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INCREASING THE EFFICIENCY OF THE FUNCTIONING OF INDUSTRIAL ELECTRICAL NETWORKS THANKS TO THE INTEGRATION OF VACUUM RECLOSERS

Abstract: *Topical matter of power supply for today is effective increase in the reliability of power supply in medium voltage overhead power systems by sectioning of lines with switching devices, such as disconnectors, controlled disconnectors or sectioning points. In such schemes, the manual approach to emergency management is used. This kind of schemes can be used where the overhead power lines are. Protective device on the outgoing feeder is switched off as soon as damage occurs in any area. As a result, all consumers of the line lose power for a long time. Remotely operated disconnectors or remote controlled sectioning points can also be installed instead of manual line disconnectors. This process of damage localization differs only in that all switching operations are performed remotely. Decision on switching is made by the dispatcher, constant communication with each controlled element of the network is necessary, otherwise it becomes virtually uncontrollable and the entire effect of remote control of disconnectors is eliminated.*

Keywords: *recloser, vacuum switch, dispatching, emergency processes, power lines, switching control*

Introduction

According to the analysis of the operation of distribution electric networks of Ukraine, it is necessary to note the following. Losses in distribution networks range from 12% to 17% (25-33% in individual power stations):

1. Energy losses for 2012-2020 – UAH 44 billion.
2. Volume of investment programs for 2012-2020 – UAH 15 billion.
3. Reduction of e/e losses 2012-2020 – UAH 0.2 billion or only 0.54%.

All these are the consequences of: Inefficient configuration of networks; Low level of network automation; Problems with connecting new subscribers, in particular distributed generation, electric heating and electric transport infrastructure; Low quality of electricity supply to consumers; Low level of automation electricity metering systems.

Proposals for a comprehensive approach to promotion energy efficiency of distribution networks:

1. Changing the network configuration – approximation high voltage networks to the consum.
2. Transition to medium voltage level of 20 kV – decreasing degrees transformation.

3. Level up network automation – Telemechanization of PS, sectioning distribution networks (using reclosers).
4. Changing the operating mode relay protection – safety of people, removal of overvoltage from equipment.
5. Level up equipment automated accounting systems – decrease commercial losses.

The goal of this paper

Propose a technical solution to significantly reduce the time to eliminate emergency shutdowns; to offer opportunities for reducing power losses in power supply networks; consider variations in improving the quality of energy supply to consumers.

Presentation of the main research material

Reclosers of E.NEXT-Ukraine Company and "Igor Sikorsky Kyiv Polytechnic Institute" are self-contained small-sized complete switchgears with great functionality (Fig. 1).

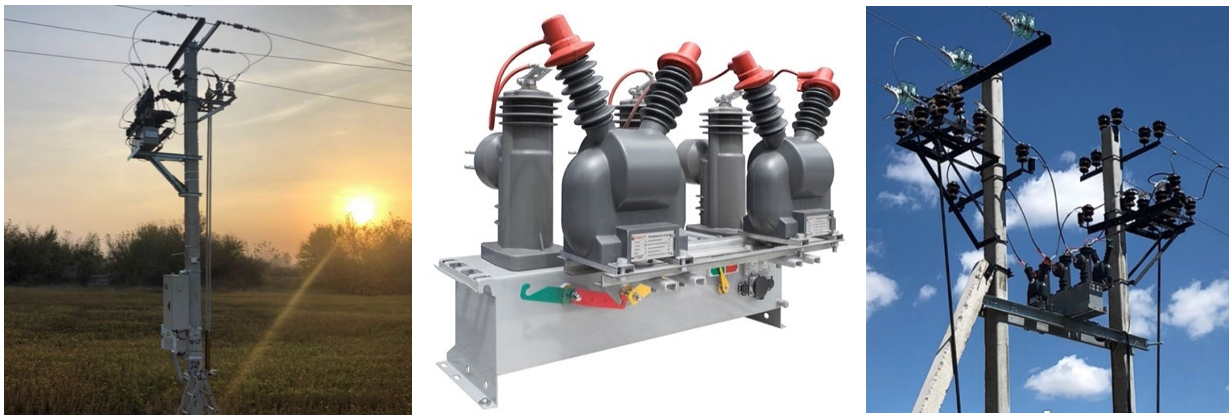

FIGURE 1. *Installation example for reclosers, switching module and control unit*

The main idea of using reclosers is the following [1, 2]:

1. One of the main problems of today's electric power industry is the frequent emergencies on medium voltage overhead lines. This is due to their considerable length and high wear and tear of the equipment of consumers connected to them. Therefore, power supply companies require the installation of sectioning devices on the overhead power lines of consumers, automatically separating this line from the general power grid in case of emergency situations on it. This kind of devices are the reclosers.
2. In case of short circuits on the power line protected by the recloser, the fast-switching vacuum circuit breaker protects the fuse link of the tap-off fuse. And only on the 2nd or 3rd automatic reclosing cycle (depending on the setting of the microprocessor protection of the recloser), when it is already possible to talk about the stability of the circuit, the device allows this insert to burn out.
3. In addition to the protective and sectioning functions, the reclosers of the E.NEXT-Ukraine Company and "Igor Sikorsky Kyiv Polytechnic Institute" can be used for remote monitoring and logging of the quality of supplied electricity, metering its consumption, including it being a part of automatic metering and telemechanics systems. It is possible to enter automatic transfer switches and backup power system with help of them.

Using of reclosers of E.NEXT-Ukraine Company and "Igor Sikorsky Kyiv Polytechnic Institute" significantly increases the reliability of the network, reduces the costs of its maintenance and losses from possible undersupply of electricity to the consumer, and allows keeping electricity metering at the

border of consumers balance inventory. Currently, about 40% of overhead lines (OHL) have reach the end of its service life and more than 80% are in need of technical re-equipment.

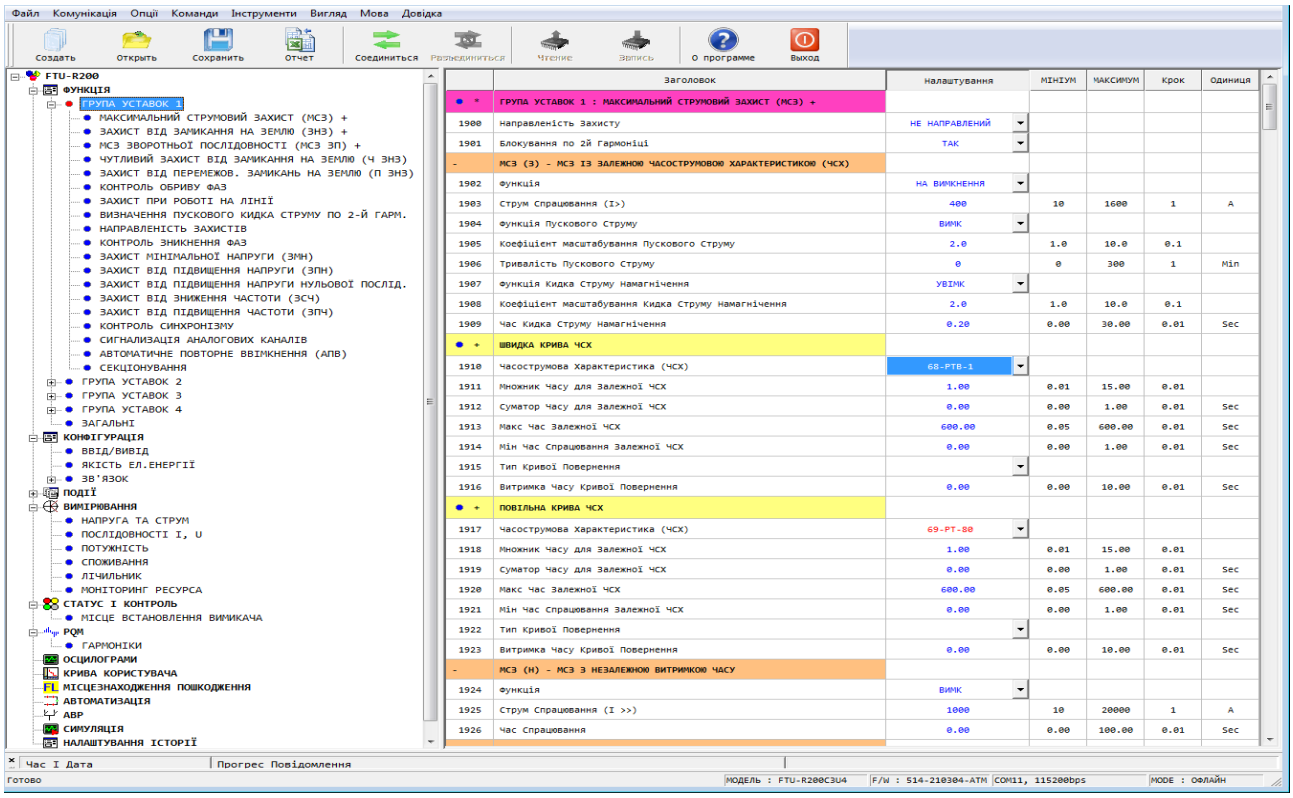

FIGURE 2. *Mnemonic frame from SCADA system*

The weakest link in the power supply system is 6 (10) kV overhead distribution networks. However, this requires large costs during the construction phase, and sometimes is not feasible due to the complexity of the placement [2, 3]. Also, in order to increase the safety of power supply to consumers, it is possible to repeatedly reserve and section the lines with manually operated disconnectors. But this method also has disadvantages. Therefore, the reliability of power supply of such power lines is increased by sectioning it into several relatively short sections with the installation of intermediate automatic protective switching devices-reclosers. Reclosers of E.NEXT-Ukraine Company and “Igor Sikorsky Kyiv Polytechnic Institute” are small circuit breakers located at the top of distribution poles and are usually used on very long distribution feeders.

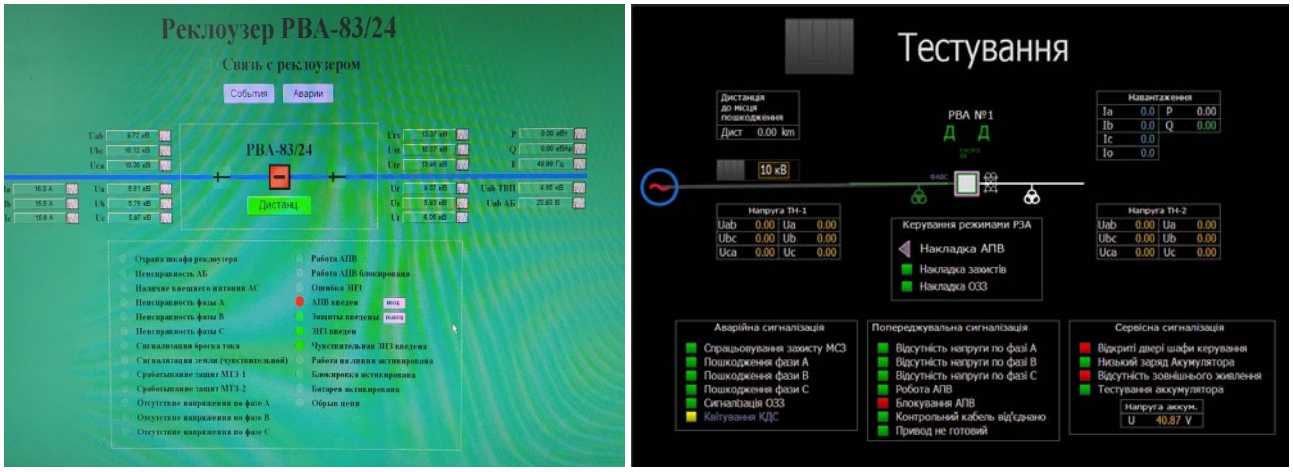

FIGURE 3. *Mnemonic frame from SCADA system*

Their function is to isolate the feeder section in the event of a malfunction or overload and thus minimize the number of unattended customers. Because they act like small circuit breakers, they have the ability to automatically restore power in situations of temporary failure, hence the name "recloser". This device is remotely controlled and allows the electrical network manager to detect a fault on the overhead line directly at the time of the fault, make decisions quickly and send the emergency repair team to the right area.

Recloser of E.NEXT-Ukraine Company and "Igor Sikorsky Kyiv Polytechnic Institute" includes: vacuum (SF6) switching device; system of primary current and voltage converters; autonomous operational power supply system; microprocessor relay protection and automation system with the ability to connect telemechanics systems; a system of ports for connecting telemetry devices; software complex. The advantages of the developed recloser [3, 4].

Installation of poles. Reclosers have external (external) pole installation, and due to this:

Increased level of insulation – the insulation of the poles of the switching module is made of epoxy resin, which has high insulating properties, resistance to ultraviolet radiation, and the ability to self-cleaning from precipitation and pollution.

No risk of internal short circuit – in the event of an internal fault or lightning strike in the switching module, a short circuit will not occur, since the poles are insulated with solid insulation without the risk of explosion. On the other hand, reclosers with indoor poles have a high risk of explosion.

Maintainability – in the event of a malfunction of one of the poles, it is possible to quickly replace the recloser pole, which is cheaper and more practical with a long service life, in comparison with the internal version, where this is not possible, in case of a malfunction, the entire switching module is replaced.

Drive mechanism. In the proposed reclosers, a spring drive mechanism is installed, which makes it possible to manually turn on and off the recloser in the presence of voltage on the line, while it does not need the presence of an auxiliary power supply, which cannot be done with a magnetic drive mechanism. Also, the latter requires frequent checking of the capacitor, which may lose capacity, which is likely under unfavorable climatic conditions (high temperature). The spring-loaded mechanism of the drive provides a higher mechanical pressure on the power contacts, which minimizes the risks of contact welding, and also withstands a higher short-circuit current compared to a magnetic drive. The spring-loaded drive mechanism is used at high-voltage switchgear/substations, which confirms the reliability and durability of this drive mechanism.

Current measurement. Reclosers use built-in current transformers (CTs) to measure current, which provide a whiter class of accuracy than Rogowski coils. The error in measuring the phase currents for CT and Rogowski coil is 0.1% and 1%, respectively, when measuring a single-phase earth fault, the error for CT and Rogowsky coil is 0.01% and 0.2%, respectively, which is a very important factor in networks with an isolated neutral LEP 6-35 kV, where earth fault currents are small compared to phase-to-phase short-circuits.

Body material. The recloser body is made of expensive 304 stainless steel, 4 mm thick, powder coated, this will ensure a long service life even in the most aggressive environments, compared to the low grade stainless steel body.

Auxiliary transformer (TSN). Complete with reclosers, single-phase TSNs with built-in fuses are used, with the ability to mount on the recloser body, which minimizes the time and material costs for installing the recloser on the power transmission line support.

Practical implementation of a technical solution

An example of the use of a recloser in power lines is presented in Figure 4.

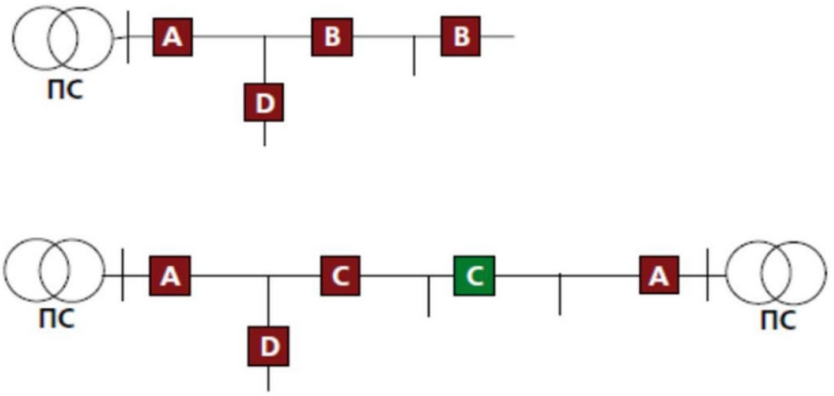

FIGURE 4. *Recloser installation options: A – device on the outgoing line; B – sectioning point in the network with 1-way power supply; C – sectioning point in the network with 2-way power supply; D – protective device on the branch line*

An example of a classic use of a recloser in radial diagrams is presented in Figure 5. Unstable short circuits are eliminated in the process of disconnection of the overhead line (up to 80-85%) and automatic reconnection inclusions of automatic reclosing – this inclusion of reclosers reduces the number of hours of disconnection. In addition, with this use, it is possible to arrange a classic relay protection redundancy scheme – zoned sensitivity, time exposure depending on the short-circuit current.

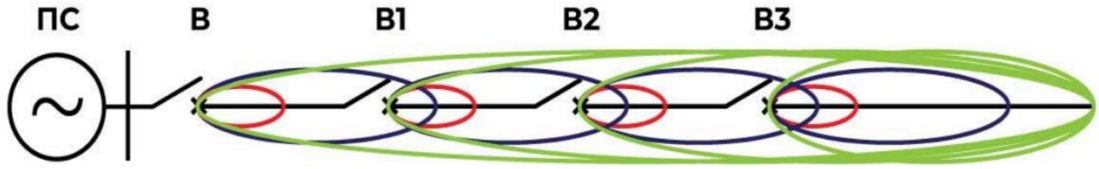

FIGURE 5. *ПС – feeder substation. B, B1, B2, B3 – reclosers. The colors show the zones of protection*

The main difficulties in installing reclosers:

1. When choosing a recloser installation point, it is necessary to take into account the payback period and/or technological period expediency.
2. In hard-to-reach places, it is necessary to organize the access of technical means to the support for the installation of power module – the weight of the structure can reach 100 kg, and despite the simplicity of the structure, it is necessary to use it installation techniques.
3. When choosing the installation point and model of the recloser, it is necessary to take into account the readiness of the system management of operators of the distribution system before working with the recloser: availability of technical measures – SCADA, control room, etc. In otherwise, the functional equipment of the recloser will not be used to its full extent.
4. Correctly determine the operating mode in which the device will be used: automatic operation, operation.
5. By centralized commands with a control room, semi-automatic – execution of automatic reactivation algorithms with expectations of further commands of the central management body.

If there is an opportunity to establish stable communication with the control room at the location of the recloser, then functional equipment allows its use as a SMART-GRID element in the collection and data transfer regarding network operation mode:

- current voltage values;
- currents;
- frequencies;
- remote control of switch position, etc.

Conclusions

The use of a vacuum switching device at the base of the recloser makes it possible to switch currents load without the risk of personal injury and equipment damage – use a recloser for switching networks both remotely from the control room and directly on site installation by personnel using a remote control, which significantly speeds up execution switches in networks. The recloser functionality allows a group of reclosers arrange full protection of the overhead line section, separation of the damaged area, preservation power in the damaged area due to time-current settings, ensure compliance nominal parameters of the network in terms of voltage, frequency, or limit the flow of power beyond the norm value in automatic mode without intervention person in the process of restoring the regime after liquidation accidents.

Further development of the technical improvement of vacuum reclosers of the ENEHT-Ukraine Company together with the Ihor Sikorskyi KPI has prospects for improving the efficiency of the functioning of the power supply system in Ukraine.

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