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Analyzing the Performance of OFDM-Architecture Using Numerous Order QAM Modulation

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***Abstract*- In this paper the study of M-QAM modulation as an efficient method to achieve multicast data on a wavelength division multiplexed passive optical network (WDM-PON) is demonstrated. By using different order M-QAM (Quadrature Amplitude Modulation) with OFDM (which can multicast signal onto various carrier signals) we will get effective data access .Thus by comparing different orders of QAM with respect to their BER (Bit Error Rate) , Signal To Noise Ratio and data rate with delays we analyzed the modulation and demodulation mechanism in OFDM system. OFDM with PON is used because of their simplicity, reliability and ease of access. The combined advantages of both attained more attention these days.**

***Keywords*- WDM, PON, M-QAM ,OFDM, BER, CP, ZP etc.**

I. INTRODUCTION

Now these days WDM-PON fiber optics networks provide the most cost effective, reliable and fantastically scalable networks which are available to address the large capacity, security and authentication, long distance transmission capabilities that each service provider and each user require while using the advantages of a passive infrastructure. All these factor's combination make WDM-PON to be the best access solution for next-generation networks and they also facilitate the triple play. Initially TDM-PON were get used and they constitute of many disadvantages like those networks do not provide high definition video access and was inefficient with respect to differentiated multimedia services. Therefore effective multicasting of the signal can achieved easily by WDM-PON as they require less power supply.

A. Passive Optics Network (PON)

As we know data propagates over fiber in the form of light signal means communication on fiber is simply can be called as number of reflections which are millions and trillions in number . Thus we have two main types of signal propagation methods which are Active Optical Network and Passive Optical Network PON . But now these days PON are mostly suited networks and as compare to (AON) active Optical Network requires, they require switching equipments that work with electricity but PON do not require this.
In PON the main three elements are
(a)Optical Line Terminal (OLT) at central office CO
(b)Passive Splitter
(c)Optical Network Unit (ONU) at receiver side and Optical Distribution Network ODN
To send the data from PON networks they constitute of optical line terminal (OLT) and optical network unit (ONU) in which burst of data is send to different FFTx where x refers to any college, home, university or any college and called as FTTH (fiber to the home) ,FTTC (fiber to the curb) and to different organisations, universities and units and bodies. Data transmission occur in form of light, light can be single mode or multimode. According to this we use single mode or multimode fibers. Fibers can be of glass or fine plastic materials.

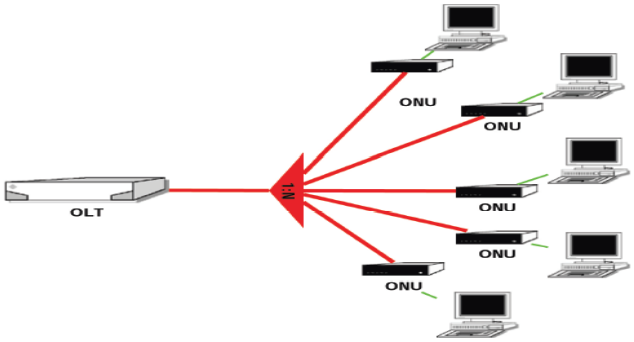

Fig-1 Block diagram of PON

B.OFDM

Now to make whole communication over PON to be possible we switch to a multicarrier scheme used for high data rate named as Orthogonal Frequency Division Multiplexing (OFDM) and Filtered Multi-Tone (FMT) out of which OFDM is used because it is less complex than FMT. OFDM is an attractive solution for next-generation wired / wireless network without any need of complex equalizer or filters as in FMT. Different standards like IEEE 802.11a, IEEE 802.16 and HiperLAN2 work on the principles of OFDM. OFDM can sends data over number of parallel carriers which can be hundredths in number to achieve very high data rate[4].
OFDM (Orthogonal Frequency Division Multiplexing) is very similar to FDM (frequency division multiplexing) but OFDM attain a unique property of orthogonality which FDM doesn't give and due to this orthogonality number of subcarriers cannot interfere with each other. More number of subcarriers can be achieved by OFDM. Thus in OFDM the chances of inter-carrier crosstalk (ICI) ,dispersion of modes of light and inter-symbol interference (ISI) is very less and also provide effective results with respect to BER (bit error rate)[2]. Orthogonal modulation is use to carry the high capacity on long- haul with high speed optical transmission system. OFDM system contains number of parameters such as subcarriers, guard time, symbol duration, subcarrier spacing, modulation type and different types of error detection and correction codes e.g. block codes,

orthogonal space time block codes (O-STBCs) used in MIMO (Multi Input Multi Output) systems for high data rates. The selection of parameters depends on BER, bandwidth, and multipath delay and fading. In this whole work signal transmission is done with M-QAM modulation and with different order QAM -8,16, 32,64 the performance of QAM-OFDM is checked with respect to BER, data rates ,SNR (Signal To Noise Ratio)[13].
OFDM technique is simply defined as a form of multi-carrier modulation in which the spacing is selected between the carriers so that each sub carrier is orthogonal with respect to each other. OFDM is technique which encodes digital data on multiple carriers.[3] OFDM is also used in wideband digital communication like digital television and audio broadcasting, DSL ,internet access, wireless network, power line networks and 3G, 4G mobile communication. The two signals are said to be orthogonal if their dot product is zero or also when the integral multiplication of two signals over the interval is zero, then the two signals are said to be orthogonal over that interval.

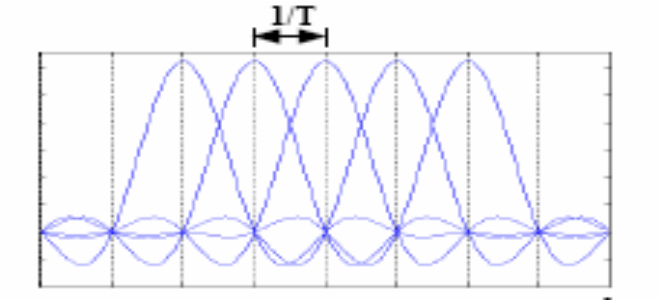

Fig 2- Multiple carriers in OFDM

C. QAM (Quadrature amplitude modulation)
It is most widely used in now these days scenario of digital data communications. A various orders and forms of QAM are available and some of them are 16 QAM, 32 QAM, 64 QAM, 128 QAM, and 256 QAM and many other higher orders. Here the order implicate the number of points on the constellation, i.e. the number of distinct states that can exist and represent the data points and these points are arranged in a square grid/matrix form with equal vertical and horizontal spacing. If we want to increase data rate more and more by using phase shift keying (PSK) also 8-PSK is the highest order PSK thus if more data rate is required we switch to QAM More than 8 PSK BER becomes too high, thus we use QAM.

It can travel greater distance and can transmit more bits per symbol. In QAM the two carriers are orthogonal and out of phase with each other by 90 degrees and recognized as Quadrature carriers. QAM is a combination of amplitude and phase shift keying(QAM=ASK+PSK)[3] .Therefore we can say that combined ASK and PSK create QAM in which amplitude and phase are changed at the same time simultaneously. QAM conveys data by modulating the amplitude of different carriers with respect to each other.

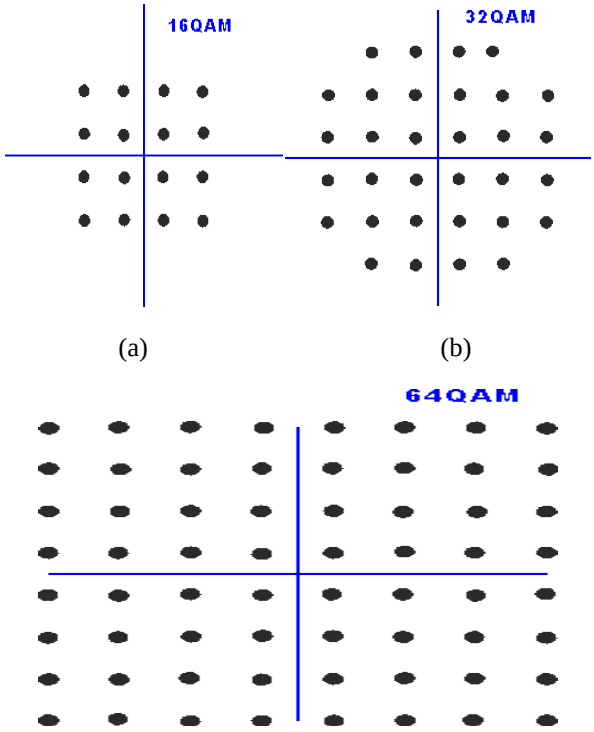

Fig 3- (a) Constellation diagram of 16-QAM, (b) Constellation diagram of 32-QAM
(c) Constellation diagram of 64-QAM

II. OFDM SYSTEM MODEL

In this section three portion are addressed which are transmitter , channel and receiver[2].

A. Transmitter

OFDM transmitter is a device that contain random data generator, modulator, S/P converter and many more blocks as shown in Fig-4[12].

*1] Random Data Generator:*Random data generator is used to generate a stream of bits of binary data in form of 0's and 1'serial which is serial in order. The stream of bits contain raw and un-modulated information which is transmitted further. The data is inserted to OFDM transmitter.

*2] S/P Converter:*This is serial to parallel converter converts the serial stream of data to parallel stream and transmitted simultaneously next block[4]. Serial data before converted to parallel is moulded to a word and those words are modulated and further transmitted. Each stream is used to modulate one subcarrier from group of orthogonal carrier.

*3] Data To Symbol Mapper:*This will do M-QAM modulation with different orders. The data on each symbol of bits is mapped with a respective phase according to the modulation used .Each phase is mapped to a unique pattern of bits Modulator modulates the serial stream bits with M-QAM modulation technique. This technique will do modulation and also called a multiplexing technique.

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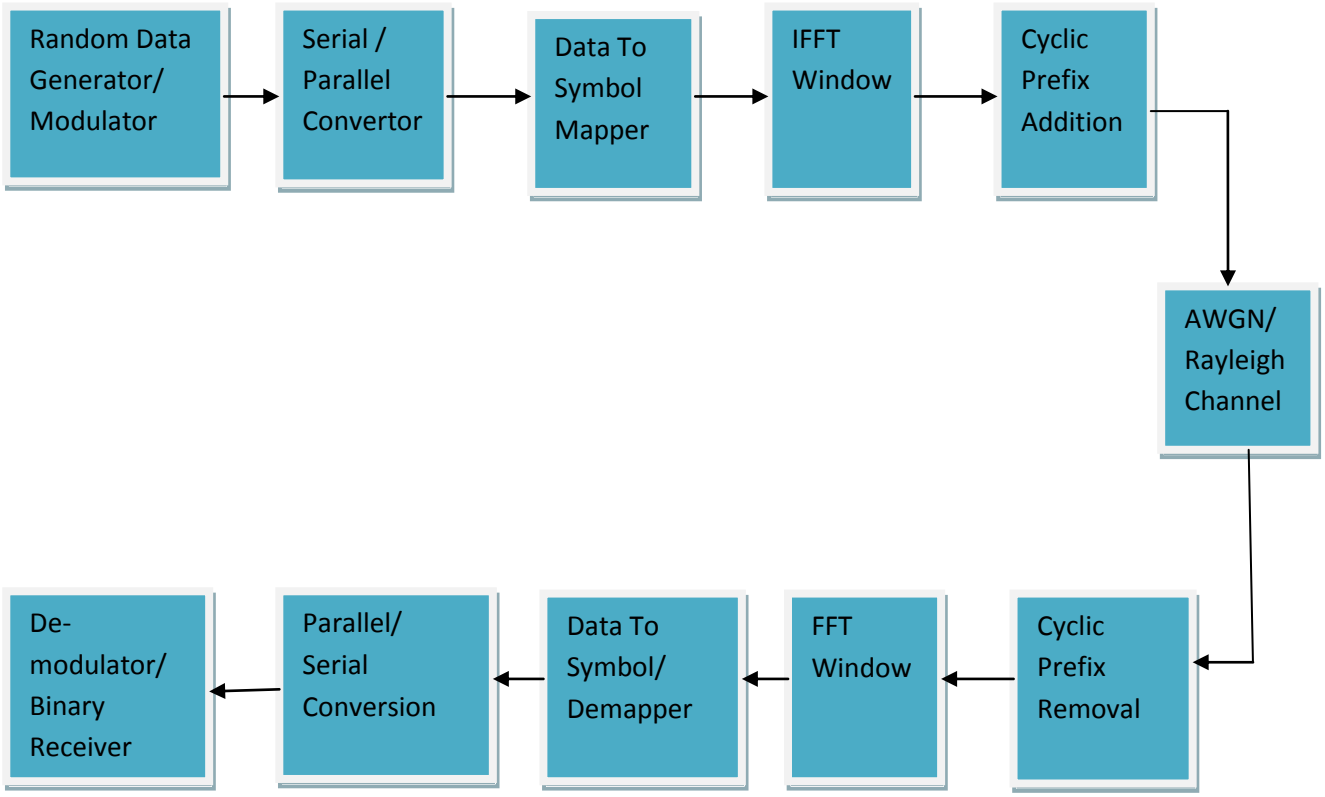

Fig-4 OFDM System Model

4] IFFT: IFFT is Inverse fast fourier transform. The inverse fast fourier transform is use to convert frequency domain signal to time domain because to analyze the signal in time domain is more convenient than frequency domain also the spectral representation of data into time domain using IFFT is more easily and efficiently used in all practical systems. IFFT window size is same as that of FFT window size.

5] Cyclic Prefix :To escape from inter symbol interference we use gaurd interval insertion in between the symbols which can be done in two ways first one is Zero Padding ZP[3], in this zeros are added between the symbols but it is not used so much due to bandwidth wastage and it also sometimes destroy the orthogonality thus we switch to Cyclic prefix CP insertion because its size is only1/4 of the symbol size where as zero padding size is 5 times the symbol size[1]. The there is less wastage of bandwidth in prefix and it do not damage orthogonality of subcarriers. Cyclic prefix addition solves the problem of ISI and ICI interferences.

B. Channel Model

AWGN is Additive white Gaussian Noise is a kind of noise in which the linear summation of white noise or wideband Gaussian noise occur, and can be originated from various natural circumstances, like due to thermal vibrations of atoms (due to movement of charge carrier whether electrons or holes) e.g. conductors also called as thermal noise or Johnson-Nyquist noise, shot noise. It can also generated due to black body radiation from warm objects and from earth, celestial bodies such e.g. sun. This noise do not deal with frequency selectivity, interference fading or flat fading occur due to band limited channel, nonlinearity or dispersion (intermodal dispersion in case of PON due to different modes of light because light in form of number of modes) ,these all factors are simply the attenuation types which may lead to damage the power and polarization component of light signal and expressed as watts per hertz of bandwidth. It is considered as Gaussian distribution of amplitude in a signal. Other type of channel is Rayleigh fading channel. In this channel fading of signal occur due to multipath propagation of light.

C. Receiver

It works opposite to transmitter. Here firstly demodulation occur .After removal of cyclic prefix and FFT (Fast Fourier Transform) performed the data is parallel to serially converted. Thus bit stream is obtained from receiver. In case of optical fiber.

III. RELATED WORK

Mr. Sumit Dalal /M.Tech Scholar and Mr Pulkit Berwal et.al[1]concluded the BER performance over Rayleigh fading channel with BPSK, QPSK, 4-QAM, 16-QAM by using MMSE (minimum mean square error equalization) and MLSE (maximum- likelihood sequence estimation) equalization techniques.BER for BPSK QPSK, 4QAM, 16QAM using CP (cyclic prefix) is calculated to reduce Inter symbol Interference (ISI) but cannot be eliminated completely in the case of MMSE and MLSE equalizer. Thus to reduce ISI effects equalization is done at receiver and results are calculated with equalization and without equalization . Average value of BER of around 0.4 in BPSK QPSK, 4QAM, 16QAM is obtained with no equalization is and BER reduced with MLSE equalization and maintained at constant value of 0.0015 in BPSK and 0.02 in QPSK, 0.12 in 16QAM, 0.0003 in 4QAM[3].

Prafulla.D. Gawande and Sirddharth. A. Ladhake Et.al[2] concluded from simulation that Cyclic Prefix and Zero Padding do not affect the BER performance Over the AWGN channel and remain consistence with analytical results with respect to the length of CP and ZP because there is no multipath delay in the AWGN channel[1]. But in case of Rayleigh fading channel which contain multipath propagation in channel between transmitter and receiver cause inter- symbol interference (ISI) and adjacent symbols get overlapped with each other. This is prevented by insertion of a cyclic prefix or zero padding between successive symbols which is discarded at the receiver to cancel out ISI. From simulation it is analyzed that with increase in CP size, BER get decreases for Rayleigh fading channel. The BER in a Rayleigh fading channel is remain in consistence with the analytical results when CP or ZP is to equal 16.

Aida Zaier and Ridha Bouallègue et.al [3] analyzed the effect of fading over AWGN channel when 16-QAM is used with OFDM over AWGN channel and propose a study of performance of the channel by using different algorithms LS, MMSE (minimum mean square error), LMMSE (linear minimum mean square error) and Lr-LMMSE (low rank MMSE) algorithms using block pilot insertion then the LMMSE algorithm still performs good in term of low BER specially when the SNR is superior to 5 dB with slow time varying channel For lower values of SNR, the first three algorithms show high BER, due to the effect of the noise but Lr-LMMSE estimator performs a little better than the others for an SNR higher than 25 Db[2].

C. W. Chow, Member, IEEE, C. H. Yeh, C. H. Wang, Student Member, IEEE, F. Y. Shih, Student Member, IEEE, and S. Chi et.al[4]concluded that 4 Gb/s of 16-quadrature amplitude modulation (QAM)-OFDM signal can be propagating over the LR-PON (Long Reach-PON) using PON (bandwidth of 1 GHz) . At splitter the splitting-ratio of 256 was achieved and also analyzed the possibility of using more higher level of QAM, such as 256-QAM .Thus the error-free operations are obtained over100-km fiber transmission without using any dispersion compensation mechanism and signal can be re-modulated over the channel.

A.Sangeetha and Y.Kavven Raja et.al[5]concluded that by using 4-QAM on 2 channels each of 12Gb/s signal transmitted with number of subcarriers from 512 to 1024 as downstream and signal of 2.5Gb/s using On-Off keying (OOK) as upstream signal with bit rate of 2.5Gbps over a 60 km fibber separately for both signal with MMSE (minimum mean square error equalization) technique in-order to avoid inter symbol interference (ISI). NRZ-OOK is used here because it can support long reach as compare to RZ-OOK. Then the BER at channel 1 is 0.000139489 and at channel 2 is 0.000976426 is obtained and with Bessel filter, adaptive filters using MMSE the BER obtained with improved value.

Hindumathi, V. et al. (2012) [6] presented the analysis of OFDM architecture with different Modulation Techniques and check there performance . The performance was observed by varying some of parameters. To avoid (ISI) Inter Symbol Interference in a mono carrier communication system the symbol period should be much greater than the delay period used in between the symbols. Now BER depends on the types of modulation techniques and the result of simulation represented that if we increase the order of PSK modulation then the BER get also increases. Thus to reduce the BER the high SNR is required with higher order modulation scheme. Therefore QAM get mostly used in comparison to QPSK and other order PSK Because in QAM if signal get disturbed or corrupted can be corrected by varying amplitude or by phase. Therefore we can say that with QAM scheme SNR will improve as compared to QPSK and BER can be reduced.

IV. SIMULATION AND RESULTS

Simulation is done on various parameters and carried out on channel using 8-QAM, 16- QAM, 32-QAM and 64-QAM modulation technique. Thus various factors like BER, performance of data rates, SNR ratio is analyzed.

A. Simulation Parameters

Simulation parameters are listed in TABLE I, in this input parameters are listed and according to them the graphical results are obtained. These whole inputs are simulated over software named as MATLAB. After running the code for OFDM-PON with QAM.

TABLE I
INPUT PARAMETERS USED

S.NO.	Parameters	Value
1.	No Of Bits	1024
2.	No Of Samples	128
3.	Subcarriers	74
4.	Cyclic Prefix Size	0.0625ns
5.	Symbol Rate	39.062500e6
6.	Radio Frequency	2.8e9
7.	M-QAM Orders	8,4,16,32

B. Results

The results of different order are compared and it is observed that the values of different parameters are somehow not so much different with each other. Here we analyse the data transfer at both transmitter and receiver side at frequency band. And thus we analyse data transfer

by using M-QAM modulation with OFDM model in which different subcarriers are orthogonal to each other with cyclic prefix delay of 0.0625ns.The following result table is analysed/ calculated when 1024 bits are transmitted with 128 total no of samples .Signal is also reshaped in between the communication.

TABLE II
RESULTS WITH DIFFERENT ORDERS

Order	BER	Data Rate	SNR	SNR (dB)
8	0.3134	8.6719e+010	0.5596	-2.5215
16	0.3351	1.1563e+010	0.5604	-2.5150
32	0.3650	1.4453e+010	0.5570	-2.5415
64	0.3744	1.7344e+010	0.5560	-2.5459

As it is clear from the result's TABLE II that BER vary with order 8-QAM and 16-QAM but become constant at 32, 64-QAM and it can be represented with graph as shown in Fig-5.

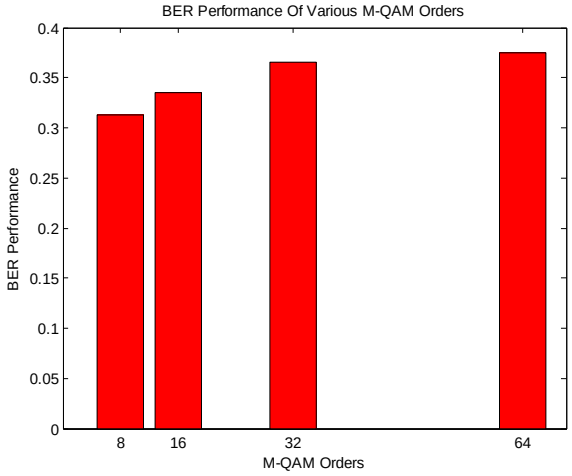

Fig-5 Graph of BER Performance

Now if we consider signal to noise ratio in OFDM M-QAM structure then according to the received values of SNR as shown in result table above ,then we will get to know that order 8 ,16 , 32 ,64 orders shows approximate same results with respect to each other can be seen in graph Fig-6.

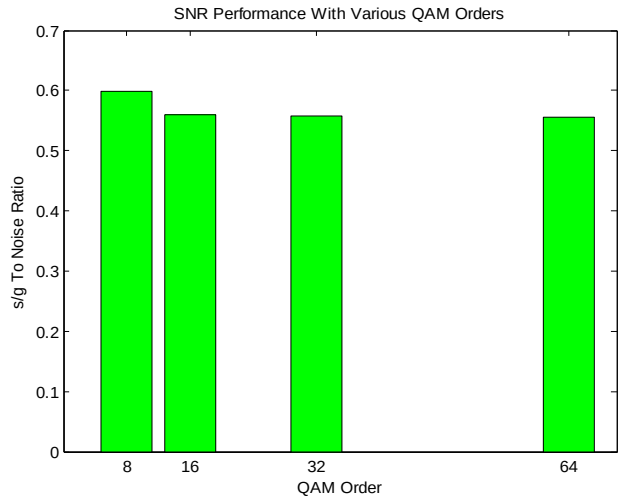

Fig-6 Graph of SNR Performance

To reduce BER we need to use higher order of QAM with high signal to noise ratio. Signal to noise ratio defines the amount of noise inserted in our transmitted and received signal thus if we get exact value of SNR then we can easily analyse our signal and complete signal. Noise inserted in signal can be of any type and can be originated by any means. In this whole work the SNR values in decibels is also drawn and represented in form of graph as shown in graph Fig-7 as below

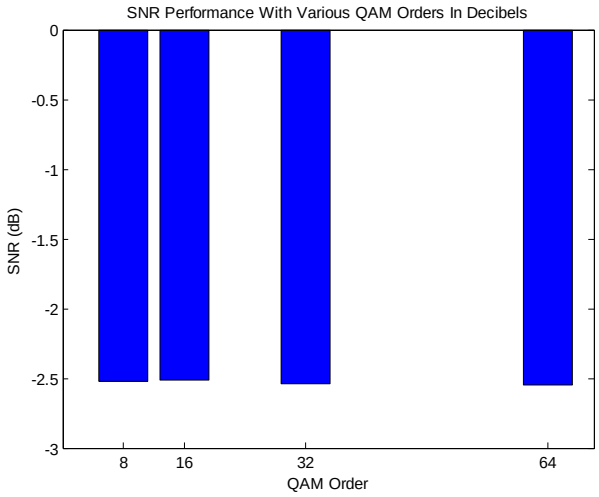

Fig-7 SNR in decibels

The SNR (dB) is represented in negative axis because all values observed are negative and there are approximate same results are obtained with the four orders used but when we observed results with respect to the data rate then we will find the difference in performance and can be seen with following graph Fig-8 below

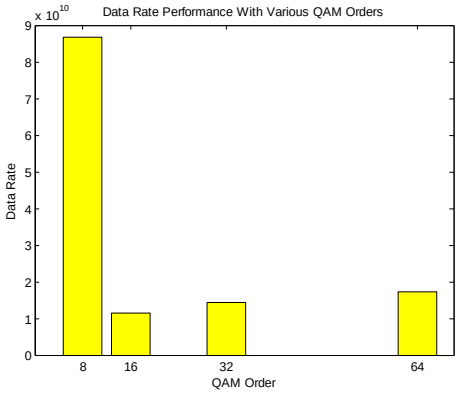

Fig-8 Graph of Data Rate Performance

It is clear that 8-QAM order give high data rate as compare to other three but in terms of SNR other three are also good. But delay generated in 8-QAM are more it can access only 3 bits altogether.

V. CONCLUSION

Conclusion after whole work comes that if we use order 8 then we get highest data rates and less BER among all other orders (16, 32, 64) but with this takes more time and delay .If we use other orders they are less delayed and among 16, 32 ,64 order 16 give less BER but if we consider concept of data rate then the order 64 is best.

VI. FUTURE SCOPE

In future we can also use more higher order to get more data rates and less BER so that our data communication on PON optics network become more efficient because with this approach we can handle more bits all together .Higher order can be helpful in cable TV transmission e.g. 24, 36, 48, 54 Mbps are the fastest four which uses the OFDM with QAM .Also IEEE802.15.4 (Zigbee) relies on PSK.Order 256 also useful and in cable TV it is currently used in many countries.

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