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COMPUTER TOOL FOR GENERATING OF TEST RADIO SIGNALS FOR VERIFICATION OF THE RADIO COMPUTER SYSTEMS SOFTWARE

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Abstract: A computer tool for generating test radio signals in the space of one repeat as an amplitude-modulated mix of composite waves of the radio signal transmitted in time space, and take into account repeat ability - as an amplitude-modulated mix of radio signals transmitted along the time axis of the k-th repeats.

The developed computer tool provides a verification procedure the correct operation of the software of radio computer systems by generating test radio signals according to the specified parameters with high correctness of their reproduction and taking into account the properties of repeat ability and stochasticity.

Keywords: *computer tool, test radio signals, simulation, generation, radio computer systems software, MATLAB.*

1. Introduction

As of mid-2021, there has been significant progress in the development of radio computer systems and their widespread use in various areas of human activity. The technology of designing radio computer systems includes an important stage of experimental set-up and testing through the procedure of verification of algorithms and software for radio signals processing [1]. Carrying out of field research (testing and set-up) of radio computer systems caused of the difficulty of interpreting the results (obtained in the process of radio signals processing) in an experimental research with variable conditions and requires large financial and time costs.

The development of a computer tool for generating test radio signals (RS) is an important problem in verification the correct work of the software of radio computer systems. The results of the verification allow detecting incorrectness in the software, which was developed based on algorithmic support that affect the correctness of all radio computer system.

Known computer tools by Leonov A.I., Leonov S.A., Nagulinko F.V., Galkin A.P., Lapin A.N., Samoilov A.G., Ghannam H., Klovsky D.D. Kontorovich V.Ya., Shirokov S.M., Glushkov A.N., Menshikh V.V., Khohlov N.S., Bokova O.I., Kalinin M.Y., Mordachev V. [1-7] and other do not allow generating RSs of random and periodic nature, which is an inherent property of real signals. Therefore, the development of a new computer tool for generating test radio signals is an important problem in the area of telecommunications for the development of algorithmic and software of radio computer systems.

2. The structure of test radio signals

As an example of a useful test signal, we used the data of the quantitative consumption of active power for five days. Fig. 1 shows the transmitting test radio signal $\xi(t)$, which structurally consists of a set of waves, which in total form a repeat of the radio signal, which primarily leads to a set of k-th repeat (days) of the radio signal with variable values of repeat (days) $T_1 = T_2 = \ldots = T_k$.

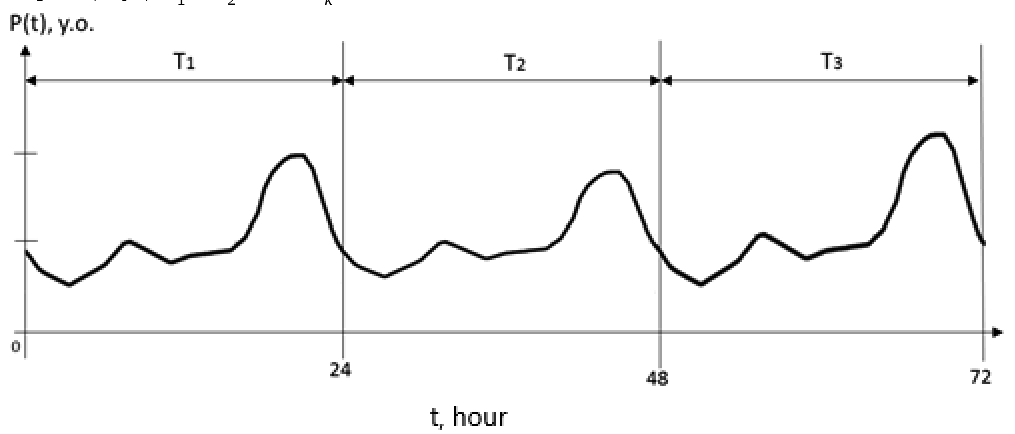

Fig. 1. Implementation of a useful signal of energy consumption (population 400,000 people.)

Taking into account the constructive structure of the radio signal (fig. 1), an algorithm of the generation a radio signal has been developed, which provides the process of generating random and repeated signals.

3. Mathematical and algorithmic support of generation test radio signals

According to the analysis of the structure of real signals, found that within one repeat the signal structurally consists of the n-th number of characteristic waves, which must be generated separately with their subsequent integration into a continuous implementation of the RS.

The algorithm for generating a test useful radio signal in the area of period is shown in fig. 2.

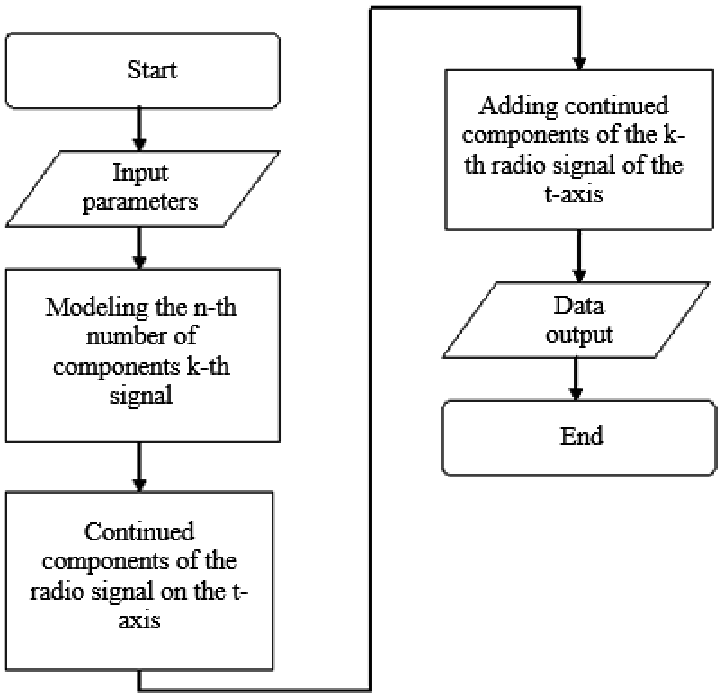

Fig. 2. Algorithm of generation a useful test radio signal in the area of one repeat

At the beginning stage, it is proposed to generate n-th signal waves within the k-th repeat, respectively, from 0 to T_{nk}, with their subsequent location on the time axis depending on their time zone, and the zones in which they are not localized are filled with zeros according to the expression:

$$\zeta_k(t) = \sum_{k \in Z} \tilde{\zeta}_{nk}(t),\ t \in [0, T_k), \tag{1}$$

where $\tilde{\zeta}_{nk}(t)$ - consistently localized wave signal in time $\zeta_{nk}(t),\ t \in [0, T_{nk})$ (1):

$$\tilde{\zeta}_{nk}(t) = \begin{cases} \zeta_{nk}(t), t \in [T_{(n-1)k}, T_{nk}) \\ 0, \quad t \notin [T_{(n-1)k}, T_{nk}) \end{cases}, \tag{2}$$

where T_{nk} – the time duration of the *n*-th signal wave on the *k*-th repeated, $T_{1k} \neq T_{2k} \neq ..T_{kn}$.

Fig. 3 is shown for a detailed understanding of the principle of forming a test radio signal, which illustrates the scheme of generating a test radio signal within the time of repeat.

The simulation model of the n-th wave generator of the test radio signal within the k-th repetition T_k is developed in the form of sinusoidal oscillations with exponential disappearance in a given time space, which takes into account the parameters of amplitudes of component waves, their time samples and their stochasticity:

$$\zeta_{nk}(t) = (A_{nk} + \psi_A)\sin(2 \cdot \pi \cdot (t + \psi_T) \cdot f_{nk}) \cdot e^{-t \cdot K_{nk}} \cdot L_{nk},\ t \in [0, T_{nk}) \tag{3}$$

where n – the current wavelength of the test radio signal at the specified time intervals, n=1,2,..., N;

N - the number of waves of the test radio signal;

T_{nk} – the limit of time space of n-th wave on the k-th repeat;

A_{nk} - the amplitude of the n -th wave of the test radio signal;

f_{nk} - the frequency of fluctuation for half sinusoids test signal;

K_{nk} - coefficients of incline nk -th component of wave test radio signal;

L_{skj} - the values of the scaling factors of the nk-th wave of the test radio signal;

where $\psi_A(M\{A\}, D(A))$, $\psi_T(M\{T\}, D\{T\})$- stochastic units of amplitude and time interval of the test radio signal (mathematical expectation $M\{A\}$ i $M\{T\}$ with the deviation $D\{A\}$ i $D\{T\}$);

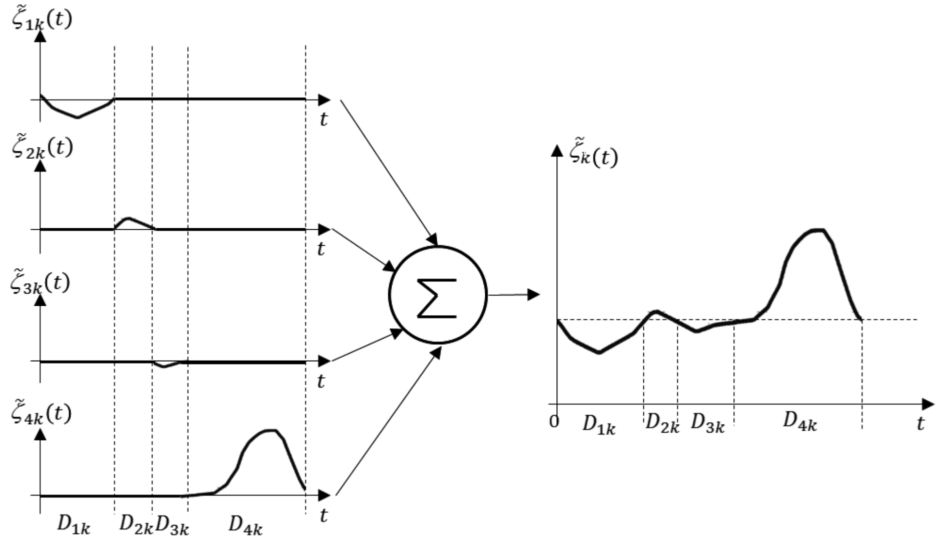

Fig.3. The scheme of formation of the k-th test radio signal within the repeat

Expressions (1) - (3) reflect the simulation model of the generator of test radio signals in the space of k-th repeats T_k , which combines stochastic of amplitudes and times.

Considering that the test radio signal must have repeat ability (almost periodic), so first of all it is necessary to generate a signal on the k-th repeats, the signal must be broadcast in time on the number of k-th repeats. The algorithm for generating a test radio signal stochastic and repeated is shown in fig. 4.

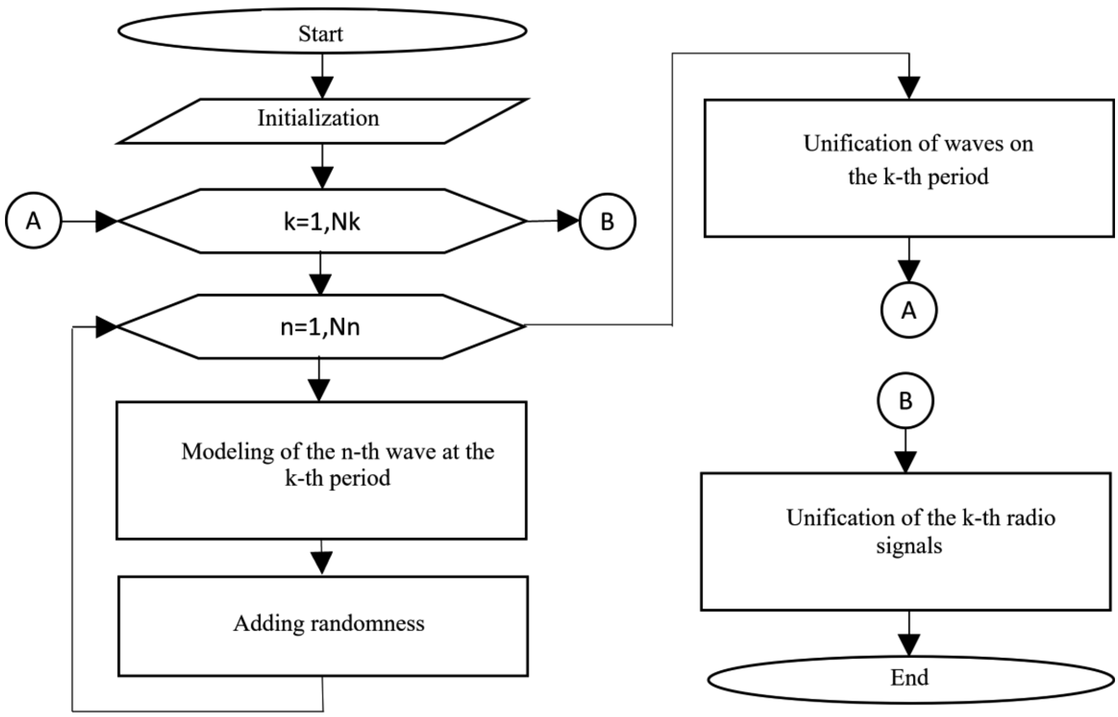

Fig. 4. Algorithm of generation test radio signal as stochastic and repeated

Considering algorithm (fig.4) for providing repeat ability of signal is carried out the procedure of modeling the k-th number of signals within the k-th repeat from 0 to T_k. Subsequently, the k-th number of signals are localized on the time axis depending on the zone of their time localization by arrangement according to the expression:

$$\xi(t) = \sum_{k \in Z} \tilde{\xi}_k(t), \quad t \in R \tag{4}$$

where $\tilde{\xi}_k(t)$ - periodically extended signal (repeated) on the time axis, $\tilde{\xi}_k(t), t \in R$:

$$\tilde{\xi}_k(t) = \begin{cases} \zeta_k(t), t \in [T_{k-1}, T_k) \\ 0, \quad t \notin [T_{k-1}, T_k) \end{cases}, \tag{5}$$

where $\zeta_k(t)$ - signal within the k-th repeat T_k, $\zeta_k(t), t \in [0, T_k)$ (1);

T_k – the time duration of the k-th signal repeat, $T_1 \neq T_2 \neq ..T_k$.

Fig. 5 illustrates a scheme of generating a test signal in the space of time repeat for a better understanding of the principle of the principle of modeling repeated signal with stochastic parameters.

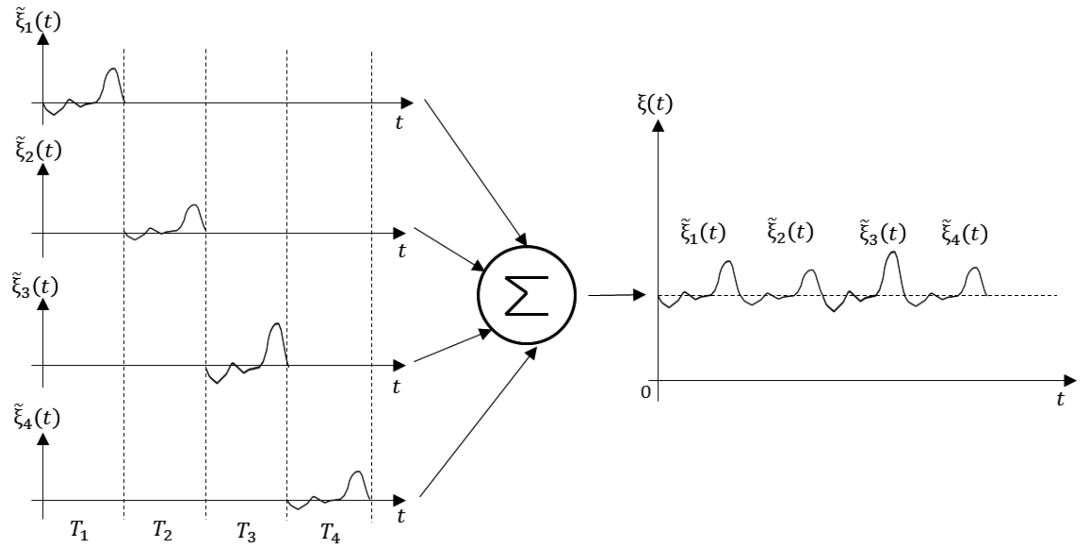

Fig.5. Scheme of generating a repeated radio signal with stochastic parameters

Taking into account the additive influence of inside and outside interference of the radio system, expression (3) will be:

$$\xi(t) = \sum_{k \in Z} \tilde{\xi}_k(t) + n(t), \quad t \in R \tag{6}$$

where $n(t)$ - the white noise.

Substituting expression (2) in (1), (1) in (5) and (5) in (6) we get the expression to generate the signal of the k-th repeat:

$$\xi(t) = \sum_{k \in Z} \left(\begin{cases} \sum_{k \in Z} \begin{cases} \zeta_{nk}(t), & t \in [T_{(n-1)k}, T_{nk}) \\ 0, & t \notin [T_{(n-1)k}, T_{nk}) \end{cases}, & t \in [T_{k-1}, T_k) \\ 0, & t \notin [T_{k-1}, T_k) \end{cases} \right) + n(t). \tag{7}$$

where $\zeta_{nk}(t)$ - the n-th wave of the test radio signal within the k-th repeat.

To generate a radio signal modulated by the parameters of the amplitude, a modulation process was performed in accordance with existing algorithms, the implementation of which is represented by the expression:

$$\xi_{AM}(t) = \xi(t) \cdot \cos(2 \cdot \pi \cdot f \cdot t + \varphi_0), \tag{8}$$

where $\xi(t)$ – non-modulated test signal (7);

f – the fluctuation of frequency of the carrier useful radio signal;

φ_0 – the begining phase of the carrier fluctuation of the test radio signal.

Expression (8) makes it possible to develop algorithmic and based on it software for computer generation of radio signals (including amplitude-modulated) for verification of software for radio systems.

4. The results of generating radio signals

Based on expression (8) and using the GUIDE utility of the MATLAB environment developed the software of the RS generator with a graphical interface, which is shown in fig.6-8.

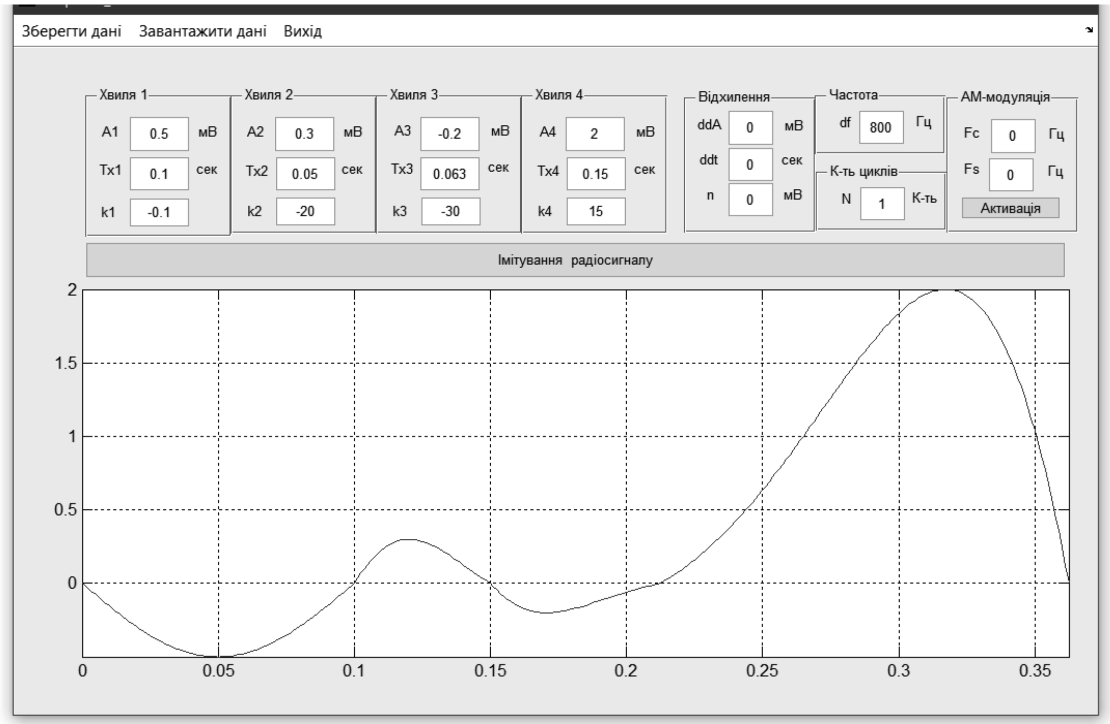

Fig. 6. The result of generating a test signal at N = 10 without interference

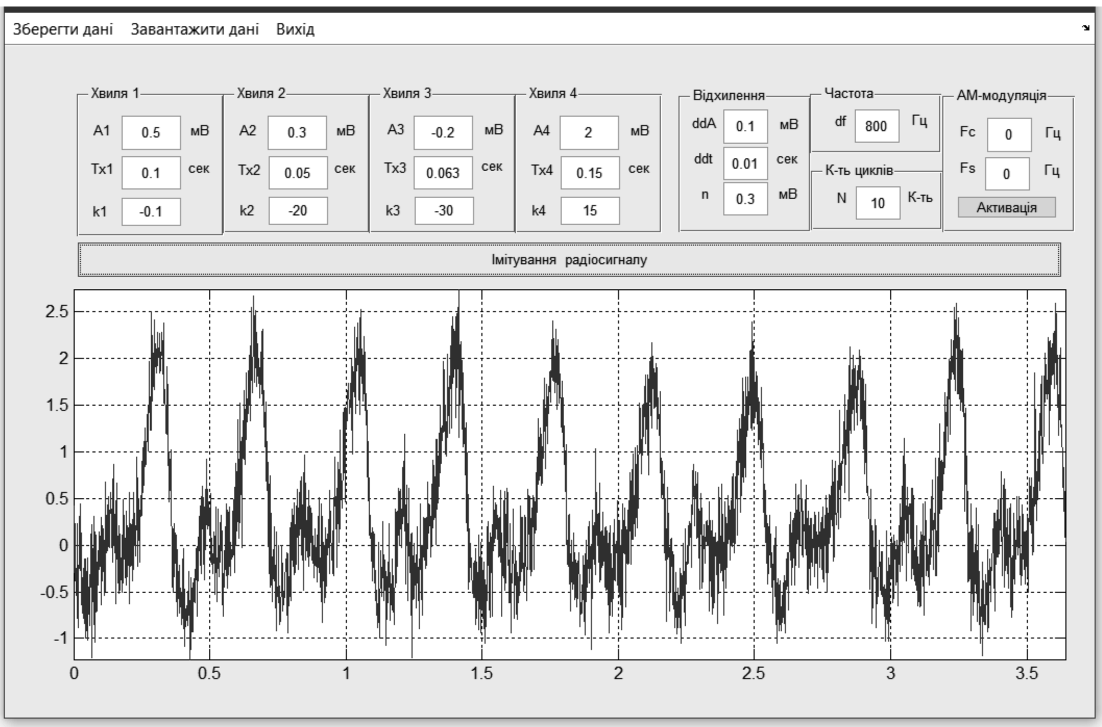

Fig. 7. The result of generating a test signal at N = 10 and interference of dispersion 0,3 mV^2

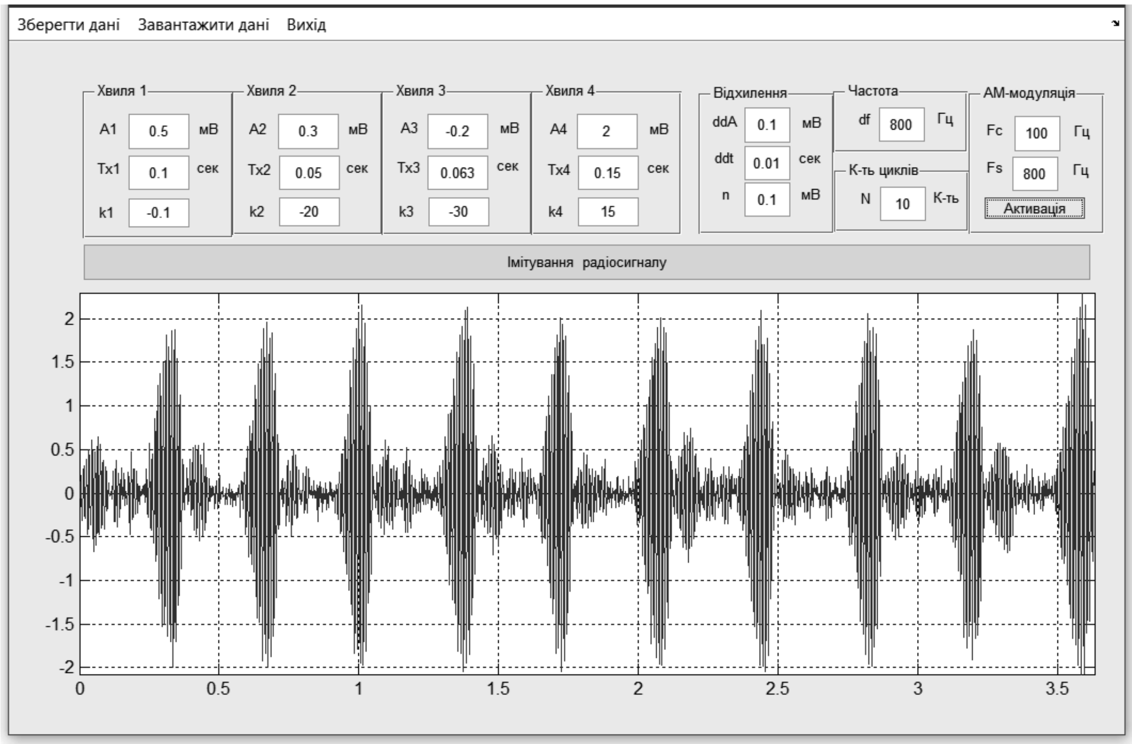

Fig.9. Computer tool interface of generating test signal

The developed software allows generating random and periodic RSs with different parameters of amplitudes, times and frequencies.

5. Conclusions

The developed model of generator of testing radio signal combines in its structure the parameters of stochasticity and repeat ability, which provided a probable reproduction of the form of test radio signals in relation to the experimental values of its parameters (parametric identification)

Developed software with a graphical shell allows you to generate testing radio signals for test the correct operation of the algorithms of radio computer systems.

It is determined that the obtained generated data of testing radio signals provide probable simulation of the constructive form of experimental radio signals of time and amplitude parameters, which indicates a high probability of generation and correctness of verification of algorithms and software of radio computer systems.

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