Bit Error Rate Performance Evaluation of Different Digital Modulation Techniques: A Review

Anshul Jain
M.Tech scholar, Babulal Tarabai Institute of Research and Technology, Sironja, Sagar,Madhya Pradesh, India.

Megha Soni
Assistant Professor, Electronics and Communication Engineering Department, Babulal Tarabai Institute of Research and Technology, Sironja, Sagar, Madhya Pradesh, India.

Abstract – Now-a-days the requirements of wireless communication are to have high voice quality, high data rates, multimedia features, lightweight communication devices etc. But the wireless communication channel suffers from much impairment. One of them is fading which is due to the effect of multiple propagation paths, and the rapid movement of mobile communication devices. This paper analyses the various digital modulation techniques used in the present Wireless communications which has become the need of today. Here we see the various digital bandpass modulation schemes like the phase shift keying, frequency shift keying, amplitude shift keying and the M- ary signalling used most widely in wireless communications these days. 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.

Index Terms – Fading, Diversity, Fading channels, Combining techniques, Amplitude Shift Keying; Phase Shift Keying; Binary Phase Shift Keying (BPSK); Quadrature Phase Shift Keying (QPSK); QAM; Quadrature Amplitude modulation.

1. INTRODUCTION

During the last decades, wireless communications have advanced at an incredible pace. The first example which changes our life-style is the mobile phone. Mobile phones have evolved from the simple phones for voice-calling in 1970s to present smart-phones with computer-like functionality. The second example is wireless local area networks (WLAN), the so-called WiFi. Equipped with a WLAN device, a laptop or desktop computer can connect easily to the Internet without the use of wires. As WLAN devices have been installed in many personal computers, video game consoles, mobile phones, printers, and other peripherals, and virtually all laptop or palm-sized computers. The third example is the Global Positioning System (GPS), a space-based global navigation satellite system which provides reliable location and time information in all weather and at all times and anywhere on or near the Earth. With the navigation of GPS, we can drive easily in any cities. GPS has become a useful tool for map-making, land surveying, commerce, scientific uses, tracking and surveillance, and hobbies such as geo-caching and way-marking.

The basic concept of a wireless communication system is almost deceptively easy to understand. An electromagnetic signal is created, modulated, amplified, and broadcast to one or more receivers that can be fixed or mobile. The data in that signal is received and demodulated in order to recover the original information that was sent. A basic system will normally consist of a transmitter, receiver, and a channel (i.e. radio frequency) that utilizes different carrier frequencies for each baseband (information signal) that is transmitted. The basic issues that one must address in the design of wireless systems are common to all of telecommunications, namely the effective use of the available frequency bandwidth and power to provide high-quality communications. Some wireless systems often involve mobile services as this implies a constantly changing environment with rapidly changing interference conditions and dynamically variable multipath reflections and scattering. This condition, plus the potential of conflicting demands for the use of radio frequencies in a free-space medium, means difficult challenges for creating high-quality signals.

2. DIGITAL COMMUNICATION SYSTEMS

Figure 1 illustrates a general block diagram for a digital communication system. In this diagram, digital data from a source are encoded and modulated for transmission over a channel. At the other side, the data are extracted by demodulation, decoding, and then sent to a sink. The encoder can be divided into two blocks, namely the source encoder and the channel encoder.

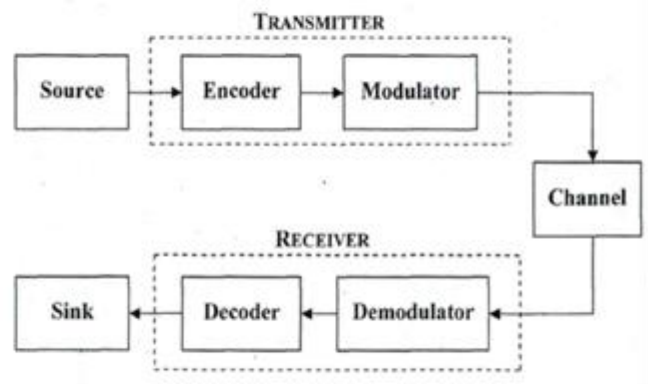

Figure 1: Block diagram of a digital communication system

In some digital communication systems, channel coding and modulation are combined together; this is called coded modulation. In general, there are two main constraints in communication systems, the available spectrum (or bandwidth) and the power required for data transmission. The bandwidth is becoming a rare commodity with the demand of high speed and high quality of service (QoS) for wireless communications. In this paper M-ary phase shift keying (M-PSK) used for improving BER performances.

3. DIGITAL MODULATION

In digital modulation schemes, binary code modulates the analog carrier signal. The digital modulator device acts an interface between the transmitter and the channel. The digital modulation schemes are categorized basically either on their detection characteristics or in terms of their bandwidth compaction characteristics. The main criteria for best modulation scheme depends on Bit Error Rate (BER), Signal to Noise Ratio (SNR), Available Bandwidth, Power efficiency, better Quality of Service, cost effectiveness . The performance of each modulation scheme is measured by estimating its probability of error with an assumption that system are operating with Additive White Gaussian Noise. Modulation methods which are capable of transmitting more bits per symbol are more immune to error caused by noise and interference induced in the channel. The delay distortion can be an important measure while deciding modulation scheme for digital radio. There are various digital modulation schemes which are used in the telecommunication system. The basic types of digital modulation scheme are Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK) and Phase Shift Keying (PSK) respectively. The ASK, FSK and PSK with nyquist pulse shaping at the baseband form the basic technique of digital modulation, but other methods are also possible by incorporating two or more basic digital modulation techniques with or without introducing pulse shaping. Thus, hybridized modulation can be designed depending upon the type of signal and the application. The implementation of ASK is simple but they are limited to deliver low amount of power and achieve low data transmission rates. The PSK modulation technique have steady envelope but but discontinuous phase transitions from symbol to symbol. DPSK, QPSK and MSK are the derivatives modulation schemes of the Phase Shift Keying. A better digital modulation scheme is to be contemplated over by the designer which has an ability of exploiting the existing transmitted power and the bandwidth to its full coverage [48]. In paper [15], author have presented the characteristics of modulation techniques and determined.

4. DIGITAL MODULATION TECHNIQUES

(i) Binary Amplitude Shift Keying (BFSK)

In BASK scheme the resultant is obtained by changing the amplitude of the carrier according to the digital signal. The BASK is a coherent modulation scheme hence the concept of the co-relation between the signals, number of basic functions, the I and Q components and the symbol shaping are not applicable here.

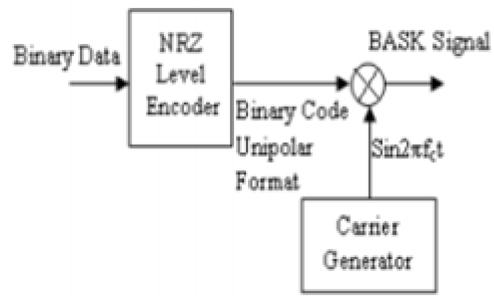

Fig.2 BASK modulation block diagram

In the block diagram of BASK modulator, the output of multiplier is modulated by binary code. The input binary sequence is converted into suitable format for product modulator by the NRZ level encoder. The bandwidth efficiency is very poor in BASK. The implementation of the BASK is simple but it is highly vulnerable to noise and the performance is good only in the linear region which does not make it suitable for mobile or wireless applications. QAM and M-ary ASK which have much significant applications with improved parameters can be obtained by combining BASK with PSK. The FPGA based modulator is presented for BASK and BPSK modulation techniques in [26] .

(ii) Binary Frequency Shift Keying (BFSK)

In the BFSK, the two different frequencies mark and space are used to represent the two different symbols [27]. Depending upon the separation between the two carrier frequencies, BFSK can be categorized as wideband or a narrowband digital modulation technique. FSK has a poorer error performance than PSK or QAM and thus is seldom used for high performance digital modulation systems [28]. Because of the separation in the carrier frequencies, it is not a bandwidth efficient scheme and generally not used because of the receiver design complexities.

(iii)Binary Phase Shift Keying (BPSK)

In BPSK digital modulation scheme is referred as the simplest form of phase modulation and in this scheme only two phase states are represented by the the carrier phase. A Coherent BPSK system is characterized by having a one dimensional signal space with a constellation diagram consisting of two message points.

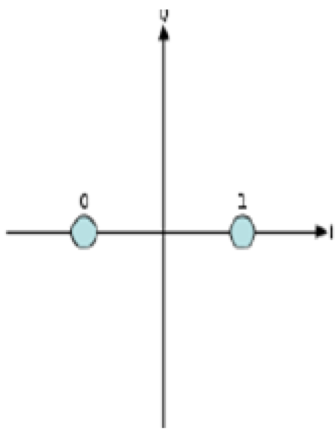

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Fig.3 Constellation diagram of BPSK

The two phases which are separated by 180 degree and can also be referred as 2-PSK. In BPSK, a single carrier is modulated by controlling its polarity according to the binary data signal to be transmitted. The magnitude of the modulated BPSK signal is kept constant, thus increasing the maximum power to be delivered.

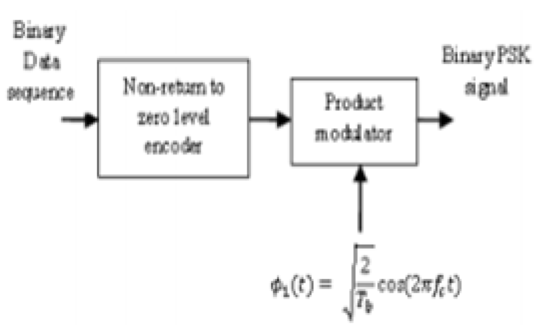

Fig.4 BPSK modulator

To produce a BPSK signal, the binary sequence in polar form with symbol 1 and 0 are represented by fixed magnitude levels of + (Eb)1/2 and - (Eb)1/2 respectively. The resulting binary wave in polar form and a sinusoidal carrier ϕ1(t), whose frequency is given by fc = (n c/T b) for some fixed integer nc are applied to the product modulator. The carrier and timing pulses used to obtain the binary wave are generally extracted from a common master clock. At the output of modulator the desired PSK waveform can be obtained. The BPSK modulator is basically a two positional switch, controlled by the data stream . The high level in data allows 0 phase and the low level in data permits the 180 phase introduced in the output. The prime advantage of Binary Phase Shift Keying is that it provides a suitable modulation format for downlink data transmission in inductive biomedical telemetry systems, because it achieves high data rates and power efficiencies. BPSK modulation is simple to design and less complex when compared to QPSK, which is almost double the complexity of BPSK design. The BPSK digital modulation technique is generally used in the application of high speed data transfer. It is simple in implementation and gives a 3dB power improvement as compared to BASK modulation technique. The BPSK modulation consists of a phase modulation with two possible states of the intermediate frequency by a serialized numerical signal. The Bit error rate (BER) of BPSK in AWGN channel can be estimated as in

$$P_b = \frac{1}{2} erfc\left(\sqrt{\frac{E_b}{N_o}}\right)$$

(iv) Quadrature Amplitude Modulation (QAM)

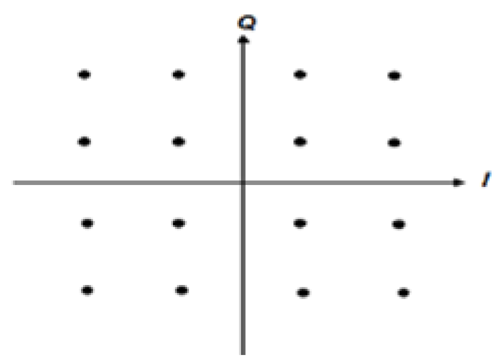

Fig.6 Constellation diagram of 16-QAM

The QAM is a modulation scheme where its amplitude is allowed to vary with phase [36]. This technique can be viewed as a combination of ASK as well as PSK [37]. QAM is widely used in many digital data communication applications , where data rates beyond 8-PSK are needed by a radio communication system then QAM modulation scheme is extensively used because QAM achieves a greater distance between adjacent points in the I-Q plane by distributing the points are more distinct and data errors are reduced [38]. The QAM modulation is more useful and efficient than the others and is almost applicable for all the progressive modems [39].

(v)Quadrature Phase Shift Keying (QPSK)

In QPSK digital modulation scheme, the division of the phase of the carrier signal is designed by allotting four equally spaced values for the phase angle as π/4, 3π/4, 5π/4 and 7π/4, thus providing a major advantage over BPSK by having the information capacity double to it.

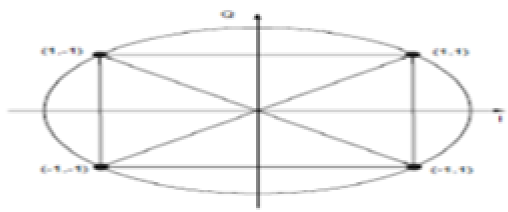

Fig. 8 Constellation diagram of QPSK system [21]

5. CONCLUSION

In this paper, the review on digital modulation techniques for wireless communication presented shows that the choice of digital modulation technique is completely application specific and should be chosen carefully. Some applications need a higher precision rate, while some schemes focus on effective utilization of available bandwidth and permissible power for the given application. The quality of service offered by wireless communication systems can be greatly improved by correctly selecting the modulation scheme. Thus, proper selection of digital modulation technique needs to be done to increase radio coverage and power consumption.

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