PERFORMANCE EVALUATION OF 1 TBPS QPSK DWDM SYSTEM OVER ISOWC

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Abstract

Optical wireless communications has been in latest trends of high speed communications. They enable the use of optical wireless channel in applications like inter satellite links and underwater communications etc. In this paper, we communicate an ultra high bit rate i.e. 1 Tbps (10 x 100 Gbps) QPSK WDM System over optical Wireless communication Link. The system is a Line of Sight optical wireless link incorporating Coherent QPSK modulation Scheme for10 channels each at 100 Gbps The performance is evaluated in terms of Q-Factor and Minimum Bit Error Rate which are noticed to be in acceptable standards. The Link is analyzed under various parameters such as Power, Distance etc and maximum achievable distance is noticed to be 50,000 km at power values ranging from 0 dBm to 40 dBm.

Key Words- *WDM, CO-QPSK, OWC*

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1. INTRODUCTION

Over the last two decades, wireless communications have undergone massive alterations and contributing remarkable alternatives for numerous high bandwidth and speed processing applications [1]. The next major step on stair towards these applications is realization of a network of optical wireless satellites. This optical satellite network can help in altering the complete scenario of space architecture as the optical wireless communications went through a huge expansion for its rewards over another competing techniques like RF. Firstly, the cost of deployment in case of optical communication systems decrements upto 10% as compared. Secondly, unlike millimeter-wave systems optical links can cover more distance in kilometers for which coventional systems required repeaters. Finally, an unlicensed spectrum of THz range can be used providing greater bandwidth and no additional inferences [3]. Verifications of command and control over pointing, acquisition ,tracking and telemetry have been made in literature [4]. These links offer higher bandwidth, tiny size, lesser weight, lower transmission power and low cost substitute to at hand microwave satellite systems [5] along with several benefits in weight diminution directly concerning to launch costs and fuel requirements [6].

In past, vast researches have been done and reported in which Inter Satellite Optical Wireless Communication Systems have been modelled [7] and the work includes various parameters that needs to be taken care of while designing optical wireless communication systems [8] such as effects of vibration[8] transmitted power [9], size of aperture of telescope [10]. Very high bit rate for OWC link have been achieved by B. Patnaik et al in [11] and A Penchala Bindushree in [12] by selecting Quadrature Phase shift Keying (QPSK) as an optimum modulation scheme and maximum achievable distance is reported up to approximately 40,000 km at 5.6 Gbps and 5,000 km at 438 Gbps.

In this paper we present a 10 x 100 Gbps QPSK modulated WDM system over Optical wireless communication Link and the system is analyzed for different Powers at different distances and aperture diameters of telescope measuring the performance in terms of Quality Factor and Bit Error Rate. The reported simulation is performed in Optiwave Optisystem Software which is a design suite for Optical Communication system design and analysis.

2. SIMULATION SETUP

The simulation setup of 10 channel QPSK WDM system over OWC link is described below in Figure 1. The bit rate at each channel is 100 Gbps and system architecture is made by utilizing wavelength division multiplexing which is a promising technology in optical systems for capacity enhancement. The system comprises of three basic entities of a communication system i.e. Transmitter, Communication medium or channel and Receiver. These three have been discussed in detail in subsections.

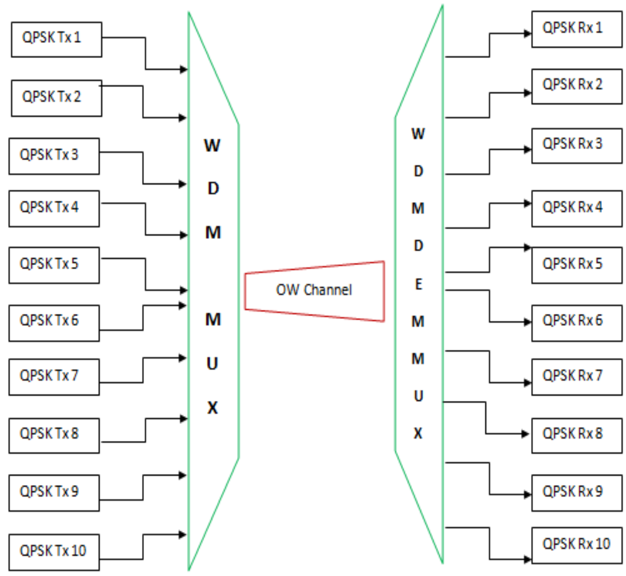

Figure 1- Block diagram of 10*100 Gbps QPSK WDM system over OW channel

2.1 Transmitter

The transmitter is a Coherent QPSK transmitter which generates the QPSK signal by using two Mach Zehnder modulators to encode QPSK symbols onto an optical carrier [12]. Each modulator modulates the in-phase (I) and Quadrature component (Q) of a carrier [11]. Number of bits per symbol is 2. The PSK Sequence generator, which generates the in-phase (I) and quadrature signals (Q) as given in (1) and (2), respectively [11]. The output of the PSK sequence generator is given to the M-array pulse generator, where M ¼ 4. Using a coupler the optical signal is fed to the Mach–Zehnder (MZ) modulator and at the end both I and Q signals is combined using an optical power combiner as shown in Figure 2. The I and Q signals are given

Ii = cos(fi) (1)
Qi= cos(fi) (2)

Where wi ¼ 2p(i 2 1)/M, i ¼ 1, 2, 3, 4 and M ¼ 4 [11]
The two symmetrical arms in transmitter each consists of a Li-Nb Mach Zehnder dual arm modulator which is fed with electrical inputs after gain and biasing of an M-ary Pulse which gets its feed from a PSK Sequence generator. One of the modulated arms' phase is shifted and are collectively fed into a coupler which at output port provides Optical QPSK Signal.

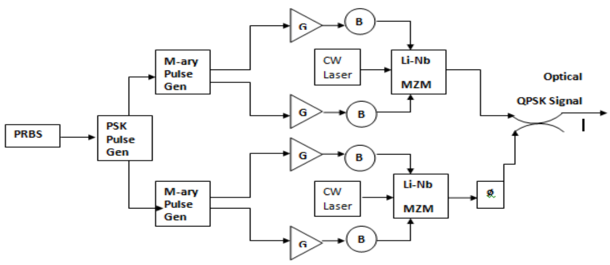

Figure 2- Coherent optical QPSK Transmitter

2.2 Optical Wireless Channel

The optical wireless channel characterized by following mathematical equation. The optical power at reception is given by

$$P_R = P_T \eta_T \eta_R \left(\frac{\lambda}{4\pi \cdot Z}\right) G_T G_R L_T L_R$$

Where P_T is optical power transmitted by transmitter; η_R and η_T are the optics efficiency of the receiver and transmitter respectively; λ is the transmitted wavelength; Z is the distance of optical wireless link; G_T is the telescope gain of transmitter; G_R is the receiver telescope gain; and L_T, L_R are the pointing loss factor of transmitter and the receiver, respectively.

2.3 Coherent QPSK Receiver

The coherent QPSK receiver consists of a photodetector which performs the optical to electrical conversion after which adequate DSP operations on signal as shown in figure are to be performed. The DSP for QPSK Block is shown in figure and it explains how signal processing operations such as DC blocking, Filtering, Resampling, time recovery, Adaptive equalizing etc are performed at signal. After this signal is fed into decision component which processes the I and Q signals from DSP block. The thresholds are now decided and I and Q signals are put into PSK Sequence decoder at which we visualize the output signal using BER test set in terms of Q factor and Bit error Rate.

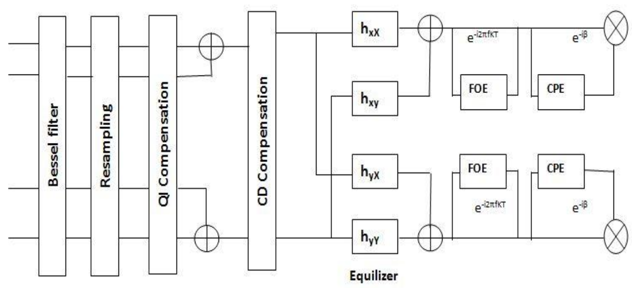

Figure 3- DSP in Receiver for QPSK [13]

3. RESULTS AND DISCUSSION

The system is simulated at1 Tbps (10 channels with 100 Gbps at each channel). The output is visualized by using BER Test Set in terms of Quality factor of received signal and bit error rate and is found to be in acceptable limits.
Table 1 shows the Q factor and minimum BER obtained at distance varying from 10,000 km to 50,000 km.

Table 1- Q-factor and Min BER at varied range of OW channel

Distance in Km	Q-factor	BER
10,000	8.12	0.432e-15
20,000	7.94	1.83e-15
30,000	7.60	28e-15
40,000	7.27	0.33e-12
50,000	6.87	6.11e-12

Figure 4 shows graph of Distance vs. Q-factor from which it can be concluded that Q factor goes on decreasing as we move forward in terms of distance.

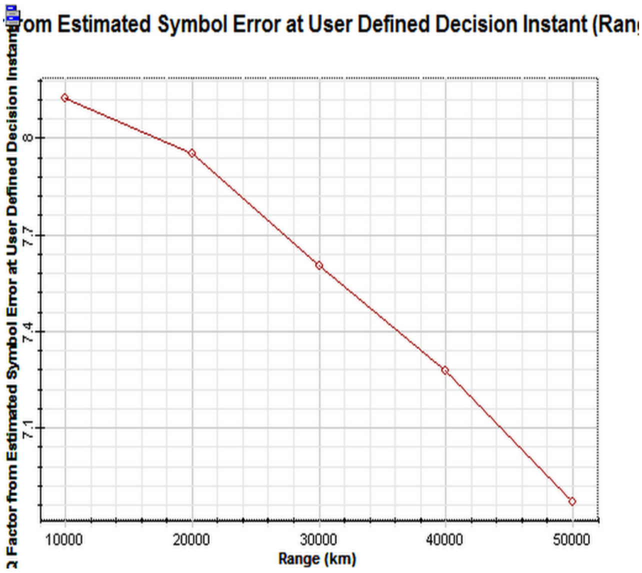

Figure 4- Graph showing Distance vs. Q Factor Trends

Figure 5 shows graph of Distance vs. log BER and shows that error rate increases as the range of optical wireless channel is increased.

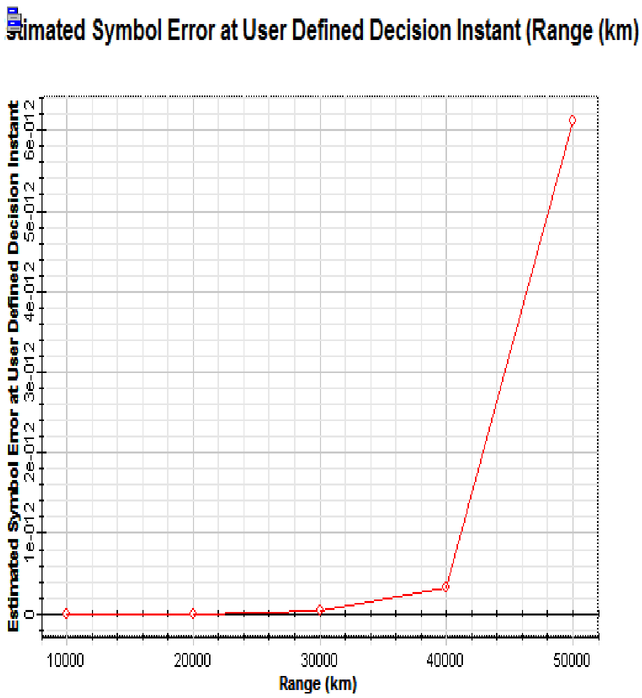

Figure5- Graph showing Range vs. BER

The Constellation diagrams of received signals at various distances are shown in Figure 6 and 7 and it becomes clear from visualization geometry that constellation gets distorted which shows the addition of noise with distance.

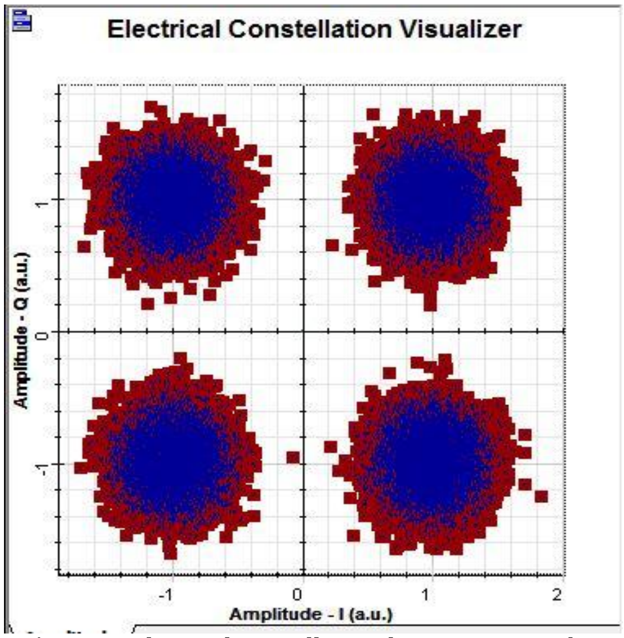

Figure 6- Electrical constellation diagram at 10000km

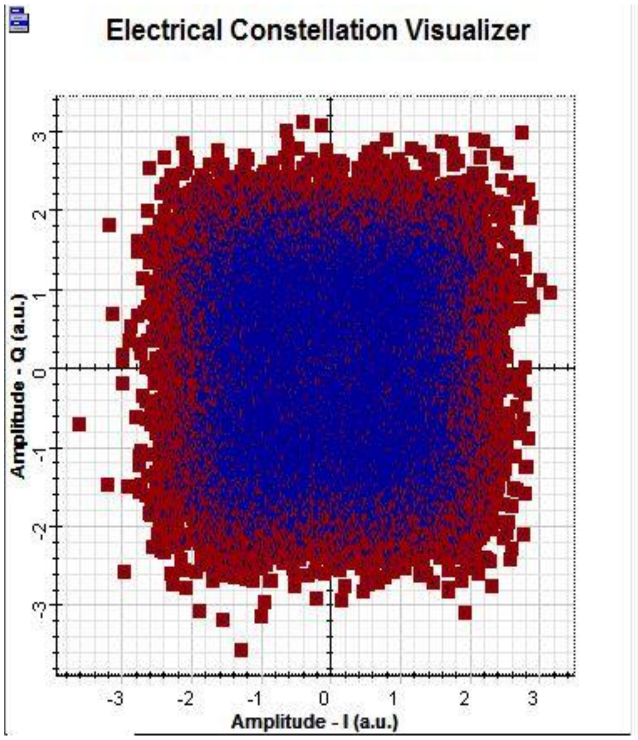

Figure 7- Electrical constellation Diagram at 50,000 km

The Constellation diagrams of received signals at minimum and max power iterations are shown in figure are shown in Figure 8 and 9 and it can be derived that the signal improves as the transmitted Power of system is increased but in case of power it is the non-linear effects and other issues like inter channel crosstalk that are to be taken into account while designing high power systems.

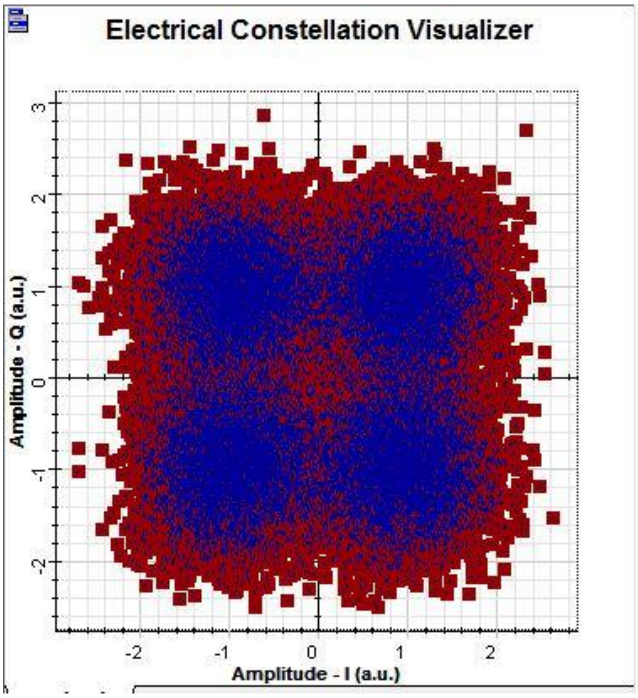

Figure 8- Electrical constellation diagram at 0dBm Power

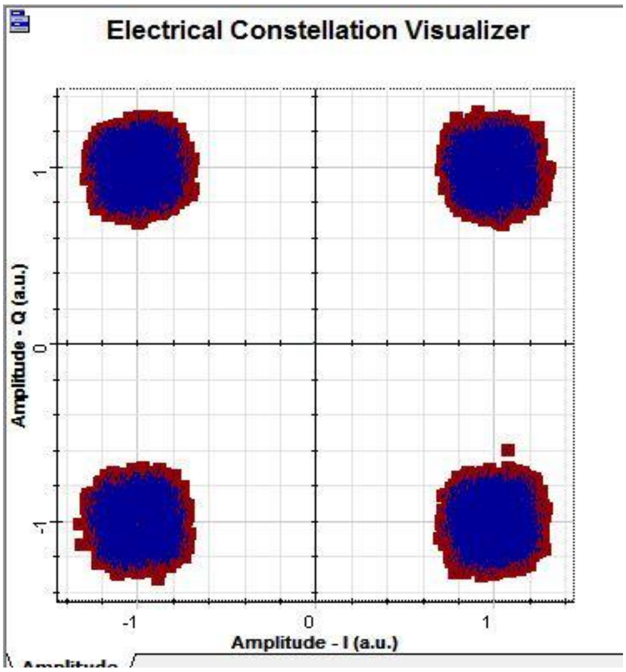

Figure 7- Electrical constellation Diagram at 40 dBm Power

Similarly Figure 10 and 11 shows the Input Power vs. Q-factor and BER respectively and it can be seen that Q-factor increases and Bit Error rate decreases as the transmitted power is increased. Power is varied from 0dBm to 40 dBm

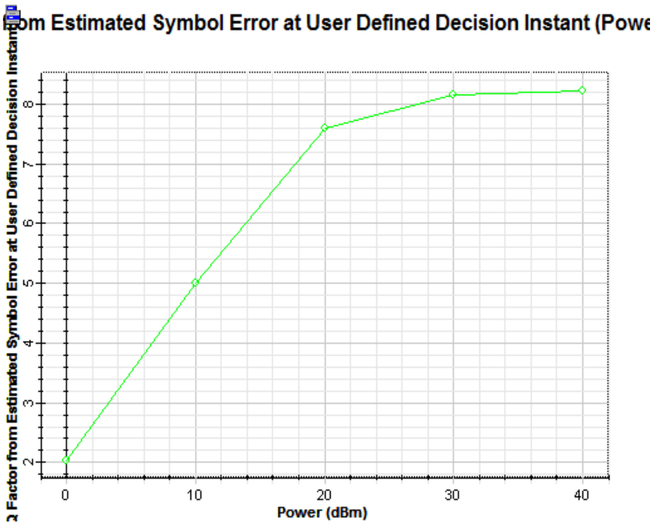

Figure 10- Trends in Q –Factor when power is varied from 0 to 40 dBm

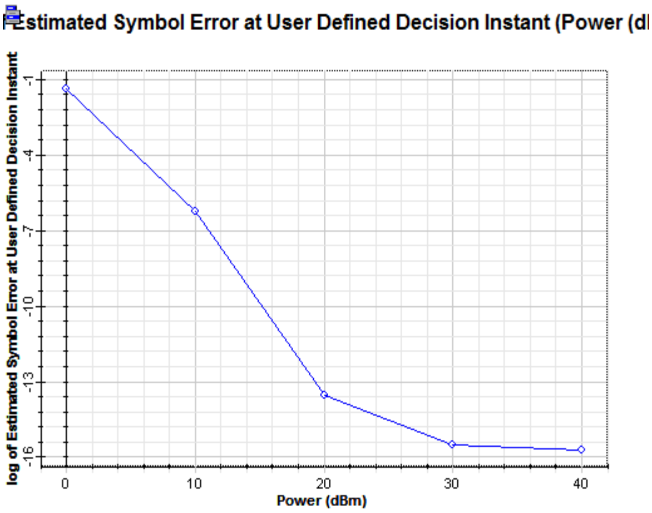

Figure 11- Plot of Power vs. log BER

CONCLUSION

From the reported work on CO-QPSK-WDM-OWC system on 1 Tbps the findings on Q-Factor and BER are under acceptable limits and system is found to travel up to 50,000 Km at 100 Gbps data rate on each channel. The power of system is varied from 0 dBm to 40 dBm and an ascending trend in Q factor has been observed. Similarly the Distance is iterated for various values and respective electrical constellations have been seen proving that noise distorts the signal as the link distance is increased up to 50000 km.

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