**ECE 546 HOMEWORK No 7 Due Friday, April 3, 2026**

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

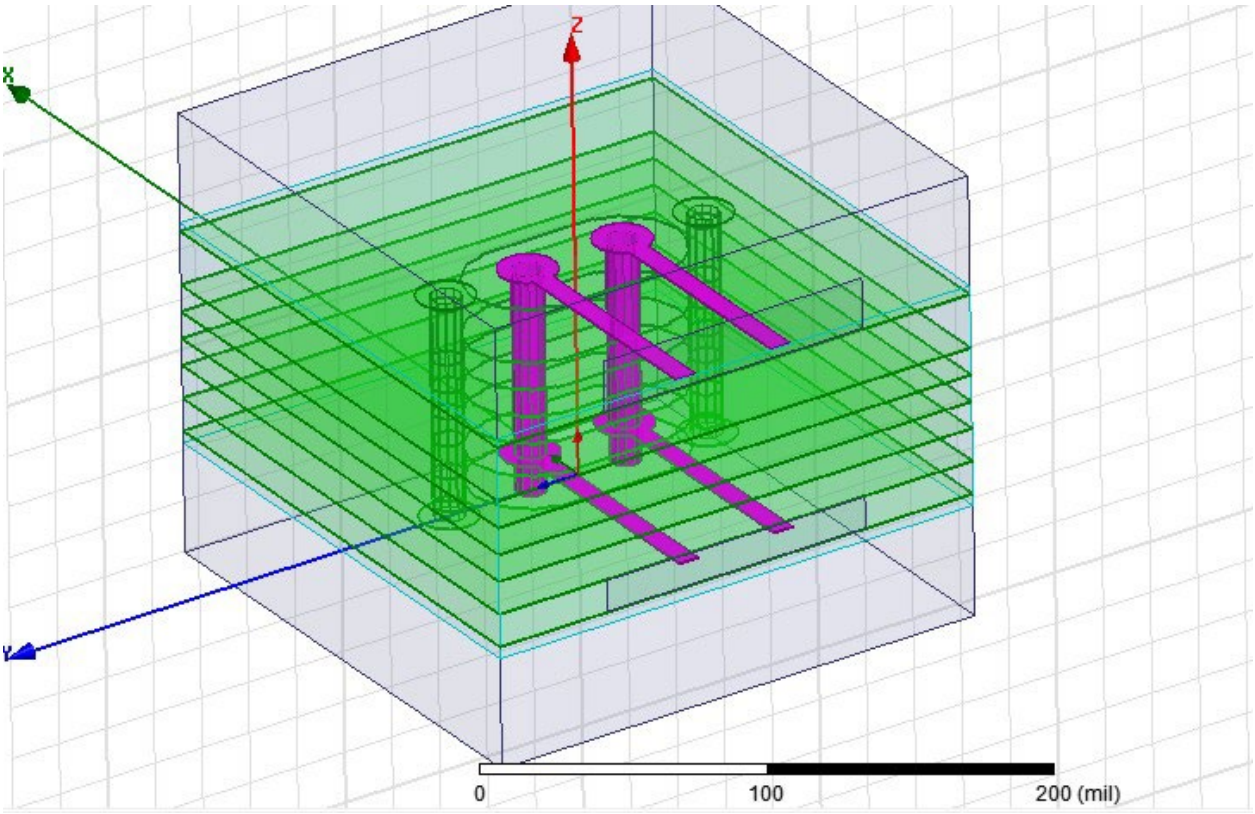



Figure 1. Geometry of a differential via pair

# 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.

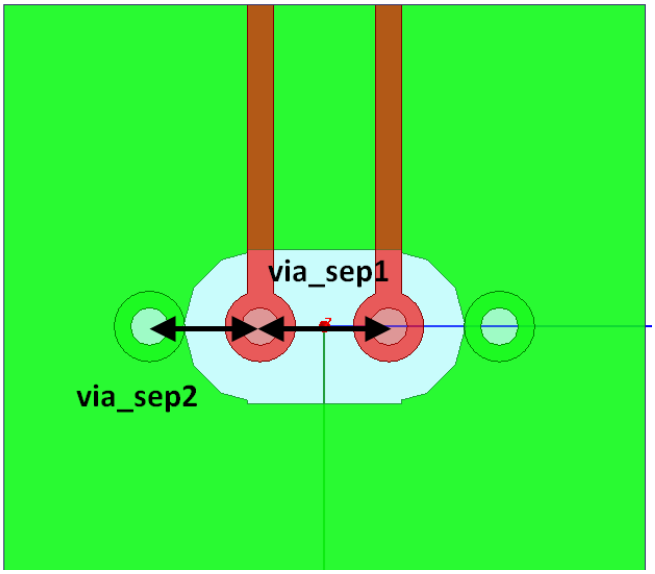



Figure 2. The separations of vias

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

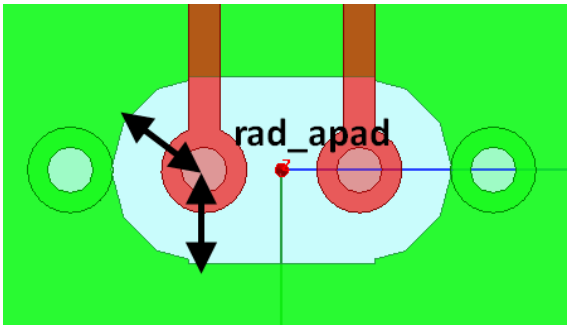



Figure 3. Design of anti-pad

# 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.

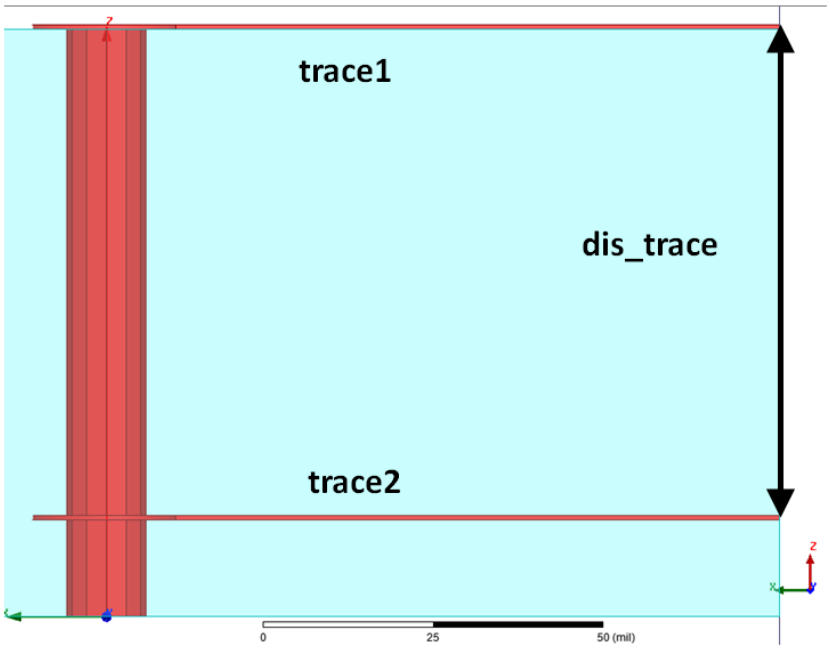



Figure 4 One trace immersed in air and the other one immersed in the dielectric layer.

# 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

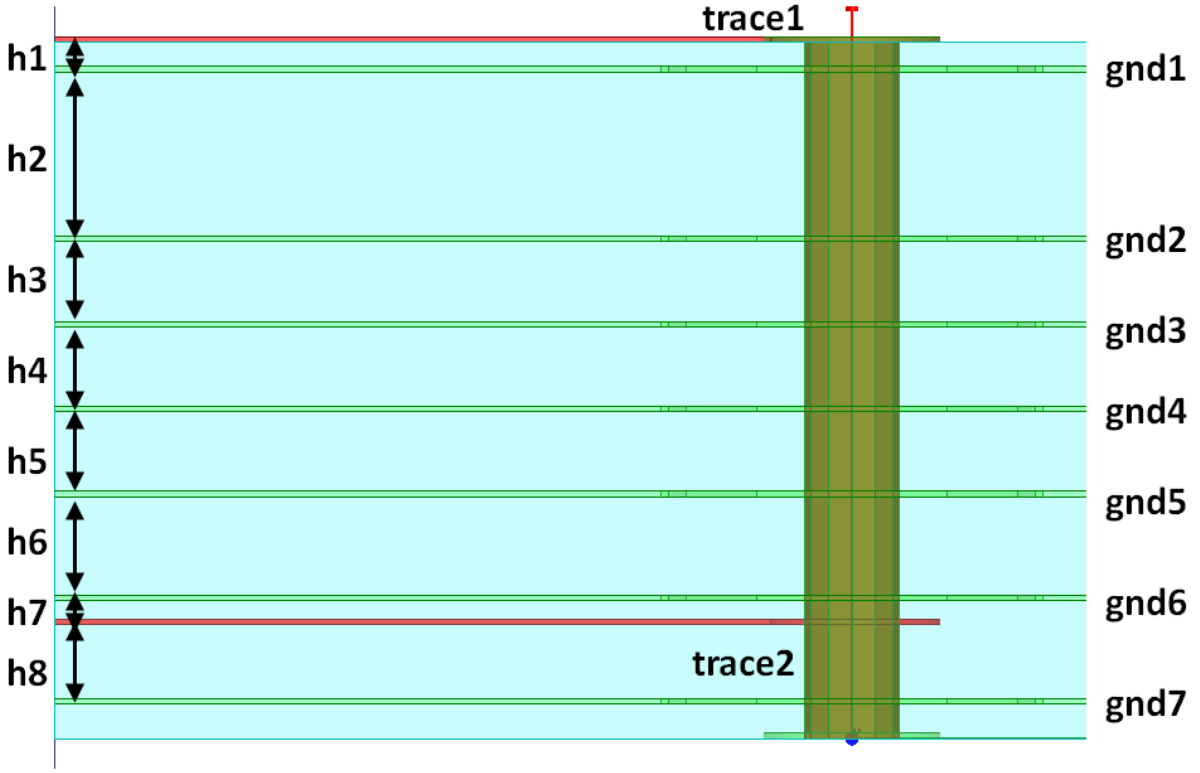



Figure 5. Locations of ground planes

# 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.

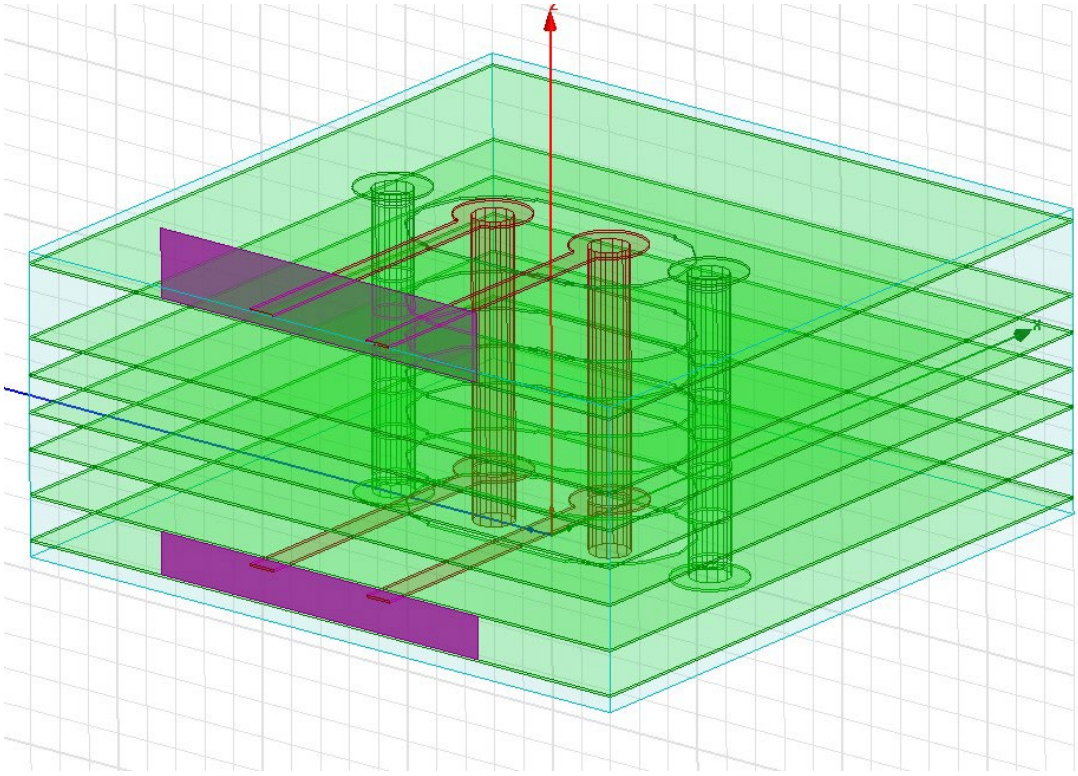


Figure 6 One microstrip line port and one stripline port

# 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?

## HW 7 Additional Instructions

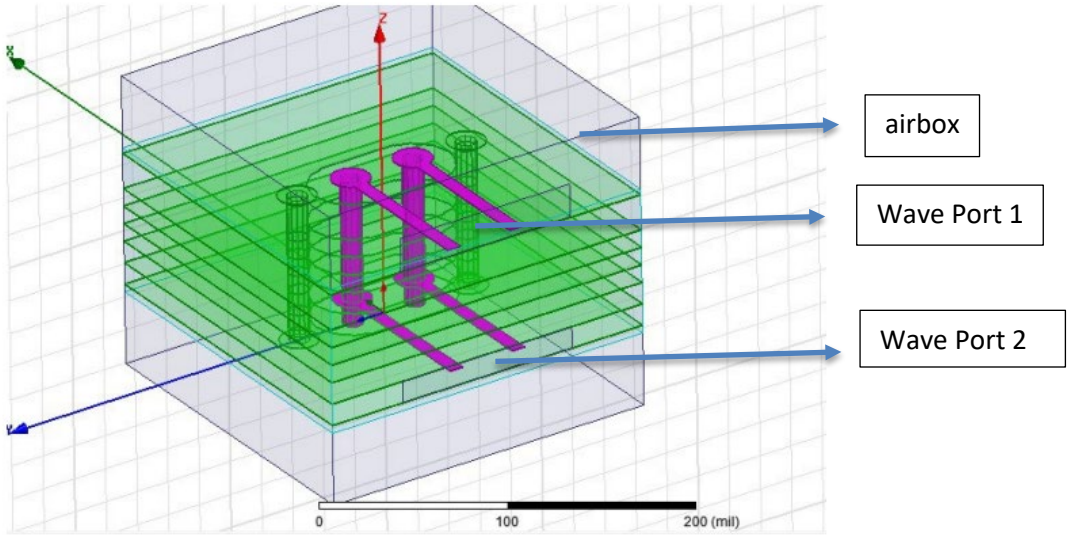
**United grounds:**

Ground planes give good shielding and avoid crosstalk between two signal lines. The ground vias join all grounds together.

In this structure, there are multiple ground planes and ground vias. It is easier if you unit all grounds into a single reference element. You can use the unite command on the top menu bar.

**Using Wave Port:**

Use wave port instead of lumped port. Because of united ground, you will now see only one reference element while assigning ports. Each wave port assignment will automatically see a pair of trace.




**Adding Differential Pair:**

In this HW, you need to use differential pair. This step comes after assigning excitation.

Right click on Excitations>Differential Pairs… → A dialogue box will appear.

Click New Pair. Then automatically a differential pair of traces will be added.

The differential reference impedance is 100 ohm, and common mode is 25 ohm.

**Don't forget the Air Box:**

You should add airbox and assign radiation boundary to it.