Constant False Alarm Rate Schemes with Receive Diversity for Code Acquisition under Homogeneous Fading Circumstances

Hyoungmoon Kwon*, Taehoon Ahn*, Iickho Song*, and Sun Yong Kim†,
*Department of Electrical Engineering and Computer Science
Korea Advanced Institute of Science and Technology
{kwon, tahn}@Sejong.kaist.ac.kr, i.song@ieee.org
†Department of Electronic Engineering
Konkuk University
kimsy@konkuk.ac.kr

***Abstract*— The performance characteristics of the cell averaging (CA), greatest of (GO), and smallest of (SO) constant false alarm rate (CFAR) processors in homogeneous environment are analyzed and compared when receiving antenna diversity is employed in the pseudonoise code acquisition of direct-sequence code division multiple access systems. From the simulation results, it is observed that the CA CFAR scheme has the best performance and the GO CFAR scheme has almost the same performance as the CA CFAR scheme in homogeneous environment.**

I. Introduction

One of the key units in acquisition receivers is the detector. Among various detectors, an attractive class that can be used under varying channel conditions is the class of constant false alarm rate (CFAR) [1] processing schemes used widely in radar systems. The threshold in a CFAR detector is set on a cell by cell basis using noise power estimated by processing a group of reference cells surrounding the cell under investigation.

In the past decade, the CFAR processors have been applied to code acquisition problems for estimating the variance in one-antenna direct-sequence code division multiple access (DS/CDMA) systems [2], [3]. It has been shown that the one-antenna DS/CDMA systems with cell averaging (CA) CFAR processor performs best in the homogeneous environment. At abrupt change of the variance (for example, when the number of users changes abruptly) or deep fading and shadowing occur, however, the one-antenna DS/CDMA systems with greatest of (GO) CFAR processor has the best performance [3].

Lately, the use of multiple antennas in DS/CDMA systems has been widely recognized as the useful means to enhance the signal-to-noise ratio (SNR) and increase the capacity of the wireless systems [4]-[6]. Several types of systems using multiple antennas have been proposed to exploit the attractive features of multiple antennas in [4], [6]. A number of spatial processing techniques have also been developed and their performance has been analyzed [5], [6]. Nonetheless, the improvement of initial synchronization using multiple antenna has rarely been considered.

In this paper, we incorporate both the modified CA CFAR processors and receiving antenna diversity in the acquisition of pseudonoise (PN) code for DS/CDMA systems. The noncoherent hybrid acquisition schemes are addressed in homogeneous environment and then the performance of the systems is investigated.

II. System Model

Figure 1 shows a hybrid acquisition system with $L \geq 2$ antenna elements. Each antenna element is followed by a bank of M parallel correlators, where $M \geq 3$ is an odd number. The whole uncertainty region of length L_c is divided into M subregions of equal length $L_p = \lceil L_c/M \rceil$, where $\lceil x \rceil$ denotes the smallest integer greater than or equal to x. In any bank each of M parallel correlators, the m-th correlator serially searches all the cells in the m-th subregion as shown in Figure 2. The outputs $\{X_{l,m}\}_{l=1}^{L}$ of the m-th correlators of the L banks are summed to produce

$$U_m = \sum_{l=1}^{L} X_{l,m}, \qquad m = 1, 2, \cdots, M, \tag{1}$$

which are then used as the inputs to the decision processor.

Note that $\{U_j\}_{j=1, j\neq m}^{M}$ are all assumed to be noise, in the m-th hard decision of Figure 3 which shows a block diagram of the decision processor in Figure 1. The threshold TZ_m of the m-th branch is the product of the CFAR output Z_m and the scale parameter T determined to satisfy the false alarm rate P_{FA}. Here, the CFAR output Z_m is obtained by one of the three CFAR processors based on the 'upper' reference branch output $Y_{m,1}$ and 'lower' reference branch output $Y_{m,2}$, where

$$Y_{m,1} = \sum_{\substack{j=1,\\ j\neq m}}^{\frac{M+1}{2}} U_j, \;\; Y_{m,2} = \sum_{j=\frac{M+1}{2}+1}^{M} U_j \;\; \text{for} \;\; m \leq \tfrac{M+1}{2}$$