Recognition of Emergency Situations in Long Lines Based on the Square-Integrated Characteristics of Coordinate Regime

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Abstract – it the article considered square-integrated method recognition regimes of three-phase short circuit and starting large motors rated voltage of 10 kV in long lines.

Key words – recognize, three-phase short circuit, starting motors.

I. Introduction

The main requirements that apply to the relay protection (RP) power transmission lines (PTL) it's the reliability of operation, selectivity and speed. The problem of selectivity is solved in different ways, where an important role is played the accuracy of processing information. Setting fact of abnormal regime implemented method comparing the current values of the allowable coordinate mode which are set respective setpoint. Apart from to reduce losses from the effects of overcurrent emergency operation should quickly identify the damaged item and unlock it from electric network the devices of RH [1].

Also in an electric network often have regimes and processes images whose coordinates are similar and they are normal exploitation regimes. For example, the processes for leap loading and three-phase short circuit (SC) or processes starting large motors and three-phase fault, etc.

The traditional way to protect power line networks 6 - 35 kV is the current cutoff, current protection with dependent or independent time delay and maximum current protection [2]. Operation times of current cutoff without time lag of 0.06 - 0.1 s, the need for coordination of defense to the action switches that triggered during atmospheric discharges. For the protection from slightly different approach for determining emergency situations include: high-speed method of current protection [3].

Most of the methods as mentioned above, a certain current value is compared with the corresponding setpoint, as our purpose is to create a method of recogniton, the implementation of which would not require reconfiguration for changing the networkconfiguration or its parameters. In other words, our task is to determine whether the images of the regime in certain situations are similar, regardless of the specific network settings, and if so, to explore the possibility of recognition of images.

II. Research results

Fig.1 and Fig.2 shows the equivalent circuit of the electric network 10 kV, which includes a source of emf, power transformer TMN-6300/110/10 aerial power lines performed gird A-25 length of 40 km and load (asynchronous electric series A4-85 / 43-4U3 capacity of 630 kW) for modeling three-phase fault regimes and start motors respectively. Digital simulations carried out in the emergency program complex RE [5].

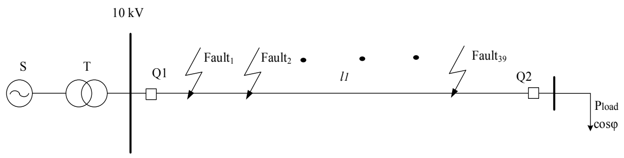

Fig. 1. The scheme of the electrical network for modeling three-phase fault in the software complex RE

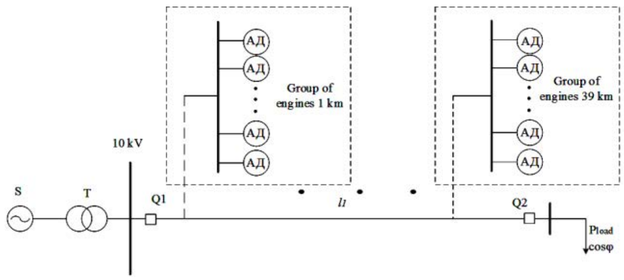

Fig. 2. The scheme of the electrical network for modeling of engine start-up in the software complex RE

For the development of device RH of SC must investigate the images coordinates regime, as at the time of short circuit and during its liquidation regime and automatically reclosing (APV).

On Fig.3 presents images of current of phases at the beginning of the line obtained through modeling processes electrical network shown in Fig.1 and Fig.2 regimes: a) three-phase short circuit at a distance of 1 km from the power source; b) three-phase short circuit at a distance of 39 km from the power source; c) Start of engines in the distance of 1 km from the power source; d) Start of engines in the distance of 39 km from the power source.

As shown in Fig.3 all described images of current regimes are similar and are characterized by a simultaneous increase in current in all phases. At the same time, it is clear that the character of this change for both regimes is different. Also it is necessary note that with increasing distance from the power source to the of electric motors a change flow of process of starting - it is longer.

In [6] are applying differential difference method of identification circuit and load surge load. The result of these studies found that distinguish the mode of three-phase circuit load surge load can be half-period power frequency. However, this method does not allow to clearly distinguish the image coordinates of three-phase short circuit regime of image coordinates regime start engines.

Consider solve this problem by using the square-integral method:

- instantaneous coordinate regime calculates the square

$$I(t)_{(A,B,C)} = (i(t)_{(A,B,C)})^2, \qquad (1)$$

where $i(t)$ – instantaneous current, A.

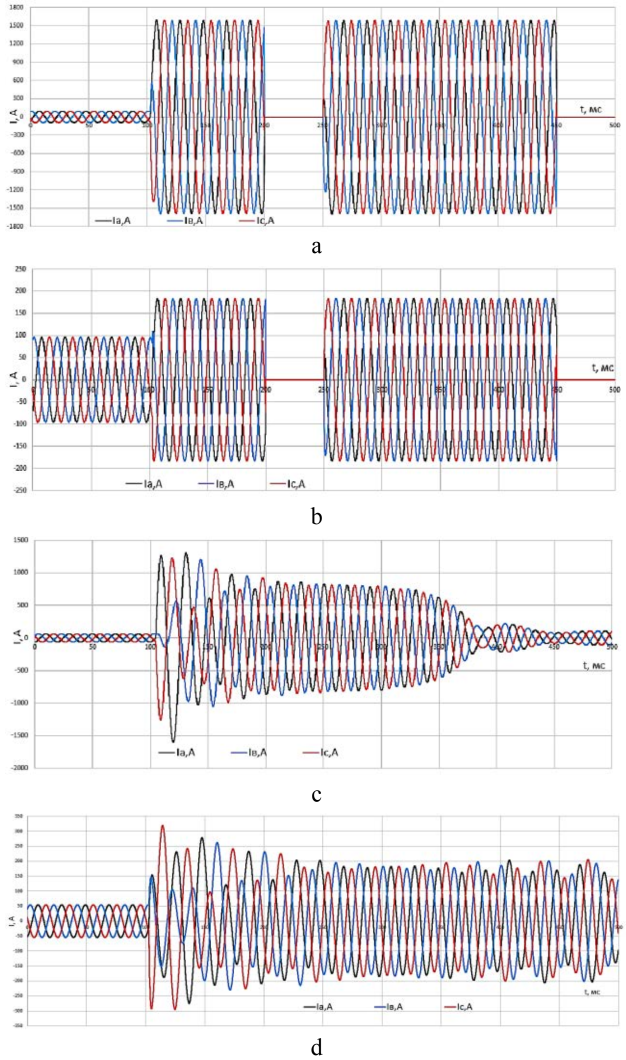

Fig. 3. The images of current of phases at the beginning of the line for: a) three-phase short circuit at a distance of 1 km from the power source; b) three-phase short circuit at a distance of 39 km from the power source; c) Start of engines in the distance of 1 km from the power source; d) Start of engines in the distance of 39 km from the power source

➢ find the difference function by subtracting the running instantaneous value coordinates regime squared (I_i) the value of the previous period ($I_{i-2\pi}$)

$$H(t)_{(A,B,C)} = I(t)_{(A,B,C)} - I(t - 0.02)_{(A,B,C)}, \qquad (2)$$

➢ find square-integral function according to the formula

$$\Delta I(t)_{(A,B,C)} = \int_{j}^{\frac{0.01}{30}+j} H(t)_{(A,B,C)}\,dt \qquad (3)$$

where $j = n\dfrac{0.01}{30}$, $n = 0, 1, 2, \ldots$.

In Fig.4 shows the result of computing square-integral characteristics (SIC) for three-phase short circuit and starting the engine at 1 and 39 km from the power source accordingly.

From Fig.4, to see that in the case of liquidation of a three-phase short circuit it comes SIC (areas 2-3 and 6-7). This allows you to discern the emergence of a three-phase short circuit on its liquidation.

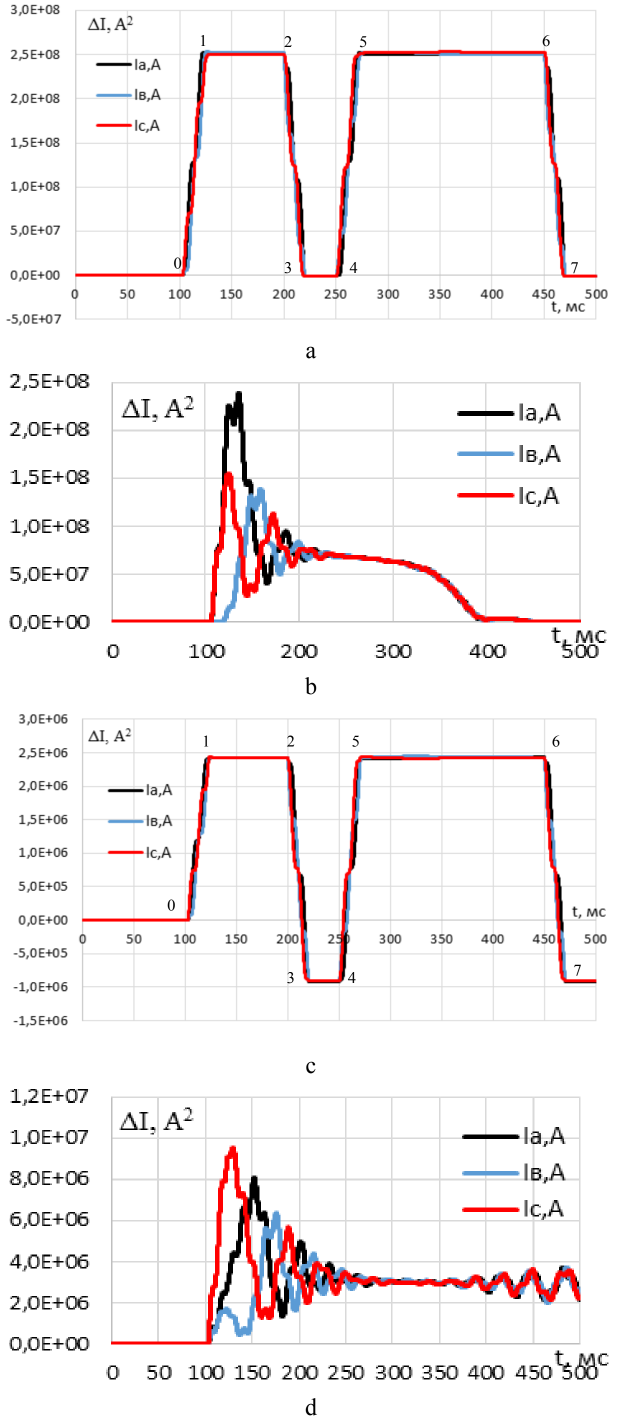

Fig. 4. The quadratic-integral characteristics of phase for: : a) three-phase short circuit at a distance of 1 km from the power source; b) three-phase short circuit at a distance of 39 km from the power source; c) Start of engines in the distance of 1 km from the power source; d) Start of engines in the distance of 39 km from the power source

From Fig.4 shows that the transition process of three-phase short circuit SIC different from SIC the transition process of starting engines. With that characteristic to starting engines (Fig.4, b, d) has a significant impact distance of their place of establishment to a power source

During engine start replacing integrals phases $\Delta I(t)_A$, $\Delta I(t)_B$ and $\Delta I(t)_C$ (Table.1) is not the same. The amplitude of these currents varies as the rate of increase of SIC. In its turn SIC current phase by phase short circuit regime is more similar. That regime distinguished three-phase short circuit on the mode you can engine start in magnitude maximum values SIC phases A, B and C and on their rate of change.

TABLE 1

INDICATORS OF SQUARE-INTEGRATED CHARACTERISTICS DEPENDING ON THE TYPE OF ABNORMAL SITUATION AND ITS PLACE OF ORIGIN

Dist.	1 km				39 km			
Phase	Three-phase short regime		Starting engines regime		Three-phase short regime		Starting engines regime	
	Max. value., A^2	Speed of change, A^2/мс	Max. value., A^2	Speed of change, A^2/мс	Max. value., A^2	Speed of change, A^2/мс	Max. value., A^2	Speed of change, A^2/мс
A	2.53×10^8	1.27×10^{10}	2.25×10^8	1.13×10^{10}	2.41×10^7	1.21×10^9	3.08×10^7	1.54×10^9
B	2.33×10^8	1.16×10^{10}	1.6×10^7	8×10^8	2.42×10^7	1.21×10^9	1.57×10^7	7.85×10^9
C	2.15×10^8	1.09×10^{10}	1.55×10^8	7.75×10^9	2.4×10^7	1.2×10^9	9.08×10^7	4.54×10^9

The ultimate sign of recognition of emergency situations may be comparing themselves transient SIC (TSIC) for both phases studied modes (Fig.5).

In Fig.5 shows a comparison result TSIC phases of abnormal situations (4)

$$k_{AB} = \frac{k_{\Delta IA}}{k_{\Delta IB}}, k_{BC} = \frac{k_{\Delta IB}}{k_{\Delta IC}}, k_{CA} = \frac{k_{\Delta IC}}{k_{\Delta IA}}, \quad (4)$$

where $k_{\Delta IA}$, $k_{\Delta IB}$, $k_{\Delta IC}$ – function comparison TSIC with the benchmark image of an abnormal situation (5)

$$k_{\Delta I(A,B,C)} = \frac{\Delta I(t)_{(A,B,C)}}{\Delta I_{\max(A,B,C)}}, \quad (5)$$

where $\Delta I(t)_{(A,B,C)}$ – instantaneous of TSIC respective phases; $\Delta I_{\max(A,B,C)}$ – maximum value of at the end of the first period of an abnormal situation.

As benchmark of TSIC take a three-phase short circuit and starting of electric motors at a distance from the power source 1 km. For better visibility doable TSIC comparison with benchmark TSIC in case of abnormal situations at a distance of 15 km and 39 km.

In case of a three-phase short circuit of comparison TSIC phase is in the vicinity of the unit (Fig.5, b). Also shows that the amount TSIC three phases almost equal to three.

With Fig. 5, b, d shows that comparative TSIC functions are not the same. This feature is related to the influence of the distance from the power source to the set of engines. However, this distance is known beforehand as establishing engines at energy facilities is carried out according to the developed projects. While the distance from the power source to the place of origin of the three-phase short circuit is random.

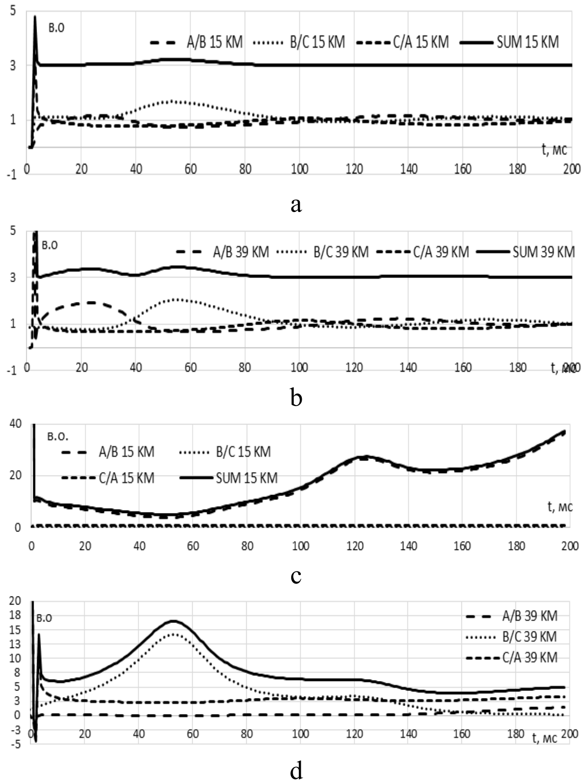

Fig. 5. The ratio of the TSIC phase for:a) three-phase short circuit at a distance of 1 km from the power source; b) three-phase short circuit at a distance of 39 km from the power source; c) Start of engines in the distance of 1 km from the power source; d) Start of engines in the distance of 39 km from the power source

It is also worth noting that in the case of electric start each comparative tool has certain direction. For example, one of the interfacial relationship goes to a value that is significantly higher than other attitude (at Fig.5, b ratio A/B 0.0124 at time of 26.4 sec.; Acting on Fig.5, d ratio B/C – 14.2 acting at time 0.0052 sec.), while the second ratio tends to zero (at the maximum Fig.5, b B/C – 0.344 acting 0.0049 sec. at time and on Fig.6, d ratio A/B to the time amounted to 0.0137 sec. less than 0.181 r.u), and the third – changes in the vicinity of a certain size (in relation Fig.5, c C/A change in the neighborhood of 1 r.u.; Fig.5, d ratio C/A is changing in the vicinity of 3 r.u).

Conclusion

Comparing SIC coordinate regime with standard allows high-speed SIC recognize emergency lines of considerable length for the time corresponding half-period power frequency.

By analyzing the comparison TSIC phase coordinate regime engine start, we can say that: first, a feature comparison TSIC phase changes in the vicinity of 1 acting, secondly, another comparison TSIC phase changes in the vicinity of zero and continue third, the last comparison TSIC phase goes to a value that is significantly higher than other relationships.

Changing the character comparison function PKIH phase coordinates regime engine start caused by changing the distance from the power source to the set of engines. Since this distance is known beforehand, then determine the appropriate PKIH is not difficult.

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