

Vitalii POBIGAYLO<sup>1</sup>

Vasyl KAINCHYK<sup>1</sup>

Sergey KUZOVKIN<sup>2</sup>

Konstantin EREMCHUK<sup>3</sup>

<sup>1</sup> NTUU "Igor Sikorsky Kyiv Politechnic Institute" Ukraine

<sup>2</sup> Commercial Director "E.NEXT-Group"

<sup>3</sup> Head of Project Sales Department "E.NEXT-Ukraine"

Corresponding author: pobigaylo@gmail.com

Doi: 10.53412/jntes-2021-2.1

## POWER DISTRIBUTION EFFICIENCY AND RELIABILITY RAISING BY USING THE 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.

**Keywords:** efficiency, reliability, vacuum reclosers

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.

Reclosers of E.NEXT-Ukraine Company and "Igor Sikorsky Kyiv Politechnic Institute", electronically controlled, vacuum- interrupting distribution automation switch provides reliable, economical switching, sectionalizing, advanced metering, and automation systems for distribution circuits rated up to 38 kV. The Recloser switch combines solid cycloaliphatic-epoxy vacuum interrupters with a reliable, lightweight operating mechanism that utilizes a magnetic actuator to provide a lifetime of trouble – free operation. The solid polymer system does not rely on a gaseous, liquid, or foam dielectric. The ZX switch is highly resistant to ozone, oxygen, moisture, contamination, and ultraviolet light. Switch operations are programmed in an electronic control with accurate characteristics and a host of advanced features. When system requirements change, program settings are easily altered with no sacrifice of accuracy or consistency. Pomanique's reclosers meet all the requirements for outdoor use in accordance with the IEEE C37.60 and IEC 62271-111.

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

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

- 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.

- 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.
- In addition to the protective and sectioning functions, the reclosers of the E.NEXT-Ukraine Company and “Igor Sikorsky Kyiv Politechnic 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 Politechnic 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 1. Installation example for reclosers, switching module and control unit

Заголовок	НАЛАНТУВАННЯ	МІНІМУМ	МАКСИМУМ	КРОК	ОДИНИЦЯ
ГРУПА УСТАВОК 1 : МАКСИМАЛЬНИЙ СТРУМОВИЙ ЗАХИСТ (МСЗ) +					
1900 напрямленість захисту	НЕ НАПРАВЛЕНИЙ				
1901 блокування по 2й гармонії	ТАК				
МСЗ (З) - МСЗ ІЗ ЗАЛЕЖНОЮ ЧАСТОТНОЮ ХАРАКТЕРИСТИКОЮ (ЧСХ)					
1902 функція	НА ВИКОНЕННЯ				
1903 струм спрацювання (I>)	400	10	1600	1	A
1904 функція пускового струму	ВИМК				
1905 коефіцієнт масштабування пускового струму	2.0	1.0	10.0	0.1	
1906 тривалість пускового струму	0	0	300	1	MS
1907 функція кидка струму намагнічення	УВІМК				
1908 коефіцієнт масштабування кидка струму намагнічення	2.0	1.0	10.0	0.1	
1909 час кидка струму намагнічення	0.20	0.00	30.00	0.01	Sec
ШВИДКА КРИВА ЧСХ					
1910 частотна характеристика (ЧСХ)	69-PTB-1				
1911 множник часу для залежної ЧСХ	1.00	0.01	15.00	0.01	
1912 суматор часу для залежної ЧСХ	0.00	0.00	1.00	0.01	Sec
1913 макс час залежної ЧСХ	600.00	0.05	600.00	0.01	Sec
1914 міні час спрацювання залежної ЧСХ	0.00	0.00	1.00	0.01	Sec
1915 тип кривої повернення					
1916 витримка часу кривої повернення	0.00	0.00	10.00	0.01	Sec
ПОВІЛЬНА КРИВА ЧСХ					
1917 частотна характеристика (ЧСХ)	69-PT-80				
1918 множник часу для залежної ЧСХ	1.00	0.01	15.00	0.01	
1919 суматор часу для залежної ЧСХ	0.00	0.00	1.00	0.01	Sec
1920 макс час залежної ЧСХ	600.00	0.05	600.00	0.01	Sec
1921 міні час спрацювання залежної ЧСХ	0.00	0.00	1.00	0.01	Sec
1922 тип кривої повернення					
1923 витримка часу кривої повернення	0.00	0.00	10.00	0.01	Sec
МСЗ (Н) - МСЗ ІЗ НЕЗАЛЕЖНОЮ ВИТРИМКОЮ ЧАСУ					
1924 функція	ВИМК				
1925 струм спрацювання (I >>)	1000	10	20000	1	A
1926 час спрацювання	0.00	0.00	100.00	0.01	Sec

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 Politechnic Institute” are small circuit breakers located at the top of distribution poles and are usually used on very long distribution feeders.

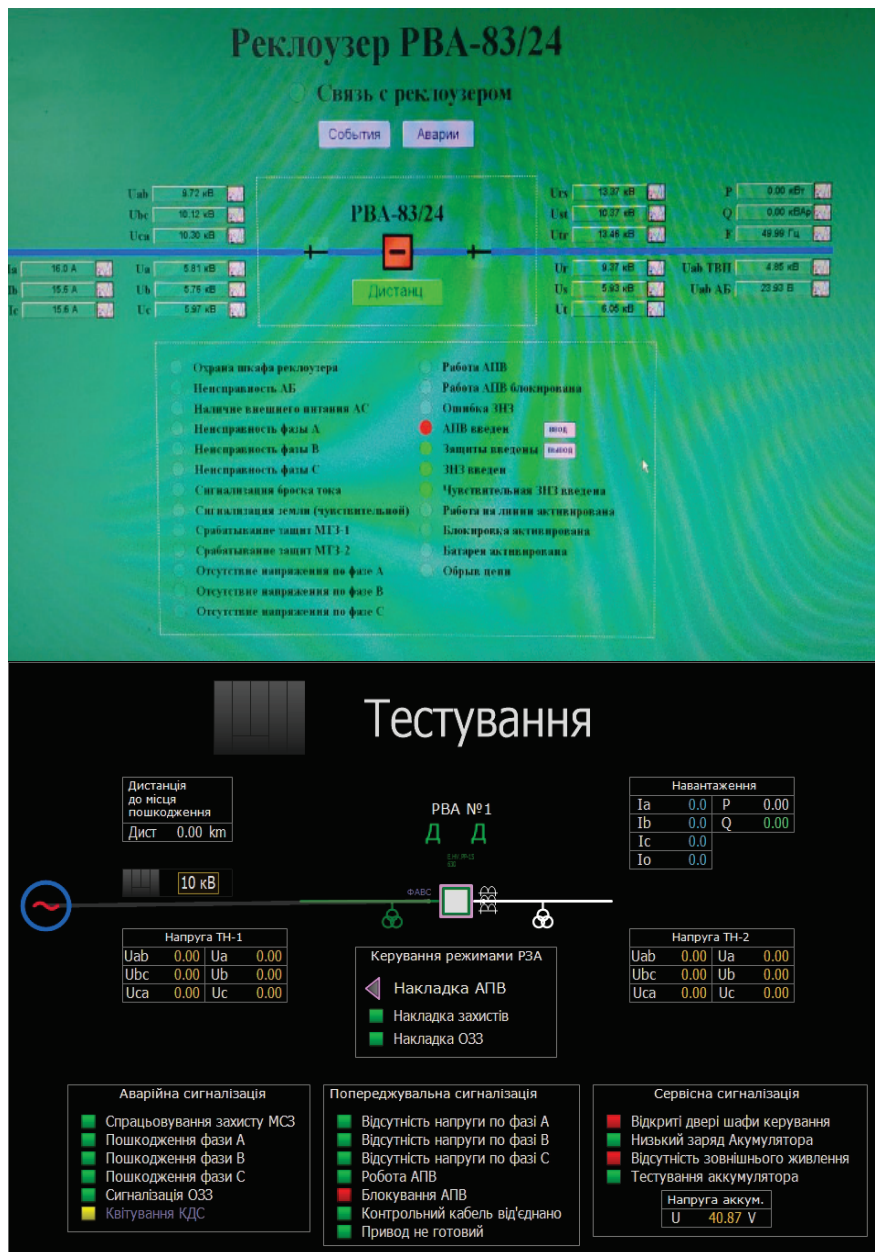


FIGURE 3. Mnemonic frame from SCADA system

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 Politechnic Institute” includes:

- vacuum (SF<sub>6</sub>) 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.

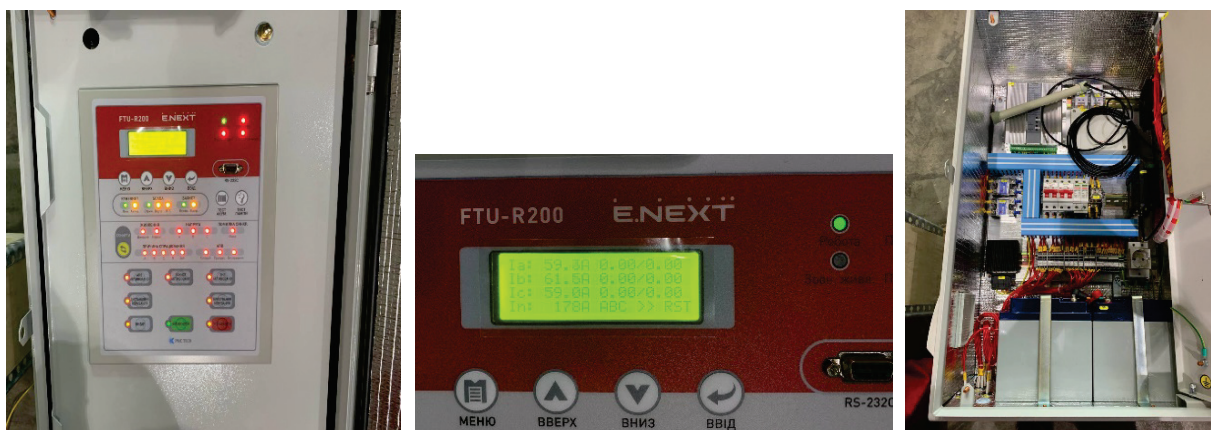
**Current measurement.** Reclosers use built-in current transformers (CTs) to measure current, which provide a whiter class of accuracy than Rogowski coils. The error in measuring the phase currents for CT and Rogowski coil is 0.1% and 1%, respectively, when measuring a single-phase earth fault, the 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.

Reclosers are the workhorses of distribution automation. Reclosers reduce outage duration and frequency, lower operating costs, and improve customer service and overall system reliability. The E.NEXT Molded Vacuum Recloser (MVR) raises the standard of recloser performance by incorporating state-of-the-art vacuum-interrupter technology with the field-proven E.NEXT-Ukraine solid-dielectric insulation system and long-life operating mechanism and magnetic actuator system. The E.NEXT MVR reclosers are compatible with the industry standard Laboratories Controls.





**FIGURE 4.** The control unit of the E.NEXT Molded Vacuum Recloser

Sensitive earth fault protection in reclosers E.NEXT is typically set to immediate lockout. This detection of small leakage currents (less than 1 ampere) on a medium voltage line can indicate insulator failure, broken cables or lines coming into contact with trees. There is no merit in applying reclosing to this scenario, and the industry best practice is not to reclose on sensitive earth fault. Reclosers with sensitive earth fault protection capable of detecting 500 mA and below are used as a fire mitigation technique, as they provide an 80% risk reduction in fire starts [4], however they are never to be used as reclosers in this application, only as single shot distributed circuit breakers which allow for sensitivity to verify the existence of these faults.

E.NEXT reclosers have over 5 years of proven field performance incorporating innovative technology and unique E.NEXT expertise, including embedded sensors with the highest accuracy and least environmental sensitivity in the market. And with multiple controller options, E.NEXT reclosers are designed to continually meet and exceed the growing demands of power distribution.

### Why E.NEXT?

Increased reliability – the highest creep distance among the recloser poles on the market ensures long-term performance in any environment.

Unparalleled performance – the HCEP (Hydrophobic Cycloaliphatic Epoxy) material of the poles provides the best insulation for outdoor use, shedding water and debris, thus reducing the probability of flashovers even in heavily polluted areas.

Simple, fast and safe maintenance as all the electronics are in the low voltage unit, eliminating the need for a bucket truck to isolate potentials to service electronics

### Key benefits of E.NEXT reclosers:

Easy integration with multiple controller options.

#### *Long life and low maintenance*

- Magnetic actuators and superior design allow pomanique's reclosers to operate for a rated 10,000 full load operations.
- Less moving parts = less maintenance for 25 years.

#### *High reliability*

- Pomanique designed a simple, magnetically actuated operating mechanism that could dependably operate with only one moving part.
- Vacuum interrupter technology make recloser with maximum reliability and minimal maintenance.
- Environmentally friendly.

#### *Optimized Measurement*

- Reclosers are equipped with current transformer and voltage sensors in each bushings to measure current and voltage.

### *Microprocessor based controller*

- Controller provides more enhanced functions in protection, monitoring, metering, communication and recorder, and can also support your power distribution system to be more reliable.
- Simple integration into Ethernet or serial-based communication networks.

**Conflicts of Interest:** The author declares no conflict of interest.

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*This article is recommended by the scientific committee of the V International Scientific-Technical Conference ACTUAL PROBLEMS OF RENEWABLE ENERGY, CONSTRUCTION AND ENVIRONMENTAL ENGINEERING, 3-5 June 2021, Kielce (Poland, Ukraine, Croatia, Slovakia, Sweden, Russia).*