

SUMMARY
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in specialty 6D071800 – Electric Power Engineering

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DEVELOPING METHODS OF MONITORING THE CONDITION OF HIGH-VOLTAGE OVERHEAD POWER LINES BASED ON THE VALUE OF LEAKAGE CURRENTS WITH TELEMETRIC INFORMATION TRANSMISSION

Relevance of the work

High-voltage overhead power lines (HVOPL) are one of the most important components of a unified power supply system designed to supply consumers with electricity. Taking into account the fact that 110-500 kV overhead lines are strategic objects for the power system of Kazakhstan, accidents on power lines lead to significant economic damage.

The condition of insulation on transmission and distribution lines is one of the basic conditions for the reliable operation of the power supply system. The analysis of the causes of overhead power transmission lines failures shows that a significant number of failures, about 30 % of the total number of damage to all the elements of overhead lines, occur due to the violation of the operating state of high-voltage insulators. The serviceability of insulation of overhead power lines depends on a lot of different factors: natural and climatic conditions of the environment, design features of elements, period of operation, thermal, mechanical, electrical loads.

Damaged insulators or insulators with electrical characteristics that do not meet the operating requirements can lead to interruptions in the operation of the power system, as well as to a significant increase in electricity losses during its transportation along the overhead line.

Studies in the field of behavior and diagnostics of the state of overhead lines insulation during operation are dealt with in the works of many scientists: G.N. Alexandrov, R.S. Arbuzov, A.G. Ovsyannikov, S.D. Merkhalev, E.A. Solomonik, V.V. Rutsikh, P.G. Pleshkov, A.I. Kotysh, and others.

The existing methods of assessing the state of insulation are based on the data from periodic inspections of overhead lines and they have characteristic drawbacks: long intervals between checks, high cost of work and, as a result, low reliability of the survey results. The limited ability to detect defects in insulators, especially at the initial stage of their inception, the inability to provide the required reliability and promptness of obtaining the information of changes in the state of insulation, the increased danger and the need for a number of methods of disconnecting equipment from voltage cause insufficient effectiveness of the methods considered.

Therefore, the improvement of systems for remote monitoring of the state of insulation in real time under operating voltage is the only way to determine the current state of high-voltage insulation, expanding the functions of already existing systems

for monitoring the state of insulation of overhead lines, as well as analyzing the possibilities of predicting the resource of insulators based on continuous monitoring of their condition is relevant and expedient.

The purpose of the dissertation work is to improve the diagnostics of external insulation of overhead power lines during operation by developing a method for remote monitoring of the state of insulation of overhead lines, based on continuous telemetric monitoring of the leakage current parameters, which makes it possible to assess its current state and to predict the resource (service life).

The idea of the study is to determine the parameters of the leakage current of strings of high-voltage insulators of overhead power transmission lines of alternating current during operation under operating voltage in the "real" time mode based on a set of scientific and technical solutions that ensure measuring leakage current signals, their noise-free transmission via the telemetric channel, which allows judging a potentially dangerous state and predicting the resource of insulators based on the analysis of these currents.

The object of the study in the work is the external insulation of 110 kV - 500 kV alternating current high-voltage overhead power lines.

The tasks solved to achieve the purpose in the dissertation work are as follows:

- analyzing the causes of failures and damage to elements of overhead lines depending on the voltage class and service life;
- substantiating and selecting criteria for assessing the quality of insulation of high-voltage transmission lines;
- studying and developing methods and means to ensure effective diagnostics, monitoring and forecasting of the state of suspended insulators of high-voltage power lines;
- developing principles of transmitting telemechanical information of the insulation state of high-voltage overhead lines;
- developing and selecting noise-proof algorithms of transmitting the information of the state of high-voltage overhead lines suspended insulators.

Scientific novelty consists in the following:

- a method of monitoring the state of insulation, which makes it possible to judge the degree of pollution and to predict the resource of high-voltage insulators of overhead line;
- noise-proof algorithms that ensure reliability of collecting and transmitting the information of the state of insulation from overhead transmission line supports under the effect of electromagnetic interference and fields.

The main scientific provisions and results presented for the defense:

- principles and methods of diagnostics of overhead power transmission lines insulation during operation under operating voltage in "real" time mode;
- principles and methods of ensuring noise-immune transmission of information in the systems of remote monitoring the state of insulation of overhead lines from overhead line supports in conditions of electromagnetic interference;
- methods of predicting the resource of insulators based on continuous analysis of leakage currents in strings of high-voltage insulators.

Research methods: scientific and practical results of the dissertation work were obtained using the methods of theory of electrical engineering, coding and transmission of information, setting and planning an experiment, probabilities and statistical data processing. Simulation studies and simulation results were performed in the Multisim Design software environment. Analyzing and processing experimental data was carried out in Microsoft Excel.

Practical significance of the results obtained consists in the following:

- developing a technical solution for the control and analysis of leakage current parameters with telemetric transmission of information from overhead transmission line supports;

- developing a methodology for determining the degree of pollution of high-voltage insulators and predicting their resource during operation, which makes it possible to increase the reliability of overhead power transmission lines and to reduce electricity losses during its transportation.

- developing a set of technical solutions for designing a system of remote monitoring the state of external insulation of overhead lines.

Justification and reliability of the results and conclusions. Scientific provisions, research results and conclusions are published in scientific literature, are confirmed by assessing the adequacy of the materials of computer modeling and experimental research and are consistent with the results of the work of other authors published earlier.

The volume and structure of the work. The dissertation work consists of an introduction, four chapters, a conclusion, a list of used literature including 117 titles and 3 appendices. The total volume of work is 127 pages including 24 tables and 65 figures.

The main results of the studies performed are as follows:

- the analysis of the causes of failures in operation and damageability of the elements of overhead lines was carried out;

- a review of research and technical solutions in the field of monitoring the state of insulation of overhead lines was carried out;

- there were considered simulation models that assessed the effect of various factors on the state of insulation of overhead lines. Based on the models obtained, experimental studies were carried out to determine the criteria for assessing the state of insulation;

- a method of monitoring the state of insulation under operating voltage has been developed, which makes it possible to monitor the degree of contamination of the insulation and to make a possible forecast of the insulators service life;

- a technical solution has been developed that makes it possible to monitor the current state of insulation of overhead lines in real time, determine the degree of pollution, draw conclusions about the place of possible insulation overlap, and also predict the possible time interval for which the state of insulation can reach the maximum permissible value, when its further operation should be stopped;

- methods of organizing a channel for transmitting the information of the state of insulation from overhead line supports were considered and noise-proof algorithms for

transmitting information under the effect of electromagnetic interference were developed;

- experimental tests of the information transmission through various communication channels were carried out and areas were determined in which reliable information transmission is possible in conditions of electromagnetic interference and overhead line fields

- a block diagram of the remote monitoring system has been developed for timely and reliable monitoring of the insulation condition;

- experimental tests of a prototype leakage current sensor for high-voltage insulators of overhead lines were carried out, based on the results of which the predicted values of leakage currents were calculated using the proposed method;

- the main scientific provisions of the dissertation are protected by patents of the Republic of Kazakhstan.

Personal contribution of the applicant consists in solving research problems, developing and substantiating the provisions that make up the scientific novelty and practical significance of the work, developing and manufacturing an experimental setup and a prototype of the proposed technical solution, in analyzing and processing experimental data.

Information of publications.

The main provisions of the doctoral dissertation were published in 15 scientific papers, including 4 articles publications recommended by the CCES, 2 publications included in the information base of Scopus database, 7 publications in international scientific and practical conferences, including 5 foreign (2 indexed in the Scopus database), 2 innovative patents of the Republic of Kazakhstan.