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PERFORMANCE EVALUATION OF MC-CDMA SYSTEM WITH MRC AND EGC DIVERSITY TECHNIQUES OVER RAYLEIGH FADING CHANNEL

Anita Mukati
PG Scholar
Department of ECE
IES, IPS Academy, Indore,M.P.,India

Mrs. Angeeta Hirwe
Associate Professor
Department of ECE
IES, IPS Academy, Indore,M.P.,India

***Abstract*— Multicarrier Code Division Multiple Access (MC-CDMA) is a promising technique for providing high data rate wireless communication. In this paper we evaluate the performance of MC-CDMA system with walsh spreading codes over Rayleigh fading channel. The performance of MC-CDMA system is evaluated in terms of Bit Error Rate (BER) and Signal to noise ratio (SNR) using MATLAB for different number of users with Maximal Ratio Combining (MRC) and Equal Gain Combining (EGC) diversity techniques using Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK) modulation schemes. Simulation results shows that EGC provide significant gain in SNR performance for a MC-CDMA system as compare to MRC and this performance improvement becomes more and more better as the number of users in the system is increases.**

Keywords — ***MC-CDMA, MRC, EGC, BPSK, QPSK, Walsh code***

I. INTRODUCTION

Multicarrier Code Division Multiple Access (MC-CDMA) is a promising technique to full fill the high-rate-data transmission requirement of the next generation diverse mobile network. MC-CDMA combines the benefits of Code Division Multiple Access (CDMA) and Orthogonal Frequency Division Multiplexing (OFDM) system [1] [2].MCCDMA system utilize the interference avoiding capabilities of OFDM system which occur in the system when the signal bandwidth exceeds the channel bandwidth and direct sequence spreading to allow multiple users to share the same spectrum simultaneously[3]. Various spreading codes such as Pseudo Noise (PN) codes, Gold codes, and Walsh codes has been proposed to spread the modulated bits In MC CDMA system[1] [4][5]. In this paper, we evaluate the BER performance of MC-CDMA system with two different combining strategies such as MRC and EGC in order to mitigate the effects of multipath fading. Two modulation schemes such as BPSK and QPSK are used for symbol mapping in conjunction with walsh spreading codes to provide different data rates over Rayleigh fading channel.

The paper is organized as follows. Section II explains the MC-CDMA system model and outlines the digital modulation schemes, Walsh hadamard codes, channel model and combining techniques. 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 MC-CDMA system with different number of simultaneously active users. The basic signal in MC-CDMA system is generated by a serial concatenation of classical DSCDMA and OFDM [6]. In the transmitter section complex valued modulated sequence d^k is multiplied with Walsh spreading codes with code length L=16

$$C^{(k)}=\{ c_0^{(k)},c_1^{(k)},c_2^{(k)},\ldots\ldots c_{15}^{(k)}\}^T \ldots\ldots\ldots(1)$$

After spreading the sequence we obtain a complex valued sequence in vector notations which is given by

$$S^{(k)}=d^{(k)}C^{(k)}=\{ s_0^{(k)},s_1^{(k)},s_2^{(k)},\ldots s_{15}^{(k)}\}^T \ldots\ldots\ldots(2)$$

The MC-CDMA transmit signal is obtained after processing the sequence S in the OFDM block. On the receiver side received sequence given by the equation (3) is first processed in inverse OFDM block.

$$r= Hs+n\ldots\ldots\ldots(3)$$

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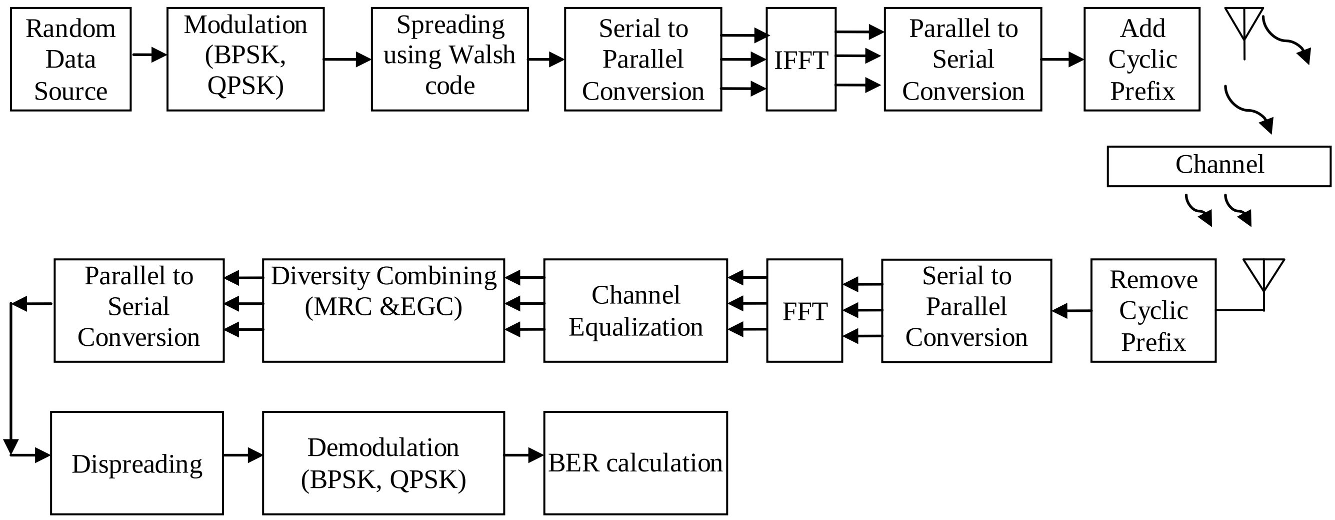

Fig. 1. System Simulation Model

Where **H** is the channel matrix and **n** is the noise vector. After channel equalization sequence is combined using MRC and EGC combining scheme in order to get an estimate of the transmitted data.

B. Digital Modulation Schemes –

For the transmission of the data bits over analog channel we map the data bits to the signal waveforms. This process of mapping data bits to the signal waveforms is known as digital modulation [7].

1. Binary Phase Shift Keying (BPSK) –

In BPSK, carrier signal phase is switched between two values corresponding to binary 1 and 0, respectively. Normally, the two phases are separated by 180° [7]. If the sinusoidal carrier has an amplitude A_c and energy per bit E_b, then the transmitted BPSK signal for $0 \le t \le T_b$ is either:

$$s_{BPSK}\ (t) = \sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t + \theta_c)\ \ (binary\ 1) \qquad \dots(4)$$

$$s_{BPSK}\ (t) = -\sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t + \theta_c)\ (binary\ 0) \qquad \dots(5)$$

where

$$E_b = \frac{1}{2}A_c^2 T_b \qquad \dots(6)$$

2. Quadrature Phase Shift Keying (QPSK) –

QPSK is also known as four level PSK in which signal carries one bit per symbol interval on both the in-phase and quadrature-phase component. In QPSK two bits are transmitted in a single modulation symbol which doubles the bandwidth efficiency of QPSK as compare the efficiency of BPSK [8]. QPSK signals are defined as

$$s_i(t) = \sqrt{\frac{2E}{T}}\cos(2\pi f_c t + \theta_i), \qquad \dots(7)$$

$$i = 1, 2, 3, 4$$

$$\theta_i = \frac{(2i-1)\pi}{4} \qquad \dots(8)$$

Where E denotes the transmitted signal energy per symbol, T is symbol duration and f_c is carrier frequency. The initial signal phases are $\pi/4$, $3\pi/4$, $5\pi/4$ *and* $7\pi/4$.

C. Walsh–Hadamard Codes –

Orthogonal Walsh–Hadamard codes are recursively generated by using the Hadamard matrix which is given by,

$$\boldsymbol{C_L} = \begin{bmatrix} \boldsymbol{C_{\frac{L}{2}}} & \boldsymbol{C_{\frac{L}{2}}} \\ \boldsymbol{C_{\frac{L}{2}}} & -\boldsymbol{C_{\frac{L}{2}}} \end{bmatrix}\ \forall \boldsymbol{L = 2^m},\ \ \boldsymbol{m \ge 1, C_1 = 1} \dots \boldsymbol{(9)}$$

The maximum number of active users K is determined by the maximum number of available orthogonal spreading codes L [6].

D. Channel Model

When there is no direct line of sight path exists between TX and RX then the Rayleigh distribution is most applicable channel model. The statistical time varying nature of the received envelope of a flat fading signal or the envelope of an individual multipath component can be efficiently described by the Rayleigh distribution [8]. The Rayleigh distribution has a PDF given by

$$p(r) = \frac{r}{\sigma^2} exp\left(-\frac{r^2}{2\sigma^2}\right) \qquad 0 \le r \le \infty \qquad \ldots (10)$$
$$= 0 \qquad r < 0$$

Where σ and σ^2 are the rms value of the received voltage signal and time average power of the received signal before envelope detection respectively.

E. Combining Techniques –

Here we considered two combining techniques which are MRC and EGC to combine the same information containing signal received from multiple paths.

1. Maximal Ratio Combining (MRC)

In MRC signals received from multiple the paths are must be co-phased first individually then weighted according to their individual signal voltage to noise power ratios and summed. After combining the multiple signals using MRC output SNR is equal to the sum of the individual SNRs. MRC receiver can produce an output with an acceptable SNR even in the absence of any of the individual signals with acceptable SNR [8].

2. Equal Gain Combining (EGC)

In EGC after processing the multiple copies of same signal we weighted them equally and then sum them to produce the decision statistic. In EGC receiver estimation of the channel carrier phase is required but the weights applied to each branch in the combiner are complex quantities whose amplitudes are all set to 1. EGC provide comparable performance to the MRC with less receiver complexity [9].

III. SYSTEM MODEL

In this section, we present and discuss the simulation results of the BER Vs SNR performance of MC-CDMA system with Walsh spreading codes over Rayleigh fading channel using MATLAB for different number of users with two different combining strategies such as MRC and EGC using BPSK and QPSK modulation schemes. Based on simulation results we have concluded that we obtain better gain in SNR performance with EGC as compared to the MRC for same number of users. Simulation parameters are given in table 1

Table 1: Simulation Parameters

Parameters	**Value**
Number of input data bits	**1000**
Number of sub-carriers	**16**
Number of users	**2,8, 16**
Spreading codes	**Walsh–Hadamard codes**
Modulation techniques	**BPSK,QPSK**
Channel model	**Rayleigh**
Number of Taps	**4**
Spreading code length *L*	**16**
FEC coding	**None**
Diversity combining	**MRC, EGC**

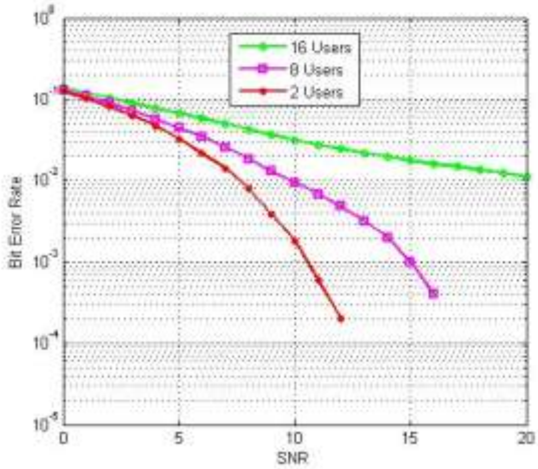

Fig 2. BER Vs SNR performance of MC-CDMA with EGC using BPSK over Rayleigh channel

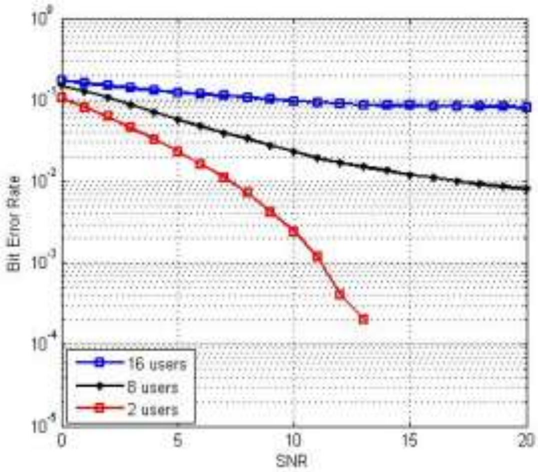

Fig 3. BER Vs SNR performance of MC-CDMA with MRC using BPSK over Rayleigh channel

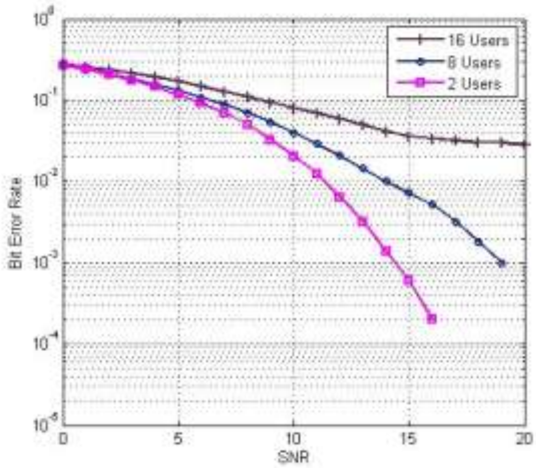

Fig 4. BER Vs SNR performance of MC-CDMA with EGC using QPSK over Rayleigh channel

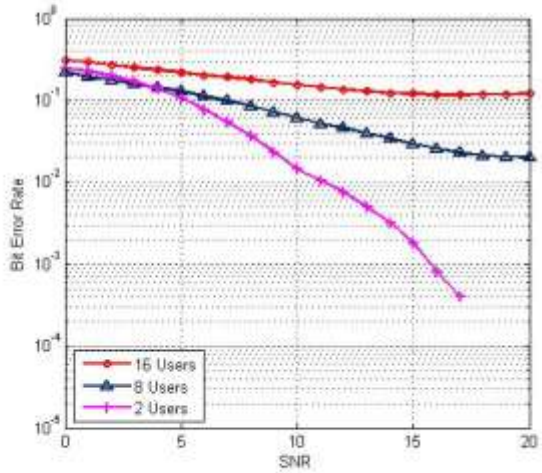

Fig 5. BER Vs SNR performance of MC-CDMA with MRC using QPSK over Rayleigh channel

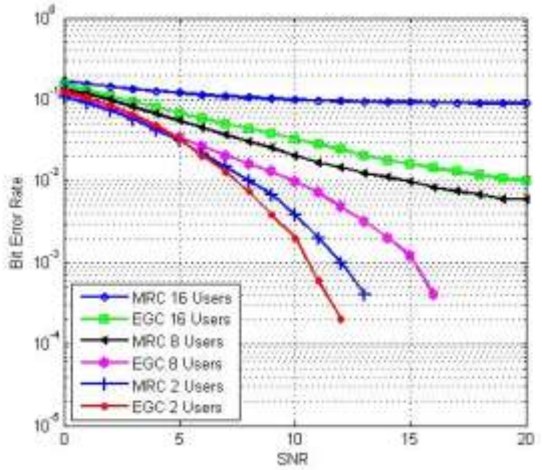

Fig 6. BER Vs SNR performance comparison of MC-CDMA with EGC and MRC using BPSK over Rayleigh channel

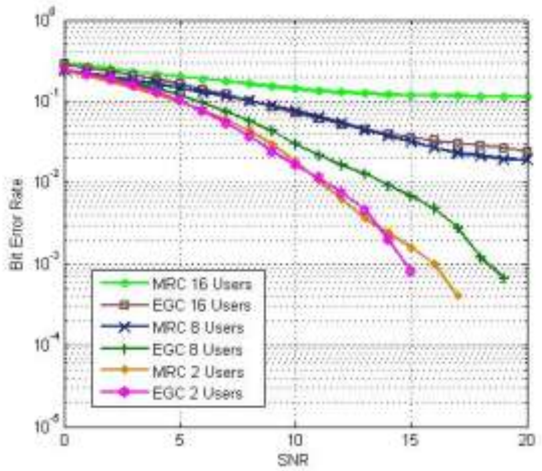

Fig 7. BER Vs SNR performance comparison of MC-CDMA with EGC and MRC using QPSK over Rayleigh channel

IV. CONCLUSION

Simulation results show the comparative analysis of MRC and EGC diversity combining techniques for MC-CDMA system with different parameter. Comparison is done against the BER and SNR performance, by using two modulation techniques i.e. BPSK and QPSK for different number of users. It is clear from the simulation results that EGC provide better gain in SNR performance for a MC-CDMA system as compare to MRC and this performance improvement becomes more and more better as the number of users in the system is increases. Based on the simulation results we have concluded that improvement in SNR performance is also depends on modulation technique used and we find that BPSK modulation scheme provides better performance improvement as compare to the QPSK for same value of BER.

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