Analysis and Reduction of Crosstalk in Hybrid TWDM System using Transmitter Line Coding Diversity

Rohit Bhardwaj*, Prabhdeep Kaur and Amit Gupta
Department of Electronics and Communication Engineering, Chandigarh University, National Highway 95, Chandigarh-Ludhiana Highway, Mohali, Punjab - 140413, India; rohitiitt01@gmail.com, prabh52409@gmail.com, amitguptacgc@gmail.com

Abstract

Objectives: Optical fibres are becoming the backbone of communication network due to its huge data carrying capacities. But there are many losses in the data transfer such as crosstalk which can reduce the data carrying capacity of an optical fibre network. Methods: This paper presents a crosstalk immune transmitter diversity hybrid modulation for wavelength division passive optical network, with the incorporation of Differential Phase Shift Keying (DPSK) format for downstream and Non Return-Zero (NRZ) for upstream. Findings: The network becomes less prone to nonlinearities and enables the system to support 6144/512 users. Data rate of system has been achieved for 120 Gbps downstream as each wavelength carry 10 Gbps and total 80 Gbps for upstream. An acceptable Bit Error Rate (BER) range i.e. 10⁻⁹ has been attained for a significant distance of 110 Km for both directions. The results have been attained without any dispersion compensation and costly modules only using Erbium Doped Fiber Amplifier (EDFA) for downstream. A semiconductor optical amplifier is placed to re modulate data streams. Also comparison is being done by using same transmitter and hybrid transmitters. It is observed that Differential Phase Shift Keying (DPSK) for one direction Non Return-Zero (NRZ) for upstream provide better results. Applications: This model can significantly reduce the crosstalk over an optical fibre network during the transmission of data in upstream and downstream by achieving 80Gbps and 10Gbps respectively.

Keywords: Crosstalk, Line Coding Diversity, Hybrid Systems, Transmitter

1. Introduction

The global telecommunication industry is transforming with new technologies. PON technology is slowly taking over the communication scenario, due its extraordinary performance parameters this research is basically focused on PON technology. Two major samples of this worldwide specialise in PON’s are the Gigabit PON (GPON) Optical Network Unit (ONU) certification timetable declared by Broadband Forum at their third quarter 2011 conference command in Shanghai, China, throughout the week of September nineteen, 2011, and therefore the high level of participation at the FTTH Council Conference and assemblage command in urban centre, Florida, throughout the week of September twenty six, 2011. There are two major objectives in next generation passive optical networks. The first objective emphasis on the increase of bit rate during transmission. The second objective works on the extension of range to reduce the deployment cost. Additionally, this technology uses dedicated bandwidth from central office to Optical Network Unit (ONU) and offers point to point connectivity as well as higher security and great services. To reduce the cost and to increase the bandwidth user can Combine Time Division Multiplexing (TDM) with Wave Division Multiplexing (WDM), and this can be referred as hybrid WDM/TDM technique. With the advancement in communication technology the necessity for prime speed net is increasing day by day that additional demands high rate and enormous information measure. Thus our future technology is needed to be variable to supply massive information measure and to support sizable...
amount of latest applications. To unravel this downside fiber optic technology has been developed that uses optical lightweight as a transmission medium. Fibre provides us adequate resolution to unravel the matter of access network. Fibre technology offers us a mix of low error chance, high information measure and enormous transmission capability. To match these requirements of higher data rate, high performance parameters such as throughput, low noise in FTTH, Gigabit-capable Passive Optical Network (GPON) may be a best option. GPON is discovered joined of the best technology to produce broadband access network in future. Access networks are created out of copper and were supported twisted combine and concentrical cables. The 3 main needs of access network are they need to be value economical they need to have high dependableness and higher performance. Passive Optical Network (PON) needs solely passive parts i.e. it doesn't need continuous provider of electricity, thus power problems and warmth aren't thought of. Passive optical network has low maintenance value since it needs less part. Fiber based mostly networks are cheaper to work. Different researches associated with improvement during this field have conjointly been analysed. Copper based mostly networks need ton of maintenance and repair as compared to optical network. Optical network has the ability to with stand in sever conditions such as noise whether it is manmade or communication noise, hence optical network is the best choice to provide services for long period of time. Thus to supply broadband services to the top users many FTTH and FTTP network has been planned. FTTH is 100% readying of optical fiber because the signal travels through the fibre its power declines as a result of the presence of varied non-linearity within the fibre.

In this work, a XT immune transmitter diversity hybrid modulation is planned for wavelength division passive optical network. With the incorporation of DPSK format for downstream and NRZ for upstream make system less prone to nonlinearities and enable system to support 6144/512 users at 120 Gbps/80 Gbps.

2. System Description

Figure 1 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 Figure 2. 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 transmits

![Figure 1. Block Diagram of WDM-PON Supporting 6144 downstream/512 upstream users.](image1.png)

![Figure 2. Block Diagram of RZ-DPSK Transmitter.](image2.png)
data by altering the phase of the high frequency carrier wave. DPSK terminates the requirement of signal processing at receiver side by mixing two basic operations at transmitter (1) differential encoding and (2) phase shift keying.

PRBS generator used to generates the sequence of bits to NRZ pulse generator, in this section binary not is used to perform the XOR function and used along with duo-binary precoder. Delay of one bit is provided with the codes by the Duo-binary precoder. Then these codes are fed to a modulator 1 for modulation and phase shift to the signal is provide by the modulator 2. Sine signal is biased at half of the given data rate to provide phase shift of one eighty and zero.

**Table 1. Simulation Parameters**

| Parameters                              | Values          |
|-----------------------------------------|-----------------|
| Speed of data bits                      | 10Gbps          |
| Count of transmission sources (down/up) | 12/8            |
| Final speed for own and upstream        | 120/80Gbps      |
| Wavelength spacing                      | 200GHz          |
| Initial Wavelength                      | 1550nm          |
| Line width                              | 10 MHz          |
| Erbium amplifier power down stream      | 10dBm           |
| Launched Power (up/ down)               | 0dBm/5dBm       |
| Link length                             | 110km           |

**Figure 3.** Sub-system showing 512 Users for all channels (Down-stream).

**Figure 4.** Block diagram of 64 Users for each channel (Up-stream).
Random data is generated by PRBS. To mitigate the effect of attenuation, EDFA amplifier with gain of 10dB and 4 dB noises Figure in down-stream and SOA gain for up-stream is used. Table 1 shows the System specifications. A signal is split into 12 equal powers by the 1x 12 power splitter. Flexibility and rotation is provided by circulators on other ports. For transmission Bidirectional SMF-28 is used in WDM passive optical network.

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.

Power is divided into 512 users, with the help of power splitters power is transmitted to DPSK in downstream i.e. 1:512 shown in Figure 3. Differential encoding and phase shift keying are operations performed by DPSK at transmitter to eliminate the requirement of a coherent reference signal at receiver side. An analog linear filter such as low pass Bessel filter with a maximally flat group/phase delay which preserves the wave shape of filtered signals in the pass band. As a filter order increases Bessel filter tends the same shape as Gaussian filter. Then the signal is passed to 3R regenerator. 3R regeneration includes three regenerating operations with incoming pulses such as again time and synchronises the data. Bit error ratio is calculated by BER analyzer that represents the signal power. Similar action takes place in up-stream for 64 users each as shown in Figure 4.

3. Results and Discussions

Analysis of frequency multiplexed passive optical system is studied with 100 GHz separation among the channels. An 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 Figure 5 for the performance of 12 data signals and also in Figure 6 for the performance of 8 data signals. The basic working of spectra is a type of simplification of Fourier examination and fed to system do not have Fourier transforms. 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. These types of equipments operate on less frequencies and contracted band widths.
The variation for upstream and downstream frequencies is shown in Figures 7-8 for downstream and upstream respectively. It represents the maximum pragmatic distance for 6144 users in downstream and 512 users in upstream.

4. Conclusion

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 make system less prone to crosstalk and enable system to support 6144/512 users. Data rate of system is 120 Gbps downstream as each wavelength carry 10 Gbps and 80 Gbps for upstream. Distance is achieved within acceptable BER range i.e. $10^{-9}$ is 110 Km for both directions. This distance is obtained without any dispersion compensation and costly modules only using EDFA amplifier for downstream. A semiconductor optical amplifier is placed to re modulate data streams. Also comparison is done by using same transmitter and hybrid transmitters. It is observed that DPSK for one direction NRZ for upstream provide better results.

5. References

1. Gebizlioglu O, Kuwahara H, Jain A, Spencer J. Passive Optical Networks (PONs): Toward Next Generation...
Analysis and Reduction of Crosstalk in Hybrid TWDM System using Transmitter Line Coding Diversity

1. Electrical structure. IEEE Communications Magazine. 2011 November; 49(11):76-77. Crossref
2. Emsia A, Le Q, Malekizandi M, Briggmann D, Djordjevic B, Kuppers F. WDM–TDM NG-PON Power Budget Extension by Utilizing SOA within the Remote Node. IEEE IPC. 2014; 6(2):1-11.
3. Wong E. Next Generation Broadband Access Network and Technologies. Journal of Lightwave Technology. 2012; 30(4):597-608. Crossref
4. Zhang J. Springer: Media Access Control and Resource Allocation for Next Generation Passive Optical Networks. 2013.
5. Kocher D, Kaler R, Randhawa R. Simulation of fiber to the house baseball play services at 2Gbits/s mistreatment GE-PON design for fifty six ONU’s. Optik-International Journal of light-weight and lepton Optics. 2013; 124(21):5007-10.
6. Kocher D, Kaler R, Randhawa R. 50 kilometre bidirectional FTTH transmission comparing totally different PON standards. Optik-International Journal of Sunshine and Electronics. 2013; 124(21):5075-78.
7. Dewra S, Sumanpreet. A review on Gigabit - passive optical Network, International Journal of Advanced analysis in pc and Communication Engineering. 2014 March; 3(3):5844-48.
8. Fernandez V, Collins RJ, Gordon KJ, Townsend PD, Buller GS. Passive Optical Network Approach to GigaHertz-Clocked Multiuser Quantum Key Distribution. IEEE Journal of Quantum natural philosophy. 2007 February; 43(2):130-38.
9. Vinayak N, Gupta A. Comparative analysis of WDM system victimisation Cascaded amplifiers in Optical wireless channel over a distance of ten thousand kilometer. SOP Transactions on Signal process. 2014; 1(1):25-32.
10. Saini S, Gupta A. Investigation to search out optimum modulation format for low power inter-satellite optical wireless communication (LP-IsOWC). Eleventh International conference on Wireless and Optical Communication Networks. 2014; p.1-4.
11. Sarup V, Gupta A. Performance associate analysis of an immoderate high capability one Tbps DWDM-RoF system for terribly slender channel spacing. Eleventh International conference on Wireless and Optical Communication Networks. 2014; p.1-5
12. Saini S, Gupta A. Modelling and Performance Analysis of DWDM based mostly a hundred Gbps Low Power Intersatellite Optical Wireless Communication (LP-IsOWC) Systems. SOP Transactions on Signal Process. 2015; 2(1):1-6.
13. Gupta A, Kaler RS, Singh H. Associate degree irreproducible programing technique for optical burst switched networks. Optik-International Journal for lightweight and electronics. 2013; 124(8):689-92.
14. Gupta A, Kaler RS, Singh H. Investigation of OBS assembly technique supported varied programming techniques for maximising turnout. Optik-International Journal for lightweight and electronics. 2013; 124(9):840-44.