International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 Issue: VI Month of publication: June 2017

DOI:

www.ijraset.com
IC Value: 45.98
Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Performance Analysis of Optical Wireless Inter Satellite Links by Using WDM And Co-OFDM Techniques

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Abstract: This paper reports the performance of co-ofdm based optical wireless inter-satellite link (isowc) integrated with wavelength-division multiplexing (wdm) between two satellites which can be virtually done by using optic system optic wave 14 simulation software. We study the distance link and aperture diameter effect in quality of received signal for system with 4 ofdm signals multiplexed by wdm multiplexer with 4 channel which spaced at 10 ghz and fixed data rate 10 gbps for each ofdm signal and optical coherent detection manner in the receiver by observing the constellation diagram of the signal at receiver side.
Keywords: inter-satellite optical wireless communication (isowc), wavelength-division multiplexing (wdm), coherent optical orthogonal frequency division multiplexing (co-ofdm), constellation diagram.

I. INTRODUCTION

As we know that a high number of satellites are being launched to achieve the user requirements as commercial services and military applications. So the wireless optical inter-satellite links (IsOWC) are playing a very significant role for exchange data between satellites. However, there are several applications of IsOWC as connect satellites in constellations and data relay between intra-orbit satellites or between different orbits (inter-orbit).

To satisfy the huge increasing demand for high capacity and high data rate in the inter-satellite wireless optical communication we should try advanced modulation and multiplexing techniques that can support this demand. So if we want to increase the data rate with better tolerance to Polarization Mode Dispersion (PMD) and the Chromatic Dispersion (CD) system we should use advanced multi-carrier modulation format as CO –OFDM which combines two powerful techniques; OFDM and coherent detection, which delivers high optical and electrical spectral efficiency. Moreover, the cyclic prefix code of the CO-OFDM makes the system more resistant to intercarrier interference (ICI) and inter-symbol interference (ISI).

We can integrate the CO-OFDM with multichannel technology Wavelength Division Multiplex (WDM) to produce a system with higher capacity and higher data rate. WDM is a technique of multiplexing which can obtain a greater capacity, good flexibility with low cost and easily upgrading the system by multiplex multiple signals with different wavelength over a single optical channel by using multiple lasers with different wavelengths to carry different signals.

II. SYSTEM ARCHITECTURE

This paper simulates and analyzes the architecture of WDM -CO-OFDM system over the inter-satellite optical wireless channel by using a commercial wireless optical system simulating tool, optimism 14. The simulation diagram is shown in figure 1, The system design model is for one-way data transmission from one satellite to another. There are several model designs were done to obtain the ideal design for inter-satellite optical wireless communication. In our simulation, We tried to improve the model design by expanding specific subsystems of optical transmitter and receiver. This expanding have done by integrating WDM with CO-OFDM techniques to produce a system with high remarkably data rate, better tolerance to CD and PMD and high spectral efficiency.

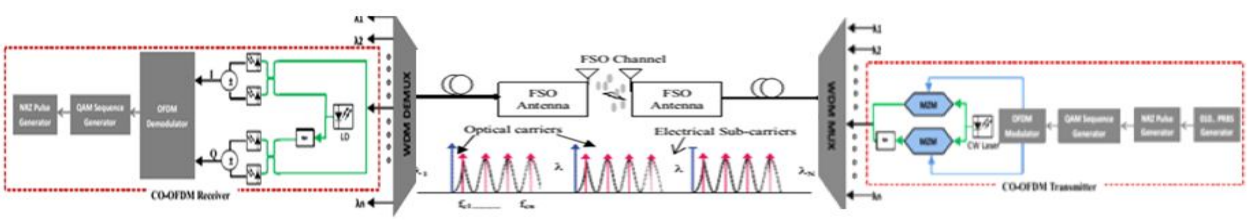

Fig. 1. Conceptual diagram of a WDM - CO-OFDM over IsOWC

Volume 5 Issue VI, June 2017
ISSN: 2321-9653

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Figures 2 and 3 show the design of CO-OFDM WDM transmitter which built with a Pseudo Random Binary Sequence (PRBS) to generate a bit sequence with data rate 10 Gbps which represent the data or information that the satellite wants to be transmitted. This data usually come from satellite's TT&C system. This data from PRBS has encoded by 4 – QAM which encode two bit per symbol. After that, the encoded signal connected to OFDM modulator with a 512 subcarrier and 1024 FFT points to reduce the multipath fading, limited Inter-symbol Interference (ISI), lower complexity of the system and more spectral efficiency (SE) because of removing guard band. The electrical OFDM signal converted to an optical signal by using two Mach-Zehnder Modulators (MZMs) and a power combiner. Simultaneously, 4 optical signals from a different data source are then multiplexed by 4x1 WDM which used 4 WDM channels (193.1, 193.2, 193.3 and 193.4 THZ) with a 10 GHz channel space and to transmit the signal over inter-satellite OWC.

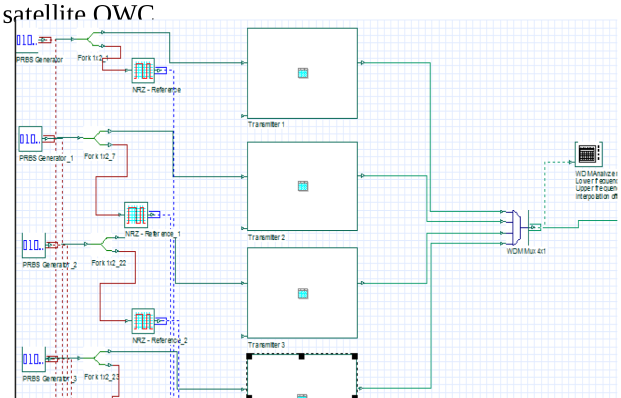

Fig. 2. WDM CO-OFDM transmitter.

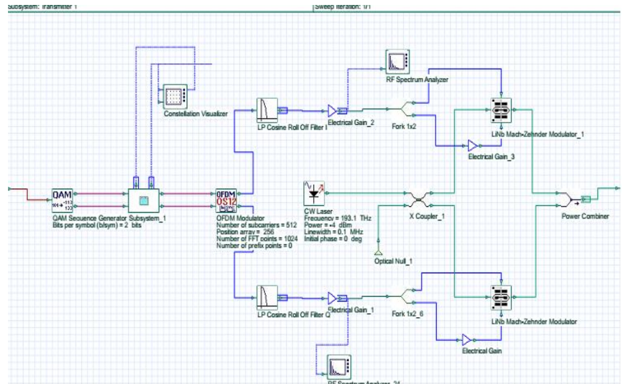

Fig .3. Single OFDM system.

Figure 4 shows the propagating medium which is the free space between two connecting satellites.This free space considered as OWC channel with no attenuation because the altitude of the satellites that is above the Earth's atmospheric layers, gains are 0dB for both transmitter and receiver, wavelength 1550 nm, ideal transmitter and receiver antenna with optical efficiency equal 1 and no pointing error. We assumed that the additional losses from mispointing and scintillation are to be zero. In our simulation, we have studied and analyzed some OWC channel parameters which can affect system performance as different distance link (50 km, 100 km, 200 km, 400 km and 800 km) and different receiver antenna aperture diameter (10 cm, 20 cm, 40 cm and 60 cm). Table 1 shows some of the simulation parameters for IsOWC system.

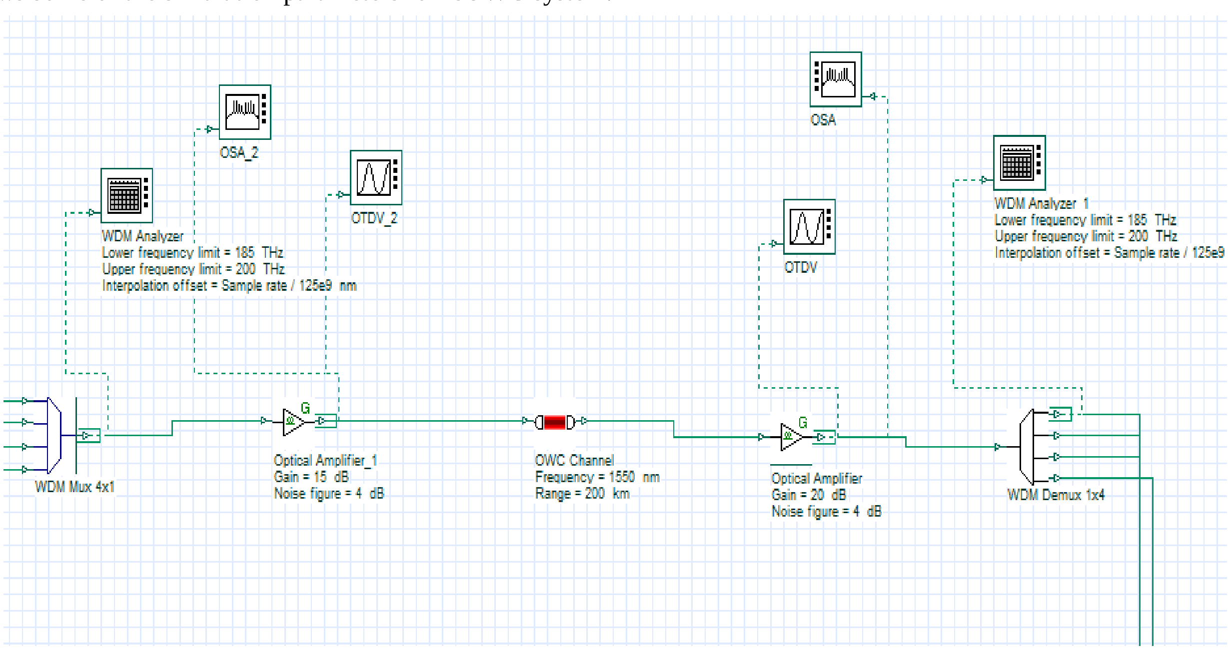

Fig .4. OWC Channel

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ISSN: 2321-9653
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Table .1. IsOWC system parameters

Parameters	values
Bit rate (Gbps)	10
OWC type	Line of sight
Operating wavelength (nm)	1550
Link distance (km)	50 , 100 , 200 , 400 , 800
Transmitter aperture diameter (cm)	15 cm
Receiver aperture diameter (cm)	10 , 20 , 40 , 60
Transmitter optic efficiency	1
Receiver optic efficiency	1

Figures 5 and 6 shows the receiver side of the system which consist of WDM demultiplexer which separates the incoming optical signal from OWC channel into 4 wavelengths and each wavelength is detected by its designed receiver. Each receiver consists of the local oscillator with power -4 dBm and line width 0.1 Mhz and two identical pairs of balanced coherent detectors that recover the electrical components of OFDM signal. Each detector consists of two PIN photodetectors and two couplers. Each PIN photodetector has a thermal noise of 100e-24 W/Hz, a responsivity of 1 A/W and dark current of 10 nA. After detecting the signal, the signal is sent to the OFDM demodulator which has the same parameters to the OFDM modulator. Finally, the resulting signal is fed into a 4-QAM decoder to create a binary signal.

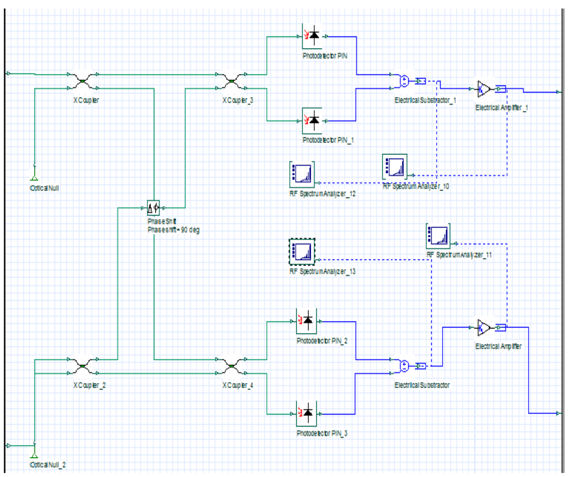


Fig .5. WDM CO-OFDM Receiver.

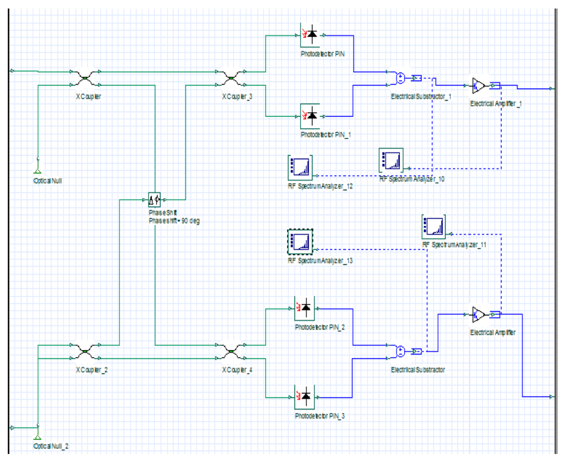


Fig .6. Coherent detection at Receiver side.

III. RESULTS AND DISCUSION

This section of the paper discussed the results obtained from our proposed simulation which has taken the transmitter as satellite 1 and receiver as satellite 2 which connected by a wireless optical channel with wavelength 1550 nm, different link distance, and different aperture diameter. By using Optisystem14 software the performance of the system is studied. Some parameters are needed to be analyzed so that the performance of system does not degrade too low in the presence of different channel conditions as attenuation varies and dispersion. These simulation parameters considered to get constellation diagrams of both TX and RX. In our simulation, we have studied some of these parameters which are a distance of the IsOWC link and antenna aperture size of sender and receiver which can affect system performance.

Figure 7 shows the four OFDM spectrums after the WDM system and before the transmission process. These Four WDM channels are 193.1, 193.2, 193.3 and 193.4 with channel spacing of 10 GHz. Figure 8 shows optical spectrum analyzer for four channels after receiving a signal from free space channel. After observing the optical analyzer figures for both states, we have seen that the receiver receiving almost the proper signals.

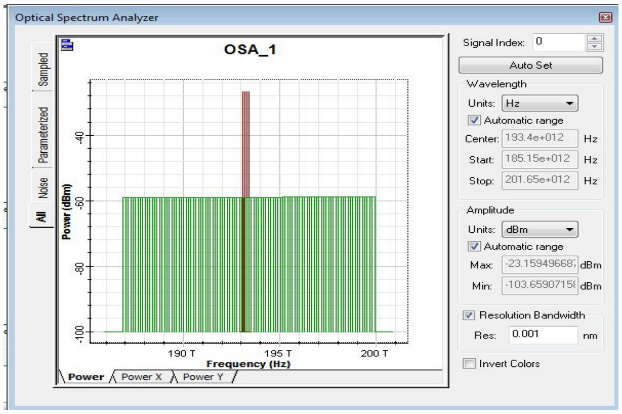


Figure 7. Optical spectrum of 4 channel OFDM WDM signals after free space transmission

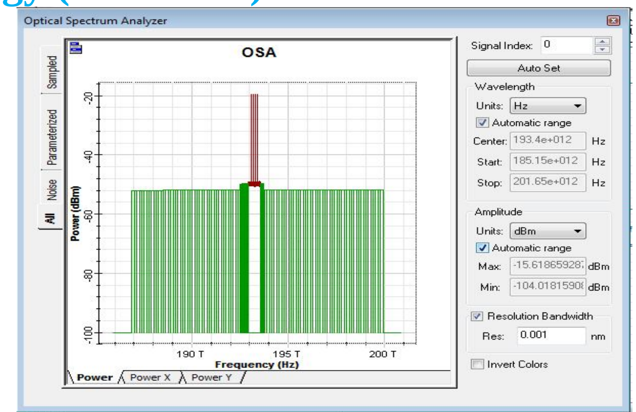


Figure 8. Optical spectrum of 4 channel OFDM WDM signals before free space transmission

Firstly we analyzed the effect of the link distance in signal. In this design, the link distance is chosen to be 50 km, 100 km, 200 km, 400 km and 800 km with bit rate 10 Gbps for each OFDM signal. Figure 9 shows the two-dimensional scatter diagram of the 4-QAM modulator at the transmitter side which helps to identify the interference and distortion that may happen for the signal.

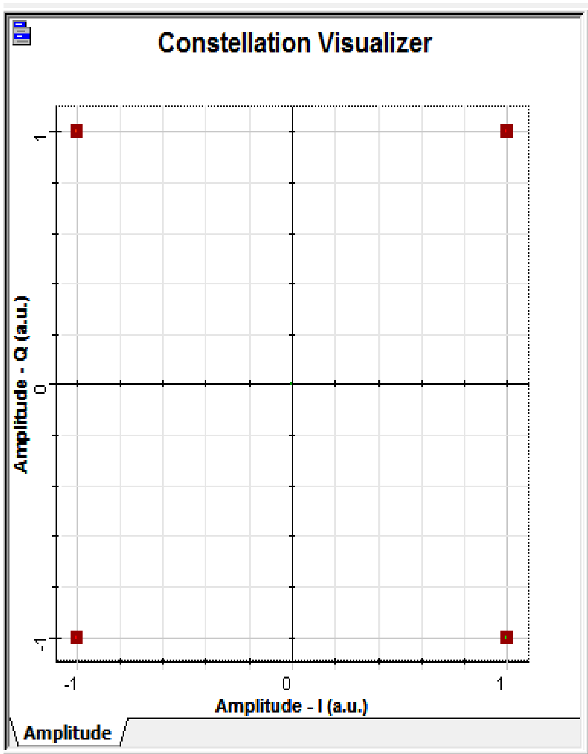


Figure 9. Constellation diagram of 4-QAM encoder at transmitter

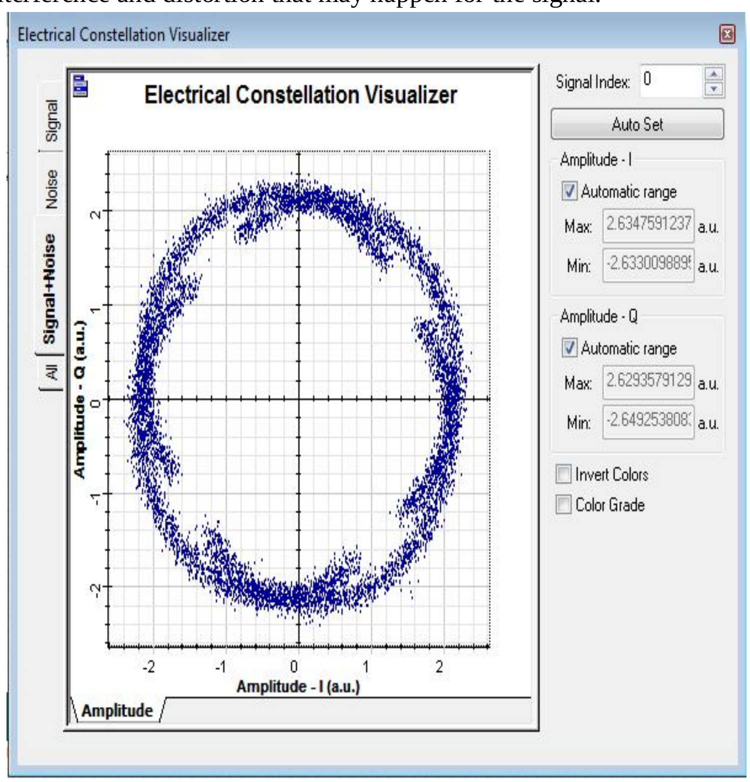


Figure 10. QAM output constellation of four channel WDM CO-OFDM system after 50 km transmission distance.

Figures 10, 11, 12, 13 and 14 shows the constellation diagram of the system after 50 km, 100 Km, 200 km, 400 km and 800 km optical wireless inter-satellite link at the receiver side. From the figures, we have seen that the signal has more distortion when the transmission distance of optical wireless inter-satellite link increase at fixed data rate and fixed receiver antenna aperture diameter especially at 800 km the signal is totally corrupted as can be seen in constellation diagram this is because of Chromatic Dispersion which causes breaking of signal and increasing of in the noise because of the large increase in distance of inter-satellite link.

Volume 5 Issue VI, June 2017
ISSN: 2321-9653

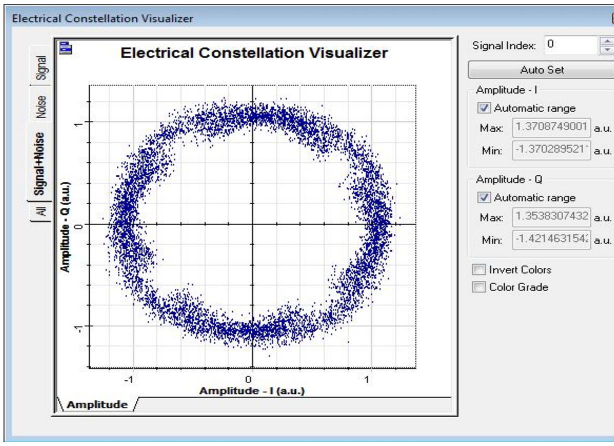


Figure 11. QAM output constellation of four channel WDM CO-OFDM system after 200 km transmission distance.

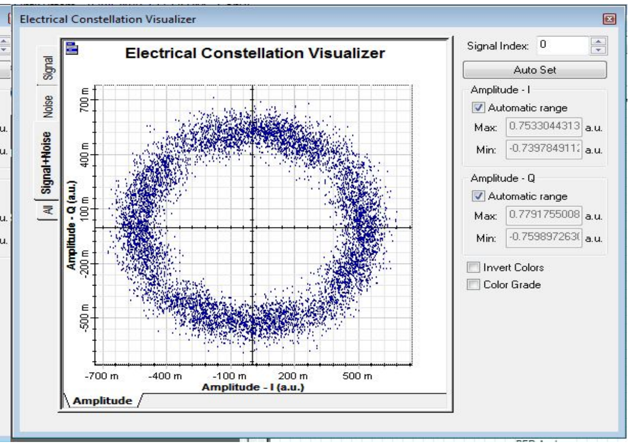


Figure 12. QAM output constellation of four channel WDM CO-OFDM system after 100 km transmission distance.

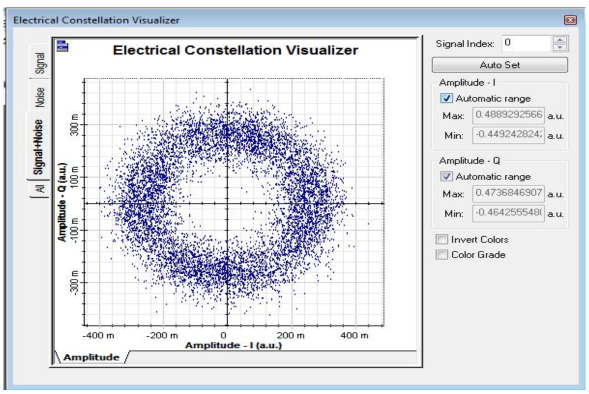


Figure 13. QAM output constellation of four channel WDM CO-OFDM system after 400 km transmission distance

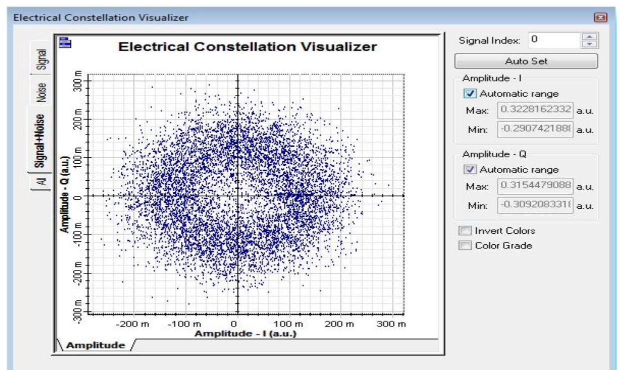
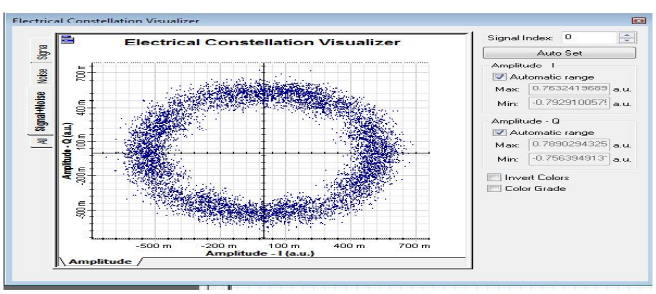


Figure 14. QAM output constellation of four channel WDM CO-OFDM system after 800 km transmission distance.

Secondly, we analyzed the effect of receiver antenna (telescope) Aperture Diameter on system performance. The aperture diameter is chosen to be 10 cm, 20 cm, 40 cm and 60 cm with fixed link distance 800 km and fixed bit rate 10 Gbps for each OFDM signal. We investigated that the increasing of the aperture diameter of receiver antenna (telescope) of satellite caused increasing in the sensitivity of antenna and also for a fixed value of distance if we increase the aperture diameter, the Q factor increases. But when we increase the distance the Q factor starts decreasing. Figures 15, 16, 17 and 18 shows the constellation diagram of the system after fixed distance 800 Km transmission optical wireless inter-satellite and fixed data rate 10gbps for each OFDM signal but with different receiver antenna Aperture Diameters (10 cm, 20 cm, 30 cm, 40 cm and 60 cm).



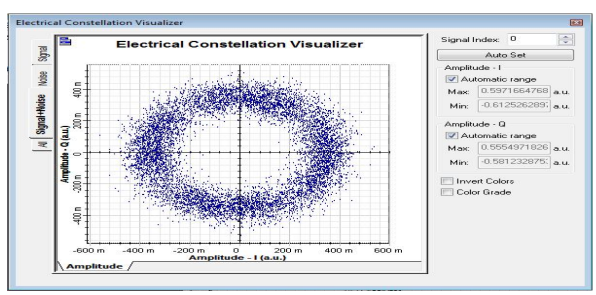


Fig. 15 constellation diagram of CO-OFDM WDM received signal at 60 cm aperture diameter

Fig. 16 constellation diagram of CO-OFDM WDM received signal at 40 cm aperture diameter

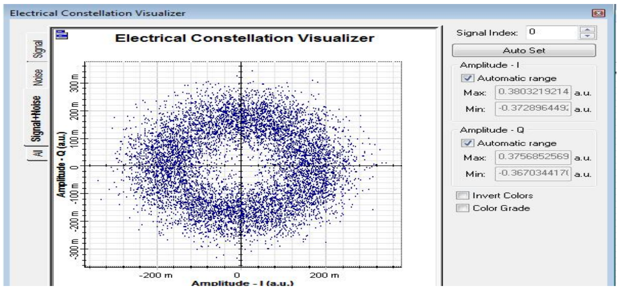


Fig. 17 constellation diagram of CO-OFDM WDM received signal at 20 cm aperture diameter

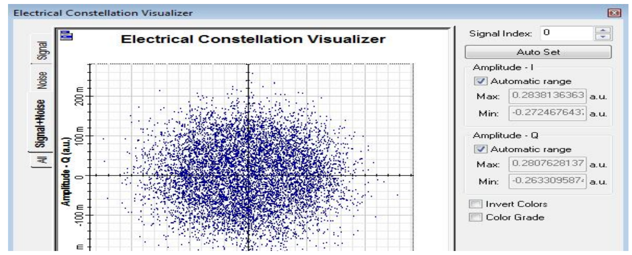


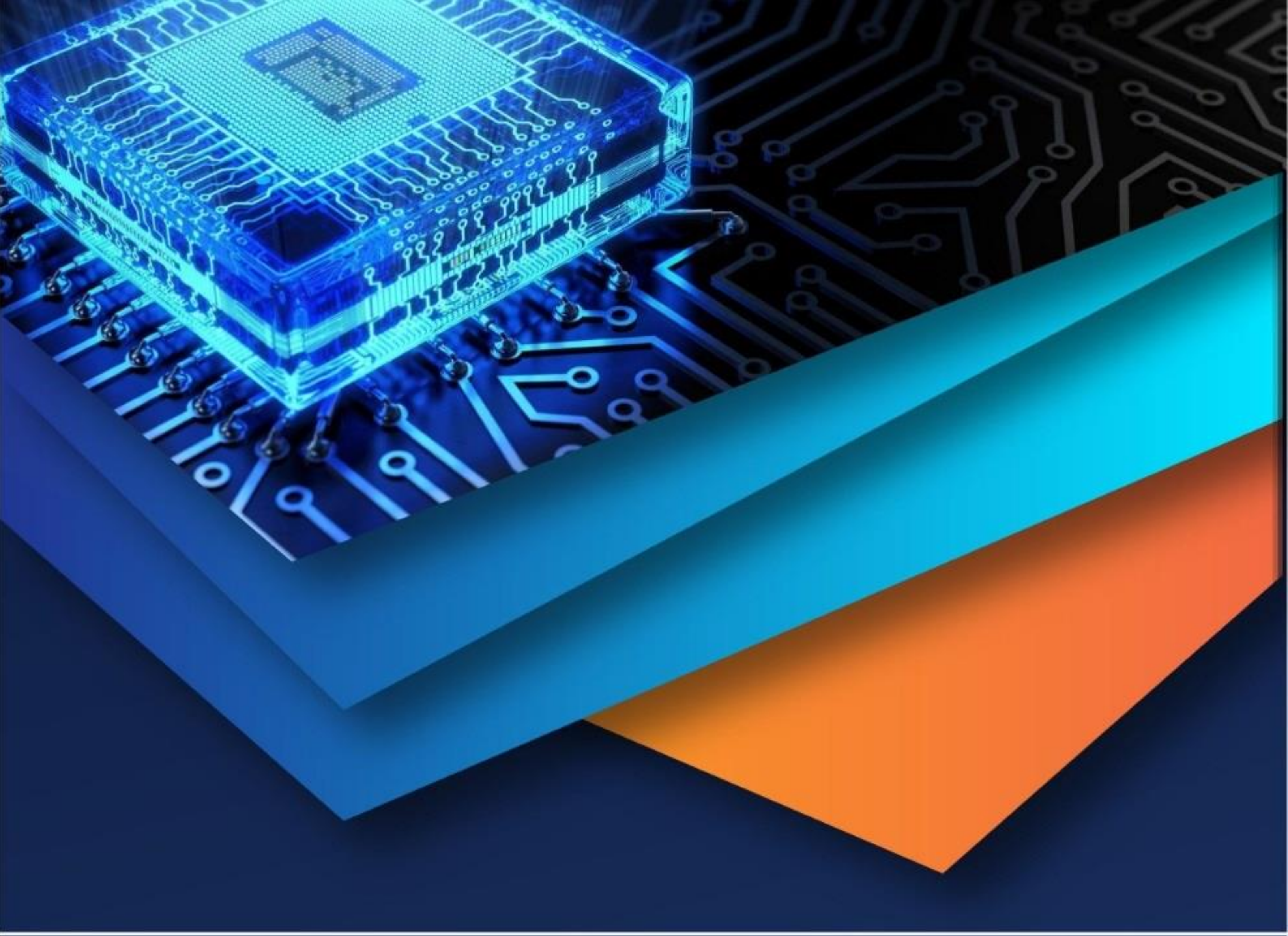
Fig. 18 constellation diagram of CO-OFDM WDM received signal at 10 cm aperture diameter

IV. CONCLUSION

This paper has been simulated and analyzed of optical inter-satellite links with using integration of the WDM with CO-OFDM techniques which provide a transmission system high spectral efficiency and solved the increased demand in data rates and bandwidth without increasing complexity of the system and cost. By using Optisystem14 software the performance of the system is studied. In our simulation, we have studied some of the system parameters which are a distance of the IsOWC link and antenna aperture size which can affect system performance. Firstly we analyzed the effect of the different link distance in received signal which are 50 km, 100 km, 200 km, 400 km and 800 km with fixed bit rate 10 Gbps for each OFDM signal and fixed aperture diameter 15 cm for both transmitter and receiver. The results that appear in the constellation diagrams shows degradation in the signal as we increased the distance of link which decrease the Q factor and increased the bit error rate. Secondly, we analyzed the effect of receiver antenna (telescope) Aperture Diameter on system performance. The aperture diameter is chosen to be 10 cm, 20 cm, 40 cm and 60 cm with fixed link distance 800 km and fixed bit rate 10 Gbps for each OFDM signal. We investigated that the increasing of the aperture diameter of satellite caused Increasing in the sensitivity of the antenna. Also for a fixed value of distance if we increase the aperture diameter, the Q factor increases. But when we increase the distance the Q factor starts decreasing.

REFERENCES

[1] [1] Gabriella Bosco, Andrea Carena, Vittorio Curri, Pierluigi Poggiolini, and Fabrizio Forghieri “Performance Limits of Nyquist-WDM and CO-OFDM in High-Speed PM-QPSK Systems " , IEEE photonics technology letters , VOL. 22 ,NO . 15 , AUGUST 1, 2010 .
[2] Aditi*, Preeti , “An Effort to Design a Power Efficient, Long Reac WDM-FSO System “2014 International Conference on Signal Propagation and Computer Technology (ICSPCT) .
[3] Hongchun Bao and William Shieh “Transmission simulation of coherent optical OFDM signals in WDM systems “ , 16 April 2007 / Vol. 15, No. 8 / OPTICS EXPRESS 4410 .
[4] 1Kirandeep Kaur, 2Kuldeepak Singh, 3Jagdev Singh “Investigations on effect of aperture diameter on various parameters of intersatellite optical wireless communication system “ , GV/ICRTEDC/66 .
[5] R.Jee , S.Chandra “Performance Analysis of WDM-Free-Space Optical Transmission system with M-QAM Modulation under Atmospheric and optical nonlinearities “ , Intional conference of microwave and optical communication , dec 18-20 , 2015 , India .
[6] Faisal Nadeem , Neelesh Agrawal , A.K. Jaiswal, Navendu Nitin , “Performance Analysis of WDM-RoF System with COOFDM for Long Distance Communication “ , International Journal of Computer Applications (0975 – 8887) Volume 129 – No.9, November2015.
[7] Sona G Dev, Sunu Ann Thomas ,” Performance Analysis Of Intersatellite Optical Wireless Link Using Multiple TX/RX And COOFDM Techniques “ , International Journal of Scientific & Engineering Research, Volume 6, Issue 10, October-2015
[8] Khaled Alatawi, Fahad Almasoudi, Mohammad A. Matin , “Performance Study of 1 Tbits/s WDM Coherent Optical OFDM System “ , Optics and Photonics Journal, 2013, 3, 330-335 .
[9] Khaled Alatawi, Fahad Almasoudi, and Mohammad A. Matin ,”Integration of Coherent Optical OFDM with WDM “ , Optics and Photonics for Information Processing VII, edited by Khan M. Iftekharuddin, .
[10] Vishal Sharma , Sushank Chaudhary “Implementation of Hybrid OFDM-FSO Transmission System “ , International Journal of Computer Applications (0975 – 8887) .
[11] Kuldeepak Singh*, Dr. Manjit Singh Bhamrah** “Investigations on Aperture Diameter of Telescope in Intersatellite Optical Wireless communication system “ , Kuldeepak Singh, Dr. Manjit Singh Bhamrah / International Journal of Engineering Research and Applications (IJERA) .
[12] Khaled Saleem Alatawi ,” High Data Rate Coherent Optical OFDM System for Long-Haul Transmission “ , University of Denver Digital Commons @ DU



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