Performance comparison of NRZ and RZ techniques over FSO-OCDMA system to transmit 10 Gbps Data

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Abstract
In this Paper, a novel approach is applied to transmit high speed data (10 Gbps) over FSO link by employing OCDMA technique. Two principal coding techniques of optical fiber communication i.e NRZ and RZ have been implemented. Coding and decoding method is based on selecting frequency of Fiber Bragg Grating. The maximum length of FSO channel considered is 1000 meters. Optisystem simulator has been used to simulate and analyze the whole network scenario. In addition, we've also compared the examined results of NRZ and RZ techniques with the previously designed SDD and IM/DD techniques in terms of eye pattern and signal to noise ratio (SNR). Results show that the performance of NRZ is better than other techniques.

Keywords:- OCDMA, FSO-OWC, Fiber bragg grating, NRZ, RZ, Optical networks.

INTRODUCTION
A wireless communication is provided at high rate from the free space by FSO, where it is difficult to reach for optical fiber. FSO is easy to use as compare to optical fiber for example ship to ship, building to building [1]. Since the beginning of history, Free-space optical communication (FSO) has been accomplished through the transmission of information which is loaded with optical radiation from a transmitter to a receiver, separated by the atmosphere[2]. In optical wireless communication carrier signal is light signal, so information signal is modulated on light signal and then transmitted through atmosphere and demodulated at received side. FSO-OWC technology is used to transmit data from one point to another at a very high speed such as speed of light without any delay, In addition to this Ancillary, lasers which are used in this technique exhibit narrow beam-width as compared to RF systems ,which results in less loss in OWC as compared to RF communication[3].

Although the basic structure of the FSO-OWC system is same as that of optical fiber communication system but in this system signal is transmit through free space not through optical fiber. The modulation technique used in FSO is ON-OFF keying, which help us to design the FSO system under given conditions. Radio access network and central network are two
important things in FSO [4]. In present time OCDMA technique is used in FSO because in OCDMA a number of users can transmit and receives data through a single channel resulting in a better communication [5]. The more features of OCDMA to provide better transmission are flexibility and scalability. On the other hand when a large number of users use a single channel the problem of interference occurs, which is a drawback of this technique [6]. To overcome this problem, fiber grating is used which provide better side band suppression ratio (SSR). In addition to this fiber grating also helps to reduce the complexity of the system due to which we can make or install the circuit easily[7].

**Description**

Fig. 1 shows the block diagram of the OCDMA based communication system in the FSO communication system. In this system we use 3 users in which one user is off. At the transmitter, data with independent NRZ and RZ digital signal is used. In this study Mach–Zehnder modulator is used. Then the modulated code sequences are combined together and transmitted through the FSO link. At the receiver, an optical splitter is used to separate the different the data for different users. Then, the decoded signal is detected by the photo detector to convert it into electrical signal. In order to recover the original transmitted data, the incoming signal is filtered using low-pass filter (LPF). Then the signal is given to user.

**Results**

In this work, a novel approach is applied to transmit Giga speed data (10 Gbps) over FSO link by employing OCDMA technique. The coding and decoding method is based on selecting
frequency of Fiber Bragg Grating. The results in terms of Signal-to-Noise Ration and eye diagram shows successful transmission of 3 channels over FSO link of 1 Km.

![Max. SNR (dB) vs Range](image1)

**Fig 2 Measured Results for RZ Scheme SNR v/s Range**

The Fig 2 shows the SNR and total power received after photo detector for RZ modulation scheme. The value of SNR is computed as 58 dB, 56.45 dB and 54.24 dB for first channel as compared to second channel which shows the SNR of 56 dB, 54.11 dB and 52.24 dB at the FSO link of 300m, 600m and 1000m respectively.

![Max. SNR (dB) vs Range](image2)

**Fig 3. Measured Results for NRZ Scheme SNR**

The value of SNR is computed as 61.4 dB, 59.88 dB and 56.34 dB for second channel as compared to first channel which shows the SNR of 60.99 dB, 58.88 dB and 56.01 dB at the FSO link of 300m, 600m and 1000m respectively as shown in Fig. 3. Which shows that NRZ modulation scheme is better as compared to RZ scheme.

Where the value of previous works
using SDD is 61dB and for IM/DD is 51dB which shows that for our work when we are using NRZ the performance is better than both the techniques. From SDD it is 0.7% better and from IM/DD it is 20% better. Result also shows that the performance of NZ is better than IM/DD by 14%.

**Eye diagram**

![Eye Diagram](image)

**Fig 4:** Eye Diagram for NRZ format for channel 1 (a) 200 m (b) 600 m (c) 1000 m, BER- $1.2 \times 10^{-2}$
Fig 5: Eye diagram for channel 2 NRZ Format (a) 200 m (b) 600 m (c) 1000 m, BER = 0.4 × 10^{-24}
Fig 6: Eye Diagram for Channel 1 RZ Format (a) 200 m (b) 600 m (c) 1000 m ,BER-0.5e-21
Fig 7: Eye Diagram for Channel 2 RZ Format (a) 200 m (b) 600 m (c) 1000 m, BER-0.5e-21
Fig 8: Eye diagram of FSO system using SAC OCDMA with SDD technique, BER = 10−21.

Fig 9: Eye diagram of FSO system using IM/DD technique, BER = 10−6.

It is clearly shows that the eye opening of NRZ is more than SDD and IM/DD and for RZ eye opening is less for SDD but it more open than IM/DD. which shows that the performance of NRZ using our technique is better.
Conclusion
In this paper the performance of FSO-OCDMA is introduced by using two principal coding techniques NRZ and RZ techniques. The performance is compared between FSO System using NRZ and RZ and previously designed SDD and IM/DD techniques. The result is compared in terms of Eye opening and Signal-to-Noise Ration. The result shows that the performance of our designed system is better by using NRZ than RZ. The result also shows that the performance of NRZ is better than other techniques.

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