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A Survey Paper on Digital Modulation Techniques

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***Abstract*—**Wireless communications has become a new field to growing rapidly in our recent life and creates a huge impact on almost all the features of our daily lives. An enormous technological transformation in the prior two decades has been provided a potential growth in the area of digital communication and lots of the most recent applications and technologies are to come each day as a result of these valid reasons. Digital modulation contributes to the growth of mobile communications by increasing the quality, speed and capacity of the wireless network. In the communication, the idea of modulation is a primary factor for the reason that without a scheme of appropriate modulation, it would be not possible to attain a planned flow. The offered bandwidth, allowable power and the level of inherent noise of the system are the constraints which must be taken into account in the development of communication systems. Because of the error free capacity in the digital modulation, it is chosen over the techniques of analogue modulation. The WiMax uses combinations of distinct modulation schemes such as BPSK, QPSK, 4-QAM and 16-QAM and it is a capable technology which provides video, data and high speed voice services. In this literature the review of documentation on the various digital modulation techniques that are typically used for wireless communication is presented.

***Keywords*—**Digital Modulation; Amplitude Shift Keying; Phase Shift Keying; Binary Phase Shift Keying (BPSK); Quadrature Phase Shift Keying (QPSK); QAM; Bit Error Rate

I. INTRODUCTION

The recent generation of wireless communication systems needs a higher level data rate transmission in order to respond to the increased demand for quality services [1]. Communicate efficiently over an enormous distance has always been the challenge for scientists and engineers and to the transition systems of the modulation of the analog to digital has more difficult situation. The analog to digital modulation transition provides additional information capacity, advanced security of data compatibility with numerical data services, a better quality of communications and a faster uptime of the system [2]. Over the past decades, an important transition from analog to digital communications has been appeared, and it may be found in all areas of communication, due to the system of digital communication is extra consistent than an analog system [3]. Digital modulation offer additional information, security of data, sharing of the RF spectrum and better quality communication capacity to put up extra services [4-5]. The digital modulation are chosen to the analog modulation due to digital modulation offer greater noise immunity requirements large bandwidth, while the obligation of audio, video and data on the mobile phone network or the computer network called third generation mobile communication presents a critical problem for the bandwidth, so that the modulation schemes existing must be modified to take account of the subject, or it can manage both the situations of bandwidth efficiency and noise [6]. The bandwidth efficiency means how competence with the allocated bandwidth is used or the capacity of a modulation scheme in order to take account of data within a limited bandwidth [7]. The digital modulation provide additional benefits over analog modulation due to its states of different transmission can further simply be detected at a receiver in the existence of noise that an analog signal, which can assume an infinite number of values.

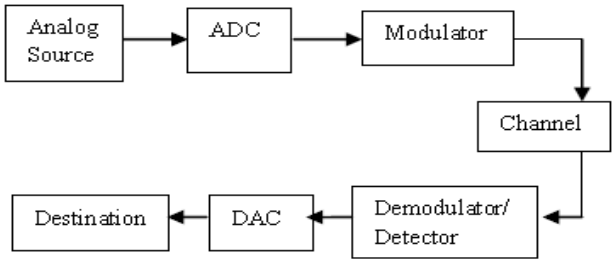

Figure-1 Basic Digital Communication System

In the communication digital system, Modulator, Analog to Digital converter and Analog source include the transmitter. If the information has been received in the form of analog, then it is converted into digital form to create the easier communication process. The analog to digital conversion is executed by the Analog to Digital converter. After that the modulator converts the digital signal into baseband signal and it is transmitted by the channel. The three blocks which

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are Demodulator, Digital to Analog converter and Destination, form the receiver. The destination data is the same as that of the transmitted data, in the case where there is no transmission error has occurred. The digital demodulator reverses the process of modulator and extracts the information in basic band binary from the modulation signal received which has been subjected to noise during its transmission on the channel. The rest of the article describes as: section II Digital Modulation techniques are described. Next section describe conclusion.

II. DIGITAL MODULATION TECHNIQUES

In the techniques of digital modulation, an analog signal is modulated with a binary code. The digital modulator device provides interface between the transmitter and the channel. The digital modulation can be classified mainly either on the basis of their bandwidth characteristics of compaction. The basic standards for the finest modulation method depends on Signal to Noise Ratio (SNR), , the efficiency of the power supply, Available Bandwidth, a better Quality of Service, Bit Error Rate (BER) and profitability [8]. The performance of every modulation method is calculated by the estimate of the probability of error with the assumption that system work with Additive White Gaussian Noise [9]. Modulation schemes which are proficient to transmit extra bits per symbol are extra error immune caused by the noise and interference induced in the channel [10]. The distortion of delay can be a significant measure as deciding of modulation method for digital radio [11].

There are different patterns of digital modulation methods which are used in the communications system. The fundamental types of digital modulation method are Phase Shift Keying (PSK), Frequency Shift Keying (FSK), and Amplitude Shift Keying (ASK) respectively [12-14]. The PSK, ASK and FSK with pulse Nyquist pulse shaping on the baseband form the fundamental technical of digital modulation, while another methods are also probable by integrating two or more digital modulation techniques of database with or without inserting pulse shaping. Therefore, the modulation can be designed hybrid corresponding to the signal types and their applications. The implementation of ASK is simple but they are limited to deliver low quantity of power and achieve a low transmission rate of data. The PSK modulation have regular envelope but discontinuous transitions phase from symbol to symbol. DPSK, QPSK and MSK are the derivatives of the modulation methods of PSK. Binary Phase Shift Keying, Quadrature Phase Shift Keying, 8-PSK and 16-PSK are the types of M-array modulation schemes [15]. The BPSK, QPSK, 16-QAM and 64-QAM modulation methods have been studied for the performance corresponding to their BER values [16]. The power efficiency methods such as Binary Phase Shift Keying and Quadrature Phase Shift Keying are used when the conditions of the channel are poor then that when the channel quality has been improved, 16-QAM or 64-QAM is used [17]. Binary Phase Shift Keying, Quadrature Phase Shift Keying and QAM has been studied to decrease the signal error performance and to compare the method which is better by channel fading Rayleigh in the existence of AWGN [18]. The evaluation of the performance of a WiMax system under distinct combinations of Binary Phase Shift Keying, Quadrature Phase Shift Keying, 4-QAM, 16-QAM digital modulation and distinct communication channels and to discoloration is allowing Additive White Gaussian Noise results presented [19]. The performance of various channel modulation schemes is studied in allowing Additive White Gaussian Noise results [20].

Table-1 Typical applications of different modulation methods

Modulation Scheme	Application
BPSK	Cable modems, Deep space telemetry
FSK, GFSK	Paging, land mobile, public safety
MSK, GMSK	Global System for Mobile
QPSK, π/4QPSK	Satellite, CDMA, cable modems, TFTS
OQPSK	CDMA, Satellite
8-PSK	Satellite, aircraft, telemetry pilots for monitoring broadband video systems
16-QAM	Modems, Microwave digital radio
32-QAM	Terrestrial microwave
64-QAM	Broadband set top boxes, Modems, MMDS

A. Amplitude Shift Keying (ASK)

Amplitude Shift Keying (ASK) is a form of digital modulation method. Here the amplitude of a carrier wave which is varied based on the signal of digital modulation. And here the frequency and phase of the signal are kept constant. And in this method to represent the logic 0, a single type of amplitude is used. And to represent the logic 1, another type of amplitude is used. This will be considered on and off of the carrier signal. Therefore this regime of modulation also qualified of ON/OFF of the overlay.

B. Minimum Shift Keying (MSK)

Minimum shift keying (MSK) is a unique type of CPFSK (continuous phase Frequency Shift Keying) with h=0.5. A modulation index of 0.5 corresponds to the spacing of minimum frequency which allows two signals FSK signals to be coherently orthogonal and the name minimum shift keying involves the separation of minimum frequency (i.e. the bandwidth) which allows the detection orthogonal.

C. Phase Shift Keying (PSK)

Phase Shift Keying (PSK) is extensively used in a multiplicity of radio communication systems. It is well-matched for large areas of coverage. Phase Shift Keying allows data to be transported on a signal of radio communications in a manner that is more effective than, Frequency Shift Keying and certain other forms of modulation. The phase of the carrier signal is a digital modulation method that transmits data by the modulation or modification of the carrier waves. The most generally and extensively used are Binary Phase Shift Keying (BPSK) and Quadrature Phase Shift Keying (QPSK). Other Phase Shift Keys are DPSK and MPSK etc.

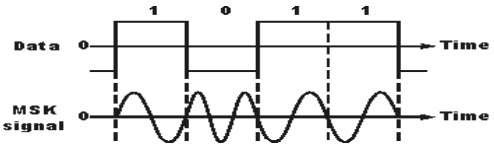


Figure-2 Signal Using MSK Modulation

D. Binary Phase Shift Keying (BPSK)

The digital modulation technique BPSK is devoted to as the easiest form of PSK and in this method, the phase of the carrier represent only two states of phase.

As any form of modulation by phase shift, there is the definition of the states or the points that are used for data bits of signaling. One of the main methods for PSK is BPSK. It is also called Phase Reversal Keying (PRK). A digital signal changing between +1 and -1 (or 1 and 0) will create phase reversals, that is to say the phase shifts to 180 degrees as the data shifts state. This operation is also called to two levels PSK as it uses two phases separated by 180º to represent binary digits. The principle equation is,

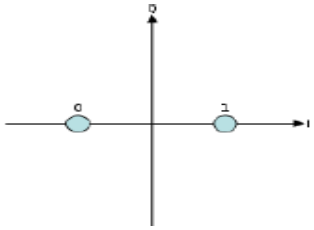
$$S(t) = A\cos(2\pi f_c t) \text{ for binary 1,}$$

$$S(t) = A\cos(2\pi f_c t + \pi) \text{ for 0,}$$

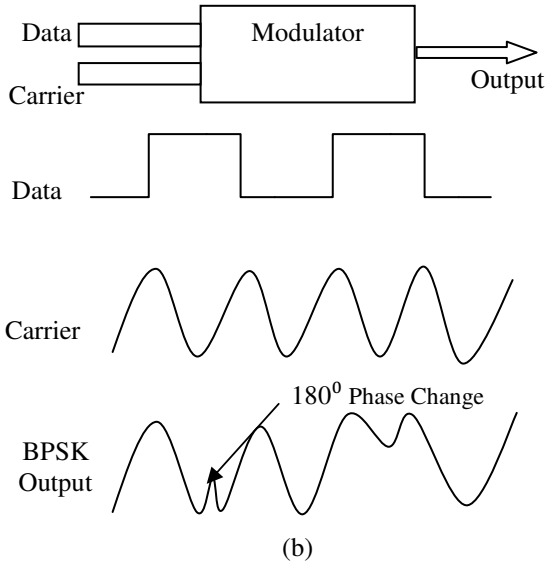
$$S(t) = A\cos(2\pi f_c t) \text{ for binary 1,}$$

$$S(t) = -A\cos(2\pi f_c t) \text{ for binary 0,}$$

This type of phase modulation is more efficient and robust in opposition to noise particularly in low data rate applications as it can modulate only 1 bit per symbol. A coherent BPSK modulation is categorized by having a one-dimensional signal of the space with a constellation diagram composed of two points of message.



(a)



(b)

Figure-3 Constellation Diagram of BPSK and Block Diagram

E. Differential Phase Shift Keying (DPSK)

For demodulating a signal to Phase modulation, it becomes apparent that the receiver has need of a reference signal consistent but if the encoding of the differential and phase shift keying are combined to the station of the transmitter and then the modulation technique resulting is called Phase Shift Keying differential [6]. In this, the phase is unchanged for the transmission of the symbol 1, while the phase of the signal is advanced by 180^0 for the transmission of the 0 symbol. The path of the information of phase change which becomes mandatory in the determination of the relative phase of change between the symbols transmitted. The full process is based on the assumption that the alteration of the phase is very slow in a measure that it can be considered as almost constant during the two intervals of bits [21].

F. Quadrature Phase shift keying (QPSK)

This operation is also called to four levels of PSK where each element represents more of a bit. Each symbol contains two-bit and it uses the phase shift of π/2, Means 90º instead of phase shift 180º. The principle of this technique lies in the equation:

$$S(t) = A\cos(2\pi f_c t + \pi/4) \text{ for 11,}$$

$$S(t) = A\cos(2\pi f_c t + 3\pi/4) \text{ for 01,}$$

$$S(t) = A\cos(2\pi f_c t - 3\pi/4) \text{ for 00,}$$

$$S(t) = A\cos(2\pi f_c t - \pi/4) \text{ for 10.}$$

In this mechanism, the constellation consists of four points, but the decision is always made in two bits. This mechanism can ensure the efficient use of the bandwidth and the spectral efficiency high.

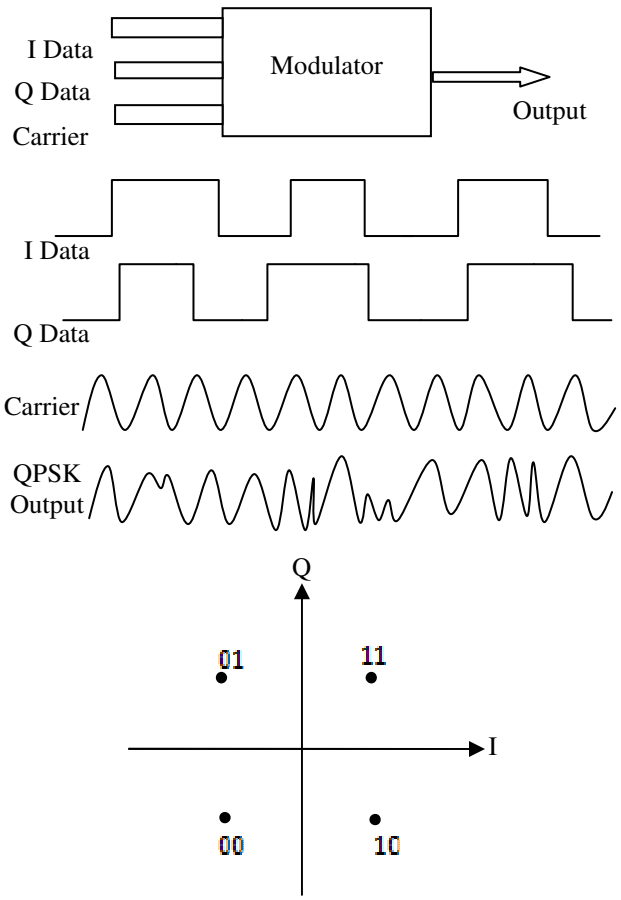


Figure-4 Block Diagram QPSK and Constellation Diagram

G. Quadrature Amplitude Modulation (QAM)

The QAM is a modulation scheme where its amplitude is allowed to vary with the phase [22]. This technique can be viewed as a combination of install as well as PSK [23].

QAM is widely used in many applications of communication of digital data, where the rate of data beyond the 8-PSK are needed by a radio communication system and then diagram of QAM modulation is widely used because QAM allows you to achieve a greater distance between the adjacent points in the plan I-Q in distributing the points are more distinct and data errors are reduced. The QAM modulation is more useful and more effective than the other and is almost applicable for all modems progressive.

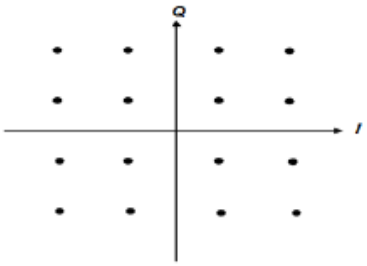


Figure-5 Constellation Diagram of 16-QAM

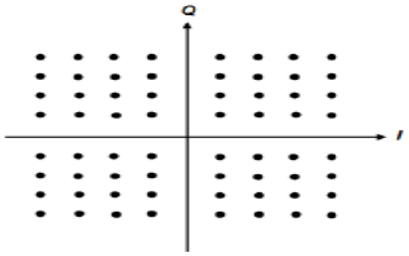


Figure-6 Constellation Diagram for 64-QAM

In the 16-QAM, the four levels of different magnitude are used. The joint stream would be of $4*4=16$ states. In this method, each symbol represents 4 bits.

It is identical to 16-QAM, except that it has 64 states where each symbol represents 6 bits. It is a complex modulation method but with superior efficiency. The mobile WiMax technology uses this technique of higher modulation when the Link status is high.

III. CONCLUSION

A survey on the digital modulation techniques has been presented in this document exposes that the choice of the technique of digital modulation is entirely dependent on the type of application specific, as an application may require a greater accuracy in the receipt of data, where that the other application necessity may be power or Available Bandwidth. The service quality supplied by the wireless communication system can be significantly improved with the help of proper selection of modulation method. Therefore, the increase of the radio coverage and reduces the consumption of energy can be found by the suitable selection of the digital modulation method. Some of the complexities of lesser technique consists in the design of the system of modulation and demodulation and establish to be cost-effective as MSK, ASK, PSK, DPSK, BPSK and patterns of QPSK modulation and can be viewed for the systems that in fact did not need to large amount of detail or when the financial budget is the main aspect and the BER performances can be tolerated. The QAM methods are used entirely for digital video, microwave digital radio, set-top boxes, and broadband in modems. In the field of mobile communication, QAM has proven its best performance over QPSK and MSK due to the best spectral efficiency.

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