A Strip-Loaded Feed-Horn Antenna

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***Abstract*—Design and development of a new feed-horn antenna with low sidelobe levels is reported. The *E*-walls of this antenna are fabricated with low-loss dielectric substrate, periodically loaded with thin conducting strips. The antenna is found to be simulating the radiation characteristics of metallic corrugated horns. This can be an ideal substitute for metallic corrugated horns with added advantages like light-weight and low production cost.**

I. Introduction

Metallic corrugated horns are popular as an ideal feed due to its excellent radiation characteristics like high efficiency, low cross-polar and sidelobe levels etc. [1], [2]. A large number of papers have appeared in the literature about the design criteria and radiation characteristics of metallic corrugated horns. However, fabrication of these horns with the required accuracy is expensive and tedious. Recently Lier *et al.* [3] have reported an alternate approach to metallic corrugated horns using periodic strip grating structure on the dielectric walls of a conical horn. In this letter, the design criteria for a pyramidal horn with a periodic strip grating structure on *E*-plane boundary walls and, its radiation characteristics are reported that have not appeared in literature.

II. Design and Experimental Results

Fig. 1 shows the schematic representation of the new feed horn antenna with its design parameters. The basic pyramidal horn structure is designed from following expressions, for an optimum horn, given by Balanis [4]. All the dimensions are normalized with respect to the center frequency. The *E*-walls of the antenna are fabricated with a low-loss dielectric substrate [$\epsilon_r = 2.56$] whose inner surfaces are loaded with a periodic structure of thin conducting strips of period $d/\lambda = 0.133$ and $a/d = 0.5$, where λ is the free-space wavelength at the designed frequency. From exhaustive experimental investigations, it is observed that corresponding to dielectric thickness of $\lambda/4\sqrt{\epsilon_r - 1}$, the antenna exhibits excellent VSWR and radiation characteristics as in [3]. Hence, in this experimental investigation, a gradual tapering from $\lambda/2\sqrt{\epsilon_r - 1}$ to $\lambda/4\sqrt{\epsilon_r - 1}$ is given to the dielectric

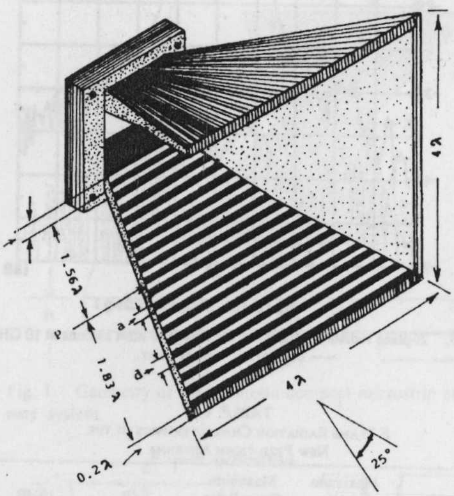

Fig. 1. Geometry of the new feed-horn antenna, $d = 0.133\lambda$, $a/d = 0.5$.

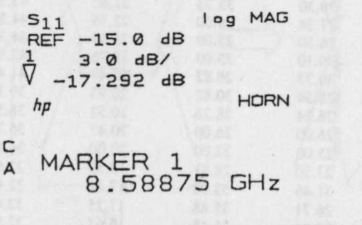

Fig. 2. Return-loss variation with frequency of the new feed-horn antenna.

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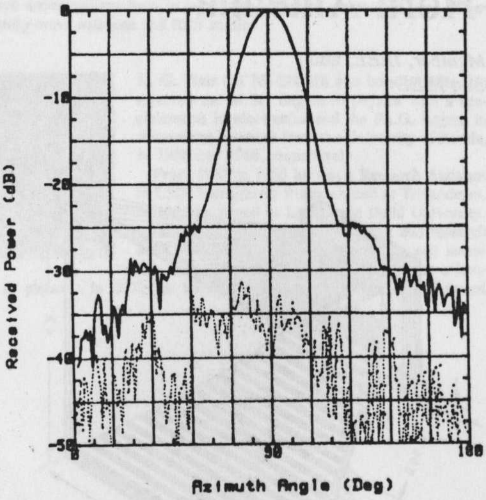

Fig. 3. *E*-plane radiation patterns of the new feed-horn antenna at 10 GHz. —— copolar, ··· cross-polar.

TABLE I
E-PLANE RADIATION CHARACTERISTICS OF THE NEW FEED-HORN ANTENNA

Frequency (GHz)	Maximum Sidelobe Level (– dB)	Maximum Cross-Polar Level (– dB)	3-dB Beamwidth (Deg.)	10-dB Beamwidth (Deg.)
8.4	29.30	33.73	21.60	41.72
8.6	27.34	26.00	22.76	44.23
8.8	26.50	25.00	23.09	44.35
9.0	30.10	35.00	22.76	42.16
9.2	30.73	26.82	22.49	41.48
9.4	28.54	30.82	20.93	39.16
9.6	26.24	28.26	20.52	38.34
9.8	26.00	26.00	20.47	36.73
10.0	25.00	32.00	20.00	34.89
10.2	27.50	28.81	18.32	33.61
10.4	31.46	33.00	17.44	32.97
10.6	26.71	35.88	17.25	32.41
10.8	34.61	36.48	16.63	32.55
11.0	28.52	28.76	16.84	34.05
11.2	38.33	27.76	16.46	34.85
11.4	27.00	25.43	16.23	35.63
11.6	38.00	39.24	15.72	40.02
11.8	32.36	33.83	15.63	44.55
12.0	34.12	38.05	15.49	50.44

substrate from the throat to the point P to achieve matching. The outer surfaces of the E-plane walls are metallized. From the point P to the aperture of the antenna the thickness is kept at $\lambda/4\sqrt{\epsilon_r - 1}$. The return-loss variation of the antenna in the X-band frequency range is shown in Fig. 2. From the figure, it is observed that in the worst case, the return-loss is 17.22 dB in the useful X-band region. Radiation patterns are measured using swept frequency mode with calibrated S_{21} response from HP8510B Network Analyzer. Typical copolar and cross-polar radiation patterns in the E-plane of the antenna at 10 GHz are shown in Fig. 3. The patterns show that the sidelobe and cross-polarization levels in the E-plane are low for the new antenna. From a comparison between the radiation patterns in the E and H-plane, it can be mentioned that the basic nature of the patterns are the same in both the planes. However, H-plane pattern is found to be slightly broader. At 10 GHz, the 3-dB beamwidth is 20° in the E-plane while it is 24° in the H-plane. The other radiation characteristics of the antenna, in the frequency band 8.4 to 12 GHz, in the E-plane are tabulated in Table I. From Table I, it is evident that all the radiation characteristics are ideal in the design frequency band.

III. CONCLUSION

A new strip-loaded feed horn antenna having excellent radiation characteristics is reported. This low cross-polar and low sidelobe antenna is really a substitute for metallic corrugated horns with added advantages. This type of horn can be easily fabricated with the desired accuracy by photolithographic technique.

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