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Design and Investigation of 32x40Gb/s WDM System based on Dispersion Compensation

Sabina
M.Tech, Scholar
Department of Electronics & Communication Engg.
SBBS University
Punjab, India
sabinasharma981@gmail.com

Manpreet Kaur
Assistant Professor
Department of Electronics & Communication Engg.
SBBS University
Punjab, India
manpreetkaur0917@gmail.com

***Abstract*— The increasing in demand of high capacity and high speed required the system or device which fulfills this requirement. This requirement results in introducing the wavelength division multiplexing (WDM). Optical wavelength division multiplexing (WDM) system is most widely used for increasing the information carrying capacity than other system. But some factor are deteriorates the performance of all optical system such as chromatic dispersion, polarization mode dispersion, and non-linear effects. In this paper, the 32 channel WDM optical communication system at 40 Gab/s has been designed and investigated with EDFA as an optical amplifier based on dispersion compensation. Optisystem 7.0 is used for designing and simulation of the proposed system. The performance is investigated on the basis of Bit error rate (BER) and Quality factor. When the dispersion is increased from 2 to 17 ps/nm/km, the post dispersion compensation using DCF and EDFA amplifier provide the better results.**

Keywords—Dispersion, wavelength division multiplexing (WDM), Erbium-doped fiber amplifier (EDFA), Bit error rate (BER).

I. INTRODUCTION

The wavelength division multiplexing (WDM) technique is most effective method used in optical communication system to increase the information carrying capacity of optical fiber transmission system. By increasing either the channel we can further enhanced the WDM system. Wavelength division multiplexing (WDM) system increasing the capacity of optical fiber system without requiring additional fiber. Wavelength division multiplexing (WDM) transmit various number of signal at same time on single fiber, each signal has different wavelength. Wavelength division multiplexing (WDM) system provides wide bandwidth for some application such as data browsing on internet voice over internet, video conferencing etc. [1][2]

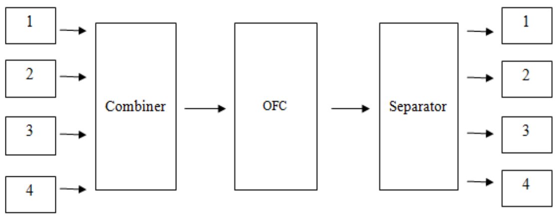

Fig.1. Block diagram of optical WDM transmission System [3]

The information transmission in WDM optical system is affected by dispersion, attenuation and the fiber non-linearity's at higher bit rates and power levels. To compensate for these attenuation losses, the optical amplifiers (EDFA, SOA, Raman amplifier) can be used in the system. Since all the channels require to be amplified simultaneously so optical amplifiers like Erbium-doped fiber amplifiers (EDFAs) are mostly used in optical fiber communication networks. EDFAs operate in 1550 nm wavelength window. [4]

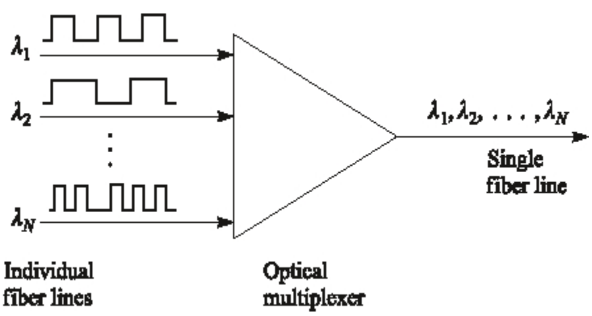

Fig.2. Wavelength Division Multiplexing

By using pre-channel data rate the information carrying capacity in WDM can be further increase. Optical fibers can carry multiple light signals of different wavelength simultaneously. The technique which allows the optical fiber to carry multiple signals is called wavelength division multiplexing. So WDM is an Analog process. It is similar to the FDM. In fiber optics transmission systems, the wavelength division Multiplexing (WDM) is a technique that multiplexes the numerous optical signals on a single optical fiber at different wavelengths of Laser light to transmit different signals. This helps to increase system capacity and also helps bi-directional transmission over a single fiber length for transmitter and receiver.

Wavelength division multiplexing system is divided into three different wavelength patterns:-

1. Normal (WDM)

2. Coarse (CWDM)
3. Dense (DWDM)

Normal WDM use the two normal wavelengths 1310nm and 1550nm on one fiber .Coarse WDM provides up to 16 channel. In coarse wavelength division multiplexing there is more spacing between the channels. So it covers fewer users. Dense wavelength division multiplexing (DWDM) use the C-band (1530nm 1565nm) transmission window. The spacing between the channels is dense. It covers more channels than coarse wavelength division multiplexing. [5], [6]

The dispersion compensation is the major issue in wavelength division multiplexing optical transmission systems. To mitigate the dispersion in WDM system, different techniques can be employed, which are microchip compensation, mid span spectral inversion, optical phase conjugation, initial pre chip, fiber brag gratings (FBG).[7]

The dispersion compensation fiber (DCF) has been used in this paper to reduce the dispersion of the fiber optic link. The dispersion compensating fiber can be connected in three configuration which are pre, and post and symmetrical.

The rest of the paper is organized as followed; in section II, the dispersion compensating fibers are discussed. Simulation Setup is described in section III. In section IV, the results and discussion is presented and section V concludes the paper.

VI. Dispersion compensating fibers (DCFs)

The idea of using dispersion compensating fibers was proposed in 1980s. DCF components are more stable, these are not easily affected by temperature, wide bandwidth, so this is most suitable method for dispersion compensation. It is currently used for dispersion compensation in long-haul WDM optical transmission system. The use of DCF is an efficient way to reduce the overall dispersion in WDM network as they have higher negative dispersion coefficient and can be connected to the transmission fiber having the positive dispersion coefficient i.e. the overall dispersion of the link becomes zero. [8], [9]

Dispersion can be compensated by three compensation techniques depending upon the position of DCF:

i. Pre-DCF dispersion compensation
ii. Post- DCF dispersion compensation
iii. Symmetrical- DCF dispersion compensation

In pre- DCF dispersion compensation scheme, the DCF is placed before the single mode fiber (SMF) to compensate the dispersion in SMF.

In post- DCF dispersion compensation, the DCF is placed after the SMF to compensate the dispersion in SMF.

In symmetrical- DCF dispersion compensation, both the schemes (pre-, post-compensation) are used i.e. DCF is positioned before as well as after the SMF to attain the dispersion compensation. [9]

In this paper, the post dispersion compensation scheme is designed and simulated.

VII. Simulation Setup

The 32 channel WDM optical communication system is designed using the Optisystem 7.0 simulator software. The 32 channel WDM system based on dispersion compensation at 40 Gbps is simulated. The post-DCF dispersion compensation scheme is designed and investigated in this paper. The parameters used for simulation are described in Table 1and fiber parameters are described in Table 2.

In the system design, the transmitter segment consists of data source, that generate a pseudo random sequence of bits at 40 Gbps. NRZ pulse generator convert the binary data into electrical pulses that modulates the laser signal using the Mach-Zehnder (M-Z) modulator. The transmitter segment block diagram is shown in “Fig. 3”.

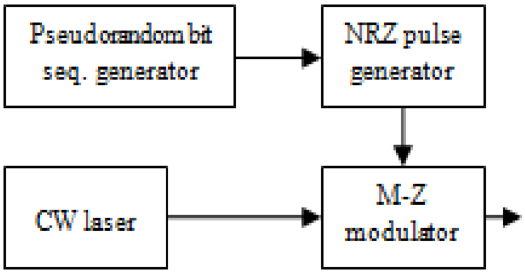

Fig.3. Transmitter section [4]

There are 32 optical sources that are generating the optical signals at different wavelengths with the channel spacing of 100 GHz.

The multiplexer combines the 32 input channels and transmit them over single fiber channel. The transmission channel consists of SMF of length 200 km and DCF of length 40 km; i.e. the total link distance is 240 km. Erbium-doped fiber amplifier (EDFA) is used to amplify the signals.

At the receiver part, the 1:32 demultiplexer is used to distribute the signals to 32 different channels. The output of the demultiplexer is given to APD photodetector and then passes through low pass electrical filter and 3R regenerator. The receiver part block diagram is shown in “Fig. 4”.

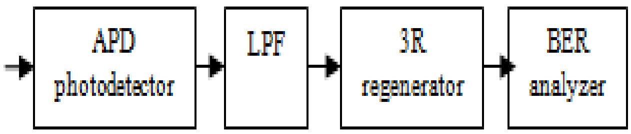

Fig. 4. Receiver section [4]

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Table I. Simulation parameters

Parameters	Value
Bit rate	40 Gbps
No of channels	32
Power	5 dbm
Central frequency of first channel	191 THz
Channel spacing	100 GHz
Capacity	32x40 Gbps

Table II. Fiber parameters

	SMF	DCF
Length (km)	200	40
Attenuation (db/km)	0.2	0.2
Dispersion (ps/nm/km)	17	-80
Dispersion slop (ps/nm^2/km)	0.08	0.3
Differential group delay (ps/km)	0.5	0.5

The simulation setup of 32 channel WDM system based on Post-DCF dispersion compensation technique is shown in "Fig. 5".

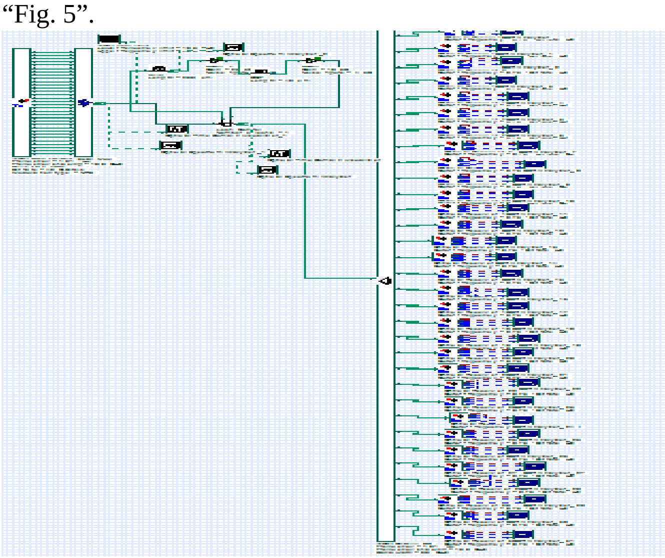
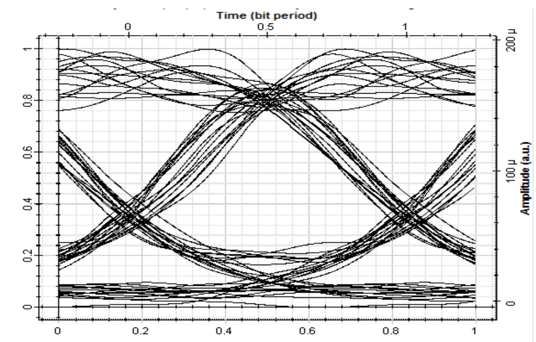


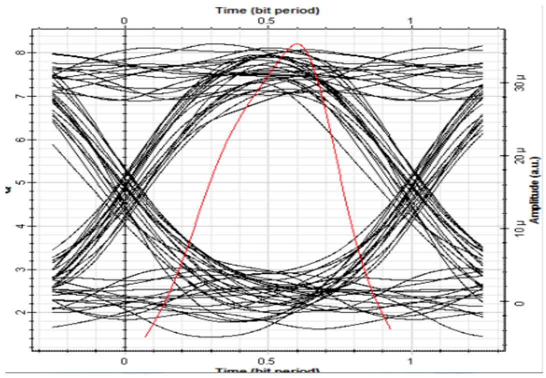
Fig. 5. Simulation setup of 32 channel WDM system based on Post-DCF dispersion compensation scheme

VIII. RESULT AND DISCUSSION

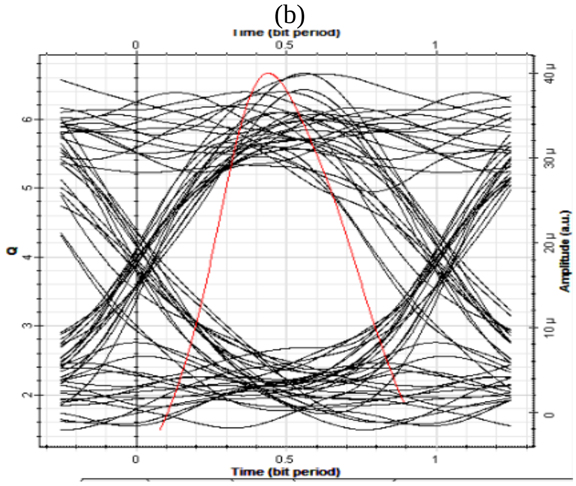
The 32 channel WDM system based on Post-DCF dispersion compensation scheme has been analyzed at 40 Gbps in terms of bit error rate (BER) and Q-factor. The eye diagrams for the different channels are shown in "Fig. 5". The parameters BER and Q-factor are tabulated in Table III.



(a)



(b)



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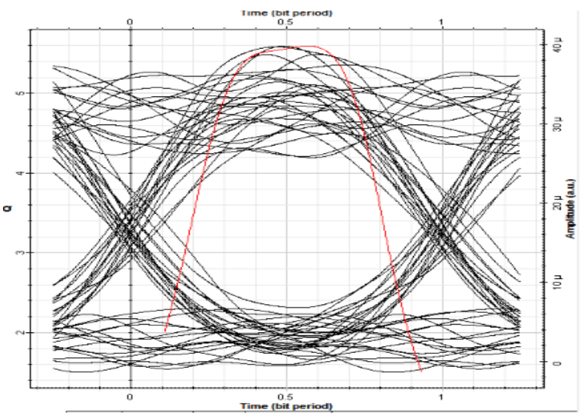

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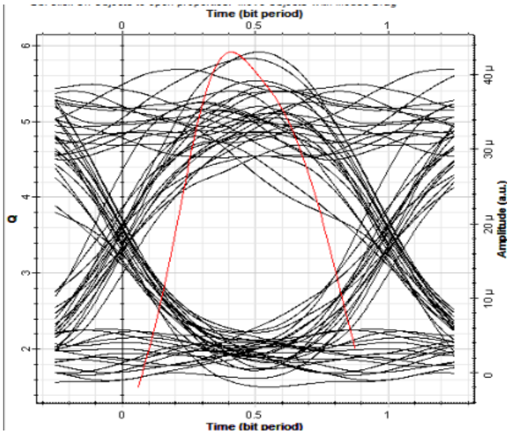

(e)

Fig.6. Eye diagrams of (a) channel at 191 THz (b) channel at 191.1THz (c) channel at 191.2 THz (d) channel at 194 THz and (e) at last channel 194.1 THz

Table III. BER and Q-Factor at different channels

Channel Frequency	Q-factor (db)	BER
191 THz	8.4439	1.48154e-017
191.1 THz	8.2084	1.12061e-016
191.2 THz	6.66538	1.2961e-011
194 THz	6.34885	1.03868e-010
194.1 THz	5.59631	1.02561e-008

IX. V. CONCLUSION

In this paper, the 32 channel WDM system based on post dispersion compensation scheme using DCF is designed and investigated at 40 Gbps with 100 GHz channel spacing. The BER and Q-factor values for different 5 users are tabulated in Table III. The average value of BER achieved is e-012. The maximum possible distance of the communication link achieved is 240 km (200 KM SMF and 40 km DCF).

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