PERFORMANCE ANALYSIS OF WDM PONS BASED ON FP-LD USING RZ-OOK AND NRZ-OOK

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ABSTRACT

Transmission medium used for communication of signal from one point to another point are copper wire, coaxial cables, wave-guides and radio links. All these mediums have their own advantages and disadvantages. Wavelength Division Multiplexing Passive Optical Networks (WDM PONs) is optical based communication which introduces a good data transmission rate and large bandwidth. WDM PON is bidirectional PON system based on a Fabry-Perot laser diode (FP-LD) with two cascaded array waveguide gratings (AWGs). The downstream data rate equals to 10 Gbps and the upstream data rate equals to 2.5 Gbps. In downstream, CW laser with frequency (193.1 THz) is modulated by AM modulator using 10 Gbps non-return to zero (NRZ) downstream data to generate the desired downstream signal. The generated signal is sent over the bidirectional Optical Fiber. A circulator is used in the CO to separate the downstream and upstream traffic. The modulated signal is sent to ONU. At the ONU, using optical splitter/coupler, portion of the modulated signal is fed to a balanced receiver. For upstream other portion of the downstream modulated signal from the splitter/coupler is re-modulated using 2.5 Gbps NRZ upstream data by FP-LD in the ONU. The re-modulated OOK signal repasses through the bidirectional Optical Fiber. Performance of WDM PONs system using different modulation techniques such as NRZ-OOK, RZ-OOK has been analyzed and in the last comparison between different modulation techniques has been done. The performance of the system is analyzed by calculating bit error rate and quality factor.

***Keywords**: FP-LD, RZ-OOK, NRZ-OOK, AWGs, Colorless Transmission*

I. INTRODUCTION

WDM PONs is optical based communication which introduces a good data transmission rate and large bandwidth. WDM PON is bidirectional PON system based on a Fabry-Perot laser diode (FP-LD). FP-LD is considered as low cost optical source, it is less costly than other sources like distributed feedback (DFB) laser, vertical cavity surface emitting lasers (VCSELs) and reflective semiconductor optical amplifier (RSOA).AM Modulator is used at central office and AWGs are used at CO and ONU. Our proposed systems are low cost system and the injection locked FP-LD is used as low cost colorless transmitters for high speed optical access exploiting WDM technology. WDM PON architecture is categorized into three main parts which are Central Office (CO), bidirectional fiber channel and Optical Network Unit (ONU) as shown in Fig. 1. Central Office is a place of convergence where data arrives from one or more directions and is forwarded out in one or more directions. Optical network unit (ONU) is the user side equipment.

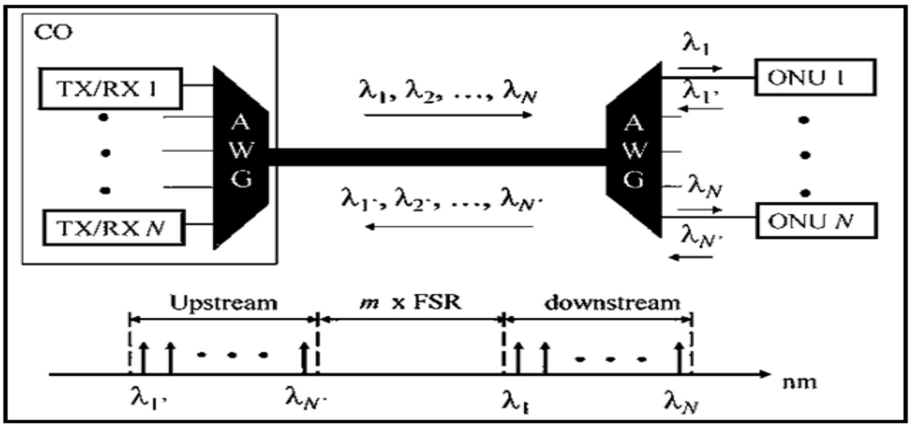

Fig.1 WDM-PON architecture

II DESIGN OF WDM PONS BASED ON FP-LD USING RZ-OOK

The first proposed PON architecture includes two cascaded AWGs at both CO and Remote Node RN with RZ-OOK as shown in Fig.2. In downstream, CW laser with 193.1 THz frequency is modulated by AM modulator using 10 Gbps NRZ downstream data to generate the desired downstream signal. The generated signal is sent to the first AWG at CO which multiplexed it and is sent over the bidirectional Optical Fiber. It passes through the second AWG at RN which multiplexed the input signal again. The multiplexed signal is sent to ONU. At the ONU, using optical splitter/coupler, portion of the multiplexed signal is fed to a balanced receiver. For upstream, other portion of the downstream multiplexed signal from the splitter/coupler is re-modulated using 2.5 Gbps NRZ upstream data by FP-LD in the ONU. The re-modulated signal repasses through the AWG which demultiplexed the upstream signal then it is sent over Bidirectional Optical Fiber. The upstream demultiplexed signal passes through the first AWG then it is received by CO. Circulator is used to avoid influencing the downstream signal, the upstream signal is sent to a PD is used to receive the upstream signal in the CO.

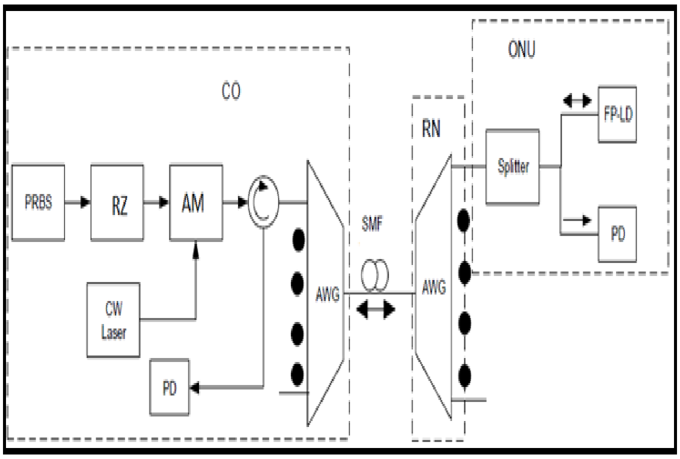

Fig.2 Block diagram of first bidirectional PON system model with RZ-OOK

2.1 Central Office

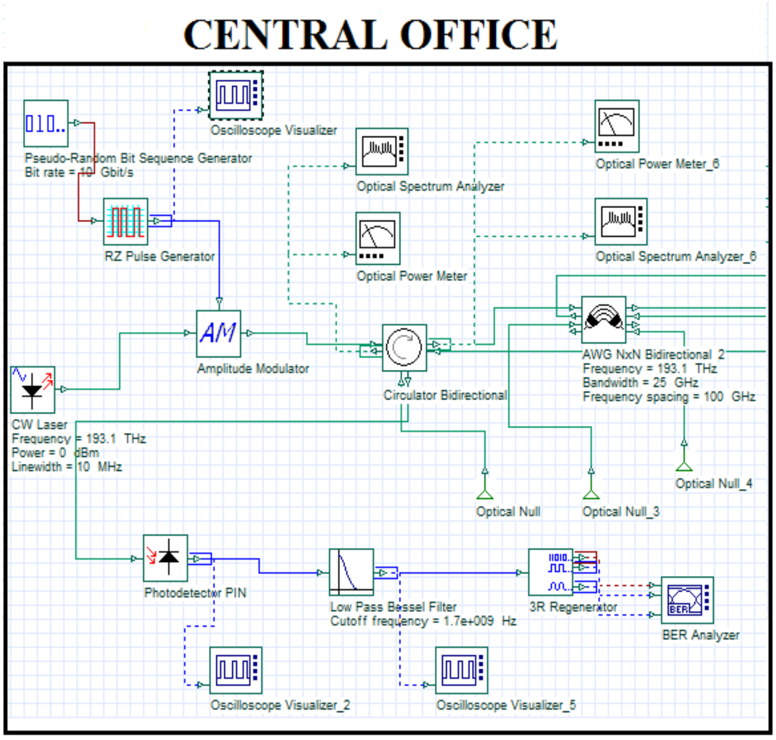

Fig.3 CO part in WDM PON with RZ-OOK

Transmitter includes PRBS generator, RZ generator, CW laser and AM modulator. Receiver contains PD, LPBF, 3R regenerator and BER analyzer.

2.2 Bidirectional channel Part

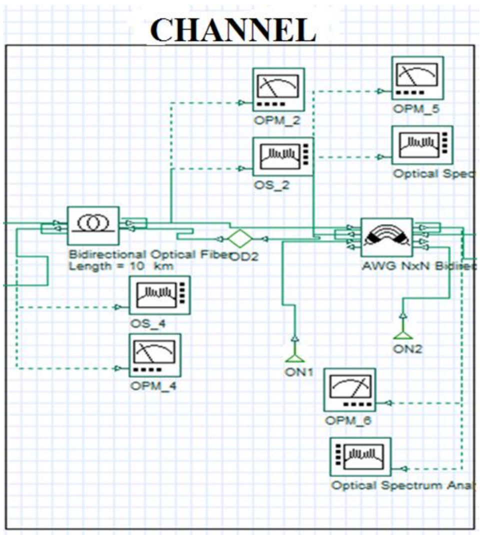

Fig.4 Bidirectional channel in WDM-PON with two cascaded AWGs

The channel includes bidirectional optical fiber as shown in Fig.4. A bidirectional single mode fiber of 10 km is used to forward the signal and to backward it with an optical delays of 1 unit in order to separate the upstream and downstream signals. The fiber cable has an attenuation loss of 0.2dB/km and length of 10 km, this means there is a 0.2 dB/km×10 km which equals to 2 dB power losses.

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2.3 ONU Part

The transceiver at ONU includes two parts, first part is used to receive the signal from CO and second part is used to send signal to CO as shown in Fig.4. ONU includes many components for receiving downstream signal and for transmitting upstream signal. Received signal components include Splitter, optical attenuator, PIN PD, LPBF, 3R regenerator and BER analyzer. Transmitted signal components include FP-LD, NRZ generator and PRBS generator.

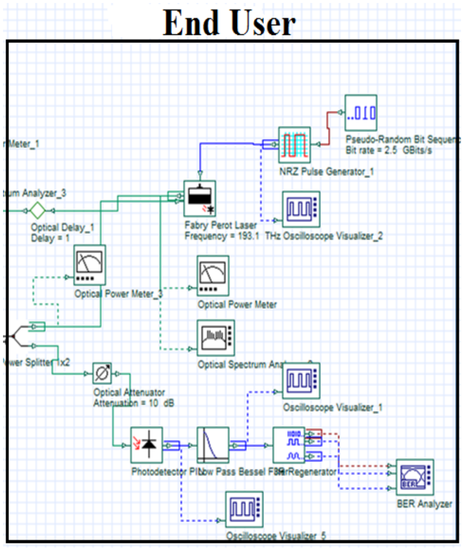

Fig.5 ONU part in WDM PON network

III DESIGN OF WDM PONS BASED ON FP-LD USING NRZ-OOK

The second proposed PON architecture includes two cascaded AWGs at both CO and RN with NRZ-OOK.as shown in Fig.6. In downstream, CW laser with 193.1 THz frequency is modulated by AM modulator using 10 Gbps NRZ downstream data to generate the desired downstream signal. The generated signal is sent to the first AWG at CO which multiplexed it and is sent over the bidirectional Optical Fiber.

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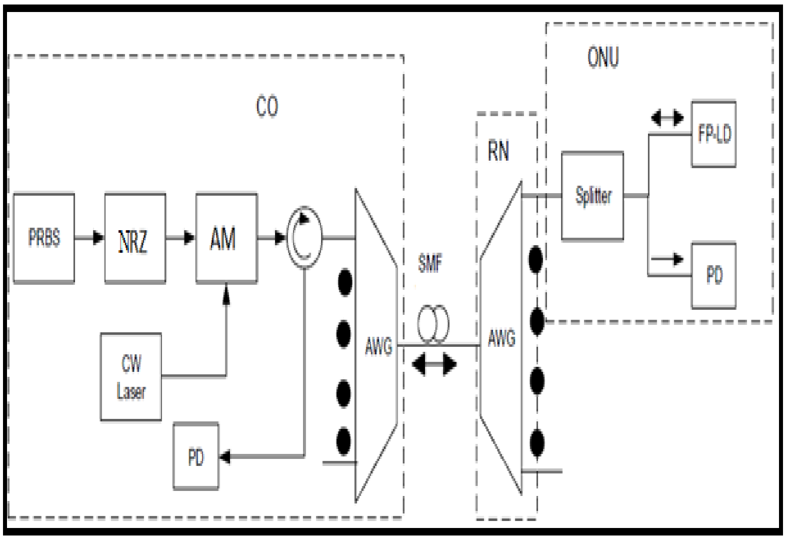

Fig.6 Block diagram of first bidirectional PON system model with NRZ OOK

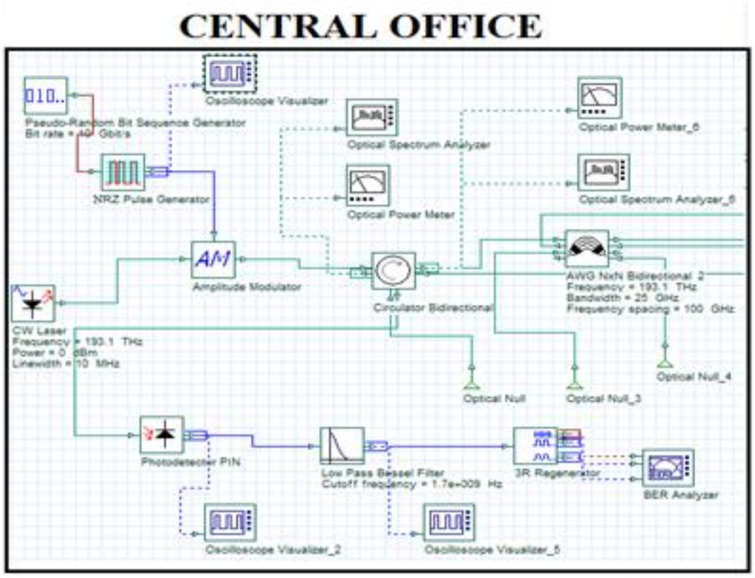

Fig.7 CO part in WDM PON with NRZ OOK Modulation

Bidirectional channel and ONU part used here is same as Fig.4 and Fig.5 and also working principle is same.

IV SIMULATION AND RESULTS

OptiSystem software is used for simulation. Optisystem software is an innovative optical communication system simulation package that designs, tests, and optimizes virtually any type of optical link in the physical layer of a broad spectrum of optical network.

4.1 Comparison on the results of the two proposed models with CW laser power variation

Effect of variation in CW laser power on the BER at CO and end user (ONU) for the two systems when the input power is fixed and it is equals to 0 dBm. All systems include FP-LD at end user for sending upstream signal. First model "WDM PON System based on FP-LD with RZ-OOK" have minimum BER of downstream signal equals to 2.35371e-011while second model "WDM PON System based on FP-LD with NRZ-OOK" have minimum BER for downstream signal 2.85646e-017. Also for first model minimum upstream BER is 3.3747e-009 and for second model minimum BER with upstream is 1.7609e-013.

Table 1 Comparison between two proposed PON models

S.No.	CW Laser Power (dBm)	WDM PON with RZ-OOK		WDM PON with NRZ-OOK	
		Downstream BER	Upstream BER	Downstream BER	Upstream BER
1.	0	2.35371e-011	3.3747e-009	2.85646e-017	1.7609e-013
2.	1	3.03521e-015	1.4251e-012	1.25056e-021	8.66847e-017
3.	2	1.17618e-016	6.24379e-014	5.51024e-024	7.07996e-018
4.	3	1.51232e-019	1.01232e-018	5.03655e-029	2.15411e-023
5.	4	8.9804e-023	1.1805e-022	2.62801e-033	2.11451e-025
6.	5	7.78229e-024	2.79583e-026	2.88596e-030	1.057e-029
7.	6	8.35113e-025	2.85363e-027	8.7651e-036	1.71036e-030
8.	7	4.65699e-030	4.80838e-029	4.74592e-041	1.51062e-031

So second proposed model "WDM PON System based on FP-LD with NRZ-OOK is better than first model "WDM PON System based on FP-LD with RZ-OOK" because the downstream and upstream BER values are good in second proposed system. Fig. 6 shows variation of Quality factor with different value of laser power. There is rise in the value of quality factor when laser power increases but NRZ gives better result.

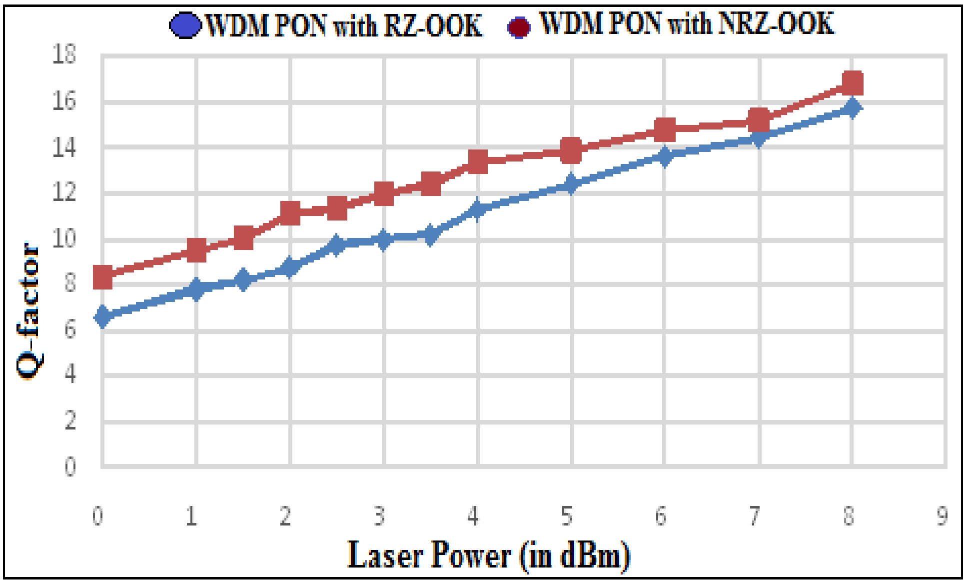

Fig.8 Graph shows variation of Quality Factor at ONU with different value of Laser Power for RZ-OOK and NRZ-OOK

4.2 Comparison on the results of the two proposed models with fiber length variation

Effect of variation in fiber length on the BER at end user (ONU) for the two systems when parameter of FP-LD is fixed.. First model “WDM PON System based on FP-LD with RZ-OOK” have minimum BER of downstream signal equals to 1.2537e-013 while second model “WDM PON System based on FP-LD with NRZ-OOK” have minimum BER for downstream signal equal to 1.68183e-026. Table 2 shows required comparison.

Table 2 Comparison between two proposed PON models

S.No.	Fiber Length (km)	WDM PON with RZ-OOK	WDM PON with NRZ-OOK
		Downstream BER	Downstream BER
1.	10	1.2537e-013	1.68183e-026
2.	12	3.9672e-014	1.37136e-024
3.	13	3.0561e-014	7.06577e-021
4.	14	3.52432e-011	6.22754e-017
5.	16	3.46068e-009	1.9318e-016
6.	18	1.54475e-008	7.14164e-014
7.	19	1.57333e-007	3.15471e-014
8.	20	7.74542e-006	1.92478e-012

So second proposed model “WDM PON System based on FP-LD with NRZ-OOK is better than first model “WDM PON System based on FP-LD with RZ-OOK” because the downstream BER values are good in second proposed system.

V CONCLUSION

Optical fiber based communication is modern medium of transmission which provide high bit rate that fulfill the demand of high speed internet. Performance of WDM PONs system using different modulation techniques such as NRZ-OOK, RZ-OOK has been analyzed by Optisystem software and in the last comparison between different modulation techniques has been done. First model “WDM PON System based on FP-LD with RZ-OOK” have minimum BER of downstream signal equals to 2.35371e-011while second model “WDM PON System based on FP-LD with NRZ-OOK” have minimum BER for downstream signal 2.85646e-017. Also for first model minimum upstream BER is 3.3747e-009 and for second model minimum BER with upstream is 1.7609e-013.So second proposed model “WDM PON System based on FP-LD with NRZ-OOK is better than first model “WDM PON System based on FP-LD with RZ-OOK” because the downstream and upstream BER values are good in second proposed system than first model .Also by using FP-LD cost of Optical Network Unit (ONU) reduces.

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