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Simulink Modelling of the Majority Pseudo-noise Sequence Acquisition Method for Multi-Carrier CDMA

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Abstract: *In this article we propose majority pseudo-noise sequence (PNS) acquisition method for multi-carrier direct sequence code division multiple access (MC-DS-CDMA) communication systems, that allows for low hardware requirements and able to operate in low-quality channels. We research this method using specially developed Simulink model. The proposed method may find application in military and public communication systems.*

Keywords: Simulink Modelling, CDMA, Pseudo-noise Sequence (PNS).

INTRODUCTION

Increase in the volume of the transmitted traffic in mobile wireless networks caused by intensive integration of telecommunication technologies in many areas of human life has encouraged the development of wireless broadband access (WBA) technologies. For example, next generation 5G networks will in near future come in place of the recently deployed 4G networks. Prospective development area of the WBA networks recently became multi-carrier communication systems based on OFDM (orthogonal frequency division multiplexing) [1], [2], in which data transmission is carried out in parallel on several orthogonal subcarriers. Fourth generation standards, such as Wimax and LTE were designed based on this method, in addition to 802.11 standard family and also digital video broadcasting DVB. High spectral efficiency and multipath resistance are primary advantages of the OFDM.

Modulation method MC-DS-CDMA (multi-carrier direct sequence code division multiple access) is one of the directions of development of OFDM-oriented communication systems. MC-DS-CDMA or MC-CDMA [3] can be used in the military communication systems for data transmission with the simultaneous enemy station jamming by means of transmitting a powerful noise signal on one of the subcarriers [4].

Using the aperiodic pseudo-noise sequences (PNS) in the MC-DS-CDMA for signal modulation means the necessity of guaranteeing reliable PNS synchronization or PNS acquisition. So in this paper a majority PNS acquisition algorithm is proposed, that offers high efficiency in low-quality channels and low hardware complexity. Article covers the experimental analysis of this algorithm using the computer model developed in Simulink.

Known PN Acquisition Methods

Basic PNS acquisition methods are serial search, sequential search, parallel acquisition and matched filter correlators method [5], [6], [7]. The multicarrier nature of modulation methods or multiple access methods in MC-CDMA / MC-DS-CDMA systems is what had defined the characteristic features of the PN acquisition methods. For instance, it is possible to treat the PN acquisition in them as a combination of some basic methods. For example, study [8] looks at PN acquisition method using a serial search system on parallel subcarriers. Key elements of it are non-coherent correlators and equal gain combining scheme. In paper [9] a modification of a parallel acquisition of PN sequences of MC-CDMA systems is suggested. In the proposed method the search region of each searcher is

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modified so that it overlaps with that of other searches. Acquisition scheme [9] is based on non-coherent correlators. The main disadvantage of many acquisition techniques is high enough complexity of hardware. Let's also point out that most studies look at acquisition methods for public communication systems that do not suffer from jamming [4]. This article looks at majority PN acquisition algorithm that is suitable for military communication systems, with multicarrier signals, and offers low hardware complexity [10].

Principle of the Method

By treating the maximum length sequence as a cyclic code (2^k-1, k), one can make a parity equation system and a corresponding parity matrix, which in turn could be modified to look like [10]:

$$H'=[IP^T], \tag{1}$$

where: I is an identity submatix.

By writing out H' (1) in expanded form, it could be seen that the last row shows a relation between the different phases of the PNS with some initial phase φ_0. Then the majority method can be presented as [10]:

$$\varphi_0 = \varphi_l \left[\alpha^{-l} \alpha^{-l+1} \dots \alpha^{-l+k-1}\right], \tag{2}$$

where: α^{-l+l} is a matrix column vector.

Fig. 1 shows a diagram representing a device that implements said synchronization algorithm. It consists of: α field element generator, receiver φ_l-phase register, "AND" element blocks, XOR block, switch, "K" counters with threshold switches, PNS detector, control block, time-shift module, correlator and a resolver. For each work cycle of a receiver φ_l-phase register the α field element generator should process"κ" cycles, which creates a sequence of the a_1, a_2,..., a_k symbols. In fact, if for the first "κ" symbols we assume that the field generator state is α^0, then by shifting it to the right we get $\alpha^1, \alpha^2, \dots, \alpha^{k-1}$, which, including α^0 will produce the following sequence in the adder register: $a_1, a_2, \dots, a_k$. After receiving the following symbol the filed generator state would be at α^1, which would produce a_1 as an adder output, and by shifting the generator to the right we would get $a_2, \dots, a_k$. Threshold elements, in turn would accumulate the a_i values, and after passing the set threshold value the decision on the initial state φ_0 is made (fig. 1).

MC-DS-CDMA systems use the same PNS to widen the spectrum on every subcarrier, and that's why during the acquisition process, it is reasonable to use the majority algorithm for acquisition purposes, since every subcarrier is processed separately in ODFM. Therefore, the solver present in the diagram on fig.1, as well as the decoding in the purposed scheme works using the majority algorithm, making the decision by using the majority of the received PNS symbols on every subcarrier.

PNS synchronization is achieved by time shifting the signal on the delay equal to the time needed to determine the phase of the received segment, which is always known on the receiving end, and by confirming the correct acquisition by using the correlation method.

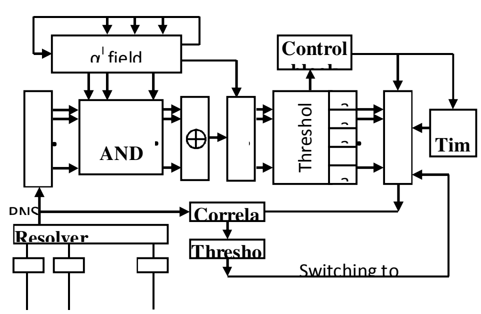

FIGURE 1. PNS ACQUISITION METHOD DIAGRAM

SIMULINK MODEL

To experimentally evaluate the proposed acquisition method, a model was created using the Simulink [11] package, that implements an acquisition system that has the PNS transmitted over parallel subcarriers. The model allows for an experimental evaluation of the probability characteristic of the proposed device and is essentially equivalent to the MC-DS-CDMA systems. Flowchart of the system is present in the fig. 2. Key elements of the model are: PNS generator [11], repeat block (serial/parallel), that does the serial to parallel signal transformation, depending on the number of the subcarriers, that are used to transmit the PNS, majority receiver, binary symmetric channel block, and a majority decoder, flowchart of which is present in fig. 3.

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It should be pointed out that the main difficulties during the model development stage have been met while attempting to save the initial system state and the intermediate states in the majority decoder subsystem. For example, in the initial implementation the in-built Simulink tools for memory read and write: *Data Store Memory* [11] have been used, but they have caused random memory "read" and "write" processes, which led to data corruption. The *Memory* [11] blocks have been used instead, (see fig. 3) and that had caused extra complication in the model because of the necessity to add new blocks that were required for the correct function of the system. This approach has allowed for the decoder to function correctly. Also, due to peculiarities in the developed subsystems and in the in-built Simulink blocks a lot of counters had to be used in the final model, to control the fill up of the *Discrete Shift Register,* fill up of the resolver counters, control over the length of the treated PNS segment, etc.(see fig. 3).

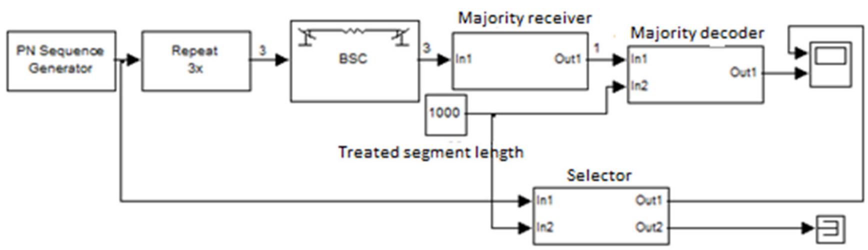

Figure 2. Simulink model diagram

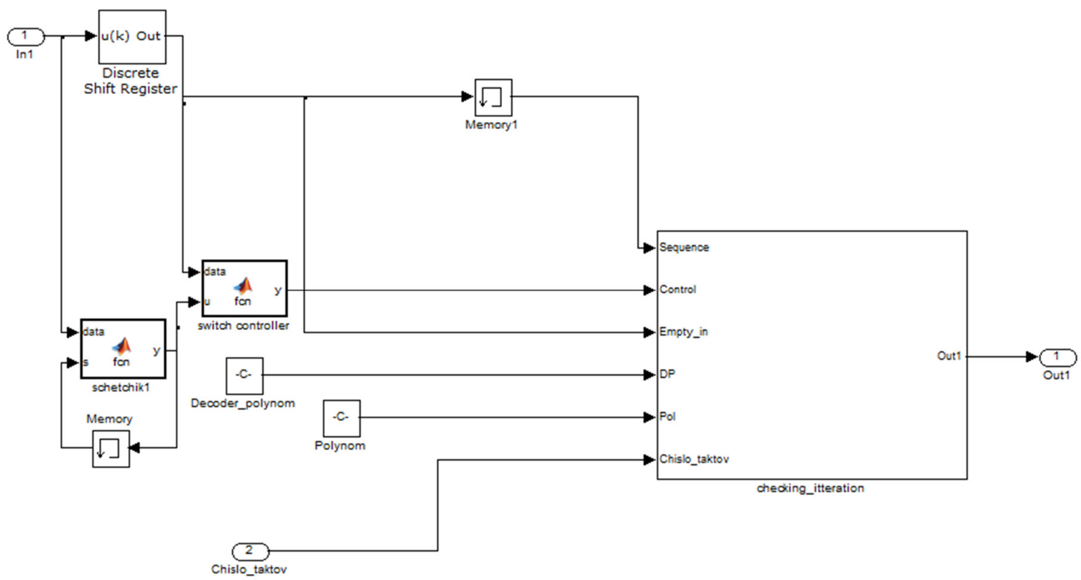

Figure 3. Majority decoder subsystem diagram

Experimental Research

Majority acquisition algorithm experimental research is performed by measuring medium bit error rate BER of majority decoder output for different system parameters, which presented in table 1. Besides model of majority algorithm authors have developed using Simulink a simple model of sequential search method to compare it with proposed acquisition algorithm. Diagram of sequential search model is shown in figure 4.

TABLE I
System Parameters

Parameter	Value
Polynom	k=20 [20 17 0] ($x^{20}+x^{17}+1$) k=29 [29 27 0] ($x^{29}+x^{27}+1$)

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Parameter	Value
Sample time	16e-5/2/1
Data type	Double
Received PN-sequence segment length	1) N=127 2) N=1000
Subcarrier number	1) Nc=3 2) Nc=5

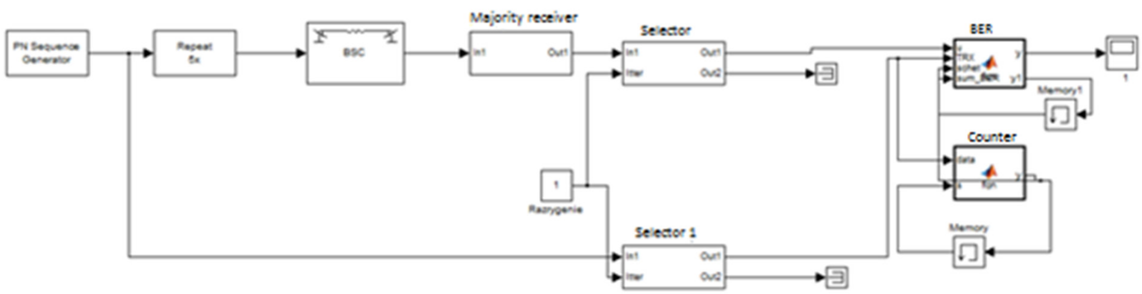

Figure 4 – Sequential search acquisition model diagram

Table 2 shows results of BER measuring for majority acquisition and sequential search models, obtained experimentally. So increasing the number of subcarriers N_c from 3 to 5 in channel with subcarrier error probability $P=0.2$ reduces majority acquisition algorithm *BER* almost five times and allow to be synchronized communication systems faster in contrast to the sequential search method, where the bit error rate is reduced by two orders of magnitude, but still remains high ($BER=5.75*10^{-2}$). As expected, increasing the length of the linear recurrent shift register *k* degrade performance of the acquisition system. Increasing the length of the treated segment *N* on the contrary is improves the accuracy of PN-sequence acquisition.

In fig. 5 is presented relation of *BER* against subcarrier error probability *P*, experimentally obtained for majority acquisition algorithm and sequential search method for system parameters: Nc=3, N=127, k=29.

Obtained results allow us to conclude that majority acquisition methods are very efficient in low-quality channels in comparison with sequential search method and permit faster synchronization in the communication system.

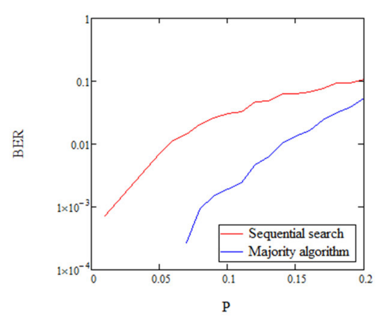

Figure 5. *BER* against of subcarrier error probability *P*

TABLE II
EXPERIMENTAL RESULTS

BER / P	Sequential search	Majority
Nc=3, N=127, k=29		

BER / P	Sequential search	Majority
0.01	0.001	0
0.1	$3.36*10^{-2}$	$1.3*10^{-3}$
0.2	$11.04*10^{-2}$	$5.24*10^{-2}$
Nc=5, N=127, k=29		
0.01	0	0
0.1	0.01	0
0.2	$5.75*10^{-2}$	$1.37*10^{-2}$
Nc=5, N=127, k=20		
0.01	0	0
0.1	$0.1*10^{-2}$	0
0.2	$5.62*10^{-2}$	$0.85*10^{-2}$

CONCLUSION

In this paper majority pseudo-noise acquisition algorithm for multi-carrier-based telecommunication systems MC-DS-CDMA was experimentally researched. Studies were conducted using developed in Simulink acquisition algorithm computer model. Key elements of the developed model are majority decoder and resolver (majority receiver). Experimental results show high efficiency of majority PN-sequence acquisition algorithm for MC-DS-CDMA system in low-quality channels and that it can be used in military communication systems.

REFERENCES

[1] K. Fazel, S. Kaiser, *Multi-carrier and spread spectrum systems: from OFDM and MC-CDMA to LTE and WiMAX,* 2nd ed. John Wiley & Sons Inc., 2008.

[2] R. Prasad. *OFDM for wireless communications systems,* Boston: Artech House, Inc., 2004.

[3] T. Ilavarasi, N. Kumaratharan, K. Rasadurai, "MC-CDMA based SDR for Next Generation Wireless Communications", *International Journal of Computer Applications*, vol. 73, no. 13, pp. 12-19, Jul. 2013.

[4] H. Wang, Y-D. Yao, R. Wang, L. Shen, Coordinated jamming and communications in an MC-CDMA system. Available: http://www.personal.stevens.edu/~hwang38/paper/CJamCom.pdf

[5] C.Regazzoni, Course acquisition and tracking in DS/SS systems. Available: http://www.isip40.it/resources/Dispense/Radio/05_PN_ACQUISITION.pdf

[6] W. S. Waseem, J. Al-Zubiady, H. M. Al-Zubiady, "Search strategies for the acquisition of DS spread spectrum signals", *Int. J. Electronics*, vol. 84, no. 2, 1998, pp. 83-104.

[7] P. Schafer, M. Nakagawa, "Direct-Sequence Multi-Carrier CDMA Parallel Acquisition in a Multipath Fading Channel" in IEEE International Conference on Communications, June 23-27, 1996, pp. 1503-1507.

[8] L-L. Yang, L. Hanzo, "Serial acquisition performance of single-carrier and multi-carrier DS-CDMA over Nakagami-m fading channels", *IEEE Transactions on wireless communications*, Oct. 2002, vol. 1, no. 4, pp. 692-702.

[9] J. Moon, Y-H. Lee, "Parallel acquisition of PN sequences in Rayleigh fading channel and the application to the multi-carrier CDMA systems," in 12th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications. Sep. 30 - Oct. 3, 2001, no. 2. pp. G6-G10.

[10] I. A. Novikov, V. N. Nomokonov, A. A. Shebanov. i dr., "K voprosu o mazhoritarnom dekodirovanii M-posledovatel'nostey," *Voprosi Radioelektroniki*. no. 5, 1976.O. Beucher and M. Weeks, *Introduction to MATLAB & SIMULINK A Project Approach,* 3rd ed. Hingham, Massachusetts, 2008.

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