

# A Low Complexity Parametric DFT and DHT -Based OFDM Transceivers

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**Abstract**—In this paper, we design new efficient and fast orthogonal frequency division multiplexing (OFDM) transceivers by introducing parametric discrete Fourier and Hartley transforms. We experimentally show that, for a specific value of the parameter and for various signal-to-noise ratios and modulation schemes such as binary phase shift keying (BPSK), quadratic PSK (QPSK), 16 quadratic amplitude modulation (QAM) and 64QAM, the resulting OFDM transceivers based on these transforms achieve performance in terms of bit error rate similar to that of the existing OFDM transceivers. The compatibility of the proposed OFDM modulators with the conventional DFT-based OFDM demodulator is also experimentally verified. In addition, compared to the existing OFDM transceivers, we show that the computational complexity of the proposed OFDM transceivers is significantly reduced.

**Key words**—OFDM transceivers, parametric DFT, parametric DHT, BER, IEEE 802.11a.

## I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is a wideband transmission technique broadly used in communication systems for its robustness against frequency selective channels, efficient use of the spectrum and elimination capability of the inter-symbol interference [1, 2]. It has been adopted in many standards like digital audio broadcasting, wireless area local networks based on the IEEE 802.11 standard, European equivalent HIPERLAN/2 and unmanned aerial vehicle communication [3-5].

The baseband modulation and demodulation of OFDM transceiver data symbols is generally performed using the inverse discrete Fourier transform (IDFT) and discrete Fourier transform (DFT), respectively [6, 7]. To deal with multipath fading channel effect, a cyclic prefix (CP) is inserted at the beginning of each OFDM symbol. The CP duration is chosen to be larger than the largest delay spread of the channel, which allows the DFT-based OFDM transceiver to diagonalize with high accuracy the equivalent circulant channel matrix. This provides decoupled memoryless subchannels with the ability to be equalized using one tap frequency domain equalizer [8].

Although the DFT-based OFDM transceiver exploit the inverse fast Fourier transform (IFFT) and fast Fourier transform (FFT) algorithms for efficient computation of the required IDFT and DFT, their computational complexity is still a challenging problem. With this problem in mind, the discrete Hartley transform (DHT) has been proposed in [7],

[8] and [11] as an alternative to the DFT for OFDM transceiver. This is due to the fact that the computational complexity of the fast Hartley transform (FHT) algorithm is lower than that of the FFT algorithm [7, 9-10]. It has been shown in [11] that the DHT-based OFDM transceiver provides performance similar to that of the DFT-based OFDM transceiver and the circulant channel diagonalization property of the latter is maintained in the former by designing a specific scheme consisting of two real-valued DHT kernels and one post processing unit (PPU). To design a DHT-based modulator (MOD)/demodulator (DEM), the authors of [11] modified the FHT algorithm in [12] and proposed a DCT-based radix-2 FHT method. Even though, this DHT-based OFDM system reduces the computational complexity compared to the classical ones, there is a crucial need in further reducing this complexity especially for modern applications requiring a huge amount of data to be communicated through communication systems.

In [13], Bouguezel et al. proposed the parametric discrete Fourier transform ( $DFT^\alpha$ ) and discrete Hartley transform ( $DHT^\alpha$ ) as well as their corresponding fast algorithms, where  $\alpha$  is a parameter that takes values in the range  $[-2\pi, 0]$ . It has been shown in [13] that the  $DFT^{-\pi/6}$  and  $DHT^{-\pi/6}$  can offer performance similar to that of the classical DFT and DHT, respectively, with reduced computational complexity. Motivated by the success use of these parametric transforms in different applications such as speech denoising [14-16], we specifically consider in this paper the  $DFT^{-\pi/6}$  and  $DHT^{-\pi/6}$  to design new faster OFDM transceivers. The performance of the proposed  $DFT^{-\pi/6}$  and  $DHT^{-\pi/6}$ -based OFDM transceivers is evaluated and compared, in terms of the bit error rate (BER) and computational complexity, to that of the DFT and DHT -based OFDM transceivers reported in [11].

The remainder of this paper is organized as follows. Section 2 gives a brief review of the existing DFT and DHT -based OFDM transceivers. Section 3 describes the proposed  $DFT^{-\pi/6}$  and  $DHT^{-\pi/6}$ -based OFDM transceivers. Section 4 presents simulation results and discusses. Finally, concluding remarks are given in Section 5.

## II. BRIEF REVIEW OF THE DFT AND DHT-BASED OFDM TRANSCEIVERS

In this section, we briefly review the OFDM transceivers, specifically those based on the DFT and DHT.