SOFTWARE SIMULATION THE HYBRID DISPERSION COMPENSATION SCHEMES BASED ON THE 16 × 40Gb/s DWDM USING RZ MODULATION FORMAT

Essa Ibrahim Essa
Computer Sciences Department, College of Computer Sciences and Mathematics, Tikrit University.
Salah-Aldeen, Iraq.
essaibrahimessa@yahoo.com

ABSTRACT

In this paper the hybrid dispersion compensation schemes with 16 × 40Gbps using RZ modulation format over standard single mode fiber (SSMF) link based on DWDM optical network are investigated and done in a series of computer simulations. The power loss was substituted by Erbium doped fiber amplifier (EDFA), and the dispersion compensated by dispersion compensation fiber (DCF). Minimizing the probability of error for the whole network is our interest, and the system performance is optimized for all users and channels in the network. The (BER < 10^{-12}), the average total power level is (-53.656dBm), while the maximum Q-factor is (5.4375). The simulation results show that data transmission rates successfully transmitted with low cost effective infrastructure with good system performance.

KEYWORDS

DWDM, RZ, FTTH, BER, Q-Factor, ISI, OSNR, and E-society.

1 INTRODUCTION

Due to the increasing demand for more bandwidth, optical networks are becoming more and more complex. An optical wavelength division multiplexing (WDM) network and its applications can contribute to and provide unlimited bandwidth with minimum costs, for all ranges of fiber optics communication systems services such as Internet access, E-society, fiber-to-the-home (FTTH), voice over internet protocol (VoIP), video, and other multimedia interactions. The WDM plays a key role in current and future optical network solutions due to its modular upgradability, transparency, flexibility, efficiency, reliability, and protection [1], [2], [3], and [4].

Optical systems with data rates of 10Gbps and higher require precise dispersion compensation and careful link engineering. On the other hand, dense wavelength division multiplexing (DWDM) enables multiple- shift usage of transmission fibers by coupling several wavelengths into the fibers through appropriate optical filters. However to ensure wavelength stability of semiconductor lasers must be selected the channel spacing is > 50GHz in current commercial DWDM systems. To deals with good channel spacing as the international telecommunication union (ITU) grids in industry and investigation must be leads to increase optical fiber transmission rate [5].

The DWDM innovation represents a revolution within the optical communications revolution, allowing the latter to continue its exponential growth. The existence and advance of optical fiber communications are based on the invention of the laser, particularly the semiconductor junction laser, the invention of low-loss optical fibers, and related disciplines such as integrated optics. DWDM technology is progressing in rapid manner enabled by new high-speed electronics, the potential bit rate per DWDM channel has increased to 40Gbps, and higher. Broadband Raman fiber amplifiers are being employed in addition to the early EDFA, and there are new fibers and new techniques for broadband dispersion compensation and broadband dispersion management [6]. New designs are being explored that take advantage of the fact that DWDM has opened up a new dimension in networking; it has added the dimension of wavelength to the classical networking dimensions of space and time [7].

Specifically, DWDM is the current favorite multiplexing technology for long-haul communications in optical communication networks since all the end-user equipment needs to operate only at the bit rate of a DWDM channel, which can be chosen arbitrarily, e.g., peak electronic processing speed. Hence, all the major carriers today devote significant effort to developing and applying DWDM technologies in their businesses [8], [9], and [10]. Also, the inherent of properties transparency of DWDM support many data formats, and future protocols without making any changes.

For DWDM system the data rates >10Gb/s/channel, the deleterious effects of dispersion and nonlinearity must be managed to achieve transmission over any appreciable distance. In optical networks to management dispersion utilize the SSMF, and, DCF with different parameters to retain the total accumulated dispersion low [11], and [12]. Ann et al. [13] has been carried out in order to find the optimum modulation format for high bit rate transmission. Fangfei et al. [14] was studied optimal operating conditions for 160Gb/s with slow light delay line based on parametric amplification. Rajniti et al. [15] compare of RZ and NRZ data formats for 2.5Gb/s bidirectional WDM/TDM-PON. Kaleret et al. [16] presented simulation results for DWDM using NRZ format with ultra high capacity up to 1.28Tb/s they investigate the impact of signal to noise ratio (SNR) on channel spacing.

The reminder of this article is divided into four sections. In section 2, the model assumption and simulation setup described in three subsections (transmitter, optical channel, and receiver). In section 3, the simulation results and discussion are presented. The work is summarized and some conclusions drawn in section 4.

2 MODEL ASSUMPTIONS AND SIMULATION SETUP

To present the results of DWDM optical systems with multichannel by observe the transmitter waveform at end side of receiver. However, if the bandwidth is reduced too much, there will eventually be intersymbol interference (ISI), as the waveform takes longer to move from one logic level to another. This results in waveform trajectories that begin to close down the eye. These results are tested and verified by using OptiSystem 7.0; a license product of Optiwave Corporation (Canadian Based Company).

This design is simulate a multi-channel DWDM system (16-channels at 40Gbps). A multiplexer must be added at the transmitter site to combine all the channels so that they can be transmitted through the optical fibers. Respectively, a de-multiplexer must be added at the receiver site which will provide the separation of the channels in the frequency domain and they can be analyzed separately. The schematic diagram for this experiment is shown in “Fig. 1”. The sequence length of pseudo random bit is (64bit), sample per bit is (256), and the number of samples is (16384). The main layout properties are shown in “Fig. 2”.

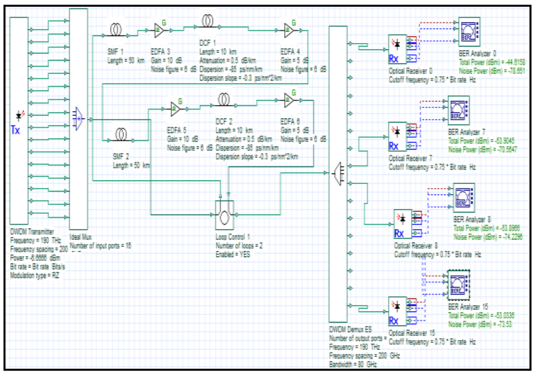

Figure 1. The main layout for the 16×40Gbps DWDM system.

Simulation	Signals	Spatial effects	Noise	Signal tracing

Name	Value	Units	Mode
Simulation window	Set bit rate		Normal
Reference bit rate	☑		Normal
Bit rate	40000000000	Bits/s	Normal
Time window	1.6e-009	s	Normal
Sample rate	1.024e+013	Hz	Normal
Sequence length	64	Bits	Normal
Samples per bit	256		Normal
Number of samples	16384		Normal

Figure 2. Main properties simulation.

2.1 The Optical Transmitter

DWDM systems require multiple transmitters and different parameters for each of them. In addition, they also require different modulation schemes and formats. By using multiple components, users can customize designs, but it is time consuming. The DWDM transmitter encapsulates different components, allowing users to select different modulation formats and schemes for multiple channels in one single component. The block diagram for each DWDM channel transmitter is shown in “Fig. 3”.

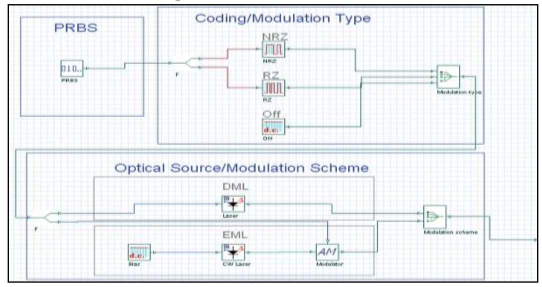

Figure 3. The block diagram for each DWDM channel transmitter.

The first stage is the Pseudo-Random Bit Sequence Generator (PRBS). Other parameters such as bit rate, order, number of leading and trailing zeros are used in the internal PRBS. A different seed will be used for each bit sequence for each DWDM channel.

The second stage is the coding/modulation. The parameter Modulation type has three options: return-to-zero (RZ), NRZ and off. RZ, and NRZ. Coding is generated by the engines of the RZ pulse generator and NRZ pulse generator respectively. A continuous wave (CW) operation of the transmitter is possible by selecting off as modulation type. The duty cycle (ordering the PRBS generator) parameter is used when modulation type RZ is selected. The most commonly used patterns in digital transmission system testing are $(2^N - 1)$ with N = 7, 10, 15, 20, 23 and 31. The corresponding pattern length (sometimes referred to as word length) is 127, 1023, 32767, 1048575, 8388607, and 2.1475×10^9 bits, respectively, per pattern. PRBS patterns have been standardized by the ITU for testing digital transmission systems.

The last stage is the optical source and modulation scheme. By using the parameter transmitter type, the user can select between an external modulated laser schemes (EML) or a directly modulated laser scheme (DML). The laser engine used in this stage is the same used in the directly modulated laser measured component. The multiplexer output is connected to the loop control components in the second stage of regime. DWDM transmitter properties are (frequency is 190THz, frequency spacing is 200GHz, power with -6.6666dBm (0.2154mW), Bitrate=Bitrate (Bit/s), and RZ modulation format).

2.2 Optical Transmission Link

The transmission span that consists of "cells" i.e. it is periodic. The "loop control" component will actually perform the multiplication of cells the necessary number of times. The use of cells stems from the necessity of dispersion compensation. At bit rates as high as 40Gbps, the design of the cell is crucial. This means that during the propagation, within one cell, not only is there a strong overlap between the adjacent pulses, but the original bit stream will be totally scrambled due to the dispersion-induced pulse broadening. Then, signals entered to the loop control are launched into the fiber link SSMF (100km), and split it into two cells (50km) for each. Which has properties such as, dispersion of (17ps/nm/km), and attenuation with (0.2dB/km), an excellent amplification process can be serve both transmitter and receiver as poster and preamplifier respectively put four EDFA with gain, and noise figure are (10, 5, 10, and 5 dB), and (6, 6, 6, and 6) respectively. There are two hybrid cells of DCF with some properties of length (10km), attenuation (0.5dB/km), dispersion (-85ps/nm/km), and dispersion slope (-0.3ps/nm2/km) for each cell. After that, the signal round trip rewards to the loop control and then enters to the receiver side.

2.3 The Receiver

The DWDM receiver design consists of (1 to 16) demultiplexer and “single-channel” receiver connected to each output port. The DWDM demultiplexer has equal spacing with frequency (190GHz), frequency spacing (200GHz), bandwidth (80GHz), depth (100dB), and second order Bessel filter to filtering each channel optically. Each demultiplexer output is connected to optical receiver subsystem as viewed in “Fig. 4”. The subsystem was built using two different types of photodetectors; one Bessel filter and the 3R regenerator. The component properties allow the user to select the internal component parameters. Depending on the choice between photodetector intrinsic negative diode (PIN) and avalanche photodetector diode (APD), the switch/select components will redirect the signal into the proper photodetector type. Then, each subsystem outputs connected to the bit error rate (BER) analyzer to be monitored the output signals by BER eye diagram and Q-Factor. The optical 3R regeneration with wavelength conversion will prove beneficial in all optical networks.

As optical signals travel in fiber link, they can be affected by a number of different factors such as dispersion, attenuation interference from other channels, noise etc... These detrimental effects cause serious distortion of the signal which must be repaired at each node. 3R regeneration of a signal includes amplification, re-shaping and re-timing. Currently 3R regeneration is performed in electrical domain with expensive optical-electrical-optical (OEO) conversions required for each channel. The 3R is connected to the BER analyzer to monitor and evaluate transmission performance.

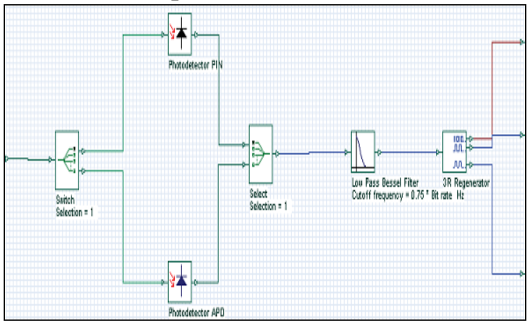

Figure 4. The optical receiver subsystem (Green Lines means optical signal, Blue means electrical signal, and Red means digital signal).

3 RESULTS AND DISCUSSION

Figure. 5 through “Fig. 11” clearly demonstrate the performance in a 40Gbps for 16-channels DWDM optical system with 100GHz channel spacing and the fiber spans for SSMF is (100km), and the (20km) of DCF. “Fig. 5” to “Fig. 11” will be subsequently described and discussed:

1) “Fig. 5”: optical spectral analyzer for all 16-channels after DWDM multiplexer (i.e., span link=0km).
2) ”Fig. 6”: optical spectral analyzer for all 16-channels, (red color) power, and (green color) noise after (100km) of SSMF, and the (20km) of DCF.
3) “Fig. 7”: Input power channel (dBm) versus wavelength (m) from the optical spectrum analyzer (OSA).
4) “Fig. 8” and “Fig. 9”: BER analyzer for output channels (1, and 16), i.e., (1577.85nm, and 1565.4nm) respectively, after (100km) of SSMF, and the (20km) of DCF, from the BER analyzers.
5) “Fig. 10”, and “Fig. 11”: Q-Factor for the output channels (1, and 16), i.e., (190THz, and 193THz) respectively, after (100km) of SSMF, and the (20km) of DCF, from the BER analyzers.

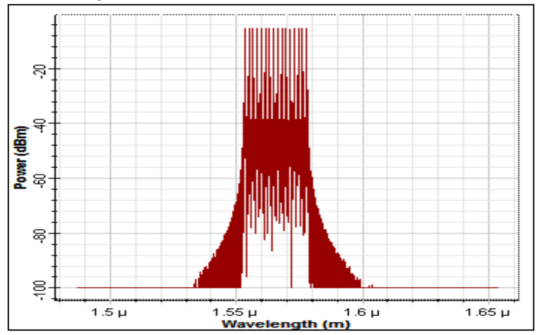

Figure 5. OSA for all 16-channels when span link=0km.

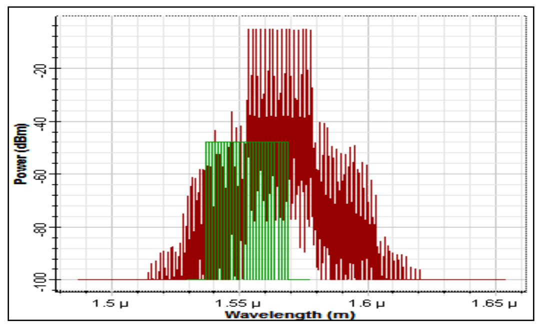

Figure 6. OSA for all channels when span link=100km.

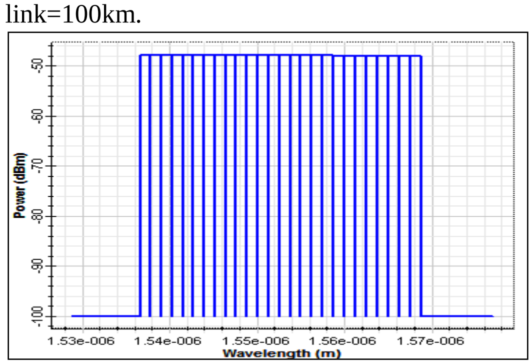

Figure 7. Input power level for all channels.

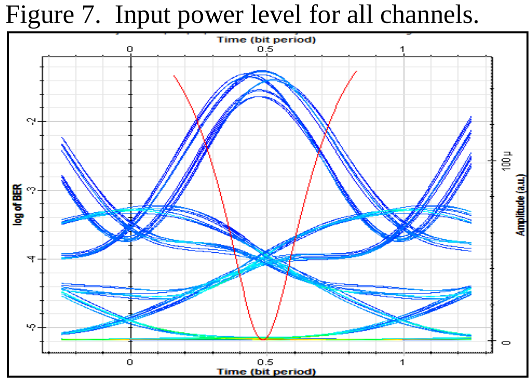

Figure 8. BER analyzer for output channel_1 (190THz) when span=120km.

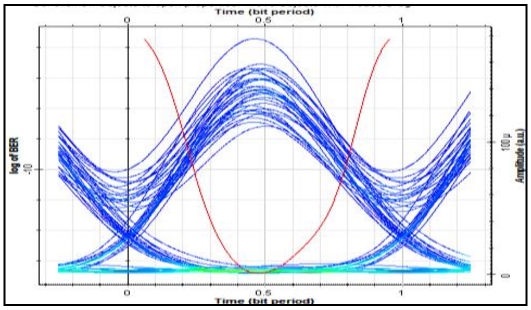

Figure 9. BER analyzer for output channel_16 (193THz) when span=120km.

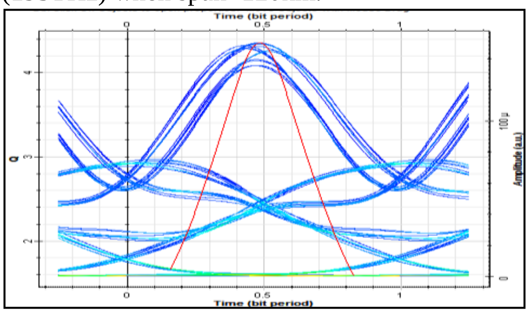

Figure 10. Q-Factor for the output channel_1 (190THz) when span=120km.

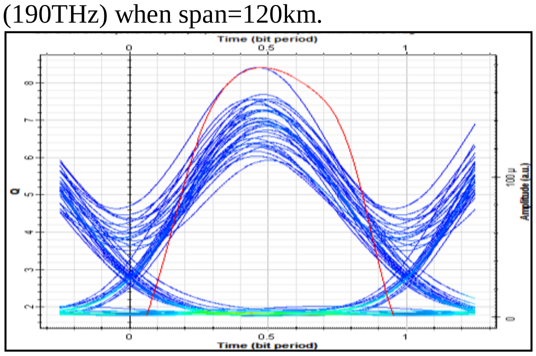

Figure 11. Q-Factor for the output channel_16 (193THz) when span=120km.

Dispersion is fully managed through compensating by hybrid DCF, and to improve degradation in signal, EDFA was be used. Based on the above figures, the evaluating performance of the system was analyzed using BER; the eye pattern gives a large opening. This means the ISI is low. The width of the opening indicates the time over which sampling for detecting is performed. The maximum eye opening yields greatest protection against noise. From the BER analyzer, the (BER $< 10^{-12}$), the average optical power level for all channels is (-53.656dBm), while the average maximum Q-factors for all 16-channels are (5.4375).

4 CONCLUSIONS

We demonstrated the (16×40Gb/s DWDM) over 120km optical link with minimum system impairments, the presence of (Passive/Active) components should be taken into considerations. The nonlinearities problems are overcome by EDFA as in-line through improve the optical signal-to-noise-ratio (OSNR), and dispersion compensation fully treated by hybrid DCF as a compensator. The simulation results show that a data transmission rates successfully transmitted, deliver a cost effective infrastructure, the DWDM systems have good performance, fully exploit the high speed, low error rate, and availability of multiple channels on a single fiber. Furthermore, this architecture is truly scalable in terms of handling additional wavelengths or nodes in an efficient manner. The major contribution is the development of the multi-destination communication over the lightwave DWDM system. By using the DWDM optical network, the majority of the people who live in urban and rural areas can use the E-society, in an easy way.

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Essa Ibrahim Essa received the B.Sc. degree in computer science from the College of Computer and Mathematic Science at the University of Mosul, Iraq, in 2001, and M.Sc. degree in computer networks and communication from IIPS, ICCI, Baghdad, Iraq, in 2006. Ph. D. networks and Communications from the College of Computer Sciences and Mathematic at the University of Mosul, in 2011, He was born in Ninava, Iraq at Dec, 1967. Now work as an instructor at the Tikrit University, Iraq. Currently, interest and working in WDM Optical Networks and my current research interests are in the area of optical communication networks. He is author/reviewer many papers in this area published in international journals and conference proceedings.