ECE 546 HOMEWORK No 7 Due Wednesday, April 3, 2024

Q1. Design a differential via pair and investigate the signal transmissions and reflections with HFSS. The differential pair is shown in Figure1.

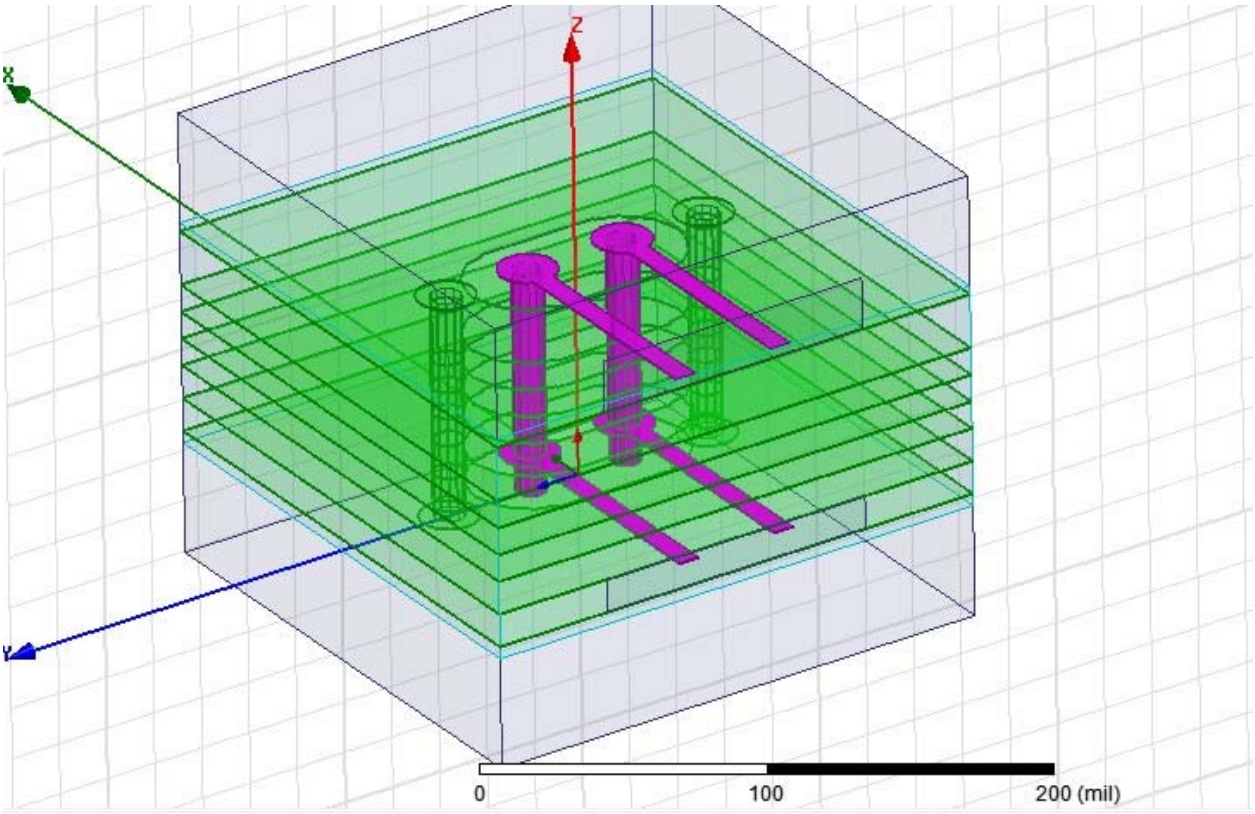

Figure 1. Geometry of a differential via pair

The design parameters

All components in the design should have the unit in **mil**

1. **Dielectric Layer:**
    a. Material: **FR4_epoxy**
    b. Dimension: (**diex, diey, diez**)
    c. **diex** = 200 mil
    d. **diey** = 200 mil
    e. **diez** = 87.3 mil
2. **Signal Via**:
    a. Material: **Copper**
    b. Radius: **rad_via** =5.9 mil
    c. Height: **h_via** = 87.3 mil
3. **Ground Via**:
    a. Material: **Copper**
    b. Radius: **rad_gvia** =5.9 mil
    c. Height: **h_gvia**=87.3 mil
4. **Ground Plane:**
    a. Material: **Copper**
    b. Width**: planex**=200 mil
    c. Length**: planey**=200 mil
    d. Thickness**: planez**=0.65 mil
5. **Antipad:**
    a. Material: **FR4_epoxy**
    b. Radius: **rad_apad**=24 mil
    c. Height: **h_apad**=87.3 mil
    d. Thickness**: planez**=0.65 mil
6. **Via pad (Signal Via):**
    a. Material: **Copper**
    b. **rad_pad_via** = 11 mil
7. **Via pad (Ground Via):**
    a. Material: **Copper**
    b. **rad_pad_gvia** = 11 mil
8. **Signal Trace:**
    a. Material: **Copper**
    b. Width: **w_line** = 8 mil
    c. Length**: l_line** = 100 mil
    d. Thickness: **t_line** = 0.65 mil

Signal and Ground Vias:

1. You should have two signal and two ground vias in your design as shown in Figure 2.
2. The separation of the two signal vias measured between the centers is **via_sep1** = 40 mil.
3. Each signal via comes in pair with a ground via. The distance measured between the centers of the signal via and the corresponding ground via is **via_sep2** = 34.5 mil.

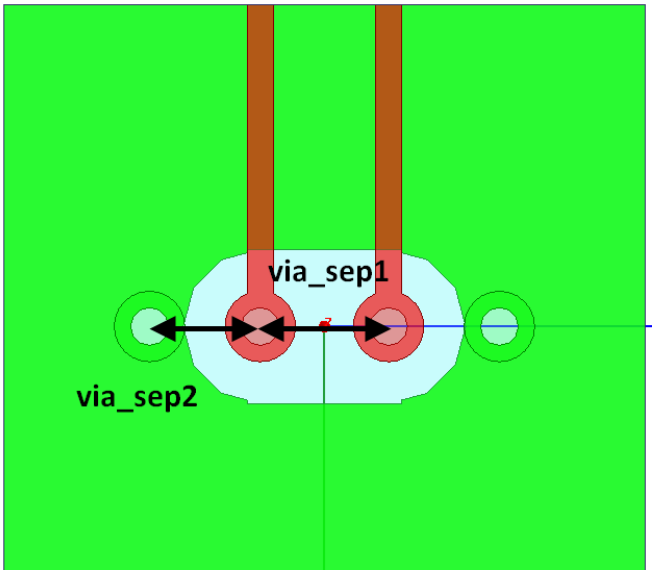

Figure 2. The separations of vias

4. The anti-pad should be designed for both signal vias as shown in Figure 3

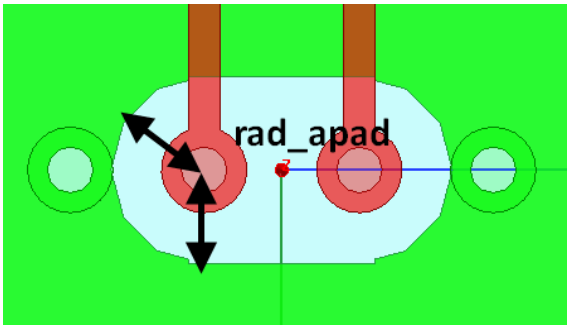

Figure 3. Design of anti-pad

Signal Traces

1. You should have four signal traces in this design as shown in Figure 1.
2. One signal trace should be placed on top of the dielectric layer, exposing to the air, while the other signal trace should be fully immersed in the dielectric layer.
3. The two pairs of traces are shown in Figure 4. The distance measured from the bottom surface of trace 1 to the top surface of trace 2 is **dis_trace** = 72.3 mil.
4. The two traces of the same pair should have a separation of **via_sep1** = 40 mil (measured between the central lines), identical to that of the signal via pairs.

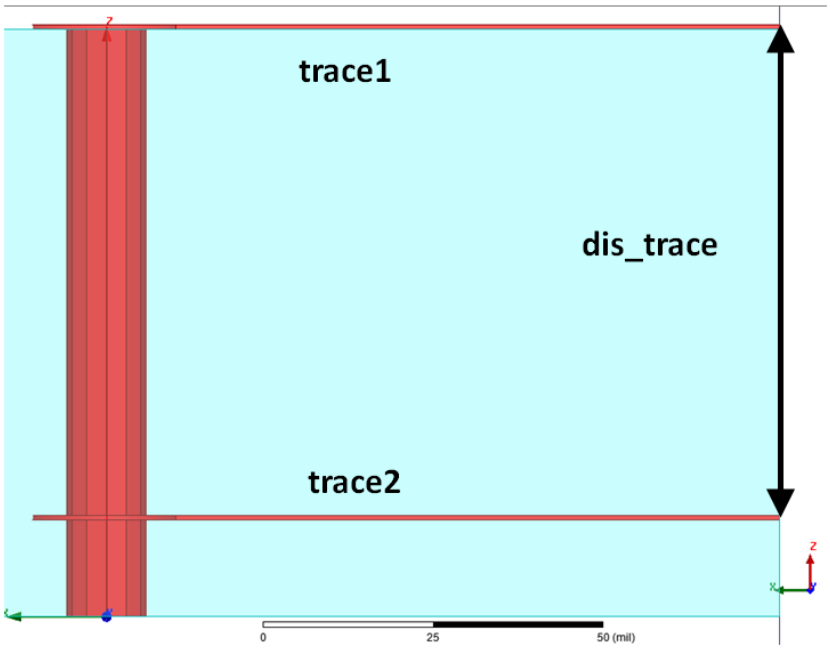

Figure 4 One trace immersed in air and the other one immersed in the dielectric layer.

Ground Planes

1. You should have 7 ground planes and all of the ground planes are of the same dimensions.
2. The locations of the ground planes are illustrated in Figure 5. We use **hx** to denote the separation of two planes/traces and **hx is measured from the lower surface of one plane/trace to the upper surface of another plane/trace, e.g. h1 is measured from the lower surface of trace1 to the upper surface of gnd1**

    a. **h1** = 3.05 mil
    b. **h2** = 20.65 mil
    c. **h3** = 10 mil
    d. **h4** = 10 mil
    e. **h5** = 10 mil
    f. **h6** = 12.35 mil
    g. **h7** = 2.35 mil, h7 is measured from the lower surface of gnd6 to the upper surface of trace 2
    h. **h8** = 9.35 mil, h8 is measured from the lower surface of trace2 to the upper surface of gnd7

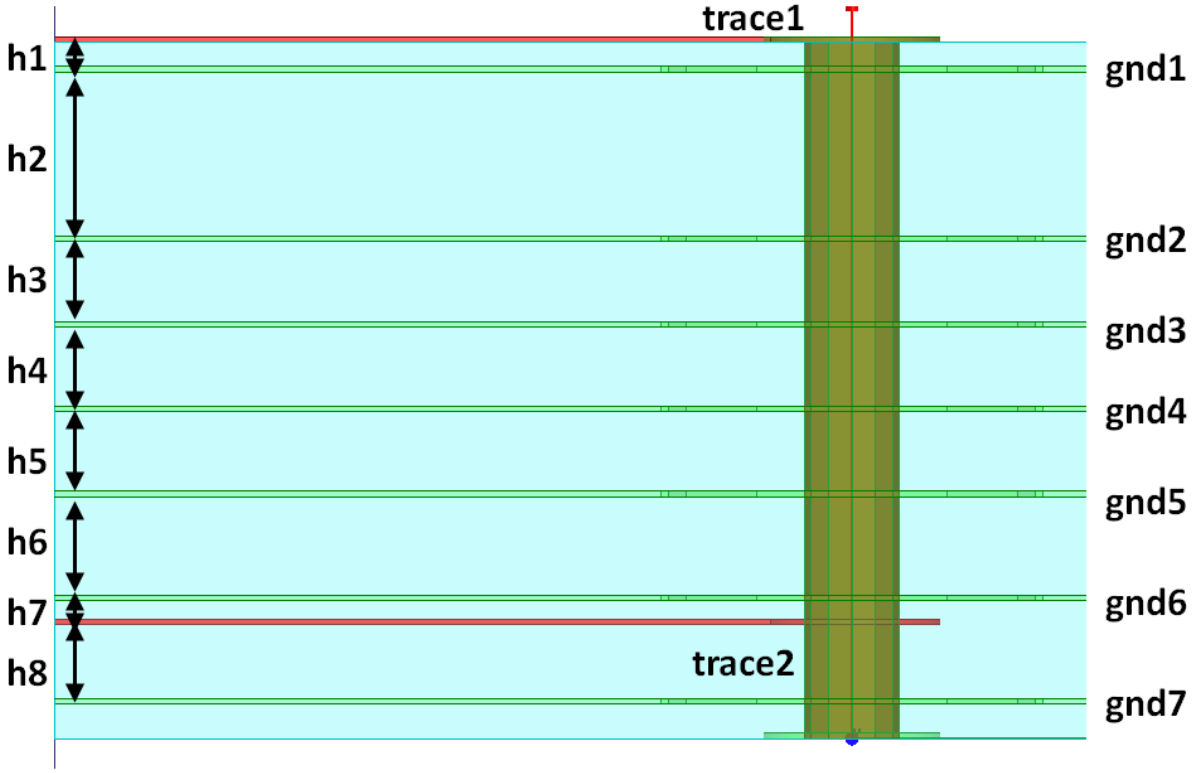

Figure 5. Locations of ground planes

Simulation Setup

1. Solution type: **Driven Terminal**
2. Port type: **Wave Port**
3. You should have one **microstrip line port** and one **stripline port**; each is defined with three pieces of conductors: two signal traces and their common ground plane as shown in Figure 6.
4. The frequency band of interest is **from 0.1 to 40 GHz**.
5. You may use **interpolating** as the type of the frequency sweep.

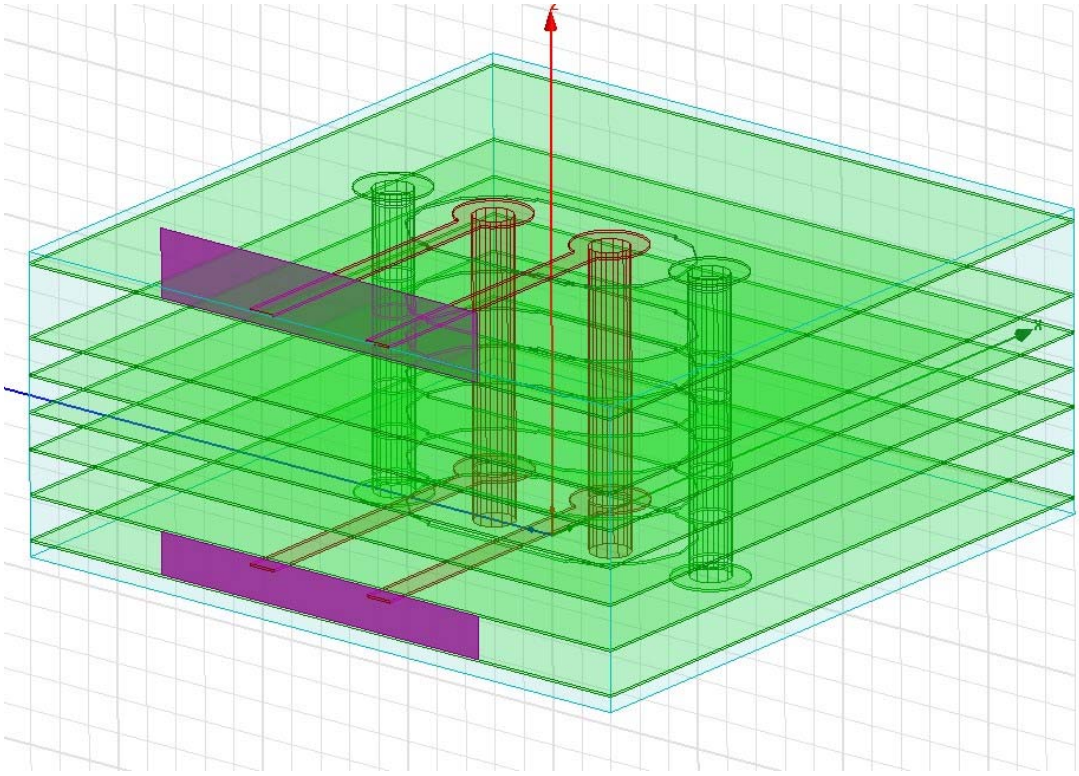

Figure 6 One microstrip line port and one stripline port

Design Parameter Analysis

1. Hand in the plot of S-parameters vs. frequency for the required frequency band.
2. Explore the influence of the separation of the signal traces on the signal transmission and reflections in terms of S-parameters.
3. Explore the influence of the ground via on the signal transmission and reflections in terms of S-parameters; you may consider the location and the dimension of the ground vias.
4. Use PEC instead of copper to re-simulate your design. What happens to the signal transmissions if the signal traces are perfect conductors?