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Performance Analysis of DWDM System Having 0.8-Tbps Date Rate with 80 Channels

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Abstract

Objectives: The main aim of this research paper is to design a 80 channel DWDM system with each channel having 10 Gbps data rate multiplexed with frequency spacing 100 GHz. Methods/Statistical analysis: Dispersion is an important factor to be considered while designing a DWDM system. Dispersion affects the penalties due to various types of fiber nonlinearities. Single mode fiber is preferred for long distance communication over Multimode fiber. In this proposed work Optisystem 7.0 simulator is used to analyze dispersion effect. The system performance is optimized by using Dispersion compensation fiber to compensate for the dispersion produced by single mode fiber. **Findings:** The system performance is limited by the dispersion. In order to compensate this we have used Dispersion compensation fiber. Between amplifier spans is standard single-mode fiber, but at each amplifier location, dispersion compensating fiber having a negative chromatic dispersion is introduced. By using this we have successfully designed a DWDM system with 80 channels each 10 Gbps data rate multiplexed with frequency spacing 100 GHz. **Application/Improvements:** It is realized that, in coming future, DWDM can emerge as a promising technique to increase the capacity and meet the bandwidth requirement. This work can further be extended to more number of channels i.e. 100 channels or more with even smaller frequency spacing.

Keywords: Dispersion Compensating Fiber (DCF), Bit Error Rate (BER), Dense Wavelength Division Multiplexing (DWDM)

1. Introduction

In the recent years, the growth in the internet activities like E-mail, audio-video conferencing, multimedia services, has increased greatly. There has been a great demand in the increase in data rate due to increase of use of large bandwidth applications and internet, thereby putting a lot of pressure on TDM to stretch its limits. It has become quite clear that as we are approaching 21st century, our society will be inhabited by the need of information services. In the past, communication only meant voice calls. But now the entire definition of communication has changed. Communication now corresponds to not only a demand of high quality voice but also video calling, text messaging, transfer of data files, videos and a lot more. Every human activity now depends on reliable and rapid communication networks[5]. This has led to an increase in demand for higher data rates for high speed internet services[1]. In order to meet these increasing data rate, the increase in bandwidth is the only solution. The bandwidth can be increased in by installing more number of cables, increasing system bit rate to multiplex more signals or multiplex different wavelengths (DWDM).

In order to meet this growing demand of bandwidth, a technique which combines various wavelengths together called as Dense Wavelength Division Multiplexing (DWDM) is developed. It is used to increase fiber's capacity[2].

It is a technique allowing multiple wavelengths to be transmitted simultaneously over a single fiber, thereby allowing carriers to increase the data rate by using already laid single fiber. Each information stream is transmitted on a unique wavelength. All the wavelengths are combined by using a mux[15]. DWDM uses an optical signal

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which carries multiple wavelengths carrying user data on each wavelength. DWDM system can handle more number of users per wavelength. But dispersion compensation plays a key role in DWDM at bit rate greater than 10 Gbps. It can be compensated by using dispersion compensating fiber[3]. WDM systems suffer from four wave mixing effect. Due to this reason, non-zero dispersion-shifted fibers are preferred. Four wave mixing effect can be minimized using OPC and dispersion compensating fibers[13].EDFA's are used in addition to DCF's to amplify and regenerate the optical signal. The mix- compensation performance is the best[8].

For long distances, Erbium-Doped Fiber Amplifier (EDFA) is preferred[6]. If EDFA is placed before SMF, it is called pre compensation and if it is used after SMF, it is called post compensation. Both these techniques can be combined to produce and deliver a good quality of optical signal at the transmitter[7]. The noise figure and gain depends on fiber length for an EDFA[11].

Fiber Bragg grating (FBG) is playing significant role in optical fiber communication as filter, stabilizer, gain flattening filter, dispersion compensator, optical router etc[14]. Furthermore, it is also used as sensor for sensing temperature, pressure and strain etc. The FBG is a special form of optical fiber where the refractive index of the core is variable[12]. As a result, the wavelength response of the fiber changes and various applications emerge[10].

2. Simulation Setup

Figure 1 shows the simulation setup of an 80 channel DWDM setup. In this set up, at the transmitter side we have used WDM transmitter and WDM mux. The Bit rate used is 10 Gb/s. The channel consists of Optical fiber, loop control, dispersion compensating fibers and EDFA's. The optical channel has two optical fibers of 25 km length, so a total fiber of 50 km is used. Various EDFA's are used to improve the quality of the signal. In addition, Dispersion compensating fiber is also used to tackle the dispersion on the channel. The receiver side consists of WDM demux, optical receivers and BER analyzers for the analysis of WDM link. This entire set up is implemented and analyzed using "Optisystem 7.0".

2.1 Transmitter

A transmitter is that component of a DWDM system which generates the different wavelengths for different channels and multiplexes them or combines them on to a single fiber. The WDM transmitter here generates 80 different wavelengths for 80 different channels with frequency spacing 100 GHz. The optical signal is transmitted at a frequency of 1555 nm with power 5dbm with NRZ type of modulation. These 80 different wavelengths are multiplexed using WDM mux. The various parameters used at the transmitter side are as shown below and are taken from simulation on optisystem software.

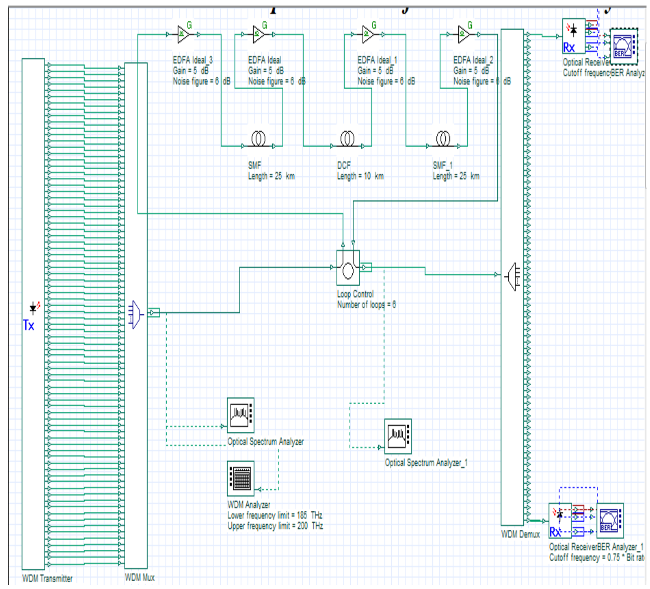

Figure 1. Structure of an 80 channel DWDM system.

Table 1. Simulation Parameters of WDM Transmitter

Parameters	Value
Frequency	1555 nm
Frequency spacing	100 GHz
Power	5dBm
Extinction ratio	30dB
Modulation	NRZ

2.2 Optical Channel

The multiplexed optical signal consisting of all the 80 wavelengths is transmitted over the channel. The optical channel consists of two single mode fibers of 25 km length so the total length is 50 km. We have used Dispersion compensating fiber to counter the dispersion occurring in the system. The optical signal is amplified at various intervals of distance by using EDFA's. For this various EDFA's and DCF are used in such an arrangement that a

SMF have an EDFA both in front and back. The various parameters of Optical channel used are as shown below:

Table 2. Simulation parameters of EDFA

Parameters	Value
Operation mode	Gain control
Gain	5dB
Power	10dBm
Noise figure	6dB

Table 3. Simulation parameters of SMF and DCF

Parameters	Value
Length	25 km
Attenuation	0.2 dB/km
DCF length	10 km
Attenuation	dB/km

2.3 Receiver

The receiver consists of WDM de-mux which de-multiplexes or separates the multiplexed signal into its constituent wavelengths. In addition to de-mux, the receiver also has optical receiver and a BER analyzer. The BER analyzer is used to analyze the various parameters of WDM link such as BER, Q factor, eye height etc. Various parameters used at receiver in optisystem software are as shown below:

Table 4. Simulation parameters of WDM de-mux and optical receiver

Parameters	Value
Bandwidth	80 GHz
Responsivity	1 A/W
Cut off frequency	0.75*bit rate

3. Result and Discussion

By using the dispersion compensating fiber as dispersion compensator, we have optimized and established an 80 channel DWDM link. The min. BER is found to be 1.24865e-087 and Q factor is found to be 19.8088 on channel 1 as shown in Figure. 2. The eye diagram in fig. 3 shows the Q factor to be 14.5085 and BER to be 5.33659e-048. The eye diagram and other parameters for channel no. 1,8,16,24,32,40,48,56,64,72,80 are analyzed and as shown from Figure. 2 to 12. A summarized table is also given at the end to show the results. All these figures and tables are the result obtained from optisystem simulator.

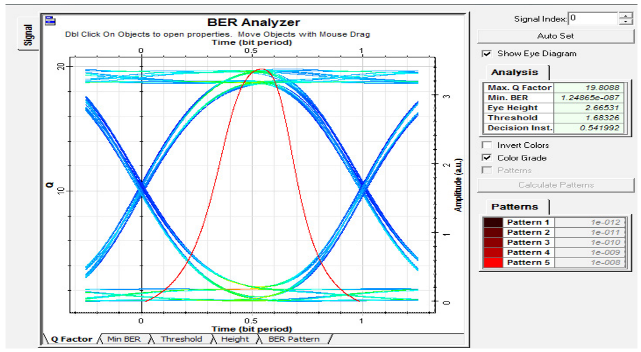

Figure 2. Eye diagram analysis of first channel.

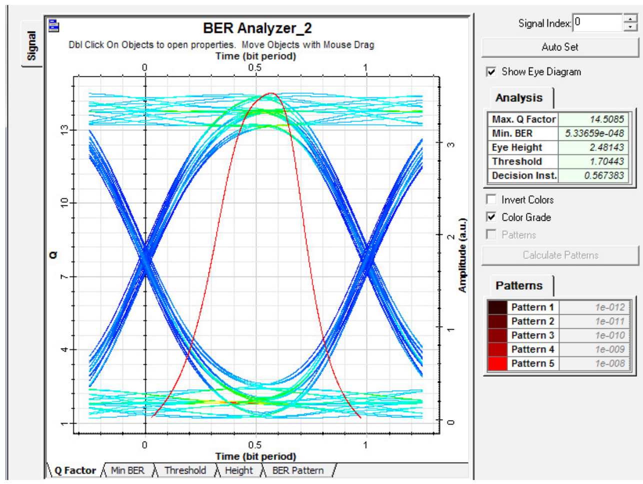

Figure 3. Eye diagram analysis of eighth channel.

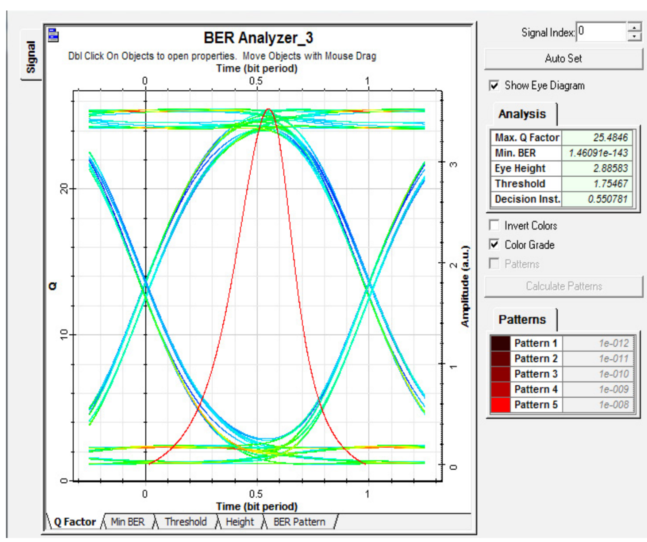

Figure. 4. Eye diagram analysis of sixteenth channel.

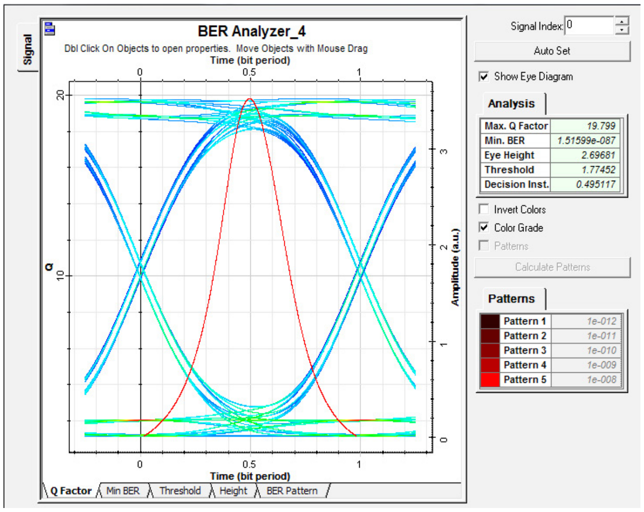

Figure 5. Eye diagram analysis of twenty fourth channel.

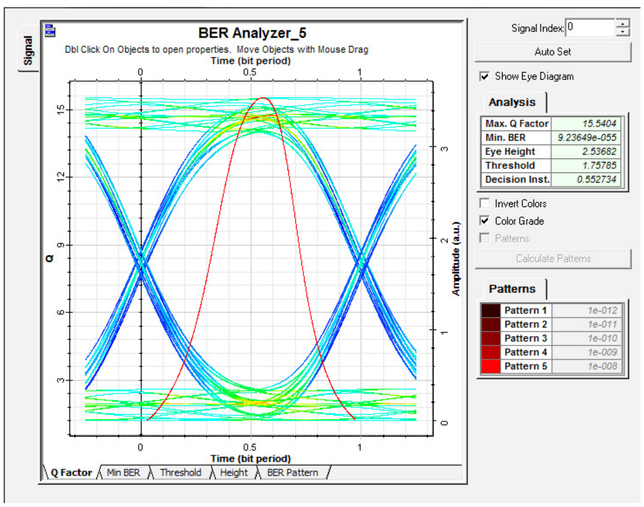

Figure 6. Eye diagram analysis of thirty second channel.

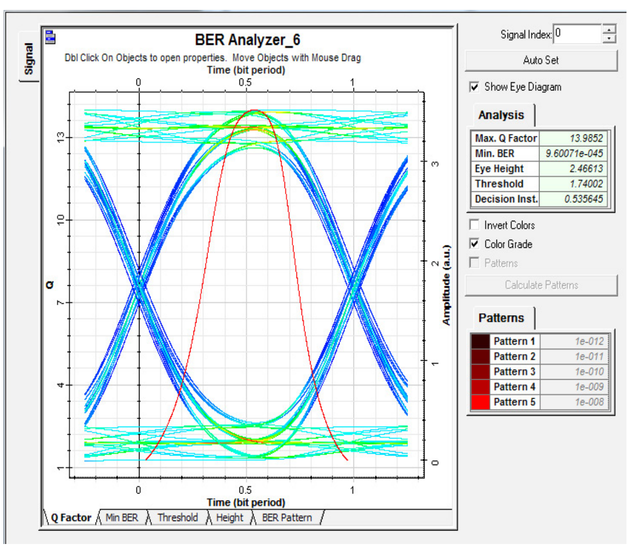

Figure 7. Eye diagram analysis of fourth channel.

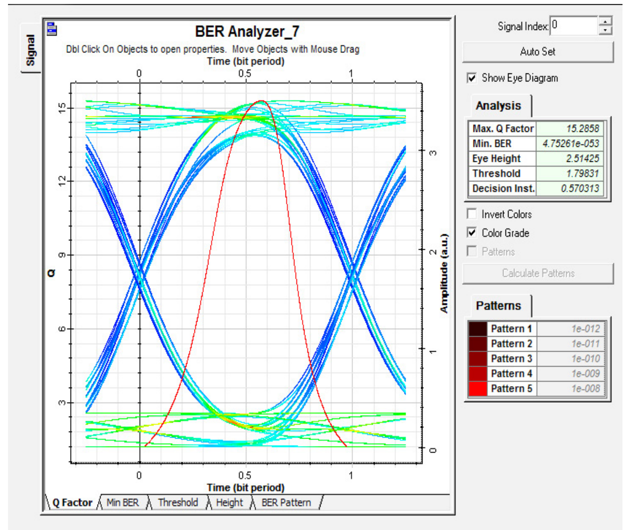

Figure 8. Eye diagram analysis of forty eighth channel.

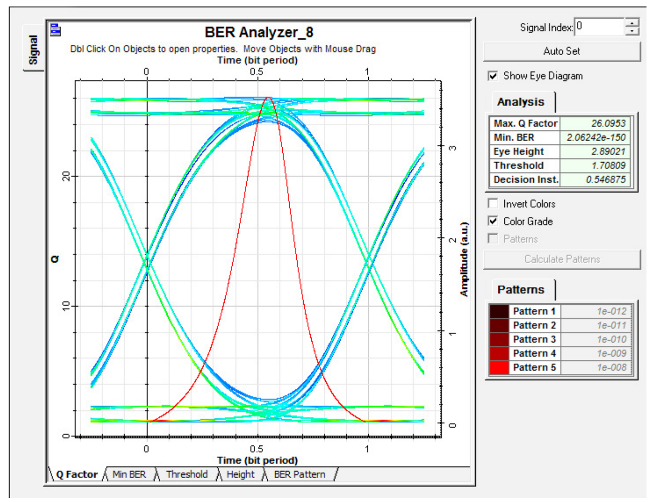

Figure 9. Eye diagram analysis of fifty sixth channel.

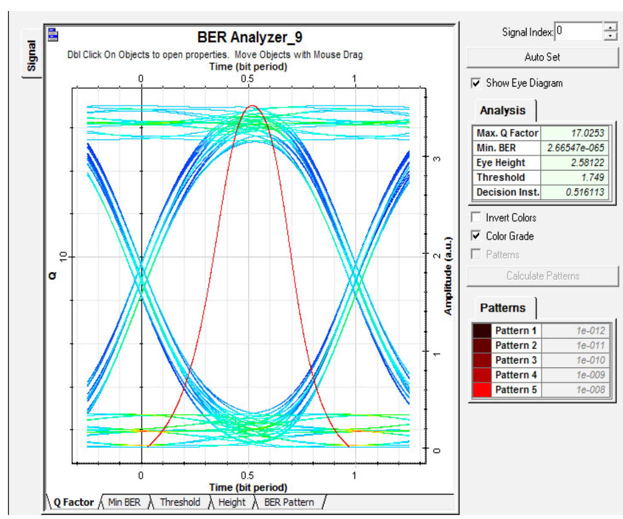

Figure 10. Eye diagram analysis of sixty fourth channel.

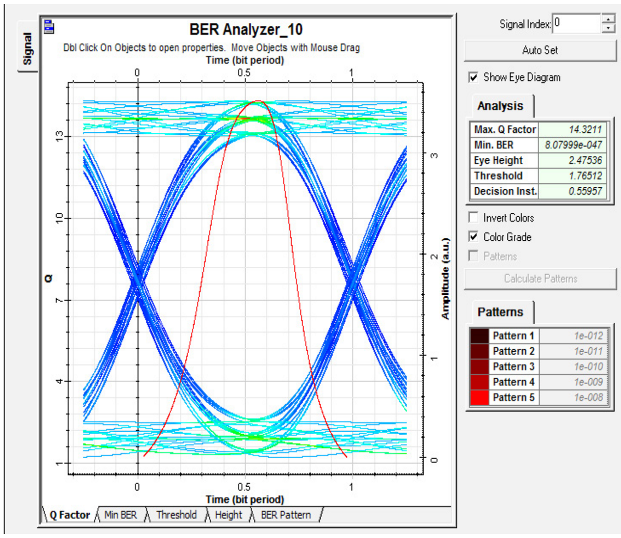

Figure 11. Eye diagram analysis of seventy second channel.

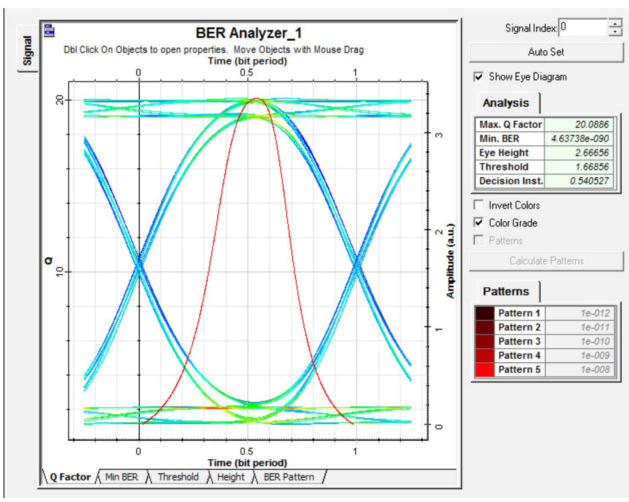

Figure 12. Eye diagram analysis of eightieth channel.

Table 5. Values of q factor and BER for various channels

Channel no.	Max. Q factor	Min. BER
1	19.808	1.24865e-087
8	14.5085	5.33659e-048
16	25.4846	1.46091e-143
24	19.799	1.51599e-087
32	15.504	9.23649e-055
40	13.9852	9.60071e-045
48	15.2858	4.75261e-053
56	26.0953	2.06242e-150
64	17.0253	2.66547e-065
72	14.3211	8.07999e-047
80	20.0886	4.63738e-090

4. Conclusion

In this work, an optimized DWDM link using DCF for dispersion compensation is presented. The system performance is limited by the dispersion. In order to compensate this we have used Dispersion compensation fiber. Between amplifier spans is standard single-mode fiber, but at each amplifier location, dispersion compensating fiber having a negative chromatic dispersion is introduced. By using this we have successfully designed a DWDM system with 80 channels each 10 Gbps data rate multiplexed with frequency spacing 100 GHz. Various EDFA's are also used to amplify and regenerate the signal. This work can be further extended to 160 channels in future as well.

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