PN Code Acquisition for a UWB TH/CDMA System in a MIMO Indoor Wireless Channel

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Abstract: *This paper deals with performance analysis of PN code acquisition for a UWB TH/CDMA system in a MIMO indoor wireless channel. The UWB channel is modeled as frequency selective lognormal fading channel. The acquisition performance is analyzed under the hypothesis of multiple synchronous states in the PN code uncertainty region. The code acquisition performance is evaluated in terms of mean acquisition time when correlator outputs are non-coherently combined by equal-gain combining (EGC) scheme. The results of the paper can be applied to the design of synchronization block of CDMA-based UWB communication systems.*

I. INTRODUCTION

UWB (ultra-wideband) communication systems basically have a number of advantages: low receiver complexity, low implementation cost, low transmission power requirement, robustness to severe multipath, and fine delay resolution property, etc. Therefore, they attracted considerable amount of attention for several commercial communications and military applications [1]. In order to develop UWB applications successfully, one of the most challenging issues is synchronization. In UWB TH/CDMA (time-hopping/code division multiple access) based UWB systems, procedure of PN code synchronization is usually divided into two steps, which are code acquisition for coarse code alignment and code phase tracking for fine alignment [2,3]. In this paper, we focus on initial code acquisition of the UWB signals since it is the first process performed at the receiver and has a great effect on overall system performance.

Typical UWB systems use low signal power and very large signal bandwidth. Moreover, the UWB channel is a dense multipath channel without significant fading [4]. Therefore, the energy of the signal is spread over several paths and the energy of each path is very low. This phenomenon has a detrimental influence on code acquisition of the UWB signals. The paths containing low power are difficult to acquire. So the acquisition system for the UWB signals should properly use the energy contained in the dense multipath. A practical way to acquire the energies of the several paths is to perform diversity combining.

In this paper, we analyze the PN code acquisition performance for a UWB TH/CDMA system in a MIMO indoor wireless channel. This paper tries to investigate the effect of multiple antennas at a receiver and to achieve additional improvement in the performance with the combination of Tx and Rx diversities. It is assumed that there are multiple synchronous cells in the uncertainty region of the PN code. The closed-form formula for performance analysis is derived when the signal with Gaussian distribution goes through lognormal fading channel. The performance is analyzed by deriving formulas for detection probability, false alarm rate, miss detection probability, and mean acquisition time of the proposed system.

The remainder of this paper is organized as follows. section II describes the signal and channel models. Proposed system is described in Section III. In section IV, the proposed system performance is analyzed. In order to analyze the performance, the statistics of the decision variables associated with the EGC (equal gain combining) scheme and the expressions for detection probability, false alarm rate, miss detection probability, and mean acquisition time are derived. The numerical results are presented in section V, and concluding remarks are given in section VI.

II. SYSTEM MODEL

A. Transmitter Signal

We consider an array of M identical transmitting antennas, sufficiently separated in space to eliminate correlation between antenna elements. For a UWB TH/CDMA system using an impulse radio, based on the UWB signal model in [1], the transmitted signal of the u^{th} user from the m^{th} transmitter antenna can be expressed as

$$S_{tr,m}^{u}(t)=\sqrt{\frac{P}{M}}\sum_{j=-\infty}^{\infty}\sum_{k=0}^{N_f}W_{tr}\left[t-(jN_f+k)T_f-\Omega(u,k)T_c-\delta D_j-\tau_m^u\right] \quad (1)$$

where P is the transmitted power. Each antenna's transmit power is reduced to P/M in order that the total transmit power is identical regardless of the