Design of Inset-fed Microstrip Antenna

Theory:

There are several techniques available to feed or transmit electromagnetic energy to a microstrip antenna.

Coaxial feed technique is one of the basic techniques used in feeding microwave power. The coaxial cable is connected to the antenna such that its outer conductor is attached to the ground plane while the inner conductor is soldered to the metal patch as shown in Fig. 1. You have already used and studied this technique of feeding in 1st lab [title: Design and Simulation of Patch Antenna].

Coaxial feeding is simple to design, easy to fabricate, easy to match and have low spurious radiation. However coaxial feeding has the disadvantages of requiring high soldering precision. There is difficulty in using coaxial feeding with an array since a large number of solder joints will be needed.

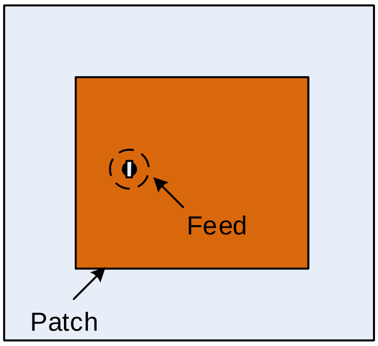


Fig. 1 Coaxial feed

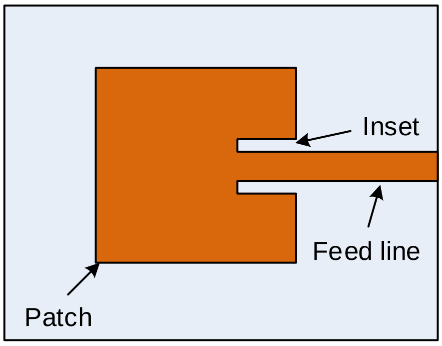


Fig. 2. Inset feed

In inset feed technique, the feeding point is placed inside the patch by selecting appropriate impedance matching location. The location of the feed is the same that will be used for coaxial feed. The 50 Ω feed line is surrounded with an air gap till the feeding point as shown in Fig. 2. The inset microstrip feeding technique is more suitable for arrays feeding networks.

Objective:

To design an inset-fed microstrip antenna at 2.4 GHz and study the performance using ADS

Step-1: Calculating Antenna Dimension

1. Select an appropriate substrate of thickness (h) and dielectric constant (ε_r) for the design of the transmission line. In present case, we shall use following Dielectric for design:
    a. Height: 1.6 mm
    b. Metal Thickness: 0.7 mil (Copper)
    c. ε_r: 4.6
    d. TanD: 0.001
    e. Conductivity: 5.8E7 S/m

2. Calculate the physical parameters of the patch antenna as shown in the geometry in Fig. 3 using the given formula.

   The width and length of the radiating surface is given by,

$$W = L = \frac{c}{2f\sqrt{\varepsilon_r}} = 29.2 \text{ mm}$$

   where,

   Velocity of light, $c = 3\times10^8$ m/s^2

   Frequency, $f = 2.4$ GHz

   Relative Permittivity, $\varepsilon_r = 4.6$

   The depth of the feed line in to the patch is given by,

$$H = 0.822\times\frac{L}{2} = 12 \text{ mm}$$

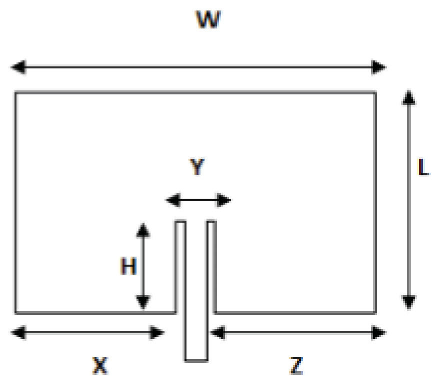


Fig. 3

   The other dimensions are,

$$Y = W/5 = 5.8 \text{ mm}$$

$$X = Z = 2W/5 = 11.7 \text{ mm}$$

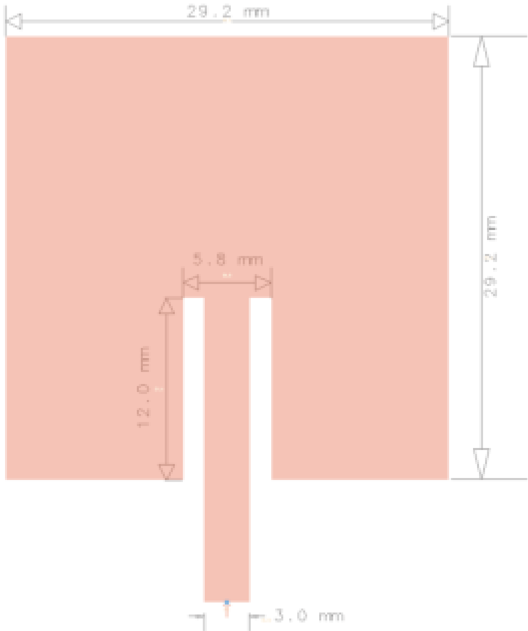
   Width of the feed line for a certain impedance can be determined by using **LineCalc** from **Schematic** as discussed in Lab-2 [title: Design and Simulation of Microstrip Transmission Line].

Step-2: Creating Inset-fed Antenna Geometry

1. Create a new workspace, name it as **Lab3_InsetFed_wrk**

2. From the main window, select **Window → New Layout**. Open the new layout cell and name it as **InsetFed**. Click **Ok** ….

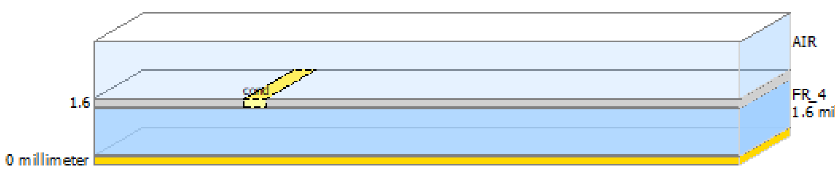
3. Use **Insert → Polygon** and use **Insert → Coordinate Entry** command to enter (X, Y) coordinates to enter required points to construct Patch Antenna geometry as per calculations in Step-1. Use **Insert → Undo Vertex** option to correct any wrong entry.



Step-3: Simulation

1. Select **Insert → Pin** and connect a pin at the center of the lower horizontal edge of the feed line.

2. Go to the **EM** setup window and click on **Substrate** and click on **New** to accept the 25 mil Alumina template. Select material by clicking on the substrate structure [left side] to change the parameters shown on the right side. If desired material name is not available in **Material** drop down list, to add new material, click on **Edit Materials** tab [right of the **Material** option] and select it from **Add from Database** list.

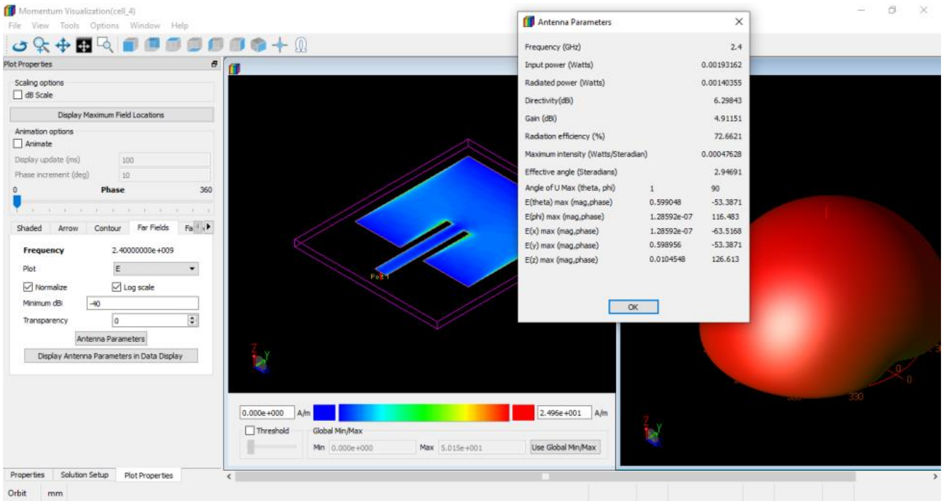


Define the substrate as below, modify the default substrate height, ε_r, TanD, and conductor height and define it as Copper. Changing name of the dielectric is optional as it has no bearing on the simulation.

3. Go to the **EM** and click on **Simulation Setup**. Set the simulation frequency range as 2 GHz – 3 GHz (adaptive sweep) from **Frequency plan**. Add another frequency as **Single** along with Adaptive and set **Fstart** = 2.4 GHz. Go to **Options → Mesh**. Assign **Cells/Wavelength** value 80 and put a tick mark in **Edge mes**h option. Click on **Simulate** and wait to observe the simulation results in data display.

Step-4: Antenna Radiation Pattern

1. For Far-Field Antenna Pattern, go to **EM → Post Processing → Far Field**. Select **Solution Setup** (from the bottom tabs) and click on the desired frequency from **Frequency**. Far field computation will be done and results will be displayed in the post processing window as shown below. We can use **Window → Tile** and then go to **Plot Properties** (from the bottom tabs) and then select **Far Field → Antenna Parameters** to see all the required data.



2. To show the 2-D radiation pattern of the antenna, go to **Plot Properties → Far Field Cut** and click on the **Enable** option. Select **Phi** and click on **Display Cut in Data Display** button. Once done, we will be able to see far field cut in the regular data display.

Task:

1. Design and investigate the performance of an inset-fed microstrip antenna. Frequency of the antenna = $\sqrt{X}$; where X is the last three digit of your student ID.