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Simulative Analysis of 80Gbps NGPON Stage-2 based TWDM Communication System for Different Data Formats

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ABSTRACT:In this paper we have investigated an 80Gbps Next generation passive optical network (NGPON) stage-2 using Time Wavelength Division Multiplexing (TWDM). In this approach we have taken 80gbps downstream (with WDM scheme) from OLTs and 10Gbps upstream (with TDM scheme) from ONUs. The simulation had been carried out using two data formats were used such as RZ and NRZ at different CW laser power and optical fibre lengths. The performance analysis has been done in terms of eye diagrams, Q-factor and BER for both upstream and downstream. The results show that RZ ensure better results as compare to NRZ in NGPON2 with TWDM scheme.

KEYWORDS:NGPON, WDM, OLT, ONU, EDFA

I.INTRODUCTION

Passive Optical Networks evolution passed from many steps toward NG-PON2. In last decade or so, due to the emergence of various high bandwidth applications, there was a strong completion between various access networks. NGPON2 is a promising solution to provide huge bandwidth and can be considered for long distance communication [1]. The exceptionally high bandwidth of optical fiber can be explored by employing WDM technique in long reach optical access networks as WDM provides high bandwidth efficiency. In this paper, we have proposed a WDM access network for long reach networks.

This proposed scheme evaluates physical layer parameters in terms of eye diagram, quality factor for NRZ and RZ modulation formats across variable optical fiber lengths that can be varied up to 200Km for optimum solution and results. It is a flexible Solution to be used in next generation access networks. Further, the bandwidth can also be utilized by using advanced modulation techniques e.g. Orthogonal Frequency Division Multiplexing(OFDM), hybrid WDM/TDM technique and Orthogonal Code Division multiplexing[2].But time wavelength division multiplexing (TWDM) is more convenient as compare to OCDMA because of its wavelength sharing capacity for uplink services from ONUs[3]. Building on the Ethernet Passive Optical Network (EPON) and Gigabit PON (GPON) standards, Next-Generation (NG) PONs (i) provide increased data rates, split ratios, wavelengths count, and fiber lengths, as well as (ii) allow for all-optical integration of access and metro networks [4]. The probabilistic analysis of the capacity (maximum mean packet throughput) and packet delay of subnetworks that can be used to form NG-PONs. Our analysis can cover a wide range of NG-PONs through taking the minimum capacity of the subnetworks forming the NG-PON and weighing the packet delays of the subnetworks. The previous numerical and simulation results indicate that our analysis quite accurately characterizes the throughput-delay performance of EPON/GPON tree networks, including networks upgraded with higher data rates and wavelength counts. Our analysis also characterizes the trade-offs and bottlenecks when integrating EPON/GPON tree networks across a metro area with a ring, a Passive Star Coupler (PSC), or an Arrayed Waveguide Grating (AWG) for uniform and non-uniform traffic. To the best of our knowledge, the presented analysis is the first to consider multiple PONs interconnected via a metro network [5].

The second stage of next-generation passive optical network (NG-PON2) based on time and wavelength division multiplexed passive optical network (TWDM-PON) was proposed by a telecommunication group research to enhance the performance of broadband access network[6]. TWDM-PON was selected as the best candidate for NG-PON2 solution because of its ability to support the NG-PON2 requirements, such as enhanced bandwidth capacity, 40 Gb/s, and coexistence with previously existing generations without any change to optical distribution network (ODN) [7].

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This paper reviewed the recent progress carried out on a TWDM-PON system configuration, with emphasis on tunable transmitter and receiver optical network unit (ONU) in terms of the amount of tuning range reported in exploiting the wavelength plan provided with cost efficiency [8]. The speed of data rate transmitted on the downstream and upstream links between optical line terminal (OLT) and ONU with the way of stacking approach in NG-PON2 is reviewed. In addition, the power system budget is reviewed to determine the number of users allocated with the system with each transmission allowed[9] As the emerging access architecture, NGPONs feature enhanced PON configurations, metro-access integration, and bimodal fiber wireless networks [10]. The moving landscape of NG-PONs provides opportunities for applying novel and promising technologies such as network coding (NC). In this work, we introduce the basic principles of NC and discuss their applicability to NG-PONs, with a focus on layer 2 design.

II.SCHEMATIC MODEL

NG-PON2, will increase PON capacity to at least 40 Gbps and deliver services of 1 Gbps or more with platforms and standards that could be deployable in 2015. It is designed to meet a broad range of communications needs, including business and mobile backhaul applications as well as residential access. Media Access Control(MAC) layer will be used in order to transmit and receive the data through optical medium. For downstream, the electrical signal is modulated with CW laser via mach-zender modulator (MZM) to provide optical signal. Erbium doped fiber amplifier (EDFA) is used for both uplink and downlink signal to increase the gain and quality factor of signal. Afterwards signal is fed into 6 port circulator which is connected with bidirectional optical fiber and it also avoids the collisions between uplink and downlink traffic. Further signal is splits into different optical network units (ONU) operatable at particular wavelength. At the receiver side optical signal is passed from photodetectors for analog one. Similarly, for uplink data is send towards different optical line terminal at central office (CO) in the form of optical one. In this architecture we use TWDM scheme which overcomes the limitations of WDM and TDM-PON. In this proposed work the bit rate capacity is enhanced up to 80gbps with the help of 8 OLTs and each provides 10Gbps of data rate for downstream and 10 Gbps data rate capacity is used for upstream. NGPON2 provides data to 128 subscribers which reflects its efficiency of large bandwidth and data rate capacity.

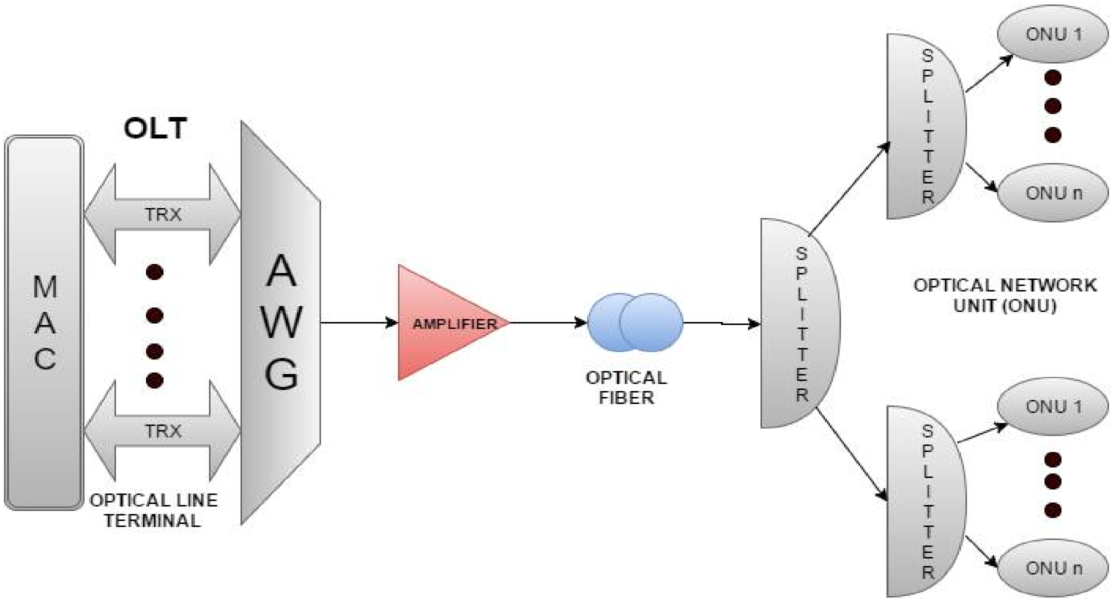

Fig.1. Next Generation Passive Optical Network (NGPON).

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III.SIMULATION SETUP OF NGPON STAGE-2 MODEL

The new approach, NG-PON2, will increase PON capacity to at least 40 Gbps and deliverservices of 1 Gbps or more. The simulation work is proposed by using optisystem software. In this model of NGPON2 uses 80Gbps downstream based on WDM (wavelength division multiplexing) concept and 10Gbps upstream based upon TDM (Time division multiplexing) concept. we use 8 OLTs and 8 ONUs which is further divided into number of units or subscribers using same wavelength.

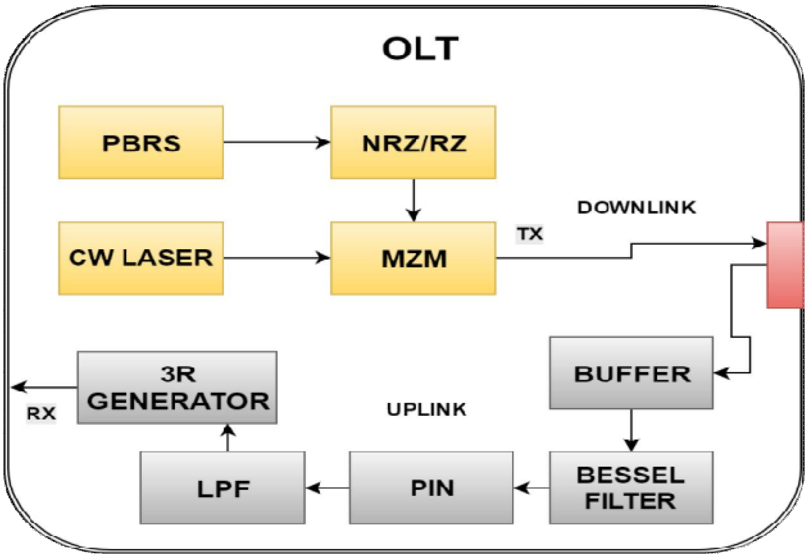

Fig.2 Optical Line Terminal (OLT) at central office (CO)

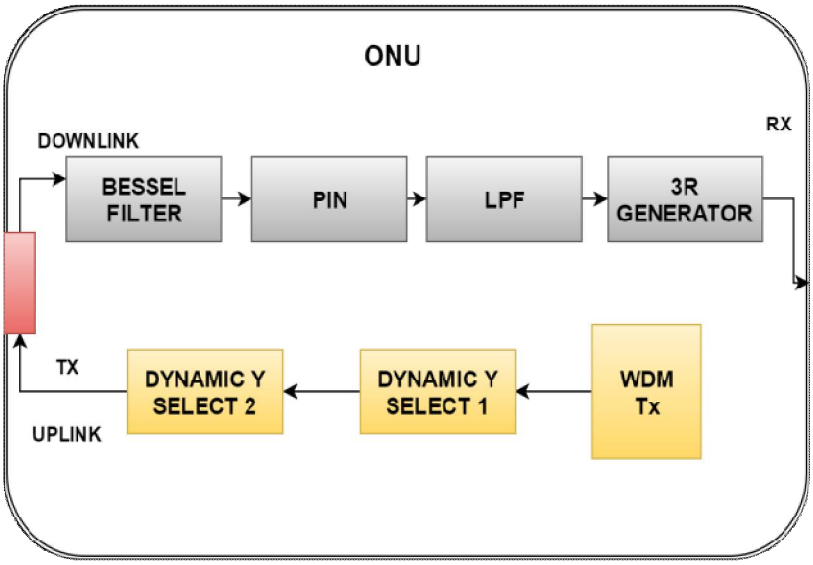

Fig.3. Optical Network Unit (ONU) architecture

For downlink each OLT is operatable at particular wavelength in a range from 1596.15nm to 1601.82nm. Each OLT consist of transmitter and receiver. Fig.2 shows the transmitter and receiver section of OLT in which PRBS (pseudo

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random bit sequence) generates the data which is further formatted with different line codes such as RZ and NRZ. These formatted sequence is modulated with CW laser with the help of MZM. Similarly, when signal is received at ONU, it first stored in buffer because data comes in terms of time slots. Then it is passed form Bessel filter which is tuned to particular frequency. Afterwards signal is passed from photodetector which converts optical signal to electrical and passed from low pass filter which extract original signal from carrier.
Fig.3 shows the receiver and transmitter section of ONU in which received signal is passed from Bessel optical filter of a particular frequency and then passed from photodetector for opt-electro conversion. Low pass filter (LPF) is use to carry out original signal from modulated one. But in transmitted side WDM transmitter generates a data sequence of RZ or NRZ format which is passed from Dynamic select for time slot because in uplink the data is transmitted in a time slots using same wavelength.

$$\text{Switching Event Time} = \frac{\text{Timeslot}}{\text{Bit rate}} \times \frac{1}{16} \times \text{Sequencelength}$$

In NGPON2, data is transmitted and received with different wavelengths for both upstream and downstream. The ITU provides the wavelength allocation scheme in which for TWDM based NGPON2 uses downstream wavelength range from 1596nm to 1603nm and uplink wavelength range is allocated from 1535nm to 1544nm. In Table 1 shows the parameters used in a simulation.

Table 1. Simulation Parameters for the NGPON Stage-2.

COMPONENTS	PARAMETERS	VALUES
PBRS Generator	Bit Rate	10Gbps
Pulse Generator	Line coding	NRZ/RZ
Downstream Laser	Power	5 To 10dBm
Downstream Laser	Wavelength	1596.15 To 1601.82nm
Upstream laser	Wavelength	1535.03 To 1540.56nm
Optical Fiber	Ref. wavelength	1550nm
	Length	10 To 50Km
	Attenuation	0.2 ps/Km
WDM mux	Frequency	1596.15nm
	Bandwidth	0.16nm
	Freq. Spacing	0.81nm
WDM Dmux	Frequency	1535.03 nm
	Bandwidth	0.16 nm
	Freq. Spacing	0.79 nm
PIN photo detector	Responsively	1A/W

As per Fig.4 shows that each ONU uses different wavelength which is used for downlink. This approach is called WDM. Similarly, in case of uplink each ONU have sub units which are tuned at same frequency and data is transmitted from these units in terms of time slots which we called as TDM.Circulators are used to provide downstream and upstream linkage with bidirectional optical fibers. In this simulation we have use total 32 subscriber and 4 sub units each ONU.

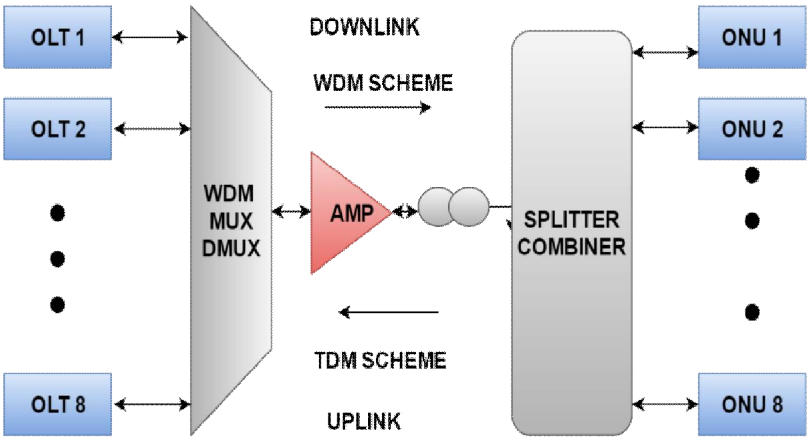

Fig.4. Simulative setup of TWDM based NGPON2

IV.RESULTS AND DISCUSSIONS

The proposed system increases the capacity of PON network. The experiments against various parameters are plotted. As per TWDM based NGPON2 consist of 8 OLTs for providing enhanced capacity of downlink. These OLTs are multiplexed by WDM multiplexer as shown in Fig.5. we can see the spectrum of each channel and signal power before transmission.

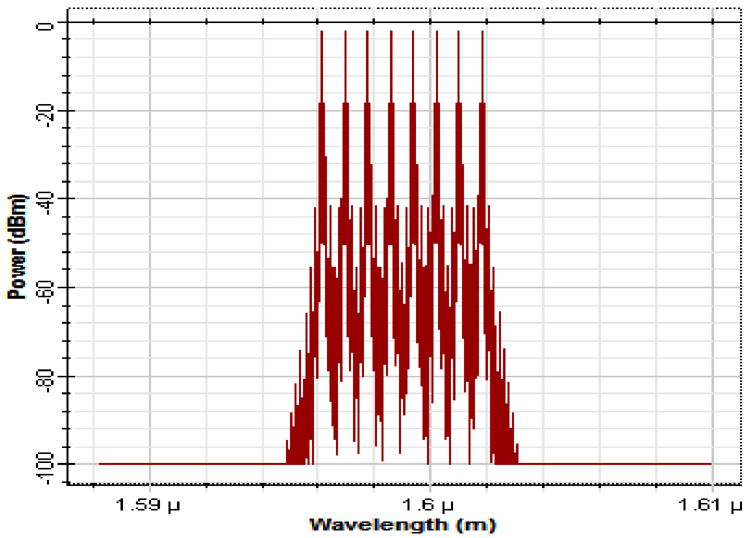

Fig.5. Output spectrum of WDM MUX.

Fig.6 shows that with increase in distance up to 50 km the q factor of both uplink and downlink starts degrading. It also shows that NRZ has small value of q factor which is18.69 for downstream and 27.05 for upstream as compare to RZ which have 36.23 for downstream and 28.79 for uplink at 10 km fiber length. But at 50km NRZ shows better results than RZ with a small difference in between their quality factor. Therefore, for short distance RZ provide good quality factor.

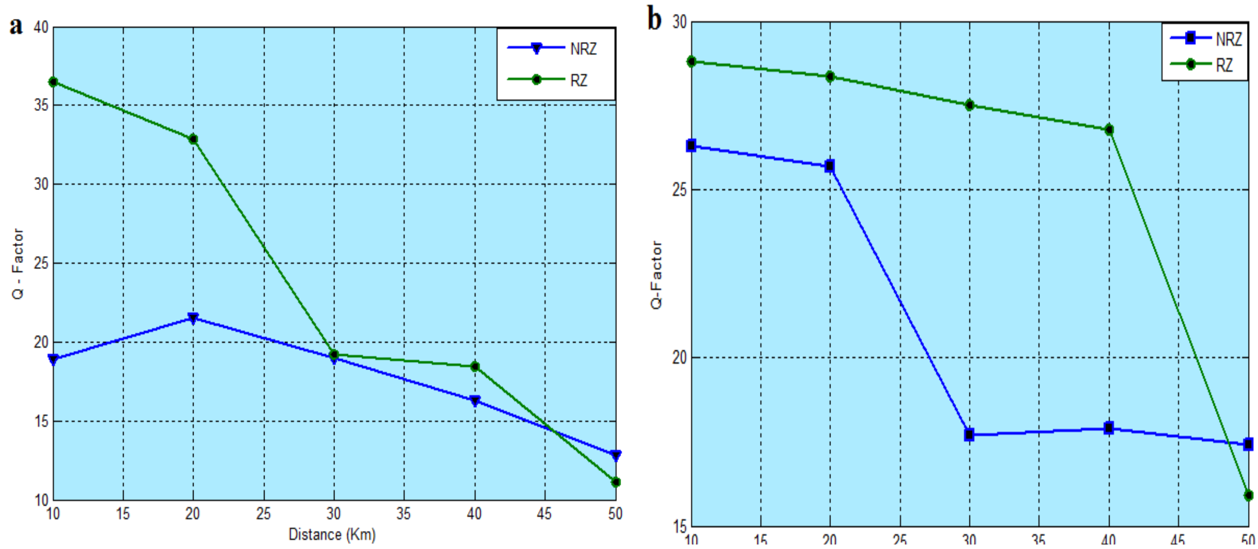

Fig.6. Distance Vs Q-Factor (a) Downlink (b) Uplink

The CW laser power in NGPON2 for downlink is varied from 5dBm to 10dBm in which with increase in power the received optical signal power also leads to increase as shown in Fig.7 (a). It shows that the Q-factor for NRZ varies from 17.33 – 27.12 for 5dBm to 10dBm laser input. But in case of RZ it varied from 27.12 to 37.73. Fig.7 (b) shows that the BER decreases with power for both RZ and NRZ

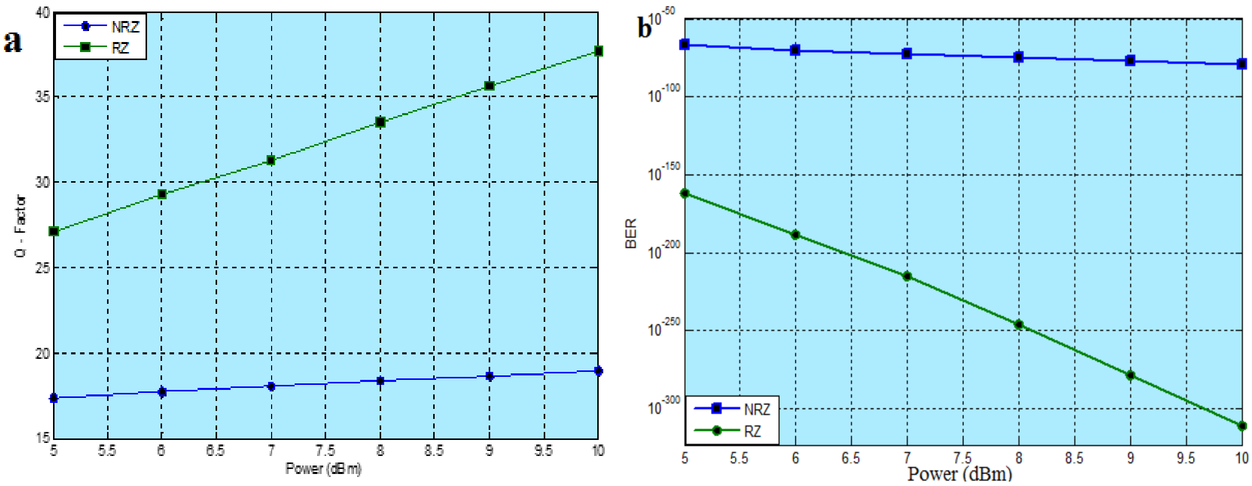

Fig.7. CW Laser Power Vs (a) Q-Factor (b) BER

The eye diagram of both uplink and downlink for both data formats NRZ and RZ as shown in Fig.8 and 9. This indicate in both formats RZ and NRZ eye opening is clear with less probability of noise. It also shows that’s uplink signal have better eye in both formats.

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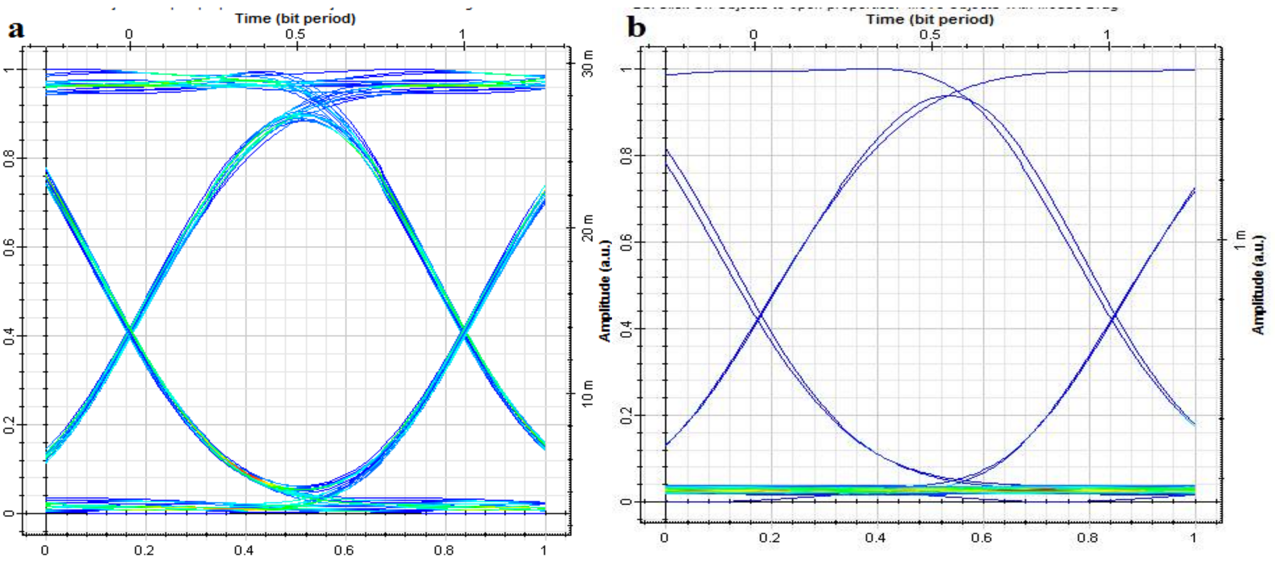

Fig.8. Eye Diagram OF NRZ Vs (a) Downlink (b) Uplink

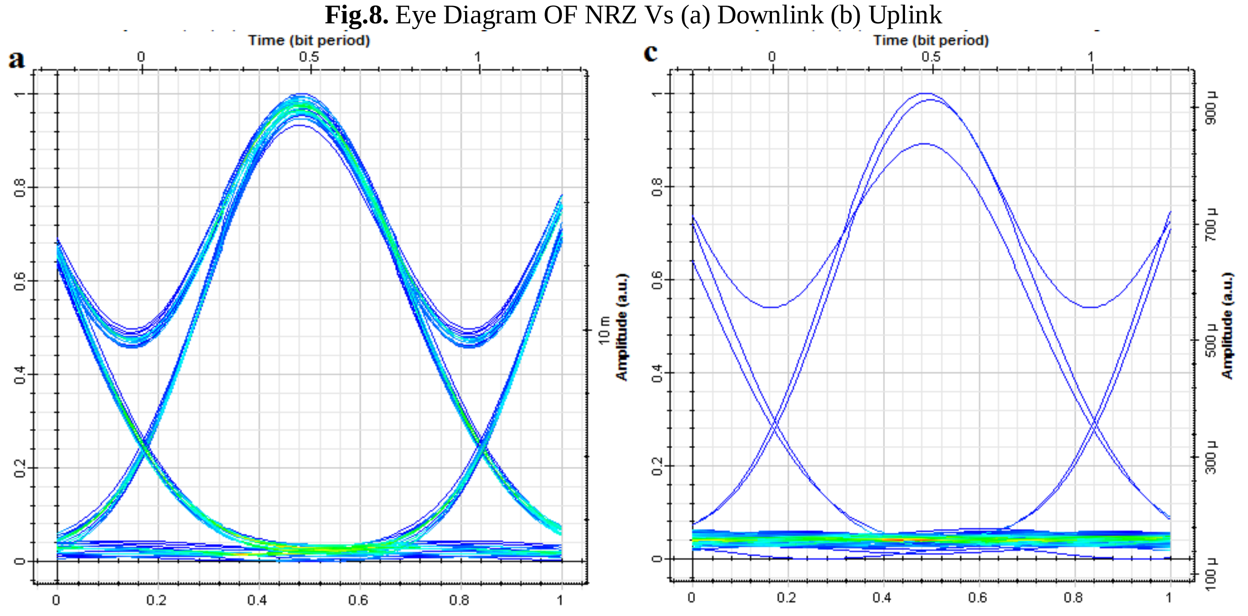

Fig.9. Eye Diagram OF RZ Vs (a) Downlink (b) Uplink

III.CONCLUSION

The second stage of next-generation passive optical network (NG-PON2) based on time and wavelength division multiplexed passive optical network (TWDM-PON) with increased capacity is proposed in this research to enhance the performance of communication systems. TWDM-PON was selected as the best candidate for NG-PON2 solution because of its ability to support the requirements of high data rate networks, such as enhanced bandwidth capacity, 80Gb/s, and coexistence with previously existing generations without any change to optical distribution network (ODN). There are two data formats are used such as RZ and NRZ. There simulation results taken by varied CW laser power and optical fiber lengths which shows that for short distance RZ shows better results but for large distances NRZ is better quality factor with less BER.In the future we will try to further enhance the bit rate and capacity of the next generation passive optical network.

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BIOGRAPHY

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