Abstract

The purpose of a communication system is to transfer information between two separate points over some medium in the presence of disturbances or distortions such as noise and dispersion. This distortion is manifested in the time domain as pulse dispersion and is labeled as Inter-Symbol Interference (ISI). As data rates increase in modern digital communication systems, ISI becomes an inevitable consequence of the dispersive nature of band-limited propagation channels. The receiver must include an equalizer to mitigate the effects of ISI. The function of the equalizer is to combat the ISI and to utilize the available spectrum most efficiently. Equalizers are cascaded to almost all kinds of channels, right from telephone lines to radio and optical fiber channels, to make the channel performance optimal. Ideally, an equalizer, when cascaded to the end of a channel, will make it behave like an ideal channel, the one which will not distort the signals in any manner. In the case of mobile cellular channels, which are generally considered to be Linear Time Variant (LTV), the design of equalizers is not a trivial problem. Moreover, the above said channel has certain uncertainties in its behaviour, which need to be tackled in the equalizer design. The Co-Channel Interference (CCI) due to frequency reuse and Adjacent Channel Interference (ACI) due to spectral leakage, both contribute to the reduction in overall Signal-to-Interference-Noise-Ratio (SINR) in mobile cellular channels.

In applications in which the Channel Impulse Response (CIR) is unknown and no training sequence is available, the equalizer must be computed/updated blindly from the received signal and knowledge of the statistics of the data source alone. A common approach in continuous transmission systems is to blindly update a Linear Equalizer (LE) using the Constant Modulus Algorithm (CMA), and then switch to a Decision Directed (DD) mode when the Symbol Error Rate (SER) is low enough.

The modeling and simulation of mobile cellular channels have been successfully carried out by several researchers. Various interference patterns including Ricean/Rayleigh fading, co-channel and adjacent-channel interferences can be found in literatures. This work is intended to model the mobile cellular channel used in an indoor environment, where the channel can be taken to be of slow fading type. The study is focused to consider the noise contributions from various sources, when they fall within the spectrum of the frequencies used in cellular telephony, and then to design an equal-
izer which will mitigate the noise present, due to CCI and ACI. When the channel over which data is sent is unknown, which is common, one must employ adaptive equalization. The Decision Feedback Equalizer (DFE) is one such adaptive equalizer. It is known that DFE generally outperforms LE for the same hardware complexity. Further, as it is indicated earlier, when the channel characteristics show Rayleigh/Ricean fading (due to the presence of multipath), Adjacent Channel Interference (ACI) and Co-Channel Interference (CCI), realization of equalizers based on neuro-fuzzy techniques seems to be most appropriate option for the mobile cellular channel.

Linear space-time equalization is shown to be effective in coping with the complicated propagation conditions for wireless broadband communication in an industrial indoor environment. This is demonstrated by realistic simulations that use real channel sounder for modeling the influence of the radio channel. Industrial indoor environments like large factory halls show typically a complicated radio channel because of the presence of many reflecting objects. This results in wide delay spreads and a considerably changing channel for a moving mobile unit. There exist a number of options to overcome the difficulties of heavy multipath propagation.

In this work, the issues in the design of the neuro-fuzzy channel equalizer to null the effects of fading are investigated. One of the objectives of this work is, to establish the fact that, within an acceptable bound, the mobile cellular channel is Linear Time Variant (LTV). Another major objective of the work is to investigate the suitability of neuro-fuzzy models as applicable to the analysis and design of mobile cellular channel equalizers. Three solutions to the channel equalizer problem are investigated in this work. First, a type-2 Fuzzy Adaptive Filter (FAF) for the above purpose is considered. Simulations show that it performs better than a type-I FAF or Neural Network Classifier (NNC) equalizer. Then the use of Adaptive Network Based Fuzzy Inference System (ANFIS) based equalizer is investigated. Lastly, a Compensatory Neuro-Fuzzy Filter (CNFF) for channel equalization is considered. Subsequently, an attempt is made to bring the various equalizer realizations in the study under the generic framework of radial basis function (RBF) neural network. Further to this, a novel modular approach for the simulation and design of equalizers for Non-Linear Time-Variant (NLTV) channels is aimed. A suitable model for Ultra-Wide Band (UWB) channel and its equalization is the last goal.

The contributions of this work are, the establishment of the fact that, the mobile cellular channel can indeed be modeled as a Linear Time-Variant channel, in general, with a Rayleigh distribution for the channel coefficients. It is shown that FAF, CNFF, and ANFIS based equalizer are capable of achieving desired SNR in presence of CCI and ACI. It is also shown that the channel equalizers based on type-2 FAF, CNFF, and ANFIS could be brought under the generic framework of Radial Basis Function (RBF) Neural Networks. A detailed performance evaluation of the equalizers is made. And, fi-
nally a modular approach for the simulation and modeling of Non-Linear Time-Variant (NLTV) channels is proposed. In the beginning it was mentioned that the mobile channels are considered to be LTV. However, when the transmitter stages are driven to their non-linear regions, the channel need to be modeled as Non-Linear (to account for the non-linearities thus introduced to the transmitted signal) and Time-Variant (NLTV). The modular approach in combating ISI is to cascade an adaptive non-linear preprocessor filter and linear adaptive equalizer, which simplifies the equalizer design. It is also shown that the ANFIS model can be successfully adapted to equalization of UWB channels.