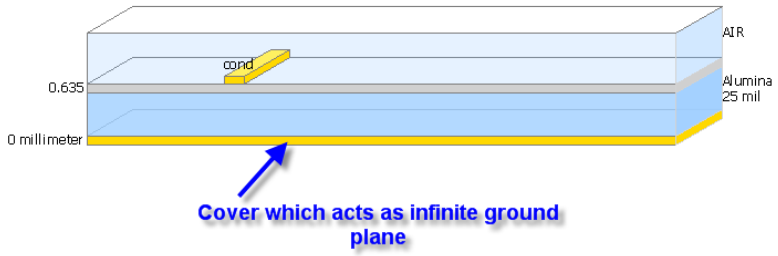
Understanding Finite Ground and Defected Ground Structures in Momentum

While performing EM simulation in ADS, we use infinite ground plane which is available by default in the substrate stackup definition. However there are situations where designers might need to have finite size ground either to model the limited ground available or at times this is also used to create defected ground structures (DGS).

ADS do offer capability to create finite ground or DGS kind of structures easily as demonstrated in this note.

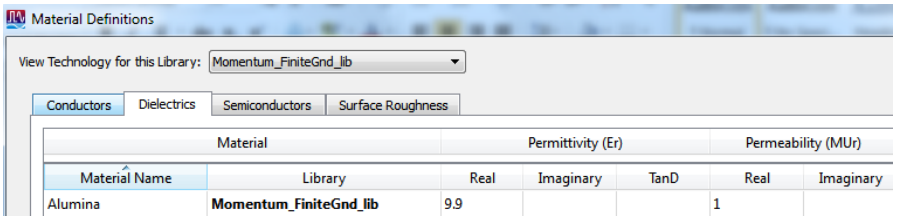
Simulation using Infinite Ground:

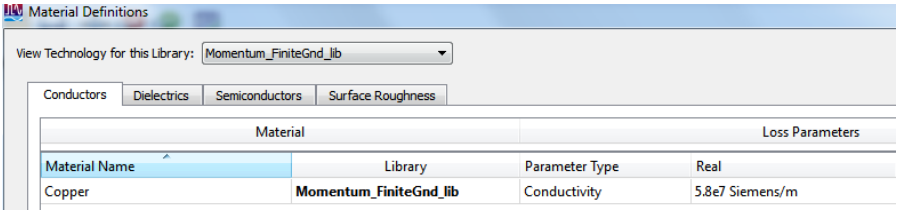
Normally when we create a new substrate in ADS following stackup is obtained whereby we have a Cover Plane at the bottom which acts as infinite ground plane. We can modify the cover layer to be a finite STRIP and same can be used to model finite ground for EM simulations.



Open a layout cell and click on Substrate icon  and select 25mil Alumina template. From the substrate editor window, click on **Technology -> Material Definitions**.

a. Modify Er (Real) of Alumina substrate as 9.9
b. From Conductors Tab, click on Add from Database and click on Copper and select OK.





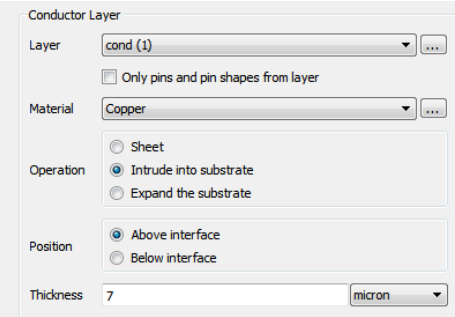
Click OK to dismiss the Material definition window.

Click on cond layer in the substrate stack up picture and modify following:

Operation -> Intrude into substrate (this shall define the metal as thick conductor)

Thickness -> 7 micron (this is the thickness of the conductor)

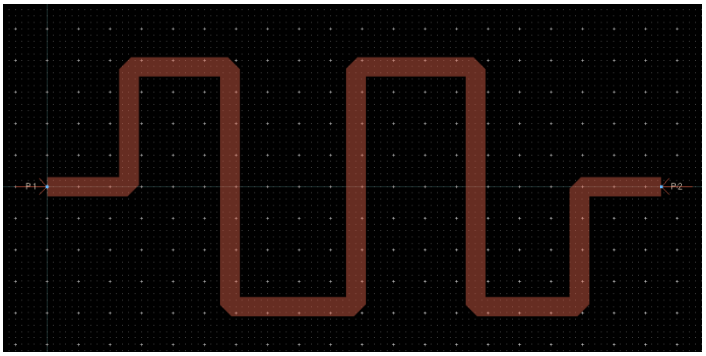
Material -> Copper



Click on File->Save and close the substrate editor.

Case Study:

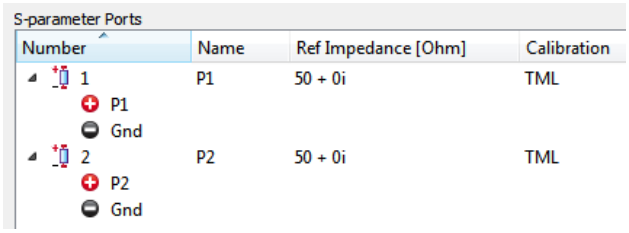
We shall use simple trace as shown below for our understanding of various options of grounding while performing EM simulation in ADS



We shall first simulate this line using the default infinite ground layer as present in the default substrate template and then model finite ground plane and DGS structure.

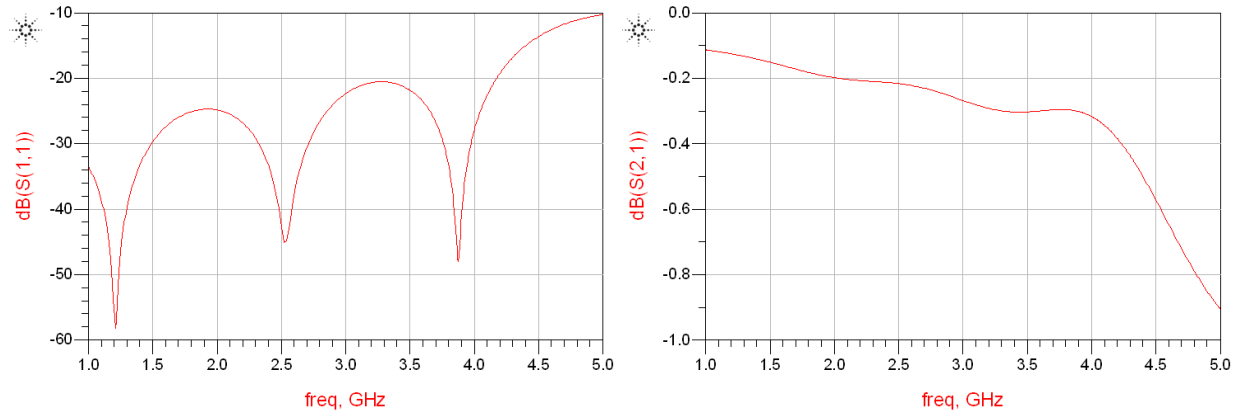
- Click on EM setup 

and click on Ports to observe the Ports setup. Here we can notice that 50Ohm termination is connected between pin P1 and Gnd and pin P2 and Gnd.



Gnd in this setup is referring to the Cover plate which is acting as infinite ground plane for EM simulation in the stackup.

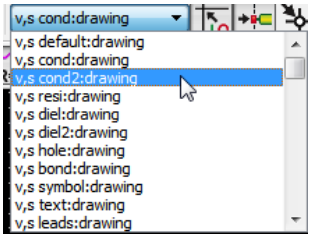
- Go to Frequency Plan and modify Start Freq = 1GHz and Stop Freq = 5GHz
- Click on Simulate button to start simulation and once simulation is finished we can see S11 and S21 results as shown in next snapshot



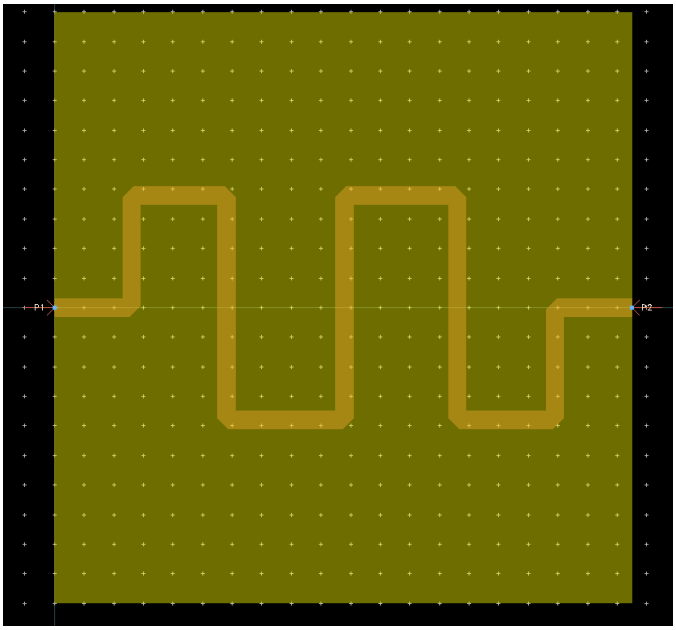
Simulation using Finite Ground:

From the layout window click on **EM-> Clear Momentum Mesh** so that the mesh created during last simulation is removed.

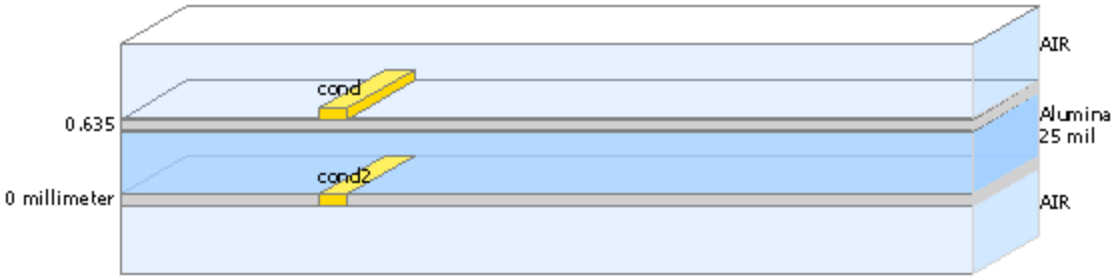
Change the drawing entry layer to cond2 as shown here. We shall use cond2 layer in our case to draw the finite ground shape with the desired dimensions.



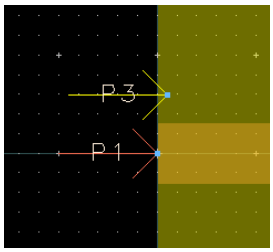
Click on Rectangle drawing icon  in the layout toolbar and draw the desired shape of the ground something similar to the one as shown below.



Click on Substrate icon in the layout toolbar  and click on the bottom cover and from the Interface option on the right side select STRIP plane as we have to map finite ground as STRIP. Right click on the bottom interface and select Map Conductor Layer and cond2 layer shall be mapped there as per the layer number order in default ADS layer setup.



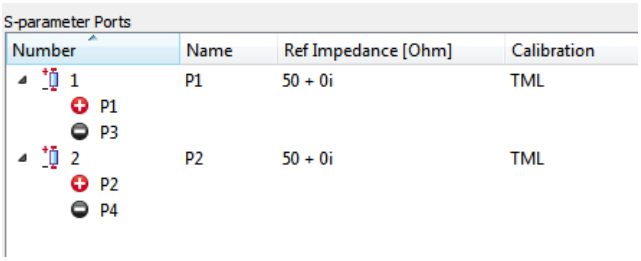
Click on cond2 and define the Material as Copper and enter thickness as 7 micron. Save the substrate and click OK to close the substrate editor.



In the layout window, place 2 more Pins on cond2 layer: **One close to P1 and another close to P2.**

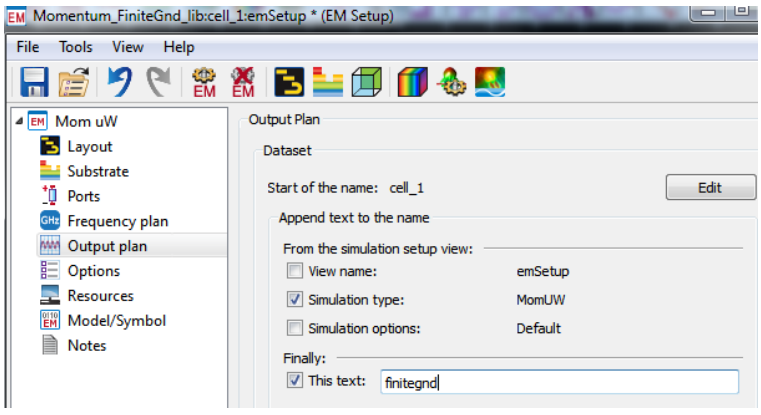
From the EM setup window, go to Ports and you shall notice that there are 4 ports with 50 Ohm termination each but this is not correct as P3 and P4 should act as –ve pins for Pin P1 and P2. Select 3 and 4 and delete them so that they appear under Unconnected Layout Pins.

Drag and drop these Pins to the –ve terminals of P1 and P2 as per the numbering in your layout something similar to shown below"

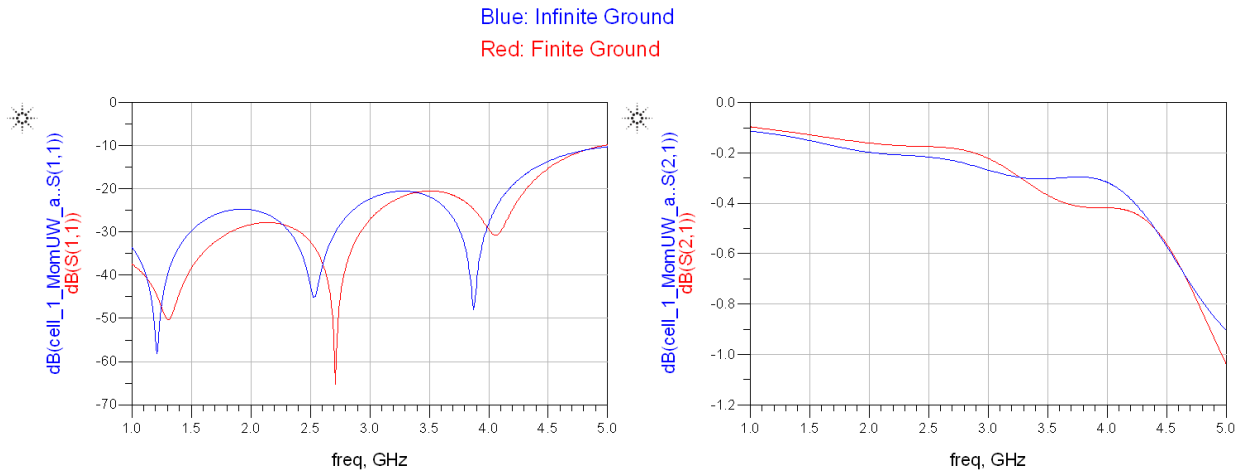


This is very important step to note as there is no meaning on Gnd in finite ground EM simulation and with this setup P3 shall act as ground reference pin for P1 and P4 acts as ground reference for P2.

Click Output plan and add a suffix "**finitegnd"** so that new dataset is created during simulation which shall allow us to compare the simulation results of infinite and finite ground results.



Click on simulate button to start simulation. Comparisons of both of these simulations are shown in the snapshot below.

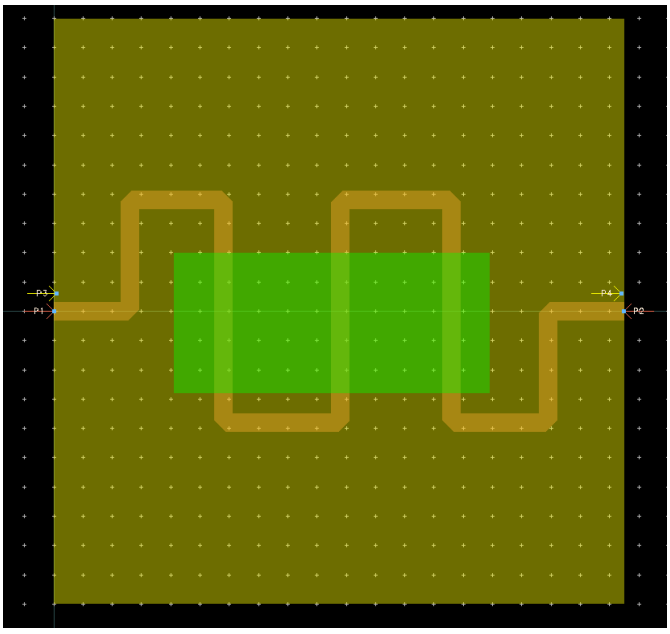


Defected Ground Structures (DGS):

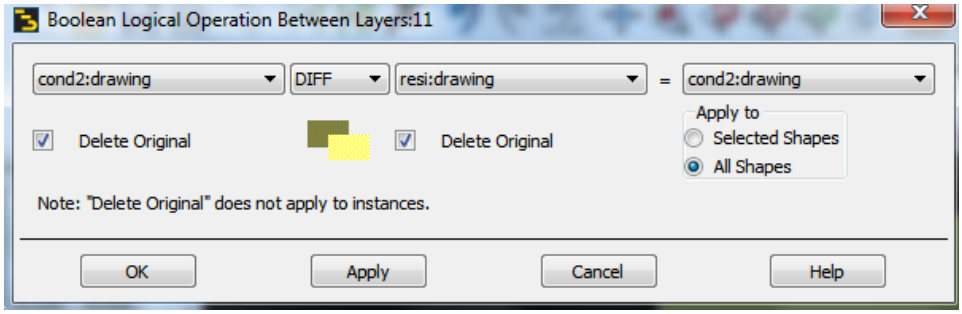
As discussed previously DGS technique can be used effectively for various purposes in RF/uWave circuit designing and below is the simple procedure one can do it in ADS.

First condition of using DGS in ADS to have finite ground structure and port setup as described in earlier section. After this designers need to create a pattern/defect in the continuous ground. Remove Momentum Mesh from **EM->Clear Momentum Mesh** to clear the previously generated mesh.

Use any layer other than the mapped ones in stackup to create the desired pattern on the layout, something as shown below:



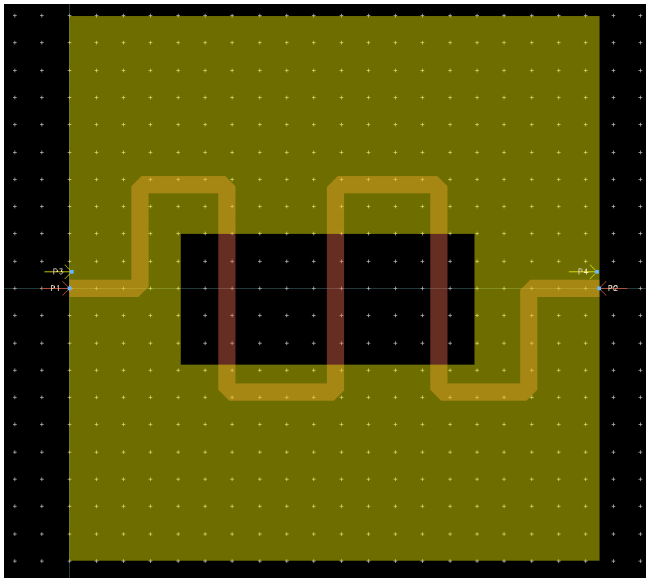
Select Edit->Boolean Logical and set it as below:



Here cond2 is out ground layer and resi is the dummy layer in which pattern is drawn and we shall use DIFF (difference) Boolean function to take away portion of the ground where shape is drawn in “resi” layer. Select option “Delete Original” for both cond2 and resi layers so that the original shapes are deleted after this Boolean operation. After = sign, we need to select the layer in which we want the results to be and in our case it is cond2.

Select Apply to: All Shapes so that this action can be perform across entire layout, alternatively we can use selected shapes if we want to perfom this action on a certain section of layout.

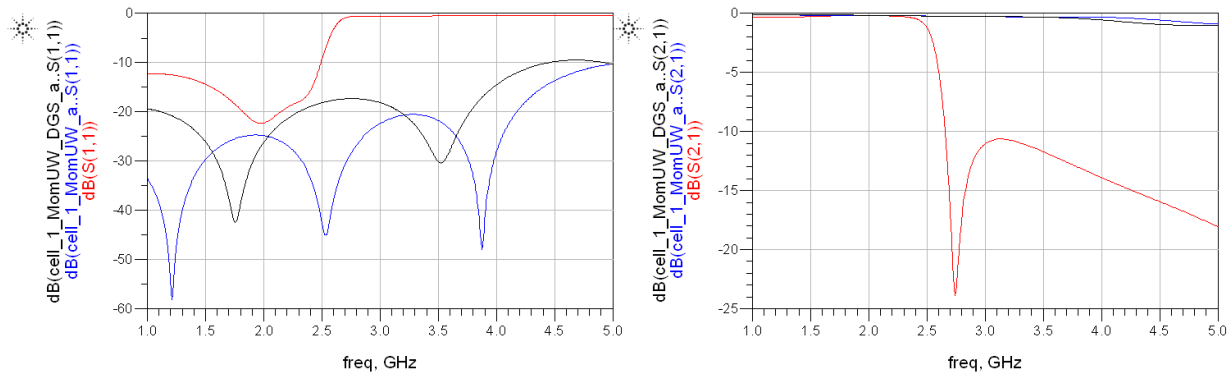
Click OK to see the resulting pattern as shown here.



From the EM setup window, select Output Plan and select new suffix as DGS (like we did finitegnd earlier) and click on Simulate to start simulation.

Once the simulation finishes, plot this new data on the earlier graphs to see comparison as shown below:

Blue: Infinite Ground
Red: Finite Ground
Black: DGS



As designers can see using DGS we were able to modify a simple line into a Low Pass Filter kind of structure and similar these kinds of structures can be used for various applications and simulated very easily in ADS.