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SIMULATIVE INVESTIGATION OF 16X5 GB/S & 16X10 GB/S WDM-FSO TRANSMISSION SYSTEM UNDER DIFFERENT ATMOSPHERIC CONDITIONS

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Abstract: In Free Space Optic (FSO) system free space requires as a communication media. Atmospheric attenuation due to communication media can degrade a system performance. To overcome this losses BER or Q-factor of a system are improved by using different type of photo-detector at receiver side & using optical receiver at link.. This paper describe the design and simulation of 16-channel WDM based Free Space Optical communication link under various Atmospheric conditions at different bit rates (5Gbps/10Gbps) using APD & PIN photo-detector & the performance of system using APD & PIN photo-detector is compared. The NRZ modulation format & semiconductor optical amplifier (SOA) is used in this design. In this simulation it observed that APD photo-detector at bit rate 5Gbps/10Gbpsgive better performance at higher attenuation.

Keywords: APD photo-detector, Atmospheric attenuation, Bit Error Rate, PIN photo-detector, Bit analyzer, 16-channel, WDM, Q-factor.

INTRODUCTION

Free Space Optical Communication system is widely used now a day's due to its high Bit Rate, huge bandwidth and minimum bit error. FSO system provide very efficient communication. In FSO communication system electrical signal first converted into light form for this purpose Laser source is used which include LED's and Laser diodes. On the other hand at receiver side optical-detector is used to covert light signal back into electrical form. [1] The photo-detector is an essential element of any optical communication system which connected at receiver side as shown in "Fig.1".

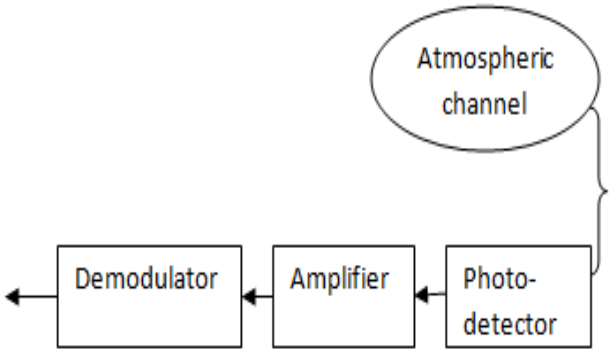


Fig.1. Receiver Section of FSO system

There are two types of photo-detector used in FSO communication system as:

I. PIN photo-detector
II. APD photo-detector

PIN photo-detector—PIN photo-detector is mainly used FSO communication system to convert optical signal into electrical form. The PIN photodiode is mainly operates on reverse bias voltage. This was invented in 1950's. A PIN diode mainly included three region as:

a. N-region
b. P-region
c. Intrinsic region

First of all electron-hole pairs are generated in depletion region by photo absorption. These generate more pair of electron and hole through impact ionization which swept out depletion region very fast i.e the transit time is very less.[2,3]

APD photo-detector—An Avalanche photo-detector (APD) is a semiconductor device which exploits the photoelectric effect to convert light to electricity. APD photo-detector provide a built-in first stage of gain. APD was invented in 1960's. APD structural configuration is same as of PIN photodiode. When high reverse bias voltage is apply to APD it show an internal current gain effect. This internal current gain effect is due to impact ionization. [4] In APD higher gain is possible due to internal multiplication. Where in PIN photo-detector current at output is proportional to light incident. So gain in case of PIN photo-detector is low compared to APD photo-detector.

SYSTEM DESIGN

The FSO system is sub divided into three parts : Transmitter, FSO channel, Receiver. The Transmitter section has four subsystem: Pseudo Random Bit Stream to generate the sequence of bit. NRZ Modulator to encode the signal. CW array laser for transmission of light signal and forth is Mach-Zehnder modulator to modulate the data.[5] The basic transmitter section is shown in "Fig.2."

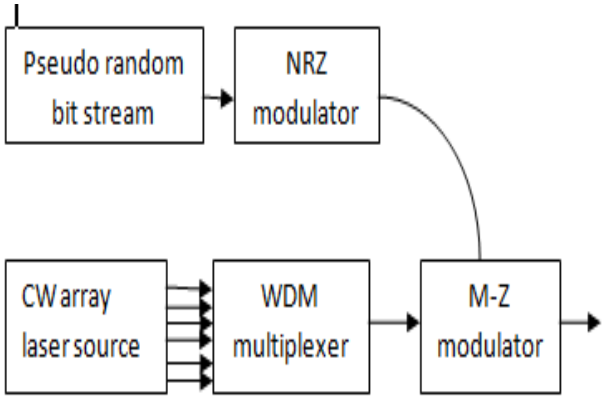


Fig.2. Transmitter section

At the receiver section: Photo-detector is used for conversion of light to electricity. A LPF is used for amplification purpose. 3R Regenerator and BER Analyzer at end of receiver to analyzed the Bit Error Rate and Q-factor.[6] The "Fig.2" show the receiver section of WDM-FSO system

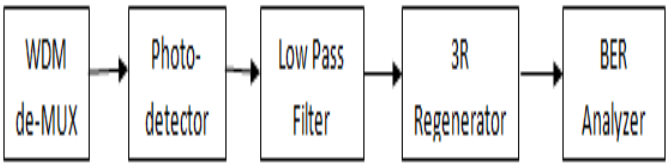


Fig.3. Receiver Section

There are two system design in this paper System I & System II. Which are discuss as below:

System I. In system I 16x5Gbps system is design using APD & PIN photo-detector. Firstly 16x5Gbps system using APD photo-detector is investigated for 4 different atmospheric conditions. Then 16x5Gbps system is design using PIN photo-detector.[7]

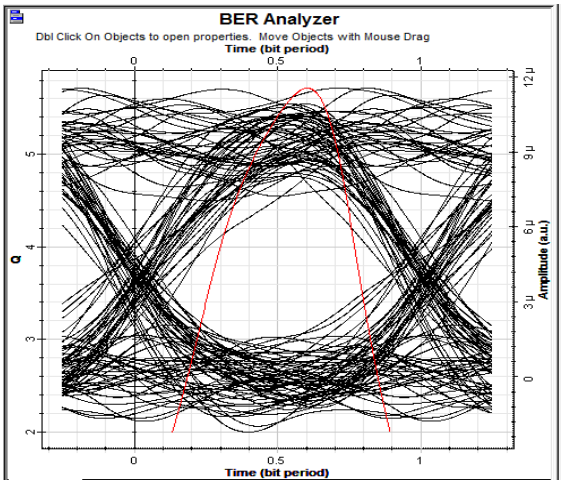
System II. In this system 16x10Gbps system is design using APD & PIN photo-detector.16x10Gbps system is design firstly using APD photo-detector. Investigate it for very clear, clear, light haze, heavy haze atmospheric attenuation. Secondly design 16x10Gbps system using PIN photo-detector and comparing it with 16x10Gbps system using APD photo-detector.[8] The simulation parameter are shown in Table .I.

Table I. Simulation parameter

Parameter	Value
Bit Rate	5Gbps, 10Gbps
CW array laser frequency	193.1THz-193.16THz
Transmitter aperture diameter	10 cm
Receiver aperture diameter	20 cm
Beam divergence	1 mard
Photodiode gain	3
Responsivity	1 A/W
Dark current	10 A

RESULT AND DISCISSION

The 16-channel WDM based Free Space Optical communication link has been analyzed at 5Gbps/10Gbps in term of Bit Error Rate and Q-factor. The Eye diagram for 16X5 WDM-FSO system using APD & PIN photo-detector are shown in "Fig.4" and "Fig.5" respectively.[9] The parameters Q-factor and BER are mention in Table. II.



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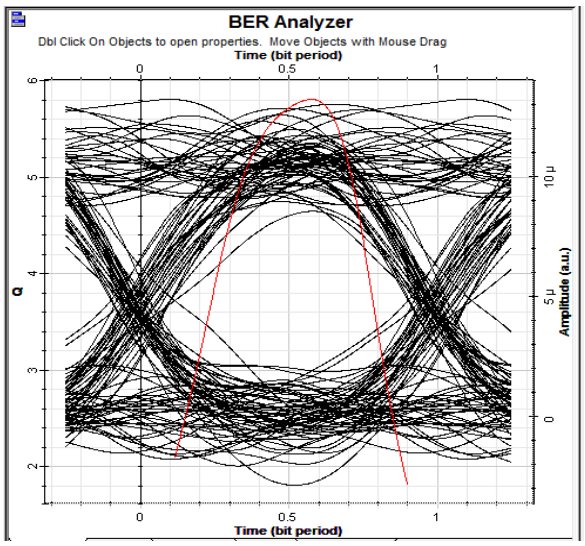

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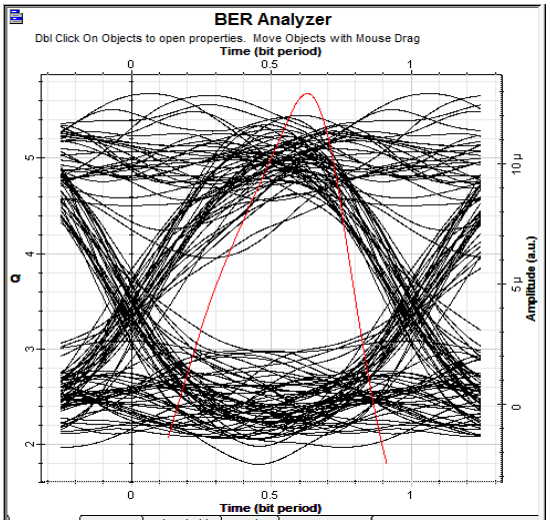

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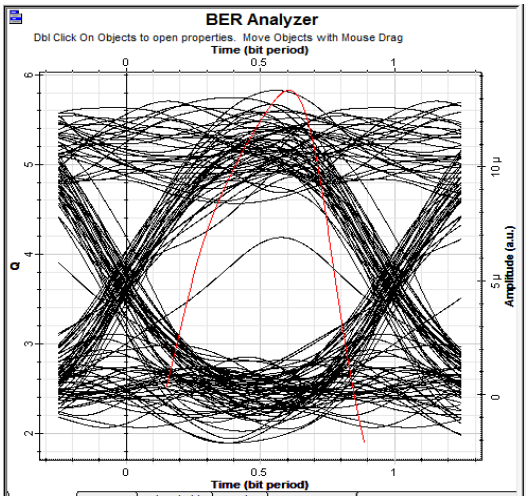

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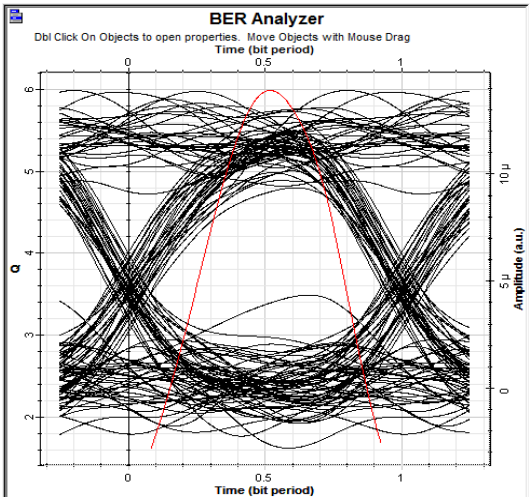
Fig.4. Eye diagram of 16x5Gbps system using APD photo-detector for different atmospheric conditions (a) Very clear sky (b) Clear sky (c) Light haze (d) Heavy haze



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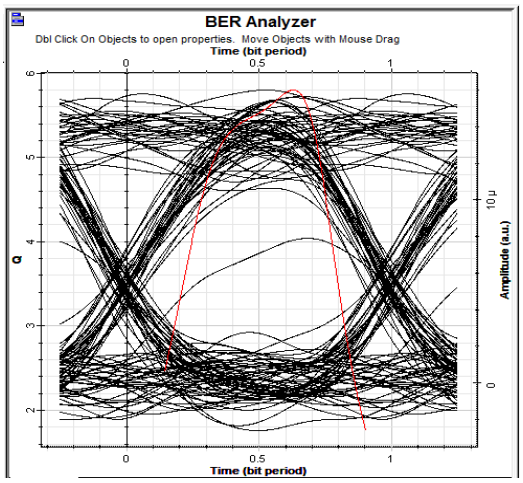

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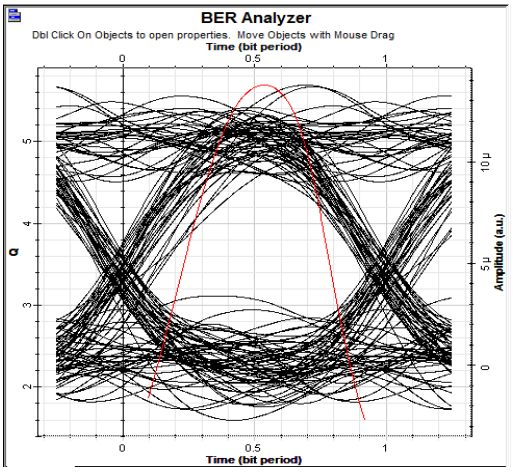

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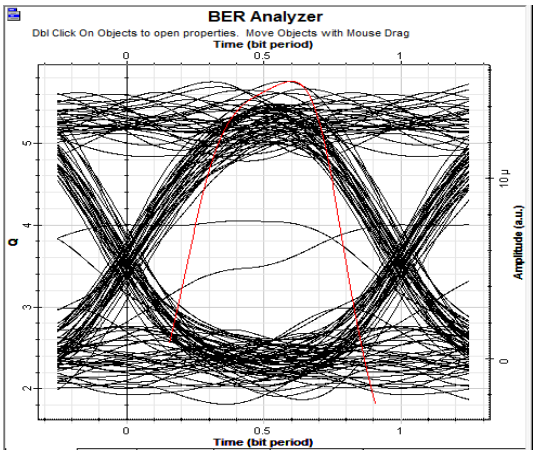


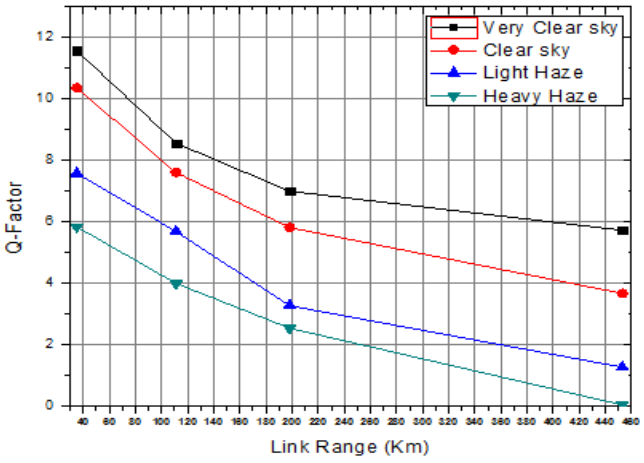
(d)

Fig.5. Eye diagram for 16x5Gbps WDM-FSO system using PIN photo-detector for different atmospheric conditions (a) Very clear sky (b) Clear sky(c) Light haze (d) Heavy haze

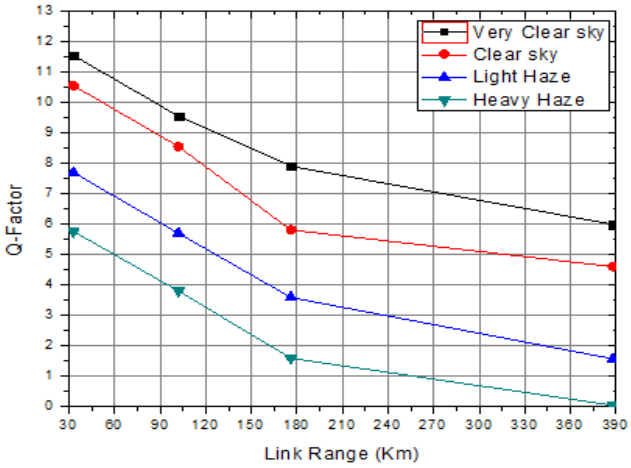
Table II. Performance analysis of 16X5Gbps WDM-FSO communication link using APD & PIN photo-detector for different Atmospheric conditions

16x5Gbps using APD photo-detector				
Atmospheric Conditions	Very clear sky	Clear sky	Light haze	Heavy haze
Attenuation	0.006	0.22	0.53	2.3

Power	3	10	20	32
Link Range	453	198	111	35
BER	5.47209 e^{-009}	3.20549 e^{-009}	6.86507 e^{-009}	2.74104 e^{-009}
Q-factor	5.71484	5.80563	5.67672	5.82803
16x5Gbps using PIN photo-detector				
Attenuation	0.006	0.22	0.53	2.3
Power	3	10	20	32
Link Range	388	176	102	32.8
BER	1.08542 e^{-009}	3.23167 e^{-009}	6.2838 e^{-009}	4.14631 e^{-009}
Q-factor	5.98384	5.79955	5.69074	5.75565

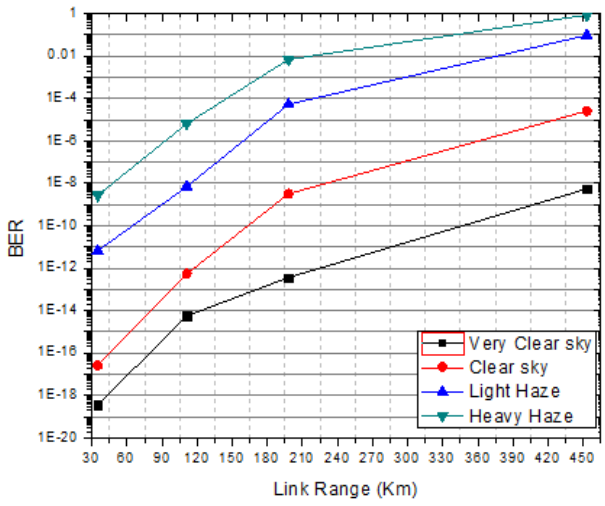


(a)



(b)

Fig.6. Q-Factor v/s Link Range for 16x5Gbps WDM-FSO system (a)using APD photo-detector (b) using PIN photo-detector



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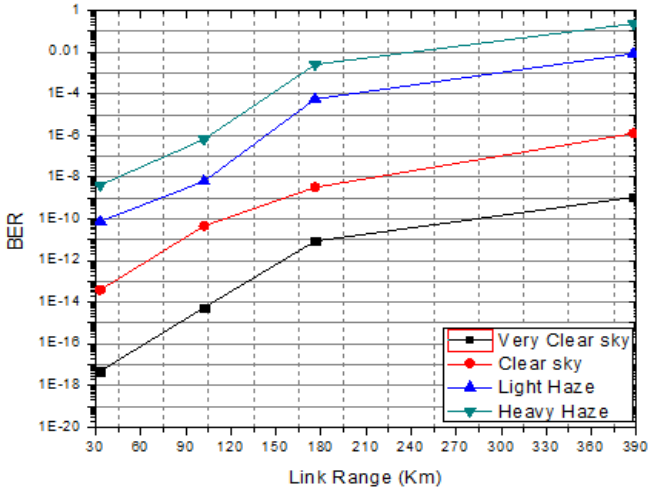
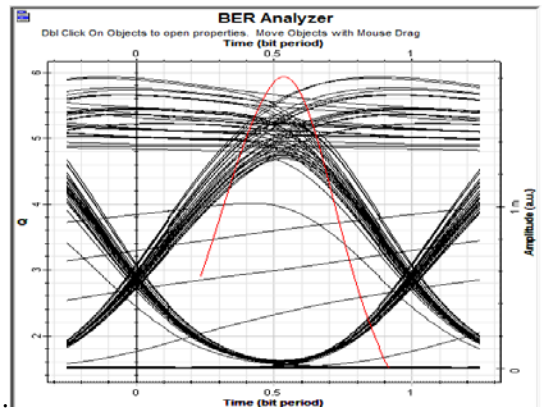


(b)

Fig.7. BER v/s Link Range for 16x5Gbps WDM-FSO system (a)using APD photo-detector (b) using PIN photo-detector

Similar as 16X5Gbps a 16X10Gbps system is design using APD & PIN photo-detector. 16X10Gbps system using APD photo-detector give better result as compare to 16X10 using PIN photo-detector. The Eye diagram foe 16X10Gbps WDM-FSO system using APD& PIN photo-detector are shown in "Fig.8" and "Fig.9". The parameters Bit Error Rate, Link Range and Quality factor are mention in Table



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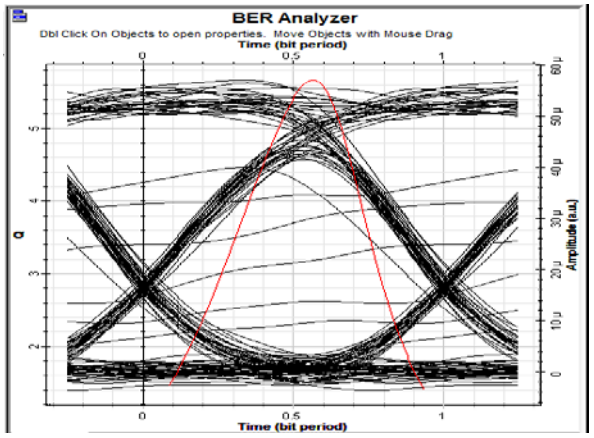

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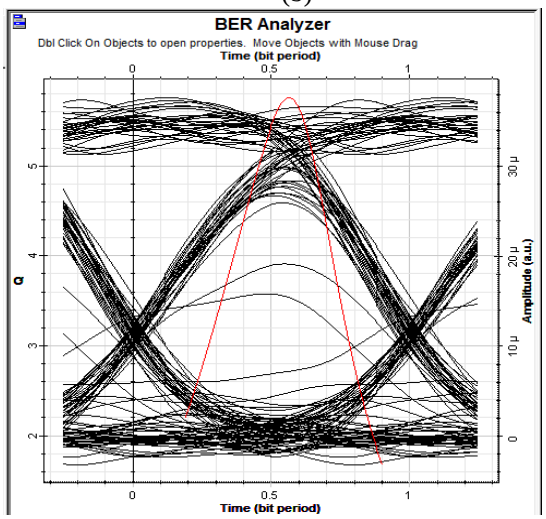

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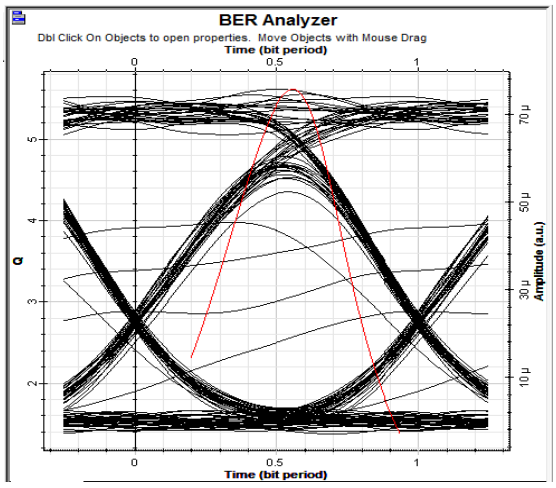
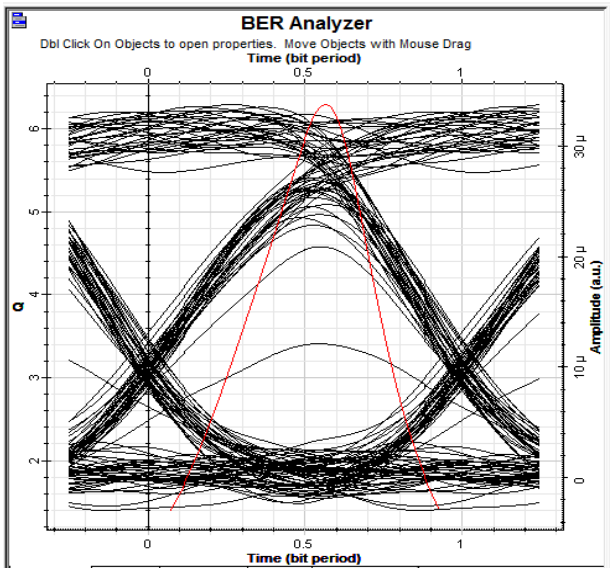
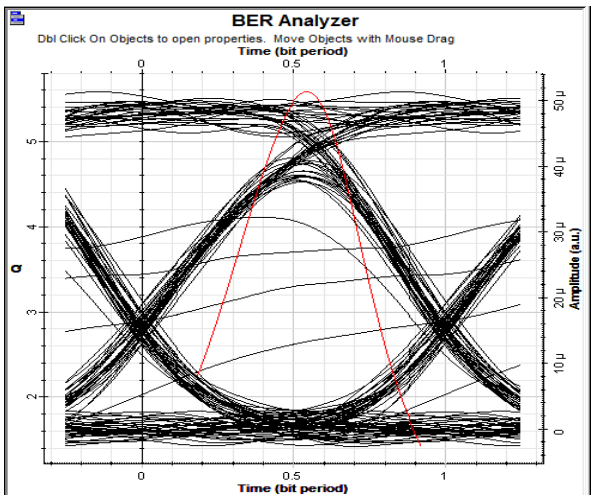


(d)

Fig.8. Eye diagram for 16X10Gbps WDM-FSO system using APD photo-detector for different atmospheric conditions (a) Very clear sky (b) Clear sky (c) Light haze (d) Heavy haze



(a)



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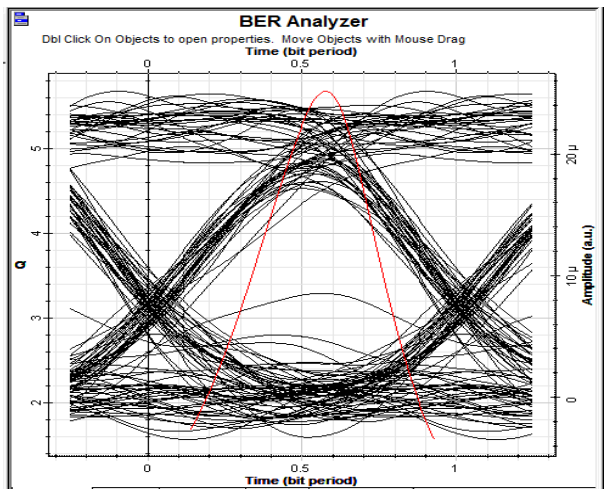

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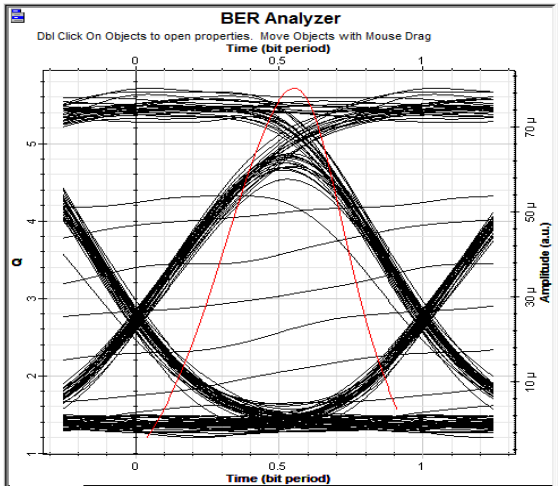
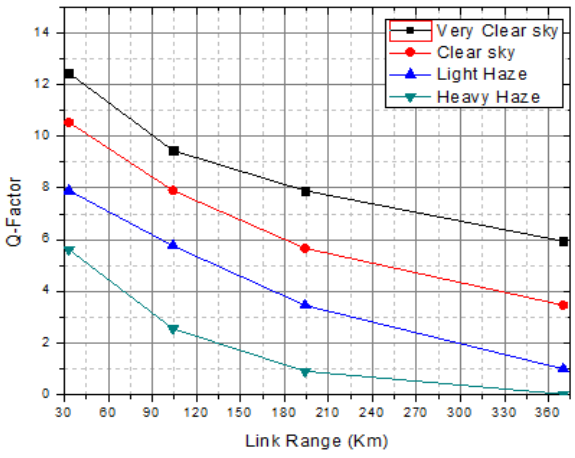


(d)

Fig.9. Eye diagram for 16X10Gbps WDM-FSO system using PIN photo-detector for different atmospheric conditions (a) Very clear sky (b) Clear sky (c) Light haze (d) Heavy haze

Table III. Performance analysis of 16X10Gbps WDM-FSO communication link using APD & PIN photo-detector for different conditions

16x10Gbps using APD photo-detector				
Atmospheric conditions	Very clear sky	Clear sky	Light haze	Heavy haze
Attenuation	0.04	0.19	0.52	2.3
Power	10	10	20	35
Link Range	370	194	104	33
BER	8.94084 e^{-010}	6.52781 e^{-009}	4.20817 e^{-009}	7.02098 e^{-009}
Q-factor	5.93701	5.66413	5.75753	5.61365
16x10Gbps using PIN photo-detector				
Attenuation	0.04	0.19	0.52	22.3
Power	10	10	20	35
Link range	590	170	99	31
BER	1.51539 e^{-010}	9.24711 e^{-009}	6.66409 e^{-009}	4.79512 e^{-009}
Q-factor	5.93546	6.29388	5.5825	5.68096



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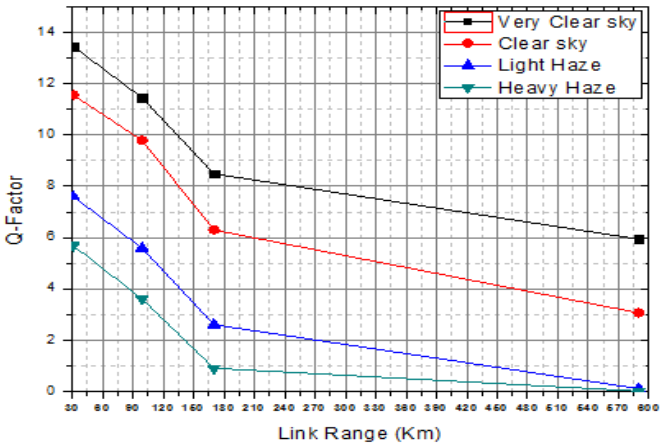
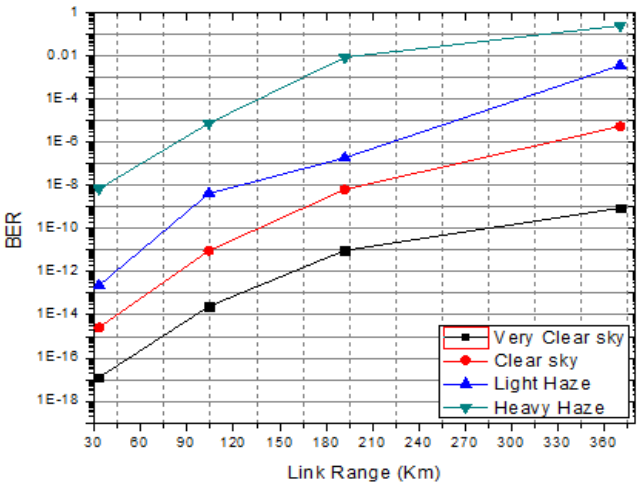


(b)

Fig.10. Q-Factor v/s Link Range for 16x10Gbps WDM-FSO system (a)using APD photo-detector (b) using PIN photo-detector



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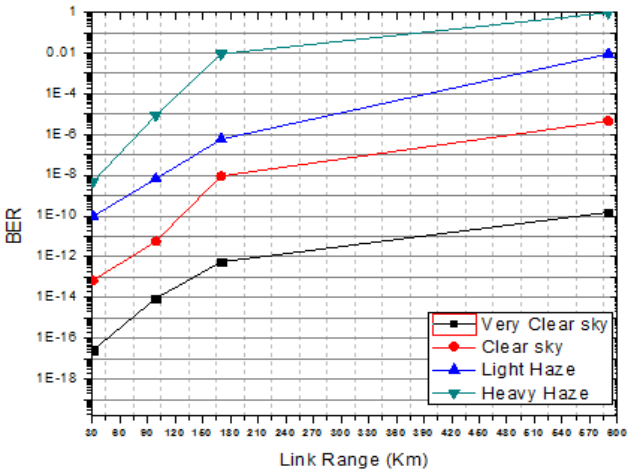

(b)

Fig.11. BER v/s Link Range for 16x10Gbps WDM-FSO system (a)using APD photo-detector (b) using PIN photo-detector

CONCLUSION

In this paper, 16-channel WDM based Free Space Optical transmission system is design and investigate at 5Gbps/10Gbps with APD & PIN photo-detector. The BER and Q-factor values for four atmospheric conditions are

evaluated. The maximum link range for 16x5Gbps system using APD photo-detector is 453 km achieved for PIN photo-detector it is up to 388 km. In 16x10Gbps system using APD photo-detector maximum link range 370 km and using PIN photo-detector it is up to 590 km. So it is conclude that 16x5Gbps system using APD photo-detector having best performance at higher attenuation. For lower attenuation 16x10Gbps system using PIN photo-detector is best.

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