

Evaluation and Analysis of Modified Return to Zero Pulse Format (MDRZ) Over FSO in Comparison to Non Return to Zero and Return to Zero Linecodings

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Abstract - Free space optical communication is very popular nowadays, due its low cost and high speed applications. In this work, a 16 channel wavelength division multiplexed system is incorporated in FSO link at ultra dense frequency difference of 50 GHz. We successfully covered the transmission distance of 5000 km at 10 Gbps in this work without any amplification. Diverse advanced modulation and linecodings such as modified return to zero, Return to zero and non-return to zero are investigate in terms of Q factor at varied link lengths and data rates. Result revealed the MDRZ is best modulation format as compared to NRZ and RZ and recommended to use in future FSO systems.

Key Words: Free space optical (FSO), Q factor, BER, WDM, MDRZ

1. INTRODUCTION

Optical wireless communication is the engaging technology in the field of communication and provides us with the fastest transmission than microwave and RF technology [1]. Optical wireless communication is the special kind of optical communication that uses wireless medium to transmit the information to the destination. It basically uses the same concept as the laser communication technology FSO stands for free space optics where the medium of communication is optical wireless therefore FSO is named or recognized as Free space optical communication [2]. Free space uses line of sight technology that seeks to satisfy the need of higher band-width over short range. In this transmission, communication takes place through the atmosphere in place of glass fiber and transmission of these light pulses are in the narrow beam form [3]. Cost of FSO link is low and moreover it is simple such that easy to install it and no authentication like license approval is required to use FSO [4]. An important factor in FSO, is time and money saving because there is no need to lay fibers by digging the streets [5]. But the issue in FSO is, limited communication to short distances because of environmental interactions [6]. Due to atmospheric turbulences in the FSO channel or medium, the quality of signal degrades because FSO links are highly dependable on atmospheric conditions [7]. The atmospheric conditions like fog, smoke, rain and scintillation are the major cause for the reducing level of FSO performance [8]. To make the performance better of FSO, numerous methods are reported

like aperture averaging, diversity or amplification of signal uses optical amplifiers. Also, WDM technique puts drastic impact owing to the potential to pack large number of channels in one optical medium such as the fiber optic reliant network and by reducing the spacing between channels by using one FSO link. Numerous researches has been reported on FSO systems Till now, many research works has been reported to generate spectrum slices [6-8], to boost weak signal with amplifiers [9], beam divergence size [10] scintillation noise compensation [11]. Although, reported techniques are good but either supports less data rate or more complexity.

In this research article, a high speed WDM-FSO system is presented using advanced modulation format and linecodings are investigated for distances and data rates. WDM channel with 16 transmitters at 50 GHz dense frequency spacing are considered for data rate 20 Gbps over 5 km.

2. SYSTEM SETUP

The purpose of this work is to investigate the system performance using diverse modulation formats such as MDRZ, MRZ and RZ. FSO transmission, named as the light based wireless transmission as well as are low cost, wideband and have persuasive profitable benefits, through the impending potential to cater data pace, cheap, and offers unregulated spectrum. In this wireless optical transmission, sender of data and recipient communicates with each other via air as shown in Figure 1.

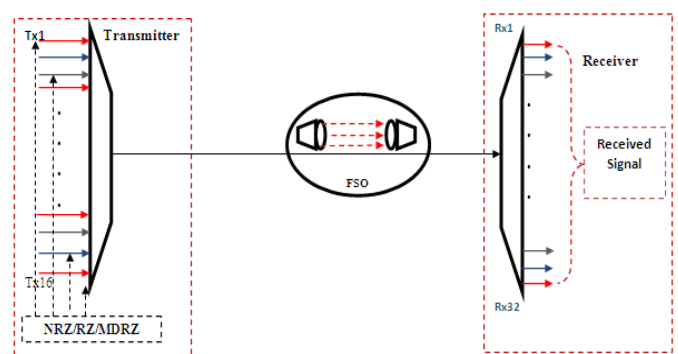


Fig-1: shows the setup of 16-channel WDM-FSO link.

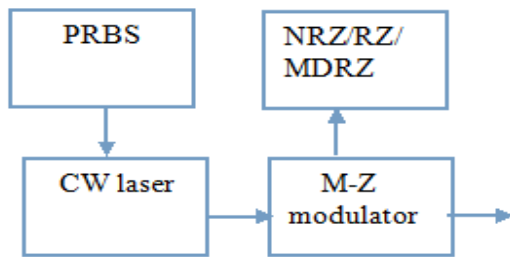


Fig-2: represents the each transmitter of WDM transmitter

Basically the fundamental working of sender module is to modulate and change the signal from E/O and transmit the signal over air. The receiver performs the inverse task to retrieve back the original signal by O/E conversion. System performance and evaluation is conducted with the reference values of Q factor and BER. The transmitter’s internal architecture is depicted in Figure 2. Transmitter consists of PRBS generator, NRZ/RZ/MDRZ Driver, as well as intensity source (laser) and mach-zehnder modulator. In order make system for long time, low power such as 0 dBm is fixed in transmitter. A WDM transmitter transmits 16 channels having 0.4 nm freq. spacing. Data speed of binary tributaries is set to 10 Gbps and accumulated data rate is that system supports is found out to be 160 Gbps.

Table 1: Parameters for simulation setup

Parameters	Descriptions
Number of channels	16
Channels spacing	0.4nm (50GHz)
Range	1km-5 km
FSO transmitter aperture diameter	5 cm
FSO receiver aperture diameter	7.5 cm
Beam divergence	0.25mrad
Attenuation	0.1 dB/Km

A Return-to-Zero/Non returns to zero/ modified return to zero are the energy provider or pulse formats that are needed to generate train of pulses with respect to the input binary data. Pulse coders are the essential and very important components of transmitter module. After modulating the 16 channels with adequate data, these are fed to the multiplexer of 16 x 1 configurations. It is used to accumulate signal powers with the reference of each channel’s frequency. Multiplexed data is inserted to the FSO module for communication. In order to realize a practical FSO system, attenuation of 0.1 dB/km is taken for clear weather. Table 1 depicts the proposed architecture parameters. In this work we investigated that as distance is

increased, the performance degrades due to attenuation and noises. A WDM transmitter with 50 GHz channel dense spacing is considered for this work with starting frequency of 193.1 THz. FSO link has a 5000-meter link with 0.25mrad of beam divergence. The FSO Tx and Rx diameters are considered as practical as possible and set to 5 cm and 7.5 cm respectively. Atmospheric clear attenuation is taken from reported works and they described this at 0.1 dB/km [12]. After transmission through air, signals are route to their respective port according to wavelengths by de-multiplexer. Figure 3 depicts the essential components of the recipient side. In receiver, to detect the light data, a photo-detector with 10 nA dark current is used. Also noises such as thermal and shot are taken to realize a practical system. Noise is accumulated after PD and removed by incorporating low pass filter and it is followed by 3-R generator. BER analyzer is end component that decides the performance of the system.

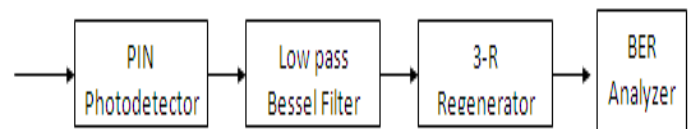
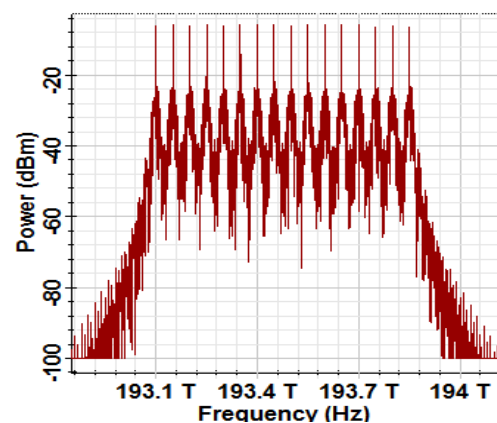


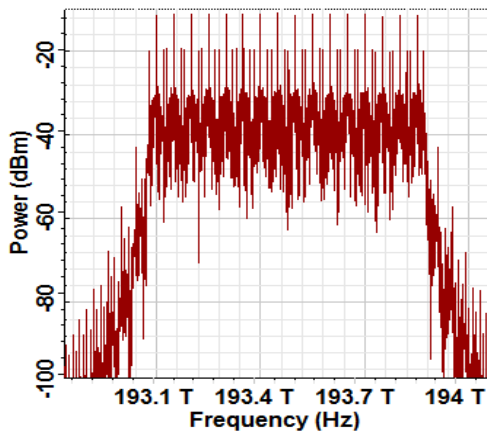
Fig-3: Components of receiver

3. RESULTS AND DISCUSSIONS

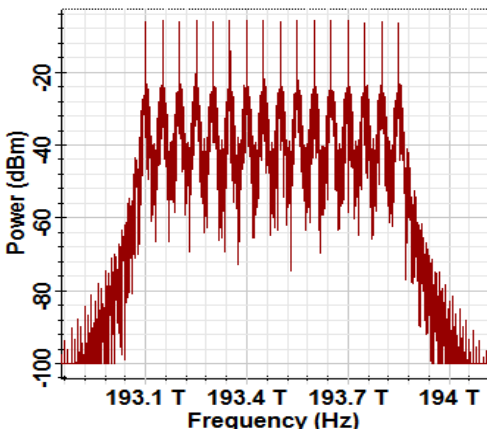
Proposed system architecture of WDM transmitter with 16 channels and 50GHz freq. spacing is investigated over FSO. Figure 4 depicts the spectrums of the WDM signal by incorporation of different modulation formats. By sampling method 16 channels $f_1=193.1$ THz, $f_8= 193.5$ THz, and $f_{16} = 193.8$ are choose for the analysis. Performance analysis of all the three modulation parameters has been studied on different FSO link distance i.e. 1 Km, 2 Km, 3 Km, 4 Km and 5 Km as shown in Fig.4. It is prominently displayed in results that MDRZ performs better than RZ and NRZ at longer distances and effects of degradation increase as distance increase.



(a)



(b)



(c)

Fig-4: Optical spectrums for 16 channels of (a) NRZ (b) RZ (c) MDRZ

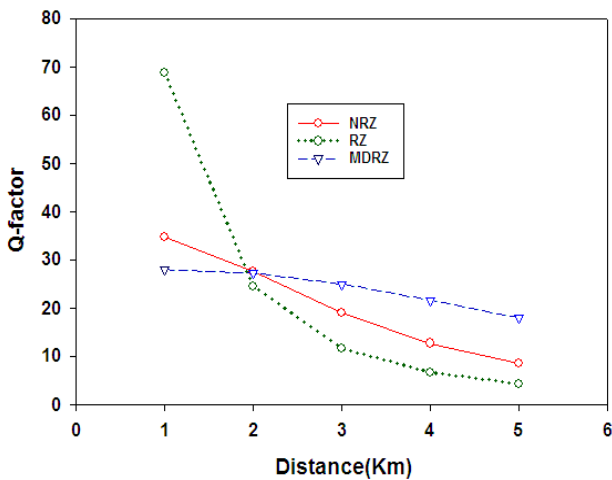


Fig-5: Performance of different modulation formats at varied distance in terms of Q-factor

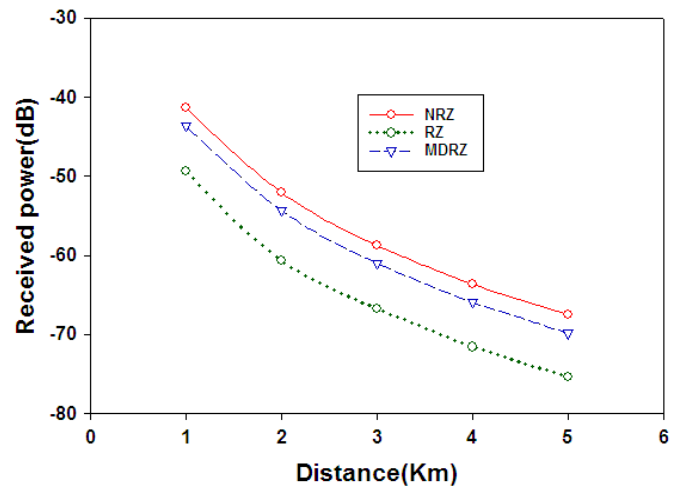
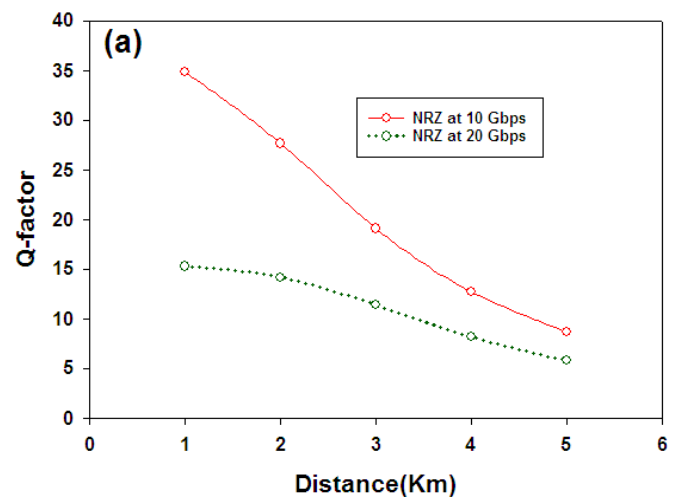


Fig-6: Received power at different distances for all modulation formats

Further all modulations FSO system is analyzed at different distances in terms of received power.

Figure 6 represents the performance of modulation formats at varied lengths. It has been concluded that the increase in distance, affects the received power due to attenuation and provide less power at prolonged distances. Further performance of different modulation formats is analyzed for different data rates such as 10 Gbps and 20 Gbps. It is observed that with the increase of data rate, bit interval decreases. As a result of this, more inter symbol interference is reported for formats. But the MDRZ exhibits better performance due to the phase shifts in adjacent bits of 0 degree and 180 degree.



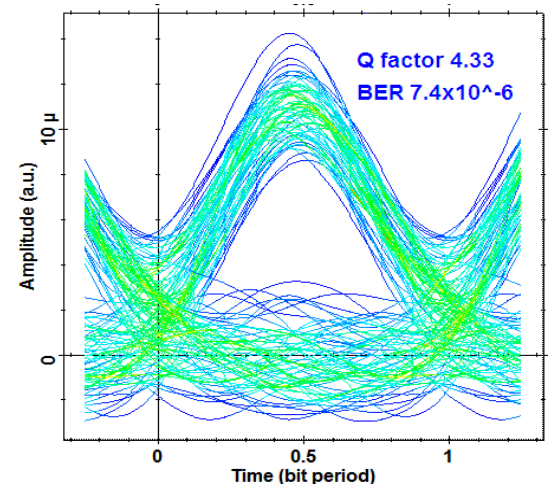
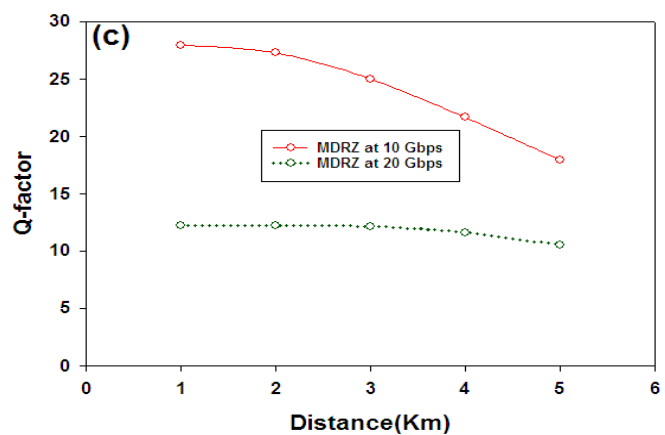
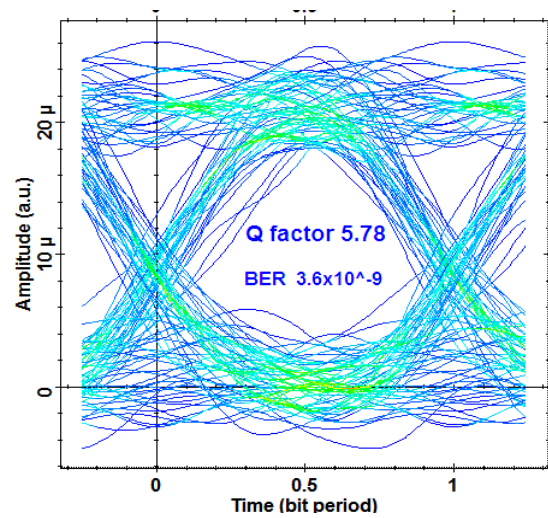
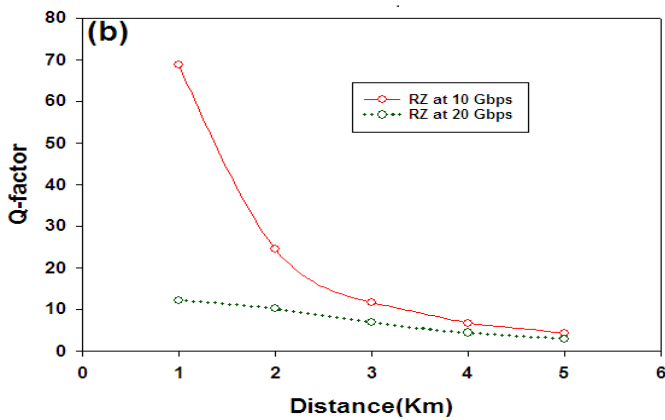
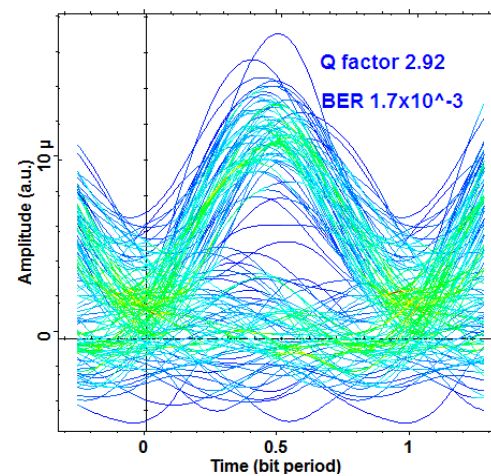
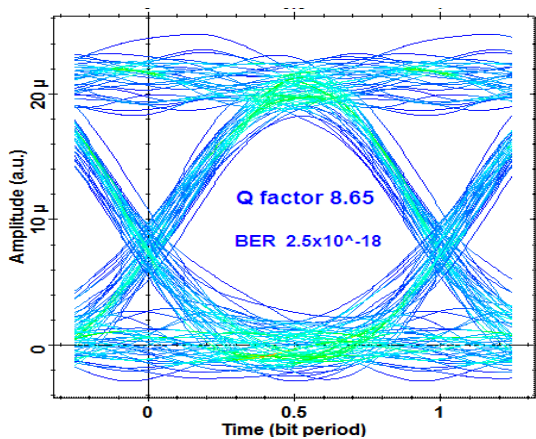


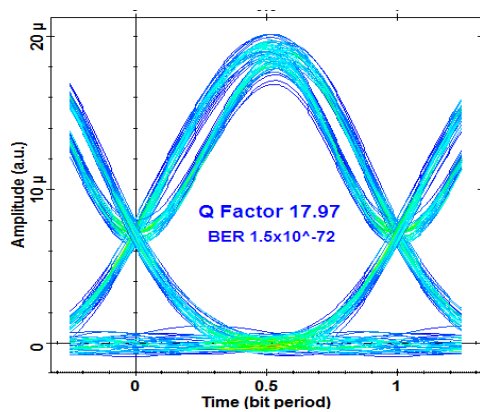
Fig-7: Q factor versus Distance for different modulation formats at 10 Gbps and 20 Gbps

Figures 8 (a), (b), and (c) represents the Eye for diverse formats such as NRZ/RZ/MDRZ modulation formats at 5 km distance. The Eye diagram is a final decision component and it is also seen that at low data rates and distances, eye opening is more. Eye opening more represents that there are less bit errors and signal received with good Q factor. From the analysis, it is evident that Eye is open widely for the MDRZ and thus, imparts less jitter and consequently fewer errors.

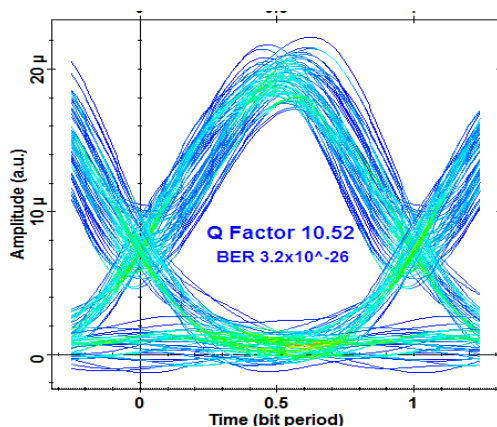


(a)

(d)



(e)



(f)

Fig- 8: Eye Diagrams of (a)(b) NRZ (c)(d) RZ (e)(f) MDRZ at 10 Gbps and 20 Gbps respectively

4. CONCLUSION

We successfully demonstrate 10 Gbps wavelength division multiplexed FSO system at 5000 m length downstream. Analysis of the demonstrated system is performed for diverse modulation formats such as RZ/NRZ/MDRZ modulation with parameter like distance. It is concluded that MDRZ exhibits best results in WDM over FSO communication system; additionally free space link investigation revealed that owing to bandwidth efficiency and phase shifts, MDRZ is obtained as optimal modulation followed by the NRZ signal. It is seen that because of the effects of amplitude degradation factor and beam divergence, Q factor decreases as link length prolongs.

There are significant deterioration in the performance when data speed is varied from 1 Gbps to 20 Gbps due to the short time of the pulse and as a result of this, dispersion emerges more. Distance supported 5 km at the rate of 20 Gbps with 16 channel WDM free space link and increase in further distance cause sharp bit errors.

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