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Research paper

Simulation, design of unequal five way wilkinson power divider for EW applications

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Abstract

This paper deals with the design and simulation of unequal 5-way Wilkinson power divider used for Electronic Warfare (EW) applications. The frequency range of operation intended for this design is 6 GHz to 18 GHz. The proposed Wilkinson power divider is designed on a low cost FR-4 substrate having height of 1.5mm, relative permittivity of 4.4 and loss tangent of 0.02. The design occupies a size of 11mm x 33 mm x 1. 5 mm. Equal split Wilkinson power dividers are utilized for implementation of this design. High isolation has been obtained throughout the frequency range of 6 GHz to 18 GHz. The design procedure is discussed. The simulated results are presented by using ADS simulation software.

Keywords: *Wilkinson Power Divider; Micro Strip; ADS; FR-4.*

1. Introduction

The research on printed multiband/wideband antennas [10-17] and [20-41] and array antennas [18-19] have grabbed lot interest to the design engineers. Power dividers [1-9] are passive devices that are widely used in RF (Radio Frequency) subsystems and also find application in Microwave environments. Corporate feed with power dividers is often employed in antenna arrays [18-19]. The purpose of a power divider is to split a given input signal and it can also be used reciprocally to combine multiple signals. The main criteria required for power dividers are reciprocity being lossless and being matched at all ports and also to provide better isolation. The N-Way Power divider was described by Wilkinson in 1960 [1]. But the cylindrical shape presented in the design may not be suitable for all applications. Unequal power split is often required when realizing dividers with more than three ports [2]. The conventional Wilkinson power divider provides narrow isolation bandwidth. So in [3] Multistage Power dividers presented for improved bandwidth is discussed. At higher frequencies, the length λ/4 (90 degrees) is not sufficient to curve the branches. To get around this 3λ/4 (270 degrees) can be used [4].Also, at lower frequencies hybrid designs involving port extensions to Wilkinson power divider [5] and lumped element isolation networks [6]- [8] are proposed. At higher frequencies the topologies involving complex isolation networks using R, L and C's find limited usage due to parasitic effects. A small size wide band unequal Wilkinson power divider is reported in [9]. Below in Figure 1 is the standard Wilkinson power divider when N =two [1].

In article, the proposed design makes use of equal split Wilkinson power divider design (WPD). A modified 3-way is presented with one less isolation resistor when compared to [1]. The 2-way is a normal equal split power divider with no modifications. Overall, one 3-way WPD and two 2-way WPD are used in the proposed design.

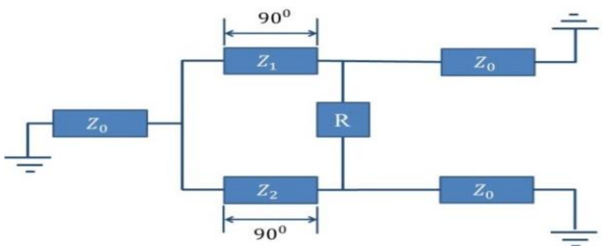

Fig. 1: Schematic Model for Wilkinson Power Divider.

2. Design of unequal 5-way power divider

The power divider is realized using microstrip. The substrate used is FR4 with substrate height 1.5mm and thickness of conductor of 0.016 mm. In this a modified 3-way, 2-way Wilkinson power dividers are used. The required impedances are in Figure 2. The impedance values are calculated from [1], [2] and the equations (1)-(5) required are given.

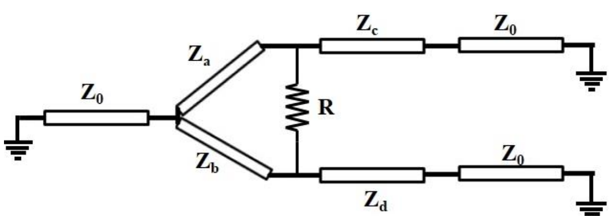

Fig. 2: Schematic Model for Unequal Wilkinson Power Divider.

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

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

$$Z_c = Z_0\sqrt{K} \quad (3)$$

$$Z_d = \left(\frac{Z_0}{\sqrt{K}}\right) \quad (4)$$

$$R = Z_0\left(\frac{1+K^2}{K}\right) \quad (5)$$

Where 'Z_0' is the system impedance.'K' is power split ratio.'R' is Isolation resistor.

Since 6 GHz to 18 GHz is the chosen frequency band for the operation of power divider, a center frequency of 12 GHz is chosen, which is used as design frequency to compute impedance and phase length. The calculations are performed through use of ADS MLIN tool. After placing them they are further tuned and optimization algorithms in ADS are used to get required characteristics. A layout is designed based on the impedances and lengths calculations. The layout is simulated on ADS Momentum simulation tool to get EM simulation data. The EM data is used for further simulation with resistor values. The block representation of the design is given in the Fig 3 and the layout of modified 2-way is presented in Figure4, modified 3-way is presented Figure 5 and the overall 5-way is presented in Figure 6.

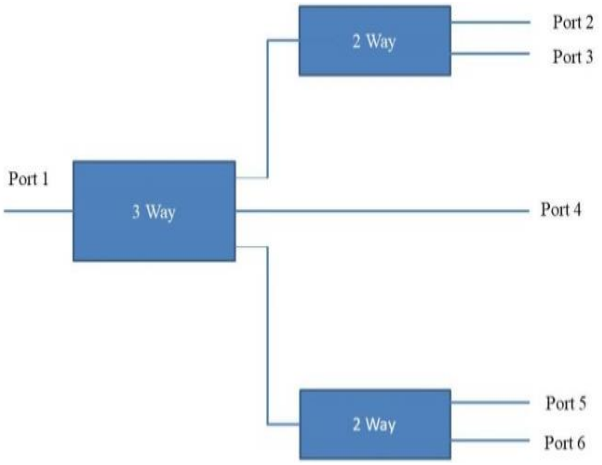

Fig. 3: Block Diagram for Proposed Design.

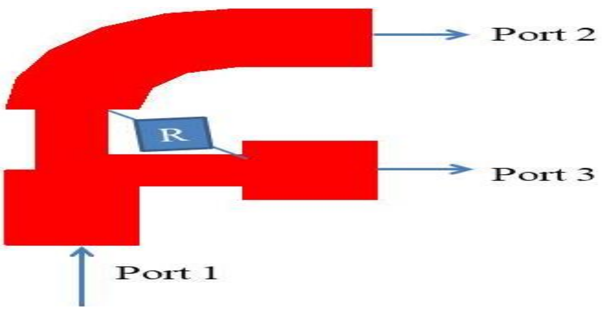

Fig. 4: Layout of the Modified 2-Way Wilkinson Power Divider

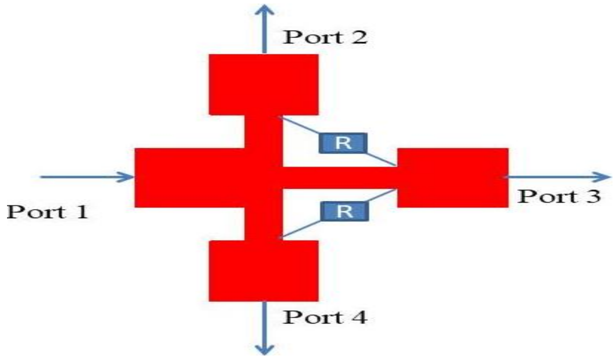

Fig. 5: Layout of the Modified3-Way Wilkinson Power Divider

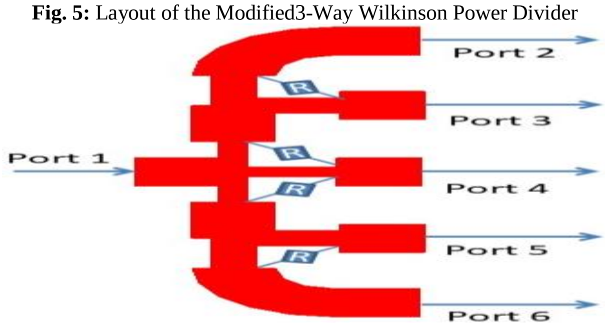

Fig. 6: Layout of the Unequal 5-Way Wilkinson Power Divider.

Here 'R' isolation resistor is taken as 50Ω after tuning in the ADS design tool.

3. Simulated results

The results are simulated using ADS 2016.01 and are presented below. The return loss data of all the ports is given in Figure 7, isolation between output arms is given in Figure 8 and insertion loss is given Figure 9.

The return loss obtained is nearly below -10 dB across the whole frequency range of 6 GHz to 18 GHz and at centre frequency of 12 GHz we obtain about -20 dB on average across all ports. The isolation between all the output ports over the entire frequency of operation is below -10 dB and at centre frequency we obtain about -20 dB average isolation. From 8 GHz to 17 GHz at least -15 dB of isolation is obtained. The insertion loss is different for port 4 and remaining ports due to the fact that port 4 is direct output from the 3-way power divider whereas others are outputs from 2-way power dividers. So, we get lower insertion loss of about -5 dB at port 4 and at other ports average of -13 dB is observed at centre frequency of 12 GHz. This can be attributed to equal power split of 3-way power divider which results in 2–way getting (1/3)rd of the total power. This can be adjusted by means of changing the impedance on the output arms of the 3-way power divider.

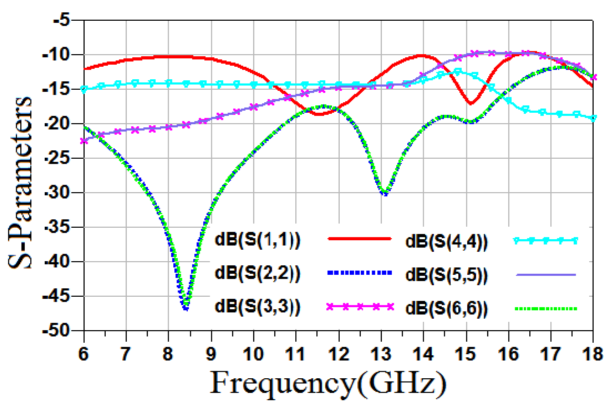

Fig. 7: Return Loss of the Proposed Design.

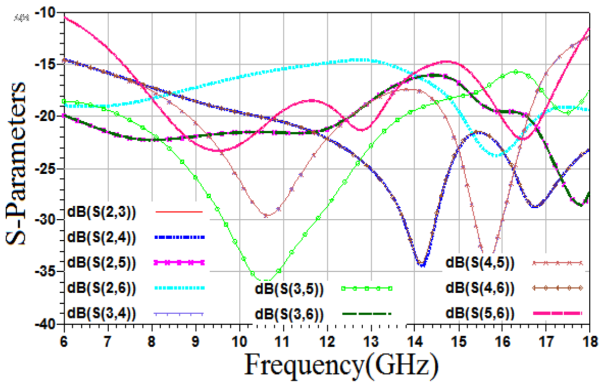

Fig. 8: Isolation of the Proposed Design

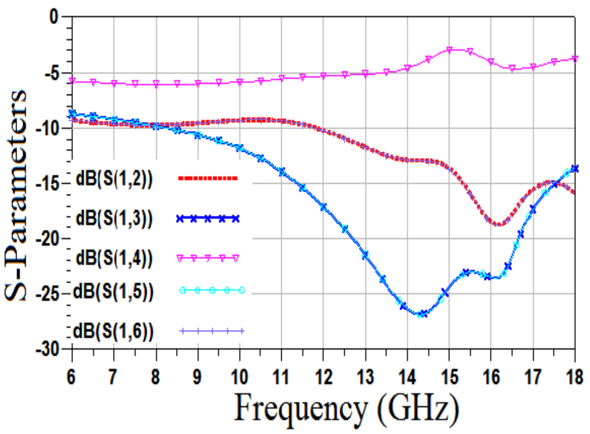

Fig. 9: Insertion Loss of the Proposed Design.

4. Conclusion

Unequal five way Wilkinson power divider for EW Applications is designed and simulated making use of 3-way Wilkinson power divider and 2-way Wilkinson power divider. The design makes use of low cost and easily available FR4 substrate. The whole design is compact in size with 11mm x 33mm x 1.5mm as overall area. The results obtained

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