REPORT

1. Insert Table with Initial design values - **WILKINSON and HYBRID** - gotten from prelab **(Z0, electrical length and microstrip L and W - from line calc).** Include (**final optimized values**)

		Characteristic Impedance	Characteristic Impedance Value (Ω)	Electrical Length (degrees)	Microstrip TL Length (mil)		Microstrip TL Width (mil)	
					Pre	Post	Pre	Post
Prelab Calculated	Wilkinson	root(2)*Zo	70.7	90	680.32	L = 635	59.65	Wc = 59.65
		Zo	50	90	660.48	N/A	115.42	Wo = 115.42
	90 degree Hybrid	Zo/root(2)	35.36	89.93	641.84	Lc = 581.979	198.94	Wc = 171.32
		Zo	50	89.93	659.56	Lo = 670.3	115.42	Wo = 96.3234

Table 1 - Include the pre-lab calculated values using Line Calc for Characteristic Impedance, Electrical length, Microstrip TL length and width for Wilkinson and 90-degree hybrid circuit.

2. The Schematics and Simulation Diagrams

a. Tee Schematic and Chart from Simulation

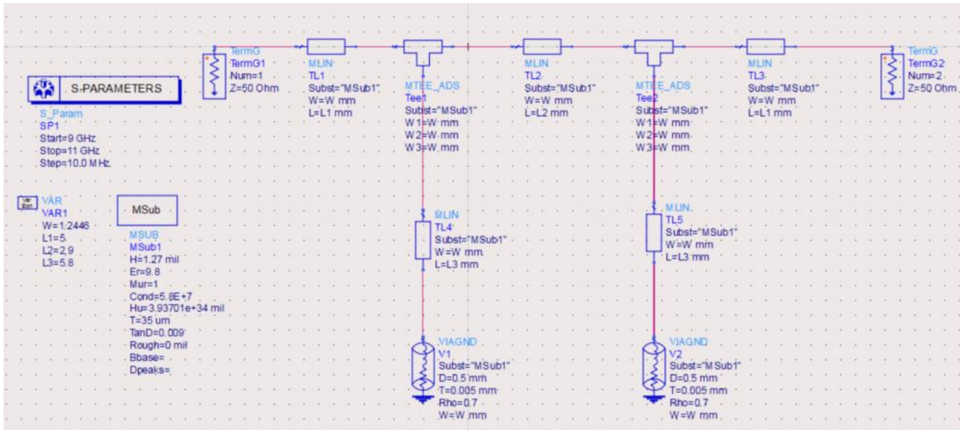

Fig 1 – Schematic for T-Junction showing design

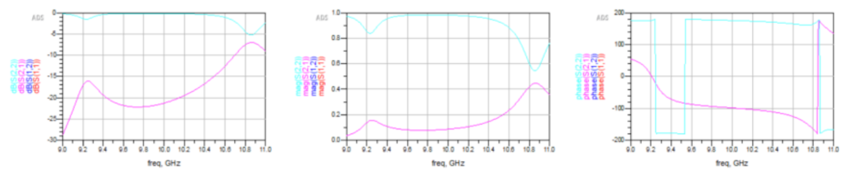

Fig 2 – Simulation for T-Junction

b. Wilkinson schematic

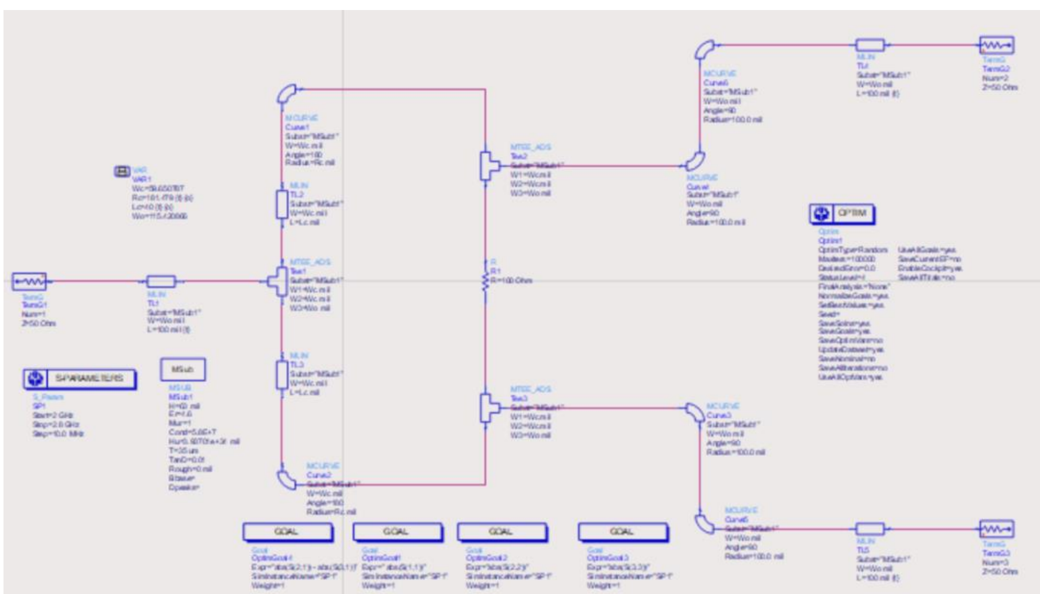

Fig 3 – Schematic for Wilkinson Power Divider showing the use of values Wc, Rc and Lc.

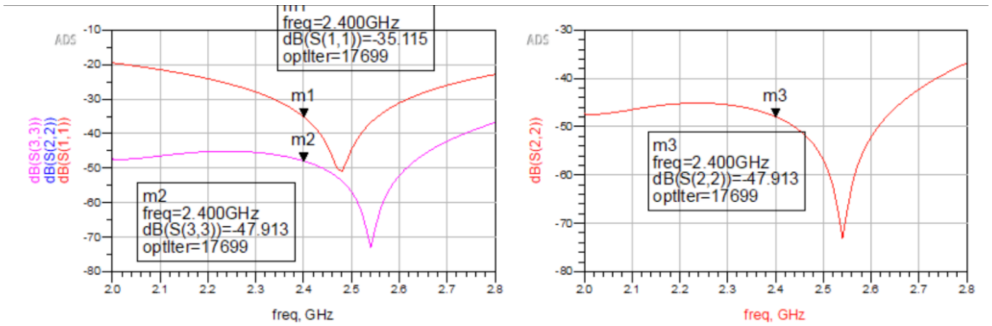

Fig 4 – Simulation of S11, S22 and S33 dB Magnitudes – showing that at 2.4GHz we see values < -25dB.

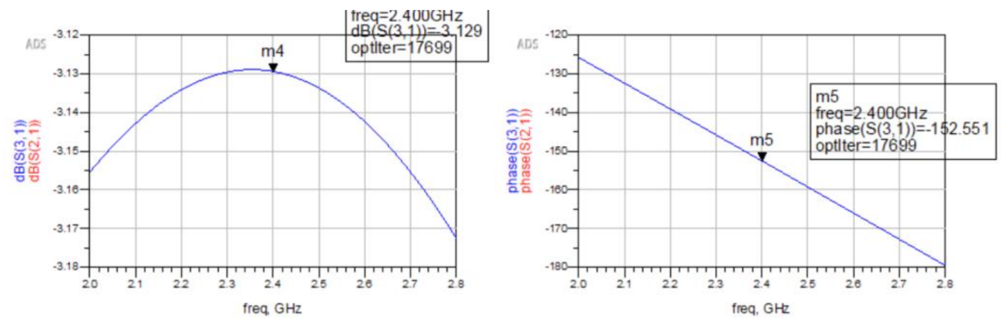

Fig 5 – Simulation of the Magnitude (left) and Phase (right) values of S31 and S21.

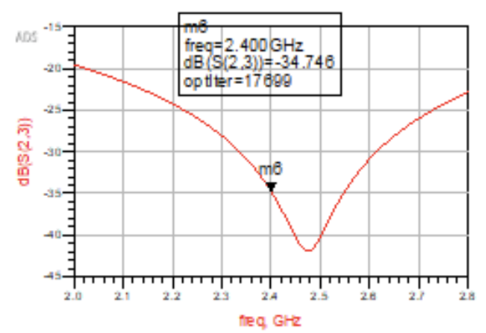

Fig 6 – Simulation of S23 dB Magnitudes – showing isolation between ports

c. Hybrid Circuit, Simulation and EM Simulation

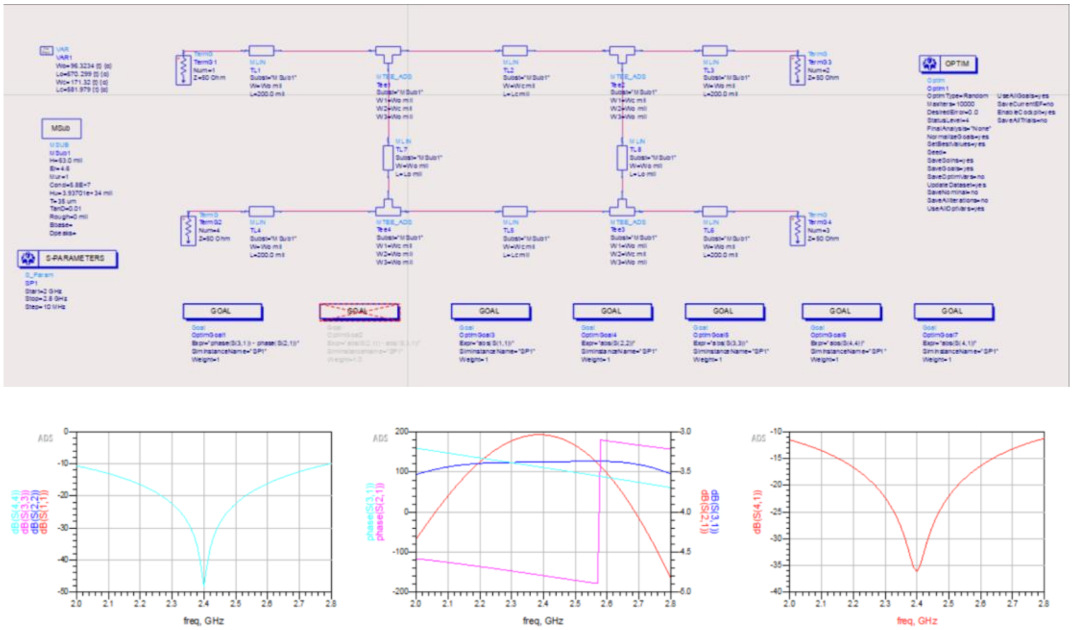

Fig 7 - Hybrid Coupler Simulation after optimization

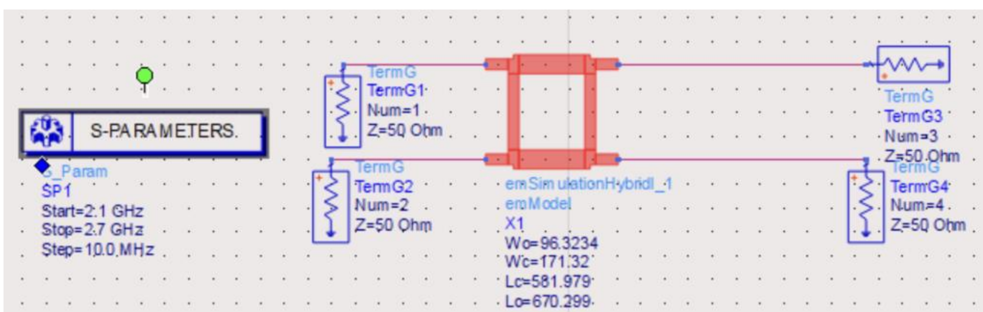

Fig 8 - EM Simulation

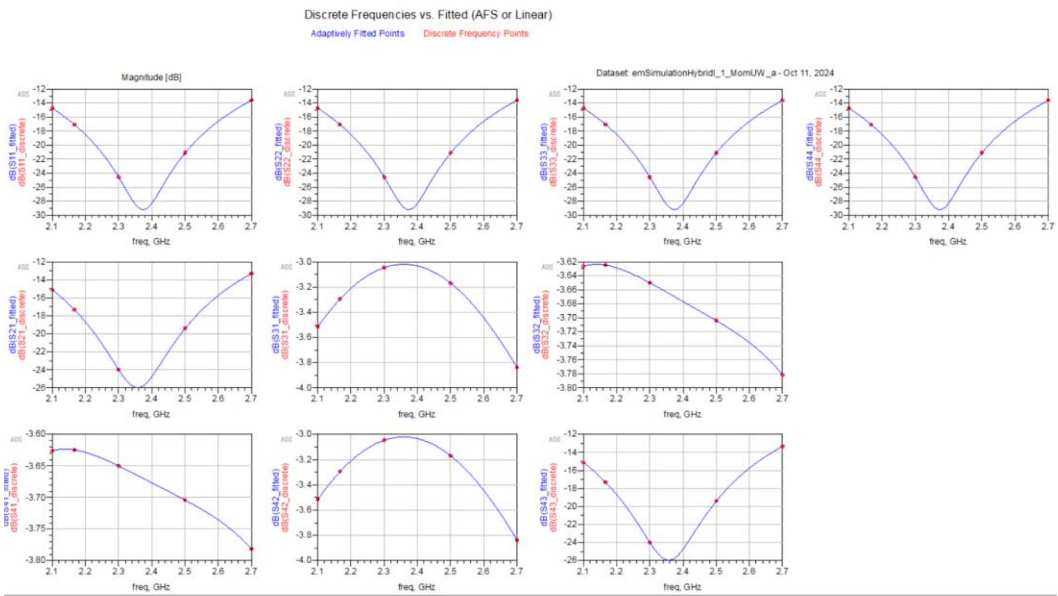

Fig 8b – EM Simulation

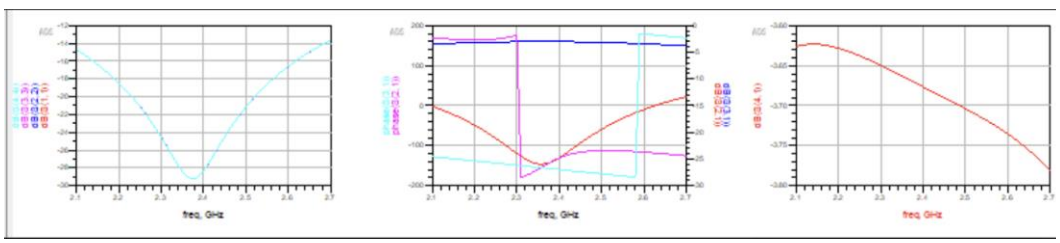

Fig 8c – EM Simulation

3. Explain interpretation of the results in a clear and concise manner :

In the Lab, we designed the schematics for the 1 - Simple microwave using T-junctions, 2- Wilkinson power dividing using microstrip lines and 3 - Hybrid Coupler. Specifically, we designed and simulated both the Wilkinson power divider and 90-degree hybrid coupler using microstrip lines. The goal set in the lab was to achieve optimal performance by ensuring 1 - good matching, 2 - minimal insertion loss, 3 - high isolation at the operating frequency of 2.4GHz.

For the Wilkinson Power Divider:

- **With Pre-lab values:** The initial pre-lab calculations found using line calc, are as they are provided in table 1. Using this the **matching and insertion loss** at 2.4GHz were not ideal.
    - **S11, S22 and S33** (Return Loss, to show matching) - Initial value was slightly above -25dB target at 24GHZ, indicating imperfect matching
    - **S21, S31** (Power Division) - Power division was equal. We noticed that the graphs overlap for S (2,1) and S (3,1), representing in phase and equal power distribution
    - **S23** (Isolation) - Isolation was moderately good. We know that a magnitude of -20 dB represents a 1/100 ration between port 2 and port 3 (meaning the power transmitted is nearly negligible), therefore with a marker at -34.7dB, we have effective isolation.
- **With Optimized values**: The optimized lab values gotten – as shown in Table 1. Using this the **matching and insertion loss** at 2.4GHz were now ideal.
    - **S11, S22 and S33** (Return Loss, to show matching) - Return loss was well below -25dB at 2.4GHz as shown in the diagrams above Fig 4.
    - **S21, S31** (Power Division) - Power division was equal, we saw no deviation in phase between the output ports as shown in Fig 5.
    - **S23** (Isolation) - Isolation between output ports was improved significantly, below -25dB at 2.4GHz, ensuring output ports were isolated from each other. Refer to Fig 6.

For the 90-Degree Hybrid Coupler:

- **With Prelab Values Optimization**: The initial prelab design for the hybrid coupler used our pre-lab calculations found with line calc as indicated in table 1. However, in the initial simulation, the return loss and isolation did not meet the design targets.
    - **S11**, **S22**, **S33**, and **S44** (Return Loss, to show matching): The return loss at 2.4 GHz was above -25 dB, suggesting poor matching at the input and output ports.

    - **S21** and **S31** (Coupling and Through Port): The power division was unequal, with significant phase and amplitude discrepancies between the coupled and through ports.
- **S41** (Isolation): Isolation between the input and coupled ports was insufficient, failing to meet the -25 dB criterion. **With Optimized Values**: After optimizing the dimensions in **ADS**, the hybrid coupler's performance improved:
    - **S11**, **S22**, **S33**, and **S44** (Return Loss, to show matching): The return loss was reduced to below -25 dB at 2.4 GHz, showing better matching at all ports.
    - **S21** and **S31** (Coupling and Through Port): The power division became more balanced, with the phase difference between the coupled and through ports approaching the ideal 90-degree phase shift.
    - **S41** (Isolation): The isolation between the input and coupled ports improved significantly, dropping below -25 dB.

After optimizing within a +25% range of our pre-lab values, we were able to notice a significant improvement, with the simulation values now meeting the requirements set at the start of the lab. We were able to achieve matching as seen in the simulation of S11, S22, S33 or S44 for the Hybrid coupler. We also saw good power division - S31, S21, and good isolation between output ports S23 for both microwave circuits.

To improve the bandwidth of the Wilkinson power divider, we can do the following:
Implementing a second quarter wave transformer. We know our input impedance is equivalent to (Zo^2)/ZL at lambda/4, therefore by selecting Zo, we can effectively match the impedance for a selected lambda. Now if we consider a second quarter wave transformer, we can accommodate for a wider range of frequencies, the first will transform the impedance to some intermediate value with some lambda, while the second will match the impedance with another lambda.

To improve the bandwidth of the 90-degree power divider, we can do the following:
We can proportionally decrease the size of the hybrid to increase the bandwidth of the hybrid. This method works as it decreases the distance between the coupled line and the input line. As this distance is decreased, more frequencies of the input signal would be coupled. Additionally, this reduces the parasitic inductances d capacitance which limits the bandwidth, which is why decreasing the size would increase the bandwidth.

In conclusion, while optimizing it we considered the trade-offs between the parameters. For 90-degree hybrid coupler we see by decreasing length and width, the simulations showed that this significantly improved matching, and isolation whereas with optimizing Wilkinson we saw little optimization, since the pre-lab values gave use simulations that were close to our goals.