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A Novel Design of a Low Cost Wideband Wilkinson Power Divider

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***Abstract*—**This paper presents analysis and design of a wideband Wilkinson power divider for wireless applications. The design is accomplished by transforming the lengths and impedances of the quarter wavelength sections of the conventional Wilkinson power divider into U-shaped sections. The designed power divider is simulated by using ADS Agilent technologies and CST microwave studio software. It is shown that the proposed power divider has simple topology and good performances in terms of insertion loss, port matching and isolation at all operating frequencies (1.8 GHz, 2.45 GHz and 3.55 GHz).

***Keywords*—**ADS Agilent technologies, CST microwave Studio, Microstrip, Wideband, Wilkinson power divider.

I. Introduction

POWER dividers and combiners are the key components in microwave and millimeter-wave system [1]-[22]. A conventional Wilkinson power divider is implemented with quarter-wave transmission line and has narrow bandwidth around a single frequency [6]-[12], [17]-[19]. In recent years, many dual-band power dividers have been reported due to the development of multiband technologies. However, they don't involve the issue of unequal power dividing ratio, which has been proposed for single band operation [13]-[15].

In this paper, we propose a new design for Wilkinson power dividers that can be used to miniaturize a size and to get wideband. This Wilkinson power divider is design by converting each quarter wavelength section of the conventional power divider to its equivalent π-shaped transmission line section. The details of the procedures are described in the following sections.

The purpose of the Wilkinson Power Divider is to split the power of the input equally between two output ports, ideally without loss. It can also be used in the reverse direction – as

a power combiner. Other properties of the Wilkinson power divider is that all ports are matched, the two output terminals are isolated from one another, and that it is reciprocal.

Resiprocality means that you get the same result if you send the signal from one port to another in either direction.

Three-port networks cannot be reciprocal and matched without being lossy. 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. It also helps isolating the two outputs when the circuit functions as a power combiner.

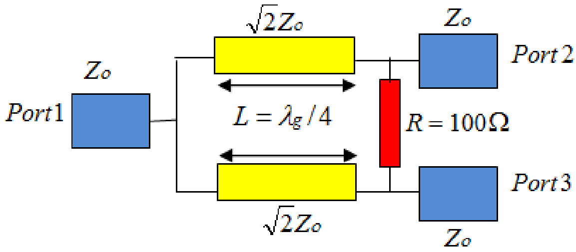

Fig. 1 The conventional Wilkinson power divider

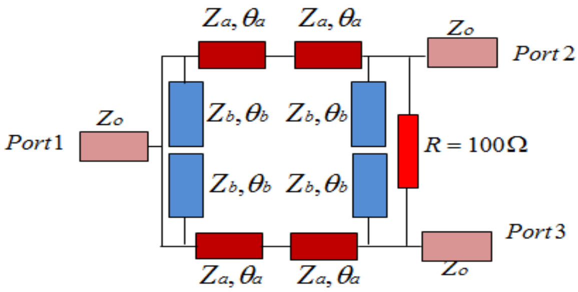

Fig. 2 The circuit of the proposed power divider

II. Design of Proposed Wideband Power Divider

One of the biggest drawbacks of the Wilkinson Power Divider is that it has a quite narrow bandwidth. This can be improved by adding stubs sections in a quarter-wavelength sections of the conventional Wilkinson power divider. Simple design equations for basic design geometry are discussed:

A. Quarter-Wavelength of Line Transmission Stage

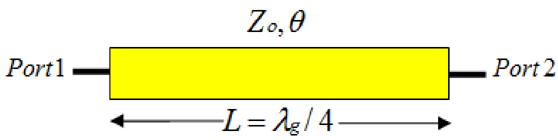

Fig. 3 The quarter wave-length transmission line

The ABCD matrix for the original transmission line, which is (λg/4) in length shown in Fig. 2 will be [6]:

$$M=\begin{bmatrix} A & B \\ C & D \end{bmatrix}=\begin{bmatrix} 0 & JZ_0 \\ JY_0 & 0 \end{bmatrix} \quad (1)$$

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B. π-Model

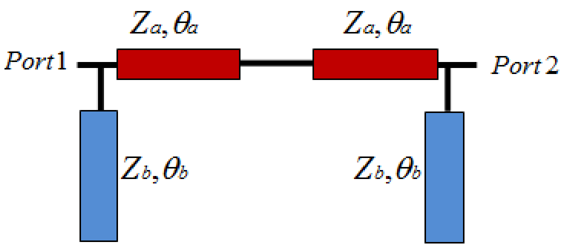

Fig. 4 Equivalent quarter wave-length transmission line of π-model

The ABCD matrix for the π-shaped transmission line section shown in Fig. 4 is:

$$M_a = \begin{bmatrix} \cos\theta_a & jZ_a \sin\theta_a \\ jY_a \sin\theta_a & \cos\theta_a \end{bmatrix} \quad (2)$$

$$M_b = \begin{bmatrix} 1 & 0 \\ jY_b \tan\theta_b & 1 \end{bmatrix} \quad (3)$$

According to the matrices M and Mπ, we obtain equations for the π -model as following:

$$Z_a = \frac{Z_0}{Sin(2\theta_a)} \quad (4)$$

$$Y_b \tan\theta_b = \frac{Cos(2\theta_a)}{Z_0} \quad (5)$$

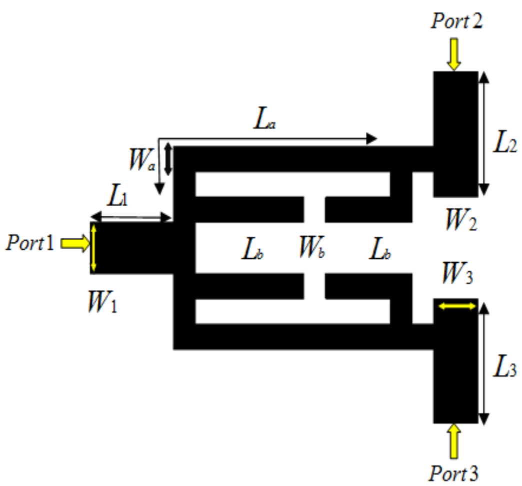

Fig. 5 Circuit the proposed power divider

After have determined the lengths electricals (θ_a,θ_b) and characteristics impedances (Z_a,Z_b), we use LineCalc tool/ADS in order to calculate dimensions (L_a,W_a,L_b,W_b) of transmission line. To account for the junction discontinuity effects, the power divider will be simulated by using a full-wave EM simulator (CSTMWS), and all the line lengths have been optimized, as shown in Table I, the schematic of the proposed power divider is shown in Fig. 5.

TABLE I
DIMENSIONS IN MM

Length	Width
L_1=4	W_1=2
L_2=L_3=5	W_2=W_3=2
L_a=11	W_a=1
L_b=5	W_b=1

III. Simulation Results and Analysis

To discuss and to simulate the performances of the proposed design, the return loss, the insertion loss and the isolation are evaluated by using ADS from Agilent Technologies and CST microwave studio. In the simulation, FR4 epoxy having a dielectric constant 4.4, loss tangent 0.025 and thickness of 1.58 mm is used, the resistor of isolation is 100 Ohm, the simulated S-parameters of the proposed coupler are presented below:

A. ADS Results

Fig. 6 shows the schematic circuit of proposed wideband power coupler. As we can see, its structure is relatively simple as it can be fabricated on a single layer printed-circuit board, with a simple ground plan, as following:

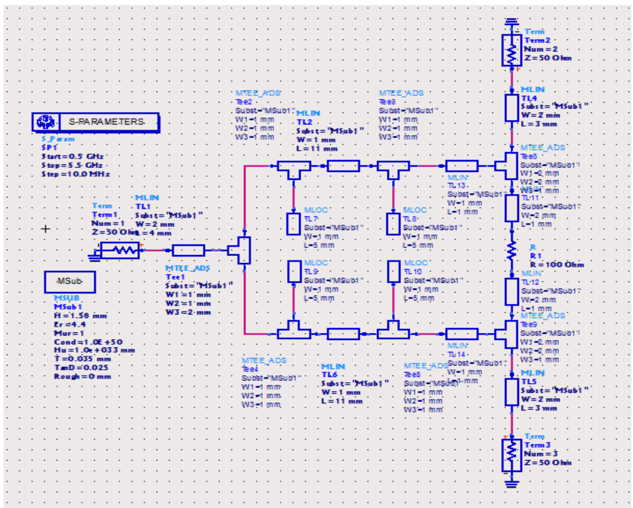

Fig. 6 The schematic of the power divider

According to the Fig. 7, it is observed that we have a good return loss over the frequency range from 1 to 3.8 GHz.

As shown in Fig. 8, the isolation between the two output ports was found to be good with the resistor connected between the two arms.

As shown in Fig. 9, ports 2 and 3 exhibit phase balance in the entire frequency band.

B. CST-MW Results

Fig. 10 shows the 3D structure of proposed wideband power coupler. As we can see, its structure is relatively simple as it can be fabricated on a single layer printed-circuit board, with a simple ground plan.

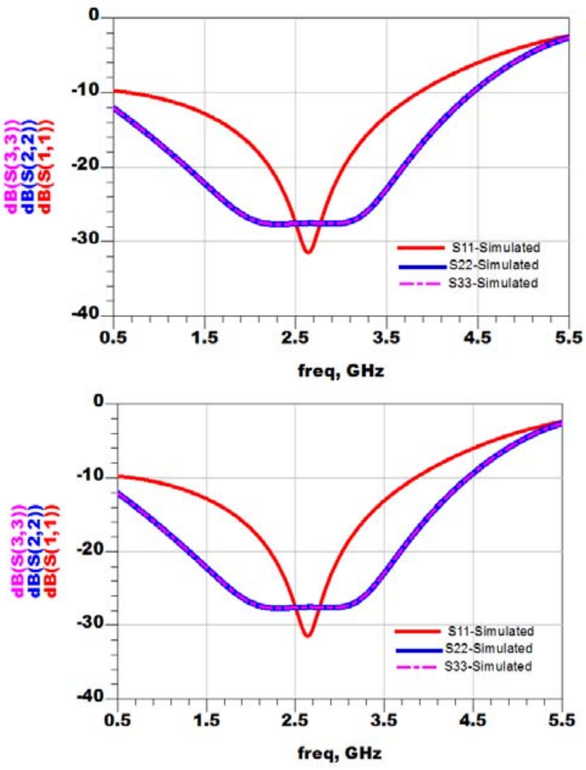

Fig. 7 Simulated return loss

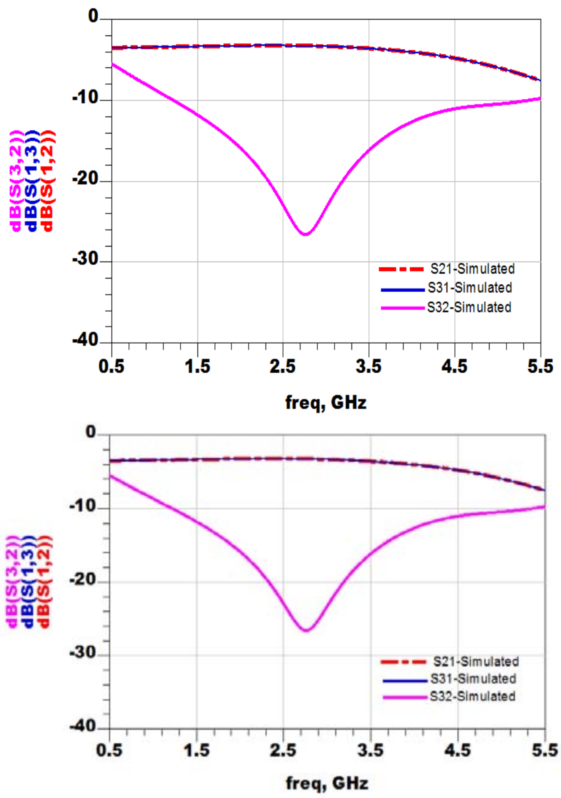

Fig. 8 Simulated transmission and isolation

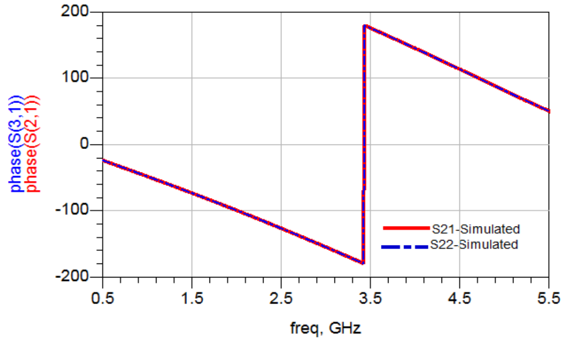

Fig. 9 Phase versus frequency

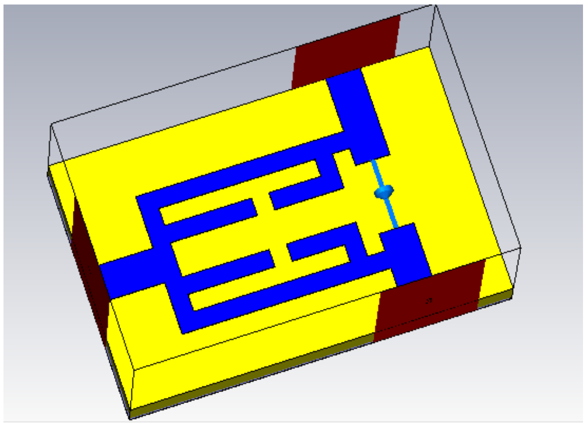

Fig. 10 The 3D coupler structure in CST-MW

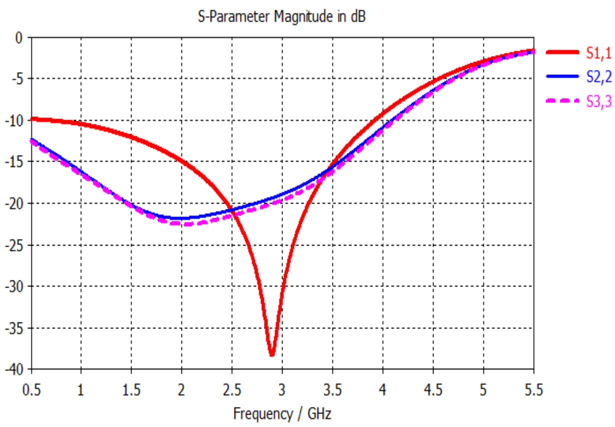

Fig. 11 Simulated return loss

According to the Fig. 11, it is observed that we have a good matching of the input impedance over the frequency range from 1 to 3.8 GHz.

As shown in Fig. 12, the isolation between the two output ports was found to be good with the resistor connected between the two arms.

As shown in Fig. 13, ports 2 and 3 exhibit phase balance in the entire frequency band.

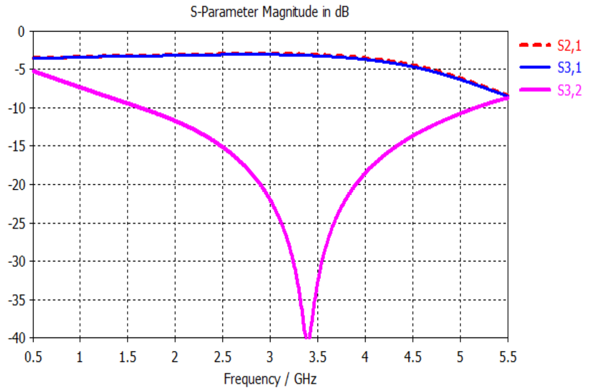

Fig. 12 Simulated return loss

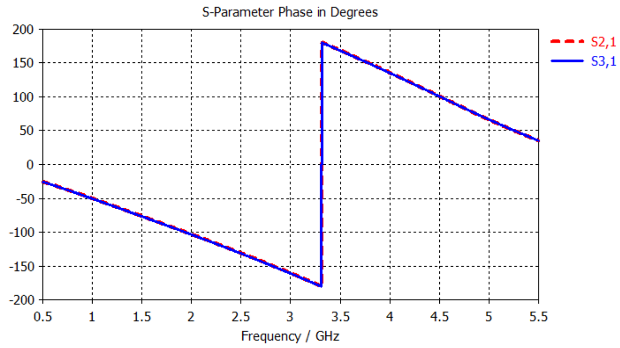

Fig. 13 Simulated return loss

After have shown the simulated the proposed design in two different softwares, we can deduce that there is found a good agreement between the simulated ADS Schematic and CST.

IV. Conclusion

This paper presents a novel design wideband equal Wilkinson power divider which can operate without reactive components. The proposed power divider can be fabricated easily and the parasitic effect can be greatly reduced. The formulas used to determine the design parameters have been validated into simulation. The wide band achieved permits the use of this power divider for telecommunication applications.

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