# COMPARISION OF DISCRETE COSINE TRANSFORM BASED OFDM WITH DFT

**Rashmi[1], Sowmya[2], Nagaraja N S[3]**

*Rashmi[1], Assistant professor, Dept of ECE, Srinivas University, Mukka, Karnataka*
*Sowmya[2], Assistant professor, Dept of ECE, Srinivas University, Mukka, Karnataka*
*Nagaraja N S[3], Head of the Department, Dept of ECE, Srinivas University, Mukka, Karnataka*

---***---

**Abstract:** The performance of high data rates communication systems is limited by frequency selective multipath fading which results in intersymbol interference (ISI). In the wireless channels, impairments such as fading, shadowing and interferences due to multiple user access highly degrade the system performance. As all the subcarriers are orthogonal to each other, they can be transmitted simultaneously over the same bandwidth without any interference which is an important advantage of OFDM. OFDM makes the high speed data streams robust against the radio channel impairments. OFDM is an efficient technique to handle large data rates in the multipath fading environment which causes ISI. With the help of OFDM, a large number of overlapping narrowband subcarriers, which are orthogonal to each other, are transmitted parallel within the available transmission bandwidth. Thus, in OFDM, the available spectrum is utilized efficiently. The main aim of this paper is o examine BER vs. SNR performance of conventional DFT based OFDM system and DCT based OFDM over different type of channel.

***Key Words*: Orthogonal Frequency Division Multiplexing, Peak to Average Power Ratio, discrete cosine transform (DCT), discrete Fourier transform (DCT).**

## 1. INTRODUCTION

With the rapid growth in technology, the demand for flexible high data-rate services has also increased. The performance of high data rates communication systems is limited by frequency selective multipath fading which results in intersymbol interference (ISI). In the wireless channels, impairments such as fading, shadowing and interferences due to multiple user access highly degrade the system performance. Multicarrier modulation (MCM) is a solution that overcomes these problems in wireless channels. It is the technique of transmitting data that divides the serial high data rate streams into a large number of low data rate parallel data streams. c (OFDM) is a kind of multi-carrier modulation, which divides the available spectrum into a number of parallel subcarriers and each subcarrier is then modulated by a low rate data stream at different carrier frequency. The conventional OFDM system makes use of IFFT and FFT for multiplexing the signals and reduces the complexity at both transmitter and receiver.

OFDM is comprised of a blend of modulation and multiplexing. The original data signal is split into many independent signals, each of which is modulated at a different frequency and then these independent signals are multiplexed to create an OFDM carrier. As all the subcarriers are orthogonal to each other, they can be transmitted simultaneously over the same bandwidth without any interference which is an important advantage of OFDM. OFDM makes the high speed data streams robust against the radio channel impairments.

## 2. PAPR PROBLEM OF OFDM SIGNALS

### 2.1 Introduction

Orthogonal frequency division multiplexing (OFDM) is one of the most promising techniques for high data rate transmission systems. It is currently the standard of IEEE 802.11a(Wi-Fi) Wireless LANs and is also being used for digital terrestrial television transmissions as well as digital audio broadcasting (DAB) digital radio . It is a parallel transmission scheme in which a single channel utilizes multiple sub-carriers on adjacent frequencies. It uses the spectrum much more efficiently by spacing all the channels more close and orthogonal. It offers high spectral efficiency, high data rate, low complexity for receivers and robustness against narrow band interference and frequency selective fading.

In spite of the advantages listed above, High Peak to Average Power Ratio (PAPR) is the major drawback of OFDM at the transmitter side. These peak values in the signal may make the high power amplifiers in the non-linear region and hence distort the signal. So, reduction in the value of PAPR is the major concern. Many PAPR reduction methods are proposed for its mitigation. These methods are divided into three categories. The first category is signal distortion techniques under which clipping, peak windowing techniques are included. The second category includes coding techniques like Block Coding, Transform techniques like Hadamard Transform, Companding, and Discrete Cosine Transform (DCT). The third category is scrambling techniques which includes selected mapping (SLM) and Partial Transmit Sequence (PTS).

## 3. DCT BASED OFDM SYSTEM

### 3.1 Introduction

Instead of using complex exponential functions, co sinusoidal functions can be used as orthogonal basis to implement multi-carrier scheme. This can be synthesized using discrete cosine transform (DCT). For fast implementation algorithms DCT can provide fewer computational steps than FFT based OFDM. The effect of carrier frequency offset (CFO) will introduce inter-carrier interference (ICI) in both the DFT-OFDM and DCT-OFDM. A single co sinusoidal functions set $\cos 2\pi N r F_\Delta t$ will be used as the orthogonal basis to implement MCM in DCT-OFDM. The minimum $F\Delta$ required to satisfy Eq. (6.1) is 1/2T Hz.

$$\int_0^T \sqrt{\frac{2}{T}} \cos(2\pi F_\Delta t) \sqrt{\frac{2}{T}} \cos(2\pi m F_\Delta t)\, dt = \begin{cases} 1, k = m \\ 0, k \neq m \end{cases}$$

(6.1)

### 3.2 The Block Diagram

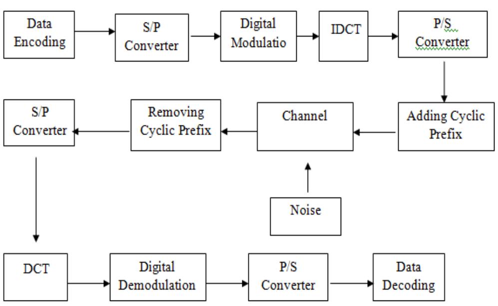


Fig 1- Block Diagram for Improved DCT Based OFDM System

The Fig 1 block diagram based implementation involves separate sets of blocks which are:

Input module for OFDM system

- Data encoding
- Serial to parallel converter
- Digital modulation
- Inverse Discrete Cosine Transform.
- Parallel to series converter
- Adding Cyclic Prefix.

Output Module for OFDM output.

- The Channel
- Inverse Cyclic Prefix
- Series to parallel converter
- Discrete Cosine Transform
- Digital demodulation
- Parallel to series converter
- Data decoding

### 3.3. Implementation Details

#### 3.3.1 Data encoding

Quadrature amplitude modulation (QAM) is both an analog and a digital modulation scheme. It conveys two analog message signals, or two digital bit streams, by changing (modulating) the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme. The two carrier waves, usually sinusoids, are out of phase with each other by 90° and are thus called quadrature carriers or quadrature components — hence the name of the scheme. The modulated waves are summed, and the resulting waveform is a combination of both phase-shift keying (PSK) and amplitude-shift keying (ASK), or (in the analog case) of phase modulation (PM) and amplitude modulation. In the digital QAM case, a finite number of at least two phases and at least two amplitudes are used.

#### 3.3.2. Serial to Parallel Converter

The Serial to Parallel Converter converts the incoming serial data into parallel In-phase and Quadrature components which are 90 degrees out of phase so that real part can be separated from the imaginary part and a faster transmission can be achieved.

#### 3.3.3 Constellation Mapping and De-mapping

The QAM technique involves constellation mapping of signal components using constellation diagram. A constellation diagram is a representation of a signal modulated by a digital modulation scheme such as quadrature amplitude modulation or phase-shift keying. By representing a transmitted symbol as a complex number and modulating a cosine and sine carrier signal with the real and imaginary parts (respectively), the symbol can be sent with two carriers on the same frequency. On the contrary, De-mapping just de-maps the constellation binary symbol components back to their original binary form. The constellation diagram for 16 bit QAM can be shown as below.

### 3.3.4 Symbol Generator and De-Generator.

The symbol generator validates the input given to it and generates valid symbols only to be passed on the DCT block. These symbols are binary symbols of course. The de-generator just converts the received noisy signal in the form required to be an input for the QAM block.

### 3.3.5. Zero Padding and Un-padding.

Zero Padding is a technique involved to separate streams of data. The stream of data is padded with zeros both before and after the data, so that every two streams of data is separated and a proper transform can be performed. In this implementation, zero padding is 32 bits wide. So, every data stream, which is 64 bits, has 32 plus 32 zero padded bits ahead of and after it respectively.

### 3.3.6. DCT and Inverse Discrete Cosine Transform (IDCT).

The multiple orthogonal subcarrier signals, which are overlapped in spectrum, need to be produced at the transmitter side. In practice, Discrete Cosine Transform (DCT) and Inverse DCT (IDCT) processes are useful for implementing these orthogonal signals. In the OFDM transmission system, N point IDCT is taken for the transmitted symbols so as to generate the samples for the sum of N orthogonal subcarrier signals. The receiver will receive a sample corrupted by additive noise. Taking the N-point DCT of the received samples the noisy version of transmitted symbols can be obtained in the receiver.

### 3.3.7 Cyclic Prefix and Inverse Cyclic Prefix

The OFDM scheme also inserts a guard interval in the time domain, called cyclic prefix (CP), which mitigates the inter-symbol interference (ISI) between OFDM symbols. Once the signal is received by the receiver, the effect of ISI is over and thus the cyclic prefix is removed by using Inverse Cyclic Prefix [5].

### 3.3.8 Output Module for OFDM output.

The Output Module acts as an OFDM signal generating module, which apart from generating the OFDM output, filters the unwanted cosine terms from the Cyclic prefixed data. This OFDM output is passed on to the receiver through the channel.

### 3.3.9 The Channel

The channel is just a transmission medium between the transmitter and the receiver in which the data flows. The OFDM output generated is passed on to the receiver through the channel.

### 3.3.10 Parallel to Serial Converter

The Parallel to Serial Converter converts the incoming parallel data components which are 90 degrees out of phase into serial output data so that it matches the input data destined for the receiver, along with noise signals.

### 3.3.11 Bit interleaving

In order to maximize the diversity in a fading channel, the error correction coding coupled with interleaver is used. It separates the adjacent coded symbols farther than the coherence time of fading process by creating large Euclidean distance between the code words of a convolution code. The burst errors occurring in the channel or caused by the detector on the receiver side are dispersed by a de-interleaver at the receiver.

### 3.4 Result and Conclusion

In this work, the conventional DFT based OFDM system using DPSK modulation technique under AWGN channel has been considered to evaluate the performance of the proposed DCT based OFDM systemMATLAB simulation has been carried out to compare the performance of DFT OFDM with DCT OFDM system.

### 3.4.1 Comparison of DCT based OFDM with DFT

The simulation results are presented as follows:

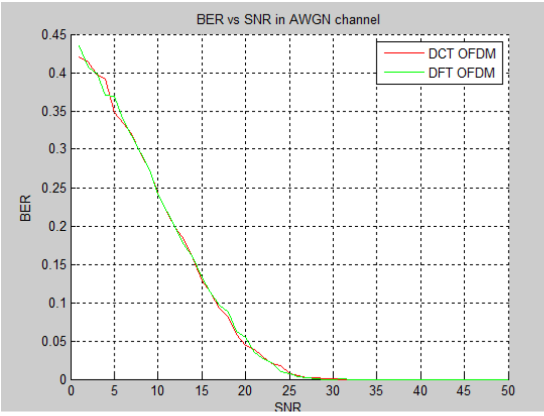


Fig. 2-Performance of DCT OFDM and DFT OFDM system under AWGN Channel

Fig. 2 shows the performance of DCT OFDM and DFT OFDM system under AWGN channel. As shown in Fig, the BER of the OFDM system is significantly improved when DFT is replaced by DWT when BER is plotted as a function of SNR. The improvement in BER performance can be examined by taking a particular value of BER and comparing the values of SNR at which it is obtained in DFT-OFDM system and DWT-OFDM system. In DFT based OFDM system, the BER of 0.07 has been obtained at SNR of 20dB and in DCT based OFDM system, the BER equals to 0.05 is obtained at same SNR when the system is observed under AWGN channel.

## REFERENCES

[1]. J. A. C. Bingham, "Multicarrier modulation for data transmission: An idea whose time has come," IEEE Communication Magazines, vol. 28, no. 5, pp. 5–14, 1990.

[2]. S. A. Fechtel, "A novel approach to modelling and efficient simulation of frequency selective fading radio channels," IEEE Journal on Selected Areas of Communication, vol. 11, pp. 422–431, 1993.

[3]. L. Wei, C. Schlegel, "Synchronization requirements for multi-user OFDM on satellite mobile and two-path Rayleigh fading channels", IEEE Transactions on Communication, vol. 43, pp. 887-895, 1995.

[4]. E. F. Casas and C. Leung, "OFDM for data communication over mobile radio FM channels- Part I: Analysis and experimental results", IEEE Transactions on Communication, vol. 39, no. 5, pp. 783-793, 1991.

[5]. L. J. Cimini Jr., "Analysis and simulation of a digital mobile channel using orthogonal frequency division multiplexing," IEEE Transactions on Communication, vol. COM-33, no. 7, pp. 665–675, 1985.

[6]Ramanjeet Kaur, Charanjit Singh , Amandeep Singh," Mitigation of PAPR in OFDM Using the Combination of Discrete Cosine Transform-II and Partial Transmit Sequence Technique", Journal of Engineering Research and Applications,2014.

[7] Zhongpeng Wang, "Combined DCT and Companding for PAPR Reduction in OFDM Signals", Journal of Signal and Information Processing, 2011.