Evaluation of ISOWC System Transmission for Different Line Codings and Ultra-Low Channel Spacing

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ABSTRACT
In this research article, the design and simulation analysis of 45×20Gbps Dense Wavelength Division Multiplexing (DWDM) Inter-satellite Optical Wireless Communication (IsOWC) System by taking into account the concept of reduced channel spacing of 50GHz has been done. The low power system is proposed and its performance analysis is observed for various parameters like transmission range and input laser line width. Moreover, the role of EDFA is noteworthy which does the task of amplification efficiently and made the system to work over a transmission range of 12500 km with acceptable Q-Factor and BER. Evaluation also has been proposed for different line codings in terms of Q-factor and BER.

Keywords
WDM, BER, IsOWC, EDFA, RF

1. INTRODUCTION
From prolonged fibers to wireless systems, optical systems had been altered into hybrid optical wireless systems to be used in space communication. IsOWC technology had been used to connect two satellites whether the satellites are in same orbits or in the different orbits. Inter-satellite links had been engaged on several satellite systems such as Iridium and NASA's tracking and data relay satellite systems (TDRSS), where RF is used to link the satellites [1]. IsOWC technology is a better technology for the transmission of high data rates but various parameters should be taken into account which degrades the system performance [2]. Because of extreme growth of internet, the demand for communication bandwidth increases. For metropolitan cities the demand is satisfied by using RF sources but it is an inadequate resource so optical wireless (OW) is the substitute to last mile problem and wavelength division multiplexing (WDM) is quite mature and is applied to all optical networks ubiquitously [3]. Today the most common type of optical communication systems are using WDM that can reach even beyond 1Terabit/s capacity and this is all because of dense wavelength division multiplexing (DWDM) [4]. DWDM is basically wavelength division multiplexing (WDM) with small channel spacing, where different optical frequencies are used in order to achieve simultaneous transmission of a definite number of optical channels over the transmission medium [5].

In modern optical communication systems the role of modulation formats is really significant for better system performance. By manipulating the spectrum of optical light, the available bandwidth can be used more proficiently. 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 [6]. 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 vaccum and can travel a long distance in thousands of kilometers with minimum bit error rate [7]. The system is admirable until the atmospheric disturbances are not present and effect of atmospheric turbulences is dissimilar for different modulation formats [8]. 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 [9][10][11][12].

In this work, we have analyzed the performance of NRZ and RZ WDM systems which has 45 channels with 20Gbps data each and channel spacing of 50GHz. Evaluation has been proposed for the total transmission reach in the case of line-coding in terms of Q-factor and BER. The system is simulated for varying transmission distances and input laser line-widths.

2. SYSTEM DESCRIPTION
Optical wireless transmission experiment is performed in optisystem7 tool and our Is-OWC WDM technique is simulated as shown in figure 1. This is designed with 45 channels each one having 20Gbps NRZ and RZ modulated signal in two cases. The proposed 45 channel DWDM system consists of a transmitter, optical wireless channel and the receiver with the starting frequency of 195THz. The system set up is shown in figure 1.

2.1 Transmitter Section
The transmitter consists of a PRBS generator, CW laser, data modulators, filters and the multiplexer. The PRBS generator generates Pseudo-random bit sequences at the rate of 1Gbps to 20 Gbps for different analysis with 2^7-1 bits. The emission frequencies are equally spaced in adjacent channels with 50 GHz starting with 195 THz. Extinction ratio of MZM intensity modulators is 30dB. Optical signals from 45 data modulators are fed to the 45 input ports of an optical multiplexer. The line-width of CW laser is varied from 0.1MHz to 50MHz. The channel spacing and operating wavelengths are as defined by ITU standards. The simulation parameters are given in table 1.1.

Table 1: Simulation Parameters

Bit Rate	**1Gbps,20Gbps**
Sequence Length	32
Samples/Bit	128
DWDM Channel Spacing	50GHz
Frequency of 1st Channel	195THz
Line Width	0.1-50 MHz
Capacity	45*20Gbps
Input Power	0dBm
Distance	12500km

2.2 Receiver Section

In the receiver side, the signals are de-multiplexed using WDM de-multiplexer having insertion loss 0dB. The 45 channels are de-multiplexed and detected by PIN photo detector which has responsibility of 1A/W and dark current of 10nA followed by low pass Bessel filter with a cut off frequency of 0.8 × Bit rate and filter order of 6. The detected signals are passed through the 3-R regenerators and visualized by the BER analyzers.

3. RESULTS AND DISCUSSION

IsOWC system designed in Optiwave Optisystem. WDM scheme has been used over 45 channels each having data rate of 20Gbps information carried and modulated over laser source of 0dBm operating at wavelength of C band and L band with the channel spacing of 50 GHz through a Mach-Zehnder modulator (MZM).

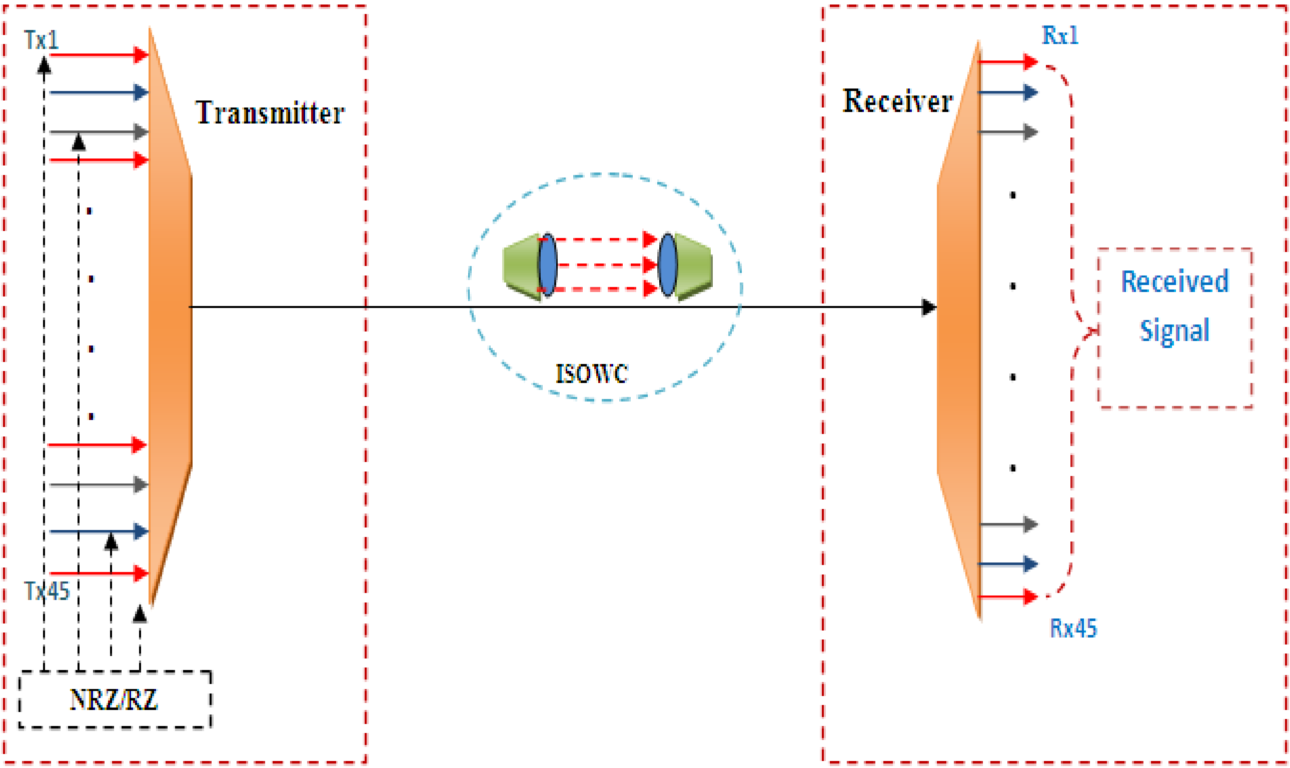


Figure 1. System architecture of 45 x 20 Gbps WDM-IsOWC System

The 45 channels are multiplexed by means of equal spaced multiplexer with no losses. Multiplexed channels are analyzed with help of optical spectrum analyzer. The channels are passed through the EDFA optical amplifier of gain 30dB and noise figure of 4dB to compensate any losses.

EDFA is recommended for optical inter-satellite systems which operate at low powers to do the pre-amplification. These pre-amplified channels are transmitted through optical wireless channel (OWC). The OWC channel comprises of transmitter and receiver antenna having aperture diameters of 20cm and 25cm respectively.

The antennas are assumed to be ideal and their optics efficiency is assumed to be 1.

The pointing error angles of both the transmitter and receiver are assumed to be 0μrad. As the system assumed to be ideal so the additional losses and propagation delay are assumed to be 0dB/km and 0ps/km respectively.

The receiver side of IsOWC system consists of a WDM de-multiplexer which de-multiplexes the channels and are further detected by PIN photo detector followed by low pass Bessel filter of order 4 and having cut-off frequency of 0.8×Bit Rate and insertion loss of 0 dB.

The performance of DWDM NRZ and RZ system is being observed with a channel spacing of 0.4 nm with the capacity of 900 Gbits/s. The line-width of CW laser has also been varied to obtain the impact over the system performance.

The transmission distance is also varied to get the Q-factor of 10^{-9} at various data rates i.e. 1Gbps, 20Gbps. The largest transmission distance of 12500 km is obtained for 20Gbps which is shown in figure 2.

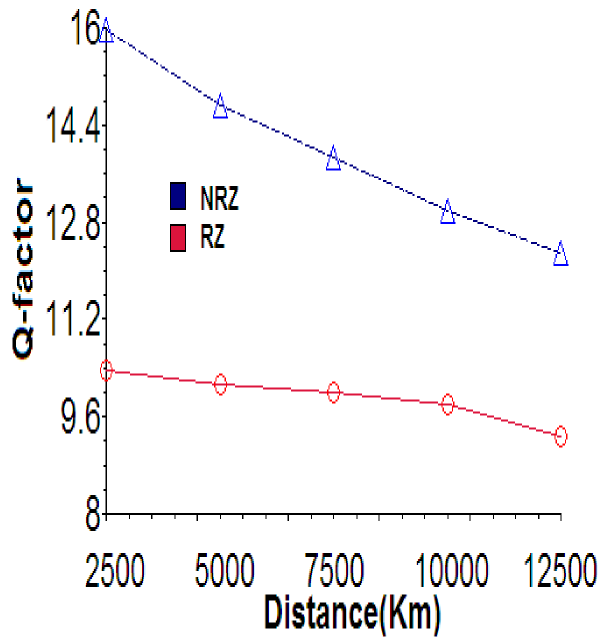


Figure 2 Q-Factor vs Transmission Distance

The maximum of 45 channels have been obtained at the data rate of 20Gbps which is a DWDM system. The data rates of 1Gbps and 20Gbps are also observed.

The results show that as the data rate is increasing, the system performance is decreasing for the maximum transmission distance of 12500 km.

The eye diagrams for the data rates of 1Gbps, 20Gbps are shown in figure 3.

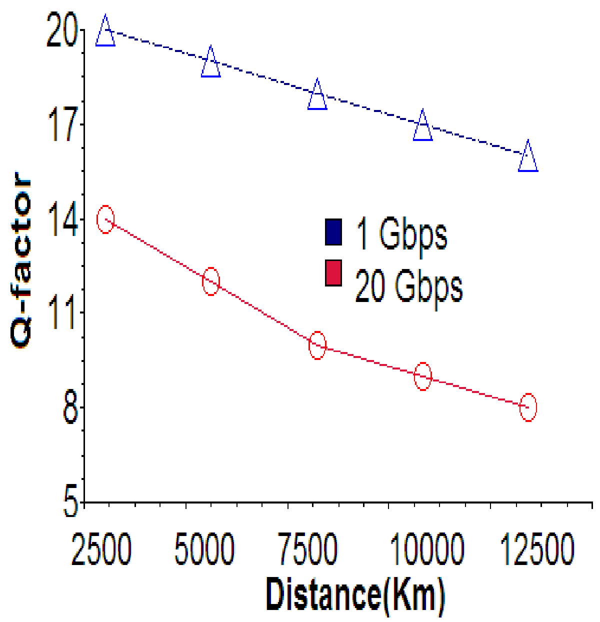
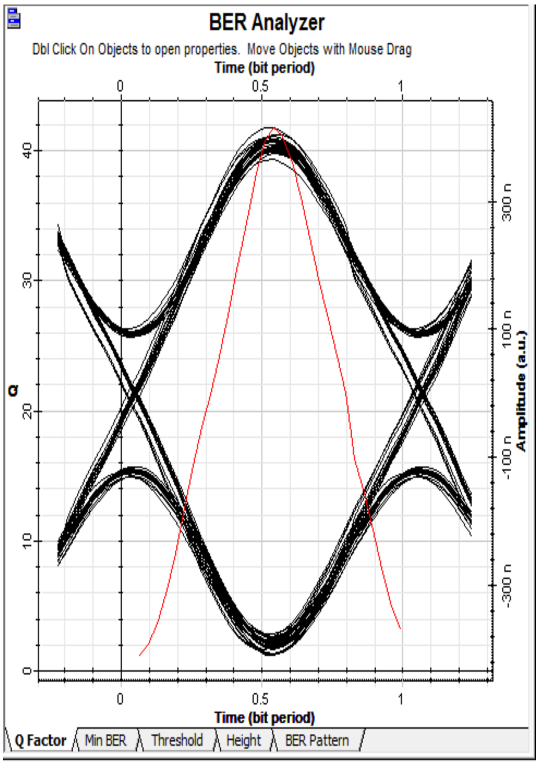
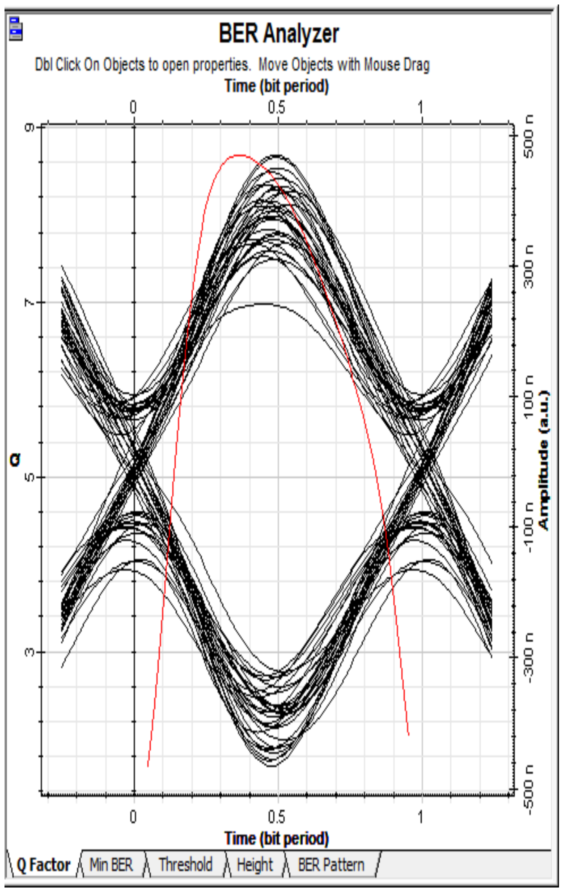


Figure 3 Q Factor vs. Distance for NRZ at different data rates



(a)



(b)

Figure 5 Eye diagrams for (a) 1Gbps (b) 20Gbps

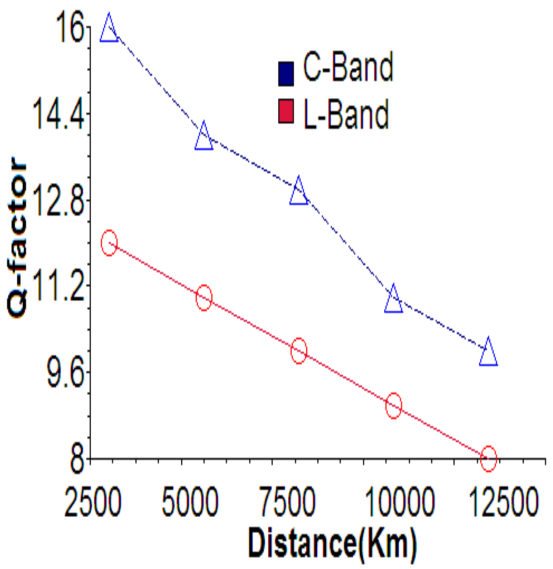


Figure 4 Depiction of the System Performance for C-band and L-band.

The diagram shown in figure 4 which shows the results of alternate channels by using different optical windows such as C band L band.

Figure 4 shows the graph between transmission Range and Q-Factor when the system is analyzed for C band and L band. The results conclude that the transmission range observed by EDFA amplifier in L band and C band is 12500 km.

4. CONCLUSION

This research article reveals that NRZ DWDM system show the high capacity for long haul transmission with the acceptable Q-factor and BER. The system has reached the capacity of 900 Gbps with the help of a system which is simple in architecture at both the transmitter and receiver sides having channel spacing of 50GHz for input laser source. C-band is found out to be best for long transmission in IsOWC. Thus the designed system provides a high capacity including less cost and simple architectural design. Thus the goal has been achieved to create a high capacity DWDM system with less channel spacing.

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