

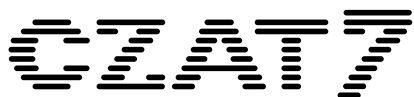


✓ IEC 61850

## Automation system for traction substations

# CZAT 7





## Automation system for traction substations



The CZAT7 controller is one of the key elements of the integrated automation system of the traction power substation. CZAT devices are directly responsible for the protection function of power supply systems of rectifier stations, as well as for the control of subordinate substation equipment and their communication with the control center. CZAT7 depending on the prepared application layer, can function as a bays controller or perform the tasks of an communication controller.

**CZAT7 as a field controller** (DC protection unit) performs tasks both in automation of a bay, and in protection functions. The most characteristic places to use the capabilities of the CZAT7 controller are railway and tram DC switch gears. Additionally, the CZAT7 automatics can be used at traction substations in: auxiliary switchboards, installation switchboards, automatic compensation choke control cabinets and traction disconnecter control cabinets.

**CZAT7 as an communication controller** is an effective element that allows you to control a power substation from the dispatcher's supervision system (e.g. from the Central Control Room). As part of this function, the communication controller is responsible for the correct connection of the substation system based on deployed field controllers called IED (Intelligent Electronic Device). For the purposes of data transmission with the supervisory system, the CZAT7 controller uses a variety of transmission media, ranging from standard copper teletechnical cables to fiber optic connectors and wireless transmission systems (GSM, radio).

The system is based on a distributed automation structure. Individual devices are connected to each other via a parallel CAN bus and using the PPM2 transmission protocol. The device implements also a communication protocols and logical structures compliant with the IEC 61850 standard, and its functionality has been extended by the DNP3 communication protocol. CZAT7 controller can be used in almost all elements of the distributed system in traction power substations. The controllers differ only regarding the applied software. This solution allows for optimization of costs arising from equipment maintenance and possible expansion of the system.

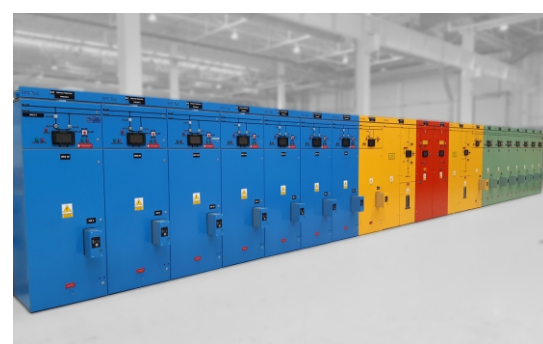
### UPK-CZAT dependency systems for high-speed circuit breakers

The UPK system is an application function of dependency system for high-speed circuit breakers. This solution ensures safe automatic operation between traction substations and between substations and sectioning cabins, dually powering a common section of a traction network.

*CZAT system have been the most frequently chosen protection automatics for train DC power systems in the Poland*

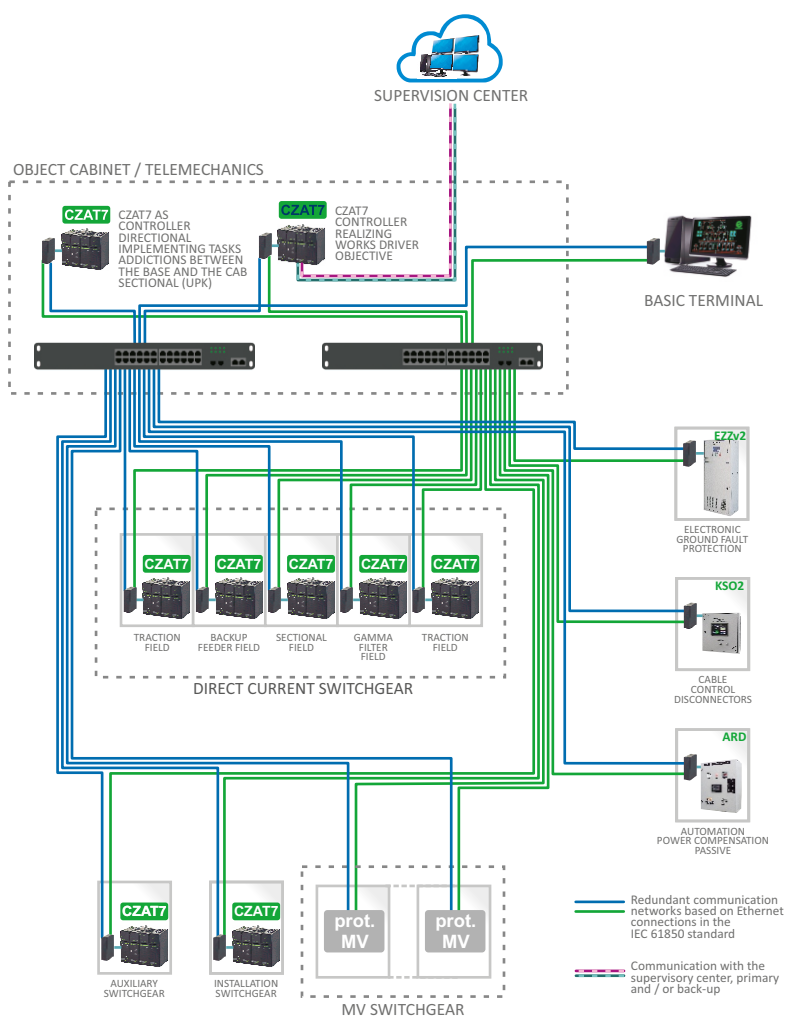


*3 kV DC switch gears for traction power substation - Kraków Płaszów. It is one of the largest DC switch gears manufactured for railway purposes in Poland. The automation of 23 fields was based on 170 electronic modules of CZAT7 controllers.*



*3 kV DC switch gears for traction power substation - Kraków Główny. The automation of 20 fields was based on 150 electronic modules of CZAT7 controllers.*

## A simplified diagram of communication on traction substations according to the IEC 61850 standard



Traction energy control center MPK Poznań. Most of the existing tram power control centers in the Poland were designed and built by ELESTER-PKP.



Traction substation „Rondo Kaponiera” (MPK Poznań)



Traction power substation - Młeczewo. One of the 50 traction substations designed in recent years by the ELESTER-PKP design office as part of the Modernization of Power Supply Equipment (MUZ) by PKP Energetyka.



One of the eight new 825 V DC switching gear of the second line of the Warsaw Metro. It has been equipped with CZAT7 automation, which uses the IEC 61850 communication protocol for the needs of the Warsaw Metro.

### Design office

- » ELESTER-PKP has one of the largest experience in the design of rail and tram power substations in Poland. Our knowledge results from many years of practice and the implementation of many tasks, including participation in pioneer and prototype projects.



### CZAT automation functions in the traction or backup feeder field

- Testing the line before it is switched on.
- Automatic transfer switch (ATS).
- Substation-cabin (for railway stations) or substation-substation dependencies.
- Voltage and current measurements of the feeder.
- Measurement of uneven load on feeder cables in twin cable feeders.
- Protections: undervoltage, overvoltage,  $I > T$ , short-circuit  $I >$ ,  $di/dt$  to detect distant short circuits (steep).
- Local and remote control.
- A blocking option (after a failed line test, from protection of the line test resistor, after immediate ejection).
- Energy measurements.
- Recording of currents and voltages.
- Recording of events.
- Counter of events (generating statistics).
- Local and remote warning signalling in the event of faults, detection of defects and loss of auxiliary voltages.
- Control by means of bypass breakers.
- Local reserve breaker.

### CZAT automation functions in the rectifier unit field

- Automatic control of the operation of units (according to schedule or load).
- Current-time protection  $I > t$ .
- Current and voltage measurements of the rectifier unit on the 660V, 3 kV side.
- Remote and local control of the unit disconnector and DC current breaker (if the station is connected to a remote control system).
- Cooperation with safety devices of other companies.
- Recording of events and a counter of events.
- Local and remote warning signalling in the event of faults, detection of defects and loss of auxiliary voltages.

### CZAT automation functions in the medium voltage switching station

- Automatic transfer switch (ATS).
- Local and remote control.
- Recording of events.
- Local and remote warning signalling in the event of faults, detection of defects and loss of auxiliary voltages.

### CZAT automation functions in the auxiliary field

- Monitoring of operation of the rectifier station's heating and ventilation system.
- Emergency shutdown of the rectifier station.
- Cooperation with the fire and burglar protection installations.
- Measurements of the station's total current on the 660V, 3 kV DC side.
- Measurements of voltage on 660V, 3 kV DC busbars.
- Local and remote control.
- Reactive power compensation.
- Recording of events.
- Automatic transfer switch.
- Local and remote warning signalling in the event of faults, detection of defects and loss of auxiliary voltages.
- Central signalling for 110kV station.

### CZAT automation functions in the gamma filter field

- Local and remote control and filter automation.
- Contact with the user via a touch screen.
- Measurement of voltage and RMS effective current value.
- Monitoring of high-voltage fuse.
- Monitoring of presence of auxiliary voltages.
- Temperature and thermal protection measurement.
- Protections: 16-step overcurrent, undervoltage, overvoltage.
- Handling of over-pressure protections for capacitors.
- Cooperation with undervoltage, ground-fault and TCK protection.



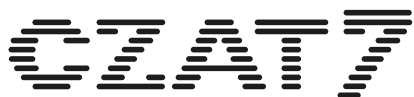
CZAT7 and HMI device CZAT Synoptic in the traction or backup feeder field - DC power substation Łachów



CZAT7 automation in the gamma filter field



CZAT7 controller, with the CZAT Synoptic HMI panel, in the auxiliary switchboard 400 / 230V, realizing the control remote and automatic transfer switching (ATS)



## Structure of the CZAT7 system



CZAT7 is a programming and hardware platform dedicated to the needs of rail transport, allowing to build various automation and control systems. Controller sets are based on the Central Processing Unit CPU and subsequent digital CZAT7 modules attached to CPU. The modular structure used is a convenient solution that allows to adjust the application in terms of the number of modules and enables easy expansion of the set with new devices. All elements have been designed in a way that ensures their safe operation in the demanding railway and tram environment.

Currently, 15 specialized digital modules of the CZAT7 system are produced. These devices are the basis for building a number of systems offered by the company and allow engaging in new research and development projects. In the applications of the electric power engineering of rail transport, CZAT7 is used in: direct current switchgear, auxiliary switchgear, automatic compensation choke control cabinet, remote control object cabinet, installation switchgear, cable control cabinet for disconnectors. The CZAT7 devices are also used in railway traffic control solutions in the computer system of level crossing and the guaranteed power supply.

### System architecture

CZAT7 controllers are modular in build. The basic unit consists of a central processing unit (CPU), a power supply module (PSU) and at least one slave input/output module (DOU, DIU, DIOU). This is the optimum solution because it allows to adjust the system to specific needs, its further expansion and execution of modernization work in stages. The basic unit can optionally also be equipped with an operator's HMI touch screen panel (CZAT Synoptic), supporting local control of particular devices (e.g. a single field).

### The mechanical design

Devices from the CZAT7 family are placed in a metal housing, providing high resistance to electromagnetic interference. The modules are designed to be mounted on a TS35 mounting rail. The communication bus between the modules is located on the front of the controller. It is a convenient solution that allows to quickly add next modules to the set.



The number of CZAT7 devices depends on the required functionality of the automation. In simplest set dedicated to the 3 kV DC traction switch gear 3kV consist of a CZAT7 CPU central procesing unit, PSU power supply unit and a DIU input / output module.

### CZAT7 units

- >> CZAT7 CPU - central processing unit
- >> CZAT7 PSU - power supply unit
- >> CZAT7 DIU - digital Input unit
- >> CZAT7 DOU - digital output unit
- >> CZAT7 DIOU - digital input - output unit
- >> CZAT Synoptic - operator panel HMI



Train 3 kV DC switchgear for traction power substation



DC Tram power substation "Ćmielowska" (Warsaw Trams). The station is operated by the Traction Automation System. DC switching station equipped with CZAT protection automatics. Remote control of all stations of the Warsaw Trams is control by CDE Central Energy Dispatching Center, designed and implemented by ELESTER-PKP.



**CZAT7 CPU** (Central Processing Unit) - the central unit is responsible for processing information from attached modules and performing logical tasks. In addition, the CPU supervises the work of the modules, ensures their diagnostics and communicates with the object controller. The cooperation between successive CPU units is ensured by the Ethernet link in the IEC 61850 standard or the CANBUS/RS-485 bus.

The CPU module is equipped with an (RJ45) Ethernet connector, two (2) RS232/485 type communication ports. For convenience, these ports are made in the form of detachable spring connectors, thanks to which there is no need for additional clamping tools. The controller has one fibre optic input and one output, allowing for direct connection of one HVM module. These may be measuring or counter modules. Fibre optic interfaces cooperate with plastic fibre optics.

Controller configuration changes can be made locally via a USB port or the CZAT Synoptic HMI panel. Remote control is provided by Ethernet network (engineering channel), CANBUS or the master display and remote control system. Reading and saving files does not require an interruption of the application currently being performed by the controller. To facilitate access during local operation with the controller (e.g. copy files from the event recorder) both the microSD card slot and USB port are located at the front of the housing.

**CZAT7 PSU** (Power Supply Unit) - the module is designed to power supply system components with 12V DC, 3A. In addition, the PSU supervises the correctness of the power supply, which allows the CPU controller to react early to its loss. The module is powered by a 230V AC voltage and must be connected to a three-wire (earthed) network. The device is protected at its input by an overvoltage protection and interference filter. The power supply unit ensures galvanic isolation from the mains and also features protection against short circuit and overload.

It is worth noting that the CZAT7 PSU module uses two additional inputs and two binary outputs. This allowed for the creation of the smallest CZAT7 control set, based only on the PSU module and the CPU module.

The PSU module can also be used independently as a universal power supply unit in industrial conditions.

**CZAT7 DIU** (Digital Input Unit), **CZAT7 DOU** (Digital Output Unit), **CZAT7 DIOU** (Digital Input Output Unit) – input / output modules allow entering information into the system as well as provide control of external devices.

**CZAT Synoptic** is an HMI panel which presents data in a text or graphic form. This terminal operates directly with the controller and uses information contained in its records. This allows not only monitoring of device operation, but also their control and modification of their settings.

Compared to standard signalling systems, a graphic terminal provides more convenient and faster operation of devices. The panel is a configurable module, so it is possible to graphically present any objects, diagrams or processes. For the needs of traction facilities, these are visualization of the status of disconnectors or circuit breakers. In addition, this module plays back audio messages and emits audible alarm signals. The panel is operated using an LCD 7" touch screen and 10 function keys. The display reacts to the intensity of light in the room, so that the screen's backlight is automatically adjusted.

The HMI terminal is placed in a durable metal housing and designed to be installed in the door of the control cabinet. The device communicates with the controller via an RS485 (4-pin type TRIAD) bus. It is equipped with RS232 interface and an SD memory card slot.



CZAT7 automation set with a visible bus connecting subsequent units



CZAT Synoptic



CZAT7 CPU



CZAT7 PSU



CZAT7 DIU, CZAT7 DOU, CZAT7 DIU

# CZAT CCU

## Non-contact current measurement - application at power traction substations

The CCU (Current Converter Unit) device is a measuring module designed for contactless measurement of currents in electric cables. The obtained values, in digital form, are transferred to master controllers in the RS485 standard. CCU is based on Hall converter and does not require additional shunts. Double galvanic isolation allows it to be used in devices powered by high voltage (e.g. near the circuits of the 3 kV DC traction). CZAT CCU measures both direct, alternating and distorted current and the data is sent in the form of average, effective and minimum values (including those determined from the one-second run). In the basic version, the device measures the current in the range of  $\pm 200\text{A}$ . If necessary, it is possible to increase the measuring range.

### Additional protection of power traction substations

The CZAT CCU module is part of the traction automation system. This system allows local and remote control of devices located at power traction substations. The basic application of the CCU module in railway and tram power facilities is the measurement of current in braids of power cables. This allows to diagnose whether there are additional external currents on individual power cables and what their possible value is. It is critical because even a small value of the current acting permanently may cause an ignition, and consequently a fire of the entire facility.

Continuous control of the current in the cable braids allows the cable diagnostics to be performed and to detect its damage or a possible short-circuit in the cable. All measurements of the CCU device are transferred directly to the CZAT controllers located in the traction feeder bays and are visible by the dispatchers of the Central Control Room (if the facility is included in the remote control system).

The CCU module in substation applications can also be used in the overvoltage limiter of the cathode choke of the rectifier unit. In this configuration, the device is connected to the CZAT controller placed in the gamma filter field. The big advantage of such a design is the possibility of departing from transmitting information to the controller in the form of voltage in favor of a digital signal. In traction applications it is particularly important due to the resistance of this type of connection to interference.



**Current Converter Unit**

» CZAT CCU is a universal device. It can work with various controllers and be used in the construction of any digital systems.

# HVM

## High Voltage Measurement Unit



The HVM is designed to take measurements of voltage and DC current, necessary to implement the protections of the automation field. The main application of this module is to take measurements in the traction feeder fields, backup circuit breakers or rectifier units. Current measurement is carried out using the voltage drop obtained on the external bypass. Depending on the version, the bypass may be located in the plus or minus rail. Two bypasses can be connected to the transducer, providing the possibility of taking measurements of uneven currents propagation for twin-cable feeders. The device is manufactured in versions with a power of 3300V, tailored to railway needs and a tramcar version with a voltage of 660V and 750V.

### The HVM transducer performs the following functions:

- measurement of voltage and DC current in tram and railway traction networks,
- measuring any inequality of load on cables for twin-cable feeders,
- measuring the power taken up and returned on the basis of the measured voltage and current,
- recording of voltage and current from the traction network,
- cooperation with the field automation (CZAT controllers), allowing implementation of traction protections.

Thanks to the measuring system being powered directly from the measured voltage, the problem of providing adequate insulation has been solved. The required level of safety is achieved through the use of a fibre optic bus, using this for the needs of the protection functions and reserving for the automation of a given field (connection with the CZAT7 controller).

### A dedicated measurement transducer for the gamma filter field

The HVM3F high voltage transducer has been prepared and adapted to the gamma filter field. It performs measurements of voltage and the effective value of current with a deformed course. Measurement of RMS current drawn through the filter, enables a multi-step overcurrent protection of  $I > T$ , reacting to the real psfometric load on capacitors. This protection protects the gamma filter against overload which can occur in case of an excessive current load on a substation, interference in the operation of diode rectifiers or the converters on vehicles.





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