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Linear Equalizer in MIMO Radio Communications Systems

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Abstract—A linear equalizer for MIMO radio communications systems has been considered. The weight coefficients of the MIMO equalizer were obtained in accordance with the criterion of minimum mean squared error. Using the computer simulation technique and analyzing the case study of HSDPA (High Speed Downlink Packet Access) channel it was shown that the application of equalizer made it possible to significantly improve the reception characteristics as compared with those of a conventional rake receiver.

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The state-of-the-art and future broadband radio communications systems should ensure high data transmission speed (tens and hundreds of Mbit/s or more) for satisfying the constantly growing requirements of multimedia applications.

In single-frequency systems, for example with code division of channels, simple rise of the bit speed is equivalent to reduction of the duration of symbols transmitted and results in a significant rise of intersymbol interferences. That is why in certain systems, for example in “high speed packet access” (HSPA) data transmission channels of UMTS standard [1], an increased data transmission speed is ensured at the fixed duration of symbol due to the use of multicode signal, when the parallel transmission of data flows is performed over the orthogonal channels. Orthogonality is ensured by the Walsh codes. While the time dispersion (multipathing interval) of the propagation channel is small, the orthogonality of signals at the receiving side is maintained. However, as the time dispersion increases the interference of other channels (intercode interference) appears at the output of channel correlators of the receiver and the power of this interference grows with the rise of the number of channels, i.e., the orthogonality of channels is violated.

Of particular interest is the use of equalizer at the receiving side that minimizes distortions caused by multipath propagation. As was shown in papers [2, 3], this approach surpasses in terms of specifications a conventional rake receiver for the case of one transmitting and several receiving antennas. A similar result was obtained for the case of one transmitting and several receiving antennas [4].The use of equalizer in single-frequency systems ensures the reception characteristics close to the characteristics of multifrequency “orthogonal frequency division multiplexing” (OFDM) systems [5] that has found wide recognition in recent years. In this case, we get rid of disadvantages intrinsic to OFDM systems, the main of which include enhanced requirements to the accuracy of frequency synchronization and a high peak factor of the OFDM signal.

Besides the use of multicode signals, another efficient technique of increasing the data transmission speed and capacity of communications systems is the application of the antenna separation during the transmission and reception (MIMO technologies) [6, 7]. High spectral efficiency of such systems is based on the independence of propagation channels between different pairs of transmitting and receiving antennas. It is well-known that the maximum capacity of MIMO system can be achieved by using the BLAST (Bell Labs Layered Space Time) technology [8].

The purpose of the present study is to consider a linear equalizer operating by the criterion of minimum mean squared error with respect to the MIMO–BLAST system.

Let us consider a radio communications system consisting of M transmitting and N receiving antennas. The general architecture of the transmitter and receiver with linear equalizer is presented in Fig. 1. At the transmitting side symbols are divided into M high-speed flows transmitted from different antennas. Each data flow, in its turn, is divided into K subflows (channels). Individual channel code $Y_k(t), k=\overline{1,K}$ (one of the Walsh functions) is imposed on symbols of each subflow. This results in formation of values of chips of different channels. Signals of channels are added and the formed values of chips of the multicode signal are transmitted to the communications channel. The equalizer at the receiving side consists of $M \times N$ transverse