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Research Article

Design and Simulation of Equal Split Wilkinson Power Divider

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Abstract

In this study, the design and simulation of an equally split C Band Wilkinson Power Divider is presented. It is aimed that the divider distributes the power equally and provides lossless, reciprocal, and high isolation between the output ports. Microstrip technology has been utilized as the design process. A micro strip is a transmission line mounted on a copper conductive material. It has been used $\lambda/4$ transformer with characteristic impedance $2 \cdot Z0$. In this system, improvements have been made to increase bandwidth and high isolation. The designed divider has been simulated in the AWR Microwave Office. It has been used FR4 substrate with 0.21 mm thickness. Operating frequency has been chosen 7.2 GHz. The designed divider is suitable for good matching and isolation according to S parameter values. While the S21 and S31 values should be -3 dB in theory, it is not possible for us to see this value in the designed systems. From the simulation results, Insertion Loss (S21 and S31), Isolation Loss (S32) are about -3.4 dB, -22 dB respectively. Input (S11) and Output return loss (S22) are respectively about -22 dB and -44 dB. The designed power divider is a passive circuit element used to divide power at the same or different frequencies in mobile and small applications. The simulated power divider has useful in RF applications.

Keywords: Wilkinson Power Divider, Equal Split, Microstrip, High Isolation, C Band.

Eşit Bölen Wilkinson Güç Bölücü Tasarımı ve Simülasyonu

Öz

Bu çalışmada, eşit olarak bölünmüş bir C Band Wilkinson Güç Bölücünün tasarımı ve simülasyonu sunulmaktadır. Bölücünün gücü eşit olarak dağıtması ve çıkış portları arasında kayıpsız, karşılıklı ve yüksek izolasyon sağlaması hedeflenmiştir. Tasarım süreci olarak microstrip iletim hattı kullanılmıştır. Microstrip, bakır iletken bir malzeme üzerine monte edilmiş bir iletim hattıdır. Karakteristik empedans $2 \cdot Z0$ olan $\lambda/4$ transformer kullanılmıştır. Bu sistemde bant genişliğini artırmak ve yüksek izolasyon sağlamak için iyileştirmeler yapılmıştır. Tasarlanan bölücü, AWR Mikrodalga Ofisinde simüle edilmiştir. 0, 21 mm kalınlığında FR4 substrate kullanılmıştır. Çalışma frekansı 7.2 GHz seçilmiştir. Tasarlanan divider, parametre değerlerine göre iyi uyum ve izolasyon için uygundur. Teorik olarak S21 ve S31 değerlerinin -3 dB olması gerekirken tasarlanan sistemlerde bu değeri görmemiz mümkün değildir. Simülasyon sonuçlarından, Ekleme Kaybı (S21 ve S31), İzolasyon Kaybı (S32) sırasıyla yaklaşık -3.4 dB, -22 dB'dir. Giriş (S11) ve Çıkış dönüş kaybı (S22) sırasıyla yaklaşık -22 dB ve -44 dB'dir. Tasarlanan güç bölücü, mobil ve küçük uygulamalarda gücü aynı veya farklı frekanslarda bölmek için kullanılan pasif bir devre elemanıdır. Simüle edilmiş güç bölücü, RF uygulamalarında faydalıdır.

Anahtar Kelimeler: Wilkinson Güç Bölücü, Eşit Bölme, Microstrip, Yüksek İzolasyon, C Bandı.

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1. Introduction

The power divider (PD) is an RF electronic component that divides the power from the input port into the output ports. PD is often used with power amplifiers, mixers and different RF applications [1-5]. Although divider is lossless in theory, it is practically impossible to be lossless. Wilkinson power divider, resistive power divider are types of dividers. Resistive dividers can make the ports match, but again there is a loss. Wilkinson power divider (WPD) is one of the basic elements used in microwave electronics. Power is divided into two or more branches with the Wilkinson power divider. It is used in power divider transceiver circuits, signal power splitting, antennas, and many circuits. WPD allocates the power in the input port to the output ports at the desired rate. Three-port power dividers are frequently used in antenna array systems and different applications [6]. The traditional WPD systems are generally adversely affected by the narrow bandwidth. Kalpanadevi et al. [7] simulate different design method to increase bandwidth 3 dB equal split power divider. The WPD has very balanced features. However, they have some disadvantages such as big size due to quarter wavelength. Authors study miniaturization of microwave power divider. Total dimension has been reduced by %50 [8]. In this letter, 2-way equal split power divider is presented. The designed power divider has three ports, one input, and two output. Power divider design parameters and system simulation graphics are created, and the design is analyzed. It is aimed to provide isolation between power divider and output ports and to ensure match between all ports. The result of poor isolation is seen on the output ports. If the S32 value is quite bad, it indicates that the isolation is bad.

2. Material and Method

The basic two-output power divider and power combiner is shown in the Figure 1. below.

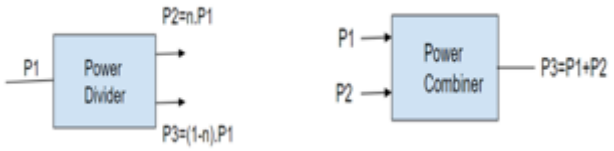

Figure 1. Basic Power Divider and Power Combiner

It can be displayed as Wilkinson Power Divider in Figure 2.

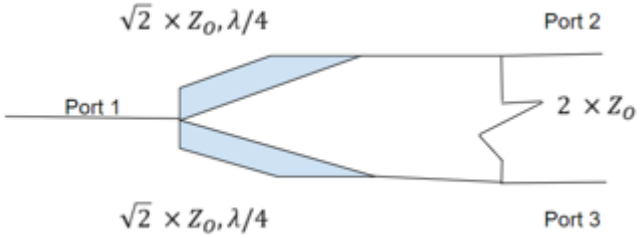

Figure 2. Transmission Line of Wilkinson Power Divider

The designed Wilkinson power divider should provide the following features.

1. Reciprocal

$$S_{ij} = S_{ji}$$

$$S_{12} = S_{21}\ ,\ S_{23} = S_{32}$$

2. Terminals are matched

$$S_{11},\ S_{22}, S_{33} = 0$$

This equation is necessary for all ports to be match. This value must be less than 0 [9]. It is generally expected to be greater than -15 dB in absolute terms.

3. Isolated Output Terminals

$$S_{23} = S_{32} = 0$$

This equality refers to the isolation between the output ports. It is generally expected to be greater than -20 dB in absolute terms.

The characteristics impedance of microstrip line and curved bend are 50 Ohm, 70.7 Ohm. Resistive impedance is 100 Ohm. To avoid simultaneous non-matching of all ports, Wilkinson Power Divider uses an isolation resistor [9, 10].

Microstrip line is used in this design. Parameters for FR4 Substrate are shown in Table 1.

Table 1. Substrate Parameters

Substrate Material	FR4
Dielectric constant	(ε_r) =3.85
Height	(H) = 0.21 mm
Tand	=0.018
Rho	= (Copper)0.7

The schematic of the designed circuit is shown in Figure 3.

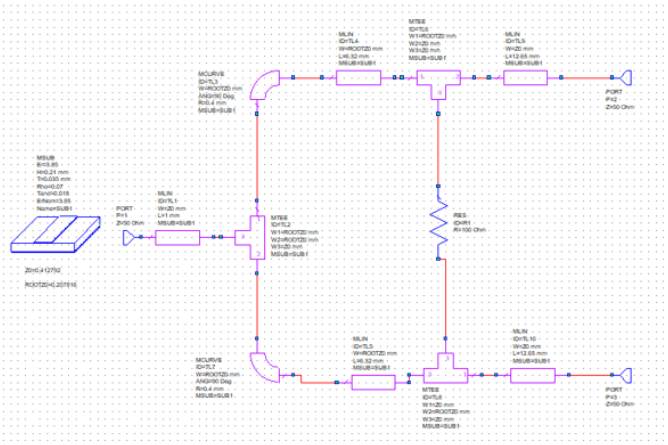

Figure 3. Two Way Power Divider Circuit Schematic

The layout of the designed circuit is shown in Figure 4.

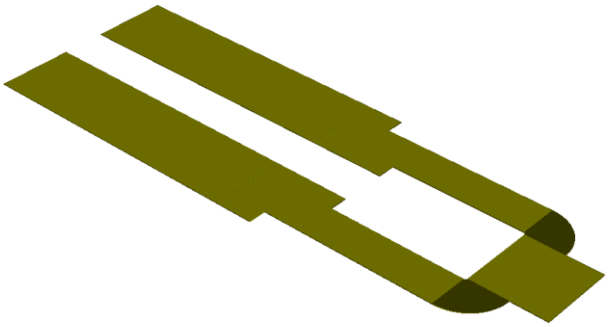

Figure 4. System Layout of Power Divider

3. Results and Discussion

High isolation and good match between output ports has been aimed in this study. From figure 5, Insertion loss (S21, S31) is about-3.4 dB. From figure 6, We see input and output return loss values. From figure 7, Isolation Loss (S32) value is approximately-21.34 dB.

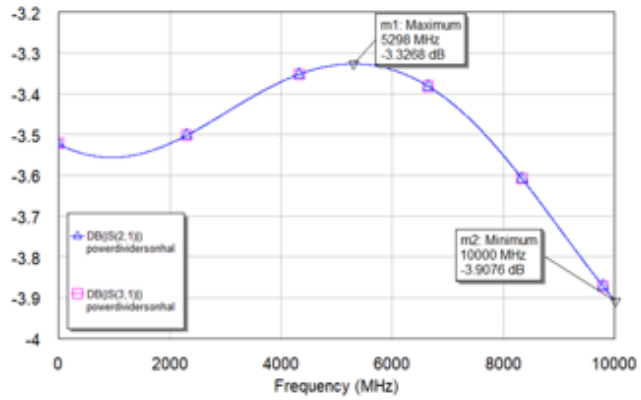

Figure 5. Transmission Graphs

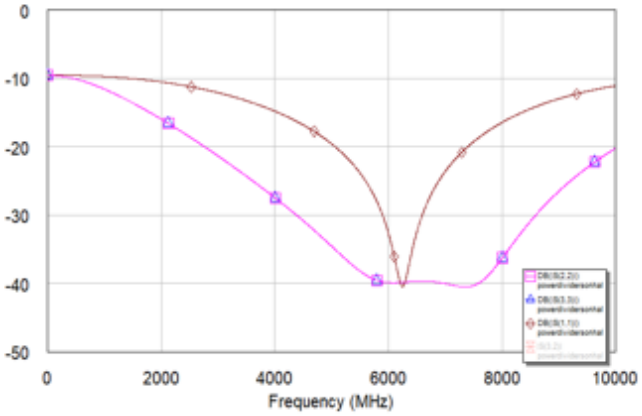

Figure 6. Matching Graphs

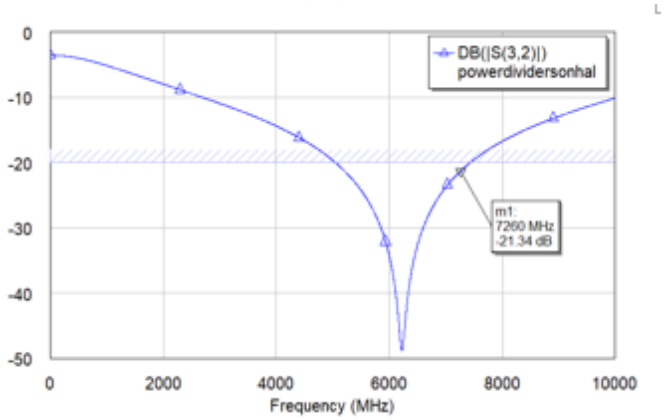

Figure 7. Isolation Graphs

Parameters resulting from the simulation of the designed circuit are given in table 2.

Table 2. The Results of Designed Circuit

Parameters	S Values	Ideal Values(dB)	Microstrip Line Values(dB)
Input Return Loss (Matching)	S11	$> -10\ dB$	$\cong -21.86\ dB$
Output Return Loss (Matching)	S22 S33	$> -10\ dB$	$\cong -44\ dB$
Insertion Loss (Transmission)	S12 S13	$= -3\ dB$	$\cong -3.34\ dB$
Isolation Loss (Isolation)	S23 S32	$> -20\ dB$	$\cong -21.34\ dB$

As mentioned in the first part, the power is expected to be divided equally on the two output ports. The designed WPD has also been studied to have a good match and isolation. While S21 AND S31 values are expected to be -3 dB, in practice this is impossible. The closer these values are to -3 dB, the better the results. The value obtained from the simulation results is-3.34 dB. Having good isolation is one of our main goals.

4. Conclusions and Recommendations

In this study, Wilkinson Power divider design that divides equal power has been made. In the simulation study, insertion loss, isolation loss, return loss values were obtained close to the desired values. It has been observed that the isolation between the output ports is provided. In future work, splitting power with more than one port will be studied and investigated.

5. Acknowledge

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