Volume 8, No. 4, May 2017 (Special Issue)

ISSN No. 0976-5697

International Journal of Advanced Research in Computer Science

REVIEW ARTICLE

Available Online at www.ijarcs.info

Design & investigation of 32x10 GBPS DWDM-FSO Link under Different Weather condition

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***Abstract*— Due to growing demand of high speed, data rate and bandwidth has led to the emergence of free space optics (FSO) technology. It has various advantages such as high data rates, bandwidth and capacity.FSO system requires free space as channel. Attenuation offered by the channel can degrade the system performance. So by using Wavelength Division Multiplexing (WDM) over FSO link, the system capacity can be increased more effectively. In this paper, 32 channels DWDM-FSO system has been designed and analyzed in worst weather conditions at 1550 nm wavelength using NRZ modulation. The performance of the simulated system has been investigated in terms of quality (Q) factor, data rate and maximum link distance. The simulation work shows that high data rate upto 10Gbps with maximum link range has been achieved at Bit Error Rate (BER) 10^{-10} under different weather conditions. The maximum link range up to 513 km at data rate of 10Gbps is achieved for very clear weather condition.**

Keywords*— Free Space Optics, Bit Error Rate, semiconductor optical amplifier, wavelength division multiplexing.

I. Introduction

Free space optical communication is a wireless optical communication technology. These systems offer excellent automatic power-level control, and eliminate short-distance optical saturation [1].Free Space Optics (FSO) is a communication technology that uses light as carrier and free space as medium to transfer information between transmitter and receiver separated by certain distance. It requires the LOS links for reliable communication between the transmitter and receiver.The data which has to be transmitted is modulated on the intensity, phase and frequency of the carrier signal [2]. In FSO system different modulation techniques are used to modulate information signal at source. Each FSO system uses a high-power optical transmitter for transmit source signal towards destination and receiving side high sensitivity receiver used. But the atmospheric attenuation is major challenge for faced by FSO systems which affect the performance of the link. The other factors which can affect the FSO are humidity, water-vapors, signals absorption, smoke, beam scintillation, spreading and wandering are some of the factors [3]. FSO systems operates around 850 and 1550 nm wavelengths.1550nm wavelength is preferred because of more eye safety and reduced solar background radiation[4]. Free space optics offers the potential of high, data rate, bandwidth capacity over unlicensed optical wavelengths so it has emerged as a viable technology for broadband wireless applications.fig.1 shows block diagram of FSO system.

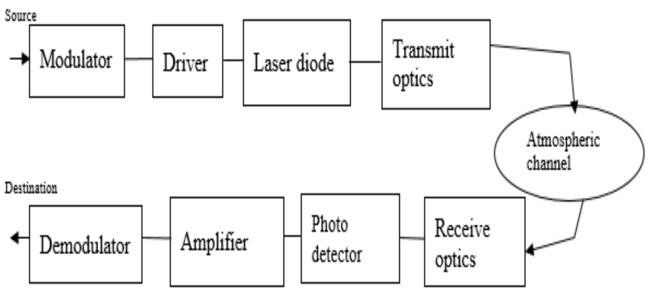


Fig. 1.Block diagram of FSO system

In the field of FSO communication, the wavelength division multiplexing (WDM) is one of the efficient techniques used to provide high-capacity long distance transmission. WDM system has high capacity so that it has ability to achieve high data rate and longer link distance due to more laser power [6]. Usually, the WDM system have the channel spacing of ≥ 200 GHz, are known as the conventional WDM system. To reduce this channel spacing, the dense wavelength division multiplexing (DWDM) system was developed, which has the channel spacing of≤ 100 GHz to enlarge the capacity of system [7]. WDM technique becomes most popular due to the fact that capacity of system can be increased by increasing the number of channels and tapering the channel spacing without using more than one FSO link. So WDM approach can be applied in FSO systems to enlarge the bandwidth in cheaper way [5]. In this paper SOA is used for amplification of optical signal because of its unique properties such as Size of SOA is compact, High-speed capability, low switching energy as compared to other Amplifiers. All these properties craft SOA a good choice for optical amplification [8].

In this paper, the work has been extended from work reported in [1], [2] by presenting less input power requirement, high data rate and Q factor by using efficient optical amplifier under worst weather condition. In this paper, 32 channel DWDM-FSO system has been designed and investigated under different weather conditions. This system has achieved distance of several kilometers with high data rate up to 10Gbps under different attenuation conditions.

Rest of the paper organized as follows: Section II describes the simulation setup. In Section III simulation results and discussion have been reported and conclusions are given in IV.

II. SIMULATION SETUP

32-channel DWDM-FSO communication system is designed and simulated in Opti-system simulator software. Figure 2 shows the block diagram of simulation setup. These system design parameters are given in Table (1). Transmitter section consists of 32 transmitters having frequency range form 193-196.2 THz with the channel spacing of 100 GHz. On the transmitter side we have used Pseudo-Random Bit Generator, NRZ Pulse Generator, CW Laser, Mach-Zehnder Modulator and WDM-MUX. Each input signal is modulated by NRZ format. The transmitter optical signal is the transmitted over FSO link under different weather attenuation conditions. On the receiver side firstly the SOA pre-amplification is done to raise the signal strength then 1x32 WDM Demultiplexer is used to separate the different signals. These separated signals are detected by Avalanche photo detector (APD). Filtering of the signal is achieved by Bessel filter and visualizer tool such as eye diagram analyzer or BER analyzer is used to visualize the signal. The quality of the received signal is considerably depends on the conditions of the FSO channel and the WDM system design.

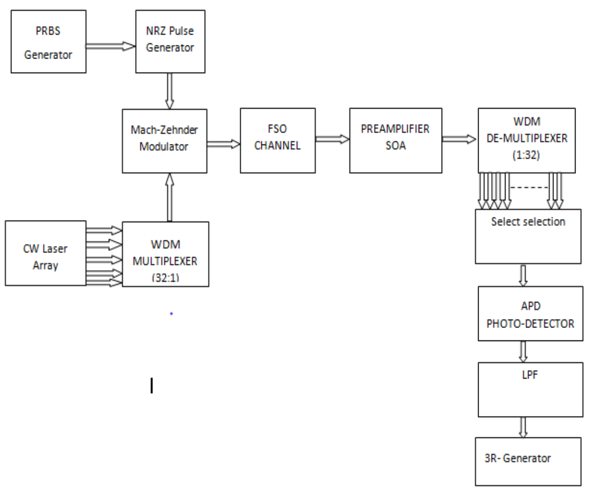


Fig. 2. Simulation setup of 32-channel WDM over FSO communication system.

Table I. Simulation parameters

Parameter	Value
Bit rate	10 Gbps
Laser wavelength (λ)	1550 nm
Cw array laser frequency	193.1-196.2THz
Transmitter aperture diameter	10 cm
Receiver aperture	20cm
Beam divergence	1 mrad

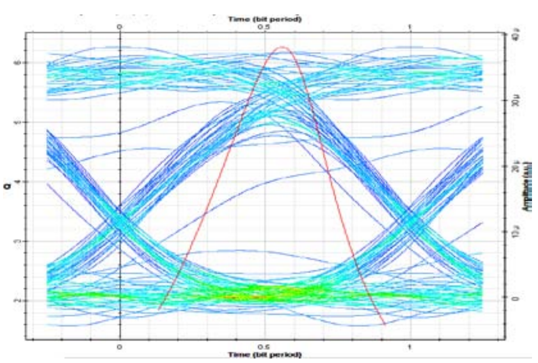
III. SIMULATION RESULTS AND DISCUSSIONS

This paper presents simulated results for analyzing the performance of 32 channel WDM-FSO communication link under different weather conditions. This system is running at maximum link range with high speed data rate up to 10Gbps. The performance evaluation of the system under heavy rain, medium rain, light rain, heavy haze, light haze, clear sky and very clear conditions are shown in Table (2). It can be seen that under optimized conditions of laser power, the increase in the attenuation causes reduce in the maximum transmission link with acceptable BER and Q-factor. From the results shows that there is increase in data rate By using SOA amplification. It can be seen that for clear weather condition the maximum link can be carried out up to 513 km while it get reduced to 5.75 km for heavy rain condition. The eye opening and BER for the clear, heavy haze, light rain and heavy rain are seen in Fig. (3).

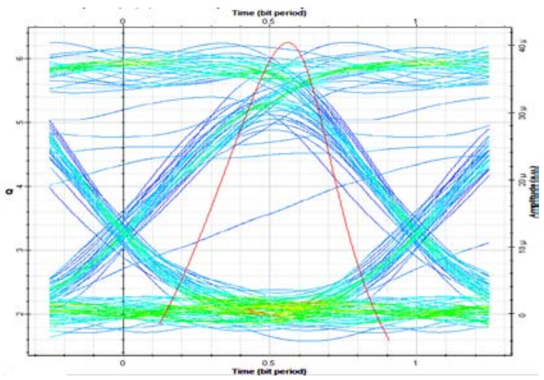
Table II: Performance analysis of system under different Weather conditions

Weather Condition	Attenuation (dB/km)	Laser Power (dBm)	Max. Link Range (Km)	BER	Q-Factor
Very clear	0.15	10	513	1.5176e-10	6.27787
Clear	0.299	10	274.6	1.6332e-10	6.26132
Light haze	0.61	10	144.8	2.5784e-10	6.19744
Heavy haze	2.62	10	27	3.112e-10	6.14708
Light rain	6.80	10	15.73	4.4693e-10	6.09957
Heavy rain	19.77	10	5.75	5.5093e-10	6.06625

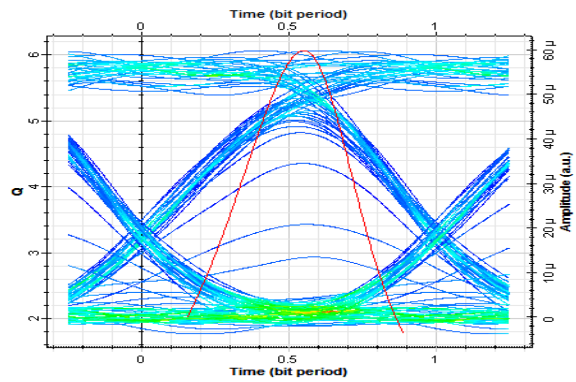
Eye diagrams at different weather conditions are shown below:



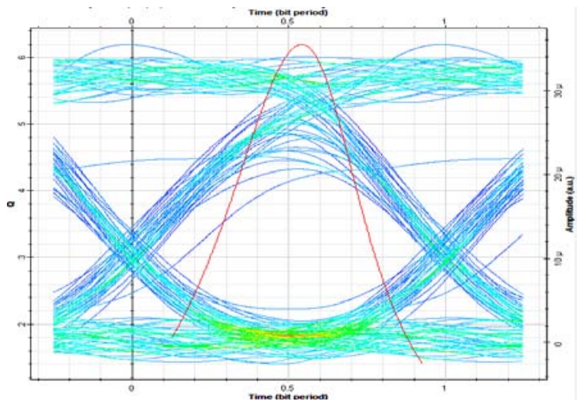
(a)



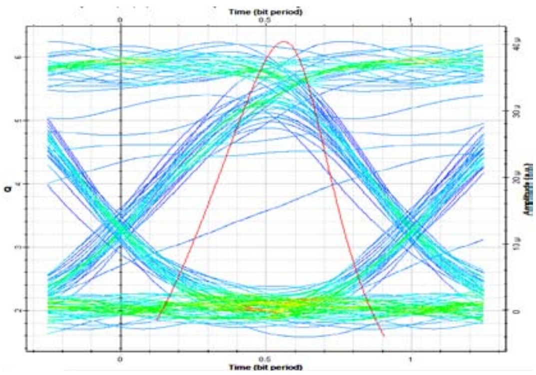
(b)



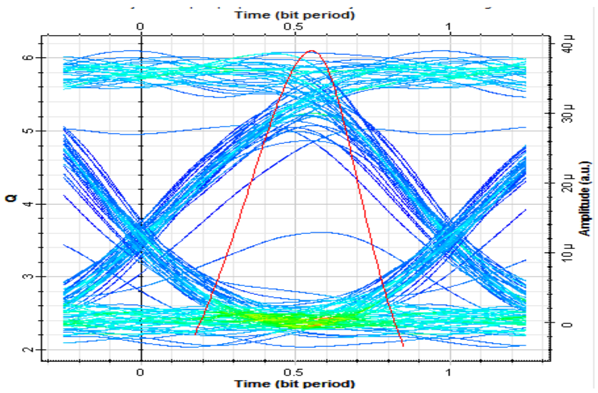
(f)



(c)



(d)



(e)

Fig. 3. Eye diagrams for different conditions: (a) very clear sky, (b) clear sky, (c) light haze, (d) heavy haze, (e) light rain& (f) heavy rain

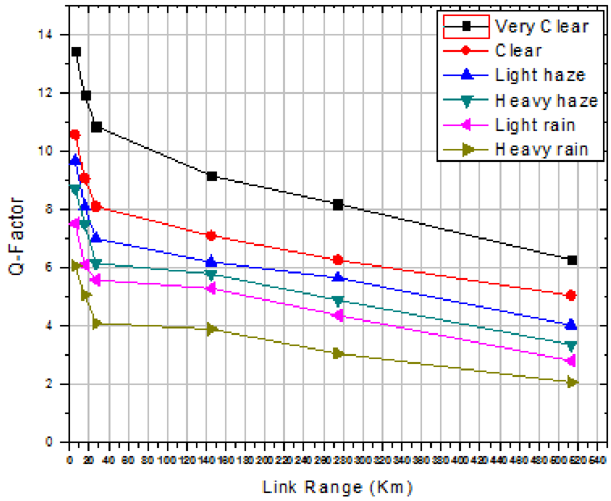


Fig.4. Q-factor v/s range

Fig. 4 shows that Max. Q. factor with respect to link distance under different weather conditions. The increase in the attenuation leads to decreasing in the dis27787 for heavy rain and very clear weather at the maximum link range.

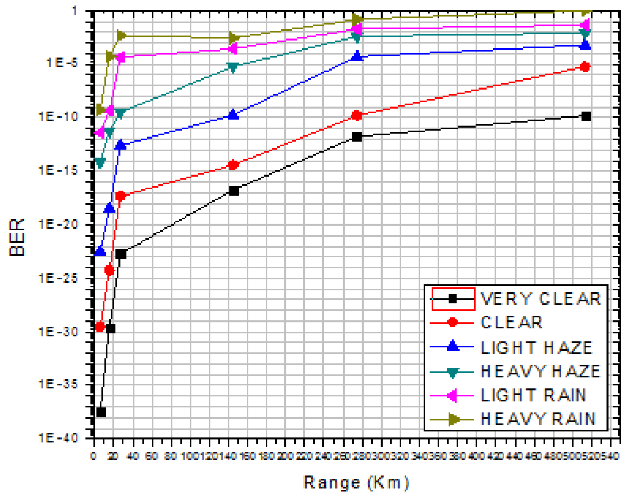


Fig.5. BER v/s range

Fig. 5 shows the curves of the BER v/s link range for different weather conditions. In this case, it is noticed that for BER 10-11, the distance transmission is limited to 513 km, 274.6km, 144.8 km, 27km, 15.73km and 5.75 km for very clear, clear, light haze, heavy haze, light rain and heavy rain respectively as shown in Table II. It can be seen that the BER curves decreases with increase in the distance of transmission. In this case, for strong attenuation the data transmission does not exceed 15.73 km and 5.75 km for light rain and heavy rain respectively. This decrease in distance of data transmission comes from increase in attenuation coefficient.

IV. CONCLUSION

This paper demonstrated the design and investigation of 32 channel DWDM-FSO link with data rate up to 10Gbps using NRZ modulation technique under different attenuation conditions. In this paper, maximum link range for the heavy rain condition is about 5.75 km at acceptable BER of 10^{-10} and for heavy haze condition about 27km at BER 10^{-11}, also for very clear sky the distance reached up 513 km at BER 10^{-10} is concluded. From simulation results, it concludes that for heavy rain condition, maximum link distance with acceptable BER of 10^{-10} with high data rate up to 10Gbps is achieved. Thus, the findings demonstrated that the DWDM systems have good performance, low bit error rate and fully exploit the high data rate speed.

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