



Performance Analysis of Advanced Modulation Formats in Inter-Satellite Optical Wireless Communication System

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Abstract- In this article, different modulation formats CSRZ, DRZ, DPSK have been investigated in inter-satellite links on optical wireless communication system. It has been observed that DPSK performs better at long range than CSRZ, DRZ techniques while CSRZ and DRZ perform better for little range. Q-Factor has been used for the assessment of the techniques to give the simulation results. The results show that DPSK which has simple design and less cost performs best at a higher transmission range at the data rate of 40Gbps. DPSK system has been simulated at different power levels and Q-factor has been observed at these power levels. The increasing aperture diameters of both transmitters and receivers have shown significant improvement in the performance of DPSK system.

Keywords: - IsOWC (Inter-Satellite Optical Wireless Communication), DPSK (Differential Phase Shift Keying), Q-Factor.

I. INTRODUCTION

Inter-satellite Optical wireless communication (IsOWC) is a capable solution for very high data rate point to point communication. With the rising popularity of high definition television and video conferencing, the demand for both high speed wired and wireless access is continuously increasing in indoor and outdoor environments [1]. The microwave and RF frequencies are used to transfer the information but they suffer from serious drawbacks like radiations make a way into walls and less data rate transfer due to losses [2]. So the microwave and RF links are replaced by optical wireless technology. The IsOWC technology has a lot of reimbursements than the disadvantages. Its high data rate capability, license free operation, unregulated bandwidth, low power, high efficiency, lesser antenna sizes and low cost. All these features made the IsOWC technology came into survival [3]. The disadvantage includes the tracking problem and misalignment of transmitter and receiver apertures and the changes due to atmospheric conditions. The tracking problem causes various noise sources such as laser relative noise intensity, Johnson noise, dark current noise. Vibration noise is the most degrading factor in IsOWC communication system. These noises made the system more susceptible towards the pointing errors. The main focus is to reduce the power dissipation and to reduce the BER. This result in high transmitter power and lesser receiver noise to obtain desired signal [4]. IsOWC has provided a bottleneck solution for the connectivity and long

range data transmission problems. The system consists of a laser beam modulated with data and is transmitted through free space with less attenuation than microwave and RF links as light travels faster in vacuum and can travel a long distance in thousands of kilometers with minimum bit error rate [5]. The system is admirable until the atmospheric disturbances are not present and effect of atmospheric turbulences is dissimilar for different modulation formats [6]. The data rate can be varied from 10Gbps to 40Gbps with a tolerable quality factor. The other parameters which affect the transmission properties include transmission aperture diameter, receiver aperture diameter and power of the operating laser source. The system needs more power when operated at large distances. The satellites should be in Line-of-Sight links to avoid the tracking problems so transmitter and receiver pointing angles must be precisely accustomed. Even a small deviation in beam angles can make the signal reception intricate or impossible [4]. So the advanced modulation schemes are investigated for the Inter-satellite optical wireless communication for the better performance. Further, the best scheme is pragmatic under different power levels and analyzed at different transmitter and receiver aperture diameters. This paper gave the comparative study of advanced modulation techniques i.e. CSRZ, DRZ and DPSK. The piece of writing presents the simulation set up of different modulation schemes in single channel ISL systems. The simulative setup description of IsOWC system is reported in section II followed by simulation results of DPSK at different powers and aperture diameters of transmitter and receiver. The simulation results discussion in section III and section IV deals with the conclusion drawn.

II. SYSTEM DESCRIPTION

IsOWC system has been modeled and performance depiction by OptiSystem7. The IsOWC basic diagram is shown in fig 1. In our proposed system, the first subsystem is the transmitter part which consists of PRBS generator. It generates the data which is to be transmitted i.e. data source. The second subsystem represents the different modulation formats which get its output from the previous block. This subsystem encodes the data from PRBS output by (CSRZ, DRZ and DPSK) techniques. The third subsystem is DML i.e. directly modulate laser which operates on wavelength of 1552 nm because of low attenuation characteristics in optical communication in this wavelength region. The free space between transmitter and

receiver is considered as OWC channel which is the propagating medium for the transmitted optical signal. The optical receiver comprises of a photo detector followed by a low pass Bessel filter. In this section of system, the optical signal is converted back into electrical signal. APD (avalanche photo-diode) is used because of its high gain property. The last subsystem is BER tester which gives the Quality factor and BER measurement. The system works on data rate of 40Gbps at a link range of 750 km.

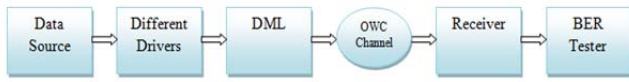


Fig.1 Basic diagram of IsOWC system

III. RESULTS AND DISCUSSION

In the system different modulation formats have been evaluated on a single channel IsOWC link. A comparative study of advanced modulation schemes CSRZ, DRZ and DPSK has been developed. The different parameters at which the system works are: Data rate 40Gbps, transmitter wavelength 1550 nm, varying distances from 350km to 750km, transmitter aperture diameters 20cm, receiver aperture diameter 25cm, transmitter and receiver optics efficiency is 1, transmitter and receiver pointing error angle are 0.8μrad and additional losses are 1dB. The best scheme among the three is DPSK which is further simulated at different transmission powers -20dB, -15dB, -10dB, -5dB, 0 dB, 5dB, 10dB, 15dB, 20dB and 25dB. The scheme is also analyzed at different transmitter and receiver aperture diameters Effect of increasing aperture sizes is observed with DPSK.

The analysis of different modulation schemes shows that the DPSK performs better than the other two at varying transmission distances with other parameters remaining equal. Fig.2 shows the graph between Q and Transmission distance at data rate of 40Gbps. It has been shown that there is a significant decrease in Q -factor when increasing transmission distance.

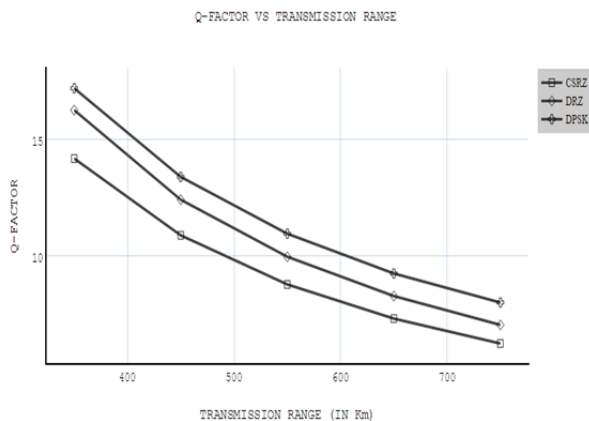
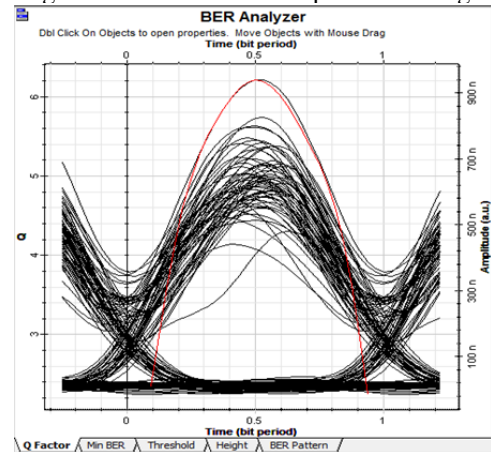


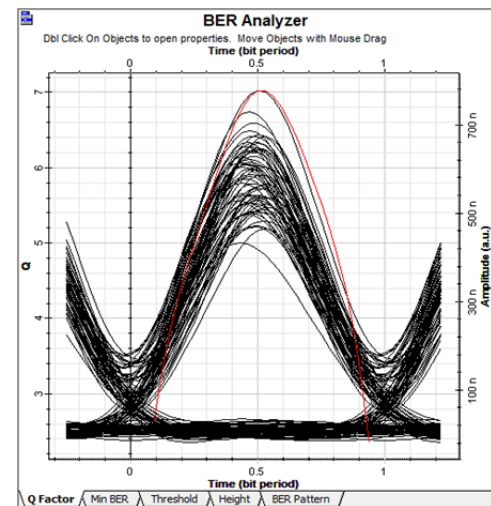
Fig.2 Q-Factor vs Range

The BER for CSRZ is 10^{-10} , DRZ 10^{-13} and DPSK 10^{-16} which affirms the better capability of DPSK modulation format at a transmission distance of 750 km. The eye

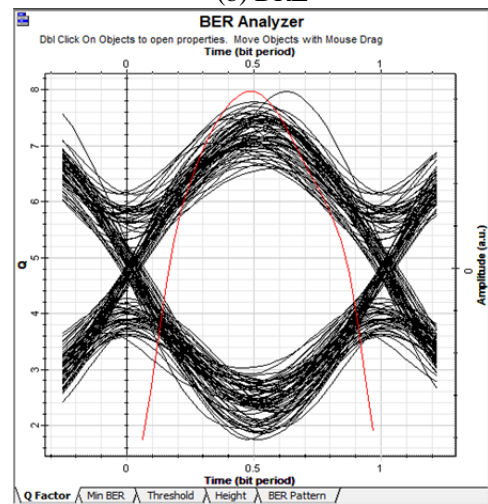
diagrams for these three modulation formats has been shown in fig.3, which shows the comparison among these.



(a) CSRZ



(b) DRZ



(c) DPSK

Fig.3 Eye diagrams of modulation formats at 750km at 40Gbps data rate (a) CSRZ (b) DRZ (c) DPSK

Furthermore, the DPSK technique is realized with different power levels varying from -20dB, -15dB, -10dB, -5dB, 0dB, 5dB, 10dB, 15dB, 20dB and 25dB. The results are shown

in fig.4 which is Q vs transmission power. The results show that reduction in power increases the bit error rate. The system gives better results at transmission power of 0dB and till 25dB the quality factor increases and below 0dB the Q is zero.

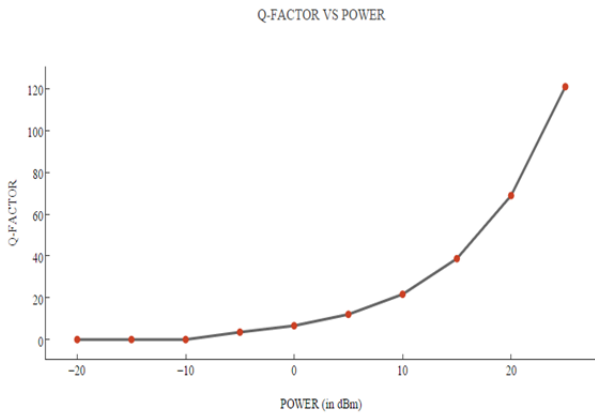


Fig.4 Q-factor of DPSK at different power levels

Now, the aperture diameters of both the transmitter and receiver are varied. The values of transmitter aperture diameter are 1cm, 5cm, 10cm, 15cm, 20cm and receiver aperture diameters are 3cm, 7cm, 12cm, 17cm, 22cm with respect to transmitter. The effect of varying the aperture diameters can be easily seen from fig. 5 and fig. 6.

Q-factor vs Aperture Diameter of Transmitter

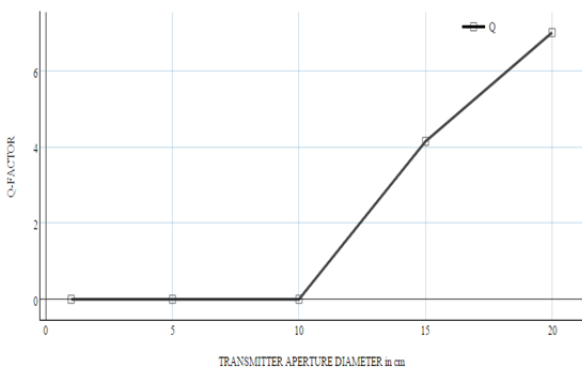


Fig.5 Q-Factor vs aperture diameter of transmitter

Q-Factor vs Receiver Aperture Diameter

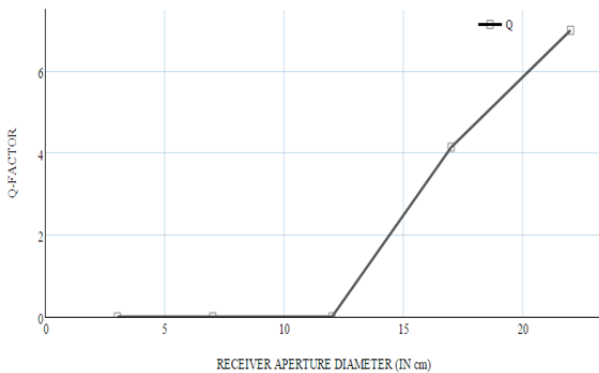


Fig.6 Q-Factor vs Receiver Aperture Diameter

The increase in aperture diameter sizes of both transmitter and receiver gives high Q-factor and less BER. There is a significant increase in Q-factor when increasing aperture sizes of both transmitter and receiver which lies within [(1,3) – 0], [(5,7) – 0], [(10,12) – 0], [(15,17) – 4.15], [(20,22) – 7.01].

IV. CONCLUSION

The different modulation schemes of CSRZ, DRZ and DPSK are compared with varying transmission distances at 40Gbps system. Out of the three schemes DPSK has given better results with a bit error rate factor of 10^{-16} at transmission distance of 750km. The transmission distance for DPSK modulated system can be further increase to obtain acceptable Q-Factor of 10^{-9} It is tested at different transmission power varying from -20dB to 25dB, the quality factor increases as the power increases and gives 0 BER at 25dB power. Increasing the transmitter and receiver aperture diameters has significantly improved the system performance at 40Gbps data rate and transmission distance of 750km. With the increase in receiver aperture diameters, there is increase in optical and electrical SNR and with increase of transmission distance Optical and Electrical SNR decreases [7].

Hence, it is concluded that DPSK is the best for long transmission distance and high data rate applications with minimum bit error rate and good quality factor.

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