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METHODS OF INCREASE RELIABILITY IN AUTOMATED CONTROL SYSTEMS

МЕТОДИ ПІДВИЩЕННЯ НАДІЙНОСТІ В АВТОМАТИЗОВАНИХ СИСТЕМАХ КЕРУВАННЯ

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Abstract. *Today, in connection with the increase in the scale and complexity of automated control systems, the problem of ensuring their reliability is becoming increasingly acute. The article analyzes the main methods and means of increasing control reliability in automated control systems.*

Key words: *automated control systems, reliability of information, fail-safe control systems, increased reliability, redundancy, reconfiguration, structural redundancy.*

Introduction.

The effectiveness and quality of functioning of automated control systems (ACS) significantly depend on the reliability of the source information and the values obtained because of processing. The necessary reliability of information in the ACS is ensured by the selection of effective control and error correction systems at all stages of data processing and storage, optimization of their storage structures. The development and operation of ACS, which provide the maximum or specified level of data probability in conditions of limited resources, is a complex problem that includes the following tasks: the development of methods for analyzing data processing systems from the point of view of probability, the development of methods for the synthesis of control systems that are optimal according to the selected performance criteria and error correction, development of optimal data processing technologies in the operation of ACS.

Requirements for the reliability of information are mandatory for any ACS. There is enough documents in various fields that regulate the main methods of probability control. Sensor readings, based on which system management decisions are made, should be as reliable as possible.

Main text.

The analysis of well-known publications in the field of reliability and validity of ASC work shows that mainly the diagnosis of ACS work is implemented using discrete methods of information processing [2]. This makes it possible to expand the possibilities of control and diagnostics due to the use of computing tools of programmable logic controllers (PLCs) and to increase the reliability characteristics.

Special measures must be taken to ensure and maintain the required system reliability during operation. The main ones are:

1. simplification of structural of individual devices and the system as a whole.
2. use of highly reliable elements with guaranteed reliability.
3. reducing the load on the elements and stabilizing the operating conditions of the equipment.
4. application of structural redundancy of devices and elements.

Technological means of increasing reliability are based on the use of a wide range of methods of improving the quality of system components at the stage of their manufacture.

Structural and hardware implementations at the initial stages of development are reduced to the creation of the minimally necessary version of the system, that is, such a variant that contains the minimally necessary number of elements, the failure of each of which leads to the failure to perform one or more functions and provides for the processing of the minimally necessary amount of information in the minimally acceptable time of period.

The reliability characteristics of the minimum required version of the system do not always satisfy the proposed requirements, which forces us to look for ways to increase the reliability of the system being developed.

The issue of increasing reliability should be addressed, first and foremost, based on the development and implementation of highly reliable components used in the system.

Among the structural methods of ensuring system reliability, two groups of methods are distinguished: methods based on the redundancy of their components, and methods that involve reconfiguring the system in case of failure situations.

Methods of system reconfiguration involve altering the operational configuration of the system during its operation. This may result in changes to individual performance metrics, such as memory capacity, processing speed, or reliability parameters.

Redundancy is a method of ensuring the reliability of an object by utilizing additional resources and/or capabilities that exceed the minimum necessary for performing essential functions.

Methods of system redundancy assume the stability of the basic working configuration of the system during its operation. In the event of component failures within the system, a straightforward replacement of the failed blocks with functional backup blocks takes place. This replacement can occur either through operational equipment switching (in which case the system downtime is considered insignificant) or as part of the process of restoring the failed blocks (in this case, the analysis of system reliability considers the finite restoration time).

However, the possibilities of redundancy are limited. This is because a significant increase in the meantime between failures of a device, even in the extreme case, can only be achieved with a practically unrealizable total number of its elements. Moreover, the greater the redundancy factor, the lower its relative efficiency [3]. Single, double, triple, and tenfold hot redundancy of one element results in an increase in the meantime between failures compared to the non-redundant option by 1.5, 1.8, 2.1, and 3 times, respectively. Analyzing the potential of overall loaded redundancy is not practical because such redundancy is less effective than element-wise redundancy. Replacement redundancy requires significant hardware complexity.

However, in ACS and any other hardware, failures can also occur, leading to disruptions in the correctness of system operation through the distortion of information. To eliminate the consequences of a failure, it is necessary to restore not the hardware, as is done in the case of a failure, but the information distorted by the failure.

Hardware of discrete action, as well as hardware used for transmitting information with discrete signals, is particularly susceptible to failures. In discrete devices, the failure intensity can reach $(0,2\text{-}2)10^{-4}$ 1/per hour failures per transistor. Experimental data indicate that in discrete hardware, failures have a significantly higher specific weight compared to faults.

The reliability of discrete devices can be enhanced by introducing structural redundancy, where the outputs of devices or systems in a reserved connection are combined by a recoverable logic element (majority element). Such redundancy can also be implemented at a lower level. To detect a failure in each of the channels, mere duplication is sufficient, and information recovery is possible with three or more channels working in parallel. Such redundancy is quite effective, especially in dealing with faults, but it requires significant overhead. Its effectiveness is significantly reduced in the event of a failure.

To enhance the reliability of system operation, information redundancy can also be employed. For example, redundant error-correcting codes or multiple repetitions of non-redundant code can be used in information transmission through communication channels. It is known that a significant information redundancy is required to correct multiple distortions. The use of error-detecting codes in data transmission systems, combined with feedback, is also associated with significant redundancy. This is also true for the repeated transmission of non-redundant codes.

It should be noted that information redundancy inevitably leads to structural redundancy, complicating the system and reducing its reliability. Information redundancy is effective only in mitigating the consequences of failures. As for reducing the impact of failures, its capabilities are quite limited.

The possibilities of ensuring the necessary operational efficiency of systems solely through the implementation of direct methods to enhance hardware reliability are limited. Alongside the application of these methods, the required efficiency can be achieved through the timely restoration of failed devices and the proper handling of the circulating information within them. To implement restoration, it is necessary to have information about the state of the system's hardware, as well as the quality of processing, transmission, and storage of information within it. This information can only be obtained through monitoring.

Monitoring provides the ability to timely detect, and address failures and adverse consequences caused by them. It can be concluded that achieving the necessary reliability and efficiency of systems is most reasonable through the implementation of direct methods to enhance hardware reliability, coupled with monitoring and subsequent resolution of failures and their consequences.

Types of control are classified based on: the purpose of implementation; the depth and completeness of performed checks; the degree of automation of control operations;

the timing and sequence of their implementation; the type of constructive implementation of control means and their location relative to the objects of verification; the hierarchy of management; the type of implemented decision-making rule; regarding the modes of operation of the system being checked.

Depending on the goal of control, it can be classified as operational control and diagnostic control [4].

In operational control, the goal of checks is to timely detect the absence or presence of malfunctions in the system under examination, as well as deviations in the form of failures in the output information.

In diagnostic control, checks are conducted with the aim of determining the location and cause of a malfunction or the nature of a failure. These types of control are based on various verification methods, which are technically implemented and used differently in different conditions.

In general, operational control is a component of diagnostic control. In principle, diagnostic control can almost always be carried out without knowing whether the system is operational or not. However, implementing diagnostic control typically requires more time. Therefore, as a rule, operational control is performed first as it is simpler and requires less time. Then, if necessary, a diagnostic check is conducted.

Hardware control is a form of control that operates continuously throughout the entire operation of the system, running in parallel with the execution of the primary tasks. It is implemented through the integration of control equipment into the system's structure.

According to the principles of practical implementation, hardware control can be divided into modular control, control using error-correcting codes, hardware-microprogram control, and majority control.

Because hardware control operates continuously throughout the entire functioning of the control object, it allows detecting both faults and failures at the moment of their occurrence or with a delay of one or two operations. Since the control operations are carried out in parallel with the main process of information processing and transmission, hardware control practically does not reduce the performance of the system's resources.

Thus, among the advantages of hardware control, its continuous operation, the ability to detect both faults (failures) and errors at the moment of their occurrence, automatic localization of faults with precision up to the functional node (more accurate localization is achieved through diagnostic tests), and the ability for self-checking can be mentioned.

A disadvantage of hardware control is the need for the introduction of additional control equipment, which itself may serve as a source of faults and failures in operation.

Conclusion.

The described methods and means provide practical implementation of hardware and information recovery, ensuring necessary reliability and durability of systems during their operation, as well as the required likelihood of information transmission and processing.

A properly organized control enhances the adaptability of the system being monitored to prevent, detect, and rectify failures, thus improving its maintainability.

Therefore, the quick restoration of control and the elimination of the consequences of failures and malfunctions is a powerful and, in many cases, the only method to maintain the required level of reliability during operation and ensure the necessary probability of information processing and transmission.

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Abstract. *На сьогоднішній день у зв'язку з підвищенням масштабів і складності автоматизованих систем керування, усе більш гостро постає проблема забезпечення їх надійності. У статті проведено аналіз основних методів та засобів підвищення надійності керування в автоматизованих системах керування.*

Key words: *автоматизовані системи керування, вірогідність інформації, безвідмовність систем керування, підвищення надійності, резервування, реконфігурування, структурна надмірність.*

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