DAYANANDA SAGAR COLLEGE OF ENGINEERING

(An Autonomous Institute affiliated to Visvesvaraya Technological University (VTU), Belagavi,
Approved by AICTE and UGC, Accredited by NAAC with 'A' grade & ISO 9001 – 2015 Certified Institution)

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

Open ended experiment Report submitted for the subject

Electromagnetics and Radiating Systems – 22EC52

Submitted by

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Under the Guidance of
Dr. Ravikumar S
Prof. Chandana

Department of Electronics & Communication Engineering
DSCE, Bengaluru

Evaluation

USN	Name		Marks
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VISVESVARAYA TECHNOLOGICAL UNIVERSITY
JNANASANGAMA, BELAGAVI-590018, KARNATAKA, INDIA
2024-25

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Shavige Malleshwara Hills, Kumaraswamy Layout, Bengaluru-560 111, India

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

CERTIFICATE

This is to certify that Open ended experiment entitled **"Design and analysis Pyramidal Horn antenna at 2GHz"** as part of **Electromagnetics and Radiating Systems – 22EC52** is a bonafide work carried out by Prajwal D Nadig (1DS22EC155), Pulluru Kamalesh (1DS22EC166), Ram Prasad H (1DS22EC170) & Ravi Gorentla (1DS22EC171) as 30-marks component in partial fulfillment for the 5th semester of Bachelor of Engineering in Electronics and Communication Engineering of the Visvesvaraya Technological University, Belagavi during the year 2024-2025. The Open ended experiment report has been approved as it satisfies the academic requirements prescribed for the Bachelor of Engineering degree.

Signature of Faculty
Dr. Ravikumar S
Prof. Chandana

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DECLARATION

We declare that we abide by the ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. The work submitted in this report of **Electromagnetics and Radiating Systems – 22EC52**, V Semester BE, ECE has been compiled by referring to the relevant online and offline resources to the best of our understanding and in partial fulfillment of the requirement for the award of the degree of Bachelor of Engineering in Electronics and Communication Engineering, at Dayananda Sagar College of Engineering, an autonomous institution affiliated to VTU, Belagavi during the academic year 2024-2025. We hereby declare that the same has not been submitted in part or full for other academic purposes.

Prajwal D Nadig (1DS22EC155)

Pulluru Kamalesh (1DS22EC166)

Ram Prasad H (1DS22EC170)

Ravi Gorentla (1DS22EC171)

Place: Bengaluru

Date: 02-12-2024

ACKNOWLEDGEMENT

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We take this opportunity to express our sincere gratitude to Dayananda Sagar College of Engineering for giving us the opportunity to pursue our Bachelor's Degrees in this institution.

In particular, we would like to thank Dr. B G Prasad, Principal of Dayananda Sagar College of Engineering, for his constant encouragement and advice.

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Table of Contents

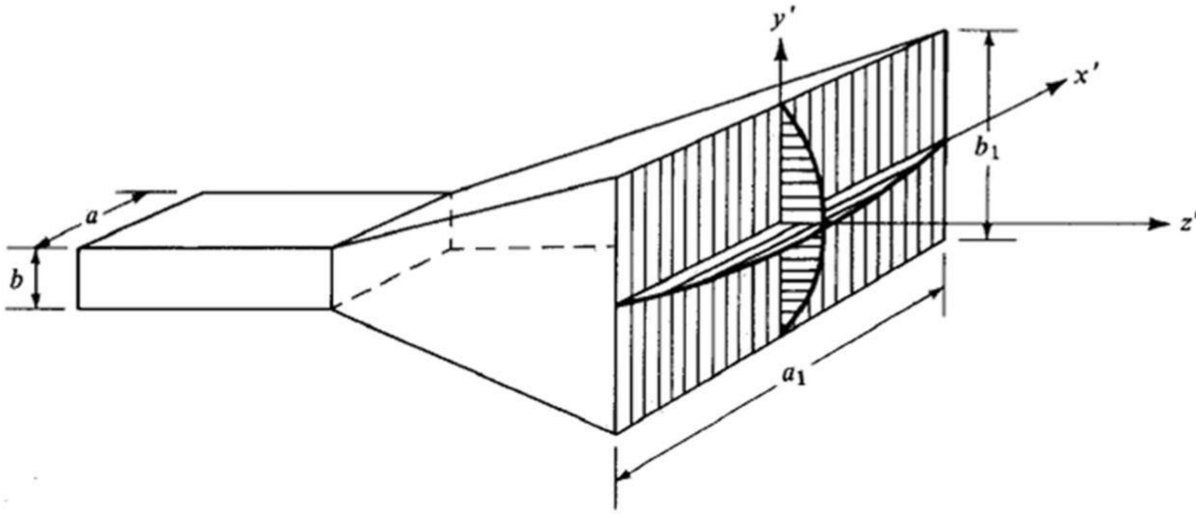
Aim: To design a radiation pattern of pyramidal Horn antenna at 5GHz and to plot S and VSWR parameters.

Introduction:

Pyramidal horn is one type of aperture antenna flared in both directions, a combination of E-plane and H-plane horns. 3D figure is shown as below. Horn antennas are commonly used as a standard gain antenna for calibration purpose of other antennas. Horn antennas are also used as a feeding element for large reflector and lens antennas in communication systems. Its radiation pattern in one plane can be adjusted by changing the aperture dimensions or length of the horn in that plane with negligible variations in the radiation pattern in another plane. By proper selection of the feeding element, a wideband horn antenna has been reported. A pyramidal horn antenna is a type of directional antenna characterized by its flaring, pyramid-like shape and rectangular cross-section. It is an evolution of a waveguide, designed to efficiently radiate electromagnetic waves into free space or receive them with minimal reflection and energy loss.

The structure of the antenna consists of a rectangular waveguide as the feeding section, which transitions into a larger flared region. This flaring occurs in both the horizontal and vertical planes, forming the distinctive pyramidal shape. The purpose of this design is to provide a gradual transition from the confined waveguide environment to free space, ensuring good impedance matching and efficient radiation.

At its aperture, the antenna emits electromagnetic waves with high directivity, forming a well-defined beam. The performance characteristics of a pyramidal horn antenna, such as gain, beamwidth, and efficiency, are directly influenced by its aperture dimensions and flare angles. These antennas operate over a wide range of frequencies, typically in the microwave range, where their simplicity, high efficiency, and precise radiation patterns make them ideal for various purposes. Pyramidal horn antenna has extensively been used as a feed element for radio astronomy, satellite communications and in the antenna test bench as a reference antenna for last several decades due to its simplicity in construction, ease of excitation, large gain and relatively better radiation characteristics at microwave frequencies.



Antenna Designs:

1. Design parameters:

- Operating frequency (f) = 2GHz
- Wavelength (⅄) $= \frac{c}{f} = \frac{(3\times10^8)}{(2\times10^9)} =$ 150mm
- Waveguide = 1.59 inch

2. Design Equation:

- Waveguide Dimensions:

  For 5 GHz, a commonly used waveguide is **WR-159**:

  a (broad side) ≈ 40.39 mm

  b (narrow side) ≈ 20.19 mm

- Aperture dimension:

  Let's assume a desired gain of 15dB

  $G_{\text{linear}} = 10^{\text{GdB}/10} = 31.62$

  Assuming efficiency(η) = 0.6

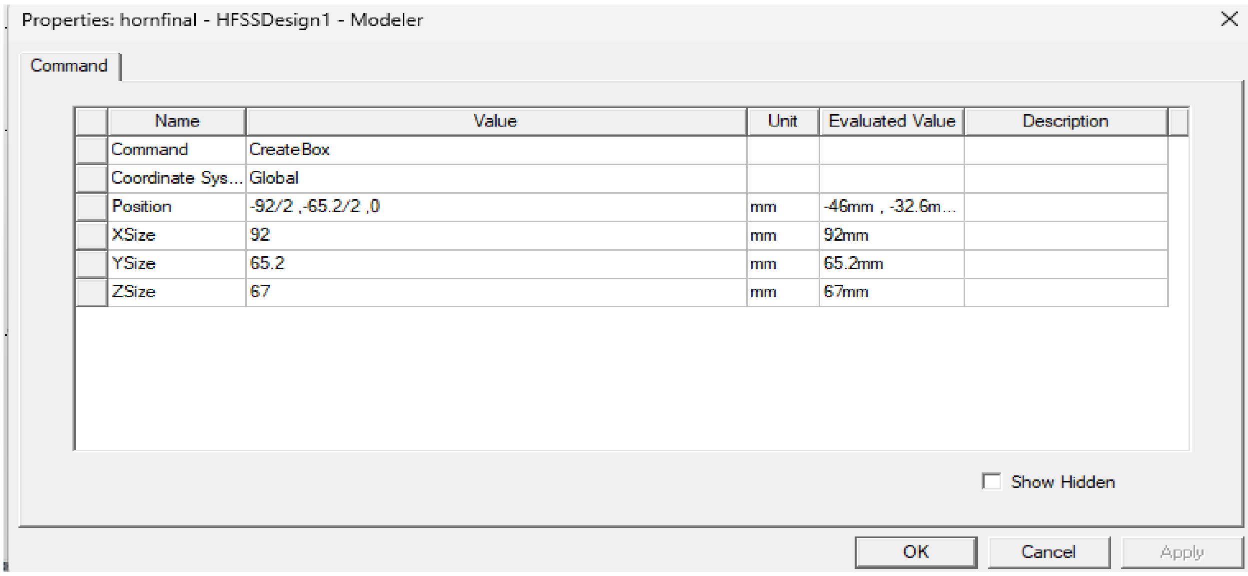
  $A = \frac{G\lambda^2}{4\pi\eta} = 47.7\ cm^2$

- Flare length:

$$L = \frac{a \times b}{\lambda \times (\sqrt{G} - 1)} = 12.7cm$$

Simulation Steps:

Create a Box (Waveguide) with the following coordinates


Properties: hornfinal - HFSSDesign1 - Modeler

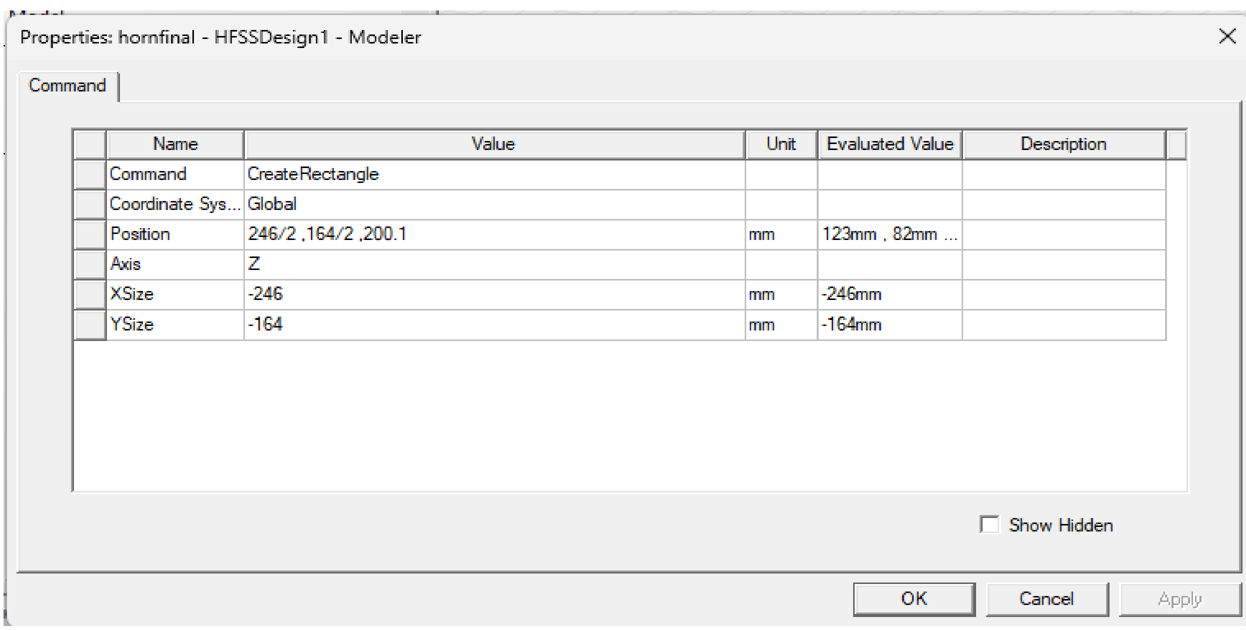
Command

Name	Value	Unit	Evaluated Value	Description
Command	CreateBox			
Coordinate Sys...	Global			
Position	-92/2 ,-65.2/2 ,0	mm	-46mm , -32.6m...	
XSize	92	mm	92mm	
YSize	65.2	mm	65.2mm	
ZSize	67	mm	67mm	

Show Hidden

OK Cancel Apply

Create a rectangle (face) with the following dimensions


Properties: hornfinal - HFSSDesign1 - Modeler

Command

Name	Value	Unit	Evaluated Value	Description
Command	CreateRectangle			
Coordinate Sys...	Global			
Position	246/2 ,164/2 ,200.1	mm	123mm , 82mm ...	
Axis	Z			
XSize	-246	mm	-246mm	
YSize	-164	mm	-164mm	

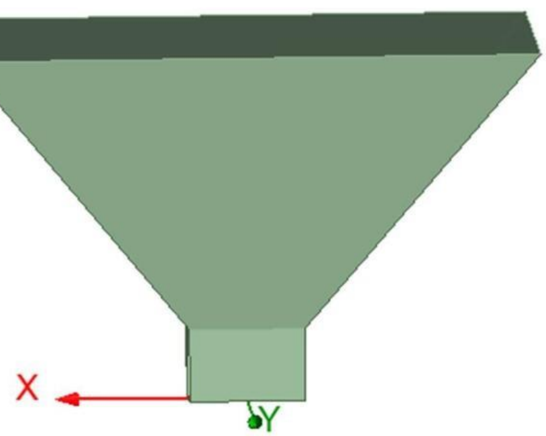
Show Hidden

OK Cancel Apply

Right click on the model section, click selection mode, Faces (F), next, select rectangle and top face of the waveguide and open modeler, click on surface, Create Object from Face.

Select both rectangle and top face of the waveguide (box), next, go to modeler, surface, connect.

The model will look as shown below



Select the top face of the model, right click, edit, surface, uncover, repeat this step until the top face of the model disappears.

Select top face of the wave guide and repeat the above step.

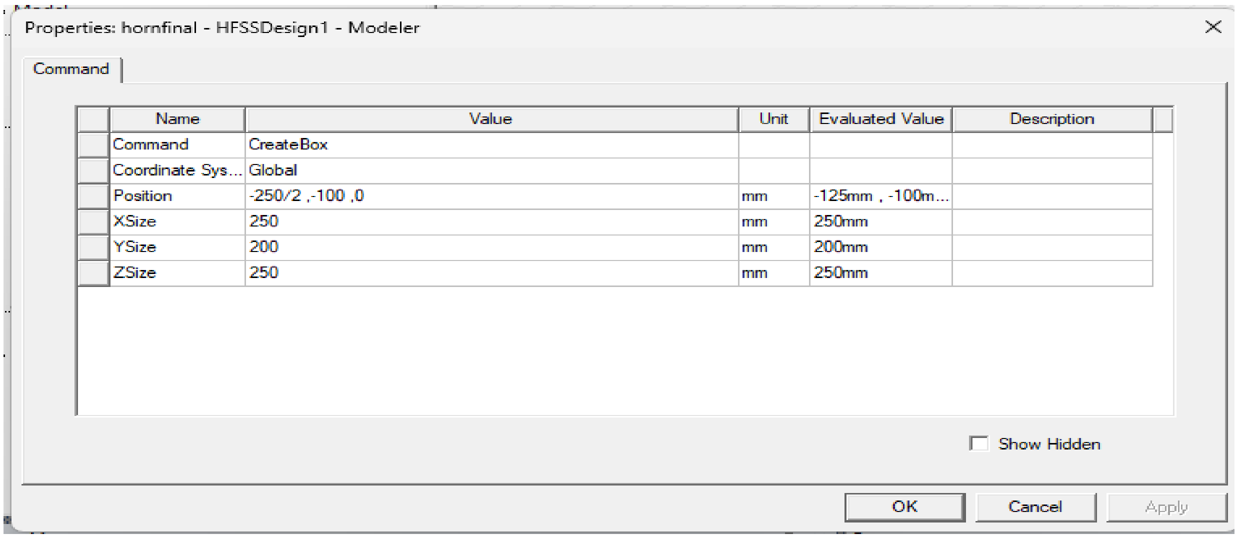
Select Box and rectangle and click unite.

Select bottom face of the waveguide, go to HFSS, excitation, assign, port, wave port, next, click on dropdown under integration line and select choose new line.

Draw a line from the right center of the face to left center of the face.

Now select all the faces of the model expect bottom face of the waveguide, right click, assign boundary, perfect E, click ok.

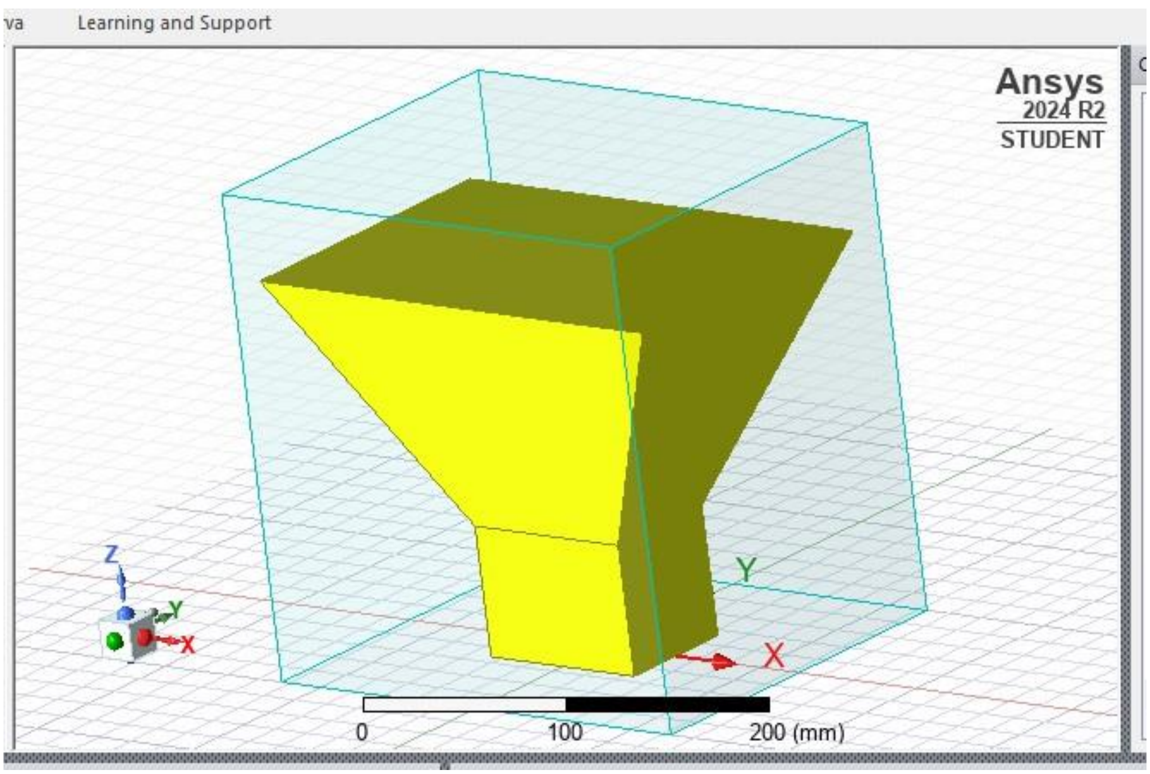
Create a Box (radiation) with the following coordinates.



Name	Value	Unit	Evaluated Value	Description
Command	CreateBox			
Coordinate Sys...	Global			
Position	-250/2 ,-100 ,0	mm	-125mm , -100m...	
XSize	250	mm	250mm	
YSize	200	mm	200mm	
ZSize	250	mm	250mm	

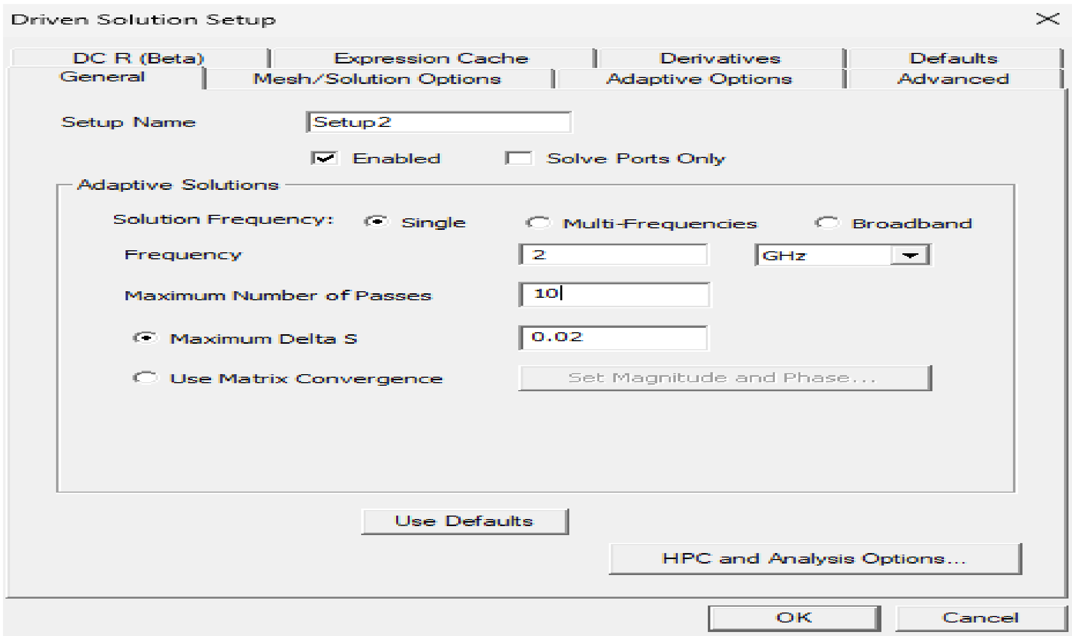
Right click on Box (radiation), assign boundary, radiation, click ok.Now

the model will look like as given below



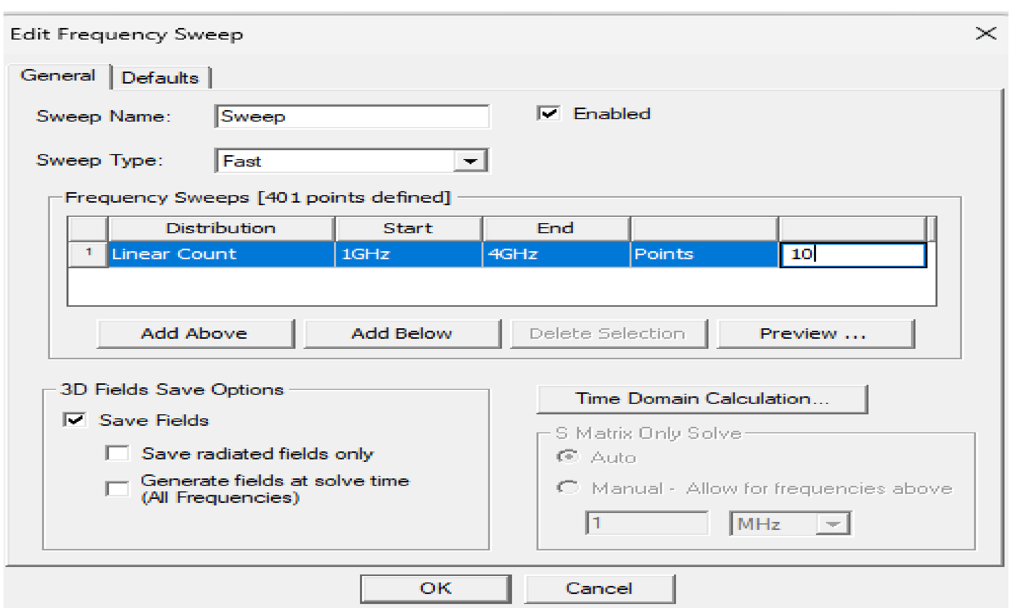
In the project manager section, Right click on analysis, solution setup, advanced.

Enter the values as given



Click on ok

In the next window that appears after clicking ok, enter the values as given below

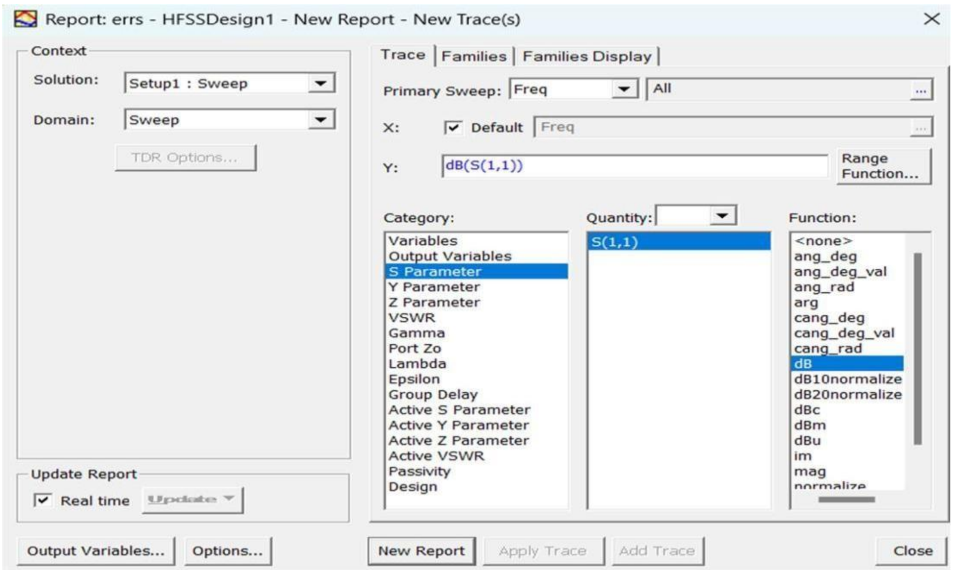


Go to HFSS, validation Check, Close the validation window.

Go to HFSS, analyze all, no errors proceed.

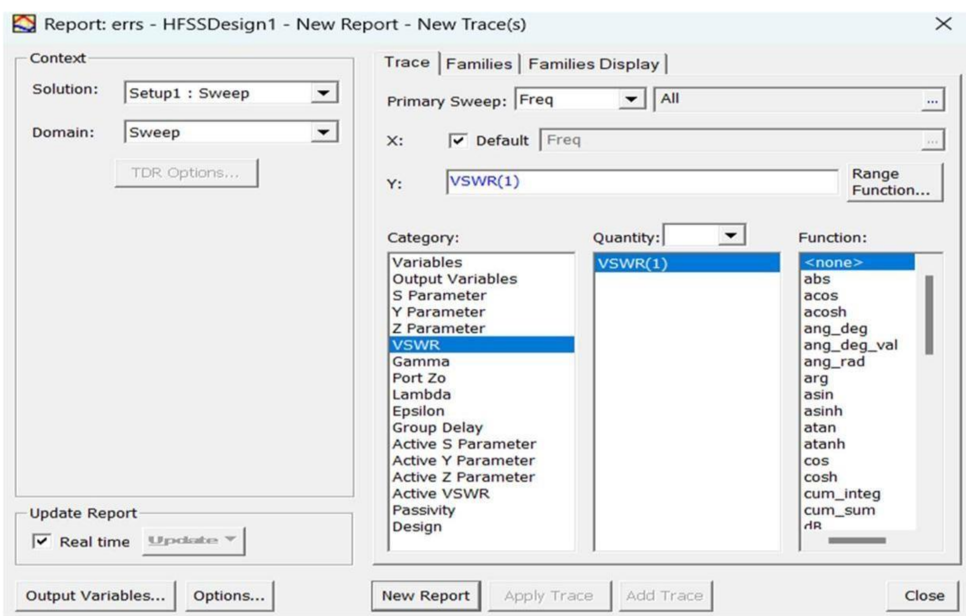
Right click on Result in Project manager section, create modal solution data report, rectangular plot.

The following window will appear



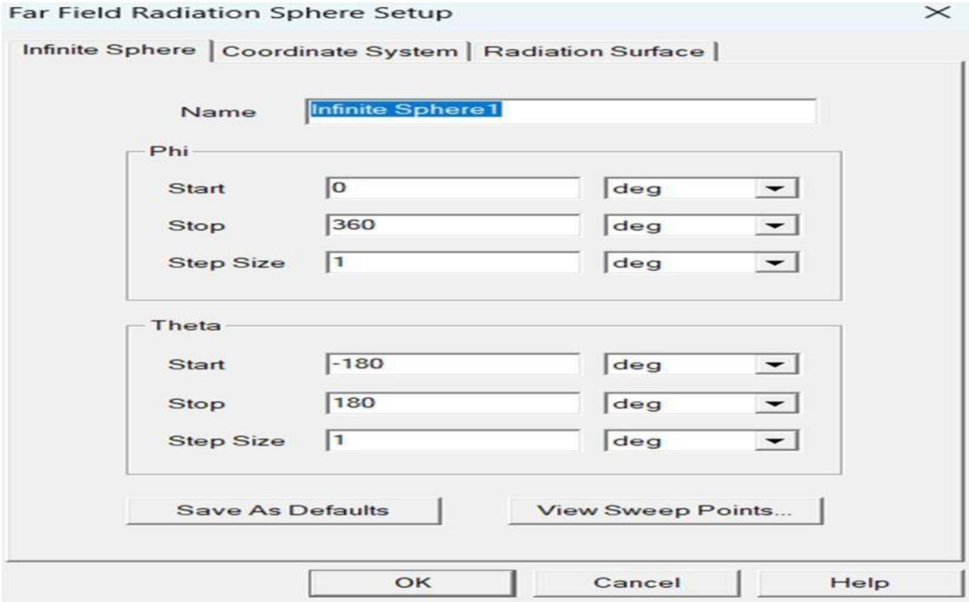
Click on new report, close.

In the same way, right click on results in project manager section, create modal solution data report, rectangular plot, select VSMR in category section, click on new report as given below.



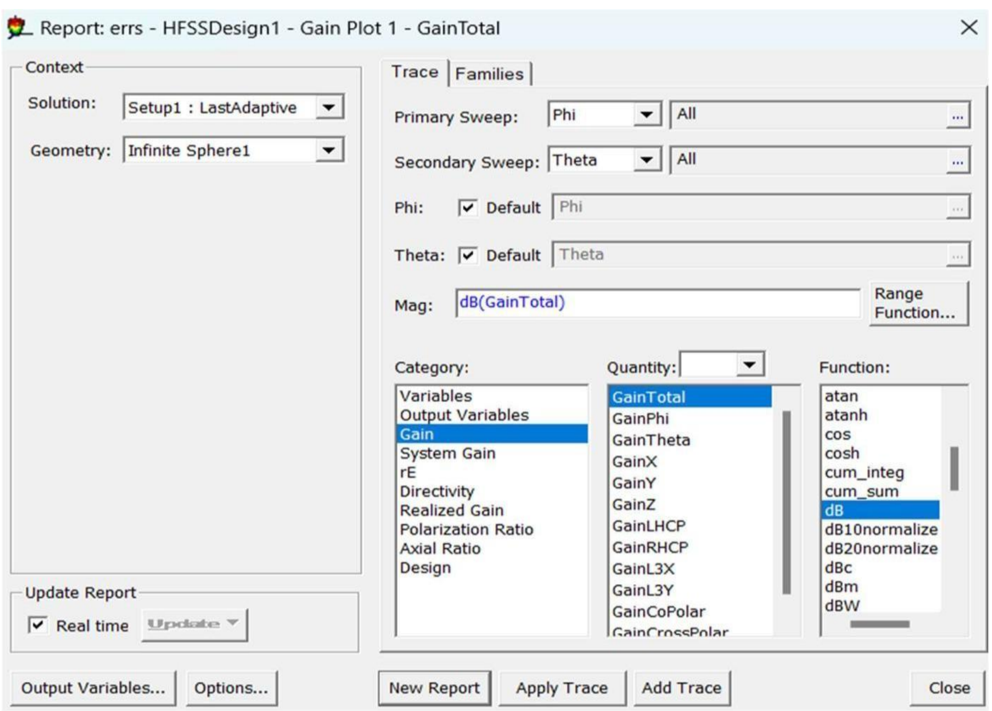
Right click on radiation in project manager window, insert far field setup, infinite sphere.

Enter the values as given below



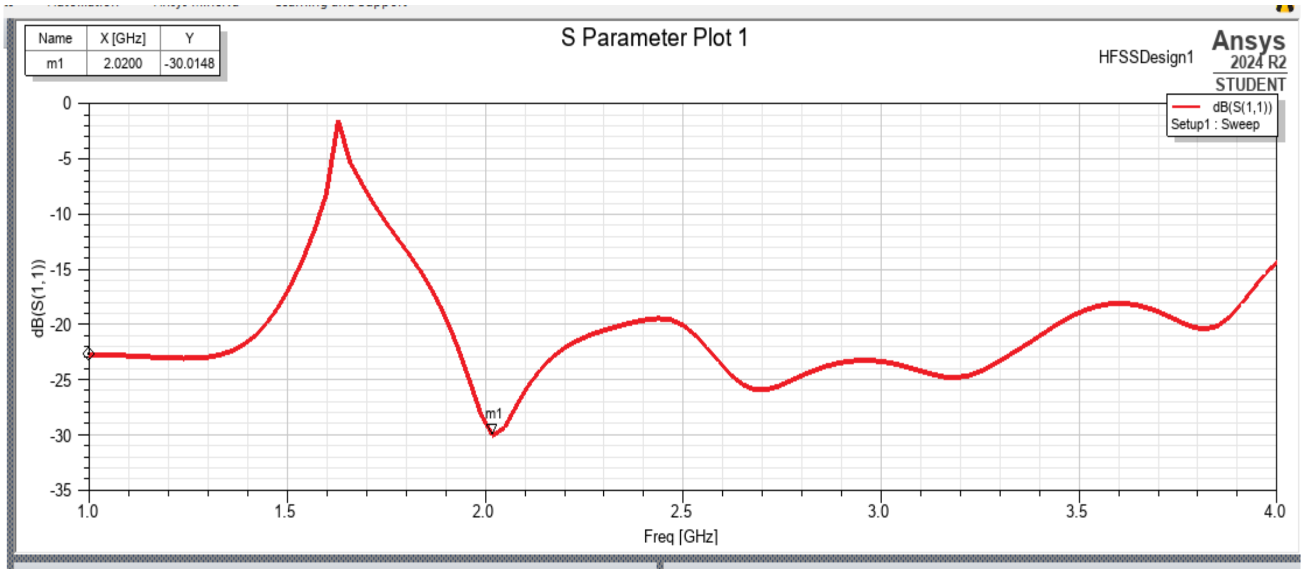
Right Click on results, create far fields report, 3D polar plot

The following window will open

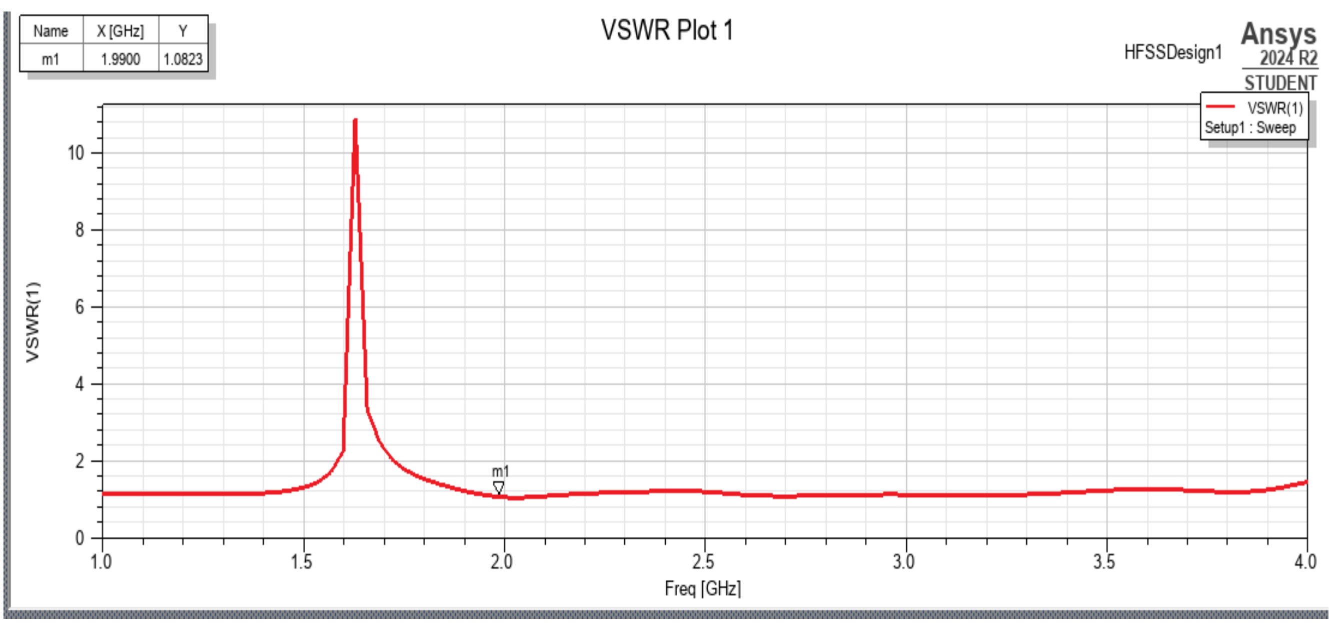


Simulation Outputs:

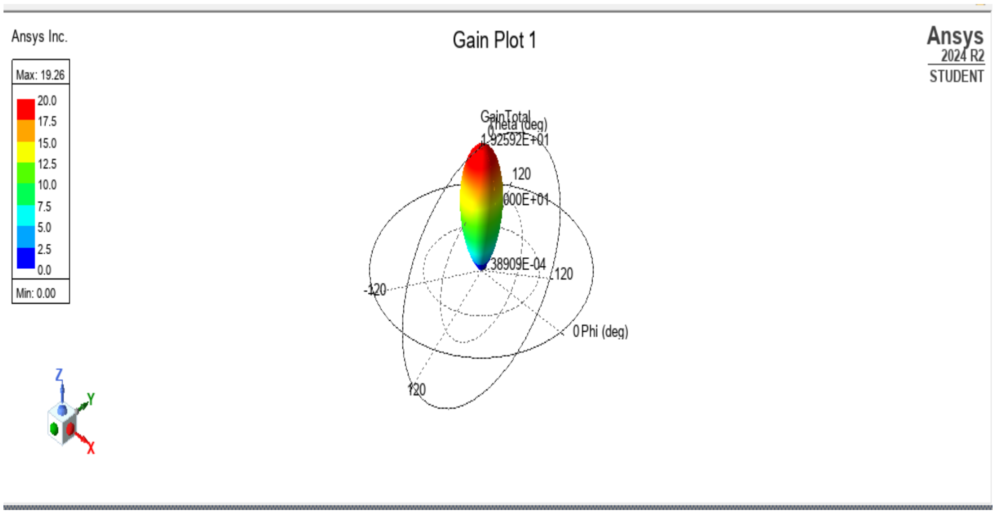
S Parameter:



VSWR Parameter:



Gain Plot:



Results and Discussion:

Sl No		Value
01	S11(in dB) at 2GHz	-30.018
02	VSWR at 2GHz	1.0251

S parameter plot:

The S11 parameter plot of the pyramidal horn antenna designed for 2 GHz shows excellent impedance matching, with an S11 value of approximately -38 dB at the target frequency. This indicates that less than 0.015% of the input power is reflected, ensuring efficient power transfer. The antenna also exhibits a wide operational bandwidth, with S11 remaining below -10 dB from approximately 4.6 GHz to 5.7 GHz, resulting in a fractional bandwidth of about 22%. This wide bandwidth is ideal for applications requiring high data rates or multi-frequency operation, such as radar or 5G communication. Additionally, secondary resonances are observed around 6.7 GHz and 7.5 GHz, indicating potential support for multi-band applications. The primary resonance at 2 GHz confirms the design's focus and minimal reflection, exceeding the target of S11 < -20 dB. Overall, the antenna demonstrates high efficiency, wide bandwidth, and versatility for various applications, with excellent performance at the intended frequency and additional multi-frequency capabilities.

VSWR parameter plot:

The VSWR plot of the pyramidal horn antenna designed for 2 GHz confirms excellent impedance matching, with a VSWR value of approximately 1.03 at the target frequency. This value indicates minimal reflection and efficient power transfer, as a perfect match would have a VSWR of 1. The plot also shows that the VSWR remains below 1.5 across a wide frequency range, from approximately 4.6 GHz to 5.7 GHz, signifying a broad bandwidth of around 1.1 GHz. This wideband characteristic ensures the antenna’s robust performance over a range of frequencies, making it suitable for high-frequency applications such as radar and wireless communication. The low VSWR values throughout the operational band reinforce the high efficiency and reliability of the antenna design.

Gain plot:

The gain plot of the pyramidal horn antenna at 2 GHz demonstrates a highly directional radiation pattern, with a peak gain of approximately **14.91 dB**. This significant gain value indicates that the antenna effectively concentrates energy in a specific direction, enhancing its efficiency in applications requiring focused radiation, such as point-to-point communication or radar systems. The plot shows a well-defined main lobe, confirming the directional nature of the antenna, while the side lobes are relatively suppressed, minimizing unwanted radiations. This result highlights the antenna's excellent performance in terms of gain and directivity, making it suitable for high-frequency, long-range applications.

Advantages and applications

Advantages:

- High Directivity
- Wide Bandwidth
- Efficient impedance matching
- High gain
- Simple design and construction
- Minimal losses
- Low VSWR
- Versatility

Applications:

- Used in radar system such as air traffic control, weather monitoring etc.,
- Used in satellite communication and microwave systems
- Used in Medical imaging and therapy such as Hypothermia
- Used in wireless communication such as Bluetooth, wi-fi, 5G communication systems etc.,
- Used in radio telescopes for observing celestial objects at microwave frequencies
- Utilized in anechoic chambers for antenna testing, calibration, and electromagnetic interference (EMI) testing

Conclusion:

In conclusion, the design and analysis of the pyramidal horn antenna at 2 GHz demonstrate its effectiveness as a high-performance antenna for various applications. The simulation results show excellent impedance matching with an S11 value of -30.018 dB and a low VSWR of 1.03 at the operating frequency, ensuring minimal reflection and efficient power transfer. The gain of 14.91 dB highlights the antenna’s strong directional capability, making it suitable for applications requiring focused radiation, such as radar, radio waves, television, satellite communication, and point-to-point wireless links. The broad bandwidth and suppressed side lobes further enhance its performance and efficiency of the antenna all of this by ensuring reliable operation over a wide frequency range while minimizing interference. Overall, the pyramidal horn antenna's superior characteristics validate its suitability for high-frequency and long-range communication systems.