

## Design and Electromagnetic Modeling of E-Plane Sectoral Horn Antenna For Ultra Wide Band Applications On WR-137 & WR-62 Waveguides

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**ABSTRACT** : The Design and EM modeling of a E-Plane Sectoral Horn Antenna for Ultra Wide Band Application on WR-137 and WR-62 standard waveguides are presented in this paper. In E-plane sectoral antenna, the E-Plane is much narrower as the flaring and dimensions of the horn are much greater in that direction. The horn flare angle, horn size, wall thickness, etc of the E-plane sectoral horn antenna are examined. The return loss, input impedance, total gain and field pattern of the E-plane sectoral horn antenna are observed. The antenna is simulated using ANSOFT HFSS 14.0.

**KEYWORDS** : Ansoft HFSS Simulator, Beam width, Directivity, E-Plane Horn Antenna, Electromagnetic modeling, Radiation Pattern, Return Loss

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### I. INTRODUCTION

An antenna is an electrical device which converts electric currents into radio waves, and vice versa. To transmit the signal a transmitter applies an oscillating radio frequency electric signal to the antenna's terminals, and the antenna radiates the energy in the form of electromagnetic waves. Horn antennas are used as antennas at UHF and microwave frequencies, above 300 MHz. They are used as feeders for larger antenna structures such as parabolic antennas. Over the hundred years, horn antennas have given the best directive and high power operation for Microwave Frequencies. Design Simplicity and large gain with best matching properties are added advantage of Horn antenna. Applications include Radar, Satellite tracking, Radio astronomy and Communication dish antennas. Other applications are Reflector feeds, Gain standards for antenna measurements, EMC/EMI tests, Communication systems, Direction finding (DF), mm-wave systems.



Fig 1 : A Practical Horn Antenna

A E-plane sectoral horn is one in which the opening is flared in the direction of the E-field.

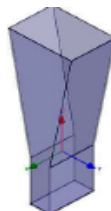


Fig 2 : E-Sectoral Horn Antenna

The E-Plane sectoral horn antennas are chosen because of their directional radiation pattern, ability to achieve high gain and directivity, and their ease of fabrication. The horn antenna which is designed was subject to the following constraints:

- Operating frequency around 8 GHz (C Band) for first case and 16 GHz (Ku Band) for second case.
- Maintain a gain of 10 dB over the entire operating frequency range

## II. ANTENNA DESIGN

The C and Ku frequency bands were selected as the operating frequency. These bands are selected as they pertain to the communication frequency bands. The design was performed to accomplish an ultra-wide bandwidth. (i) For the first case of 8GHz (C Band) the operating frequency was chosen to be 8GHz. The waveguide dimensions are  $a = 34.85\text{mm}$ ,  $b = 15.8\text{mm}$ , waveguide length = 31.75mm. These indicate the standard WR-137 waveguide. Horn size dimensions are  $b=44.45\text{mm}$ , horn flare length = 95.25mm, wall thickness = 1.626mm. (ii) For the second case of 16GHz (Ku Band) the operating frequency was chosen to be 16GHz. The waveguide dimensions are  $a = 15.8\text{mm}$ ,  $b = 7.9\text{mm}$ , waveguide length = 15.88mm. These indicate the standard WR-62 waveguide. Horn size dimensions are  $b=22.23\text{mm}$ , horn flare length = 47.63mm, wall thickness = 1.016mm. For both the cases the outer boundary condition is Radiation Boundary Condition. The Radiation Boundary Condition are as follows :

- Absorption achieved via 2nd order radiation boundary
- Place at least  $\lambda/4$  from strongly radiating structure
- Place at least  $\lambda/10$  from weakly radiating structure
- The radiation boundary will reflect varying amounts of energy depending on the incidence angle. The best performance is achieved at normal incidence. Avoid angles greater than  $\sim 30^\circ$ . In addition, the radiation boundary must remain convex relative to the wave

In HFSS to properly model the far field behavior of an antenna, an appropriate volume of air must be included in the simulation. Truncation of the solution space is performed by including a radiation boundary condition on the faces of this air volume that mimics free space. The appropriate distance between strongly radiating structures and the nearest face of the air volume depends upon whether a radiation boundary condition is used. HFSS also uses Finite Element Method (FEM) as analysis & solution to Electromagnetic problems by developing technologies such as tangential vector finite elements, adaptive meshing, and Adaptive Lanczos-Pade Sweep (ALPS).

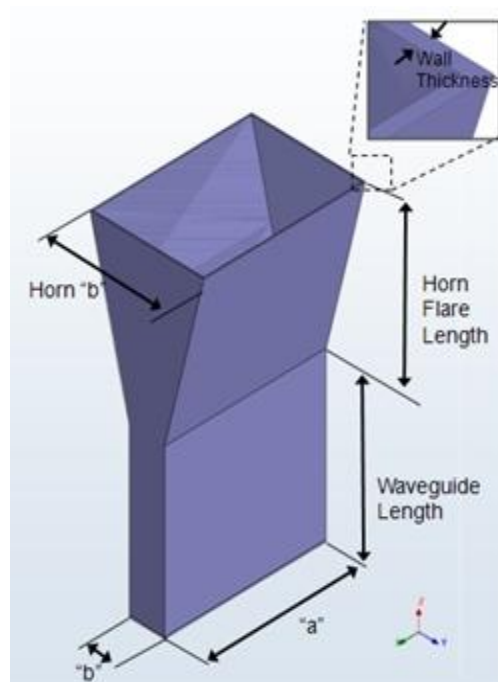


Fig 3 : Structure of the proposed E-Plane Horn Antenna

## III. PROPOSED MODEL IN ANSOFT HFSS 14.0 FOR CASE 1

The 3D view of the designed E-Plane Horn Antenna in HFSS for a solution frequency of 8GHz (C-Band) is shown below. The boundaries for the air-box are set as an ideal propagation space and the ground plane as perfect electric conductor.

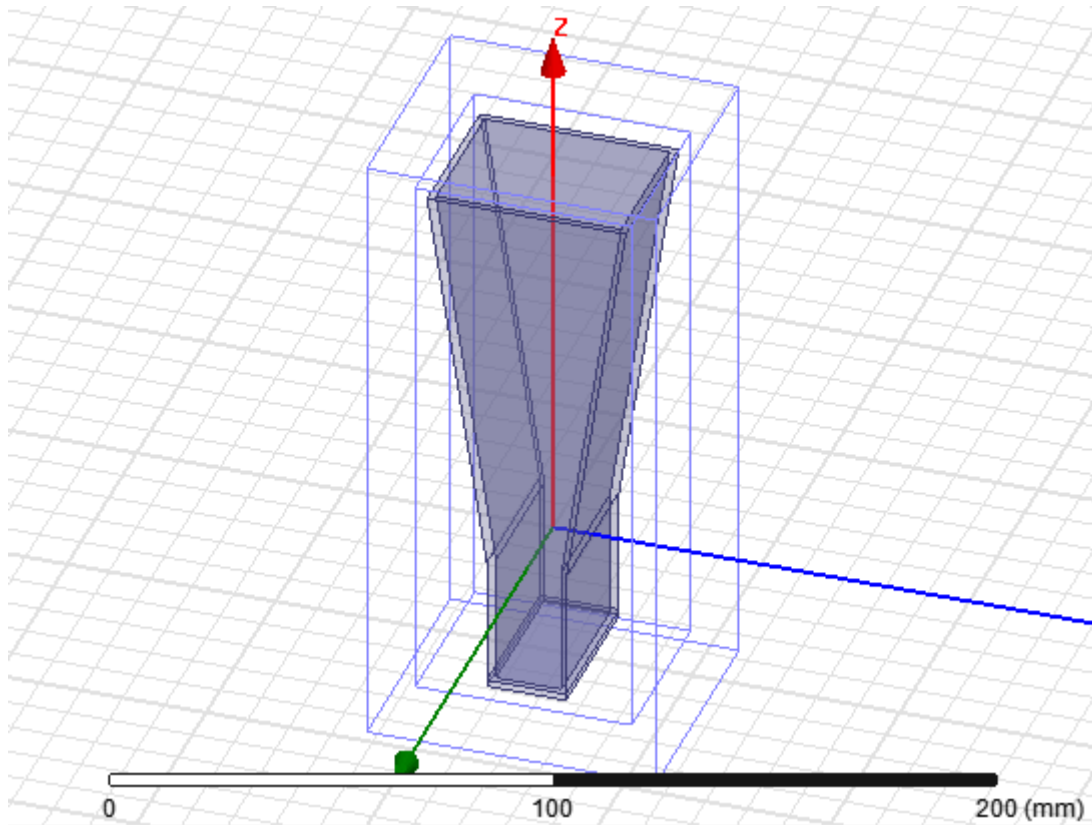


Fig 4 : 3D View of the E-Plane Horn antenna in HFSS for a solution frequency of 8Ghz

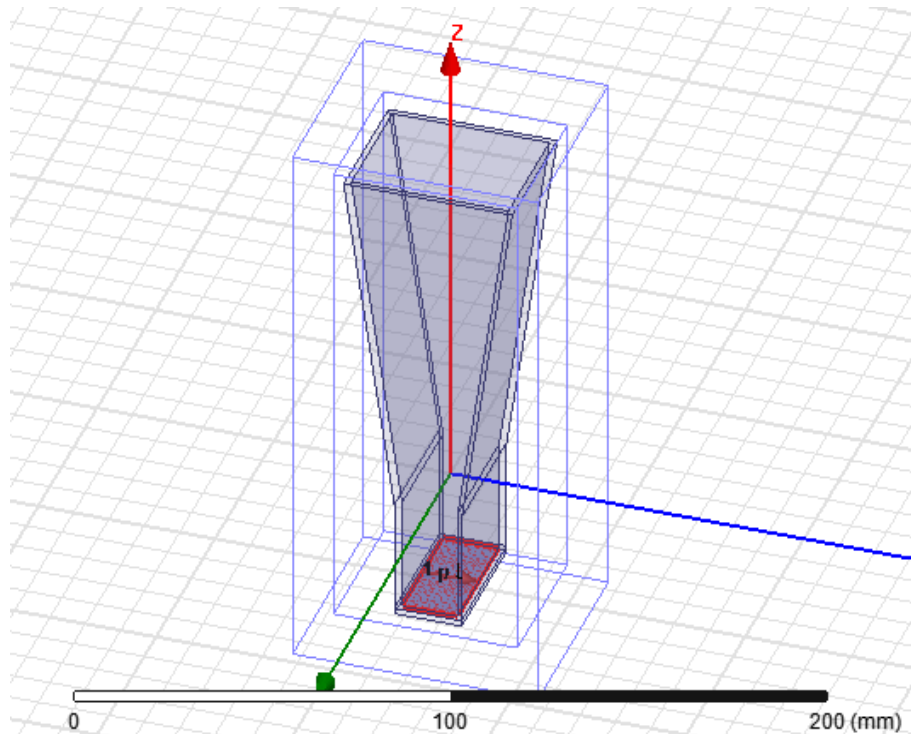


Fig 5 : Figure showing the direction of excitation for a solution frequency of 8Ghz

#### IV. RESULTS AND DISCUSSION FOR CASE 1

The parameters which verify the success of antenna design are beam width, impedance matching , etc. These are analysed here. The gain of the antenna versus frequency with return loss is -44dB at 8Ghz is shown below.

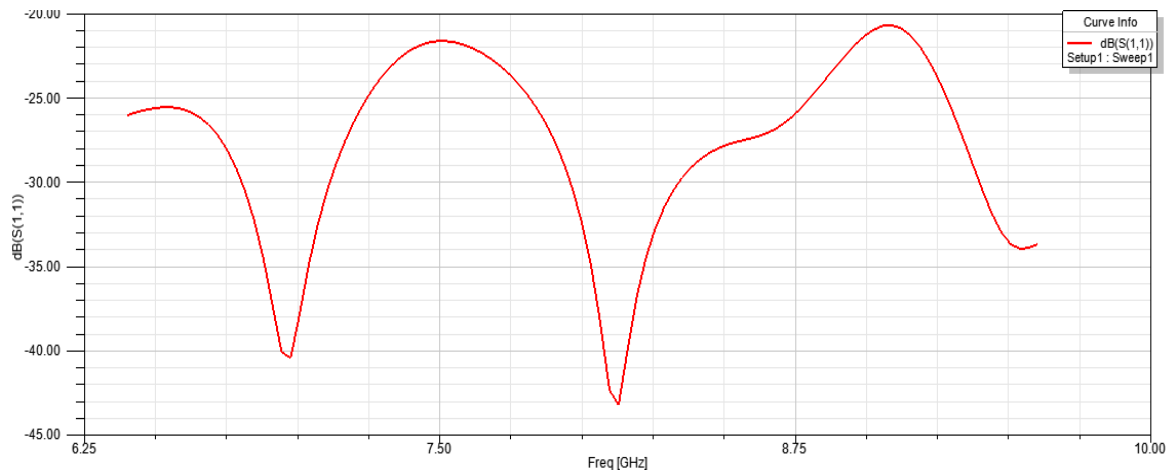


Fig 6 : Return loss in db over frequency range for a solution frequency of 8Ghz

The Radiation pattern for the antenna design in 3D is shown in below.

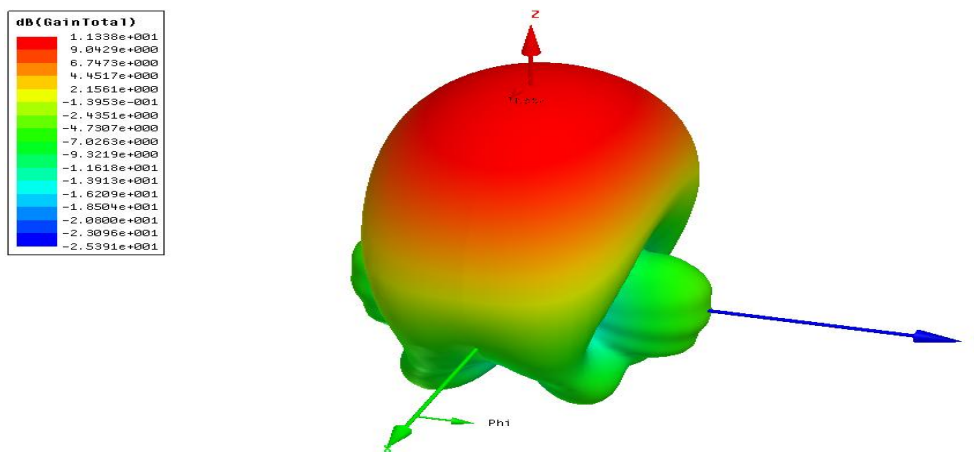


Fig 7 : 3D Radiation pattern of the antenna in HFSS for a solution frequency of 8Ghz

The 2D plot is total gain for phi = '0 deg' and phi = '90 deg' is shown below.

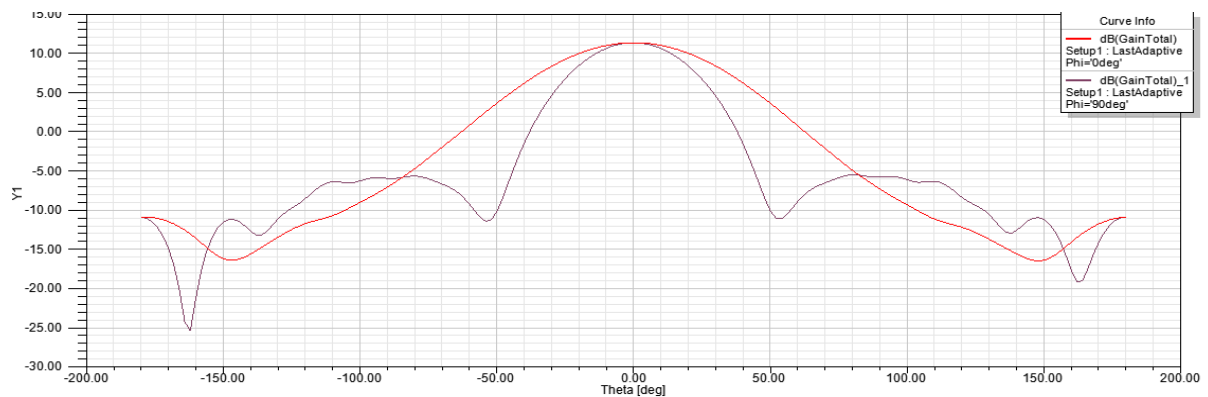


Fig 8 : 2D Plot for total gain versus theta (deg) with phi for a solution frequency of 8Ghz

**V. PROPOSED MODEL IN ANSOFT HFSS 14.0 FOR CASE 2**

The 3D view of the designed E-Plane Horn Antenna in HFSS for a solution frequency of 16Ghz (Ku-Band ) is shown below.

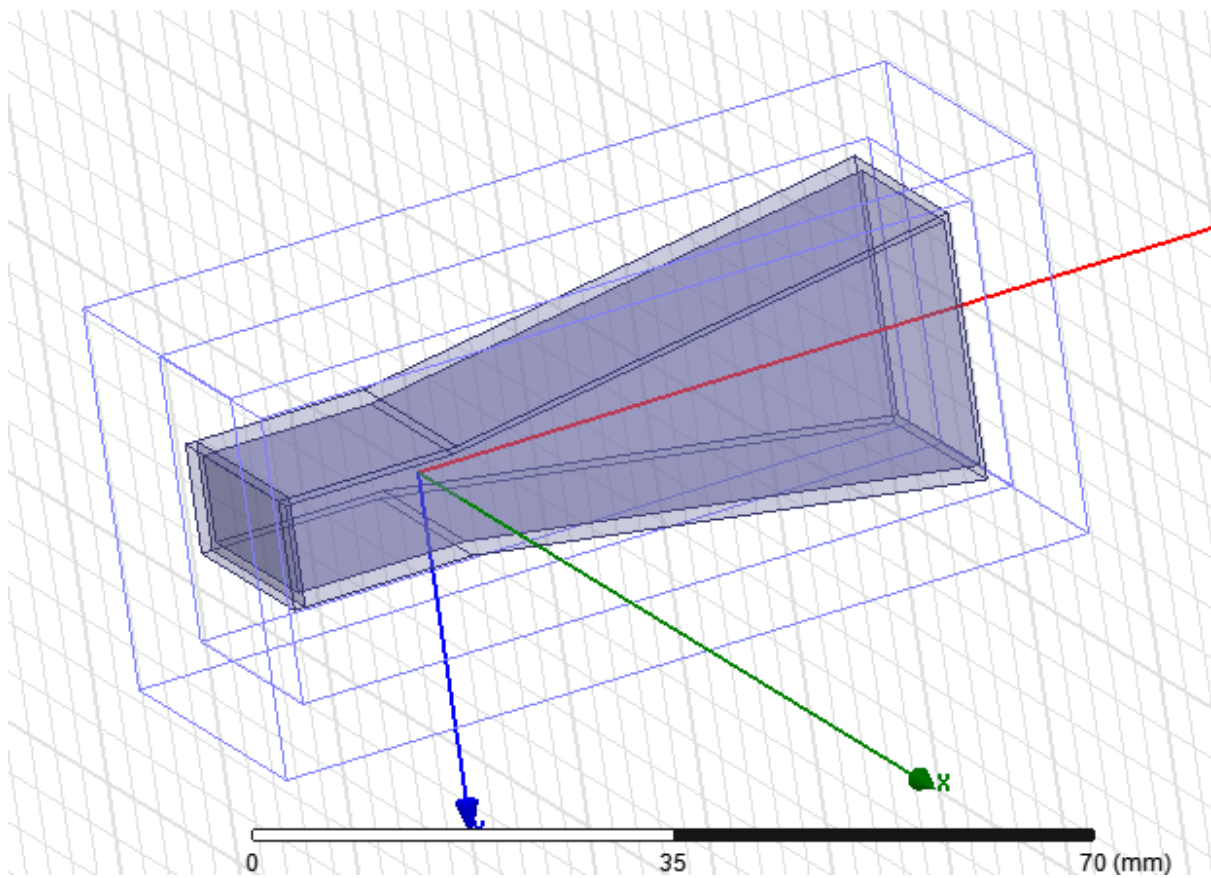


Fig 9 : 3D View of the E-Plane Horn antenna in HFSS for a solution frequency of 16Ghz

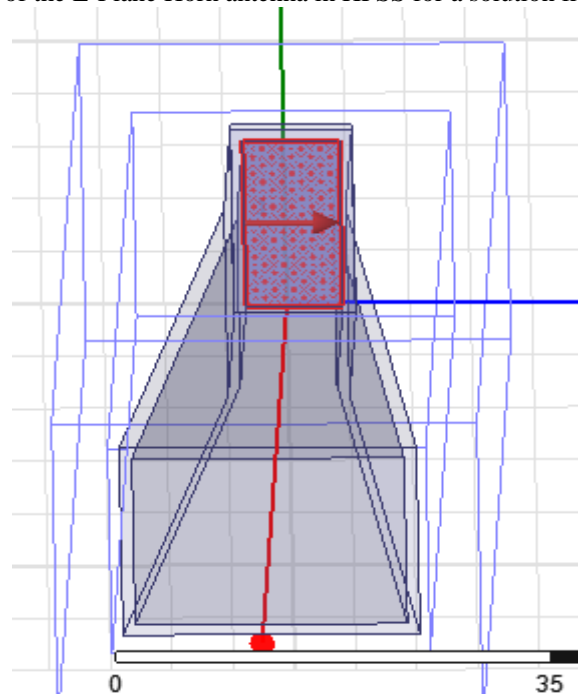


Fig 10 : Figure showing the direction of excitation for a solution frequency of 16Ghz

## VI. RESULTS AND DISCUSSION FOR CASE 2

The parameters which verify the success of antenna design are beam width, impedance matching, etc. These are analysed here. The gain of the antenna versus frequency with return loss is -49dB at around 16 GHz is shown below.

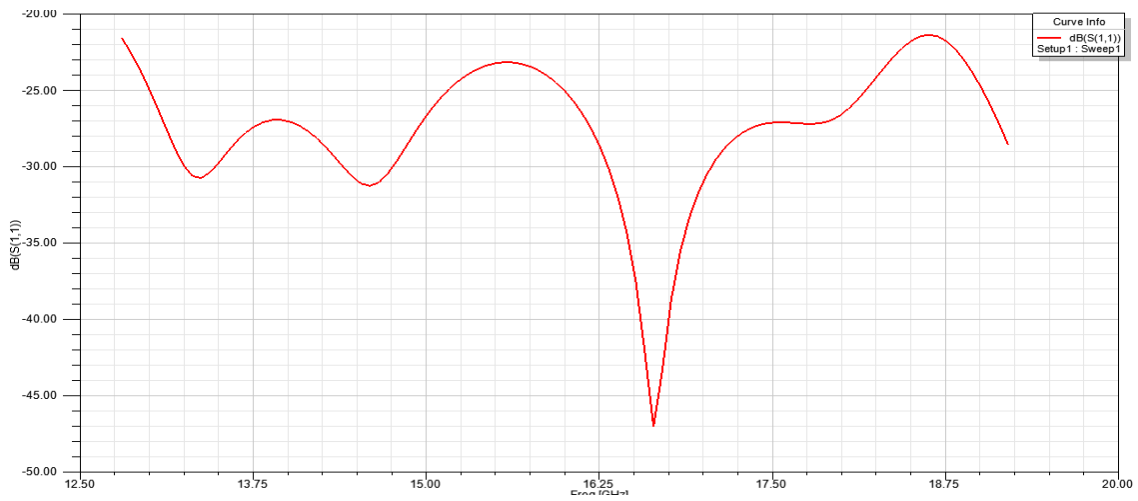


Fig 11 : Return loss in db over frequency range for a solution frequency of 16GHz

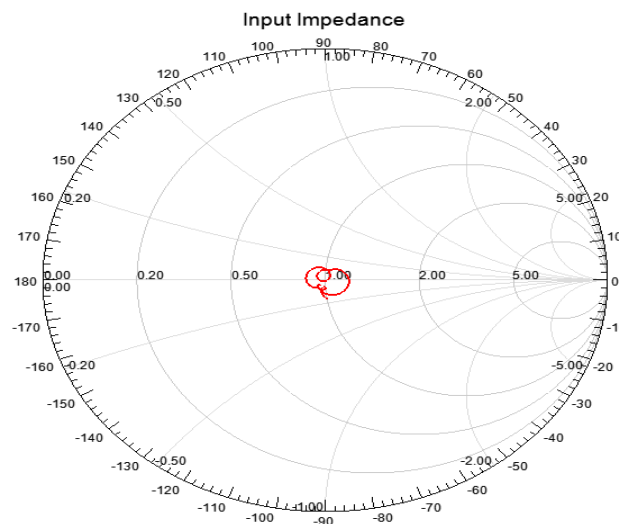


Fig 12 : The range of input impedance is shown below for a solution frequency of 16GHz

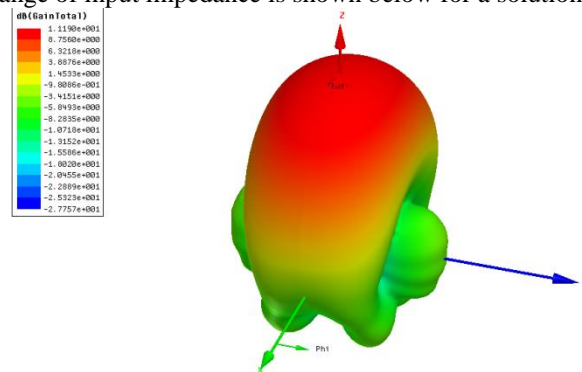


Fig 13 : 3D Radiation pattern of the antenna in HFSS for a solution frequency of 16GHz

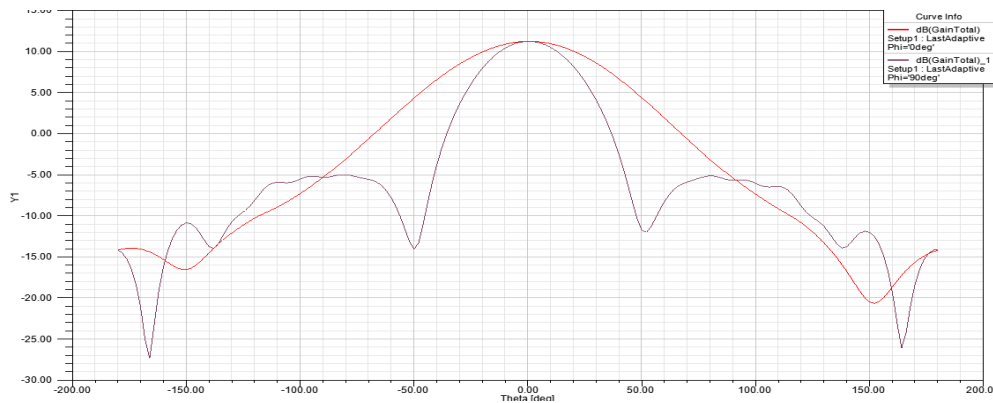


Fig 14 : 2D Plot for total gain versus theta (deg) with phi for a solution frequency of 16Ghz

## VII. CONCLUSION

An Ultra Wide Band E-Plane sectored Horn Antenna operating at solution frequencies of 8Ghz and 16Ghz frequency range was designed. The horn antenna which was designed satisfied the following constraints: (i)Operating frequency around 8 GHz (C Band) for first case and 16 GHz (Ku Band) for second case; (ii)Maintain a gain of 10 dB over the entire operating frequency range. The return loss for both the cases was found to be greater than -40db. Thus the desired results are achieved and the simulated structures are suitable for various applications.

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## BIOGRAPHY

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