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INDICATORS OF RELIABILITY AND PROBABILITY OF OPERATING CONDITION OF SIGNAL SENSORS OF MICROPROCESSOR TELECOMMUNICATION DEVICES

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A B S T R A C T

This article is devoted to the study of the probabilities of the operating state of a monitoring sensor, control of telecommunications and communication devices by electric current and voltage. In practice, it is necessary to calculate the probability indicators of the functioning of the sensor elements involved in the formation of Uev - output voltage based on the I - primary current, magnetic, thermal and other quantities and parameters.

K E Y W O R D S

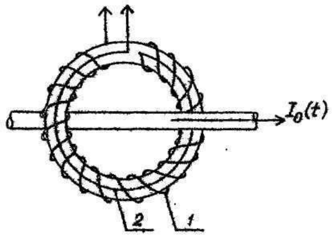
Sensor, signal, control, management,microprocessor, electronic devices, telecommunication, communication, operating state probability.

Introduction

Principles of constructing three-element signal sensors.

One of the possible conversion methods is to receive a signal about the primary current of phase A - IA of the electrical network of a telecommunications and communication device to a secondary voltage and the elements of converting a three-element primary current sensor into a secondary voltage - signal, are presented in Figures 1 and 2 [1-3].

In a three-element sensor, the process of converting the primary electric current to a secondary voltage - a signal based on a classical sensitive element - a secondary winding - is carried out on the basis of a Rogowski coil - a secondary measuring winding located on a magnetic field (Fig. 1) [3].

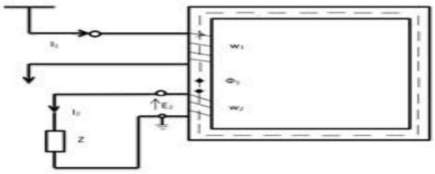


Picture. 1. Rogowski belt:

1 – secondary winding, 2 – rod consisting of identical, connected long solenoids in an arbitrary closed form, 3 - I0(t) – primary conductor.

In this type of electrical network current signal sensor of telecommunications device, one of the outputs of the secondary winding lies on the axis of the magnetic core, and the other end is made in the shape of a solenoid wrapped around the needle. This ensures that the output signal - the secondary voltage - will be proportional to the primary current of the electrical network of the telecommunications device [2,3].

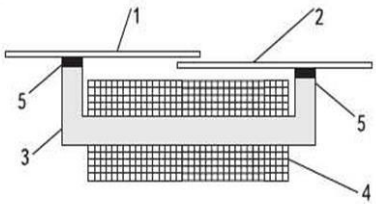
One of the varieties of the primary measuring sensor of the current signal of the electrical network of the telecommunications and communications device is the primary current transformer - I1 to the secondary current - I2, there are three main conversion elements (Fig. 2.) [2]:



Picture. 2. Current transformer. 1 - primary winding - w1, 2 - magnetic circuit, 3 - secondary winding - w2.

The principle of constructing four-element signal sensors.

Prof. V. Kovalenkov created a single-phase four-element magnetically controlled contact - the main elements of the sensor (reed switch) [3], which is presented in Fig. 3. In a single-phase four-element primary circuit, the 4-current conductor is connected to the 1-terminal contact, the 2-terminal contact, when current flows out of the primary circuit, the 1-terminal contact is disconnected from
2-pin when the current stops.

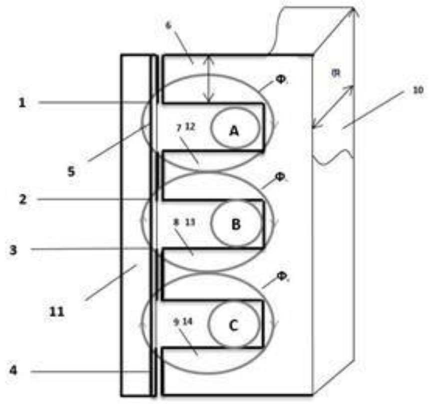


Picture. 3. Magnetic controlled contact prof. V. Kovalenkova [6]: 1-fixed contact, 2-exciting contact, 3-magnetic center,
4-conductive-primary rod.

The four-element reed switch type sensor uses 5-insulation as an auxiliary insulating material.

The change in the three-phase IA, IB and IC primary current flowing through the electrical networks of the telecommunications device to the secondary voltage, the main elements of the change in the signal of a four-element sensor are shown in Fig. 4 [3].

Conversions of the three-phase primary current of the electrical network of a telecommunications and communications device to a secondary voltage for monitoring and control are carried out through 1, 2, 3 and 4 - sensitive elements (simple or flat measuring windings or reed switches) of the sensor, 5 - insulating plates, 6, 7, 8 and 9 – parallel magnetic rods, 10 – a common base of magnetic rods, 11 – additional magnetic rods, while 12 (phase A), 13 (phase B) and 14 (phase C) are the current conductors of the electrical network of the telecommunications and communications device, i.e. e. – primary exciting windings of the sensor [1].



Picture. 4. The structure of the signal sensor about IA, IB and IC of primary currents to the secondary voltage of the electrical network of a telecommunications and communications device.

The operating principle of this four-element current signal sensor of the electrical network of a telecommunications and communications device is based on converting the magnitude of primary three-phase currents into a signal in the form of a secondary voltage [2-4]:
The current conductors of the electrical network of the telecommunications and communications device - the primary windings of the sensor 12 (phase A), 13 (phase B), and 14 (phase C) create magnetic fluxes ΦμA, ΦμB and ΦμC, which flow through a common magnetic base 10 and parallel rods 6, 7, 8 and 9, intersect the turns of the sensitive elements - secondary measuring windings 1, 2, 3 and 4 through the magnetic rod 5 and are expressed as follows [1]:

Φμ1 = (IA wп1) / Rμ1, Φμ2 = (IB wп2) / Rμ2,
Φ3C,= (IC wп3) / Rμ3,

here: IA, IB, IC – phase currents passing through the phases of the electrical network of the telecommunications and communications device, that is, through the primary excitation windings of the signal sensor; wп1, wп2, wп3 – the number of turns of the primary windings, (that is, the number of windings wп1= wп2= wп3=1 ÷ 5 vit., that is, the number of turns of each primary conductor – the number of excitation windings, which takes a value from one to five turns);
Rμ1= Rμ2 =Rμ3 - total magnetic resistance of magnetic conversion sections and air gaps.
The magnetic resistance of the magnetic conversion sections and air gaps is determined as follows:
Rμ1=Rμ base + Rμ air, Rμ base = L μ base / (μ×F),
Rμ air = δ/(μ0 ×F),

Rμ base magnetic resistance of the magnetic base,
Rμ air – magnetic resistance of air gaps,
Lμbasis - the active length of the magnetic transformation elements (the length of the magnetic flux path in the magnetic part of the transformation);
L μ air – δ - geometric dimensions - length of the air gap; μ, μ0 - magnetic conductivity and permeability of magnetic transformation elements and the environment (air).

Construction principles

a) Three-element signal sensors

One of the factors that determines the general state of reliable operation of the sensor for monitoring and controlling the electrical network of a telecommunications and communications device is the possible reliable operating state of the signal conversion elements.

Based on an analysis of the principle of construction and operation of the primary current sensor of the electrical network of a telecommunications and communication device for a signal in the form of a secondary voltage, a methodology for studying possible states has been developed, which allows one to study the reliability indicators and possible states of the conversion elements and is presented in the form of Table 1.

When converting a signal about the primary currents of the electrical network of a telecommunications device into a secondary signal in a three-element sensor, the probability of each element being in working condition is taken accordingly as follows [2-3]:

Pmagnetic circuit =0.99; Psensitive element =0.99;
Pconductor of the electrical network = 0.99.

The probability of an operational state of a three-element signal sensor about controlled and controlled currents in the electrical network of a telecommunications and communication device is a state based on models for studying the reliability indicators and operational state of the sensor elements given in Table 1. [1-2].

b) Four-element signal sensors

The method for calculating the probability of the operating state of a four-element three-phase current sensor of the electrical network of a telecommunications and communications device, which allows one to analyze the principle of signal change, is presented in Table 2.

When converting a signal about the primary currents of the electrical network of a telecommunications and communications device to a secondary signal in a four-element sensor, the probability of each element being in working condition (magnetic core, sensitive element, additional rods and conductors-excitation winding) is taken accordingly as follows [1-4]:

Pmagnetic circuit =0.99;
Relement sensitive =0.99;
Pconductor of the electrical network = 0.99;
Additional rods = 0.99.

Table 1. Calculation of probabilities of the operating state of a three-element signal sensor.

Sensor Element Condition	Model for calculating worker probability state of elements sensor	Elements of transformation of sensors and their states	Calculation results
C1	*P1P2P3*	1 – magnetic circuit, 2-sensitive element, 3 – electrical network conductor – field winding	0,970299
C2	$P_1P_2(1-P_3)$	sensor element is faulty	0,009801
C3	$P_1P_3(1-P_2)$	magnetic converter elements are faulty	0,009801
C4	$P_2P_3(1-P_1)$	excitation winding - the primary conductor of the electrical network is faulty	0,009801
C5	$P_1(1-P_2)(1-P_3)$	magnetic transducer elements and sensing element are faulty	0,000099
C6	$P_2(1-P_1)(1-P_3)$	excitation winding - the primary conductor of the electrical network and the sensitive element are faulty	0,000099
C7	$P_3(1-P_1)(1-P_2)$	excitation winding – primary electrical conductor networks and magnetic converting elements are faulty	0,000099

Table 2. Probability of the operating state of a four-element three-phase current sensor of an electrical network.

№	Item State	Probabilistic models of the operating state of sensor elements	Quantitative indicators of the probability of the elements being in good condition	Sensor elements and their general condition
1	C1	P1P2P3P4	0,96059601	1; 2; 3; 4
2	C2	P1P2P3 (1-P4)	0,00970299	1; 2; 3
3	C3	P1P2P4 (1-P3)	0,00970299	1; 2; 4
4	C4	$P_1P_3P_4$ $(1-P_2)$	0,00970299	1; 3; 4
5	C5	$P_2P_3P_4$ $(1-P_1)$	0,00970299	2; 3; 4
6	C6	$P_1P_2(1-P_3)(1-P_4)$	0,00009801	1; 2
7	C7	$P_2P_3(1-P_1)(1-P_4)$	0,00009801	2; 3
8	C8	P_3P_4 $(1-P_1)(1-P_2)$	0,00009801	3; 4
9	C9	$P_1P_4(1-P_2)(1-P_3)$	0,00009801	1; 4
10	C10	$P_1P_3(1-P_2)(1-P_4)$	0,00009801	1; 3
11	C11	$P_2P_4(1-P_1)(1-P_3)$	0,00009801	2; 4
12	C12	$P_1(1-P_2)(1-P_3)(1-P_4)$	0,00000099	1
13	C13	$P_2(1-P_1)(1-P_3)(1-P_4)$	0,00000099	2
14	C14	$P_3(1-P_1)(1-P_2)(1-P_4)$	0,00000099	3
15	C15	$P_4(1-P_1)(1-P_2)(1-P_3)$	0,00000099	4

Based on Table 2., summing up the probabilities of all three-phase current data of the electrical network of the device, possible operating situations of the elements, the total probability of the four-element sensor being operable is calculated as follows:

P total = P1P2P3P4 - P1P2P3(1-P4) - P1P2P4 (1-P3) - P1P3P4 (1-P2) - P2P3P4 (1-P1) - P1P2(1-P3)(1-P4) - P2P3(1-P1)(1-P4) - P3P4 (1-P1)(1-P2) - P1P4(1-P2)(1-P3) - P1P3(1-P2)(1-P4) - P2P4(1-P1)(1-P3) - P1(1-P2)(1-P3)(1-P4) -
P2(1-P1)(1-P3)(1-P4) - P3(1-P1)(1-P2)(1-P4) - P4(1-P1)(1-P2)(1-P3) = 0.92

Based on the results obtained, we can conclude that the probability of the working ability of a four-element three-phase current sensor of the electrical network of a telecommunications device is R = 0.92.

Conclusion

1. A calculation method and model have been developed in the form of tables of indicators of reliability and probability of the operating state of signal sensors of microprocessor and electronic telecommunications and communications devices based on the creation of Fμ-magnetic moving forces (m.m.f.) in magnetic circuits, the magnetic fluxes Fμ generated by them, ensuring high formalization and clarity of research.
2. The results of studies conducted on the basis of models of reliability indicators and the probability of the operating state of signal sensors of microprocessor and electronic telecommunications and communications devices, taking into account the probabilities of operating states, showed that the total probability of operation of a three-element sensor is Rob = 0.95.
3. The total probability of operation of a four-element sensor for monitoring and controlling three-phase primary current of signal sensors of microprocessor and electronic telecommunications and communication devices is Total = 0.92, that is, the total probability of operation of a sensor of this design in relation to a three-element sensor is 3.3% less.

The main advantage of four-element three-phase primary current sensors is that they can simultaneously provide an appropriate secondary signal for monitoring and controlling microprocessor-based and electronic telecommunications devices.

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