

# High-voltage smart electricity metering of 110 kV digital electric networks

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**Abstract.** Were considered the technical solutions sufficient for the development of smart systems for automatic information and measurement metering of electrical energy and monitoring of overhead power transmission lines of the 110-220 kV electrical grids, considering the integration of the data flow into Scada-systems of digital substation workplaces in all the accordance with the standard protocols of IEC 61850. The device allows you to control the quality of transmitted electricity, remotely monitor the condition of the line, thereby increasing the reliability of power supply and power flows in the power system, reducing the cost of operational teams for their inspection.

## 1 Introduction

Nowadays, technical solutions in the sphere of the installation of commercial metering points on 110-220 kV power transmission lines are poorly implemented; there is a shortage of domestically developed devices on the manufacturers' market. The measuring indicators of the proposed devices are very huge - usually with the total mass of a metering point in a three-phase version exceeds 250 kg, which complicates the installation and operation. It also leads to significant mechanical loads in ice conditions and, as a result, can cause a faster collapse of power transition lines, figure 1.



**Fig.1.** Collapse of power transition line, caused by icing

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The lack of integration into the Scada-systems and low (limited) functionality of devices reduces the observability of electrical network objects and does not increase its reliability [1, 2].

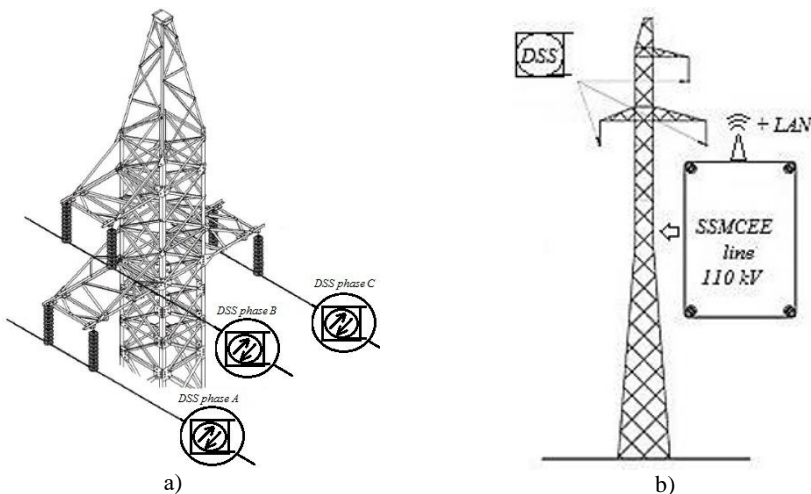
## 2 Methods and materials

Digital automatic smart systems for commercial measuring and control of electrical energy (SSMCEE) are the key pillar of a digital electrical network with a voltage of 110-220 kV, collecting and transmitting data to an automatic regulation system, which controls overhead power lines 110-220 kV. Smart systems will allow to organize measuring and control units for both transit and dead-end power transmission lines at any points of the digital electrical grids with the ability to be included into any ASCME system [3,4]. The implementation of Smart Grid technology will make it possible to distribute energy resources in a correct way, ensuring the reliability of their consumption and efficiency [5, 6, 7].

The development of digital smart systems for measuring and control of electricity 110-220 kV is highly important and relevant nowadays. The use of smart systems for commercial measuring of electricity and monitoring (SSMCEE-110-220) directly at the border of the ownership of various subjects of production associations of electricity can help in solving contentious situations between grid companies and electricity consumers. A self-contained electricity measuring cabinet SSMCEE -220 must be installed in a 110-220 kV network in an outboard and closed way (anti-vandal), as the most relevant (not requiring an additional land plot and expanding the security zone of the line, fig 2, fig. 3).



**Fig. 2.** Installing a smart-system on an overhead power line support



**Fig. 3.** Installation of a smart system on an anchor-angle support of a power transmission line:  
a) digital smart sensors (DSS) information; b) cabinet of smart electricity metering and control system (SSMCEE)

The smart system must be installed in a closest place to the balance boundary, with the technical possibility of installation. The technologies and solutions used in the development and manufacturing of the SSMCEE -220 shall provide the small dimensions and weight of the device, as well as its resistance to external factors. Which makes it possible to install the system not only at substations, but also on any anchor support of a power transmission line of 110-220 kV. The smart system must be resistant to wind load and remain operational under ice formation. It is proposed to use such digital current and voltage converters as digital smart sensors (DSS) [8] information, fixed on the phase conductors of the line, operating under phase wire potential [9,10]. Communication with the smart-system cabinet located on the line support will be realized by means of a dielectric optical cable (short-circuit bridges are excluded in case of cable breaks). High-voltage digital smart sensors are resistant to wind load of no more than 40 m / s without ice and up to 20 m / s with ice, maximum current resistance up to 40 kA for 1 s. The mass of one information sensor fixed on the line should not exceed 0.65 kg. The smart system will consist of the following levels:

- information and measurement complex (IMC): digital current and voltage sensors, temperature sensors, accelerometers, inclinometers, measuring devices, a meteorological station;
- information and computing complex of electrical installations: data collection and transmission devices, communication equipment, interface converters, time synchronization device); electrical installations: data collection and transmission devices, communication equipment, interface converters, time synchronization device);
- information and computing complex: data collection server, Scada - systems.

A smart system should solve the issue of organizing electricity metering with an accuracy suitable for commercial offsets, directly at the border of the balance of various subjects of the electricity market in the accuracy class: 0.2s, 0.2 [11,12]. Information from electricity meters is transmitted to any ASCME system in accordance with fixed principle. Working temperature range: -40 ... + 70 °. All measuring points are combined in a single system complexly with all devices, which provides simplicity and clarity of settings for further maintenance. It is possible to use Smart Grid technologies along with the installation of a complex measuring system. It is necessary to note the remote access to the information-measuring system, the automatic system for registering current loads and the duration of the overload of the overhead line with determining the change in the wiring sags, the system for transmitting information from autonomous weather stations about abnormal weather phenomena on the overhead lines, the temperature monitoring system for the overhead line wire. There are two independent mutually redundant data transmission routes provided for the data transmission between the objects of the digital electric network in the technological IP-network. The dispatcher can observe all the necessary information from the meters on a mnemonic diagram in a real time. Distanced from the device, the service personnel can change the settings of the smart system and set the necessary parameters at any time. Independent fiber-optic communication lines or the installation of GSM / GPRS modems at each point of the installation must be implemented to create a technological IP data transmission network using the IEC-61850-8-1 standard protocol. Functional capabilities of the digital SCADA-system.

For the control, accounting and management of smart meters, it is proposed to use a modern SCADA system:

- power supply management;
- collection, analysis and processing of information with the results in the form of diagrams, graphs, tables, reports, statements;
- monitoring, data recording, etc.

The optimized SCADA accounting system for smart meters has a well-developed client-server architecture with the ability to install both on one and on multiple servers;

The SCADA server works as a data storage device. The server scales, analyzes apertures, and controls the accuracy of smart meter information. The work is carried out in accordance with the IEC 60870-9.2 protocol.

For ease of using, the reports are formed in different formats by personnel's choice, including in the form of diagrams. There is an access to archived data as well. The SCADA complex will allow you to provide data on unauthorized opening of a smart meter, dates of setting parameters, data on phases, data on breakdowns, accidents, etc.

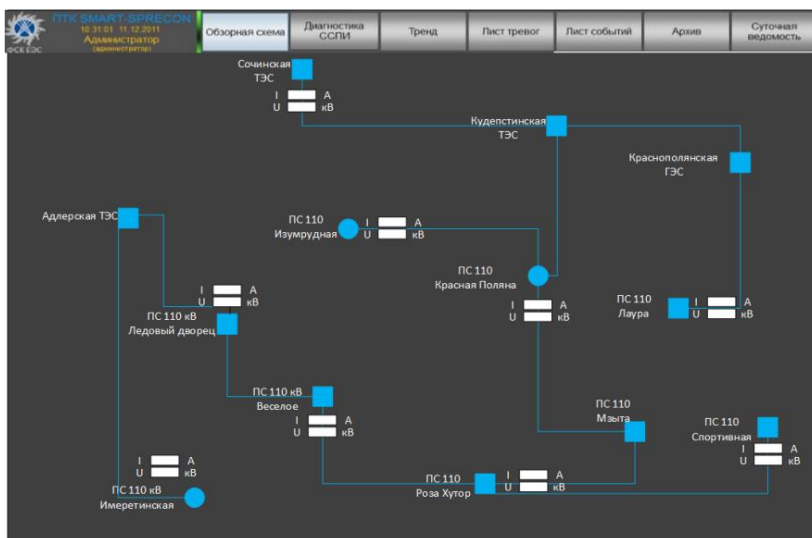
### 3 Results and discussion

Receiving data from an electricity meter is only one of the options for using the SCADA system. The complex is capable of receiving information from other digital sources operating at the substation, including relay protection and automation units, measuring instruments, input / output modules, telemechanical devices, etc. Subsequently, a centralized transmission of information to the highest level is carried out through various telemechanical channels and protocols.

Visualization of information on electricity measuring obtained from smart meters is available in the form of graphs and tables:

- by load;
- instant indicators of half-hour capacities;
- daily indicator of recorded energy;
- monthly indicator of the recorded energy;
- cumulative result;
- power flows and mnemonic diagrams of overhead line sections at automated workstations of operators of ASCME, AW

Screen forms help to monitor the status and events of registered smart meters in real time. The benefits of using SCADA for automation will take working processes to the next level. Screen forms will allow to lead online monitoring of the status and events with smart meters Fig.4.



**Fig. 4.** An example of an informative window of an automated workstation for a digital electric network control operator

## 4 Conclusion

With the development of digital technologies in the electric power industry, it becomes possible to increase the observability of the parameters of the electrical network and, as a consequence, to increase the reliability of the controlled object due to the possible forecasting of the situation. At the same time, light weight and size not only simplify the maintenance of devices, but also reduce emergency risks in case of bad weather conditions, the presence of remote access to the device saves the time of the operating personnel. The proposed high-voltage smart system for measuring electricity and monitoring the condition of the power transmission line allows you to locally control power flows in electrical networks, create both local control points of lines at the border of the balance ownership of subjects, and entire power centers of digital electrical networks 110-220 kV. The system allows you to control the quality of transmitted electricity, by increasing the observability of the main current and voltage parameters, remotely monitor the state of the line, namely the line sag and its temperature, wind speed, the process of ice formation, thereby increasing the reliability of power supply and power flows in the power system, reducing the costs of operational teams for their inspection, which is especially important along difficult routes, increasing energy efficiency and reducing the cost of electricity transportation. Calculation of the economic effect of using the system is possible after implementation on a real object.

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