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Enhancing noise performance of decorrelator detectors in multiuser systems using pulse position modulation signature codes

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ABSTRACT

Multiuser systems suffer from multiple access interference (MAI) due to the correlations between users signature codes. The decorrelator detector uses the inverse correlation matrix of the signature codes to eliminate the MAI. The major disadvantage of the decorrelator detector is the enhancement of the noise power at its outputs as mentioned in many previous works. This statement is not always true for non-orthogonal correlation matrix. The decorrelator detector can reduce the noise power at its outputs at certain conditions for non-orthogonal correlation matrix. If the sum of the eigenvalues of the non-orthogonal correlation matrix is greater than the sum of the eigenvalues of its inverse, the decorrelator detector will not enhance the noise power at its output. Moreover, the exponential of the determinant of the correlation matrix should be greater than the exponential of the determinant of its inverse. These two conditions are presented and proved in this work. A new family of signatures codes is also proposed to match the proposed conditions for the correlation matrix. The new signature codes are based on pulse position modulation (PPM). The paper shows that the new codes have three degrees of freedom to change the correlation coefficients between them.

1. Introduction

The decorrelator is a linear multiuser detector, which is used to remove interferences among users in multiuser systems. It is usually used with code-division-multiple-access (CDMA) systems [1]. The decorrelator detector completely removes the MAI in multiuser systems [2–4]. Its operation is similar to the zero-forcing equalizer, which removes the inter-symbol interference (ISI) between the received symbols in band-limited channels [5–7]. The decorrelator detector is used after a group of matched filters, which are matched to the signatures codes of the users in CDMA system. Due to the correlations between the signatures codes, the output of each matched filter contains the symbols of its corresponding user, the interfering symbols from the others users in the system, and the channel noise. The noise samples at the outputs of the matched filters are correlated [8]. The decorrelator detector removes the MAI from the outputs of the matched filters if the correlation matrix of the used signatures codes is well known. The decorrelator detector multiplies the output vector of the matched filters with the inverse of the correlation matrix of the signatures codes. The decorrelator detector increases the noise power in the decision variables at its outputs due to the correlation between the noise samples at its inputs. This is the main disadvantage of the decorrelator detector [9,10]. This information is well known in communications literatures. However, it is not always true for any non-orthogonal correlation matrix. In this work, it is proved that the decorrelator detector reduces the noise power at its outputs under specific conditions for the correlation matrix. These conditions are presented and proved in the next section. The proposed conditions represent the rules, which prevent noise-enhancement at the outputs of the decorrelator detector.

The paper also represents a new family of signature codes, which based on PPM. Each code in the new proposed family contains an active part with different position inside the symbol period. The proposed PPM codes use sinc pulses in their constructions. The eigenvalues of the correlation matrix of proposed PPM codes can be varied with three degrees of freedom. They can be changed by changing the width of the first null of the used sinc function, or the width of the truncated sinc function, or the symbol rate. Therefore, the correlations between the new signature codes can be varied to satisfy the deduced conditions for the correlation matrix.

The main work in this paper is organized in three sections. Section 2 shows the noise power at the outputs of the decorrelator detector and the factors affect on it. The proposed conditions for reducing noise power at the outputs of the decorrelator detector are deduced and presented in this section. Section 3 introduces the new proposed family of signature codes. The structure of the new codes is displayed in this section. The mathematical

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