

Wideband Branchline Hybrid Coupler for Ultra High Frequency applications

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Abstract : This paper presents the design and simulation of 50 Ω branchline hybrid coupler. The 3 dB power divider is designed to operate at 2.5 GHz. The important design specifications such as bandwidth, return loss and angle between the through port and coupled port for proposed branchline hybrid coupler are simulated and analyzed using Applied wave research (AWR) microwave office simulation tool. The obtained bandwidth is 1000 MHz and achieved a good return loss around -35 dB. The measured phase difference between the through port and coupled port is 90 degree.

IndexTerms— bandwidth, compactness, phase difference, hybrid coupler, insertion loss.

I. INTRODUCTION

The power dividers and couplers are very important passive components which are used in microwave communication systems for dividing or combining of power is shown in Fig. 1. In power division mechanism the input signal divided into two or more signals which give lesser amount of power.

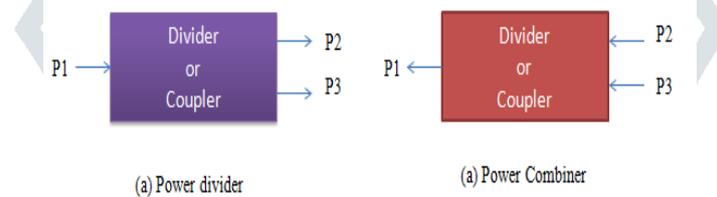


Fig.1. Power divider and combiner

The power coupler can be of three ports or four ports microwave component, which can be designed with loss or without loss. The network with three ports configuration looks like a T-junction and the network with four ports configuration take the form directional couplers and hybrids. The branch line hybrid couplers are microwave passive components that can be used in various applications of microwave communication system [1, 2].

The couplers are largely used in microwave circuits such as frequency discriminators, mixers, balanced amplifiers, phase shifters [3]. Because of their simplicity, the branch line couplers are used as feeding networks in antenna for automatic level control. Bandwidth and miniaturization are two important criteria to reach the requirement of high performance systems. When the operational bandwidth of the coupler is increased the size also increases, but in communication system requires compact circuit without altering the performance is the challenging research area [3-9]. Yu-Tzu Chen et al [10], designed and developed a minimal X-band CPW branch line coupler using the glass integrated passive device. To achieve the compact circuit and to maintain the same return-loss bandwidth of the conventional coupler, The T-structure with asymmetrical CPW branch type is used. Meriam Gay Bautista et al. [11] designed and implemented a Quadrature hybrid branch line coupler that uses the 0.13 μm Bi-CMOS technology for millimetre wave applications.

II. OVERVIEW OF BRANHLINE HYBRID COUPLER

The directional couplers can be modelled in various forms shown in Fig.1.the directional coupler is having four ports, when the power is incident at port 1 called input port the power is divided equally at the port 2 called through port and port 3 called coupled port and no power transmitted to port 4 is called Isolated port.

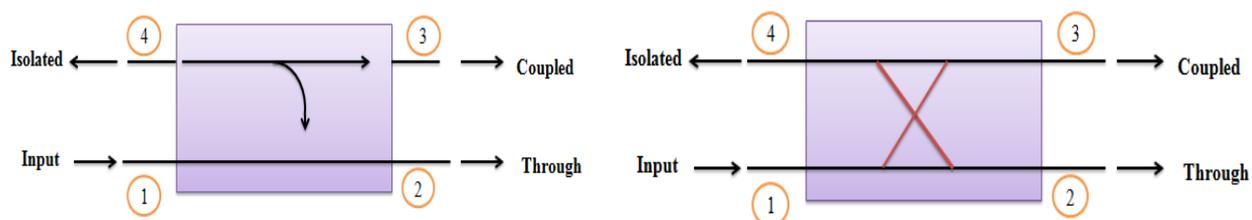


Fig.2.Direction couplers symbols and power flow conventions

Quadrature hybrids are 3 dB directional couplers having 90 degree phase difference between outputs of the through port and coupled port. This type of hybrid structure can be build by using microstrip or stripline form shown in Fig.3.and is known as branch line hybrid.

The [S] matrix of the branch line hybrid coupler is given as

$$[S] = -\frac{1}{\sqrt{2}} \begin{bmatrix} 0 & j & 1 & 0 \\ j & 0 & 0 & 1 \\ 1 & 0 & 0 & j \\ 0 & 1 & j & 0 \end{bmatrix}$$

III. BRANCHLINE HYBRID COUPLER DESIGN

The branchline hybrid couplers are generally utilized in numerous RF and microwave systems in order to achieve phase shifting, power combining and splitting. The realization of the RF circuits basic building blocks such as frequency multiplier, oscillators, filters and amplifiers where compactness and bandwidth are crucial design specifications to achieve high performance circuit. The proposed design of branchline hybrid coupler is shown in Fig.3. It is a four port microwave passive component where port-1 is input port, port-2 is through port, port-3 is coupled port and port-4 is Isolated port.

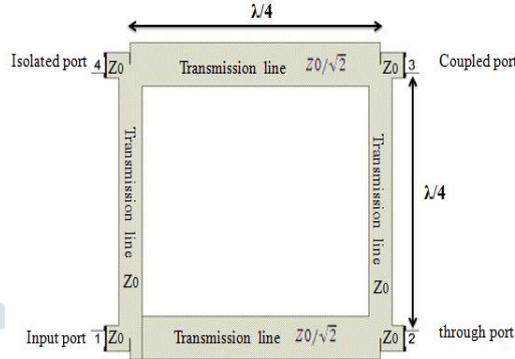


Fig.3. Structure of branchline hybrid coupler

the characteristic impedance of the proposed branchline hybrid coupler is 50 Ω. the lines of the branchline hybrid junction couplers are λ/4 lines at the designed frequency of 2.5 GHz and branchline impedance are calculated with the equation is given as

$$\frac{Z_0}{\sqrt{2}} = \frac{50}{\sqrt{2}} = 35.4 \Omega \tag{1}$$

The length of the branchline coupler can be calculated by using the equation

$$L = \frac{\lambda_g}{4} \tag{2}$$

Where λ_g is the guided wavelength. The width of the lines are calculated by using online microstrip line calculator by passing all the parameters such as impedance of the line, loss tangent of substrate, thickness of the substrate material and designed frequency.

IV. RESULTS AND DISCUSSION

The proposed structure of branchline hybrid coupler is designed and important specifications such as bandwidth, Return loss, Isolation loss and phase difference between through port and coupled port are analyzed in applied wave research (AWR) microwave simulation tool.

The substrate material used in this branchline hybrid coupler is FR4 with relative permittivity of 4.3, the height of the substrate is 0.8 mm, and loss tangent is about 0.016. The copper is used as a conductor with height of 0.01 mm and another substrate is air thickness about 20 mm.

The branchline hybrid coupler is designed to operate at 2.5 GHz frequency. To analyze the power division at each port is done with the help of scattering parameters so the frequency response graph is plotted which is shown in Fig.4.

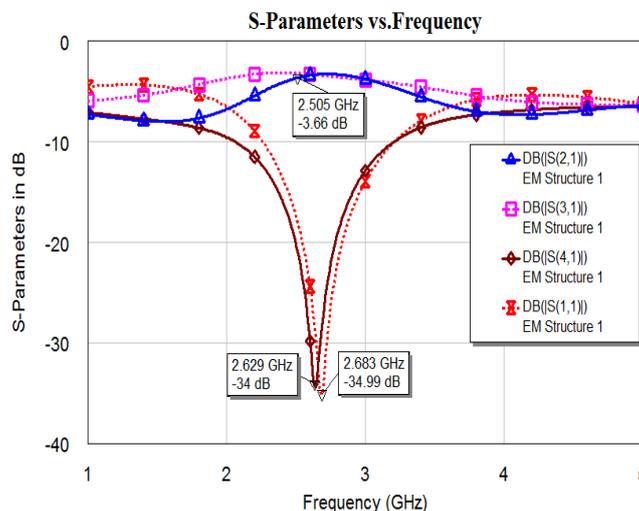


Fig.4. S-parameter magnitude vs frequency

The Scattering parameter magnitude is calculated at each port with respect to frequency, for the designed frequency that is 2.5 GHz frequency the obtained power division at port 2 and 3 is 3.66 dB which shows equal power division between port 2 and 3. The perfect Isolation loss and Insertion loss are achieved at 2.5 GHz frequency. The obtained isolation loss is about -34 dB and Return loss is around -34.99 dB.

The phase difference between the through port and coupled port of the branchline hybrid coupler is 90 degree. In order to analyze the phase difference the angle plot with respect to frequency is plotted is shown in Fig.5

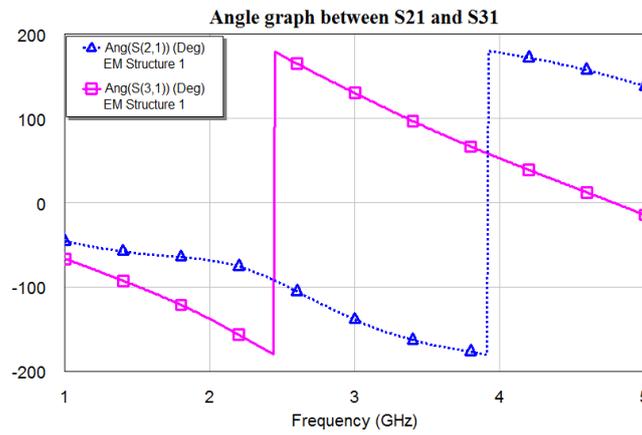


Fig.5. Angle graph vs. frequency

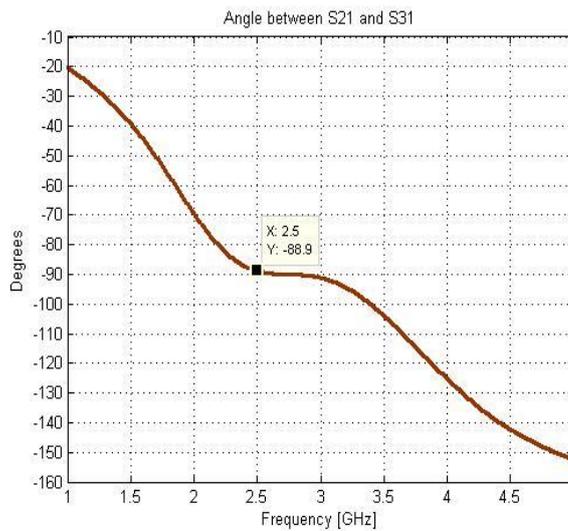


Fig.6. Phase difference between port-2 and port-3

the phase difference plot is drawn in Microsoft excel shown in Fig.6 after tracing the data from the graph shown in Fig.5 obtained from AWR simulation tool, clearly its showing that the phase difference between through port and coupled port is almost 90 degree. The obtained value is 88.90 degree.

The operational bandwidth of branchline hybrid coupler can be obtained from return loss plot which is simulated in AWR microwave office tool is shown in Fig.7.

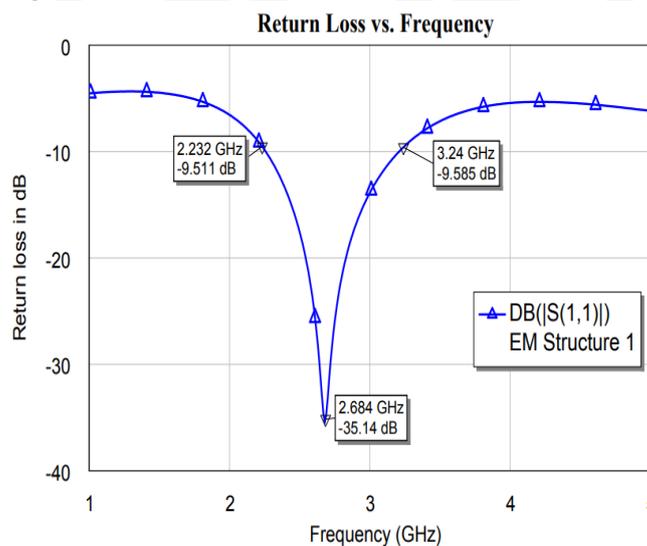


Fig.7. Bandwidth calculation plot

The bandwidth of the proposed branchline hybrid coupler can be calculated using upper and lower cut-off frequency taken at 9.5 dB either side. The upper cut-off frequency is 3.24 GHz and lower cut-off frequency is 2.324 GHz the difference between the upper and lower cut-off frequency is the bandwidth of branchline hybrid coupler. The obtained bandwidth is of 1000 MHz.

V. CONCLUSION

Design of 50 Ω branchline hybrid coupler for microwave system and millimeter wave application is implemented using AWR microwave office simulation tool. The perfect matched hybrid coupler divides the power equally at port-2 and port-3 is about 3 dB. The obtained return loss is around -35 dB at 2.5 GHz frequency and the operational bandwidth of 1000 MHz is achieved.

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