SOFTWARE FOR PREDICTING THE RELIABILITY OF THE ELECTRONIC SYSTEM BY ITS TECHNICAL STATES SET ANALYSIS METHOD

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Abstract. The method of direct selection of the system technical states is the simplest and most understandable method for predicting the reliability of an electronic system under any connection scheme from the point of view of the reliability of its component parts (devices). If the number of devices entering the system is more than 8 ... 10, algorithms are needed to generate and further process large amounts of data on possible technical conditions of the system. Such algorithms are proposed and used in the developed software tool for assessing (predicting) the reliability of the electronic system. This software tool allows you to build a structural scheme of reliability in an interactive mode on a computer. After entering the data about the system components (devices) reliability the computer calculates the reliability indicator automatically.

In a number of cases technical systems, including electronic systems of different functional purpose, from the point of view of reliability, have such a structure of their component parts connection (or interaction) that is not reduced to parallel-sequential or sequentially parallel circuits. An example of such a connection structure is the bridge circuit (Figure 1).

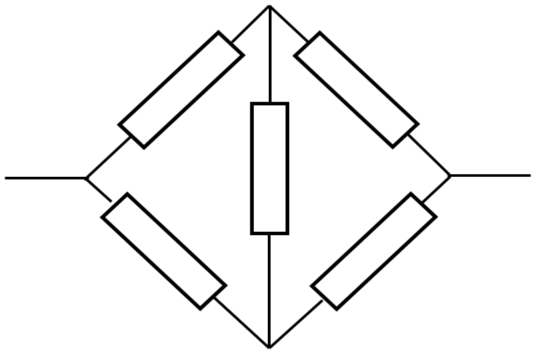

Fig. 1. Bridge connection of electronic system devices in terms of reliability

In practice, such schemes may exist for electronic systems containing information and computer subsystems.

We will assume that the system under consideration contains n devices. The system can be in two states: functionality and failure. We mark the state of the system by R symbol. We assume that R takes value 1 if the system is functional and value 0 if it fails. The state of the j^{th} device of the system is indicated by x_j symbol. We assume that x_j takes value 1 if the j^{th} device is working without fail, and the value is 0 if it fails ($j = 1, 2, ..., n$).

The state of the electronic system depends on the state of its devices, i.e.,

$$R = \varphi(x_1, x_2, \ldots, x_n), \tag{1}$$

where φ is the symbol of the functional connection.

Function (1) is called the structural function of the system. For existing electronic systems the following relations hold true:

$$\varphi(0, 0, \ldots, 0) = 0;$$

$$\varphi(1, 1, \ldots, 1) = 1;$$

$\varphi(x_1, x_2, \ldots, x_n) \geq \varphi\ (y_1, y_2, \ldots, y_n)$ provided that x $x_j \geq y_j$, ($j = 1, 2, \ldots, n$).

Physically, the last condition denotes that the failure of the device can not transfer the system from its inoperative into operable state.

In [1-3] one can become familiar with the methods of calculating and evaluating the reliability of technical systems not reducing to parallel-sequential or sequentially parallel schemes.

The simplest and most understandable method for calculating the probability of an operable state of these systems is the method of direct selection of system technical states. This method can be successfully applied also to reliability calculation of the systems that, from the point of view of reliability, reduce to parallel-series or series-parallel devices connection.

The essence of the direct search method. Taking into account the criterion for the failure of the electronic system the entire set of its technical states G is divided into two subsets: the operable states of G_1 and the inoperative states of G_0. For each state of the electronic system $X = \{x_1, x_2, ..., x_n\}$ we can calculate its probability p_x and then find the probability of a functional state of the electronic system ($P_{эс}$):

$$P_{эс} = P\{X \in G_1\} = \sum_{X \in G_1} p_X\ , \tag{2}$$

where $P\ \{...\}$ hereinafter denotes the probability of the event indicated in curly brackets.

The probability of an inoperative state of the electronic system can be defined as

$$Q_{\text{эс}} = P\{X \in G_0\} = \sum_{X \in G_0} p_X \quad . \tag{3}$$

For the probability of the system X state, under the assumption of the independence of the devices from the point of view of the occurrence of their failures, the formula is true

$$p_X = \prod_{j=1}^{n} p_{x_j}, \tag{4}$$

Where p_{xj} is the probability of the state x_j of the j^{th} device of the system (x_j = 1 or x_j = 0).

In the general case, without applying IT-technologies, the method is justified if a number of devices in the system is relatively small ($n \leq 6$ ... 10), since with the number of devices in the system n = 10 the number of possible technical states S for the system is $S = 2^n = 1024$, which is actually problematic for engineering analysis.

To quantify the probability of the electronic system's functionality it is necessary to consider the possible technical states of the system. These states are determined by the technical states of the devices making up the system [4]. For devices, as a rule, one of two states can exist: either inoperative or operable, while for the system as a whole there are many states that differ by combinations of operability and inoperability of system devices. Some of these states correspond to the state of inoperability of the system as a whole, others - to the state of operability.

Estimating the reliability of a complex electronic system by examining the system as a whole in practice causes many difficulties due to the excessive number of the possible system S technical states. For example, with the number of devices n = 30, the value S> 1 billion. The total amount of data needed to describe such a number of possible technical system states will approach the size of Big Data [5]. However, with the value n <30 ... 40 the reliability analysis of the electronic system can be performed using traditional methods on a computer with medium performance, but this requires algorithms employing prediction principles [6]. These principles allow us to systematize and further process large volumes of data on possible technical states of electronic system. Such algorithms are proposed and used in the developed application software for assessing (predicting) the reliability of the electronic system by the method of enumeration of technical states.

The developed software allows to build a structural scheme for calculating the reliability of the electronic system in the interactive mode on a computer. After entering the data about the reliability of the components (devices) the computer calculates the reliability index of the system automatically. The application software was developed at the Information and Computer Systems Design Department of BSUIR.

Below are the explanations that allow you to get the most general idea about the software. A fragment of its main window is shown in Figure 2.

The software application for the implementation of the project for the reliability of the electronic system analysis includes the following steps:

1 Clarification of the electronic system condition. At this stage it is necessary to find out what is the operability of the system: complete or partial (the latter presupposes normal functioning). Such operability is considered to be the performance of the electronic system while its functional parameters are within the limits specified in the technical documentation.

2 Structural scheme for calculating the electronic system reliability construction. This scheme is built by the user, with the help of computer graphic capabilities software and the electrical structural and / or functional circuit of the system under consideration accounting the conditions for its opera-

bility and normal functioning. The dialog box of structural scheme for calculating the electronic system reliability construction is shown in Figure 3. It shows the already constructed structural scheme for calculating the reliability of the electronic system under consideration. The software allows you to set the functional parts of the system interactively on the working field of the monitor, assign names (identifiers) to them and make the necessary connections taking into account the conditions of the electronic system operation.

3 Entering data about the components (devices) of the electronic system reliability and calculating the probabilities of its operable and inoperative states. The calculation is performed automatically by the software by means of analyzing the built structural scheme of the system reliability. The windows for data input, output of the results analysis and calculation of the system reliability indicators are shown in Figure 4.

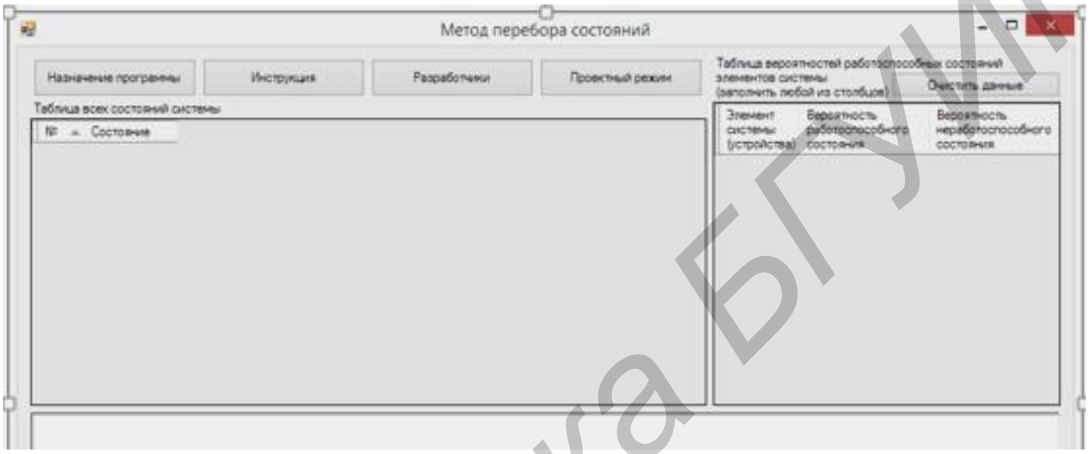

Fig. 2. Main window of the software

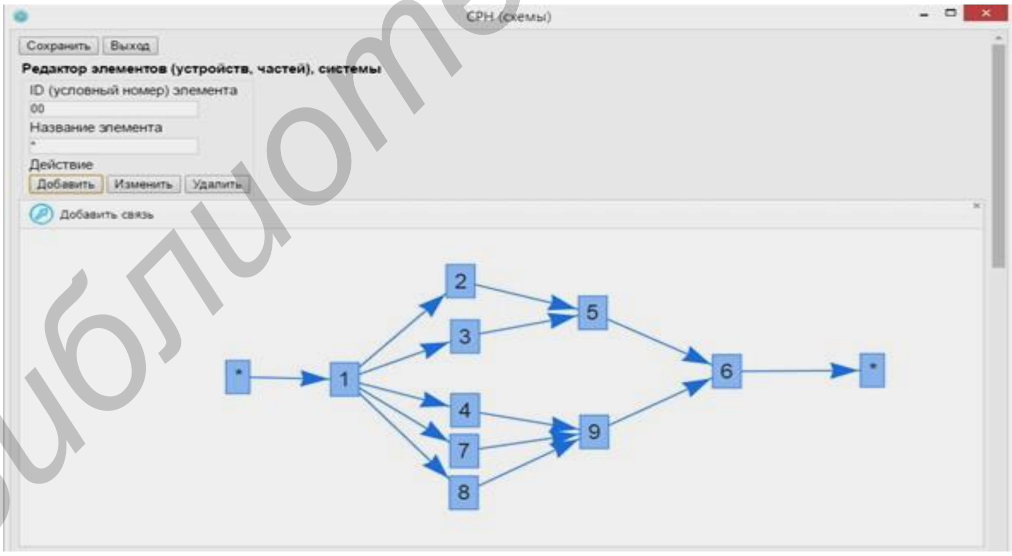

Fig. 3. The constructed structural scheme for calculating the system reliability

The right table of Figure 4 displays the entered data on the reliability of the system components (devices). In the left table the first column shows the system state number, the second column indicates which subset of technical states the state of the electronic system is related to: green color - a subset of operable states, red - a subset of inoperative states. In the following columns number "1" in the symbolic designation of the device status corresponds to its operable state, and digit "0" - to the inoperative state of the device. The rightmost column of the table indicates the probability of the corresponding state of the electronic system with four digits after the decimal point. Value "0" (zero) means that the probability of this state is less than 0.00005. When the value is slightly more than 0.00005, rounding to the value 0.0001 is performed.

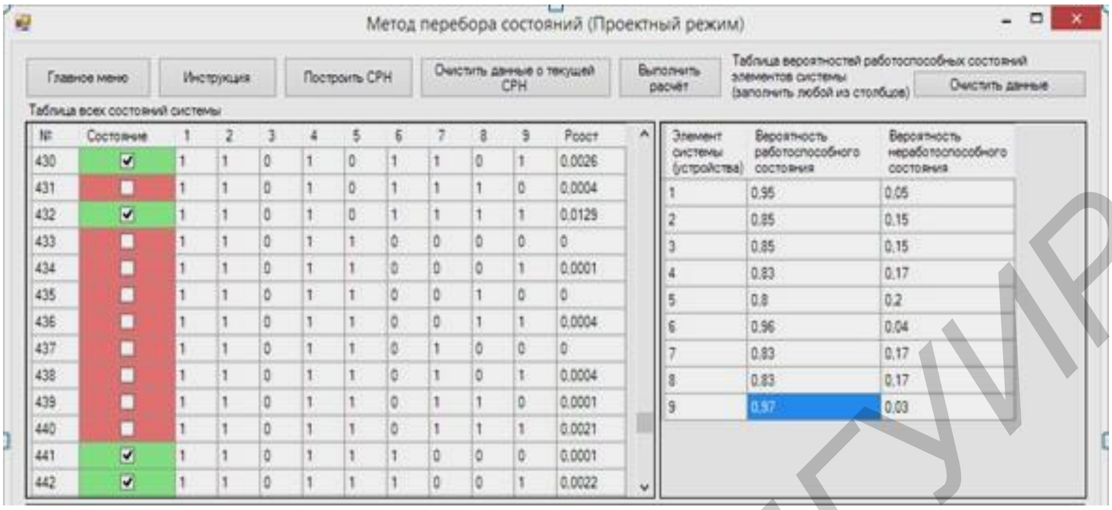

Fig. 4. Electronic system reliability analysis and calculation results

The bottom window (see Figure 4) shows the results of calculating the electronic system probabilities of an operational and inoperative state, indicating the number of states of each subset.

Developed software testing proved that it successfully solves the problem of estimating (predicting) the reliability of the electronic system with up to 30 functional parts (devices) in it. With their number n = 30 it took about 1.5 hours to complete the task. The computer had the following resources: RAM - 8 GB; Processor - Intel, 2 cores - 2.5 GHz.

Conclusion: the development of successful algorithms and their use for computer information processing allows to solve the problems in calculating the complex electronic systems reliability, even though the description of technical states of the hypothetical data volume is close to the size of Big Data.

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