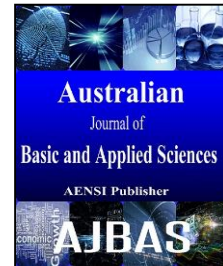




AUSTRALIAN JOURNAL OF BASIC AND APPLIED SCIENCES

ISSN:1991-8178 EISSN: 2309-8414
Journal home page: www.ajbasweb.com



Investigation of Passive Optical System with Dispersion Compensation and Error Correction

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ARTICLE INFO

Article history:

Received 18 February 2017

Accepted 15 May 2017

Available online 18 May 2017

Keywords:

DCF, GPON, Forward Error

Correction, Passive Optical Network

ABSTRACT

Background: With the continually expanding necessity for broadband applications coupled with economical broadband access systems developments has realized a broadband network configuration based on passive optical network (PON). **Objective:** In this paper, investigation of PON system for 1.25 and 2.50 Gbps data rates are done using dispersion compensation and error correction mechanism. **Results:** By employing forward error correction mechanism the span of network is enhanced up to 30 Km. Dispersion of the information signal is reduced by using pre and post compensation methods. **Conclusion:** The results of two compensation methods have been compared and it is found that the post- compensation method is superior to pre-compensation method.

INTRODUCTION

With the regularly expanding client's requests for broadband applications to bolster various services like IPTV applications and user to user multimedia applications, fiber to the home (FTTH) has as of late exceeded thirty million clients worldwide and is still keeping on developing at a fast rate. FTTH arrangements can offer extensive cost effective advantages (FTTH council, 2008). To accomplish various FTTH arrangements, passive optical systems (PONs) have been considered as the most encouraging innovation (P. Cadro *et al.*, 2001).

PON is a point to multipoint optical system, where an Optical Line Terminal (OLT) situated at the Central Office (CO) is associated with numerous Optical Network Units (ONUs) situated at the client's premises by the use of optical fiber and optical splitters (Frank J. Effenberger *et al.*, 2010), (Md. Shamim Ahsan *et al.*, 2011). PON is categorized as APON (ATM PON), EPON (Ethernet PON) and GPON (Gigabit PON) on the premise of the protocol employed. EPON is generally referred as Gigabit Ethernet Passive Optical Network (GEPON) in Japan (Petar S. Matavulj *et al.*, 2009), (Monika Gupta *et al.*, 2010).

GEPON architecture has been assuming a key part in the fast extension of Fiber to the home (FTTH). Over the last decade, GEPON has led to expanding the network of FTTH by adding more than millions of clients (Chadi M. Assi *et al.*, 2003). PON network is constrained by the split ratio of not more than 64 and system reach up to 20 km as specified by the various standards. Higher split ratios build the advantages of a PON by bringing down cost by using a shared OLT among a bigger number of clients through a fiber and all the more. In spite of these advantages of expanding the separation and split size of the PON, the optical power budget remains a noteworthy test.

Various studies investigated in (Chien Aun Chan, 2010), (Darren P. Shea, 2007) the use of the forward error correction mechanism with optical amplifier for attaining higher split ratios with longer reach. PON when operating at high data rate may require forward error correction (FEC), particularly for transmission over longer

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To Cite This Article: Ankur Singhal and Singh., Investigation of Passive Optical System with Dispersion Compensation and Error Correction. *Aust. J. Basic & Appl. Sci.*, 11(8): 80-86, 2017

separations (Chien Aun Chan, 2010), (Christophe Peucheret, 2000). The standard PON conventions, for example, XG-PON (ITU-T. recommendation 984.3, 2014), describe FEC encoding of the whole of information frame transmitted in the downstream direction, as opposed to encoding on a for every client premise. Dispersion is the most significant restrictions on communication involving optical fibre. It results in broadening of pulse. Dispersion affects both single mode and multimode optical cable. The utilization of dispersion compensating fibre (DCF) is a proficient approach to update links made of standard single mode fibre (SMF) (Christophe Peucheret, 2000).

In this paper, we have investigated the performance of GEPON; information signal is conveyed to 32 users. Information is represented in multiple ways i.e. data, Voice and video signal. Data and voice signals are transmitted at a wavelength of $1.4900 \mu\text{m}$. Video signal is conveyed at a wavelength of $1.5500 \mu\text{m}$ over a distance of up to 30 Km. Effects of dispersion on the received signal are observed. Dispersion is compensated using pre and post compensation mechanism. Further, the quality of the received signal is enhanced by applying forward error correction on the transmitted signal. Forward error correction (FEC) technique is used at receiver side and provides the detection and correction of the signal at the receiver. Quality of the signal is measured in the form of bit error rate (BER) and quality factor (Q-factor). Simulation of 30 Km long normalized section is investigated using the post- and pre-compensation schemes in a systematic fashion at 1.25 and 2.5 Gbps data rates with the use of FEC technique. Dispersion compensation is achieved using DCF. The fiber length of 30 Km is divided into three segments and every segment is having a length of 10 Km. SMF is set to 8 Km and DCF is to 2 Km. Pre and post-compensation mechanism are employed, by varying the position of DCF with respect to SMF. In post compensation technique, DCF is positioned after SMF but in DCF is placed before the SMF in pre compensation mechanism. Erabium Doped Fiber Amplifier (EDFA) is employed for compensating the loss in power produced by information signal passing through SMF and the DCF.

Here, in segment 2, the architecture of GEPON is presented. The simulated results of GEPON model are presented and discussed in section 3. At last in section 4, conclusions are made.

Gepon System:

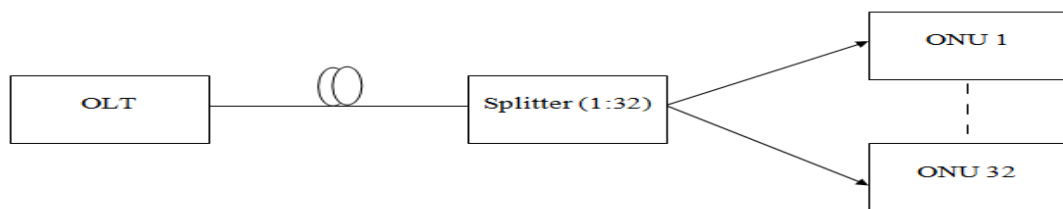


Fig. 1: GEPON System

GEPON system consists of OLT, ONU and passive splitter (Abdallah Shami, 2005). The system as shown in Figure 1, in which information signals from an OLT is sent to various ONUs. OLT are placed in CO and associates the optical access system to the metro and backbone system. Concurrently, the ONU is situated close to client areas and must bolster a wide cluster of multimedia services. The OLT is associated with up to 32 ONTs (Ahmad R. Dhaini *et al.*, 2007).

RESULTS AND DISCUSSION

Using post-dispersion compensation:

Figure 2 shows, that with the increase of span from 10 Km to 30 Km, dispersion rise. Also, it is observed that dispersion rises when video signal having a wavelength of $1.5500 \mu\text{m}$ is communicated in comparison to the voice/data signal transmitted at a wavelength of $1.4900 \mu\text{m}$.

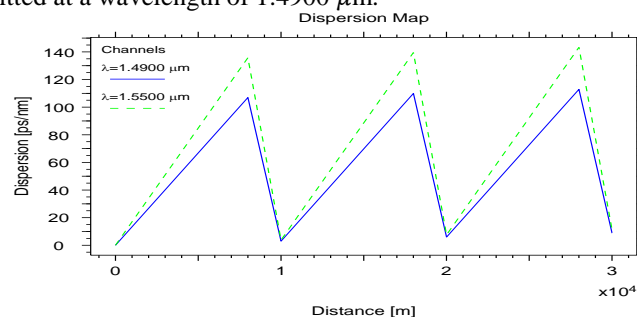


Fig. 2: Effect of Distance on dispersion

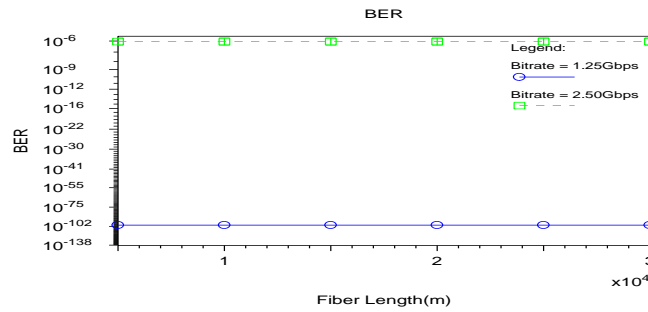


Fig. 3: Effect of Distance on BER

Figure 3 displays, the relationship between BER and distance. BER is recorded when information is transmitted when error correcting code is applied. It is noted that with the rise in distance, BER also increases. It is noticed that BER is more for the transmission rate of 2.50 Gbps as compared to 1.25 Gbps when information signal is communicated without correcting it with FEC.

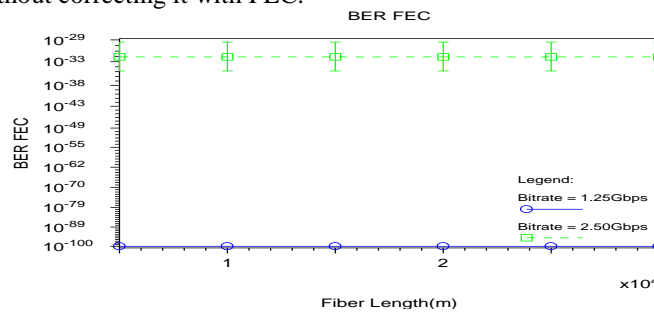


Fig. 4: Effect of Distance on BER

Figure 4 demonstrates the effect of FEC technique on the transmitted information, When FEC is applied to the communicated data signal, BER is reduced at different data rates of 1.25 and 2.50 Gbps. Also, we have observed that with the decline in BER the fiber length are scaled up to 30 Km with acceptable quality of the received signal. Figure 5 gives the effect of distance on quality factor. Q-factor is measured when information is transmitted without correcting the errors with the use of FEC technique. Information is communicated at data rate of 1.5 Gbps and 2.50 Gbps. It is noted that Q-factor reduces with the increase in fiber length from 20 Km to 30 Km. It is observed, that at the data rate of 1.25 Gbps the Q- factor is more in comparison to the bit rate of 2.50 Gbps.

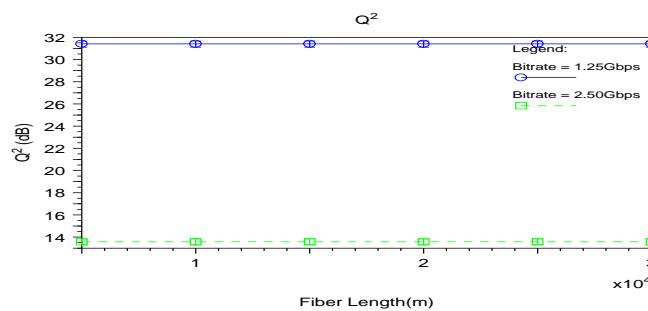


Fig. 5: Effect of Distance on Q-Factor

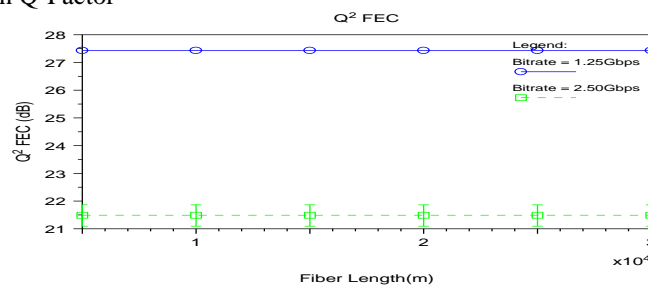


Fig. 6: Effect of Distance on Q-Factor

Figure 6 depicts the effect on transmitted information when error correcting code FEC is applied. It is noted that Q- factor rises with the rise of separation from 20 Km to 30 Km. It is analyzed that, with the help of FEC technique the quality is enhanced as the system is spanned up to 30 Km.

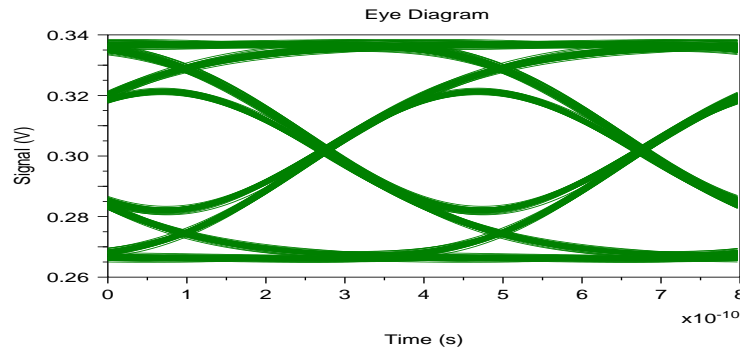


Fig. 7: Eye Diagram

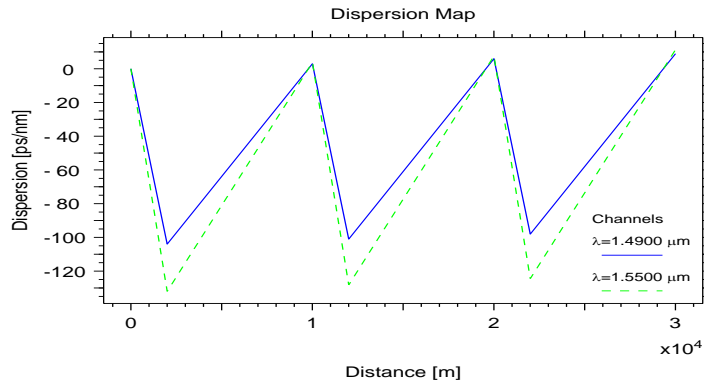


Fig. 8: Relation of Distance with dispersion

The effect of rise in distance on dispersion is depicted in Figure 8. It is visible that with the rise of distance, dispersion grows for the signals communicated at different wavelengths. As demonstrated in figure 9, BER rises when the separation between OLT and ONU is enhanced. BER observed to be more when the signal transmits at the bit rate of 2.50 Gbps.

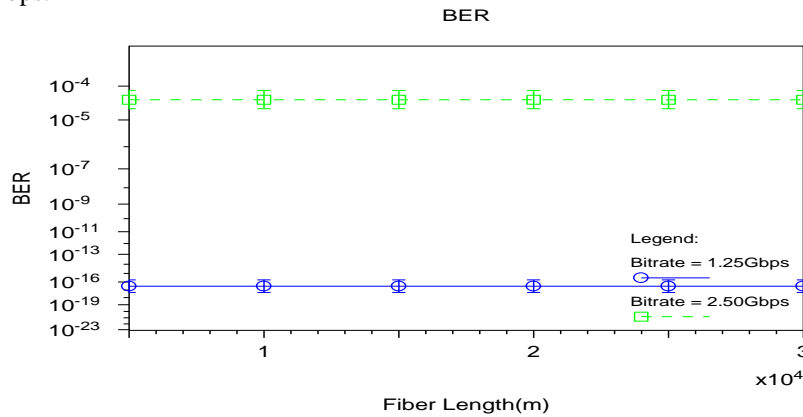


Fig. 9: Relationship between BER and distance

As we observed in figure 10, it is noted that by using the FEC technique, BER is reduced which improves the performance of the system. The system performs better but not so in comparison to the system where post-dispersion compensating fiber is used. Q-factor reduces when the distance is increased. This decrease is more when the signal transmits at the information rate of 2.50 Gbps. The relationship is shown in figure 11. Figure 12 depicts the relationship between distance and q- factor. The result of GEAPON model demonstrates that by using the error correction the q-factor of network is enhanced. With FEC mechanism, Q-factor grows even when separation is increased from 20 Km to 30 Km.

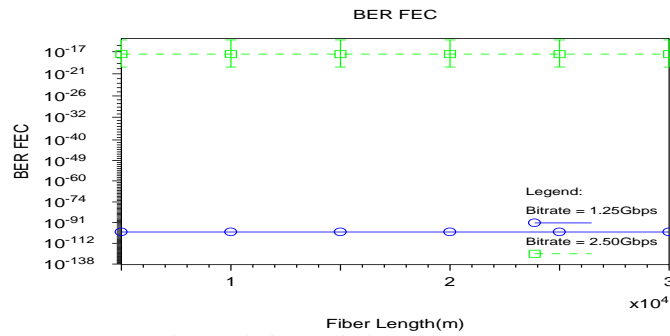


Fig. 10: Effect on BER when error correcting code is applied

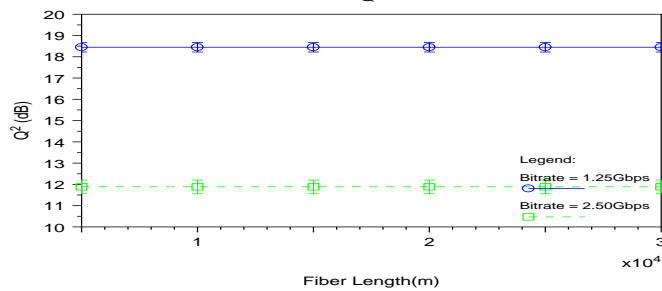


Fig. 11: Results of Q-factor with distance

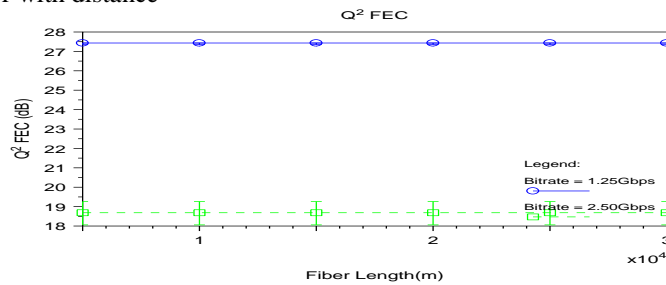


Fig. 12: Results of Q- factor with Error correction

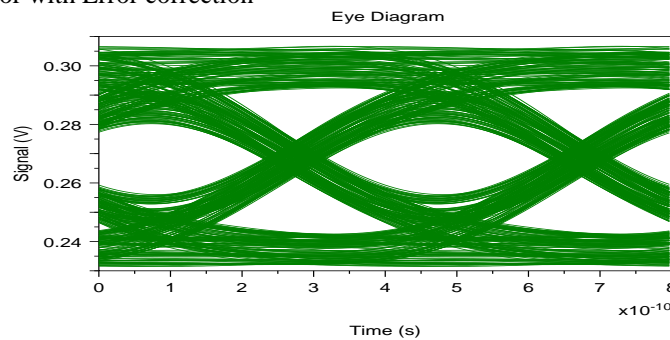


Fig. 13: Eye Diagram

Eye diagram displayed in figure 13, elaborates that by using Pre-dispersion compensation fiber the height and width of the eye is decreased. So, it can be described that the received signal is distorted.

From the table 1, it is observed that dispersion is reduced when post compensation technique is employed. Also, it is noted that data and audio signal encounters less dispersion in comparison with a video signal over a distance of 30 km. Dispersion affects more to a video signal which can be better compensated by using post compensation technique in comparison with a pre compensation technique.

Table 2 and 3, shows the effect of post compensation with and without the use of FEC. Bit error rate (BER) and Q-Factor is noted at a transmission rate of 1.25 Gbps and 2.5 Gbps. The transmission span is taken as 30 Km. It is observed, that the quality factor is 31.46 db when measured for 1.25 Gbps and is 13.6 db for 2.5 Gbps. Quality factor improves for 2.5 Gbps when measured with FEC. BER also improves with the application of FEC.

Tables 4 and 5, shows the effect of pre compensation technique for the data rate of 1.25 & 2.5 Gbps. It is noted that bit error rate (BER) is less at 1.25 Gbps and increases when information signal is communicated at a rate of 2.5 Gbps. It further, drops when data is transmitted after applying FEC.

Table 1: Values of Dispersion for 30 Km

Distance	Post-Compensation		Pre-compensation	
	Dispersion [ps/nm]		Dispersion [ps/nm]	
	Data/Voice	Video	Data/Voice	Video
30 km	8.83	9.30	9.55	9.85

Table 2: Values of Post-compensation mechanism

Distance	Post- compensation			
	Without error correction			
	1.25 Gbps		2.5 Gbps	
	Bit Error Rate	Q-Factor (dB)	Bit Error Rate	Q-Factor (dB)
30 km	2.18e-99	31.46	1.07e-6	13.6

Table 3: Values of Post-compensation mechanism

Distance	Post- compensation			
	With error correction			
	1.25Gbps		2.5Gbps	
	Bit Error Rate	Q-Factor (dB)	Bit Error Rate	Q-Factor (dB)
30 Km	1.93e-100	27.45	9.38e-33	21.5

Moreover, it is noticed that q factor is reduced with the rise in data rate. Q factor is improved further when information is communicated with FEC. It is deduced from the above discussion that quality of the received information is improved by applying forward error correction. Also, with the rise of transmission rate dispersion grows. Dispersion is better compensated by using post compensation technique. Further, information can be communicated at a high rate which is an essential requirement of optical access systems.

Table 4: Values of Pre-compensation mechanism

Distance	Pre-compensation			
	Without error correction			
	1.25Gbps		2.5Gbps	
	Bit Error Rate	Q-Factor (dB)	Bit Error Rate	Q-Factor (dB)
30Km	3.54e-17	18.46	4.33e-5	11.91

Table 5: Values of Pre-compensation mechanism

Distance	Pre compensation			
	With error correction			
	1.25 Gbps		2.5Gbps	
	Bit Error Rate	Q-Factor (dB)	Bit Error Rate	Q-Factor (dB)
30 Km	1.72e-100	27.43	4.71e-18	18.71

Conclusion:

In this paper, we observed that by using the error correction technique the distance is increased up to 30 Km and data rate is increased up to 2.50 Gbps. By comparing all these results and eye diagrams it is deduced that

post-dispersion compensation performs better. Compensating through pre compensation mechanism, it is noted that the height and width of the eye is reduced and the information signal received is deformed. Further, by employing post-dispersion compensation technique, it is noted that height and width of the eye is wide and information received is of good quality. So, we can deduce that the quality of the conveyed multimedia signal is enhanced by the use of dispersion compensation and error correction.

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