METHODS OF PROTECTION AGAINST SINGLE-PHASE SHORT CIRCUIT TO EARTH IN NETWORKS WITH ISOLATED NEUTRAL

Nurov Xomid

Lecturer at Bukhara Institute of Natural Resources Management E-mail: n.homid1965@gmail.com

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***Introduction**: With the development of the energy industry, various types of problems began to arise related to the transmission, distribution, consumption, improvement of the quality of transmitted energy, as well as the problem of protecting networks from various types of damage. One of the problematic tasks of the power transmission system in networks with isolated neutral is protection against single-phase short circuits to earth.*

Аннотация.*С развитием энергетической отрасли стали возникать различного рода проблемы, связанные с передачей, распределением, потреблением, улучшением качества передаваемой энергии, а также проблемой защиты сетей от различных видов повреждений. Одной из проблемных задач системы передачи электроэнергии в сетях с изолированной нейтралью является защита от однофазных коротких замыканий на землю.*

Methods: One of the most common types of damage on power lines is a single-phase earth fault - this is a type of damage when one of the phases of a three-phase system is shorted to earth or to an element electrically connected to earth. The processes occurring in the network during such a short circuit largely depend on the mode of operation of the neutral of this network.

Cases of single-phase earth faults can be very different, but they all occur due to a violation of the transmission equipment of electrical installations, especially on cable or overhead power lines. Insulation failure can occur due to its aging, as well as mechanical consequences at the electrical installation, most often this occurs during significant earthworks or a tree branch falling on overhead lines, etc.

In the CIS countries, in networks with a voltage of 6-35 kV, the neutral mode isolated from the ground is used.

Methods of the last century

Individual protections are the simplest, but at the same time they have a high percentage of false positives.

1. Zero sequence current protection.

The simplest and most common of the protection against SPZ is the current individual protection of the zero sequence, which reacts to the zero sequence current (hereinafter referred to as NP) of the operating frequency. However, to ensure the conditions of selectivity of action, these protections must have a detuning from the feeder's own capacitive current, taking into account the surges of the capacitive current at the moment of switching on, it limits the sensitivity of the protection.

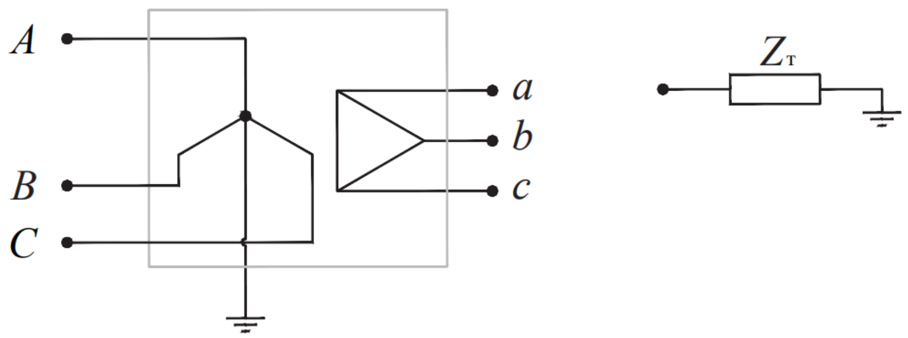

Figure 1.

Zero-sequence equivalent circuit of a transformer with a star-delta connection of the transformer windings

In general, an individual non-directional overcurrent protection against SPCA can only be effective in installations with a large number of connections connected to the section, each of which has a small capacitive current. Then detuning from this current will not lead to an unacceptable decrease in sensitivity. This case is typical, for example, for workshops of enterprises with a large number of low-power electric motors connected by short cables. However, if an arcing reactor is installed in such a network, then protection built according to this principle is not able to ensure stable operation, since the capacitive current of 50 Hz of the damaged connection will be compensated.

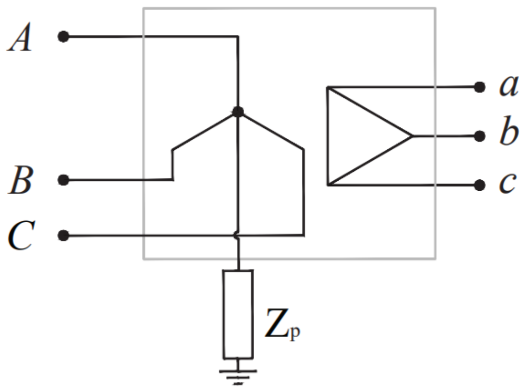

Figure 2. Neutral grounding through resistance

2.Current directional zero sequence protection.

Protections using only one PV current signal, despite their simplicity, are significant phenomena that lead to their non-selective actions. In the course of a consistent increase in efficiency, two protective signals began to be used - the current and voltage of the NP to determine the directions. A large number of directional protections react to the direction of the zero sequence power in the set mode. The sensitivity of such protections is higher than non-directional ones, since their current is disconnected only from the unbalance current in the maximum operating mode, and detuning of protection from its own capacitive current line is not required, since it is globally detuned from this current. A common disadvantage of the protective type is non-selective actions or failures in actions during intermittent arc faults.

3. Zero sequence active power protection.

Another method for determining a faulty connection from the current and voltage signals of the LP is the calculation of the active power of the zero sequence in the steady state. Protections implemented according to this principle have a higher stability of operation in modes with an intermittent arc at the fault site and are more tuned against capacitive current surges in transients. It is possible to ensure the stable functioning of such protections mainly in networks with resistive neutral grounding.

4. Zero sequence protection for higher harmonic currents.

Since the main disadvantage of protections that use currents and voltages of industrial frequency NP is that they are not able to work in networks with a compensated neutral due to the lack of a stable useful signal with a frequency of 50 Hz, protections against single-phase earth faults have been developed that respond to higher harmonics of electrical quantities. During arc faults, the content of higher harmonics in the network increases sharply, especially in the current of the damaged line, where their proportion is much greater than in the zero sequence currents of undamaged lines. These processes are observed in networks of all types of neutral grounding.

General disadvantages of devices made using higher harmonics:

- probability of detection in case of SP by transient resistances;

- instability of the composition and the highest level of harmonics in the NP current.

Features of detecting non-excitability when detecting ground faults and excitation in case of violations of the absolute measurement organs, the harmonic increases mainly at large substations and power plants with a large number of connections.

5. Protection that reacts to the imposed current.

To increase the stability of protection against single-phase earth faults that respond to a non-commercial frequency fault current, protection has been developed that responds to an imposed current. The superimposed current can be either above or below the mains frequency. To create a current of increased frequency, you can use a non-linear resistance connected between the network neutral and earth. However, such an arrangement greatly increases the cost of such protections and may reduce the reliability of the protection. It can also be noted that a significant high-frequency component may be present in the connection currents in normal mode. First of all, this applies to networks associated with industries that have a non-linear load. In such cases, the described method of protection is unsuitable. In addition, as some studies show, harmonics with a frequency of 100 Hz appear almost 2 times more often than, for example, with a frequency of 25 Hz and their amplitudes are much larger.

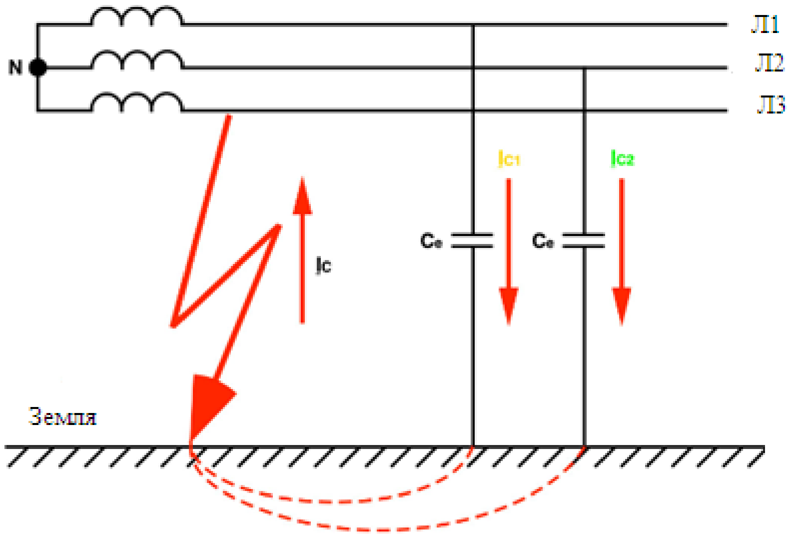

Figure 3.

Network with isolated neutral - short-circuit currents on ground phase L3

The main disadvantages of protections that respond to an imposed current with a frequency below the industrial one include the need to include a special device in the network neutral to create a control current, as well as the impact on stability. Protection that increases with decreasing operating frequency, complication of the primary switching circuit due to the need to connect a superimposed current source and the complexity of connecting an auxiliary current source when using several in a network installed at different sites. Also, there are difficulties in detuning from its own harmonic components at external arc currents of discontinuous circuits, in which the current spectrum depends on the parameters of the network and the mode of grounding its neutral.

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