Bit Error Rate (BER) Comparison in AWGN Channel of BFSK and QPSK using Matlab and Simulink

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Abstract - **The MATLAB software is used to find out the comparison of Bit Error Rate (BER) between two of the most popular Digital Modulation Techniques i.e. BFSK and QPSK and to design their respective Simulink models to showcase the signal propagation with the help of the relevant Toolbox. There are basically three types of Digital Modulation Techniques most commonly used i.e. ASK, FSK and PSK. BFSK and QPSK are the types fall under FSK and PSK respectively. For the communication medium various kinds of channels are used for wireless communication. In this paper, the AWGN channel is used between transmitter and receiver. This paper focuses on the BFSK and QPSK signal, their modulated waveforms, their BERs, comparison of their BER by using MATLAB code and plotting it in a graph in the output and their respective Simulink model to generate the signal waveforms. A brief introduction of AWGN channel is stated as the communication medium is considered as AWGN channel.**

Index Terms - **AWGN Channel, BFSK and QPSK.**

I.INTRODUCTION

In the recent times for fast growing wireless technologies, the performance of the transmitting and receiving systems are very important. Communication System can be defined as transferring data from one place to another, is done in wired or wireless manners. In either way we have to modulate the baseband signal to make it suitable for transmission over the medium, this is called Digital Modulation. Digital modulation is a process that impresses a digital symbol onto a signal suitable for transmission over a wired or wireless medium in order to receive to that signal at receiving end correctly without any loss of information. QPSK and BFSK are one of the most popular digital modulation techniques used for satellite communication and sending data over cable network, videoconferencing and cellular phone system

etc over RF. The BER (bit-error rate) is the main performance parameter of a digital communication system. AWGN (Additive white Gaussian Noise) channel is the simplest model of a channel and is well suited for wired communication. MATLAB is considered to be a good choice to perform our study because of its programming capability which allows user-developed functions. MATLAB has been enhanced by the very powerful SIMULINK to check whose BER is greater [1-2].

II.ADDITIVE WHITE GAUSSIAN NOISE(AWGN) CHANNEL

The AWGN channel as shown in Fig.1 adds White Gaussian noise with a constant spectral density to an input signal. A Gaussian channel is a time-discrete channel with output Yi, input Xi. And noise Zi at time i such that Yi = Xi +Zi, Zi~ N (0, N). The channel does not account for fading, frequency selectivity, interference nonlinearity or dispersion. AWGN is commonly used to simulate background noise of the channel under study, in addition to multipath, terrain blocking, interference, ground clutter and self-interference that modern radio systems encounter in terrestrial operation maintaining the Integrity of the specifications [6].
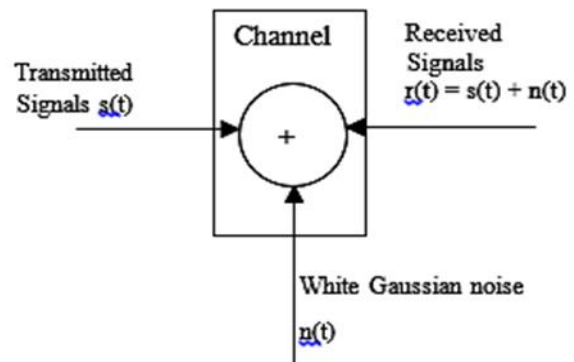

Fig.1 Block Diagram of AWGN channel model

III. DIGITAL MODULATION

In Digital Modulation a digital information signal is encoded into the amplitude, phase, or frequency of the transmitted signal. The encoding process affects the bandwidth of the transmitted signal. The most commonly used Digital Modulation techniques are Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Binary Frequency Shift Keying (BFSK), Binary Phase Shift Keying (BPSK) and Quadrature Phase Shift Keying (QPSK).Here we will discuss about BFSK and QPSK [2].

A. Binary Frequency Shift Keying (BFSK)

Binary frequency shift keying (BFSK) is one type of digital modulation which uses for modulating signals between analog and digital signals. The frequency of carrier will be varied by binary information (1 or 0) shown in Fig.2.BFSK is the simplest FSK.BFSK uses a pair of discrete frequencies to transmit binary information (0s and 1s). This technique is used in communication system such as telemetry, weather balloon radiosondes, caller id, garage door openers and low frequency radio transmission in the VLF and ELF bands [2].
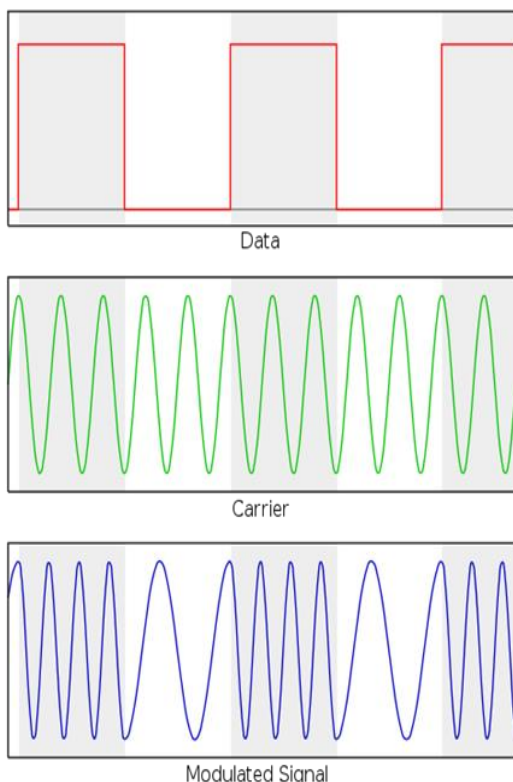

Fig.2 BFSK Signal

B. Quadrature Phase Shift Keying (QPSK)

The QPSK signal is a variation of BPSK signal as shown in Fig.3.It is also a Double Side Band Suppressed Carrier DSBSC modulation scheme, which sends two bits of digital information at a time, called as digits. Instead of the conversion of digital bits into a series of digital stream, it converts them into bit pairs. This decreases the data bit rate to half. In QPSK, information carried by the transmitted signal contained in the phase. Phase of the carrier takes on one of four equally spaced values, $\pi/4$, $3\pi/4$, $5\pi/4$, and $7\pi/4$ as shown in Fig.3.The receiver in a standard QPSK system is essentially two BPSK receivers using phase-orthogonal carriers [2].
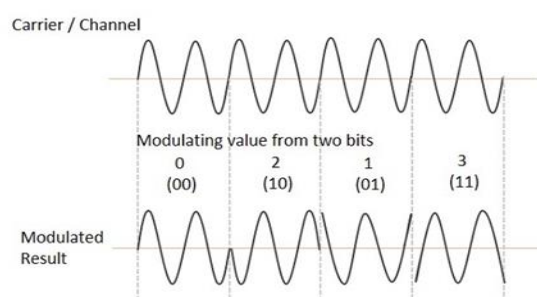

Fig.3 QPSK Modulated Signal

IV. BIT ERROR RATE

Bit Error Rate helps in analyzing system performance that transmits digital data from one location to another. When data is transmitted over a data link errors are being introduced into the system. So, it is necessary to assess the performance of the system, and BER provides an ideal way in which this can be achieved. BER assesses performance of a system including the transmitter, receiver and the medium between the two. BER= NO OF BITS WITH ERROR: TOTAL NO OF BITS SENT [1].

A. Bit Error Rate (BER) of BFSK and QPSK:
The BER of BFSK is

$$P_e = \frac{1}{2} erfc\left(\sqrt{\frac{E_b}{2N_0}}\right) \qquad (1)$$

where P_e represents error probability, E_b is the energy per bit and $N_0/2$ is the two-sided power spectral density of the additive white Gaussian noise channel. As we increase the transmitted signal per energy bit, E_b, for a specified noise spectral density N_0, the message points corresponding to symbols 1 and 0

move further apart, and the average probability of error P_e is correspondingly reduced in accordance with the above equation.

The BER of QPSK is

$$P_e = \frac{1}{2} erfc\left(\sqrt{\frac{E_b}{N_0}}\right) \qquad (2)$$

where P_e= Error probability, E_b is the energy per bit and N_0/2 is the two-sided power spectral density of the additive white Gaussian noise channel [1].
Observation:
QPSK:
Making a QPSK system is equivalent to making two BPSK systems in parallel. So, there is no difference in BER using two in phase quadrature carriers [3-4]. In QPSK
E(symbol error)= 2√E_b (Eb is the bit error)
so probability of bit error in each channel of coherent QPSK system

$$P_e = \frac{1}{2} erfc\left(\sqrt{\frac{E_b}{N_0}}\right) \qquad (3)$$

BFSK:
Frequency shift keying is a frequency modulated scheme in which digital information is transmitted with the instantaneous changes of carrier frequency. BFSK uses two orthogonal frequencies to represent 0 and 1. In this scheme the 1 is called mark frequency and 0 is called space frequency [3-4]. In BFSK
E(symbol error)= $\sqrt{E_b}$ (Eb is the bit error)
so probability of bit error –

$$P_e = \frac{1}{2} erfc\left(\sqrt{\frac{E_b}{2N_0}}\right) \qquad (4)$$

Matlab code:
EbN0dB=0:10
EbN0=10.^(EbN0dB/10);
pe_bfsk=0.5*erfc(sqrt(EbN0/2));
pe_qpsk=0.5*erfc(sqrt(EbN0));
semilogy(EbN0dB,pe_bfsk,'k+-
',EbN0dB,pe_qpsk,'g.-');
legend('BFSK-C','QPSK-C');
xlabel('Eb/N0(dB)');
ylabel('BER');
title('BER comparison of AWGN channels for BFSK and QPSK');[5]
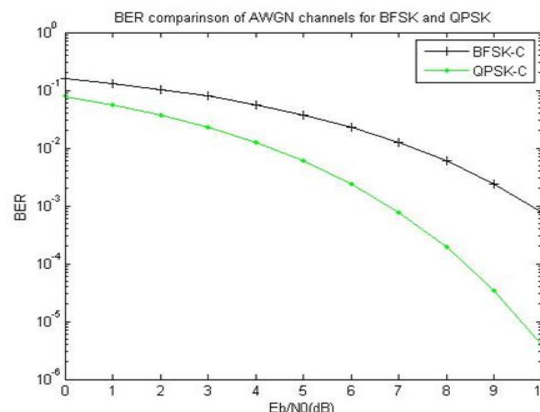
Output:

Fig.4 Output of Matlab code

With the help of signal space diagram, we will see the equivalent distance between two points in BFSK is lower than that of QPSK. If the distance is higher probability of error will be less [1]. So, by MATLAB code, BER of BFSK and QPSK signal has successfully been compared and thus obtained the BER of BFSK signal is greater than QPSK signal as shown in Fig.4.

V.SIGNAL GENERATION USING MATLAB SIMULINK
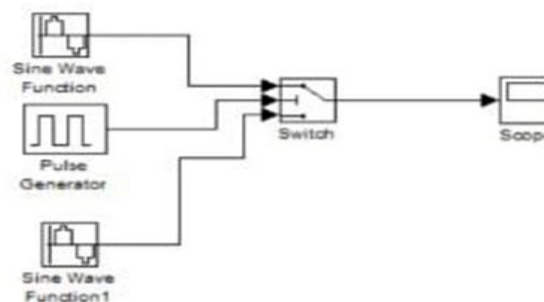
A. Matlab Simulink of BFSK:

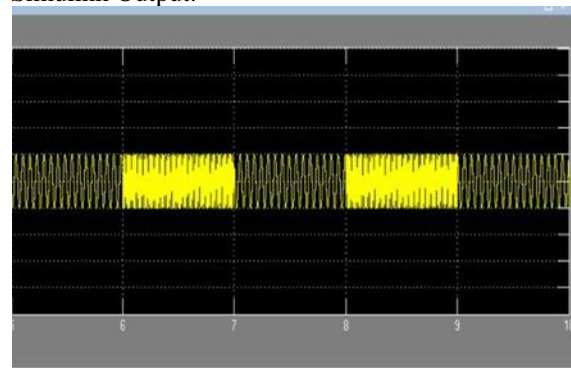Fig.5 Simulink design of BFSK signal generation

Simulink Output:

Fig.6 Simulink output (BFSK signal)

Here we generated a BFSK signal by MATLAB SIMULINK model shown in Fig.5 where the frequency of the carrier signal has been shifted in accordance to input signal thus we get a frequency shifted modulated signal which is the nature of BFSK signal as shown in Fig.6.
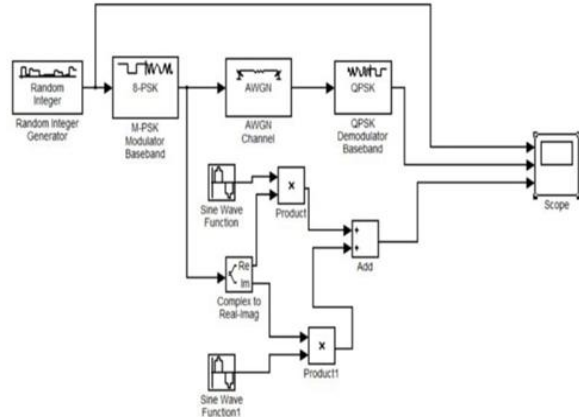
B. Matlab Simulink of QPSK:

Fig.7 Simulink design of QPSK signal generation
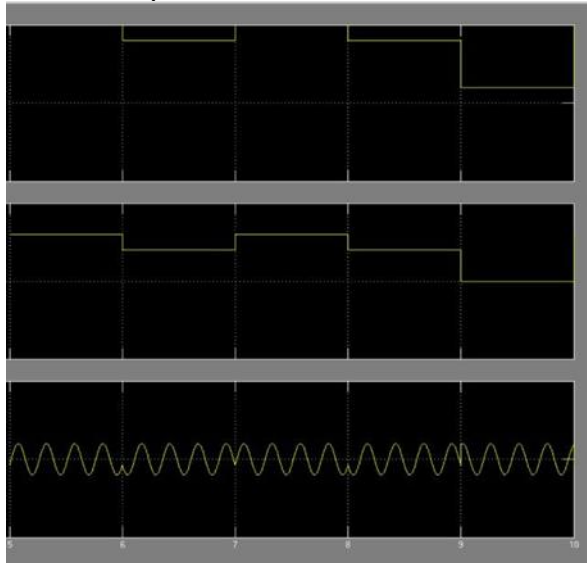
Simulink Output:

Fig.8 Simulink output (QPSK signal)

Here the output as shown in Fig.8 shows the Modulating, Demodulated, Modulated signal in the three different blocks of the Simulink output respectively. The Modulating signal has been followed by the Demodulated signal which refers that the modulation and demodulation has been done correctly as per our Simulink design as shown in Fig.7. We are getting a phase shifted modulated signal.

VI. CONCLUSION

In this project bit error rate comparison of BFSK and QPSK was found out. The equivalent distance between two points in BFSK is lower than that of QPSK. If the distance is higher probability of error will be less. By MATLAB code we came to know that BER of BFSK is greater than QPSK. By MATLAB SIMULINK we designed the Simulink model to generate BFSK & QPSK signal and the output shows their signal propagation respectively.

REFERENCES

[1] Vinay Panwar and Sanjeet Kumar. "Bit Error Rate (BER) Analysis of Rayleigh Fading Channels in Mobile Communication".
[2] T.S. Rappaport. "Wireless Communications: Principles and Practice".
[3] MATLAB/Simulink for Digital Communication by "Won Yang".
[4] Digital Communication Systems Using MATLAB and Simulink by "Dennis Silage"
[5] Website:-www.mathworks.com
[6] Website:-www.gaussianwaves.com