Performance Comparison of 10gbps Inter Satellite Optical Wireless Communication System With Different Pulse Generators

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***Abstract*— In this modern world the role of satellite is important. The data collected by the satellite in the space need to be communicated with the earth station. To achieve high speed data transmission Inter-satellite Optical Wireless Communication(IsOWC) is used. IsOWC system is a good alternative to present microwave satellite system since it uses light at a near infrared frequency to communicate. The IsOWC system has three main parts – transmitter, propagation channel and receiver. In this paper we are comparing the performance of the system in RZ, NRZ and Gaussian pulse generators at 10gbps for different ranges and found that the performance of the system is better in the case of NRZ pulse generator than the other two. The system performance is analysed on the basis of Q-factor and OSNR using Optisystem simulator.**

Keywords*— Inter-satellite Optical Wireless Communication(IsOWC), Non-return to zero(NRZ), Q-factor.

I. INTRODUCTION

Inter-satellite Optical Communication is an important application in Free Space Optics(FSO). For sending information between the satellites and from satellite to ground station wireless communication is needed. IsOWC system is a good alternative to present microwave satellite systems as it provides high bandwidth, light weight, low cost, small size and low power. The ability to send high speed data to a distance of thousands of kilometers using small size payload is the advantage of optical link over radio frequency links. IsOWC can connect one satellite to another satellite, whether the satellite is in the same orbit or in different orbit. It uses light at near infrared region to send data. Therefore, by using light data can be send without much delay and it has minimum attenuation as the space is considered to be vaccum.

Satellite is any body that revolve around another larger body in a mathematical predictable path called orbit. For research and communication purposes man made satellites has been developed for the benefit of mankind [9]. There are three types of orbits-Low Earth Orbit(LEO), Medium Earth Orbit(MEO), Geosynchronous Earth Orbit(GEO). They differ in their altitude above the earth surface. Orbit with orbital height of about 2000km or less is known as LEO and it is relatively low in altitude. MEO has an orbital height ranging from 5000 to about 25,000km. GEO has an orbital height of about 36,000km from the earth usually occupied by communication satellites for broadcasting and telephone relay [2]. Inter satellite link (ISL) is a link that connects the satellites in same and different orbits. ISLs can be divided into two categories: intra-layer ISLs with same orbital altitude (MEO-MEO, GEO-IGSO) and inter-layer ISLs with different orbital altitude (GEO-MEO, IGSO-MEO), and the former can be divided into intra-plane ISLs and inter-plane ISLs [10]. The Inter-satellite communication employing optical link was successfully achieved on March 2003 between ARTEMIS and Satellite Pour L'Observation De La Terre 4 SPOT-4 [3].

The European Space Agency (ESA) has instigated an in-orbit demonstration project known as SILEX(Semiconductor Laser Inter-satellite Link Experiment) using a pre-operational link between the French SPOT-4 low earth orbit satellite and the ESA Advanced Relay and Technology Mission Satellite (ARTEMIS) [6]. The simplex communication from ARTEMIS to SPOT-4 was done by using data transmitted at 50Mbps with signal wavelength of 850nm and optical signal with the power of 120mW. Artemis was placed in Geo earth orbit while SPOT-4 was in Low earth orbit at altitude of 832km [3].

Paper organized as follows. Section II describes the survey done on the paper "Performance Comparison Of 10gbps Inter Satellite Optical Wireless Communication System With Different Pulse Generators". This section goes through six various documents giving an overview on Inter satellite Optical Wireless Communication System(IsOWC) and its performance. Also gives an idea to improve the performance of the system. Section III describes the system model. Section IV describes about the proposed model and simulation in Optisystem simulator. Section V discuss about the results obtained during simulation in Optisystem simulator. Section VI presents the conclusion.

II. INTER-SATELLITE OPTICAL WIRELESS COMMUNICATION SYSTEM

The following are the papers surveyed for the need of doing the project. Optisystem simulator is used here to evaluate the performance of the system.

Inter satellite Optical Wireless Communication system is one of the important application of FSO/WSO technology. In the work [1], they have designed an Inter-satellite Optical Wireless Communication system to establish a 1000km length inter satellite link between two satellite at 2.5 Gbps data rate with and without SM module and concluded that using SM module SNR ratio is improved in conjunction with acceptable BER can be achieved.

In the work [2], they have designed IsOWC system is designed with and without square root module using Optisystem simulator and reported the improved investigation through SR module at a distance of 5000km with BER 10^{-7} at 1.25 Gbps data rate. Hence an efficient improvement in IsOWC system is achieved through square root module.

A novel method is proposed in the work [3] for low power communication between two Low Earth Orbiting satellites. With a minimum input power 27.02 dBm at 2.5 Gbps an error free communication between two LEO satellites is possible. The power requirement is reduced to -7.6 dBm by incorporating a square root module and also in system efficiency 67% increment is observed.

IsOWC for inter satellite communication which can provide communication at higher speed and upto a larger distance as compared to ordinary radio frequency link is analysed [4]. For different transmission distances of 200, 400, 600, 800 and 1000km at 5, 10, 15gbps the performance is evaluated and founded that as the data rate increases the Q-factor decreases and also observed that at a particular data rate the Q-factor decreases with increase in communication distance.

Laser communication links in space are attractive alternative to the present microwave links. High capacity inter satellite communication links permit more efficient and reliable operation of future satellite system. Inter satellite communication is limited by satellite vibration. The effect of satellite vibration on various parameters are studied in [6]. Rayleigh distribution is used for the statistical description of pointing errors. From the analysis founded that the vibration due to relative motion of satellite causes pointing angle error and as the pointing angle error increases the received power decreases. If the vibration amplitude is increased by some means then the BER is also increased.

As the number of satellites revolving the earth is increasing year by year a link is needed between the satellites to send data from one satellite to next and to the ground station. [7] analysed the performance of the system such as bit rates, input power, wavelength and distance on an inter satellite link. By using SM module, ISL give improved SNR in conjunction with acceptable BER is achieved and required less transmitted power to transfer externally modulated data over an ISL link.

III. SYSTEM DESCRIPTION

The IsOWC system consists of three main parts-transmitter, propagation channel and receiver in which the transmitter is placed in the first satellite whereas the receiver in the second satellite. For communication, optical wireless communication(OWC) uses light at near infrared range.

Fig.3.1 shows the basic block diagram of IsOWC system. The transmitter which is placed in satellite-1 receives data from satellite's Telemetry, Tracking and communication system which contains informations like satellite position and altitude tracking, captured image for remote sensing satellite, etc. These datas are then send to pulse generator which produces the data as electrical pulses. Here we are using NRZ, RZ and Gaussian pilse generators to compare the performance of the system in each one. The main component in optical signal is the light source as the communication is done by transmitting light. The commonly used optical sources in optical communication are Light Emitting Diode(LED) and Injected Laser Diode(ILD). The light emitted by ILD is coherent, monochromatic and has high radiance that make it suitable for long distance transmission in free space. The two signals, that is, the signal from TT&C and the output of ILD is modulated using a modulator. The modulated signal is then transmitted to the receiving satellite through Optical Wireless Channel(OWC).

The receiver which is placed in satellite-2 contains a photodiode and a Low Pass Filter(LPF). Since Avalanche Photodiode(APD) has a characteristics of producing high amplification for low or weak optical signals, APD is used as photodetector for long distance transmission of optical data in free space. Then the performance of the system is analysed using a BER analyser or eye diagram analyser.

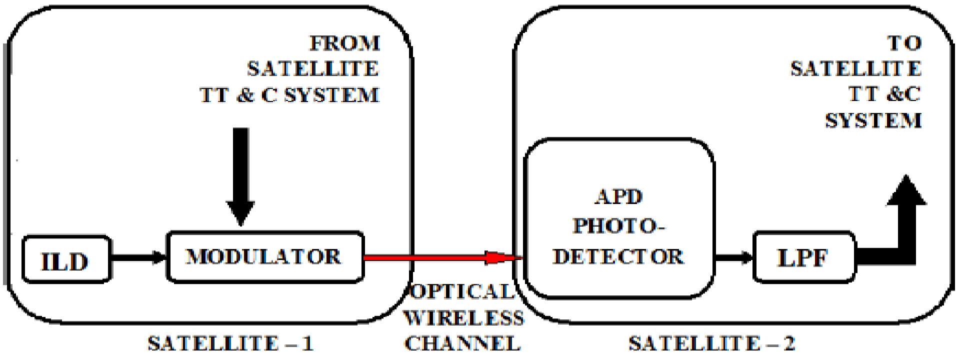

Fig.3.1 Block diagram of IsOWC system

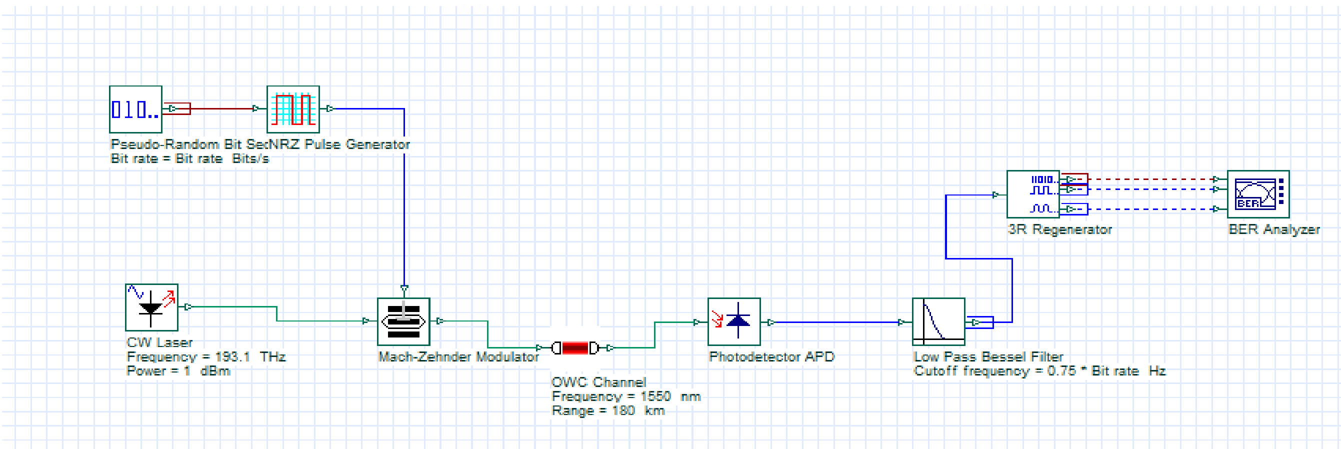

Fig.4.1 Model of IsOWC system in Optisystem simulator

IV. PROPOSED MODEL

The simulation of the proposed model is done in Optisystem simulator. Figure 4.1 shows the model of IsOWC system done in Optisystem simulator.

V. RESULT AND DISCUSSION

An IsOWC system is designed using Optisystem simulator. The system is designed for different pulse generators, namely, NRZ, RZ and Gaussian at different transmission ranges 100, 120, 150, 180 and 200km and at a data rate of 10gbps.

Table1: Variation of Q-factor with distance

Range(km)	NRZ	RZ	Gaussian
100	19.7	13.50	16.99
120	14.0398	9.788	12.35
150	9.122	6.53	8.21
180	6.371	4.66	5.82
200	5.169	3.83	4.76

Table2: Variation of OSNR with distance

Range(km)	NRZ	RZ	Gaussian
100	78.7	73.78	77.7
120	77.19	72.20	76.12
150	75.25	70.26	74.18
180	73.67	68.68	72.59
200	72.75	67.76	71.68

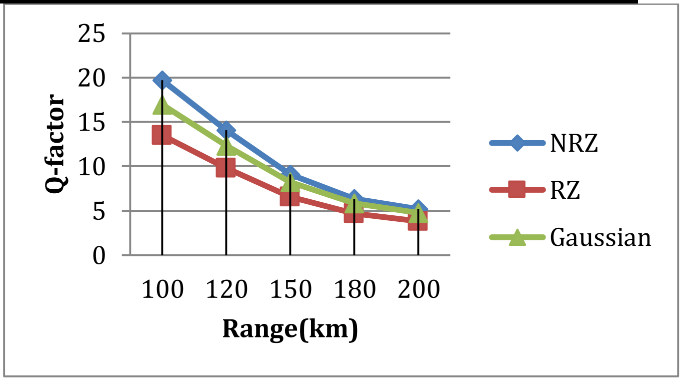

Fig.5.1 Variation of Q-factor with increasing distance

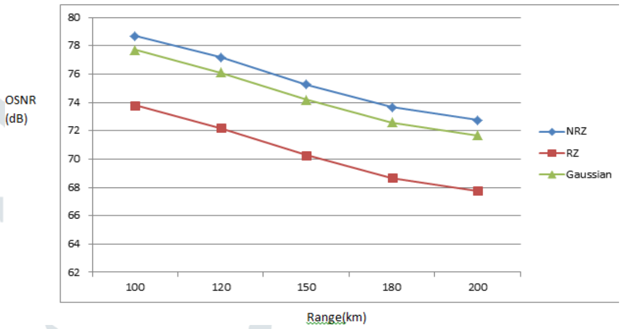

Fig.5.2 Variation of OSNR with increasing distance

Table 1 and 2 shows the variation of Q-factor and OSNR with respect to the distance and the corresponding graph is plotted in figure 5.1 and 5.2. from the graph it is clear that the value of Q-factor and OSNR decreases as the distance increases.

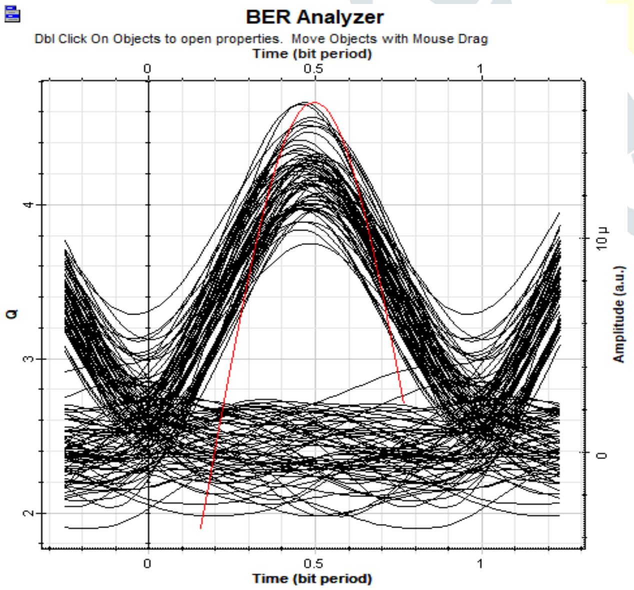

Fig.5.3(a)

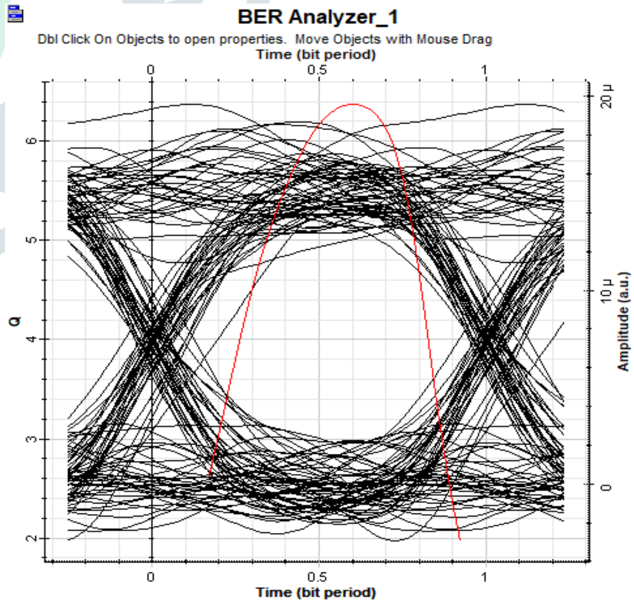

Fig.5.3(b)

Figure 5.3(a), (b), (c) shows the eye diagram of IsOWC system using RZ, NRZ and Gaussian pulse generators at a range of 180km. Figure 5.4(a), (b), (c) shows the eye diagram of IsOWC system using RZ, NRZ and Gaussian pulse generators at a range of 100km.

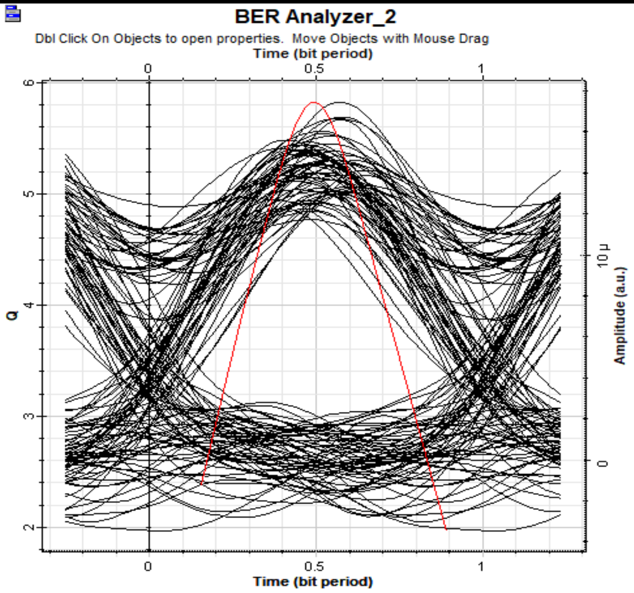

Fig.5.3(c)

Fig.5.3 Eye diagram of ISOWC system at a range of 180km using (a)RZ (b)NRZ (c)Gaussian

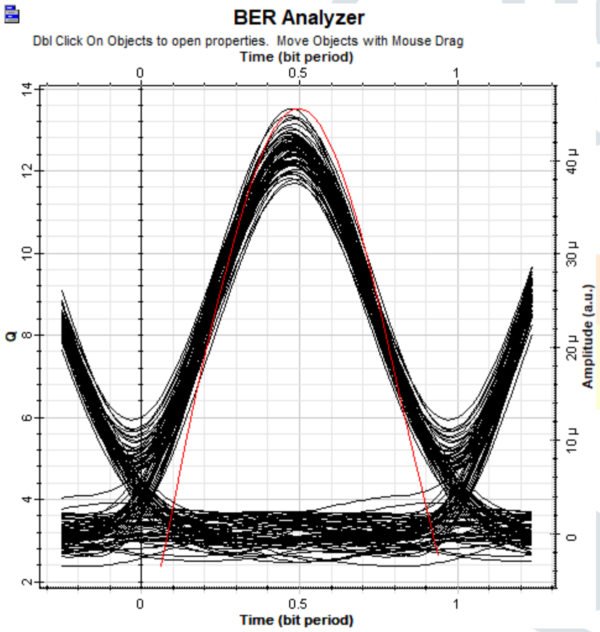

Fig.5.4(a)

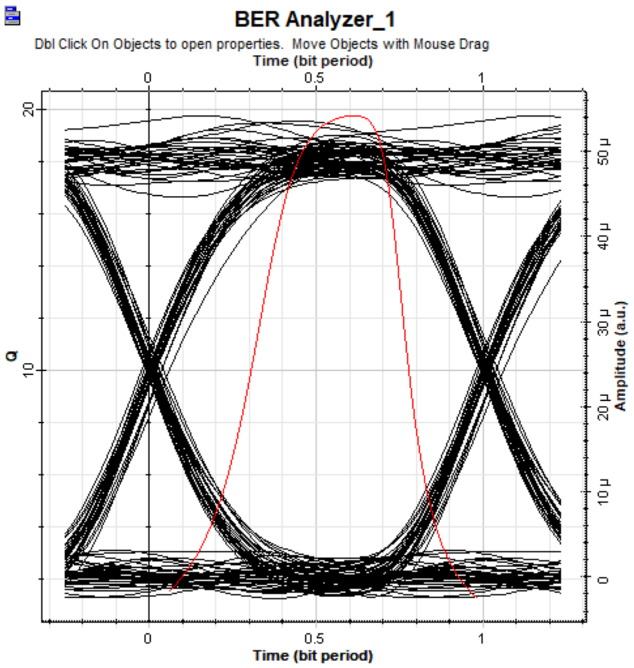

Fig.5.4(b)

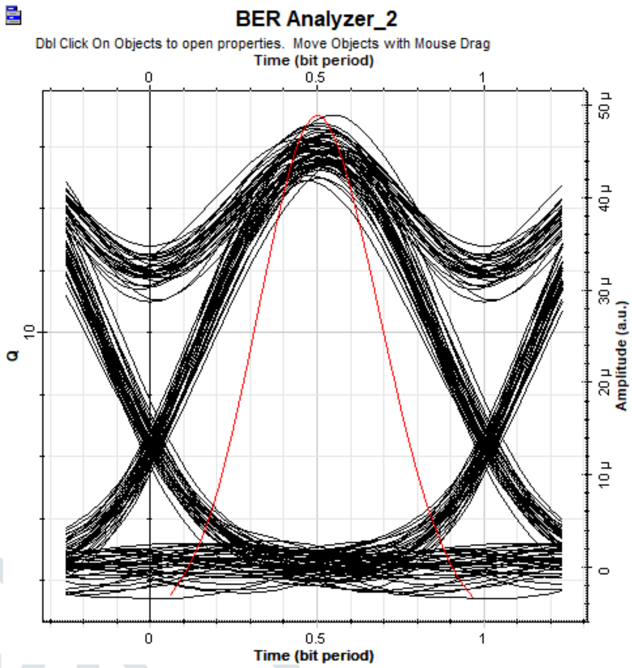

Fig.5.4(c)

Fig.5.4 Eyediagram of IsOWC system at a range of 100km using (a)RZ (b)NRZ (c)Gaussian

VI. CONCLUSION

Different pulse generators RZ, NRZ and Gaussian are compared at different ranges 100, 120, 150, 180 and 200km at a wavelength of 1550nm. Obtained the variation of system for Q-factor and OSNR in NRZ, RZ and Gaussian pulse generators. From the analysis we found that as the distance increases the value of Q-factor and OSNR decreases and also found that the system using NRZ pulse generator give better performance than the system with RZ and Gaussian pulse generators.

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