International Journal of Signal Processing, Image Processing and Pattern Recognition
Vol.8, No.11 (2015), pp.119-126
http://dx.doi.org/10.14257/ijsip.2015.8.11.12

Simulative Analysis of 40 Gbps DWDM System under the Impact of Channel Spacing

Karanjot Singh*, Jyotsana and Jyoteesh Malhotra

Department of Electronics and Communication Engineering, GNDU Regional Campus, Jalandhar, Punjab, India
**karanghuman1990@yahoo.com*

Abstract

In this paper 40 Gbps DWDM system is implemented in presence of FWM and chromatic dispersion under the impact of equal and unequal channel spacing. Dispersion is mitigated by using dispersion compensation fibre. An analysis based on comparison of DWDM system is carried out with equal channel spacing of 0.2nm, 0.3nm, 0.4nm, 0.8nm and 1.6nm with a distance of 680km. System is also analyzed for unequal channel spacing of 0.27nm, 0.275nm, 0.28nm and 0.4nm, 0.45nm and 0.5nm among four channels.

Keywords*: DWDM, FWM, DCF*

1. Introduction

As the need for higher data rate increases along with the advancements in opto-electronics technology, it is possible to have multiple wavelengths in a single fibre. In DWDM system multiple light waves travels down a single optical fibre. Due to enormous bandwidth it can support higher data rates as compared to copper cable. Chromatic dispersion and fibre non-linearities degrade the system performance parameters [1]. Dispersion compensation in DWDM system suppress GVD and FWM [2]. FWM effect is reduced on increasing the channel spacing. It is said to be avoided but it provide various applications such as wavelength conversion *etc.* In order to improve system performance, it is important to understand non-linear effects and dispersion [3]. Generally FWM light results in degradation of SNR, since FWM light is proportional to cube of optical power [4]. Chromatic dispersion is caused due to spectral width, thus longer wavelengths arrive at receiver ahead of shorter wavelengths causing pulse spread [5]. Transmission link is increased without electrical regeneration by using EDFA, but due to long interaction length non-linear effects impose limit on link length [6]. Many methods were developed to suppress FWM which includes hybrid WDM/TDM system, ultra-low unequal channel spacing, optical code division multiplexing and dispersion compensation [7]. In this paper BER and Q-factor of four channels are analyzed over a distance of 680 km in presence of four wave mixing under equal channel spacing of 0.2 nm, 0.3 nm, 0.4 nm, 0.8 nm and 1.6 nm. Also using unequal channel spacing of 0.27 nm between channel 1 and 2, 0.275 nm between channel 2 and 3 and 0.28 nm among channel 3 and 4. The paper is divided into 4 sections, Section 1 include introduction to FWM, Section 2 provides simulation setup, Section 3 gives results and discussion and Section 4 provides the conclusion.

2. System Design

The system design is shown in Figure 1. Four channels each of data rate 10 Gbps is used. Each input channel consist of PRBS generator, NRZ generator, CW laser and Mach-Zehnder Modulator. Then, these signals are multiplexed with the help of a

* Corresponding Author

ISSN: 2005-4254 IJSIP

multiplexer, then they are sent on the SMF having dispersion of 16.75 ps/nm.km and of length 40 km. EDFA is used to amplify the signal, which has gain 10 dB and noise Figure of 6 dB. DCF is used to compensate the dispersion effect. Firstly equal channel spacing of 0.2 nm followed by equal channel spacing of 0.3 nm followed by 0.4 nm, 0.8 nm and 1.6 nm. The wavelength of first channel used here is 1552.52 nm. Then, unequal channel spacing of 0.27 nm between channel 1 and 2, 0.275 nm between channel 2 and 3 and 0.28 nm between channel 3 and 4 nm is applied. Also unequal channel spacing of 0.4nm between channel 1 and 2, 0.45 nm between channel 2 and 3 and 0.5 nm between channel 3 and 4 nm is applied. The receiver section contains PIN diode, followed by low pass Bessel filter, 3-R regenerator and eye diagram analyzer.

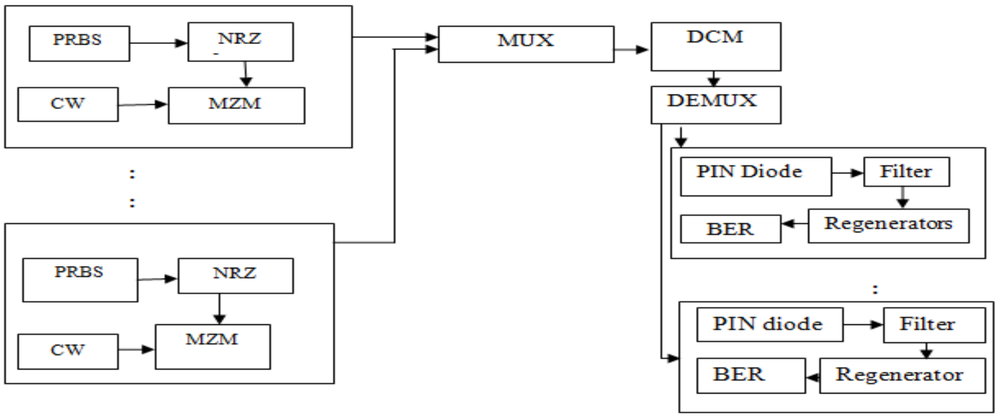

Figure 1. Block Diagram of 40 Gbps DWDM System

3. Results and Discussions

BER and Q-factor are two important parameters for analysis of optical communication system. Eye pattern analyzer gives eye diagram, from which BER and Q-factor is generally calculated. Figure 2 and 3 shows eye diagram for channel 1 and channel 4 at an equal channel spacing of 0.2 nm. Figure 4 shows the spectrum showing FWM components. The BER achieved is 10^{-24}, 10^{-24}, 10^{-23}, 10^{-23} of channel 1-4 respectively. The Q-factor measured is 10.07, 10.23, 9.89, 9.69 respectively. Figure 5 and 6 shows eye diagram of channel 1 and channel 4 at an equal channel spacing of 0.3 nm. Figure 7 shows the spectrum showing FWM components. The BER achieved is 10^{-26}, 10^{-22}, 10^{-22}, 10^{-25} of channel 1-4 respectively. The Q-factor measured is 10.44, 9.63, 9.49, 10.25 respectively.

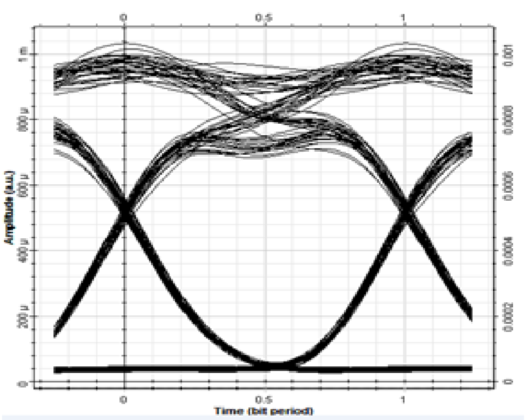

Figure 2. Eye Diagram for Channel 1

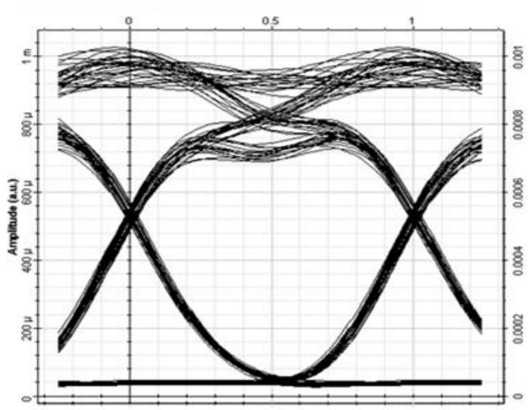

Figure 3. Eye Diagram for Channel 4

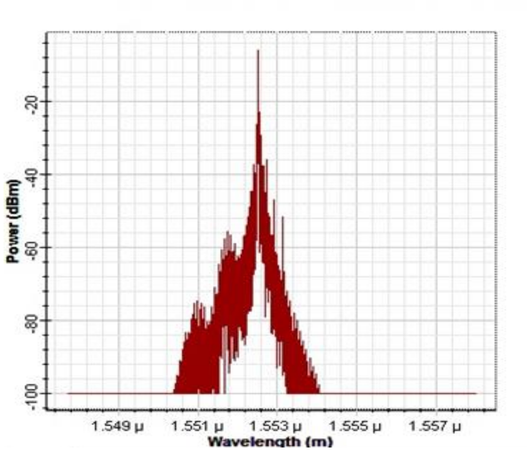

Figure 4. Output of Spectrum Analyzer Channel Spacing of 0.2 nm

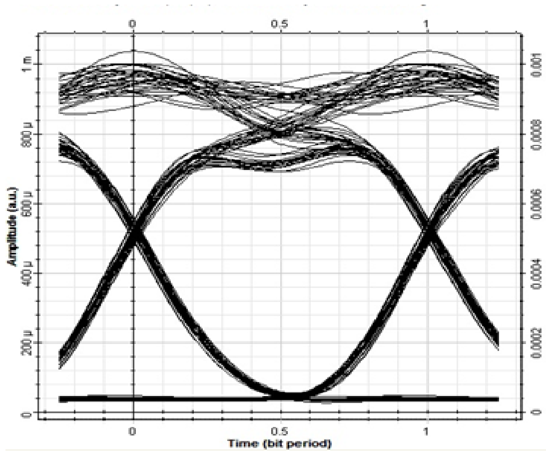

Figure 5. Eye Diagram for Channel 1

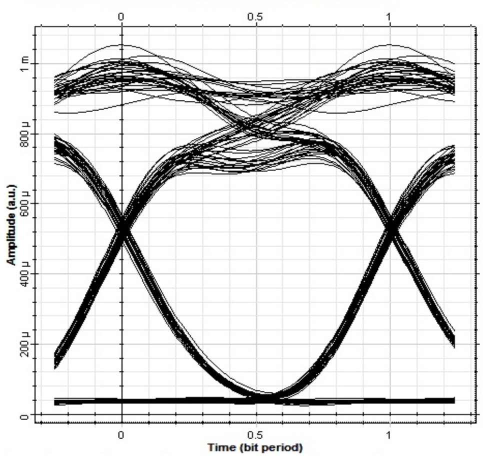

Figure 6. Eye Diagram for Channel 4

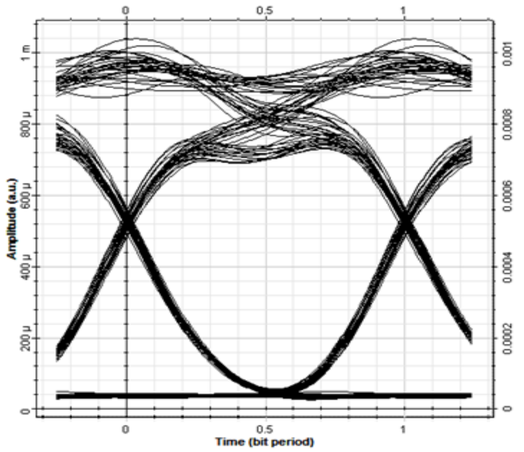

Figure 8. Eye Diagram for Channel 1

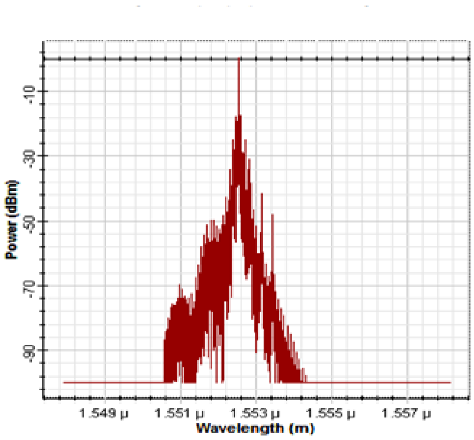

Figure 7. Output of Spectrum Analyzer at Channel Spacing of 0.3 nm

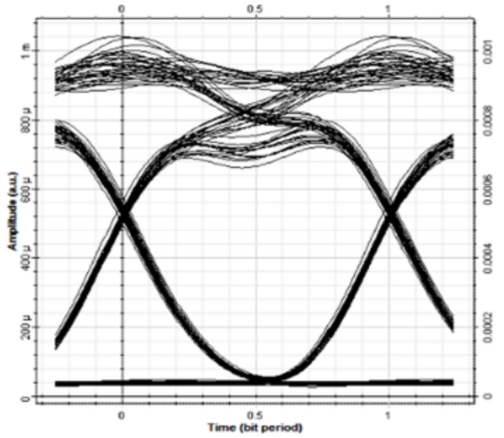

Figure 9. Eye Diagram for Channel 4

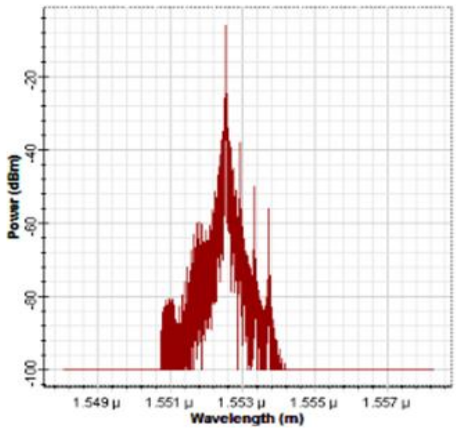

Figure 10. Output of Spectrum Analyzer at Channel Spacing of 0.4 nm

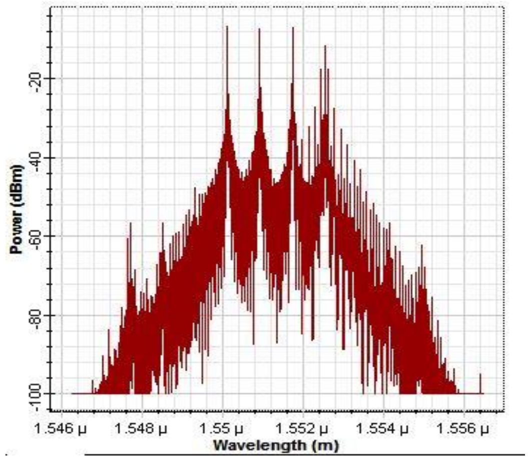

Figure 13. Output of Spectrum Analyzer at Channel Spacing of 0.8 nm

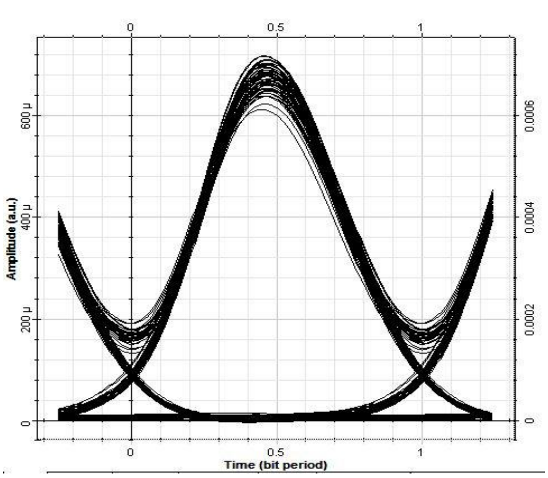

Figure 11. Eye Diagram for Channel 1

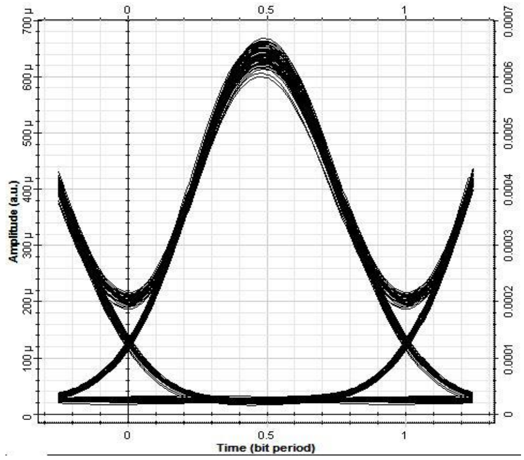

Figure 14. Eye Diagram for Channel 1

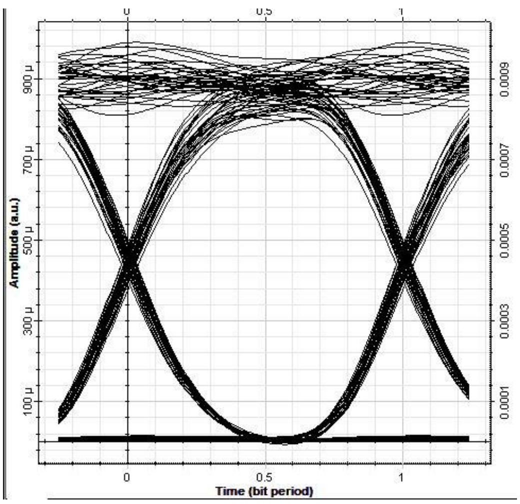

Figure 12. Eye Diagram for Channel 4

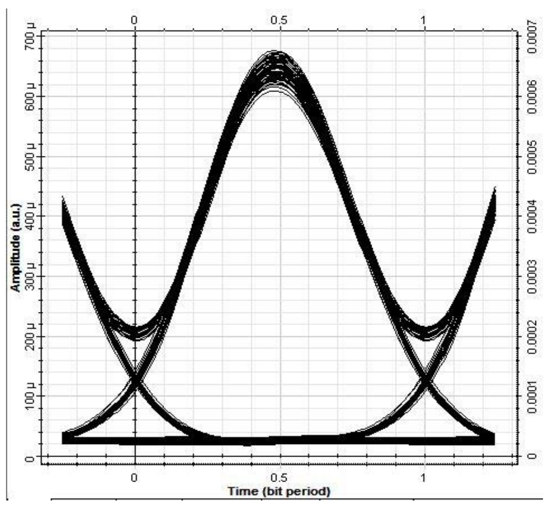

Figure 15. Eye Diagram for Channel 4

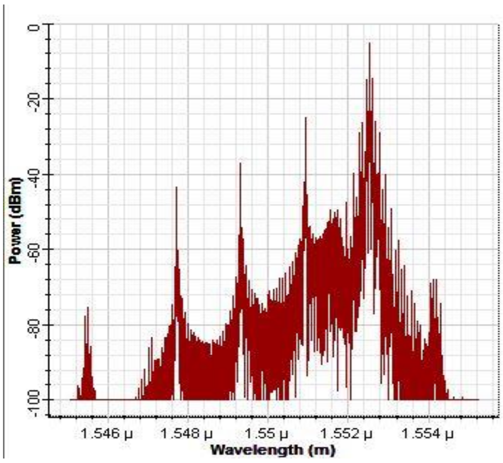

Figure 16. Output of Spectrum Analyser at Channel Spacing of 1.6 nm

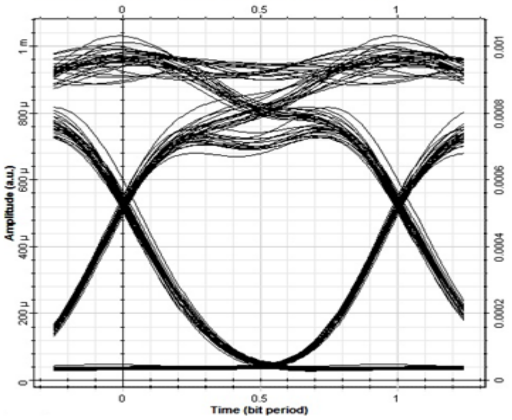

Figure 17. Eye Diagram for Channel 1

Figure 8 and 9 shows eye diagram for channel 1 and channel 4 at an equal channel spacing of 0.4 nm. Figure 10 shows the spectrum showing FWM components. The BER achieved is 10^{-25}, 10^{-21}, 10^{-23}, 10^{-25} of channel 1, 2, 3 and 4 respectively. The Q-factor measured is 10.26, 9.28, 9.89, 10.18 respectively. On increasing the spacing, BER and Q-factor is improved. Further on increasing the channels even yields better results. Making system more denser degrades the system performance. On increasing the channel spacing to 0.8nm the BER and Q-factor of DWDM system is further improved. Figure 11 and 12 shows eye diagram for channel 1 and channel 4 at spacing of 0.8nm. Figure 13 shows the spectrum. The Q-factor measured is 24.66, 25.44, 17.10, 22.90 and BER achieved is 10^{-135}, 10^{-143}, $10^{-66}$and 10^{-116} for channel 1, 2, 3 and 4 respectively. Figure 14 and 15 shows eye diagram for channel 1 and channel 4 at spacing of 1.6 nm. Figure 16 shows the spectrum. The Q-factor measured is 36, 32.81, 29.22, 34.07 and BER achieved is 10^{-284}, 10^{-236}, $10^{-188}$and 10^{-255} for channel 1,2,3 and 4 respectively.

For unequal channel spacing, the first channel is 1552.52 nm, second channel is 1552.79 nm, third channel is 1553.065 nm and fourth channel is 1553.345 nm. Figure 17 and 18 shows eye diagram for channel 1 and channel 4 at an unequal channel spacing of 0.27nm between channel 1 and channel 2, 0.275nm between channel 2 and 3 and 0.28nm between channel 3 and 4. Figure 19 shows the spectrum showing FWM spectral components.

The BER achieved is 10^{-21}, 10^{-23}, 10^{-24}, 10^{-24} of channel 1, 2, 3 and 4 respectively. The Q-factor measured is 9.41, 9.80, 10.01, 10.06 of channel 1, 2, 3 and 4 respectively. Figure 20 and 21 shows eye diagram for channel 1 and 4 at unequal channel spacing of 0.4nm, 0.45nm, 0.5nm between channel 1, 2, 3 and 4 respectively. Figure 22 shows output of spectrum analyzer. The BER achieved is 10^{-26}, 10^{-23}, 10^{-24} and $10^{-24}$and Q-factor is 10.27, 9.89, 10.11 and 9.92.

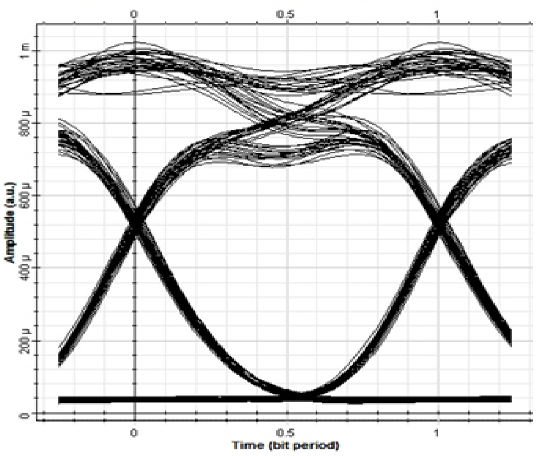

Figure 18. Eye Diagram for Channel 4

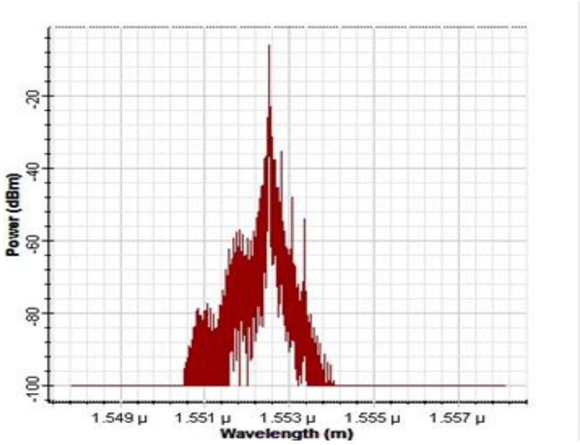

Figure 19. Output of Spectrum Analyzer at Unequal Spacing of 0.27nm

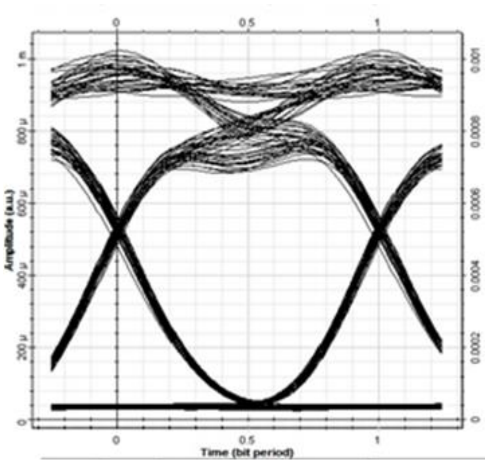

Figure 20. Eye Diagram for Channel 1

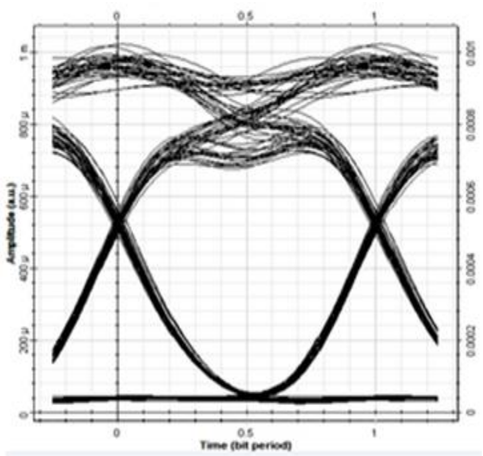

Figure 21. Eye Diagram for Channel 4

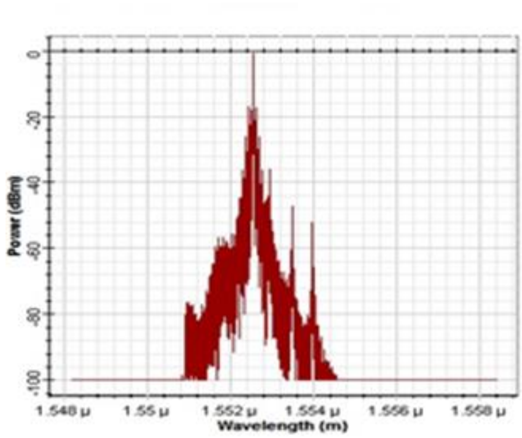

Figure 22. Output of Spectrum Analyzer at Unequal Spacing of 0.4 nm

Table 1. Comparative Analysis of Equal Channel Spacing

Equal channel spacing	BER	Q-factor
0.2 nm	10^{-24}	9.69
0.3 nm	10^{-25}	10.2
0.4nm	10^{-26}	10.26
0.8nm	10^{-143}	24.66
1.6nm	10^{-284}	36.00

Table 2. Comparative Analysis of Unequal Channel Spacing

Parameters	Unequal channel spacing			
	Ch1-Ch2	Ch3-Ch4	Ch1-Ch2	Ch3-Ch4
	0.27 nm	0.28 nm	0.4 nm	0.5 nm
BER	10^{-21}	10^{-24}	10^{-26}	10^{-24}
Q-factor	9.41	10.01	10.27	9.92

4. Conclusion

An implementation of 40 Gbps DWDM system is investigated over an optical span of 680 km in presence of chromatic dispersion and FWM under the impact of equal and unequal channel spacing to evaluate BER and Q-factor. On varying the spacing from 0.2 nm to 1.6 nm results in better system performance. Also unequal channel spacing of 0.27 nm between channel 1 and 2, 0.275 nm between channel 2 and 3, and 0.28nm between channel 3 and 4 gives better performance than equal channel spacing of 0.2 nm. Unequal spacing suppress FWM. The BER of equal channel spacing of 0.2 nm, 0.3nm, 0.4nm, 0.8nm and 1.6nm is in order of 10^{-24}, 10^{-25} , 10^{-26}, 10^{-143}, 10^{-284} respectively. There is an improvement in BER and Q-factor with unequal channel of 0.4 nm, 0.45 nm and 0.5 nm between channel 1, 2, 3 and 4 as compared to that of 0.27 nm.

Acknowledgment

The author wishes to thank Ms. Jyotsana and Mr. Jyoteesh for their guidance in the research work.

References

[1] V.Sharma and R. Kaur, "Implementation of DWDM system in presence of four wave mixing under the impact of channel spacing", optik, vol. 124, **(2013)**, pp. 3112-3114.
[2] G.Belloti and C.Francia, "Intensity distortion induced by cross phase modulation and chromatic dispersion in optical fibre transmission with dispersion compensation", IEEE photonics technology letter, vol. 10, no.12, **(1998).**
[3] A.Wason, Monika and R.S. Kaler, "Investigation of four wave mixing effect with different number of input channel at various channel spacing", optik, vol. 124, **(2013)**, pp. 4227-4230.
[4] J.S.Malhotra, M.Kumar and A.K. Sharma, "Estimation and mitigation of FWM penalties in dispersion managed 32 channel long haul DWDM soliton link", optik, vol. 124, **(2013)**, pp. 3029-3032.
[5] P. Dalotr and H. Singh, "Effect of chromatic dipersion on FWM in optical WDM transmission system", International journal of advance research in computer and communication engineering, vol. 2, issue 6, **(2013).**
[6] G. Kaur and M.L Singh, "Effect of four-wave mixing in WDM optical fibre system", optik, vol. 120, **(2009)**, pp. 268-273.
[7] H. J. Abed, N. M. Din and M. H. Al-Mansoori , "Recent four wave mixing suppression methods", optik, vol. 124, **(2013)**, pp.2214-2218.

[8] S. Sarkar and N. R. Das, "On the optimum detection threshold for minimum bit error rate due to FWM in a WDM system", Journal of Optical Communications and Networking, vol. 5, no.4, **(2013).**
[9] L.K. Tyagi, A.K.Jaiswal, M. Kumar and T. Joshi, "Performance analysis of four wave mixing based wavelength conversion in commercial optical fibre", International journal of scientific and research publications, vol. 2. **(2012).**
[10] S.P. Singh and N. Singh, "Non-linear effects in optical fibre: origin, management and applications", progress in electromagnetic research, PIER 73, **(2007)**, pp. 249-275.

