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DESIGN AND SIMULATION OF HORN ANTENNA AT 2GHZ WITH HFSS

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Abstract: The design and simulation of a rectangular pyramidal horn antenna at 2GHz are described in this work, which may be utilized in electromagnetic sensing, antenna calibration, microwave heating and different wireless communication systems. Pyramidal horn antennas have many merits such as simple in manufacturing low fabrication cost, moderate bandwidth; because of these merits, they find more applications in electromagnetic compatibility measurements and radars. To design the desired horn antenna a maximum gain of 15 dB at 2 GHz is considered and the range of frequency chosen is 1.6 to 2.4GHz, which is often L-band or S-band. The horn antenna design and its simulation are explained in this study. ANSYS HFSS software was used for the simulation. A gain of 12.94 dB was attained at 1.96 GHz, according to the simulation results.

Keywords: ANSYS HFSS, Horn antenna, Radiation pattern, Gain

I. INTRODUCTION

Horn antennas are a form of aperture antenna used in a variety of applications including wireless communication, LAN extensions, naval communication, reflector feed elements, microwave and electromagnetic heating, satellite communication, lens antenna and phased arrays. These antennas are also frequently used to calibrating other antennas [1].The radiation field from an antenna aperture may be calculated using the fields over the aperture. At higher frequencies especially on UHF, the horn antenna is quite common. Theoretical study of the electromagnetic horn antenna is obtained from Maxwell equations [2].
Horn antennas may have different sizes and shapes. Sectoral, Pyramidal and conical are the different types of horn antenna. Simplest and largely used horn antenna in the wireless communication applications is the Pyramidal horn. The input impedance for horn antennas is constant and impedance-bandwidth is wide.

Horn antenna can be designed by flaring waveguides. The flare is created to match impedance. Waveguide impedance is around 50–60 ohm, whereas intrinsic impedance is roughly 377 [3]. Horn antenna gain is usually high and it enhances the antenna's directivity. They largely applied for long-range communication and as a feed for big parabolic reflector antennas since it is a directional antenna [3]. The directed pattern may be used to concentrate the emitted power in the desired direction. Although there is a broad selection of antennas available today, commercial antennas may not always meet the needs of users; for example, the gain may be insufficient or the frequency range may be insufficient. As a result, our only choice is to construct our own antenna. Low VSWR, broad bandwidth, sturdy design, easy excitation and simple construction are all advantages of horn antennas. They come in a wide range of forms and sizes to accommodate a wide range of practical uses [4-10].

II. HORN ANTENNA DESIGN

Design of a pyramidal horn antenna is done by considering some certain specifications. Frequency range is the one of the important parameters. The horn antenna is implemented for S-Band application with center frequency of 2 GHz. Determining the antenna gain needed for the desired frequency of operation will be the first step in designing the horn antenna. When compared to the horn antenna, the dipole antenna has a much lower gain. As a result, the goal of this study is to obtain a gain of 15 dB at 2 GHz, which is commonly utilized for communication. For a desired gain G and frequency of operation f and waveguide dimensions a & b the horn antenna as shown in figure 1 can be designed as follow:

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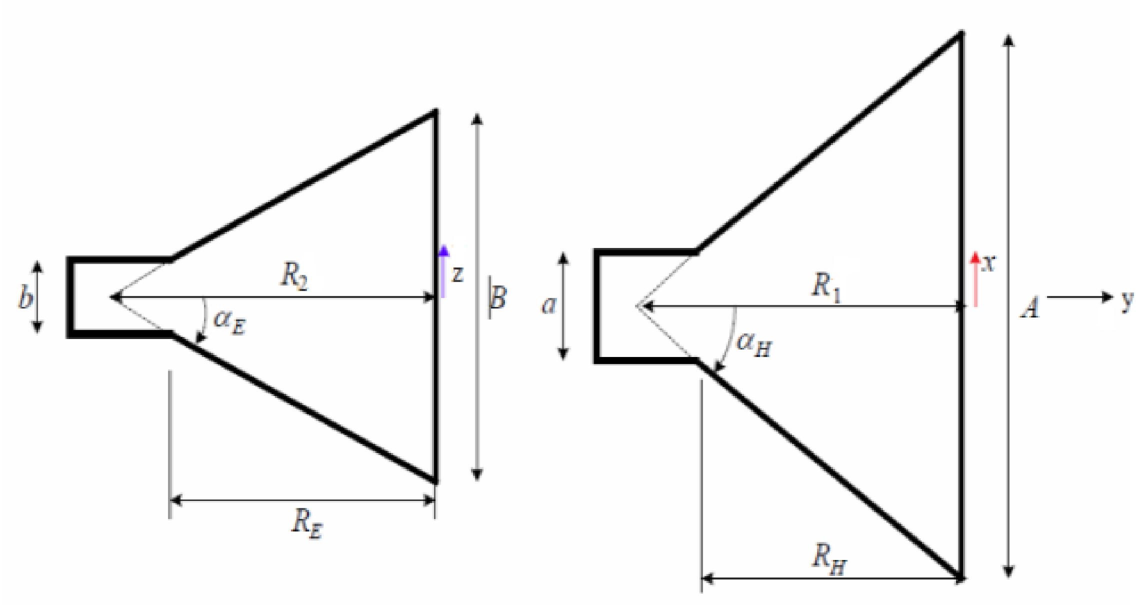

Figure 1: Horn antenna parameters

- Find first approximate value forA using

$$A = 0.45\lambda\sqrt{G} \quad ---(1)$$

- Calculate B

$$B = \frac{1}{4\pi}\frac{G\lambda^2}{0.51A} \quad ---(2)$$

- Calculate R_1

$$R_1 = \frac{A^2}{3\lambda} \quad ---(3)$$

- Calculate R_2

$$R_2 = \frac{B^2}{2\lambda} \quad ---(4)$$

- Calculate R_E

$$R_E = R_2\left(1 - \frac{a}{A}\right) \quad ---(5)$$

- Calculate R_E

$$R_H = R_1\left(1 - \frac{b}{B}\right) \quad ---(5)$$

Check if$R_E = R_H$. If not, change the approximation of A and repeat the above procedure until $R_E = R_H$ is satisfied.

HFSS microwave tool is used to get the numerical results of the structure. This tool uses finite element method where it model the structure in electromagnetic form by Maxwell equations. Through this tool, we can visualize the parameters, which are required to analyze and optimize the pyramidal horn antenna. Return loss, bandwidth, radiation patterns, gain, VSWR are the different parameters we can use to analyze the performance of the pyramidal horn antenna. Figure 2 represents the 3D view of proposed simulated model of pyramidal horn antenna in HFSS tool.

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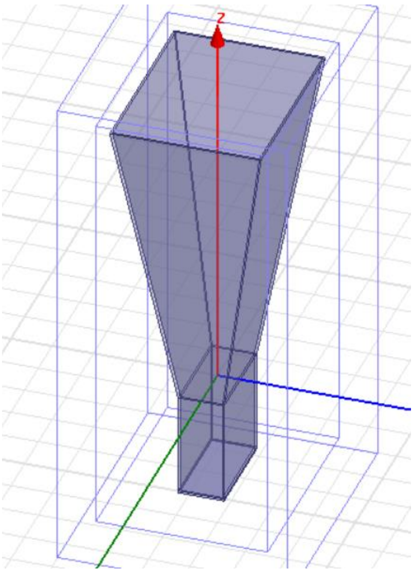

Figure 2: 3D view of Pyramidal Horn antenna in HFSS

Using the process outlined above, a horn antenna for 2 GHz is designed and the dimensions are shown in table 1.
Table 1: Different parameters of horn antenna.

Parameter	Dimension (mm)
a	114.3
b	50.8
Waveguide Length	127
Horn a	228.6
Horn b	177.8
Wall thickness	2.54
Horn Flare Length	381

II. RESULT AND ANALYSIS

The numerical values for the proposed Horn antenna are obtained by using HFSS microwave simulation software. Different types of parameters are studied by using simulation software such as: reflection coefficient with respect to frequency, 2D and 3D view of radiation pattern, voltage standing wave ratio etc. Return loss indicates the amount of lost energy while antenna is radiating the signal. It tells to what extent the transmitter impedance is matched with antenna impedance. The S11 represents the return loss graph and it is a function of frequency.
Figure 3 represents the return loss graph and -40.77dB of return loss is attained at the 1.96 GHz operating frequency. This value of return loss indicates good impedance match.

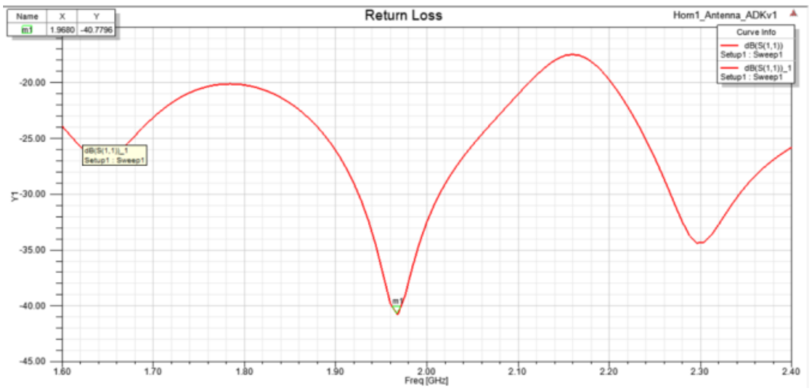

Figure 3: Return loss of pyramidal horn antenna.

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VOLTAGE STANDING WAVE RATIO (VSWR)

It represents the degree of mismatch of an antenna with respect to the transmitting and /or receiving system. VSWR of a perfectly matched antenna system would be close to 1, that means the all the amount of energy reflected or transferred into the cable. The following figure 4 shows VSWR of the antenna. At 1.96 GHz the VSWR, the value is 1.04.

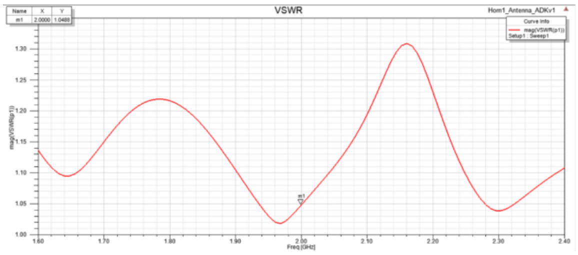

Figure 4: VSWR graph

Fig. 4 represents that the VSWR value is around 1 throughout the full frequency range swept by the proposed antenna, indicating that the antenna is well adapted to the power supply system.

DIRECTIVITY AND RADIATION PATTERN OF AN ANTENNA

Directivity: It is defined as the ratio of an antenna's radiation intensity in a given direction to the radiation intensity averaged over all directions. Peak directivity in turn, is the maximum directivity over all the user-specified directions of the far-field infinite sphere.

Radiation Pattern: Represents geometric distribution of radiation power in the different directions of the space. The following figure shows the radiation pattern in 2D of the proposed antenna. This figure represents both E-plane and H-plane radiation patterns.

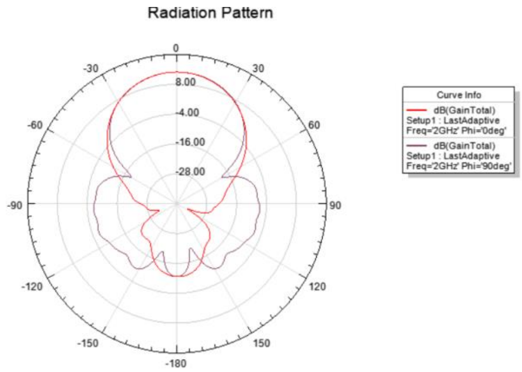

Figure 5: Radiation patterns of designed horn antenna

Gain in 3D: The capacity of an antenna to radiate in certain directions to an excitation source is referred to as antenna gain. Normally, the gain is calculated in the directions of maximum radiation (Main lobe). The figure 6 represents the 3D radiation pattern with gain. Simulated gain 12.94 is achieved.

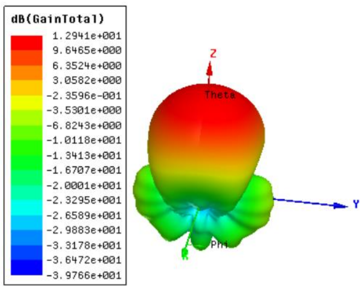

Figure 6: 3D radiation pattern with gain

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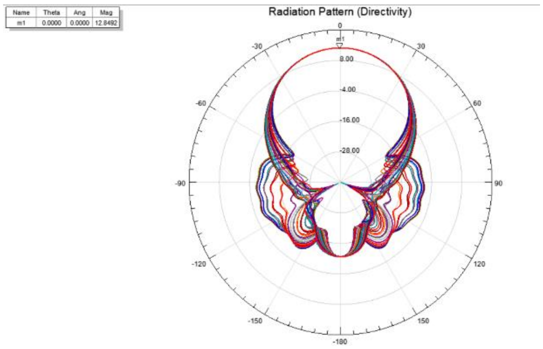
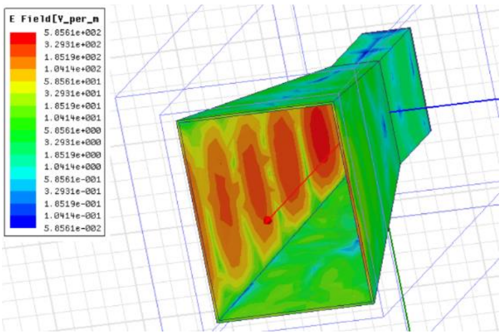


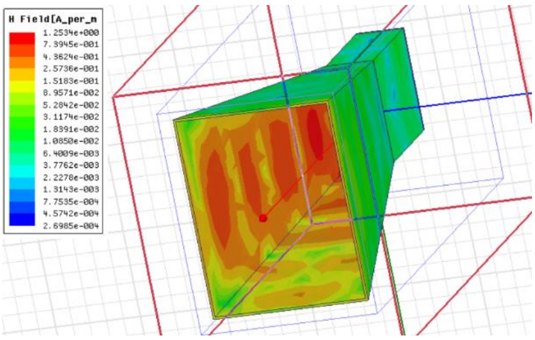
Figure 7: 2D radiation pattern with directivity

It can be seen from this radiation pattern that this horn antenna has stable radiation pattern with a resonant frequency of 1.96GHz.

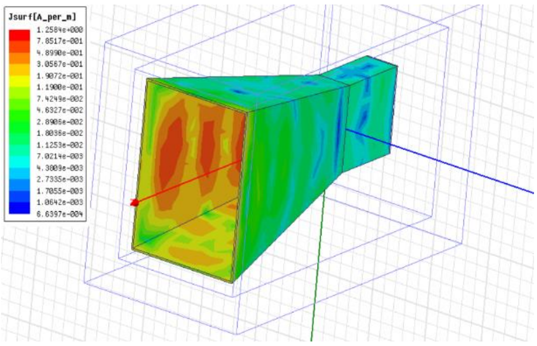
The E-field, H-field and surface current distribution of the designed horn antenna are shown in figure 8. Microwave propagation is greatly aided by the dispersion of electric fields inside the horn. When the mouth of the rectangular waveguide opens at a certain distance, both electric and magnetic fields are released from the waveguide and move in free space. Pyramidal horn concentrates its beam pattern in E and H planes.



a. E-field distribution



b. H-field distribution



c. Surface current distribution

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Figure 8: a. E-field distribution b. E-field distribution and c. Surface current distribution of designed horn antenna

Figure 8c depicts the surface current density travel along the boundary with a value of 1.25 A/m.
The results of the designed horn antenna at 1.96 GHz are summarized and presented in table 2.

Table2: Results summary

Parameter	Value
Return Loss	-40.77dB
VSWR	1.04
Directivity	12.84 dB
Gain	12.94 dB

This Horn antenna is proposed to detect the objects in visually obstructed area for long rage detection, because Ultra wide band electromagnetic waves that are able to penetrates the varies obstacles on the other side of the wall. UWB horn antenna has very wide bandwidth in order to detect the object clearly and effectively. Ultra Wide Band radars are used for this purpose and it may be satisfied the condition.

IV CONCLUSION

The design and simulation of a large rectangular waveguide pyramidal horn antenna intended for L and S-band applications is presented. The design and simulation of horn antenna at 2 GHz is done in ANSYS HFSS tool. Simulated gain of 12.94dB is achieved at 1.96 GHz. WLAN connection aboard ships and other applications are possible with this antenna. Although the antenna is designed for 2GHz, it may be utilized with a high gain for frequencies ranging from 1.6 GHz to 2.4 GHz.

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