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DIFFERENT SPREADING SEQUENCES FOR PERFORMANCE COMPARISON OF DS-SS SYSTEM

B Ch Kiran Patrudu*, D.Anil Prasad, B Ravi Kumar
* Assistant Professor Department of ECE, ANITS, Visakhapatnam, India

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ABSTRACT

In this work, the performance analysis of Bit Error rate (BER) Vs Ratio of Bit Energy to Noise Power Spectral Density (Eb/No) of simulink based DS-SS system is presented using the BERTool module. We have simulated the DS-SS system simulink model with 16-QAM, 32-QAM 64-QAM modulation techniques and from the simulation results it is found that bit error rate is increasing as the value of M increases i.e bit rerror rate of 64-QAM is higher than the bit error rate of 32-QAM. Similarly bit error rate of 32-QAM is higher than the bit error rate of 16-QAM. Also DS-SS system with M-QAM modulation using different spreading sequences (PN, Gold, Kasami) is simulated for BER analysis and found that DS-SS system showed better BER performance with 32-QAM and 64-QAM modulation technique using Gold sequence and Kasami sequence respectively. From the simulation results, it is concluded that by choosing the type of modulation technique and spreading sequence can enhance the performance of DS-SS system.

INTRODUCTION

Spread spectrum techniques have been widely used in wired and wireless communications. The spreading of the signal spectrum gives us many advantages such as robustness against interference and noise, low probability of intercept, realization of Code Division Multiple Access (CDMA) and so on. In order to spread the bandwidth of the transmitting signals, pseudo-noise (PN) sequences have been used extensively in spread-spectrum communication systems [1].

Direct Sequence Code Division Multiple Access (DS-CDMA) is a method of multiplexing users by distinct codes and in this method all users use the same bandwidth. In DS-CDMA each user has its own spreading code. The selection of a good code is important, because auto-correlation properties and length of the code sets bound on the system capacity. Spreading codes used in CDMA systems include Walsh-Hadamard sequences, Gold codes, Kasami codes, m-sequences etc. [2, 3]. In any multiple access system, the main reason that affects the performance is the multiple access interference. Because of this reason, the selection of spreading codes to differentiate the users plays an important role in the system capacity. In this work, different spreading sequences were used to evaluate the performance of DS-SS system.

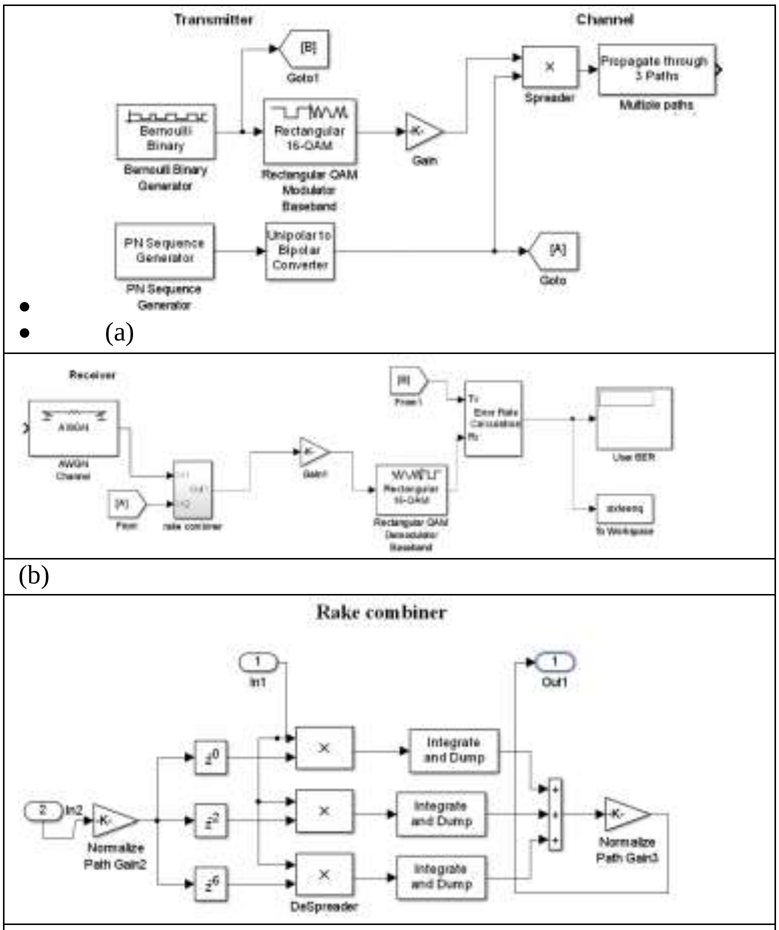
In BPSK, QPSK, and M-ary PSK we transmit, in any symbol interval, one signal or another which are distinguished from one another in phase but are all of the same amplitude. In each of these individual systems the end points of the signal vectors in signal space falls on the circumference of a circle. To distinguish one signal vector from another in the presence of noise will depend on the distance between the vector end points. It is hence rather apparent that we shall be able to improve the noise immunity of a system by allowing signal vectors to differ, not only in phase but also in amplitude. We call this as amplitude and phase shift keying or Quadrature amplitude modulation (QAM) which has been widely used in adaptive modulation because of its efficiency in power and bandwidth [4]. In digital communication systems, the relevant measure of performance, in terms of its error-producing behavior, is the bit-error-rate (BER) versus Ratio of Bit Energy to Noise Power Spectral Density (E_b/N_o) characteristic. Accurate prediction of this performance curve enables the determination of acceptable modulation methods, coding techniques and receiver implementations in operating environments.

In this work, the performance of Direct Sequence Spread Spectrum Communication System is evaluated is evaluated for different Quadrature Amplitude Modulation (QAM) techniques at different bit rates (16, 32, and 64) based on the Bit Error Rate (BER) versus the Ratio of Bit Energy to Noise Power Spectral Density (E_b/N_o). The performance is evaluated using the BERTool module provided under MATLAB/SIMULINK software package. Also the effect of spreading sequences on the performance of DS-SS system is studied using different spreading sequences. The code sequences (PN, Gold and Kasami) were used in this work.

SIMULINK MODEL OF DS-SS SYSTEM AND SIMULATION

Simulink model of DS-SS system

The transmitter of the simulink model of DS-SS system is represented in fig.1 (a) in which the binary data is generated by Bernoulli binary generator. This randomly transmitted data is then modulated by M-QAM modulator. PN sequence generator generates the spreading code. This code spreads the QAM modulated data effectively and then it is transmitted in three paths through AWGN channel as shown in fig. 1(a).



(a)

(b)

(c)

Fig. 1: Simulink model of DS-SS system using M-QAM modulation scheme a) transmitter b) receiver c) rake combiner

The receiver DS-SS is shown in fig.1(b).

The DS-SS transmitted signal after passing through the AWGN channel is first combined by rake combiner using despreading operation as shown in fig.1 (c). Inorder to improve the performance of the system, rake receiver is used, which exploits multipath delay components. A rake receiver combines the information from several correlators, each one tuned to a different path delay, producing a stronger version of the signal than a simple receiver with a single correlator tuned to the path delay of the strongest signal.[5]

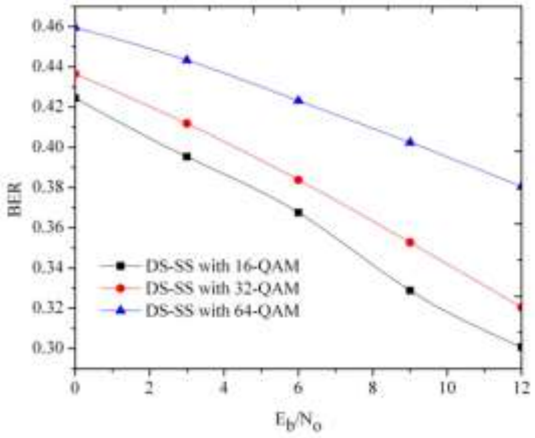
The signal from rake combiner is fed to rectangular M-QAM demodulator which demodulates the signal into binary data. This is fed as an input to Error Rate Calculation block which compares this data with original data and calculates bit error rate, no of errors, no of input bits.

SIMULATION METHODOLOGY

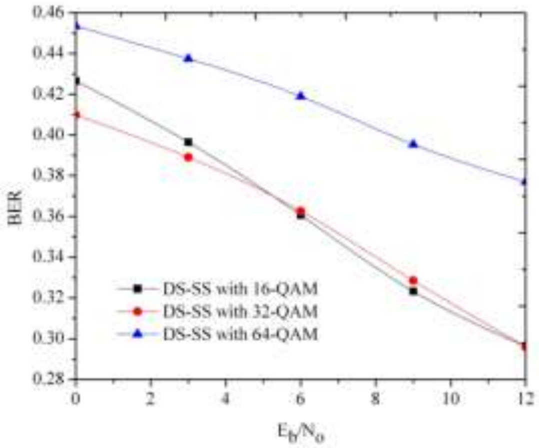
In digital communication systems, the relevant measure of performance, in terms of its error-producing behavior, is the bit-error-rate (BER) versus signal-to-noise ratio (SNR) characteristic. Accurate prediction of this performance curve enables the determination of acceptable modulation methods, coding techniques and receiver implementations in operating environments.

BER TOOL

BER Tool is an interactive GUI for analyzing communication system's bit error rate (BER) performance. Using BER Tool you can generate BER data for a communication system using Closed-form expressions for theoretical BER performance of



(a)



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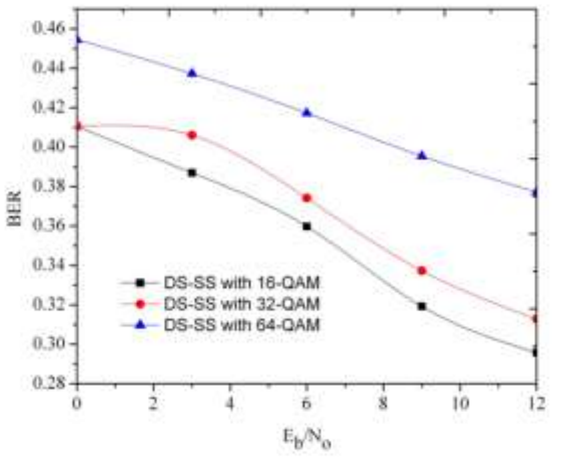
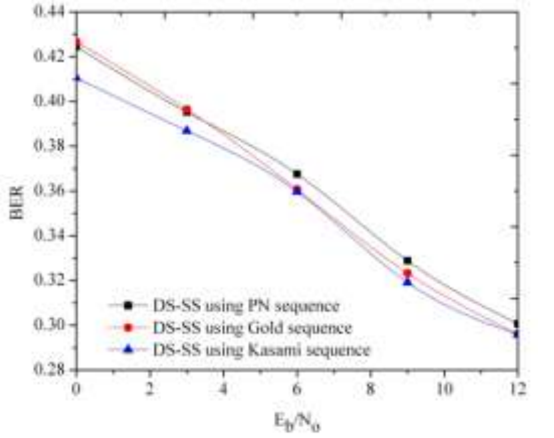
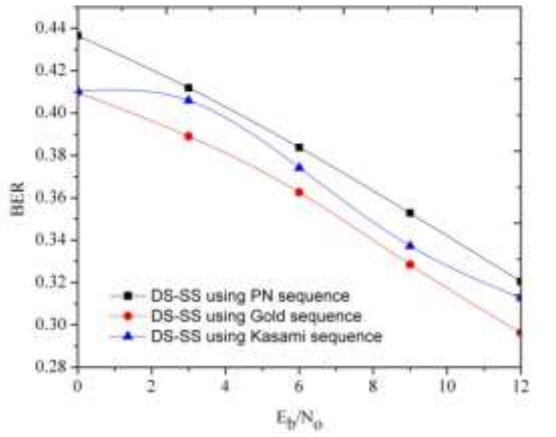


(c)

Fig. 2 : BER performance comparison of DS-SS system with different M-QAM modulation techniques(i.e 16-QAM,32-QAM and 64-QAM) using spreading sequences (a)PN sequence (b) Gold sequences (c) Kasami sequences.



(a)



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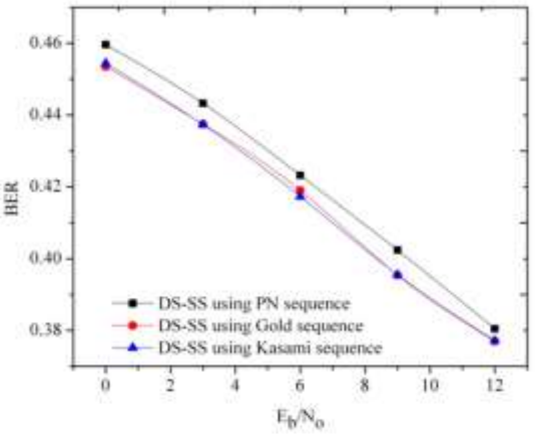

(c)

Fig. 3 : BER performance comparison of DS-SS system using different spreading sequences with different M-QAM modulation techniques (a) 16-QAM (b) 32-QAM and (c) 64-QAM

selected types of communication systems. After you create a function or model that simulates the system, BERTool iterates over your choice of E_b/N_0 values and collects the results. Plot one or more BER data sets on a single set of axes. Fit a curve to a set of simulation data. Send BER data to the MATLAB workspace or to a file for any further processing you might want to perform.

BER performance comparison of DS-SS system with different M-QAM modulation techniques(i.e 16-QAM,32-QAM and 64-QAM) using spreading sequences (a)PN sequence (b) Gold sequences (c) Kasami sequences are as shown in fig. 2(a), fig. 2(b) and fig. 2(c) respectively.

From the fig. 2(a), we can observe that BER decreases monotonically with increase in signal power E_b/N_o with different M-QAM modulation techniques using PN-sequences. In order to achieve BER of 0.38, the signal energy required for the DS-SS system with 16-QAM, 32-QAM and 64-QAM is 3dB, 6dB and 12dB respectively.

From the fig. 2(b), we can observe that BER decreases monotonically with increase in signal power E_b/N_o with different M-QAM modulation techniques using Gold-sequences. In order to achieve BER of 0.38, the signal energy required for the DS-SS system with 16-QAM, 32-QAM and 64-QAM is 3dB, 3dB and 9dB respectively.

From the fig. 2(c), we can observe that BER decreases monotonically with increase in signal power E_b/N_o with different M-QAM modulation techniques using Kasami-sequences. In order to achieve BER of 0.38, the signal energy required for the DS-SS system with 16-QAM, 32-QAM and 64-QAM is 3dB, 3dB and 6dB respectively.

In order to study the effect of spreading sequences on the BER performance of DS-SS system, the spreading sequences PN, Gold sequences and Kasami sequences were considered in this work. The BER performance comparison of DS-SS system using different spreading sequences with modulation techniques 16-QAM, 32-QAM and 64-QAM are as shown in the fig. 3(a), fig. 3(b) and fig. 3(c) respectively.

From fig. 3(a), the signal energy required for the DS-SS system with 16-QAM modulation technique in order to achieve BER of 0.38 is found to be more in case of using PN sequence as spreading sequence than compared to Gold and Kasami sequences.

From fig. 3(b), the BER performance of DS-SS system with 32-QAM modulation technique is found better in case of using Gold sequence as spreading sequence than compared to PN and Kasami sequences.

From fig. 3(c), the BER performance of DS-SS system with 64-QAM modulation technique is almost similar in case of using Gold sequence and Kasami sequence as spreading sequences than compared to PN sequence.

RESULTS AND DISCUSSIONS

It is observed from fig. 2, that BER is monotonically decreasing with increase in energy per bit to noise power spectral density ratio E_b/N_o. This is because BER and E_b/N_o are inversely proportional to each other as shown below

$$P_b = \left(\frac{3}{2k}\right) erfc\left(\frac{kE_b}{10N_0}\right)^{\frac{1}{2}}$$

where P_b=Power per bit,

k=$\log_2$M, N_o=Noise spectral density,

E_b=Energy per bit.

When there is increase in E_b(energy per bit),the noise effect can be decreased and therefore the BER is decreased. The BER performance of DS-SS system with 64-QAM is found to be more than compared to 16-QAM and 32-QAM as shown in fig. 2. This is because as the M order is increased, the distance between points is decreased which results in increase of probability of error. This is because if the points are very closely located, then receiver may identify 1 as 0 and 0 as 1. Also the carrier to interference ratio in 16-QAM is less when compared to 32-QAM and 64-QAM.

It can be observed that, BER performance of DS-SS system is high with 32-QAM modulation technique when using Gold sequence as spreading sequence as shown in fig. 3(b). With 64-QAM modulation technique, BER performance of DS-SS system is found better and similar using both Gold and Kasami sequences as spreading sequences than compared to PN sequences as shown in fig. 3(c). This is because spreading sequences have low cross-correlation properties, such as the ideal orthogonal codes.

CONCLUSIONS

Simulink model of Direct Sequence Spread Spectrum(DS-SS) system is simulated using MATLAB-SIMULINK software package for bit error rate analysis with different M-QAM modulation techniques. From the simulation results obtained, It is found that there is no significant change in the BER for M>16. Also while using PN sequence, BER is high when compared to Gold and Kasami sequence. Gold sequence can be used for 32-QAM and Kasami sequence can be used for 64-QAM.

It is concluded that by choosing the type of modulation technique and the spreading sequences, the BER performance of the DS-SS system can be improved.

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