EERF 6311 – Final Design Project, Nithin Kumar Santha Kumar

A Novel Unequal Power Divider Design With Dual-Harmonic Rejection and Simple Structure

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I. Review Paper Summary

The objective of this paper, which was published on March 10, 2011, is to showcase an unequal power divider design that allows for dual-harmonic rejection with a simple structure. This design improves on the conventional Wilkinson power divider which has harmonic bands as a major drawback. This power divider operates at 1 GHz and is fabricated on a Duroid substrate with a relative permittivity of 3.38 and a substrate thickness of 0.813 mm. The power divider itself is implemented using microstrip. Simulations and measurements of the power divider were done using a 4-port network analyzer (Agilent E5071A) from 0.5 GHz to 3.5 GHz.

II. Conventional and Paper Design Details

The conventional Wilkinson power divider from Pozar and the novel unequal power divider were simulated using TLIN at the center frequency of choice (1 GHz) [1]. For the conventional design, as seen in fig. 1, the transmission lines had electrical lengths of 90 degrees with impedances of $\sqrt{2} * Z_0$. In addition to this, a resistor is added to connect port 2 and port 3. This resistor has a value of $2 * Z_0$. The characteristic impedance, Z_0, was 50Ω for the conventional Wilkinson power divider. For the novel unequal power divider, the authors designed a power divider that consisted of four branch-line sections, an open stub, and a resistor [2]. As shown in Table 1, the electrical lengths for the four branch-lines (Z_A, Z_B, Z_1, Z_2) were 109 degrees for Z_A and Z_B, and 45 degrees for Z_1 and Z_2. The open stub, Z_C, had an electrical length of 30 degrees. The impedances for these lines are shown in Table 1. The resistor, R, has an impedance of 82Ω, while ports 2 and 3 are terminated with impedances of R_L and $k^2 R_L$ respectively.

III. Simulation

The conventional Wilkinson power divider was simulated using TLIN as shown in Fig. 1. The novel unequal power divider was simulated using TLIN and MLIN at the center frequency of 1 GHz as well as a simulation using MLIN at 3 times the center frequency. For the MLIN simulations, I used a Duroid substrate with a dielectric constant of 3.38 as specified by the authors [2]. Since there was no loss tangent specified, I found the loss tangent of RT/Duroid 5880 and used that for the simulation [3]. Additionally, a substrate thickness of 0.813 mm was specified by the authors [2]. The simulation was done at the same frequency as specified by the authors. This can be seen in Figures 2-4. Additionally the novel power divider was also simulated at $3 * f_0$ which can be seen in Fig. 4.

IV. Results and Discussion

As shown in figures 2-4, the simulations match what the authors show in their paper [2]. The only issue was that the S-parameters for the TLIN simulation did not match the authors' simulations and small changes had to be made to fix this. For this fix, the electrical lengths were modified so that the S-parameter data fit with the authors'. The electrical lengths of Z_A and Z_B were increased by 1.4 degrees while the electrical lengths of Z_1 and Z_2 were decreased by 5.4 degrees. Z_C's electrical length was also reduced by 1.6 degrees to match the authors' simulation results. This was the only modification to the design I had to make in order to successfully simulate the novel unequal power divider.

Design Frequency (GHz)	Impedance (ohm)	Width (mm)	Electrical length (degrees)	Physical length (mm)
1 - f_0	$Z_1 = 44.60$	2.23	45.00	23.91
	$Z_2 = 89.20$	0.61	45.00	22.00
	$Z_A = 34.00$	3.30	109.00	54.41
	$Z_B = 68.00$	1.09	109.00	56.90
	$Z_C = 33.30$	3.40	30.00	14.05
3	$Z_1 = 44.60$	2.23	45.00	7.57
	$Z_2 = 89.20$	0.61	45.00	7.95
	$Z_A = 34.00$	3.30	109.00	18.02
	$Z_B = 68.00$	1.09	109.00	18.88
	$Z_C = 33.30$	3.40	30.00	4.95

TABLE I

Design parameters for power divider at f_0 and $3f_0$

When compared to the Pozar design seen in Fig. 1, the novel unequal power divider had better dual-harmonic rejection compared to the Wilkinson power divider. This is due to the presence of harmonic bands in the Wilkinson power divider [2]. With the novel unequal power divider, this is not the case as shown in Figures 2-4.

V. Conclusion

The novel unequal power divider showcases a simple power divider design that has a better dual-harmonic rejection compared to the conventional design. Due to the simplicity of the divider, there is no need for more complex structures which were traditionally used to address issues with the Wilkinson power divider.

This simulation took 4 hours to complete.

References

[1] D. M. Pozar, *Microwave Engineering*, 4th ed. Wiley, 2011.

[2] W.-C. Ip and K.-K. M. Cheng, "A novel unequal power divider design with dual-harmonic rejection and simple structure," *IEEE Microwave and Wireless Components Letters*, vol. 21, no. 4, pp. 182–184, 2011.

[3] R. Corp, "Rt/duroid 5870 - 5880 data sheet," [Online]. Available: https://rogerscorp.com/advanced-electronics-solutions/rt-duroid-laminates/rt-duroid-5880-laminates.

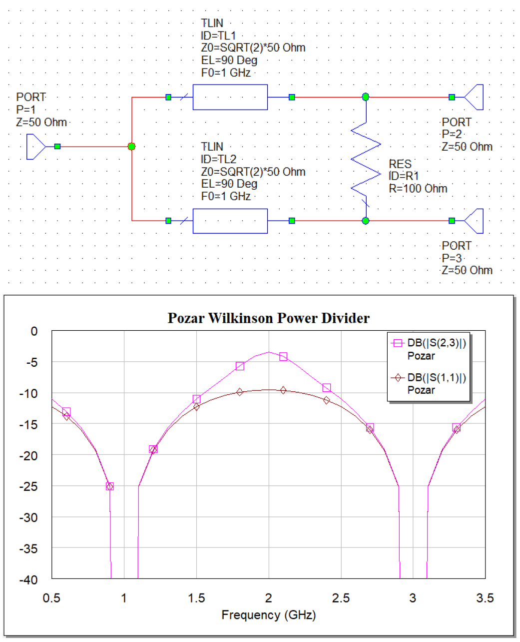

Fig. 1. Conventional Wilkinson Power Divider from Pozar [1]
. Schematic diagram of conventional design and graph of S_{11} and S_{23} parameters.

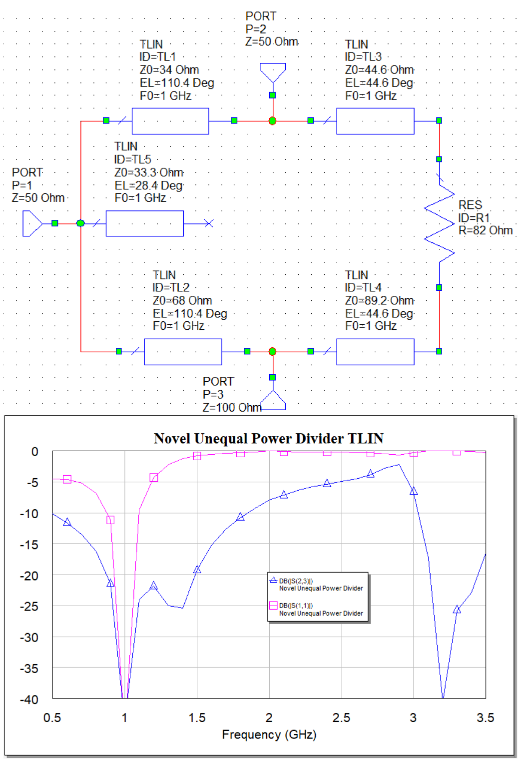

Fig. 2. Novel Unequal Power Divider using TLIN.
Schematic Diagram of Novel Unequal Power Divider using TLIN and graph of S_{11} and S_{23} parameters.

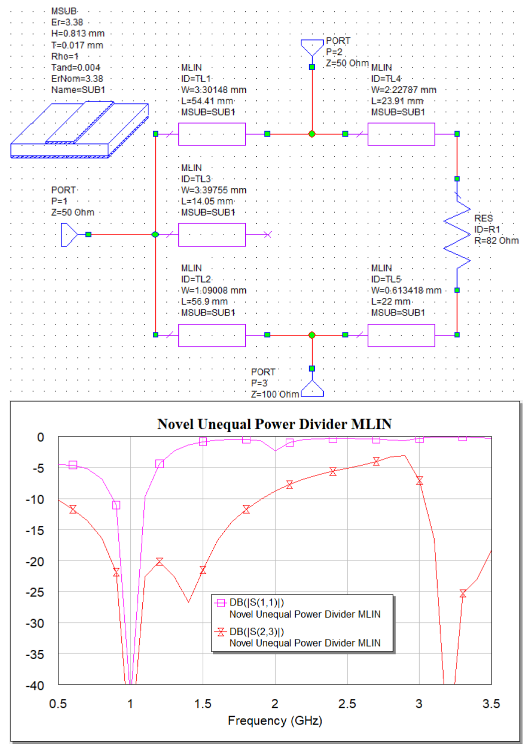

Fig. 3. Novel Unequal Power Divider using MLIN at f_0
Schematic diagram of novel power divider using MLIN and graph of S_{11} and S_{23} parameters simulated at $f_0 = 1GHz$

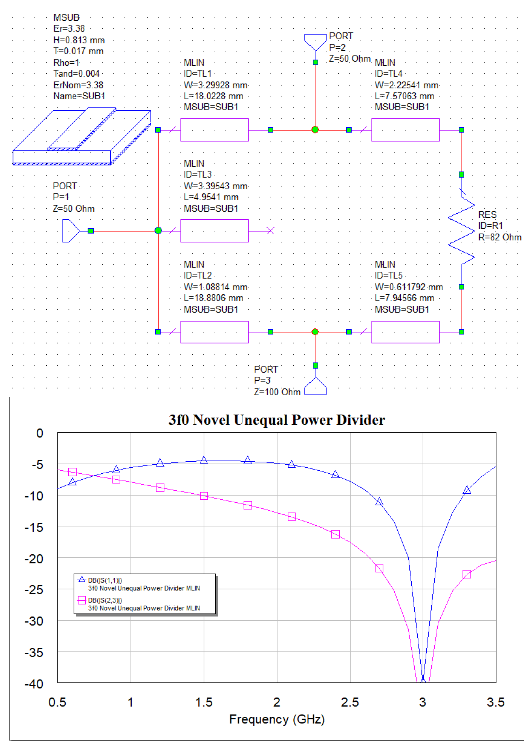

Fig. 4. Novel Unequal Power Divider at $3f_0$
Schematic of novel power divider using MLIN at $3f_0$ and graph of S_{11} and S_{23} parameters.