Computer Modeling of Transmitter of a Digital Communication System

Angel Hristov Chekichev, Daniela Antonova Shehova, Velislava Hristova Raydovska and Zlatin Ilkov Hunev

Abstract – **The report offers a computer model of the transmitter part of a digital communication system for data transmission, which was developed in the environment of Matlab Simulink.**
Keywords – **digital communication system, digital transmitter.**

I. Introduction

In the digital transmission of the information, fundamentally the new methods for signal processing allow creating devices with unique features, unavailable for the methods of analog signal processing.

The architecture of the digital communication systems ensures efficient use of the spectrum and the energy resource of the communication channel in ever-changing conditions of signal distribution in it [1].

The aim of the report is to provide a computer-based method for examination of the behavior of the transmission part of the digital communication system based on block-diagram, which was developed in the graphical environment for imitation modeling Simulink.

II. Digital Transmitter – Conceptual Block Scheme

It's presented conceptual block scheme of a digital transmitter in figure 1.

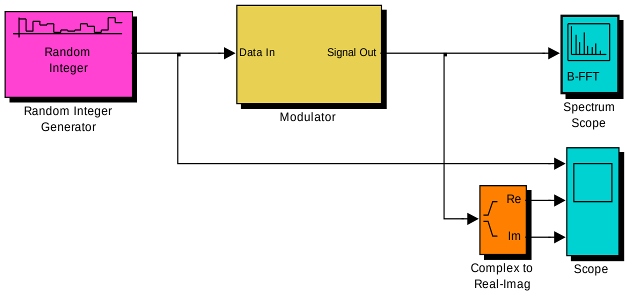

Fig. 1. Conceptual block scheme of a digital transmitter

A. Chekichev is with the Technical College by Plovdiv University “Paisiy Hilendarski”, 4700 Smolyan, Bulgaria, e-mail: a216@abv.bg
D. Shehova is with the Technical College by Plovdiv University “Paisiy Hilendarski”, 4700 Smolyan, Bulgaria, e-mail: dani_shehova@abv.bg
V. Raydovska is with the Technical College by Plovdiv University “Paisiy Hilendarski”, 4700 Smolyan, Bulgaria, e-mail: veli_45@abv.bg
Z. Hunev is students in the Technical College by Plovdiv University “Paisiy Hilendarski”, 4700 Smolyan, Bulgaria, e-mail: zlati_hunev_94@abv.bg

The model of a digital communication system allows the committing of a simulation examination under input data's shown in Table 1.

TABLE 1. THE INPUT DATA'S FOR MODELING OF A DIGITAL COMMUNICATION SYSTEM

№	Type manipulation	Positional of the constellations	Multiplicity of the constellation
0	BPSK	2	1
1	QPSK	4	2
2	8PSK	8	3
3	16PSK	16	4
4	32PSK	32	5
5	16QAM	16	4
6	32QAM	32	5
7	64QAM	64	6
8	128QAM	128	7
9	256QAM	256	8

In figure 2 are visualized signal constellations under different kinds of manipulations, and in figure 3 – their energy efficiency [2].

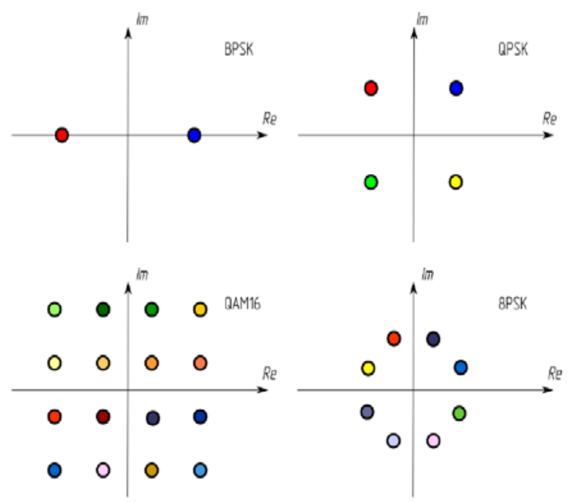

Fig. 2. Signal constellations under different kinds of manipulations

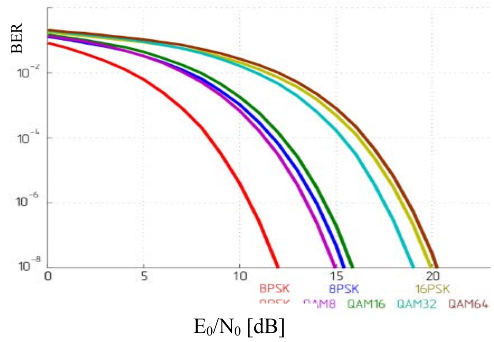

Fig. 3. Energy efficiency of kinds of digital manipulations

For the creation of the conceptual block scheme of a digital transmitter (fig. 1.) the following blocks are used [4]:

- Random Integer Generator – generator of random numbers;

In the settings of the generator of random numbers it is required to set positional assembly (M-ary number) according to the version (Table 1) and the sampling frequency - Sample Time 1/9600, which corresponds to the symbol rate of transmission data's 9600 baud/sec.

- Complex to Real-Imag – block for distribution of the real and the imaginary parts of a complex signal;
- Scope – the input signal of the oscilloscope is the signal from datas, according to the output complex signal of transmitter, which are distributed in the block Complex to Real-Imag;
- Spectrum Scope – analyzer of signal spectrum (spectrum-analyzer).

In the settings of Spectrum Scope it is necessary to indicate the size of the window of the fast Fourier transform - 1024 and includes a buffer input signal with buffer size - 1024 discretes.

- Modulator – it is formed by the signal of the transmitter and is constructed as a Subsystem presented in Fig. 4.

III. Modulator – Shaper of the Signal in the Digital Transmitter

An important block in the transmission part of the digital communication systems (fig. 1) is the modulator, which forms the signal, emitted by the transmitter. The modulator is constructed as a Subsystem, structure of which is shown in fig. 4.

For clear study processes, the formation of the signal in the modulator made by given below blocks:

- 1-D Lookup Table – correlation table (the veracity);
- Raised Cosine Transmit Filter – forming filter with characteristic feature of cosine increases;
- Gain – signal amplifier;
- Discrete-Time Eye Diagram Scope;
- Discrete-Time Signal Trajectory Scope – block, for display the trajectory of the vector of the complex signal envelope on the plane;
- Discrete-Time Scatter Plot Scope – block, for display of the diagram of the scattered signal.

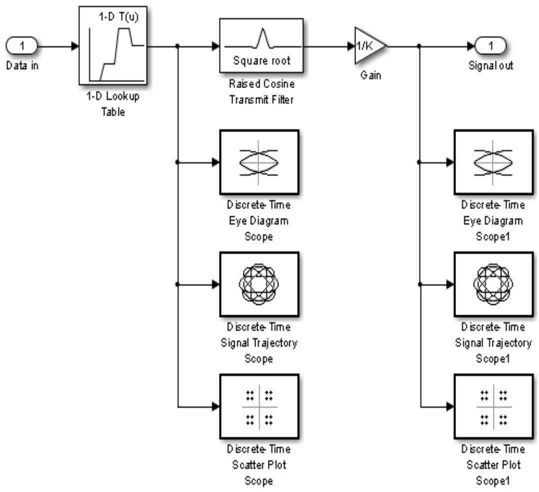

Fig. 4. The structure scheme of the shaper of a signal in the digital transmitter

Table 2. The correlation table for various type manipulations

<table>
<tr><th>Manipulation</th><th>Positional of the constellations</th><th colspan="4">Datas for the transmission</th><th colspan="4">Output of shaper of the complex envelope</th></tr>
<tr><td>BPSK</td><td>2</td><td colspan="2">0</td><td colspan="2">1</td><td colspan="2">-1-1j</td><td colspan="2">+1+1j</td></tr>
<tr><td rowspan="2">QPSK</td><td rowspan="2">4</td><td colspan="2">0</td><td colspan="2">1</td><td colspan="2">-1+1j</td><td colspan="2">+1+1j</td></tr>
<tr><td colspan="2">2</td><td colspan="2">3</td><td colspan="2">+1-1j</td><td colspan="2">-1-1j</td></tr>
<tr><td rowspan="4">QAM16</td><td rowspan="4">16</td><td>0</td><td>1</td><td>2</td><td>3</td><td>-3+3j</td><td>-1+3j</td><td>+1+3j</td><td>+3+3j</td></tr>
<tr><td>4</td><td>5</td><td>6</td><td>7</td><td>-3+1j</td><td>-1+1j</td><td>+1+1j</td><td>+3+1j</td></tr>
<tr><td>8</td><td>9</td><td>10</td><td>11</td><td>-3-1j</td><td>-1-1j</td><td>+1-1j</td><td>+3-1j</td></tr>
<tr><td>12</td><td>13</td><td>14</td><td>15</td><td>-3-3j</td><td>-1-3j</td><td>+1-3j</td><td>+3-3j</td></tr>
</table>

A. Block 1-D Lookup Table

For the proper functioning of the Subsystem, the appropriate setting in Function Block Parameters: 1-D Lookup Table has to be carried out.

In the determination of the correlation table (1-D Lookup Table) the correlation between the vector input symbols and the points of signal assembly are proved.

In the field Breakpoints of the dialog box for parameter settings of the block 1-D Lookup Table, the vector input symbols, according to the position assembly (Table 2) are proved. For example, for 16QAM it is: [0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15] (fig. 5.). For manipulations of higher-order a method for automatic generation of vectors in MATLAB is being used.

In the field Table Data the points of constellations, corresponding to the input symbol are proved, as for 16QAM they are:
[-3+3*i -3+1*i -3-3*i -3-1*i -1+3*i -1+1*i -1-3*i -1-1*i +3+3*i +3+1*i +3-3*i +3-1*i +1+3*i +1+1*i +1-3*i +1-1*i], (fig. 5.).

The correlation table for various type manipulations, needed for the setup of this block is shown in TABLE 2.

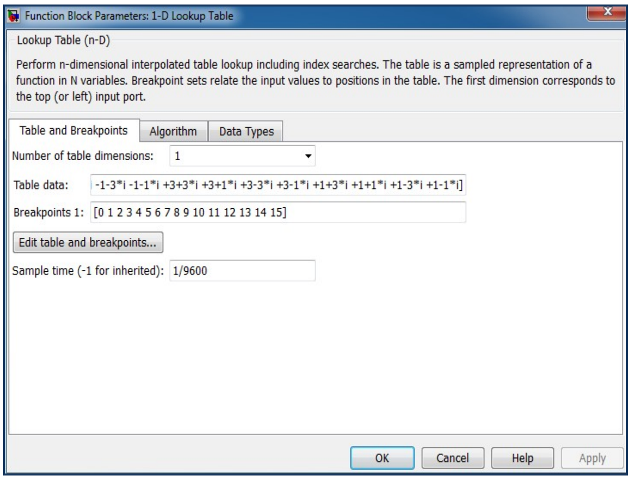

Fig. 5. Parametric settings of block 1- D Lookup Table

B. Block Raised Cosine Transmit Filter

Restriction of the signal spectrum is carried out by a block Raised Cosine Transmit Filter. Filter settings for the performed simulation studies are reported in TABLE 3.

The complex signal from the output of the forming filter enters in Gain, in which its norming is carried out.

The transmission factor of the amplifier is equal to 1/K and is estimated with the formula:

$$K = \sqrt{\frac{1}{N}\sum_{i=0}^{N-1}\left|s_i\right|^2}\ , \qquad (1)$$

in which N – positioning assembly (constellation).

The parameter settings made in the functional block Raised Cosine Transmit Filter are shown in fig. 6, and fig. 7 illustrate the fundamental characteristics of the Filter.

TABLE 3. SETTINGS OF RAISED COSINE TRANSMIT FILTER

Settings of Raised Cosine Transmit Filter		
1.	Filter Type	Square Root
2.	Group Delay	5 symbols
3.	Rolloff Factor	0.8
4.	Upsampling factor	8
5.	Input Processing	sample based

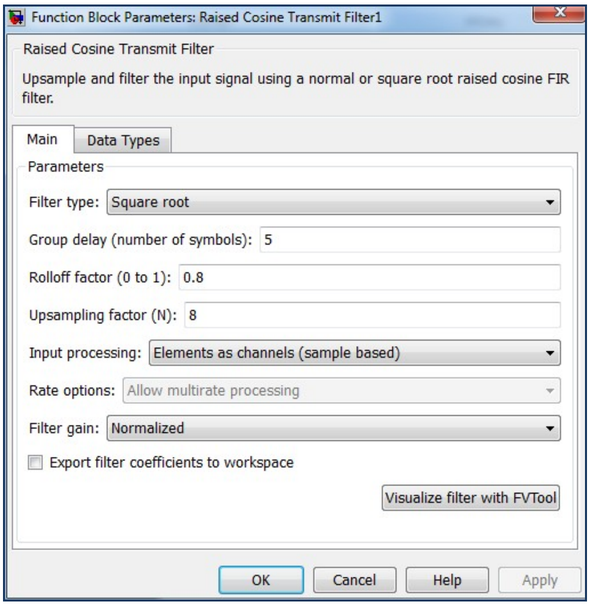

Fig. 6. Parametric settings of block Raised Cosine Transmit Filter

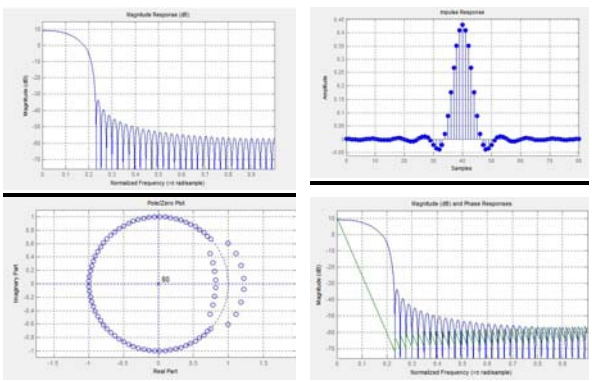

Fig. 7. Basic characteristics of the Filter

As it was already explained the blocks Discrete-Time Eye Diagram Scope, Discrete-Time Signal Trajectory

Scope, Discrete-Time Scatter Plot Scope are designed for viewing the processes of the forming signal in the modulator. The results from the simulation studies are shown in fig. 8.

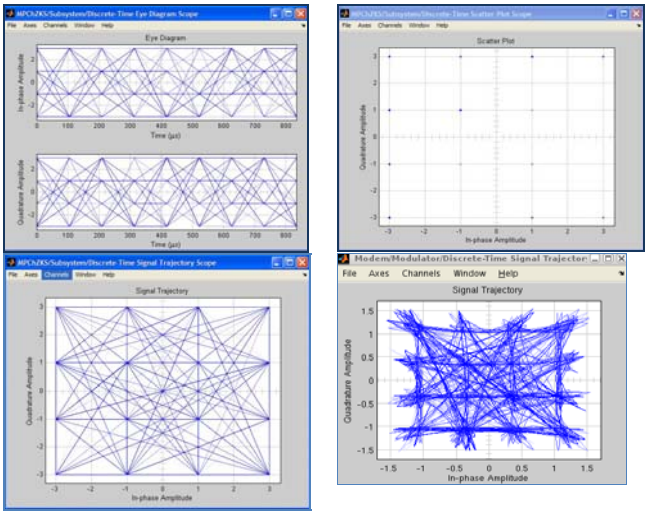

Fig. 8. Blocks for display of the information for the forming signal

The spectrum of the formed signal in the transmitter of the digital communication system from fig. 1 was observed with the virtual Spectrum Scope.

The parametric settings for optimal functioning of the block are shown in fig. 9, and in fig.10 the spectrum of the formed signal is displayed.

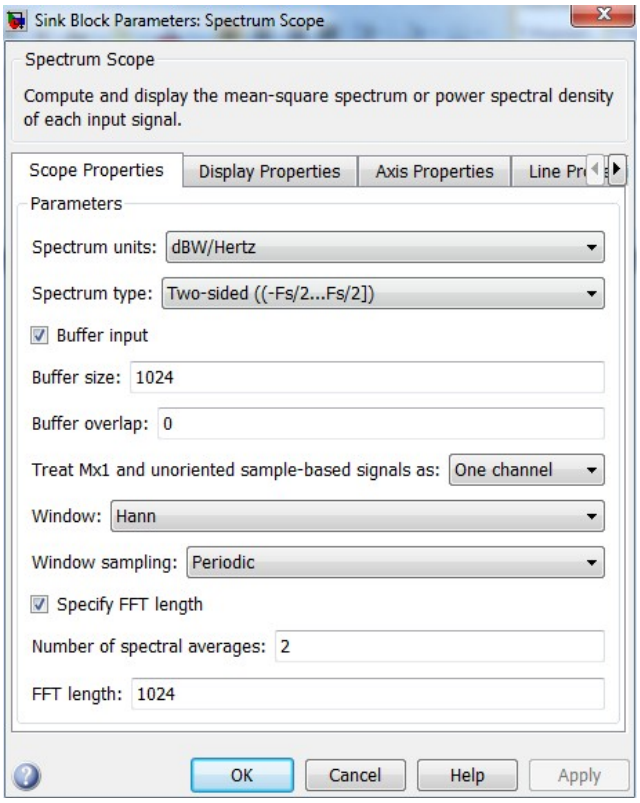

Fig. 9. Parametric settings on Spectrum Scope

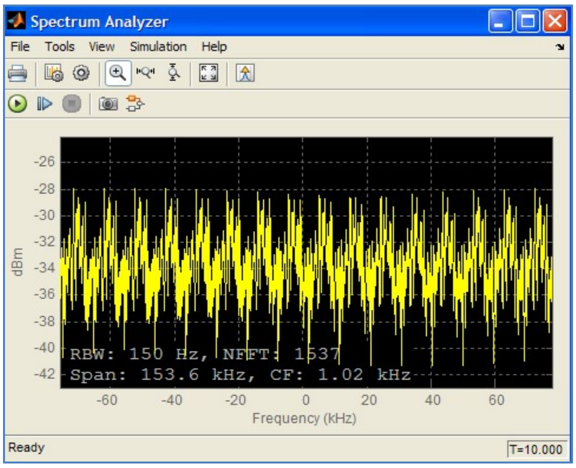

Fig. 10. The spectrum of the formed signal

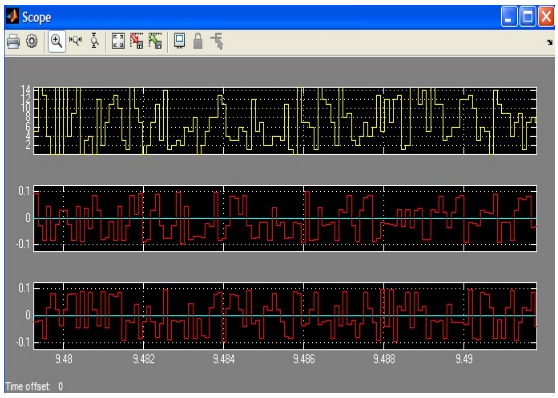

Fig. 11. Waveforms, observed with triple-channel oscilloscope transmitter output

IV. Conclusion

The creating of a computer model of the transmitter of a digital communication system provides an opportunity to visualize the forming process of the transmitted signal. In a subsequent report the authors will present models of the communication channel and the receiving part of the communication system, and a comprehensive computer model of a digital communication system will be build.

Acknowledgement

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