CDMA SIGNALING TECHNIQUE USING MATLAB

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ABSTRACT

This paper evaluates the Code Division Multiple Access (CDMA) signaling techniques using MATLAB. Various codes used to employ this technique are PN Sequence codes, Walsh-Hadamard codes and Gold codes. At the time of transmission, signal undergoes fading. Further the Bit Error Rate (BER) performance of the system is also affected by the number of users as well as different types of spreading codes. In this project, we have analyzed the signal reception and different detection techniques are simulated using different MATLAB functions and different MATLAB program segments to minimize the BER and to overcome fading.

***Keywords*: BER, CDMA System, Gold Sequence, PN Sequence, Rayleigh Channel, SNR, Walsh-Hadamard Code.**

I INTRODUCTION

Code Division Multiple Access (CDMA)[1] is a promising technique for radio access in cellular mobile and personal communication system. CDMA in cellular system offers attractive features such as the potential spectrum efficiency, soft capacity, soft handover and for high macro diversity. In CDMA communication system, a unique binary code is assigned for each call to every user. The user's signal is multiplied by the assigned code and spread onto a bandwidth much wider. All active users share the same frequency spectrum at the same time. CDMA employs spread-spectrum technology. Spread Spectrum is defined as a means of transmission in which the signal occupies bandwidth much in excess of the minimum necessary to send the information. The advantage of spread spectrum is that many users can simultaneously use the same bandwidth without significantly interfering with one another.

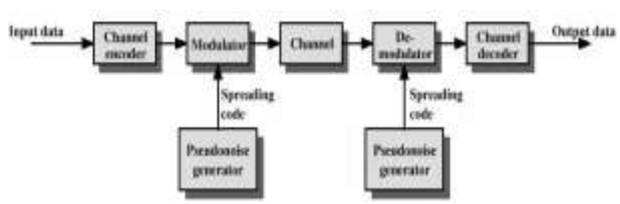


Fig.1. General Model of Spread Spectrum System

II CDMA SIGNALING CODES

The definition of spread spectrum mentions that the band spread is accomplished by a means of a code which is independent of the data and a synchronized reception with the code at the receiver is used for despreading and subsequent data recovery.

Various codes that are used in spread spectrum techniques are as:

A. *Pseudo Noise Sequence*

B. *Walsh-Hadamard codes*

C. *Gold Code*

2.1 Pseudo Noise Sequence

The code used for spreading the signal is a pseudorandom code that is mixed with the data to spread the signal in a statistically random matter. Thus for the spread signal to appear noiselike, the code needs to be random but reproducible. These codes are considered fast codes as they run many times the information bandwidth or data rate. These special "Spreading" codes are called "Pseudo Random" or "Pseudo Noise" codes. They are called "Pseudo" because they are not real Gaussian noise. Periodic binary sequences can be conveniently generated using linear feedback shift registers (LFSR).

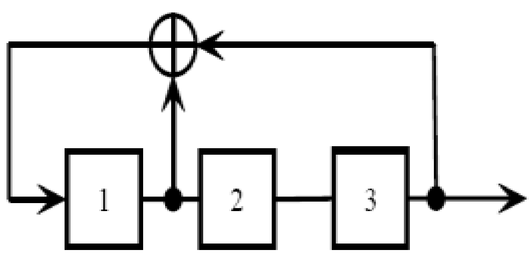


Fig.2. PN Sequence Generator

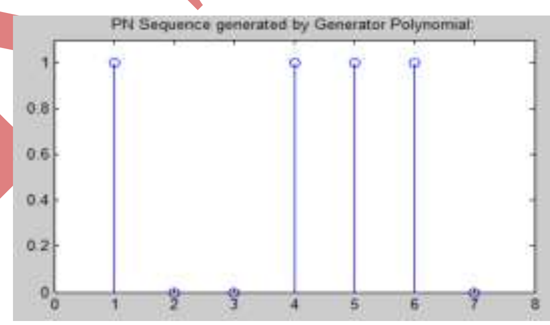


Fig.3. Simulation Result

2.2 Walsh-Hadamard Codes

Walsh codes are the most common orthogonal codes used in CDMA applications. *It provides zero cross correlation among all users.* A set of Walsh codes of length n consists of n rows of an n X n Walsh matrix. Orthogonal spreading codes such as the Walsh sequences can only be used if all the users in the same CDMA channel are synchronized to the accuracy of a small fraction of one chip. Walsh-sequences have the advantage to be orthogonal, in this way we should get rid of any multi-access interference

$$H_{N+1} = \begin{pmatrix} H_N & H_N \\ H_N & \overline{H_N} \end{pmatrix}$$

Where $\overline{H_N}$ is the inverse of H_N

```
>> walshcodes
no. of users: 3
     1     1     1     1
     1    -1     1    -1
     1     1    -1    -1
     1    -1    -1     1

>> walshcodes
no. of users: 5
     1     1     1     1     1     1     1     1
     1    -1     1    -1     1    -1     1    -1
     1     1    -1    -1     1     1    -1    -1
     1    -1    -1     1     1    -1    -1     1
     1     1     1     1    -1    -1    -1    -1
     1    -1     1    -1    -1     1    -1     1
     1     1    -1    -1    -1    -1     1     1
     1    -1    -1     1    -1     1     1    -1
```

Fig.4. Simulation Result

2.3 Gold Code

For CDMA, we need to construct a family of spreading sequences, one for each which, in which the codes have well-defined cross-correlation properties. In general, m-sequences do not satisfy the criterion. One popular set of sequences that does are the Gold sequences. Gold sequences help generate more sequences out of a pair of m-sequences giving many more different sequences to have multiple users. A Gold sequence is constructed by the XOR of two m-sequences with the same clocking.

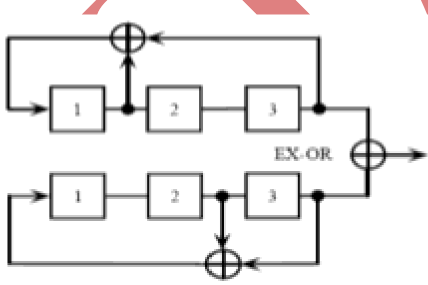


Fig.5. Gold Code Generator

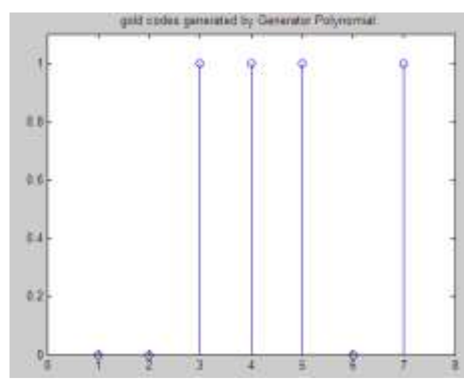


Fig.6. Simulation Result

III DIRECT SEQUENCE SPREAD SPECTRUM

The use of DSSS techniques in communication systems has grown considerably over the past decades. This is because CDMA is considered a promising technique to obtain high spectral and power efficiency in multiple access applications. In Direct Sequence-Spread Spectrum the baseband waveform is XOR by the PN sequence in order to spread the signal. After spreading, the signal is modulated and transmitted.

Fig.7. DSSS Transmitter and Receiver

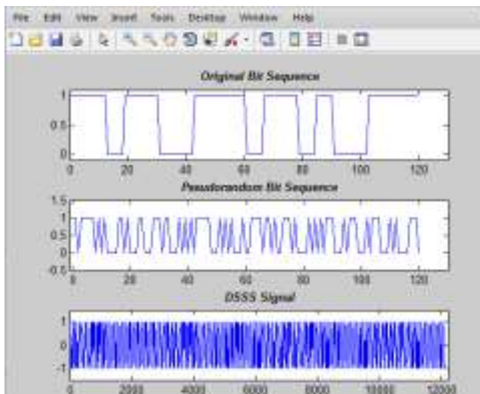


Fig.8. Simulation Result

IV PERFORMANCE MEASUREMENT

The criteria to measure the performance of DS-CDMA is to evaluate the bit error rate (BER) of the system over the Rayleigh channel.

Bit Error Rate:

In digital transmission, the number of the bit errors is the number of the received bits of a data stream over a communication channel that have been altered due to noise, interference, distortion or bit synchronization errors. The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval.

Fading:

Fading [2] is the rapid fluctuations of the amplitudes, phases or multipath delays of a radio signal over a short period of time or travel distance. It is caused by interference between two or more versions of the transmitted signal which arrive at the receiver at slightly different times. Rayleigh fading models assume that the magnitude of a signal that has passed through communications channel will vary randomly, or fade according to a Rayleigh distribution.

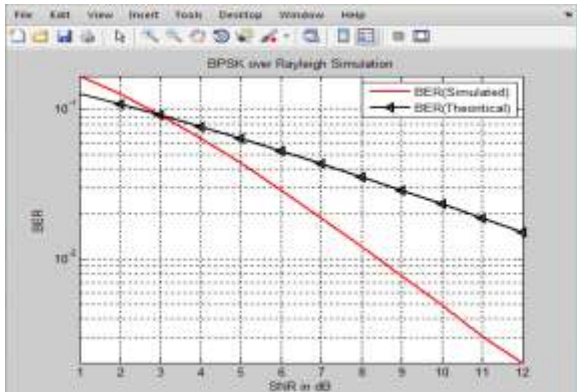


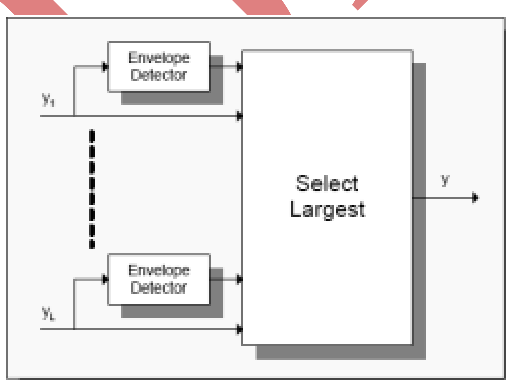
Fig.9. Rayleigh Fading

V DIVERSITY TECHNIQUES [3]

The short term multipath fading can severely reduce transmission accuracy. Diversity is an effective way to combat channel fading. Diversity improves transmission performance by making use of more than one independently faded version of the transmitted signal. If several replicas of the signal, carrying the same information, are received over multiple channels that exhibit independent fading with comparable strengths, the chances that all the independently faded signal components experience deep fading simultaneously are greatly reduced. This will significantly improve transmission accuracy as transmission errors are most likely to happen when the instantaneous SNR is low during a deep fading period. Different detection techniques employed in the proposed complementary codes (CC) based CDMA system used to detect the received signal. Detection techniques are as:

5.1 Selection Diversity Technique

In selection diversity, the branch with the largest signal magnitude is selected. The receiver monitors the SNR value of each diversity channel and chooses the one with the maximum SNR value for signal detection. This technique is much easier to implement without much performance degradation, especially for the reverse link transmission where the diversity branches can be physically located at different base stations.



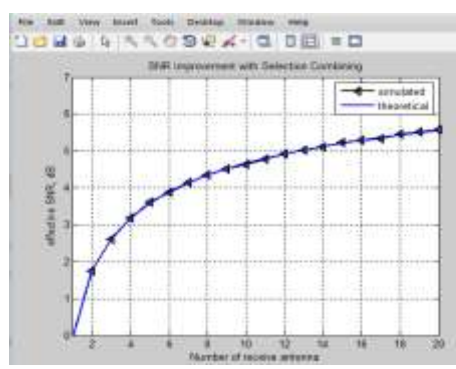
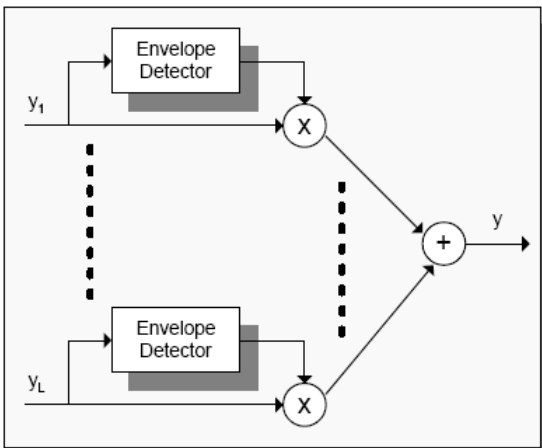


Fig.10. Selection Diversity Technique **Fig.11. Simulation Result**

5.2 Maximal Ratio Combining Technique

MRC produces an output SNR equal to the sum of individual SNR. This combining technique assumes that the receiver is able to accurately estimate the amplitude fading and carrier phase distortion. In Maximal Ratio Combining (MRC), the signal all the branches are co-phased and individually weighed to provide the optimal SNR at the output. It can be shown that the output SNR is maximized when the signals in each of the diversity branches are weighed by their own envelopes. Maximal ratio combining achieves the best performance.



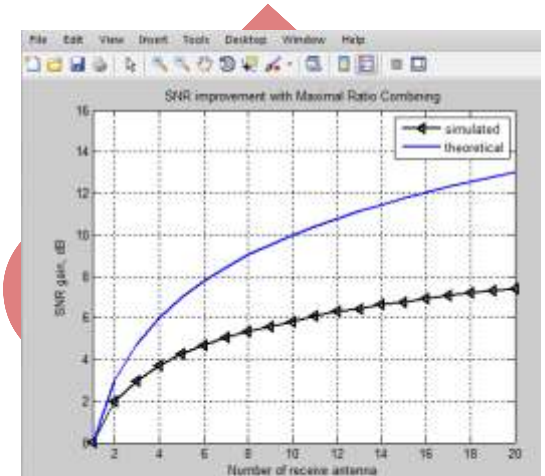
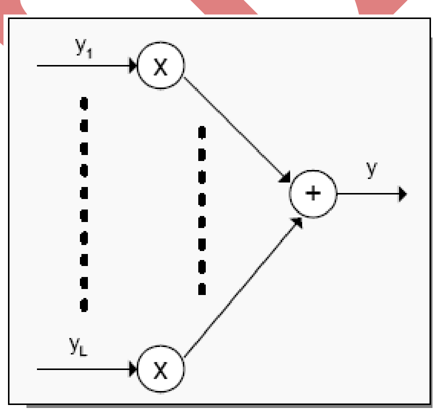


Fig. 12. Maximal Ratio Combining Technique

Fig.13. Simulation Result

5.3 Equal Gain Combining Technique

In Equal Gain Combining (EGC), all the signals are weighted equally after coherent detection. The coherently detected signals from all the branches are simply added and applied to the decision device. As the receiver does not need to estimate the amplitude fading, its complexity is reduced as compared with that of maximal ratio combining. The performance of EGC is only marginally inferior to the optimal maximal ratio combiner.



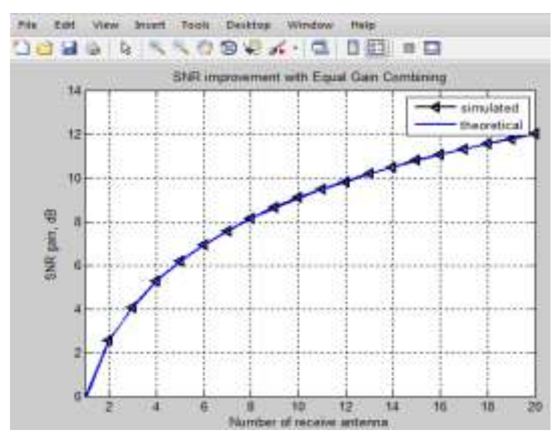


Fig.14. Equal Gain Combining Technique

Fig.15. Simulation Result

Among the three combining schemes, maximal ratio combining achieves the best performance followed by equal gain combining. Thus the transmitter, channel and complementary code design must be constant. The only difference is between their receivers that employs the different detection techniques.

VI FREQUENCY HOPPED SPREAD SPECTRUM

Frequency hopping[4] involves a periodic change of transmission frequency. FHSS is one of the most common forms of spread spectrum, in which frequency is not remained fixed to the specified band of the frequency. Here the carrier frequency changes from one frequency to the other at every instant of time.

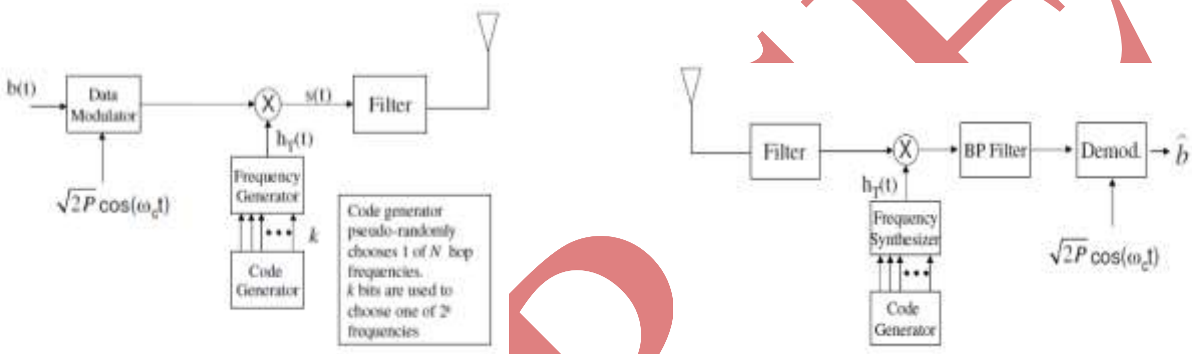


Fig.16. FHSS Block Diagram

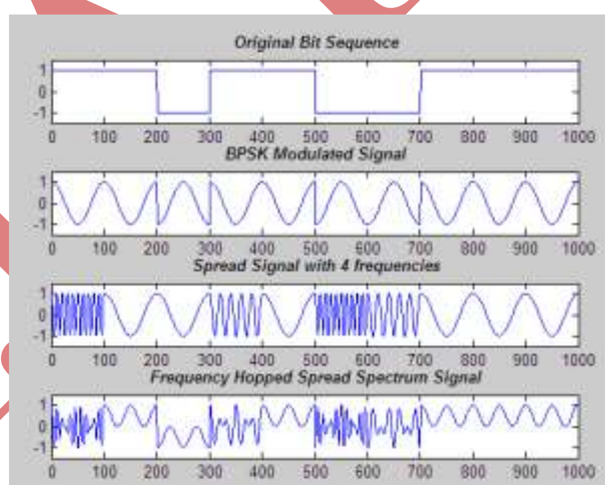


Fig.17. Simulation Result

In FHSS, synchronization of transmitter and receiver is necessary. In case, if the receiver is not synchronized with the transmitter due to any reason, the recovery of the original information from its spread spectrum is merely impossible. By comparing the performances of both DSSS and FHSS techniques relative to a few parameters of communication systems, we found that there is no “good” technology and “bad” technology, but there are applications where FHSS performs better than DSSS, and obviously there are applications where the opposite is true.

VII CONCLUSION

This paper work emphasizes on those effects that have a strong influence on the performance of CDMA system using PN sequence code, walsh-code and gold sequence code. The performance comparison of CDMA system using various diversity techniques is included. After analysis, the diversity technique that produces the lowest BER rate would be the best technique to be the proposed detection techniques for complementary codes based CDMA system. Further this would be extended to evaluate comparison of the performance of DSSS and FHSS in CDMA system.

VIII FUTURE SCOPE

In future there is a scope of various new implementations like Slow frequency and Fast frequency hopping which can be extended in the performance of FHSS. It can be further extended to the implementation of OFDM Technique.

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