EC452 Ultra High Frequency Techniques

Title: Lab 1 - Laboratory Best Practices

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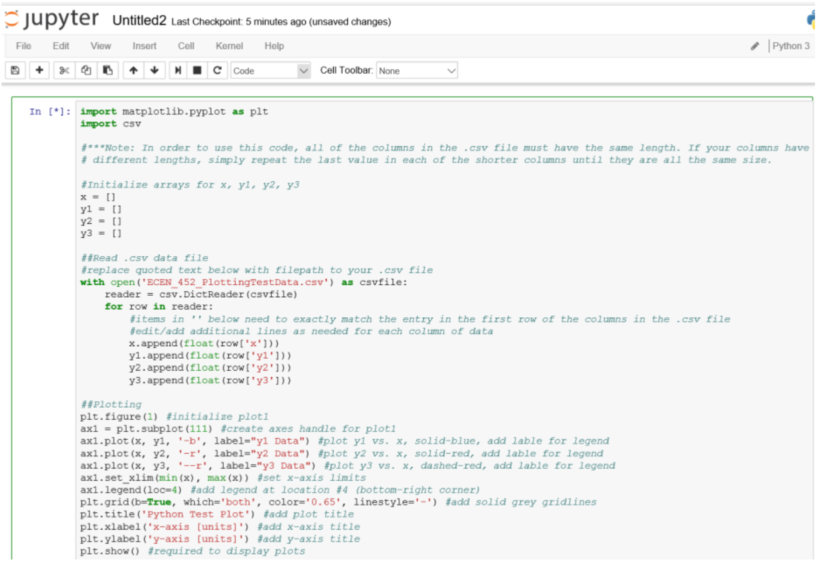
Date: 02/10/2016

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

Ans:



```
In [*]: import matplotlib.pyplot as plt
import csv

#***Note: In order to use this code, all of the columns in the .csv file must have the same length. If your columns have
# different lengths, simply repeat the last value in each of the shorter columns until they are all the same size.

#Initialize arrays for x, y1, y2, y3
x = []
y1 = []
y2 = []
y3 = []

##Read .csv data file
#replace quoted text below with filepath to your .csv file
with open('ECEN_452_PlottingTestData.csv') as csvfile:
    reader = csv.DictReader(csvfile)
    for row in reader:
        #items in '' below need to exactly match the entry in the first row of the columns in the .csv file
        #edit/add additional lines as needed for each column of data
        x.append(float(row['x']))
        y1.append(float(row['y1']))
        y2.append(float(row['y2']))
        y3.append(float(row['y3']))

##Plotting
plt.figure(1) #initialize plot1
ax1 = plt.subplot(111) #create axes handle for plot1
ax1.plot(x, y1, '-b', label="y1 Data") #plot y1 vs. x, solid-blue, add lable for legend
ax1.plot(x, y2, '-r', label="y2 Data") #plot y2 vs. x, solid-red, add lable for legend
ax1.plot(x, y3, '--r', label="y3 Data") #plot y3 vs. x, dashed-red, add lable for legend
ax1.set_xlim(min(x), max(x)) #set x-axis limits
ax1.legend(loc=4) #add legend at location #4 (bottom-right corner)
plt.grid(b=True, which='both', color='0.65', linestyle='-') #add solid grey gridlines
plt.title('Python Test Plot') #add plot title
plt.xlabel('x-axis [units]') #add x-axis title
plt.ylabel('y-axis [units]') #add y-axis title
plt.show() #required to display plots
```

Figure 1 - The Python Code Edited in Anaconda

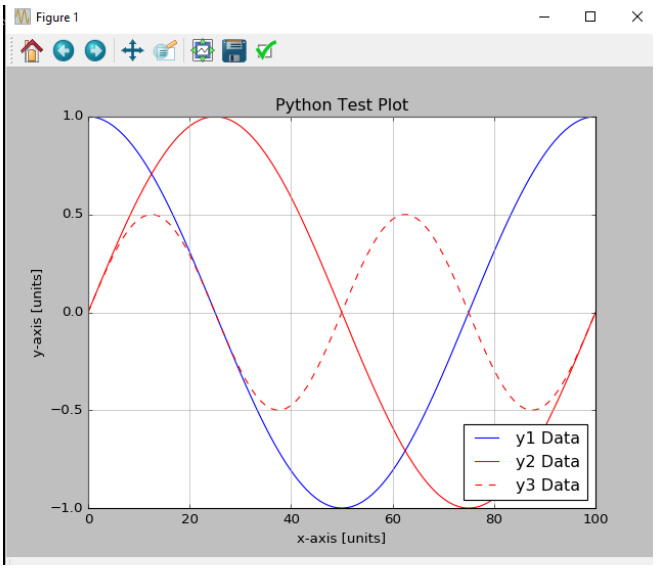


Figure 2 - The Plot of the Dataset

2.Email your GitHub account ID.

Ans: stevenyeh66

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”.

Ans:

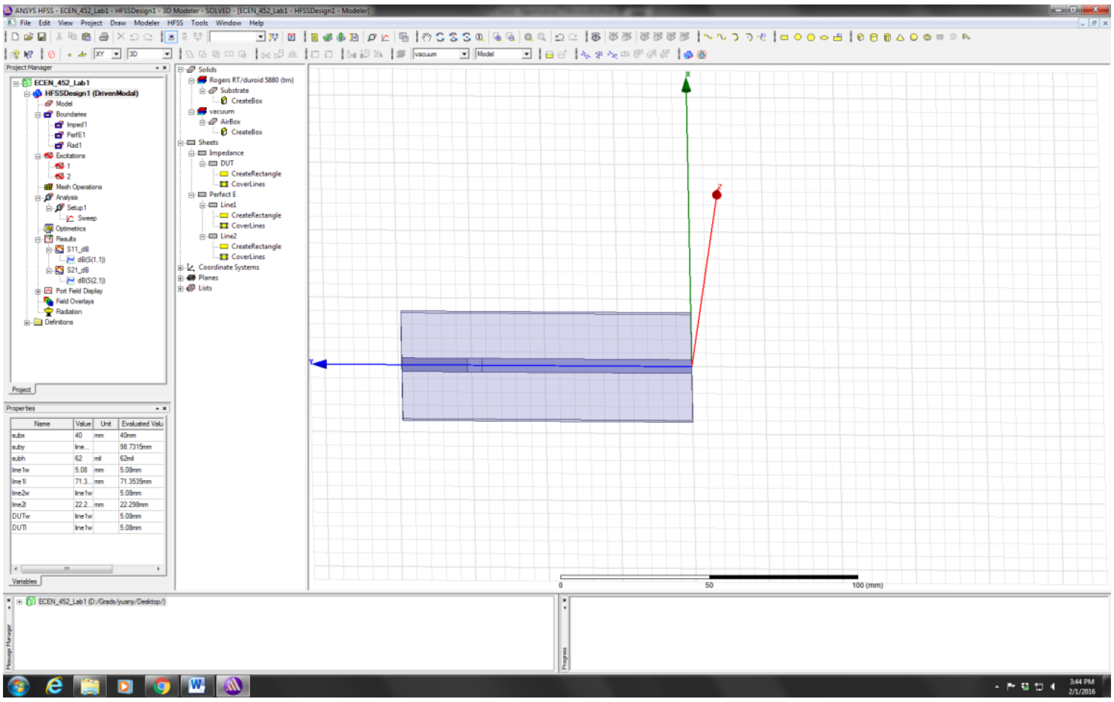


Figure 3 - The ECEN_452_Lab1.hfss Run in HFSS

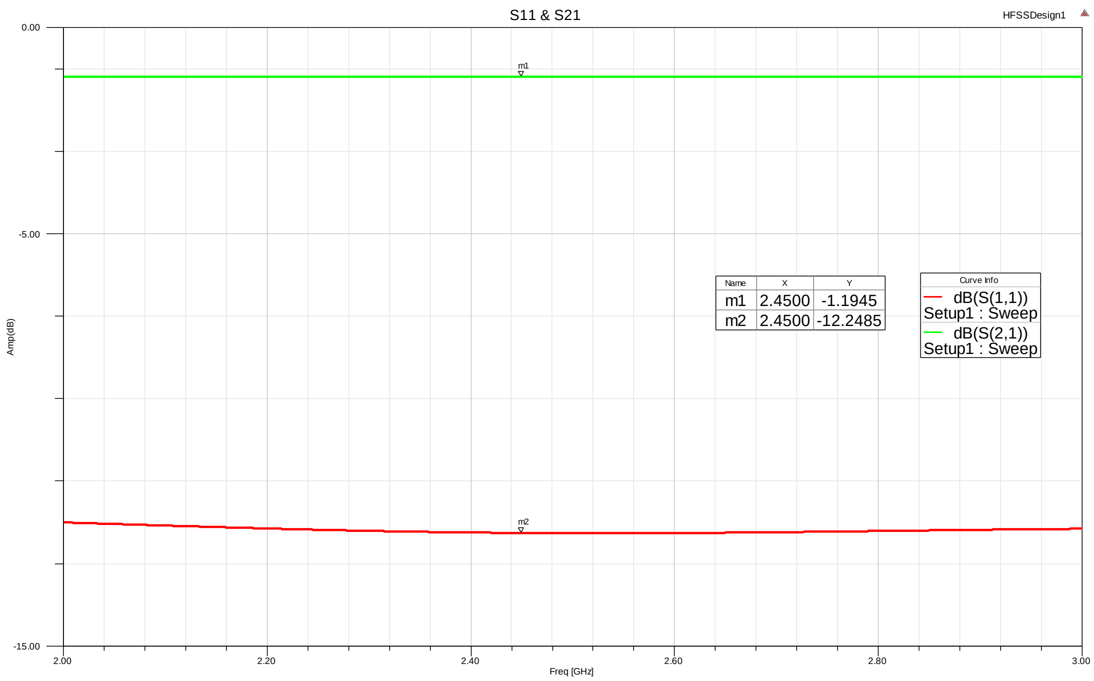


Figure 4 - The Simulation Results of the S_{11} and S_{21} Amplitude in dB

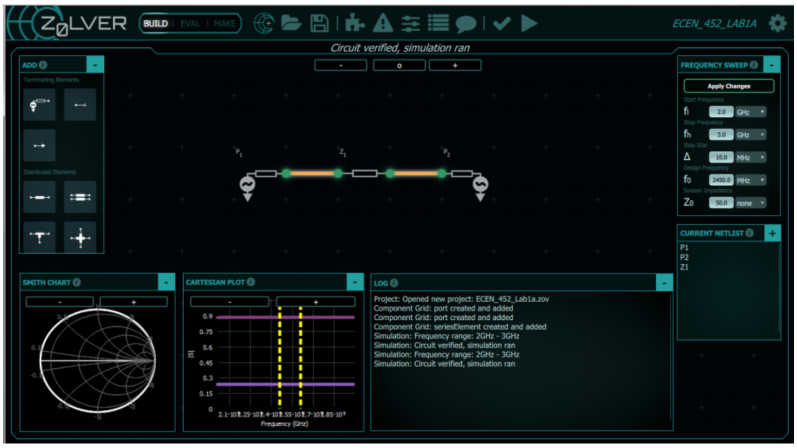


Figure 5 - The ECEN_452_Lab1a.zov Run in Z0lver

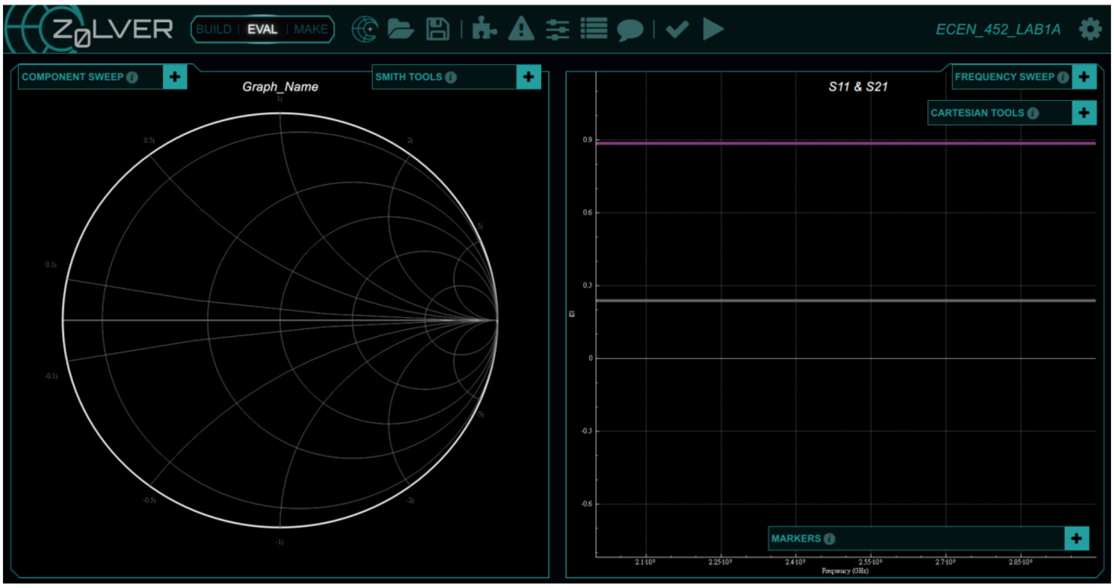


Figure 6 - The Simulation Results of S_{11} and S_{21} in Z0lver (ECEN_452_Lab1a.zov)

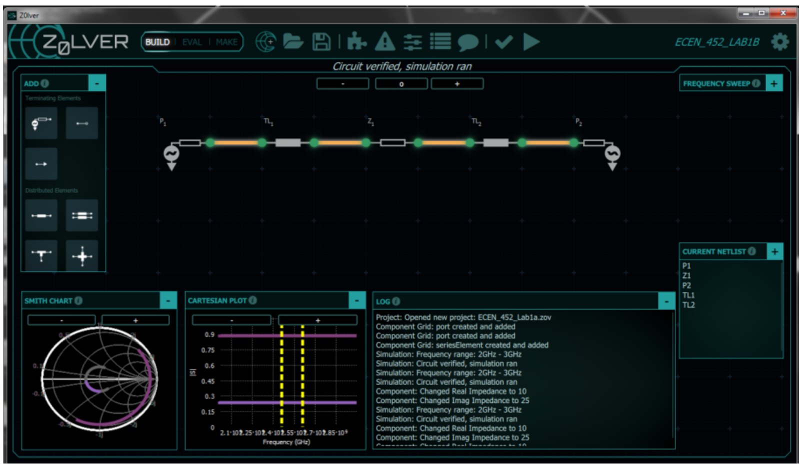


Figure 7 - The ECEN_452_Lab2a.zov Run in Z0lver

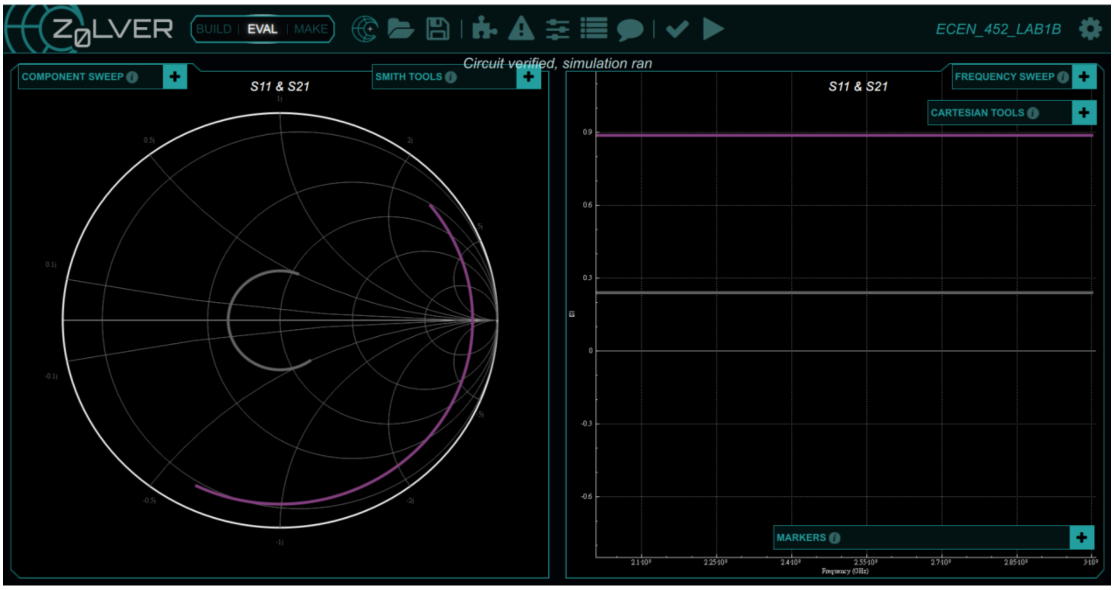
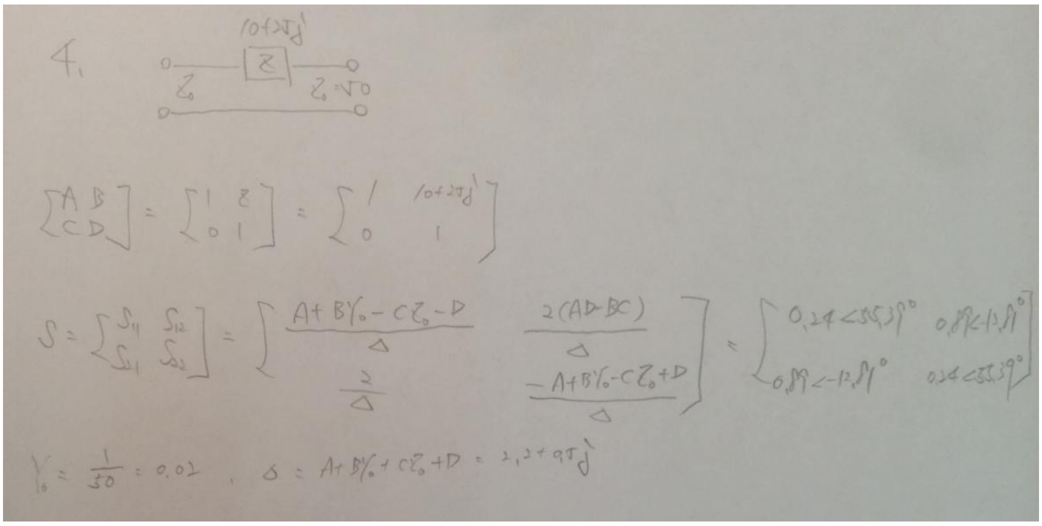


Figure 8 - The Simulation Results of S_{11} and S_{21} in Z0lver (ECEN_452_Lab2a.zov)

4. Calculate the two-port S and ABCD-matrices for a series impedance Z = 10+25j Ω using a system impedance Z_0 = 50 Ω and the frequency sweep parameters from the simulations.

Ans:



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.

Ans:

5. shift 0.8λ @ port 1 & shift 0.25λ @ port 2

$\theta_1 = \beta_1 l_1 = \frac{2\pi}{\lambda} \times 0.8\lambda = 1.6\pi = 288°$

$\theta_2 = \beta_2 l_2 = \frac{2\pi}{\lambda} \times 0.25\lambda = 90°$

$$[S'] = \begin{bmatrix} e^{-j\theta_1} & 0 \\ 0 & e^{-j\theta_2} \end{bmatrix} \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \begin{bmatrix} e^{-j\theta_1} & 0 \\ 0 & e^{-j\theta_2} \end{bmatrix} = \begin{bmatrix} e^{-j\theta_1} S_{11} & e^{-j\theta_1} S_{12} \\ e^{-j\theta_2} S_{21} & e^{-j\theta_2} S_{22} \end{bmatrix} \begin{bmatrix} e^{-j\theta_1} & 0 \\ 0 & e^{-j\theta_2} \end{bmatrix}$$

$$= \begin{bmatrix} e^{-j2\theta_1} S_{11} & e^{-j(\theta_1+\theta_2)} S_{12} \\ e^{-j(\theta_1+\theta_2)} S_{21} & e^{-j2\theta_2} S_{22} \end{bmatrix} = \begin{bmatrix} e^{-j216°}\, 0.24\, e^{j55.39°} & e^{-j118°}\, 0.89\, e^{-j12.81°} \\ e^{-j18°}\, 0.89\, e^{-j12.81°} & e^{-j180°}\, 0.24\, e^{j55.39°} \end{bmatrix}$$

$$= \begin{bmatrix} e^{-j160.61°} \times 0.24 & e^{-j130.81°} \times 0.89 \\ e^{-j30.81°} \times 0.89 & e^{-j124.61°} \times 0.24 \end{bmatrix}$$

6. Create two separate plots comparing analytical, Z0lver, and HFSS; one with the magnitude of S_{11} in dB and the other with the magnitude of S_{21} in dB.

Ans:

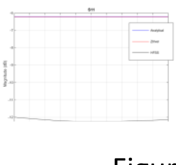


Figure 9 - Comparisons of S_{11} Between Analytical, Z0lver and HFSS

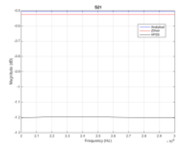


Figure 10 - Comparisons of S_{21} Between Analytical, Z0lver and HFSS

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

	FR4	Duroid 5880	Duroid 6006	Duroid 6010.2
ε_r	4.4	2.2	6.15	10.2
Tanδ	0.02	9e-4	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