



DC SWITCHGEARS

CITY ELECTRIC TRANSPORT ■
RAILWAYS ■ METRO

ABOUT COMPANY

PLUTON is the modern innovative manufacturer of electrotechnical equipment for city electric transport, metro and railways. The Company holds key positions in electrical industry and has been successfully working over 30 years implementing the strategy of intensive growth, development and continuous improvement of products and services quality.

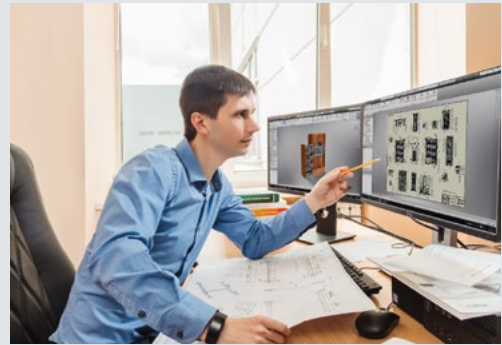
More than 70 types of PLUTON equipment are supplied to various countries of the world and successfully applied in the field of transport, power industry and production sector. PLUTON Group has representative offices in 8 countries and continues to develop dynamically and extend its global presence.

PLUTON confirmed compliance of its management principles with international standards of quality management system ISO 9001:2015, Environmental Safety ISO 14001:2015, as well as occupational safety and health ISO 45001:2018 requirements.

Due to our vast experience and innovative technologies, we provide secure, reliable and efficient power distribution. We are building the future, creating products of up-to-date level in compliance with the international standards that ensure safety and comfort of Customers.

We provide a full range of services: from design up to installation and commissioning of the supplied equipment on operation site. Furthermore, we provide the following services after equipment start-up:

- personnel correct and safe operation and maintenance training;
- warranty and post-warranty maintenance;
- spare parts supply.



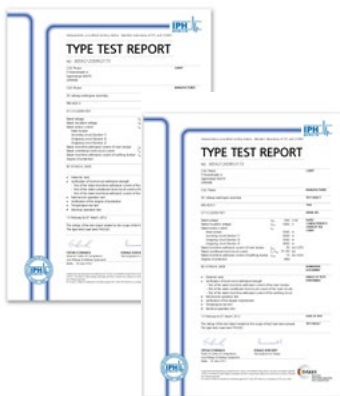
DC SWITCHGEARS

DC switchgears manufactured by PLUTON are provided for power receiving and distribution at traction substations of metro, city electric transport and railways.

DC switchgears meet all the requirements to the modern DC traction power supply systems, providing safety of passengers, maintenance staff and equipment.

Reliability and safety

- / application of components with high switching capacity, high dynamic resistance to short-circuit currents and long mechanical life;
- / safe operation due to electrical and mechanical interlockings, and to separating and protective parts;
- / safety and reliability are successfully type-tested for compliance with International Electrotechnical Commission (IEC) standards in IPH Institut (Berlin, Germany) and IEL (Warsaw, Poland) test centers, including internal arc testing. DC switchgears meet the international standards EN 50123-1:2003 / IEC 61992-1:2014, EN 50123-6:2003+A1:2014 / IEC 61992-6:2014.



Maintenance

- / no need for frequent periodic maintenance and periodic repairs;
- / convenient inspection due to application of withdrawable component (trolley with circuit breaker and line disconnecter);
- / unilateral maintenance provides free access to all components of the cubicle and maintenance safety.

Protection, monitoring, diagnostics

- / easy switching devices control, trolley rolling in and out control using touch screen;
- / quick displaying of information on the switching devices condition, trolley position, current and voltage values, messages history, trends, settings;
- / protection of traction network against short circuit currents and harmful overloads;
- / support of IEC 61850 power protocol.



▲ Stockholm, Sweden

MAIN COMPONENTS

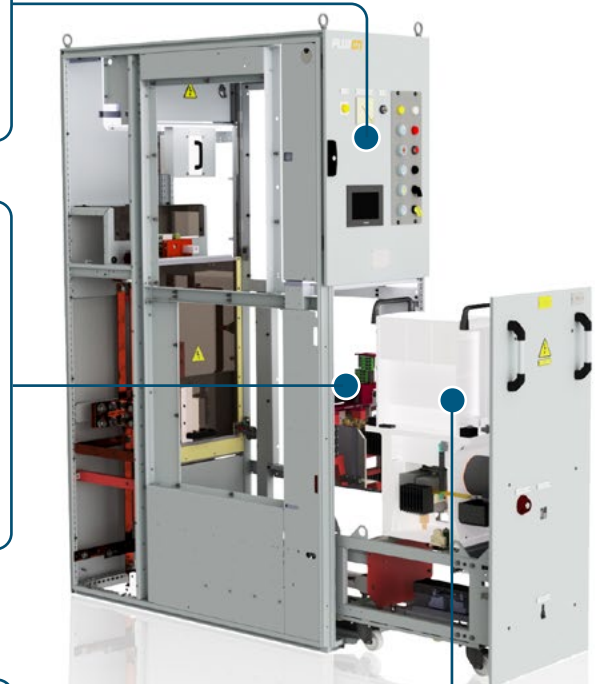
Control, monitoring and protection system SOTA®

- full automation of cubicle and traction substation control;
- traction network protection;
- cubicle and traction substation equipment condition monitoring with equipment self-diagnostics function;
- events logging;
- communication with the upper control level.



Two-pole disconnecter

- crimp-type;
- wiping contacts;
- long time without maintenance (once every ten years);
- electric drive with low power consumption;
- high electrodynamic resistance.



High Speed Circuit Breaker UR (Sécheron)

- circuit breaker with traditional arc chute type;
- high switching capacity;
- long lifetime;
- minimum tripping time.



AFB® ultra high-speed circuit breaker (PLUTON)

- arc-free switching principle;
- high wear resistance and long lifetime;
- ultra high-speed short circuit current interruption;
- operational and environmental safety, no damaging effect of arc.



COMPONENTS

High speed circuit breakers manufactured by Sécheron (Switzerland)



Circuit breakers of this type have high breaking capacity and dynamic stability to short circuit currents.

Main advantages of high speed circuit breakers:

- high mechanical resistance — 8x25000 cycles;
- reduced overvoltage during tripping;
- stepless regulation of trip setting;
- automatic adjustment of contact tightness.

Technical parameters of high speed circuit breakers UR

Name of parameter	Unit	High speed circuit breaker type								
		UR 26-81(82)	UR 36-81(82)	UR 40-81(82)	UR 60-81(82)	UR 80-81	UR26-64	UR36-64	UR40-64	UR60-64
Type of arc chute	-	81 (82)				81	64			
Main circuit current type	-	Direct								
Rated operating current, cabinet installation	A	2600	3600	4000	6000	8000	2600	3600	4000	6000
Rated voltage of main circuit	V	900 (1800)*				900	3600			
Setting currents limits	kA	1.4-8.0	2.0-15.0	2.0-15.0	6.0-18.0	8.0-24.0	1.4-8.0	2.0-15.0	2.0-15.0	6.0-18.0
Breaking capacity in non-inductive circuit: - rated - peak	kA	125 (80)* 180 (115)*				125 180	40 57			
Mechanical strength without maintenance, cleaning and greasing (non-emergency trippings)	-	8 x 25000								
Special inspection	-	Inspection after 250 overload trippings								
Test voltage, 50 Hz, 1 min	kV	15 (12)*				15	15			
Impulse test voltage at voltage increase 1.2/50 ms	kV	20				18	30			
Voltage of control coil, DC	V	24, 48, 60, 64, 110, 125, 200, 220								

* - The values shown in parentheses are consistent with Sécheron's arc chute type 82

ABF® ultra high-speed circuit breakers manufactured by PLUTON

Main advantages:

- ultra-high speed of short circuit currents interruption due to forced arc interruption in the vacuum interrupter with countercurrent from a precharged capacitor and application of high speed mechanical drive (opening time is no more than 1 ms);
- switching during dead time (arc-free current switching concept) ensures short-circuit currents breaking in line (total break time — maximum 4 ms) and low load currents breaking;
- built-in microprocessor measurement and protection system allows precise adjustment of settings and provides high response speed;
- built-in overcurrent protection and high di/dt protection allows effective breaking of nearby and far short circuit currents in line.



Technical parameters of ABF® arc-free circuit breakers

Name of parameter	Unit	High speed circuit breaker type	
		AFB25	AFB40
Maximum operating voltage U_{max}	V DC	1000	
Insulation voltage U_{Nm}	V DC	1800	
Test impulse voltage U_{Ni}	kV DC	1	
Maximum switching overvoltage Zone B acc. to EN50124.2 (< 20 ms)	V DC	<2500	<6000
Rated service current I_{NE}	A DC	2500	4000
Duty class acc. to IEC 60146-1-1	-	VI	
Steady-state short-circuit current I_{Nss}	kA	80	
Peak of the short-circuit current \hat{I}_{Nss}	kA	100	
Maximum breaking current I_{max}	kA	25	
Forward current di/dt limit	kA/ms	20	
Contacts opening time	ms	< 1	
Total break time	ms	< 4	
Breaking current setting range			
- forward	A	400 - 7500	400 - 12000
- reverse		400 - 3750	400 - 7500
Commutation life	switchings	3 x 50 000	
Protection level	-	IP 00	
Auxiliaries supply voltage	V DC	110, 220	

COMPONENTS

ABF® ultra high-speed circuit breakers manufactured by PLUTON

Safety

- no plasma emission during short-circuit currents breaking due to switching in vacuum interrupter;
- no combustion products and their deposits on the circuit breaker components and on the switchgear units;
- reduction of fire risk due to no open plasma formation area during switching;
- disconnecter, built-in into the circuit breaker, provides safety of operational switching.

Maintenance

- no arc chute and, thereby, no need for its maintenance;
- no need for the main circuit contact system maintenance during operation due to application of vacuum interrupter and arc-free AFB® circuit breaker interruption;
- no need for inspection, maintenance, and replacement of vacuum interrupter until the end of its mechanical life along with numerous operational switchings and short-circuit current trippings.



▲ Zgierz, the Republic of Poland

Disconnectors

EST, EDT disconnectors manufactured by Elpro (Germany) are applied for electric power circuit switching.

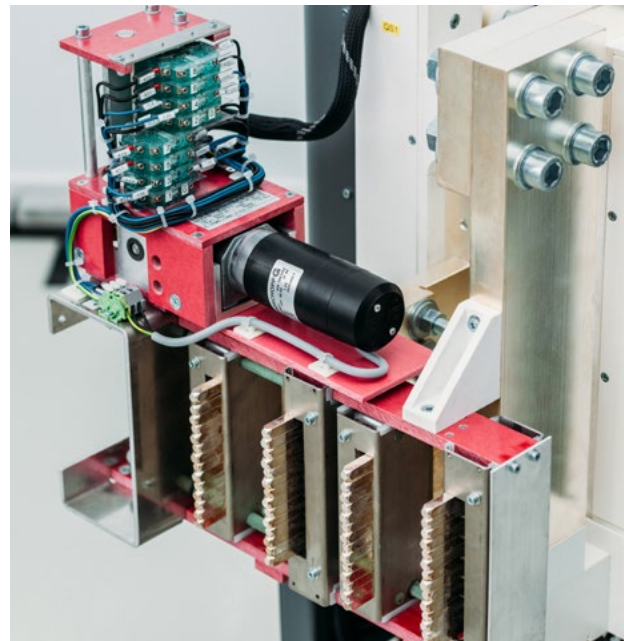
Disconnectors have a unique crimp-type contact system design with double gap and wiping contacts, geared by a small-sized electric drive.

Easy rolling out of trolley with circuit breaker and EDT double-pole disconnector is achieved due to disconnector unique design.

Each pole has two rows of lamellae. They are separated from each other in off-line state, and allow connected busbars entering lamellae gaps smoothly, without mechanical withstand strength.

When activating disconnector electric drive brings lamellae rows together and crimps a busbar with high effort.

EST and EDT disconnectors are classified as maintenance-free components, with the number of cycles before maintenance — 10.000 cycles (or 10 years).



Disconnectors are equipped with a noiseless efficient electric drive, capacity of 18 W. Application of electric drives controlled with automation system reduces risk of disconnectors and support insulation damage in case of false staff operation with undue exertion.

Technical parameters of EST, EDT disconnectors

Name of parameter	Unit	Disconnector type				
		EST 1000	EDT 2500	EDT 4000	EST 3-10	EDT 3-40
Rated voltage	V	1000	1000	1000	3600	3600
Rated current	A	1000	2500	4000	1000	4000
Short-time current maximum value	kA	80	100		80	100
Mechanical strength (maximum number of switchings)	-	30000	20000		30000	20000
Drive force	N	7	10		7	10
Maintenance intervals	-	Every 10000 cycles (or once per 10 years)				

COMPONENTS

Control, monitoring and protection system



DC switchgears are equipped with microprocessor control and diagnostics system with displaying information on the visualization panel. The control system is based on **SOTA® controller**, that meets a series of standards for PLC — **IEC 61131** and provides support of **IEC 61850** protocol.

Due to application of visualization panel, the required information is displayed in convenient intuitive form and switching units control is performed via touch to the touch screen.

SYSTEM FUNCTIONS:



Cubicle operation control (PLC)



Events logging



Protection of traction network against short circuit currents and harmful overloads



Generation of emergency oscillograph records of traction network electrical parameters



Monitoring of traction network parameters



Data storage for further analysis



Support of communication protocols



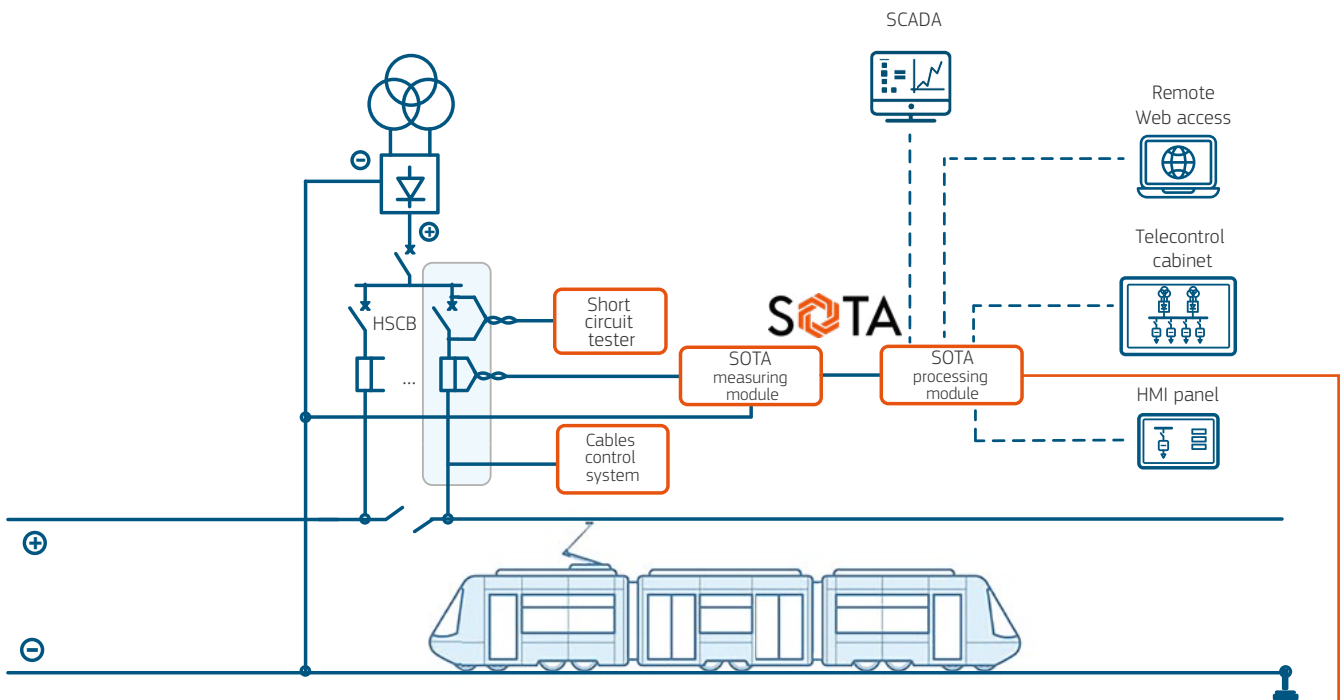
Storage of daily trends



System remote control



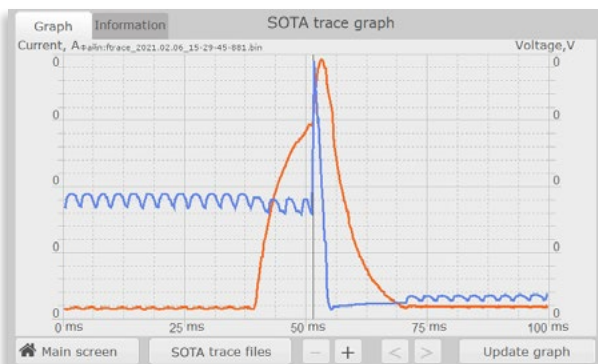
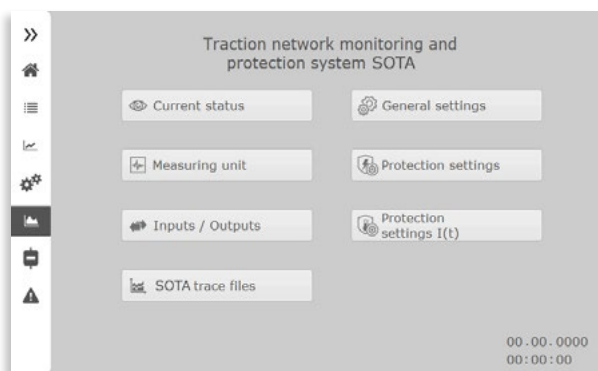
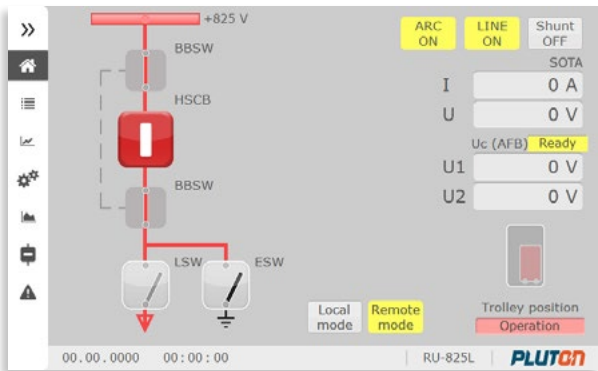
Programming of PLC operation algorithms using programming languages IEC 61131-3 (ST, IL, LD, FBD, SFC)



Support of PLC programming languages	Compliance with international standards	Support of communication
IEC 61131-3	IEC 61131-1, 2 EMC IEC 60255-26 mechanical and environmental resistance IEC 60068-2-1, -2, -6, -14, -27, -30, -31, -78 IEC 60255-21-1, -2, -32	IEC 61850 IEC 60870-5-101 IEC 60870-5-103 IEC 60870-5-104 Modbus DNP 3.0 CANopen SNTP client

COMPONENTS

Control, monitoring and protection system



▲ Screens on the visualization panel

Traction network protection is provided by continuous control and analysis of traction network current and voltage dynamics history with issuing commands to open DC switchgear high speed circuit breaker in case of protection functions set parameters exceed.

Types of electronic protections (ANSI code):

- instantaneous overcurrent (50);
- overcurrent protection (76);
- current rate of rise protection;
- current increment directional protection;
- overvoltage protection (59);
- undervoltage protection (27);
- thermal protection (49);
- breaker failure (BF);
- DDL protection;
- impedance protection.

SOTA® generates and stores the following records:

- events log;
- failures log;
- emergency oscillograph records.

Two emergency oscillograph records are generated and stored when one of the protective functions operates:

- “Fast track” record (the depth of outreach by time is 100 ms);
- “Slow track” record (the depth of outreach by time is 100 s).

Emergency records can be viewed via Web interface, read by the upper level system via Ethernet interface or stored to the external USB drive for further analysis using PC.



▲ “Fast track” diagram in the Web interface

TECHNICAL PARAMETERS

Technical parameters of DC switchgears

Name of parameter	Unit	Value		
Rated voltage	V	600, 750, 825	1500, 1650	3000, 3300
Maximum operating voltage	V	1000	2000	4000
Rated insulation voltage	V	3000		4800
Rated current of power circuit	A	up to 8000*		up to 6000*
Test voltage, 50 Hz, 1 min	kV	5	18.5	
Type of high speed circuit breaker	-	UR 26-81, UR 36-81, UR 40-81, UR 60-81, UR 80-81, AFB 25, AFB 40	UR 26-82, UR 36-82, UR 40-82, UR 60-82, UR 80-82	UR 26-64, UR 36-64, UR 40-64, UR 60-64
Electrodynamic resistance	kA	100	80	55
Breaking capacity in noninductive circuit: rated / peak	kA	125/180 (UR) 80/100 (AFB®)		40/57
Control	-	microprocessor		
Reverse current protection setting	A	0.05 -1 I _{rat.}		
Rated voltage of control circuits	V	110, 220		
Rated voltage of lighting AC circuits	V	220		
Rated voltage of signaling DC circuits	V	24		
Cooling	-	natural air		
Protection degree	-	IP43		
Overall dimensions of cubicles with power circuit rated current up to 6 kA	mm	W 600 800 H 2200 2000 D 1400 1200	W 800 H 2200 D 1500	
Overall dimensions of cubicles with power circuit rated current from 6 kA up to 10 kA	mm	W 800 H 2200 D 1500	W 800 H 2200 D 1600	

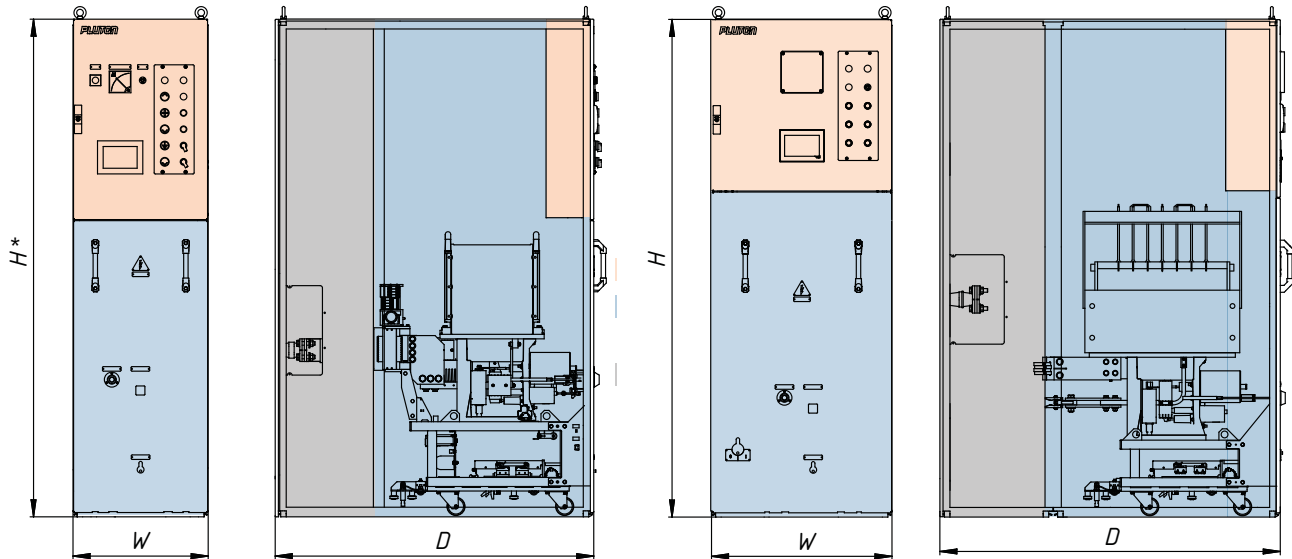
*- manufacturing of DC switchgear with parameters different from those stated above is made by special order

OVERALL DIMENSIONS

DC switchgears with UR circuit breaker

600, 750, 825 V

1500, 1650, 3000, 3300 V

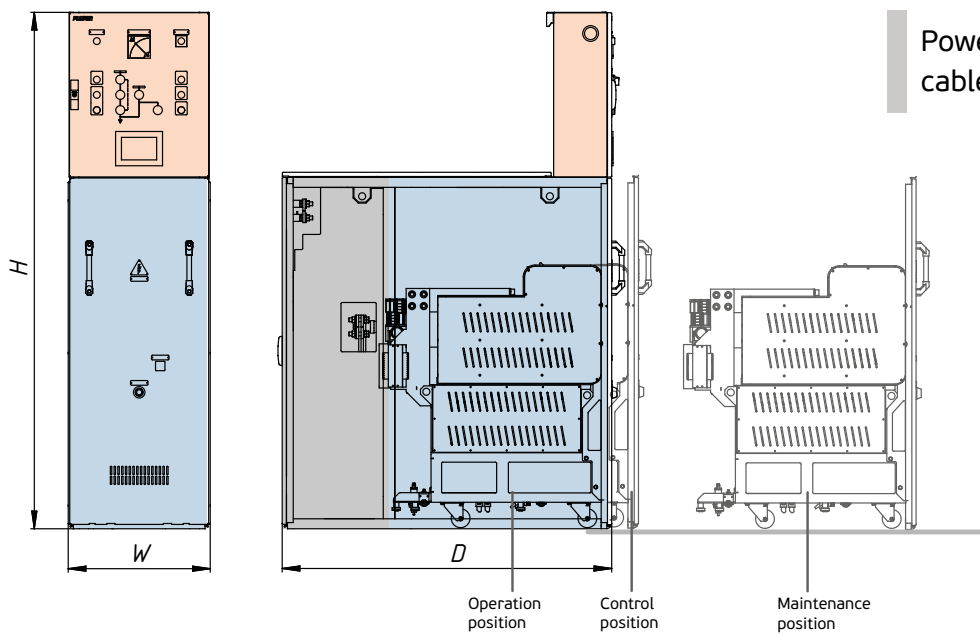


*- values of parameters are listed in the table (p.13)

DC switchgears with AFB® circuit breaker

600, 750, 825 V

- High speed circuit breaker compartment
- Automatics and control compartment
- Power busbars and cables compartment



DESIGN

Switchgear components are installed into the separate compartments. High and low voltage compartments are separated from each other. The separation ensures operation reliability, equipment servicing and operational safety.

High speed circuit breaker compartment:

- DC high speed circuit breaker;
- operating busbar two-pole disconnecter (or plug-in contacts);
- interlocks operational units;
- line tester (short circuits tester SCT);
- secondary circuits output terminal;
- withdrawable unit electric drive.

High speed circuit breaker, line disconnecter and short-circuit tester (SCT) are mounted on the withdrawable trolley. Application of withdrawable trolley in design provides quick inspection and equipment reconditioning in case of failures.

Withdrawable trolley has three positions:

- operation;
- control;
- maintenance.

Withdrawable trolley moves automatically from operation position to control position, and back, from control to operation position, due to electric drive with low power consumption, without applying any effort by maintenance staff. This ensures safe operation due to the electromechanical interlocking system.

Power part is made using technology of maintenance-free contact connections. There is no need for the contact connections control, periodical readjustment, cleaning during operation.

Automatics and control compartment:

- SOTA® controller with visualization panel;
- mechanisms control modules;
- contactor relay devices.

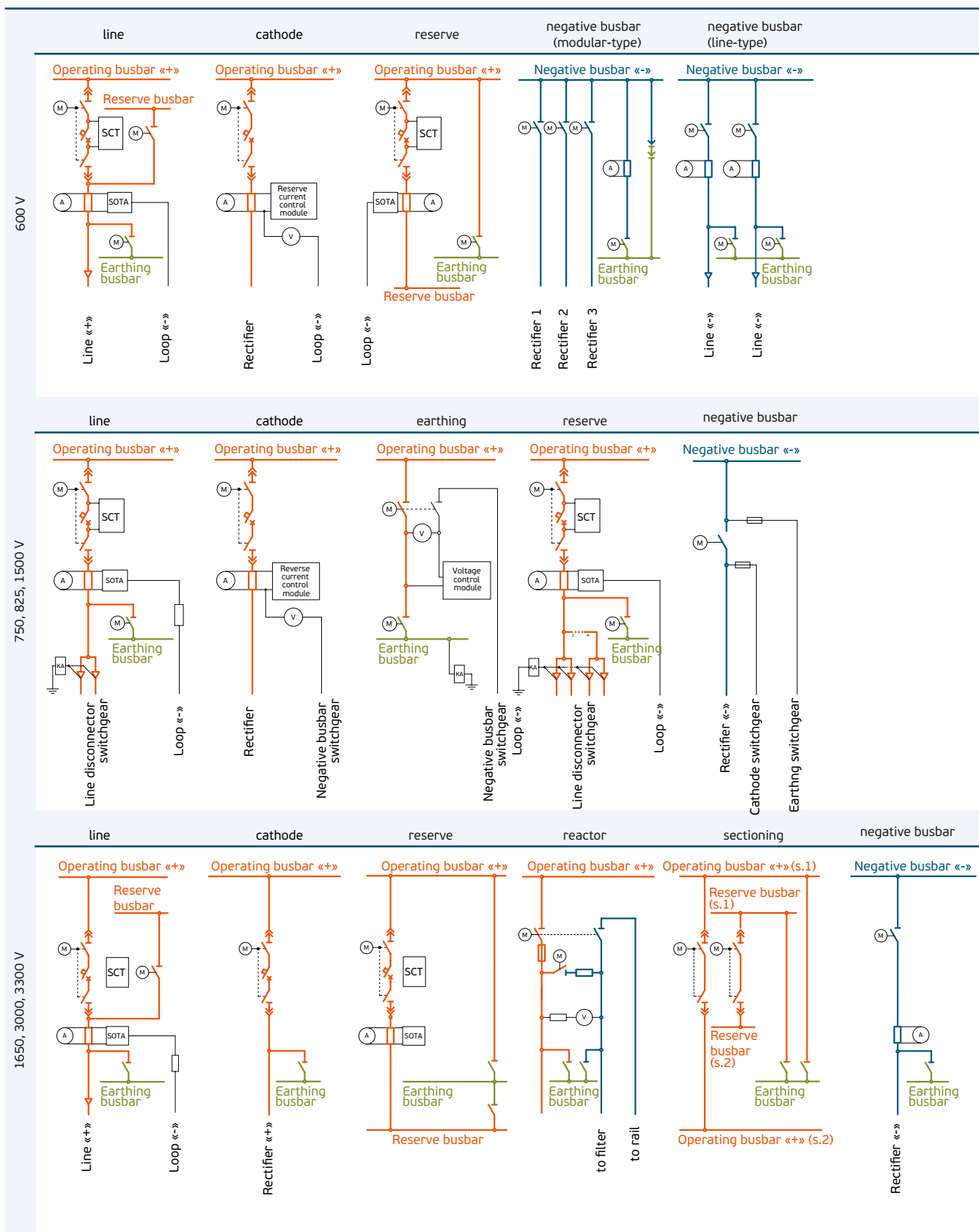
Power busbars and cables compartment:

- operating and output busbars;
- earthing busbar;
- disconnectors of various purpose (reserve, earthing);
- power cables mounting frame;
- cables control system;
- components of protection device against remote short circuits;
- SOTA® measuring module (or similar).

The following equipment is also installed in the compartment depending on the purpose and type of DC switchgear:

- power circuit shunt;
- power circuit current and voltage control components;
- reserve busbar.

SWITCHGEAR SINGLE-LINE DIAGRAMS



	600 V	750 V	825 V	1500 V	1650 V	3000 V	3300 V
Tram	■	■	■	■			
Trolleybus	■	■					
Light rail	■	■	■	■			
Metro		■	■	■			
Railway				■	■	■	■

Type of switchgear	Designation
cathode	for traction substation rectifier cathode circuit switching and protection
line	for the line supply circuits switching and protection
reserve, stand-by	for the line supply circuits switching and protection as a backup unit for line switchgear
sectioning	for busbars sectioning
earthing	for operating busbar earthing
reactor	for exhaust reactor and filter device connection to power circuit
negative busbar	for closing and opening of negative line dead sections



▲ Lodz, the Republic of Poland

NEGATIVE BUSBAR SWITCHGEARS

Negative busbar switchgears are provided for operation at traction substations, depot substations for receiving and distribution of electricity, as well as for switching of public electric transport, metro, railways lines power circuits.

Negative busbar switchgears are applied to close and open feeder negative line dead sections.

The switchgears are manufactured as individual metal cabinets for unilateral maintenance. Installation in a row is provided.

Depending on design solutions, switchgears can be manufactured for outdoor installation.

Switchgears' design provides:

- high reliability and maintainability;
- easy access for internal inspection;
- convenient access to measuring devices, as well as to components subject to regulation and adjustment;
- no fasteners loosening due to design;
- maintenance with standard tools.

Disconnectors' manual control is provided with the help of handle.

Modular-type switchgears are provided for rectifying units negative pole connection to negative busbar.

Line-type switchgears are provided for overhead network outgoing feeders connection to substation negative busbar.



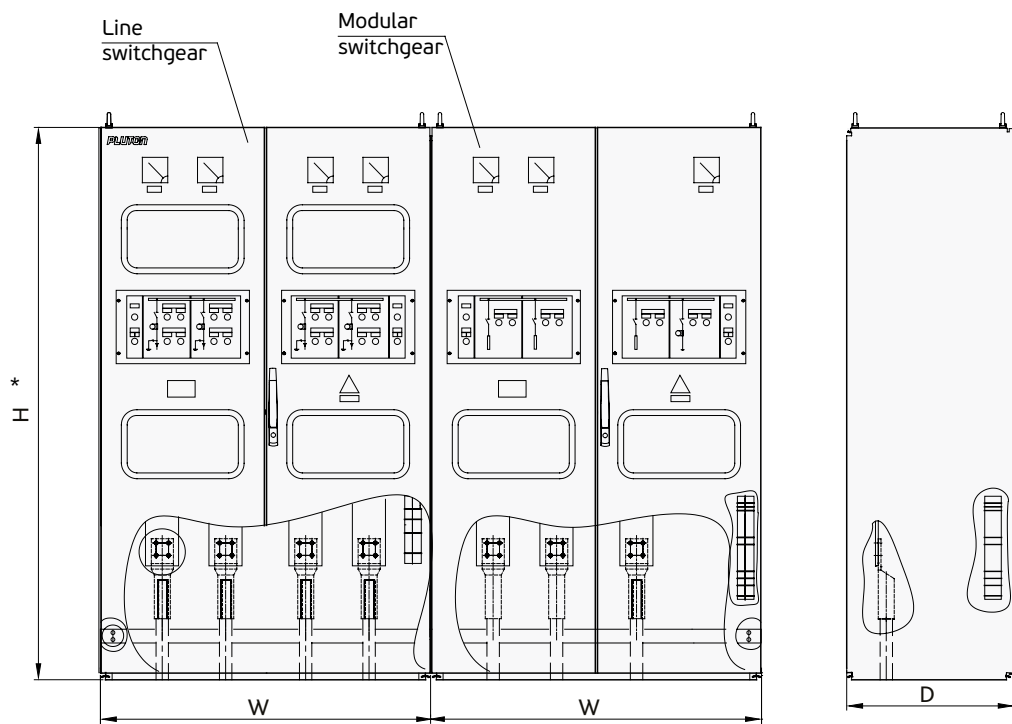
▲ Negative busbar switchgear (on the right), withdrawable rectifier (in the middle) DC switchgear (on the left)



▲ Negative busbar switchgear

OVERALL DIMENSIONS

Negative busbar switchgears for city electric transport

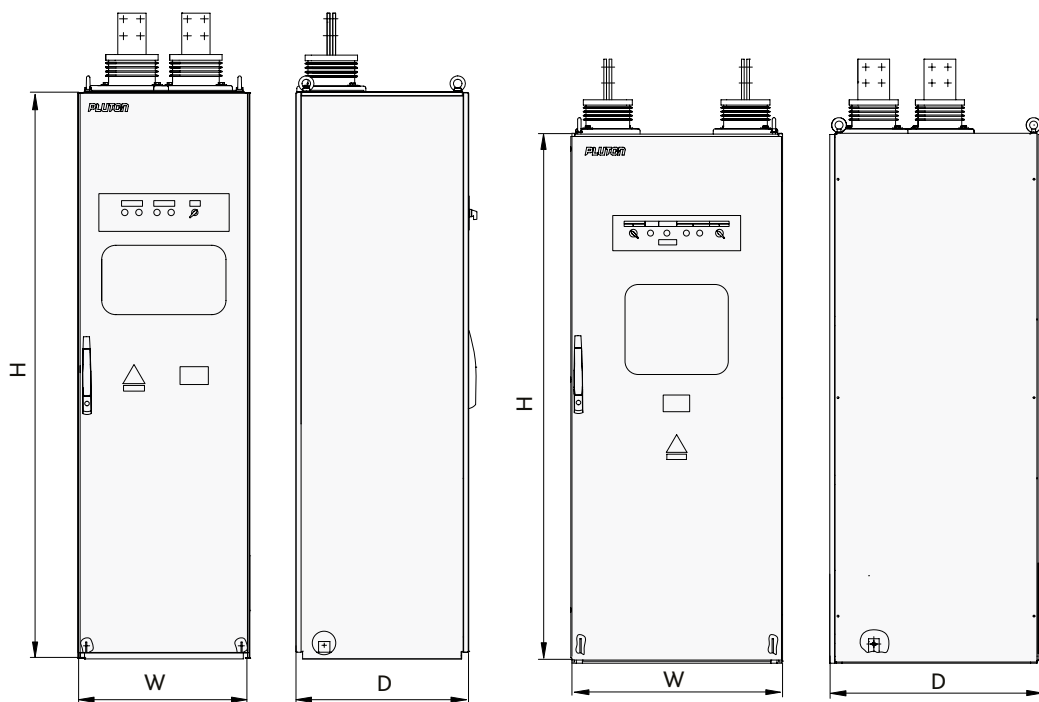


*- values of parameters are listed in the table (p.20)

Negative busbar switchgears for metro and railways

up to 4 kA

up to 8 kA



NEGATIVE BUSBAR SWITCHGEARS

Technical parameters of negative busbar switchgears

Name of parameter	Unit	Value				
Rated voltage of power circuit	V	600		750, 825	1500, 1650	3000, 3300
Negative switchgear type	-	line	modular	-		
Rated current of power circuit	A	1000	2000	up to 8000*		
Electrodynamic resistance	kA	80	100		80	55
Test voltage	kV	10				
Control	-	microprocessor				
Rated voltage of control circuits	V	110, 220				
Rated voltage of lighting AC circuits	V	220				
Rated voltage of signaling DC circuits	V	24				
Cycling	times per hour	40				
Mechanical strength, minimum	cycles	20000	30000	20000 (30000)**		
Protection degree	-	IP43				
Cooling	-	natural air				

*- manufacturing of negative switchgear with parameters different from those stated above is made by special order

**- the value depends on disconnector type

Overall dimensions	City electric transport			Metro, Railways	
	line-type		modular-type	up to 4 kA	up to 8 kA
	1-2 lines	3-4 lines	2-4 units		
Width	W 600	W 1200		W 600	W 800
Height	H 2000	H 2000		H 2000, 2200	H 2000
Depth	D 600	D 600		D 600	D 800

IMPLEMENTED PROJECTS

METRO

Sweden	Stockholm Metro	DC Switchgear 750 V - 36 units
Romania	Bucharest Metro	DC Switchgear 825 V - 8 units
Republic of Kazakhstan	Almaty Metro	DC Switchgear 825 V - 103 units
Republic of Azerbaijan	Baku Metro	DC Switchgear 825 V - 72 units
Ukraine	Kyiv Metro	DC Switchgear 825 V - 132 units
	Kharkiv Metro	DC Switchgear 825 V - 26 units
Republic of Uzbekistan	Tashkent Metro	DC Switchgear 825 V - 75 units
Republic of Korea	Busan City Metro	DC Switchgear 1500 V - 2 units
	Dawonsys Company	DC Switchgear 1500 V - 4 units
Republic of Turkey	Izmir Metro	DC Switchgear 750 V - 6 units

CITY ELECTRIC TRANSPORT

Sweden	Stockholm	DC Switchgear 750 V - 33 units
		DC Switchgear 1500 V - 18 units
Republic of Poland	Lodz, Poznan, Zgierz, Konstantynów Łódzki	DC Switchgear 660 V - 77 units
Romania	Oradea, Medias, Vaslui	DC Switchgear 750 V - 27 units
Republic of Madagascar	Antananarivo	DC Switchgear 1200 V - 13 units
Ukraine	Kyiv, Odesa, Lviv, Vinnytsia, Kramatorsk, Dnipro, Mykolaiv, Kryvyi Rih, Ivano-Frankivsk, Sumy	DC Switchgear 600 V - 295 units
AR of Crimea	Simferopol, Kerch	DC Switchgear 600 V - 49 units
Republic of Tajikistan	Dushanbe	DC Switchgear 600 V - 88 units

RAILWAYS

Ukraine	Ukrainian Railways (Ukrzaliznytsia)	DC Switchgear 3.3 kV - 44 units
	Southern Mining Company (Kryvyi Rih), departmental railway	DC Switchgear 1.65 kV - 15 units
	Kryukovsky Railway Car Building Works (Kremenchuk)	DC Switchgear 3.3 kV - 1 unit
Republic of Azerbaijan	Azerbaijan Railways	DC Switchgear 3.3 kV - 4 units
Georgia	Georgian railway	DC Switchgear 3.3 kV - 14 units
Republic of Estonia	Estonian Railways	DC Switchgear 3.3 kV - 2 units

IMPLEMENTED PROJECTS



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