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Performance Analysis of Next Generation High Capacity Ultra Dense Wavelength Division Multiplexing (UDWDM) Based on Inter-Satellite Optical Wireless Communication (OWC)

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ABSTRACT

In this paper, high capacity inter satellite Optical Wireless Communication (OWC) system using different modulation for upstream and downstream is presented. The propose system is achieve by using 64 channels with Ultra Dense Wavelength Division Multiplexing (UDWDM) by different methods. Ultra dense wavelength division multiplexing passive optical network (UDWDM PON) based on Carrier Suppressed Return to Zero (CSRZ) format for downstream and Amplitude Modulation (AM) format for upstream. The inter satellite link at 20 GB/s with channel spacing 25GHz and input power 20 dBm, covered the distance up to 15000km. To shows the good performance of the proposed system, its eye diagram, optical spectrum and Q factor are shown. The analyze system will be highly useful for present and next generation optical communication between satellite. The overall system is design without amplifier which shows advantage for the network. A wavelength reused scheme is used to carry the upstream data by Amplitude Modulation (AM) at the Optical Network Unit (ONU). The downlink 20Gbps signal can achieve a Bit Error Rate (BER) performance of $1.368\times e^{-013}$and Q factor should be 7.30517. The uplink 20Gbps signal can achieve a Bit Error Rate (BER) performance of $1.2406\times e^{-011}$and Quality factor should be 6.67337. We evaluate the performance of the network in terms of Bit Error Rate, coverage area and obtain a network with an excellent access property.

Keywords*: - *Bit Error Rate (BER), Eye diagram, Inter Satellite Optical Wireless Communication (IS-OWC), Passive Optical Network (PON), Q factor, Ultra Dense Wavelength Division Multiplexing (UDWDM).

I. INTRODUCTION

For recent development of new infrastructures communication network and technologies; wireless connectivity and high speed data transmission are two main reasons. Earlier communication systems used bulky copper cables which were applied to only for limited distance communication. After than optical fibers are used which in comparison to copper cables were more reliable, efficient and also covered large distance. But also optical fiber had some losses. This is led to the development of optical wireless communication systems which have provided huge bandwidth, modest power and long transmission distance. At the present, mobile backhaul

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networks are based on three physical media; copper, wireless (microwave radio, free space optics) and optical fiber. [1]

The optical wireless communication systems are based on the basic principle of data transmission through air and using light as the carrier. [2] Optical wireless communications are providing an alternate for the bandwidth hungry communications. [3] The signal carrying information is being modulated on a laser which acts as a light source. The signal multiplex by multiplexer and send to another satellite in the free space. On the receiver side, light is detected using a photo detector and converted back into electrical signal. Optical Wireless Communication (OWC) is one of the best and efficient technologies which provide to the user higher transmission speed and immunity to interference. In inter satellite optical wireless communication; transmission is governed by free space propagation medium between satellites. [4]

Optical Wireless Communication system using Ultra Dense Wavelength Division Multiplexing (UDWDM) is very best solution in providing high data rate transmission with very low Bit Error Rate (BER). UDWDM-PON is basically used to represented high capacity of the network. [5] Ultra Dense Wavelength Division Multiplexing (UDWDM) is most recent phenomena for the advancement of technology. It is a technology that can transmit multiple data simultaneously over the single fiber with very narrow channel spacing.

II. SYSTEM DESCRIPTION AND RESULTS

The growing demand for commercial software for simulation and design of optical communication system has led to the availability of a number of different software solutions. In optical communication network, software which simulates and analyzed the results of the system is opti system. With the advancement of technologies opti system 14.0 is useful and innovative optical communication system simulation tool for designing, testing and optimization of optical link. In opti system software tool a component library is present which contains a various numbers of components. To represent these components icons are used in opti system. With the help of opti system software tool network achieves good and efficient results. The proposed 64×20Gbps ultra dense wavelength division multiplexing passive optical network optical communication system as shown in fig. 1.1 is modeled by using opti system software. Network shows full duplex communication from Optical Line Terminal (OLT) to Optical Network Unit (ONU) or vice versa.

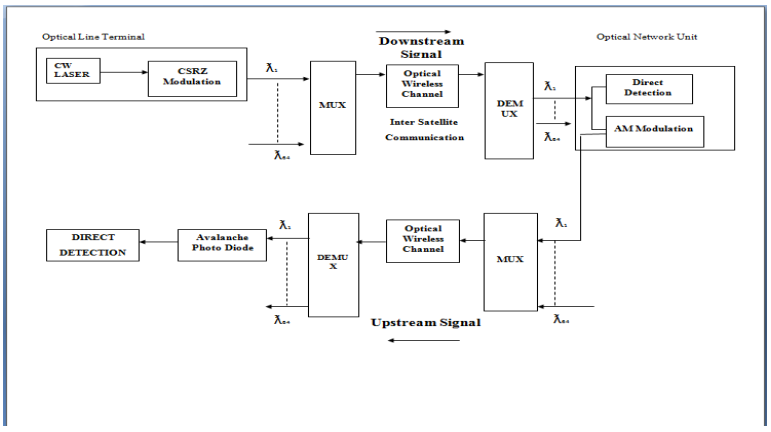

Figure 1.1 Block Diagram of IS-OWC Channel for UDWDM PON (Ultra Dense Wavelength Division Multiplexing passive optical network)

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The downstream wavelength signals are re modulated with uplink data and then sent upstream towards the central office. [6] Both the upstream and downstream channels use the same wavelength to improve the wavelength utilization efficiency. Inter Satellite optical wireless communication system based on ultra dense wavelength division multiplexing is represented by the block diagram is shown. The network consists of transmitter, receiver and free space communication channel between them. A pseudo random bit sequence generator (PRBS) is operated at 20 GB/s which is use to generate a random sequence with different mode of operation. At the optical line terminal side, there are 64 distributed laser sources, followed by Carrier Suppressed Return to Zero (CSRZ) modulation scheme. Frequency starts from 193.1 THz with 25 GHz channel spacing to mitigate effects of cross talk in ultra dense wavelength division multiplexing. Continuous wave laser is modulated by CSRZ using 12 dBm power and 20GB/s data rate to generate the desired downstream signal. The signal are multiplexed by a Wavelength Division Multiplexer ES (Equally Spaced) combines the 64 different wavelengths and transmit overall speed of 1280 GB/s followed by optical spectrum analyzer for inspection.

The aggregate signal is transmit over 15000 km long into free space optical communication channel. The advantage of Optical Wireless Communication over Radio Fiber communication are such as, it minimized the size of antenna hence reducing the weight of the satellite, minimized the power consumption with higher data-rate. [7] The frequency range of the optical wireless communication channel is 1550nm. The modulation technique CSRZ formats are used to achieve long haul and high bit rate communication. The integration of Ultra Dense Wavelength Division Multiplexing (UDWDM) with Carrier Suppressed Return to Zero (CSRZ) improves the spectral efficiency of Inter satellite optical wireless communication system. The network has one advantage; it does not use of any optical amplifier and without that system achieves very good results. At the Optical Network Unit side, the WDM signals are de multiplexed by DE-MUX ES (Equally Spaced) where signals with various wavelengths are sent to different Optical Network Unit (ONU) with channel spacing 25GHz. An optical splitter is used to divide the signal having a loss of 3 db. After that half of the Carrier Suppressed Return to Zero (CSRZ) modulated signal is fed to a detector for downstream signal and other half is modulated by Amplitude Modulator (AM) for upstream signal with the data rate of 20 GB/s. The proposed system is design using opti system 14.0 and parameters used in system design are listed below in table 1.1

Table 1.1 Parameters of the proposed System

Parameters	Values
Modulation	CSRZ, AM
Capacity	64 Channels
Power	20 dBm
Data Rate	20 GB/s
Frequency Spacing	25 GHz
Transmission Distance	15000 Km

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Centre Frequency	193.1 THz
Bandwidth	150 GHz
Photo Detector	APD
Wavelength Range	1550 nm

The re-modulated signal is achieved back through a MUX ES (Equally Spaced) at the optical network unit side via 15000km. Optical Wireless Communication channel to the optical line terminal side where it is de-multiplexing by DEMUX ES and receives by Avalanche Photo Diodes (APDs). An APD is suitable for applications requiring high sensitivity and long distance communications. [8] In this network, APD photo diodes are used for detection of the signal which is to be passed through low pass filter and detected by Bit Error Rate (BER) visualizes.

III. DOWNSTREAM TRANSMISSION PERFORMANCE AND RESULTS DISCUSSION

The Ultra Dense Wavelength Division Multiplexing Passive Optical Network (UDWDM PON) system is simulated using opti system package from optiwave. The Bit Error Diagram of downlink at 20 GB/s of Carrier Suppressed Return to Zero (CSRZ) modulated signal with channel spacing 25 GHz are shown in Figure 1.4

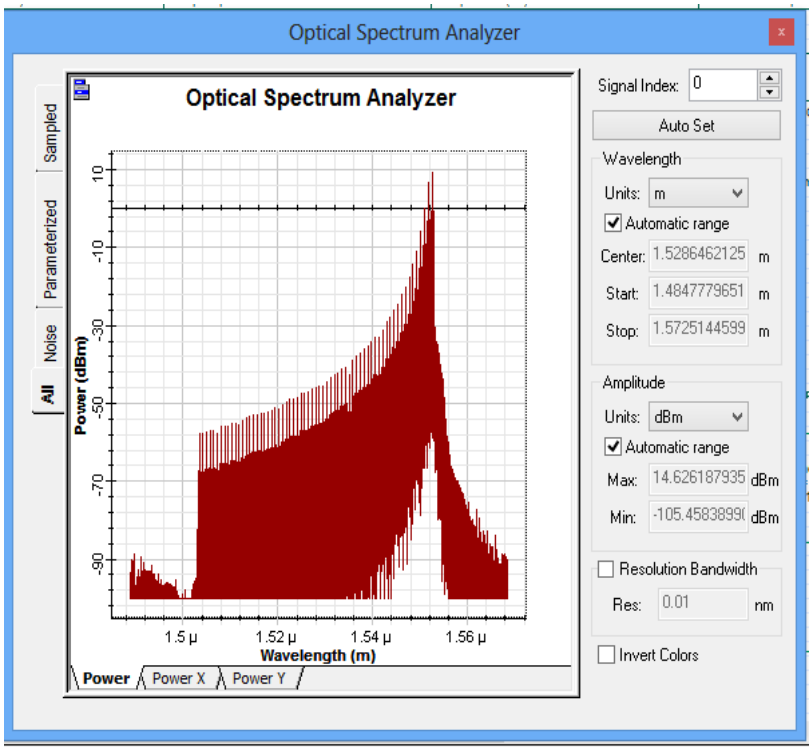

Figure 1.2 Optical Spectrum of CSRZ modulation scheme 64 channels by 20Gbit/s

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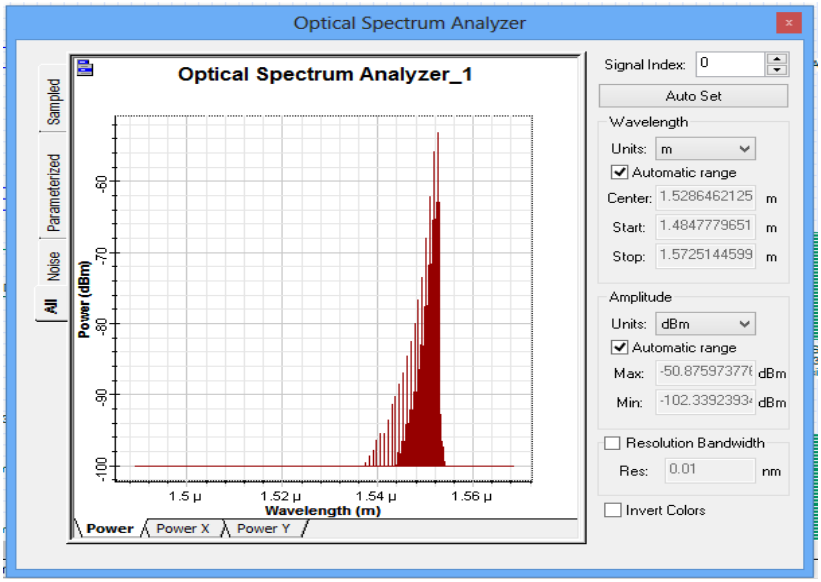

Figure 1.3 Optical Spectrum of optical wireless communication modulated channels

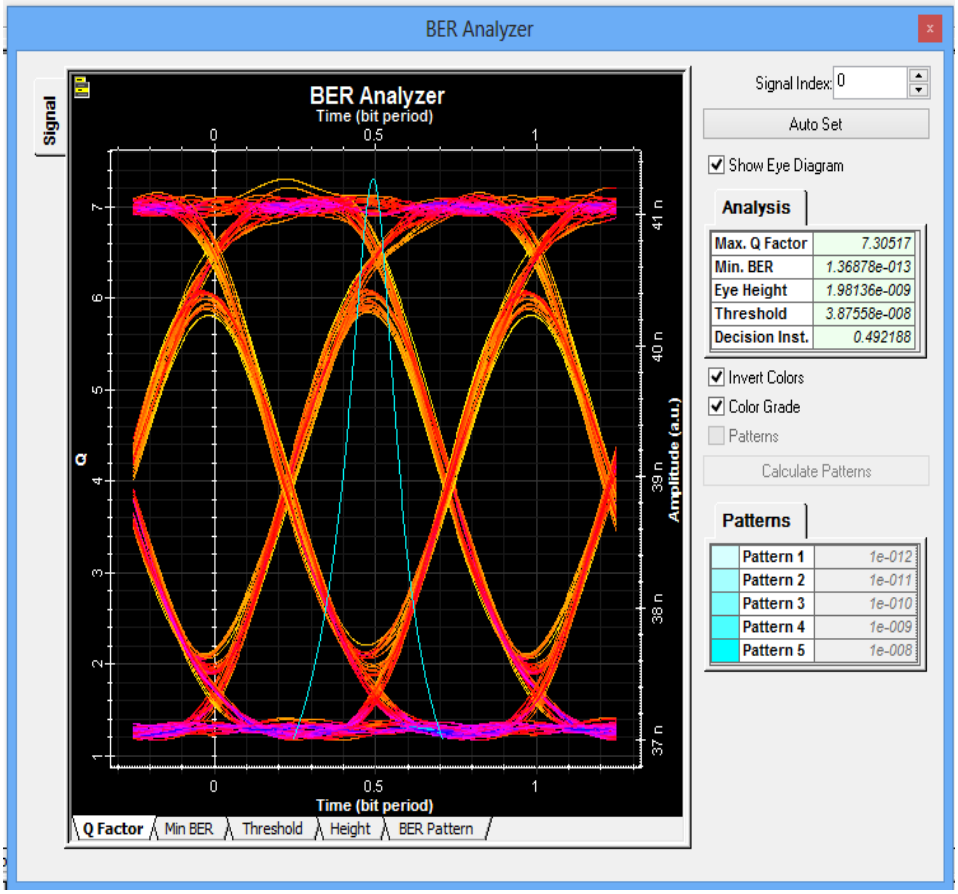

Figure 1.4 Eye Diagram of downstream inter satellite optical wireless communication channel after 15000km.

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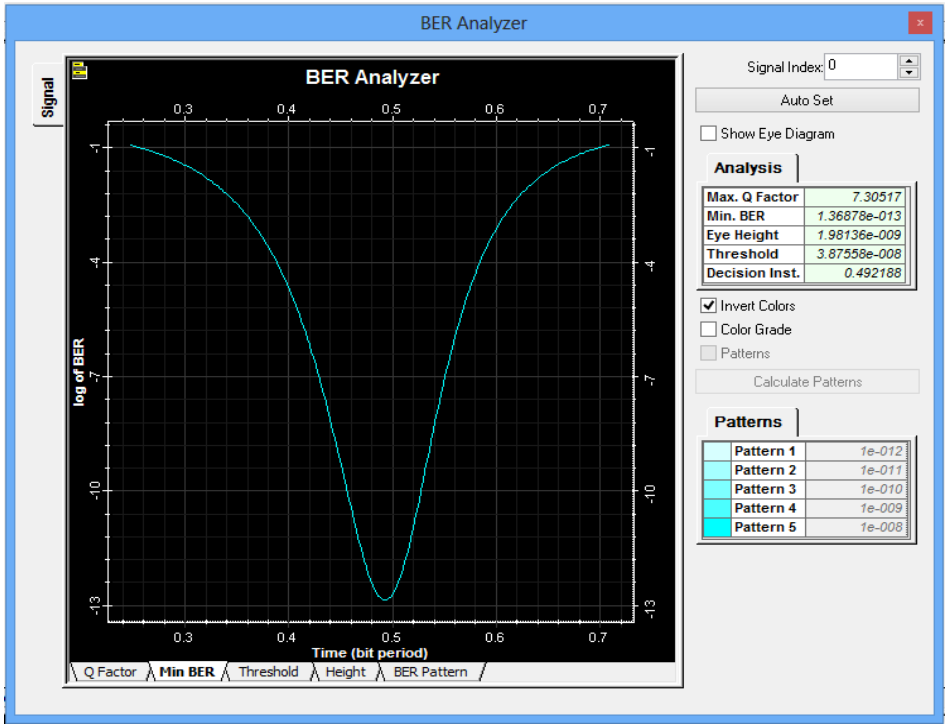

Figure 1.5 The Min Bit Error Rate (BER) Curve of downstream at a distance of 15000 Km

The network achieve clear eye opening which means the system is error free and noise free transmission can be observed. The downstream 20 Gbps signal can observe a bit error performance of and Q factor should be with Carrier Suppressed Return to Zero (CSRZ). Results shows a clear eye opening which means system is noise free.

IV. UPSTREAM TRANSMISSION PERFORMANCE AND RESULTS DISCUSSION

The upstream transmission performance of inter satellite optical wireless channel can achieve excellent results. The Bit Error Diagram of uplink at 20 GB/s of Amplitude Modulation (AM) signal with channel spacing 25 GHz at 15000km are shown in figure 1.6

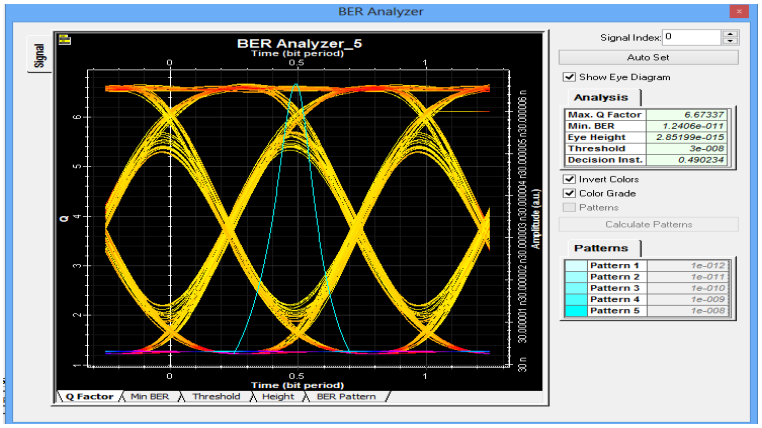

Figure 1.6 Eye Diagram of upstream inter satellite optical wireless communication channel after 15000km

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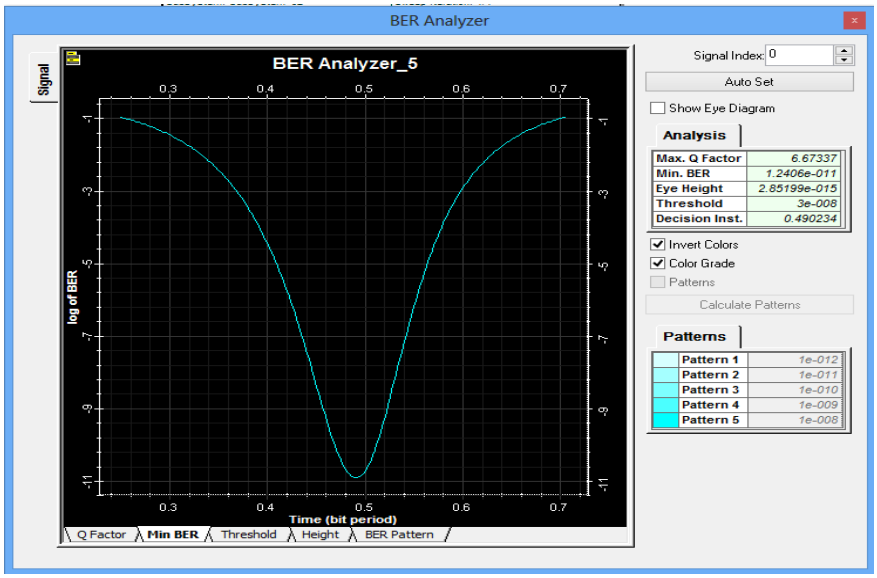

Figure 1.7 The Min Bit Error Rate (BER) Curve of upstream at a distance of 15000 Km

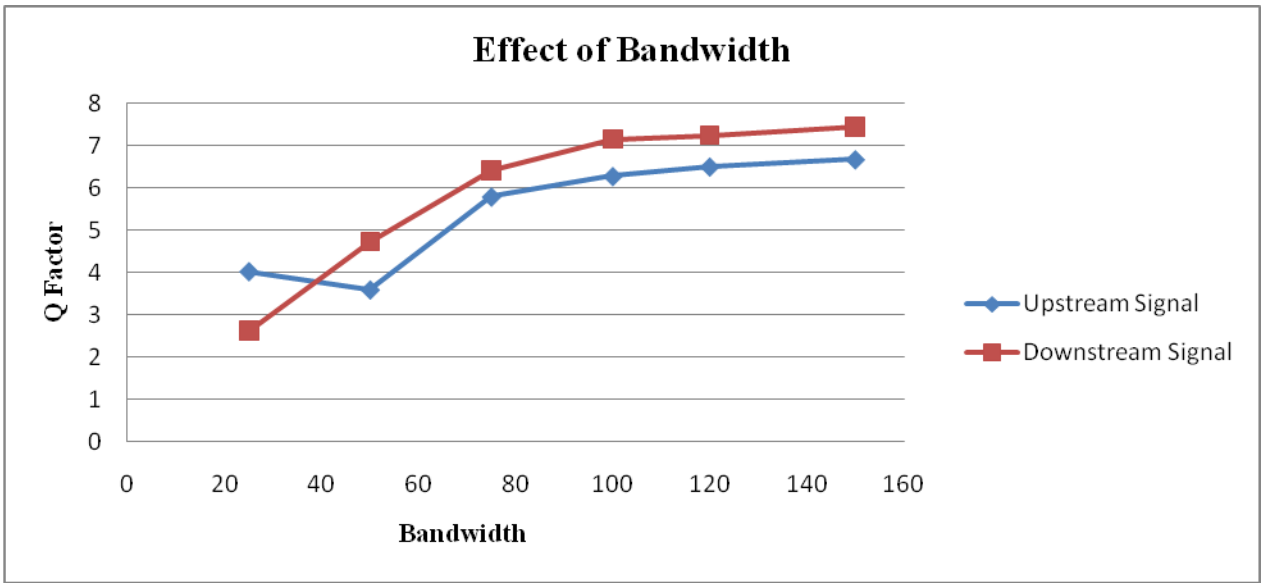

Figure 1.8 Graphical representation of system for both upstream and downstream signal

V. CONCLUSION

This paper proposed a inter satellite long distance transmission up to a distance of 15000 km for Ultra Dense Wavelength Division Multiplexing (UDWDM) system. Ultra dense wavelength division multiplexing is very effective technique for providing high data rates with very low bit error values in optical wireless communication. Multi carrier source are based on a single laser using different wavelengths. In this work, 64 channels, each carrying 20 GB/s data are transmitted independently by using Carrier Suppressed Return to Zero (CSRZ) modulation technique for downstream signal and Amplitude Modulation (AM) scheme for upstream signal. The performance of the designed ultra dense wavelength division multiplexing passive optical network

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transmission system is evaluated in terms of Q factor, Bit Error Rate (BER) and total received power and eye diagrams. For detection of signal Avalanche Photo Diodes is used. As compare with other diodes like PIN or other Optical receiver; APD diodes have better sensitivity and good quality factor performance. The results of the system shows BER performance for downstream are $1.368\times e^{-013}$ and $1.2406\times e^{-011}$ for upstream. We calculated the performance of the network in terms of Bit error rate, distance covered, Q factor and observe a system with an excellent access property.

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