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Reliability of microprocessor control modules of AC and DC electric switch drive

Boltaev Sunnatillo Tuymurodovich, Rakhmonov Bobomurod Bakhtiyorovich, Kurbonov Janibek Fayzullayevich, Kosimova Qamara Amonovna, Ergashov Bekhruz Golibugli

Candidate of Technical Sciences, Associate Professor, Tashkent state transport university Department of “Automation and Telemechanics” Tashkent, Republic of Uzbekistan
Dept., assistant, Tashkent state transport university Department of automation, telemechanics, Tashkent, Republic of Uzbekistan,
Doctor of Technical Sciences, Associate Professor,Tashkent state transport university Department of “Automation and Telemechanics” Tashkent, Republic of Uzbekistan,
Master's student of MAB-38 group - Department of “Automation and Telemechanics” Tashkent State Transport University, Tashkent, Republic of Uzbekistan,
Master's student of MAB-1 group -Department of “Automation and Telemechanics” Tashkent State Transport University,Tashkent, Republic of Uzbekistan

ABSTRACT: This scientific article is based on the failure rate of microprocessor control modules of PST-MP, PS-MP and PS-PST-MP microprocessor control and alternating current conductors, which are currently being developed in the research laboratory "Alarm Centralization Blocking and Communication" of the Tashkent Institute of Railway Engineers. Also, the fault intensity of the PST-MP, PS-MP, and PS-PST-MP microprocessor-based control module was compared with the reliability of the currently available AC and AC switch relay PST and PS-220M block.

KEY WORDS: electric switch drive, switch, power centering, relay blocks, microprocessor module, level of security, reliability, fault intensity.

I. INTRODUCTION

At present, the reliable operation of automation and telemechanic relay devices and systems in railway transport ensures the safety of trains. However, after the speed of the train exceeds 160 km / h, relay devices and systems will be added to ensure the safety of trains [1]. High-speed train safety is currently achieved through the use of microprocessor-based devices and systems. Taking into acount , a number of microprocessor-based electrical interlocking systems and devices are tested for safety at the tolerable hazard rate (THR) SIL (EN50129, 2003) listed in Table 1 for use on railways around the world.It is worth taking into account the current starting power centralization (EM) and processor power starting centralization (RPEM) systems use a constant current control switch PS-220M (1 and 2 a, c, a picture is starting blocks are in use). The failure rate of PS-220M is $\lambda_{ПС\text{-}220M}=0,4*10^{-6}$ 1/hour [1]. This does not meet the requirements of the SIL4 requirements for devices and systems in railway transport when the probability of operation of the block without failures is compared with the values of Safety integrity level (SIL) in Table 1.

Table 1

THR per hour and per function (h-1)	Safety integrity level SIL
10-9≤THR≤10-8	SIL4
10-8≤THR≤10-7	SIL3
10-7≤THR≤10-6	SIL2
10-6≤THR≤10-5	SIL1

Taking into account the above are designed to manage the switches created a constant current PST-PS, PS-MP and MP-MP PST-developed microprocessor module. The use of PST-MP, PS-MP and PS-PST-MP modules in the control of DC arrows to ensure the safety of trains reduces energy consumption and provides reliable control of switches.

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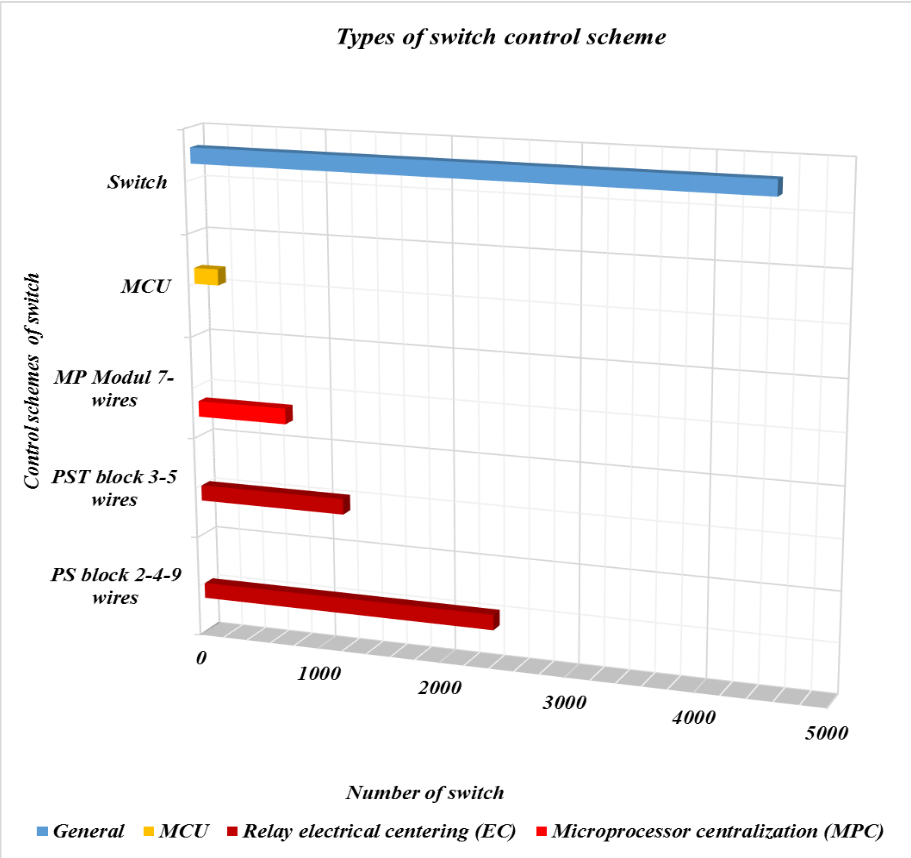

Fig. 1. Number of control circuits of switches in relation to the total number of switches used in JSC "Uzbekistan Railways"

II. PRACTICAL CALCULATION OF RELIABILITY OF PST-MP, PS-MP AND PS-PST-MP MICROPROCESSOR CONTROL MODULE

The main disadvantages of PST and PS-220M relay blocks are the large number of relay control blocks of AC switches used at railway stations, the large space required for relay racks, high power consumption and low reliability. [1, 4, 5].

Reliability calculation in the design of microprocessor devices [2-6, 8] Preliminary determination of the expected reliability at the design stage of the system and the scientific substantiation of the proposed project also solves organizational and technical issues:

- select an alternative to the structure;
- backup methods;
- the number of spare elements.

The program logic of microprocessor devices of railway automation and telemechanics [6-19] consists of two parts - hardware and software:

- The hardware part characterizes the physical reliability of the element and distributes the life cycle over time: regulation (i.e. the phase of reliability decline at the beginning of operation), normal operation and failure (inevitably a decrease in reliability). Unreliable operation of railway automation and telemechanics devices occurs over time or due to improper operation.
- The reliability feature of the software is that the software does not become obsolete and crashes. Reliability is limited by errors in design, maintenance, and implementation. An increase in software reliability is achieved by

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correcting errors in the system over time.

The failure rates of the constituent elements of non-reserved assembly modules are calculated using formula (1) [6, 8, 16, 17].

$$\lambda_{SM} = \sum_{i=0}^{n} \lambda_i * k_{ni} \qquad (1)$$

$$k_{ni} = \prod_{i=0}^{n} k_{pi} * k_{\phi i} * k_{\partial нi} * k_{Ui} * k_{Эi} \qquad (2)$$

The failure rates of the constituent elements of the backup assembly modules are calculated using formula (3) [6, 8, 16, 17] .

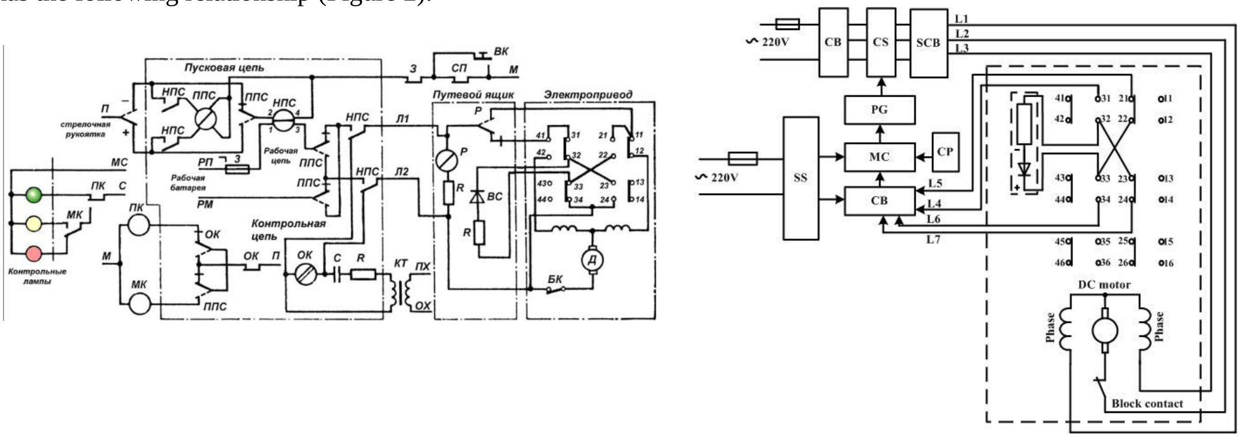
(3) in the formula: λ_i – fault intensity of the element under consideration;
k_p – a coefficient that takes into account the regime depending on the ambient temperature and / or the electrical load of the current;
$k_ф$ – the functional purpose of the element taking into account;
kдн – coefficient taking into account the dependence of power distribution (current) on the load under the technical conditions to the maximum allowable value;
k_U – a coefficient that takes into account the dependence of the magnitude of the operating voltage on the specifications relative to the maximum allowable level;
$k_Э$ – coefficient taking into account the dependence on operating conditions;
PST and PS-220M microprocessor control module calculation of kr coefficient taking into account the mode depending on the ambient temperature and / or current load.

The resistance values of the elements depending on the temperature change depending on the material properties are selected accordingly.

To calculate the fault intensity of the PST and PS-220M microprocessor module controlling the AC switch, the coefficients taking into account the external and internal influences that may affect the module during module operation are introduced. These coefficients affect the failure rate of the PST-MP, PS-MP, and PS-PST-MP modules, taking into account the effects that may occur over a period of time.

$$\lambda_{SM} = \frac{(\lambda_1 * k_{n1}) * (\lambda_2 * k_{n2}) * \ldots * (\lambda_n * k_{n\_n})}{(\lambda_1 * k_{n1}) + (\lambda_2 * k_{n2}) + \ldots + (\lambda_n * k_{n\_n})} \qquad (3)$$

The probability of trouble-free operation of the PST and PS-220M relay block currently used in railway stations and the microprocessor modules PST-MP, PS-MP and PS-PST-MP created by TashTIRE in the exponential distribution law has the following relationship (Figure 2).



a) b)

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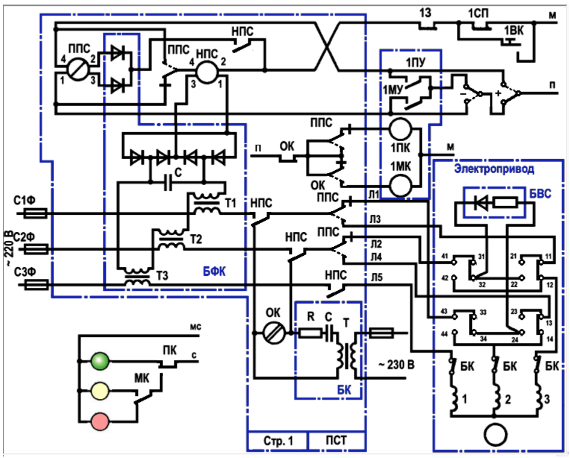
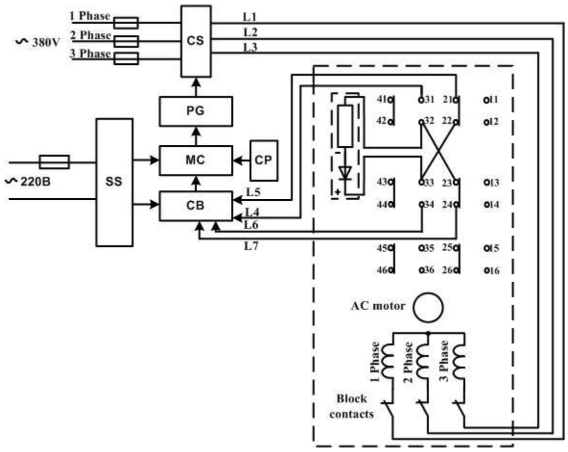
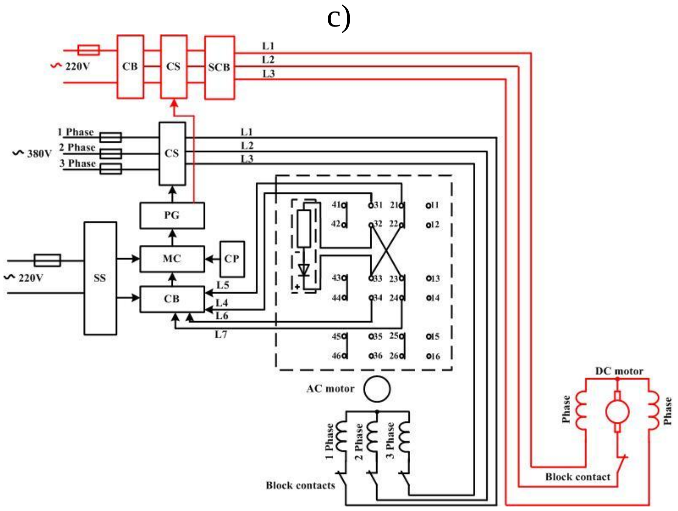


c)



d)



e)

Figure 2 AC and DC current switch control circuits: a - Schematic diagram of the PS-220M block of the AC relay control relay; b - Functional scheme of PS-MP microprocessor module; c - Schematic diagram of the PST block of the AC relay control relay; d - Functional scheme of PST-MP microprocessor module; e – Functional scheme of PS-PST-MP microprocessor module.

The probability of trouble-free operation of the relay block PST and PS-220M is calculated by the exponential distribution law using the following formula (4).

$$P_i = e^{-\lambda_i * t_o} \qquad (4)$$

Here: λ_i –AC DC arrow control accordingly PST and PS-220M relay block fault intensity; t_0 – intermediate time;

Fault intensityλ_i of PST and PS-220M relay block is specified in the block passport.

To calculate the probability of trouble-free operation of PST-MP, PS-MP and PS-PST-MP microprocessor control modules according to the exponential distribution law, we calculate the fault rates of PST-MP, PS-MP and PS-PST-MP using formula (6).

$$\lambda_{i\_MP} = \frac{\lambda_1 * \lambda_2}{\lambda_1 + \lambda_2} \qquad (6)$$

Here is: λ_1 –Fault intensity of the logic circuit of PST-MP, PS-MP and PS-PST-MP microprocessor control module; λ_2 –the intensity faultof Schematic of the software logic of the microprocessor control modules PST-MP, PS-MP and PS-PST-MP;

The probability of trouble-free operation of PST-MP, PS-MP and PS-PST-MP microprocessor modules is calculated using the following formula (5).

$$P_{i\_MP} = e^{-\lambda_{i\_MP} * t_o} \qquad (5)$$

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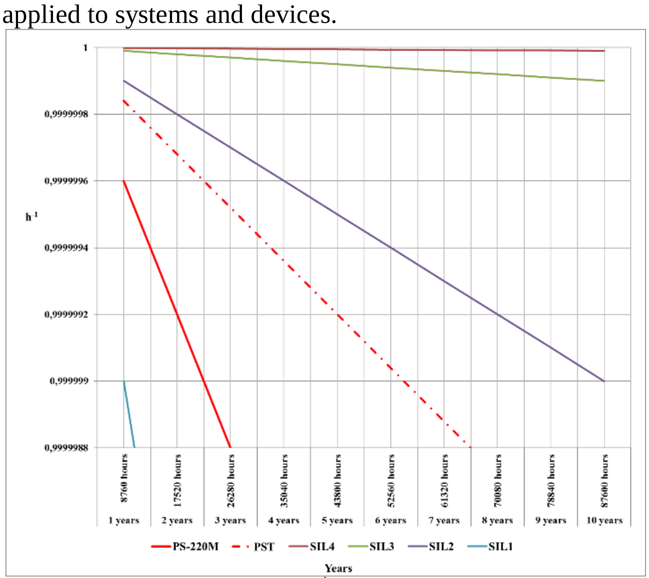
Here is: λ_{i_MP} – Fault intensity of PST-MP, PS-MP and PS-PST-MP microprocessor control modules of alternating and constant current switches; t_0 – intermediate time.

III. CONCLUSION

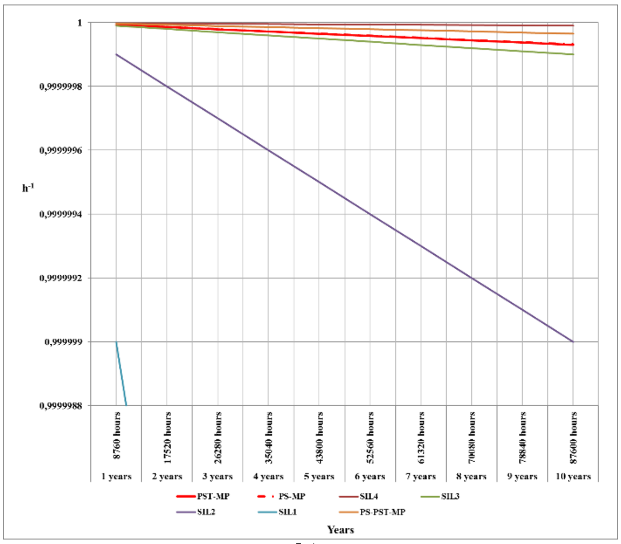
In conclusion, the PS-MP, PST-MP and PS-PST microprocessor modules can be used in existing relay power centering systems without any additional relay interfaces instead of PS and PST relay blocks. If PS-MP and PST-MP modules are used in relay electrical interlocking systems, the fact that these modules can be easily connected to the new system, even when these systems are later redesigned into microprocessor systems, is the basis for their widespread use.

The creation of microprocessor control modules for AC and AC conductors has led to a reduction in operating costs and a reduction in the time required by service personnel to detect and eliminate possible faults in the switches.

Calculations show that (3) DC switches and a constant current control block and the modules failure intensity SIL1, SIL2, SIL3 and SIL4 level compared tograph the likelihood of crashing Figure 3, c graphics are automatics and robot perform the criteria requirements or meet the need. In other words, we can see from the comparison graphs that the fault intensity of PS-MP, PST-MP and PS-PST is close to the probability of trouble-free operation of the SIL4 level applied to systems and devices.



a)



b)

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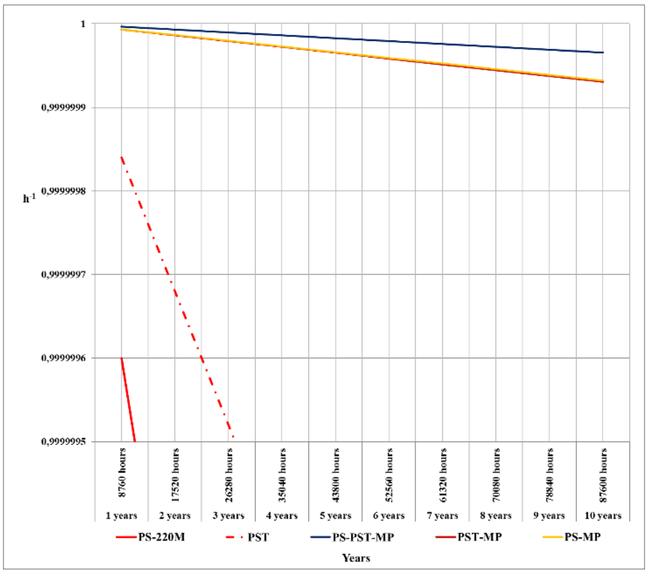

c)

Figure 3 Comparison of fault rates of AC and DC switch control units fault rates SIL1, SIL2, SIL3 and SIL4 failure probability graphs: a) With PST, PS-220M relay blocks; b) **With PST-MP, PS-MP and PS-PST-MP microprocessor modules;** c) **With PST, PS-220M relay blocks and PST-MP, PS-MP and PS-PST-MP microprocessor modules.**

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