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ANALYSIS OF 64-QAM AND 128-QAM MODULATION TECHNIQUE IN DIGITAL COMMUNICATION SYSTEM USING SIMULINK

Ayan Shah
Scholar Bachelor of Engineering, final year
Department of Electronics Engineering
School of Engineering & Technology
Vikram University, Ujjain, India

Amit Thakur
Head
Department of Electronics Engineering
School of Engineering & Technology
Vikram University, Ujjain, India

Abstract— **This paper presents the present deep research on the digital communication sub-systems. Mainly on the high-level modulation technique for high data rate transmission, this system is based on simulation model of M-ary Quadrature Amplitude Modulation (M-QAM). In this research we study different simulation model of M-ary QAM modulation. A comparative analysis of two different modulation models of 64-QAM and 128-QAM techniques has been done. These models are executed in MATLAB to design their simulink based simulation models along with MATLAB/ BERTool is also implemented. MATLAB/ BERTool is used to analysis the Bit Error Rate (BER). Results of phase noise on the constellation along with frequency offset on Bit Error Rate (BER) figures for 64-QAM and 128-QAMs are analyzed and compared. In this paper we also analyze the affect of unstable power of input signal; frequency offset on Bit Error Rate (BER) and phase noise are presented. The analysis is done on the results of the simulation models constellation figures under different circumstances.**

Keywords— **M-ARY Quadrature Amplitude Modulation (QAM), Bit Error Rate (BER), Phase Noise, MATLAB, Additive White Gaussian Noise (AWGN), BER Tool, Simulation.**

I. INTRODUCTION

IJEAST In last several decades there is a rapid advancement in the field of communication systems from analog to digital. The main advantage of digital communication is that, it is more reliable, provides high capacity of information transmission with excellent quality and has ability of fast data transmission than analog communication system. The basic strands difference between digital communications system over analog system is modulation their technique. Therefore digital communication systems are more popular than analogues ones. The digital system carries a number of series of binary data in terms of zeros and ones. In present modulation techniques the main accomplishment is that the digital baseband data consign by differing envelope and phase/frequency of a carrier wave. In view fact that the envelope and phase/frequency offer two degrees of freedom, the outcome of this modulation system gives more than four possible carrier signals.

The QAM is defined as the technique which transmits information by changing amplitude and phases of a carrier wave, so that by doubling effective bandwidth. QAM is also called quadrature carrier multiplexing (QCM). Basically, in the QAM signal, carrier wave directly comes in quadrature, that's why it is called "quadrature". It indicates the phase difference between two carriers is 90 degrees but same in frequency. One signal is called the in-phase "I" signal given by sine wave (sinωt), similarly quadrature "Q" signal given by cosine wave (cosωt). The QAM is again classified into analog and digital system, here in this research we are using digital M-ary QAM technique. Research is done on 64-QAM and 128-QAM to study their performance, Simulink-based simulation model are designed. In the paper, the theory of M-ary QAM and the details of the simulation model are provided. In the simulation model, the parameter settings for random generator, QAM modulation and demodulation, AWGN wireless channel are provided. Error rates of QAM system versus the signal-to-noise ratio (SNR) are used to evaluate the QAM system for adaptive modulation. The model can be used not only for the criteria for adaptive modulation but also for a platform to design other modulation systems. in this duration the routine control of system is not considered.

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The extensive advancement in digital communication seriatim, creates a need to look for automated system for analyzing the outcome of digital modulation types using MATLAB/ Simulink software. Mainly the basic modulation techniques are Quadrature Amplitude Modulation (QAM), Amplitude Shift Keying (ASK), Phase Shift Keying (PSK), Frequency Shift Keying (FSK). The QAM is very popular modulation techniques reason is its capability in bandwidth and power. In the QAM technique, two signals of amplitude-modulated (AM) are used and combined into a one channel, where by doubling the effectual bandwidth power. Whenever the Quadrature Amplitude Modulation (QAM) technique like 64-QAM and 128-QAM, better signal-to-noise ratios (SNRs) are needed to overcome any interference and maintain a certain bit error ratio (BER).

In this paper we have done a comparative analysis on the two different modulation models. The 64-QAM and 128-QAM modulation techniques based on the different factors of their output characteristics has been done. These models are executed in MATLAB to design their simulink based simulation models along with MATLAB/ BERTool is also implemented. The factors which effects 64-QAM and 128-QAM model are input signal power, Additive White Gaussian Noise (AWGN), phase noise and frequency offset on behavior of these modulations. Constellation diagrams and Bit Error Rate (BER) curves for mentioned variants of M-QAM are obtained and examine.

II. LITERATURE SURVEY

The digital modulation techniques which gives an information about carrying data transmission capacity, high quality communication channel, security of data and RF spectrum divided to accommodate additional services [1]. The advancement in modulation contributes in wireless mobile communication system [6]. The modulation techniques are classified in to amplitude, phase, frequency, continuous phase and trellis-coded modulation. The trellis-coded modulation is further classified in phase shift keying (PSK) and quadrature amplitude modulation (QAM) [4]. In the M-ary signaling system, it will send number of M possible signals, mathematically it is given as, s1(t),s2(t)s3(t),s4(t),s5(t)..sm(t) in the time of every signaling interval of duration TS. But for every applications, the numbers of possible signals is given as $M=2^m$, here m called integer which corresponds to number of bits per symbol in a system and the symbol duration TS=mTb, Tb stands for bit duration [7] [8]. Whenever there is a change in amplitude, phase/frequency the modulation technique is called M-PSK (M-ary Phase Shift Keying)/M-FSK (M-ary FSK Frequency Shift Keying)/M-ASK (M-ary Amplitude Shift Keying) [2]. The modulation that helps to make difference in amplitude and phase is known as M-QAM (M-ary Quadrature Amplitude Modulation). For the improvement in M-ary modulation techniques have to analyzing the unwanted factors seen in their characteristics.

III. RELATED MEASURES

A. On SIGNAL-TO-NOISE RATIO (SNR)

The signal to noise (SNR) defined as the ratio of signal power to noise power in decibel (dB) called SNR. It is used to measure quality of a communication link. When the SNR is high, then communication link is under good condition.

$$SNR = 10 \log \frac{\text{Signal power}}{\text{Noise power}} \text{ dB}$$

B. Bit error rate (ber)

The BER used to find the difference between main transmitted & received signal at the receiving end. Mathematically, it is given as BER(t) = abs(x(t) –y(t)) Where, x(t) is main signal generated by transmitter and y(t) is the received signal at the receiver end with respect to time (t). BER is the number of bit error per unit time.

$$BER = \frac{\text{Number of bit error}}{\text{Total number of bits sends}}$$

The bit Error Rate known as is the ratio of number of bit error to the total number of bits sends.

C. Multipath fading

There are different effects which produce a notable cause when the signal propagation takes place in the air and closed to ground, this effect is called the effect of free path loss denoted by Ls. After that the main effect on signal propagation is due to deterioration multipath fading. The multipath fading creates change in the received signal's amplitude, phase and angle of arrival. Mainly it is classified into Two fading effects in communications system one is called large-scale fading and another is small scale fading. Large scale means path loss and small scale mean rapid variation in signal amplitude and phase.

D. Additive white gaussian noise (awgn)

The additive white Gaussian noise (AWGN) is mainly used in wired communication system. AWGN defined as a noise model commonly used in communication retrieval to imitate the effect of Nemours random processes occurs in communication system. It is the combination of additive, white and Gaussian, every term have its specific background means, Additive added to any noise that might be intrinsic to the information system. White is the uniform power across the frequency band for the information system. Gaussian stands for normal distribution in the time domain with an average time domain value of zero. AWGN is not related to the multipath fading and other losses in communication system.

IV. M-ARY QAM

After M-ary quadrature amplitude modulation (M-QAM) is defined as the modulation technique that carries a data by modulating the data transmission in to the amplitude by two carrier waves signal. Where the quadrature carrier signal have a phase difference of 90° apart with main carrier signal with two input signals. When the data is transmitted by the carrier waves, depends on the type of data information there is change in amplitude and phase of the carrier wave. It is such a class of non constant envelope schemes that can achieve higher bandwidth efficiency than M-PSK with the same average signal power [4].Mathematically, M-ary QAM can be written as shown in equation given below.

$$s_{kl}(t) = A_k \cos(2\pi f_c t + \theta_l), \quad (1)$$

$$k = 1, 2, ...M_1, \quad l = 1, 2, ...M_2,$$

Where, A_k is the signal amplitude, phase, carrier, M_1 is the number of possible amplitudes of the M_2 is the number of possible phases of the carrier, and f_c is the carrier frequency. θ_l is the signal, l q is the signal.

V. SIMULATION MODEL

A. The 64-QAM MODULATION

The Simulink model of 64 QAM is designed on matlab with the help of simulation tool, where a tab called library. It consists of different elements which are used to design simulink model. By using these different elements a module is designed and the combinations of these modules 64 QAM model are designed. The modules are Modulator and demodulator Rectangular QAM Modulator and demodulator Baseband module, Bit Error Rate statistics module, and constellation figure module. To design 64-QAM modulation and demodulation model, the random integer generator is used which generates a random numbers, and then integer to bit converter s used which converted Integer to Bit Converter. This bit is passed through rectangular QAM modulator base band it is basically a 64-QAM modulator connected to AWGN channel. The AWGN channel is used to imitate the effect of noise in modulation, then Bit to Integer block is used to modulate the signal for defining how many bits are mapped to every inter. This entire model is the QAM modules for modulation of signal. Then last is the demodulation of the signal. In this module the phase noise is added, which affects the phase of carrier signal. It is also known as phase noise level density (PNLD). The 64-QAM Modulation model and demodulation model is given below where, the output is BER, SER.

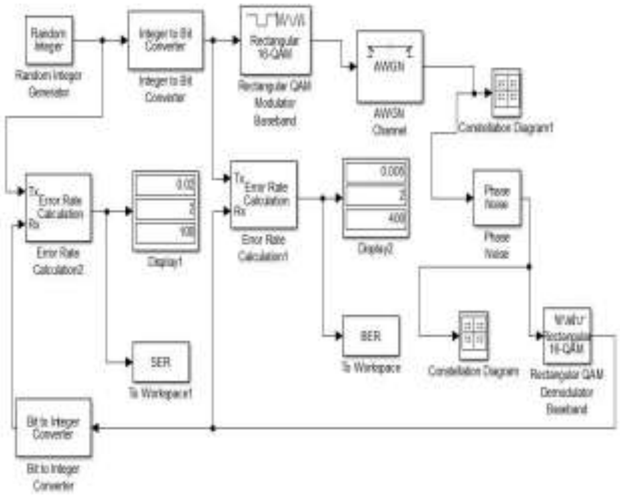

Figure 5.1 A 64-QAM modulation Simulation model with phase noise.

B. 128-qam modulation model

It is also similar as above simulation model, in 128-QAM simulink model. The Modulator and demodulator Rectangular QAM Modulator are used with demodulator Baseband module, Bit Error Rate statistics module and constellation figure module. To design 128-QAM modulation and demodulation model, the random integer generator is used which generates a random numbers, and then integer to bit converter s used which converted Integer to Bit Converter. This bit is passed through rectangular QAM modulator base band to AWGN channel. The AWGN channel is used to imitate the effect of noise in modulation, then Bit to Integer block for defining bits and they are mapped at each and every inter. At last is the demodulation of the signal. In this module the phase noise is added, which affects the phase of carrier signal called PNLD The 128-QAM Modulation model and demodulation model is given where the phase noise SER is increased.

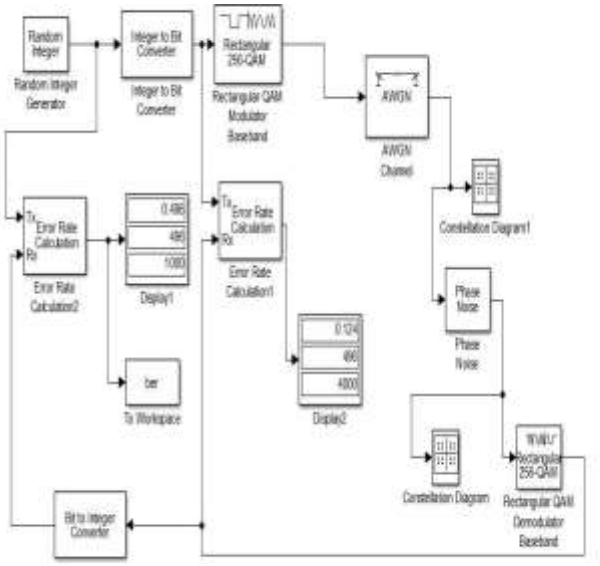

Figure 5.2 A 128-QAM modulation Simulation model with phase noise.

VI. SIMULATION RESULTS

1. Results of 64-qam

The 64-QAM simulink model performance graph in different simulation BER curve is given below, where the dependence of BER vs Eb to the No. ratio for various values of input signal power is analyzed. Input signal power, the value is varied from 0.5W, 2W, 4W and 6W.This is due to the proportional relation between the signal input power and the noise variance. As shown in the figure 6.1 below.

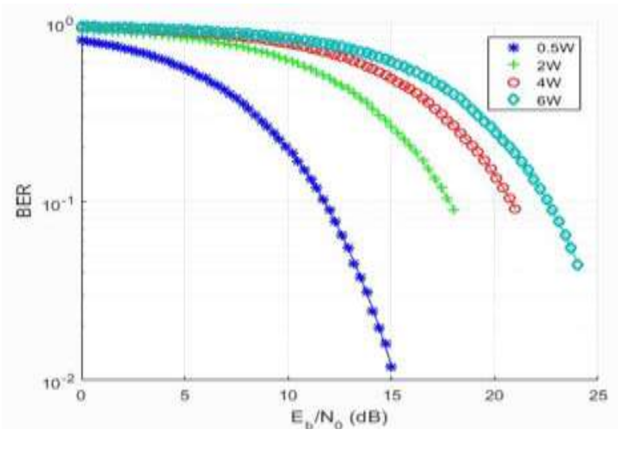

Figure 6.1: BER vs. Eb/No for 64-QAM graph at the different values of the Input signal power.

In the next graph figure 6.2 the 64-QAM shows the BER vs Eb to the No ratio at the different values of the frequency, here the frequency is varied from 100 Hz to 200Hz and 300 Hz. It is clear that the frequency is varied at the interval of every 100 Hz. The phase noise level density (PNLD) so the PNLD is –60dBc/Hz.

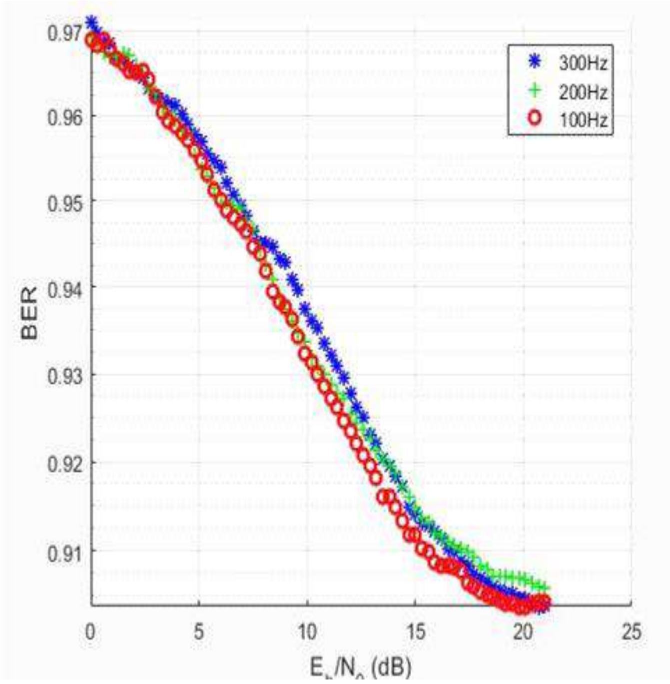

Figure 6.2: BER vs. Eb/No for 64-QAM graph at the different values of the frequency offset

The figure 6.3 shows the graph of 64-QAM model with and without various phase noise level starts from -70 dBC/Hz to -70 dBc/Hz only with AWGN.

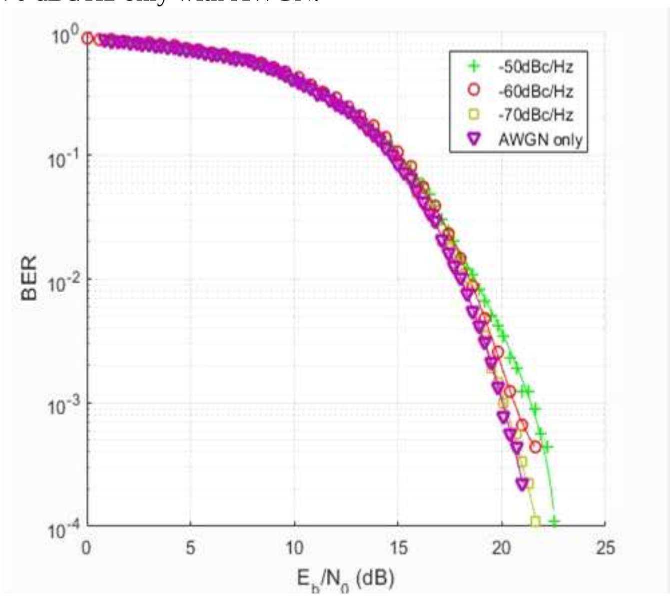

Figure 6.3: BER vs. Eb/No for 64-QAM at different phase noise level densities and without the presence of phase noise

2. Results of 128-qam

The 128-QAM model analyzed at the value of .5W, 2W, 4W and 6W simultaneously with phase noise of –60 dBc/Hz .If, we increase the power of input signal then the rate of error is also increased. The graph shows the BER vs Eb to the No ratio, at various offsets from carrier frequency is simulated varied from 100Hz, 200Hz and 300Hz. It is clearly seen from the graph that all three BER curves almost clashes to each other. The PNLD is varied from -50dBc/Hz to -70dBc/Hz and only using AWGN without noise a graph is obtained.

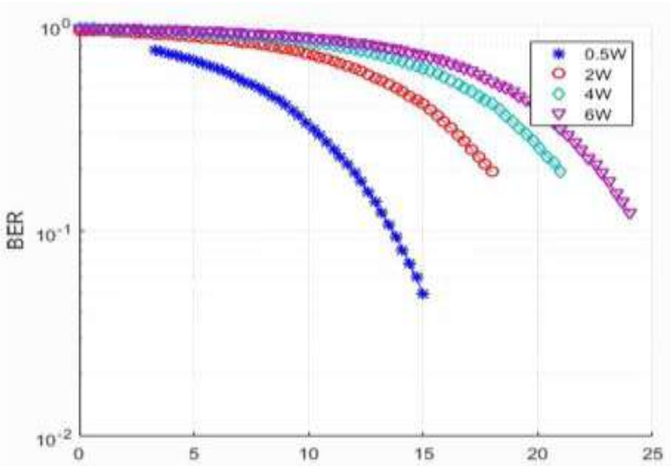

Figure 6.4: BER vs. Eb/No for 128-QAM graph at the different values of the input signal power

Similar in figure 6.5 for BER vs. Eb to the No for 128-QAM model at the different value of the frequency offset varied from 100Hz, 200Hz and 300Hz

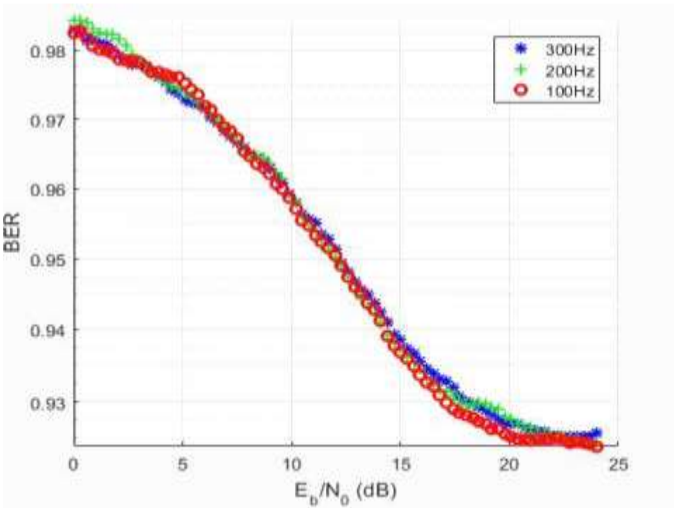

Figure 6.5: BER vs. Eb/No for 128 QAM model at the different value of the frequency offset

The 128-QAMmodel is shown below, where BER vs Eb to the No ratio at the different values of the frequency, here the frequency is varied from 100 Hz to 300 Hz. The phase noise level density (PNLD) is – 70dBc/Hz with AWGN.

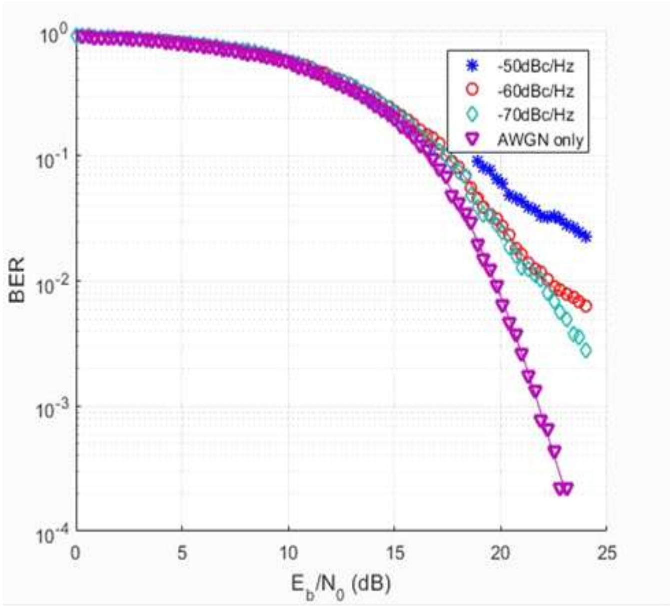

Figure 6.6: BER vs. Eb/No for 128 QAM at different phase noise level densities and without the presence of phase noise**.**

VII. CONCLUSION

The graphical results of the 64-QAM and 128-QAM based on BER vs different values of input power signal are analyzed at different level, frequency offset is varied from 100 to 300 Hz and with and without phase noise with – 70dBc/Hz with AWGN are compared. The result shows the quantity and quality of data transmitted through the system. The simulink models are used to study QAM system modeling implemented with the help of AWGN for analyzing performance of BER. We use the verity of modulation techniques for transmitting different bits per symbol to get desired output. The reason QAM modulation technique is used because it provides high efficiency in power and bandwidth, where two amplitude modulated signals are combined into a single channel and then transmitted at different bit rates which are multiples of 4 bits in a system.

VIII. REFERENCE

[1] Ho Sam, W., "Adaptive modulation (QPSK, QAM), " www.intel.com/netcomms/technologies/wimax/303788.pdf, December 30, 2007.

[2] Li Xiaolong, "Simulink-based Simulation of Quadrature Amplitude Modulation (QAM) System", Proceedings of The 2008 IAJC-IJME International Conference.

[3] Kader Md. Abdul, Ghani Farid and Badlishah R., "Development and Performance Evaluation of Hierarchical Quadrature Amplitude Modulation (HQAM) for Image Transmission over Wireless Channels", Third International Conference on Communication, Networking & Broadcasting, 2011.

[4] Surekha T. P., T. Ananthapadmanabha, "Modeling and Performance Analysis of QAM-OFDM system with AWGN channel, " IEEE Proceedings,2011.

[5] Patel Jigisha N., Dalal Upena D., "A Comparative Performance Analysis of OFDM using MATLAB Simulation with M-PSK and M-QAM Mapping", International Conference on Computational Intelligence and Multimedia Applications 2007.

[6] Ma Usha S. ; Nataraj Dr. K.R.., "Bit Error Rate Analysis Using QAM Modulation for Satellite Communication Link", Volume-25, Pg 456 – 463, 2016.

[7] Tharranetharan S. ; Saranraj M. ; Sathyaram S. ; Herath V. R., "A performance comparison of nonlinear phase noise tolerant constellation diagrams", 6th International Conference on Industrial and Information Systems,2011.

[8] Nikolovski S., Maric P., Mravak I., "Reliability assessment of distribution networks using sequential Monte Carlo simulation'', 18th International conference on Electricity distribution, Turin, 6-9 June 2005.

[9] Marmat Amit and Nagar Ritesh, "Appropriateness of Parametric Bootstrap System for Appraise Mean Time to Failure of a Problematical System", IJRESM, vol. 3, no. 12, pp. 161–163, Dec. 2020.

[10] Nagar Ritesh, Bhatt SK "A Comparative analysis of a Conventional and cross phase UPQC for enhancing the Power Quality", volume 7issue 7. IJSHRE 2018.

[11] Voudoukis Nikolaos F "Performance Analysis, Characteristics, and Simulation of Digital QAM" EJECE, European Journal of Electrical and Computer Engineering Vol. 1, No. 1, October2017

[12] Zeng Fnxin and Zhang Zhenyu ""General QAM Golay complementary sequences based on binary signals as their inputs", 2016 9th International Congress on Image and Signal Processing, BioMedical Engineering and Informatics (CISP-BMEI), pp.1101-1106, 2016.

[13] Proakis J. G. 2001. Digital Communications, McGraw-Hill, New York, NY, USA, 4th Edition.

[14] Najafizadeh L., Tellambura C. 2005. Exact BER analysis of an arbitrary square/rectangular QAM for MRC diversity with ICE in nonidentical Rayleigh fading channels. IEEE International Conference on Communications. 5: 2387-2391.

[15] Smith J. G. 1975. Odd-bit quadrature amplitude shift keying, IEEE Trans. Communications. COMM-23(3):385-389.