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The Energodynamic Method of Diagnostics of Electronic Equipment Digital Devices

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ABSTRACT

The energydynamic method of Diagnostics of Electronic Equipment Digital Devices is considered in the paper. It is established the next. Energodynamic method allows to determine the technical condition at the level of the digital device as a component of the unit. The power bus and output contacts digital device are used as a control point. The diagnostic information is taken from the resistor, which is connected to the power bus and is the value of the current of the quasi-short-circuit pulses. Analog-digital device is used to convert the diagnostic information from analog to digital form. Depth of diagnosis – digital device, in some cases - radio electronic component. Reference information is recorded in the database (library). Equipment of the first level, which implements this method, allows to achieve a probability of correct diagnosis of 0.95. The limitation of the method is to use it to diagnose digital device. The decision on the technical condition is made on the basis of comparison of the diagnostic information obtained at the control point with the reference. Application of the method - to restore the functionality of the digital device in the repair shops, i.e., after the failure of the digital device.

Key words : Energodynamic method, diagnostics, digital device, electronic equipment

1. INTRODUCTION

The development of information technologies and principles of construction of electronic equipment necessitates the improvement of existing automated systems of technical diagnostics, which will ensure the determination of the technical condition of digital devices to the nearest one at the place of operation [1]–[5]. Digital devices are used in electronic systems for various purposes: medicine [1]–[2], [6]–[7] radio [5], [8]–[24], optoelectronic [4], [25]–[37], etc.

However, compliance with the requirements of maintaining a sufficient level of reliability of digital devices, with limited capabilities of repair bodies can not be performed without the development of new methods based on modern principles of diagnostic information processing.

Currently, existing diagnostic methods need improvement. This is due to the fact that they require the use of a large number of control points and diagnostic parameters when diagnosing, which complicates the diagnostic equipment and increases the time of monitoring the technical condition. Obviously, there is a need to develop new methods for diagnosing digital devices that automate the process of monitoring the technical condition, provided that the necessary reliability of control.

Therefore, the aim of the paper is to develop an energy-dynamic method for diagnosing digital devices of electronic equipment.

1.1 Problem analysis

The functions of technical diagnostics include determining the technical condition, forecasting it, localization of faults, monitoring of technical condition [3], [38]–[40]. To perform these functions, it is necessary to ensure the receipt of the test for the input of the circuits to be tested [3].

In practice, the main attention is paid to the creation of fault simulation programs and test sequence synthesis programs for digital devices [3]. This is due to their relatively simple functional saturation, which allows at the stage of production control to detect a sufficiently large percentage of faults. In order to simplify the procedure of control and diagnostics of a digital device, various rules and restrictions are applied in their design, the essence of which is to provide most digital devices with the ability to build a test for the class of constant faults with a detection rate of 90-100% and a search depth of integrated circuits [1], [3].

To determine the technical condition of the digital device, it is necessary to ensure the receipt of the test sequence at its input, which is generated by the generator of the test sequence, so it is important to build test tests. They are a test sequential integrated circuit, upon receipt of which all digital radio electronic component from the digital device will receive a partial check test. The following algorithms are used for the synthesis of test sequences.

1. Formation of test sets that correspond to a complete search of binary combinations. The method of counting conversions, the method of counting units, and so on. As a result of application of similar algorithm so-called counter sequences are generated.

2. Formation of random test sets with the required probable integrated circuit of single and zero symbols on each input of the digital circuit.

3. Formation of pseudo-random test sequences.

It is known that digital devices, which are divided into combinational and serial integrated circuits, can be considered as a deterministic automaton, and the output signals they implement can be described by boolean functions or functions of transitions and outputs [3], [41]. Combination devices are characterized by the fact that the output signals Y(t) depend on the values of the input signals X(t), i.e. Y(t)=F[X(t)], where F is the output function of the combination device [3].

The signals at the outputs of serial devices (devices with memory) Y (t) at time t is determined not only by the value of the signals X (t) received at the same time, but also by the internal state S (t) in which the device was at the same time t, ie, where is the output function digital device with memory [3].

If the input signals X(t) are independent random events, then the model becomes a probable integrated circuit automaton [3]. The random nature of the signals at any point digital device suggests that the sequential integrated circuit at the inputs of the i-th logic element with the probable integrated circuit P chip are sets that provide a manifestation of any fault in the logic element. The set of integrated circuits of such sets is called a partial verification test [1]–[2], [6]–[7].

It is known [3]–[4], [18]–[20] that testing digital device is based on the formation of test sequence, which come to their input and allow you to detect a given set of their faults.

The classical methods include the deterministic method and the method of random search [3]–[4], [18]–[20]. Ensuring the conditions of the testing procedure involves the storage of test sequences and reference initial reactions of the circuits to their impact. The decision on the technical condition is made on the basis of comparison of the received initial reactions with reference, thus in case of conformity of the received reactions of the scheme to the reference technical condition is considered serviceable, in other cases faulty.

For a number of typical digital devices currently in production, the classical approach requires significant time both for the formation of test sequences and for the testing procedure. In addition, large amounts of test information and reference initial reactions suggest the presence of complex equipment for conducting a test experiment. In this regard, the cost and time required to implement the classical approach, increase by more than the complexity of the digital devices themselves. Therefore, based on the above, it is proposed to use a pseudo-random test sequence to construct a verification test [3]–[4].

The test sequence will be used to determine the technical condition of the digital device by diagnostic tools in which the methods of physical diagnosis are implemented. Given the use of different test sequences for each of the methods of physical diagnosis, it is important to build a test sequence and use it for each of them. Given the initial data, which determines the reliable integrated circuit diagnostics, which is required, there is a problem of choosing the test sequence before the diagnosis, the solution of which is implemented in the work of integrated chips. In the complex using of physical diagnosis methods, several test sequences will be used, according to the methods chosen by the integrated chip [3].

2. MAIN MATERIAL

For clarity, we present a block diagram of a diagnostic device that implements the energy-dynamic method shown in Figure 1.

The diagnostic process begins with downloading to the computer data about the digital device to be diagnosed. The information about the digital device is specified through dialog means. Then the requirements to the diagnostic parameters are determined (operation control, abbreviated check, full check, etc.). Then in the knowledge base the analysis of the received information on the digital device, and also that is is carried out, then rules of carrying out diagnostics are formed.

Based on the specified conditions, the control commands of the information acquisition module are formed. For the block of formation test sequence the algorithm of diagnosing, and also sets of elementary test influences which represent functionally finished sequences of commands is defined. Elementary test effects are selected according to the diagnostic algorithm defined in the knowledge base, based on the specified conditions.

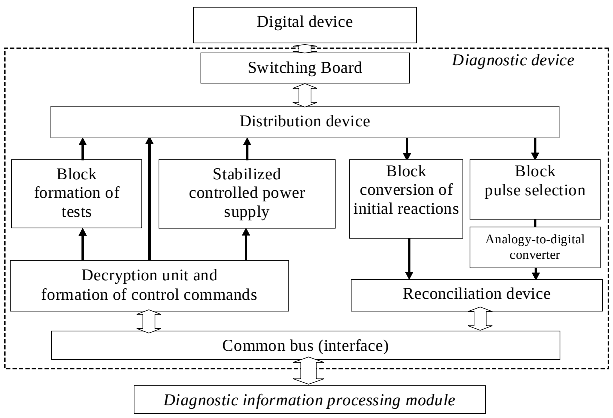

Figure 1: The block diagram of a diagnostic device that implements the energy-dynamic method

One of the following methods is used to select the source data [3]:
– a pre-prepared database, which contains optimized data calculated for each type of digital device;
– directly from the computer in the process of diagnosis;
– a combined method, which involves the use of a database in which the optimized data are recorded, as well as the improvement and replenishment of this database due to the time reserve provided in the diagnostic process.

During the operation there is an improvement and replenishment of the database, as well as experts in this subject area.

The number of elementary test effects is determined in the block of knowledge, based on the specified parameters of diagnosis, namely, probability and time. From the processing module through the common bus control commands for formation of the set test sequence arrive. The decryption unit and the formation of control commands converts the received code into a parallel command code of the control unit of the test effects and the power supply.

The unit for the formation of test effects forms a test sequential integrated circuit to check the technical condition of the digital device and fault localization. The power supply according to the control commands generates the appropriate voltage to power the digital device. The choice of voltage level depends on the type of digital device and the diagnostic task.

Diagnostic information is quasi-short-circuit current pulses and initial reactions. The latter come to the conversion unit, where they are converted to a form suitable for further processing and transfer to the processing model. At the same time in the power bus digital device is the release of current pulses quasi-short circuit.

The unit consists of a filter and an amplifier, which amplifies the current pulses of the quasi-short circuit to the required level, after which they are fed to a high-speed digital device, in which they are converted from analogy to digital. Next, through the matching device, the signal enters the processing module. Digital signal processing is performed in order to convert and analyse the received diagnostic information in the frequency domain, after which a decision is made on the technical condition of the digital device. Diagnostic information enters the database of the processing module, where it accumulates, and from the database it enters the block of fuzzy inference, at this time this block receives information from the knowledge base and values of membership functions from the library of membership functions. In this block there is a step-by-step comparison of the parameters of the values of the obtained diagnostic information with the standard for this type of digital device, which is in the knowledge base, using the appropriate membership functions.

After comparison with the standard in the relevant block, a decision is made about the technical condition of the digital device, which is tested, based on a fuzzy inference and display of this information to the user. Based on this information, from the knowledge base data are selected relevant situation and sent to the knowledge base, where in the form of control commands, they come to the unit of formation of the test sequence. Therefore, the number of elementary test effects and data sets, as well as the order of their passage may vary depending on the obtained diagnostic information.
This solution eliminates some basic test effects for the reason that the results of the obtained data eliminate the need for them. As a result, this reduces the number of sets in the test sequence, which in turn reduces the time of diagnosis.

The decision to use sequential execution of commands with the current status analysis allows you to diagnose before finding the first faulty component and further search for other faulty components by excluding information about the previously detected. On the basis of the received diagnostic information and options of decision-making accumulated in the knowledge base, the formation of new elementary test effects is carried out.

If it is impossible to make an unambiguous decision, the user by changing the type of membership function or current data in the knowledge base or database can make changes to the decision-making mechanism. In case the use of new data will increase the probability of diagnosis, they will be entered into the knowledge base and used in the future.

The device consists of two parts – the module of removal and the module of processing of the diagnostic information [3]–[4], [18]–[20], [41]–[43]. The first is designed to obtain diagnostic information and transmit it to the processing module. It includes (Figure 1) the next.

The switching board is designed to switch test tests to different digital devices, with each connector connected to a switchgear.
The purpose of the switchgear is to switch the appropriate connector of the switching board and match the digital device with the unit for generating test sequences and the unit for pulsing short-circuit current in the power bus, as well as sending test sequences, connecting power from a stabilized source. In addition, the distribution device provides the device for processing diagnostic information of the received reactions and parameters of the energy-dynamic process in the power bus digital device.

The switchgear is designed to connect the appropriate connector of the switching board and match the digital device with the unit for generating test sequences and the unit for pulse generation in the power bus, sending test codes, connecting the voltage from a stabilized power supply, and for transmitting information to the receiving device. initial reactions and parameters of the energy-dynamic process in the power bus digital device.

The unit for forming test sequences is designed to form a given sequence of test effects and logic levels (depending on the technology of manufacturing the element base digital device) for diagnosing according to control commands.
The decryption unit and the formation of control commands is designed to convert the code of commands received from the operator from the diagnostic information processing unit, in parallel command code of the test unit, distribution device and software-controlled stabilized power supply.

The unit for converting initial reactions digital device is designed to bring this diagnostic information to a form convenient for further analysis (code conversion, compression into a signature).

Software-controlled stabilized power supply is designed to obtain stabilized supply voltages, which change according to the law set by the control teams. Diagnosis digital device must be carried out at least two levels of supply voltage: nominal, at which all its components work stably; limit, at which the working elements work steadily, and the inoperable (or those that are in a pre-failure state) lose their working integrated circuit and cause failure digital device.

The unit for selecting the image of the pulses in the power bus digital device is designed to filter and select the method of diagnostic information, amplifying the selected diagnostic pulses to the appropriate level. Image - a set of sequences of diagnostic information, formed by a switched logic element when performing a certain elementary test effect. The isolation unit must have characteristics that allow you to emit pulses with an amplitude of 100-1000 mV and a duration of 4-75 ns against the background of noise in the power bus.

The block of the analog-to-digital converter is intended for conversion of an image of sequence of pulses of current of quasi-short circuit from the analog form to digital, the analog-to-digital converter has to be high-speed for the purpose of qualitative conversion of signals.

Due to the average pulse short-circuit pulse duration, which averages about 20 ns, an analog-to-digital converter with a sampling rate of at least 1 GHz and a bit rate of at least 8 bits and high-speed random access memory is required for reliable pulse recognition and analysis.

The matching device is designed to convert diagnostic information into a form convenient for transmission and processing in the module for processing diagnostic information.

The common bus (interface) is designed to connect the capture module to the processing module, as well as to transmit control commands from the processing module to the digital device and transmit output reactions and quasi-short-circuit pulses to the processing module.

The design and wiring diagram are determined by how the unit is connected to the PC

5. CONCLUSION

This allows us to draw the following conclusions.
1. Energodynamic method allows to determine the technical condition at the level of the digital device as a component of the unit.
2. The power bus and output contacts digital device are used as a control point. The diagnostic information is taken from the resistor, which is connected to the power bus and is the value of the current of the quasi-short-circuit pulses.
3. Analog-digital device is used to convert the diagnostic information from analog to digital form.
4. Depth of diagnosis – digital device, in some cases - radio electronic component.
5. Reference information is recorded in the database (library).
6. Equipment of the first level, which implements this method, allows to achieve a probability of correct diagnosis of 0.95.
7. The limitation of the method is to use it to diagnose digital device.
8. The decision on the technical condition is made on the basis of comparison of the diagnostic information obtained at the control point with the reference.
9. Application of the method - to restore the functionality of the digital device in the repair shops, i.e., after the failure of the digital device.

The direction of further work is to compare the advantages and disadvantages of energy-dynamic and other methods of physical diagnosis, such as the energy-static method.

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