BER and LLR Analysis with MC-CDMA using BPSK/QAM Techniques for Wireless Communication

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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.After the modulation of signals, different noises are added to the modulated signal. And checking the received signal, BER, SNR, checks the fidelity of the transmitted signal. Noises are added because when the signal is generated in the transmitted channel the signal is affected due to noises. The reasons of these improvements have been explained analytically and the simulations results verified the analytical results. There are several modulation schemes such as BPSK; QPSK and QAM. For providing different data rates, modulation schemes are using along with MC-CDMA technique.

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)

I. 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 used to allow the system which supports multiple users at a same time. In frequency domain, MC-CDMA spreads symbol for each user.

Various radio communication technologies are using Code division multiple access (CDMA) for channel access method. The concept of data communication is to transmitting the information from transmitter to receiver over a single communication channel. Multiplexing is used to share a bandwidth of frequencies; it allows several users at a time. 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. In TDMA it divides into time, while in FDMA it divides into frequency.

Similarly, in radio CDMA, a code will share data to all users in each group. Same channel can access many codes, but particular code can understand each other while users associated.

II. STATE OF 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 analyze the performance of OFDM system in terms of BER. It provide large data rates. By using computer simulation results, it has evaluated. A result shows that for high capacity data rate transmission, QAM is better than PSK.

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 it studies errors of channel estimation on the BER performanace. It gives the simulation output values which is same to the theoretically calculated from the closed loop equations. The amount of degradation can be measured by using results.

In [3] analyzing the asynchronous multicarrier code-division multiple-access (MC-CDMA) systems in closed-form bit-error rate performance with a guard

period (GP) over frequency selective multipath fading channels in the form of a cyclical prefix. The resulting diagnostic results show that a GP is required for MC-CDMA systems in order to get desired signal power degradation and Make less severe the effect of intersymbol and intercarrier interference.

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 is achieved by using JD algorithms and an equalizer structure is comparable with the performance of other methods which exhibit higher complexity.

In [5] they are providing antenna array at the base station in the MC-CDMA system and the performance of the MC-CDMA system in a fading channel has analyzed. An explicit direction of arrival estimation or training signals is not required is derived for the MC-CDMA system in the reverse link, and it reduces the interferences from all users, it increases the system's user capacity. Also, MC-CDMA shows the better performance than the direct-sequence CDMA approach when both approaches employ the code filtering technique for antenna array.

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

In [7] it analyzes the performance of bit-error rate (BER) and asynchronous space–time block-coded (STBC) capacity. Multicarrier Code-Division Multiple-Access (MC-CDMA) systems in between the transmitter and receiver oscillators the presence of carrier frequency offset (CFO).Using equal gain combining (EGC) for deriving expression to get exact BER and by using maximum ratio combining (MRC)for deriving expression to get appropriate BER. To verified the BER expressions through simulations. By using these equations, the systems will satisfying the minimum BER required when EGC and MRC are used. Hence, it has a possibility to compare STBC MC-CDMA and MC-CDMA systems in terms of achievable capacity. It is concluded that it has insignificant effect on the BER while using small CFO.

In [8], generalized MC DS-CDMA scheme using binary phase shift keying modulation and it deals with Nakagami-m fading in wireless channels. In BPSK MC DS-CDMA system, it proposes for deriving the BER expressions over Nakagami-m fading channels. For various values of (Nakagami factor) m, (number of users) K, and (jamming interference) JSR, it plotted the results for BER vs SNR by using MATLAB software. In this system it observes the performance analysis by using MRC at the receiver and for different values of m; it observes the difference between independent and correlated. When compared with the independent fading, the correlated fading has high in terms of BER.

III. RELATED WORKS

In this paper, by using BPSK and QAM modulation techniques is used in the MC-CDMA system to analyze 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.

In frequency selective channels, it uses direct sequence spread spectrum techniques with PN codes and Rake receivers and PSK modulation techniques. The main reason for designing PN code generator is to adjust the chip duration short. And for preventing the effects of delay spread.MC-CDMA will provide some advantages like better spreading property and better multipath rejection property.

By using non-spread spectrum techniques, it removes or degraded the effects of multipath fading and other impairments of frequency selective channels. QAM gives the best results as the modulation scheme for non-spread spectrum systems.

IV.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. Each user data is first spread using a given high rate spreading code in the frequency domain. Corresponding to the symbol a fraction of the symbol 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 stream or channel for each subcarrier. After that, each subcarrier signal is modulated with low symbol rate, and then the total data rate of these subcarrier signals will be equal to conventional single carrier data rate. The main idea of this technique is, a signal with long symbol duration time is less effected by multipath fading as compare to signal with short symbol duration like in CDMA.

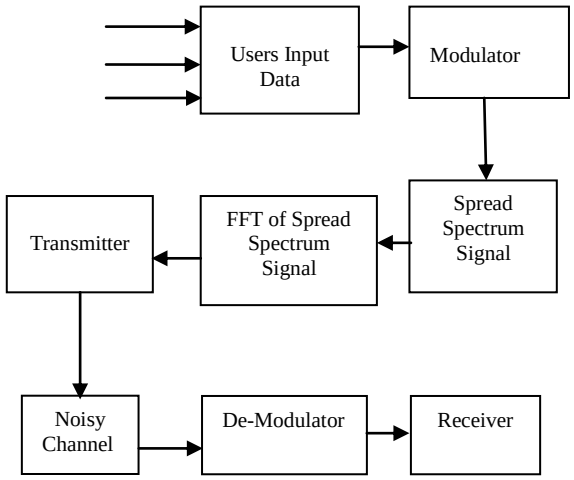
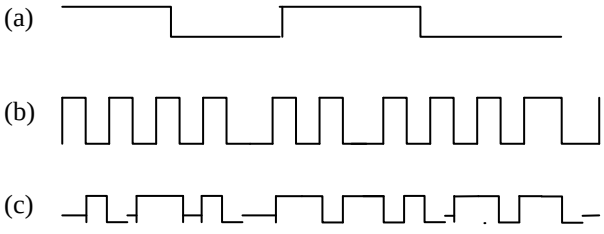


Fig 1: Block Diagram of MC-CDMA

CODE DIVISION MULTIPLE ACCESS (CDMA)

Compare with information bandwidth, the bandwidth of the coded signal has large bandwidth. Information signal is for spreading. The coding process is called a spread spectrum modulation, and coded signal is called a spread-spectrum signal. In CDMA. spreading of the information signal gives the multiple access capability.

Fig(2) shows that CDMA using PN(Pseudo Noise) and it does not have any sharply defined system like TDMA and FDMA systems.



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

Fig (2): Pseudo-Noise code sequence spread/ despread the signal.

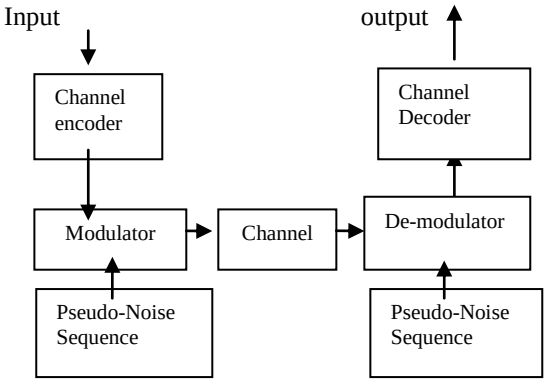


Fig (3): Block diagram of CDMA

QUADRATURE AMPLITUDE MODULATION (QAM)

QAM (Quadrature amplitude modulation) is both analog and digital modulation scheme. Using the (amplitude-shift keying) ASK digital modulation scheme or (amplitude modulation) AM analog modulation scheme, by changing modulating (amplitudes) of two carrier waves, it conveys two digital bit streams or two analog message signals.

The two carrier waves, generally sinusoids, these are out of phase which are differ by 90° each other, this is called quadrature carriers or quadrature components. The modulated waves are added and consequential waveform is a grouping of both (phase-shift keying) PSK and (amplitude-shift keying) ASK, or (phase modulation) PM and (amplitude modulation) AM.

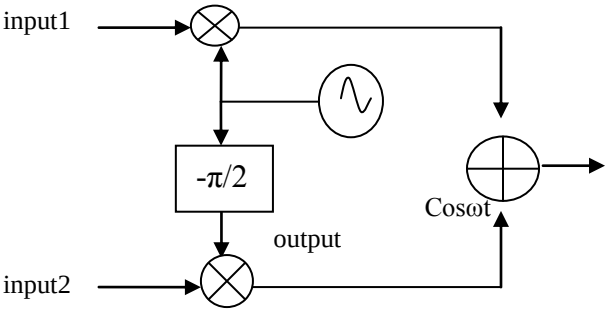


Fig (4): QAM (Quadrature Amplitude Modulator)

BINARY PHASE SHIFT KEYING (BPSK)

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

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

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

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

Where A represent it's peak value of sinusoidal carrier.Thus the above equation can be written as

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

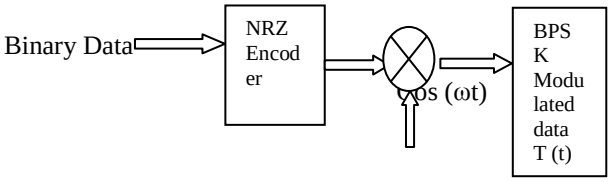
$$T_{BPSK}(t) = \pm\sqrt{PT}\cos 2\Pi f_c t$$

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

E represents the energy contained in the bit duration.

BPSK MODULATOR

BPSK modulator is implemented by NRZ coding the message bits (1 represents +ve voltage and 0 represents -ve voltage) and at carrier frequency ω, output is multiplied by by reference oscillator which it's running.



Fig(5):BPSK Modulator

BPSK DEMODULATOR

In the demodulator the received signal is multiplied by a reference frequency generator. By using integrator, it integrates the multiplied output over single bit period. Based on a threshold detector, it makes a decision on each integrated bit.

Since an NRZ signalling format is used with equal amplitudes in positive and negative direction, the threshold for this case would be '0'.

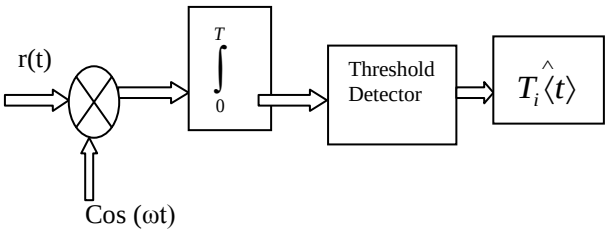


Fig (6): BPSK Demodulator

AWGN CHANNEL MODEL

Additive White Gaussian Noise channel means, adding Gaussian noise directly to the signal and it converts the information signal to noise signal. Additive white Gaussian noise.The noise in an AWGN channel is typically described by quantities such as

- SNR (Signal-to-Noise Ratio) per sample. It is the actual input consideration to the AWGN function.
- Relation between bit energy to noise power spectral density (Eb/No).
- Relation between symbol energy to noise power spectral density (Es/No).

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

$$\frac{E_s}{N_0}(dB) = \frac{E_b}{N_0}(dB) + 10\log_{10}(k)$$

LOG-LIKELIHOOD RATIO FOR MC-CDMA SYSTEMS

In MC-CDMA systems, transmitting coded bit b^k in parallel on L sub-carriers. 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

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

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

BER (BIT ERROR RATE)

A Bit Error Rate is defined as the rate at which errors occur in a transmission system while transmitting the data from source to its destination. Also, it measures the number of bits were destroyed or corrupted. Using stochastic computer simulations, the BER has analysed.

In a noisy channel, the BER represents the function of the normalized carrier-to-noise ratio (Eb/N0) or Es/N0 (energy per modulation symbol to noise spectral density). The bit error rate can be translated into a simple formula is given below eq. (2)

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

$$\text{BER} = \frac{1}{2\text{erfc}\sqrt{E_b/N_0}}$$

V.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 CDMA by using QAM BPSK modulation techniques.

And the BER performance of both BPSK and QAM is calculated.

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.

.For each subcarrier and user, it has different code values. By using BPSK and QAM modulation techniques, it modulates the input stream and transmitting through transmitter.

And it passes them through the AWGN channel. After that it demodulates the received symbol based on the location in the constellation. Finally it will count the number of errors repeated the same for multiple Eb/No values.

The receiver combines all subcarrier signals and the receiver could separate the signals of different users, because each user has 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 it can transmit the one symbol whereas in OFDM each sub carrier transmit separate symbol.

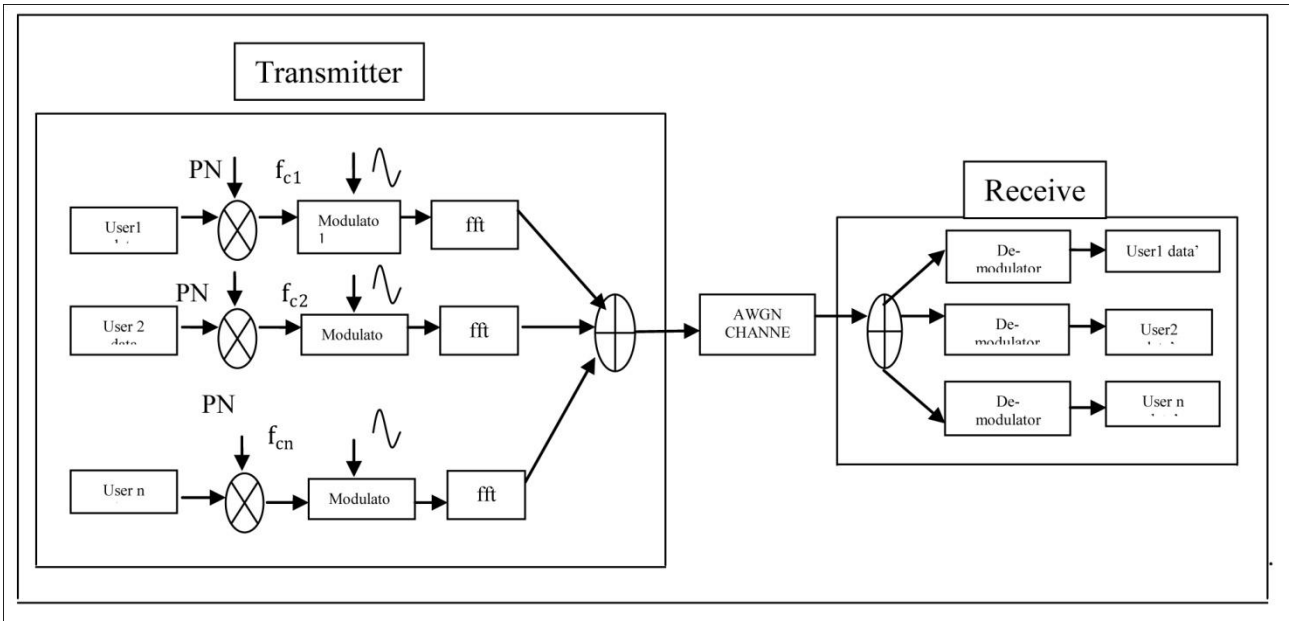


Fig 7: Proposed Method for Modification MC-CDMA

VI.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.

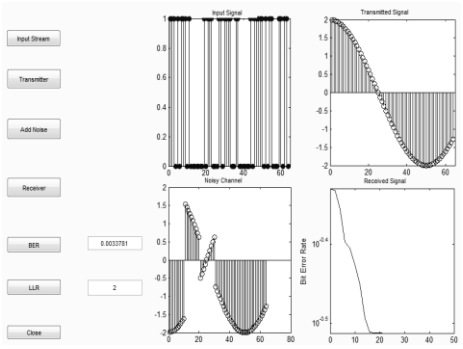


Fig 8: MC-CDMA Using BPSK Modulation

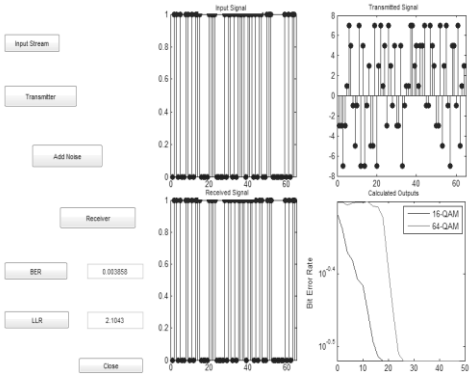


Fig 9: MC-CDMA Using QAM Modulation

Analysis of MC-CDMA using BPSK modulation

In Fig (10), its showing that input signal which consists users input data

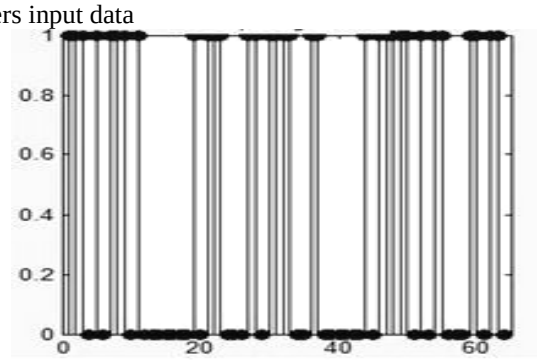


Fig 10: Input Signal

In Fig(11), modulating the binary data which is given by the several users using BPSK modulation

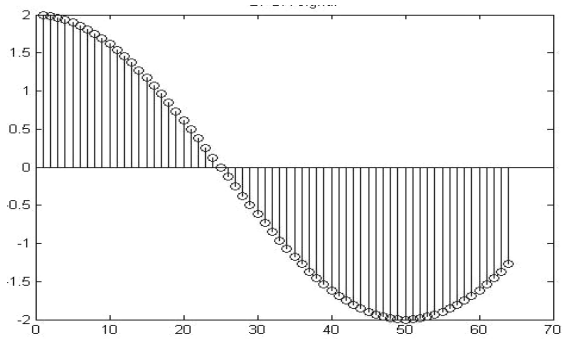


Fig11:BPSK modulated output

In Fig(12),it representing the spread spectrum of a modulated signal

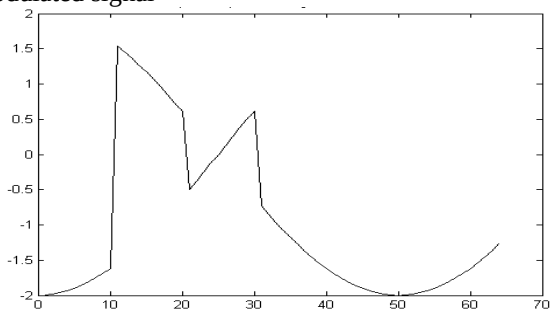


Fig 12:Spread Spectrum Signal

In Fig(13),using FFT for modulated signal

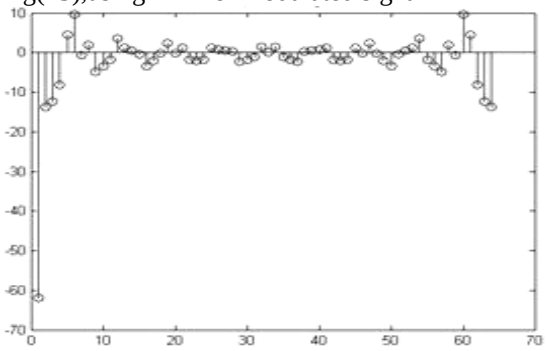


Fig13:FFT Output

In Fig(14),transmitting the BPSK modulated signal to the AWGN channel through transmitter,it representing the transmitted output

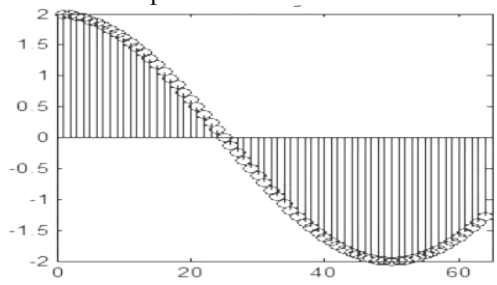


Fig 14: Transmitter Output

In Fig (15), output of the noisy channel which is transmitted modulated signal through AWGN channel to De-Modulator

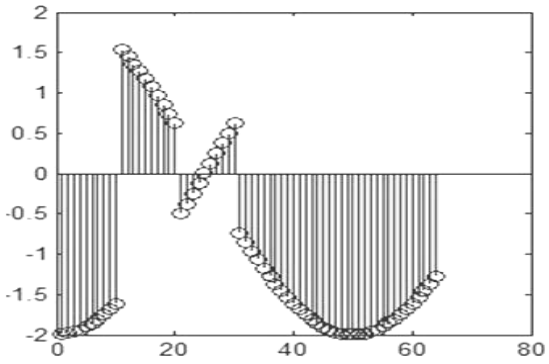


Fig 15: Noisy Channel

In Fig (16), its shows that the output of the BPSK De-Modulator

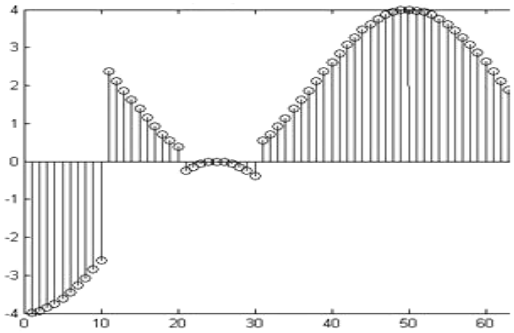


Fig 16: BPSK De-Modulated Output

In Fig (17), after De-Modulating the signal, at the receiver it receives the output without noise

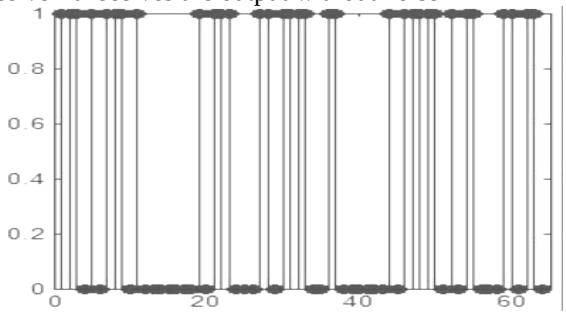


Fig 17: Receiver Output

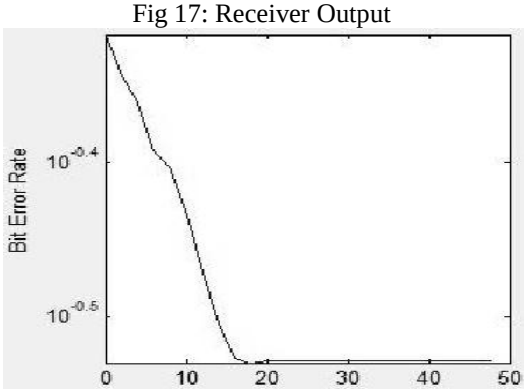


Fig 18: BER Performance of MC-CDMA using BPSK Modulation

ANALYSIS OF MC-CDMA USING QAM MODULATION:

In Fig (19), its showing that input signal which consists users input data

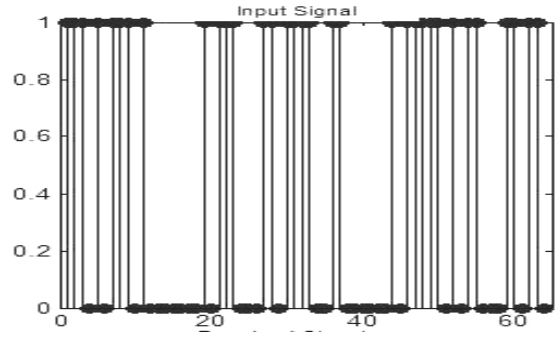


Fig 19: Input Signal

In Fig(20),transmitting the QAM signal to the AWGN channel through transmitter,it representing the transmitted output

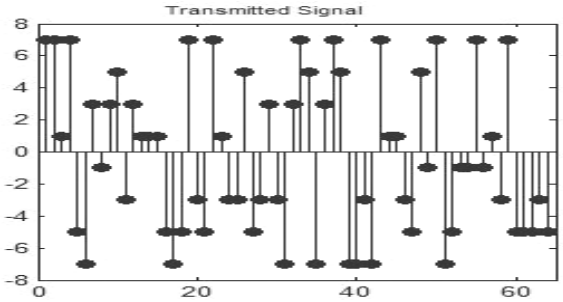


Fig 20: Transmitter Output

In Fig (21), output of the noisy channel which is transmitted signal through AWGN channel to De-Modulator?

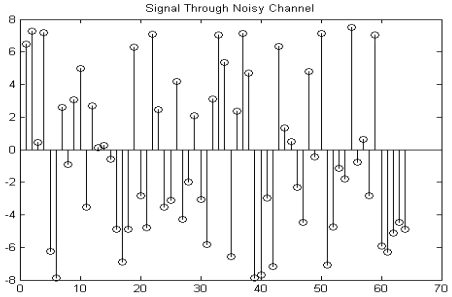


Fig 21: Noisy Channel

In Fig (22), it shows that receiver it receives the output without noise

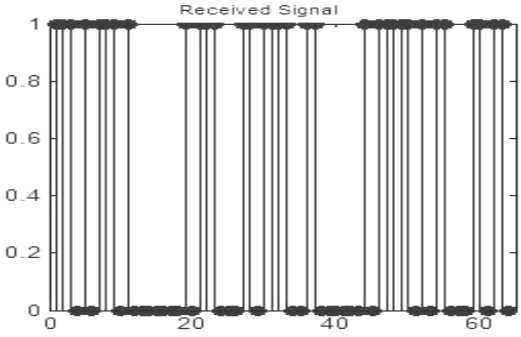


Fig 22: Receiver Output

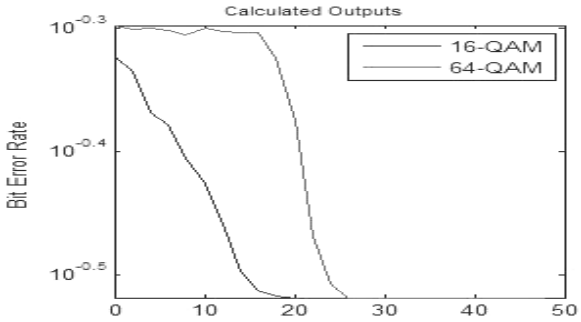


Fig 23: BER Performance of MC-CDMA using QAM Modulation

In Table(1) 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.

Input Data	BER using BPSK	BER using QAM	LLR using BPSK	LLR using QAM
110100 010011	0.0033332	0.0038725	2.1043	2.0417
101010 010101	0.003326	0.0039067	2.2302	2.0625
110011 001100	0.0033763	0.0039067	2.1252	1.9687
010100 010011	0.0033332	0.0038725	2.1068	2.0189
101110 010011	0.003345	0.0039025	2.2395	2.0900
010011 001101	0.003358	0.0039067	2.1245	1.9799

Table 1: Results

VII.CONCLUSION

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