and until the moment of fixation of the integral failure; The state of a latent defect can be diagnosed using, for example, coding pulse modulation.

Thus, introducing the concepts of "differential failure" and "integral failure", we get the possibility of a more detailed description (the beginning of the failure, the end of the failure) of the same failure. Combining these concepts into one, i.e. in the integro-differential failure, we can already talk about the survivability of the element in the failed state or the lifetime of the failure. In turn, knowledge of the “failure time” parameter allows one to uniquely determine such an important system parameter as the “residual resource”. The state of the integral failure, occurring after the state of the differential failure, will correspond to the already lower frequency, given the increase in the duration of the pulse front. The range of change of the duration of the fronts from the differential failure to the integral can be determined either experimentally (before operation) or by simulating the failed states, taking into account the influence on them of various data on the latency of the test element. An original order for constructing a sensor for an integro-differential failure state, tuned, for example, to two frequencies (upper and lower) corresponding to the differential and integral failed states of the element, is proposed in [1].

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ACCOUNT OF THE OPERATION MODEL OF ELECTRONIC COMPONENTS IN STATISTICAL MODELING

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Abstract – The paper the model is considered, allowing to receive realization of an operating time of an electronic component for the set model of its operation. The model was obtained within the limits of those limitations and assumptions that are adopted in regulatory documents on the reliability of electronic components.

Keywords – electronic component, reliability, statistical modeling.

INTRODUCTION

The issues of increasing the accuracy dependability prediction of radio-electronic equipment are still relevant today.

At the same time, a significant number of studies in this area are devoted to the development of analytical methods for assessing the reliability of structurally complex technical systems. At the same time, it can be stated that simulation methods based on the Monte-Carlo method are becoming increasingly common [1].

As a rule, these methods are also used to calculate the reliability indicators of structurally complex technical systems of the type “operating time”.

However, in these methods, obtaining implementations of the developments of electronic components is carried out for one, as a rule, the most “hard”, application mode for obtaining “lower” estimates of reliability indicators. In the second case, there is a need to improve reliability, which may be unnecessary if the operating model of the equipment contains “lightweight” modes, as well as storage and transportation modes.

Thus, in order to increase the accuracy dependability prediction of electronic equipment using the Monte-Carlo method, it is necessary to take into account its operating model and the corresponding modes and conditions when obtaining the realizations of the operating time of the electronic component.

PROBLEM STATEMENT

The initial data in the task of obtaining the implementation of the electronic component's performance are reliability characteristics (reliability, durability and storability) and its operating model (modes and conditions of use, as well as the application time in each of the modes during the lifetime).

Proceeding from this, the mathematical problem of obtaining the realization of operating time to failure of the electronic component ($\hat{t}_{\mathrm{OTF}_{\mathrm{EK}}}$) can be represented as follows:

$$\hat{t}_{\mathrm{OTF}_{\mathrm{EK}}} = f\left(\hat{t}_1,\hat{t}_2,...,\hat{t}_i....,\hat{t}_I\right) \tag{1}$$

where $\hat{t}_i$ is realizations of the electronic component in the i-th mode and conditions of use.

Thus, to solve (1), it is necessary to determine the form of the function (f) and the value $\hat{t}_i$.

SOLUTION OF THE PROBLEM

Issues of obtaining $\hat{t}_i$ for the operation mode, taking into account the conditions of use in this mode are considered in [2-5], where the description and justification of the following model is given:

$$\hat{t}_i = \begin{cases} \mathrm{T}_{\mathrm{OT.M}_i} \text{ with } \hat{x} = 1 \\ f_{\mathrm{E}}\left(\lambda_{\mathrm{O}_i}, \mathrm{T}_{\mathrm{OT.M}_i}, \hat{x}\right) \text{ with } x_{1_i} \le \hat{x} < 1 \\ f_{\mathrm{N}}\left[C_i, m\left(t_{\mathrm{L}}\right)_i, \sigma\left(t_{\mathrm{L}}\right)_i, \hat{x}\right] \text{ with } x_{2_i} \le \hat{x} < x_{1_i} \\ \mathrm{T}_{\mathrm{L.M}_i} \text{ with } \hat{x} = 0 \end{cases}, \tag{2}$$

where:

$\mathrm{T}_{\mathrm{OT.M}i}$ is the minimum operating time;

f_{E} is an exponential distribution function;

$\lambda_{\mathrm{O}i}$ is failure rate;

f_{N} is normal distribution function;

C_i is the normalization factor;

$m(t_{\mathrm{L}})_i$ is the expected value of the life;

$\sigma(t_{\mathrm{L}})_i$ is the standard deviation of the life;

$\mathrm{T}_{\mathrm{L.M}i}$ - maximum lifetime;

$\hat{x}$ - realization of the base random variable;

x_{1i}, x_{2i} are parameters that determine the scope of the models f_{E} and f_{N};

i - number of the operation mode.

For example, for the storage mode, the model will look like this:

$$\hat{t}_i = \begin{cases} \mathrm{T}_{\mathrm{ST.M}_i} \text{ with } \hat{x} = 1 \\ f_{\mathrm{E}}\left(\lambda_{\mathrm{S}_i}, \mathrm{T}_{\mathrm{ST.M}_i}, \hat{x}\right) \text{ with } x_{1_i} \le \hat{x} < 1 \\ f_{\mathrm{N}}\left[C_i, m\left(t_{\mathrm{S}}\right)_i, \sigma\left(t_{\mathrm{S}}\right)_i, \hat{x}\right] \text{ with } x_{2_i} \le \hat{x} < x_{1_i} \\ \mathrm{T}_{\mathrm{L.M}_i} \text{ with } \hat{x} = 0 \end{cases} . \qquad (3)$$

where:

$\mathrm{T}_{\mathrm{ST.MP}i}$ is the minimum storage time;

f_{E} is an exponential distribution function;

$\lambda_{\mathrm{S}i}$ is failure rate;

f_{N} is normal distribution function;

C_i is the normalization factor;

$m(t_{\mathrm{S}})_i$ is the expected value of the storage time;

$\sigma(t_{\mathrm{S}})_i$ is the standard deviation of the storage time;

$\mathrm{T}_{\mathrm{L.M}i}$ - maximum lifetime;

$\hat{x}$ - realization of the base random variable;

x_{1i}, x_{2i} are parameters that determine the scope of the models f_{E} and f_{N};

i - number of the storage mode.

With regard to standby, storage and transportation, the values $\hat{t}_i$ for these modes can be obtained similarly. Thus, it remains to determine the form of the function f.

To do this, we use the model given in [6] to calculate the gamma-percentile lifetime of the electronic component before decommissioning ($\mathrm{T}_{\mathrm{LM}\gamma\mathrm{D}}$), taking into account the model of its operation:

$$\begin{aligned} \mathrm{T}_{\mathrm{LM}\gamma\mathrm{D}} = & \sum_{i=1}^{I}\left[\mathrm{K}(\mathrm{op})_i \cdot \mathrm{T}_{\mathrm{L}\gamma\mathrm{D}}(\mathrm{op})_i\right] + \sum_{i=1}^{I}\left[\mathrm{K}(\mathrm{s})_i \cdot \mathrm{T}_{\mathrm{L}\gamma\mathrm{D}}(\mathrm{s})_i\right] + \\ & + \sum_{j=1}^{J}\left[\mathrm{K}(\mathrm{st})_j \cdot \mathrm{T}_{\mathrm{L}\gamma\mathrm{D}}(\mathrm{st})_j\right] + \sum_{k-1}^{K}\left[\mathrm{K}(\mathrm{tr})_k \cdot \mathrm{T}_{\mathrm{L}\gamma\mathrm{D}}(\mathrm{tr})_k\right] \end{aligned} , \qquad (4)$$

where:

$\mathrm{K}(\mathrm{op})_i$, $\mathrm{K}(\mathrm{s})_i$ are the intensity factors of the component operation in the application mode (operation and standby) under the i-th conditions;

$\mathrm{T}_{\mathrm{L}\gamma\mathrm{D}}(\mathrm{op})_i$, $\mathrm{T}_{\mathrm{L}\gamma\mathrm{D}}(\mathrm{s})_i$ are the gamma-percent life of a component in the application mode (work and standby) in the i-th conditions;

$\mathrm{K}(\mathrm{st})_j$ is coefficient of intensity of operation of a component in storage mode in j-th conditions;

$\mathrm{T}_{\mathrm{L}\gamma\mathrm{D}}(\mathrm{st})_j$ is gamma-percentage life of the component in storage mode in j-th conditions;

$\mathrm{K}(\mathrm{tr})_k$ is coefficient of intensity of operation of the component in the mode of transportation in the k-th conditions;

$\mathrm{T}_{\mathrm{L}\gamma\mathrm{D}}(\mathrm{tr})_k$ is gamma-percentage life of the component in the mode of transportation in the k-th conditions;

I is the total number of conditions of use;

J is the total number of storage conditions;

K is the total number of transportation conditions.

Note that (2) gives the optimal distribution of time for each of the modes of operation, which leads to the maximum possible value of $\mathrm{T}_{\mathrm{LM}\gamma\mathrm{D}}$, since in proportion to K, it is not a lifetime, but a life that is distributed. Fig. 1, as an example, shows the formation of $\mathrm{T}_{\mathrm{L}\gamma\mathrm{D}}$ a component whose operation model contains 3 modes of application with K_1=0,7, K_2=0,2, K_3=0,1, and $\mathrm{T}_{\mathrm{L}\gamma\mathrm{D}2}=2 \bullet \mathrm{T}_{\mathrm{L}\gamma\mathrm{D}1}$, $\mathrm{T}_{\mathrm{L}\gamma\mathrm{D}3}=3 \bullet \mathrm{T}_{\mathrm{L}\gamma\mathrm{D}1}$.

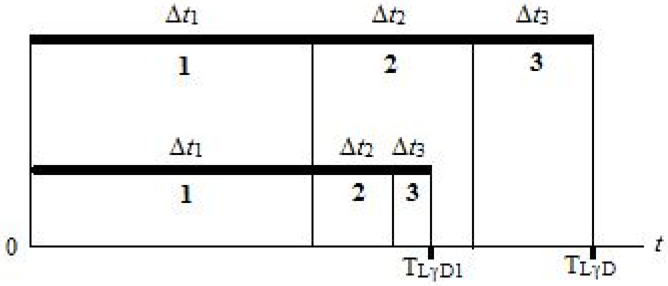

Fig. 1. The formation of the lifetime of the model (2)

As can be seen from fig. 1, with a constant developed life (Δt_1), the values of Δt_2 and Δt_3 increase, which leads to an increase in $\text{T}_{\text{L}\gamma\text{D}}$ due to a change in the values of К (К_1=0,5, К_2=0,29, К_3=0,21).

Note that the values of $\hat{t}_i$ are calculated taking into account resource failures in the modes of operation, waiting for storage and transportation. Then, by analogy with (2) we can write:

$$\begin{gathered}\hat{t}_{\text{OTF}_{\text{EK}}}=\sum_{i=1}^{I}\left[\text{К}(\text{op})_i\cdot\hat{t}(\text{op})_i\right]+\sum_{i=1}^{I}\left[\text{К}(\text{s})_i\cdot\hat{t}(\text{s})_i\right]+\\+\sum_{j=1}^{J}\left[\text{К}(\text{st})_j\cdot\hat{t}(\text{st})_j\right]+\sum_{k-1}^{K}\left[\text{К}(\text{tr})_k\cdot\hat{t}(\text{tr})_k\right]\end{gathered}, \tag{5}$$

where:

$\hat{t}(\text{op})_i$ *i*, $\hat{t}(\text{s})_i$ are the realization of the component in the application mode (work and standby) in the *i*-th conditions;

$\hat{t}(\text{st})_j$ is realization of the component's work in the storage mode under the *j*-th conditions;

$\hat{t}$ ($\hat{t}(\text{tr})_k$ is realizations of the component's operating time in the mode of transportation in the *k*-th conditions.

Thus, we determined the type of function (1) and its parameters.

As can be seen from (5), $\hat{t}_{\text{OTF}_{\text{EK}}}$ is the realization of the component's lifetime before decommissioning ($\hat{t}_{\text{OTF.D}_{\text{EK}}}$). Since the limiting state of a component is its failure in the application mode (work and standby), the value of the resource realization before decommissioning ($\hat{t}_{\text{1..D}_{\text{EK}}}$) will be equal to:

$$\hat{t}_{\text{1..D}_{\text{EK}}}=\text{К}_1\cdot\left\{\sum_{i=1}^{I}\left[\text{К}(\text{op})_i\cdot\hat{t}(\text{op})_i\right]+\sum_{i=1}^{I}\left[\text{К}(\text{s})_i\cdot\hat{t}(\text{s})_i\right]\right\}, \tag{6}$$

where К_1 is coefficient taking into account the intensity of use, which is determined from the condition:

$$\text{К}_1\cdot\left\{\sum_{i=1}^{I}\left[\text{К}(\text{op})_i\right]+\sum_{i=1}^{I}\left[\text{К}(\text{s})_i\right]\right\}=1. \tag{7}$$

Similarly, you can determine the realization of the shelf life (including transportation) before decommissioning ($\hat{t}_{\text{ST-TR.D}_{\text{EK}}}$):

$$\hat{t}_{\text{ST-TR.D}_{\text{EK}}}=\text{К}_2\cdot\left\{\sum_{i=1}^{I}\left[\text{К}(\text{st})_j\cdot\hat{t}(\text{st})_j\right]+\sum_{i=1}^{I}\left[\text{К}(\text{tr})_k\cdot\hat{t}(\text{tr})_k\right]\right\}, \tag{8}$$

where К_2 is coefficient taking into account the intensity of storage and transportation, which is determined from the condition:

$$K_2 \cdot \left\{ \sum_{i=1}^{I} \left[K(\mathrm{st})_j \right] + \sum_{i=1}^{I} \left[K(\mathrm{tr})_k \right] \right\} = 1 \tag{8}$$

As well as necessary for the calculation of storability indicators of the realization of the storage period before decommissioning ($\hat{t}_{\mathrm{ST.D_{EK}}}$) and transportation before decommissioning ($\hat{t}_{\mathrm{TR.D_{EK}}}$).

Thus, the proposed model allows us to obtain realization of the operating time of electronic components for a given model of their operation, which are necessary in statistical modeling to determine the following dependability indicators:

- $\hat{t}_{\mathrm{OTF_{EK}}}$ is used to assess the reliability function for a given lifetime, gamma-percentage lifetime and mean lifetime;
- $\hat{t}_{\mathrm{1..D_{EK}}}$ is used to assess the reliability function for a given operating time, gamma-percentage operating time to failure (gamma-percentage life) and mean time to failure (mean life);
- $\hat{t}_{\mathrm{ST\text{-}TR.D_{EK}}}$, $\hat{t}_{\mathrm{ST.D_{EK}}}$, $\hat{t}_{\mathrm{TR.D_{EK}}}$ are used to assess the reliability function for a given storage time and (or) transportation, the gamma-percentile storage time and (or) transportation and the mean storage time and (or) transportation.

CONCLUSION

The use of the models discussed above for dependability prediction when using the method of statistical modeling will improve the accuracy of the estimated estimates by taking into account the operation model. This will avoid the use of unnecessary measures aimed at improving the dependability and, consequently, unnecessary costs.

At the same time, the considered models have limited accuracy due to the accepted assumptions and limitations. Therefore, the estimated estimates of dependability indicators should be adjusted according to the results of tests and controlled operation.

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ACTUAL ISSUES OF THE TASK OF DEVELOPING UNMANNED VEHICLES

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Abstract—this article describes the main tasks faced by the developers of the unmanned vehicle control system. Analyzed the problem of solving tasks. The existing solutions and possible options for the consequences of these problems are given.

Keywords— unmanned control technology; unmanned vehicle; 5G; V2X; high precision cards; machine vision; cybersecurity of autonomous vehicles; artificial intelligence.

INTRODUCTION

For the mass introduction of unmanned control technology, it is necessary to deal with a number of technological and legal issues. Now, the transport industry cannot solve a number of important challenges related to unmanned vehicles.

5G DATA TRANSFER TECHNOLOGY (IMT-2020)

One of the key tasks facing developers is to ensure high-speed uninterrupted network connectivity. The solution to this issue already exists - the creation of a network of the fifth generation (5G).

The network will allow the exchange of information between road users and receive information from the surrounding infrastructure at high speeds. When using unmanned technology, the slightest delay in data transmission is considered critical. Also, 5G will have lower latency and the ability to connect more devices (sensors and smart devices) at the same time.

In early 2017, the International Telecommunication Union (ITU) published the first draft specification, which described the 5G standard. At the end of 2017, the first official 5G standard was created.

In Russia, in March 2018, the first tests were performed in Skolkovo. Skolkovo representatives predict the emergence of the first non-commercial 5G network by 2020. The speed record in the experimental environment belongs to Megafon, which in June achieved a data transfer rate of 35 Gbit/s. Tests were conducted on Huawei equipment.

VEHICLE-TO-EVERYTHING (V2X) TECHNOLOGY

The V2X system allows the vehicle to exchange information with surrounding objects. This technology provides for the transmission to the vehicle via wireless communication lines of warnings about changes in road conditions and approaching vehicles before it appears in the driver’s field of vision. For effective interaction, the surrounding infrastructure must fit and be smart.

The next step in the development of this technology is the use of cellular communication. Such systems form a new complex called Cellular-V2X [1].

In April 2018, on the Bavarian highway A9, such a system was successfully tested with using 5G wireless communication. Two vehicles were able to exchange data at a speed of 120 km / h. This experience formed the basis for the creation of autonomous cruise control (ACC - Autonomous Cruise Control) - a system that guards the speed of the vehicle, warns of possible emergencies and keeps a certain set distance from the vehicle ahead.