

Performance Comparison of Various Digital Modulation Schemes based on Bit Error Rate under AWGN Channel

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Abstract— In 21st century most of the technology works is on digital mode whether it's AI or digital communication. Digital signals require modulation for transmitting data from one place to another. There are many techniques available for modulating digital signals but the most commonly used are Binary Amplitude Shift Keying (BASK), Binary Phase Shift Keying (BPSK) and Binary Frequency Shift Keying (BFSK). These techniques are selected on the basis of factors like low Signal to Noise Ratio (SNR), low Bit Error Rate (BER), complexity of design and final cost of the product etc. This paper will focus on the performance comparison of theoretical and simulated BER of above three schemes and then comparing the BER of all three schemes in same conditions and predicting the best technique for digital signal transmission. The simulation is done in the MATLAB software.

Keywords—MATLAB, BER, BASK, BFSK, BPSK

I. INTRODUCTION

The root stage of all wireless communication is modulation. Modulation is the process of encoding a message signal in a way it is suitable for transmission. Almost every transmission nowadays is digital. There are multiple ways or techniques for digital modulation. For countless times, governments have wanted to extend a common digital modulation classification feature in their ADC systems. As there is an enhancement of the communication industry, the benefits in terms of these techniques enhance the usefulness of the communication system worldwide. This Paper investigates the goodness and cutoff points of a computerized balance classifier, as by comparing the three most used methods the output will of great use in communication line.

This paper is the relative examination of the 3 widely used digital modulation techniques i.e. Binary Amplitude Shift Keying (BASK), Binary Frequency Shift Keying (BFSK) and, Binary Phase Shift Keying (BPSK). When there is a transmission of information across a link, there can be a chance that some error may be introduced in the system. once the errors are being introduced, the system may not work efficiently. Concluding it is very important to determine the performance of our system and by calculating BER (bit error rate) there will be an ideal way of how it can be achieved. Suppose A signal contains crucial information with almost zero

tolerance for errors and different other signals are interrupting our signal. So, now the work of the receiver would be so challenging to translate the real signal. In brief, this is what makes having a high signal to noise ratio so important. This is how bit error rate and signal to noise ratio plays a vital role in the transmission of the signal. In order to know the efficient technique based upon certain parameters like BER and SNR, this is a comparative study on all the above-mentioned techniques. [1]

II. THEORY

There are different modulation techniques used for both analog and digital modulation. Modulation transforms a low pass signal into a modulated signal. An analog signal is being used whose values varies with time from 0 to 100 in analog communication, whereas a digital signal is being used in digital communication which can have two amplitudes either 0 or 1 but the similarity is both of them are modulated using an analog carrier. Modulator works for modulation and demodulator performs demodulation. [2]

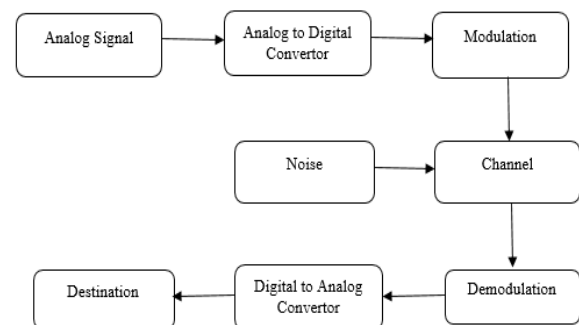


Figure 1 Digital Communication System

Starting with the block diagram shown above, the three blocks are shown in the starting i.e. An analog source, an analog to the digital converter, and a modulator. Talking about the transmitter side, these are all the blocks that comprise to be a transmitter in this communication system. The source

portrays the information to be dispatched which however includes several types i.e. video, image, speech text, etc. To make the communication more manageable, we need to convert the analog form of information into digital if any detected. This task of converting analog value into digital is to be done by the A to D converter block mentioned over there. The digital signal then is being converted into the bandpass signal for further transmission and this is done by the modulator. Then this bandpass signal transmits through the channel. [3]

So, now the receiver part of the communication system comprises the last few blocks i.e. demodulator, DAC, and destination. Demodulator's work is to invert the procedure and extort the binary lowpass data from the modulated signal which has been subjugated to noise and other deformities in its way. DAC converts again the converted digital signal to analog and then it reaches the end which is just the data we transmitted.

Digital Modulation gives more data capability, powerful data security, more responsive system availability with quality communication. Therefore, digital modulation techniques have a higher demand, for their capacity to carry larger amounts of information than analog. There are numerous sorts of procedures for carrying out modulation. The fundamental types of digital modulation techniques are Amplitude Shift Keying, Phase Shift Keying, and Frequency Shift Keying. [3]

A. Bit Error Rate (BER): -

When data is being transmitted from one end to another, by any means let's say wireless link or wired communication link. The main parameter is the data received at the receiver end is error-free or how much error does it contain. The bit error rate is the amount of bits errors per unit time. If we see mathematically, it is essentially the ratio of two quantities i.e. total number of error bits to total number of transmitted bits. [4]

$$BER = \frac{\text{Total number of error bits}}{\text{Total number of transmitted bits}}$$

B. Signal to noise ratio (SNR): -

The SNR is the ratio of carrier signal power to the noise signal power. On a logarithmic scale it can be expressed in (dB).

$$SNR = \frac{\text{Signal Power}}{\text{Noise Power}}$$

C. Noise: -

Additive White Gaussian Noise (AWGN) model is used to represent the random behavior of nature. Normally when information or signal is transmitted through communication channel the random signals are added to the desired signals. These random signals are called AWGN. Since these are additive in nature and it gives the same appearance for all the

frequency range of signal. This type of noise is having Gaussian type of normal distribution which has mean at zero and variance is $N_0/2$, where N_0 is noise power. [4]

III. MOULATION TECHNIQUES

a) Binary Amplitude Shift Keying (BASK)

There are 2 input signals needed in Amplitude shift keying. The 2 inputs are the binary signal and the carrier signal respectively. The amplitude of the carrier wave should be higher than that of binary input. [5]

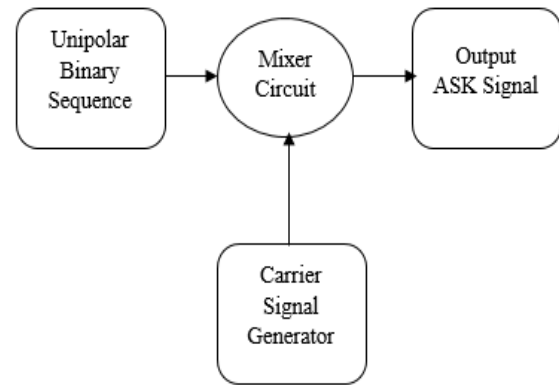


Figure 2 BASK Modulator

BASK (Binary Amplitude shift keying) is a Modulation that mirrors the digital data as variations in the amplitude of a carrier wave. As per the modulating signal the amplitude of an analog carrier changes. Phase and frequency continue to be constant. Here, there is a multiplication of binary signal with the carrier signal with its time intervals.

In ASK, firstly a unipolar binary signal is generated (Unipolar signal transmits the signal as it is for logic 1 and 0 for logic 0). At the mixer circuit part when there is high logic at any time intervals or it can be said logic 1, the same amplitude to be transmitted to the output as in those intervals switch is being closed. Now when the logic is low i.e. logic 0, No output would be generated, as binary input has generated 0 and when it gets multiplied with the carrier it generates zero. [5]

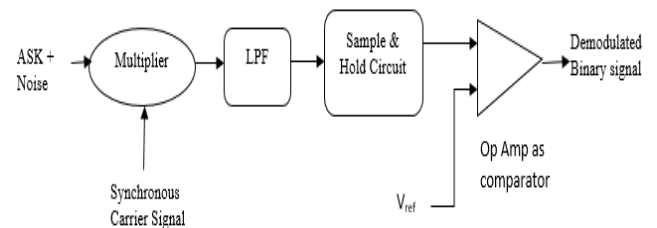


Figure 3: BASK Demodulator

As noise is introduced to the modulated ask signal, to remove it we should pass the signal from the multiplier and then through LPF i.e. low pass filter. The block named here as sample and hold is used to convert the discrete signal. Then, there is a comparison done between the output of the sample and hold circuit with the reference voltage. This will provide us the real binary signal. [6]

b) Binary Phase Shift Keying (BPSK)

It is a scheme in which 2-phase modulation is used, here the digital information that is 0 and 1 are represented as two separate phases in the carrier signal.

For different bits, phases will be different and for the same, it will be the same. If the binary input signal value changes from 1 to 0 then there will a change of phase of 180 degrees in the output modulated signal. The same will happen if the input changes from 0 to 1. [6]

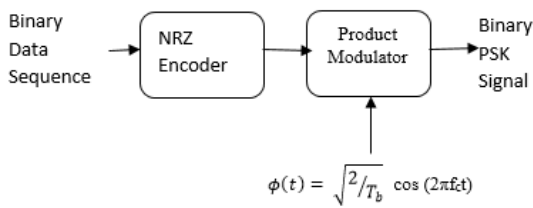


Figure 4 BPSK Modulator

To generate the BPSK signal the carrier signal can be applied to the balanced modulator as shown in the Figure 4. The input of the product modulator is supplied by bipolar NRZ encoder.

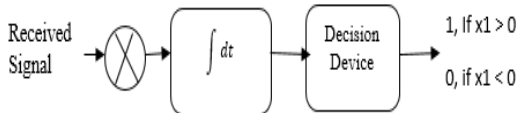


Figure 5 BPSK Demodulator

To detect back the signal there is a need for an integrator and a multiplier. Firstly, we apply the BPSK signal to the multiplier and following it compare it to the coherent signal locally generated. The comparison takes place between the multiplier output and the threshold of zero volts. If it is greater than "0" Then pass 1 and if it is lesser than zero, then "0" is passed as an output. [6]

c) Binary Frequency Shift Keying (BFSK)

Frequency modulation is a method in which digital data is being transmitted by a change in frequency of the carrier wave. The most simplistic is binary FSK (BFSK). It proposes using different frequencies for the binary data that is either 0s or 1s. Frequency shift keying is basically a way of carrier wave. BFSK utilizes two frequencies which are orthogonal to picture 0 and 1. In this keying, 1 is the mark frequency and 0

is the space frequency. FSK is generally practiced for caller ID and remote metering purposes.

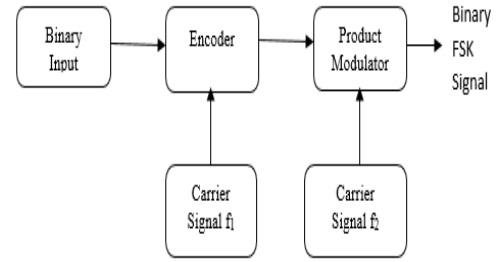


Figure 6: BFSK Modulator

As the Figure 6 explains the BFSK is being generated in the following manner. The encoder is fed with the binary information i.e. 1 or 0. The input to the product modulator is the output of encoder. In the product modulator two more inputs are two sinusoidal carriers. [7]

In Figure 7, there are two carrier waves that are being used to provide distinct frequencies for the product modulator showed there. After that signal is passed through the Bandpass filters. The decision part of the circuit monitors the 2 outputs and takes the decision about which is the one. The dependence of bandwidth is on the bit rate of the message. There may be a separation of the merest frequency expected of the two expressions. These types of demodulators are further complicated than the asynchronous ones. [8]

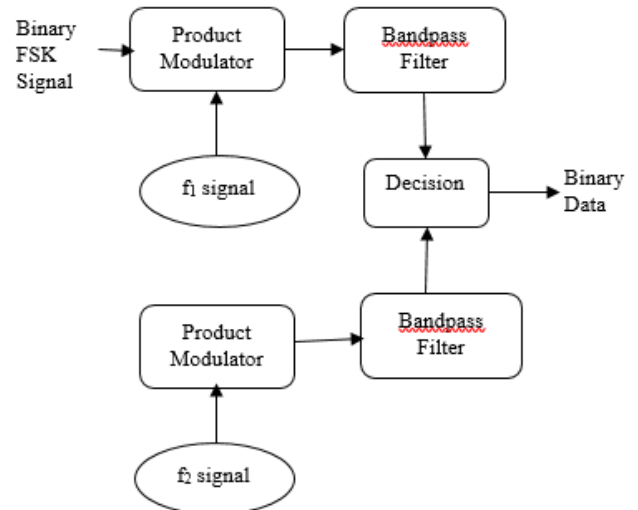


Figure 7 BFSK Demodulator

IV. LITERATURE REVIEW

M.N. Rajesh et. all, discussed about the BER performance of various adaptive modulation methods used for higher spectral efficiency. Also various techniques such as pulse shaping filters, convolution encoding, match filter are used to improve the BER performance of Signal. [10] M. Jain et all, discussed about the BER analysis for reliable signal transmission for different fading environment for different

modulation schemes. [11] M. M. Madankar et. al discuss various error control schemes to reduce the BER for different industrial and military applications for wireless sensor network. [12] T. Patra et. al discussed the BER analysis for different modulation schemes under the different values of SNR for Rayleigh Channels. They have also applied the convolutional coding to get the better results. [13] B. Chirag et. al discussed about the use of various modulation schemes under different levels of noise for a channel. They have different parameters to do this classification. [14] N. Fatima et. al discussed the performance of various modulation schemes under the AWGN channel. They also analyzed the modulation schemes using audio and speech signal. [15]

V. BER CALCULATIONS OF BPSK, BFSK BASK

Bit error rate calculation with E_b/N_0 (dB) is done to find out the impact of E_b/N_0 (dB) on the bit error rate. This is done to find the performance of different modulation technique. On x axis different values of E_b/N_0 (dB) has been taken and simulation is done on MATLAB. The theoretical formulas are given below to calculate the BER. [12]

$$P_{e,BPSK} = 0.5 * \left(\operatorname{erfc} \left(\sqrt{E_b/N_0} \right) \right)$$

$$P_{e,BFSK} = 0.5 * \left(\operatorname{erfc} \left(\sqrt{E_b/(2N_0)} \right) \right)$$

$$P_{e,BASK} = 0.5 * \left(\operatorname{erfc} \left(\sqrt{E_b/(4N_0)} \right) \right)$$

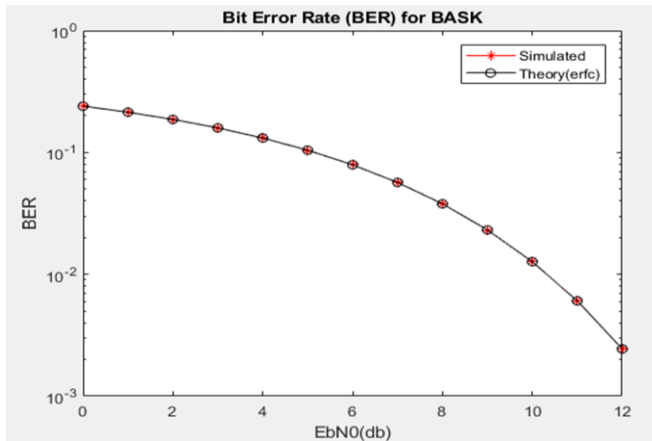


Figure 8 BER vs E_b/N_0 (dB) for BASK

E_b = Energy per bit
 N_0 = Noise power spectral density

Here, Sample points (N)=100000000 is taken and SNR values are varying from 0 dB to 12 dB. The simulation for all three schemes are done and a comparison is done between their simulated graph (using real scenario) and theoretical

graphs. In Figure 8, 9 and 10, it is observed that practical simulated graph of BER for each schemes are exactly following the theoretical graph. [9]

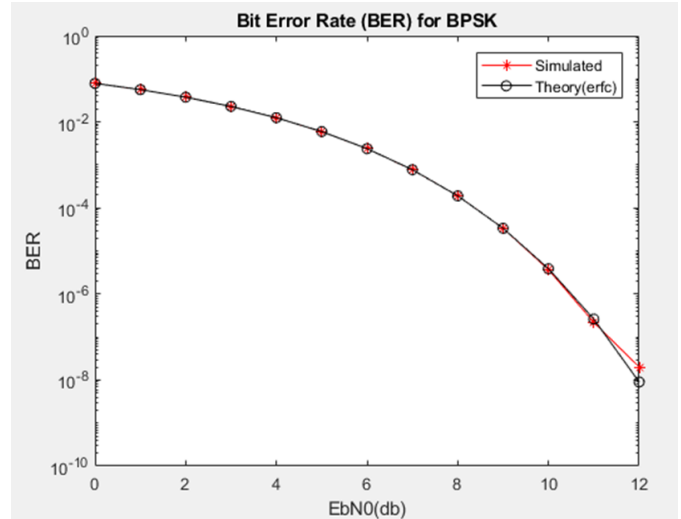


Figure 9 BER vs E_b/N_0 (dB) for BPSK

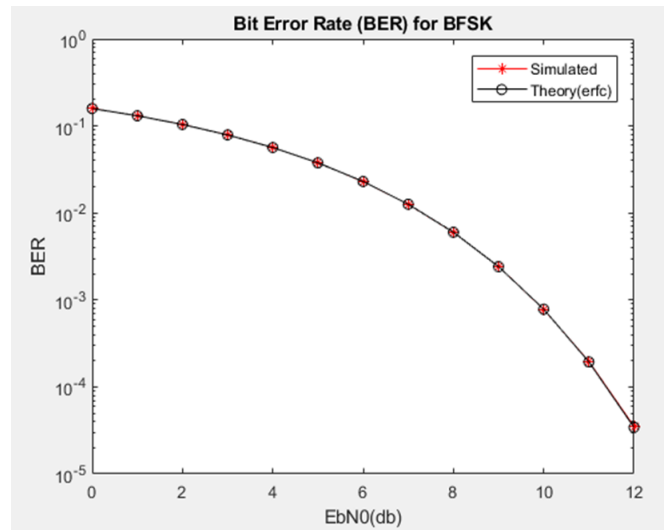


Figure 10 BER vs E_b/N_0 (dB) for BFSK

VI. COMPARISON OF BER Vs E_b/N_0 (dB) FOR BPSK, BFSK AND BASK

In Figure 11, comparison of BER Vs E_b/N_0 (dB) is done for various modulation scheme. Here different values of SNR (0 dB to 12 dB) has been taken against the bit error rate for finding the best modulation scheme which will be more efficient. It is seen that the BER for BASK is more compare to BFSK, and BER of BFSK is more compare to BPSK. It means that BPSK Scheme is more efficient in terms of Bit error rate compare to other two schemes.

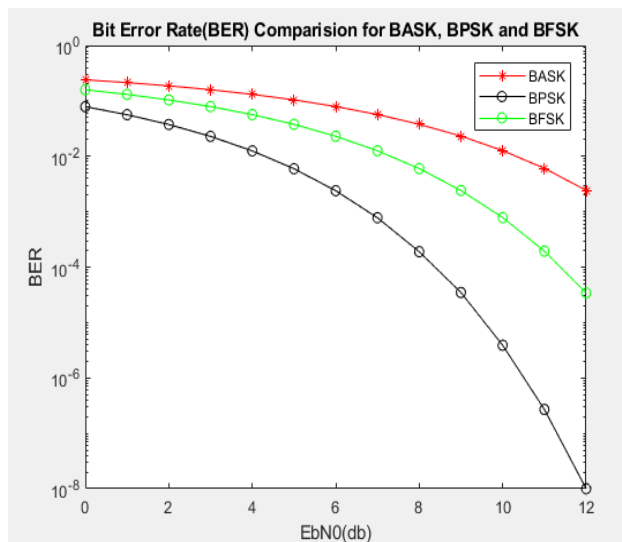


Figure 11 BER Comparison for BASK, BPSK and BFSK

VII. RESULT AND DISCUSSION

It is observed from Figure 11 that the BPSK modulation has lower bit error rate for the different values of SNR for same number of bit transmitted and received comparison to BFSK and BASK Schemes. In practical cases, there are some limitation for adjusting the value of SNR. Higher performance is required with minimum SNR and low bit error rate for detecting the message at output end. Here the BPSK modulation technique gives the best performance with less power consumption even for less SNR.

There is other higher order modulation schemes i.e QPSK, QAM and M-ary PSK that are used for high data rate communication. Orthogonal Frequency Division Multiplexing (OFDM) is also used for high data rate communication. It uses multicarrier communication in which several low frequency orthogonal carriers are used for data communication.

VIII. CONCLUSION

In this paper Bit Error Rate Analysis has been done for digital modulation schemes named as BASK, BFSK and BPSK. This analysis is done using MATLAB software. After comparing the BER Vs SNR, it is observed that BPSK modulation scheme has better performance with same message bits and same SNR values.

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