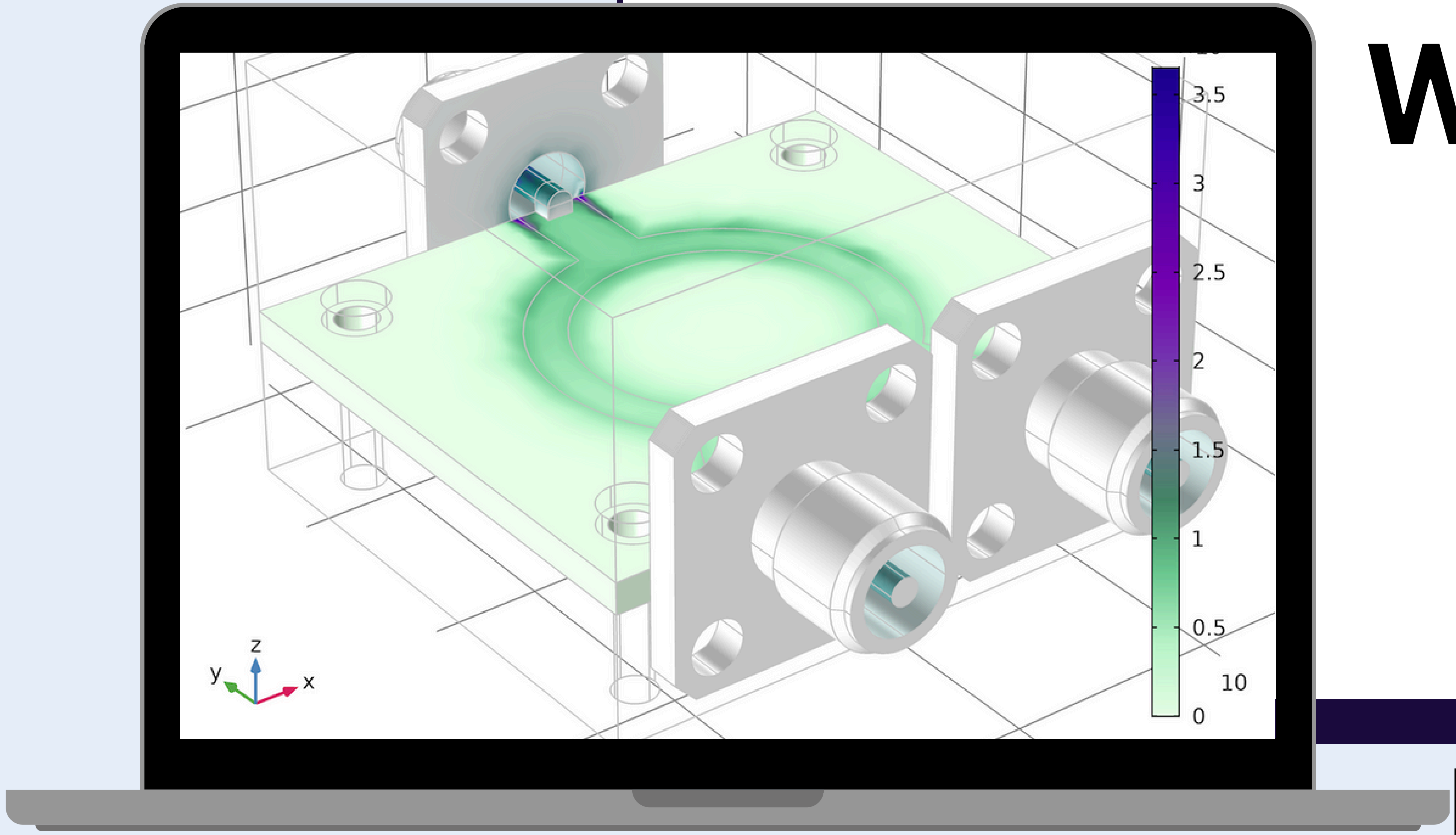
Applied Fields and Waves Project

Realization of Wilkinson Power Divider



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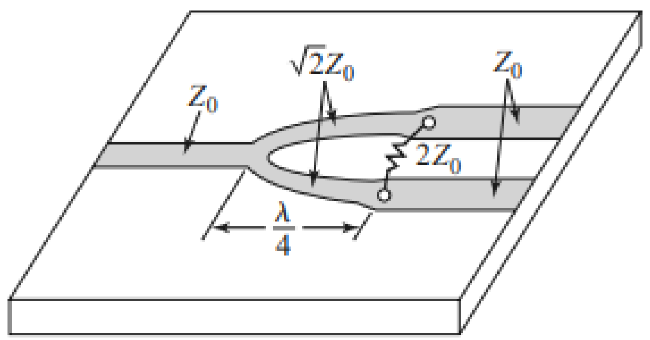
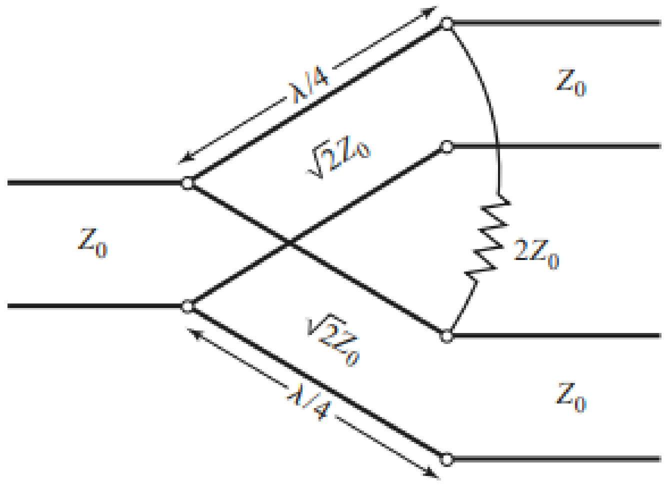
Ojective and Description

- **Theoretical Analysis:** To study the design principles behind the Wilkinson Power Divider using theoretical models and simulations.
- **Practical Implementation:** To design, simulate, and validate the performance of a Wilkinson Power Divider through full-wave simulation using ADS.
- **Comparison and Optimization:** To compare theoretical predictions with simulation results to identify any discrepancies and optimize the design.

Description:





1. A Wilkinson power divider is a passive device used in RF/microwave systems to divide power equally between output ports while maintaining impedance matching.
2. It consists of quarter-wavelength transmission line sections and resistive terminations.
3. It is a 3 port device, i.e., Matched, Reciprocal and Lossy.

APPROACH

- **Type:** A 3-port device with a distinct scattering matrix.
- **Unique Component:** Features a 2Z0 resistor between ports 2 and 3, enabling both impedance matching at these ports and isolation between them.
- **Resemblance:** Similar to a lossless 3dB divider but enhanced with the resistor for better functionality.

Design Parameters:

Frequency : 1 GHz operation,
FR4 substrate (H=1.6, εr=4.4, H=1.6 mm,T=35um, Hu=75 mm(lambda/4), tan δ=0.008).

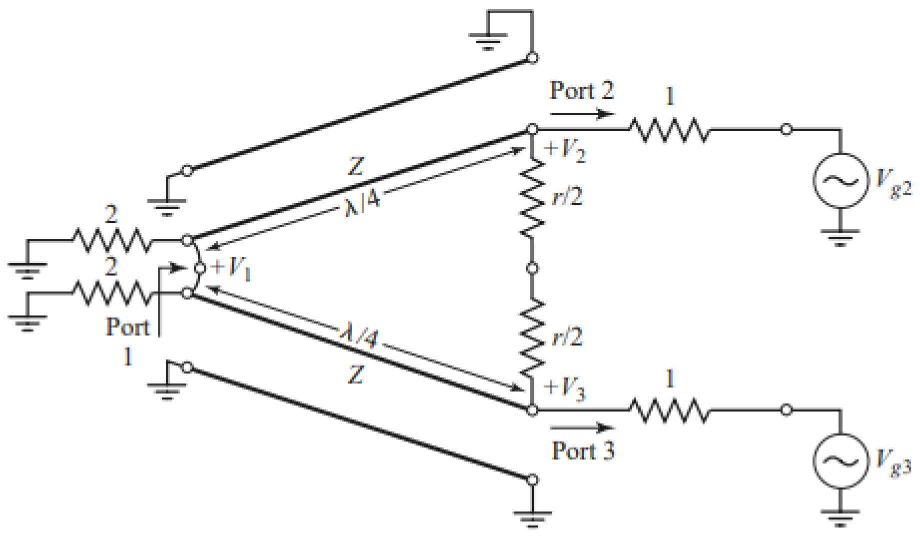
- **Applying Odd/Even Analysis.**

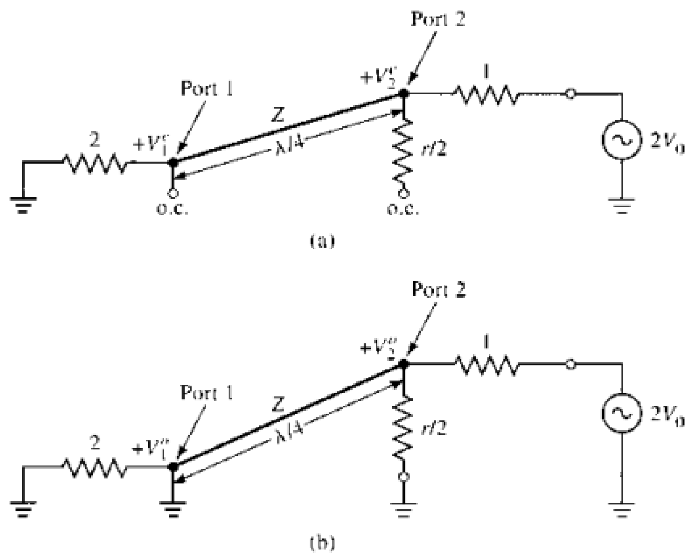
Even Mode Analysis

- Both Port 2 and Port 3 receive the same voltage, denoted as Vg2=Vg3=2V0.
- Due to this excitation, there is no current flow through the *r*/2 resistors.
- By bisecting the circuit at these points, the network simplifies, allowing for easier analysis.

Odd Mode Analysis

- In the odd mode, the excitation is such that Vg2=−Vg3=2V0.
- This creates a voltage null along the middle of the circuit.
- Bisecting the circuit under odd mode excitation reveals a different simplified network.





RESULT

Impedance Normalization:

- All impedances normalized to the characteristic impedance Z0.
- Quarter-wave transmission lines with Z=sqrt(2)Z0
- Shunt resistor r=2Z0 for isolation and matching.

Mode Analysis Results:

- **Even Mode:** No current through r/2 resistors; impedance looking into port 2, Zin=(Z^2)/2=1. Effective transmission ensuring matching.
- **Odd Mode:** Voltage null at center; impedance at port 2 seen as open circuit due to λ/4 shorted line, confirming isolation.

Theoretical Predictions

- **Scattering Parameters**

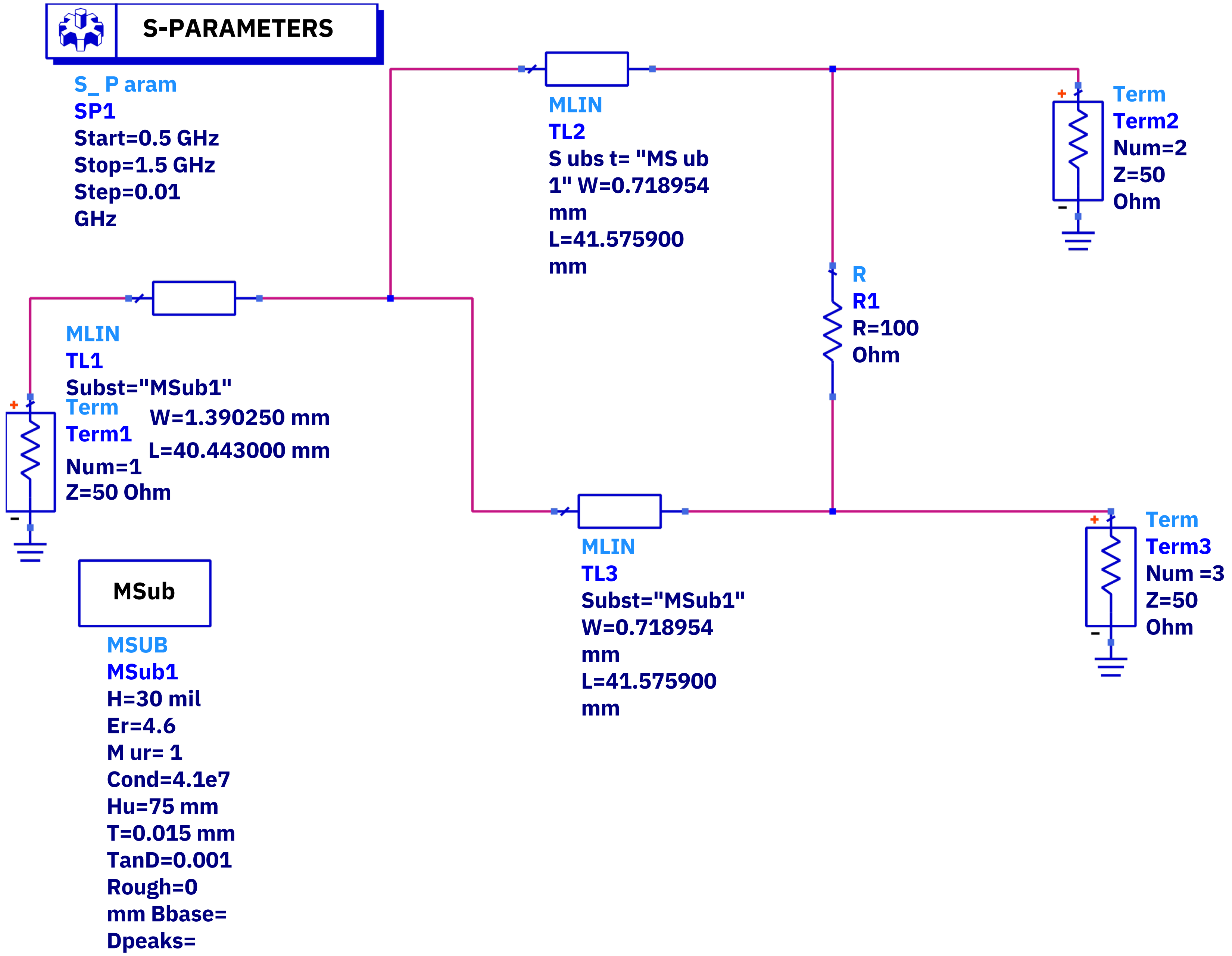
$$\mathcal{S} = \begin{bmatrix} 0 & -j/\sqrt{2} & -j/\sqrt{2} \\ -j/\sqrt{2} & 0 & 0 \\ -j/\sqrt{2} & 0 & 0 \end{bmatrix}$$

$$|\mathcal{S}_{11}|^2 + |\mathcal{S}_{21}|^2 + |\mathcal{S}_{31}|^2 = 1$$

S11=0: Perfect match at port 1, no reflection.
S22 = S33 = 0: Ports 2 and 3 are well-matched.
S12 = S21 = -j/2^0.5 : Due to the symmetric and reciprocal nature of the network.
S13 = S31 = -j/2^0.5 : Symmetry of port 2 and 3.
S23 = SS32 = 0 : (due to short or open at bisection).

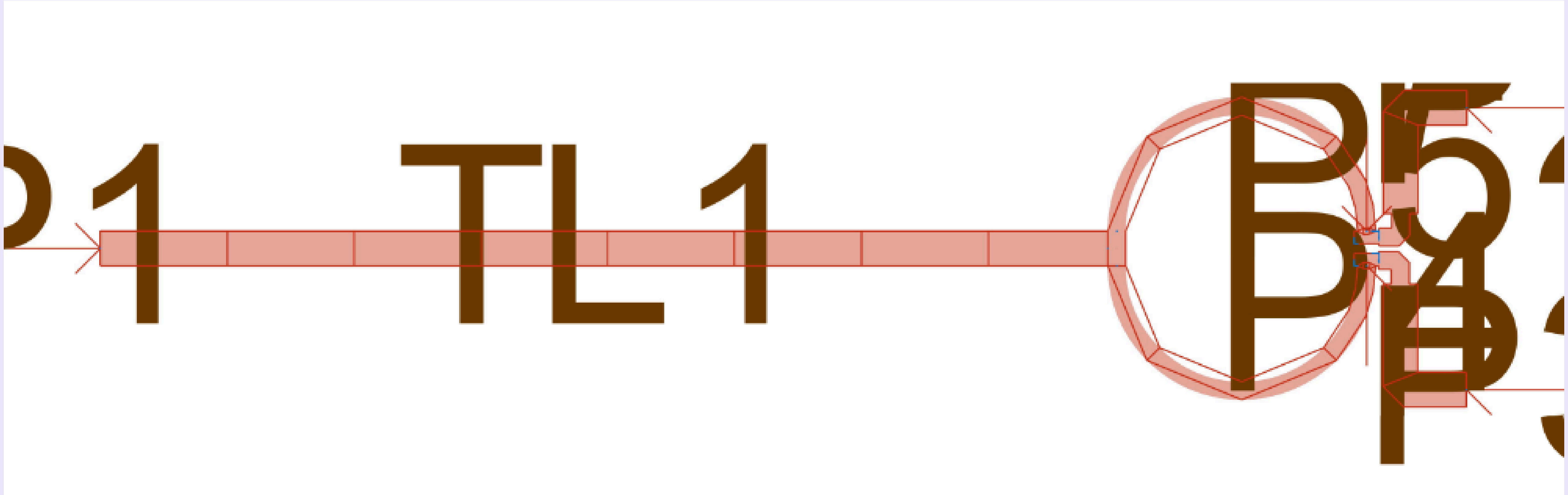
P2 = (|S21|^2)P1+ = P1+/2
P3= (|S31|^2)P1+ = P1+/2

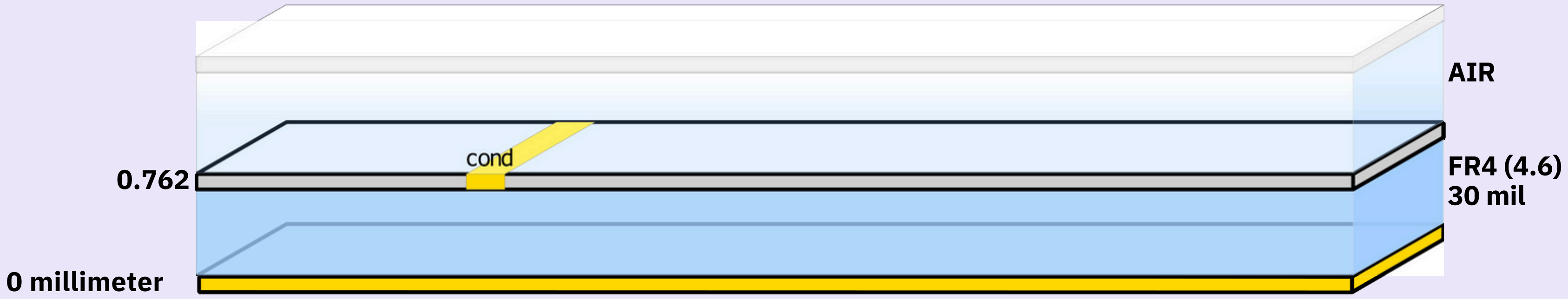
SCHEMETIC



S-PARAMETERS
S_ P aram
SP1
Start=0.5 GHz
Stop=1.5 GHz
Step=0.01
GHz
MLIN
TL2
S ubs t= "MS ub
1" W=0.718954
mm
L=41.575900
mm
Term
Term2
Num=2
Z=50
Ohm
R
R1
R=100
Ohm
MLIN
TL1
Subst="MSub1"
W=1.390250 mm
L=40.443000 mm
Term
Term1
Num=1
Z=50 Ohm
MLIN
TL3
Subst="MSub1"
W=0.718954
mm
L=41.575900
mm
Term
Term3
Num =3
Z=50
Ohm
MSub
MSUB
MSub1
H=30 mil
Er=4.6
M ur= 1
Cond=4.1e7
Hu=75 mm
T=0.015 mm
TanD=0.001
Rough=0
mm Bbase=
Dpeaks=

LAYOUT

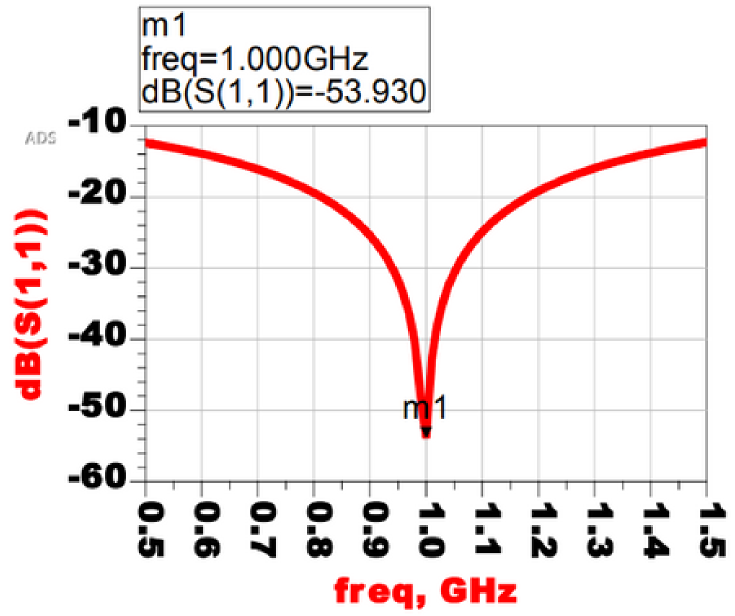


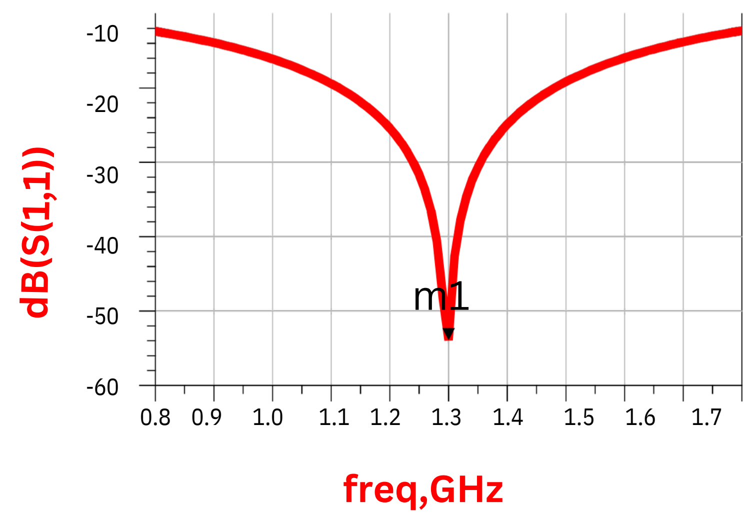


RESULT

Empirical Results

- Simulation and Measurement:
- Return loss and insertion loss measured across a frequency range from 0.5f0 to 1.5f0.
- Matched simulation results with theoretical predictions confirming the design efficacy.
- Highlighted any discrepancies for further analysis.





PROGRESS AND WORK DISTRIBUTION

Progress

- **Voltage and S-Parameter Calculations:** Successfully computed node voltages and S-parameters, verifying theoretical predictions.
- **Graphical Results:** Obtained graphs demonstrating the expected performance of the divider.
- **Circuit Design:** Completed both schematic and layout for the Wilkinson Power Divider, ready for simulation.

Work Distribution

Prince Kumar:

- Led circuit design and theoretical analysis.
- Prepared simulation data and initial schematics.

Aayush Choudhary:

- Prepared simulation data and initial schematics..
- Managed data visualization for presentation.

Rohit Barman:

- Managed project timelines and coordination.
- Handled documentation and presentation materials.

CONCLUSION

Summary of Findings:

- The Wilkinson Power Divider was thoroughly analyzed and modeled, confirming its capability to split power equally while maintaining excellent impedance matching and isolation between output ports.
- Both theoretical analysis and simulation results demonstrated that the divider operates effectively at the designated frequency with the specified design parameters.

Key Achievements:

- Successful validation of the Wilkinson Power Divider's design through even-odd mode analysis, leading to accurate predictions of its performance.
- Achieved nearly same simulation results and theoretical expectations , underscoring the robustness of the design.

REFERNCES

- David M. Pozar: Microwave Engineering.
- https://www.researchgate.net/publication/272986684_Design_and_Realization_Wilkinson_Power_Divider_at_Frequency_2400MHz_for_Radar_S-Band
- https://youtu.be/CUXAqMJCkb0?si=6x1K-TG_Qk3IIpN1

Thank you!