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SIBCON

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Welcome
message from the Technical Chairs

Dear Colleagues,

On behalf of members of the Scientific and Technical Program Committees, Omsk State Technical University it is an honor and pleasure to invite you to participate in the 2015 International Siberian Conference on Control and Communications. We believe the SIBCON is so special for Siberia among these premier-class international conferences, because it is biannually providing opportunities for exchanging information and ideas in control and communications.

This year the Conference has new venue – Omsk. We welcome all of you to Omsk and to Siberia. Omsk was the capital of Siberia for some years and it is proud of its traditional art and cultural heritage. It has some of the *most* interesting cultural sites in Siberia. We are sure you will enjoy visiting in Omsk as well as attending the Conference.

Tomsk IEEE Joint Chapter, been established in 2000, has proposed SIBCON conference with the support of the IEEE Electron Devices Society to address interconnect issues from both fundamental materials viewpoints as well as system-level perspectives.

This SIBCON we received a record number of 672 paper submissions among which 508 papers will be presented in oral form in 11 sessions. This year's program is the culmination of a rigorous selection procedure: the acceptance ratio is 32 %. Thus we believe the quality of the papers is high. At the first time, technical Program Committee consists of a balanced mix of both of industry and academia, and as a result, the technical program should interest both industry and academia.

Along with the exciting conventional conference programs, we have prepared the great quality plenary talks, panel discussions, tutorials, normal technical papers, student design contest, an event called an industry program. It is our firm belief that SIBCON will play an important role in establishing a milestone and a new direction in our effort to push forth the design industry. More than 15% of the submissions came from the industry, which indicates their interest in the conference. The unique industry program prepared by National Instruments R&D is intended to have attendees share an industry trend and information on cutting-edge product chips. The presentations in the program will include demos of the actual products. So, the motto of our Conference is "Renaissance of academy and industry during dark day season". Some of the sessions will include tutorials and invited papers on topics of current interest to our audience.

The selected papers are organized in three parallel tracks of Sessions made of 15 papers grouped around the traditional topics of SIBCON, namely: The Fundamental Problems of Communication and Control Theory; Radiophysics; Radar, Microwaves, and Antennas; Control of the Large-Scale Systems; Control of the Electro-Mechanical Systems; Nanotechnology; Semiconductor Materials, Sensors, and Electron Devices; National Instruments for Education, Science, and Industry. There are 3 invited speakers who will deliver plenary talks. In addition to these plenary invited papers, there are 3 additional invited speakers who are part of the SIBCON program and who will address NI and AWR seminars, and seminar on the joint grant programs with USA and Canada. The conference program is completed with a post-conference day including several sessions and social program. To complement the formal talks, we have arranged evening rump sessions on interesting and provocative subjects to give you an opportunity to participate in the discussions with international participants.

The excellent program owes very much to the outstanding efforts of the Technical Program Committees, under the excellent leadership of the General Chairman, Prof. Anatoly V. Kosykh, and Chair of Steering Committee, Olga I. Babenko. The Committees, Tomsk-Krasnoyarsk participants, reviewers, constituted of leaders in the topics of interests, have achieved outstanding work to solicit strong papers, and to select and organize the attractive technical sessions. We especially thank the members of our Technical Program Committee for their diligent efforts, the authors of the technical papers for their high-quality submissions. We would like to express our deep appreciation to all the contributors who help make this Conference successful and keep the event up to a premier international standard. We hope you will fully enjoy this international Conference particularly and the friendships among top experts, and hope you keep Proceedings in your library, which may be of use for you and your colleagues on future researches. The official website of SIBCON has been operational since the year of 2000. You may visit this site to obtain more information including the event.

Finally, we hope that this meeting provides a stepping stone for the universal realization of high level knowledge society which is contributing to a better life for people, and an opportunity for all of us to cooperate as a friend to achieve that goal.

Next year, the Conference will be held in Moscow, together with the National Instruments Days. We hope you will attend.

Oleg V. Stukach
Tomsk Polytechnic University

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Siberian Federal University

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Method the Estimated Life of Electronic Devices for Control and Communication Systems*

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Abstract **- The report covers the method of the estimated life of electronic devices of control and communication systems at the stage of their development. Mathematical model of life control and communication systems and electronic devices are provided. It is shown that the value of the life of control and communication systems significantly depends on the coefficient of variation of life of electronic devices.**

Keywords - Control and Communication Systems, Electronic Devices, Dependability, Durability, Life, Mathematical Model

I. INTRODUCTION

To modern control and communication systems responsible destination high demands on dependability. One of the important indicators of the dependability of such systems is the indicators of durability. However, if the provision of indicators of reliability of such systems can be achieved by introducing redundancy (reserve), then their performance durability (life) is directly determined by the characteristics of durability of components of electronic devices. Used in the present methods of calculating durability is based on the use of information about the life of electronic devices in the maximum allowable modes, which leads to significant errors. Therefore, to improve the accuracy of the calculation life of electronic devices it is necessary to consider their real modes in control and communication systems.

II. METHOD THE ESTIMATED LIFE OF ELECTRONIC DEVICES FOR CONTROL AND COMMUNICATION SYSTEMS

Calculation of the durability of the control and communication systems (is carried out according to the methodology provided in OST 4.012.013 [1]. For example, when the failure criterion is formulated as "the Deterioration of the functioning of the control and communication systems is not more than 0%", the value of the indicator durability (T_{CMS}) is defined as:

$$T_{CMS} = \min_{i=1,I} \{T_{CP1}, T_{CP2}, ..., T_{CPI}\}, \quad (1)$$

where:

T_{CPi} is life of the i-th component parts;

I is total number of parts in the control and communication systems.

Initial information for calculation of indicators of the durability of component parts are the data on the durability of electronic devices that are listed in the Data Sheet and is listed in the Handbook "Dependability ERP" [2].

The Handbook "Dependability ERP" [2] provides standardized in the Data Sheet gamma-percent life (T_γ) electronic devices.

If T_γ electronic devices outlined in the Handbook "Dependability ERP" [2] for values of γ other than that for which is calculated control and communication systems, gamma-percent life electronic devices to the write-off for the required values of γ is determined by the formula OST 4.012.013 [1]:

$$T_{\gamma_1} = \frac{(1-0,15\cdot\chi_1)}{(1-0,15\cdot\chi_2)} \cdot T_{\gamma_2}, \quad (2)$$

where:

χ_1 is quantile of the normal distribution for the probability γ_1;

χ_2 is quantile of the normal distribution for the probability γ_2;

$T\gamma_2$ is gamma-percent life of electronic devices.

The values of χ_1 and χ_2 are determined by the normalized function Laplace:

$$\Phi(\chi) = \frac{1}{\sqrt{2\cdot\pi}} \cdot \int_{-\infty}^{\chi} e^{-\frac{z^2}{2}} dz. \quad (3)$$

The graph of the function $\Phi(\chi)$ is shown in Fig. 1.

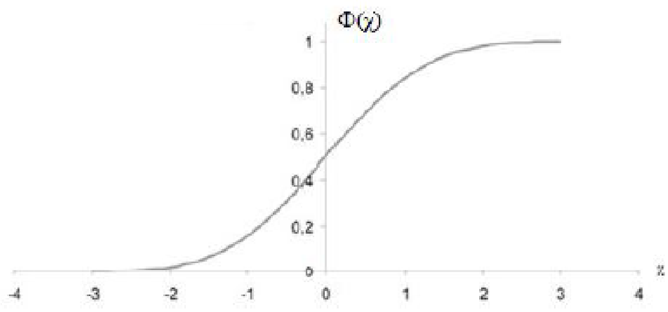

Fig. 1. Graph of the function $\Phi(\chi)$

Values for χ used in practice values of γ are given in table. 1.

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TABLE I. THE QUANTILES OF THE NORMAL DISTRIBUTION

№	γ, %	Φ	χ
1	2	3	4
1	90.0	0.900	1.282
2	95.0	0.950	1.645
3	97.5	0.975	1.960
4	98.0	0.980	2.054
5	99.9	0.999	3.090

As follows from (2), (3) life electronic devices is a random value (t_l) with a normal distribution:

$$f(t_l)=\frac{1}{\nu\cdot m(t_l)\cdot\sqrt{2\cdot\pi}}\cdot\exp\left\{-\frac{\left[t_l-m(t_l)\right]^2}{2\cdot\left[\nu\cdot m(t_l)\right]^2}\right\}. \quad (4)$$

where:

ν is coefficient variation of the life electronic devices;

$m(t_l)$ - mathematical expectation of the life electronic devices;

t_l is life.

The graph of the probability density of the normal distribution shown in Fig. 2.

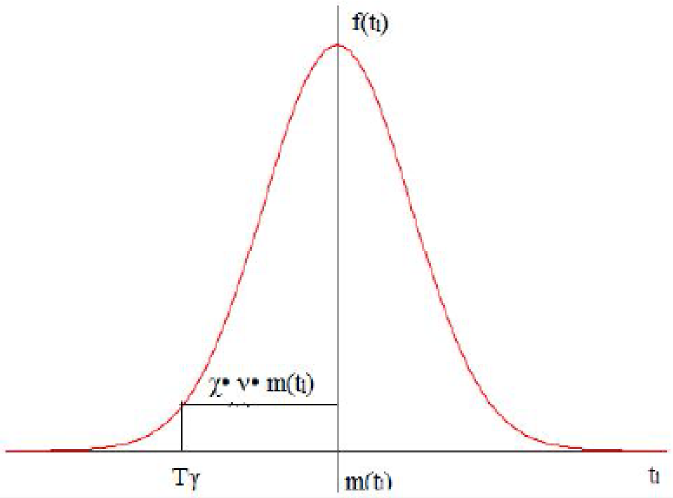

Fig. 2. The probability density of the normal distribution

As follows from Fig. 2, the mean life electronic devices (T_m) equal to:

$$T_m=m(t_l)=\frac{T_\gamma}{1-\nu\cdot\chi_\gamma}. \quad (5)$$

As follows from (2), the value of ν in the OST 4.012.013 [1] is assumed to be equal to 0.15 for all types electronic devices:

$$\nu=\frac{1}{N}\cdot\sum_{n=1}^{N}\nu_n=0{,}15, \quad (6)$$

where:

N is total number of electronic devices in the control and communication system;

ν_n is coefficient variation of the life electronic devices.

However, the results of studies of various types electronic devices show that the values of ν can be changed in the range 0,1÷0,25. In table. 2 presents the results of the calculation of T_m for different γ and ν when $T_\gamma = 1$.

TABLE II. THE RESULTS OF THE CALCULATION T_M

№	γ, %	T_m			$T_m(\nu_3)/T_m(\nu_1)$
		ν_1=0,1	ν_2=0,15	ν_3=0,25	
1	2	3	4	5	6
1	90.0	1.147	1.240	1.472	1.28
2	95.0	1.197	1.328	1.669	1.42
3	97.5	1.244	1.416	1.960	1.58

As follows from the table. 2, (see column 6) mean life electronic devices can change more than 1.5 fold.

The value of coefficient variation can be clarified, if we use the value of the minimum operating time electronic devices, which are listed in the Handbook “Dependability ERP“ [2]. In accordance with OST 4.012.013 [1] minimum operating time (T_{mot}) is numerically equal to gamma-percent life electronic devices for γ = 99.9%. Then, allow (2) with respect to ν we obtain:

$$\nu_n=\frac{T_{\gamma_n}-T_{mot_n}}{\chi_{\gamma=99.9}\cdot T_{\gamma_n}-\chi_{\gamma_n}\cdot T_{mot_n}}. \quad (7)$$

In table 3, as an example, the results of calculations of ν and T_m for some types of resistors.

TABLE III. THE RESULTS OF the CALCULATION ν AND T_M

№	Type	Source data			Result	
		T_γ, thousand hours	γ, %	T_{mot}, thousand hours	ν	T_m, thousand hours
1	2	3	4	5	6	7
1	R1-1	50	95	25	0.22	78.46
2	R1-12	40	95	25	0.18	57.08
3	S2-29V	60	95	25	0.24	99.84

In table 3 the values T_m obtained for the maximum permissible operating modes electronic devices and time schedule continuous operation. For lightweight mode electronic devices in the OST 4.012.013 [1] gives the following formula:

$$T_\gamma=\frac{T_{\gamma bs}}{K_{IO}\cdot K_L}, \quad (8)$$

where:

$T_{\gamma DS}$ is gamma-percent life electronic devices on Data Sheet;

K_{IO} is factor of the operating modes intensity;

K_L is load factor.

The value of K_{IO} in (8) is determined by the formula:

$$K_{IO} = \frac{t_{om}}{t_{om} + t_{nm}}, \qquad (9)$$

where:

t_{om} is time of operating mode electronic devices;

t_{nm} is time of nonoperating mode electronic devices.

The value of K_L in (8) is determined by the formula:

$$K_L = \frac{R_{om}}{R_{DS}}, \qquad (10)$$

where:

R_{om} is load of the electronic device in operating modes;

R_{DS} is maximum load of the electronic device on Data Sheet (the critical parameter).

Figure 3 shows the dependence of T_γ from K_{IO} and K_L.

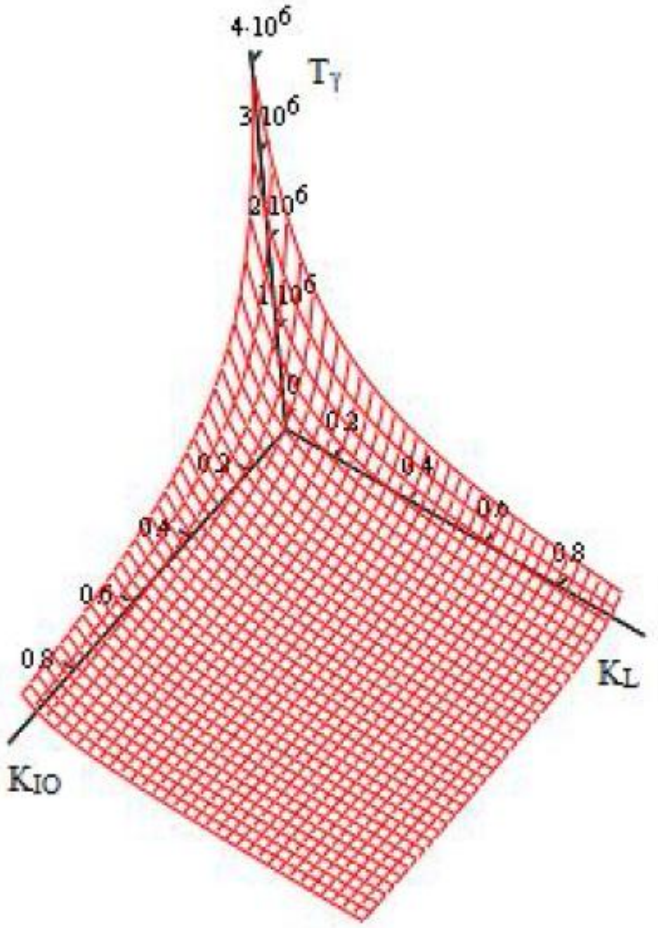

Fig. 3. Dependence of T_γ from factors K_{IO} and K_L

As follows from (9) the value of T_γ does not take into account expending life in the nonoperating mode. Moreover, the coefficient K_L depends only on one (critical) parameter, while the electronic devices of such parameters may be several.

In [3], it is shown that the value of the life in proportion to the value of the failure rate electronic devices:

$$\frac{T_\gamma}{T_{\gamma_{DS}}} \sim \frac{\lambda_{S_{DS}}}{\lambda_{S_{om}}} \Rightarrow T_\gamma \sim \frac{\lambda_{S_{DS}}}{\lambda_{S_{om}}} \cdot T_{\gamma_{DS}}, \qquad (11)$$

where:

$\lambda_{S_{DS}}$ is failure rate electronic device in session mode (Data Sheet);

$\lambda_{S_{om}}$ is failure rate electronic device in session mode (operating mode).

The failure rate electronic devices in session mode is calculated according to the formula:

$$\lambda_S = K_{IO} \cdot \lambda_{om} + (1 - K_{IO}) \cdot \lambda_{nm}, \qquad (12)$$

where:

λ_{om} is failure rate electronic device in operating mode;

λ_{nm} is failure rate electronic device in nonoperating mode.

Then:

$$\frac{1}{T_{\gamma_S}} = K_{IO} \cdot \frac{1}{T_{\gamma_{om}}} + (1 - K_{IO}) \cdot \frac{1}{T_{\gamma_{nm}}}, \qquad (13)$$

where:

$T\gamma_{om}$ is life electronic device in operating modes;

$T\gamma_{nm}$ is life electronic device in nonoperating modes.

The value of $T\gamma_{om}$ will be found in the assumption that when the minimum values of the factor s in the model failure rate:

$$T_\gamma\left(\overline{K_{min}}\right) \approx T_{\gamma_{DS_{nm}}}, \qquad (14)$$

where:

$T\gamma_{DSnm}$ is life electronic device in nonoperating mode (Data Sheet).

The value of $T\gamma_{om}$ will be found in the assumption that when the minimum values of the factors in the model failure rate:

$$T_{\gamma_{om}} = \frac{T_{\gamma_{DS_{nm}}} \cdot \left[\Pi(DS) - \Pi(min)\right]}{\left[\Pi(DS) - \Pi(min)\right] + \left(\frac{T_{\gamma_{DS_{nm}}}}{T_{\gamma_{DS}}} - 1\right) \cdot \left[\Pi(om) - \Pi(min)\right]}, \qquad (15)$$

where:

$\Pi(DS)$, $\Pi(om)$, $\Pi(min)$ are multiplying factors.

$$\Pi = \prod_{i=1}^{I} K_i, \qquad (16)$$

where:

K_i is factors of the mode;

I is total number of factors;

The value of $T\gamma_{nm}$ we find, using (11):

$$T_{\gamma_{nm}} = \frac{K_{R_{om}}}{K_{R_{nm}} \cdot K_{R_{min}}} \cdot T_{\gamma_{om}}, \qquad (17)$$

where:

K_{Rom} is factor of load in the operating mode;

K_{Rnm} is factor of load in the nonoperating mode;

K_{Rmin} is factor of minimum load.

Consider the calculation of resource resistors type R1-12 on the model (8) and (16) for the following conditions apply:

- Group equipment is 1.3
- The ratio of the electric load is 0.4
- Operating temperature is 40 ^{0}C
- Factor of the operating modes intensity is 0,5

Permanent leadless resistors of general application, R1-12, (see figure 4) designed for use in electrical circuits of DC and AC currents and pulse mode, the surface mount circuit boards and hybrid circuits.

Fig. 4. Resistors type R1-12

Characteristics of the resistor shown in ShKAB.434110.002 TU [4], are summarized in table 4.

TABLE IV. CHARACTERISTICS OF THE RESISTOR R1-12

№	Characteristic	Value	Units
1	2	3	4
1	Nominal power dissipation	0,25	W
2	95-percent life	40000	hours
3	Minimum operating time	25000	hours
4	Minimum storage (nonoperating) time	25	years
5	Increased ambient temperature at nominal power dissipation	70	^{0}C

Find the value of the resource by the method of OST 4.012.013 [1].

95-percent life in operating mode:

$$T_{\gamma_{om}} = 40000/0,4 = 100000.$$

95-percent life:

$$T_{\gamma} = \frac{40000}{0,4 \cdot 0,5} = 200000.$$

Mean life:

$$T_m == \frac{200000}{1 - 0,15 \cdot 1,645} = 265516.$$

Minimum operating time:

$$T_{mot} = \frac{25000}{0,5 \cdot 0,4} = 125000.$$

Find the value of the life by the proposed method.

Coefficient variation:

$$v = \frac{40000 - 25000}{3,09 \cdot 40000 - 1,645 \cdot 25000} = 0,18.$$

95-percent storage (nonoperating) time:

$$T_{\gamma_{ns_{nm}}} = \frac{(1\text{-}0,18 \cdot 1,645)}{(1\text{-}0,18 \cdot 3,09)} \cdot 25 \cdot 8760 = 347350.$$

The values of the factors of the model failure rate resistor R1-12 identified in the tables of Handbook “Dependability ERP“ [2] and are shown in table 5.

TABLE V. CHARACTERISTICS OF THE RESISTOR R1-12

№	Mode	Factors	
		K_R	K_E
1	2	3	4
1	Operating mode	0.57	5.0
2	Nonoperating mode	1.09	5.0
3	Mode of Data Sheet (maximum)	1,71	10.0
4	Minimum values	0.35	1.0

95-percent life in operating mode:

$$T_{\gamma_{om}} = \frac{347350 \cdot (17{,}1\text{-}0{,}35)}{(17{,}1\text{-}0{,}35) + \left(\frac{347350}{40000} - 1\right) \cdot (2{,}85\text{-}0{,}35)} = 159382 \cdot$$

Figure 5 shows the dependence of $T\gamma_{om}$ from K_R and K_E.

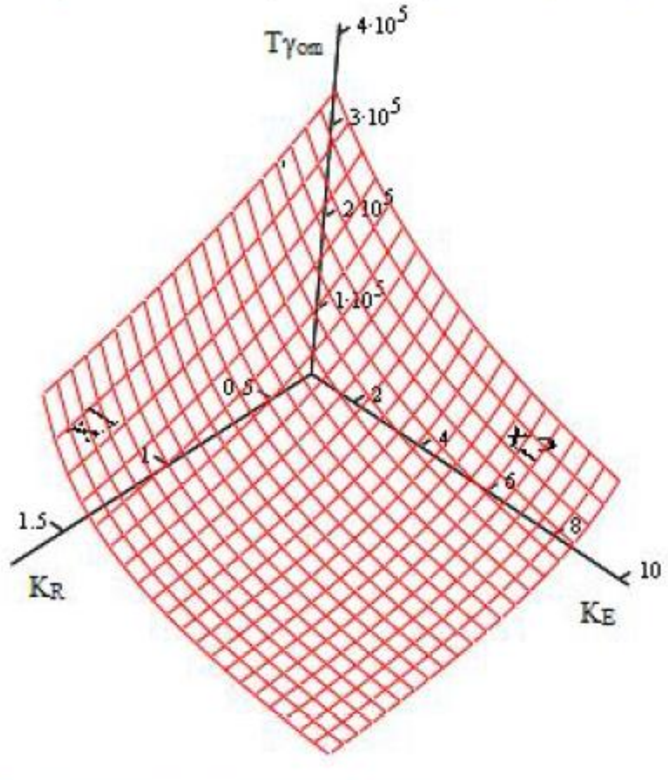

Fig. 5. Dependence of $T\gamma_{om}$ from factors K_R and K_E

95-percent life in nonoperating mode:

$$T_{\gamma_{oo}} = \frac{159382 \cdot 0{,}57}{1{,}09 \cdot 0.35} = 238133 \cdot$$

95-percent life:

$$T_{\gamma} = \frac{159382 \cdot 238133}{0{,}5 \cdot 159382 \cdot +0{,}5 \cdot 238133} = 190956 \cdot$$

Mean life:

$$T_m = \frac{190956}{1 - 0{,}18 \cdot 1{,}645} = 271282 \cdot$$

Minimum operating time:

$$T_{mot} = (1\text{-}0{,}18 \cdot 3{,}09) \cdot 271282 = 120394$$

Table 6 shows the values of the durability of the resistor and the accuracy of their estimates calculated by the formula:

$$\delta = \frac{T_{OST} \text{-} T_{PM}}{T_{PM}} \cdot 100 \cdot$$

where:

T_{OST} is value of the durability by method OST 4.012.013 [1];

T_{PM} is value of the durability by proposed method.

TABLE VI. CHARACTERISTICS OF THE RESISTOR R1-12

№	Characteristic	Method		δ, %
		OST	Proposed method	
1	2	3	4	5
1	ν	0.15	0.18	-16.7
2	$T\gamma_{om}$	100000	159382	-37.3
3	T_γ	200000	190956	4.7
4	T_m	265516	271282	-2.1
5	T_{mot}	125000	120394	3.8

As can be seen from table 6, the estimate error of the resource in the mode of application of more than 35%. From this we can conclude that the use of load factor (K_L) leads to a significant underestimation of the value of the life.

Therefore, in the calculations according to the method of the OST 4.012.013 [1] instead of load factor, use mode factor (K_R). In this case the error will be:

$$\delta = \frac{40000 \cdot {}^{0{,}57}\!/_{1{,}71} \text{-} 159382}{159382} \cdot 100 = -24{,}7 \cdot$$

III. CONCLUSION

The method evaluate the durability of the control and communication systems allows to take into account not only the load elements and the intensity of their exploitation, but also the modes and conditions of use. Software implementation of the method will be a new system for program complex ASONIKA-K [4, 5]. As for performance assessment of lifetime, these issues are considered in [6].

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