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Effects of using RZ and NRZ modulation formats for TDM-PON system on Transmission Characteristics for Downstream Signals

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Abstract: In this paper, the simulative analysis of 8 channels TDM-PON system has been carried out by using NRZ and RZ modulation formats for downstream signals. The performance of TDM-PON system has been evaluated by varying input Pin (0 - 25) dBm for both modulation formats at a constant bit rate of 622Mbps.It has been observed that the TDM-PON system gives the optimum performance at power 20dBm and it is found that RZ is superior to NRZ. The transmission performance characteristic of TDM-PON for both the modulation formats has been evaluated in terms of Q-factor and BER. The System shows the repeaterless transmission up to the distance of 130 km.

Keywords: PON, TDM, NRZ, RZ, OLT, ONU.

1. Introduction

Telecommunication's future access network is increasing day by day with a need to meet greater bandwidth and reliable data transmission. Optical access network is the most demanding network for industry after the deployment of optical fiber in metro areas, where the use of optical fiber technology by reducing the CO(Central Office) equipments and maintenance cost of these systems with provision of higher data transmission operating over repeater less P2P networks. The overall aim is to provide better solutions with higher scalability to service providers to make fiber reach to end user. To accomplish it, Network needs to be promising improved for high data rates and long reach results by implementing optical fiber using Passive Optical networks [1].

Passive Optical Network is considered to be one of the most widely used networks in this scenario because they provide the cheapest way to provide fiber to home. A Passive optical network is a point to multipoint network consists of a central office node, called an optical line terminal (OLT), one or more user nodes, called optical network units (ONUs) and the fibers and splitters between them. The cost-effectiveness of PON comes from the two facts, one is other than passive element (splitter), and no other active element is present in the link. Secondly, a transmitter, the feeder fiber and remote splitter is shared among many subscribers.PON uses a single wavelength to transmit the data in both directions i.e in Downstream direction and upstream direction. Different flavors of PON are emerged in recent years; Ethernet-PON (EPON) which is a recent version, standardized in the IEEE 802.3, Broadband-PON (BPON), and Gigabit-PON (GPON).

2. BROADBAND PASSIVE OPTICAL NETWORKS (BPON)

Fast evolution access networks become evidence under the pressure of demand for broadband internet services, which are requested both by the residential and corporate users, today's predominant broadband access solutions deployed are digital subscriber line(DSL),community antenna television based networks, which can support up to 50Mb/s in downstream direction.

Broadband passive optical network is applied to support triple play services such as voice, video, data economically and effectively. BPON technology transmits 622Mb/s in downstream direction and 155Mb/s for upstream direction. This network uses the ATM technology as a data transport mechanism. ATM protocol provides support for different types of service by means of different adaptation layers .The small size of ATM cells and the use of virtual channels and links allow the allocation of available bandwidth to end users with a fine granularity.BPON operates on principle of Time Division Multiplexing, (TDM-PON), since PON delivers services with different multiplexing techniques, such as TDM, Hybrid-TDM, WDM (Wave division multiplexing) [2- 3].

2.1 TDM-PON

Time division Multiplexing PON systems proposed so far are mostly based on Bit interleaving technique for Time division multiplexing, This is because some users demands different speeds depending on subscribed services. This raised the need to delivered services in data packets or asynchronous transfer mode [4].The Data transmission is carried out after a particular time delay at transmitter side and same delay is utilized at receiver side in order to reduce traffic.

3. LITERATURE REVIEW

Shaukat et al.[5] analyzed the system on the basis of Data Rate, Fiber length, Coding technique, number of users, wavelengths and their effects on Bit Error rate (BER) as the key performance parameter using OptiSystem Simulator version 7. It had been found that, in downstream direction, higher data rates correspond to degrade system performance over differing fiber lengths provided the number of users was kept constant.

Bock et al. [6] they had proposed WDM/TDM-PON architecture by using free spectral range FSR periodicity and arrayed waveguide grating AWG. A shared tunable laser, photo receiver, DBA and remote modulation were used for Tx and Rx. Transmission test showed correct operation at 2.5Gb/s to a 30 km. by mean of optical transmission test, they demonstrated that this architecture was feasible and offered good performance with low optical losses as compared to other PON architectures.

Calabretta et al. [7] proposed an innovative architecture to realize a single feeder bidirectional WDM/TDM-PON on modified NRZ (DPSK) downstream signals at 20Kb/s and narrowband AWG.AWG was used as the channel distributer and demodulator for all the DSPK Channels. The experimental results showed that a system employing 8 * 20 Gb/s downstream TDM channels with a 1 : 4 power splitter can serve up to 32 ONUs at average traffic of 5 Gb/s (downstream) and 250 Mb/s (upstream).

Rajniti et al. [8] analyzed 2.5Gb/s eight channel bidirectional WDM-PON over transmission distance of 70km.The Performance of system was analyzed by varying the extinction ratio from 2 to22 dB, and concluded that with the increase in ER of the modulator from 2 to22 dB, BER (Bit error rate) decreases and Q value improves for WDM-PON system up to 20dB beyond which it saturates. Q value decreases sharply with increase in transmission distance. Finally concluded that NRZ is superior to RZ and system gives optimum performance at input power 10dB.

4. EXISTING WORK

With the standardization of Time-division-multiplexing passive optical networks (TDM-PONs), a cost-effective

Components	Parameters	
	Type	Value
Light Source	Frequency	193.1THz
	Power	5dBm
PRBS generator	Bit rate	2-5Gb/s
Photo detector	Responsivity	1A/W
	Dark current	10nA
Modulator	Modulation format	RZ
Time Delay	OLT1	0sec
	OLT2	1/(Bit Rate)*1/4 sec
	OLT3	1/(Bit Rate)*2/4 sec
Optical Fiber	Fiber length	20-100

Table1: The parameters and their values for TDM PON Network

access technology based on optics has been developed. However, further development needs to be carried out in order to fully exploit the benefits of optical fiber technology. The Existing technologies achieved performance with TDM PON and WDM PON using different Coding Schemes by the use of 16 users in Optical Network Unit (ONU) receiver side. They analyzed the performance achieved by TDM/WDM-PON for Manchester, non-return-to-zero (NRZ), return-to-zero (RZ) modulation formats. The Fig.1 shows the transmitter consists of pseudo generator and the bit sequence is modulated using a RZ/NRZ and Mach Zehnder modulator. Optical signal from each user is then combined using a power Combiner and is sent through the SMF. At the receivers end a Power Splitter is used, which directs the optical data signals to each one of the ONU and synchronized according to time intervals. The Simulation Set up, parameters used (with values) were as follows:

It was revealed that Manchester coding showed better performance through Min BER, Max Q factor, and Eye Diagram when compared with RZ and NRZ coding techniques.

5. PROPOSED WORK

In the proposed work, the simulation of 8 channels TDM-PON has been carried out by varying input Power by using RZ and NRZ modulation of formats. The Fig.2 shows at transmitter side, Optical transmitters (Bit rate 622Mb/s) operating at frequency 193.1, with variable input power (0 to 25 dBm) has been used by varying modulation formats.

Since the data is sent in form of packets, optical delay of 1 sec is used.

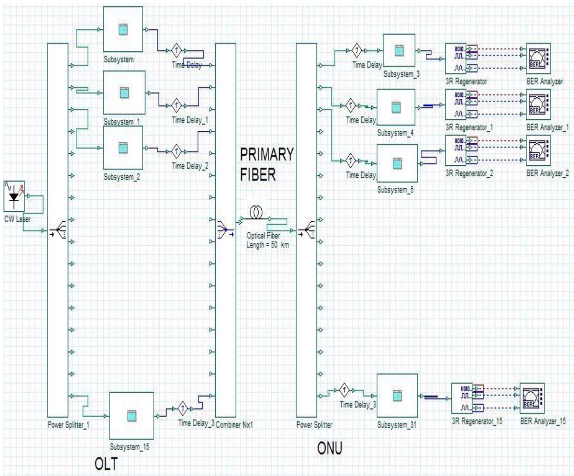


Fig.1: TDM-PON Simulation Set up

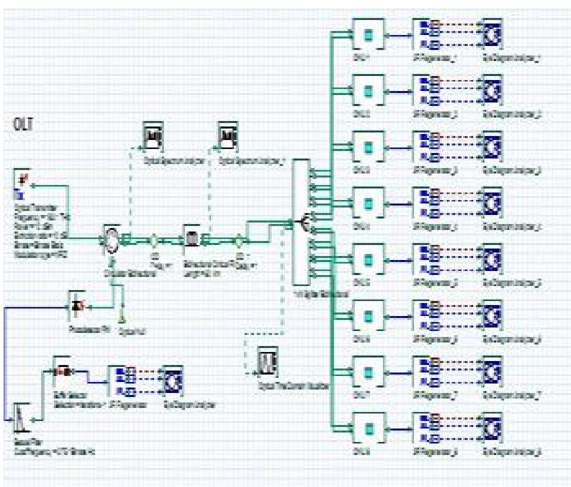


Fig.2: TDM-PON Simulation Set up

PIN photo detector detects the electrical signal. It has responsitivity of 1A/W and Dark current=10nA.The Optical Spectrum Analyzers and time domain visualizers are used to evaluate the input/output spectrum and time domain respectively. The Signal from Optical transmitter is sent through the bidirectional optical fiber includes attenuation affect=0.2dB/Km, Dispersion

Slope at=0.075ps/km-nm and Dispersion at=16.75ps/Km-nm.

At Receiver side, a Power Splitter is used to direct the signal to each of 8 ONU's, followed by 3R regenerator, which is used to regenerate the electrical signal. Each 3R regenerator is further directly connected to BER analyzer, which we used to obtain the graphs and to measure the performance of

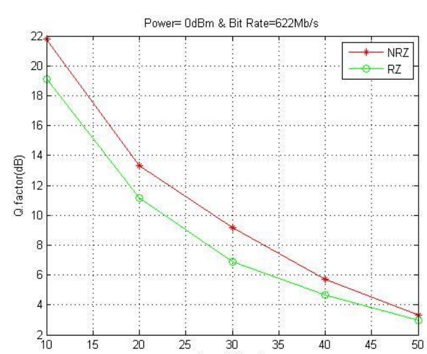
Table 2: The parameters and their values for Proposed TDM PON Network.

Components	Parameters	
	Type	**Value**
Light Source	Frequency	193.1THz
	Power	0 to 25 dBm
Optical transmitter	Bit rate	622Mb/s
Photo detector	Responsivity	1A/W
	Dark current	10nA
Modulator	Modulation format	RZ/NRZ
Time Delay	OLT	1sec
Optical Fiber	Fiber length	10-150km
Bessel Filter	Filter order	4
	Insertion loss	0dBm

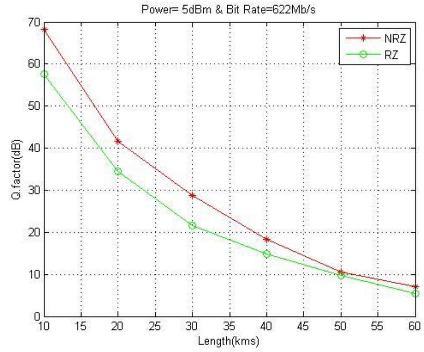
eye diagram, Min BER, Q-value and Eye Height.

6. RESULTS AND DISCUSSION

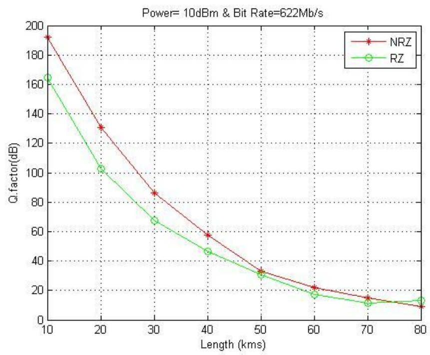
To estimate the performance, we have compared two modulation formats by varying by input power and Length of fiber. The Fig.3 (a), 3(b), and 3(c) shows the graphical representation of Q value as a function of transmission distance at varied input power (0-25) dBm and with constant Bit Rate of 622Mbps for NRZ and modulation formats for downstream direction respectively.



(a)



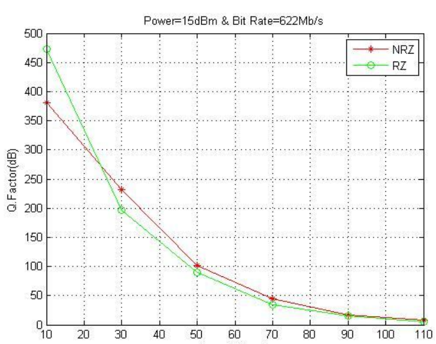
(b)



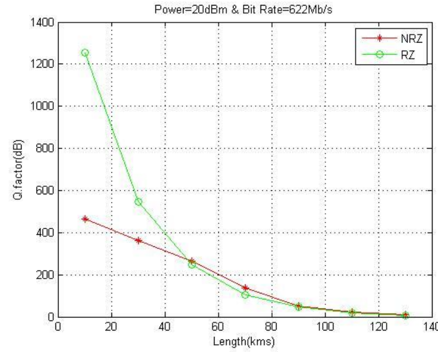
(C)

Fig.3: Length vs. Q-factor for NRZ, RZ modulation formats at Bit rate 622Mb/s (a) Pin=0dBm (b) Pin=5dBm (c) Pin=10dBm.

It is cleared from graphs with increase in Power and Length of fiber, system performance also increases in terms of NRZ Data format. This can be understood from the fact that for low powers, the performance of NRZ system degraded. However at higher powers, after Pin=10dB, the performance of RZ improved and gives better system performance as compared to NRZ.



(a)



(b)

Fig.4: Length vs. Q-value for NRZ, RZ modulation formats at Bit rate 622Mb/s (a) Pin=15dBm (b) Pin=20dBm

The fig.4 (a), 4(b) shows the graphical representation of Q-value as a function of transmission distance for varied Pin (0-25) dBm for NRZ and RZ modulation formats for downstream data respectively. We have evaluated the system performance by varying power rates up to 25dBm.It is clearly indicated from graphs as the increase the power, an abrupt change has been observed in system performance. It has been observed that with increase in higher power rates, RZ gives the better performance as compared to NRZ.RZ gives the optimum performance at power=20dBm than NRZ.

Fig.4 shows the eye diagrams for NRZ and RZ in downstream direction respectively. As the power rates increases, and reaches up to 10dBm, it is clearly visible from fig.4.1 that the performance of NRZ modulation format goes on decreasing due to signal distortion or XPM (Cross Phase modulation) effects i.e. decreasing the Q-value.

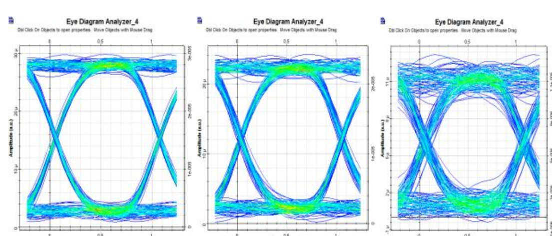


Fig.4.1: Eye diagrams for NRZ at Pin (a) 0dBm, (b) 5dBm, and (c) 10dBm at distance 10km, 40km, 80km respectively.

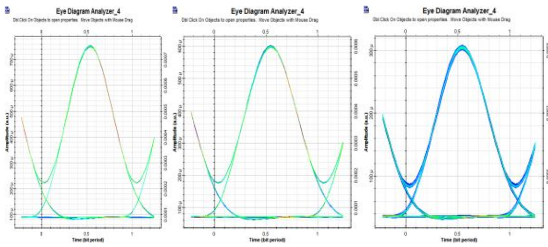


Fig.4.2: Eye diagrams for RZ at Pin (a) 15dBm, (b) 20dBm, and (c) 25dBm at distance 10km, 40km, 80km respectively.

7. CONCLUSION

We have simulated eight channels TDM-PON system over a transmission distance of 130km, with varying input power and length of fiber. It has been observed that with increase in power up to power =10dBm, and with increase in length of fiber, Q-value also increases for NRZ. But after higher power rates at 15dBm, 20dBm, and 25dBm respectively, it starts decreasing and RZ starts increases, and faithful transmission distance covered is 150 km. Further, it has been concluded that RZ gives optimum performance at Power 20dBm than NRZ.

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