Chapter 5

Blind Equalization for Broadband Access using the Constant Modulus Algorithm

Mark S. Leeson
University of Warwick, UK

Eugene Iwu
DHL Supply Chain, UK & Ireland Consumer Division, Solstice House, 251

ABSTRACT

The cost of laying optical fiber to the home means that digital transmission using copper twisted pairs is still widely used to provide broadband Internet access via Digital Subscriber Line (DSL) techniques. However, copper transmission systems were optimally designed for voice transmission and cause distortion of high bandwidth digital information signals. Thus equalization is needed to ameliorate the effects of the distortion. To avoid wasting precious bandwidth, it is desirable that the equalization is blind, operating without training sequences. This chapter concerns the use of a popular blind adaptive equalization algorithm, namely the Constant Modulus Algorithm (CMA) that penalizes deviations from a fixed value in the modulus of the equalizer output signal. The CMA is set in the context of blind equalization, with particular focus on systems that sample at fractions of the symbol time. Illustrative examples show the performance of the CMA on an ideal noiseless channel and in the presence of Gaussian noise. Realistic data simulations for microwave and DSL channels confirm that the CMA is capable of dealing with the non-ideal circumstances that will be encountered in practical transmission scenarios.

INTRODUCTION

It is widely recognized that broadband access to the Internet has implications beyond the communication technology. In addition to the growing number of government and other services accessible on line, it is believed that advanced communication capabilities play a role in increased economic growth (Paltridge, 2001). The average
penetration of fixed broadband services in the EU had reached almost 22% in July 2008 but this hid a range from over 37% in Denmark to less than 10% in Bulgaria (European Commission, 2008). There was also a gap between urban and rural areas with the latter running at typically half the value found in the former (Falch & Henten, 2009). Continued growth in demand and desires to increase social inclusion mean that growth in broadband access is likely to continue for the foreseeable future. Given the economic realities of installing optical fiber cables to reach millions of homes (Koonen, 2006) it is likely that fast digital transmission will be via copper twisted pairs using Digital Subscriber Line (DSL) technologies. The family of xDSL-techniques, where “x” is commonly H for High Rate, A for Asymmetric or V for Very High Rate, allows fast implementation of many new digital services without changing the transmission medium. The growing demand for high speed digital services ensures that xDSL technologies will continue to be the favorable bridge to high speed backbone optical networks for many years to come (Walkoe & Starr, 1991).

A major drawback for xDSL technologies is that these copper transmission systems were optimally designed for voice transmission. When such systems are used to transmit high bandwidth information signals distortion, interference and attenuation occur. In digital communications, a critical manifestation of distortion is inter-symbol interference (ISI), whereby symbols transmitted before and after a given symbol corrupts the detection of that symbol.

Equalization

Since ISI is a problem that is common to many communication channels, its removal has formed and continues to form a subject of major interest and research. To restore a sequence of received symbols distorted by an unknown system to those that were transmitted is the purpose of equalization (Qureshi, 1985). In the sense understood in recent times, equalization began with the use of linear prediction by Wiener (Makhoul, 1975) and has since found wide application in many fields. Linear channel equalization is often utilized to ameliorate the effects of linear channel distortion and can be considered to be the application of a linear filter (the equalizer) to the received signal (Proakis & Salehi, 2007). The equalizer attempts to estimate the transmitted symbol sequence by counteracting the effects of ISI, thus improving the probability of correct symbol detection. Since channel characteristics change over time the equalizer has to be adaptive in structure, usually involving the use of training signals known in advance by the receiver. The receiver then adapts the equalizer, for example via a least mean square (LMS) approach (Haykin, 2001), so that its output closely matches the known reference (training) signal.

Fractionally Spaced Equalizers

By the early 1970s equalizers with a tap spacing of less than the symbol rate had been implemented, and these have become known as fractionally spaced equalizers (FSEs) (Gitlin & Weinstein, 1981). Standard communication theory indicates that the best receiver for a linear modulation channel is a filter matched the channel followed by a $T$-spaced equalizer, where $T$ denotes the symbol duration. (Forney, 1972). The use of an FSE offers the chance to synthesize the characteristics of an adaptive matched filter and a $T$-spaced equalizer in a way that is not possible using symbol rate sampling with the constraints of filter length and delay (Qureshi, 1985). Sampling at the symbol rate causes aliasing with constructive or destructive interference between the overlapping components. As a result, changes in the sampler phase produce variations in amplitude and phase characteristics in the overlapping regions. This means that the minimum mean squared error (MSE) achieved by a $T$-spaced equalizer depends on the sampler phase. Using fractional spacing on the other hand does not produce spectral overlap and greatly
Related Content

**Detecting Corners for 3D Objects**
[www.igi-global.com/chapter/detecting-corners-objects/77046](www.igi-global.com/chapter/detecting-corners-objects/77046?camid=4v1)

**Counting People Using Blobs and Contours**
[www.igi-global.com/article/counting-people-using-blobs-and-contours/87247](www.igi-global.com/article/counting-people-using-blobs-and-contours/87247?camid=4v1)

**A Holistic Approach for Handwritten Hindi Word Recognition**
[www.igi-global.com/article/a-holistic-approach-for-handwritten-hindi-word-recognition/177201](www.igi-global.com/article/a-holistic-approach-for-handwritten-hindi-word-recognition/177201?camid=4v1)

**Performance Analysis of Anisotropic Diffusion Based Colour Texture Descriptors in Industrial Applications**