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Title of the Thesis ----- Design and Analysis of MMSE Decision Feedback Equalizer for Wideband CDMA

Abstract

In recent times, there has been a lot of interest in integration of voice, data and video traffic in wireless mobile communication networks. Further, to satisfy ever-increasing demands for higher data rates as well as to allow more users to simultaneously access the network, there has been a lot of interest in wideband code division multiple access (WCDMA). Thus, with the all these growing interests, wideband code division multiple access (WCDMA) has immerged as an attractive access technique. The performance of WCDMA system is deteriorated in presence of multipath fading environment. The thesis presents design and analysis of minimum mean square error (MMSE) decision feedback equalizer (DFE) for wideband code division multiple access (WCDMA) in a frequency selective channel using various approaches. In each approach, the filter coefficients in MMSE DFE are optimized to suppress noise, intersymbol interference (ISI), and multiple access interference (MAI) with reasonable system complexity. Firstly, we present the intersymbol interference characteristics of bandwidth constrained communication channel. Then we design a Simulink model to analyze the performance of various equalizers under different channel conditions and also formulate the signal models for various traditional receivers for WCDMA. The performance evaluation of MIMO space-time coded wireless communication systems has also been discussed. After that the work includes the design of the DFE when there is no diversity. It is called one-dimensional (1-D) MMSE DFE. Then, we design and analyze an interference cancellation based MMSE DFE with various transmit diversity approaches for WCDMA downlink channel. This design makes use of transmit diversity in the form of space-time spreading and Alamouti approaches at the transmitter end. Finally, we have designed and analyzed MMSE DFE with space-time processing and signature waveform matched filter in WCDMA downlink channel. For all the above structures, we have presented the estimation of Bit Error Rate (BER) for a MMSE DFE using computer simulation experiments. The simulation process takes into consideration the effects of interference which includes additive white Gaussian noise, multipath fading, intersymbol interference (ISI) and multiple access interference (MAI). Furthermore, the performance is compared with standard adaptive linear equalizer (LE) and rake receiver. Numerical and simulation results show that the MMSE DFE exhibits significant performance improvement over the standard adaptive linear equalizer (LE) and rake receiver and hence improves the system capacity.

Findings

The thesis presents design and analysis of minimum mean square error (MMSE) Decision Feedback Equalizer (DFE) for wideband code division multiple access (WCDMA) in a frequency selective channel using various approaches. This thesis is organized into eight chapters. In chapter 2, we have discussed about intersymbol interference characteristics of bandwidth constrained communication channel. From simulation curves, it is obvious that the choice of a suitable value for the step-size parameter involves making a compromise between fast tracking and reducing the excess mean-square error. Chapter 3 gives a Simulink model to analyze the performance of various equalizers under different channel conditions Through Simulink model, the performance using linear transversal equalizer and that using non-linear decision feedback equalizer (DFE) is compared in wireless communications. Chapter 4 presents design and analysis of one dimensional (1-D) minimum mean square error (MMSE) decision feedback equalizer (DFE) for wide band code division multiple access (WCDMA) system in a wireless Rayleigh fading environment. Bit error rate analysis of the system illustrates significant improvement in capacity. The optimum performance and BER results show the capabilities of this receiver in minimizing the effects of interference, multipath fading, and AWGN in a slow acting power control environment. Chapter 5 presents performance evaluation of MIMO space-time coded wireless communication systems. Space-time codes employ redundancy to minimize the effects of fading, noise and interference. In a space-time block code, transmission of the signal takes place in blocks. The computer simulation compares the bit error rate (BER) performance of coherent binary PSK over an uncorrelated Rayleigh-fading channel for three different schemes. From simulation results, it is obvious that the performance of the Alamouti code is worse by about 3dB, compared with the maximal-ratio combiner. This 3-dB penalty is attributed to the fact that, in the space-diversity-on-transmit scheme using the Alamouti code, the transmit power in each of the two antennas is one-half of the transmit power in the space-diversity-on receive scheme using the maximal ratio combiner. Chapter 6 presents the design and analysis of an interference cancellation based MMSE DFE with various transmit diversity approaches for WCDMA downlink channel. It has been shown that the proposed method can restore the orthogonality on downlink channel and suppress multiple access interference (MAI). In comparison with the rake receiver equipped with multiple antennas, the proposed method not only provides antenna diversity gain, but also suppresses multiple access interference (MAI), while the rake receiver can only have antenna diversity gain. Hence, the proposed method can offer significant improvement in performance and capacity. Chapter 7 presents the in-depth design and analysis of a minimum mean-square error (MMSE) decision feedback equalizer (DFE) with space–time processing and signature waveform matched filter for WCDMA downlink channel to achieve better performance than the adaptive linear equalizer (LE) and a RAKE receiver in a frequency selective channel. According to simulation curves, a MMSE DFE outperforms an adaptive LE and a RAKE receiver for the large number of users and also when BER is compared with respect to the E_b/N_o values. This happens because a MMSE DFE suppresses interference more efficiently compared to an adaptive LE and a RAKE receiver. It is also concluded that the structure of a MMSE DFE with space-time processing and signature waveform matched filter, when compared to other schemes of similar complexity, provides a reasonable balance between noise, ISI and MAI. Thus, this scheme works well when any of these three problems dominates. As a whole, it is concluded that, in a wireless system, equalization, diversity, and STBC coding can be used together to boost the received signal quality and link performance.