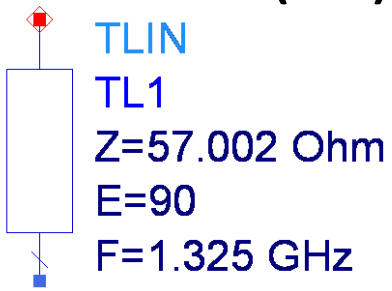
Quarter-wave, $\lambda_0/4$, Impedance Transformer

ISSUE: Consistency in FEM Simulations

$\lambda/4$ Impedance Transformer Design Parameters

- Frequency of operation, f_0 = 1.325-GHz
- Parameters of the transmission line employed:
  - Electrical length at f_0, $\theta_C(f_0)$ = 90-degree
  - Characteristic impedance, Z_C = 57.002-Ohms
  - Port impedance, Z_0 = 50-Ohms

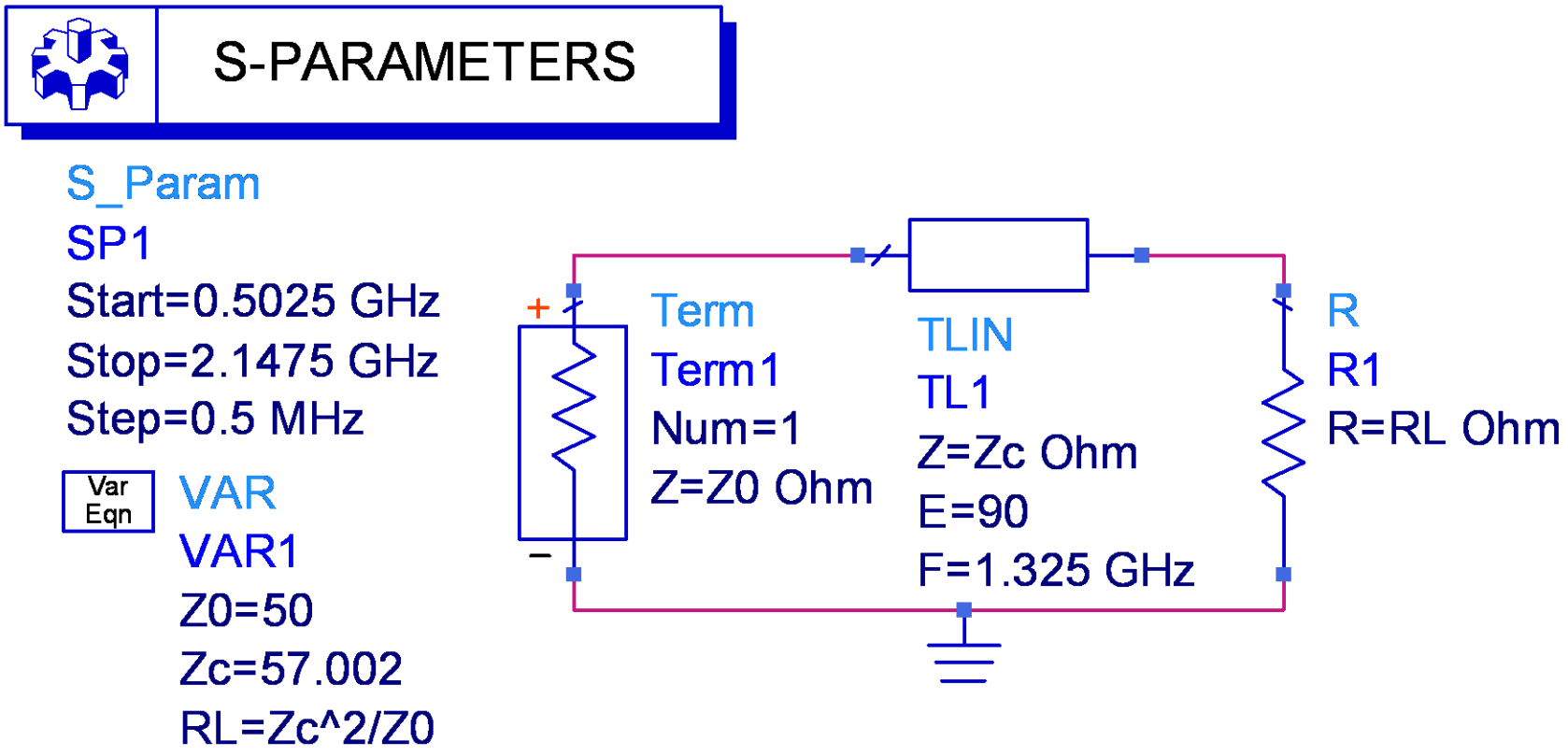
- ADS model for ideal transmission line (TL) based $\lambda/4$ impedance transformer:



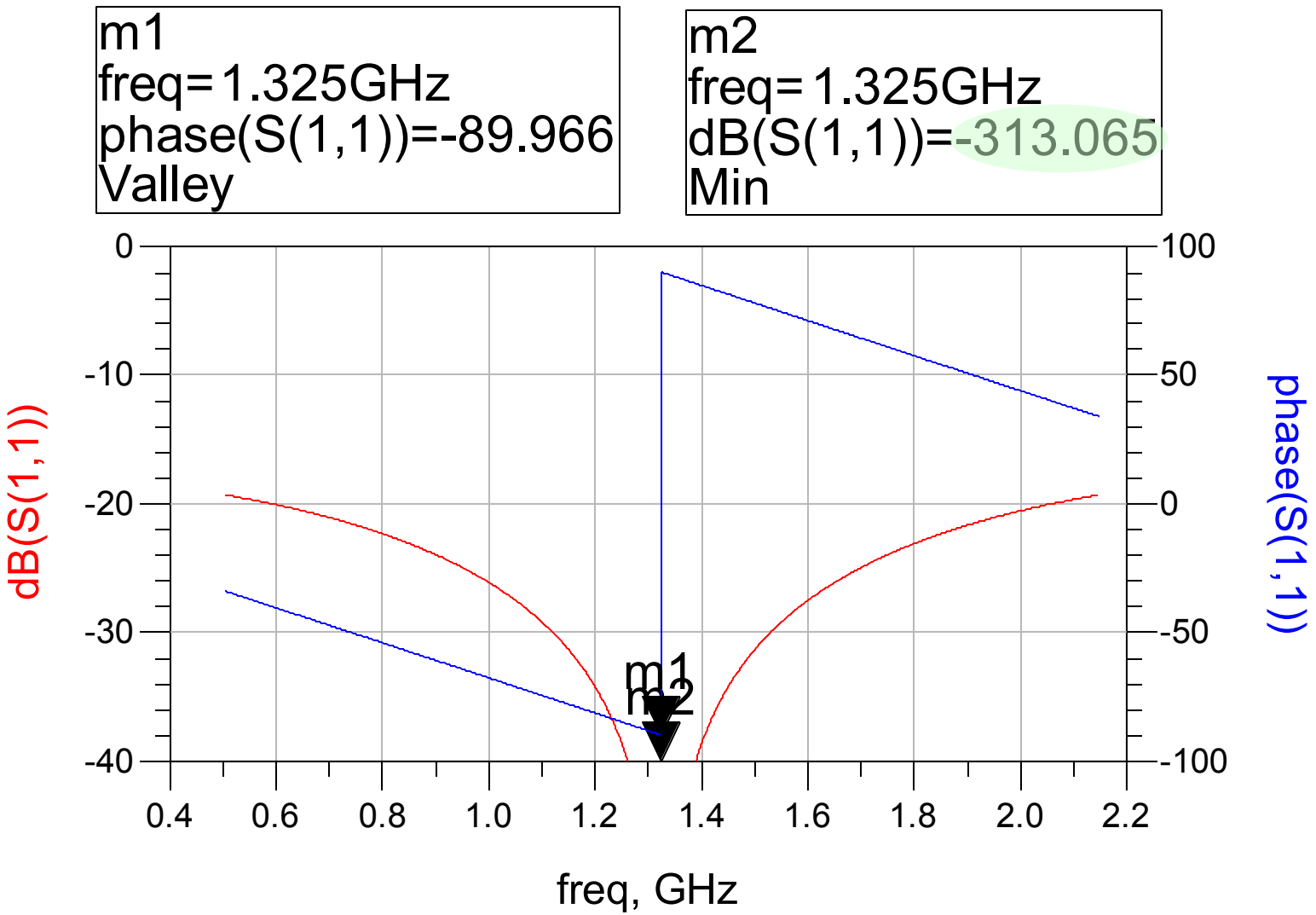
S-Parameter Simulation of Ideal Transmission Line based $\lambda/4$ Impedance Transformer

S-Parameter Simulation Set-Up

- Simulation of ideal transmission line based $\lambda/4$ impedance transformer



S-Parameter Simulation Result



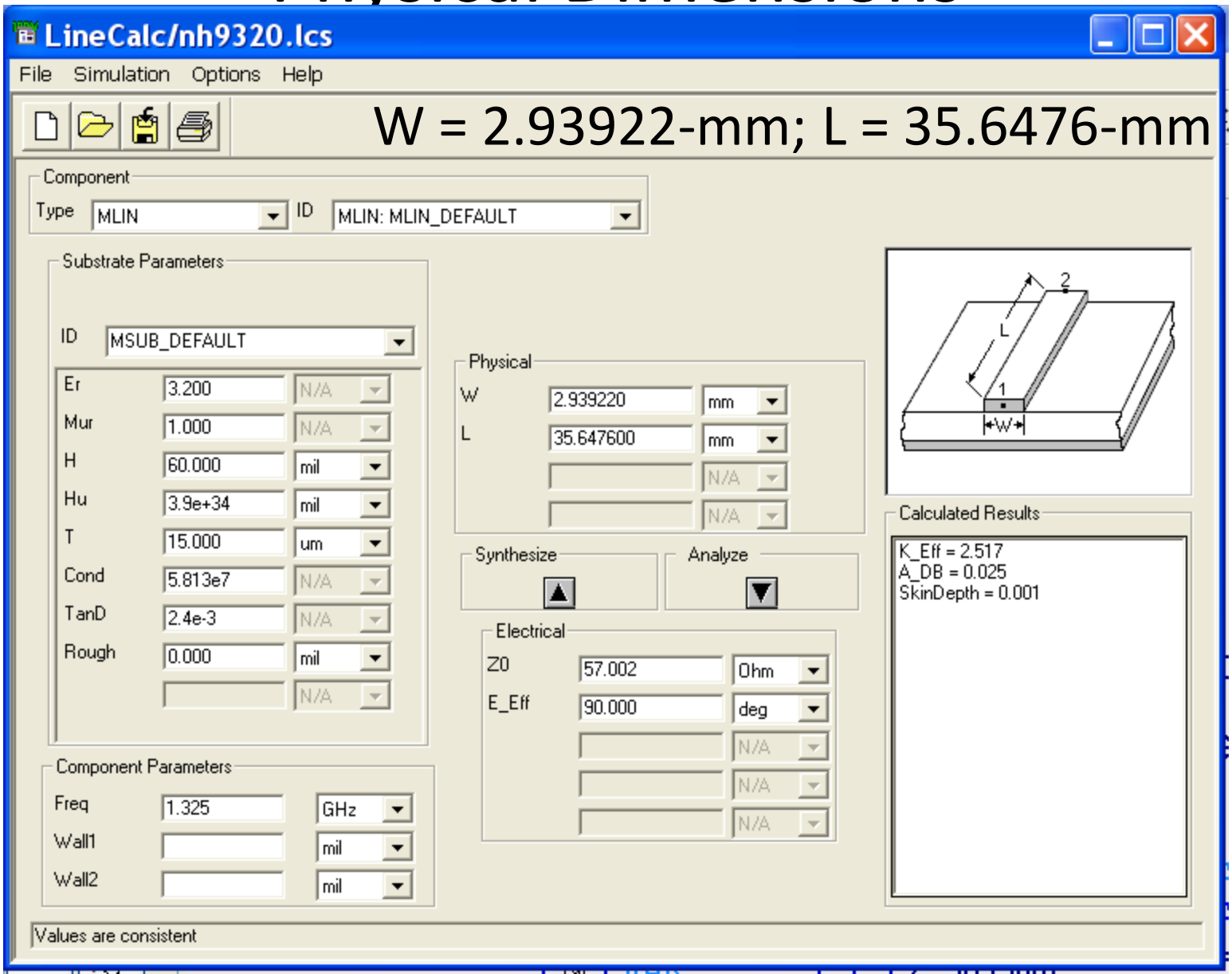
- Simulation result, with ideal TL resonator, is as per the theory:

$$S_{11} = 0 \text{ at } f_0$$

Substrate Parameters for Microstrip Transmission Line

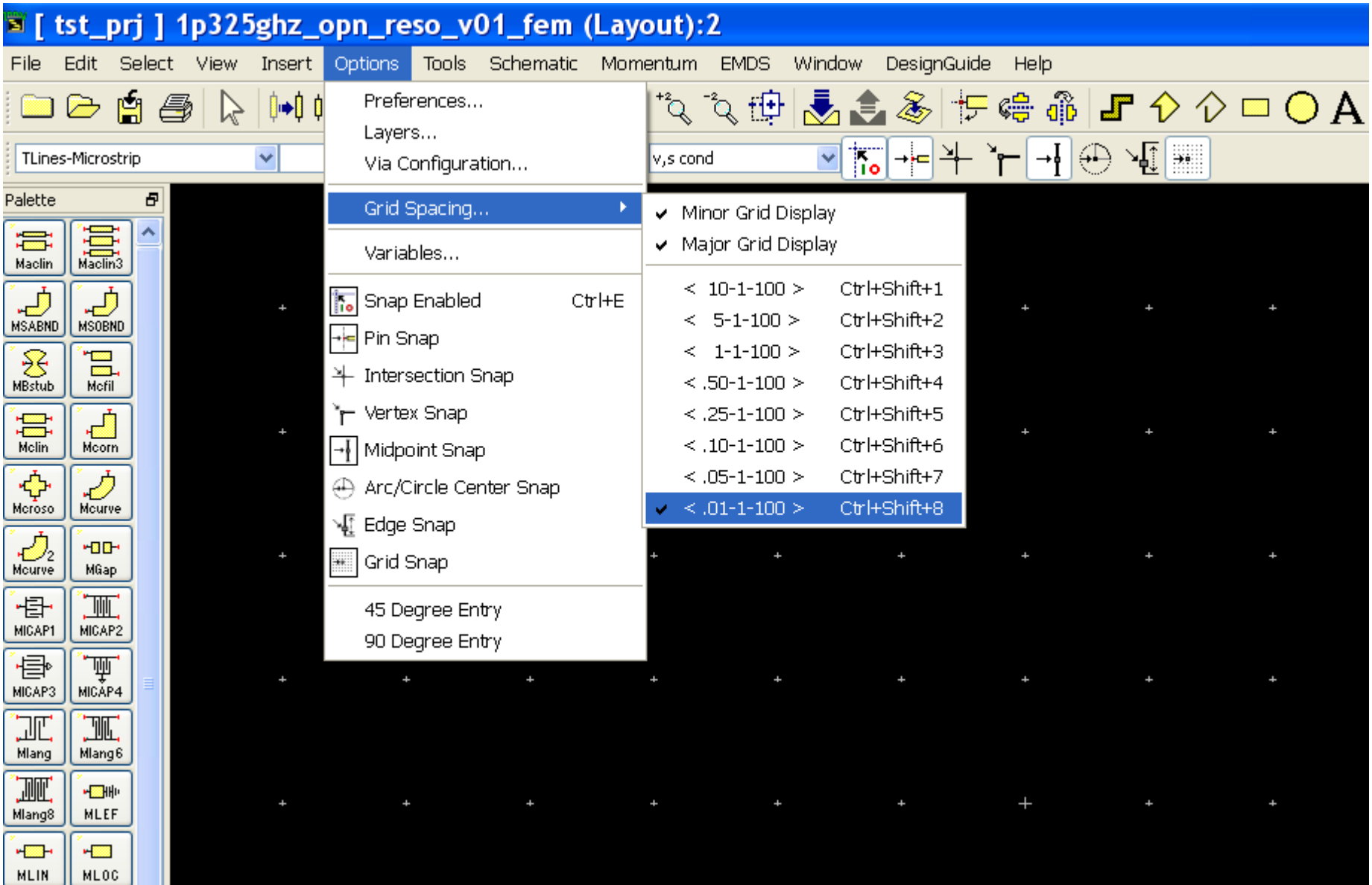
- Substrate parameters:
  - Dielectric constant, $\varepsilon_r = 3.2$
  - Height, h = 1.524-mm (or 60 milli-inch)
  - Loss tangent, $\tan \delta = 0.0024$
- Conductor parameters:
  - Thickness, t = 15-microns
  - Conductivity (Copper), $\sigma = 5.813 \times 10^7$ S/m

Quarterwave Impedance Transformer Physical Dimensions

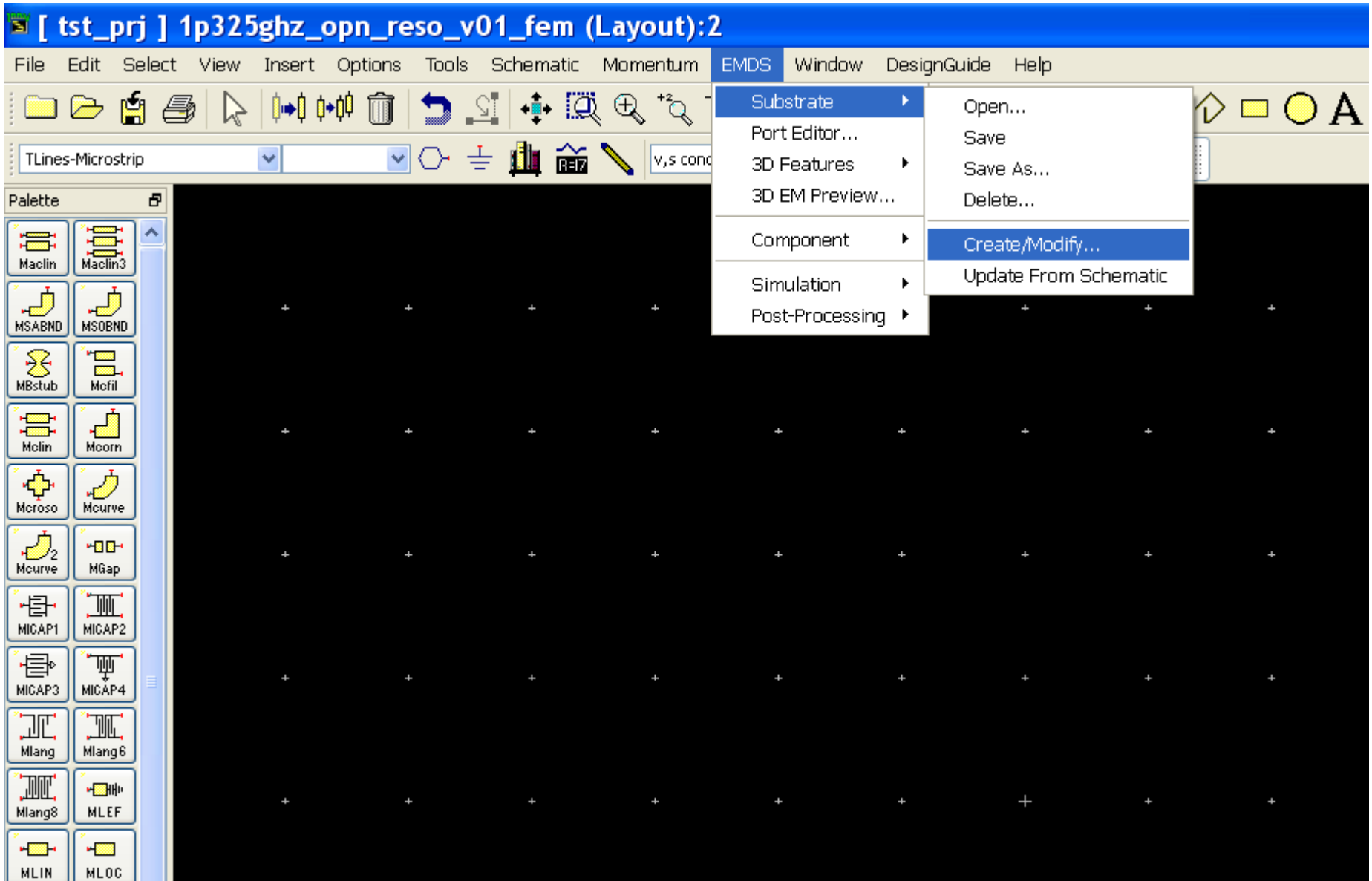


Layout Creation of the $\lambda/4$ Microstrip Line Impedance Transformer

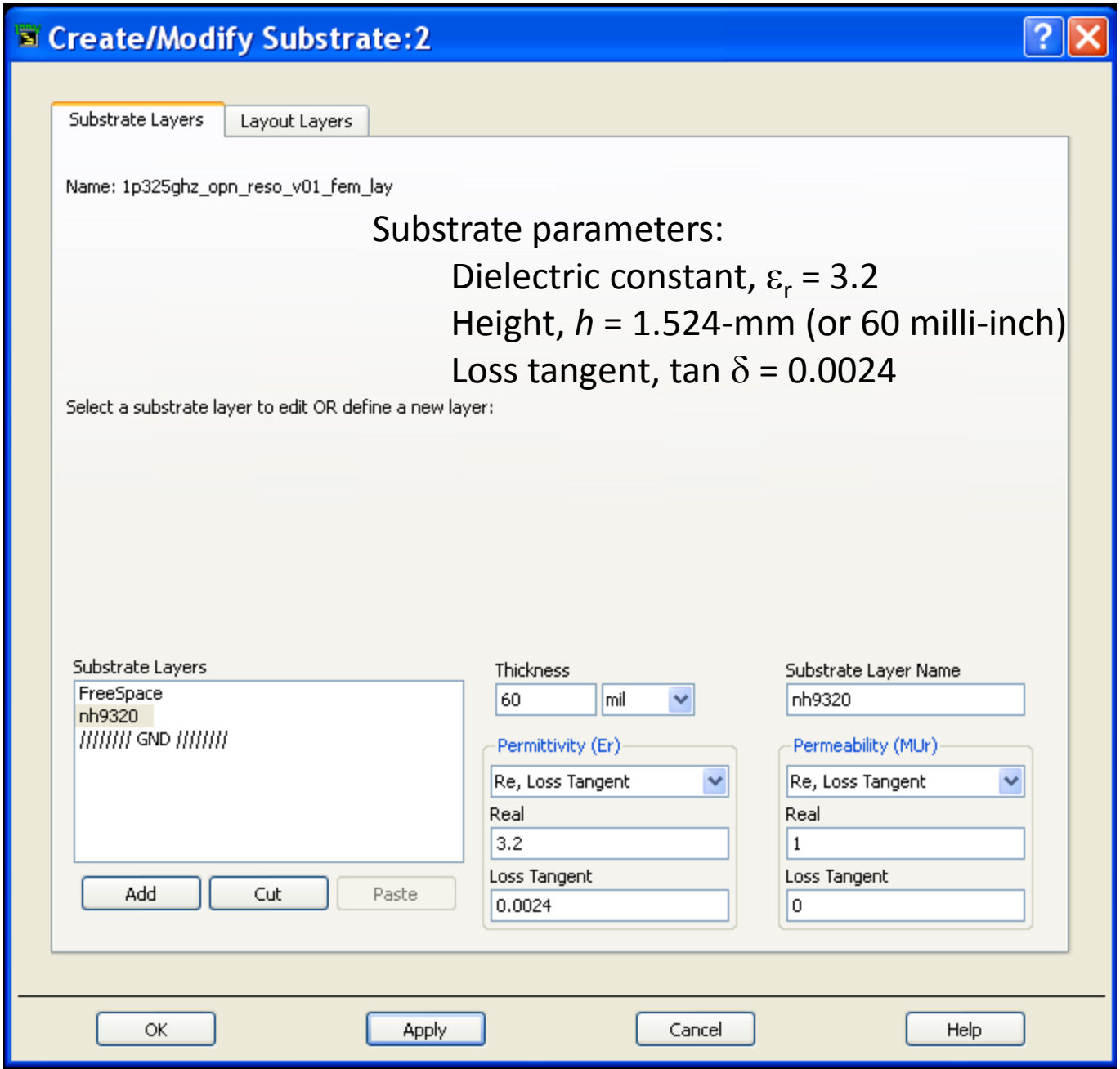
Grid Spacing & Snap Options



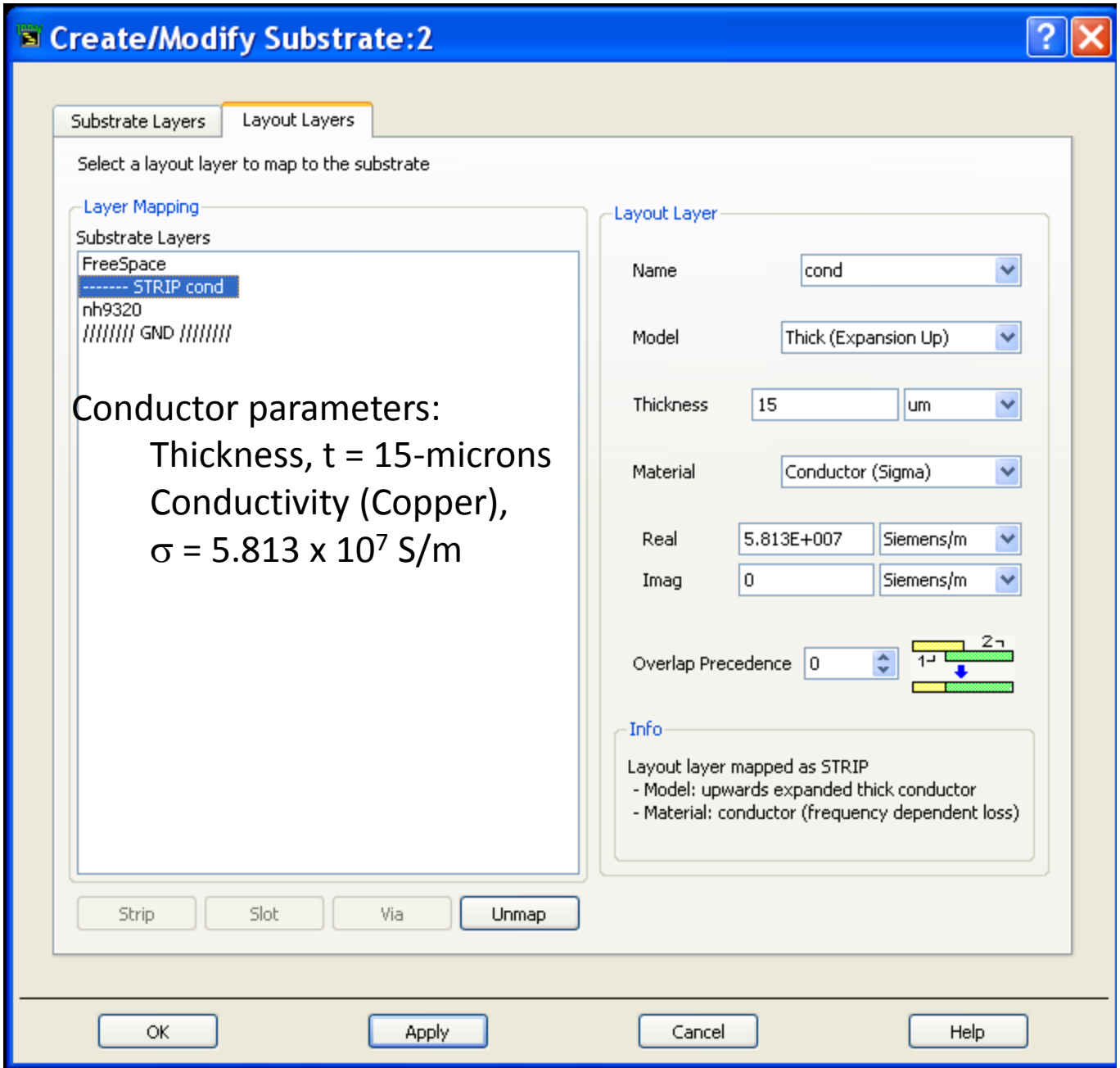
Defining Substrate for Layout



Substrate Definition: Part 1



Substrate Definition: Part 2



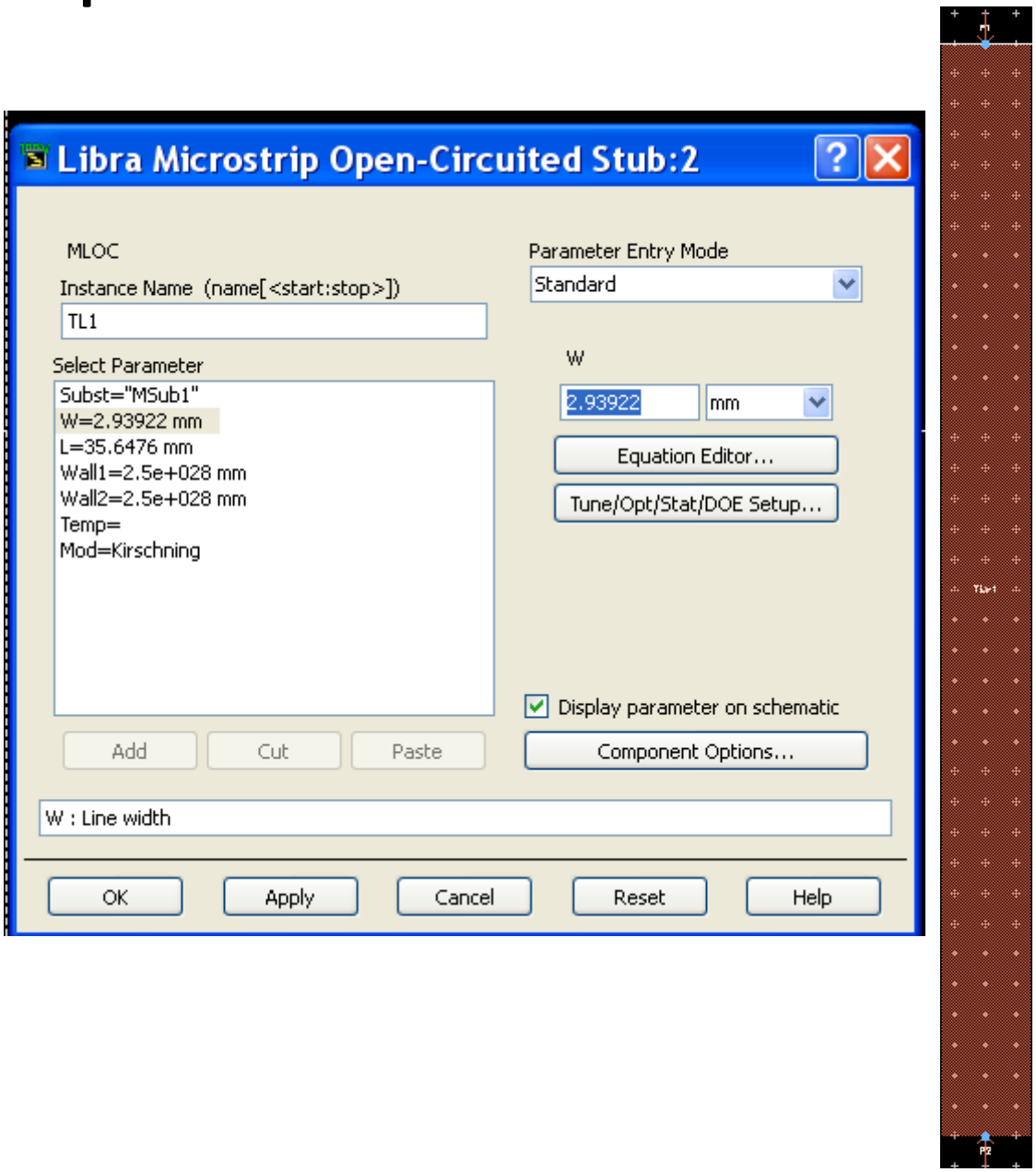
Conductor parameters:

Thickness, t = 15-microns

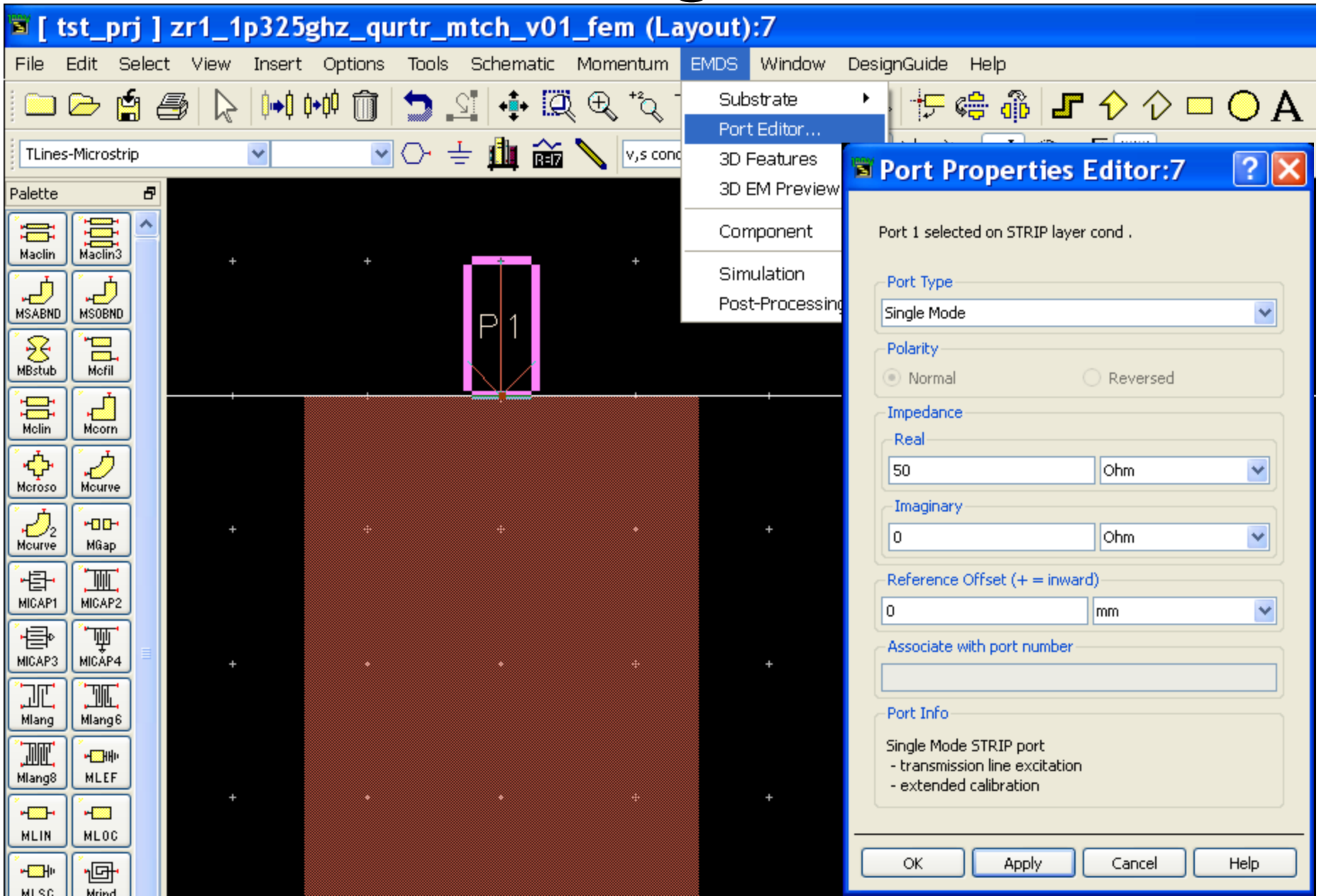
Conductivity (Copper),

$\sigma = 5.813 \times 10^7$ S/m

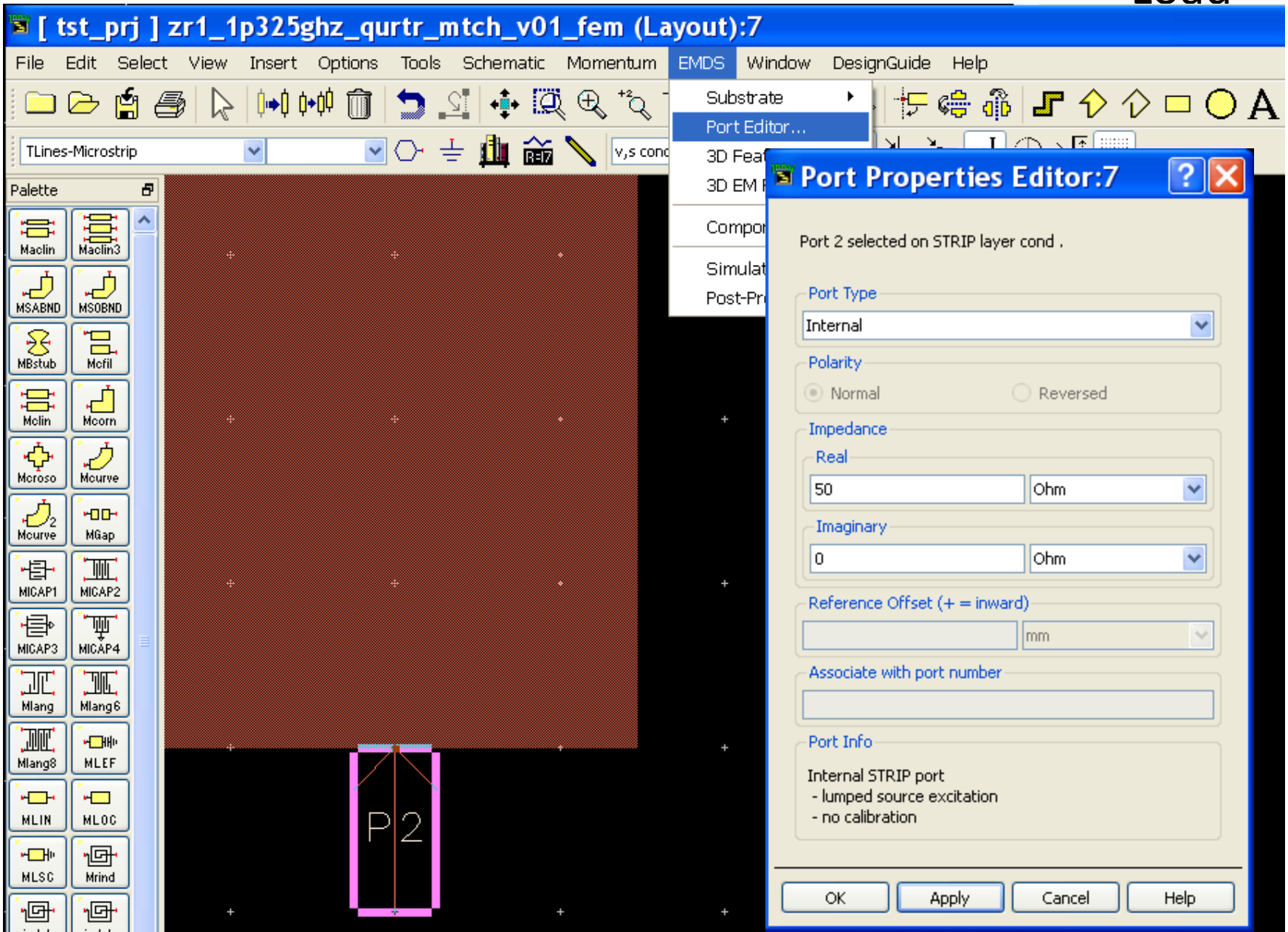
λ/4 Impedance Transformer's Layout



Port 1: Single Mode

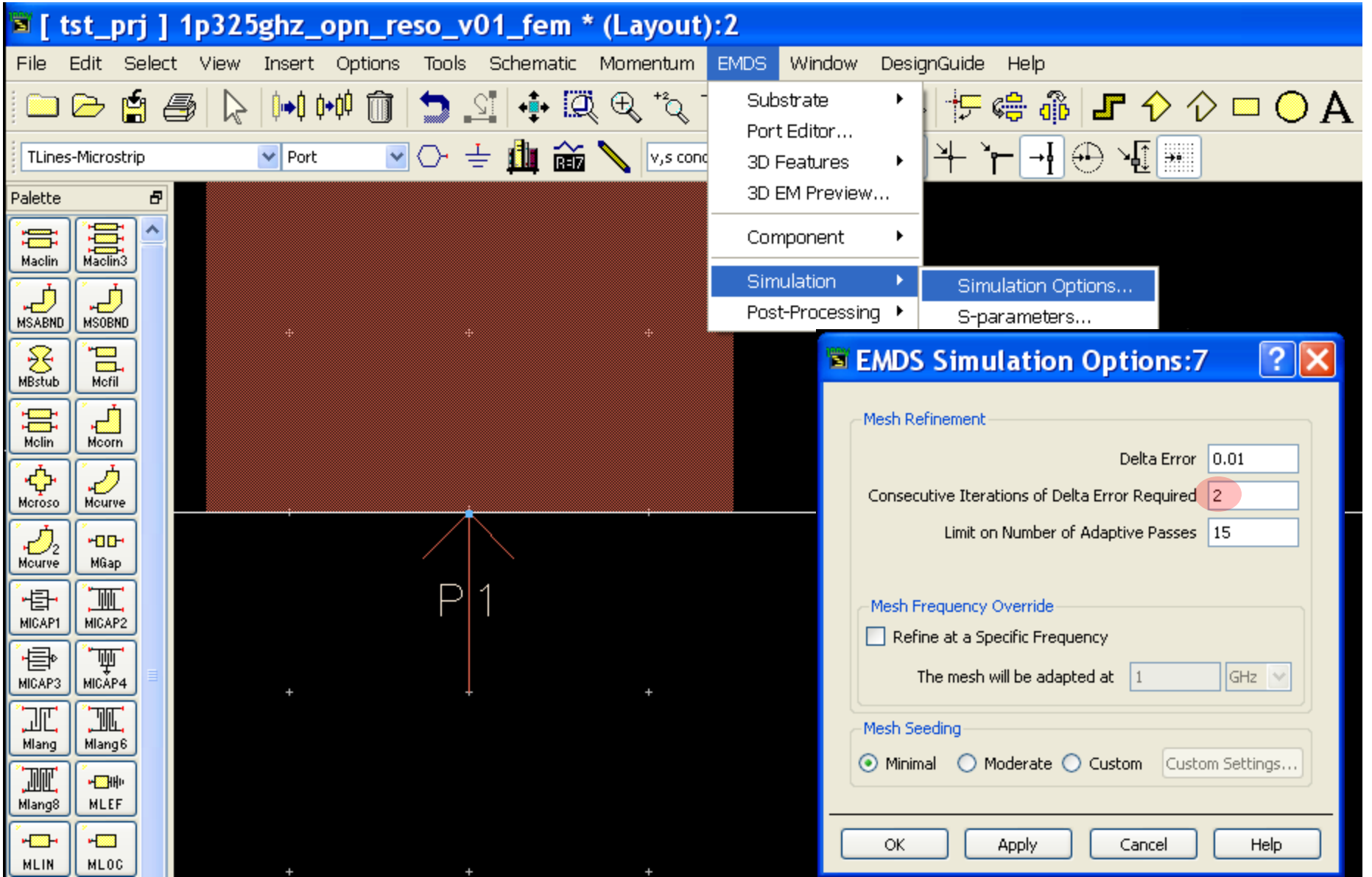


Port 2: Internal Type (to connect R_{Load})

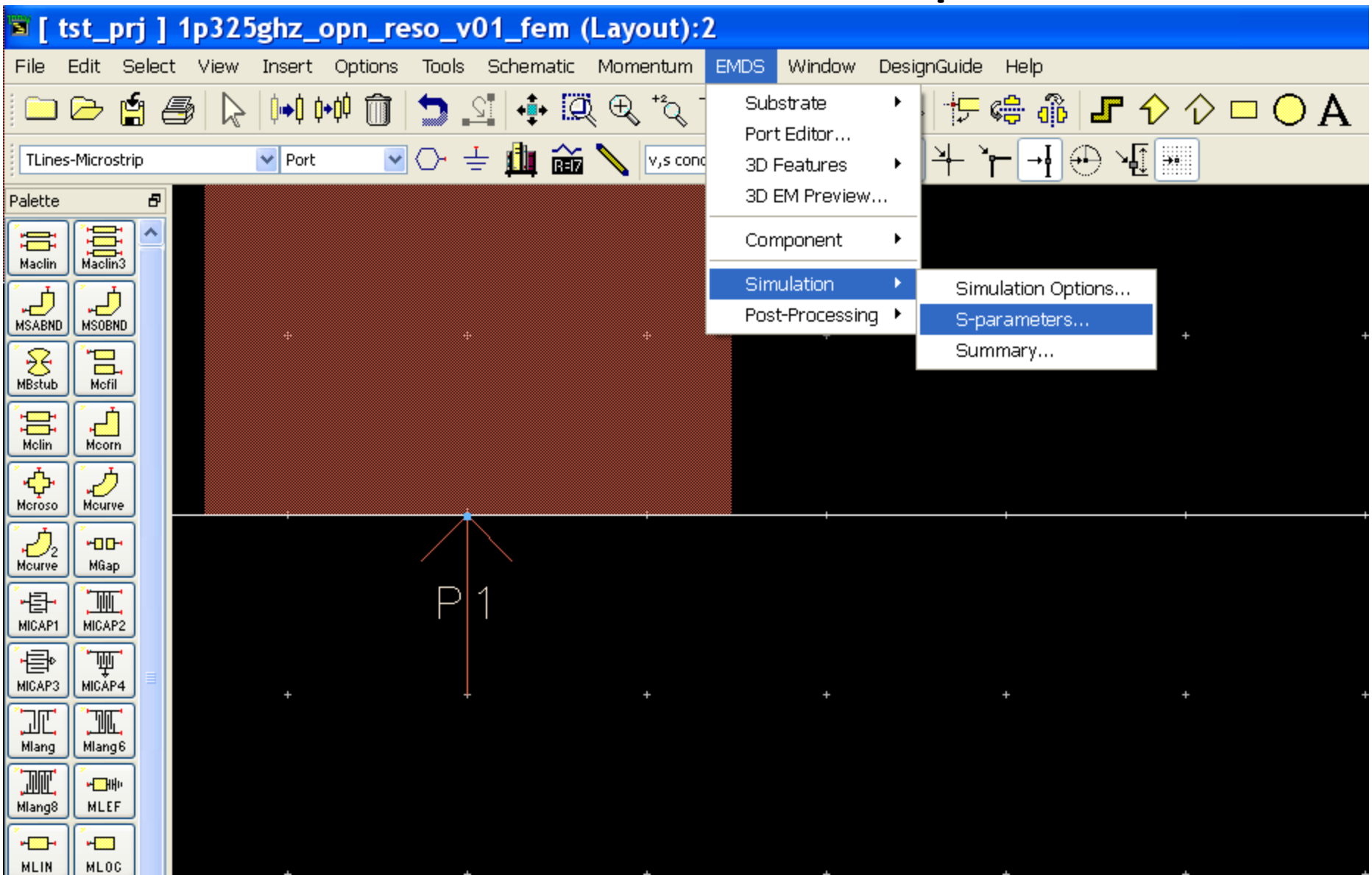


EMDS (FEM) based S-Parameters EM-circuit Co-Simulation of the $\lambda/4$ Microstrip Line Impedance Transformer Layout

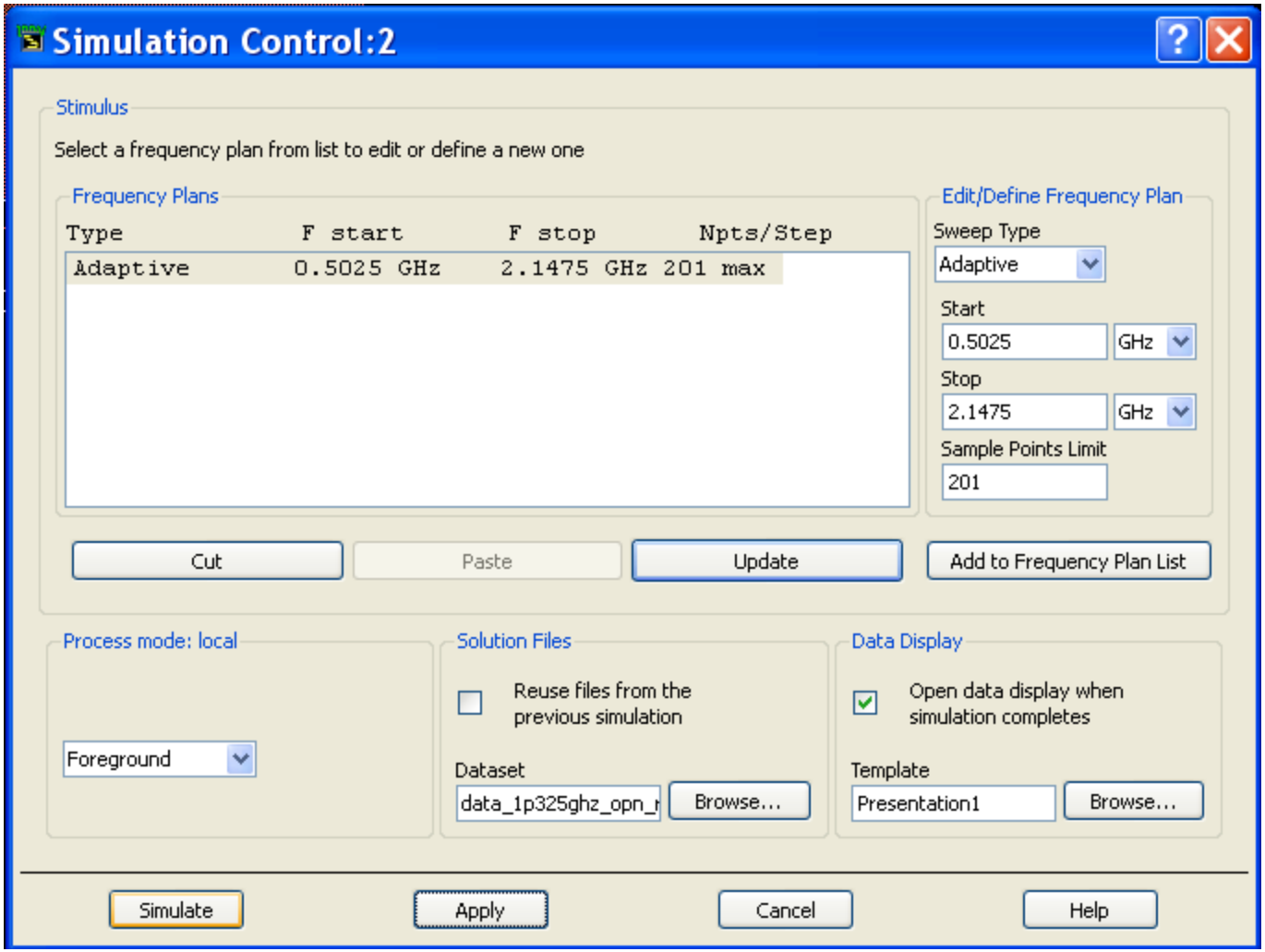
EMDS (FEM) Simulation Options



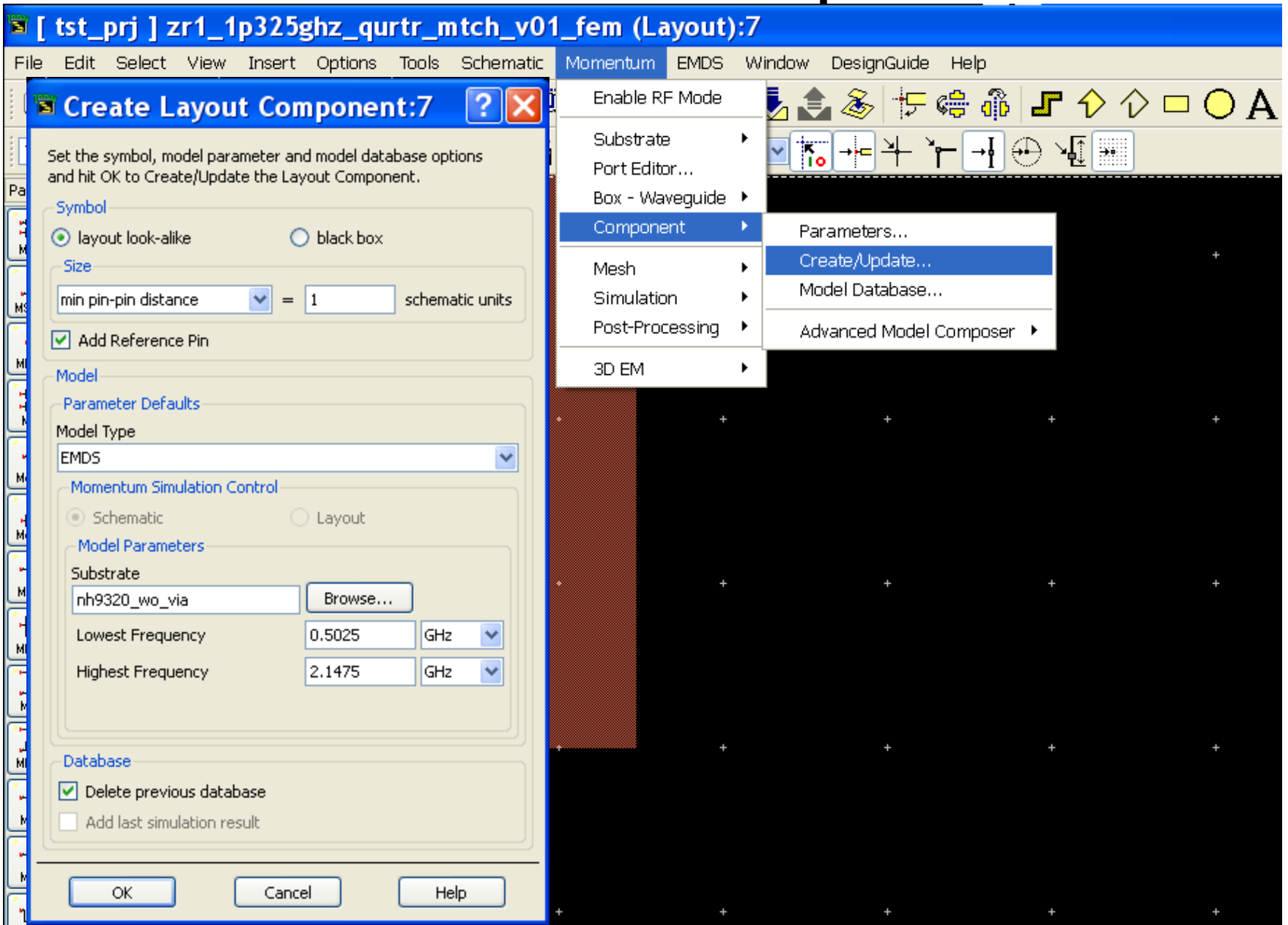
EMDS (FEM) S-Parameters EM Simulation Set-Up



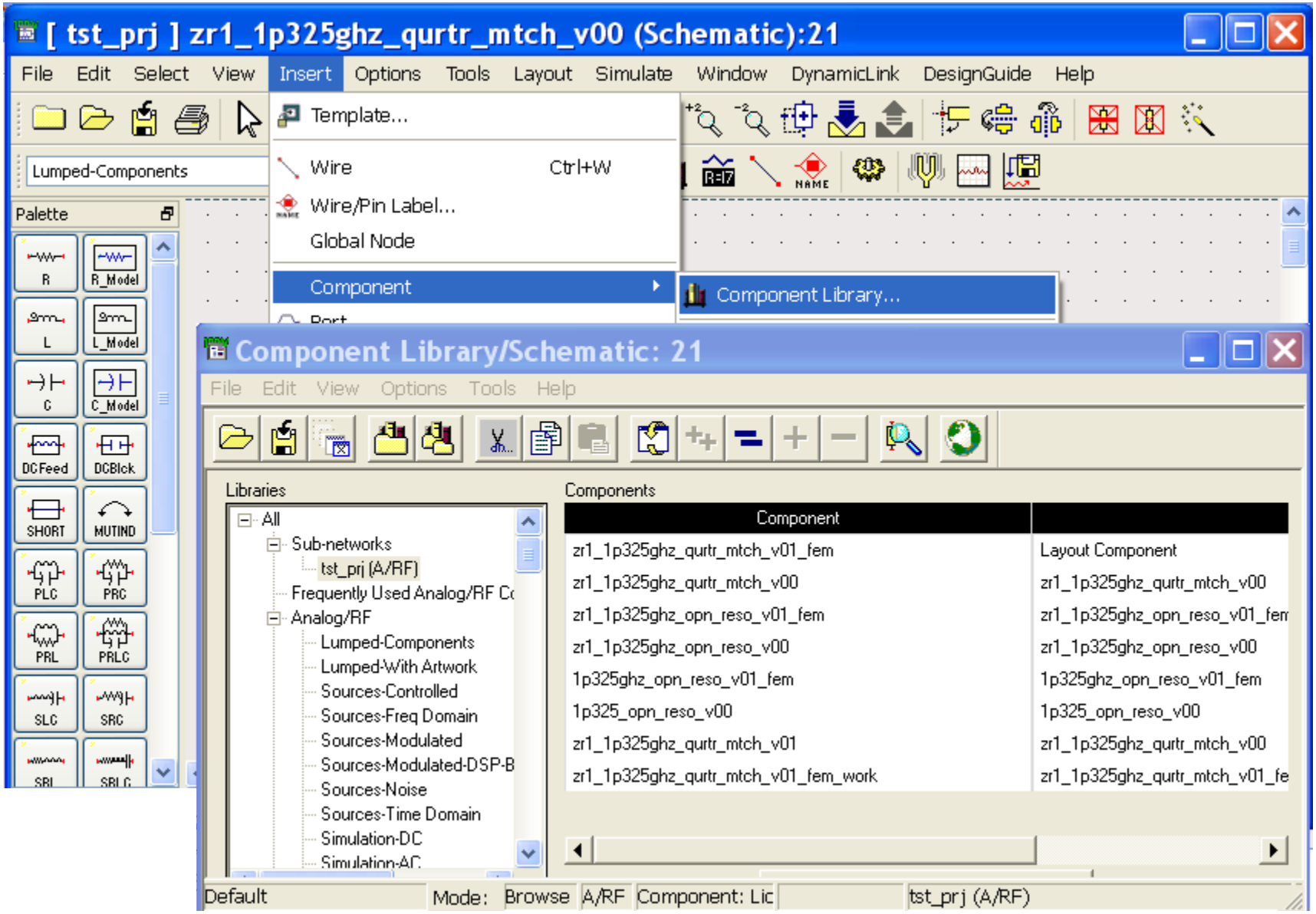
EMDS (FEM) S-Parameters EM Simulation Set-Up



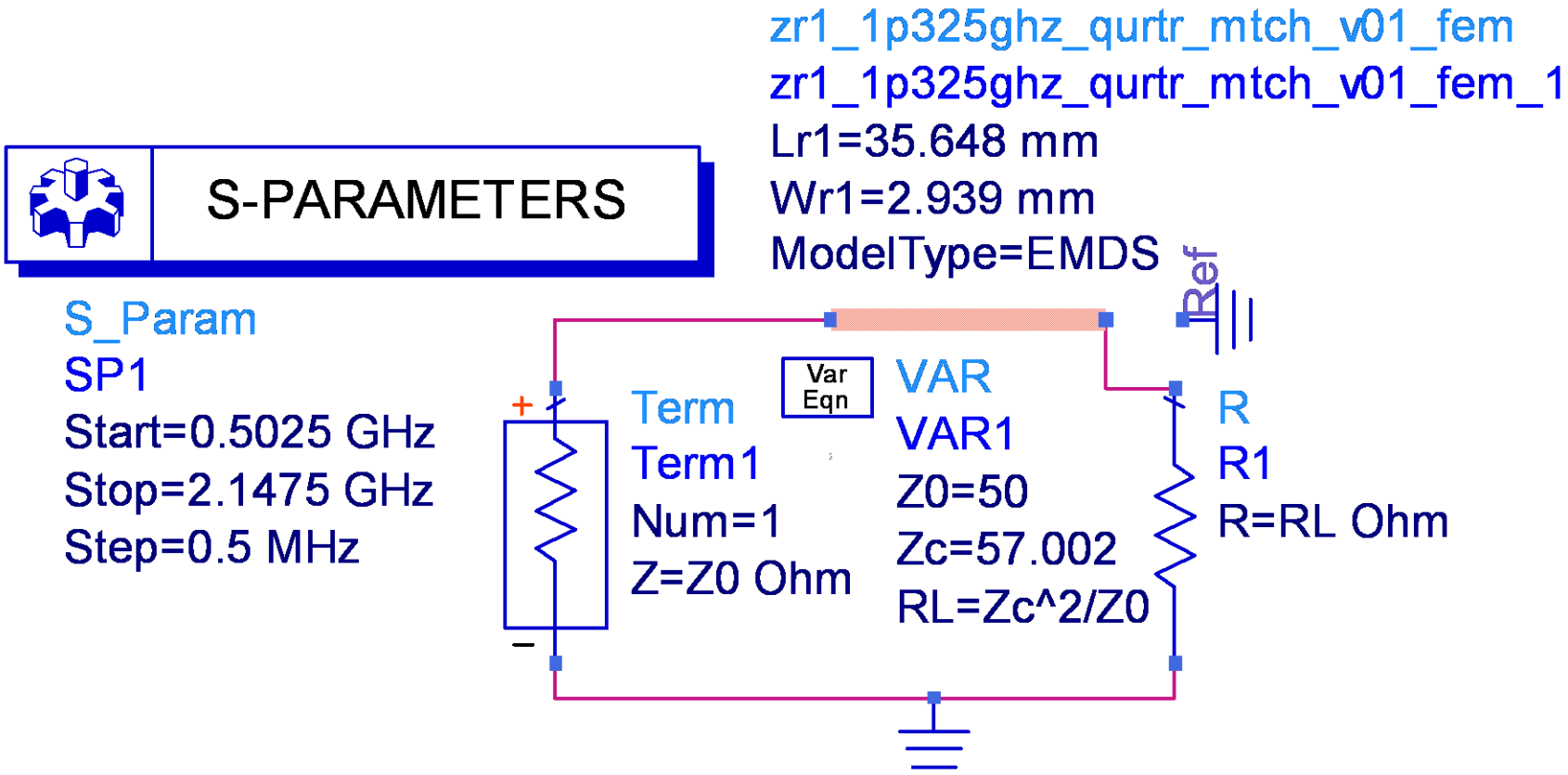
Create FEM Component



Insert FEM Component into Schematic



ADS Schematic with FEM Component for EM-Circuit Co-Simulation

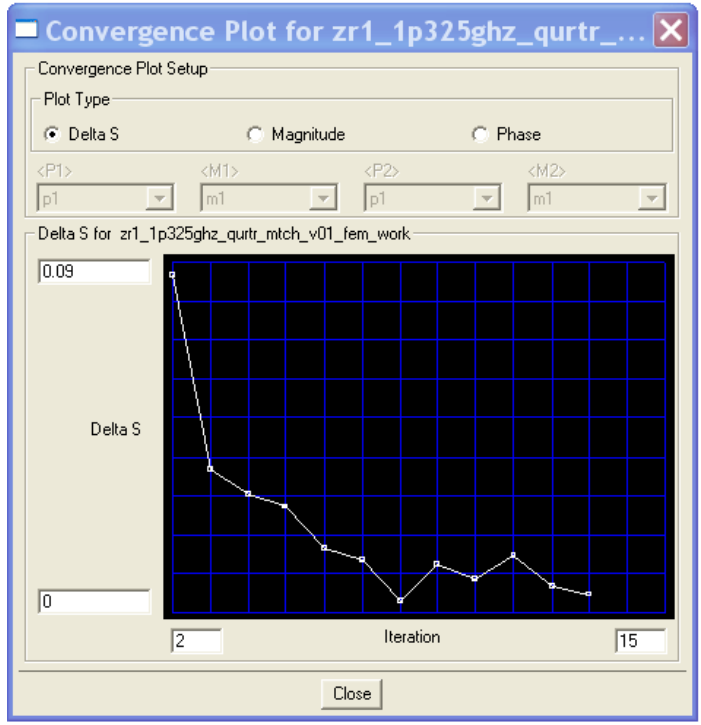


```
Computer Operating System: Microsoft Windows XP Service Pack 3
Obtaining license to run zr1_1p325ghz_qurtr_mtch_v01_fem_work @ RFIC1: Fr:

-------------------------------------------------------------------------------
                    Pass 1 : Fri Nov 30 20:36 2012
-------------------------------------------------------------------------------
PORTS 1
                CPU time:    00:00:00
GRADE 1
                CPU time:    00:00:01
MESH 1
                Node count after EDGE seeds:          41
                Node count after FACE seeds:          41
                Node count after VOLUME seeds:        41
                Number of Elements:                   48
                CPU time:    00:00:00
PORTS 1
                CPU time:    00:00:00
SOLVE 1
                Frequency:    2.147500 GHz      Unknowns:      331
                CPU time:    00:00:00           Memory:     409.69 Kbyte

-------------------------------------------------------------------------------
                    Pass 2 : Fri Nov 30 20:36 2012
-------------------------------------------------------------------------------
ADAPT 2
                Number of Elements:                264
                CPU time:    00:00:00
PORTS 2
                CPU time:    00:00:00
SOLVE 2
                Frequency:    2.14750
                CPU time:    00:00:00

                Delta S:     0.086592
```



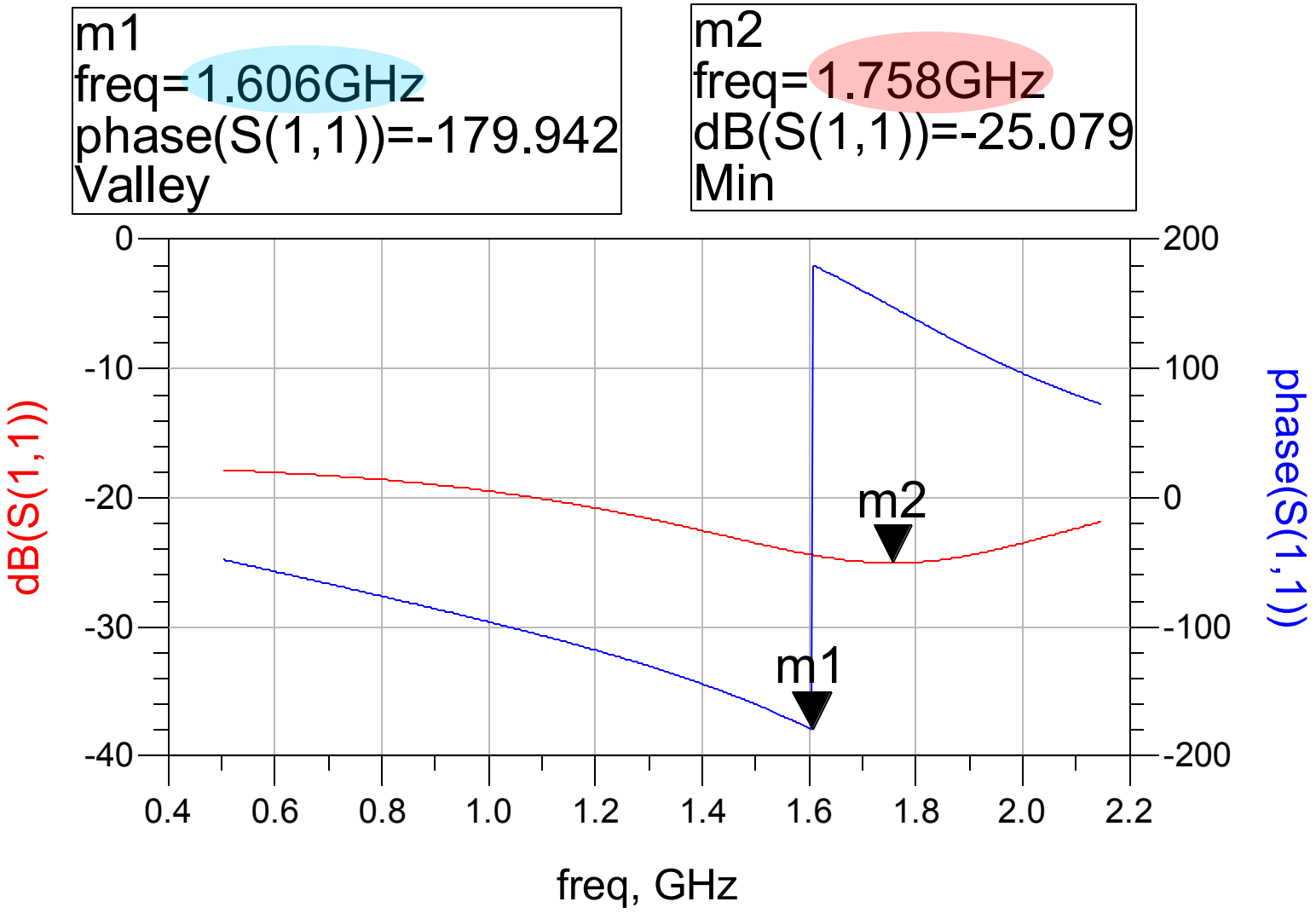

```
-------------------------------------------------------------------------------
                    Pass 13 : Fri Nov 30 20:36 2012
-------------------------------------------------------------------------------
ADAPT 13
                Number of Elements:                7518
                CPU time:    00:00:01
PORTS 13
                CPU time:    00:00:00
SOLVE 13
                Frequency:    2.147500 GHz      Unknowns:    48321
                CPU time:    00:00:12           Memory:     170.22 Mbyte

                Delta S:     0.004712           [Target:   0.010000]

-------------------------------------------------------------------------------
                Computing Solution : Fri Nov 30 20:37 2012
-------------------------------------------------------------------------------
PORTS
                CPU time:    00:00:00
SOLVE
                Frequency:    1.325000 GHz      Unknowns:    38165
                Fast Frequency Sweep: 502.500000 MHz to    2.147500 GHz
                CPU time:    00:00:12           Memory:     225.58 Mbyte
DONE
-------------------------------------------------------------------------------
Total CPU Time     = 00:00:56
Total Elapsed Time = 00:01:05
-------------------------------------------------------------------------------
```

EMDS (FEM) Simulation

Co-Simulation Result



Co-Sim Results Inconsistency

- For same dimensions, same frequencies (at which phase-shift is 180^{0} in BLUE) are not achieved:

		Meshes								Input Match	
Wr1 (mm)	Lr1 (mm)	Feed	Start	Stop	Iterations	Passes	Last ∆err	Time	180-deg	S11	freq (GHz)
2.939	35.952	Minimal	253	11829	15	2	0.015	2:04	1.676	-23.7	1.792
2.939	35.952	Minimal	253	36552	20	2	0.01	11:34	1.742	-21	1.81
2.939	36.000	Minimal	250	1725	7	2	0.009	0:10	1.373	-23	1.665
2.939	36.000	Minimal	250	35826	20	3	0.01	11:25	1.739	-21	1.808
2.939	36.000	Minimal	250	56301	22	3	0.01	24:20		Memory	ISSUE
2.939	36.000	Moderate	1058	4573	8	2	0.004	0:24	1.525	-22.7	1.768
2.939	36.000	Moderate	1058	23569	15	3	0.008	4:38	1.702	-22.1	1.799

- As length increases, frequency (at which phase-shift is 180^{0}) does not consistently reduce:

		Meshes						Input Match	
Wr1 (mm)	Lr1 (mm)	Feed	Start	Stop	Iterations	Time	180-deg	S11	freq (GHz)
2.939	35.648	Minimal	264	7554	13	1:02	1.606	-25	1.758
2.939	35.952	Minimal	253	36552	20	11:34	1.742	-21	1.81
2.939	35.987	Minimal	365	9477	14	1:24	1.641	-24	1.781
2.939	36.000	Minimal	250	1725	7	0:10	1.373	-23	1.665
2.939	36.002	Minimal	265	1776	7	0:13	1.375	-23.5	1.651
2.939	36.072	Minimal	351	6141	12	0:40	1.634	-24	1.849