

# Optimization of Bit Error Rate and Q-factor in Fiber Optic Communication using Dense WDM

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## Abstract

In telecommunication, a method for working dispersion that combines two or more types of single mode fiber to create the preferred dispersion over the whole link span has been offered. The total dispersion can be set at virtually any value as the contributions from different components may have opposite signs (i.e. either positive or negative) and hence they can partially, or completely, terminate each other. Dispersion-compensating fibers can be either placed at one location or distributed along the length of the fiber connection. Typically, dispersion management must consider single-mode fiber chromatic and Polarization mode dispersion (PMD) dispersion over a range of wavelengths. We design the dense WDM system signals at central wavelengths in the area of 1550 nm. This method offers almost negligible dispersion by reducing the jitter portion in Eye diagram. This method also offers high value of Q-factor and reduced BER in long haul optical communication networks.

## Keywords

BER improvement, Modulation techniques, Optimization, NRZ, Chromatic dispersion, PMD, DCF, Q-factor, Threshold value, Dense WDM.

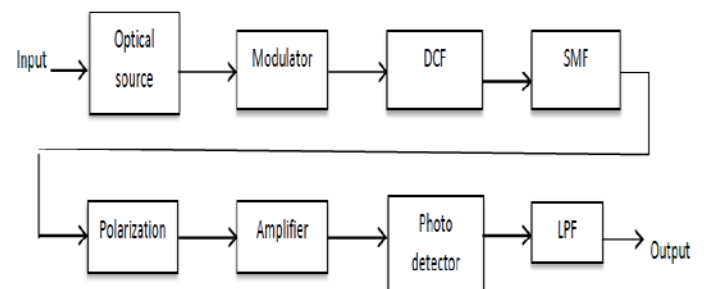
## 1. Introduction

WDM Networks deals with everlasting demand for bidirectional Information transmission. These systems are Immune to Interference and offers very large Bandwidth, Flexibility and very high level of reliability. However s Some parameters like Attenuation, Dispersion, Coupling and bending losses degrades its performance. Attenuation can be reduced up to zero level by processing the signal through power amplifiers as well as coupling and bending losses can also be minimized by careful system design. The enormous bandwidth of optical fiber provides a potential to transmit signal at very high speed, yet this bandwidth cannot be fully utilized a significant reason is the fiber dispersion. Usually the fiber dispersion includes intermodal dispersion and polarization mode dispersion (PMD). In single mode fiber intermodal dispersion is low & the system used today intermodal dispersion is not a significant problem. Polarization mode dispersion (PMD) is the main limitation that confines the optical fiber transmission from utilizing the bandwidth efficiency. However Dispersion is the main parameter which needs to be compensated for faithful signal transmission Fiber Bragg's Grating is one of the solution to compensate it, but only up to a certain level. But by using DCF technique we can minimize intermodal dispersion as well

as Polarization mode dispersion (PMD). So this technique increases the performance of the system parameters.

## 2. System Model

Block diagram of the system model



## 3. Previous Work

In 2012 Amemiya et al evaluated the details of a system that transfers a frequency standard over optical fiber to distant locations and allows for a large number of users through optical amplification and distribution. They assumed a hydrogen maser-class device as the specific standard signal

source, and described four devices, a transmitter with phase compensation, an optical receiver, a bidirectional optical amplifier, and an optical amplified distributor, needed to send and receive without loss of the original stability, and also described the characteristics of this configuration. They also evaluated a method allowing improved suppression of amplitude fluctuations and improved phase linearity, which are important when integrating the doubled harmonics wave using a mixer under the proposed method.

**In 2012 Bobrovs et al** implemented an experimental high-speed DWDM-PON system solution where different types (DCF and FBG) of accumulated CD compensation configuration are used for pre-compensation or post-compensation. The maximum achievable reach improvement of DWDM-PON system using proposed CD compensation methods and two different DCM unit positions (before and after SMF fiber span) have been investigated. The possible transmission length of realized DWDM-PON system without CD compensation was 57 km, but it has been shown that using appropriate CD compensation methods (DCF and FBG) system maximum transmission reach can be improved.

**In 2013 Peng et al** proposed a new infrastructure as a service architecture utilizing optical network virtualization. They introduced novel PLI-aware VON composition algorithms suitable for single-line-rate (SLR) and mixed-line-rate (MLR) network scenarios. A replanting strategy is proposed for the MILP mapping method in order to increase its efficiency. In the MLR networks, a new virtual link mapping method suitable for the MLR network scenario and two line rate distribution methods were proposed. With the proposed PLI-aware VON composition methods, multiple coexisting and cost-effective VONs with guaranteed transmission quality can be dynamically composed.

**In 2013 Khan et al** Designed and verified a high capacity optical fiber communication system through simulation. They simulated a 40 Gbps single optical fiber link for telecommunication traffic transmission which could be possible to implement in developing countries with few modifications in their existing optical fiber transmission link. They used soft-Opti Sim commercial software to simulate it. Designed single optical fiber link length was 1000 km and the bit error rate found was  $4.29 \times 10^{-10}$ . Next, they used 8 channels WDM system in this link to get higher data transmission capacity which was 320 Gbps and the center channel i.e. 1550 nm, bit error rate found was  $2.7362 \times 10^{-12}$ .

#### **4. Proposed Methodology**

##### **Dispersion Compensation Methodology-**

Dispersion management refers to the approaches to circumvent the transmission degradations caused by different types of single mode optical fiber and other nonlinear passive optical devices. Hence multiple sections of constant dispersion single-mode fiber and dispersion-compensating elements whose lengths and group velocity dispersion are chosen to optimize the overall transmission performance of an optical fiber communication system are usually employed.

The Simulation model of transmitter and Receiver for optical fiber Communication is implemented on "OPTISYSTEM-7.0" software using 200 KM long Single mode fiber. A sequence generator with sequence =10101100, Bit rate 2.5 Gbps is considered. NRZ pulse generator has maximum amplitude of 1 a.u. and 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 13 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 1 A/W and Dark current 10 nA the down sampling rate is 800 GHz for the central frequency 193.1 THz considering thermal noise  $2.048 \times 10^{-23}$  W/Hz. The Random seed index is 11 with the filter sample rate 5 GHz.

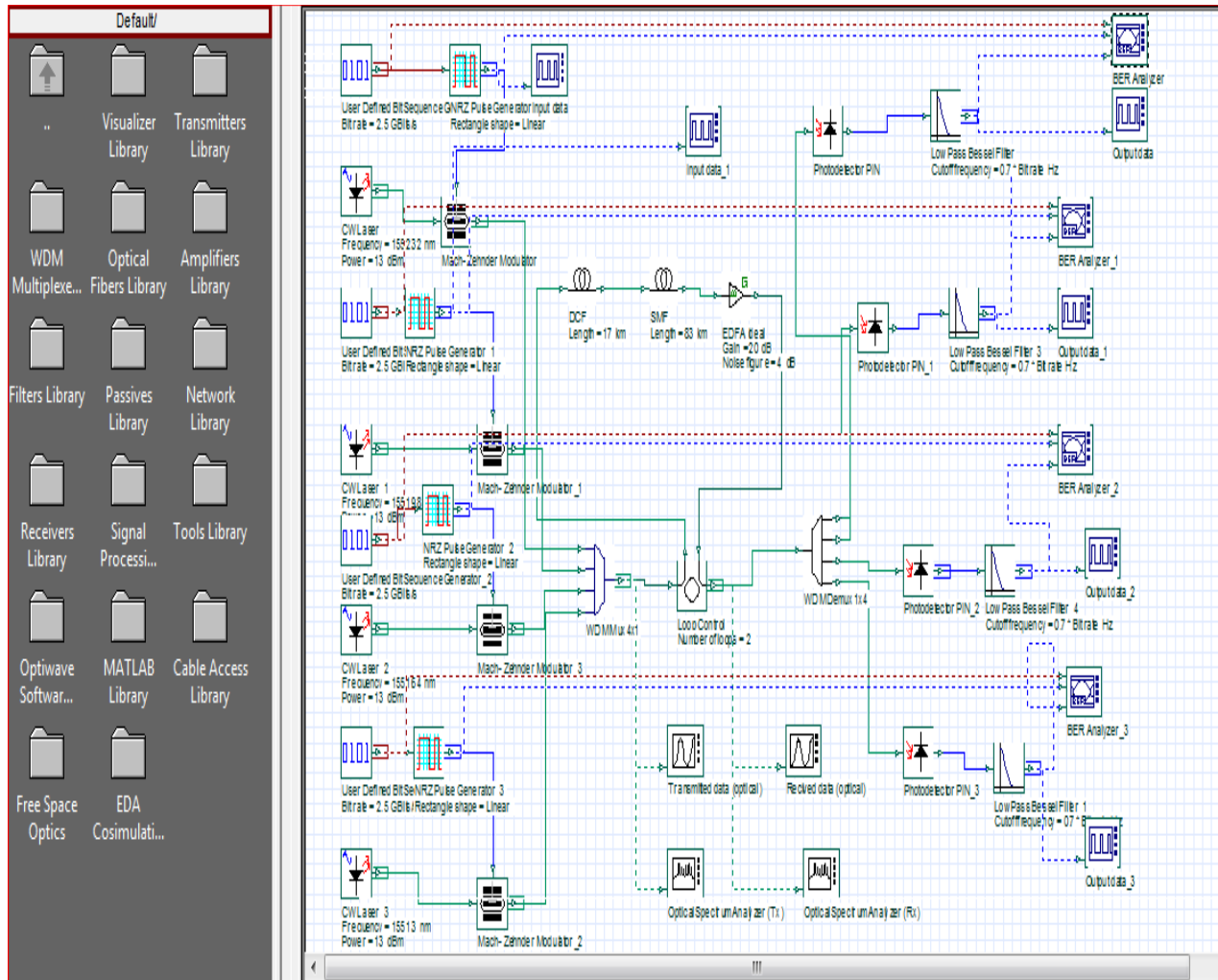
In this model we design dense wavelength division multiplexing (DWDM) having channel spacing 0.5nm. In this model MUX and DEMUX have bandwidth 10GHz, depth 100dB and a second order Bessel filter. In dense WDM system channel spacing should be 100GHz to 12.5 GHz (0.1nm to 0.8nm at 1550nm) and number of channel can be increased up to any extent by using minimum channel spacing.

#### **5. Simulation/Experimental Results**

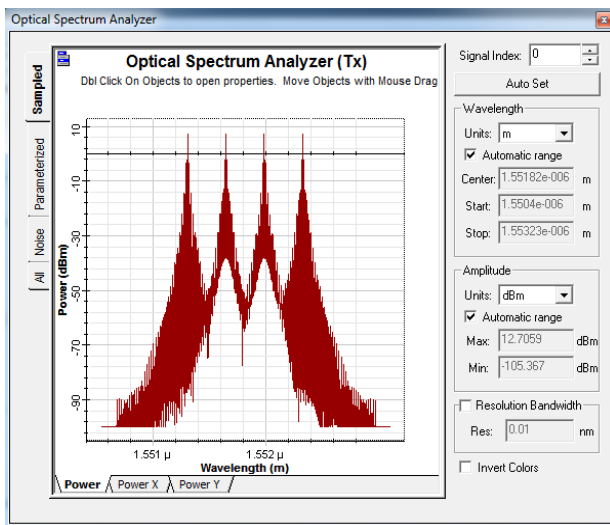
##### **Result and Discussion**

##### **Spectrum analysis**

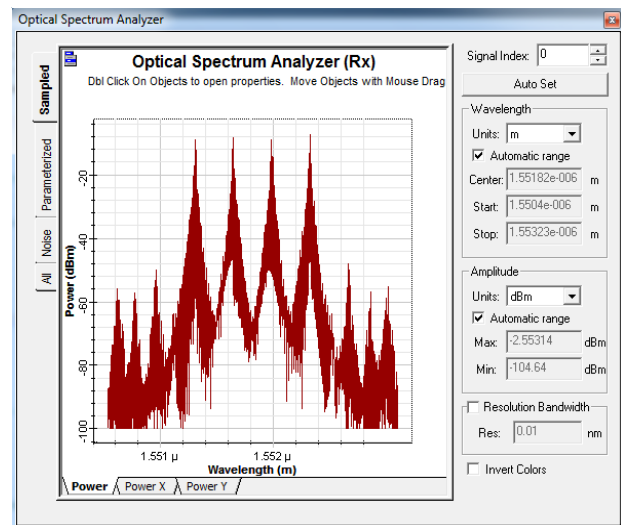
Bandwidth of an optical fiber determines the data rate. The mechanism that limits a fiber's bandwidth is known as dispersion. Dispersion is the spreading of the optical pulses as they travel down the fiber. Optical spectrum analyzers (OSA) can divide a light-wave signal into its constituent wavelengths. This means that it is possible to see the spectral profile of the signal over a certain wavelength range. The profile is graphically displayed, with wavelength on the Vertical axis and power on the Horizontal axis. 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 wavelengths.



Simulation model for 4-channel Dispersion Compensation Technique (DCF)



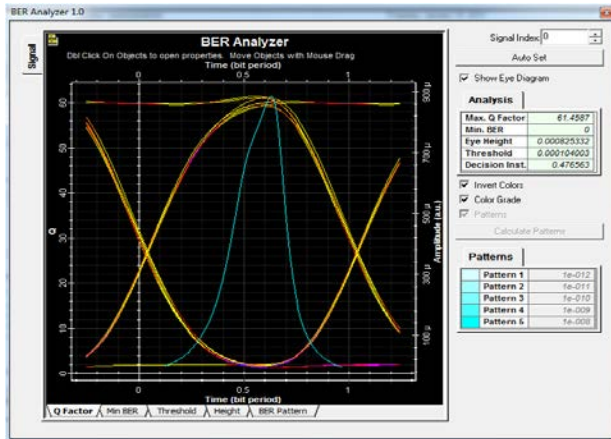
(a) Transmitted spectrum



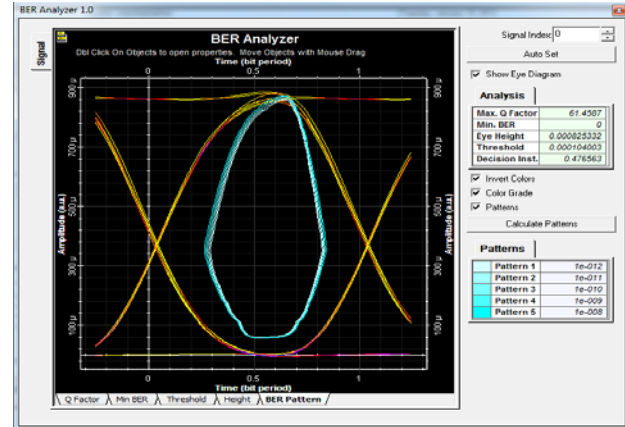
(b) Received spectrum

Figure : Power vs. wavelength of proposed model

## Eye diagram analysis for first channel

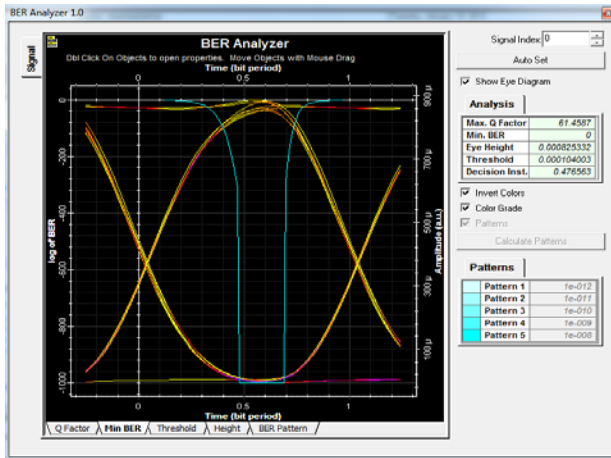


(a)



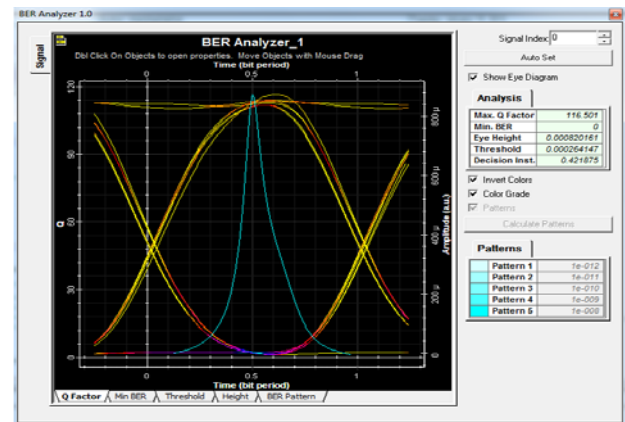
(d)

Eye diagram analysis with reference to (a) Q-factor (b) Min BER (c) Threshold value (d) BER Pattern

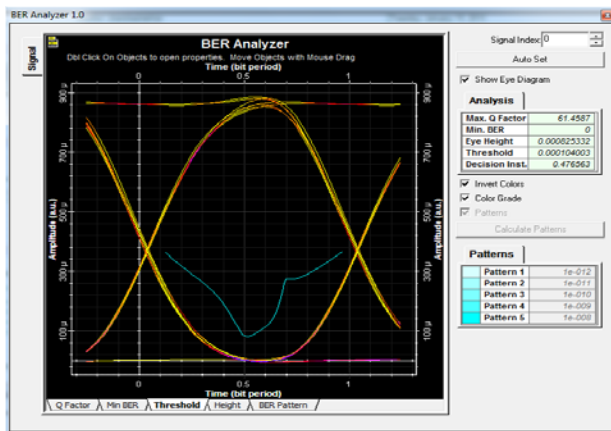


(b)

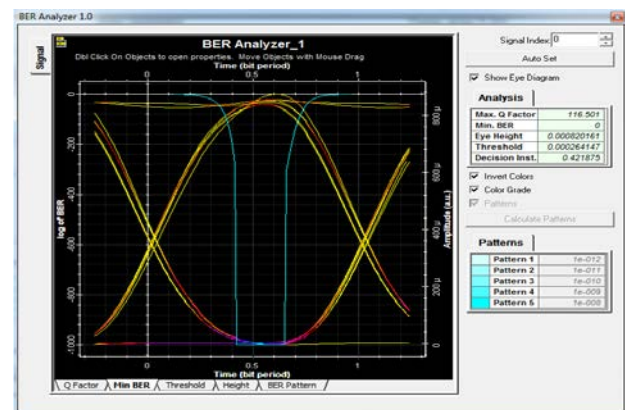
## Eye diagram analysis for second channel



(a)

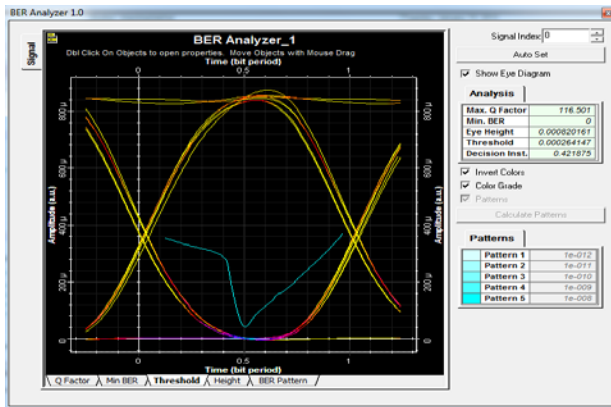


(c)

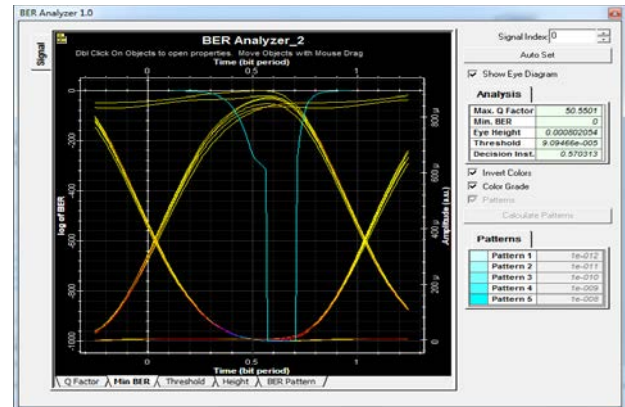


(b)

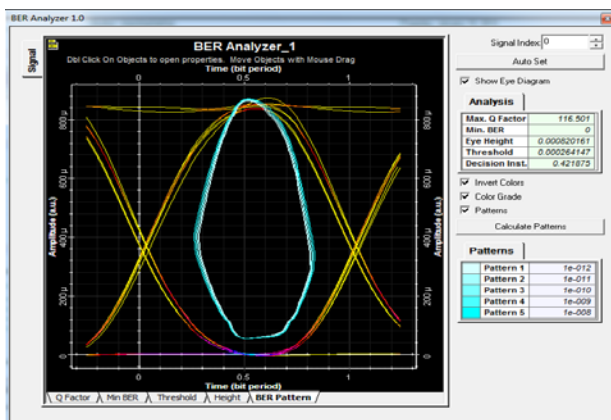




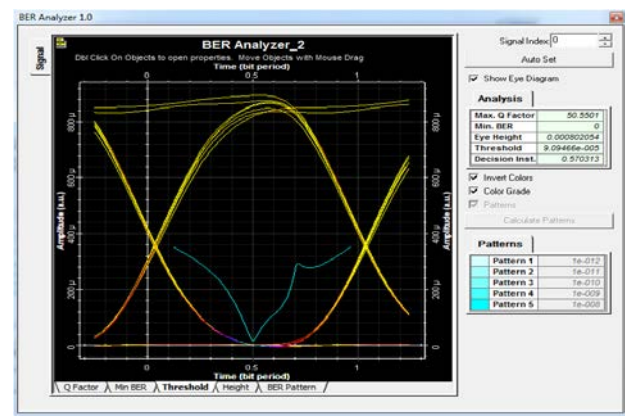
(C)



(b)



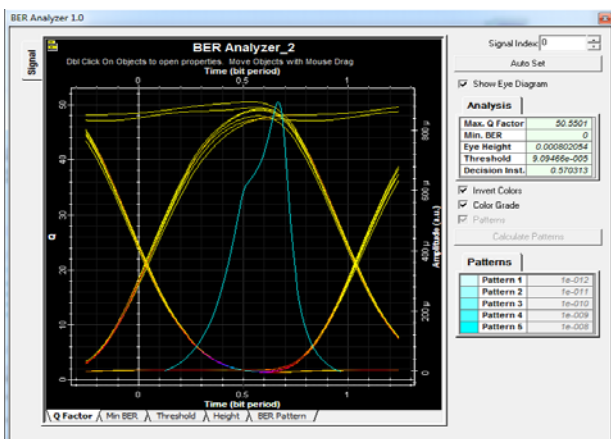
(d)



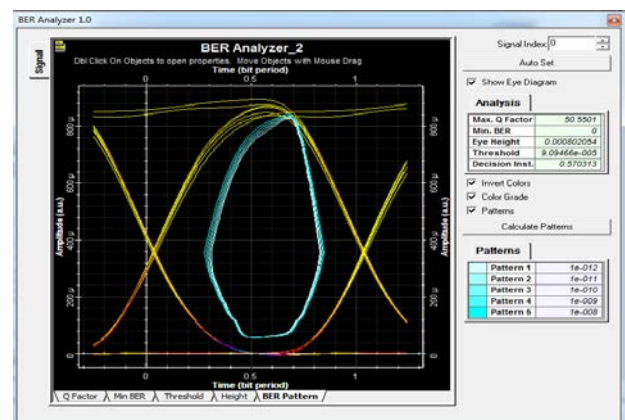
(c)

Eye diagram analysis with reference to (a) Q-factor (b) Min BER (c) Threshold value (d) BER Pattern

### Eye diagram analysis for third channel



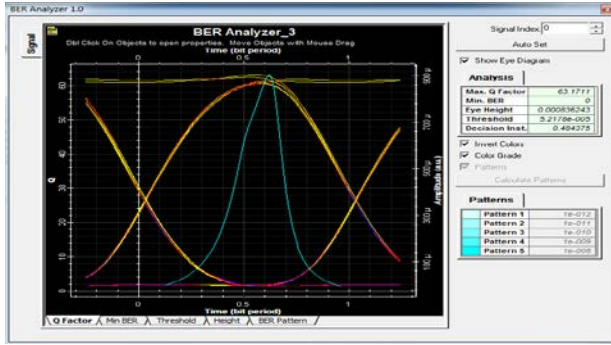
(a)



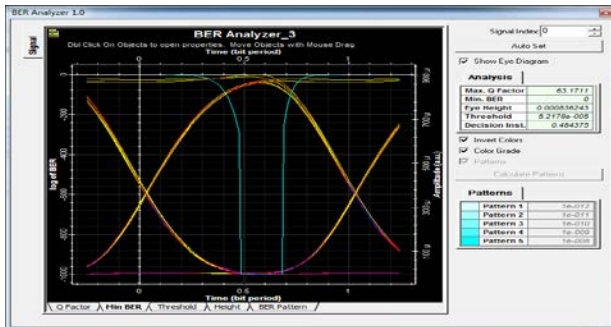
(d)

Eye diagram analysis with reference to (a) Q-factor (b) Min BER (c) Threshold value (d) BER Pattern

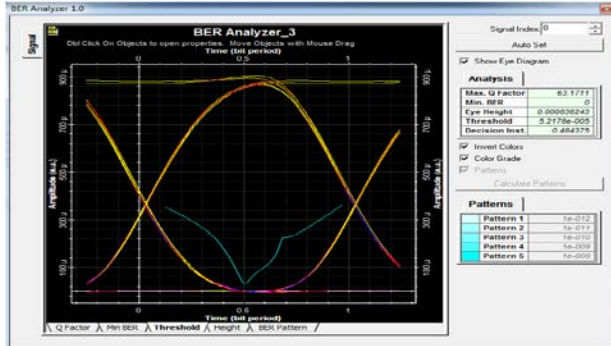
### Eye diagram analysis for fourth channel



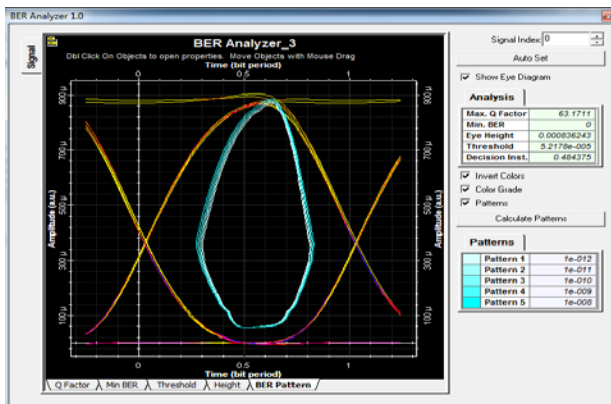
(a)



(b)



(c)



(d)

Eye diagram analysis with reference to (a) Q-factor (b) Min BER (c) Threshold value (d) BER Pattern

### Comparison Table

S. No.	Parameters	Reference Model	Proposed Model
1	No. Of Channel	1	4
2	Q-Factor	44.1695	Channel 1 = 61.4587 Channel 2 = 116.5010 Channel 3 = 50.5501 Channel 4 = 63.1711
3	Min. BER	0	Channel 1 = 0 Channel 2 = 0 Channel 3 = 0 Channel 4 = 0
4	Power (dBm)	15	13
5	Distance (Km)	50	200
6	Dispersion	Present	Negligible
7	Channel Spacing(nm)	----	0.34

### 6. Conclusion

This method offers improved value of performance parameters such as Q-FACTOR, MIN BER and THRESHOLD value.. These parameters will be improved by minimizing dispersion in the system model. In the Proposed method dispersion compensation fiber (DCF) Technique is used to minimize dispersion and to increase system parameters compared to other compensation technique and reference model . During the analysis of simulation result it is also observed that BER pattern is much better than other available methods for dispersion compensation. Eye diagram shows better value of THRESHOLD and HIGHT which alternatively results in reduced jitter.

### 7. Future Scopes

- DCF Technique can be used for higher bit rate transmission above 100 GHz range in OFDM Networks, where synchronization is a serious issue.

- Dispersion free optical fiber channel can be obtained with some future work on proposed technique.
- SA noise free transmission can be obtained in future with adequate system design using DSP analysis.
- Available jitter portion in the Eye-diagram can be minimized up to zero level with some changes in system design.

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## Author's Profile



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