Experiment – 5: Microstrip Transmission Line

1. **Aim:** To design and analyze a 50-Ω transmission line at 5 GHz using a FR4 substrate with the help of simulation software.
2. **Requirement:** ANSYS R2022 software.
3. **Theory:**

Transmission Line

- In general, a transmission line is a medium or structure that forms a path to direct energy from one place to another.
- Transmission lines are specialized cables and waveguides designed to carry alternating current (AC) and electromagnetic waves of radio frequency → the currents with frequency high enough that its wave nature has to be taken onto account.
- RF transmission lines "enclose" electromagnetic waves, preventing them from being radiated off the line, which would cause power loss.
- The transmission lines are characterized using the Scattering parameters or S-parameters which describe the behavior of linear microwave networks.
- S-parameters are widely used in RF/microwave measurements as they formulate the transformation properties in terms of incident and reflected waves and use matched loads. S-parameters can be directly measured with network analyzers.

4. **Procedure:**

i. **Design theoretically the microstrip line using the given specifications and compute L and W.**
ii. **Getting started using simulation:**

• Microsoft **Start > Programs > Ansys**

• After program initialization, click on the blue icon for (**Insert HFSS Design**)

• Select the menu item **HFSS>Solution Type**, choose **Driven Terminal** click **OK**

• Select the menu item **3D Modeler>Units**, choose **mm** and click **OK**

• Select the menu item **3D Modeler>Grid Plane > XZ**

iii. **Draw the Structure:**

- Select the menu item **Draw > Rectangle (ground)** with the dimensions of 20 x 40 in mm and name the rectangle as a **ground.**
- Select the menu item **Draw > Box (substrate)** with the dimensions of 20 x 40 x 1.6 in mm above ground and name the box as **substrate** also select the material as **"FR4_epoxy".**

- Select the menu item **Draw > Rectangle (line)** with the dimensions of 3 x 40 in mm above and at the center of the substrate and name the rectangle as a **microstrip.**
- Select **ground plane**, right click on it and choose **Assign Boundaries > Perfect E** then click **OK.**
- Select **microstrip line**, right click on it and choose **Assign Boundaries > Perfect E** then click **OK.**
- **Assign Excitations** to port 1 and port 2 on either sides of the line
- To draw Radiation Box, select the menu item **Draw > Box** with dimensions such that microstrip patch is equidistance from all the sides of the Radiation Box.

iv. Analysis:

• **HFSS > Analysis Setup > Add Solution Setup**
In the **General** view:
Frequency = 5 GHz
Maximum number of passes = 10
Maximum Delta S = 0.02
Click **OK**

• **HFSS > Analysis Setup > Add Sweep Discrete** type of sweep from 2 GHz to 10 GHz with the step of 0.1GHz

• Check the validity by **HFSS>Validation Check** and if there is no error go ahead and run the simulation **HFSS > Analyze All**. Wait a few minutes for the simulation to be done.

v. View Results:

- **Result > create modal solution data report > rectangular plot**
- In **Category** select **S-parameters** and in **Function** select **dB,** now select all the four S-parameters and click on **New Report.**
- **Similarly get the Z-plot under results**

5. Observations:

Sr. No	Parameter	Values	Interpretation
1	S11		
2	S22		
3	S12		
4	S21		
5	Z		

Conclusion:

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Post Experiment Exercise:

1. Differentiate between a microstrip and a stripline
2. Draw and explain the equivalent circuit diagram of a two-conductor transmission line
3. With respect to the transmission line define and explain the following parameters
   a. VSWR
   b. Reflection Coefficient
   c. Characteristic Impedance
   d. Propagation Constant
4. What does the characteristic impedance of the transmission line depend upon? In the experiment why did we prefer designing a 50-ohm transmission line?
5. List and prove the properties of S-parameters.