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TYPES OF PROTECTION AGAINST SINGLE-PHASE EARTH FAULTS (OZZ)

Annotation: *we examined the Factors affecting the protection against OZZ: the type of circuit, the stability of the circuit, the presence of unbalances in the network, transients similar to the processes in the OZZ. We considered various options for protection against OZZ as their complexity and effectiveness increase. Generally divided into two types - individual and centralized protection. Individual protections are the simplest, but at the same time they have a high percentage of false positives.*

Key words: *esistance, reliability, instability, non-directional current protection, overcurrent, failure to operate, detuning complexity.*

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ВИДЫ ЗАЩИТЫ ОТ ОДНОФАЗНЫХ ЗАМЫКАНИЙ НА ЗЕМЛЮ (ОЗЗ)

Аннотация: *Нами были рассмотрены факторы, влияющие на защиту от ОЗЗ: тип цепи, устойчивость цепи, наличие дисбалансов в сети, переходные процессы, аналогичные процессам в ОЗЗ. Также мы выделили различные варианты защиты от ОЗЗ по мере повышения их сложности и эффективности. Два вида - индивидуальную и централизованную охрану. Индивидуальные защиты являются самыми простыми, но в то же время они имеют высокий процент ложных срабатываний.*

Ключевые слова: *сопротивление, надежность, нестабильность, ненаправленная токовая защита, перегрузки по току, отказ в работе, сложность отстройки.*

Factors affecting the protection against OZZ

The problem of the mass application of protection against OZZ is that most of the devices currently used show low efficiency due to frequent failures in operation, false and unnecessary trips. The low efficiency of these protections is associated with the complexity and variety of factors associated with the processes that are used to protect against earth faults. The main factors affecting the operation of earth fault protection are:

1. Type of circuit (metal connection, circuit through transition resistance, circuit through arc);

2. The stability of the circuit (stable and unstable: intermittent circuit and circuit through an alternating arc);

3. The presence of unbalances in the network;

4. Transients similar to those in the case of OZZ (switching on the line, pickup from other power lines in case of OZZ, etc.).

Consider the various options for protection against OZZ as their complexity and effectiveness increase. Basically, it is possible to divide protection against OZZ into two types - individual and centralized protection.

Individual protection - the solution of the last century

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

1. Current protection of zero sequence.

The simplest and most common protection against OZZ is the current individual protection of the zero sequence, reacting to the zero-sequence current (hereinafter referred to as NP) of the operating frequency. However, to ensure the conditions for selectivity of action, these protections must be detached from the feeder's own capacitive current, which, taking into account the surges of the capacitive current at the time of closure, limits the sensitivity of the protection.

In general, individual non-directional overcurrent protection can be effective only in installations with a large number of connections connected to the section, each of which has a small capacitive current. Then the 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 via short cables. However, if an arcing reactor is installed in such a network, the protection built on this principle is not able to ensure stable operation, since the capacitive current of 50 Hz of the damaged connection will be compensated.

2. Current directional protection of zero sequence.

Protections that use only one NP current signal, despite their simplicity, have significant drawbacks that will lead to their non-selective actions. In the course of further improvement of such protections, two signals began to be used - the current and voltage of the NP to determine the direction. A large number of directional protections respond to the direction of zero sequence power in steady state. The sensitivity of such protections is higher than non-directional, since their response current is tuned only from the unbalance current in the maximum operating mode, and the detuning of protection from the line's own capacitive current is not required, since it is aligned in this direction from this current. A common disadvantage of this type of protection is their non-selective actions or failure to operate during intermittent arc OZZ.

3. Protection by active power of zero sequence.

Another method for determining a faulty connection using current and voltage signals of a power supply is to calculate the active power of the zero sequence in steady state. The protections implemented on this principle have a higher stability of operation in the modes with an alternating arc in the OZZ place and are more detuned from surges of capacitive currents in transients. To ensure the stable operation of such protections is possible mainly in networks with resistive earth neutral.

4. Protection of the zero sequence at the currents of higher harmonics.

Since the main disadvantage of protections using currents and voltages of industrial frequency NPs is that they are not able to work in networks with compensated neutral due to the absence of a stable useful signal of 50 Hz, protection against single-phase earth faults that respond to higher harmonics of electrical quantities. With the occurrence of arc SCRs, the content of higher harmonic components in the network increases sharply, especially in the current of the damaged line, where their share is much larger than in the currents of the zero sequence of undamaged lines. These processes are observed in networks of all types of neutral grounding.

General disadvantages of devices made using higher harmonics:

- the probability of a failure in the operation during OZZ through transition resistance;

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

The conditions for the selectivity of malfunctioning with external SCR and the stability of operation with internal damage for devices for absolute measurement of higher harmonics are provided mainly at large substations and power plants with a large number of connections.

5. Overcurrent protection.

To increase the stability of the functioning of protection against single-phase earth faults that respond to a fault current of a non-industrial frequency, a protection was developed that responds to superimposed current. The superimposed current can be either higher than industrial or lower. To create a current of increased frequency, it is possible to use a nonlinear resistance connected between the neutral of the network and the ground. However, this device significantly increases the cost of such protections and can reduce the reliability of the protection. It can also be noted that a significant high-frequency component may be present in the connection currents and in normal mode. This primarily applies to networks associated with industries with 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.

The main disadvantages of protections that respond to an applied current with a frequency lower than the industrial one include the need to connect a special device in the neutral of the network to create a control current, the impact on the stability of the protection of the TTNP errors that increase with decreasing operating frequency, the complexity of the primary switching circuit due to the need to connect the superimposed current source and the difficulties of connecting the auxiliary current source when using several GDRs installed on different volumes in the network ktah. Also, the difficulties of detuning from natural harmonic components with external arc alternating OZZs are not excluded, in which the current spectrum depends on the network parameters and the grounding mode of its neutral, the position of the OZZ point in the network.

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