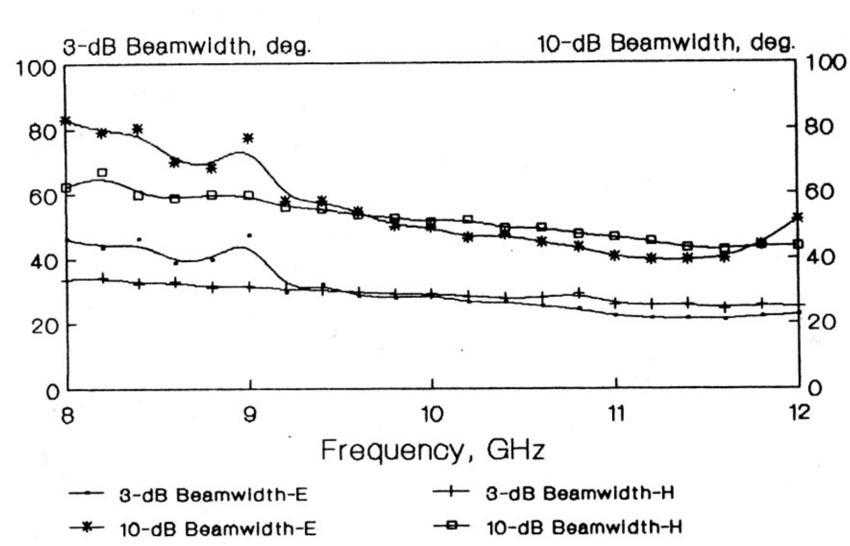

Fig.3. Variation of 3 dB and 10 dB beamwidths of the horn with frequency

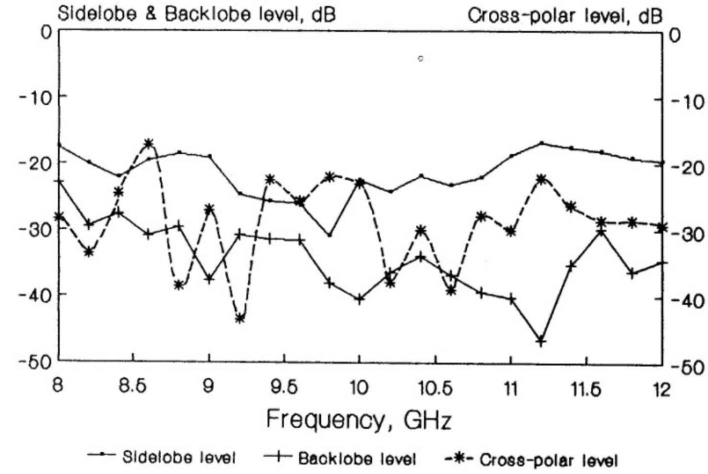

Fig. 4. Variation of sidelobe, backlobe and cross polar levels of the horn with frequency

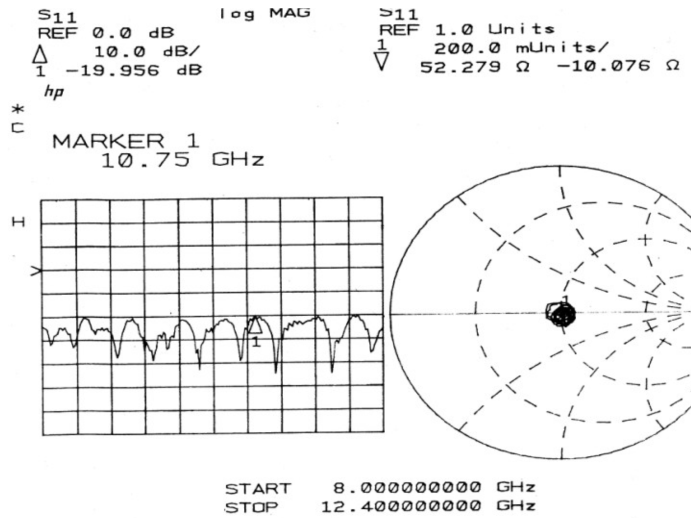

Fig. 5. Frequency response of the return loss of the horn with frequency

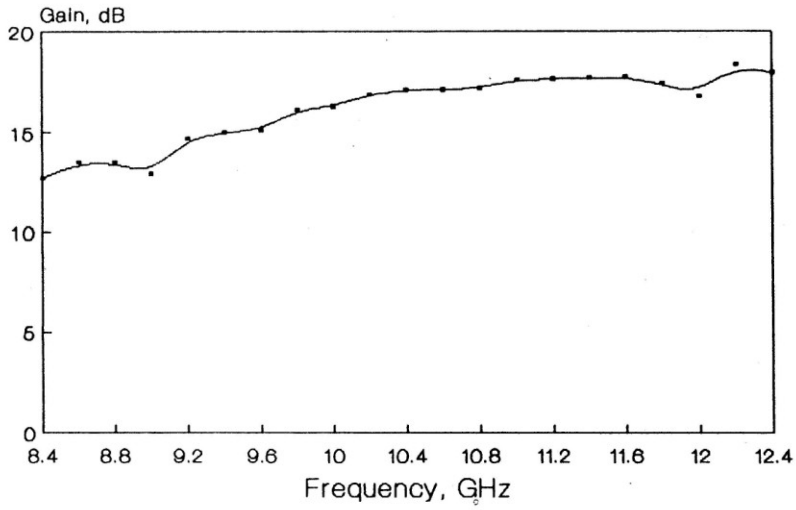

Fig. 6. Variation of the gain of the horn with frequency

IV. Conclusion

The radiation characteristics of the test horn are studied in detail. The horn showed beam symmetry in the two principal planes in the central region of the 8 GHz to 12 GHz frequency band around the design frequency. Though the sidelobe and backlobe levels of this horn are within the acceptable levels, the cross polarization characteristics in the frequency range considered are slightly high. The small aperture of the horn, 2.5 λ at the design frequency, may be the cause of such observed characteristics.

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