International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:2682
Vol.4, No.11, November 2015 DOI:10.15693/ijaist/2015.v4i2.285-288

Analysis of Horn Antenna Loaded with different substrates for Microwave 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 and also compared with different substrate for Microwave 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 with different substrate materials are compared and analyzed and results in a decent gain of about 13 dB for PEC material over operating range while delivering 4-13 GHz bandwidth.**

Index terms – HFSS,horn , PEC,gain,directivity,microwave.

I. INTRODUCTION

A. Horn antenna

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. RELATED WORK

Marc Esquius-Morote [9] have proposed Novel Thin and Compact H-Plane SIW Horn Antenna In this paper , substrate integrated waveguide (SIW) technology allows to construct several types of commonly used antennas in a planar way. However, some practical constraints limit their performances when frequencies below 20 GHz are considered. The resulted gain by using this type of Horn antenna is 7.1 dB. Jorge Teniente, Ramón Gonzalo, and Carlos del-Río

[1] have concentrated on Ultra-Wide Band Corrugated Gaussian Profiled Horn Antenna Design. Return loss features are limited by the rectangular–circular transition restricting the real bandwidth of this design.

Jashanpreet Singh, Amandeep Singh Dhaliwal [10] have proposed Optimization and Designing of Conical Horn Antenna.In this paper the size of the antenna is somewhat larger dimensions. This should be reduced.

M.Ameena banu , N.R.Indira , M .Pandimadevi [11] have proposed the Design of Pyramidal Horn Antenna for UWB Applications In this paper , Flare angle is designed a higher degree .this is reduced in this proposed paper.

III. . DESCRIPTION OF PYRAMIDAL HORN ANTENNA

A. Objectives

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]. .

IV. PROPOSED 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 =3.6in and b=1.6in, waveguide length of L=4in, Horn dimensions of Horn _a=7.2 in and Horn _b=5.6in, horn Flare angle FL=12 degrees and wall thickness t=0.08mm and is shown in fig. 1. And table.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.

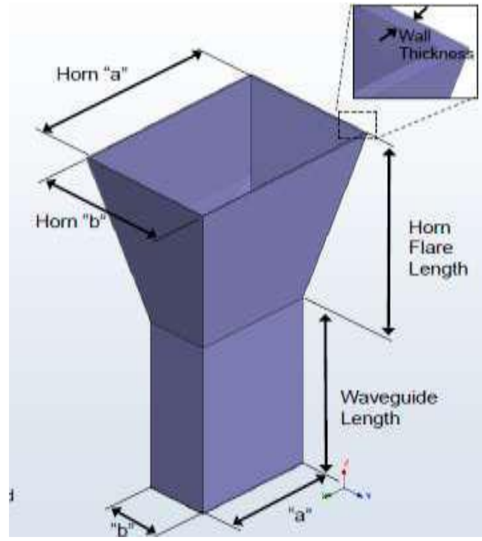

Figure.1 Structure of Proposed Horn Antenna

Pyramidal Horn Antenna	
Units	in
Solution Frequency (GHz)	2.5
Waveguide "a" Dimension	3.6
Waveguide "b" Dimension	1.6
Waveguide Length	4
Horn Size in "a" Dimension	7.2
Horn Size in "b" Dimension	5.6
Horn Flare Length	12
Wall Thickness	0.08
Outer Boundary	ABC
Standard Waveguide	WR-90

Table -1 Dimensions of Proposed Horn antenna

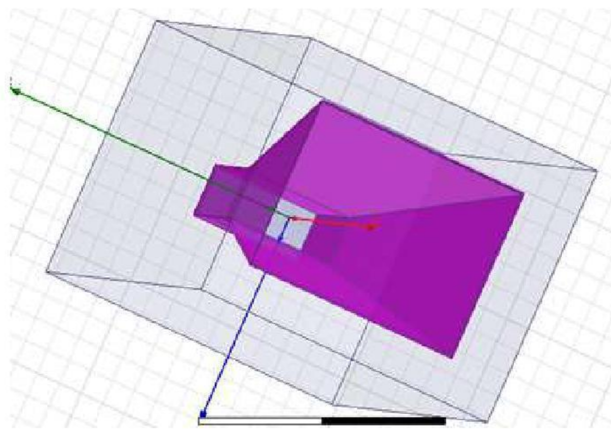

Figure.2 3D view of Pyramidal Horn in HFSS

The type, direction, and 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].

V. 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 is shown in Fig.3

A. Simulation Model and Parameters

We use Ansoft HFSS to simulate our proposed antenna design.

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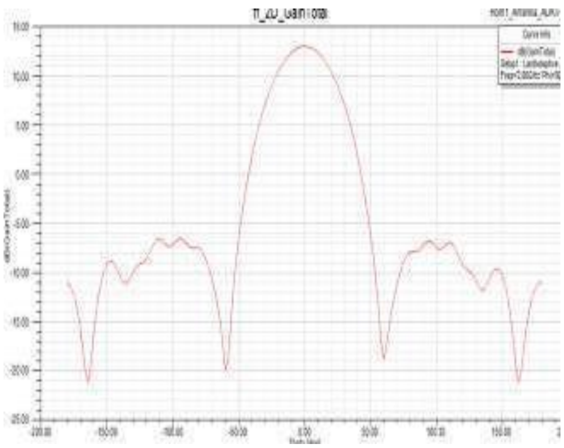

Figure.3 Gain in db over frequency range

The Radiation pattern for the proposed antenna design is shown in Figure.4 .

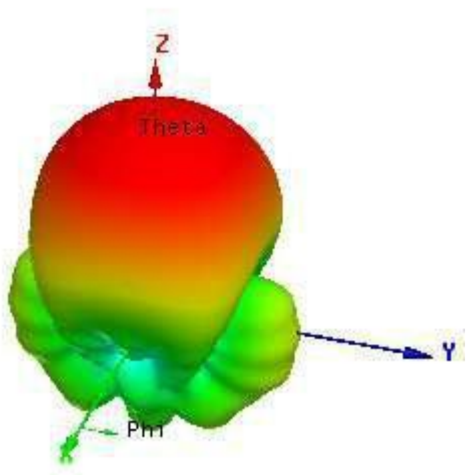

Figure.4 Radiation pattern of the antenna in HFSS

The Radiation pattern for the proposed antenna design in 3D is shown in Fig.4. HFSS has the capability to calculate and plot a 3D image depicting the real beam of the gain [8].

The Gain of the horn antenna with different substrate materials is compared with the PEC material and tabulated in table.2.

MATERIAL	GAIN (db)
PEC	13
Polymide	10
Polysterene	8

Table.2 Comparison of gain with different materials

Of this, It is analysed that Horn antenna with PEC material has a increased gain over other substrate materials. The dimensions used are considered same values for all the different substrate materials.

VI. 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 13 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 14 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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