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Performance Analysis and enhancement of WDM optical networks

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Abstract- *In this digital era the communication demand has increased from previous eras due to introduction of new communication techniques. As we can see there is increase in clients day by day, so we need huge bandwidth and high speed networks to deliver good quality of service to clients. Fibre optics communication is one of the major communication systems in modern era, which meets up the above challenges. This utilizes different types of multiplexing techniques to maintain good quality of service without traffic, less complicated instruments with good utilization of available resources .Wavelength Division Multiplexing (WDM) is one of them with good efficiency. It is based on dynamic light-path allocation. Here we have to take into consideration the physical topology of the WDM network and the traffic. We have designed here an 8-channel WDM system and carried out detailed analysis to evaluate the dependencies of the performance evaluating parameters onto the various system parameters. This paper focuses on design of an multi channel WDM trans-receiver System and then optimizing its performance parameters. Simultaneously evaluation of dependencies of various performance evaluating parameters onto various system parameters was obtained. Moreover effect of optical amplification was obtained onto system performance.*

Keywords- *WDM , Optical Networks, Optical Amplification, FWM*

I. INTRODUCTION

In this digital era the communication demand has increased from previous eras due to introduction of new communication techniques. As we can see there is increase in clients day by day, so we need huge bandwidth and high speed networks to deliver good quality of service to clients. Fiber optics communication is one of the major communication systems in modern era, which meets up the above challenges. This utilizes different types of multiplexing techniques to maintain good quality of service without traffic, less complicated instruments with good utilization of available resources .Wavelength Division Multiplexing (WDM) is one of them with good efficiency. It is based on dynamic light-path allocation. Here we have to take into consideration the physical topology of the WDM network and the traffic. We have designed here an 8-channel WDM system and carried out detailed analysis to evaluate the dependencies of the performance evaluating parameters onto the various system parameters.

II. WDM

In optical communication, wavelength division multiplexing (WDM) is a technology which carries a number of optical carrier signals on a single fibre by using different wavelengths of laser light. This allows bidirectional communication over one standard fibre with in increased capacity. As optical network supports huge bandwidth; WDM network splits this into a number of small bandwidths optical channels. It allows multiple data stream to be transferred along a same fibre at the same time. A WDM system uses a number of multiplexers at the transmitter end, which multiplexes more than one optical signal onto a single fibre and demultiplexers at the receiver to split them apart. Generally the transmitter consists of a laser and modulator. The light source generates an optical carrier signal at either fixed or a tuneable wavelength. The receiver consists of photodiode detector which converts an optical signal to electrical signal [1]. This new technology allows engineers to increase the capacity of network without laying more fibre. It has more security compared to other types of communication from tapping and also immune to crosstalk [2].

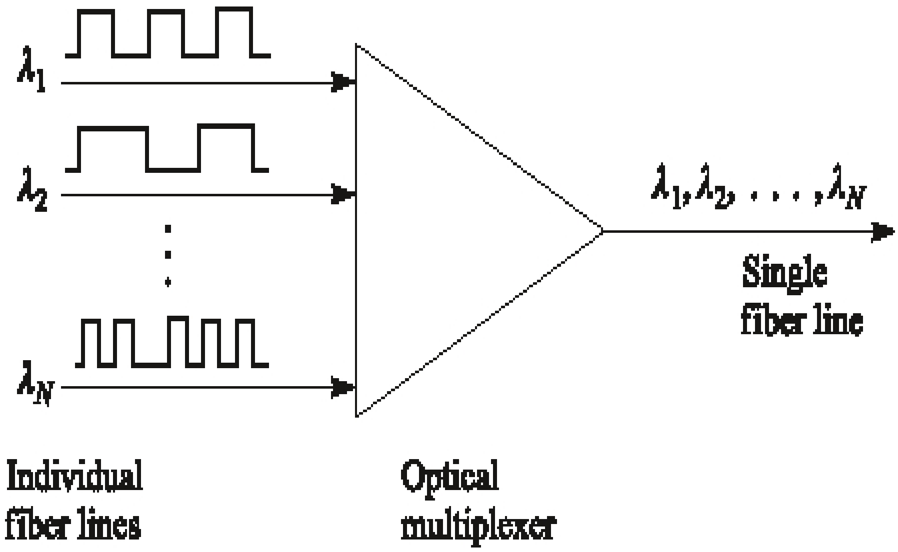

Fig. 1 Wavelength Division Multiplexing System

III. WDM TYPES OF NETWORKS

The optical network has huge bandwidth and capacity can be as high as 1000 times the entire RF spectrum. But this is not the case due to attenuation of signals, which is a function of its wavelength and some other fibre limitation factor like imperfection and refractive index fluctuation. So 1300nm (0.32dB/km)-1550nm (0.2dB/km) window with low attenuation is generally used.

According to different wavelength pattern there are 3 existing types as:-

- WDM (Wavelength Channel Multiplexing)
- CWDM (Coarse Wavelength Division Multiplexing)
- DWDM (Dense Wavelength Division Multiplexing)

Table1 Types of WDM Networks

Parameter	WDM	CWDM	DWDM
Channel Spacing	1310nm & 1550nm	Large,1.6nm- 25nm	Small,1.6nm or less
No of base bands used	C(1521-1560 nm)	S(1480-1520 nm)C(1521-1560 nm),L(1561-1620 nm)	C(1521-1560 nm),L(1561-1620 nm
Cost per Channel	Low	Low	High
No of Channels Delivered	2	17-18 most	hundreds of channel possible
Best application	PON	Short haul, Metro	Long Haul

IV.WDM BENEFITS

Wavelength Channel Multiplexing (WDM) is important technology used in today's telecommunication systems. It has better features than other types of communication with client satisfaction. It has several benefits that make famous among clients such as:

A. Capacity Upgrade

Communication using optical fibre provides very large bandwidth. Here the carrier for the data stream is light. Generally a single light beam is used as the carries. But in WDM, lights having different wavelengths are multiplexed into a single optical fibre. So in the same fibre now more data is transmitted. This increases the capacity of the network considerably

B. **Transparency**

WDM networks supports data to be transmitted at different bit rates. It also supports a number of protocols. So there is not much constraint in how we want to send the data. So it can be used for various very high speed data transmission applications.

C. Wavelength Reuse

WDM networks allows for wavelength routing. So in different fibre links the same wavelength can be used again and again. This allows for wavelength reuse which in turn helps in increasing capacity [3].

D. Scalability

WDM networks are also very flexible in nature. As per requirement we can make changes to the network. Extra processing units can be added to both transmitter and receiver ends. By this infrastructure can redevelop to serve more number of people.

E. Reliability

WDM networks are extremely reliable and secure. Here chance of trapping the data and crosstalk is very low. It also can recover from network failure in a very efficient manner. There is provision for rerouting a path between a source destination node pair. So in case of link failure we will not lose any data [4].

V.**OPERATIONAL BLOCK DIAGRAM**

The operational block diagram of a general WDM system is given below in Fig2

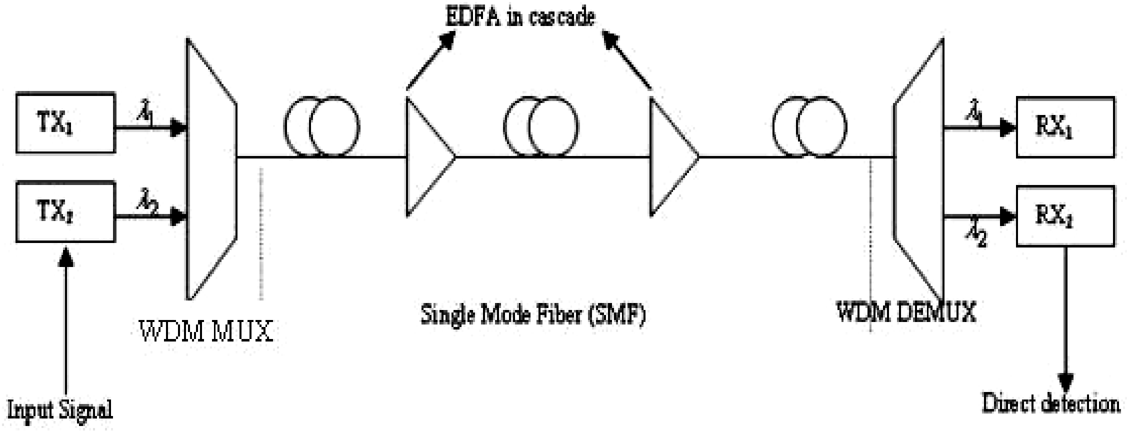

Fig. 2 Block Diagram of a general WDM System

Here input data (Digitized) generated at different wavelengths is given to the input of a WDM multiplexer which multiplexed them into a single data stream. This data after proper electro-opto conversion and external modulation is transmitted to the desired length via single mode optical fiber. Proper amplification is provided by deployment of looped EDFA amplifier with adequate gain. At reception the data streams are separated by WDM de-Mux and filtered to their respective wavelengths after proper opto-electro conversion.

VI. PERFORMANCE EVALUATING PARAMETERS FOR WDM SYSTEM

The various parameters which give us a measure of how good or bad the transmission is are called as Performance Evaluating parameters. The various Performance evaluating parameters are

Bit Error Rate (BER): In telecommunication transmission, the bit error rate (BER) is the percentage of bits that have errors relative to the total number of bits received in a transmission, usually expressed as ten to a negative power.

Q-Factor: Physically speaking, Q is 2π times the ratio of the total energy stored divided by the energy lost in a single cycle or equivalently the ratio of the stored energy to the energy dissipated per one radian of the oscillation. Equivalently, it compares the frequency at which a system oscillates to the rate at which it dissipates its energy.

Eye Height: Eye diagrams show parametric information about the signal – effects deriving from physics such as system bandwidth health, etc. It will not show protocol or logical problems – if logic 1 is healthy on the eye, this does not reveal the fact that the system meant to send a zero. The height of such an eye diagram from bottom to top is called eye height and is a performance evaluation component, the larger the eye height the better is the transmission.

OSNR: Optical Signal to Noise Ratio(OSNR) is defined as the ratio of optical signal power to the noise power within the system. Higher the OSNR better is the signal reception.

VII. SIMULATION SETUP

The system was simulated through optisystem9 simulator and the setup is shown in Fig3

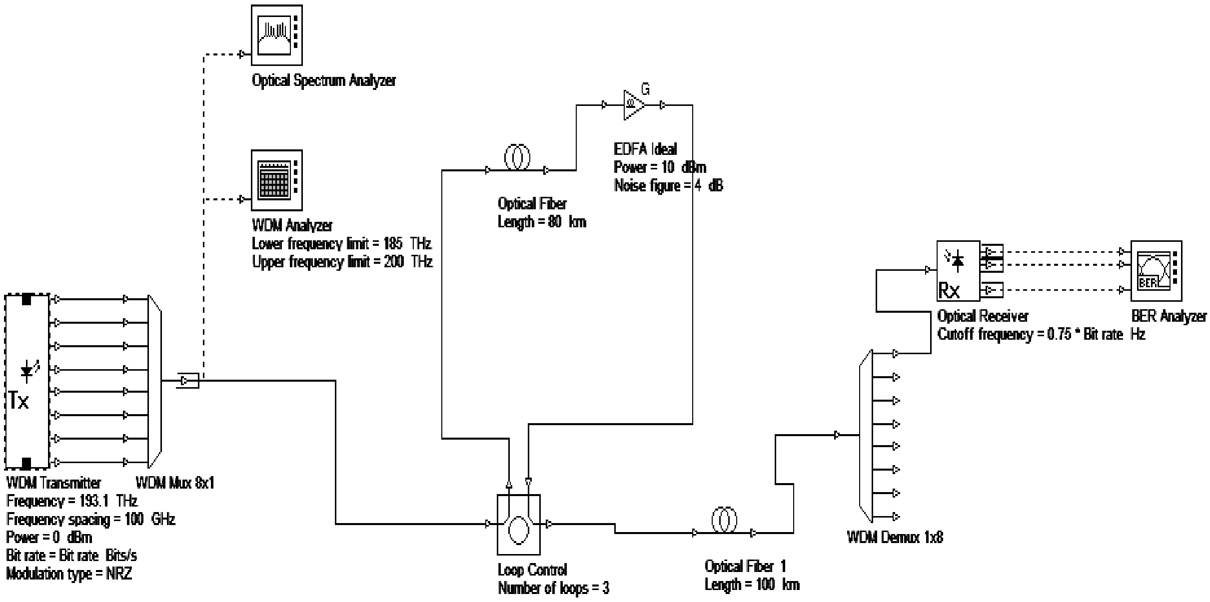

Fig. 3 Simulation Setup for an 8-Channel WDM System

Here Input data streams are generated through WDM Transmitter. This transmitter does the job of data generation, data sequencing, Electrical Modulation, Optical Conversion and External modulation using MZ Modulator. The eight data channels are then multiplexed in wavelength domain by an 8x1 WDM Multiplexer and then transmitted after proper amplification by looped EDFA amplifier through an optical fiber.At reception these data channels are separated in wavelength by an 1x8 WDM de-Multiplexer. All these data channels are then brought back to original form and format with optical Receivers deployed at back end. The quality of reception is checked by the BER Analyzers and various optical and electrical analysers.

VIII. EYE DIAGRAMS

Eye diagrams are generated at the reception end of WDM System and are a means of measuring the quality of signal transr-reception. Better eye opening means better signal trans-reception.Comparison of eye opening were made on altering the various system parameters and noting the corresponding change in the eye opening and performance evaluating parameters. All the performance evaluating parameters can be extracted from the corresponding eye diagrams. Various Eye diagrams were generated against various varying system parameters some of them are shown below.

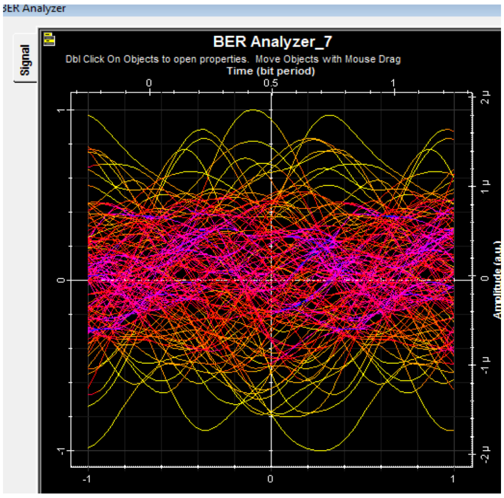

Fig 4 Eye Diagram for Channel8 at 10GHz spacing

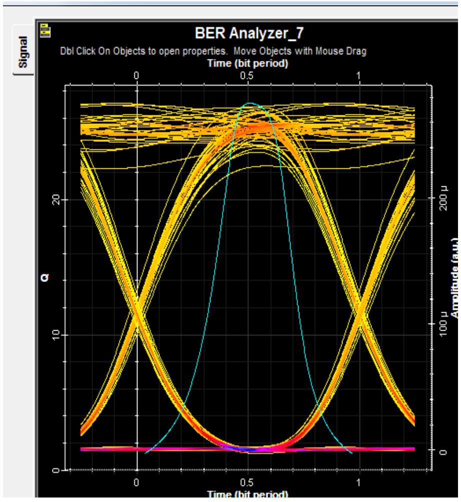

Fig 5 Eye Diagram for Channel8 at 100 GHz spacing

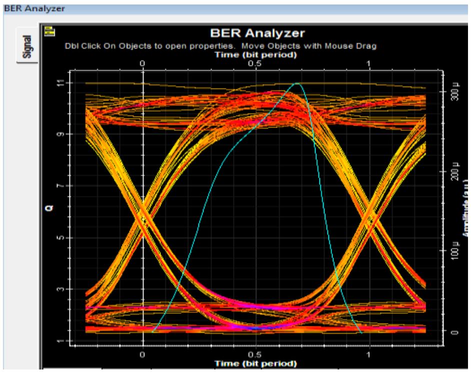

Fig.6 Eye Diagram for Channel 1 at 193.1THz

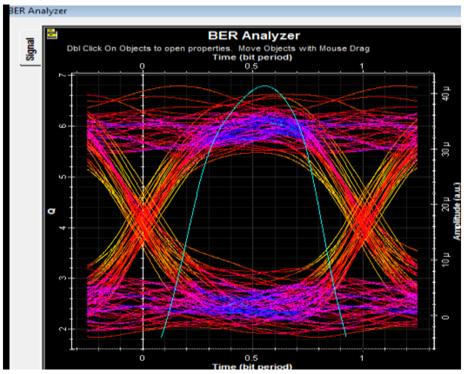

Fig. 7 Eye Diagram for Channel 1 at 199THz

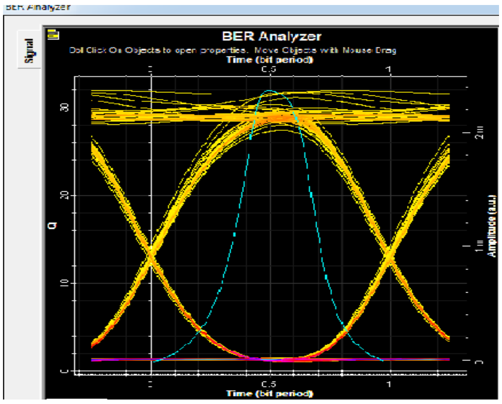

Fig.8 Eye Diagrams for Channel 1 at 5Km Fiber Length

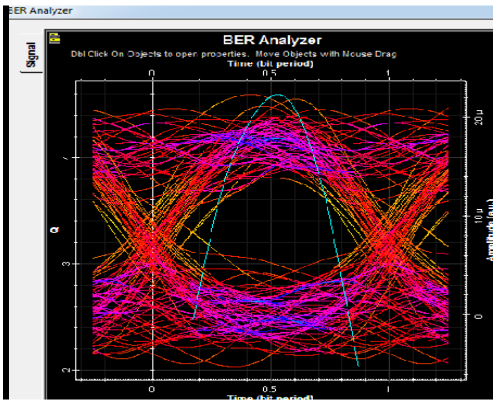

Fig.9 Eye Diagram for Channel 1 at 110 Km

XI. **SIMULATION GRAPHS**

The data retrieved from various eye diagrams at the receiving BER analyser was extracted and plotted.Thus the dependencies of various performance evaluating parameters onto various system parameters has been plotted graphically which are shown as follows

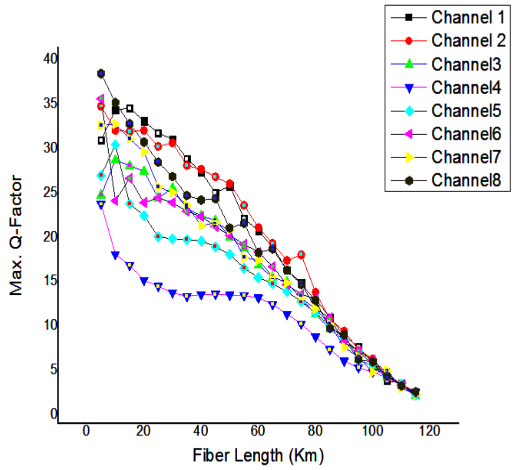

Fig.10 Max Q-Factor Vs Fiber Length(With EDFA)

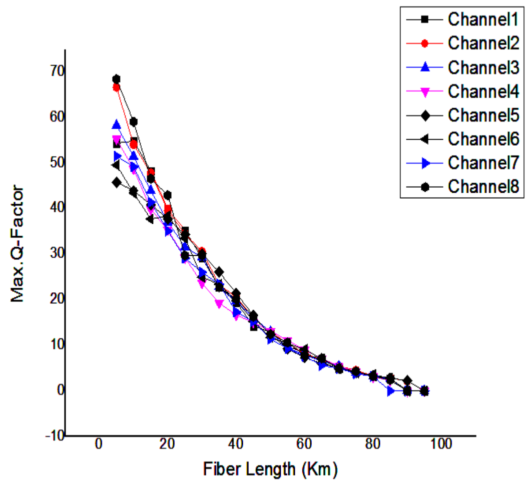

Fig.10 Max Q-Factor Vs Fiber Length(Without EDFA)

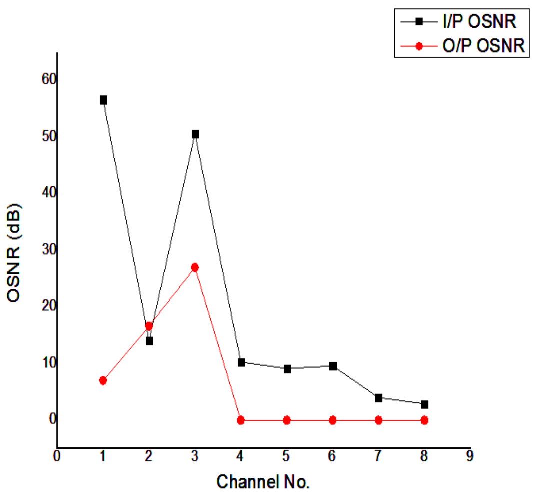

Fig.11 OSNR of Various Channels at 30GHz frequency Spacing

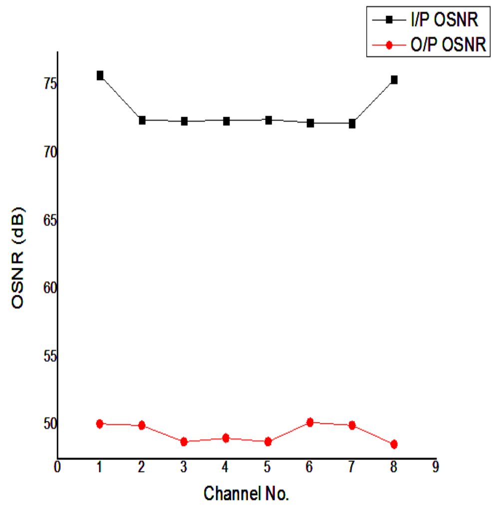

Fig.12 OSNR of Various Channels at 100GHz frequency Spacing

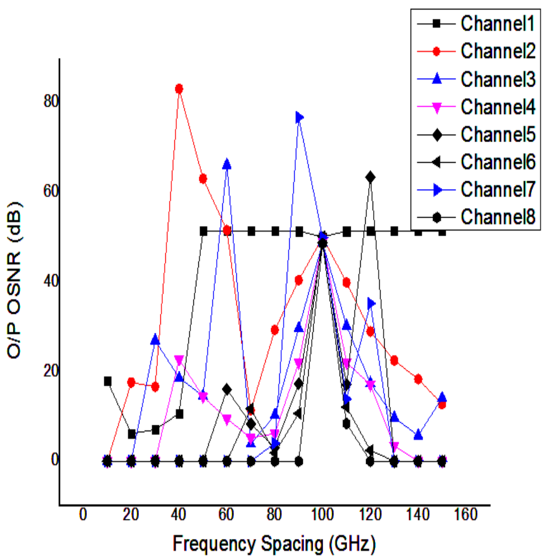

Fig.13 O/P OSNR Vs Frequency Spacing

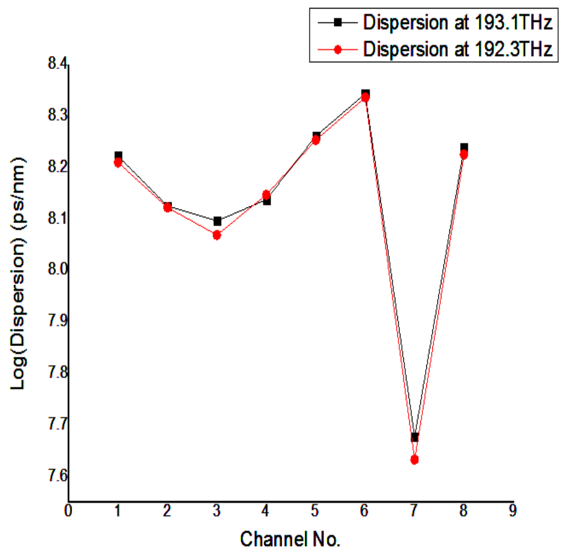

Fig.14 Dispersion across Various Channels

IX. DISCUSSIONS FROM GRAPHS

From the above graphs it was observed that

A. BER Increases with Fiber length,and maximum fiber length which the system could support was found out to be 110 Kms with EDFA and 90 Kms without EDFA

B.OSNR of all channels dropped as the frequency spacing was reduced and best OSNR was seen around frequency spacing of 100GHz.

C. Difference between I/P OSNR and O/P OSNR was seen minimum when operated at frequency spacing of around 100GHz

D. Dispersion first increased reached a maximum and then decreased to reach a minimum (Channel7) at channel frequency set at 193.8 THz.

X.**CONCLUSION**

Here the dependencies of various performance evaluating parameters i.e. Min.BER, Max. Q-Factor, Eye Opening, Dispersion and OSNR on various system parameters i.e. Fiber length, Operating Channel Frequencies, Adjacent channel spacing , and EDFA gain were evaluated .The obtained results were found in well accordance with real results.

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