Lab5 Microstrip Resonator Design

EERF – 6396

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1. Introduction

Objectives:

a. Design, simulate and build shunt microstrip resonator with f_o = 2.5 GHz
b. Compare the design against physical results and Axiem simulation

2. Significance

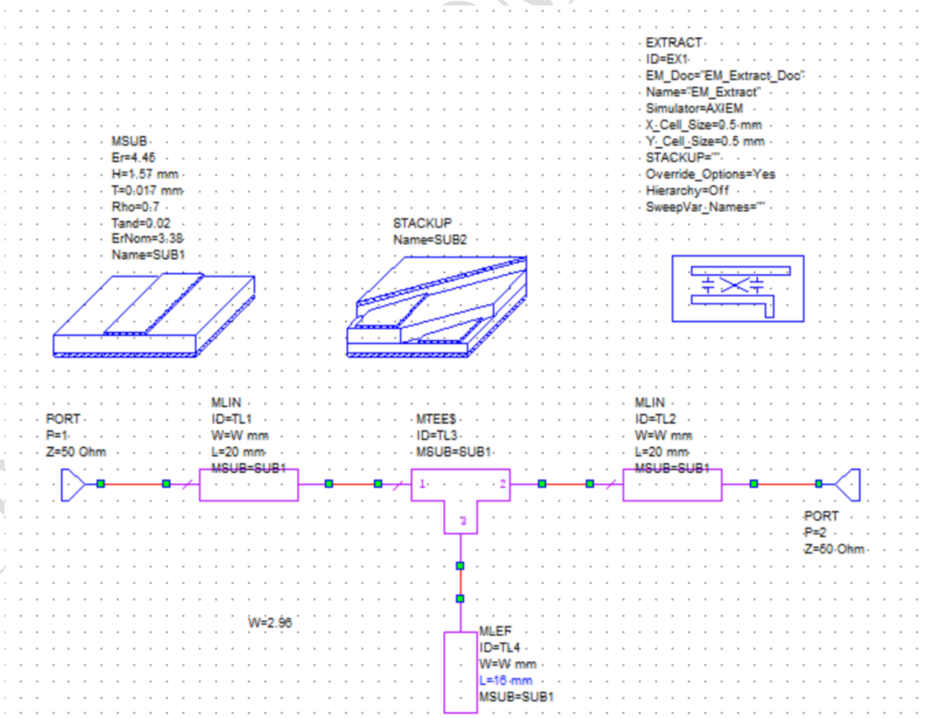
1) The quarter wave resonators are building blocks of RF filters, resonators, amplifiers and are extensively used in impedance matching networks.
2) Building and tuning resonators is therefore essential to the study of RF engineering

3. Design

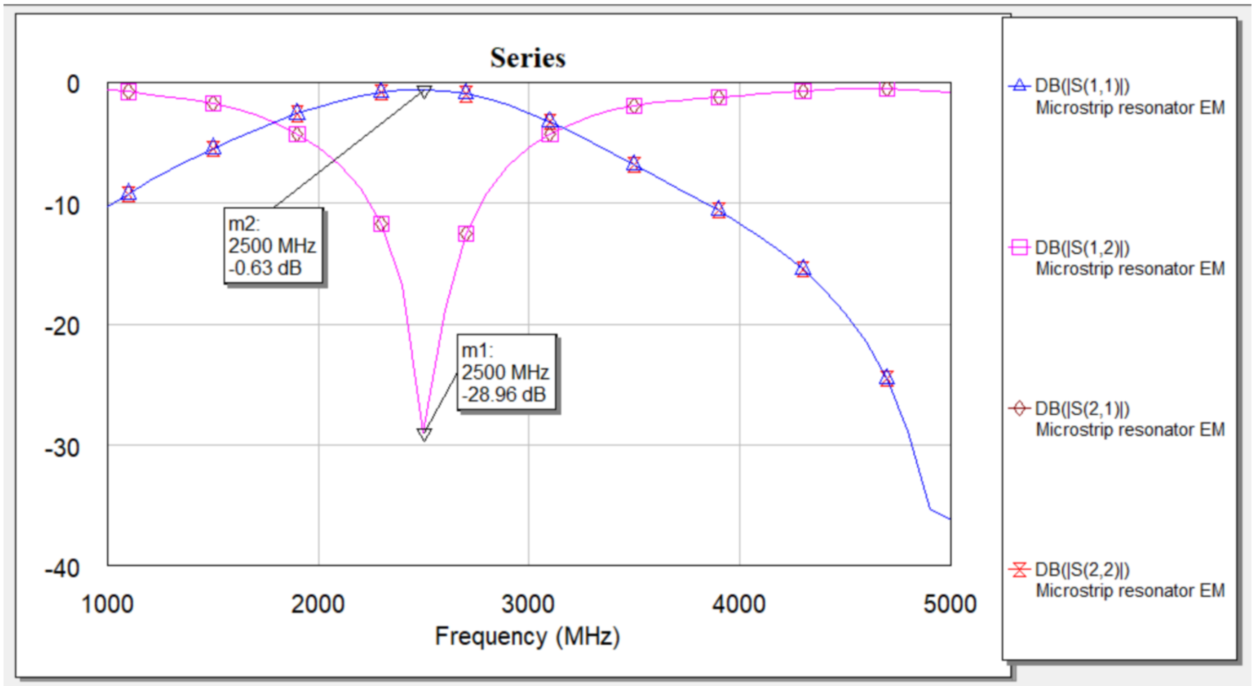
I. Series microstrip resonator – Behnam Pouya

1. The design goal is to build to series microstrip resonator with center frequency of 2.5 GHz.
2. Accordingly, the values of width, λ_{eff} and length were calculated from Tx line tool in AWR MWO
3. The λ\4 O.C stub was placed at the center of the 50Ω Tx line
4. The circuit was built in MWO and tuned for the required results
5. The design goals were met at the resonant frequency
6. Axiem mesh was built and the performance was noted
7. The circuit was built and the S-parameters were measured in the lab

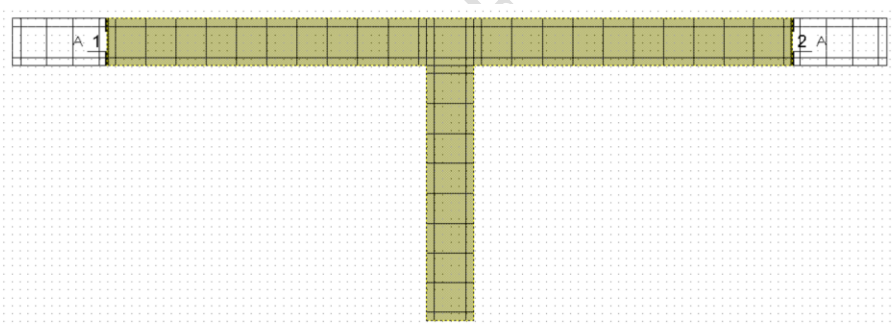
- **Series resonator schematic**



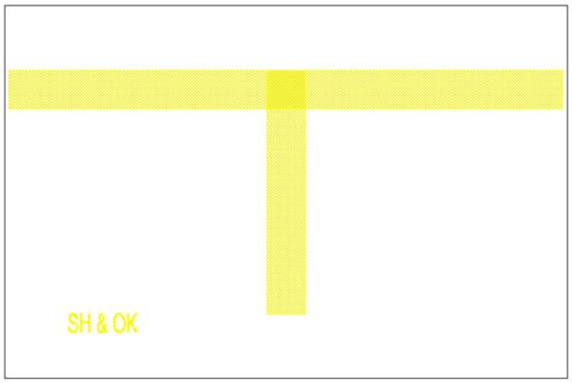
- **S-parameters form circuit simulations**



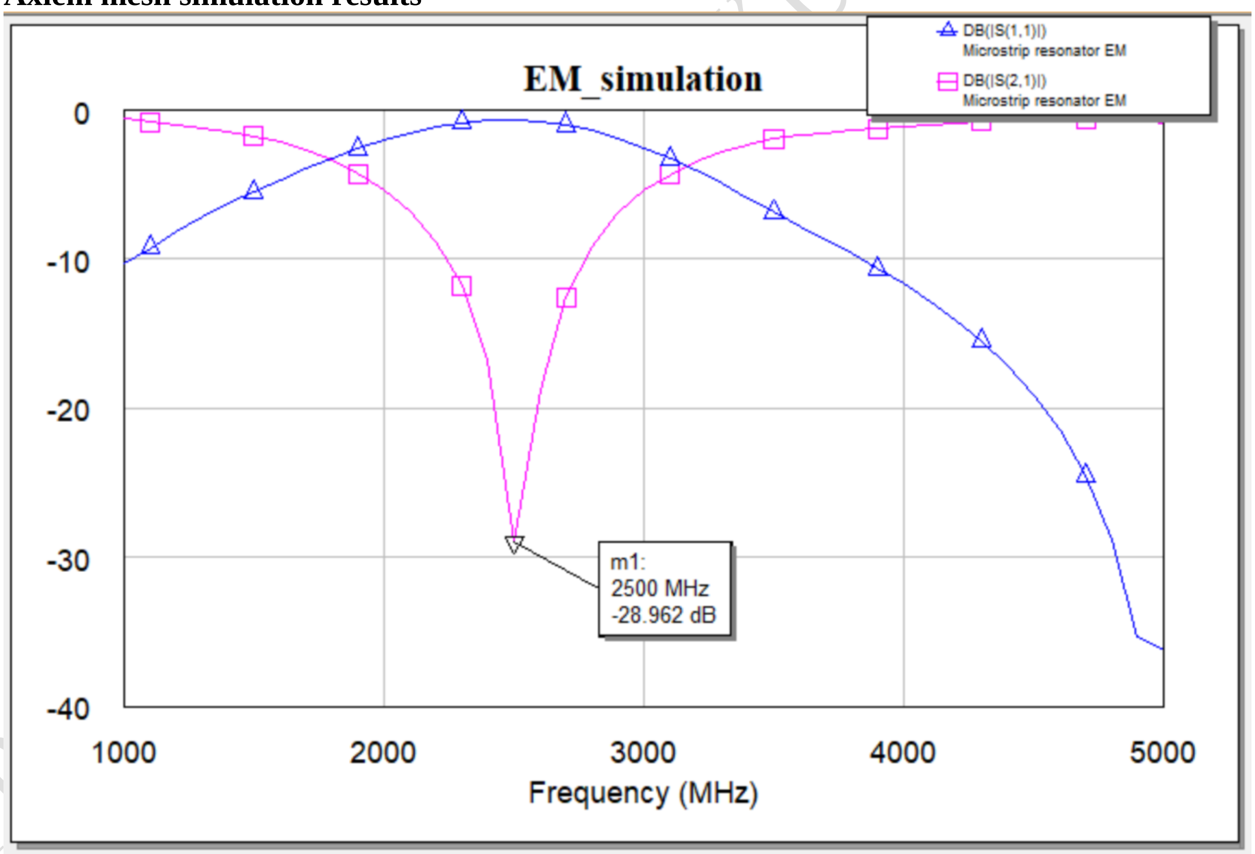
- **Axiem Mesh**



- **Board layout**



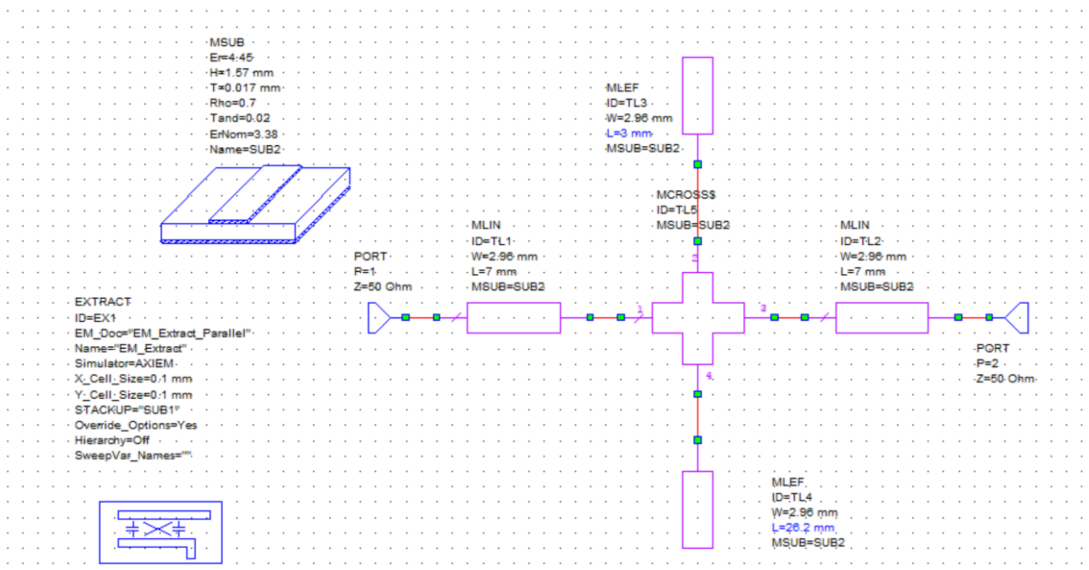
- **Axiem mesh simulation results**



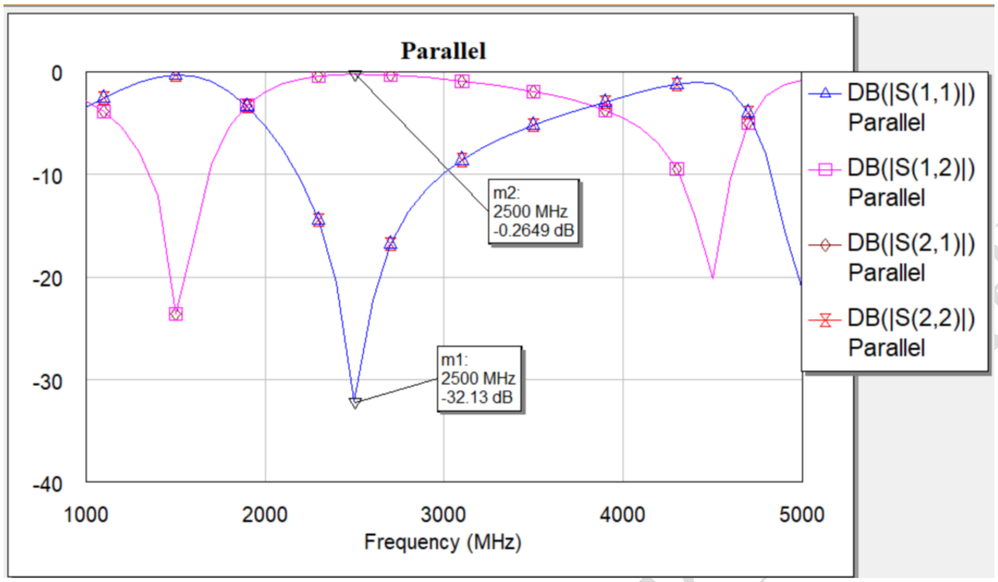
II. Parallel microstrip resonator – Omkar Kulkarni

1. The design goal is to build to parallel microstrip resonator with center frequency of 2.5 GHz.
2. Accordingly, the values of width, λ_{eff} and length of the inductive and capacitive stubs were calculated from Tx line tool in AWR MWO
3. The inductive and capacitive O.C stub were placed at the center of the 50Ω Tx line
4. The circuit was built in MWO and tuned for the required results
5. The design goals were met at the resonant frequency
6. Axiem mesh was built and the performance was noted
7. The circuit was built and the S-parameters were measured in the lab

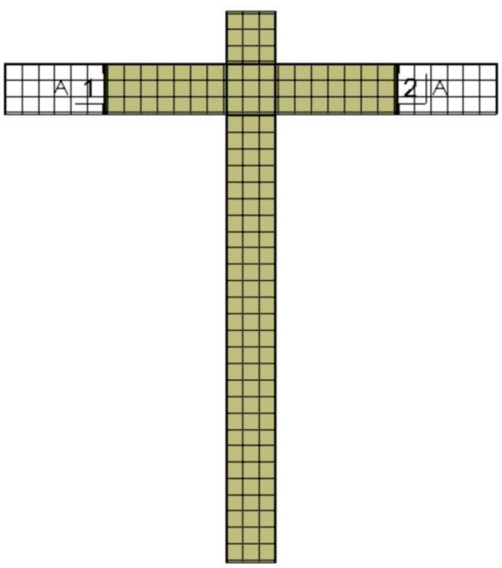
- **Parallel microstrip resonator schematic**



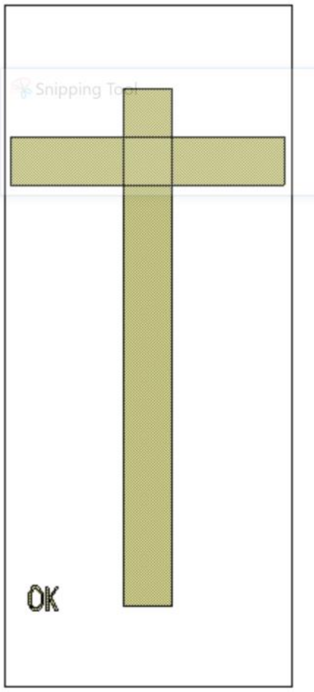
- **S-Parameters form the circuit simulations**



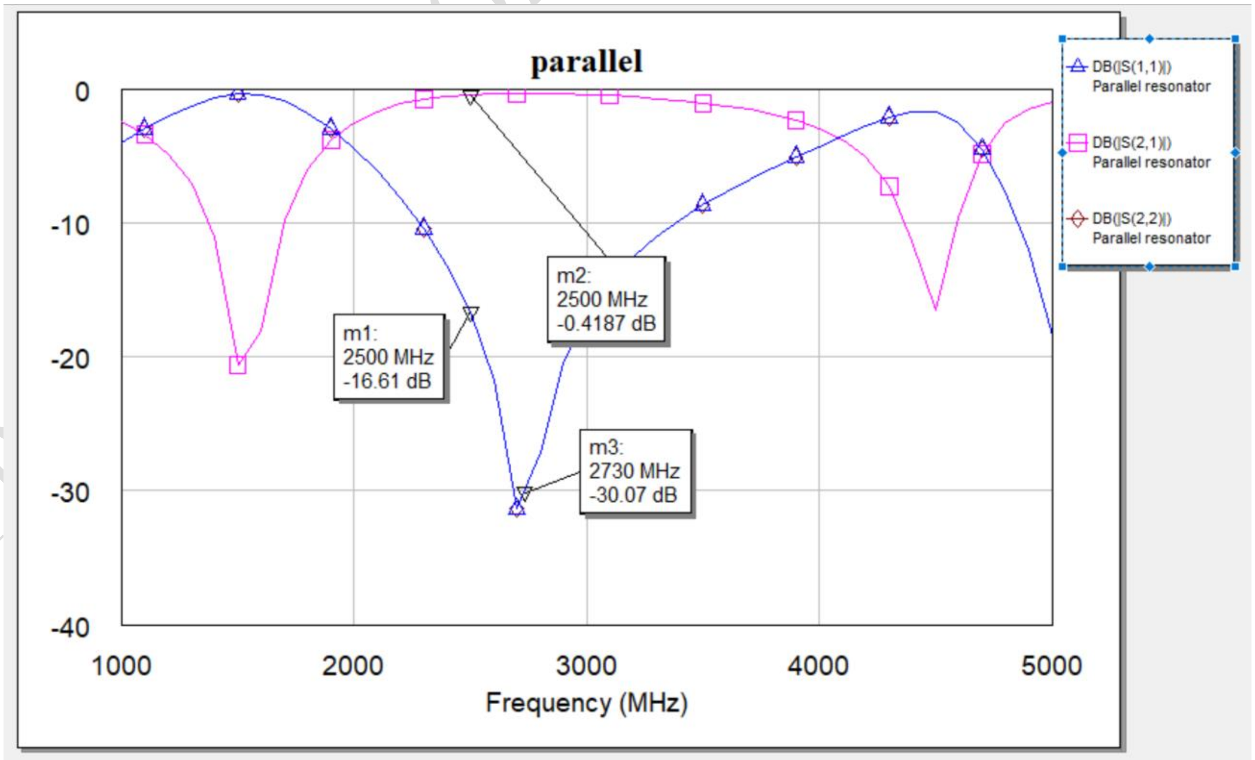
- **Axiem Mesh**



- **Board layout**



- **Axiem mesh simulation results**



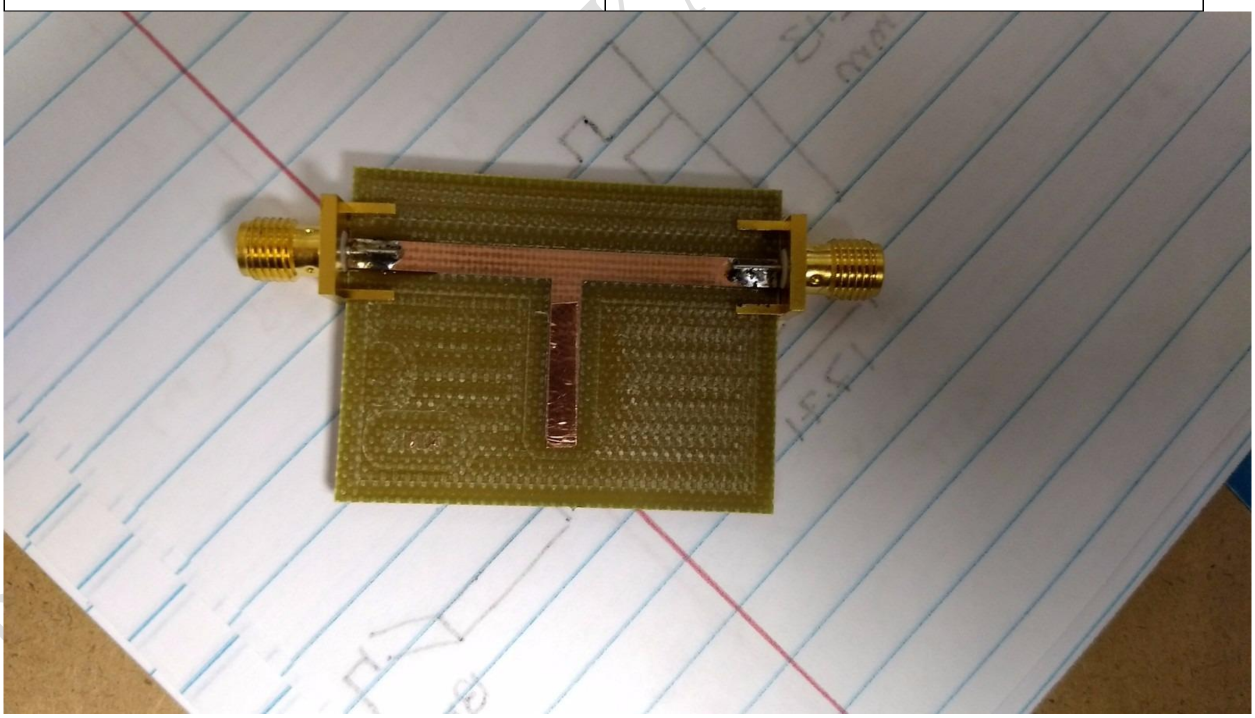
- **Summary:**
  From the comparison of the circuit and EM simulation it is evident that even though the same schematic is used there is a considerable amount of difference between the circuit simulation and the EM simulation from Axiem software.
  This means that the circuit simulations doesn't accommodate all the parameters require to model the response. To get the desired output the tune tool from AWR MWO was used.

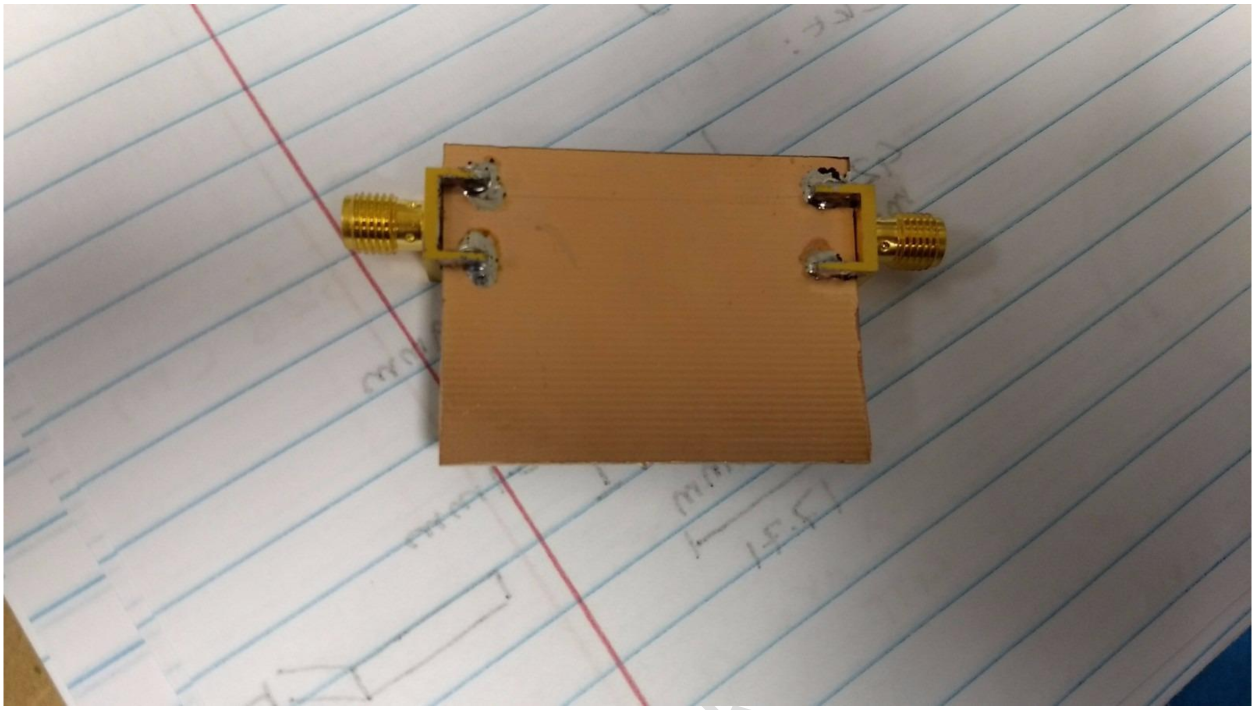
4. **Lab Measurements**

I. Series resonator circuit board

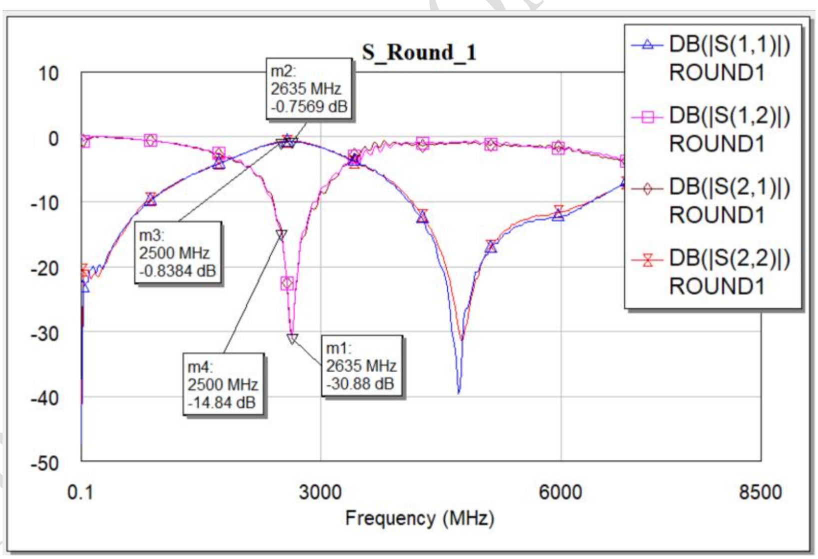
- The length of the stub of tuned till the resonant frequency of 2.5 GHz was achieved.

Thickness	14 mm
Length	33.1 mm
Breadth	43.2 mm
50Ω line length	43 mm
Stub length	16.16 mm

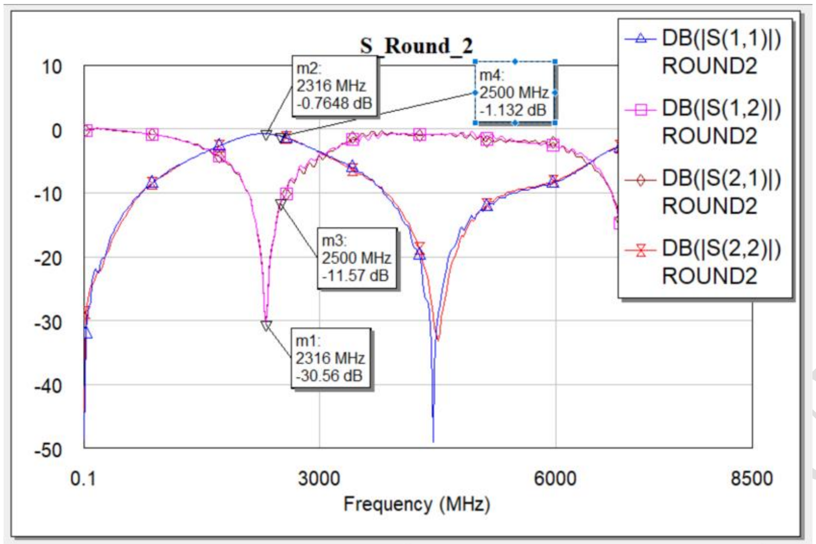




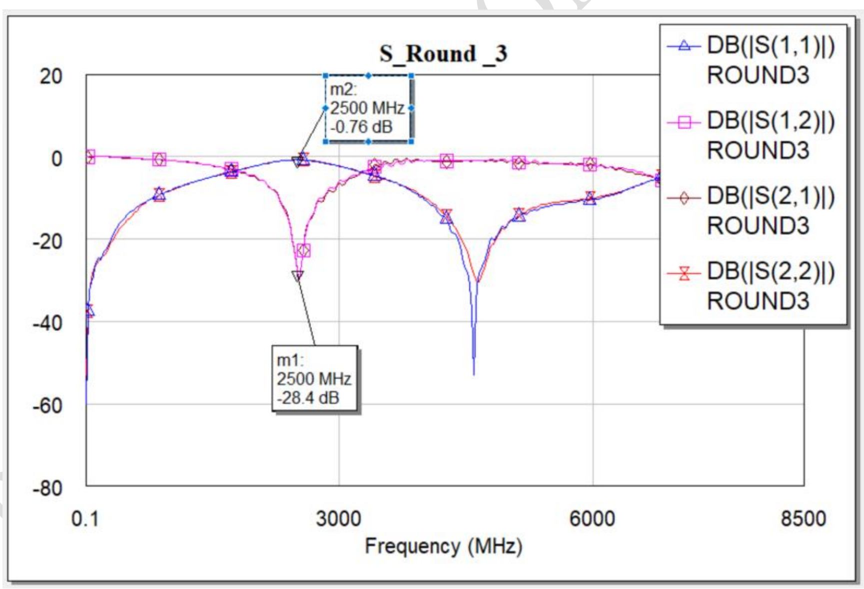
- **Round 1 Series circuit test:**
  Length of stub = 16.16 mm
  Resonant frequency = 2.635 GHz



- **Round 2 Series circuit test:**
  Length of stub = 17.35 mm
  Resonant frequency = 2.316 GHz



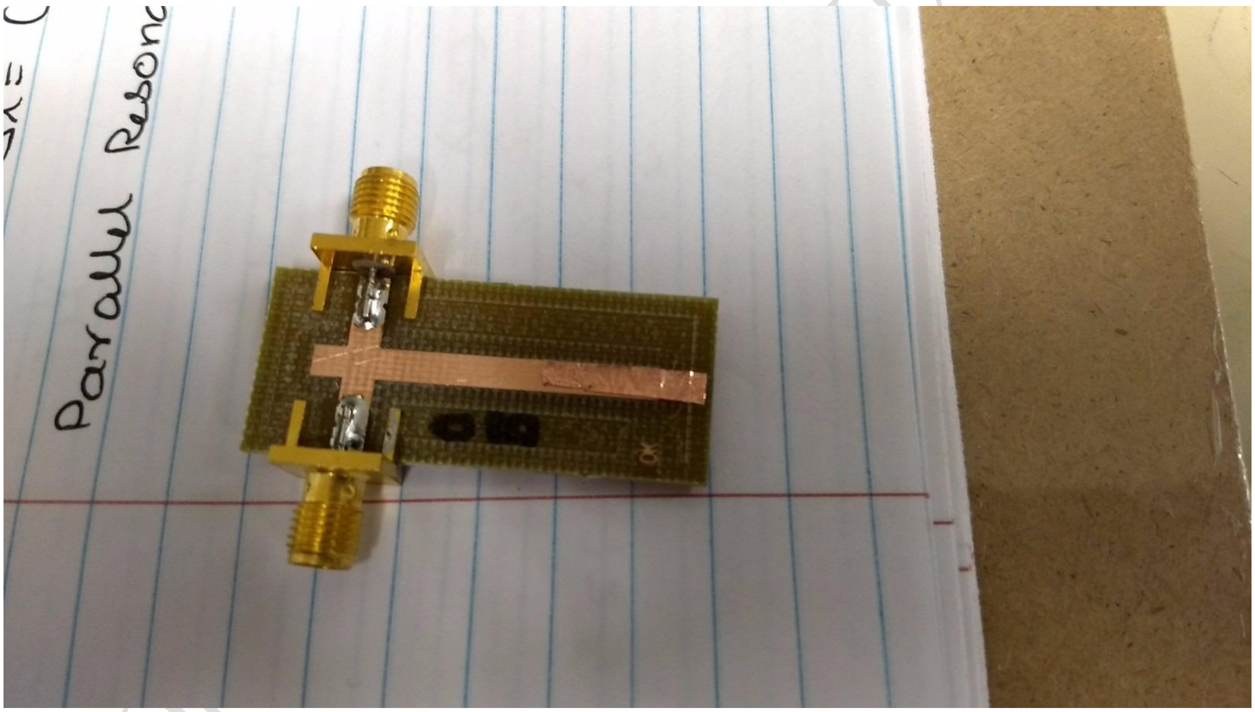
- **Round 3 Series circuit test:**
  Length of stub = 17.1 mm
  Resonant frequency = 2.5 GHz

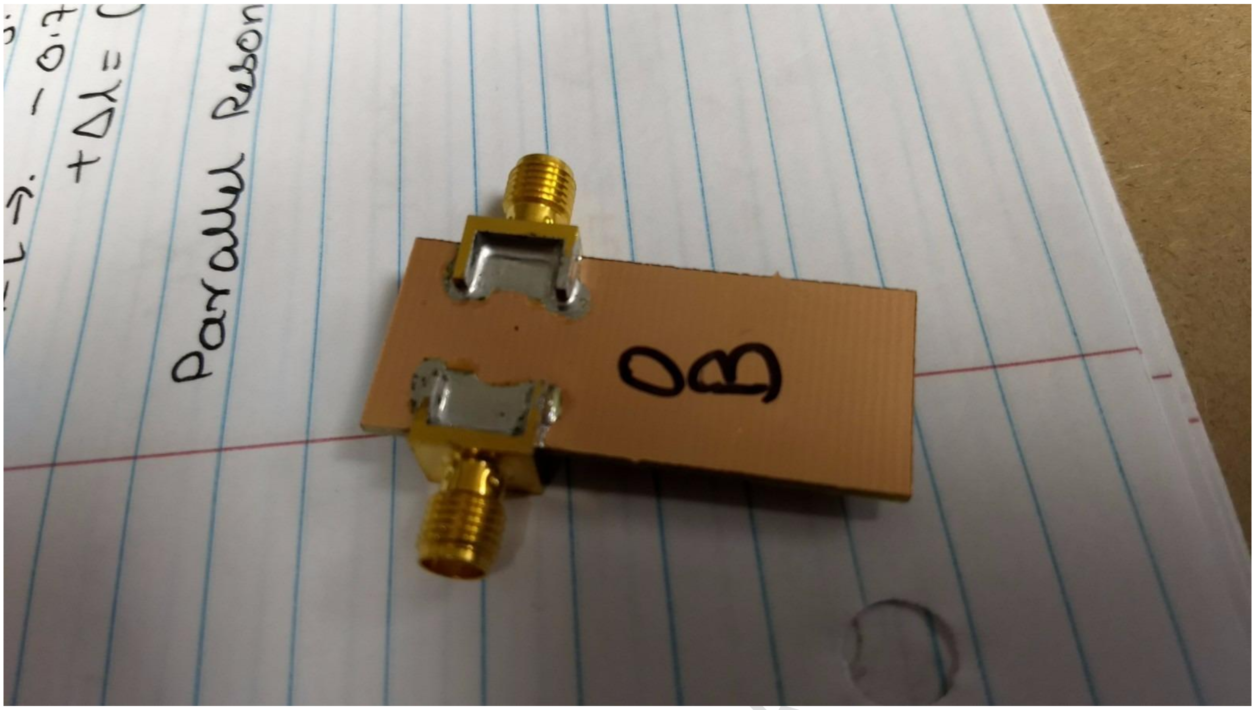


II. Parallel resonator circuit board

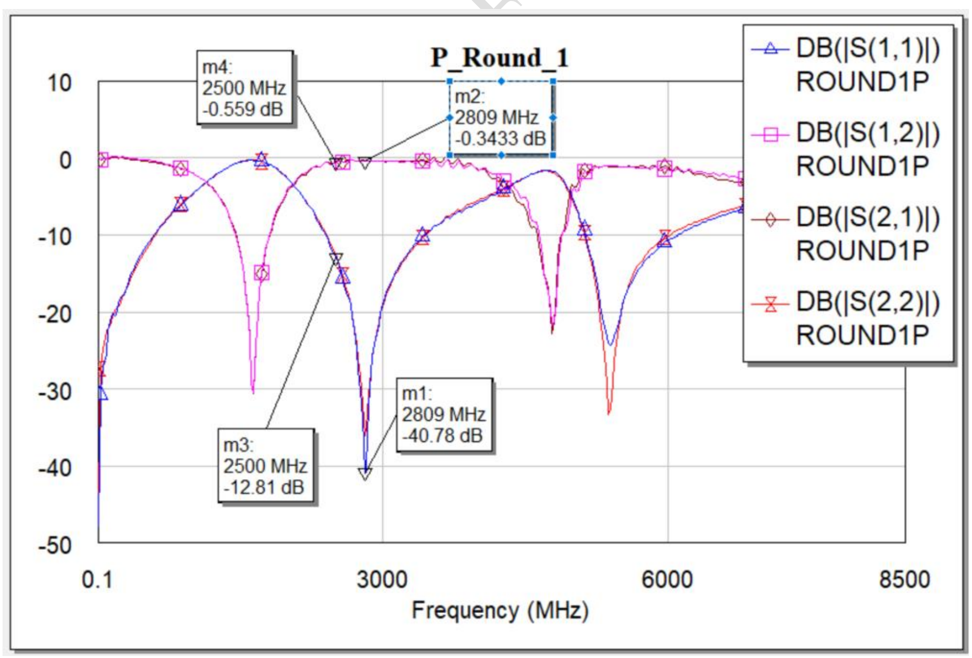
- The length of the inductive stub of tuned till the resonant frequency of 2.5 GHz was achieved.

Thickness	13 mm
Length	17.71 mm
Breadth	42.13 mm
50Ω line length	16.71 mm
Capacitive Stub length	2.9 mm
Inductive Stub length	26.1 mm

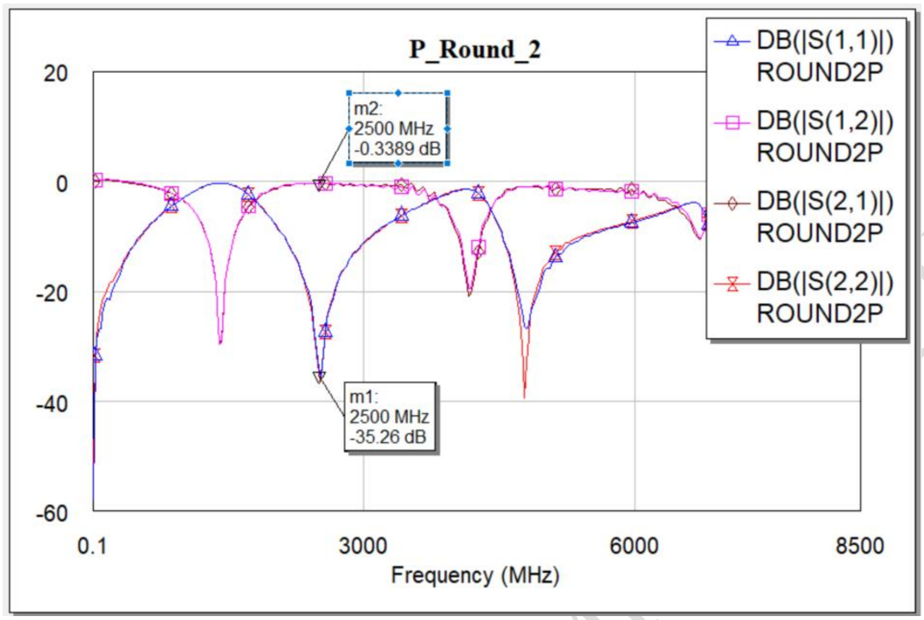




- **Round 1 Parallel circuit board**
  Length of inductive stub = 26.1 mm
  Length of capacitive stub = 2.9 mm
  Resonant frequency = 2.809 GHz



- **Round 2 Parallel circuit board**
  Length of inductive stub = 30.06 mm
  Length of capacitive stub = 2.9 mm
  Resonant frequency = 2.500 GHz



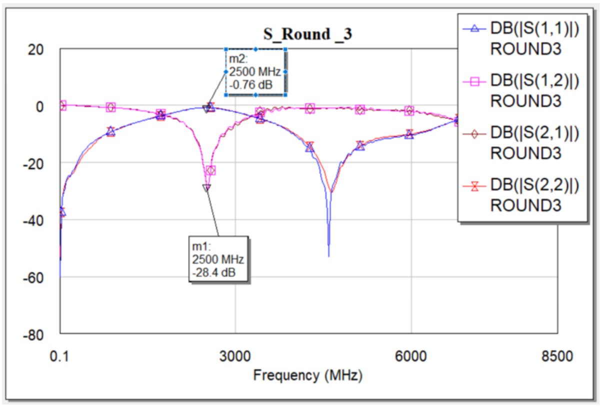
Summary:

The microstrip resonators did not resonate at the desired frequency. They had to be tuned by adding extra length of copper strips to get f_0 = 2.5GHz. For the series resonator extra length of copper added was 0.94 mm. For the parallel resonator extra length of copper added was 3.96 mm.

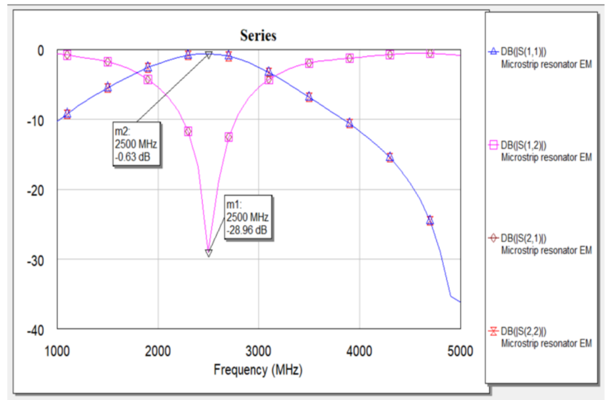
Analysis:

I. Comparison of measured and predicted data:

- **Series circuit:**

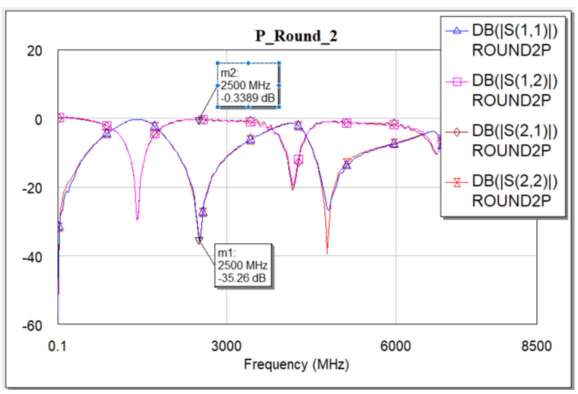


Tuned measured performance

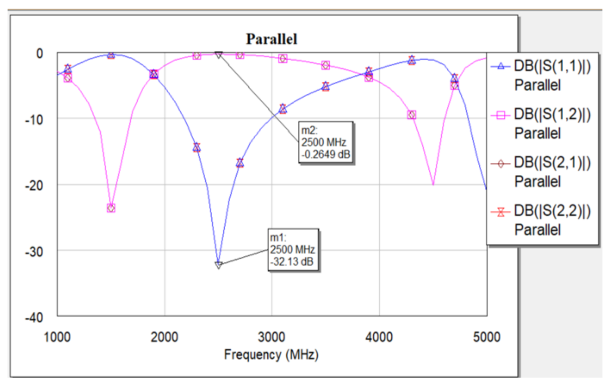


Simulated Performance

Parallel circuit:



Tuned measured performance



Simulated performance

II. Compliance Matrix:

- **Series Circuit**

Parameter	Design Goal	Simulated Performance	Measured Performance Built	Measured Performance Tuned	Compliant (Yes/No)
Design Frequency (GHz)	2.5	2.5	2.635	2.5	Yes
Input Return Loss (dB)	<1	0.63	0.7569	0.76	Yes
Output Return Loss (dB)	<1	0.63	0.7569	0.76	Yes
Insertion Loss @ 2.5GHz (dB)	>20	28.96	30.88	28.4	Yes

- **Parallel Circuit**

Parameter	Design Goal	Simulated Performance	Measured Performance Built	Measured Performance Tuned	Compliant (Yes/No)
Design Frequency (GHz)	2.5	2.5	2809	2.5	Yes
Input Return Loss (dB)	>20	32.13	40.78	35.26	Yes
Output Return Loss (dB)	>20	32.13	40.78	35.26	Yes
Insertion Loss @ 2.5GHz (dB)	<1	0.2649	0.3433	0.3389	Yes

Summary:

All the design goals were met as reflected from the compliance matrices. In fact, the response of the parallel resonator was better than the simulated performance.

The practical performance was not the same as the simulated one due to the complexities involved in practical implementation like junction capacitances, non-ideal bends and fringing effects. Tuning the boards helped in getting performance spot on.

Conclusion:

I. Was your design successful? Why or why not?

All the design goals were achieved so the design was successful. In the beginning some of the goals were not realized. After meticulous tuning all the goals were achieved. Even though the boards were tuned in AWR MWO to the exact performance using the tune tool. It doesn't take into consideration junction capacitances that are formed at the 90^{o} T bends. The effect of these stray capacitances and undesirable fringing effects cause the practical results to be deviated from the ideal value.

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

Designing the future boards using an electromagnetic approach will alleviate the situation. Using Axiem simulator to solve Maxwell's equation for the future designs will prove helpful.

III. What lessons did you learn from the lab?

The lossy nature of FR4, the inhomogeneities in the material, the oxide film on the copper, inherent inaccuracies in the milling process all cause deviation in the practical performance. Having knowledge of effective dielectric constant will be helpful to attain desired results.