Performance Analysis of DFT-OFDM, DCT-OFDM, and DWT-OFDM Systems in AWGN Channel

Abstract—**In this paper, the bit error rate (BER) performance of conventional discrete Fourier transform (DFT) - OFDM system is compared with discrete wavelet transform (DWT)-OFDM system and discrete cosine transform (DCT)-OFDM system in an AWGN environment. Several wavelets such as Haar, Daubechie and Symlet are considered. We give the performance with two modulation format such as BPSK and QPSK. Simulation results show that Haar wavelet based scheme yields the lowest average bit error probability and the performance of DFT-OFDM and DWT (Haar)-OFDM with QPSK is better than BPSK modulation format.**

Index Terms—**Daubechies, DCT, DFT, Haar, Symlets, wavelets.**

I. INTRODUCTION

IN 4G wireless communication systems, bandwidth is a precious commodity, and service providers are continuously met with the challenge of accommodating more users with in a limited allocated bandwidth. Orthogonal frequency division multiplexing (OFDM) is multicarrier modulation (MCM) technique which provides an efficient means to handle high-speed data streams on a multipath fading environment that causes ISI. To eliminate ISI a cyclic prefix is added. But this can decrease bandwidth (BW) efficiency greatly .To decrease the BW waste brought by adding CP , wavelet based OFDM is proposed due its excellent orthogonality between subcarriers and spectral containment[1]. According to proposals of the IEEE 802.16.3, the PHY overhead for wavelet-based OFDM (DWT-OFDM) is less than that of Fourier based DFT-OFDM modulations, since it doesn't need CP. Traditionally, OFDM cyclic prefix of 20% or more are typical for wireless transmission thus giving Wavelet OFDM an advantage of roughly 20% in bandwidth (BW) efficiency [2].Also in the literature, [3] proposed using a DCT rather than a DFT, to implement MCM, because of the bandwidth advantage a DCT- based system can achieve .

In this paper, we will first compare the BER performance of DCT-OFDM and DWT-OFDM with conventional DFT-OFDM using BPSK modulation format over an AWGN channel. In case of DWT-OFDM, we will consider three widely used wavelets i.e. Haar, Daubechie and Symlets. We then compare the BER performance of DWT (Haar)-OFDM and DFT-OFDM systems with different modulation formats. In many OFDM systems a CP is added to maintain the orthogonality of subcarriers. In this paper, the OFDM systems are performed without CP for fair considerations.

II. OFDM SYSTEMS

A. DFT-OFDM

In OFDM systems, digital modulation and demodulations can be realized with the inverse DFT (IDFT) and DFT, respectively [4]. OFDM employs Ns separate subcarrier to transmit data instead of one main carrier. Input data is grouped in to a block of N bits, where $N = N_s \times m_n$ and m_n is the number of bits used to represent a symbol for each subcarrier. In order to maintain orthogonality between the subcarriers, they are required to be spaced apart by an integer multiple of the subcarrier symbol rate R_s. The subcarrier symbol rate is related to overall coded bit rate R_c of the entire system by $R_s = R_c / N$. The output signal of an OFDM can be written as:

$$X(t) = \sum_{n=0}^{N_S-1} C_k e^{2\pi j(n - N_S/2)t/T_S} \quad . \tag{1}$$

Where C_k are the complex representations of the subcarrier symbols and T_s is the symbol period [5]

B. DCT-OFDM

The complex exponential functions set is not the only orthogonal basis that can be used to construct baseband multicarrier signals. A single set of cosinusoidal functions can be used as an orthogonal basis to implement the MCM scheme, and this scheme can be synthesized using a discrete cosine transform (DCT) [6]. Hence, we will denote the scheme as DCT-OFDM. The output signal of a DCT based OFDM system can be written as

$$X(t) = \sqrt{\frac{2}{N_s}} \sum_{n=0}^{N_S-1} d_n \beta_n \cos\left(\frac{n\pi t}{T_S}\right) \quad . \tag{2}$$

Where $d_0, d_1 \ldots d_{Ns-1}$ are N_s independent data symbols obtained from a modulation constellation, and

$$\beta_n = \begin{cases} \frac{1}{\sqrt{2}}, & n = 0 \\ 1, & n = 1,2,\ldots, N_S - 1 \end{cases} \tag{3}$$