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Performance Comparison of Digital Modulation Techniques used in Wireless Communication System

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ABSTRACT: The move to digital modulation provides more information capacity, compatibility with digital data services, higher data security, better quality communications, and quicker system availability. The main objective of this paper is to give an overview of the digital modulation techniques used in wireless communication systems and to conclude with a better modulation technique among those , which are compared in this work. This paper presents different modulation techniques with the help of MATLAB/SIMULINK that are amplitude shift keying (ASK), quadrature phase shift keying (QPSK), binary phase shift keying (BPSK), frequency shift Keying (FSK) ,On-off keying (OOK), DPSK & 8-PSK. Simulation models of above techniques involved in signal modulation are proposed in this paper and comparative study of the same have been done at the later stages which includes the performance of these techniques based on bit error rate (BER).

KEYWORDS: Digital Modulation, MATLAB/SIMULINK, ASK, FSK, QPSK, BPSK, OOK, DPSK, 8-PSK

I. INTRODUCION

Modulation is the process of varying one or more properties of a periodic waveform, called the carrier signal, with a modulating signal that typically contains information to be transmitted. A modulator is a device that performs modulation. A demodulator (sometimes detector or demod) is a device that performed, the inverse of modulation. A modem (from modulator–demodulator) can perform both operations. The aim of digital modulation is to transfer a digital bit stream over an analog band pass channel, for example over the public switched telephone network (where a bandpass filter limits the frequency range to 300–3400 Hz) or over a limited radio frequency band.

The next generation wireless communication systems require higher data transmission rates in order to meet the higher demand of quality services. Communicating effectively over a huge distance has always been the challenge for engineers and scientists and with the transition of modulation systems from analog to digital has further complicated the situations. Digital modulation schemes provide more information carrying capacity, better quality communication, data security and RF spectrum sharing to accommodate more services. The digital modulation schemes are preferred over analog modulation schemes because digital modulation schemes provide larger immunity to noise at the cost of large bandwidth requirements, whereas the requirement of video, audio and data over the computer network or the mobile telephony network termed as the third generation mobile communication poses a serious problem for the bandwidth, so the existing modulation schemes need to be modified for the purpose, where it can handle both the situations of noise and bandwidth efficiency [6].

Digital modulation has innate benefits over analog modulation because its distinct transmission states can more easily be detected at a receiver in the presence of noise than an analogue signal, which can assume an infinite number of values. But implementation of the digital modulation techniques like the Amplitude Shift Keying, Frequency Shift Keying and Phase Shift Keying comes with the different trade-offs. There is a trade-off need to be made between the available bandwidth and the number of bits/symbol that can be transmitted over the line, which in turn limits the maximum data rate on the link. Thus the selection of digital modulation techniques is absolutely critical, especially in an environment like the satellite uplink-downlink where resources are very limited and time slots are auctioned at very high rates.

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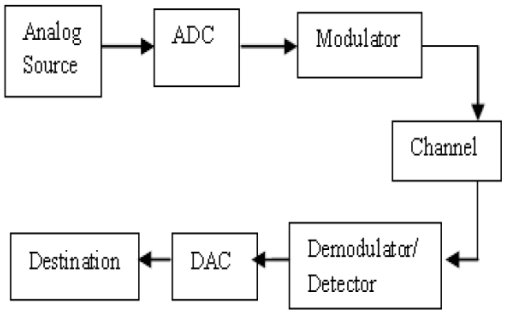

Figure1. block diagram of communication system

Digital Modulation Techniques

In digital modulation techniques, an analog carrier signal is modulated by a binary code. The digital modulator device acts an interface between the transmitter and the channel. The digital modulation schemes can be categorized basically either on the basis of their detection characteristics or in terms of their bandwidth compaction characteristics. The basic 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.

II. LITERATURE SURVEY

D.K.Sharma, A. Mishra & Rajiv Saxena,3 July 2010: A tremendous technological transformation during the last two decades has provided a potential growth in the area of digital communication and lot of newer applications and technologies are coming up everyday due to these reasons. Restricting overself to the domain of modulation techniques a brief overview over different analog and digital modulation techniques has been provided in this article through extensive literature survey in a tabular manner enabling to analyze and establish the superiority at a glance of a specific modulation technique for a particular application.

Umesh Sharma, August 2012: The migration to 4G networks will bring a new level of expectation to wireless communications. As after digital wireless revolution made mobile phones available for everyone, the higher speeds and packet delivery of 4G networks will make high quality multimedia available everywhere. The key to achieving this higher level of service delivery is a new air interface. Orthogonal Frequency Division Multiplexing (OFDM) is an alternative wireless modulation technology to CDMA. OFDM is a digital modulation and multiplexing technique. In this paper, we have discussed various digital modulation techniques such as BPSK (2bits), QPSK (4 bits), QAM, 16 QAM and 64 QAM. We have designed simulation environment in MATLAB with various configurations of OFDM technique. The main objective of our work is to measure Bit Error Rate with different modulation schemes and come to the best configuration to achieve better utilization of bandwidth. We have studied existing configurations with analog and digital modulation techniques and compared the results. The driving force behind the need to satisfy this requirement is the explosion in mobile telephone, Internet and multimedia services coupled with a limited radio spectrum.

***M. Sheik Dawood, R. Aiswaryalakshmi, R Abdul Sikkandhar,G. Athisha , February* 2013**: A standard wireless sensor network comprises of a huge number of sensor nodes with data processing and communication capabilities. The sensor nodes pass the gathered data using radio transmitter, to a sink either straightforwardly or through other nodes in a multi-hop approach. Wireless sensor network is a power consuming system since nodes perform on restricted power supply which decreases its lifetime. Optimally selected modulation and coding is extremely vital technique in wireless sensor networks. This paper surveys the performance of different modulation schemes and error control codes used in

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Sensor Networks. The survey also analyzes the role of modulation and coding techniques apply to different channel conditions to improve the lifetime of the clustered sensor network.

Harjeevan Singh, Mohit Arora, January 2015: Free space optical (FSO) communication link is a line of sight (LOS) wireless link between the nodes separated by an unguided medium such that visible and infrared bands of the spectrum are used as data carrier. Recent past has witnessed huge revival of research interest in this field so as to make FSO commercially viable and looking into this prospective, data modulation techniques are one of the primary ways to enhance link sustainability. In this paper, comparison of modulation techniques like M-ary QAM, BPSK and DPSK has been studied by creating turbulent atmospheric conditions using gamma-gamma turbulence model. During this link analysis, BPSK performed far better in comparison to DPSK and M-ary QAM in terms of BER for similar SNR values and interestingly, higher the order of M-QAM and higher the link range, greater was the degradation of link performance observed.

III. MATLAB SIMULATION AND RESULT

The coding done for different modulation techniques have been implemented on MATLAB 7.11 (R2010b) and the system configuration of Intel Core i3- 1.90 GHz with 64 bit operating system. Several functions of respective modulation techniques have been developed which is then called by master code. This code creates a window in which options for modulation techniques are available. The output plots of these techniques have been discussed below simultaneously. Simulation result is then obtained in which bit error rate curves are obtained on the basis of which the best technique is decided.

A. Binary Phase Shift Keying (BPSK)

BPSK (also sometimes called PRK, phase reversal keying, or 2PSK) is the simplest form of phase shift keying (PSK). It uses two phases which are separated by 180° and so can also be termed 2-PSK. It does not particularly matter exactly where the constellation points are positioned, and in this figure they are shown on the real axis, at 0° and 180°. This modulation is the most robust of all the PSKs since it takes the highest level of noise or distortion to make the demodulator reach an incorrect decision. It is, however, only able to modulate at 1 bit/symbol (as seen in the figure) and so is unsuitable for high data-rate applications.

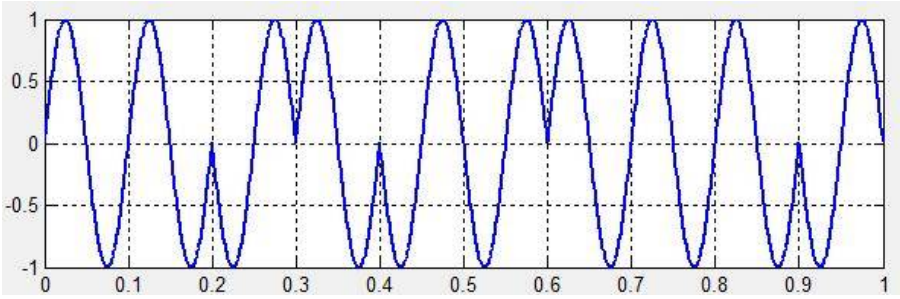

Figure2.Phase change of frequency with binary signal

B. Quadrature phase shift keying (QPSK)

Quadrature Phase Shift Keying (QPSK) is a form of Phase Shift Keying in which two bits are modulated at once, selecting one of four possible carrier phase shifts (0, 90, 180, or 270 degrees). **QPSK** allows the signal to carry twice as much information as ordinary PSK using the same bandwidth.

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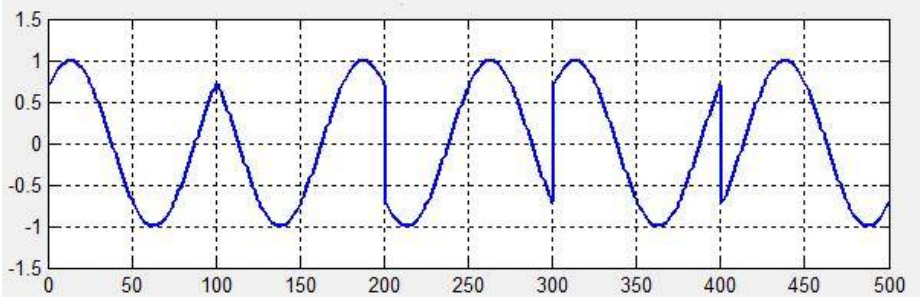

Figure3.Phase change of QPSK signal with time

C. Amplitude shift keying (ASK)

Amplitude-shift keying (ASK) is a form of amplitude modulation that represents digital data as variations in the amplitude of a carrier wave. In an ASK system, the binary symbol 1 is represented by transmitting a fixed-amplitude carrier wave and fixed frequency for a bit duration of T seconds.

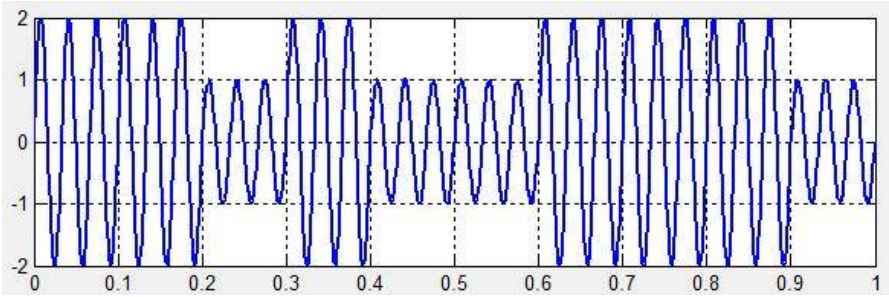

Figure4.Modulation signal of ASK

D.Frequency shift keying (FSK)

Frequency-shift keying (FSK) is a frequency modulation scheme in which digital information is transmitted through discrete frequency changes of a carrier wave. The simplest FSK is binary FSK(BFSK). BFSK uses a pair of discrete frequencies to transmit binary (0s and 1s) information.

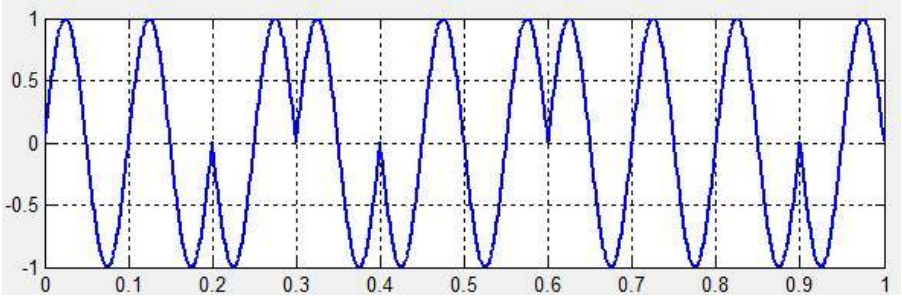

Figure5.Phase change of frequency with binary signal

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E. On-off keying (OOK)

OOK modulation (On/Off Key) is the special case of ASK (Amplitude Shift Key) modulation where no carrier is present during the transmission of a zero. FSK modulation (Frequency Shift Key) is commonly believed to perform better in the presence of interfering signals.

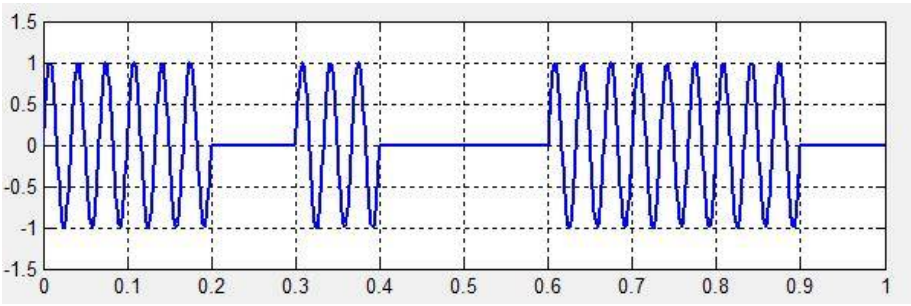

Figure6. (On/Off Key) modulation

F. DPSK

Differential phase shift keying (DPSK) is a common form of phase modulation that conveys data by changing the phase of the carrier wave. As mentioned for BPSK and QPSK there is an ambiguity of phase if the constellation is rotated by some effect in the communications channel through which the signal passes. This problem can be overcome by using the data to *change* rather than *set* the phase

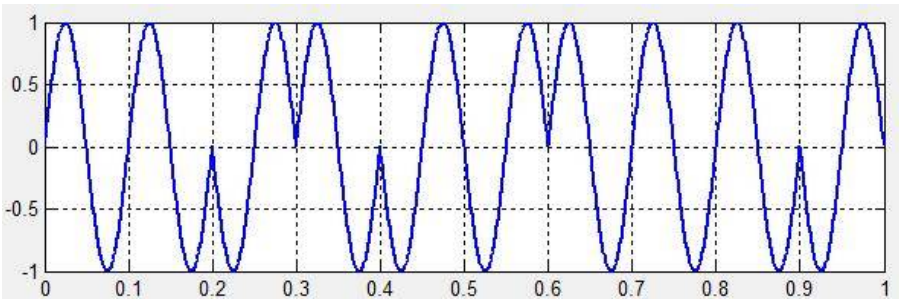

Figure7.Differential phase shift keying (DPSK)

G. 8-PSK

In BPSK modulation digital data of 1 and 0 is represented by 180 degree phase change. In QPSK by phase shift of 90 degree, here 2 bits are mapped on each signal. In Multilevel PSK more than 2 bits are mapped using different phase angles. In 8-PSK eight different phase angles are used to represent bits, here 3 bits. Figure below shows constellation of 8-PSK signal.

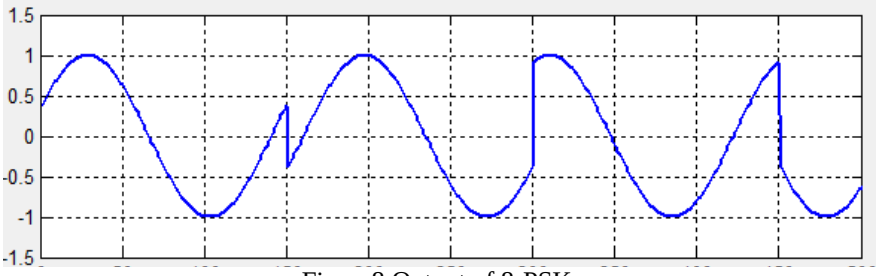

Figure8.Output of 8-PSK

IV. COMPARISON

The matlab code developed for the comparison of digital modulation techniques when executed, produces a Graphical

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User Interface which is shown below. In this GUI, there are options for the user to do analysis of the said modulation techniques. These options include, the Matlab models of each modulation techniques through which the simulation results can be obtained, comparison on basis of bit error rate of all the techniques and it also includes options for direct simulation of these digital modulation techniques.

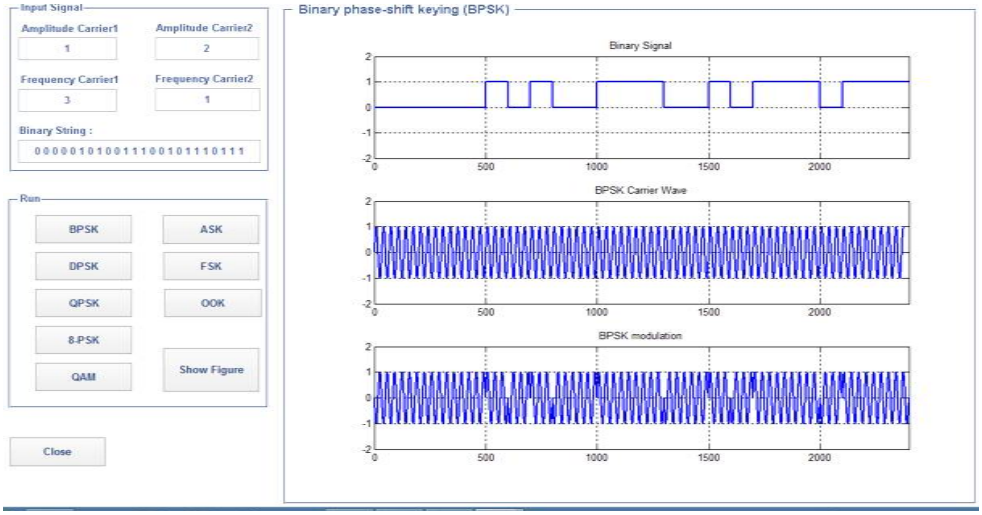

Figure 9 . Graphical User Interface

E_b/N_0 (the energy per bit to noise power spectral density ratio) is an important parameter in digital communication or data transmission. It is a normalized signal-to-noise ratio (SNR) measure, also known as the "SNR per bit". It is especially useful when comparing the bit error rate (BER) performance of different digital modulation schemes without taking bandwidth into account.

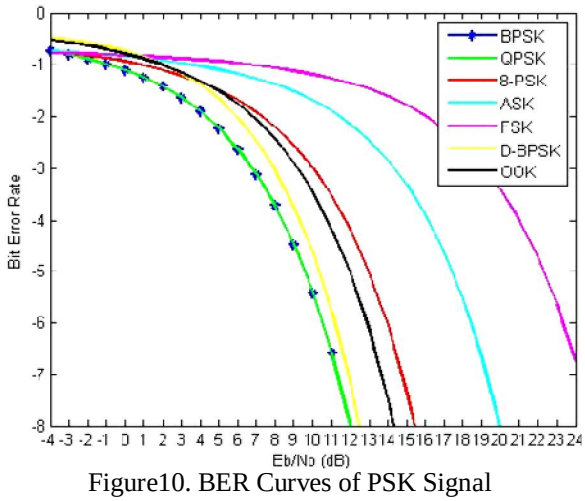

Figure10. BER Curves of PSK Signal

In digital transmission, the number of bit errors is the number of received bits of a data stream over a communication channel that has been altered due to noise, interference, distortion or bit synchronization errors. The bit error rate (BER) is the number of bit errors per unit time. The bit error ratio (also BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unitless performance measure, often expressed as a percentage.As shown above, the plot summarizes the theoretical BER (given SNR per bit ration – Eb/N0) for various linear modulations. The performance of all the modulation techniques is more or less the similar but

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for higher SNR values, BPSK modulation technique delivers better BER performance than the other discussed techniques.

IV. CONCLUSION

A comparative study has been done of digital modulation techniques used in wireless communication system. The simulation model and the output waveform of the different digital modulation techniques have been discussed in this paper. The selection of digital modulation technique is exclusively dependent on the type of specific application, as one application may need higher precision in reception of data, where as the other application requirement may be available bandwidth or power. The quality of service provided by wireless communication system can be greatly enhanced with the help of correct selection of modulation scheme.

The performance of all the modulation techniques is more or less the similar but for higher SNR values, BPSK modulation technique delivers better BER performance than the other discussed techniques.
Thus, increased radio coverage and reduced power consumption can be obtained by the proper selection of digital modulation technique. But the search for a better modulation scheme doesn't end here as the criterion for higher data rate communication is taking the lead role in almost every field of communication and thus the Inter Symbol Interference and Bit Error Rate calculation become very crucial and important aspect for any ultramodern digital modulation scheme.

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