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Channel Shortening Equalizer for Multi-Access TH-UWB in the Presence of Multipath and Multiuser Interference

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Abstract—In this paper a novel channel shortening equalizer (CSE) for time hopping ultra wideband (TH-UWB) multiple access system with pulse position modulation (PPM) is presented. As UWB channels have very long impulse responses as compared to the narrow pulse width, CSE can reduce the number of correlators. In UWB systems, due to the received pulse that is very similar to the channel impulse response (CIR), the proposed algorithm maximizes the shortening signal to inter-symbol and multiuser interferences ratio (SSINR), defined as the ratio of the received signal energy inside the desired window to the energy in the wall and multiuser interference. The existence of the proposed CSE before correlation receiver decreases the complexity of the receiver architecture by significantly reducing the number of effective channel taps. Further we extend our method to derive general expression for the bit error rate (BER) performance in the presence of inter-symbol and multiuser interferences. Computer simulation results are provided to compare the performance of the proposed method with a MSSNR CSE, lower bound, also known as All-Rake, Partial-Rake, and Selective-Rake in terms of Rake operational temporal windows and BER.

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1. INTRODUCTION

Impulse radio (IR) time-hopping (TH) ultra-wideband (UWB) is an emerging technology for high data rate networks over short range multiuser communication [1–4]. For a TH multiple access UWB system, the capability of providing high data rate with relatively low complexity and low power consumption, is the key.

Due to the long channel delay spread, system TH-UWB performances are affected by multiuser interference (MUI), inter-frame interference (IFI) which includes inter-symbol interference (ISI) [5, 6].

Rake receiver is usually adopted through many correlators to increase the received signal-to-noise ratio (SNR) and mitigate the channel fading [6–9]. However, the major consideration in the design of UWB Rake receiver is the number of paths to be combined, since the complexity increases with the number of fingers increase.

Channel shortening equalizer (CSE) [also known as a time domain equalizer (TEQ)] is necessary to deal with the unnecessary signals (both ISI and MUI) and to simultaneously enable the Rake receiver implementation with less number of finger, but still capturing a large proportion of the channel energy [6, 7]. This makes the Rake receiver efficient, simple, realizable and cost effective. CSE forces the effective channel impulse response to be confined within a specified temporal window. CSE have a wide variety of applications. Most of the recent applications of CSE are specifically developed for multicarrier modulation (MCM) system [10–16] to mitigate the ISI produced due to the length of the channel is longer than the cyclic prefix (CP) [13–16].

The CSE is also useful in the TH-UWB system where the number of correlator needed for detection of pulse, can be reduced by shortening the multipath channel [17–20].

In this paper, due to the impulse like pulses used in UWB systems, the received pulse is very similar to the channel impulse response (CIR) [19], we successfully develop a new channel shortening method for TH-UWB systems which introduces the Shortening SINR (SSINR) as the ratio of the received signal energy of the user of interest inside the desired shortened multipath to that outside the desired shortened multipath and the multiuser contribution, so we choose the CSE in order to maximize this SSINR.

The proposed method maintains a simple Rake receiver with a less number of correlators, with short effective channel delay spread, and reduces the manufacturing cost. Therefore, performance of the proposed

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