Implicit and Explicit Receiver Training in Flat Fading Channels Modeled as Finite State Markov Processes

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Abstract — **We study the effect of training method on the receiver bit error rate (BER) performance in constant envelope phase modulation schemes that are transmitted through flat fading channels. Here we propose a novel method for receiver training by sending information bits with unbalanced probabilities. We call this method implicit training and compare it with traditional (explicit) training scheme in which known periodic training sequences are sent to the receiver. The simulation results show superior performance of implicit training where the gain is 2 dB at information rate of 0.15 bits/channel use.**

I. INTRODUCTION

In the detection of constant envelope phase modulation schemes that are transmitted through flat fading channels, it is vital to have a good estimate of the phase component of the channel response. In the simplest example of BPSK detection the minimum requirement is to know whether the channel is in phase inverting or non-inverting mode. Here we propose a simple two-state Markov channel to estimate fading channel phase at the receiver side [1], [2]. Finite state Markov model brings us the possibility of trellis-based joint MAP sequence state estimation and data detection [3]. Usually in order to provide the receiver with side information about the channel behavior, periodic training sequences are inserted between channel symbols [1]. We refer to this method as explicit training, since the training bits are clearly known to receiver and they convey no detectable information. Explicit training leaves the receiver unsupervised between the training periods that becomes a major problem as the fading rate increases, moreover training bits are of no use in the decoding process. We propose a new method in which the receiver is constantly supervised, in an implicit fashion, by the a priori knowledge of non-symmetrical distribution of information source. One of the advantages of this method is that training is available for all channel symbols. Also a priori knowledge about bit distribution is useful for both channel estimation and decoding.

II. SYSTEM MODEL AND SIMULATION RESULTS

The simplified model for flat fading channel is given by [1], [2]

$$y(t) = e^{j\theta(t)}x(t) + z(t), \qquad (1)$$

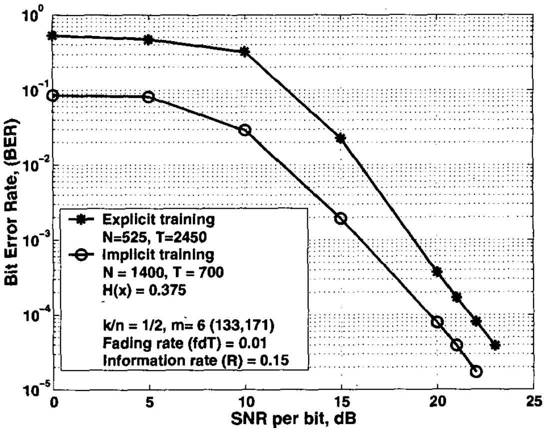

Fig. 1: Receiver BER performance.

where $x(t)$, $z(t)$, $\theta(t)$, $y(t)$ are the channel input, zero mean AWGN, fading channel phase and channel output respectively. The channel phase process is mapped to a two-state finite state Markov model. Hence, in the receiver the channel is either in inverting, $S = -1 : \theta \in [\pi/2, 3\pi/2]$, or non-inverting, $S = 1 : \theta \in [-\pi/2, \pi/2]$, mode. Joint MAP state estimation and sequence detection is summarized as

$$(\widehat{\mathbf{S}}, \widehat{\mathbf{X}}) = \arg\max \left(\prod_{i=1}^{n} Pr\left(Y_i|S_i, X_i\right) Pr\left(S_i|S_{i-1}\right) Pr\left(X_i\right) \right) \qquad (2)$$

In the simulations, a rate $k/n = 1/2$ non-systematic convolutional coder and channel block interleaver are used. Estimates of the channel phase state are passed to the decoder in hard-estimation format: $(S = 1)$ or $(S = -1)$. We define the the general system rate as

$$R = NkH(x)/(Nn + T) \qquad (3)$$

where $H(x)$ is the source entropy, and N and T are the number of source and explicit training bits in each block respectively. Fig. 1 shows the result of simulations for $R = 0.15$ bits/channel use.

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