

Performance and Complexity Evaluation of OTR-UWB Receiver

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ABSTRACT

This article presents a new transmitted reference UWB receiver; which utilizes the orthogonal property of even and odd order derivatives of Gaussian pulses in neighboring chips for synchronization. This system, referred to as orthogonal TR-UWB (OTR-UWB), employs only a single spreading code, which results in much lower mean detection time compared to DS-UWB systems. The hardware complexity for OTR-UWB receiver is significantly reduced against conventional TR-UWB systems. In addition, simulation results show that BER performance is improved, while the new system is capable of supporting higher data rates. Also, this article presents the FPGA implementation of OTR-UWB, with a bit-rate of 25Mb/s without using equalizer. In addition, we present the DSP algorithm of baseband. Hardware of this system is implemented on two different FPGAs from ALTERA and XILINX, CycloneII (EP2C35F672C6) and Spartan 3 (3s4000fg676-5). Gate estimation and power analysis are performed by Quartus II 7.2 (ALTERA) and ISE 8.1 (XILINX) softwares. [Article copies are available for purchase from InfoSci-on-Demand.com]

Keywords: Acquisition; DS-UWB; FPGA; OTR-UWB; UWB

INTRODUCTION

Ultra-wide band (UWB) radio has attracted much more attention as an excellent candidate for various applications own to its appealing feature, such as less complex hardware, low power consumption and high

bit rate, as well as high-precision ranging capability 0. UWB impulse radio operates by transmitting very short pulses with bandwidth about several gigahertzes, illustrating numerous advantages compared to narrowband systems including robustness to multipath fading and potential for achieving

high capacity 0. It's very wide bandwidth, however, poses several design challenges, among which channel estimation and synchronization appear to be the two major ones. At this point, three merged technical approaches, referred to as multi-band orthogonal frequency division multiplexing (MB-OFDM), direct-sequence ultra-wideband (DS-UWB), and time-hopping ultra-wideband are considered as strong candidates for some applications such as ranging, positioning, sensor networks and WPAN standard. The direct-sequence (DS) spread spectrum technique is a well-known and powerful multiple-access technology. Antipodal signaling, such as binary phase shift keying (BPSK), can be employed with DS-UWB and is supported by the current technology. In DS-UWB, multiple pulses are transmitted during one data symbol duration using bipolar modulation based upon a certain spreading sequence. This method has many attractive properties, including low peak-to-average power ratio and robustness to multiuser interference. On the other hand low complexity of DS-UWB is an important advantage of DS-UWB than MB-OFDM. For DS-UWB, which preserves the original UWB pulse nature, due to the short length of the impulse, in the order of nanosecond, one of the tough challenges existed in UWB system is high performance and low complexity timing acquisition. DS-UWB is used with one pseudo random sequence (PN) code for spreading each bit. Transmitted reference (TR) UWB is a DS-UWB system that used two PN codes which it explain in follow.

TR modulation schemes have been proposed because of the ease of channel estimation in a dense multipath environment and the low implementation complexity 0. In TR-UWB systems, the energy in the multipath can be collected by autocorrela-

tion of the received signal and a delayed version of itself. TR-UWB system with DS signaling consists of an *outer* code and an inner code, where the former modulates both the reference and the data pulses, while the latter modulates only the data pulse. The polarity of every alternate received pulse in the product signal depends only on the modulating bit and the inner code. Therefore, given the phase of the inner code, the bit can be demodulated without knowledge of the phase of the outer code 0.

The authors have proposed a new TR-UWB system with BPSK modulation, which employs even and odd derivatives of Gaussian pulse in neighboring chips along with a single spreading code 0. Since the two neighboring pulses are orthogonal, autocorrelation between the received signals with a delayed version of itself approximately gives zero DC. From this, the receiver rapidly acquires chip's timing (coarse synchronization) because the search space is a function of sampling frequency. Then, the system, referred to as orthogonal TR-UWB (OTR-UWB), performs the code acquisition with a search space linearly proportional to code length. Lower search space reduces the complexity of the system by decreasing the number of multipliers, adders, and memories. Therefore, the OTR system illustrates better acquisition performance and higher data rate than that of conventional UWB counterparts.

The reminder of this article is organized as follows. In Section 2, we review some applications of UWB which used characteristics of UWB pulses or standards. The properties of Gaussian pulses are reviewed in Section 3. In Section 4, the OTR-UWB system is described. Section 5 explains and reviews acquisition approaches in UWB communication system. The results of performance analysis and simulation are

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