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10 Gbps Inter-Satellite Optical Wireless Link under the Impact of Transmitting Pointing Error

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Abstract: ***With the advancement in communication technologies, need of high data rates have been evolved over the years. Our work is focused in designing such a system that can withstand effects of turbulences. A single channel 10 Gbps Inter-Satellite Optical Wireless Communications (Is-OWC) system is designed to transmit data under the impact of transmitting pointing errors over a distance of 1000 Km. Minimum acceptable Bit Error Rate (BER) is obtained and successful transmission of data is replicated by Eye Diagrams.***
Keywords: Inter-Satellite Optical Wireless Communications, Bit Error Rate (BER), Inter Satellite Link (ISL)

I. INTRODUCTION

Communication has a great importance in our life. We use different services like voice, video, text etc. Demand of various services is increasing day by day. Also there is a large demand of bandwidth, transmission capacity. Communication can be n various forms like wired, wireless etc. In the few years technology has moved from desktop to portable mobile formats. Videos, cameras, laptops, computers, etc requires high quantity of data. High performance links are required for data transmission from one place to another [1, 2]. Optical Wireless Communication is one of the prominent technologies. A communication for which there is no guided path. It uses different bands like Visible (390-280nm), Infrared (750-1600nm) and Ultraviolet (200-280nm) [3]. This technology has some advantages such as high security, immune to interference, unregulated spectrum, can be used upto long distances, easy deployment and many others [4]. Optical Wireless Communication has a variety of applications ranging from indoor to outdoor. Indoor applications includes interconnection between integrated circuits and outdoor includes interbuilding links to satellite communication.

Optical Wireless Communication mainly uses non directed links such as diffused links, Line-Of –Sight in which no precise alignment is required between the transmitter and receiver [5].

One of the applications of OWC is Inter-Satellite Communication. It is one of the remarkable technologies which tend to meet the rising demands of broadband services. IsOWC is the communication between the satellites rotating in the same orbit or different orbits. There are different orbits such as LEO, MEO, GEO. Satellites orbiting in the range of about 1000Km from Earth are called as Low Earth Orbit (LEO), Medium Earth Orbit (MEO) includes the range of about 5000-25000Km and Geostationary Satellites (GEO) are about 35,786Km above the Earth [6]. IsOWC has some features such as higher data transmission, low cost, small size, long range, unregulated spectrum, higher immunity to interference etc [7]. Communication between any two places in the Earth is an attractive goal. One of the best solution s to connect the satellites together. This is required when the two Earth stations which are opposite to each other then the information should be transmitted through the nearby satellite, the satellite then sends the information to its nearby satellite and so on. In this way several satellites are connected together and transmit the information down to the ground station. Thus inter-satellite link (ISL) plays an important role for the communication purpose for global coverage [8]. Intersatellite communication uses various links such as Point-to-Point, Laser links for communication which do not require precise alignment between the transmitter and the receiver section. However during the transmission path there are temperature and pressure variations which creates some problems such as change in the refractive index due to which the condition of TIR is lost due to which fading occurs which degrades the system performance which results in increase of Bit Error Rate (BER), delays in transmission, decrease of Quality factor and many others [9].

That is the reason these are used together with multiplexing techniques and modulation techniques in order to enhance the performance of the system. Here in this system we are using OCDMA (Optical Code Division Multiplexing) together with PDM that is Polarization Division Multiplexing. OCDMA is a category of multiplexing and internetworking technologies that uses codes for encoding and decoding signals by using some components such as signal multiplexing, routing, switching etc. However this system has some limitations also which includes Multiple Access Interference (MAI). Due to MAI there is overlapping in the encoded signal due to which nit errors are formed which degrades the system performance [10] .Polarization Division Multiplexing

(PDM) is used together with Optical code Division Multiplexing (OCDMA) to enhance the performance of the system. It is a method of multiplexing signals in which information from the two channels can be transmitted using the same carrier frequency by using waves of two different polarization states so that there is no overlapping. It is used for optical communication by using left and right circularly polarized light beams. It is used together with phase modulation or optical Quadrature Amplitude Modulation (QAM). It allows transmission speed of upto 100 Gbit/sec. it is used with Wavelength Division Multiplexing (WDM) so that sets of PDM wavelength signals can be carried therefore increase the capacity of the system. PDM has some limitations also. Due to physical changes in the environment, there are drifts in the polarization state which results in error and degrades the system performance. These errors are Polarization Mode dispersion (PSD), cross polarization, polarization-dependent loss etc. That is the reason it is used with the channel coding techniques[11].

II. SYSTEM DESCRIPTION

The performance of proposed Is-OWC link is evaluated under the impact of space turbulences in OptiSystem software. Figure 1 shows the schematic diagram of proposed system under the impact of space turbulences. The space turbulences are considered as transmitting pointing errors. The simulation is carried out from 1 µrad to 5 µrad transmitting pointing error.

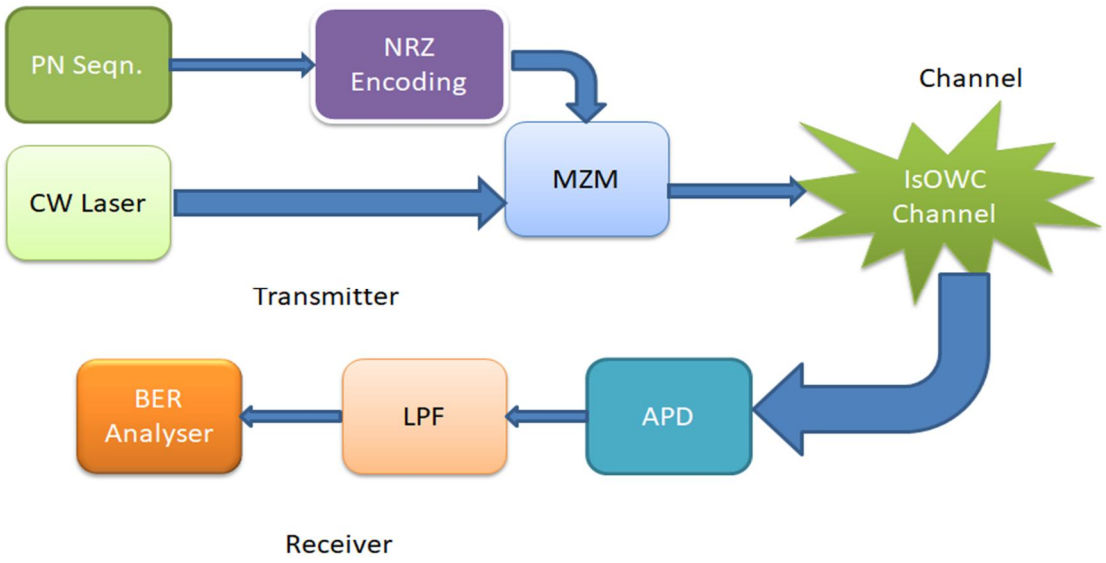

Fig. 1. Proposed Is-OWC system under the impact of Turbulences

III. RESULTS AND DISCUSSION

In this section, results obtained from the simulation of proposed single channel Is-OWC system over 2000 km Is-OWC link under the impact of transmitting pointing errors and receiving pointing errors are presented and discussed. Figure 2 shows the measured minimum BER and max q factor for proposed system upto 2000 km while Figure 3 Shows the measured minimum BER and max q factor for proposed system upto 1000 km under the impact of transmitting pointing errors of 1µrad upto 5µrad.

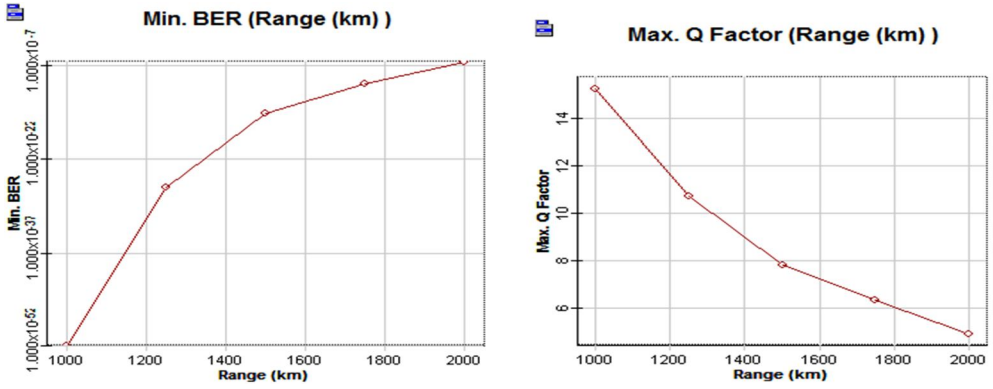

Fig 2. Minimum BER and Max Q Factor vs Range

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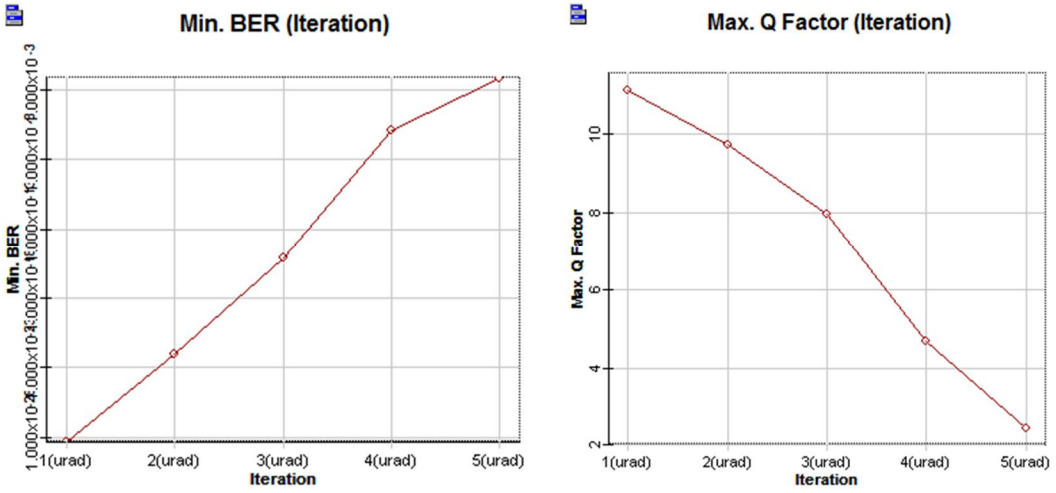

Fig. 3 Minimum BER and Max Q factor Vs Transmitting Pointing errors

The value of BER for system with is noted as 1.19×10^{-52}, 2.79×10^{-15} and 4.41×10^{-7} at a distance of 1000, 1500 and 2000 km respectively without any turbulence whereas Max Q factor of 15.21, 7.08 and 4.90 at a distance of 1000, 1500 and 2000 km respectively was measured. The system is further subjected to turbulences that is pointing error from 1µrad to 5 µrad at a distance of 1000km. The value of BER for system with is noted as 4.13×10^{-29}, 8.39×10^{-16} and 0 whereas Max Q factor of 11.11, 7.95 and 2.46 at transmitter pointing error of 1µrad, 3µrad and 5 µrad respectively was measured.

Figure 4 and 5 shows the eye diagrams for both the cases with turbulence and without turbulence. As it is clear from the eye opening that data has been successfully received.

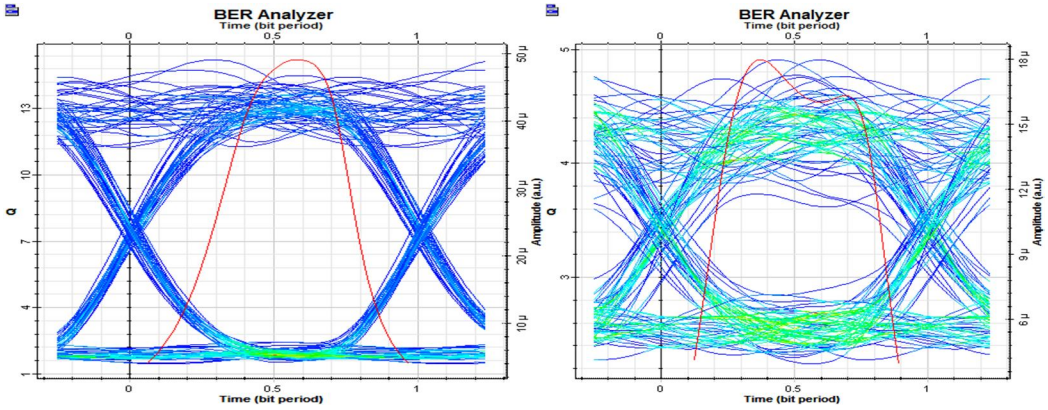

Fig. 4 Eye diagram at 1000 Km and 2000 Km without Turbulences

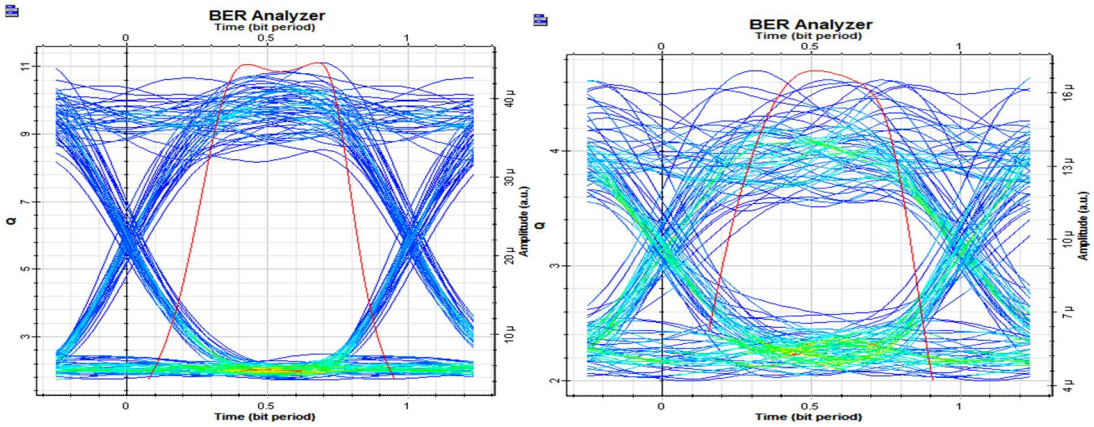

Fig. 5 Eye diagram at 1000 Km and Transmitting Pointing Error of 1µrad and 4 µrad.

IV. CONCLUSION

In this work, we have successfully transmitted 10 Gbps of data over a distance of 2000 km without any turbulences and upto 1000 km with transmitter pointing errors.. The reported result shows the successful transmission of 10 Gbps data Is-OWC link with acceptable BER and Q factor and eye pattern under the impact of transmitting pointing errors.

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