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Requirements for a microprocessor-based protection system against single-phase ground faults

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ABSTRACT: It is shown that the developed current Converter with pulse-width modulation for small deviations of the pulse width can be represented as a series of connected chains of linear dynamic links with amplitude-pulse modulation, and for more accurate studies of dynamic properties - as a key that forms δ-pulses and a nonlinear shaper that forms positive rectangular pulses.

KEYWORDS: Operating modes of the battery, autonomous power sources, pulse-width regulator, overcharge, control circuit, linear characteristic, negative feedback.

I. INTRODUCTION

Single-phase ground faults (SGF) are one of the most common causes of accidents in distribution power grids, especially in grids with isolated neutral. Such accidents can lead to serious consequences, including equipment damage, reduced reliability of power grids, and a threat to personnel safety. Modern protection systems based on microprocessor technologies allow for effective solutions to detect single-phase ground faults. This article discusses the requirements for a microprocessor protection system against SGF.

II.ENERGY EFFICIENCY

A single-phase ground fault is a situation where one of the phase conductors of a circuit is in electrical contact with the ground. This leads to changes in the normal operating parameters of the network, which must be promptly recorded and eliminated by the protection system.
In isolated neutral networks, the transformer neutral is not connected to the ground, which means there is no direct grounding and no path for the ground fault current. In such systems, in the event of a single-phase ground fault, the fault current is limited only by capacitive currents and can be very small, which complicates fault diagnostics and requires special protection methods.

III.RESULTS AND DISCUSSIONS

In the event of a single-phase ground fault in such networks, the following occurs:
Incomplete closure. The fault current is limited by capacitive currents, which results in voltages that do not exceed safe levels for personnel and equipment, but create a hazard due to the duration of the fault.
Problem of diagnostics. In a network with an isolated neutral, earth fault currents can be so small that standard relays and protective devices may not operate or operate with a delay, which makes their diagnosis and elimination difficult.
In this regard, protection against single-phase ground faults in such systems must ensure high sensitivity and response accuracy at minimum fault currents.
One of the methods of implementing a microprocessor protection system is to record changes in electrical parameters during an isolated neutral fault in electrical networks. To do this, it is necessary to create logical systems that will collect all the data in a short time and take the necessary measures. Which will be implemented using special algorithms for

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comparing the modes during an accident with the operating mode. To do this, it is necessary to first create data collection methods for such microprocessor protection systems.
For a deeper understanding of how the protection system should respond to a single-phase short circuit in such networks, let us consider a mathematical description of the process.

In the case of a single-phase ground fault in a network with an isolated neutral, the fault current is determined through the network capacitive resistance, since there is no direct path for the current. The fault current I_f can be expressed through the capacitive resistance X_C of the circuit:

$$I_f = \frac{U_p}{X_C}$$

where I_f - is the fault current, U_p - is the phase voltage on the line, X_C - is the capacitive resistance between the phase and the ground.
The capacitive reactance for a network with isolated neutral can be expressed in terms of the circuit capacitance C, line length, and frequency:

$$X_C = \frac{1}{2\pi f C}$$

where f - is the line frequency (50 Hz for most countries), C - is the total line capacitance per unit length.
In the case of a single-phase earth fault, the earth voltage U_g can be expressed as a fraction of the phase voltage U_p, depending on the fault resistance and the line capacitive reactance. In a network with an isolated neutral, the earth voltage is determined by the following formula:

$$U_g = U_p \cdot \frac{X_C}{R_f + X_C}$$

where R_f - is the earth fault resistance (with a very high R_f earth fault resistance, the voltage on the ground can be quite high).
In a network with isolated neutral, the fault current is limited exclusively by capacitive currents, which makes it small. However, the protection system must be configured to detect even such small currents. The microprocessor protection system must monitor currents and voltages in real time and trigger when a minimum threshold is reached, for example:

$$I_f > I_{\text{threshold}}$$

where $I_{\text{threshold}}$ - is the minimum threshold for triggering protection, which depends on the type of equipment, network and installation.
The microprocessor protection system must ensure sensitivity to very low fault currents, since in networks with isolated neutral such currents can be extremely small (for example, within a few milliamps). To achieve this, the system must provide the ability to:
Detection of small changes in currents and voltages.
Fast detection of single-phase earth faults, even with very high fault resistance.
To achieve this, the protection system uses digital filtering and signal analysis algorithms that allow for the accurate detection of low currents and voltages typical of single-phase short circuits.
The microprocessor protection system must be configured in such a way as to minimize the probability of false alarms that may occur due to changes in the network (for example, due to voltage or current fluctuations caused by external influences). This is achieved by using:
Algorithms for detecting only those changes that correspond to a real short circuit.
Setting threshold values for triggering protection, taking into account the network type and possible parameter fluctuations.

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For our case, detection algorithms. It is necessary to automatically detect and recognize abnormal conditions of power transmission line equipment.
In the case of a single-phase earth fault, it is important to disconnect the faulty section as quickly as possible to prevent further damage to equipment and safety hazards. The response speed of the protection in a network with an isolated neutral must be maximum, despite the small fault currents. This requires:
Quick analysis of the current state of the network and determination of the magnitude of current and voltage.
High-speed response calculation algorithms to minimize response time.

The microprocessor protection system should provide not only protection against accidents, but also monitoring of the network status in real time. In the case of a single-phase ground fault, it is important not only to record the fact of the fault, but also to conduct diagnostics to determine the location and nature of the fault.
This requires:
The presence of an interface for transmitting information about the current state of the network.
Using algorithms to analyze and localize the location of damage, which allows for prompt troubleshooting and minimizing consequences.
Thus, the protection system must be configured to detect currents I_f and voltages U_g in order to effectively respond to emergency situations in such networks.

IV. CONCLUSION

Microprocessor protection systems against single-phase ground faults in isolated neutral networks require high sensitivity and accuracy in detecting small fault currents and voltages. The main requirements are minimization of false alarms, high response speed and the ability to monitor the network status in real time. Such systems significantly increase the reliability of the operation of electric power networks, ensuring the safety of equipment and personnel.

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