



## Performance Analysis of Hybrid WDM-TDM Passive Optical Network with Different Bit Rates

**Ramandeep Sharma**

M.Tech. student Department of ECE,  
Shaheed Bhagat Singh State Technical Campus,  
Ferozepur, Punjab, India

**Sanjeev Dewra**

Associate Professor,  
Shaheed Bhagat Singh State Technical Campus,  
Ferozepur, Punjab, India

---

**Abstract-** *This paper presents an investigation on the performance of Hybrid WDM-TDM PON in the scenario of triple play services with 128 ONUs. The performance has been compared at different distances and has been evaluated on the basis of Q factor and BER. In triple play service: data, voice and video signals are transmitted up to 60 km having Q factor of 6.4 and BER of  $8.8 \times 10^{-10}$  at 2.5 Gbps. It is observed that maximum transmission distance of 50 km and 40 km is achieved at bit rate of 5 Gbps and 7.5 Gbps with acceptable Q factor (6.25) and BER ( $1.5 \times 10^{-9}$ ) respectively.*

**Keywords-** *CDMA (code division multiple access), SCMA (subcarrier multiple access), NRZ (non return to zero), Q factor, GPON*

---

### I. INTRODUCTION

A passive optical network is one of the various FTTH implementations that have become a good solution for access networks because of point to multipoint architecture [1]. Ethernet passive optical network (EPON) and Gigabit passive optical network (GPON) standards are based on the time division multiplexing (TDM-PON) which has its limitation. Therefore mixing the TDM-PON with WDM-PON capabilities can overcome these problems [2]. Furthermore, other wavelength division multiplex hybrid schemes based on added subcarrier multiple access or code division multiple access from today's point of view do not seem to offer advantage over the hybrid WDM-TDM PON [3]. Various techniques and component of the network are designed to achieve high data rate transmission to large bandwidth such as tunable optical add/drop multiplex [4], colorless ONU [5], self-homodyne and differential coding [6], a reflective semiconductor optical amplifier (SOA) [7], and Bragg reflectors [8]. Triple play service is believed to be a promising business models for the network [9]. DWDM is an important improvement in optical network [10] and provides very high-capacity networks required by our communication society. DWDM is known for its impressive increase in transmission ability and flexibility in optical networking [11]. In literature, different works on hybrid (WDM-TDM) PON have been done for high capacity PON with triple play services. Kocher et.al. [12] evaluated and compared the PON architecture at 2 Gbps bit rate up to distance 20 km with 56 subscribers. Malhotra et.al. [13] investigated the performance of high capacity and 32 channels FTTH for downstream link. P.J.Urban et.al [4] considering two channels to transmit signal up to a distance of 26 km at 1.25 Gbps bit rate. Su Hwan oh et.al. [8] Evaluated the WDM-PON design at 20 km distance with 25 wavelength channels are transmitted. Rakesh Goyal et.al [12] analyzed the performance of hybrid (TDM-WDM) PON with 128 ONUs at 1.25 Gbps up to distance 28 km.

Till now, the proposed PON were limited with lesser data rates 1.25 Gbps and covered lesser transmission distance up to 28 km.

In this paper previous work has been extended by investigating the proposed hybrid WDM-TDM PON with bit rate at 2.5 Gbps over maximum reachable distance up to 60 km.

### II. SYSTEM SETUP

Hybrid (WDM -TDM) passive optical network uses four wavelengths in downstream direction as shown in fig.1. In this simulation setup each group of users share one wavelength in time domain. The triple services: data, voice and video are transmitted simultaneously and received at 128 numbers of users. The communication through the optical fiber path employs the dense wavelength division multiplexing technique. As shown in fig.2 PRBS generator are used to generate different data rate such as 2.5 Gbit/s, 5 Gbit/s, and 7.5 Gbit/s as downstream traffic data and is directly fed to the NRZ electrical driver which convert bits stream into electrical pulses, now the output of electrical driver is goes to the direct modulator laser and finally get amplified. Then data and video signals are combined. For video, there is two sine wave generator having different frequencies and goes to the input of the summer mixes the frequencies and finally goes to direct modulator laser and then amplifier amplifies the signals

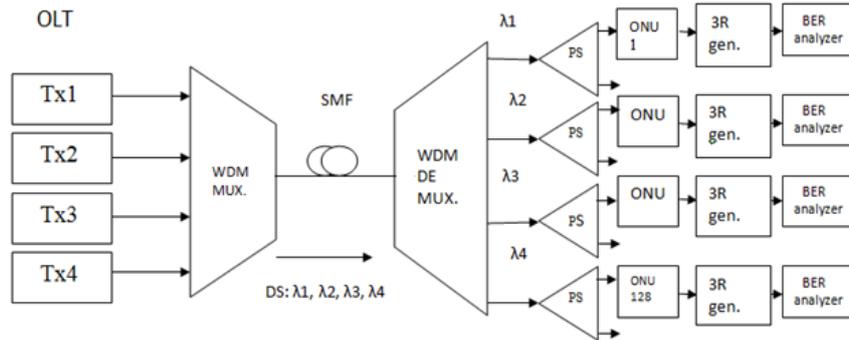


Fig.1 Architecture of Hybrid WDM- TDM PON

The video signal is transmitted within 1550-1560 nm range with 0.5 channel spacing. The output of both amplifier are fed into multiplexer, both video and data/voice signals combines and transfer on optical fiber.

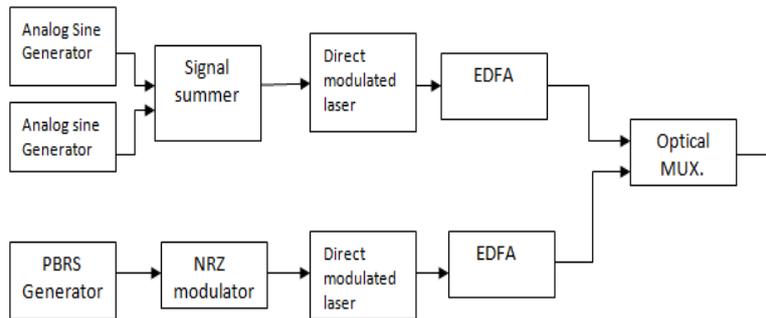


Fig.2 Internal architecture of transmitter

These signals are received at each ONUs by different time delay. At ONUs these signals are demultiplexed into video signal and data /voice signal centre wavelength is set for desire service. The analyzers estimate the Q factor and BER values for the signals. The Q factor is equal to the ratio of resonant frequency to the bandwidth of cavity resonance. To visualize optical spectrum, waveforms, eye diagram with various values, different analyzers are to be used liked BER analyzer, optical spectrum analyzer etc. The Q factor and BER values are also observed to verify the results.

### III. RESULTS AND DISCUSSION

In hybrid (WDM-TDM) PON the Q factor and BER observed by changing the transmission distance.

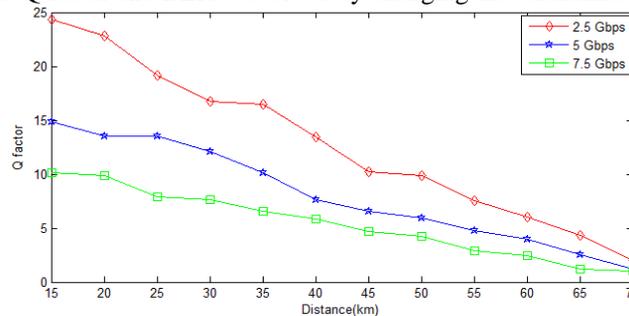


Fig 3 Q-factor versus distance (km) with downstream wavelength 1490 nm

In order to observe the performanc of different bit rate, Q factor versus distance graphs are shown in Fig.3. It is evident that as the transmission increase, the value of Q factor decreases. It is observed that acceptable Q factor of 6.40 is shown from hybrid PON with bit rate 2.5 Gbps at 60 km distance where as in case of 5 Gbps and 7.5 Gbps bit rate the acceptable value of Q factor 6.25 and 6.02 achieved at 50 km and 40 km respectively.

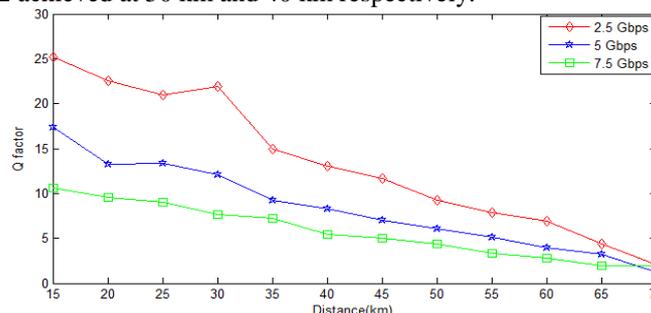


Fig. 4 Q factor versus distance (km) with downstream wavelength 1490.5 nm

Fig.4 depicts the graph between Q factor and distance. It is observed from the graph that as the transmission distance increase from 15 km to 70 km, the value of Q factor decreases. The variation of Q factor from 25 to 3 for bit rate 2.5 Gbps, 17.42 to 4 for bit rate 5 Gbps and 10.57 to 2.80 for bit rate 7.5 Gbps. It is observed that acceptable Q factor of 6.40 is shown from hybrid PON with bit rate 2.5 Gbps at 60 km distance where as in case of 5 Gbps and 7.5 Gbps bit rate the acceptable value of Q factor achieved at 50 km and 40km respectively

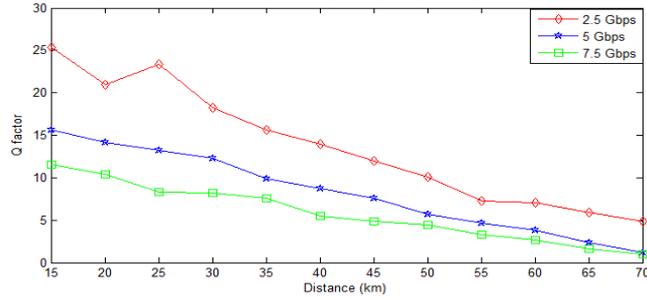


Fig. 5 Q factor versus distance (km) with wavelength 1491 nm

Fig. 5 depicts the variation of Q-factor versus distance. It is observed from the graph that as the transmission distance increase from 15 km to 70 km, the value of Q factor decreases. The variation of Q factor from 25 to 5 for bit rate 2.5 Gbps, 15 to 2 for bit rate 5 Gbps and 11.57 to 2.80 for bit rate 7.5 Gbps. It is observed that acceptable Q factor of 6 is shown from bit rate 2.5 Gbps at 60 km distance where as in case of 5 Gbps and 7.5 Gbps bit rate the acceptable value of Q factor achieved at 50 km and 40 km respectively.

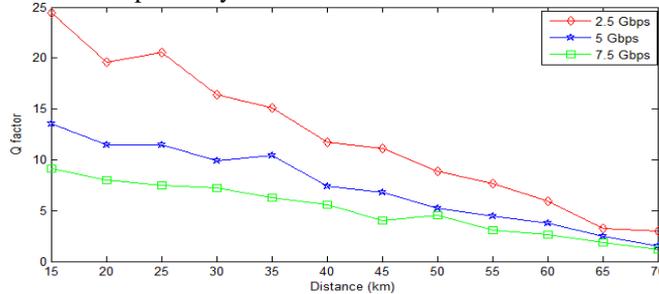


Fig. 6 Q factor versus distance (km) with downstream wavelength 1491.5 nm

Fig. 6 depicts the variation of Q-factor v/s distance. It is observed from the graph that as the transmission distance increase from 15 km to 70 km, the value of Q factor decreases. The variation of Q factor from 25 to 3 for bit rate 2.5 Gbps, 13 to 2 for bit rate 5 Gbps and 9.5 to 2.8 for bit rate 7.5 Gbps. It is observed that acceptable Q factor of 6 is shown from hybrid PON with bit rate 2.5 Gbps at 60 km distance where as in case of 5 Gbps and 7.5 Gbps bit rate the acceptable value of Q factor achieved at 50 km and 40 km respectively. If the data rate or fiber length is increases the Q factor is decreased simultaneously due to fiber non-linearity such as crosstalk, dispersion, attenuation.

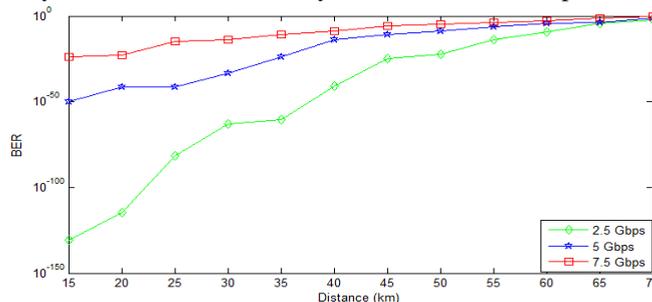


Fig.7 BER versus distance (km) with wavelength 1490 nm

Similarly for downstream transmission, the variation of BER versus transmission distance is depicts in Fig.7. The least value of BER i.e.  $8.8 \times 10^{-10}$  is obtained in hybrid PON with bit rate 2.5 Gbps (at transmission distance 60 km) as compare to bit rate 5 Gbps and 7.5 Gbps which have acceptable BER at 50 km and 40 km respectively.

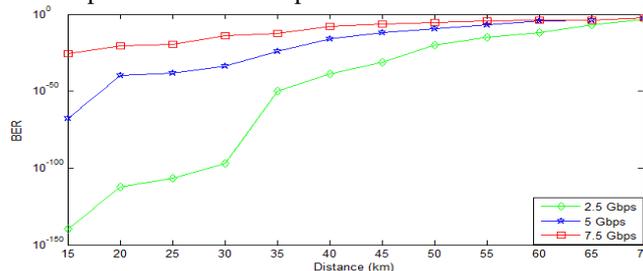


Fig.8 BER versus distance with wavelength 1490.5 nm

Fig.8 depicts the variation of BER with distance. The least value of BER i.e.  $1.7 \times 10^{-12}$  is obtained in hybrid PON with bit rate 2.5 Gbps (at transmission distance 60 km) as compare to bit rate 5 Gbps and 7.5 Gbps which have acceptable BER at 50 km and 40 km respectively.

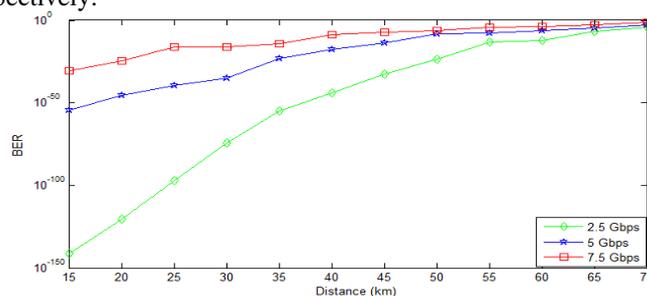


Fig.9 BER versus distance (km) with downstream wavelength 1491 nm

Fig.9 depicts the variation of BER with distance. The least value of BER i.e.  $9.6 \times 10^{-13}$  is obtained in hybrid PON with bit rate 2.5 Gbps (at transmission distance 60 km) as compared to bit rate 5 Gbps and 7.5 Gbps which have acceptable BER at 50 km and 40 km respectively.

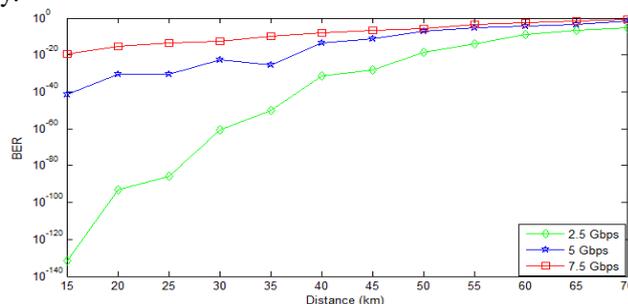


Fig. 10 BER versus distance with wavelength 1491.5 nm

Fig.10 depicts the variation of BER with distance. The least value of BER i.e.  $1.5 \times 10^{-9}$  is obtained with bit rate 2.5 Gbps (at transmission distance 60 km) as compared to bit rate of 5 Gbps and 7.5 Gbps which have acceptable BER at 50 km and 40 km respectively. Our results are in coincidence with [12] where they transmitted the signal at 1.25 Gbps over 28 km distance. Here in this paper data signal is transmitted at 2.5 Gbps bit rate per wavelength and transmission distance is increased up to 60 km. So, there is an improvement of 32 km transmission distance with higher bit rate.

#### IV. CONCLUSION

This paper evaluated the comparative performance of different bit rates on Hybrid PON with 0.5 nm channel spacing. The wavelengths kept in the range 1490-1550 nm in downstream direction and data signals is transmitted at different bit rates 2.5 Gbps, 5 Gbps and 7.5 Gbps for 128 numbers of users. It is observed that data signals transmitted with bit rate 2.5 Gbps provides acceptable Q factor of 6.40 and minimum BER of  $8.8 \times 10^{-10}$  at 60 km transmission distance and with 5 Gbps and 7.5 Gbps bit rate, data is transmitted up to a distance of 50 km and 40 km respectively. The Hybrid (WDM-TDM) PON shows better results at bit rate 2.5 Gbps than 5 Gbps and 7.5 Gbps in terms of Q factor, transmission distance.

#### REFERENCE

- [1] M.Hernández, A.Arcia, R.Alvizu, M.Huerta, "A review of XDMA-WDM-PON for next generation optical access networks", In Proceedings of the IEEE Global Information Infrastructure and Networking Symposium (GIIS),pp.1-6,2012.
- [2] M.A.Elmagzoub, Abu Baker Mohammad, Redhwan Q.Shadded, Samir.A.Al-Gailani, "Physical layer performance analysis of hybrid and stacked TDM-WDM 40G-PON for next generation PON", Optik 2014.
- [3] K.Grobe, M.Roppelt, A.Autenrieth, J.b.Elbers, M.Eiselt, "cost and energy consumption analysis of advanced WDM-PONs", IEEE Communication mag. 49(2),pp-25-32,2011.
- [4] P.J Uraban, E.G.C. Pluk,M.M.de Loat, F.M.Huijskens, G.D khoe, A.M.J.Koonen, H.de Waardt, "1.25 Gbps transmission over an access network link with tunable OADM and reflective SOA",IEEE Photonics technol. Lett.21 (6) pp- 380-382,2009.
- [5] Patryk J.Uraban, Frans M.Huijskens, G.D khoe, A.M.J.Koonen, H.de Waardt, "Reconfigurable WDM/TDMaccess network providing 10-Gb/s/wavelength over 27 km SSMF with colorless ONU", IEEE Photonics tech. lett. 21(23)pp- 1758-1760,2009.
- [6] Sou Jin Park ,Young Bok Choi, Seung Pil Jung , Keun Young Cho,Yuich Takushima, Yun Chur Chung, "Hybrid WDM/TDMA PON using self homodyne and differential coding", IEEE Photonics tech. lett.21(23) pp- 465-467,2009.
- [7] Bernhard Schrenk, Francesc Bonda, Jose A.Lazaro, Josep Prat, "Remotely pumped long reach hybrid PON with wavelength reuse in RSOA based ONUs", Journal light wave technology 29(5),2011.

- [8] Su Hwan oh, Ki-hong Yoon, Ki soo Kim, Jongbae Kim, O-Kyun Kwon, Dae Kon Oh, Young –Ouk Noh, Jun – Kyu Seo ,Hyung-Jong Lee, “Tunable external cavity laser by hybrid integrating of a super luminescent diode and a polymer Bragg reflector”, IEEE Journal Sel.Top Quantum electron 17(6) pp1534-1541, 2011
- [9] Simranjit Singh, “Performance evaluation of bi-directional passive optical networks in the scenario of triple play service”, Optik 125 pp 5837-5841, 2014.
- [10] Sanjeev Dewra, Aruna Rani.“Performance evaluation of DWDM system using semiconductor optical amplifier in the presences of fiber non linearities.” IJERSTE (3) pp 301-305, 2014.
- [11] Sanjeev Dewra, R.S.Kaler. “Performance evaluation of optical add drop multiplexers with Mach-Zehnder interferometer techniques for dense wavelength division multiplexed system.” Optik. (124) pp347– 351, 2013.
- [12] D.Kocher, R.S kaler, R. Randhwa, “Simulation pf fiber to home triple services at 2 Gbit/s using GE –PON architecture for 56 ONUs”, Optik (121) pp 5007-5010, 2013.
- [13] J.S. Malhotra, M.Kumar, A.K Sharma, “Performance optimization of high capacity long reach 32 channel FTTH downstream link employing triple play services”, Optik (124) pp-2424-2427, 2013.
- [14] Rakesh Goyal ,R.S Kaler, “ A novel architecture of hybrid (WDM/TDM) Passive optical networks with suitable modulation format”, Optical Fiber technology (18),pp 518- 522, 2012.