Orkun İbrahim Kök 22003656

EEE412 Lab #1 Preliminary Work

"I completed this homework assignment independently."

Question #1

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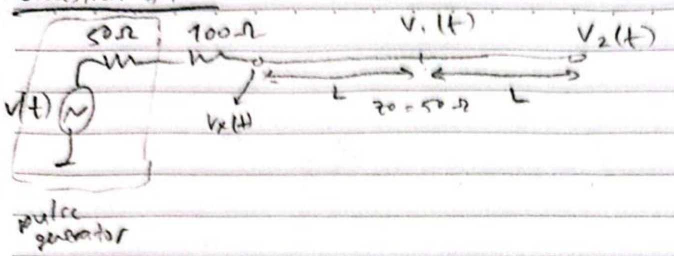
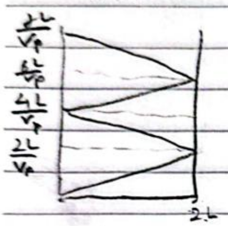


a) $V_x = 5 \cdot \frac{50}{150+50} = 5 \cdot \frac{1}{4} = 1.25\text{V}$

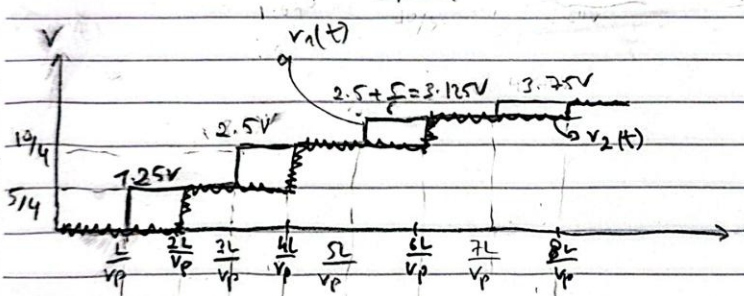
$\Gamma_L = \frac{\infty - 50}{\infty + 50} = 1 \qquad \Gamma_S = \frac{150 - 50}{150 + 50} = \frac{1}{2}$



$V_0^+ = \frac{5}{4}, \quad V_0^+ \cdot \Gamma_L = \frac{5}{4} \cdot 1 = \frac{5}{4} \qquad V_0^+ \cdot \Gamma_L \cdot \Gamma_S = \frac{5}{4} \cdot 1 \cdot \frac{1}{2} = \frac{5}{8}$

↳ There is a pattern:

$\frac{5}{4} \to \frac{5}{4} + \frac{5}{4} \to \frac{5}{4} + \frac{5}{4} + \frac{5}{8} \to \frac{5}{4} + \frac{5}{4} + \frac{5}{8} + \frac{5}{8} \to \ldots$



$\boxed{\frac{2L}{V_p} = 50.5\text{ ns}}$

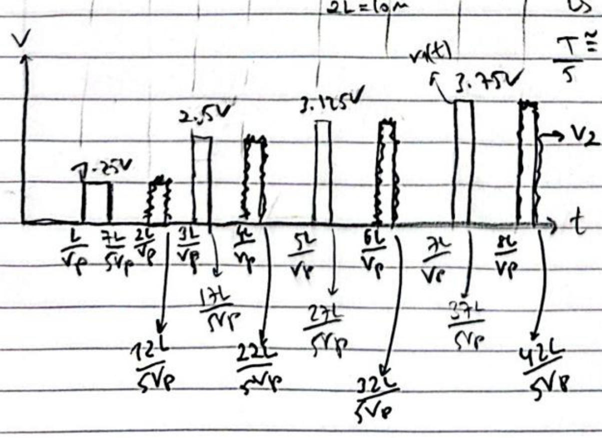
b) $V_c = V_p = 0.66 \times c \to x = V_c \cdot t \Rightarrow T = 50.5$ ns

$2L = 10$ m

↳ $10\text{ ns} = \frac{T}{5}$

$\frac{T}{5} \cong \frac{2L}{5V_p}$

for pulse, there will be lons peaks.



as $t \to \infty$, voltage converges to 5V as in circuit theory.

Question #2

A triple-stub tuner is created to match the impedance of the load, which is 22Ω resistor in series with 12nH inductor. L_x and L_0 values are given as 50mm and 88mm respectively. The goal is to find the lengths of three shorted to GND transmission lines.

Initially, the frequency is chosen as 200MHz. Then, using the V_c/c values, λ and β values are found, then electrical length of the transmission lines are calculated. Below equations shows the steps of the calculations.

$$\lambda = \frac{V_c}{f}\ (m)$$

$$\beta = \frac{2\pi f}{V_c}\ (\frac{rad}{m})$$

$$Electrical\ length(e) = length\ of\ TL(mm) \times \beta(\frac{deg}{mm})$$

To convert rad/m to degree/m, following mathematical operation will be done.

$$\frac{rad}{m} \times \frac{180}{\pi} = \frac{degree}{m}$$

Lastly, the values will be converted to mm scale.

The electrical length calculation for Z_1 = 36Ω transmission line (V_c/c=0.7) is given below.

$$V_c = 0.7c$$

$$\lambda = \frac{0.7c}{200MHz} = 1.05m$$

$$\beta = \frac{2\pi \times 200MHz}{0.7c} = 5.98rad/m$$

$$\beta \times \frac{180}{\pi} = 342.63deg/m$$

$$Electrical\ length\ (e) = 30.15^{\circ}$$

The electrical length calculation for Z_0 = 50Ω transmission line (V_c/c=0.8) is given below.

$$V_c = 0.8c$$

$$\lambda = \frac{0.8c}{200MHz} = 1.2m$$

$$\beta = \frac{2\pi \times 200MHz}{0.7c} = 5.24rad/m$$

$$\beta \times \frac{180}{\pi} = 300deg/m$$

$$Electrical\ length\ (e) = 26.4^{\circ}$$

The electrical length calculation for Z_2 = 45Ω transmission line (V_c/c=1) is given below.

$$V_c = c$$

$$\lambda = \frac{c}{200MHz} = 1.5m$$

$$\beta = \frac{2\pi \times 200MHz}{0.7c} = 4.19rad/m$$

$$\beta \times \frac{180}{\pi} = 240deg/m$$

After the calculations, Fig. 1 shows the overall circuit.

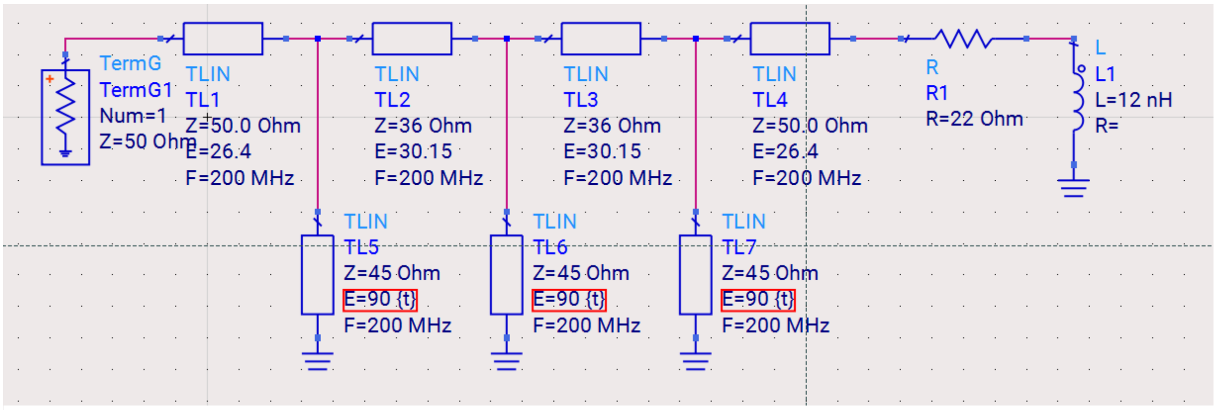


Fig. 1: Triple stub tuner with output load circuit

Now, using the Smith chart of S11, the electrical lengths of the bottom three transmission line will be found using Tuning function of ADS. The goal is to match the impedances, so we need to get close to point 1.0 at Smith chart. Fig. 2 shows the found electrical lengths of the transmission lines.

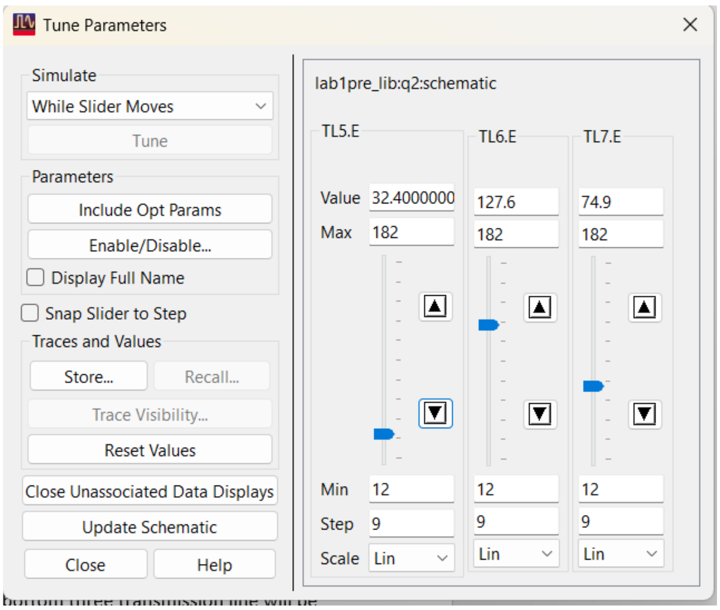


Fig. 2: Measured electrical lengths of TL5, TL6, and TL7 respectively

The Smith chart of S11 can be seen in Fig 3.

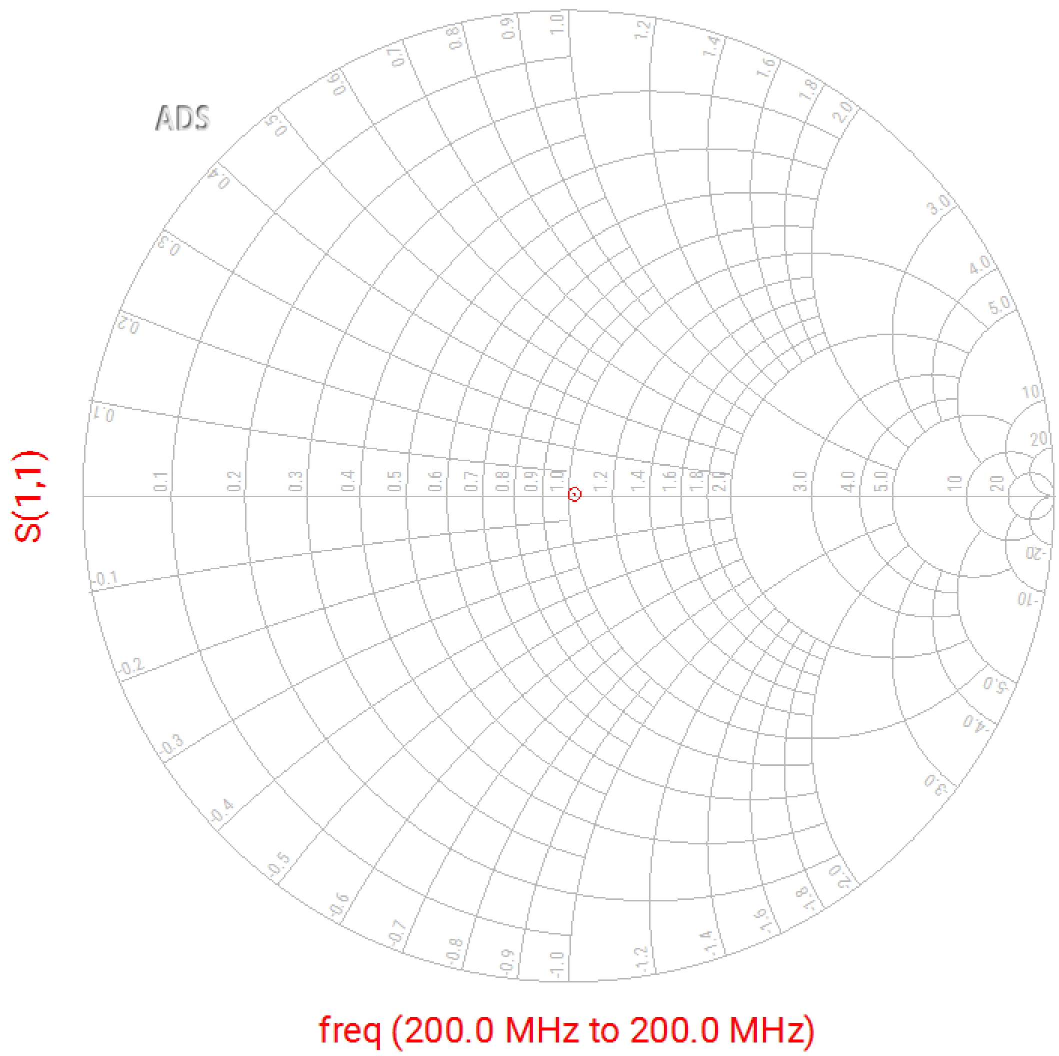


Fig. 3: Smith Chart of S11

As seen from Fig. 3, we have achieved a point very close to 1.0. To convert the electrical lengths to metrics, following operations will be done.

$$Electrical\ length(e) = length\ of\ TL(mm) \times \beta(\frac{deg}{mm})$$

$$length\ of\ TL(mm) = \frac{Electrical\ length(e)}{\beta(\frac{deg}{mm})}$$

$$L_{TL5} = 135mm$$

$$L_{TL6} = 531.67mm$$

$$L_{TL5} = 312.08mm$$

The compeleted version of the circuit is given in below figure.

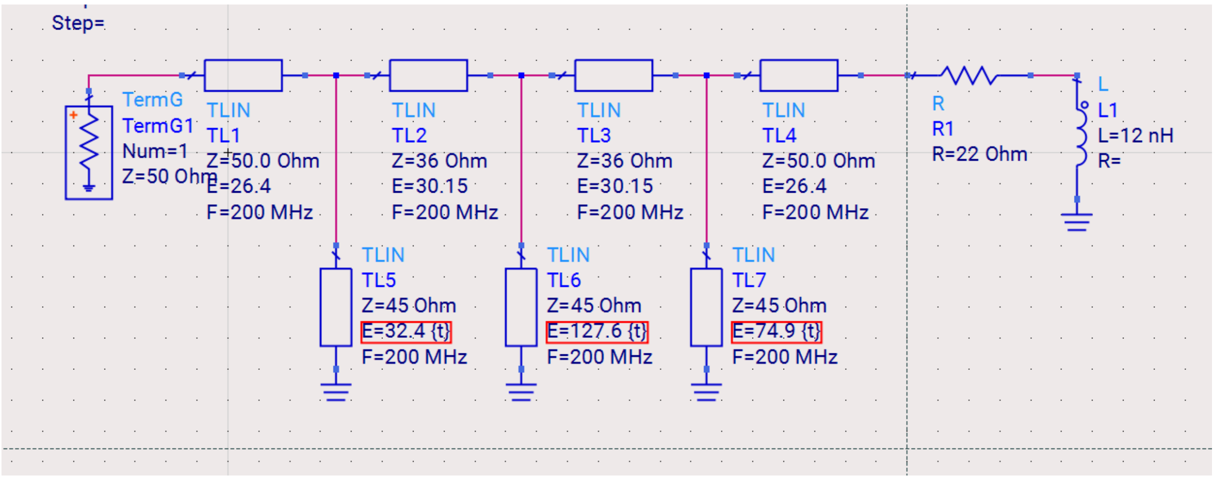


Fig. 4: Final version of the circuit

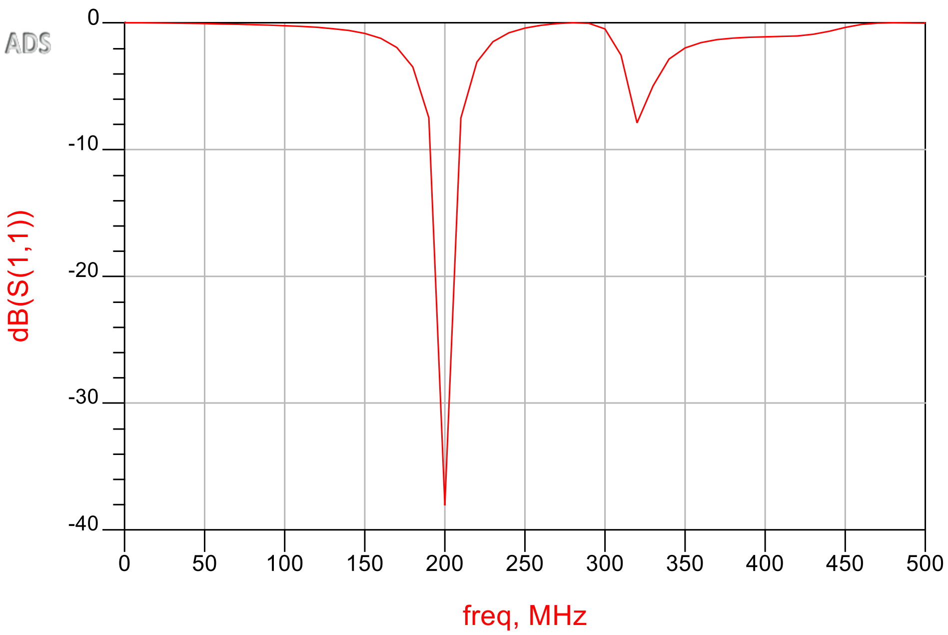


Fig. 5: S11 plot of the created circuit

As seen from Fig. 5, S11 plot has a negative peak at 200MHz, valued as -38.7dB.

Question #3

A microstrip low-pass filter with the given design specifications are built. Fig. 6 shows the microstrip low-pass filter schematic. The S_{11} and S_{21} of the filter are plotted. Fig. 7 shows the corresponding plots. The corner frequency of the designed low-pass filter is measured by a marker, which is around 2.4GHz. Basically, the corner (cutoff) frequency is the -3dB point.

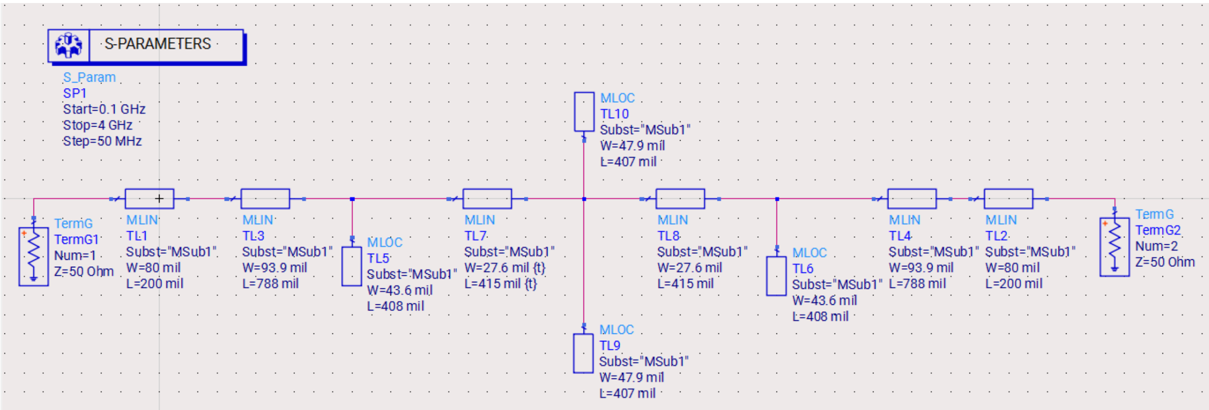


Fig. 6: Designed microstrip low-pass filter

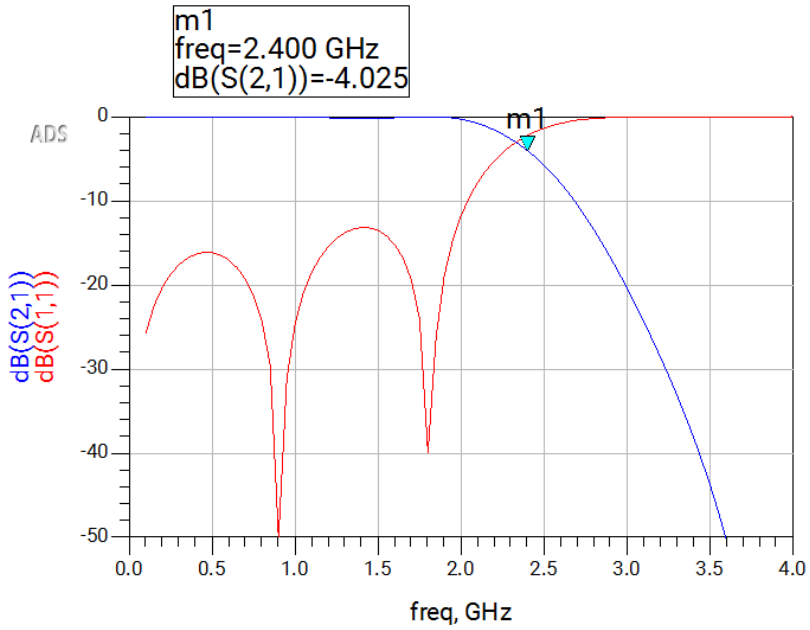


Fig. 7: Microstrip low-pass filter S_{11} and S_{21} plots

To change the corner frequency, changing the W or L of the microstrips' will be enough. I changed L of TL1 and TL2 to 100mil and L of TL7 and TL8 to 250mil. New schematic is given in Fig. 8.

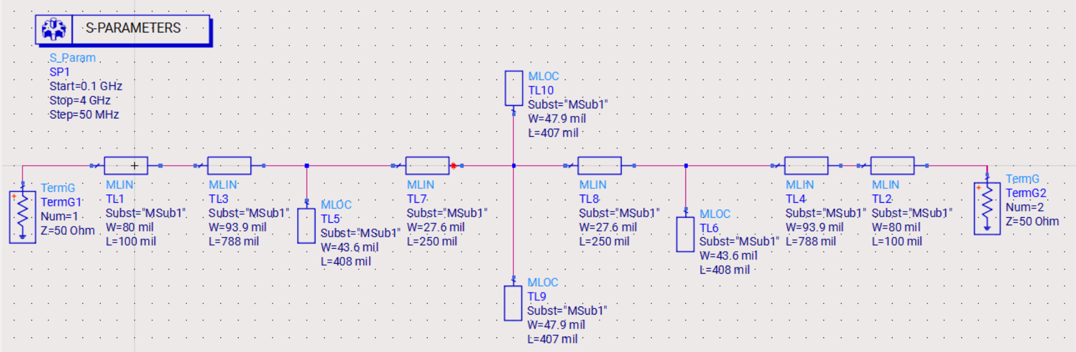


Fig. 8: New microstrio low-pass filter with changed L values

Fig. 9 shows the new S_{11} and S_{21} plots. The new corner frequency (-3dB point) is measured around 2.9GHz.

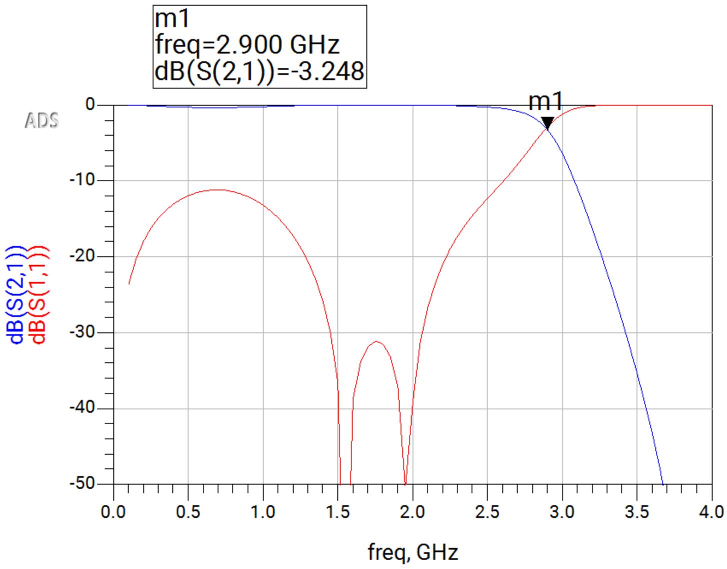


Fig. 9: New microstrip low-pass filter S_{11} and S_{21} plots

The layout of the new filter is given in Fig. 10.

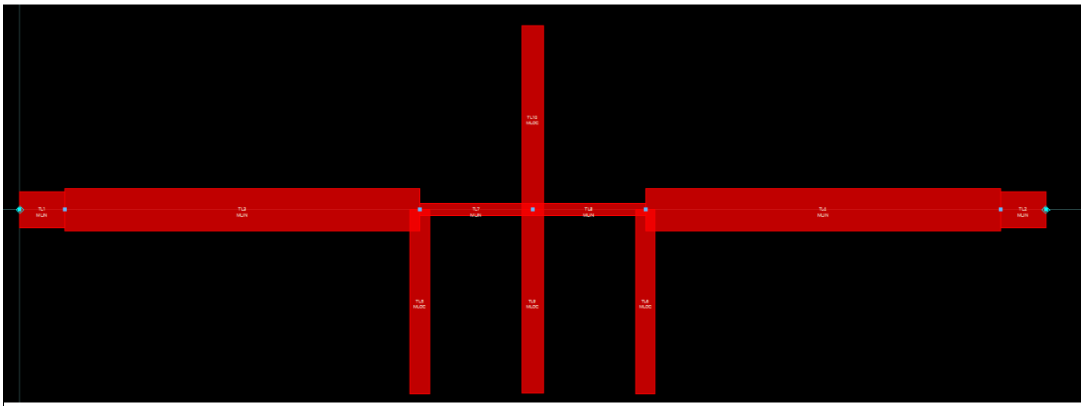


Fig. 10: Layout of the new low-pass filter

Question #4

In this part, a microstrip bandpass filter is designed and simulated. The circuit designed with the given specifications can be seen in the below figure.

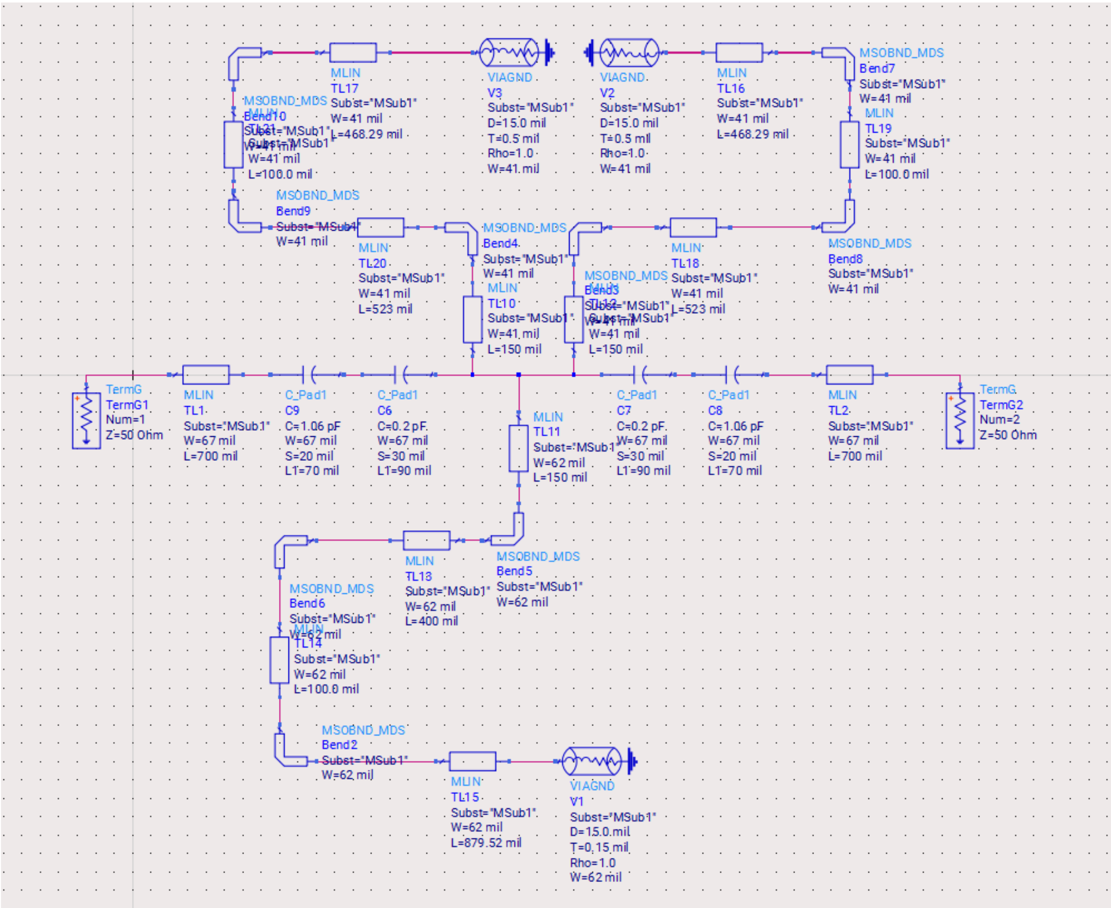


Fig. 11: Microstrip bandpass filter

The corresponding S_{11} and S_{21} plots are given in Fig. 12.

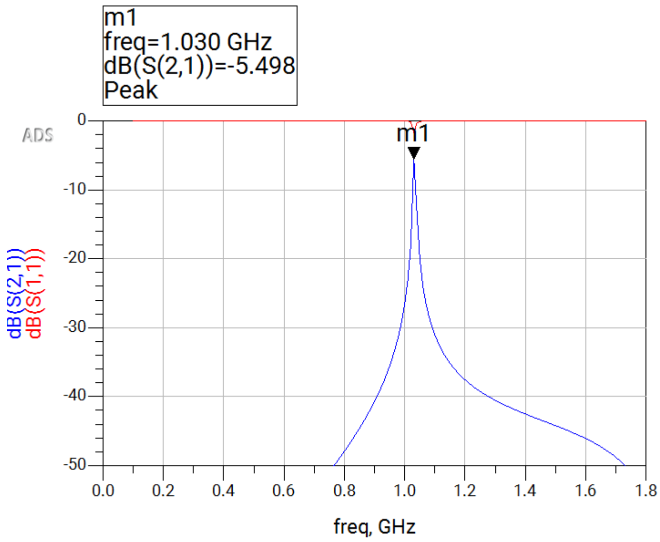


Fig. 12: Microstrip bandpass filter S_{11} and S_{21} plots

The center frequency of the bandpass filter is measured as 1.03GHz.

To change the center frequency, again, W or L values of the microstrips will be changed. The L values of TL20 and TL18 reduced to 100mil, the W values of TL10 and TL12 increased to 67mil. The new schematic is given in Fig. 13.

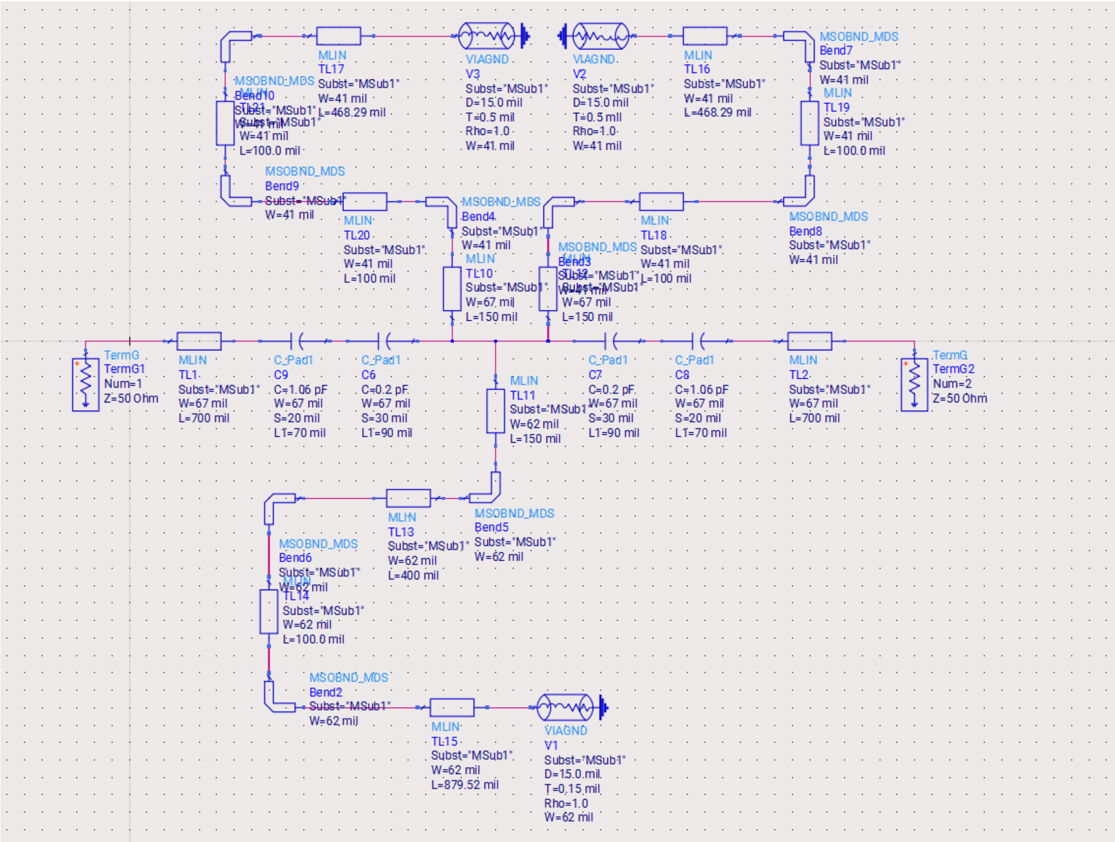


Fig. 13: New schematic of the microstrip bandpass filter

The new microstrip bandpass filter's S_{11} and S_{21} plots are given in the below figure.

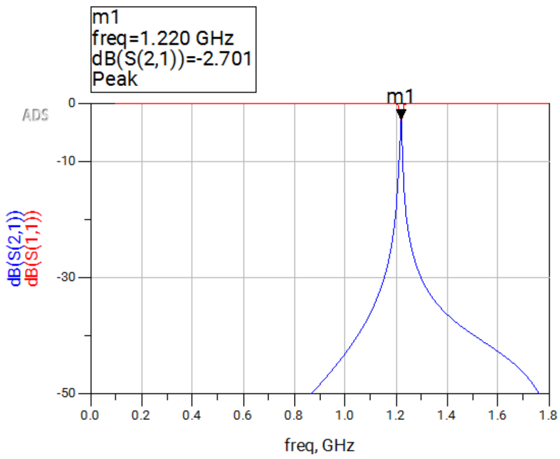


Fig. 14: New microstrip bandpass filter S_{11} and S_{21} plots

As seen from Fig. 14, the new center frequency of the bandpass filter is measured as 1.22GHz. Previously it was 1.03GHz. Fig. 15 shows the layout of the new microstrip bandpass filter.

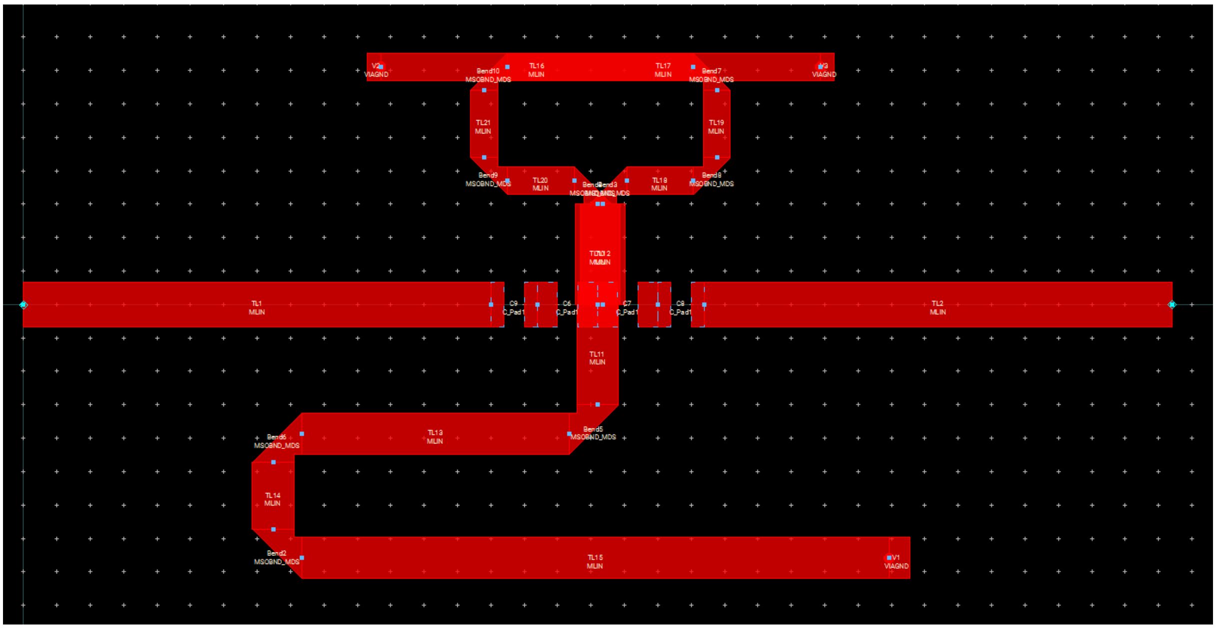


Fig. 15: Layout of the new bandpass filter