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Design of Corrugated Conical Gaussian profiled Horn Antenna for Multi Beam Application

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Abstract –In this paper, the Design of the probably widely used and simplest Microwave antenna is the horn antenna. Horn antenna used as feed element in Radio astronomy, Satellite tracking Communication dishes. Corrugated horns have smaller side lobes, wider bandwidth, and Cross-polarization. There are three main reasons for the existence of corrugated horn antennas. First They exhibit radiation pattern symmetry, which offers the potential for producing reflector antennas with high gain. second They offer a wide bandwidth response and third They radiate with very low cross polarization, which is essential in dual polarization systems. Using HFSS tool for KU-band and 16 GHz frequency conical Corrugated Horn Antenna will be simulated, Which useful for receivers, such as for direct broadcast satellite (DBS) for radio astronomy. By using Gaussian profile in corrugated horn we can achieved improvement of bandwidth, reduction of side lobes and Significant reduction of cross polarization with achievement of high efficiency. Multiple horn antennas used for different polarization levels but it increases interference. To reduce the interference between polarization levels a Gaussian profiled corrugated horn antenna can be used. Therefore, this antenna are usually the preferred choice for bandwidth enhancement.

***Key Words*: HFSS systems, Mode Converter.**

1. INTRODUCTION

One of the simplest and probably the most widely used microwave antennas are the horn antennas. The horn antennas are nothing more than the hollow pipe of different cross sections, which has been flared with a larger opening. Horn antennas consist of the flaring metal waveguide shaped like a horn to direct radio waves in a beam. They ware used as feeders (feed horns) for larger antenna structures such as parabolic antennas and as directive antennas for such devices. They ware used as a feed element for large radio astronomy, satellite tracking systems and communication dishes. Its widespread applicability stems from its simple in con-struction, ease of excitation, versatility, wider gain, and preferred overall performance. Horn antennas are popular in the KU band (above 16 GHz) for satellite communication.

In the 1960s, the idea of corrugated horns was first considered by Kay [2], Simons and Kay [1] and Minnett and Thomas [4], [5]. This was due to the specific interest in achieving symmetric radiation patterns so that low-side lobe and high efficiency reflector antennas could be produced. It was also realised in the 1970s by Parini, Clarricoats, and Olver [5] that corrugated horns radiate very low levels of cross polarisation, which is essential for dual-polarisation operation or frequency re-use. This is the situation where two signal channels are transmitted on orthogonal polarisations at the same frequency, and no interaction takes place between the two channels. Therefore the channel capacity is doubled for a single antenna. Corrugated horns supporting so-called hybrid modes have become well established as feeds for reflector antennas, and even as direct radiators. It is not difficult to trace the popularity of the corrugated horn, given the ability of certain hybrid modes to produce radiation pattern having extremely batter beam symmetry with lower cross-polarization levels, a high beam efficiency with lower side lobes level, and the potential for wide-bandwidth performance [6,7]. Why they ware called “corrugated” is clear from the typical example of a horn shown in Figure1, where the inside wall is manufactured in a succession of slots and “teeth.” The purpose of the corrugated surface is to provide the means to support the propagation of hybrid modes within the horn [3]. Hybrid modes are basically a mixture of the TE and TM modes. For this combination to propagate as like single entity with a common propagating velocity, the horn and waveguide must have anisotropic surface-reactance properties: proper-ties that are satisfied by the corrugated surface. It is worth pointing out that hybrid modes can also be supported by other means, such as waveguides or horns partially filled with dielectric. However, these alternative possibilities are outside the scope of this design note [3]. We begin with some practical considerations.

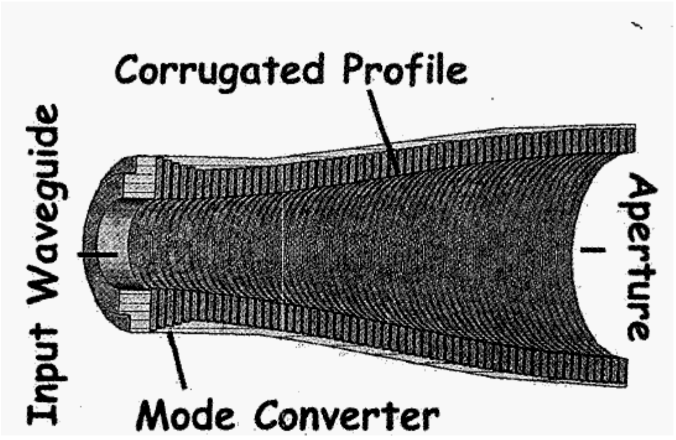

Fig 1: A cut-away view of a typical corrugated horn [3].

The band-width of a horn is usually defined by the frequency range over which the horn is required to have a suitable beam width and beam symmetry for a return loss with a cross polarization. These values are typical, but many better-performance applications have much tighter specifications [3]. As illustrated in Figure 1, it is usual for the corrugated horn to be connected to a circular, smooth-walled, input waveguide. The fundamental mode of this guide is the TE11 mode, and there is the need for a so-called "mode converter" at the transition between the smooth-walled input waveguide and the body of the corrugated horns. This mode converter is designed *to* provide a smooth transition from the TE11 to the HE11 mode supported by the corrugated horn [3].

2.DESIGN AND CALCULATION

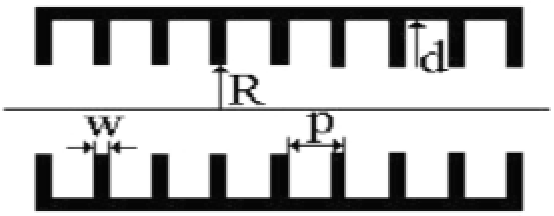

Fig 2: Phasing section with corrugations

Fig.2 show that phasing section with courrugation Because of compactness of corrugated horn antenna in first section, directivity is low and phase centers on E and H planes are not coincident. So we use a phasing section toplace phase centers together in the desired frequency band.Also it improves the mixture of TE11 and TM11 modes.Actually when this section is attached to the normalcorrugated horn, they result in a potter like horn with newcharacteristics in bandwidth and radiation pattern (We named it potter corrugated horn). The phasing section is shown inFig. 2 and design parameters is *w*=3.12mm, *p*=6.25mm,

r=7.3mm,l=150mm.

(1) period (p)

(2) corrugation depth (d)

(3) corrugation width (w)

(4) input radius (r)

All these parameters are depends upon the wavelength (λ), and wavelength is calculated by the mid frequency of the frequency band for optimum performance.

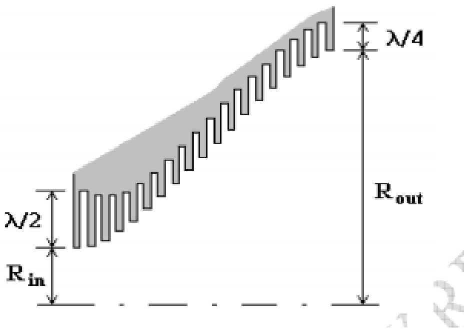

Fig 3: Corrugation depth λ/2 to λ/4

Important parameters for the design of the corrugated wave guide mode converter are As per theory period of the corrugation is λ/3

Width of the ridge is p/2

Corrugation depth starts from λ/2 and decrease to λ/4. Input radius is 0.39*λ and profile angle α is 5 degree

TABLE 1: Parameters & Result

No	Parameter	Value
1	Frequency band	Ku band (12GHz to 18GHz)
2	Operated frequency	16GHz
3	Wavelength λ	18.75mm
4	period p	6.25 mm
5	width w	3.125 mm
6	input radius r	7.3125 mm
7	Length L	150 mm

2.1 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. It consist of four sections : Input waveguide, Corrugated profile, Mode converter, Aperture. 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.

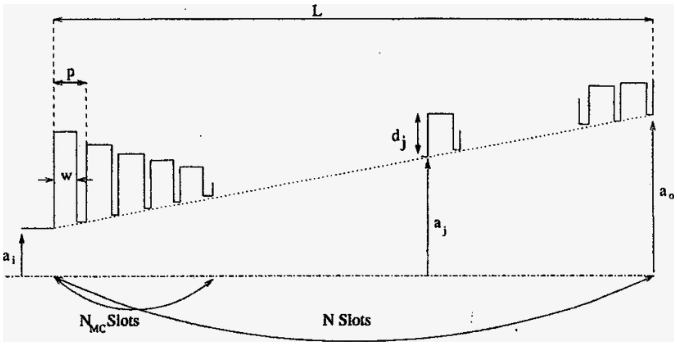

Fig .4: Variable depth slot mode converter for mode conversion

2.2 LINEAR PROFILE

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

$$a(z) = a_i + (a_0 + a_i)\frac{Z}{L}$$

a_i = input Radius

a_o = Output Radius

L = Total length

2.3 GAUSSIAN PROFILE

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

$$a(z) = \sqrt{\frac{a_i^2 + z^2\,(a_o^2 - a_i^2)}{L^2}}$$

a_i = input Radius

a_o = Output Radius

L = Total length

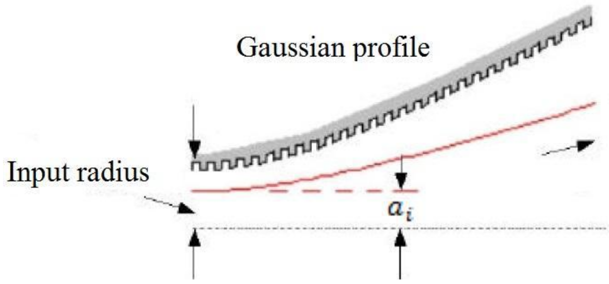

Fig 5: Gaussian profile

3. SIMULATION RESULTS

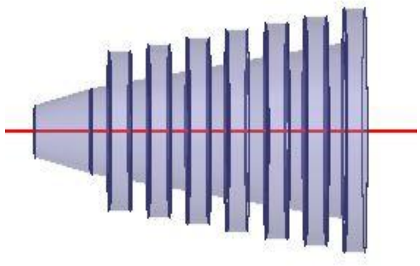

Fig 6: Side view of courragated conical horn antenna

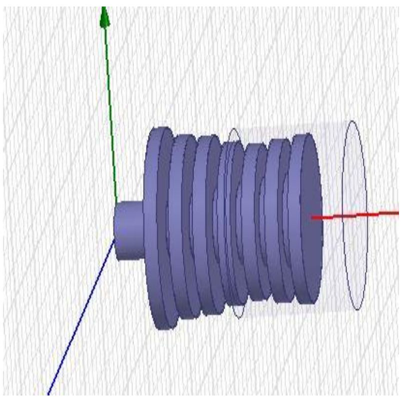

Fig 7: Linear profile Courragated conical horn antenna

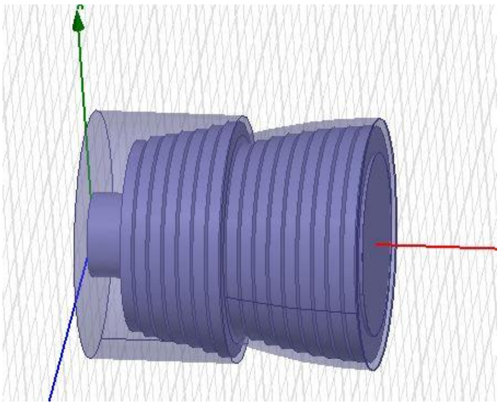

Fig 8: Gaussian Profiled Courragated Conical Horn Antenna

Fig.6 show that the design of courregated conical horn antenna and Fig.7 and Fig.8 show Linear and Gaussian Profile of Courragated conical horn antenna . Fig. 9 and Fig.13 shows the Gain of the linear and Gaussian Profile antenna. Fig.10 and Fig.14 shows the Cross level of the Linear and Gaussian Profile of Courragated conical horn antenna , Fig.11 and Fig.15 Show the Radition Pattern of the Linear and Gaussian Profile of Courragated conical horn antenna and Fig. 12 and Fig 16 Show the Band width of the Linear and Gaussian Profile of Courragated conical horn antenna.

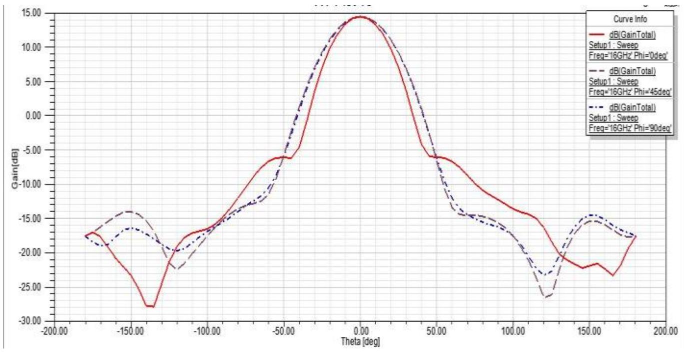

Fig 9: Gain of Linear Profile corrugated conical horn antenna

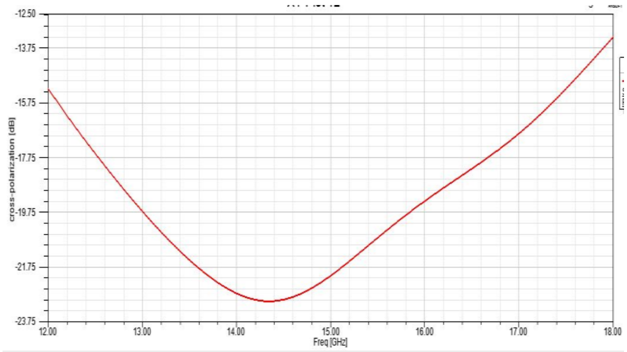

Fig 10: Cross Polarazation of Linear Profile courragated conical horn antenna

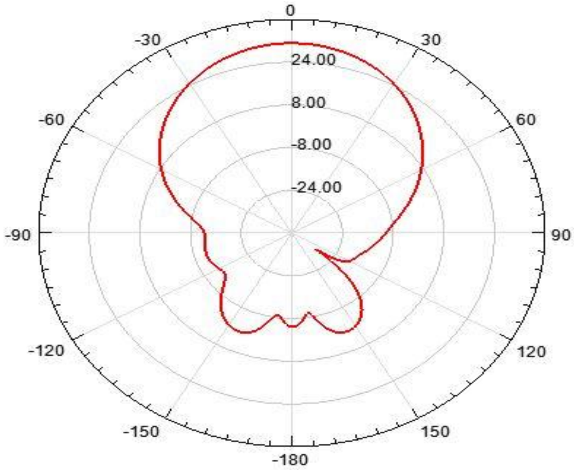

Fig 11: Radiation pattern of Linear Profile courragated conical horn antenna

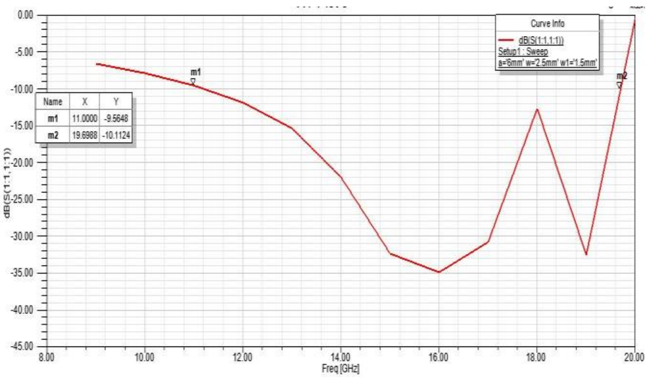

Fig 12: Bandwidth of Linear Profile courragated conical horn antenna

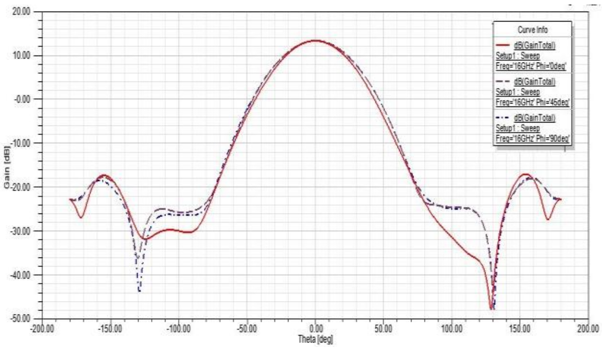

Fig 13: Gain of Gaussian Profile corrugated conical horn antenna

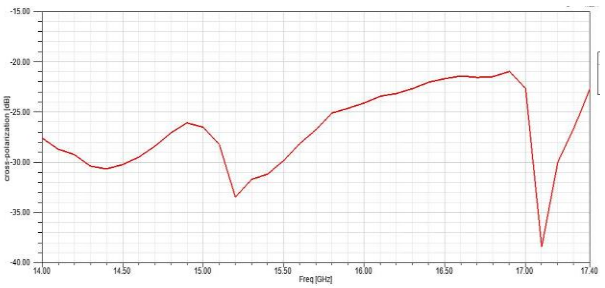

Fig. 14. Cross Polarazation of Gaussian Profile courragated conical horn antenna

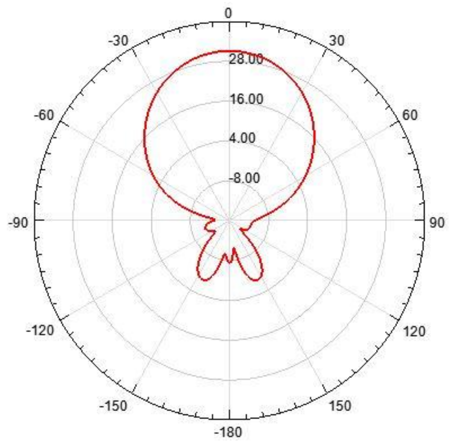

Fig 15: Radiation pattern of Gaussian Profile courragated conical horn antenna

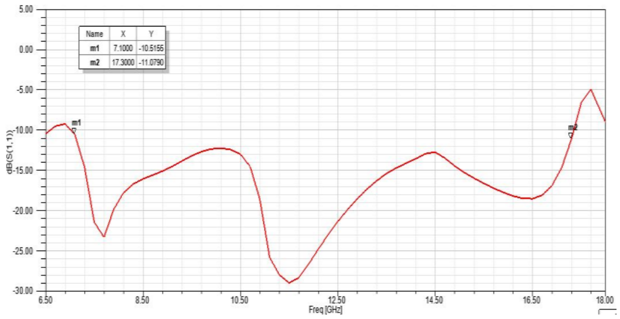

Fig 16: Bandwidth of Gaussian Profile courragated conical horn antenna

4. CONCLUSIONS

I Review and design parameter of corrugated horn is pre-sented in this paper.

Table 2: comparisons of the profiles

	Linear Profile	Gaussian Profile
Gain	14 dB	14dB
Band width	56%	83%
Cross pole level	-15 dB	-22 dB
Side lobe level	-15 dB	-20 dB

By comparing linear profile and Gaussian profile we can conclude that the crosspole level and sidelobe level of Gaussian profile is better then the linear profile. Multiple horn antennas used for different polarization levels but it increases interference.To reduce the interference between polarization levels a Gaussian profiled corrugated horn antenna can be used.By using Gaussian profile in Corrugated horn one can achieve Improved bandwidth, more side lobes reduction, low cross pole level and high efficiency.

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