DESIGN OF BIDIRECTIONAL PASSIVE OPTICAL NETWORK USING DIFFERENT MODULATIONS

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Abstract : Wavelength division multiplexed passive optical network is well competent and premier technique to support high speed and large number of users. WDM-PON networks are very popular due to numerous advantages such as reliability, low cost, wide bandwidth and can support large number of optical network units. In this work, we accentuated on the design of WDM PON system incorporating different modulations for upstream and downstream. Bidirectional passive optical networks are need of the day. A 40-km-long colorless symmetrical WDM-PON with differential quadrature phase shift keying (DQPSK) in downstream and non return to zero (NRZ) modulation format in upstream is investigated to reduce crosstalk. Also comparison has been made with the system containing DPSK for downstream and NRZ for upstream in WDM PON system. WDM PON operated at 10 Gbps and 4 WDM channels are considered in this work.

***IndexTerms* - WDM, DQPSK, NRZ, PON, BER**

I. INTRODUCTION

The deployment of the time delay or time division multiplexing has been reported for passive optical networks to cater the wide bandwidth requirements of internet services [1]. But, the time division causes the issue of bandwidth sharing and consequently led to wastage of time as well as cost. On contrary, wavelength division multiplexing is a prominent and potential technology to overcome these limitations [2]. For FTTH services, WDM-PON is considered as the ultimate solution to offer wide bandwidth and fast communication. Bidirectional or full duplex passive optical networks are needed to cater the ever increasing demands of bandwidth hungry services [3]. However, bidirectional WDM PON networks suffers from a serious issue of crosstalk between downstream and upstream channels. In order to suppress this crosstalk, numerous investigations are proposed so far using similar and dissimilar modulations for upstream and downstream [4]. At present, use of the NRZ is popular due to simple generation. But, in near future, advanced modulations such as DQPSK and DPSK are needed due to their high spectral efficiency and has power to combat with dispersions effects. Moreover, wavelength reuse is an important factor to consider in passive optical networks to design a low cost WDM bidirectional system [5]. Many research articles are reported so far to incorporate wavelength reuse. However, they used expensive intensity modulators, which is itself an issue [6]. Consequently, we have designed a WDM passive optical network by considering these important factors.

II. SYSTEM SETUP

Figure.1. depicts the proposed WDM passive optical network at 10 Gbps employing differential quadrature phase shift keying (DQPSK) in downstream and non return to zero (NRZ) in upstream. Novelty of the system is use of DQPSK and NRZ combination to combat with crosstalk issue at 10 Gbps. System proposed is symmetrical and also centralized lightwave that supports 4 WDM channels in this work. A laser light wave source at 193.1 THz frequency and 0 dBm input power is used. Major region to used C-band frequency is the low losses and scattering effects of this band over fiber optic cables. Four WDM channels are modulated in central office with DQPSK modulation. From this point, downstream communication in bidirectional passive optical network initiates. The modulated DQPSK WDM signals are accumulated with the multiplexer of 4 x 1, as well as the multiplexed signal is transmitted over 40-km SMF-28 (single-mode fiber). After transmission of 40 km, signal is de-multiplexed by 1 x 4 wavelengths with frequency spacing of 100 GHz. Receiver section consisting of optical couplers with coupling ration of 50:50 and divide signal for two pairs of photo-detectors that receives drive with time delay and phase shift to input signal. A p-i-n photodetector with 100% responsivity and 10 nA dark current is placed in the receiver by considering shot, thermal and ASE (Amplifier spontaneous noise) distortions. Electrical bias is provided to electrically subtracted output of balanced photodetectors followed by 3-R regenerator. A 3-R regenerator employed for re-sampling, re-shaping and re-amplification of the received data. Bit error rate analyzer is decision making component which calculate the final received quality factor, bit error rate (BER), signal to noise ratio (SNR) etc of the received signals.
One half of downstream DQPSK signal is demodulated and other half is provided to the re-modulation. Reflective amplifier is modulated the data of NRZ signal over four frequency channels and multiplexed to travel for upstream. After 40 km transmission, signal is de-multiplexed and detected through PIN photo-diode followed by low pass filter and Eye diagram analyzer as shown in Figure.1. Here, we have considered two different cases such as case 1 for DQPSK in downstream and NRZ in upstream. Case 2 for DPSK in downstream and NRZ for upstream. Both cases are compared and results are evaluated to suggest the optical

configuration to provide better crosstalk suppression. Internal structure of DQPSK and DPSK are shown in Figure 2 (a) and 2 (b) respectively.

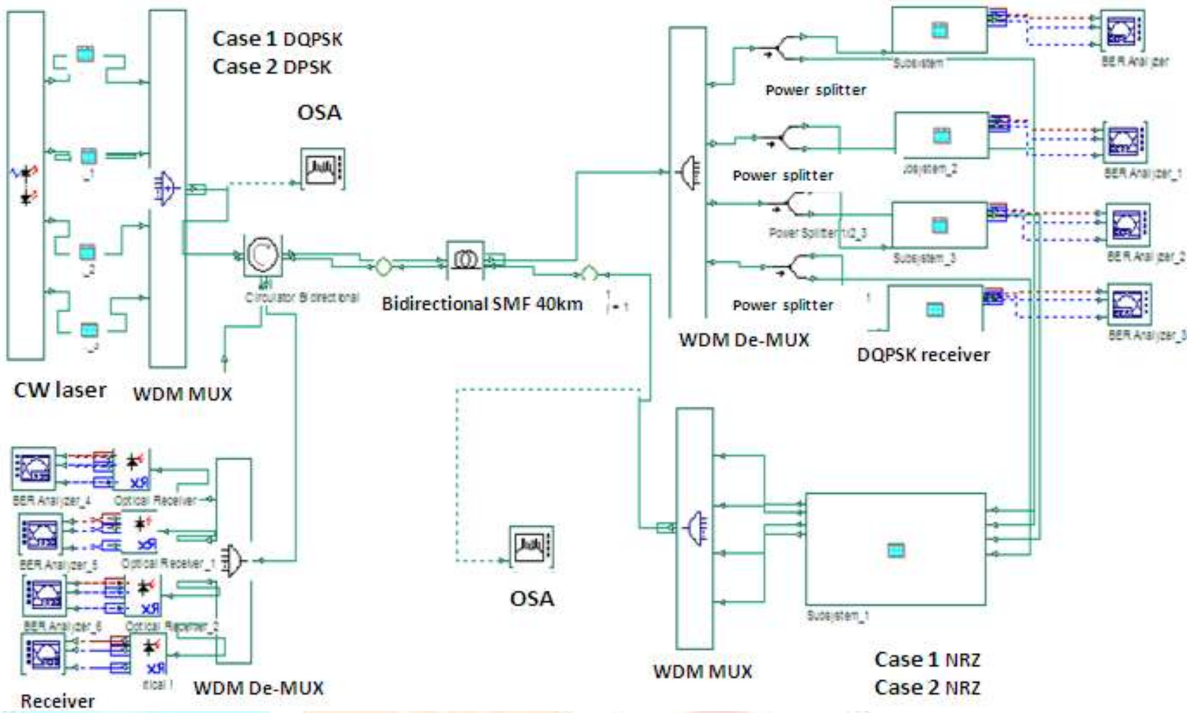
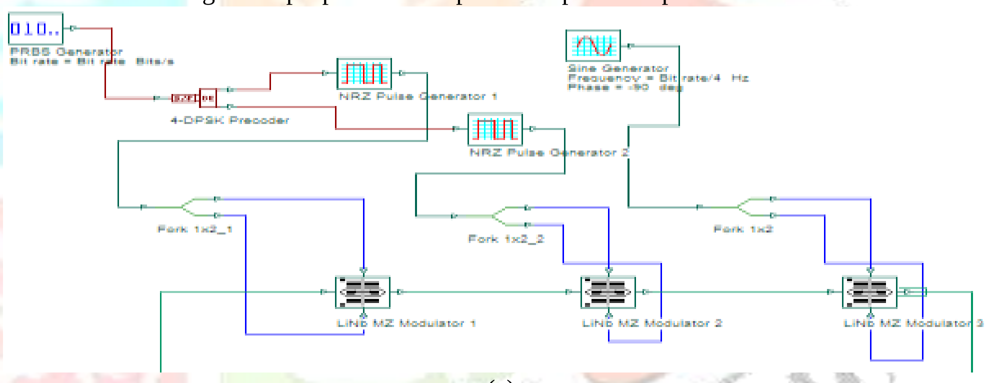
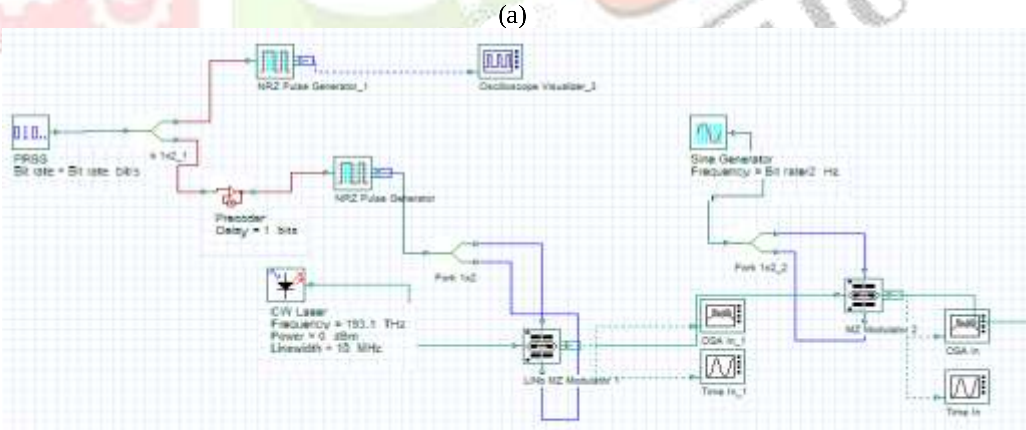


Figure 1: proposed 10 Gbps WDM passive optical network.



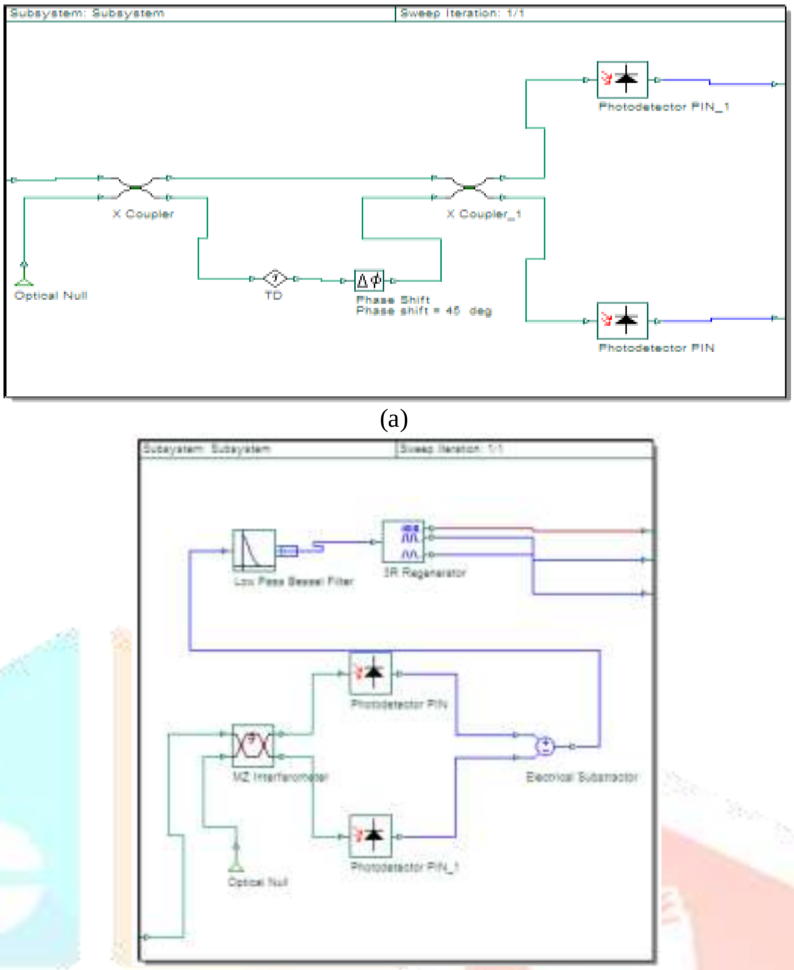
(a)



(b)

Figure 2: The internal structure of transmitter at OLT (Optical Line Terminal) side for (a) DQPSK (b) DPSK.

A pseudo random bit sequence generator is used to provide binary bit streams. For DPSK, binary data is delayed by one bit and XOR function is performed for coding and then passed through NRZ line-coder for pulse shape. Mach zhendar modulator 1 is placed to modulate data into optical light signal. Then a sine generator with half the frequency of bit rate is modulated the data to provide 0 and 180 degree shifts to adjacent bits. In DQPSK, A pseudo random bit sequence generator is used to provide binary bit streams. Binary data is provided to 4-DPSK pre-coder and is performed for coding followed by two NRZ line-coders for pulse shape. Mach zhendar modulator 1, 2 are placed to modulate data into optical light signal. Then a sine generator with 1/4 the frequency of bit rate is modulated the data to provide different shifts to adjacent bits.



(a)

(b)

Figure 3: The internal structure of receiver at ONU for (a) DQPSK (b) DPSK.

Figure 3 (a) shows that at the ONU in receiver for DQPSK end, the signal is passed through coupler and split the signal half-half and one signal is given to PD and another to time delay + phase delay. Signal detected and passed though regenerator and eye diagram analyzer. Figure 3 (b) depicts the receiver of DPSK. Received signal is passed though the MZI for delay compensation and detected at Eye diagram.

III. Results and Discussions

WDM passive optical network model using differential quadrature phase shift keying (DQPSK) and differential phase shift keying (DPPSK) has been successfully simulated using optisystem 7 software. The results are investigated and analyzed accurately. For proposed system setup, data signal with 10 Gbps bit rate is modulated by DQPSK-NRZ in fist case and DPSK-NRZ in second case. The reference wavelength used by the channels is 1550 nm. The sequence length is considered 64. The Sequence length should be set based on the simulation objectives. The length of the bit sequence depends on number of bits. It must be a power of two. Comparison has been proposed for the different link lengths in WDM passive optical network that incorporates DQPSK-NRZ and DPSK-NRZ for the system analysis. Link length is varied from 10 km – 50 km with the difference of 10 km. Results are evaluated in terms of Q factor over diverse link lengths as shown in Figure 4.

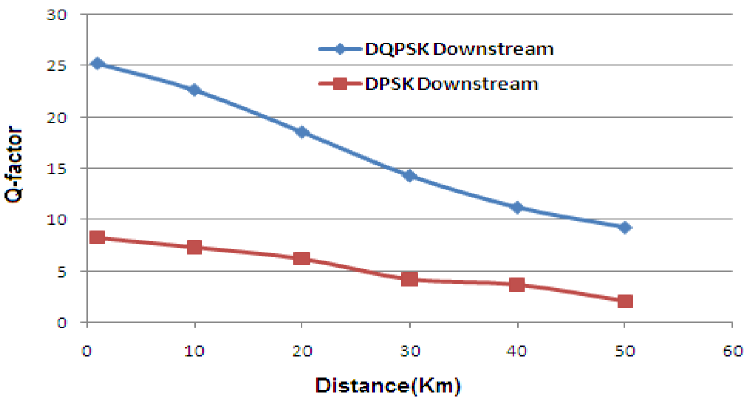


Figure 4: Representation of distance versus Q-factor for downstream

It is evident that as we prolong the fiber length, emergence of attenuation, dispersion and nonlinearities is more. Consequently the Q factor deteriorates as we go to fewer distances to prolonged distances. Results also revealed that Q factor of DQPSK decreases to less extent as compared to DPSK. It is due to reason that in bidirectional DPSK-NRZ system, crosstalk is induced more as compared to DQPSK-NRZ WDM passive optical network. At distance of 10 km, DQPSK provides Q factor of 25.2 and at same distance Q factor of DPSK is 7.64. It is observed that DPSK-NRZ system works for 25 km only and DPSK-NRX signal travel up to 50 km with acceptable value of Q i.e. 6.

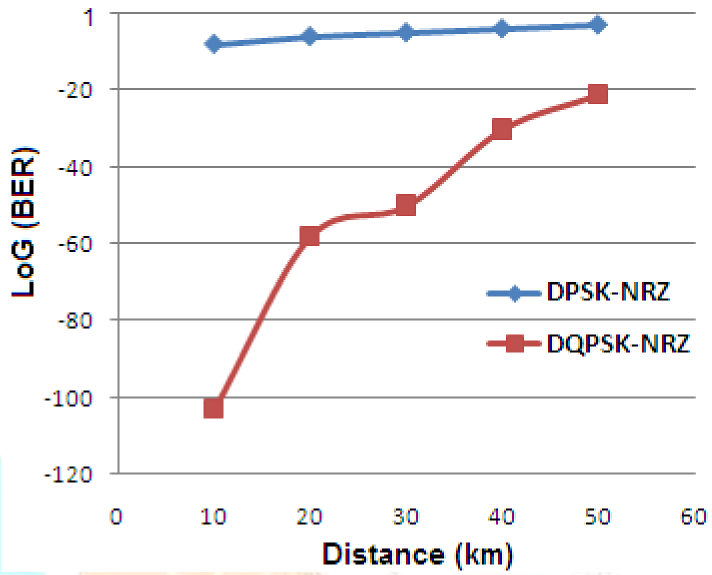


Figure 5: Representation of distance versus Q-factor for downstream

Bit error rate is most important measure for any communication system. It provides the information that whether communication system is valid or not. It is basically a ratio of the errors in bits after transmission at receiver to the total bits transmitted from central office. Acceptable range of BER is 10^{-9} for optical serial modulation. Figure 5 depicts the variation of LoG (BER) with link length. It is seen that Q factor and BER varies inversely. BER increase that is more errors are observed at prolonged distances rather than shorter one. BER is more in the DPSK)NRZ system and less in DQPSK-NRZ system. Reason again are the different linear and nonlinear factors that emerges in fiber optic communication. Further analysis is also performed for the upstream for two different cases. NRZ is a key modulation format for both the cases in upstream irrespective the transmitter modulation in downstream. Figure 6 depicts the performance of NRZ signal in upstream for diverse link lengths. It is seen that in upstream also, linear and nonlinear effects of fiber optical degrade the system performance. Q factor decreases as the enhancement of link length from 10 km to 50 km. Results revealed that DQPSK-NRZ is superior to the case two modulation due to less crosstalk in the optical fiber. Q factor of 18.32 is reported for DQPSK-NRZ system and 7.32 for the DPSK-NRZ system. Thus it is concluded that former case is better to suppress crosstalk in WDM-PON system.

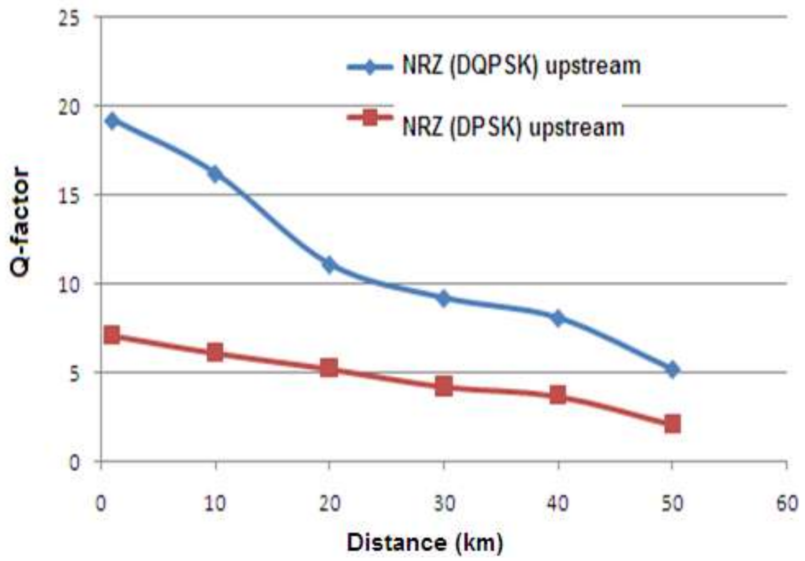


Figure 6: Representation of distance versus Q-factor for upstream

Eye diagram is the decision depiction of signals and provide results of Q factor, bit error rate etc. Eye diagrams of demonstrated system are shown in Figure 7. In case of DQPSK-NRZ WDM passive optical network, eye diagram is represented at 40 km in Figure 7 (b) and for DQPSK-NRZ signal back to back is depicted in Figure 7 (a).

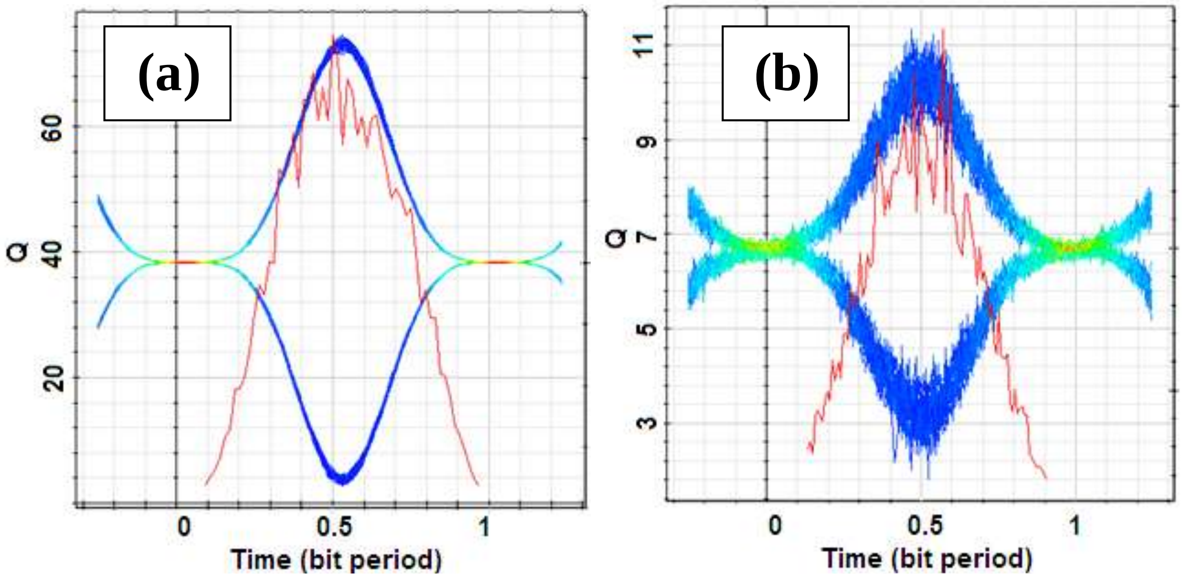
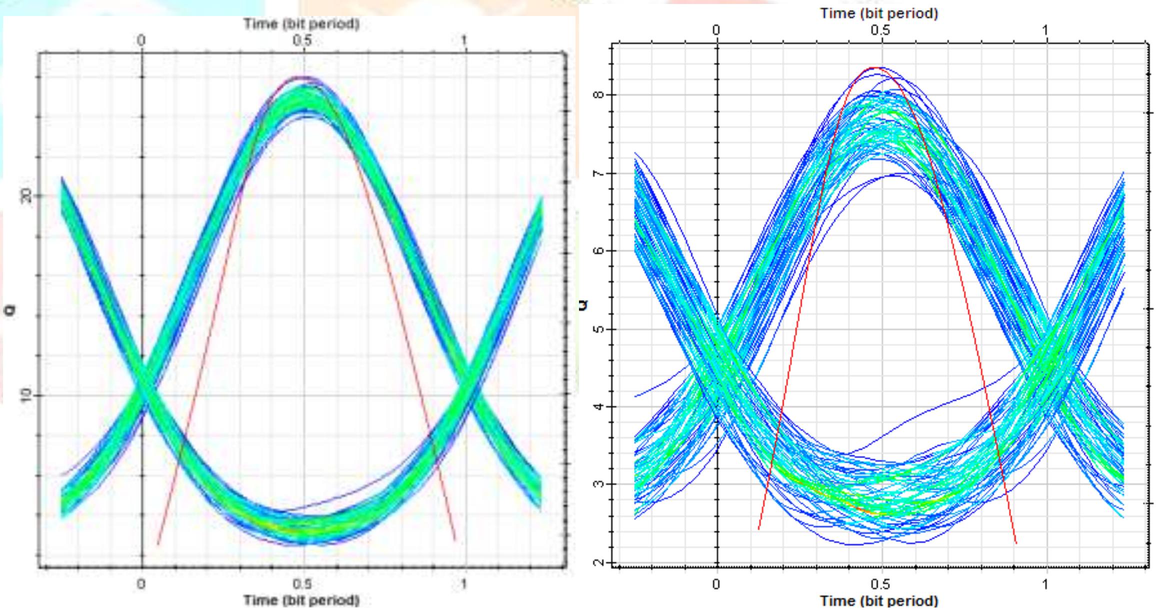


Figure 7: Eye diagram for (a) B-T-B (b) 40 Km for DQPSK

Figure 8 (a) (b) depicts the Eye diagram curves at back to back and after 40-km distance in the context of non return to zero modulation for upstream. RSOA is used to re-modulate the data from PRBD and NRZ. The results revealed that the Eye diagram is very sharp and thin for back to back analysis and it is thicker for 40 km distance. Furthermore, it is evident from Figure 4.5 that the 10 Gbit/s uplink NRZ signals can attain at BER of 3.2×10^{-17}. Therefore, with DQPSK-NRZ, we successfully achieved the 40 km link distance.



(a) (b)

Figure 8: Eye diagram for (a) B-T-B NRZ (b) 40 Km for NRZ

IV. CONCLUSION

We accentuated on the design of WDM PON system incorporating different modulations for upstream and downstream in order to suppress crosstalk. A 40-km-long colorless symmetrical WDM-PON with differential quadrature phase shift keying (DQPSK) in downstream and non return to zero (NRZ) modulation format in upstream is investigated to reduce crosstalk. It is observed that crosstalk effect are minimized by incorporating constant envelop differential phase shift keying in downstream and non-return to zero in upstream. RSOA is employed for re-modulation and also makes system cost efficient. Further, a comparison is established between DPSK-NRZ system and DQPSK-NRZ passive optical network. It is observed that DQPSK-NRZ is prone to less crosstalk than DPSK-NRZ and results are evaluated n terms of Q-factor.

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