DEFINITION OF A SET OF DIAGNOSTIC FEATURES AT A GIVEN DEPTH AND COMPLETENESS OF TESTING ELECTRONIC

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Abstract: *Paper is devoted to the development of an original method of identifying a set of diagnostic features of electronic means, which meets the requirements of the depth and completeness of testing. A criterion for assessing the significance of features for ranking and informed choice diagnosed elements. Results may be recommended for testability design electronic means. This work was supported by RFBR (grant № 14-07-00414). Modern electronic means, made in the form of a printed board assembly, can be composed of hundreds components. It can lead to such an increase of the diagnostic model complexity, that will require unreasonably high computational resources, and cumulative computational error will make the use of the results of computer modeling almost unnecessary and unjustifiable. Thus, for example, the Ebers-Moll or Hummel-Pune models for the bipolar transistor can have from a several to a few tens of parameters, each of them is a diagnostic feature in the evaluation of its technical condition.*

Key words: *diagnostic features, testing electronic, electronic, original method, electronic means*

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1. Introduction

Providing testability of electronic means (ES) is an actual design problems that must be addressed at early stages of the life cycle. Otherwise, the product will be slightly adapted to the control and diagnosis, leading to significant cost to the control stages and the output stage of operation.

Due to current trends in the design and development (high density mounting, wide range of features and so on.), the model of electronic means is characterized by lots of diagnostic features.

Based on the characteristics of production, availability of time and financial constraints of control procedures and diagnosis, as well as the requirements specification for the indicators of depth and completeness of testing. The developer needs to reduce the number of diagnostic features, forming a corresponding set of the most significant.

2. Method of determining significance of diagnostic electronic means features

The paper proposes a method of determining the set of significant diagnostic features corresponding to electronic components, at a given depth and completeness of testing electronic means. The block diagram of this method is shown at Figure 1.

To determine the significance of the diagnostic feature as well as the significance of it's corresponding. ERE serves to analyze the sensitivity function (S), reliability indicators (Q), the values of the tolerances on the parameters of ERE (D), as well as statistical data ES failure. Enter the weight factor - factor of significance $R = f(S, Q, D)$.

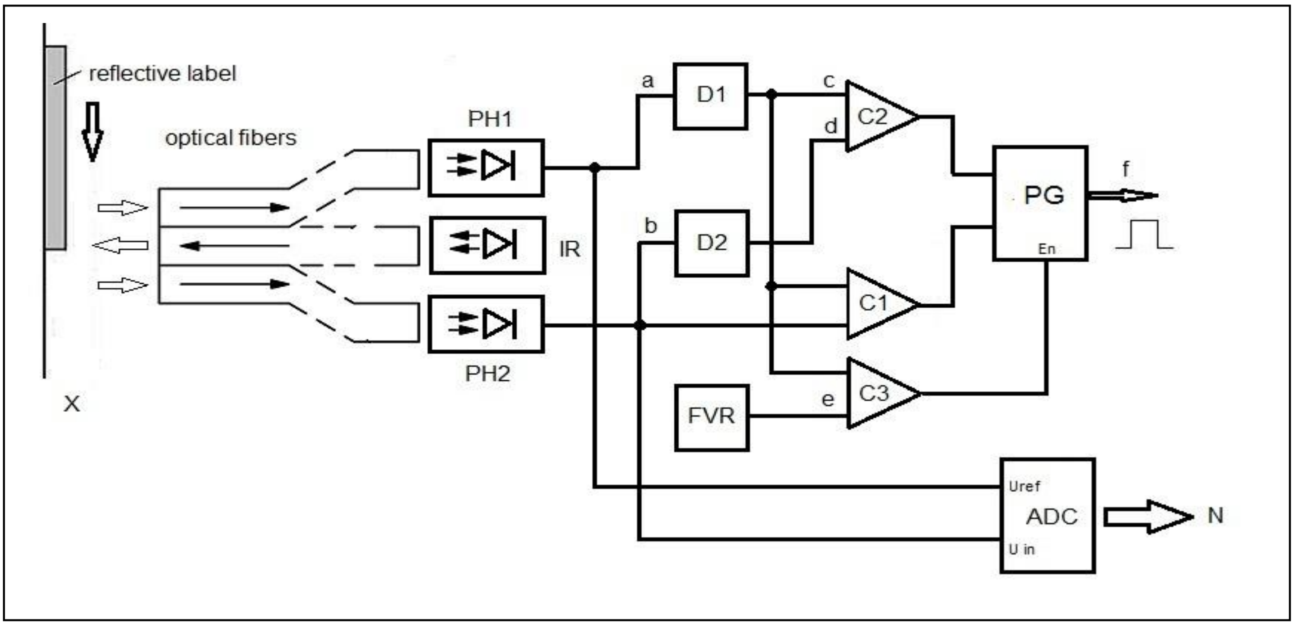

Fig. 1. Block diagram of the method for determining the significance of diagnostic features

In accordance with the theory of the sensitivity deviation of the internal parameter ERE from its nominal value which affects the output characteristics of the entire electronic means. This parametric sensitivity function has the form:

$$A_{q_j}^{y_i} = \left(\frac{\partial y_i}{\partial q_j} \right), \tag{1}$$

Y=[y_1,y_2...y_i]- set of of output characteristics;
Q=[q_1,q_2...q_j] - set of of input characteristics.

Most of the ERE is characterized by many internal parameters, that is why fixed output is function of the sensitivity of a row vector:

$$A_{q_j}^{y_1} = \left(A_{q_1}^{y_1}, A_{q_2}^{y_1}, ..., A_{q_m}^{y_1} \right), \tag{2}$$

j=1..m, *m* - number of parameters element.

To reduce the dimension of the solving problem is invited to choose the maximum value of the sensitivity function of the output characteristic to modify the elements. So conditionally accepted value of the sensitivity of the output characteristic to this ERE (). Availability in ES elements of various dimensions of physical quantities (resistors, capacitors, inductor, etc.) necessitates the use of dimensionless quantities. To this end, the absolute sensitivity function are translated into relative:

$$S_{q_i}^{y_1} = A_{q_j}^{y_1}(N_i) \cdot \frac{q_j}{y_1}, \tag{3}$$

$$S_{N_i}^{y_1} = \max_{j=1..m}[S_{q_j}^{y_1}(N_i)], \tag{4}$$

Electrical Model	The Thermal Model	Mechanical Model
Electrical Conductivity	Thermal Conductivity	Equivalent Coefficient of Resistance
Electrical Resistance	Thermal Resistance	The Reciprocal of The Equivalent Resistance Factor
Electrical Capacity	Heat Capacity	Weight
Inductance	-	Compliance
Current	Dissipated Power	Impulse Power, Strength, or a Derivative of Force
Voltage	Temperature	Displacement, Velocity or Acceleration

Tab. 1. The analogy between the parameters of heterogeneous physical processes

A similar calculation of the sensitivity function is performed for all the species of the physical processes, namely, electrical, thermal and mechanical. The task is greatly simplified if one considers the electro-thermal mechanical analogy (Table 1), which is widely used in electronics. This approach also allows the mathematical modeling of physical processes in a complex heterogeneous.

On important elements in terms of the tasks of monitoring and diagnosing affects the reliability of the elements. One of the main parameters characterizing the reliability of the element is the probability of failure-free operation during the time t:

$$P(t) = e^{-\lambda_e t}, \tag{5}$$

λ_e – operational failure rate ERE, which is calculated:

$$\lambda_e = \lambda_b \times \prod_{i=1}^{n} K_i, \tag{6}$$

λ_b – basic failure rate of ERE calculated from the results of tests on the ERE, reliability, durability, service life;

K_i – coefficients that take into account changes in the operational failure rate, which depends on various factors, distinguish rate regime, service factor, the coefficients of the models of specific classes of ERE and others;

n – number of factors taken into account.

A high value *P(t)* indicates that the element is likely not refuse and, therefore, will not affect on output characteristics of the product. In this case of great importance to have the elements with a high probability of failure *Q(t):*

$$Q(t) = 1 - P(t), \tag{7}$$

The following parameters effect on significance of the diagnostic feature. ERE is the tolerance on the internal parameters. ERE parameters q_j can be represented as $q_j = q_j^{\text{b}} \pm \Delta q_j$ where Δq_j - tolerance on the nominal parameter q_j^{b}.With the standpoint of diagnosis is the most important parameter to a smaller value of tolerance. To convert the values of tolerance D in dimensionless use the expression

$$D = \frac{\Delta q_j}{q_j^{\text{b}}}, \tag{8}$$

Based on this, write down the expression for the coefficient of the significance of *i*-ERE:

$$R_i' = [\max_j S_{q_j}^{y_1}(N_i)] \cdot Q(t) \cdot [1/D], \tag{9}$$

Significance factor R_i' is the weighting factor of the element N_i. Sum of weighting factors must be equal to one. Consequently, it is necessary to normalize the value R_i' of the unit:

$$\frac{R_i'}{\sum_i R_i'} = R_i : \sum_i R_i = 1, \; i = 1, 2 ... n, \tag{10}$$

Spending ranking of electroradioelements are included in the scheme under consideration. Obtain a set N_r, which is composed of elements N_i^{Ri}, ordered by weighting values from largest R_i to smallest.

When specifying a set of elements, diagnosed coefficient of completeness is fundamental, because the total number of permits have ranked items to choose the required amount of respect that provide testability.

Among the entire set elements have ranked N_r excerpts, forming set of N_q' so that:

$$N_q' = K_{ПП} \cdot N_r, \tag{11}$$

If the same types devices are in operation and received the complaint, the method provides possibility of replacing elements of the set with the lower coefficient values for the significance of the elements of the list N_S claims.

Similarly possible to account expert opinion, in which can be a designer himself, through the replacement of insignificant elements formed on a set of more meaningful N_E.

The final set of diagnosed elements represented by the set N_q.

3. Method of ranking and selection of relevant parameters in engineering design practice

For the practical use of the proposed method has been developed an engineering technique that is presented in the form of IDF0 diagram in Figure 2.

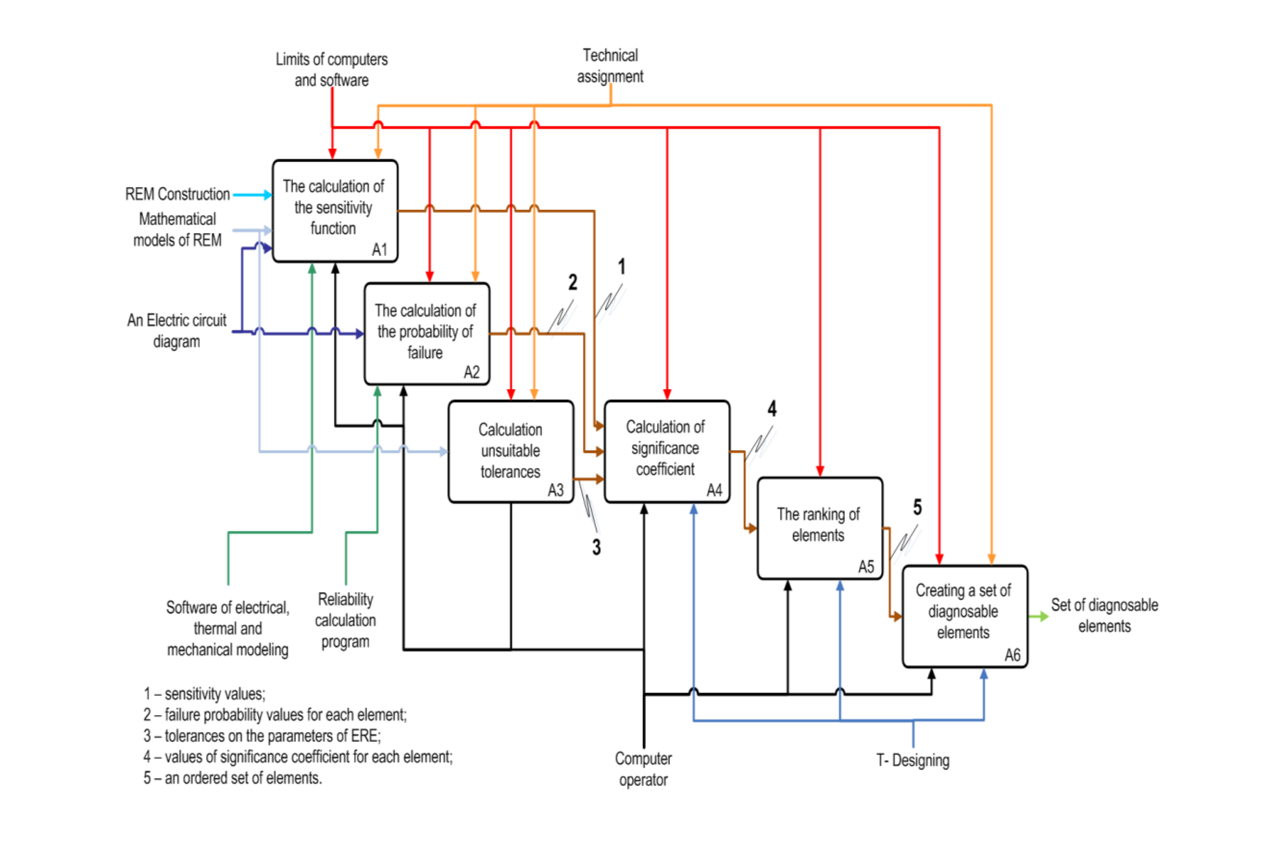

Fig. 2. Scheme of the formation of diagnosed parameters set

- Calculation of the sensitivity function (A1). Calculation of the sensitivity of the output characteristics (e.g., voltage at the output of the temperature on the elements) is carried out by dint of the module of the T-Designing to change internal parameters. Wherein the maximum value is chosen and considered as the sensitivity of the output characteristic to modify the element.
- Using the reliability program ASONIKA-K provides us to calculate the probability of failure of each element (A2). The output file of the program containing the necessary data is converted to a module of the program to ensure testability, responsible for determining the significance of ERE.
- Using the reference data on the ERE (radio-electronic elements), as well as the data of operating conditions specified in the specifications, tolerances of element parameters (A3) are formed.
- The obtained probability values of failure-free operation are converted to probability values of failure. “Classic” tachometer. The timer counts the pulses generated by the passage of the reflective label.
- Fast measuring device of the "instantaneous" rotation speed. The timer counts the duration of time intervals between the edges of the pulses generated by passing the reflective label. In this case, the calculated value of the rotation speed is updated after each turnover of the actuator.
- By multiplying the sensitivity and failure probability values, the reciprocal of the tolerance, which is held in the automatic mode by dint of the program T-Designing, we get the boost factor of each element (A4).

- We order ERE according to a significance factor (A5).
- To ensure testability of the T-Designing program we introduce the completeness check coefficient, which is taken from the specification.
- In accordance to the coefficient of fullness sampling inspection elements (A6) is carried out.
- In the manual mode the selected set of elements may be changed.

Proposed method and the technique allow the entire set of electronic components and their diagnostic features highlight the most significant and the most influence on the state of engineering in general.

Creating a set of diagnostic parameters should be started on the stages of circuit design and construction, while in the specifications for the mandatory introduction of indicators of depth and completeness of the diagnosis.

The effectiveness of this method and the technique can be assessed in the form of reducing the cost and time of the diagnostic operations.

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