© 2017 IJEDR | Volume 5, Issue 2 | ISSN: 2321-993

A Long Haul Carrier Generated Ultra Dense Passive Optical Network Incorporating Low Cost VCSEL

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Abstract: **An ultra-dense WDM passive optical network is proposed at 6.25 GHz channel spacing. A low cost VCSEL laser is incorporating in the system for the generation of multiple wavelengths. Results revealed that proposed system can successfully achieve 120 km in both optical line terminal (OLT) and optical network unit (ONU) at 2.5 Gbps.**

Index Terms- **Vertical cavity surface emitting laser (VCSEL), Optical line terminal (OLT), Optical network unit (ONU), Remote node (RN), Carrier generation**

I. INTRODUCTION

With the extensive growth in the internet services and bandwidth hungry applications, has increases the requirements of high capacity and high speed networks. Wavelength division multiplexing is a right candidate to fulfill the demands of current optical networks [1]. Wavelength division multiplexing (WDM) passive optical network (PON) has been extensively recognized as a striking way out of access network to convene the bandwidth requirement as well as offer multi-service incorporation [2]. In order to cater the large number of users through passive optical networks due to increase in broadcast terminals, dense channel spacing among WDM channels is preferred with relatively low cost [3]. Moreover, the extent of access networks is geographically prolonged; consequently the consolidation of PONs and metro networks can be made to decrease upholding cost and energy expenditure in networks [4]. Subsequently, a dense WDM passive optical network is considered as a useful technology for next generation access networks. To alleviate the management issues and makes system cost effective, a cheap intensity source is desirable. Numerous researches have been reported so far to increase system reach and operational data rate. However, these works are either realized by complex techniques or operational with the help of costly modules such as modulators [5], amplifiers [6], lasers [7] and advances modulations [8] etc.

Penze R.S. et al have proposed a dense WDM passive optical network with 100 GHz channels spacing and transmitted the signal over 20 km single mode fiber. Reflective semiconductor optical amplifier is incorporated in the optical line terminal (OLT) for central office to user end transmission and also in optical networks units for upstream modulation [9]. In [10], DWDM-PON system is demonstrated at 25 GHz to make system bandwidth efficient. Also system reach is achieved till 60 Km within acceptable range of Q-factor and BER. Major problem was the low data carrying capacity over long distances and use of expensive laser sources. To overcome this problem, distributed feedback (DFB) lasers are employed in the systems. But DFB laser further increase cost of the system due to large sources needed in WDM systems. Also carrier generation with single febry-parrot laser is used to generate 80 carriers for downstream and upstream [11].

FP laser and electro-absorption modulator is a costly intensity source and also system was limited to 150 km downstream and 80 Km upstream at 1.25 Gbps. So, work needs to be done at cost effectiveness and enhancement of speed, distance of reported works that are reported so far.

In this research article, a carrier generation based on vertical cavity surface emitting laser (VCSEL) is demonstrated for DWDM passive optical network at 6.25 GHz channel spacing. Proposed system successfully achieved the 120 Km symmetrical transmission in both downstream and upstream. It is noteworthy that no amplifier for transmission and dispersion compensation is included in the system.

II. System Setup

For the realization of proposed work, a prominent and widely used simulation tool Optiwave Optisystem™ is used. Figure 1 represents the architecture of dense wavelength division passive optical network. In Optical line terminal, a comb source is used to generate carriers centered at different frequencies. Data rate of the system is 2.5 Gbps and this is a symmetrical PON architecture that carries same data speed for both downstream and upstream. An optical Bessel filter is placed to filters out 80 wavelengths, with 40 channels for upstream and 40 for downstream. Generated carries are firstly separated with two 40:1 multiplexers and the one set of 40 wavelengths is modulated with help of non return to zero (NRZ) pulse generator that receives drive from binary data. After passing through a demultiplexer, all the downstream seeding wavelengths are injected into the MZM (mach-zhender modulator) for downstream data modulation.

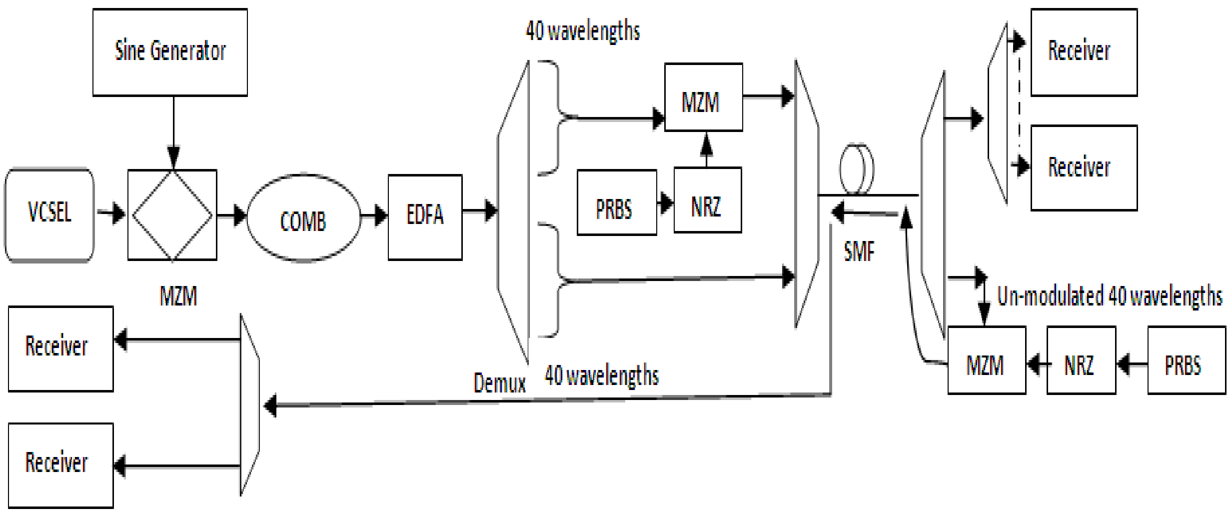


Figure 1 Architecture of proposed ultra dense passive optical network based on VCSEL carrier generation

Data fed to optical fiber SMF-28 that has attenuation 0.2 dB/Km and dispersion 17 ps/nm/Km and all nonlinear effects are also considered. In remote node (RN), the demultiplexer with equal channels spacing is used to de-multiplex the downstream signals. Now, the modulated signals are detected at receiver of downstream and 40 channels that are un-modulated that are used for upstream. All the upstream channels are modulated with on-off keying modulation format. MZM is considered as an upstream modulator due its numerous advantages such as high extinction ratio and different points of operation. Total distance of optical fiber is considered 120 Km for both the downstream and upstream. Figure.1 depicts the architecture of the carrier generation setup that consists of a laser source (VCSEL), a sine generator and intensity modulator MZM. Eternal modulator, in order to generate carries, is operated at 2.5 GHz. Carrier separation is fixed to 6.25 GHz to make system bandwidth efficient and efforts have been made to accommodate maximum number of channels. An optical spectrum analyzer is a depicter that represents the carrier frequencies with respect to power as shown in Figure 2. Following the design represented in Figure.1, simulation is set up for investigating the demonstrated system DWDN-PON. The output wavelength and temperature of VCSEL laser are set as 1 552.52 nm and 20 degree Celsius, respectively. For upstream, the 40 channel seeding light signals centered at 1 550.51nm are also filtered out in OLT, and then assigned to each ONU for upstream signal modulation. The p-i-n photodiodes are used in both ONU and OLT to detect the signals, and the received electrical signals are observed and analyzed by an oscilloscope. In this proposed DWDM-PON, the seeding light is provided by the comb source instead of spectrum sliced ASE.

III. Results and Discussion

In proposed 80 channels WDM architecture, performance of upstream and downstream UDWDM passive optical network is investigated in terms of Q-factor and BER (Bit error rate). Also VCSEL laser source is scrutinized as a source for carrier generation to perceive optimal comb of carriers for prolonged distances.

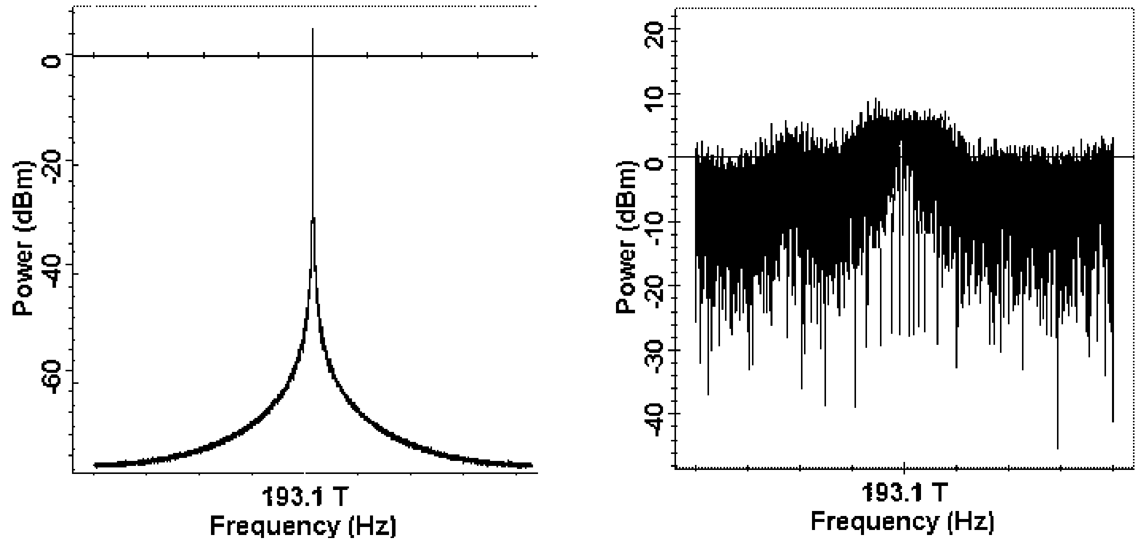
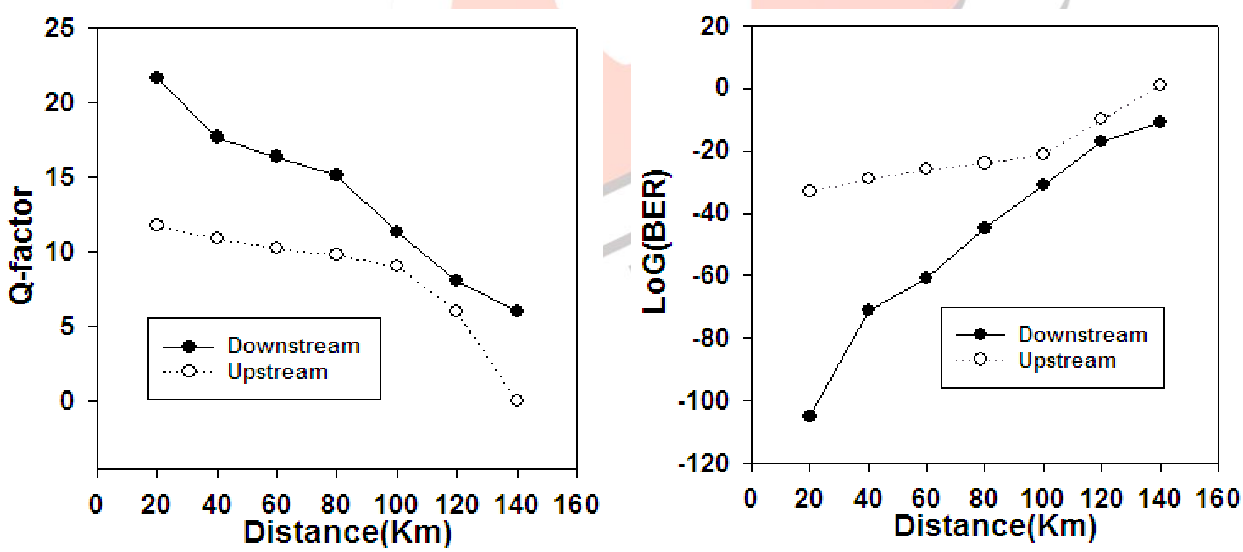


Figure 2 Depiction of OSA for (a) VCSEL (b) after carrier generation

A vertical cavity surface emitting laser generates the seeding light and then the seeding light is injected into MZM. The intensity modulator output signal at 2.5 Gbit/s transmitted via a 120 km SMF (single mode fiber). The carrier spectra and eye diagrams for evaluation are both observed by the signal analyzer in proposed simulation. The simulation outcomes are represented in Figure.3 (a). It is depicted from Fig.3 (a) that with the distance increasing from 1 Km-150 Km, the output spectrum of intensity modulator is clearly broadened. Attenuation and dispersion or pulse broadening is a major cause of degradation in Q factor in upstream as well as downstream. Moreover, the noise floor is progressively rising as the distance prolongs and the broadening of transmitted pulses takes place. Broadened optical spectrum enhance the inter symbol interference and deteriorates the output results. Downstream signals exhibits better performance as compared to upstream signals. In order to study the effect of distance on bit error rate, Graph is represented in Figure 3(b). It is clearly seen that as the distance increases, BER increases. This is because of the reason that at higher distances, attenuation, dispersion and nonlinear effects are more. BER is more in upstream and less in the case of central office to user end transmission.



(a) (b)

Figure 3 Graphical representation of UDWDM-PON system at different distances versus (a) Q-factor (b) BER

Consequently, regularly degrading eye diagrams caused by intensity noise is shown in Fig 4. It is seen that the employed carrier generation has better performance than the spectrum sliced amplifier spontaneous emission noise for long haul communication in the UDWDM system reliant on VCSEL mach-zehnder modulator. The performance of downstream and upstream signals after various fiber length transmissions is evaluated. Fig.4 (a) and (b) show the bit error rate (BER) performance and eye diagrams for upstream and downstream signal. To make system cost effective and performance tradeoff, booster or amplifier in pre and post configuration is not used in optical network unit for downstream and upstream detection. Considering the case of upstream transmission, with forward error correction (FEC), 120 km single mode fiber transmission is achieved with acceptable range of error 10^{-17} BER. Signal to noise ratio is also observed to evaluate the system performance and it is reported that with the increase in link length, SNR degrades. Signal-to-noise ratio (SNR) drop caused by Rayleigh backscattering and is the major issue that restrict the transmission reach. For downstream transmission, errors are less and maximum errors emerged at 150 km. In this case we only achieve BER at 10^{-7} level due to the low optical received power.

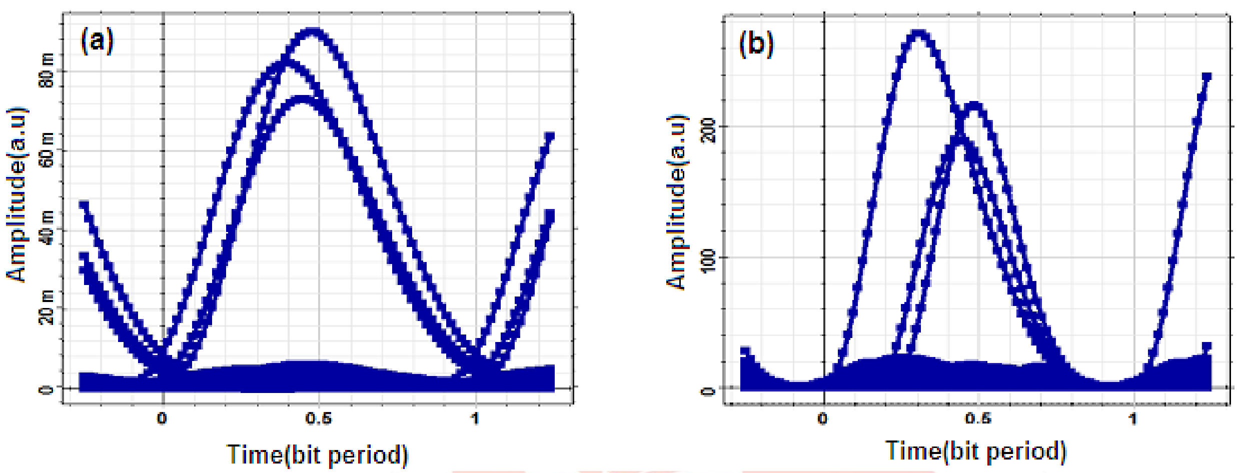


Figure 4 Eye diagram analyzer for (a) Downstream (b) Upstream at 20 km

Figure 5 (a) depicts the SNR values at different distance for upstream and downstream. Also received power is investigated with the function of distance as shown in Figure 5(b).

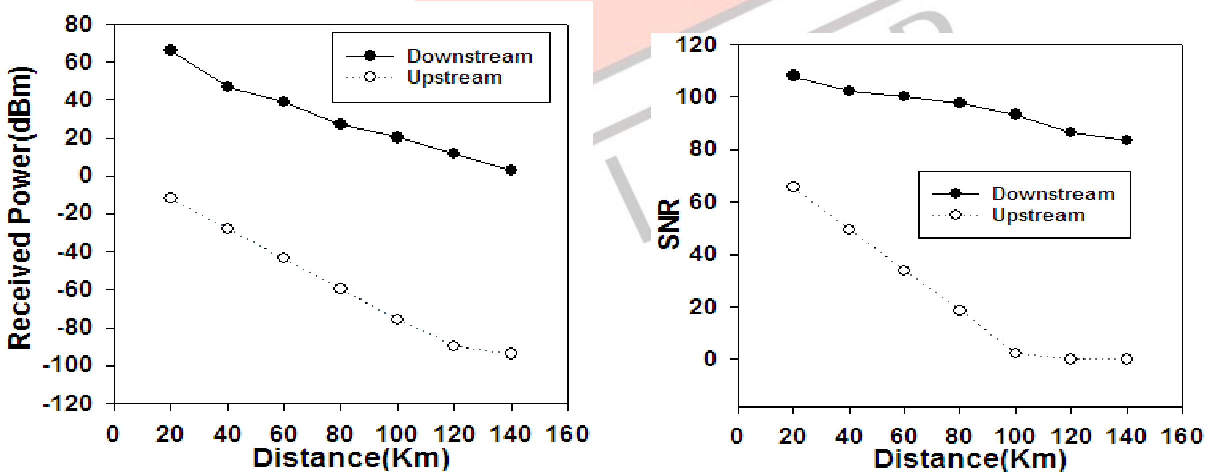


Figure 5 Depiction of proposed system for (a) Distance versus Rx power (b) Distance versus SNR

Maximum SNR is seen in the case of downstream due to fewer losses and less SNR for upstream because the more number of errors. Similarly, received power is calculated from BER analyzer and it also exhibits same performance as SNR. Received power is more in downstream and less in upstream for demonstrated system. Figure 6 shows the value of Quality for time according to bit slots. At 0.5 bit period, Q is maximum and pulse is considered in steady state. As the bit period varies from 0.5 bit period in either direction, Q decreases.

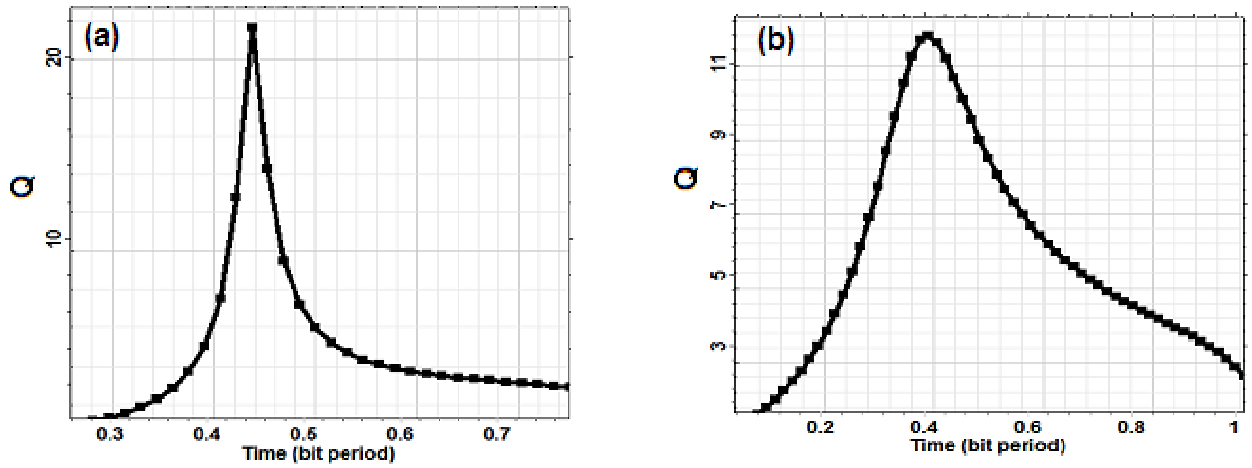


Figure 6 Q factor versus time bit period for (a) downstream (b) upstream at 20 Km

Figure 7 shows the Eye diagram of system and is a decisive analyzer that compute the errors, Q-factor, SNR, eye closer, eye opening etc. It represents the average no. of ones and zeros with their Quality and bit errors. Noise can be attributed to the fluctuations observed on the peak of the broadened eye. Wide eye opening and high quality with acceptable limits of errors at 10 Km is perceived for Downstream. It is observed that more the opening of eye, less are the errors and BER varies inversely with Q-factor and eye opening. In proposed architecture, distance of 120 Km symmetrically, is achieved successfully within acceptable range of Q-factor and BER (10^{-9}).

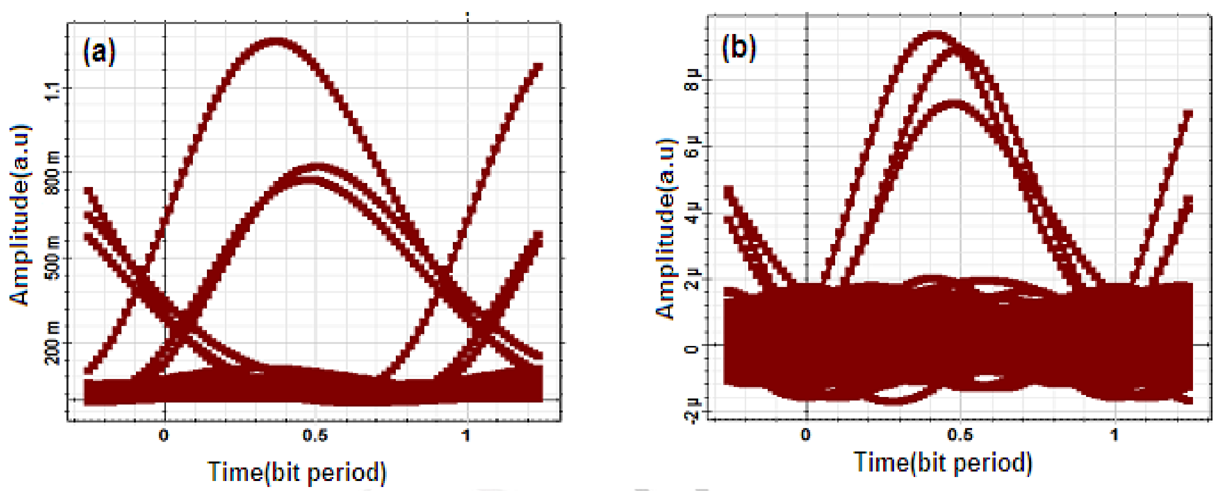


Figure 7 Eye diagrams for (a) Downstream (b) Upstream at 120 Km

Conclusion

An UDWDM-PON system reliant on carrier generation through low cost VCSEL laser is demonstrated for bidirectional passive optical network at 2.5 Gb/s. Proposed architecture sustains 80 carriers that are divided in 40 modulated (Downstream) and 40 un-modulated channels with 6.25 GHz channel spacing. We have successfully achieved 120 km in both downstream and upstream direction within acceptable range of BER. Proposed system could sustain more than 300 channels in C band because of very dense spacing. Due to its potential and low cost property, the demonstrated system is important for ultra dense WDM passive optical networks.

References

[1] A.O. Aldhaibani, S.M. Iris and Zulkilfi N., " 2.5 Gb/s Hybrid WDM/TDM PON using Radio Over Fiber Technology," Optik, vol.124, pp.3678-3681, 2013.

[2] Y. Luo, X. Zhou , F. Effenberger, X. Yan, G. Peng, Y. Qian, and Y. Ma , “ Time- and Wavelength-Division Multiplexed Passive Optical Network (TWDM-PON) for Next Generation PON Stage 2 (NG-PON2),” IEEE Journal Of Lightwave Technology, Vol. 31, No.4,2013.
[3] J. Kani, “Enabling Technologies for Future Scalable and Flexible WDM-PON and WDM/TDM-PON Systems, ” IEEE Journal Of Selected Topics In Quantum Electronics, Vol. 16, No. 5, pp. 1290-1297,October 2010.
[4] I. Mohamed and M.S. Ab-Rahman, “ Options and challenges in next-generation optical access networks (NG-OANs) ,” Optik, vol.126, pp. 131-138 , 2015.
[5] V. Kachhatiya and S. Prince, “Four-fold increase in users of time-wavelength division multiplexing (TWDM) passive optical network (PON) by delayed optical amplitude modulation (AM) upstream,” *Optical Fiber Technology*, vol. 32, pp. 71–81, 2016.
[6] Naoki Suzuki, Satoshi Yoshima, Hiroshi Miura, Kuniaki Motoshima, “Demonstration of 100-Gb/s/λ-Based Coherent WDM-PON System Using New AGC EDFA Based Upstream Preamplifier and Optically Superimposed AMCC Function”, journal of Lightwave technology, IEEE, vol. 35, no. 8, pp. 1415-1421, 2017.
[7] Marco Presi, Fabio Bottoni, “All DFB-Based Coherent UDWDM PON With 6.25 GHz Spacing and a >40 dB Power Budget” , IEEE photonic technology letters, vol. 26, no. 2, pp. 107-110, 2014.
[8] Han Chenyang, Hong Wei, “Simulation and Comparison of Advanced Modulation Formats for Wavelength Reuse in High-SpeedWDM-PON System”, journal of physics IOP, vol. 276, no. 1, pp. 1-9, 2011.
[9] Ulysses Duarte, Rivael S. Penze, Joao B. Rosolem, Fernando R. Pereira, Fernando F. Padela, and Murilo A. Romero, “Combined Self-Seeding and Carrier Remodulation Method for Reflective Transmitters in WDM-PON”, National Fiber Optic Engineers Conference, Optical Society of America, 2013.
[10] Joon-Young Kim, Sang-Rok Moon, Sang-Hwa Yoo, and Chang-Hee Lee, “DWDM-PON at 25 GHz channel spacing based on ASE injection seeding”, Optics express, vol. 20, no. 6, pp. 45-51, 2012.
[11] Zhou Zhao, NIE Hai-tao, Wang Yao-jun, “Long reach DWDM-PON with 12.5 GHz channel spacing based on comb source seeding”, Optoelectronics letters, vol. 12, no. 4, pp. 304-307, 2016.