Potter Horn Antenna

Abstract: This example shows how to model a Potter Horn Antenna[1]. This project uses an FE-BI radiation boundary for its open region. The horn is parametrized to facilitate the simulation of different geometry suited for various desired frequencies and gains. A frequency sweep from 28 to 32 GHz with a 0.02 GHz linear step increment has been defined.

Version: 2023 R2

Simulation Time: 00:03:40 (8-core machine with 64 GB RAM)

Model and Setup Details:

The Potter Horn is a dual-mode feedhorn, which provides an excellent radiation pattern with suppressed sidelobes (at least 30 dB) and symmetrical beamwidths. The port at the small end of the model is excited at two modes, the fundamental TE_{11} mode and the TM_{11} second mode. The waves travel through a cylindrical guide (**A** in **Figure 1**) followed by taper (**B**). There is a step increase in diameter at the end of taper B. The two modes reach this step discontinuity with a relative amplitude and relative phase angle. The relative amplitudes of the two modes are controlled by the step, which converts a small percentage of the incident power from the TE_{11} mode to the TM_{11} mode, causing the E-Plane sidelobes to cancel. As the waves propagate through the phasing section (**C**), the relative phase angle is reduced prior to entering the flare (**D**). The length of section C is chosen so that the TE_{11} and TM_{11} modes are in phase when they reach the aperture.

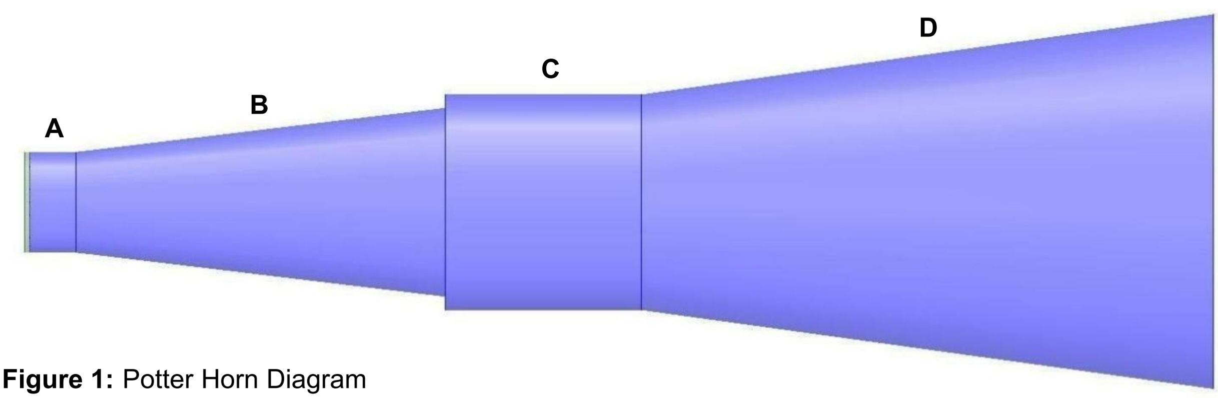


Figure 1: Potter Horn Diagram

The horn has *w*λc* wall thickness and it is defined as Aluminum. The port is internal to the solution region and is capped by a PEC object.

Details about the geometry and parameters can be seen in the History Tree and via **HFSS** > **Design Properties** (see **Figure 2**). This Potter Horn example has a very small flare angle (approximately 0.42°), as dictated by variables rC and rD:

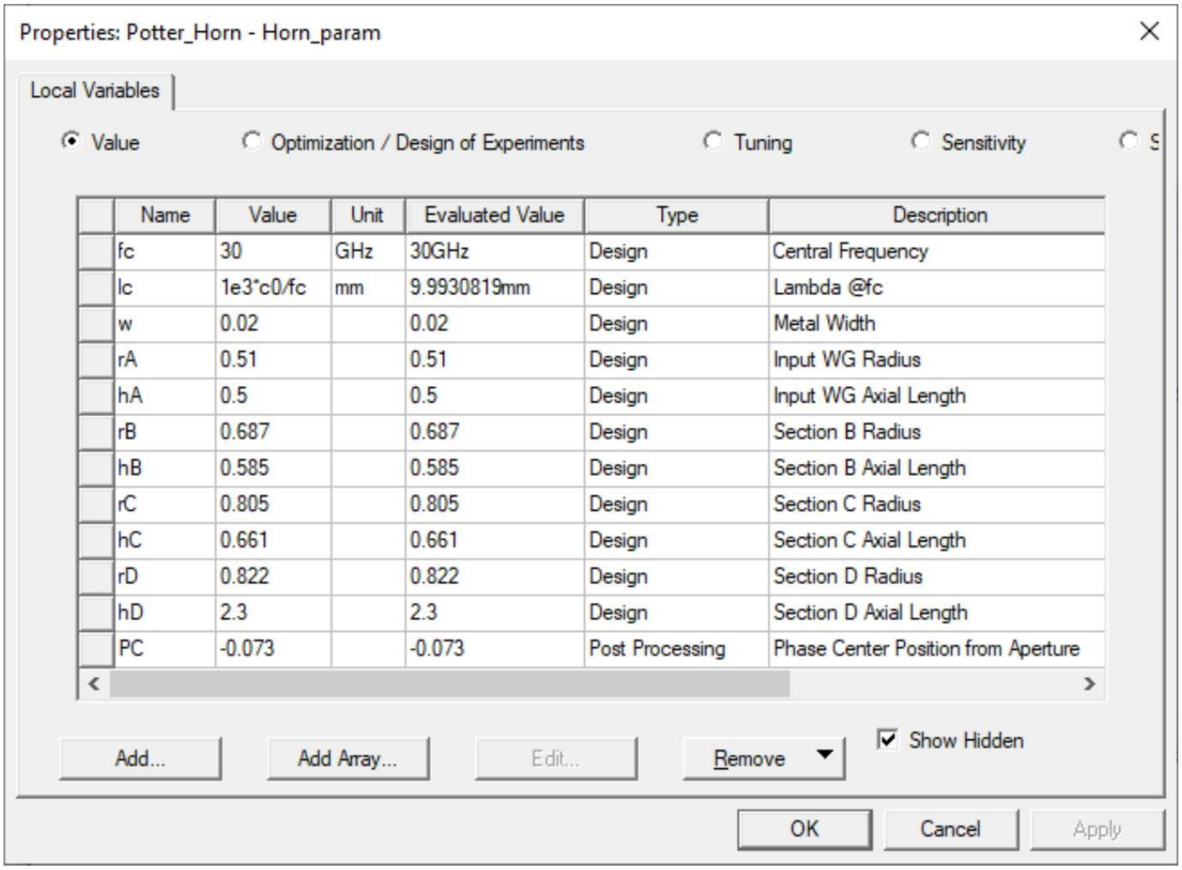


Figure 2: Horn Parameters

A Post Processing variable (*PC*) is defined to vary the position of the Far-field radiation coordinate system (*Aperture_PC*) along the z-axis for the phase center location calculation.

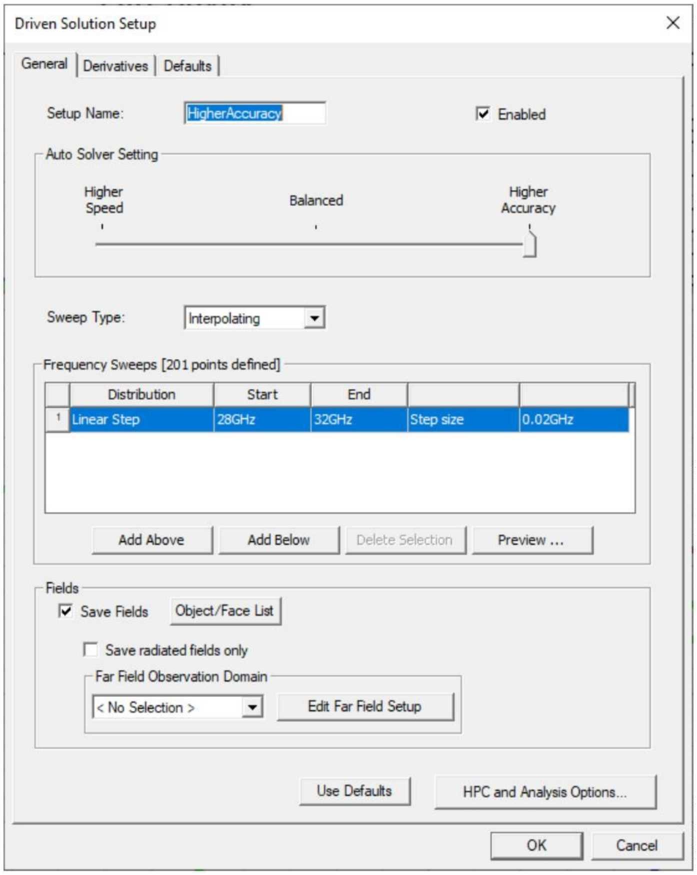
This horn has been analyzed for the next Directivity values: *13, 15 and 20 dBi*. These designs start with an input waveguide radius, *rA=0.51λc* and input Axial Length, *hA=0.5λc*. Starting with this dimension, an optimization within Ansys Optimization tools, quickly produce a design very close to the desired gain that radiates with low cross-polarization and very symmetrical radiation pattern. Next table shows Potter Horn Design Parameters (*λc* normalized):

Table 1: Parametric analysis of the Potter Horn

Gain (dBi)	hD	rD	hC	rC	hB	rB	X-Pol Boresight (dB)	10 dB Beamwidth (º)
13.0	2.3	0.822	0.661	0.805	0.585	0.687	-38	79.2
15.0	4.1	1.02	1.5	0.961	3.062	0.833	-36	60.2
20.0	6.2	1.963	2.076	1.117	4.057	0.982	-37.5	33.6

To setup any of these horns you only need to change the parameters described in **Figure 2** and change the analysis setup to the desired frequency sweep range and increment.

Figure 3 shows the analysis setup (**HFSS** > **Analysis Setup** > **Add Solution Setup** > **Auto**) for the Potter Horn example. **Figure 4** shows the initial mesh settings (**HFSS** > **Mesh** > **Initial Mesh Settings**) that were specified:



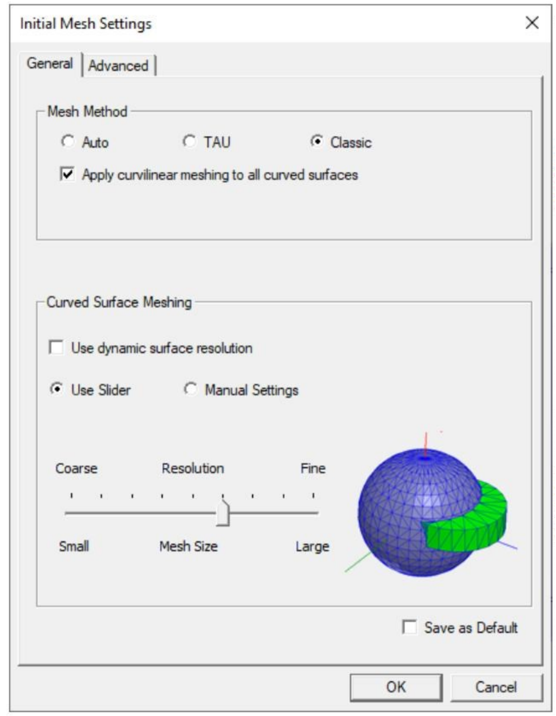


Figure 3: Analysis Setup

Figure 4: Initial Mesh Settings

After solving (**Simulation** > **Analyze all**), you can view different post-processing results, look in the Project Manager under Results and double click on the different results (**Figure 5**). In **Appendix 1** you will find the results obtained for a 13 dBi horn at 30 GHz. S Parameters are plotted for the specified sweep frequency range of 28 to 32 GHz.

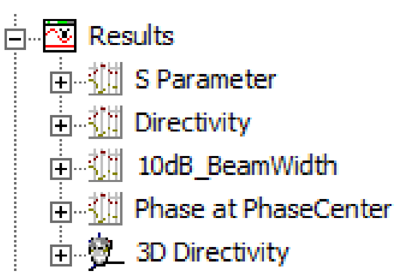


Figure 5: Post-Processing Results

If you want to calculate the position of the phase center, please use the methodology defined in the Help Section: *Determining Phase Center Using Optimetrics*.

Once you simulate the horn alone you will be able to export it as a 3D Component (**Draw** > **3D Component Library** > **Create 3D Component**) and simulate it as the feed of a reflector or quasi-optical system.

Appendix 1:

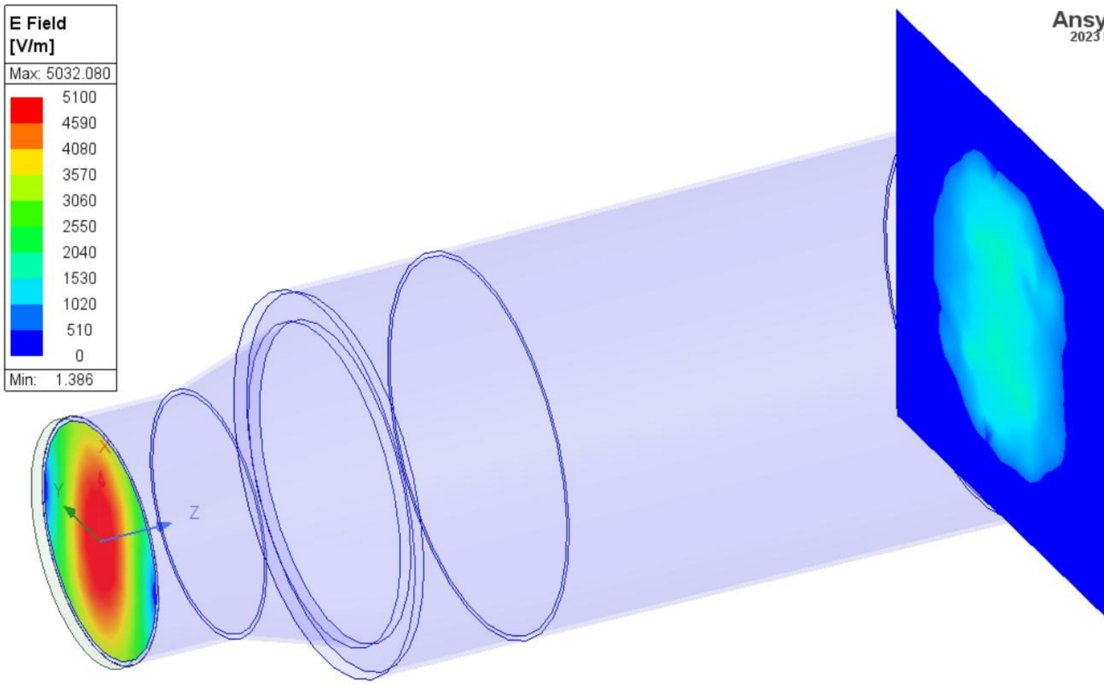


Figure 6: E-field @ Port 1 and Radiation Boundary (Aperture End) – 30 GHz

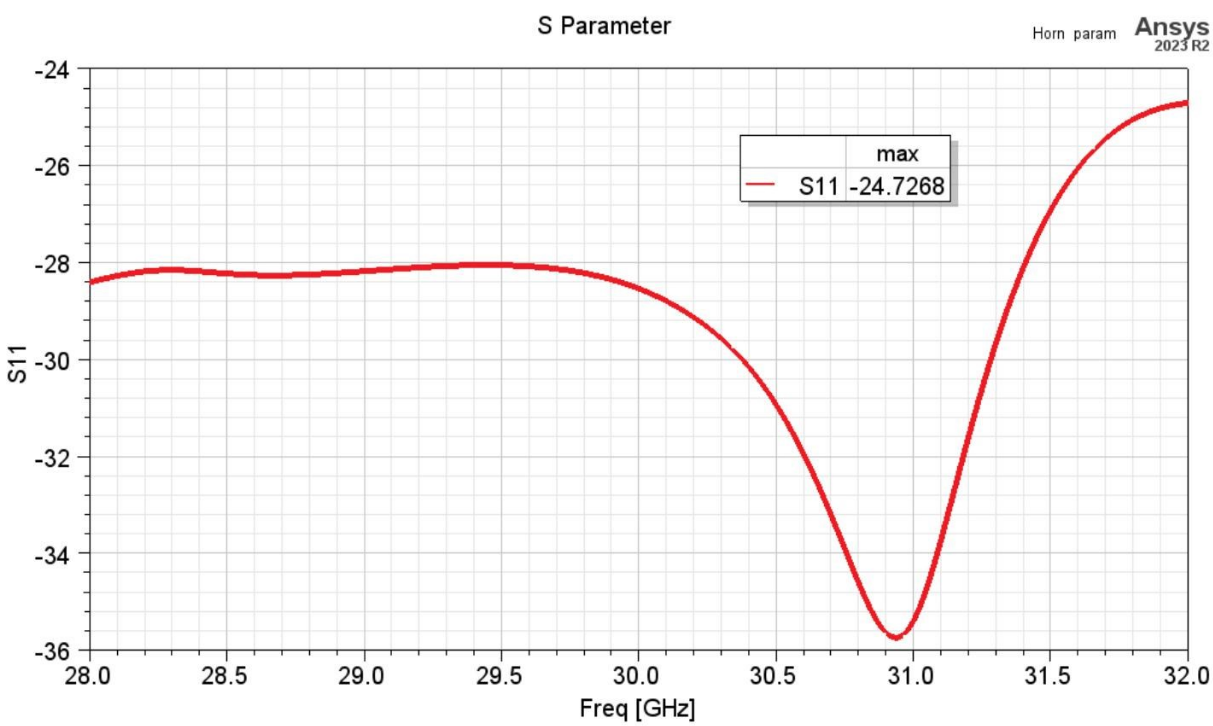


Figure 7: S Parameter vs. Frequency

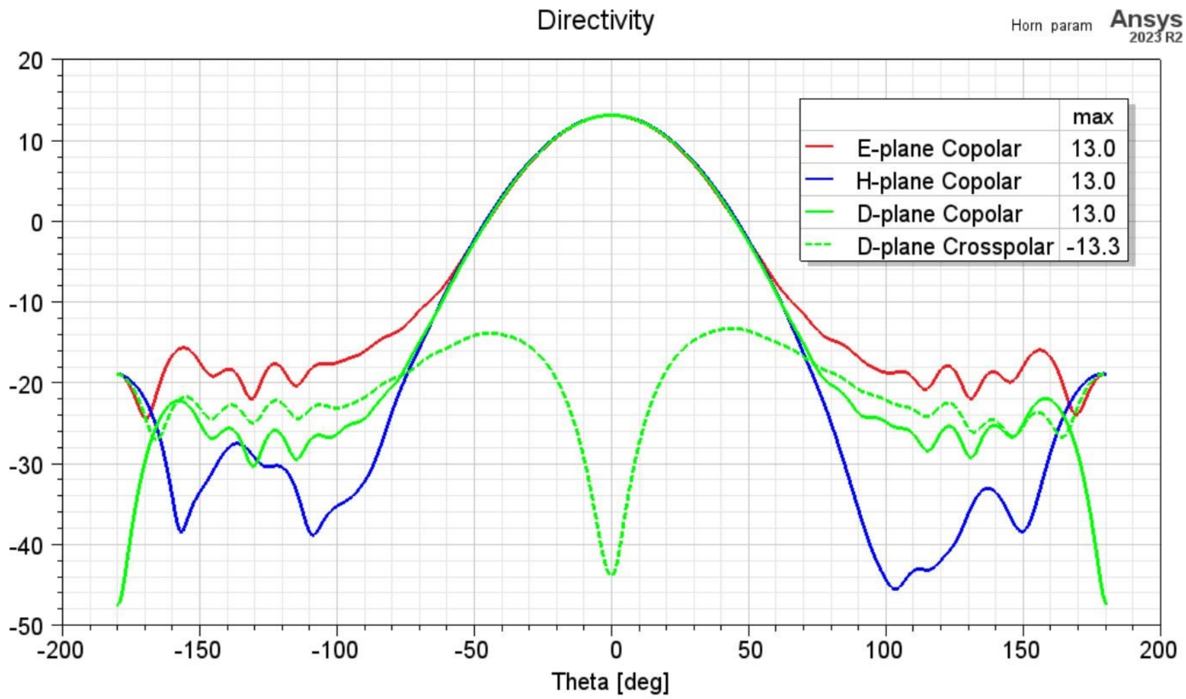


Figure 8: Directivity – 30 GHz

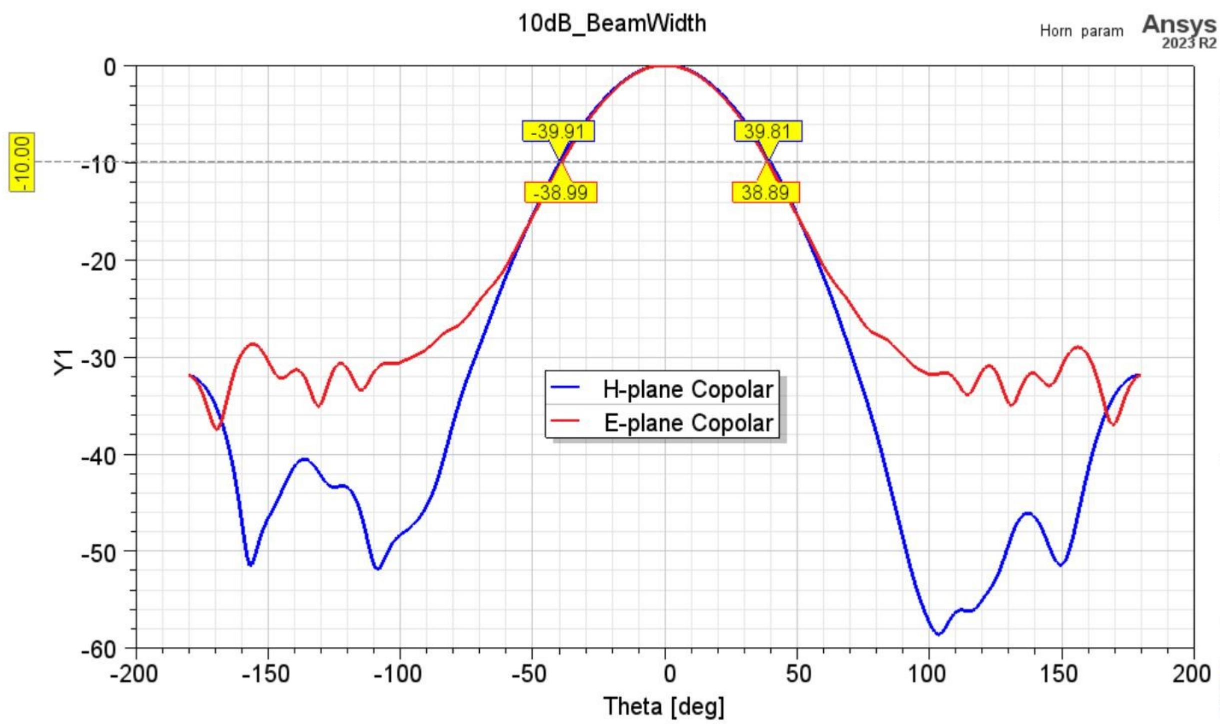


Figure 9: 10 dB Beam Width – 30 GHz

To overlay the 3D plot on the model, right-click **HFSS** > **Fields** > **Plot Fields** > **Radiation Field**. Select **Visible** for *3D Directivity* and set the desired **Transparency** and **Scale**:

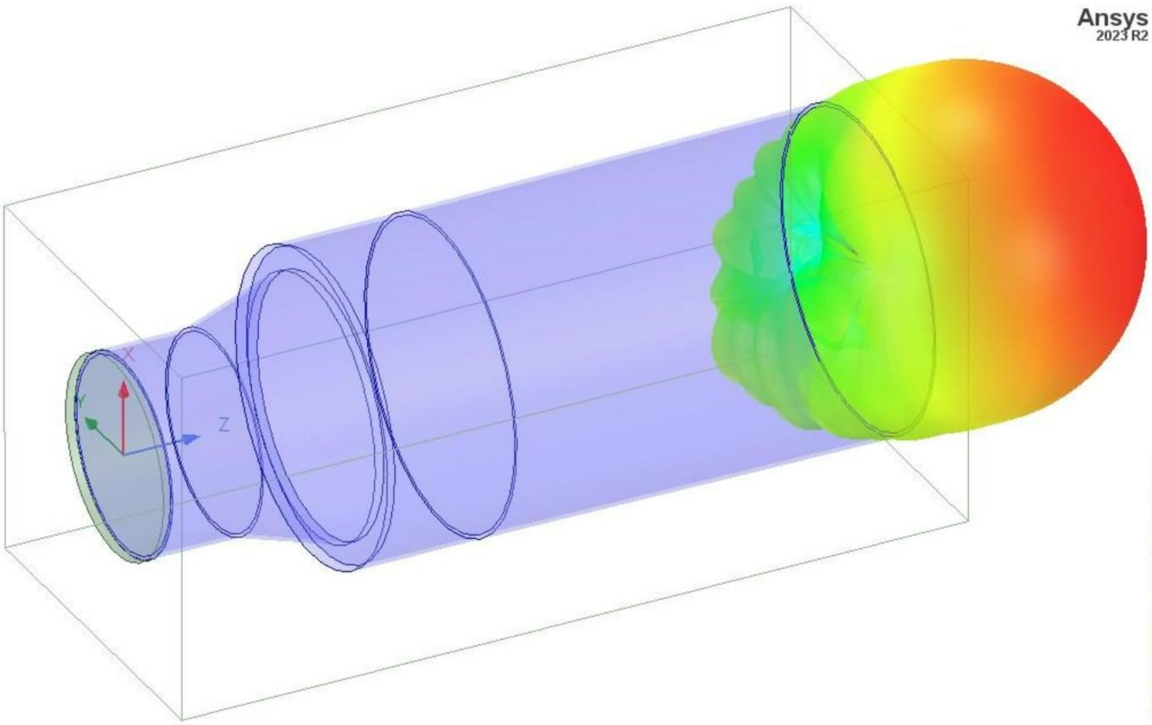


Figure 10: 3D Directivity Overlay

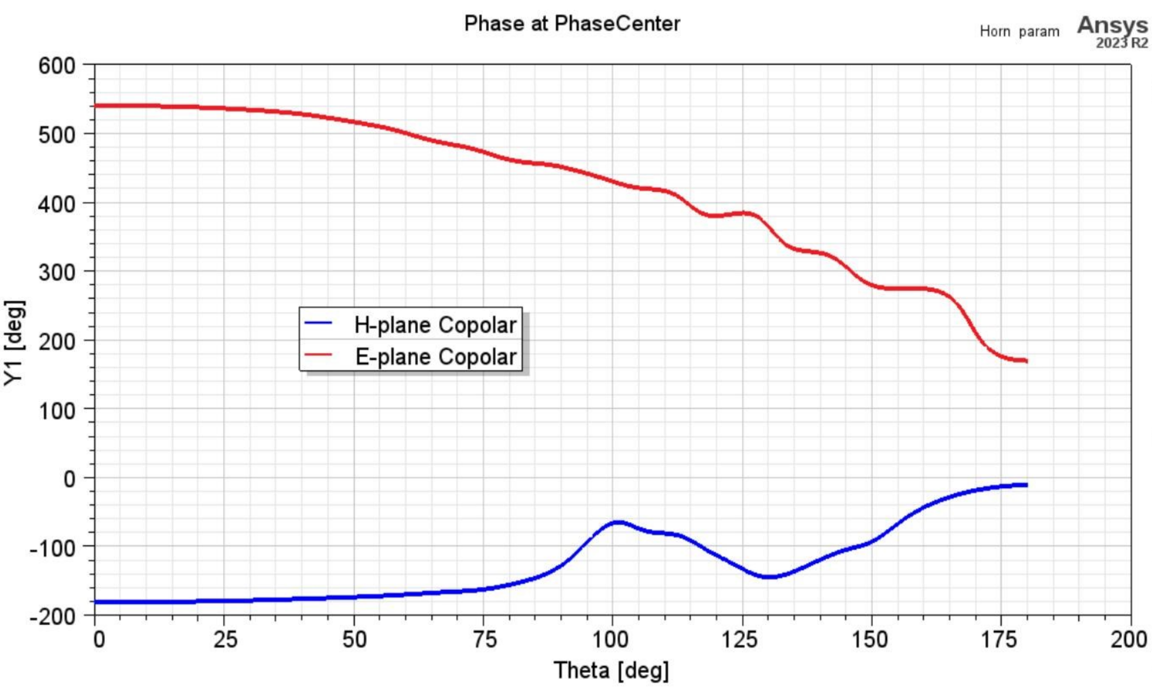


Figure 11: Phase at Phase Center

References:

[1] P. Potter, "A new horn antenna with suppressed sidelobes and equal beamwidths," Microwave Journal, pp. 71-78, June 1963.