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Investigation of Hybrid WDM/TDM PON in the Presence of Optical Amplifiers to enhance the System Capacity

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Abstract: ***This paper evaluates the performance of hybrid wavelength-division-multiplexing/time-division-multiplexing (WDM/TDM) passive optical network (PON) with 320 ONUs(optical network units) up to distance 160km. The splitters are used as a PON element which distribute the data signal and creates the communication link between CO and users. It is observed that the network accommodate more number of users and an amplifier is used as a booster. This architecture also investigated for different modulation formats RZ, NRZ and Manchester for different distances from a CO and performance is evaluated in terms of BER and Q factor.***

Keywords: Passive optical network (PON), optical network unit (ONU), optical line terminal (OLT), wavelength division multiplexing (WDM), time division multiplexing (TDM).

I. Introduction

With the recent advancements in access networks the TDM PON, like Ethernet passive optical network (EPON) and Gigabit Passive optical network (GPON), are now widely used as optical access network solutions to distribute reasonably high bandwidths to the customers through an optical fiber network infrastructure [1-3]. Researchers are aiming at optical access network concepts known as hybrid WDM/TDM access passive optical networks [2]. Various techniques and components of the network are designed to achieve high data rate transmission to large bandwidth such as tuneable optical add/drop multiplexer (OADM) [9], colorless ONU [11], self-homodyne and differential coding [12], a reflective semiconductor optical amplifier (SOA) [13] and Bragg reflectors [14]. The passive optical networks are constituted of a centralized OLT located in the central office and a number of ONUs located at the users premises to some distance away from the OLT[4].

In literature various works on hybrid WDM/TDM PON has been reported Kaler et al. [10] employed Giga Ethernet hybrid passive optical network architecture with 1:8 splitter for 10 GBits/s has been investigated at different lengths. Urban et al. [9] proposed two 1.25-GBits/s wavelength channels over 26-km distance with standard single-mode fiber carrying data to and from the user. The experiments on the test bed of a hybrid WDM/TDM access network based on optical add–drop multiplexer and a reflective semiconductor optical amplifier were carried out. Kim et al.[7]proposed a hybrid PON system consisting of a 2.5 GBits/s reflective semiconductor optical amplifier based 32 channel loopback WDM–PON and a colorless OEO-based frame-level reach extender. This hybrid PON is designed to support a 128 split ratios per wavelength through an increased optical link budget of about 54 dB over a 50 km transmission distance per single wavelength channel. Goyal et al[4] analyzed the performance and feasibility of a hybrid WDM/TDM PON system with 128 ONU at 28km distance and transmitted the triple play services to all ONUs.

Till now, we observed that the proposed PON were limited with lesser number of users [10], covered lesser transmission distance [4-9]. In this paper the previous work has been extended by investigating the proposed hybrid WDM/TDM PON with large number of users over maximum reachable distance. Further the system performance is increased by comparing the different modulation formats. This paper is organized into four sections. In Section 1, introduction to hybrid WDM/TDM passive optical networks is described. In Section 2, the system setup for hybrid WDM/TDM PON is described. In Section 3, comparison results and discussion have been reported for the different modulation formats. Finally in Section 4, conclusion and future scope are made.

II. System Setup

The block diagram of system setup is shown in Fig1. In the system setup 320 users can access data signal up to 160km. In this architecture the central office (CO) is equipped with OLT devices and ONU is installed on subscriber end. Fiber distribution is done using a tree and branch architecture. The OLT is connected to ONUs by splitting the fiber to 20×16 times.

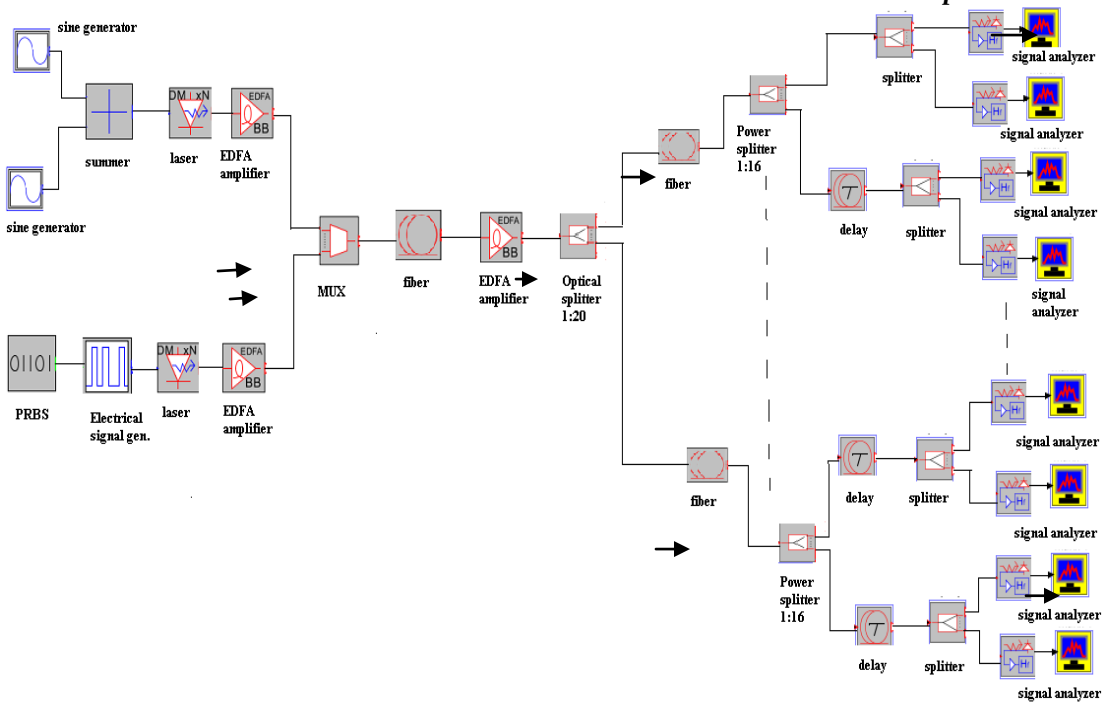


Fig1. System setup

The system offers the data signals are realized at central office. The signals are generated using direct modulated laser, and electrical signal generator generates the signals using pseudo-random data generator (PBRS) and transmitted using RZ/NRZ and Manchester modulator driver. At direct modulated laser source the wavelength is kept within the range of 1490-1550nm.EDFA (erbium doped fiber amplifier) is used as a pre amplifier to boost up the signals before transmitting. The signal is transmitted from OLT through the SMF (single mode fiber) 110 to 160 km to ONU. In the first remote node SMF is followed by post amplifier with the 1:20 optical splitter. All these 20 outputs are transmitted through another 1km fiber to reach second remote node. The second remote node is consisting of 1:16 power splitter is followed by the EDFA and delay blocks. Then each individual channels are received at individual ONU with the different delay value of 10ps i.e. the signal at first ONU with zero time delay and at second ONU with 10s and the delay so on. At the receiver end these signals are received as data and voice signals with the center wavelength set for the desired service. The analyzers estimate the Q factor and BER values for the signals. The Q factor is equal to the ratio of the resonant frequency to the bandwidth of the cavity resonance. To visualize optical spectrum, waveforms, eye diagrams with various values different analyzers are to be used like optical spectrum analyzer, power meter, Q estimator etc. The Q factor and BER values are also observed to verify the results.

III. Results and discussion

In hybrid WDM/TDM PON system, combined signals (data, video) are transmitted over the fiber with different modulation formats and by varying the fiber length different waveforms will be observed. The Q factor and BER is observed by varying the fiber length and observe eye diagrams and optical spectrums.

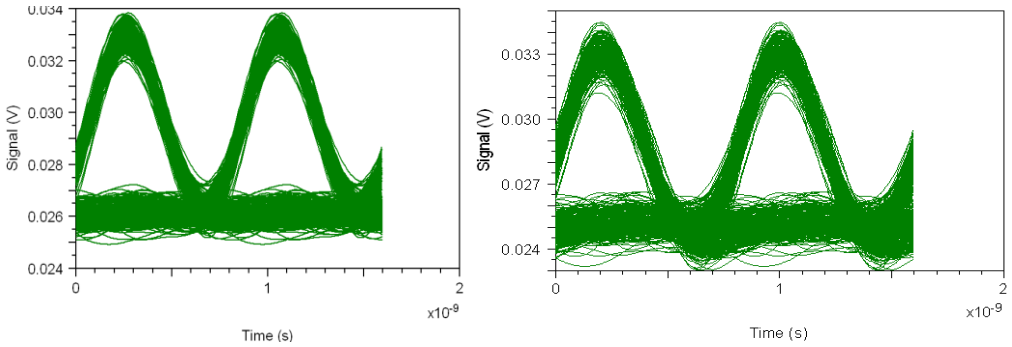
Table 1

Observed values of BER and Q factor for RZ modulation format.

Distance(km)	Q(dB)	BER
110	19.51	1.66×10^{-21}
120	19.46	2.68×10^{-21}
130	19.26	1.93×10^{-20}
140	18.87	7.67×10^{-19}
150	18.25	1.36×10^{-16}
160	17.39	6.05×10^{-14}
170	16.32	2.92×10^{-11}
180	15.04	7.84×10^{-09}

It is observed from Table 1 that as the transmission distance increases from 110 to 160 km the BER is decreases simultaneously due to fiber non-linearities such as crosstalk, dispersion, attenuation, cross-channel interference. Hence 320 ONUs can transmit their data signal using RZ modulation format up to 160km with the acceptable performance.

Fig2 (a)-(b) shows the eye diagrams with RZ(return to zero) modulation format at 110 and 160km distance respectively. At 160 km it provides acceptable output power. After this distance the performance is degraded due to power loss and fiber non-lineraties.



(a) (b)

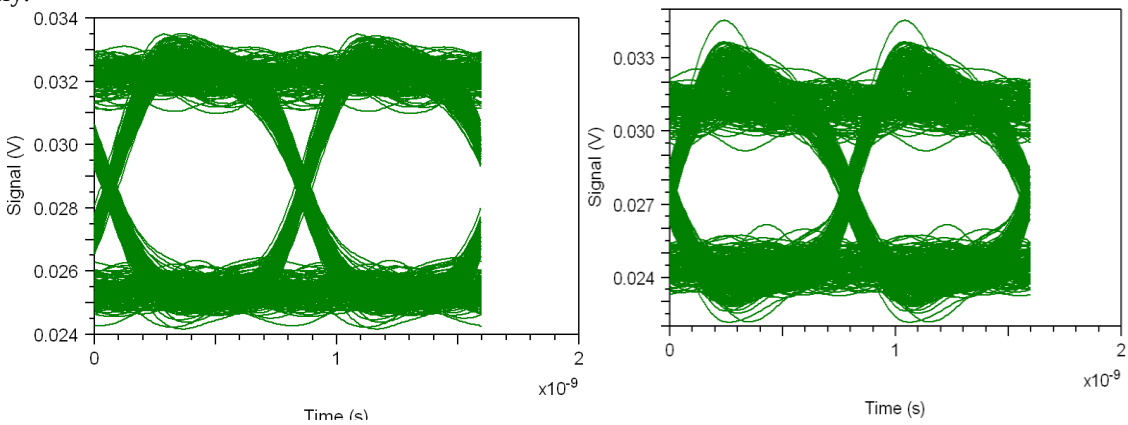
Fig2. (a)–(b)Eye diagrams of hybrid passive optical network system using 320 users with RZ modulation format at (a) 110 (b)160 km distance respectively.

Table 2

Observed values of BER and Q for NRZ format.

Distance(km)	Q(dB)	BER
110	19.15	5.00×10^{-20}
120	18.87	8.48×10^{-19}
130	17.26	1.72×10^{-15}
140	16.93	1.00×10^{-12}
150	15.77	3.96×10^{-10}
160	14.54	4.77×10^{-08}

Fig. 3 (a)–(b) shows the eye diagrams with NRZ (non-return to zero) modulation format at 110 and 160 km distance respectively.



(a) (b)

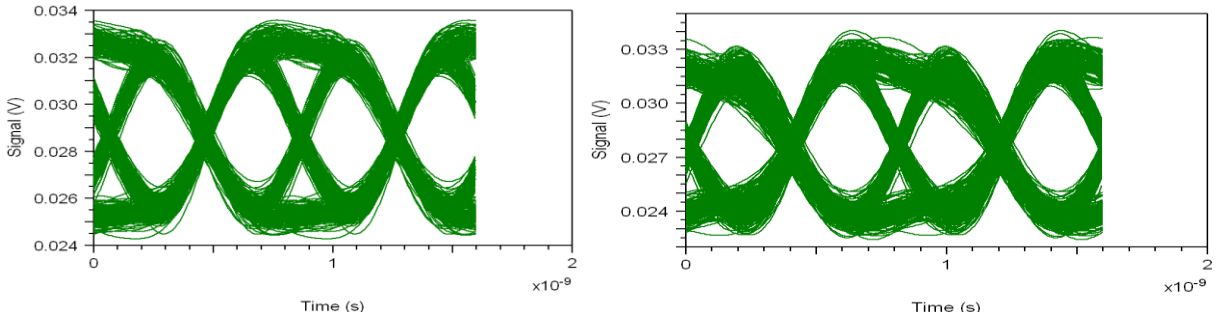
Fig3 Eye diagrams of hybrid passive optical network system using 320 users with NRZ modulation format at (a) 110, (b) 160 km distance respectively

Table3

Observed values of BER and Q for Manchester format

Distance(km)	Q(dB)	BER
110	19.25	2.12×10^{-20}
120	19.12	8.24×10^{-20}
130	18.42	3.91×10^{-17}
140	17.42	5.42×10^{-14}
150	16.29	3.21×10^{-11}
160	15.43	1.67×10^{-09}

In fig. 4(a)–(b) shows the eye diagrams of hybrid PON system with Manchester modulation format at 110and 160km distance respectively.

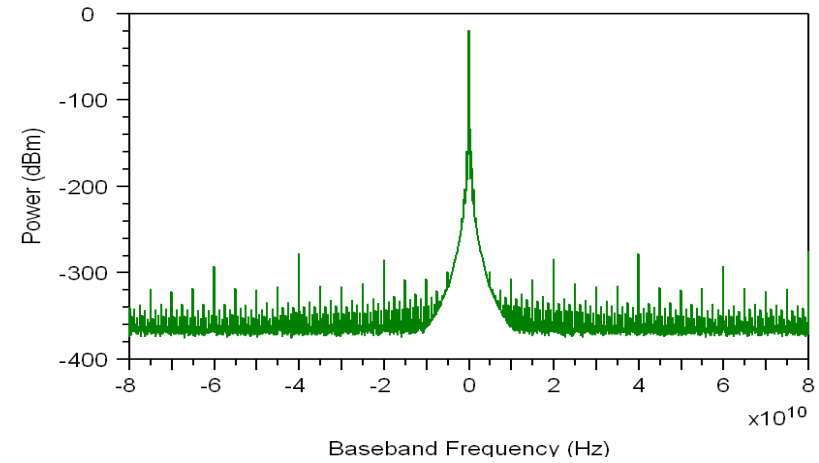


(a) (b)

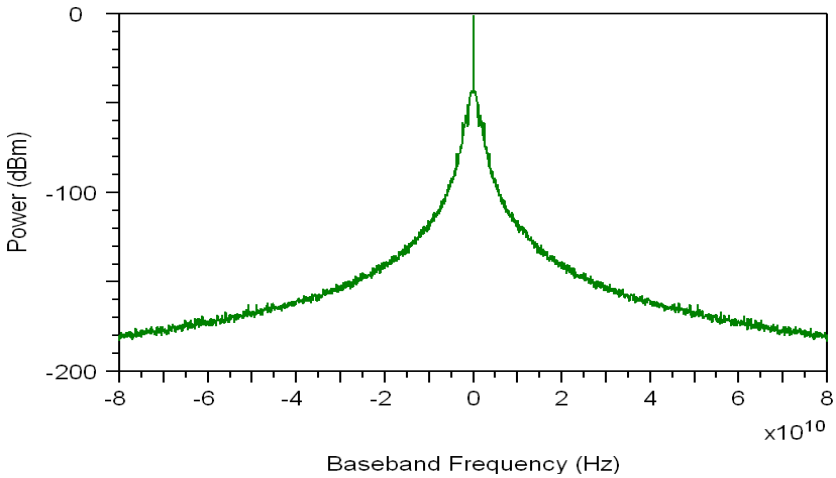
Fig4. Eye diagrams of hybrid passive optical network system using 320 users with Manchester modulation format at (a) 110, (b) 160 km distance respectively.

It is observed from Fig 3-4 that as the transmission distance increases from 110 to 160 km the eye opening is decreases. It is evident from Table2 and Table 3 that the performance of hybrid PON with NRZ and Manchester modulation format is improved up to 150km. There is a noticeable noise after this distance due to dispersion and power loss increases in the fiber linearly with the increase in the transmission distance. Hence 320 ONUs can transmit their data signal up to 150km with the acceptable performance in both the modulation formats.

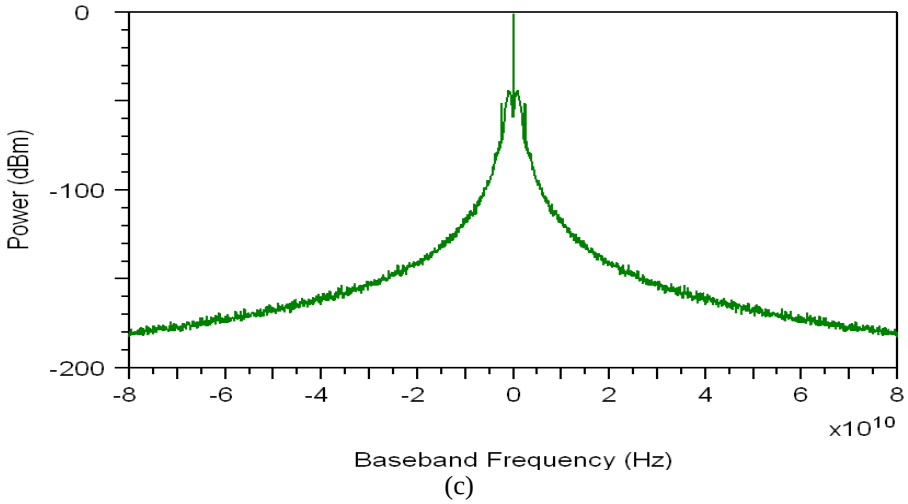
Fig. 5(a)-(c) shows a baseband signal spectrum diagram for hybrid passive optical networks system using 320 users. The baseband frequency vs. power variation for RZ ,NRZ and Manchester modulation format.



(a)



(b)



(c)

Fig 5 .Baseband signal spectrum (a) for RZ (b) for NRZ (c) for Manchester modulation format.

It is mandatory to observe the performance of system in the term of BER for the different modulation formats (RZ, NRZ and Manchester) with different transmission distances. Fig. 6 illustrates a bit error rate versus the fiber length. It is observed that RZ modulation allows the longest transmission which provides the acceptable BER of 6.05×10^{-14} at 160km respectively. On the other hand NRZ and Manchester shows poor performance according to Table1, Table2, and Table3 with 320 users. So, the RZ modulation is suitable for hybrid passive optical networks for long reach system.

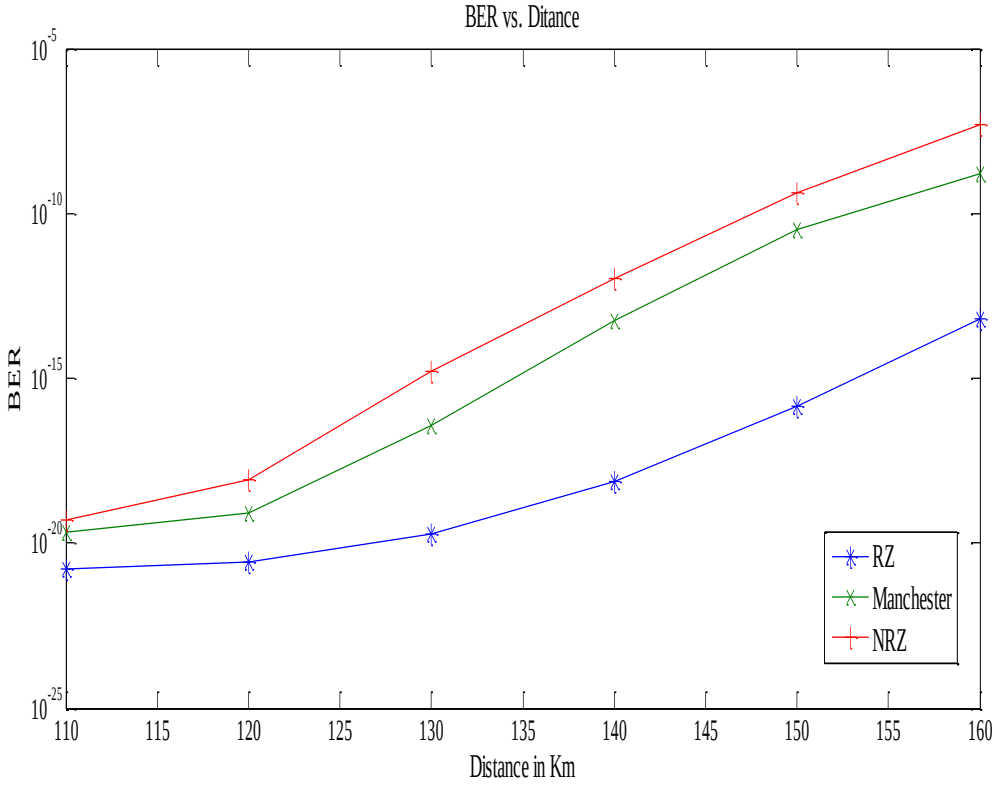


Fig6:- BER vs. distance

Fig. 7 represents the Q factor versus fiber length. Q factor can be seen for all the modulation formats and as the fiber length varies from 110 km to 160 km, the Q-factor gets decreased due to the fiber non-linearities. The better Q value is provided by the RZ data format 17.39 dB even for the worst case at 160 km. The variation in Q-factor for RZ, NRZ and Manchester are 19.51–17.39 dB, 19.15–14.54 dB and 19.25–15.43 dB, respectively. From the reported results, RZ rectangular data format provides the better result as compared to other formats.

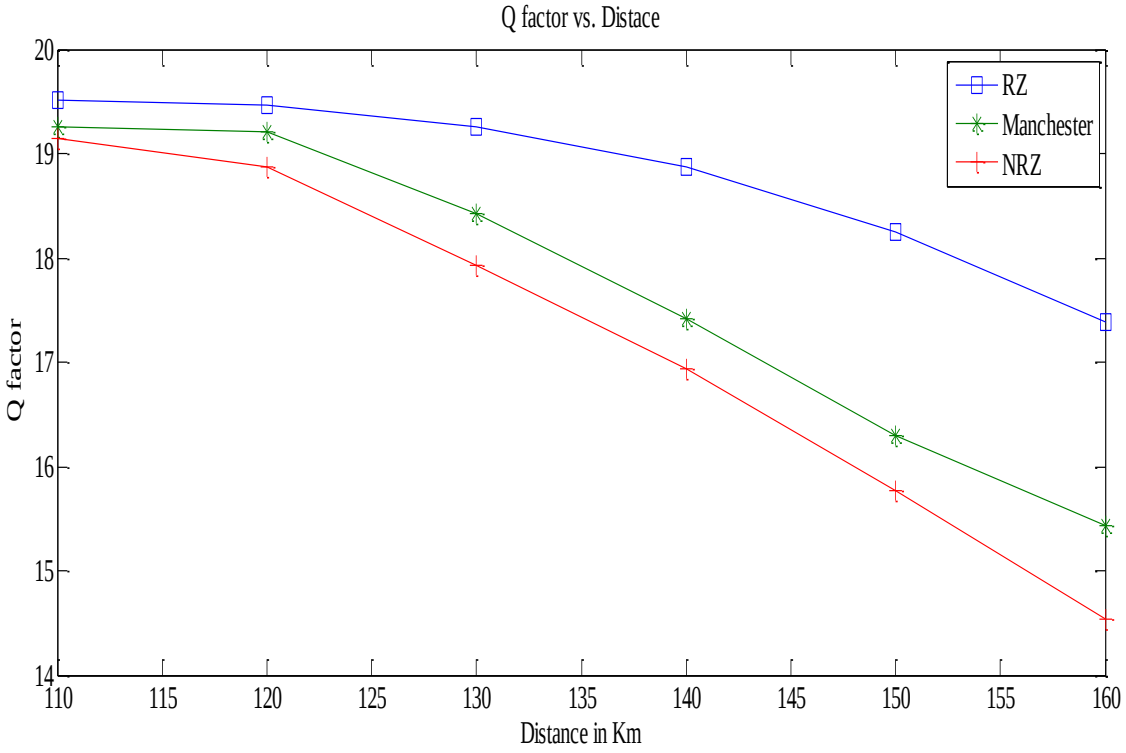


Fig7:- Q-factor vs. distance

IV. Conclusion

In this paper the performance of hybrid WDM/TDM PON is investigated for maximum number of users. The wavelength is kept within the range of 1490-1550nm and data signal is transmitted at 1.25Gbits/s bit rate for 320 users at 160km. The comparative investigation and suitability of various data formats for data transmission are also being done. The impact of modulation formats (NRZ, RZ and Manchester) on hybrid has been investigated and RZ is more adversely affected by nonlinearities, where as NRZ and Manchester is more affected by dispersion, RZ provides good quality factor and less eye closure at the respective distance as compare to other existing modulation formats. The hybrid PON networks will be used to increase the number of users in the present passive optical networks. There is much scope for further work to increase the number of users, to achieve longer distance and to improve component performance, particularly source output power and fiber losses.

Refrences

[1] T. Koonen, Fibre to the home/fibre to the premises: what, where, and when? Proceedings of the IEEE 94 (5) (2006) 911–934

[2] Peter Ossieur, Cleitus Antony, Aisling M. Clarke, Alan Naughton, Heinz-George Krimmel, Y. Chang, Colin Ford, Anna Borghesani, David G. Moodie, Alistair Poustie, Richard Wyatt, Bob Harmon, Ian Lealman, Graeme Maxwell, Dave Rogers, David W. Smith, Derek Nesset Russell P. Davey, Paul D. Townsend, A 135-km 8192-split carrier distributed DWDM–TDMA PON with 2 32 10 Gb/scapacity, J. Lightw Technol. 29 (4) (2011) 463–474. February 15.

[3] Goutam Das, Bart Lannoo, Abhishek Dixit, Didier Colle, Mario Pickavet, Piet Demeester Flexible hybrid WDM/TDM PON architectures using wavelength selective switches, Optical Switching and Networking 9 (2012) 156–169

[4] Rakesh Goyal a, R.S. Kaler A novel architecture of hybrid(WDM/TDM) passive optical networks with suitable modulation format, Optical Fiber Technology 18 (2012) 518–522

[5] Jiajia Chen, Lena Wosinska, Mohsan Niaz Chughtai, and Marco Forzati Scalable Passive Optical Network Architecture for Reliable Service Delivery VOL. 3, NO. 9/SEPTEMBER 2011/J. OPT. COMMUN. NETW. 667

[6] Jingjing Zhang, Student Member, IEEE, and Nirwan Ansari, Fellow, IEEE ,Scheduling Hybrid WDM/TDM Passive Optical Networks With Nonzero Laser Tuning Time

[7] Kwang-Ok Kim , Jie-Hyun Lee , Sang-Soo Lee , Youn-Seon Jang , Demonstration of a WDM/TDM hybrid PON based on a colorless frame-level reach extender, Optical Fiber Technology 18 (2012) 190–198

[8] Huifeng Bai, Yang Wang, Tunable wavelength converters based switching structure for WDM-TDMhybrid PON, Optik xxx (2013)

[9] P.J. Urban, E.G.C. Pluk, M.M. de Laat, F.M. Huijskens, G.D. Khoe, A.M.J. Koonen, H. de Waardt, 1.25-Gb/s transmission over an access network link with tunable OADM and a reflective SOA, IEEE Photonics Technol. Lett. 21 (6) (2009) 380–382. March 15.

[10] Rajneesh Kaler, Pradeep Teotia, R.S. Kaler, Simulation of FTTH at 10 Gbit/s for 8 OTU by GE-PON architecture, Optik – Int. J. Light Electron Opt. 122 (22) (2011) 1985–1989.

[11] Patryk J. Urban, Frans M. Huijskens, G.D. Khoe, A.M.J. Koonen, Huug de Waardt, Reconfigurable WDM/TDM access network providing 10-Gb/s/k over 27-km SSMF with colorless ONU, IEEE Photonics Technol. Lett. 21 (23) (2009) 1758– 1760. December 1.

[12 Soo-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 Technol. Lett. 21 (7) (2009) 465–467. April 1.

[13] Bernhard Schrenk, Francesc Bonada, Jose A. Lazaro, Josep Prat, Remotely pumped long-reach hybrid PON with wavelength reuse in RSOA-based ONUs, J. Lightw. Technol. 29 (5) (2011) 635–641. March 1.

[14] 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 integration of a superluminescent diode and a polymer Bragg reflector, IEEE J. Sel. Top. Quantum Electron. 17 (6) (2011) 1534–1541. November/December.

