DESIGN OF A DWDM SYSTEM FOR GROUND TO SATELLITE USING RZ/NRZ SIGNALING SCHEME

Saumya Srivastava[1], Kamal K Upadhyay[2], Nikhlesh K Mishra[3], Nar Singh[4]
[1,2,3,4]Department of Electronics & Communication, University of Allahabad

Abstract
Dense Wavelength Division Multiplexing (DWDM) is one of the hopeful and ultimate solution for proper utilization of bandwidth and increasing capacity. In this paper, we demonstrate a 10x16 GB/s DWDM system with frequency spacing of 50 GHz is done in case of clear weather conditions and turbulence incorporated in the channel for a distance of 15000 km. It was observed that Q-factor increase with increase in transmitted optical power and decreases with increase in increasing turbulence effects in the case of RZ and NRZ modulation format. Analysis of the above performance parameters it can be easily concluded that RZ format is better than NRZ format
Index Terms: DWDM, OWC, BER, Q-Fator.

I. INTRODUCTION

With the development of laser communication, a new method to connect satellite with one another and to ground stations has become popular and wireless medium came into existence[1]. Optical wireless communication (OWC) system is the backbone of our new generation communication system and a great outdistance to the existing technology[2]. The major advantages of using OWC are high data rate and secure and fastest communication. It contributes to its victory over the prevailing technologies. Various experiments have been done to achieve maximum data rate with minimum delay. One of the solution in this is dense wavelength division multiplexing. In this technique, the multiplexing of optical signals at different frequencies with frequency spacing is done which exploit the bandwidth provided by OWC. The multiplexed signals transmitted over OWC channel (OWCC) are received at receiver with the help of de-multiplexer. While passing over OWCC, the laser beam encounter various factors like scattering, atmospheric losses etc. which deteriorates the signal quality[3]. A key attention in satellite communications is the received optical power and a few strategies have been proposed to relieve the transmission related losses[4]. Optical amplification is an engaging hopeful, particularly in earth-to-satellite uplinks. We have proposed a 10x16 Gbps DWDM system with 16 users sending 10Gbps each with channel spacing 50 GHz to satellite. RZ and NRZ formatting is done in this 16 channels are multiplexed at the transmitter side. We compare the various turbulences from weak to strong and analyze the eye diagram and Q-factor for different channels for different transmitted power.

II. SYSTEM DESCRIPTION

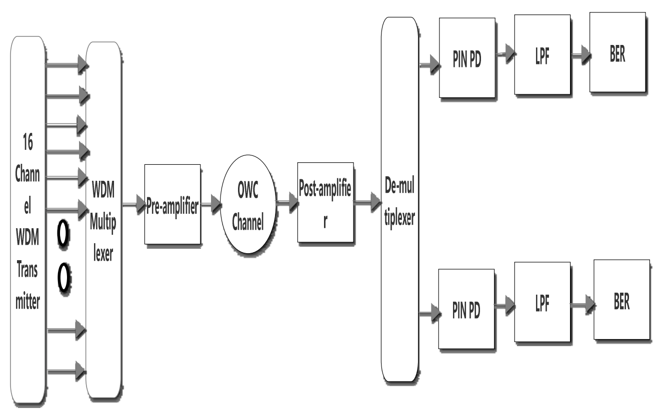


Fig. 1 Block Diagram of DWDM OWCC System

Fig. 1 shows the proposed design of ground to satellite uplink using different parameters. Three main part of DWDM optical communication system are WDM transmitter, OWC and receivers. WDM Transmitter involves the use of Pseudo-Random Bit Sequence (PRBS) generator which creates a PRBS data according to different operation modes. This bit sequence is encoded with different coding/modulation formats. In our case, we are using Return to Zero (RZ) and Non Return to Zero (NRZ) coding which is generated by the engines of RZ and NRZ pulse generator. The laser is modulated either externally or directly where the modulation part takes place and the data is sent to the pre-amplifier to strengthen the power applied to the channel before it is sent to the channel. A typical subsystem of WDM transmitter is shown in fig. 2.

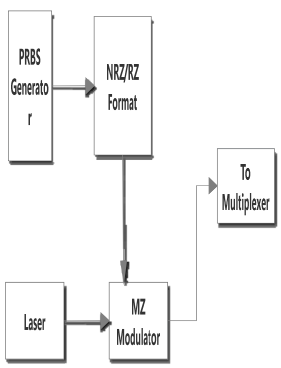


Fig. 2 WDM Transmitter

The OWCC is a subsystem of two telescopes at transmitter and receiver respectively with a wireless channel engraved in between them. Simulation of FSO is done using OWC channel. After passing through the channel, the signal is again applied to the post amplifier before applying to the de-multiplexer. At the receiving section, the de-multiplexed signal is applied to a detector, filter and 3R regenerator. The detector detects the output from OWCC and this optical signal is then converted into an electrical signal on the basis of responsivity of photo diode (PD). After filtering is done with low pass Bessel filter (LPBF), regeneration of electrical signal is done using 3R regenerator. After that BER tester is used to analyse the performance of the system.

An earth-to-satellite uplink is considered where an optical signal is coded and then modulated to carry the information via OWCC. For this, the signals from various users are multiplexed and then transmitted. The transmitted optical data is attenuated by turbulence existing in the atmosphere and is received at the receiver in correspondence to equation 1 [5].

$$R = T\eta GL\left(\frac{\lambda}{4\pi X}\right)^2 \quad (1)$$

Where R is received optical power after passing through the OWC channel and the input of the photodiode (PD), T is the transmitted laser beam which has constrained values, η is product of efficiencies of transmitter and receiver. G is product of transmitter gain and receiver gain of telescopes, λ is the wavelength used and X is the distance of propagation.

Table 1 Parameter Used in this Set-Up

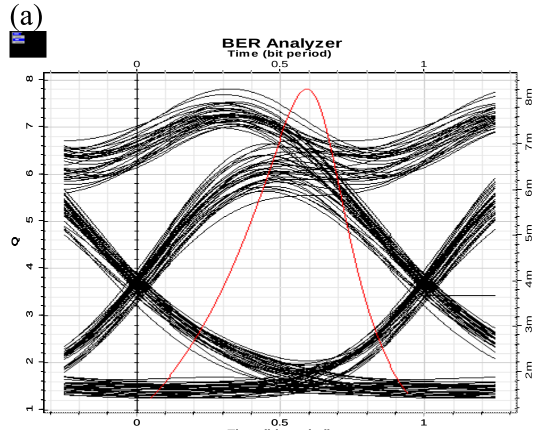
S.No.	Parameter	Values
1.	No. of Output Ports	16
2.	Frequency	1550nm
3.	Frequency Spacing	50GHz
4.	Power	0-40dBm
5.	Extinction Ratio	10dB
6.	Range	15000Km
7.	Transmitter Aperture Diameter	5cm
8.	Receiver Aperture Diameter	30cm
9.	Index Refraction Structure	10e-17 to 10e-13

III. RESULT AND DISCUSSION

The different modulation format have been compared for 16x10Gbps DWDM system in term of BER, Quality factor. To analyze the system with the help of eye diagram at different weather condition.

For RZ modulation format, eye diagram and Q factor are shown in fig. 3, 4, 5 for clean weather, moderate turbulence and strong turbulence at different input power.

(a)



(b)

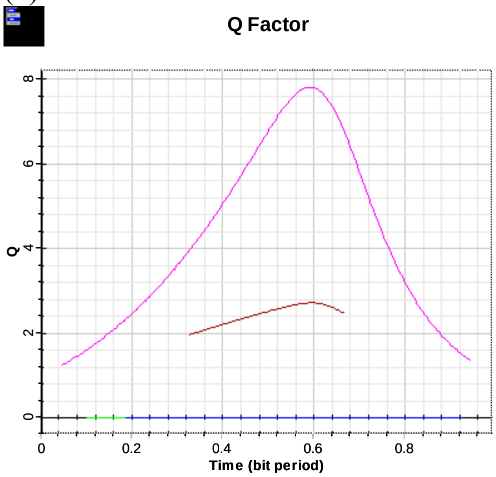
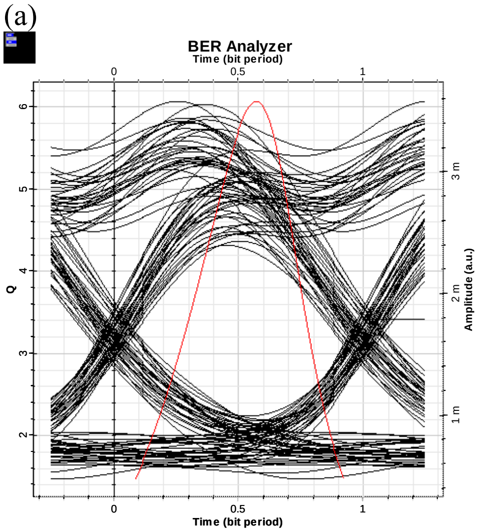


Fig. 3 (a) Eye Diagram and (b) Q Factor at different input power for clean weather

(a)



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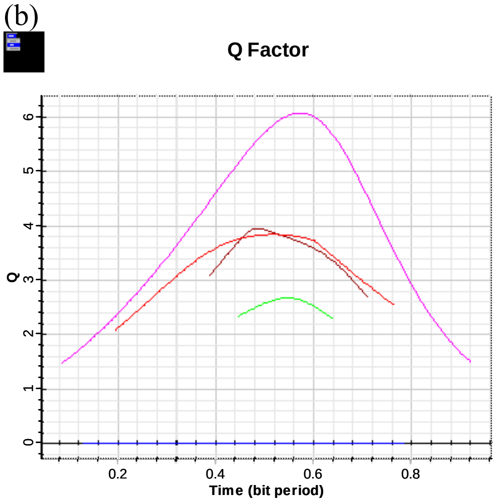
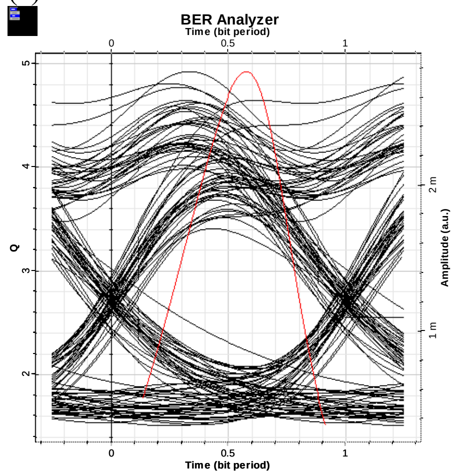


Fig. 4 (a) Eye Diagram and (b) Q Factor at different input power for Moderate Turbulance

(a)



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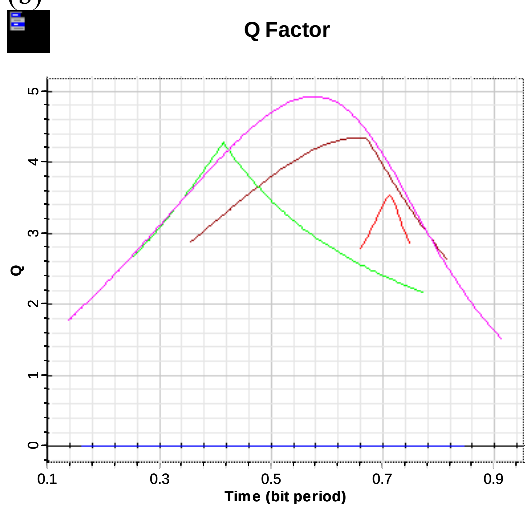


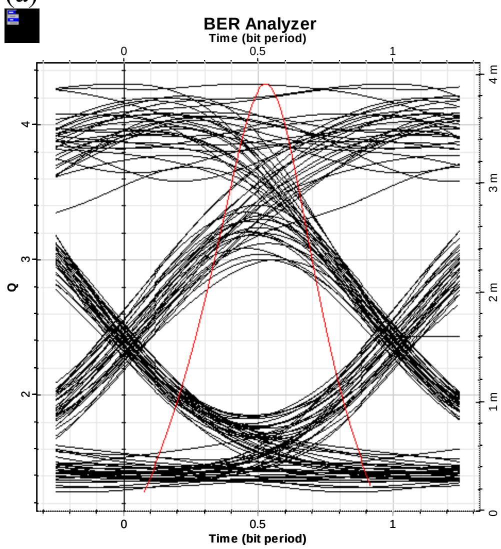
Fig. 5 (a) Eye Diagram and (b) Q Factor at different input power for Strong Turbulance

BER for clean weather is around 10e-15 and Q-factor increase with increase in input power. Adding the turbulence value from weak to strong changes Q-factor is decreases as shown in fig. 3(b), 4(b) and 5(b).

Eye diagram for Strong turbulence is shown in fig. 5(a). The strong turbulence is 10e-13 which is ground based refraction index parameter shows a decrease in quality factor.

For NRZ modulation format, eye diagram and Q factor are shown in fig. 6, 7, 8 for clean weather, moderate turbulence and strong turbulence at different input power.

(a)



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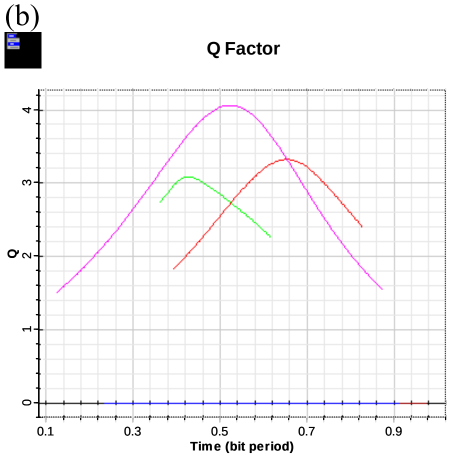
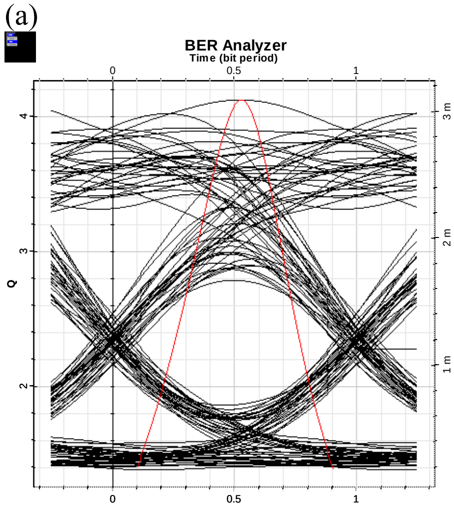


Fig. 6 (a) Eye Diagram and (b) Q Factor at different input power for clean weather

(a)



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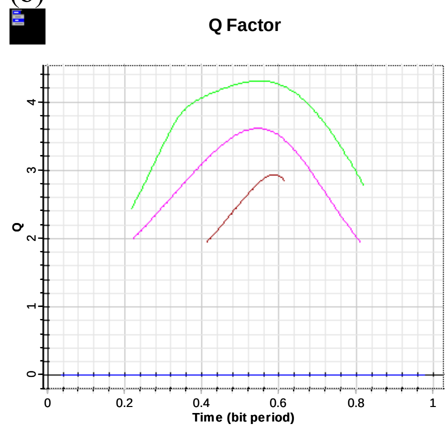
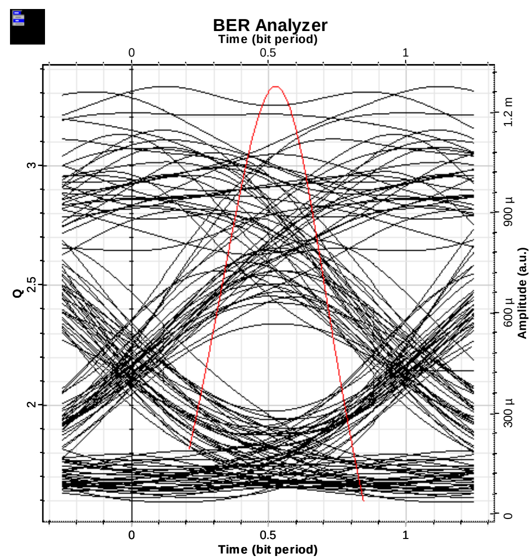


Fig. 7 (a) Eye Diagram and (b) Q Factor at different input power for Moderate Turbulance

(a)



(b)

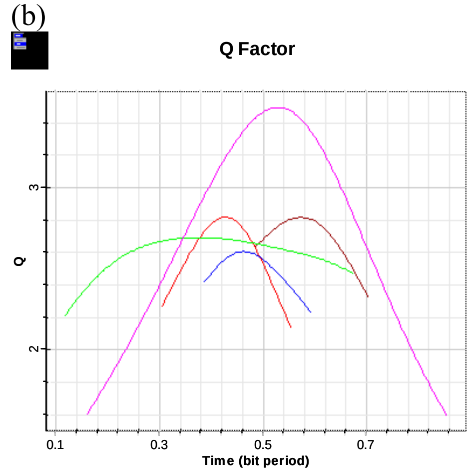


Fig. 8 (a) Eye Diagram and (b) Q Factor at different input power for Strong Turbulance

BER for clean weather is around 10e-9 and Q-factor increase with increase in input power. Adding the turbulence value from weak to strong changes Q-factor is decreases as shown in fig. 6(b), 7(b) and 8(b).

If we increase the input power, BER is minimized in both the modulation format i.e. NRZ and RZ but RZ gives better result as compare to NRZ. On increasing the power of the input signal, Q factor increases proportionally in NRZ and RZ both the format, but the value of Q factor is more in case of RZ modulation format[9]

IV. CONCLUSION

The usage of Internet has shown a steep rise in multimedia users who demand high data rates. OWC has emerged as a rescue to its problem by providing huge data rates at a high security level. The biggest challenge in this approach is to preserve the beam quality in presence of adverse conditions as well as turbulence. From the model simulation results, it is found that for a standard system error free communication between ground to satellite (15000km) is possible. From NRZ and RZ modulation format, RZ perform better as compare to NRZ hence it is suitable for ground to satellite communication.

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