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Performance Analysis and Optimization with Varied Parameters for Inter-Satellite Optical Wireless Communication System

Roshni Joy[1], Prof. Viral H. Mehta[2], Ami Lavingia[3]

[1]Communication System Engineering Department, SVBIT, India

[2]Electronics and Communication Department, SVBIT, India

[3]Electronics and Communication Department, India

Abstract-The day to day evolution has advanced the optical communication system from lengthy fibers to wireless system. This can be concluded as the optical systems have resulted to be used in space as a medium to communicate between two satellites. Optical wireless communication provides a very important method for the satellites orbiting around the earth to communication with each other such as inter-satellite transmission system. For exchanging data from different states, country numbers of satellite are increasing day by day. So, for inter-satellite communication we are using optical wireless communication to exchange the data while depending upon the parameters like Bit error rate, Q-factor and the received power. In IsOWC link two parameters mainly distance and aperture diameter is adjusted. In this optical inter-satellite link is modeled where the effect of distance, bit rate and input power are varying with aperture diameter of the transmitter and the receiver telescope is analyzed. And we are also optimizing the results with varied parameters like aperture diameter of the transmitter and receiver, bit rate, input power and the received power. The inter-satellite links were modeled and simulated with the help of optical system simulator named OPTISYSTEM software.

Keyword- BitRate, Free Space Optics, IsOWC, Optisystem, Transmission Distance

I. INTRODUCTION

The correspondence through the link infrastructure has turned into a piece of our past. Following optical fiber communication is better in a few regards such as vast separation communication up to 40 km without requiring a repeater device, adaptable nature, which made it prepared to be utilized anyplace, duplex method of communication, EMI (electromagnetic interface) resistive nature and expansive transfer speed supporting limit. Be that as it may, aside from all these, present day environment requests for more effective transfer speed use and better information sheet, which prompt another method of communication called as free space optical communication. Following optical fiber cabled foundation has neglected to come to a less cell end point. In any case, this constraint is evacuated by free space optical communication. It utilizes free space for the communication reason, so otherwise called fiber glass optics or optical remote.

Not with standing physical correspondence, OWC additionally has a huge part in space applications. In 1977, European Space Agency (ESA) began the project semiconductor laser Inter-satellite connection test (SILEX) to understand the correspondence between satellites in space.[1] This program, which came to genuine operations in 2003, prompted result in making the ESA all around perceived in space bury satellite correspondence joins. The essential application of OWC as between satellite is appeared in the Fig. 1. SILEX is taking into account a blend of two optical correspondence payloads i.e. French Earth perception rocket. SPOT-4 furthermore, Advanced Relay and Technology Mission Satellite (ARTEMIS) which permits the information transmission of 50 Mbps by utilizing GaAlAs laser diodes [3].

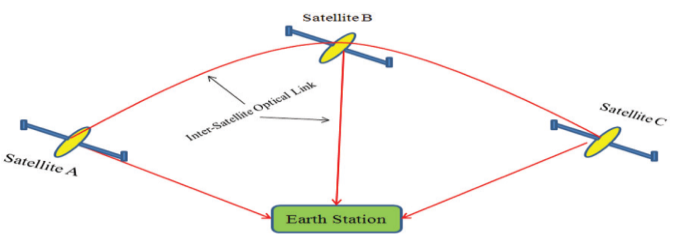


Fig: 1 OWC as Inter-Satellite communication link [3]

The Intersatellite Optical Wireless Communication (IsOWC) system has various points of interest. To begin with, no licensing is required in terrestrial communication. Another point of interest is the invulnerability to the radio signal interference, on the other hand immersion has included the security highlights in this innovation. The point-to-point laser signal is too hard to capture. It is difficult to tap the IsOWC link. Ecological shrewd, FSO does not contaminate the earth with electromagnetic radiations since the wavelength of IsOWC is just from 850 nm to 1500 nm. The performance investigation will be as far as measured received power, eye pattern and BER.

II. System Design

The simulation is done using OptiSystem Simulation Software. OptiSystem is a thorough programming outline suite that empowers to arrange, test, and rebuild optical connections in cutting edge optical systems. Propose algorithm comprises of a transmitter with NRZ signals, OWC channel, and optical receiver consisting of PIN photodetector, Bessel filter and BER analyzer to analyze the yield result. At the input side CW laser is used to provide the light source to the link, along with that pseudo random bit sequence generator and mach zehnder modulator is taken as in. Inter-satellite optical wireless communication (IsOWC) system is categories into three stages: the transmitter, OWC channels the propagated medium and the receiver where the transmitter act as first satellite and receiver act as the second satellite. The effect of transmitter and receiver aperture diameter is analyzed. The simulation is carried out on eight channel system. The simulation link is shown in below figure.

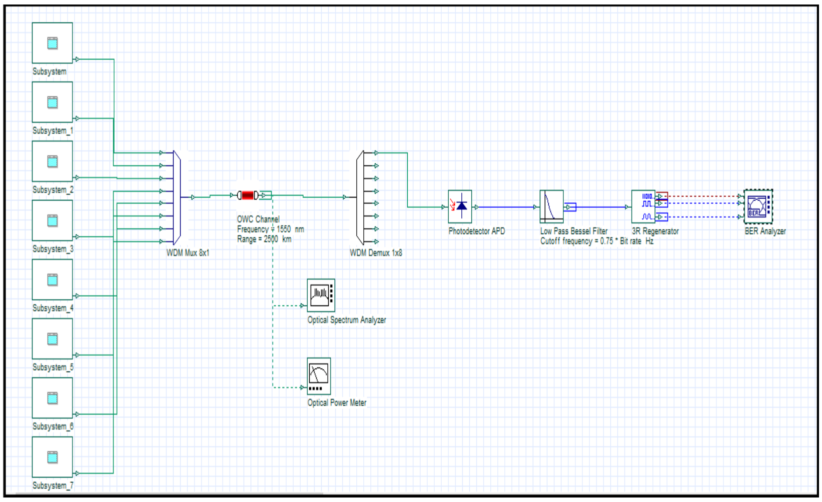


Fig:2 Simulation link

III. Simulation Result and Analysis

In this inter-satellite optical wireless communication (IsOWC) system the effect of transmitter and receiver aperture diameter is analyzed with respect to distance, bit rate, input power and received power.

3.1 Effect of Distance with varying Aperture Diameter

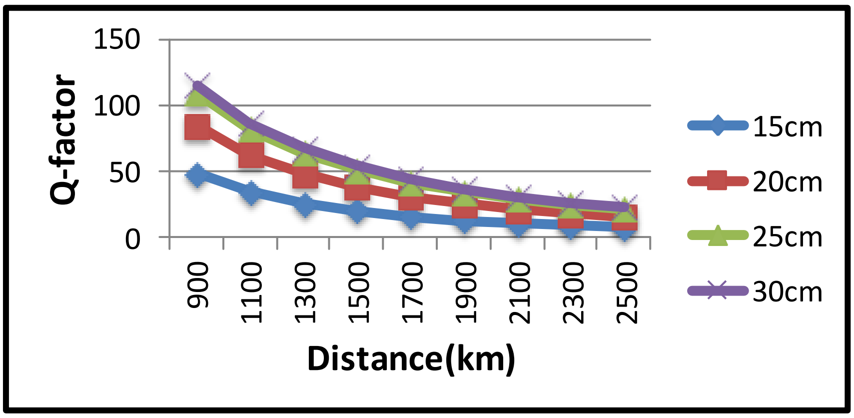
We have simulated the optical link working at varied aperture diameter. The transmission distance effects are analyzed in terms of Q Factor, BER with the use of Eye Diagrams.

For longer transmission distance the wavelength taken is 1550 nm and bit rate is set at 10Gbps. The input power is maintained at 15dbm and CW laser frequency set at 193.4 Thz. Transmitter and receiver aperture diameters of same values are taken. The aperture diameter of the system is varied and the coverage distance is obtained for various aperture diameters. The values of aperture diameter were set at 15 cm, 20 cm, 25 cm, 30 cm and the distance varies from 900 to 2500 km. By performing simulation, if we adjust aperture diameter at 30 cm for data rate of 10Gbps, we can obtain error free communication up to the distance of 2500 km only.

Table 1: Simulation Parameters

Parameters	Values
Bit Rate	10 Gbps
Modulation	NRZ
Distance (km)	900, 1100, 1300, 1500, 1700, 1900, 2100, 2300, 2500
Tx & Rx Pointing Error Angle	1.7µrad
Transmitting Power	15dbm
Photo detector	APD
Tx and Rx Efficiency	1
Wavelength	1550 nm

The system is simulated for different distances. The performance of the system is evaluated by analyzing the BER and Q-Factor. By varying the distance between two satellites with different aperture diameter of the transmitter and receiver, Q-Factor values is obtained and the graph is plotted between Q-factor verse distances.



Graph -1: Q-factor vs. Distance

The Eye diagrams are shown in figure below:

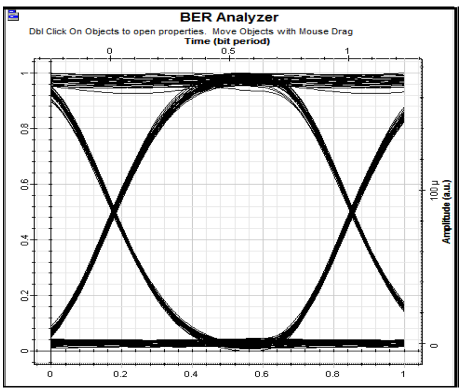


Fig: 3 Eye diagram for Aperture diameter 15cm at distance 900 km

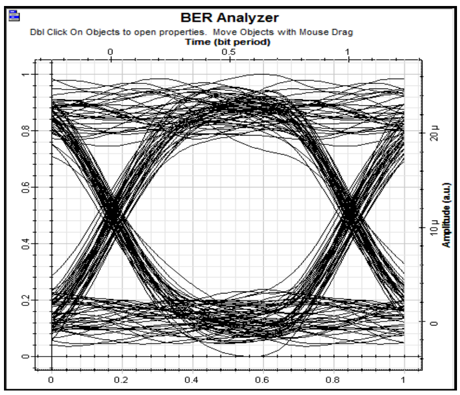


Fig: 4 Eye diagram for Aperture diameter 15 cm at distance 2500 km

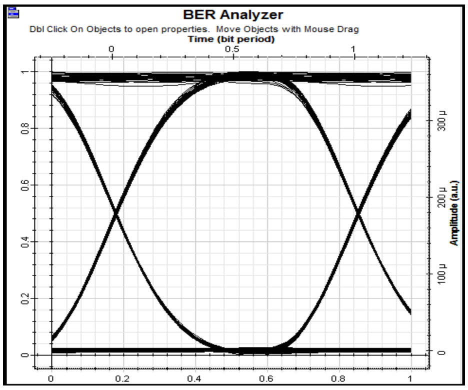


Fig: 5 Eye diagram for Aperture diameter 20 cm at distance 900 km

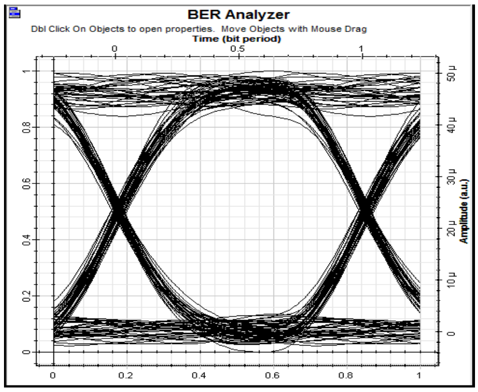


Fig: 6 Eye diagram for Aperture diameter 20 cm at distance 2500 km

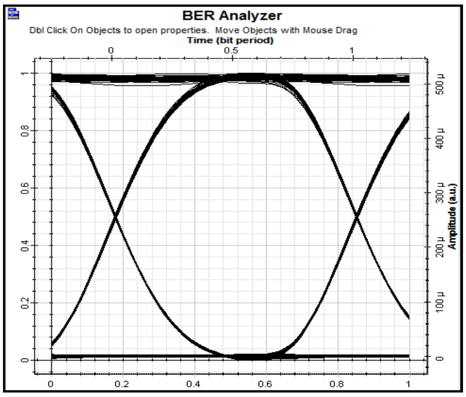


Fig: 7 Eye diagram for Aperture diameter 25cm distance at 900 km

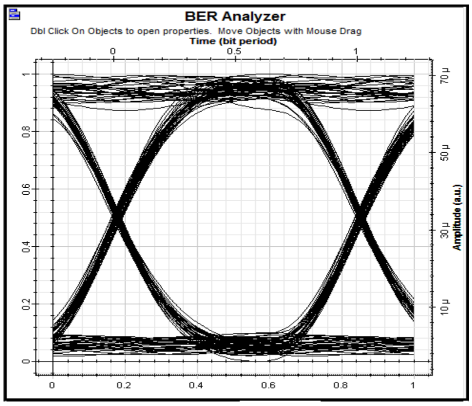


Fig: 8 Eye diagram for Aperture diameter 25cm cm at distance 2500 km

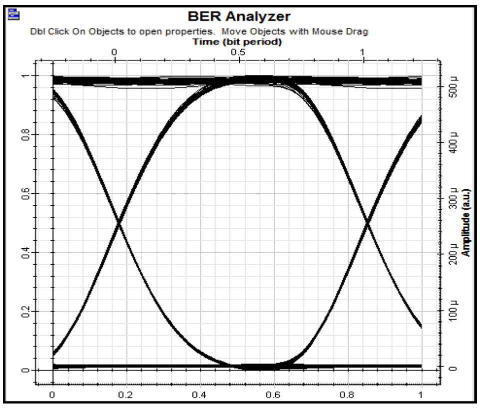


Fig: 9 Eye diagram for Aperture diameter 30 cm at distance 900 km

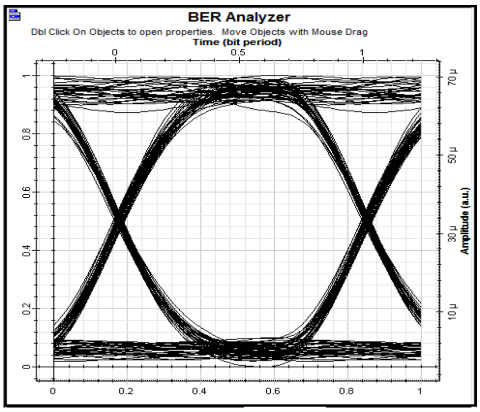


Fig: 10 Eye diagram for Aperture diameter 30 cm at distance 2500 km

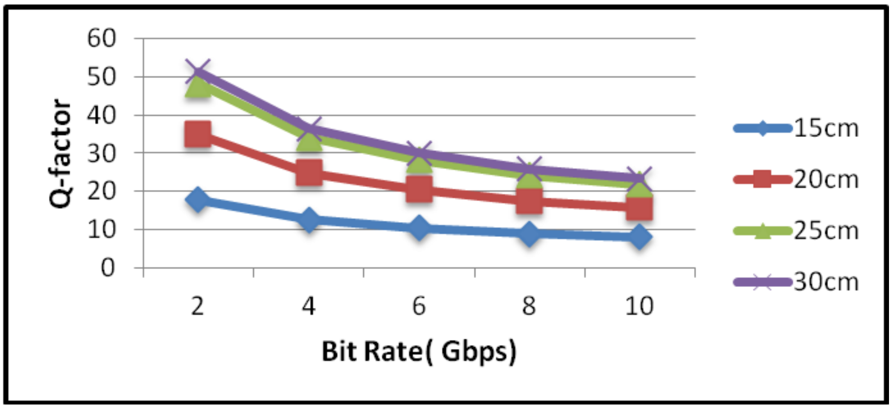
3.2 Effect of Bit Rate with varying Aperture Diameter

IsOWC system is modeled and simulated for bit-rate of 10Gpbs.The transmission power applied is 15dbm with optical signal wavelength of 1550nm. The same values of transmitter and receiver aperture diameters are taken. The values of aperture diameters are set at 15 cm, 20 cm, 25 cm and 30 cm. When we adjust aperture diameter at 30 cm for maximum distance of 2500 km, we can get error free communication up to bit rate of 10Gbps.

Table 2: Simulation Parameters

Parameters	Values
Bit Rate	2, 4, 6, 8, 10 Gbps
Modulation	NRZ
Distance (km)	2500
Tx & Rx Pointing Error Angle	1.7μrad
Transmitting Power	15dbm
Photo detector	APD
Tx and Rx Efficiency	1
Wavelength	1550 nm

The graph of Q-Factor verse bit rates with variable aperture diameter is plotted. From graph we analyze that as we increases aperture diameter, the Q- factor also increases at fixed bit rate. But as we increasing the bit rate, the Q-factor starts decreasing.



Graph -2: Q-factor vs. Bit rate

The Eye diagrams are shown in figure below:

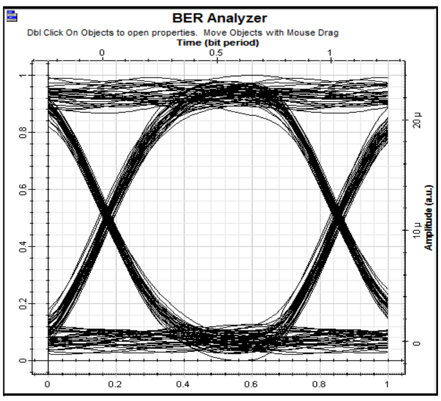


Fig: 11 Eye diagram for Aperture diameter 15 cm at bit rate 2 Gbps

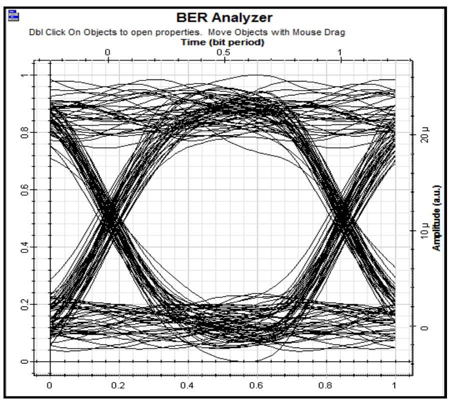


Fig: 12 Eye diagram for Aperture diameter 15 cm at bit rate 10 Gbps

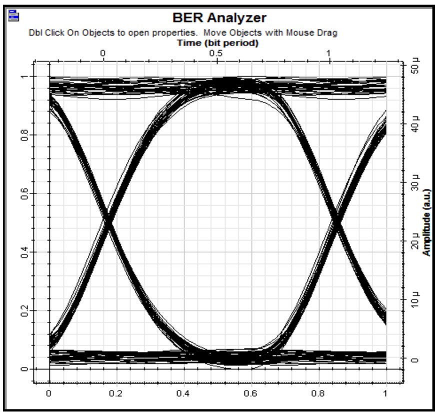


Fig: 13 Eye diagram for Aperture diameter 20 cm at bite rate 2 Gbps

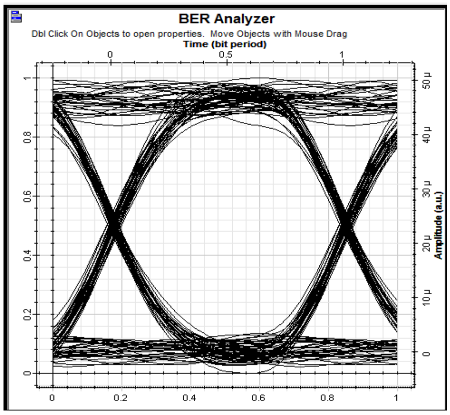


Fig: 14 Eye diagram for Aperture diameter 20 cm at bit rate 10 Gbps

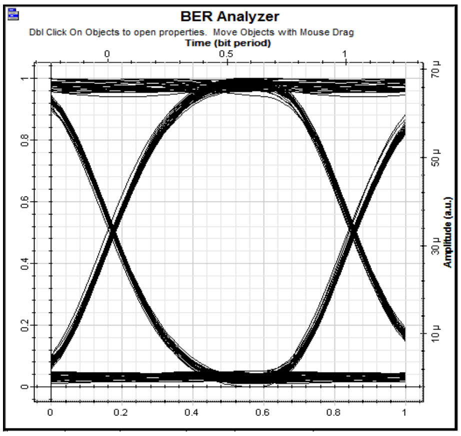


Fig: 15 Eye diagram for Aperture diameter 25 cm at bit rate 2 Gbps

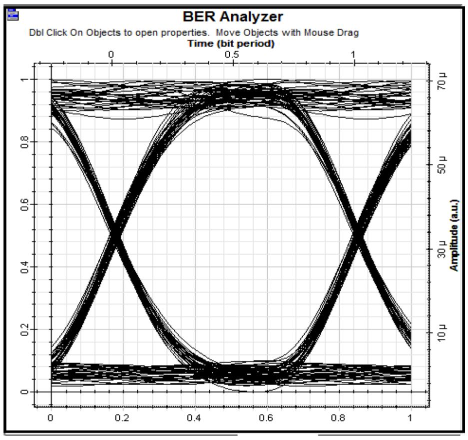


Fig: 16 Eye diagram for Aperture diameter 25 cm at bit rate 10 Gbps

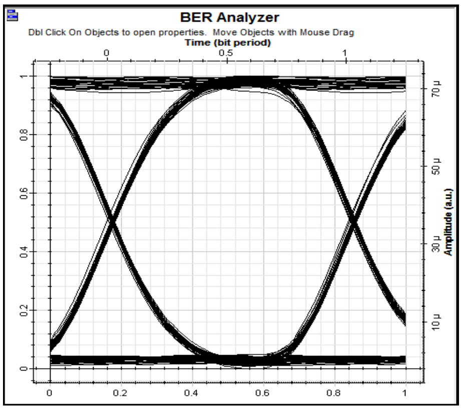


Fig: 17 Eye diagram for Aperture diameter 30 cm at bit rate 2 Gbps

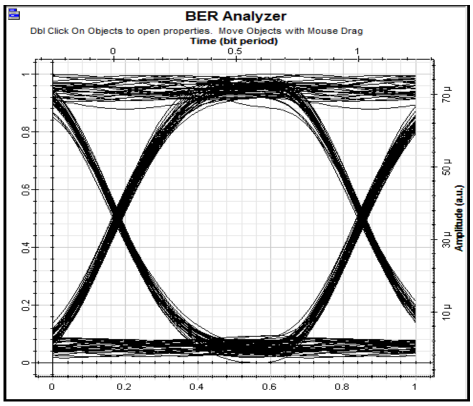


Fig: 18 Eye diagram for Aperture diameter 30 cm at bit rate 10 Gbps

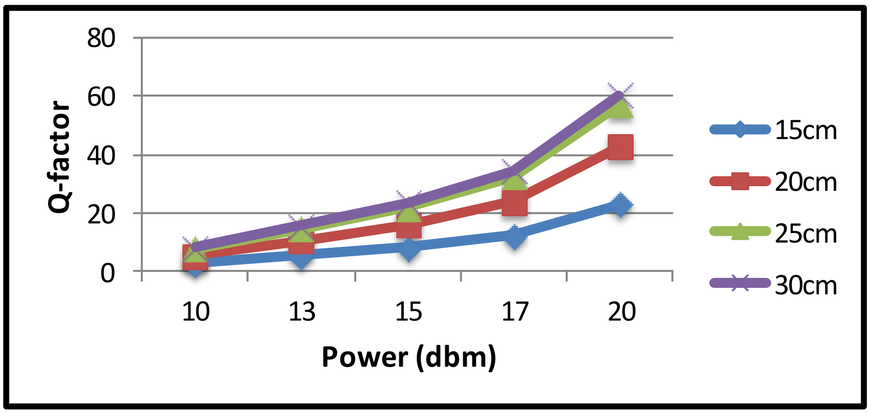
3.3 Effect of Input Power with varying Aperture Diameter

The parameters used in this are transmission range 2500km, wavelength 1550nm, laser frequency 193.4 Thz and data rates 10Gbps. Two parameters like aperture diameters and input power of IsOWC link is adjusted. To achieve error – free communication of IsOWC link the input power could be maximum value at 2500km, this helps to improve the system performance and reduces the cost. Here the effect of aperture diameter on Input power and Q-factor is examined. Aperture diameters are set at 15 cm to 30 cm. The Input power values are taken from 10 dbm to 20 dbm.

Table 3: Simulation Parameters

Parameters	Values
Bit Rate	10 Gbps
Modulation	NRZ
Distance (km)	2500
Tx & Rx Pointing Error Angle	1.7μrad
Transmitting Power	10,15, 20, 25 dbm
Photo detector	APD
Tx and Rx Efficiency	1
Wavelength	1550 nm

A graph of Q-factor verse input powers with variable aperture diameter is plotted. In this the effect of input power on aperture diameter is shown. From this graph we concluded that as we increasing the aperture diameter of the transmitter and receiver, the Q-factor also increases as the input power increases.



Graph -3: Q-factor vs. Input power

The Eye diagrams are shown in figure below.

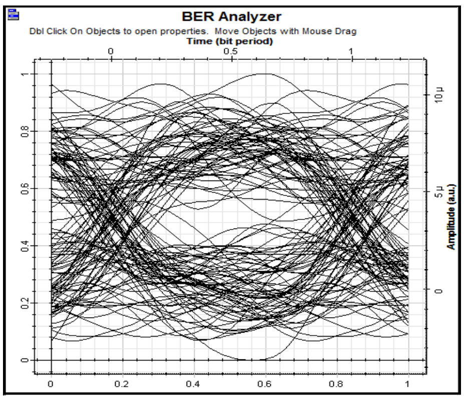


Fig: 19 Eye diagram for Aperture diameter 15cm at power 10 dbm

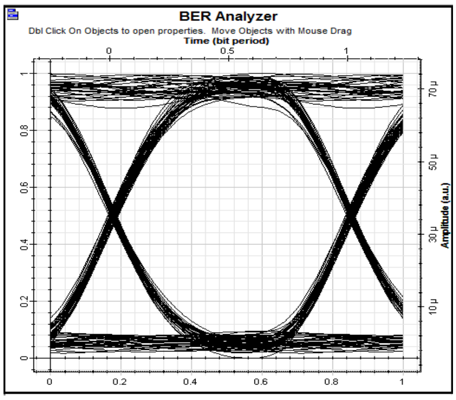


Fig: 20 Eye diagram for Aperture diameter 15 cm at power 20 dbm

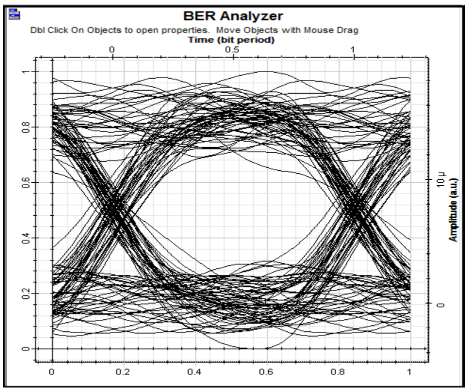


Fig: 21 Eye diagram for Aperture diameter 20 cm at power 10dbm

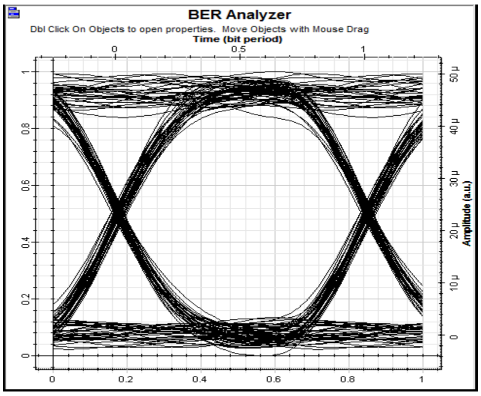


Fig: 22 Eye diagram for Aperture diameter 20 cm at power 20dbm

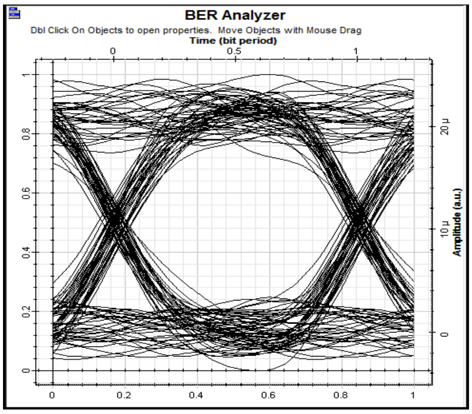


Fig: 23 Eye diagram for Aperture diameter 25cm at power 10dbm

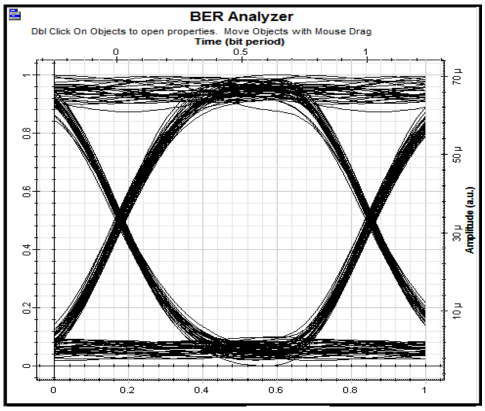


Fig: 24 Eye diagram for Aperture diameter 25cm cm at power 20dbm

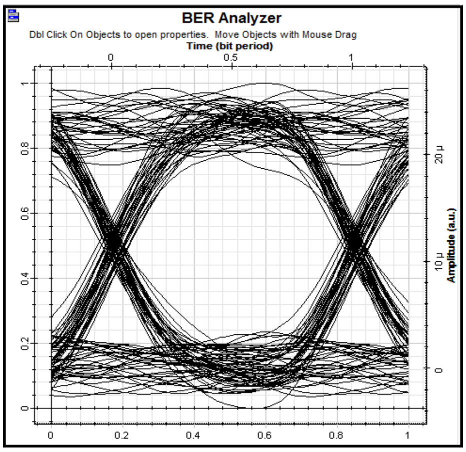


Fig: 25 Eye diagram for Aperture diameter 30 cm at power 10dbm

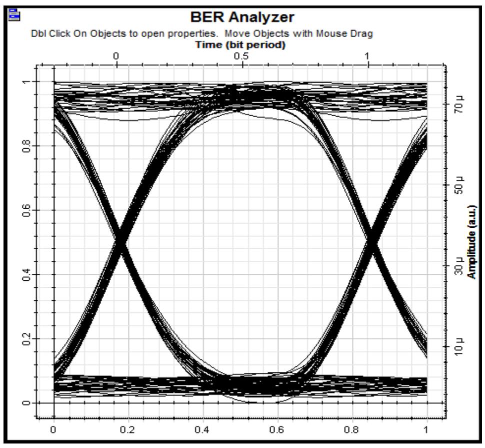


Fig: 26 Eye diagram for Aperture diameter 30 cm at power 20dbm

IV. CONCLUSION

The system model was analyzed for 8 channels where several parameters of system are characterized and varied. In this the effect of transmission distance, input power and bitrates at different Aperture diameter is taken into consideration and simulated. It is concluded that for longer distance and higher bit rate, the eye diagram has smaller eye opening. For higher input power the eye diagram has larger eye opening. From the graph of Q-factor vs. distance with respect to aperture diameter as the distance increases it impacts the overall system performance, and q-factor decreases. From the graph of Q-factor vs. power with respect to aperture diameter as the input power increases the Q-factor is also increases. From the graph of Q-factor vs.bit rate with respect to aperture diameter as the bit rate increases it impacts the overall system performance and Q-factor decreases. From this it is concluded that, for longer distance the input power should be kept more with lower bit rate to get better result.

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