Analysis and Reduction of Crosstalk in WDM Passive Optical Network using Transmitter Line Coding Diversity

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ABSTRACT
A passive optical network architecture is proposed to quell the crosstalk effects in high speed wavelength divioned passive optical network for future generation. Incorporation of DPSK format for downstream and NRZ for upstream, makes system less prone to nonlinearities and enable system to support 6144/512 users. Each wavelength from central office to user end carry 10 Gbps and total capacity for downstream is 12x10 Gbps. For upstream transmission 8 wavelengths carry the load and operating at 80 Gbps. Distance is achieved within acceptable BER range (10^{-9}) [is] 110 Km for both directions. This distance is obtained without any dispersion compensation and costly modules. A semiconductor optical amplifier is placed to remodulate instead of external modulator such as MZM and EAM. Also comparison is done by using same transmitter and hybrid transmitters to evaluate the crosstalk and Quality of reception. It is observed that DPSK for downstream and NRZ for upstream provide best results.

Keywords
WDM, PON, Transmitter diversity, BER, Q-factor

1. INTRODUCTION
With the advancement in communication technology the need for high speed internet is increasing day by day which further demands high data rate and large bandwidth [1]. So our future technology is required to be adaptable to offer large bandwidth and to support large number of new applications [2]. To solve this problem fibre optic technology has been developed which uses optical light as a transmission medium. Optical fiber provides us adequate solution to solve the problem of access network [3]. Optical fiber technology offers us a combination of low error probability, high bandwidth and large transmission capacity. In conventional time, Access networks are made out of copper and were based on twisted pair and coaxial cables. The three main requirements of access network are they must be cost efficient; they must have high reliability and better performance [4][5]. Passive optical network (PON) requires only passive components i.e it doesn't require continuous supply of electricity, therefore power issues and heat are not considered. Passive optical network has low maintenance cost since it requires less components. Fiber based networks are cheaper to operate. copper based networks requires lot of maintenance and repair as compared to optical network, which is less prone to outside conditions could lead to important operational savings for operation in long run. [7]. WDM-PON is a best choice to provide multispeed high data rate, high efficiency and full services of next generation (FTTH) system. WDM PON is observed as one of the finest technology to provide broadband access network in future. Full services access network (FSAN) and International Telecommunication Union (ITU-T) are presently finalizing particulars of the physical layer standard for PON [8] .PON focus on two major objectives. One objective is to increase the delivered bit rate to each subscriber. The second objective is to extend the reach to each customer in order to reduce deployment costs [9]. By employing wavelength division multiplexing [10] (WDM) technology in future PONs, the guaranteed bit rate can be increased for each user at the cost of higher optical losses introduced by additional optical multiplexers/de-multiplexers [11] [12].In this work, a crosstalk immune transmitter diversity hybrid modulation is proposed for wavelength division passive optical network. With the incorporation of DPSK format for downstream and NRZ for upstream makes system less prone to interference and enable system to support 6144/512 users at 120 Gbps (DS)/80 Gbps (US\).

2. SYSTEM DESCRIPTION
For the realization of bidirectional PON system, a commercial Optiwave optisystem simulation tool is used. Optisystem suit is a pioneering optical fiber communication (OFC) system simulation package to design, test and optimize virtually with any type of optical link in physical layer of broad spectrum. In this paper, the proposed system have 12 transmitter CW lasers with the wavelength of 1550nm with the channel spacing of 1.6 nm using DPSK modulation format for downstream and 8 transmitter for upstream, which are NRZ modulated. This transmitter diversity for both directions reduces crosstalk. A pulse format return differential to 0 phase shift system is depicted in fig 1. This is receiving drive from data source which transmit random bits referred as PRBS. Two line coders followed by intensity modulators are used DPSK is a digital form of phase modulation that transmit data by altering the phase of the high frequency carrier wave. DPSK terminates the requirement of coherent reference signal at receiver side by combining two basic operations at transmitter (1) differential encoding and (2) phase shift keying. Random data is generated by PRBS. To mitigate the effect of attenuation, EDFA amplifier with gain of 10dB and 4 dB noise figure in downstream and SOA gain for upstream is used. Table 1 shows the System specifications. A signal is split into 12 equal powers by the 1x12 power splitter. Flexibility and rotation is provided by circulators on other ports. For transmission Bi-directional SMF-28 is used in WDM passive optical network.

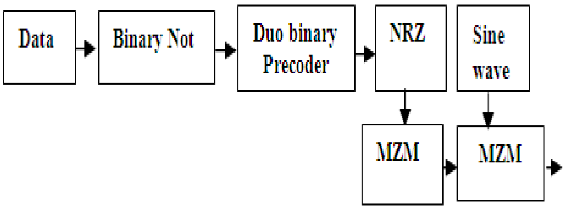

Fig.1: Setup of RZ-DPSK Transmitter

Table 1. Architecture specifications

Parameters	**Values**
Data rate	10Gbps
Wavelengths(DS/US)	12/8
Accumulative Speed	120/80Gbps
Wavelength spacing	200GHz
Initial Wavelength	1550nm
Line width	10 MHz
Erbium amplifier power down stream	10dBm
Launched Power (DS/US)	0dBm/5dBm
Link length	100km

Optical receivers are devices which have photo detector followed by a low pass Bessel filter. This section has a conversion of optical signal back into electrical signal. Optical signal is detected by PIN and Bessel filter is used to remove the noise. A regenerator is placed to provide reference and re sampling to the incoming received signal.BER tester is the last subsystem which is used to gives the Q factor and bit error rate values. In downstream, Power is divided among 512 users and then power is transmitted to the DPSK receiver with the help of Power splitter i.e 1:512. Differential encoding and phase shift keying are operations performed by DPSK at transmitter to eliminate the need for a coherent reference signal at receiver. An analog linear filter such as low pass Bessel filter with a maximally flat group/phase delay (maximally linear phase response), which preserves the wave shape of filtered signals in the pass band. The Bessel filter is very similar to the Gaussian filter, and tends towards the same shape as filter order increases.

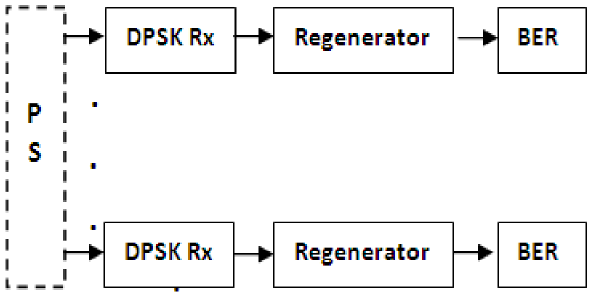

Fig.3: Subsystem representing 512 Users for Each channel (Downstream)

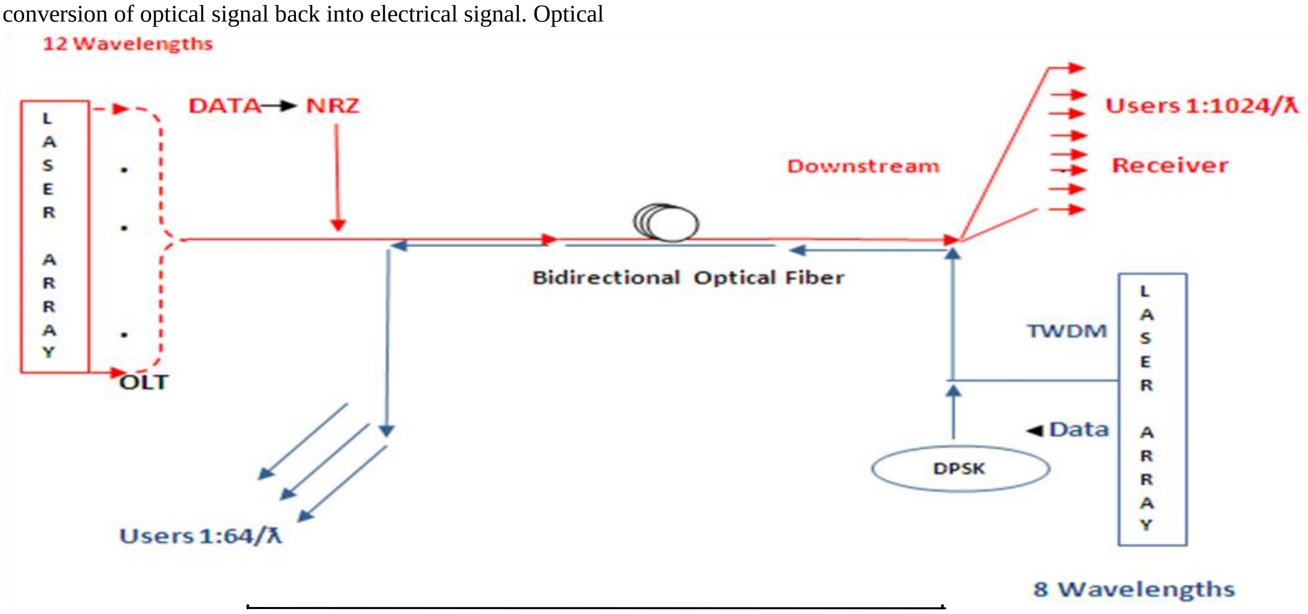

Fig 2: Proposed architecture of WDM-PON supporting 6144 downstream/512 upstream users

The Bessel filter has better shaping factor, flatter phase delay, and flatter group delay than a Gaussian of the same order. Then the signal is passed to 3R regenerator. 3R regeneration includes three regenerating operations with incoming pulses such as again time and synchronies the data. Bit error ratio is calculated by BER analyzer that shows the signal strength. Same processes take place in upstream for 64 users each as shown in Fig 4.

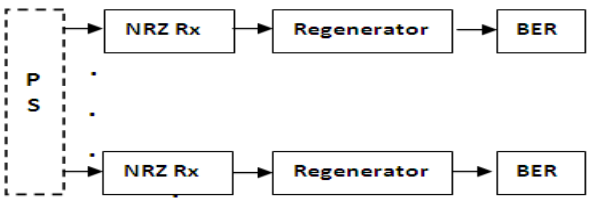

Fig 4: Subsystem representing 64 Users for Each channel (Upstream)

3. RESULTS AND DISCUSSION

Analysis of frequency multiplexed passive optical system is studied with 100 Ghz separation among the channels. A accumulative speed of 120 Gbps is transmitted form data source for downstream. System reach is varied in terms of distance and also to see the effects of increased users on proposed system. Depiction is represented in fig 5 for the performance of 12 data signals and also in figure upstream signals are shown. The basic working of spectra is a type of simplification of fourier examination and fed to system do not have fourier trans forms. It shows that with what technique power of the time series is spread over the various frequencies. For the context of signal,it is seen a stationary process and STFT is approximation of power densities. This type of equipments operated on less frequencies and contracted band widths. To study and analyze the effects of crosstalk on different and same transmitters has been done for downstream and upstream. First and foremost, use of non return to zero for DS and US is carried out. Subsequent method is to propose differential-differential shift keying for both directions. Lastly, transmitter diversity is demonstrated fir passive optical networks. Dpsk is incorporated for transmission from central office to optical network unit and non return to zero for reverse transmission. Graphical depiction of three methods is shown in It is evident and clears from the depiction that differential phase shift keying for downstream and non return to zero for upstream exhibit better performance and suffering from very less crosstalk.

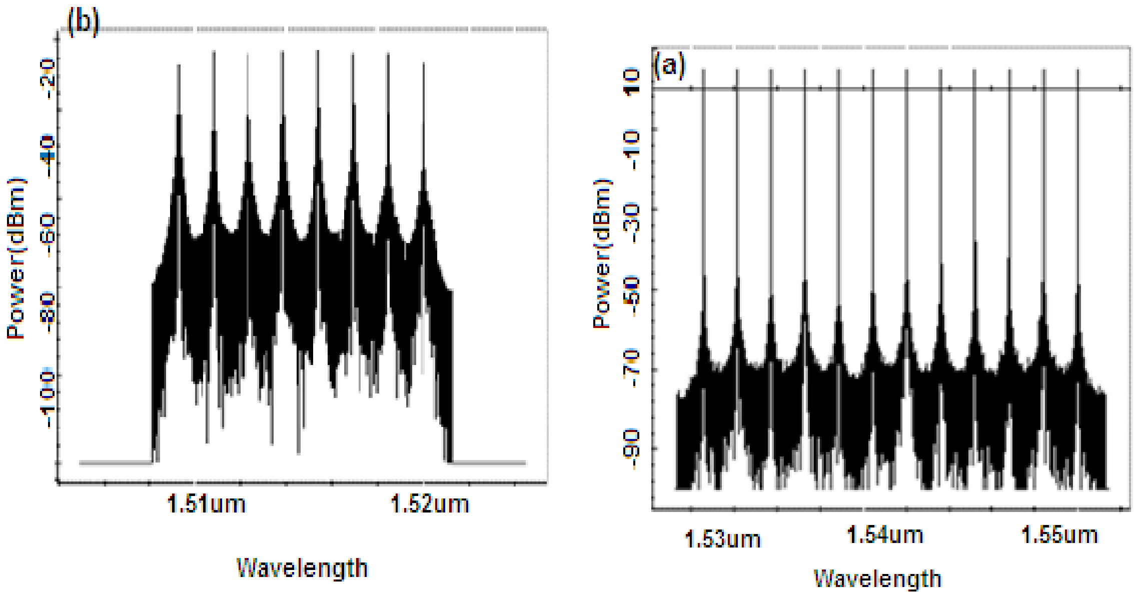

Fig 5: Power spectrum analyzer for (a) 12 WDM channels (Downstream) (b) 8 channels (Upstream)

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Fig 6 represents the values of Quality obtained at varied distance of link length when different transmitters and same transmitters are used. It is clear from the depiction that received power tends to reduce when distance is enlarged and also additional errors are observed on prolonged distances. Fig 7 shows the same scenario for uplink with the splitting ratio of 1:64 for each wavelength. It is evident and clears from the depiction that differential phase shift keying for downstream and non return to zero for upstream exhibit better performance and suffering from very less crosstalk. So, aforementioned method is best suitable for long reach WDM PON supporting dual direction transmission. Moreover, DPSK and NRZ exhibits better performance than NRZ –NRZ but falls lower to DPSK-NRZ. Third pulse shape for bidirectional transmission shows worst results due more cross interaction od signals in downstream and upstream.

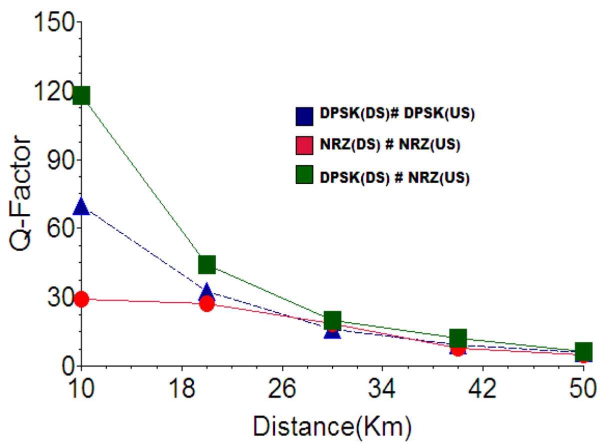

Fig 6: Graphical depiction of Q-factor versus transmission distance of WDM PON for different transmitters downstream and upstream

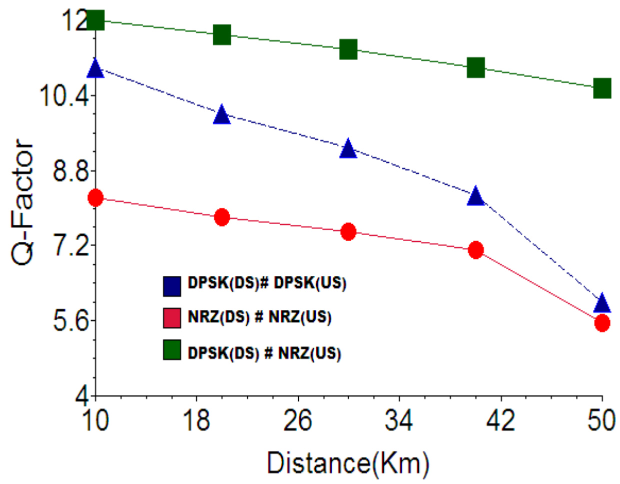

Fig 7: Propose architecture performance for different modulation formats in downstream and upstream

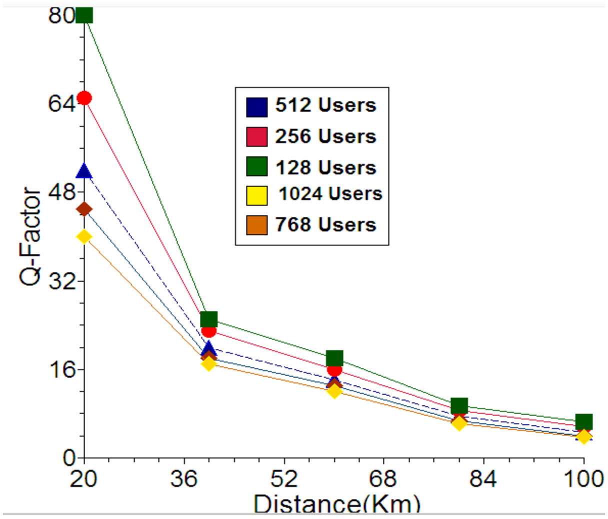

Fig 8: Variation of Q-factor with distance in the context of user supported for DPSK-NRZ

Fig 7 depicts the dependence of quality of signal for eight wavelengths in upstream scenario at different link distances. The major variation for lengths is shown in these graphical representations for bidirectional communication. We measured the eye diagrams and the sensitivities of the signal in both directions when the transmission distance varies from 0 to 100 km with an increasing step of 20 km. we can see gentle sensitivity degradation with the increase of transmission distance, which can well handle the reach difference. Therefore DPSK-NRZ can well support long distance transmission. For the short distance case, although the sensitivity is low, the split ratio can also be as high as 1:1024 because of the lower transmission loss of the shorter fiber link. Further for the evaluation of the system it operated on different speeds such as 1 Gbps, 5 Gbps and 10 Gbps. It is observed that for 64 users each wavelength, received quality decreases with the increase of the speed or data rate. Fig 9 represents the variation of Q-factor with respect to the system data generation speed. This depiction represents that as the data speed start with pace, it degrades the value of Q-factor and increase bit error rate. Bit rate is inversely proportional; to quality of signal received. In optical communication systems, only optical signal to noise ratio (OSNR) could not accurately measure the system performance, especially in WDM systems.

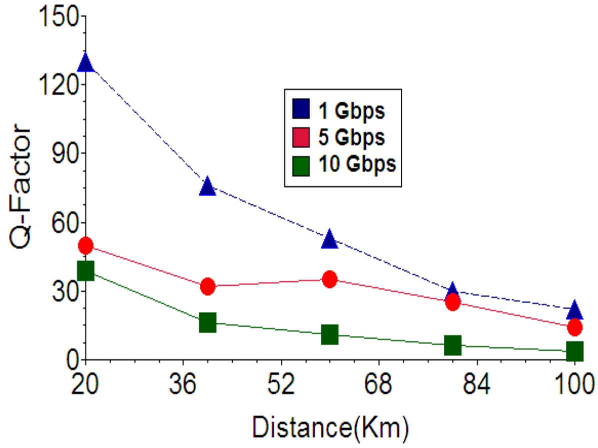

Fig 9: Graphical representation of different speed on Q-factor

Typically, quality factor Q is a one of the important indicators to measure the optical performance by which to characterize the BER. It represents the average no. of ones with their Quality and bit errors along with signal to noise ration, eye closer penalty etc. Noise can be attributed to the fluctuations observed on the peak of the broadened eye.

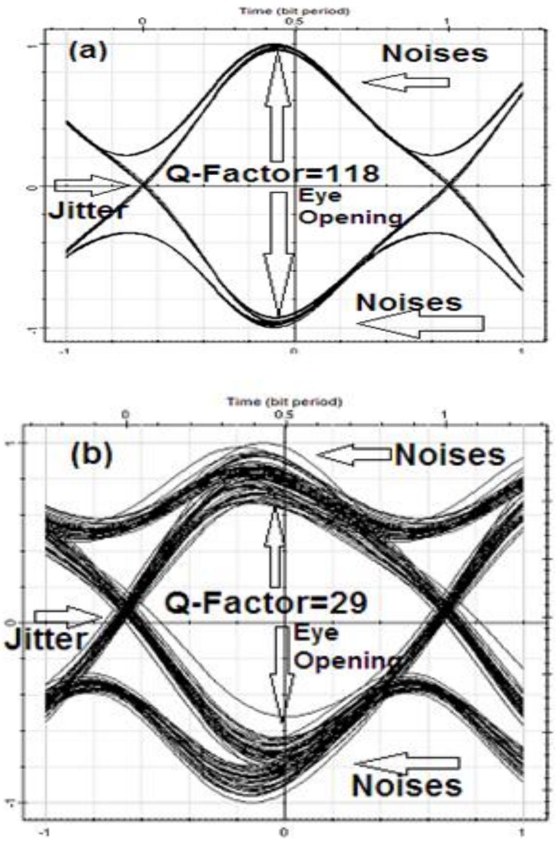

Fig 10: Depiction of Eye diagram for DPSK (DS) and NRZ (US) for 10 Km

4. CONCLUSION

In this research article, a architecture is proposed to quell the crosstalk effects in high speed wavelength divioned passive optical network for future generation. To suppress the inference of channels in WDM PON, an effective solution to nullify the effects has been proposed with the help of transmitter diversity in downstream and upstream. Use of differential phase shift keying for downlink and non return to zero for uplink makes arrangement reliable and suppress the interference among the dual direction channels. A semiconductor optical amplifier is placed to remodulate instead of external modulator such as MZM and EAM. Use of this transmitter diversity exhibit very effective results on system architecture.

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