International Journal of Electrical Engineering.
ISSN 0974-2158 Volume 7, Number 1 (2014), pp. 43-51

http://www.irphouse.com

Performance Analysis of 2. 5 Gbps downlink GPON

Prof. S. Sugumaran[1], Prof. P. Arulmozhivarman[2],
M. S. R. Praneeth[3], P. Saikumar[4], Prof. A. Jabeena[5]

[1, 2, 5]Faculty (SENSE), VIT University, Vellore, [3, 4] B. Tech (ECE),

Abstract

In this paper we discuss the performance of a Giga byte Passive Optical Network (GPON) for different wavelengths and power in a system having multiple users. The main characteristics is the use of passive splitters in the fibre distribution network, enabling one single feeding fibre from the provider's central office to serve multiple homes and small businesses. GPON architecture offers converged data and voice services at speeds upto 2. 5 Gbps. The quality of performance of a digital communication system is specified by its BER or Q factor.

Index Terms – BER, DBA, Eye diagram, GPON, Q-factor.

I. INTRODUCTION

A passive optical network (PON) technology was available since the mid 90s. It is a network architecture that brings fibre cabling and signals to the home using a point-to-multipoint scheme that enables a single optical fibre to serve multiple premises. Passive Optical Network (PON) has no active components between Central Office and customer. Passive equipment has no electrical power needs, it guides the traffic signals contained within specific optical wavelengths. Voice, video and data traffic flows (triple play) can be easily implemented using different wavelengths. GPON has a downstream capacity of 2. 488 gbps and upstream capacity of 1. 244 Gb/s that is shared among user. The passive optical network technology is based on passive star fibre network and offers a cost effective optical access solution. Although there are other technologies that could provide fibre to the home, passive optical networks (PONs) like GPON are generally considered the strongest candidate for widespread deployments.

The main components of PON architecture includes optical line terminal (OLT), optical network unit (ONU) and passive optical splitters, in which splitters are the main characteristics in the fibre distribution network it also has a maximum split ratio of 1:128. A typical deployed split factor is 1:32, a result of trade-off between the distance from the home and the splitter and the number of homes passed. GPON has a protocol that enables the line terminal to overlap the idle time slot in each packet transmission with the virtual polling cycle to increase the effective bandwidth. It uses time division multiplexing to sent data packets on to the network and the total bandwidth is shared using dynamic bandwidth allocation (DBA) protocol. Two types of multiplexing are possible wavelength division multiplexing and time division multiplexing. With wavelength division multiplexing used in downstream each customer transmits their signal unique wavelength. With TDM, the customer takes turns transmitting information. TDM equipment has been on the market the longest [4].

In this paper, we endeavour to study the downlink part alone. We present the transmission performance of a downlink GPON network with a bit rate of 2. 5 Gbps.

II. GPON ARCHITECTURE

Active transmission equipments consist of optical line terminal (OLT), optical network unit (ONU). The data is transmitted from the central office to a single optical fibre which runs from the central office to the optical splitters. This splitter then divides the power into N separate paths that goes to different subscribers. The number of splitting paths can vary from 2 to 64. The optical fibre transmission span from the central office to each subscriber can be up to 20km. The below diagram shows the basic network structure of GPON.

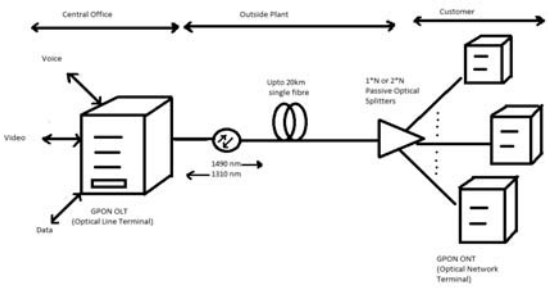

Fig1. Typical GPON architecture

GPON standard defines a lot of different line transmission rates for downstream and upstream direction.

TABLE I NORMAL BIT RATES

Transmission direction	Bit rates
Upstream	155. 52Mb/s
	622. 08Mb/s
	1244. 8Mb/s
	2488. 32Mb/s
Downstream	1244. 16Mb/s
	2488. 32Mb/s

III. FEATURES OF GPON

Bit rate Error

Bit rate error is defined as the number of bit errors is the number of received bits of a data stream over a communication channel that has been altered due to noise, interference, and distortion or bit synchronization errors. The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure, often expressed as a percentage. The curve given in this figure is usually referred as performance curve or BER curve of a conventional optical transmission system with high intensity modulation and direct detection [2].

Q Factor

The quality factor or Q factor is a dimensionless parameter that describes how under damped the oscillations are. Higher Q factor indicates lower rate of energy loss.

Eye diagram

Eye patterns are a widely used tool for studying the quality and stability of optical communication systems. The quality of the signals can be judged from the appearance of the eye. It is an experimental tool for the evaluation of the combined effects of channel noise and inter symbol interference on the performance of a baseband pulse-transmission system. It is the synchronised superposition of all possible realisations of the signal of interest viewed within a particular signalling interval.

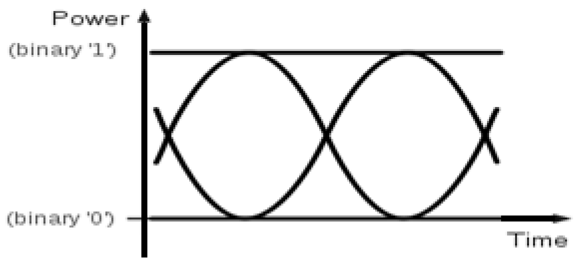

Fig. 2 Eye diagram

Dynamic Bandwidth Allocation

Dynamic Bandwidth Allocation (DBA) is a technique by which traffic bandwidth in a shared telecommunication medium can be allocated on demand and fairly between different users of that bandwidth. Dynamic bandwidth allocation takes advantage of several attributes of shared networks:

1. All users are typically not connected to the network at one time.
2. Even when connected, users are not transmitting data (or voice or video) at all times.
3. Most traffic occurs in bursts -- there are gaps between packets of information that can be filled with other user traffic.

DBA improves the efficiency of the PON upstream bandwidth by dynamically adjusting the bandwidth among the ONUs in response to ONU burst traffic requirement also network operators can add more end subscribers for a given PON due to the more efficient utilization. The end subscriber can enjoy enhanced services, such as those bandwidth peaks beyond the traditional fixed allocation. Fundamentally, DBA algorithms are based on two kinds of information: Status Reporting and Non Status Reporting.

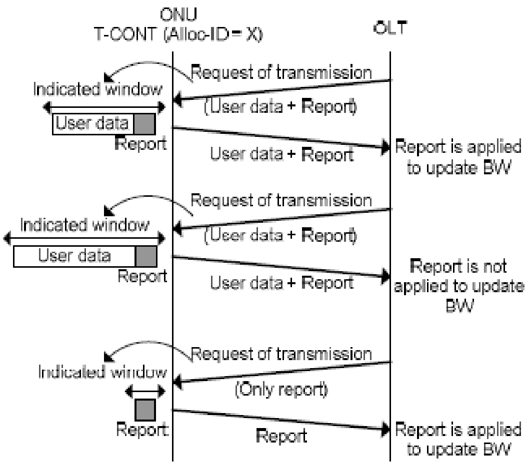

Fig. 3 DBA process

DBA service requires traffic containers (T-cont) that carry traffic flow / connections and are used for the management of upstream bandwidth allocation in the PON section of the Transmission Convergence layer. T-CONTs are primarily used to improve the bandwidth utilization in PON section [3]-[7].

IV SIMULATION DESIGN

Simulation model of GPON downstream optisystem is shown in the figure below which has 4 users on the left side, where the transmitter part is located.

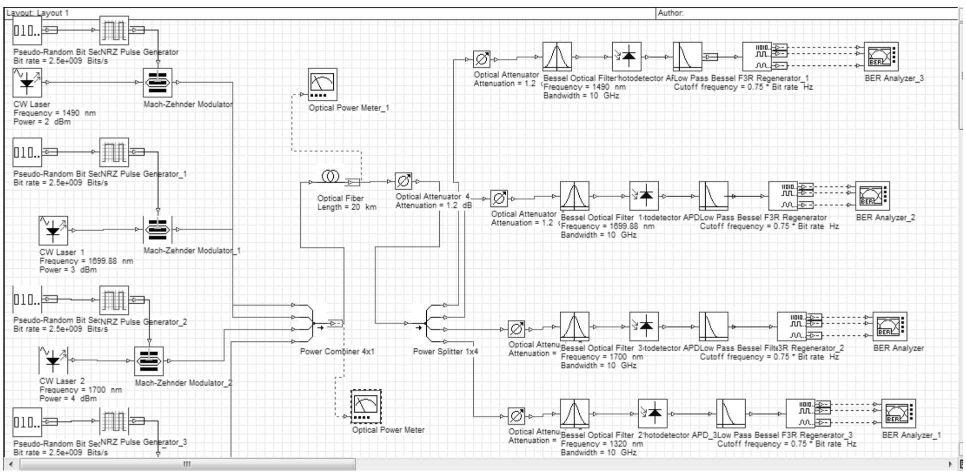

Fig. 4 Simulation model in optisystem

The left side of the model contains pseudo random bit sequence, NRZ pulse generator, CW laser, Mach-zehnder modulator, optical power meter and a power combiner which connects to the optical fibre having attenuation 1. 2dB/km. The right side of the model contains optical attenuator with the attenuation 1. 2dB which is connected to the power splitter that splits into 4 parts. The simulation is done for different source powers and wavelengths. The wavelength varies from (1480-1500 nm) and (1535-1565nm). The mean launched power should range from (1. 5-5) dBm [1]-[5].

TABLE II RESULTS FOR DIFFERENT PARAMETERS

Power (dBm)	Wavelength (nm)	Maximum Q factor	Minimum Bit Error Rate
10	1400	131. 013	0
3. 5	1381	56. 2345	0
7	1500	113. 398	0
6	1560	87. 2655	0

Following figures shows the eye diagram for various wavelengths

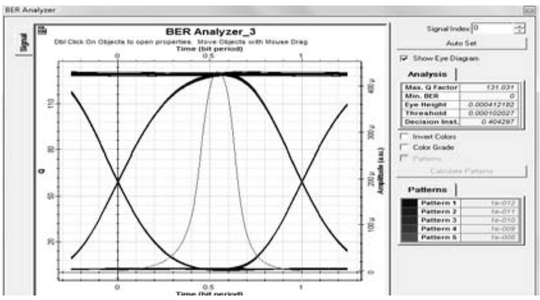

Fig. 5 (a) Eye Diagram For 1400nm

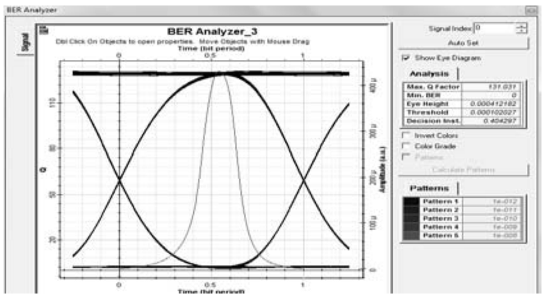

Fig. 5 (b) Maximum Q Factor

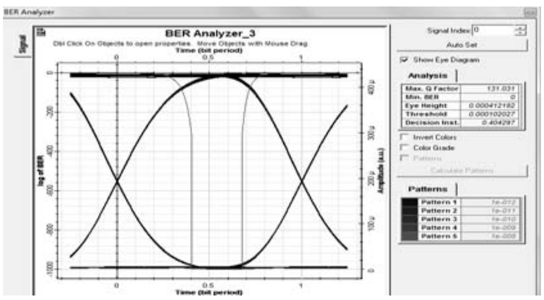

Fig. 5 (c) Minimum BER

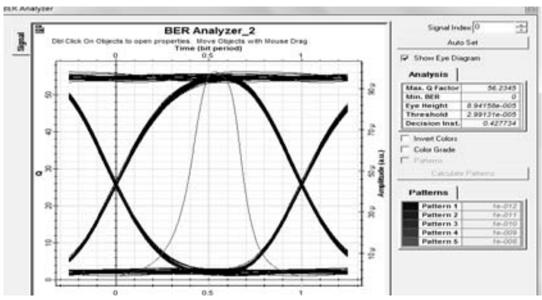

Fig. 7 (a) Eye Diagram for 1381nm

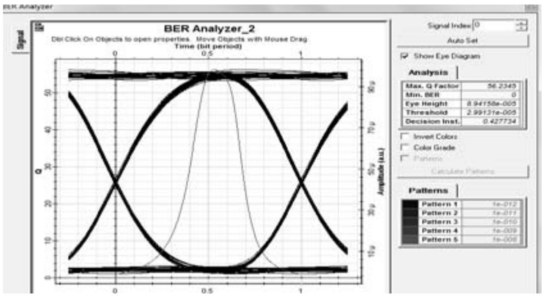

Fig. 7 (b) Maximum Q Factor for 1381nm

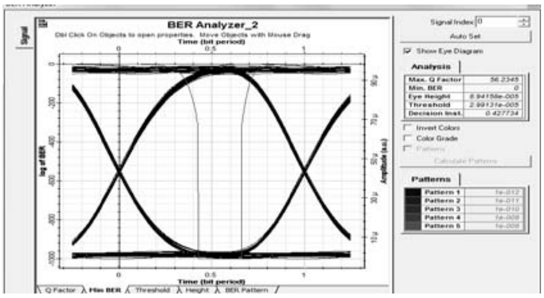

Fig. 7 (c) Minimum BER for 1381nm

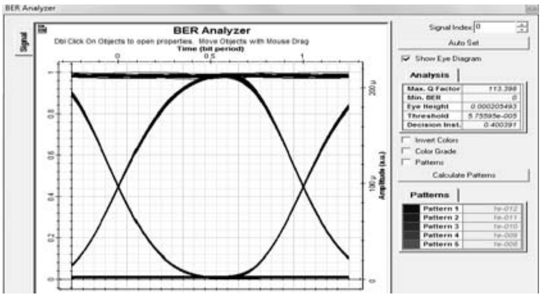

Fig. 8 (a) Eye Diagram for 1500nm

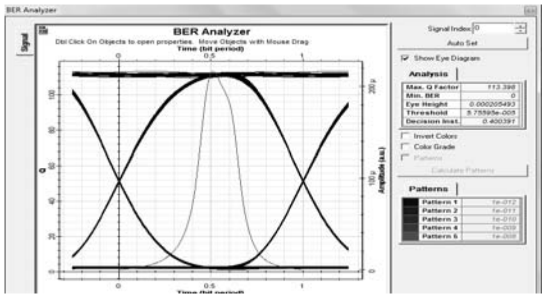

Fig. 8 (b) Maximum Q Factor for 1500nm

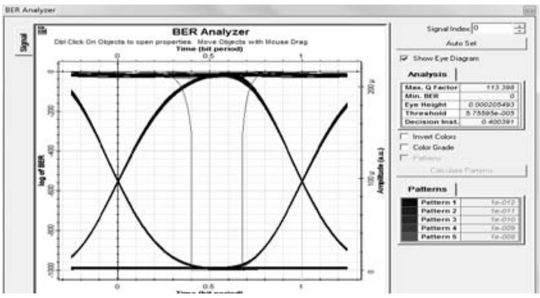

Fig. 8 (c) Minimum BER for 1500nm

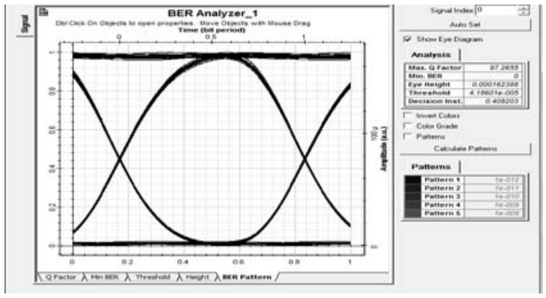

Fig. 9 (a) Eye Diagram for 1560nm

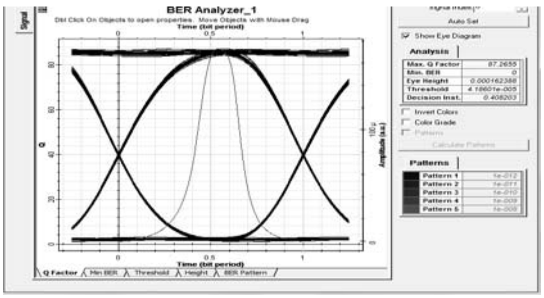

Fig. 9 (b) Maximum Q Factor for 1560nm

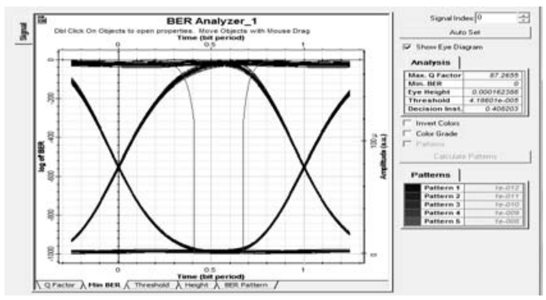

Fig. 9 (c) Minimum BER for 1560nm

For the above cases the mean optical power at the transmitter is 4. 104 dBm and on the receiver is 0. 104 dBm.

By changing the parameters such as power and wavelength on the transmitter side of the network we calculate more results.

TABLE III RESULTS FOR DIFFERENT PARAMETERS

Power (dB)	**Wavelength (nm)**	**Maximum Q factor**	**Minimum. Bit Error Ratio**
5	1492	80. 0687	0
8	1535	108. 189	0
7	1600	102. 287	0
3	1700	3. 77423	7. 6801e-005

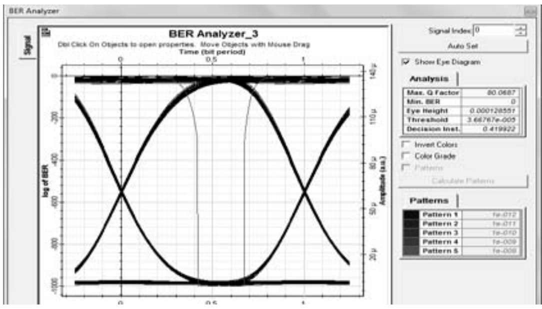

Fig. 10 Eye Diagram for 1492nm

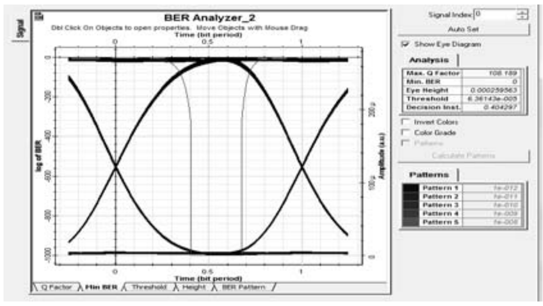

Fig. 11 Eye Diagram for 1535nm

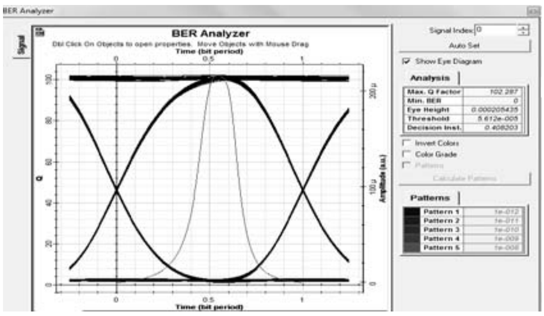

Fig. 12 Eye Diagram for 1600nm

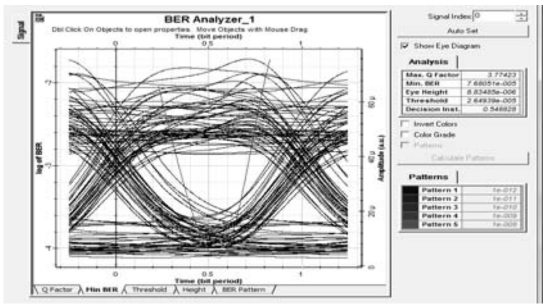

Fig. 13 Eye Diagram for 1700nm

From the above case we see that the mean optical power at the transmitter is 3. 003 dBm and on the receiver is -1. 103 dBm.

TABLE IV RESULTS FOR PARAMETERS

Power (dBm)	**Wavelength (nm)**	**Maximum Q factor**	**Minimum Bit Error Rate**
7. 5	1545	119. 751	0
4	1360	62. 209	0
8	1550	126. 629	0
6	1495	92. 2821	0

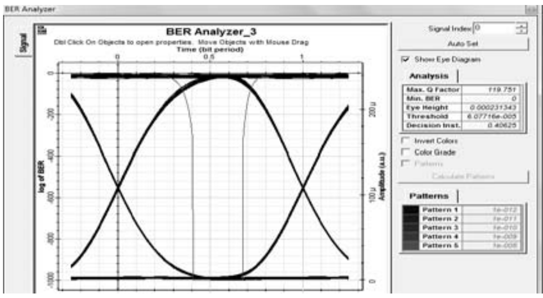

Fig. 14 Eye Diagram for 1545nm

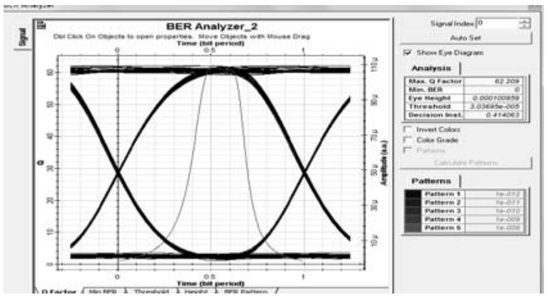

Fig. 15 Eye Diagram for 1360nm

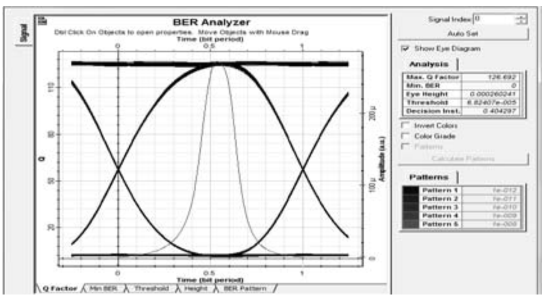

Fig. 16 Eye Diagram for 1550nm

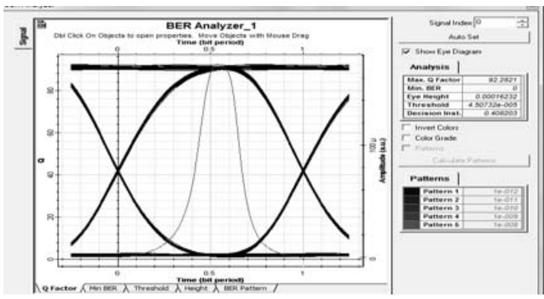

Fig. 17 Eye Diagram for 1495nm

For this case the mean optical power in transmission is 3. 488dBm and on receiver it is -0. 512 dBm.

V CONCLUSION

From table 2, range of wavelength is (1381-1560) nm in which Q factor for wavelength 1381 nm is lowest since the corresponding power is less and for 1400 nm is highest as the power is more and the eye diagram has maximum opening thus very less noise or disturbance is present for this wavelength.

From table 3, range of wavelength is (1492-1700) nm in which the Q factor is lowest for 1700 nm as it lies outside the range and also power corresponding to it is less. The eye diagram shows a lot of jitter as compared to rest of the cases. Highest Q factor is for 1535 nm, this is because the power is more and it lies in the range of wavelength of GPON.

As seen from table 4, wavelength ranges from (1360-1550) nm we found that the wavelength 1550 nm has maximum Q factor which indicates lower rate of energy loss and for wavelength 1360 nm has the lowest Q factor also from the eye diagram it is clear that jitter is more compared to other wavelengths.

Thus, from the different cases we see that as the power decreases the Q factor also decreases and there will be a noise when working on wavelengths that are below 1480nm between (1500-1535nm) and above 1565nm. Also from all the cases discussed here we get maximum Q factor for 1550 nm wavelength (RF video) and will have much less rate of energy loss.

ACKNOWLEDGEMENT

We would like to thank Dr. G. Ramachandra Reddy, Dean, SENSE, for their kind guidance and support in the compilation of this paper.

REFERNCES

[1] Mr. Vikas Shrivastav, MTech IV sem (D. C), SSSIST Sehore, Prof. Mukesh Tiwari, Dean Academic, SSSIST Sehore, Prof Jai Karan Singh, HOD EC, SSSIST Sehore, Prof Sanjay Rathor, SSSIST Sehore "SIMULATION OF 2GB/S DOWNSTREAM TRANSMISSION PERFORMANCE OF GPON" from IJATER 6 NOV 2012.

[2] Hesham A. Bakarman, Sahbudin Shaari, Member, IEEE, and Mahamod Ismail, Member, IEEE "Simulation of 1. 25 Gbps Downstream Transmission Performance of GPON-FTTx", 2010

[3] Wenjia Wang, Didi Ivancovsky, Walt Soto, Tony Anderson Anh Ly, Ron Rundquist "DBA (Dynamic Bandwidth Allocation) Overview", October 2001.

[4] S. Rajalakshmil[1], Ankit Srivastava[2], Ashish Pandey[3] Assistant Professor (Senior), School of Electronics Engineering, "Performance Analysis of Receivers in WDM for Extended Reach Passive Optical Networks", from IJCSI, 3 March 2012.

[5] ITU-T Recommendation G. 984. 1, "General characteristics for Giga bit capable Passive Optical Networks" 2003.

[6] McGarry MP, Maier M, Reisslein M. Ethernet PONs: a survey of dynamic bandwidth allocation (DBA) algorithms. IEEE Communications Magazine 2004; 42:S8–S15

[7] Ivica Cale, Aida Salihovic, Matija Ivekovic "Gigabit Passive Optical Network – GPON" Proceedings of the ITI 2007 29th Int. Conf. on Information Technology Interfaces, June 25-28, 2007