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Simulation of Pre & Post Compensation Techniques for 16 Channels DWDM Optical Network using CSRZ & DRZ Formats

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Abstract

Dense Wavelength Division Multiplexing (DWDM) is a promising technique which can meet the increasing demand for communication bandwidth. It multiplexed all the channel signals onto single fiber thus increases the capacity of existing fiber. It is a perfect substitute for long haul networks. The major problem that DWDM technique suffered is dispersion which results in degradation of system performance and causes broadening of light pulses.
In this paper a proposed setup of long haul 16 channels DWDM network have been simulated using CSRZ and DRZ modulation formats. Two dispersion compensation techniques i.e. Pre and Post is used in the system to overcome the dispersion problem and the dispersion of SMF is completely compensated using Dispersion Compensated Fiber (DCF) which helped in achieving maximum transmission distance up to 1200 km.

Keywords: DWDM, SMF, DCF, CSRZ, DRZ, Q-Factor.

1. INTRODUCTION

Optical networks are telecommunication network with high capacity, which are basically based on optical technology and components .Such networks provides routing, restoration at wavelength level as well as wavelength based services. Having in mind that today telecommunication networks are facing with continuous problems for transmitting different class of services, operators always are looking for new alternatives or substitute, in order to transmit multimedia services with high quality. Due to the internet boom the demand for transmission capacity is growing rapidly day by day .So there is a tremendous growth of the Internet and the World Wide Web (www) both in terms of number of customers and amount of time and thus the bandwidth taken by each customer which is a major factor. Such factors have driven the development of high-capacity optical networks. Thus Optical data transmission is the key to meet this requirement.
The demand for more bandwidth in telecommunication networks has rapidly expanded the development of new optical components and devices (especially Wavelength Division Multiplexers). Basically the origin of optical networks is associated to Wavelength Division Multiplexing (WDM) which leads to provide more and more capacity on existing fibers. The Dense WDM technique send multiple light waves at different wavelength onto single fiber and also increases the capacity of fiber because it multiplexed multiple signals and send it together. The major problem that DWDM network suffers is the problem of dispersion. This problem can be solved by using different dispersion compensation techniques, Dispersion compensation fiber etc. In history mostly the modulation formats used were NRZ and RZ but the results were not satisfactory. So now advanced are used like CSRZ (carrier suppressed return to zero), DRZ (duo-binary return to zero) and MDRZ (modified duo-binary return to zero). These advanced formats has given satisfactory results and worked well with DWDM transmission system.

2. RELATED WORK

Farzana I. Khatri had focused on the incorporation of advanced DWDM technologies as well as customer usability features. These features are used to provide the service providers to support multiple platforms and reduce transport system operation costs [1]
M. R. X. de Barros, M. L. Rocha, M. T. Furtado, J. B. Rosolem, M. R. Horiuchi, M. **A.** D. Santos, J. ***S.*** Pereira, L. F. C. Fernandes, and C. D'Amico have presented the results of simulation of 16 channels DWDM system at 10 Gb/s Bit rate. Data have been transmitted over 73km and 112 km using single mode fiber and low loss, low dispersion DCFs. Power penalties were measured and conclusion was in order to obtain lower power penalty the dispersion must be compensated because the dispersion is the main source of penalty as expected for STD-SMF [2]
Sawsan Abdul-Majid , Saleh AL.Qarawy and Yousra Abdul-Sahib proposed a WDM de multiplexer design using fiber bragg grating. The main motive was to achieve high level accuracy, the time and cost saving by using latest state of art. The performance of the design was measured using Q factor and BER i.e. bit error rate.[3]
R.S.Kaler, T.S.Kamal, and Ajay.K Sharma presented the simulation of DWDM systems with ultra high capacity up to 1.28 Tb/s . Parameters were analyzed on the basis of impact of sound to noise ratio and results obtained were explained on the basis of nonlinear effects. Conclusion was with increase in channel spacing, the SNR increases to maximum value

and then it decreases. For small wavelength spacing the SNR depends on number of channels but becomes independent for large wavelength spacing. When channel spacing kept constant then SNR decreases with increase in length.[4]

Besim Limani and Arben Sylejmani in this paper analyzed the signal losses in optical backbone links. And long links was analysed and measured to see if the noises had affected the quality of signal transmitted through these fibers. OTDR analyzer was used to measure the signal losses. [5]

Lucky Sharan and V K Chaubey analyzed the affect of non linearity on the WDM systems. CSRZ modulation scheme was used for the system in the presence of Kerr affects and various input power for different distances under different compensation techniques were analyzed. The performance of the system was measured using Q factor and eye diagram. And conclusion came out to be that post compensation performed better in comparison with other two compensation techniques [6]

Essa Ibrahim Essa investigate the hybrid dispersion compensation schemes with 16 channels using RZ format over single mode fiber based on DWDM network. EDFA was used to substitute power loss and dispersion was compensated by dispersion compensation fiber i.e. DCF. Main aim was to reduce the error rate and transmit the quality at cost effective way [7]

Sandeep Singh, Vaibhav Bhushan Tyagi, Anuj Bhardwaj and Neeraj Gupta have simulated the WDM system and concluded that among all the three compensation techniques, the mix compensation technique is the best. It can greatly reduce the effect of non linearity and increases the transmission distance of the communication system. The results were analyzed in terms of Q factor and Bit error rate. Input power taken was 16 dB which gave BER performance better [8]

Muhammad Imran, Hamdan Awan and Mohammed Arafah have design the dispersion compensated DWDM system using Hybrid Amplifier. Among all the factors that affects the DWDM system, the unsuitable parameters i.e. dispersion and optical fiber loss are major ones. So it became important to eliminate these factors in order to achieve optimum performance of the system. So instead of using EDFA alone, the author have used EDFA–RAMAN hybrid amplification instead of EDFA alone to achieve acceptable signal at the receiver with improved Q-Factor and BER. [9]

3. DISPERSION COMPENSATION FIBER

The long haul network's major problem is dispersion which has to be reduced otherwise it degrades the system performance. Dispersion means broadening of light pulses and signal distortion due to the difference in group velocity of different modes which causes the signal interference and results in the inter symbol interference effect. In optical network there are many factors that affects the performance of system like non linearity nature of propagation , Kerr's effect etc and because of non linearity the performance of the system depends on the input power levels at input of fiber ,amount of negative dispersion of DCF and on the position of DCF. The DCF have large negative dispersion value of -80ps/nm.km to -90 ps/nm.km and used in compensating the positive dispersion of SMF. A DCF has low optical nonlinearity, low insertion loss and large negative dispersion coefficient. By placing a DCF with large negative dispersion after SMF with positive dispersion, the total dispersion should become zero. Following equation is used to calculate weather dispersion becomes zero or not.

$$D_{(SMF)} * L_{(SMF)} = D_{(DCF)} * L_{(DCF)} \qquad (1)$$

D_{SMF} and L_{SMF} are dispersion and length of single mode fiber and D_{DCF} and L_{DCF} are dispersion and length of dispersion compensated fiber. Also two dispersion compensation techniques are used to compensate the dispersion depending on the position of DCF.

Pre- Compensation: In this type of compensation technique, the dispersion compensation fiber with negative dispersion is placed before the single mode fiber with positive dispersion.

Post-Compensation: In this type of compensation technique, the dispersion compensation fiber with negative dispersion is placed after the single mode fiber with positive dispersion.

4. DESCRIPTION OF SIMULATION SETUP

In DWDM network in order to achieve higher capacity then the network should be enhanced to compensate the dispersion. In order to reduce dispersion, different dispersion compensation techniques must be used periodically in the network. Several methods have been used to solve the problem of compensation like fiber Bragg gratings, dispersion compensation fiber, electrical dispersion compensation etc.

Figure 1 shows schematic simulation of long haul 16 channels DWDM network. The simulation parameters used in the simulation setup are given in Table 1.

The simulation setup of 16 channels DWDM network composed of three sections i.e. the DWDM transmitter section, the optical link and the receiver section.

The Transmitter section: The DWDM transmitter consists of CW laser array, Ideal Multiplexer and Modulation formats. The CW laser array has 16 output ports and the frequencies are equally spaced between the channels i.e. frequency spacing is 200 GHz between the user channels , emission frequency range is from 190 THz to 193 THz and Line width is 120 MHz . All the channels from CW laser are connected to 16 input port of Ideal Multiplexer and then fed into advanced modulation formats i.e. CSRZ and DRZ.

The Optical link: In optical DWDM network the basic problem is the problem of dispersion which results in degradation of the system network performance. So for this problem the dispersion compensating fiber have been used to compensate the dispersion occurred in the optical transmission link. DCF have negative dispersion of -85 ps/nm.km which compensates the positive dispersion of SMF. The position of DCF should be in such a way that placing DCF with negative dispersion after SMF with positive dispersion, the total dispersion should become zero. The transmission link composed of DCF and SMF each of length 10km and 50 km respectively. Link is designed in such a way so that dispersion is compensated completely. The data is transmitted over 24 spans of SMF of length 50 km each. The Erbium doped fiber amplifiers (EDFAs) is used in the simulation setup which is placed after each fiber in a way that it compensates the losses occurred due to preceding fiber. The system is simulated for two compensation techniques. First is Post compensation which is shown in Figure1 and second is Pre compensation as shown in Figure2 shown below.

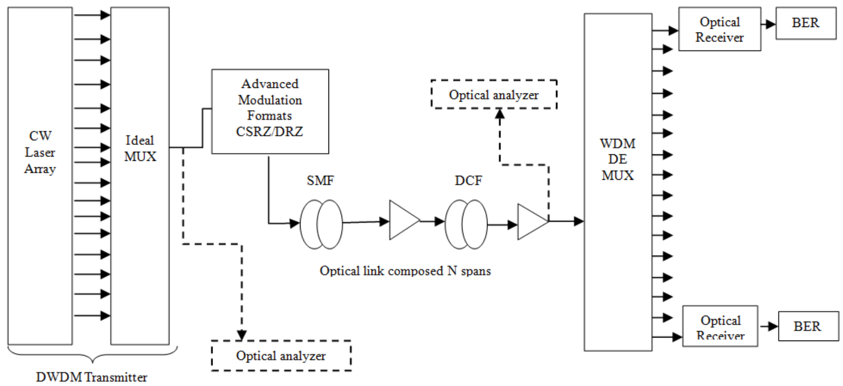


Figure 1 Post Compensation Dense WDM network

In post compensation, the DCF fiber of 10 km is placed after the SMF fiber of 50 km length to compensate the dispersion and in Pre compensation technique the DCF fiber of 10 km is placed before SMF fiber of 50 km to do the dispersion compensation. Four inline EDFAs are used which are placed after each fiber to recover the losses of fiber and amplify the signals transmitted.

In post compensation, the DCF fiber of 10 km is placed after the SMF fiber of 50 km length to compensate the dispersion and in Pre compensation technique the DCF fiber of 10 km is placed before SMF fiber of 50 km to do the dispersion compensation. Four inline EDFAs are used which are placed after each fiber to recover the losses of fiber and to boost and amplify the signals transmitted.

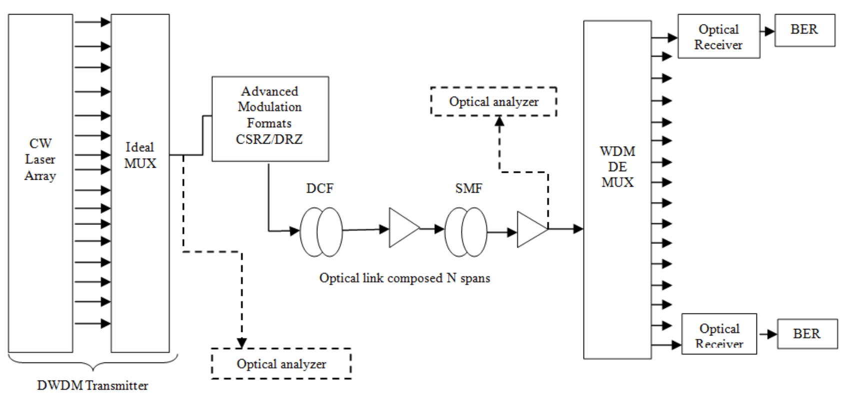


Figure 2 Pre Compensation Dense WDM network

The Receiver Section: At the receiver the WDM de multiplexer is used to split the signals apart. It has 16 output ports with equal frequency spacing of 200GHz and having bandwidth of 80 GHz. The Bessel filter is used with depth of 80dB. The signals will be detected by the optical receiver which is connected to the output port of WDM De Mux. The optical receiver is composed of two types of photo detectors, Bessel filter and 3R regenerator. In this setup APD have photo detector have been used. Each optical receiver is directly connected to BER analyzer which is used to generate results i.e. Eye diagram, Bit error rate and Quality factor which are the performance parameters.

Table 1: Simulation Parameters of Dense WDM Network

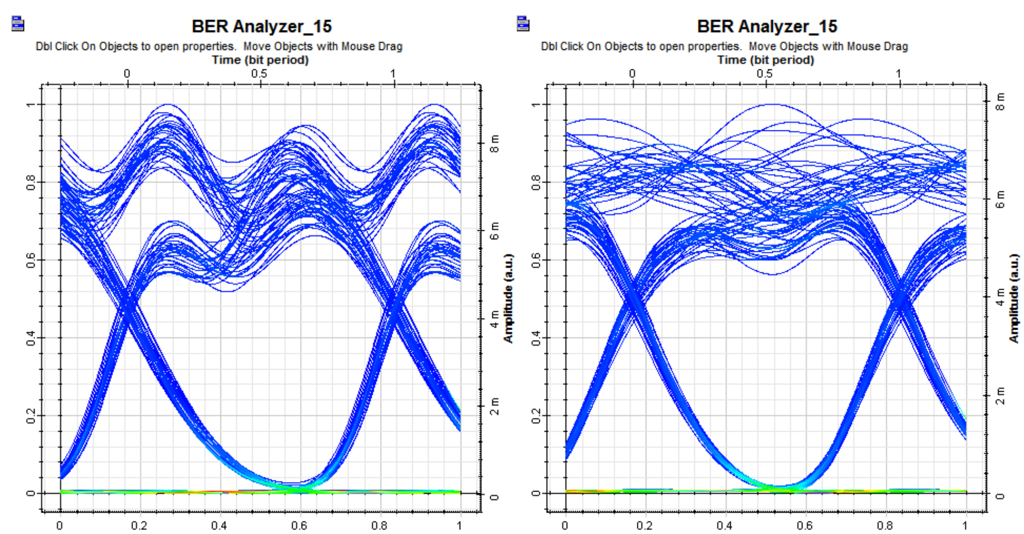
S. No.	Parameters	Value
1	Bit Rate	0 to 10 Gbps
2	Length of SSMF	50km
3	Length of DCF	10 km
4	No. of spans	24
5	Power	1 mW to 5 mW
6	Attenuation of DCF	0.5 db/km
7	Attenuation of SMF	0.2 db/km
8	Dispersion of DCF	-85 ps/nm/km
9	Dispersion of SMF	17 ps/nm/km
10	Gain of EDFA after DCF	5 db
11	Gain of EDFA after SMF	10 db
12	Bandwidth	80Ghz
13	Filter Type	Bessel Filter
14	Frequency	190 THz
15	Line width	120 MHz

5. RESULTS AND DISCUSSIONS

Essa Ibrahim Essa demonstrated the 16 channels DWDM system at constant Bit rate 40 Gbps using RZ format over 120 km Optical link. The average Q factor of DWDM system using RZ modulation format at distance 120 km is 5.4375 [7]

In this paper the two dispersion compensation techniques i.e. Pre and Post compensation have been simulated for 16 channels Dense WDM network using advanced formats CSRZ and DRZ. To analyze the system, output of last channel have been taken at input powers 1m W and 5m W for bit rate 10 Gbps.

The Eye diagram and Optical spectrum analyzer of Post dispersion compensation using CDRZ and DRZ at Input Power=5m W and Bit rate 10Gbps is shown below.



(a) (b)

Figure 3 (a) & (b) shows the Eye diagram of Post compensation CSRZ and DRZ at Power=5m W and Bit rate = 10 Gbps when Distance is 1200 km respectively

The figure above of Post compensation technique using CSRZ and DRZ gives the Q Factor of 10.5093 and 7.75883 respectively

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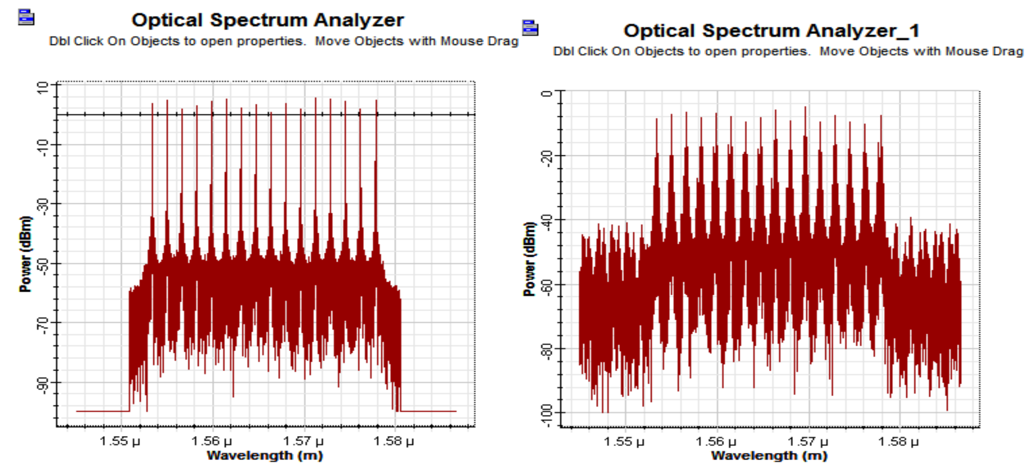
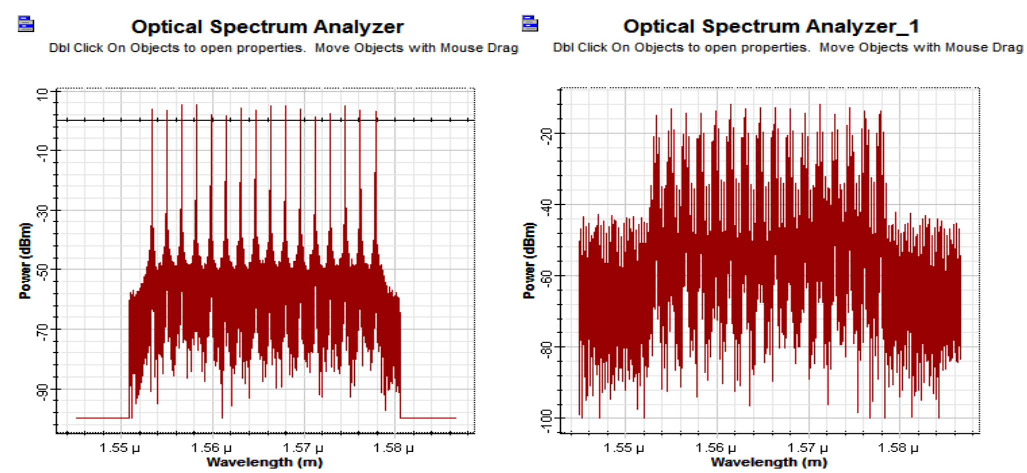


(a) (b)

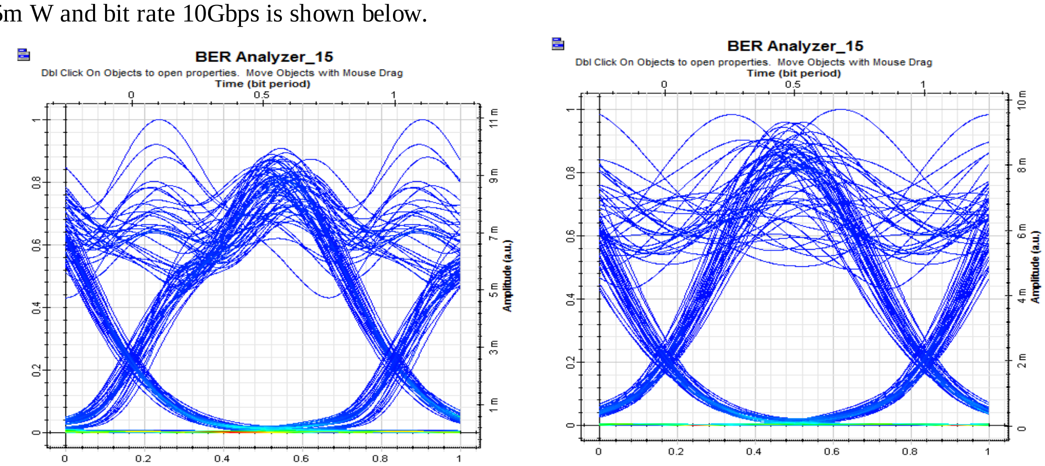
Figure 4 (a) & (b) shows the Optical spectral analyzer for all 16 channels at Distance 0 km and 1200 km respectively using CSRZ Post compensation technique



(a) (b)

Figure 5 (a) & (b) shows the Optical spectral analyzer for all 16 channels at Distance 0km and 1200 km respectively using DRZ Post compensation technique

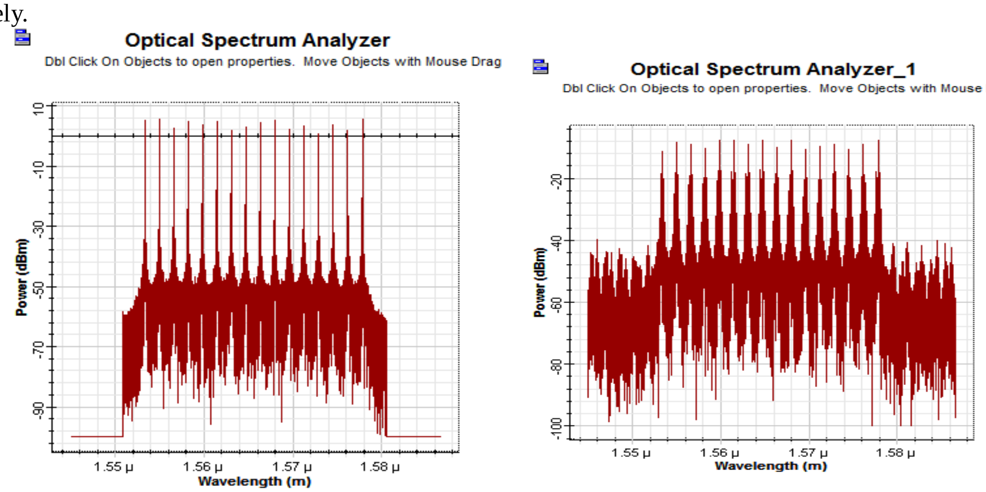
The Eye diagram and Optical spectrum analyzer of Pre dispersion compensation using CDRZ and DRZ at Input Power=5m W and bit rate 10Gbps is shown below.



(a) (b)

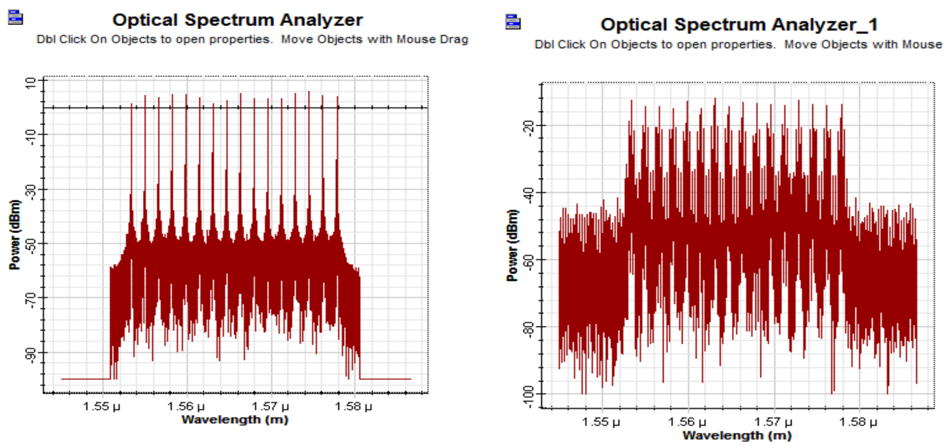
Figure 6 (a) & (b) shows the Eye diagram of Pre compensation CSRZ and DRZ at Power=5m W and Bit rate = 10 Gbps when Distance is 1200 km respectively

The figure shows above of Pre compensation technique using CSRZ and DRZ gives the Q Factor of 9.92243 and 6.73939 respectively.



(a) (b)

Figure 7 (a) & (b) shows the Optical spectral analyzer for all 16 channels at Distance 0 km and 1200 km respectively using CSRZ Pre compensation technique when Input Power= 5m W & Bit rate= 10 Gbps



(a) (b)

Figure 8 (a) & (b) shows the Optical spectral analyzer for all 16 channels at Distance 0 km and 1200 km respectively using DRZ Pre compensation technique when Input Power= 5m W & Bit rate= 10 Gbps

The performance comparison of different dispersion compensation techniques formats for CSRZ and DRZ modulation formats is shown in Table 4 and Table 5 below.

Table 2: Showing results of CSRZ format at Distance 1200 km when Power= 5m W &Bit rate= 10 Gbps

CSRZ Modulation Format			
S No.	**Compensation Type**	**Q Factor**	**Distance Covered**
1	Post	10.5093	1200 km
2	Pre	9.92243	1200km

Table 3: Showing results of DRZ format at Distance 1200 km when Power= 5m W &Bit rate= 10 Gbps

DRZ Modulation Format			
S No.	**Compensation Type**	**Q Factor**	**Distance Covered**
1	Post	7.75883	1200 km
2	Pre	6.73939	1200km

6. CONCLUSION

In this paper, we have simulated the long haul 16 channels Dense WDM network with two dispersion compensation techniques i.e. Pre and Post to overcome the problem of dispersion. The two modulation formats CSRZ and DRZ were simulated for both the dispersion techniques. The simulation results showed that the distance have been improved up to 1200 km and CSRZ outperformed DRZ modulation format in terms of Q factor of received signals.

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