IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Design and analysis of pyramidal Horn antenna

[1] **Mrs. Rikita Gohil**, [2] **Mrs. Niti P. Gupta**

Electronics and Communication Engineering Department

S.V.I.T. Vasad, Gujarat, India

Abstract: This paper discusses the design of a pyramidal horn antenna with high gain, suppressed side lobes. The horn antenna is widely used in the transmission and reception of RF microwave signals. Horn antennas are extensively used in the fields of T.V. broadcasting, microwave devices and satellite communication. It is usually an assembly of flaring metal, waveguide and antenna. The physical dimensions of pyramidal horn that determine the performance of the antenna. The length, flare angle, aperture diameter of the pyramidal antenna is observed. These dimensions determine the required characteristics such as impedance matching, radiation pattern of the antenna. The antenna gives gain of about 25.5 dB over operating range while delivering 10 GHz bandwidth. Ansoft HFSS 13 software is used to simulate the designed antenna. Pyramidal horn can be designed in a variety of shapes in order to obtain enhanced gain and bandwidth. The designed Pyramidal Horn Antenna is functional for each X-Band application. The horn is supported by a rectangular wave guide.

Index Terms **- Gain, Horn, Impedance, RF, Rectangular Waveguide, Return loss, Radiation pattern.**

INTRODUCTION

Pyramidal horn is one type of aperture antenna flared in both directions, a combination of E-plane and H-plane horns. 3D figure is shown **as Figure 1.**Horn antennas are commonly used as a standard gain antenna for calibration purpose of other antennas. Horn antennas are also used as a feeding element for large reflector and lens antennas in communication systems. Its radiation pattern in one plane can be adjusted by changing the aperture dimensions or length of the horn in that plane with negligible variations in the radiation pattern in another plane. By proper selection of the feeding element, a wideband horn antenna has been reported [1].

The horn antenna is most widely used simplest form of microwave antenna, which comes from the aperture antenna family. The flaring of the metal helps in the gradual matching of the impedance of the waveguide, usually 50 Ω, that of the free space i.e., 377 Ω. The advantages of a horn are its wide bandwidth, low VSWR and simplicity of construction. They are designed in variety of shapes and sizes to fulfill many practical applications, such as communication systems, electromagnetic sensing, directive antenna applications, microwave applications, biomedical applications and as a reference source for testing of other antennas.

These horns can be used as feeds for other antennas such as reflectors, compound and lens antennas due to the horn antenna can be preferred over other aperture antennas. Basically the horn antennas are classified as rectangular horn antennas and circular horn antennas. The rectangular horns are further divided into sectoral horn and pyramidal horn. The sectoral horn is divided into two types based on the direction of flaring in accordance of the field vectors. The E – plane sectoral horn is obtained when the flaring is done in the direction of the electric field vector. The H – plane sectoral horn is obtained when the flaring is done in the direction of the magnetic field vector. When the flaring of the walls of the waveguide is done along the direction of both E and H field vectors, it gives rise to a horn called Pyramidal Horn The pyramidal horn antennas are the most extensively used antennas since they have the combined characteristics of both E – plane and H – plane sectoral horns.

The characteristics of an antenna can be understood by the antenna parameters. The various parameters such as radiation pattern, beam width, directivity, and radiation intensity is used for the analysis of an antenna.

Pyramidal horn antennas are widely used in various applications in the microwave range due to its high gain, moderate bandwidth and low voltage standing wave ratio VSWR. Its construction is relativity simple and they are often used as feeders of reflectors and currently in applications where wide bandwidth is required, such as the technology WiMAX.

Pyramidal horn antenna has extensively been used as a feed element for radio astronomy, satellite communications and in the antenna test bench as a reference antenna for last several decades due to its simplicity in construction, ease of excitation, large gain and relatively better radiation characteristics at microwave frequencies. Much research work has been devoted to develop improved feed systems utilizing corrugated horns in pyramidal and conical shapes [2] to reduce spillover efficiency and increase radiation efficiency.

The advantages of horn antenna are moderate directivity, low standing wave ratio, broad bandwidth, easy to construct and adjustment. One of the first horn antennas was constructed in 1897 by Indian radio researcher Jagadish Chandra Bose in his pioneering experiments with microwaves [3] Horn antenna also selects the polarity of the waves to be received, which helps to attenuate unwanted signals from the adjacent channels and other communication satellites. The beam width calculated is minimizing the spillover losses, illumination losses for the reflector dish and to increase the reflector efficiency [4].

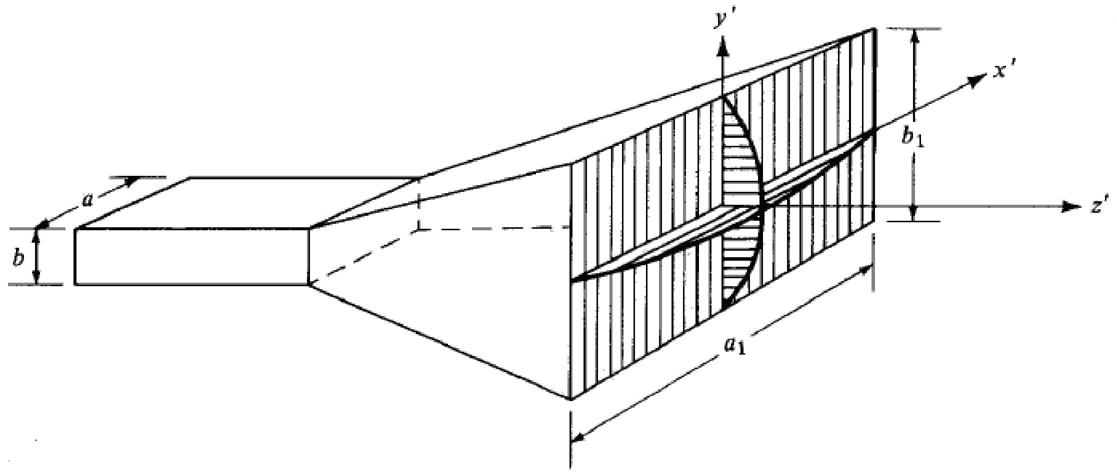
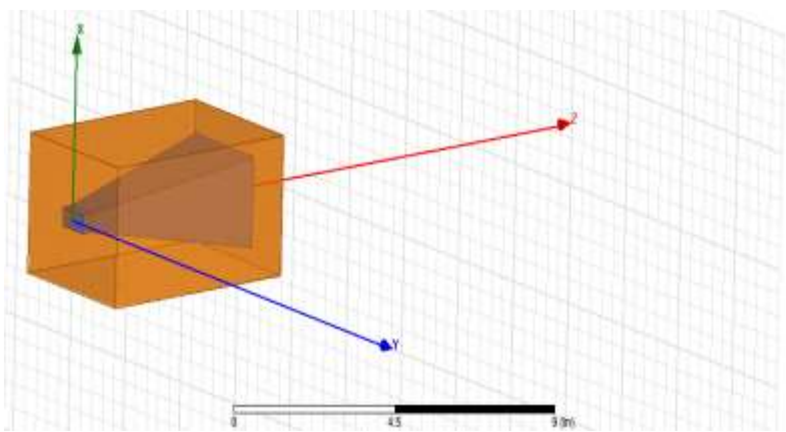


Fig. 1 E and H plane Horn

DESIGN EQUATION

$$E'_y(x',y') = E_0 \cos\left(\frac{\pi}{a}x'\right)e^{-j\left[k\left(\frac{x'^2}{2\rho_2}+\frac{y'^2}{2\rho_1}\right)\right]}$$

Structure Of Pyramidal Horn antenna



Condition for Physical Realization:

1. **The slant height of pyramidal horn is given by**

$$P_e=(b1-b)\left[\left(\frac{\rho_e}{b_1}\right)^2-\frac{1}{4}\right]^{1/2}$$

$$P_h=(a1-a)\left[\left(\frac{\rho_h}{a_1}\right)^2-\frac{1}{4}\right]^{1/2}$$

The pyramidal Horn Design is not possible if $P_e$is not equal to P_h.So, it is the necessary condition for designing horn antenna $P_e = P_h$

2. The directivity of a pyramidal horn can be expressed as a combination of the directivities of the sectoral feed horns. The directivity of the antenna is calculated by,

$$D_p=\frac{\pi\lambda^2}{32ab}D_E D_H$$

3. Horn width in H-plane

$$a_1=\sqrt{3\lambda\rho_2}\approx\sqrt{3\lambda\rho_h}$$

4. Horn width in E-plane

$\rho_2=\rho_h$

$$b_1=\sqrt{2\lambda\rho_1}\approx\sqrt{2\lambda\rho_e}$$

$\rho_1=\rho_e$

ANALYSIS AND RESULTS

S-parameters are complex scattering parameters and are called because both the magnitude and phase of the input signal are changed by the network. The analysis of the design with S(1,1) parameter is done on XY-plot 1 is shown below. The reflected energy caused due to impedance is match in the system is called the return loss. The return loss is a numerical value that indicates how much of signal that is reflected back into the cable from the terminating equipment. Return loss is essential in applications that use simultaneous bidirectional transmission. Return loss is generally calculated in dB. Larger values are better as they indicated less reflection. Results shown below are obtained after the simulation.

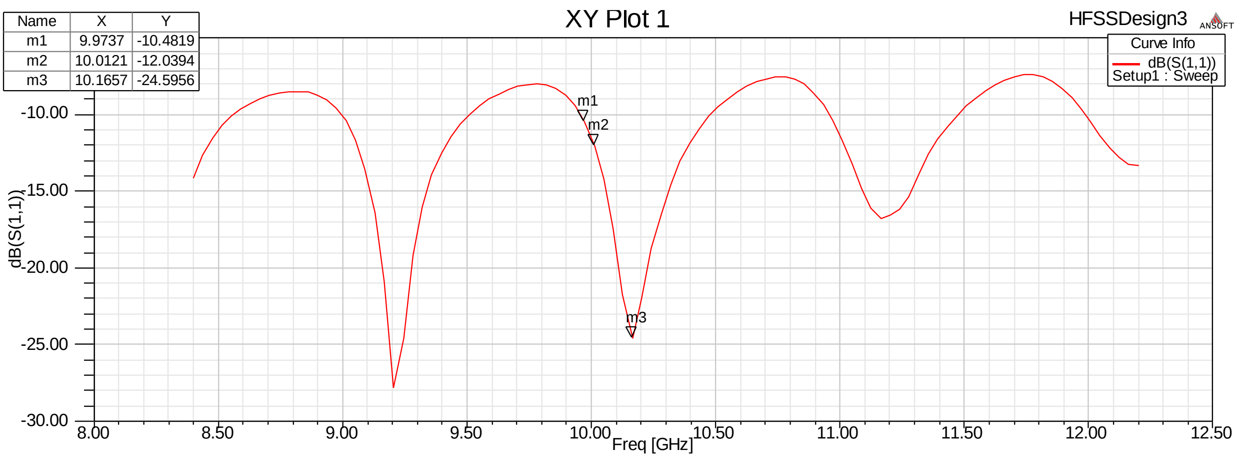


Fig. 2 S11 curve of pyramidal horn antenna

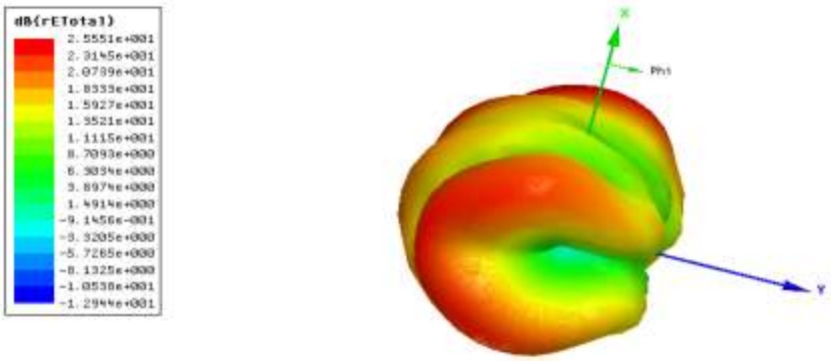


Fig. 3 Directivity Curve

Radiation pattern

Radiation pattern refers to the graphical representation of electromagnetic power distribution in free space. It also means amount of field strengths radiated by the antenna.

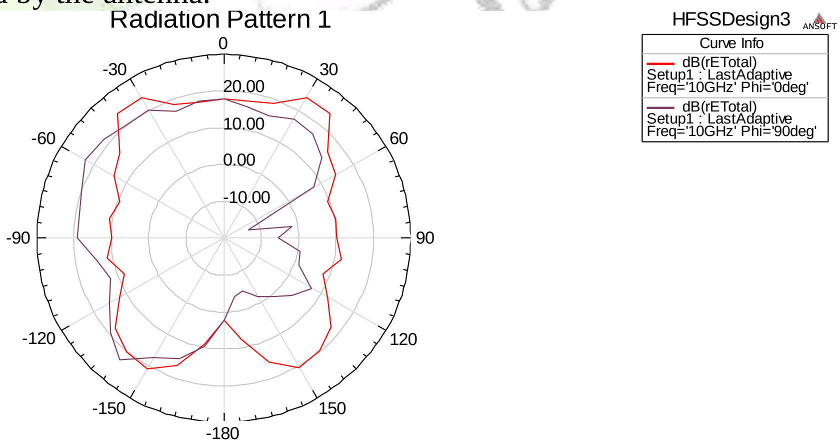
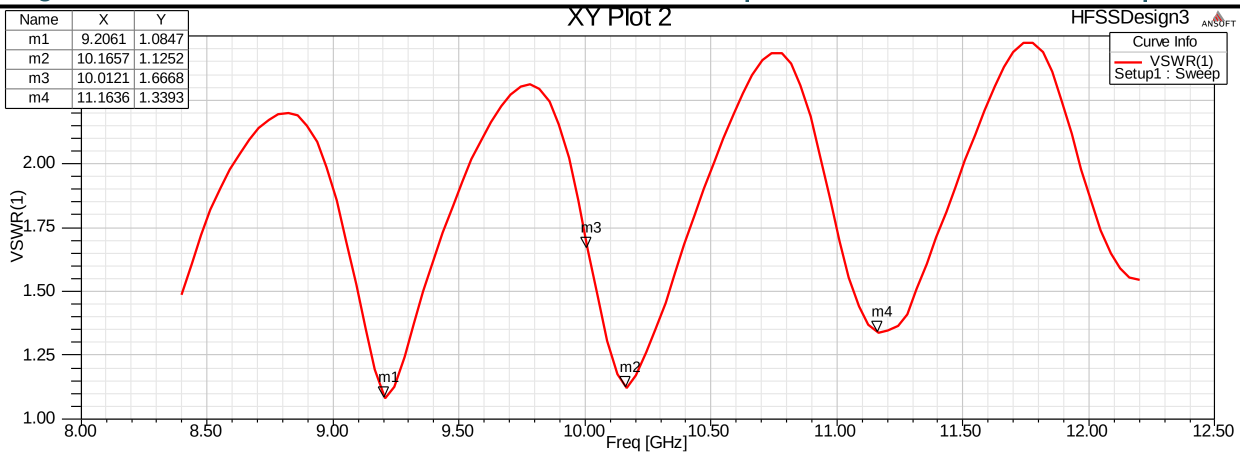


Fig. 4 Radiation pattern

VSWR:

Voltage standing wave ratio gives us the value that how our antenna is matched with the load resistance or with transmission line impedance. The graph for VSWR is given below. The value of voltage standing wave ratio calculated through simulation is less than 2 hence can be considered fair for signal transmission when there is low attenuation present.



Current distribution analysis

Electric field distribution inside the horn contributes major role in the propagation of microwaves. According to the results above, the designed horn antenna is considered to be stable and suitable to be operated within the frequency range of 8-12 GHz. The lower return loss and voltage standing wave ratio (VSWR) assures that the signal radiated is almost in equilibrium state. The radiation pattern shown in polar plot is considered to be good.

Conclusion:

Design presented is an Optimum Pyramidal horn antenna, operating in the complete X band i.e. 8-12 GHz. Pyramidal Horn antenna have several advantages over other conventional antennas such as their light weight higher directivity. Also the horn antennas have to be designed as per the selected waveguide. This antenna can be used for applications in wireless communications. These antennas are used significantly where directivity of the signal or information is of main area. According to the results above, the designed pyramidal horn antenna is suitable to be operated within a frequency range of 8 – 12 GHz. The lower return loss and voltage standing wave ratio assures that the signal radiated is almost in equilibrium state. The antenna radiate in particular direction with higher radiated power.

Referances:

1. C. Ozdemir et al. “Ultra-wide band horn antenna design for ground penetrating radar: A feeder practice,”in 15th International Radar Symposium (IRS), Gdansk, June 2014, pp. 1–4.
2. A. D. Olver et al., “ Microwave Goms and Feeds”, IEEE Electromagnetic Series 39, 1994

3. Emerson D. T., The work of Jagadish Chandra Bose: 100 years of mm-wave research, IEEE transactions on microwave theory and techniques, 1997, 45(12).

4. Syed Azhar Hasan, “ Design , simulation, development & testing of wideband high performance pyramidal horn feed for terrestrial microwave(LOS) communication in mobile & wireless applications” CJMW 2011 proceedings

5. C. A. Balanis, Antenna Theory and Design, 3rd edition, New York, 2005.

6. Ayodele S.Oluwole,viranjan M. Srivastava, “Design of smart antenna using waveguide-fed pyramidal horn antenna for wireless communication systems”, IEEE(INDCON),2015.

7. Katsushige Harima, Makato Sakasai, Katsumi Fujji, “Determination of gain for pyramidal horn antenna on basis of phase center location”, IEEE (ISEC), 2008.