A Serial Unequal Error Protection Code System using a Decision Feedback Equalizer with an Adaptive Error Prediction Filter for Fading Channels

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I. INTRODUCTION

In many information communication systems, the advantage of using unequal error protection (UEP) codes rather than equal error protection codes is that bits that are deemed to be important can be protected more than bits of lesser importance. We have studied UEP using a multilevel Trellis Coded Modulation (TCM) approach with various signal constellation sets and showed our system's effectiveness for fading channels [1],[2]. In this paper, we propose an improvement of the proposed system using Decision Feedback Equalizer (DFE) as a frequency selective fading measure [2].

II. PROPOSED UEP SCHEME

We described the proposed scheme in detail in previous papers [1], [2]. Therefore, we describe the main point of this paper, that is, imprtive equalization techniques. During the training period, we use the RLS algorithm which has a higher convergence speed to focus on transmission efficiency. On the other hand, during the tracking period the LMS algorithm, which is not computationally intensive, is used to reduce the computational load. However, as the LMS algorithm has a slower convergence speed, we propose a DFE with a linear predictive filter to improve convergence properties. A linear predictive filter consists of a FIR filter of order *P*, and future sample values can be predicted from previous values sampled in a fixed time period.

The predictive error is the difference between the predicted sample value and the actual sample value. By minimizing the mean square of the predictive errors adaptively using the LMS algorithm, a linear predictive filter has the effect of flattening the frequency response and we can expect an improvement in the convergence speed. Therefore, we propose an Adaptive Error Prediction Filter (AEPF) with a DFE in cascade called AEPF-DFE. The value predicted from *P* previous input values is given by (1).

$$\hat{u}(n \mid n-1, n-2, \ldots n-p) = \sum_{i=1}^{p} a_i(n) u(n-i) \tag{1}$$

The output of AEPF, that is, the predictive errors, $x(n)$ is the difference between the input $u(n)$ and the prediction expressed by (1) and is given by (2).

$$x(n) = u(n) - \sum_{i=1}^{p} a_i(n) u(n-i) \tag{2}$$

The vector of tap gains of the AEPF, $\mathbf{a}(n)$, are updated by (3), that is Normalized LMS algorithm,and $\mathbf{u}(n)$ is the vector of the tap inputs.

$$\mathbf{a}(n+1) = \mathbf{a}(n) + \frac{m}{a + u^2(n)} x(n) \mathbf{u}(n) \tag{3}$$

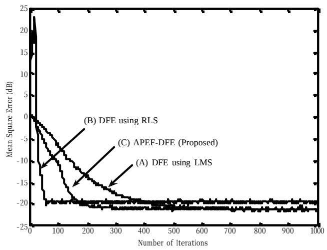

Fig.1 Convergence properties

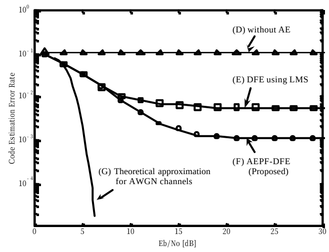

Fig.2 Code estimation error rate.

III. PEFORMANCE EVALUATION

First, we evaluate the performance of the AEPF-DFE alone. As channel model, AWGN and Non Minimum Phase (NMP) channel are considered, which is called a Raised Cosine channel model. The main simulation parameters are μ=0.05 and ?=0.7. The convergence properties are shown in Fig.1. In this condition, the proposed scheme has better performance than the previous scheme as can be seen by comparing (B) and (C) in terms of minimizing MSE after about 200 iterations. This fact was similar to BER performance. For (B), as the RLS algorithm is used in both FF and FB filters, the computational load is $5N^2+9N$. On the other hand, for (C) as the NLMS algorithm is used in AEPF, FF and FB filters, the computational load is $6N+3$. Therefore, we confirmed the effectiveness and domination of the proposed AEPF-DFE in terms of convergence, BER and computational load.

Second, we introduce the AEPF-DFE into the proposed UEP system [1],[2] and confirm the effectiveness of the total system in a frequency selective fading channel. The main simulation parameters are $f_d T_s = 7.4 \times 10^{-4}$, two waves model, DU=0dB, Delay time=1 symbol, ring ratio β=0.5, importance switching rate N=30 and so on. In Fig.2, the code estimation error rate for the 2RING constellation [2] versus E_b/N_0 is shown. The effectiveness of adaptive equalization can be seen by comparing (D) and (E) or comparing (D) and (F).

IV. CONCLUSION

A decision feedback equalizer with an Adaptive Error Prediction Filter (AEPF-DFE) is proposed to combat frequency selective fading. The effectiveness of the AEPF-DFE alone and the AEPF-DFE in the proposed UEP system are shown.

Reference

[1] S. Yamazaki and D. K. Asano, "An Unequal Error Protection System Using Trellis Coded Modulation and an Adaptive Equalizer," *IEEJ Transactions on Electronics, Information and Systems*, vol. 129, No. 1, pp. 147-148, 2009.

[2] S. Yamazaki and D. K. Asano, "A Serial Unequal Error Protection System Using Multilevel TCM and a Decision Feedback Equalizer," WPMC'09 (accepted).