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To Design High Speed and Long Reach Inter-Satellite Communication System by Incorporating Orthogonal Frequency Division Multiplexing Scheme

Mahavir Singh Chauhan[1], Amit Kapoor[2], Prof. (Dr.) Vinay Bhatia[3]
Post Graduate Student, Dept. of ECE, Baddi University of Emerging Sciences and Technology, Baddi, HP, India[1]
Assistant Professor, Dept. of ECE, Baddi University of Emerging Sciences and Technology, Baddi, HP, India[2]
Professor, Dept. of ECE, Baddi University of Emerging Sciences and Technology, Baddi, HP, India[3]

***Abstract*—Free space optics technology provides a promising answer for future broadband networks, providing high data transmission compared to RF technology. In this paper we have investigated the performance of an Inter-Satellite Optical Wireless Communication (ISOWC) system with Orthogonal Frequency Division Multiplexing (OFDM) using Quadrature modulation. The high capacity 10 Gbps data traffic is successfully transmitted using a 4-level Quadrature Amplitude modulated sequence through the ISOWC system without space turbulence's. We have observed that by using semiconductor optical amplifier, 10 GBPS data stream has been successfully transmitted to 15000 km with an acceptable SNR**

***Index Terms*— Free space optics, Inter-Satellite Optical Wireless Communication, Orthogonal Frequency Division Multiplexing, Quadrature Amplitude Modulation**

I. Introduction

Inter-satellite optical wireless communication (ISOWC) is one of the essential applications of FSO. It involves line of sight and point to point laser links from transmitter to receiver through the space. ISOWC is capable to provide communication between two satellite weather satellites is in same circle or may be in different circle. ISOWC came into existence because it provides higher bandwidth and lower losses as compared to RF and microwave frequencies [1] [2]. It has ability to send high speed data to longer distances by using small size payload due to which mass and cost of satellite also reduces. Our proposed system includes transmitter section propagation section and receiver section. Transmitter and receiver section are kept on two satellites and optical wireless communication is used as a propagation medium. ISOWC transmitter receives data from telemetry tracking and communication system by using OFDM with ISOWC [3] [5].

We can improve the channel capacity, transmission rate and complexity in digital signal processing. We used integration of semiconductor optical amplifier (SOA) with OFDM scheme in ISOWC to increase the transmission 15000 km by using OptiSystem simulator. In our research we have taken data rate of 10 Gbps without space turbulences and optimize the ISL in between two satellites on simulation software. To attain the highest receiving power, antenna of transmitter and receiver section should be properly aligned [6].

In literature survey various works on the performance of ISOWC with various modulation format has been reported. Navjot Kaur et al. [7] represented performance analysis of ISOWC by using NRZ and RZ modulation formats and covered the distance of 1700km at the data rate of 3Gbps. Chaudhary et al. [3] investigated realization of FSO by using OFDM and QAM modulation formats and by integrating a SOA achieved distance is 185 km at the data rate of 10Gbps without atmospheric turbulence with atmospheric turbulences distance extended up to 2.5km. Till now we have observed that proposed ISOWC system was investigated under lesser transmission distance by using NRZ and RZ modulation formats. So we have designed a system that is ISOWC by using OFDM and 4QAM modulation scheme and by adding SOA to achieve a better transmission distance.

In our analysis 10 Gbps data is generated by PRBS generator and with 4-QAM proper encoding sequence i.e. 2 bit/symbol. This 10 Gbps QAM data signals then passed to OFDM modulator which is using 512 subcarriers and FFT size is kept to 1024. OFDM Modulator will generate analog data signals which further passed to QAM modulator of 7.5 GHz, whose output is 10 Gbps analog data signals which is carried by light carrier generated by CW laser its power is kept -4dbm and operating at 850 nm. In our proposed model space loss is considered 2dB/km and optical modulator data is transmitted through an optical wireless communication. The rest of the paper is organized into following sections: Section II describes the simulation setup for OFDM–SOA system and Section III describes the simulation results and discussion. The paper is concluded in Section IV.

II. Simulation Setup

Inter-Satellite Optical Wireless Communication System contains three main communication blocks that is transmitter section propagation section and receiver section. The simulation setup of ISOWC system with Orthogonal Frequency Division Multiplexing and Quadrature Amplitude Modulation is shown in figure 1. Transmitter section contains transmitter circuitry which is kept on one satellite similarly a receiver circuitry is kept on another satellite. In between two satellites channel is considered as an optical wireless communication channel.

In our analysis OFDM-ISOWC transmitter section contains PRBS generator which will generate10GBPS data for generation of proper encoding sequences this 10 Gbps data is passed through 4 QAM sequence generator which will generate 2 bit/symbol sequences.

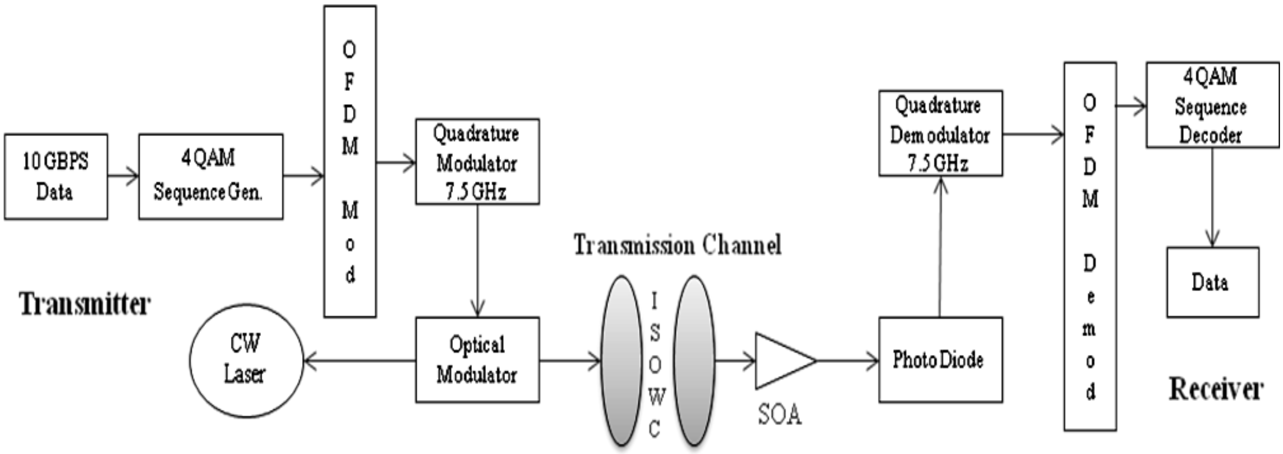

Fig. 1.Simulation Setup of Inter-Satellite Optical Wireless Communication System

OFDM modulator which is using 512 subcarrier and 1024 FFT and 32 cyclic prefix code will provide OFDM analog data signal of 10 Gbps which is further passed through a Quadrature modulator of 7.5 GHz and provide QAM-OFDM analog data signal of 10 Gbps. This data is modulated using a light carrier which is generated by CW laser having a wavelength of 198.1THz and power kept at -4dBm, with the help of optical modulator this modulated output signal of optical modulator is transmitted through a optical wireless communication channel. The ISOWC channel contains SOA which is used for post amplification. On receiving side OFDM signal is detected with the help of photo detector (PIN diode) it will convert light signal back to the electrical signal and passed to QM demodulator followed by OFDM demodulator and QAM sequence decoder in order to get 10Gbps data back. The RF spectrum is shown in figure 2 (a) & figure 2 (b), it is observed that the RF power decreases as the distance increases and the ISOWC link cannot prolong to 15000 km.

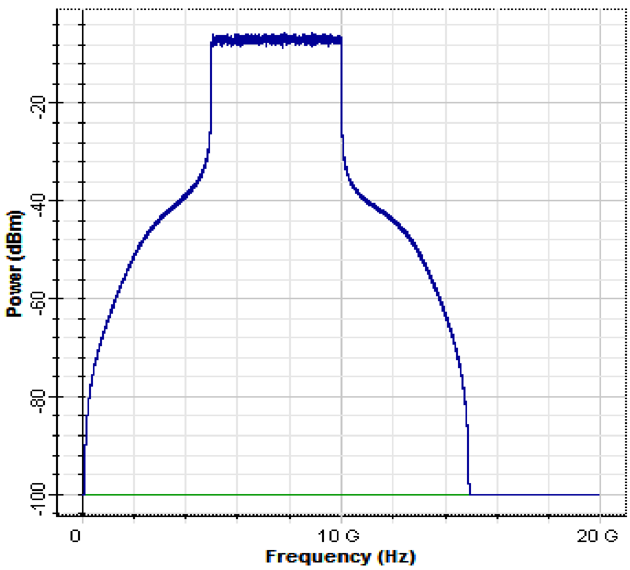

Fig. 2 (a) RF Spectrum at Transmitter Side

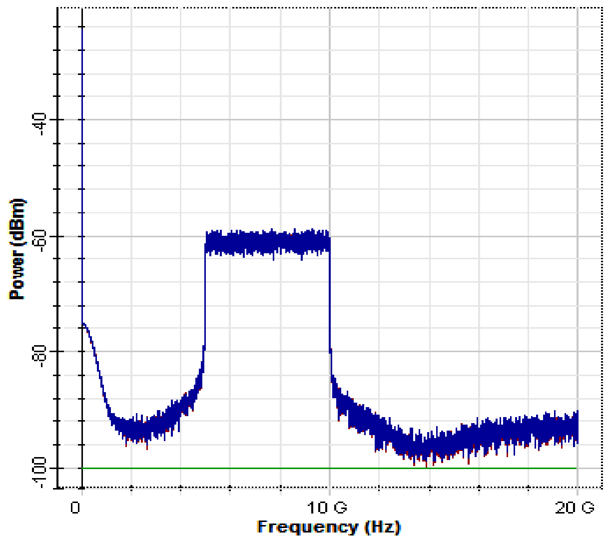

Fig. 2 (b) RF Spectrum at 15000 Km Transmission Distance

III. Simulation Results and Discussion

As per results we have obtained that SNR and received power is inversely proportional to distance. If we increase the distance then SNR and received power will be decreased. The different observed value of SNR and total Power at different ranges for ISOWC transmission link is reported in table 1.

Table 1: SNR and Total Power at different ranges for ISOWC Transmission link

Range (KM)	850 nm SNR (dB)	1550 nm SNR (dB)	850 nm Total Power (dBm)	1550 nm Total Power (dBm)
5000	37.41	31.50	-62.00	-68.46
7500	33.69	26.29	-66.29	-73.70
10000	30.42	22.08	-69.58	-77.91
12500	27.53	18.60	-72.46	-81.38
15000	24.98	15.66	-75.01	-84.32

In our results we have represented SNR and received power operating at 850nm and 1550nm bandwidth without space turbulences. As per analysis it has been observed that transmission on 850nm give better improvement of 9.32dB as compare to transmission on 1550nm after 15000km. The total received power after 15000 km is measured as −75.01 dBm and −84.32 dBm for 850nm and 1550 respectively. The constellation diagrams of the proposed OFDM–ISOWC system after 15000 km are shown in figure 3(a) and 3(b). It is reported that the signal strength decreases as the distance increases.

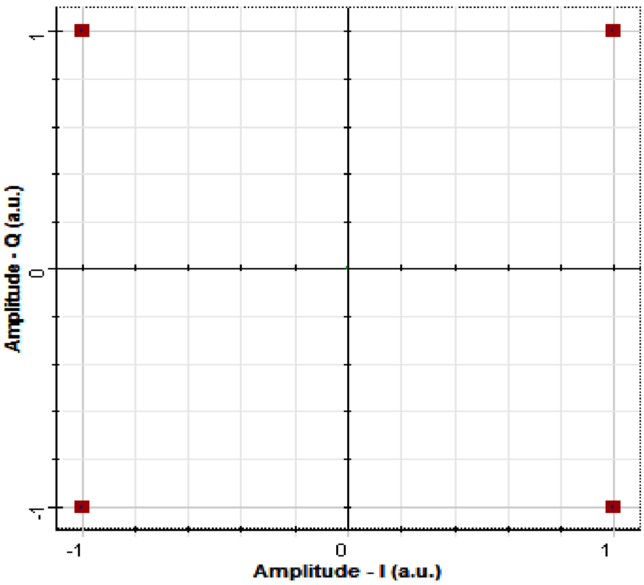

Fig. 3(a) Constellation Diagram at Transmitter Side

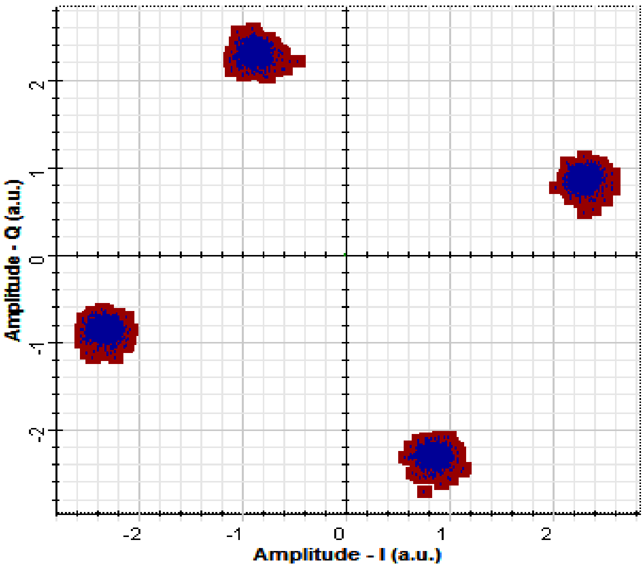

Fig. 3(b) Constellation Diagram after 15000 Km Transmission Distance

To analyze the performance of high speed and long reach Inter-Satellite Communication System by incorporating Orthogonal Frequency Division Multiplexing scheme the graph between maximum signal to noise ratio versus transmission range has been drawn to verify the result at receiver side. The variation in SNR with respect to different transmission range is shown in figure 4(a). We have observed that transmission on 850 nm give better improvement of 9.32dB as compare to transmission on 1550nm after 15000km. The graph between max total power at different transmission distance range is shown in figure 4(b). We have observed that the total received power after 15000 km is measured as −75.01 dBm and −84.32 dBm for 850nm and 1550 respectively.

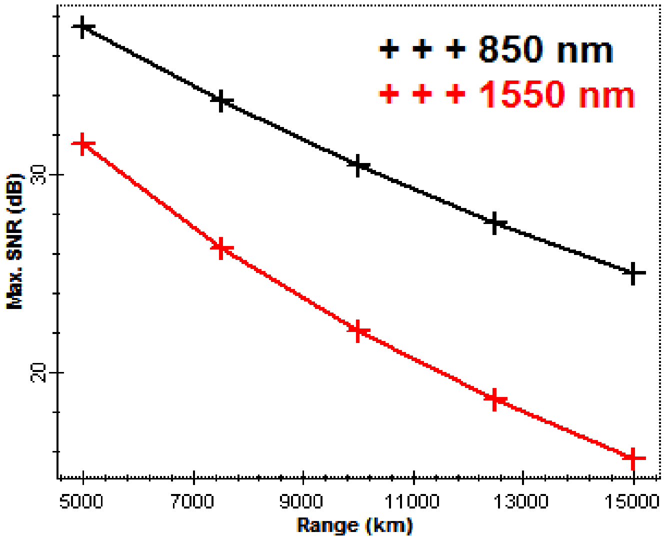

Fig. 4(a) Graph between Max SNR and Transmission Range

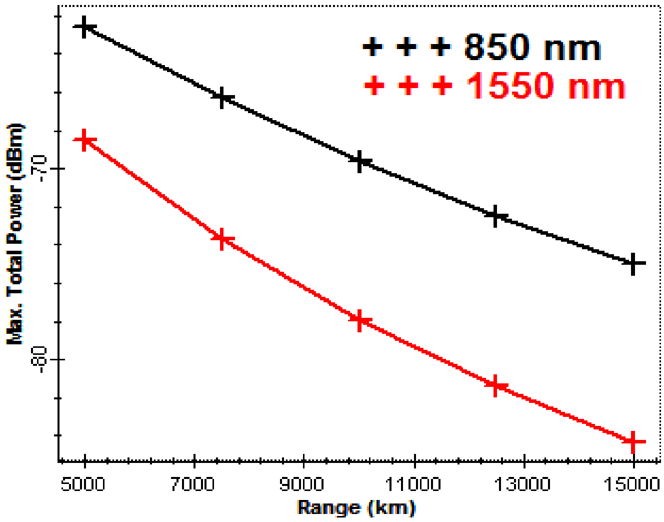

Fig. 4(b) Graph between Max Total Power and Transmission Range

IV. Conclusion

From our results it is obtained that smooth transmission of 10Gbps data can be carried out with our designed system that is ISOWC by using OFDM scheme, a technique which used integration of semiconductor optical amplifier (SOA) to increase the transmission distance. We observed that high capacity 10 GBPS data transmission between transmitter and receiver at 850nm give better performance improvement of 9.32 dB as compare to transmission on 1550 nm after 15000km. Hence it is concluded that our system can communicate over a transmission distance of 15000 km at 850 nm with an acceptable SNR and received power without taking any kind of space turbulence.

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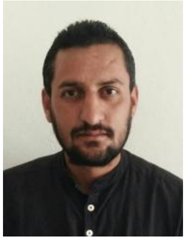

Mr. Mahavir Singh Chauhan is pursuing M. Tech. from Baddi University of Emerging Science and Technology, Baddi, HP, India. He has received Diploma and B.Tech. Degree from Himachal Pradesh Takniki Shiksha Board, Dharamshala and Uttarakhand Technical University, Dehradun respectively, India in Electronics and Communication Engineering. Currently he is working as a Trainer in Technical Education, HP, India. His research area is focused on Free Space Optics and Inter-Satellite Optical Wireless Channel.

Mr. Amit Kapoor received the M.Tech. Degree from Punjabi University, Main Campus Patiala in Electronics and Communication Engineering. He has been working as an Assistant Professor at Baddi University of Emerging Science and Technology, Baddi, HP, India since 2014.
His research is focused on Passive Optical Networks, Optical Hybrid Amplifier and Free Space optics. He has published 1 research paper in Elsevier and 8 research papers in International and National journals and conferences.

Prof. (Dr.) Vinay Bhatia is a B.Tech, M.Tech, Ph.D in Electronics and Communication Engineering. Currently he is serving as Professor and Head, Department of Electronics and Communication Engineering at Baddi University of Emerging Sciences and Technology, Himachal Pradesh (INDIA). He has authored about 80 research papers in various national international conferences and journals. Currently he is working on routing and security issues pertaining to wireless networks. His main research interests include mobile and adhoc wireless networks, wireless mesh networks and wireless securities
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