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Filterless 16-Tupled Optical Millimeter-Wave Generation Using Cascaded Parallel Mach-Zehnder Modulators with Extinction Ratio Tolerance

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Abstract—A 16-tupling frequency system for millimeter-wave generation using cascaded arrangement of parallel Mach-Zehnder modulators is presented in this paper. Parallel non-ideal Mach-Zehnder modulators are used to realize a Mach-Zehnder modulator (MZM) with an ideal splitting ratio of 0.5. Hence, parallel MZMs work as a modulator with ultra-high extinction ratio. A 5 GHz radio frequency signal is 16-tupled to 80 GHz with optical sideband suppression ratio of 64 dB and radio frequency spurious sideband suppression ratio of 31 dB. The system has radio frequency spurious sideband suppression ratio $\geq$ 10 dB for modulation range of 2.79 to 2.86. Further, optical sideband suppression and radio frequency spurious sideband suppression ratios are independent of extinction ratio of MZMs.

1. INTRODUCTION

From the past decade, there has been accelerated penetration of wireless devices in the forms of smartphones, tablets, and laptops. Further, a large number of innovative applications run on these devices and require wireless data connection. To cater the emerging wireless bandwidth demands, it has been emphasized to transfer from existing microwave bands to millimeter-wave bands for next generation telecommunication [1]. However, generation and distribution of such high frequency signals using conventional techniques are cumbersome. Radio-over-fiber (RoF) technology provides an amalgam of high-bandwidth optical communication and adaptability with wireless communication [2]. Generation of high-quality mm-wave frequency signal and optimal design of transmission system of such signal along with data has been of great interest to researchers.

Various optical millimeter-wave (mm-wave) generation techniques have been proposed such as — Stimulated Brillouin scattering (SBS) [3], Four-Wave Mixing (FWM) [4, 5], Optical heterodyne [6–8], direct [9] and external modulation. Using SBS approach, the generation of frequency is limited to multiples of Brillouin frequency [10]. Stimulated Brillouin scattering is also known for the cause of performance degradation due to back-scattering of signal power. The frequency generation using FWM in nonlinear systems such as semiconductor optical amplifier (SOA) or highly non-linear fiber (HNLF) lacks operation stability. Optical heterodyne employing beating of two independent laser outputs using photo-detector provide simple system configuration. However, it results in poor phase noise characteristics due to mismatch of phases in two independent lasers. Direct modulation can be used for only low-frequency generation due to chirp and nonlinear effects [11]. Among the mentioned techniques, mm-wave generation by external modulation using MZMs offers higher reliability, frequency multiplication factor (FMF), and operation tunability.

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