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MODELING AND INVESTIGATION OF NOISE IMMUNITY REED-SOLOMON CODE TO PROVIDE INCREASED IMMUNITY IN DVB-T2 STANDARD DIGITAL TELEVISION SYSTEM

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Abstract
In this paper, the noise-correcting Reed-Solomon code is investigated and modeled to provide an increase in noise immunity in a digital television system of the DVB-T2 standard. Theoretical and practical algorithm of functioning of the Reed-Solomon noise-correcting codec has been studied. The error-correcting Reed-Solomon code in the DVB-T2 standard digital television system 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 Reed-Solomon code is modeled and investigated.

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

When receiving code packets (digital television signal of the DVB-T2 standard), an erroneous signal reception is formed on the receiver due to the influence of various interference and noise or interference on the communication channel.

Channel coding and decoding uses an outer Reed-Solomon code to detect and correct errors in digital television broadcasting.

The Reed-Solomon code is a linear block code and is a subset of BCH codes. Reed-Solomon codes are non-binary block cyclic codes that allow you to correct errors in data blocks. They are non-binary, because the elements of the code word are not bits, but bytes. This code allows you to correct up to 8 erroneously received bytes in each transport packet.

We analyze the Reed-Solomon encoder algorithm, the Reed-Solomon encoder receives a block of digital streams and adds additional “redundant” bits to them to ensure the correction of received errors and restore the transmitted code packets using the Reed-Solomon decoder. Generated number and types of errors that can be recovered, depending on the properties of the Reed-Solomon encoder.

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The Reed-Solomon code is specified as RS (n, k) s - bit characters. This means that the encoder takes k information symbols in s-bits each and adds parity symbols to form an n symbol code word [1].

The coding process. To generate the Reed-Solomon code, arithmetic with polynomials in Galois fields and a polynomial generator are required, for example, as a result of generation, you can get the following:

$$(a^1-x)*(a^2-x)*(2^3-x)*(a^4-x), \qquad (1)$$

(1) the expression can be rewritten as follows:

$$(2^1-x)*(2^2-x)*(2^3-x)*(2^4-x) \qquad (2)$$

Where: a is a primitive field member (usually 2 is chosen) and x is the number of redundant characters.

The Reed-Solomon decoder can correct up to t symbols that contain errors in the code word, where 2t=n-k. The diagram below shows a typical Reed-Solomon code word (Figure 1): [1].

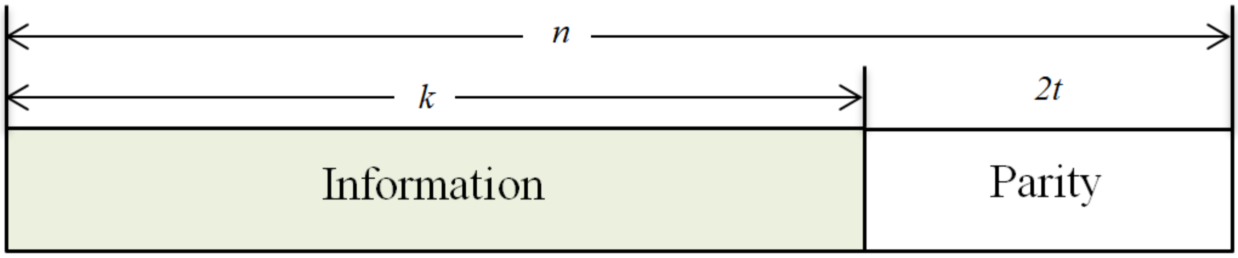

Fig.1. Code word for RS code

Decoding process. According to the functioning algorithm, the Reed-Solomon code during decoding can correct errors and restore lost everyday characters. The Reed-Solomon decoder can correct errors up to t and recover losses up to 2t. The generated loss of everyday symbols may be captured by the demodulator.

To ensure the decoding of received code packets, you can choose three decoding options [1]:

1. If $2s+r < 2t$ (s errors, r losses), then the original transmitted code word will always be recovered.
2. The decoder detects a situation where it cannot recover the original code word.
3. The decoder incorrectly decodes and incorrectly reconstructs the code word without any indication of this fact.

The probability of each of these options depends on the type of Reed Solomon code used, as well as on the number and distribution of errors [1].

To study and simulate the noise-correcting Reed-Solomon 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

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the dependence of the number of errors on the error probability for the error-correcting Reed-Solomon code.

To study and simulate the noise-correcting Reed-Solomon code in a digital television system of the DVB-T2 standard using the Matlab / Simulink software environment, we use the following parameters (Fig. 2,3,4,5,6) and set the block characteristics for the code (128.98) digital television system of the 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	Reed-Solomon
6.	Code word length	128
7.	Message length	98

Below are the parameters of the model (Fig.2,3,4,5,6).

On (Fig.7,8,9) the studied scheme of the model of the noise-correcting Reed-Solomon code 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), RS Encoder (encoder), Binary Symmetric Channel (transmission channel), RS Decoder (decoder), Error Rate Calculation (error analyzer) and Display.

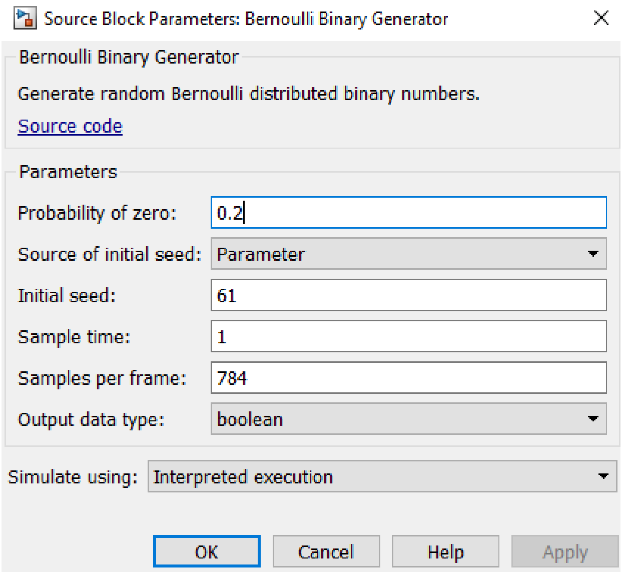

Fig.2. Parameters of Bernoulli Binary Generator

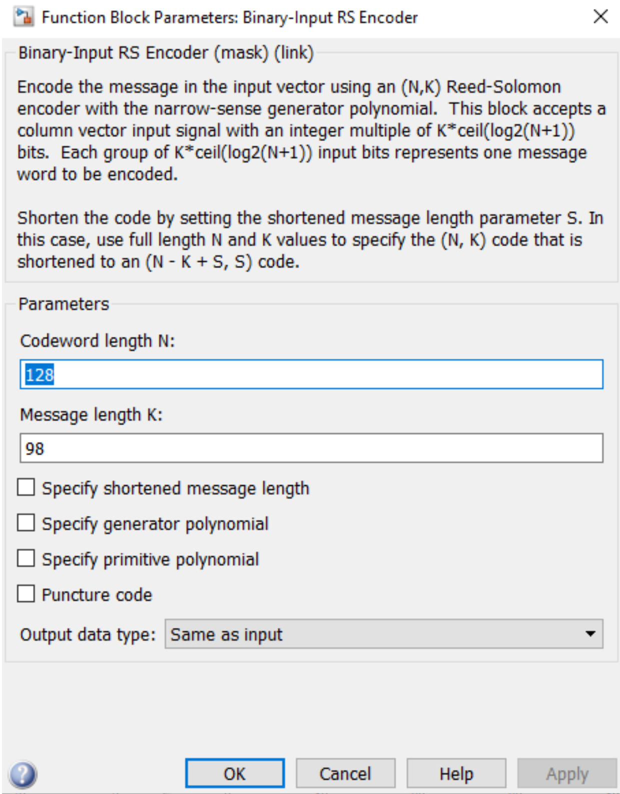

Fig.3. Parameters of Reed-Solomon Encoder

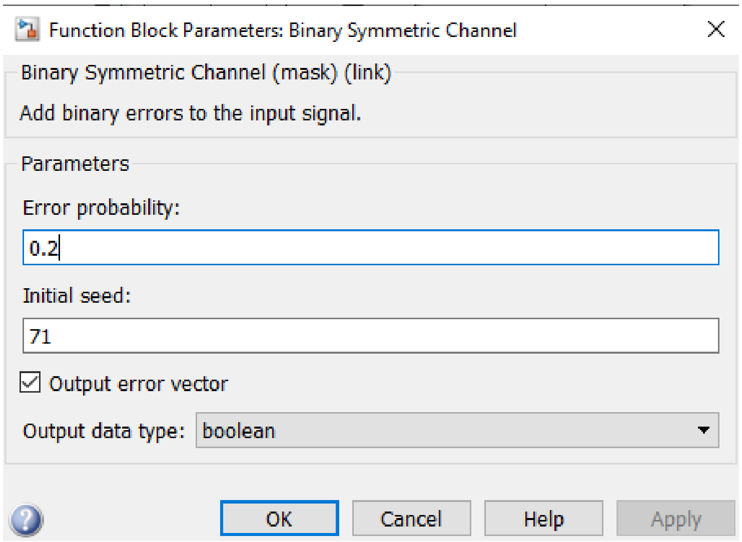

Fig.4. Parameters of Binary Symmetric Channel

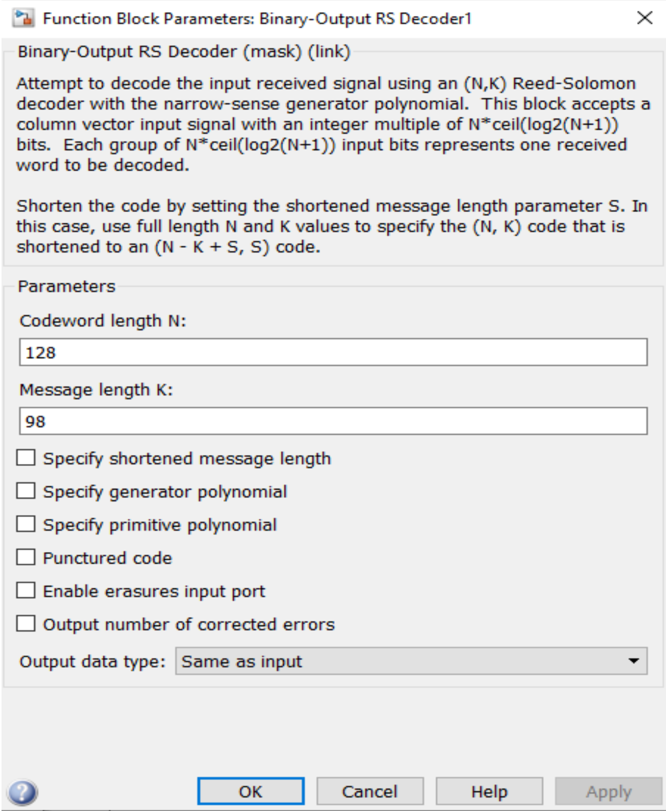

Fig.5. Parameters of Reed-Solomon Decoder

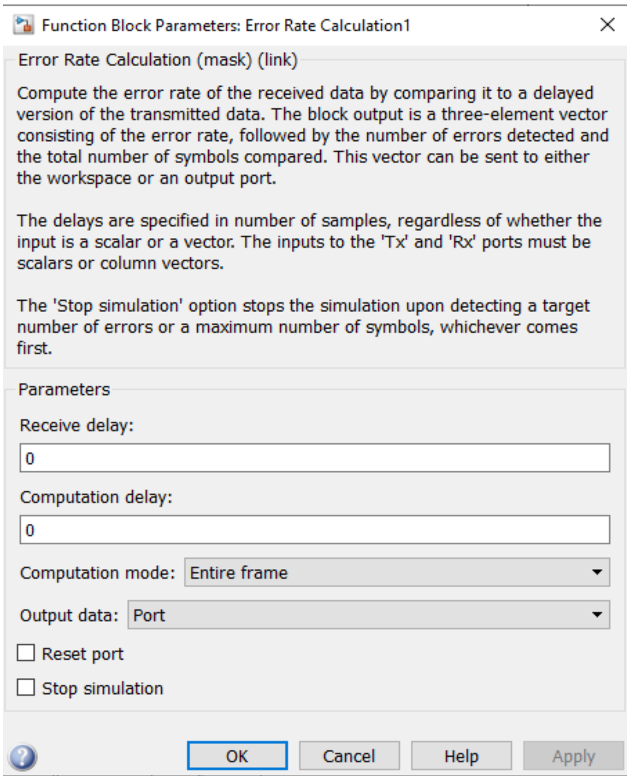

Fig.6. Parameters of Error Rate Calculation

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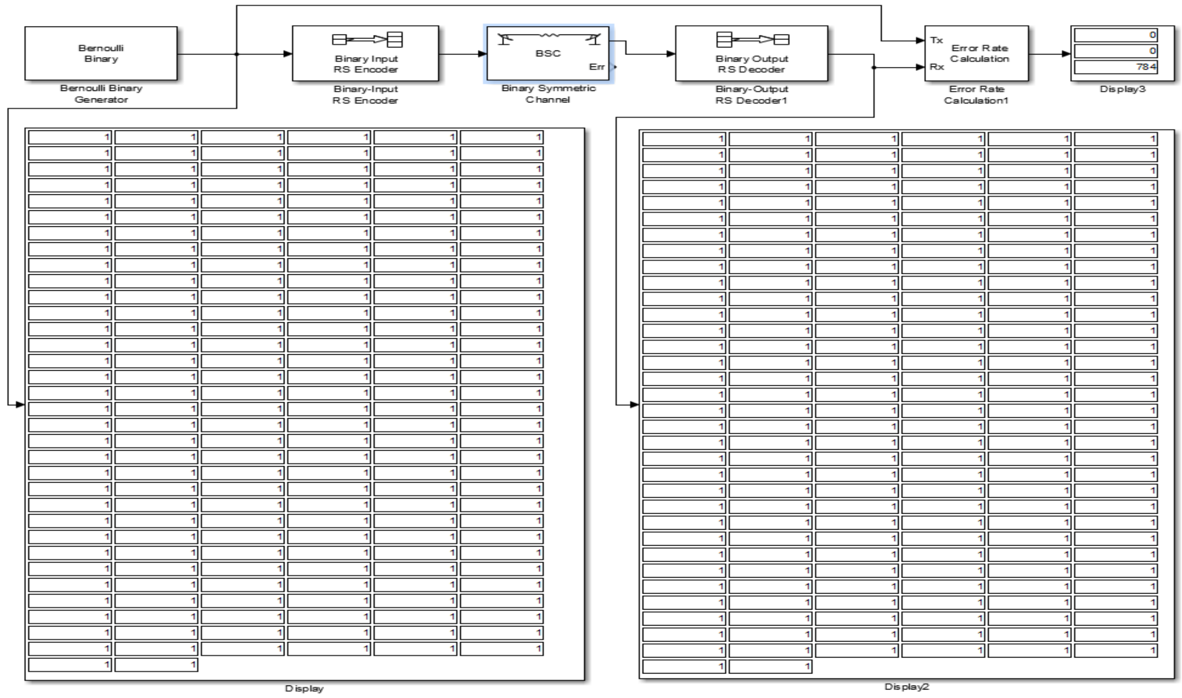

Fig.7. Scheme of the model of the error-correcting Reed-Solomon code in a digital television system of the DVB-T2 standard (error probability is 0)

The displays of the model demonstrate: a transmission line using the Reed-Solomon code. Input combination, encoded sequence, output combination, errors (probability of errors is 0).

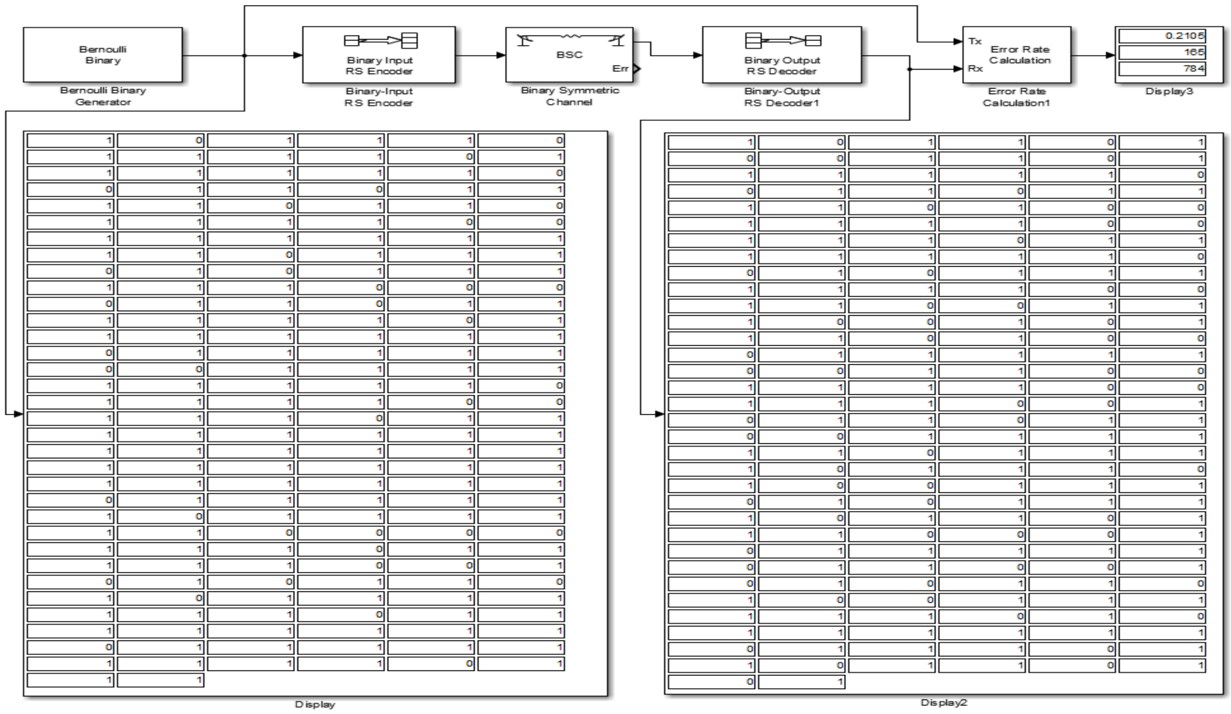

Fig.8. Scheme of the model of the error-correcting Reed-Solomon code in the digital television system of the DVB-T2 standard (error probability is 0.2)

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

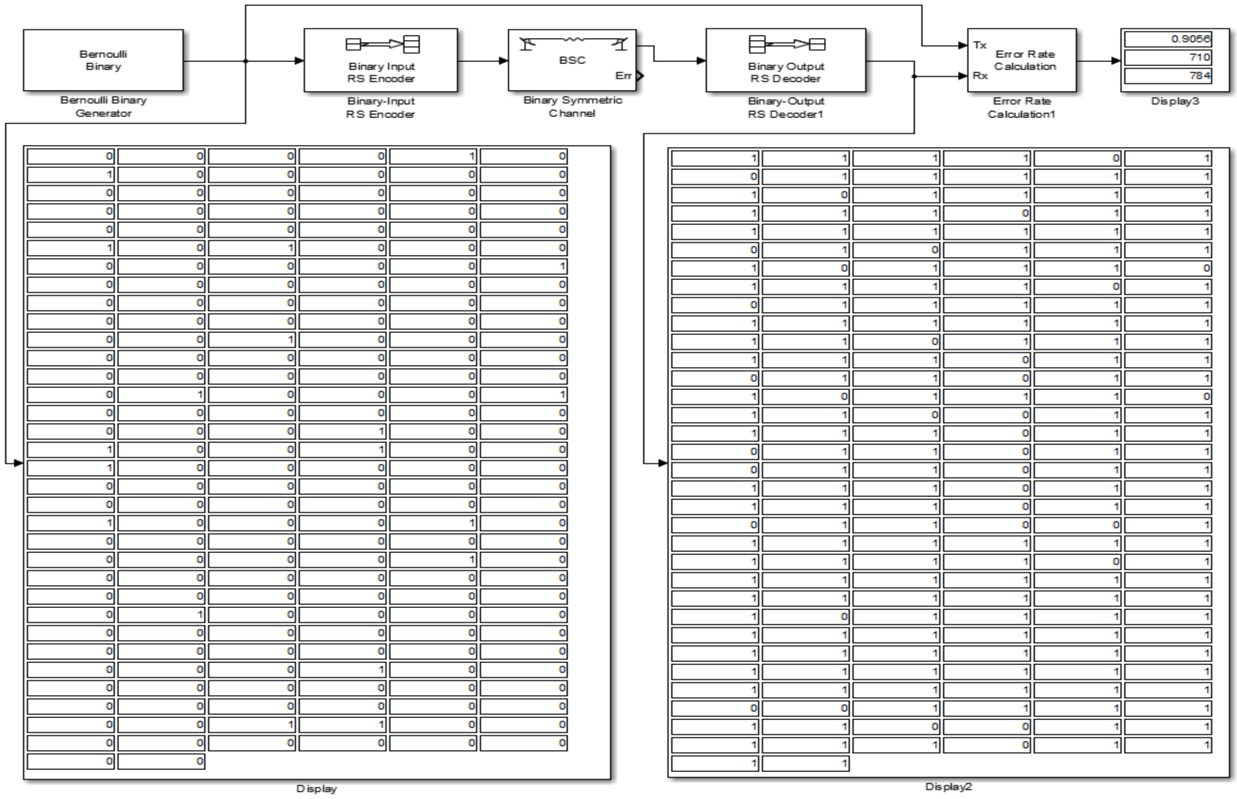

Fig.9. Scheme of the model of the error-correcting Reed-Solomon code in the digital television system of the DVB-T2 standard (error probability is 0.9)

The displays of the model demonstrate: a transmission line using the Reed-Solomon code. Input combination, encoded sequence, output combination, errors (error probability is 0.9). 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
1.	0	0	0	784
2.	0,1	0,1135	89	784
3.	0,2	0,2115	165	784
4.	0,3	0,3214	252	784
5.	0,4	0,4158	326	784
6.	0,5	0,5179	406	784
7.	0,6	0,5995	470	784
8.	0,7	0,7003	549	784
9.	0,8	0,7959	624	784
10.	0,9	0,9056	710	784
11.	1	1	784	784

A study was made using the model (Fig. 7,8.9) of the dependence of the number of errors on the error probability for the noise-correcting Reed-Solomon code in the digital television system of the DVB-T2 standard.

In Figure 10, the simulation results are presented: the dependence of the number of errors (OY) on the probability of error (OX) for

Reed – Solomon code (128.98).

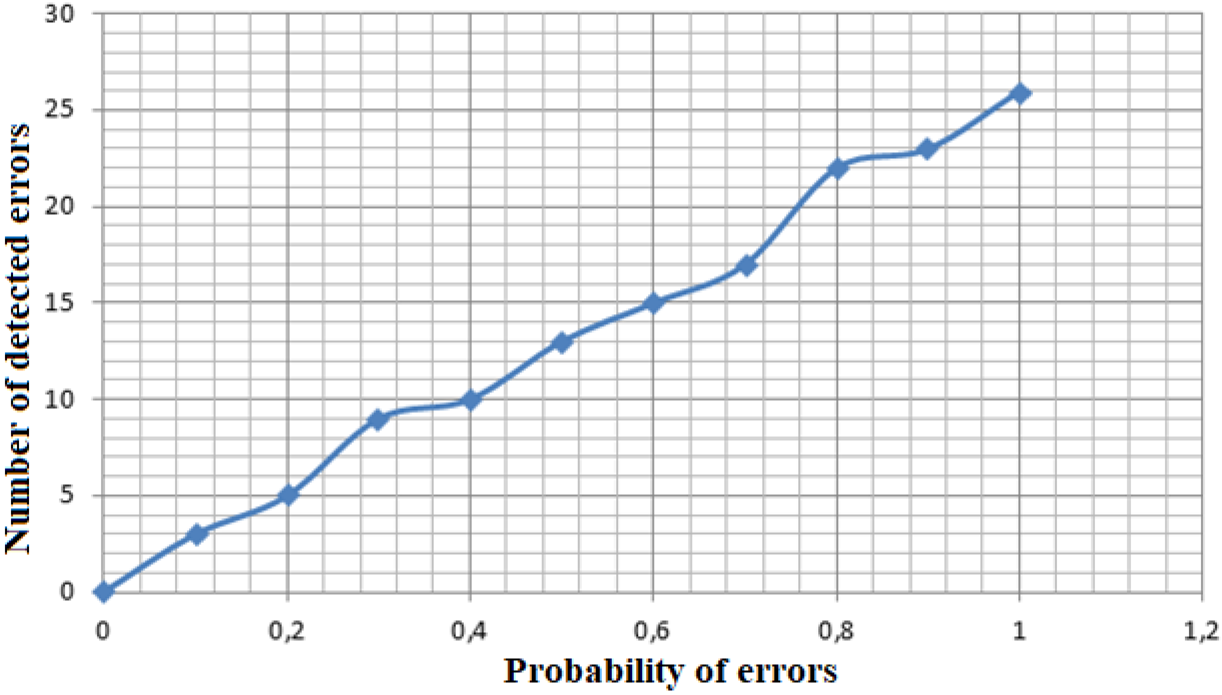

Fig.10. Graph of the number of errors (OY) against the probability of error (OX) for the Reed-Solomon code (128.98)

The results of the study and modeling show that in channel coding and decoding, an external Reed-Solomon code is used to detect and correct errors in digital television broadcasting.

In practice, in a digital television system, the Reed-Solomon code is used for external coding. The Reed-Solomon code is a linear block code and is a subset of BCH codes. Reed-Solomon codes are non-binary block cyclic codes that allow you to correct errors in data blocks. The dependence of the number of errors on the error probability for the error-correcting Reed-Solomon code was produced and modeled, the results show that such a code provides protection of information from errors, the code allows you to correct up to 8 bytes received with errors in each transport packet. The lower 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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