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Implementation of Digital Moduation Techniques Using Radio over Fiber for Hybrid Passive Optical Networks

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Abstract: Hybrid gigabit-passive optical network (GPON) is a hybrid passive optical network, which integrates wavelength division multiplexing (WDM) and time division multiplexing (TDM) into a single passive optical network with reduced cost, high scalability and increased data rate. The objective of this paper is to investigate and analyze the performance of 8-DPSK and 16-QAM data modulation techniques for 5.1 Gbps, 5.5 Gbps, 6.5Gbps and 8.5 Gbps using 25 km single mode fiber. It is described that 16-QAM offers better performance at higher data rates than 8-DPSK modulation technique. The simulated model can support 32 and 64 users. The analysis have been made on the basis of the performance of eye diagram, constellation diagram, optical signal to noise ratio (OSNR) and received optical power.

Keywords: Hybrid WDM-TDM PON, digital modulation, radio over fiber, 8-DPSK, 16-QAM, DPSK, QAM, OSNR, eye diagram.

I. INTRODUCTION

The hybrid WDM TDM passive optical network is a prestigious architecture for next generation optical access network. It is an optimal combination of an optical backhaul and a wireless front-end for an efficient access network [1] [2]. A hybrid WDM/TDM Passive optical network (PON) combines the WDM domain with a TDM PON and can deliver both the benefits of an increased capacity delivered by WDM and the inherent capacity sharing of a TDM PON [3]. Hybrid multiplexing network are deployed and replace the ordinary optical network due to more versatile, survival and much integrated to existing technologies [4]. TDM-PON is not preferred to meet the demands of Next Generation Access (NGA) due to lower data rates and power splitting losses. The solution is provided by wavelength division multiplexed based networks (WDM-PONs) in which the capacity of the network can be enhanced by allocating different wavelengths to individual users who share a single fiber [5]. A set of wavelengths is shared over time by different ONUs instead of being dedicated as in WDM–PON [6]. The fiber-optic remoting of radio signals is used in the diversity of wireless networks [7]. Radio-over-fiber (RoF) is the fiber-wireless network (WiFi) [8] incorporating the analog transmission of the radio signals via optical backhaul networks. The concept of RoF involves modulation of optical signal by the radio frequency signal in the optical transmitter and is then fed to the optical fiber. At optical receiver, photo detector detects the modulated optical signal and converted into RF signal with the help of demodulator [9].

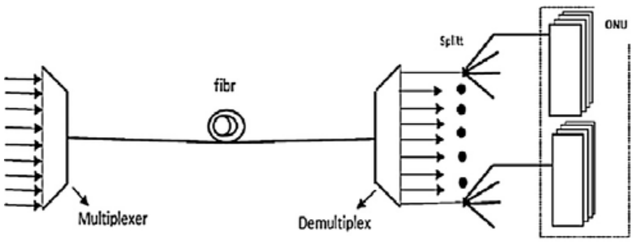


Figure 1: hybrid WDM TDM PON [10]

One of the attractive features of PONs has always been the long distance capability of the fiber medium, feasible to its low intrinsic loss and excellent immunity to interference and crosstalk. PON requires passive equipment, such as optical splitter or arrayed waveguide grating.[1]The passive optical networks are constituted of a centralized optical line terminal (OLT), located in the central office and a number of ONUs located at the users' premises to some distance away from the OLT[11]. In the upstream direction, the traffic is transmitted from the ONU to the OLT whereas in the downstream direction, the traffic is transmitted from the OLT to the ONU (optical network unit) through one fiber. [12][13].

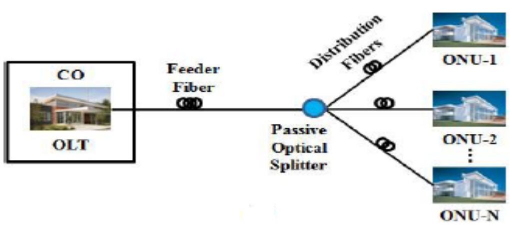


Figure 2: Passive optical network [13]

This paper is organized into six sections. In Section 1, introduction to hybrid passive optical networks is described.

In section 2, proposed techniques are discussed. In Section 3, hybrid architecture has been represented. In section 4, the simulation setup for downstream hybrid GPON is described. In Section 5, comparison of results for the different modulation formats has been presented. In Section 6, conclusion and future scope are made.

II. PROPOSED TECHNIQUES

In this paper, we use the hybrid WDM TDM PON architecture combined with radio over fiber (RoF) technique. the performance of network is compared for 8-DPSK and 16-QAM digital modulation for (5.1 Gbps. 5.5 Gbps, 6Gbps, 8Gbps) for 25 km optical fiber.

A. Radio over Fiber Technology

Radio-over-fiber (RoF) technique is an attractive scheme to provide transparent transmission of the radio signals via optical backhaul networks. The radio frequency signal (either modulated by an analog or digital modulation) can be transported by an analog fiber optic link. The RF signal is used to modulate the optical source in transmitter. The resulting optical signal is launched into an optical fiber. At optical receiver, modulated optical signal is converted into RF again, with the help of a demodulator [14]. Digitized RoF technique improves spectral efficiency, and also reduces the hardware count [15].

B. Multilevel Digital Modulation

Digital modulation techniques like M-DPSK, M-QAM provide high spectral efficiency and better utilization of bandwidth. Constellation results are given by using this formula [16]

$N=\log_2 M$

(1)

Here M represents the levels of modulation technique. In 8-DPSK signal where M=8, uses eight different phase shifts 45° apart to represent 3-bit code groups from 000 to 111.These codes are defined by the circle in the constellation diagram-QAM uses a combination of both amplitude and phase to represent multiple-bit words. QAM is usually square (M = symbols).Most common forms are 16-QAM, 64-QAM and 256-QAM used to transmit more bits per symbol [17].16QAM is the extension of DPSK encoding four bits into the phase difference of two consecutive symbols and in amplitude of each symbol. For higher data rates usually QAM is preferred since it can achieve a greater distance between adjacent points in the I-Q plane as the constellation points are more evenly distributed. But using QAM can lead to greater symbol errors [16] [18].

III. HYBRID ARCHITECTURE

Hybrid PON architecture system combines optical line terminal to the many number of optical network units through single optical fiber. The transmitters at the OLT generate a single wavelength carrying the data destined for a specific ONU. In the OLT, the RF signal is modulated by a DPSK sequence generator or a QAM pulse generator and combined with CW laser at wavelengths 193.1 THz and 193.2 THz. These wavelengths are then coupled onto a single fiber using WDM Multiplexer (MUX), with specific insertion loss located inside the CO. The frequency spacing is 100 GHz which makes the transmission Dense-WDM (DWDM). The output signal through a single mode fiber (SMF) of length 25 km terminates on a WDM Demultiplexer (DEMUX) as shown in Fig. 1. The WDM DEMUX separates all the wavelengths, according to the way they were combined at the OLT side, and feeds each one to a power splitter which distributes the signal to four users as shown in Fig. 3. The hybrid WDM/TDM PON consists of 8 ONUs as shown in Fig.4. They split into eight WDM groups, sharing eight wavelengths in a WDM mode. Within each group, four ONUs share one wavelength in a TDM mode. The frequency spacing is 100 GHz, which indicates Dense-WDM (DWDM) transmission [10[[17].

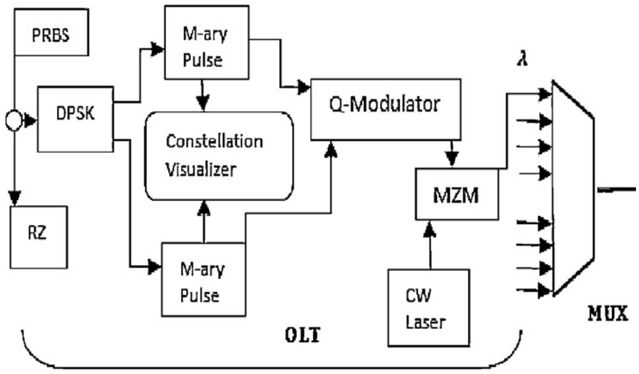


Figure 3: Schematic diagram of Optical Line Terminal (OLT) in hybrid PON [10]

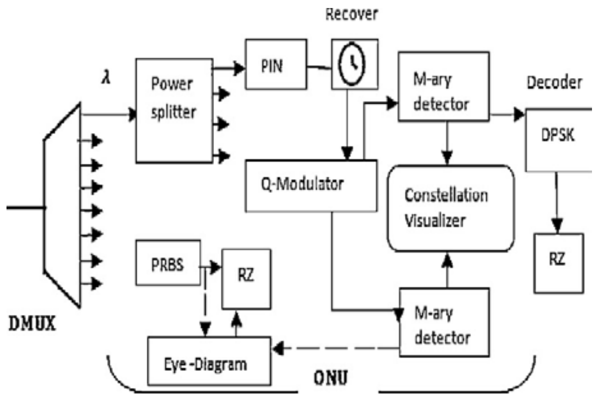


Figure 4: Schematic diagram of Optical Network Unit (ONU) in hybrid PON [10]

IV. SIMULATION DESIGN & SETUP

This section describes the simulation setup in OptiSystem 14. All necessary parameters are based on the GPON standardized properties [11].The architecture shown in schematic Fig.3 and Fig.4 is used to simulate the hybrid PON architecture, using 16-QAM over RoF for the downstream transmission only. The simulation of 8-DPSK modulation technique is discussed in [10]. The generation, transmission and reception of 16-QAM signals are discussed below.

TABLE 1: General parameters required for simulation.

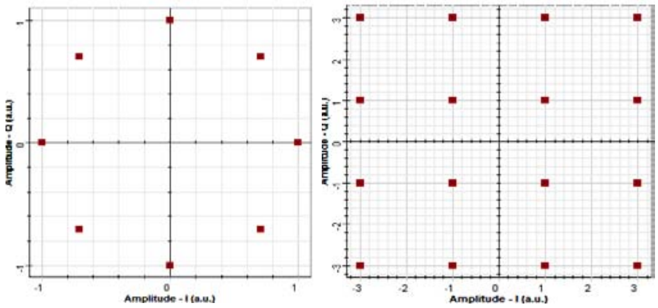
PARAMETERS	FOR 8DPSK	FOR 16QAM
RoF operating frequency	**12 GHz**	**12GHz**
Type of encoding	**DPSK**	**QAM**
Bit rate(Gbps)	**5.1Gbps**	**5.1Gbps**
Symbol rate(Gbps)	**Bit rate/3**	**Bit rate/4**
Sequence length	**128**	**512**
Samples per bit	**64**	**64**
Reference wavelength	**1550nm**	**1550nm**
Fiber length	**25km**	**25km**

As shown in table 1, for 8DPSK modulation, data signal with 5.1 Gbps bit rate is modulated by a radio frequency signal using a quadrature modulator at 12GHz.it uses 8 bits per symbol. For 16QAM modulation, data signal with 5.1 Gbps bit rate is modulated by a radio frequency signal using a quadrature modulator at 12 GHz. It uses 16 bits per symbol.

At the optical line terminal (OLT), the electrical data signal is generated by the pseudo-random bit sequence (PRBS) generator with 5.1Gbps bit rate. The data signal is modulated by a QAM pulse generator, using 4 bits/symbol to generate a 16-QAM signal. The QAM signal is fed into a quadrature modulator (QM) at 12 GHz. A CW laser diode is modulated at a frequency 193.1 THz by a MachZehnder Modulator (MZM) to convert the electrical signal into an optical signal which is transmitted through a 25 km single mode fiber (SMF). At the Optical network unit (ONU) in receiver, the signal is detected by a photodiode, amplified, and fed to clock recovery in order to recover the data stream before it is passed to a quadrature demodulator (QD). The output of the QD is fed to two M-ary threshold detectors (for I and Q signals respectively). The signal is quantized based on suitable value of threshold amplitudes. The constellation diagram of the signal is displayed by using an electrical constellation visualiser. An eye-diagram visualiser tool is used to plot the M-ary signal at the QM output of the receiver. A combination of PRBS generator, RZ generator and eye diagram analyzer are used to generate the eye-diagrams

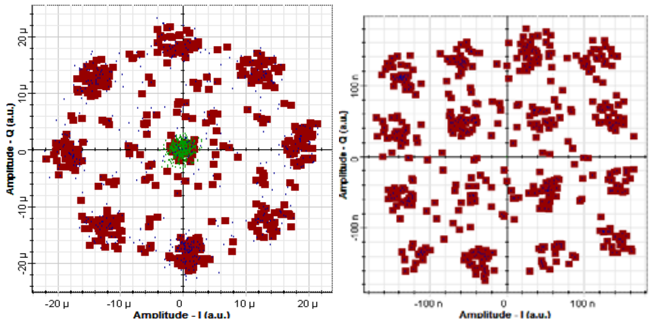
V. RESULTS AND DISCUSSIONS

Hybrid WDM-TDM passive optical network model has been simulated and analyzed by OptiSystem 14 software. The model has been constructed using the general parameters given in the Table 1.



a) b)

Figure 5: Ideal constellation diagrams at transmitter, for a) 8- DPSK, and b) 16-QAM

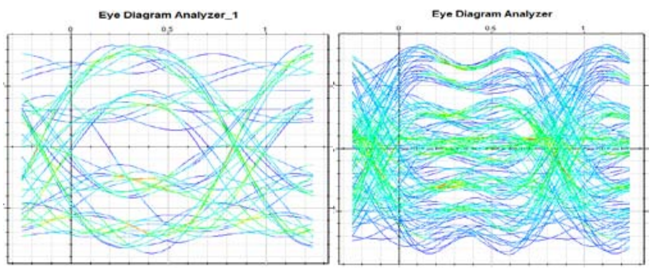


a) b)

Figure 6: Constellation diagrams at receiver, for a) 8-DPSK, and b) 16-QAM

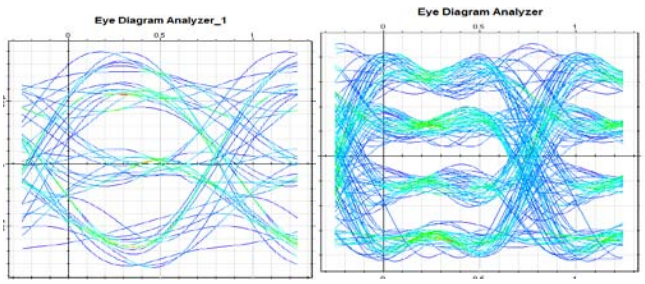
A constellation diagram is a representation of a signals modulated by a digital modulation scheme such as differential phase shift keying or quadrature amplitude modulation. It shows the phase and amplitude values for each symbol. For 8-DPSK signal, the number of bits per symbol is 3, while for 16-QAM it is 4 and the constellation results are given by formula .The constellation diagrams of the transmitted signals are shown in fig.5 (a) and 5(b) respectively. The received signal at the receiver is shown in Fig.6 (a) and 6(b). It is seen that the constellation of the output signal is similar to the input signal with some amplitude and phase error.

Eye diagrams are a good indicator to determine the performance of the system. The eye opening clearly indicates that the system performance is good.



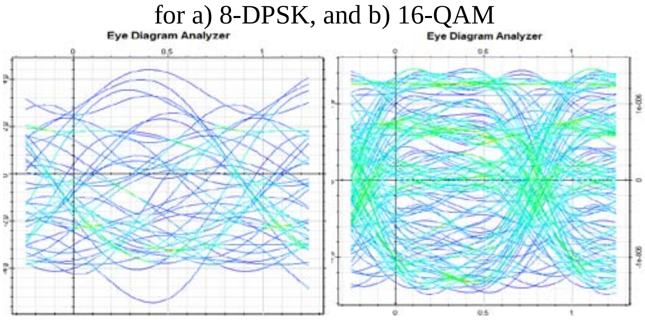
a) b)

Figure 7: Eye diagrams at receiver for 5.1 Gbps data rate, for a) 8-DPSK, and b) 16-QAM



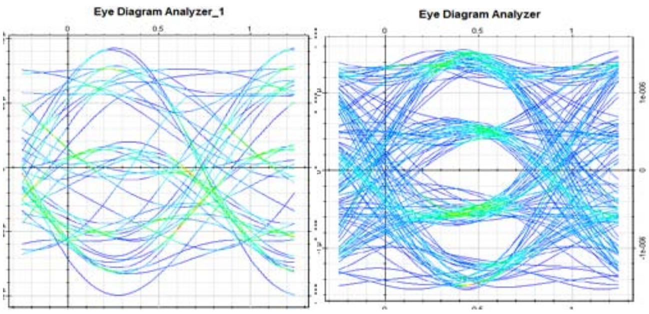
a) b)

Figure 8: Eye diagrams at receiver for 5.5 Gbps data rate, for a) 8-DPSK, and b) 16-QAM



a) b)

Figure 9: Eye diagrams at receiver for 6 Gbps data rate, for a) 8-DPSK, and b) 16-QAM



a) b)

Figure 10: Eye diagrams at receiver for 8 Gbps data rate, for a) 8-DPSK, and b) 16-QAM

The performance of 8-DPSK and 16-QAM has been compared at different data rates: 5.1Gbps, 5.5Gbps, 6Gbps and 8Gbps. At 5.1 Gbps, it is seen that the eye openings for both modulation techniques are wide, so performance is good as shown in Fig. 7(a) and 7(b). At 5.5 Gbps, the eye pattern for 8-DPSK and 16-QAM is still good is shown in Fig. 8(a) and 8(b). At 6 Gbps, the eye opening pattern for 8-DPSK is degraded, but for 16-QAM is still acceptable is shown in Fig. 9(a) and 9(b). Then again eye pattern is too good for both the modulation techniques is shown in Fig. 10(a) and 10(b).

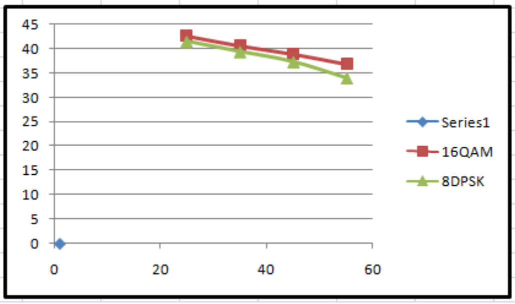


Figure 11: OSNR vs. fiber length at 5.1 Gbps

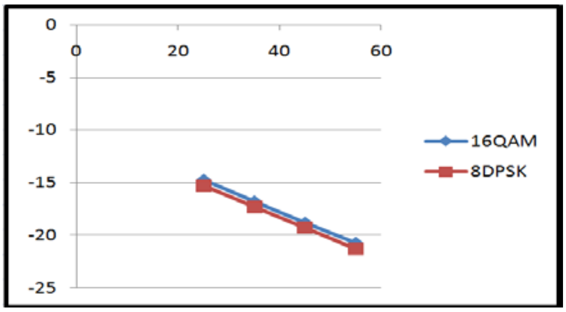


Figure 12: Received power vs. fiber length at 5.1 Gbps

For 8-DPSK and 16-QAM, the optical SNR (OSNR) performance for the varying fiber lengths, at 5.1 Gbps is shown in Fig. 11. It can be seen that the OSNR at 0.1 nm bandwidth displays a decreasing pattern as the length of the fiber increases. The graph for both techniques is almost the same. Value of OSNR is slightly higher for 16-QAM.

Fig. 12 illustrates the received optical versus the fiber length. The power (dBm) is found to be reduced linearly with increasing fiber length due to attenuation. The optical power at the transmitter is 0 dBm. It can be seen from Fig. 12, that, the received optical power is around−21.2 dBm for both 8-DPSK and -20.6 dBm 16 QAM. The power is reduced due to attenuation, dispersion, and losses which are contributed to by all devices of the network.

VI. CONCLUSION AND FUTURE WORK

The Hybrid WDM-TDM PON using RoF, with 8-DPSK and 16-QAM techniques were analyzed. The performance of the two methods was compared on the basis of constellation diagram, eye diagram, OSNR and received power. In 16-QAM, as we have seen the symbol rate obtained at the output of the quadrature modulator is 1/4 of the data rate, compared to 1/3 of data rate for 8- DPSK. Thus the spectral efficiency is improved. However, it is likely that 16-QAM will suffer from more symbol errors because of signal impairments, as there are a greater number of phase shifts, which is shown by shift in constellation points from their ideal positions. The OSNR and received optical power graphs are better for 16 QAM as compare to 8 DPSK. Good eye opening pattern for 16- QAM offers a better performance, which is noticeable at higher data rates. It has been seen that acceptable performance is obtained at 5.1 Gbps .The eye opening pattern is quite good, but still with some shifts in constellation point. The 16-QAM modulation scheme, although leading to better performance, suffers from symbol errors at high data rates. Measurement of phase and amplitude errors can be estimated by error vector magnitude (EVM).In future our main focus will be to reduce symbol errors. The various types of modulation techniques like 32-QAM, 64- QAM offer promising solutions but can lead to high bit / symbol error rates in conventional design.

REFERENCES

[1] https://en.wikipedia.org/wiki/Passive_optical network.

[2] R. Q. Shaddad, A. B. Mohammad, S. A. Al-Gailani, E. F. Aon, "Scalability Analysis of Hybrid Optical Wireless Access Network (HOWAN)", IEEE 10th International

Colloquium on Signal Processing & its Applications, pp. 48-52, 2014.

[3] G. Das, B. Lannoo, D. Colle, M. Pickavet, P. Demeester, "Flexible hybrid WDM/TDM PON architectures using wavelength selective switches", Optical Switching and Networking,Vol. 9, Issue 2 ,pp. 156–169, 2012.

[4] .S. Singh, S. singh, "Performance analysis of hybrid WDM-OTDM optical multicast overlay system employing 120 Gbps polarization and subcarrier multiplexed unicast signal with 40 Gbps multicast signal", Optics Communications, vol. 385, pp. 36–42, 2017.

[5] A. Kaur, B. Kaur; K. Singh, "Design and Performance analysis of Bidirectional TWDM-.PON employing QAM-OFDM for Downstream and Re-modulation for Upstream", Optik - International Journal for Light and Electron Optics, Jan 2017.

[6] F. J. Effenberger, J. Kani, and Y. Maeda, "Standardization Trends and Prospective Views on the Next Generation of Broadband Optical Access Systems", IEEE Journal on selected areas in communications, vol. 28, Issue no. 6, August 2010.

[7] D. Novak, R.B. Waterhouse, A. Nirmalathas, C. Lim, P.A. Gamage, T.R. Clark,M.L. Dennis and J.A. Nanzer, "Radio-Over-Fiber Technologies for Emerging Wireless Systems," IEEE Journal of Quantum Electronics, vol. 52, Issue no. 1, pp. 1-11, 2015

[8] S. Mitatha, R. Putthacharoen and P.P. Yupapin, "THz frequency bands generation for Radio-over-Fiber systems", Optik-International Journal for Light and Electron Optics, vol. 123, Issue 11, pp. 974-977, 2012.

[9] V. Sarup and A. Gupta, "A Study of various Trends and Enabling Technologies in Radio over Fiber (RoF) Systems", Optik-International Journal for Light and Electron Optics, vol. 126, Issue no. 20, pp. 2606-2611, 2015

[10] A.O. Aldhaibani, S. Yaakob, R.Q. Shaddad, S.M. Idrus, M.Z.A. Kadir and A.B.Mohammad, "2.5 Gb/s hybrid WDM/TDM PON using radio over fiber technique, "Optik-International Journal for Light and Electron Optics", vol. 124,pp. 3678-3681,2013.

[11] https://www.itu.int/itudoc/gs/promo/tsb/85155.pdf.

[12] M. D. Andrade, A. Buttaboni, M. Tornatore,P. Boffi, P. Martelli,A. Pattavina, "Optimization of long-reach TDM/WDM passive optical networks", Optical Switching and Networking, vol. 16, pp. 36–45, 2015.

[13] M.. S Ahsan, M. S. Lee, S. H. Shah Newaz and Syed Md. Asif, "Migration to the Next Generation Optical Access Network", journal of networks, vol. 6, Issue no. 1, pp. 18-25,january 2011.

[14] Y. Yang, C. Lim, A. Nirmalathas, "Experimental demonstration of multi-service hybrid fiber-radio system using digitized RF over fiber technique," Journal of Lightwave Technology, pp. 2131–2137, july 2011.

[15] R. P. Almeida, R. S. Oliveira, N. S. Moritsuka, C. R. L. Frances, A. Teixeira, and J. C. W. A. Costa, "Digital Radio over Fiber transmission based on SCM and WDM system for C-RAN architecture", IEEE Conference, 2014.

[16] Mayur Gambhir, Nayana Shenvi ,"Comparitive Analysis of 8-DPSK and 16-QAM Digital Modulation, using RoF for Hybrid WDM-TDM PON", International Journal of Scientific & Engineering Research, Vol. 6, Issue 6, June-2015.

[17] M. Gambhir, N. Shenvi,"Comparative Analysis of 8-DPSK and 16-QAM Digital Modulation using RoF for Hybrid WDM-TDM PON", International Journal of Scientific & Engineering Research, Vol. 6, Issue 6, June-2015.

[18] N. Sotiropoulos, T. Koonen, H. de Waardt**,** "Bidirectional Incoherent 16QAM Transmission over Hybrid WDM/TDM Passive Optical Network", 12th International Conference on Transparent Optical Networks, pp. 1-4,july 2010.

