S.p.25. MOHANAN, P.–Formation of elliptically polarized beam from H-Plane sectoral horns using corrugated flanges –1985–Dr. K.G. Nair.

Design and development of an elliptically polarized and matched H-plane sectoral horn antenna is reported. By proper trimming of the flange parameters any desired polarization can be synthesized.

First chapter highlights the pioneer works of Maxwell, Hertz, Bose etc. A brief description of different types of electromagnetic antennas, beam shaping in horn antennas, etc. are given with special reference to circularly polarized radiators.

An elaborate review of the past work done in the field of electromagnetic horn antennas, circularly polarized horns, beam shaping of sectoral horns, corrugated horns and surfaces etc. ae given in the second chapter. The review starts from the memorial lecture of Sir Oliver Lodge in 1894.

Third chapter is devoted to the description of the equipment and measurement techniques. Technical details of Antenna Positioner, Antenna Polarization Positioner, Flange Moving Mechanism, etc. are described.

The outcome of the experimental results carried out on H-Plane sectoral horns fitted with tilted corrugated flanges are presented in the fourth chapter. The experimental investigations have been conducted at X-band for the dominant TE_{10} mode. The following antenna characteristics were studied in detail:

1) Co-polar and cross-polar on-axis power density.
2) Polarization pattern
3) Axial ratio
4) Tilt angle
5) Sense of rotation
6) Radiation pattern
7) VSWR
8) HPBW
9) Directive gain

Variation of all these antenna characteristics with various flange parmeters like the position of the flange from the aperture of the horn, tilt of corrugation with H-vector, flange angle, corrugation period and frequency etc. are studied in detail. Following are the important conclusions about the flanged H-plane sectoral horn.

1. It is found that on-axis co-polar and cross-polar power densities are very much dependent on the position of the flange from the aperture. For a particular position of the flange from the aperture, there is an appreciable amount of cross polar component which is nearly equal in amplitude to that of co-polar power when the corrugation tilt angle is 45°. If the tilt angle is greater than or less than 45°, the cross-polar component is very small. So the optimum tilt angle for elliptical polarization is 45°.

Axial ratio is strongly influenced by the position of the flange from the aperture of the horn. Axial ratio fluctuate from a maximum to minimum as the flanges are moved back from the horn aperture. At the certain position the axial ratio approaches 0.26 dB, and the radiation is almost circularly polarized. It is found that depending upon the position of the flange a linearly polarized co-polar or cross-polar radiation can be produced. The observations shows that very low axial ratio can be obtained only when the tilt of corrugation is 45°. For a particular flange, there is an optimum flange angle for which the polarization is nearly circular. The bend width of the present system is found to be 1 GHz is 9 to 10 GHz at X-band. The variation of axial ratio with azimuth shows that the antenna radiation is circularly polarized over an earth coverage angle of 10° in the H-plane. The polarization is essliptical in nature beyond that. Typical curves are given for the variation of axial ratio and tilt of the polarization of axial ratio and tilt of the polarization ellipse with the corrugation period.

Tilt angle of the polarization ellipse is also depending on the position of the flange, flange angle, tilt of corrugation, corrugation period etc. But at the circula polarization position the tilt angle is found to be nearly zero.

The sense of rotation of the polarized wave emanating from a flanged horn is experimentally determined by the use of two identical helical antennas of oppsotite sense. The flanged horn act as an elliptically polarized rdiator in the right handed sense when the tilt of corrugation is 45°. But when the tilt of corrugation is 135°, it is polarized in the opposite sense. Radiation patterns received by LHCP and RHCP helical antennas for different corrugation tilt is shown in fig. (1).

When the flange is at the aperture of the horn VSWR is found to be less than the natural horn. Then it is increased to a high value and then decreased. But at the circular polarization position the VSWR is found to be less than the natural horn (ie., horn without flanges). Therefore matching is found to be improved at the circular polarization position. This observation is again confirmed by the HPBW and Gain measurements.

Drastic changes occur to the polarization of the radiated energy when the position of the flange is moved back from the horn aperture. Radiation pattern are taken in four different planes namely co-polar, cross-polar, 45° polar and 135° polar. For a critical flange position all these radiation patterns are nearly identical, ie., circularly polarized. For certain position the cross-polar component is very small, ie., it is linearly polarized the co-polar plane. For another position the co-polar component is small. But the cross-polar component is increased. In this case it is cross-polarized. Thus any desired polarization can be produced by trimming the position of the flange.

The E-plane radiation pattern of a H-plane sectoral horn or H-plane radiation pattern of an E-plane sectoral can be shaped by the flange technique. When the tilt of corrugation is zero ie., tips of the corrugations are orthogonal to the E-vector, a narrow pencil beam or split beam can be produced using this technique. At the optimum position of the flange all the antenna characteristics like Gain, VSWR, HPBW, band width etc. are improved very much than a natural horn.

At the circular polarization position the beam width of the co-polar, cross-polar, 45° polar radiation patterns are found to be nearly equal. The HPBW is found to be less than that of the natural horn.

The gain of the antenna is also found to be increased at the circular polarization position. A gain of 18 db is obtained at the circular polarization position with a horn of gain 14 dB. When the tilt of corrugation is zero, a gain of 27 dB is obtained with a horn of 8 dB gain in the E-plane.

Theoretical analysis of axial ratio and tilt angle of the polarization ellipse is presented in the fifth chapter. This is on the basis of secondary radiation and the method of images. The incident radiation from the horn is resolved into two components namely TM and TE waves. The component which is parallel to the tips of corrugation is TE waves and the other perpendicular to that is called TM waves. TE waves are completely reflected from the tips of corrugation but TV waves propagate into the slot and reflected back. The amplitude and phase of these two waves are calculated and axial ratio and tilt angle is computed. The theory is found to be in good agreement with the experimental observations.

Summary of the investigations carried out and comments of the results are presented in the concluding chapter. Description of further work in continuation with this work is also presented. Compared to other existing systems, the present system is not a fixed device. Therefore, it is easy to achieve any desired desired polarization by simply adjusting the flange parameters. Hence, the same system can be used for obtaining a beam with a specific polarization characteristic.

An axially symmetric radiation patterns from a flanged sectoral horn is presented in appendix I. Modified H-plane and E-plane sectoral horn antennas using corrugated flanges are described. Half power beam width and gain are improved with enhanced matching.

Compared to a fixed pyramidal horn the present system offers great convenience in trimming the anthenna characteristics. A technique for improving the coupling between a feed horn and a parabolic reflector is presented in appendix II. It is found that corugated flabges on feed horn may act as "antenna trimmers" for the fine adjustment of different antenna characteristics. Phase modulation of *microwave signal using print contact G signal diode is presented in appendix* III. The maximum insertion loss of the system is fond to be less than 1 dB. This system can also to used as a continuously variable electronic phase shifter. Phase shift is found to be 80° for current of 12 mA.