Performance Analysis of Hybrid Passive Optical Networks in Smart Cities Using NRZ and RZ coding

Anjumanara Begam[1], Dr. Md. Asraful Sekh[2]
[1,2]*Member, Aliah University*

***Abstract*- In optical communication system one of the biggest challenges is large bandwidth requirement. The principle of Optical Access Networks can solve the issue. Here in this paper, we have designed Hybrid Passive Optical Networks which can increase the bandwidth. Here we have changed some parameters like NRZ, RZ to improve the data transmission and also used EDFA to enhance the performance. Opti System 13 has been used to simulate the design and check its results.**

Keywords- Passive optical networks, Hybrid-PON, Wavelength Division Multiplexing, Time Division Multiplexing, EDFA, Q factor, BER etc.

I. INTRODUCTION

This paper is based on the performance analysis Hybrid Passive Optical Networks. It is the combination of WDM and TDM.Wavelength division multiplexing which is used in passive optical networks. In this paper we can use an option of comparing different output by changing some parameter for advanced optical network designs. The total optical power budget can be controlled by the parameters in optical access infrastructures. Fiber to the home (FTTH) is very much useful to our daily life because of its power saving nature. It provides large band width and long reach data transmission. Triple Play services (data, voice, and video) can be done. FTTH is being the best solution for providing advanced data transmission. Passive Optical Network (PON) provides very high bandwidth to the customers. Passive Optical Networks can reduce the power requirements. In Passive Optical Networks we can off the unused section if we want. the Point-to-MultiPoint (P2MP) topology is used for Passive Optical Networks. In case of Wavelength Division Multiplexing (WDM) PON allows higher bandwidth because each wavelength is dedicated to a single subscriber throughout the total time duration. The WDM PON offers strong network security.

In TDM-PON a power splitter is used. Where it can transmit the stream of incoming wavelengths to its multiple output ports. So, all transmitted wavelengths from the OLT are split to each output port of the splitter, from where each ONU can receive the signals [5].

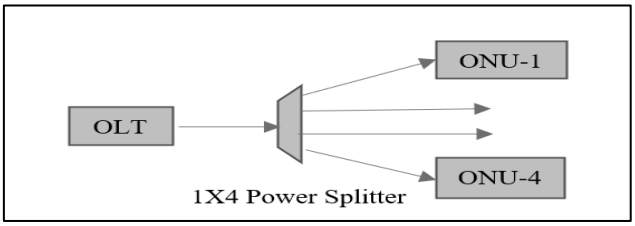

Fig. 1 TDM PON Architecture

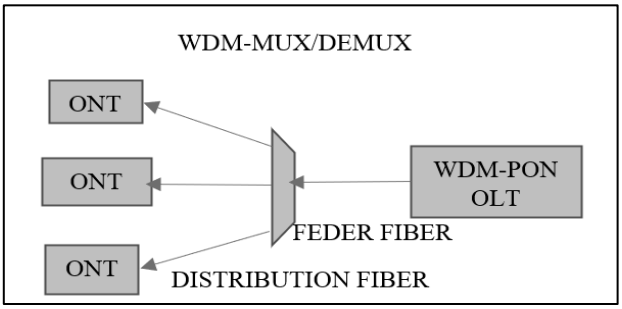

Fig. 2 WDM PON Architecture

A WDM Passive Optical Network can be built by a different wavelength channel, for both downstream and upstream directions. This technique produces a complete connection between the CO and each ONU, which will be different from the point-to-multipoint topology. Each ONU can utilize the full bit rate of individual wavelength channel. Different wavelengths may be work at different bit rates. But the TDM PON cannot support the requirements of future network evolution for bandwidth and the allowable power budget. A small number of users with low speed and for short distances can be covered [7]. These problems can be mitigated with Wavelength Division Multiplexed Passive Optical Networks (WDM PONs), where ONUs are assigned for individual wavelengths. WDM PON allows one to support higher bandwidth since each wavelength is dedicated to a single subscriber.

A Passive Optical Networks (PON) is a highly cost-effective. It gives passive optical path between the service provider (SP) or optical line terminal (OLT) and the user

device or optical network unit (ONU). In this path we can use fibers and optical passive splitters/combiners. WDM and TDM system can be used here. Because both have some advantages and disadvantages. Hybrid WDM/TDM PON is a good solution for next generation broadband access technology. To provide the advantages of WDM PON and to enhance WDM PONs output with the existing TDM based PONs, here in this paper Hybrid TDM/WDM architectures have been proposed. Hybrid architectures is advantageous as it can combine the advantages of WDM-TDM PON networks. Large bandwidth capacity will be helpful for data transmission and network can be well utilized. Based on the network utilization bandwidth can be set as per requirements, because it has huge difference between home or any business buildings. Hybrid PONs architectures provide cost-effective, long reach and large bandwidth to the customer as per requirement. Here we have designed Hybrid PON with best utilization and got good results.

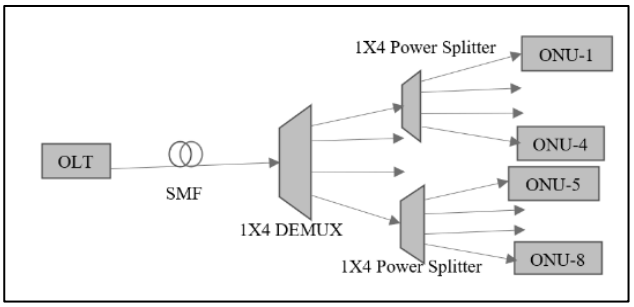

Fig. 3 Hybrid PON Architecture

In this paper, we can analysis the performance of hybrid WDM/TDM PON in terms of Q-factor and BER [3]. First, we have taken the generated bit sequences. This bit sequence is then fed into a NRZ pulse generator which transforms the bit sequences into NRZ pulses. These pulses are modulated using a Mach-Zehnder Modulator. Here P2MP network architecture, improves the data transmission between office or home or in any wide area connection. One self-contained wavelength channel comes from OLT terminal to each ONU unit must be utilized for both downstream and upstream directions without any interference. P2MP connection is created between OLT and ONU equipment's. Different wavelength channels can be used for different bit rates. In light of these different properties, a demand is created for a hybrid network that can give positive characteristics of both of these multiplexes (WDM/TDM) and we can get better result. By changing some parameters, we can also find the best performance results.

II. SYSTEM DESIGN

We have design hybrid PON using Opti System version.17. Two different wavelengths 193.1 THz and 193.2 THz with Bit rate 2.5 Gbps is generated pulse generator is used here. Optical fiber lengths 50KM taken and we have used WDM MUX and DEMUX. Also we have used two 1X2 power splitters. From BER analyzer to see the Q factor value and EYE diagram.

We have changed some parameters like RZ instead of NRZ and used EDFA (Erbium doped fiber amplifier). After modification we got better result. Some measuring instruments like optical spectrum analyzer, BER analyzer and eye diagram analyzer are used here.

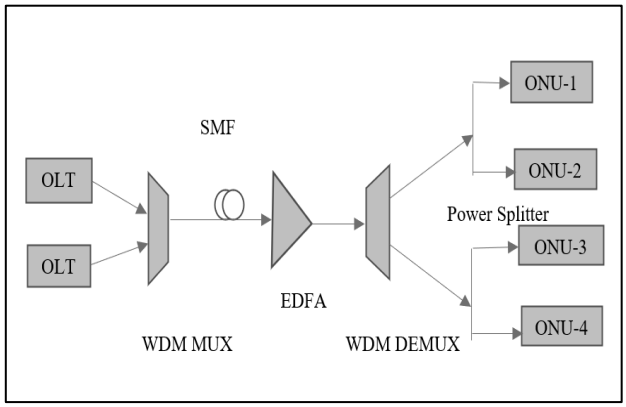

Fig. 4 Simulation setup for Hybrid PON system

Actually Q-factor is a parameter to measure the signal quality and the transmission performance for determining the BER. The Q-factor is defined as -

$$Q=\frac{m1-m0}{\sigma1+\sigma0} \quad (1)$$

Where m1, m0 are the average value of the receiving signal at sampling instants when a logical 1 or 0 is transmitted and $\sigma1, \sigma0,$ are the standard deviations.

The bit error rate defines as the percentage of error bits divided by the total number of transferred bits during a fixed time interval [12]. It is commonly expressed as tens to a negative power. If BER is low, the performance will be better. With respect to the Q-factor, the BER can be expressed by -

$$BER=\frac{1}{2}\text{erfc}\ \frac{Q}{\sqrt{2}} \quad (2)$$

In eye diagram, the best time for sampling of a received waveform is when the height of eye opening as large as possible. But for amplitude distortion in the signal the eye height can be reduced. For a good result we can take vertical distance between the maximum signal level and the top of the eye opening.

III. RESULTS AND DISCUSSION

Eye diagram can describe the quality of the received signal with respect to the transmitted signal. In the absence of noise or in error-free transmission, the eye height must be kept some large vertical opening, otherwise it will give some interference between symbols which will create some errors. Therefore, the higher vertical opening means the greater immunity to noise signal. In The transmitter of above architecture is shown in "Fig.4". The pseudo random bit sequence generator will generate bit sequences (either 1 or 0) in random manner. We assumed that the given information that is to be transmitted. This bit sequence generator is then fed into a NRZ pulse generator which transforms the bit sequences into NRZ pulses. These pulses are modulated using a Mach-Zender Modulator with the carrier power coming from the laser sources with low attenuation. On the receiver side as shown in "Fig.4", the photo detector converts the optical signal into electrical signal. This signal is then passed through a low pass Bessel's filter and then through a 3R regenerator [12]. The Bessel's filter considerably reduces the peak overshoot. The regenerator reconstructs and regenerates the signal and feeds it into a BER analyser where the output signal can be visualised. By which we can determine the performance factors like-Q Factor, BER, Eye Height etc.

NRZ (Non-Return-to-Zero) coding is a line code in which binary value 1 is represented by positive voltage and 0 is represented by negative voltage shown in Fig.5. It requires only half the bandwidth than other coding. NRZ codes are easy and it makes efficient use of bandwidth. In RZ (Return-to-Zero) encoding, a binary 1 is represented by first half of the bit duration, during the second half the level returns to zero. Absence of a pulse represents a binary 0, during the entire bit duration. Twice the bandwidth is required for RZ coding, because for data transmission it takes only half a bit duration time.

The output of BER analyser is shown in "Fig.6" and "Fig. 7" where the output curves of the receivers in the OLT and ONU respectively, plotted between Q-factor and bit period.

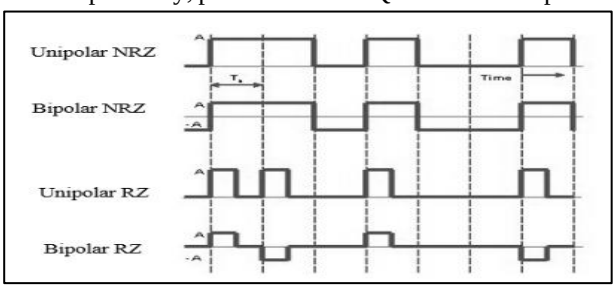

Fig. 5 NRZ and RZ format

The variation of Q Factor as a function of fiber length for different bit rates is shown in "Fig. 5". It is found that as the bit rate increases the Q-factor decreases. NRZ is better for 1 Gbps while RZ is better for 5 and 10 Gbps. For large bandwidth requirement can be provided by the current access network [8]. TDM and WDM PON technologies provide a solution for next generation data transmission. Although it has its own pros and cons. So, the best way to create a Hybrid WDM/TDM PON that would have positive characteristics of both the multiplexing techniques. It can provide a solution for the drawbacks faced by TDM and WDM PON system. A comparative study of Hybrid WDM/TDM PON using different coding techniques, bit rates, input power and fiber length are done in this paper. It is simulated using Opti System software and the results were analyzed. Hybrid WDM/TDM PON offers very attractive solution for the future next generation access network.

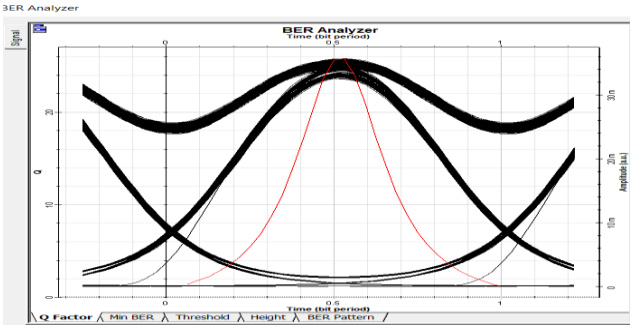

Fig. 6 Eye diagram with NRZ data signal

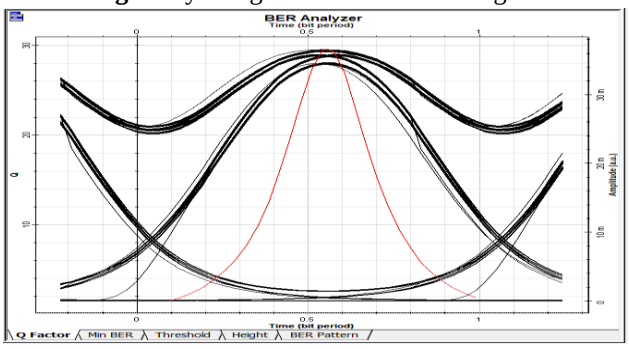

Fig. 7 Eye diagram with RZ data signal

Spectrum analyzer is used to observe the WDM multiplex signal when multiplexed signal with a spacing of minimum 1nm can be designed. Q factor is also observed [3].

Table 1. Analysis Of NRZ Coding

Parameter	BER Analyzer	BER Analyzer_1	BER Analyzer_2	BER Analyzer_3
Max. Q factor	24.1331	24.1371	23.0595	23.4513
Min. BER	1.0013×10^{-27}	1.0955×10^{-26}	1.2154×10^{-27}	1.1501×10^{-27}

Table 2. Analysis Of RZ Coding

Parameter	BER Analyzer	BER Analyzer_1	BER Analyzer_2	BER Analyzer_3
Max. Q factor	29.5566	28.6922	29.3322	29.95382
Min. BER	1.9215×10^{-30}	1.0023×10^{-30}	1.9561×10^{-29}	1.327×10^{-30}

From "Table 1" and "Table 2" we observed that Q factor and Minimum BER value can be improved by using RZ and EDFA. WDM/TDM PON increases the number of wavelengths in each stream to provide the high bandwidth of optical fibers.

Here Hybrid WDM/TDM PON deployed by smoothly reduce the advantages of TDM and FDM [5]. Hybrid PONs architectures provide cost-effective, long reach and large bandwidth to the customer as per requirement. Which gives low power consumption.

IV. CONCLUSION

Hybrid PON system offers a large coverage area, reduced fiber deployment as the result of its point-to-multipoint (P2MP) architecture, low cost of maintenance due to the use of passive components in the network. Low power consumption is required. WDM PON with RZ and EDFA provides improved performance. We have used flexible hybrid WDM-TDM PON architectures to utilize the advantages of both TDM-PON and WDM-PON. These architectures reduce the energy consumption and cost for variable traffic loads. Moreover, also provides additional desirable features such as large bandwidth, reliability, resiliency and broadcasting etc.

We observed that RZ format gives better performance on the basis of Q factor, bit error rate (BER) and eye opening. This research work helps to low power data transmission by RZ modulation format. It will be faithful for long distance communication. In future we can increase the number of users and also increase the data rate in PON system. A comparative study of Hybrid WDM/TDM PON using different coding techniques, bit rates, input power and fiber length are done. Hybrid WDM/TDM PON offers a great potential and a very good solution for the next generation access network.

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