Design Microstrip Antenna Using HFSS

Introduction:

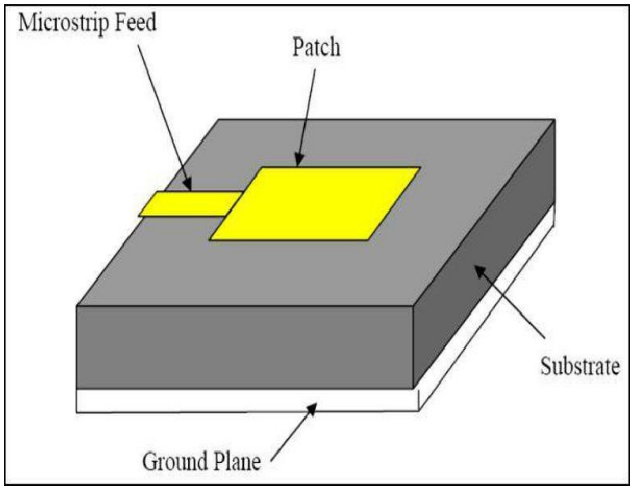
Antennae , could be classified as wire antennae, aperture antennae, printed antennae, array antennae, reflector antennae and lens antennae.

Microstrip antenna

The most common version of printed antenna is microstrip antenna. the printed antenna is one that is fabricated using standard photolithography technique.

Advantages of microstrip antennas :

- Low cost to fabricate
- it's easy to form curved surfaces
- Easy to form a large array, spaced at half-wavelength or less
- Light weight



Disadvantages :

- Limited bandwidth (usually 1 to 5%, but much more is possible with increased complexity
- Low power handling

To design Microstrip patch antenna, there are parameters should we know :

1. Resonance frequency f_0
2. Dielectric constant of the substrate, ε_R
3. Thickness of substrate, h

In this documentation I will use :
* f_o =500 MHZ ,
* FR4 pcb material (with h=0.039 inches , dielectric constant =4.5 or 4.4)

secondly , we should know the equations to Calculate width of patch (W) , effective dielectric constant , actual length of patch (L)

$$Width = \frac{c}{2f_o\sqrt{\frac{\varepsilon_R+1}{2}}}; \quad \varepsilon_{eff} = \frac{\varepsilon_R+1}{2} + \frac{\varepsilon_R-1}{2}\left[\frac{1}{\sqrt{1+12\left(\frac{h}{W}\right)}}\right]$$

$$Length = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} - 0.824h\left(\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)}\right)$$

c = velocity of light = 3×108m/s

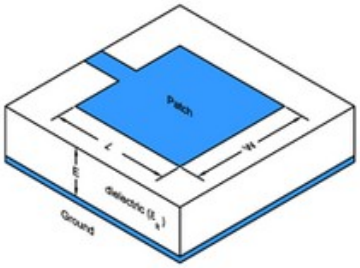
now let’s calculate them (you can use online calculator)

Dielectric Constant | 4.5

Dielectric Height: | 0.039 | Inches

Operation Frequency: | 500 | MHz

Calculate



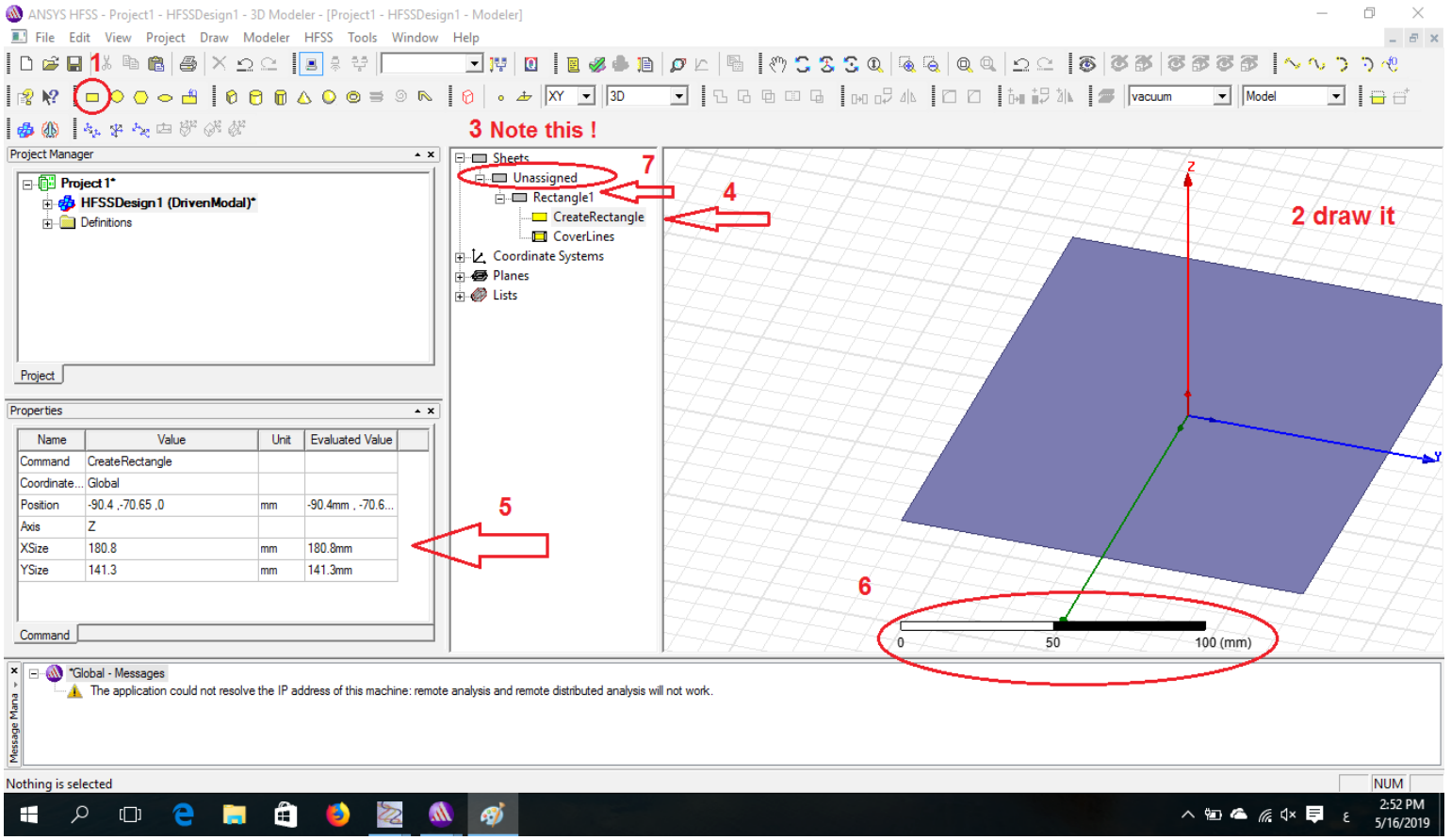
Result:

Width: 180.8 mm
Length: 141.3 mm

* install HFSS correctly

* open it >> click file >> project

step 1 ‘Draw Patch’



1 , 2) Use the rectangle shape to draw the patch
“ the object Rectangle will appear “

3) Note that ‘ Unassigned ’

4) Click on ‘create rectangle’

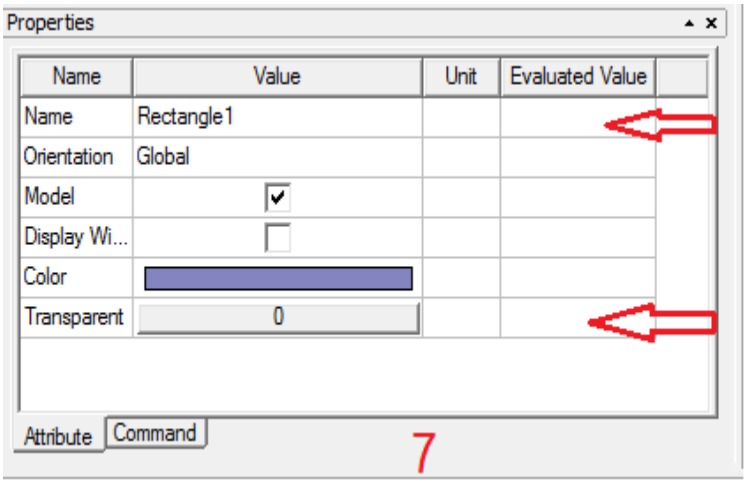
5) Edit the length from the properties box (X= 180.8 mm , Y=141.3mm)

6) Edit the scale

7) Rename it with ‘patch’

by clicking on rectangle object

and change name from the properties box

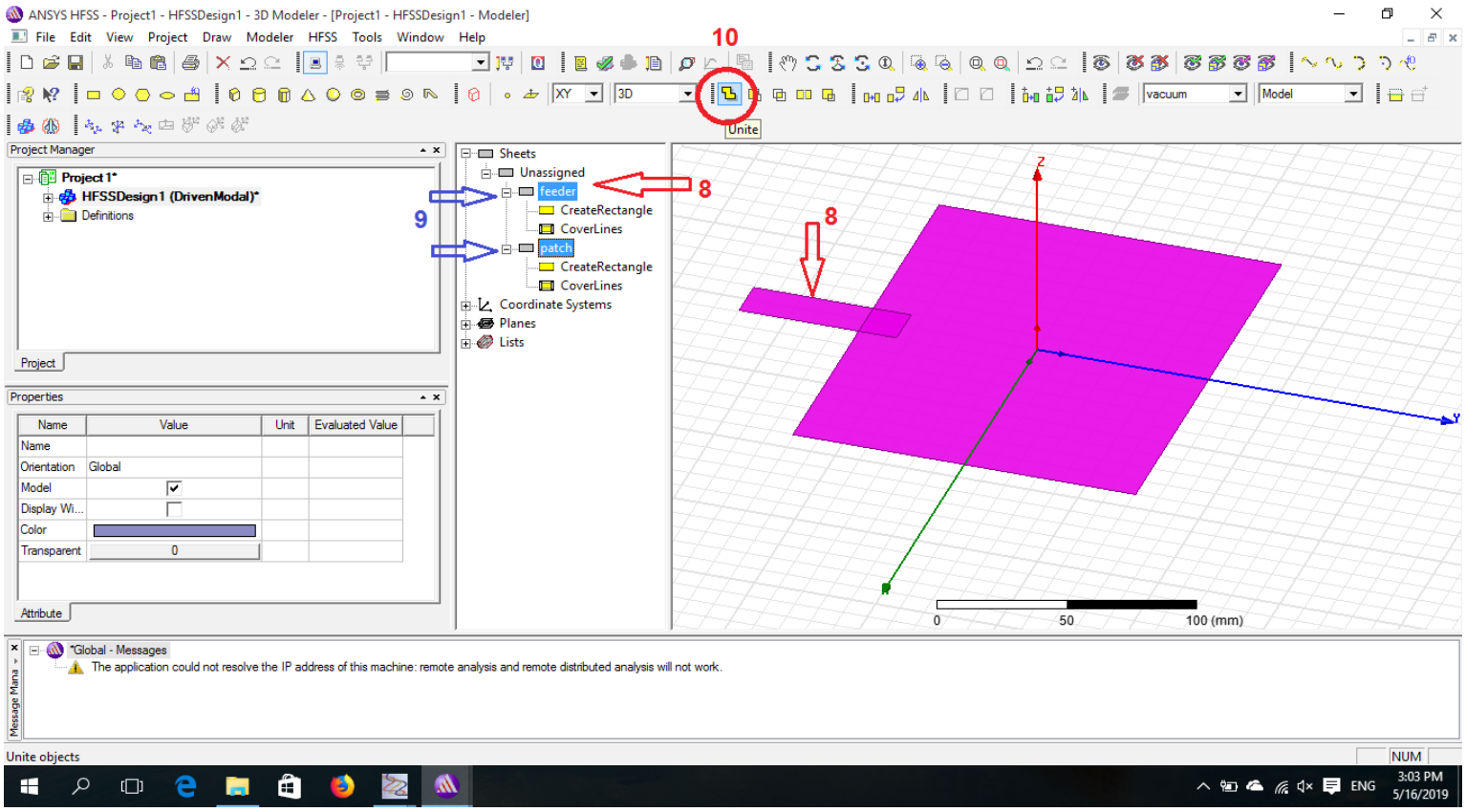


feel free to edit transparent and see what’s happen !

HINTS

FR4 epoxy glass substrates are the material of choice for most PCB applications. The material is of low cost and has excellent mechanical properties, making it ideal for a wide range of electronic equipments.

Step 2 ‘Draw The Feeder’

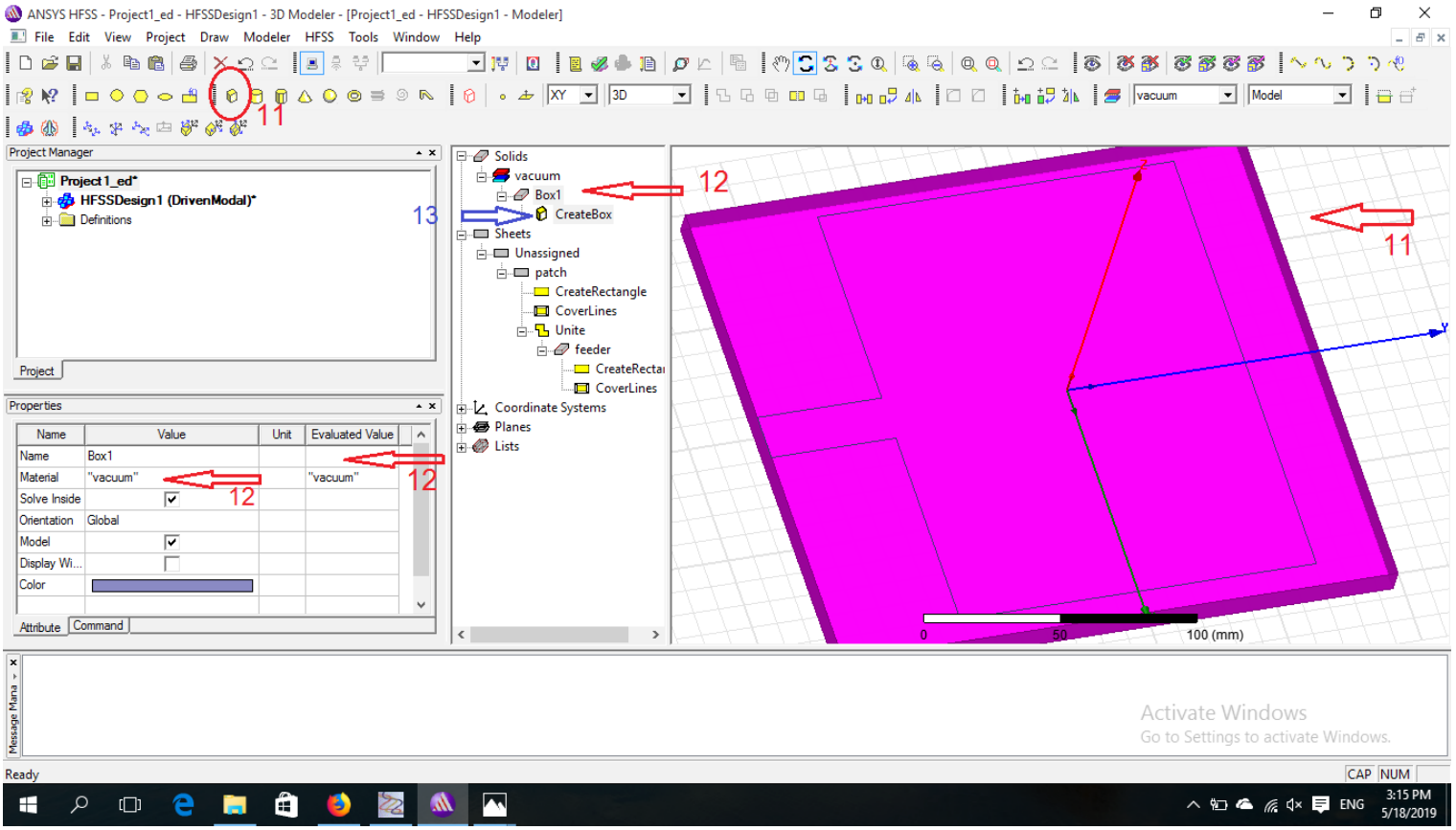


8) Create an rectangle object and rename it feeder .

9) Select the 2 objects – patch and feeder -.

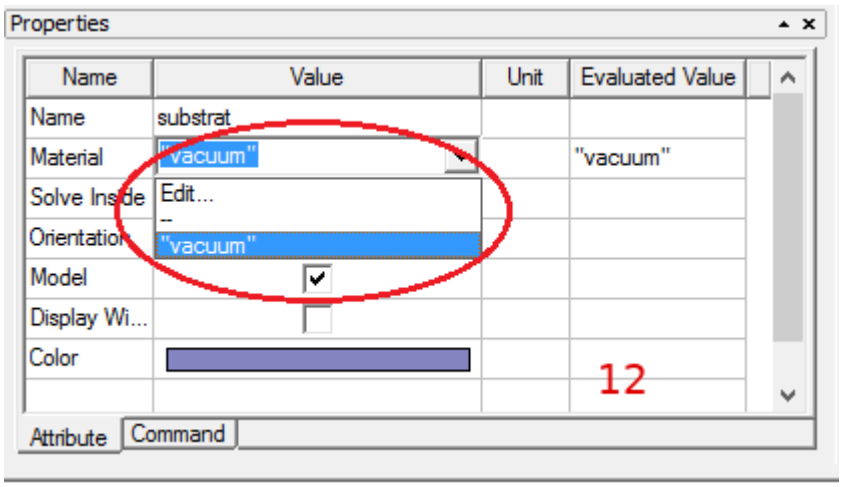
10) Click **Unite** button .

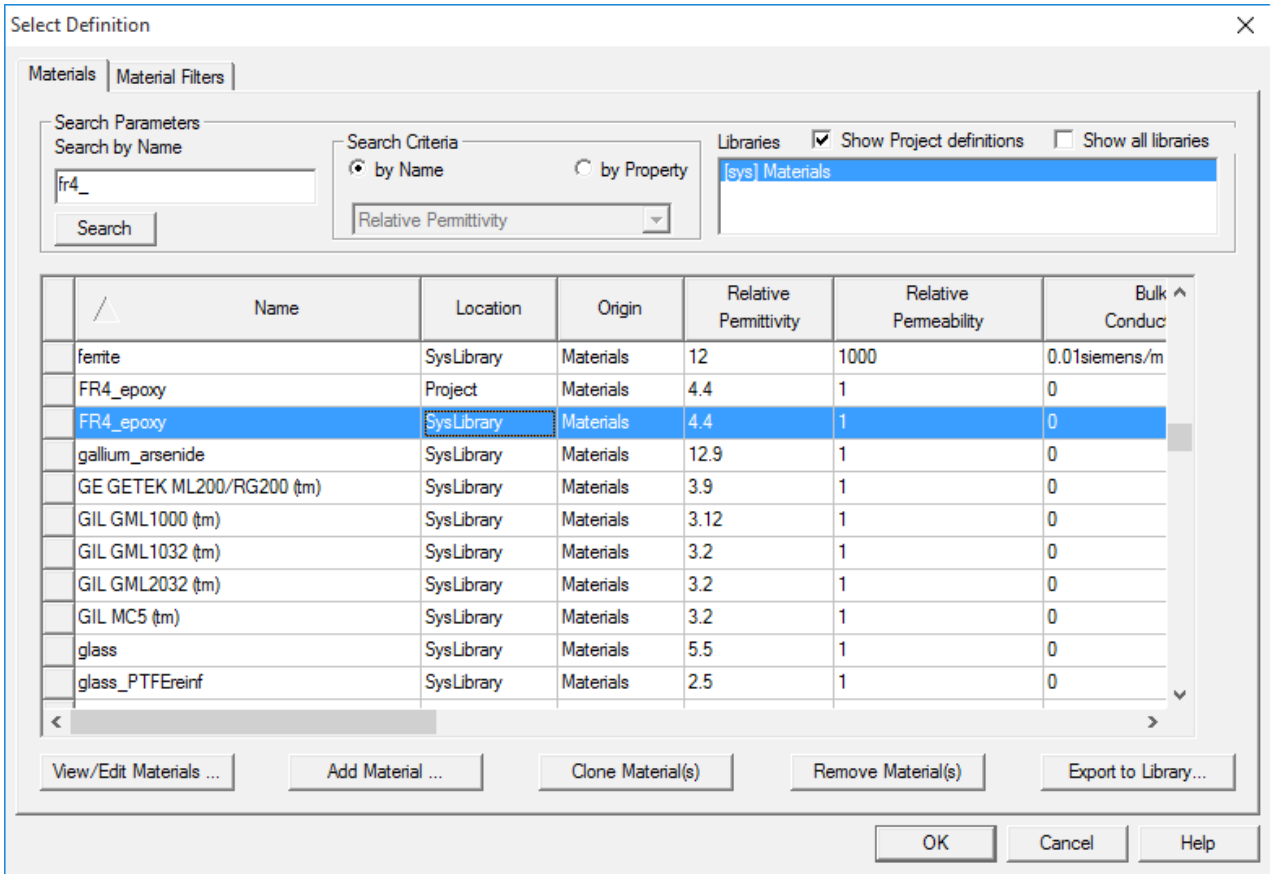
Step 3 ‘ The Substrate’



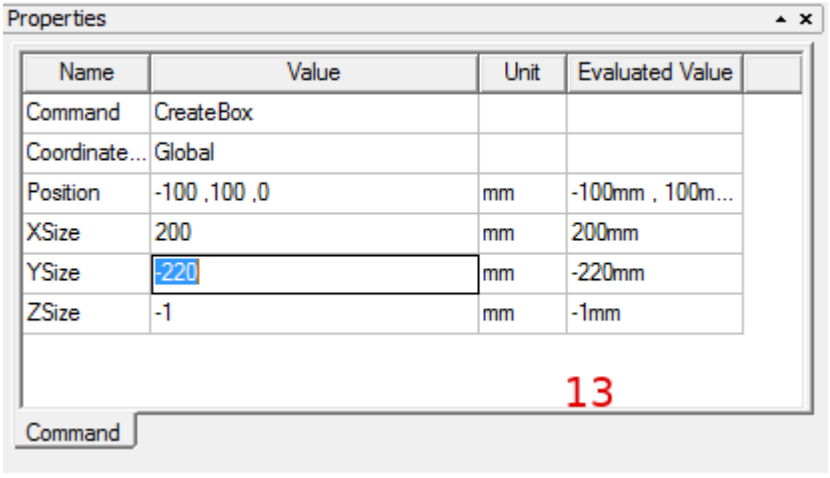
11) Using cubic draw the substrate

12) Rename it and edit the material
select FR4-epoxy





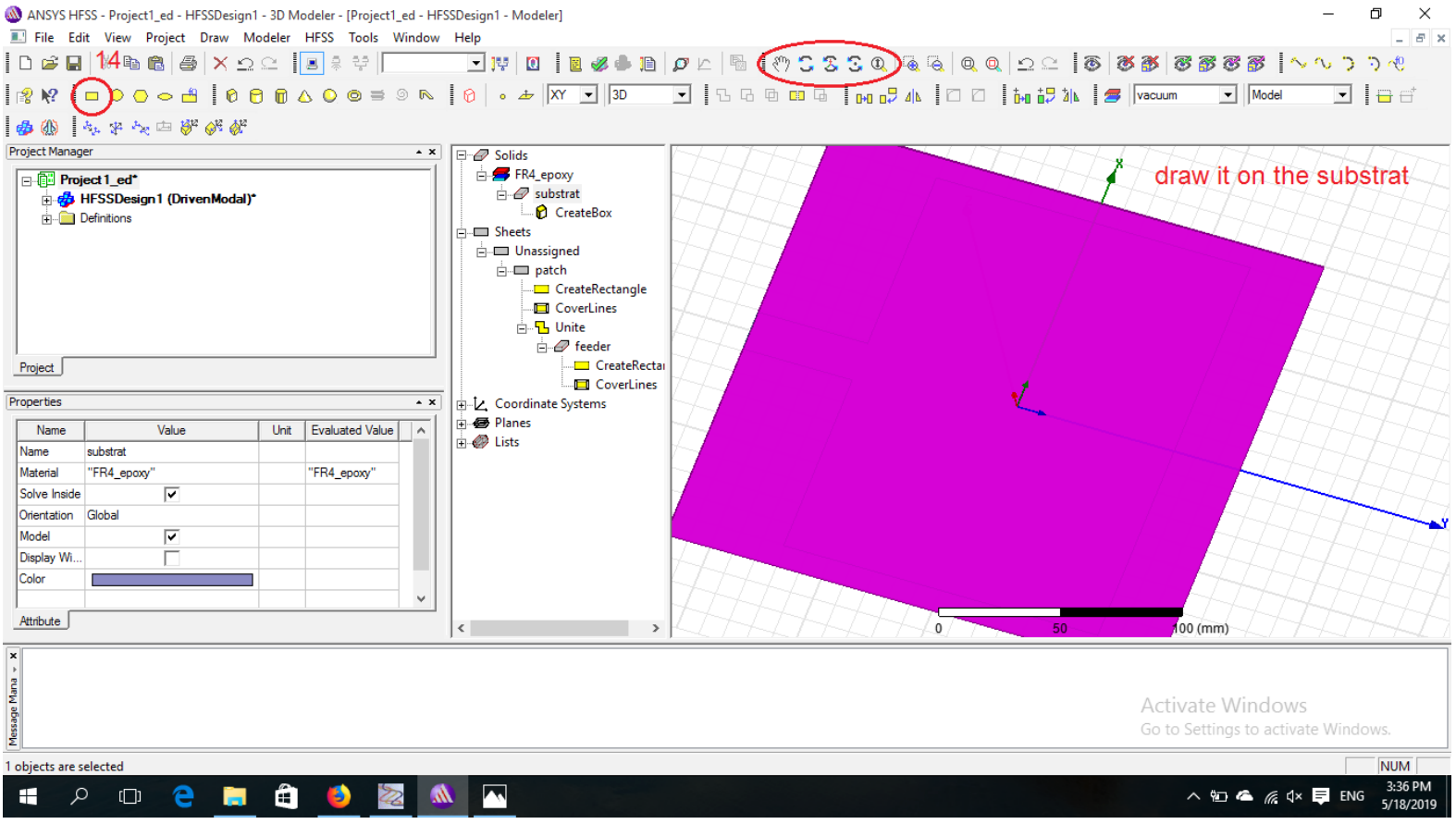
13) Edit the Thickness of substrate (Z=-1mm)



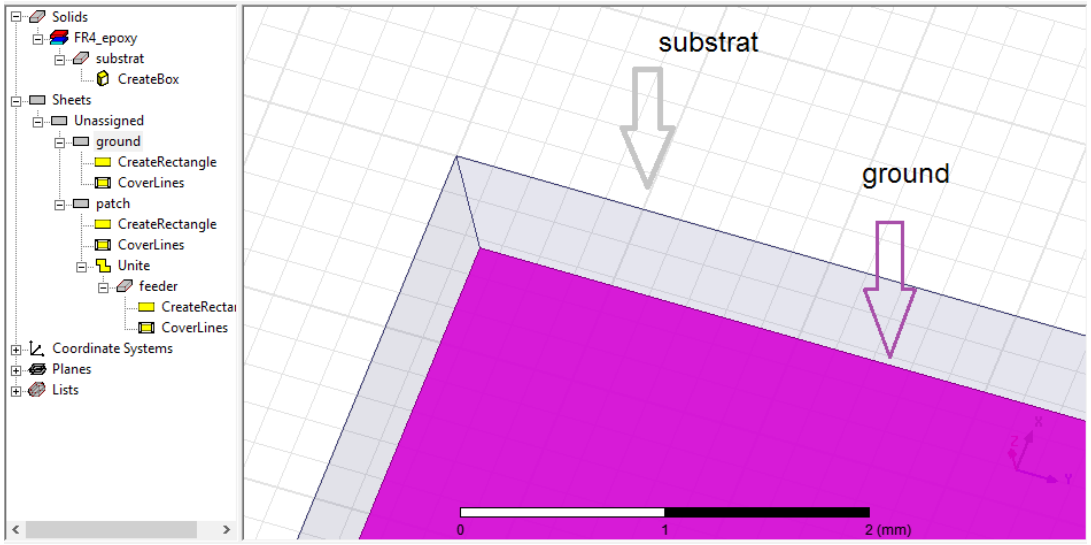
Step 4 ‘The Ground’

* use this nice tools to move the design
  get the bottom of the substrate

14) Use the rectangle to draw it

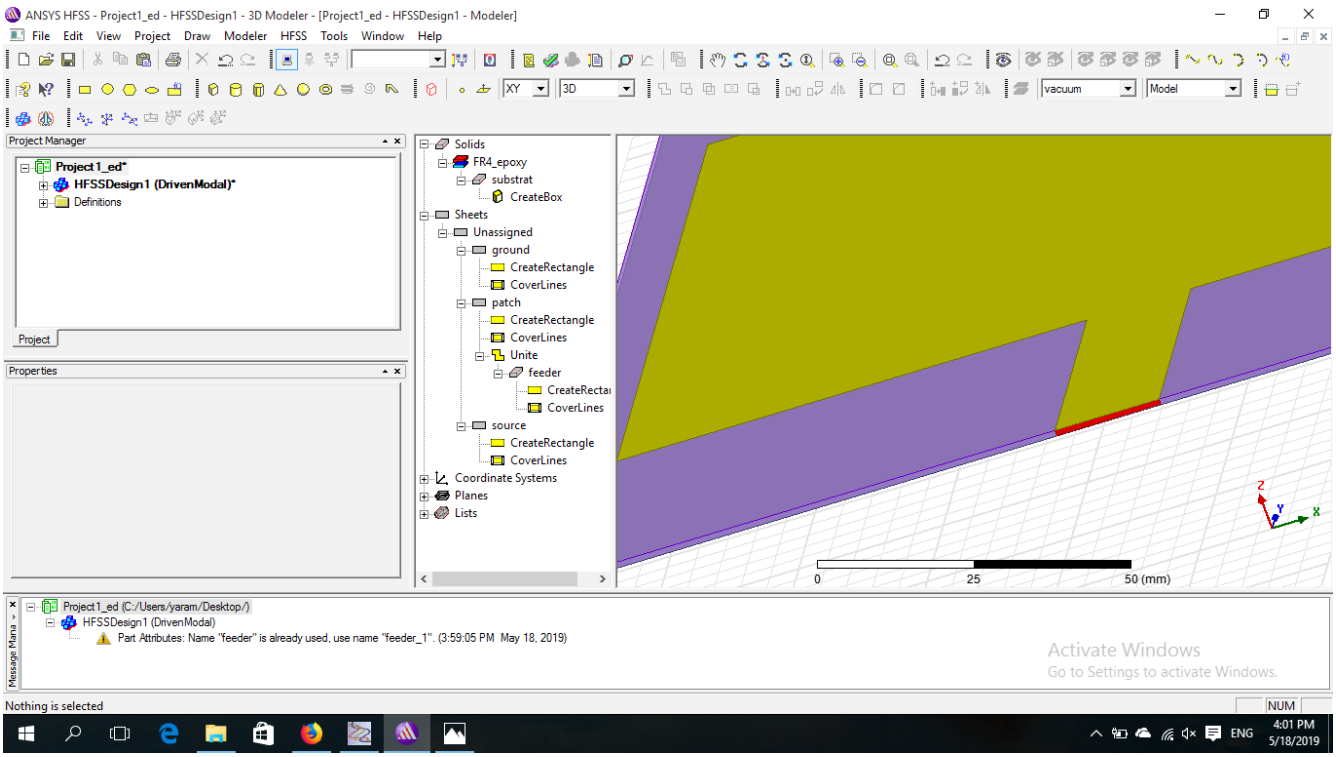


you can notice this here.



Step 5 ‘Set The Source’

Use the rectangle object to draw the source “ the red part “

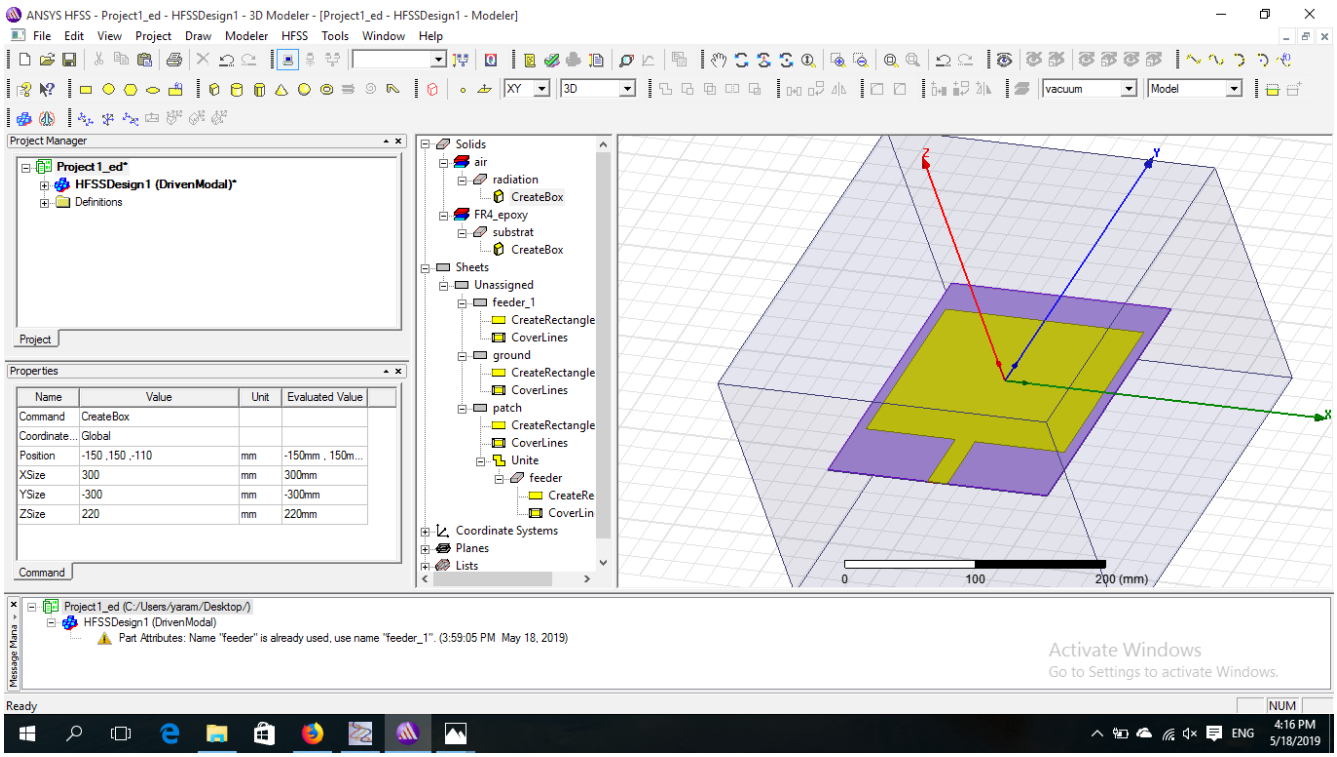


Hint : zoom the scale in and draw the source between the surface (feeder) and the bottom (ground)

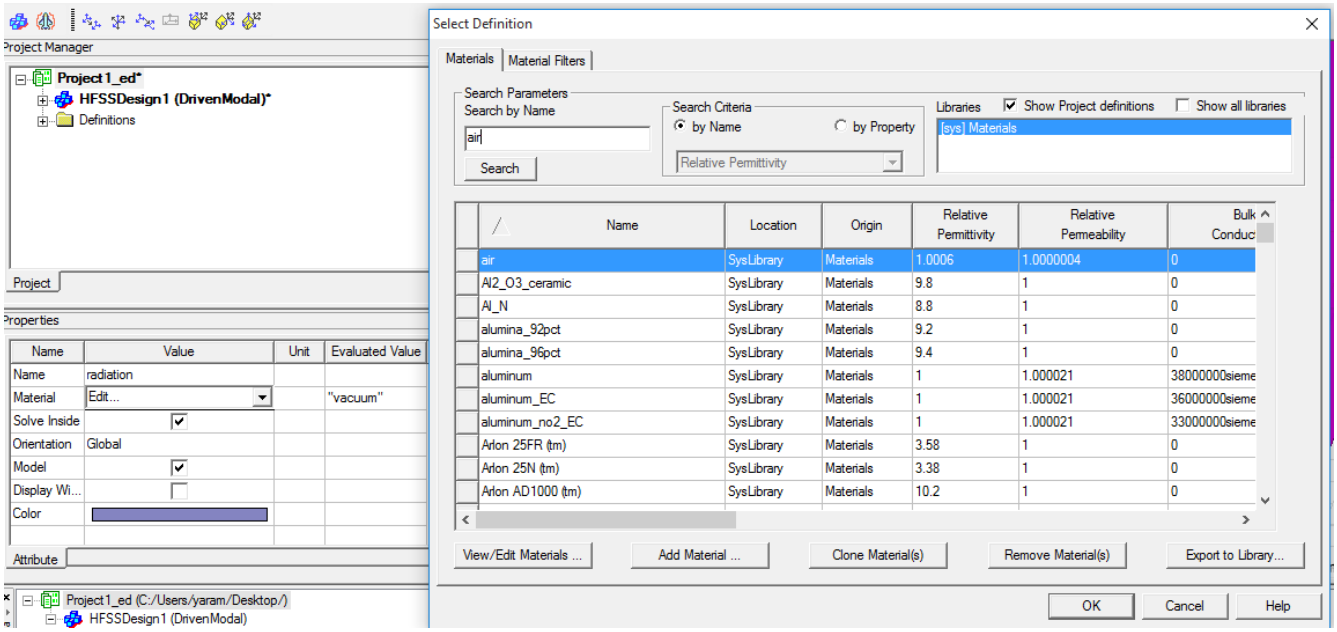
step 6 ‘Set The Radiation Box’

17) draw cubic box around the antenna and rename it ‘Radiation’

18) set transparent to 0.8 see step 1

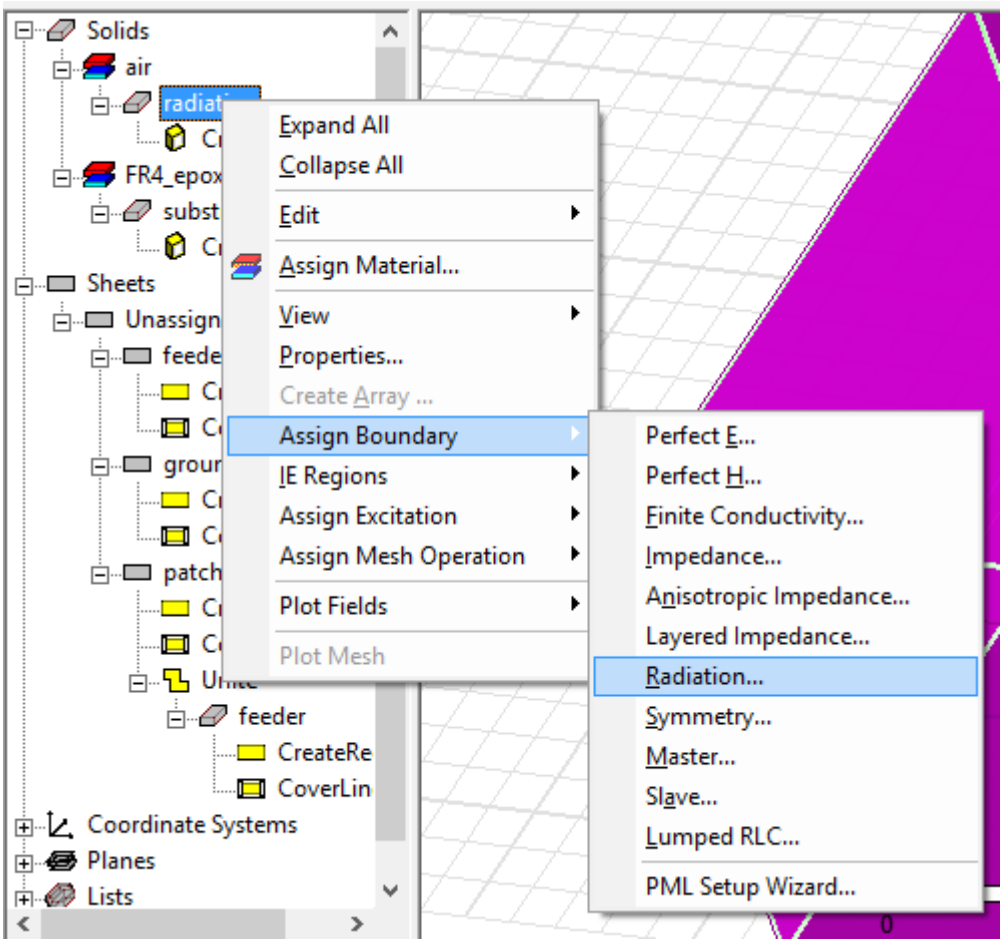


19) from properties edit the material ,set it to ‘air’ see step 3



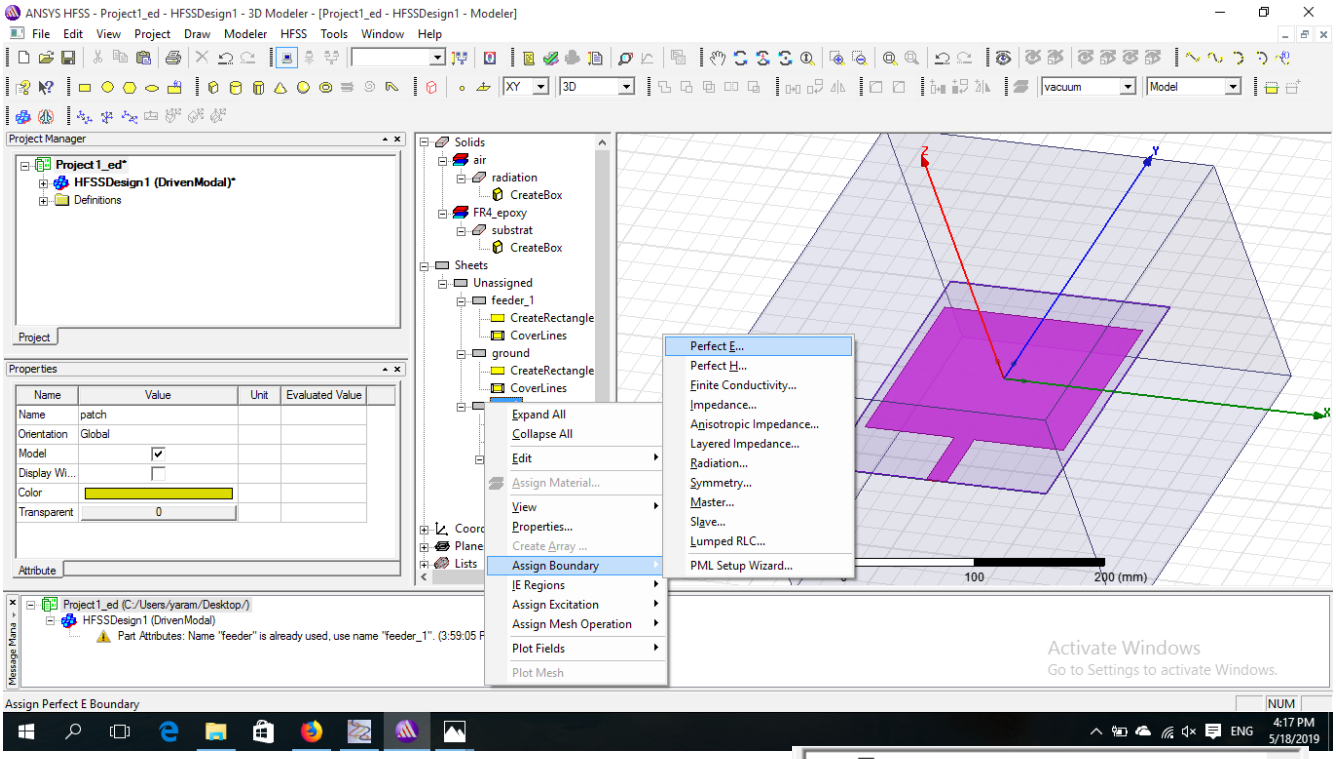
20) right click on radiation object

Assign Boundary >> Radiation



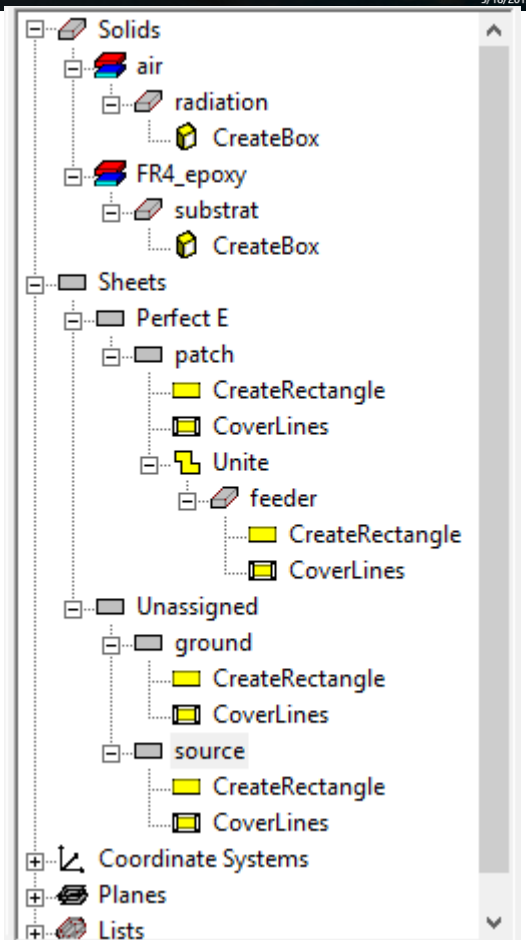
step 7 ‘Assigned Boundary ‘

21) Right click on patch >> Assigned boundary >> perfect E



* NOW NOTE WHERE THE PATCH GO .

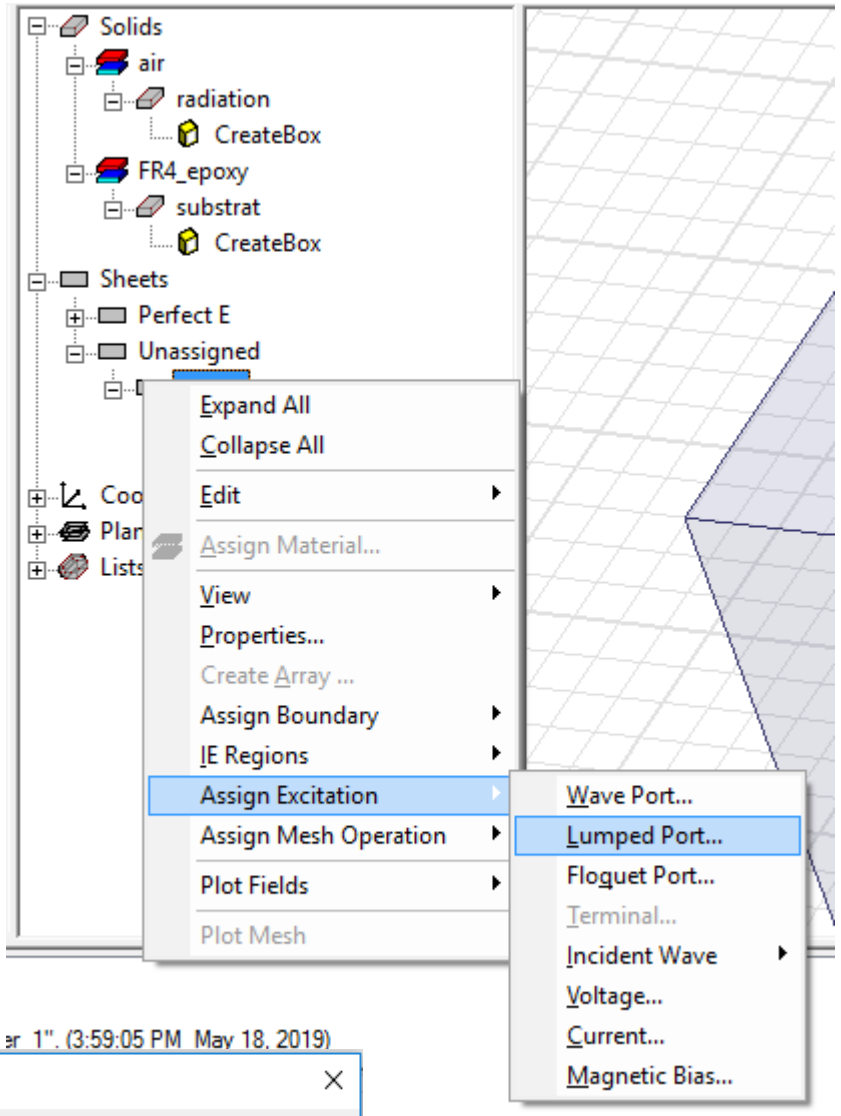
so don't forget to assign all objects on The Unassigned part .

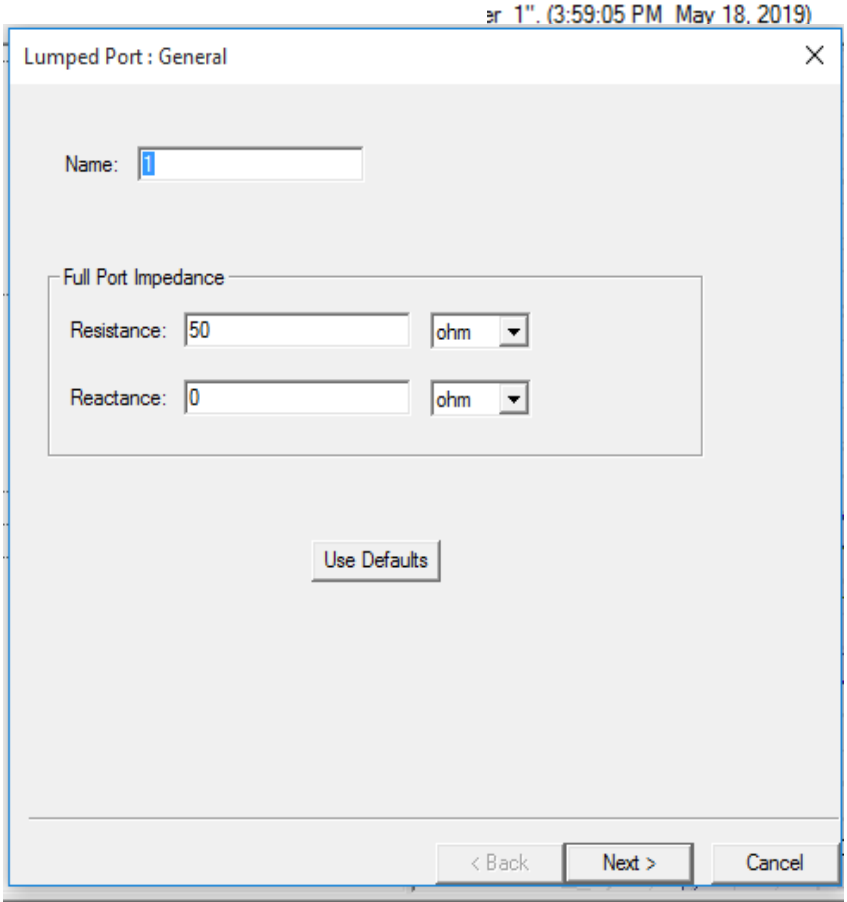


22) set ground to perfect E

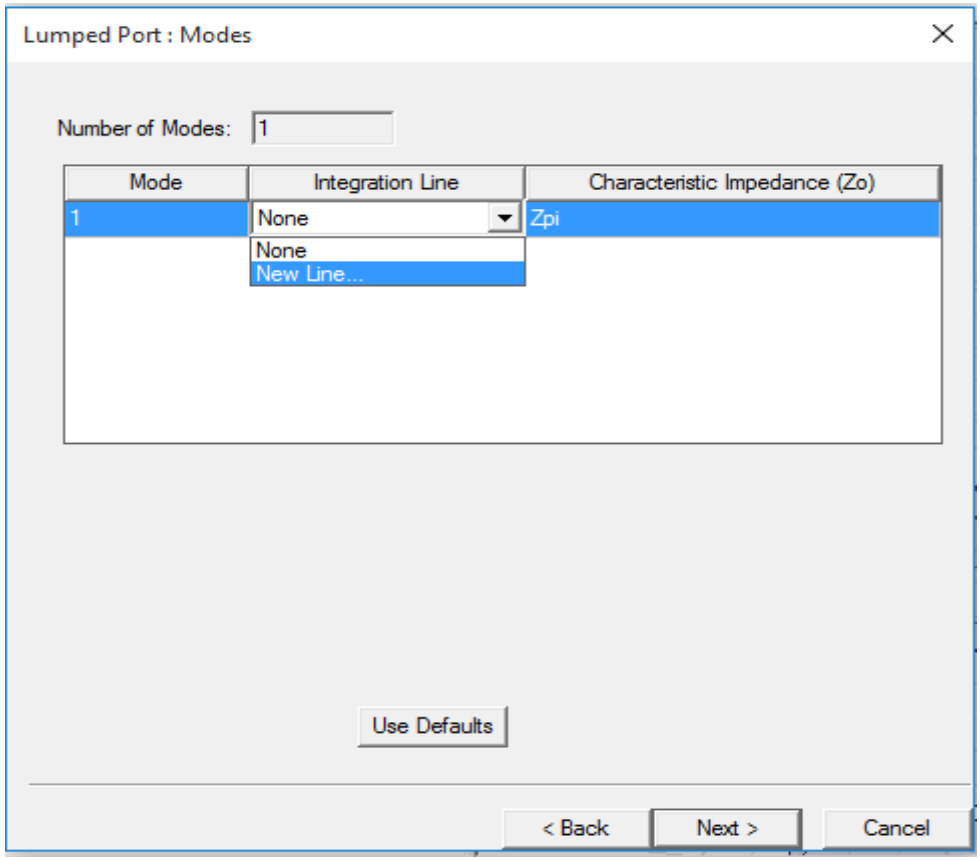
23) set source to

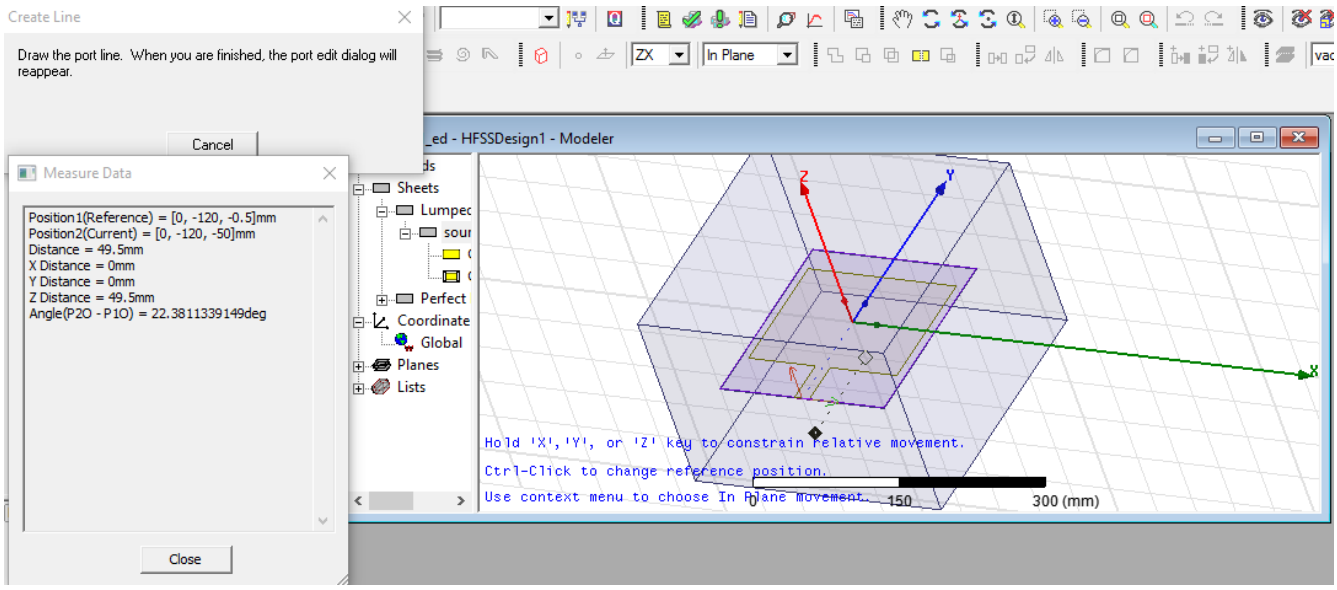
Assign excitaion >> Lumped port >> Next



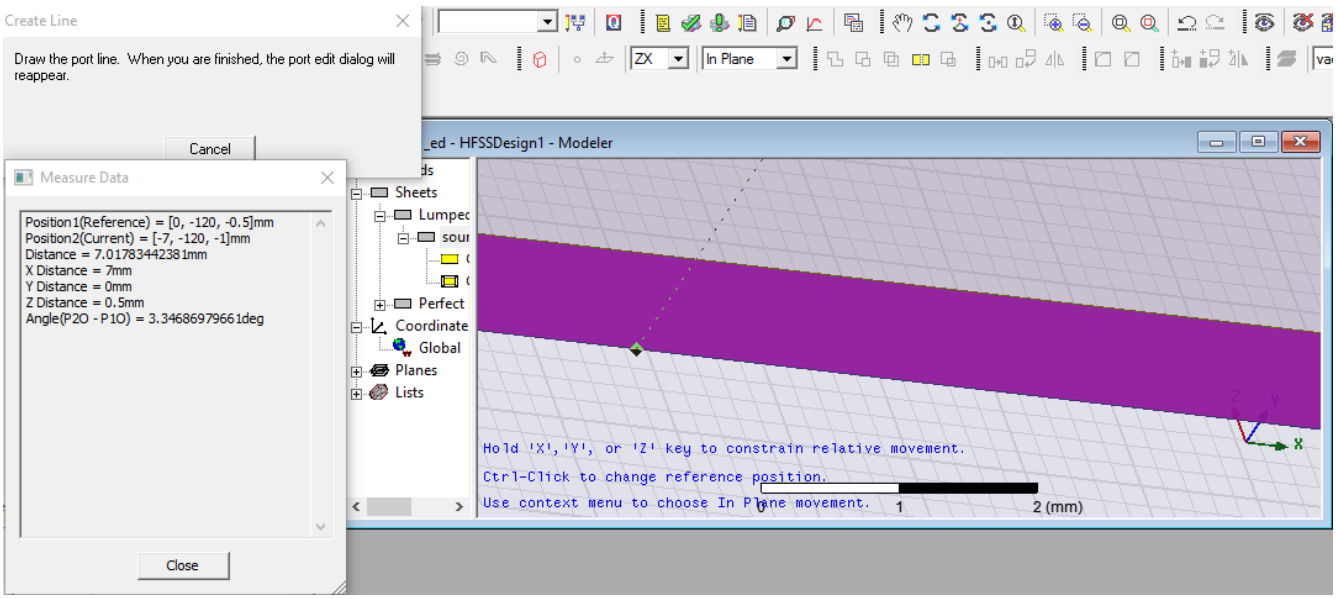


set new line >> next

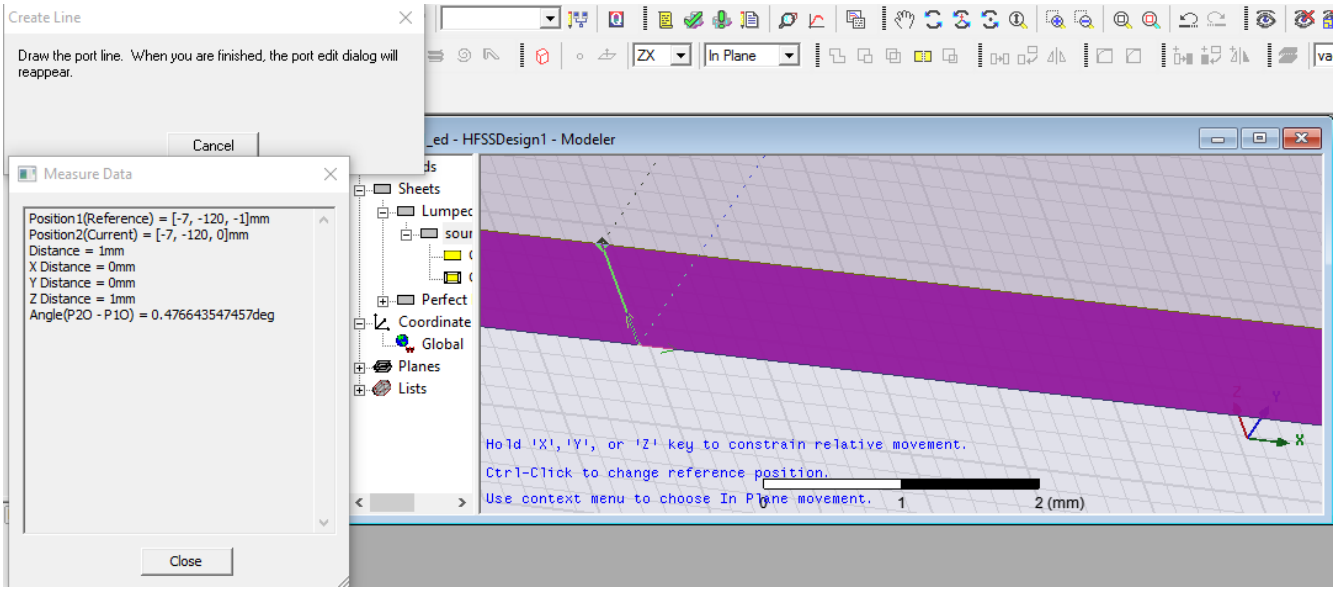


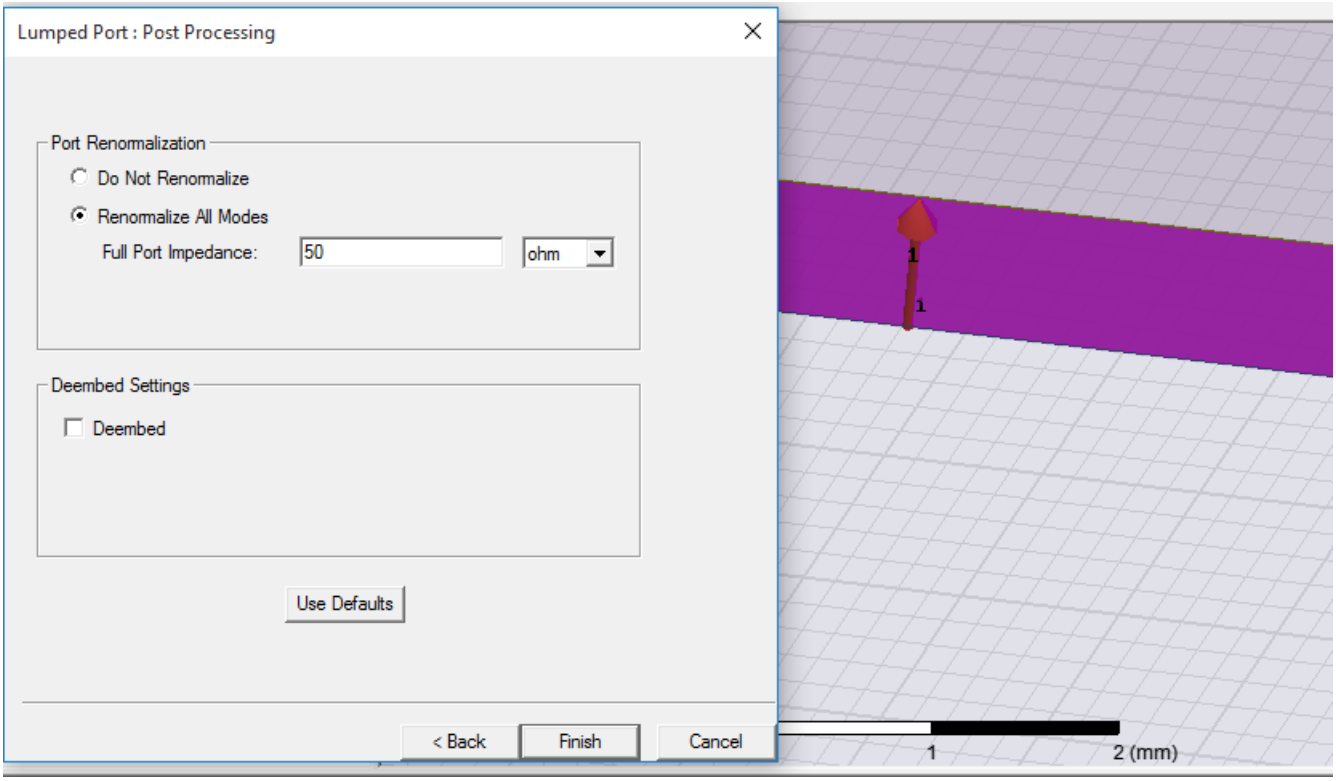


zoom-in till reach the edge of source



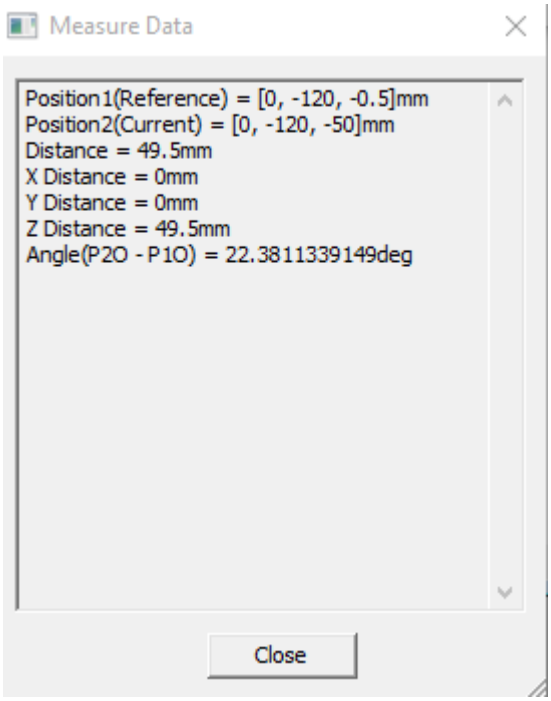
move to the second edge in direction of +z





Hint the vector may you see it in the +z direction , but it doesn't so MAKE SURE THAT

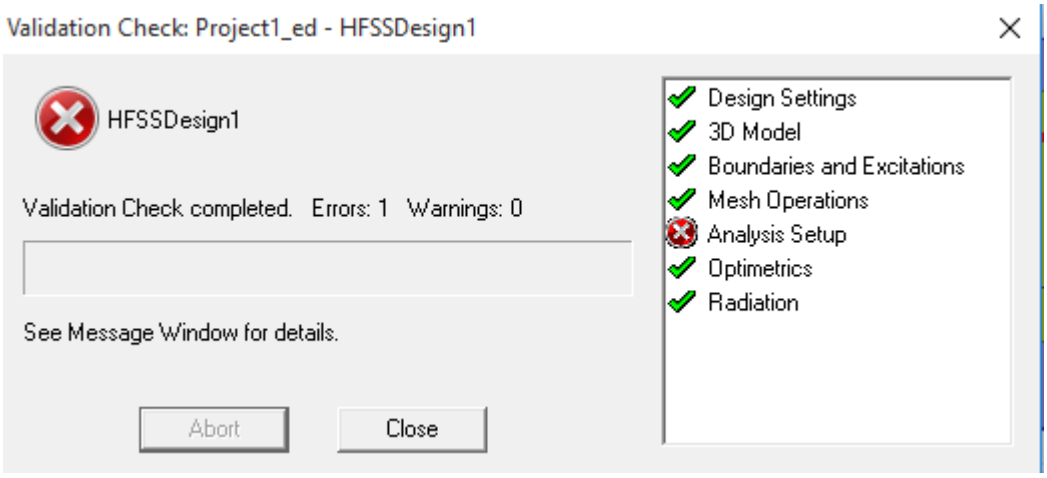
$X = 0$ mm , $Y = 0$ mm



step 8 ‘Analysis’

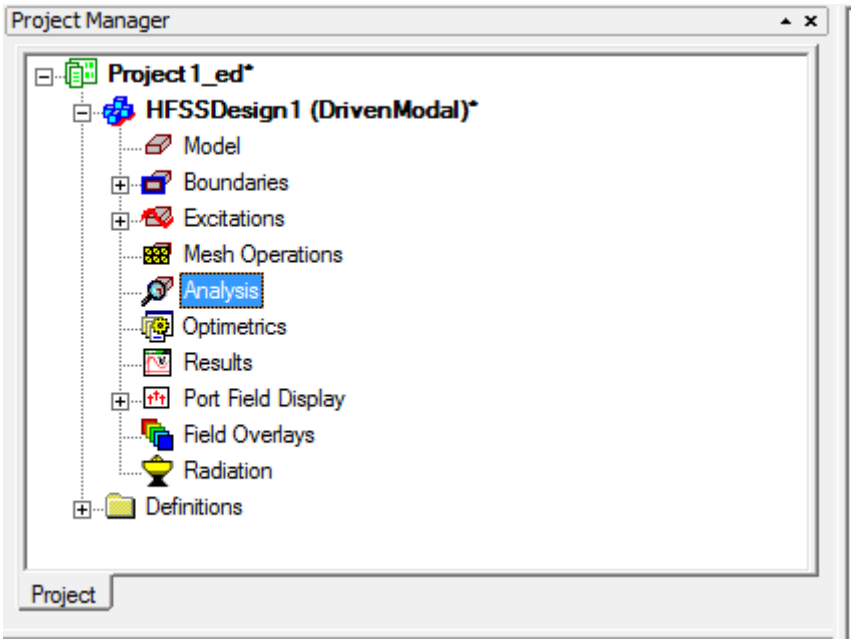
This is the time to analyze our design ,

click on 

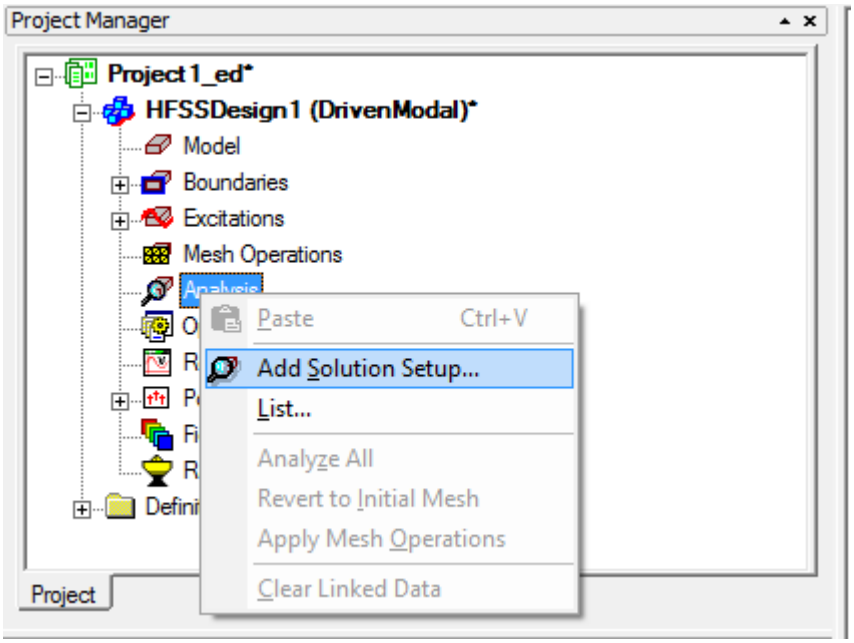


ooh ! What about this error !

To solve it ..
1 . Go to the project manager box >> right click on analysis

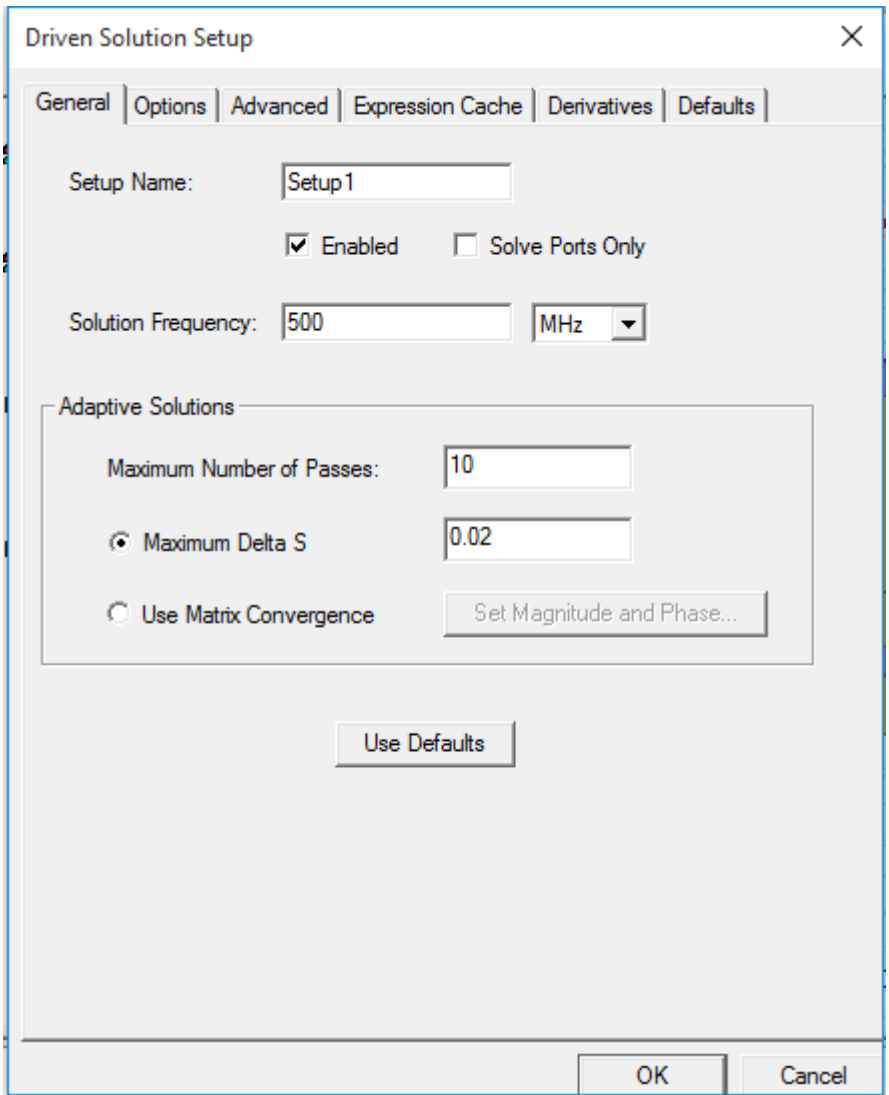


2.



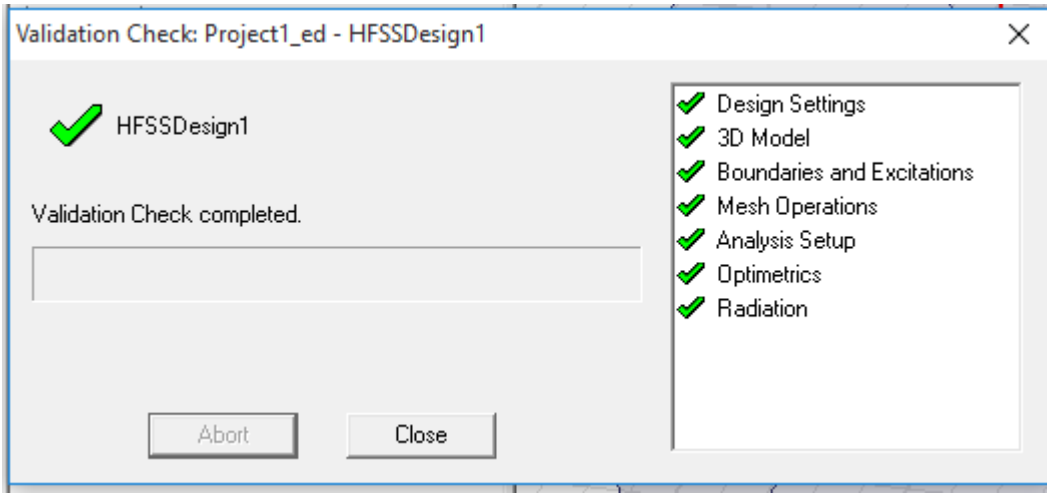
3. now put your frequency
f_0

>> ok



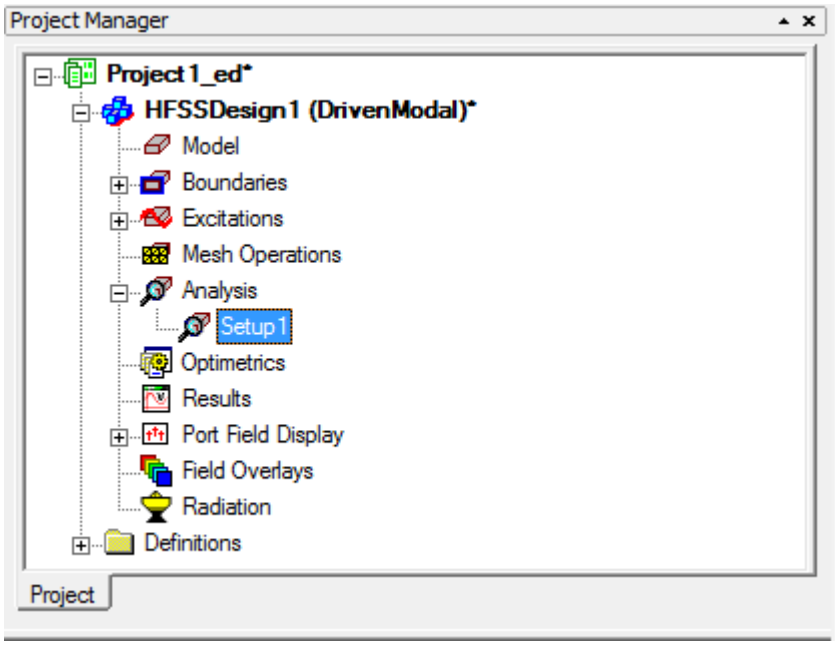
check it again 

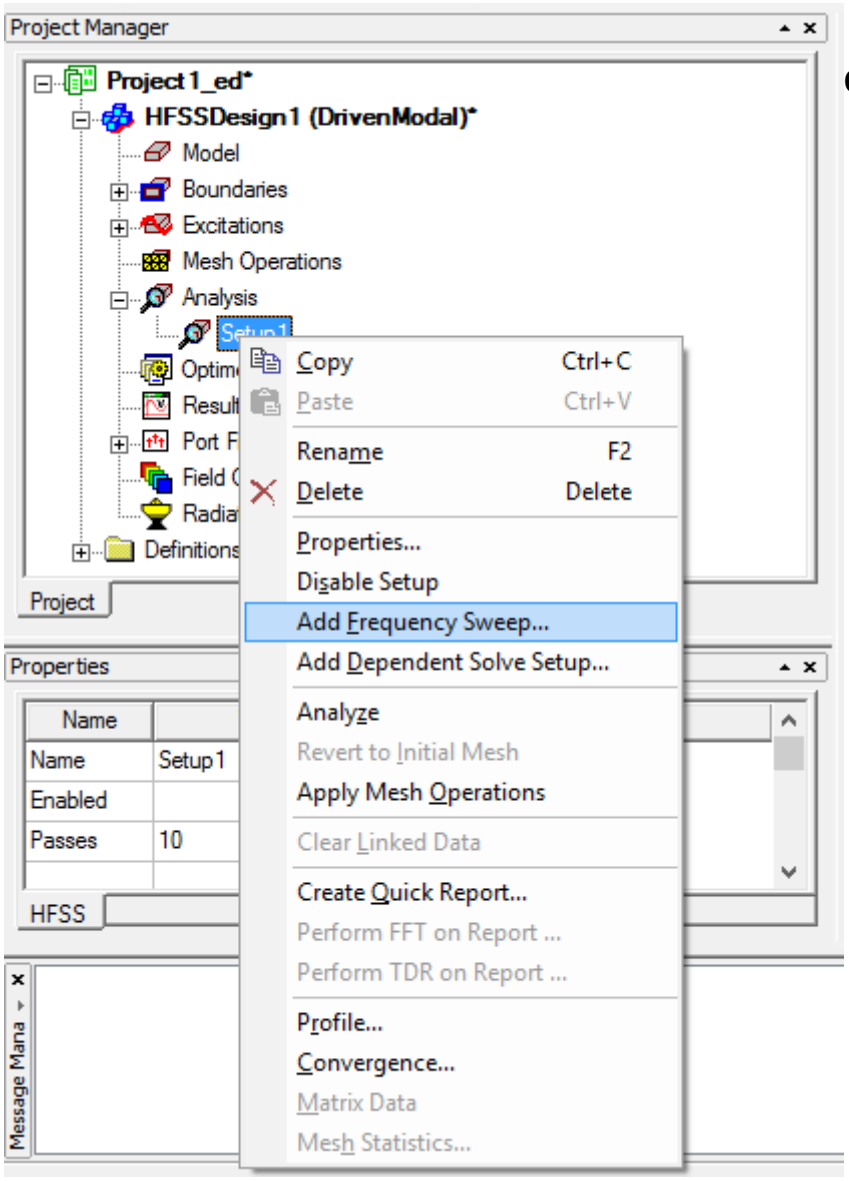
good job !



Step 9 ‘Draw S parameter ’

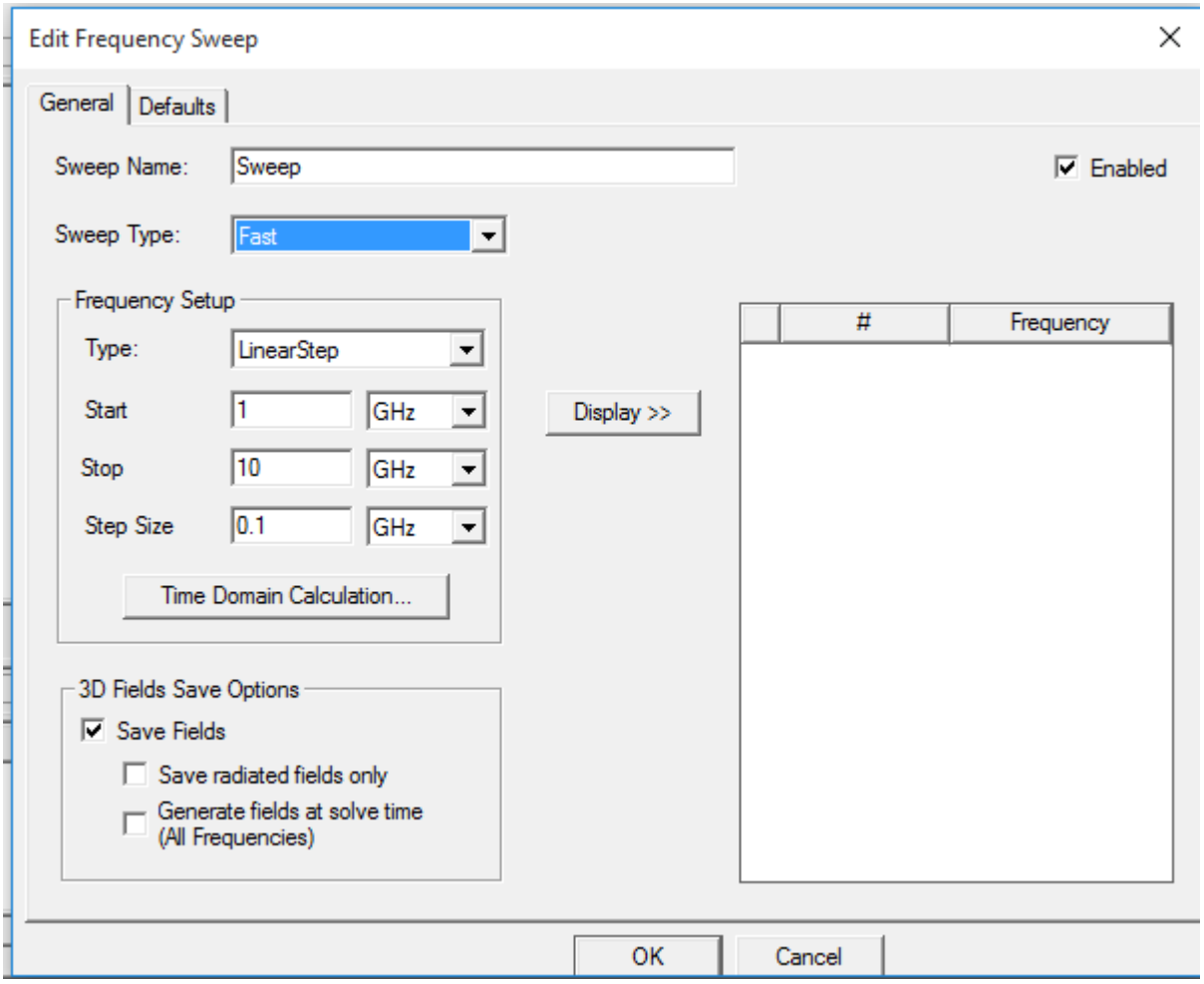
right click on setup1



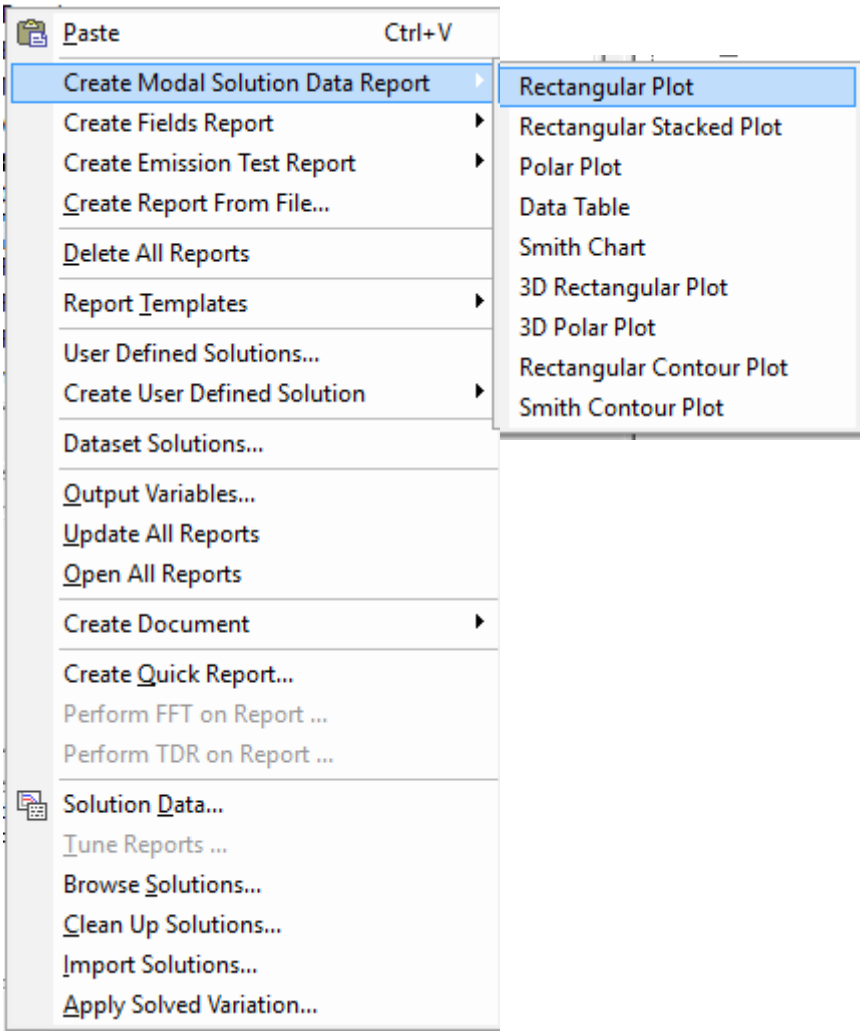


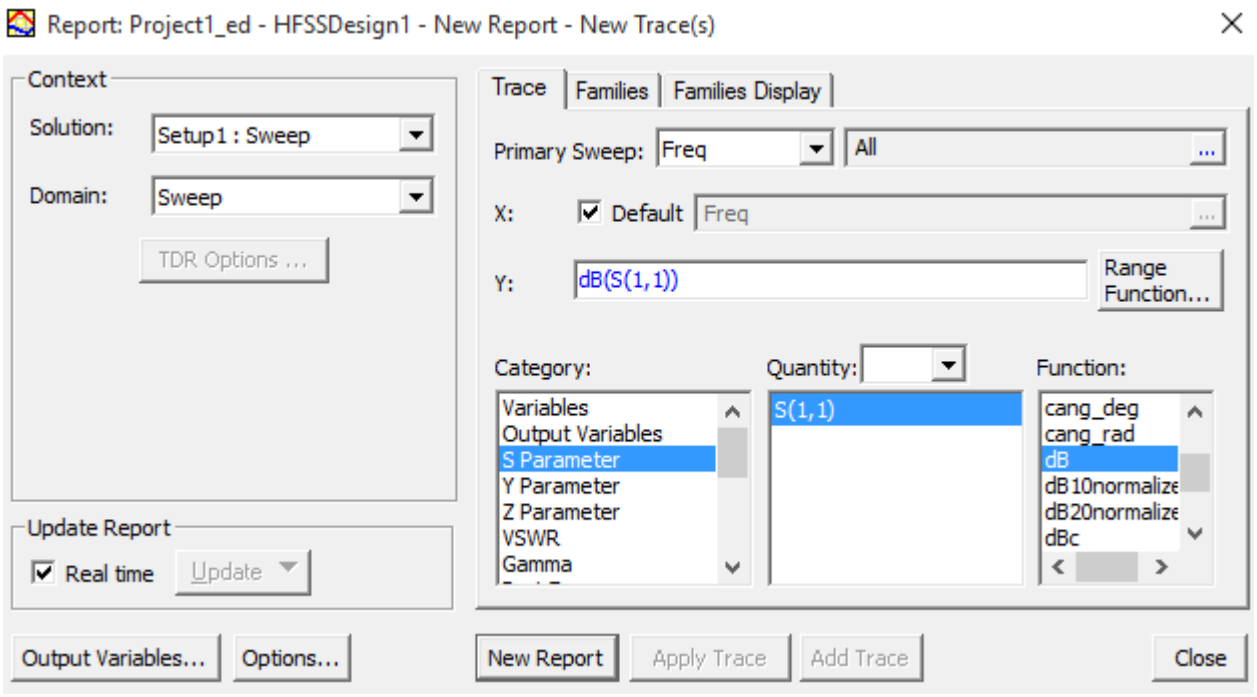
click on
Add frequency sweep

put the start , stop and step size frequency
click on display >> ok

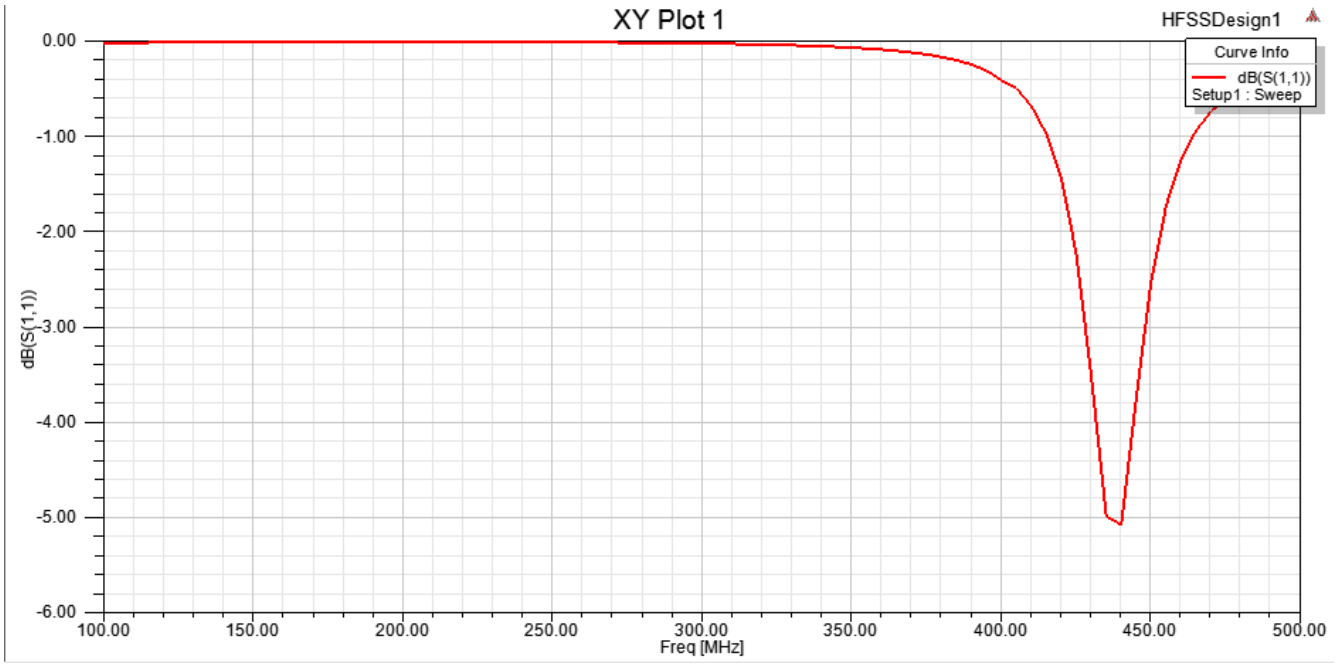


now right click again on setup1

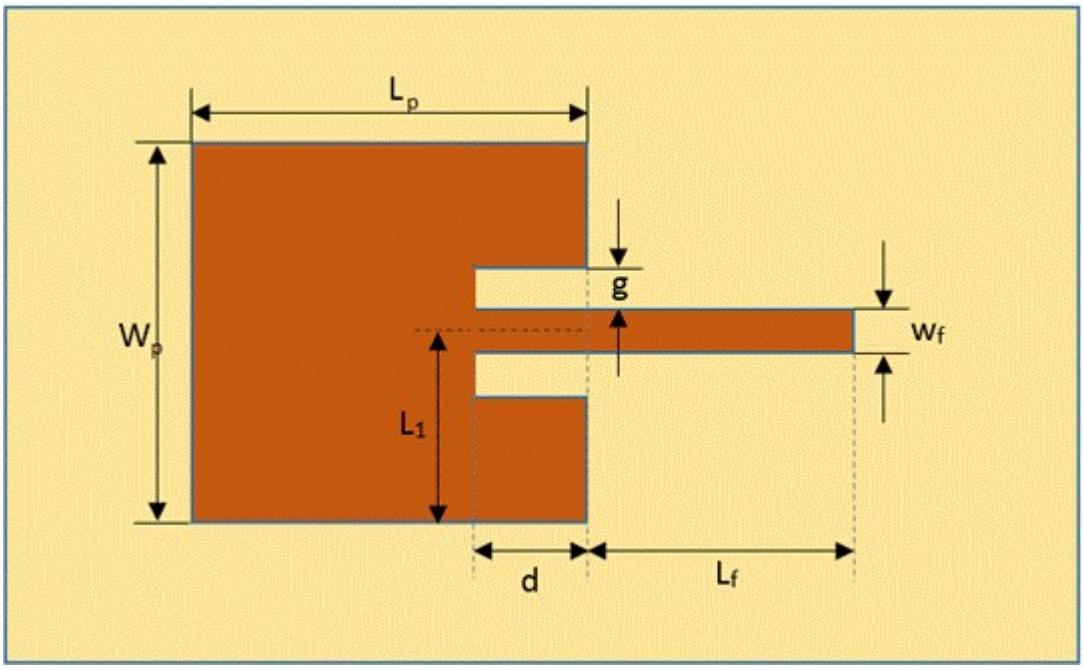




congratulation , you did it !



Now we will refer to a different design for microstrip antenna



calculation of inset depth d

R_{in} is the resonant input resistance when the patch is fed at a radiating edge. (input impedance)

$$Z_o = R_{in} \cos^2\left(\frac{\pi}{L} d\right)$$

Z_0 is equivalent to the feed line impedance. (Characteristics impedance)

L length of patch

if you want to know more about it ,
this is a good reference:“ http://www.jeasd.org/images/2016edition/issue_1/8.pdf “