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A miniaturized branch-line hybrid coupler microstrip for long term evolution applications

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Abstract

This paper presents the miniaturized microstrip branch-line 3dB hybrid coupler (BLHC) is designed and simulated as a platform in producing a significant reduction in the operating frequency 2.2 GHz in Long Term Evolution (LTE) application. High and low impedance transmission line are used to miniaturize the conventional Branch-Line Hybrid Coupler. The proposed branch line coupler is utilized from meander line Technique. The design and simulated results of all above components are validated by electromagnetic simulation (by Method of Momentum using the Advance Design System (ADS) tool from Agilent technologies), which confirms the theory and validates the proposed coupler design. After this validation into the simulation. The Branch-Line Hybrid Coupler which has been designed using a substrate material of FR-4 with dielectric constant (4.3), substrate thickness (h=1.570 mm). The size of the implemented branch-line 3dB hybrid coupler (BLHC) is 50x19.51mm², which is 29.72% compared to the conventional couplers for the higher LTE frequency band. Also, the reflection coefficient, the isolation and the phase difference between two output ports are as good agreement simulated results permits to confirm the designed coupler structure.

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Keywords: Branch-Line Hybrid Coupler (BLHC); Miniaturized Hybrid; 2.2GHz frequency; FR-4 Substrate; Advance Design System (ADS).

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1. Introduction

The branch-line Hybrid couplers (BLHCs) are from of the most passive components find various applications in our modern microwave and millimeter wave communication systems [1]. There are a lot of application of 90 degree hybrid, are often used in frequency discriminators, microwave integrated circuits (MICs) as well as in monolithic microwave integrated circuits (MMICs) [2], such as balanced amplifiers, mixers, reflection type phase shifters, high isolation between ports, antenna systems due to their simplicity, antenna feeding networks, automatic level controls and many other applications. There are many techniques for size reduction of the quadrature hybrid coupler structure [3, 4, 5, 6, 7, 8]. In most cases the empty space between λ/4 transmission lines is occupied with special parts [2, 9]. This space in conventional 3dB hybrid is impractical. However, In this paper, a BLHC with a novel configuration using U and T-shape microstrip lines technique as shown in Fig. 1 is proposed in order to both reduce the size and suppress higher harmonics of its operating frequency [3, 5], which can be realized with high or low impedance. Moreover reduces size of line causes to increase branch line coupler in branch-line coupler. Only engross small space, but also reveal good circuit performances compared with that of the conventional branch-line type, and it can be used as an element of phase array feed an array. Good agreements between the results of the conventional and proposed branch-line coupler are experiential.

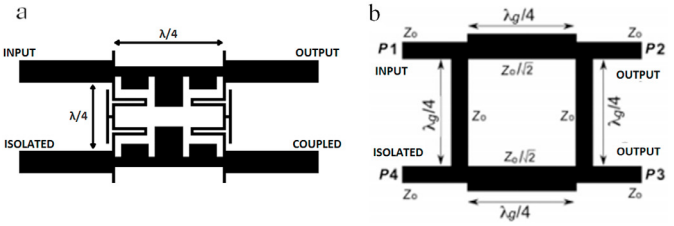

Fig. 1. (a) The novel and (b) conventional branch line coupler.

Nomenclature

BLHC	Branch-Line Hybrid Coupler
LTE	Long Term Evolution
ADS	Advance Design System
FR-4	Flame Resistant 4
MICs	Microwave Integrated Circuits
MMICs	Monolithic Microwave Integrated Circuits

2. Theoretical background of the novel branch-line hybrid coupler

In order to miniaturize the structure, a T-shaped line section is adopted individually in the effort of shortening quarter-wavelength transmission lines thus miniaturized the microstrip branch-line couplers as illustrated in Fig.2. Defining the sets $Z_T \equiv [Z_{T1}, Z_{T2}, Z_{T3}]$ and $\theta_T \equiv [\theta_{T1}, \theta_{T2}, \theta_{T3}]$ represent the characteristic impedances and the electrical lengths of T-shaped transmission line with three open stubs [10, 11], respectively. Using the even- and odd- mode theory for the sake of analysis, the proposed structure is assumed to be reciprocal and lossless, the series and shunted sections.

The ABCD parameters [11] of the proposed T-shaped line section with three open stub demonstrated in Fig.2 can be expressed as:

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix}_{\lambda/4} = \begin{bmatrix} cos(\theta_T) & j\,Z_T sin(\theta_T) \\ j\,sin(\theta_T)/\,Z_T & cos(\theta_T) \end{bmatrix} = \begin{bmatrix} 0 & \pm jZ_T \\ \pm jY_T & 0 \end{bmatrix} \quad (1)$$