Hybrid CATV/GPON system integration based on Bit Error Rate (BER) Performance Evaluation with 1.31/1.49/1.55 pm WDM transceiver module

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Abstract - In this article three wavelengths WDM transceiver module with a pigtail fiber designed for GPON and Cable TV specifications working integrally are described whereas the BER (phenomenon of physical layer) performance evaluation of the network line are applied which brings god optimum result for the necessary signal communication. The discussion about Cable TV/ GPON integration system is addressed on duplex transmission measurement of gigabit-capable data and multi-channel video signal.

Key Words: Cable TV, GPON, BER, WDM, Central Office (CO)

1. INTRODUCTION

Gigabit-capable Passive Optical Network (GPON) is the most useful technology as broadband access network because of unlimited bandwidth characteristic having the capability to exploit for high rate data communication used for video signal. Various advantages of GPON like low infrastructure deploying cost, bandwidth efficiency utilization and network service extended capability of GPON make it the automatic choice for the area of application in the field like cable TV. This kind of application meets a transmission distance of 20 km with complete Fiber to the Curb (FTTC), Fiber to the Building (FTTB) or Fiber to the Home (FTTH) technology. GPON optical network unit (ONU) transceiver used to works on burst mode transmission with ability for upstream data processing and it combines Cable TV applications by Ethernet Internet Protocol data networking for downstream data communication. This article shows the three wavelengths WDM transceiver module and verifies data and video transmission character with current standard specification [1] [2]. Our present work mostly deals with the evaluation of BER performance of PON system which connects different Remote Nodes (RNs) at various distances [4]. BER is a phenomenon of the physical layer. So BER performance analysis is also one type of physical layer performance analysis. The lower BER values determine better communication through the channel. BER figure also dependent on the received power levels communicated from different distances. A significant interplay is observed during our work between the transmitting power and distance variation of the Optical Network Units (ONU) while examining the loss and BER characteristics of a given Wavelength Division Multiplexed Passive Optical Network (WDMPON) [5, 6]. In order to maximize the fiber capacity, full-duplex bidirectional transmission of 1.31/ 1.49/ 1.55 µm WDM signals modulated at around 1.25 Gb/s are employed for GPON with multi channel video transmission system. In this paper presents a standard beforehand three wavelengths WDM transceiver module and related parameters especially burst mode items.

2. GPON TRANS-RECEIVER MODULE SETUP

PON's are major focus of attraction due to the capacity to deliver high bandwidth data directly to the home. Fig. 1 show the typical point-to-multipoint structure of a PON [3] that provides a dedicated fiber strand between each subscriber and the central office (CO). In shared fiber architecture, a single optical fiber from the CO serves several dozen subscribers. Perhaps signal rate and format transparency are the most interesting features of a PON based access network. PON based system are very easy to upgrade from lower bit rate to higher bit rate, than other access technology systems.

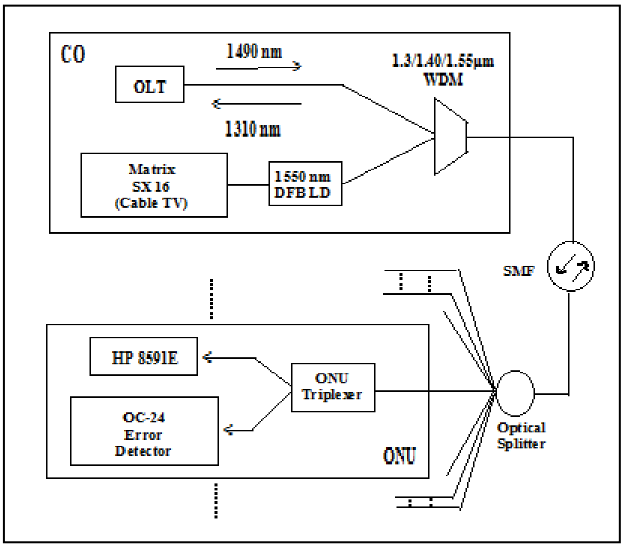


Figure 1. The GPON Trans- receiver module setup for measurement

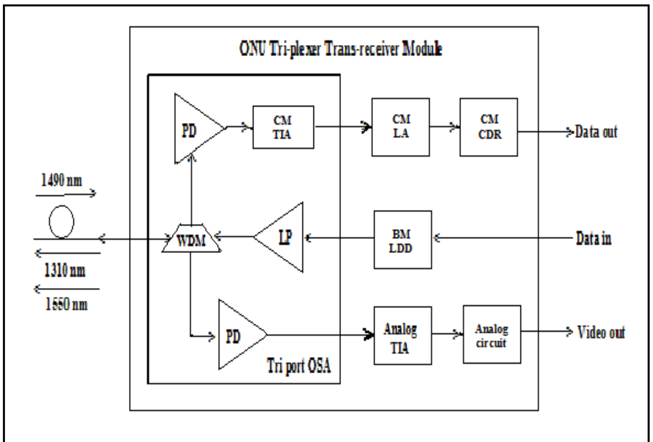
In this paper, we also deploy the three wavelengths WDM transceiver module as GPON ONU triplexer transceiver module. The transceiver module package outline and footprint are based on the industry standard 2 * 10 Pin-Through-Hole (PTH) and 75 ohm SMB connector. The transceiver module

that consists a burst mode optical transmitter, continuous mode optical receiver, and optical CATV receiver with a SMB output. The 1.31 km wavelength light is used for transmitting the signals from user's homes to a central office

(CO). On the other hand, the analog (graphic/video) and digital (voice/data) signals are transmitted from the CO to the user's homes with 1.55 pm and 1.49 pm light respectively. The optical transport networks make use of wavelength- division multiplexing (WDM) technology.

The use of different types of splitters (splitters having different split ratio) and erbium doped fiber amplifiers (EDFAs) enables long-reach PON to provide enormous bandwidth over large distance [8, 9], but this may also deteriorate receivers bit error rate (BER) performance. By the way, upstream power penalty due to branches and simultaneously transmission of the on/off performance challenges light source and driving technique. BER performance of any optical receiver depends on parameters like noise variances for transmitting binary "0" and binary "1" which is further depends on several noise factors like signal-to-crosstalk beat noise variance crosstalk- to-crosstalk beat noise variance, crosstalk variance due to adjacent channels. Considering all this noise factors, standard deviation for beat "0" and beat"1" may be calculated which helps to deduce the threshold (Ith) for detecting binary "0" and binary "1" at the receiver end. Finally based on all the calculations value of BER for any receiver of optical signal, is possible to calculate where the received power by the receiver or the transmitted power from the transmitter is known including the distance between transmitter and receiver.

To achieve all criteria, the GPON ONU triplexer transceiver module consists of a bidirectional tri-port optical subassembly (OSA), a burst mode laser diode driver (LDD), a continues mode limiting amplifier (LA), a continues mode clock data recover (CDR), a system burst mode control mechanisms, an analog trans-impedance amplifier (TIA) and an analog circuits all compact integrated as illustration in Fig. 2.



CDR: Check and Data recovery LA: Limiting Amp.
CM: Continue Mode control LD: Laser Diode
LDD: Laser Diode Driver PD: Photo Diode
BM: Burst Mode control; TIA: Trans-impedance Amp.

Figure 2. Functional block of the GPON ONU tri-plexer Trans- receiver module setup.

3. EXPERIMENTAL RESULTS AND DISCUSSION

PON system consists with the optical line terminal (OLT) at the CO, distribution fiber, optical distribution network (ODN) and an ONU at the subscriber's premises. The maximum range of the network lies from 20 km and 64 physical ONU's can be supported by deployment of the optical splitter. Communication from the CO towards the subscribers is entitled as downstream traffic, the opposite direction is called as upstream traffic and both direction communications are possible using Time Division Multiple Access (TDMA) transmit signals towards CO at a wavelength of 1310 rim. In PON system specific time slots are allocated for the transmission and reception of data by a subscriber. A Cable TV having an extra downstream channel in the 1550-1560 rim range is possible to be used to bring high capacity video services towards the customers. In between two data burst, the ONU transmitting power (Tx) must keep silent and may not launch any optical power into the channel and avoid disturbing signals transmitted by other ONU's. To balance the BER among ONUs and to reduce the variance the BER performance of the channel need to be calculated and applied in the system [11]

In order to keep the upstream transmission efficiency high, the ONU Tx must be able to switch on/off the laser within a few nanosecond or bits preceding the upstream data [4]. In other words, the transmitter in the upstream direction must turn on/off quickly enough to be equal to the burst envelope signal. Here, the main problem is the ability of laser driver's that can drive the laser up to the bias level in a sufficient duration. Fig. 3 shows the burst envelope signal (upper pattern sequence in the figure) that enables the bias level (lower pattern sequence in the figure) is applied to enable the driver to test the transmitter actual T_N timing. The turn on and turn off of the burst are shown in Fig. 3.

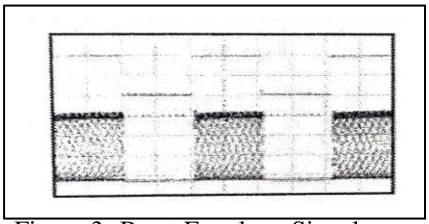


Figure 3: Burst Envelope Signal.

Now the BER calculation needs to be carried for each ONU to CO connection path. So here BER performance for upstream direction data flow is computed for different distance with different transmitting power vs BER (as sample). The results are:

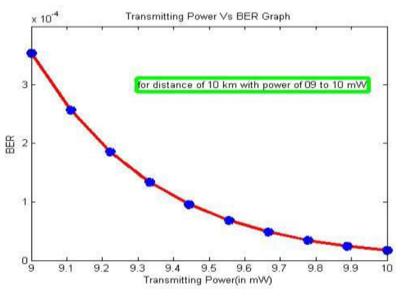


Figure 4(a): For 10 km distance with 09 to 10 mw transmitting power.

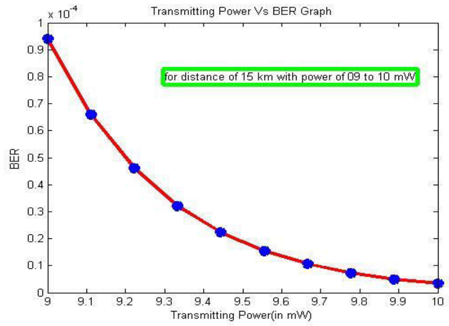


Figure 4(b)**:** For 15 km distance with 09 to 10 mw transmitting power.

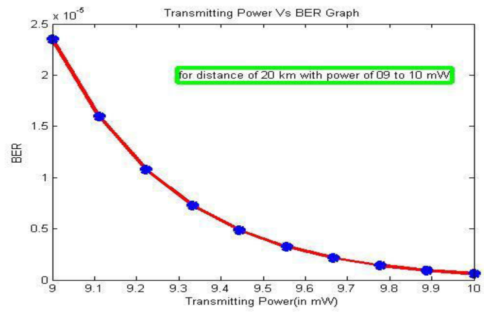


Figure 4(c)**:** For 20 km distance with 09 to 10 mw transmitting power.

From the Fig. 4(a,b,c) it is clear that the BER value ranges between 1X 10^{-4} to 4X 10^{-4}. which is good for communication. Based on the analysis result, the delay of modulation signal needed to be as long as 16-bits in 1.25 Gb/s (12.8 ns) to let the transmitter turn on fully. In addition, the transmitter just needs 16-bits time in 1.25 Gb/s (12.8 ns) to turn off completely. The bias level is reached within 12 pre-bias bits (9.6 ns).The disabling of the bias takes about 10 ns. The maximum allowed enabling and disabling time of the transmitter are specified in ITU-T G.984.2 as 16 bits each at 1.25 Gb/s [1]. The measured results in the system are as follows: Table 1. The sensitivity of the receiver was -25 dBm.

Table – 1: Specifications of GPON ONU trans-receiver module

Parameter	Unit	OES	Specifications Reference [1]
Bit Rate (Upstream and Downstream)	**Gb/s**	**1.25/ 1.25**	**1.25/ 1.25**
Transmission Distance	**km**	**20**	**20**
Minimum Extintion Ratio	**dB**	**>10**	**10**
Burst Transmission turn ON/ OFF time	**ns**	**<12/12**	**12.8/ 12.8**
Bit error ratio	**N/A**	**10^{-12}**	**10^{-12}**
Minimum sensitivity	**dBm**	**-25 (Typ)**	**-25**
Minimum overload	**dBm**	**-2 (Typ)**	**-4**
CSO/ CTB/ CNR	**dB**	**60/63/48**	**53/53/43**

In Fig. 1, a NTSC Matrix SX-16 signal generator was used to feed 80 subcarriers into a directly modulated Tee-bias transmitter with a central wavelength of 1550 rim and an optical modulation index (OMI) of ~3.5 % per channel. Fig. 4 shows the measured CNR, CSO and CTB values for AM-VSB Cable TV under NTSC channel number (CH2 CH75).

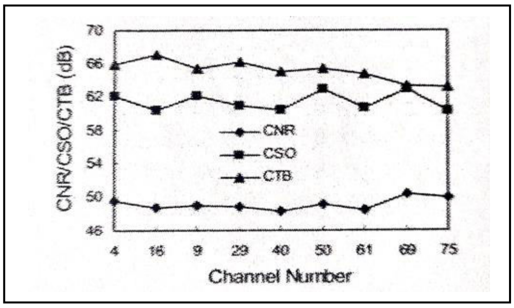


Figure 4**:** CNR, CSO, CTB values of cable TV.

The CNR values of 48 dB for the system can satisfy the fiber optical CATV specifications, it can be attributed to the appropriate received optical power at the receiver site. For the better performance of the AM-VSB optical receiver, the received optical power need to be kept (-3 ~ +3) dBm, whereas the received optical power for the analog optical receiver is -1.3 dBm. As to CSO and CTB performs the CSO values (≥63 dB) for the system also can satisfy the fiber optical cable TV specification.

4. CONCLUSION

In conclusion this can be stated that the three wavelength module for GPON and cable TV applications including the systemic evaluation on burst mode data transmission in PON network is practicable where the BER performance evaluation is necessary during the application. With verification of the BER performance of the communication line the video signal or the three wavelength hybrid WDM transport system with cable TV and GPON video and digital applications can be demonstrated with excellent performance. Low BER value < **10^{-9}** can be achieved during the hybrid mode operation of cable TV/ GPON integrated system.

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REFERENCES

1. ITU-T G.984.2 Class B "Gigabit-capable passive optical networks (GPON): Physical media dependent (PMD) layer specification, "March, (2003).
2. J. A. Chiddix, H. Laor, D. M. Pangrac, L. D. Williamson, and R. W. Wolfe, "AM video on fiber CATV systems: need and implementation," IEEE J. Select. Areas in Communication. 8, 1229-1239 (1990).
3. G. Kramer, and G. Pesavento, "Ethernet passive optical network: Building a next-generation optical access network," IEEE Communication Magazine, 40, 66-73 (2002).
4. J. Segarra, and J. Prat, "Optical Burst Switched Passive Access Network," ICTON, Mo. D2.6, 162-165 (2003).

5. S. Mandal, S. Reddy, G. Das, and D. Datta, "Transmission Impairments in Long-Reach WDM- PON using RSOA-based ONUs", *Photonic Network Communications*, vol. 30, pp.321-323, 2016.
6. A. Banerjee et. al, "Wavelength-division-multiplexed passive optical network (WDM-PON) technologies for broadband access: a review", *Journal of Optical Networking,* vol. 4, pp. 737–758, 2005.
7. T. Koonen, "Fiber to the home/fiber to the premises:what, where, and when?",*Proc. IEEE*, vol. 94, pp. 911–934, 2006.
8. L. G. Kazovsky, W. T. Shaw, D. Gutierrez, N. Cheng, and S. W. Wong, "Next-generation optical access networks", *Journal of light-wave technology*, vol. 25, pp. 3428–3442, 2007.
9. H. Song, B. W. Kim, and B. Mukherjee, "Long-reach optical access networks: a survey of research challenges, demonstrations and bandwidth assignment mechanisms", *IEEE communications surveys & tutorials*, vol.12, pp. 112–123, 2010.
10. P. M. Hubel, J. Liu, and R. J. Guttosch, "Spatial Frequency Response of Color Image Sensors: Bayer Color Filters and Foveon X3", *Proc. SPIE*,vol. 5301, pp. 402-407, 2004
11. S. K. Biswas, M. Chakraborty "Passive Optical Network Design with application of Path Minimization Planning and Novel Wavelength Allocation scheme based on Bit Error Rate (BER) Performance," International Journal of Engineering Research and Application, ISSN: 2248-9622, Vol. 10, Issue 10, (Series-IV) October 2020, pp. 08-14 (2020).

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