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Design of Wilkinson Power Divider for Mobile and WLAN Applications

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Abstract: *Power dividers are commonly used in microwave systems. One most popular configuration is Wilkinson power divider, due to its simplicity, good match at the input and output ports. However, it operates at single frequency but of large size especially at lower frequency band and there is presence of spurious harmonic. As the frequency increases, wavelength decreases. Conventional power divider operates at a fundamental frequency and odd harmonics. The component values were initially computed. Investigations on the configurations were performed using advanced design system software. It can be concluded that the modified power divider has been successfully designed to operate in 915 MHz and 2.4 GHz with equal power division of -3 dB at each output port for their respective applications.*

I. Introduction

Power dividers are passive devices which are used to divide the input signal power into many output ports or vice versa according to required design. The Wilkinson power divider plays an important role in communication systems, such as transceivers, phase arrays, and power amplifiers, due to its ease of design and good performance. The traditional Wilkinson power divider provides perfect input and output port matching, high isolation, and low loss in very narrow band.

One popular topology for 3 dB power divider is WPD because of its characteristic which is simple configuration, impedance matching at all ports and high isolation between the two output ports [1]-[3]. It can also perform an insufficient division under port mismatched and incomplete isolation at its even harmonics. However, the WPD is only optimized at single frequency due to the limitation of the quarter-wave transformer. It makes the size of PD large especially at the lower frequency band and due to the periodic characteristic of the transmission lines it has spurious pass band responses. The main factors of large in circuit size are because of the uses of two quarter-wavelength ($\lambda/4$) transmission line in each transmission path. It is possible to achieve small circuit sizes by replacing the $\lambda/4$ transmission lines with different architectures.

But the main advantage of divider is that all ports are theoretically matched and output ports are isolated from one another [4]. It is usual, but not mandatory, for the transmission from the input port to be identical to all output ports. It can be designed with different transmission line sections such as s strip line, coaxial, microstrip, airstrip and lumped element circuit topographies to realize its designs. Three-port networks cannot be reciprocal and matched without being lossy [5,6]. The solution to this, in the Wilkinson Power Divider, is to add a resistor between the two outputs. This resistor absorbs energy if there is a mismatch between the outputs. There are two types of Wilkinson power divider, namely equal power divider and unequal power divider. In our investigation equal power divider, which splits an input signal into two equal phase output signals, was designed and applied accordingly. Moreover, single-section and multi-section Wilkinson power dividers were constructed to operate in narrowband (11.5-12.5GHz) and broadband (6-18 GHz) regions respectively [7].The aim of this project is to design a planar WPD that has reduced size. It is designed by using Advanced Design Systems (ADS) software.

II. Design Methodology

Power divider usually employs quarter wave transmission line sections at the design center frequency, and Wilkinson power consists of two quarter wave line segments at the center frequency f_0 with characteristic impedance $\sqrt{2}Z_0$, and a $2Z_0$ lumped resistor connected between the output ports [7]. Such is the design of Wilkinson power divider that it provides low loss, equal-split (ideally 3 dB) matching at all ports and high isolation between output ports (figure 1) [8].

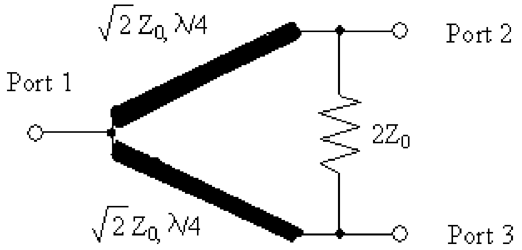

Figure 1 Wilkinson equal power divider

As shown in the figure above, there are four different sections [7].

1. Input port
2. Quarter-wave transformer
3. Isolation resistors
4. Output ports

Input and output ports are identical with impedance value Z_0 [7]. Quarter-wave transformer parts are characterized by the length of these parts, which are equal to one fourth of the wavelength of the electromagnetic wave, which is propagating in this three port network. This length is also related to the operation frequency λ g [9].

Nominal Wavelength λ_0 * Centre frequency f = Phase velocity V_0

Operation wavelength $\lambda g = \dfrac{no\min al\_wavelength\lambda 0}{\sqrt{\varepsilon r}}$

The quarter-wave transformers are used in the circuit since they lead to the matched ports. Matching of the output ports is necessary for better power transfer from input to output, because if the output ports are matched, the reflected power from the network when we input some amount of power is zero. This means, there is no reflection from the outputs and all of the power is transmitted to the output ports [7].

Isolation resistor is to isolate the output ports. If there is a coupling effect between output ports, in other words, the power comes from one output port has an effect on the other output port, the perfect division of the power would be impossible. This isolation resistor avoids the coupling effects of the output ports [7].Output ports are the terminals that divided power comes out. These ports have the same impedance value Z_0 as the input port [7].

III. Simulation And Measurement Result

The layout of the WPD has been designed is shown in Fig. 2. As for the results of the simulation of the 2-way WPD has been designed is shown in Fig. 2. The layout diagram useful for electromagnetic simulation can be generated from the schematic diagram at ADS2011.10 software. The layout diagram was further fine-tunedto improve its performance by changing a length of the λg/4 transmission line on ADS2011.10 software.

Layout of Wilkinson power divider of 915 MHz

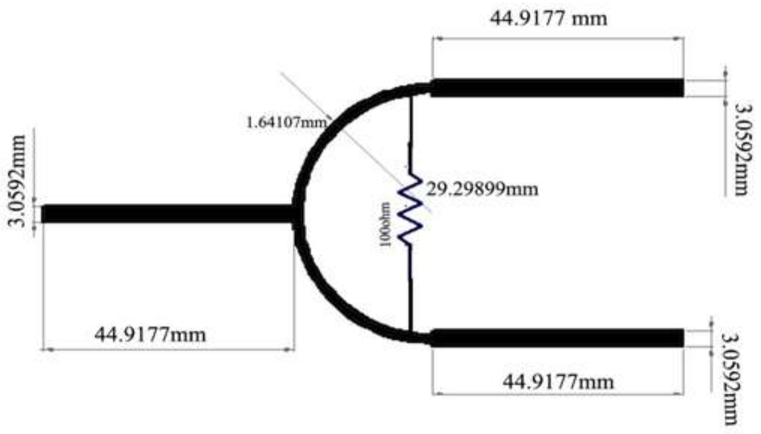

Figure2: Layout Diagram of Wilkinson Power Divider of 915 MHz

The result of this simulation contains graphs of the return loss, insertion loss and isolation of the WPD has been designed as depicted in Fig. 2. For the WPD, all the ports have excellent well matched with excellent return loss below -32dB. So that, the outputs power between the two output ports have a slightly different about 0.107 dB at frequency center, it's called as amplitude unbalanced. The isolation between the both output ports has good isolations about -54dB.

Result of Wilkinson Power Divider of 915 MHz

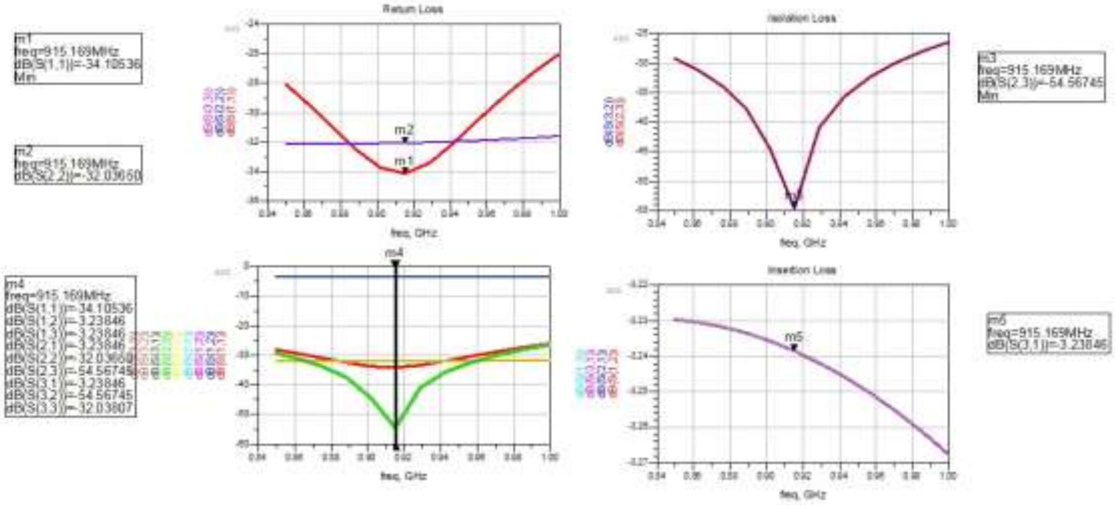

Figure. 4 Simulation Result of Wilkinson Power Divider of 915 MHzhas been designed.

Layout of Wilkinson power divider of 2.4 GHz

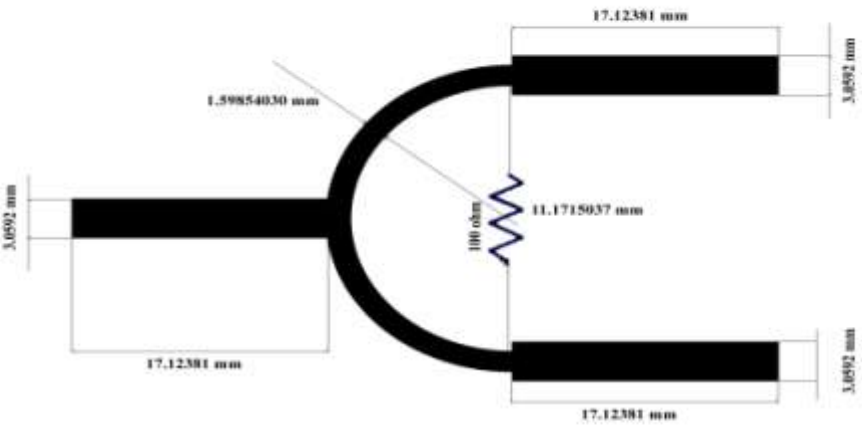

Figure3: Layout Diagram of Wilkinson Power Divider of 2.4 GHz

The result of this simulation contains graphs of the return loss, insertion loss and isolation of the WPD has been designed as depicted in Fig.3. For the WPD, all the ports have excellent well matched with excellent return loss below -28dB.So that, the outputs power between the two output ports have a slightly different about 0.107 dB at frequency center, it's called as amplitude unbalanced. The isolation between the both output ports has good isolations about -48dB.

Result of Wilkinson Power Divider of 2.4 GHz

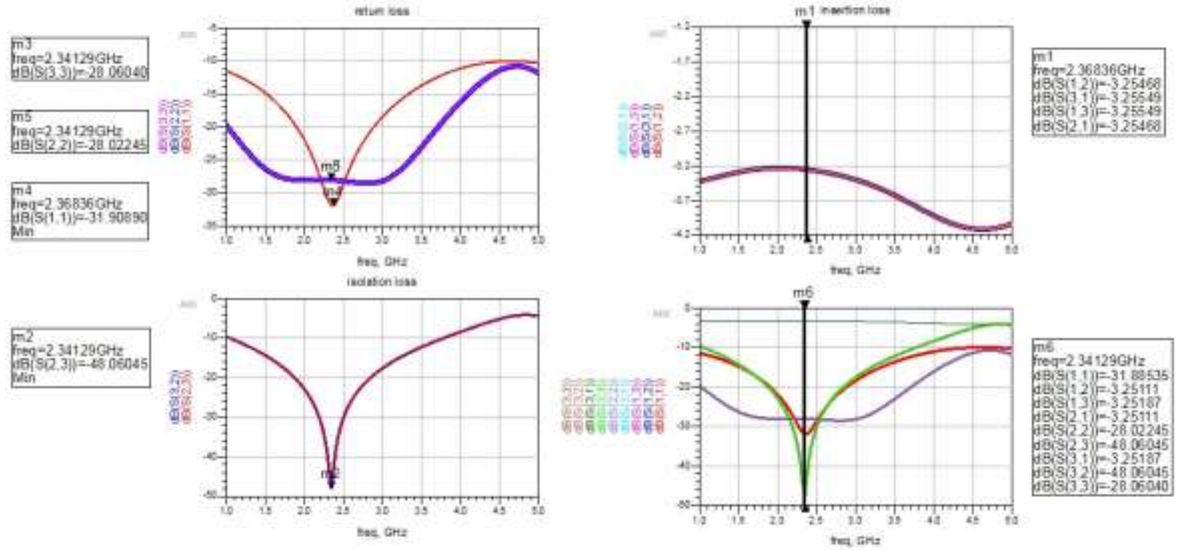

Figure.5 Simulation Result of Wilkinson Power Divider of 2.4 GHz has been designed.

Simulation and experiment results show that our proposed Wilkinson power divider performs well and the design method are applicable. The power dividing ratio is equal in the frequencies of 915 MHz and 2.4 GHz respectively and a good isolation effect at two output port can be obtained using the proposed design.

IV. Conclusion

Wilkinson equal power divider is a passive microwave component which could effectively divide input power into two identical output parts without any power loss, power gain ratio -3dB. It basically contains four parts: one input port, quarter-wave transformers, isolation resistor and two output ports. It was found that the isolated resistor absorbs no power, and the quarter-wave transformers length affects the output ports power gain. The insertion loss is above 20 dB for a frequency of 2.4 GHz. Possible errors and defects of Wilkinson power dividers were investigated to optimize the result in the design. The WPD has been successfully designed and simulated.

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