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Development of Control Algorithm for Adaptive Leakage Current Protection Devices' using Fuzzy Logic

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Abstract

New approaches and technology of development adaptive to voltage oscillation leakage current protection systems used in isolated neutral system are proposed. The control algorithm of protection device developed using fuzzy logic, which allows adapting of protection devices' thresholds to network parameters changing. Linear integrated and square-law integrated criteria of protection device's threshold adaption for network parameters changing are developed and proved. The model and structure of automatic thresholds adaption system are developed, based on the fuzzy controller.

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Keywords: Leakage current; Fuzzy logic; Adaptive; Control algorithm

1. Introduction

To ensure safe operation of isolated neutral system and electrical equipment in the mining industry, leakage currents protecting devices are widely used [1]. Considerable voltage oscillations observed in mining's power network during operation (-30 % to +20 % from nominal value) because of limited capacity of quarry's networks, that essentially exceeds admissible standards of norm [2]. Thus, oscillations could have a stepwise character associated with switching on – switching off of various electric equipment, or monotonic character associated with smooth changing of loading, and also harmonic character during fluctuations of loading or at periodic switching on – switching off processes of equipment. Application of variable frequency electric drive in mining is also accompanied by voltage oscillation of electric grid. Nevertheless protection device's thresholds remain invariable

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that leads to decreasing of safety level during overvoltage and to malfunctions during under voltage. The leakage currents protection devices aren't used in 6 kV cable power transmission lines which used for electrical supply of digging machines and cabled in open-cast mines and coal pits, because of insufficient response time of existing devices.

Existing leakage currents protection devices is inefficient due to the complexity of the physical phenomena associated with leakage currents. Existing devices do not carry out automatic adapting of thresholds depending on the voltage oscillation in the controllable network nor depending on the single-phase and diphasic short circuits, both of which lead to increasing of the admissible current. In underground electrical supply networks, lengths of protected lines occasionally changes: such uncontrollable changes of parameters lead to decreasing of leakage current protection devices' efficiency. Protection device should possess adaptive properties [3] which allow changing it according to network's characteristics. We have developed an algorithm to control such adaptive leakage current protection system, using fuzzy controller. Proposed control algorithm will provide protection devices with the aforementioned adaptive properties.

2. Development of control algorithm

We have created a model of isolated neutral system using Matlab 7.01 (Fig. 1), in order to develop control algorithm and to measure the features of such network and obtain necessary data [4].

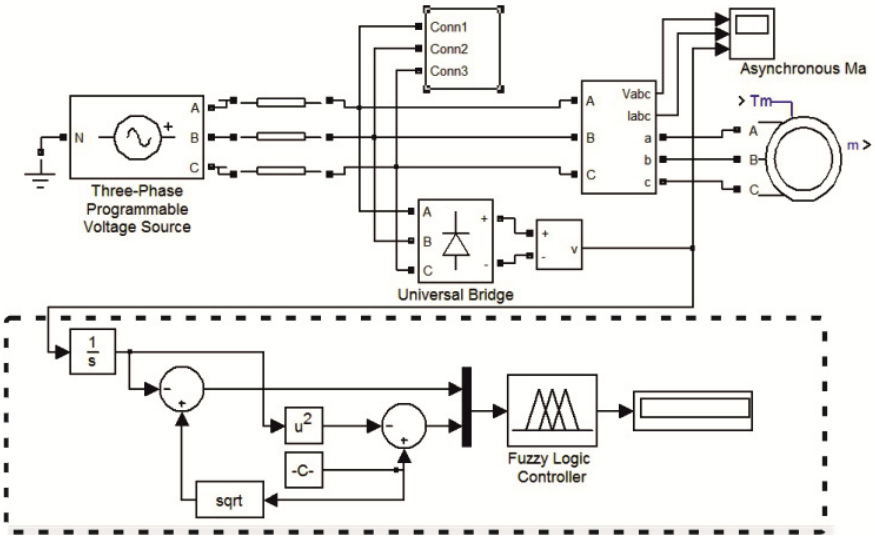

Fig. 1. Model of an isolated neutral system.

In the model stepwise, linear and harmonic changes of voltage are provided. Experiment data of the processes' features received by modelling from output of the scheme 6V. The scheme 6V used as the sensor of leakage current protection device and provides fast response time at the controllable network's voltage oscillation.

For automatic adaption of protection device's thresholds during voltage oscillation it's necessary to determine response criteria. If we choose voltage amplitude changing as response criterion, it will significantly complicate practical realization of system and reduce noise stability that will lead to malfunctions.

We know from the automatic control theory that integrated assessments of quality give the complex characteristics, which directly proportional to energy consumption in the majority of technical systems, that corresponds to controllable network's voltage oscillation. Owing to the linear integrated assessments are applied to monotonous dynamic processes, such criteria are effective at linear and stepwise character of the voltage oscillation. Square-law integrated assessments are applied to oscillatory processes; these criteria are effective at harmonic character of the voltage oscillation.