Method for assessing the diagnosis of the technical condition of an integrated microprocessor pulse generator of railway automation and telemechanics

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Abstract. The article discusses the question why we need an integrated microprocessor pulse generator and deals with the issue of determining the diagnosis of the technical condition of an integrated microprocessor pulse generator for automation and telemechanics systems in railway transport. The theoretical models of the operational failure rate for implementing a microelectronic unit are given in particular detail. All calculations that are given in the article for railway automation telemechanics’s code track transmitter plug mode.

During the period of active introduction of microcontrollers, the urgent task is to determine the assessment of the diagnosis of the technical condition of these devices. Furthermore, there is a tendency, using microprocessors in most devices insufficiently effective application functions of the microprocessor. For example, in railway automation at this moment, several types of code generators (transmitters) are used, which differ in both the design and the methods of generating pulses. There are developments of microelectronic analogues of these devices, [1] while the problem of diagnosing them, i.e. about the determination of their technical state. [2] At This article discusses the issue of determining the diagnosis of the technical condition of an integrated microprocessor pulse generator (IMPG), concentrated in the functions of these transmitters as the MT1, MT2, and KPTSH5, KPTSH7. [3] It is reasonable to assume that for this it is necessary to know the operational failure rate (OFR) of the proposed device [4].

The mathematical model for determining the OFR is given in [4]. Object of research are theoretical models OFR means of implementation of the microelectronic unit, namely, microcontrollers, optical relays, resistors, connecting elements and a printed circuit board.

At the work E.K. Ametova was determined base failure rate (BFR) microelectronic block management paired arrows railway automatic, based on this for the integrated microprocessor pulse generator (IMPG) can be assumed that

$$\lambda_{b.f.m.p.g} = \lambda_{b.mk} + \lambda_{b.opt} + \lambda_{b.res} + \lambda_{b.board} + \lambda_{b.coup}.$$ (1)

while the
\(\lambda_{b.f.m.p.g}\) - BFR microprocessor pulse generator;
\(\lambda_{b.mk}\) - BFR microcontrollers;
\(\lambda_{b.res}\) - BFR resistors;
\(\lambda_{b.opt}\) - BFR optocouplers.
\[ \lambda_{e.board} - \text{BFR board;} \]
\[ \lambda_{e.coup} - \text{BFR coupling.} \]

The hardware implementation of the (IMPG) involves the use of the same type of microprocessor, as in the microelectronic control unit for paired arrows, therefore, the calculation of the BFR value of the microcontroller is \( \lambda_{b.mk}=0,2310^6 \), 1/h, and the operational failure rate of the microcontroller is \( \lambda_{e.mk}=0,23210^6 \), 1/h [5], while the main contribution to the quantitative indicator of OFR, in this case, determined parameter failure rate board, which at least on three orders of magnitude higher than those of other components of the formula (1). Therefore, to determine the EIO of an IMPG device, it is enough to determine this parameter for a variable, which is calculated by the formula

\[ \lambda_{e.board} = \lambda_{e.board} \times \left[ N_1 \times \lambda_{e.board} + N_2 \times (K_{e.board} + 13) \right] \]

At the same time \( \lambda_{b.e} = \text{BIO depending on the technology of the coupling.} \) According to [2] for printed wiring it is assumed equal to 0,0017 \( 10^6 \), 1 / h. or 0,17 \( 10^6 \)
\[ \text{K}_{e.board} - \text{stringency conditions application fee is assumed to be fired one;} \]
\[ \text{N}_1 - \text{the number of through holes soldered by the wave, in this case taken equal to 0;} \]
\[ \text{N}_2 - \text{the number of through holes soldered by manual soldering is taken equal to 120;} \]
\[ \text{K}_{e.board} - \text{factor depending on the number of layers in the plate, when the number of layers equal nym 2, taken = 1 [9,10].} \]

Substituting the obtained values, we obtain the EIO of multilayer boards with metallized through holes during operation

\[ \lambda_{e.board}=285,6 \times 10^6, 1/h \]

Consequently, the EIO of the IMFI device is \( 285,6 \times 10^6 1 / h. \)

To determine the diagnosis of the technical condition of IMPG, we use the Bayes method [6] [7]. As a diagnostic parameter, we choose the time of the first pulse in the formation of the most complex code "3", which has three pulses and three intervals. Then the total probability of the event is determined by the formula

\[ P(D_i / k) = \sum_{i=1}^{n} \frac{P(D_i)P(k_i / D_i)}{P(D_i)P(k_i / D_i)} , \tag{2} \]

where \( k_i - \text{sign of the presence of deviations from the permissible values of the pulse time or interval;} \)
\( D_i - \text{the state of the object when defects occur;} \)
\( D_s - \text{state s - the number of objects in the event of defects , \( \cdot \) in this case is equal to 6, as available three-pulses and three intervals;} \)
\( P(D_i) - \text{a priori probability of diagnosis s - the number of objects;} \)
\( P(D_s) - \text{a priori probability of diagnosis of the i - th object;} \)
\( P(k_i / D_i) - \text{the probability of the appearance of signs \( k_i \) in the system in a state \( D_i \);} \)
\( P(k_i / D_s) - \text{probability of occurrence of symptoms \( k_i \) in the system , in a state \( D_s \).} \)

In order to use the formula (1) will make a number of assumptions, namely that due to the operation IMPG device at the exit of limits pulses or intervals of time, if \( k_j \) the device fails in \( n\% \) events. Let us determine the probability of a working state of IMPG in \( t \) hours, this amount of time is determined by the calculated failure rate of the device. In this state \( D_1 \) - soot vets exists good condition device, and \( D_2 \) - a fault condition. To determine the probability of working devices make
use of state m camping known formula \( P(D_i) = e^{-\lambda t} \), Substituting the value \( \lambda_{c,board}=285.6 \times 10^6, \text{1/h} \) we obtain \( P(D_i) = e^{-2.86 \times 10^{-2}} \times n \times 10^{-2} \), based on the theorem of total event \( P(D_i) + P(D_j) = 1 \), \( P(k_i / D_i) + P(k_j / D_j) = 1 \), determine the value \( P(D_j) = 1 - n \times 10^{-2} \), \( P(k_i / D_2) = 1 - n \times 10^{-2} \), and substituting the obtained values into the formula (1), we obtain

\[
P(D_i / k_j) = \frac{e^{-2.86 \times 10^{-4} \times n \times 10^{-2}}}{e^{-2.86 \times 10^{-4} \times n \times 10^{-2}} + (1 - e^{-2.86 \times 10^{-4} \times s \times n \times 10^{-2}}) \times (1 - n \times 10^{-2})}.
\]

If there are statistical results regarding the device's operability and the specified time interval, according to this formula, you can determine the probability of the device's operability when a sign appears that determines the deviation of the time parameters of the first pulse of the code of the code path transmitter. [8] If necessary, determine the probability of appearance of signs \( k_j \) of other pulses of the entire device KPTSH5, should use the Bay’s general formula:

\[
P(D_i / K^*) = \frac{P(D_i)P(K^* / D_i)}{\sum_{j=1}^{n} P(D_j)P(K^* / D_j)},
\]

where \( K^* \) - the number of signs of going beyond the permissible values of the studied parameters \( K \);

\( n \) – total number of parameters considered.

Since the codes of the code path transmitter are taken as an example, we will determine the value \( n \) using the formula:

\[
n = n_{z,z} + n_{z,t} + n_{j,j} + n_{k,k} + n_{k,z},
\]

where \( n_{z,z} \) - pulses in the code is the number "Z", is 3;

\( n_{z,t} \) - the number of intervals in the code "Z" is 3;

\( n_{j,j} \) - the number of pulses in the code "J" is 2;

\( n_{k,k} \) - the number of intervals code a "J" is 2.

\( n_{k,z} \) - the number of pulses code a “KJ” is 1;

\( n_{k,z} \) - the number of intervals of the code "KJ" is equal to 1.

Therefore, in this case \( n = 12 \).

From this can be determined and be the number of feature vector Bay using the formula:

\[
K = k_{i,z,1} + k_{i,z,2} + k_{i,z,3} + k_{i,z,4} + k_{i,z,5} + k_{i,j,1} + k_{i,j,2} + k_{j,j,1} + k_{j,j,2} + k_{k,k} + k_{k,z},
\]

where \( k_{i,z,1} + k_{i,z,2} + k_{i,z,3} \) - signs of deviation from the set time parameters of the pulses of the code "Z";

\( k_{i,z,4} + k_{i,z,5} + k_{i,z,3} \) - signs of time deviation of the inter-pulse intervals of the code "Z";

\( k_{i,j,1} + k_{i,j,2} \) - signs of deviation from the set time of the 1st and 2nd pulses of the code "J";

\( k_{j,j,1} + k_{j,j,2} \) - signs of deviation from the permissible value of the diagnosed inter-pulse intervals of the code "J";

\( k_{k,k} \) - a sign of deviation of the pulse duration of the code "KJ";

\( k_{k,z} \) - a sign of deviation of the "KJ" code interval is rejected.

Similarly, you can determine the probability of technical diagnostics of other IMPG operating modes, such as KPTSH7, MT1 and MT2.

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