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The Unequal Wilkinson Power Divider 2:1 for WLAN Application

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Abstract

A power divider is a three-port microwave device that is used for power division or power combining. They are reciprocal devices, i.e. they can also be used to combine the power from output ports into the input port. The power dividers are widely used in microwave circuit designs. Indeed, this paper describes the design and simulation of 2:1 power divider at 3.6 GHz (802.11y) frequency for Wireless Local Area Network (WLAN) applications using Advanced Design System software (ADS). This device provides maximum isolation among three ports. It is highly advantageous for limited bandwidth applications. The Wilkinson Power Divider can also be manufactured with distribution of unequal powers.
Therefore, in this article a conception of a Wilkinson unequal Power Divider is presented and our interest is a ratio of 2:1 at central frequency of about 3.6 GHz.

Keywords: Power Divider; Wilkinson power divider; Microstrip technology;2:1 ratio.

1. Introduction

The Wilkinson power divider was invented in 1960 [1] and has completely matched output ports with sufficiently high isolation between them. This device is also potentially lossless provided that no reflected power from output ports enters into it [2]. It is a three-port microwave device that is used for power division or power combining as

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shown in Fig. 1. It is reciprocal device, i.e. it can also be used to combine the power from output ports into the input port. The power dividers are widely used in microwave circuit designs. In an ideal power divider the power given in port 1 is equally split between the two output ports for power division and vice versa for power combining [3]. This device provides maximum isolation among three ports. It is highly advantageous for limited bandwidth applications. This divider has wide applications in microwave circuits and antenna feeds, but it has a narrow bandwidth, which has the best performance at a center frequency. Several schemes have been devised to increase its bandwidth [4,5].The Wilkinson Power Divider can also be manufactured with distribution of unequal powers.

They are widely used as one of the key components in various microwave applications for power allocation and synthesis. Wilkinson power divider is widely used due to its high return loss and isolation as well as low insertion loss by structure of simplicity. However, a conventional Wilkinson power divider has weakness in size, because it is composed of quarter wavelength transmission lines.

This paper describes the design and simulation of 2:1 power divider at 3.6 GHz (802.11y) frequency for WLAN applications using ADS software. Indeed, in the following sections we will study the design procedure of the proposed unequal Wilkinson power divider 2:1.

2. Design Procedure

In this paper, it proposes designing of a 2:1 Power divider using advanced design system softward. Therefore, a conception of a Wilkinson unequal Power Divider is presented and our interest is a ratio of 2:1 at central frequency of about f_0=3.6 GHz.

The matrix of scattering parameters of symmetric Wilkinson Power Divider with 2 ports is given by [3]:

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

Indeed, this latter reveals that this network is reciprocal (S_{ji}=S_{ij}), the terminal is adapted (S_{11}=S_{22}=S_{33}=0) and the output ports are isolated (S_{23}=S_{32}=0).

The power Divider topology is given by:

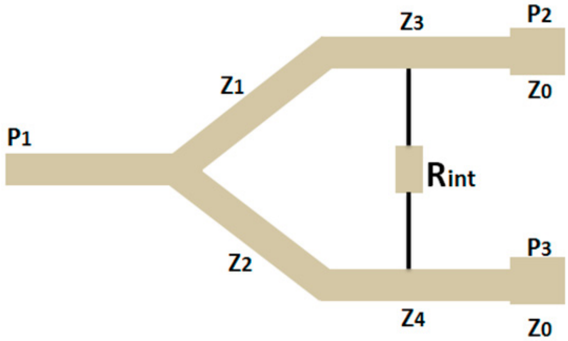

Fig.1. 2:1 Power Divider with Quarter Wavelength Section.

At higher frequencies (above 500 MHz) these devices are usually realized as a micro strip or Strip line Wilkinson design. Fig.1 shows a simple 2-Way or 2:1 Wilkinson power dividers. Being a lossless reciprocal three port network, it acquires every one of its properties which express that this kind of network can't have all the ports simultaneously matched.

To solve this, isolating resistor is placed between the two output ports, since no current flows through the resistor; this resistor does not contribute to any resistive loss. This makes an ideal Wilkinson a 100% efficient device. This resistor also provides excellent isolation even when the device is used as a combiner. Another property of the Wilkinson divider is that it is separated into quarter wavelength sections [6].

The power ratio between ports 2 and 3 is $K^2=P_2/P_3$ and the following design equations are used:

$$Z_1 = Z_0\sqrt{K(1+K^2)} \tag{2}$$

$$Z_2 = Z_0\sqrt{\frac{1+K^2}{K^3}} \tag{3}$$

$$R_{int} = Z_0\left(K+\frac{1}{K}\right) \tag{4}$$

$$R_3 = \frac{Z_0}{K};\ \ R_2 = Z_0.K \tag{5}$$

The impedances of Z_4 and Z_5 can be determined by:

$$Z_4 = \frac{Z_0}{\sqrt{K}}\ \ ;\ \ Z_3 = Z_0\sqrt{K} \tag{6}$$

Therefore, for Power Divider with 2:1 ratio, we have:

$$K^2=N=2$$

Therefore the results are given by the following Table 1:

Table 1. Conversion from electrical values to physical ones.

Characteristic impedance (Ω)	Z_0	Z_1	Z_2	Z_3	Z_4	R_{int}
	50	103	51.5	59.5	42.05	
L(mm)	4	7.990550	7.495010	7.595750	7.360700	106.1
W(mm)	2.938090	0.586990	2.832830	2.184490	3.956110	

3. Results and Discussions

3.1. Schematic Simulation Procedure for 2:1 Power Divider

The theoretically evaluated lumped component circuit diagram of Wilkinson power divider using ADS is shown in Fig. 2.

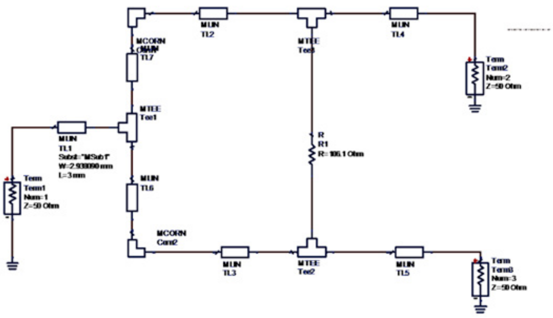

Fig. 2. Design of 2:1 power divider using ADS.

The power divider as shown in Fig.2 has one input port and two output ports. The three ports are isolated with each other. The performance of the network for S-parameters is studied using 50 Ohms termination at all the ports.

After doing the schematic simulation of the circuit studied with ADS, we find the S parameters results at 3.6 GHz as shown in Fig. 3.

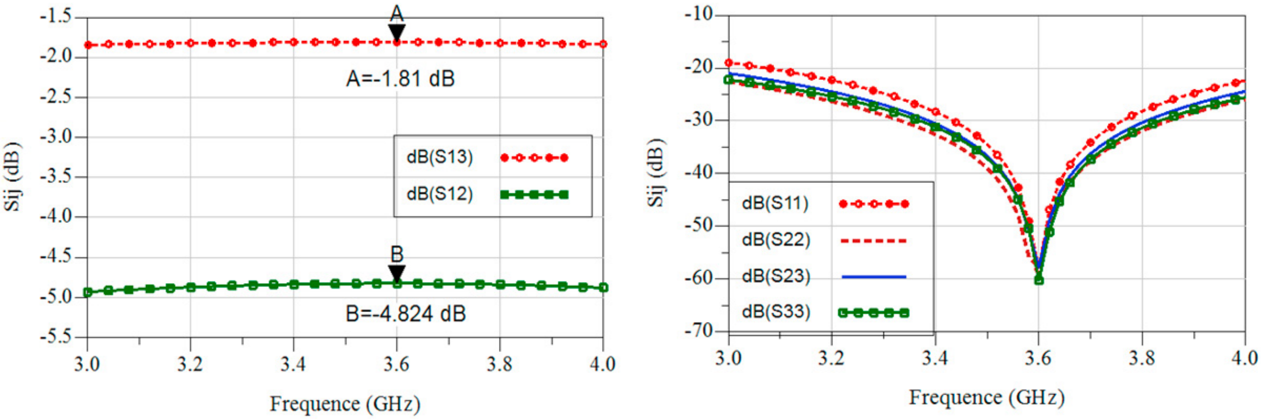

Fig. 3. Frequency responses of scattering parameters of Power Divider.

The frequency responses of reflexion coefficients and transmission coefficients of the power divider are studied in the range of 3 to 4GHz and with step size of 0.2GHz is shown in Fig.3.

The results show the adaptation between the 3 ports thanks to values of reflexion coefficients which are inferior to -10 dB. The result of transmission coefficients (S_{12}, S_{13}) ensures the good performance of our proposed Power Divider with 2:1 ratio. And also the results of isolation are very good since S_{23} and S_{32} are very small which shows good isolation between the 2 ports.

3.2. Electromagnetic Simulation Procedure for 2:1 Power Divider

Fig.4 below shows the layout Power Divider at 3.6 GHz (26.5mm x 28.5mm).

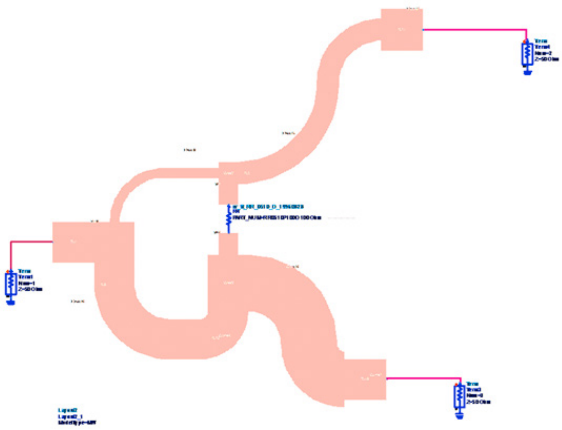

Fig. 4. Wilkinson Power Divider 2:1.

The following table (Table 2) shows the optimized values of divider power after replacing the ideal resistor with the real one (sr_tft_RR_0510_D_19960828).

Table 2. Optimized values of divider power with change of the ideal resistance by real one.

	$Z_{0\ opt}$	$Z_{1\ opt}$	$Z_{2\ opt}$	$Z_{3\ opt}$	$Z_{4\ opt}$
L (mm)	4	0.6973748	12.095	16.12	10.30945
W(mm)	2.938090	9.4977	2.87501	1.5928	4.01

The next plot (Fig.5) was generated in Agilent ADS and shows the frequency responses of the proposed optimized Power divider.

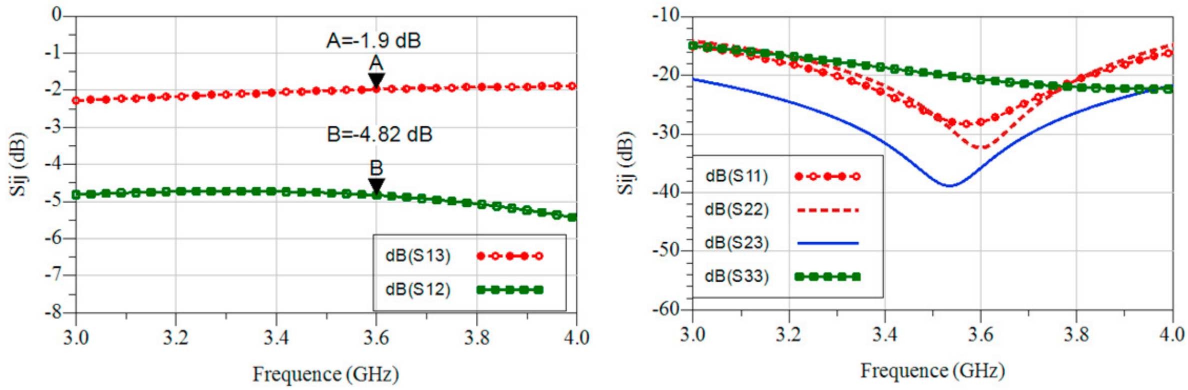

Fig. 5. Frequency responses of scattering parameters of Power Divider.

The reflexion coefficient S_{11} is of -28dB at port 1 and S_{22} of -32.3dB at port 2 and S_{33} of -35.7 dB.The results show the adaptation between the 3 ports thanks to values of reflexion coefficients which are inferior to -10 dB. The result of transmission coefficients (S_{12}, S_{13}) ensures the good performance of our proposed Power Divider with 2:1 ratio. And also the results of isolation are very good since S_{23} and S_{32} are very small which shows good isolation between the 2 ports.

4. Conclusion

In this paper, the 2:1 Power Divider for WLAN application has been successfully designed and simulated using Advanced Design System. The achievement is made through technology microstrip in total of four impedances and quarter transformers wave for the adaptation of the input with the output. To conclude, there is unequal power division at port 2 and 3 (-1.9 dB and -4.82 dB respectively), and very good isolation between the output ports is obtained in the required frequency 3.6 GHz.

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