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Design of Compact Branch Line Coupler

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Abstract. The objective is to design a compact branch line coupler to operate at a 2.4GHz frequency. The branch line coupler focuses on -3dB power division with 90^0phase difference. T-shaped structure is used to construct the compact branch line coupler. Conventional branch line coupler is also designed and counterfeit using ADS software along with the compact branch line coupler for comparison. The S-parameters for the both coupler are counterfeit and compared. The simulation results of compact branch line coupler had Better return loss, isolation, amplitude and phase difference are all accomplished. Using the proposed method 44% size reduction is achieved. Many microwave applications and integrated circuits, such as amplifier, phase shifters and balanced mixers use branch line couplers.

Keywords. Branch line coupler, T-shaped structure, Transmission lines, compact, size reduction.

1. Introduction

Directional coupler is a waveguide junction with four ports. It is made up of two waveguides: primary waveguide 1-2 and a secondary wave guide 3-4. When all of ports have been terminated in their respective impedances, in ports 1 and 2,powers is transmitted freely without any reflection and there is no power transmission between the ports 1 and 3 or in between ports 2 and 4 since there isn't any coupling between two pairs of ports. The degree of coupling between ports1 and 4 and ports 2 and 3 is determined by the coupler's structure. Many microwave applications and integrated circuits, such as amplifiers, phase shifters and balanced mixers used branch line coupler .Branch line coupler can be used as either power divider or power combiner or a part in mixer. Coupler size is large at low frequency. So many techniques are there to make coupler in compact size, For example patch with T slot, lumped object, slow wave structure, stubs with open end etc.

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2. Related works

M.Y. Algumaei, et al.,(2018) [1] said Balanced Mixer using Compact BL, frequency rateis 3.1–10.6 GHz.Li Chang and Tzyh-Ghuang Ma et al.,(2017) [2] proposed DualBL/Rat-Race Coupler.Kyo-Soon Choi et al., (2014) [3]said compact BLCalong suppression with t-shaped model.Chih-Jung Chen et al .,(2013) [4] proposed a model where coupler wins 29% fractional bandwidth.He-XiuXu et al.,(2012) [5] proposed RL Handed Transmission Line.Myun-JooPark et al.,(2007) [6] proposed BL (stubbed), transforming balun based on BL structure. The operating frequency is0.75 GHz to 1.25 GHz. J.-L. Le et al., (2007) [7] proposed balunwith enhancement of the bandwidth. The operating frequency is1.5 GHz.Compared to the conventional type a circuit of capacity 20% is gained in this model. Hani Ghali et al., (2004) [8] has designed the Miniaturized Fractal Rat-Race, Branch-Line, and Coupled-Line Hybrids.Space-fitting curves have been used to realise a family of miniaturized hybrid.H.R. Ahn et al., (1994) [9] depicted a new technology for mini sized 3 dB terminated by arbitrary types utilizingelements is presented &the operating frequency is 900 MHz.

3. Structure Description and Analysis

Branch-line coupler is designed using microstrip structure. Branch-line coupler is a kind of directional coupler. Usually it is 3dB, 4 ports directional couplers having 90^0difference between two output ports. Also denoted as quadrature hybrid made of microstrip. In symmetrical four port, First port is named as Input port, second and third port as output ports and fourth port as isolated port.

Table 1. BLC dimensions

Parameter	Zo	Zo/√2
A	1.530	1.128
Width (W)	3.058mm	5.235mm
Effective permittivity (∈eff)	3.330	3.491
Length (L)	17.12mm	16.723mm

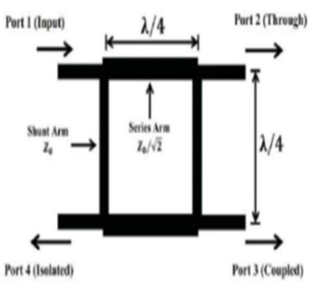


Figure 1. Structure of BLC

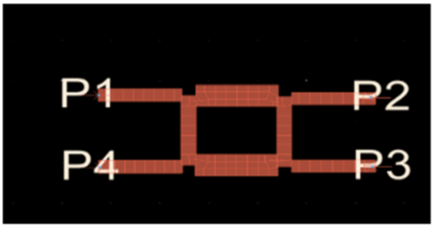
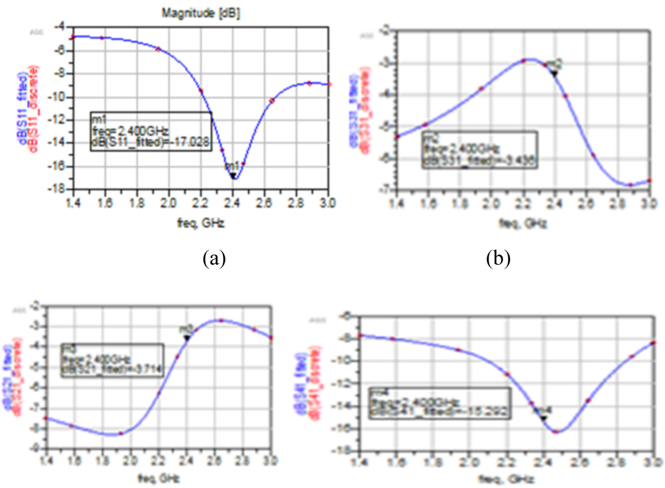


Figure 2. Layout design of Branchline coupler using ADS software

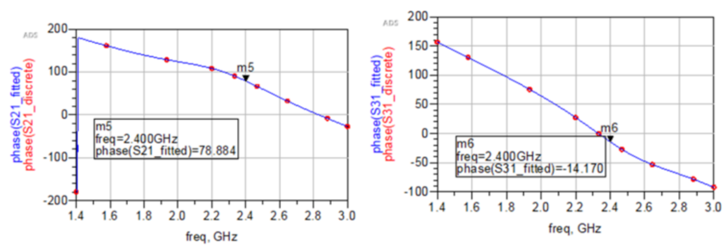


(a) (b)

(c) (d)

Figure 3(a). Simulation results S_{11} **(b).**S_{21} (c)**.**S_{31} **(d).** S_{41}

The Fig 3(a) depict the simulation result of BLC operating at 2.4 GHz. The S-parameter $S_{11}$is obtained as -17dB for operating frequency of 2.4 GHz. Thus above Fig 3(b) & 3(c) shows S_{21}& S_{31} which are -3.7 dB and -3.4 dB respectively. Fig 3(d) the shows that the value of S_{41} is -15.29 dB.



(a) (b)

Figure 4(a). Phase of S_{21} **4(b).**Phase of S_{31}.

The simulated phase values are shown in Fig 4 (a) and (b). The phase is obtained for S_{21} is 78^0 and phase is obtained for S_{31} is -14.17^0. Thus the total phase difference is 92^0.

4. Size Reduction Technique

Branch line coupler architecture is proposed. Size of conventional BLC is reduced using T-shaped model. In this method, (λ/4) length trans-mission line is implemented using T- shape structure. T-shaped model consists of 2 transmission lines,1 shunt open stub resides middle of 2 series lines. λ/4 transmission line is substituted by T-shaped structure.

The equation for Z_2 and Z_3 are

$Z_2 = Z_1 \cot\theta_2$ ……………[1]

$Z_3 = \cos^2\theta_2 \tan\theta_3/(1-2\sin^2\theta_2)$ …………..[2]

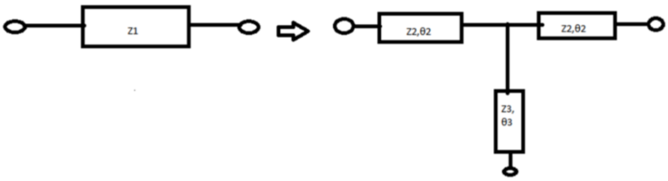


Figure 5. λ/4 Transmission line is transformed to T- shaped structure .

Table 2. Dimesions of compact BLC

	Horizontal section		Vertical section	
Parameters	Z_2=61.22	Z_3=30.22	Z_2=5.649	Z_3=42.75
A	1.8355	0.986	2.5319	1.331
Width(mm)	2.164	4.770	1.0367	3.929
E_{eff}	3.277	3.458	3.08	3.4
Length(mm)	5.823	5.649	5.935	5.649

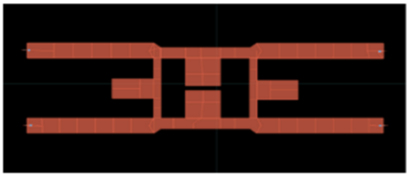
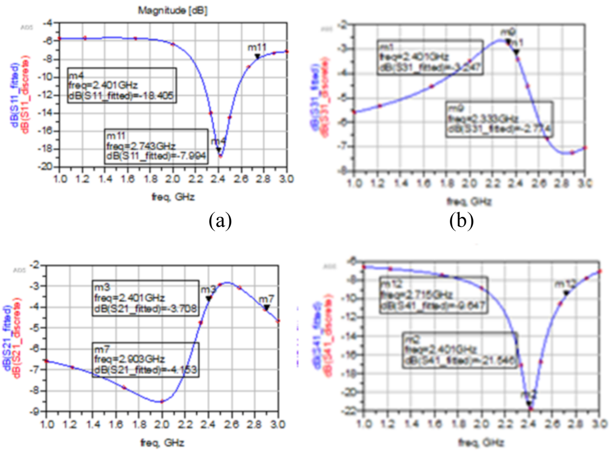


Figure 6. Layout of compact Branchline coupler using ADS software

5. Results And Discussion



(a) (b)

(c) (d)

Figure 7.(a) Simulated Results S_{11} **(b).** S_{21} **(c).** S_{31} **(d).** S_{41}

The Fig 7(a) shows the simulation result of compact BLC operating at 2.4 GHz. S-parameter S_{11} is obtained as -16.87 dB. Thus above Fig 7(b)& 7(c)counterfeitS_{21}& S_{31} are -3.9 dB and -3.1dB respectively. The Fig 7(d) shows S_{41} is -18.992 dB. The phase got for S_{21} is 80.1^0 and phase is obtained for $S_{31}$is -3.9^0. Total phase difference is 84^0.The size and counterfeit S-parameters of BLC (compact) is compared with BLC (conventional) and depicted in Table 3.

Table 3. Comparison of conventional BLC and compact BLC

Parameters	Conventional BLC	Compact BLC
S_{11}(dB)	-17.028	C
S_{21}(dB)	-3.7	-3.9
S_{31}(dB)	-3.4	-3.1
S_{41}(dB)	-15.242	-18.992
Phase difference of S_{21} and S_{31}	92^0	84^0
Size of the coupler	1547.68mm^2	867.6mm^2

The size of the designed BLC (compact) is 867.6 mm^2. The size of the BLC (conventional) is 1547.68 mm^2. Thus the proposed method achieved the size reduction of 44%.

6. Conclusion

A compact BLC is modeled using T-shaped structure operating at 2.4 GHz The said so design shows that overall capacity reduction of 44% is obtained when compared to conventional BLC. The counterfeit S-parameters of compact BLC are weighted with the conventional BLC. Thus the overall response of compact BLC characteristic have two -3 dB outputs with 90^0 of phase.

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