International Research Journal of Education and Technology
ISSN 2581-7795

Performance Analysis of Time and Wavelength Division Multiplexed Passive Optical Network (TWDM-PON) Using Different Placements of Dispersion Compensation Modules

Amandeep Kaur[1] and Rishav Diwan[2]
[1]Student, Bhai Gurdas Institute of Engineering and Technology, Sangrur
[2]Assistant professor, Bhai Gurdas Institute of Engineering and Technology, Sangrur

Abstract: Time and Wavelength Division Multiplexed Passive Optical Network (TWDM-PON) is very competent next generation multiplexing technique and is becoming popular among researchers these days. In this proposed work, diverse placements of dispersion compensation module are explored in O band based 20 km long TWDM-PON system. Total four wavelength channels each at 25 Gbps are taken and modulated with directly modulated lasers (DMLs). Many PON systems employ digital signal processing (DSP), although this adds to the system's complexity and expense. A dispersion correction module in an optical line terminal (OLT) can be used to adjust dispersion in all channels using a single device. Dispersion compensation module is placed in three different ways such as (1) prior to the transmission fiber (2) after the transmission fiber (3) in between the fiber or inline and results are investigated in terms of Q factor, BER and received power.

Keywords: **Optical line terminal, Optical network unit, Dispersion compensation, BER, Q factor**

1. INTRODUCTION

Nowadays, ever-increasing internet services comprising audio, data and video i.e. Triple play services are emerging as the inevitable part of the optical communication networks. Expansion of internet services, online gaming, high definition television and 4K videos increases the users and therefore, to fulfil this demand, more Bandwidth in fiber to the home (FTTH) networks is required [1]. Networks supporting 10 Gbps speed was perceived to be high speed network but not sufficient these days due to accommodation of more and more users. High capacity of core networks is an important trait however significant bandwidth reaching per user is utmost concern. Pont to point (P2P) communication and networks based on this are high cost, as each user require dedicated communication channel [2]. Single channel PONs and FTTH networks experience limitation of high deployment cost but, emergence of WDM-PON has introduce paradigm shift in the field of high capacity optical access networks. Owing to its excellent bandwidth, improved data rates, massive capacity, channel sovereignty, flexibility, format transparency, it has drawn considerable attention, safety and expandability of a network. For next generation optical carriers, several conditions are should be met such as (1) flexible, manageable, bandwidth network, (2) should have back compatibility (3) improved performance (4) economical network and (5) high capacity [3] [4] [5]. A symmetric 100G-PON with non-return to-zero format for dispersion correction in the O-band without DSP is demonstrated in [6]. For both downstream and upstream channels, a dispersion correction module with a dispersion of roughly -150 ps / nm at 1310 nm is employed in the optical line terminal to compress the pulse

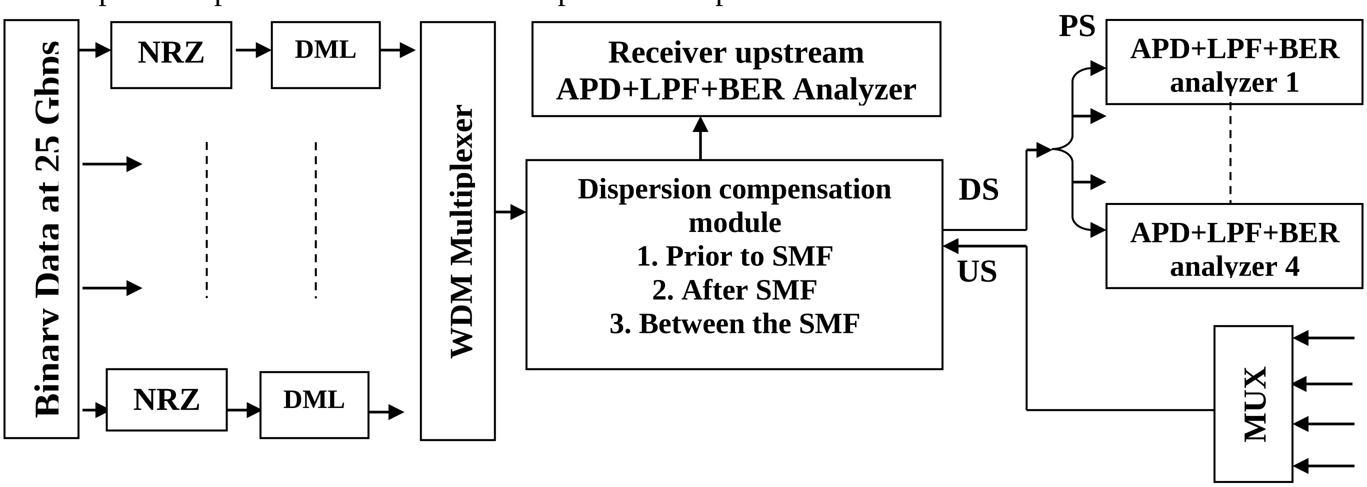
International Research Journal of Education and Technology
ISSN 2581-7795

width of directly modulated signals. In addition, in 100 Gbps TWDM PON, a semiconductor optical amplifier (SOA) is utilized for attenuation correction, with the primary goal of lowering costs and improving performance with pre DSE. However, the author only investigates a configuration in which the dispersion compensation module is placed before the transmission fiber in TWDM PON, although alternative dispersion compensation fiber locations can also be investigated [7].

In this work, diverse placements of dispersion compensation module are explored in O band based 20 km long TWDM-PON system. Total four wavelength channels each at 25 Gbps are taken and modulated with directly modulated lasers (DMLs). Dispersion compensation module is placed in three different ways such as (1) prior to the transmission fiber (2) after the transmission fiber (3) in between the fiber or inline and results are investigated in terms of Q factor, BER and received power.

2. SYSTEM SETUP

In this work, a TWDM-PON system is studied, which can support four WDM channels at a data rate of 25 Gbps each. In both upstream and downstream directions, four pairs of wavelengths are used to produce a total data rate of symmetric 100 Gb/s. Binary data is generated at 25 Gbps speed from binary data generator and further linecoded by using NRZ format and four DMLs. Wavelengths used fall in O band and these wavelengths are 1270 nm to 1330 nm with the difference of 20 nm. For interference reduction among nearby channels, the difference in downstream and upstream wavelengths is at 1.6 nm. Launched power from each DML laser is fixed to 10 dBm and length of single mode fiber is taken 20 km. For the accomplishment of dispersion compensation and amplification, a dispersion compensation fiber and SOA is incorporated in the system. Different placements of this dispersion compensation module are studied in the downstream and upstream. Four downstream channels travel through SMF and dispersion compensation module and then received by de-multiplexer which isolate the specific signals according to the wavelength and each channel then passed through avalanche photodetector, low pass filter and BER analyzer. For the upstream transmission, 1.6 nm spacing is adjusted between the downstream wavelengths such that upstream wavelengths becomes 1271.6 nm, 1291.6 nm, 1311.6 nm and 1331.6 nm. Similar to the downstream transmission, upstream signals also goes through 20 km SMF, dispersion compensation module and then demultiplexed. Channels in upstream are also received with APD, LPF and BER analyzer. Figure 1 depicts the performance of various dispersion compensation module locations in TWDM-PON.



APD: Avalanche photo diode, DS: Downstream, US: Upstream **upstream data**
PS: Power splitter, LPF: Low pass filter, SMF: Single Mode Fiber

Figure 1 Block diagram of proposed system

Simulation setup of TWDM-PON system consisting of DCF prior to SMF is shown in Figure 2.

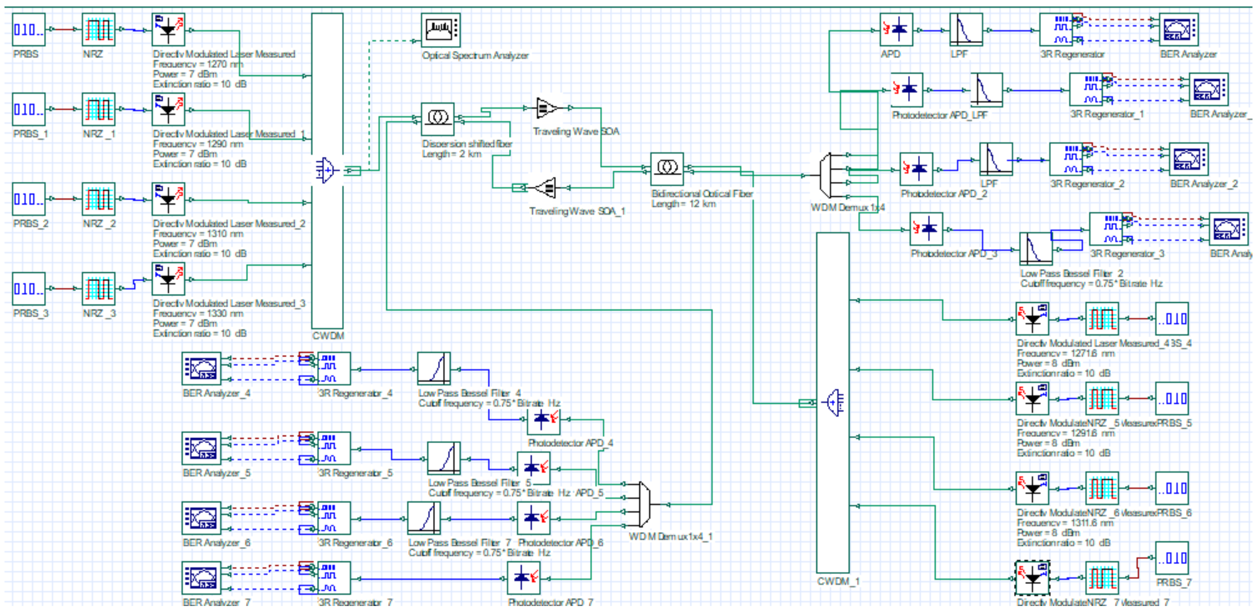
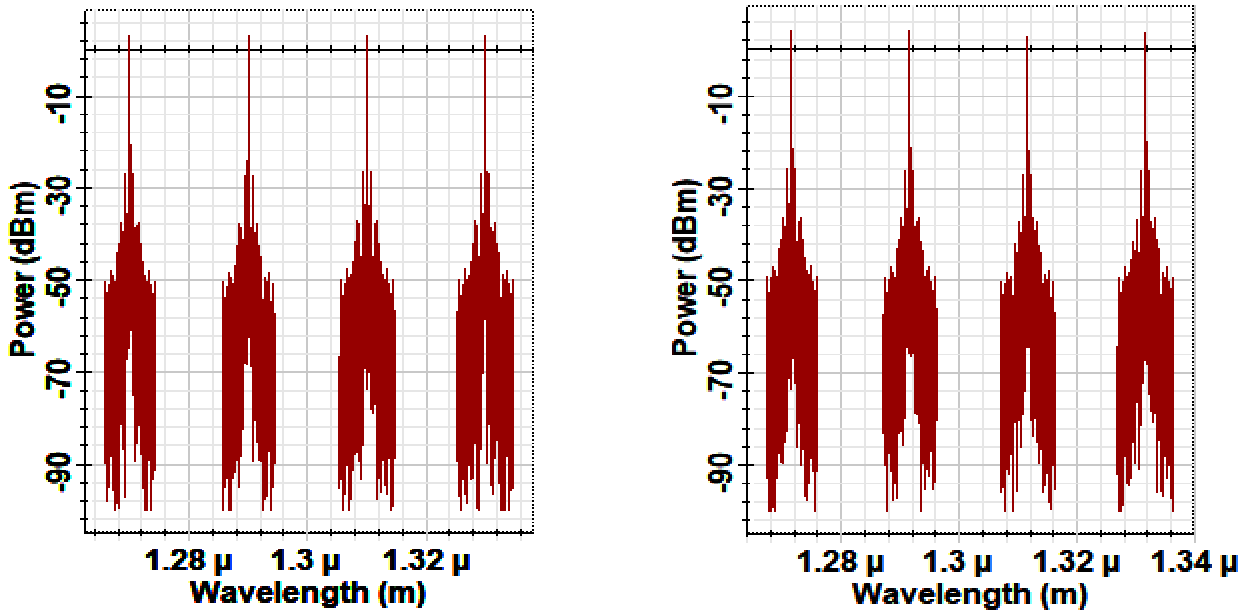


Figure 2 Simulation model of proposed work

3. RESULTS AND DISCUSSIONS

Investigation of TWDM-PON systems is performed at different optical fiber link lengths and for the assessment of optical spectrum of carrier, optical spectrum analyzer is placed at multiple positions. Here, utmost work of these carrier analyzers is to represent wavelength of each carrier and power on them. Figure 4 depicts the carrier spectrums of upstream and downstream wavelengths after multiplexers in Figure 3 (a) and Figure 3 (b) respectively.



(a) (b)

Figure 3 Carrier spectrums of (a) DS signals (b) US signals

Figure 4 depicts the performance of various dispersion correction module configurations in the proposed system at various distances in terms of Q factor. The dispersion compensation module is examined prior to SMF, after SMF, and between SMF, and it is discovered that as the distance between the SMF increases, the Q factor of all three configurations falls owing to attenuation, dispersion, and scattering. Due to the least amount of noise emergence, the performance of the dispersion correction module between SMFs of similar length is the best. The performance of the dispersion correction module after SMF is then compared to the performance of the dispersion compensation module before SMF.

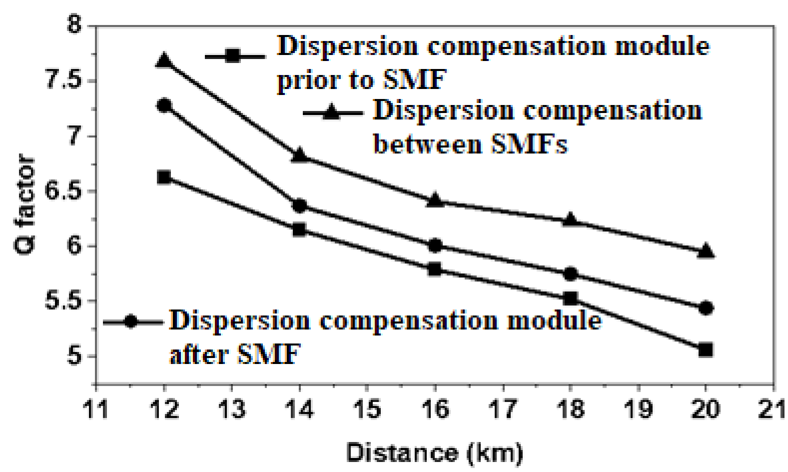


Figure 4 Performance comparisons of dispersion compensation module at different positions in TWDM-PON in terms of Q factor in downstream

Figure 5 depicts the performance of the proposed system's dispersion correction module in terms of log BER at various distances. Because of losses, disturbances, and nonlinear effects, log BER

International Research Journal of Education and Technology
ISSN 2581-7795

of all three setups increases as the fiber distance grows. In two equal halves, the dispersion correction module between SMFs displays the least BER and the highest efficacy.

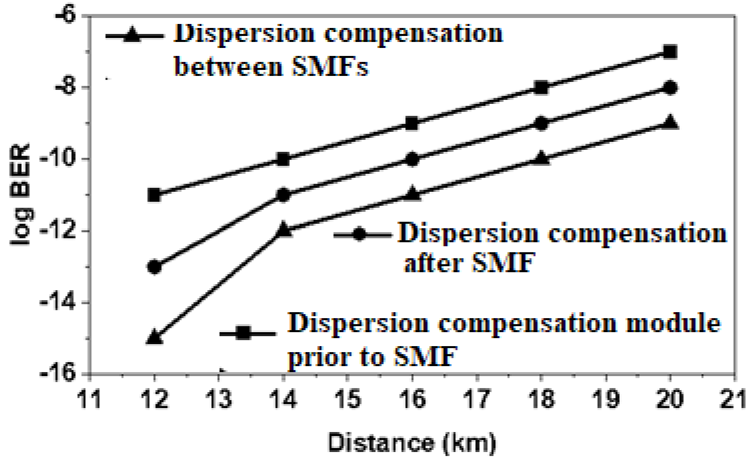


Figure 5 Performance comparisons of dispersion compensation module at different positions in TWDM-PON in terms of log BER in downstream

Received power at BER is the overall received power, which is made up of both signal and noise power. Because low pass filters are employed in the receiver to remove sounds, higher power may improve the system's performance. Furthermore, minor APD thermal effects are taken into account, resulting in the maximum power levels at the receiver for the dispersion correction module between SMFs. Due to insertion losses, component attenuations, and dispersion, the system loses power. The maximum power is received in the dispersion compensation module between SMFs configuration, as shown in Figure 6, and it is followed by the dispersion compensation module following SMF. In WDM systems, received power is impacted by attenuation, scattering, nonlinear phenomena such as four wave mixing, cross phase modulation, and gain modulations, etc.

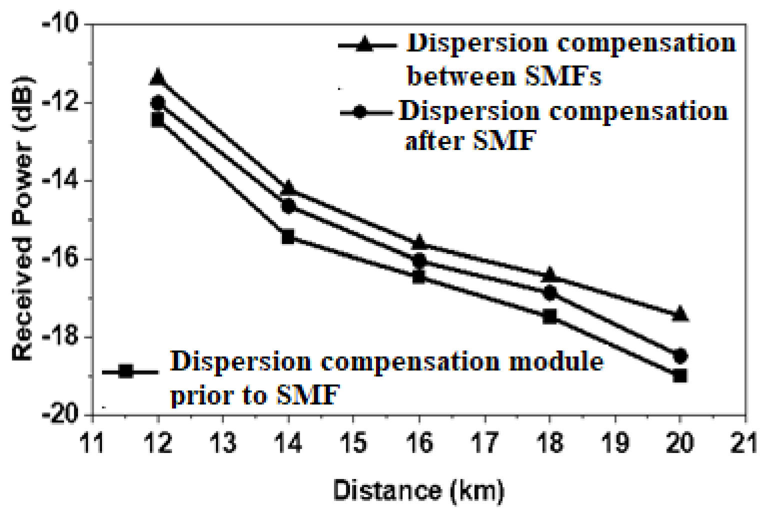


Figure 6 Performance comparisons of dispersion compensation module at different positions in TWDM-PON in terms of received power in downstream

The BER's sensitivity to received power is such that when high power is received on the receiver, bit errors are reduced. Figure 7 demonstrates that the SMF dispersion correction module has the fewest faults and receives the most power.

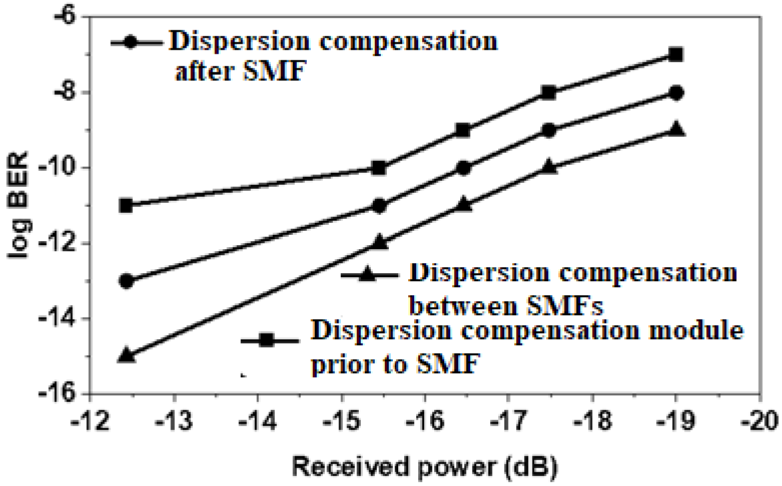


Figure 7 Performance comparisons of dispersion compensation module at different positions in TWDM-PON in terms of received power in downstream

Figure 8 shows a comparison of downstream and upstream transmission performance in the proposed system across various distances. The results are derived using the dispersion correction module between SMFs, which is the most efficient of all the configurations. Distances vary from 12 to 20 kilometers. Because of lower losses and an optimal atmosphere in the central office, downstream Q factors are better than upstream. Upstream transmitters, on the other hand, are located at the user's location, resulting in somewhat larger degradations. The suggested system can traverse 20 km in both directions, downstream and upstream, within an acceptable BER range, according to the results.

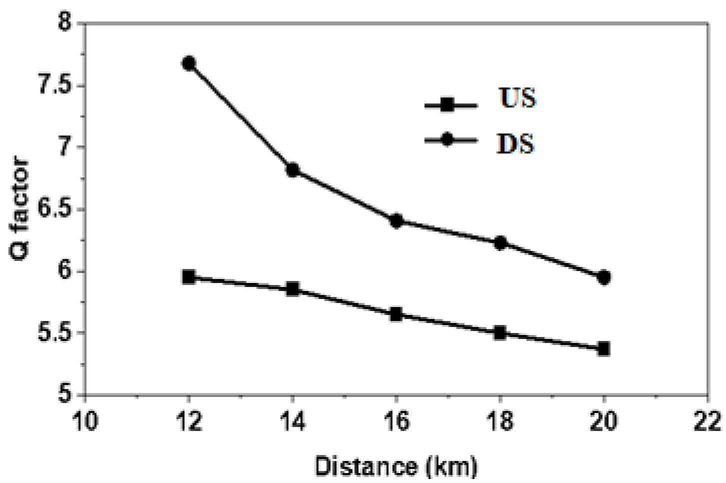


Figure 8 Performance comparisons of dispersion compensation module between SMFs configurations only in upstream and downstream in terms of Q factor

4. CONCLUSIONS

In this work, O band based TWDM-PON is demonstrated over 20 km using different placements of dispersion compensation modules i.e. (1) prior to the transmission fiber (2) after the transmission fiber (3) in between the fiber and results are investigated in terms of Q factor, BER and received power. The Q factor for dispersion correction module prior to the transmission fiber, after the transmission fiber, and in between the fiber at 20 km was found to be 5.06, 5.44, and 5.95 in the same sequence. Because of improved dispersion tolerance, attenuation, and nonlinear compensation, the dispersion correction module performs better when positioned between equal length SMFs.

REFERENCES

[1] S. Kaur, M. Kaur, A. Verma, "An Integrated High-Speed Full Duplex Coherent OFDM-PON and Visible-Light Communication System", Journal of Optical Communication, ahead of printing, 10.1515/joc-2018-0236, 2019.

[2] J. Mirza, W. Imtiaz, A. Aljohani, A. Atieh, S. Ghafoor, "Design and analysis of a 32 × 5 Gbps passive optical network employing FSO based protection at the distribution level", Alexandria Engineering Journal, vol. 59, no. 6, pp. 4621-4631, 2020.

[3] S. Kaur, M. Kaur, A. Verma, "A Novel Hybrid Passive Optical Network, Free Space Optical and Visible Light Communication System", International Journal of Emerging Technologies and Innovative Research, vol. 6, no. 4, pp. 258-261, 2019.

[4] Y. Zhou, C. Gan, B. Chen, "An upgradeable WDM-PON for broadcast and LAN services", Opt. Quant. Electron., vol. 42, pp. 157–163, 2020.

[5] T. Horvath, P. Munster, V. Oujezsky, N. Bao, "Passive Optical Networks Progress: A Tutorial", Electronics, vol. 9, no. 1081, pp. 1-31, 2020.

[6] H. Ji, L. Yi, Z. Li, X. Lei, X. Li, Q. Yang, S. Wang, Y. Yang, J. Xu, S. Yu and W. Hu, "Field-trial of a real-time 100 Gb/s TWDM-PON based on 10G-class optical devices," J. Lightwave Technol., vol. 35, no. 10, **(2017)**, pp. 1914-1920.

[7] L. Xue, L. Yi, H. Ji, P. Li, and W. Hu, "First Demonstration of Symmetric 100G-PON in O-band with 10G-Class Optical Devices Enabled by Dispersion-Supported Equalization," presented at the Optical Fiber Communication Conf. Exhibition, Los Angeles, CA, USA, **(2017)**, M3H.1.