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Design and Analysis of Conical Horn Antenna for Ku-Band Applications

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Abstract: ***This paper discusses the. Design and Analysis of Conical Horn Antenna for Ku-Band Applications. In this paper we have designed the light weight, compact size and high directivity Circularly Polarized Conical Horn Antenna with high Directivity, high Gain, low return losses and good VSWR . The layout is very simple and depicts the dimensions of conical horn antenna that expresses the performance of conical horn antenna. In this we have varied the length, flare angle, aperture diameter of the conical antenna. These dimensions will explain the required features such as impedance matching, radiation pattern of the horn antenna. The Conical Horn Antenna is Optimized and simulated by developing a PCAAD (Evaluations) program. The Optimization of Conical Horn has been based on considering a Radiation pattern for calculating maximum value of Gain, Directivity & Phase Error at a particular frequency. The electromagnetic accuracy of the antenna is measured with the help of High Frequency structure simulator (HFSS) Software. The measured results of the conical antenna confirmed the simulation results and satisfied the design requirement. In view of this paper, the measured results show that this antenna has gain of 18.75 to 20.20dB, directivity is 18.40 to 19.64db, VSWR <1.14, return losses level of -38db , suppressed side losses level of -38dB and array factor is 1. A conical horn antenna is being developed into high gain and good VSWR from the TE11 mode in the feeding circular waveguide. Simulation for horn antenna has been done on Ansoft HFSSv11.***

Keywords: aperture radius, axial length, flare angle, Horn antenna.

1. Introduction

There are many mediums for communication like cables, coaxial cables, optical fibers. But now a day's most of the communication is done by air. The wireless communication antenna plays an important role both in transmitter and receiver. We use radio waves for the wireless communication. The High power Microwave research started in 1970s. Compact sources allow for advances in the technologies of power beaming, space propulsion, and high power radar. 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 [1, 2]. The goal of the system is to maximize the power transfer from the source to the radiating system while keeping the system as compact as possible. A compact conical horn antenna has been designed that operates in the Ku band that produces a forward directed radiation beam with maximum directivity. Horn antenna typically consists of a rectangular or cylindrical metal tube, closed at one end and flaring into open end or pyramidal shape on other end. These techniques in 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 [1,2]. They can be easily flush mounted on the satellite structure body. It affords a gradual transition structure to match the impedance of a tube to the impedance of free space, enabling the waves from the tube to radiate efficiently into space. Horn antenna is used to transmit radio waves or collect radio waves into a waveguide. Horn antenna consists of a short length of rectangular or cylindrical metal tube, closed at one end and flaring into an open-ended conical or pyramidal shaped on the other end .The radio waves are introduced into the waveguide by a coaxial cable attached to the side. The waves then radiate out the horn end in a narrow beam. However in some equipment the radio waves are conducted between the transmitter or receiver and the antenna by a waveguide, and in this case the horn is just attached to the end of the waveguide.

The radiation characteristics of a conical horn are disposed by its dimensions in wavelengths, it has been convenient to normalize all dimensional data in terms of wavelength. Advantages of horn antenna over other types of antenna are: (a)Complexity involve in the design of horn antenna is less as compared to phased array antennas & corrugated cousins [3].(b) Feeding a horn antenna is less complex as compared to other antennas which require complex feeding techniques.(c)High data rate systems needs to be operated at a higher frequency range in order to carry out higher bandwidth. This can be easily carry out using a horn antenna[12].(d)Power handling capability of horn antenna is superior to other antennas as it is waveguide fed antenna, especially in the of TWTs used in satellites, radars and many other applications making it an ideal choice for space applications[14].(e)If horn antenna is properly designed & optimized than side lobes can be suppressed to very low levels. Various space programs in which horn antennas are used by NASA, ESA.

2. Description of Conical Horn Antenna

Conical Horn Antennas are fed by circular waveguide and conical aperture. Bessel Function and Legendre polynomials are used to calculate the modes traveling within the antenna by using spherical coordinate system [4]. Pure mode conical horns do not make good feed horns for reflectors because the pattern symmetry is pure and the cross polar radiation level is high. The exception is a small diameter horn where low cross polarization is possible [5,6]. TE11 mode is the dominant mode in circular waveguide therefore it would be a mode with a smallest Pmn to propagate having transverse-field pattern. 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. Next high order mode to be generated at junction is the TM11 [7].

3. Experimental Setup for Antenna Design and Simulation

The Conical Horn Antenna is Optimized and simulated by using a PCAAD Software . The Optimization of Conical Horn has been based on considering a Radiation pattern for calculating maximum value of Gain, Directivity & Phase Error for a particular frequency. The Simulation Parameters for conical Horn Antenna are operating Frequency, Aperture radius, axial horn length and phase error. In PCAAD (Personal Computer Aided Antenna Design) fig. 1, shows the view of antenna;

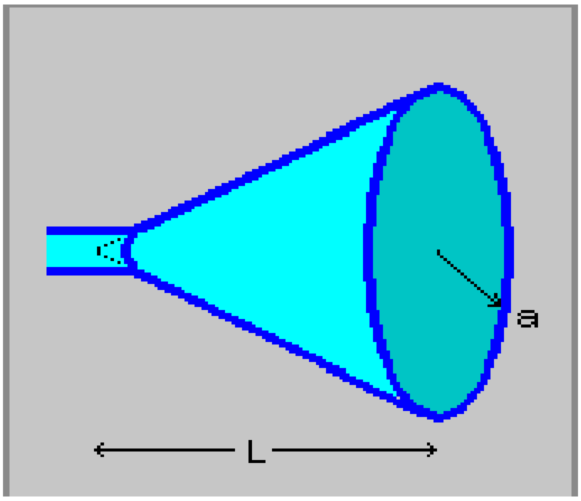

Figure 1: view of conical horn antenna in PCAAD

After doing simulation in PCAAD, the optimum dimensions that are found for radius of taper is 1.94cm & axial length is 3cm for a frequency of 18GHz. Because at these dimensions maximum values of gain & directivity is achieved with a moderate phase error.

Transverse electric (*TE*) *modes* no electric field in the direction of propagation. These are sometimes called *H modes* because there is only a magnetic field along the direction of propagation (*H* is the conventional symbol for magnetic field). The TE11 mode is the lowest order possible for a circular waveguide, and is the fundamental mode of a circular waveguide, due to the fact that it has the lowest cutoff frequency. It is sometimes referred to as the dominant mode. In this mode, the Electrical field strength depends on both the radius and the azimuthal angle. TE11 mode is the principle mode in the circular waveguide which is shown below.

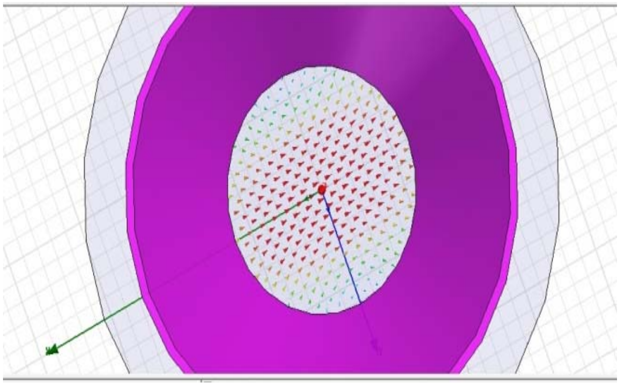

Figure 2: 3D view of E and H field distribution of TE11 mode in the circular waveguide using HFSS.

4. Simulation & Results

Modeling of Conical Horn antenna has been performed using advance EM simulation software 'HFSS .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) [10]. The geometrical view of Conical Horn Antenna in HFSS is shown below.

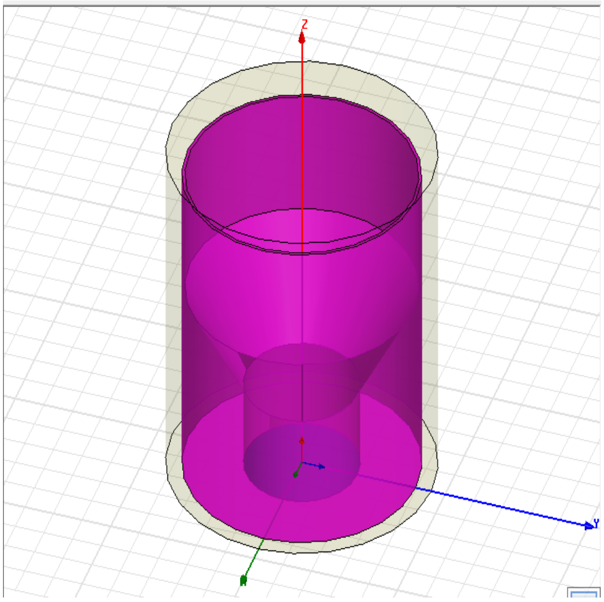

Figure 3: 3D view of Designed Conical Horn Antenna in HFSS.

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. 2D simulation shows that this antenna has gain of 18.75 to 20.20dB, directivity is 18.40 to 19.64db, VSWR <1.14, return losses level of -38db , suppressed side losses level of -38dB and array factor is 1.

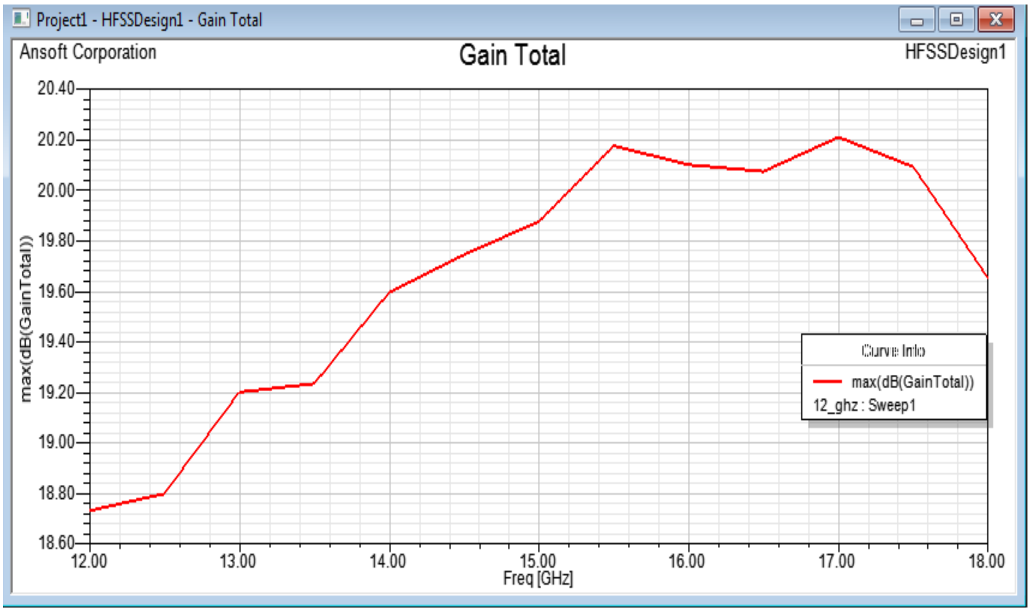

Figure 4: 2D rectangular plot for gain of conical horn using HFSS at 12 to 18GHz

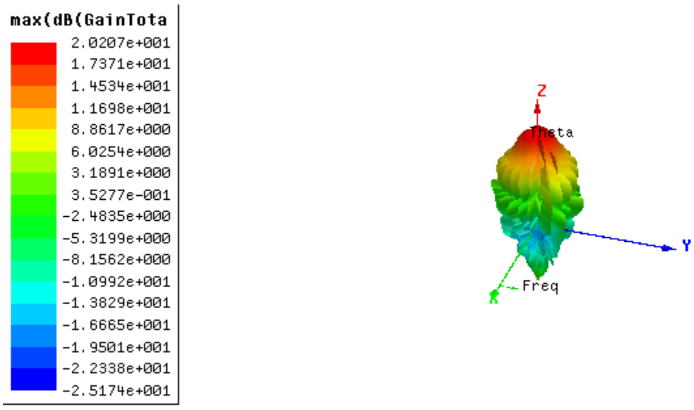

Figure 5: 3D polar plot for gain 12 to 18GHz of conical horn antenna using HFSS

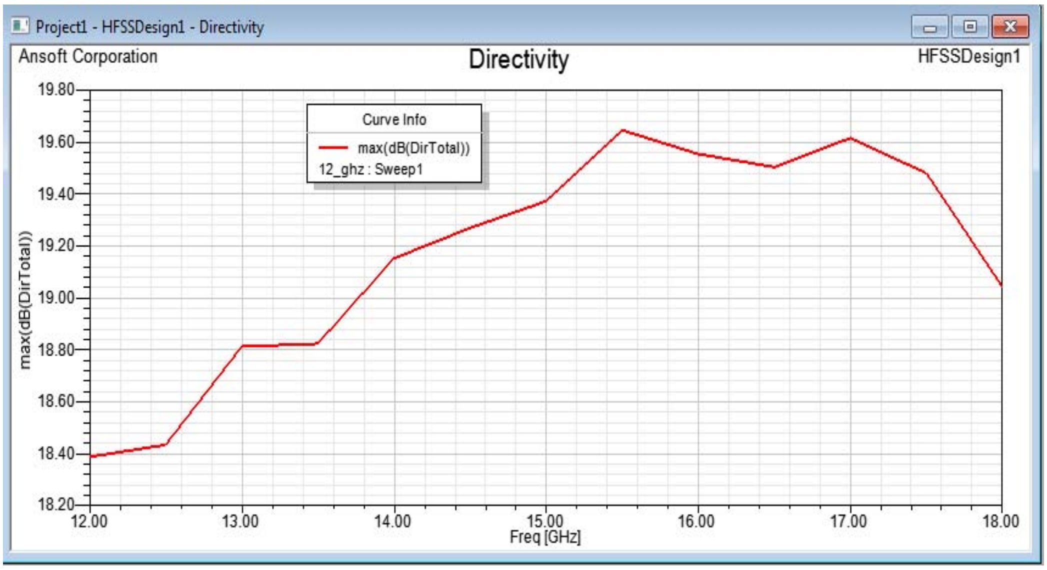

Figure 6: 2D rectangular plot for directivity of conical horn using HFSS at 12 to 18 GHz

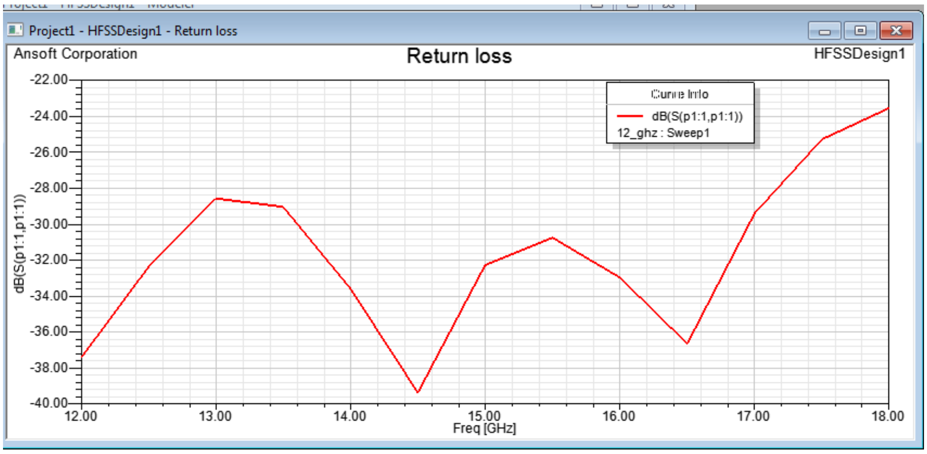

Figure 7: 2D rectangular plot for return losses of conical horn using HFSS at 12 to 18GHz

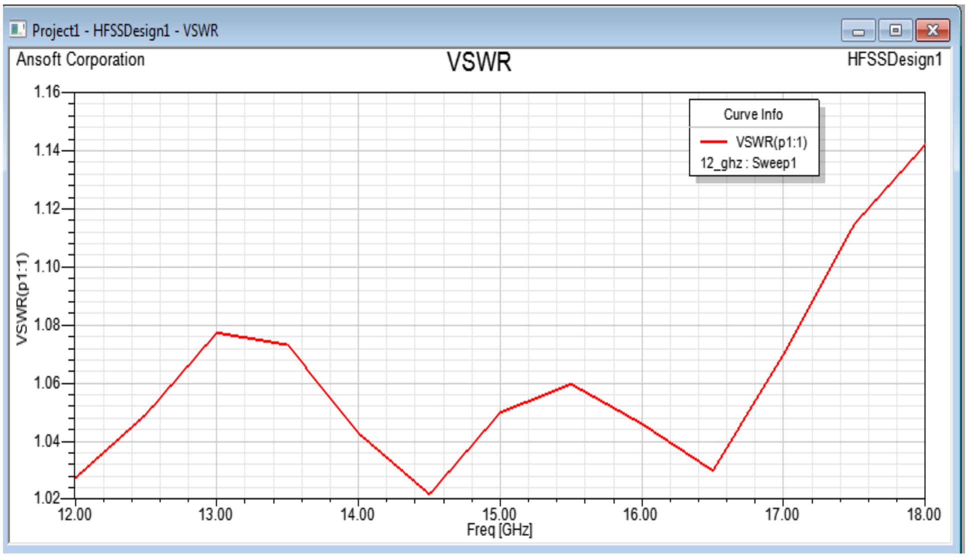

Figure 8: VSWR plot for Designed conical horn Antenna using HFSS at 12 to18 GHz

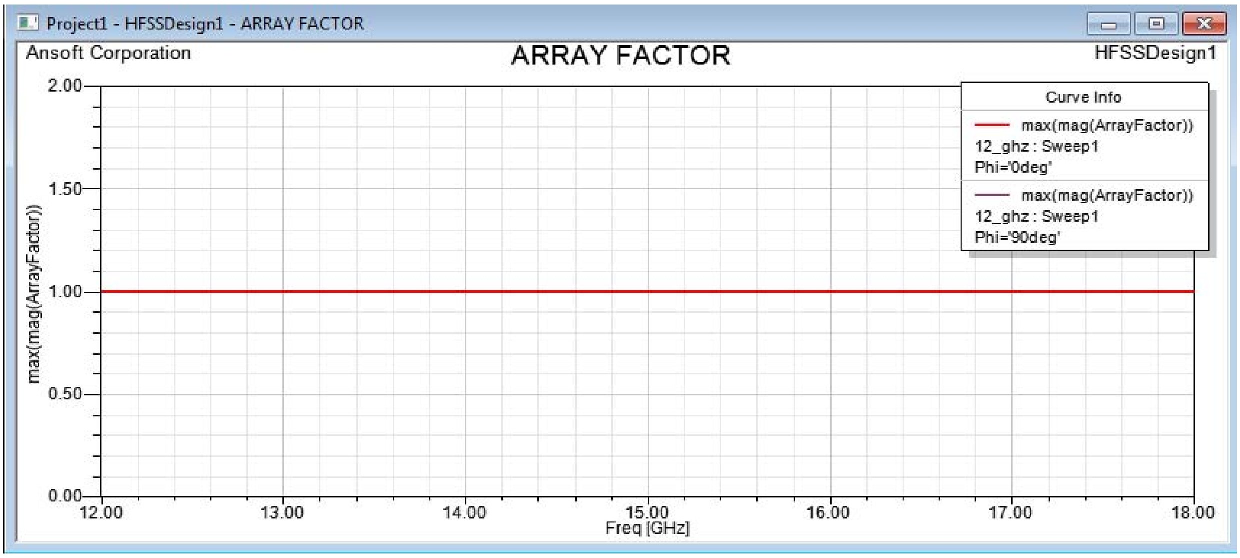

Figure 9: Array Factor plot for Designed conical horn Antenna using HFSS at 12 to 18GHz

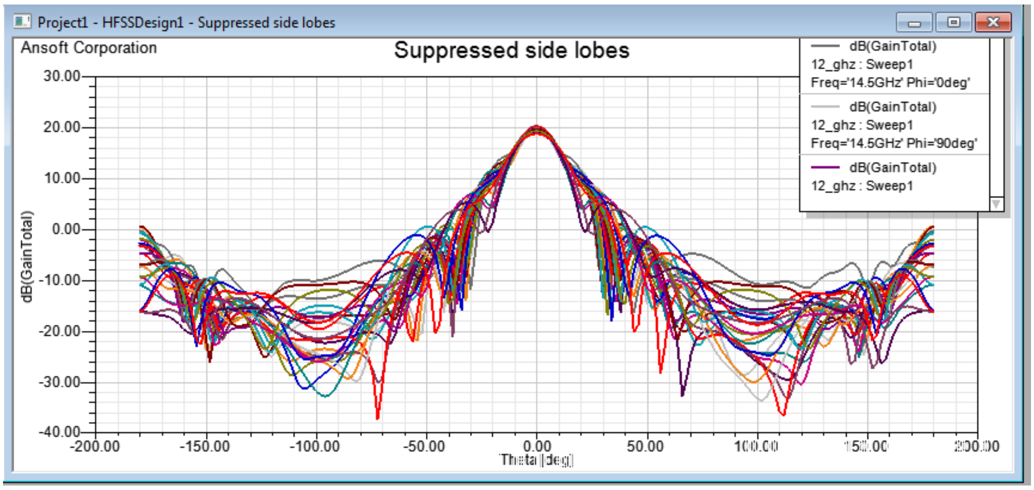

Figure 10: 2D rectangular plot for conical horn side lobes of level using HFSS at 12 to 18GHz

5. Conclusion

This paper discusses the. Design and Analysis of Conical Horn Antenna for Ku-Band Applications of 12-18Ghz conical horn antenna with high gain, suppressed side lobes , good VSWR. All requirements for space application have been tried to meet according to international space standards. This conical horn antenna can be used in space applications. The procedure is straightforward, and determines the physical dimensions of a conical horn that determine the performance of the antenna. To examine the accuracy of this design procedure, antenna was designed over 12to 18GHz with specific electromagnetic features. The measurement results showed that the antenna's gain of 18.75 to 20.20dB, directivity is 18.40 to 19.64db, VSWR <1.14, return losses level of -38db, suppressed side losses level of -38dB and array factor is 1. These measurement results confirmed the results of the simulations and satisfied the design requirements.

6. Future Scope

For further reduction in size of an antenna, the present work is done on Meta materials.

7. Acknowledgement

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Author Profile

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