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Equalizer Design For Wireless Communications

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Abstract

As the speed of communication systems increases into the gigabits per second range, new applications such as high definition video streaming and real time imaging systems become feasible in an indoor environment. Wireless transfer rates for these applications are far in excess of what can be accommodated in the currently used bands at 2.4 GHz and 5.2 GHz. An obvious solution is to resort to the newly opened millimeter wave bands. Unfortunately 60 GHz systems exhibit many challenges that have made them difficult to deploy [8]. One of these challenges is the severe frequency selective fading due to multiple path reflections. To recover the transmitted signal from the effects of fading, a carefully designed channel equalization scheme must be deployed at the receiver. For systems with multi-gigabit per second transmission rates, the heating of the components is a crucial factor for circuit design. Because the analog circuits have higher power efficiency than digital signal processing (DSP), people are looking for solutions to use continuous time signal processing technology for very broadband signals.

In the first part of this dissertation, we propose two "semi-analog" channel equalizer designs for communications at multi-gigabit per second data rate. The first equalizer is designed from frequency domain. We propose a stable equalizer whose Laplace transform is close to the ideal equalizer except for some constant group delay. The second equalizer is designed from time domain analysis. It targets at the multipath channel and recovers transmitted signal by removing all the reflected ones from the received signal.

In the second part, a continuous time Kalman filter-based simple smoother is discussed to recover the transmitted data sequences. Although the continuous time Kalman filter is designed for Additive white Gaussian noise only, we propose a new dynamic system under this environment which has the same performance as the matched filter. This provides more flexibility for system design.

In the latter part of the dissertation, we propose a novel blind equalizer design. Adaptive equalization generally requires an initial training period during which a known data sequence is transmitted. However in wireless communications, channel changes very frequently, which makes it impractical or impossible to send a training sequence. Blind equalization is an essential technique to remove the intersymbol interference introduced by the channel when training sequence is unavailable. Our approach is quite different from traditional stochastic gradient descent algorithm. We use eye diagram technique and Viterbi decoding algorithm to recover the transmitted data sequences without knowing the data transmission rate.