Journal of Scientific Research and Development 2 (11): 44-50, 2015
Available online at www.jsrad.org
ISSN 1115-7569

Increase of the reliability of electric power supply and security of electrical receiver utilization in the electric networks 6 – 10 kw

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Abstract: Increase of the reliability of electric power supply and security of electrical receiver utilization in the electric networks 6 – 10 kW, by means of control of neutral line regime in expanded electrical networks with tension 6-10 kW and capacitive current of earth locking over 15 A, development of the means and arrangement of automated determination of current of one-phase earth locking.

Key words: Reliability; Capacitive current; Active current; Inductive current; One-phase lockings (OPEL); Earth grounding; Neutral line; Arc-suppression coil; Compensation; Microprogramme Mealy automation; Moore automation; Mathematical model

1. Introduction

In the electric networks with tension 6-10 kW, one-phase earth lockings (033) are the most frequent type of insulation damage (up to 80%). Because of the non-selective work of non-fault protections from 033, the considerable share (up 50 %) alarm signals, which specify that the isolation damage takes place, which can lead to utilization of the network to inter-phase locking, is observed (Betsezhev, 1989; Utegulov et al., 2003).

The reliable works on the protection relay means, increase of the security and continuity of electric power supply is determined in many regimes of electric network neutral line.

Taking into account the regimes "free" or grounded through arc-suppression coil (APC), existing on the majority of enterprises, neutral line of electric networks 6 – 10 kW is not optimal, as it doesn't provide the reliable operation of protections from 033, and often promote to appearance of overpressures on the damaged and undamaged phases, create conditions for the development of ferroresonant processes in network (Vigovskiy, 1988; Obabkov, 1980).

Recently implemented on many manufacturing associations, high-ohmic resistant earth grounding of the neutral line allowed solving many of the listed problems. Owing to overlapping of the active additional current in the place of locking and application of current centralized protections from one-phase earth lockings, crosscut selectivity of these protection action is achieved, overpressures in the networks are considerably reduced and the possibility of ferroresonant processes is reduced to minimum (Tsapenko, 1986; GOST 13109-97).

However, the high-ohmic resistant earth ground of "free" neutral line according to the conditions of security is possible only in the electric networks 6 kW with capacitive currents of earth locking up to 15 A. Over this current it is necessary to take measures on compensation of capacitive current 033 that in practice, as a rule, is reduced to connection of APC network into the neutral line on one of the fixed tip-offs. The last circumstance can lead to the loss of labour capacity of the protections from 033 directed principle of action (ZZP-1, RZN-3 and etc.) at stepwise change of the network capacity typical for the electric networks (disconnection of the outgoing feeders) (GOST 12.4.155-85; GOST 1516.2-97).

In this networks the bigger part (up to 12-15 %) of appeared one-phase isolation damages transits into the inter-phase ones through the earth that can cause multiply damages and high danger of electric shock injury of the service staff (Mikryukov, 1981; Sirota, 1960; GOST 12.1.030-81).

Analysis of the protection devices from OPEL shows that the existing protection devices from OPEL doesn't possess the sufficient reliability because of the low selectivity at disconnection of the protected network damaged line, one or several feeders, where phase isolation in relation to the land is not damaged, is excluded at the same time, and also the change of network configuration in the process of utilization is not taken into account (Gladilin et al., 1977; Tkachuk et al., 2002).

Based upon above-mentioned it follows that the task of responsibility increase of the network electric supply system that lies in the development of single complex, binding the neutral line regime control, and also the development of the device and automated current determination device of one-phase earth

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locking, is topical and has important scientific and practical value.

The aim of the work is the increase of electric supply responsibility and security of electric receiver utilization in the electrical network 6 – 10 kW on the basis of regularities establishment in the neutral line control regime in the earth extended electric networks having tension 6-10 kW with the capacitive currents of locking the over 15 A, and also the development of the device and automated current determination device of one-phase earth locking.

2. Methods and objects of the study

The idea of work lies in the choice of optimal correlations between the active and inductive constituents of the current in neutral line, in the development of means and automated current determination device of one-phase earth locking in electric network 6 – 10 kW, with the aim of increase of electric supply responsibility and security of technological equipment utilization of the enterprises.

The systems of enterprises' internal electric supply have different scheme of distributing networks, where basic consumers are high-productive machines, mechanisms and electric power units of technological productions, which delay can cause appreciable damage. Therefore, the task of reliability provision of the internal electric power supply is topical one and, first of all, implies the application of measures and means, directed on the reduction of probability of appearance of one-phase earth lockings (OPEL), as the most frequent and heavy emergency conditions.

The notion "responsibility" in application to the internal electric power supply systems of enterprises is closely connected with the notion "electric security" at utilization of the electric power units with tension 6 – 10 kW. The electric networks with tension 6 – 10 kW are traditionally utilized in the regime of isolated neutral line; therefore the one phase earth locking is not the accident. However, with the increase of extension of electric networks, the currents of one-phase earth lockings are increased, which represent the danger for service staff.

For provision of uninterrupted operation of the internal electric power supply system of the enterprises and increase of the electric security level at utilization of the electric power units with tension 6-10 kW, it is necessary to periodically control the state of isolation and have reliable data of OPEL current module value, which characterizes the basic parameters of the electric security, such as tension of touch and step.

In the practice of utilization, the isolation damages of any phase in relation to the earth, leading to OPEL appearance, take place. The known methods of OPEL current determination didn't find wide application, as they have one shortcoming: staff recruitment for visual removal of the tension modules and currents, necessary for the calculation of OPEL current value.

Therefore, with the aim of increase of the electric security level and automation of the electric power supply elements of the enterprises, it is necessary to develop the device for automated OPEL current determination in the networks 6 – 10 kW, which basic advantages are automated determination and accumulation of the dynamics of change of OPEL current in the course of time.

In the scientific work the analysis of issue state and substantiation of the tasks of study was conducted. The means of earth grounding and neutral line regimes in the electric networks with tension 6 – 10 kW were considered. The analysis of direct, calculation and indirect methods of current determination of one-phase earth locking in the electrical network 6 – 10 kW was conducted.

"R_B – network" should be acknowledged the most optimal one of neutral line regimes on the enterprises existing today in the networks 6 – 10 kW with capacitive currents 033 less than 15A. The transition 033 into double through the earth arises one more important task of protection from such damage, especially in the extended networks, where even currents of "dull" metallic locking between phases can turn out be lower than the start-up currents of electric engines of the machine and complex drives. Such situation is dangerous at arcing, intermittent earth double lockings, as in the places of damage at that the big quantity of thermal energy is separated, which can cause the cable ignition, serious damage of engine winding isolation and etc.

Also in the work the choice of earth grounding way and optimal parameters of neutral line regimes in the electric networks 6-10 kW with the current earth lockings was conducted.

The task of determination of the neutral line optimal regime lies in finding such regime, at which the biggest technical (including electric safety) and ecological effectiveness is provided.

3. Results and discussion

In the work the methods of study and choice of optimal parameters of active-inductive resistance in the neutral line is represented. As a variant of scheme solutions, which allow providing the reliable and selective work of the protection from 033, minimal level of over-pressure at arcing lockings and electric security at touching the earth grounded equipment, were offered: parallel combination of the neutral line resistor and APC; successive inclusion of resistant modules and APC.

Moreover, in the work the device of active-inductive earth grounding of the electric network neutral line 6 kW was developed, for which the choice of the parameters and types of arcing reactor and resistors for R-L earth ground device of the neutral line in the networks with capacitive earth locking currents over 15 A.

The content and scheme of inclusion and principles of the R-L device operation of network neutral line earth grounding 6 kW (UZNP-6) were determined. The device consists (Fig. 1) of the steel cabinet – 1; four resistors of RSh2-SSN type with resistance 30-40 Ohm for the successive device, and 100-150 Ohm for the parallel one – 2; isolation supports – 3; control panel – 4; four magnetic starters KM1-KM4, located in the chamber – 5; wall tube insulator – 6; measuring current transformer – 7. The electric principal scheme of successive device is represented in Fig. 2.

Zero resistance level that doesn't allow possibility of network neutral line translation in the regime of "dull" earth grounding exist in the principal electric scheme of parallel device R-L neutral line earth ground.

In scientific work the way of microprocessor device of automated current compensation of one-phase earth locking in the network 6-10 kW was developed.

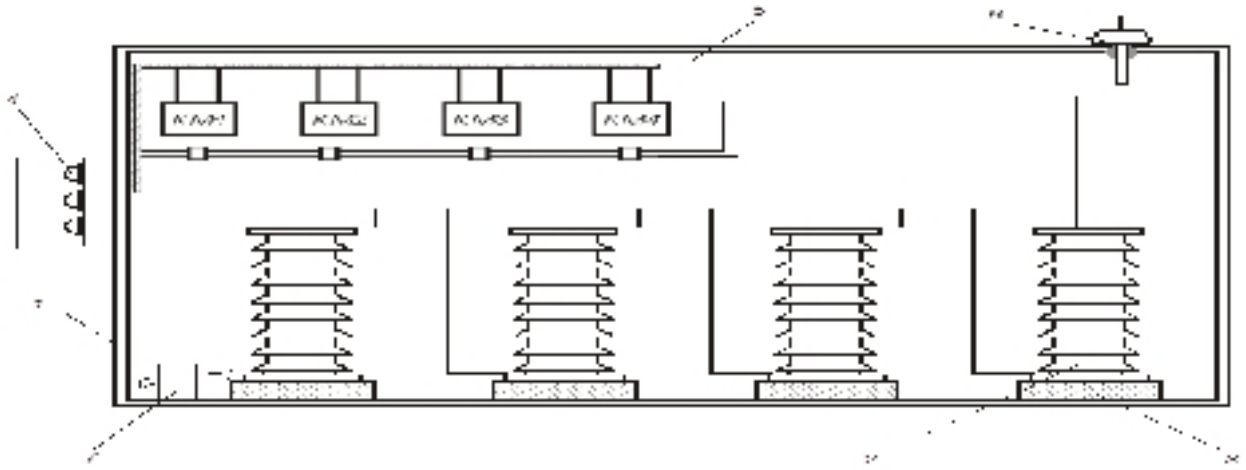

Fig. 1: General form of device for neutral line network earth grounding 6 kW (the cabinet door is removed).

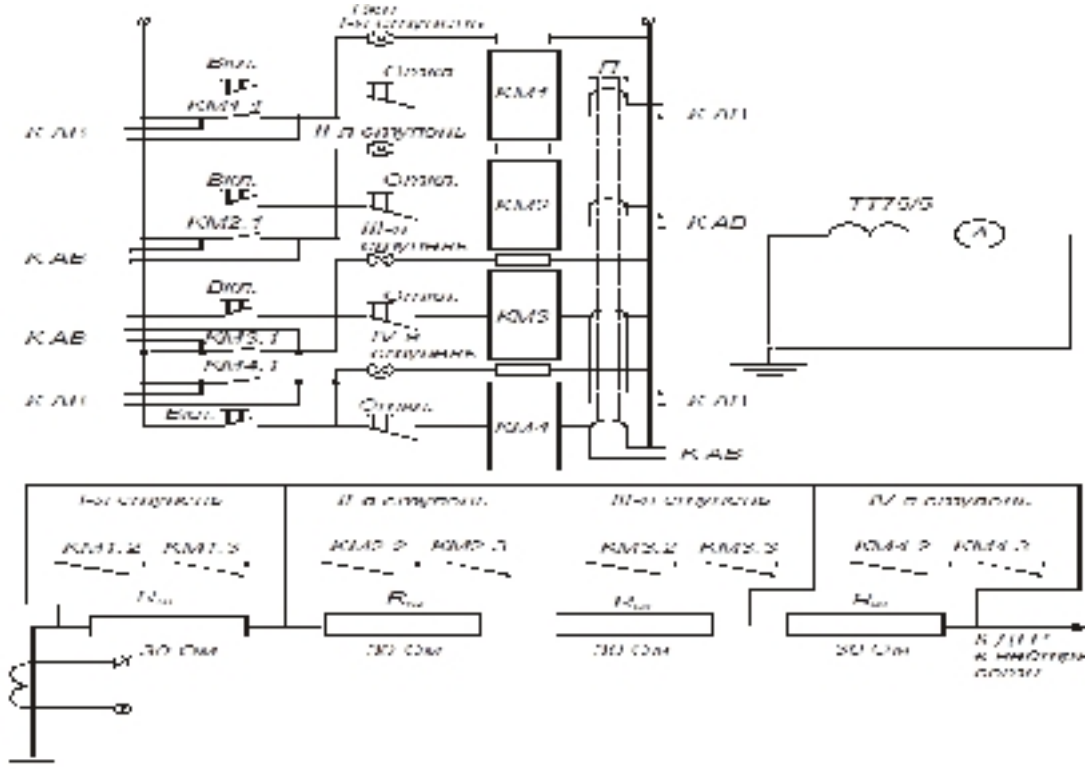

Fig. 2: UZNP-6 principal electric scheme.

The basic structural elements of the developed way of automated current determination of the one-phase earth locking in the electric network 6 – 10 kW include the architecture of the realized developed ways of the device, which determine and substantiate its basic functional blocks and functional scheme; algorithm of OPEL automated current determination in the electric network 6-10 kW, which determine the succession of operation execution.

The developed architecture is based on main way – module principle of organization of the microprocessor devices and systems and allows maximal reduction of the volume of device software

provision due to those operations on analogue-digital transformation and calculation of the hardware-based time intervals by means of implementation of the corresponding blocks.

The functional scheme of the developed device is represented on Fig. 3. For achievement of big information capacity and obviousness of reflection, microprocessor blocks of the device are interrelated with each other by means of the general main way, which units include data bus, address bus and control bus.

According to the results of the conducted analysis of the methods of current determination of one-phase earth locking as a prototype for the development of OPEL automated current determination algorithm in the electric network 6 – 10 kW, the indirect method of current determination of one-phase earth locking is taken in the electric network with tension over 1000 V isolated by neutral line, which found wide application in the practice. The method is based on measuring the modules of linear tension and phase tension in relation to the earth, tension of zero sequence after connection of one of the phases of electric network and earth of additional capacitive conductivity. The basic advantage of this method in comparison with other analogous indirect methods of OPEL current determination is the substantial simplicity of measurement of the earth phase tension, linear tension, and zero sequence tension and OPEL current value calculation based upon the measured data at high accuracy of determined current OPEL.

The analysis of the mathematical determination methods of digital computer machines showed that the methods of the automation theory are the most effective ones, which allow synthesizing enough complex models of computing devices for determination of the applied tasks. Also in the process of OPEL current mathematical determination in the electric network 6 – 10 kW, the elements of Boolean algebra, theory of graphs and algorithms are used.

The developed model of controlling micro programme Mealy automation of the automated current determination device of one-phase earth locking in the electric network 6 – 10 kW, where as an algorithm of mathematical model work of the developed device the algorithm of OPEL automated current determination in the electric network 6 – 10 kW, which content GSA is represented on Fig. 4.

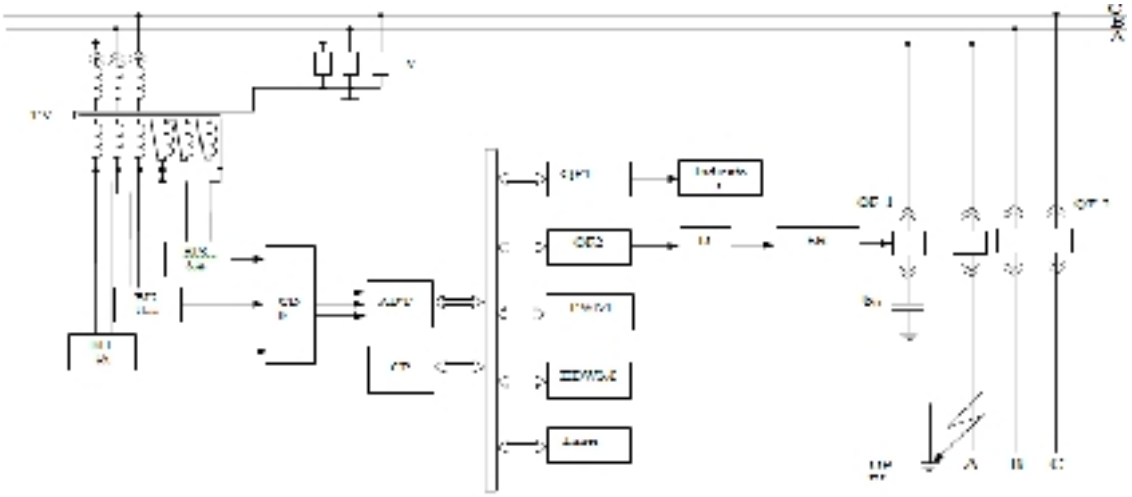

Fig. 3: Functional scheme of the OPEL automated current determination in the electric network 6 – 10 kW.

The developed mathematical model allows execution of the automated current determination of one-phase earth locking in the electric network with tension 6 – 10 kW. The basic tasks of micro programme Mealy automation is the development of sequences of controlling signals, distributed in the course of time, under which effect some operations are executed in the operational automation.

The developed model of controlling micro programme Moore automation of the automated current determination device of one-phase earth locking in the electric network 6 – 10 kW was developed. The marked graph-scheme of the algorithm and graph of the model of controlling micro programme Moore automation of OPEL automated current determination device in the electric network 6 – 10 kW are represented on Fig. 5.

In the scientific work, the automated current determination of one-phase earth locking in the electric network 6 – 10 kW was developed.

The development of automated current determination device of one-phase earth locking in the electric network 6 – 10 kW lies in the choice and substantiation of the element basis for technical realization of its architecture. The basic requirements, produced to the controlling blocks of the data processing devices, which contains the developed OPEL automated current determination device in the electric network 6 – 10 kW, includes low cost, high responsibility, high level of miniaturization, low power consumption, labour capacity in the strict conditions of utilization, sufficient productivity for execution of the required functions and universality. The automated current determination device of one-phase earth locking in the electric network 6 – 10 kW on the basis of

microcontroller control system can meet these requirements. The functional scheme of the OPEL automated current determination device in the electric network 6 – 10 kW is represented on Fig. 6 and contains three-phase electric network with phase A, B and C; TV tension transformer; full electric network conductivity Y; additional capacitive conductivity b_0; load-break switch QF1, commuting additional capacitive conductivity; load-break switch QF2, commuting power of electric receivers; microcontroller MC; block of tension measuring unit BTMU; analogue-digital transformer ADT; timer; energy-dependent working memory EDWM; executive body EB; power supply unit PSU; key control block KCB; electric separation unit ESU.

Microcontroller control system (MCCS) is equipped with the impulse electric power supply with 10 W capacity and is located in the hermetic metal frame sized 300×320×40 mm and protection level IP64. Thus, sufficiently reliable protection of control system from the unfavourable conditions of utilization was provided, such as mechanical damages, dust, moisture and external electromagnetic noises and is equipped with the electronic thermostat heater that provides the working temperature range ± 50 °C.

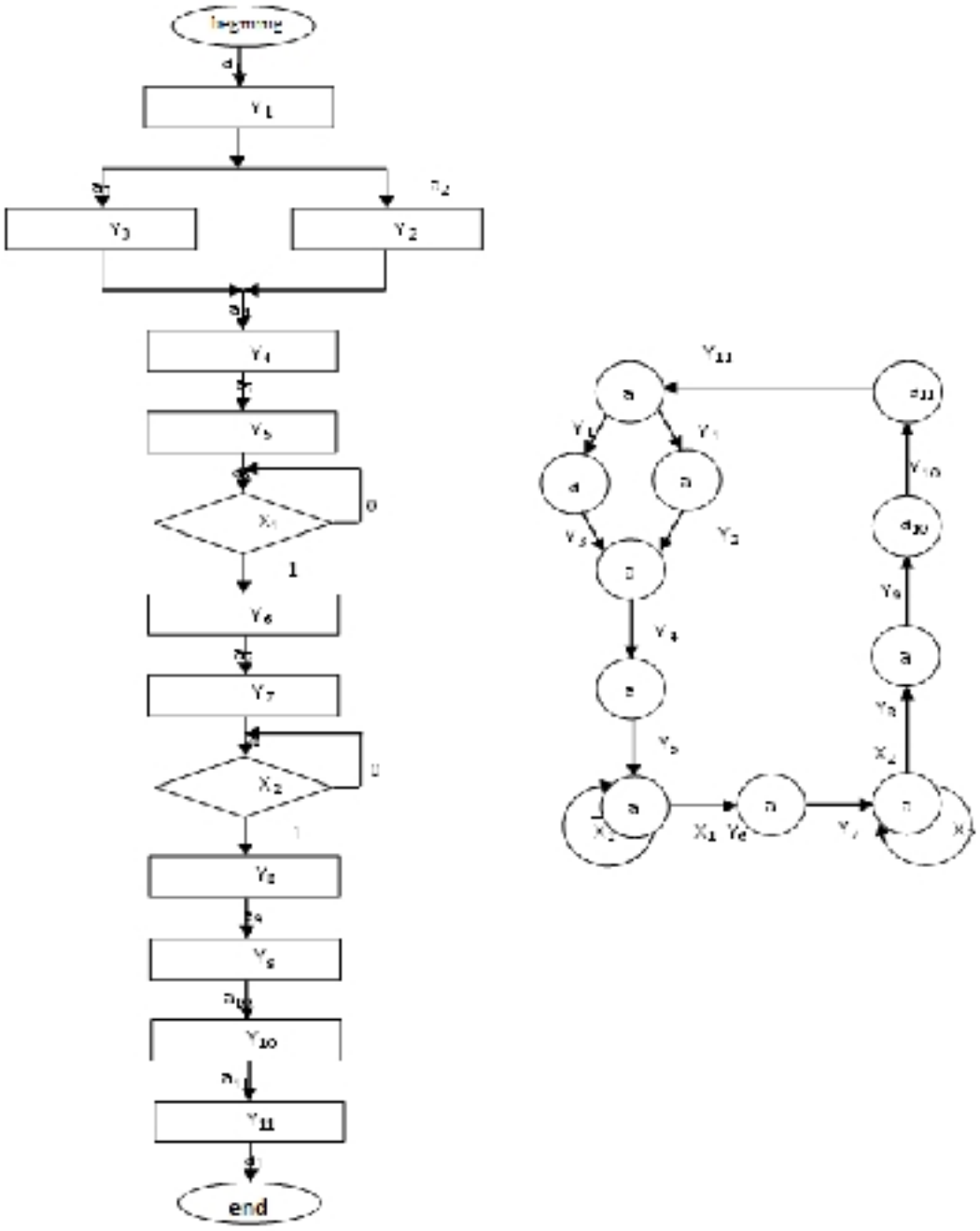

Fig. 4: Marked graph-scheme algorithm and graph of the model of microprogramming Mealy automation control device of OPEL automated current determination in the electric network 6 – 10 kW.

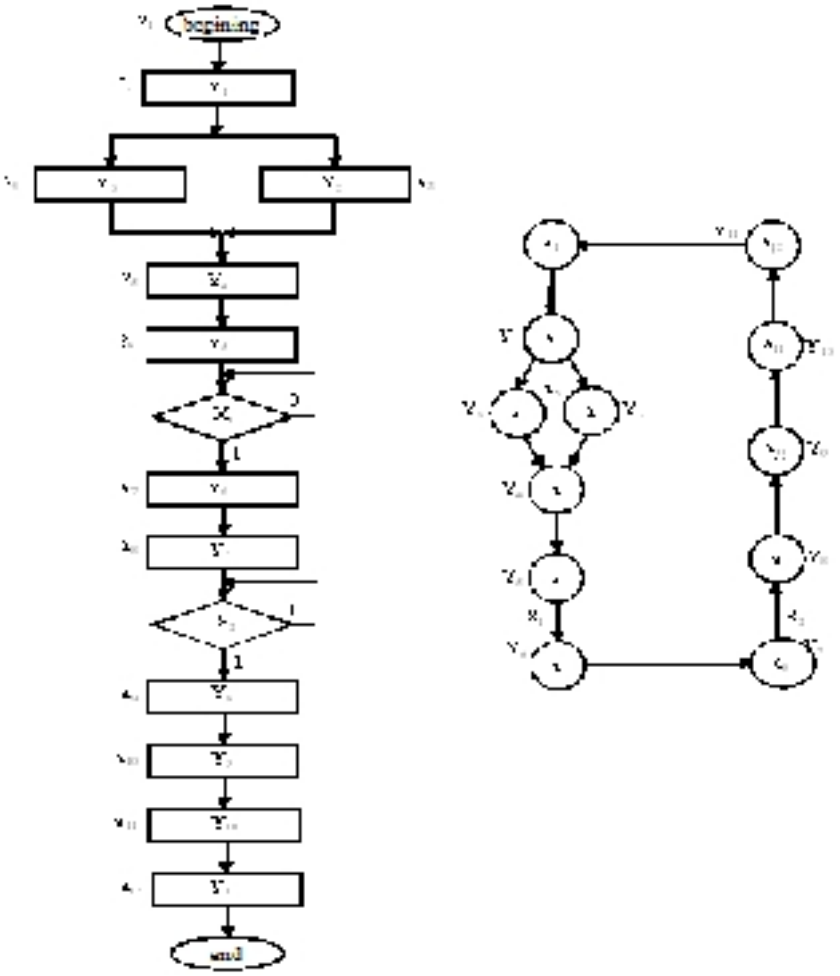

Fig. 5: Marked graph-scheme algorithm and graph of the model of microprogramming Moore automation control device of OPEL automated current determination in the electric network 6 – 10 kW.

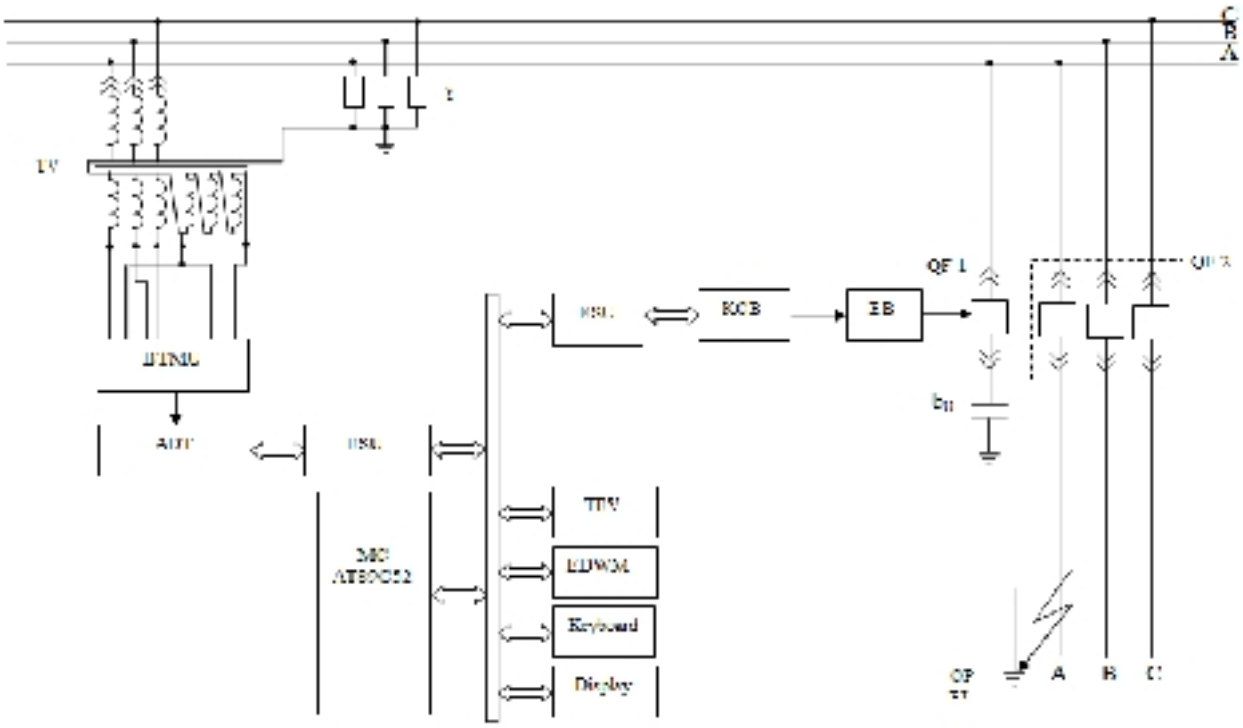

Fig. 6: Functional scheme of OPEL automated current determination in the electric network 6 – 10 kW, realized in MCCS

4. Conclusion

The scientific novelty of the studies conducted lies in that:

− the relations between active and inductive constituent of the current in a neutral line at the successive R-L network earth grounding I_a/I_L = (0.5 ÷ 0.3) were established, which provide the reliable work of protections from 033 both current and directed principles of operation, including at step-wise change of the network capacity, caused by commutation of out coming lines;

− the analysis of existing methods of current determination of one-phase earth locking and means of compensation of the capacity currents in the electric network 6 – 10 kW was conducted;

− the architecture of the automated current determination device of one-phase earth locking in the electric network 6 – 10 kW was developed;

− the algorithm of automated current determination of one-phase earth locking in the electric network 6 – 10 kW was developed. As the basis of algorithm the indirect method of OPEL current parameter determination in the electric network with isolated neutral line with tension over 1000 V was taken;

− the mathematical models of automated current determination device of one-phase earth locking in the electrical network 6 – 10 kW were obtained: the model of micro programme Mealy control automation and model of micro programme Moore control automation.

The practical value of the work lies in the development of means and automated current determination device of one-phase earth locking in the electric network 6 – 10 kW, directed on the increase of electric power supply responsibility and security of electric receiver utilization in the electric networks 6 – 10 kW.

At the implementation of the results of work, the effect will reflect itself in the reduction of unjustified delays of technological equipment for 30-40% as a result of non-selective action of the basic types of relay protection and over-pressure in the network at arcing intermittent earth lockings.

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