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A new approach for designing and implementing ADF equalization for 5G frequency selective channel based on two operating phases of LS and RLS algorithms

A. Y. Hassan[1]

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Abstract

In this paper, a new approach is proposed for implementing an adaptive decision feedback equalizer (ADFE) for the 5G channel. The proposed equalizer works in two phases. In the first phase, a least-squares (LS) algorithm with a variable-length training sequence is used to estimate the coefficients of the channel and the equalizer. In the second phase, the recursive least-squares algorithm estimates the channel and adapts the equalizer, jointly. According to the channel quality, a variable-length training sequence is used to estimate the channel vector and the coefficients of the equalizer. The feed-forward equalizer (FFE) compensates the effects of the transmitting filter and the channel filter. No matched filter is used in the receiver. The noise samples at the input of the proposed FFE are independent. The noise enhancement of the proposed FFE is less than the noise enhancement of its corresponding one in the conventional ADFE. The overall filtering response (OFR) from the input of the transmitting filter to the output of the FFE is calculated and used to estimate the coefficients of the feedback equalizer (FBE). The channel model, the FFE coefficients, the OFR vector, and the FBE coefficients are continuously updated every symbol period. Using a variable training sequence increases the bandwidth efficiency of the transmitted signal. Simulation results and real-time implementation measurements show that the convergence time and the steady-state error at the output of the proposed equalizer are smaller than their corresponding values in the conventional ADFE.

Keywords Inter-symbol interference · Linear equalizer · Decision feedback equalizer · Least square channel estimation algorithm · Frequency selective channel · 5G mobile communication

1 Introduction

Modern communication standards, such as the new generations of cellular communication networks and digital video broadcasting (DVB), use high data rate transmission to meet the needs of the provided services. The transmitted signals in these standards are considered as wideband signals [1–5]. The propagation channel in cellular communication standards is considered as a frequency selective channel since the coherent bandwidth of the channel is always smaller than the bandwidth of the transmitted signal. In satellite standards, the propagation channel is a line-of-sight channel and there is no multipath signal propagation. However, the bandwidths of the filters in the transmitter and the receiver may be smaller than the bandwidth of the modulated signal. Therefore, the modulated signal will face a frequency selective channel too. The received signal from a frequency selective channel always suffers from inter-symbol interference (ISI). The received symbols undergo interference from the preceding and next symbols. Two classical approaches are usually used to fight ISI in wideband signaling [6]. The first approach uses a shaping pulse in the transmitter to limit the frequency spectrum of the transmitted signal. This approach concentrates most of the transmitted signal power in a smaller bandwidth [7]. The second approach uses an equalizer in the receiver to compensate for the effect of the propagation channel on the transmitted signal [8]. In this work, the two approaches are used. Moreover, a new framework to the second approach is proposed to design and implement the adaptive decision feedback equalizer for 5G cellular channels.

✉ A. Y. Hassan
ashraf.fahmy@bhit.bu.edu.eg

[1] Benha Faculty of Engineering, Benha University, Benha, Egypt