

Miniaturization and harmonic suppression of the branch-line coupler based on radial stubs

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Abstract: In this article, a compact branch-line hybrid coupler (BLC) which can suppress upper order harmonics of the conventional BLC is proposed. By adding a radial stub in the center of each branch, a compact BLC which can suppress the upper order harmonics are achieved. The proposed BLC is designed and simulated at 0.93 GHz. The proposed structure is 27% of the conventional BLC, while maintaining the characteristics of the conventional BLC at the center frequency. There are two transmission zeroes at 3.6 and 5.6 GHz. The third upto seventh harmonic are suppressed at least 20 dB.

Keywords: branch-line hybrid coupler, compact size, harmonic suppression, microstrip transmission line, radial stub

Classification: Microwave and millimeter wave devices, circuits, and systems

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1 Introduction

The Branch line hybrid coupler (BLC) is one of the extremely important circuit components in various fields of microwave engineering. It is usually constructed by using the two part quarter-wave transmission lines, which limit Branch line coupler operation around the center frequency and at the odd harmonic frequencies. The quarter wavelength transmission line occupies a significant amount of circuit size at low frequencies. The several compact BLCs have been proposed to improve its circuit size [1, 2, 3, 4]. Also, modern microwave systems require harmonic suppression of the BLC to avoid interband and interband interference. Recently, a few design methods have been introduced for miniaturization and harmonic suppression of the BLC [5, 6, 7, 8, 9]. In [5, 6], the defected ground structure (DGS) and microstrip electromagnetic bandgap (EBG) structure are proposed to suppress upper order harmonics and miniaturization of the conventional BLC.

However, the EBG and DGS, need etching process and extra fabrication efforts. Although in [7], the spiral compact microstrip resonance (SCMR) cell has been proposed for harmonic suppression and size reduction, the SCMR cell needs high impedance microstrip transmission line for resonator, and its fabrication is a little complex. In [8], by using the T-shaped transmission lines and in [9] by using the P-shaped transmission lines, compact BLCs which can suppress upper order harmonics are achieved. However, straight stubs are not desirable at higher the frequencies with low line characteristic impedances.

In this article, a novel compact microstrip BLC which can suppress upper order harmonics is introduced and designed.

2 Proposed BLC

The geometry of the proposed BLC is presented in Fig. 1 (a). The proposed BLC consists of several transmission microstrip lines and radial stubs. The equivalent lumped element circuits of transmission microstrip line and radial stub are showed in Fig. 1 (b) and (c), respectively [10, 11, 12]. The Radial stub is a wideband microstrip element which is well-known in microwave

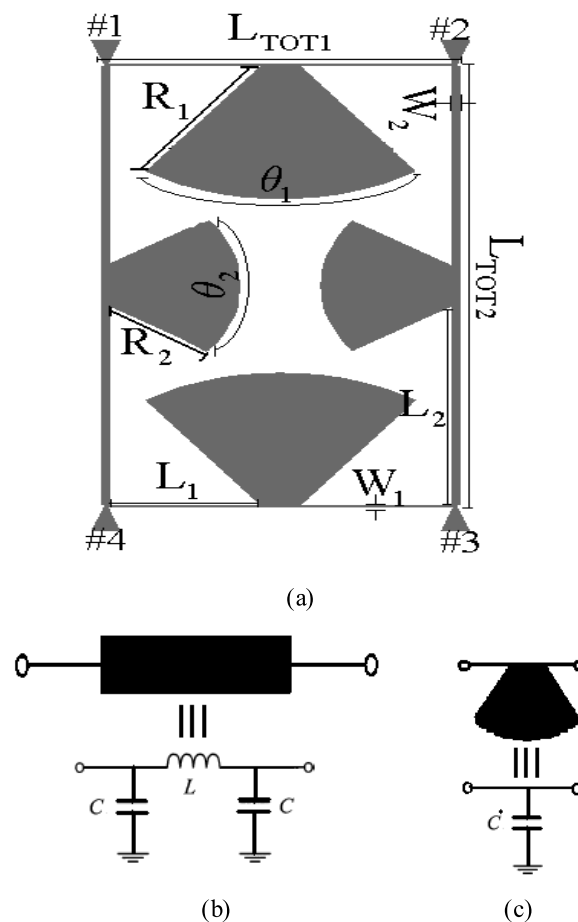


Fig. 1. (a) The geometry of the proposed BLC, (b) Equivalent circuit of single transmission line, and (c) radial stub.

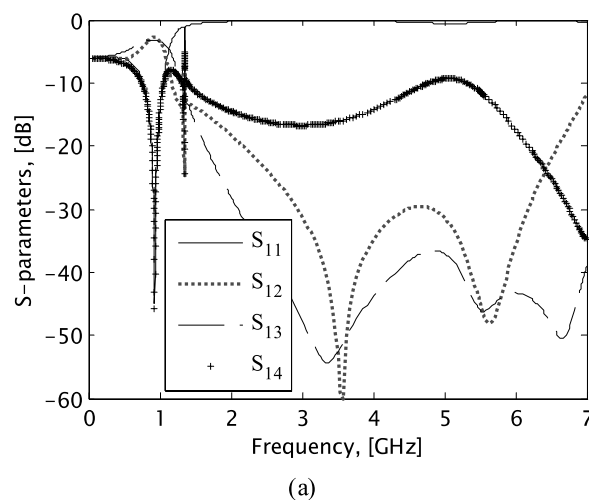
circuits. Generally, a radial stub and its variant have been used for bandstop applications such as bandstop and passband filters [12, 13, 14, 15, 16]. The radial stub works better than low impedance straight stubs as an accurate localization of a zero-point impedance is needed, and it can maintain the lower impedance level over a wide frequency range. Also it has wider stopband and better impedance matching.

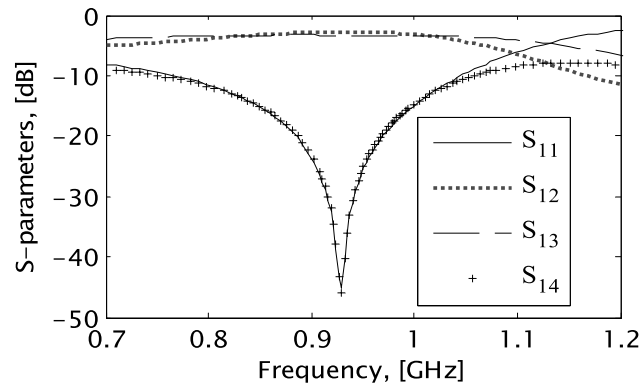
3 Simulation and results

The proposed BLC is designed and simulated on a substrate with a thickness of 0.79 mm and a relative dielectric of 3.38 by using commercial software Advanced Design System (ADS). The fundamental frequency for the proposed BLC is 0.93 GHz. The software-optimized geometrical parameters of the proposed BLC are listed below: $L_1 = 7.6$ mm, $L_2 = 16.2$ mm, $L_{TOT1} = 18.7$ mm (0.095λ), $L_{TOT2} = 36$ mm (0.18λ), $R_1 = 10.34$ mm, $R_2 = 6.1$ mm, $W_1 = 0.2$ mm, $W_2 = 0.5$ mm, $\theta_1 = 70^\circ$, and $\theta_2 = 70^\circ$. Simulated results are displayed in Fig. 2. In the passband, the insertion losses of the proposed BLC ($|S_{12}|$ and $|S_{13}|$) are greater than 3.5 dB from 0.8 to 1 GHz. The return loss and isolation are better than 20 dB from 0.89 to 0.97 GHz. Phase difference of the proposed BLC is 90° . In the stopband, rejection levels are larger than 20 dB from 2.17 to 6.6 GHz. A comparison of BLCs for the miniaturization and harmonic suppression is summarized in Table I. The proposed BLC is very useful to use in the balanced mixer, due to it can suppress upper order harmonic of the oscillator signal and the input signal. In order to investigation the effect of R_1 and L_2 on the insertion loss ($|S_{12}|$), simulated results are depicted in Fig. 2 (d) and (e), respectively. As R_1 is increased, the first transmission zeros are moved to lower frequency region. When L_2 is decreased, the second transmission zeros are moved to higher frequency region.

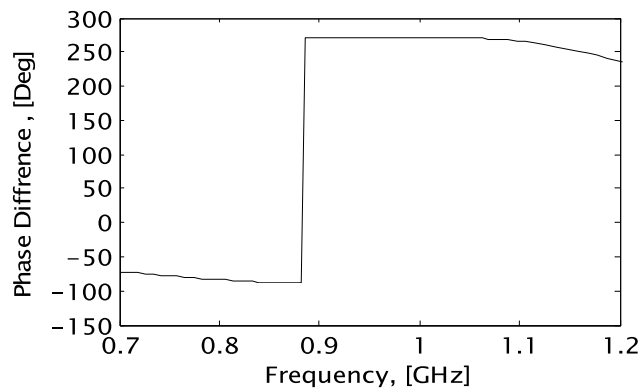
4 Conclusion

In this article, a novel compact BLC has been proposed and designed by using radial stubs. The proposed BLC has a wide rejection level and can suppress the second to seventh harmonic. Relative size of the proposed BLC is 27%

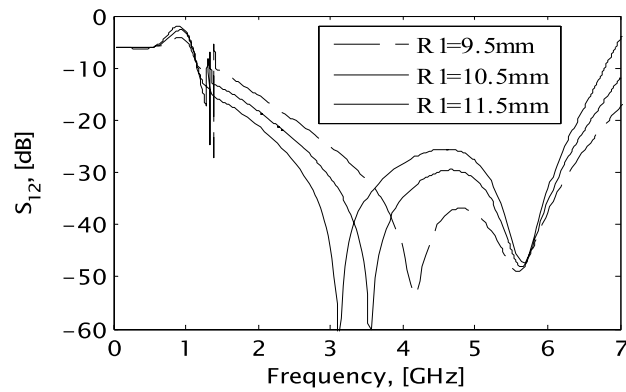




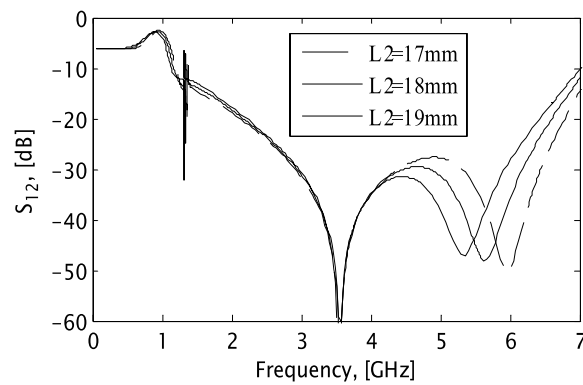
(b)



(c)



(d)



(e)

Fig. 2. S-parameters of the proposed BLC. (a) Magnitude from 0.05 to 7 GHz, (b) Magnitude from 0.7 to 1.2 GHz, (c) Phase difference, (d) effect of R_1 , and (e) L_2 on the insertion loss ($|S_{12}|$).

Table I. Performance summary of the published BLC and this work.

| Ref. | Harmonics suppression($\min(S_{12} , S_{13})$) (dB)> 20 dB | | | | | | | Relative area (%) | technique | Center frequency (GHz) |
|------------|--|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-------------------|---------------|------------------------|
| | 2 nd | 3 rd | 4 th | 5 th | 6 th | 7 th | 8 th | | | |
| This paper | no | yes | yes | yes | yes | yes | no | 27 | Radial Stub | 0.93 |
| [5] | no | yes | yes | yes | yes | yes | yes | 35 | DGS | 1 |
| [6] | 18dB | yes | no | no | no | no | no | 35.86 | EBG | 1.35 |
| [7] | yes | yes | no | no | no | no | no | 24 | SCMRC | 2.4 |
| [8] | no | no | yes | no | no | no | no | 50 | T-shaped line | 2 |
| [9] | no | yes | yes | yes | no | no | no | 37 | P-type line | 2.4 |

of the conventional one, while operates as well as conventional one at the center frequency. There are two transmission zeroes at 3.6 and 5.6 GHz. 20 dB-wideband of the passband is 9% of the center frequency. The proposed BLC has excellent impedance matching, low insertion loss, and excellent isolation in the passband.

Acknowledgments

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