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Increasing the selective operation of microprocessor terminals

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Abstract: The article is devoted to a comprehensive study of microprocessor protection terminals for contact network feeders in terms of increasing the selectivity of its operation by reducing the number of outages for unknown reasons. The research is based on a method for visualizing, processing and storing information about the magnitudes and duration of currents and voltages (in the form of oscillograms) flowing in the contact network. An option for upgrading the existing terminal is proposed and the possibility of creating an individual template characterizing instantaneous operating parameters (setting) for various modifications of the train schedule (TS) is assessed.

Keywords: relay protection, selectivity, train schedule, oscillogram, spline interpolation, unified template, setting

1. Introduction

Relay protection (RP) is a set of devices designed for quick, automatic (in case of damage) identification and separation of damaged elements of this system from the electrical power system in emergency situations in order to ensure normal operation of the entire system

With the development of relay protection technology, its dimensions and self-consumption have decreased, its characteristics have improved, its performance, sensitivity and reliability have increased, and its operating algorithms have been improved. All this allows us to more confidently solve the main problem: a clear distinction between emergency and normal modes.

The purpose of relay protection and the requirements for it are that the devices must monitor the operation of electrical equipment, respond in a timely manner to changes in the operating mode, instantly disconnect the damaged section of the network and signal to personnel about an accident.

The following requirements apply to relay protection and automation systems:

1. Selectivity. In the event of an emergency, only the area in which an abnormal operating mode is detected should be switched off. All other electrical equipment must work.

2. Sensitivity. Relay protection must respond even to the most minimal values of emergency parameters (set by the response setting).

3. Performance. An equally important requirement for relay protection and automation, because The faster the relay operates, the less chance there is of damage to electrical equipment, as well as danger.

4. Reliability. Of course, the devices must perform their protective functions under the given operating conditions [4, 5].

Their use allows:

– implement fundamentally new possibilities for constructing protections;

– ensure the operation of protection in the presence of incomplete information;

– predict pre-emergency situations;

– implement self-diagnosis of protection;

– implement higher quality characteristics;

– process a large amount of information, incl. and from adjacent objects;

– implement self-adjusting (adaptive) systems.

The greatest effect of a microprocessor protection (MPP) system is realized when it is used in a complex manner, when not only the functions of relay protection and automation are performed, but also the location of damage is determined, digital oscillography is used to analyze the reasons that caused the protection to operate, etc. It is also possible to build multi-level automated control systems (ACS) based on MH units, thanks to the combination of protection functions with the functions of communication, data transfer, recording and displaying information (including about emergency situations) [1, 2].

However, there are many problems when using MPP systems:

– issues of operational reliability, etc.;

– problems with electromagnetic compatibility and noise immunity, especially in a situation of increasing danger of intentional remote impacts of powerful directed electromagnetic pulses;

– functional redundancy and complexity of settings for operation;

– relatively high cost;

– excessive sensitivity leading to false alarms;

– reliability is no higher than that of other types of relay protection, even with a built-in self-diagnosis capability.

The undoubted advantage of the MH system includes its design principles, namely: multiprocessing; modularity; decentralization; hierarchy; dynamic redistribution of functions; system development; complex design.

2. Research methodology

The object of further research is the microprocessor protection of AC railway contact network feeders.

This microprocessor protection has a modular-block design system, where current sensor modules (CSM) and voltage sensors (VSM), a measurement and protection controller module (MPCM) and an automation controller module (ACM) are located in a cassette manner (one after another) [3].

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Let's consider the process of operation of the MPP from a hardware and software point of view.

A simplified functional diagram of microprocessor relay protection is as follows (Fig. 1).

The input elements are intermediate voltage transformers IVT and current ICT, the output signals from which are fed to frequency filters (FF), which pass current and voltage components of 50 Hz and do not allow high-frequency harmonics (interference). Next, the analog signals must be converted into discrete ones using an analog-to-digital converter (ADC). The resulting discrete signals in the form of binary code are fed to the input of a programmable microprocessor system (MPS).

MPS functions as follows:

– food is supplied;

– the first command is loaded into the address register (AR);

– the first command transfers control to the control command;

– the control command tests the MPP (memory devices, external devices, etc.), rewrites the main program (MPr) into a random access memory device (RAM) and transfers control to it;

– the main program begins to work, performing the functions of the system in real time: the OPr enters into the OP the instantaneous values of the input signals, converted into digital form using an analog-to-digital converter;

– performs arithmetic and logical operations in accordance with the algorithm;

– compares the converted numbers with the setting of the starting element;

– if the trigger is triggered, the program starts working again.

The operation of microprocessor protection occurs as follows: controlled signals are continuously removed from current and voltage transformers and are fed to primary low-pass frequency filters, where higher harmonic components are cut off.

Next, the current and voltage signals are digitized for the purpose of subsequent discrete Fourier transform, which underlies the operation of digital filters.

The main task of digital filters implemented at the microprocessor software level is to isolate the first (fundamental) harmonic from the input non-sinusoidal signal.

The microprocessor analyzes and processes the parameters of the sinusoidal signal at the software level, issuing the appropriate control action through a digital-to-analog converter to the executive bodies (contact line feeder switches). In parallel, information about emergency modes is sent to the control panel of the operating personnel and stored in the memory module microprocessor protection digital automation protection.

The decision to trigger microprocessor protection is made mainly based on an assessment of the phase difference between the current and voltage vectors. Meanwhile, digital filters provide a large error in determining the phases if the signal frequency deviates from their nominal values.

Microprocessor protection is equipped with a display for current visual monitoring of parameters, but also with the ability to save information about cases of emergency shutdowns, false alarms, etc. Eighteen causes of emergency events are recorded and stored, which are stored in the EMERGENCIES menu and sixteen oscillograms of the last emergency shutdowns of the circuit breaker.

Oscillograms are recorded during recording with a sampling interval of 0.833 ms. The duration of the registration process is 1.2 s: - 0.5 s - accident background (before the accident); - 0.7 s - emergency process.

The contact network is a special case of a standard single-phase (multiphase) electrical network that does not have a reserve (although it belongs to the first category in terms of power supply reliability). Taking into account the specifics of the possible operating modes of the traction power supply system, a number of increased requirements and additional conditions are imposed on relay protection devices for AC contact network feeders.

Microprocessor protection) performs not only the functions of protection and automation, control and alarm, but also local and remote control of the traction network feeder.

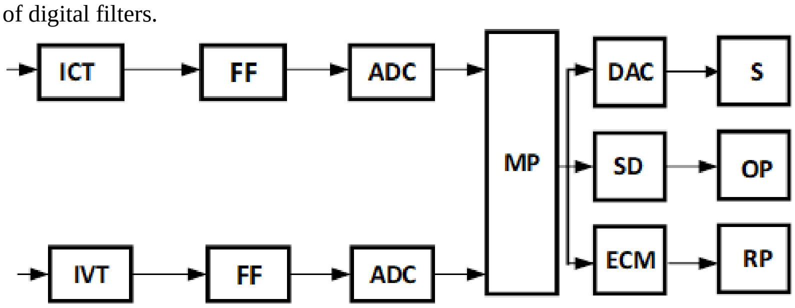

Fig. 1. Block diagram of microprocessor protection:
ICT – intermediate current transformer; IVT – intermediate voltage transformer; FF – frequency filters; ADC – analog-to-digital converter; MP – microprocessor; DAC – digital-to-analog converter; SD – signaling device; S – switch; OP – operational personnel; RP – relay personnel

Since microprocessor protection can be included in the automated control system of a traction substation as a lower-level subsystem, it provides two control modes:

- local control - by buttons located on the remote control unit;

- remote control carried out via a serial channel from an automated control system or through special discrete inputs from a traditional telemechanics rack.

One of the disadvantages in the operation of microprocessor protection is the inability to record into the device’s memory data on changes in currents and voltages flowing in the traction network in on-line mode (only a limited number of emergency oscillograms are recorded) and the ability to visualize them (on-line viewing) on the display control unit.

Investigating the possible reasons that led to such frequent (including) operation for unknown (unidentified) reasons, it can be assumed that rigidly introduced settings (which do not change with changes in the train situation and the operating mode of the traction power supply system) do not allow the relay protection device to recognize the modes , associated with a short-term increase in traction current and a change in the phase shift angle between current and voltage in normal operation when starting heavy trains, when resuming the power consumption mode after passing the neutral insert, when switching operating modes of electric locomotive engines, turning on recuperation modes, and trains entering coverage area of protection and exit from it during a batch traffic schedule, passage of heavy and double trains, etc.

3. Conclusion

As a result of a detailed study and analysis of the operation of existing and operated microprocessor relay protection of contact network feeders from the point of view of their modern level of automation, the following points were identified:

- there is no comprehensive approach to ensuring the reliability of the operating modes of the traction power supply system, including well-founded solutions in terms of hardware and software of devices and relay protection and automation systems, ensuring the survivability of objects of the traction power supply system;
- issues of organizing remote access and cybersecurity have not been fully resolved;
- the development of an automated relay protection system with active-adaptive algorithms is required;
- development of communication networks of information channels about the parameters of moving trains, track profile, train traffic modes, traffic schedules, etc.

The work proposes the following predicted changes in the general level of relay protection and automation systems:

- the use of microprocessor devices with significant computing capabilities;
- distributed hardware architecture - separation of functions between application functions of relay protection devices (formation of a database of settings templates, etc.) and control devices;
- development of communication networks of information channels about the parameters of moving trains, track profile, train movement modes, traffic schedules, etc.;
- use of modern communication means, mainly serial fiber-optic connections for new and modernized systems, duplication of communication ports;
- application of adaptive configuration, built-in damage assessment, improved algorithms for non-traditional instrument transformers;
- comprehensive monitoring of the energy system;
- use of modern automation tools.

The subject of this study is the standard algorithm for the operation of a device for digital protection and automation of a 27.5 kV overhead contact network feeder, which is proposed to be improved through the use of an analog-to-digital converter - an electronic USB oscilloscope, an additional (auxiliary) microcontroller and dedicated wired communication channels according to the “analog block” scheme. - digital converter – microcontroller unit – “GID” software – workplace of the duty personnel of the traction substation.”

The study was carried out using the conversion of instantaneous values of input signals into digital values, the fast Fourier transform method, the method of analytical representation of digitized signals using spline interpolation (first, second and third degrees with various options for gluing functions at their interface points), adaptation methods and joint storage of the received data from the auxiliary microprocessor and with a specialized software shell “GID” (graph of the executed movement) at the workplace of the duty personnel of the traction substation in the form of a database of unified settings templates

References

[1] S.Amirov, D.Rustamov, N.Yuldashev, U.Mamadaliev, M.Kurbanova, Study on the Electromagnetic current sensor for traction electro supply devices control systems, IOP Conf. Series: Earth and Environmental Science 939, 012009 (2021). https://www.researchgate.net/publication/356818951.

[2] S. Amirov, K.Turdibekov, D.Rustamov, S.Saydivaliev. Mathematical models of magnetic circuits of high currents induction sensors for electric power supply systems devices of electric transport. V International Scientific Conference “Construction Mechanics, Hydraulics and Water Resources Engineering” (CONMECHYDRO - 2023), V International Scientific Conference “Construction Mechanics, Hydraulics and Water Resources Engineering” (CONMECHYDRO - 2023).

[3] K.Turdibekov, D.Rustamov, S. Xalikov. Digital protection of electrical equipment in railway transport (2023). E3S Web of Conferences, 461, art. no. 01064, Citedtimes.DOI:10.1051/e3sconf/202346101064https://www.scopus.com/inward/record.

[4] Relay protection and automation in electrical networks (Russian language). - M.: Alvis, 2012. - 640 p.

[5] Лундалин А. А. Направления развития релейной защиты и автоматики в российских электрических сетях (Russian language) / А. А. Лундалин, Е. Ю. Пузина, И. А. Худоногов // Современные технологии. Системный анализ. Моделирование. – 2019. – Т. 62, № 2. – С. 77–85.

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