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Design and Analysis of a Compact Hybrid Equal and Unequal Power Divider with Wide Isolation

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Abstract— *In this paper, a novel compact Hybrid Power divider is work at 2.4Ghz frequency band application. The hybrid power divider consists of two transmission lines, a pair of symmetric and asymmetric coupled lines for equal or unequal power-dividing ratio. Hybrid power dividers are simulated and investigated.*

Comparing to the conventional power divider, the new power divider save its arbitrary and non arbitrary power dividing ratio. The proposed power divider is fabricated using FR4 substrate with thickness of 1.6 mm. The dimension of the power divider is 42 mm × 68 mm. The proposed power divider has typical power division of –3 dB and -6dB and better than –15 dB of isolation, less than –10 dB returns loss from 1.0 to 4.0 GHz.

Keywords— **Arbitrary power division, coupled line, Wilkinson power divider, wideband Asymmetric microstrip line, and hybrid power divider.**

I. INTRODUCTION

The Wilkinson Power Divider is a specific class of power divider circuit that can achieve isolation between the output ports while maintaining a matched condition on all ports.

Emerging applications of radio frequency and microwave technologies demand miniaturized broadband components that accommodate multiple functionalities and high performance at low cost. There has been a paradigm shift in the design and development of microwave systems recently. A definite emphasis can be observed towards broadband systems as opposed to narrowband systems. Microwave broadband power dividers find applications in modern high data rate wireless communications, Microwave imaging systems, Software Defined Radio (SDR), Cognitive Radio, Ultra-Wide Band (UWB) radio etc. Broad band power dividers are used for distributing or tapping signals in various radio frequency and microwave communication subsystems. Broad band Power dividers having different structures are reported in [1]-[12] by researchers. In [1]-[2], design of broadband power dividers is reported using Lange couplers. Broadband frequency response is the advantage of Lange coupler, but wire bonding is the critical issue which limits the highest frequency.

Recently, the design of unequal split Wilkinson power dividers (WPDs) with high power split ratio has attracted much attention and interest. Many papers presented the design of equal and unequal branch line couplers [1-6]. In [7], a single substrate was proposed for the design of unequal and equal split WPD. In many applications, there is a need to use microstrip Wilkinson power divider with unequal power division ratio. However, for the unequal Wilkinson power divider with high power dividing ratio, the characteristic impedance of one of the microstrip lines becomes high.

The double-sided parallel strip-lines have been proposed to realize high characteristic impedances and an unequal Wilkinson power divider has been fabricated by this technique [8]. However, implementations of these methods have some difficulties, because the proper transition between microstrip and double-sided parallel strip- line is needed. The grooved substrate has been proposed for realizing the power divider with high dividing ratio [9]. However, fabrication of the grooved substrate is a little difficult in comparison to the conventional microstrip line. In this paper Hybrid power divider and broadside coupled lines, a novel two-way broadband equal and unequal power divider is reported in this paper using narrow microstrip line. This power divider can be treated as modification to the one in with a symmetric and asymmetrical coupled lines replaced by to achieve equal or unequal power division. In this proposed system, coupled micro strip line with the quarter wave transmission lines in the top layer. Symmetrical broadside coupled lines have been used as the key element to construct equal broadband power divider. The power divider has several advantages such as size compactness, inherent band pass characteristics and fabrication ease.

II.ANTENNA CONFIGURATION

A. Broadband Equal And Unequal Power Divider

Symmetric couple line microstrip structure has been used to design broadband equal power divider with 158% bandwidth. Fig. 1 depicts the proposed broadband hybrid power divider. The overall structure is different from the conventional Wilkinson power divider. This structure equally divides the power over wide frequency band using symmetric coupled lines and unequal power divide using asymmetric microstrip coupled lines. The power divider is constructed on soft substrate having thickness of 1.6mm, permittivity of 4.4 and loss tangent of 0. 0027.

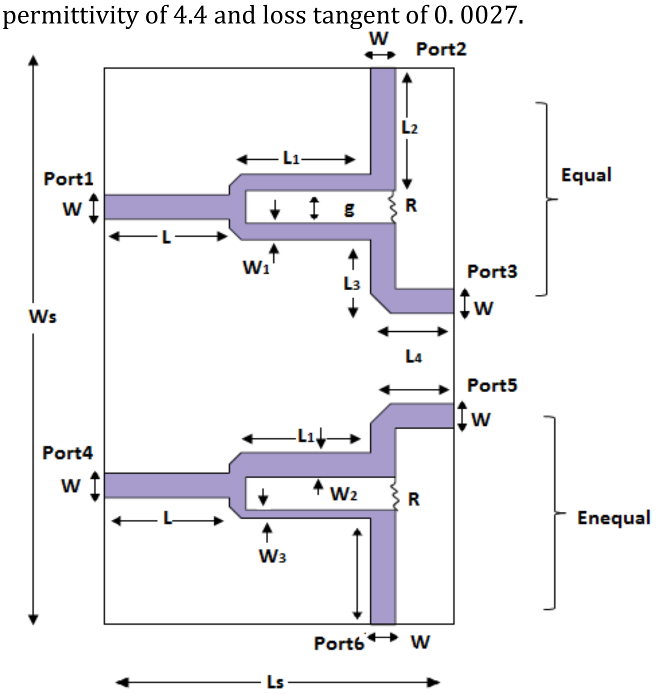

Fig. 1. Proposed broadband power divider

As shown in Fig. 1, transmission lines in the top layer and the ground plane on backside of substrate. The centre frequency of the power divider is 2.5GHz and broad side coupled lines are quarter wave long at 2.4GHz. Lengths L1 can be varied to alter the centre frequency. L1 are quarter wave at the centre frequency of operation and spacing between the coupled lines 'g1' controls the coupling of power between the arms. The proposed power divider, Maximum fractional bandwidth of 148% can be achieved using wider the width of coupled line. In the design, a R=100Ω resistor is placed between the coupled lines in the upper and lower power divider as shown in Figure 1 to achieve good isolation between the output ports. When power incident at port1 then equal power ratio will be getting at port2 and port3 and power lunch into port 4 then unequal power will be getting at port4 and port6.

TABLE I. Dimensions of proposed power divider

Dimensions	**Values(mm)**
L	15
W	3
L1	17
L2	13.5
W1	2.0
W2	3.0
W3	1.0
L3	6.5
L4	7.0
G	4
Ls	42
Ws	68

The proposed equal power divider was simulated using HFSS software and the results are shown in Fig. 2. It is clear from the results that the operating frequency band is from 1 GHz to 4GHz (148%). It is observed from the simulations that the proposed power divider performs the integrated actions of band pass filter and power divider. Physical dimensions of the proposed power divider are listed in Table I.

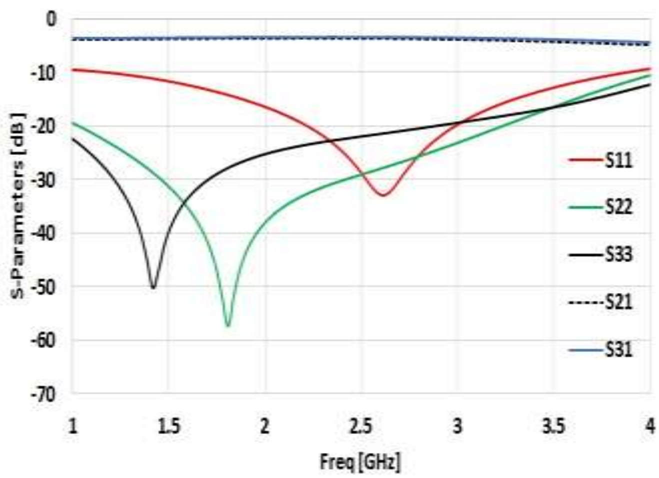

Fig. 2. S-parameters results of the proposed equal power divider

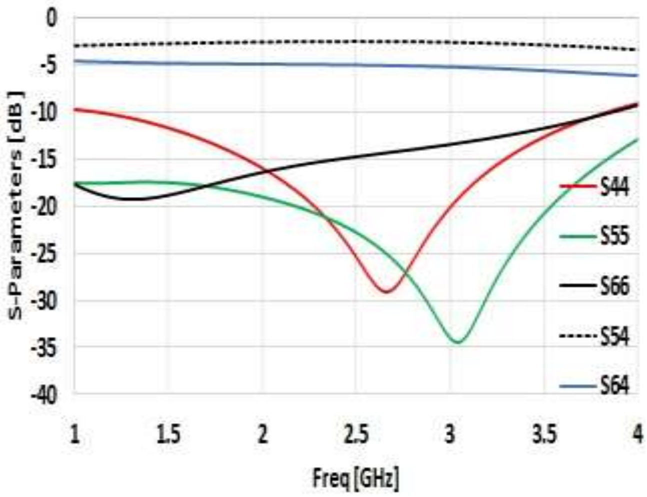

Fig. 3. S-parameters results of the proposed unequal power divider

Simulation results show that proposed power divider exhibits broadband frequency characteristics (1GHz to 4GHz). Simulated insertion loss of the equal power divider is 0.2dB and the amplitude variation between the ports is within ± 0.2dB. The isolation between the ports is more than -20dB. The input/output return loss of the power divider is better than -15dB.

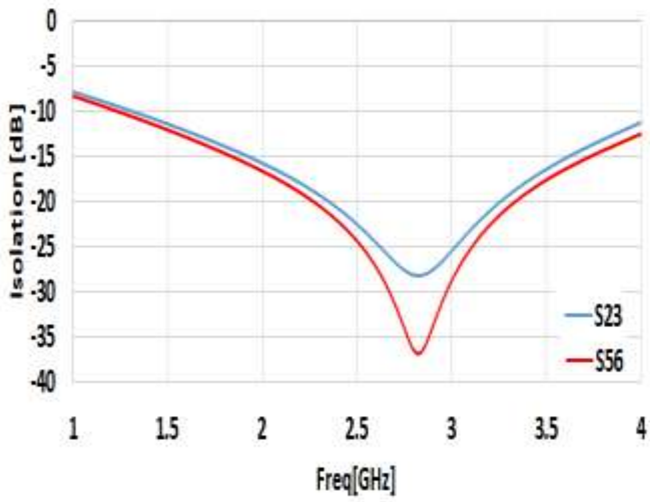

Fig. 4. Isolation of the proposed unequal power divider

III. CONCLUSION

This paper has presented a novel hybrid broadband equal and unequal power divider. The design is based on broadside coupled microstrip lines. An experimental power divider has been manufactured and tested to verify the electrical performances. The coupled power is 3.4dB at port2 and port3 over 1.2GHz to 3.2GHz at the output of equal power divider and the coupled power is -3.4dB at port5 and -5.6 port6 over 1.2GHz to 3.2GHz at the output of unequal power divider. The return loss at all the ports is better than -15dB. The simulation results of the modified power divider showed a 116% fractional bandwidth. It also achieved good impedance matching, equal and equal power splitting and high isolation performance over the range from 1.0-4.0GHz.

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