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Ultra high capacity inter-satellite optical wireless communication system using different optimized modulation formats

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ABSTRACT

In this paper, an ultra-high capacity inter-satellite optical wireless communication (OWC) system using different modulation is presented. The proposed system is achieved by using 64-channel dense wavelength division multiplexing (DWDM) by different modulation methods. The inter-satellite link has been designed for various distance and external modulation of carrier-suppressed return-to-zero (CSRZ), duo binary return-to-zero (DRZ) and modified duo binary return-to-zero (MDRZ) at different bit rate. The proposed system is simulated at different bit rates, 10, 20 and 40 Gbps by using atmosphere model. To show the good performance of the proposed system, its eye diagram, received power and *Q*-factor are shown. The comparative analyses show that at 10 and 20 Gbps, the proposed system has maximum quality factor, *Q*, and minimum bit error rate (BER) for all three modulations. Also, at 40 Gbps the MDRZ modulation has better performance in comparison to the CSRZ and DRZ modulations.

1. Introduction

Combination of Dense Wavelength Division Multiplexing (DWDM) with Optical Wireless Communication (OWC) systems results in high speed and high bandwidth as well as higher bit rate transmission over long distance. An optical communication system consists of three main blocks such as transmitter, transmission channel and receiver. The channel block consists of different devices such as fiber and wireless component [1]. Free space optical (FSO) communication can be defined as a type of optical transmission technology, which transmit signal and data through air, water or vacuum [2]. The OWC could be operated in several electromagnetic bands such as infrared wavelength (750–1600 nm) or ultraviolet communications (200–280 nm) [3]. In digital transmission, the bit errors is the received bits of signal that has reaction with noise, interference and distortion, and bit rate is the number of bits that carried per unit of time [4]. Using of OWC system at inter-satellite, results in high bit rate, low bit errors and sufficient security [5]. In [6], the comparison of Quadrature phase shift keying (QPSK) modulation and Differential Phase Shift Keying (DPSK) modulation systems on FSO communication have been presented. Results show that QPSK has high *Q*-factor in comparison to DPSK modulation. A 32 channel OWC system operating at 10 Gbps with two modulation method of Return to Zero (RZ) and Non-Return to Zero (NRZ) was designed and simulated in [7]. In [8], the free space link with various numbers of transmitter and receiver has been proposed. The OWC is a form of the optical communication in which unguided visible, infrared (IR) or ultraviolet (UV) wavelengths, which is used to carry

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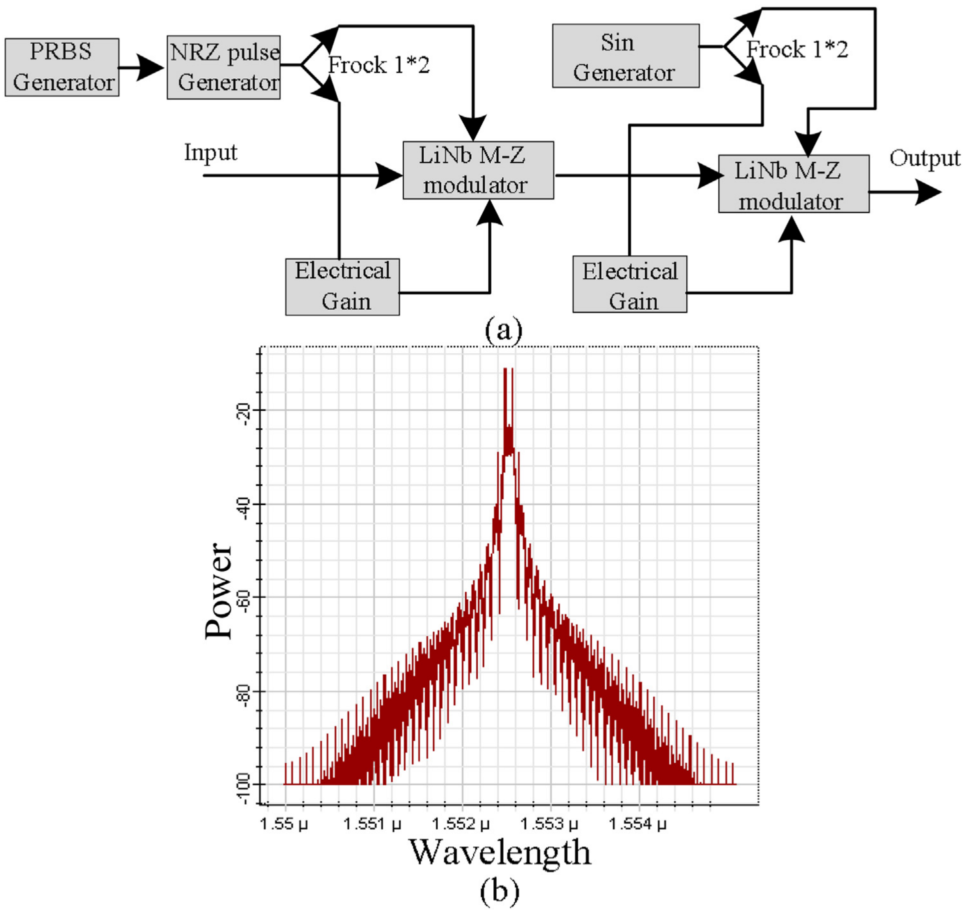

Fig. 1. (a) The schematic of CSRZ modulation, (b) optical spectrum of CSRZ modulation.

a signal. We can used the OWC system in visible band (390–750 nm) that refer to visible light communication (VLC) such as wireless local area network and wireless personal area network. In this paper, an ultra-high capacity inter-satellite OWC system using different modulation is presented.

The paper is organized as follows. In Section 2, description of different modulation techniques and the model of atmosphere are presented. Proposed system is expressed in Section 3, Simulation description and results are expressed in Section 4 and finally we conclude the paper in Section 5.

2. Description of modulation techniques and atmosphere model

Fig. 1(a) shows the schematic of the CSRZ modulation, which is one of the advanced modulation formats in optical communication systems [9,10]. It is characterized by reversing the sign of the optical field at each bit transition. The CSRZ modulation pseudo-multilevel modulation format has better tolerance to fiber nonlinearity and residual chromatic dispersion (CD). In this modulation, RZ optical signal after Mach-Zehnder modulator (MZM) goes through phase modulator. The 180° phase shift between adjacent bits in CSRZ modulation is the main difference between the CSRZ and RZ modulation. Fig. 1(b) shows the optical spectrum of CSRZ modulation with CW (Continuous Wave) laser at 193.1 THz.

Fig. 2(a) shows the schematic of DRZ modulation, which is a type of modulation that transmits R bits/s using less than $\frac{R}{2}$ Hz of bandwidth [9,10]. This modulation format can increase tolerance to the effects of CD and improved narrowband optical filtering. In this format, first NRZ duo-binary signal is created by a duo-binary pre-binary pulse generator. The generator drives the first LiNb MZM and then connected to second LiNb MZM that driven by a sine generator with phase 90°. Fig. 2(b) shows the optical spectrum of DRZ modulation at 193.1 THz.

Finally the schematic of MDRZ modulation formats is shown in Fig. 3(a) [9,10]. In this modulation, first NRZ duo-binary signal with a delay and subtract circuit is created that driven the first LiNb MZM and then connected to the second LiNb MZM that is driven by a sine wave generator with phase 90°. The MDRZ modulation has good received attention because it reduces self-phase modulation in single channel, cross-phase modulation and four-wave mixing in WDM transmission system. Fig. 3(b) shows the optical spectrum of the MDRZ modulation at 193.1 THz [9].