Experiment 7 : Dipole Antenna Design Using HFSS

Aim

To design and simulate a dipole antenna using ANSYS HFSS and to study its S-parameter characteristics, radiation pattern, gain, and electric field distribution at an operating frequency of 5 GHz

Software Required

ANSYS Electronics Desktop (HFSS)

Theory

A dipole antenna is one of the simplest and most widely used antennas in wireless communication systems. It consists of two equal-length conductive arms placed collinearly and fed at the center by a balanced source. The most common form is the half-wave dipole, whose total length is approximately $\lambda/2$, where λ is the wavelength of operation.

When an alternating current is applied at the feed point, currents flow in opposite directions in the two arms of the dipole. These time-varying currents produce electromagnetic radiation. The maximum current occurs at the center of the dipole and gradually decreases to zero at the ends, while the voltage is minimum at the center and maximum at the ends.

The dipole antenna radiates maximum power in the plane perpendicular to its axis and minimum power along the axis of the antenna. Hence, its radiation pattern is bidirectional and resembles a figure-of-eight in the E-plane. The radiation is linearly polarized, and the polarization depends on the orientation of the dipole.

Procedure

1. **Open HFSS**
   - Open ANSYS HFSS
   - New Project → **Insert HFSS Design**

2. **Draw Dipole (Copper Cylinder)**
   - Draw → **Cylinder**
   - Material: **Copper**
   - Axis: **Z**
   - Radius: **1**
   - Height: **12**
   - Position: **(0, 0, 0.5)**
   - No. of segments: **0**
   - Fit All (Ctrl + D)

3. **Duplicate for Second Arm**
   - Duplicate the cylinder
   - Rotate about X-axis = 180°
   - Ok

4. **Dipole Formation**
   - Select both cylinders
   - Ensure **double arm dipole**
   - **Unite**
   - Change **color**
   - Set **Transparency = 0.6**

5. **Feed Creation**
   - Select **YZ Plane**
   - Draw → **Rectangle**
   - Zoom in and rotate
   - Rectangle name: **Rectangle1 (Feed)** **Rectangle Properties:**
     - Position: **(0, -1, -0.5)**
     - Axis: **X**
     - Y-size: **2**
     - Z-size: **1**

   (feed be placed at the center of the dipole)

6. **Assign Excitation**
   - Select **Rectangle1**
   - **Excitations** → **Assign** → **Lumped Port**
   - Click **New Line**
   - Assign reference conductor
   - OK

   (Dipole feed gap is very small and not a transmission line-hence lumped port is used)

7. **Radiation Box**
   - Select **XY Plane**
   - Create → **Box**
   - **Dimensions**
     - X = 4
     - Y = 4
     - Z = 40
   - **Position**: (-20, -20, -20)
   - Set **Transparency = 0.8**
   - Assign **Radiation Boundary**

8. **Analysis Setup**
   - Analysis → **Add Solution Setup**
   - **Frequency = 5 GHz**

9. **Frequency Sweep**
   - Sweep Type: **Fast**
   - Start: **5 GHz**
   - Stop: **10 GHz**
   - Points: **451**

10. **Far Field Setup**
    - Results → **Create Far Fields Report**
    - Select **Radiation**
    - Insert **Far Field Setup**
    - Magnitude & Phase
    - Angular Values:
      - Phi (ϕ) : $-180°$ to $+180°$, Step = $2°$
      - Theta (θ) : $-180°$ to $+180°$, Step = $2°$

11. **Visibility OFF**
    - Turn axis / grid **visibility OFF**
    - Used for clear plots

12. **Field Overlay**
    - Results → **Field Overlay**
    - Plot Fields → **E**
    - Shows electric field distribution

13. **Validation & Analysis**
    - HFSS → **Validate Design**
    - Click **Analyze All**

14. **S-Parameter Plot**
    - Results → **Create Modal Solution Data Report**
    - Rectangular Plot
    - **S(1,1) in dB**
    - Add marker if required

15. **3D Far Field Plot**
    - Results → **Create Far Field Report**
    - **3D Polar Plot**
    - Quantity: **Gain (Total)**
    - Units: **dB**

16. **Radiation Pattern**
    - Results → **Create Far Field** Report
    - **Radiation Pattern**
    - Gain (Total) in dB

17. **E-Field Animation**
    - Results → **Animate Fields**
    - Select **Mag_E**
    - Observe radiation behavior

Result

A dipole antenna was designed and simulated in HFSS at 5 GHz. The S_{11} plot shows good impedance matching, and the radiation pattern obtained is bidirectional, confirming proper dipole antenna operation.