EXPERIMENT: Design & Simulation of Dipole Antenna using CST

Related course: KIE3004 (Applied Electromagnetics) or KEET4208 (Antenna & Propagation)

EQUIPMENT:
Software (CST)

INSTRUCTIONS:
1. Record all your results and observations in a log book.
2. Follow the demonstrator's instructions throughout the experiment.

OBJECTIVES:
To familiarize with CST software.
To have basic understanding of dipole antenna and its designing.
To know about the antenna parameters:
- S-parameter.
- Gain.
- Surface currents.
- Radiation pattern.

Description:
An antenna is a transducer designed to transmit or receive radio waves, which are a class of
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electromagnetic waves. In other words, antennas convert radio frequency electrical currents into electromagnetic waves and vice versa. Antennas are used in systems such as radio and television broadcasting, point-to-point radio communication, wireless LAN, radar, and space exploration. Antennas usually work in air or outer space, but can also be operated underwater or even through soil and rocks at certain frequencies for short distances. Physically, an antenna is an arrangement of conductors that generate a radiating electromagnetic field in response to an applied alternating voltage and the associated alternating electric current, or can be placed in an electromagnetic field so that the field will induce an alternating current in the antenna and a voltage between its terminals.

Simple Dipole Antenna: Just about the simplest form of antenna is called the dipole. This is a conductor that is divided in the middle and is connected at this point to a feeder (or feed line). This feeder then connects the antenna to the receiver or transmitter. Feeders come in many forms. Probably, the most commonly used is coaxial cable. This is the type of feeder used in this trainer.

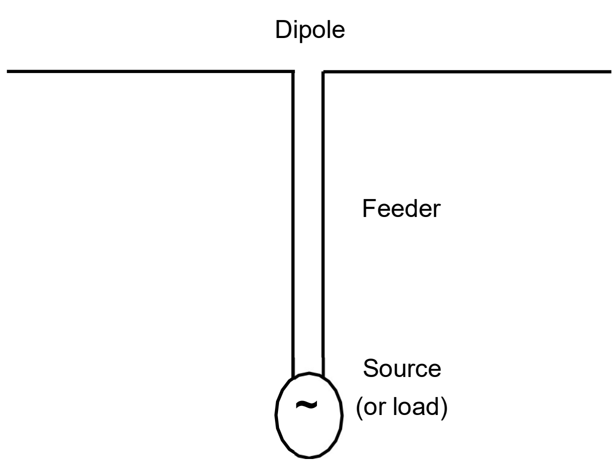


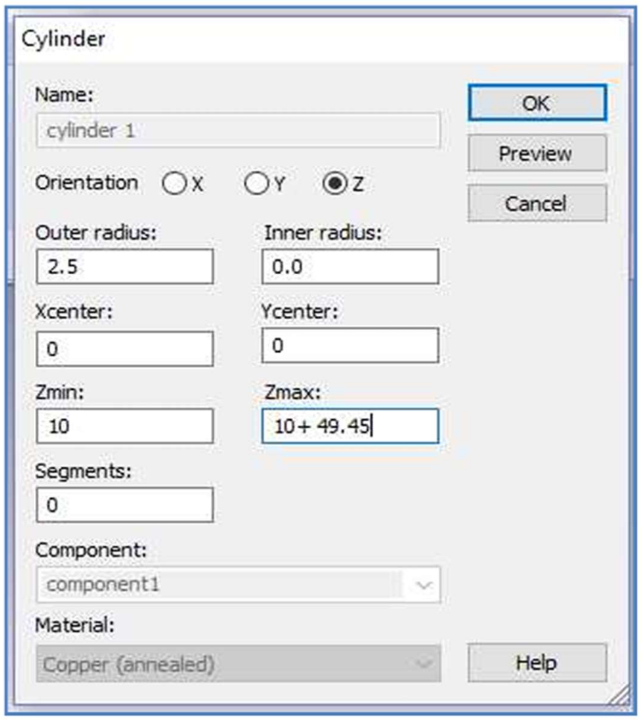
Figure 1: A dipole and feeder

TEST 1: Antenna Designing on CST Software

Method-1 (Part-1: Design of Dipole):

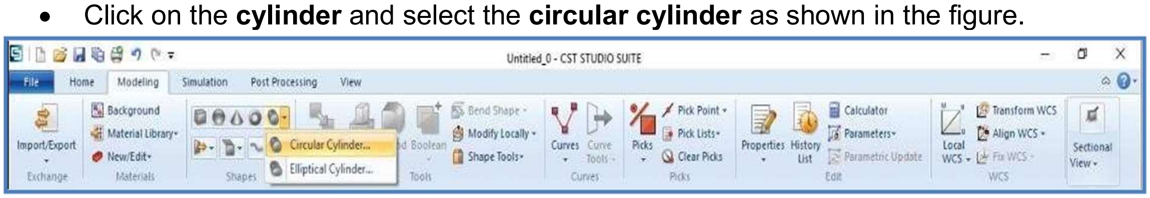
- Click on modeling from menu bar.
- Click on the **cylinder** and select the **circular cylinder** as shown in the figure.

- Press the **ESC** key to show the Dialogue box.
- **Enter the following values** in the Dialogue Box and select **material as copper annealed** by **loading it from the library**.

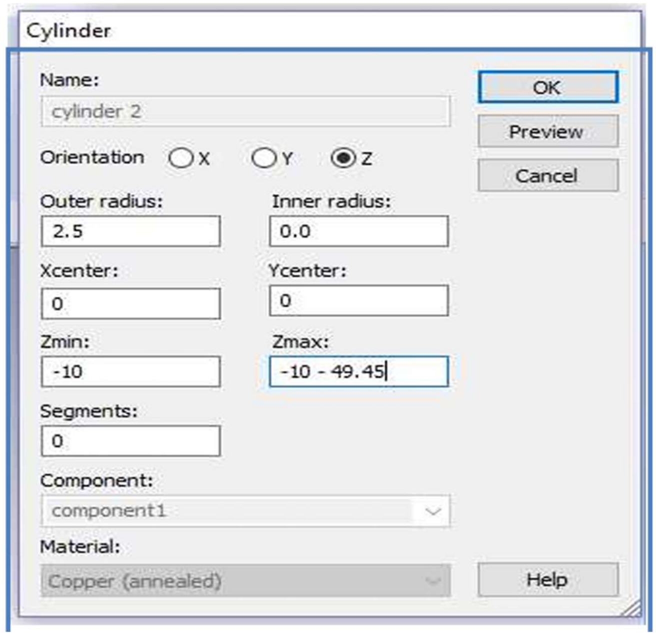


Method-1 (Part-2: Design of Dipole):

- Click on modeling from the menu bar.
- Click on the **cylinder** and select the **circular cylinder** as shown in the figure.



- Press the ESC key to show the Dialogue box.
- **Enter the following values** in the Dialogue Box and select **material as copper annealed** by **loading it from the library**.

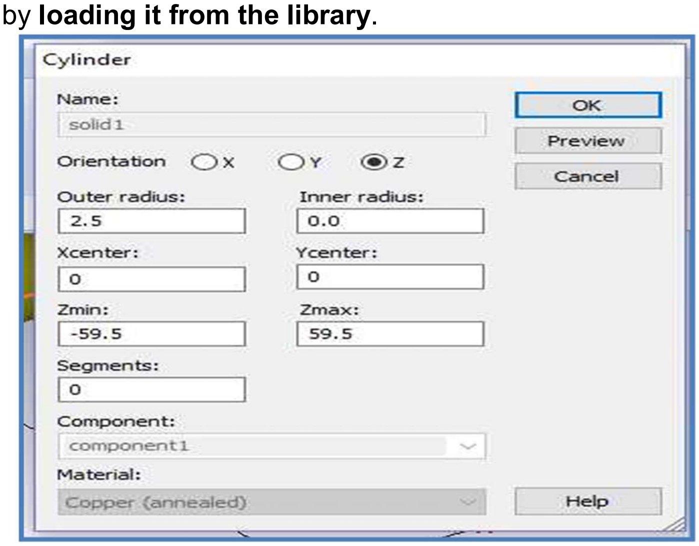


The total gap between dipoles is 20mm.

Method-2 (Design of Dipole):

- Click on modeling from menu bar.
- Click on the **cylinder** and select the **circular cylinder** as shown in the figure.

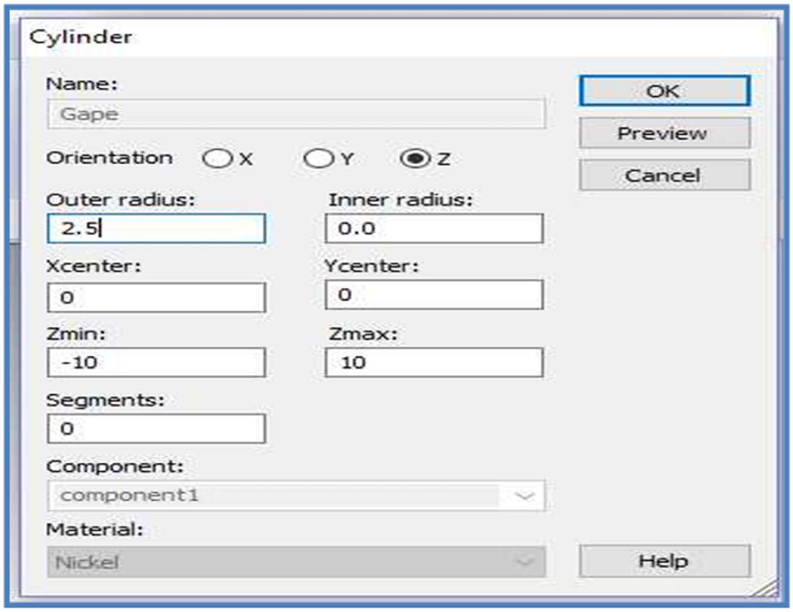
- Press the ESC key to show the Dialogue box.
- **Enter the following values** in the Dialogue Box and select **material as copper annealed** by **loading it from the library**.



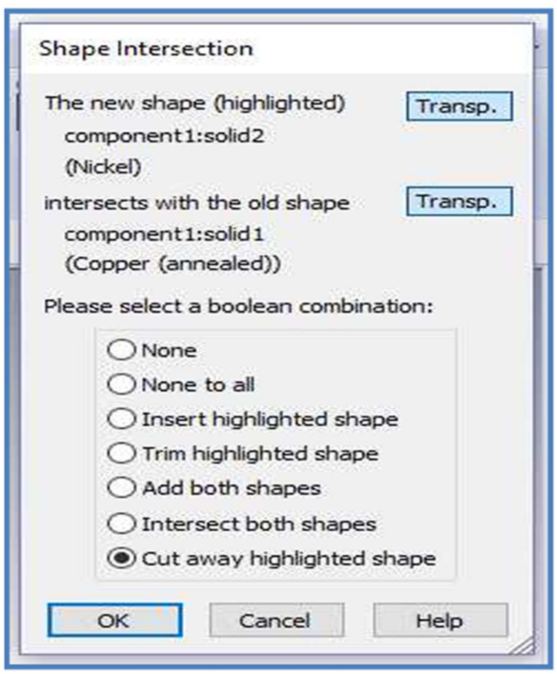
Gap is required between the two poles but it is a long pole without any gap, so draw another shape of different material at its central position to cut it away from the shape.

- Click on **Modeling** from the Menu Bar.
- Click on **cylinder** and select **circular cylinder** as shown in the figure.

- Press **Esc** key to show the Dialogue Box.
- **Enter the following values** in the Dialogue Box and select **material as Nickel** by loading it from the library.

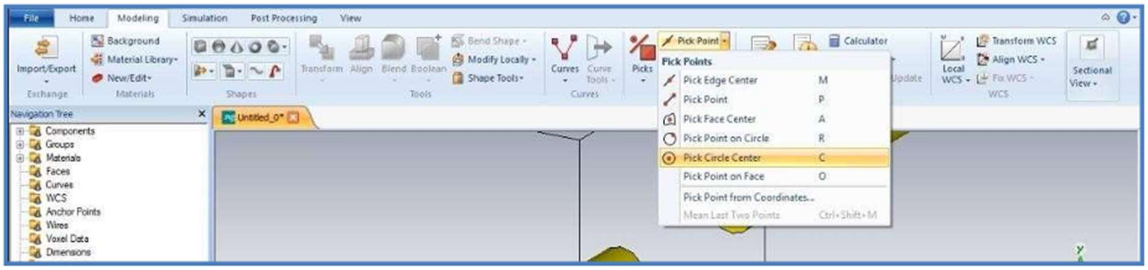


- Click ok.
- Following Dialogue Box will pops up, select **cut it away highlighted shape**.

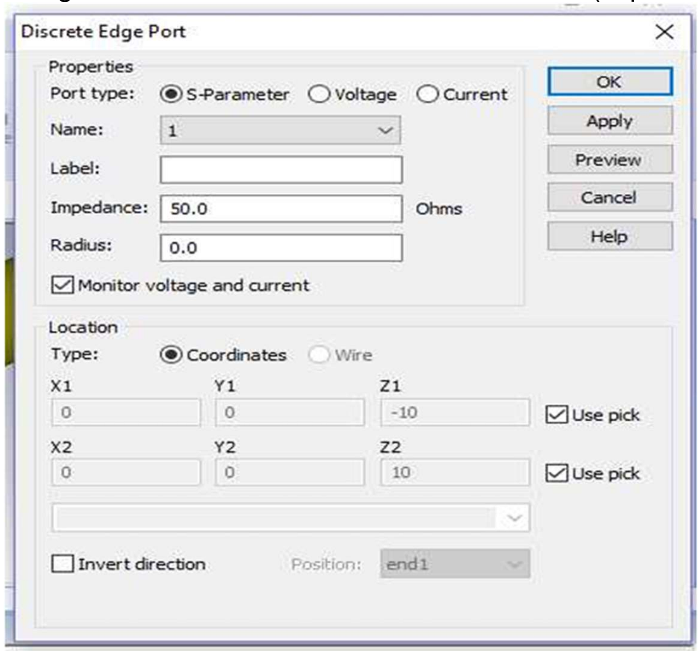


Wave port Excitation:

- **Select the designed dipole** from Components.
- **Rotate and Zoom** the central faces of the dipole from View.
- Click on **Modeling** and select **Pick Circle Center** from **Pick Point** as shown in Figure.

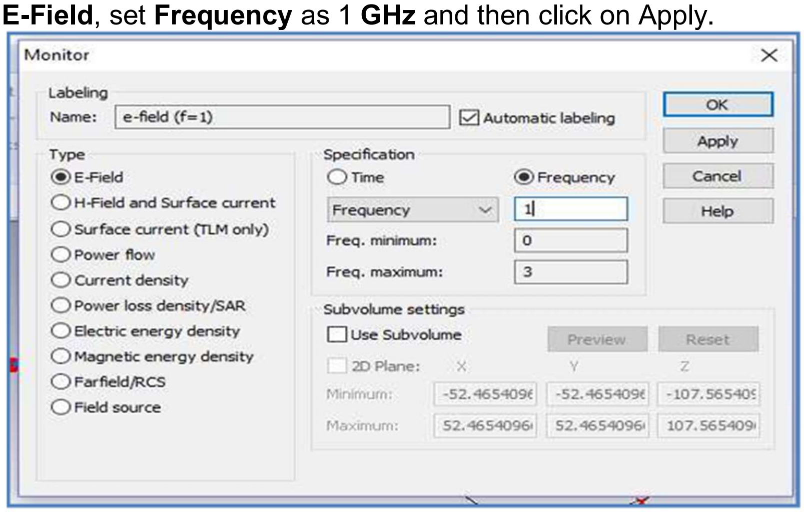


- **Double click** on one of the central points of the face to select the point **P1**.
- **Rotate** the dipole to view its other central side and **Repeat** the previous step for the selection of another point **P2**.
- Go to **Simulation** and select **Discrete Port**.
- Following Dialogue Box will be shown and write the values (impedance = 50 ohm):



Results/Analysis:

- **Go** to **Simulation** and select **Field Monitor**.
- Following Dialogue Box will be shown.
- Select **E-Field**, set **Frequency** as 1 **GHz** and then click on Apply.



- Select **E-Field** and **Surface Current**, set **Frequency** as 1 GHz and then click on **Apply**.
- Select **Surface Current** (TLM only), set **Frequency** as 1 GHz and then click on **Apply**.
- Finally, click on **Ok**.
- Go to **Home** and Click on **Start Simulation**.
- You can check the results of antenna after the Simulation is complete.

Analysis of S-Parameters (Return Losses):

- Click on 1D Results, **S-Parameters** and then **S11** from Project manager.
- Right click anywhere on the shown graph, select **Add Curve Marker** and double-click on lowest value of curve to show the exact value of **S11** of that point.

Analysis of Gain:

- Click on **Far Fields** and then **Far Field (3D-1)** from Project manager.
- From **Menu Bar**, select **Far Field Plot** and change Directivity to **Gain (IEEE)**.

Analysis of Radiation Pattern

- Click on **Far Fields** and then **Far Field (3D-1)** from Project manager.
- From **Menu Bar**, select **Far Field Plot** and click on **Polar**.
- Set the value of **Cut angle** = 0°.
  Graph represents the radiation pattern for **E-Field**.
- Set the value of **Cut angle** = 90°.
  Graph represents the radiation pattern for **H-Field**.

Analysis of Surface Current

- Click on 2D/3D Results and then **Surface Current (3D-1)** [1] from Project manager.
- 2D/3D Plot will be shown on **Menu bar**, click on **Animate Fields**.
- Click on **Properties** to change Scaling or any other parameter.

Task 1: Analysis of Antenna Parameters

You are provided with the simulation data of a dipole antenna operating at 1 GHz. Based on this data, perform the following tasks:

a. Plot the graph for **S-parameters** (S11), and explain the significance of return losses in the design of the antenna. Identify the lowest point in the S11 curve and describe its importance.

b. Plot the **Gain** pattern using the Far Field plot, and analyze the antenna's directional gain. Compare the IEEE Gain values and discuss their implications on antenna performance.

c. Plot and discuss the **Radiation Pattern** for both the E-field and H-field. How do the radiation patterns change with respect to different cut angles (e.g., 0° and 90°)?

d. Evaluate the **Surface Current Distribution**. Explain how the distribution changes across the surface of the antenna, and discuss how these currents influence the overall radiation behavior of the dipole antenna.

Task 2: Antenna Design Based on Group Frequency

- Remodel the working of the dipole antenna based on the frequency assigned to your lab group number. The frequency for each group is determined by your group number:
- For example:
  - Group **A1**: Frequency = 1 GHz
  - Group **A5**: Frequency = 5 GHz
  - Group **A10**: Frequency = 10 GHz
  - And so on…

Follow the same steps in CST for each frequency as described in **Task 1** (plotting S-parameters, Gain, Radiation Patterns, and Surface Current distribution).
At the end, compare the antenna's behavior at different frequencies and explain how frequency impacts antenna performance in terms of return losses, gain, radiation pattern, and surface current.

- Does the dipole radiate equally in all directions?
- Provide your calculations in the report as well:

Frequency	Length	Radius	Gap

Frequency (f) = X GHz
Wavelength = c / f = XXX mm
Length (L) = (λ/2) = XXX mm
Radius = Wavelength / 1000 = X.XX mm
Gap = Length / 200 = X.XX mm

END OF EXPERIMENT