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Branchline Coupler as Duplexer

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Abstract

This paper presents design of branch line coupler as a duplexer for 3 GHz frequency. This paper also presents connections of transmitter, antenna, and receiver with different port of branch line coupler to make them work as a duplexer. Simulation is done using Serenade SV software for various parameters. Simulated values of S-parameters at 3 GHz had been reported. The values of return loss and transmission loss at 3 GHz had been reported. After analyzing the results we had concluded that this proposed duplexer can provide good isolation between transmitter and receiver.

Keywords: Duplexer, Hybrid coupler, branch line coupler, Return loss, Transmission loss.

Introduction

In radar and radio communications systems, there should be isolation between the receivers and transmitter and this is achieved by sharing a common antenna. This is the basic principle of duplexer. In duplexer a single antenna is used for both transmission and reception of signal or in other words we can say that a duplexer is an electronic device in which bi-directional (duplex) communication is allowed over a single path. In radar, a transmit-receive (TR) switch is present that alternately connects the transmitter and receiver to a common shared antenna. The switch consists of a gas-discharge tube that is connected between the input terminals of the receiver. When the transmitter is active, it causes the tube to start conducting due to resulting high voltage and shorting together the receiver terminals[1].

The sender can be both sides for both the sender and the recipient with the help of the same antenna, in or at the same frequency. This concept uses a radar, where the signal would be counter frequency very close to the frequency of transmitted signal, such as the T / R situation. It is a network of three ports allowing the sender and receiver the radar or communications system with the help of only one antenna. It can also be used as a roller device unit double-sided prints in low-power applications, or it can be used in a T / R Kafraz radioactive gas radar Almigawat. It requires a sender unit Duplex low between the sender and the antenna in transfer (less than dB 1 desirably), high isolation between the sender and the recipient (as much as 80 dB for systems Almigawat), low loss between the antenna and the recipient under the reception (less than 1 dB desirably) and quick transfer between the sender and recipient, and sometimes "automatically replaced by the transmittal signal, and sometimes by the command signal [1,12].

While designing a duplexer is one should kept in mind this receiver and transmitter must be isolated from each other. In other words, the phase change between receiver and transmitter must be 180 °.There are wide variety of duplexers are available which can accomplished this task. Various types duplexers are circulators, diodes such as PIN diodes are available. But at the same time microwave circuitry such as phase shifters can also be used as duplexers. Phase shifters such as branch line couplers, turnstile junctions and hybrid junctions such as rat race couplers can also be used as duplexers. The advantage of using microwave circuitry such branch line coupler as a duplexer is due to their A flat structure that does not require any active or negative elements, so there is no way to sound through these devices.

This paper presents designing of duplexer using 90 degree hybrid or branch line coupler. While designing a duplexer there are three most important thing we should keep in mind are firstly, at the time of transmission, transmitter should be connected to the antenna and disconnected from the receiver. Secondly, during reception receiver should be connected to the antenna and disconnected from the transmitter. Thirdly, there should be sufficient isolation between transmitter and receiver at all times. This isolation between transmitter and receiver can be provided if we provide 180 degree phase shift between transmitter and receiver and as we all know branch line coupler or 90 degree hybrid provides 90 degree phase shift between its output. So if we use two branch line coupler sections then together they provide 180 degree phase shift. So if transmitter and receiver are connected at its output ports then 180 degree phase shift can be achieved and this provide good and complete isolation between transmitter and receiver. Branch-line-couplers are 3 dB direct couplers that have a phase difference between 90 and 10 deep brain. This type of hybrid is often made in micro strip line or strip line form as shown in Figure 1.1 and is also known as a branch-line hybrid.

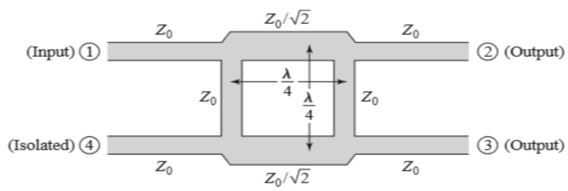


Figure 1.1.Geometry of Branchline Coupler

Required all ports are adjusted. If the force in port 2 is divided into port 1, then the phase difference between the output ports is 90 degrees. Without power is connected to port 4, it is an isolated port. There are restrictions on setting the output so it can always be ported on the side of the intersection of the input and the remaining port on the same side of the input port is the decorated port. [1]

Now we are using this branch line coupler as a duplexer so we had to arrange the connection of transmitter, receiver and antenna accordingly. By placing the transmitter at input port 1, receiver at isolated port 4, a 50Ω termination at port 2 and at one of the output port 3 antenna is placed. The power moves from transmitter to antenna in quadrature phases, and the signal is send back to the receiver by the antenna. In this way, isolation is achieved between transmitter and receiver, also they both are completely unaffected by each other. Here in this design with receiver we have to used mixer for up-conversion and down conversion, power divider.

Design

Now with reference to figure 1.1 we had designed the 90 degree hybrid accordingly on the Serenade software. According to the figure length of a and b arms is λ/2 and Z0 is the characteristic impediment of the transmission line. It can be seen in the figure that there are two horizontal and two vertical arms designated as 'a' and 'b' arms respectively. Impedance of 'a' arm is $Z_0/\sqrt{2}$ and 'b' arm is Z_0 where Z_0 is the characteristics impedance of the line and electrical length of 90^o. The impedance values of all other arms are 50Ω.

Table 1.1:Value of Impedance And Electrical Length Of Different Arms

Impedance	**Impedance**	**Electrical Length**
Z_A	35.4	90
Z_B	50	90
Z_0	50	90

The value of transmission line impedance (Z_0) = 50 ohm.The value of 'a' arm impedance (Z_A) = $Z_0/\sqrt{2}$ = 35.4 ohm. The value of 'b' arm impedance (Z_B) = Z_0 = 50 ohm. By using Serenade SV software simulation has been done for analyzing the results. In the proposed duplexer,branchline coupler had been designed for 3 GHz frequency for providing phase difference of 90 degree. And accordingly if we used two branchline coupler then together they will provide total 180 degree phase shift between transmitter and receiver. Transmission lines of combination with impedances 50 ohm and 35.34 ohm provide power division and phase change at output ports.

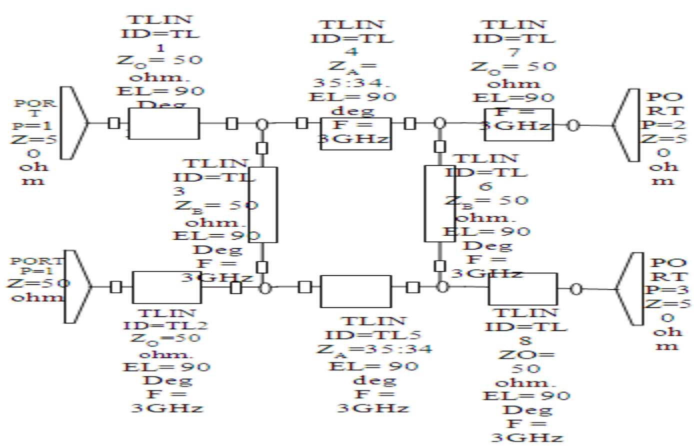


Figure.1.2 Figure showing design of branchline coupler

All the input values such as characteristic impedance, electrical length and frequency are shown in figure 1.2 which are to used in serenade software for making the design. The screenshot of the design of branchline coupler by using the above input values on serenade software is shown in figure 1.3.

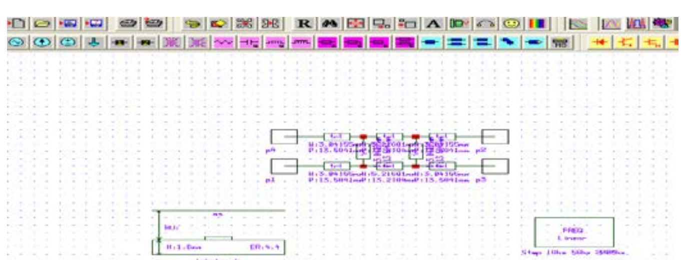
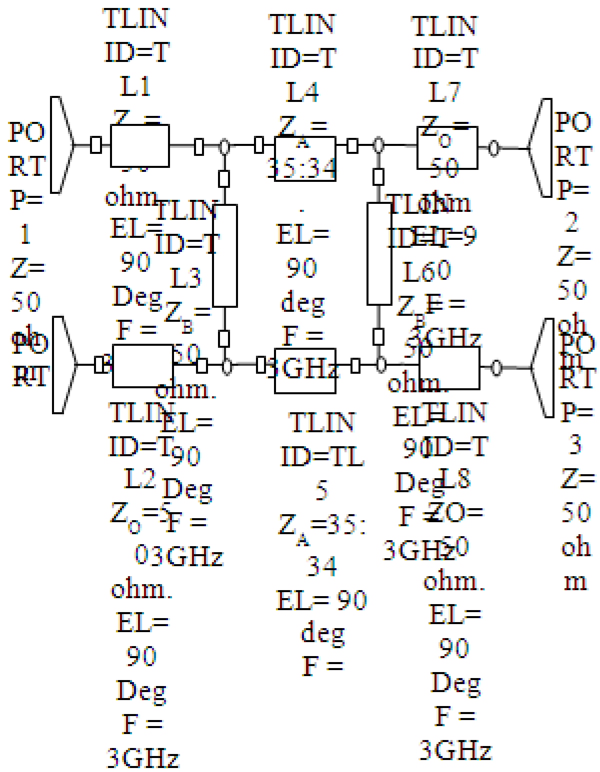


Figure 1.2 Screen shot for the design of Branchline Coupler using Serenade Software.



FREQ [GHz]	dB(S_{11})	dB(S_{12})	dB(S_{13})	dB(S_{14})
2.4	-8.48	-3.4	-5.23	-10.14
2.6	-11.81	-3.14	-4.08	-12.71
2.8	-17.98	-3.06	-3.29	-18.22
3	-43.32	-3.06	-3.02	-45.52
3.2	-17.52	-3.06	-3.32	-17.79
3.4	-11.54	-3.16	-4.17	-12.51
3.6	-8.28	-3.44	-5.35	-10.02

Simulated Results

Different S parameters are measured for 3 GHz 90 degree hybrid coupler such as S_{11},S_{12},S_{13},S_{14}. The values of return loss and transmission loss had been reported at 3 GHz and frequencies nearby it. The S_{11} parameter represents the return loss at port 1 i.e the amount of power that is reflected back. It is also known as reflection coefficient. The values of return loss at different frequency should be less than -10dB. If value of S_{11} is -10 dB that means 3dB of power is reflected back and rest is delivered to antenna. The delivered power is either radiated or absorbed as losses. Similarly, S_{12} represent the transmission loss i.e power received at port 1 relative to power input at port 2. Also transmission loss should also be less than -10 dB.

S-parameter versus frequency graph

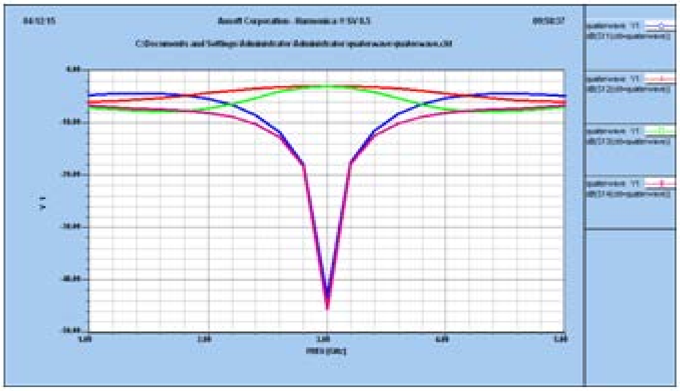


Fig.1.3 Simulated S_{11}, S_{12}, S_{13} And S_{14} For The 3ghz Branchline Coupler

Table 1.2: Different s parameters for 3ghz branchline coupler

4.2	-4.72	-4.92	-7.82	-7.71
4.4	-4.48	-5.34	-7.86	-7.44
4.6	-4.45	-5.66	-7.66	-7.19
4.8	-4.59	-5.87	-7.35	-6.94
5	-4.85	-5.99	-7	-6.7

Table 1.3: Angular Difference For 3ghz Branchline Coupler

FREQ [GHz]	Ang(S12[deg])	Ang(S13[deg])
2.4	80.91	162.63
2.6	53.55	140.94
2.8	26.21	115.96
3	-0.72	89.27
3.2	-27.74	62.57
3.4	-55.29	37.59
3.6	-82.91	16
3.8	-109.73	-1.51
4	-135.3	-15.95
4.2	-159.72	-29.24
4.4	176.69	-42.98
4.6	153.54	-57.9
4.8	130.55	-74.12
5	107.49	-91.52

Conclusion

Hence we concluded that simulated results shows good values of return and transmission losses at and nearby 3 GHz frequencies. The values of return and transmission loss is less than (-10dB). So using branchline coupler as a duplexer provides good isolation between transmitter and receiver but since we want 180 degree phase shift between transmitter and receiver so we have to use two branchline couplers to obtain complete isolation i.e 180 degree phase shift between both.

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