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Research Article

A Novel Coupled Line Directional Coupler Design for L-Band Wireless Applications

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Abstract

Directional couplers are commonly used in microwave circuit design. Therefore, miniaturization of these components is very important. This paper presents the miniaturized microstrip coupled line directional coupler (CLDC) for L-band wireless applications. The coupled line directional coupler presented in the article was designed and simulated. In this paper coupler line directional coupler has been proposed with a low coupling factor. The proposed CLDC operates at the L-band and it is designed for use in mostly wireless applications. High and low impedance transmission lines are used to miniaturize the CLDC. The CLDC has been designed using a substrate material of FR-4 with a dielectric constant of 4.3 and substrate thickness of 1.57 mm. The size of the designed CLDC is 33.4 x15.05 mm^2. This is 58 % less than are of the conventional coupled line directional couplers. Also, The reflection coefficient and isolation level are in the permissible level in order for the proposed CLDC to be utilized in L-band wireless applications. The coupling factor of the designed coupled line directional coupler is between 28 dB and 21 dB at the L-band. The measured return loss value is better than 19 dB. Same time the isolation value is better than 23 dB at L-band.

Keywords: Coupled Line Directional Coupler (CLDC), Wireless Applications, L-Band, FR-4 Substrate, Miniaturization

L Bandı Kablosuz Haberleşme Uygulamaları İçin Yeni Kuplör Tasarımı

Özet

Yönlü kuplörler mikrodalga devre tasarımında yaygın olarak kullanılmaktadır. Bu nedenle, bu bileşenlerin minyatürleştirilmesi çok önemlidir. Bu makale, L-bant kablosuz uygulamalar için minyatürleştirilmiş bağlaşık hatlı yönlü kuplör tasarımı (CLDC) sunmaktadır. Makalede sunulan bağlaşık hatlı yönlü kuplör tasarlanmış ve simule edilmiştir. Makalede önerilen bağlaşık hatlı yönlü kuplörün kuplaj faktörü oldukça düşüktür. Önerilen CLDC L bandında çalışmaktadır ve çoğunlukla kablosuz haberleşme uygulamalarında kullanılmak üzere tasarlanmıştır. Aynı zamanda CLDC'nin boyutlarını küçültmek için yüksek ve düşük empedanslı iletim hatları kullanılmıştır. CLDC, dielektrik sabiti 4,3 ve kalınlığı 1,57 mm olan FR-4 malzemesi kullanılarak tasarlanmıştır. Tasarlanan CLDC'nin boyutu 33.4 x15.05 mm^2 'dir. Bu, geleneksel bağlaşık hatlı yönlü kuplörün boyutundan %58 daha küçüktür. Ayrıca önerilen CLDC'nin L-bant kablosuz haberleşme uygulamalarda kullanılabilmesi için yansıma katsayısı ve izolasyon seviyesi izin verilen seviyededir. Tasarlanan bağlaşık hatlı yönlü kuplörün kuplaj faktörü L bandında 28 dB ile 21 dB arasındadır. Ölçülen geri dönüş kaybı değeri 19 dB'den , izolasyon değeri ise L bandında 23 dB'den daha iyidir.

Anahtar Kelimeler: Bağlaşık Hatlı Yönlü Kuplör (CLDC), Kablosuz Haberleşme Uygulamaları, L-Band, FR-4 Malzeme, Minyatürleştirme.

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1. Introduction

In recent years with the rapid development in wireless component technology, novel microwave components with improved performance features have to be introduced instead of conventional microwave and millimeter-wave component designs to follow the technological developments of wireless communication systems [1-5].

The directional coupler is an important component in microwave devices, which is balanced power amplifiers, modulators balanced mixers and balanced several antennas feeding networks [6]. Especially, the 90◦ hybrid directional couplers are often used in circularly polarized antenna systems, which can be realized in four-port or three-port structures [7].

Directional couplers are four-port passive circuit elements used to divide or combine power. Power combiners take two or more signals and combine them at the output gate, while power dividers split the input signal into two less powerful output signals. Some quantities are used to describe a directional coupler. These are Coupling, Directivity, Isolation and Insertion Loss. Coupling Factor indicates the ratio of the input power that is coupled to the output port. Directivity is a measure of the coupler's capability to insulate forward and backward waves. The isolation is a measure of the power transferred to the insulated port. The insertion loss accounts for the input power transferred the through the port, lowered by power transferred to the coupled and isolated ports [8,11].

Conventional CLDC is one of the structure directional couplers. CLDC has a four-port network and it consists of two unshielded transmission lines in close proximity to each other [10]. Because of this proximity electromagnetic fields interact with each other and power transfer occurs between the two lines. The conventional CLDC is shown Fig 1.

The development of wireless technology has also steered the exploration toward the miniaturization of these circuit elements [9]. Conventional CLDC occupies a larger circuit area under a certain frequency and has a narrow bandwidth. So its application is restricted. However, In this paper, a CLDC with a new configuration using the Meander loop and T-shape microstrip lines technique is proposed in order to reduce the size of its operating frequency. Using these techniques, the size of CLDC is reduced by %58. Also, It has broadband at L-band.

2. Material and Method

In this section, the design of the CLDC is introduced. The CLDC is designed to operate at the L-band and implemented on a FR-4 substrate with a 4.3 dielectric constant and 1.57 mm thickness. The overall size of CLDC is 33.34x15.05 mm^2. CLDC design consists of a few stages. Firstly, the CLDC has been structured then the shunt stub position has been shifted in the -x direction on port 1 and S-Parameters values have been numerically computed.

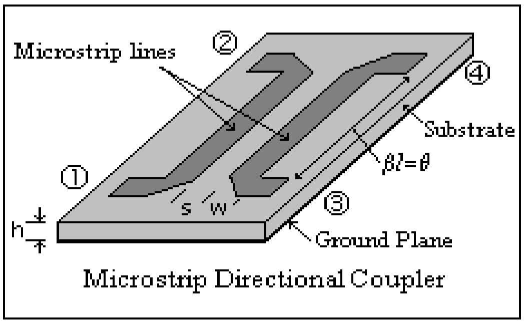

Fig. 1 Conventional CLDC

2.1. Design of CLDC

First of all, CLDC has been structured and S-Parameters values have been investigated. The designed CLDC is shown in Figure 2. The simulation results are given in Figure 3. According to the results, it has been observed that the S_{11} value is better than -13 dB, the S_{21} value is better than -0.64 dB, and the S_{41} value is better than -22 dB at the L-band. The measured S_{31} value is between -28 and -21 dB across the L-band. The S_{11} represents the return loss, the S_{41} value isolation and the S_{31} value represents the coupling factor in the S-Parameter.

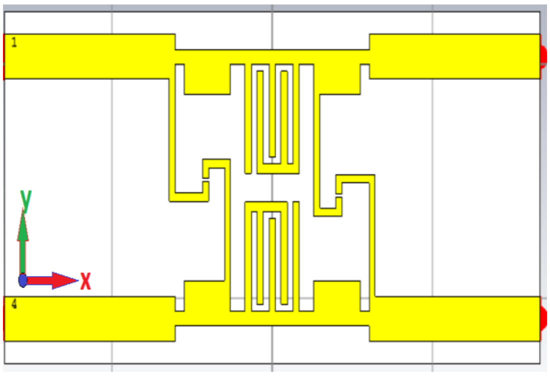

Fig. 2 Initial Designing of CLDC

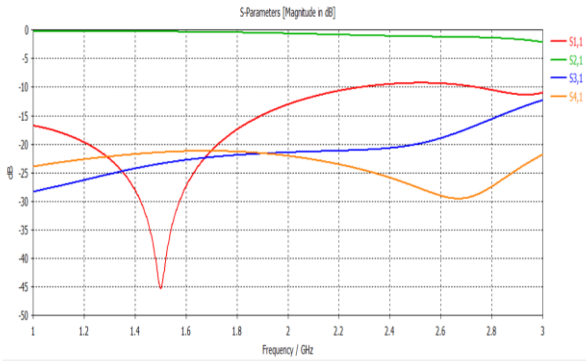

Fig. 3 S-Parameters of Initial Design

In the second step of the design, the shunt stub position has been shifted 2 mm in the -x direction on port 1 and S-Parameters values have been investigated. According to the results, it has been observed that the measured S_{11} value is better than -15 dB, the S_{21} value is -0.57 dB, the S_{41} value is better than -22.4 dB at the L-band. The Measured S_{31} value is between -28 and -21 dB across the L-band. The designed CLDC is shown in Figure 4. The simulation results are given in Figure 5.

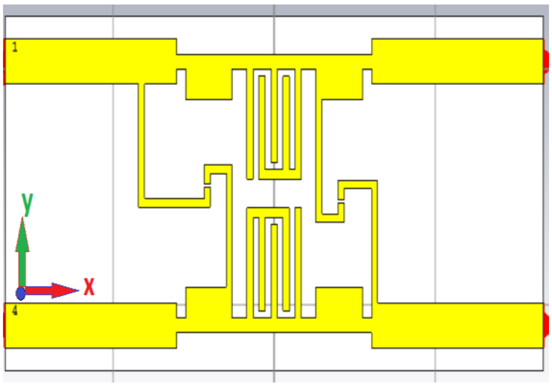

Fig. 4 Designing of CLDC (after has been shifted 2mm in -x direction)

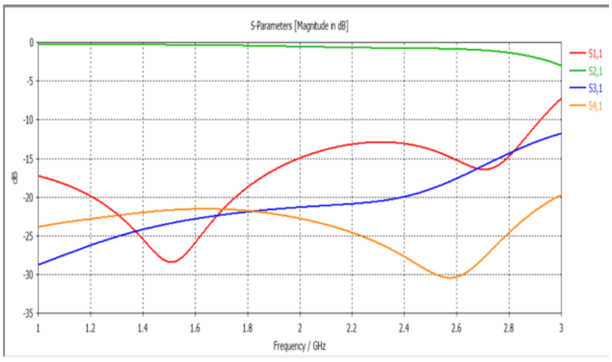

Fig. 5 S-Parameters of CLDC (after has been shifted 2mm in -x direction)

2.2. The Final Design of CLDC

At the final stage of design, the shunt stub position has been shifted in the -x direction between 0 and 5 mm using the parameter sweep tool in CST and the most optimal results have been found at 3.8 mm. According to the results, it has been observed that the measured S_{11} value is better than –19 dB, the S_{21} value is better than -0.51 dB, and the S_{41} value is better than -23 dB at L-band GHz. The designed CLDC is shown in Figure 6. The simulation results are given in Figure 7.

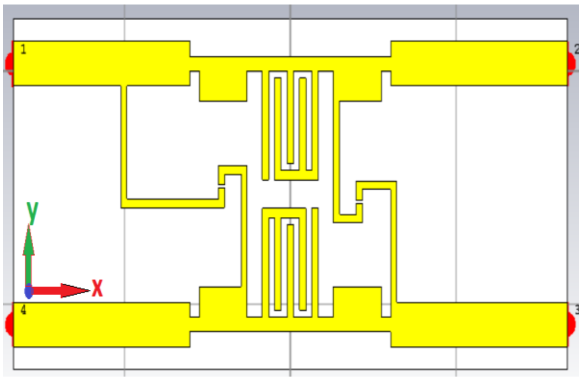

Fig. 6 The Final Designing of CLDC

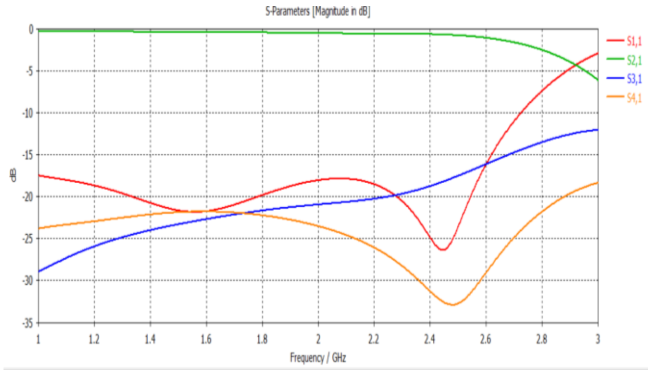

Fig. 7 S-Parameters of The Final Design

2.3. Dimensions of The Designed CLDC

The dimensions of the designed CLDC are shown in Figure 8 and Figure 9.

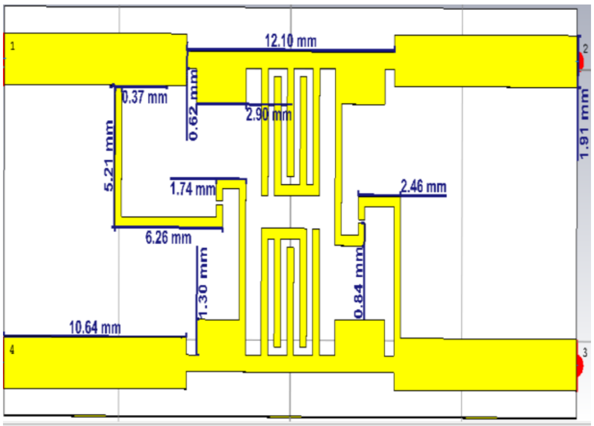

Fig. 8 Dimensions of The Designed CLDC

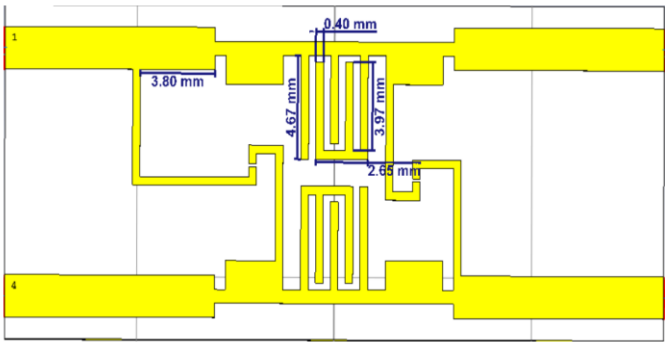

Fig. 9 Dimensions of The Designed CLDC

3. Results and Discussion

As a result in this paper, we design novel miniaturized broadband coupled line couplers with a low coupling factor at the L-band for wireless applications.

The reflection coefficient and isolation level are in the permissible level in order for the proposed novel coupled line directional coupler to be utilized at the L-band for wireless applications. CLDC is implemented on a FR-4 substrate with a 4.3 dielectric constant and 1.57 mm thickness. The overall size of CLDC is 33.34x15.05 mm^2. The simulated results satisfy the requirements of wireless communication.

4. Conclusions and Recommendations

A compact CLDC is demonstrated using a meander loop line, a T-shape line and a series line in place of series lines of conventional CLDC. The size of the proposed CLDC is more compact than conventional CLDC. The measured return loss is better than 19 dB and the coupling factor is between 28 and 21 dB at the L-l-bandband. A novel CLDC design has been proposed for Wireless applications.

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