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Modeling and Investigation of the LDPC Immunity Code to Provide Increased Immunity in the Dvb-T2 Standard Digital Television System

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Abstract. In this paper, an error-correcting LDPC code has been investigated and modeled to provide an increase in noise immunity in a digital television system of the DVB-T2 standard. The algorithm of functioning of the noise-correcting LDPC codec was studied theoretically and practically. The noise-correcting LDPC code in the digital television system of the DVB-T2 standard with the developed interactive computer simulation program in the Matlab/Simulink programming language, the dependence of the number of errors on the error probability for the noise-correcting LDPC code was modeled and investigated.

Keywords: LDPC code, error-correcting code, DVB-T2 standard, encoder and decoder, noise immunity, interference, noise, error probability, syndrome, codeword length.

With the development of telecommunication technologies, interest in transmitting information with a minimum number of errors has grown again. Low-density parity codes have become part of the DVB-S2 satellite data transmission standard for digital television and have entered the IEEE 802.3 an Ethernet 10G network standard. A replacement has also taken place in the DVB-T2 standard for digital television broadcasting. Low-density parity codes are a powerful error correction technique that outperforms many well-known coding schemes. The codes can be used in any communication system where energy savings are significant or the signal-to-noise ratio is very low [1].

Low Density Parity Codes (LDPCs) are linear block codes whose parity matrix is sparse, i.e. contains a small number of zeros. Depending on the type of LDPC code and the method of its synthesis, the number of zero elements in the check matrix will vary. In addition to the matrix description, LDPC codes can also be described using a bipartite undirected Tanner graph. It is called bipartite because the nodes of the graph are divided into two different types. This representation makes it possible to more clearly describe the decoding algorithm [2].

Information processing using noise-correcting coding procedures allows to provide the required error probability, however, the use of coding requires encoder, decoder, interleaved devices, and, consequently, additional processing costs. In conditions where it is required to maintain a high transmission rate while ensuring a given noise immunity, it is necessary to have codes that can effectively deal with occurring errors and have fast encoding/decoding procedures [3].

In 1948, Claude Elwood Shannon published his work on the theory of information transmission. One of the key results of the work is the information transmission theorem for a noisy channel, which indicates the possibility of minimizing the probability of transmission error over the channel by choosing a sufficiently large length of the keyword - a unit of information transmitted over the channel. When transmitting information, its stream is divided into blocks of a certain (most often) length, which are converted by the encoder (encoded) into blocks called keywords. Key words are transmitted over the channel, possibly with distortion. On the receiving side, the decoder converts the keywords into a stream of information, correcting (if possible) transmission errors. Low Density Parity Check (LDPC) codes are a class of linear block codes that provide excellent performance with relatively low computational cost to decode them. These codes were proposed by Robert Gallagher back in 1963, but were forgotten for forty years due to the complexity of the implementation of their decoding algorithms [4].

In practice, in a digital television system, Bowes-Chowdhury-Hokvingham (BCH) codes are used for outer coding, and a low-density parity check (LDPC) code for inner.

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It should be noted that the efficiency of irregular LDPC codes is higher than the efficiency of regular codes. This is explained by the fact that in irregular codes, due to the different number of ones in rows and columns, information symbols are protected differently. As a result, during decoding, the so-called wave effect appears, when more secure bits are decoded faster and then, as it were, help in decoding less secure bits [4].

To study and simulate the noise-correcting LDPC code in a digital television system of the DVB-T2 standard, an interactive computer simulation program was developed in the Matlab/Simulink programming language. The program is designed to simulate and calculate the dependence of the number of errors on the error probability for the error-correcting LDPC code.

To study and simulate the noise-correcting LDPC code in the digital television system of the DVB-T2 standard using the Matlab / Simulink software environment, we use the following parameters (Fig. 1,2,3,4,5) and set the characteristics of the blocks for the code (32400) of the digital television system DVB-T2 standard (Table 1).

Table 1

№	Parameter name	Parameter value
1.	Frequency range: DMV	(474-858) MHz with 8MHz channel bandwidth
2.	Modulation type	16-QAM
3.	Constellation position	16
4.	Bandwidth	8 MHz
5.	Error-correcting code	LDPC
6.	Code word length	32400

Below are the parameters of the model (Fig.1,2,3,4,5).

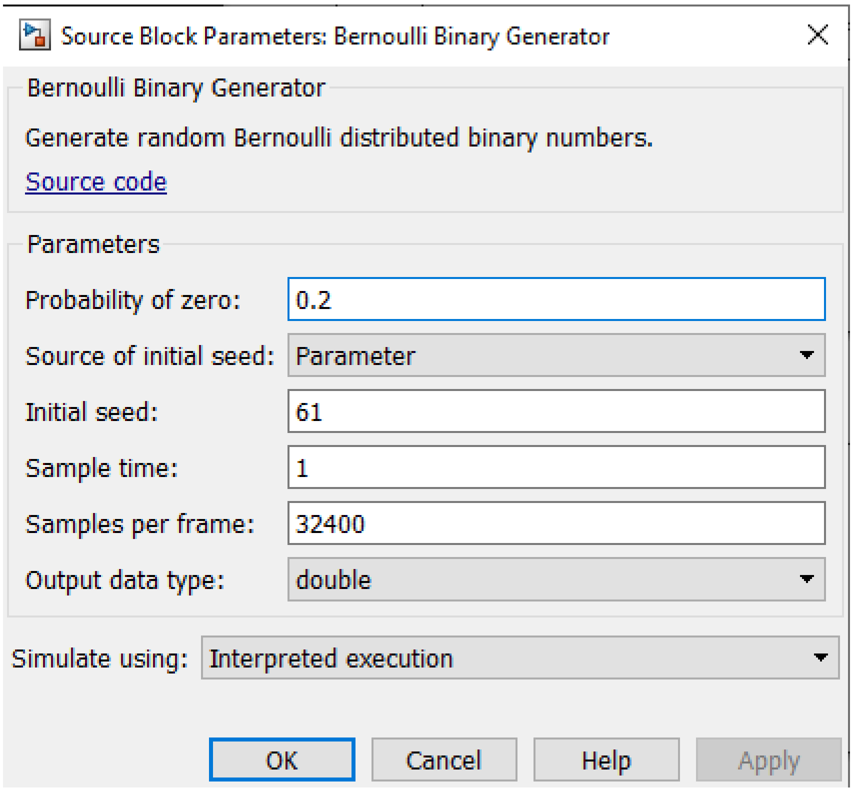

Fig.1. Parameters of Bernoulli Binary Generator

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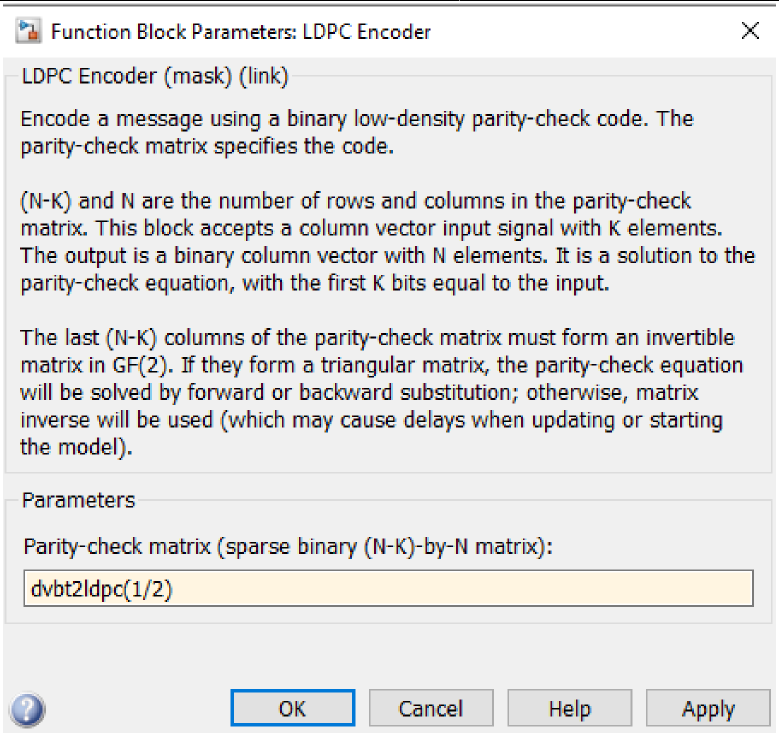

Fig.2. Parameters of LDPC Encoder

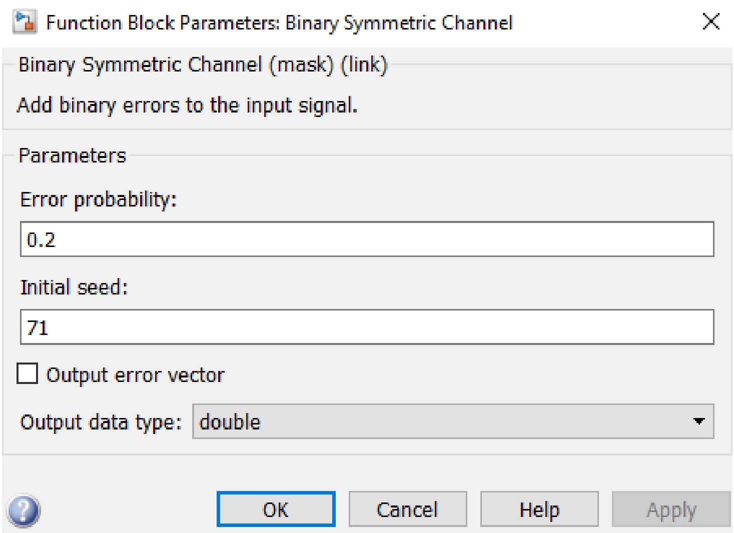

Fig.3. Parameters of Binary Symmetric Channel

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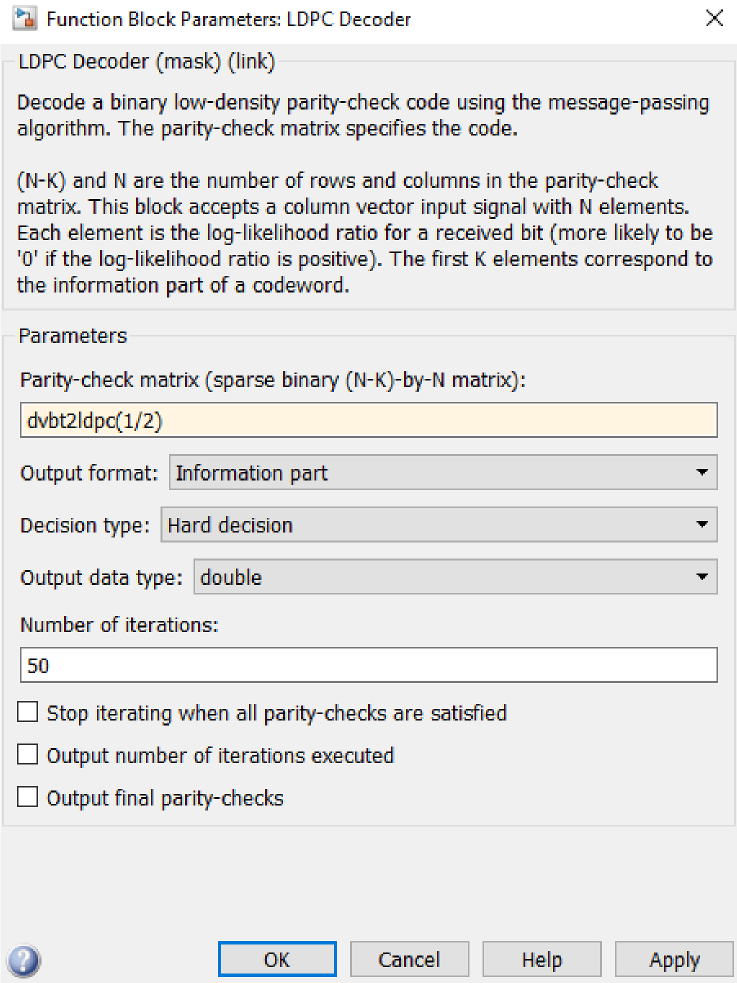

Fig.4. Parameters of LDPC Decoder

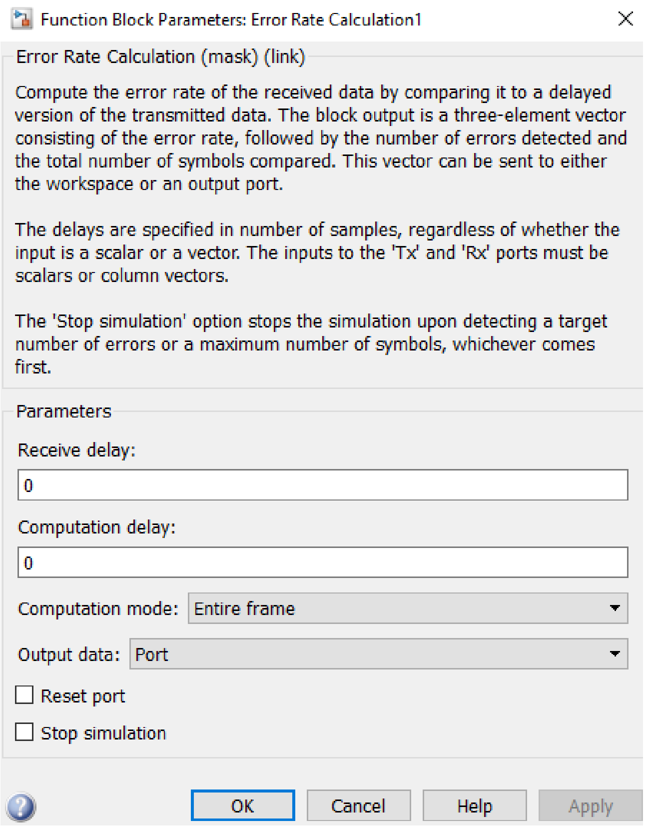

Fig.5. Parameters of Error Rate Calculation

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On (Fig.6,7,8) the investigated scheme of the model of the noise-correcting code LDPC in the digital television system of the DVB-T2 standard is shown. The model scheme under study consists of the following blocks: Bernoulli Binary Generator (generator), LDPC Encoder (encoder), Binary Symmetric Channel (transmission channel), LDPC Decoder (decoder), Error Rate Calculation (error analyzer) and Display.

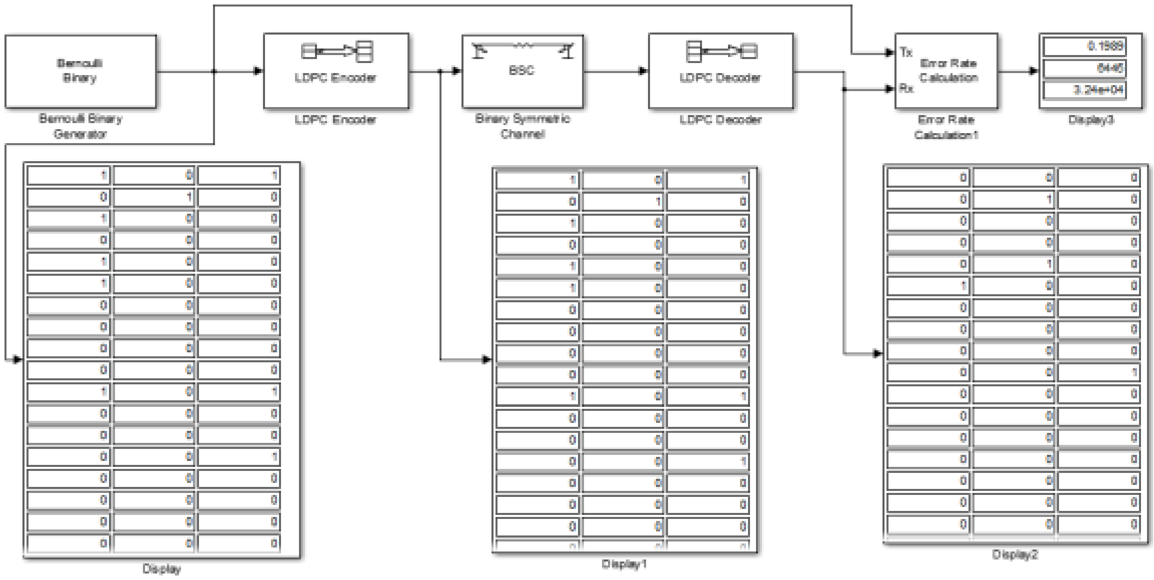

Fig.6. Scheme of the LDPC error-correcting code model in a DVB-T2 digital television system (error probability is 0.2)

The displays of the model demonstrate: a transmission line using the LDPC code. Input combination, encoded sequence, output combination, errors (error probability is 0.2).

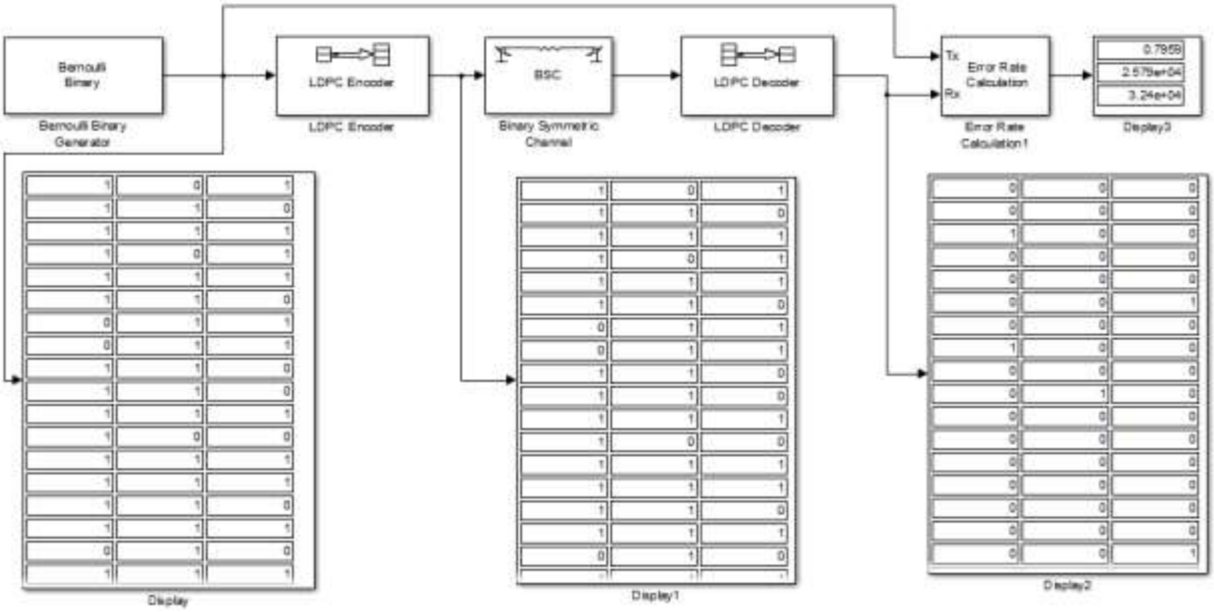

Fig.7. Scheme of the model of the noise-correcting code LDPC in the digital television system of the DVB-T2 standard (error probability is 0.8)

The displays of the model demonstrate: a transmission line using the LDPC code. Input combination, encoded sequence, output combination, errors (error probability is 0.8).

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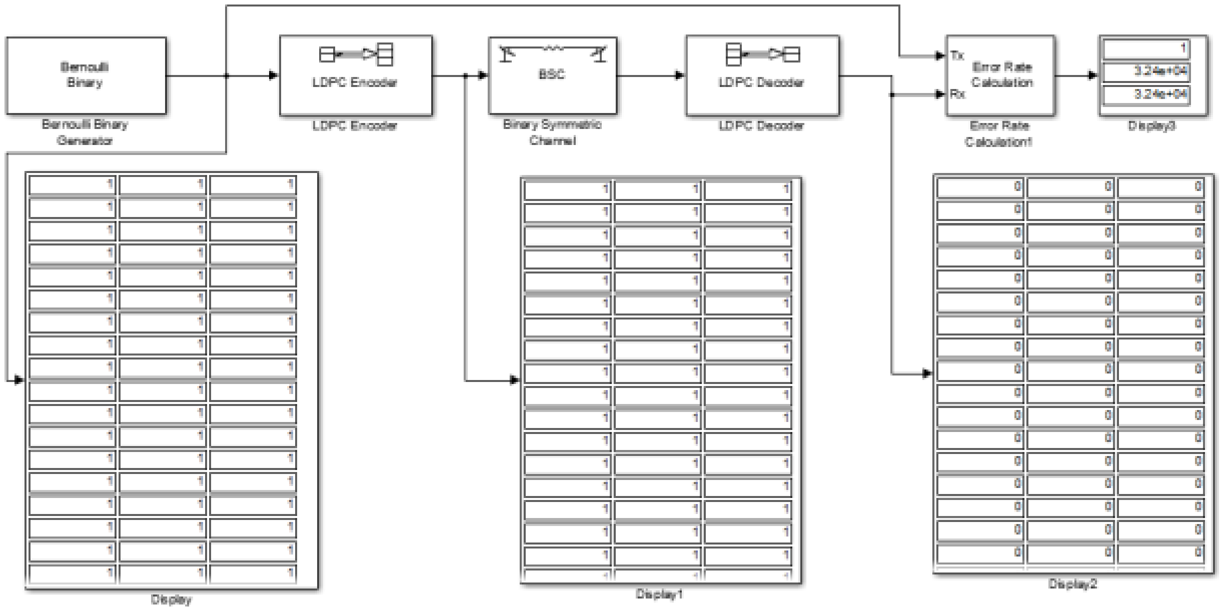

Fig.8. Scheme of the LDPC error-correcting code model in a DVB-T2 digital television system (error probability is 1.0)

The displays of the model demonstrate: a transmission line using the LDPC code. Input combination, encoded sequence, output combination, errors (error probability is 1.0).

The simulation results and calculated values are summarized in Table 2.

Table 2.

№	Probability of errors	Frequency error	Number of detected errors	Total number of characters compared
	0	0	0	3,24e+4
	0,1	0,0991	3211	3,24e+4
	0,2	0,1989	6445	3,24e+4
	0,3	0,2995	9672	3,24e+4
	0,4	0,3986	1,296e+4	3,24e+4
	0,5	0,5008	1,623e+4	3,24e+4
	0,6	0,6007	1,946e+4	3,24e+4
	0,7	0,7003	2,269e+4	3,24e+4
	0,8	0,7959	2,759e+4	3,24e+4
.	0,9	0,9011	2,916e+4	3,24e+4
.	1	1	3,24e+4	3,24e+4

A study was made using the model (Fig.6,7,8), the dependence of the number of errors on the error probability for the noise-correcting LDPC code in the digital television system of the DVB-T2 standard.

Figures 9 and 10 show the simulation results: the dependence of the error rate, the number of detected errors on the error probability for the LDPC code (32400).

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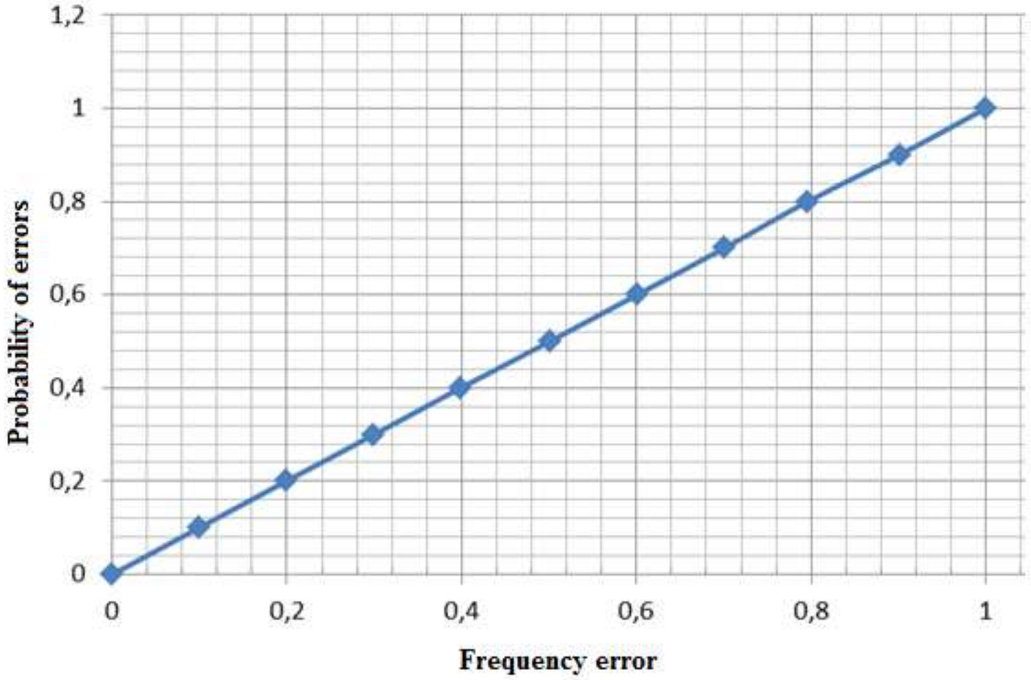

Fig.9. Graph of error rates versus error probability for LDPC code

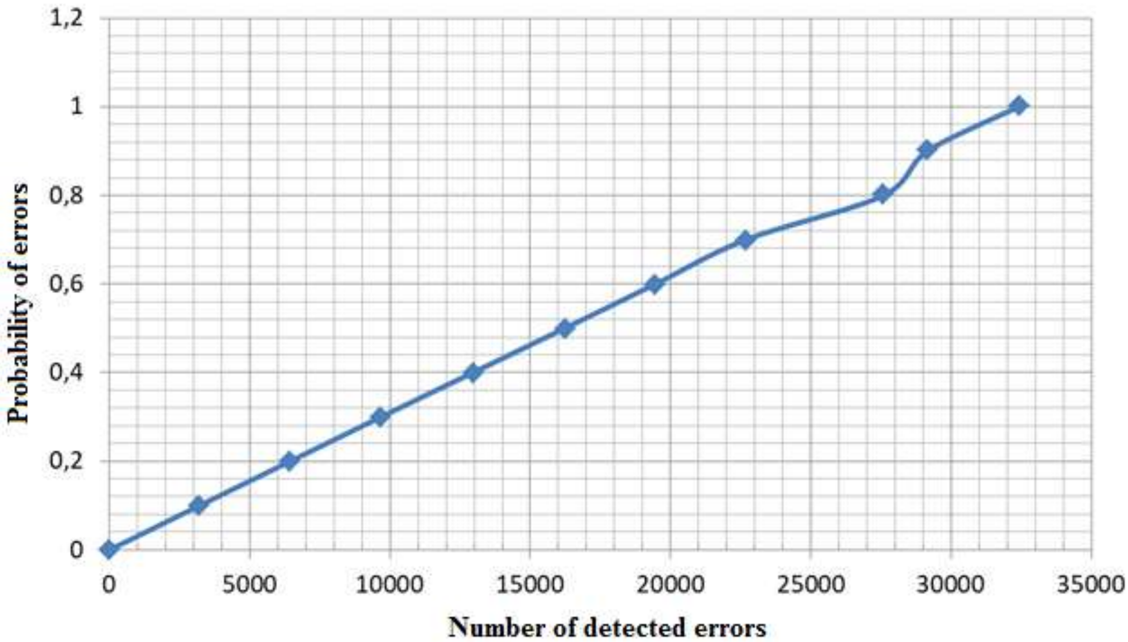

Fig.10. Graph of the number of detected errors versus the error probability for the LDPC code

The results of research and modeling show that low-density parity codes are a powerful error correction technique that outperforms many well-known coding schemes. The codes can be used in any communication system where energy savings are significant or the signal-to-noise ratio is very low [1].

In practice, in a digital television system, *Bose-Chowdhury-Hokvingham* (BCH) codes are used for outer coding, and a low-density parity check (LDPC) code for inner.

It should be noted that the efficiency of irregular LDPC codes is higher than the efficiency of regular codes. This is explained by the fact that in irregular codes, due to the different number of ones in rows and columns, information symbols are protected differently. As a result, during decoding, the so-called wave effect appears, when more secure bits are decoded faster and then, as it were, help in decoding less secure bits [4].

Produced and modeled the dependence of the number of errors on the error probability for error-correcting LDPC code, the results show that such codes provide a high degree of error correction. The lower

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the probability of the influence of interference on the communication channel, the less will be the erroneous reception of binary symbols.

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