Control and Monitoring Elements of High-Voltage Power Lines System

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**Abstract**

This paper presents the development of control and monitoring elements of high-voltage power lines system, which should provide emergency descent and increase the reliability of power transmission at high voltage power lines. Control and monitoring system consists of 4 levels. Each level solves the problem described in the article. It is also represented by the hardware of each level. The block diagram of the system’s hardware and the connection of functional blocks are presented in the article.

**Keywords:** control, monitoring, electrical network, high-voltage power lines, support of high-voltage power lines, leakage current, insulators, icing accident.

**INTRODUCTION**

The electrical network is a set of electrical installations for power transmission and distribution. It consists of a substation, switchgear, conductors, overhead and cable transmission lines, distributed over large areas, and refers to the distribution of technological complexes. Accidents on the high-voltage lines may be associated with insulation breakdown, breakage of current-carrying wires, supports of high-voltage power lines fall. They can lead to a lack of power supply of entire regions of the country. The present level of development of software and hardware automation makes it possible to create a system of control and monitoring elements of high-voltage power lines, with the transfer of information in the control room for the prevention and elimination of emergency situations. Developments in the field of distributed systems of information transfer along high-voltage lines are not available. Therefore, the creation of such a system is an urgent task that will ensure reduction of accidents and increase the reliability of power transmission on strategic high-voltage power lines.

Reliability of operation and the value of active power losses of transmission lines depends on the state of suspension insulators. Condition monitoring is carried out by suspension insulators periodic testing high voltage, resistance measurement, control voltage distribution on insulator structure, their visual inspection. The ineffectiveness of these methods is the complexity, high-risk and the need to disconnect the equipment from the power source. Such methods is not possible to detect the deterioration of the insulation or the insulators at an early stage of their operation. The main parameter characterizing the condition of the insulation are leakage currents. In the development of the automatic control system of the state of suspension insulators should be performed by measurements of leakage currents. Information about the state of insulators of high-voltage transmission line supports must be periodically transmitted to the control station [1].

Icing accident at the high-voltage lines are one of the most difficult and hard disposable due to off-road winter, frozen ground, and at the same time a large number of affected areas. Due to the icing deposits on the wire and ground wire appears broken wires, insulators mechanical destruction and
deterioration of their properties. Timely removal of ice on the wires is an important task of power supply organizations [2].

THE STRUCTURE OF THE SYSTEM
Control and monitoring system consists of 4 levels.
The zero level of the complex allows using the control indicator sensors to monitor parameters: leakage currents of insulators, icing current wires, the positioning of the support of high-voltage power lines, the amplitude of the vibration supports.

The first level in each support of high-voltage power lines are transmitted telemetry data from the sensors to a local subsystem of collection and primary processing and preparation of the information collected for subsequent transfer it to the control station.

The second level of the system is realized the following tasks:
- the transfer of information from the supports (from the local collection and primary processing sub-systems) to the control station;
- systematic diagnosis telemetry communication channel.

The third level of the system is realized the following tasks:
- analysis of information on the reliability;
- restoration of lost or inaccurate information;
- construction of approximating functions of emergencies;
- construction of predictive models;
- diagnosis and localization of accidents occurring;
- notification of the dispatcher on the ensuing emergency;
- the formation of the current accounting log information;
- visualization of the received information.
- archiving and storage of incoming information;
- the formation of algorithms and mathematical models of information management with the support of the diagnosed portion of power lines.

The hardware of the zero and first levels of the system consists of the following components:
- Inductive filter in the power supply circuit that protects the hardware of the local system in the event of lightning hit into the ground wire. Structurally is dust - moisture impervious assembly - welding construction;
- An electronic unit serves as the collection, initial processing and transmission of information to the control station. It is an assembly structure, within which are mounted - power supply, telemetry subsystem, control subsystem insulators leakage current, icing control subsystem, coordination unit. Antenna, ambient temperature sensor, connectors for power supply and signal sensors in information is on the electronic unit surfaces. On the shell side is installed icing sensor, Development of software and hardware of the electronic unit and constructions presented in [3].
- Leakage current of pin insulators (of phases A, B and C) sensors perform the functions of control of the integral values of the background current and partial discharge current.
- Icing sensor - is commercially available tens resistance sensor probe, protected by a plastic protective casing cylindrical shape with grooves [4].

The extent of the probe indicates the degree of icing of power lines.

The most difficult tasks in the local system of zero and first levels are the problem of the transmission of information from the sensors and control indicator in the electronic control unit and the provision of electronic power supply unit from the induced energy in the ground wire. These problems were solved in the project [3]. Structurally sensor background current and partial discharge current are combined in a single unit. To solve the first problem developed structural sensor circuit using primary transformer type transducers.

In order to determine the start time of icing wires, through the use of the indirect method, developed the structure of the hardware [3], three types of processing information signals: linear accelerations measured triaxial accelerometer in the three planes X, Y, Z; ambient temperature sensor measuring a parameter; ambient humidity.

Thus, control station in the automated equipment control system from the local system located on each support, the following information signals are transmitted on the telemetry channel [5]:
- humidity of the environment;
- ambient temperature;
- bearing pin vibrations in three planes;
- leakage current of three insulators.

The block diagram of the system’s hardware and the connection of functional blocks are shown in Figure 1.

The electronic unit is placed on each support portion controlled power lines. The structure of each of the electronic unit includes a power supply [6]. Leakage current of pin insulators (of phases A, B and C) sensors, humidity and the ambient temperature sensor, three-axis vibration sensor (accelerometer); coordination unit; transceiving device get their energy from the power supply. Information signals from the sensors and control indicator are input to Preliminary information processing controller. Output signals from the leakage current sensing pin insulators are converted from current to voltage in the form of coordination unit.
LCPIS - the leakage current of pin insulators (of phases A, B and C) sensor; HATS - the humidity and ambient temperature sensor; Three-AVS – the three-axis vibration sensor (accelerometer); EU - the electronic unit, CU – the coordination unit; PIPC – the preliminary information processing controller; TD - the transceiving device; BTE – the basic telephone exchange; S-HNS – the software - hardware network structure, I - the Internet, SS - the server station; DC – the dispatchers’ computers

**Figure 2:** The block diagram of the system’s hardware and the connection of functional blocks

The main functions of the preliminary information processing controller [7]:
- checking of control and indicator sensors;
- checking transceiving device;
- activation of the mode of transmission transceiving device;
- the transfer of information data packet to controller;
- calculation for a given algorithm points in time the onset of ice on wires.

The most popular and up-to-date data in a distributed version control system and monitoring of high-voltage transmission line supports is the organization for GSM data.

When using the GSM wireless technology data can be transmitted in three main ways: by using the service of short messages SMS (Short Message Service), via the GSM voice channel and using a packet data transmission GPRS (General Packet Radio Service) [8].

The main feature of the data transmission using GPRS packet data is the possibility of permanent connection of the subscriber to the network. The radio channel is available to the subscriber only at the time of transmission of the data packet, the rest being used for the transmission of packets other network users. In this process, the organization of communication payment is only for traffic, not for the time of the communication. GPRS technology is optimal for use in continuous monitoring systems, mobile and stationary objects. The maximum possible speed of data exchange via GPRS technology can theoretically reach 170 Kbit / s [9]. The frequency of measurement parameters and leakage currents icing leaves once an hour.

Parameters microcontroller should provide low current consumption, have a sufficient speed and accuracy of the analog signal processing. Number of I / O ports must provide connection to all peripherals without additional electronic modules. It is recommended to use a line of RISC controllers with technology leading firms, manufacturers of electronic components: Company MicroChip or Atmel.

GSM-modem must be configured to transmit telemetry information through GSM-networks of local operators 900/1800 MHz band at a transmission speed of at least 9600 bits / sec [10].

Top of the system is the control station. It collects and displays information from all monitored supports high-voltage lines, the parameters included in the control station monitoring system. Dispatch center is a workstation controller, control cabinet and a personal computer on which the software is installed SCADA-system. SCADA - a software package designed to develop or provide real-time acquisition, processing, displaying and archiving of information on the subject of monitoring or control.

Subsystem information in the system of automatic control of the parameters of high-voltage power line supports should perform the following functions:
- parameter monitoring leakage currents of high voltage insulators in real time;
- monitoring icing high-voltage wires in real time;
- notification of an emergency operator in real time, and archiving;
- representation of measured readings in graphical form;
- generation from the measured parameters reports.

The functions of the monitoring parameters of the current high-voltage insulators leakage includes processing and display the value of current flowing through the insulator current wires.
The functions of monitoring of high-voltage wires icing includes mapping gain mechanical load on the high-voltage wires.

The function of the emergency and archiving operator alert includes a visual and audible alarm on exceeding any of the measured parameter above the limit set by regulations in the operation of high-voltage lines.

The function in the measured readings in graphical form part of the display supports location-bound terrain, the display of measured values as trends for any support and fixation of emergency under certain changes in the monitored parameters.

The reporting functions of measured parameters include the formation of reporting on measurement of the state of elements of high-voltage lines over a certain period and the conclusion in the required form in the «EXEL» file format. It is also possible reporting on emergencies for the period.

CONCLUSION

Control and monitoring system allows sending to supports of high-voltage power lines to the control station following information signals:

- humidity of the environment;
- ambient temperature;
- vibrations in three planes;
- leakage current of three pin insulators.

The system provides visualization and display of leakage current of insulators, the value of the mass of ice on wires. It provides transmission of telemetric information on elements of support by the state of the construction of cellular telephony in the control station.

The system alerts the operator of the emergency situations in real time.

The system provides registration information transmitted from the supports of high-voltage power lines at normal operating conditions - daily, and in emergency mode - hourly.

Transmission of telemetry data to the control station is carried out by means of mobile telephony and the Internet.

REFERENCES


