Analysis of chromatic scattering in 2*8 channel at 4*10 gbps at various distances

[1]Aparna Mishra, [2]Manoj kumar gautam, [3]Swatantra Tiwari

***Abstract*: [1] In Fiber-Optics communication network pulse broadening due to chromatic dispersion becomes an important factor for signal quality degradation. This may become worse when we increase the data transmission rate. So in order to achieve high data transmission rate at long distance light wave system, the chromatic dispersion in the fiber must be compensated. Many compensation techniques have been studied and they show a variety of different and often complimentary properties. Transmitter compensation techniques are the most easily implemented tecnique. The most commercially advanced technique is negative dispersion fiber. We discuss the design of a Wavelength Division Multiplexed system (WDM) with dispersion compensation fiber (DCF). The result of both pre- compensation and post -compensation techniques has also been discussed. The bit error rate (BER) of the system under two different modulation schemes is also discussed.**

***Keywords*: BER, WDM, Dispersion Compensation, Return-to-zero (RZ), Non-return to zero (NRZ)**

I. INTRODUCTION

Communication is transmission of information from one place to another through any medium. Mankind has been using many mediums for the data transmission. One of these mediums that really had a big impact on data transmission was coaxial-cable system. The first coaxial-cable system, deployed in 1940 [2], was a 3MHz system which could transmit 300 voice channels. But these coaxial-cables, they mostly suffer from high cable losses and repeater spacing is also very limited and is costly for a longer transmission length. And these shortcomings led to the development of microwave communication system. Optical fibers are cheap than the conventional wires. Optical Fiber Cables are flexible and easy to install. Optical fibers are less affected by fire. In Optical Fiber Cables signal can propagate longer transmission distances like 50km or more (Single Mode fiber cables) without the need to regenerate the signal anywhere in-between transmitter and receiver.

Therefore, the purpose of this paper is to identify the best dispersion compensation technique and modulation scheme in WDM architecture. The most commonly used modulation formats are Non-Return-to-Zero (NRZ) and Return-to-Zero (RZ). Due to higher peak power, NRZ may suffer more from Nonlinearities. Due to shorter pulse width, RZ may suffer more from dispersion. So this paper also compares the two modulation formats and identifies the better modulation format in WDM network. This project is focusing on one design parameter against a performance parameter; distance vs. bit error rate (BER). The simulation results are produced using Optisystem 13.0.

II. TECHNOLOGY REVIEW

[6]In fiber-optic communications, wavelength-division multiplexing (WDM) is a technology which multiplexes a number of optical carrier signals onto a single optical fiber by using different wavelengths (i.e. colors) of laser light. This technique enables bidirectional communications over one strand of fiber, as well as multiplication of capacity. A WDM system uses a multiplexer at the transmitter to join the signals together and a demultiplexer at the receiver to split them apart. With the right type of fiber it is possible to have a device that does both simultaneously, and can function as an optical add-drop multiplexer. In an access network, there are many ways to multiplex data in the transmission line such as time division multiplexing (TDM) and wavelength division multiplexing.

This paper discusses the WDM transmission as this research focuses on WDM technology. WDM is a bidirectional multiplexing using different optical wavelength for up and downstream signals. It is an analog multiplexing technique to combine optical signals. The purpose of WDM is to increase the transmission and reception capability of fiber optic cable systems. WDM is a technology that transmits different types of data at distinct optical wavelengths over a single fiber channel as shown in Figure 1.1.

[3] The technology will let users transmit large volumes of data, video or voice over a fiber backbone. This technology is possible because there is different transmission speed along refractive index of material and wavelength when light first passes through material then as feature of light. This phenomenon which allows the sun spectrum to show different color by wavelength from visible beam domain as it passes through a prism, each wavelength having a different refraction index.

In other words, invisible optics from WDM transmission system is transmitted through optical fiber by different routes depending on wavelength. Therefore, WDM method is also called chromatic multiplexing. WDM provides dedicated point-to-point connections to each user without any of the concerns associated with multiple users sharing a single downstream transmission channel.

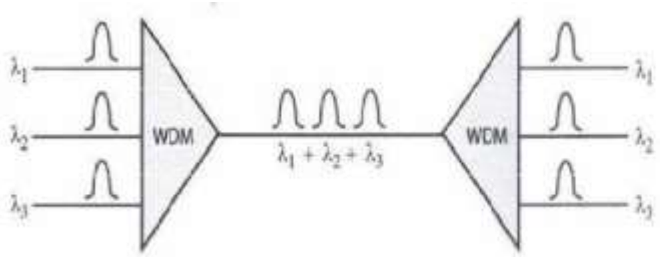

Fig 1.1: Wavelength Division Multiplexing system

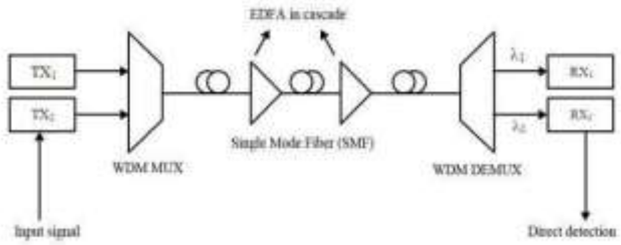

Fig 1.2: A basic WDM optical network

A WDM system uses a multiplexer at the transmitter to join the signals together and a demultiplexer at the receiver to split them apart. With the right type of fiber it is possible to have a device that does both simultaneously, and can function as an optical add-drop multiplexer. The concept was first published in 1970, and by 1978 WDM systems were being realized in the laboratory. The first WDM systems only combined two signals. Modern systems can handle up to 160 signals and can thus expand a basic 10 Gbit/s fiber system to a theoretical total capacity of over 1.6 Tbit/s over a single fiber pair. WDM systems are popular with telecommunications companies because they allow them to expand the capacity of the network without laying more fiber.

WDM systems are divided in different wavelength patterns, conventional or coarse and dense WDM. Conventional WDM systems provide up to 16 channels in the 3rd transmission window (C-band) of silica fibers around 1550nm. DWDM uses the same transmission window but with denser channel spacing. In this paper we are considering DWDM.
DWDM system:
At this stage, a basic DWDM system contains several main components:

A DWDM terminal multiplexer:

The terminal multiplexer actually contains one wavelength converting transponder for each wavelength signal it will carry. The wavelength converting transponders receive the input optical signal (i.e., from a client-layer SONET/SDH or other signal), convert that signal into the electrical domain, and retransmit the signal using a 1550-nm band laser. (Early DWDM systems contained 4 or 8 wavelength converting transponders in the mid-1990s. By 2000 or so, commercial systems capable of carrying 128 signals were available.) The terminal mux also contains an optical multiplexer, which takes the various 1550-nm band signals and places them onto a single SMF-28 fiber. The terminal multiplexer may or may not also support a local EDFA for power amplification of the multi-wavelength optical signal. 31.

(1) An intermediate optical terminal or Optical Add-drop multiplexer:

This is a remote amplification site that amplifies the multi-wavelength signal that may have traversed up to 140 km or more before reaching the remote site. Optical diagnostics and telemetry are often extracted or inserted at such a site, to allow for localization of any fiber breaks or signal impairments. In more sophisticated systems (which are no longer point-to-point), several signals out of the multi wavelength signal may be removed and dropped locally.

(2) A DWDM terminal demultiplexer.

The terminal demultiplexer breaks the multi-wavelength signal back into individual signals and outputs them on separate fibers for client-layer systems (such as SONET/SDH) to detect. Originally, this demultiplexing was performed entirely passively, except for some telemetry, as most SONET systems can receive 1550-nm signals. However, in order to allow for transmission to remote client-layer systems (and to allow for digital domain signal integrity determination) such demultiplexed signals are usually sent to O/E/O output transponders prior to being relayed to their client layer systems. Often, the functionality of output transponder has been integrated into that of input transponder, so that most commercial systems have transponders that support bi-directional interfaces on both their 1550-nm (i.e., internal) side, and external (i.e., client-facing) side. Transponders in some systems supporting 40 GHz nominal operation may also perform forward error correction (FEC) via 'digital wrapper' technology, as described in the ITU-T G.709 standard.

III. DESIGN OF WDM SYSTEM WITH DCF

The management of dispersion and non-linearity's is of prime importance in WDM systems. In a chromatic dispersion-limited system in which the total accumulated dispersion for a traveling pulse is greater than the maximum allowable dispersion, the system cannot function because of tremendous ISI or just pure pulse spread. Therefore, we need to place dispersion compensation units (DCUs) at different positions in a network. When we are designing a high bit rate WDM link (where dispersion can be considered major design impairment), we should use dispersion maps to effectively design a system.

[2] Dispersion maps are two-dimensional maps that plot the accumulated dispersion versus the length of transmission. They are particularly useful maps that help designers tell where to place dispersion compensators in a network. Accumulated dispersion is calculated by multiplying the fiber and the laser dispersion specifications for a given bit rate with respect to the length of the fiber. [7]For example, an SMF fiber's typical value of dispersion is 16 ps/nm-km, which means that for every traversed kilometer of SMF fiber, a pulse at 10 Gbps (100 ps pulse width) spreads for about 16 ps from its mean. Ensure that the accumulated pulse spread across 'x' km is less than the maximum dispersion limit (which might be 1600 ps/km-nm for a 10 Gbps signal).

[3]From this discussion, it is obvious that the signal can travel 16x = 1600 km (if x = 100) of SMF fiber at a 10 Gbps bit rate. It is important to note that as the signal traverses a greater distance, the accumulated dispersion also increases. For a given bit rate and at a given operating wavelength (or operating band), the maximum allowable accumulated dispersion is given by a standard specification. At no point in the dispersion map should the value of the curve go higher than the dispersion tolerance limit. Note that the dispersion parameters depend on many factors. The main factors are the bit rate (which gives the pulse width), the length of the fiber, the basic dispersion parameter, and the spectral width of the laser, which qualitatively provides the amount of dispersion induced (GVD). An interesting speculation is that of the variation of power penalty for dispersion-limited systems as a function of the dispersion parameter D, which is derived from the specification of the basic fiber. D can be considered a balancing component between the bit rate, the length of the fiber, and the width of the spectral source that emits the pulse.

[5]Two techniques—pre-compensation and post compensation—can compensate dispersion using any of these methods. As the name implies, *pre-compensation* means compensating for dispersion before the signal is induced in the system. This is a technique of compressing the pulse in advance with DCUs; it takes care of the accumulated dispersion in advance. In contrast, post compensation uses compensating equipment that is placed at the end of a fiber. In pre-compensation, we can place the DCU after the postline amplifier. Such units have loops of fiber with dispersion profile opposite to that of the transmission fiber. For example, a transmission fiber would have dispersion parameter of 16
ps/nm-km. [9]A DCU could hypothetically be made to have a dispersion profile of ~ 50 ps/nm-km. The signal passes through such fiber spools (DCU) and the pulse is precompensated. Conversely, with post compensation techniques, the DCU modules are placed before the preline amplifier.

IV. RESULTS

This paper analyzes the performance of a 40Gbps DWDM network for 16 end users at various transmission distances and various modulation schemes using Optisystem 13.0. Table 1 show the simulation results of a basic WDM network at various transmissions distance and modulation schemes. The different transmission distance considered here are 60km, 160km, 240,280km and the modulation schemes used are return-to-zero (RZ) and non-return to zero (NRZ).

5Gbps	NRZ	NRZ	40Gbps	NRZ	NRZ
distance	pre	post	distance	pre	post
80km	4.65x10^{-17}	6.08x10^{-15}	80km	0.00	0.00
100km	2.30x10^{-16}	5.24x10^{-13}	160km	2.97338e-308	6.14e-272
			240km	1.76485e-155	8.58e-158
			280km	6.55526e-118	7.81e-119

The proposed WDM system for NRZ data

5Gbps	RZ	RZ	40Gbps	RZ	RZ						
Distance	Pre	Post	Distance	Pre	Post						
80 km	4.92x10^{-31}	4.25x10^{-24}	80 km	0.00	0.00						
100km	2.48x10^{-25}	8.59x10^{-20}	160km	0.00	0.00						
			240km	2.39e-043	2.88e-045						
			280 km	1.03e-028	2.45e-026						

The proposed WDM system for RZ data

CONCLUSION

The work has emphasized on the dispersion compensation techniques in a WDM network at 5Gb/s. A simulation model is presented for the dispersion compensation in optical fibers for a single channel fiber. It is observed that the length of dispersion compensating fiber (DCF) effects the dispersion compensation for the schemes Pre-compensation & Post- compensation. Also the pre-compensation technique with RZ modulation format yields

acceptable BER in the order of 10^{-25} at a transmission distance of 100km.Thus we see that the RZ modulation scheme with pre-compensation technique exhibits better performance at all the transmission distances when compared to NRZ modulation scheme with post – compensation technique.

REFERENCES

[1] Gopi, N.; Muthumani, I.; Sivanantha Raja, A.; Selvendran, S., "Dispersion compensation for WDM signals with polarization insensitivity," Information Communication and Embedded Systems (ICICES), 2013 International Conference on , vol., no., pp.840,844, 21-22 Feb. 2013

[2]Bo-ning Hu; Wang Jing; Wang Wei; Rui-Mei Zhao, "Analysis on dispersion compensation with DCF based on Optisystem," Industrial and Information Systems (IIS), 2010 2nd International Conference on , vol.2, no., pp.40,43, 10-11 July 2010

[3] Saurabh Kumar;Prof. A. K. Jaiswal; Er.Mukesh Kumar; Er.Rohini Saxena,"Performance Analysis of Dispersion Compensation in Long Haul Optical Fiber with DCF"IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)e-ISSN: 2278-2834,p-ISSN: 2278-8735.Volume 6,Issue 6(Jul-Aug. 2013), PP19-23

[4]Optimization for the Best Performance for Wavelength Division Multiplexed Passive Optical Network, NikShahidah Afifi bt. Md. Taujuddin, Maisara Othman and Zarina Tukiran, Proceedings of EnCon2008 2nd Engineering Conference on Sustainable Engineering Infrastructures Development & Management December 18 -19, 2008, Kuching, Sarawak, Malaysia . ECO2008-F-28

[5] Symmetrical Dispersion Compensation For High Speed Optical Links, Ojuswini Arora1, Dr.Amit kumar Garg2, Savita Punia3, IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 6, No 1, November 2011 ,ISSN (Online): 1694-0814 ,www.IJCSI.org

[6] Keiser, G. Optical Fiber Communications, Third Edition. McGraw-Hill, 2000.

[7] Roeland J. Nuyts, Yong Kwan Park , and Philippe Gallion,

―Dispersion equalization of a 10 Gb/s Repeatered Transmission System Using Dispersion compensating Fibers‖, Journal of Lightwave Technology, Vol.15, Issue 1,1997. pp.31-42

[8] J. Yu and P. Jeppesen, ―Investigation of cross-phase modulation in WDM systems with NRZ and RZ modulation formats‖, Opt. Comm. 184, pp. 367, 2000

[9]M. I. Hayee and A. E. Willner, ―NRZ versus RZ on 10-40 Gb/s dispersion managed WDM transmission systems‖, IEEE Photon. Tech. Lett. 11, pp. 991, 199