Exp.No.:05 Date:24/04/23	**CONEWAVEGUIDE-TM02 MODE**

OBJECTIVE:

To construct a rectangular wave guide using TM_{02} mode.

AIM:

To design a rectangular wave guide using TM_{02} mode.

SOFTWARE REQUIRED:

ANSYSVERSION2022

THEORY:

An electromagnetic wave is a type of wave that consists of oscillating electric and magnetic fields that travel through space at the speed of light. These waves are generated by the movement of charged particles and can travel through a vacuum or through various materials, such as air or water. Electromagnetic waves have a wide range of frequencies and wavelengths, which determines their properties and uses. Some common examples of electromagnetic waves include radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays.

TM_{02}MODE:

TM02 mode is a type of electromagnetic wave propagation in a cylindrical waveguide or resonant cavity. When a magnetic field is applied, it can affect the propagation characteristics of the TM01 mode. In the presence of a magnetic field, the TM01 mode becomes elliptically polarized, meaning that the electric and magnetic fields are no longer perpendicular to each other. The orientation of the ellipse changes as the wave travels along the waveguide or cavity. The strength of the magnetic field also affects the propagation characteristics of the TM02 mode. As the magnetic field strength increases, the frequency of the mode shifts towards higher values, a phenomenon known as the "magnetic field dispersion. In addition, the magnetic field can also affect the loss of the TM02 mode, with higher magnetic fields generally leading to lower losses. Overall, the magnetic field can have a significant impact on the behaviour of the TM02 mode in a waveguide or resonant cavity, making it an important factor to consider in many applications.

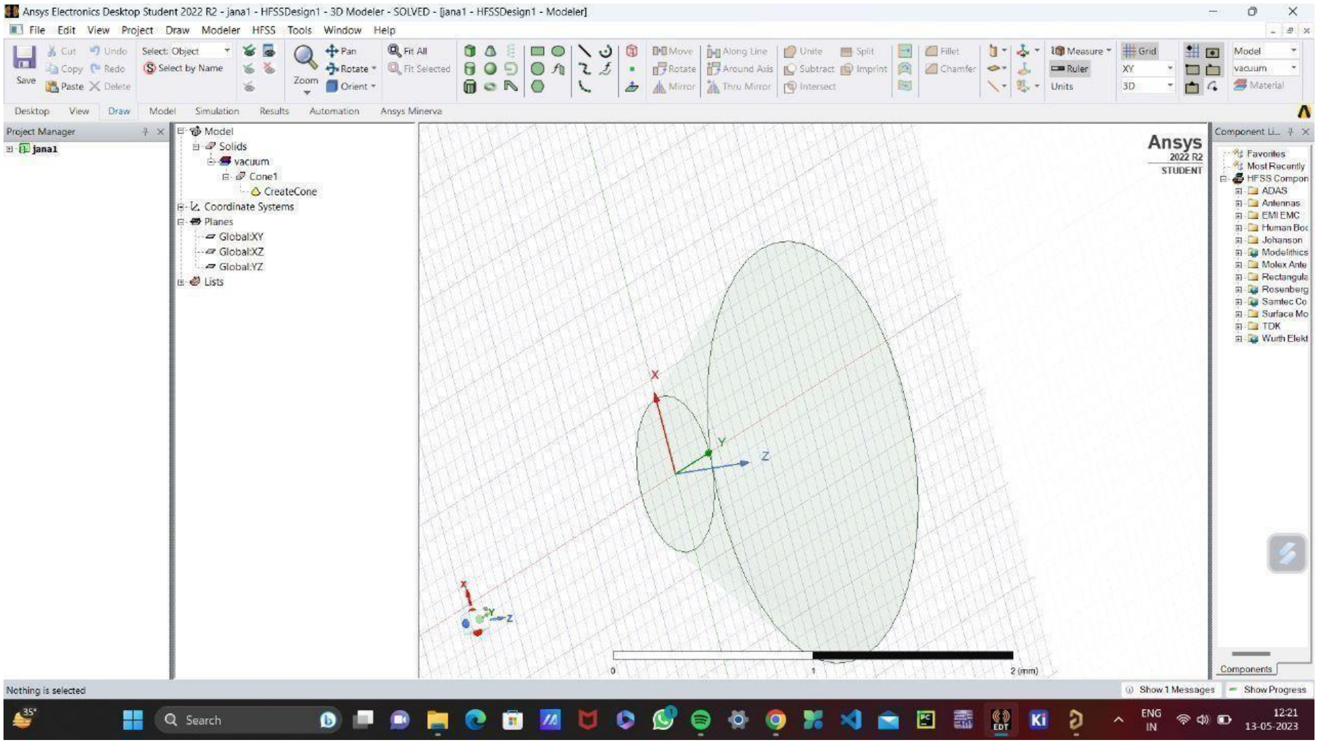

Figure: 5.1 Cone waveguide

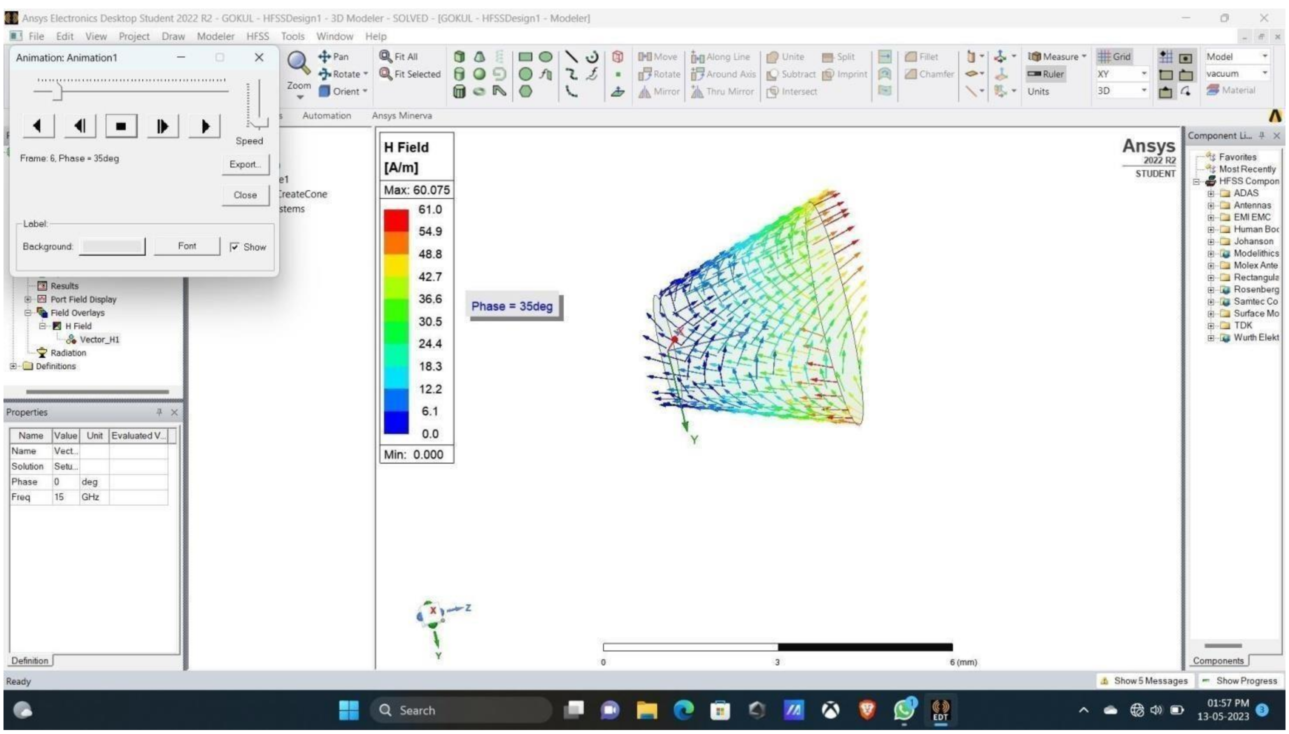

Figure: 5.2 Cone waveguide TM02 mode (35degree)

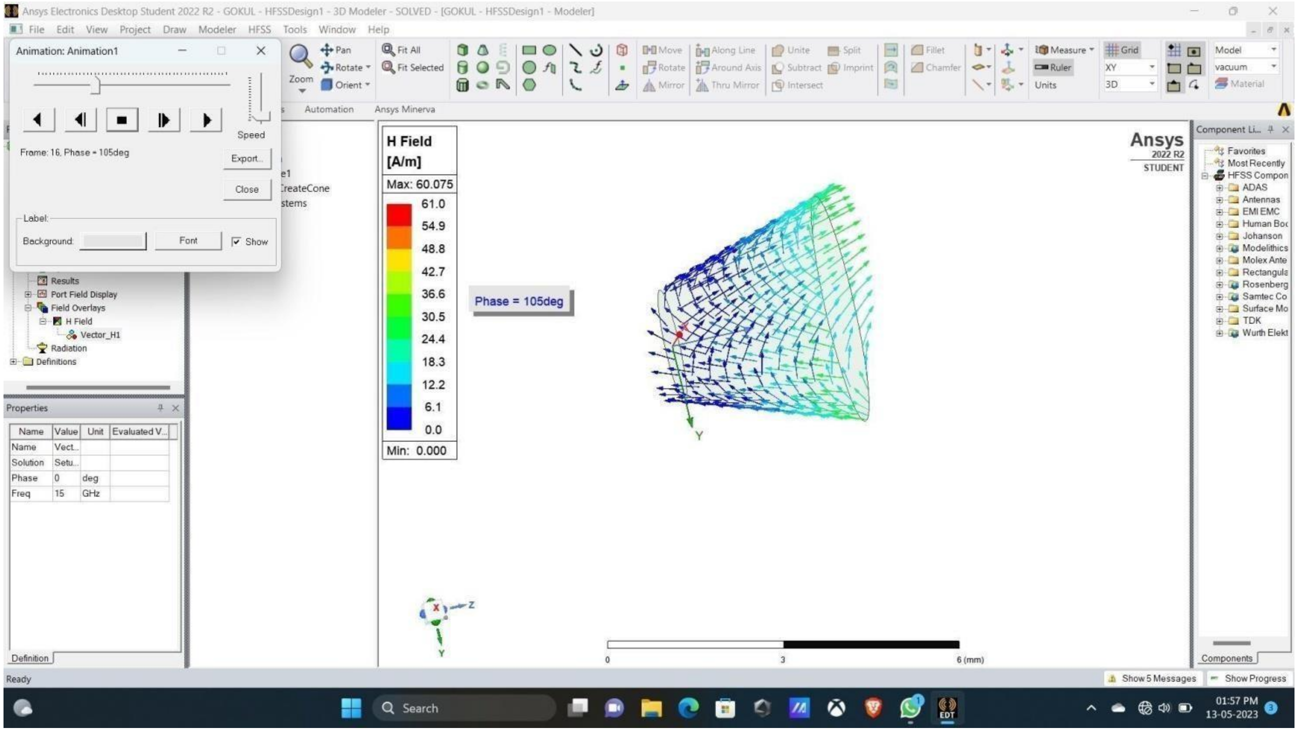

Figure: 5.3 Cone waveguide TM02 mode (105degree)

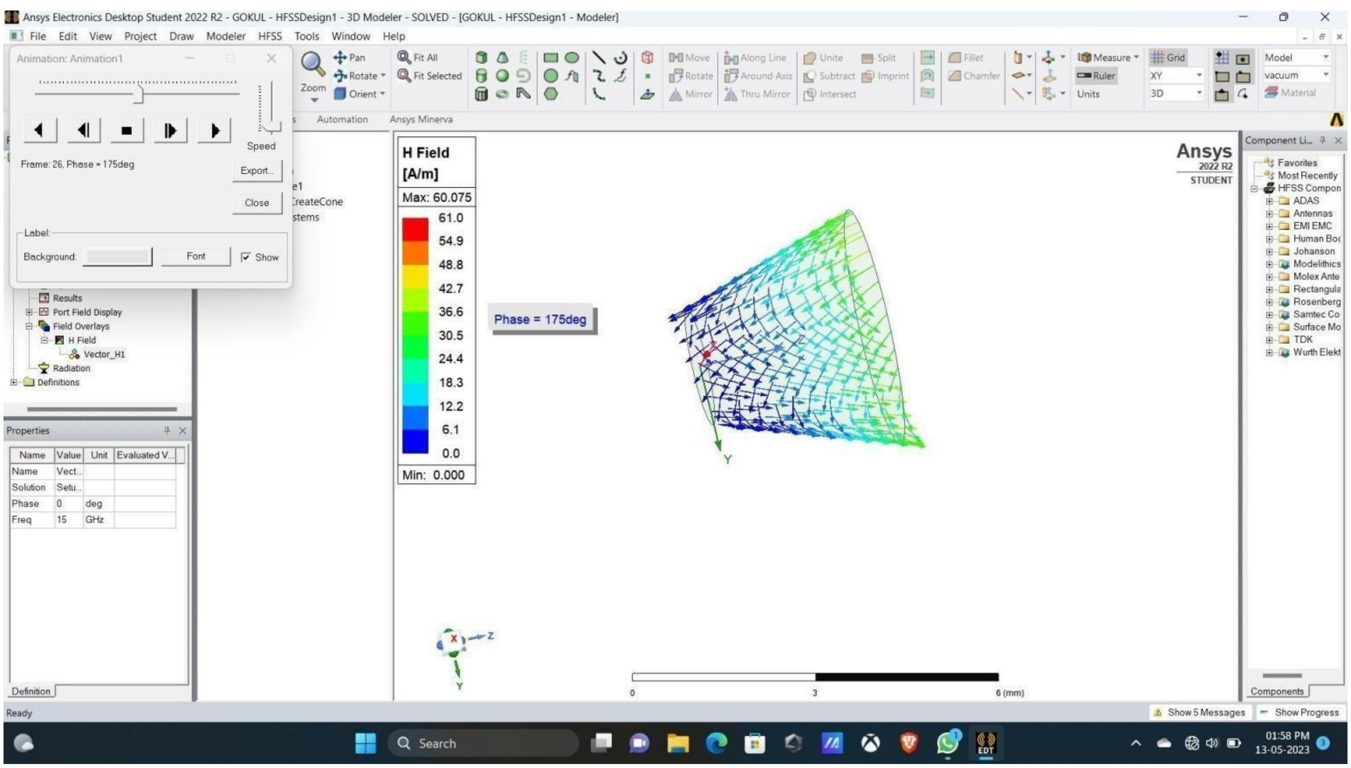

Figure: 5.4 Cone waveguide TM02(175degree)

PROCEDURE:

1. Create a new project: Open ANSYS software and create a new project. Save it with an appropriate name and location
2. Set the working environment: Select the working environment as "HFSS" (High Frequency Structural Simulator) to work with electromagnetic simulations.
3. Create a new design: Click on "Insert" and select "Design" from the dropdown menu. Then, select "Rectangular Waveguide" and enter the dimensions of the waveguide in the respective fields.
4. Create boundaries: To simulate the electromagnetic behaviour of a waveguide, you need to define the boundaries of the simulation. Click on "Boundaries" and create perfect electric conductor (PEC) boundary conditions on all sides of the waveguide.
5. Define materials: Define the material properties of the waveguide by clicking on "Material Properties". Select "Add Material" and choose the appropriate material for the waveguide.
6. Create a waveguide port: Click on "Excitations" and select "Waveguide Port". Select the mode of operation for the port and specify the dimensions of the port.
7. Mesh the design: Click on "Mesh" and select "Mesh Operations". Choose the appropriate meshing technique for the design and set the mesh parameters.
8. Solve the simulation: Click on "Solve" and select "Solve Setup". Choose the appropriate solver settings and start the simulation.
9. Analyze the results: Once the simulation is complete, click on "Results" to view the simulation results. You can analyze the S-parameters, radiation patterns, and other electromagnetic properties of the waveguide.
10. Optimize the design: You can optimize the design by tweaking the dimensions of the waveguide and port until you achieve the desired performance.

FIELD EQUATION:

- For TE mn mode, the field equations for a rectangular waveguide are:[2]
- E_{x} = (jco*mu)/(h ^ 2) * ((n*pi)/b) * cos((m*pi*x)/a) * sin((n*pi*y)/b)
- E_{y} = (- j * omega*mu)/(h ^ 2) * ((m*pi)/a) * sin((m*pi*x)/a) * cos((n*pi*y)/b)
- E_{sigma} = 0
- H_{x} = (j*beta)/(h ^ 2) * ((m*pi)/a) * sin((m*pi*x)/a) * cos((n*pi*y)/b)
- H_{J} = (j*beta)/(h ^ 2) * ((n*pi)/b) * cos((m*pi*x)/a) * sin((n*pi*y)/b)
- H_{z} = cos((m*pi*x)/a) * sin((n*pi*y)/b)
- For TM ma mode, the field equations for a rectangular waveguide are:
- E_{x} = (- j * beta)/(h ^ 2) * ((m*pi)/a) * cos((m*pi*x)/a) * sin((m*pi*y)/b)
- E_{y} = (- j * beta)/(h ^ 2) * ((n*pi)/b) * sin((m*pi*x)/a) * cos((n*pi*y)/b)
- E_{s} = sin((m*pi*x)/a) * sin((n*pi*y)/b)
- H pi = j omega e hbar^ 2 ((n*pi)/b) * sm((m*pi*x)/a) * cos((n*pi*y)/b)
- H_{x} = (- j * sis)/(h ^ 2) * ((pi*pi*x)/a) * cos((pi*a*pi*x)/a) * sin((pi*pi*y)/b)
- H_{z} = 0

PRELABQUESTIONS:

1. **Define dominant mode.**

The dominant mode is the mode of propagation that has the lowest cut off frequency and the highest characteristic impedance. It is the mode that can propagate through the waveguide with the least attenuation and distortion, and it is the mode that carries the majority of the power in the waveguide.

2. **What are dominant mode and degenerate mode in cone waveguide?**

The dominant mode in a waveguide is the primary mode of propagation that has the lowest cut off frequency and the highest power transmission capability. It is the mode that can propagate with the least amount of energy loss and distortion. In the case of a CONE waveguide, the dominant mode is typically the TE11 mode, which refers to the transverse electric mode with one variation in the electric field across the waveguide cross-section. This mode is commonly used in practical applications due to its desirable propagation characteristics.

3. **Define wave impedance.**

Wave impedance is defined as the ratio of the magnitude of the electric field to the magnitude of the magnetic field of an electromagnetic wave propagating through a medium.

4. **What is dominant mode of TE and TM waves in circular wave guide.**

For the TE modes, the dominant mode is the TE11 mode, which is the lowest-order mode that has no azimuthal variation in the electric field. The TE11 mode has a single radial electric field component and no magnetic field component along the direction of propagation. It is the mode that carries the majority of the power in the waveguide and is the most commonly used mode in practical applications.

POSTLABQUESTIONS:

1. **TEM waves is not possible through hollow rectangular wave guides. justify.**

In hollow waveguides (single conductor), TEM waves are not possible, since Maxwell's Equations will give that the electric field must then have zero divergence and zero curl and be equal to zero at boundaries, resulting in a zero field with boundary conditions guaranteeing only the trivial solution).

2. If the dimensions of the wave guide increases what happens on cut off frequency?

The cut off frequency will decrease. This is because as the waveguide dimensions increase, the wavelength of the propagating electromagnetic wave increases. At a certain point, the wavelength of the wave becomes too large to fit within the waveguide dimensions, and the wave cannot propagate in the waveguide without significant attenuation.

3. What is the difference between TE wave and TM wave?

In a TE wave, the electric field is transverse to the direction of propagation and the magnetic field is parallel to the direction of propagation. The magnetic field does not need to be zero inside the conductor for the wave to exist. Same is true for TM wave. So, both modes exist in this case.

RESULT:

Designing a cone waveguide TM02 mode using Ansys software involves setting up a 3D model of the waveguide, applying the appropriate boundary conditions for the TM02 mode. Ansys software provides advanced simulation capabilities to analyze the waveguide's performance, including the propagation characteristics, attenuation, and mode conversion. The results of the simulation can provide valuable insights into the waveguide's behaviour, including the field distributions, the transmission coefficient, and the reflection coefficient. These results can help optimize the design of the waveguide for specific application sand fields.

MARK ALLOCATION:

S. No	Parameters	Mark Allotted	Mark Awarded
1	Circuit Design/ code developing and debugging / Trouble shooting	0-3	
2	Implementation and Demonstration	0-3	
3	Discussion	0-3	
4	Report writing & Presentation	0-3	
5	Contribution & Team Dynamics	0-3	
Total		15	

Signature of Lab In-charge