Performance Analysis of CO-OFDM-FSO System using PDM

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Abstract *- Free space optics is an optical wireless communication technology that uses space for transferring data between two given points. It is used in regions where physical links are not possible. By using Orthogonal Frequency Division Multiplexing (OFDM) is a modulation technique for transmission of communication through recent wireless and optical channel. The OFDM is a recent multiple access technology for both wired and wireless mediums. It provides the data on a large number of subcarrier which has been adapted to the recent broadband communication system. This research focus to carry out investigation of performance analysis of CO OFDM FSO system using Polarization Division Multiplexing as compare to WDM-FSO system under adverse weather condition. A 10 Gbps data is transmitted using 4-QAM through free air space under light rain, heavy rain and wet snow conditions. Results show that by employing polarization division multiplexing, CO-OFDM-FSO link prolongs to 17 km with acceptable bit error rate (BER≤10^{-9}) under light rain conditions, while under heavy rain conditions, the maximum distance is extended to 6 km and CO-OFDM-FSO system using PDM provides enhanced values of quality factor.*

Keywords- *Free Space Optics (FSO), Coherent orthogonal frequency Division Multiplexing (CO-OFDM) and Polarization Division Multiplexing (PDM).*

I. INTRODUCTION

In FSO, air is utilized as medium to transfer data between any two given points. It can be used in areas where physical connections are not feasible [1]. FSO is very useful because of its license-free operation, high data rate transmission, full duplex transmission, higher bandwidth as well as the power utilization is less in the case of FSO. But there is degradation in the quality of the output signal due to the atmospheric attenuation. FSO system is prone to different weather conditions like fog, snow, rain and dust particles. Phase fluctuation and intensity scintillation causes the instability in the signal. FSO is used in so many applications like in biomedical, under water communication, for disaster recovery etc. OFDM is reliable modulation system to access broadband because it provides high channel efficiency and also the effect of multipath fading reduces [2]. Using this modulation scheme each subcarrier is modulated by carrier signal information. The inter symbol interference (ISI) can also be reduced between subcarriers because they are orthogonal to each other. Using correlation scheme the partition becomes easier at receiver end [6]. So by using OFDM multiple channel transmission is possible in FSO system. Coherent optical orthogonal frequency division multiplexing (CO-OFDM) and free space optics (FSO) system has been confirmed under different atmospheric condition. However first time, we have demonstrated CO-OFDM FSO system using PDM (Polarization Division Multiplexing) under different weather condition like light rain, heavy rain and wet snow and what will max distance for communication at acceptable SNR and BER. Basically, Polarization Division Multiplexing (PDM) is a physical layer system for multiplexing signal carry on electromagnetic wave, allows two channels of information to be transmitted on the carrier frequency by using two waves of orthogonal polarization states. it is used in fibre optic communication by transmitting separate left and right circularly polarized light beams through the same optical fibre. Polarization division multiplexing typically use together with optical QAM and phase modulation. It allows transmission speeds of 100 gbit/s or more over a single wave length signal can be carries over wavelength division multiplexing infrastructure, potentially expanding its capacity. . In section 2, simulation design and description of CO-OFDM FSO system using PDM in OPTSYSTEM is given. In section 3 the Bit error rate curve and Quality factor curve plotted against distance (range) for different weather conditions, and result discussion is given.

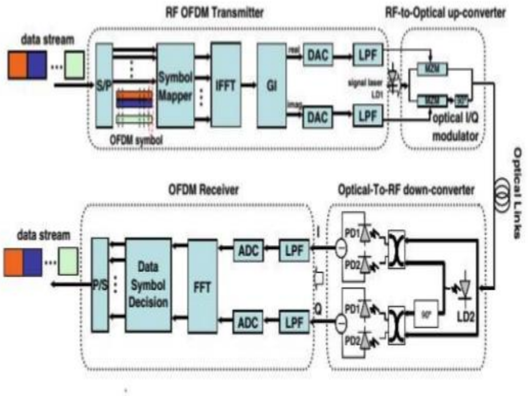

Fig. 1 Conceptual Diagram of CO-OFDM-FSO System

II. CO-OFDM-FSO SYSTEM DESIGN AND DESCRIPTION

Coherent detection CO-OFDM required more complex transceiver design which shows the crucial performance in spectral efficiency and receiver sensitivity etc. [7]. CO-OFDM is suitable for long haul transmissions and provides high spectral efficiency and it also avoids the interference by using signal set orthogonality. In CO-OFDM systems the optical carrier is generated through laser by using local oscillator thus the less transmitted power required by the CO-OFDM system even though it is more sensitive to phase noise. The main benefits of CO-OFDM system is very beneficial because it provides high spectral efficiency, robustness against PMD and CD as well as it provides high range of receiver sensitivity and least oversampling factor.

Fig .1 shows the block diagram of CO -OFDM and FSO system. A basic CO-OFDM system has five basic functional blocks: RF to optical (RTO) up converter, optical to RF (OTR) down converter, OFDM transmitter, optical link and OFDM receiver. The diagram illustrates a 10 gbps coherent 512- sub carrier 4 QAM OFDM scheme, on the other hand separate modulation format such as QAM, BPSK and QPSK etc. It can be used for data input for OFDM modulator. Both modulation and multiplexing are obtained digitally using an opposite fast Fourier transform (IFFT). The subcarrier frequency is mathematically orthogonal over one OFDM sign period. A CW laser and two Mach- Zehnder modulators are helpful to up converter the RF data into optical domain. A coherent receiver with a local oscillator is utilized to down converter the data to the RF domain and finally data is demodulated and send to the detector and decoder for measurement of BER.

A. SIMULATION SETUP OF CO-OFDM-FSO SYSTEM USING PDM

In the proposed system simulative analysis of the CO-OFDM-FSO system using PDM under rain and snow weather conditions has been performed and their performance has been compared based on Quality Factor, BER and eye diagrams of a received signal. 2 it can be seen that with the increase in the attenuation values for different weather conditions, the performance of CO-OFDM-FSO using PDM system degrades and maximum link distance with acceptable performance levels reduces. The maximum link distance in the case of light rain is 17 km which limits to 6 km in heavy rain. Similarly, the maximum link distance in the case of wet snow is 7.7 km. The eye diagrams of received signals under light rain, heavy rain and wet snow at link distance of 13 km, 4 km and 3.7 km respectively. After the amplification of the signal, the output from OFDM transmitter is launched into free space on the receiver side and Polarization beam combiner (PBC) is used to recombine the two signals at output. System performance is observed under various weather conditions like light rain, heavy rain, and wet snow, with attenuation of 6.27 dB/km, 19.28 dB/km, and 13.73 dB/km correspondingly by using Optisystem. Two coherent receivers are placed to detect the two polarizations of received signal, which are being separated with the help of Polarization splitter and then amplified optical signal is fed to PIN Photodiode to convert optical information into electrical output.

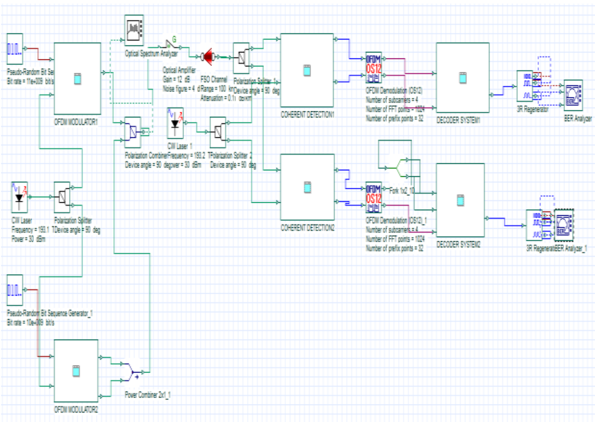

Fig.2 Design of CO-OFDM-FSO System

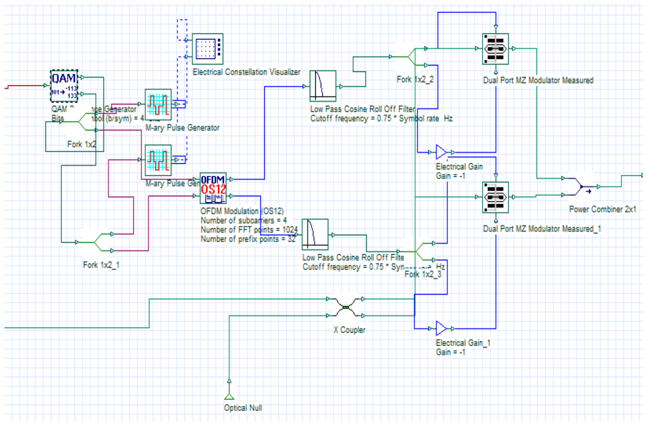

Fig.3 Internal layout of OFDM Modulator

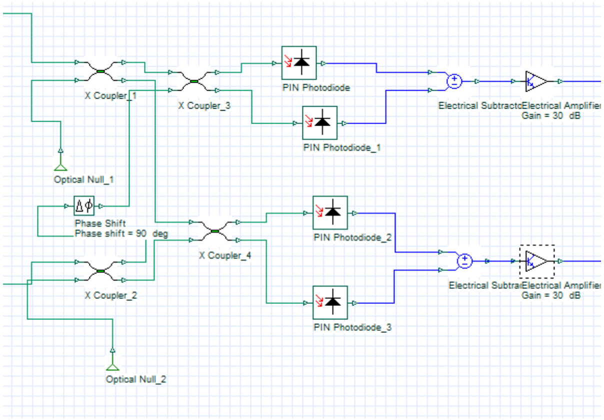

Fig. 4 Internal layout of Coherent Detection

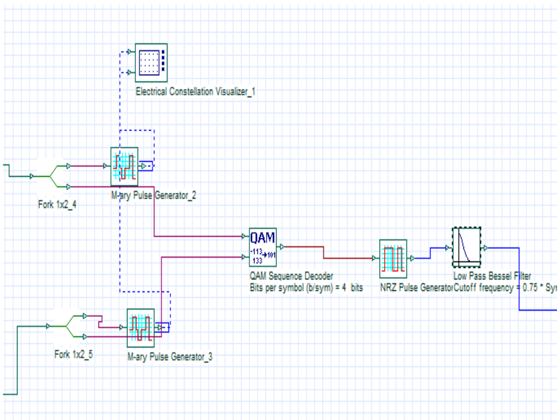

Fig.5 Internal Layout of Decoder System

III. RESULT AND DISCUSSION

Although FSO has to experience atmospheric turbulence but it provides many advantages as compared to other communication system. Research is going on to improve FSO link impairments caused by atmospheric turbulence. Many new technologies implemented in FSO system like OFDM FSO techniques. . The system performance gets better using OFDM-FSO. Such a system has a big scope in future for long reach applications. Performance of coherent orthogonal frequency division multiplexing and free space optics (CO-OFDM FSO) system using polarization division multiplexing (PDM) technique is checked in this paper and also checks how the act of system will change as atmospheric condition change. If we set BER at 10^{-4} the proposed CO-OFDM FSO system perform at 9dB SNR thus system will work at low SNR value. So CO-OFDM FSO system will be good option for higher data rate and higher range of communication.

A. PERFORMANCE ANALYSIS OF CO OFDM FSO SYSTEM USING PDM

In the proposed system simulative analysis of CO OFDM FSO system using PDM beneath rain and snow weather conditions has been performed and their comparison is done on the basis of Quality Factor, Bit error rate and Eye diagrams of received signal.

Table I Simulation Parameters of CO-OFDM FSO System

Component Used	Parameter	Range
OFDM Modulator/Demodulator	No. of sub carriers Position array No. of fft points No. of prefix points	4 256 1024 32
Tx. CW Laser	Power Frequency	0dBm 193.1 THz
FSO Channel	Beam Divergence Tx Diameter Rx Diameter	2 mrad 5 cm 20 cm
CW Laser	Power Frequency	193.1 THz 30 dBm

Table II Performance analysis of CO-OFDM-FSO system using PDM under different weather conditions

Weather conditions	Attenuation (dB/km)	Max. link distance (km)	Q Factor (dB)	BER
Light rain	6.27	17 km	7.57	$1.957e^{-12}$
Heavy rain	19.28	6 km	8.669	$2.154e^{-18}$
Wet snow	13.73	7.7 km	8.96	$1.519e^{-19}$

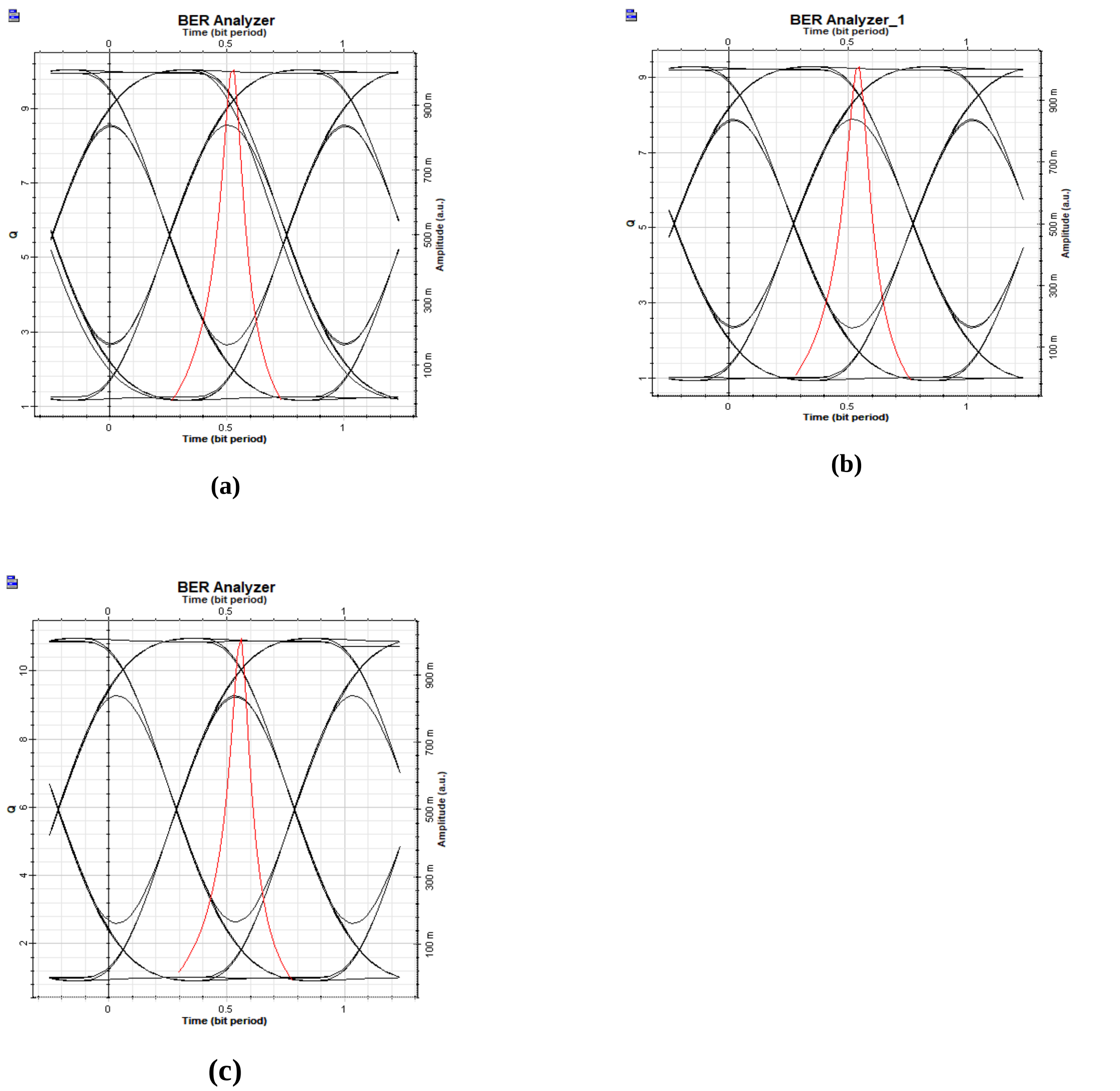

Fig.6 Eye Diagram of the received signal under (a) light rain at link distance of 13 km, (b) heavy rain at link distance of 4 km and (c) wet snow at link distance of 3.7 km

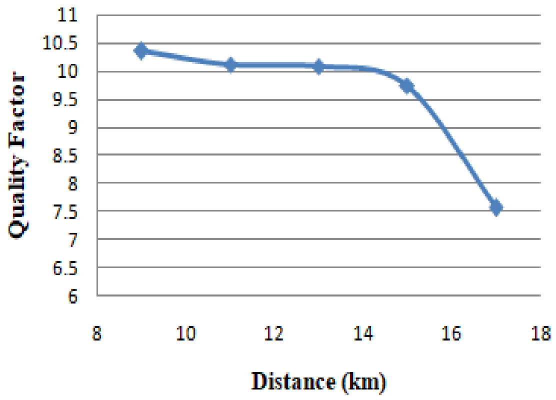

Fig.7 Variation of Q Factor with variation of FSO link Distance for Light rain

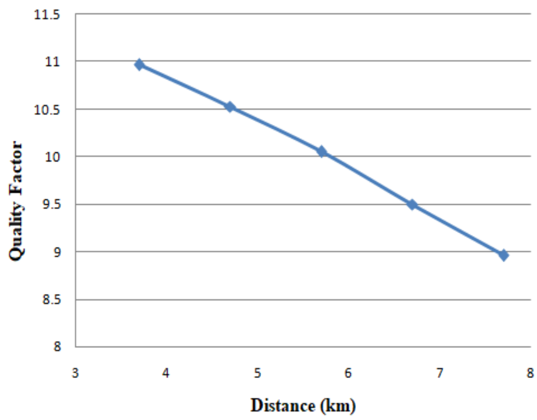

Fig. 8 Variation of Q Factor with variation of FSO link Distance for wet snow

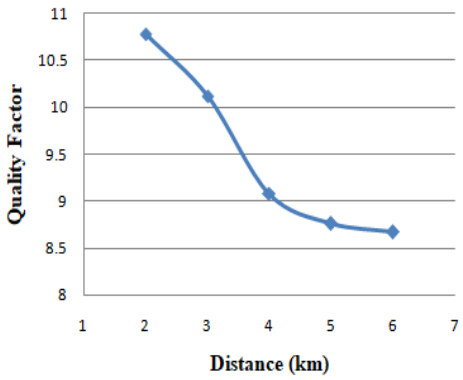

Fig. 9 Variation of Q Factor with variation of FSO link Distance for Heavy rain

B. COMPARATIVE ANALYSIS OF CO - OFDM - FSO SYSTEM BY USING PDM

The WDM-FSO system does not support high bit rates at longer distance. A significant development in Q-Factor can be seen as shown in Table 3.

Table III Comparative analysis of previous work and current work

S.No.	Parameters	Current work	Previous work (Singh, 2018)
1.	**Multiplexing Technique**	Polarization Division Multiplexing	Wavelength Division Multiplexing
2.	**Max. Distance (km)** i) Light Rain ii) Heavy Rain iii) Wet Snow	 17 6 7.7	 16.5 5.4 7.6
3.	**Max. Q-Factor** i) Light Rain ii) Heavy Rain iii) Wet Snow	 10.35 10.78 10.96	 5.79 5.93 5.77
4.	**BER** i) Light Rain ii) Heavy Rain iii) Wet Snow	 $1.88e^{-25}$ $2.082e^{-27}$ $2.682e^{-28}$	 $3.18e^{-9}$ $1.39e^{-9}$ $3.64e^{-9}$

VI. CONCLUSION

Polarization Division Multiplexing technique is use the CO-OFDM FSO System to tackle the impact of scintillation during propagation through atmospheric channel, because the atmosphere has weakest depolarizing property. Hence signal can cover long distance under high turbulence. Moreover, at receiver side Coherent detection is also used for improvement of system accuracy and efficiency. So, by CO-OFDM FSO System better communication link can be built up to 17 km, 6 km and 7.7 km under light rain, heavy rain and wet snow respectively.

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