High Speed and Long Reach DPSK-OFDM-Is-OWC under Impact of Space Turbulences

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ABSTRACT
Inter-satellite communication is a free-space optical technology which is used to establish communication between satellites in space. This work is focused on the transmission of 10 Gbps data over 10,000 km inter-satellite communication link by incorporating orthogonal frequency division multiplexing scheme. The performance of proposed system is evaluated in terms of signal-to-noise ratio, total received power, radio-frequency spectrum and constellation diagrams.

Keywords
Inter-satellite communication (Is-OWC), Orthogonal frequency division multiplexing (OFDM), Differential phase shift key (DPSK).

1. INTRODUCTION
In early 1960's, Laser technology was gaining its popularity in the field of optical communication and finding its applications for communication between satellite and earth station as well as submarines[1]. Numerous advantages of laser such as higher band width, minimal power requirements, marginal electro-magnetic interference (EMI) encouraged it's application in radio frequency (RF) technology [2, 3]. Laser being coherent finds its application in free space communication known as Optical Wireless Communication (OWC) and further was used for communication between satellites more commonly known as Inter Satellite Optical Wireless Communication (Is-OWC). In Is-OWC, the information signal is modulated over laser light and transmitted to other orbiting satellites using Free Space Optics. These satellites may be orbiting in the same or in different orbit. At receiving satellites, received signal are demodulated using photodiodes and thus original signal is recovered [4-7]. In OWC, Orthogonal Frequency Division Multiplexing (OFDM) technology has played an vital role for it capacity in reducing multipath fading effects [8-16]. OFDM uses subcarriers which are separated by specific frequencies of overlapping band for data transportation. Further for orthogonal sequence, these subcarriers utilize Fast Fourier Transformation (FFT) [17, 18]. Thus OFDM is used for high data transmission and lower fading impacts [19-21]. Though the vacuum is assumed to be perfect, path loss which increases as square f the distance is huge. Further Is-OWC links are sensitive for pointing errors which may arise due to misalignment, vibrations or tracking errors [22-35][2-12]. In our work OFDM-DPSK-Is-OWC system is designed to transmit 10 Gbps data over a distance of 10,000 Km under the impact of turbulence. The rest of the paper is divided as follows: Section 2 explains the system description; Section 3 presents the results and discussion followed by Section 4 which provides the conclusion.

2. SYSTEM DESCRIPTION
The performance of proposed DPSK-OFDM-Is-OWC link is evaluated under the impact of space turbulences in OptiSystem software. Figure 1 shows the schematic diagram of proposed system under the impact of space turbulences. The space turbulences are considered as transmitting pointing errors and receiving pointing errors. The simulation is carried out from 1 µrad to 5 µrad transmitting pointing error and 1 µrad to 5 µrad receiving pointing error.

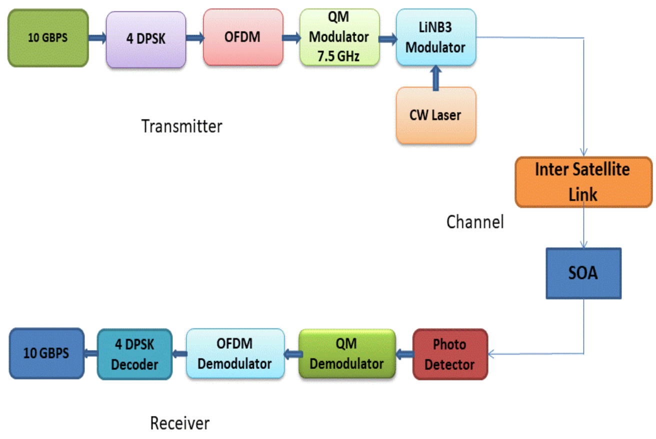


Fig 1: DPSK-OFDM-Inter-Satellite Communication System under Space Turbulences

3. RESULTS AND DISCUSSION
In this section, results obtained from the simulation of proposed 10 Gbps DPSK-OFDM-Is-OWC system over 10000 km Is-OWC link under the impact of transmitting pointing errors and receiving pointing errors are presented and discussed. Figure 2 shows the measured SNR for proposed system with -4 dBm power and 0 dBm power under the impact of transmitting pointing errors. The value of SNR for system with -4 dB input power is noted as 31.83 dB, 14.21 dB and 0 at transmitting pointing error of 1 µrad, 3 µrad and 5 µrad whereas for the system with 10 dB input power it is noted as 38.91 dB, 35.69 dB and 0 at transmitting pointing error of 1 µrad, 3 µrad and 5 µrad. This shows that improvement of 8 dB in SNR is noticed when input power is increased from -4 dBm to 10 dBm. Similarly Figure 3 shows measured total received power under the impact of transmitting pointing error.

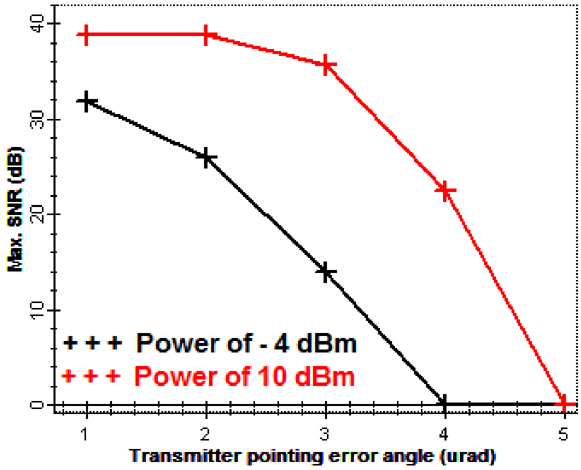


Fig 2: Measured SNR under the impact of transmitting pointing error

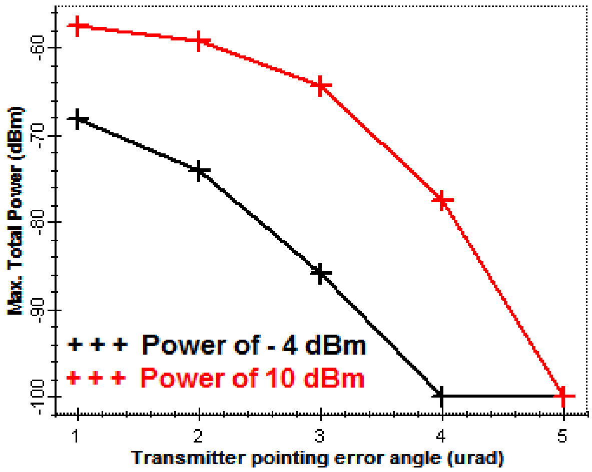
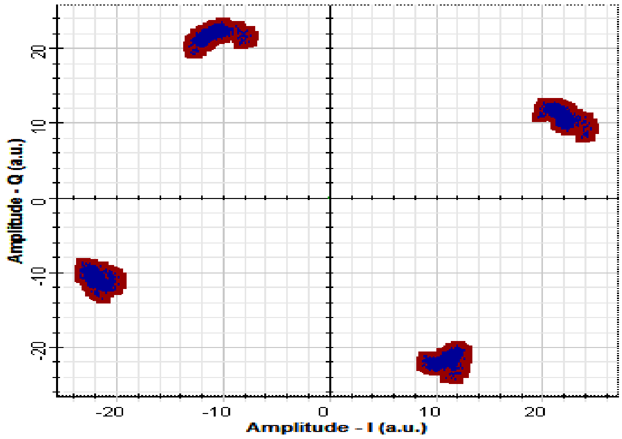


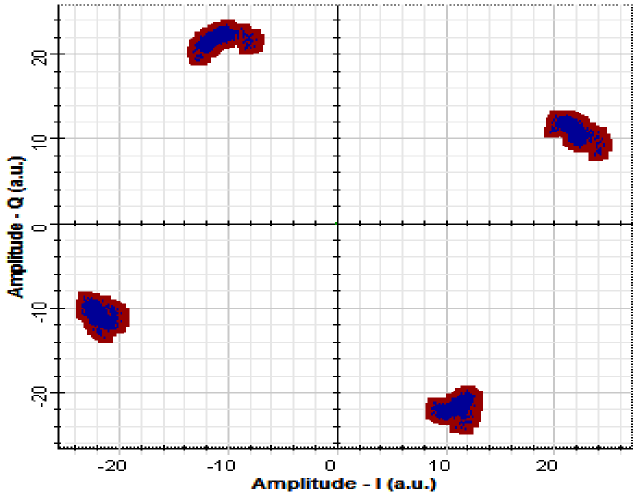
Fig 3: Measured Total received power under the impact of space turbulences

The value of total received power for system with -4 dB input power is noted as -68.11 dBm, -84.98 dBm and -100 dBm at transmitting pointing error of 1 µrad, 3 µrad and 5 µrad whereas for the system with 10 dB input power it is noted as -57.11 dBm, -64.32 dBm and -100 dBm at transmitting pointing error of 1 µrad, 3 µrad and 5 µrad. This shows that improvement of -10 dBm in total received power is noticed when input power is increased from -4 dBm to 10 dBm.

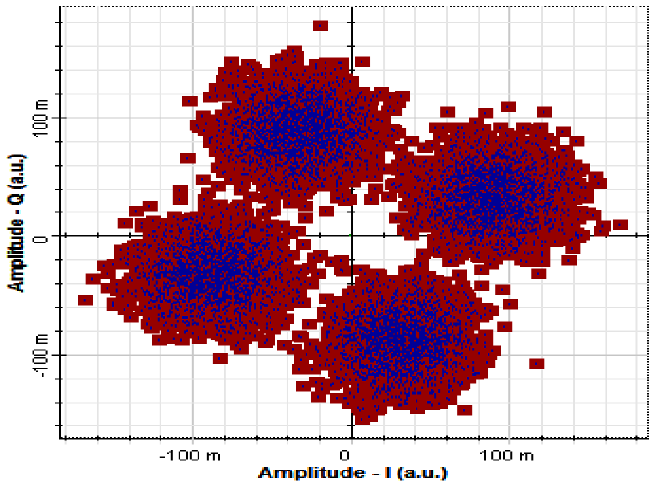
Figure 4 and 5 shows the measured constellations and RF spectrums under the impact of transmitting pointing error with input power of 10 dBm. The clear constellations and RF spectrum shows the successful transmission of data over 10000 km Is-OWC link under impact of 4 µrad transmitting pointing error. Beyond that value, the proposed system shut downs.



(a)

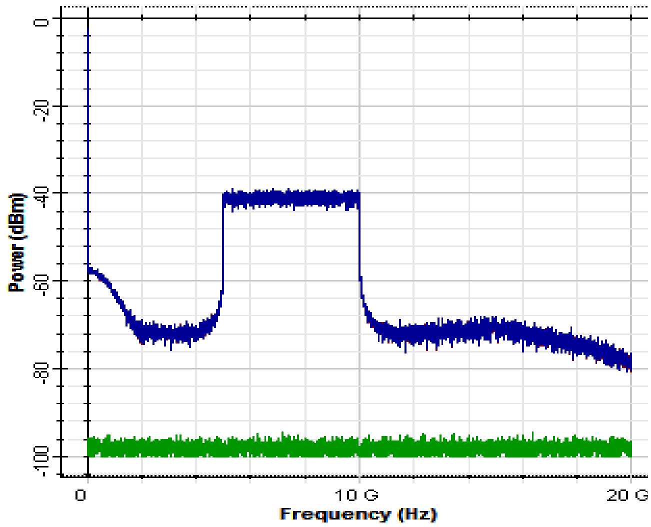


(b)

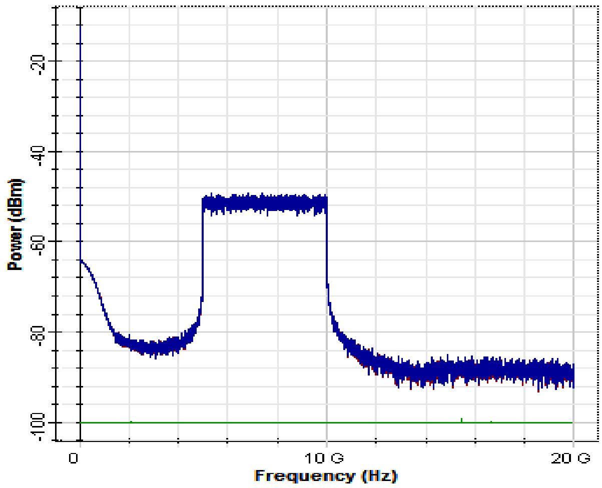


(c)

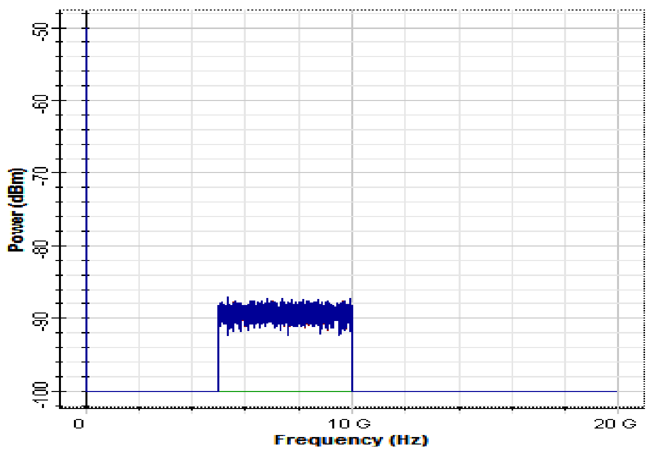
Fig 4: Measured Constellations under impact of transmitting pointing error (a) At 1 µrad (b) At 3 µrad (c) At 4 µrad



(a)



(b)



(c)

Fig 5: Measured RF Spectrums under impact of transmitting pointing error (a) At 1 µrad (b) At 3 µrad (c) At 4 µrad

4. CONCLUSION

In this work, 10 Gbps data is transmitted over Is-OWC link having a span of 10,000 km by incorporating DPSK scheme followed by the OFDM technique. The reported result shows the successful transmission of 10 Gbps data over 10000 km Is-OWC link with acceptable SNR and constellations under the impact of transmitting pointing errors.

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