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ON THE PERFORMANCE OF DCT BASED MC-CDMA SYSTEM

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***Abstract*— Multicarrier Code Division Multiple Access (MC-CDMA) is multicarrier based technique. It is a combination of Orthogonal Frequency Division Multiplexing (OFDM) and Code Division Multiple Access (CDMA) techniques. CDMA is a spread spectrum technique. It facilitates various signals to occupy a single transmission channel. It has a soft capacity. OFDM is a bandwidth efficient technique. MC-CDMA signal has high PAPR due to OFDM. In this paper to reduce PAPR, DCT based MC-CDMA system is proposed in which MC-CDMA is realized by using a Discrete Cosine Transform (DCT). MC-CDMA system based on DCT is referred as DCT-MC-CDMA system. Conventionally MC-CDMA transmitters and receivers are realized by using Inverse Discrete Fourier transform (IDFT) and Discrete Fourier transform (DFT) respectively. This work analyzes the PAPR performance of DCT-MC-CDMA system for transmit and receive signals and compare the results with DFT-MC-CDMA system.**

***Index Terms*— MC-CDMA, OFDM, CDMA, IDFT, DFT, DCT, PAPR.**

I. INTRODUCTION

There has been rapid growth in the field of wireless communication due to growing demand of mobile users. MC-CDMA can provide high data rate and high capacity. It is a combination of Orthogonal Frequency Division Multiplexing (OFDM) and Code Division Multiple Access (CDMA) techniques [1]. CDMA is a spread spectrum technique. It facilitates various signals to occupy a single transmission channel. It has a soft capacity [2]. Orthogonal frequency division multiplexing is multicarrier and high-speed data transmission scheme. In Single Carrier (SC) system, single carrier occupies the entire bandwidth, while in multicarrier system the bandwidth is divided into many sub-carriers, thus, each sub-carrier has a part of bandwidth as compared to the bandwidth of the single carrier system. High speed transmission through multicarrier systems is possible with the help of OFDM [3,4]. It is implemented in various high speed wireless communication standards, such as wireless local area network, wireless metropolitan area network, digital video broadcasting and digital audio broadcasting. The new mobile standard, Mobile WiMAX IEEE 802.16e which allows high data rates uses OFDM for improved multipath performance in non-line of sight environment. OFDM is a combination of modulation and multiplexing. Conventionally to implement an OFDM system, Inverse Discrete Fourier transform (IDFT) is used in the transmitter and the and Discrete Fourier transform DFT used in the receiver side. The DFT/ IDFT length N defines the total number of subcarriers present in the OFDM system. In OFDM cyclic prefix is added to each OFDM symbol which mitigates the problems of ISI and ICI [1-3]. The main drawback of OFDM system is high Peak to Average Power Ratio (PAPR) of the transmitted signals. Partial Transmit Sequence (PTS), clipping and Selective Mapping (SLM) techniques are used to reduce PAPR. It is found that there is a significant reduction in PAPR by using these techniques but with some disadvantages [6-9].

In this paper, Discrete Cosine Transform (DCT) and Inverse Discrete Transform (IDCT) based MC-CDMA system is used to improve the PAPR performance. The DCT based OFDM is studied in [10]. It is found that BER performance of DCT based OFDM in an AWGN environment outperform FFT based OFDM. In [11], the Bit-Error Rate (BER) of a DCT-OFDM system on Additive White Gaussian Noise (AWGN) channels in the presence of frequency offset is derived using different modulation techniques. The performance of a DCT-OFDM with a zero-padding guard-interval scheme is found better with a zero-padded DFT-OFDM [10-13].

The rest of the paper is organized as follows: Section II describes of the transmitter and receiver model for DFT-MC-CDMA. DCT-MC-CDMA techniques is given in section III, simulation results are shown in section IV and paper is concluded in section V.

II. DFT-MC-CDMA BLOCK DIAGRAM

DFT-MC-CDMA system is shown in Fig-1. Input data sequence is modulated by digital modulation scheme such as QAM/PSK modulation. The modulated symbols are then spread by Walsh Hadamard (WH) spreading code and then sent to the IDFT module to transform the symbols into time domain signals. At the receiver side, DFT operation is performed to transform the received signal into frequency domain signals then these signals are de-spread by Walsh-Hadamard spreading code and then resultant signal is demodulate by QAM/PSK demodulation technique to get the original information [1, 3-5].

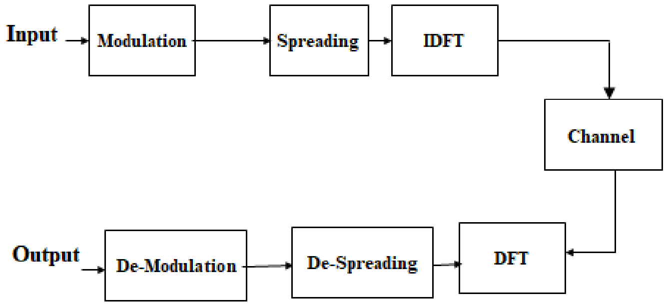

Fig.1 DFT-MC-CDMA Block Diagram

The main drawback of DFT-MC-CDMA system is high Peak to Average Power Ratio (PAPR) of the transmitted signal due to OFDM. High PAPR increases the complexity of the Analog-to-Digital(A/D) and Digital-to- Analog(D/A) converter. In an MC-CDMA signal, Power Amplifier with large linear range are required, which makes it a costly affair. If power amplifier with limited linear range is used, then its operation in nonlinear mode introduces distortion [6].

PAPR can be defined as the relationship between the maximum power of a sample in a transmitted OFDM symbol and its average power

$$(PAPR)_{(dB)} = 10 \log_{10} P_{peak} / P_{average} \quad (1)$$

Where, P_{peak} and $P_{average}$ are the peak and average power of a given OFDM symbol [7,8]. The Cumulative Distribution Function (CDF) is used to measure the efficiency of PAPR technique. Normally, Complementary CDF (CCDF) is used instead of CDF. CCDF helps us to measure the probability that the PAPR of a certain data block exceeds the given threshold. CCDF is defined as the probability that the PAPR is greater than a reference value denoted as PAPR0. CCDF of the PAPR can be given by

$$CCDF = Pr\,(PAPR > PAPR_0) \quad (2)$$

PAPR reduction techniques are mainly categorized into two groups: **Signal Scrambling Techniques** such as Block Coding Techniques, Selected mapping (SLM), Partial Transmit Sequence (PTS), Interleaving Technique, Tone Reservation (TR), Tone Injection (TI) and **Signal Distortion Techniques** such as Clipping, Clipping and filtering, Peak Windowing, Envelope scaling. These techniques achieve PAPR reduction at the expense of Bit Error Rate (BER) and also increases the computational complexity [7,9]

In this paper, to reduce PAPR a single set of sinusoidal cosine functions is used as the orthogonal basis to construct baseband multicarrier signals. This Multicarrier Modulation scheme is synthesized using a discrete cosine transform. It is denoted the scheme as DCT-MC-CDMA.

III. DCT-MC-CDMA BLOCK DIAGRAM

The Discrete Cosine transform (DCT) is similar to the Discrete Fourier transform; it transforms a signal or image from the spatial domain to the frequency domain [10].

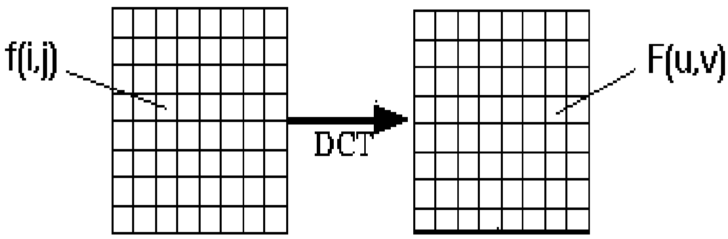

Fig 4.1: DCT Matrix

The DCT is defined by the following equation

$$F(u) = (2/N)^{1/2} \sum_{i=0}^{N-1} A(i).\cos[\pi.u/2.N(2i+1]f(i) \quad (3)$$

Where,

$$A(i) = \{1/\sqrt{2} \text{ for } \xi = 0 \text{ ; 1 otherwise}\}$$

Inverse DCT is defined by

$$F^{-1}(u) \quad (4)$$

)

Sinusoidal cosine functions can be used as an orthogonal basis to implement multi-carrier modulation scheme in DCT-MC-CDMA system instead of complex exponential functions. This is possible by using DCT. For fast implementation algorithms, DCT provide fewer computational steps than DFT-MC-CDMA. DCT-MC-CDMA is robust to the multipath induced Inter Symbol Interference (ISI) due to the orthogonal property similar to DFT-MC-CDMA system [10-12]. The block diagram of DCT-MC-CDMA is shown in Fig-2.

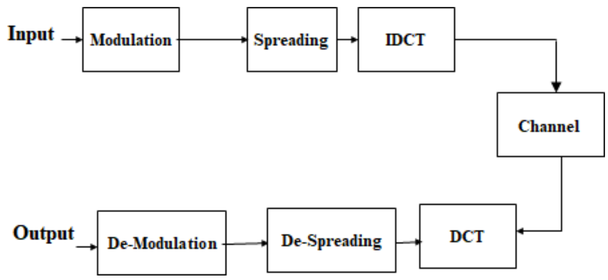

Fig.2 DCT-MC-CDMA Block Diagram

Input signal is modulated by digital modulation scheme such as QAM/PSK modulation. The modulated symbols are then spread by Walsh-Hadamard spreading code and then sent to the IDCT module to transform the symbols. At the receiver side, DCT operation is performed to transform the received signal then this signal is de-spread by Walsh-Hadamard spreading code and then resultant signal is demodulate by QAM/PSK demodulation technique to get the original information. The signal is then passed through AWGN environment. At the receiver, DCT is performed and then demodulated by choosing corresponding demodulation scheme i.e., QAM/PSK demodulation.

IV. Simulation and Result

In this paper DCT based MC-CDMA system is simulated using MATLAB and results are compare with DFT based MC-CDMA system. For simulation number of subcarriers are taken as 256, cyclic prefix is ¼ and length of W-H spreading code is 8.

Fig-3, shows the comparison of PAPR of transmitted signal for DCT-MC-CDMA system and DFT-MC-CDMA system for 16-PSK modulation technique. Result shows that the PAPR of DCT-MC-CDMA system is less than the PAPR of the DFT-MC-CDMA system.

In Fig-4 result shows the comparison of PAPR of DCT-MC-CDMA system and DFT-MC-CDMA system with 16-QAM modulation technique for transmitted signal. Result shows that the PAPR of DCT-MC-CDMA system is far better than the PAPR of the DFT-MC-CDMA system.

PAPR comparison of DFT-MC-CDMA and DCT-MC-CDMA received signal with 16-PSK modulation technique is shown in Fig-5. Result shows that the PAPR of DCT-MC-CDMA system is less than the PAPR of the FFT-MC-CDMA system.

In Fig 6 result shows the comparison of PAPR of DFT-MC-CDMA and DCT-MC-CDMA received signal with 16-QAM modulation technique. Result shows an improvement in PAPR of DCT-MC-CDMA system in comparison with the PAPR of DFT-MC-CDMA system.

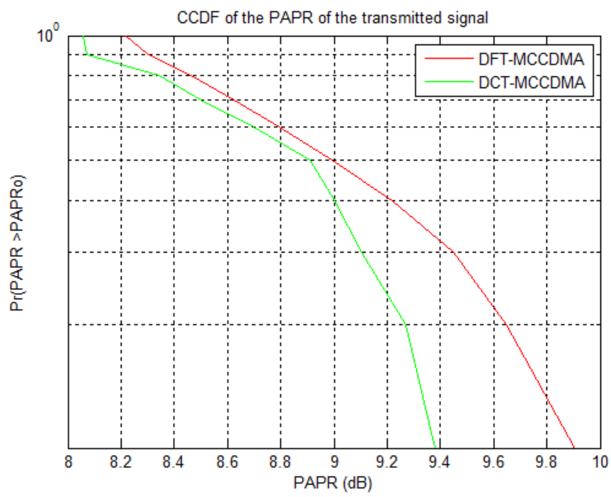

Fig.3 PAPR of transmitted signal with 16-PSK

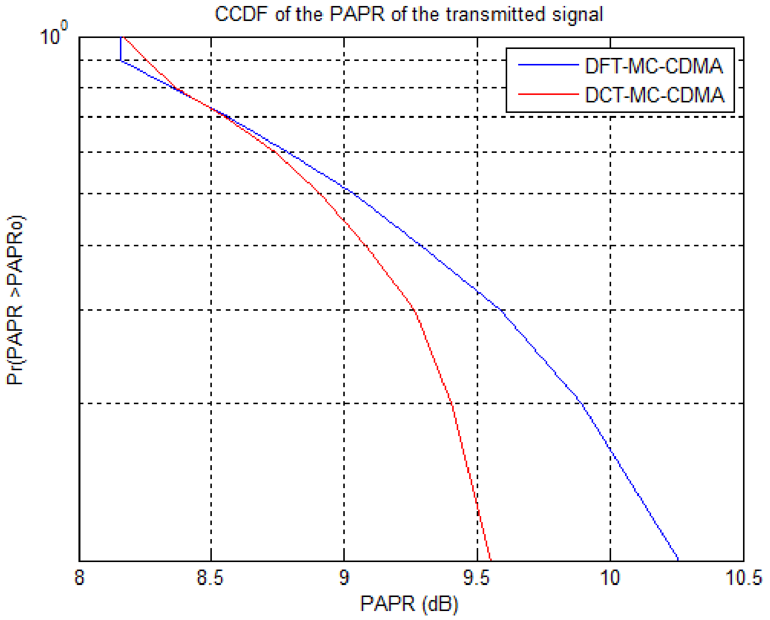

Fig.4 PAPR of transmitted signal with 16-QAM

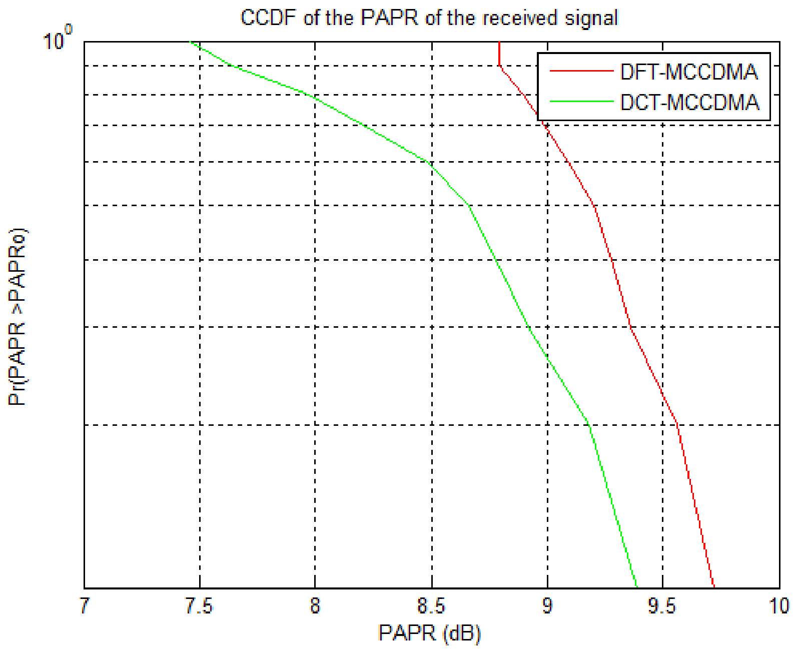

Fig.5 PAPR of received signal with 16-PSK

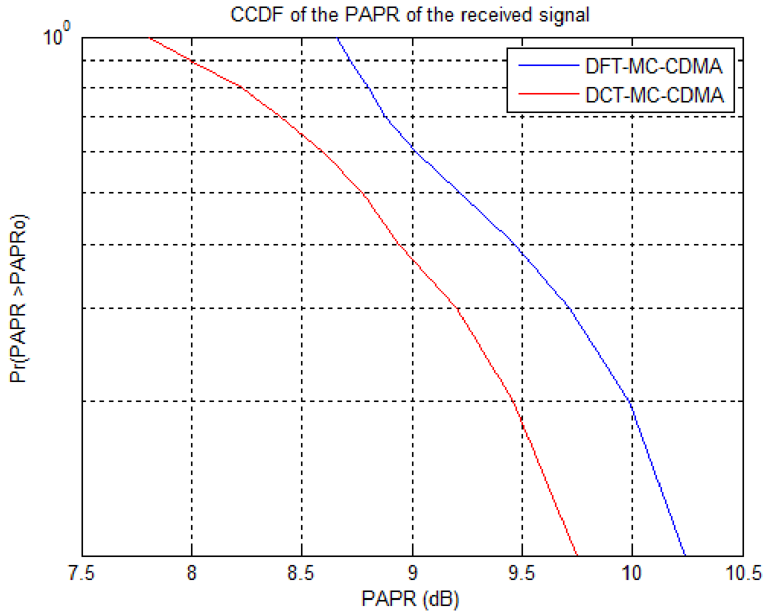

Fig.6 PAPR of received signal with 16-QAM

V. Conclusion

DFT-MC-CDMA system has high peak to average power ratio of the transmitted signal and received signal. In this paper, to reduce high PAPR of an MC-CDMA signal a single set of sinusoidal cosine functions is used as the orthogonal basis to construct baseband multicarrier signals. Therefore, to implement MC-CDMA system, IDCT and DCT is applied instead of IDFT and DFT. It is observed that the CCDF of PAPR of transmitted and received signal for DCT based MC-CDMA system is far better than the PAPR of the FFT based MC-CDMA system with PSK/QAM modulation techniques. Thus, DCT based MC-CDMA system can be used as an alternative to the DFT-MC-CDMA system to reduce PAPR

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