Microstrip Resonators

Microwave Design and Measurements (EERF 6396)
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Submitted By

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1. Introduction

Objectives:

- Design, simulate and build series and shunt microstrip resonators with f_o = 2.5 GHz; analyze over 1-5 GHz using AWR MWO (Axiem). (substrate = FR-4)
- Compare the measurement results and Axiem simulation results.

2. Design

A. Design Process

Single microstrip resonator: Resonant frequency = 2.5GHz (Megha Sarvagnappa)

- Tx line tool in AWR MWO was used to calculate the width, length and λeff values.
- $\lambda/4$ open circuit stub was connected in parallel to the 50-ohm transmission line at the middle.
- The circuit was built and tuned in AWR MWO to achieve the optimum length of line ($\lambda/4$) for resonance at f_o.
- Axiem mesh was build and performance was recorded.
- S-parameters of the build circuit were measured in lab.

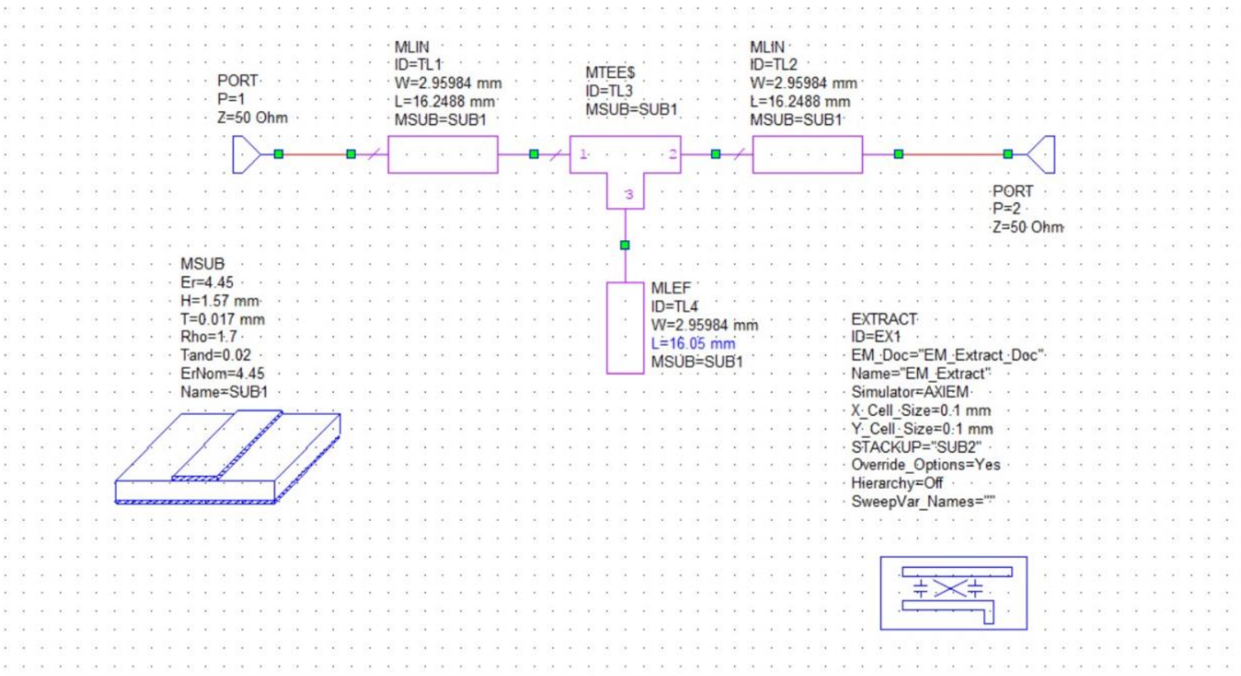
Parallel microstrip resonator: Resonant frequency = 2.5GHz (my design)

- Tx line tool in AWR MWO was used to calculate the width, λeff, length of inductive and capacitive stub.
- Inductive and capacitive open circuit stubs are connected in parallel to 50-ohm transmission line at the middle.
- At resonant frequency, the reactance of inductive stub and capacitive stubs will cancel each other out.
- So, for this design, return loss will be high and insertion loss will be low.
- The circuit was built and tuned in AWR MWO to achieve resonance at f_o.
- Axiem mesh was build and performance was recorded.
- S-parameters of the build circuit were measured in lab.

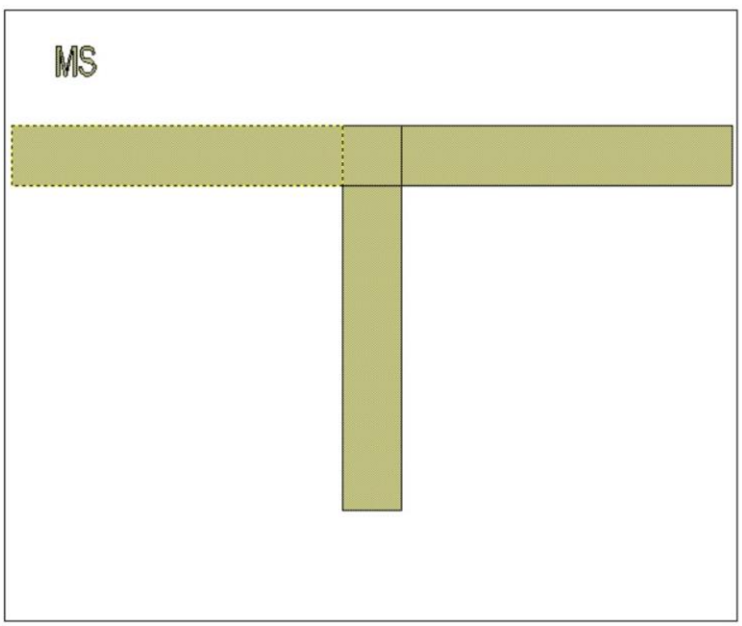
B. AWR MWO Simulation

1. Single microstrip resonator

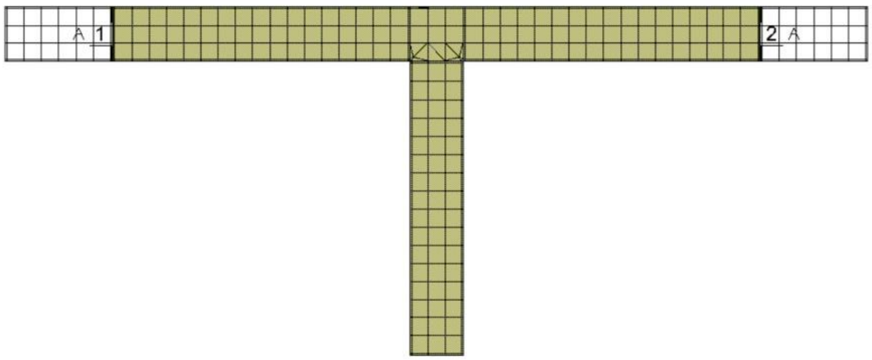
Circuit Schematic:



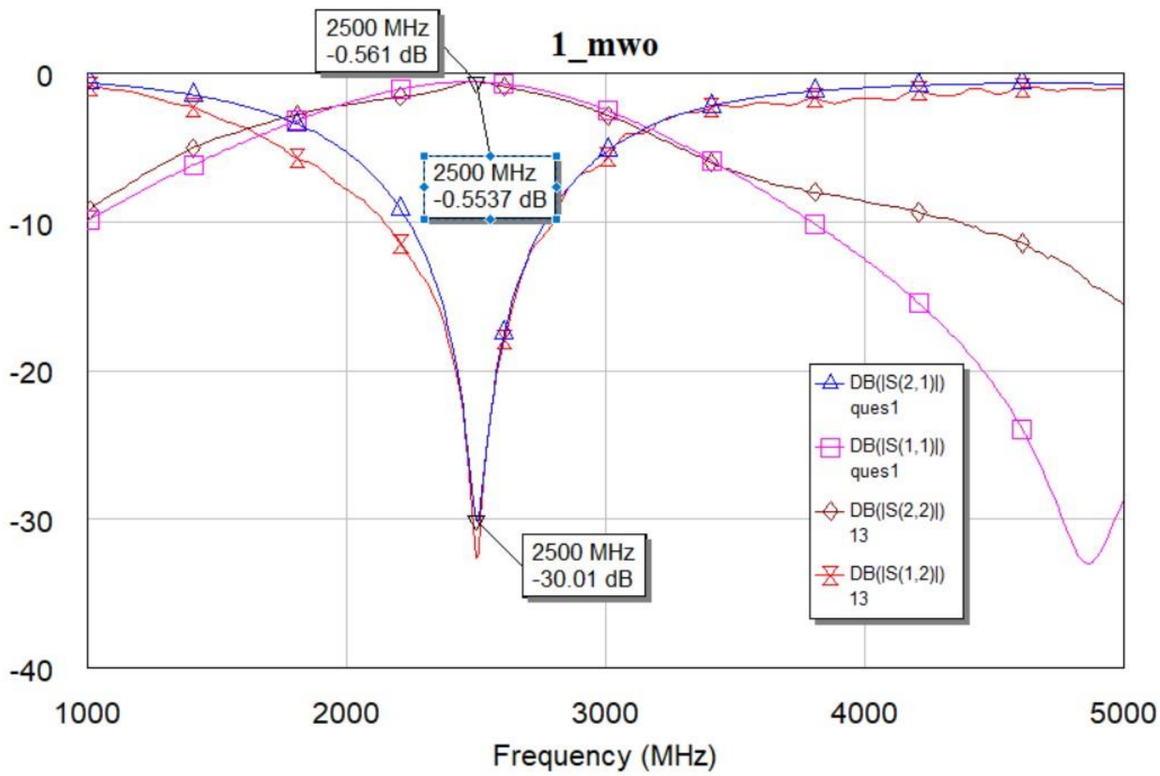
Layout:



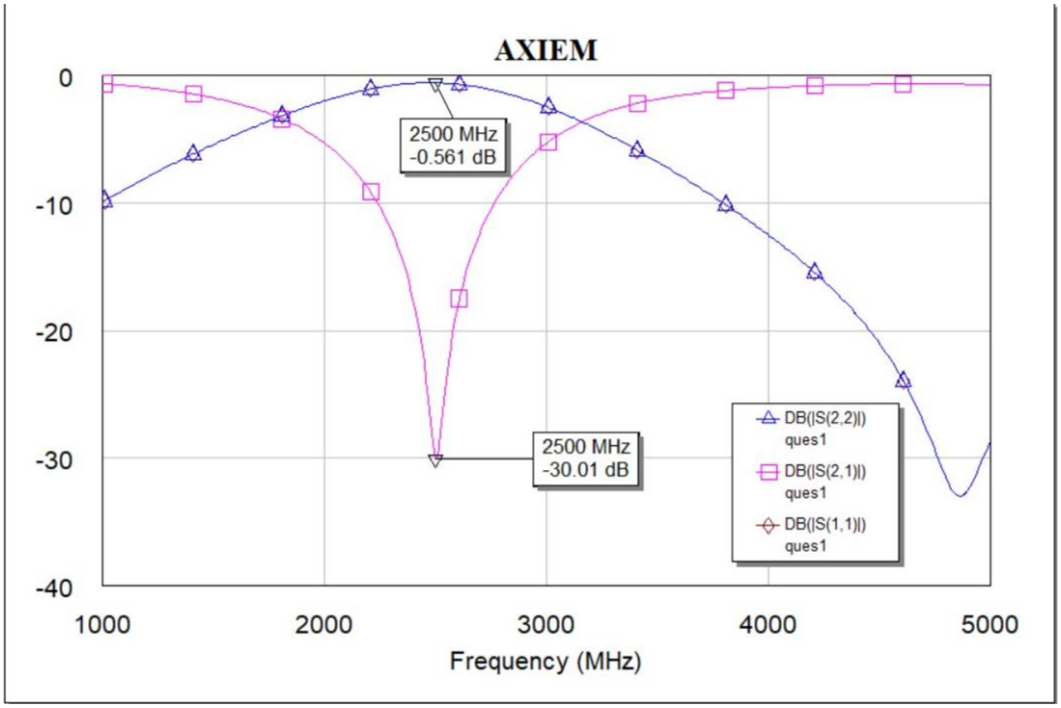
AXIEM Mesh Layout:



MWO Simulation:

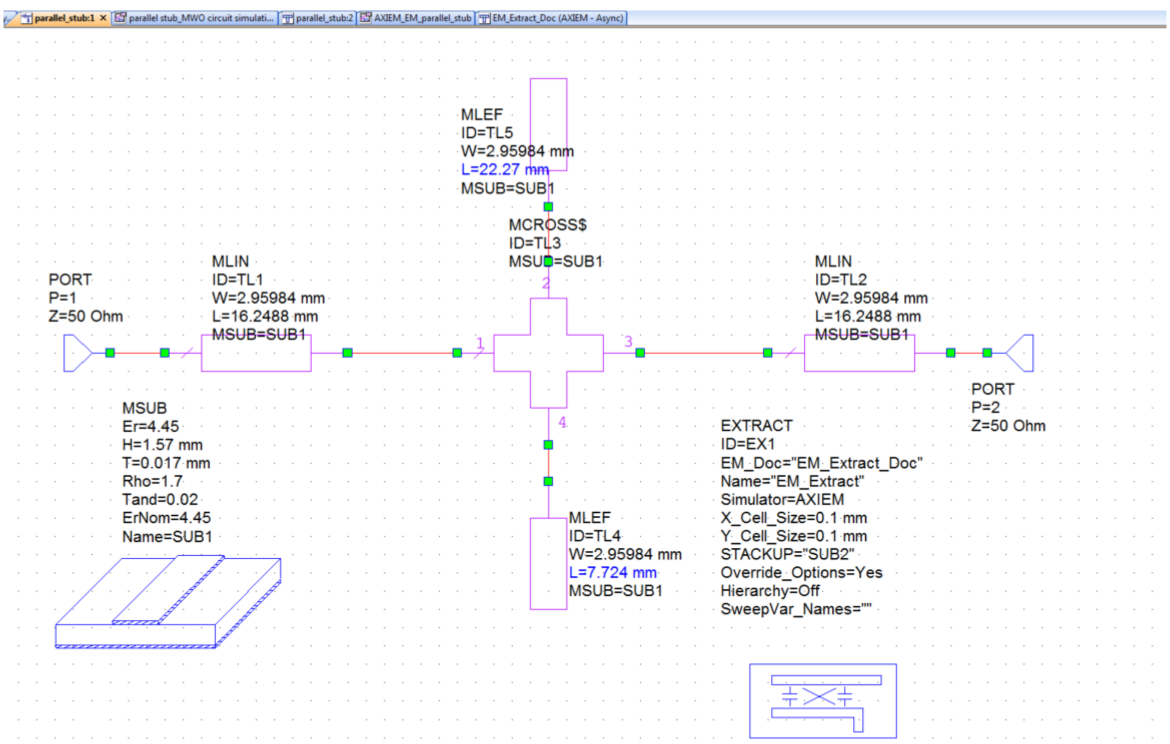


AXIEM Simulation:

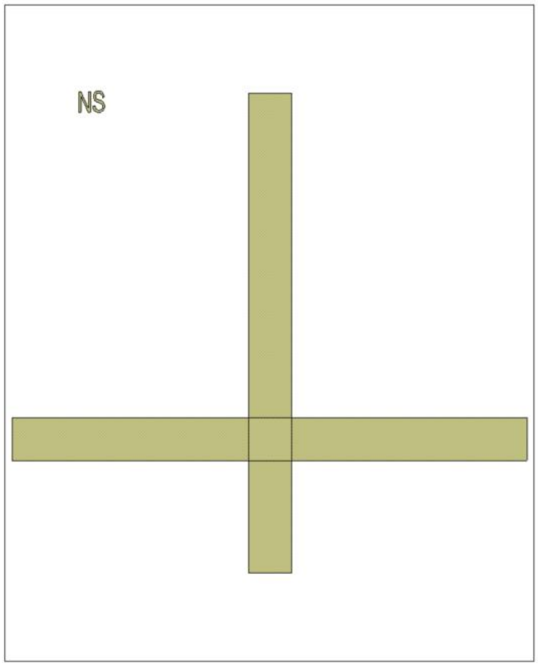


2. Parallel microstrip resonator

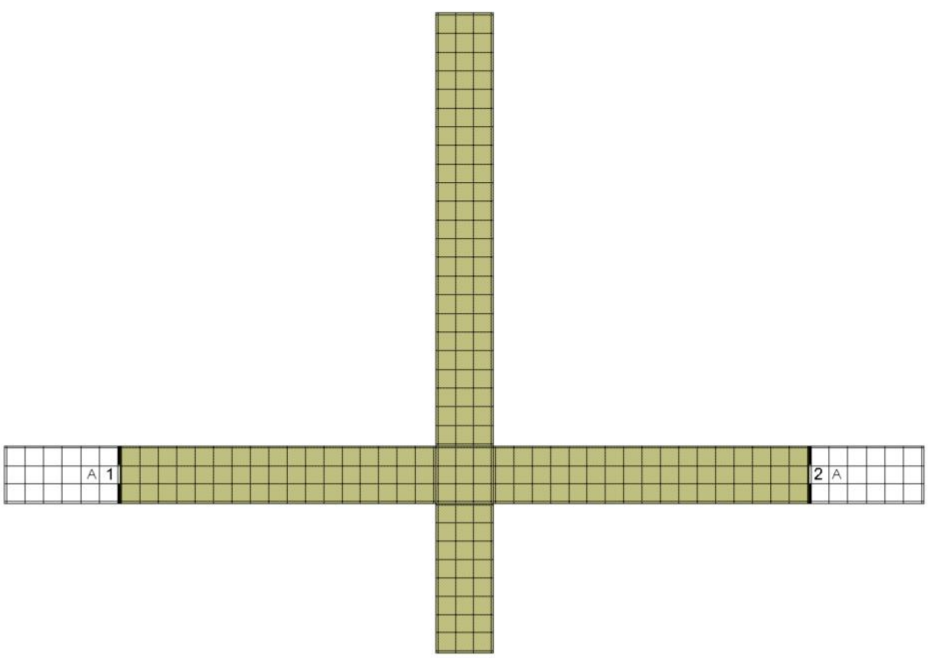
Circuit Schematic:



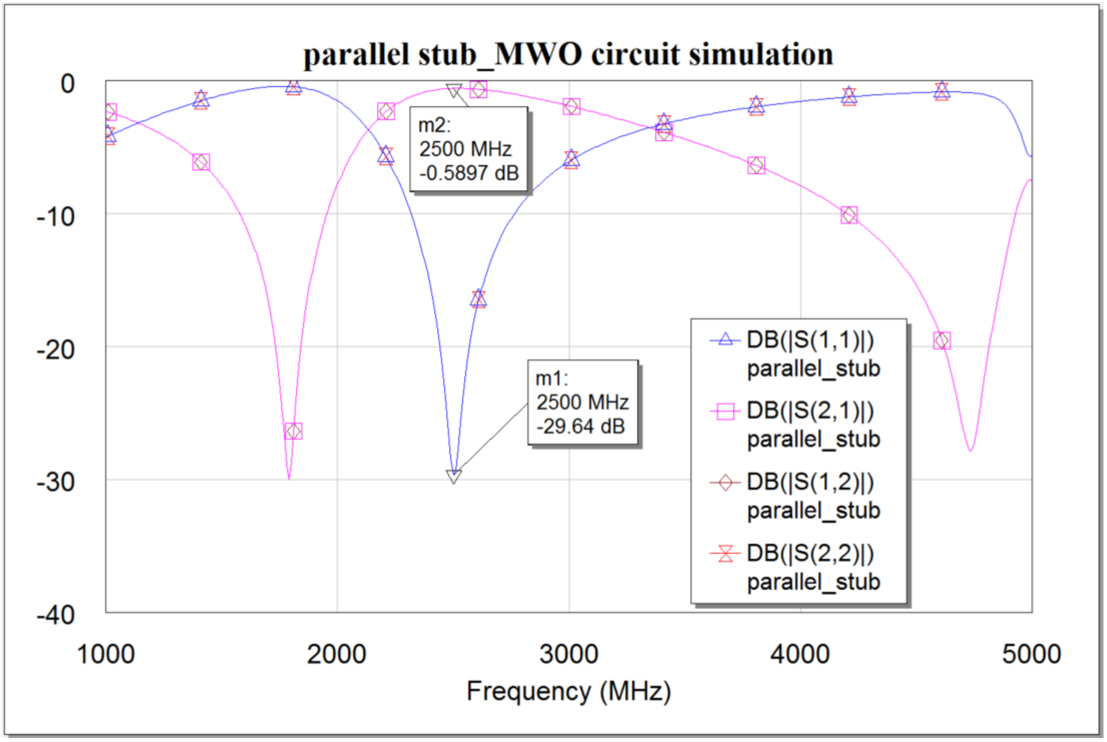
Layout:



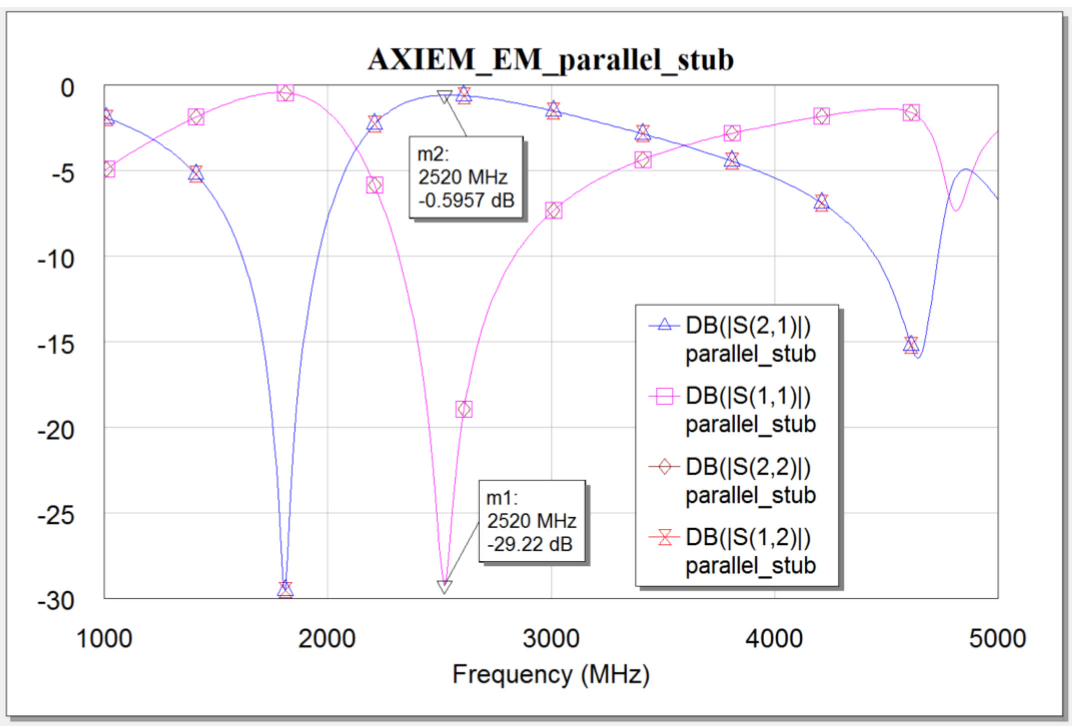
AXIEM Layout:



MWO Simulation:



AXIEM Simulation:



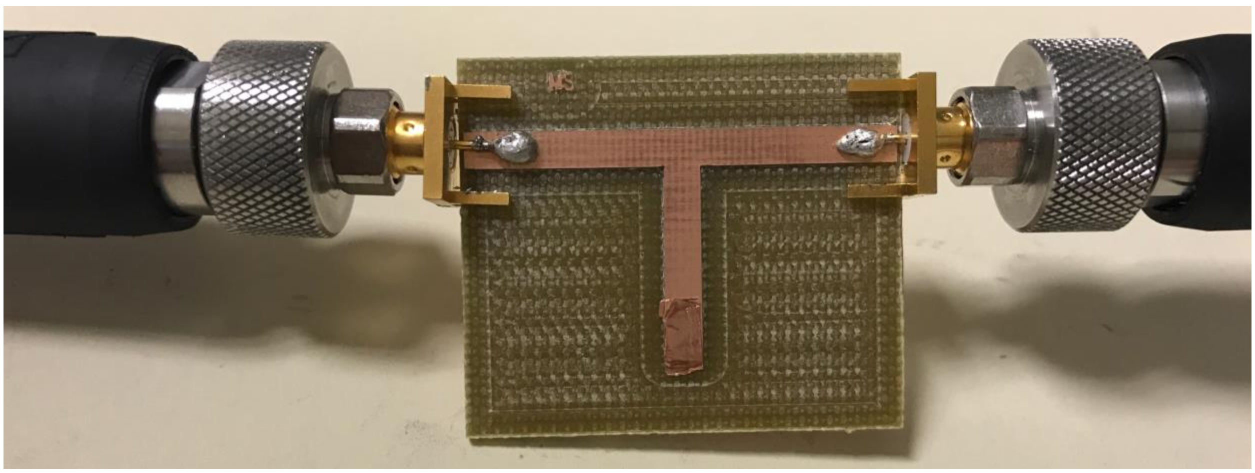
3. **Measurement Data**

A. **Photographs of measured circuit:**

Single microstrip resonator:

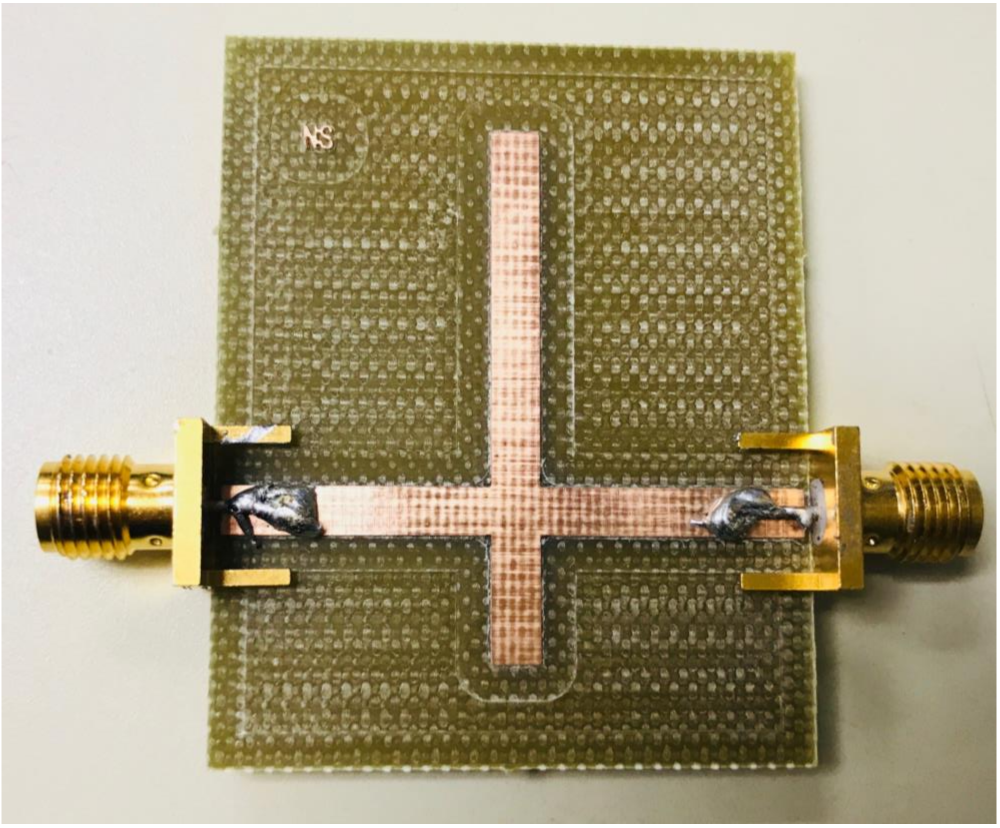
Before tuning:

After tuning:

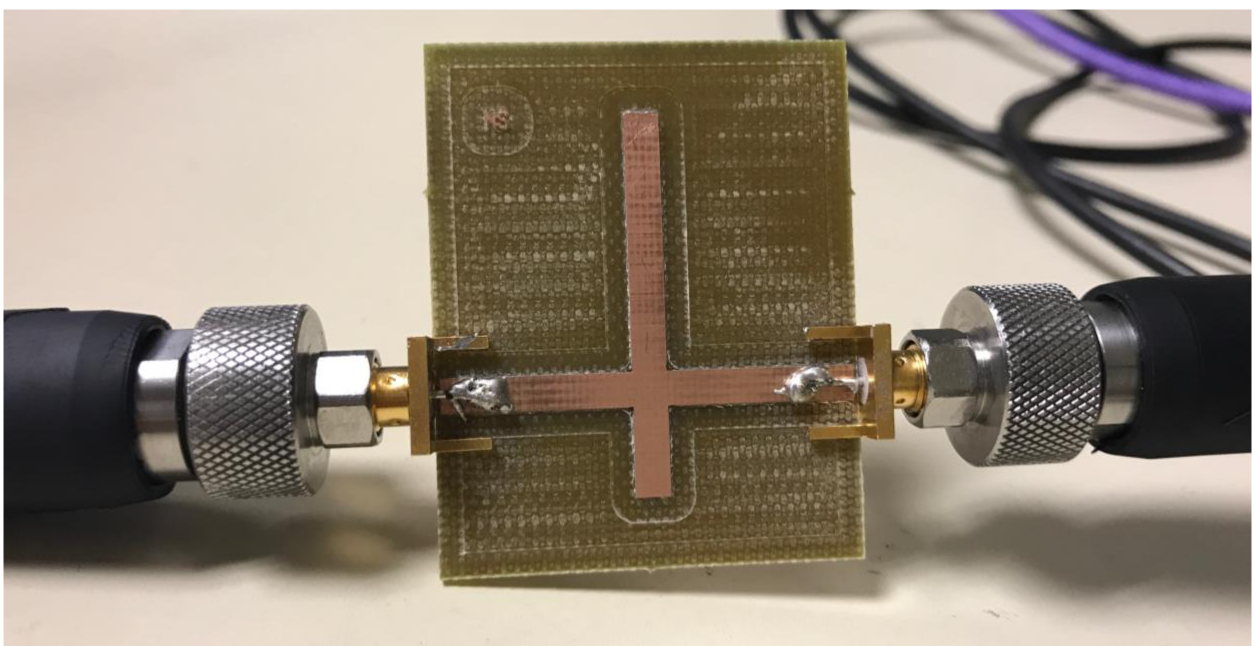


Parallel microstrip resonator :

Before tuning:



After tuning:



B. Plots of Measured Data

1. Single microstrip resonator

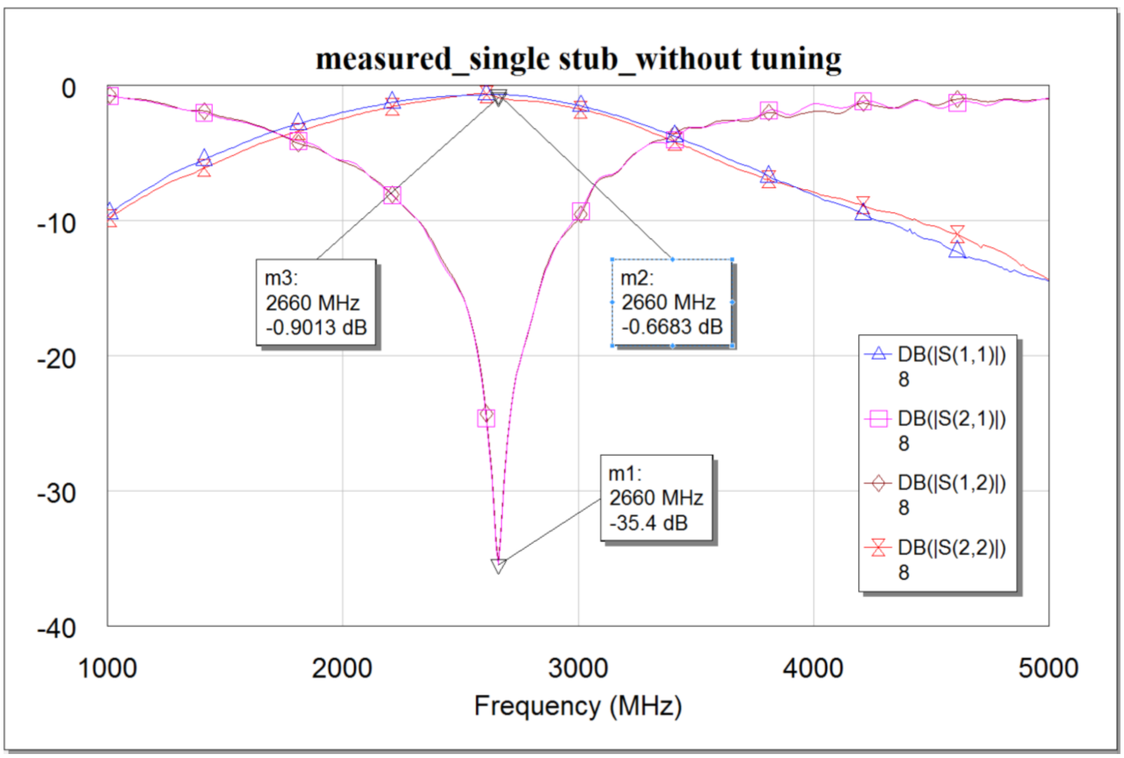
Expected length of stub (as in schematic) = 16.05 mm

Length of stub before tuning = 15.7 mm

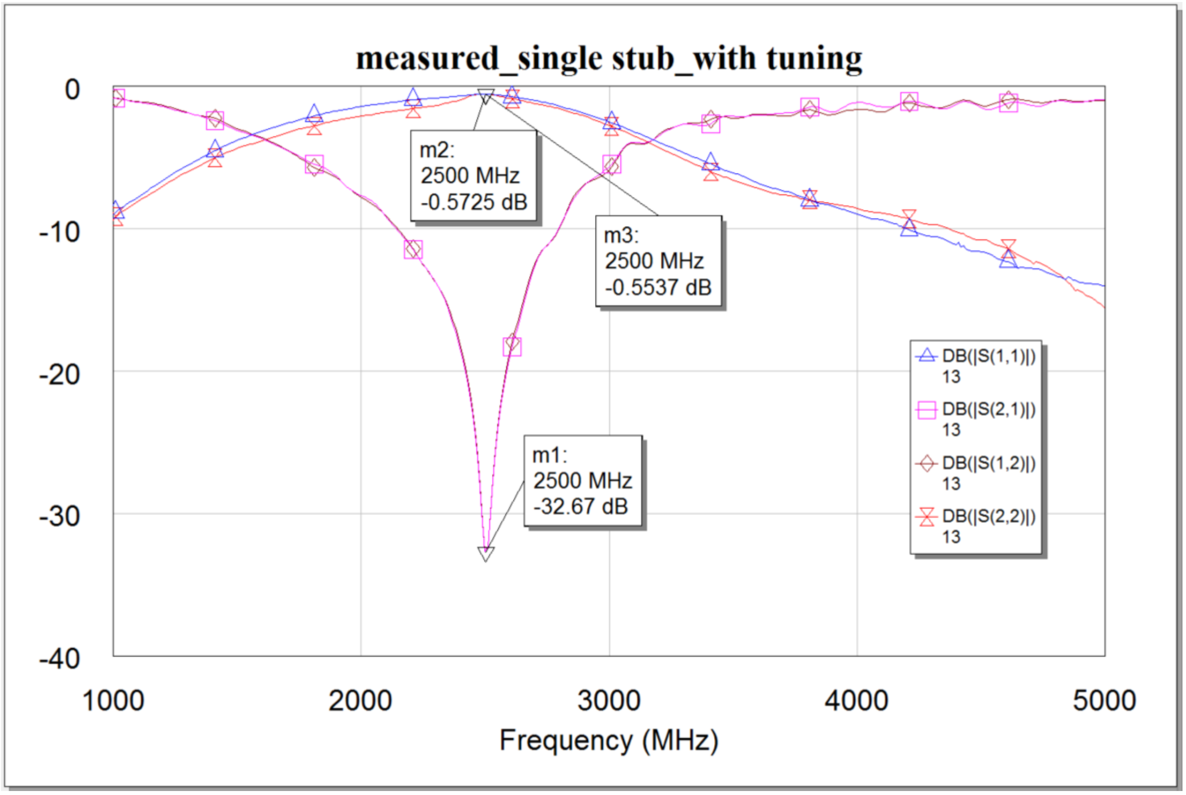
Length of stub after tuning = 19.99 mm

Note: Resonant frequency before tuning was found to be 2.66 GHz. Length of the stub was increased to decrease resonant frequency to 2.5 GHz.

Measured data Before tuning (as built):



After tuning:



2. Parallel microstrip resonator

Expected length of longer stub (as in schematic) = 22.27 mm

Expected length of shorter stub (as in schematic) = 7.724 mm

Length of longer stub Before tuning (as built) = 21.7 mm

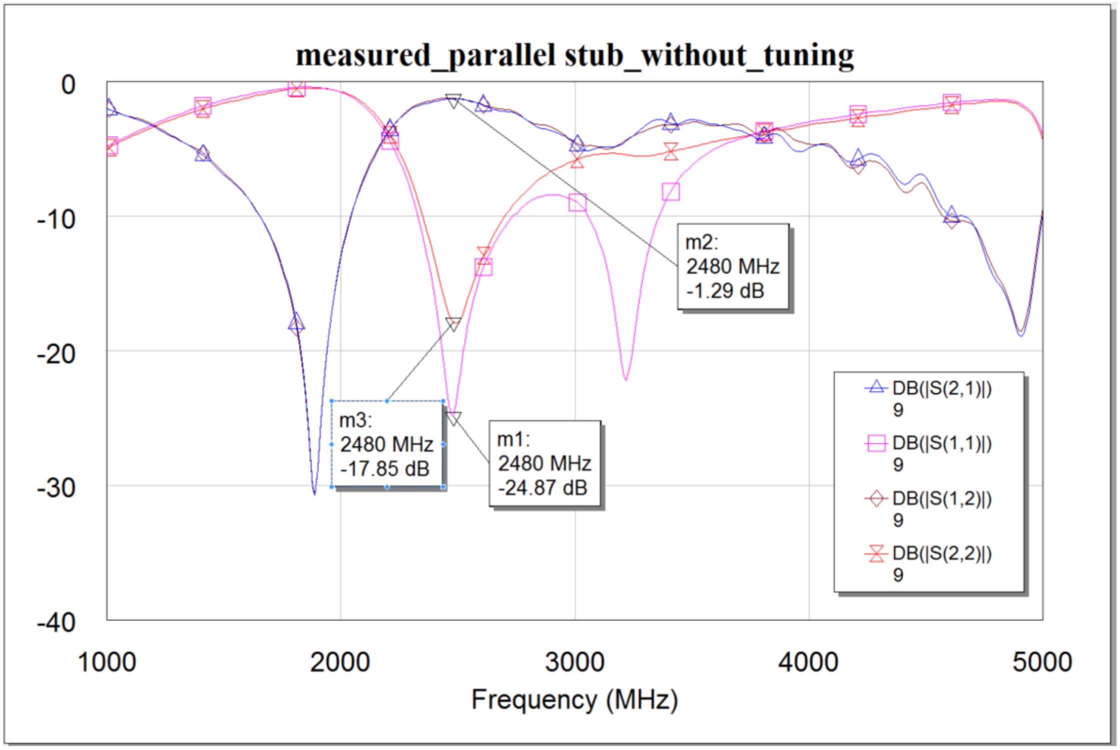
Length of shorter stub Before tuning (as built) = 7.2 mm

Length of longer stub after tuning = 21.3 mm

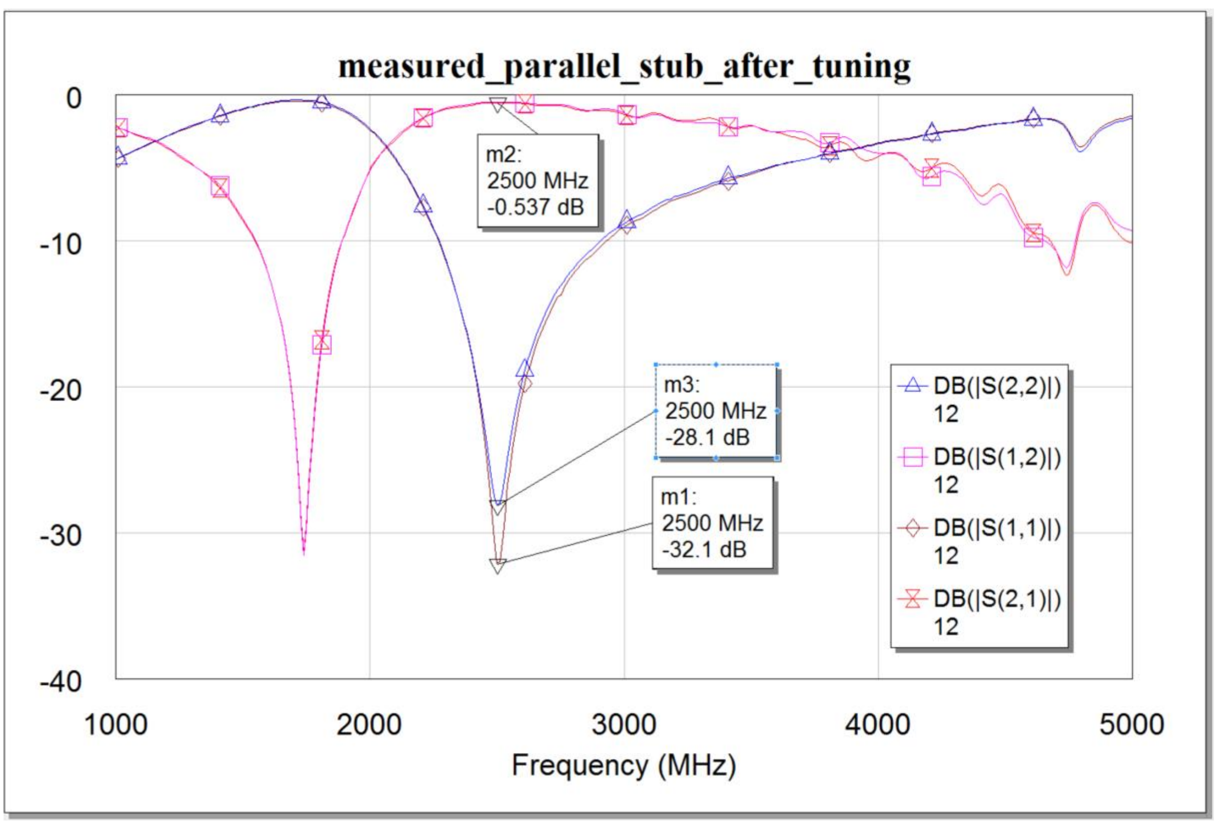
Length of shorter stub after tuning = 7.2 mm

Note: Resonant frequency before tuning was found to be 2.480 GHz. Length of the longer stub was decreased to increase resonant frequency to 2.5 GHz.

Measured data Before tuning (as built):



Measured data after tuning:



C. Summary

1. Single microstrip resonator

Board Size: 36.2 mm x 30.99 mm

Board Thickness: varied from 1.35 mm to 1.4 mm

Width of the stub = 3 mm

Length of 50-ohm line = 36 mm.

Expected length of stub (as in schematic) = 16.05 mm

Length of stub Before tuning = 15.7 mm

Length of stub after tuning = 19.99 mm

- Resonant frequency before tuning was found to be 2.66 GHz for length of stub 15.7 mm.
- To achieve resonant frequency at 2.5 GHz, the length of the stub was tuned (increased) and made 19.99 mm.

2. Parallel microstrip resonator

Board Size: 40.52 mm x 30.65 mm

Board Thickness: varied from 1.15 mm to 1.3 mm

Width of the stub = 2.85 mm

Length of 50-ohm line = 35 mm.

Expected length of short stub (as in schematic) = 22.27 mm

Expected length of longer stub (as in schematic) = 7.724 mm

Length of longer stub Before tuning (as built) = 21.7 mm

Length of shorter stub Before tuning (as built) = 7.2 mm

Length of longer stub after tuning = 21.3 mm

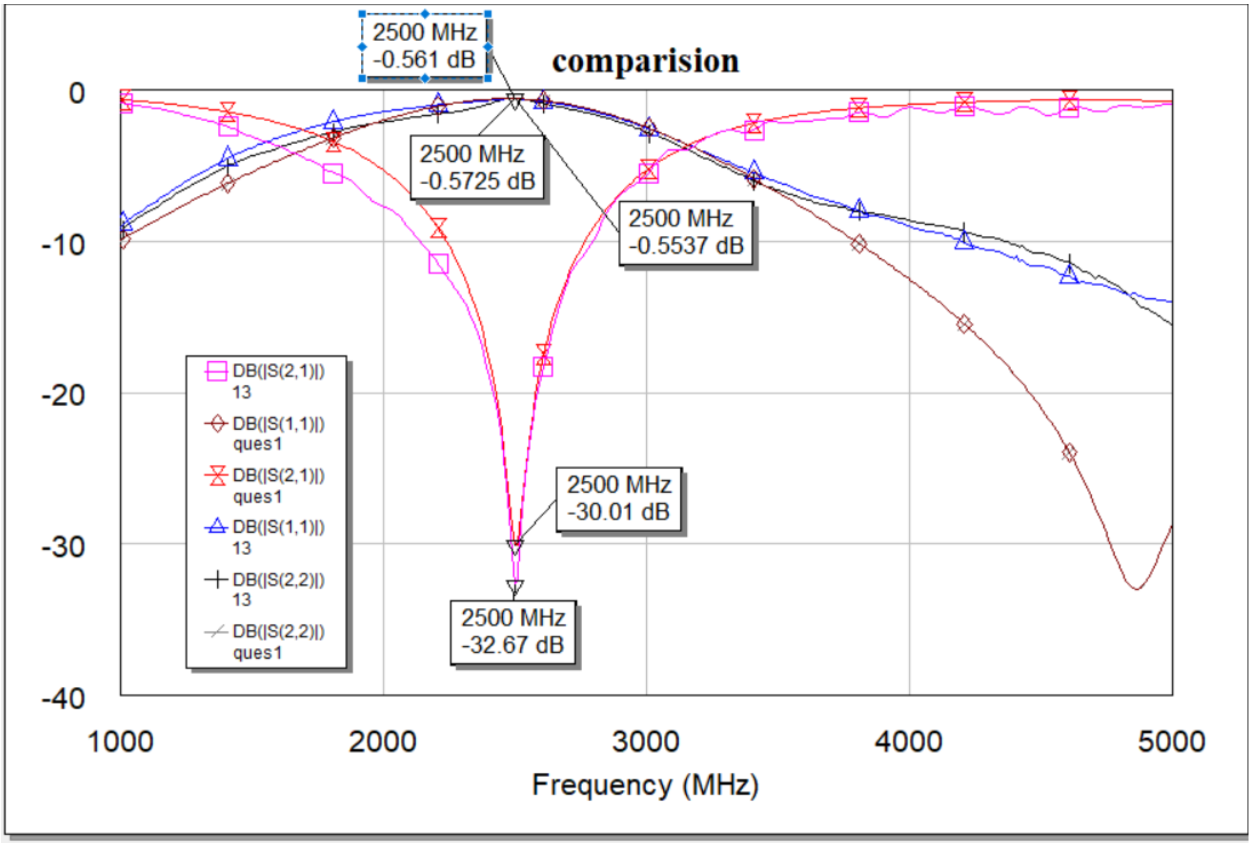
Length of shorter stub after tuning = 7.2 mm

- Resonant frequency before tuning was found to be 2.48 GHz for length of longer stub 21.7 mm.
- To achieve resonant frequency at 2.5 GHz, the length of the longer stub was tuned (decreased) to 21.3 mm.

4. Analysis

A. Comparison graph of predicted and measured graph

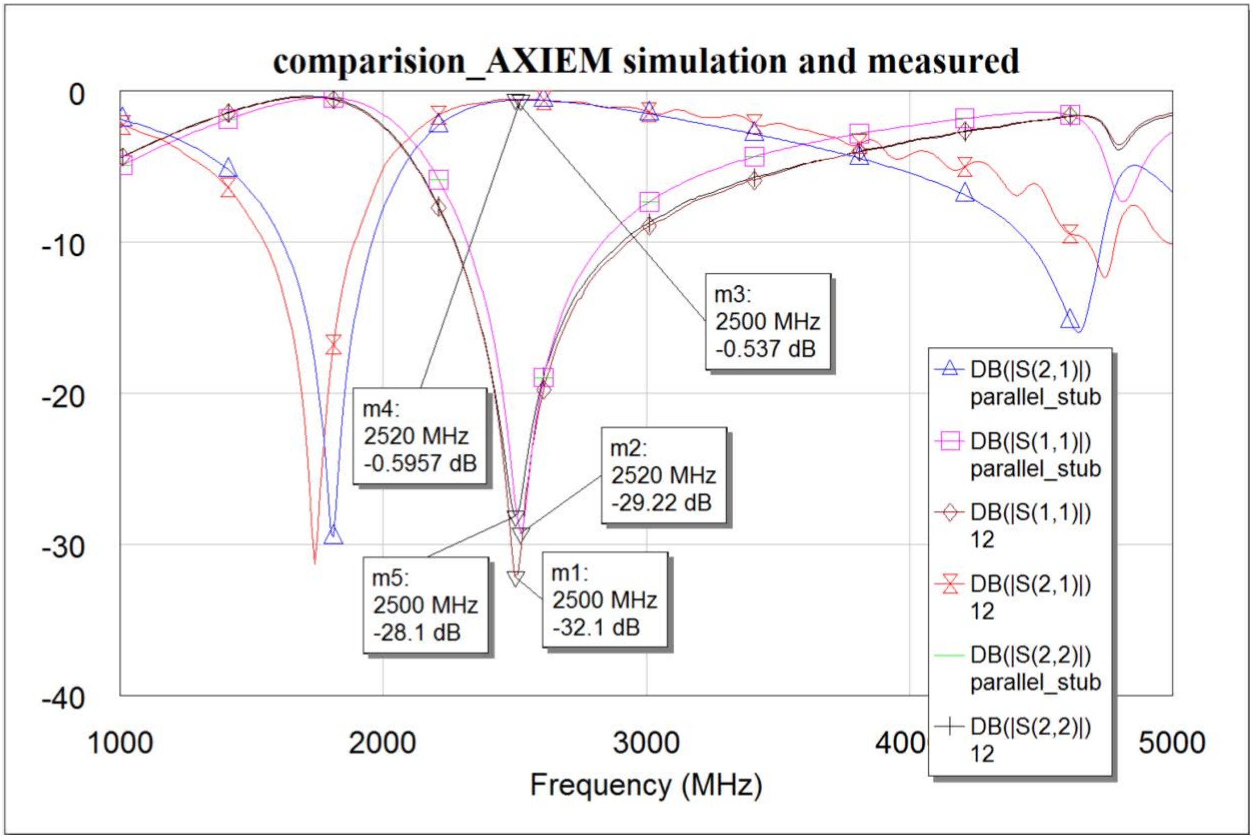
Single microstrip resonator:



Graph values:

S-parameter	Predicted value	Measured value
S11	-0.561 dB	-0.5725 dB
S22	-0.561 dB	-0.5537 dB
S21	-30.01 dB	-32.67 dB

Parallel microstrip resonator:



Graph values:

S-parameter	Predicted value	Measured value
S11	-29.22 dB	-32.1 dB
S22	-29.22 dB	-28.1 dB
S21	-0.5957 dB	-0.537 dB

B. Compliance Matrix

Single microstrip resonator:

Parameter	Design Goal	Simulated Performance	Measured Performance (as built)	Measured Performance(tuned)	Compliant (Yes/No) (+/- 5%)
Design Frequency (GHz)	2.5	2.5	2.66	2.5	Yes
Input Return Loss @ 2.5GHz (dB)	<2	0.561	0.6683	0.5725	Yes
Output Return Loss @ 2.5GHz (dB)	<2	0.561	0.9013	0.5537	Yes
Insertion Loss @ 2.5GHz (dB)	>20	30.1	35.4	32.67	Yes

Parallel microstrip resonator:

Parameter	Design Goal	Simulated Performance	Measured Performance (as built)	Measured Performance(tuned)	Compliant (Yes/No) (+/- 5%)
Design Frequency (GHz)	2.5	2.5	2.480	2.5	Yes
Input Return Loss @ 2.5GHz (dB)	>20	29.22	24.87	32.1	Yes
Output Return Loss @ 2.5GHz (dB)	>20	29.22	17.85	28.1	Yes
Insertion Loss @ 2.5GHz (dB)	<1	0.5957	1.29	0.537	Yes

C. Summary

Reasons for difference between predicted and measured performances:

- Length of the stub in the milled (built) design varied than length of the stub in the schematic circuit which lead to change in resonant frequency.
- All the design goals were met after tuning the circuits and measurement of parallel microstrip resonator was better than simulated performance.

5. Conclusion

A. Was the design successful? Why or why not?

Yes, design was successful and all the design goals were achieved after tuning the milled circuits. Variation was observed in measured and predicted values due to stray capacitances and fringing effect.

B. What would you do differently in the design next time?

For the next time, using AXIEM simulator to tune the circuit would be a better idea. This time it was solved by changing the length of the stub on the milled design.

C. What lessons did you learn from the lab?

From this lab, I learned that effective dielectric constant plays a great role in practical performance of circuit. As FR-4 has lossy nature, we need to take that into consideration while tuning the circuit in MWO. Another thing I learned is that soldering the connectors to the board without air gap between them is important for taking accurate readings.