Design & Investigation of 8x5Gb/s & 8x10 Gb/s WDM-FSO Transmission Systems Under Different Atmospheric Conditions

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Abstract

FSO is version of fiber optic communication system using free space as communication media. This paper describe the design and simulation of 8-channel WDM based free space optic(FSO) transmission system at 5Gb/s & 10 Gb/s under different atmospheric conditions. The performance of system is evaluated in term of BER and quality factor. The optical amplification is achieved by using TWT-SOA amplifier. Optic system is used as simulation tool to simulate the WDM-FSO link. The minimum value of bit error rate is achieved is greater or equal to 10^{-9} for optimize link range.

Keywords —- *SOA Amplifier. WDM-FSO, 8-Channel, Bit Error Rate, Travelling wave amplifier.*

I. INTRODUCTION

Due to growing the demand of wireless broadband communications the FSO has received appreciable attention as an alternative to existing RF communication and fiber optic system. This is because FSO has low cost as compared to fiber optic communication and offers low dispersion. The working of Fiber optic communication and FSO is same, the only difference is in FSO the atmosphere is use as channel instead of optical fiber. There is no need of cable in FSO system so installation time is reduces. FSO offer higher data rate and lower bit error rate. [1]

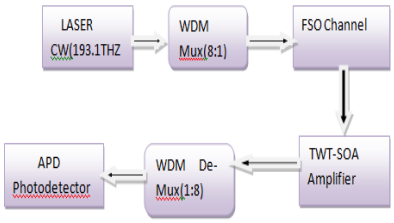


Fig.1: WDM-FSO System

The major challenge for FSO system are the effects of weather condition such as rain, snow, dust, haze and fog which provides the significant attenuation to the system.

BER and Q factor are factors used to study the link performance and effect of attenuation on the FSO system for different system conditions. The signal attenuation in FSO is due to visibility problem which arises from haze. Visibility is factor which decide how far an FSO link can go. Value of Bit error rate is increase with increase in attenuation. A WDM system uses a multiplexer at transmitter to multiplex a number of optical carrier signal on to single FSO channel, and de-multiplexer at receiver to split them apart. So WDM system is design to achieved high data rate. Due to higher capacity of WDM system used to overcome the signal degradation in FSO system. The signal degradation in FSO system occurs due to atmospheric turbulence. At more laser power it is possible to achieve longer link distance using WDM system.[2] The selection of wavelength is also most important to minimize the effect of attenuation on FSO. Generally used wavelength is 1550nm which offer low attenuation.
The rest of paper is organized as the section II discussed the system design of 8-channel WDM-FSO system results and discussion are described in section III and conclusion is described in section IV.

II. SYSTEM DESIGN

WDM-FSO communication under different weather condition design has simulated for performance characterization by using optisim 7. Figure 2 show the main components of optical link. In the simulations the transmitter section consists a data source, NRZ pulse generator, laser source and Mach-Zehnder modulator as shown in fig.1. At transmitter pseudo-random bit sequence is generates which represent the data that want to be transmit. NRZ electrical pulse generator is convert the binary data into electrical pulses.[3] Eight CW array laser is main source. The power of laser is set to 12dBm and the frequencies range from 193.1 THz to 193.8 THz. A -Z modulator is used to modulate the data coming from WDM multiplexer and NRZ electrical pulse generator.

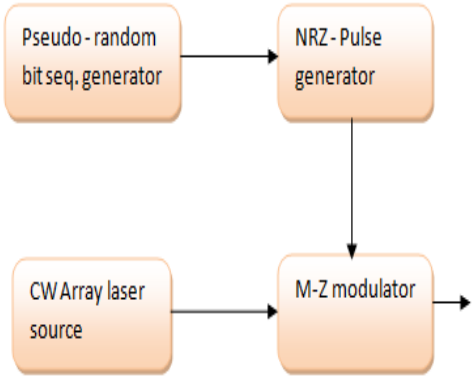


Fig.2: Transmitter Section

WDM multiplexing and de-multiplexing systems are used to achieve a maximum link range. WDM multiplexer transmit a number of optical carrier signal at different wavelengths, where de-multiplexer split them apart. Traveling wave SOA amplifier is used for amplification having inject current 0.15A.[4] In this (WDM-FSO) system modulated light is amplified after transmission. The simulation setup of 8-channel WDM over FSO communication system is shown in "fig.2."

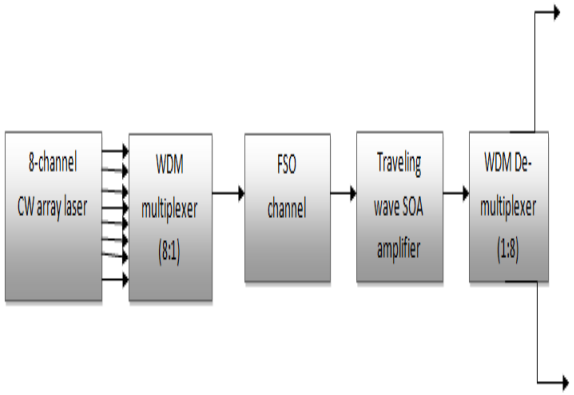


Fig.3: Simulation Setup of 8-Channel WDM-FSO System

At receiver side optical signal is received by APD photo-detector and is followed by low pass Bessel filter having cut-off frequency 0.75 bit rate. [5] A 3R regenerator at receiver end used for re-amplification and reshaping of data pulse. This simulation use visualizer name BER analyzer. BER is used to calculate the value of Q-factor, BER value and eye diagram. The receiver section is shown in fig.3.

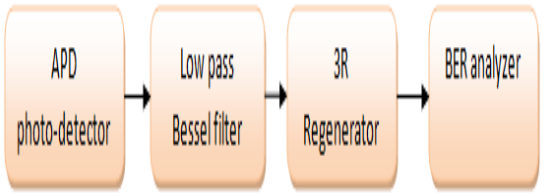


Fig.4: Receiver Section

The aperture diameter is set to 10 cm for transmitter and 20 cm for receiver. Where beam divergence is set to 1 mard. The parameter optimization of FSO system is illustrated in Table (1). [6]

Table I: Data Parameter

Parameter	Value
Bit rate	5 Gb/s, 10Gb/s
Power	12 dBm
Transmitter aperture diameter	10 cm
Receiver aperture diameter	20 cm
Beam divergence	1 mard
Photodiode gain	3 dBm
Responsivity	1 A/W
Dark current	10 nA
CW array laser frequency	193.1-193.8 THz

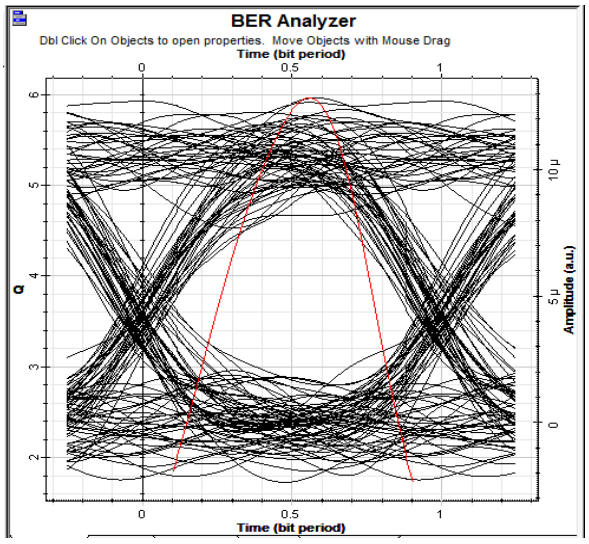
III. RESULTS AND DISCUSSION

WDM-FSO system with power of 12dBm and bit rate 5 Gbps / 10 Gbps are analyzed different weather conditions such as heavy rain, moderate rain, light rain, heavy haze, moderate haze, light haze, clear sky, very clear. Under very clear weather condition, the maximum rang 190 km at BER 10^{-9} and 176 km at BER 10^{-10} can achieved by using 8x5 Gbps and 8X10 Gbps respectively. Under heavy rain condition maximum link range 3.98 km at BER 10^{-9} and 4 km at BER 10^{-9} using 8x5 Gbps and 8x10 Gbps system respectively. So the 8x5 Gbps system performance is better than the 8x10 Gbps system. The 8x5 Gbps system is useful for higher attenuation, provide high link range rather than 8x10 Gbps system.

Table II: Performance Analysis of 8x5 Channel WDM-FSO System Under Different Weather Conditions.

Weather conditions	Attenuation (dB/km)	Power (dBm)	Link range (km)	BER	Q-factor
Heavy rain	19.3	12	3.98	$1.245e^{-9}$	5.963
Moderate rain	12	12	6.22	$3.597e^{-9}$	5.785
Light rain	4	12	16.2	$2.935e^{-10}$	5.817
Heavy haze	2	12	30.3	$4.898e^{-9}$	5.113
Moderate haze	1.4	12	40.3	$2.468e^{-9}$	5.851
Light haze	1.12	12	50.5	$1.102e^{-9}$	5.976
Clear sky	0.8	12	66.3	$2.154e^{-10}$	6.240
Very clear sky	0.31	12	153	$1.581e^{-9}$	5.905
Very clear sky*	0.233	12	190	$1.555e^{-9}$	5.925

The Eye diagrams for 8x5 Gbps WDM based Free Space Optic transmission system are shown in “Fig.5”. Where maximum link range 190 km is achieved for very clear sky and 3.98 for Heavy rain.



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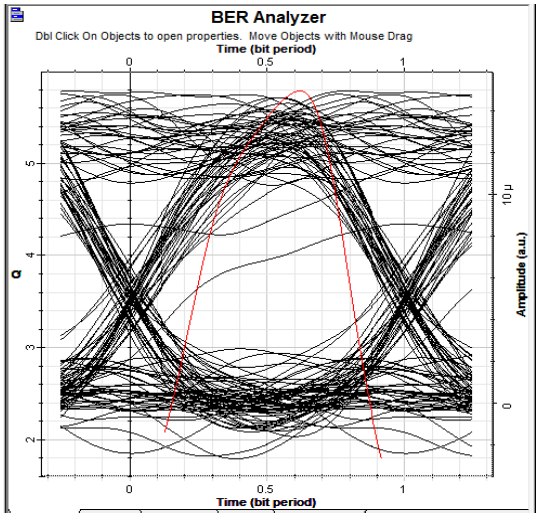

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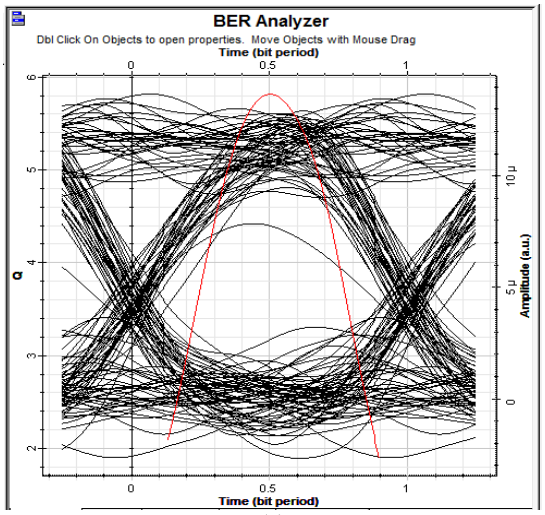

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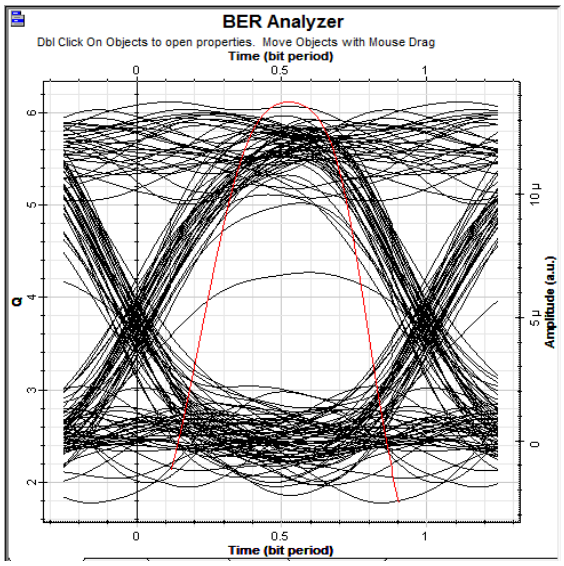

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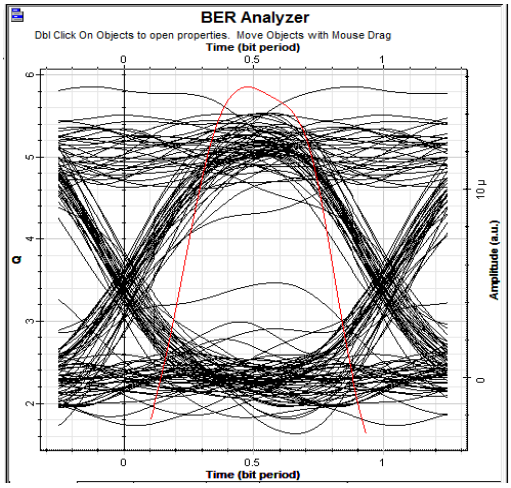

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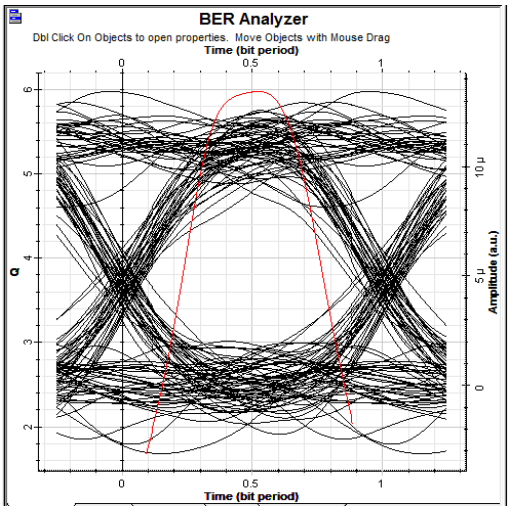

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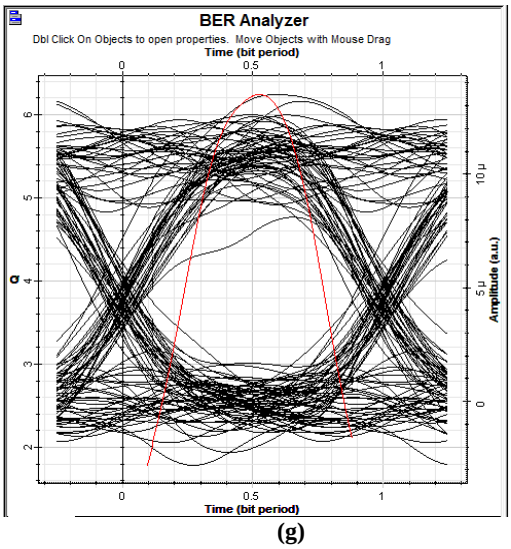

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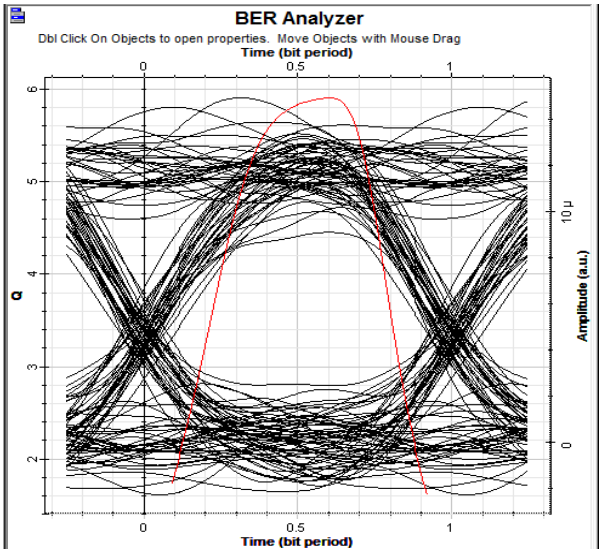

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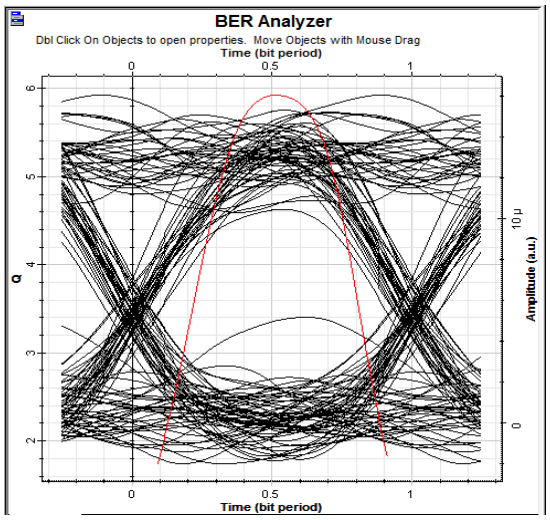


(i)

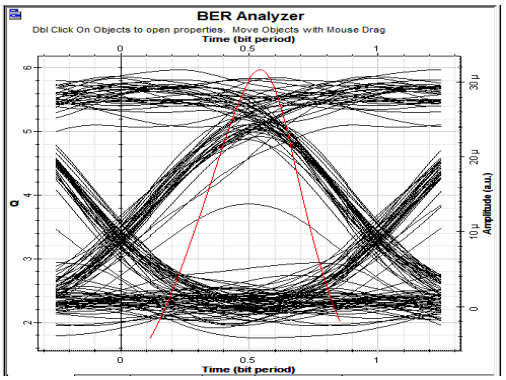
Fig.5. Eye Diagram for 8x5 Channel WDM-FSO System (a) Heavy Rain (b) Moderate Rain (c) Light Rain(d) Heavy Haze(e) Moderate haze (f) Light Haze(g) Clear sky(h) Very Clear Sky(att.=0.31) (i) Very clear Sky(att.=0.233)

The performance analysis of 8x10 Gbps WDM based Free Space Optic communication system is describe in Table III.. where maximum link range is 178 km for very clear sky and 4 km for heavy rain is achieved. The performance Table is describe as below:

Table III. Performance Analysis of 8x10 Channel WDM-FSO System Different Weather Condition

Weather condition	Attenuation (dBm/km)	Power	Link range	BER	Q-factor
Heavy rain	19.3	12	4	$1.105e^{-9}$	5.971
Moderate rain	12	12	6	$1.363e^{-9}$	5.937
Light rain	4	12	14	$6.222e^{-10}$	6.005
Heavy haze	2	12	24	$7.63e^{-9}$	5.658
Moderate haze	1.4	12	32	$8.981e^{-9}$	5.630
Light haze	1.12	12	42	$3.083e^{-9}$	5.788
Clear sky	0.8	12	58	$2.999e^{-10}$	6.187
Very clear sky	0.31	12	128	$6.748e^{-9}$	5.621
Very clear sky*	0.233	12	178	$2.49e^{-9}$	6.190

The Eye diagrams for 8x10 Gbps WDM based Free Space Optic transmission system are shown in "Fig.6". The maximum link range 178 km is achieved using 8x10Gbps system for very clear sky. For heavy rain condition it is up to 4km.



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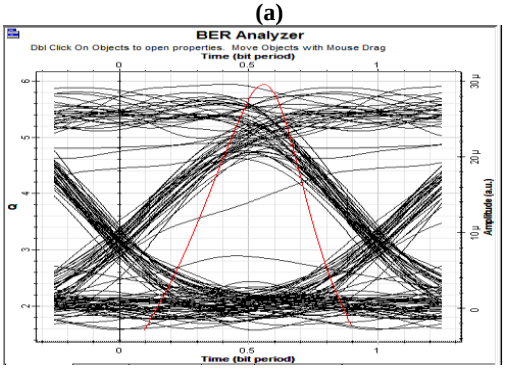

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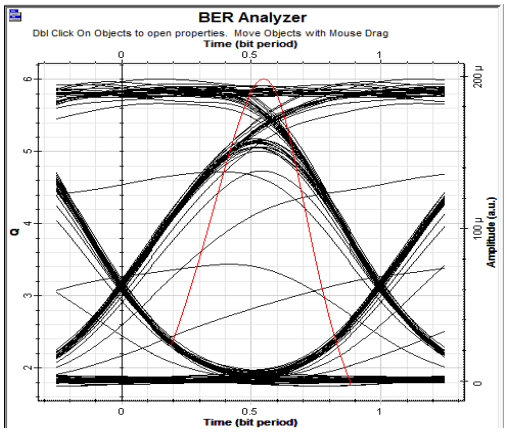

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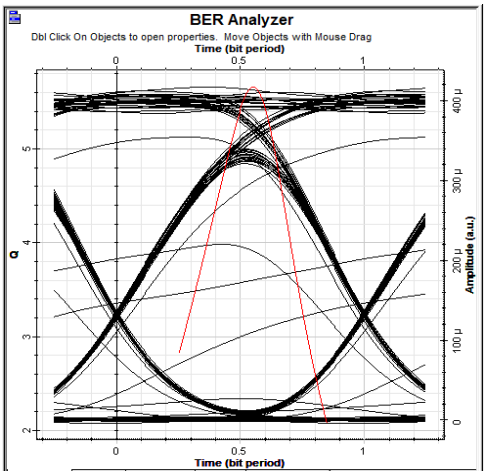

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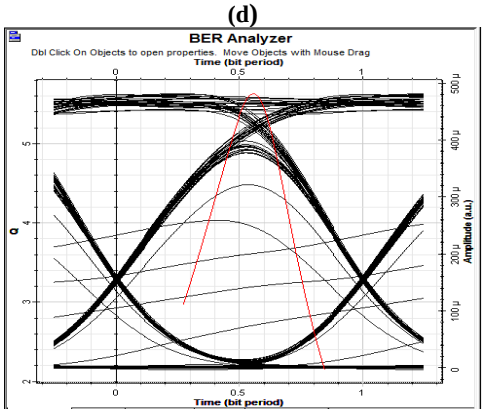

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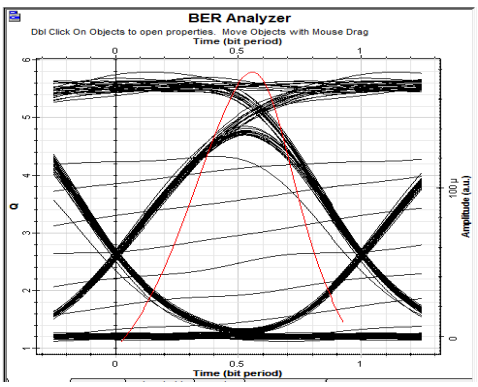

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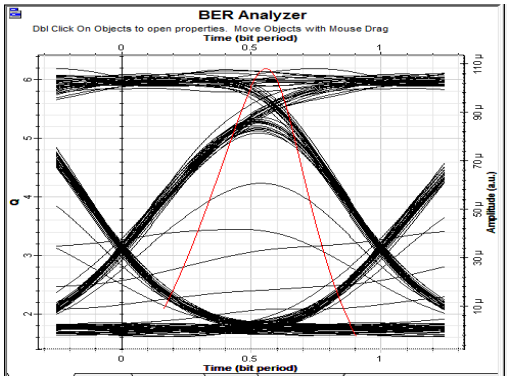

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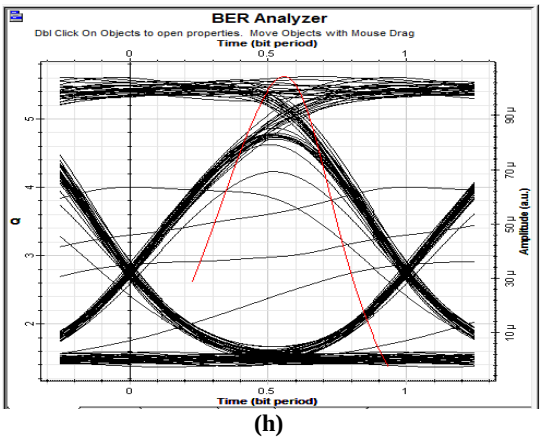

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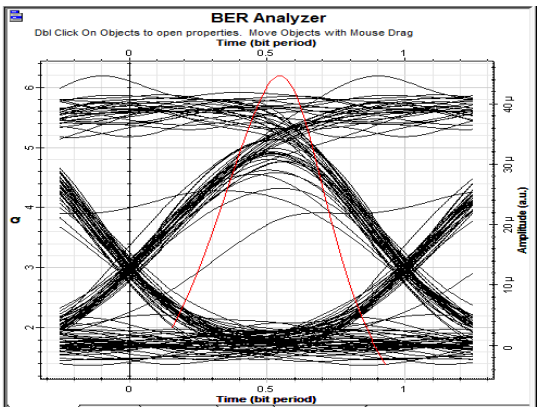

(i)

Fig.6. Eye Diagram of 8x10 Channel WDM-FSO System (a) Heavy Rain (b) Moderate Rain (c) Light Rain (d) Heavy Haze (e) Moderate Haze (f) Light Haze (g) Clear sky (h) Very Clear sky(att.=0.31) (i) Very Clear sky(att.=0.233)

IV. CONCLUSION

Different weather conditions such as rain, haze and dust is major challenges to operate FSO link. This paper emphasizes on the simulation analysis of 8-channel WDM-FSO communication link using traveling wave-SOA amplifier chosen from component library of Optisystem. It is concluded that with the use of TWT-SOA amplifier along with APD receiver WDM-FSO link range is improved and signal degradation due to attenuation is reduced. WDM-FSO system using 8x5 Gbps achieve the link range 190 km at BER 10^{-9} very clear sky where for 8x10 it is upto 178 km at BER 10^{-10}. So it conclude that the 8x5 Gbps system give better performance than 8x10 Gbps system.

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