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MODELLING OF COMMUNICATION SYSTEMS WITH IMPULSE-RADIO ULTRA-WIDE BAND SIGNALS

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Моделювання систем зв'язку, що використовують імпульсні надширокосмугові сигнали

Представлено імітаційну модель найпростішої системи зв'язку, що використовує імпульсні надширокосмугові (IR-UWB) сигнали. Модель реалізує метод неенергетичного прийому імпульсів. При цьому застосовано найпростіший метод канального кодування із пасивним нулем.

Nowadays, investigations into the systems that use Impulse-Radio Ultra-Wideband (IR-UWB) signals are of great interest due to many positive properties they have [1 – 4]. The most important features of such signals are: high communication channel capacity; low power consumption (owing to discrete structure of the signal); difficult signal identification (owing to small spectral density of the signal). These and some other properties of IR-UWB signals reduce possibility of unauthorized access to the information being transmitted through the channel [3] and make them perfect for use in military communication systems.

In this paper, a model of a communication system that uses IR-UWB signals is considered. In such a communication system, receiver generates a sequence of Gaussian pulses. The duration of a single pulse is taken to be 2.63 ps at level -3 dB, as it is shown in Fig. 1. Such a small pulse duration has been chosen in order to move the maximum of signal's spectrum to higher, less used, frequency band. The maximum of the power spectral density in this case will be at frequency of 103 GHz, as can be seen from Fig. 2.

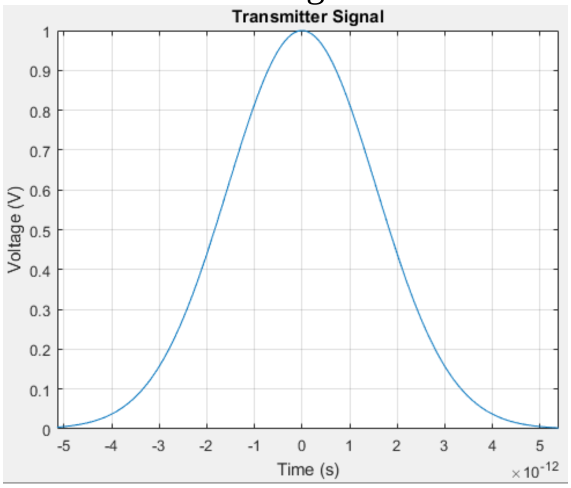

Fig.1. Shape of transmitted pulses.

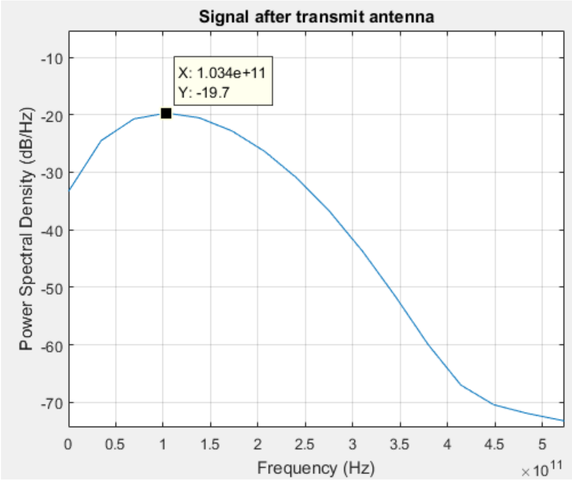

Fig.2. Spectral density of pulse in channel.

However, a short pulse has small energy in case of a feasible magnitude of the pulse. This complicates retaining synchronization. Thus, the system with IR-UWB signals should be asynchronous. An approach to effective asynchronous transmission over an IR-UWB channel was proposed in [1]. This IR-UWB pulses processing technique was called “non-energy” receiving method. According to this approach, the receiver doesn’t accumulate the energy of incoming pulses, but implements the selection of their position in time domain.

In the system that is proposed, the receiver selects the impulses, whose amplitudes exceed the mean noise level. Each selected pulse triggers a monostable generator, which generates an impulse with longer duration and fixed amplitude. Described non-energy receiver is the main component of the considered communication system, model of which is shown in Fig. 3. The advantage of such a system is its simplicity. The model implements both Simulink and Matlab means of simulation and programming.

At first, previously formed in Matlab uniform sequence of Gaussian pulses is modulated by a random sequence of rectangular pulses (Random Integer Generator Block). This sequence is sent at the input of the differentiating block Derivative2 and being than scaled in Gain4. The last two blocks simulate the antenna at the transmitting side. We assume the antennas ideal. Therefore, after differentiating blocks the signal is multiplied by the calculated in Matlab coefficient in order to keep the energy of the signal the same.

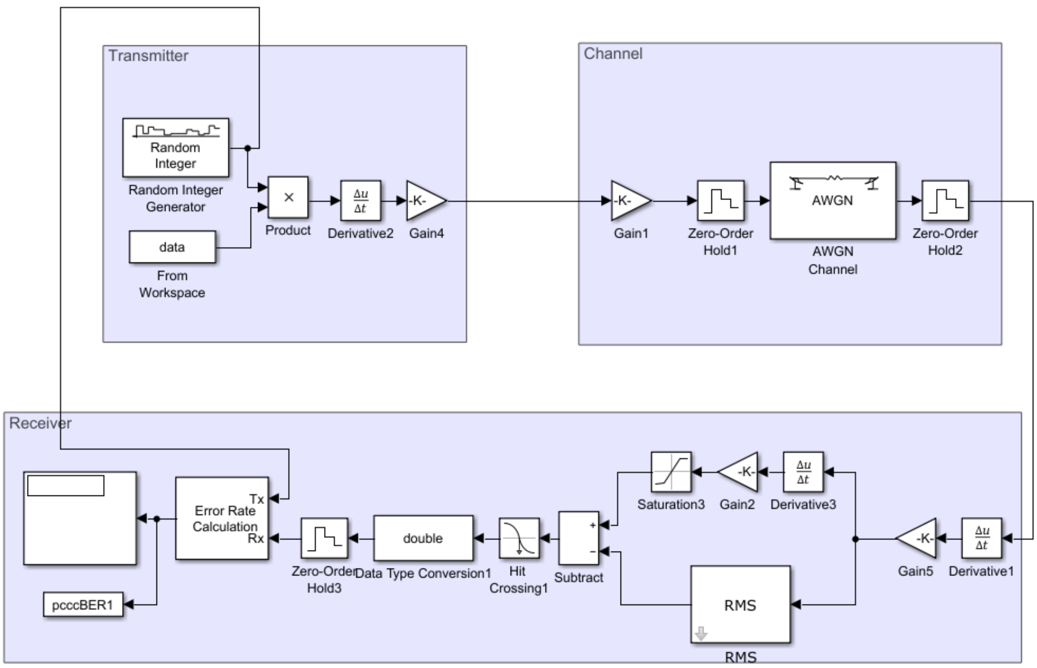

Fig.3. Functional diagram of IR-UWB system.

In the radio channel, the signal is attenuated in Gain1 that simulates the signal loss in open space, and then summed with white Gaussian noise in AWGN Channel. After that, the signal is differentiated again in Derivative1 and scaled in Gain5. These two blocks simulate the receiver antenna.

In the receiver, the signal is sent to two parallel chains. One of them differentiates the signal, whereas another one integrates it giving its root-mean-square (RMS) value at the output. The difference of these two signals is then sent to the input of the monostable multivibrator (Hit Crossing1), triggered by the falling edge of an impulse. The threshold for the multivibrator is chosen to be -0.4 V.

The resulting bit error rate for different values of the ratio E_b/N_o is shown in Fig. 4. It should be noted, that this graph is built for ideal conditions and demonstrates very high noise immunity of the channel. This is caused by very small power of the signal (of a few pW order) relative to the mean value of Gaussian noise.

It is proposed to put at transmitter output and receiver input broadband filters with bandwidth of 50 GHz – 150 GHz. This will not only cut off most of the noise and decrease the probability of erroneous reception, but also reduce noise created by the designed system to other communication systems in the adjacent bands.

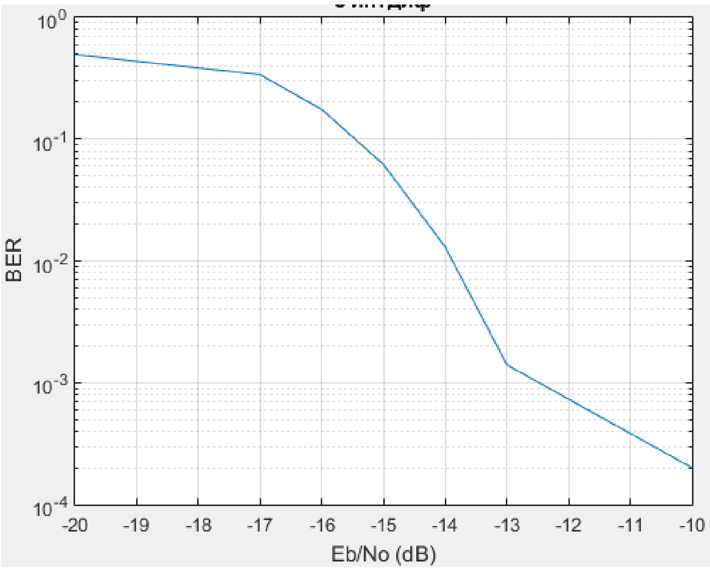

Fig.4. BER

In this paper, a communication system that uses broadband pulsed signals was modelled using Matlab /Simulink. Energy parameters were calculated for simulated system.

References

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