Performance Monitoring of Optical Network using Bit Error Rate

Ankush Chaudhary, Karamjit Kaur, Anil Kumar
Amity University Gurgoan, Haryana
Email Id: karam_sekhon@yahoo.co.in, ankushchaudhary2@gmail.com

Abstract:- With the increase in demand of broadband services, channel complexity has been increased. Therefore it has become necessary to monitor the performance of optical networks. Quality of service monitoring is very important tool in maintaining a strong, reliable and high capacity optical network. When one talks about QoS, BER is the parameter which needs to be monitored. In the proposed work, BER for 1m and 3m fiber cable is calculated through experimental setup and simulations. Simulations has been done in OPTSIM and later on behavior of network is compared with the experimental data.

*****

1. Introduction

Next-generation optical networks will be able to support various emerging broadband applications as well as emulate many kinds of legacy services over the same infrastructure, with minimal engineering investment. So there will be need of motoring parameters like OSNR, BER, Q-Factor, Jitter etc. The ultimate parameter for monitoring the performance of a channel is the BER. It determines the true health and original quality of a signal. In traffic, BER measurement can be performed using Monte Carlo method. In this method some test sequences are sent within the optical transport network frame. In various networks, BER monitoring can be performed at every regeneration site and is a simple tool for maintenance and fault localization procedures. On the other hand in transparent networks such an approach cannot be performed. In a transparent network the signal transmission between end nodes is at the optical domain, so the signal needs to be converted to the electronic domain. In order to correctly locate any source of impairment, network node should implement some type of monitoring on the pass-through signal which possibly shared among different channels. Monitoring could thus be implemented through a bank of transponders, but this solution turns out to be neither power efficient nor cheap, while it substantially reduces the benefits of optical transparency. Several techniques has been proposed in past literature to monitor BER. It should either be by optical measurement or electrical measurement. There are few methods reported in literature using piottone detection [1-2], delaytap plots [3] and spectral measurement [4]. The problem with these techniques was their complexity, therefore another techniques was used to reduce the complexity in the system named as time domain techniques [5-6] in which digital processing of transmitted signals is not required. These techniques may be synchronous or asynchronous based upon the histogram using different samples. [7-11]. these samples are further used to generate eye diagram from which BER can easily be calculated. There is another technique which is based on factor estimation and this can provide effective BER for limited on-off keying (OOK) signals [12]. The method was based upon finding a threshold voltage from optimum level to measure the errors in the signal. The drawback in this method was statistical samples needs to be collected over a wide range and region. Then average value was considered as a threshold which in real difficult to perform and can only be used for low set of values.

In the proposed work, Bit Error Rate monitoring based on electronic processing technique has been demonstrated. For obtaining the network behavior, a simple 10 Gbps network of length 1Km has been simulated in optsim. The network is obtained at destination in form of eye diagram, optical spectrum which is being analyzed to calculate amount of BER present in different system configuration. The experimental work is being carried out for 1m and 3m fiber cable and result obtained are then compare with simulation result. In this paper section1 includes introduction to basic principles. Section2 starts with the need of monitoring and causes of signal degradation. On the other hand section3 discuss simulations and experimental set up used for BER monitoring has been discussed in section4 followed by result and conclusion.

2. Background

I. Need for Optical performance monitoring:

The need of optical performance monitoring is a natural extension as communication systems are moving from electronic to optical. In Electronic performance monitoring health of an electronic system is being checked by monitoring the quality of electronic signals. On the other hand optical performance monitoring (OPM) checks the quality of optical signals. Optical performance monitoring is necessary to manage high capacity optical transmission and switching systems [13-14]. Therefore to determine the health of the signal and to make it effective and efficient, BER needs to be monitored. However signal degradation is the other reason for monitoring BER. The signal degrades

 ISSN: 2321-8169
2807 - 2810

mainly due to attenuation, scattering, dispersion or bending losses. These losses may lead to various changes which affects the quality of signal.

II. Bit Error Rate

In general term BER can be defined as the no of error received as per the total bits transmitted. The bit error is regarded the decisive quality measure in optical communication links. Higher will be the bit error rate, lower will be the speed of data. If BER is reduced, the probability of getting higher data rates increases. Therefore to find the errors in a system it become necessary to monitor such parameter. The main cause of error bits is noise which is generated randomly in the system. By reducing the bandwidth, errors can be reduced but one can't do that because bandwidth required to transmit the signal is limited. Other factor that reduces BER performance is quantization errors. The way to reduce these quantization errors is to use higher power transmission so as to increase the energy per bit but this option is also limited as there is a chance to lose system capacity. These errors occurs during reconstructing a digital waveform. The formula used here to calculate BER is

BER=Total no of Errors/Total no of bits transmitted

To calculate BER, signal samples in terms of volt were taken as input and output value. On the other threshold value was obtained by calculating the mean value of the signal samples. According to this threshold error bits were determined. Finally BER was calculated from above general formula. The result then compared with the simulation results which are shown in the next section.

3. Experimental setup

Basic experimental kit for optical fiber communication Tx and Rx Trinity kit (FO-1304) is used for the research.

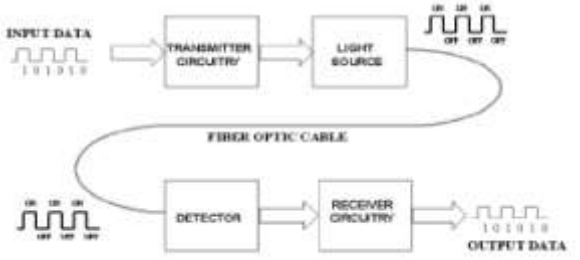

Fig1.

Basic principal for optical network

A fiber optic data link basically contains three main elements: a transmitter, an optical amplifier and a receiver. The transmitter takes data previously in electrical form and transforms it into optical energy containing the same information. The optical fiber is the medium which carries energy to the destination. At the receiver, light is converted back into electrical form with the same pattern as originally fed to the transmitted by the person who sent the message.

The following waveforms are obtained through DSO by providing the different optical fiber cable length of 1m and 3m respectively.

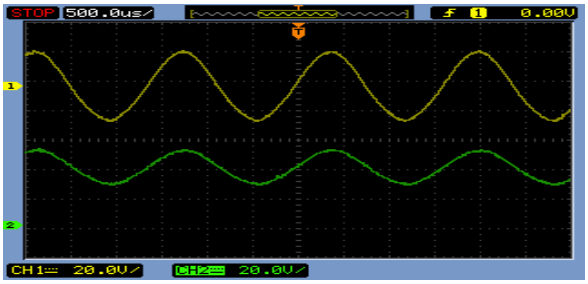

Fig 2. Sine wave generated on DSO (1m)

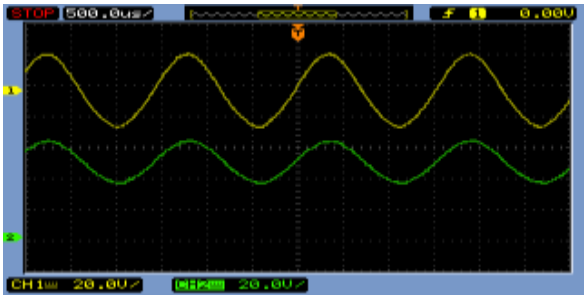

Fig 3. Sine wave generated on DSO (3m)

4. Simulation Setup

In order to meet the objective of proposed work used simulation network is shown in Fig. 4 Through the desire model Eye diagram, Optical spectrum and Electrical spectrum is obtained and corresponding BER is calculated.

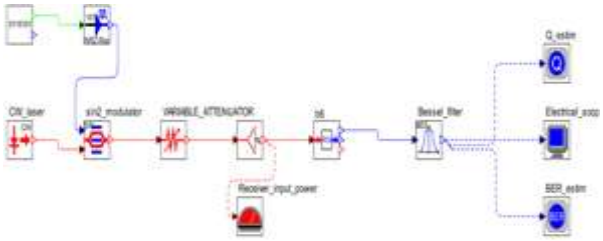

Fig.4. Simulation setup in OPTSIM

BER is calculated using simulation in above network. The signal transmitted was 10Gbps NRZ having a bandwidth of 10GHz. Optical amplifier is there to add noise which is additive Gaussian noise. The signal was then optically filtered, the photodiode is modeled as an ideal intensity detector, followed by a 4th order Bessel filter having 10GHz bandwidth, sampled at the center of the bit, and finally processed at the receiver end. The eye diagram and optical spectrum obtained from the above setup (Fig 4) is shown in Fig.5 and Fig.6.

 ISSN: 2321-8169
2807 - 2810

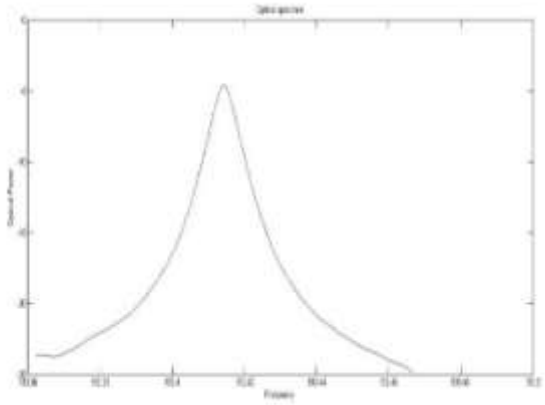

Fig 5. Optical spectrum

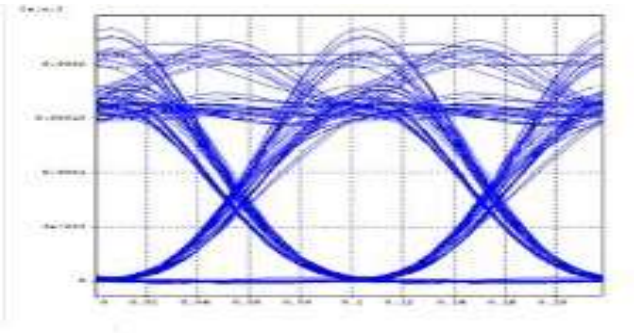

Fig 6. Eye diagram

The Bit error rate has been varied from Transmitter Power (Tx) in the CW laser. Tx power is varied from -38db to -16 db. Table 1 includes the various values of BER and OSNR which were varied during simulations by changing the Rx power.

Fig.5 shows the variation of BER with respect to Receiver power.

Fig.6 shows the variation of BER corresponding to OSNR.

Power	OSNR	BER
-38	14.57	0.00650559
-36	15.86	0.00252916
-34	17.14	0.00027799
-32	19	0.00061572
-30	19.91	0.00027027
-28	19.81	0.00016926
-26	21.19	0.00026674
-24	20.73	0.00022955
-22	22.44	0.00015551
-20	22.77	0.00016501
-18	23.03	0.00014559
-16	23.19	0.00014576

Table 1. Values of OSNR and BER

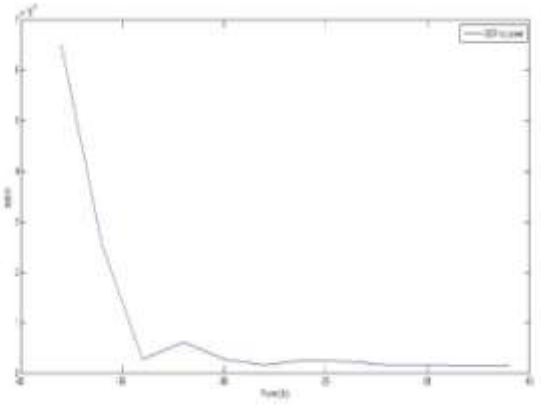

Fig 7. Power vs BER

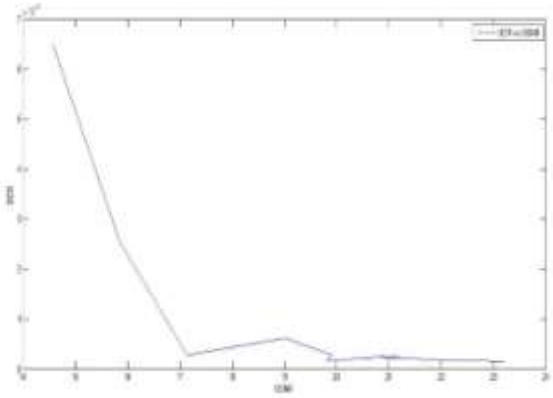

Fig.8. BER vs OSNR

5. Result & Conclusion

Results so obtained through the experiment are given as

S.No.	Fiber length	No of Bits transmitted	Error Bits	Bit Error rate
1	1m	600	13	0.217
2	3m	600	17	0.283

Table 2. Results obtained through experiment and calculations

BER monitoring based on Electronic post processing has been proposed. Bit Error Rate is calculated for 1m and 3m fiber cable through experimental readings and formula and is found to be and respectively. Simulations has been done and Bit error rate has been varied with Receiver Power. The technique used here is cheap, accurate and economical.

6. References

[1] K. Otsuka et al, "A high-performance optical spectrum monitor with high speed measuring time for WDM optical network," in Proc. 23rd Eur. Conf.Optical Commun.(ECOC'97),pp.147–150, ,1997.

[2] S. K. Shin et al, "A novel frequency and power monitoring method for WDM network,"in Proc. Optical Fiber Commun. Conf. (OFC'98), pp. 168–170, 1998.

ISSN: 2321-8169
2807 - 2810

[3] G.R.Hilletal. at el, "A transport nlayer based on optical network elements," J. Lightw. Technol., vol.11, no. 5, pp. 667–679, May 1993.
[4] F. N. Khan et al, "OSNR monitoring for RZ-DQPSK systems using half-symbol delay-tap sampling technique," IEEE Photon. Technol. Lett., vol. 22, no. 11, pp. 823–825, Jun. 1, 2010.
[5] I.Shake at el "Optical signal quality monitoring method based on optical sampling," Electron.Lett., vol. 34, no. 22, pp. 2152–2154, Oct. 1998.
[6] J. D. Downie at el, "Performance monitoring of optical networks with synchronous and asynchronous sampling," in Proc. Optical Fiber Communication Conf. (OFC2001), vol. 3, pp. WDD50-1–WDD50-3, 2001.
[7] I.Shake at el ,"Simple measurement of eye diagram and BER usinghigh-speed asynchronous sampling," J. Lightw. Technol., vol. 22, no. 5, pp. 1296–1302, May 2004.
[8] M. Rasztovits-Wiech at el, "Bit error probability estimation algorithm for signal supervision in all-optical networks," Electron.Lett.,vol.35,no.20,pp.1754–1755,Sep.1999.
[9] R. Luis at el, "Performance monitoring in optical network using asynchronously acquired samples with non-ideal sampling systems and intersymbol interference," J. Lightw. Technol., vol. 22, no. 11, pp. 2452–2459, Nov. 2004.
[10] B. Kozicki at el , "Optical performance monitoring of phase-modulated signals using asynchronous amplitude histogram analysis," J. Lightwave Technol., vol. 26, no. 10, pp. 1353–1361, May 2008.
[11] N.Hanik at el,"Application of amplitude histograms to monitor performance of optical channels,"Electron. Lett., vol. 35, no. 3, pp. 403–404, Mar. 1999.
[12] P.A.Humblet at el, "On the bit error rate of lightwave systems with optical amplifiers," J. Lightw.Technol., vol.9,no.11,pp. 1576–1582, Nov. 1991.
[13] D. C. Kilper et al, "Optical performance monitoring." IEEE/OSA J. Lightw. Technol. 22.1, pp 294-304, 2004.
[14] Karamjit kaur et al,"An algorithm of impairment aware routing for wavelength division multiplexed optical networks", Microwave and optical tech. let. 57(7), PP 1632-1636, July 2015.