Dynamics of Continuous, Discrete and Impulsive Systems
Series **B:** *Applications & Algorithms* **12 (2005)** 383-395

A Space-Time-Frequency Coded Multi-Band Ultra-Wideband MIMO System

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Abstract. In this paper we study the system architecture and error performance of space-time-frequency coding when applied to pulse-based multiband ultra-wideband (UWB) systems with multiple transmit and receive antennas for indoor environments. The 7.5GHz UWB spectrum is divided into multiple sub-bands (e.g., 528MHz each), and multiple sub-bands are used for data transmission simultaneously. We design codes that maximize coding and diversity gains for multiple-antenna systems over the frequency selective UWB channels and provide detailed detection and decoding procedures. The proposed multi-antenna multi-band UWB system could dramatically increase link throughput as compared to existing schemes over non-line-of-sight (NLOS) dense multipath channels. In addition, the system offers significant performance gain achieved through diversity in both spatial and frequency domains.

Keywords. Multi-band ultra-wideband systems, multiple-input multiple-output antennas, space-time-frequency coding, indoor wireless channels.

1 Introduction

As an effective method for high-speed wireless data transfer mechanism and location awareness, ultra-wideband (UWB) techniques [1–16, 26] have generated significant research and commercial interest. The FCC has defined UWB as a signaling scheme that occupies at least 500MHz bandwidth with a power density not exceeding -41.25dBm/MHz (for indoor applications) in the 3.1-10.6GHz spectrum. Impulse radio based UWB uses ultra-short-duration pulses, typically a fraction of a nanosecond to a few nanoseconds, for data transmission. UWB systems have many merits including high capacity, interference immunity, and multipath diversity. The high capacity of UWB is by virtue of the large bandwidth, and multipath fading is not severe due to the extremely short duration of pulses (less constructive and destructive additions) and the fine multipath resolution. Because interference immunity is proportional to bandwidth, UWB being a high bandwidth radio has high interference immunity [1]. UWB systems are capable of multiple access with an aggregated transmission rate of hundreds of Mbps at bit error rates of 10^{-4} to 10^{-7} with moderate system complexity [11]. Because of these merits, UWB has been considered to be an excellent choice of low-power low-complexity solution for short-range indoor wireless communications.