МРНТИ 44.29.31

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DIGITIZATION OF ELECTRIC POWER SYSTEM

Abstract. In this paper a concept as the electric power industry has been considered. According to recent developments regarding the strategy "Kazakhstan 2050", there is brought into operation and manufacture of renewable sources of energy, which are by nature very complex concepts. Due to the high dependence on climate and weather conditions, renewable energy sources are very complex in terms of the operation for the production of electrical energy. There fore, there is proposed the development of intelligent power systems based on the concept of Smart Grid, which can guarantee a social development, a breakthrough increase in the consumer properties of the energy system, efficiency of operation of energy taking into account all development criteria electric power industry in the future.

Keywords: intellectual electric power system, protection relay, electricity transmission, renewable energy sources, digital substation.

Introduction. Power engineering is an important part of human life. It is already impossible to imagine life without electrical energy. Such a wide distribution is explained by its specific properties: the ability to transform into practically all other types of energy (thermal, mechanical, sound, light, etc.); the ability to relatively easily be transmitted over long distances in large quantities. In industry, electrical energy is used both to drive various mechanisms and directly in technological processes. Without it, the development of cybernetics, computer technology and space technology would have been impossible. Electricity plays a huge role in the transport industry. In everyday life it is the main part of ensuring a comfortable life for people. The level of its development reflects the level of development of the productive forces of society and the possibilities of scientific and technological progress.

No matter how reliable are the power systems, they inevitably experience damage and abnormal modes, which in turn can lead to accidents. At the same time, it is necessary to manage electric power systems so that consumers do not notice the consequences of these damages and unwanted disturbing influences. Due to the lack of time and the need of the highest accuracy of actions in these conditions, control is carried out automatically using automation devices and relay protection. In the event of damage or an undesirable mode, the control of electrical systems must be carried out according to special algorithms. This is necessary in order to ensure normal power supply (albeit not absolutely to all) consumers, even in extreme conditions, to prevent the development of an accident and reduce the possible amount of destruction of damaged electrical equipment [1].

Relay protection is a huge control system, which is a set of coordinated and purposefully acting interconnected (diverse in nature) elements and automatic devices. It covers almost all the main elements of the electrical power system (large and small), from generators that generate electrical energy to consumers of electrical energy that convert it into other types of energy. Regardless of what principles are used as the basis for individual relay protection devices for detecting damage, the system as a whole must accurately find the damaged elements and separate them from the serviceable part of the electric power system. The key role in solving this management problem is played by the logic of purposeful interaction of devices and the parameters of their operation, which ensure the implementation of interaction procedures. Calculations performed in order to determine the specific values of the parameters of the actuation of relay protection devices have the highest practical importance and form a methodological basis for the coordination of relay protection devices in unified system [1,2].

Research conditions and methods. The actions of relay protection devices are organized according to the principle of continuous assessment of the technical condition of individual controlled elements of electrical power systems. The figure shows a diagram of an electrical network containing power lines of different voltage levels W1 - W6, transformers T1 - T4, electric motor M1, fuses F1 - F3, switching devices and an equivalent power source Ec. Separate relay protection devices (RPD) installed on the elements of electric power systems (generators, transformers, power lines, electric motors, etc.) are combined into unified relay protection system with a common purpose of functioning [2].

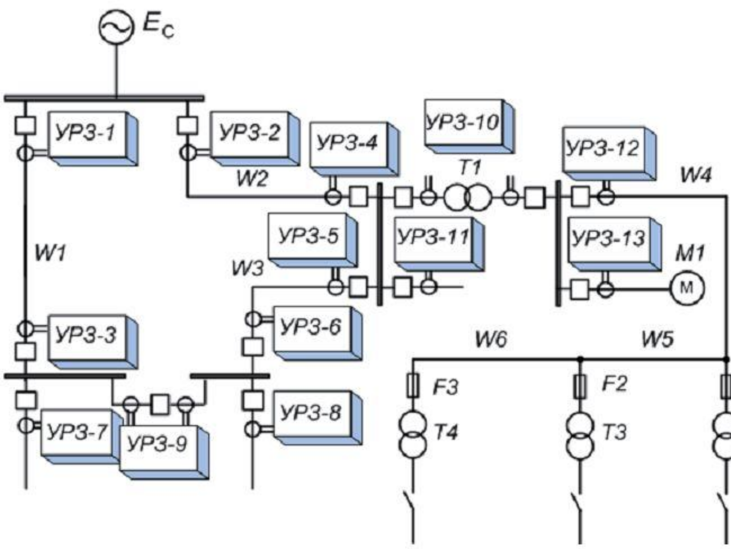

Figure 1. An example of an electrical distribution network diagram with relay protection devices

In accordance with this principle, individual relay protection devices (for example, RPD-1 - RPD-13) are functionally interconnected practically only by a common logic of actions. Причём каждое устройство релейной защиты для локализации повреждения может воздействовать только на коммутационные аппараты того объекта, на котором оно установлено.

It should be noted that the relay protection system, as a rule, includes devices that are not only different in the principles of damage detection, but also different in the way they influence the controlled object. So, both the most complex multifunctional relay protection devices acting on circuit breakers and other control devices and the simplest protective devices (for example, fuses), in which the functions of identifying and switching a damaged electrical circuit are combined, should obey an unified logic of actions. In the figure, fuses F1, F2, F3 are shown in the supply circuits of transformers T2 - T4. In some cases, RPD form only light and sound signals, and the separation of the damaged element from the serviceable part of the electrical network can be done manually by operating personnel [3].

The coordination of actions of devices located at significant distances from each other, as a rule, is achieved due to certain triggering parameters (without the use of physical communication channels). These parameters mainly determine the accuracy and efficiency of the entire relay protection system. In turn, this determines the survivability of electric power systems and the degree of risk of developing emergency situations when damage occurs.

Logic links work in all conditions and are not affected by external electrical and electromagnetic interference. Largely due to this property relay protection has the highest degree of reliability.

In the Address of the President of the Republic of Kazakhstan-Leader of the Nation N.A. Nazarbayev in december 14, 2012 was presented "Strategy" Kazakhstan - 2050: a new political course of an established state ", in the section" Green "economy and the environment" the goal is to achieve 50% of the share of alternative and renewable energy use by 2050. In general, in the electric power industry, according to the concept, it is planned to achieve the total share of alternative and renewable energy sources in the amount of 30% by 2030.

Research results. The impetus in the development of smart grids was the large-scale use of renewable energy sources, which are characterized by the inconsistency of electricity generation, both in time and in power. All this caused additional difficulties in the regulation of power and "power flows" in the electrical network. As a result, a new concept of power grids was needed, which would be able to ensure social development, a breakthrough increase in consumer properties and energy efficiency, taking into account all the factors of the development of the electric power industry in the future. This concept has become Smart Grid.

Renewable energy sources (wind and sun) are driven by weather and climate conditions, which makes managing and distributing electricity even more challenging. As a consequence, the stability of networks in terms of voltage and frequency is affected [4].

The integration of consumer-grade renewable energy sources (typically small wind turbines and rooftop solar modules), storage and distributed generation of electricity, electric vehicles and autonomous power grids have significantly changed the face of the modern power supply system.

One of the most important advances over the years of smart grid operation is the reversal of roles: consumers are now producing consumers.

In technical terms, an intelligent grid is a combination of power lines of all voltage classes, active devices for electromagnetic conversion of electricity, switching devices, protection and automation devices, information technology and adaptive control systems. When creating it, modern control facilities, new diagnostic systems and high-speed information transmission systems should be used [5].

Intensive data exchange, when specially designed information and communication platforms manage information flows between participants in the electrical system, helps to avoid problems, control power generation and regulate network loads.

The innovative development of the electric power industry today is characterized by the unification of power grid and information infrastructures at network nodes - digital substations. A digital substation (DSP) is an element of an active-adaptive (intelligent) power grid with a monitoring, protection and control system based on the transmission of information in digital format. DSP technology makes it possible to reduce the cost of construction of substations, reduce their size, increase reliability and, ultimately, improve the quality of power supply to the consumer without increasing the cost. This, in turn, gives an increase in noise immunity, a reduction in the number of equipment, secondary switching circuits and space savings. DSPs can be built faster and easier to develop standard projects for replication [3].

With the advent of the first microprocessor-based relay protection devices, information from them also began to be integrated into Automatic Transformer Substation Control Systems(ATSCS). Gradually, the number of devices with digital interfaces increased (emergency control systems, power equipment monitoring systems, DC switchboard monitoring systems and auxiliary needs, etc.). All this information from the low-level devices was integrated into the ATSCS via digital interfaces.

The transition to qualitatively new automation and control systems turned out to be possible with the emergence of new DSP standards and technologies, which, first of all, include the specially developed IEC 61850 standard. Unlike others, it regulates not only the issues of information transfer between individual devices, but also issues formalization of the description of circuits - substations, protection, automation and measurements, device configuration. This standard provides for the possibility of using new digital measuring devices (including those with a digital optical output) instead of traditional analog meters (current and voltage transformers). For example, digital instrument transformers transmit instantaneous voltages and currents via the IEC 61850-9-2 protocol to bay-level devices. As a result, IT makes it possible to move to the automated design of DSPs controlled by digital integrated systems, and here there will be analogies with control systems from the ICT industry.

All information connections on the DSP are digital and form a single process bus. This opens up opportunities for fast and direct exchange of information between devices, which ultimately allows you to abandon the mass of copper cable connections, individual devices, and also achieve a more compact arrangement. So, the main feature of the DSP is that all its secondary circuits are digital data transmission channels that form a single information network (data transmission network).

Discussion of scientific results. Thus, the DSP is based on a unified telecommunications infrastructure based on modern technologies. The main idea inherent in the DSP ideology is to monitor all processes as close as possible to information sources, transfer the received data to all subsystems via fiber-optic communication lines and virtualize most of the functions performed at the substation [5].

To compare the "past" and new technologies, we can provide approximate calculations for the equipment of a "traditional" substation and a DSP similar in terms of tasks. In the first case, 150 km of copper cable, 100 automatic control cabinets, 900 m^2 of area will be required, and the total cost of equipment and installation is about 2,400 million tenge. The second option requires 15 km of fiber-optic cable, three protection and control cabinets (double redundancy of the same server), 150 m^2 of area and total costs - about 960 million tenge. Well, if we consider that remote monitoring and everything else in the DSP can be handled by one operator with a tablet PC, it is not difficult to imagine the overall benefit in terms of capital and operational investments [5,6].

Conclusion. The mass implementation of digital substation solutions based on the standards of the IEC 61850 series has begun in the world, intelligent grid control technologies are being implemented, which indicates the relevance of research work on the study of signal transmission over the station bus and the Process Bus according to the IEC 61850 08-1 GOOSE and IEC 61850 09-2 protocol between intelligent - electronic relay protection and automation devices from manufacturers of different companies".

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Material received 18.03.21.

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ЦИФРОВИЗАЦИЯ ЭНЕРГОСИСТЕМЫ

Аннотация. В данной статье было рассмотрено такое понятие как электроэнергетика. Согласно недавним событиям, касающихся стратегии «Казахстан 2050», вводятся в эксплуатацию и производство возобновляемых источников энергии, которые являются по природе очень сложными концепциями. Из-за большой зависимости от климата и погодных условий, возобновляемые источники энергии являются очень сложными в плане эксплуатации для производства электрической энергии. С этой целью предлагается развитие интеллектуальных энергосистем на основе концепции SmartGrid, которая способно гарантировать общественное развитие, прорывное повышение потребительских свойств энергосистемы, эффективности эксплуатации энергии учитывая все критерии развития электроэнергетики в будущем.

Ключевые слова: интеллектуальная энергосистема, релейная защита, электропередача, возобновляемые источники энергии, цифровая подстанция.

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ЭНЕРГИЯ ЖҮЙЕСІН ЦИФРЛАНДЫРУ

Аннотация. Бұл мақалада электрэнергетика түсінігі, тұжырымдамасы қарастырылды. «Қазақстан-2050» стратегиясына қатысты соңғы жаңалықтарды ескере отырып, жаңартылатын энергия көздері қолданысқа енгізілді, бұл табиғаты өте күрделі ұғымдар. Климаттық және ауа райы жағдайына тығыз байланысты болуының арқасында жаңартылатын энергия көздері электр энергиясын өндіру үшін өте күрделі. Осы мақсатта болашақта электр энергетикасын дамытудың барлық критерийлерін есепке ала отырып, қоғамдық дамуды қамтамасыз етуге қабілетті Smart Grid тұжырымдамасына негізделген интеллектуалды қуат көздерін дамыту, энергетикалық жүйенің тұтынушылық қасиеттерін серпінді арттыру және энергия тиімділігі көзделінілді.

Тірек сөздер: интеллектуалды энергия жүйесі, релелік қорғаныс, қуат беру, жаңартылатын энергия көздері, цифрлық қосалқы станция.