# ON TRANSMISSION SECURITY USING SPREAD SPECTRUM SYSTEMS

**Ion Tutănescu**

Department of Electronics and Computers, University of Piteşti, Romania

**ABSTRACT**

**In order to assure transmissions security, there are used signals with a complex structure and a great number of low amplitude components, such as spread spectrum signals. In this paper we simulate a direct sequence spread spectrum system, whose security is based mainly on the randomness of the sequence added to message. Because a spread-spectrum system distributes the transmitted energy over a wide bandwidth, the signal-to-noise ratio at the receiver input is low. The receiver is capable of operating successfully, because the transmitted signal has distinct characteristics relative to the noise.**

## I. INTRODUCTION

The assurance of information's security in communications (Comunications Security, ComSec) represents an important goal for everybody who sends data in a communication system.

ComSec means the protection resulting from all measures designed to deny unauthorized persons information and the possession and study of telecommunications data. The main ComSec's elements are Emission Security (EmSec), Transmission Security (TranSec), and Crypto Security (CryptoSec).

EmSec comprises all measures taken to deny unauthorized persons information of value got from the interception and analysis of compromising emanations from information systems, telecommunications systems and crypto-equipment.

TranSec consists in application of measures designed to protect transmissions from interception and exploitation by means other than cryptanalysis.

CryptoSec is a component of communications security that results from the provision of technically sound cryptosystems and their proper use.

For assuring TranSec it is necessary to use signals with a complex structure and with a great number of low amplitude components, such as spread spectrum signals and signals with variable structure and parameter values during the transmission.

In order to increase transmission security, all signal's elements should be equally probable, because this uniform distribution law has the maximum entropy.

## II. A DIRECT SEQUENCE SPREAD-SPECTRUM SYSTEM

The spread-spectrum systems are used in the communications where the requirements point out to security and reliability, because of difficulties to detect the signals, extract the message and jam the transmission. A spread-spectrum transmitter produces a signal with a bandwidth much wider than the message bandwidth. These systems distribute the transmitted energy over the wide bandwidth.

An important class of spread-spectrum systems is the class of the direct sequence systems. The binary message is summed with a pseudo-random sequence and the resulted signal is modulated for transmission.

Pseudo-random sequence is generated by a pseudo-random code generator. The sequence is periodic and the repetition period is very large.

The modulation is Binary Phase Shift Keying (BPSK) and uses two or four phases. The security of direct sequence spread-spectrum systems is based mainly on the randomness of the sequence added to message.

In this paper we present the simulation of a direct sequence spread-spectrum system operation. We used for this the Simulink tools of the Matlab software.

The basic block diagram of a direct sequence spread-spectrum transmitter is depicted in Figure 1. The binary message is summed with a pseudo-random sequence and the resulted signal is modulated for transmission.

The pseudo-random sequence is generated by a pseudo-random code generator. The sequence is periodic and the repetition period is very large. The modulation is Phase Shift Keying (PSK) and could be with two or four phases.

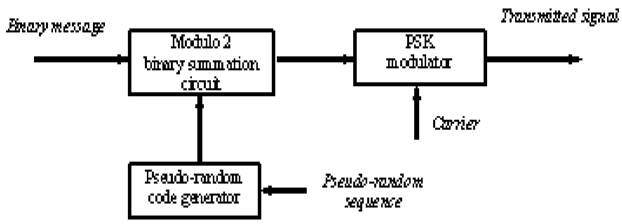


**Figure 1. - Basic block diagram of the direct sequence spread-spectrum transmitter.**

## III. THE SIMULATION OF THE TRANSMITTER

In order to simulate in Matlab the operation of the direct sequence spread-spectrum transmitter we use Simulink tools.

The general scheme that we have simulated (Figure 2) is very similar with that depicted in Figure 1.

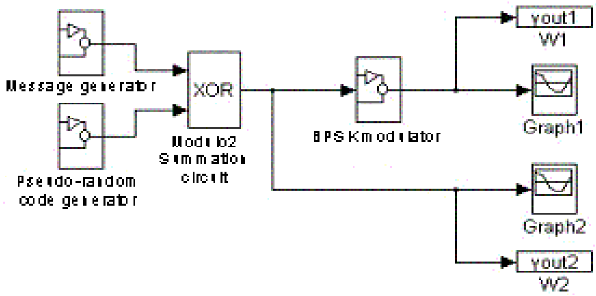


**Figure 2. - Transmitter's block diagram.**

Several signal processing stages are realised in this diagram:

a) The pseudo-random code generator is realised as in Figure 3.

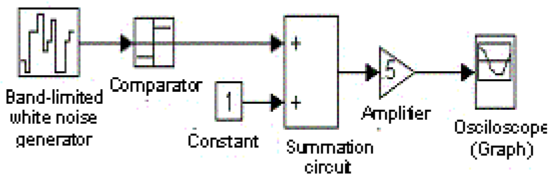


**Figure 3. - Pseudo-random code generator.**

The white noise generator signal is transformed in binary signal using a threshold comparator, resulting a signal with levels -1 and +1 (Figure 4b).

b) The message is generated with a similar scheme, but its repetition period is different (Figure 4a).

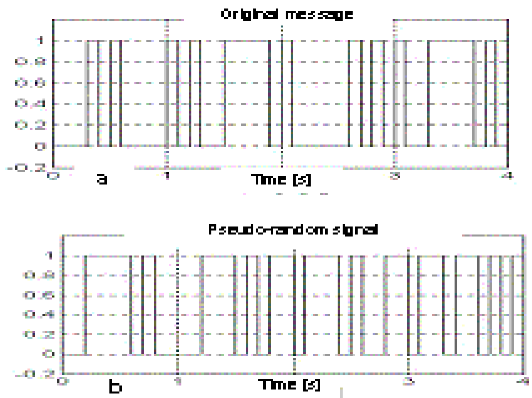


**Figure 4. - The original message (a) and pseudo-random sequence (b).**

c) The modulo 2 summation circuit is simulated with a block that implement XOR logical operator.

d) We use for modulation a binary phase shift keying (BPSK) modulator with block diagram depicted in Figure 5.

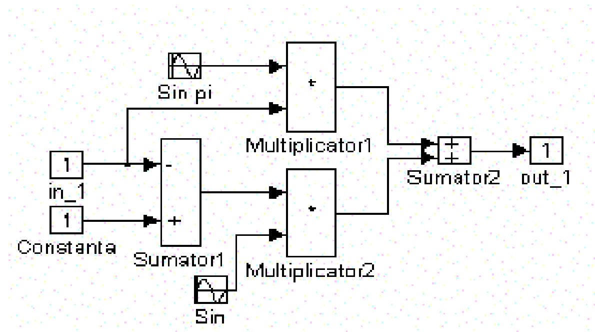


**Figure 5. - BPSK modulator.**

The general relations for a signal modulated with a binary modulator and for its spectral density are:

$$s_{PSK}(t) = A\sum_{k}\sin(2\pi f t + \theta + \Phi_k)\,p_T(t-kT), \tag{1}$$

$$S_{PSK}(f) = \frac{1}{r}\left[\frac{\sin(\pi f/r)}{(\pi f/r)}\right], \tag{2}$$

where $A$ - signal amplitude, $f$ - carrier frequency, $\theta$ - initial phase, $\Phi_k$ - phase shift ($\pm\pi$), $p_T(t)$ - waveform of modulator symbol, $T$ - period of the modulator signal, $r = 1/T$ - binary rate of the modulator signal.

The waveforms of the modulator signal, PSK signal and frequency spectrum of PSK signal are presented in Figure 6:

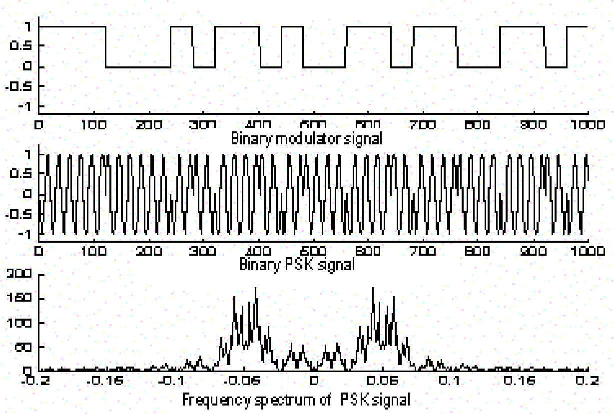


**Figure 6. - The waveforms of binary modulator signal and BPSK signal and frequency spectrum of BPSK signal.**

In a simplified manner, relation (1) could be written:

$$s(t) = A\sin[\omega_0 t + \Phi_k(t)], \qquad (3)$$

where $\Phi_k(t) = 0$ or $\pi$, when binary modulator signal is 0, respectively 1.

The modulator commutes two sinusoidal generator, delayed one by other with $\pi$, implementing the relation:

$$p_T(t)\, A\, \sin(\omega_0 t) + [1 - p_T(t)]\, \sin(\omega_0 t + \pi), \qquad (4)$$

where $p_T(t) = 0$ or 1.

The binary modulator signal and BPSK signal are represented in Figure 7:

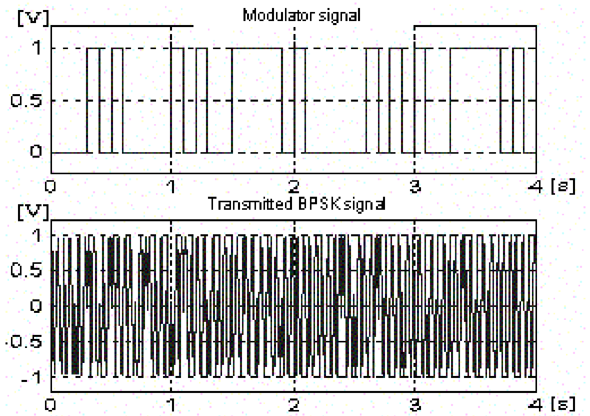


**Figure 7. - Modulator signal and transmitted BPSK signal.**

## IV. THE SIMULATION OF THE RECEIVER

The block diagram of the direct sequence spread-spectrum receiver is depicted in Figure 8.

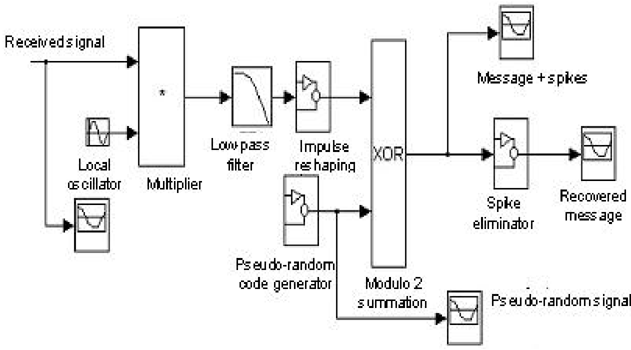


**Figure 8. - The block diagram of simulated direct sequence spread spectrum receiver.**

Several signal processing stages are realised in this diagram:

a) The receiver gets the transmitted signal in the communication channel. Without considering the noise effect, the transmitted signal is applied to the receiver input. For a better viewing the displayed signal (Figure 9) is zoomed in the time interval $1 \div 2$ s.

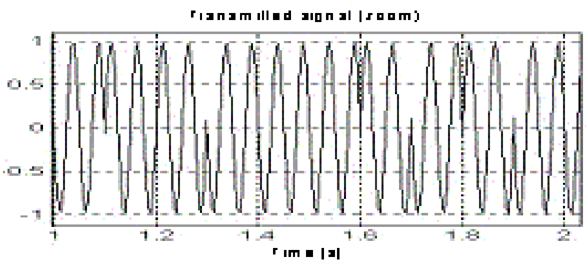

**Figure 9. - The signal at the spread-spectrum receiver input.**

b) The received signal is mixed with a sinusoidal signal having the same frequency with that used in the transmitter.

c) The mixed signal is filtered with a low pass filter for eliminating the high frequency components.

d) For reshaping the impulse fronts, the resulted signal is applied to a circuit for reshaping of impulses (Figure 10).

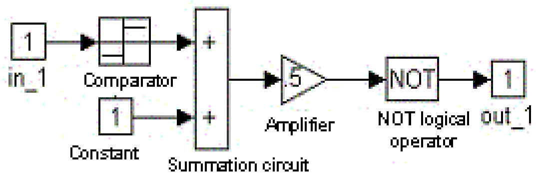


**Figure 10. - The circuit for reshaping of impulses.**

e) Using a pseudo-random code generator synchronised with the transmitter one, the original (plaintext) message is recovered. The pseudo-random sequence of this generator is depicted in Figure 11.

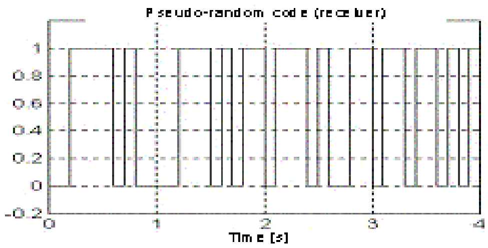


**Figure 11. - The pseudo-random sequence of receiver's pseudo-random code generator.**

f) Because of front reshaping with some delays in the circuit for the reshaping of the impulses, the summation circuit produces a signal that has spikes (Figure 12). For this reason a spike eliminator is used (Figure 13).

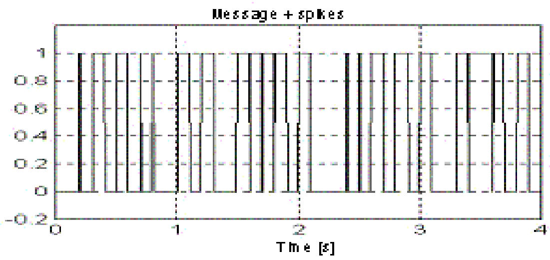


**Figure 12. - The signal with spikes from the summation circuit output.**

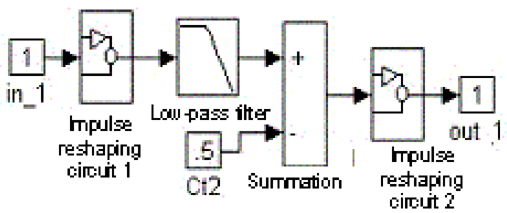


**Figure 13. - The block diagram of spikes eliminator.**

g) The recovered signal is presented in Figure 14.

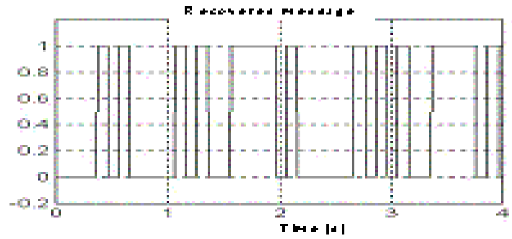

**Figure 14. - The recovered signal at the spread-spectrum receiver output.**

## V. CONCLUSION

It can be seen that the designed spread-spectrum transmitter realises in good conditions its functions. The transmitted signal is a BPSK modulation having phase shifts corresponding to "0" to "1" and "1" to "0" transitions of the modulator signal.

The designed spread-spectrum receiver eliminates the spikes appeared because of signal processing in its scheme. It can be seen that the recovered signal from the spread-spectrum receiver output is the same with that generated by the spread-spectrum transmitter.

### References:

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