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Design of Pyramidal Horn Antenna for UWB Applications

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Abstract: This paper discusses the design of a pyramidal horn antenna with high gain, light weight, linearly polarized, suppressed side lobes for UWB applications. The procedure is straightforward, and determines the physical dimensions of pyramidal horn that determine the performance of the antenna. The length, flare angle, aperture diameter of the pyramidal antenna is examined. These dimensions will determine the required characteristics such as impedance matching, radiation pattern of the antenna. The proposed antenna is simulated with commercially available packages such as Ansoft HFSS. The antenna gives decent gain of about 35 dB over operating range while delivering 4-13 GHz bandwidth.

Keywords: UWB, HFSS, flare angle, horn antenna

I. INTRODUCTION

Horn antennas have been widely used for space applications from the very beginning due to their capability of being best operation from Megahertz to Gigahertz to Terra hertz range. Advantages of horn antenna over other types of antennas are: (a) High data rate systems needs to be operated at a higher frequency range in order to achieve higher bandwidth. This can be easily achieved using a horn antenna (b) Complexity involve in the design of horn antenna is less as compared to phased array antennas & corrugated cousins [3]. (c) Feeding a horn antenna is less complex as compared to other antennas which require complex feeding techniques (d) If horn antenna is properly designed & optimized than side lobes can be suppressed to very low levels. (e) Power handling capability of horn antenna is superior to other antennas as it is waveguide fed antenna, especially in the use of TWTs used in satellites, radars and many other applications making it an ideal choice for space applications. Horns have conventionally been used in terrestrial microwave communications. They can also be found on many Line-Of-Site (LOS) microwave relay towers [1]. Horn Antennas are used in remote sensing satellites, communication satellites, geographic information & weather satellite. Various space programs in which horn antennas are used by NASA, ESA.

II. . DESCRIPTION OF PYRAMIDAL HORN ANTENNA

Antennas are one of the most important parts of a communication chain. In Modern times need for wideband applications has increased. The Horn Antenna is widely used in the EMC measurement, radar and communication system. Pyramidal Horn is the best horn as it has equal radiation patterns in both E-plane and H-plane along with its high gain and directivity. So, the need to develop a Wideband horn antenna for communication and calibration purposes[6]. With the development of measurement, communication system, radar techniques and electromagnetic, the horn antenna has been widely used which made it one of the most practical antennas. this horn antenna can effectively extend the working bandwidth of the antenna and improve the impedance matching between waveguide and free space [2].

III. ANTENNA DESIGN

The design was performed to accomplish an ultra-wide bandwidth (more than 40%), with low side-lobe and cross-polar levels. The selected frequency bands were X and Ku. The Antenna was designed using advance EM simulation software Ansoft HFSS with waveguide dimensions of a =22.86mm and b=10.16mm, waveguide length of L=25.4mm, Horn dimensions of Horn _a=45.72mm and Horn _b=35.56mm, horn Flare angle FL=76.2mm and wall thickness t=0.508mm and is shown in fig. 1. HFSS uses Finite Element Method as analysis & solution to Electromagnetic problems by developing technologies such as tangential vector finite elements, adaptive meshing, and Adaptive Lanczos- Pade Sweep (ALPS) [4]. Low aperture diameter is used to have high aperture efficiency low phase factor resulting in compact size. Higher order modes are excited at junction between aperture and waveguide due to large flare angles. The horn is nothing more than a hollow pipe of different cross sections, which has been tapered (flared) to a larger opening. The type, direction, and

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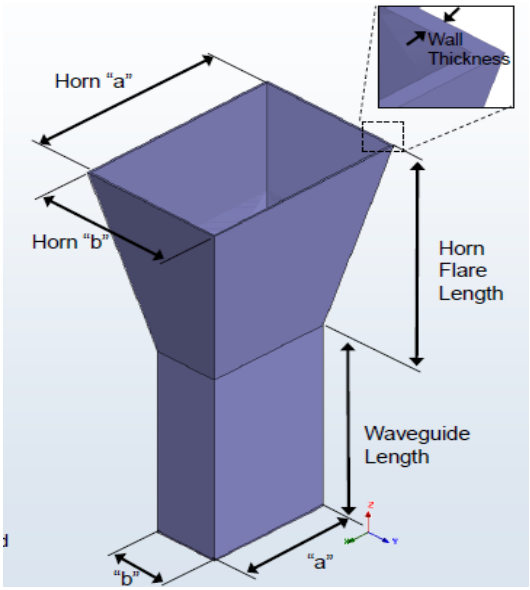

Fig.1 Structure of Proposed Horn Antenna

amount of taper (flare) can have a profound effect on the overall performance of the element as a radiator. The geometrical 3D view of designed Pyramidal Horn Antenna in HFSS is shown below in fig.2 It is very important to remember that the boundaries for the "air-box" and the "ground plane" have been set as an ideal propagation space and a perfect electric conductor, respectively[8].

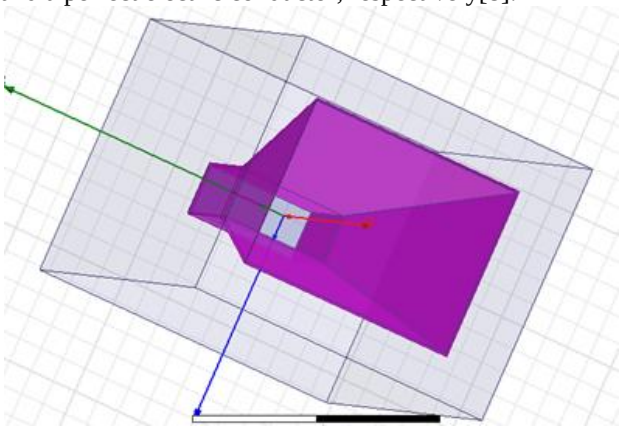

Fig.2 3D view of Pyramidal Horn in HFSS

III RESULTS AND DISCUSSION

There are certain parameters which verify the success of antenna design as when measurement results match simulation analysis well such as gain, directivity, polarization, impedance matching, beam width, front lobe to side lobe ratios and many more. There are many techniques by which these parameters can be measured and then verified with the simulation results. The gain of the proposed antenna versus frequency with return loss of -24dB is shown in Fig.3

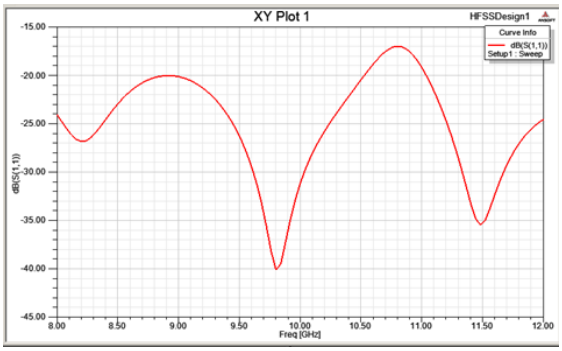

Fig.3 Return loss |s| db over frequency range

The Radiation pattern for the proposed antenna design directivity 35dB is shown in Fig.4 .

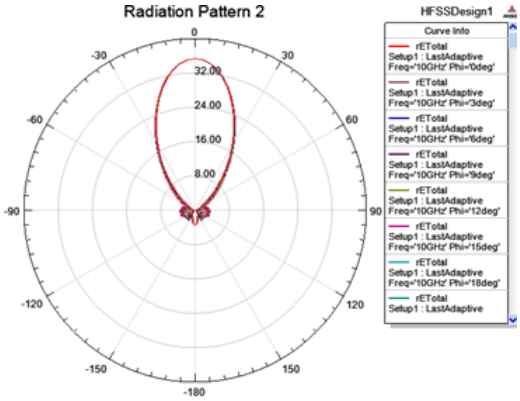

Fig.4 Radiation pattern of the antenna in HFSS

The Radiation pattern for the proposed antenna design in 3D is shown in Fig.5. HFSS has the capability to calculate and plot a 3D image depicting the real beam of the gain [8].

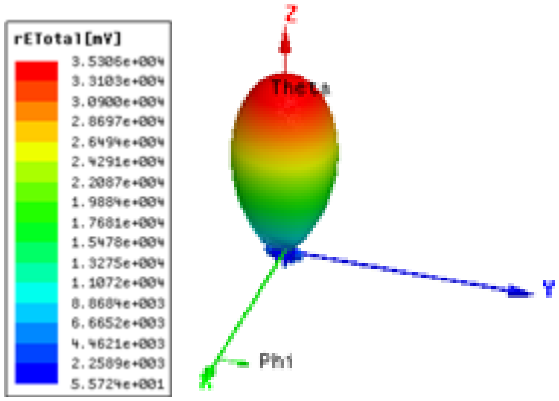

Fig.5 3D Radiation pattern of the antenna in HFSS

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IV CONCLUSION

An Ultra Wideband Pyramidal Horn Antenna operating in frequency range of 4-13 GHz is designed and optimized using HFSS. This linearly polarized antenna regardless of its size gives decent gain of about 35 dB over operating range while delivering 13 GHz bandwidth. This pyramidal horn antenna can be used in space applications. All the parameters of antenna have been carefully optimized to achieve superior performance with in the limited constraints. The antenna's gain is 35 dB, with return loss of -24 dB, side lobe level of -23 dB. These measurement results confirmed the results of the simulations and satisfied the design requirements. Desired results are achieved and the simulated structures are suitable for our applications. Structures are yet to be fabricated and measurement results will be presented accordingly. Efforts are going on to further improve bandwidth so as to accumulate even wider frequency range especially K Band and lower bands (L and S).

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BIOGRAPHY

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