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Method for Enhancing the Accuracy of Frequency Offset Estimation in OFDM Modulation Based Communication Systems

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Abstract—The paper proposes a method for enhancing the accuracy of estimation of frequency offset for OFDM modulation based communication systems. An increase accuracy of the proposed method is achieved at the expense of combined use of pilot and information symbols of OFDM signal. The main factors determining the accuracy of proposed method were identified. Mathematical simulation of the proposed method was performed for a multipath radio wave propagation channel. The proposed method efficiency was shown in comparison with existing methods for the estimation of frequency offset. Advantages and disadvantages of existing and proposed methods were described. The relationships of the root-mean-square error of frequency offset estimation as a function of the signal-to-noise ratio were built for the proposed and existing methods. The attainable high accuracy of frequency offset estimation by employing the proposed method makes its use expedient in control and measuring equipment. Conclusions have been made regarding the simulation results obtained and the expediency of proposed method applications.

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INTRODUCTION

The orthogonal frequency division multiplexing (OFDM) technology finds a wide application in many modern wireless telecommunication systems, such as LTE, WiMAX, IEEE 802.11, DAB, DVB-T2 and others [1–4]. One of the main advantages of OFDM modulation is the possibility of eliminating distortions caused by the signal passage through a multipath radio wave propagation channel.

The issues of time and frequency synchronization during the signal processing are vital in the development of communication systems using OFDM signals [5]. Time synchronization errors lead to a phase incursion in frequency domain. They can be easily removed by using an equalizer [6]. The frequency synchronization errors lead to the violation of orthogonality of subcarrier frequencies that, in turn, leads to noise contamination of signal constellation and additional errors in data demodulation.

The accuracy of frequency offset estimation provided by existing methods is sufficient for the operation of communication systems. However, improving the accuracy of frequency offset estimation is a topical problem in measuring equipment, because it requires the provision of maximum estimation accuracy of signal parameters.

There is a number of papers devoted to the frequency offset estimation on the basis of the training sequence (preamble) [7, 8]. Examples of such training sequences are described in standards IEEE 802.16e, IEEE 802.11a/g/n, and others [2, 9]. The estimation of frequency offset based on the maximum likelihood method using a training sequence is described in [10], including the case of a multipath channel. A disadvantage of these methods lies in the fact that their operation is based only on using the known pilot signals. In case of using a short training sequence and at low values of the signal-to-noise ratio (SNR), the error of frequency offset estimation, while using the specified methods, amounts to about tens and hundreds of hertz (Hz) [12].

For enhancing the accuracy of frequency offset estimation, there are methods using both pilot sequences and succeeding information symbols. These methods provide for the estimation of frequency offset in two stages [12, 13]. Their disadvantage lies in the fact that a fairly large number of OFDM symbols is required for achieving a high accuracy of estimation. Since the duration of sequence of OFDM symbols must not

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