Simulation of the Gaussian profiled horn using variable depth slot mode converter

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Abstract - *The corrugated horn antenna becomes very popular because it provides very high efficiency in wideband. It is mostly used as a feed for reflector in satellite communication system. The corrugated horn antenna with Gaussian profile is discussed and analysis of results for cross polarization level is stated in this paper. The variable depth slot mode converter is used for wideband satellite applications.*

Key Words: Gaussian profile, Corrugated horn, Variable depth slot mode converter, Horn antenna.

1. INTRODUCTION

There are three main reasons for the existence of corrugated horn antennas. Firstly, they exhibit radiation pattern symmetry, which offers the potential for producing reflector antennas with high gain and low spillover; secondly, they radiate with very low cross polarization, which is essential in dual polarization systems and finally, they offer a wide bandwidth response. Now-a-days, in the age of the communications, horn antennas take a very important role in the development of the actual and future communications systems with high requirements in their radiations patterns. In fact, corrugated feeds are the best feeds ever developed. Ten to twenty years ago, corrugated horn antennas were restricted to be used in high performance applications, like being on board of satellites, earth station radio telescope horns, antenna measurement chambers and very few more applications. They were restricted to those applications for two main reasons: difficulties in the design and difficulties in the manufacture process of a corrugated feed. At present, the communication systems require really high performance antennas; side lobe and cross polar levels should be reduced in the radiation pattern as well as the size of the antenna. Low cross polar levels are inherent to the corrugated horn antenna technology and this parameter has been conveniently improved during the last decades with the use of corrugated feeds. But side lobe level of corrugated horns Paragraph comes content here. Paragraph comes content has got stuck and no improvements have been made till the last five years. Probably, the improvement in side lobe level has not been really necessary up to now. The incredible quantity of new communication systems that interact between them has made necessary to reduce the mutual interferences through side lobes.

2. CORRUGATED HORN ANTENNA

Corrugated horns have become now-a-days the preferred choice of feed antenna for use in high restrictive applications. This is because of their superior radiation performance and in particular their high copular pattern symmetry and low cross polarization.

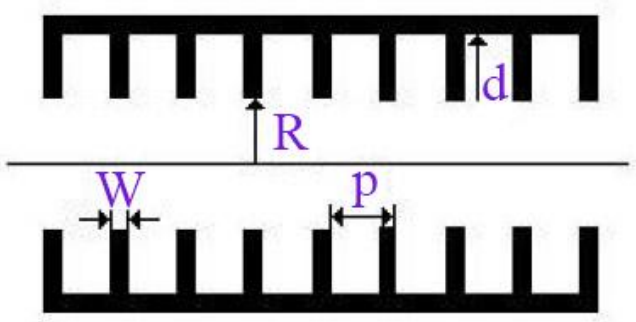

Fig -1: Corrugated Horn design

The operation principle of corrugated horns can be physically explained by considering the way in which the corrugated wall affects the field distribution inside a corrugated waveguide (fig.1). As it will be demonstrated, the corrugations change the fields travelling through the waveguide to produce the desirable radiating properties of axial beam symmetry, low side lobes and low cross polarization. In this figure 1

W=width of the corrugation
R = radius of the circular waveguide
p = pitch
d = depth

3. MODE CONVERSION

The corrugated horn supports a hybrid mode that produces radiation patterns having extremely good beam symmetry with low cross polarization levels, high beam efficiency with very low side-lobes, and the potential for wide-bandwidth performance. A typical cut-away view of the corrugated horn is given below. As shown in fig 2.[1] It consist of four sections : Input waveguide, Corrugated profile, Mode converter, Aperture. As shown in fig 2[1] the inside wall is manufactured in a succession of slots and "teeth." The main objective of corrugated surface is to support propagation of hybrid modes within the horn. The variable depth slot mode converter is shown in fig 3 which is used in horn design for converting TE11 mode to HE11 hybrid mode. The hybrid mode is combination of both TE mode and TM mode.

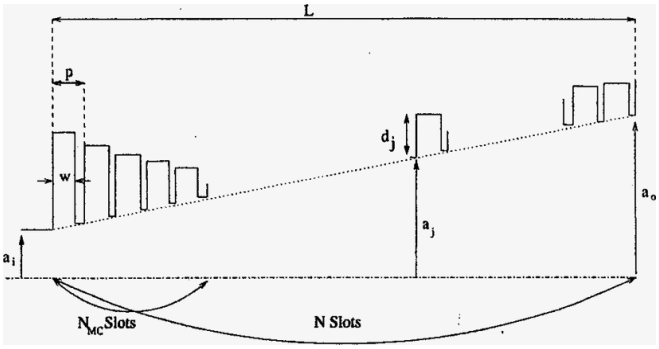

Fig -2: Variable depth slot mode converter for mode conversion[1]

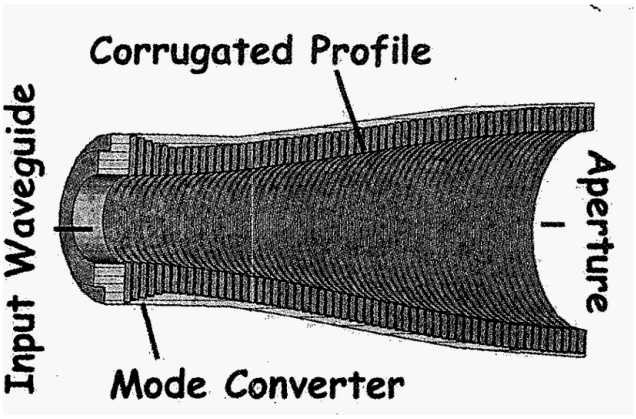

Fig -3: Corrugated Horn Antenna main components[1]

4. DESIGN EQUATIONS

Horn design consists of very complex equations as given below. These are the equations for variable depth slot mode converter that is calculated for every corrugation of horn antenna for specific frequency range. If we change our frequency range then we have to repeat same procedure for all calculation. In this calculation, we have to solve all these equations for each slot and that process becomes very difficult.

When$1 \le j \le N_{MC}+1$, then the slot depth of the jth slot is[1]

$$d_j = \left\{\sigma - \frac{j-1}{N_{MC}}\left(\sigma - \frac{1}{4}exp\left[\frac{1}{2.114(k_c a_j)^{1.134}}\right]\right)\right\}\lambda_c$$

Where $\sigma\ (0.4 \le \sigma \le 0.5)$ is a percentage factor for the first slot depth of the mode converter.

When$N_{MC}+2 \le j \le N$, then the slot depth of the jth slot is[1]

$$d_j = \frac{\lambda_c}{4}exp\left[\frac{1}{2.114(k_c a_j)^{1.134}}\right] - \left(\frac{j-N_{MC}-1}{N-N_{MC}-1}\right)\left\{\frac{\lambda_c}{4}exp\left[\frac{1}{2.114(k_c a_O)^{1.134}}\right] - \frac{\lambda_O}{4}exp\left[\frac{1}{2.114(k_O a_O)^{1.134}}\right]\right\}$$

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5. GAUSSIAN PROFILE

The Gaussian profile equation used for designing corrugated horn is given below.

$$a(z) = a_i \cdot \sqrt{1 + \left(\frac{2 \cdot z}{k \cdot {a_i}^2}\right)^2}$$

here, a_i = Input radius ;

$z = (j-1)z_{step}$;

$k = {}^{2\pi}/_{\lambda}$

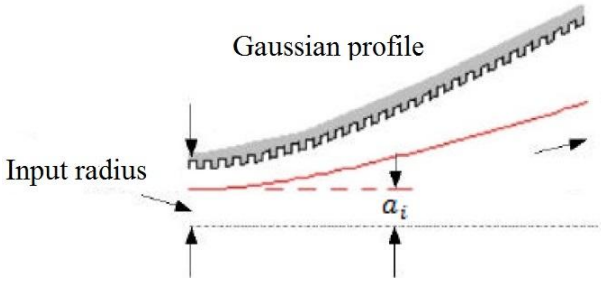

Fig -4: Gaussian profile

The Gaussian profile horn design for Ku-band given below. The Gaussian profile is as shown in fig. 4. This horn is designed for frequency band 10.7 – 14.5 GHz. The design frequency for this design is 12.46 GHz.

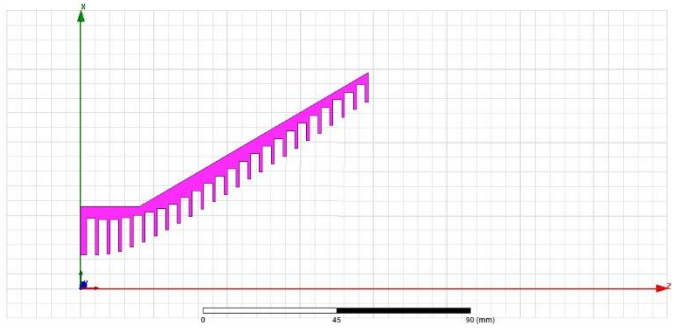

Fig -5: Gaussian profile in HFSS

6. RESULT ANALYSIS

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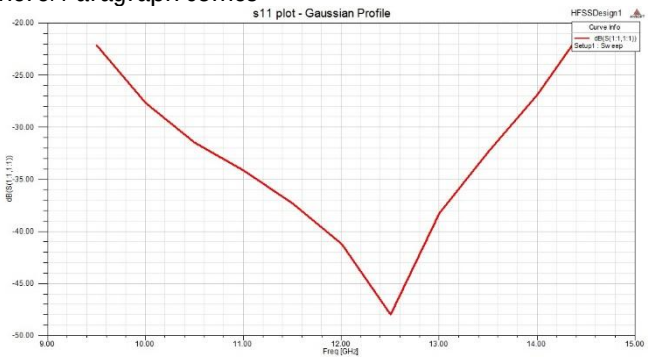


Fig -6: Return loss

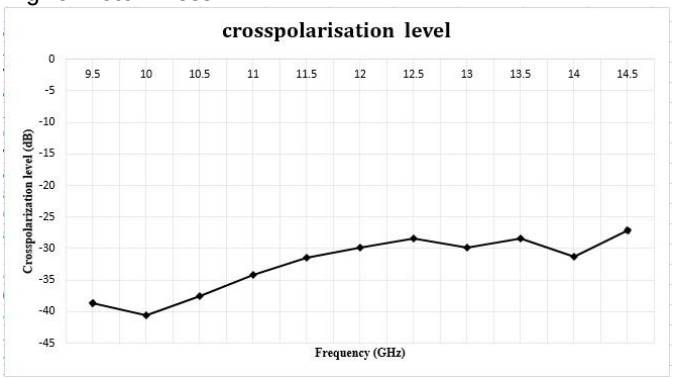


Fig -7: Crosspolarization level

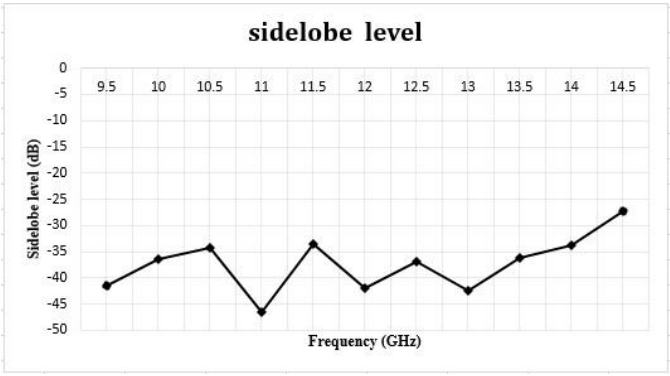


Fig -8: Sidelobe level

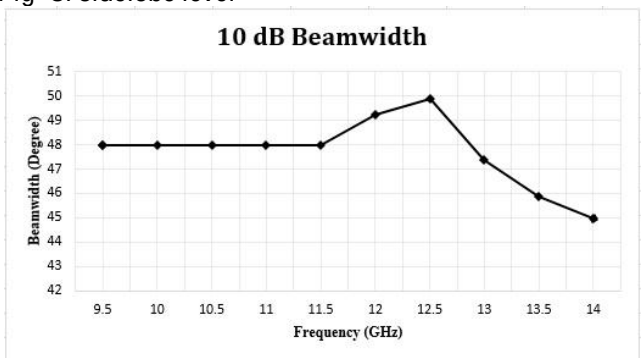
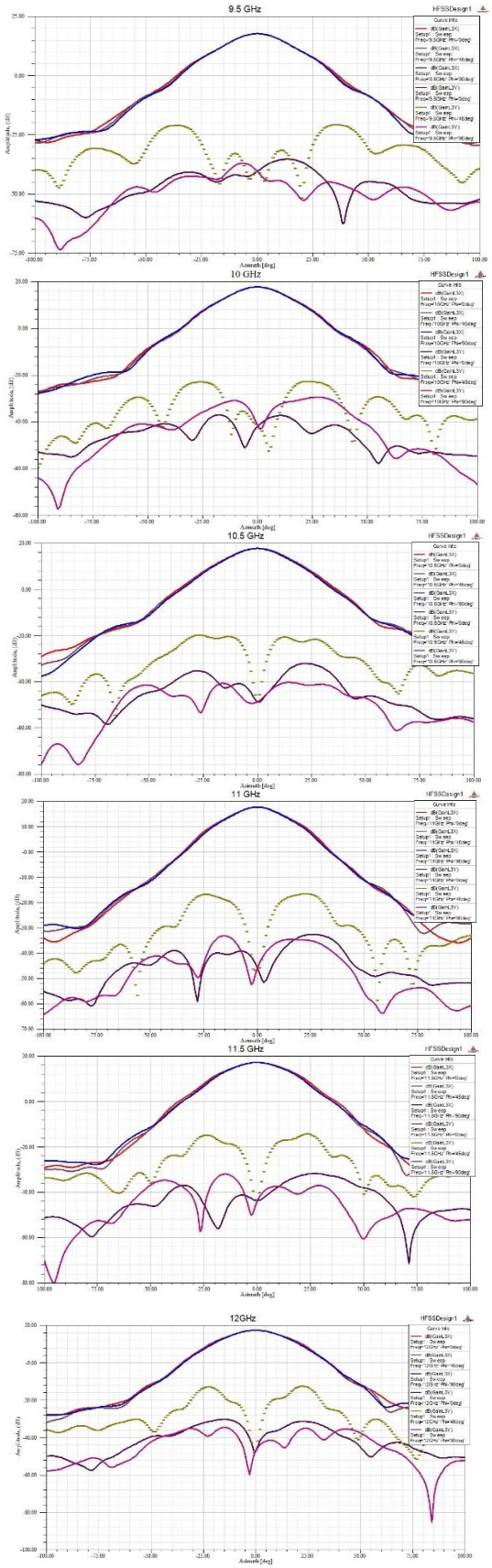


Fig -9: 10 dB Beam width



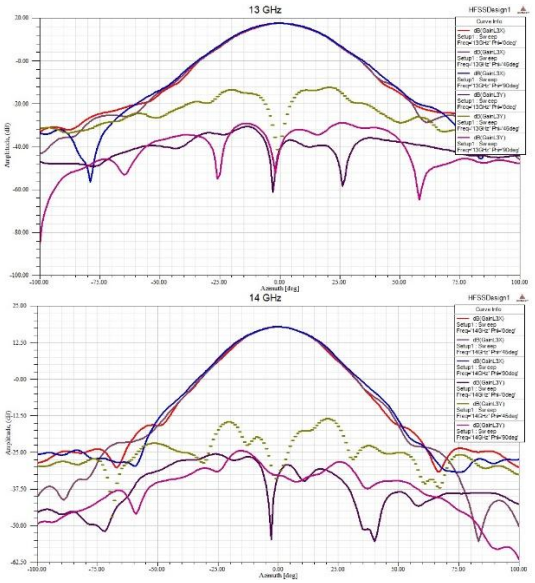


Fig -8: Radiation pattern of Gaussian profile horn antenna with variable depth slot mode converter, [A] 9.5 GHz, [B] 10 GHz, [C] 10.5 GHz, [D] 11 GHz, [E] 12 GHz, [F] 13 GHz

7. CONCLUSIONS

The corrugated horn antenna is most popular feed for parabolic reflector in satellite communication system. These type of corrugated horn used because it provides very low cross polarization level. In this paper, we have presented corrugated horn antenna with Gaussian profile using variable depth slot mode converter. We achieved 25 dB down bandwidth is 36.78% and bandwidth ratio is 1.45:1. We can achieved return loss of -47.40 dB and cross polarization level below -30 dB in almost bandwidth. The corrugated horn antenna for different profile is an open research area.

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BIOGRAPHIES

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