Parameter Optimization of Automatic Gain Control for Improved Performance in OFDM Systems

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Abstract. In the OFDM systems for high data rate and burst data traffic networks, the fast convergence of the signal level is required in the short period of time at the input of the analog-to-digital convertor (ADC). This operation should be carried out at the header part of the frame which is normally called the training sequence or preamble. It is very important to minimize the processing time of gain decision for incoming baseband signals at the receiving end. In this paper, optimal level of the automatic gain control (AGC) is determined based on the statistics of the incoming signal including the degree of saturation as well as the signal power.

Keywords: Automatic gain control, quantization noise, OFDM

1 Introduction

In general the high data rate system requires broadband frequency band which is vulnerable to frequency selective fading effects. The orthogonal frequency division multiplexing (OFDM) is suitable for highly multipath channel which results in severe intersymbol interference in time domain. One of the most popular systems supporting high quality multimedia data is IEEE 802.11 based Wireless LAN which is better known as WiFi. In packet based WiFi systems, automatic gain control (AGC), synchronization and channel estimation are processed based on the preamble located in the beginning of the data packet [1]. Since the time duration available for frontend operations is limited, it is essential to minimize the processing time in the AGC which is the first block in the receiver. The effect of asynchronization which could be originated in the preamble interval causes the loss of orthogonality between subcarriers and intersymbol interference which results in performance degradation [2-3].

The goal of AGC is to maintain the input power at the desired level at the input of the analog-to-digital convertors (ADC) while minimizing the quantization noise level at the output of ADC. In a previous research work, an AGC circuit with two different update loops is proposed for the MIMO-OFDM system [4]. In this previous work the

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saturation level over the ADC dynamic range is decided based on a few samples. In this paper, a modified AGC scheme is proposed where more gain loops are utilized and more observation samples are utilized for determination of the saturation statistics for the faster convergence.

2 Optimization Scheme

If AGC does not have a sufficient response rate or the completion of the operation is delayed, the following signal in the same frame is saturated or does not provide enough precision for the remaining demodulation operation. This can be one of the reasons for failure of time synchronization.

The first step in the AGC parameter setting is the determination of the target or steady state level. The signal to quantization noise ratio (SQNR) at the output of ADC can provide the initial baseline to roughly determine the range of candidate signal levels. The bit-error-rate (BER) performance as well as SQNR can also provide good baselines to find the optimum operating point of the AGC which is more closely related to the overall system performance. Another important statistics other than input signal level utilized in the proposed scheme is number of saturated samples. Different gain control values are applied in the AGC operation depending on the number count. As it can be expected larger values are assigned for more saturation counts. When the received signal exceeds the saturation threshold, the precision level of the measured power is decreased. This means that the gain control level should be determined by saturation count rather than relatively inaccurate measured input power when the saturation is monitored.

3 Results

For the BER simulation OFDM symbols are modulated with BPSK scheme. The BER is measured at the output of the demapper. Two cases are compared where the first case is with non-optimized gain set. The other case assumes the optimized gain sets to cover the whole range of AGC operations. The optimum case maintains the best BER performance from the lower limit to the upper limit of the input signal level while the non-optimized case cannot provide the proper performance in some part of the signal ranges.

4 Conclusion

It is difficult to achieve a desired performance if the gain control fails at the start of the data frame since it affects the accuracy of the estimated parameters at the signal recovery stages of the receiver. The expedited processing time for gain decision is essential in the AGC block. In this paper, an optimization method is proposed for the high speed AGC to control the gain of the received signal in the OFDM system. In the

proposed method saturation number counts of the ADC output signal is utilized to determine the optimal set of control gain. To verify the performance of the optimized AGC, the BER performances are tested for all ranges of input signal power.

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