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DEVELOPMENT OF THE ARC-SUPPRESSION COIL CONTROL METHOD FOR CAPACITATIVE CURRENT COMPENSATION IN THE NETWORK OF VOLTAGE 6 - 10 KV

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Abstract – in the article, a method of automatic regulation of an arc extinguishing reactor in networks of 6–10 kV is based on regulating the inductance of an arc extinguishing reactor depending on the magnitude of the zero sequence voltage, while determining the damaged phase of the electrical network. The developed mathematical model of a three-phase electrical network is based on measuring the magnitudes of the voltage modules of phases A, B, C relative to the earth and the line voltage, and is implemented by a mathematical relationship that allows you to simulate the state of existing electrical installations with voltages above 1000 V. Experimental studies in the laboratory of the method of controlling an arc-suppressing reactor to compensate for capacitive current in networks of 6–10 kV in industrial enterprises were held, which proved to be effective through the use of a device for determining the damaged phase in networks of 6–10 kV. Using the method of automatic regulation by an arc-suppressing reactor in networks of 6–10 kV, to reduce single-phase earth-fault current, provides an increase in: the reliability of the power supply system and an increase in electrical safety during operation of operating electrical installations with a voltage of 6 - 10 kV.

Key words: current, voltage, electrical safety, network, neutral.

Introduction

Compensation of capacitive earth fault currents in networks is realized by switching in neutrals of generators or transformers of arc-suppressing reactors, the inductive resistance of which is adjusted according to the capacitance of the compensated network by changing the reactor inductance. In the case of the network insulation breakdown and the occurrence of a ground fault, the capacitive current is compensated by the inductive current of the arc-suppressed reactor, thus reducing the arc at the point of the circuit and slowing down the process of the insulation destruction. It also ensures the reduction of the total current of a single-phase short circuit to earth (OZZ) in the network to the minimum level due to its active component.

In order to achieve maximum current limiting of an SPG, resonant tuning of reactors is carried out, but to maintain and stabilize the full compensation of the capacitive current of an SPG, arc suppression reactors (DGR) of special structures are necessary, equipped with automatic compensation systems of capacitive currents of the SPG in all possible modes of the network, which allow to quickly and smoothly change the inductive DGR resistance. Calculation of the determined setting (resonant or overcompensation) of the network capacity is made for the metal ground fault variant, since when a short circuit occurs through intermittent resistance transients are observed due to periodic ignitions and extinction of the arc at the insulation breakdown point. Therefore, the adjustment is performed based on the values of steady-state currents and zero-sequence voltages.

When the metal circuit to earth, the potential of the neutral becomes equal to the phase voltage of the network. The current of the arc-suppressing reactor, the capacitive current of the network and the active current due to the active losses of the insulation and the arc-suppressed reactor flow at the fault location.

According to regulating the inductance magnitude method the GDR are divided into reactors with smooth regulation and stepwise inductance change.

DGR with continuously adjustable inductances are divided into plunger ones, which are regulated by changing the size of the air gap in the magnetic circuit and biasing reactors, the inductance of which changes under the action of direct current biasing in special control windings.

Smoothly controlled DGR also includes reactors in which the pulse-width modulation of the neutral bias voltage is carried out with a thyristor key by interrupting the current through the rector (PWM-controlled DGR).

DGR with a stepped regulation of inductance are classified into reactors with a small-scale and a large-scale change in the inductance of the GDR.

1 Automatic compensation systems for capacitive earth-fault currents in electric networks of 6 - 10 kV

The most common in the literature descriptions of phase automatic compensation systems (ASC), designed to operate in the normal mode of the network, to date are the only type of industrially implemented regulators for high-voltage networks. The advantage of these ASC is the performance in single-phase earth fault modes [1 – 7].

In the normal network mode, in order to ensure the operability of phase ACK when determining the frequency characteristics of the neutral bias voltage or asymmetry current flowing through the GDR, which in most cases is not stable in both amplitude and phase, create an artificial asymmetry current by switching on one of the network phases a special asymmetric capacitor or a high-resistance resistor, a change in the number of turns of the winding of one of the phases of the connecting transformer, or the application of a power frequency voltage through co-limiting choke, capacitor battery in the secondary winding of the DGR or a special transformer connected in parallel or in series of the DGR. This is the main disadvantage of phase ACS, since the creation of artificial asymmetry in networks degrades the performance characteristics of electrical installations and contributes to the reduction of service life.

More universal are the resonant tuning systems that supplement the amount of working information due to the parametric effect on the object. The most well-known of this class of systems are resonance tuning systems using the extreme dependence of the output coordinates of the network zero sequence circuit on the GDR inductance: neutral bias voltage, DGR current or voltage of the damaged phase. These parameters are recorded by the amplitude detector at the output of the controlled object, which forms the extreme dependence of the amplitude of oscillations on the inductance of the GDR. The main disadvantage of such systems is the complexity of the DGR control algorithm and the construction of the ASC.

A feature of the development is an artificially created periodic (with a search frequency) modulation of the amplitude of the voltage introduced into the network from an external source of artificial asymmetry, which stands out from the neutral bias voltage or the DGR current as a search frequency signal. Depending on the choice of the output coordinate and the method of creating artificial asymmetry, these signals are orthogonal or in phase with respect to the input search modulation input. These systems have typical flaws: impulsiveness of the control characteristic and non-quasistationary effects.

2 Automatic compensation systems for capacitive earth fault currents with arc suppression reactors with stepwise inductance control

Step DGR in power supply systems of industrial enterprises are obsolete unregulated reactors and reactors with step regulation type ZROM for 6–35 kV networks of the Moscow Transformer Plant, having five branches, reactors of the Karl Liebknecht transformer plant, having nine branches for 6–10 kV networks, as well as currently available RZDSOM type reactors for various capacities and voltages, in which the switching of stages is carried out manually when disconnected from the network from power switch branches. The possibilities of adjusting such reactors are very limited: manual switching of branches, a small number of branches or a large step of inductance does not allow them to be used as the executive bodies of the ASC of capacitive currents of the RPG. However, since up to 80% of such devices are in operation, the task of creating ways to compensate for capacitive currents in networks with unregulated DGR remains relevant [2, 6].

To eliminate the drawbacks of the above mentioned reactors, various works were carried out [10] aimed at developing the thyristor switch of the windings of serial DGR type ZROM and RZDOSM. By including the windings in various combinations, it is possible to significantly reduce the inductance step, which makes it possible to assign these coils to reactors with a small-step change in inductance. Such GDR surpass all others in speed, since the time of any change in inductance in the limit can reach 20 ms, have the same linearity as the GDR of the plunger type, do not consume bias energy and are inferior to the DGR with bias only in cost and reliability due to electronic parts [2, 8]. The disadvantages of the data DGR is the bulkiness of the thyristor switch, the high cost.

3 Automatic compensation systems for capacitive earth fault currents with PWM-controlled arc suppression reactors

PWM-controlled DGR in the form of a non-tunable DGR, connected to the ground by a thyristor key, have high speed. Regulation of the key unlocking angle at each half-period determines the inductive properties (by the first harmonic) of the given circuit. In [4], a variant of high-speed PWM-controlled DGR is presented based existing DGR of type ZROM, ZRDSOM, RZDPOM and the like by installing thyristor keys of type T253-1250-42-71, necessary protection of the power module (SM) and automatic controller UARK. 103

The general algorithm for the functioning of the system provides for signaling abnormal modes of network operation and faults, a number of protections and self-control elements, both of the the control unit microcontroller, and of the means of interface with the object.

Algorithms, programs for measuring amplitudes and phases of harmonic signals, as well as instantaneous values of the neutral bias voltage (at the time of arc breakdown) without using traditional analog-digital converters, have been developed. With the same purpose, the enabling pulses of all the thyristors of the keys are formed by the microcontroller without the involvement of additional hardware. A significant drawback of systems with PWM-controlled DGR is the high content of higher harmonics in the compensating current of these reactors, as well as the bulkiness of high-voltage thyristor switches.

4 Automatic systems for compensating capacitive earth fault currents with arc suppression reactors with bias

Magnetic biasing reactors have somewhat worse characteristics than plunger DGR: linearity of the order of (3 ÷ 5)%, high harmonic currents of (3 ÷ 5)%, non-linear adjusting characteristics, high bias settings when switching from the normal mode to the AGD mode. Reactors with local biasing of part of the magnetic circuit are more economical. [8].

Guided by the magnetization of the DGR of a new generation of RUOM, DOW, they possess more advanced characteristics close to the plunger DGR. These reactors consist of two main functional units: an electromagnetic part and a thyristor converter. The controlled reactor phase is a double-wound split-rod transformer. One of the windings, network, is connected to the electrical network, the second is the control, connected to a variable in size source of DC voltage. Sections of the network and control windings are included in anti-parallel and do not have direct electromagnetic coupling. Each of the phase windings creates its own magnetic fluxes: network winding - alternating current of industrial frequency; control - a constant, adjustable in magnitude, the flow of bias. A constant bias flow shifts the variable flow to the saturation region of the magnetization curve of steel, which leads to a change in the inductive resistance of the device.

This device in its purpose is a filter attachment zero sequence. For the voltage of the direct and reverse sequences, it has a very high resistance, several times higher than the idling resistance of a two-winding transformer of similar power, and for a zero-sequence voltage its resistance is negligible.

The control of the reactor parameters in the normal mode of the network in the case of single-phase circuit of the network to earth is carried out using the electronic control system STANK. As long as the instantaneous value of the zero-sequence voltage on the secondary winding of the voltage transformer (NAMI) has not reached the critical value of 0.15 maximum of the nominal voltage of this winding, the control system perceives this as normal network operation. In this mode, the control system generates current pulses with a duration of about 1 ms through the RUOM signal winding.

The repetition interval of current pulses depends on the power of the reactor, the state of the network and is within 0.1 ÷ 0.3 seconds, the current pulse recharges the network capacity, which causes a subsequent resonant damped voltage fluctuation between the network capacity and the reactor. By the nature of the oscillatory process, the network capacity, reactor inductance and the quality factor of the zero-sequence circuit are determined, since the capacitive conductance of the network is inversely proportional to the rate of voltage rise at the neutral. The ratio of the frequency of free oscillations to the operating frequency of the network shows the degree of detuning of the reactor from resonance. The oscillation decay rate characterizes the quality of the network; according to this indicator, the minimum allowable interval between adjacent current pulses is set. The measurement and storage of new values of the capacitive conductivity of the network is realized in the SANK (RUOM) control system only by the rate of rise of the voltage front on the neutral at the moment of generation of the current pulse.

Information obtained from measuring network capacity is used by the control system to generate two types of command signals. One of them sets and maintains the reactor conductivity for an indefinitely long time required for precise resonant tuning with the network capacity. The second ensures that the operating point of the magnetic fluxes in the reactor rods is shifted to such a position that the free components of the transition process in the reactor will be zero, and when an earth fault occurs, a steady state immediately occurs in it corresponding to the fine tuning of the reactor for arc current compensation. The command signals of the first type affect the thyristors of the converter of the reactor, the second - on its magnetic system.

When a ground fault occurs and a neutral voltage of more than 15% of the phase is generated, the control system stops generating a pulse and inductive conductivity is set in the reactor, which is equal to the last value before the capacitance of the network. Compensation of the main harmonic of the reactive component of the capacitive current occurs instantaneously, the residual arc current in the case of using RUOM is somewhat distorted by higher harmonics, however, their values do not exceed the active component of the reactor current and the total residual current does not exceed 3A (rms value).

In the case of the disappearance of the circuit, the reactor continues to maintain conductivity unchanged and the frequency of free voltage fluctuations at the reactor remains equal to the network frequency. This ensures smooth recovery of voltage in phases without any overvoltage. [6].

The advantages of such reactors is their speed in the mode of the SPG, the restructuring time of the entire range of inductance is 1 ÷ 3 s.

In view of the above, the disadvantages of controlled DGR should be attributed to the fact that the automatic control system is based on the use of zero-sequence voltage, as it is the case that the operated networks contain zero-sequence voltages with a good network insulation condition.

In accordance with the above, one of the promising areas of increasing electrical safety and automation of elements of the power supply system of industrial enterprises is the development of an innovative method for compensating capacitive current in electric networks with an insulated neutral voltage of 6 - 10 kV.

Thus, it is necessary: to develop a method for controlling an arc extinguishing reactor to compensate for capacitive current; develop a mathematical model of capacitive current compensation; conduct experimental studies in laboratory conditions of the control of an arc-suppressing reactor to compensate for capacitive current, in networks of 6–10 kV for industrial enterprises

The control method of the arc-suppressing reactor to compensate for capacitive current in networks of 6 - 10 kV

A method has been developed to automatically control an arc-suppressing reactor in networks of 6–10 kV, which is based on controlling the inductance of an arc-suppressing reactor depending on the magnitude of the zero-sequence voltage and determining the damaged phase of the electrical network.

The proposed method is illustrated by the functional diagram (Figure 1), containing: a three-phase electric network 1 with phases A, B and C; auxiliary transformer - 2;

capacity of the phases of the electrical network - 3; voltage transformer type NTMI - 4; an arc extinguishing reactor of the RUOM type - 5; block of system for automatic adjustment of capacitive current compensation - 6; block determining the damaged phase of the electrical network - 7; The block of connection of the zero-sequence voltage to the input of the automatic compensation adjustment system is 8.

The method is as follows.

If there is no damage to any phase of the electrical network relative to the earth from the device for determining the damaged phase 7, there is no signal to the zero-sequence voltage connection block at the input of the automatic compensation adjustment system - 8, while if there is a zero-sequence voltage on the open triangle of the voltage transformer 4 , then the voltage of the zero sequence is not fed to the input of the block of the system for automatic adjustment of the capacitive current compensation - 6.

If insulation is damaged between one of the phases of the electrical network relative to the earth, the device for determining the faulty phase 7 receives a signal to the zero sequence voltage connection unit at the input of the automatic compensation adjustment system - 8. The zero sequence voltage connection module at the input of the automatic compensation adjustment system - 8 delivers zero voltage the sequence of the input block of the system for automatically adjusting the capacitive current compensation - 6.

When a zero-sequence voltage is applied to the block of the system for automatically adjusting capacitive current - 6, the compensation of the RUOM-5 arc extinguishing reactor is automatically adjusted. When the RUM-5 arc-extinguishing reactor automatically adjusts, a single-phase earth fault is reduced.

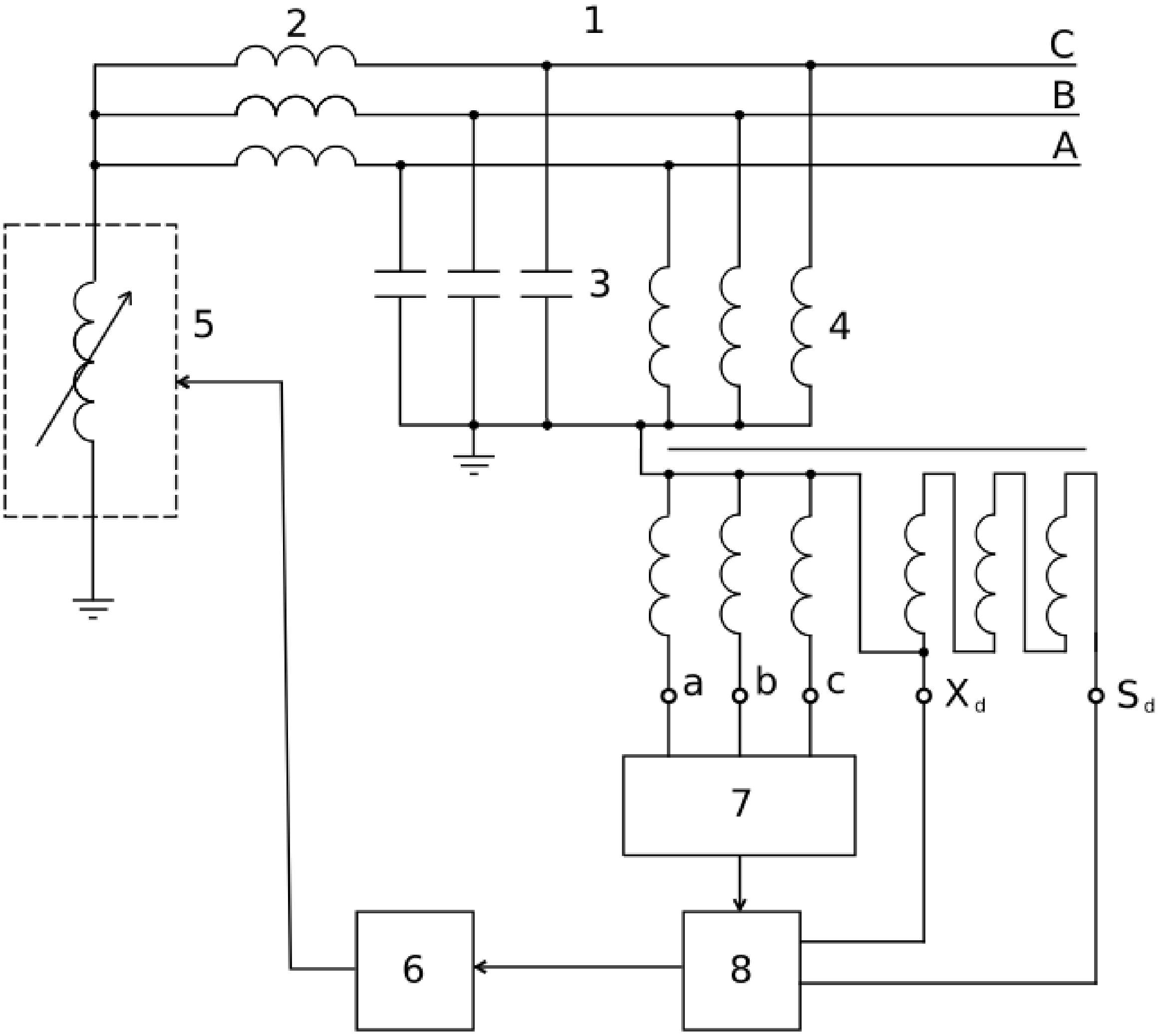

Figure 1 - Scheme of automatic control arc extinguishing reactor in networks of 6 - 10 kV

Reducing the current of a single-phase earth fault provides a growth in: the reliability of the power supply system and an increase in the electrical safety level when operating existing electrical installations with a voltage of 6 kV of industrial enterprises.

Modeling and experimental studies in the laboratory of the method of controlling an arc-suppressing reactor to compensate for capacitive current in networks of 6-10 kV

A mathematical model of a three-phase electric network based on measuring the values of voltage modules of phases A, B and C relative to earth and line voltage has been developed for conducting experimental studies in laboratory conditions of a device for controlling an arc-suppressing reactor to compensate for capacitive current in networks of 6–10 kV. the state of the electrical safety level when operating electrical installations with a voltage higher than 1000 V.

The power supply system of industrial enterprises has a distribution network of 6–10 kV, which produces sewage of electrical energy to industrial facilities with a complex technological process, the reliability of the system, whose power supply is defined by the first category.

One of the factors affecting the reliability of the internal power supply system of industrial enterprises is mainly single-phase earth faults in distribution networks of 6–10 kV. Since the reliability of operation of distribution networks with a voltage of 6–10 kV is associated with single-phase earth faults, it follows from this that electrical safety issues are also open. Therefore, under the increase of the operating efficiency of distribution networks with a voltage of 6–10 kV, ensuring their reliability and electrical safety is taken.

To increase the reliability and ensure the growth of the electrical safety level, it is necessary to create a mathematical model for monitoring the state of electrical safety during operation of electrical installations with a voltage higher than 1000 V.

Currently, the most promising direction for improving the level of safety in existing electrical installations with voltages above 1000 V is the creation of an automatic control system based on the use of standard computing programs. [8 – 19].

The development of an automated electrical safety management system of a company requires a mathematical model for assessing the state of a three-phase electrical network in order to select a strategy to solve the problems of ensuring the safety and reliability of power supply using innovative capacitive current compensation technologies in networks with insulated neutrals above 1000 V [7 – 19].

The developed mathematical model of a three-phase electrical network is based on measuring the magnitudes of the voltage modules of phases A, B, C relative to the ground and the line voltage, and is implemented by a mathematical relationship that allows you to simulate the state of existing electrical installations with voltages above 1000 V:

$$Q=\frac{\sqrt{\begin{gathered}(U_A^2+U_B^2+U_C^2)^2+(U_B^2+U_C^2-U_Л^2)^2+\\+(U_A^2+U_B^2+U_C^2-U_Л^2)^2+U_B^4+U_C^4\end{gathered}}}{U_A^2+U_B^2+U_C^2-U_Л^2}. \qquad (1)$$

When changing variables:

$$U_{A*}=\frac{U_A}{U_Л};$$

$$U_{B*}=\frac{U_B}{U_Л};$$

$$U_{C*} = \frac{U_C}{U_Л},$$

function is obtained:

$$Q = \frac{\sqrt{\begin{gathered}(U_{A*}^2 + U_{B*}^2 + U_{C*}^2)^2 + (U_{B*}^2 + U_{C*}^2 - 1)^2 + \\ + (U_{A*}^2 + U_{B*}^2 + U_{C*}^2 - 1)^2 + U_{B*}^4 + U_{C*}^4\end{gathered}}}{U_{A*}^2 + U_{B*}^2 + U_{C*}^2 - 1}, \tag{2}$$

defined in the area of three-dimensional space with Cartesian rectangular coordinates U_{A*}, U_{B*}, U_{C*}, shown in Figure 2.

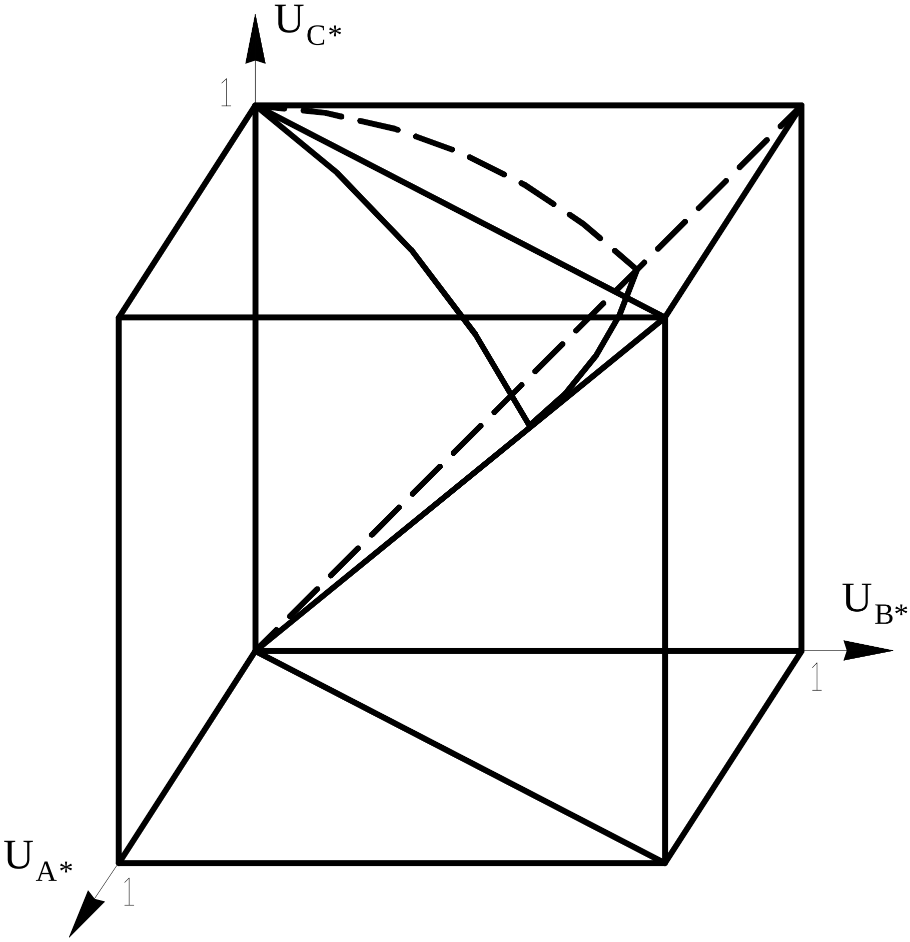

Figure 2 - Three-dimensional space with Cartesian rectangular coordinates, describing the function of a mathematical model for assessing the state of a three-phase electrical network

Since the technical conditions:

$$0 < U_{A*} < U_{B*} < U_{C*} < 1.0,$$

then this region is the part of the tetrahedron with vertices at the points (0, 0, 0), (0, 1, 1), (1, 1, 1), где:

$$U_{A*} + U_{B*} + U_{C*} > 1.0.$$

The corresponding body is the result of removing from the tetrahedron the part of the ball of unit radius belonging to it with the center at the origin.

Consider the marginal relative error:

$$\Delta Q = \frac{1}{|Q|}\sqrt{\begin{array}{l} U_A^2\left(\frac{\partial Q}{\partial U_A}\right)^2 \Delta U_A^2 + U_B^2\left(\frac{\partial Q}{\partial U}\right)^2 \Delta U_B^2 + \\ + U_C^2\left(\frac{\partial Q}{\partial U}\right)^2 \Delta U_C^2 + U_Л^2\left(\frac{\partial Q}{\partial U}\right)^2 \Delta U_Л^2 \end{array}}, \qquad (3)$$

where ΔU_A, ΔU_B, ΔU_C, – relative error parameters U_A, U_B, U_C.

The coordinates for the relative error parameters represent the sensitivity of the first order of the function to change the arguments U_A; U_B; U_C; $U_Л$:

$$\begin{gathered} S_A = \frac{U_A}{|Q|} \times \frac{\partial Q}{\partial U_A}, \\ S_B = \frac{U_B}{|Q|} \times \frac{\partial Q}{\partial U_B}, \\ S_C = \frac{U_C}{|Q|} \times \frac{\partial Q}{\partial U_C}, \\ S_Л = \frac{U_Л}{|Q|} \times \frac{\partial Q}{\partial U_Л}. \end{gathered} \qquad (4)$$

These sensitivities are functions of arguments U_{A*}, U_{B*}, U_{C*} and depend on parameters $U_Л$, eg,

$$S_A = S\,(U_{A*}, U_{B*}, U_{C*}, U_Л). \qquad (5)$$

The smallest modulo values in the area they take at the point (1, 1, 1):

$$S_A(1, 1, 1; U_A) = -4\,U_Л^2 + 1{,}25; \qquad (6)$$

$$S_B(1, 1, 1; U_B) = -4\,U_Л^2 + 1{,}75;$$

$$S_C(1, 1, 1; U_C) = -4\,U_Л^2 + 1{,}75;$$

$$S_Л(1, 1, 1; U_Л) = -4\,U_Л^2 - 0{,}75.$$

As the point tends M (U_{A*}, U_{B*}, U_{C*}) to sphere $U_{A*} + U_{B*} + U_{C*} = 1.0$, their absolute values increase indefinitely. Thus, it has the same properties and rms sensitivity of the first order of the function Q to the change of arguments:

$$S_Q = \sqrt{S_A^2 + S_B^2 + S_C^2 + S_Л^2}\,. \tag{7}$$

For it:

$$\Delta Q \le \frac{S_Q}{\sqrt{\Delta U_A^2 + \Delta U_B^2 + \Delta U_C^2 + \Delta U_Л^2}}\,. \tag{8}$$

Magnitude S_Q is a function of arguments U_{A*}, U_{B*}, U_{C*} and depends on the parameters $U_Л$,

$$S_Q = S(U_{A*}, U_{B*}, U_{C*}, U_Л). \tag{9}$$

Its lowest value in the area D is:

$$S_Q(1, 1, 1; U_Л) = \sqrt{16 \times U_Л^2 + 8{,}25}\,. \tag{10}$$

When aiming a point M(U_{A*}, U_{B*}, U_{C*}) to the sphere:

$$U_{A*} + U_{B*} + U_{C*} = 1.0, \tag{11}$$

unlimited value S_Q increases.

To analyze the state of electrical safety in networks with voltages higher than 1000 V, the function levels are examined:

$$f(U_{A*}, U_{B*}) = F(U_{A*}, U_{B*}, 1). \tag{12}$$

To assess the state of electrical safety, the developed mathematical model requires implementation through the use of innovative technologies for compensating capacitive current in networks with insulated neutral with a voltage higher than 1000 V. The resulting model, when implemented, allows to increase the level of electrical safety based on automatic control of technical means: neutral; devices for determining the damaged line and phase, etc.

Experimental studies of the mathematical model and the device for determining the damaged line and phase were carried out at the laboratory installation of the Department of Power Supply of S. Seifullin KATU.

The developed control circuit device of an arc-suppressing reactor for compensation of capacitive current in networks of 6–10 kV of industrial enterprises is based on the device for determining the damaged line and the phase of the electrical network.

Designed control circuit device. In the three-phase electrical network, symmetric parameters of active and capacitive insulation conductances are set, which is presented in Table 1.

Table 1 - parameters of active and capacitive conductance of network insulation

Active conductivity of insulation cm			Capacitive conductivity of insulation, cm		
Фазы А	Фазы В	Фазы С	Фазы А	Фазы В	Фазы С
0,5x10^{-3}	0,5x10^{-3}	0,5x10^{-3}	1,5x10^{-3}	1,5x10^{-3}	1,5x10^{-3}

With an increase in the active conductivity of the insulation in the studied network of phase A by the value of 0.001 cm, the voltage at phase B rose from 57 V to 84 V, and the voltage at phase C rose from 57 V to 92 V. The change in phase voltages shows the adequacy of the obtained mathematical model in three phase electrical network based on measuring the magnitude of the voltage modules of phases A, B and C relative to the ground and line voltage, which allows the state of electrical safety to be assessed during operation of electrical installations with a voltage higher than 1000 V.

CONCLUSION

In this work, a method of automatic regulation of an arc suppression reactor in networks of 6–10 kV is based on regulating the inductance of an arc suppression reactor depending on the magnitude of the zero sequence voltage, while determining the damaged phase of the electrical network.

The developed mathematical model of a three-phase electrical network is based on measuring the magnitudes of the voltage modules of phases A, B, C relative to the ground and line voltage, and is implemented by a mathematical relationship that allows to simulate the state of existing electrical installations with a voltage higher than 1000 Depending on the magnitude of the zero-sequence voltage electrical network.

Experimental studies in the laboratory of the method of controlling an arc-suppressing reactor to compensate for capacitive current in networks of 6–10 kV in industrial enterprises, which proved to be effective due to the use of a device for determining the damaged phase in networks of 6 to 10 kV, were carried out.

Using the method of automatic regulation by an arc-suppressing reactor in a 6 kV network, to reduce the single-phase short-circuit current to earth, it improves: the reliability of the power supply system and the increase in electrical safety during operation of the existing 6 kV electrical installations of industrial enterprises.

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КӨЛЕМДІК АҒЫМДАРДЫ ҚОЛДАНУ ҮШІН АРКА РЕАКТОРЫН БАҚЫЛАУЫНЫҢ ӘДІСТЕМЕСІН ДАМЫТУ
6 - 10 КВ КЕРНЕУ ЖЕЛІСІНДЕ

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Түйін. 6 – 10 кВ желілердегі доғалы сөндіру реакторын автоматты түрде реттеу әдісі электр желісінің зақымданған фазасын анықтау кезінде нөлдік тізбектің кернеу шамасына байланысты доға сөндіру реакторының индуктивтілігін реттеуге негізделген. Үш фазалы электр желісінің дамыған математикалық моделі жер, желілік кернеуге қатысты А, В, С фазаларының кернеу модульдерінің шамаларын өлшеуге негізделген және 1000 В жоғары кернеулі қолданыстағы электр қондырғыларының жай-күйін модельдеуге мүмкіндік беретін математикалық қатынастар арқылы жүзеге асырылады.

Доғалық сепараторды бақылауды эксперименттік зерттеу өнімділігі 6-10 кВ өнеркәсіптік желілерде сыйымдылықты өтемді өтеу 10 кВ - 6 бөлінген фаза кернеу желілерін анықтау үшін құрылғыны пайдалану арқылы. 6-10 кВ желілерінде доғаның күшейтетін реакторы арқылы автоматты түрде реттеу әдісімен бір фазалы жерге тұйықталған токты төмендету үшін: 6-10 кВ кернеумен жұмыс істейтін электр қондырғыларын пайдалану кезінде электрмен жабдықтау жүйесінің сенімділігі мен электр қауіпсіздігін арттыру.

Кілттік сөздер: ток, кернеу, электр қауіпсіздігі, желі, бейтарап.

РАЗРАБОТКА СПОСОБА УПРАВЛЕНИЯ ДУГОГАСЯЩЕГО РЕАКТОРА ДЛЯ КОМПЕНСАЦИИ ЕМКОСТНОГО ТОКА В СЕТЯХ НАПРЯЖЕНИЕМ 6 – 10 КВ

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Резюме. В работе разработан способ автоматического регулирования дугогасящего реактора в сетях напряжением 6 – 10 кВ основан на регулировании индуктивности дугогасящего реактора в зависимости от величины напряжения нулевой последовательности, при определение поврежденной фазы электрической сети. Разработанная математическая модель трехфазной электрической сети основана на измерении величин модулей напряжений фаз А, В, С относительно земли и линейного напряжения, и реализуется математической зависимостью, которая позволяет моделировать состояние действующих электроустановок напряжением выше 1000 В. Проведены экспериментальные исследования в лабораторных условиях способа управления дугогасящего реактора для компенсации емкостного тока в сетях напряжением 6 – 10 кВ промышленных предприятий, которое показало свою эффективность за счет использования устройство определения поврежденной фазы в сетях напряжением 6 – 10 кВ. Использование способа автоматического регулирования дугогасящим реактором в сетях напряжением 6 – 10 кВ, для снижения тока однофазного замыкания на землю обеспечивает повышение: надежности системы электроснабжения и рост уровня электробезопасности при эксплуатации действующий электроустановок напряжением 6 – 10 кВ кВ.

Ключевые слова: ток, напряжение, электробезопасность, сеть, нейтраль.