

Performance Analysis of OTDM and WDM Optical Communication System

< Sunita Rani>¹, <Dr. Amandeep Singh Sappal>²

¹Student, Department of Electronics and Communication Engineering,
Punjabi University, Patiala
Sunitarani547@gmail.com

²Assistance Professor, Department of Electronics and Communication Engineering,
Punjabi University, Patiala
Sappal73as@yahoo.com

Abstract: Optical time division multiplexing (OTDM) is a technique used to accomplish the demand of large capacity. It is an alternative to wavelength division multiplexing (WDM). Capacity can be enlarged by enhancing the bit rate of already existing channel in time division multiplexing. In this paper, to compensate dispersion different dispersion compensation techniques are used. Optical Time Division Multiplexing (OTDM) system has large bandwidth and large transmission capacity as compared to Wavelength Division Multiplexing (WDM) system. So, DCF techniques are employed on WDM and OTDM and both are compared in terms of Quality Factor and Bit error rate at 40 Gb/s bit rate.

Keywords: Dispersion, Dispersion compensation fiber (DCF), Optical time division multiplexing (OTDM).



1. Introduction:

Optical fiber is one of the most useful method of transmitting information from one place to another. It is impossible to communicate, to transmit telephone signals and internet communication without optical fibers. Optical fiber having myriad boons over copper wires such as Large bandwidth, Non-conductive in nature, Small Lightweight cables. Due to the different types of optical fiber and having different wavelength, dispersion occurs in optical fiber. Optical time division multiplexing technique is a purely digital technique. In OTDM, high bit rate data streams constructed directly by time division multiplexing of lower bit rate data streams. In this paper four channels of 10 Gb/s bit rate are used. This data is transmitted over 130km single mode fiber.

1.1 Organization of the work:

This section describes the organization of the paper. 1st section includes the introduction of optical fiber and dispersion. 2nd section includes the introduction of dispersion compensating fiber. 3rd section includes the introduction of OTDM. 4th section shows the experimental setup of proposed work. 5th section shows results and discussions and then last section shows the conclusion and future scope.

1.2 Dispersion:

Dispersion is the broadening of pulse or spreading of the light signal when its travels down the optical fiber because the different frequency or mode of light pulse transmits through the fiber. Dispersion limits the bandwidth and information carrying capacity of the optical signal. The performance of single mode fiber is limited by the chromatic dispersion. The dispersion becomes the major limiting factor in long distance fiber optical transfers. Different types of dispersion occurs in optical fiber:

- Intermodal (modal) dispersion
- Intramodal (chromatic) dispersion
- Polarization mode dispersion (PMD)

1.3 Different compensation techniques:

- Dispersion compensating fiber (DCF).
- Chirped fiber Bragg gratings (FBG).
- High order mode (HOM).

The use of dispersion compensating fiber to compensate dispersion in optical fiber is mostly used. DCFs are more stable, not easily affected by the temperature, having more bandwidth. Several dispersion compensation schemes are proposed. These are:

- Pre compensation.
- Post compensation.
- Mix or symmetric compensation

2. Dispersion compensation fiber (DCF):

Dispersion compensation is a fiber or technology to compensate dispersion through the length of optical fiber. A proper length of dispersion compensation fiber (DCF) allows the compensation of chromatic dispersion present in transmitting fiber. DCF consists of an optical fiber that has a special design such as providing a large negative dispersion. The main advantage of this technology is the fact that it provides a broadband with a smooth dispersion property and good optical characteristics.

2.1 Schematic of dispersion compensation techniques:

The schematic of three dispersion compensation techniques: pre-, post- and symmetrical is shown:

- In pre compensation the DCF is placed before the single mode fiber.
- In post compensation the DCF is placed after the single mode fiber.

- In mix compensation the DCF is placed before and after the single mode fiber.

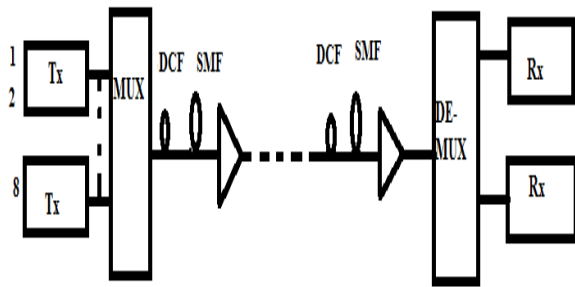


Figure1: schematic of pre compensation

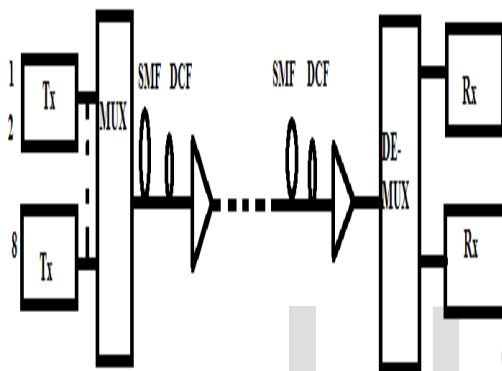


Figure2: Schematic of post compensation

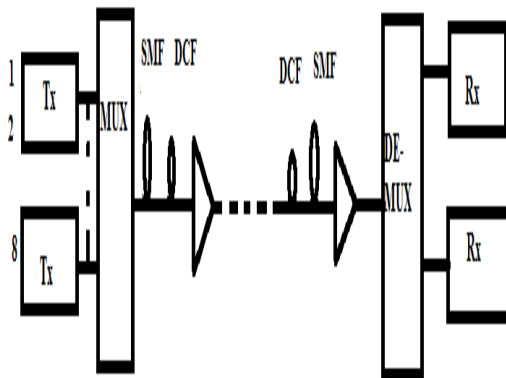


Figure3: schematic of mix compensation.

3. Optical Time Division Multiplexing(OTDM):

This paper is based on OTDM. OTDM system having large bandwidth as compared to the WDM systems. OTDM is a very powerful optical multiplexing technique that delivers very high capacity of data over an optical fiber. The basic principle of this technology is to multiplex a number of low bit rate optical channels in time domain. In optical time division multiplexing each of the available channels is optically modulated on to the periodic train of very short optical pulses, which are of the same wavelength. By bit interleaving modulated pulse train, the channels are multiplexed and are transmitted through the optical

fiber. It is a proven method used to obtain aggregate bit rates. It provides potential improvements in network performance in terms of user access time, delay and throughput, depending on the user rates.

4. Experimental setup:

The transmitter section consists of a CW laser having 193.1 THz frequency and 0dbm power. This section consists of the four pseudorandom pulses, RZ pulse generator, AM Modulators and Optical delay. A laser source produces regular streams of light. Pseudorandom generate the 10 Gbits/s. The time division multiplexing technique is purely digital technique. OTDM offer design flexibility, adjustable bandwidth allocation in different baseband channel and simple architecture. In this paper we describe the multiplexing & demultiplexing of the high data bit using new devices by which losses are curtailed. In this we transmit 4 channel 10 Gbits/s data and receive 40 Gbits/s data bit rate. In this paper we have used the different delays for four channel i.e. 25ps, 30ps, 35ps, 40ps. Loop control is used to proliferate the length of the fiber for the transmission in a very high distance. In the channel section single mode fiber, EDFA and DCFs are used in pre, post and symmetrical manner. The receiver section consists of the Demux and clock recovery and the PIN photodiode. Clock recovery at the receiver is used to drive and synchronize the demultiplexer. At the receiver end the 40 Gbits/s pulses are demultiplexed into the original data channel and we perceive the output in the form of optical spectrum i.e. eye diagram.

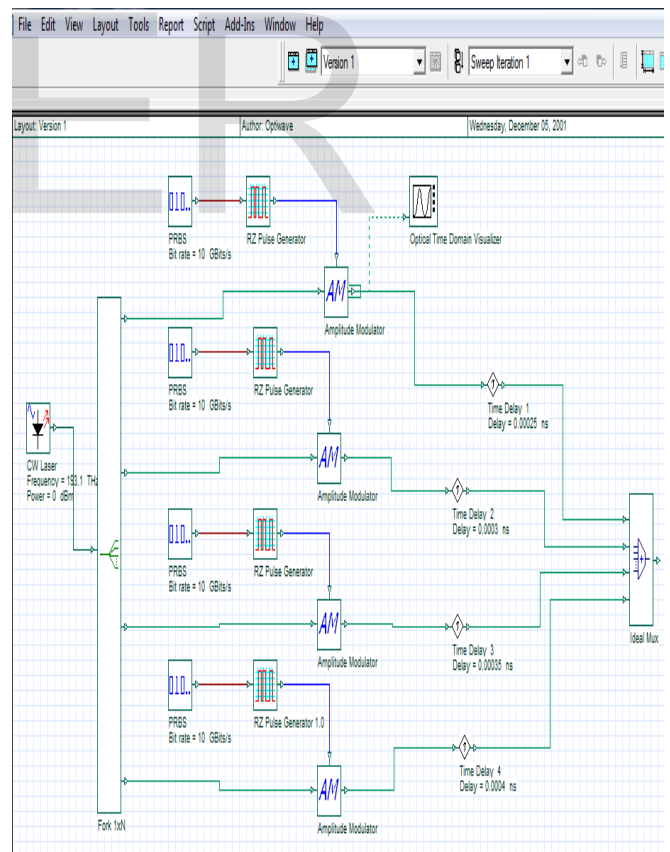


Figure4: Transmitter section of OTDM

In the transmitter section a CW laser having 193.1 THz frequency and 0dbm power is used. In this section pulse sources are used for high bit rate transmission. PRB's used to generate digital data. Pseudo random generate the 10 Gbits/s. The electrical signal is converted to optical signal by AM Modulator. Each of these

channels can be modulated independently by an electrical data source at a bit rate. Before being multiplexed, a delay is provided to each signal i.e. 25ps, 30ps, 35ps, 40ps . Then these delayed signals are fed to the 4x1 multiplexer. This multiplexed 40Gbps signal travels through the single mode fiber, where the pulse gets broadened due to the presence of chromatic dispersion. Then to compensate this dispersion, dispersion compensation fiber (DCF) is used. After that the signal is passed through the loop control. This is used to augment the length of the fiber for long distance transmission.

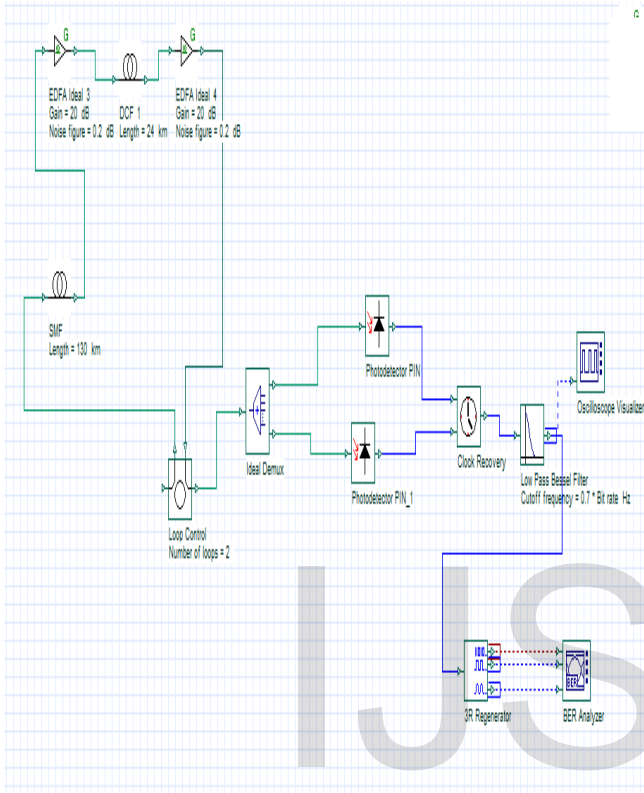


Figure5. Receiver section of OTDM

The receiver section of OTDM consists of demultiplexer. The incoming 40Gbps signal is given to the PIN photodiode. It will convert the optical signal into electrical signal at the receiver side. The clock recovery device provides the timing signal for the optical gate. After the clock recovery the low pass filter (LPF) is used. It will pass the low frequency signal and discard high frequency signal. LPF will filter the electrical signal. At the end of the receiver section a BER analyzer is connected to get results in terms of Q-Factor and Bit Error rate.

5. RESULTS AND DISCUSSIONS

In this paper 40Gb/s signal is transmitted over 130km length of single mode fiber using dispersion compensation fiber in pre, post and mix compensation manner. Both the systems i.e. WDM and OTDM operated at same data rate. The performance of both the systems is concluded in terms of Q-Factor and Bit Error Rate. The OTDM system provides better quality factor than WDM system at 130km length of single mode fiber (SMF) and 24km length of dispersion compensation fiber (DCF). OTDM using pre and post DCF provides better Quality factor than mix compensation.

5.1 Spectrums of BER Analyzer:

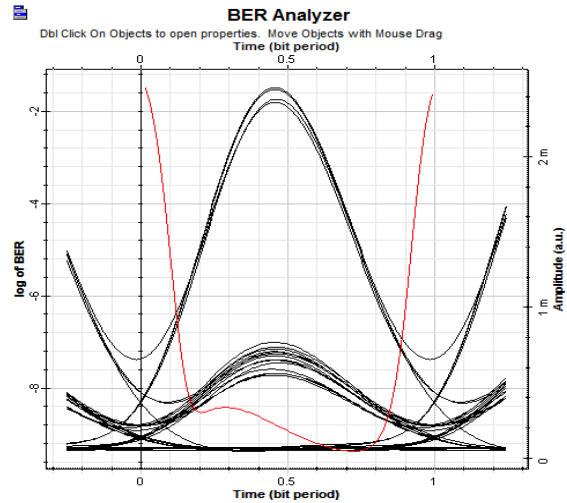


Figure6. Eye- diagram of Pre DCF OTDM

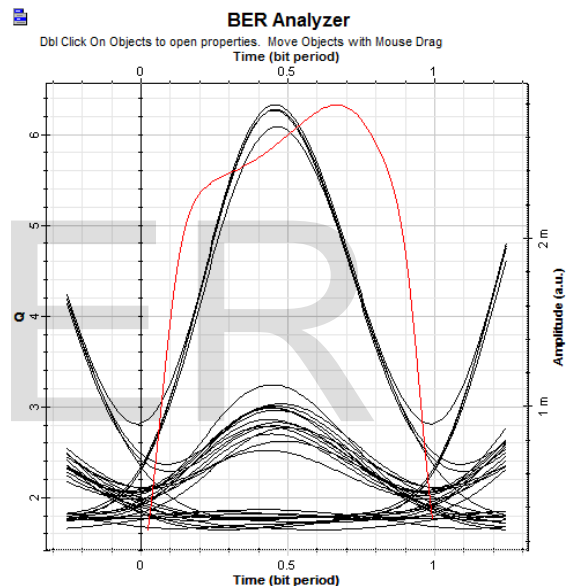


Figure7. Eye- diagram of Post DCF OTDM

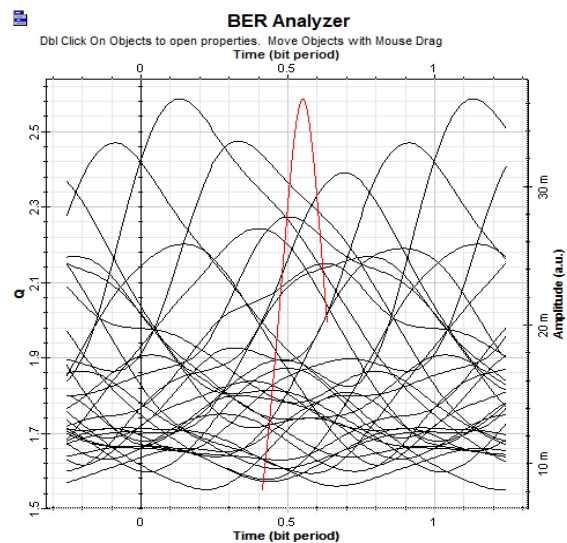


Figure8. Eye- diagram of Mix DCF OTDM

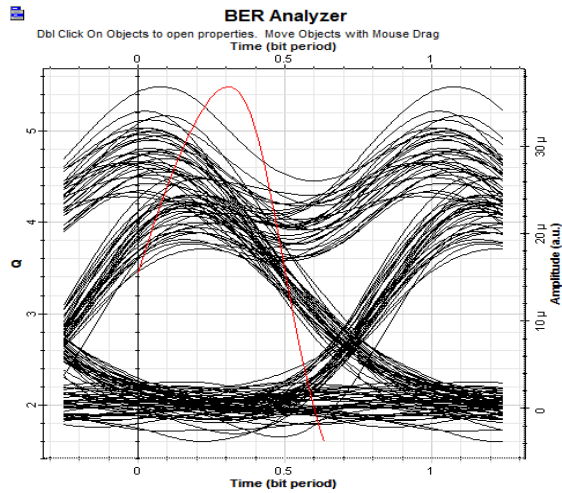


Figure9. Eye- diagram of Pre DCF WDM

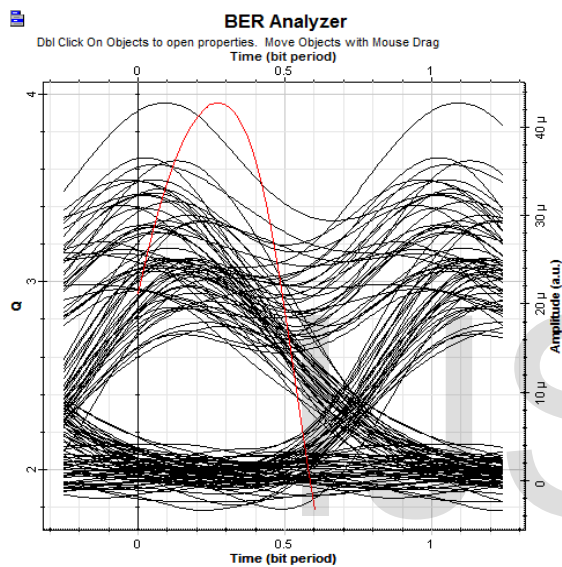


Figure10. Eye- diagram of Post DCF WDM

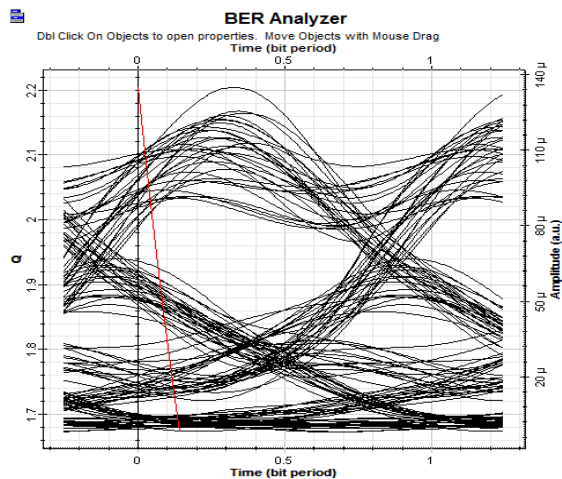


Figure11. Eye- diagram of Mix DCF WDM

Table 1: OTDM results at 130km SMF and 24km DCF

Compensation technique	Q-Factor	BER
pre	6.13573	4.23359e-010
post	6.32366	1.26172e-010
mix	2.5861	0.0044158

Table2: WDM results at 130km SMF and 24km DCF

Compensation technique	Q-Factor	BER
pre	5.4826	1.92138e-008
post	3.95189	3.27451e-005
mix	2.20384	0.012274

6. Conclusion and future scope:

It has been concluded that the performance of single mode fiber and dispersion compensation fiber performs better in OTDM system than WDM system. The performance of both the systems is compared at 40 Gb/s data rate. In the OTDM system the multiplexing, demultiplexing and timing recovery can be achieved without the need for very high bandwidth. The OTDM and WDM systems perform better in pre and post compensation than mix compensation. The results of OTDM can be improved by changing the fiber configurations. Data rate and no. of channels can be increased or decreased by using same bandwidth. By using the combination of OTDM and WDM, code division multiplexing (CDM) system can be made, where bandwidth and channel both can be brushed up on.

References:

[1] G. Raybon, B. Mikkelsen, R.-J. Essiambre, "Transmission of short pulse OTDM signals over nonzero-dispersion fiber", IEEE 2000.

[2] In 2003 Jie Li, Bengt-Erik Olsson, Magnus Karlsson and Peter A. Andrekson, "OTDM Demultiplexer Based on XPM-Induced Wavelength Shifting in Highly Nonlinear Fiber", IEEE Photonic Technology letters, Vol.No.15, Issue No.12, 2003.

[3] Hans-Georg Weber, Reinhold Ludwig, "Ultrahigh-speed OTDM-Transmission Technology", IEEE Journal of Lightwave Technology, Vol.No.24, Issue No.12, 2006.

[4] Prince M. Anandarajah, Aisling M. Clarke, "System-Performance Analysis of Optimized Gain-Switched Pulse Source Employed in 40- and 80-Gb/s OTDM Systems", IEEE Journal of Lightwave Technology, Vol.No.25, Issue No.6, 2007.

[5] N. Ravi Teja, M. Aneesh Babu, T.R.S. Prasad, "Different Types of Dispersions in an Optical Fiber", International Journal of Scientific and Research Publication, Vol. No. 2, Issue No. 12, 2012.

[6] Ojuszisni Arora, Amit Kumar Garg, "Dispersion Compensation for High Speed Optical Networks", International Journal of Electronics and Communication Engineering, Vol. No.2, pp 1-4, 2012

[7] Manjari Sharma, P.K. Raghav, "Analysis on Dispersion Compensation in WDM Optical Network using Pre, Post and Symmetrical DCF based on Optisystem", International Journal of Electronics and Communication Engineering, Vol.No.1, pp 53-68, 2014.

[8] Darshan D. Patel, Rohit B. Patel, "Extending the reach of 160 Gbps WDM link using dispersion compensation", International Journal of Advanced Research in Electronics and Communication Engineering, Vol.No.3, Issue No.4, 2014.

[9] Monika Srivastava, Mukesh Kumar, A.K. Jaiswal, Anil Kumar, "Design and performance analysis of optical time division multiplexing for very high bit-rate transmission", International Journal of Current Engineering and Technology, Vol. 4, Issue No. 3, June 2014.

[10] Parul Singh, Rekha Chahar, "Performance Analysis of Dispersion Compensation in Long Haul Optical Fiber using DCF", International Journal of Engineering And Sciences, Vol.No.3, Issue No.8, pp 18-22, 2014.

IJSER