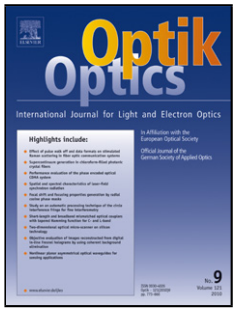

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Microwave photonic mixer with large mixing spurs suppression and high RF/LO isolation

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Abstract: A microwave photonic single sideband mixer based on a dual-polarization dual-parallel Mach-Zehnder modulator (DP-DPMZM) modulator is proposed. A radio frequency (RF) signal and a local oscillator (LO) signal were loaded to the modulator through two electrical 90° hybrid couplers, respectively. The carrier-suppressed single sideband (CS-SSB) modulation was achieved by setting the six DC biases of the DP-DPMZM modulator. Experimental results demonstrate that the proposed mixer for both the upconversion and downconversion has high purity with a large suppression ratio of the undesired signals (~30 dB). Since the RF and LO signals respectively drive the DP-DPMZM modulator through two electrical 90° hybrid couplers, the proposed link has good RF/LO isolation that reaches 49.1 dB. The proposed microwave photonic mixer provides an alternative with high purity and isolation for the transmitter, receiver and phased array beamforming in microwave photonic applications.

Keywords: Microwave photonics; Single-sideband mixer; Carrier-suppressed single-sideband modulation.

1. Introduction

Microwave frequency mixer, which has the capability of realizing frequency upconversion and downconversion, is widely used in receiver and transmitter in the fields of radar, phased array beamforming and wireless communications, etc[1,2]. Compared with the traditional electric mixer, microwave photonic mixer has the advantages of wide bandwidth, low loss, light weight and immunity to electromagnetic (EMI) [3-6].

Due to the above advantages, microwave photonic mixer has been extensively investigated in recent years. Various methods have been reported for the implement of microwave photonic mixers [7-25]. Two Mach-Zehnder modulators (MZM) were cascaded to achieve frequency mixing with high isolation between radio frequency (RF) and local oscillator (LO) signals. However, since the modulators are operated at double sideband (DSB) modulation, the intermediate frequency (IF) detected by a photodetector (PD) has lots of spurious signals [7]. In order to suppress the LO and RF spurs generated during frequency beating, carrier suppressed double sideband (CS-DSB) modulation was employed to reduce the influence of the useless carrier [8-18]. Fiber Bragg grating (FBG) [8-11] or stimulated Brillouin scattering (SBS) [12-13] were applied to filter out the optical carrier directly. A dual-parallel Mach-Zehnder modulator (DPMZM) or a dual-drive Mach-Zehnder modulator (DMZM) operated at the minimum transmission point was used to suppress the optical carrier [14-16]. Also, in order to reduce the frequency requirement of LO signal, several microwave photonic mixers with a frequency doubled LO were reported [17-18]. Nevertheless, the mixing spurs between the ±1st order sidebands of RF and LO signals still exist. In addition, the microwave photonic mixer based on DSB modulation can only achieve upconversion and downconversion simultaneously. However, only one of the functions (upconversion or downconversion) needs to be implemented in practical applications such as the transmitter or receiver. In that case, if the upconvertion signal is demanded, then the downconversion signal will become noises and extra optical or electrical filter is needed to filter out the useless signal.

In order to solve the above problems, microwave photonic mixer based on carrier suppressed single sideband (CS-SSB) modulation is proposed [19-25]. A reconfigurable microwave photonic mixer was presented based on two parallel modulators and optical filters [19]. However, the parallel structure is quite complex and the optical filter needs to be adjusted for the change between up and downconversion. Besides, a sagnac loop based frequency downconverter with the tunable phase shift was demonstrated by theoretical and simulation analysis [20], and the CS-SSB modulation was realized by an optical bandpass filter (OBPF). This link can only implement the frequency downconversion. A microwave photonic SSB upconverter was proposed based on a dual-polarization dual-parallel Mach-Zehnder modulator (DP-DPMZM) modulator [21], and a FBG was employed to filter out the LO -1st order sideband. Another filter-free microwave photonic mixer was developed recently [22]. CS-SSB modulation was