Digital Predistortion for Self-heterodyne DCT-Based OFDM Systems over Fading Channels

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Abstract

This paper presents a novel technique to compensate intermodulation distortion at the receiver of a self-heterodyne direct conversion OFDM system in multipath fading channels. In this letter, channel estimation is performed using a training sequence and then the predistortion coefficients with regards to estimated channel parameters are derived to compensate the receiver nonlinearity. Computer simulation demonstrates that the proposed approach improves BER performance of the self-heterodyne direct conversion system in multipath fading channels.

I. Introduction

The millimeter wave bands of the 802.16 standard are explored to meet strong demands for high transmission rate indoor and short-range outdoor wireless applications [1], [2]. However, it is known that the drawback of OFDM is the sensitivity of the receiver to oscillator instabilities, such as frequency offset and phase noises [14]. This is particularly troublesome when the carrier frequency over 10 GHz is used because the production of a stable and low cost oscillator is difficult.

[3] introduces the self-heterodyne scheme to compensate the oscillator instabilities. In this scheme, the transmitter sends out a local carrier as well as a modulated RF signal. The received signal is demodulated using a self-mixer. Such a scheme is suited for broadcasting applications and broadband WLAN systems to reduce the effect of high frequency-local oscillator (LO) instabilities.

Alternative to the conventional self-heterodyne scheme is the self-heterodyne direct conversion scheme with system predistortion technique [4]. Baseband signals at the transmitter are pre-distorted to compensate the intermodulation distortion at the receiver self-mixer output. The self-heterodyne direct conversion system has the advantage that simple and low cost receivers can be built to be completely immune to any phase noises or frequency offset. The spectral efficiency and the receiver sensitivity of the self-heterodyne direct conversion system could be improved compared with the conventional self-heterodyne system because the local carrier locates within the modulated signal bands so that not only required transmit bandwidth but detected noise power would decrease.

However, [4] has neglected to consider the effects of wireless channel characteristics. The indoor radio channel shows frequency selective multipath characteristics due to the highly reflective indoor environment [1], [5], which results in severe signal dispersion. Therefore the predistortion coefficients should be correlated with the channel parameters in the self-heterodyne direct conversion system. The objective of this paper is to estimate the discrete channel impulse response (CIR) before eliminating intermodulation products and then derive the predistortion coefficients with regard to both the channel parameters and the receiver nonlinearity. The proposed approach enables the system predistorter to be robust in multipath fading channels.

II. System Model

A simplified block diagram of the baseband-equivalent system for a DCT-based OFDM system is shown in Fig. 1. The serial to parallel block converts an M-ary amplitude shift keying (MASK) input data stream to a block of $N/2$ symbols, which modulate the corresponding subcarriers [6]. After the OFDM modulation is performed by the $N/2$-point inverse discrete cosine transform (IDCT), a symmetric extension is applied to satisfy the cyclic shift properties of the discrete Fourier transform (DFT) in OFDM systems [7]. Next, the cyclic prefix longer than the largest delay spread is inserted to remove the intersymbol interference (ISI). At the receiver the N-point DCT is performed.

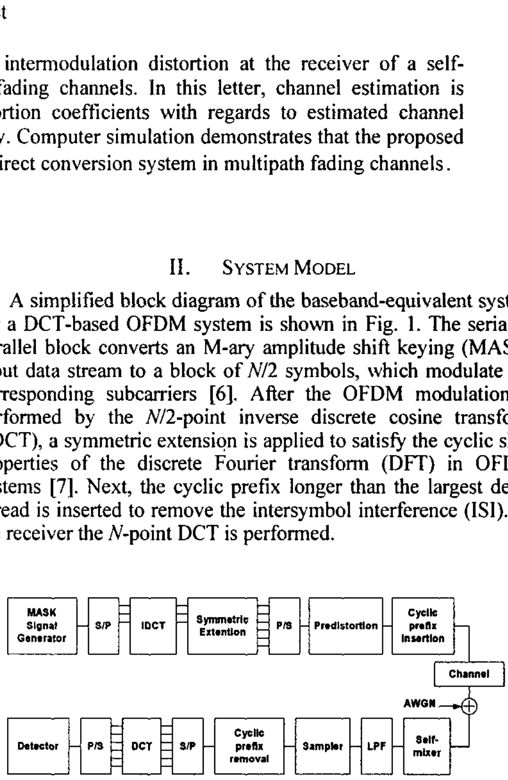

Figure 1. DCT-based OFDM system with digital predistortion

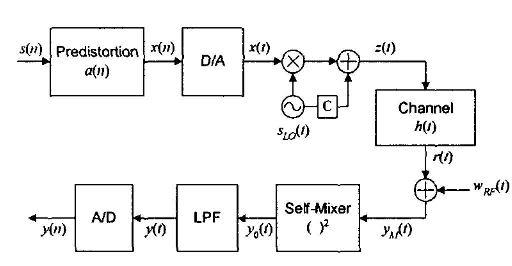

Figure 2. Self-heterodyne system employing direct conversion and predistoter

The self-heterodyne direct conversion model with the predistorter is illustrated in Fig. 2 to consider the channel parameters. Let us describe a baseband predistorter model with input $s(n)$ and output $x(n)$ as $x(n) = a(n)s^2(n) + s(n)$ with a real-valued predistortion coefficient $a(n)$. Here, $x(t)$ is the signal to be transmitted; $s_{LO}(t)$ is the transmit local carrier; $h(t)$ is the impulse response of the multipath fading channel, which is assumed that its