Module 4: HFSS 3D Layout Ports

ANSYS HFSS 3D Layout Getting Started Course
LE04

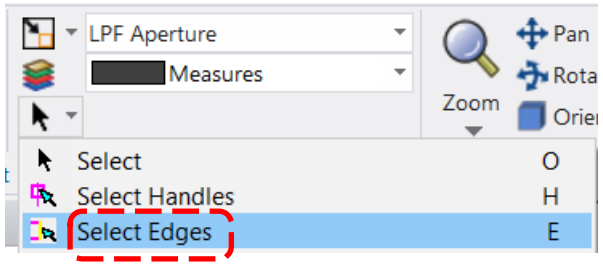
Outline HFSS 3D Layout Ports

- Gap Ports
  - Reference planes
  - Comparison HFSS 3DL/ECAD to HFSS MCAD
- Wave Ports
  - Select two edges to make a wave port
  - Comparison HFSS 3DL/ECAD to HFSS MCAD
- Coupling Ports
  - Make a wave port from two gap ports.
  - Decouple terminals in a wave port to get back to gap ports.
- Gap(coax)Ports
  - External placement
  - Multiple mode
- HFSS 3D Layout Ports Rationalize Solvers
  - Different port implementations for different solvers
  - Auto ports are used for automated processes

Select An Edge to Make a Gap Port

Ports can be created by selecting an edge, or multiple edges, and then right-clicking and choosing Port > Create.

A gap port is a type of edge port.



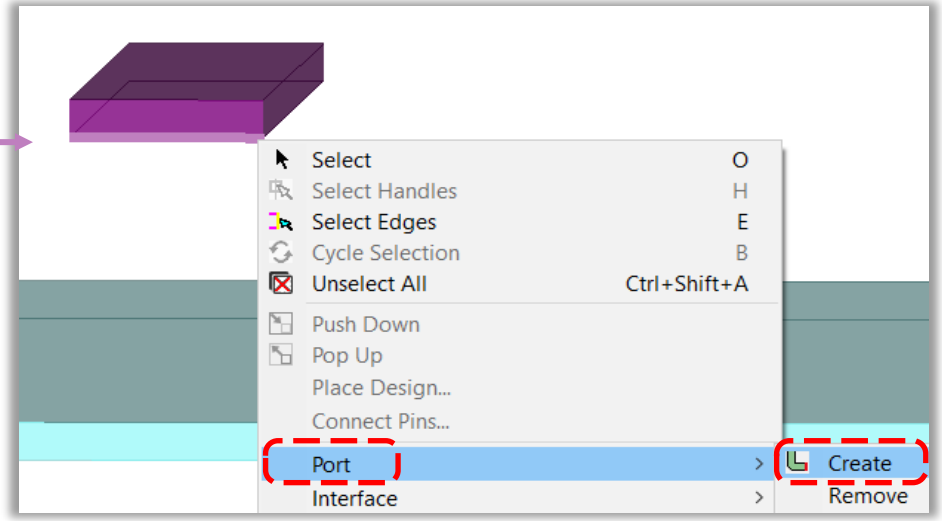
Creating an Edge Port

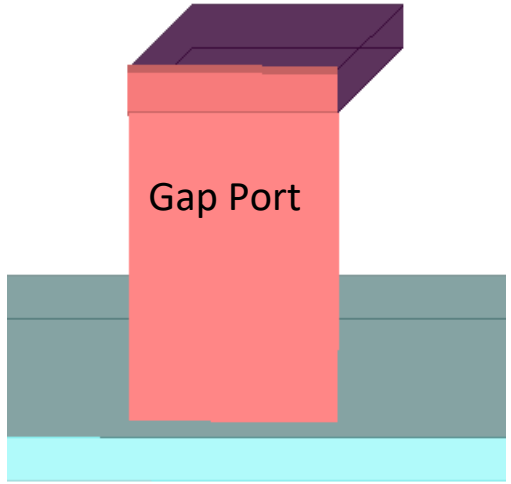
1. Select the signal layer on which the port lies.
2. On the **Edit** menu, click **Select Edges**.
3. Click the edges of the model on which the port lies.
4. On the **Draw** menu, click **Port > Create**.

The edge port is listed under Excitations in the project tree.

HFSS 3D Layout 15-50

This lighter color indicates that the edge is selected. This always appears on the bottom of the edge, even though the whole edge is selected.





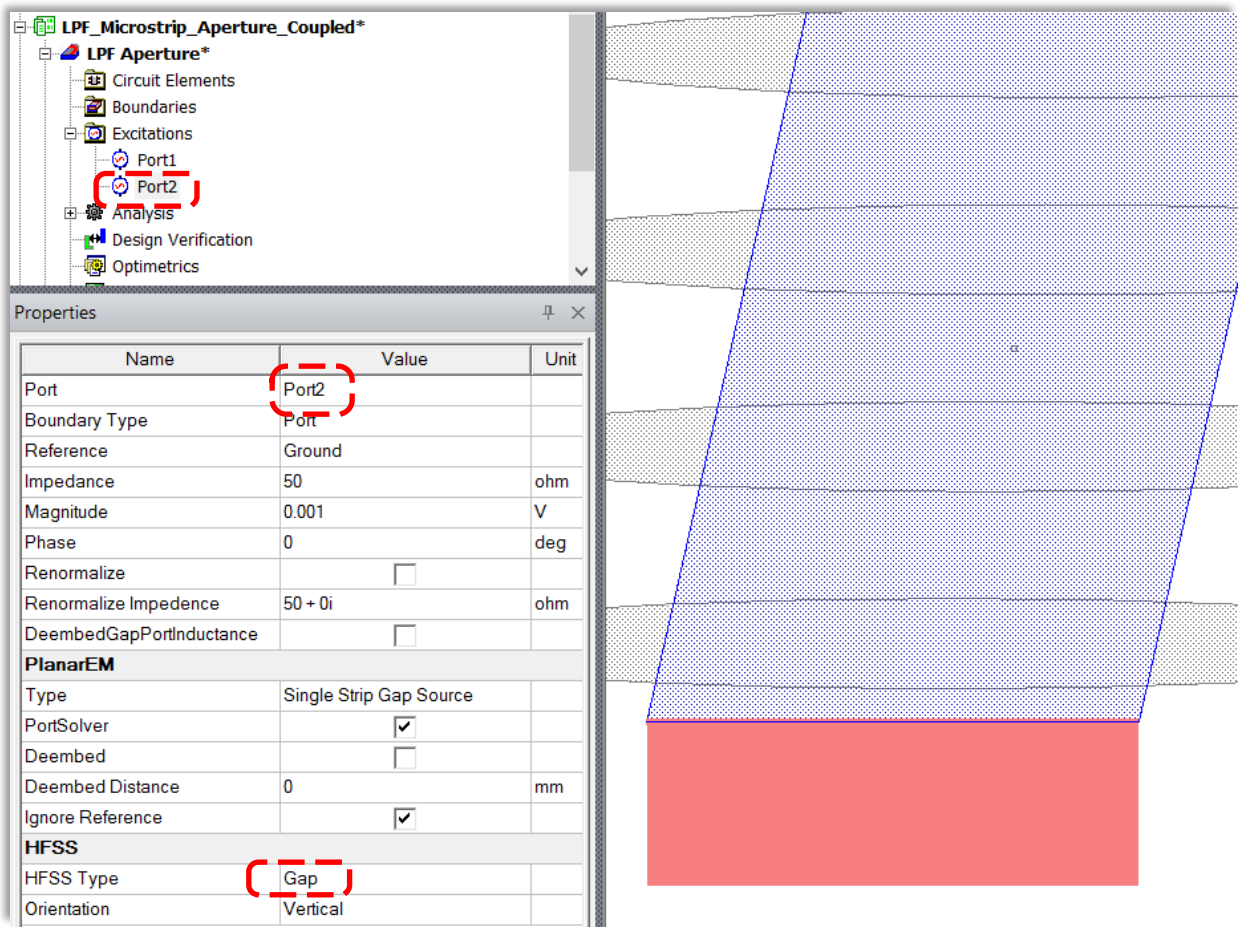
Gap Port on Microstrip Transmission Line

Port 2 is a ***Gap*** port that references the ground plane.

In the HFSS design type (and the MCAD fully arbitrary 3D modeling interface), this ***Gap*** port would be referred to as a ***Lumped*** port. The two terms are often used interchangeably.

The ground plane doesn't appear here because it is negative. The gray-colored circles represent holes (apertures) in the ground plane.

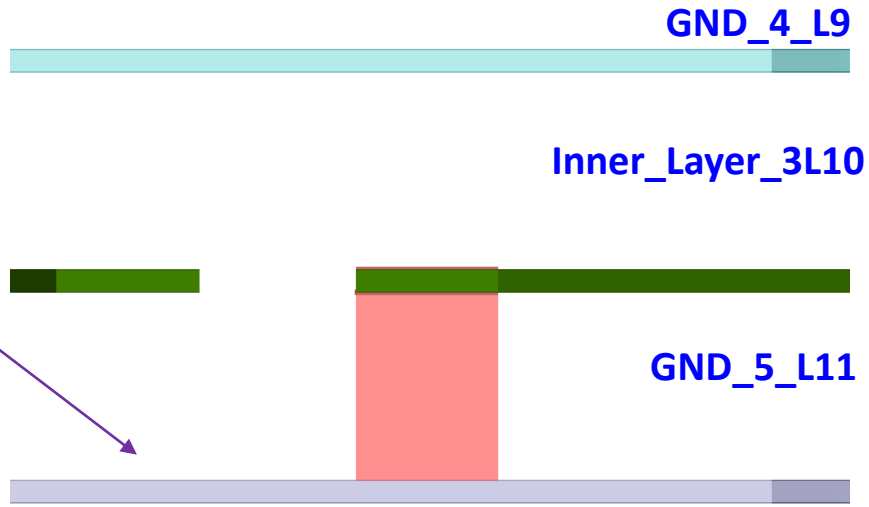
Name	Type	Negative	Material
Trace	signal	☐	copper
Dielectric	dielectric		diel_233
Ground	signal	☑	copper



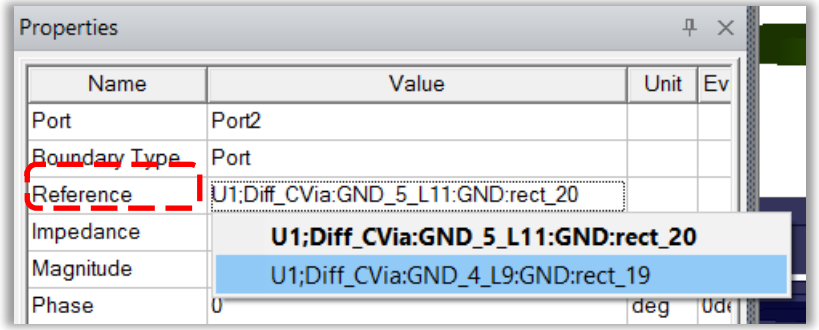
Port 2

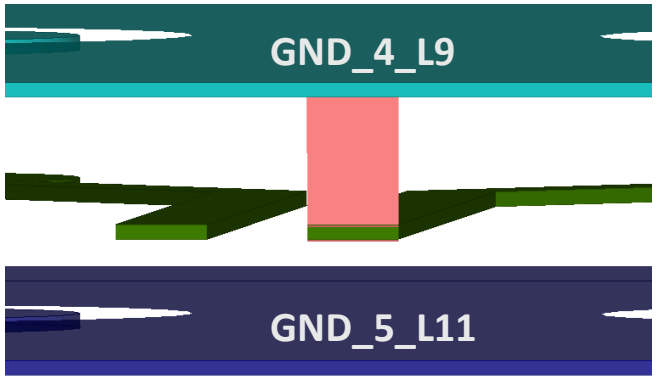
Gap Ports Find the Closest Reference Plane

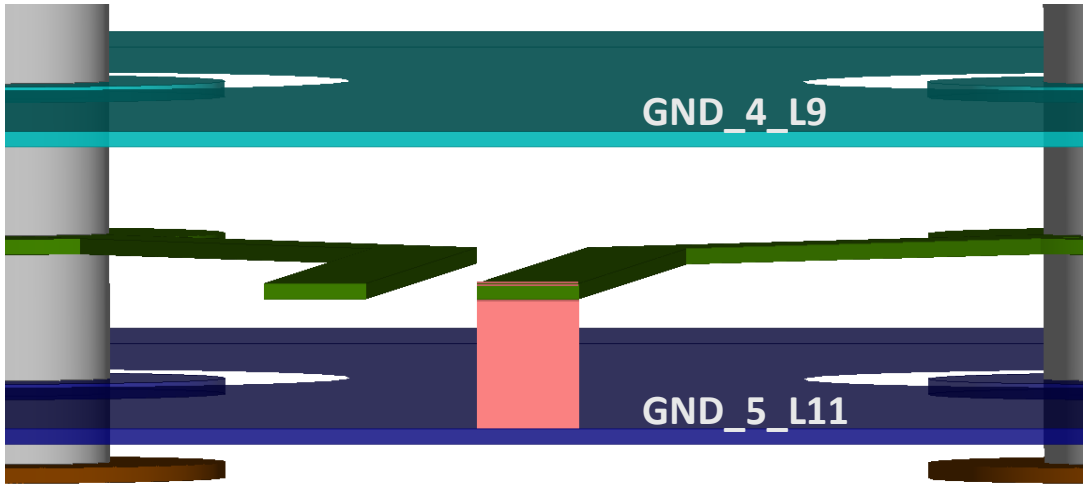
The intelligent port creation in HFSS 3D Layout will choose the nearest valid ground reference to the port. In this case, the port chose the ground plane ***GND_5_L11*** below the port.



This choice of ***Reference*** can be easily changed in the ***Properties*** of the port by assigning a different plane as ***Reference.***







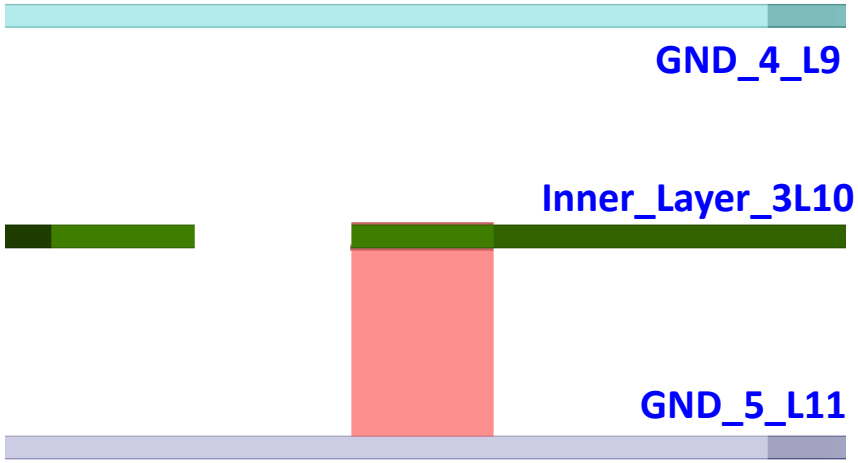
Gap and Lumped Ports in HFSS ECAD versus HFSS MCAD

Characteristic	HFSS 3D Layout - ECAD	HFSS MCAD
Port from transmission line edge to ground	Gap port	Lumped port
Geometry Orientation	The editor constrains gap ports to be oriented vertically or horizontally.	Lumped ports can have any geometric orientation.
Geometry Creation	The port geometry is created along with the port.	The geometry must already exist; the lumped port is assigned to the port geometry.
Terminals related to ports	HFSS 3DL corresponds to driven terminal; ports have terminals.	Driven modal or driven terminal, in driven modal solution type, lumped ports don't have terminals.

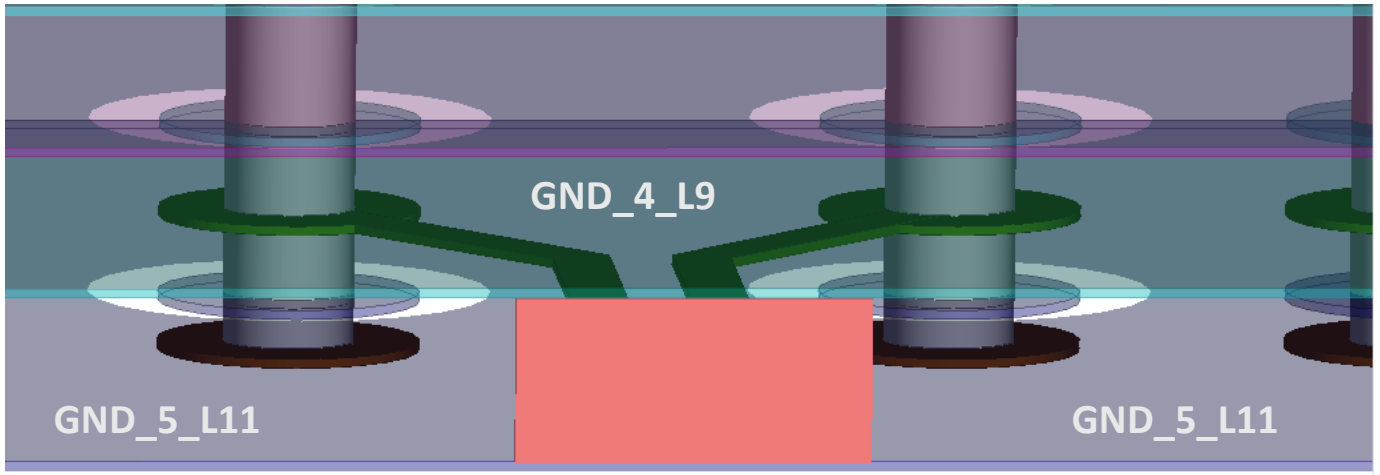
Don't Use Gap Ports for Stripline

This structure, with a ground above and below the signal traces, makes a good example for gap port reference plane choices.

But either choice of reference, ***GND_4_L9*** above or ***GND_5_L11*** below the signal trace, does not reference the other ground plane. From an engineering point of view, here it is better to use a wave port, which can reference both ground planes in the stripline.



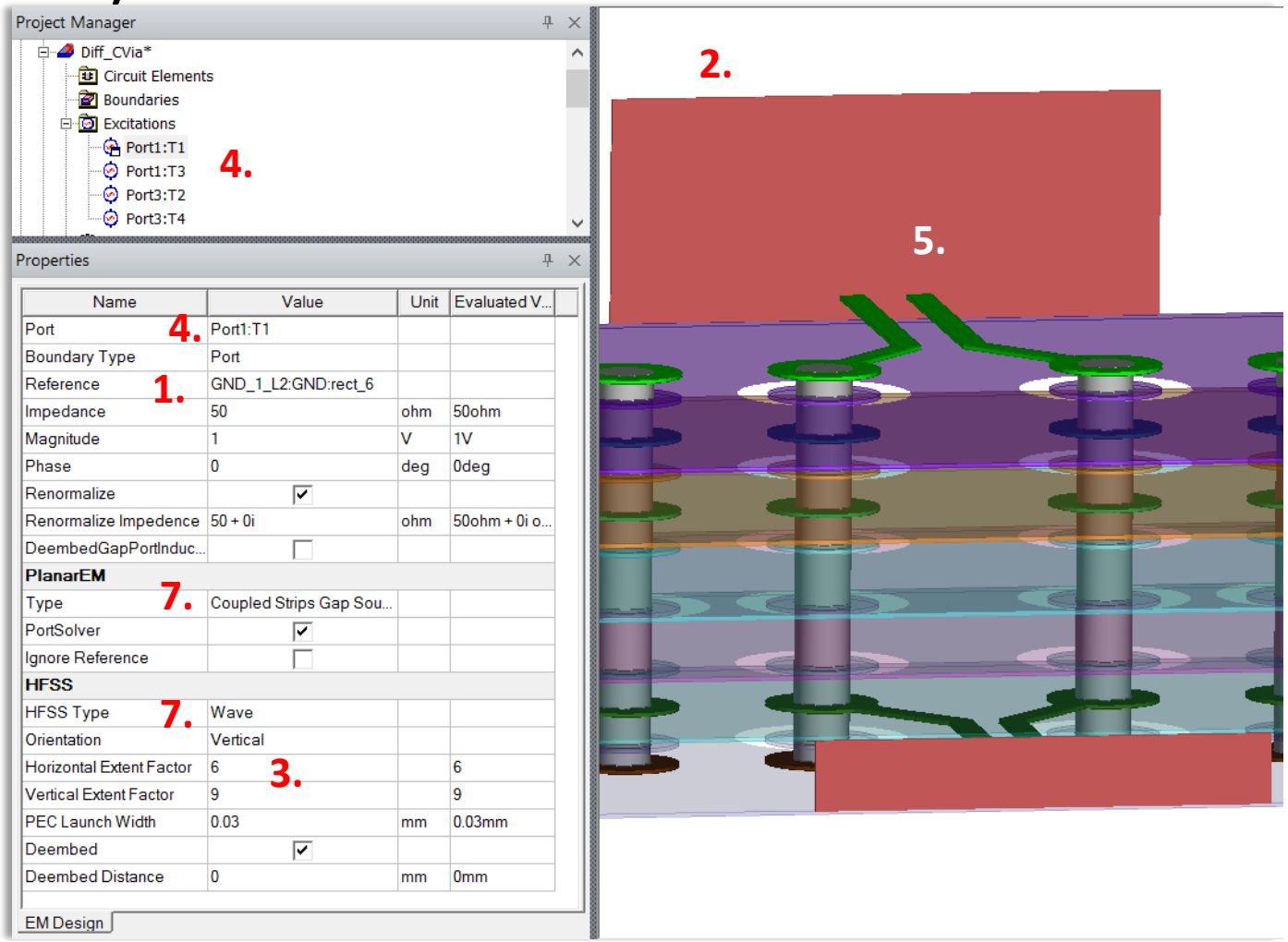
The definition of stripline includes ground planes above and below the signal trace.



Wave ports can take two reference planes into account.

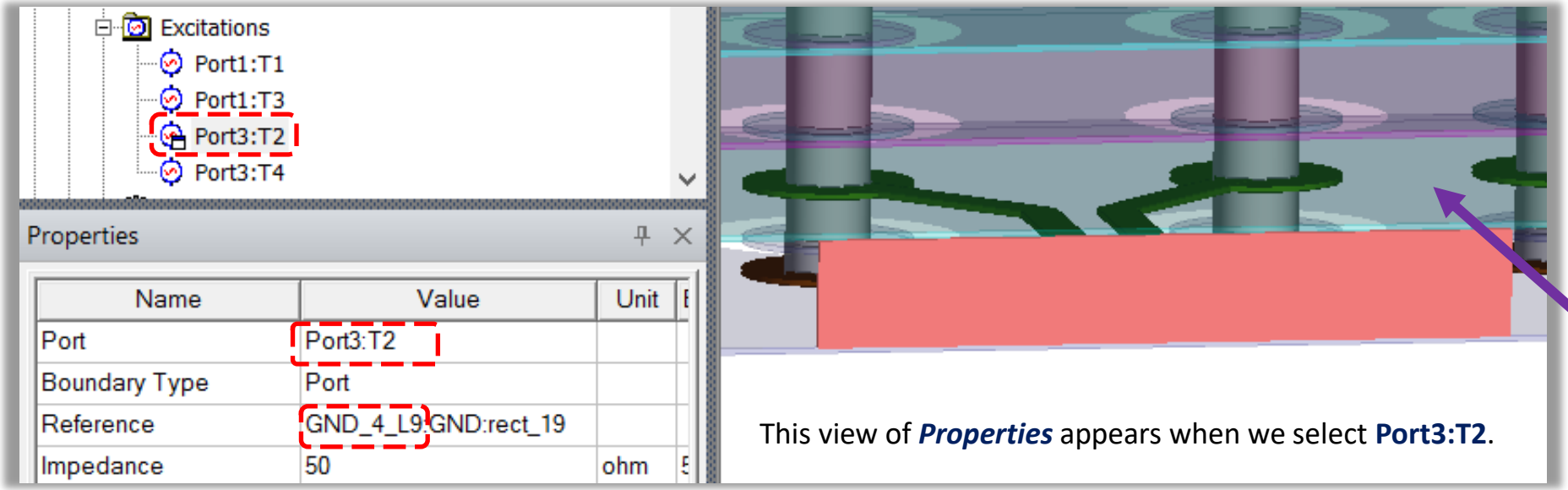
Wave Ports Overview in HFSS 3D Layout

1. Wave ports have reference planes.
2. Wave ports generate their own geometry.
3. Wave ports have extent factors.
4. Wave ports have excitation terminals.
5. Wave ports can have many excitation terminals.
6. Wave ports have net names. (not shown on this page)
7. Wave ports work with the HFSS and planar EM solvers, but not with the SIwave solver in HFSS 3D Layout.



This single ***Properties*** tab ***EM Design*** appears when the port terminal is selected in the ***Project Manager***. If the port rectangle geometry is selected, then three tabs appear in ***Properties***

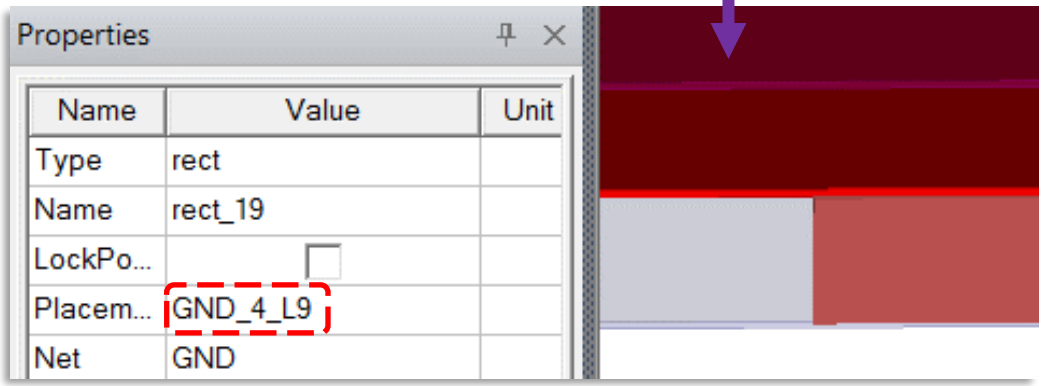
Wave Ports' Reference Planes in HFSS 3D Layout



This view of ***Properties*** appears when we select **Port3:T2**.

GND_4_L9: rect_19

When created, wave ports look up and down to find the nearest reference plane. In the case of this stripline wave port, with ground planes above and below, each of the two terminals on the ground plane has a different reference plane. ***Port3:T2*** references ***GND_4_L9: rect_19***. When we select the plane, we see in ***Properties*** both the geometry name ***rect_19*** and the net name ***GND.***



This view of ***Properties*** appears when we select **GND_4_L9: rect_19**.

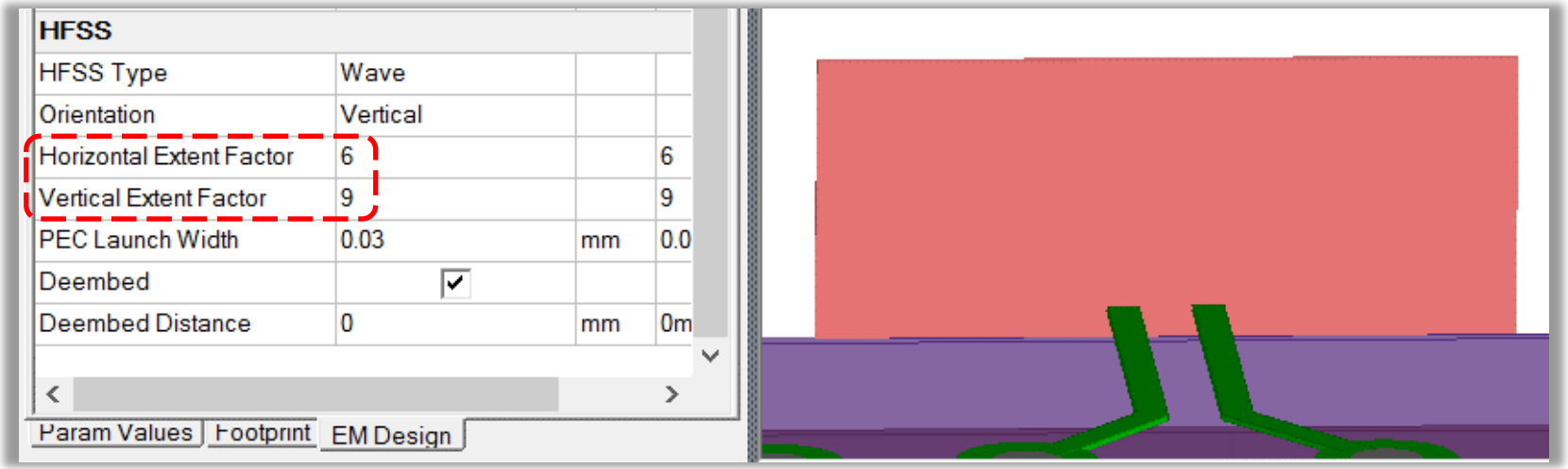
Wave Ports' Extent Factor in HFSS 3D Layout

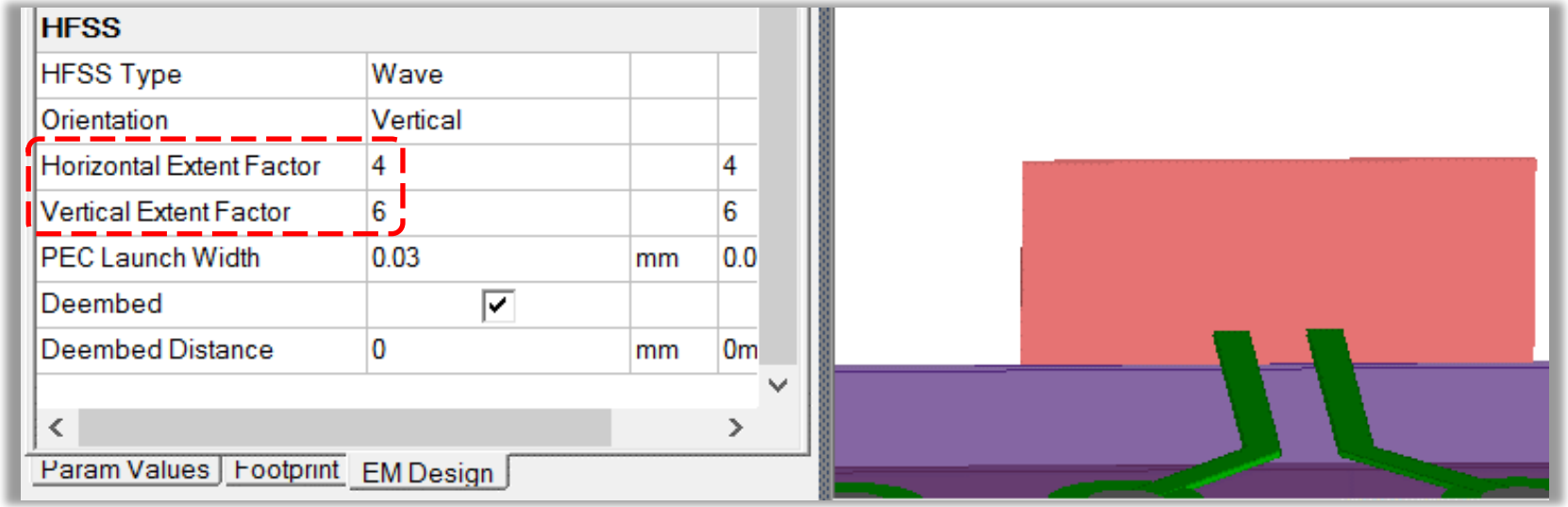
Wave ports create their own geometry, which is sized by ***Extent Factor***, which are multiples of the selected edge.

In the case of this microstrip wave port, there are both horizontal and vertical extent factors.

The stripline wave port only had horizontal extent factor.

Since the port rectangle geometry is selected, three tabs appear in ***Properties.***





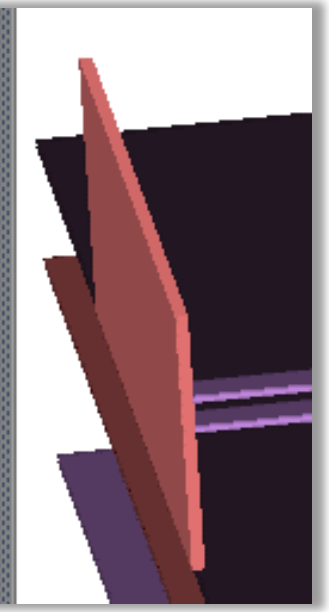
Wave Ports Have PEC Backing

Wave ports are backed by PEC (perfect electrical conductor), sometimes called a PEC cap.

The wave port does not need to be on the outer boundary of the simulation space (the extents).

In the ***Properties*** menu for the wave port, the thickness of the port appears in the ***PEC Launch Width*** line.

PlanarEM			
Type	Coupled Strips Gap ...		
PortSolver	☑		
Ignore Reference	☐		
HFSS			
HFSS Type	Wave		
Orientation	Vertical		
Horizontal Extent Factor	6		6
Vertical Extent Factor	8		8
PEC Launch Width	1.45	mil	1.4



Wave Ports in HFSS 3D Layout versus HFSS MCAD Fully Arbitrary

Characteristic	HFSS 3D Layout - ECAD	HFSS MCAD
Geometry …the rectangle needed for wave port definition	Geometry gets created with port creation.	Ports get assigned to an existing geometric object.
Reference	At least one ground reference plane is needed.	No reference plane is needed.
Boundary/backing	Wave ports have extents factors.	Wave ports have boundaries.
Terminals	HFSS 3DL corresponds to driven terminal; wave ports have terminals.	Driven modal or driven terminal are both available, in driven modal wave ports can have modes and no terminals.
Deembedding	Wave ports can be deembedded.	Wave ports can be deembedded.

Edge Port is a Geometric Designation

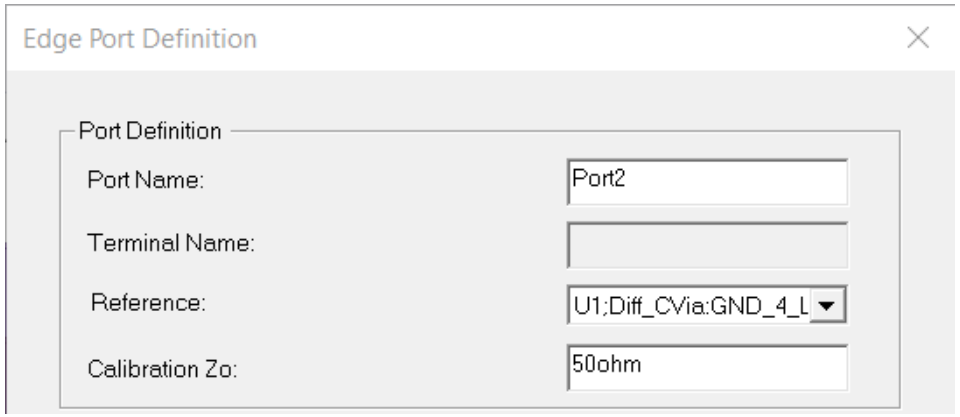
An edge port is a port attached to a physical edge.

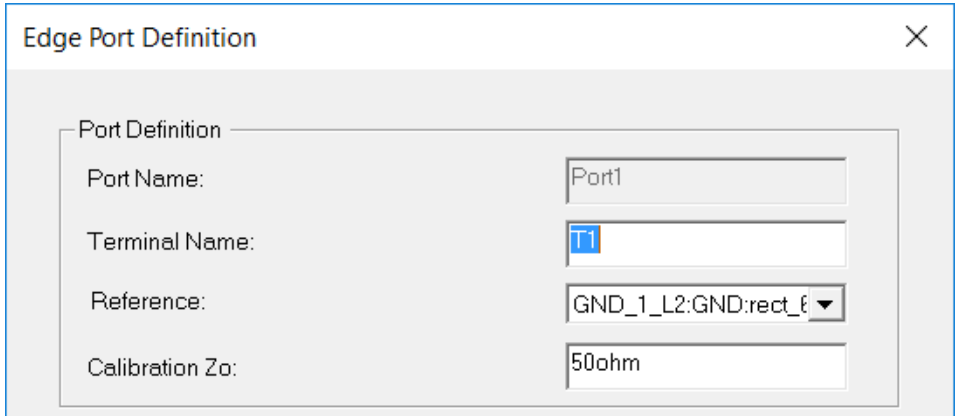
Wave* ports** and ***Gap ports can both be considered edge ports in HFSS 3D Layout.

Edge ports can also be thought of as a way to create a port. If you select one edge, perhaps the end of one transmission line in a differential pair, you get a gap port. If you select the edges of both transmission lines, you get a wave port.

The term edge port appears in menus. In the ***Project Manager***, under ***Excitations*****,** double-click on different ports to see the ***Edge Port Definition*** menu.

The term edge port also appears in the HFSS 3D Layout documentation.

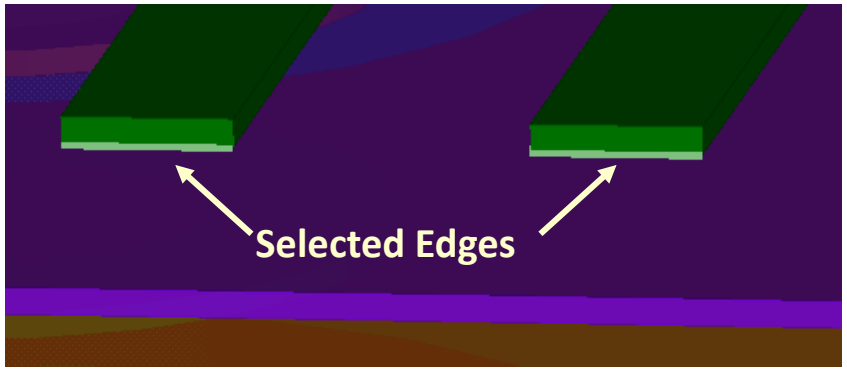




*The presence of a terminal **T1** tells you that this bottom definition refers to a wave port with more than one terminal. The top definition refers to a gap port.*

Gap Ports for One Terminal - Wave Ports for Two

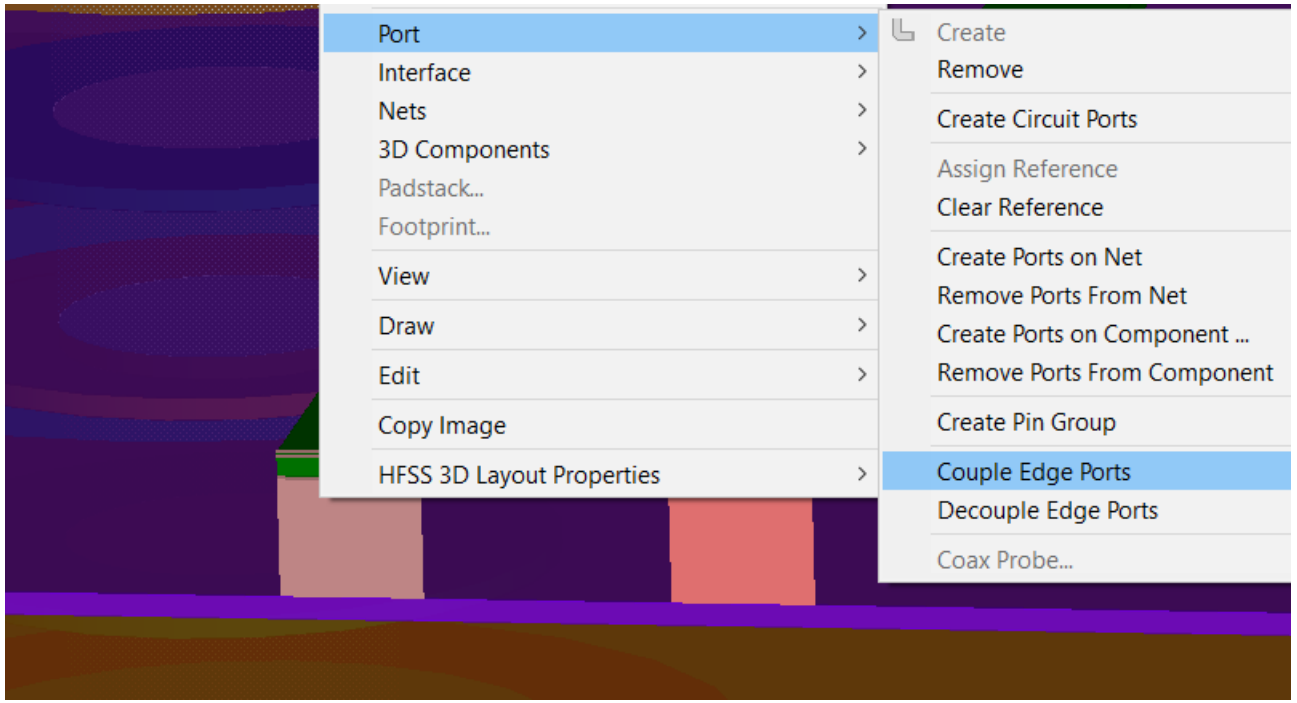
Select one edge, get a gap port.

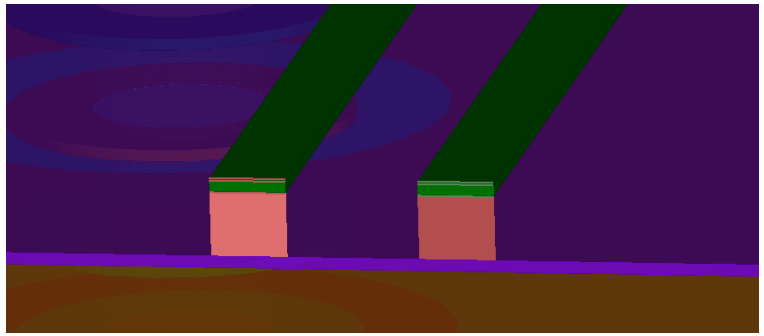


Select two edges, get a wave port.

Two Gap Ports Can Group into a Wave Port

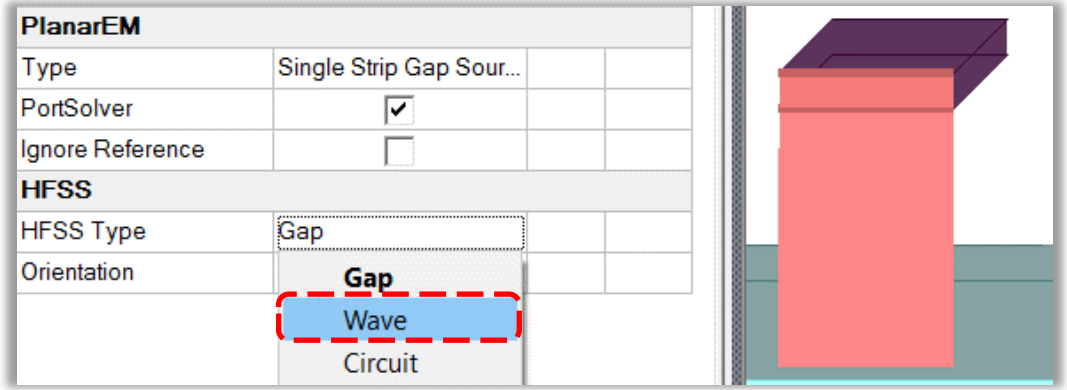
Two ***Gap*** ports can be coupled to form a ***Wave*** port.





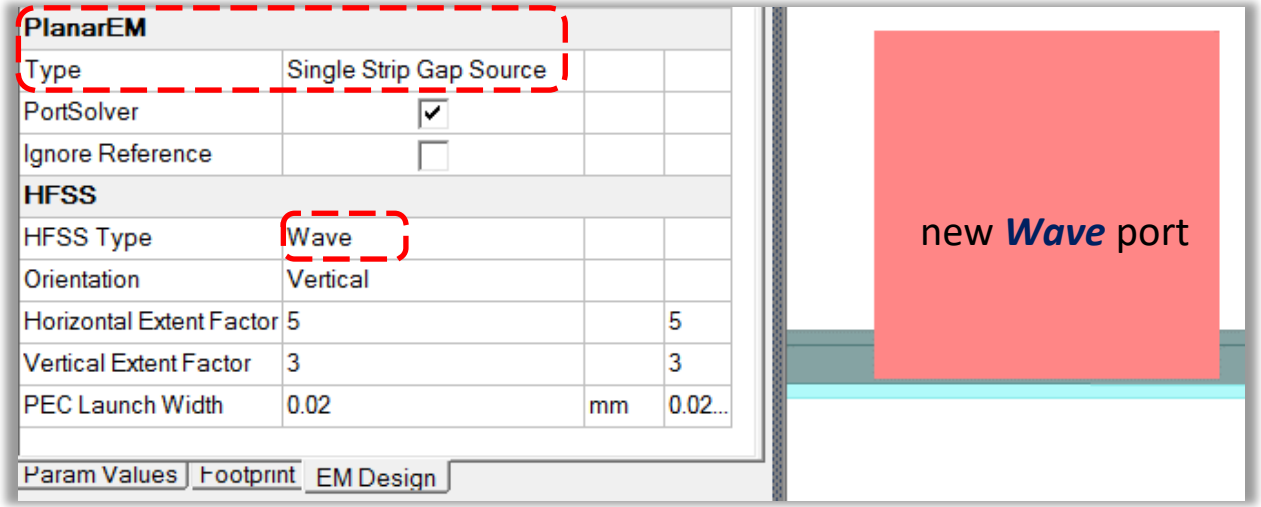
Converting One Gap Port to a Wave Port

A (single individual) *Gap* port can be converted to a *Wave* port in the port *Properties*. (Select/highlight the port geometry in the layout editor and the *Properties* appear.) Right-click and select *Wave*.



To convert a ***Gap*** port to a ***Wave*** port on microstrip, right-click and select ***Wave***.

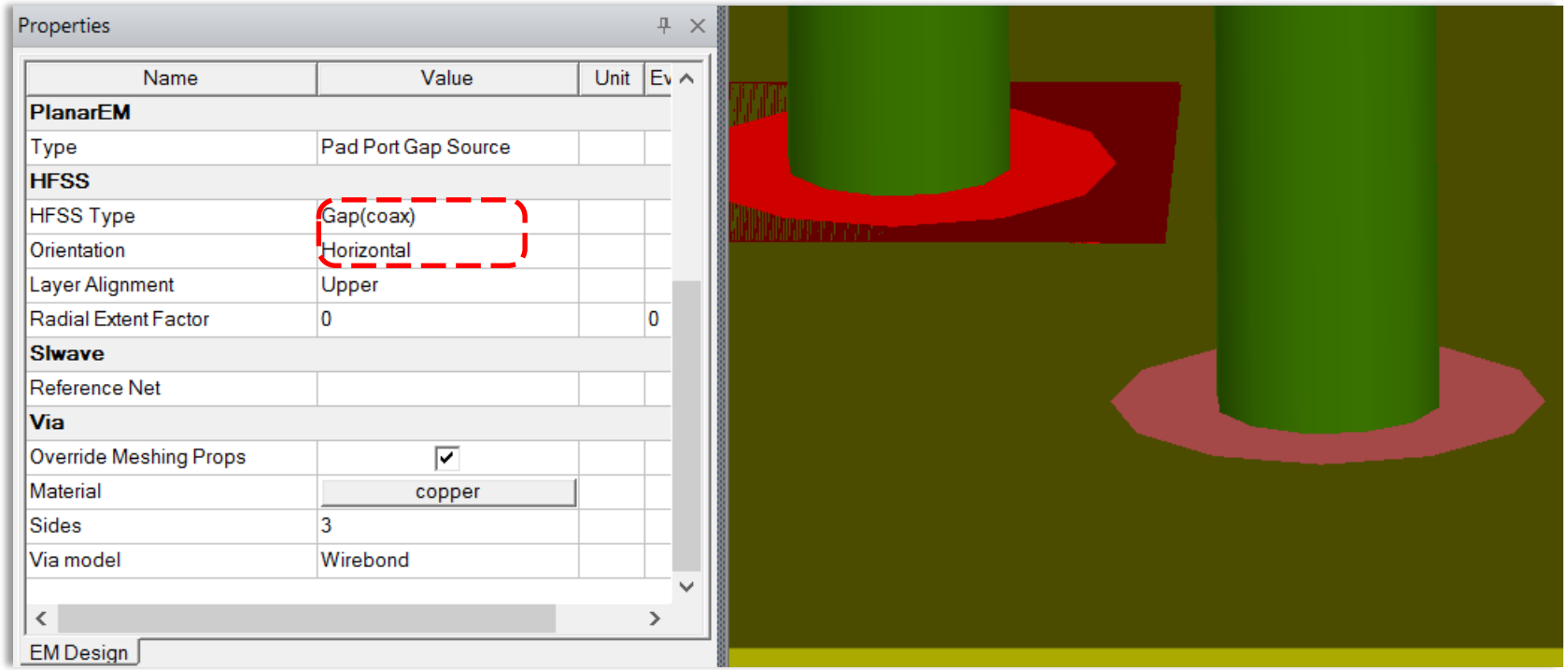
Notice that after changing the port from ***Gap*** to ***Wave***, from the point of view of the ***HFSS*** solver, the ***PlanarEM Type*** remains the same ***Single Strip Gap Source***.



Gap(Coax) Ports in HFSS 3D Layout

In addition to the ***Gap*** port, that connects microstrip traces to a ground reference, there are ***Gap(coax)*** ports which have a coaxial cross section.

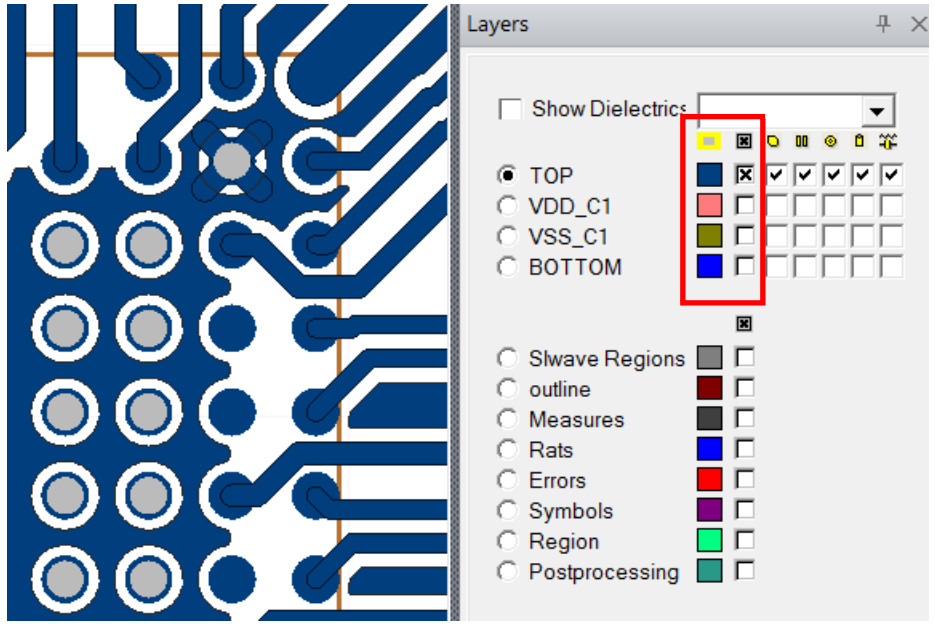
Gap(coax) ports are often created by selecting a ***Pin*** and choosing ***Create > Port***.



HFSS 3D Layout Gap(Coax) Port - Edge Selection

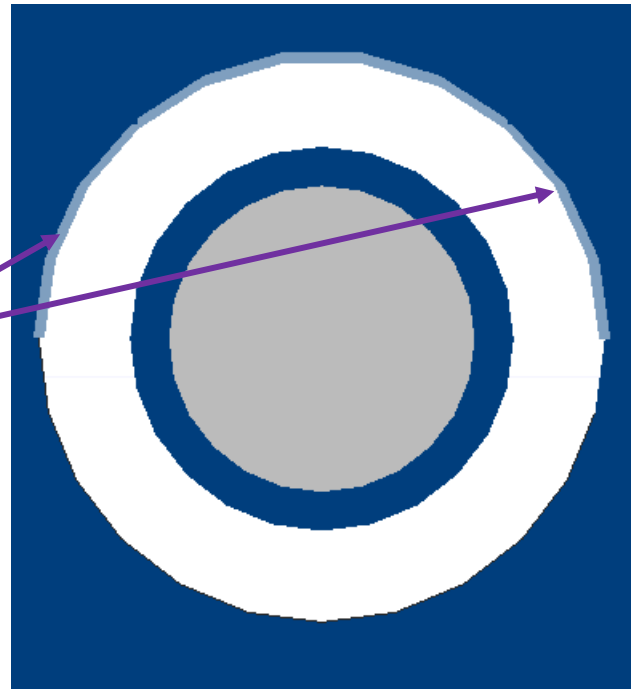
Looking down on a BGA (ball grid array), we show only the top layer. (Notice the empty check boxes below ***Top Layer***).

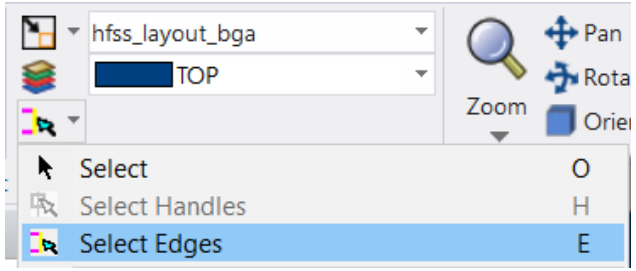
In this example, the only reason a coax port is created instead of a rectangular lumped port is that the selected edge is an arc-segment.



Press ***E*** to invoke ***Select Edges***.

Click on the outside edge of the torus shape to select an edge for the ***Gap(coax)*** port.

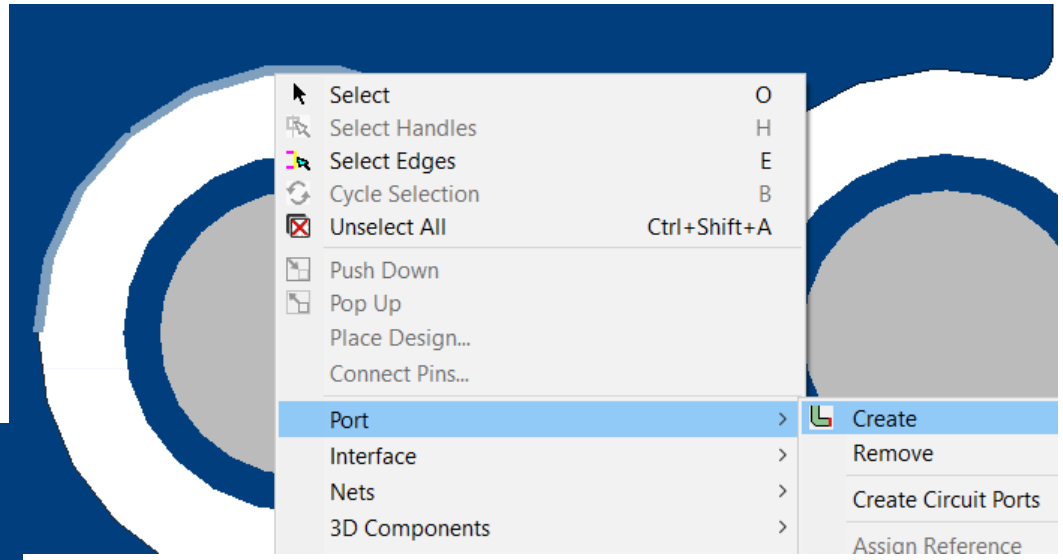




HFSS 3D Layout Gap(Coax) Port in Horizontal Plane

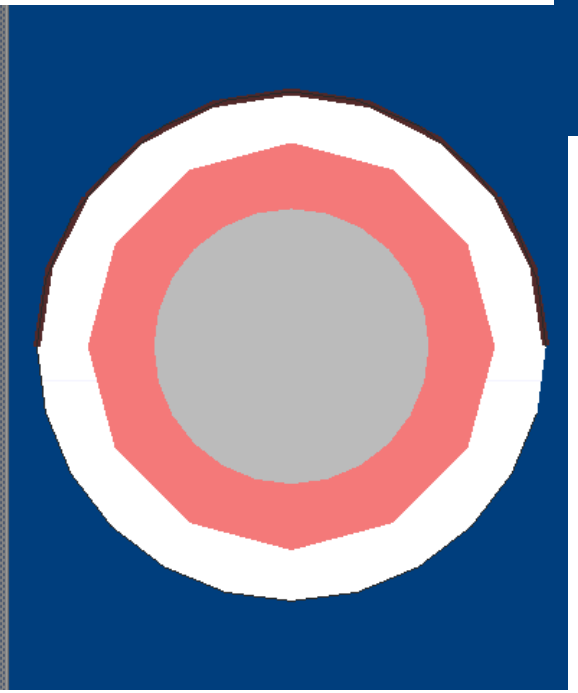
With the edge selected, choose ***Port > Create*** to get a ***Gap(coax)*** port.

These a ***Gap(coax)*** ports include intelligent pre-processing that can subtract geometry to size the port and automatically assign terminals.



Properties

Name	Value	Unit	Eva...
Port	Port1		
Boundary Type	Port		
Reference			
Impedance	50	ohm	50o...
Magnitude	1	V	1V
Phase	0	deg	0deg
Renormalize	☑		
Renormalize Impeden...	50 + 0i	ohm	50o...
DeembedGapPortInd...	☐		
PlanarEM			
Type	Pad Port Gap Source		
HFSS			
HFSS Type	Gap(coax)		
Orientation	Horizontal		
Layer Alignment	Upper		
Radial Extent Factor	0		0
Slwave			
Reference Net			



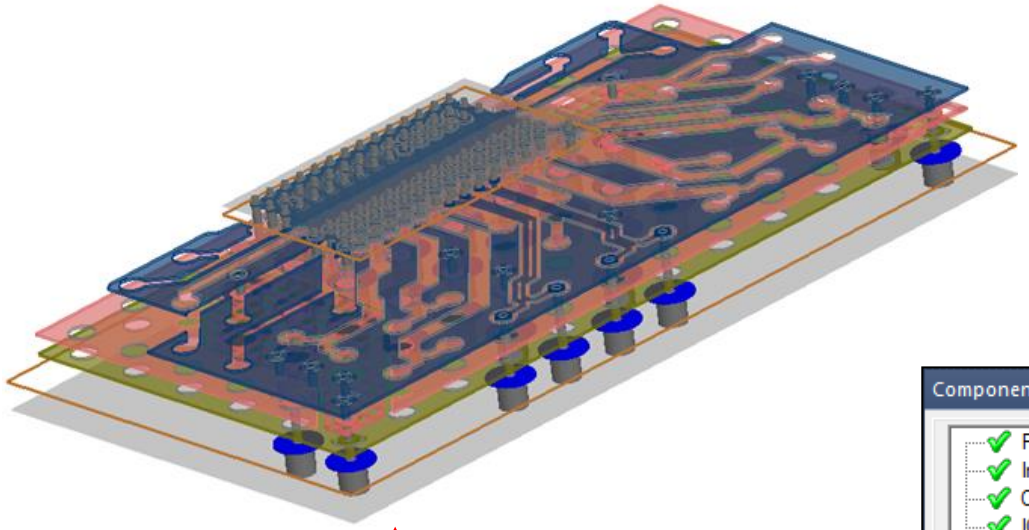
The center circle (gray-colored) pad is being driven with respect to the blue around it.

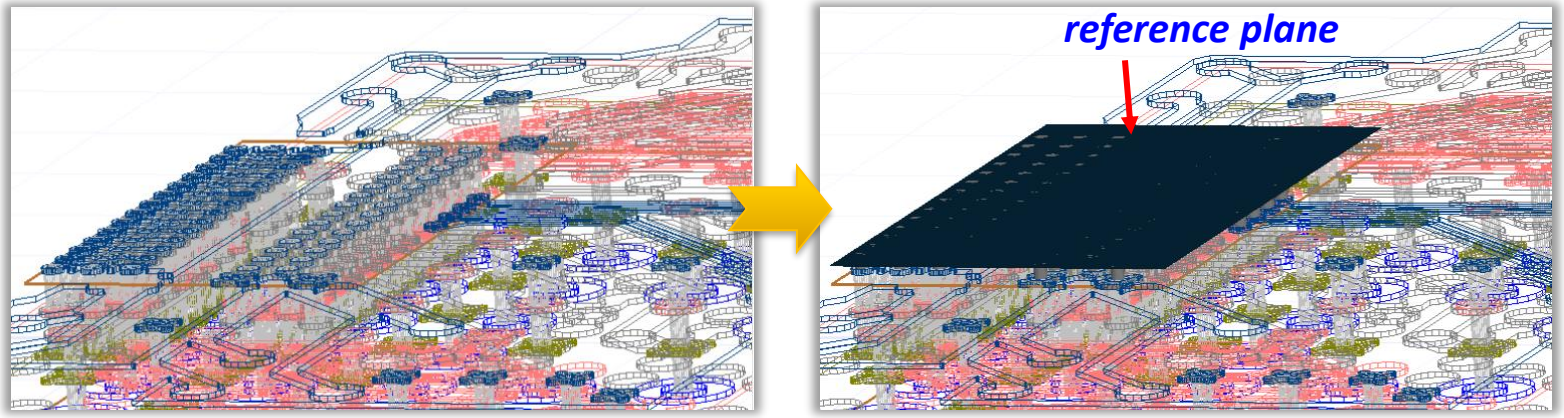
Gap(coax) port ***Properties***. Notice how the ***PlanarEM*** solver considers this to be a ***Pad Port Gap Source***.

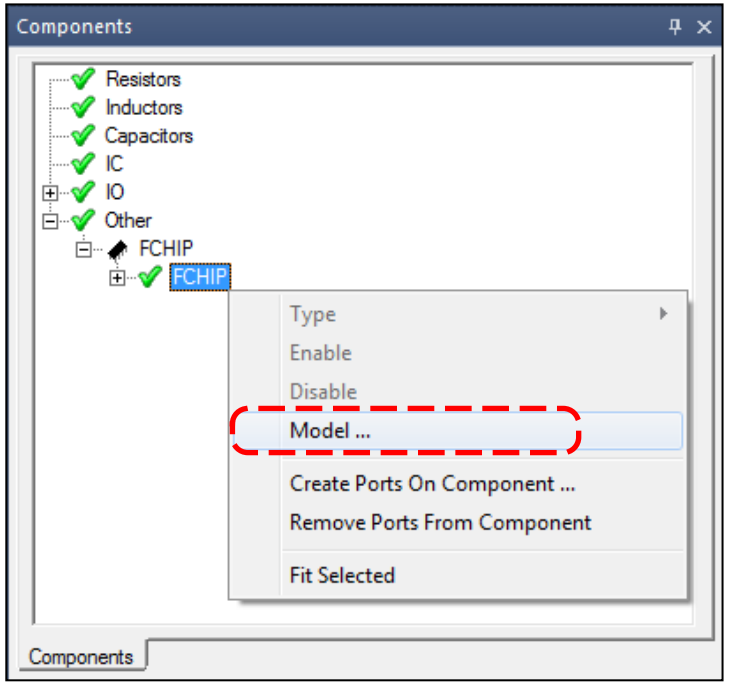
Radial Extent Factor adjusts the size of the port.

Component Level Automation of Solder Balls/Flip Chip Bumps

- Component Level Automation available in HFSS 3D Layout allows the simultaneous specification of solder balls and flip chip bumps on multiple nets.
- This automation also includes the ability to establish common reference plane for all of the connections.

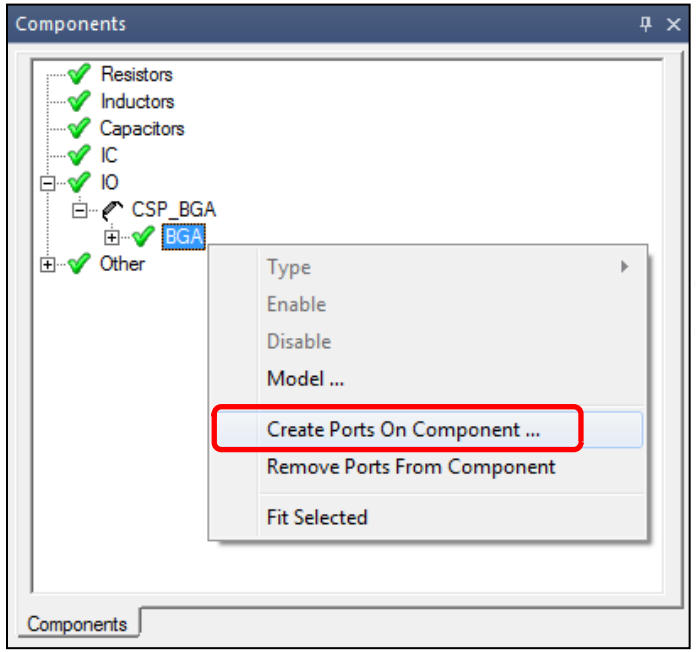


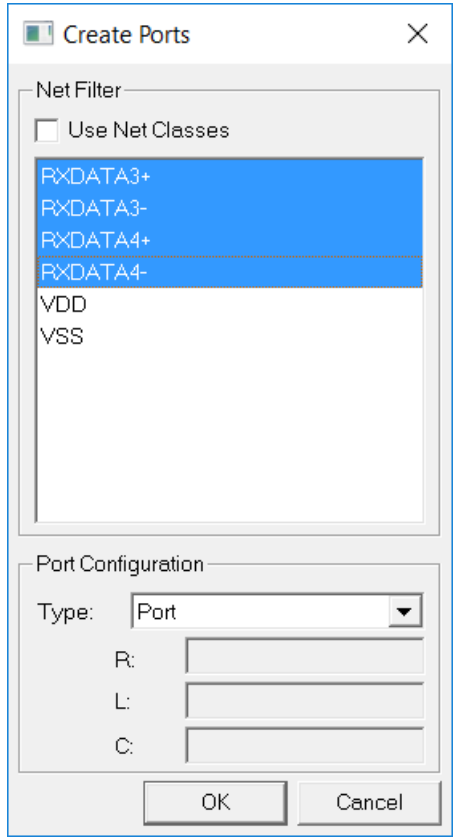


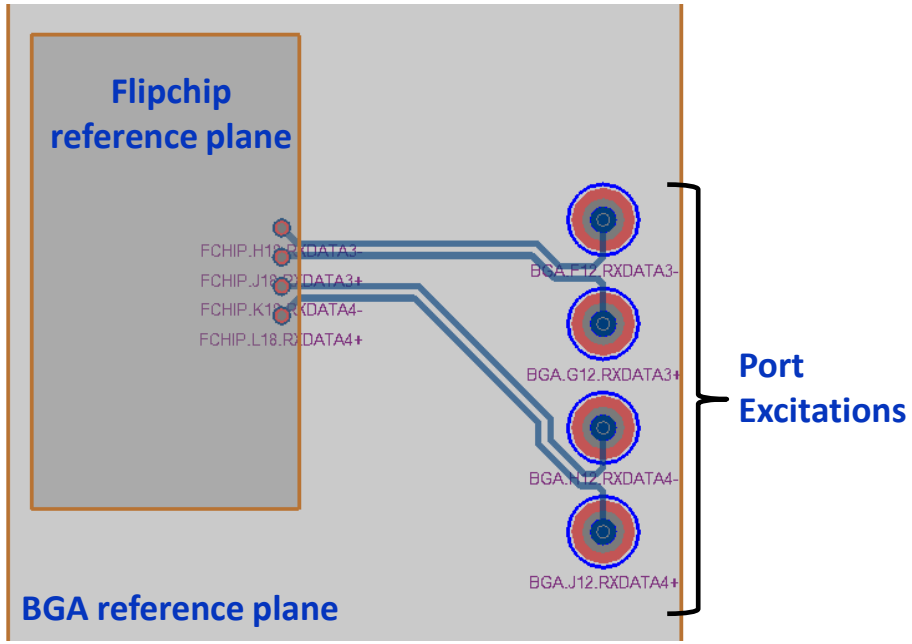


Component Level Automation to Create Multiple Ports

- Component Level Automation available in HFSS 3D Layout allows the simultaneous specification of multiple ports.
- The ports all use the common reference plane.







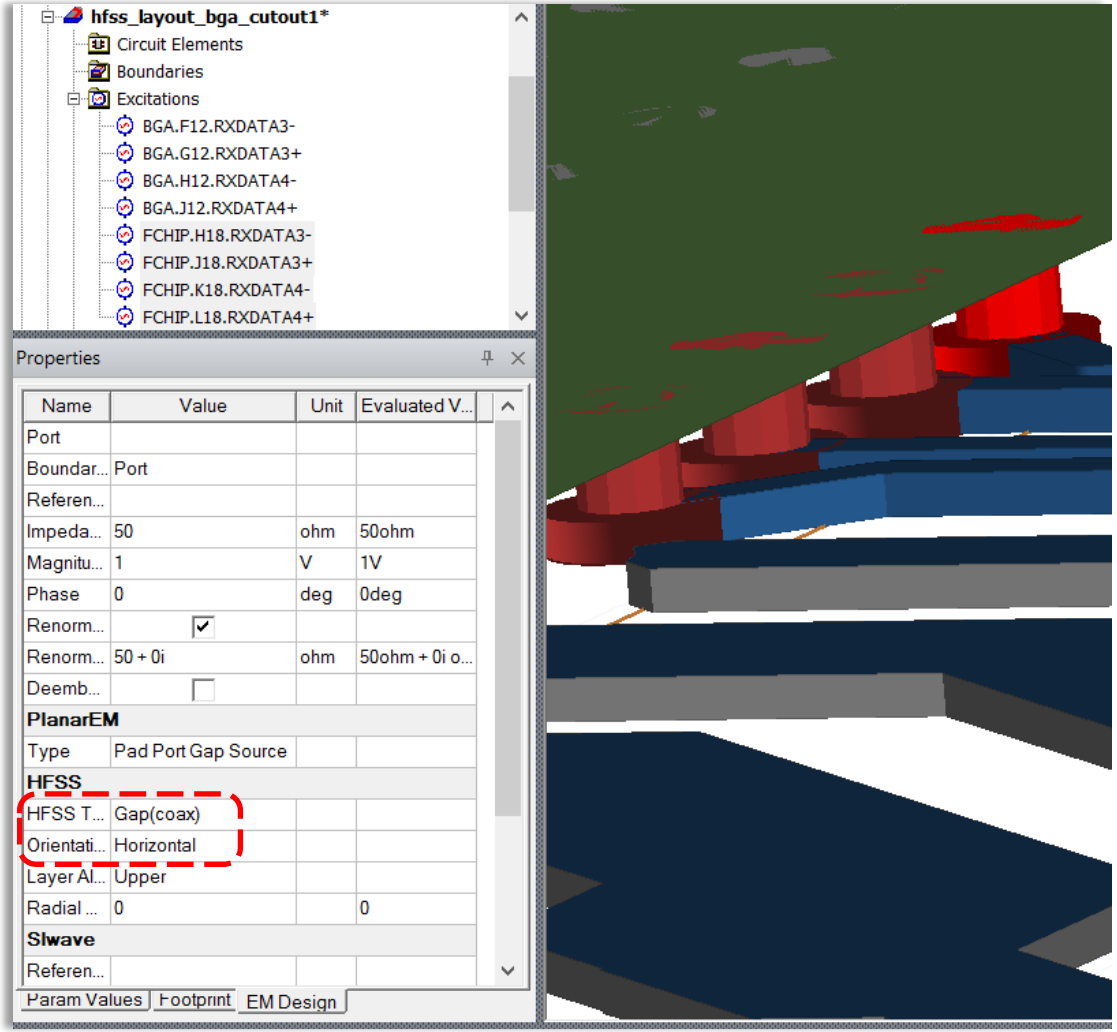
Gap(Coax) Port Automation Based on Reference Offset

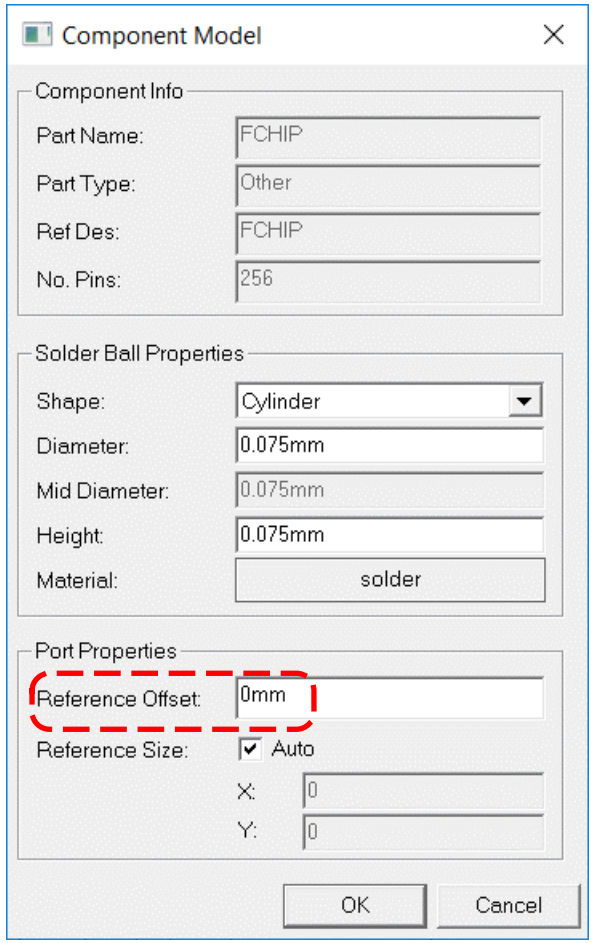
Solder Ball Properties are set for the ***Component*** FCHIP, which created the local reference plane.

Four ports, in red, are ***Gap(coax)*** oriented horizontally in the plane.

In the ***Component Model…Port Properties***, the ***Reference Offset*** is set to 0 mm.

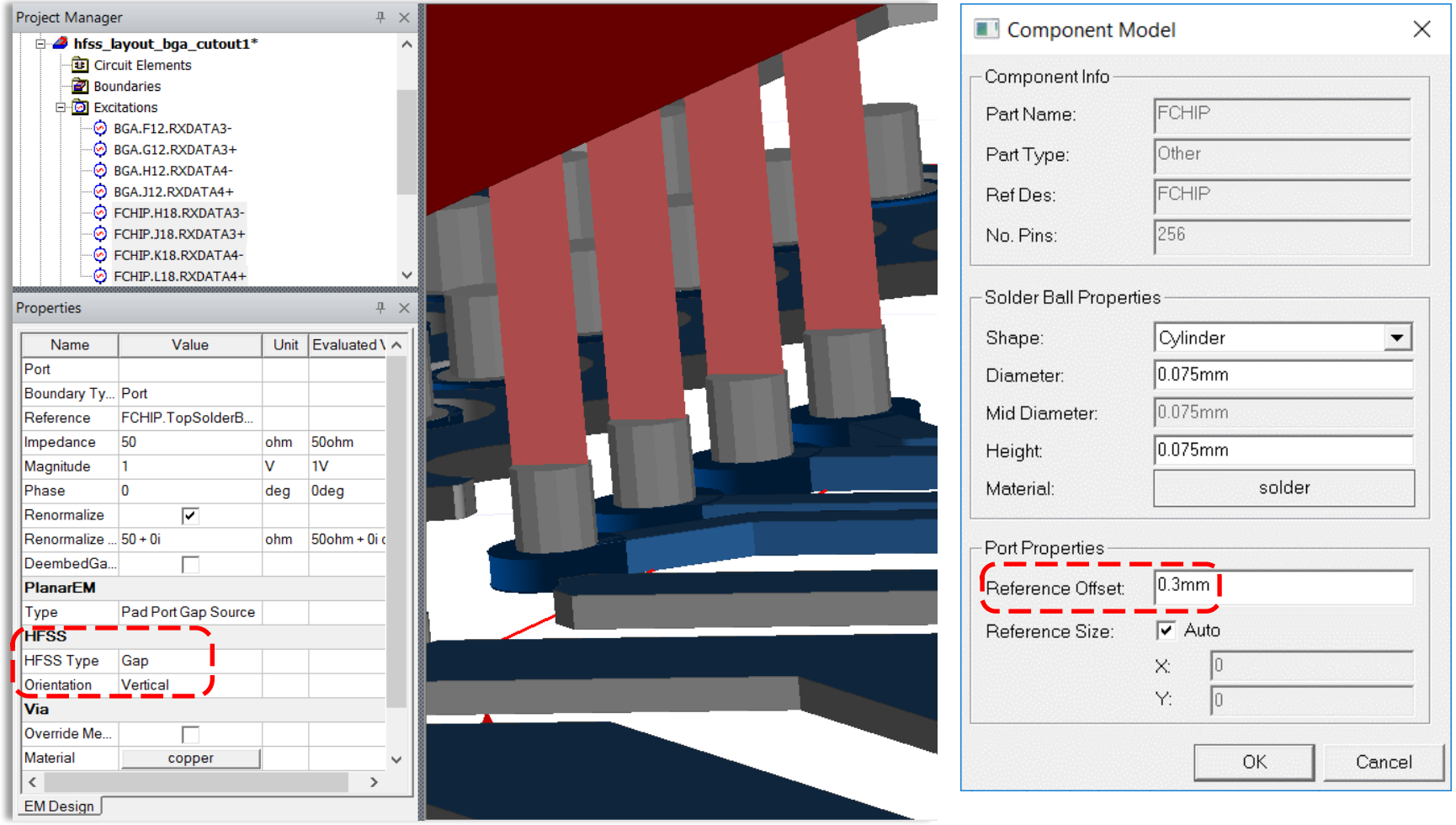
…continued…





Vertical Gap Port with Larger Reference Offset

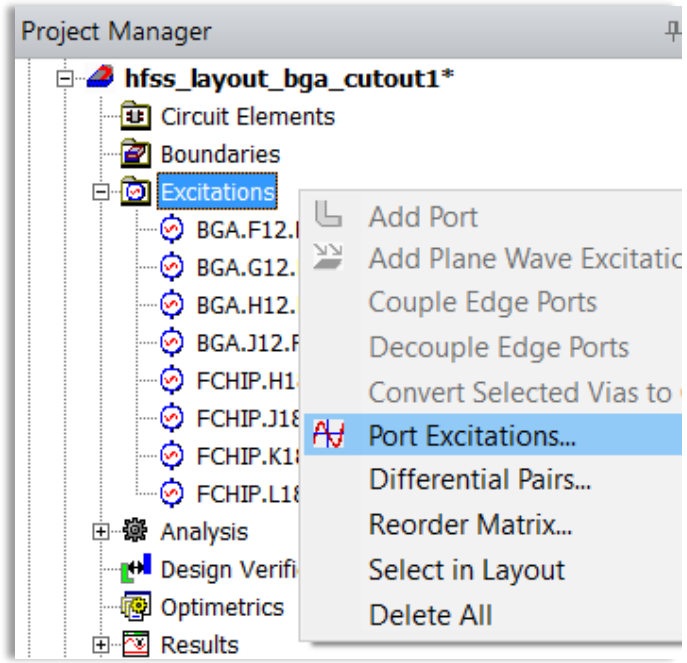
When the ***Reference Offset*** is larger (now 0.3mm), and the ***Gap(coax)*** ports are no longer valid, HFSS 3D Layout automatically changes the ***Gap(coax)*** ports to ***Gap*** ports oriented vertically.

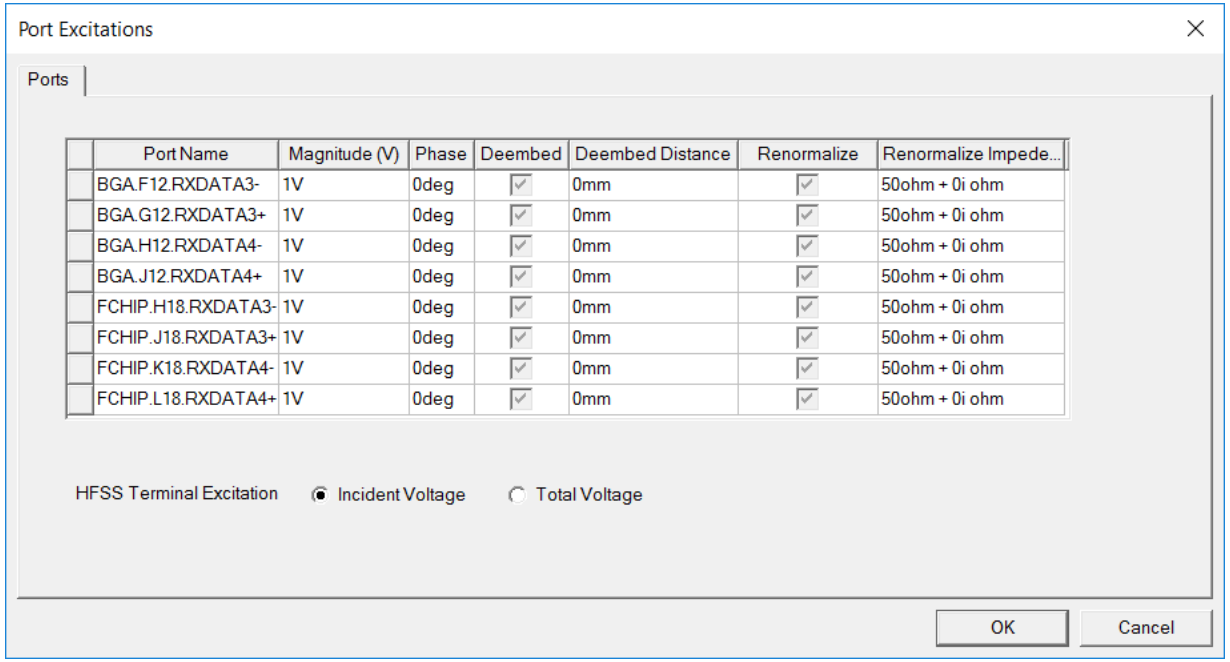


Port Excitations

Ports are listed in the ***Project Manager*** under ***Excitations*****.**

Ports Excitations include magnitude, phase, deembedding and renormalizations settings. The magnitude and phase settings affect fields post-processing.

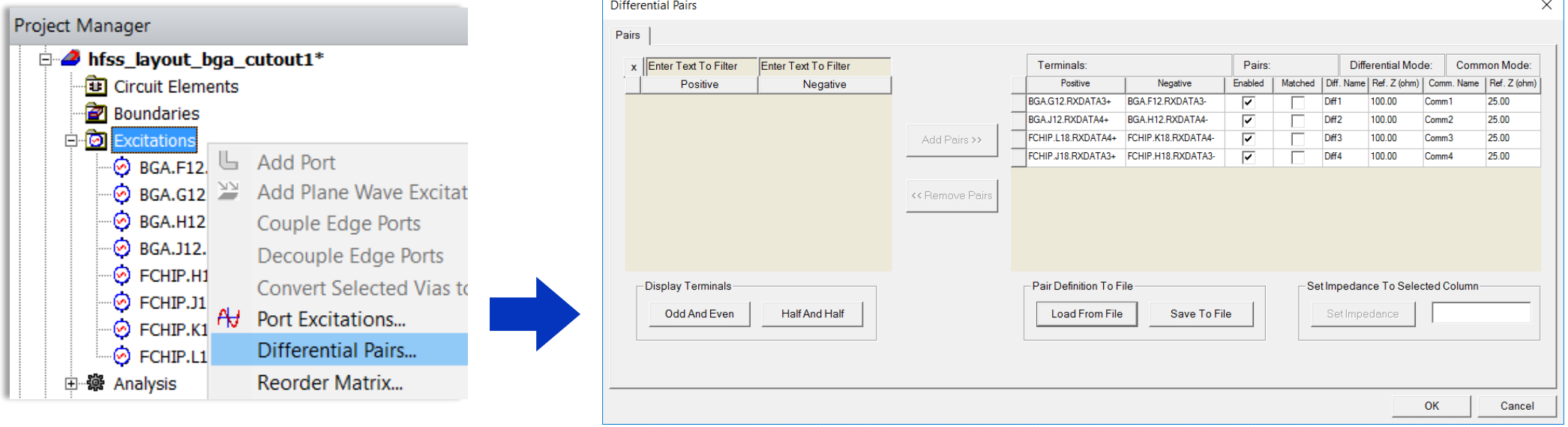




Differential Pairs Are a Post-Processing Function

Ports are listed in the ***Project Manager*** under ***Excitations*****.**

Differential Pairs do not need to be set up before a simulation. They can be configured afterward as a post-processing function. If Differential Nets are defined in the layout editor, the differential pairs can be automatically created from this dialog.



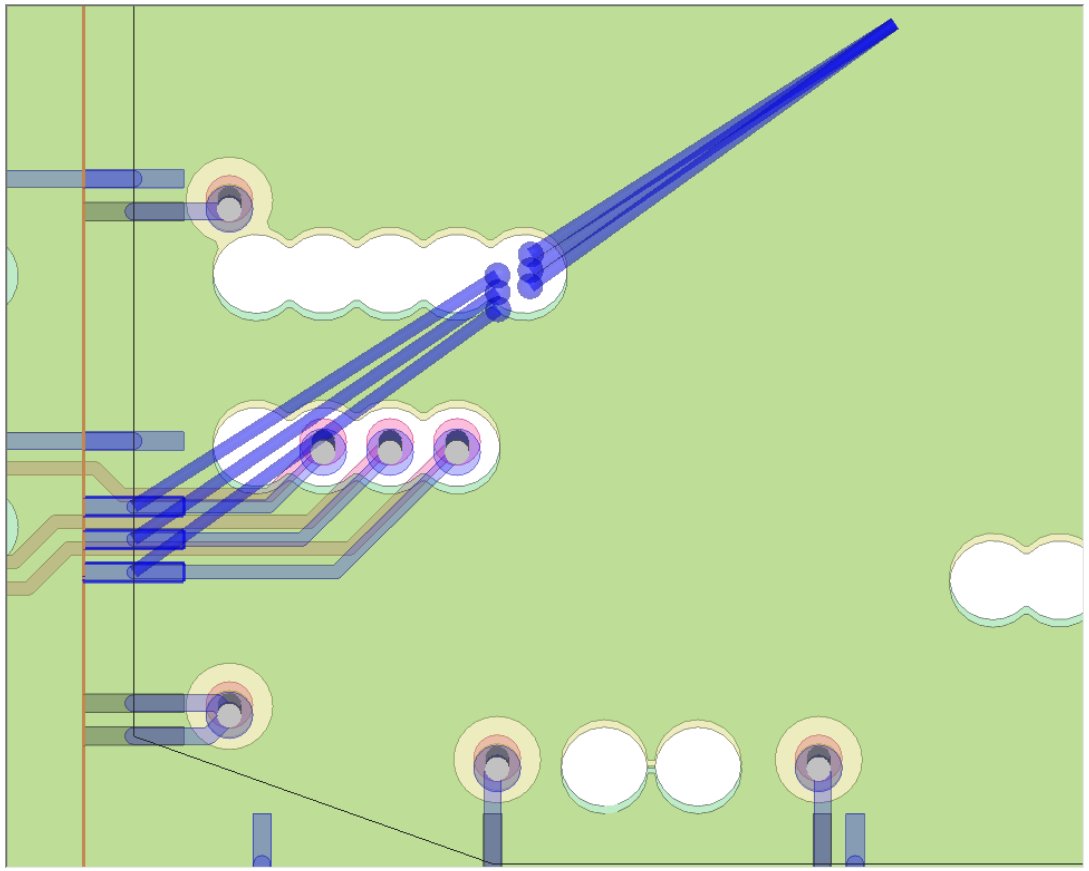
Circuit Ports

Circuit ports in HFSS 3D Layout are circuit element sources along with an impedance. Circuit ports are connected between any two points in the mesh. Circuit ports are presumed to be electrically short.

Circuit ports can be placed between points in the model with no physical constraints.

The generality of circuit ports, e.g. the ability for a circuit port to penetrate through a ground plane, also requires that care be exercised in the use of circuit ports.

Circuit Ports are always used by the SIwave solver. HFSS gap ports are converted to Circuit Ports when invoking the SIwave solver.



HFSS 3D Layout Ports Depend Upon Solver Choice

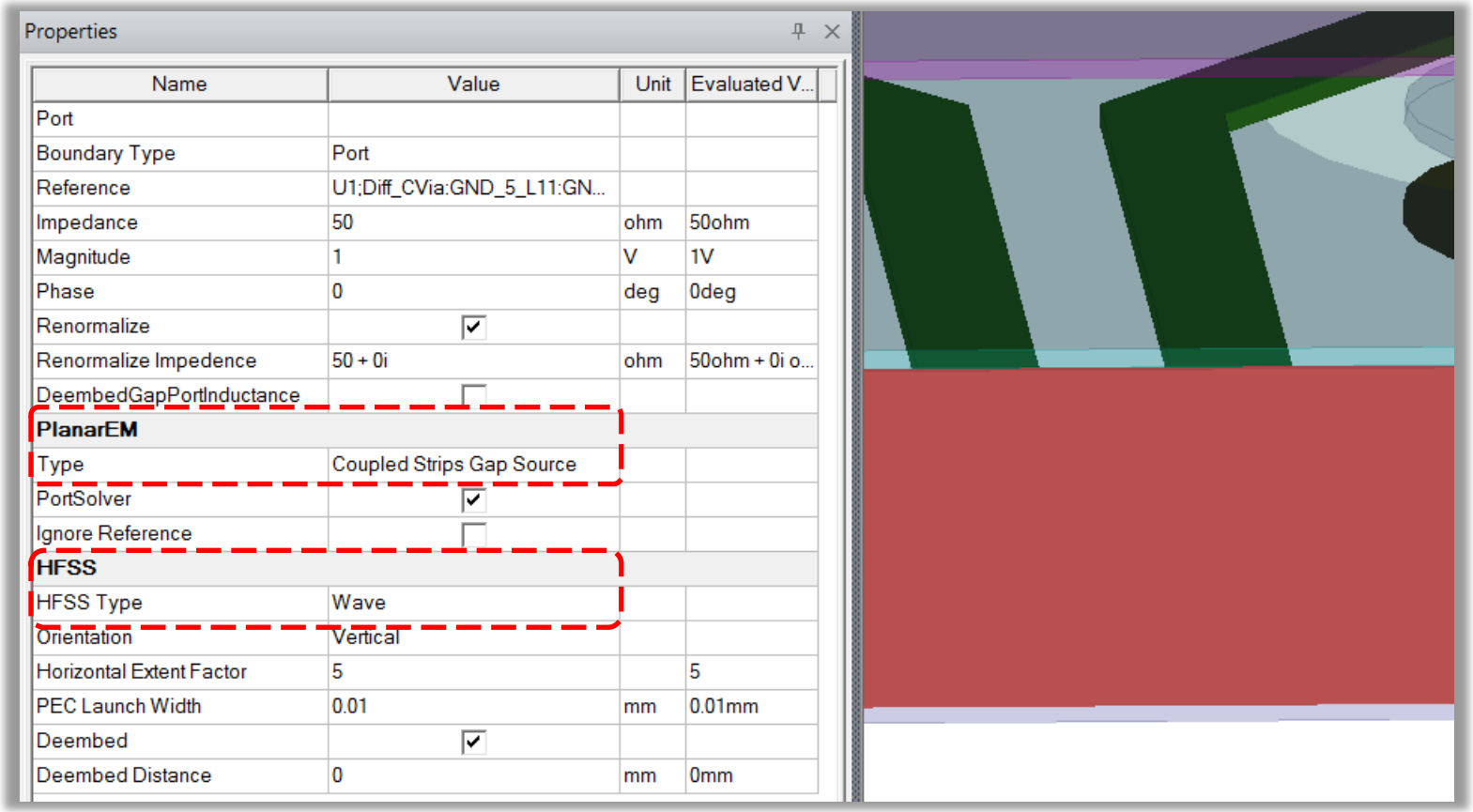
HFSS 3D Layout attempts to accommodate multiple solvers with the same port structure. In the example below, what the ***HFSS solver*** will interpret and simulate as a wave source, will be interpreted and simulated as ***Coupled Strips Gap Sou***rce by the ***PlanarEM*** (planar method-of-moments - MoM - solver).

Wave Ports for the HFSS solver

versus

Coupled Strips Gap Sources

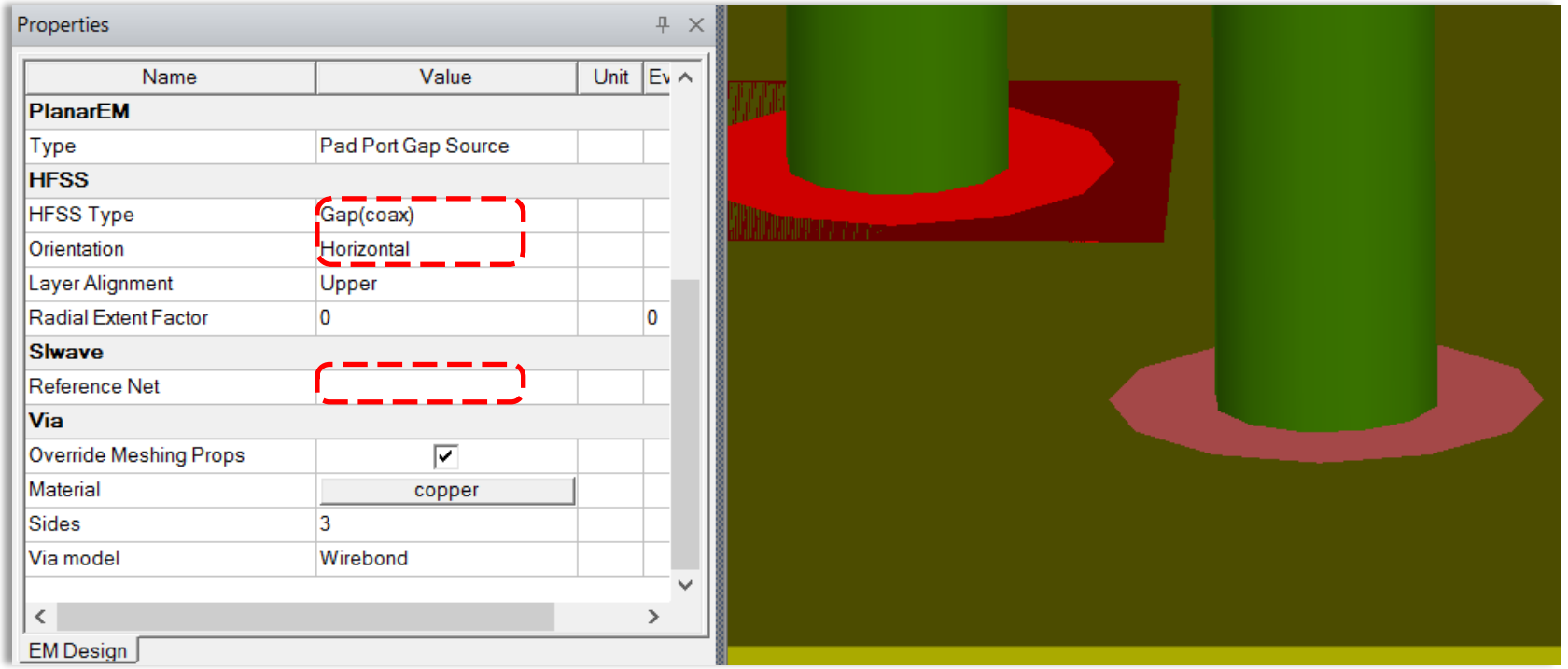
for the PlanarEM solver



Gap(Coax) Ports for HFSS Map to Circuit Ports for SIwave Solver

Gap(coax) ports for the HFSS solver in HFSS 3D Layout correspond to ***Pad Ports*** for the ***PlanarEM*** solver. The term pad port refers specifically to the context of planar EM (planar method-of-moments - MoM).

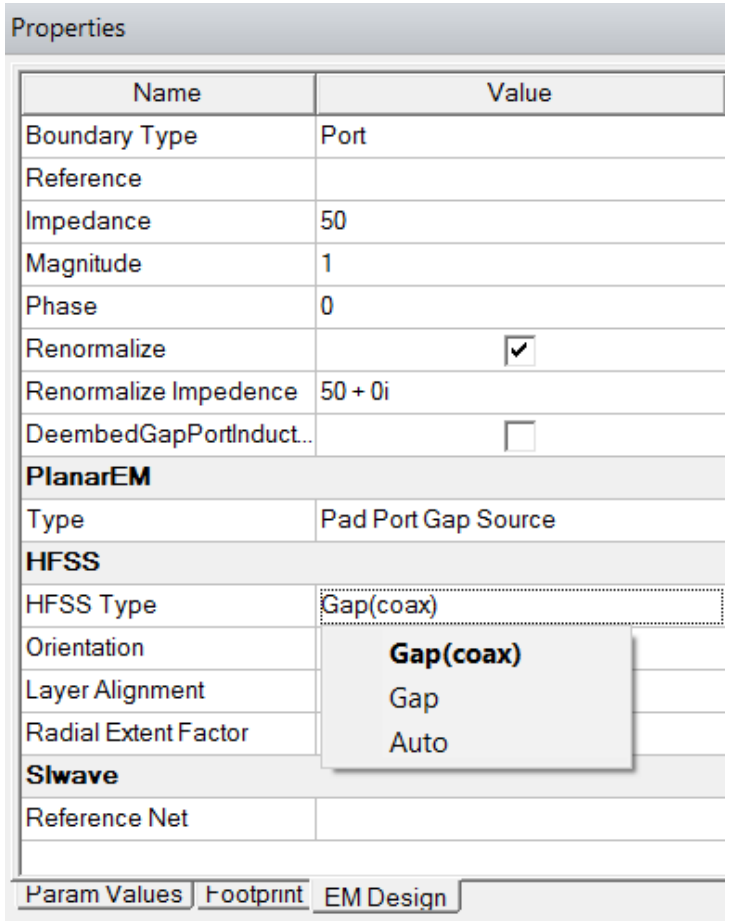
Gap(coax) don't have any realization for the SIwave solver. For the SIwave solver, HFSS 3D Layout always casts gap ports as ***Circuit*** ports. The user can assign a reference net.



Auto Port Type

An ***Auto*** port type goes through a progression of logic in an effort to always find a valid port type

Auto ports are used mainly for creating ports in an automated way, perhaps using scripts. If you're manually configuring individual ports, you're not likely to choose ***Auto*** ports.




Ansys