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A Frequency-Diversity System With Diversity Encoder and OFDM Modulation

ASHRAF Y. HASSAN
Benha Faculty of Engineering, Benha University, Benha 13512, Egypt
e-mail: ashraf.fahmy@bhit.bu.edu.eg

ABSTRACT In this work, a diversity encoder maps vectors of N modulated symbols to vectors of N diversity symbols using an orthogonal matrix. Each modulated symbol appears in N diversity symbols. An Orthogonal-Frequency-Division-Multiplexing (OFDM) modulator converts the diversity vectors to OFDM symbols. The number of subcarriers in the OFDM symbol equals N. Each diversity symbol modulates one subcarrier; therefore, each modulated symbol is transmitted by N orthogonal subcarriers. The diversity bandwidth of the modulated symbols is N times the subchannel bandwidth. The modulated symbols experience independent fading gains on each subchannel since the diversity bandwidth (OFDM bandwidth) is chosen to be multiple of the coherence bandwidth of the transmission channel. In the receiver, an OFDM demodulator converts back the OFDM symbols to vectors of diversity symbols. The diversity detector maps the diversity vectors to vectors of modulated symbols. The noise samples at the output of the diversity detector are uncorrelated. Maximum likelihood and linear decorrelator detectors are used as diversity detectors. The transmitter and the receiver of this work are implemented using Field-Programable-Gate-Array (FPGA) technology. The performance of the implemented system is the same as the performance of the N channels diversity system with the Maximal-Ratio-Combiner (MRC) receiver.

INDEX TERMS Frequency diversity, orthogonal-frequency-division-multiplexing, frequency selective fading channels, maximal-ratio-combiner, maximum likelihood detector, linear decorrelator detector.

I. 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 in time, frequency, and space. In time diversity, the modulated symbol is transmitted in different time slots. Time diversity increases the reliability of the communication system, but it reduces its spectrum efficiency [3], [4]. In frequency diversity, the modulated symbol is sent on 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 are 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 article, a frequency-diversity system is implemented to enhance signal transmission in frequency-selective fading channels. In the system used, bandwidth expansion does not occur due to signal diversity. The system in

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