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# A REVIEW ON BPSK MODULATION TECHNIQUES AND DEMODULATION SCHEMES

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## ABSTRACT

High data-rate is desirable in many recent wireless multimedia applications. Modulation techniques have concerned increasing attention in optical wireless communications. In this paper, we implemented a Binary Phase Shift Keying (BPSK) modulator and demodulator for a digital communication. This is a review paper, in which we discussed about the basic components of Digital Communication process and the various techniques of Transmission and Receiving of Digital data bits. Since, in today's world, error-free data transmission with proper or approximate accurate Synchronization covers a wide area of scientific researches, we put concern about the transmission of error free data or less error containing data from the transmitter end to the receiver end but using various modulation techniques like Hamming Code, Cyclic Code, BCH Codes, Reed-Solomon Codes and others. As the PSK output signal is in suspended strip line, two BPSK modulators can be easily combined together to work as QPSK modulator.

**KEYWORDS:** BPSK Modulation Demodulation, Modulation Techniques, Error Free Data Transmission, AWGN Channel, MATLAB Simulink, OFDM.

## INTRODUCTION

In Digital Communication System, since the channel is the most important part as in channel, the signal can get well corrupted by noise, distorted and attenuated with many problems. Therefore it is desirable that the digital modulation scheme to be implemented by Electronics and Communication Engineers, would provide low bit error rates at low received Signal-to-Noise Ratios Error control coding therefore has been the subject of intense study since 1940, to overcome the said problems [2, 4, 8, 9, 12].

Phase Shift Keying is a Digital Modulation scheme widely used in Digital Communication. It is divided into two different types: balanced or double balanced type and a path - length modulator (unbalanced) type. Binary Phase Shift Keying (BPSK) or Phase Reversal Keying is the simplest form of it PSK Modulation [3, 5, 7, 10, 13]. In BPSK, the phase of the sinusoidal carrier signal is changed according to the message level ('0' or '1'), while keeping the frequency and amplitude of the message signal constant.

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There is always a requirement for good codes that ensures reliable communication with minimum redundancy In coding theory, forward error correction or channel coding is a technique used for controlling errors in data transmission over unreliable or noisy communication channels. FEC is accomplished by adding redundancy or parity data to the transmitted information using algorithm which is further discussed in IT Theory & Coding [2, 4, 12].

The authors in various papers, have evaluated performance of Phase Keying Modulation scheme using BCH Code, Cyclic Code and Hamming Code through AWGN (Additive White Gaussian Noise) Channel, as can be seen. AWGN Channel is the most common type of noise-added over the channel. It is Gaussian because whose probability density function can be accurately modelled to behave like a Gaussian distortion model [1, 2, 3, 4, 12]. The source may be either an analogue signal such as audio or video signal or a digital signal, such as the output of a computer. The sequence of the binary digits from the source are encoded and modulated for transmission over a channel. During transmission, the signal gets corrupted by noise, distorted and attenuated channel noise can be added at the transmitter along the path and in the receiver as well. In order to find the error in received signal, sending of extra bit, namely parity bit is introduced to make complete code-words [2, 9, 11, 15, 16].

In this cases, if we represent noise and ISI on Euclidian space with power and time axis, then noise internal and external, impulsive and induced, cross talk and attenuation are represented by power axis. Distortion, fading channel, phase distortion, delays, jitters and ISI are therefore reflected by time axis [11].

## LITERATURE SURVEY

This paper presents extended Works on BPSK Modulation at Low Bit Rate and also presents Simulation results and FPGA implementation of BPSK demodulation at Low Bit Rate 1200 bits/second. Here Binary Sequence, Carrier Frequency and sampling frequency are user controllable in BPSK modulation that was designed already. This paper present Design of BPSK Demodulation which demodulate pattern comes at output of BPSK modulation at 1200 bits/second. [1].The brief description of digital communication system which is more reliable, secure and efficient than that of analogue communication. In Digital communication, BPSK is most important and efficient technique in terms of signal power. In this paper BPSK modulator and demodulator are purely design by using hardware description language (VHDL) and implementing it on Spartan 3E FPGA kit [2].This paper focuses on the Binary Phase Shift Keying Digital Modulation Technique for Noiseless and Noisy Transmission with the following objectives: to design a BPSK system ; to show the modulation and demodulation of a BPSK technique through a noiseless channel and to show the modulation and demodulation of the same technique through a noisy channel [3]. In this, this system separately modulates the BPSK and QPSK signals with same input information and then combines in adder to its resultant. Then it can demodulate with a common detector and we get the same output as input which we can analyse the performance of these modulation techniques when system is subjected to AWGN and fading are consider in the channel. Subsequently, a comparison study is carried out to obtain BER performance for each PSK based transmission scheme. The design will be simulated by MATLAB tool later. We will use MATLAB R2014a for simulation and evaluation of BER and SNR for system models. The output signal waveform will be measured and tested to find signal quality and the SNR or Signal to Noise Ratio [4] and hence shown the constellation block. OFDM (Orthogonal Frequency Division Multiplexing) is a multicarrier technique that offers high spectral efficiency value. MIMO (Multiple Input Multiple Output) configuration provides enhanced

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capacity with the same transmit power [5]. The constellation diagram is a representation of a signals modulated (ICs) and other active and passive circuit components/devices [12]. This paper presents the Bit Error Rate (BER) Comparison of BPSK in AWGN by considering block codes and convolution codes. Hamming codes, cyclic codes, BCH codes, RS codes, convolutional codes are designed and the BER performance is measured for AWGN channel. All the codes have been compared in terms of BER and energy per bit to noise ratio and the simulation was done using MATLAB R2014b software. In general, Convolutional codes demonstrate better performances [7].It displays the signal as a 2-dimensional X-Y plane scatter diagram in the complex plane at symbol sampling instants.

In this review, we used MATLAB environment to generate the constellation diagram of M-array PSK and QAM modulation systems [6]. In this paper the bit error rate (BER) analysis of binary phase shift keying (BPSK) modulated signal detection in the presence of two BPSK modulated co-channel interfering signals and additive white Gaussian noise is presented with elaboration. The detection of a desired signal with minimum achievable BER in co-channel interfering environment with two interferers is analyzed, the traditional single carrier modulation techniques can achieve only limited data rates due to the restrictions imposed by the multipath effect of wireless channel and the receiver complexity, reducing errors. Orthogonal Frequency Division Multiplexing (OFDM) is a potential to fulfil the requirements of current and next generation wireless communication systems. However, Peak-to-Average Ratio (PAPR) and Inter-Carrier Interference (ICI) are two major challenges in implementing an OFDM system [8]. This paper discusses different techniques for mitigating the fading problems and errors. A solution to the problem is to add a fading margin on the transmitter, but these are not so effective solution. The other solution is to use an alternative statistical behaviour of fading channels which use two or more inputs on the receiver to ensure the correlation of signal [9]. This paper is about study and discussion on Convolutional code system comparing different modulation schemes such as BPSK and QAM. The performance has been concluded based on BER and SNR through MATLAB Simulation and shown hence [10]. Bit-error-rate measurements and eye diagrams are used to compare the links' performance with Conventional BPSK modulation and demodulation techniques [11].Modern mobile communication systems use digital modulation techniques and hence the advancements in very large-scale integration (VLSI) and digital signal processing (DSP) technology have made digital modulation more cost effective than analogue transmission systems. In this paper, an effort has been made to construct a BPSK transmitter using available Integrated circuits which presents the performance evaluation and comparison of various concatenated error correcting codes using Binary Phase Shift Keying (BPSK) modulation scheme. All pairs of concatenated codes have been compared in terms of bit error rate & energy per bit to noise power ratio (SNR) and their performance reflects their error correcting capability. All simulation was done using MATLAB R2013a software. In general Convolutional-Bose Chaudhuri Hocquenghem code (BCH) demonstrate better performance compared to Convolutional-Hamming and Convolutional-Cyclic concatenation pairs [14]. Modulation and Demodulation are the key feature in wireless communication for data transmission. Digital modulation techniques play an efficient role in performing modulation process. Binary Shift Keying (BSK) is one of the existing techniques out of them.

## BASIC THEORY

The basic components of digital communication system are shown in Figure 1.

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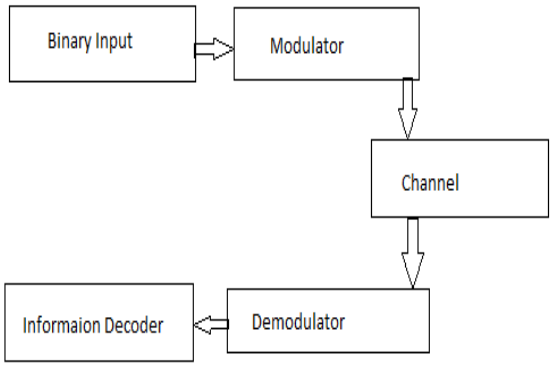


**Figure 1.Basic Components of Communication System. [Ref. 1-2, 4, -5, 12]**

When the phase of the carrier wave is altered with reference of the modulating signal, then the resultant modulation scheme is termed as Phase Shift Keying (BPSK). BPSK is the simplest form of PSK. It uses two phase which are separated by π. It is known as binary because the carrier phase represents only two phase states/ It is normally used for High Speed Data Transfer Application, provides a 3dBpower advantage over the BASK Modulation technique and is robust and simple in implementation. It is however only able to modulate at 1bit data and hence not suitable for 1 bit data transmission. [7]. There are various modulation techniques like BPSK, QPSK, PSK 16, PSK 32 etc. Each has its own error function and error correction function. In BPSK, the pair of signals, let S1(t) and S2(t) be used to represent the binary symbols 1 & 0 respectively. Then it is defined as follows -

S1(t) = √(2Eb\No)/Tbcos(2πft)

S2(t) = √(2Eb\No)/Tbcos(2πft+π)

=-√(2Eb\No)/Tbcos(2πft) where 0≤t≤Tb

Transmitted signal energy per bit (Eb) = (0.5(Ac^2)Tb)

and bit error rate for coherent BPSK is (Pe) = 0.5erfc(√Eb/No) [2, 5, 8, 10, 12]

The author of the references have evaluated the performance of PSK modulation scheme using BCH Code, Cyclic Code & Hamming Code through AWGN Channel. The simulation can be performed dividing into 3 parts - simulation without error correcting codes, simulation with error correcting codes namely Hamming Cyclic, BCH & Convolutional Code & finally simulation with concatenation of Convolution Hamming, Convolutional Cyclic & Convolutional BCH Codes using BPSK modulator and demodulator in AWGN environment. Orthogonal Frequency Division Multiplexing (OFDM) is a multi carrier transmission technique in which data is transmitted on a set of orthogonal independent sub carriers. In an OFDM System, the high data rate signal is split into several parallel lower data rate streams and transmitted with several narrow band sub carriers. The MIMO-OFDM Systems, where MIMO signifies Multiple Input Multiple Output, uses to independent space-time codes for two sets of two transmit antennas. This presents channel estimation scheme based on Leaky Least Mean Square (LLMS) algorithm proposed for BPSK-QPSK-PSK MIMO OFDM System [1] which offers flexibility. OFDM is a method of encoding digital signal data on multiple carrier frequency (MCF). It takes all the low data rate frequency channels and then combine them into one high data rate frequency channel and here the data is modulated to time signal and can be generated using Q-PSK, D-PSK B-PSK etc modulation methods. The symbols are divided into different frames therefore data can be modulated frame by frame during modulation. One requirement of the OFDM transmitting and

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receiving systems is that they must be linear in nature. If any non-linearity appears, then it will cause interference between the carriers as a result of happening of inter-modulation distortion.

This will introduce all the unwanted signals that would cause interference and impair the orthogonally of the transmission. The figure represents an OFDM transmitting and receiving system, as shown in figure 2 [3, 7, 14].

## BENEFITS OF OFDM

There are many advantages of OFDM system for next generation wireless communication.

- High spectral efficiency present
- Resiliency towards Radio Frequency interference
- Lower is the multi-path distortion
- Makes efficient use of the spectrum by allowing optimum overlap.
- By dividing the channel into narrowband flat fading sub channels, OFDM becomes more resistant to frequency selective fading than single carrier systems are.
- Eliminates Inter Symbol Interference and IFI through use of a cyclic prefix.
- Using adequate channel coding and interleaving one can recover symbols lost due to the frequency selectivity and inefficiencies of the channel.
- Channel equalization becomes simpler and easier than by using adaptive equalization techniques with single carrier systems.
- It is possible to use maximum likelihood decoding with reasonable complexity property

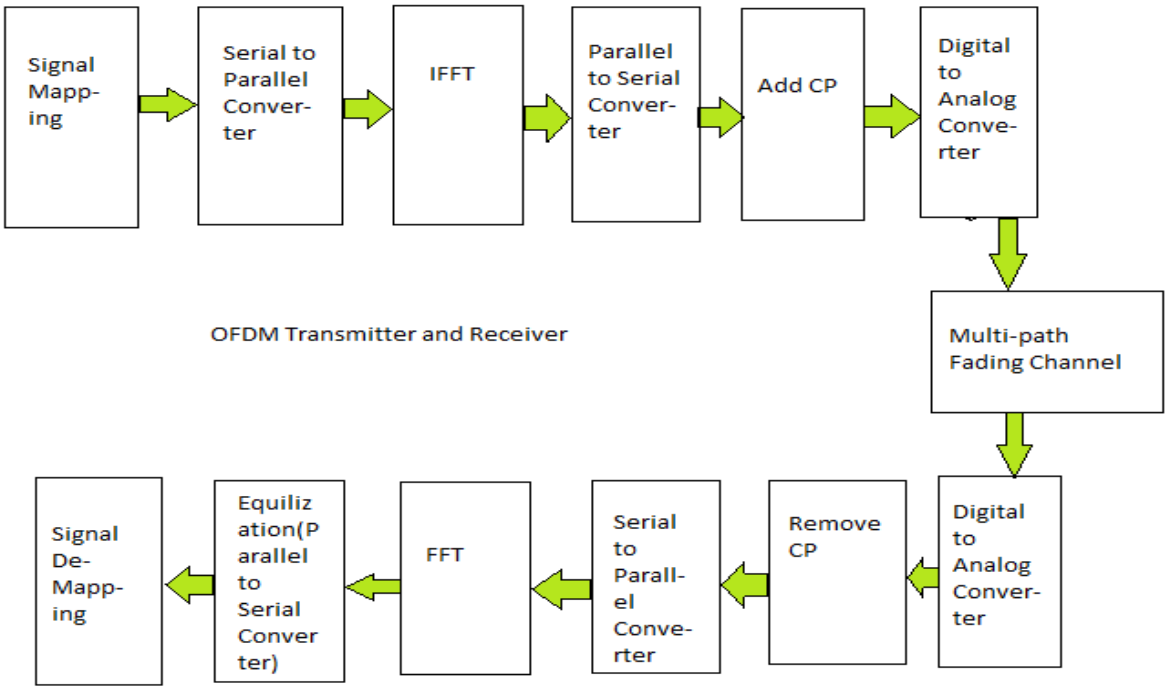


**Figure 2.OFDM Transmitter & Receiver**

- OFDM is computationally made efficient by using the FFT techniques to implement the modulation and demodulation functions.
- Is less sensitive to sample timing offsets than single carrier systems are. This provides good protection against co channel interference and impulsive parasitic noise.

## DISCUSSION ON CONSTELLATION OF BPSK

QPSK uses four points on the constellation diagram, equi spaced around a circle and with four phases, QPSK can encode two bits per symbol (sometime with Gray coding), to minimize

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the Bit Error Rate (BER)-sometimes misperceived as twice the BER of BPSK. The implementation of QPSK is more general than that of BPSK and also indicates the implementation of higher-order PSK.BPSK have only two signal elements, one with a phase of 0 degree, and the other with a phase of π. BPSK also uses only an in-phase carrier. However, we use a polar NRZ signal for modulation. It carries two different types of signal elements, one with amplitude 1, and the other with amplitude. [9, 11, 22].

The MATLAB Code:-

```
clc
clear all
num_symbols=10000
int_symbols=randi( [1,2],1,num_symbols)
bpsk_symbols=zeros(size(int_symbols))
bpsk_symbols(int_symbols==1)=1
bpsk_symbols(int_symbols==2)=-1
plot(real(bpsk_symbols),imag(bpsk_symbo
ls),'ored','linewidth',3)
xlim( [-2 2])
ylim( [-2 2])
xlabel('Real Part')
ylabel('Imaginary Part')
title('Constellation BPSK')
line(xlim, [0 0],'Color','k','linewidth',1) %x-
axis
line( [0 0 ],ylim,'color','k','linewidth',1) %y-
axis
grid on
```

Simulation Results of the MATLAB program is furnished in Figure 3.

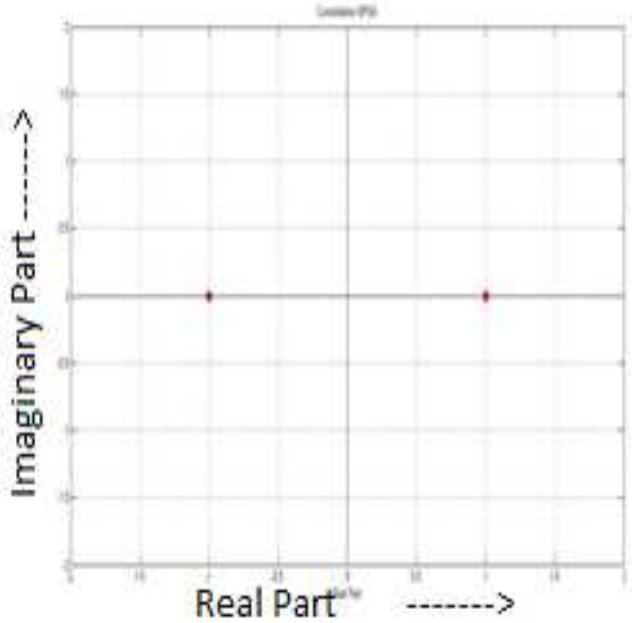


**Figure 3.Output Constellation Graph for BPSK**

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## DIFFERENT ERROR CORRECTING CODE MODELS

In coding theory forward, we may say error correction during channel encoding decoding is a technique used for controlling errors in data transmission over unreliable or noisy communication channels. FEC is accomplished by adding redundancy or parity data to the transmitted information using algorithm. It can be recovered by a receiver even when ber of errors were introduced either during the transmission or on storage. Since the receiver does not have retransmission of the data a back channel is not required in forward error correction and it is suitable for simplex communication such as broadcasting etc.

Communication system can be improved by coding the signals to service channel impairments (channel coding method) and reduce their redundancy (source coding method). There are mainly two types of channel encoding namely a)block coding and b)convolution coding. Block codes are processed on a block by block basis (m=2K). In block coding, a block of k information bits are encoded into a block of n bits known as codeword (n>k).Totally 2K code words are possible in general. Code rate is given by Rc=(k/n). Block coding schemes are memory less in nature [3]. Convolutional codes are processed on by bit basis. In convolutional coding each k bits information symbol to be encoded and transformed in to n bit called as codeword so that n>k and transformation is a function of the last L information symbols where L is the constraint length of the code. Code rate is defined be same as of the block codes [4].

BER = Total number of errors / Total number of bits transmitted**.**

### A. WITHOUT CODE MODEL

The digital data is modulated by using BPSK over AWGN channel, by using random function 10, 000 bits are generated and modulated with BPSK modulation and transmitted over AWGN channel. At the receiver the signal gets demodulated and compared with original transmitted data bits, the bit error rate is calculated.

### B. HAMMING CODES

Hamming codes are the earliest and simple example of linear block codes. This led to a revolution to the coding technology. The parameters of Hamming code are (n, k) block code [4]

Code length= n

Number of information bits=k

Number of parity check bits m=n-k To calculate number of check bits the equation used by $2m \geq (m+k+1)$

### C. CYCLIC CODES

Cyclic codes were studied by Prange in the year 1957, first. These codes are attractive for two under-said reasons, 1) encoding and syndrome computation can be implemented easily by employing shift registers with feedback connections (like the sequential circuits), which is economic as well. 2)They have considerable inherent algebraic structure, with interesting algorithm-making scopes.

A (n, k) linear code C is called a cyclic code if every cyclic shift of a code vector in c is also a code vector in C. This does not mean every code vector have the same weight. There are groups of code vectors with the same weight. Simulation with cyclic code (7, 4) and without code is shown in Fig4. the Bit Error Rate is 0.0107. at Eb\No=2 dB.

### D. BOSE CHAUDHURI HOCQUENGHAM (BCH) CODES

Block length n=2m -1

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Number of parity check bits: n-k≤ mt

Minimum distance dmin ≥ 2t+1

Clearly, this code is capable of correcting any combination of t or fewer errors in a block of n=2m -1 digits and named as a t –error correcting BCH code. [4]

The simulation of BPSK with BCH code (7, 4) is shown in Fig5. BER is 0.0103 at EbNo=2 dB

## E. REED- SOLOMON CODES

In coding theory, Reed-Solomon (RS) codes are non binary cyclic error correcting codes. These codes were named after the inventor, Irving S.Reed and Gustave Solomon. They described a systematic way of building codes that could detect and correct multiple random symbol errors in a different way. An RS code can detect any combination of up to 't' symbols, or correct up to (t/2) symbols.

A 't' error correcting Reed Solomon codes, with symbols from GF (q) has the following parameters that are summed up as follows -

Block length (n) = (2^m -1)

Let the Message size is = k

Number of parity check digits: (n-k) = 2t

Minimum distance d (minimum) = (2t+1)

Number of correctable symbol in error t = (n- k)/2 [12]

## F. CONVOLUTIONAL CODES

A convolutional code is a type of error correcting code was first mentioned by Elias in 1955. In convolutional code, each k bit information symbol to be encoded is transformed into an n-bit symbol, where k/n is the code rate (n≥k) and the transformation is a function of the last L information symbols, where L is the constraint length of the code. Constraint length is the number of bits that the encoder uses to encode n bits.

Convolutional codes are often characterized by the base code rate and the depth (memory) of the encoder (n, k). The base code rate is typically given as n/k, where n is the input data rate and k is the output symbol rate. The depth is also as constraint length K. Convolutional code that generates parity symbols via the sliding application of a Boolean polynomial function to a data stream. The sliding application represents the convolution of the encoder over the data, which gives rise to the term convolution coding.

## BPSK DEMODULATION

BPSK modulated signal is being demodulated by a synchronous detection system. It uses a modulator to multiply the received signal and regenerated carrier wave. The frequency and phase of the regenerated carrier wave must be synchronized with the carrier wave used on the transmitting end. If multiplication is performed with a regenerated carrier wave that is not synchronized, the amplitude level may vary, the signal polarity may be reversed, and many errors may occur, making it unusable. Frequency multiplication and other methods are used to regenerate the carrier wave. When the received signal is regenerated, the result is as follows. (1)

## ADVANTAGES OF BPSK

- It is the most robust modulation technique due to the fact that binary 1 and 0 are separated by 180 degree phase shift of the carrier for which, BPSK modulated data can travel longer distances when transmitted from base station or subscriber stations. Hence BPSK modulation is employed in pilot carrier as well as in preamble sequences. These are used for time/frequency synchronization and channel estimation/ equalization purpose.

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- BPSK modulation is used by most of the cellular towers for long distance communication or transmission of the data.
- BPSK demodulator requires to make only two decisions in order to recover original binary information which makes it more simpler to compare with other demodulation schemes.
- BPSK is power efficient modulation technique as less power is needed to transmit the carrier with less number of bits, making it more economic.
- It has the simplest of the systems designs and and it has the power efficiency to be optimum.
- BPSK modulation is less susceptible to errors compared to ASK.

## DISADVANTAGES OF BPSK

- In BPSK modulation, one bit is carried by one single analog carrier and Hence data rate in bits per second is same as the symbol rate. This is half in comparison to the QPSK modulation technique and many times less compared to other higher modulation techniques like 16QAM, 64QAM etc.
- Due to above reason, BPSK is not bandwidth efficient modulation technique compare to other modulation types.

## RECENT RESEARCH WORKS

In recent years, with the constant improvement of the general computer performance and technologies, experienced from hardware platform towards digital platform of software radio technology, the platform of DSP in communication system is beginning to change the direction of development. The signal after the A/D directly complete real-time processing in pure software processing based on general computer platform [1].

BPSK is a kind of excellent modulation method, and in medium and high speed data transmission has been widely applied. This paper is based on "CPU + GPU" heterogeneous platform, the real-time BPSK signal demodulation algorithm and the method based on CUDA parallel programs are researched. In view of the implementation, parallel programming test verify the feasibility of the system.

## CUDA

Launched by NVIDIA, CUDA is a kind of general parallel computing architecture, initial designed to speed up image real-time processing which run on the GPU development platform and full use of GPU's high memory bandwidth and very large scale of floating point calculation unit. It can handle large parallel problems, especially large-scale floating point data computing. GPU is mainly designed for the intensive and high parallelism computation, so calculation of the design will therefore be used in data processing rather than data caching and flow control [18].

A Bernoulli Binary Generator feeds into digital modulation techniques (BPSK, QPSK, DBPSK, and QAM) for transmission. To analyze the effect of noise, the modulated signal along with the Rayleigh, Gaussian and Rician noise is transmitted. Through the AWGN channel, this happens. The received signal is demodulated using various demodulation techniques and hence is used to calculate the bit error rate for transmission process and the BER is calculated by using the Monte Carlo simulations in MATLAB Simu-link Tool [2].

a. **GAUSSIAN NOISE:** Various types of noise sources are Gaussian and have a flat spectral density over a wide frequency range. Such a spectrum has all frequency components in equal proportion and hence it is called white Gaussian noise otherwise it is non-white Gaussian noise, as proved mathematically. The Gaussian noise generator block used is used to generate discrete time with Gaussian noise.

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b. **RAYLEIGH NOISE:** In digital communication, we are interested in 2D noise distributed around each state in the phase plane. The noise can be characterized in ways. A 3D picture is given by the product of two orthogonal Gaussian distributions with the same standard deviation. Alternately, with the polar coordinates centered on the un-deviated position of the state, the radial distribution of the noise is described by the Rayleigh distribution. The Rayleigh noise generator block used, generates Rayleigh distributed noise in channel. **c**. Rician Noise: Unlike additive Gaussian noise, Rician noise is signal-dependent and consequently separating signal from noise is a difficult task. This is problematic for low signal-to-noise ratio [19]. In the last years, it became necessary to transition from analog to digital modulation techniques in developing communication systems. Digital communi-cation system is more reliable than an analog in terms of signal processing algorithms, as far observed [3]. It is needed for analog systems excessive number of waveforms and large bandwidth for the symbol transmission operations and hence face heating, high power dissipation and cost problems, etc. However, digital systems can reduce hardware, noise and minimize Inter Symbol Interference (ISI) problems with high speed and decimated silicon area cost [1]. Also, it provides higher data security, best quality communication with large bandwidth and more of information capacity. So, instead of analogue circuitry, Field Programmable Gate Arrays (FPGAs) are preferred due to their high flexibility and attractive speeds.

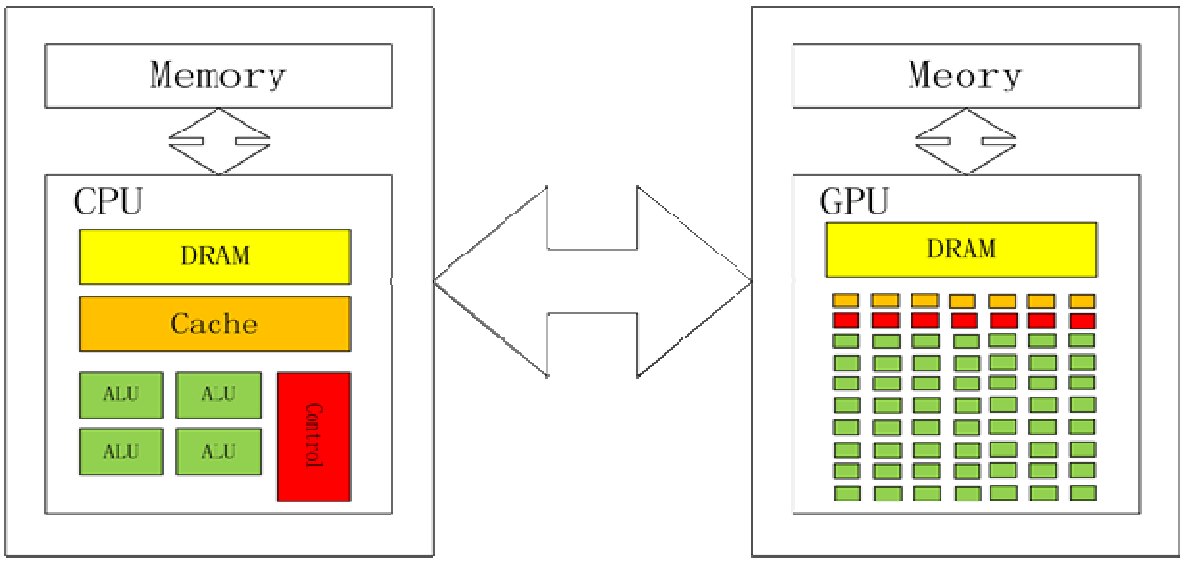


**Figure 4.CPU GPU Block Diagram**

Digital modulation is more reliable than analogue modulation in many fields. The FPGA implementation of BPSK digital modulation technique using NCO and DAC modules are proposed. All of them were implemented on the Spartan 3E FPGA kit followed by software. This provides the parallel implementation of hardware results in faster rate of algorithm execution. Hence, design and implementation results show that, BPSK modulation is well-fitted to FPGA implementation techniques [20].

As the customer in today's world not only requires the mobile phone to be connected to other network, they require multimedia services (like data, audio, video) and want everything to be connected to single network. It can be possible only if the lower data rate can be converted into higher data rate. OFDM technique

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is the solution. In OFDM technique, higher data rate is divided into number of lower data rate and are transmitted simultaneously over a large number of subcarriers. OFDM is a type of multi-carrier modulation (MCM) technique which transmits signals through multiple carriers. These multiple carriers (subcarriers) have different frequencies and all subcarriers are orthogonal to each other. It is used in both wired (ADSL) and wireless communications (wireless LAN) [4].

## FUTURE SCOPES FOR RESEARCH

1. The simulation shows that the performance of concatenated block and convolutional Error control codes compared to single codes is better. The performance of Convolutional (2, 1, 7) -BCH (7, 4) is best among Hamming (7, 4) , Cyclic (7, 4) , BCH (7, 4) , Convolutional (2, 1, 7) -Hamming (7, 4) , Convolutional (2, 1, 7) -Cyclic (7, 4) codes. The performance could be further improved by adding more redundancy. This confirms the fact that by concatenation of Error correction codes we can improve the correction capability of codes and could reach near to the Shannon limit. However this increases the complexity of the communication system. But for reliable communication there must be some trade-off between system complexity and correction capability of the codes. Hence the objective of the research is successfully achieved in which this paper, success to analyse and simulates the performance of BPSK using different types of concatenated error control codes through AWGN channel. In future, this research paper can be extended by evaluating the performance of these concatenated error correcting codes over higher order modulation schemes. Further we could also extend our work tohybrid ARQ codes which will be of great use now days.
2. FUTURE SCOPE OF THE WORK In this thesis, MIMO V-BLAST for OFDM and CDMA based MUD, GA and PDA for CDMA based MUD for wireless communication systems has been implemented in MATLAB 7.0 Since OFDM and CDMA both are current generation techniques, many research is possible on both of these techniques, but here OFDM is implemented with limited number of parameters such as FFT and IFFT size, type of prefix to symbol, modulation technique, etc and also CDMA is implemented with fix chip rate and up to 16 number of users. A few possible extensions to the work presented in this thesis are described below. > In OFDM we can analyze the performance of V-BLAST technique by varying FFT and IFFT size, using different type ofprefix added to symbol, using modulation technique GMSK etc. > In CDMA, we can analyze its performance using Asynchronous CDMA, using Different Length of Spreading Code. OFDM and CDMA based MUD for wireless communication systems using VBLAST, GA and PDA may also be implemented in DSP processor, to analyze their BER performance for different no. of users because the DSP is faster and is a real time application. For the same purpose, these algorithms may also be implementedin VHDL or VERILOG which is CHIP level implementation.
3. In this study, different problems of OFDM system have been considered and suitable solutions are provided. As the established fact is, that research is never ending process, a new beginning is always waiting. Therefore, following are the works that may be considered as a future scope: (a) The channel estimation is an area which required a lot of attention and improper channel estimation degrades the performance of system and therefore it is assumed that channel is estimated perfectly. Hence one can evaluate the performance of proposed work with different channel estimation method and algorithms. [156] (b) The algorithm of timing offset estimation can be extended for

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channel estimation in OFDM system efficiently. (c) The proposed timing offset and frequency offset estimator can be utilized well for MIMO-OFDM system. (d) The proposed PAPR reduction method can be used with MIMO OFDM System. (e) The closed form expression of BER can be derived for OFDM system with proposed PAPR reduction method. (f) The windowing method of ICI reduction can be clubbed with ICI self-cancellation scheme as modern research observed.

## CONCLUSION

Digital Modulation is more reliable than Analogue Modulation in many terms. In telecommunication field the major challenges is to convey the information as efficiently as possible through limited bandwidth with less number of errors in transmitted data. Though some information bits are lost in most of the cases and signal which is sent originally will face fading. To reduce the bit error rate the loss of information and signal fading should be minimized. While studying on PSK Modulation, we observed that a simple circuit, which is combination of QPSK and BPSK can be constructed and this circuit is of low cost. The cost can be reduced as well as the performance of the total circuit can be improved by the use of MATLAB.

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