Scientific Journal of Impact Factor(SJIF): 3.134
e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2,Issue 7, July -2015

Adaptive QAM modulation: Latest technique for wireless communication

Ms. Priya[1], Mr. Sumit Kumar[2]

[1,2]E & EC Department, DRONACHARYA COLLEGE OF ENGINEERING

ABSTRACT: *Adaptive modulation is a method by which the spectral efficiency is improved according to the error probability of a radio link. Idea of Adaptive Modulation comes into existence after major drawbacks of the fixed modulation schemes in terms of maximum bandwidth utilization, high bit error rate, and poor performance at high data rates. QAM is different from other modulation scheme in terms of its higher order form of modulation and more bits of information per symbol. If the data rate is to be increased then higher order format of QAM are used.*

KEYWORDS: *OFDM, Adaptive QAM, SNR, Bit error rate.*

I. INTRODUCTION

With the advancement of communications technology comes with the demand for higher data rate services such as multimedia, voice and data over both wired and wireless links. New modulation schemes are required which must be able to adapt to different requirements of individual services in terms of their data rate, allowable Bit Error Rate (BER), and maximum delay. One of the new modulation scheme which has received significant attention over the last few years is a form of multicarrier modulation called as Orthogonal Frequency Division Multiplexing (OFDM) but it suffers from limitations such as sensitivity to carrier frequency offset, large Peak to Average Power Ratio (PAPR) and fixed modulation scheme leading to poor BER performance. BER performance improvement is necessary and it leads to use of new modulation scheme known as Adaptive QAM Modulation.

Adaptive modulation for wireless communications has received significant interest in the past five years [1]. It has long been recognized that adaptive modulation provides more efficient use of the channel than fixed modulation schemes. Specifically, change in bit error rate performance will be improved while using adaptive modulation scheme with channel conditions being varied .In this paper, modulation scheme used by the transmitter is changed in response to the changing channel conditions. In essence, it is a way to optimize the transmission scheme according to the state of the channel for a required fidelity. For example, when the channel is in a poor state (i.e., low SNR), the signal constellation size is reduced. Conversely, when the channel is in a good state (high SNR), the signal constellation size is increased in order to increase the data rate achievable [2].

II. METHODOLOGY FOR ADAPTIVE QAM MODULATION

A modulation method is used to carry information over a channel. Many different fixed modulation methods have been designed for various channels and applications. Quadrature Amplitude Modulation (QAM) is a communication scheme used in both an analog and a digital. It carries either two message signals or two digital bit streams. If change in the amplitudes of two carrier waves is done then use either one modulation scheme Amplitude Shift Keying (ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme. The two carrier waves used in QAM is generally sinusoids. They are out of phase with each other by 90^0 and are so this is called quadrature carriers or quadrature components. After the modulation waves are summed and the waveform obtained is a combination of both phase shift keying (PSK) and amplitude shift keying (ASK).

QAM, Quadrature amplitude modulation is used in many applications but mainly in data communications applications. Different forms of QAM are available and which are more common forms is as 4QAM, 16 QAM, 32 QAM, 64 QAM, 128 QAM, and 256 QAM. Here the figures show the number of points on the constellation, which give the information about the number of distinct states that can exist.

Expressions represent here for the symbol-error rate of rectangular QAM:

$$P_{sc} = 2(1 - \frac{1}{\sqrt{M}})Q\left(\sqrt{\frac{3}{M-1}\frac{E_s}{N_0}}\right)$$

$$P_s = 1 - (1 - P_{sc})^2$$

Where $P_{sc}$is symbol error rate per carrier and P_s is the symbol error rate. E_s/N_0 is the ratio of signal energy to noise energy.

The bit-error rate calculated that depends on the bit to symbol mapping, but for E_b/N_o>>1 and a Gray-coded assignment, so that each symbol error causes only one bit error, the bit-error rate is approximately given as :

$$P_{bc} = \frac{P_{sc}}{{}^{1}/_{2k}}$$

Where P_{bc} is bit error per carrier and P_{sc} is symbol error rate per carrier.
Since the carriers are independent from each other, the overall bit error rate is the same as the per-carrier error rate.

$$P_b = P_{bc}$$

Where P_b is bit error rate.
In QAM a greater distance can be achieved between adjacent points in the I-Q plane by distributing the points more effective way means in evenly manner. By doing so the distance between the points on the constellation is increased and then data errors are reduced [3].

If we want to send or transmit more bits per symbol, then the necessary condition is that the energy of the constellation is to be the same. When the points on the constellation are closer to each other then the transmission becomes more near to noise and result in a higher bit error rate as compared to the lower order QAM variants. It is proved that there should be balance between bit error rate which is to be maintain and higher data rates for any communications system.
By using the above concept now a day many radio communications systems work. To obtain the highest data rate first they sense the channel conditions. SNR value of the channel is known from the channel estimation techniques and then adaptive rules are implemented as shown in the Figure 1.1. The formulation of these rules depends on the performance analysis of the various modulation techniques for considering parameters such as modulation index, input power, data rate etc.

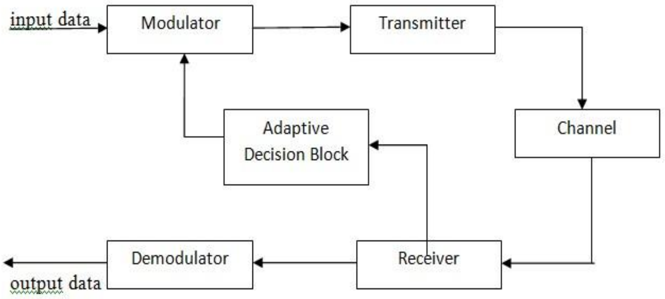

Figure1.1 Basic Block Diagram for Adaptive Modulation

III. METHODOLOGY

The methodology of adaptive can be implemented in various ways. Instead of changing the modulation scheme of transmitter, other parameters can also be changed depending on the channel conditions [4]. These parameters with their brief descriptions are listed in Table 1.1.

Table 1.1 List of Adaptive parameters

Adaptive parameter	**Description**
Modulation index	Changing the modulation scheme affecting the data rate of the system
Coding scheme	Changing the encoding scheme of the message bits resulting into the number of encoded bits to be transmitted per symbol and per second
Input power	Changing the signal power resulting into a signal having multiple power levels
Cyclic prefix	Changing the length of the cyclic prefix reducing ICI depending upon the SNR if the channel
Data Rate	Changing the input data rate depending upon channel environment

In Most applications maximum BER is required. For deigning adaptive modulation, BER is constant for all channel SNRs. In fixed modulation schemes the spectral efficiency remains constant but its value increase with increasing SNRs in the adaptive scheme, which show that average spectral efficiency of the adaptive scheme, can be improved.
BER curves with respect to SNR and data rates for 4QAM Technique are shown in Figure 1.1
Analysis report: BER value of 4QAM is good till data rates up to 100bps. At this data rate BER vs SNR curve shows that performance of 4QAM is very good, in fact 0 BER value is achieved beyond 5dB SNR value.BER curves with respect to SNR.

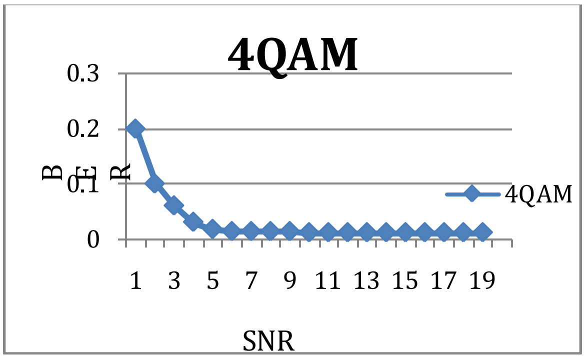

Figure 1.1 BER vs SNR for 4 QAM

Data Rate for 8QAM Technique are shown in Figure 1.2.

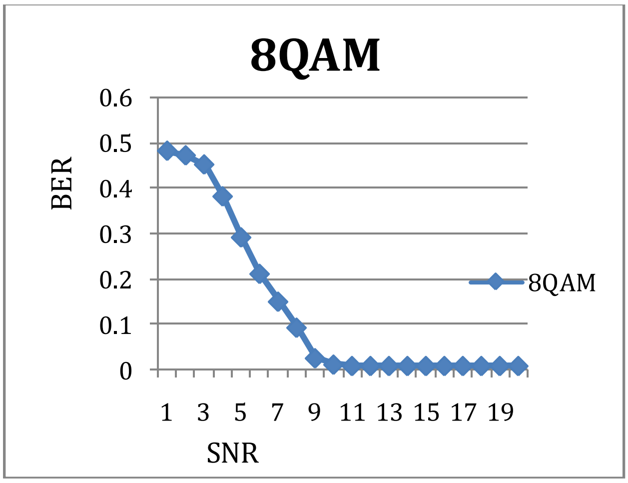

Figure 1.2 BER vs SNR for 8 QAM

Analysis report:BER value of 8QAM is good till data rates up to 1000bps. At this data rate BER vs SNR curve shows that performance of 8QAM is very good , in fact .05 BER value is achieved at 9 dB SNR value.

BER curves with respect to SNR and data rates for 16QAM Technique are shown in Figure 1.3

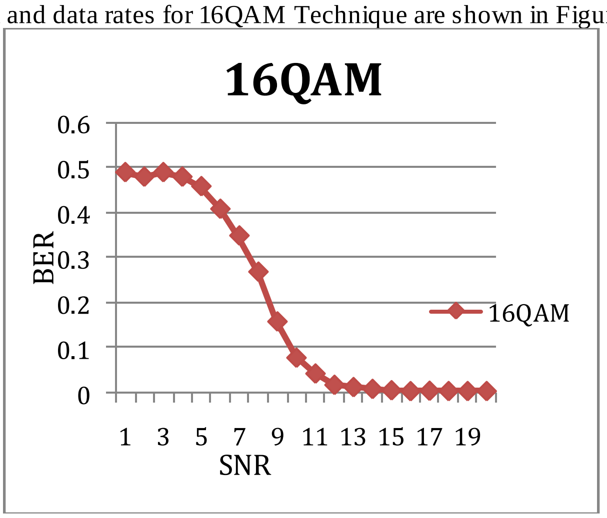

Figure 1.3 BER vs SNR for 16 QAM

Analysis report: BER value of 16QAM is good till data rates up to 10000 bps. At this data rate BER vs SNR curve shows that performance of 16QAM is better than 8QAM and 4QAM, in fact almost zero BER value is achieved beyond 15dB SNR value.

BER curves with respect to SNR and data rates for 32QAM Technique Figurer 1.4

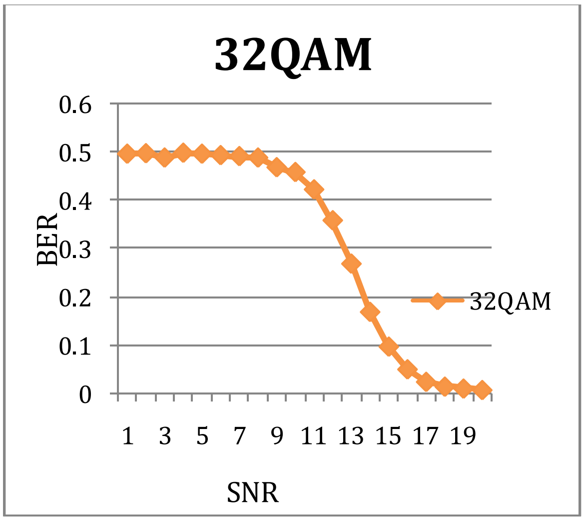

Figure 1.4 BER vs SNR for 32 QAM

Analysis report: BER value of 32QAM is very good till data rates up to 100000 bps At this data rate BER vs SNR curve shows that performance of 32QAM is better than 8QAM, 4QAM and 16 QAM, in fact .015 BER value is achieved beyond 18dB SNR value.

BER curves with respect to SNR and data rates for 64QAM Technique is shown in Figure 1.5

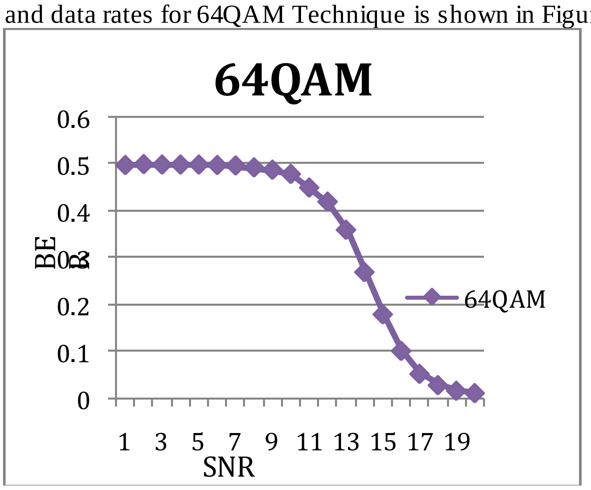

Figure 1.5 BER vs SNR for 64 QAM.

Analysis report**:** BER value of 64QAM is best among all QAM techniques discussed so far till data rates up to 1000000 At this data rate BER vs SNR curve shows that performance of 64QAM is better than 32QAM, 16QAM, 8QAM and 4QAM in fact .01 BER value is achieved beyond 20dB SNR

IV. PROPOSED ADAPTIVE METHODOLOGY:

Based on the analysis of the above BER curves for various modulation schemes a methodology for adaptive modulation schemes is formulated as shown in Table 1.2

Table1.2 Proposed methodology for OFDM system

SNR dB	Modulation scheme	Data rate	Achieved BER
1-5	4QAM	.1 kbps	.06
6-10	8QAM	1 kbps	.025
10-15	16QAM	10 kbps	.015
15-18	32QAM	100 kbps	.012
>18	64QAM	1000 kbps	.011

Selection of the QAM technique is on the basis of Data rate of the system and SNR values of AWGN channel. A combination of both data rate and QAM technique is the key for designing of the methodology. The flow chart shown in Figure 4.16 describes the whole methodology designed for adaptive modulation. The SNR value is processed in the script and checked for SNR intervals and depending on the SNR interval in which its value lies. The performance of different QAM techniques for OFDM systems using the BER Analysis Tool is analyzed and results are compared with each other and then compared with Adaptive QAM methodology as shown in Table 1.3 and figure 1.6. Finally, it is shown that adaptive methodology applied on OFDM system reduces the average BER and also improves the performance of the system in terms of data rate.

Table 1.3 Parameters Used in All Simulations

Parameter	Value
Type of Baseband Modulation	4,8,16,32,64 QAM
Number of FFT Carriers	64
Data Rates	Up to 100kbps
Data size	Up to 180samples per frame
IFFT Size	64
Cyclic Prefix Length	16
Number of pilots	4
SNR	Up to 20dB
Minimum Distance between Points	2
Input Power (referenced to 1 ohm)	.04 to 1.2watt

.

BER curve for 4QAM techniques applied on an OFDM system with 64 number of sub-carriers (i.e. $N = 64$). The x-axis represents the SNR values in dB and the y-axis represents the BER and varies logarithmically. As can be seen from the graph, as the SNR increases, BER decreases considerably.

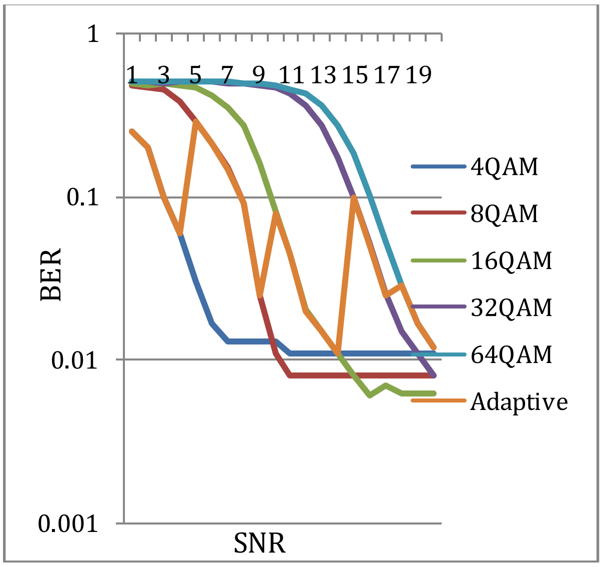

Figure 1.6 BER vs SNR for all QAM Techniques

V. FUTURE SCOPE

A lot of research is going on in the field of cognitive radio technology which is an example of intelligent and efficient system. The proposed adaptive scheme can be implemented in a cognitive radio and further design improvement can be done using channel estimation techniques. Instead of the QAM modulation number, the encoding scheme can also be made adaptive in accordance with SNR of the channel. Higher values of data rates with low BER values can also be achieved changing the cyclic prefix length in accordance with the data rate and SNR simultaneously leading to Adaptive Cyclic Prefix which reduces the ISI of the OFDM system.

REFERENCES

[1] Gupta, B. & Saini, D. S., 2010. BER Performance Improvement in OFDM Systems using Equalization Algoritms. s.l., IEEE, Proc. International Conference on PDGC, pp. 49-54.

[2] J.Faezah1 & K.Sabir, 2009. Adaptive Modulation for OFDM Systems. International Journal of Communication Networks and Information Security, 1(2), pp. 1-7.

[3] Surekha, T., Ananthapadmanabha, T. & Puttamadappa, C., 2011. Modeling and Performance Analysis of QAM-OFDM System with AWGN Channel. IEEE, PACCS(July), pp. 1-4.

[4] Tan, P. H., Wu, Y. & Sun, S., 2008. Link Adaptation Based Modulation and Coding for Multiple Antenna OFDM System. *IEEE*, 26(8), pp. 1599-1606.

[5] Chang R., 1966. Synthesis of Band-limited Orthogonal Signals for Multichannel Data Transmission. *Bell Sys Tech J*, *45*, pp.1775-1796

[6]Bingham, J. A. C., 1990. Multicarrier Modulation for data transmission: An Idea Whose time has come. *IEEE.*

[7]WEINSTEIN, S. B. & EBERT, P. M., 1971. Data Transmission by Frequency-Division Multiplexing. *IEEE*, 19(5)

[8]Peled, A. & Ruiz, A., 1980. Frequency Domain DATA Transmission using Reduced Omputional Complexity algorithms. *Proc. ICASSP 80, Denver, CO, USA*, pp.964–967

[9]Cimini, L.,1985. Analysis and Simulation of a Digital Mobile Channel using OFDM, *IEEE Trans. Commun.*, 33(7), pp. 665-675

[10]Zhao, Y. & Häggman, S.-G., 2001. Intercarrier Interference Self-Cancellation Scheme for OFDM Mobile Communication Systems. *IEEE*, 49(7), pp. 1185-1191.