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EEE412 Lab #1

"I completed this homework assignment independently."

Question #1)

In the first question, transmission line circuit was setup. The input voltage is 5V. Initially, the open circuit voltage is measured.

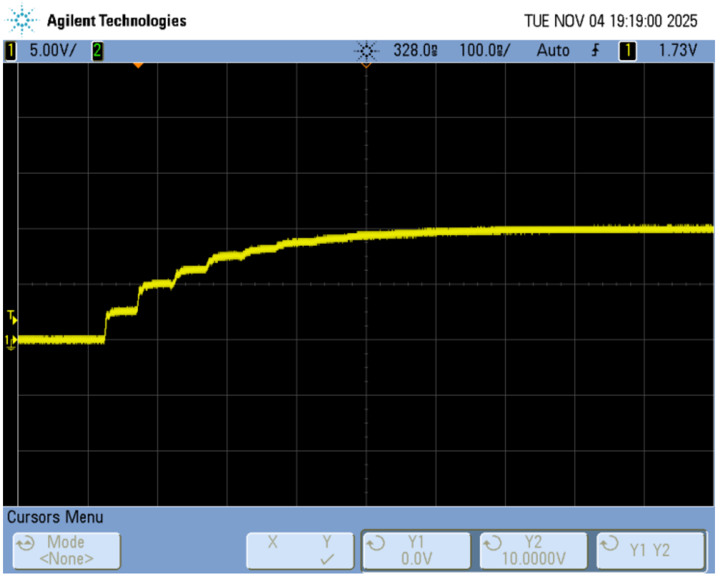

Fig. 1: Open circuit 5V step input transmission line voltages

As seen from Fig. 1, the steady-state voltage is 5V, because the input voltage of 5V is given, which corresponds to 2 squares (2 grid). Therefore, the initial voltage is measured as 1.25V. Then it goes up to 2.5V. These results are the same with the ones calculated in the preliminary work.

The next step is measuring the voltage with a 50Ω load connected. Fig. 2 shows the corresponding graph.

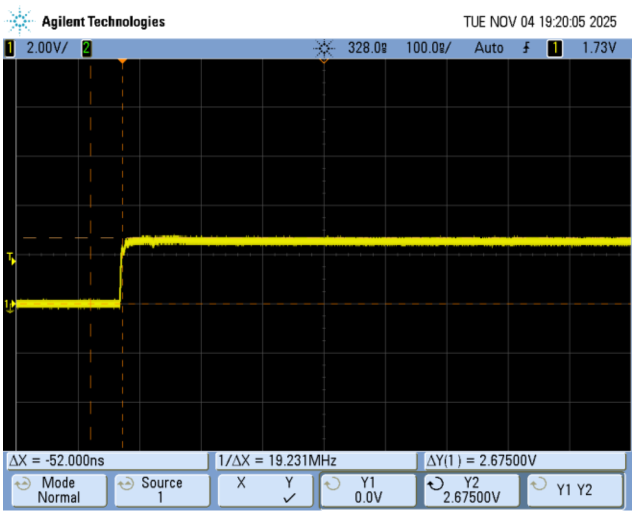

Fig. 2: 50Ω load connected to transmission line with input voltage 5V

Theoretically, because the input impedance is 50Ω, and we connected a 50Ω load, a simple voltage divider will give the output voltage. The calculated output voltage is 2.5V which is the half of the input voltage, 5V. The measured value is 2.675V, which is nearly the same, the error might be due to the insensitivity of the experimenter.

The last step for the step input is shorting the transmission line and observing the voltages. Fig. 3 shows the correspinding votlage graph.

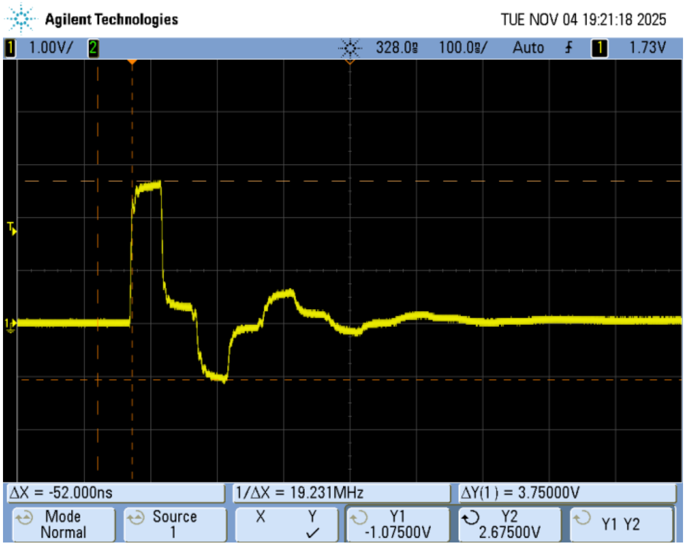

Fig. 3: Short circuit 5V step input transmission line voltages

When we short the transmission line, the reflection coefficient value becomes -1. Also, steady-state voltage is measured as 0V, because we shorted the transmission line.

The second part of the first question requires an input voltage as pulses with pulse width of 4ns, and an amplitude of 5V.

Again, initially the open circuit voltage of the transmission line with pulse input is observed.

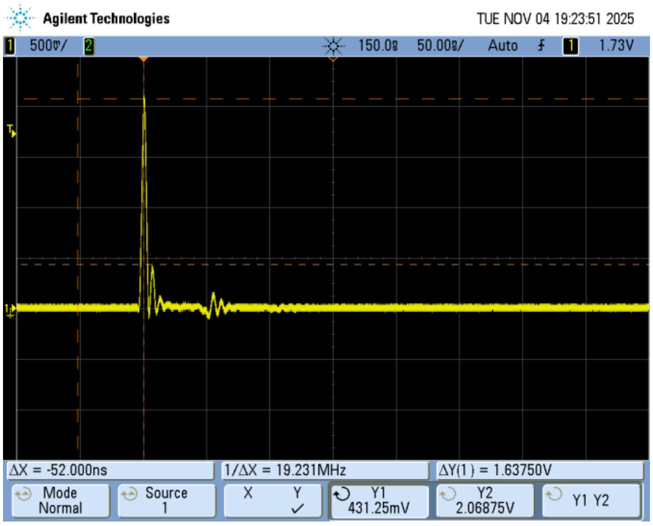

Fig. 4: Open circuit 5V pulse input transmission line voltages

The second step requires a load of 50Ω connected to the other end of the transmission line. Fig. 5 shows the corresponding voltage graph.

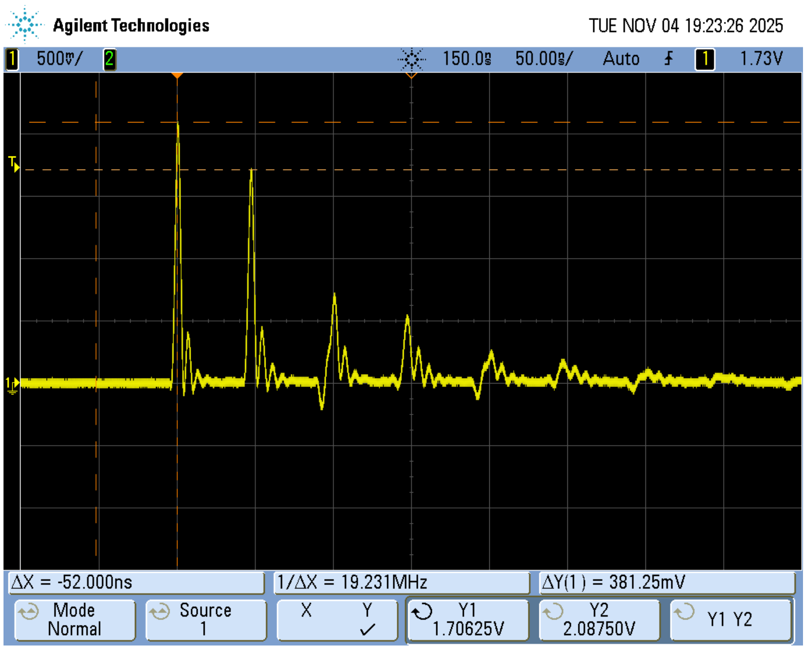

Fig. 5: 50Ω load connected to transmission line with input voltage 5V pulse

The final step of the first question is shorting the transmission line and observing the voltages when a pulse with an amplitude of 5V is given to the circuit.

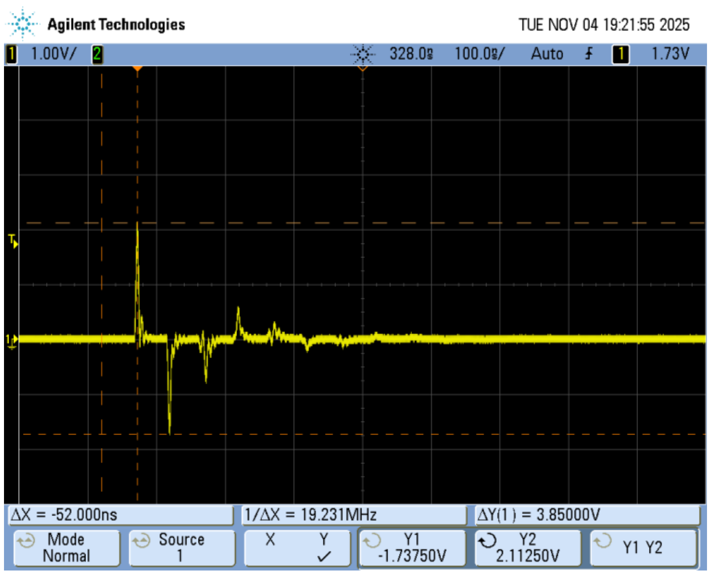

Fig. 6: Short circuit 5V pulse input transmission line voltages

As expected, the voltages appear as spikes whereas in Fig. 3, due to step input, voltages appear as square waves.

Question #2)

In this question, the frequency is chosen as 200MHz. The S_{11} parameter is shown on the Smith Chart. Our goal is to make S_{11}=0, which corresponds to the center point of the Smith Chart, i.e. 50Ω. In preliminary work, the lengths of the stubs are found as follows.

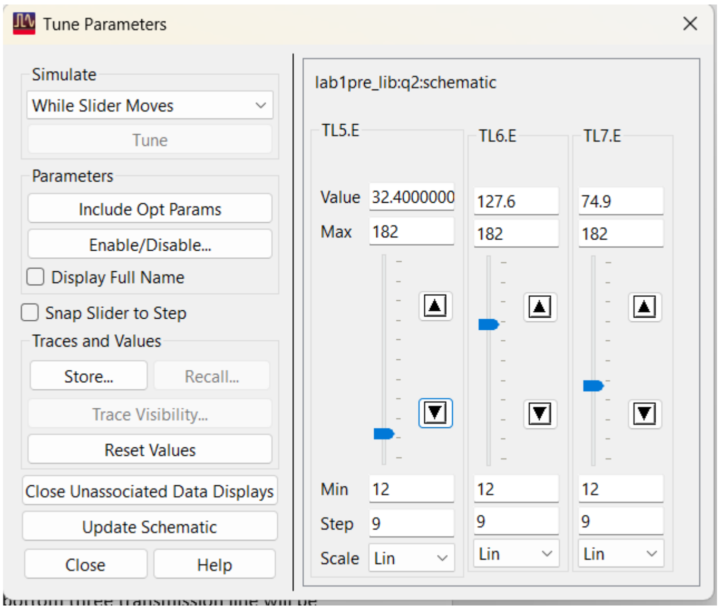

Fig. 7: Measured electrical lengths of TL5, TL6, and TL7 respectively

To convert the electrical lengths to metrics, following operations will be done.

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

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

$$L_{TL5} = 135mm$$

$$L_{TL6} = 531.67mm$$

$$L_{TL7} = 312.08mm$$

These are the simulation results that were achieved in the preliminary work. Fig. 8 shows the circuit. The leftmost stub is TL7 and rightmost stub is TL5.

Fig. 8: Used stubs in question #2 (the lengths are not tuned)

The measured lengths of the stubs from are given in the bottom line.

$$L_{TL5} = 141mm$$

$$L_{TL6} = 504mm$$

$$L_{TL7} = 329mm$$

The corresponding S_{11} value on the Smith Chart is given in Fig. 9.

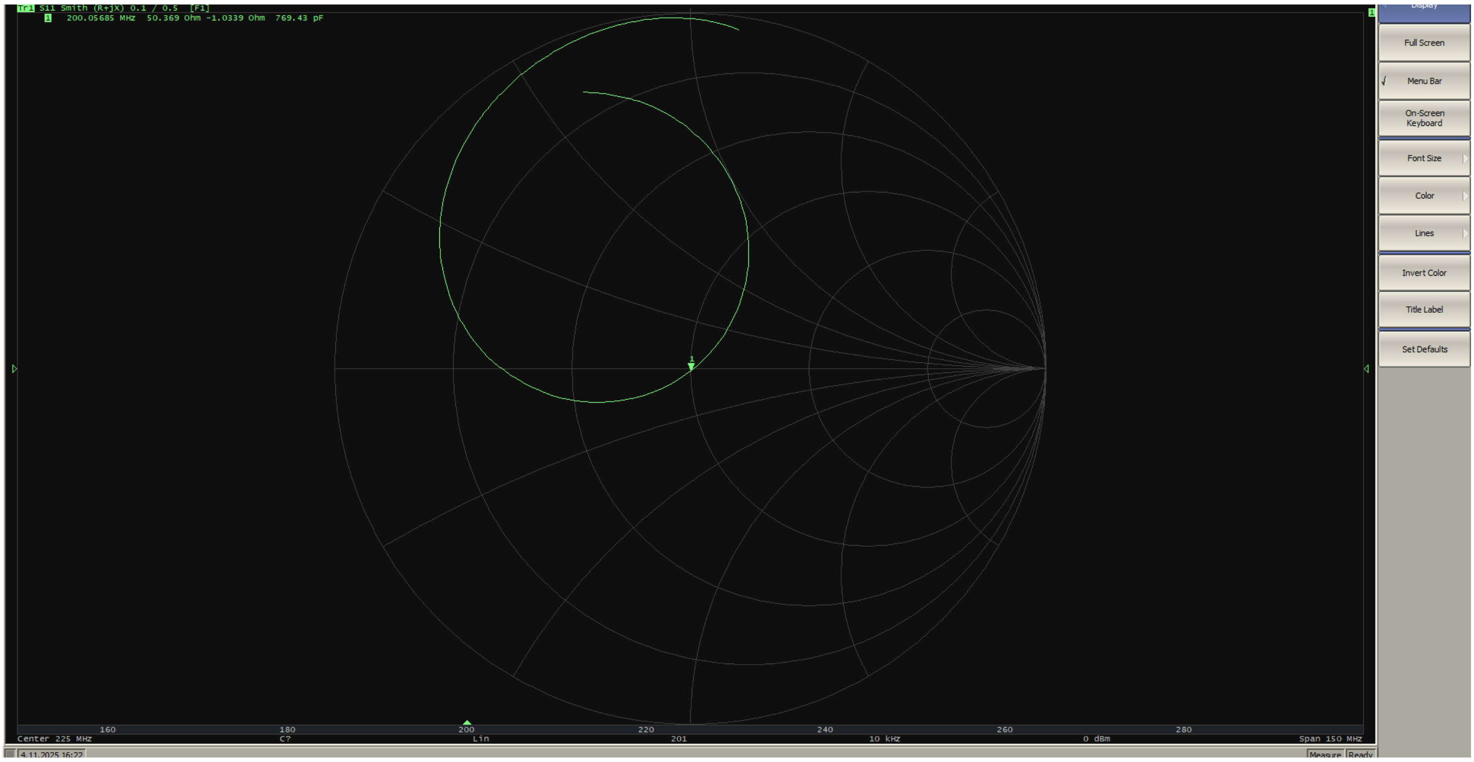

Fig. 9: S_{11}=0 on the Smith Chart

As seen from Fig. 9, on the top left corner, the impedance value is 50.369Ω. Which shows that S_{11}=0 nearly. Consequently, the requirement is satisfied.

Question #3)

In this question, the microstrip low-pass filter is connected to the HP5071C vector network analyzer. S_{11} and S_{21} are plotted. Fig. 10 shows these plots.

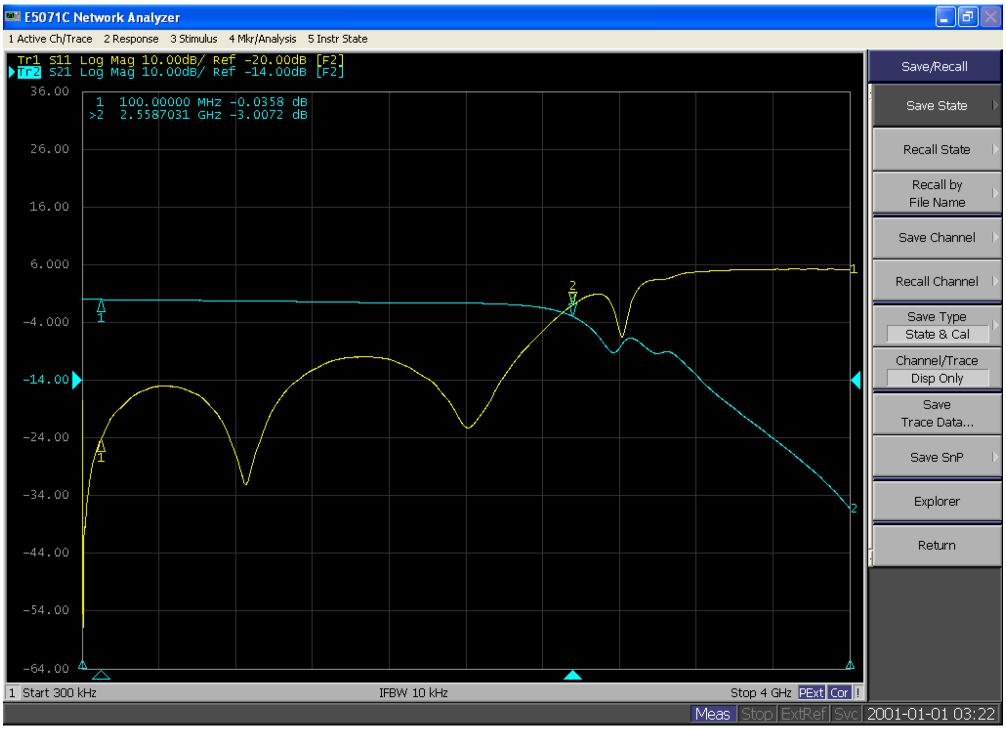

Fig. 10: S_{11} (yellow curve) and S_{21} (blue curve) of the microstrip low-pass filter

Fig. 11 shows the simulation result, also indicating the -3dB point, which is measured around 2.4GHz

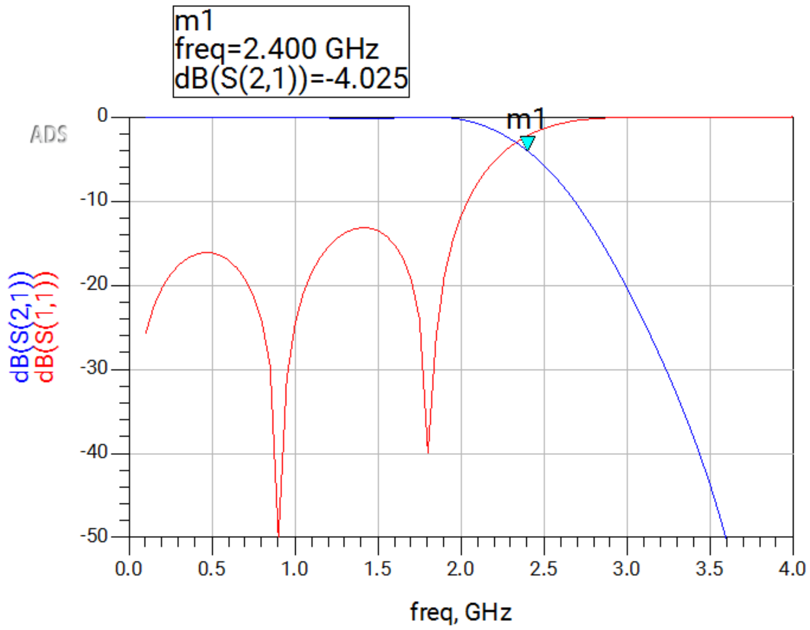

Fig. 11: : Simulation results of S_{11} (red curve) and S_{21} (blue curve) of the microstrip low-pass filter

Comparing the experimental and simulated results, the corner frequency value is measured as 2.55GHz in the experimental data, whereas it was measured as 2.4GHz in the simulation. The results are nearly the same with a small error included. Also, in experimental plot, there is a ripple, which I think caused by the electric-field susceptance of the microstrip low-pass filter. Because when I hover my finger on the microstrip, the graph changes.

Question #4)

The simulated S_{11} and S_{21} plot in the preliminary work is given in Fig. 12.

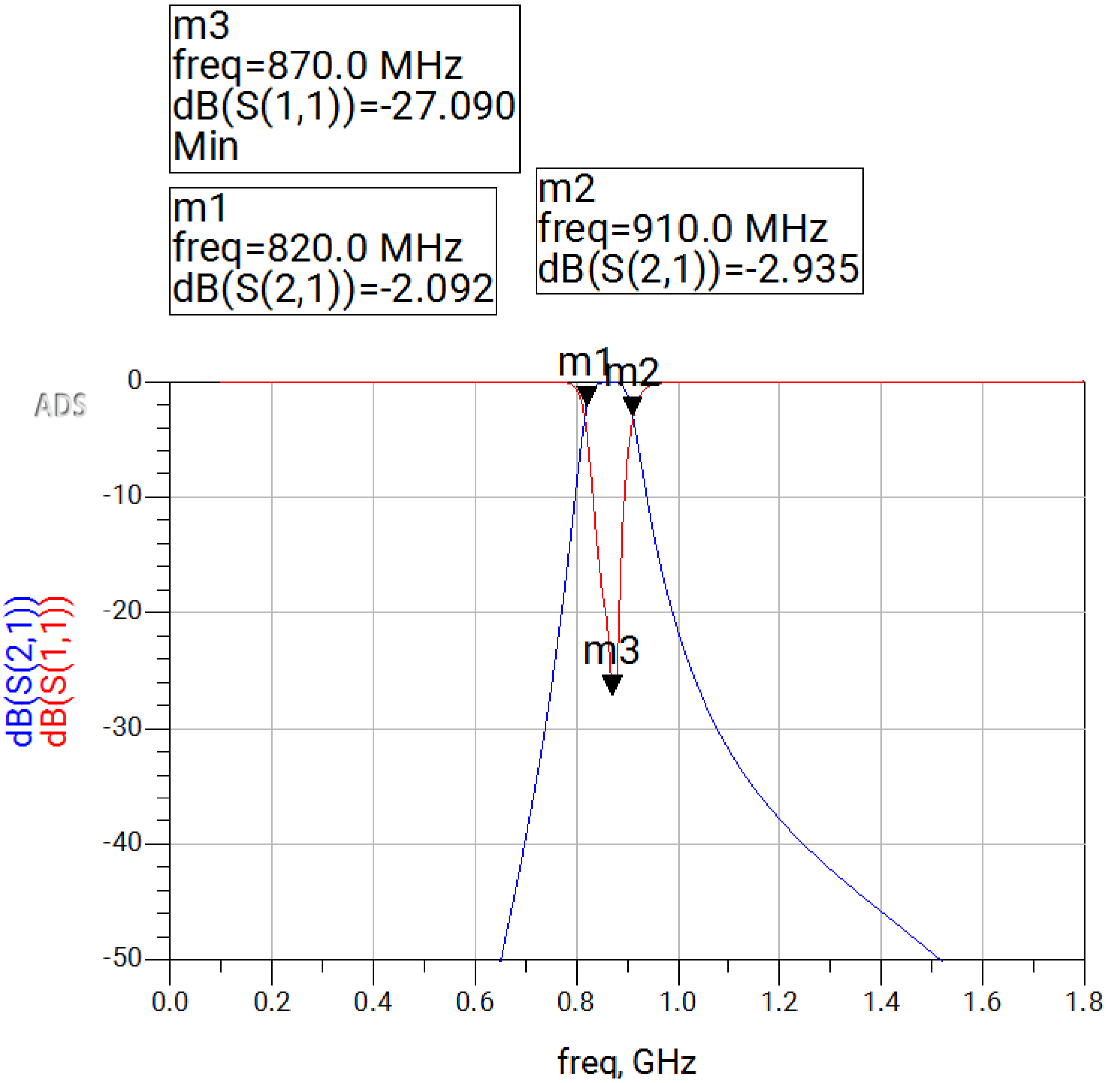

Fig. 12: S_{11} and S_{21} plots of the microstrip bandpass filter

As seen from Fig. 12, the corner (-3dB) frequencies as measured around 820MHz and 910MHz. Fig. 13 shows the experimental data.

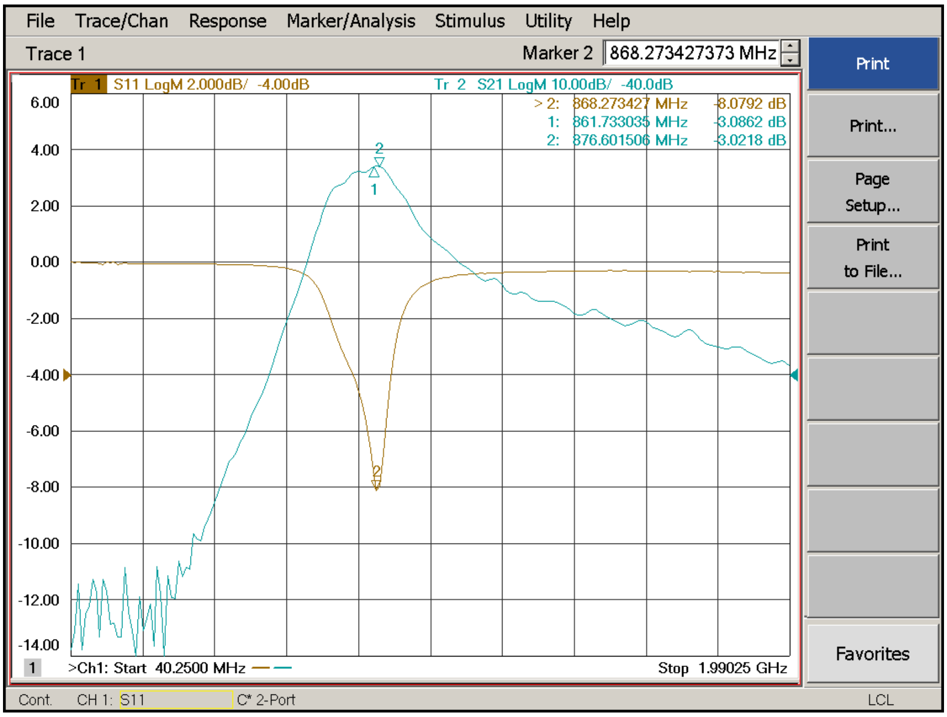

Fig. 13: Experimental results of S_{11} and S_{21} plot of the microstrip bandpass filter

In the experimental data, -3dB points are measured as 861.73MHz and 876.6MHz. Whereas in the simulation, these values are measured around 820MHz and 910MHz respectively. A small difference is present between the experimental and simulation results, which can be considered as the measurement error.