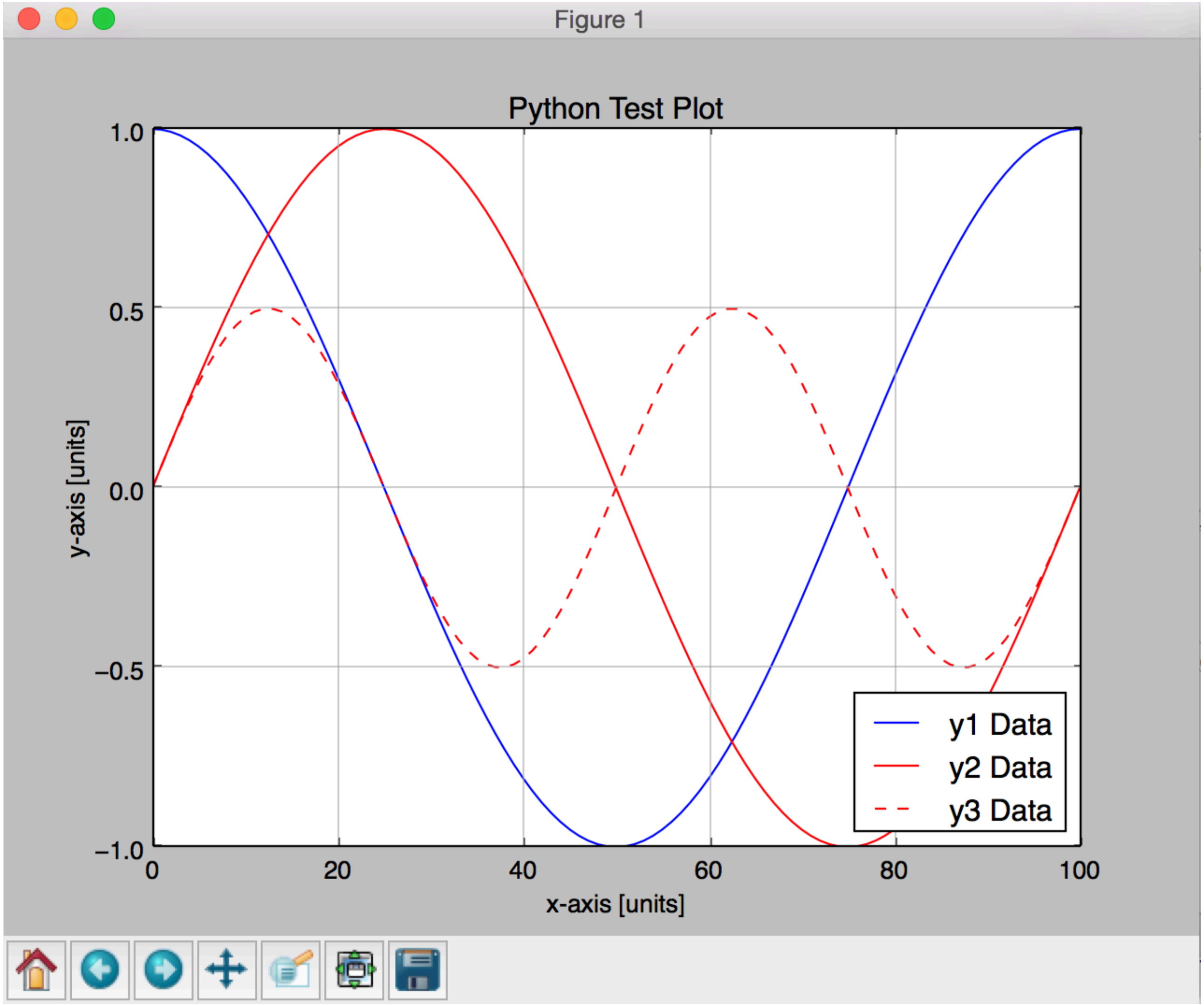
ECEN 452
Lab 1 – Laboratory Best Practices

1. Demonstrate the operation of your Python installation by running the plotting program using the three datasets provided in "ECEN_452_Plotting.zip".



2. Email your GitHub account ID.

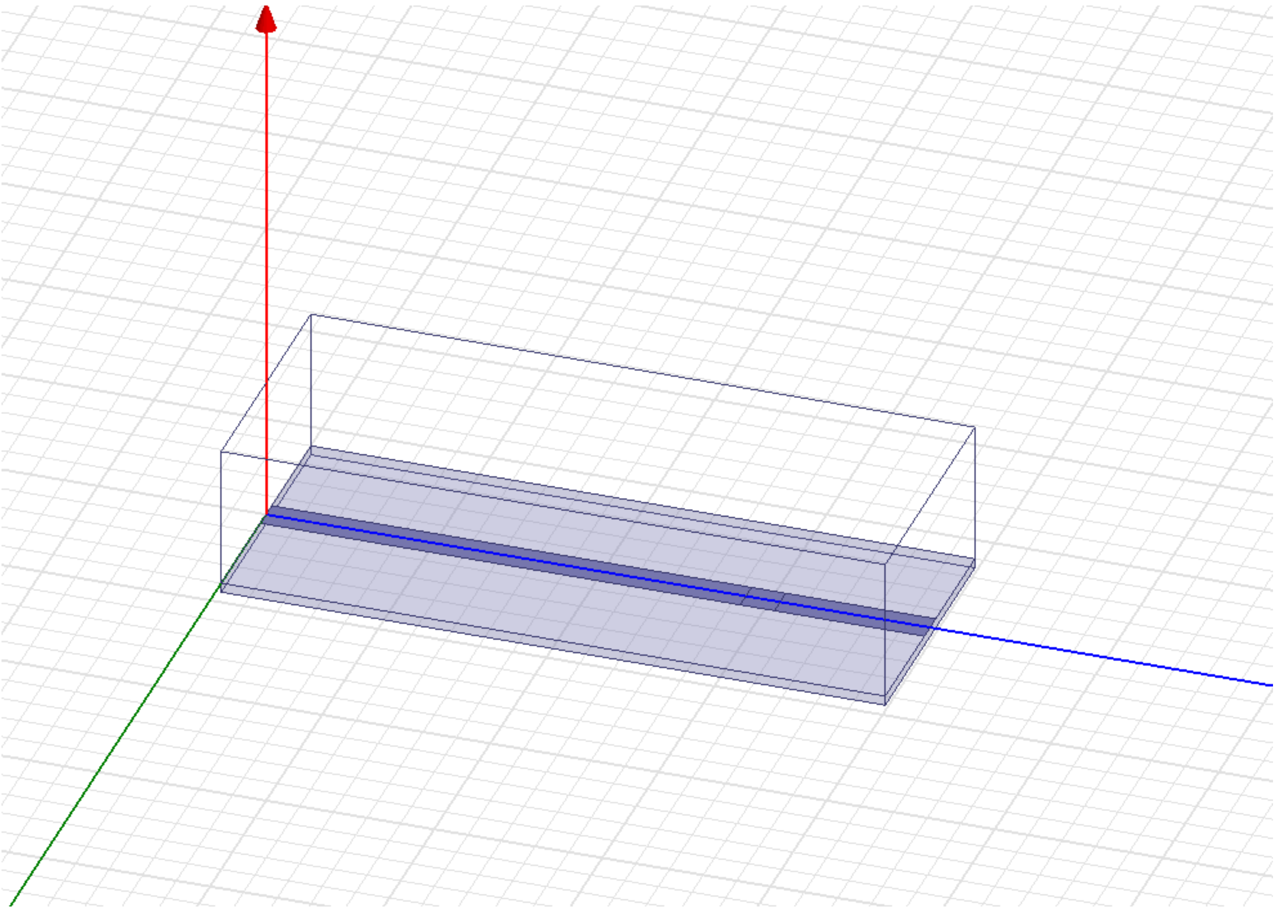
Emailed to Dr.Huff.

3. Familiarize yourself with the design and simulation environments in HFSS and Z0lver by downloading and simulating the files "ECEN_452_Lab1.hfss", "ECEN_452_Lab1a.zov", and "ECEN_452_Lab1b.zov".

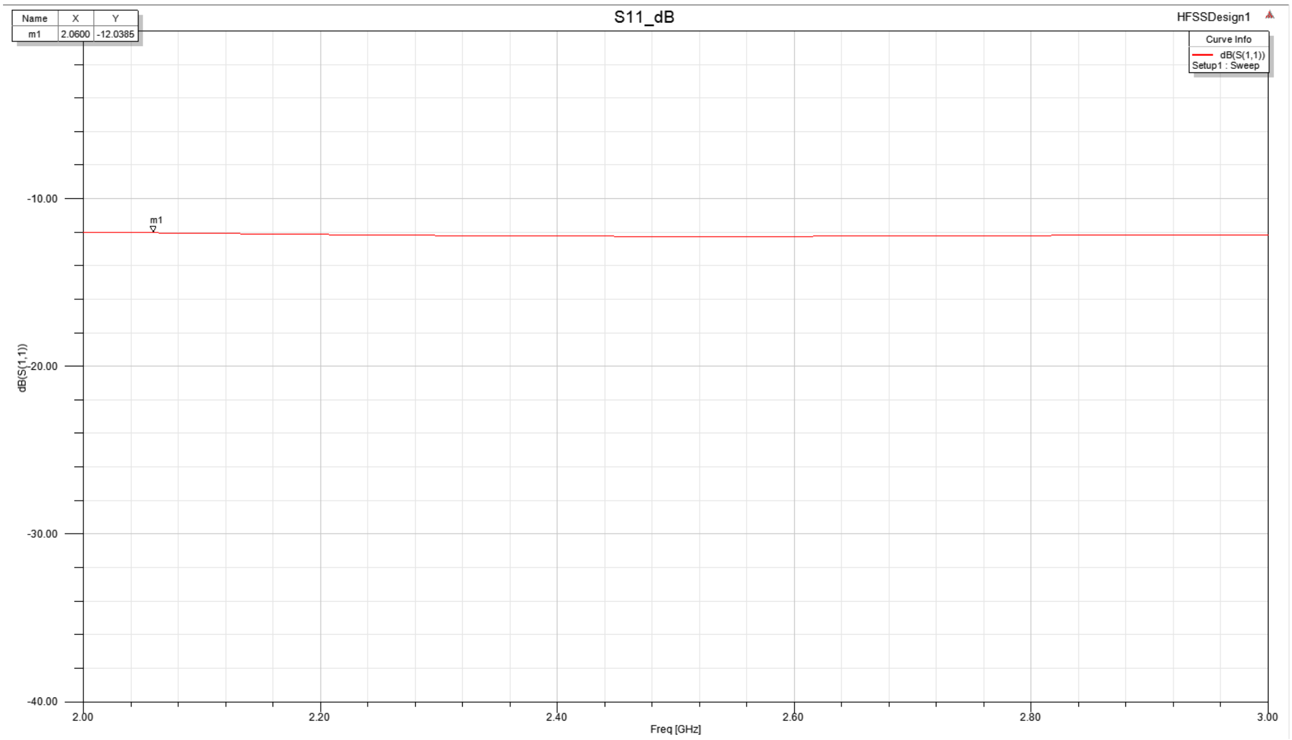
   HFSS –

   For file "ECEN_452_Lab1.hfss"

   HFSS Model

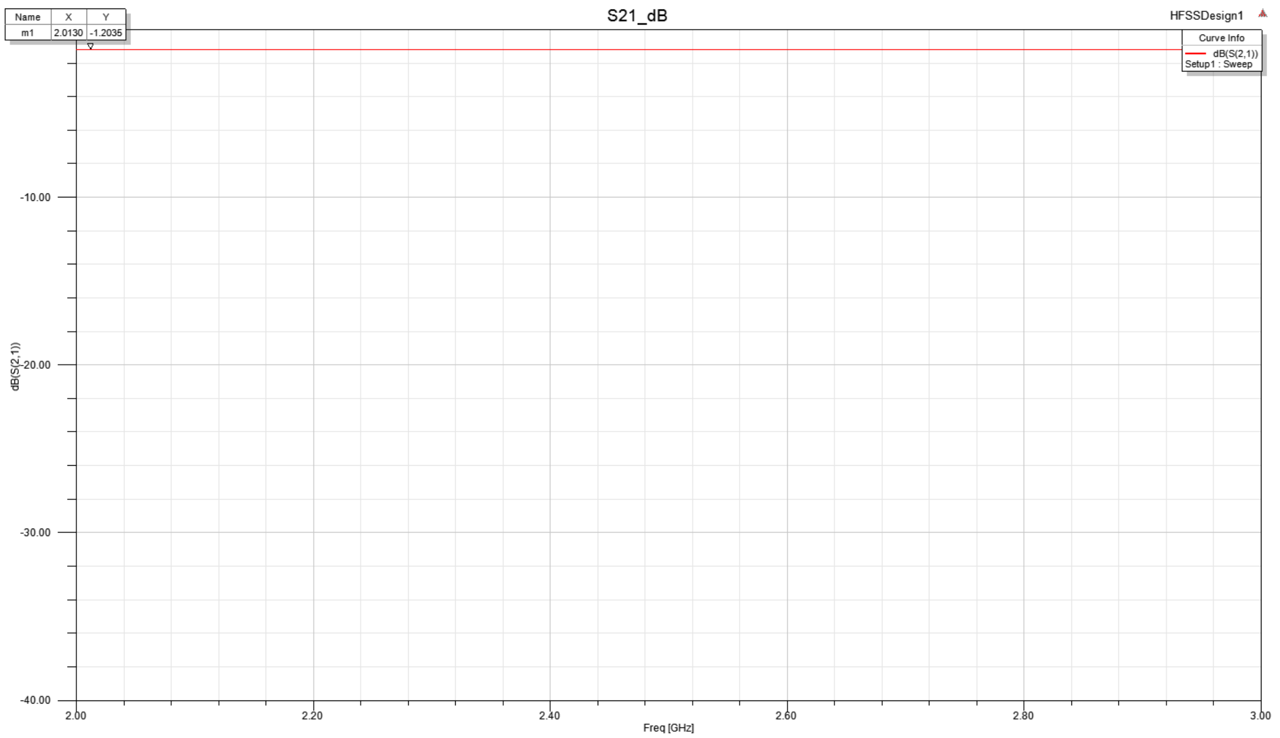


S11



Name X Y
m1 2.0600 -12.0385
S11_dB
HFSSDesign1
Curve Info
dB(S(1,1))
Setup1 : Sweep
m1
-10.00
-20.00
-30.00
-40.00
dB(S(1,1))
2.00
2.20
2.40
2.60
2.80
3.00
Freq [GHz]

S21

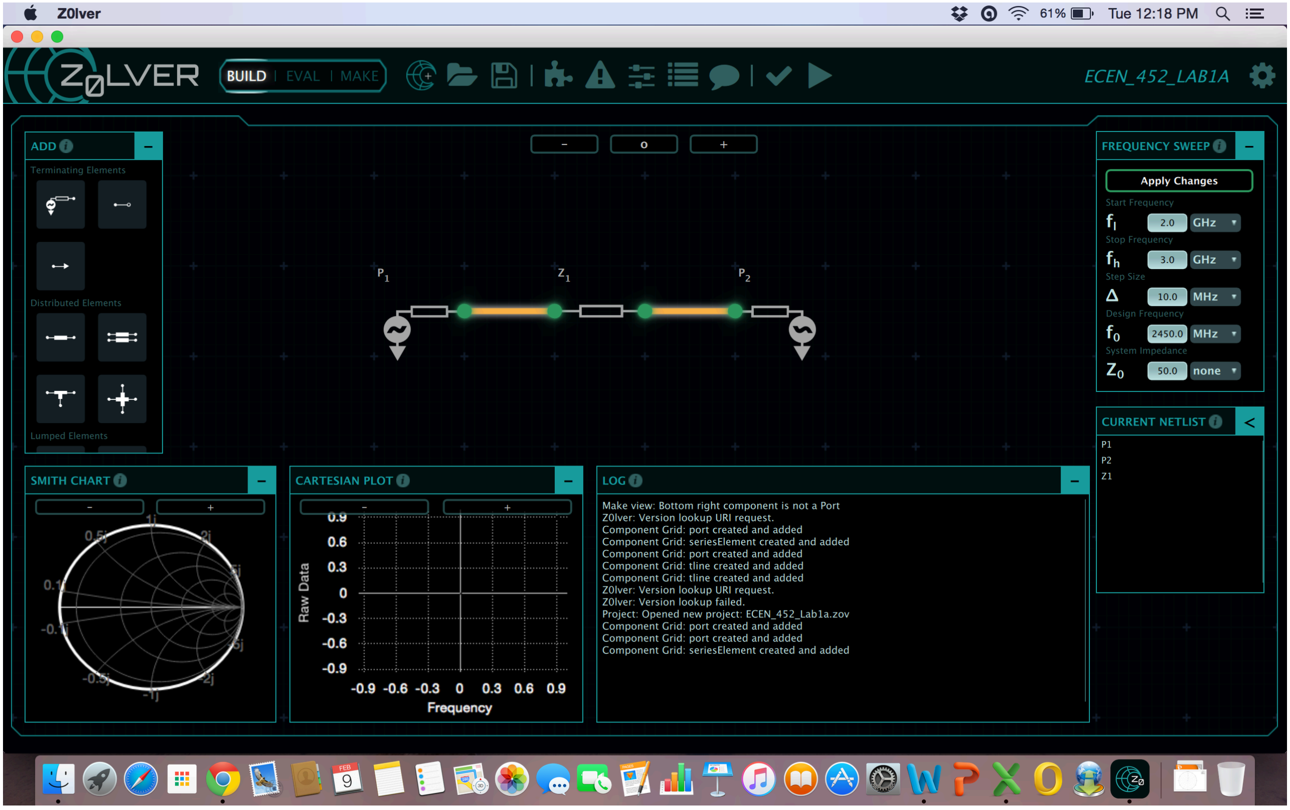


Name X Y
m1 2.0130 -1.2035
S21_dB
HFSSDesign1
Curve Info
dB(S(2,1))
Setup1 : Sweep
-10.00
-20.00
-30.00
-40.00
dB(S(2,1))
2.00
2.20
2.40
2.60
2.80
3.00
Freq [GHz]

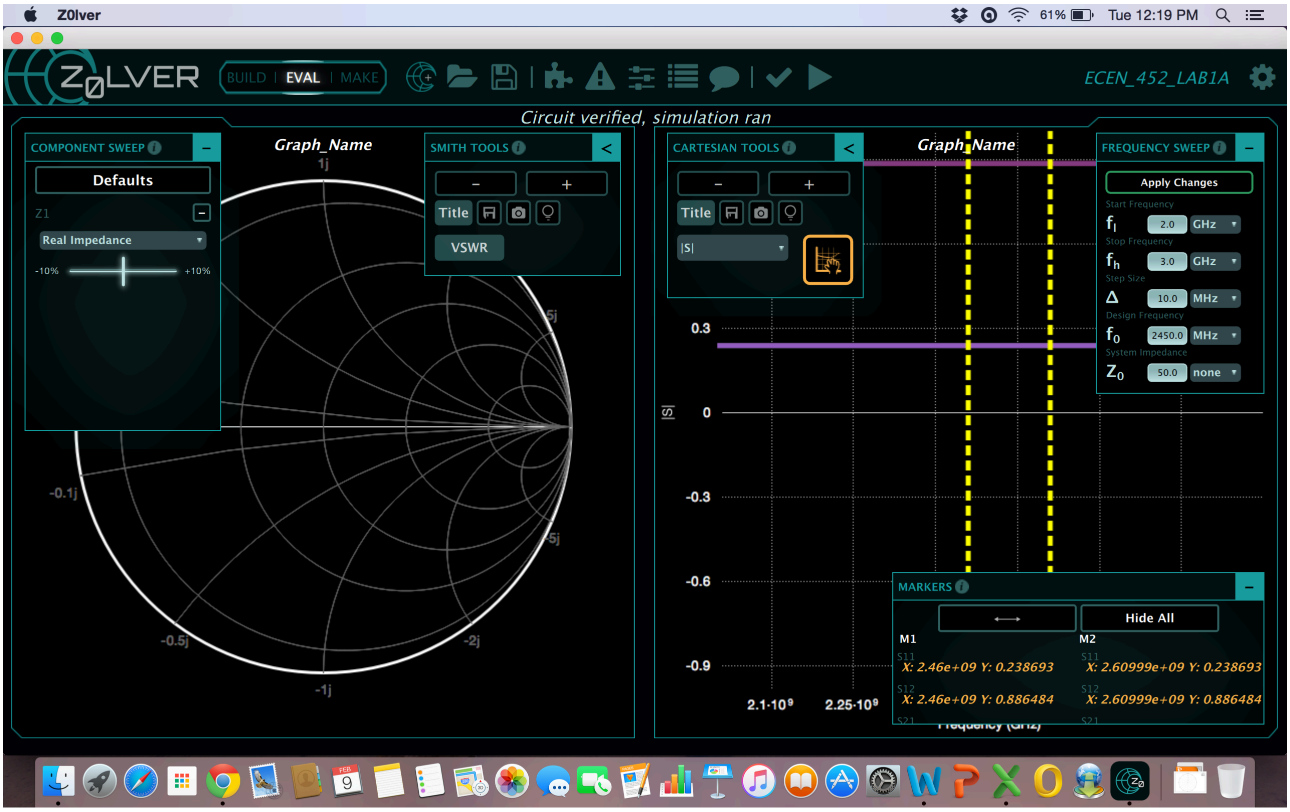
Z0lver –

For file “ECEN_452_Lab1a.zov”

Z0lver model –

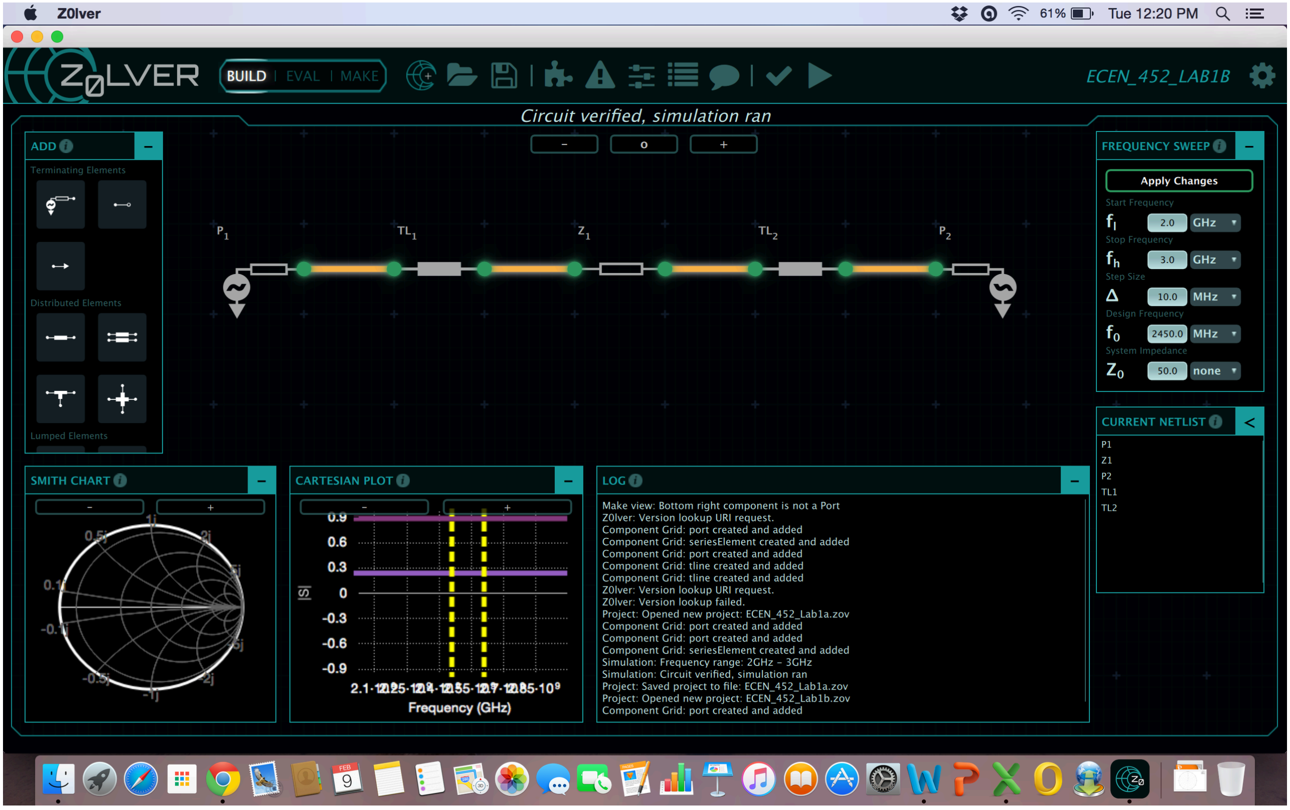


Simulation Results –

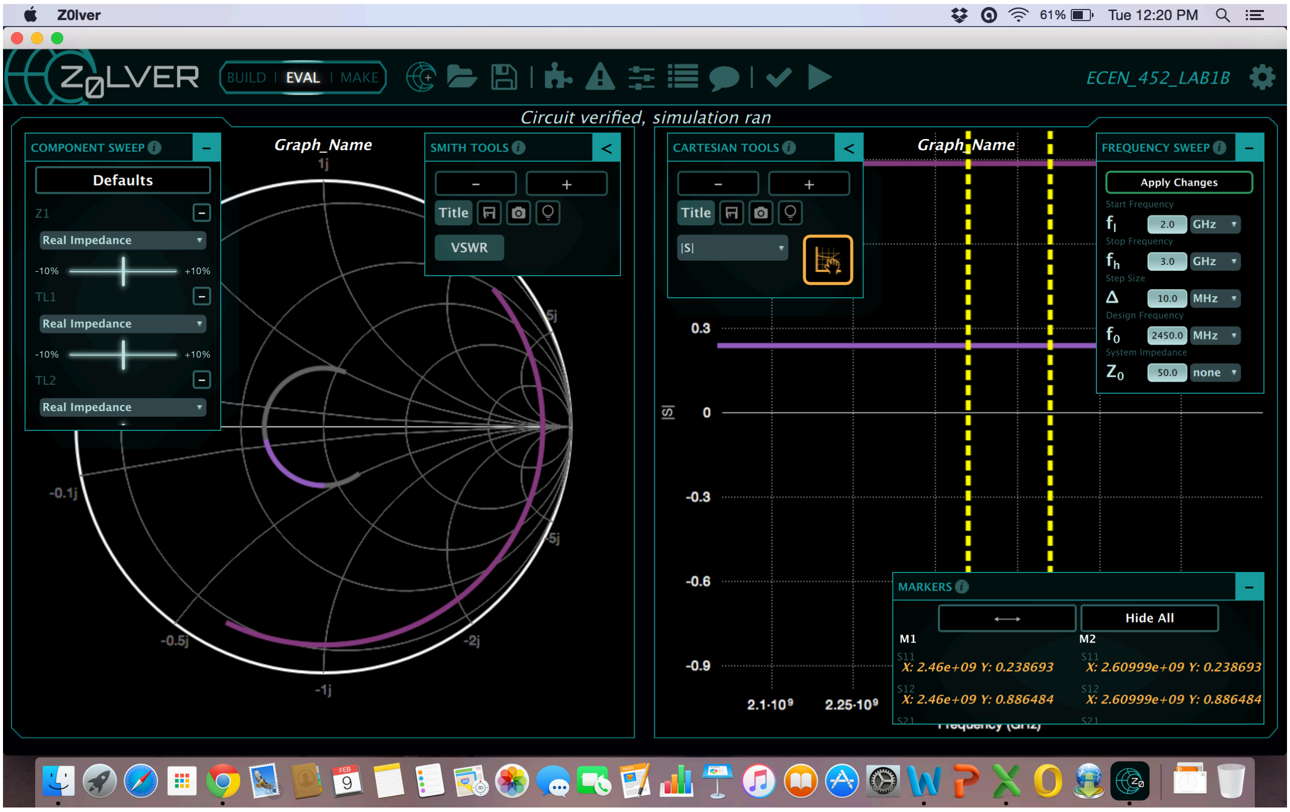


For file “ECEN_452_Lab1b.zov”

Z0lver Model –



Simulation Results –



4. Calculate the two-port S- and ABCD matrices for a series impedance Z=10+j25 Ω using a system impedance Z_0=50 Ω and frequency sweep parameters from the simulations.

$$Z_{T1} = Z + Z_0$$

$$S11 = \frac{Z_{T1} - Z_0}{Z_{T1} - Z_0} = \frac{Z}{Z + 2Z_0}$$

$$S11 = \frac{10 + j25}{10 + j25 + 100} = \frac{10 + j25}{110 + j25} = 0.2387\angle 55.394°$$

$$S21 = \frac{2Z_0}{Z + 2Z_0}$$

$$S21 = \frac{2\times 50}{10 + j25 + 2\times 50} = \frac{100}{110 + j25} = 0.8865\angle{-12.804°}$$

From Symmetry,

S11 = S22 and S21 = S12.

Therefore,

$$S = \begin{bmatrix} 0.2387\angle 55.394° & 0.8865\angle{-12.804°} \\ 0.8865\angle{-12.804°} & 0.2387\angle 55.394° \end{bmatrix}$$

The ABCD Matrix of series impedance is given by

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1 & 10 + j25 \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 26.926\angle 68.1985° \\ 0 & 1 \end{bmatrix}$$

5. Shift the reference planes of both matrices calculated in the previous problem by assuming they are connected to lossless lines of characteristic impedance Z_0=50 Ω with a length 0.8 λ at Port 1 and 0.25 λ at Port 2.

$$S = \begin{bmatrix} 0.2387\angle 55.394° & 0.8865\angle{-12.804°} \\ 0.8865\angle{-12.804°} & 0.2387\angle 55.394° \end{bmatrix}$$

$$S' = \begin{bmatrix} S11e^{-j2\theta_1} & S12e^{-j(\theta_1+\theta_2)} \\ S21e^{-j(\theta_1+\theta_2)} & S22e^{-j2\theta_2} \end{bmatrix}$$

At port 1, the length is l_1 = 0.8 λ
Let f = 2.45 GHz. Then,

$$l_1 = 0.8\times\frac{c}{f} = 0.8\times\frac{3\times 10^8}{2.45\times 10^9} = 0.098\, m$$

and

$$\theta_1 = \beta l_1 = \frac{2\pi}{\lambda}\times l_1 = \frac{2\pi\times f}{c}\times l_1 = \frac{2\pi\times f}{3\times 10^8}\times 0.098 = 2.0515\times 10^{-9} f$$

At port 2, the length is l_2 = 0.25 λ
Let f = 2.45 GHz. Then,

$$l_2 = 0.25\times\frac{c}{f} = 0.25\times\frac{3\times10^8}{2.45\times10^9} = 0.031\ m$$

and

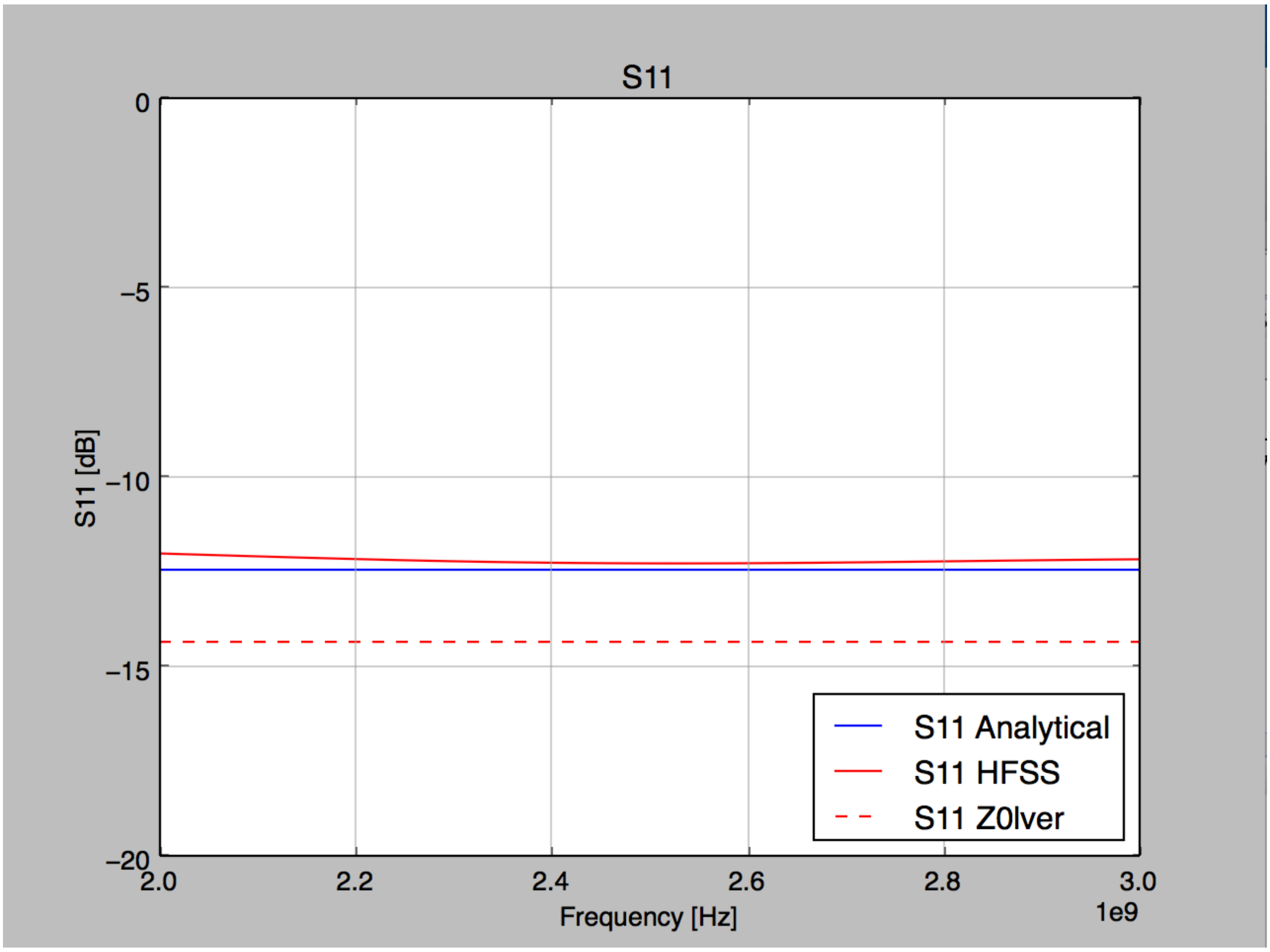
$$\theta_2 = \beta l_2 = \frac{2\pi}{\lambda}\times l_2 = \frac{2\pi\times f}{c}\times l_2 = \frac{2\pi\times f}{3\times10^8}\times0.031 = 0.6489\times10^{-9}f$$

Thus,

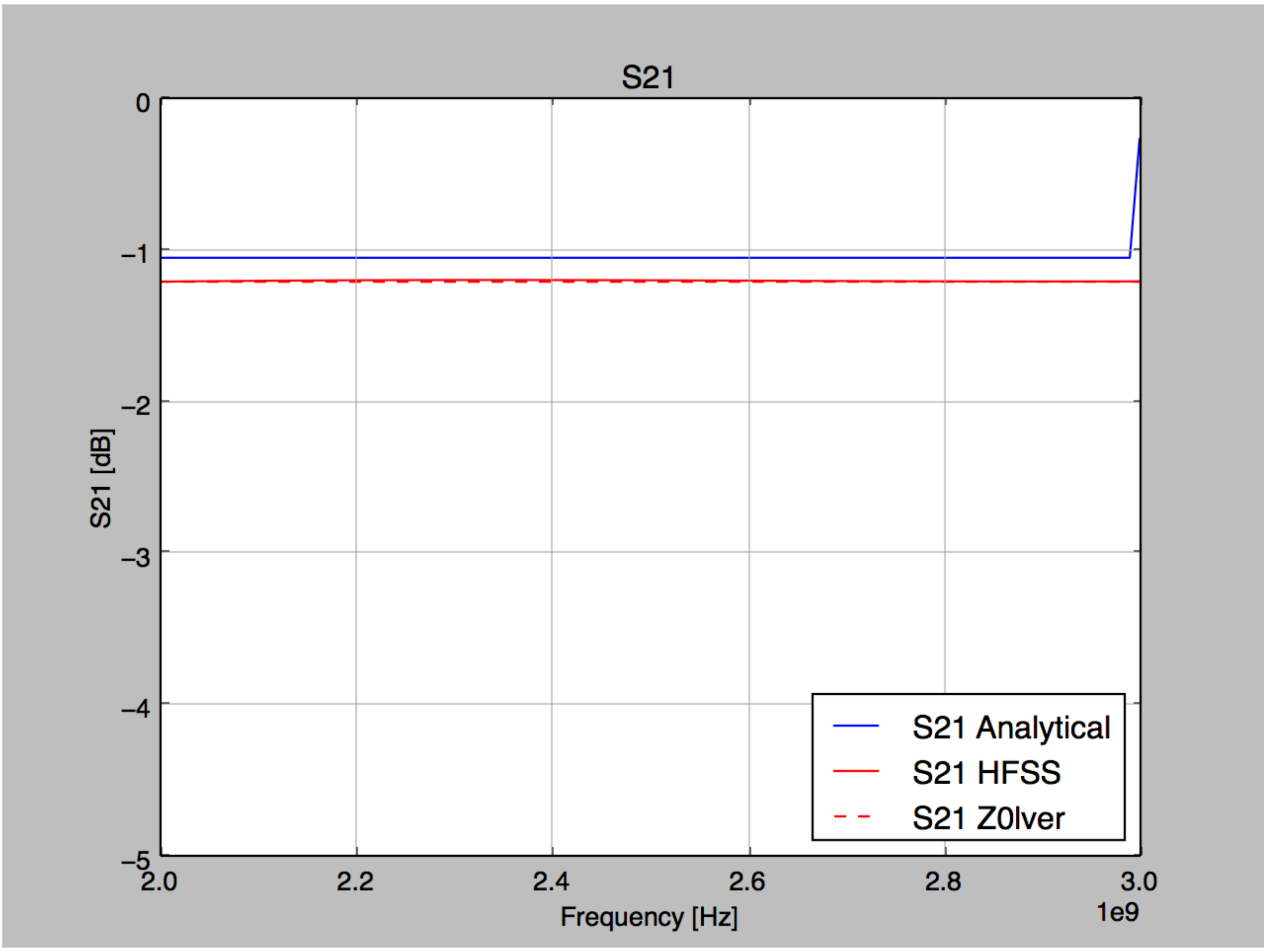
$$S' = \begin{bmatrix} 0.2387\angle55.394°e^{-j4.103\times10^{-9}f} & 0.8865\angle-12.804°e^{-j2.7004\times10^{-9}f} \\ 0.8865\angle-12.804°e^{-j2.7004\times10^{-9}f} & 0.2387\angle55.394°e^{-j1.2978\times10^{-9}f} \end{bmatrix}$$

6. Create two separate plots comparing analytical, Z0lver and HFSS; one with the magnitude of S11 in dB and the other with the magnitude of S21 in dB.

Plot of S11 in dB



Plot of S21 in dB



7. Become familiar with the following substrates by filling out the table below.

	FR4	Duroid 5880	Duroid 6006	Duroid 6010.2
ε_r	4.8	2.2	6.45	10.7
tan δ	0.017	0.0004	0.0027	0.0023

8. Fill in the table below by indicating which connector types can be mated (Y/N).

	Type N	SMA	3.5 mm	2.92 mm	2.4 mm	1.85 mm
Type N	Y	N	N	N	N	N
SMA	N	Y	Y	Y	N	N
3.5 mm	N	Y	Y	Y	N	N
2.92 mm	N	Y	Y	Y	N	N
2.4 mm	N	N	N	N	Y	Y
1.85 mm	N	N	N	N	Y	Y

9. Conclusion

Since the transmission lines added are lossless, there will be no change in the magnitude of S parameters. The only change is in the phase. This is demonstrated by Z0lver results and analytical calculation. Since, the method of calculating the S parameters is different in HFSS, it has slightly different results.