ON THE DESIGN OF ROBUST ORTHOGONAL ADAPTIVE DECISION FEEDBACK EQUALIZERS FOR UNCERTAIN DISPERSIVE CHANNELS

P. D. DOÑATE[†], C. MURAVCHIK[‡] and J. E. COUSSEAU[†]

[†] *Dto. de Ing. Eléctrica y Computadoras, Univ. Nac. del Sur, 8000 Bahía Blanca, Argentina*
pdonate@criba.edu.ar
[‡] *Fac. de Ing., Univ. Nac. de La Plata, 1900 La Plata, Argentina*
carlosm@ing.unlp.edu.ar

***Abstract*— This paper presents the theoretical aspects of a methodology for the design of robust orthogonal adaptive decision feedback equalizers. The dispersive transmission channel is assumed to have a transfer function type of description with small uncertainties in the parameters. A decision feedback equalizer is designed minimizing a mean square error objective function that takes into account the uncertain description of the channel. The equalizer is conceived with an orthogonal basis structure, so that the basis parameters inherit the robustness properties of the design to parameter perturbations. Adaptation of the coefficients that linearly combine the basis elements is also considered and the development of the adaptation algorithm is included. The resulting equalizer has a very flexible, modular and easy to implement structure. An example with comparisons of performance with FIR designs is included.**

***Keywords*— Communications, Uncertainty modeling, Equalization, Robust Filtering**

I. INTRODUCTION

Channel equalization is nowadays an unavoidable signal processing procedure to apply if high-speed communication over severely band limited channels is to be established. This is particularly true when we are dealing with the transmission of digital information over copper wire lines such as in Digital Subscriber Line systems (xDSL). The lack of shielding, minimum conditioning and narrow bandwidths are the reasons for the heavy intersymbol interference (ISI) present in these channels (Starr *et al.*, 1999; Bingham, 2000). Linear Equalization (LE) and the more efficient Decision Feedback Equalization (DFE) are effective methods of reducing the ISI and constitute a good tradeoff between computational cost and performance (Belfiore and Park, 1979; Cioffi *et al.*, 1995).

The design of the equalizer relies in the a priori knowledge of the channel characteristics that can be materialized in a mathematical model. This model will normally represent a compromise between good practical representation of measured effects and mathematical tractability.

This paper presents a design procedure for an orthogonal adaptive DFE. The design requires good knowledge of the transmission channel, with a transfer function type of model, of known order but allowing the existence of small uncertainty in the parameters. The uncertainty is described from a statistical point of view and the design minimizes a mean square error objective function. This approach follows the lines of work of Sternad and Ahlén (1990, 1993) and Chen and Lin (1996). An orthogonal structure is then considered for the implementation of the DFE and a coefficient updating algorithm is developed based on this representation.

The paper is organized as follows. Section II introduces some notation, gives a description of the equalization problem and presents the channel model. Section III deals with the design procedure. Section IV, presents the implementation structure using orthogonal functions. Section V describes the development of an updating algorithm and an example is presented in Section VI. Finally, some conclusions are drawn in Section VII.

II. EQUALIZATION PROBLEM AND CHANNEL MODELING

Figure 1 shows the usual structure of a DFE. The random uncorrelated symbol sequence $a(k)$ of variance σ_a^2 is dispersed in time by the channel $H(q^{-1},\alpha)$ and is corrupted by noise. $D(q^{-1},\beta)$ is the linear filter that shapes the white noise sequence $n(k)$, of variance σ_n^2. The sequences $a(k)$ and $n(k)$ are independent with $E\{a(k)n(k)\}=0$. The received signal enters the precursor portion of the equalizer $F(q^{-1})$ that deals with the non-causal effects of the ISI and noise. The detected symbols $\hat{a}(k)$ are filtered by $R(q^{-1})$ and fed back to the detector input. $R(q^{-1})$ is the causal part or post cursor portion of the DFE and it has the function of canceling the ISI introduced by the past symbols.

Both $H(\alpha)$ and $D(\beta)$ are considered linear time invariant filters, of orders N and S respectively, with uncertainties in the parameter vectors α and β. They have causal impulse responses and belong to the space $\mathrm{H}_2(T)$ of square (Lebesgue) integrable functions on the unit circle $T=\{z:|z|=1\}$, which are analytic outside T, $\{z:|z|>1\}$. α and β are parameter vectors of the form