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Design And Comparative Analysis of Inter Satellite-Optical Wireless Communication (Is-Owc) For Return to Zero (Rz) & Non-Return to Zero (Nrz) Modulation Formats Through Channel Diversity Technique

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Abstract
IS-OWC (Inter Satellite Optical Wireless Communication) is a novel method of establishing interconnection between two satellites. Inter-satellite Optical Wireless Communication is concerned with the use of lasers instead of traditional radio and microwave systems for wireless optical communication. When compared to a single channel, the channel diversity strategy produces better results. The IS-OWC device uses a diversity technique in which several signal paths are available, allowing the Q-factor and signal intensity to be extended or increased over a large distance. In this paper, the Q-factor and the Bit Error Rate (BER) are analyzed with diverse modulation formats like Return to Zero (RZ) and Non-Return to Zero (NRZ) using the channel diversity technique.

Keywords: Optical Wireless Communication (OWC); BER; Q-factor; Return to Zero (RZ); Non-Return to Zero (NRZ).

1. Introduction

An Inter Satellite Optical Wireless Communication (IS-OWC) can be used to link any two satellites, whether they are in the same orbit or in different orbits. Low earth orbit, medium earth orbit, and geostationary earth orbit are the most common orbits used by satellites to orbit the earth. A highly accurate tracking system is needed, which includes the use of beacon signals on one hand and a quadrant detector with a tracking system on the other, to ensure that the linked satellites are well aligned and have an accurate line of sight. Data can be sent without substantial delay and attenuation because light travels at 3×10^8 m/s.

The ability to transmit high-speed data over thousands of kilometres with a small payload is a benefit of using optical links over radio frequency (RF) links. The proposed IS-OWC system is implemented using the optical Inter-Satellite Link (ISL) which is a simulation investigation with optisystem-16 software. This system uses two satellites separated by 2500 km, a wavelength of 1550nm, and a transmitted power of 15dbm at a data rate of 10Gbps using diverse modulation formats such as Return to Zero (RZ) and Non-Return to Zero (NRZ) modulation.

Kumar et al. demonstrated that, among all SM module strategies, the Non-Return to Zero modulation is the best format for achieving the longest communication distance of 1000 km while maintaining a good signal to noise ratio and a low bit error rate.

To obtain an improved estimate of the Quality factor and Bit error rate, Pooja Sharma et al. used the Mach-Zehnder Modulator. As the distance between the satellite and the ground increases, the obtained power decreases. At a similar bit rate, the frequency decreases, the quality factor increases, and the BER decrease.

Priya Sharma et al. used a variety of modulation techniques to help boost the IS-OWC framework's exhibition over a distance of 5000 km with a data rate of 1Mbps [8]. In this paper, a channel variety strategy with multiple transmitter and receiver antennas is used to investigate the results for a 10 Gbps data rate with 15 dBm input power at different channel counts using various types of adjustment techniques (NRZ, RZ).

2. Proposed System Model

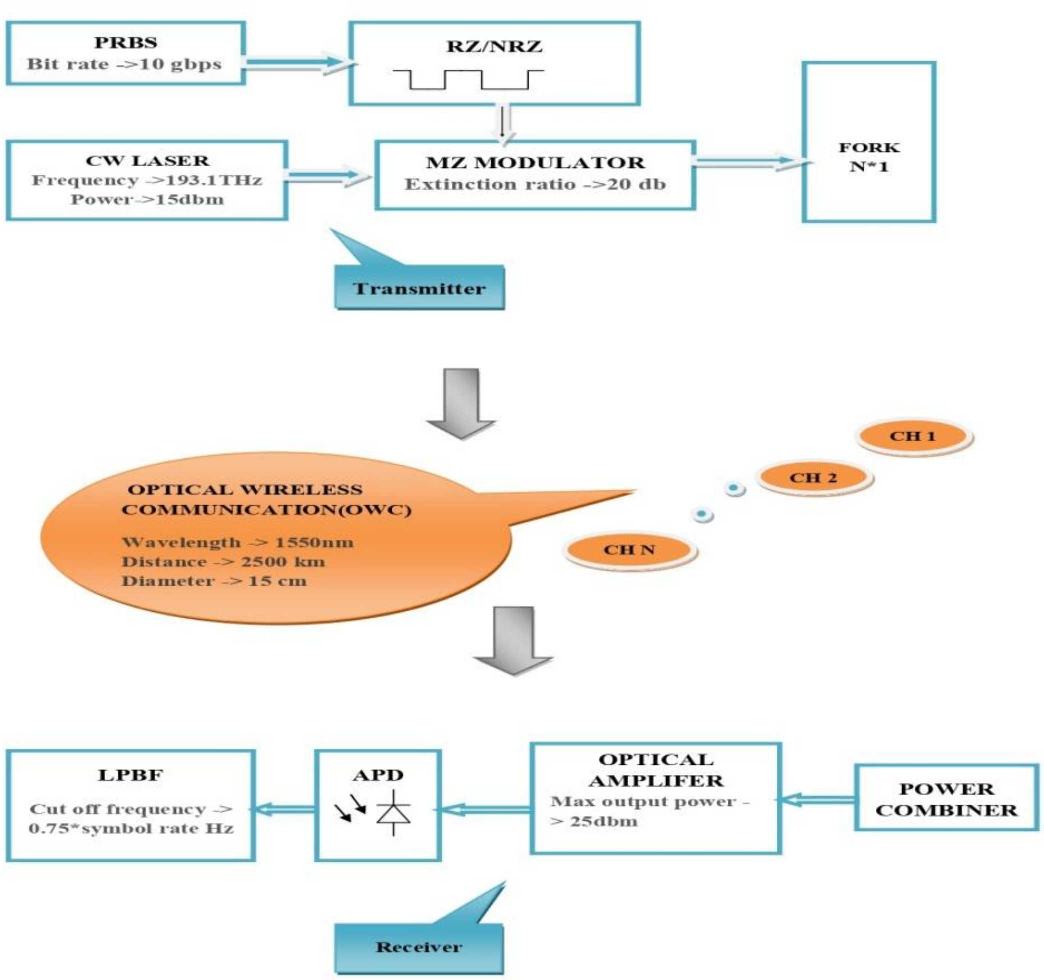

Figure 1 Block diagram of IS-OWC system using channel diversity technique

Figure 1 shows the block diagram of the IS-OWC method with the channel diversity technique. A transmitter, propagation medium, and receiver make up the IS-OWC system. The binary signal is generated by the Pseudo Random Bit Sequence (PRBS), which is then converted into an electrical signal by the RZ and NRZ pulse generators. The MZ modulator assists in modulating the voltage of the RZ and NRZ generators with carrier signal (laser light). With the aid of a power combiner, the optical signal is propagated to Fork 1: N, which provides independent signal replicas to N number of optical wireless channels. An Avalanche Photodiode (APD) is used in the receiver to convert the optical domain signal to an electrical signal. The redundant signal is filtered out using a Low Pass Bessel Filter (LPBF). For different modulation schemes, the performance of the BER analyzer is evaluated in terms of the Q-factor or BER.

3. Results and Discussion

This section presents the details of the experiment carried out for implementation. The system was simulated with opti-system-16.0 software.

3.1 Q Factor Analysis for RZ & NRZ

A. 2 and 4 channel

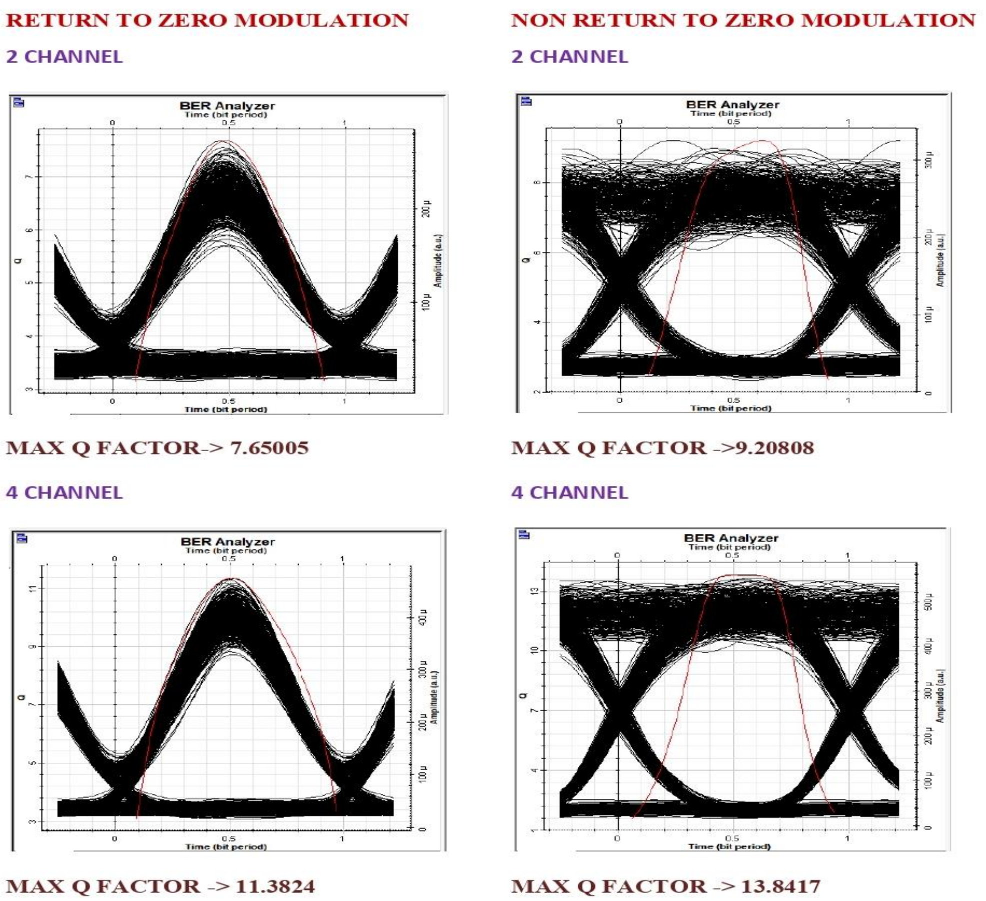

Figure 2 Maximum Q-factor of 2 and 4 Channel for RZ and NRZ modulation

B. 6 and 8 channel

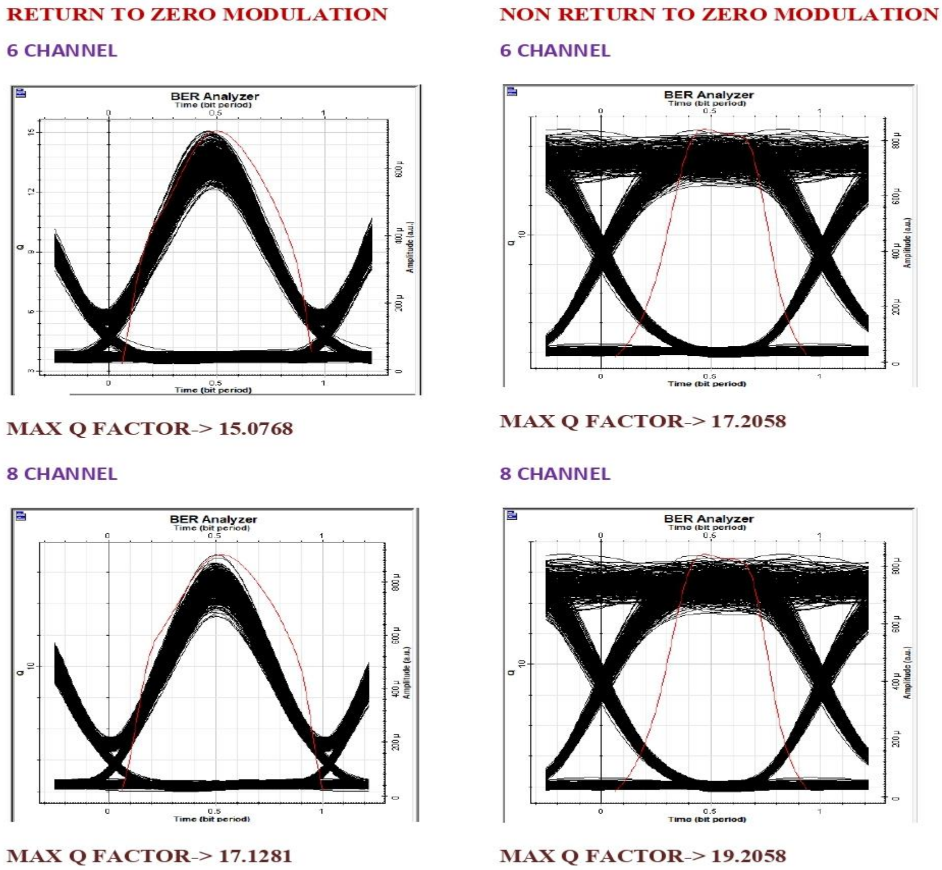

Figure 3 maximum Q-factor of 6 and 8 channels for RZ and NRZ modulation

The Q-factor for return to zero and non-return to zero modulation formats is shown in Figures 2 and 3. In terms of eye diagram, the channel 2, 4, 6, and 8 outcomes for return to zero and non-return to zero formats are shown above. The "eye" of a digital signal is the human eye-shaped pattern on an oscilloscope that shows transmission system output, and the "eye" reflects the consistency of the SNR in the "eye" of a digital signal. The sampling process with the largest "eye-opening" is the best place to determine if a given bit is a "1" or a "0." The larger the "eye-opening," the greater the difference between the mean values of the signal levels for "1" and "0."

The eye diagram for channel 2, 4, and 6 furnishes a small eye-opening which means that the Inter Symbol Interference (ISI) is high. The eye diagram of channel 8 provides a big opening which refers that the Inter Symbol Interference (ISI) is low. The maximum Q-factor obtained in channel 8 is 17.1281 for return to zero formats and 19.2058 for non-return to zero formats. Furthermore, the system with 8 channels Optical Wireless Communication confers a superior Q-factor of value 19.2058 at 2500km distance compared to others.

3.2 BER Analysis for RZ & NRZ

C 2 and 4 channel

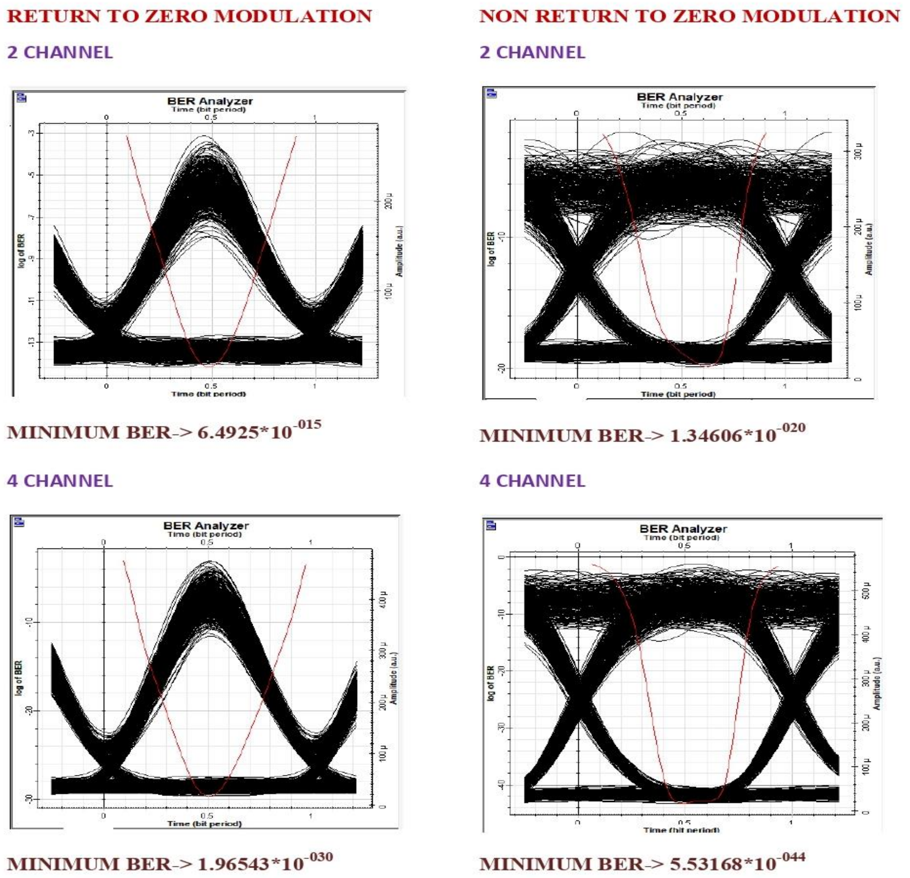

Figure 4 minimum BER of 2 and 4 channel for RZ and NRZ modulation

D 6 and 8 channel

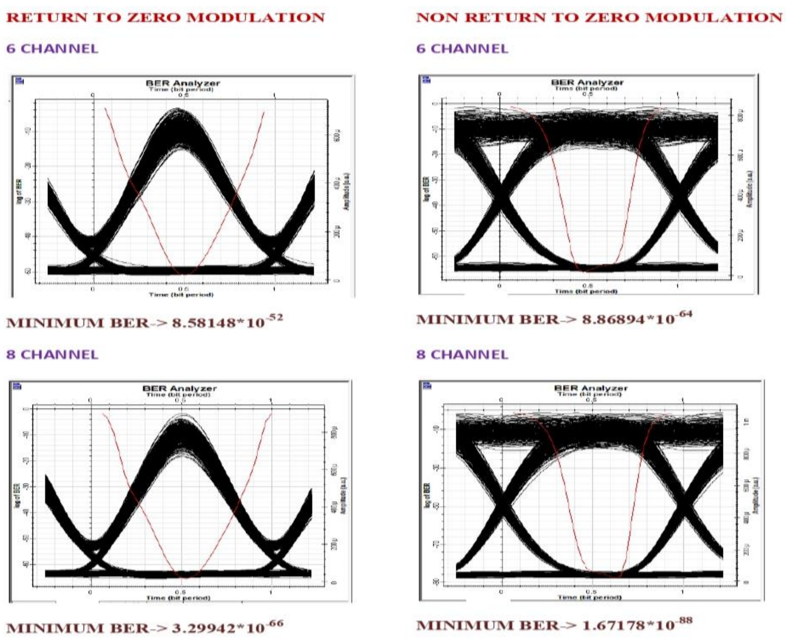

Figure 5 Minimum BER of 6 and 8 Channel for RZ and NRZ Modulation

Figure 4 and 5 shows the minimum BER for the channels 2, 4, 6 and 8 of return to zero and non-return to zero modulation formats. The BER is the probability of incorrect bit identification by the decision circuit .The design of optical wireless communication system relies on the estimation of performance figures of merit such as BER. One of the most commonly used parameters is the receiver sensitivity defined as the minimum averaged received optical power required to achieve a given BER. The comparison of channels 2, 4, 6, 8 implies that the bit error rate is minimum in the range of $3.29942*10^{-66}$ for return to zero formats and $1.67178*10^{-88}$ for Non-return to zero formats.

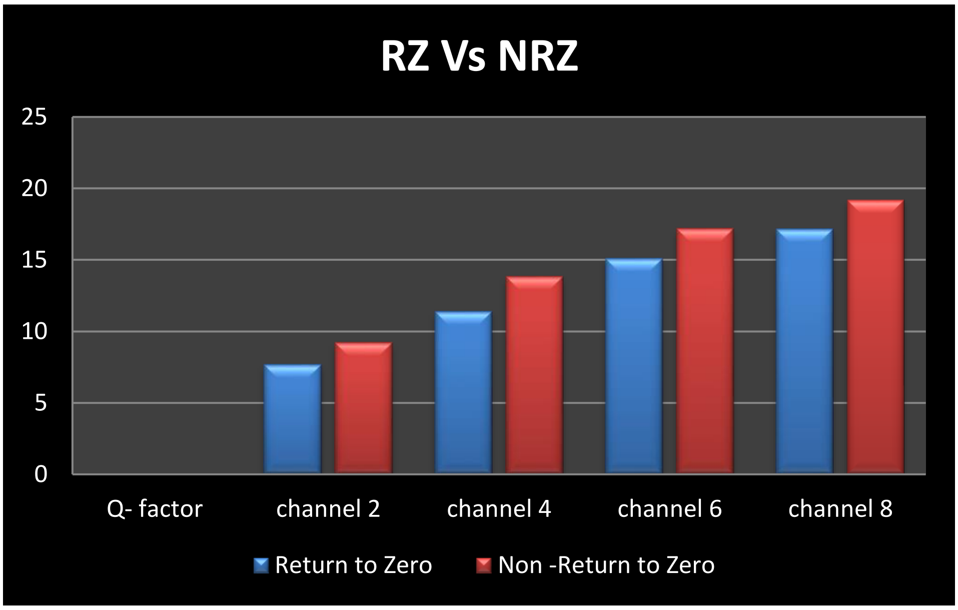

Figure 6 Comparison of Return to Zero and Non-Return to Zero for Q-factor

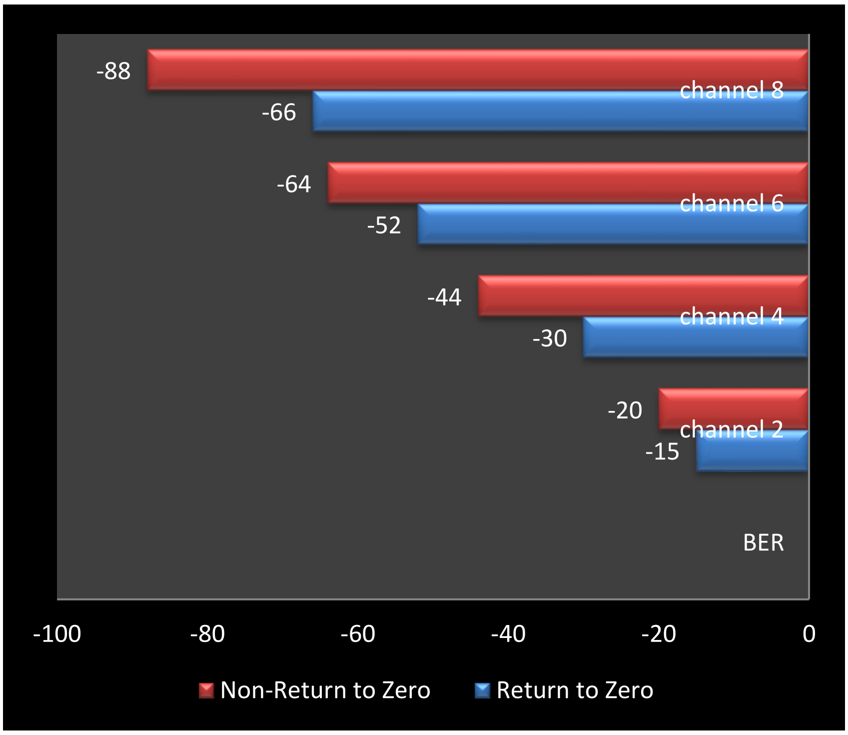

Figure 7 Comparisons of Return to Zero and Non-Return to Zero for BER

Figure 6 and 7 shows the comparison of Return to Zero and Non-Return to Zero in terms of Q-factor and BER. The RZ and NRZ modulation formats of channels 2, 4, 6, and 8 have been introduced and compared in terms of Q-factor and BER. The NRZ modulation format has a higher quality factor and lower BER than the RZ format. As a result, the 8-channel system's optical wireless communication achieved the highest Q-factor in the Non-Return to Zero modulation format.

4. Conclusion

An n-channel IS-OWC system operating at 10Gbps with various modulation formats for 15dBm input power is included in the modeled system. By linking multiple OWC channels between the transmitter and receiver, the channel diversity technique improves inter-satellite signals and allows them to travel long distances. Non-Return to Zero modulation is better than Return to Zero modulation in an optical wireless communication device because it has a lower bit error rate and a higher Q-factor. The minimum Q-factor obtained in the proposed method in the 2 channel OWC is 9.02392, while the highest Q-factor obtained in the 8 channel OWC is 19.4385. Furthermore, increasing the number of channels improves the efficiency of low-power inter-satellite links.

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