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Modeling of Communication Channel in the Simulink Environment

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Abstract— **The article discuses a study of the phenomena and processes that occur in the communication channel in a digital communication system for data transmission in Simulink.**

Keywords-communication channel, Simulink, block, Subsystem

I. INTRODUCTION

In telecommunications and computer networking, a communication channel or channel, refers either to a physical transmission medium such as a wire, or to a logical connection over a multiplexed medium such as a radio channel [1].

A channel is used to convey an information signal, for example a digital bit stream, from one or several senders (or transmitters) to one or several receivers. A channel has a certain capacity for transmitting information, often measured by its bandwidth in Hz or its data rate in bits per second. [2].

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

II. COMMUNICATION CHANNEL – CONCEPTUAL BLOCK SCHEME

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

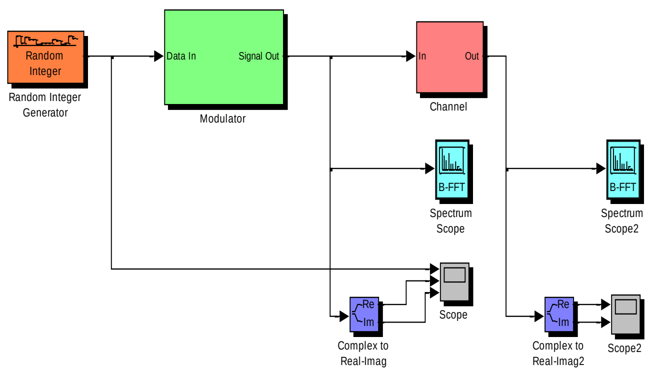

Figure 1. Conceptual block scheme of a digital transmitter and communication channel

The conceptual block scheme of a communication channel and digital transmitter allows the committing of a simulation examination under input data shown in Table 1 [3].

TABLE I. THE INPUT DATA FOR MODELING OF A CONCEPTUAL BLOCK OF A COMMUNICATION CHANNEL

№	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

To perform the task assigned the use of the following blocks is necessarily:

- Additive white Gaussian noise (AWGN) – a channel with AWGN and it is a basic noise model used in Information theory to mimic the effect of many random processes that occur in nature;
- Phase/Frequency Offset – a block that realizes phase and frequency modifications of the input signal;
- Variable Fractional Delay – a block for fractional hindrance of the signal;
- Constant – a constant;
- Complex to Real-Imag – a 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 data, according to the output complex signal of the transmitter, which are distributed in the Complex to Real-Image block;
- Discrete-Time Eye Diagram Scope;
- Discrete-Time Signal Trajectory Scope – a block for displaying the trajectory of the vector of the complex signal envelope on the plane;
- Discrete-Time Scatter Plot Scope – a block for displaying of the diagram of the scattered signal;
- Subsystem – a subsystem allowing the formation of parts of the model in the form of separate blocks;
- Spectrum Scope – an analyzer of signal spectrum (signal spectrum-analyzer).

For the creation of the first part (Modulator) of the model of digital transmitter and communication channel (fig. 1) the following blocks are used [4, 5]:

- 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. 2.

III. Modulator

An important block in the transmission part of the modeling system (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. 2.

In order to be possible to study processes, associated with the formation of the signal in the modulator are used 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.

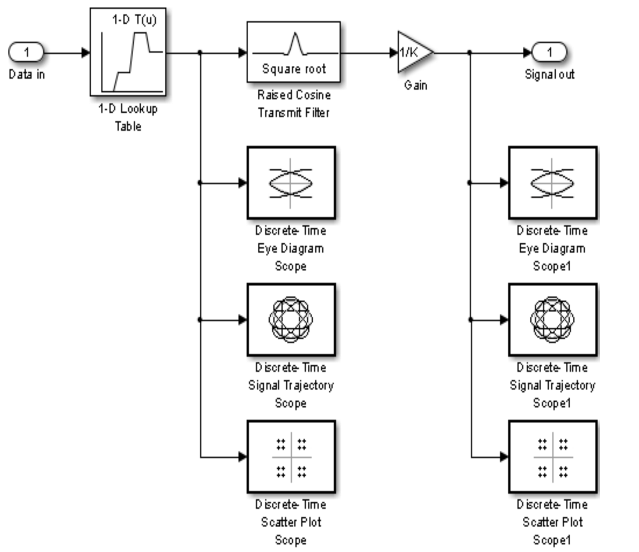

Figure 2. The structure scheme of the shaper of a signal

IV. Communication Channel

The model of the communication channel is shown in fig. 3. It includes in itself the AWGN Channel block, a block for frequency and phase offset and a block for fractional hindrance of the signal, which is set as a constant.

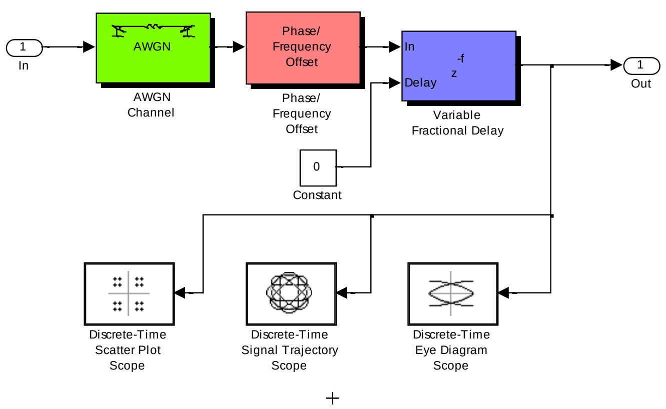

Figure 3. The structure scheme of the communication channel

A. AWGN Channel block

When setting of the AWGN Channel block SNR mode (Mode) is selected and the signal/noise ratio is set to be 13 dB. A zero phase (Phase offset) and frequency hopping (Frequency offset) signal is adjusted when making the setting for the Phase/Frequency Offset. Linear Interpolation (Interpolation mode - Linear) mode in the Variable Fractional Delay block of partial retention is selected.

The model is started and using the block for coverage of the information the signal is displayed and the operability of the pattern created is checked.

The setting of the AWGN Channel block is shown in fig. 4.

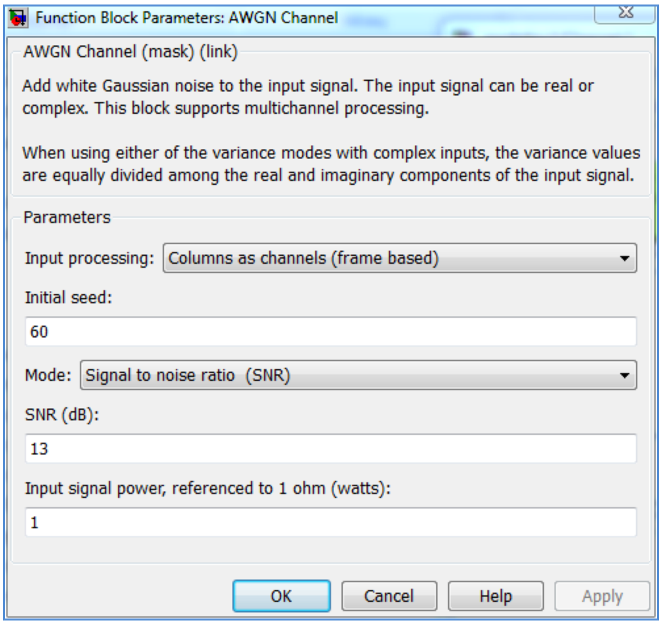

Figure 4. Parametric settings of the AWGN Channel block

B. Phase/Frequency Offset block

The Phase/Frequency Offset block applies phase and frequency offsets to an incoming signal.

The block applies a phase offset to the input signal, specified by the Phase offset parameter.

The block applies a frequency offset to the input signal, specified by the Frequency offset parameter. Alternatively, when is selected the Frequency offset from port check box, the Frequency input port provides the offset to the block. The frequency offset must be a scalar value, vector with the same number of rows or columns as the data input, or a matrix with the same size as the data input.

If is set Frequency offset to 2 and Phase offset to 0, the angles of points in the constellation change linearly over time. This causes points in the scatter plot to shift radially, as shown in fig. 5 and in fig. 6 illustrates the fundamental setting of the block.

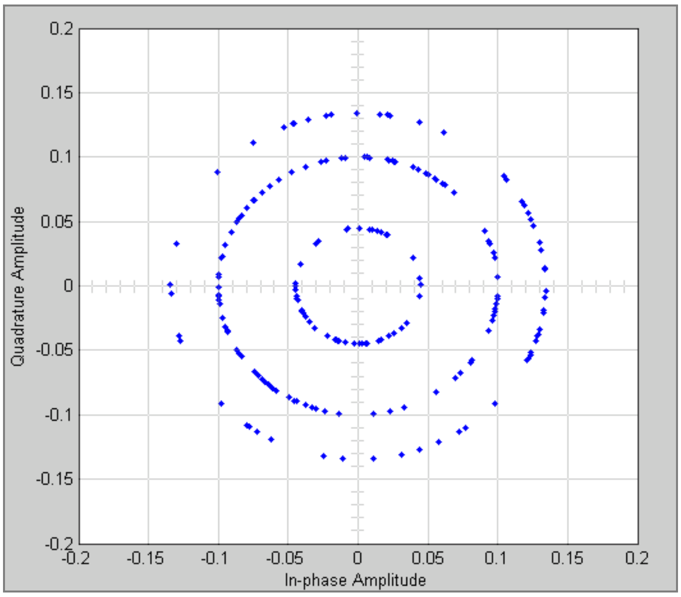

Figure. 5. Points in the Scatter Plot Scope which are shift radially

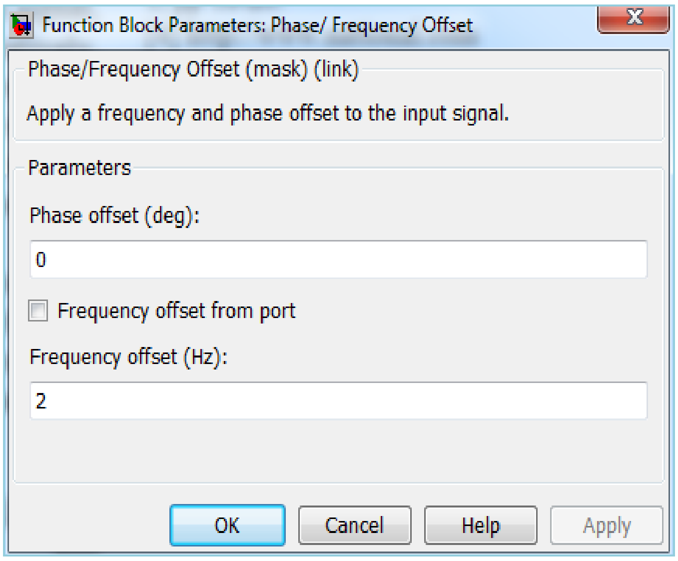

Figure. 6. Parametric settings of the Phase/Frequency Offset block

C. Variable Fractional Delay block

The Variable Fractional Delay block delays each element of the discrete-time N-D input array, u, by a variable number of sample intervals. The input delay values can be integer or non-integer values. The block provides three different interpolation modes: Linear, FIR, and Farrow.

The block computes the value for each channel of the output based on the stored samples in memory most closely indexed by the Delay input, v, and the interpolation method specified by the Interpolation mode parameter. Fig. 7 illustrates the fundamental setting of the block.

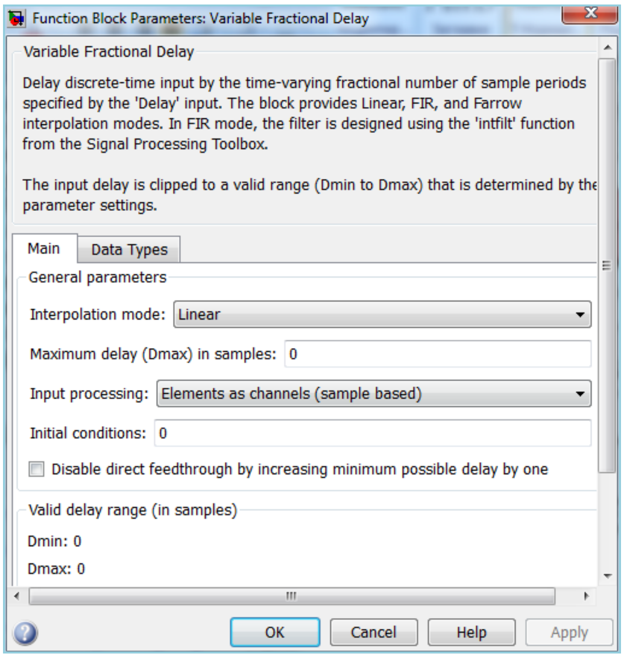

Figure. 7. Parametric settings of the Phase/Frequency Offset block

The results from the simulation studies are shown in fig. 8.

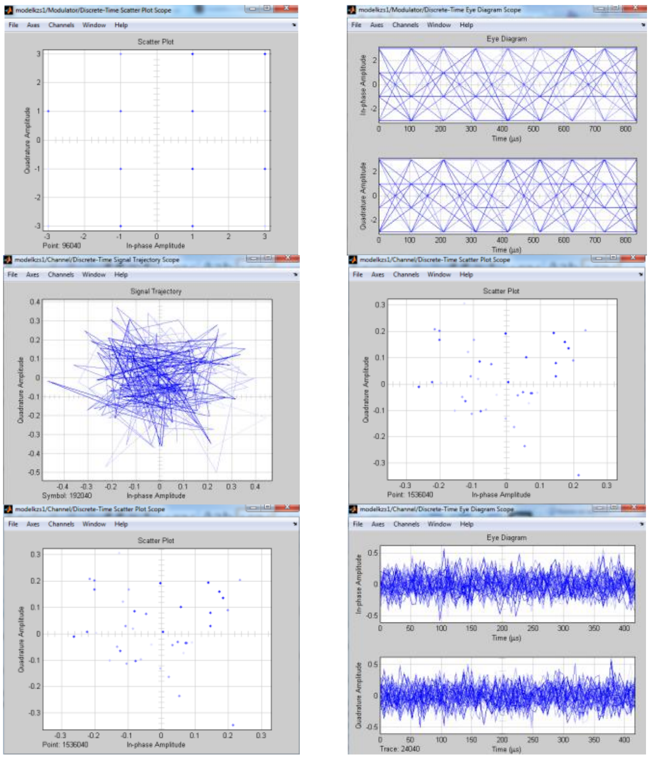

Figure. 8. Results of the simulation of the blocks in the modeling communication system

The spectrum of the formed signal in the transmitter and communication channel of the digital communication system from fig. 1 was observed with the virtual Spectrum Scope (fig. 9).

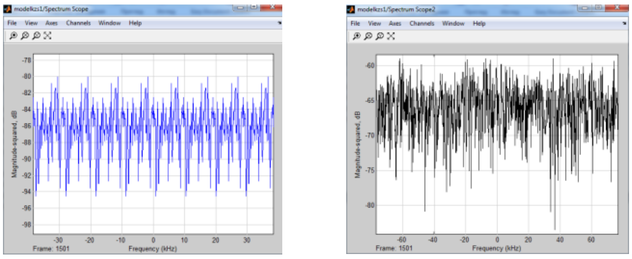

Figure. 9. The spectrum of the formed signal after the Modulator block and the Channel block

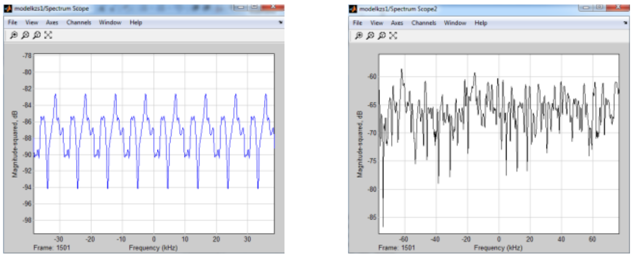

Figure. 10. The spectrum of the formed signal with Kaiser's window and coefficient - 100

V. Conclusion

The creating of a digital model of the transmitter and communication channel of a digital communication system provides an opportunity to visualize the process of forming digital signals.

The authors present a model of the transmitter and communication channel of the digital communication system in the Simulink environment unto change of the parameters: signal/noise ratio, phase offset, time delay and frequency offset.

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