Crosstalk suppression and user capacity enhancement in time and wavelength division multiplexed passive optical network incorporating different modulation formats

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Abstract - **In this paper aninnovativescheme has been presented to alleviate the effect of crosstalk in Time and Wavelength Division Multiplexed Passive Optical Network (TWDM PON) by using different modulation formats. Aprecise way has been suggested to increase number of users of system and least inter symbol interference on TWDM data. To support multiple user, hybrid modulation is proposed for TWDM PON with the integration of Differential Phase Shift Key(DPSK) format for downstream and Non Return To Zero(NRZ) formatfor upstream. Thus system is competent to support 1024/64 users per wavelength.Data rate of system is 120 Gb/s for downstream as each wavelength carry 10 Gb/s and 80 Gb/s for upstream. This is found that projected technique is appropriate to and exhibit best results in terms of Quality.**

Index Terms—Differential Phase Shift Key (DPSK), Passive Optical Network (PON), Bit Error Rate (BER), Time and Wavelength Division Multiplexing (TWDM), Non Return To Zero (NRZ).

INTRODUCTION

As communication technology is advancing day by day. Subsequently, demand for high data rate and large bandwidth has increased. To succeed higher data rate and large bandwidth requirement, lightwave technology has been developed known as fiber optic technology[1]. Full services access network (FSAN) and International Telecommunication Union (ITU-T)are presently finalizing particulars of the physical layer standard for PON (, as specified in ITU-T 989 Recommendation) [2] .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 [3]. By employing wavelength division multiplexing (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 [4].Additionally, this technology offers point-to-point connectivity with dedicated bandwidth from central offices (COs) to optical network units (ONUs), higher security, and better quality of service [5]. Time division multiplexing (TDM) can be incorporated together with WDM technology, which is referred as hybrid WDM/TDM technique, to reduce the cost and share the increased bandwidth among subscribers [6]. The cost is shared among all subscribers using TDM splitters for each optical channel.

However,PON channels may non-linearly interact with the multi wavelength legacy channels due to nonlinear effects along the PON feeder fiber for the downstream direction [7].Generally several consequences arises: (i) a power transfer takes place among the lower wavelengths, for example upperTWDM PON wavelengths, since lower channels act as pumps for TWDM PON signals [8]; (ii) nonlinear optical crosstalk takes place between signals and legacy PON channels [9].The main novelties of this paper summarized as the development of a technique that can generate the minimum amount of crosstalk for the TWDM data stream as well as less complex transmitter coding [10].

SYSTEM DESCRIPTION

In this work, proposed system consisting of 12 transmitter CW lasers from 1603 nm to 1596 nm with the channel spacing of 75 GHz using DPSK modulation format for downstream and for upstream 8 transmitter from 1539 nm to 1545 nm modulated using NRZ format. This transmitter diversity for both directions reducescrosstalk.

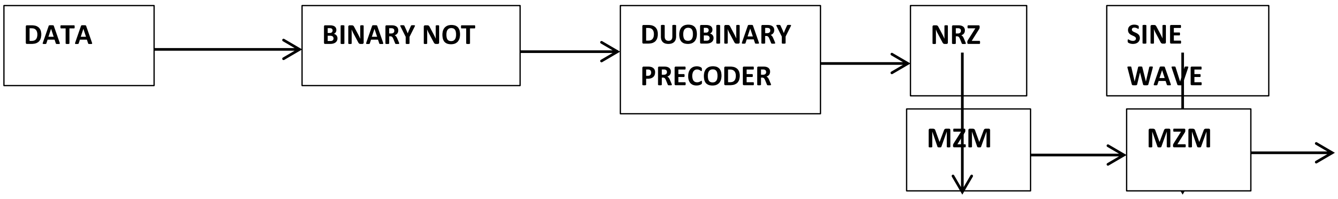


Figure.1.1Differential Phase Shifting Keying

Differential Phase Shift Keying (DPSK) transmitter system consists of PRBS generator, two NRZ pulse generator, two Lithium Niobate Mach-Zehnder(LiNb MZ) modulator and sine wave generator. Fig.1.1 represents the simulation setup diagram of DPSK transmitter.

DPSK is a common form of phase modulation that conveys data by changing the phase of the carrier wave. DPSK eliminates the need for a coherent reference signal at receiver by combining two basic operations at transmitter (1) differential encoding and (2) phase shift keying.

PRBS generator generates the bits of sequence to NRZ pulse generator. Duo-binaryprecoderis used to provide the codes to the bit with the delay of 1 bit. Then these codes are transferred to the modulator 1 for modulation process and modulator 2 provides a phase shift to the signal. For '0' bit phase shift is 180° and for '1' phase remain same.

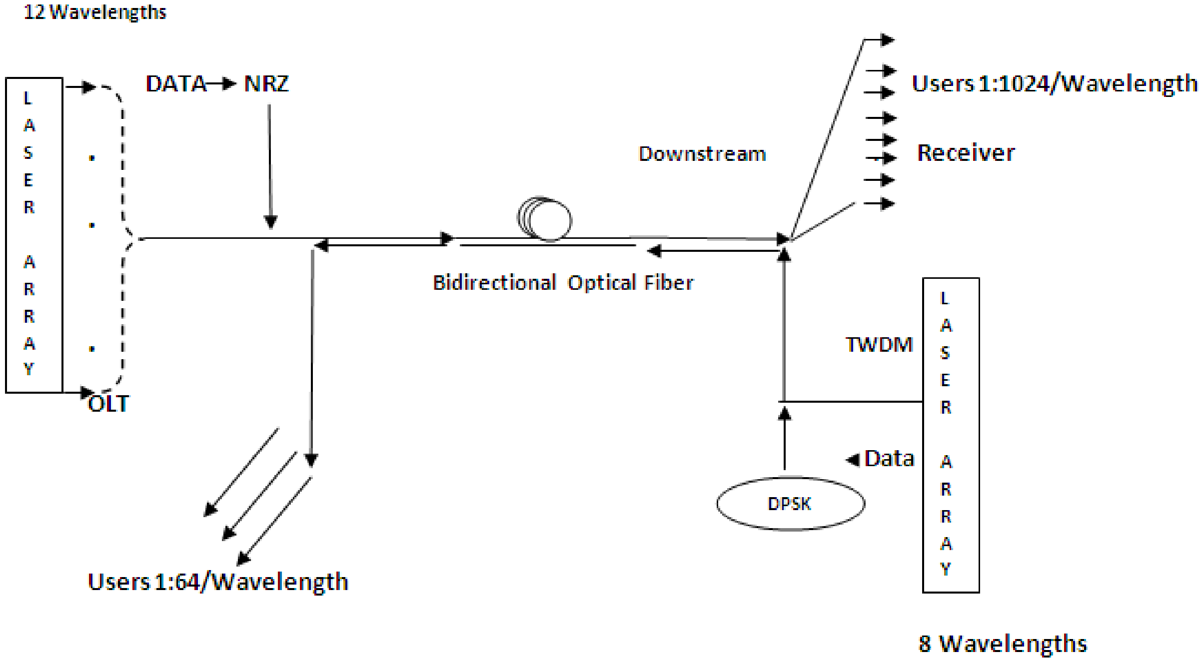


Figure.1.2 Representation of TWDM PON

PRBS is used to generate the random data. System specifications are shown in table 1.1. A 1x12 power splitter is used to split the signal into 12 equal powers. AWG (array waveguide gratings) are used to provide flexibility and rotation of signals to respective port. Bidirectional SMF-28 is used for the transmission in WDM-PON

Table 1.1 Simulation Parameters

Parameters	Values
Bit Rate	10Gbps
No. of channels (Upstream/Downstream)	8/12
Total data rate Upstream/Downstream	80/120Gbps
DWDM channel spacing	75GHz
Wavelength of the 1st channel	1603 nm
Linewidth	10 MHz

Optical receivers comprises of a photo detector followed by a low pass bessel filter used. Photo detectors used because to detect the optical signal and bessel filter is used to remove the noises. A 3R regenerator is used for re-sampling, re-shaping and re-amplification. At last, BER tester expresses the Quality factor and BER measurement.

In downstream, subsystem represents the working of the system. Power splitter 1:1024 is used i.e. power is splitted among 1024 users and then power is transmitted to the DPSK receiver. DPSK eliminates the need for a coherent reference signal at receiver by combining two basic operations at transmitter (1) differential encoding and (2) phase shift keying. A low pass bessel filter keeps the wave shape of filtered signals in the pass band.In comparison of shaping factor, flatter phase delay, and flatter group delay, bessel filter performs better than a Gaussian of the same order. Then the signal is passed to 3R regenerator. 3R regeneration includes three regenerating operations with a signal: regeneration of amplitude (amplification), regeneration of signal waveform and regeneration of synchronization. BER analyzer is used to calculate the bit error ratio that shows the signal strength of the signal.

RESULTS

The performance of TWDM-PON system is being observed with a channel spacing of 75 GHz with the capacity of 120 Gb/s. Fig.1.3 represents the spectrum for (a)12 WDM downstream channels (b) 8 TWDM channels for upstream.The study of the power spectrum is a kind of generalization of Fourier analysis and applies to functions which do not possess Fourier transforms. It describes how the power of a signal or time series is distributed over the different frequencies. If the signal being analysed can be considered a stationary process, the Short Time Fourier Transform (STFT) is a good smoothed estimate of its power spectral density. These devices work in low frequencies and with small bandwidths.

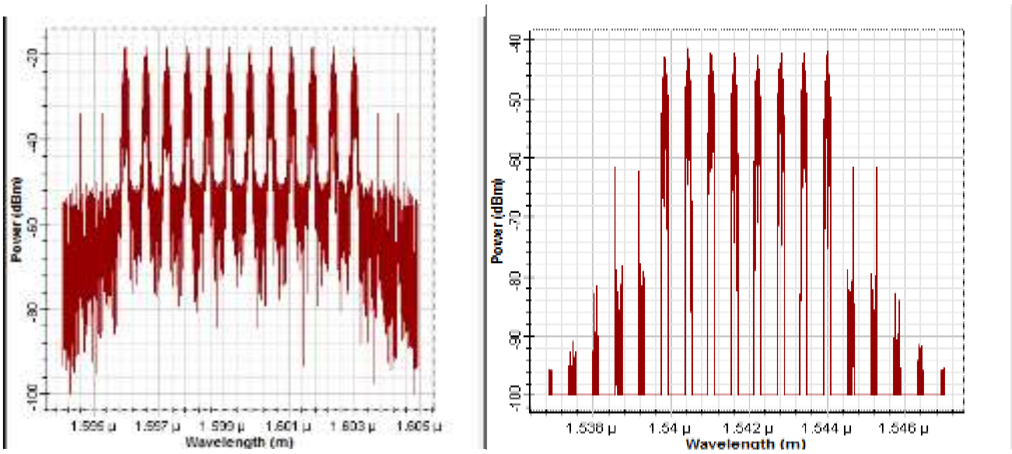


Figure.1.3 Power spectrum analyzer for (a)12WDM channels (Downstream) (b)8 channels (Upstream)

Firstly NRZ modulation format used for both directions and investigated the Quality of reception along with the errors introduced. Similarly, DPSK-DPSK and DPSK-NRZ are considered for bidirectional transmission.It is observed DPSK-NRZ has best value of Q-factor and less crosstalk as compared to DPSK-DPSKandNRZ-NRZ.

Fig.1.4depicts the comparative result in terms of Q-factor with respective of varied distance from 10 to 50 Km when signal sent CO to user end with 1024 users per wavelength for downstream. Power received tend to decrease when distance is increased and also more errors are reported on longer ranges. Fig.1.5 represents the identical scenario for upstream with the splitting ratio of 1:64 for each wavelength. Total 512 users are supported and all the wavelengths are time divisional and wavelengths division in case of upstream to minimize crosstalk. It is clearly seen that DPSK-NRZ performs best. NRZ-NRZ is least suitable for the transmission because of more crosstalk.

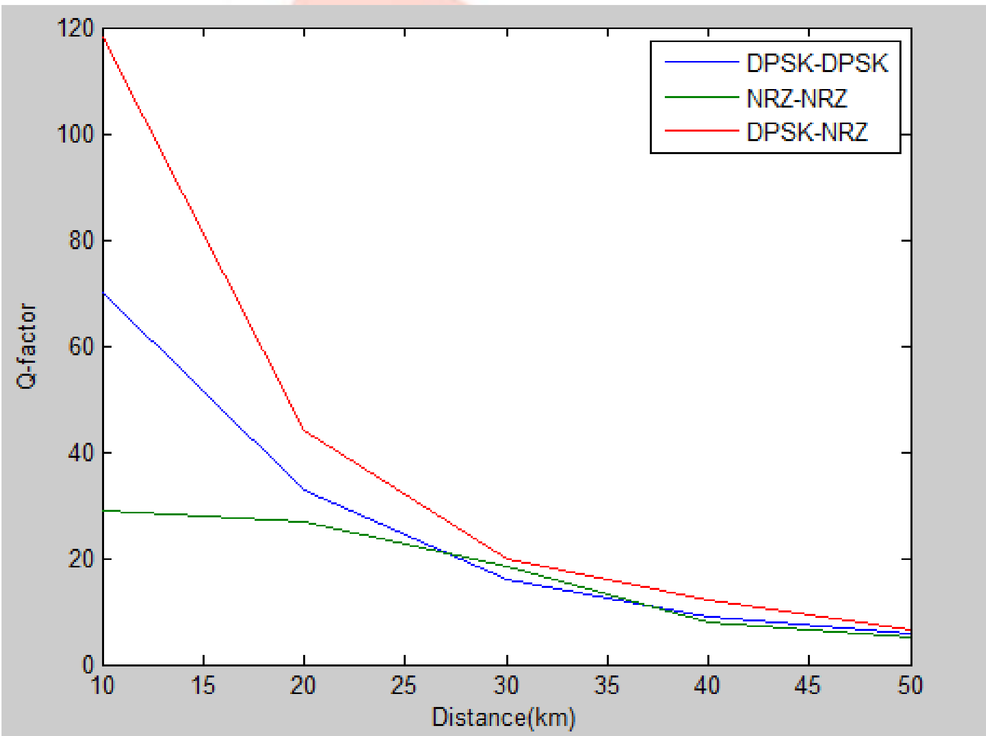


Figure.1.4 Graphical representations and comparative result of Q-factor with respective of varied distance for downstream

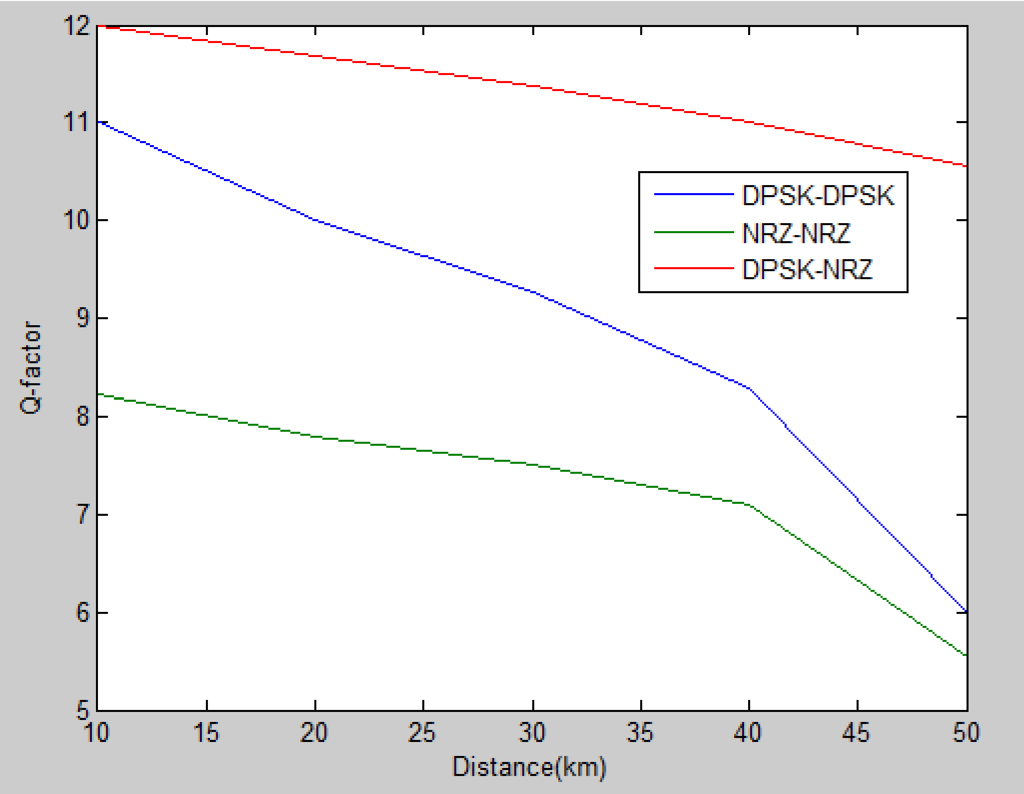
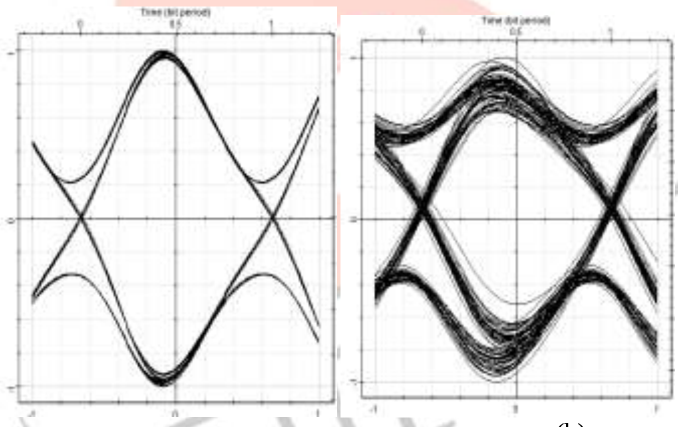


Fig.1.5 Comparative result in terms of Q-factor with respective of varied distance for upstream



(a) (b)

Fig.1.6 Eye diagrams for DPSK-NRZ at 10 Km (a) Downstream (b) Upstream

CONCLUSION

Acrosstalkimmune hybrid modulation is proposed for wavelength division passive optical network. With the incorporation of DPSK format for downstream and NRZ for upstream, system is less prone to crosstalk and enable system to support 1024/64 users per wavelength for downstream/upstream.Data rate of system is 120 Gb/s downstream as each wavelength carry 10 Gb/s and 80 Gb/s for upstream. Distance is achieved within acceptable BER range i.e.10^{-9} is 50 Km for both directions. This distance is obtained without any dispersion compensation and costly modules amplifiers. Also comparison is done by using same transmitter and hybrid transmitters. It is observed that DPSK for one direction NRZ for upstream provide best results.

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