Design and Analysis of DSSS-CDMA through MISO Transmission Techniques for Various Modulation Schemes

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Abstract - In the field of communication today, the most popular area is the wireless communication. Next Generation Wireless Networks Development depends on Wireless and Access Schemes suitability. DSSS-CDMA is mainly Concentrated in this paper. MATLAB-Simulink tool is used to design a DSSS-CDMA System. A PN Sequence generator is used along with Binary Phase shift keying(BPSK), Quadrature Phase Shift Keying (QPSK),8-Phase shift keying(PSK), 16-Phase Shift Keying and Quadrature Amplitude Modulation (QAM), Modulators. Corresponding demodulators, Synchronization unit and correlator are used at the receiver. With the Comparison between transmitted data and received data, Evaluation of System performance is done. Analyzing the effect of Noise, through different channels with calculation of BER

Keywords: Direct-Sequence Spread Spectrum (DSSS), Code Division Multiple Access (CDMA), Pseudo Noise (PN) code, BPSK modulator, 16 Phase Shift Keying (16PSK) and Quadrature Amplitude Modulation (QAM), Bit Error Rate(BER), Quadrature Phase Shift Keying (QPSK), Phase Shift Keying(PSK)

I. INTRODUCTION

One of the widely used Data Communication scheme is Spread Spectrum Communication. [6] Many features like secure, Multiple Access make it suitable and other properties that communication system is in need of. Spread Spectrum is a type of transmission where the signal is occupied with more bandwidth compared to the minimum necessary to transmit Information.

DS/SS System is the preferred one due to its ease of implementation and its simplicity in the field of Wireless Communication [2]. Using PN Sequence, the baseband information is spread in DS/SS System. Based on the coding scheme, Spread Spectrum technique performance is dependent. During design a PN Sequence Chip Rate, Code Length and type of code parameters are considered. This paper objective is to design and implement a Matlab-Simulink based Direct Sequence Spread Spectrum CDMA Systems and to study the performance evaluation of Bit Error Rate through Various modulation schemes.

[3] Military and Intelligence Applications are the areas the Spread Spectrum Technology was developed. For good Anti-jamming properties a very popular technology used is Spread Spectrum.

II. LITERATURE SURVEY

The paper [1], describes that in Wireless Networks, there are several techniques, OFDM and Code Division multiple Access(CDMA) are few of them. For better accessibility of speed these two techniques will assist and help in Rural Areas Wireless Connections

This paper [2] comprises of contents on Direct Sequence Spread Spectrum (DS/SS). Using Simulink tool DS/SS System is designed. Resulting into the outcome of better performance of the system in the presence of AWGN.

The paper [3] analyzes various phase modulation techniques performances in which Direct Sequence Spread Spectrum (DSSS) systems is used in idealistic AWGN (Additive White Gaussian noise) channel.

The objective of this work [4] is to analyze and model a CDMA system with the observation of one user response with respect to the variation in the number of users. Little Analysis was there on this topic.

This paper [5] brings a comparison, in terms of simulation, through the performance of CDMA and MC- CDMA system both are operating under similar testing conditions.

The objective of this paper [6], it has discussed Spread Spectrum Feature. More focus on Direct Sequence Spread Spectrum Scheme, Pseudo Noise Signals, Hardware

Implementation, demodulators and modulators with the illustration of DS-SS System features.

III. IMPLEMENTATION OF PROPOSED SYSTEM

The implementation of the paper design can be given as below:

a) System Requirements:

1. Operating System: Windows 11 (or) Windows 10 (version 1909 or higher)
2. Processor: Any Intel or AMD x86-64 processor
3. RAM: 4GB or more
4. Storage Capacity: 10GB or more and an SSD

b) Software Requirements:

1. MATLAB SIMULINK
   - 2022a Version 9.10

A. DESCRIPTION

MATLAB Simulink.:

MATLAB is a numeric and computing platform used to Analyze data by scientists and Engineers in order to create models and develop Algorithms.

MATLAB [7],is used in in Industry and Academia, for certain range of Applications , like computational biology, Control Systems, Image and Video Processing , Signal Processing , Deep Learning, Image Processing and Machine learning.

Simulink is suitable for multidomain simulation and also for model based design [8]. Simulink provides solvers for modeling and simulating and also provides customizable block libraries, Graphical Editor.

Simulink has integrated with MATLAB, with which MATLAB Algorithms can be incorporated into models leading to further Analysis by exporting simulation Results.

1. **PN- Sequence Generator**: PN Sequence Generator Design place major role in DS-CDMA Communication System.

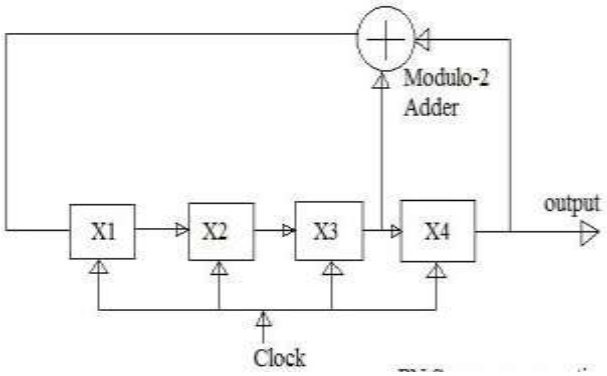

Figure 1: PN Sequence Generator Block Diagram

"Figure 1" shows the PN Sequence Generator block diagram. Random properties and finite length sequence are the characteristics of a Pseudo-Random Noise(PN) Sequence code. [9] Using Linear feedback shift register (LFSR), the PN Sequence generator can be implemented. (Maximal length sequence) LFSR based PN Sequence generators are maximum length sequences that is possible

The PN Sequence length will be of 2n-1 bits for size for n bit size shift registers.

The baseband waveform is multiplied with PN Sequence in Direct Sequence Spread Spectrum. The PN generartor is used to produce the PN Sequence.

Frequency of the data signal is lower than PN.The system consists of a Shift Register , and Logical circuit which leads to the determination of PN signal.

The signal is going to be modulated and transmitted after spreading. [8]

2. **Relation of Output signal to noise ratio and Processing Gain:** In the [3] PN Sequence encoding and decoding, it has the effect of SNR increase in DS-SS with the help of code length N.

   [10] Defining the ratio of Instantaneous peak power Eb to the variance, as the Signal to Noise Ratio given by equation (1)

   $$\text{Output SNR}(SNR)_0 = (E_b/JT_C)/2 \text{----------(1)}$$

   $$\text{Input SNR}(SNR)_i = (E_b/T_b)/j(SNR)_0 = (2T_b/T_C)\,(SNR)_i$$

   $$10\log_{10}(SNR)_0 = 10LOG_{10}(SNR)_i+3+10\log_{10}(PG)db$$

   Where,

   PG = Processing Gain, E_b = Bit Energy

3. **Antijam Characteristics:**

   Probability of Error of DS-SS BPSK system is given by equation (2)

   $$Pe = erfc\sqrt{(2Eb/JTc)} \text{ ------ (2)}$$

We may express bit energy to noise density ratio as from equation (3)

$$Eb/N = (Tb/Tc)\,(p/j) \text{ ------- (3)}$$

Jamming Margin (J/P) = PG/(Eb/N) Jamming Margin in b given by equation (4)

$$(\text{Jamming Margin})\,db = (PG)db - 10\log_{10}(Eb/N)min \text{ ----(4)}$$

Where (Eb/N)min is the ratio which is required towards Probability of Error Average support. Processing gain places major role in deciding the performance of System. Jamming Margin can be improved by reduction in the minimum bit energy and increase in the Processing Gain(PG).

IV. ANALYSIS OF SPREAD SPECTRUM COMMUNICATION SYSTEM

A simplified model of DSSS - CDMA system transmitter and receiver are as shown in the Figures 2 and 3,

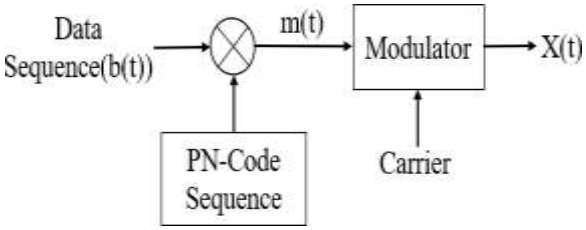

Figure 2: DSSS-CDMA Transmitter

"Figure 2" describes DSSS-CDMA Transmitter System with the basic building blocks.

Two satges of Modulation are present in Transmitter. Product Modulator or Multiplier are in the first stage and data sequence & PN Sequence are the two inputs. On the code length Data rate of PN Sequence is decided. BPSK, QPSK, 8- PSK, 16-PSK, QAM are the various modulation schemes present in the second stage. [11]

b(t) represents Information signal with values + or – as pulse stream with a data rate given. Spreading sequence c(t) multiplied by narrow band signal resulting into Chip Rate with higher data rate. Noise like wide band signal transformation taken from narrow band data sequence. Binary phase shift keying modulator comes in second stage where the base band signal b(t)is converter into band pass signal x(t).

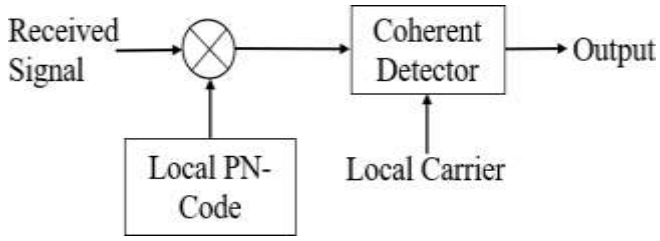

Figure 3: DSSS-CDMA Receiver

"Figure 3" describes the DSSS-CDMA Receiver system with basic building blocks.

Two stages of demodulation are present in the receiver. To the multiplier two inputs are the signal from first stage and PN Sequence that has been generated. In the second stage, the output of coherent detector will provide the estimate of original data sequence.

V. DESIGN OF DSSS-CDMA TRANSCEIVER

MISO DSSS-CDMA transceiver is implemented using MATLAB/Simulink. Two stages of modulation are present in Transmitter. Product Modulator or Multiplier are present in first phase, data sequence and PN Sequence are as the inputs given. In order to overcome errors, certain level of Robustness has to be maintained, proposed system is designed towards the data at higher data rates. Also, to reduce overall signal interference, to resist unintended (or) intended jamming and to share a single channel among multiple.

Using Simulink, Transmitter and Receiver are implemented towards DSSS-CDMA shown in "Figure 4

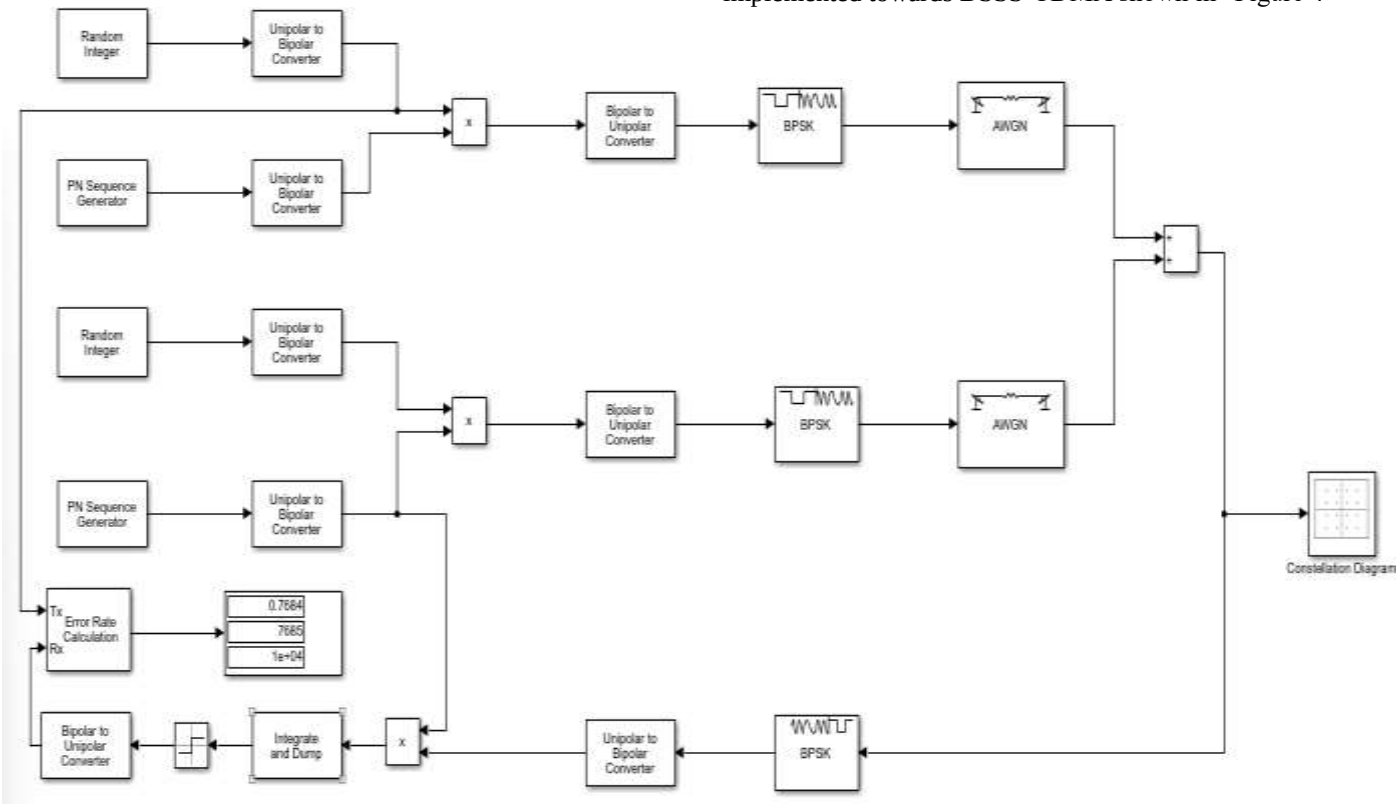

Figure 4: DSSS-CDMA System with MATLAB Simulink Model

"**Figure 4"** shows that, For DSSS-CDMA using different subsystem blocks MATLAB Simulink model is developed in presence of Additive White Gaussian Noise Channel.

Data Sources used in the communication sources are Random Integer generator. Communication Blockset produces random uniformly distributed 0 & 1 with 10kb/sec as a data rate. The PN Sequence generator generates with Linear feedback shift register, a sequence of pseudorandom binary numbers. Transmitted data and PN Sequence are applied to product multiplier resulting into spreading data. Spreading data conversion from unipolar to Bipolar takes place with BPSK Modulator.

In the transmitter shown in Figure 4 Random Integer generator generates binary data, in the transmitter. In two pseudorandom sequence generator, switching to any of the PN Generator towards generation of pseudorandom sequence The Through multiplication of PN Sequence and message signal generation of spreaded signal done.

System Quality of service depends on the modulation scheme selection. With the estimation of Probability of error performance measurement of each modulation scheme is measured. Popular digital modulation techniques as BPSK, QPSK,8PSK,16PSK, QAM are experimented with the assumption that Additive White Gaussian Noise is present.

VI. RESULTS AND DISCUSSION

The below "Table 1" describes the comparison between BER v/s Eb/N0 for DSSS-CDMA with MISO transmission techniques under various Modulation schemes.

Eb/No	BPSK	QPSK	8PSK	16PSK	QAM
-10	0.6475	0.7005	0.7535	0.7544	0.6287
-8	0.6432	0.6863	0.756	0.7563	0.6589
-6	0.6407	0.6722	0.7638	0.764	0.6941
-4	0.6417	0.6595	0.7603	0.7725	0.7326
-2	0.6387	0.6406	0.7649	0.7807	0.7653
0	0.6405	0.6397	0.7582	0.7947	0.7867
2	0.6399	0.6351	0.7417	0.8087	0.776
4	0.642	0.638	0.7111	0.8227	0.7096
6	0.6443	0.6402	0.6479	0.8274	0.5277
8	0.644	0.6439	0.6475	0.8245	0.2488
10	0.6451	0.6442	0.6425	0.809	0.0523

Table 1: BER v/s Eb/N0(in db) comparison under various Modulation schemes for DSSS-CDMA

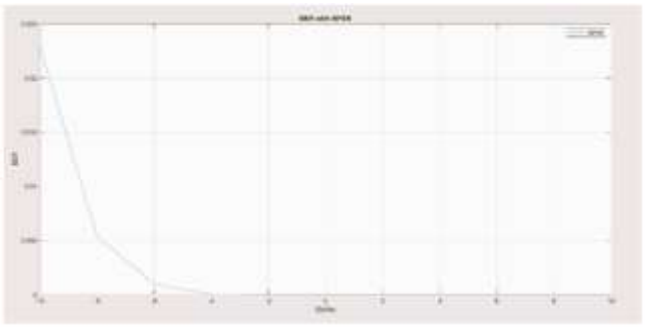

Figure 5: BER vs E_b/N_0 plot for DSSS-CDMA BPSK

"Figure 5" describes the plot of BER vs E_b/N_0 plot forDSSS-CDMA with multiple input single output transmission technique under BPSK modulation scheme. Using MATLAB Simulink, testing the performance of the system in terms of BER. , the Simulink process was carried ,resulting into that w for simulation time period of 10ms time, 0.642 BER was found, at SNR equal to 4db, further with increased value of Eb/No improvement in the system performance is observed. After the conduction of the analysis of BER towards band pass modulation and demodulation of BPSK Technique, the system performance ofDSSS-BPSK performance is improved version towards band BPSK. pass band modulation and demodulation.

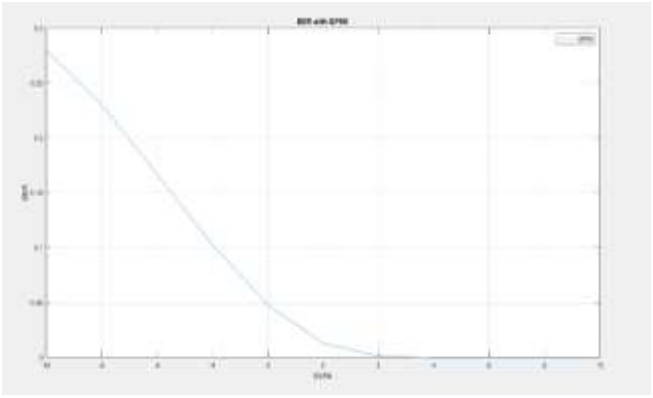

Figure 6: BER vs E_b/N_0 plot for DSSS-CDMA QPSK

"Figure 6" describes the plot of BER vs E_b/N_0 plot for DSSS-CDMA with multiple input single output transmission technique under QPSK modulation scheme

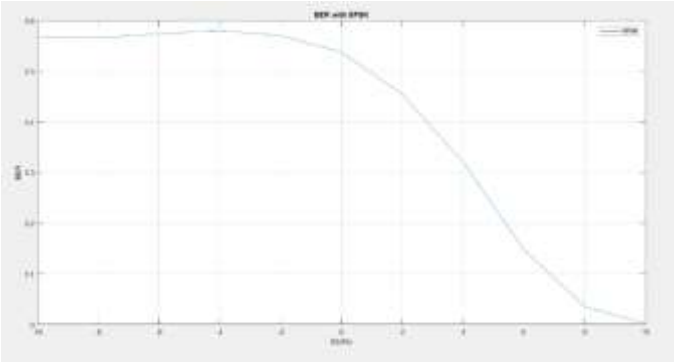

Figure 7: BER vs Eb/N0 plot for DSSS-CDMA 8PSK

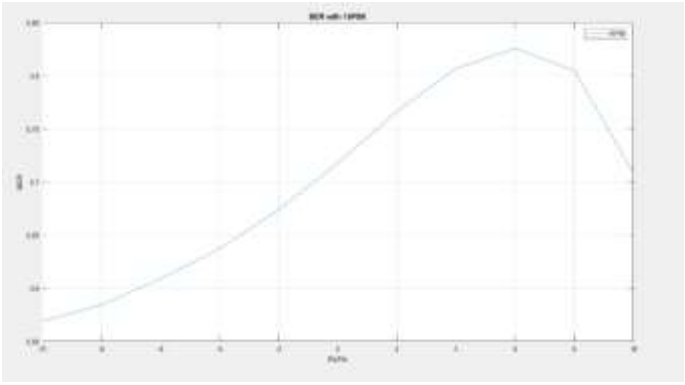

Figure 8: BER vs Eb/N0 plot for DSSS-CDMA 16PSK

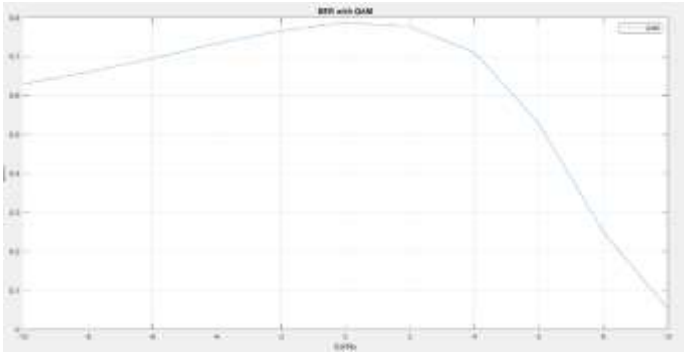

Figure 9: BER vs Eb/N0 plot for DSSS-CDMA QAM

"**Figure 7"** describes the plot of BER vs Eb/N0 plot for DSSS-CDMA with multiple input single output transmission technique under 8-PSK modulation scheme.
"Figure 8" describes the plot of BER vs Eb/N0 plot for DSSS-CDMA with multiple input single output transmission technique under 16-PSK modulation scheme.
"Figure 9" describes the plot of BER vs Eb/N0 plot for DSSS-CDMA with multiple input single output transmission technique under QAM modulation scheme.
"**Figure 10"** describes the plot of BER vs Eb/N0 plot for DSSS-CDMA with multiple input single output transmission technique under various modulation scheme.

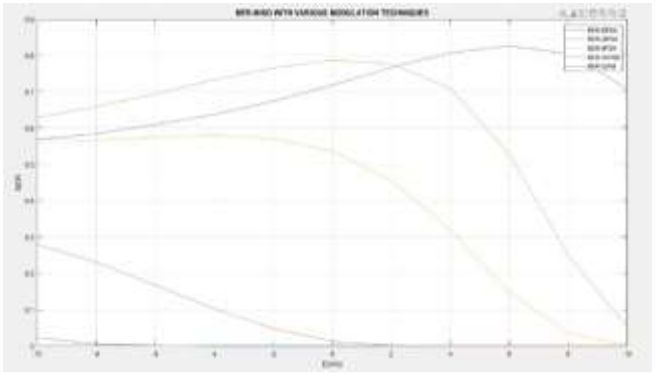

Figure 10: BER vs Eb/N0 plot for DSSS-CDMA under various modulation schemes

Towards various modulation schemes as BPSK, QPSK,8PSK,16PSK, QAM, DSSS System Simulation was performed. For the given data rate with the presence of type of channel conditions in terms of error performance, DSSS- BPSK combination is better compared to other phase modulation techniques.

VII. CONCLUSION

Wireless Systems have gained interest in terms of industrial community technique. DSSS-CDMA is the frequent used and the efficient technique. In the paper, transmitted and receive data has been tested, BER is computed at the receiver for AWGN Channel, Under various modulation schemes. DSSS/BPSK in terms of BER Performance comparison, it is far better compared to other modulation techniques.

VIII. FUTURE SCOPE

In mobile and Wireless Communication, Spread Spectrum Communication techniques, DSSS-CDMA is widely accepted. Major features of Spread Spectrum are. Antijam, Security and Multiple Accesses. Extension of concept towards CDMA System towards chip length of 1023 technique can be implemented.

IX. ACKNOWLEDGEMENT

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