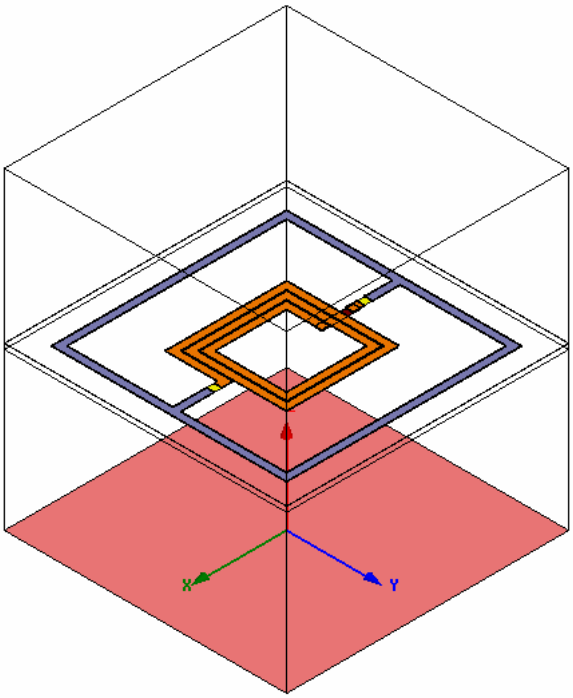
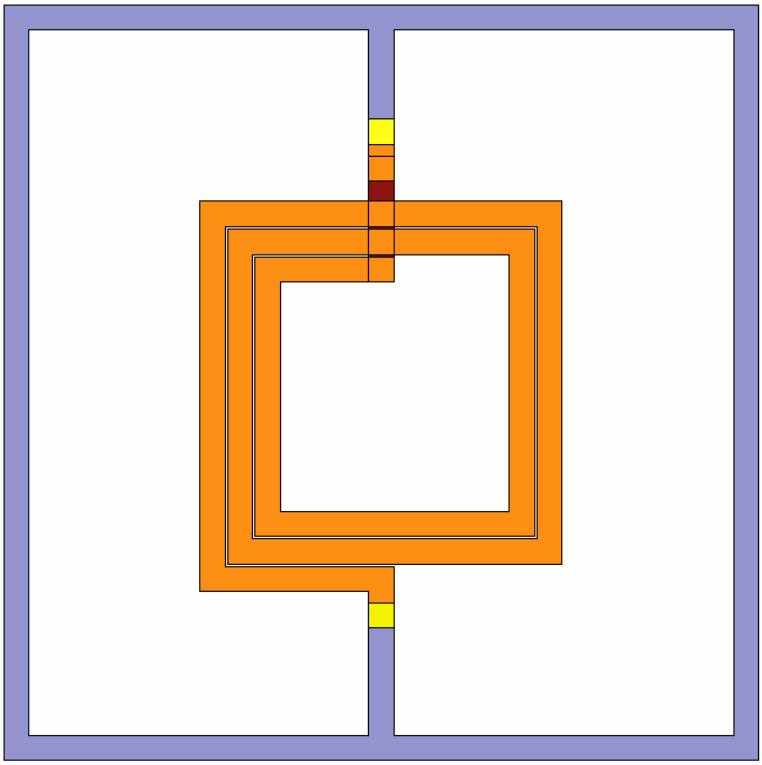
Example - Silicon Spiral Inductor

The Silicon Spiral Inductor

This example is intended to show you how to create, simulate, and analyze a 2.5 turn spiral inductor using the Ansoft HFSS Design Environment.





Nominal Design:

Spiral: 2.5T, W=15um, S=1.5um, Rad=60um

M6, 2um, σ= 2.8e7 S/m

Underpass: M5, 0.5um, σ= 2.8e7 S/m

Stackup:

Passivation: 0.7um

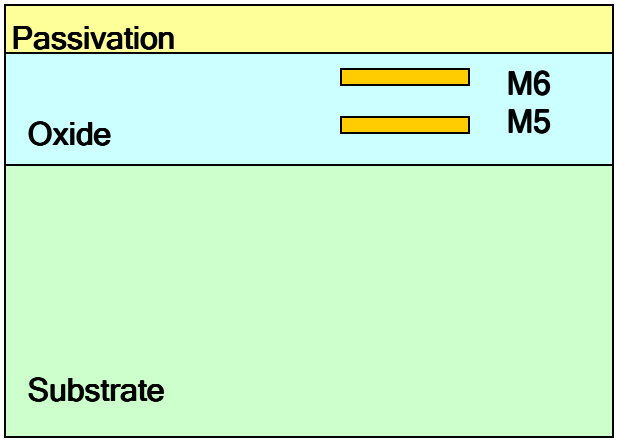
εr = 7.9

Oxide: 9.8um

εr = 4.0

Substrate: 300um

εr = 11.9, σ= 10 S/m



Getting Started

Launching Ansoft HFSS

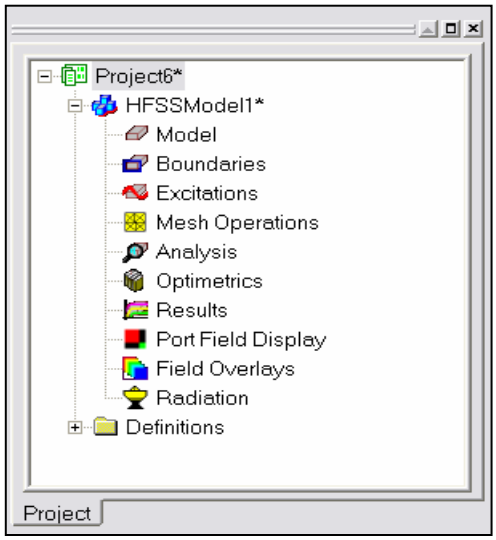
1. To access Ansoft HFSS, click the Microsoft **Start** button, select **Programs**, and select the **Ansoft > HFSS 10** program group. Click **HFSS 10**.

Setting Tool Options

- **To set the tool options:**
  - **Note:** In order to follow the steps outlined in this example, verify that the following tool options are set :
  1. Select the menu item *Tools > Options > HFSS Options*
  2. HFSS Options Window:
     1. Click the **General** tab
        - Use Wizards for data entry when creating new boundaries: ☑ **Checked**
        - Duplicate boundaries with geometry: ☑ **Checked**
     2. Click the **OK** button
  3. Select the menu item *Tools > Options > 3D Modeler Options*.
  4. 3D Modeler Options Window:
     1. Click the **Operation** tab
        - Automatically cover closed polylines: ☑ **Checked**
     2. Click the **Drawing** tab
        - Edit property of new primitives: ☑ **Checked**
     3. Click the **OK** button

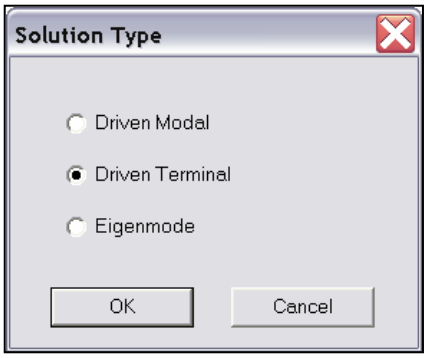
Opening a New Project

- **To open a new project:**
  - In an Ansoft HFSS window, click the 🗋 On the Standard toolbar, or select the menu item ***File > New***.
  - From the ***Project*** menu, select ***Insert HFSS Design***.



Set Solution Type

- **To set the solution type:**
  - Select the menu item ***HFSS > Solution Type***
  - Solution Type Window:
    - Choose **Driven Terminal**
    - Click the **OK** button



Creating the 3D Model

Set Model Units

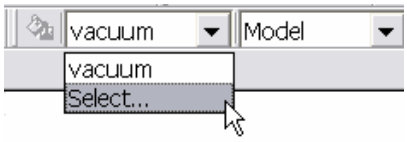
To set the units:

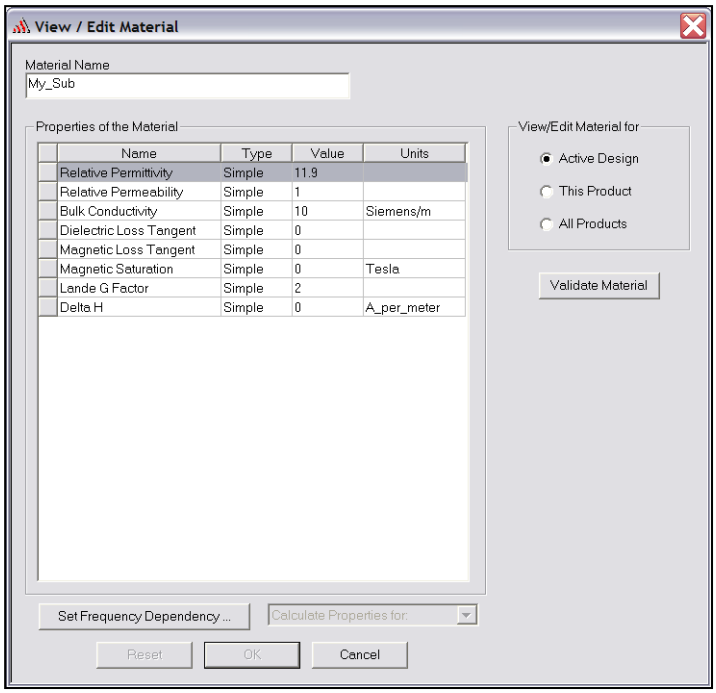
1. Select the menu item ***3D Modeler > Units***
2. Set Model Units:
    1. Select Units: **um**
    2. Click the **OK** button

Set Default Material

To set the default material:

1. Using the 3D Modeler Materials toolbar, choose **Select**
2. Select Definition Window:
    1. Click the **Add Material** button
    2. View/Edit Material Window:
        1. For the **Material Name** type: **My_Sub**
        2. For the **Value** of **Relative Permittivity** type: **11.9**
        3. For the **Value** of **Bulk Conductivity** type: **10**
        4. Click the **OK** button
    3. Click the **OK** button





Create Substrate

To create the substrate:

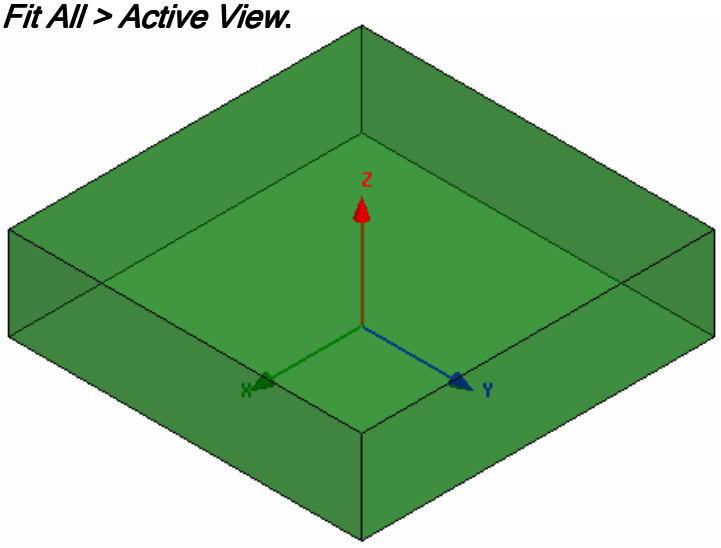
1. Select the menu item ***Draw > Box***
2. Using the coordinate entry fields, enter the box position
   - X: **-270.0**, Y: **-270.0**, Z: **0.0**, Press the **Enter** key
3. Using the coordinate entry fields, enter the opposite corner of the box:
   - dX: **540.0**, dY: **540.0**, dZ: **300.0**, Press the **Enter** key

To set the name:

1. Select the **Attribute** tab from the **Properties** window.
2. For the **Value** of **Name** type: **Sub**
3. Click the **OK** button

To fit the view:

1. Select the menu item ***View > Fit All > Active View.***



Set Default Material

To set the default material:

1. Using the 3D Modeler Materials toolbar, choose **Select**
2. Select Definition Window:
   1. Click the **Add Material** button
   2. View/Edit Material Window:
      1. For the **Material Name** type: **My_Oxide**
      2. For the **Value** of **Relative Permittivity** type: **4.0**
      3. Click the **OK** button
   3. Click the **OK** button

Create Oxide

To create substrate:

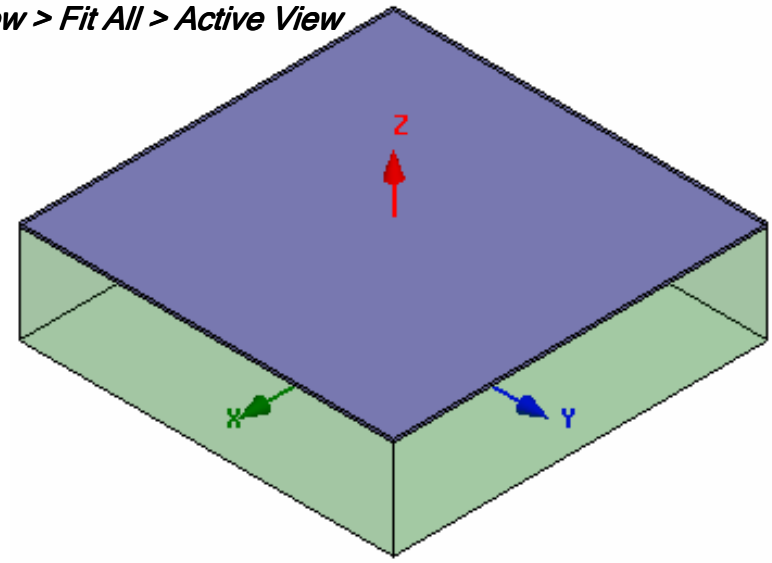
1. Select the menu item ***Draw > Box***
2. Using the coordinate entry fields, enter the box position
   - X: **-270.0**, Y: **-270.0**, Z: **300.0**, Press the **Enter** key
3. Using the coordinate entry fields, enter the opposite corner of the box:
   - dX: **540.0**, dY: **540.0**, dZ: **9.8**, Press the **Enter** key

To set the name:

1. Select the **Attribute** tab from the **Properties** window.
2. For the **Value** of **Name** type: **Oxide**
3. Click the **OK** button

To fit the view:

1. Select the menu item ***View > Fit All > Active View***



Set Default Material

To set the default material:

1. Using the 3D Modeler Materials toolbar, choose **Select**
2. Select Definition Window:
   1. Click the **Add Material** button
   2. View/Edit Material Window:
      1. For the **Material Name** type: **My_Pass**
      2. For the **Value** of **Relative Permittivity** type: **7.9**
      3. Click the **OK** button
   3. Click the **OK** button

Create Passivation

To create substrate:

1. Select the menu item *Draw > Box*
2. Using the coordinate entry fields, enter the box position
   - X: **-270.0**, Y: **-270.0**, Z: **309.8**, Press the **Enter** key
3. Using the coordinate entry fields, enter the opposite corner of the box:
   - dX: **540.0**, dY: **540.0**, dZ: **0.7**, Press the **Enter** key

To set the name:

1. Select the **Attribute** tab from the **Properties** window.
2. For the **Value** of **Name** type: **Pass**
3. Click the **OK** button

To fit the view:

1. Select the menu item *View > Fit All > Active View*

Set Default Material

To set the default material:

1. Using the 3D Modeler Materials toolbar, choose **vacuum**

Create Air

To create air:

1. Select the menu item *Draw > Box*
2. Using the coordinate entry fields, enter the box position
   - X: **-270.0**, Y: **-270.0**, Z: **0.0**, Press the **Enter** key
3. Using the coordinate entry fields, enter the opposite corner of the box:
   - dX: **540.0**, dY: **540.0**, dZ: **600.0**, Press the **Enter** key

To set the name:

1. Select the **Attribute** tab from the **Properties** window.
2. For the **Value** of **Name** type: **Air**
3. Click the **OK** button

To fit the view:

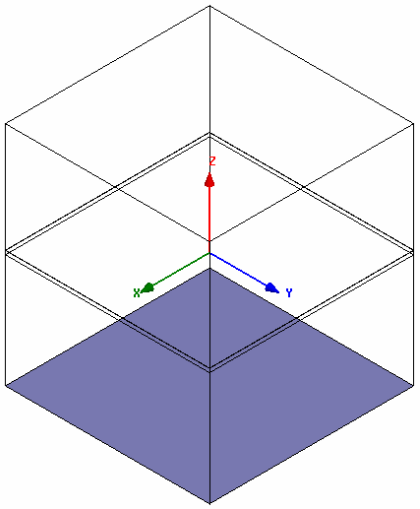
1. Select the menu item *View > Fit All > Active View*

Create Radiation Boundary

- **To select the object Air**:
  - Select the menu item *Edit > Select > By Name*
  - Select Object Dialog,
    - Select the objects named: **Air**
    - Click the **OK** button
- **To create a radiation boundary**
  - Select the menu item *HFSS > Boundaries > Assign > Radiation*
  - Radiation Boundary Window
    - Name: **Rad1**
    - Click the **OK** button

Create Ground

- **To create ground:**
  - Select the menu item *Draw > Rectangle*
  - Using the coordinate entry fields, enter the box position
    - X: **-270.0**, Y: **-270.0**, Z: **0.0**, Press the Enter key
  - Using the coordinate entry fields, enter the opposite corner of the base rectangle:
    - dX: **540.0**, dY: **540.0**, dZ: **0.0**, Press the Enter key
- To set the name:
  - Select the **Attribute** tab from the **Properties** window.
  - For the **Value** of **Name** type: **Ground**
  - Click the **OK** button
- **To fit the view:**
  - Select the menu item *View > Fit All > Active View.*



Assign a Perfect E boundary to the Ground

- **To select the ground:**
  1. Select the menu item *Edit > Select > By Name*
  2. Select Object Dialog,
     1. Select the objects named: **Ground**
     2. Click the **OK** button
- **To assign the Perfect E boundary**
  1. Select the menu item *HFSS > Boundaries > Assign > Perfect E*
  2. Perfect E Boundary window
     1. Name: **PerfE_Ground**
     2. Click the **OK** button

Hide Dielectrics

- **To hide the dielectrics:**
  1. Select the menu item *Edit > Select All Visible*
  2. Select the menu item *View > Hide Selection > All Views*

Set Default Material

- **To set the default material:**
  1. Using the 3D Modeler Materials toolbar, choose **Select**
  2. Select Definition Window:
     1. Click the **Add Material** button
     2. View/Edit Material Window:
        1. For the **Material Name** type: **My_Met**
        2. For the **Value** of **Bulk Conductivity** type: **2.8e7**
        3. Click the **OK** button
     3. Click the **OK** button

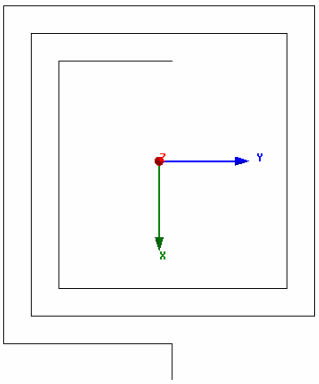
Create Offset Coordinate System

- **To create an offset Coordinate System:**
  1. Select the menu item *3D Modeler > Coordinate System > Create > Relative CS > Offset*
  2. Using the coordinate entry fields, enter the origin
     - X: **0.0**, Y: **0.0**, Z: **304.8**, Press the **Enter** key

Create Spiral Path

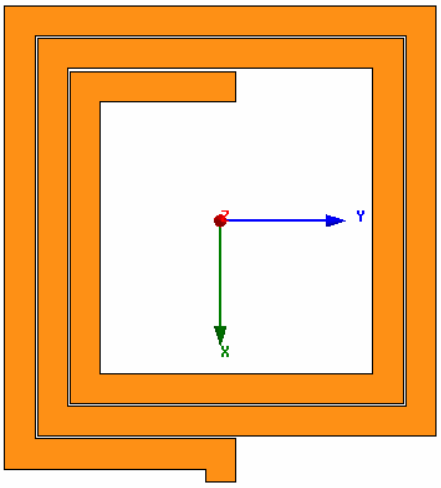
To create the path:

1. Select the menu item ***Draw > Line***
2. Using the coordinate entry fields, enter the vertex point:
   - X: **-60.0**, Y: **7.5**, Z: **0.0**, Press the **Enter** key
3. Using the coordinate entry fields, enter the vertex point:
   - X: **-60.0**, Y: **-60.0**, Z: **0.0**, Press the **Enter** key
4. Using the coordinate entry fields, enter the vertex point:
   - X: **76.5**, Y: **-60.0**, Z: **0.0**, Press the **Enter** key
5. Using the coordinate entry fields, enter the vertex point:
   - X: **76.5**, Y: **76.5**, Z: **0.0**, Press the **Enter** key
6. Using the coordinate entry fields, enter the vertex point:
   - X: **-76.5**, Y: **76.5**, Z: **0.0**, Press the **Enter** key
7. Using the coordinate entry fields, enter the vertex point:
   - X: **-76.5**, Y: **-76.5**, Z: **0.0**, Press the **Enter** key
8. Using the coordinate entry fields, enter the vertex point:
   - X: **93.0**, Y: **-76.5**, Z: **0.0**, Press the **Enter** key
9. Using the coordinate entry fields, enter the vertex point:
   - X: **93.0**, Y: **93.0**, Z: **0.0**, Press the **Enter** key
10. Using the coordinate entry fields, enter the vertex point:
    - X: **-93.0**, Y: **93.0**, Z: **0.0**, Press the **Enter** key
11. Using the coordinate entry fields, enter the vertex point:
    - X: **-93.0**, Y: **-93.0**, Z: **0.0**, Press the **Enter** key
12. Using the coordinate entry fields, enter the vertex point:
    - X: **109.5**, Y: **-93.0**, Z: **0.0**, Press the **Enter** key
13. Using the coordinate entry fields, enter the vertex point:
    - X: **109.5**, Y: **7.5**, Z: **0.0**, Press the **Enter** key
14. Using the coordinate entry fields, enter the vertex point:
    - X: **131.0**, Y: **7.5**, Z: **0.0**, Press the **Enter** key
15. Using the mouse, right-click and select **Done**
16. Click the **OK** button when the Properties dialog appears



Create the Spiral

- **To set the grid plane:**
  1. Select the menu item *3D Modeler > Grid Plane > XZ*
- **To create conductor profile:**
  1. Select the menu item *Draw > Rectangle*
  2. Using the coordinate entry fields, enter the box position
     - X: **-60.0**, Y: **7.5**, Z: **0.0**, Press the **Enter** key
  3. Using the coordinate entry fields, enter the opposite corner of the base rectangle:
     - dX: **-15.0**, dY: **0.0**, dZ: **2.0**, Press the **Enter** key
- **To set the name:**
  1. Select the **Attribute** tab from the **Properties** window.
  2. For the **Value** of **Name** type: **Spiral**
  3. Click the **OK** button
- **To Sweep the profile:**
  1. Select the menu item *Edit > Select > By Name*
  2. Select Object Dialog,
     1. Select the objects named: **Polyline1, Spiral**
     2. Click the **OK** button
     - **Note**: You can also select the object from the Model Tree
  1. Select the menu item *Draw > Sweep > Along Path*
  2. Click the **OK** button when the Sweep along path dialog appears
- **To fit the view:**
  1. Select the menu item *View > Fit All > Active View*.



Set Grid Plane

To set the grid plane:

1. Select the menu item *3D Modeler > Grid Plane > XY*

Create Underpass

To create underpass:

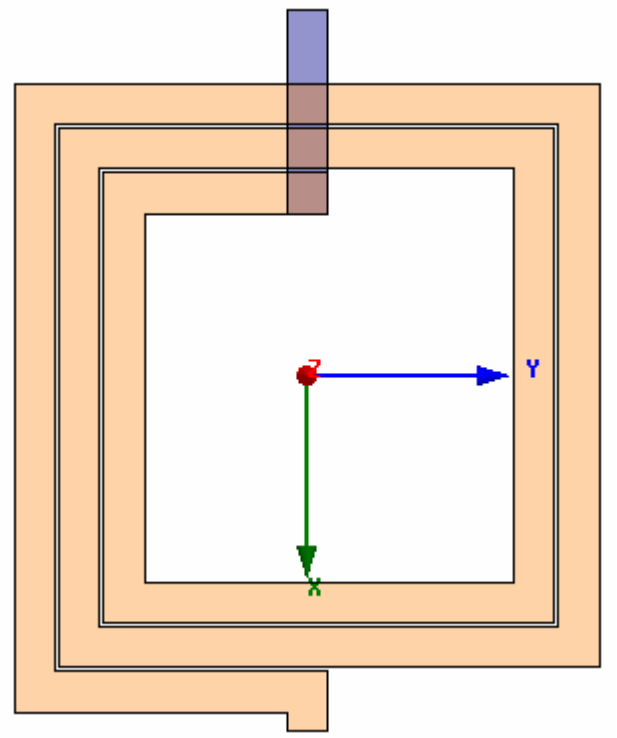
1. Select the menu item *Draw > Box*
2. Using the coordinate entry fields, enter the box position
   - X: **-60.0**, Y: **7.5**, Z: **-0.8**, Press the **Enter** key
3. Using the coordinate entry fields, enter the opposite corner of the box:
   - dX: **-75.0**, dY: **-15.0**, dZ: **-0.5**, Press the **Enter** key

To set the name:

1. Select the **Attribute** tab from the **Properties** window.
2. For the **Value** of **Name** type: **Underpass**
3. Click the **OK** button

To fit the view:

1. Select the menu item *View > Fit All > Active View*.



Create Via1

To create via:

1. Select the menu item ***Draw > Box***
2. Using the coordinate entry fields, enter the box position
   - X: **-60.0**, Y: **7.5**, Z: **0.0**, Press the **Enter** key
3. Using the coordinate entry fields, enter the opposite corner of the box:
   - dX: **-15.0**, dY: **-15.0**, dZ: **-0.8**, Press the **Enter** key

To set the name:

1. Select the **Attribute** tab from the **Properties** window.
2. For the **Value** of **Name** type: **Via1**
3. Click the **OK** button

To fit the view:

1. Select the menu item ***View > Fit All > Active View.***

Create Via2

To create via:

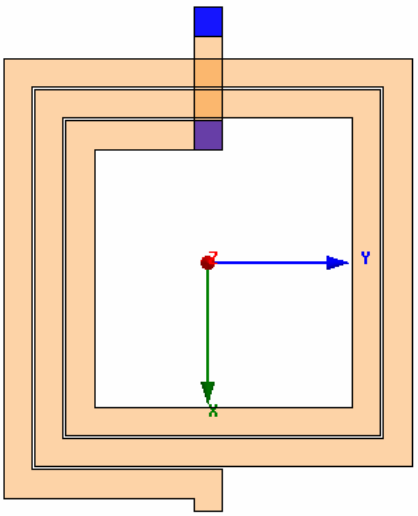
1. Select the menu item ***Draw > Box***
2. Using the coordinate entry fields, enter the box position
   - X: **-120.0**, Y: **7.5**, Z: **0.0**, Press the **Enter** key
3. Using the coordinate entry fields, enter the opposite corner of the box:
   - dX: **-15.0**, dY: **-15.0**, dZ: **-0.8**, Press the **Enter** key

To set the name:

1. Select the **Attribute** tab from the **Properties** window.
2. For the **Value** of **Name** type: **Via2**
3. Click the **OK** button

To fit the view:

1. Select the menu item ***View > Fit All > Active View.***



Create Feed

To create feed:

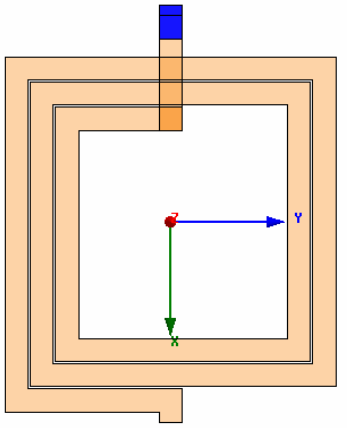
1. Select the menu item ***Draw > Box***
2. Using the coordinate entry fields, enter the box position
   - X: **-120.0**, Y: **7.5**, Z: **0.0**, Press the **Enter** key
3. Using the coordinate entry fields, enter the opposite corner of the box:
   - dX: **-22.0**, dY: **-15.0**, dZ: **2.0**, Press the **Enter** key

To set the name:

1. Select the **Attribute** tab from the **Properties** window.
2. For the **Value** of **Name** type: **Feed**
3. Click the **OK** button

To fit the view:

1. Select the menu item ***View > Fit All > Active View***.



Solve Inside Conductors

To solve inside:

1. Select the menu item ***Edit > Select All Visible***
2. Select the menu item ***Edit > Properties***
3. Properties Dialog Attribute Tab
   1. Solve Inside: ☑ **Checked**
   2. Click the **OK** button

Click the **OK** button for all warning messages (Solving inside a solid with high conductivity may require a large mesh)

Seed Mesh Conductors set for Solve Inside

To solve inside:

1. Select the menu item ***Edit > Select All Visible***
2. Select the menu item ***HFSS > Mesh Operations > Assign > Inside Selection > Length Based***
3. Element Length Based Refinement Dialog
   1. Restrict Length of Elements: ☐ **Unchecked**
   2. Restrict Number of Elements: ☑ **Checked**
   3. Maximum Number of Elements: **5000**
   4. Click the **OK** button

Set Default Material

- **To set the default material:**
  1. Using the 3D Modeler Materials toolbar, choose **Select**
  2. Select Definition Window:
     1. Type **pec** in the **Search by Name** field
     2. Click the **OK** button

Create Ground Ring

- **To create outer ring:**
  1. Select the menu item ***Draw > Box***
  2. Using the coordinate entry fields, enter the box position
     - X: **-225.0**, Y: **-225.0**, Z: **0.0**, Press the **Enter** key
  3. Using the coordinate entry fields, enter the opposite corner of the box:
     - dX: **450.0**, dY: **450.0**, dZ: **2.0**, Press the **Enter** key
- **To set the name:**
  1. Select the **Attribute** tab from the **Properties** window.
  2. For the **Value** of **Name** type: **Ring**
  3. Click the **OK** button
- **To fit the view:**
  1. Select the menu item ***View > Fit All > Active View***

Create Inner Ring

- **To create inner ring:**
  1. Select the menu item ***Draw > Box***
  2. Using the coordinate entry fields, enter the box position
     - X: **-210.0**, Y: **-210.0**, Z: **0.0**, Press the **Enter** key
  3. Using the coordinate entry fields, enter the opposite corner of the box:
     - dX: **420.0**, dY: **420.0**, dZ: **2.0**, Press the **Enter** key
- **To set the name:**
  1. Select the **Attribute** tab from the **Properties** window.
  2. For the **Value** of **Name** type: **Inner**
  3. Click the **OK** button
- **To fit the view:**
  1. Select the menu item ***View > Fit All > Active View***

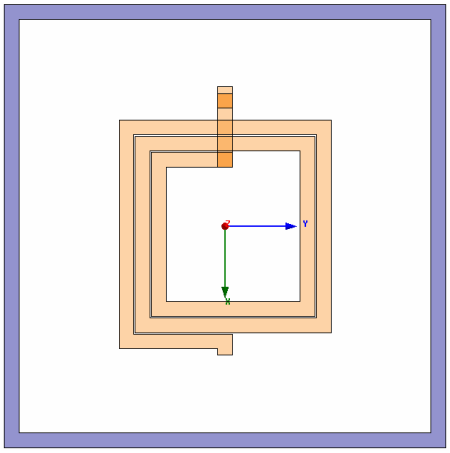
Complete the Ring

To select the objects Ring and Inner:

1. Select the menu item *Edit > Select > By Name*
2. Select Object Dialog,
    1. Select the objects named: **Ring, Inner**
    2. Click the **OK** button

To complete the ring:

1. Select the menu item *3D Modeler > Boolean > Subtract*
2. Subtract Window
    - Blank Parts: **Ring**
    - Tool Parts: **Inner**
    - Click the **OK** button



Create Extension 1

To create extension:

1. Select the menu item *Draw > Box*
2. Using the coordinate entry fields, enter the box position
    - X: **-157.0**, Y: **7.5**, Z: **0.0**, Press the **Enter** key
3. Using the coordinate entry fields, enter the opposite corner of the box:
    - dX: **-53.0**, dY: **-15.0**, dZ: **2.0**, Press the **Enter** key

To set the name:

1. Select the **Attribute** tab from the **Properties** window.
2. For the **Value** of **Name** type: **Ring_Ext1**
3. Click the **OK** button

To fit the view:

1. Select the menu item *View > Fit All > Active View*

Create Extension 2

To create extension:

1. Select the menu item *Draw > Box*
2. Using the coordinate entry fields, enter the box position
   - X: **146.0**, Y: **7.5**, Z: **0.0**, Press the **Enter** key
3. Using the coordinate entry fields, enter the opposite corner of the box:
   - dX: **64.0**, dY: **-15.0**, dZ: **2.0**, Press the **Enter** key

To set the name:

1. Select the **Attribute** tab from the **Properties** window.
2. For the **Value** of **Name** type: **Ring_Ext2**
3. Click the **OK** button

To fit the view:

1. Select the menu item *View > Fit All > Active View*

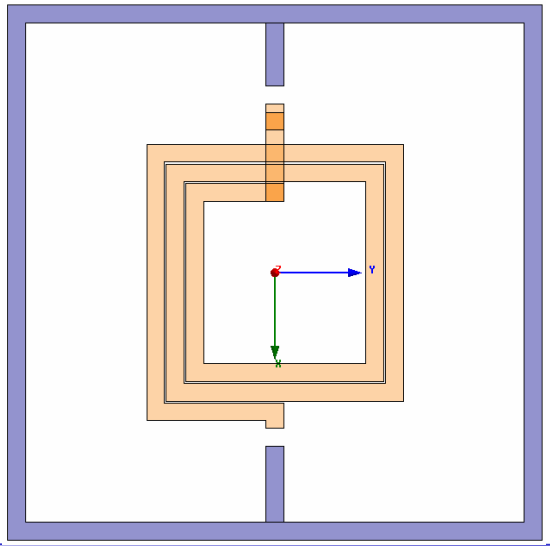
Group the Conductors

To group the conductors:

1. Select the menu item *Edit > Select > By Name*
2. Select Object Dialog,
   1. Select the objects named: **Ring, Ring_Ext1, Ring_Ext2**
   2. Click the **OK** button
3. Select the menu item, *3D Modeler > Boolean > Unite*

To fit the view:

1. Select the menu item *View > Fit All > Active View*.



Create Source 1

To create source:

1. Select the menu item *Draw > Rectangle*
2. Using the coordinate entry fields, enter the box position
   - X: **-142.0**, Y: **7.5**, Z: **1.0**, Press the **Enter** key
3. Using the coordinate entry fields, enter the opposite corner of the base rectangle:
   - dX: **-15.0**, dY: **-15.0**, dZ: **0.0**, Press the **Enter** key

To set the name:

1. Select the **Attribute** tab from the **Properties** window.
2. For the **Value** of **Name** type: **Source1**
3. Click the **OK** button

To fit the view:

1. Select the menu item *View > Fit All > Active View*.

Assign Excitation

To select the object Source:

1. Select the menu item *Edit > Select > By Name*
2. Select Object Dialog,
   1. Select the objects named: **Source1**
   2. Click the **OK** button
   - **Note**: You can also select the object from the Model Tree

To assign lumped port excitation

1. Select the menu item *HFSS > Excitations > Assign > Lumped Port*
2. Lumped Port : General
   1. Name: **p1**,
   2. Resistance: **50**
   3. Reactance: **0**
   4. Click the **Next** button
3. Lumped Port : Terminals
   1. Number of Terminals: **1**,
   2. For **T1**, click the **Undefined** column and select **New Line**
   3. Using the coordinate entry fields, enter the vector position
      - X: **-157.0**, Y: **0.0**, Z: **1.0**, Press the **Enter** key
   4. Using the coordinate entry fields, enter the vertex
      - dX: **15.0**, dY: **0.0**, dZ: **0.0**, Press the **Enter** key
   5. Click the **Finish** button

Create Source 2

To create source:

1. Select the menu item *Draw > Rectangle*
2. Using the coordinate entry fields, enter the box position
   - X: **131.0**, Y: **7.5**, Z: **1.0**, Press the **Enter** key
3. Using the coordinate entry fields, enter the opposite corner of the base rectangle:
   - dX: **15.0**, dY: **-15.0**, dZ: **0.0**, Press the **Enter** key

To set the name:

1. Select the **Attribute** tab from the **Properties** window.
2. For the **Value** of **Name** type: **Source2**
3. Click the **OK** button

To fit the view:

1. Select the menu item *View > Fit All > Active View*.

Assign Excitation

To select the object Source:

1. Select the menu item *Edit > Select > By Name*
2. Select Object Dialog,
   1. Select the objects named: **Source2**
   2. Click the **OK** button
   - **Note**: You can also select the object from the Model Tree

To assign lumped port excitation

1. Select the menu item *HFSS > Excitations > Assign > Lumped Port*
2. Lumped Port : General
   1. Name: **p2**,
   2. Resistance: **50**
   3. Reactance: **0**
   4. Click the **Next** button
3. Lumped Port : Terminals
   1. Number of Terminals: **1**,
   2. For **T1**, click the **Undefined** column and select **New Line**
   3. Using the coordinate entry fields, enter the vector position
      - X: **146.0**, Y: **0.0**, Z: **1.0**, Press the **Enter** key
   4. Using the coordinate entry fields, enter the vertex
      - dX: **-15.0**, dY: **0.0**, dZ: **0.0**, Press the **Enter** key
   5. Click the **Finish** button

Show All

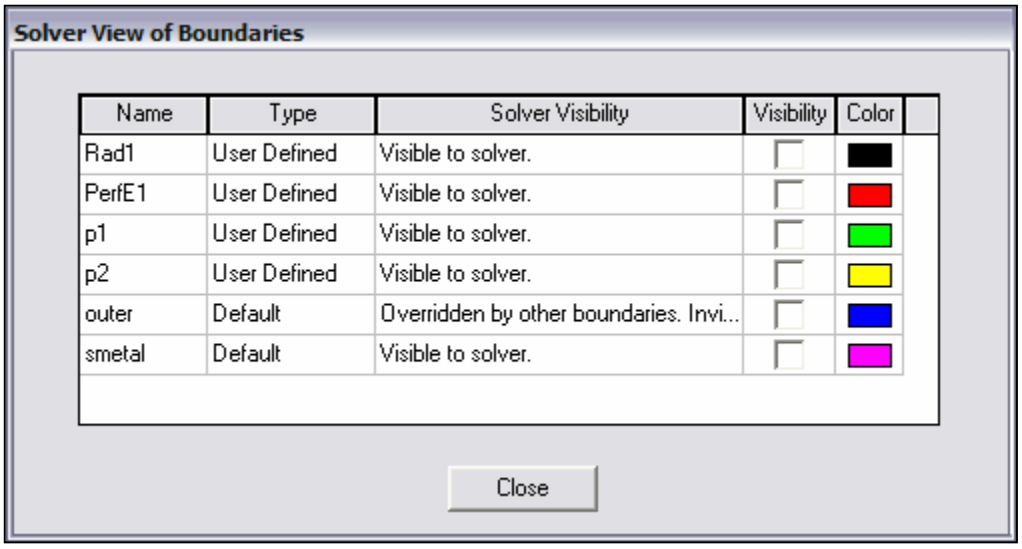
To show all object

1. Select the menu item ***View > Show All > All Views***

Boundary Display

To verify the boundary setup:

1. Select the menu item ***HFSS > Boundary Display (Solver View)***
2. From the Solver View of Boundaries, toggle the Visibility check box for the boundaries you wish to display.
   - **Note:** The background (Perfect Conductor) is displayed as the **outer** boundary.
   - **Note:** The Perfect Conductors are displayed as the **smetal** boundary.
   - **Note:** Select the menu item, ***View > Visibility*** to hide all of the geometry objects. This makes it easier to see the boundary
3. Click the **Close** button when you are finished



Analysis Setup

Creating an Analysis Setup

- **To create an analysis setup:**
  1. Select the menu item *HFSS > Analysis Setup > Add Solution Setup*
  2. Solution Setup Window:
     1. Click the **General** tab:
        - Solution Frequency: **12.0GHz**
        - Maximum Number of Passes: **20**
        - Maximum Delta S: **0.02**
     2. Click the **Options** tab:
        - Do Lambda Refinement: ☑ **Checked**
        - Target: **0.05**
        - User Low-Order Solution Basis: ☑ **Checked**
     3. Click the **OK** button

Adding a Frequency Sweep

- **To add a frequency sweep:**
  1. Select the menu item *HFSS > Analysis Setup > Add Sweep*
     1. Select Solution Setup: **Setup1**
     2. Click the **OK** button
  2. Edit Sweep Window:
     1. Sweep Type: **Interpolating**
     2. Click the **Setup Interpolation Basis** button
        - Max Solutions: **20**
        - Error Tolerance: **0.5%**
        - Click the **OK** button
     3. Frequency Setup Type: **Linear Step**
        - Start: **0.1GHz**
        - Stop: **20.0GHz**
        - Step: **0.1GHz**
     4. Click the **OK** button

Save Project

To save the project:

1. In an Ansoft HFSS window, select the menu item ***File > Save As***.
2. From the **Save As** window, type the Filename: **hfss_spiral_inductor**
3. Click the **Save** button

Analyze

Model Validation

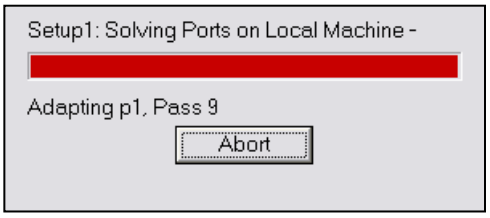
To validate the model:

1. Select the menu item ***HFSS > Validation Check***
2. Click the **Close** button
   - **Note:** To view any errors or warning messages, use the Message Manager.

Analyze

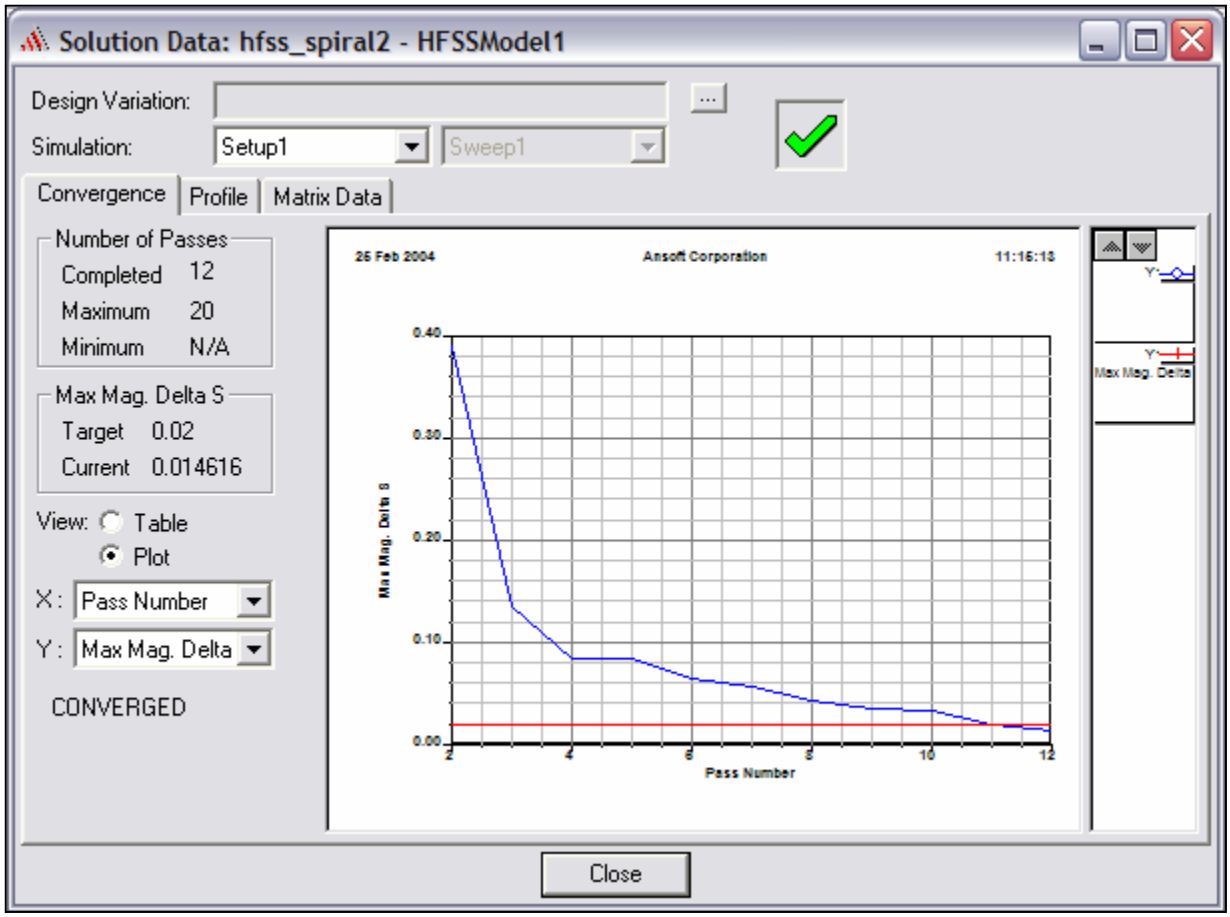
To start the solution process:

1. Select the menu item ***HFSS > Analyze All***



Solution Data

- **To view the Solution Data:**
  1. Select the menu item *HFSS > Results > Solution Data*
     - **To view the Profile:**
       1. Click the **Profile** Tab.
     - **To view the Convergence:**
       1. Click the **Convergence** Tab
          - **Note:** The default view is for convergence is **Table**. Select the **Plot** radio button to view a graphical representations of the convergence data.
     - **To view the Matrix Data:**
       1. Click the **Matrix Data** Tab
          - **Note:** To view a real-time update of the Matrix Data, set the Simulation to **Setup1, Last Adaptive**
  2. Click the **Close** button

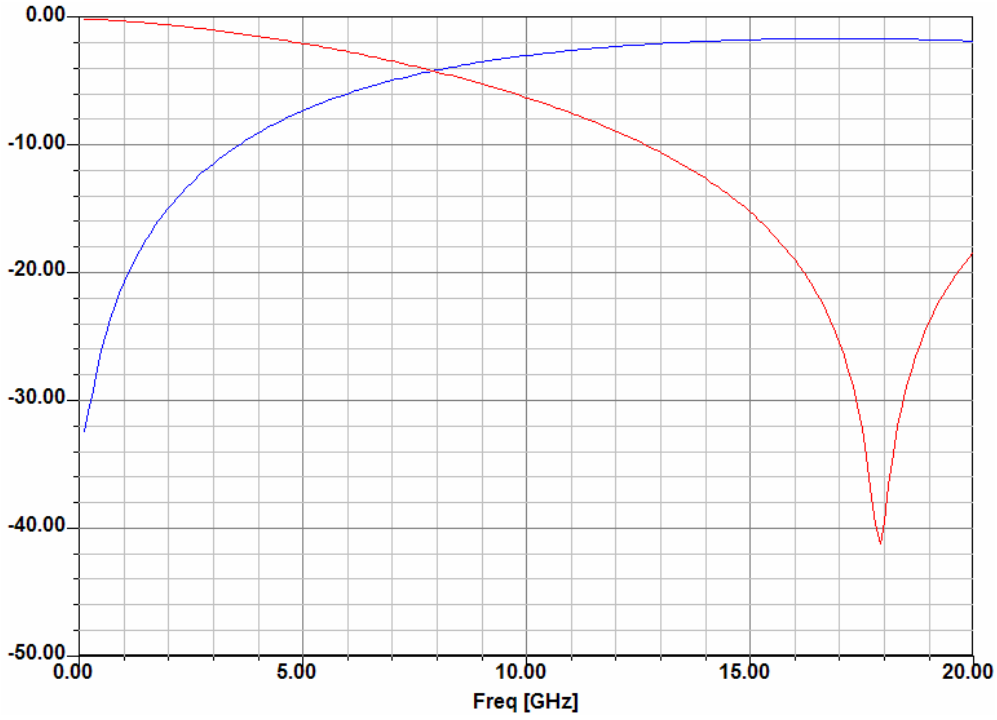


Create Reports

Create S-parameter vs. Frequency

To Create a report:

1. Select the menu item *HFSS > Results > Create Report*
2. Create Report Window:
    1. Report Type: **Terminal S Parameters**
    2. Display Type: **Rectangular**
    3. Click the **OK** button
3. Traces Window:
    1. Solution: **Setup1: Sweep1**
    2. Click the **Y** tab
        1. Domain: **Sweep**
        2. Category: **Terminal S-Parameters**
        3. Quantity: **St(p1,p1), St(p2,p1)**
        4. Function: **dB**
        5. Click the **Add Trace** button
    3. Click the **Done** button

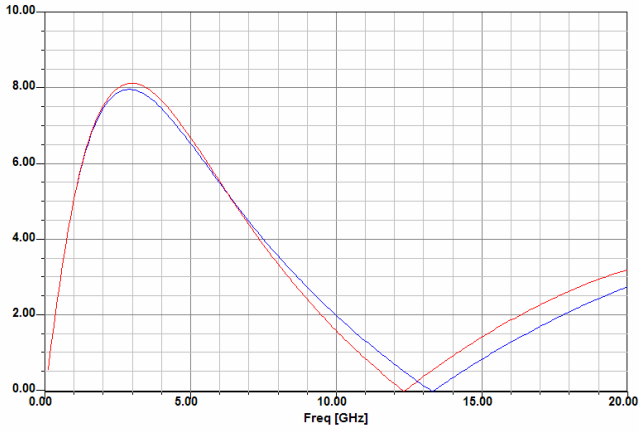


Create Reports (Continued)

Custom Equations - Output Variables

1. Select the menu item ***HFSS > Results > Create Report***
2. Create Report Window**:**
   1. Report Type: **Terminal S Parameters**
   2. Display Type: **Rectangular**
   3. Click the **OK** button
3. Traces Window**:**
   1. Click the **Output Variables** button
   2. Output Variables dialog:
      1. Name: **Q11**
      2. Expression:
         - Category: **Terminal Y Parameters**
         - Quantity: **Yt(p1,p1)**
         - Function: **im**
         - Click the **Insert Quantity into Expression** button
         - Type: **/**
         - Quantity: **Yt(p1,p1)**
         - Function: **re**
         - Click the **Insert Quantity into Expression** button
      3. Click the **Add** button
      4. Repeat for **Q22**, by replacing **Yt(p1,p1)** with **Yt(p2,p2)**
      5. Click the **Done** button
   3. Solution: **Setup1: Sweep1**
   4. Domain: **Sweep**
   5. Click the **Y** tab
      1. Category: **Output Variables**
      2. Quantity: **Q11, Q22**
      3. Function: **abs**
      4. Click the **Add Trace** button
   6. Click the **Done** button

$$Q_{nn} = \frac{\mathrm{Im}(Y_{nn})}{\mathrm{Re}(Y_{nn})}$$

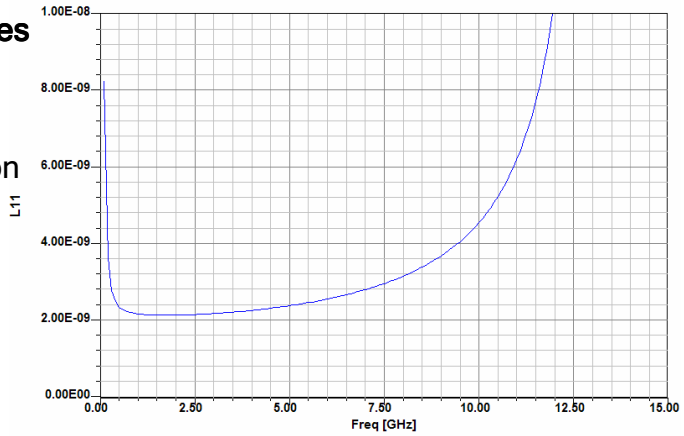


Create Reports (Continued)

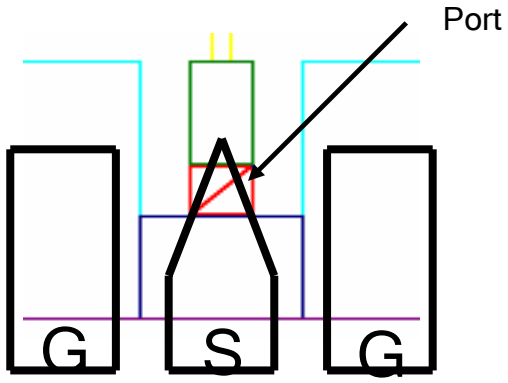
Custom Equations - Output Variables

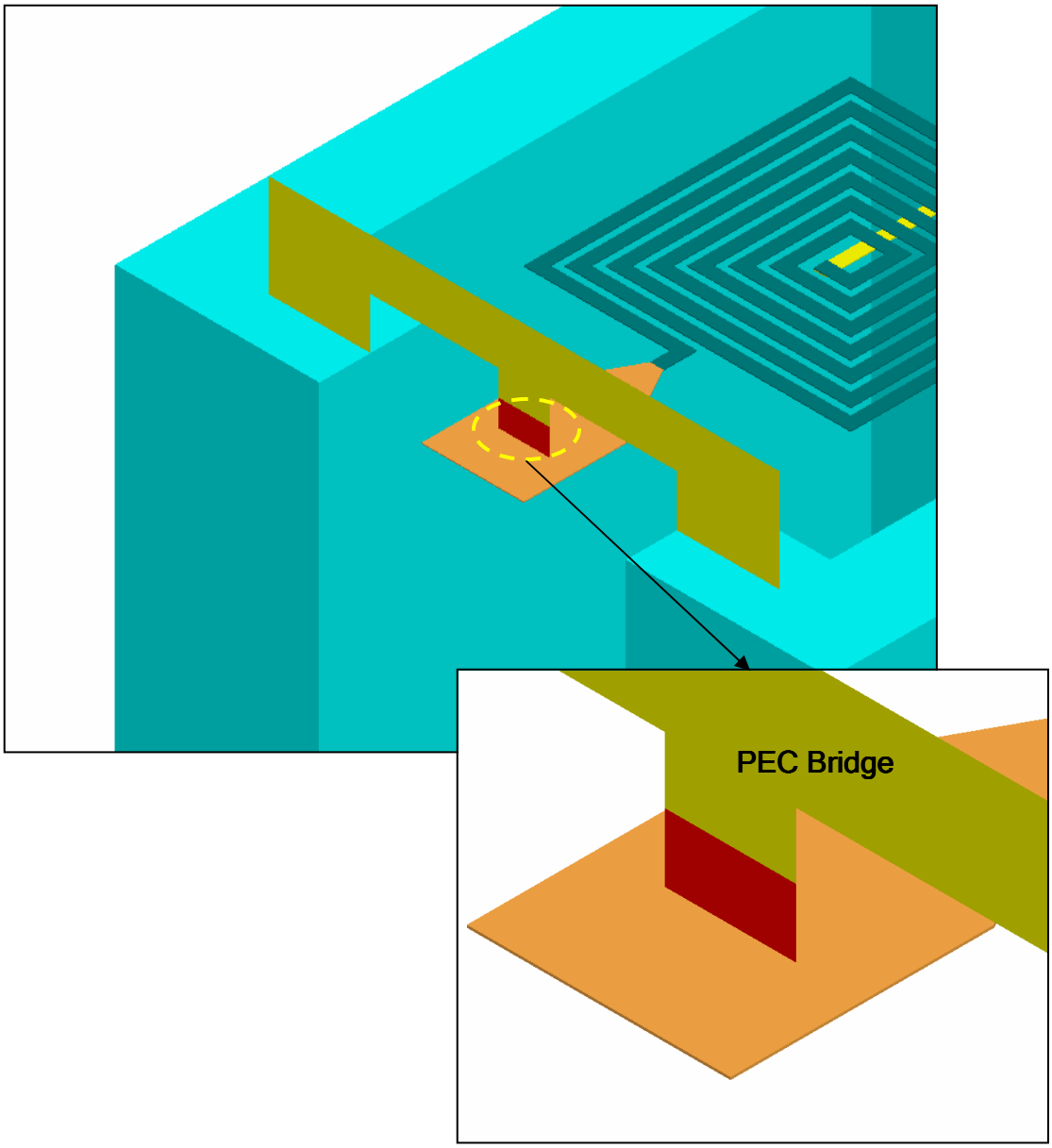
1. Select the menu item ***HFSS > Results > Create Report***
2. Create Report Window**:**
   1. Report Type: **Terminal S Parameters**
   2. Display Type: **Rectangular**
   3. Click the **OK** button
3. Traces Window**:**
   1. Click the **Output Variables** button
   2. Output Variables dialog:
      1. Name: **L11**
      2. Expression:
         - Type: **-1/(2*pi*freq***
         - Category: **Terminal Y Parameters**
         - Quantity: **Yt(p1,p1)**
         - Function: **im**
         - Click the **Insert Quantity into Expression** button
         - Type: **)**
      3. Click the **Add** button
      4. Click the **Done** button
   3. Solution: **Setup1: Sweep1**
   4. Domain: **Sweep**
   5. Click the **Y** tab
      1. Category: **Output Variables**
      2. Quantity: **Y11**
      3. Function: **none**
      4. Click the **Add Trace** button
   6. Click the **Done** button

$$L_{nn} = \frac{-1}{2\pi \cdot f \cdot im(Y_{nn})}$$

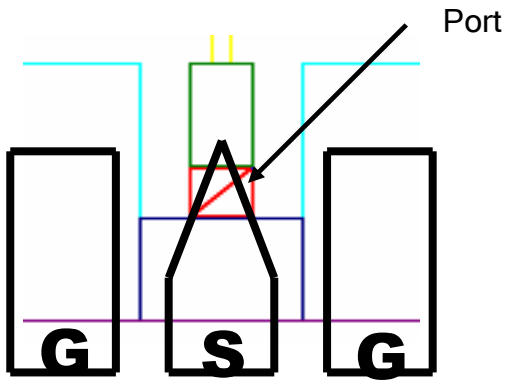


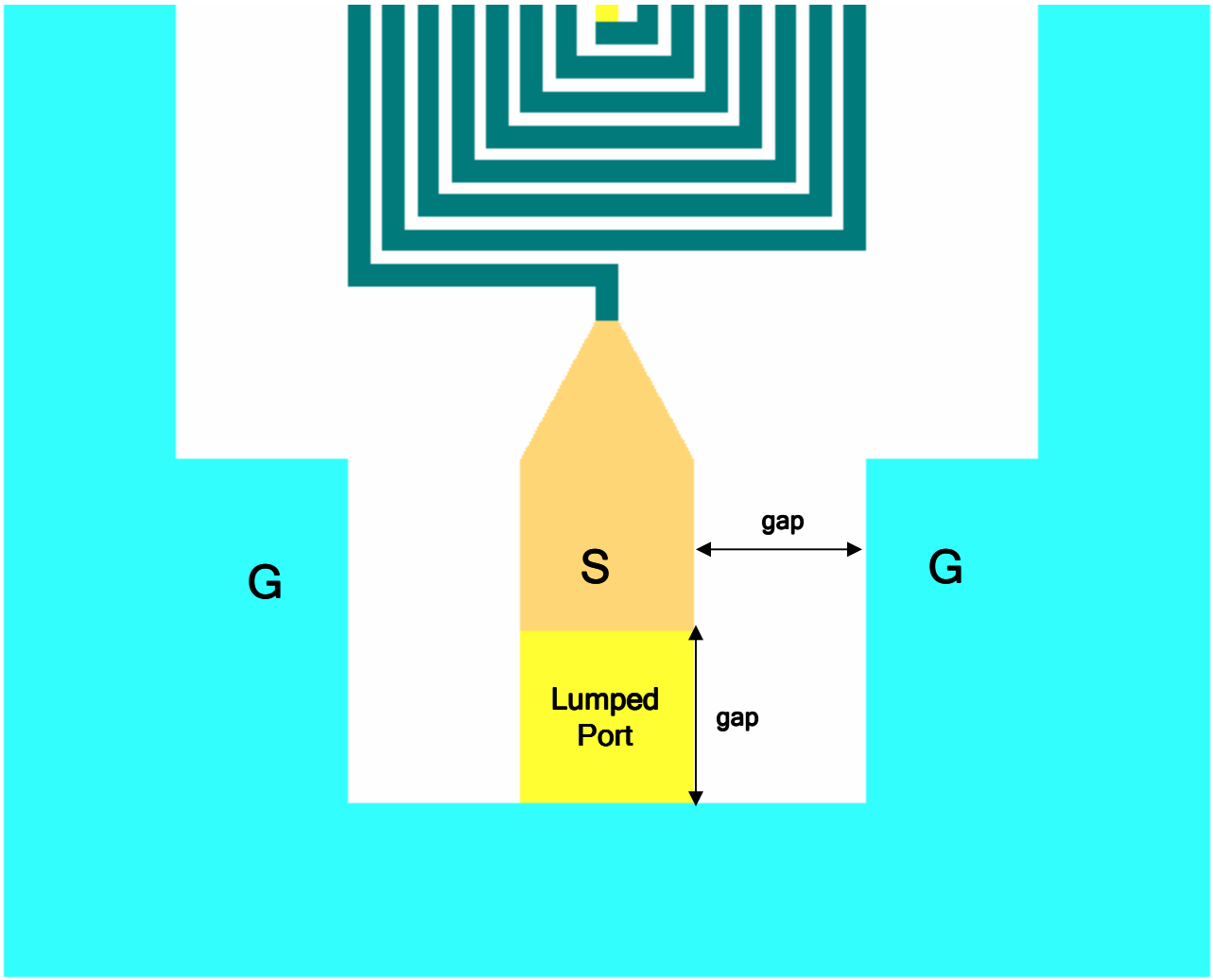
Appendix – Alternative Lumped Ports





Appendix - Alternative Lumped Ports





Appendix - Alternative Lumped Ports