

Comparative Analysis of Different Digital Modulation Techniques on the Basis of Their Bit Error Rate in VHDL

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Abstract – In digital communication system design, the main objective is to receive data as similar as the data sent from the transmitter. It is important to analyze the system in term of probability of error to view the system's performance. Each modulation technique has different performance while dealing with signals, which normally are affected with noise. General explanation for probability of error is explained and simulated in this paper. It focuses on comparative performance analysis of basic BPSK, QPSK 8PSK and 16PSK system. The different modules of system model is going to be designed using VHDL and simulated by Xilinx ISE 8.1i. The BER curves for different digital modulation techniques which are obtained after simulation are compared with theoretical curves.

Keywords – AWGN Channel, Bit Error Rate (BER), BPSK, Digital Modulation Techniques, 8PSK, 16PSK, Signal to Noise Ratio (SNR), QPSK, VHDL.

I. INTRODUCTION

In digital communication system design, the main objective is to receive data as similar as the data sent from the transmitter. It is important to analyze the system in term of probability of error to view the system's performance. Each modulation technique has different performance while dealing with signals, which normally are affected with noise. General explanation for probability of error is explained and simulated in this paper. It focuses on comparative performance analysis of BPSK and QPSK. BER versus the signal-to-noise ratio (SNR) are used to evaluate the performance of different digital modulation techniques. The BER curves obtained after simulation are compared with theoretical curves.

II. SYSTEM DESIGN

In the figure given below System design is shown for different Digital Modulation techniques.

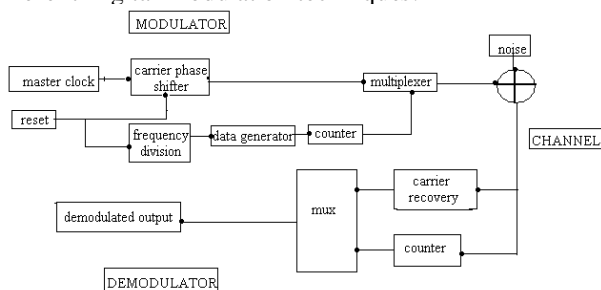


Fig. 3. Simulation model

III. DIGITAL MODULATION TECHNIQUES

Digital modulation is the process by which binary bits are transformed into waveforms that are compatible with the characteristics of the channel. In this paper we consider following modulation techniques

A. Binary phase shift keying (BPSK)

BPSK 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 on the real axis, at 0° and 180° .

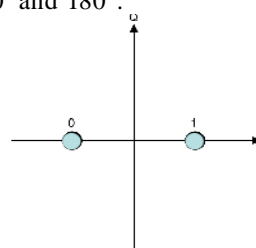


Fig 2: BPSK Constellation Diagram

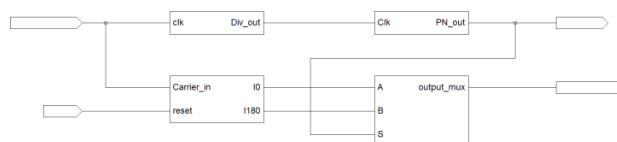


Fig.3. BPSK Modulator Diagram

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 and so is unsuitable for high data-rate applications.

B. Quadrature phase shift keying (QPSK)

Another extension of the PSK digital modulation technique is the division of the phase of the carrier signal designed by allotting four equally spaced values for the phase angle $0, 90, 180$ and 270 degrees.

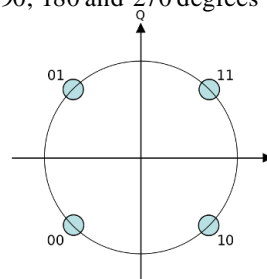


Fig.4. QPSK Constellation Diagram

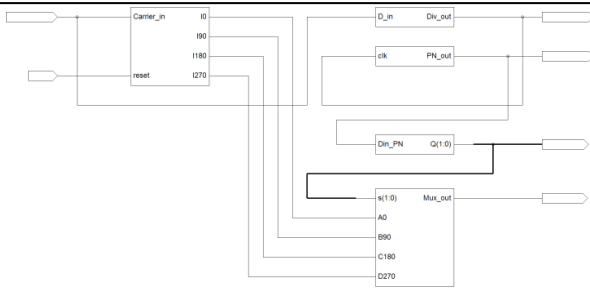


Fig.5. QPSK Modulator Diagram

The QPSK has four message points in the constellation diagram and so it becomes a highly bandwidth efficient digital modulation technique.

C. M-PSK: 8PSK & 16 PSK

M-PSK is a method of modulating a carrier with a unique symbol. Each symbol consists of two or more bits. The number of unique data states is defined as

$M = 2^n$, where n represents the number of bits. A 8-PSK scheme would utilize a symbol containing three data bits to shift the phase of a Carrier b , 8 distinct amounts

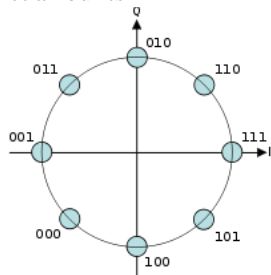


Fig 4: 8PSK Constellation Diagram

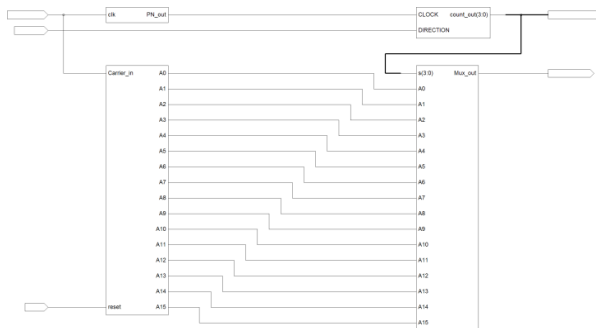


Fig.6. 8PSK Modulator Diagram

A 16-PSK scheme would utilize a symbol containing four data bits to shift the phase of a carrier b , 16 distinct amounts. As value of M increases, the error probability also increases over AWGN channel.

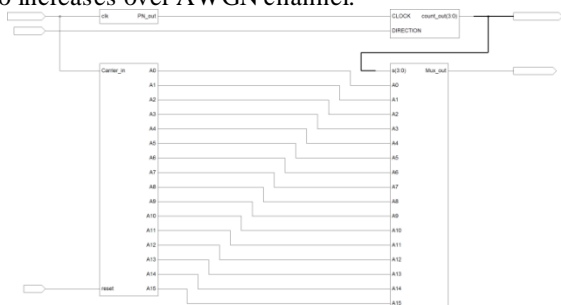


Fig.7. 16PSK Modulator Diagram

IV. BIT ERROR RATE

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 or bit error ratio (BER) is the number of bits in error divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure; often expressed as a percentage. The bit error probability P_b is the expectation value of the BER.

$$\text{Bit error Rate } P_b = \frac{\text{Number of bits in error}}{\text{Total number of bits}} \quad (4)$$

The performance of each modulation is measured by calculating its probability of error with assumption that systems are operating with additive white Gaussian noise. Modulation schemes which are capable of delivering more bits per symbol are more immune to errors caused by noise and interference in the channel.

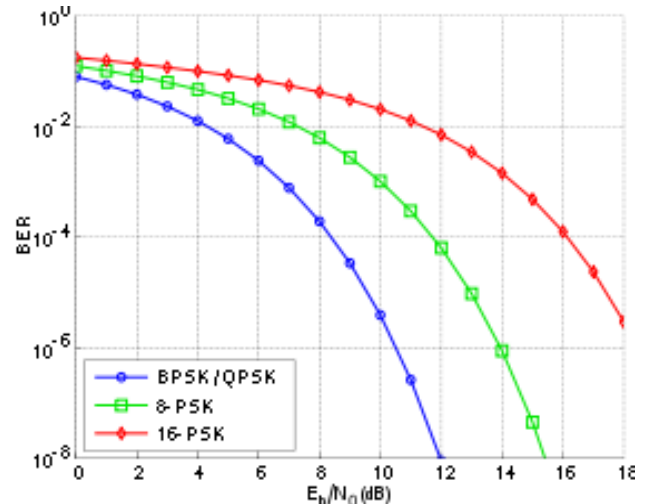


Fig.5. Theoretical Curves for BER Vs Eb/No.

V. AWGN CHANNEL

The term noise refers to unwanted electrical signals that are always present in electrical systems and the term additive means the noise is superimposed or added to the signal that tends to mask the signal where it will limit the receiver ability to make correct symbol decisions and limit the rate of information transmission. The transmitted waveform gets corrupted by noise 'n', typically referred to an Additive White Gaussian Noise (AWGN), illustrated as

Additive: As the noise gets 'added' (and not multiplied) to the received signal,

White: The spectrum of the noise is flat for all frequencies

Gaussian: The values of the noise 'n' follow the Gaussian probability distribution function $p(z)$, where σ is the variance

$$p(z) = \frac{1}{\sigma\sqrt{2\pi}} \text{Exp} \left[-\frac{1}{2} \left(\frac{z-a}{\sigma} \right)^2 \right] \quad (5)$$

Thus, AWGN is the effect of thermal noise generated by thermal motion of electron in all dissipative electrical components i.e. resistors, wires and so on. A simple model for thermal noise assumes that its power spectral density is a flat for all frequencies and is denoted as:

$$G_n(f) = \frac{N_0}{2} \quad (6)$$

Where the factor of 1/2 is included to indicate that $G_n(f)$ is a two-sided power spectral density and indicates that half the power is associated with positive frequencies and half with negative frequencies. When noise power has such a uniform spectral density, it is referred as white noise. The word Gaussian in the phrase additive white Gaussian noise is due to a Gaussian distribution of the amplitude of the noise.

VI. SIGNAL TO NOISE RATIO (SNR)

The signal to noise ratio is a measure of the sensitivity performance of a receiver. SNR is defined as the ratio of signal power to noise power it is usually measured in decibel. The SNR mathematically can be expressed as follows:

$$\text{SNR db} = 10 \log_{10} P_{\text{signal}} / P_{\text{noise}} \quad (7)$$

VII. CONCLUSION

The BER for digital modulation techniques decrease monotonically with increasing values of E_b/N_0 . A QPSK system transmits information at twice the bit rate of a BPSK system for the same channel BW due to which QPSK is mostly used in practice. It is observed from the simulation curves and the mathematical analysis of the signals that as the number of signals or number of M increases, the error probability also increases over AWGN channel. It is seen that 8PSK and 16PSK modulations exhibit higher error-rates; in exchange however they deliver a higher raw data-rate. Increasing the data rate will increase the SNR, however, increasing R_b (Bit rate in bits/second) will also cause more noise and noise term also increases. So, we cannot increase SNR by simply increasing R_b . We must strike a compromise between the data rate and the amount of noise our receiver can handle.

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