Signal Processing for Efficient Transmission over Network

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ABSTRACT: *In recent years, CDMA becomes most widely used spread spectrum technique in wireless communication system because MC-CDMA allows multiple users to share the same frequency spectrum simultaneously. In this paper, generating an input signal and modulating it using MC-CDMA is the primary work. After the modulation of signals, different noises are added to the modulated signal and checking the received signal, BER, SNR. To check the fidelity of the transmitted signal, noises are added because when the signal is generated in the transmitted channel and the signal is affected due to noises. The reasons of these improvements have been explained analytically and the simulations results with the verified analytical results. There are several modulation schemes such as BPSK, QPSK and QAM. Modulation schemes are used in conjunction with MC-CDMA technique to provide different data rates to fulfil the requirement of different application. In MC-CDMA system signals arrive at the receiver from multiple paths due to reflection, diffraction and scattering which results in signal fading and degrade the performance of the system.*

Keywords: MC-CDMA (Multi-Carrier Code Division Multiple Access), QAM (Quadrature Amplitude Modulation, BER (Bit Error Rate), SNR (Signal-to-Noise Ratio), LLR (Log Likeli-Hood Ratio)

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1. Introduction

MC-CDMA is used to support multiple users with high speed data communications. And it avoids the problem of Inter symbol Interference and also exploits frequency diversity. In MC-CDMA, due to multipath fading which badly affects its performance when transmission over fading channel multi-cell interference occurs and this degrades the performance of the system.

MC-CDMA formed by combining OFDM and CDMA.It is well suited for high data rate applications in frequency selective fading channels and the later is a multiplexing technique where number of users is simultaneously available to access a channel.

Multi-Carrier Code Division Multiple Access (MC-CDMA) is a multiple access scheme used in OFDM-based telecommunication systems, allowing the system to support multiple users at the same time.MC-CDMA spreads each user symbol in the frequency domain.

There are many ways to describe the MC-CDMA, but generally it is described as DS-CDMA again modulated by an OFDM carrier, the number of sub-carriers depends upon the length of spreading code used with DS-CDMA. One major difference between MC-CDMA and OFDM is the subcarriers in MC-CDMA at any instant transmits the one symbol but in OFDM each sub carrier transmit separate symbol, the efficiency of MC-CDMA is hidden in orthogonal sub carrier by which the overlapping spectrum of successive subcarriers can be separated other advantage comes from a wideband coverage of carriers and slower transmission time or larger transmission duration for each bit.MC-CDMA technique has some unique advantages over its root techniques (OFDM, DS-CDMA) Compared to Direct Sequence (DS) CDMA.CDMA is an example of multiple access, which is where several transmitters can send information simultaneously over a single communication channel. This allows several users to share a band of frequencies (see bandwidth). To permit this to be achieved without undue interference between the users CDMA employs spread-spectrum technology and a special coding scheme (where each transmitter is assigned a code).

Code division multiple access (CDMA) is a channel access method utilized by various radio communication technologies. It should not be confused with the mobile phone standards called CDMAOne and CDMA2000 (which are often referred to as simply "*CDMA*"), that use CDMA as their underlying channel access methods. One of the basic concepts in data communication is the idea of allowing several transmitters to send information simultaneously over a single communication channel. This allows several users to share a bandwidth of frequencies. This concept is called multiplexing. CDMA employs spread-spectrum technology and a special coding scheme (where each transmitter is assigned a code) to allow multiple users to be multiplexed over the same physical channel. By contrast, time division multiple access (TDMA) divides access by time, while frequency-division multiple access (FDMA) divides it by frequency.

CDMA is a form of "*spread-spectrum*" signaling, since the modulated coded signal has a much higher data bandwidth than the data being communicated. An analogy to the problem of multiple access is a room (channel) in which people wish to communicate with each other.

To avoid confusion people could take turns speaking (time division), speak at different pitches (frequency division), or speak in different languages. CDMA is analogous to the last example where people speaking the same language can understand each other, but not other people.

Similarly, in radio CDMA, each group of users is given a shared code. Many codes occupy the same channel, but only users associated with a particular code can understand each other.

2. State of the Art

In [1] Orthogonal frequency division multiplexing (OFDM) is a spread spectrum techniques, they used QAM & PSK over an AWGN(Additive Gaussian Noise Channel) to analyse the performance of OFDM system in terms of BER. It is only because it can provide large data rates. This is evaluated through a computer simulation, the results from which make it clear that, for high-capacity data rate transmission, the QAM modulation is better than the PSK modulation.

In [2] Closed-form expressions for the bit error rate (BER) performance of space-frequency block coded OFDM (SFBC-OFDM) systems are derived and evaluated for frequency selective fading channels. In the performance analysis, both Mary phase shift keying (MPSK) and M-ary quadrature amplitude modulation (MQAM) are considered, and the effects of channel estimation errors on the BER performance are studied. It gives the simulation output values which is same to the theoretically calculated from the closed loop equations. By using that result the amount of degradation can be quantified.

In [3] analyzing the asynchronous multicarrier code-division multiple-access (MC-CDMA) systems with a guard period (GP) in the form of a cyclic prefix over frequency selective multipath fading channels, which results in closed-form bit-error rate performance. The analytical process proposed here is extended to the case without a GP. The derived analytical results show that a GP is required for MC-CDMA systems in order to mitigate not only the effect of intersymbol interference and intercarrier interference, but also the desired signal power degradation.

In [4] they proposed an inverse algorithm as a method of joint detection (JD), which is capable of rejecting intersymbol and multiple-access interference at a reasonable complexity. They provided Computational complexity calculations as well as recent performance results of the proposed method. The bit-error rate performance achieved by the simulated JD algorithms and equalizer structures is comparable with the performance of other methods which exhibit higher complexity.

In [5] they propose a multicarrier code-division multiple-access (MC-CDMA) system employing an antenna array at the base station, and analyze the performance of the MC-CDMA system in a fading channel. An optimal beam former not requiring explicit direction of arrival estimation or training signals is derived for the MC-CDMA system in the reverse link, and is shown to reduce interferences from other users significantly, thus increasing the system's user capacity. Also, it is shown that the MC-CDMA approach can achieve better performance than the direct-sequence CDMA approach when both approaches employ the code filtering technique for antenna array.

In [6] it deals with the communication system that uses M-ary Phase-Shift-Keying (M-PSK) and M-ary Quadrature Amplitude Modulation (M-QAM) to transmit information using OFDM technique over Rayleigh communication channel. In terms of Symbol Error Rate (SER), the performance of different modulation schemes using OFDM techniques in Rayleigh channel is analyzed. For different types of modulation schemes (QPSK, 16-QAM, 16-PSK, 64-QAM, 64-PSK) gray coded bit mapping has been used with OFDM techniques. So, better performance is shown in different modulation scheme by using gray coded bit mapping. Here in this paper, it is our goal to show the way through which the SNR result varies between M-PSK and M-QAM.

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In [8] the bit-error rate (BER) performance and capacity of asynchronous space–time block-coded (STBC) multicarrier code-division multiple-access (MC-CDMA) systems in the presence of carrier frequency offset (CFO) between the transmitter and receiver oscillators are analyzed. They derived the exact BER expression when using equal gain combining (EGC) and the approximate BER expression when using maximum ratio combining (MRC). These BER expressions are verified through simulations. Using these derived expressions, the achievable system capacity satisfying a minimum BER requirement can be studied for the two cases when EGC and MRC are used and, hence, it is possible to compare the achievable capacity of STBC MC-CDMA systems with that of MC-CDMA systems. It is concluded that small CFO has an insignificant effect on the BER and capacity of STBC MC-CDMA systems and that this range of CFO is important in transceiver design. Besides, STBC MC-CDMA systems with multiple receive antennas can achieve higher capacity than that of the MC-CDMA systems; this amount can be obtained analytically using the theoretical BER expressions derived.

In [9] it deals with simulation of Nakagami-m fading in wireless channels using generalized MC DS-CDMA scheme using binary phase shift keying modulation. The paper proposes for deriving Bit Error Rate (BER) in BPSK MC DS-CDMA system over Nakagami-m fading channels. The numerical results are plotted as BER vs SNR for various values of Nakagami factor m, number of users K, and jamming interference (JSR) using MAT LAB software. The performance analysis for a system using MRC at the receiver was carried out and difference between independent and correlated fading for various values of m was observed. It is observed that the BER of correlated fading is high when compared with the independent fading. There is a decrease in Bit Error Rate for increase in m for MC DS-CDMA. The number of users k, JSR increases as Bit Error Rate increases for MC DS-CDMA. As the Correlation coefficient increases the Bit Error Rate increases for MC DS- CDMA. Effect of fading is more for high correlation coefficients.

In [10] Fading problem is a major impairment of the wireless communication channel. In this paper we considers different diversity techniques to mitigate the fading problem in wireless channel for DS CDMA (Direct sequence Code Division Multiple Access) system. Diversity is an effective method for increasing the received signal-to-noise ratio of a wireless communication system in a flat Rayleigh fading channel. Diversity branches can be established through frequency, time, antenna, or any combination of these diversity mechanisms. The branch outputs can be processed using schemes such as selection combining, equal gain combining, or maximal ratio combining. The diversity combining technique used in this paper improved the performance of the DS CDMA system. For this system, three spreading code sequences are used to spread the spectrum of the signal namely, an M-sequence, a Gold sequence, and an Orthogonal Gold sequence. The BER performance in a two path flat Raleigh fading environment for DS CDMA system with diversity combining is evaluated using MATLAB 7 computer simulation software.

3. Related Works

In this paper, by using BPSK and QAM modulation techniques is used in the MC-CDMA system to analyse the performance in terms of BER and LLR.In the previous papers they used FDM,PSK,ASK,QPSK for finding the BER and SNR performance, Compare with the previous techniques this model gives the better efficiency and less BER values.

Direct sequence spread spectrum techniques can be used in frequency selective channels with properly designed PN codes, Rake receivers and PSK modulation techniques. The key parameter of designing PN code generator is to adjust the chip duration short enough to prevent the effects of delay spread.MC-CDMA will provide some advantages like better spreading property and better multipath rejection property.

Effects of multipath fading and other impairments of frequency selective channels can also be removed or degraded by non-spread spectrum techniques. QAM gives the best results as the modulation scheme for non-spread spectrum systems.

4. Proposed Model

In this section, Fig (1) describes the MC-CDMA system. Here, symbols are modulated on many subcarriers to introduce frequency diversity instead of using only one carrier like in CDMA. Thus, MC-CDMA is robust against deep frequency selective fading compared to DS-CDMA. Each user data is first spread using a given high rate spreading code in the frequency domain. A fraction of the symbol corresponding to a chip of the spreading code is transmitted through different subcarriers.

Dividing a single carrier signal to multiple subcarrier signals means that data are actually divided in to several parallel data streams or channels, one for each subcarrier. Each subcarrier signal is then modulated with low symbol rate such that the total data rate of these subcarrier signals will be equal to conventional single carrier data rate. The main idea behind this technique is that a signal with long symbol duration time is less effected by multipath fading as compare to signal with short symbol duration, like in CDMA.

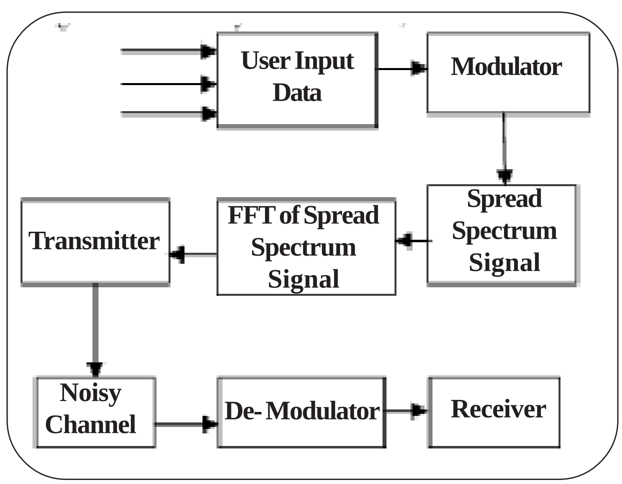
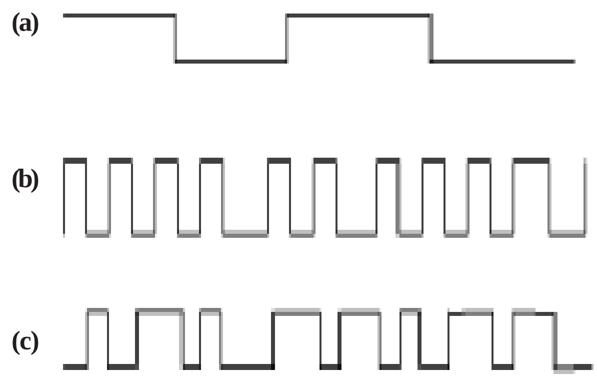


Figure 1. Block Diagram of MC-CDMA

4.1 Code Division Multiple Access (CDMA):

The bandwidth of the coded signal is much larger than the information bandwidth. One may say the information signal was spread. The coding process is therefore also called a spread spectrum modulation, while the coded signal is called a spread-spectrum signal. The spreading of the information signal gives the CDMA its multiple access capability. In Figure, it is shown that subscribers can be separated in the frequency, time, or code domain.

A key feature of CDMA systems using Figure.2 representing Pseudo Noise (PN) sequences is that they can tolerate overload (these are situations where the actual Bit Error Probability (BEP) is very high for a short time), if all wireless terminals in one cell can tolerate certain degradation in their performance. Thus CDMA systems using PN sequences do not have any sharply defined system capacity, like TDMA or FDMA systems. But for CDMA systems using PN sequences the Bit Error Probability (BEP) increases with the number of active terminals.



(a) Data Signal, (b) Pseudo-Noise Code,(c) Transmitted signal: Data Signal XOR with Pseudo-Noise Code

Figure 2. Pseudo-Noise code sequence spread/ despread the signal

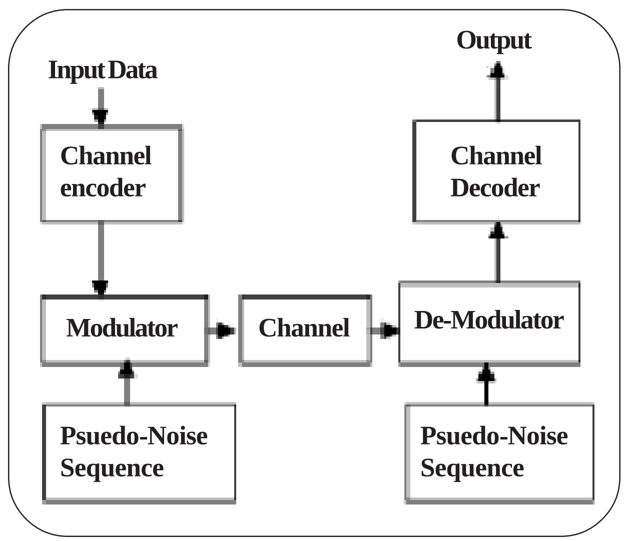


Figure 3. Block diagram of CDMA

4.2 Quadrature Amplitude Modulation (Qam)

Quadrature amplitude modulation (QAM) is both an analog and a digital modulation scheme. It conveys two analog message signals, or two digital bit streams, by changing (modulating) the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme. The two carrier waves, usually sinusoids, are out of phase with each other by 90° and are thus called quadrature carriers or quadrature components — hence the name of the scheme. The modulated waves are summed, and the resulting waveform is a combination of both phase-shift keying (PSK) and amplitude-shift keying (ASK), or (in the analog case) of phase modulation (PM) and amplitude modulation. In the digital QAM case, a finite number of at least two phases and at least two amplitudes are used. PSK modulators are often designed using the QAM principle, but are not considered as QAM since the amplitude of the modulated carrier signal is constant with only the phase varying.

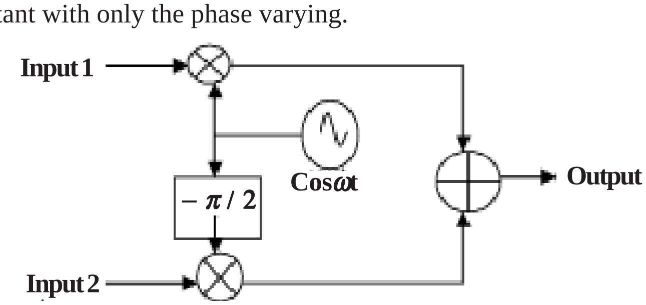


Figure 4. QAM (Quadrature Amplitude Modulator)

4.3 Binary Phase Shift Keying (BPSK)

In phase shift keying (PSK), the phase of a carrier is changed according to the modulating waveform which is a digital signal. In BPSK, the transmitted signal is a sinusoid of fixed amplitude. It has one fixed phase when the data is at one level and when the data is at the other level, phase is different by 180 degree. A Binary Phase Shift Keying (BPSK) signal can be defined as

$$T_{BPSK}(t) = b(t)\sqrt{2P}\cos 2\Pi f_c t, \text{ where} \ldots 0 < t < T \qquad (1)$$

Where $b(t) = +1$ or -1. f_c is the carrier frequency, and T is the bit duration. The signal has a power

$$P = A^2/2, \ so \ldots A = \sqrt{2P}$$

Where A represents the peak value of sinusoidal carrier.Thus the above equation can be written as

$$T_{BPSK}(t) = \sqrt{2P}\cos 2\Pi f_c t$$

$$T_{BPSK}(t) = \pm\sqrt{PT}\cos 2\Pi f_c t$$

$$T_{BPSK}(t) = \pm\sqrt{E}\left(\sqrt{2/T}\right)\cos 2\Pi f_c t,$$

Where $E = PT$ is the energy contained in the bit duration.

4.4 BPSK Modulator

A BPSK modulator can be implemented by NRZ coding the message bits (1 represented by +ve voltage and 0 represented by -ve voltage) and multiplying the output by a reference oscillator running at carrier frequency ω.

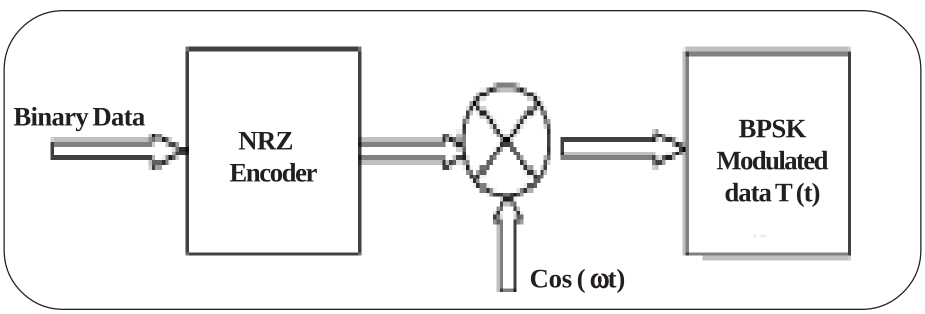


Figure 5.BPSK Modulator

4.5 BPSK Demodulator

In the demodulator the received signal is multiplied by a reference frequency generator (assuming the PLL/Costas loop be present). The multiplied output is integrated over one bit period using an integrator. A threshold detector makes a decision on each integrated bit based on a threshold. Since an NRZ signalling format is used with equal amplitudes in positive and negative direction, the threshold for this case would be ‘0’.

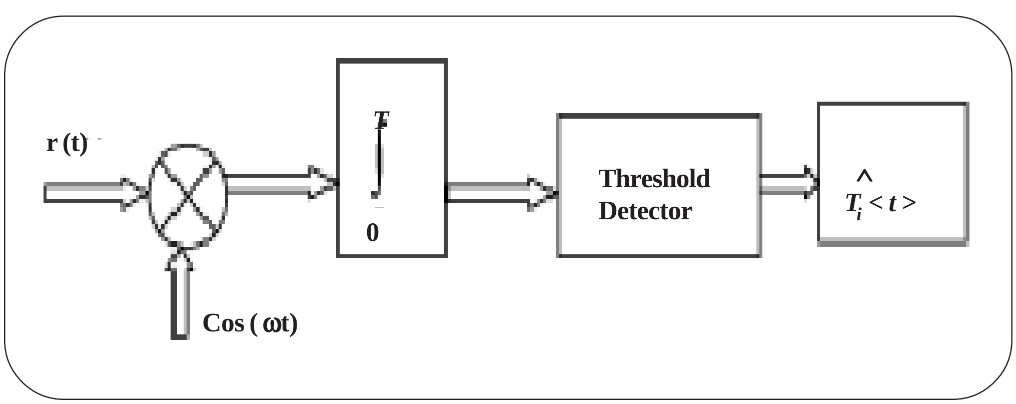


Figure 6. BPSK Demodulator

4.6 AWGN Channel Model

Additive White Gaussian Noise channel model as the name indicate Gaussian noise get directly added with the signal and information signal get converted into the noise in this model scattering and fading of the information is not considered. Additive white Gaussian noise (AWGN) is a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral density (expressed as watts per hertz of bandwidth) and a Gaussian distribution of amplitude. The model does not account for fading, frequency selectivity, interference etc.However, it produces simple and tractable mathematical models which are useful for gaining insight into the underlying behavior of a system before these other phenomena are considered.The relative power of noise in an AWGN channel is typically described by quantities such as

• Signal-to-noise ratio (SNR) per sample. This is the actual input parameter to the AWGN function.

• Ratio of bit energy to noise power spectral density (Eb / No). This quantity is used by BER Tool and performance evaluation functions in this toolbox.

• Ratio of symbol energy to noise power spectral density (Es / No).

The relationship between *Es* / *No* and *Eb* / *No*, both expressed in *dB*, is as follows:

$$\frac{E_s}{N_o}(dB) = \frac{E_b}{N_o}(dB) + 10\log_{10}(k)$$

4.7 Log-Likelihood Ratio for MC-CDMA Systems

Since in MC-CDMA systems a coded bit b_k is transmitted in parallel on *L* sub-carriers, where each subcarrier may be affected by both independent fading and multiple access interference, the LLR for OFDM system is not applicable for MC-CDMA systems. The LLR for MC-CDMA systems is give as

$$L^{(k)} = \frac{2\left|\sum_{l=0}^{L-1}\left|C_l^{(k)}\right|.\left|C_l^{(k)}\right| G_{l,l}\, H_{l,l}\right|}{\sigma^2_{MAI} + \sigma^2_{noise}}$$

Where $G_{l,l}\ H_{l,l}$ are the equalized channel coefficients of the L sub-carriers used for the transmission of b^k.

4.8 BER (Bit Error Rate)

As the name implies, a bit error rate is defined as the rate at which errors occur in a transmission system. This can be directly translated into the number of errors that occur in a string of a stated number of bits. The BER may be analyzed using stochastic computer simulations.

If a simple transmission channel model and data source model is assumed, the BER may also be calculated analytically. An example of such a data source model is the Bernoulli source. Examples of such simple channel models are Binary symmetry channel (used in analysis of decoding error probability in case of non-bursty bit errors on the transmission channel) Additive white Gaussian noise (AWGN) channel without fading. In a noisy channel, the BER is often expressed as a function of the normalized carrier-to-noise ratio measure denoted *Eb* / *N*0). The definition of bit error rate can be translated into a simple formula is given below equation. (2)

BER is often expressed as a function of the normalized carrier-to-noise ratio measure denoted *Eb*/*N0*, (energy per bit to noise power spectral density ratio), or *Es* / *N*0 (energy per modulation symbol to noise spectral density)

$$BER = \frac{number\ of\ errors}{total\ number\ of\ bits\ sent} \qquad (2)$$

$$BER = \frac{1}{2\,erfc\sqrt{E_o/N_o}}$$

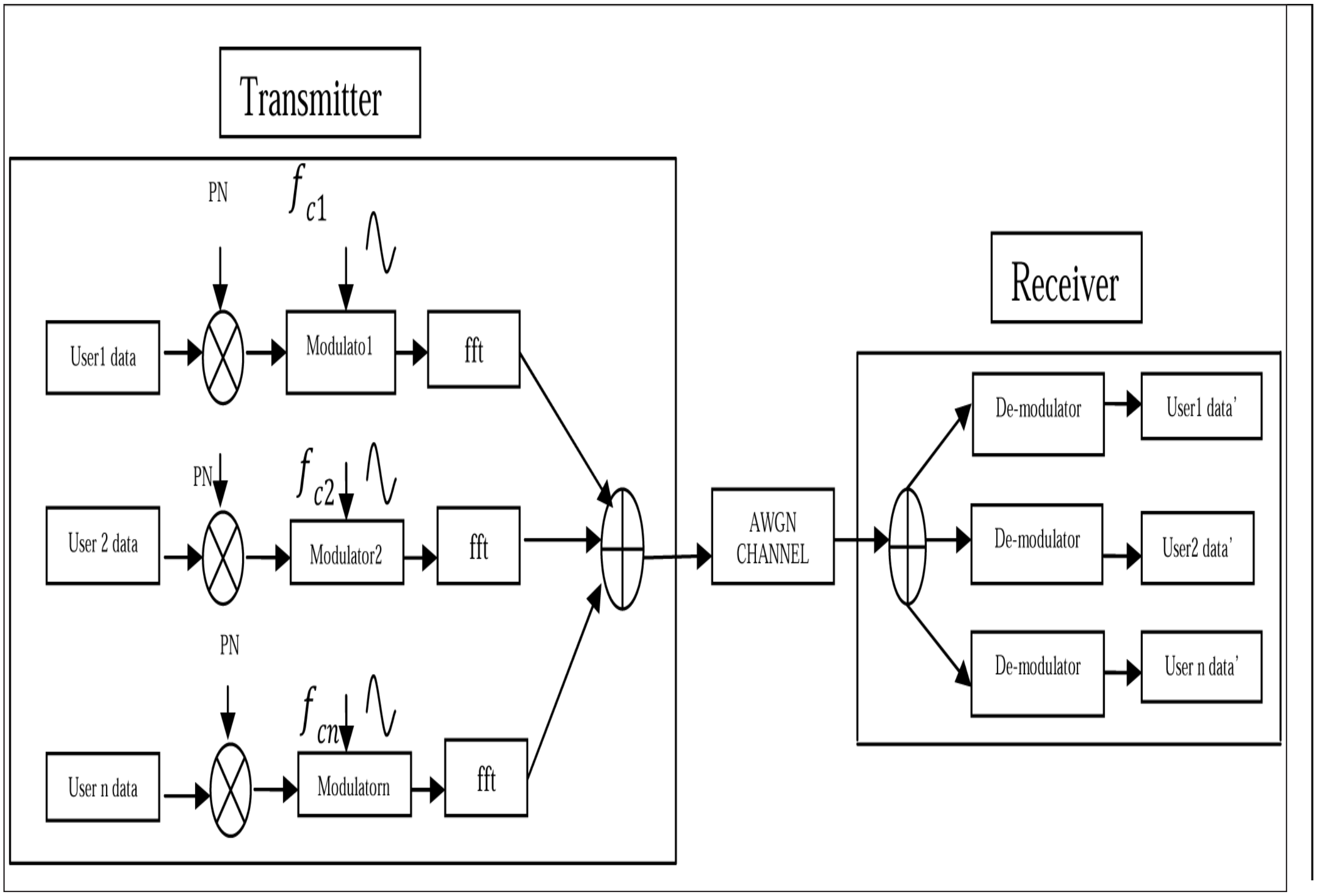


Figure 7. Proposed Method for Modification MC

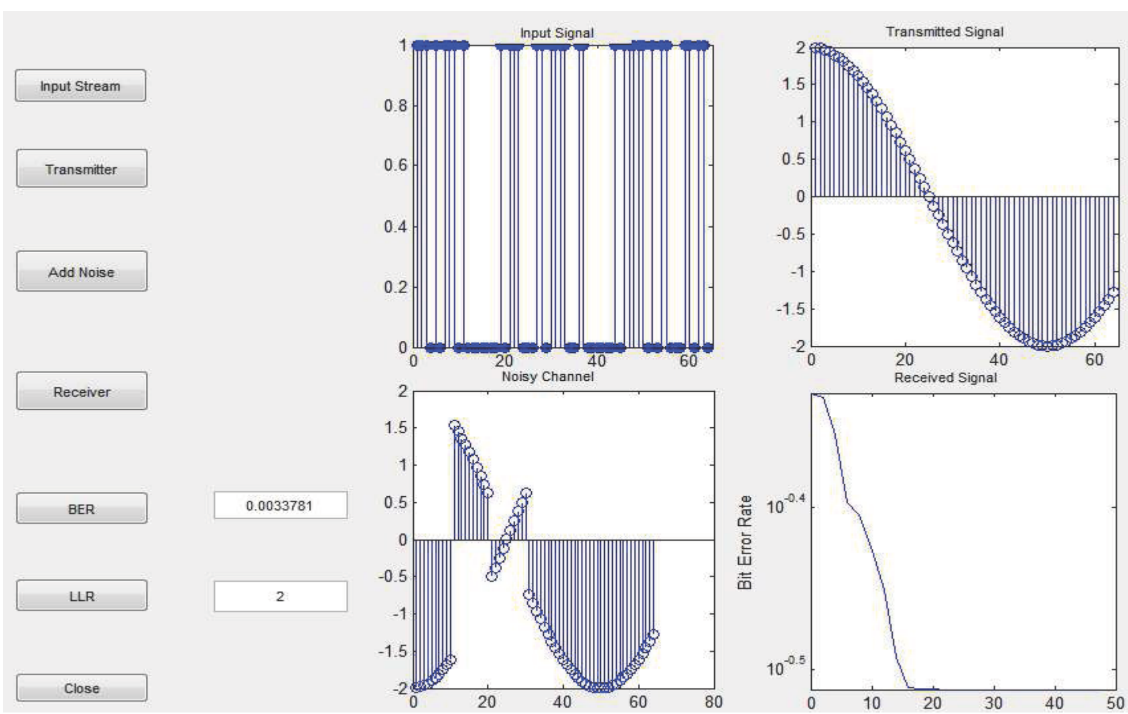


Figure 8. MC-CDMA Using BPSK Modulation

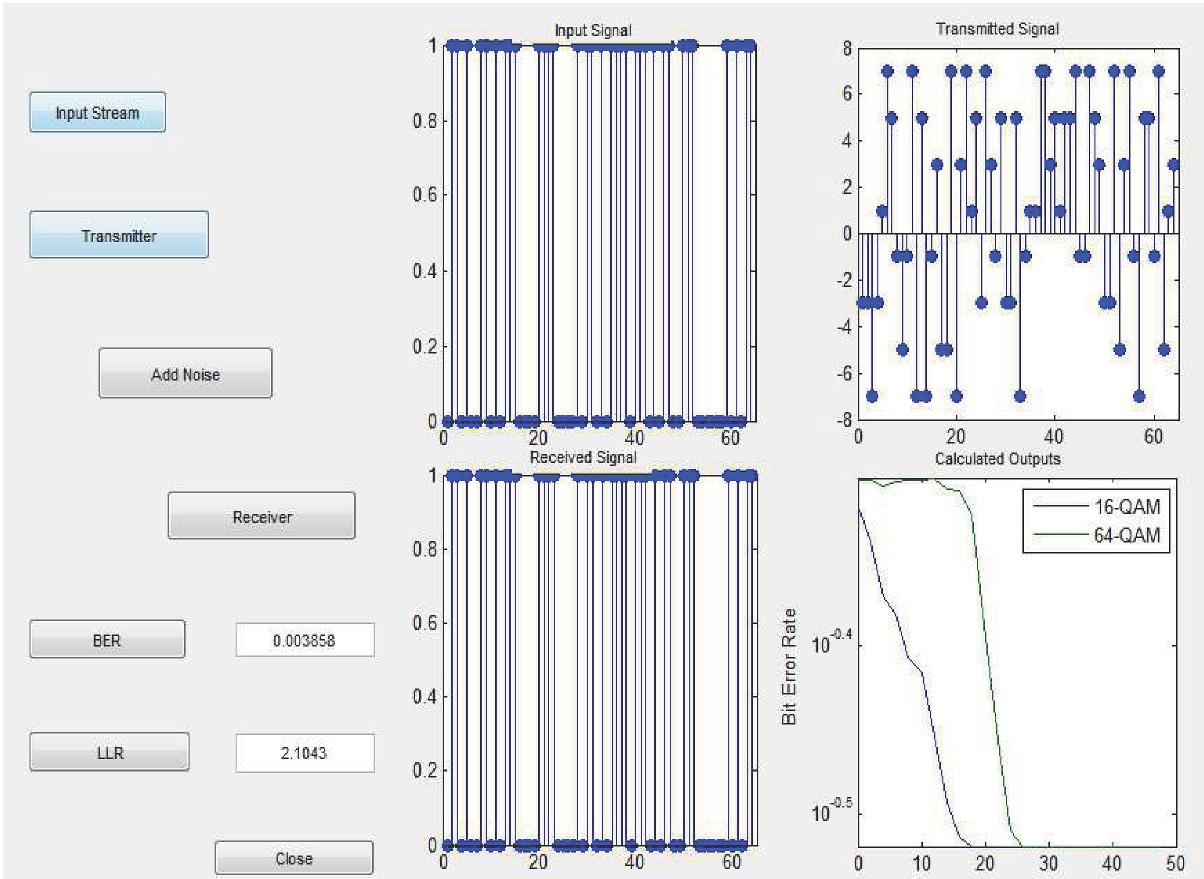


Figure 9. MC-CDMA Using QAM Modulation

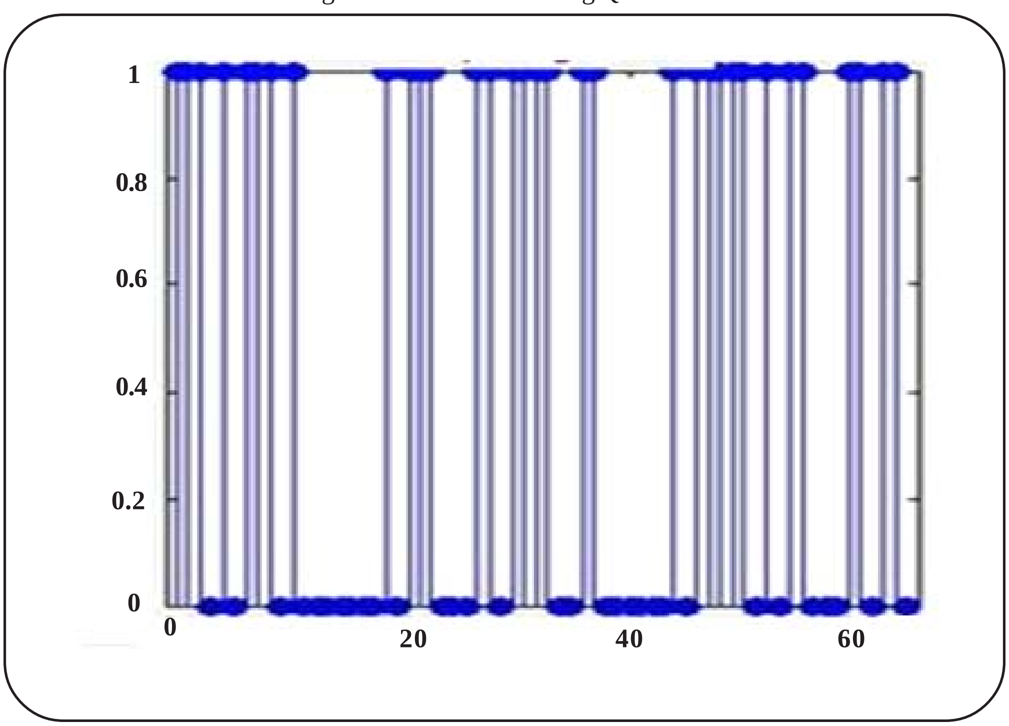


Figure 10. Input Signal

5. Implementation

The implementation is done in Matlab.The implementation is as follows for both CDMA and QAM techniques as shown in figure 7.

This model is simulated by MATLAB for performance analysis of QAM and CDMA modulations. And the BER performance of both CDMA and QAM is calculated. The simulation is done in this project by using M-files. A script can be written in MATLAB editor or another text editor to create a file containing the same statements that can be typed at the MATLAB command line.

BER is a performance measurement that specifies the number of bit corrupted or destroyed as they are transmitted from its source to its destination. Several factors that affect BER include bandwidth, SNR, transmission speed and transmission medium.

Multi-Carrier Code Division Multiple Access (MC-CDMA) is a multiple access scheme, allowing the system to support multiple users at the same time. MC-CDMA spreads each user Symbol. That is, each user symbol is carried over multiple parallel subcarriers, but it is phase shifted (typically 0 or 180 degrees) according to a code value.

The code values differ per subcarrier and per user. Modulating the input stream by using different modulation techniques are BPSK and QAM and transmit the modulated signal through transmitter.

And then we pass them through the AWGN channel after that we demodulate the received symbol based on the location in the constellation and then we count the number of errors finally repeat the same for multiple Eb/No values.

The receiver combines all subcarrier signals the receiver can separate signals of different users, because these have different (e.g. orthogonal) code values. Since each data symbol occupies a much wider bandwidth (in hertz) than the data rate (in bit/s), a signal-to-noise-plus-interference ratio.

One major difference between MC-CDMA and OFDM is the subcarriers in MC-CDMA at any instant transmits the one symbol but in OFDM each sub carrier transmit separate symbol, the efficiency of MC-CDMA is hidden in orthogonal sub carrier by which the overlapping spectrum of successive subcarriers can be separated other advantage comes from a wideband coverage of carriers and slower transmission time or larger transmission duration for each bit.

6. Simulation Results

This model is simulated by MATLAB for performance analysis of MC-CDMA.And performance of MC-CDMA is calculated by using QAM and BPSK modulation techniques. In this paper, we have evaluated the BER, LLR performance of an MC-CDMA system with two digital modulation schemes, namely M-ary PSK and M-ary QAM, over an AWGN channel. MC-CDMA is a powerful modulation technique to achieve high data rate and is able to eliminate ISI. It is computationally efficient due to its use of FFT techniques for implementing modulation and demodulation functions. As we have done the analysis for PSK & QAM modulation techniques.

Below figures represents the GUI (Graphical User Interface) of MC-CDMA systems using MATLAB software.

6.1 Analysis of MC-CDMA using BPSK Modulation

In Figure 10. its showing that input signal which consists users input data

In Table1. showing that considering different inputs for the MC-CDMA system, Comparing the results of MC-CDMA system using BPSK and QAM modulation techniques as shown in above figures and the below table in terms of BER, LLR.

7. Conclusion

In this paper, the performance of MC-CDMA using modulation techniques are BPSK and QAM has analysed. By comparing

In Figure 11. Modulating the binary data which is given by the several users using BPSK modulation

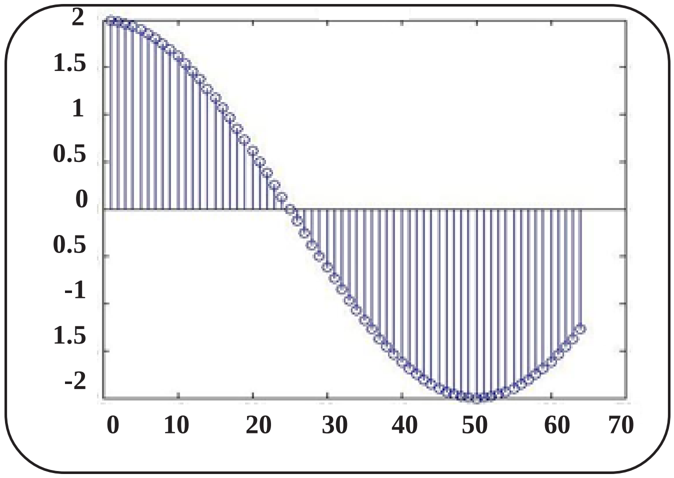


Figure 11. BPSK modulated output

In Figure 12. It representing the spread spectrum of a modulated signal

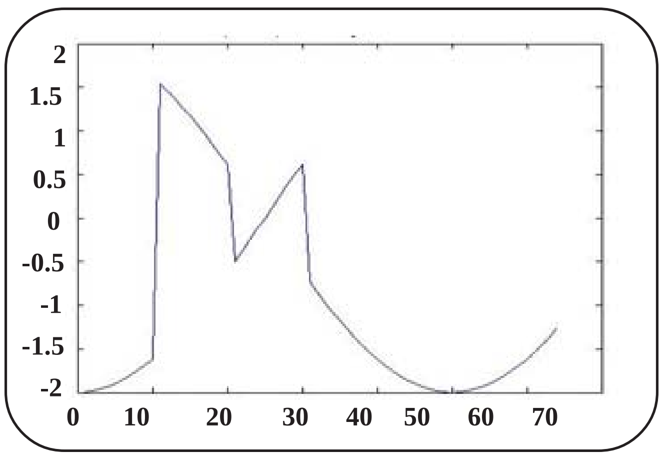


Figure 12. Spread Spectrum Signal

In Figure 13. using FFT for modulated signal

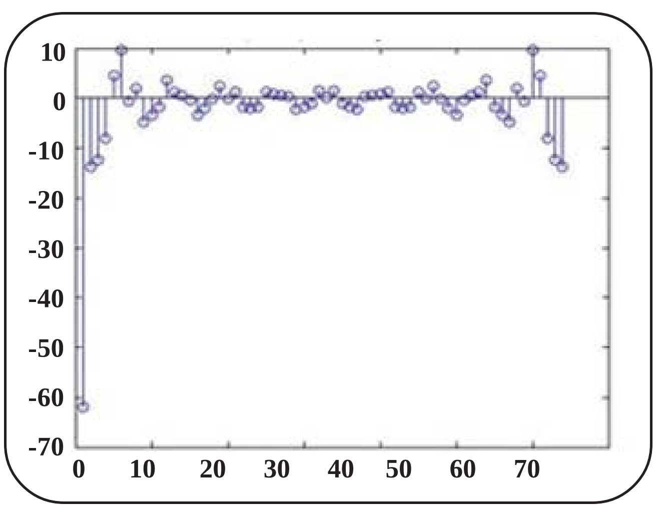


Figure 13. FFT Output

In Figure 14.transmitting the BPSK modulated signal to the AWGN channel through transmitter,it representing the transmitted

Output

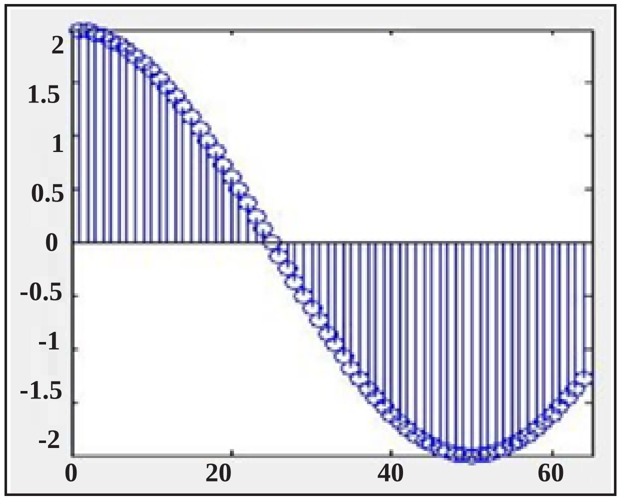


Figure 14. Transmitter Output

In Figure 15. Output of the noisy channel which is transmitted modulated signal through AWGN channel to De-Modulator

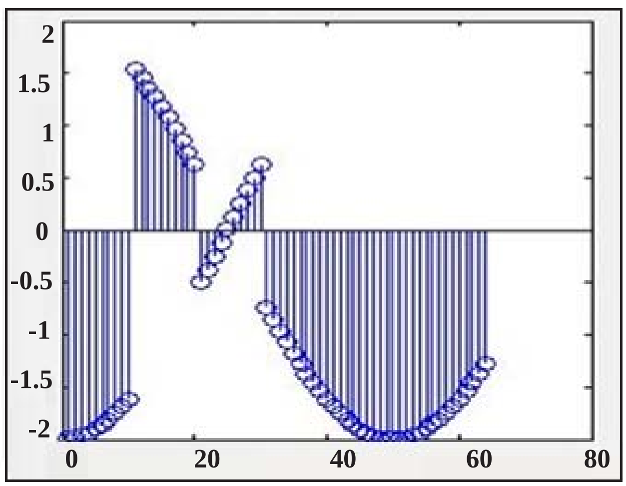


Figure 15. Noisy Channel

In Figure 16 its shows that the output of the BPSK De-Modulator

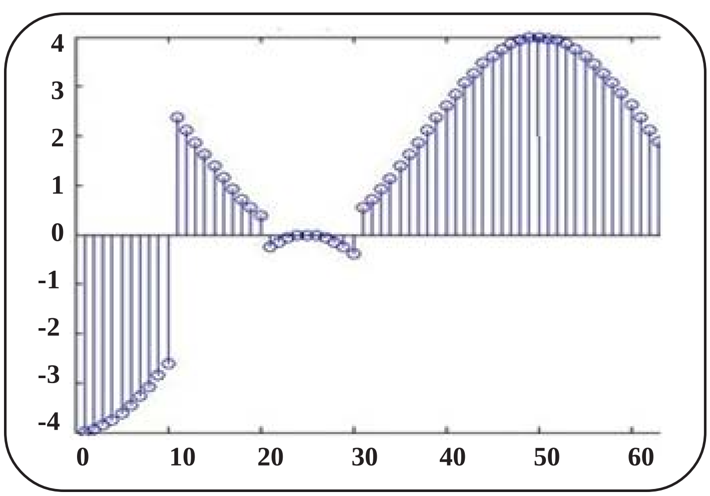


Figure 16. BPSK De-Modulated Output

In Figure 16. its shows that the output of the BPSK De-Modulator

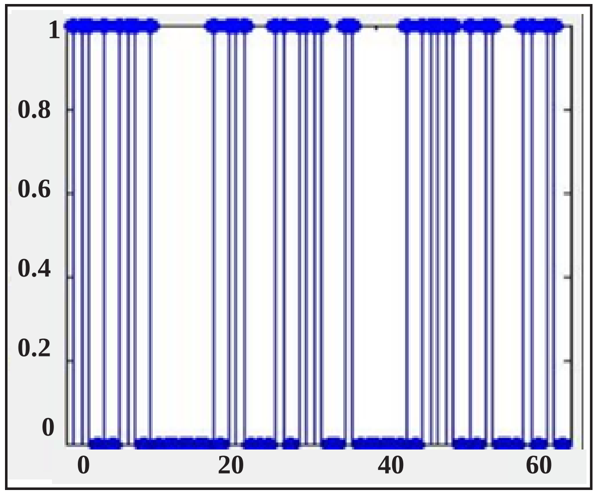


Figure 17. Receiver Output

In Figure 17. after De-Modulating the signal, at the receiver it receives the output without noise

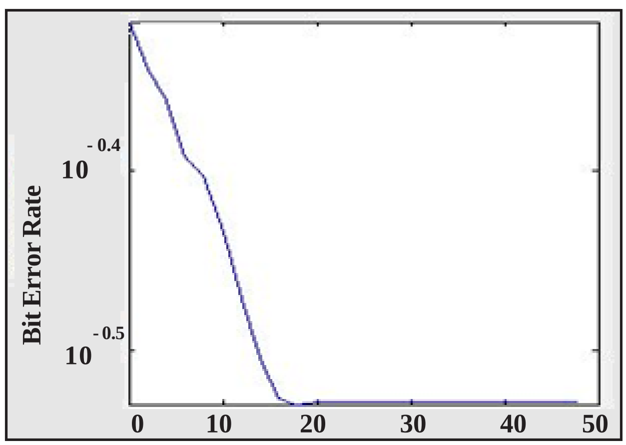


Figure 18. BER Performance of MC-CDMA using BPSK Modulation

6.2 Analysis of MC-CDMA using QAM modulation

In Figure 19. its showing that input signal which consists users input data

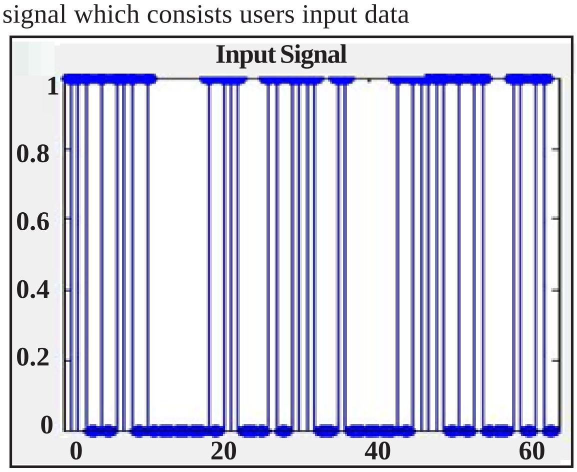


Figure 19. Input Signal

In Figure 20.transmitting the QAM signal to the AWGN channel through transmitter,it representing the transmitted output

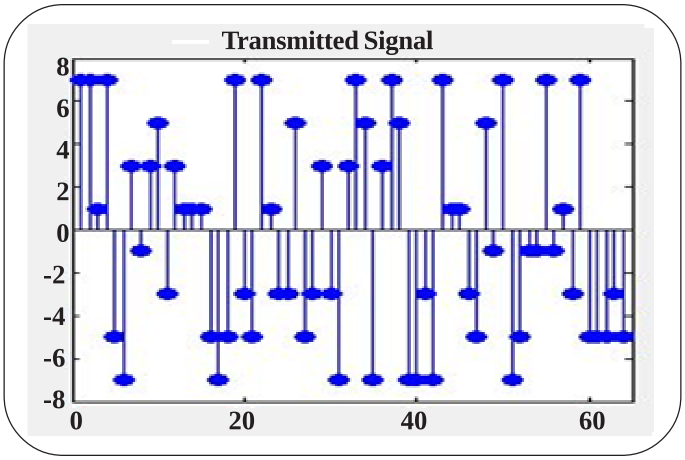


Figure 20. Transmitter Output

In Figure 21. output of the noisy channel which is transmitted signal through AWGN channel to De-Modulator?

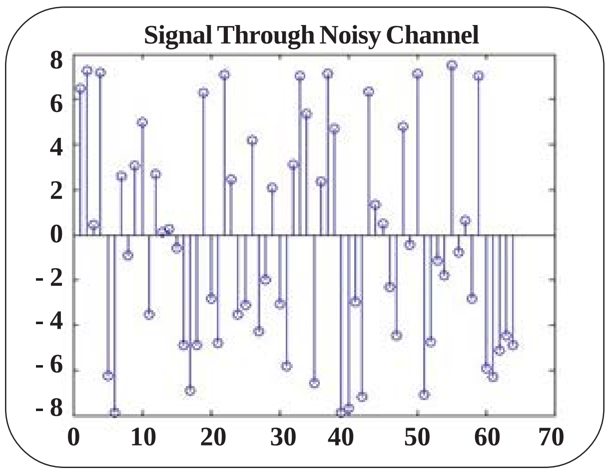


Figure 21. Noisy Channel

In Figure 22.it shows that receiver it receives the output without noise

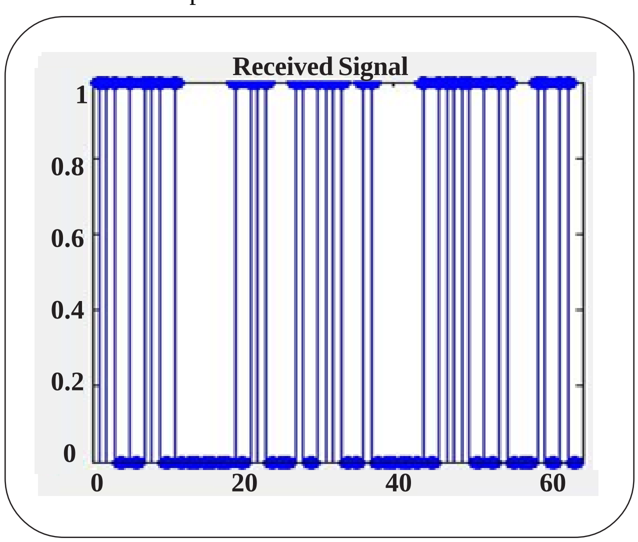


Figure 22.Receiver Output

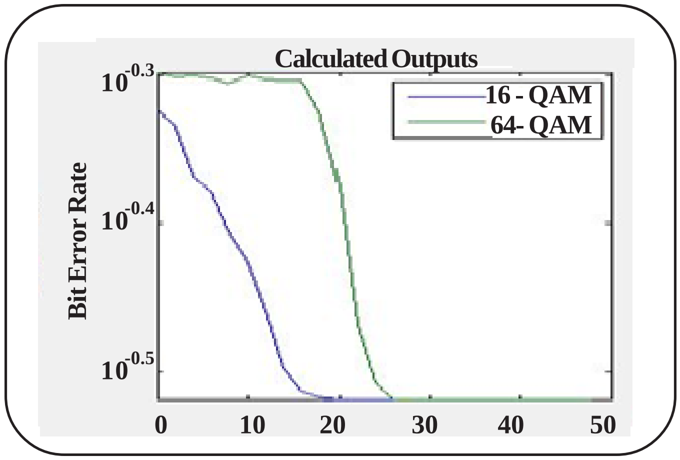


Figure 23. BER Performance of MC-CDMA using QAM Modulation

InputData	BER using BPSK	BER usingQAM	LLR using BPSK	LLR usingQAM
110100010011	0.0033332	0.0038725	2.1043	2.0417
101010010101	0.003326	0.0039067	2.2302	2.0625
110011001100	0.0033763	0.0039067	2.1252	1.9687
010100010011	0.0033332	0.0038725	2.1068	2.0189
101110010011	0.003345	0.0039025	2.2395	2.0900
010011001101	0.003358	0.0039067	2.1245	1.9799

Table 1. Results

the results in table 1.its showing that BPSK modulation gives the better performance for MC-CDMA Spread Spectrum Technique compared with QAM modulations technique in terms of BER, & LLR.

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