Design and Simulation of Microstrip Transmission Line

Theory:

Microstrip consists of a strip conductor on the top surface of a dielectric layer and a ground plane on the bottom surface of the dielectric. A simple schematic layout of the microstrip line is illustrated in Fig. 1. The electromagnetic wave travels partly in the dielectric and partly in the air above the conductor resulting in quasi-TEM transmission. Despite the drawbacks of the quasi-TEM mode, microstrip is often favored for its easy compatibility with printed circuits. In any case, these effects are not so severe in a miniaturized circuit.

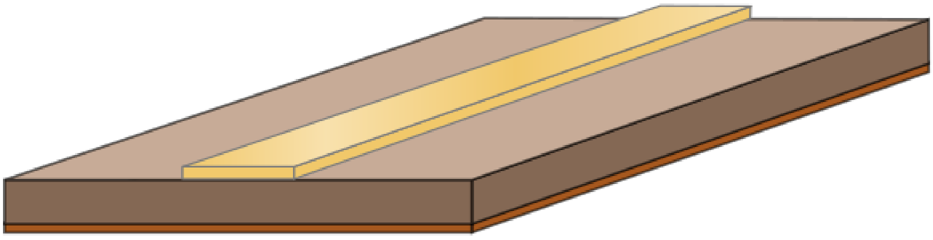


Fig. 1 Schematic Layout of a microstrip line

Another drawback of microstrip is that it is more limited than other types in the range of characteristic impedances that it can achieve. Some circuit designs require characteristic impedances of 150 Ω or more. Microstrip is not usually capable of going that high so either those circuits are not available to the designer or a transition to another type has to be provided for the component requiring the high impedance.

The tendency of microstrip to radiate is generally a disadvantage of the type, but when it comes to creating antennae it is a positive advantage. It is very easy to make a patch antenna in microstrip, and a variant of the patch, the planar inverted-F antenna, is the most widely used antenna in mobile devices.

For a given characteristic impedance Z_0 and dielectric thickness d, the width of the strip (W) can be found as

$$\frac{W}{d} = \begin{cases} \frac{8e^{A}}{e^{2A}-2} & for\ \frac{W}{d} < 2 \\ \frac{2}{\pi}\left[B - 1 - \ln(2B-1) + \frac{\varepsilon_r - 1}{2\varepsilon_r}\left\{\ln(B-1) + 0.39 - \frac{0.61}{\varepsilon_r}\right\}\right] & for\ \frac{W}{d} > 2 \end{cases}$$

Where $A = \frac{Z_0}{60}\sqrt{\frac{\varepsilon_r + 1}{2}} + \frac{\varepsilon_r - 1}{\varepsilon_r + 1}\left(0.23 + \frac{0.11}{\varepsilon_r}\right)$

$B = \frac{377\pi}{2Z_0\sqrt{\varepsilon_r}}$

Ref.:

1. https://en.wikipedia.org/wiki/Planar_transmission_line [accessed: 20 March 2020]

2. Microwave engineering – D. M. Pozar

Objective:

To design a microstrip transmission line at 2.4 GHz and investigate the performance using ADS

Step-1: Calculating Transmission Line Width

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 transmission line using built-in line calculator (LineCalc) of ADS. To run **LineCalc** as shown in Fig. 2:

   From the **Schematic** window, choose **Tools** → **LineCalc** → **Start LineCalc**.

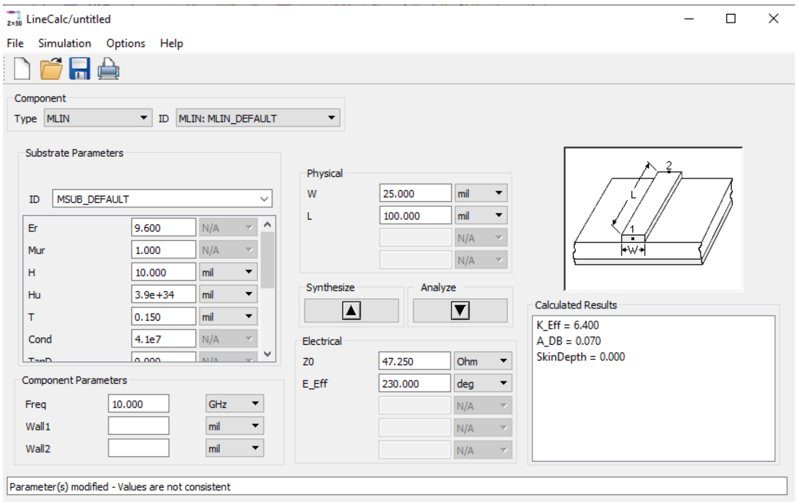


Fig. 2

3. Change the value of **Er, H, T, Cond, TanD** under the **Substrate Parameters** as per Dielectric properties and **Freq** under **Component Parameters**.

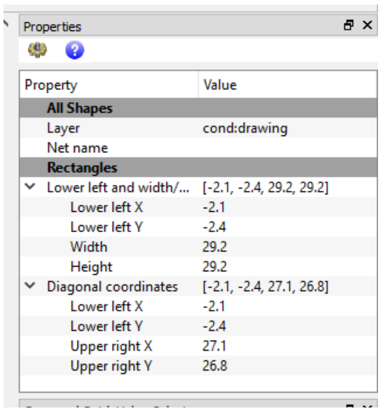
4. You can compute the **Physical** parameter values from **Electrical** data by clicking **Synthesize**. Clicking **Analyze** computes the **Electrical** component parameters from **Physical** data. Change the value of **Z0** as 50 Ω from **Electrical** and click **Synthesize** to determine the width (*W*) of the microstrip transmission line.

Step-2: Creating Microstrip Transmission Line Geometry

1. Create a new workspace, name it as **Lab2_MTLine_wrk**

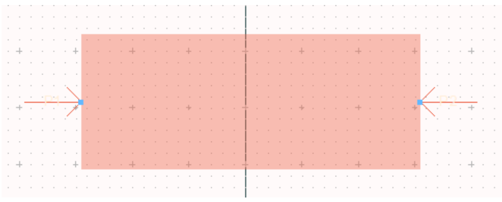
2. From the main window, select **Window** → **New Layout**. Open the new layout cell and name it as **MTLine**. Click **Ok** ….

3. Use **Insert** → **Rectangle** and draw a rectangle randomly. Click on the rectangle to select it and change the **Width** (W) from the **Properties** window as per calculation of Step-1. Choose a random **Height** value and put it in the **Properties** window.



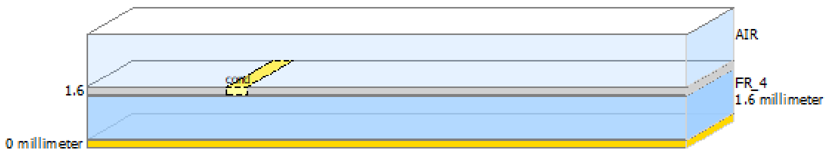
Step-3: Simulation

1. Select **Insert** → **Pin** and connect two pins (as shown in the below figure) at the center of the two edges as like as below figure.



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.

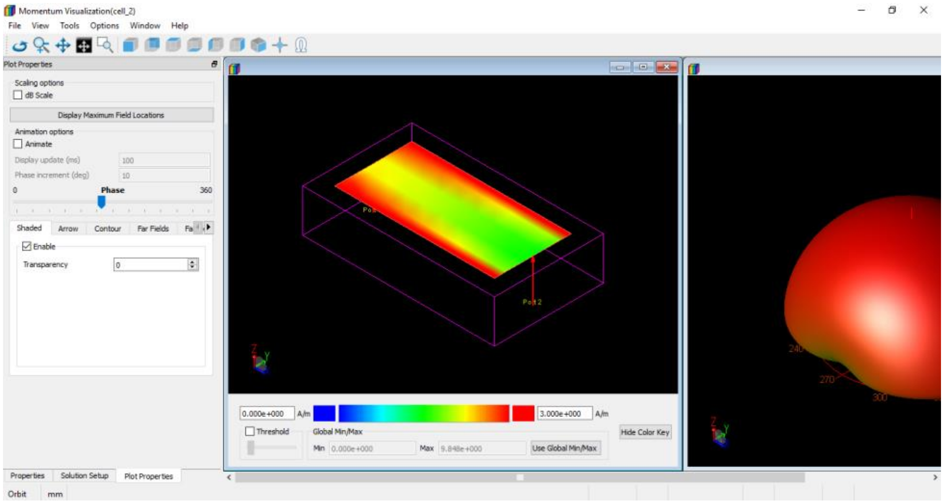
   Define the substrate as below, modify the default substrate height, ε_r, TanD, and conductor height and define it as Copper. Changing name of the dielectric is optional as it has no bearing on the simulation.



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: Surface Current Distribution

1. To check the surface current distribution, 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. We can use **Window** → **Tile** and then go to **Plot Properties** (from the bottom tabs) and then select **Shaded** tab. Click **Enable** and active **Animate** from Animation options. Current distribution with respect to phase will be displayed in the post processing window as shown below.



Task:

1. Change the **Width** of the strip line for some lower and higher values from the **Properties** window [keep the **Height** fixed]. What change do you observe in the magnitude and phase of S_{21}?

2. Change the **Height** of the strip line for some lower and higher values from the **Properties** window [keep the **Width** fixed]. What do you understand from this study?

3. Investigate the effect of pin impedances on the performances.

4. Use your designed microstrip transmission line to feed the designed antenna for Lab-1.

   i) What result do you get?

   ii) Explain the reason for finding such kind of results?

   iii) If the result is not satisfactory in 3(i), how can you solve it?