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# Simulation Comparison between HFSS and CST for Design of Conical Horn Antenna

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**Abstract**— In this paper comparison between two famous antenna design softwares, HFSS and CST microwave studio, has been made by simulating the circular horn antenna. These days it is very important to sort out the software which is best suited to our required antenna design. Complex antenna structures cannot be simulated without using these softwares, known as electromagnetic solvers. Results are compared for accuracy and simulation time. Circular horn antenna has been selected due to its moderate directivity (gain), low SWR, broad bandwidth, and simple construction and adjustment. 3D models of horn antennas in both softwares are presented with their 3D and polar gain plots. Brief overview of these softwares along with their operating environment and different tools used in it are also given.

**Keywords**—HFSS; CST; Conical Horn

## 1. Introduction

Antenna designs are becoming increasingly complex with the advancement in modern communication systems. We cannot solve the complex antenna problems analytically and need computational electromagnetic (CEM)[1] field application for viewing our results.. CEM models the interaction of electric and magnetic fields with physical objects and their environment to find the numerical approximation of Maxwell's equations. [2] Therefore its use in the antenna field is inevitable. It uses electromagnetic solvers which are specialized computer software that solve the subset of the Maxwell's equation directly. Software's that are compared here are HFSS [3] and CST [4] that are two most widely used software for antenna design simulations. HFSS stands for high frequency structure simulator and based on finite element method (FEM). CST stands for computer simulation technology and has number of solvers in it both frequency and time domain. However in this paper only transient solver is used which is time domain solver. CST is based on finite domain time difference method (FDTD).

In CEM some property of electromagnetic wave has to be discretized which is necessary to know to decide which software is best for our antenna design.

This property is electric field in case of FEM and both electric and magnetic field in case of FDTD.

All simulations in this paper are performed on HP XW 8400 workstation Intel(R), Xenon(R) CPU, E5345@2.33 GHz and 3GB of RAM.

## 2. Conical Horn Antennas

Conical horn has circular aperture and is fed by circular waveguide. Spherical coordinated are used for finding different modes in the circular horn and are in form of spherical Bessel functions and Legendre Polynomials. Horn antenna are used as feeders for larger antennas like parabolic dish antenna. Their advantages are moderate directivity (gain), low SWR, broad bandwidth, and simple construction and adjustment.[3] They are also used as standard calibration antennas to measure the gain of other antennas. Other application includes radar guns, automatic door openers and microwave radiometers.

Qualitative description of the performance of horn is given in the form of curves as shown in figure 2. The gain of the horn increases as the flare angle decreases until it reaches a certain limit beyond which the gain began to decrease. For constant aperture horn, maximum directivity is obtained when the flare angle approaches to zero or length approaches to infinity. For the minimization of quadratic phase error a lens is usually places at the aperture of the conical horn.

Directivity of the conical horn with aperture efficiency  $\epsilon_{ap}$ , circumference C and radius at aperture a is given by the equation

$$D \text{ (dB)} = 10 \log_{10} [\epsilon_{ap} (4\pi/\lambda^2)(\pi a^2)] \\ = 10 \log_{10} (C/\lambda)^2 - L(s)$$

Whereas  $L(s) = -10 \log_{10}(\epsilon_{ap})$

$L(s)$  is called the loss figure of the horn and is approximated by the equation

$$L(s) \approx (0.8 - 1.71s + 26.25s^2 - 17.71s^3)$$

where  $s$  denotes the maximum phase deviation in terms of wavelength and is equal to  $s = dm^2/8\lambda l$

Directivity of the conical horn is maximum when its diameter is equal to  $d_m \approx \sqrt{3l\lambda}$ . [5]

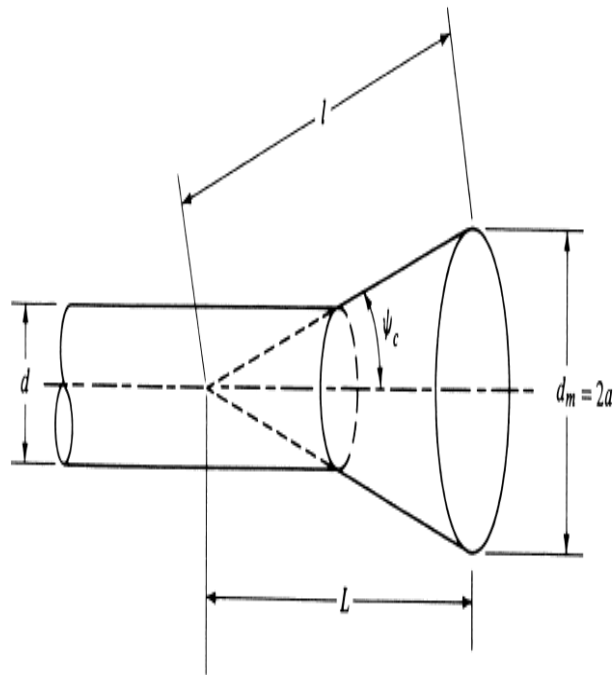


Figure 1. Circular horn antenna

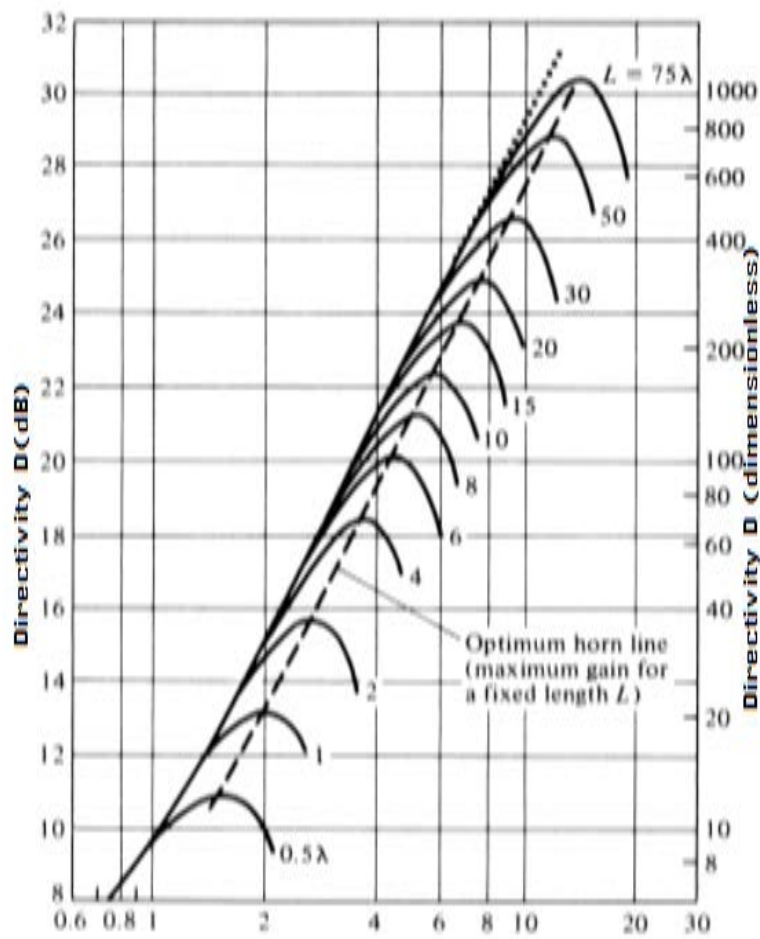


Figure 2. Directivity of conical horn as function of aperture diameter for different axial length horns.

### 3.Horn antenna in HFSS and CST

CST microwave studio is a module in CST which is dedicated to fast and very accurate 3 Dimensional electromagnetic simulations of high frequency problems. This module contains different solvers for simulations of structures both in time and frequency domain. However in this paper only transient solver used which is time domain solver. However the drawing of circular feed horn is little bit more complex. The wave port through

which radiations enter or leave the structure is assigned at the back end of the horn waveguide. Figure 1 shows the GUI of the CST microwave studio. We can view different structural element and simulation results of our structure through navigation tree. Structures primitives are drawn in the drawing plane. Parameters windows define different parameters of our structure like radius of dish and horn etc. Different steps for transient solver that must be completed to view the results are shown in Figure 2.

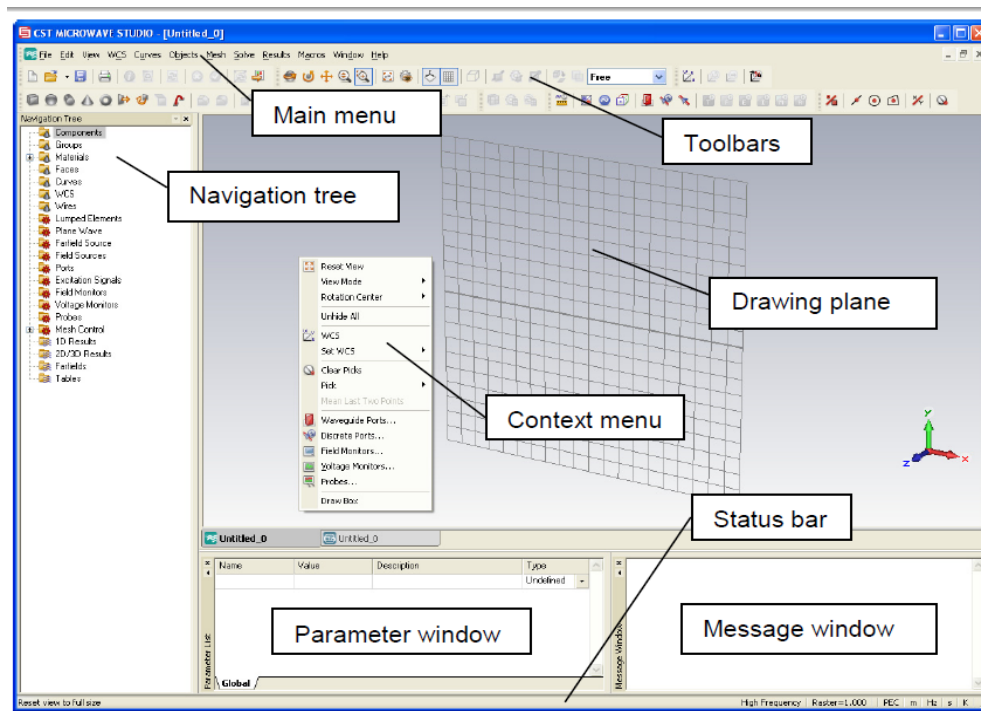


Figure 3. GUI of CST

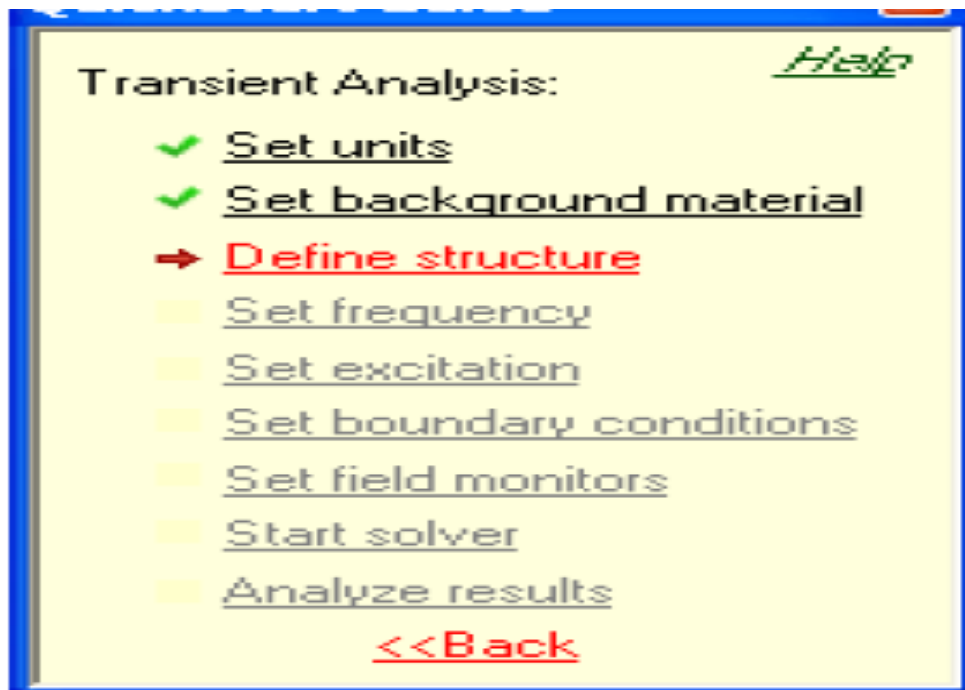


Figure 4. Steps for transient solver

HFSS is a electromagnetic(EM) field simulator for 3D modeling that takes advantage of the familiar Microsoft Windows graphical user interface. It integrates simulation, visualization, solid modeling, and automation in an easy-to-learn environment . SParameters,Resonant Frequency, and Fields can be calculated using this software.[2]Its basic mesh element is in the shape of tetrahedron which helps users to develop variety of shapes and curves in its 3D modelling window.In 3D modeler window we create the model geometry.Project manager contains all the projects that are opened in

HFSS.The project manager contain the geometry model , boundary conditions , material assignments, field solution and post processing information.Progress window is used to monitor the solution’s process.Message manager shows messages associated with the development of project.Property window contains two tabs attribute tab and command tab.Attribute tab display information about the material properties of the object while command tab shows the information about the action that has been selected in the history tree to modify or create an object Figure 3.[6][7][8]

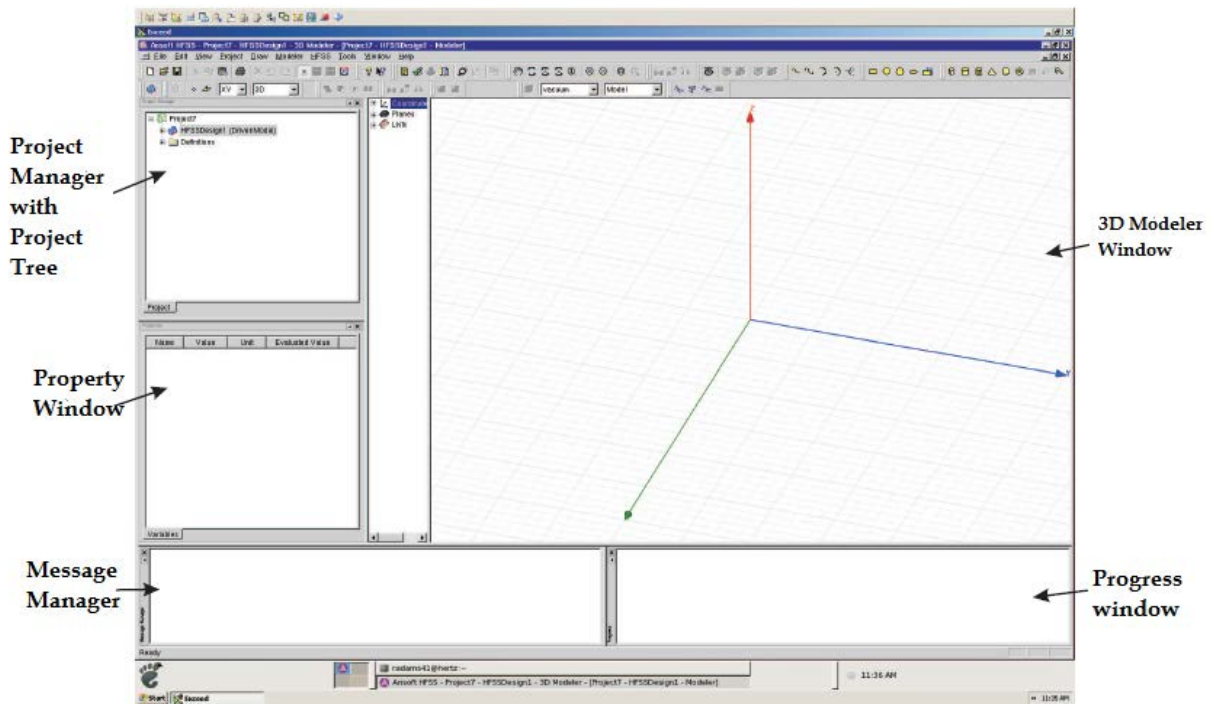


Figure 5. Main window of HFSS

#### 4. Simulations and Results

Horn antenna has been compared in HFSS and CST with operating frequency of 10GHz and time taken by both the solvers to complete the above simulation has been noted Figure 6.

Horn parameters are

- Upper radius of cone = 30.88 mm
- Lower radius of cone = 15 mm
- Waveguide length = 31.25 mm
- Waveguide radius = 15 mm

- Total length of horn = 43.25 mm
- Edge taper = 11 dB
- Material = Perfect Electric Conductor
- Thickness of horn sheet = 0.1 mm
- Excited by = wave port

Boxes around horns present the radiation boundary of these horns. As shown in figure 6 results obtain from both the horns are very close and comparable. CST took about 4 minutes to complete the above simulation with default mesh properties while HFSS took 40 seconds for the same task

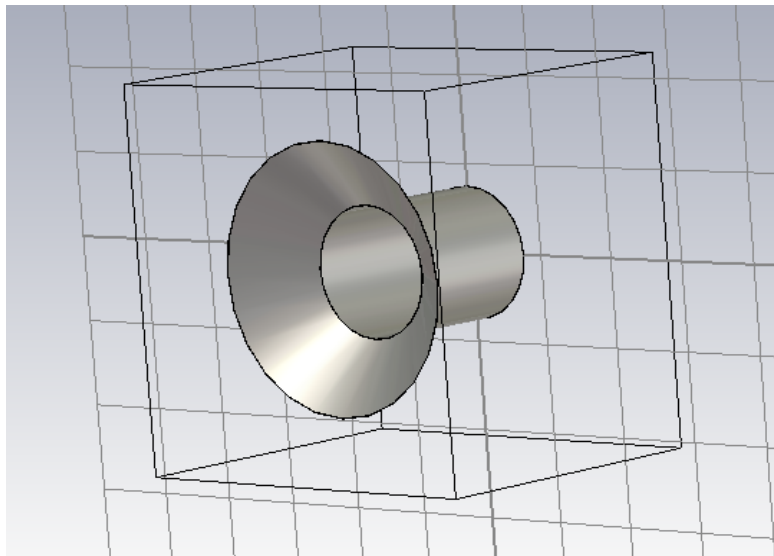


Figure 6(a). Model of horn antenna in CST

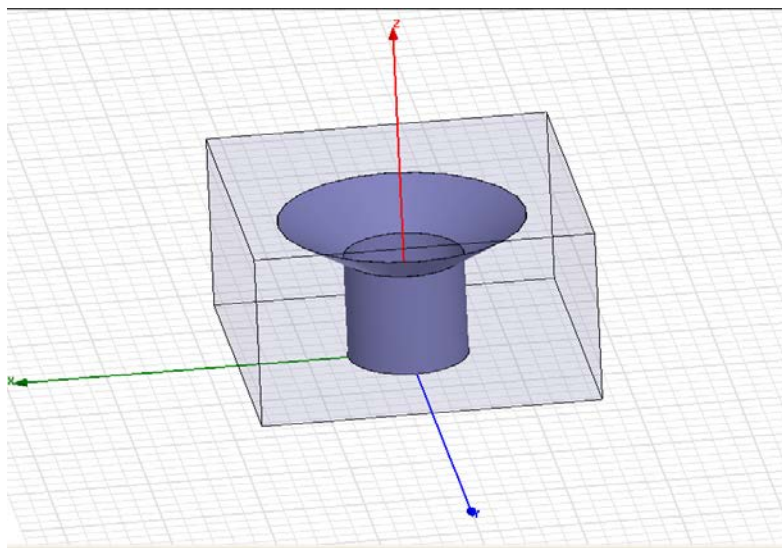


Figure 6(b). Model of horn antenna in HFSS

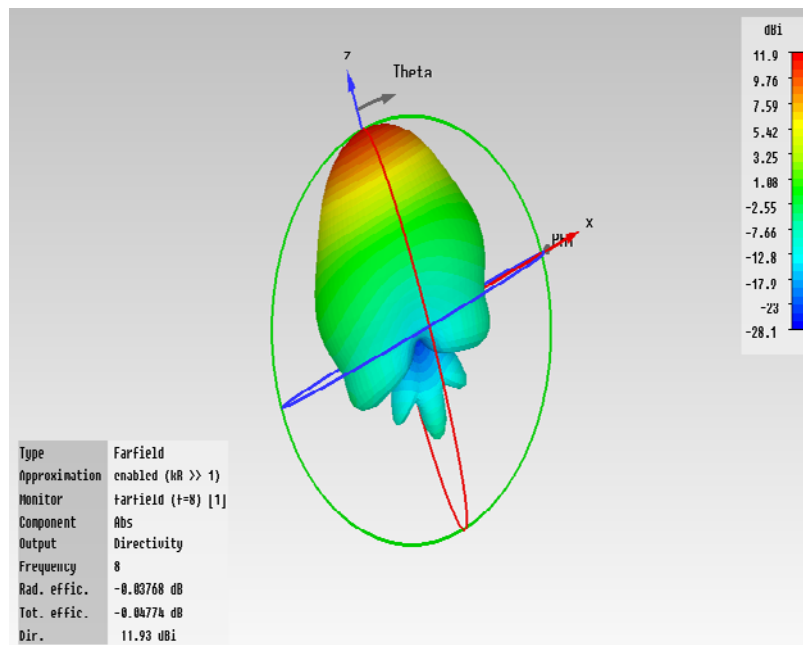


Figure 6(c). 3D gain plot of horn in CST

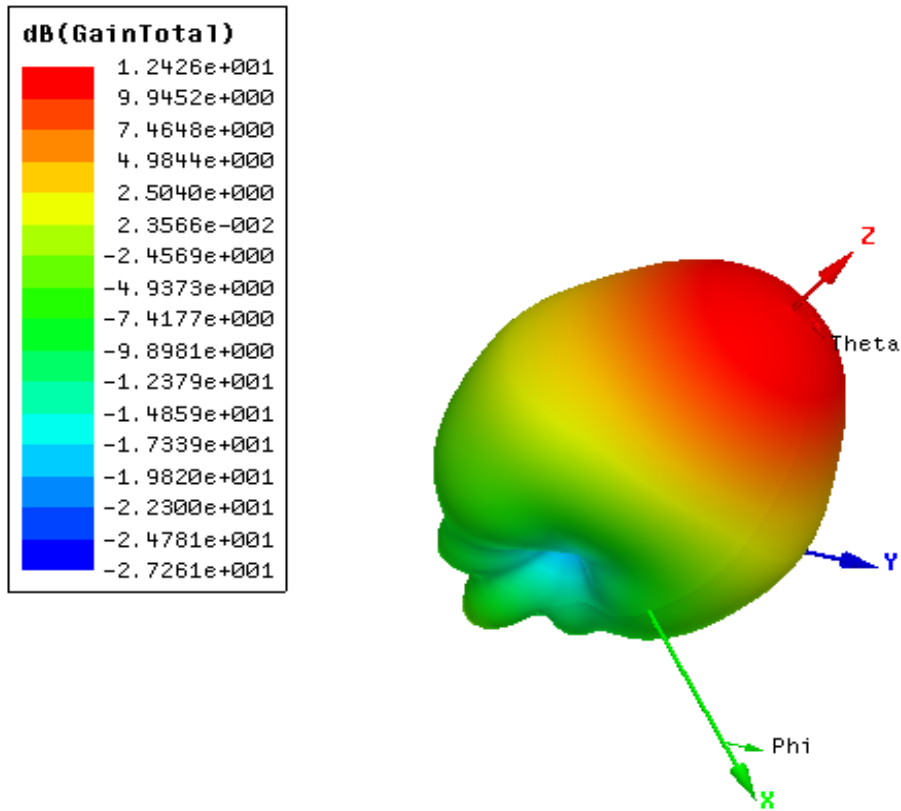


Figure 6(d). 3D gain plot of horn in HFSS

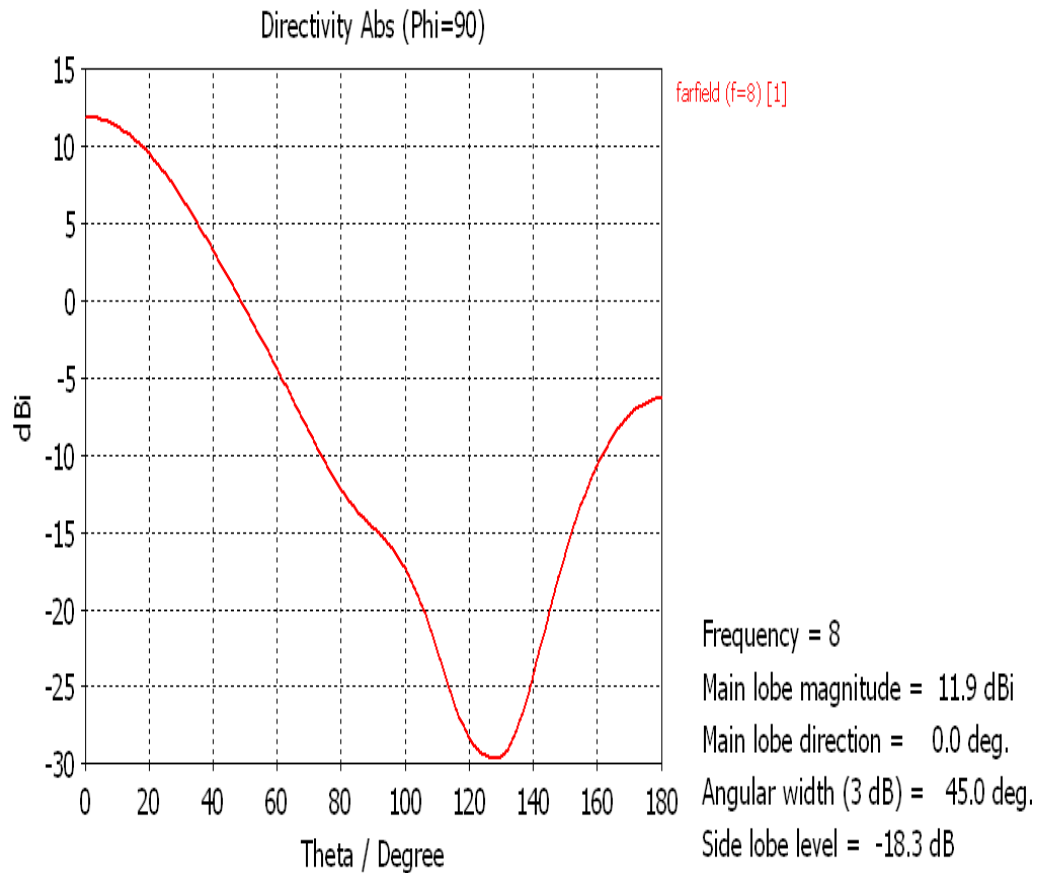


Figure 6(d). 2D gain plot of horn in CST

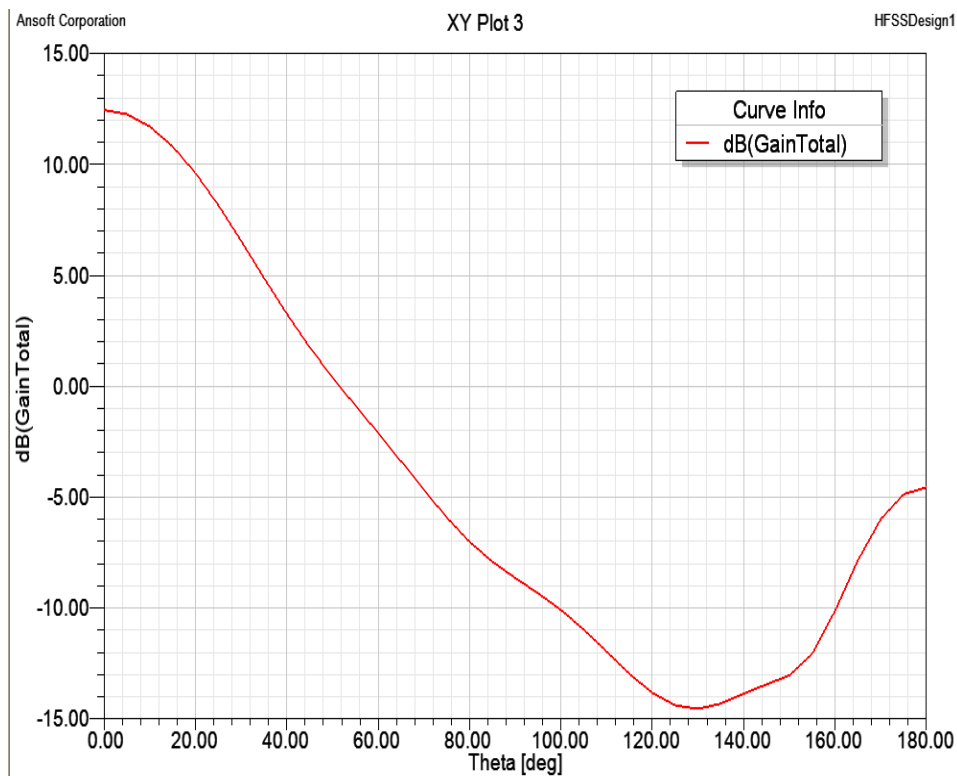


Figure 6(f). 2D gain plot of horn in CST

## Conclusion

Every antenna design software has its strong and weak points which one should know to get the best result out of these softwares. Both softwares shows almost same result for the simulation of conical horn antenna in terms of accuracy. However HFSS is better in terms of time. Reason for this is its frequency domain solver while CST used time domain transient solver. As antenna operates on single frequency at 10GHz so it solve the result in single frequency sweep. On the other hand CST time domain solver is suitable for wide band problems.

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