UDC 681.518.3

V.V. Dovgal′ [1], associate professor, c.t.s.
N.A. Minyajlo [1], associate professor, c.t.s.
V.K. Malyj [2], main engineer of project

RESERVATION OF SYSTEMS AUTOMATION FOR OBJECTS WITH ADVANCED DANGER OF PAJ «UKRGRAPHITE»

[1] Zaporozhe state engineering academy, Ukraine
[2] PAJ «Ukrainian graphite», Zaporozhe, Ukraine

The methods of the hardware reservation for the systems of automation, used on technological objects with an advanced danger are examined. The structural scheme of the positive system of automation, containing the minimum quantity of surplus elements, is offered. There are got analytical dependences for the calculation of probability of failure-free work of reserved automation system with the consistently-parallel structure of elements.

Keywords: automation system, positivity, «hot» reservation by substitution, probability of failure-free work, duplication

Reservation serves as the widely applied method of increase of reliability for the systems of automation for technological objects with an advanced danger and allows to create high reliability automatized systems of management [1].

In the systems of automation widely use two methods of reservation: «hot» reservation by a substitution and method of voting. At the «hot» reservation basic and reserve elements of the system are in the charged state. At reservation by a substitution reserve elements activate in work systems after the failure of basic elements. In the systems of reservation with voting a few identical equivalent elements use which work simultaneously and perform the same duty, and the select of signal is carried out by the scheme of voting. There are distinguished the common reservation (reserve the system on the whole) and separate (reserve separate elements).

It is first of all necessary to reserve the processor module («processor») of the system of automation, because his failure results to the failure of all system. Simultaneously with a processor reserve the power module and industrial network. Complication of reservation for processors consists in that in the moment of substitution a reserve processor must have the internal state, identical to the basic processor state. For it rapid repainting in the systems of reservation by a substitution is used an optical timing channel.

For passing to the working state a reserve processor must have the opportunity of detection the failure of basic processor; to synchronization with the basic processor of work for the application program, accumulated data, got from entries and sent on outputs, states of pid-regulators and registers, and also substituting for a basic processor. After primary synchronization it is repeated in every controller cycle, that allows to have information about readiness of reserve controller to substituting for basic. Switching of processor is usually executed without a commutator by a change its address in the networking's devices.

At reservation of industrial networks if mostly reserves flow lines. For this purpose there are used two network ports, to one of them connect a basic industrial net-

work, to other – reserve. Every controller has environment of controls of working capacity for network and in the case of it failure commutes the port on a reserve network. The basic problem of reservation for networks by the method of substitution is detection of failure, which must be executed by every participant of network autonomically, that possibly only in networks, having the special hardware controls.

At development of PCS an utilization boiler room for PAJ «Ukrainian graphite» (Zaporozhe), which applies to the nonexplosion technological objects with the high cost of downtime, used the separate hot reservation by a substitution.

This system is built on the hardware platform of firm «SIEMENS» with the use of program logical controller S7-400H with the reserved structure and the stations of the distributed input-conclusion of ET-200M with the reserved networks PROFIBUS-DP, constrained with help the duplicated field network of PROFIBUS-DP, is three-level and territorial distributed on-line. Instrumental SCADA-package «WinCC» and Softlogic-package «STEP 7» used for software development of program. PCS executes the functions of operative control and management by technological processes of boiler room, collection and storage of technological information, diagnostics of working capacity of equipment, functioning twenty-four-hour real-time.

All reserve resources constantly are in work and simultaneously involved in implementation of management tasks. In two central processors there is the identical user program, which is synchronously executed by them. A reserve subsystem is always synchronized with events in a basic subsystem. Distinction between basic and reserve processors consists in providing of producibility of reaction on errors. At the failure of reserving connection a reserve processor passes to the state «STOP», while remains basic processor in the regime «RUN».

Probability of failure-free work of the system on statistical data about failures estimate with the use of expression [2]:

$$P(t) = \frac{n(t)}{N}\ , \qquad (1)$$

where $P(t)$ is a statistical estimation of probability of failure-free work of elements; $n(t)$, N is accordingly quantity of elements, not saying no to the moment of time t, and put on tests.

For the estimation of probability of failure on statistical data correlation is just:

$$q(t) = \frac{N - n(t)}{N}\ , \qquad (2)$$

where $q(t)$ is a statistical estimation of probability of failure of elements; $N - n(t)$ is a quantity of elements, saying no to the moment of time t.

Every element of reservation diminishes probability of failure of unit in accordance with a formula:

$$Q = \prod_{i=1}^{m} q_i \ , \qquad (3)$$

where Q is probability of failure of all elements); m is a quantity of reserve elements (multiplexes of reservation); q_i is probability of failure of i element.

Probability of failure-free work of control system can be defined, using standart procedures of calculation for elements, united consistently or in parallel.

At successive connection of elements the system is working capable, if all it elements are working capacity, because the failure of one element results in the failure of all system. Probability of failure-free work $P_i(t)$ of such system for time t is determined by a formula:

$$P_c(t) = P_1(t) \cdot P_2(t) \cdot \ldots \cdot P_n(t) = \prod_{i=1}^{m} P_i(t) \ , \qquad (4)$$

where $P_i(t)$ is probability of failure-free work of i element for time t; n is a quantity of the consistently united elements.

At parallel connection of elements (duplication) the system remains of working capacity, if one element in good condition. In this case probability of failure-free work $P_c(t)$ of the system for time t is determined by a formula:

$$P_c(t) = 1 - \left[1 - P(t)\right]^2 \ . \qquad (5)$$

Using formulas (4) and (5), final expression for the calculation of probability of failure-free work of PCS the boiler room of PAJ «Ukrainian graphite» gets:

$$P_{\text{ÀÑÓ}} = P_{\text{ÀÐì}} \cdot P_{SW}^3 \cdot P_{AD}^2 \cdot \left[1 - \left(1 - P_{WF}\right)^2\right]^2 \cdot \left[1 - \left(1 - Ð_{\text{ÀÐì}}\right)^2\right] \cdot$$

$$\cdot \left[1 - \left(1 - P_{PLC}\right)^2\right] \cdot \left[1 - \left(1 - P_{ET} \cdot P_{WR}\right)^2\right] \cdot \left[1 - \left(1 - P_{AD}\right)^2\right]^2 \cdot \left[1 - \left(1 - P_{ET}\right)^2\right] \qquad (6)$$

where $Ð_{\text{ÀÐì}}$ P_{SW}, P_{AD}, P_{WF}, P_{PLC}, P_{ET}, P_{WR} are accordingly probability of failure-free work of workstation for operator, commutator, adapter, fiber-optic cable, controller, station of the distribution of input-conclusion and cable of PROFIBUS-DP.

Conclusion. The minimum quantity of surplus elements in worked out PCS of boiler room of PAJ «Ukrainian graphite» is provided with the use of the element wise reservation by the method of duplication of the most responsible units the faultiness of which results to the complete failure of this system. Thus it is rises substantially vita-lity of PCS and the downtimes of plant equipment, caused by its faultinesses, are eliminated.

LIST OF LITERATURE

1. Каштанов, В. А. Теория надежности сложных систем. [Текст] : учеб. пособие / В. А. Каштанов, А. И. Медведев; – 2-е изд. – М. : ФИЗМАТЛИТ, 2010. – 606 с. – Библиогр. : с. 602-606. – ISBN 978-5-9221-1132-4.
2. Острейковский, В. А. Теория надежности. [Текст] / В. А. Острейковский. – М. : Высшая школа, 2003. – 463 с. – Библиогр. : с. 457-458. – ISBN 5-06-004053-4-9.