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Axially Symmetric Radiation Patterns from Corrugated Flanged *H*-plane Sectoral Horns

P MOHANAN, C K AANANDAN & K G NAIR
Department of Electronics, University of Cochin, Cochin 682 022

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A modified *H*-plane sectoral horn antenna with identical *E*- and *H*-plane patterns over the X-band frequency is discussed. This system has significantly reduced side lobes and back lobes. Half-power beam width and gain of the antenna are also improved with enhanced matching. Experimental results for a number of horns with various flanges are presented. These find practical application for illuminating symmetric antennas like paraboloids and polarization measurements in radio astronomy, etc. Compared to the fixed pyramidal horns, the present system offers great convenience in trimming the antenna characteristics.

1 Introduction

Many workers reported that a *H*-plane sectoral horn with corrugated flange can have a beam with adjustable characteristics[1]. It is established that conducting corrugated flanges satisfying certain optimum conditions are very effective, and produce identical *E*- and *H*-plane patterns in an *E*-plane sectoral horn[2]. But the effect of corrugated flanges in *H*-plane sectoral horn for symmetric radiation patterns is not presented so far. This paper deals with such a phenomenon. It is believed that a corrugated flange with corrugation edges perpendicular to the *E*-vector will not modify the *H*-plane radiation pattern. But from the experimental results, it is clear that it can modify the *H*-plane radiation pattern also.

Fig. 1 shows the geometry of the corrugated flanged *H*-plane sectoral horn. The flanges are mounted with their corrugation edges perpendicular to the *E*-vector. The width of the flange is greater than the wavelength used, and nearly equal to 3λ. The height h, of the corrugation is of the order of $\lambda/4 < h < \lambda/2$ to prevent surface waves[3]. The slot walls are vanishingly thin compared to the slot width. The antenna system is excited by using microwaves at X-band generated by a Gunn-diode, where the propagation is in the TE_{10} mode. The *E*- and *H*-plane radiation patterns of various corrugated flanges with different parameters, at the optimum on-axis power density positions are plotted using an automatic antenna turn-table and recorder in an anechoic chamber as mentioned in Ref. 3.

2 Experimental Results & Discussion

It is observed that depending upon the position of the flange from the aperture, Z, we get maximum and minimum on-axis power density. The position giving maximum value of on-axis power density is called 'O' position and the other 'M' position[4]. So, for a particular horn with fixed flange parameters, there are more than one 'O' positions. A flange at the 'O' position gives a sharp beam in the *E*-plane with low side lobes. In the 'M' position, it gives a split beam[1]. It is observed that a symmetric radiation pattern is possible only when the flange is in the second optimum position from the aperture of the horn. In the first optimum position, it is noted that the *E*-plane half-power beam width is less than the *H*-plane. Optimizing the corrugation periods (N) flange angle (2β), etc. we can produce symmetric radiation patterns.

Fig. 2 shows the dependence of VSWR and normalized on-axis power with the position of the flange from the aperture of the horn. At the second optimum position (O_2) where the pattern is axially symmetric (Fig. 2), the VSWR of the system is less than the natural horn (i.e. horn without flanges) with enhanced on-axis power. Fig. 3 shows typical radiation patterns of a flanged *H*-plane sectoral horn at 9.5 GHz. Natural radiation patterns of the horn are also shown for comparison in Fig. 4. The natural half-power beam

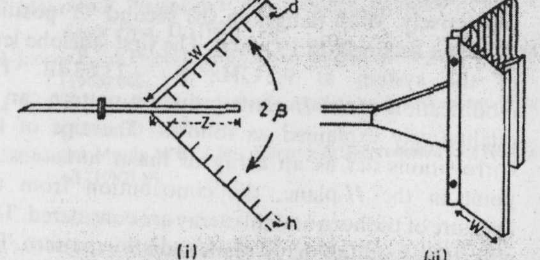

Fig. 1—Geometry of the flanged *H*-plane sectoral horn [(i) *E*-plane view (W=width of the flange, d=corrugation width, h=corrugation depth); and (ii) *H*-plane view]

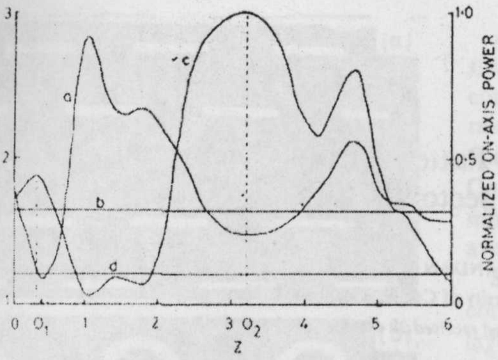

Fig. 2—Variation of VSWR and normalized on-axis power with the position of the flange from the aperture (z) at frequency 9.5 GHz, $2\beta = 60$ and $N = 9$ [(a) VSWR with flange; (b) natural VSWR of the horn; (c) on-axis power with flange; (d) natural on-axis power of the horn; O_1, the first optimum position; and O_2, the second optimum position]

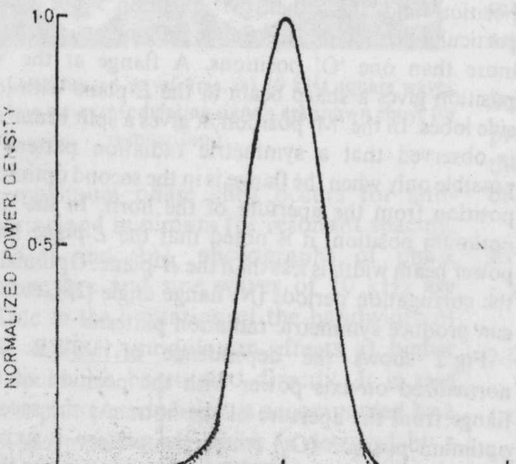

Fig. 3—Radiation patterns of flanged *H*-plane sectoral horn at 9.5 GHz for $z = 3.2$, $2\beta = 60°$ and $N = 9$ (......, *H*-plane; ——, *E*-plane)

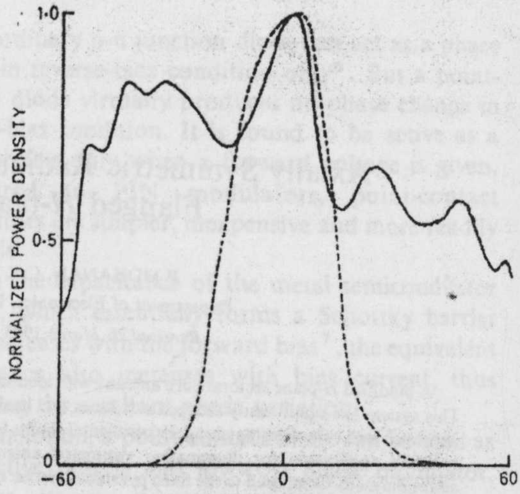

Fig. 4—Natural radiation patterns of the *H*-plane sectoral horn (without flanges) at 9.5 GHz (-----, *H*-plane; ——, *E*-plane)

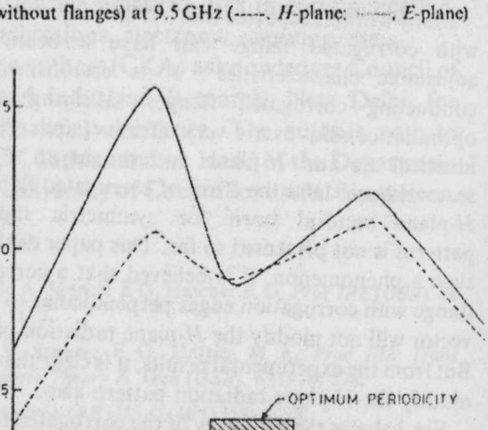

Fig. 5—Variation of HPBW with corrugation period when the flange is kept at the optimum position at 9.5 GHz and $2\beta = 60°$ (-----, *H*-plane; ——, *E*-plane)

width (HPBW) in *E*- and *H*-plane are 91.56° and 28.09°, respectively. With flanges in the second 'O' position (Fig. 3) it becomes 20.19° each. The first sidelobe level of the system at 9.5 GHz is −23.63 dB. The modification of the *H*-plane radiation pattern can be qualitatively explained as follows. The tips of the corrugations act as an array of linear antennas. A point in the *H*-plane, the contribution from the aperture of the horn and this array are considered. This effectively modifies the *H*-plane radiation pattern. The variation of on-axis power density with flange position can also be explained. The distance between the aperture of the horn and this effective array is varied as we move the flange from the aperture. Depending upon the distance, we can obtain an end-fire (sharp beam along the on-axis) or broadside (split beam), etc.

Fig. 5 gives the variation of the HPBW in both the planes with corrugation periods at 9.5 GHz. It is evident from Fig. 5 that a symmetric radiation pattern is possible only for a critical region. This region is marked as optimum periodicity region in Fig. 5. Shown in Fig. 6 is the dependence of the HPBW on flange angle. Again, symmetric pattern is obtained when the flange angle is 60° for this typical case. The dependence of HPBW on frequency is shown in Fig. 7. Over the frequency range of 8-11 GHz, the two beam widths virtually go together. Variations of antenna gain with corrugation period and frequency are given in Tables I

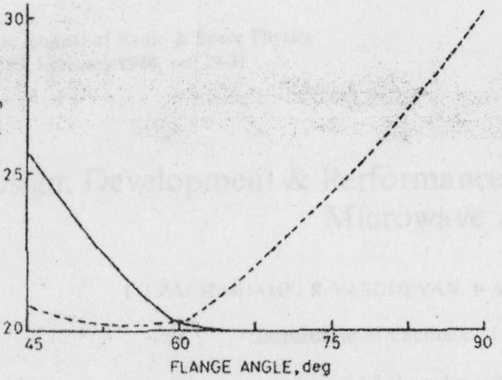

Fig. 6 — Variation of HPBW with flange angle when the flange is kept at the optimum position at 9.5 GHz and $N=9$ (-----, H-plane; ——, E-plane)

Table 1 — Variation of Antenna Gain with Corrugation Period (Frequency = 9.5 GHz, $2\beta = 60°$)

Period of corrugation	E-plane gain dB	H-plane gain dB
17	19.54	19.78
13	23.64	21.28
9	22.18	23.88
7	21.50	21.70
5	21.54	23.12
Natural horn	6.10	23.18

Table 2 — Variation of Antenna Gain with Frequency ($2\beta = 60°$, $N=9$)

Frequency GHz	E-plane gain dB	H-plane gain dB
8.2	20.64	20.28
8.5	27.46	27.80
9.0	20.44	20.68
9.5	20.70	20.52
10.0	23.12	21.98
10.5	25.30	26.52
11.0	23.74	22.12
11.2	24.72	27.18

and 2, respectively. The gain is calculated from the radiation patterns. The natural H- and E-plane gains are also given for comparison. The gain is found to be constant over the entire frequency band. Considerable improvement in gain is noted with corrugated flanges.

3 Conclusion

It is established that conducting corrugated flanges satisfying certain critical conditions will give

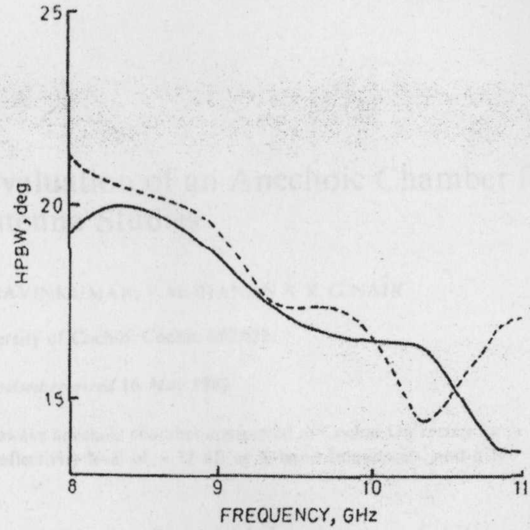

Fig. 7 Variation of HPBW with frequency when the flange is kept at the optimum position at $2\beta = 60°$ and $N=9$ (-----, H-plane; ——, E-plane)

symmetrical E- and H-plane patterns. Compared to a fixed compound horn[5], the present system offers great convenience in adjusting the antenna characteristics by trimming the flange parameters, i.e. by adjusting the flange position, we can obtain sharp, broad, or split beams.

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