Software Experiments

6. Microstrip line Design

Objective: To study the performance of different two port networks by determining their scattering parameters.

Equipment required : HFSS software

Specifications : Characteristic impedance Z_0 =

Operating frequency f =

Substrate thickness H =

Metal thickness T =

Dielectric constant ε_r =

Loss tangent L =

Theory:

Microstrip lines: The simple microstrip line uses a single strip conductor on the dielectric that rests on a single ground plane. Generally the ground plane made up of with good conductor like silver or copper and the material used for the dielectric is Teflon or Aluminum or Silicon, etc.. It is possible to use several independent strips with the same ground planes and dielectric. Microstrip lines use quasi TEM mode of propagation. The ground plane of the microstrip line must be wide compared with the top conductor, so it appears like a nearly infinite wide ground plane with only very small electric field fringes at its edges. The characteristic impedance of a microstrip line depends on the strip line width, thickness, the

distance between microstrip line and ground plane and the dielectric constant of the dielectric material.

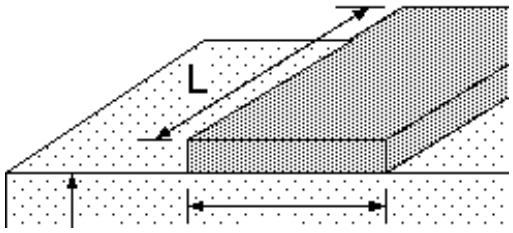

Figure 1

Design Equations: The effective dielectric constant is calculated by:

$$\varepsilon_e = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2\sqrt{1 + 12\left(\frac{H}{W}\right)}}$$

$$\frac{W}{H}=\left\{\begin{array}{l}\dfrac{8e^{A}}{e^{2a}-2}\\ \dfrac{2}{\pi}\left[B-1-\ln(2B-1+\dfrac{\varepsilon_r-1}{2\varepsilon_r}\left\{\ln(B-1)+0.39-\dfrac{0.61}{\varepsilon_r}\right\}\right]\end{array}\right\}\ for Z_0>44-2\varepsilon_r narrow strip$$

$$A=\frac{Z_0}{60}\sqrt{\frac{\varepsilon_r+1}{2}}+\frac{\varepsilon_r-1}{\varepsilon_r+1}\left(0.23+\frac{0.11}{\varepsilon_r}\right)$$

$$B=\frac{377\pi}{2Z_0\sqrt{\varepsilon_r}}\ for wide strip$$

$$\beta l=\phi \qquad l=\frac{\phi}{\beta} \qquad \beta=\frac{2\pi}{\lambda_g} \qquad l=\frac{\phi\lambda_g}{2\pi}$$

W= Width of the microstrip line, l = Length of transmission line, H = Thickness of the substrate, A,B constants, Φ = Phase shift, λ_g=Guide wavelength.

Simulation procedures of Microstrip strip line in HFSS (Circuit design):

1) Opening Circuit design window

Open HFSS, Goto Project (menu bar) → Insert Circuit design

2) To assign the unit length

Tools→Options→General Options→default Tap→length→ select 'mm' as length

Click Ok

3) Substrate definiation:

In project manager, Right click the 'Data'icon → Add substrate definition (enter the value as shown)

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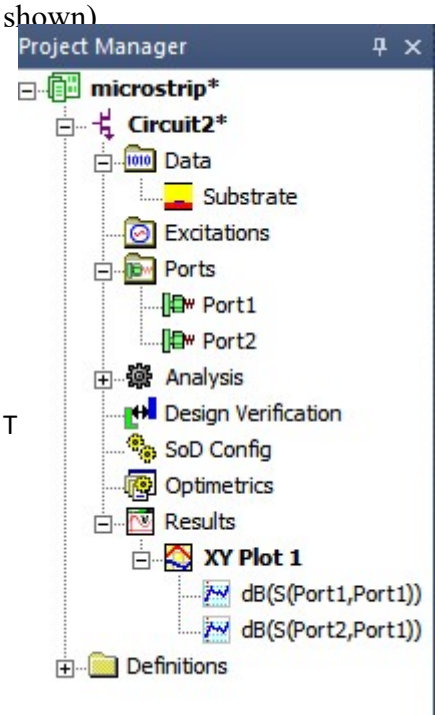
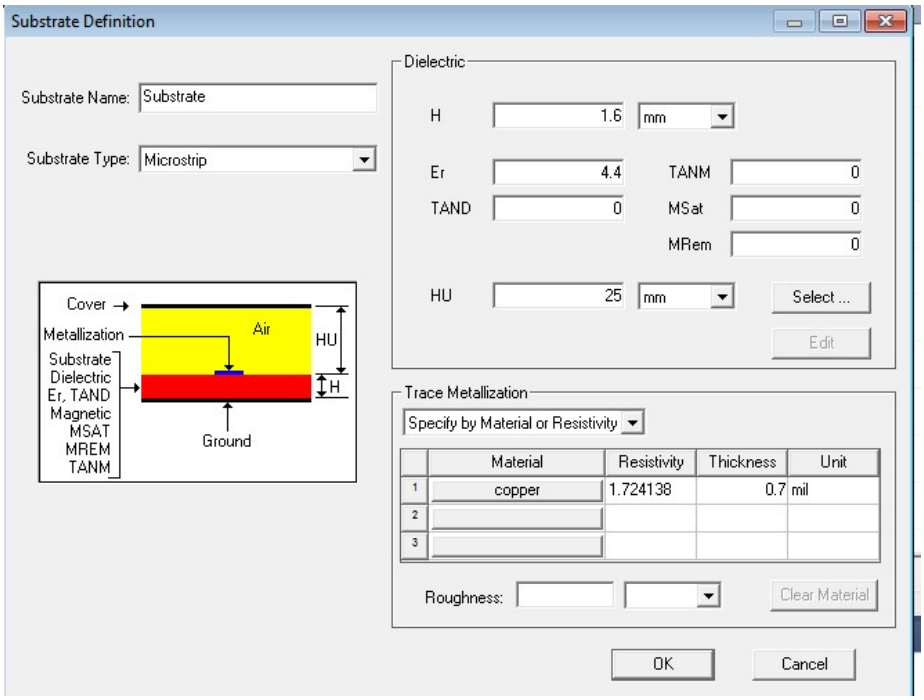
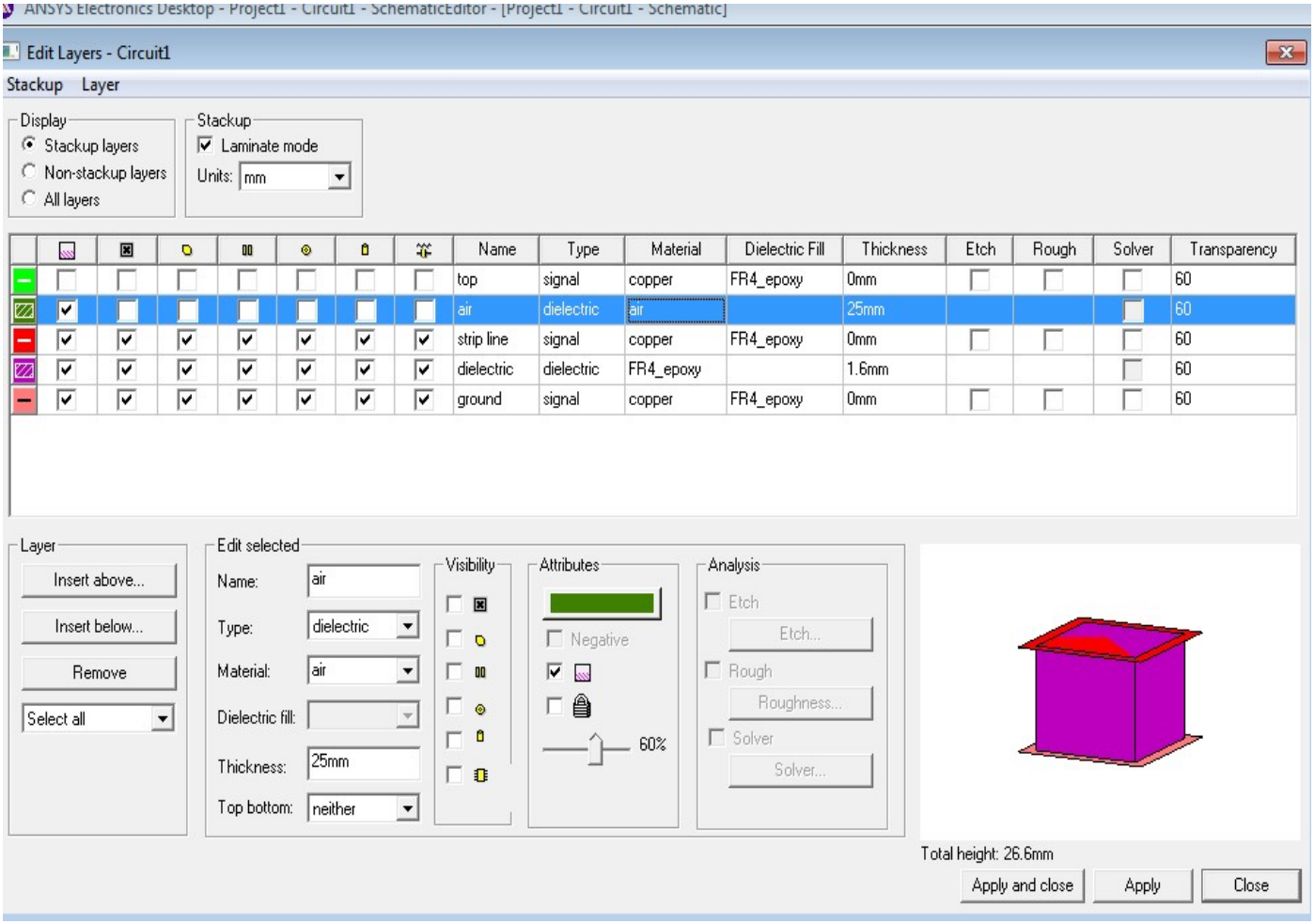




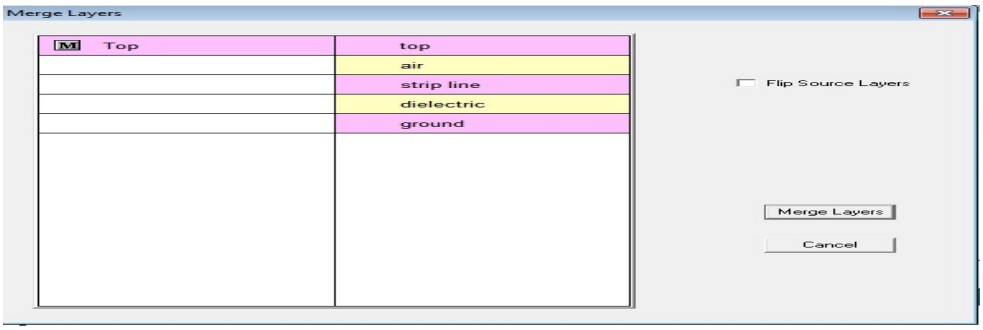
4) Definiting stackup Layers and metarial definiation:

Click Schematic→Layout stackup (enter the layers as follows by clicking insert below tab)



5) To place microstripline in the work space

Components→Distributed→ microstripline →Transmission line→SL_TRL:TL Transmission Line, Physical Length (Double click) and drag to the workstation. Click merge layers and place that in the work space



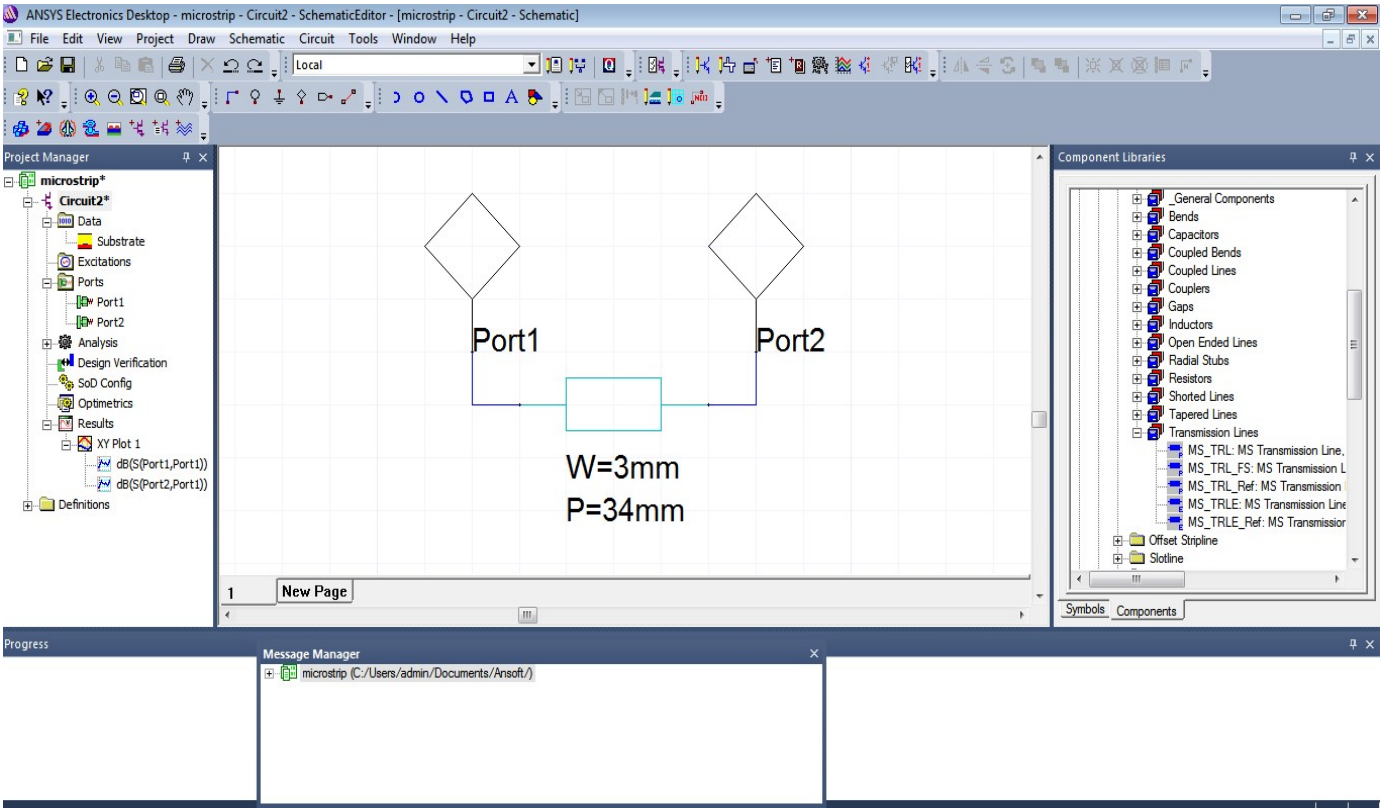
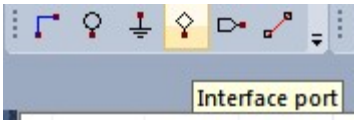
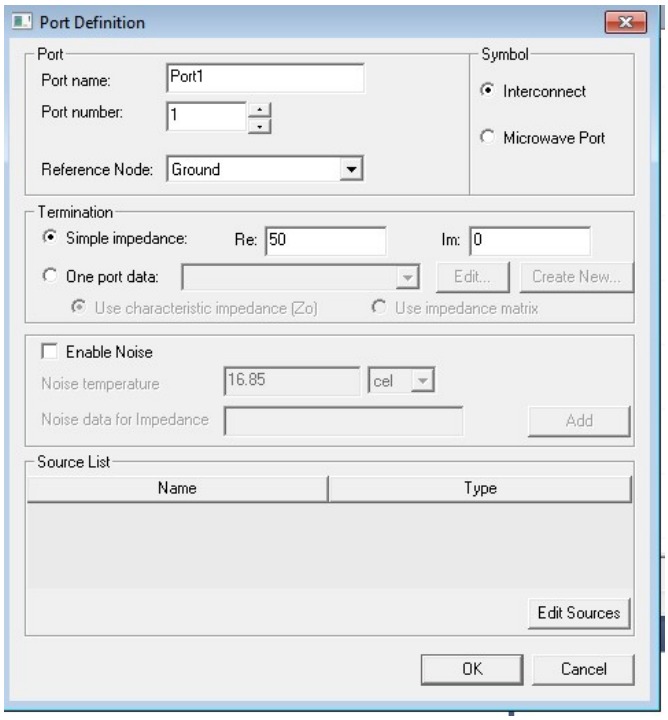


Fig. 2: Microstrip line setup in HFSS circuit design

6) Adding Ports:

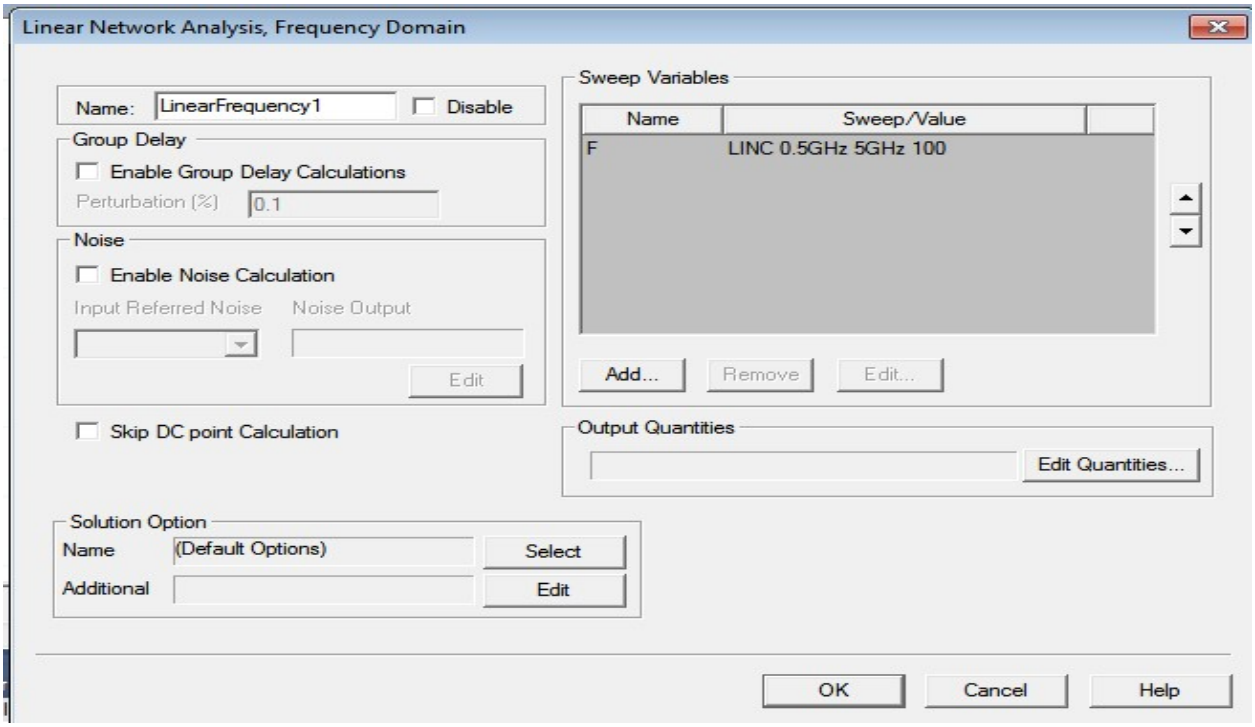
To add port with Transmission lines click this icon and add ports.



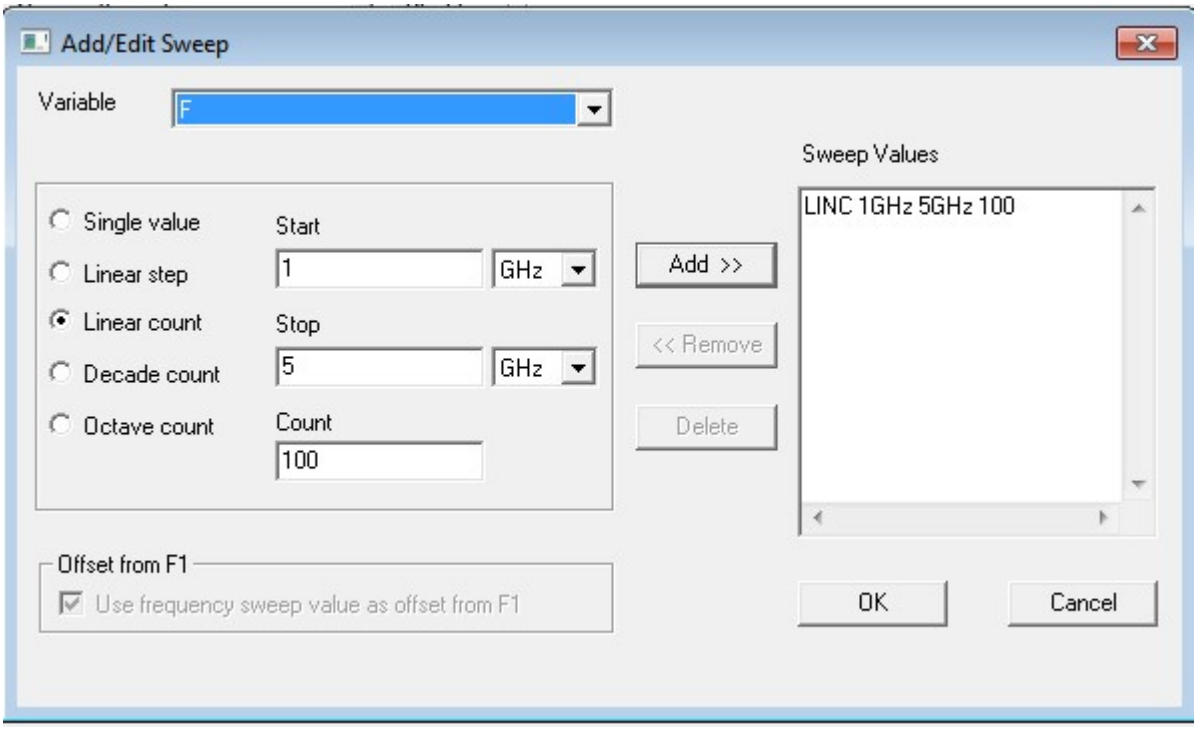


7) Setting analysis SETUP(Frequency SETUP):

Circuit→ Add nexxim solution set up→ Liner Network Analysis



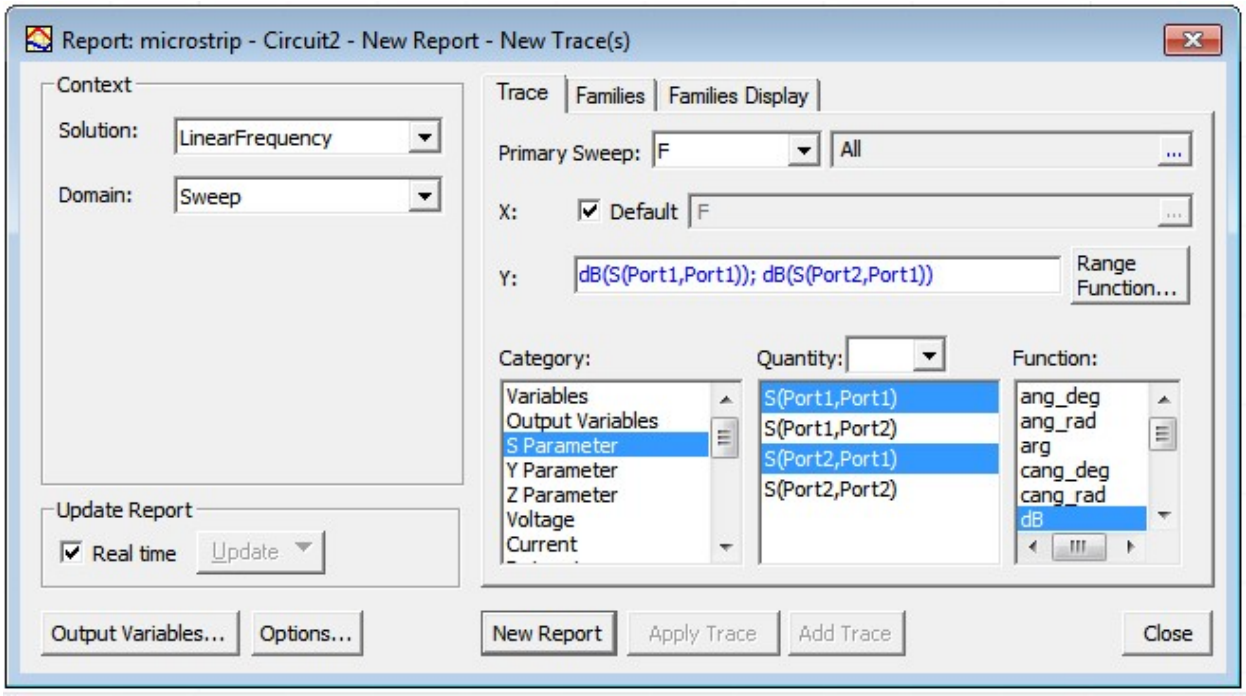
Click add button to enter required sweep value



8) Result Analysis:

To Run the design, Circuit→ click Analyze

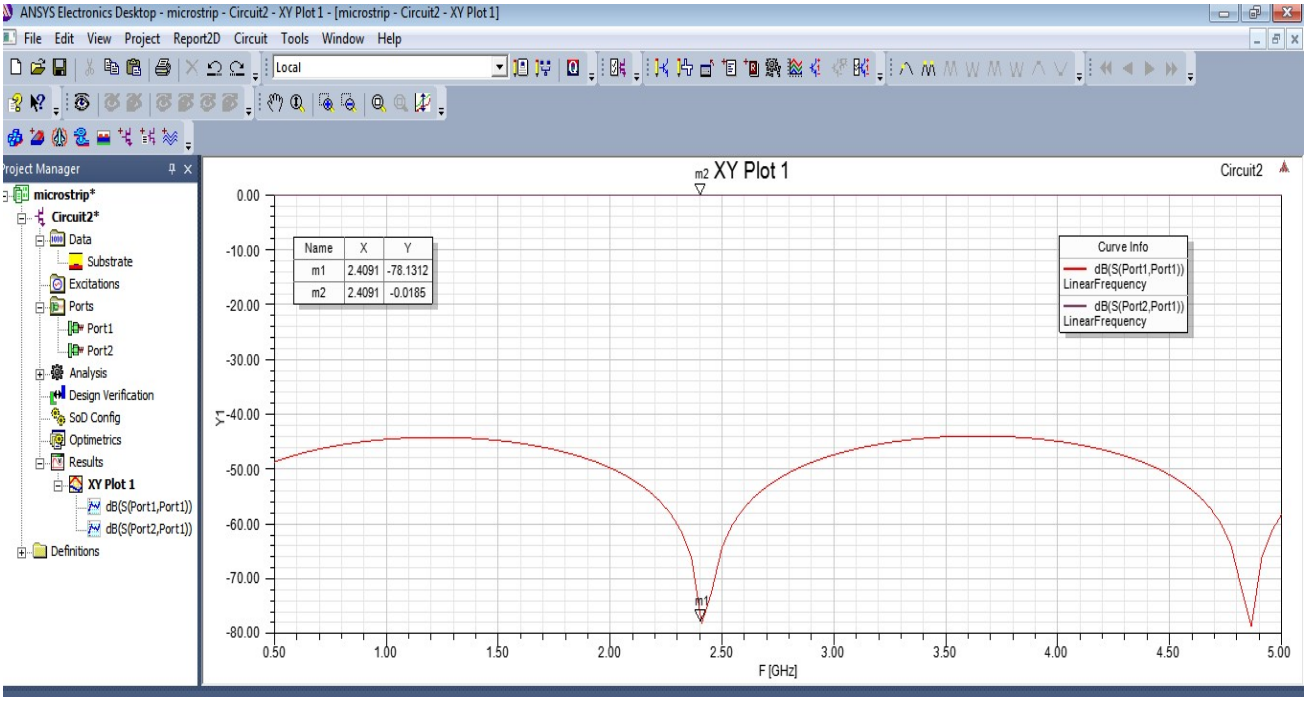
Goto Project mangner →right click on RESULTS→Create standard report→Rectangular report



Sample Observations: The behaviour of a two port network when matched with 50 ohm at both input and output ports for a typical microstrip line with the following specifications is shown below.

$\boldsymbol{Z_0}$ = 50 Ω, $\boldsymbol{f}$ = 2.4GHz , $\boldsymbol{H}$ = 1.6 mm, T = 0.036 mm, $\boldsymbol{\varepsilon_r}$ = 4.4 , L = 0.001

Model graph:



Practical Observations:

Frequency	S_{11}	S_{12}	S_{21}	S_{22}

Conclusions:

The design and simulated frequency of the Microstrip line are matching.