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Performance Analysis of Multitone RoF system using DPSK based Optical Modulators

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ABSTRACT

In this paper, the performance of multitone Radio over Fiber (RoF) system has been analyzed by employing different optical modulators. These modulators have been modeled and analyzed using OptiSystem (14.0) software. To evaluate the transmission performance of RoF system, various performance metrics such as Q-factor, BER, and Eye Height are considered. Simulation results indicate that Single Drive Mach-Zehnder modulator provides better Q-factor and minimum BER as compared to existing optical modulators in RoF system.

Keywords

Single drive MZM, Dual drive MZM, Electro-absorption Modulator, Amplitude Modulator

INTRODUCTION

The high data rate and broadband demands of wireless and wired-line networks have proliferated in recent years. Due to the increasing demand for mobile broadband services and the diffusion of high capacity, wireless networks require a substantial increase of their total bandwidth [1]. One of the major access network solutions for future high bandwidth wireless communication systems is based on optical fibers for the transmission of radio signals between the base Station (BS) and central Station(CS), which is generally referred to as a Radio over Fiber (RoF) solution [2]. RoF technology takes the benefits of optical fiber with the mobility and ubiquity of wireless networks [3] as the optical fiber has low attenuation, immune to electromagnetic interference and superior signal integrity. The information is transported through the optical fiber with the help of modulation. Optical modulators are used to convert electrical signals into modulated optical signals. Optical modulation differs from electrical modulation due to the characteristics and limitations of the devices employed for modulation. At optical frequencies, most of the modulators operate upon the carrier intensity rather than the amplitude of the carrier. Optical modulators are based on direct or external modulation. In direct modulation, the optical source is turned on and off at intervals [4]. The limitations of direct modulation are the high value of peak-to-average power ratio which causes distortion at the transmitter side [5]. In external modulation, the optical source is operated continuously and the light at the output is modulated using an external modulator. External modulators are broadly classified into two types i.e. absorptive modulators and refractive modulators. Electro-absorption optical modulator is a modulator in which the optical absorption coefficient of a substance varies depending on the electric field applied to it. EAM has a higher insertion loss of about 10dB [6]. The high insertion loss can be eliminated by using semiconductor optical amplifiers [6]. Mach-Zehnder modulator is an interferometric modulator in which refractive index of the substance changes with applied voltage. MZM provides excellent performance by reducing insertion loss as compared to EAMs [6]. The non-linear distortion can be suppressed by using single drive Mach-Zender modulator with EDFA in a single-tone RoF system [7]. In this paper, the multitone channel of 250GHz and 255GHz are modulated using single drive MZM, dual drive MZM, EAM and optical amplitude modulator and the performance of various optical modulators in terms of Q-factor, BER, and eye height has been compared.

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SIMULATION SETUP

The simulation setup of a multitone RoF system is designed using OptiSystem (14.0) and is shown in Fig.1. In the transmitter section, the input data stream of 1Gbps and two electrically modulated DPSK signals of 250GHz and 255GHz are filtered, electrically combined and used to modulate a laser output using external modulation techniques i.e. single drive MZM, dual drive MZM, EAM, AM over a continuous wave laser biased at 193.1THz with a line width of 10MHz. The optically modulated signal is transmitted over an optical fiber of 20km length and amplified by the optical amplifier. In the receiver section, the two channels are split, filtered and detected by PIN photodetector whose responsitivity is fixed at 1A/W. The detected electrical signal has been monitored using BER analyzer and Eye Diagram analyzer.

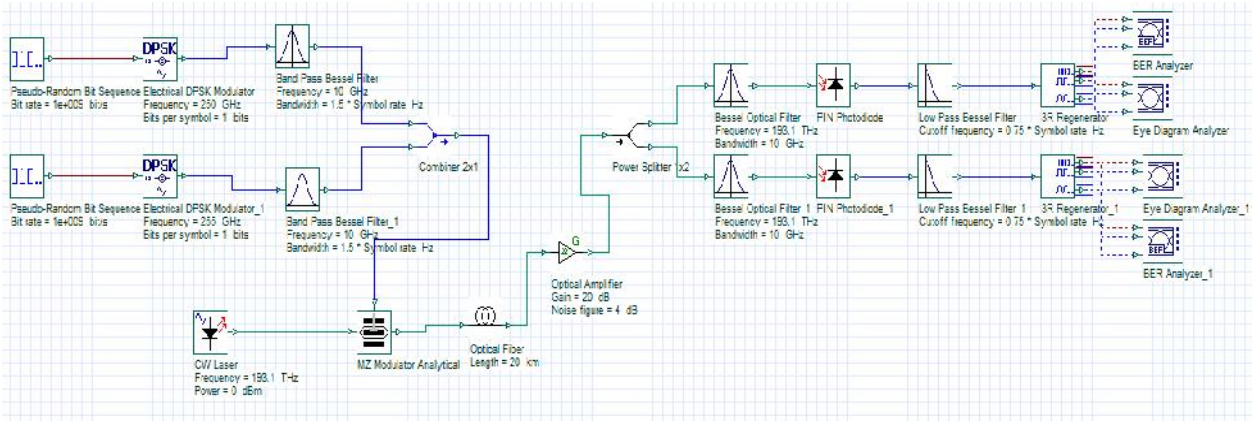
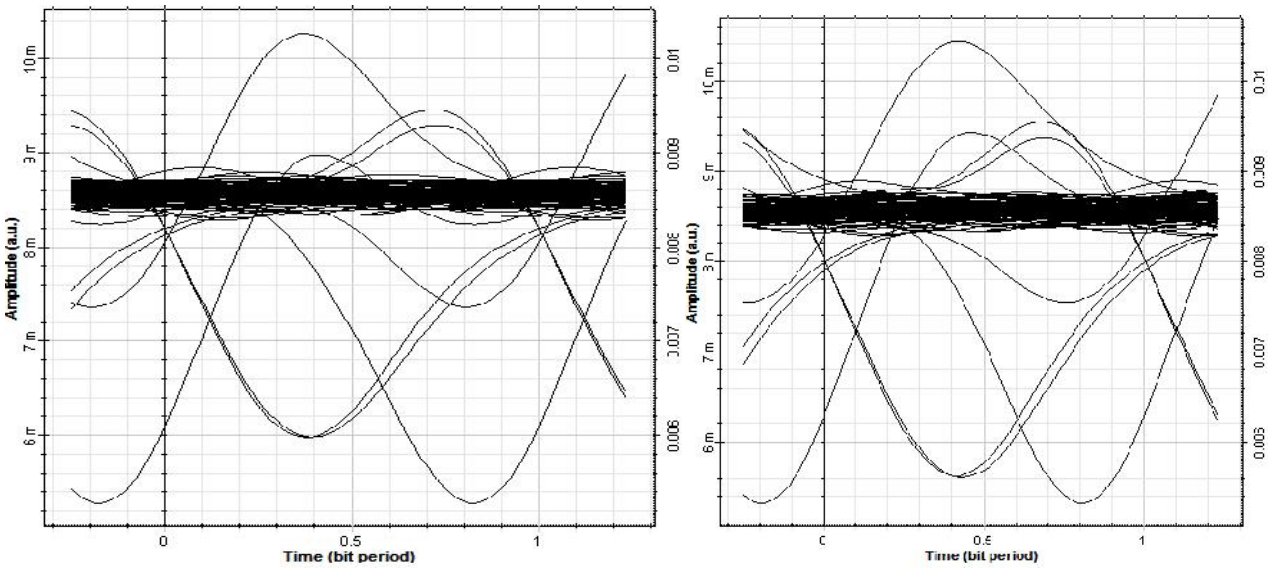


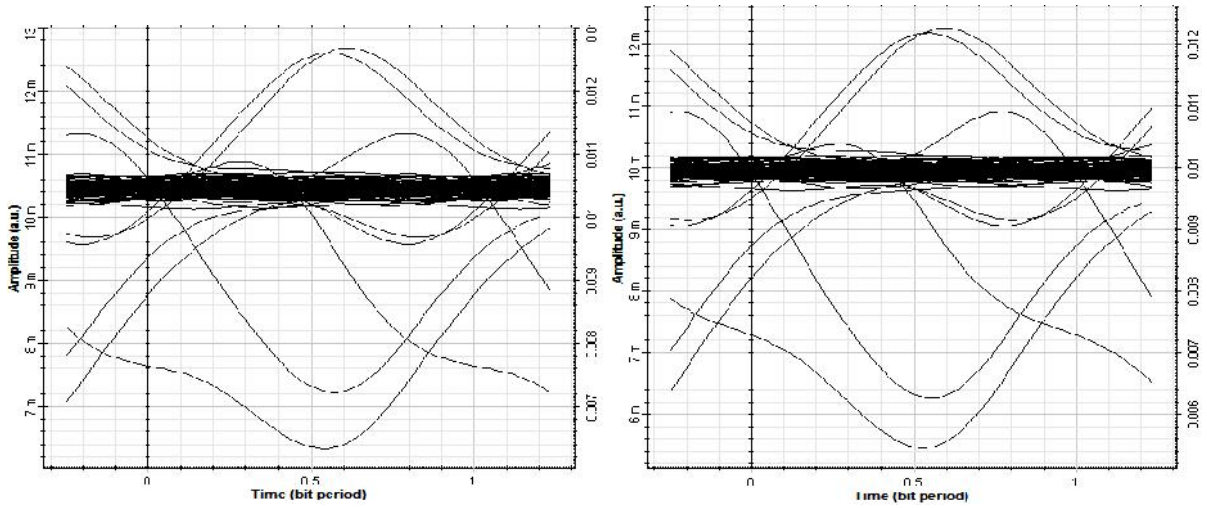
Fig 1: Simulation setup of DPSK based optical modulator.

RESULTS

The simulation setup used to investigate the impact of various optical modulators on the performance of multitone RoF system is shown in Fig 1. The received eye diagram for multitone RoF system is clear and completely opened in case of single drive MZM as shown in Fig 2. (a).



(a) (b)



(c) (d)

Fig 2: Eye Diagram of multitone DPSK based RoF system with:

(a) Single drive MZM

(b) Dual drive MZM

(c) EAM

(d) Amplitude modulator.

Table 1. Comparison of DPSK based optical modulators in RoF system

Performance metrics	**Optical Modulators**			
	Single drive MZM	Dual drive MZM	Amplitude Modulator	Electro-absorption Modulator
Q-factor	13.73	13.61	5.78	4.95
BER	3.09×10^{-43}	1.61×10^{-42}	6.96×10^{-10}	5.78×10^{-8}
Eye Height	0.0020	0.0022	0.0019	0.0014

The Q-factor with single drive MZM is calculated as 13.73 and reduced to 13.61 using dual drive MZM, which again reduces to 5.78 using amplitude modulator, which is further, reduces to 4.95 in the case of EAM. It is seen in Table 1. that single drive MZM has better Q-factor and minimum BER as compared to existing optical modulators.

CONCLUSION

In this paper, the impact of various optical modulators on the performance of DPSK based multitone RoF system has been investigated. From the results, it is concluded that an improvement in Q-factor, eye height, and BER is achieved using single drive MZM as compared to existing optical modulators. Further, it is expected that the present work contributes to enhancing the performance of multitone RoF system.

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