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RESEARCH OF CONDITIONAL DIAGNOSTIC ALGORITHMS MANY SOURCE OBJECTS

Abstract. Without regard to the swift increase of reliability of element base of modern special communication means actual is a question of providing of their a fitness is to repair, of value of indexes of that regulated by leading documents. Considerable time of permanent repair of special communication means occupies the search of defective elements, that is why important enough improvement of the diagnostic providing. It is arrived at by the use of effective algorithms of searching activity of masters that abbreviate the necessary amount of verifications of the damaged apparatus. It is set that to 30 percent of refuses of special communication means conditioned by disrepairs their sources of secondary power supply, that behave to the class of many source objects. In the article with drawing on modern accomplishments of technical diagnostics and metrology, that was not taken into account before, research possible variants of construction of conditional diagnostic algorithms. Also research their indexes of quality depending on the structural features of object of diagnosticating and the brought results over of comparison. The terms of repressing choice of algorithms of search of defects are set on the criterion of a minimum of mean time of renewal, the order of decision of this task is formalized. The got results it is expedient to draw on during development of the diagnostic providing of perspective special communication means, and also and at the improvement of existing. Thus, taken off part of limitations that is used in the known methodologies, that allows to promote efficiency scientifically reasonable practically implemented recommendations in relation to time of proceeding in special communication means at the refuse of their sources of secondary power supply.

Keywords: diagnostic algorithm, many source object, average recovery time.

Introduction

Modern software-controlled means of special communication (MSC) are constantly complicated in the direction of automation of technological operations, quality assurance and continuity of communication, which leads to an increase in the number of elements, which in turn does not contribute to the required values of reliability.

Therefore, the problem of the effectiveness of the diagnostic process during the current repair of the MSC is quite relevant and requires a continuous solution and improvement as technology develops.

That is, we have a contradiction between the improvement of the MSC, increasing the number of elements and the need to ensure the directive values of reliability indicators. Its removal in modern conditions is possible by improving the diagnostic support, namely the introduction of effective algorithms for finding defects during the current repair of the SC [1].

Analysis of SC failures shows that up to 30% falls on the failure of secondary power sources [2-5].

It is established that the subsystem of power supply of MSC belongs to the class of multi-output objects (MO), which differ in the peculiarities of the process of recovery [6, 7].

Therefore, there is a need to study the most effective algorithms for diagnosing MO, which minimize the average recovery time.

Basic material and results

Known methods of developing diagnostic software MO [1, 2, 7, 8] do not take into account the results of recent research in the field of technical diagnostics [9] and metrology [10, 11]. To increase the accuracy of estimating the value of the average recovery time, it is proposed to take into account the probability of correct diagnosis and metrological reliability of the measured equipment (ME).

The value of these indicators in the known methods is limited: that is, the probability of correct evaluation of the test result at the time of diagnosis is equal to one, and the ME is valid in advance.

These provisions do not correspond to the real conditions of recovery of the MSC in the field [2, 5, 7]. These shortcomings are eliminated in this article, the purpose of which is to study the conditional algorithms for diagnosing (CAD) MO, taking into account the probable indicators of the defect search process – the probability of correct diagnosis and metrological reliability of ME in contrast to known studies and publications.

In the general case, the ME (power supply subsystem, generator equipment or allocation of communication channels in radio relay stations, tropospheric communication stations or multi-channel hardware field communication) can be represented in the form of Fig. 1 (for power supply subsystems, it is a transformer with secondary windings, rectifiers, filters, voltage stabilizers), where M is the number of outputs (in the general case – ME units), n is the number of typical replacement elements (TRE) that are part of spare parts with depth to which it is necessary to determine the defect.

According to the recommendations [1], the general CAD MO takes the form of Fig. 2.

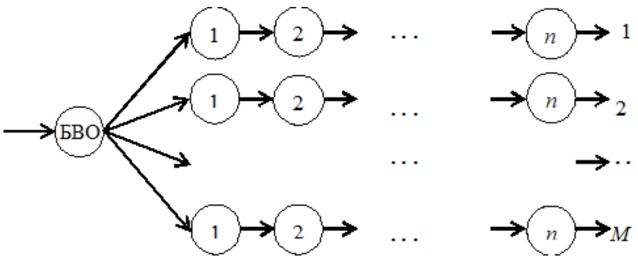

Fig. 1. Block diagram of a multi-output object

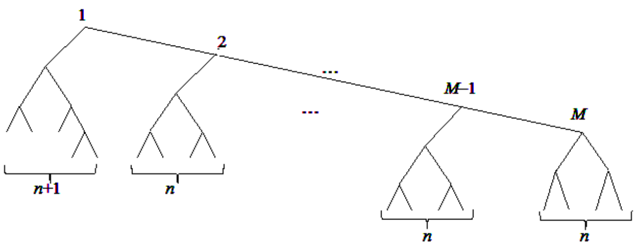

Fig. 2. General conditional algorithm for diagnosing a multi-output object

The total number of inspections for this CAD is equal to

$$K_{\Sigma} = (n+1)\left(1+\log_2(n+1)\right)+$$
$$+n\left((M-1)+\sum_{L}^{M-1} i+(M-1)\log_2 n\right)=$$
$$=(n+1)\left(1+\log_2(n+1)\right)+$$
$$+n\left((M-1)(1+\log_2 n)+0{,}5(M-1)M-1\right),$$

and the average number of inspections when searching for a defect is

$$K=\frac{K_{\Sigma}}{1+nM}=\frac{K_{\Sigma}}{L},$$

where L is the total number of MO elements.

In that case, the average recovery time of the MO

$$T_1=\frac{Kt_{в}}{p^{K}P},$$

where $t_{в}$ – the average measurement time when performing the test; p – the probability of correct evaluation of the measurement result; P – metrological reliability of the FTA.

In Fg. 3 shows the dependences of the average recovery time of the MO on the number of blocks (M ⇄)and the time of measurement (tв), provided that p = 0,9997 and P = 0,98 [10, 11], and L = 256.

Consider the second option for diagnosis: measuring the output signals when searching for a faulty unit and diagnosing it with CAD minimal form:

$$K_{б}=\frac{(M-1)(M+2)}{2M};\ K_e=\log_2\frac{L}{M};\ \mathrm{T}_2=\left(\frac{\mathrm{K}_{б}}{\mathrm{p}^{\mathrm{K}_{б}}}+\frac{\mathrm{K_e}}{\mathrm{p}^{\mathrm{K_e}}}\right)\frac{\mathrm{t}_{в}}{\mathrm{P}},$$

where $K_{б}$ is the average number of checks when searching for a faulty unit; K_e – the average number of checks when searching for a faulty replacement element. We believe that in both cases use one ME. Unlike the first option, it is a two-stage diagnostic process.

In Fig. 4 shows the dependences $T_2(M,t_{в})$, under the same conditions as T_1.

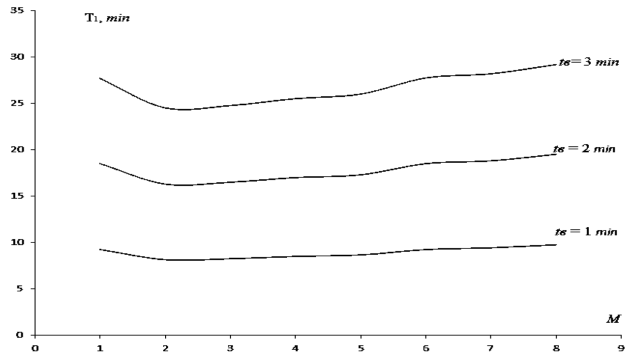

Fig. 3. The dependences of the average recovery time of a multi-output object on the number of blocks and the execution time of the scan

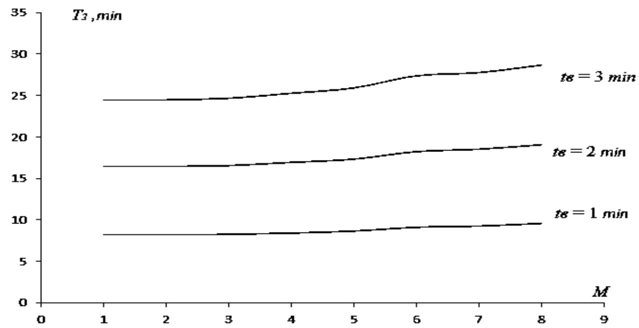

Fig. 4. Dependencies of the average recovery time in the two-stage process of diagnosing a multi-output object

Comparison of Fig. 3 and Fig. 4, shows that this option is not better than the previous one, but with increasing value of M we have a slower increase in recovery time.

We consider further the two-stage process of diagnosing: search of the faulty block by procedure of trial replacements, and TRE as before. The procedure of trial replacements is very simple and does not require ME, but only a serviceable set of TRE as part of spare parts, or the presence of a serviceable set of MSC. The average recovery time

$$T_3=K_{б}t_3+\frac{K_{е}t_{в}}{p^{K_e}P},$$

where t_3 is the average test execution time of the unit.

Dependencies $T_3(M,t_{в})$ at $t_3=1$min are shown in Fig. 5.

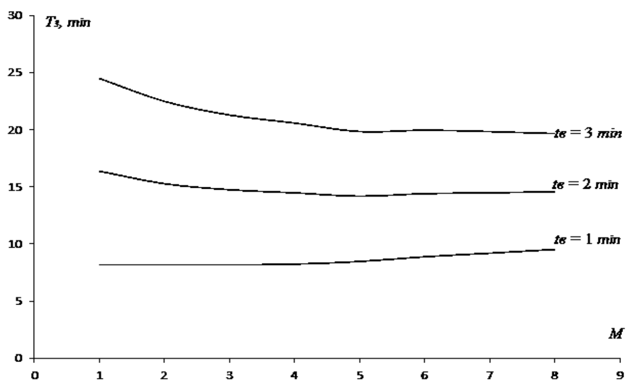

Fig. 5. Dependencies of the average recovery time when using trial replacement procedures at the first stage of diagnosis

The advantage of this procedure is performed if

$$T_2 - T_3 = K_б \left(\frac{t_в}{p^{K_б} P} - t_3\right) > 0,$$

that is

$$\frac{t_в}{t_3} > p^{K_б} P$$

This inequality is always satisfied because $t_в > t_3$ and $p^{K_б} P < 1$.

When restoring the MSC in the field in the hardware of the hardware at the first stage of diagnosis, it is advisable to use a group search for defects, when specialists simultaneously perform measurements of parameter values. In this case, the maximum number of block checks is equal to

$$K_m = \left[\frac{M-1}{\mu}\right],$$

where [A] means rounding the number A to an integer value (for example, $[2{,}1] = 3$). And the average value of the number of inspections in a group search for defects

$$K_г = \frac{\mu K_m (K_m + 1)}{2M},$$

Then the total recovery time of the MSC is equal to

$$T_4 = \frac{t_в}{P}\left(\frac{K_г}{p^{K_г}} + \frac{K_e}{p^{K_e}}\right).$$

The dependences of $T_4(M, t_в)$ for $\mu = 2$ are shown in Fig. 6.

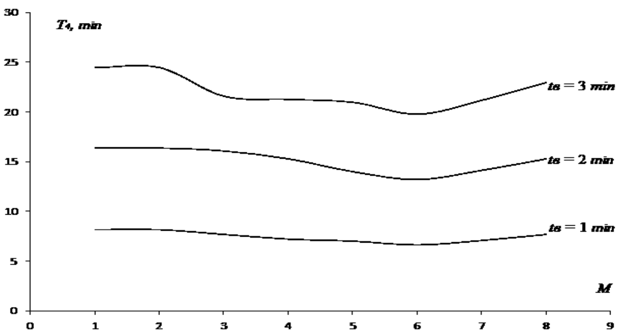

Fig. 6. Dependencies of the average recovery time of the product during the implementation at the first stage of group search of the faulty unit

A comparison of the last two diagnosis options shows that

$$T_3 - T_4 = K_6 t_3 - \frac{K_г t_в}{p^{K_г} P} > 0,$$

Provided

$$\frac{K_б}{K_г} p^{K_г} P > \frac{t_в}{t_3}.$$

Since $p^{K_г} P < 1$, the number of specialists is $\mu > 1$ and $K_г < K_б$ provided $\frac{M-1}{M+1} < \mu$, which is always executed, then $T_3 > T_4$.

If there are no fuses, you can use the procedure to disconnect the connectors or remove the units to search for a short circuit in the power supply circuits. Then from the beginning it is advisable to turn off 0.5 M and check the power supply, then 0.25 M and so on until the overload unit is installed. The number of simultaneously switched off units at each step of the test is halved, ie the total number of outages is equal to

$$N = \frac{M}{2} + \frac{M}{4} + \dots + \frac{M}{M} = M \sum_{i=1}^{M} 2^{-i} = M(1 - 2^{-M}).$$

In this case, the total time of diagnosis is

$$T_5 = M(1 - 2^{-M}) t_p \log_2 M + t_в K_e / p^{K_e} P,$$

where t_p is the time to disconnect the ($t_p < t_в$) connectors.

Dependences of $T_5(M, t_в)$ at $t_p = 1$ are given in Fig. 7.

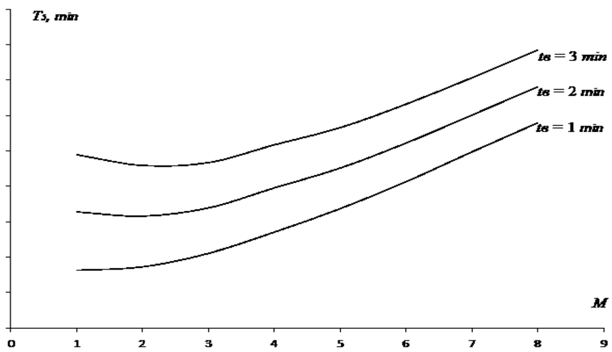

Fig. 7. Dependences of the average time of diagnosing the product with the disconnection of the blocks from power supply

Since in the two-stage search for defects (first block, then TRE) always increases the value of M in the product, the search time of the block increases, and the search time TRE decreases, the function $T_i(M)$ has a minimum value that should be considered when designing MSC. This value can be found by an algorithmic increase in the value of M from one to L.

A comparison of options shows that always $T_5 < T_3$, because

$$\frac{2M \log_2 M}{(M-1)(M+2)} < \frac{t_3}{t_p} < 1.$$

In the best case, if the facility has indicators at all outputs of the power supply unit or the ability to check the voltage with built-in FTA, their readings are checked taking into account the probability of the preferred choice, ie starting with the least reliable. In this case, the total time of diagnosis is

$$T_6 = \frac{M(t_n + t_i)}{p_1^M P_1} + \frac{t_в K_e}{p_2^{K_e} P_2}$$

if you use built-in and external ME with different values of p and P, where t_n is the switching time of the built-in device, t_i is the time of evaluation of its indicators.

The dependences of $T_6(M, t_в)$, at $t_n + t_i = 1$ are shown in Fig. 8 and also have a minimum value for a number of blocks.

A comparison with the previous diagnostic procedure shows that $T_6 < T_5$ when the condition is met

$$\frac{1}{p_1^M P_1 (1 - 2^{-M}) \log_2 M} < \frac{t_p}{t_n + t_i}.$$

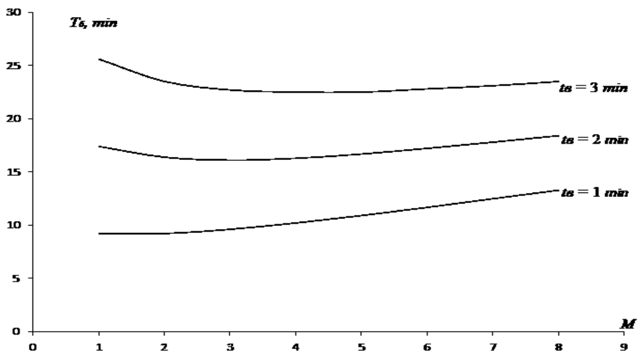

Fig. 8. Dependences of the average time of diagnosing the product on the number of blocks when using built-in and external measuring instruments

Thus, the article considers practically feasible options for diagnosing BVI and obtained a quantitative estimate of the average time of diagnosis.

The average recovery time in all cases is equal to

$$T_{\text{ві}} = T_i + t_y \leq T_{\text{вдоп}},$$

where $i = \overleftarrow{1,\ 6}$ is a variant of diagnosis, t_y – the average troubleshooting time, $T_{\text{вдоп}}$ – allowable recovery time according to guidelines.

Conclusions

Analysis of the results shows that there is no universal diagnostic procedure.

The functional dependences of the average time of diagnosis on the design of the product and time indicators of operations, which differ from those known taking into account the quality of metrological support of the current repair of the GCC, are obtained.

In the future, it is advisable to use the results in the method of choosing the algorithm for diagnosing BVI depending on their design and recovery conditions.

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Дослідження умовних алгоритмів діагностування багатовихідних об’єктів

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Анотація. Незважаючи на стрімке зростання надійності елементної бази сучасних засобів спеціального зв’язку актуальним є питання забезпечення їх ремонтопридатності, значення показників якої регламентується керівними документами. Значний час поточного ремонту засобів спеціального зв’язку займає пошук несправних елементів, тому досить важливе удосконалення діагностичного забезпечення. Це досягається використанням ефективних алгоритмів пошукової діяльності майстрів, які скорочують необхідну кількість перевірок пошкодженої апаратури. Встановлено, що до 30 відсотків відмов засобів спеціального зв’язку обумовлено несправностями їх джерела вторинного електроживлення, які відносяться до класу багатовихідних об’єктів. В статті із використанням сучасних досягнень технічної діагностики і метрології, які не враховувались раніше, досліджені можливі варіанти побудови умовних алгоритмів діагностування. Також досліджені їх показники якості залежно від конструктивних особливостей об’єкта діагностування і приведені результати порівняння. Встановлено умови переважного вибору алгоритмів пошуку дефектів за критерієм мінімуму середнього часу відновлення, формалізовано порядок рішення цього завдання. Отримані результати доцільно використовувати під час розробки діагностичного забезпечення перспективних засобів спеціального зв’язку, а також і при удосконаленні існуючих. При цьому знята частина обмежень, які використовуються у відомих методиках, що дозволяє підвищити ефективність науково обгрунтованих практично реалізуємих рекомендацій щодо часу відновлення засобів спеціального зв’язку при відмові їх джерел вторинного електроживлення.

Ключові слова: алгоритм діагностування, багатовихідний об’єкт, середній час відновлення.