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A time diversity scheme with multi-symbol detector for data transmission through flat fading Rayleigh channels

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ABSTRACT

In this work, a new time diversity scheme is proposed to achieve time diversity in flat fading channels without affecting the data transmission rate. The conventional time diversity system reduces the transmission rate of the modulated symbols by a factor equal to the time diversity order. However, in the proposed time diversity system, any required time diversity order is achieved without reducing the transmission rate of the modulated symbols. In the proposed system, a diversity encoder maps vectors of N modulated symbols to vectors of N diversity symbols. By transmitting the diversity symbols, each modulated symbol is transmitted N times through N successive periods. Therefore, a time diversity with order N is achieved without affecting the modulated symbols rate since the transmission rate is N symbols per N channel uses. In the receiver, the outputs of a matched filter during the diversity period are stored in a buffer of length N. After filling the buffer, its contents are multiplied with the conjugate of the fading matrix. Multi-symbol detector removes interferences among the modulated symbols in the decision vector. It applies the algorithm of the diversity decoder and combines the corresponding received symbols to estimate the modulated symbols. The noise samples in the decision vector of the multi-symbol detector are uncorrelated. Maximum likelihood and linear decorrelator detectors are used as multi-symbol detectors. The performance of the proposed system is the same as the performance of the N channels diversity system with maximal ratio combiner receiver.

1. Introduction

Channel fading is a big problem in wireless communications. Channel fading reduces the received signal to noise ratio (SNR). It also distorts the transmitted signal causing inter-symbol interference (ISI) among the received symbols. Signal diversity is used to provide the receiver with different copies of the transmitted symbols. The receiver uses these copies with a proper signal-combining scheme to increase the received SNR [1,2]. Signal diversity is usually done through time, frequency, and space. In time diversity, the modulated symbol is transmitted through different time slots. Time diversity increases the reliability of the communication system, but it reduces its spectrum efficiency [3,4]. In a frequency diversity system, the modulated symbol is sent through different carrier frequencies. Frequency diversity saves the transmission rate, but it increases the transmission bandwidth and reduces the spectrum efficiency of the communication system too [5,6]. In space diversity, different transmitting antennas and different receiving antennas are used to send and receive the modulated symbols. Space diversity does not reduce the transmission rate or increase the transmission bandwidth. However, it introduces interference among the transmitted symbols [7,8]. Space–time codes are used in the transmitter to guarantee orthogonality among the transmitted symbols in time and spatial domains [9,10]. Special detectors such as sphere detector and QR-detector are used in the receiver to detect the transmitted symbols without interferences [11,12]. Space–time codes complicate the transmitter and the receiver structures, but it saves the spectrum efficiency of the system. In spread spectrum systems, spreading codes may be used to achieve signal diversity. This scheme is called code diversity. Code diversity is used with time diversity to achieve full signal diversity in fast fading channels and to save the transmission rate of the modulated symbols [13]. In [14], a special scheme of signal diversity is introduced using orthogonal shaping pulses. This diversity system achieves transmit diversity of order two without using space–time codes.

In this paper, a new time diversity system is proposed to enhance signal transmission through flat fading channels. Some factors give us the motivation to work on this proposal. The first factor is the power consumption in the transmitters of space diversity systems. The proposal in this paper aims to reduce the power consumption in the transmitter by using one transmitting antenna with one driving circuit. Using multiple antennas in the transmitter requires a separate RF driving circuit for each antenna. The power consumption of these circuits is not trivial [15–

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