Miniaturization of Bagely Polygon Power Divider using Dual Transmission Line Technique

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Article Info

Abstract

In this paper, the technique of dual transmission lines is applied to the quarter wavelength arms of the Bagley Polygon Power Divider and the overall size of the power divider is considerably reduced. The ($\lambda/4$) arm line between the 1st port and the 2nd and 3rd port is replaced by a dual arm with lengths ($\lambda/6$) and ($\lambda/3$) each and the ($\lambda/2$) arm between the 4th port and the 2nd and 3rd port is replaced by a length of ($\lambda/12$). The proposed design is simulated in ADS and the return loss performance is found to be greater than 18dB and the power division between the output ports is equal and approximates to the ideal value. A size 38.5% is achieved.

1. Introduction

Microwave power dividers are passive components which are useful in diving the power between input and a number of output ports. There are numerous power dividers like Wilkinson Power Divider [1], Gysel Power Divider [4] etc. Recently one of the power dividers which attracted more attention is based on Bagley Polygon [5]. The design of power dividers based on Bagley Polygon is very easy to fabricate since it does not use any lumped components.
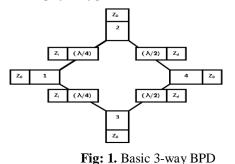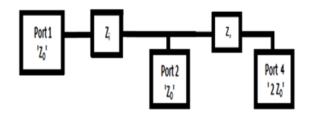
The main focus of recent advancements is that the size reduction of the power dividers, enabling multiple and wide bandwidth. The size reduction techniques which are present are given below. In [5] an open stub is utilized between two transmission line sections, in [6] two composite right/left handed (CRLH) transmission lines is used, in [7] non-uniform transmission lines is used, in [9] π-shaped s7ection is used, in [10] deflected ground structure is employed.

In this paper, we propose a novel design of 3-way power divider based on Bagley polygon using dual transmission lines.
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2. Basic Theory

2.1 Bagley Polygon Power Divider

Fig: 1. Basic 3-way BPD

The power divider based on Bagley polygon consists of one input and n-number of output ports. The immediate arms from the input port is of quarter-wavelength and the remaining arms between the output ports are of half-wavelength. Equal power division is obtained by appropriately setting the impedance values of the corresponding arms. The equivalent circuit can be formed by dividing the power divider by virtue of equal symmetry.

Fig: 2. Equivalent Circuit

3. Miniaturization

3.1 Modifications

The two modifications are made to miniaturize the basic Bagley polygon power divider and the modified equivalent circuit is given in fig 3.1.1.

1) The impedance of the arm between the output ports 'Z_d' is made equal to '$2Z_0$' and there by nullifying the impedance mismatch between port '4' and port '2' & '3'.
2) The single impedance arm between the input port '1' and the output ports '2' & '3' is split into two.
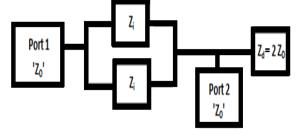3) The impedance of the dual arms is doubled

Fig: 3. Equivalent circuit of modified BPD

Fig: 5. Layout Model

3.1.2 Trial and Error Method

The idea behind miniaturization is to suitably vary the electrical lengths of the split impedance arms. One arm is made larger in relative to the other arm. The larger arm is suitably designed to meander within the smaller arm so that the overall size can be reduced. The trial and error method is employed to find the best possible lengths of the three modified arms. A tabulation of the performance of the power divider for various electrical length combination is given in the table 3.1.2. The power divider divides the power equally between the three output ports and gives a satisfactory performance when the dual arm electrical lengths are made 110º and 60º and the arm between the output ports is made equal to 30º.

Table: 1. S_{11} values for various combinations of electrical lengths

$\boldsymbol{\theta_1}$	$\boldsymbol{\theta_2}$	$\boldsymbol{\theta_3}$	S_{11}
90	60	30	-16dB
100	60	30	-18dB
110	**60**	**30**	**-20dB**
120	60	30	-17.7dB
130	60	30	-14dB
140	60	30	-10dB

4. Proposed Design

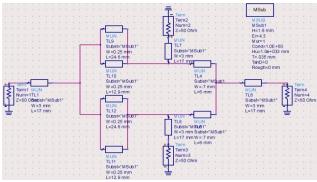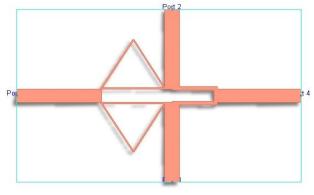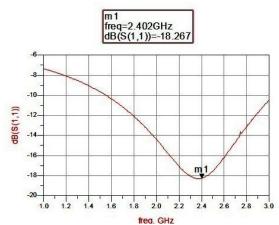The proposed design is simulated after applying the modifications in ADS
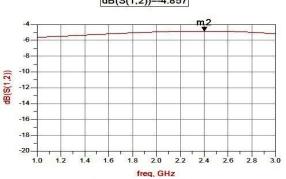
Fig: 4. Proposed Design

The proposed design is realized using a substrate of FR4 of 1.6mm thickness and permittivity of 4.3. The copper strip thickness is about .035mm as shown in the figure 4.2
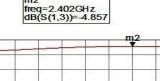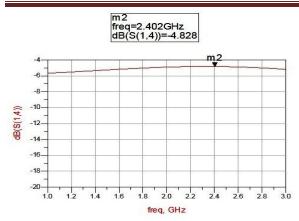
5. Results

m2
freq=2.402GHz
dB(S(1,4))=-4.828

37.5 mm^2 which is a miniaturized size compared to the basic design which is 78.5 x 44.4 mm^2. The size reduction achieved is **38.5%** compared to the basic design.

7. Future Work

- Isolation between the output ports can be improved
- Dual transmission line technique can be replaced by triple transmission lines and further
- miniaturization can be explored
- Even though the size between the arms of the ports have been reduced, the size of the terminating impedance at the ports remain the same. They can be reduced by the technique of Deflected Ground Structure (DFS).

6. Conclusion

In this paper the size of a basic 3-way Bagley polygon power divider is reduced by employing dual transmission line technique. The size of the fabricated design is 56.9 x

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