Channel Impulse Response Length and Noise Variance Estimation for OFDM Systems with Adaptive Guard Interval

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Abstract

In this paper, a new algorithm estimating channel impulse response (CIR) length and noise variance for orthogonal frequency division multiplexing (OFDM) systems with adaptive guard interval (GI) length is proposed. To estimate the CIR length and the noise variance, the different statistical characteristics of the additive noise and the mobile radio channels are exploited. This difference is due to the fact that the variance of the channel coefficients depends on the position within the CIR, whereas the noise variance of each estimated channel tap is equal. Moreover, the channel can vary rapidly, but its length changes more slowly than its coefficients. An auxiliary function is established to distinguish these characteristics.

The CIR length and the noise variance are estimated by varying the parameters of this function. The proposed method provides reliable information of the estimated CIR length and the noise variance even at signal-to-noise ratio (SNR) of 0 dB. This information can be applied to an OFDM system with adaptive GI length, where the length of the GI is adapted to the current length of the CIR. The length of the GI can therefore be optimized. Consequently, the spectral efficiency of the system is increased.

Index Terms

CIR length and noise variance estimation, OFDM systems with adaptive GI length.

I. Introduction

In OFDM systems, the multi-path propagation interference is completely prevented, if the GI is longer than the CIR length, namely the maximum time delay of the channel. However, the GI carries no useful information. Therefore, the longer the GI, the more the spectral efficiency will be reduced. The GI length is a system parameter which is assigned by the transmitter. However, the CIR length depends on the transmission environment. So, when the receiver moves from one transmission environment to another, the CIR length must be changed. The purpose of this paper is to design an OFDM system with adaptive GI length, where the GI is adapted to the CIR length of a transmission channel. This avoids unnecessary length of the GI, and, thus, increases the spectral efficiency of the system. To implement this concept, we have to deal with the two following problems. Firstly, the CIR length must be estimated very precisely. Secondly, the network must be organized in such a way that the information of the currently estimated CIR length at the receiver can be fed back to the transmitter to control the GI length.

In a coherent OFDM system, the channel must be estimated for equalization. Generally, even though the channel is estimated, the CIR length remains unknown. This is because the estimated CIR is affected by additive noise and by different kinds of interference such as intercarrier interference, co-channel interference or multiple access interference. This task is more difficult for a time-varying channel, since both the channel coefficients and the CIR length are changeable.

In the literature, there are some methods to estimate the CIR length [1], [2], [3], [4], [6], [5]. The method described in [1] estimates the CIR based on the estimated SNR. Similar to this method, the CIR length is estimated in [2] by comparing the estimated channel coefficients with a predetermined threshold. The method in [3] is based on the generalized