Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 104 (2017) 429 – 436

Procedia Computer Science

ICTE 2016, December 2016, Riga, Latvia

Enhanced Decision Adjusted Modulus Algorithm for Blind Equalization

Deniss Kolosovs[a,b,]*, Albert Zelenkov[b], Aleksandrs Jersovs[b]

[a]*Institute of Radioelectronics, Riga Technical University, Azenes st. 12, Riga, Latvia*
[b]*SAF Tehnika JSC, Ganibu dambis st. 24a, Riga, Latvia*

Abstract

A new Enhanced Decision Adjusted Multimodulus Algorithm (EDAMA) for blind equalization is proposed in this article. It is based on ensuring of minimal detection error probability. This algorithm is characterised by smaller steady-state error than Constant Modulus Algorithm (CMA).A comprehensive theoretical description of the optimisation method is provided. EDAMA, CMA and other equalization algorithms comparative test result are appended.

Peer-review under responsibility of organizing committee of the scientific committee of the international conference; ICTE 2016

Keywords: Blind equalization; Cost function; Optimal decision; Enhanced decision adjusted multimodulus algorithm

1. Introduction

Despite of an enormous popularity growth of various new communication standards in recent years notorious Quadrature Amplitude Modulation (QAM) concept still remains widely used. Particular widespread is obtained in high capacity channel for example in radio relay lines. In case of such transmission technique one of the main phenomena that causes received signal degradation is a multipath fading. Channel equalization is a signal processing operation that aims to mitigate fading effects. Typically the most complex and therefore significant phase of equalization process is an initial acquisition stage. The simplest way to perform it is a usage of training sequences. If it is impossible or undesirable to use training pattern the only way of solving this problem is blind equalization.

* Corresponding author. Tel.: +371-27528148.
E-mail address: deniss.kolosovs@saftehnika.com

Peer-review under responsibility of organizing committee of the scientific committee of the international conference; ICTE 2016
doi:10.1016/j.procs.2017.01.156

Originally the fundamental principles of the blind equalization concept were formulated by Y. Sato[1] during development of theory for Pulse-Amplitude Modulation (PAM). Later his ideas had been generalized by D. N. Godard[2] who formulated a method of QAM signal equalization commonly known as CMA algorithm[3]. As it is shown[4], CMA algorithm steady-state error is not equal to zero even in case of ideal equalization. Therefore there were numerous attempts to overcome this CMA drawback. An approach that should be mentioned in this context is an introduction of decision based cost function. One of the first algorithms that applies this technique is Decision Adjusted Modulus Algorithm (DAMA)[5]. Unlike CMA this algorithm ensures much lower residual error level but significantly concedes in the ability of acquisition. So, its further occurrence in the literature is not wide. Later other algorithms were proposed to replace CMA[4,6], however they aimed to improve CMA rather than develop DAMA. This paper authors propose an optimized version of DAMA is proposed in this paper.

2. Constant modulus algorithm

Fig. 1 presents typical QAM transmission model block diagram in case of multipath fading.

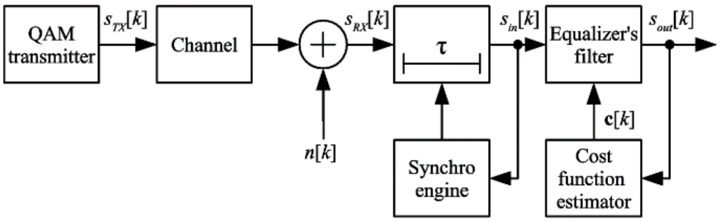

Fig. 1. QAM transmission system block diagram. $s_{TX}[k]$ – transmitter's output signal formed by Nuquist RRC filtering of QAM symbols flow with desired baud rate; $s_{RX}[k]$ – QAM receivers input signal, corrupted by multipath fading and AWGN in transmission channel; $s_{in}[k]$ – input signal of equalizer retrieved from timing synchronization block, which provides data symbol localization inside received samples flow; $s_{out}[k]$ – output signal of equalizer with removed intersymbol interference (ISI).

An equalizer is a finite impulse response filter with variable coefficients $\mathbf{c}[k]$. The equalizer's output signal $s_{out}[k]$ is passed to the cost-function evaluation block that forms coefficient $\mathbf{c}[k]$ correction for the next symbol. The cost function definition determines the differences between various equalization algorithms.

In case of CMA coefficient adjustment is based on the stochastic gradient calculation for the following cost function:

$$J[k] = E[(|s_{out}[k]|^2 - R_{CMA}^2)^2] \tag{1}$$

where dispersion constant $R_{CMA}^2 = E[|a|^4]/[|a|^2$ is derived from the constellation structure (a — constellation point position). Evaluation of stochastic gradient for a given cost function yields to:

$$\mathbf{c}[k+1] = \mathbf{c}[k] - \mu \frac{\partial J[k]}{\partial \mathbf{c}^*[k]} = \mathbf{c}[k] - \mu s_{out}[k][R_{CMA}^2 - |s_{out}[k]|^2]\mathbf{s}_{in}^*[k], \tag{2}$$

where μ — is an equalizer's weights step-size parameter that controls convergence speed. The fact that $s_{out}[k] = \mathbf{c}[k]\mathbf{s}_{in}^T[k]$ is also used for gradient calculation.

3. Decision-adjusted multimodulus algorithm

DAMA algorithm introduction aimed to reduce residual error. In case of CMA expression $R_{CMA}^2 - |s_{out}[k]|^2$ is not zero even for ideal equalization. This will continuously produce misadjustments of the equalizer. To get rid of this problem[5] authors propose to use multiple dispersion constants, equal to squared radii of the constellation points. Assume there are points of N different radii in the constellation. Cost function of DAMA in this case is: