Investigation of circular Horn Antenna for X-band Radar and Space Communications

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Abstract:
A horn antenna is a type of antenna that is created when the end of the antenna flares out in the shape of a horn. It is an important component of the microwave family it provides moderate gain and high directivity. Additionally, it serves as a feed antenna for various microwave antennas known as "parabolic reflector antenna and lens antenna" that are employed in high gain operations. Utilized in radar speed control. This paper will focus on simulating a conical/circular horn antenna at 12 GHz, using the program HFSS.v.15.0.

***Keywords*— conical horn, ANSYS HFSS, wedged plate, horn antenna.**

I. Introduction:

If the waveguide is stimulated on one side and glowing on the other, the open end will radiate energy into empty space [1]. But because there is no impedance matching between the waveguide and free space at the open end, only a little portion of the incident wave is radiated by the waveguide, and the larger remainder is reflected back through that open end., diffraction at the edges the waveguide leads to weak radiation power in the waveguide. Thus the radiation pattern is non-directional in nature. Thus, to overcome the defects associated with the waveguide, its end is opened in the form of an electromagnetic horn using wedged plates this allows for smooth transition of the wave between the waveguide and free space. By terminating the waveguide with a horn-like structure, the discontinuity between the waveguide and free space is eliminated by impedance matching the of 377 ohms. This increases directivity, reduces diffraction and better gain. The ability of horn antennas to work optimally in the megahertz to gigahertz to terahertz range has led to their widespread use for space applications since the beginning of time. [2] Conical horns constitute a special type of aperture antenna that finds wide applications in microwave engineering including satellite communications, multi-channel radio links, high-power systems [3, 4].

II. Classification of Horn Antenna:

Figure 1 illustrates how horn antennas are categorized. It is separated into two categories: circular and rectangular horn antennas.

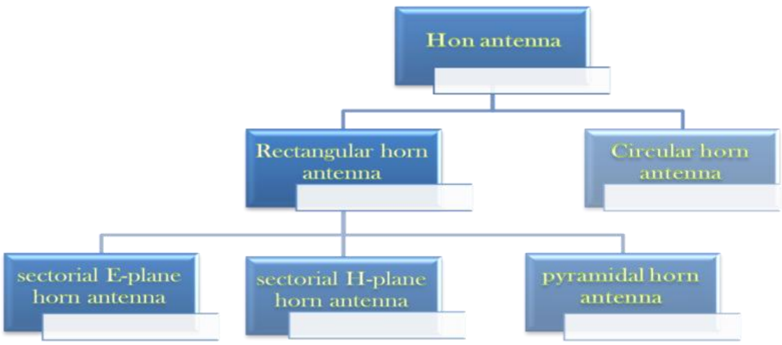

Fig1. Types of Horn Antenna

A rectangular waveguide serves as the feeding mechanism for rectangular horn antennas, whereas a circular waveguide serves the same purpose for circular horn antennas.

Based on the flare direction, rectangular horn antennas are divided into sectorial and pyramidal horns. if there is only one direction of flare. Sectorial horn antenna of the E-plane is what is referred to if the flaring is in the direction of the electric vector, and sectorial horn antenna of the H-plane if it is in the direction of the magnetic vector. Pyramidal horn antenna results from flaring in the rectangular waveguide's electric and magnetic vectors. The circular waveguide ignition is the main component of the conical horn antenna. Figure 2. Showing all four types of horn antennas.

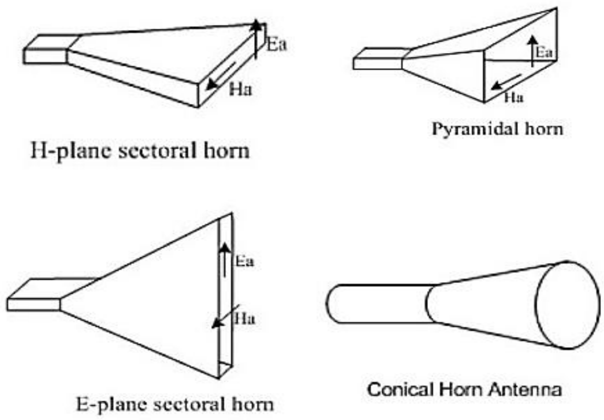

Fig2. Classification of Horn Antenna.

III. DESIGN OF CIRCULAR HORN ANTENNA:

Increasing the value of the directivity factor and achieving matching between the transmission line and the propagating media is the main objective of the horn antenna. The geometry of a conical horn antenna shown in Figure3. Horn in a cone Circular waveguide and conical aperture are used to feed antennas. Utilizing a spherical coordinate system, Bessel Function and Legendre polynomials are utilized to determine the modes moving through the antenna. [2].One of the main characteristics of a horn antenna is The angle of flare the wave . There can be a different angle for both the E-plane and the H-plane and this is referred to as θ_E and θ_H. After applying the Pythagorean Theorem, Equations 1 and 2 are the horn antenna design equations.

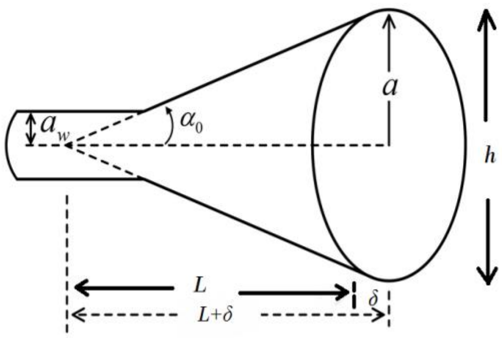

Fig3: Conical Horn Antenna

$$\cos\theta = \frac{L}{L+\delta}$$

$$\theta = \cos^{-1}\left(\frac{L}{L+\delta}\right) \qquad \dots(1)$$

$$\theta = \tan^{-1}\frac{h}{2L} \qquad \dots(2)$$

$$\text{diameter} = \sqrt{3\lambda L} \qquad \dots(3)$$

$$(L+\delta)^2 = L^2 + \left(\frac{h}{2}\right)^2$$

$$L = \frac{h^2}{8\delta}$$

L: is the length of the horn, δ phase angle variation reported as a percentage of 360° is acceptable, λ is the wavelength of the signal,h is the length of the flare ***section,*** a_w***: is the waveguide radius, and θ is the semi flare angle.***

if there is an excessive flare angle (2θ). For a given aperture distribution, the directivity is proportional to the size of the aperture. The non-uniform phase distribution on the horn aperture reduced the directivity and increased the beamwidth, and the extremely narrow flare angle depicts the antenna as an open-ended waveguide. At the maximum flare angle that does not exceed a predetermined value, maximum directionality is attained. For a conical horn, the typical values for flare angle are 0.32. A pyramidal or conical horn antenna's increased directivity is due to their multiple flaring angles.. The following formula is possible but approximate to half power.

$$\theta_E = \frac{56\lambda}{h} \quad \text{degrees}$$

$$\theta_H = \frac{67\lambda}{w} \quad \text{degrees}$$

where θ_E & θ_H *represent half-power width (HPBW).In the E and H direction, respectively*

$A = h \times w = \text{horn mouth opening area.}$

$$D = \frac{7.5A}{\lambda^2}$$

$$G = \frac{4.5A}{\lambda^2}$$

Where D&G Directivity and given respectively

IV. Simulation and Results:

We designed the conical horn antenna and implemented it using advanced simulation software "HFSS". The geometry and dimensions of the conical horn antenna in HFSS is shown in Figure 4.

The field distribution on a conical horn antenna's inner surface is depicted in Figure 5. The return losses for a conical horn antenna are shown in Figure 6, and its resonance frequency is 12 GHz. Figures 7 and 8 depict the 3D radiation patterns of conical horn antennas with right- and left-handed circular polarization, respectively. Figures 9 and 10 depict the left-handed circularly polarized conical horn antenna's two-dimensional radiation pattern

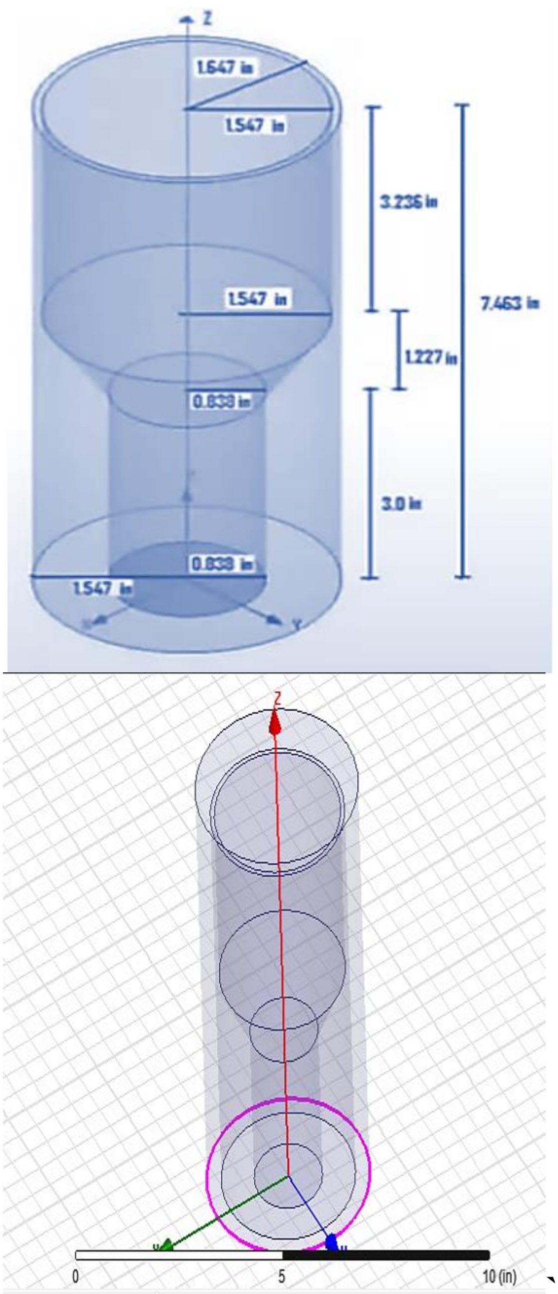

Fig4. Dimensions of Conical Horn Antenna

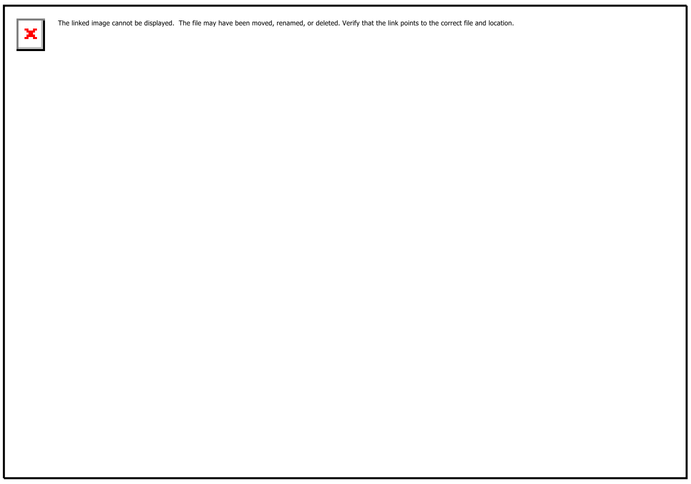

Fig5. field distribution.

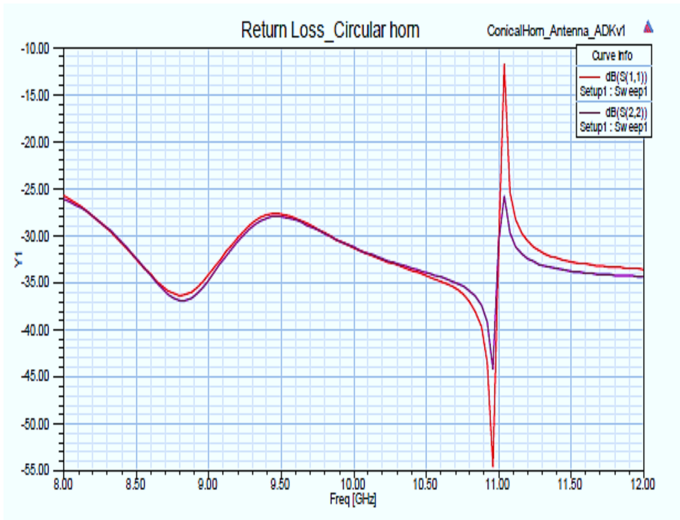

Fig5. Return Loss

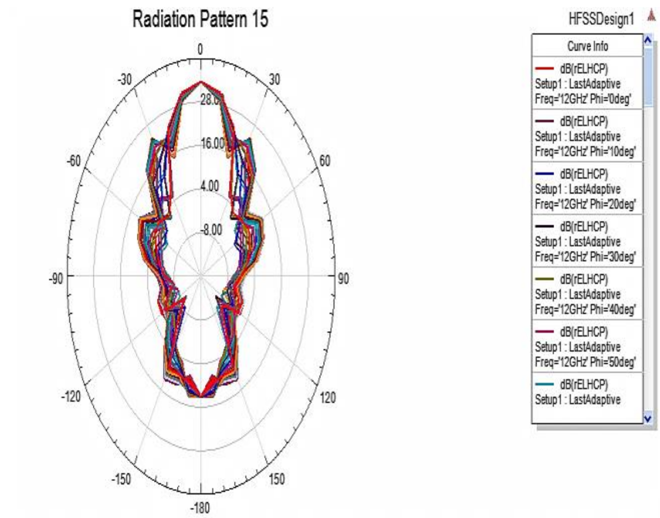

Fig6. Radiation pattern of LHCP

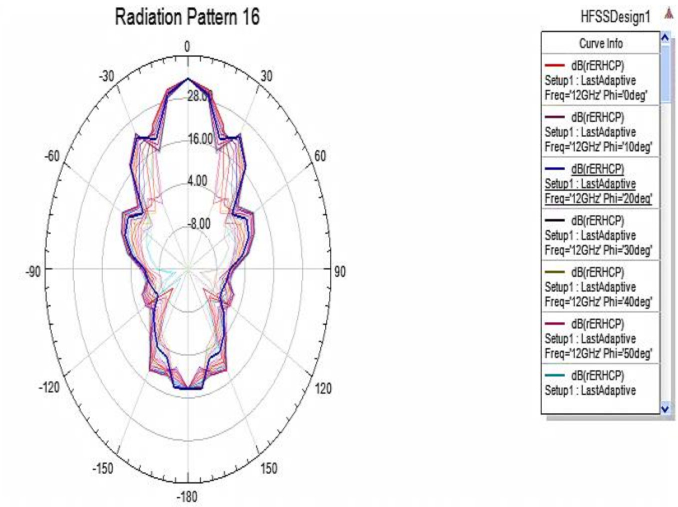

Fig7. Radiation pattern of RHCP.

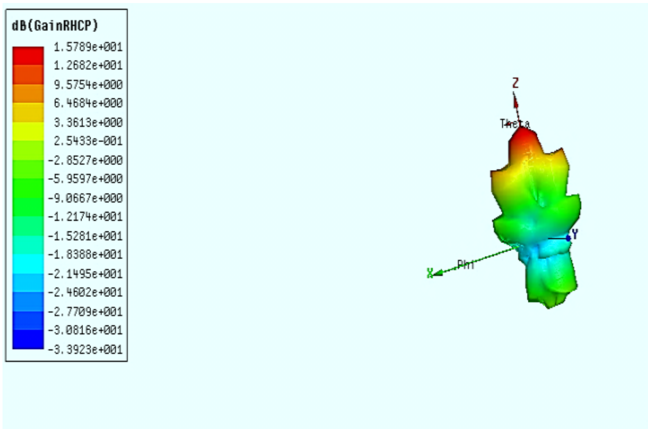

Fig9. Polar plot RHCP.

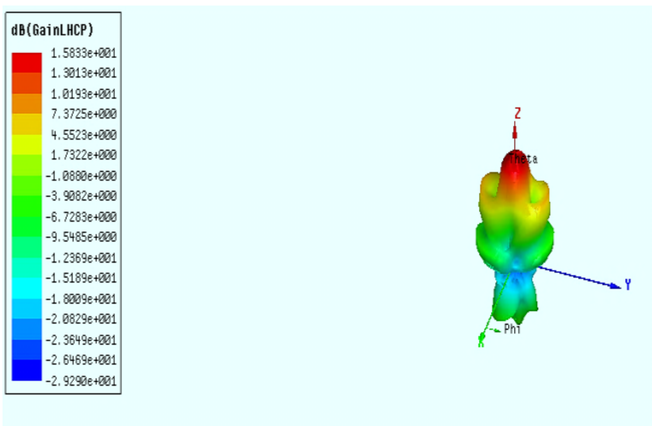

Fig10. Polar plot LHCP.

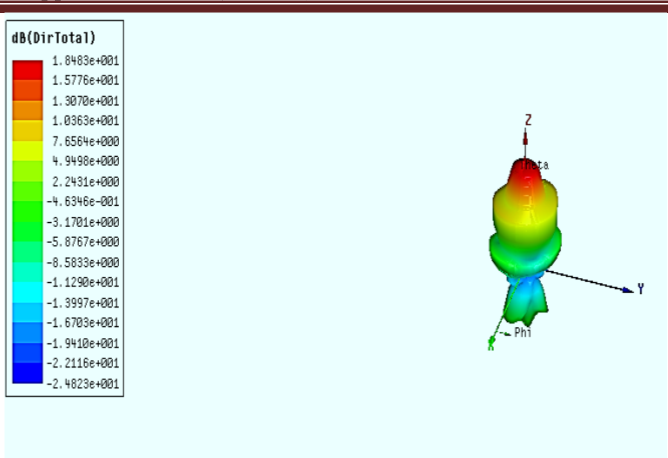

Fig11. Polar directivity in dB

V. CONLUSIONS:

Conical horn antenna design has been undertaken to be used for determined high power applications in X-band for radar and space communications. . HFSS software was used to design, simulate the horn. This conical horn antenna is used as a feed for an X-band radar or uplink satellite antenna systems. It is also expected to be suitable for blocks of systems in other space communication missions.

VI. RECOMMENDATION FOR FUTURE WORK:

Size of antenna, and changing the material with Metamaterials could be an alternative for any determined future research work.

VII. REFERENCES:

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