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BER PERFORMANCE OF MC-CDMA SYSTEM WITH DIFFERENT SPREADING CODES

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***Abstract*— There is huge demand of higher data rate in Today's multi user wireless communication systems. Multi Carrier- Code Division Multiple Access (MC-CDMA) system provides optimum solution to this high speed data rate requirement. MC-CDMA systems are designed by combining the benefits of two technologies known as Code Division Multiple Access (CDMA) and Orthogonal Frequency Division Multiplexing (OFDM).In this paper the BER performance of MC-CDMA system is evaluated for two different spreading codes such as Walsh codes and Gold codes in multipath Rayleigh fading environment using MATLAB simulation.**

Keywords*— *MC-CDMA, Walsh codes and Gold codes, Rayleigh fading

I. INTRODUCTION

In Past years wireless communication systems are used only for the voice and text transmission but today's wireless communication systems are used to provide various multimedia services such as image, data, speech, audio and video [1]. To provide such multimedia services communication system must be able to transfer data at higher rates. In recent years it found that MC-CDMA is a promising technique to fulfill this high speed data transfer requirement of today's wireless communication system. MC-CDMA system combines the Inter-Symbol Interference (ISI) cancellation capabilities of OFDM technique with the efficient spectrum utilization capabilities of CDMA technique [2].

In Literature we have find that the performance of MC-CDMA system suffers from the large amount of amplitude fluctuation due to the multicarrier modulation. So the selection of spreading codes becomes crucial to solve this problem because the Peak-to-Average Power Ration of transmitted signals is characterized by the spreading sequences [3]. To spread the modulated bits different spreading codes such as Walsh codes, complementary Golay codes and Gold codes has been proposed in literature [4] [5].

In this paper the performance of MC-CDMA system is evaluated for two different spreading codes such as Walsh codes and Gold codes. The performance has been evaluated in terms of BER and SNR through MATLAB simulation. Simulation is performed using BPSK and QPSK symbol mapping technique in multipath Rayleigh fading environment

The paper is organized as follows. Section II contains system model of MC-CDMA system and overview of the spreading codes. Simulation parameter and simulation results are discussed in Section III. Section IV explains conclusion in brief.

II. SYSTEM MODEL

A. MC-CDMA system

We have considered an MC-CDMA system with 4 users. Block diagram of the system under consideration is shown in figure 1. User generates the data in form of binary 0's and 1's. User data is modulated using Binary Phase Shift Keying (BPSK) and Quadrature Phase Shift Keying (QPSK) modulation technique. Spreading of the modulated symbols is performed using Walsh codes and Gold codes with code length L=16. Let $m^{(l)}$ denotes the modulated data symbol of the l^{th} user and $c^{(l)}$ spreading code allotted to the l^{th} user. Then the k^{th} data symbol of l^{th} user after spreading can be given as

$$s^l(k) = m^l(k)c^l(j) \;\; for\; j = 0,1,2, \dots . L \qquad \textbf{....1}$$

After spreading in frequency domain data symbols are processed in OFDM block to generate the MC-CDMA transmit signal. Received sequence on the receiver side is given by

$$r = Hs + n \qquad \textbf{....2}$$

Where **H** is the channel matrix and **n** is the noise vector. Received sequence is first processed in inverse OFDM block. After the channel equalization data symbols are despread using spreading code which is synchronized with the transmitter code.

B. Spreading codes

Spreading codes are also known as spreading sequences. Spreading of data signals increases the bandwidth of the data signal. Spreading and dispreading of the signals in performed using the same code [6]. In multiuser environment interference may occur between the users which are accessing the channel simultaneously. To avoid this problem each user is uniquely

allotted with a spreading code. Selection of the spreading sequences depends on the various parameters such as, correlation properties, orthogonality and peak-to-average power ratio [5].
In this paper we consider two types of spreading codes namely Walsh codes and Gold codes.

Walsh Code-

Walsh Code is a group of spreading codes having good autocorrelation properties and poor cross correlation properties. Orthogonal Walsh–Hadamard codes are generated by using the Hadamard matrix which is a square matrix where each row in the matrix is orthogonal to all other rows, and each column in the matrix is orthogonal to all other columns. The Hadamard matrix H_n is generated by starting with zero matrix and applying the Hadamard transform successively. Each column or row in the Hadamard matrix corresponds to a Walsh code sequence of length n. Orthogonality between codes in the Hadamard matrix is defined such that the cross-correlation values, associated with zero offset between the pair of sequences is zero. Given by,

$$H_{2n} = \begin{bmatrix} H_n & H_n \\ H_n & H_n \end{bmatrix} \qquad \text{.....3}$$

Thus, n = 1 and we get:

$$H_2 = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix} \qquad \text{.....4}$$

Repeating the Hadamard transform again for n = 2, we get H_4 as:

$$H_4 = \begin{matrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 \end{matrix} \qquad \text{.....5}$$

Repeating the Hadamard transform again for n = 4, we get:

$$H_8 = \begin{matrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 & 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 1 & 0 & 1 \end{matrix} \qquad \text{.....6}$$

The interesting property of the matrix is that any column (or row) differs from any other column (or row) in exactly N/2 positions. [7].

Gold Code-

In year 1967 "R. Gold" proposed the concept of gold code. PN codes can be created by Linear Feedback Shift Registers (LFSR) [8]. The Gold code is generated by using the preferred pairs of m-sequences by a process of all possible cyclically shifted modulo-2 additions of the preferred pair. The m-sequence family has one such unique preferred pair for each sequence length; the preferred pains have good correlation properties. Due to the use of the preferred pair, both the autocorrelations and cross-correlations of Gold codes take on the values {-1, -*t(m)*, *t(m)*-2}, where t*(m)* is given by

$$t(m) = \begin{cases} 2^{\frac{m+1}{2}} + 1 & for\ m\ odd \\ 2^{\frac{m+2}{2}} + 1 & for\ m\ even \end{cases} \qquad \text{.....7}$$

Gold codes have lower peak cross-correlations than m-sequences, but have worse autocorrelation properties than m-sequences.
The family of the 2^m-1 derived sequences plus the preferred pair are collectively known as Gold codes; there are all together 2^m+1 Gold codes of code length 2^m-1, for *two* m-sequences of order *m.* Like the m-sequence, all the 2^m+1 Gold codes are balanced, with 2^{m-1} Ones and 2^{m-1}-1zeros [9].

III. SIMULATION RESULTS

We have presented system model of MC-CDMA system in section II. We have simulated the MC-CDMA system using MATLAB. Simulation has been carried out for two spreading codes namely Walsh codes and Gold codes. We get the simulation results in terms of BER Vs SNR when the system is employing BPSK and QPSK modulation schemes. Various simulation parameters used for simulation shown in Table 1.

Table 1: Simulation Parameters

Parameters	Value
Number of input data bits	**10000**
Number of sub-carriers	**16**
Number of users	**4**
Spreading codes	**1. Walsh–Hadamard codes** **2. Gold codes**
Number of channel taps	**4**
Modulation schemes	**BPSK,QPSK**
Channel model	**Rayleigh**
Spreading code length *L*	**16**
Combing scheme	**Zero Forcing**

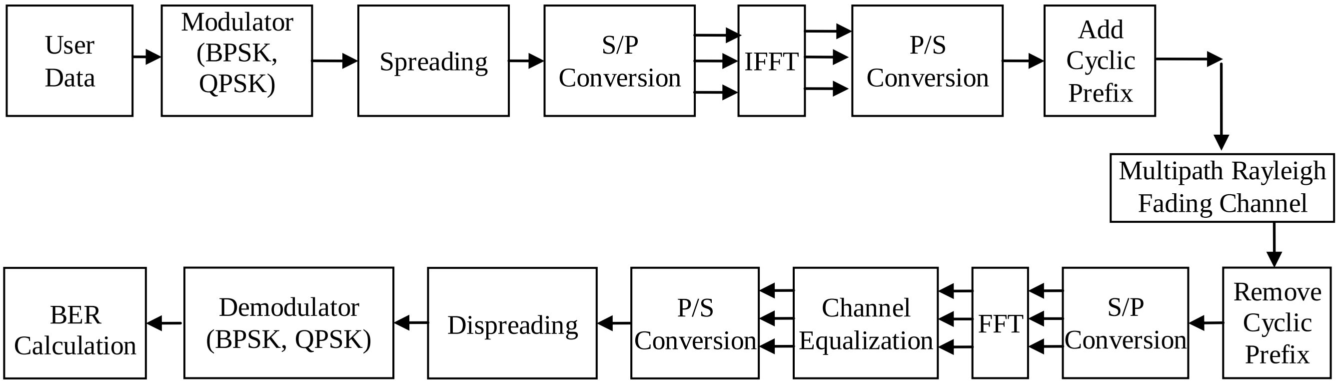

Fig. 1. System Simulation Model

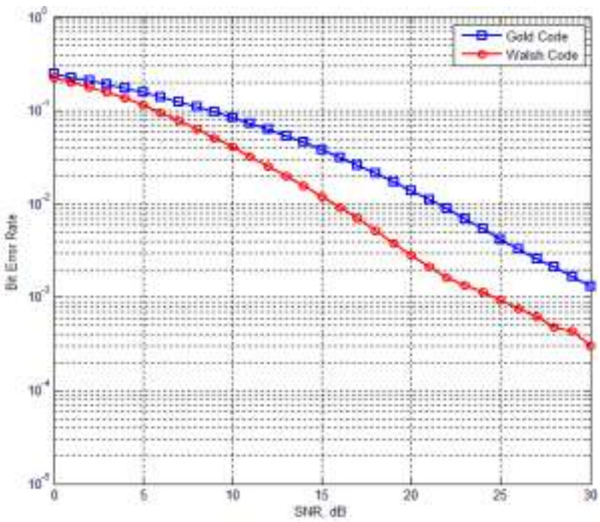

Fig.2 BER Vs SNR performance comparison with Walsh and Gold spreading codes using BPSK modulation

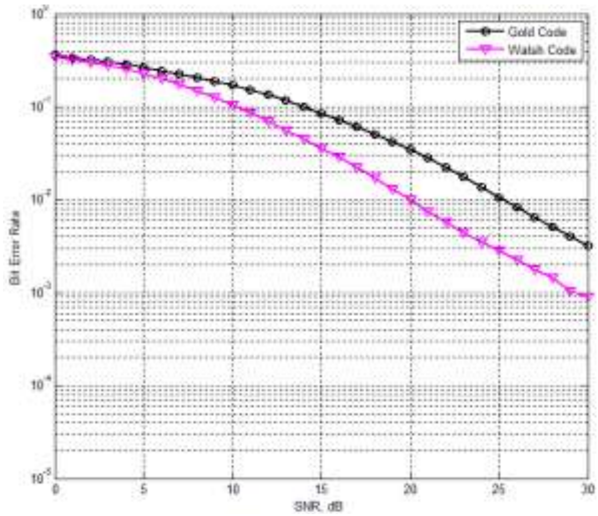

Fig.3 BER Vs SNR performance comparison with Walsh and Gold spreading codes using QPSK modulation

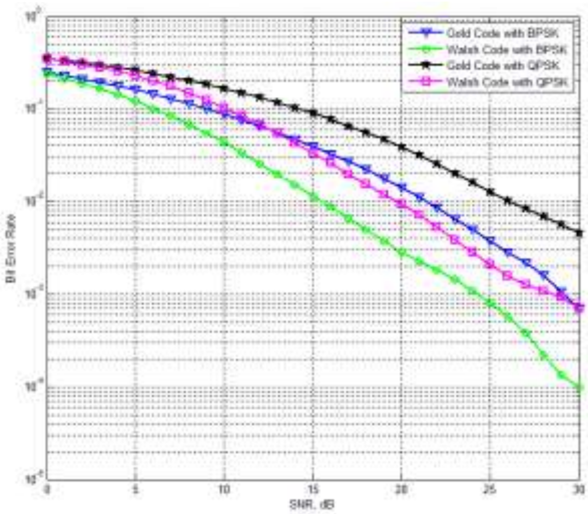

Fig.4 BER Vs SNR performance comparison with Walsh and Gold spreading codes using BPSK and QPSK modulation

IV.CONCLUSION

In this paper the performance of MC-CDMA system is evaluated for two different spreading codes such as Walsh codes and Gold codes. The performance has been evaluated in terms of BER and SNR through MATLAB simulation. Simulation is performed using BPSK symbol mapping technique in multipath Rayleigh fading environment. Here we use Zero forcing detection strategy. Based on the simulation results we have concluded that we obtain better gain in SNR with Walsh code as compare to the Gold code for the same level of BER. The effect of modulation scheme on BER performance is also evaluated in frequency selective Rayleigh fading channel. It is observed that BPSK improves the BER performance in significant amount as compare to the QPSK.

In future this work can be extended for different detection strategy and FEC coding techniques over multipath Rayleigh fading environment.

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