EERF 6311 – Final Design Project, Sujanthini Manohar Nimmikumari
Dual-band, cross coupled branch line coupler

I. Review Paper Summary

The main objective of this paper is it talks about implementing a cross coupled branch line coupler which enables dual band operation.A conventional branch line coupler can only operate a single frequency but a cross coupled branch line coupler has a dual band functionality.The coupler designed here operates at two different frequencies 1GHz and 2GHz and the material which leveraged this dual band functionality is Teflon with a relative permittivity of 2.5 and a thickness of 0.8mm.The method used by the author in this paper is the Even Odd composition Method and further the ABCD transmission matrix to analyze the equivalent Even and odd mode half circuits. Furthermore the author has designed this using MLIN ,i.e a microstrip line.The author hasn't specifically mentioned the simulation tool to design the schematic but we can perform such simulations using software like AWR,ADS,etc.The paper published date is 26 September 2005 but the paper was issued by IEEE on October 2005.The basic component conventional branchline coupler or the quadrature hybrid coupler is improved by the implementation of this design.

II. Conventional Design Details

The basic design given in the pozar book is the conventional branchline coupler.The conventional branchline coupler can also be called as Quadrature Hybrid Coupler because each one of the branches has an electrical length of quarter wavelength. There are 4 different ports in this conventional branchline coupler and they are namely the input port, through port,the coupled port and the isolated port.Any port among the 4 can be considered as the input port and the port exactly opposite to it is the through port and the port which is diagonally opposite is the coupled port.The thorugh port and the coupled port have outputs with a phase difference of $\deg 90$.Branchline couplers are basically used for dividing and combining power.

The impedance of these branches are Zo and Zo$\times 1.414$. Figure 1 shows conventional branchline coupler with 8 different ports matched at 50ohm. The results were simulated for frequencies 1GHz and 2GHz.

III. Paper Design Details

In fig 3 we can see that coupling branches were introduced in the original design. So like mentioned above the Even and Odd mode analysis and further ABCD analysis is done on the two equivalent circuits. For odd mode,Z3 is connected in parallel to the impedance Z2 and for even mode,Z3 is connected in series to the horizontal impedance Z1. We will consider f2/f1 ratio while designing the schematic. This band ratio is important for scaling of the impedance also according to a graph published by the author.

IV. Simulation

The schematics and simulations were done with the help of the AWR design software. TLIN is used for designing the conventional branchline coupler and for simulating the paper design microstrip line was used.Microstrip Substrate specifications were mentioned,i.e relative permittivity of 2.5,thickness of 0.8mm ,etc. Furthermore in-order to calculate the width and the length of the MLIN's used TXLine is used to generate physical characteristics from electrical characteristics and vice-versa. The fig 1 structure is designed for operating frequencies 1 and 2 GHz .Similarly fig 3 is also designed for those frequencies.

Design Frequency (GHz)	Impedance (ohm)	Width (mm)	Electrical length (degrees)	Physical length (mm)
1 - 2	52.6	2.08009	60	34.6747
	86.6	0.81	60	37.674
	43.3	2.72	60	33.52
2.5- 5	52.6	2.07781	60	13.8625
	86.6	0.847161	60	14.259
	43.3	2.7852	60	13.7204

TABLE I
Tabulated are the results for the dual band branchline coupler operating at 1,2,2.5,5 GHz

Fig 3 and Fig 5 has additional branchline couplers which are designed with the help of MLIN. In Design 2 and Design 3 the electrical length used is $\deg 60$ and the electrical length used in Design 1 is $\deg 90$. For all the three designs the characteristic impedance value is the same which is 50 ohms.

V. Results and Discussion

With the normalized impedance vs band ratio graph given in the paper we were able to create design 3 by simply scaling. Also the interconversion of electrical characteristics to physical or vice-versa can only be done when we know some parameters of either one of these characteristics. Here we have successfully found the values of Z1,Z2 and Z3 and have designed the circuit by the scaling graph given in the paper.Also knowing the frequency and impedance alone is not sufficient we also need to meet the electrical length(in deg) to obtain the parameters of the MLIN (width,length). Here we have taken the electrical length of these impedance values as $\deg 60$ for both design 2b and design 3.

For the design proposed in fig 3 the S parameters were plotted and the results were 27.09dB Return Loss, 3.936dB Transmission,3.425dB Coupled and 23.37dB Isolation at frequency 1GHz and moving on for 2GHz frequency 19.46dB Return Loss, 3.499dB Transmission,4.772dB Coupled and 25.37dB Isolation.

For the design proposed in fig 5 the S parameters were plotted and the results were 30.83dB Return Loss, 3.533dB Transmission,3.599dB Coupled and 30.83dB Isolation at frequency 2.5GHz and moving on for 5GHz frequency 24.68dB Return Loss, 4.022dB Transmission,4.129dB Coupled and 25.76dB Isolation.

Similarly from the figures we can also see the output phase difference for the corresponding frequency values.

Therefore implementing the dual band serves useful for various applications including dual band antenna that can transmit and receive at different frequencies.This paper proved to be really useful in my study and helped me enhance my knowledge about the subject as well as the software.

VI. Conclusion

The Dual Band Cross Coupled Branchline coupler was successfully implemented for frequencies 2.5 and 5 GHz. Also , we can say that with the band ratio and the normalized impedance graph we can design for various different frequencies by using the scaling technique.Also we have implemented a 20 deg feed line with maximum frequency to optimize the obtained output values at each port. Fig 3 and Fig 5 each has the 20 deg feedline attached to ports 1 and 4. Also by simulating the designs with the help of AWR DESIGN environment I got to know a lot about the software especially the capabilities of it to design high frequency circuits.

VII. References

[1] D. M. Pozar, Microwave Engineering, 2nd ed. New York: Wiley, 1998. [2]Myun-Joo Park and Byungje Lee, Member ”Dual-Band, Cross Coupled Branch Line Coupler” in IEEE Microwave and wireless components letters Vol. 15. No. 10. October 2005. [3] K. K. M. Cheng and F. L. Wong, “A novel approach to the design and implementation of dual-band compact planar 90 branch line coupler,”IEEE Trans. Microw. Theory Tech., vol. 52, no. 11, pp. 2458–2462, Nov.2004.

VIII. Figures

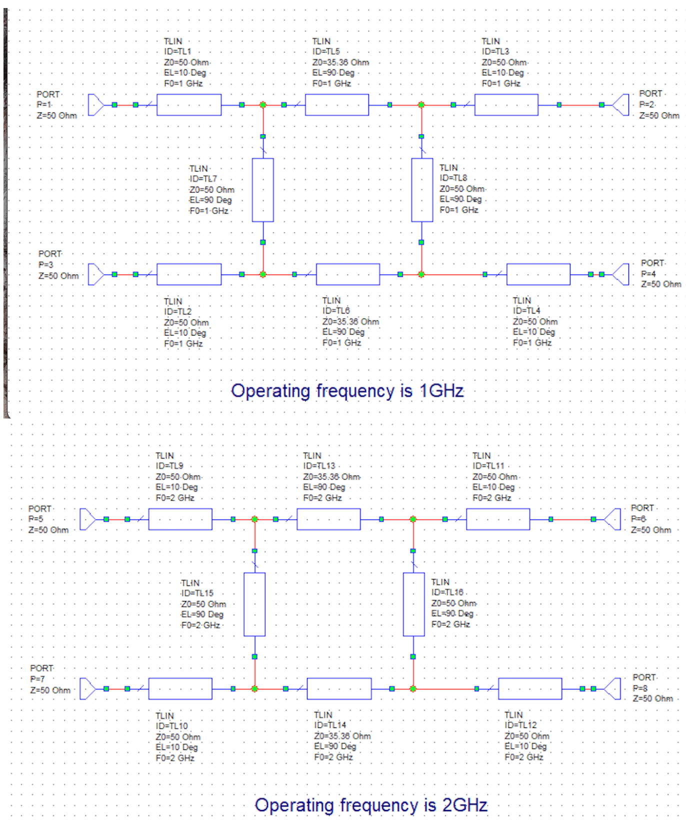

Fig. 1. Design 1: Schematic diagram of conventional branchline coupler for operating frequencies 1 and 2 GHz

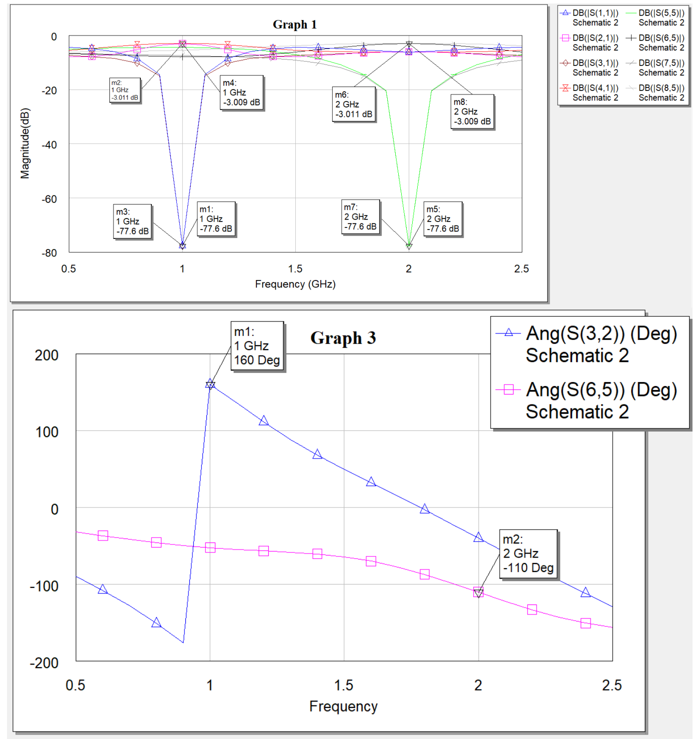

Fig. 2. Measured response of the conventional branchline coupler magnitude and output phase difference for operating frequencies 1 and 2 GHz

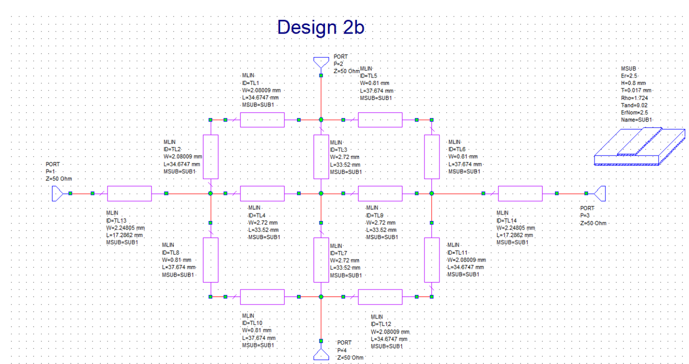

Fig. 3. Design 2b:Schematic diagram of cross coupled branchline coupler for operating frequencies 1 and 2 GHz

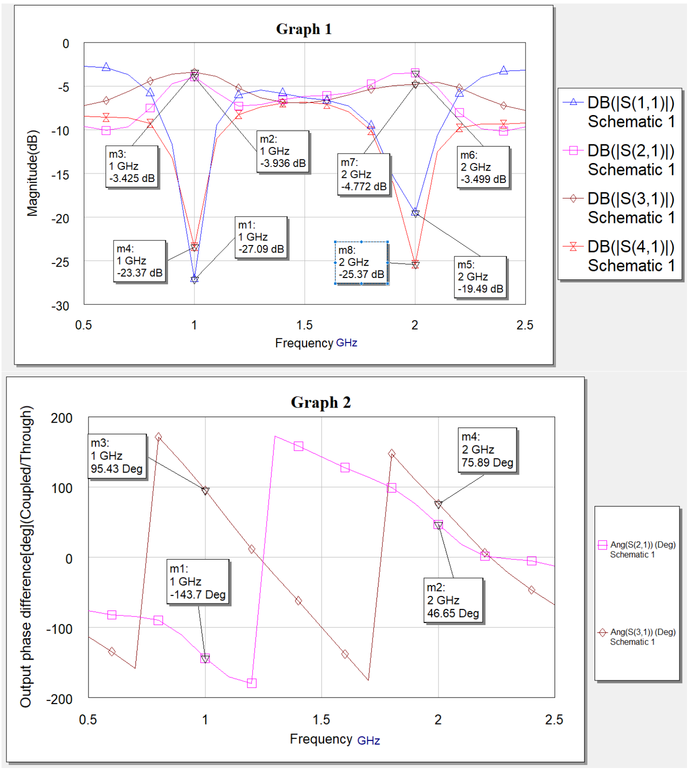

Fig. 4. Measured response of the cross coupled branchline coupler magnitude and output phase difference for operating frequencies 1 and 2 GHz

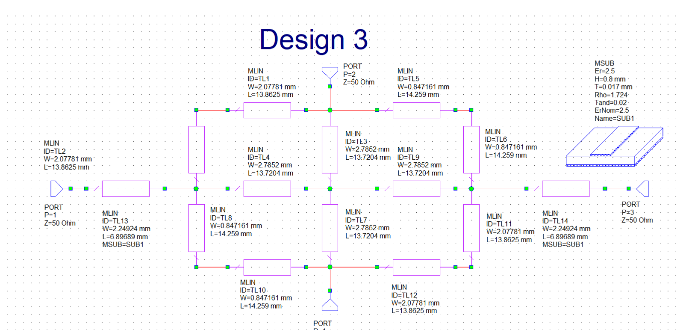

Fig. 5. Design 3:Schematic diagram of cross coupled branchline coupler for operating frequencies 2.5 and 5 GHz

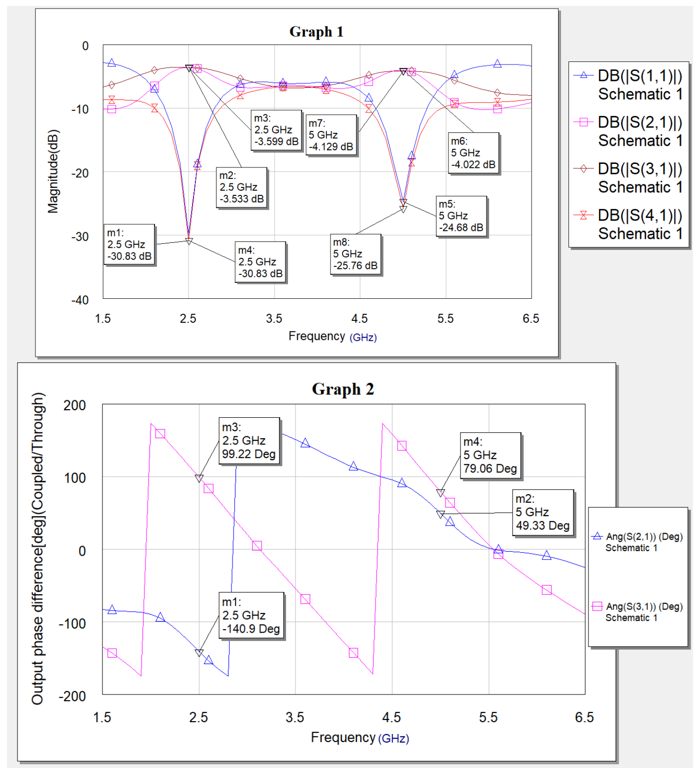

Fig. 6. Measured response of the cross coupled branchline coupler magnitude and output phase difference for operating frequencies 2.5 and 5 GHz