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RZ BASED DISPERSION COMPENSATION TECHNIQUE IN DWDM SYSTEM FOR BROADBAND SPECTRUM

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***Abstract:*--In telecommunication, an optical signal weakens from attenuation mechanisms and broadens due to the dispersion effects as it travels along a fiber. Eventually these two factors will cause neighboring pulses to overlap. After a certain level amount of overlap occurs, the receiver can no longer distinguish the individual adjacent pulses and errors arise when interpreting the received signal. The total dispersion can be set at virtually any value as the contributions from different components may have opposite signs and hence they can partially, or completely, cancel each other. Dispersion compensating fibers can be either placed at one location or distributed along the length of the fiber link. Typically, dispersion management must consider single mode fiber chromatic and polarization mode dispersion over a range of wavelength. We design the dense WDM system for broadband spectrum at central wavelengths in the region of 1550 nm. This method offers almost negligible dispersion by using RZ pulse generator and also reducing the jitter portion in the eye diagram. This method also offers high value of Q-factor and reduced BER in long haul optical communication networks.**

***Keywords*—Chromatic dispersion, PMD, DCF, Q-factor, BER, threshold value, Dense WDM.**

I. Introduction

To use the available bandwidth in optical communication systems different multiplexing techniques are adopted, so that multiple users can access and use the bandwidth efficiently. The most common techniques are frequency division multiplexing, time division multiplexing, optical code division multiplexing, wave length division multiplexing and dense wavelength division multiplexing.

In FDM, users share the bandwidth according to the frequencies allotted to them, therefore, for a given bandwidth the number of users to access the bandwidth and use for communication are limited. TDM allows users to share bandwidth according to the time slots allotted to them. This is an efficient technique. But the electronic devices required for multiplexing and de-multiplexing channels become bottleneck .

WDM allows the users to share bandwidth according to the wave lengths assigned to them. This technique has been used for long and is one the most common techniques for optical communication but it has low spectral efficiency as it uses wide range of wavelengths. WDM network offers everlasting demand for bidirectional information transmission. The systems are immune to interference and offers very large Bandwidth, Flexibility and very high level of reliability. However some parameters like attenuation, Dispersion, Coupling and bending losses degrades its performance. Attenuation can b reduced upto zero level by processing the signal through power amplifiers as well as coupling and bending losses can be also be minimized by careful system design.

Usually the fiber dispersion includes intermodal dispersion and polarization mode dispersion. Dispersion is not a significant problem. PMD is the main limitation that confines the optical fiber transmission from utilizing the bandwidth efficiency. An improved methodology for dispersion compensation and Dense WDM system for broadband spectrum design is discussed in this work, which offers much better performance compare with NRZ pulse generator in long haul optical fiber networks.

II. SIMULATION SETUP

The Simulation model of transmitter and Receiver for optical fiber Communication is implemented on "OPTISYSTEM-7.0" software using 100 KM long Single mode fiber. Bit rate 2.5 Gaps. RZ pulse generator has maximum amplitude of 1 auk and duty cycle 1 bit. Both rise and fall time is 0.05 bit. A CW laser is taken as an optical source having frequency value of 193.1 THz with sweep power level 0 dBm. MZM have the Excitation ratio 30 dB and symmetry factor -1. The loop control system has 2 loops. The PIN photo detector have the Responsivity 1A/W and Dark current 10 and the down sampling rate is 800 GHz for the central frequency 193.4 THz considering thermal noise 2.048e-023 W/Hz. The Random seed index is 11 with the filter sample rate 5 GHz. A fourth order low pass Bessel filter is connected at the output having 100 dB depth and sweep value of Cut frequency "0.7*Bit rate" Hz.

An EDFA is considered having Gain and Noise figure of 20 dB, 4 dB respectively with power and saturation power level of 10 dBm, the noise BW is 13 THz and noise bin spacing is 125 GHz. For center frequency of 193.4 THz. SMF have the reference wavelength of 1550 nm with attenuation 0.25 dB/km, Dispersion 16 ps/nm/km and dispersion slope 0.08 ps/nm^2/km with β2=-20 ps^2/km and β3=0 ps^2/km. Differential group delay for PMD is taken 3ps/km with the PMD coefficient of 0.5 ps/km. To find the dispersion of transmission by using following formula.

$$L_{dcf} = |D_{tx}/D_{dcf}| * L$$

L_{dcf} for length of the dispersion compensating fiber, D_{tx} for dispersion of single mode fiber, D_{dcf} for dispersion of dispersion compensating fiber, L for length of the single mode fiber. A dispersion compensated fiber is used before the SMF. The total length of fiber channel is remains same, however it segmented in the ration of 1:5 i.e. 17 km DCF and 83 km SMF. The value of dispersion coefficient β2 for DCF fiber, is calculated here in terms of β1(dispersion coefficient for SMF) in such way so that after certain distance the total chromatic dispersion DT must be equal to zero.

The parameters for DCF are reference wavelength 1550 nm attenuation 0.6 dB/km, dispersion -80 ps/nm/km, dispersion slope -0.21 ps/nm^2/km, β2= -20 ps^2/km, Differential group delay 3 ps/km, PMD coefficient 0.5 ps/km, mean scatter section 50 m, scattering section dispersion 100, lower calculation limit 1200 nm, upper calculation limit 1700 nm, effective area 30 um^2, n2= 3e-020 m^2/w, Raman self-shift time 1 = 14.2 fes, Raman self-shit time 2 = 3 fes,. Raman contribution 0.18 and orthogonal Raman factor 0.75.

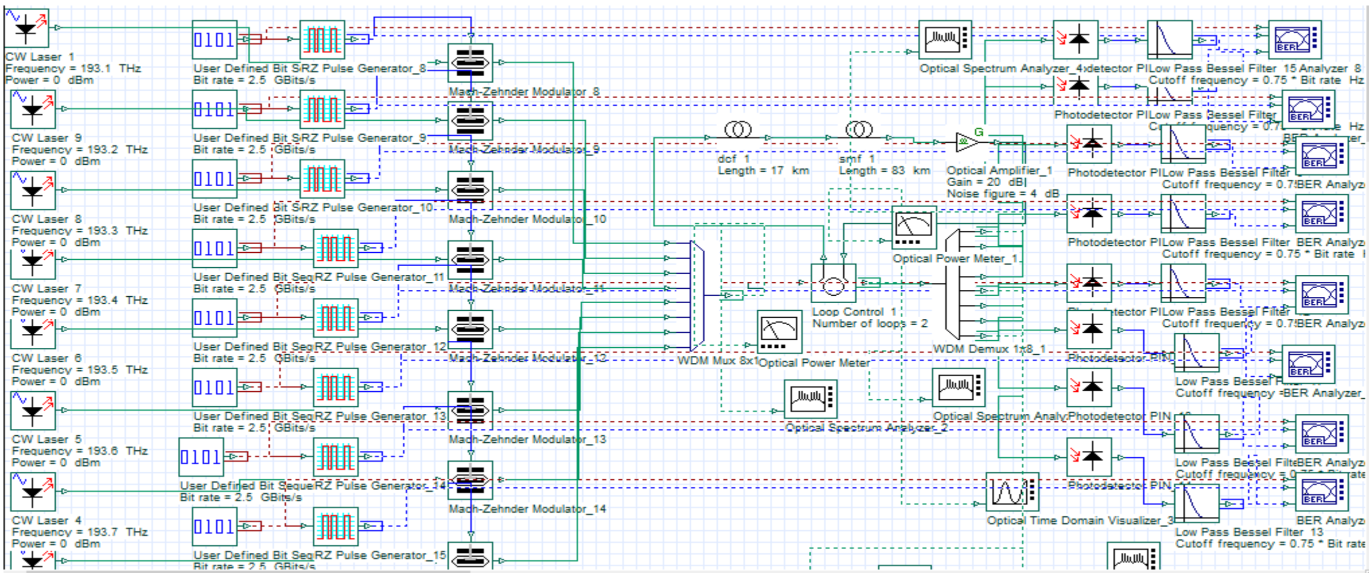


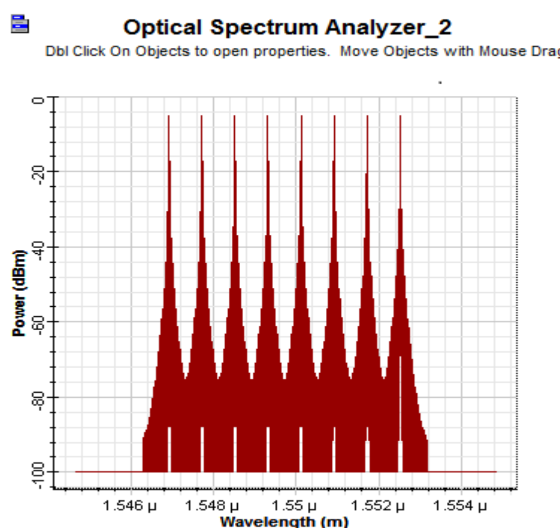
Figure 1: Simulation setup for 8-channel Dispersion Compensation Technique (DCF)

In this model we design dense wavelength division multiplexing (DWDM) having channel spacing 0.8nm and 8-channels. In this model MUX and DEMUX have bandwidth 10GHZ, depth 100dB and a second order Bessel filter. In dense WDM system channel spacing should be 0.8nm and number of channel can be increased up to any extent by using minimum channel spacing.

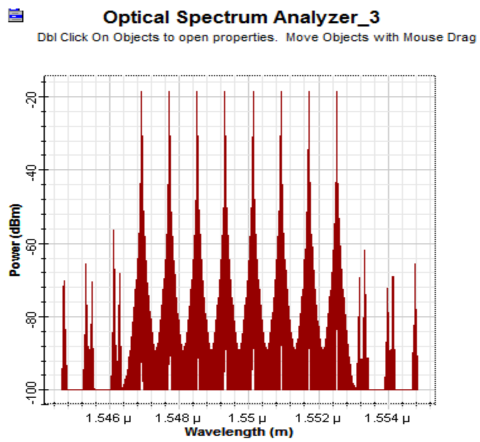
III. RESULT AND DISCUSSION

a) Spectrum analysis

Broadband spectrum of an optical fiber determines the data rate. The mechanism that limits a fiber's bandwidth is known as dispersion. Optical spectrum analyzer(OSA) can divide a light wave signal into its constituent wavelength. This means that it is possible to see the spectral profile of the signal over a certain wavelength range. In this way, the many signals combined on a single fiber in a dense wavelength division multiplexing(DWDM) system can be taken apart to perform per-channel analysis of the optical signal and its spectral interaction with the other wavelength.



(a) Transmitted spectrum



(b) Received spectrum

Figure 2.power vs wavelength

The transmitted and received spectrums are shown in the fig.(2) for DCF system which shown that spectrum does not decrease due to other nonlinear effects thus, DCF method offers better broad spectrum for wavelength routed channel.

b) Eye diagram analysis

The use of eye diagram is a traditional technique for quickly and intuitively assessing the quality of a received signal and also a common indicator of performance in digital transmission system. Modern bit error rate measurement instruments construct such eye diagram by generating a pseudorandom pattern of ones and zero's at uniform rate but in a random manner. When the pulses in this pattern are superimposed simultaneously an eye pattern is formed. The eye diagram is an oscilloscope display of a digital signal, repetitively sampled to get a good representation of its behavior.

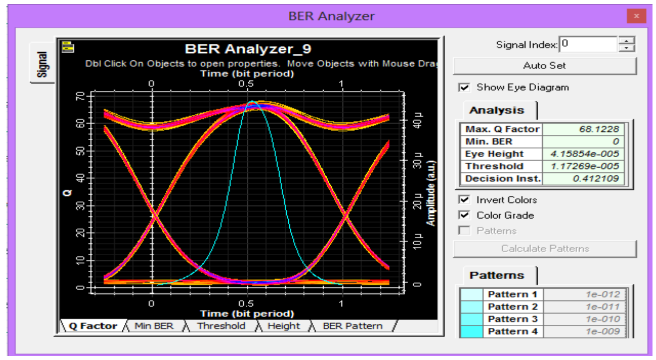


Fig. (a) channel 1

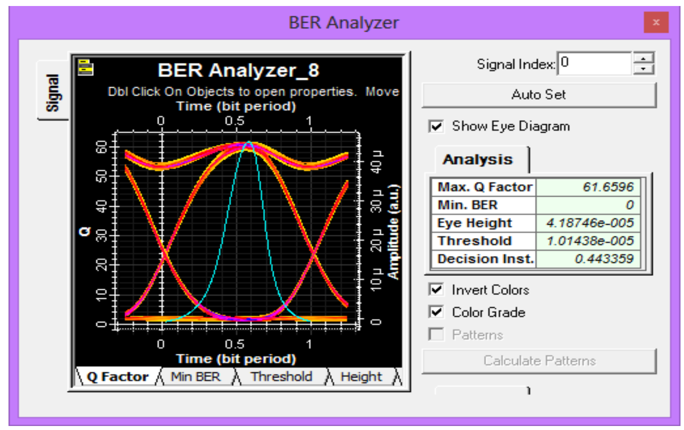


Fig. (b) channel 2

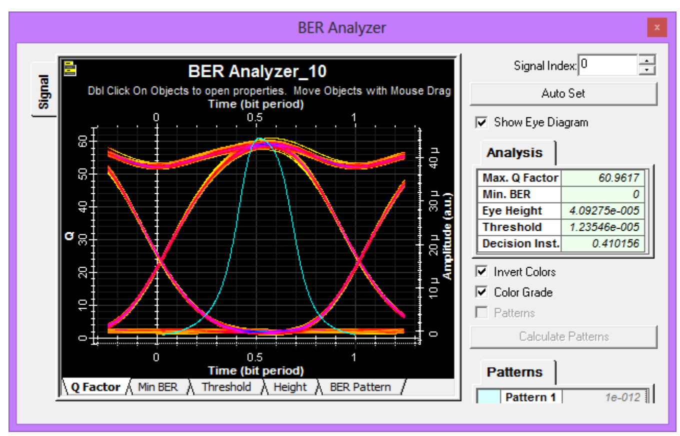


Fig. (c) channel 3

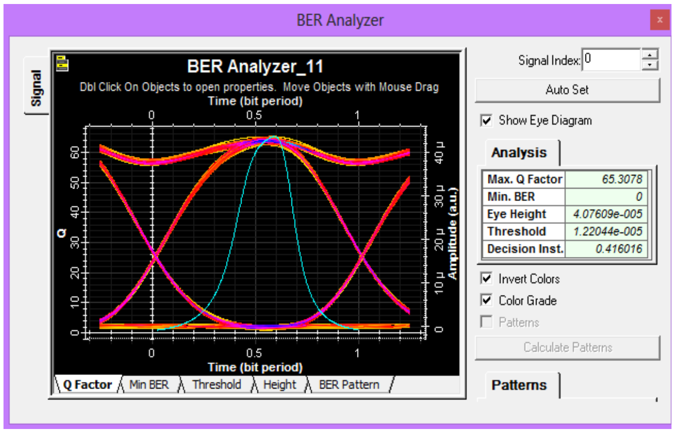


Fig. (d) channel 4

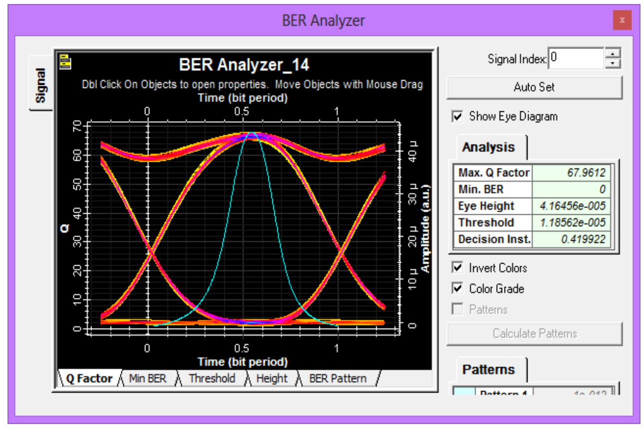


Fig. (g) channel 7

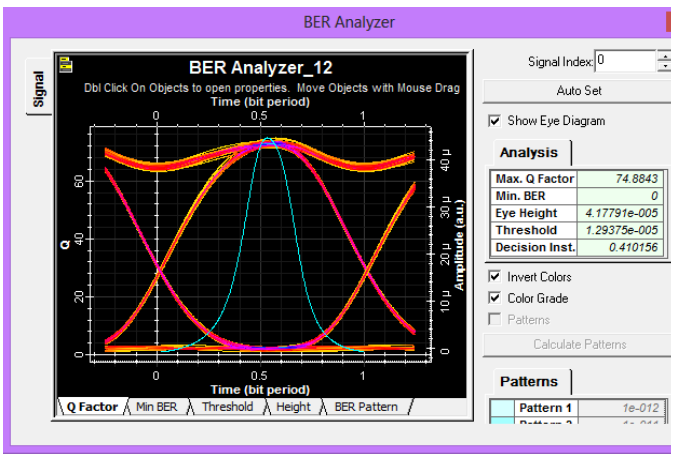


Fig. (e) channel 5

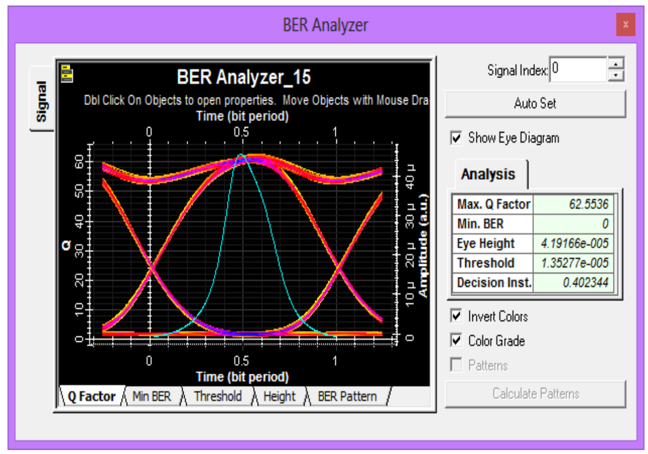


Fig. (h) channel 8

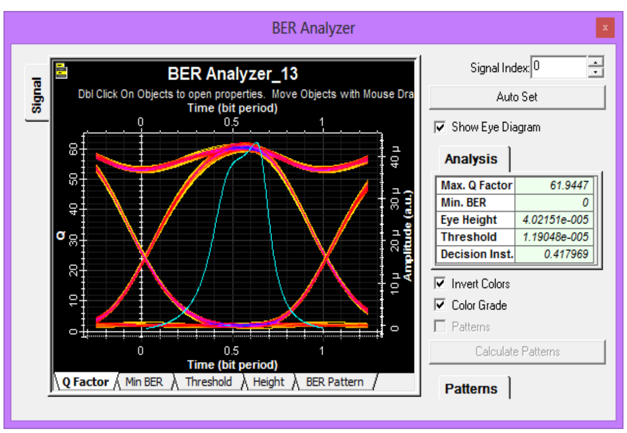


Fig. (f) channel 6

Fig. 3 Eye diagram analysis for eight channels

c) Graph analysis:

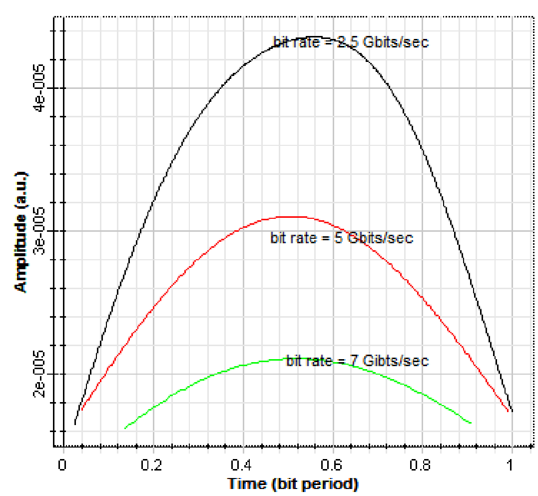


Fig. (a) Eye Amplitude

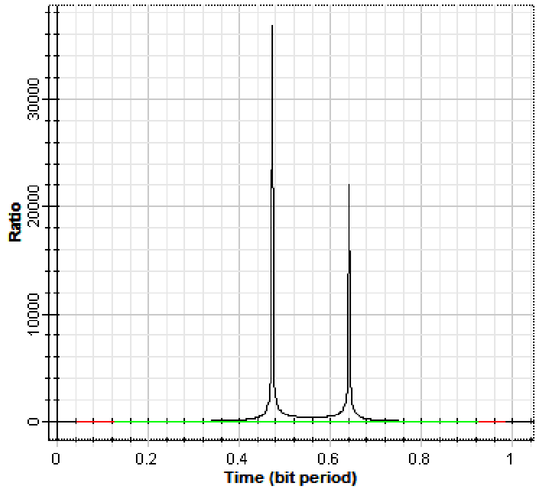


Fig. (b) Eye extinction ratio

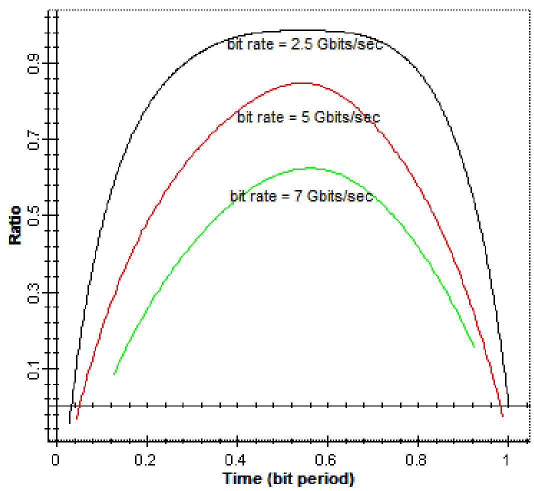


Fig. (c) Eye opening

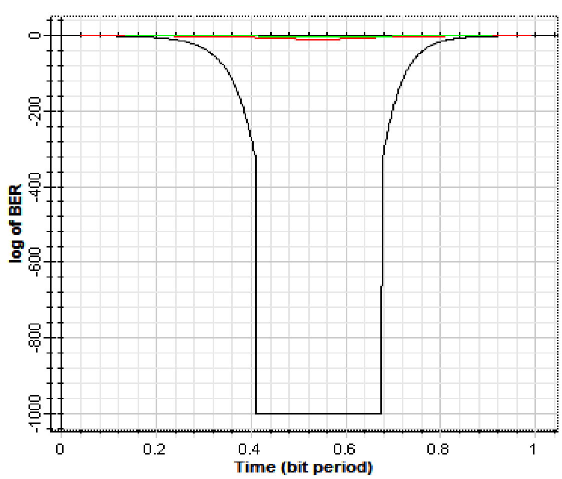


Fig. (d) Min BER

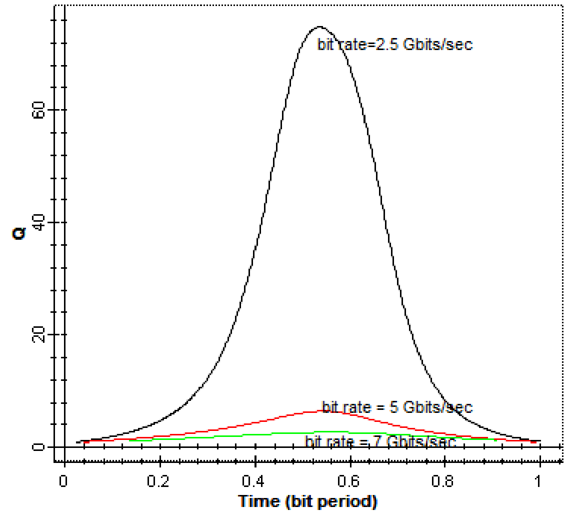


Fig. (e) Q factor

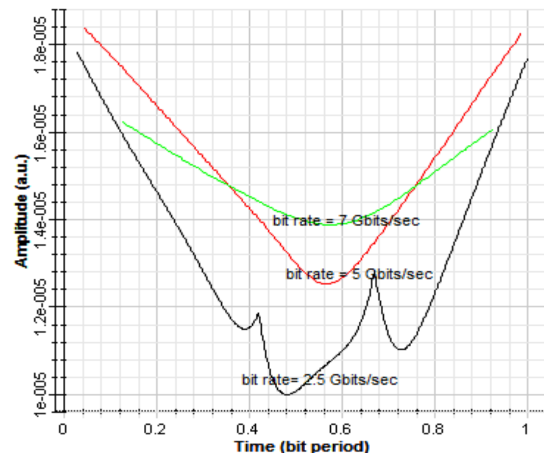


Fig. (f) Threshold at Min. BER

Fig. 4 Graph analysis for 4th channel

As seen from the figure 4 (a) to (f) graph analysis for 4th channel. The bit rate values are 2.5, 5 and 7 Gbits/sec. In 2.5 Gbits/sec best for eye amplitude, eye opening, Min. BER, extinction ratio and Q factor compare with 5 and 7 Gbits/sec in length of the fiber 200 km and also best for RZ modulator compare with NRZ modulator.

IV. COMPARISION TABLE

parameters	NRZ modulator	RZ modulator
No. of channel	8	8
Q- factor	Ch1 =8.27 Ch2 =8.45 Ch3 =8.66 Ch4 =8.47 Ch5 =8.36 Ch6 =7.78 Ch7 =7.52 Ch8 = 7.72	Ch1 =61.65 Ch2 =68.12 Ch3 =60.96 Ch4 =65.30 Ch5 =74.88 Ch6 =61.94 Ch7 =67.96 Ch8 =62.55
Min. BER	Ch1 =4.12e-017 Ch2 =2.21e-017 Ch3 =2.24e-018 Ch4 =2.06e-017 Ch5 =2.90e-017 Ch6 =3.40e-015 Ch7 =2.71e-014 Ch8 =5.51e-015	
Received power	23.532e-6w	182.2e-6w

V. CONCLUSION

In this work, an improved methodology “The DCF Technique” for dispersion compensation by using RZ pulse generator in DWDM for broadband spectrum is discussed. This method offers improved value of performance parameters such as Q-factor, Min.BERand received power value. During the analysis of simulation result it is also observed that BER pattern is much better than NRZ pulse generator.

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