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Research paper

Design of compact wideband unequal wilkinson power divider with improved isolation

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Abstract

In this article, a compact unequal, planar Wilkinson power divider with ultra-wideband operation is proposed. The composed power divider having the size of 11.6 mm × 18.5 mm. It consists of one input and two output branches with individual resistive values. Two isolation resistors are used to provide better isolation between the two output ports. The impedance values of each transmission branch and isolation resistors is varied based on the output power division ratio i.e. (P2/P3). The ADS package simulated results of the designed unequal WPD satisfy the operating range (S11 ≤ -10 dB) from 2.5 GHz to 18 GHz and isolation are obtained over the entire frequency of operation.

Keywords: *ADS; EW Applications; Isolation Bandwidth; Micro strip Line; Phased Array Antennas; Unequal Wilkinson Power Divider*

1. Introduction

Recently, many printed antennas [8-18], [21-37] and Phase Array Antennas (PAA) [19-20] have been reported for wireless communication applications. In case of PAA power dividers plays a major role and the essential principle of the power divider or power splitter is to separate the given input signal at the input port into two or more output signals at the respective output ports with equal or unequal power distribution over the operating frequency range. Depending upon the range of operation and splitting ratio of input signal (equal or unequal) various power dividers [1-7] are used in RF Communication devices. A distinct unequal, planar, wideband, ultra-wideband power dividers has been presented in the literature with their own frequency operation and structure [1-7]. A typical Wilkinson power divider is presented and designing discussed in [1]. A specific set of equations are proposed by Ernest J. Wilkinson in 1960 [1]. Two types of commonly used power dividers are discussed in [1], one is corporate feed structure and another one is circularly symmetry connection. A three port microstrip unequal 4:1 Wilkinson power divider presented in [2]. The designed power divider works over the entire frequency range from 1.2 GHz to 1.8 GHz. A 2way (output) planar unequal power divider with division ratio of (5:1) is presented in [3]. It is printed on the substrate of thickness 0.8 mm and relative permittivity 9.6. The simulated and measured results show the operating range starts from 1GHz up to 2.5 GHz at resonant mode of 1.7 GHz. In [4], planar unequal split (10:1) Wilkinson power divider is proposed. The presented power divider designed by using the coupled transmission lines. The simulated and measured result satisfies the isolation and return loss -20 dB and 16% respectively. Wilkinson power divider with dc isolation is proposed in this paper [5]. It is printed on the Ro4350B substrate of thickness and relative permittivity 1.5 mm and 3.66 respectively. It is operated at the frequency of 2.4 GHz [7].

In this paper, a small in size (11.6×18.5 mm^2) Wilkinson power divider with unequal power splitting is designed on the RT5880 substrate and simulated. The simulated results such as return loss and isolation are obtained 2.5 GHz to 17 GHz and 15 dB respectively.

2. Power divider design & analysis

A regular unequal Wilkinson power divider consists of three ports is shown in Fig 1. It illustrates that 1 is input port and 2 and 3 are output ports. It splits the applied input signal power into two unequal output powers, named as P_2 and P_3 i.e. $P_2 \neq P_3$. It accommodates unequal length of quarter wave transmission branches with distinct impedance profiles. These impedance values can be varied depend upon the power division ratio at outputs P2/P3. The isolation resistor R1 is placed in between the two output branches to provide the better isolation.

The line impedance and isolation resistor values can be calculated by using the design equations shown in below (1) – (5). An additional isolation resistor R2 is inserted at the end of transmission lines is shown in Fig 2. It provides isolation among the Ultra-wideband range

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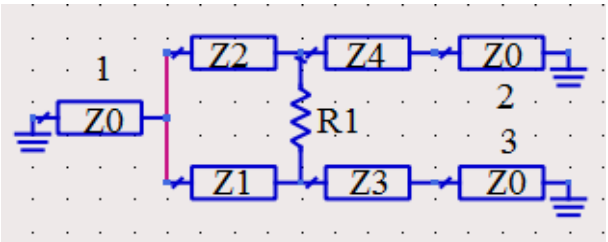


Fig. 1: Traditional Unequal Wilkinson Power Divider.

$$Z_1 = Z_0\sqrt{\frac{1+K^2}{K^3}} \quad (1)$$

$$Z_2 = K^2 Z_1 = Z_0\sqrt{K(1+K^2)} \quad (2)$$

$$Z_3 = (Z_0/K) \quad (3)$$

$$Z_4 = Z_0 K \quad (4)$$

$$R_1 = Z_0\,(K + \frac{1}{K}) = R_2 \quad (5)$$

Here Z_0 is input impedance and K^2 is Power division ratio, the output impedances can be terminated with the input impedance Z_0. The varied impedance values are calculated and tabulated below in the Table 1.

Table 1: Rate of Impedance

K^2	Z_1	Z_2	Z_3	Z_4	R1= R2
2	39.5	79.0	35.3	70.7	106.1
3	30.4	91.2	28.9	86.6	115.5
4	25.7	103	25.0	100	125.0
5	22.8	114	74.7	34.5	134.2
10	15.8	158	88.9	28.1	174.0

By using these impedance values the Wilkinson power divider is designed and generated the simulated layout of the respective transmission branches of the power divider. The generated layout of the designed unequal Wilkinson power divider is shown in Fig 3. It shows 1 is input port, 2 and 3 output ports respectively. Z1, Z2, Z3, Z4 and R1=R2 impedance costs can be selected based on the power division ratio K^2, according to the Table 1.

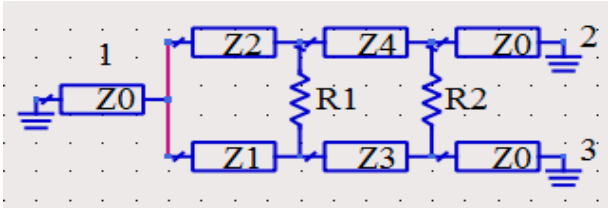


Fig. 2:.Presented Unequal Wpd.

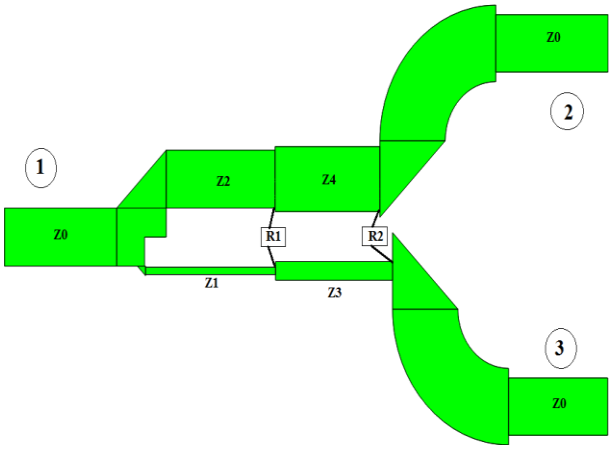


Fig. 3: Generated Layout of Proposed Wilkinson Power Divider.

3.2. Simulated, results and discussion

The composed unequal Wilkinson power divider (UWPD) designed on the RT5880 substrate of 1.5 mm thickness and permittivity 4.4, in ADS tool. The total volume of the designed Wilkinson power divider is 11.6 × 18.5 × 1.5 mm^3. The designed Wilkinson power divider covers the frequency spectrum bandwidth is 15.5 GHz with starting frequency 2.4 GHz to 17 GHz. Figure 4 and 5 Shows the simulated return loss of power divider and operated at the deep resonant frequency of 6 GHz.

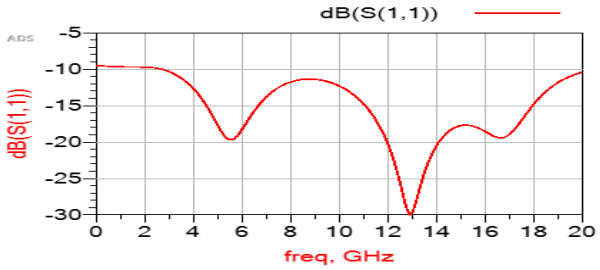


Fig. 4: Simulated Results of Return Loss.

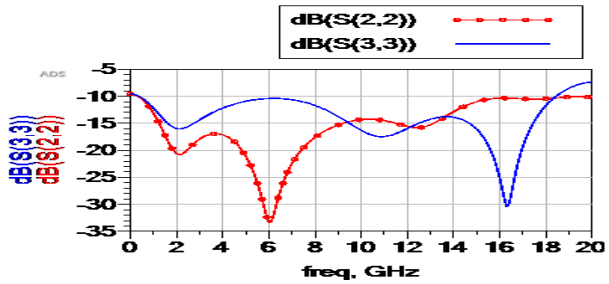


Fig. 5: Simulated Results of S_{22}, S_{33}.

The proposed Wilkinson power divider simulated return loss and isolation between the ports 2 and 3 results are shown in Fig 6. It indicates the maximum isolation is occurred at resonant frequency 16 GHz around 50 dB. The proposed Wilkinson power divider insertion loss at port 2 and port 3 is shown in Fig 7. It indicates the maximum isolation is obtained at resonant frequency 16 GHz around 50 dB. The phase relation of S(1,3) and S(1,2) is simulated and plots compared with each other, shown in Fig 8.

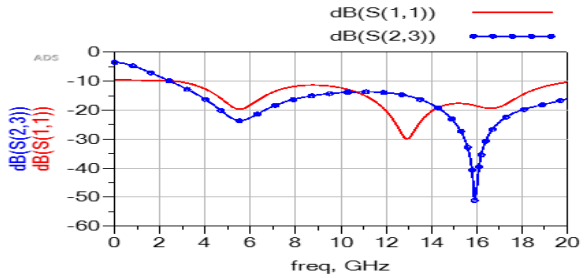


Fig. 6: Simulated Return Loss and Isolation At Port 3.

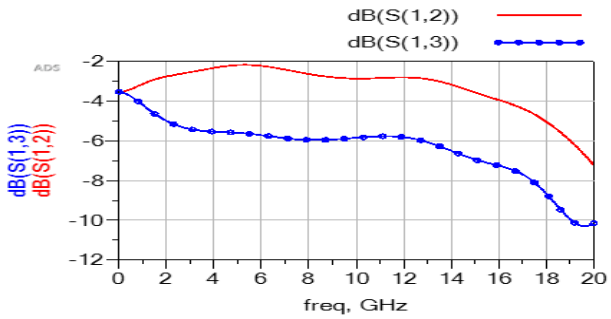


Fig. 7: Simulated Insertion Loss at Port 2 and Port 3.

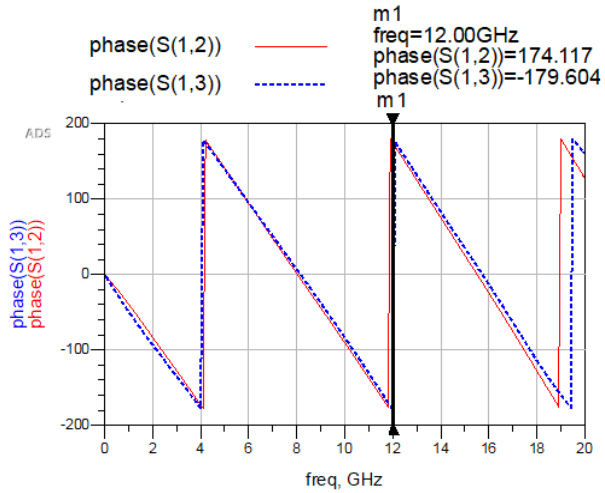


Fig. 8: Simulated Phase Relation S (1, 2), S (1, 3) Vs Frequency.

3. Conclusion

A simple planar, microstrip based 1 to 2 unequal Wilkinson power divider (UWPD) is designed and simulated on RT5880 substrate of 1.5 mm height. From the ADS software package analysis, it is seen that the proposed structure is operating in the ultra-wideband (UWB) frequency range i.e. 2.5 GHz to 18 GHz.

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