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PERFORMANCE ANALYSIS OF ISLS FOR OPTICAL WIRELESS COMMUNICATION

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ABSTRACT

RF carriers are nowadays being replaced by the much faster optical carriers for Inter-Satellite links (ISLs).Use of optical carriers instead of the conventional RF carriers enables high data rate upto several Gbps to be transmitted. The focus of this paper is the performance analysis of IS-OWCs (Intersatellite-Optical Wireless Channel). The choice of transmitting wavelength is significant. Though 1550nm gives a lower Q-factor of 18.22, it is more robust against scattering. The length of OWC directly affects the Q-factor. 10 Mbps cannot be transmitted beyond a distance of 3000 km as the Q-factor decreases to 5.22.

Keywords: Inter-Satellite Link (ISL), Optical Wireless Channel (OWC), Transmitting Wavelength, Bit-Rate, Q-Factor.

I. INTRODUCTION

Inter-Satellite links (ISLs) are used to provide connections between earth stations in the service area of one satellite to earth stations in the service area of another satellite when neither of the satellites covers both sets of earth stations. There are two different links possible: radio and optical links depending on the mass and power consumed. Radio links are more advantageous for low throughputs (less than 1 M bit/s). Optical links are preferred for high capacity links (in Gbps) [1].Z.Sodnik *et.al* [2] have discussed the notable achievements in optical inter-satellite communications. The European Space Agency (ESA) and Japanese Space Agency (JAXA) have been very active in this field. Several experiments conducted have proved the reliability and feasibility of optical links for ISLs. The success of SILEX (Semiconductor laser Inter-satellite Link Experiment) has made ESA a world leader in optical inter-satellite links. This paper focuses on different transmitter wavelength and data rates and their impact on the performance of the ISL for Optical Wireless Channel (OWC). This paper aims to find the most suitable transmitting wavelength and the maximum channel length for different data rates for ISLs.The simulation model with the necessary parameters is presented in section II. The performance for various modulation types have been investigated using the Q-factor, the results and discussion is presented in section III. Finally, section IV concludes the paper findings.

II. SYSTEM MODELLING

The ISL link for Optical Wireless Channel (OWC) has been modelled using OptiSystem v9 software. The arrangement is as shown in Fig 1.The system consists of a transmitter, OWC (Optical Wireless Channel) and a receiver section. A CW laser with input power of 10dBm is considered .It is externally modulated by MZ modulator. The OWC channel consists of a pair of telescope lenses and the free space channel between them. The major loss of signal power is due to the free space path loss of the channel. The receiver section essentially consists of a photodetector, filter and 3R regenerator as shown in Fig1.

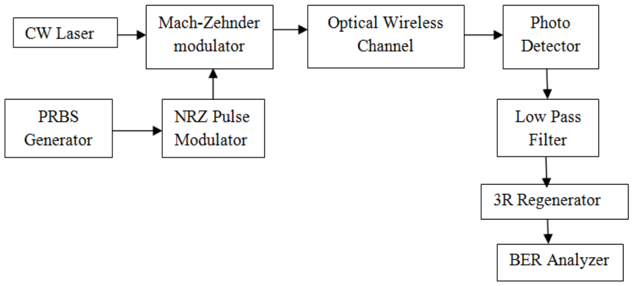


Fig 1: Block Diagram of Inter-Satellite Link

TABLE I: Static Parameters for IS -OWC System

Parameters	Value
Input power of CW Laser	10dBm
Wavelength	850 nm/1550nm
Responsivity	0.8A/W
Dark current	10nA
Transmitter and Receiver aperture diameter	15cm

The static parameters considered in this paper are given in Table I. The OWC distances 200-5000 kms have been considered for simulation. The data rate is varied from 1Mbps to 10 Gbps and the resulting Q-factor is observed for each case.

III. RESULTS AND DISCUSSION

Fig. 2 shows the simulation setup for IS-OWC on Optisystem software. This paper simulates the IS-OWC and the performance of the link is interpreted through the Q-factor. The data rates are varied from 1 Mbps upto 10Gbps and distance from 200-5000kms. The subsequent effect on Q-factor is observed from the BER analyser.

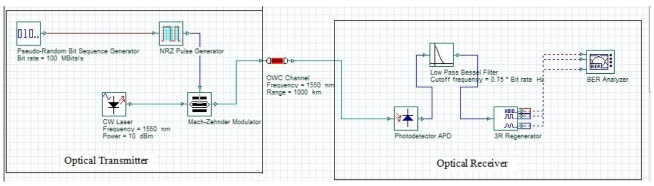


Fig 2: Simulation set-up for ISL

The PSRB Generator is varied through 1Mbps, 10Mbps, 100Mbps, 1Gbps and 10Gbps. This binary bit is converted into NRZ format before being modulated by the Mach-Zehnder modulator. The frequency of the CW laser is fixed at 1550 nm and power at 10 dB. The IS-OWC consists of transmitter telescope, free space channel and receiver channel. The default size of aperture diameter for transmitter and receiver telescope is 15 cm. Free space path loss is enabled. On the receiver side, the APD photodetector converts the optical to electrical signal from which the original data is recovered by means of 3R regenerator. The eye diagram and Q-factor are viewed using the BER analyzer.

Case 1: Effect of Transmitting wavelength on eye diagram

In optical communication, transmitting wavelength of 850 nm and 1550 nm are commonly used. The effect of wavelength is observed through the eye diagram presented in Fig. 3(a) and 3(b) .The data rate and optical wireless channel distance are held constant at 1Gbps and 500 kms respectively.

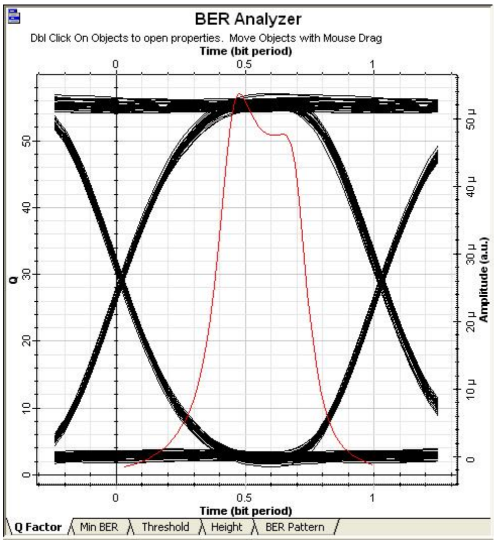


Fig 3(a): Eye Diagram for 850 nm Wavelength

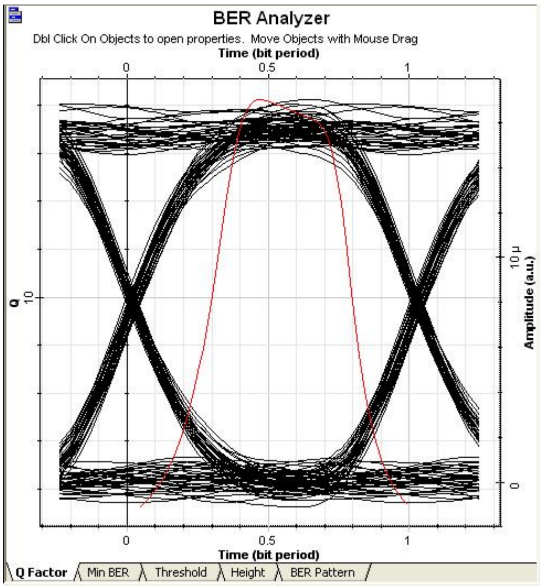
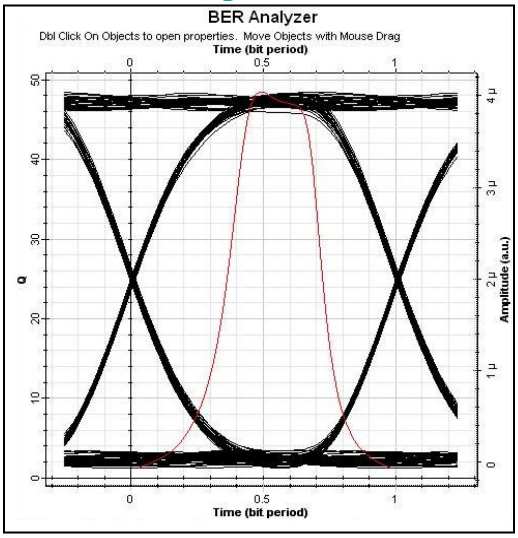


Fig 3(b): Eye Diagram for 1550 nm Wavelength

In Fig.3 (a), when a transmitting wavelength of 850 nm is used, a very high Q-factor i.e. 57.05 is obtained. In the case of 1550 nm, the Q-factor is reduced to 18.22 as shown in Fig.3 (b). It is, thus, observed that when the transmitting wavelength is higher, more bit-errors are present. However, longer wavelengths are practically preferred as they reduce the effect of scattering. Also, attenuation due to Rayleigh and Mie scattering is inversely proportional to the wavelength. Hence, 1550 nm is suitable for IS-OWC.

Case 2: Effect of Channel length on eye diagram

The IS-OWC length is varied from 1000km to 3000 km for a data rate of 10 Mbps.



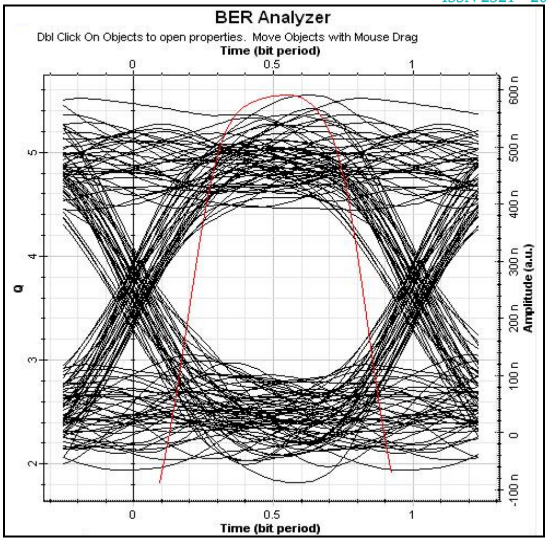


Fig 4(a): Eye Diagram for Channel Length of 1000 km

Fig 4(b): Eye Diagram for Channel Length of 3000 km

From Fig 4(a), it is seen that for a distance of 1000km a Q-factor achieved is 48.43 while for a distance of 3000 km the Q-factor sharply decreases to 5.22 as seen from Fig. 4(b). This decrease in Q-factor is due to the free-space path loss, which increases with transmission distance.

Case 3: Max Q-factor versus distance for different bit rates

In Fig 5, the data rate is varied from 1 Mbps to 10 Gbps. For each data rate the distance is varied through 200-5000kms. The maximum Q-factor obtained for each case is noted from the BER analyser. It is seen that for the maximum distance considered i.e. 5000km, data rate greater than 1Mbps cannot be supported. 1Mbps at 5000km gives a Q-factor of 5.96. 10 Mbps can be transmitted upto 3000km for a Q-factor of 5.55. 100Mbps at 2000km gives a Q-factor of 14.94. 1Gbps cannot be transmitted beyond 1000km while 10Gbps may be transmitted over a maximum of 200km only for a Q-factor of 6.14.

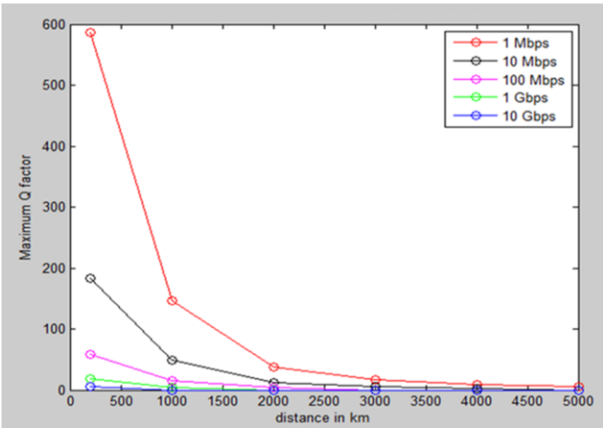


Fig 5: Max Q-Factor Versus Distance for Different Bit Rates

IV. CONCLUSIONS

The goal of this paper was to analyze the performance of the Inter-satellite link for OWC based on different parameters. It is found that the most suitable wavelength for transmission over OWC is 1550nm. The results show that 1550nm wavelength for OWC achieves a Q-factor of 18.22 for data rate of 1Gbps at 500kms. The maximum possible data rates for different channel lengths were also investigated. For a distance of 200km, a maximum data rate of 10Gbps corresponding to Q-factor of 6.14 may be supported. However, only 1Mbps may be transmitted when the channel length is 5000km.

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