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Simulation & Performance Evaluation of Optical Access Network Based on WDM–PON

Riddhi H Solanki[1] , Harsha A Gupta[2], Ami Lavingia[3], Kruti Lavingia[4]

PG Student, Dept. of Electronics & Communication, SOCET, Ahemdabad, Gujarat, India[1]

Asst. Professor, Dept. of Electronics & Communication, SOCET, Ahemdabad, Gujarat, India[2]

Dept. of Electronics & Communication, Ahemdabad, Gujarat, India[3]

Asst. Professor, Dept. of Computer Science & Engineering, Nirma University, Ahemdabad, Gujarat, India[4]

ABSTRACT: WDM-PON with its low energy consumption and huge bandwidth availability has been considered to construct an optical access network. The architecture of WDM-PON is been introduced and its performance characteristics is analyzed. The WDM-PON architecture is a bidirectional high speed system consisting of passive components such as circulators and MUX/DEMUX. The introduced system is used to obtain a system bit rate of 40 Gbps. To reduce the overall cost of the proposed system, the bidirectional multiplexed technique is used. Quality factor, bit error rate, and eye diagrams are derived for different transmission distance as well as at various input power level and then it is used to compare the results in order to select the transmission distance that gives the best performance. The pulse shapes used in this paper are non-return to zero pulse. Upstream and downstream data are analyzed using bit error rate analyzer.

KEYWORDS: WDM-PON, Passive Network, RZ Modulation, Circulators, PON Communication.

I. INTRODUCTION

PON stands for Passive optical network which is a technology that modulates the light wave signal from optical line terminal (OLT) which is located at central office (CO) and transmits it through optical fiber to optical network units (ONUs) located at end user. It is designed to provide practically unlimited bandwidth to the subscribers. Passive Optical Network (PON) has earned interest in recent years from network providers and researchers alike due to their tremendous economic advantages for application in last mile services and optical sensing.[1] PONs introduces a good data transmission rate and large bandwidth. It is demonstrated that it is a bidirectional PON system. It is a point to multipoint technology. The PON system can be described as fiber-to-the-curb (FTTC), fiber-to-the building (FTTB), or fiber-to-the-home (FTTH).

Any PON system consists of three main parts:

- Optical line terminal (OLT) at central office (CO)
- Remote node (RN) such as passive splitter or array waveguide grating (AWG) in the channel
- Optical network unit (ONU) at end user.

PON networks can be classified into different forms such as broadband PON (BPON), Ethernet PON (EPON), Gigabit PON (GPON), and WDM PON.

The rest of the paper is organized as follows. Section 2 presents the architecture of simulated WDM-PON bidirectional high speed system consisting of circulators and MUX/DEMUX. And a 40 Gbps bidirectional WDM-PON is constructed and simulated by using Optisystem. In Section 3, the performance of the 40 Gbps bidirectional WDM-PON is analyzed. Finally, we conclude the paper in Section 4.

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II. DESIGN & SIMULATION SETUP

The architecture of bidirectional WDM-PON using single fiber based on circulator is shown in Figure. The isolation of optical signals of uplink and downlink can be done using circulators, and hence to realize bidirectional transmission in single fiber. The burst data from clients are uploaded using uplinks and downlinks are applied to transmission download multimedia data to clients, such as audio, video and data services. Bidirectional single fiber WDM-PON can reduce the use of fiber links, as well as the number of network equipments, and hence reduce energy consumption and the cost. [2]

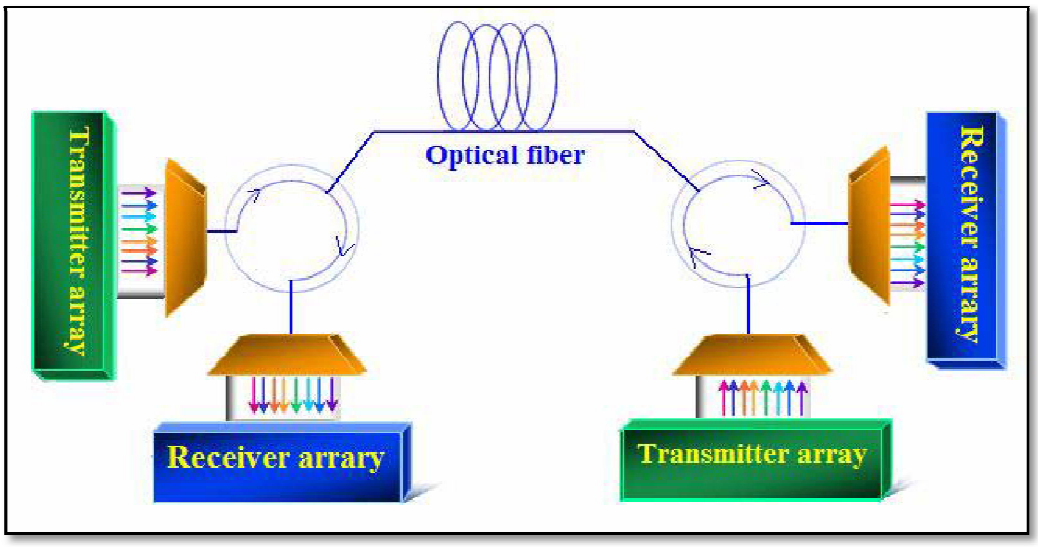

Figure 1: The architecture of bidirectional WDM-PON using single fiber based on circulator [2]

Simulation Setup:

The proposed algorithm is shown in figure 2. The algorithm consists of continuous wave laser as an input light source. Return-to-zero modulation is used and the signal is modulated using Mach-Zehnder Modulator (MZM) at OLT at central office. It is a bidirectional PON system. Four optical signals are multiplexed using MUX. The frequencies of downlink signals are 193.1 THz to 193.4 THz, and that of uplink signals are 228.2 THz to 228.5 THz. Circulators are placed in between the links to isolate the uplink and downlink signals.

At the ONU receiver side photoelectric PIN detector is placed which is followed by low pass Bessel filter and 3R generators. The performance is measured in terms of eye diagram, Q-factor and BER with the use of optical visualizer. BER analyzer is taken as visualizer. The PON link is simulated at 40 Gbps for both uplink and downlink data signals.x.

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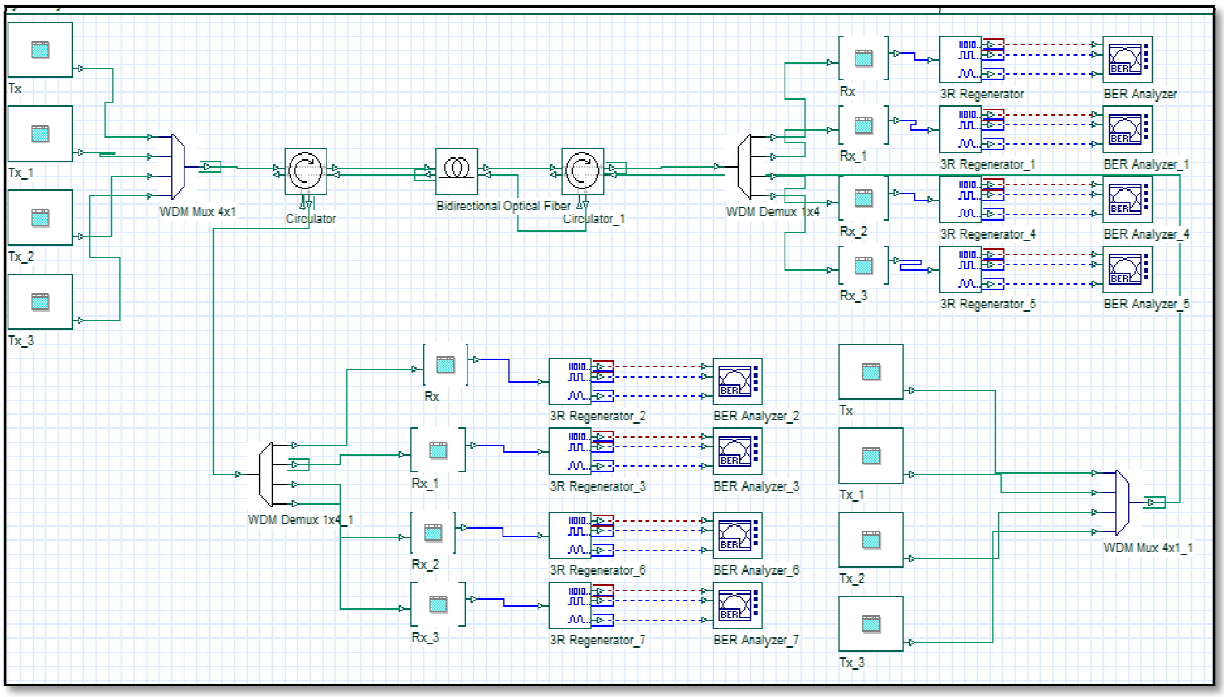

Figure 2: WDM – PON Simulation Link

The following table shows the list of parameters considered during the simulation of WDM-PON link.

Table 1: Simulation Parameters

Parameters	Values
Bit Rate	40 Gbps
Modulation	Return-to-Zero
Distance	5,10,15,20,25,30,35.40 kms
Power	0dbm, 5dbm, 10dbm
Downlink Signal Frequencies	193.1 to 193.4 THz
Uplink Signal Frequencies	228.2 to 228.5 THz

III. RESULTS & SIMULATION

It is simulated the optical link working at 40 Gbps. The non- linear effects at different transmission distance is taken into consideration. The nonlinear effects are analyzed in terms Q Factor, BER with the use of Eye Diagrams.

Following table shows the impact of nonlinear effects on the Q-factor in accordance to the increase in transmission distance for RZ modulation.

The signals are analyzed at the various input power level i.e., 0dbm, 5dbm, 10dbm at different transmission distances varying from 5km to 40 km. The value of Q-factor and BER is shown in below table at different distance.

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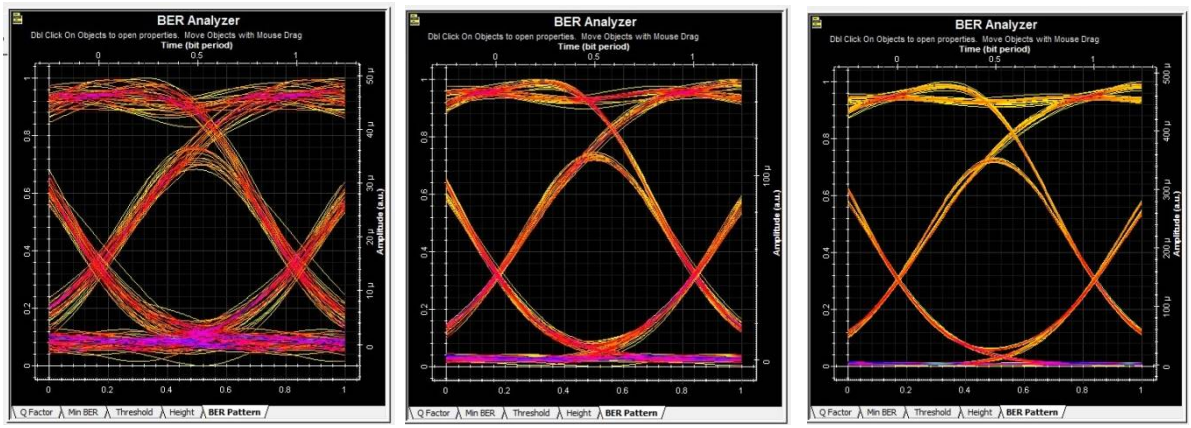
Table 2: Q-factor Result

Power	5 km	10 km	15 km	20 km	25 km	30 km	35 km	40 km
0dbm	9.27	9.35	9.01	8.88	8.22	7.50	7.46	7.14
5dbm	9.53	9.56	9.34	9.24	8.87	8.45	8.44	8.07
10dbm	9.59	9.57	9.38	9.27	9.03	8.74	8.67	8.25

Table 3: BER Result

Power	5 km	10 km	15 km	20 km	25 km	30 km	35 km	40 km
0dbm	6.5E-021	3.2E-021	7.7E-020	2.4E-019	8.4E-017	2.6E-014	3.7E-014	4.2E-013
5dbm	5.3E-022	3.9E-022	3.4E-021	8.3E-021	2.6E-019	1.1E-017	1.2E-017	2.9E-016
10dbm	2.8E-022	3.7E-022	2.3E-021	6.3E-021	6.4E-020	8.4E-019	1.6E-018	6.1E-017

From the table it can be seen that, as the transmission distance increases the value of Q-factor decreases. That is, the signal gets distorted on increase in distance. The eye diagram at 40 km for input power 0dbm, 5dbm and 10dbm is shown in figure 3.



(a) (b) (c)

Figure 3: Eye diagram at input power of (a) 0dbm (b) 5dbm (c) 10dbm.

From the eye pattern it can be seen that as the power level increases the signal gets more cleared. The effect of distortion gets more nullified. But as the input power level gets increased, the effect of nonlinearities affects the performance of output signals. But, with greater input power level, the transmission distance can be increased such as at that distance. The better eye pattern got with sufficient value of Q-factor and lower bit error rate. So, the power level should be kept, considering both the parameters.

IV. CONCLUSION

WDM-PON with its low energy consumption and huge bandwidth availability has been proved as an efficient solution for the future access networks. In this paper, we designed a bidirectional high speed WDM-PON using single fiber based on circulator. It is demonstrated that 40 Gbps WDM-PON by the simulation, and analyzed the impact of optical power and the transmission distance on the performance of the WDM-PON. As the power increases, performance gets better for longer distance. In addition, reasonable design of parameters i.e., input optical power helps to achieve better performance and reduce energy consumption and the cost.

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