NEW APPROACH FOR DESIGNING CDMA LINEAR DECORRELATOR DETECTOR

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Abstract

Code Division Multiple Access (CDMA) is a widely used multiple access method in a lot of nowadays vital applications. The systems that are designed based on CDMA are suffering from multiple access interference (MAI) problem [1]. A lot of CDMA detectors are designed to overcome the (MAI) problem. But as the capability of CDMA detector in (MAI) cancellation increases, the complexity of the detector increases too [2]. This paper gives a proposal of a new linear CDMA detector that has the same multiple access interference (MAI) cancellation capability as CDMA decorrelator detector. The structure complexity of this new proposed detector is as simple as the matched filter detector structure. Solving the (MAI) problem in CDMA system with simple detector structure at the receiver helps on increasing the CDMA system capacity. The new proposed detector operation is based on the symmetry property of CDMA signatures' codes cross-correlation matrix.

Keywords

Code division multiple access (CDMA)–multiple access interference (MAI)–matched filter–decorrelator detector–minimum mean square error (MMSE) detector– signature codes correlation matrix.

1. Introduction

Linear CDMA detectors are widely used in CDMA systems' design because the complexity of these detectors is linear with the number of system's users [2]. Matched filter, Decorrelator, and MMSE adaptive filter are examples of these linear detectors. CDMA system is interference limited system where the multiple access interference (MAI) signals from the system users that affect the desired user signal is the most influential factor on the performance of this desired user signal [3]. Matched filter detector is the simplest CDMA detector. It is the optimum receiver of a known signal in AWGN environment [1]. But in CDMA system, the matched filter is not the optimum receive because the power of system's MAI signals is very high at the output of the matched filter [4]. So it can be said that the matched filter is the worst linear CDMA detector in the present of high system interference signals' power. On the other hand, the decorrelator detector is the linear CDMA detector that can completely cancel all MAI signals at the output of the detector [2]. But the decorrelator detector enhances the Gaussian noise power at the detector output. Also, the structure of the decorrelator detector is quiet complex where the detector should know all the signatures' codes of all system users in order to form the detector matrix that represents the inverse of the cross-correlation matrix among the system users' signatures' codes. Another source of complexity is that in decorrelator detector the received signal should first pass through a bank of K matched filters where K is the number of system users. These matched filters are matched to the signature codes of the K users. The matched filters are used to produce a vector of K-users' energies that will be multiplied by the inverse of K×K signatures' codes cross-correlation matrix [5]. From all of that the complexity of decorrelator detector is greater than the complexity of the matched filter detector. The MMSE detector is an adaptive algorithm detector that compromises between the matched filter detector and the decorrelator detector [6]. The MMSE detector minimizes the MAI signals' powers and the noise power jointly at the output of the detector. The MMSE detector needs to know the desired user signature code only. So the structure of the MMSE detector is simpler than the structure of decorrelator detector. But the MMSE detector is still complex with respect to matched filter detector. MMSE detector needs a training sequence in the initiation of the communication link to adjust the MMSE adaptive filter taps. During communication course, the adaptive algorithm is working in decision directed mode to minimize the MMSE between the income signal and the detector output.

Here, a new linear CDMA detector is proposed to approach the performance of the decorrelator detector but with simpler structure as matched filter detector structure. This detector is based on a mathematical observation relating to the symmetry property of the cross-correlation matrix among the CDMA system users' signature codes [7]. This new proposed detector with simpler structure may help in increasing CDMA system capacity by allowing more number of system's users to share the same CDMA system's resources.

The reminder of this paper is organized as follows. In section (2), the mathematical system model is represented. This model helped in understanding the system behavior and the problems that are faced. Section (3) shows the main idea of the new proposed detector. The system structure of the new proposed detector is also represented in this section. The probability of error in the new proposed detector is represents in section (4). This probability of error is compared with the probability of error in the case of matched filter and decorrelator detectors. In section (5), the simulation results of the proposed detector are shown. The simulations results include comparison between the proposed detector and the standard linear CDMA detectors. These comparisons use different two criterions to