Enhancement of MC-CDMA Performance System using Rotated Modulation

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***Abstract*—The transmission system with high data rate and high mobility is needed. However, the system is susceptible to frequency selective fading and fast fading. We propose MC - CDMA system with Rotated Modulation that be able to solve the problems. MC - CDMA is a combination of OFDM and CDMA system which offer high spectral efficiency. However, this system still requires high power, so in this study Rotated Modulation is added to reduce the power. Rotated Modulation implements rotating signal constellation and use quadrature and inphase interleaver. The simulations result show MC - CDMA with Rotated Modulation produce a system that require less power compared with MC-CDMA non Rotated Modulation systems.**

***Index Terms*—MC-CDMA, Rotated Modulation, power efficiency, modulation.**

I. Introduction

Rapid development of information and communication technologies cause requirement of high data rate and high mobility. However, the communication system susceptible to frequency selective fading and fast fading. Now, not only need a system that is resistant to problems of frequency selective fading and fast fading, but also a system that can deliver power efficiencies in poor channel conditions.

Based on those weaknesses, so is designed communication system to overcome the problem of selective fading and fast fading with efficient power. This can be overcome by applying Multi-Carrier Code Division Multiple Access (MC-CDMA) with Rotated Modulation techniques. MC-CDMA is a combination of OFDM and CDMA which offer high spectral efficiency [1][2][3], this technique can reduce the problem of selective fading and fast fading.

Rotated Modulation implemented by rotating the signal constellation [4][5][6] and used quadrature and inphase interleaver with interlever subcarrier. Its expected that the MC-CDMA system which has high spectral efficiency and Rotated Modulation which produces less power can produce a good performance system.

This paper is divided into four main sections. First, the introduction, discusses the background of the problems and explain the sections of paper simply and convey the contributions that resulted from this research. Second, scenario of research about the MC- CDMA and Rotated Modulation. Third, result and analysis, related to the simulation and discussion of the research results. The last, Conclusion is a summary of the results of research that has been done.

II. System Model

Simulation process in this reasearch is conducted at MC-CDMA system. Rotated Modulation method is added in which output mapper is rotated in certain θ, so that, each new value is given to each symbol. Process simulation in this study is has been done on the system MC-CDMA downlink. The channel is used fading channels by Rayleigh Fading model. Modulation used is 16 QAM. The parameters are Bit Error Rate vs. Eb / No.

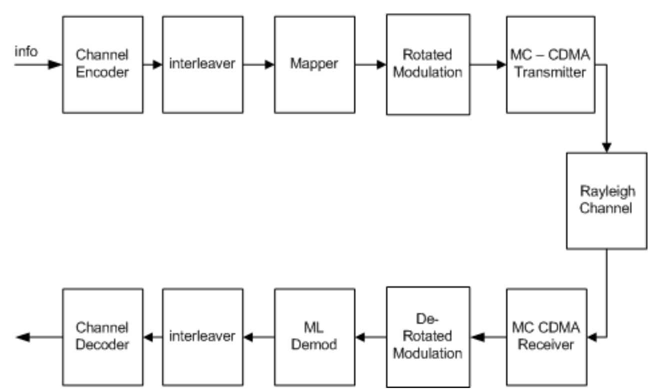


Fig. 1: MC-CDMA with Rotated Modulation scheme

A. Transmitter

1) Data Source: Digital input system consists of bits, 1 and 0, which is simulated in uniform distribution and generated randomly.

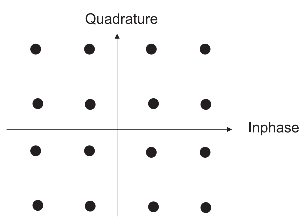
2) Encoder: Convolutional code encoder is designed with the same code as with 8 constraint length for 16 QAM.

3) Mapper: Output process from interleaver is bit serial form. It formed into complex symbols which is compatible with 16 QAM which is every symbol will carry 4 bit information. Mapping output of 16 QAM is divided into two value, inphase and quadrature.

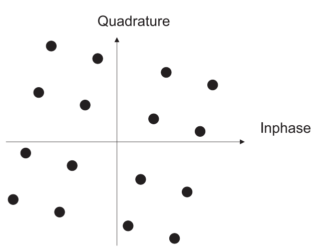
4) Coding Rotated Modulation: Rotated Modulation (RM) is a rotation process for the signal constellation in accordance with certain angle mapper used.[4][7] Compared with ordinary MPSK modulation / QAM, rotated modulation can be obtain diversity modulation by rotate some angle[8]. For example, the convolutional constellation QPSK (A, B) into a new rotated constellation (X, Y) by rotate some angle, as shown in Figure 2a2b which is following formula:

$$\begin{pmatrix} X \\ Y \end{pmatrix} = R_2 \begin{pmatrix} A \\ B \end{pmatrix} = \begin{pmatrix} \cos\theta_1 & \sin\theta_1 \\ -\sin\theta_1 & \cos\theta_1 \end{pmatrix} \begin{pmatrix} A \\ B \end{pmatrix} \quad (1)$$

X , Y = Rotated Constellation
R = Matrix Generator
A, B = Konventional Constellation
θ_1 = Rotated angle



(a) Convolutional Constellation



(b) Rotated Modulation Constellation

Fig. 2: 16 QAM Constellation

Figure 2 illustrates if it considers the "deep fade hits" is only one component of the vector signal is transmitted., It can be seen that the "compression" constellation in the image (b) an empty circle offering greater protection against the effects of noise, because there are two points that collapse together as it did in the picture (a). Components interleaver / de interleaver necessary to assume that the inphase and quadrature components of the received symbol is affected by fading that independent (independent fading). [4][5]

In the process of rotation is accompanied interleaving process on Inphase and Quadrature component of the symbol. Interleaver used in the simulation are the type of interleaver block, where the components are arranged quadrature column per column and read line by line. Interleaver block is overcome multipath conditions on the channel that led to the arrival of the signal at the receiver side through two or more paths with different distances. This resulted accumulation of received signal will be distorted, resulting in statistically significant dependence between the order of the symbol. This resulted in a sequential likelihood of error or burst error, than error events isolated or independent.

The symbol that has been mapped is rotated by a certain angle. This research applied $\theta = 5^\circ$, 10° , 15° , 20°. The step of Rotated Modulation can be seen in figure 3.

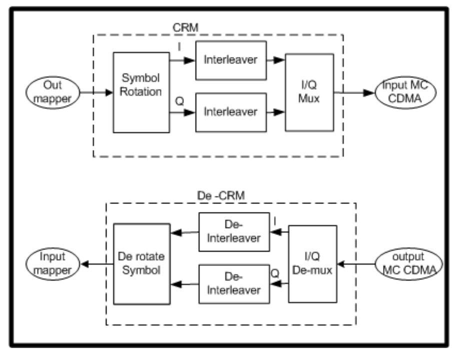


Fig. 3: Flowchart of Rotated Modulation

Constellation overview of the simulation results can be seen in figure 4

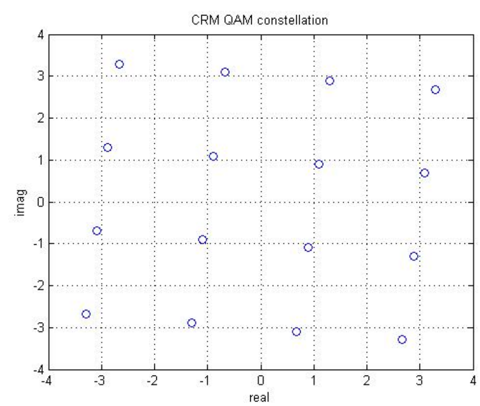


Fig. 4: Rotated 16 QAM with rotate angle 15°

5) MC - CDMA:

Output from Rotated Modulation block goes to the input of MC CDMA block. It will first come into the serial to parallel block. In this block, string of serial data which has been modulated is divided into rows parallel data. Afterwards, it goes into spreading block where spreading process in frequency domain

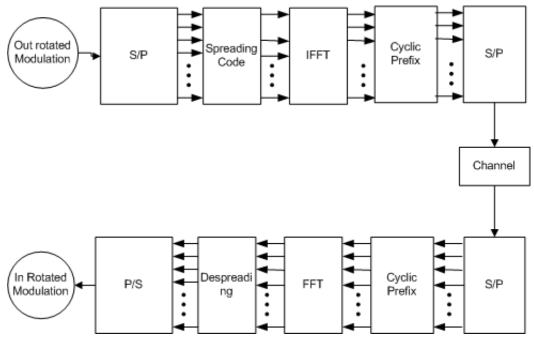


Fig. 5: Block diagram of MC - CDMA

is being held. The bit is timed by every bit from on Walsh code string. Every user owns a distinguishable Walsh code. Then, symbol data goes straight into the IFFT system. IFFT usage guarantee orthogonality between subcarrier. Amount of IFFT point that is used is equal to the amount of total subcarrier. It will end with cyclic prefix. Then, the signal will be transmitted and will be formed in serial. It will goes to channel.

B. Receiver

At the receiver, do the opposite of the process that occurs in the transmitter.

1) MC - CDMA receiver: In receiver, the process is the opposite of transmitter. First,S/P output parallel signal enters into cyclic prefix to be deleted. Then FFT is making the information signal demodulation in conversion from time domain to frequency domain. the FFT parallel block N in order to gaining parallel representation in frequency domain. The amount of FFT point in the receiver should be equal as the amount of IFFT point in the transmitter. Then, it is despreaded. The parallel signal is timed by every Walsh code bit that is compatible with each user to gain the desired signal. The previous data in the in the parallel data string is combined into serial string. It goes to the next prosess, de Rotated Modulation block.

2) De- Rotated Modulation: De Rotated Modulation process is the reverse of the Rotated Modulation process in which each symbol rotates as far as θ so its come back to its original position with a value of Inphase and quadrature are same.

3) De- interleaver: Deinterleaver process is the exact opposite of interleaver process of quadrature component in transmitter. The quadrature components goes into the deinterleaver block per row and goes out per column.

III. Simulation Result

In this study focused on the performance of the downlink transmission system (signal transmission from the Base Station to the user). This study emphasized to explore MC-CDMA system performance with Rotated Modulation scheme. The goal is to address the problem of high data rate, the problem of frequency selective fading and fast fading, and power efficiency. Taking into account these problems, in this section we present the simulation results support the hypothesis. Table I shows the simulation parameter of our system :

TABLE I: Simulation Parameter

Parameter	Value
Frequency	2.6 GHz
velocity	120 km/h
Mapper	16 QAM
Code Rate	1/2
Channel Coding	Convolutional Code
Subcarrier	256
Rotation Angle	5°, 10°, 15°, 20°, 25°
Channel	Rayleigh Fading

fig 6 shows the simulation result of MC-CDMA system using Rotated Modulation compared to MC-CDMA without using Rotated Modulation. As shown in the figure, the Rotated Modulation MC - CDMA scheme has the better performance compared with non Rotated Modulation. MC-CDMA with Rotated Modulation need Eb / No 8.32 dB to achieve value for BER 10^{-4} , while non Rotated Modulation MC -CDMA systems need Eb / No 10.96 dB.

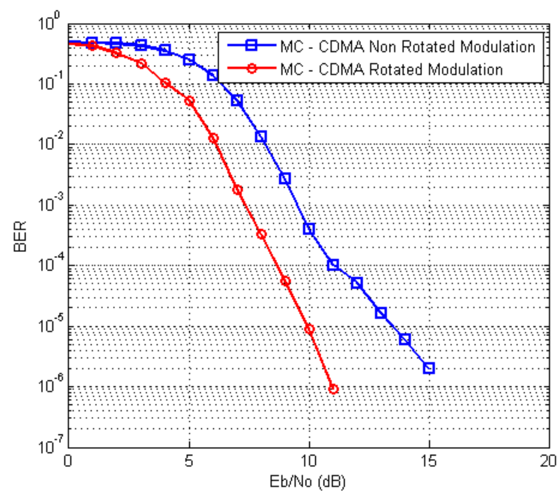


Fig. 6: Comparison performance chart of MC-CDMA system with Rotated Modulation and non Rotated Modulation

fig 7 shows the performance of Rotated Modulation MC - CDMA using different rotated angle. As shown in the figure,to reach a value of BER 10^{-4} on the system MC - CDMA with angle 5° requires Eb/No 10 dB, for an angle 10° need Eb/No 9.96 dB, 15° need Eb/No at 8,32 dB, 20° need Eb / No 9.24 dB, and 25° need Eb / No 10.17 dB.

The farther angle provides Eb / No value is smaller because the distance between symbols are far, so error is getting smaller. but the circumstances prevailing when the symbols are located in the same quadrant, when the symbol already started approaching other quadrants limit, Eb / No value will increase again.

fig 8 shows the performance of Rotated Modulation MC -CDMA using different velocity. As shown in the figure,to reach a value of BER on the system MC - CDMA with speed

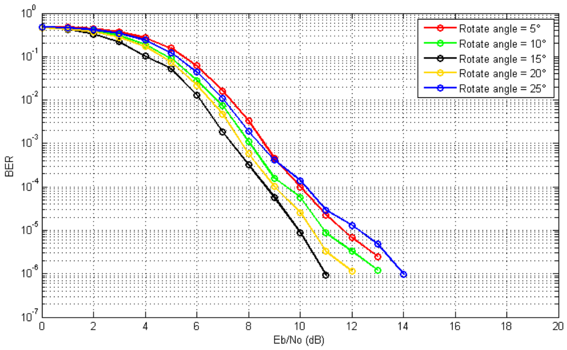


Fig. 7: comparison of performance system with different angles

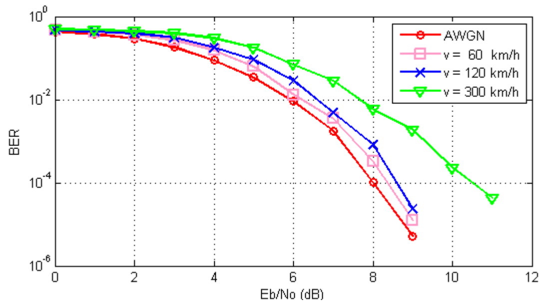


Fig. 8: comparison of system performance with different velocity

of 300 km/h requires Eb/No 10.35, for speed of 120 need Eb/No 8.32 dB, speed of 60 km/h need Eb/No 8.21 dB, and for AWGN need Eb/No 8dB.

From the figure above, it appears that the Eb / No in AWGN channel is needed to get 10^{-4} BER value is smaller than the Eb / No required signal through AWGN and Rayleigh channel. This is because in AWGN channel signal is affected by thermal noise in device only. In AWGN channel signal received is considered LOS (Line Of Sight), the signal from the mobile station is not disturbed anything in the vicinity when the signal is sent.

Figure 9 shows the comparison between OFDM and MC-CDMA. The simulations performed with the same parameters in both systems. From the figure above, to reach a value of BER of 10^{-3} on the system OFDM requires Eb/No of 14.12 dB,while the MC CDMA system that uses Rotated Modulation need Eb / No 7.98 dB. MC - CDMA using Coding Rotated Modulation produce a better performance than using OFDM around 6.14 dB.

IV. Conclusion

From the research results, it is concluded that in general proposed Rotated Modulation will provide a good performance. MC-CDMA with Rotated Modulation scheme give better performance compared to MC-CDMA non Rotated Modulation scheme. MC- CDMA systems that implement

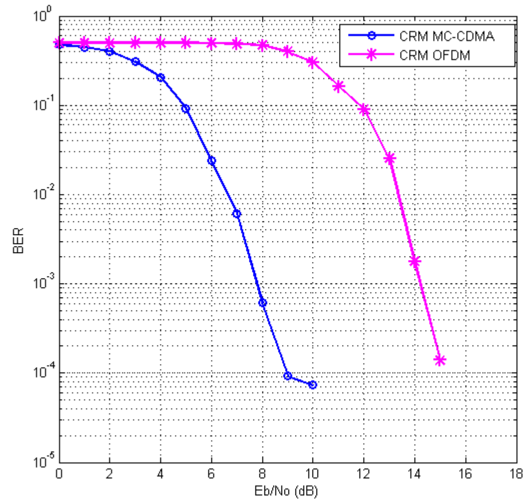


Fig. 9: comparison of CRM performance system with OFDM and MC - CDMA

Rotated Modulation require less power compared with non Rotated Modulation MC-CDMA systems around 2.64 dB. However, the proposed scheme only work well while use optimal rotated angle. Optimal angle value in this research is $15°$, with requires power by 8.32 dB to reach BER 10^{-4}.The combination between MC-CDMA and Rotated Modulation is potential scheme to solve fast fading and power efficiency.

Acknowledgment

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