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A simple transmit diversity system for fading channels using shaped sinusoidal functions

A.Y. Hassan

Benha Faculty of Engineering, Benha University, Egypt

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ABSTRACT

This paper proposes a transmit-diversity system using a pair of orthogonal pulses. The system uses a set of orthonormal-basic functions, which contains four shaped-sinusoidal pulses with the same frequency. The first two elements in the set are shaped sine and cosine pulses. The second two elements are the same sine and cosine pulses but they are shaped with the Hilbert transform of the shaping pulse of the first two elements. The modulator in the proposed system produces two modulated symbols for each data symbol. It uses the first two elements in the proposed set in modulating the first modulated symbol and the second two elements in modulating the second modulated symbol. The modulated symbols are transmitted though two antennas. The diversity order of the proposed system is twice the number of antennas in the receiver. In the proposed system, no space-time coding is used and the channel gains change every symbol period. This is different from the Multiple-Input-Multiple-Output (MIMO) system. The receiver of the proposed system consists of two matched filters for each receiving antenna. No special detectors or interference cancelation techniques are used because there is no interference between the outputs of the matched filters.

1. Introduction

Diversity is used in communication system to enhance the performance through fading channels. Diversity may be done through time, frequency, and space. In last decade, space diversity got a great interest. In space diversity, the modulated symbols are transmitted through different antennas and they are received using one or more antennas. Several antennas provide a receiver with multiple replicas of the same signal. Each replica experiences a different interference environment. Therefore, if one replica experiences a deep fade, it is probably that another has a sufficient energy [1,2]. Combining techniques are used to combine the signal energies from different fading paths to form one decision variable to the detector.

MIMO system is the famous space diversity system. It is used in many communication standards such as WI-FI (IEEE 802.11), HSPA +, WiMAX, and LTE [3,4]. MIMO systems use space-time codes to prevent interference between the transmitted symbols at the receiver. If a MIMO system uses N_T transmitting antennas and N_R receiving antennas, the maximum diversity gain will be $N_T \times N_R$, and the maximum spatial multiplexing rate will be min (N_T, N_R) [5–9]. MIMO systems have two disadvantages. MIMO system assumes that the channel is static or quasi-static. This means that the channel gains are constant over a block of M modulated symbols, where M is the number of symbol periods for transmitting one block of coded MIMO symbols. This condition is unattainable in dynamic channels, whose gains change every symbol period. The second disadvantage is the system complexity. Space-time encoder increases the complexity of the transmitter, and space-time decoder and the interference cancelation unit increase the complexity in the receiver.

The system, which is proposed in this paper, achieves the same diversity gain and spatial rate as the diversity system presented by Alamouti in [10]. Alamouti assume that the channel gains are constant during two successive symbols interval. On the other hand, the proposed system assumes that the channel gains vary every symbol period. The transmitter of the proposed system is simpler than the transmitter of Alamouti's system, because no space-time encoder is used in the transmitter of the proposed system. The proposed system uses two orthogonal shaping pulses to modulate each transmitted symbol. The two modulated symbols are transmitted simultaneously through two independent antennas. On the receiver, no more than two matched filters are needed to detect the received symbols from each antenna. The proposed system uses no space-time decoder or interference cancelation block. The orthogonality between the used shaping pulses prevents inter-

E-mail address: Ashraf.fahmy@bhit.bu.edu.eg

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