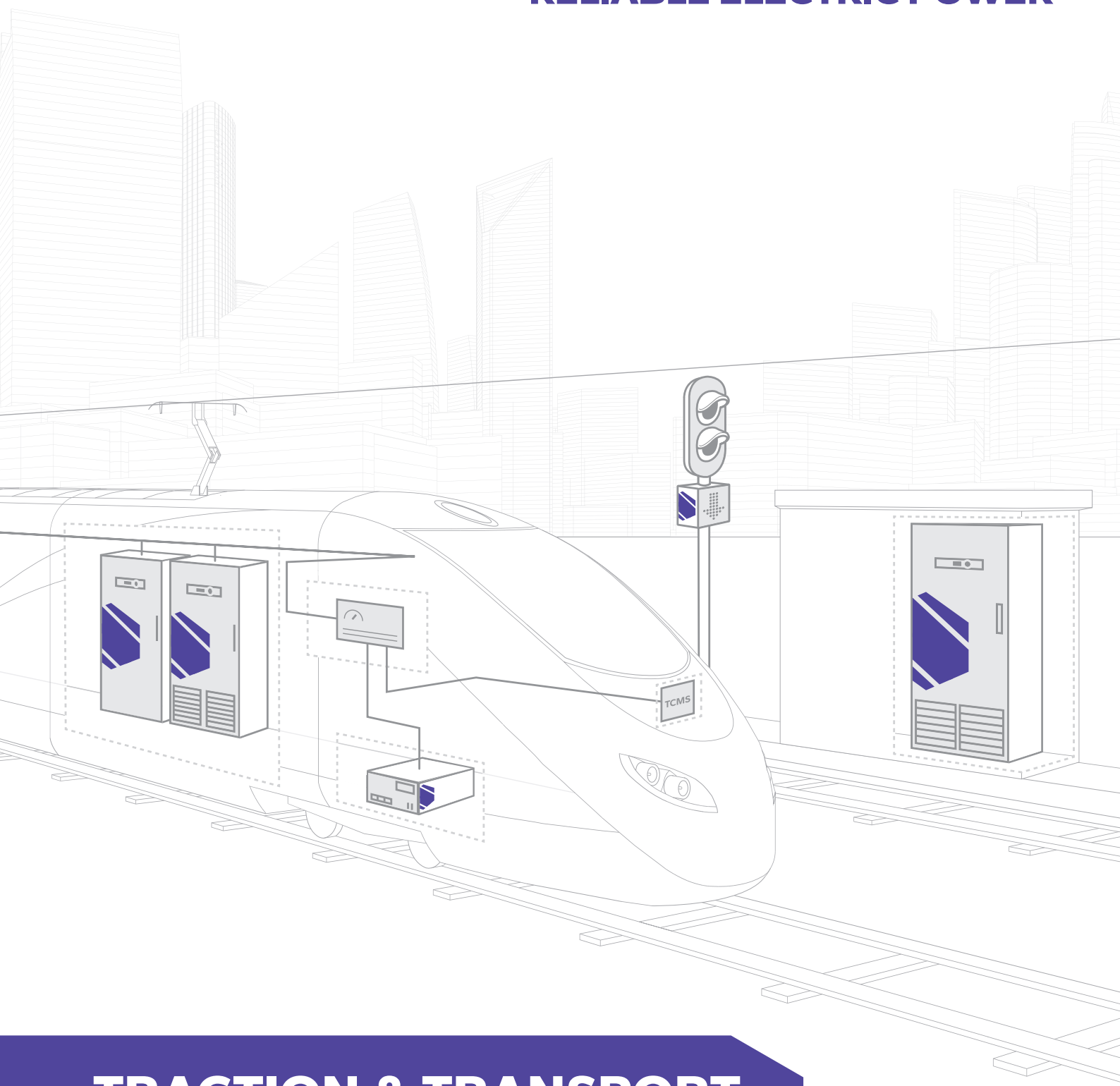
APS energia

30 YEARS ON THE MARKET

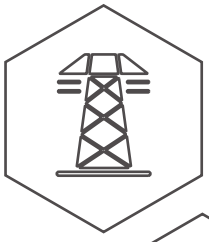
RELIABLE ELECTRIC POWER



TRACTION & TRANSPORT

PRODUCT CATALOG

OUR OPERATION AREAS



ENERGY

INDUSTRY

TRACTION & TRANSPORT

DEFENSE INDUSTRY

NUCLEAR ENERGY

OIL AND GAS

ENERGY STORAGE

RES

E-MOBILITY

For more than 30 years, APS Energia SA has been building trust as an experienced partner in securing key economic and industrial sectors in Poland and around the world. We design and manufacture power supply systems for conventional power generation and electricity distribution, mining, oil and gas industries, traction, transport, nuclear power and defense sectors. We focus on quality and safety. We offer cutting-edge solutions and the support of our experts, and help businesses eliminate the risk of power outages.

WE DESIGN CUSTOMIZED SOLUTIONS

We manufacture power supply systems tailored to the specific needs of each project, taking full account of the individual needs of our clients. Our team of experienced engineers analyzes technical characteristics and operating conditions, and designs reliable solutions that guarantee the continuous operation of key processes. **In the area of traction and public transport, our equipment supports the power supply of railroad, tram, and subway rolling stock, as well as electric buses, station infrastructure, LED railroad signaling equipment, and railroad route signage.** With a flexible approach and advanced technologies, we ensure stability and security in a demanding operating environment.

QUALITY CONFIRMED BY CERTIFICATES

The high quality of our equipment is confirmed by certificates awarded by Polish and international accredited certification bodies. Each solution undergoes detailed tests in our laboratory and in accredited third-party laboratories, where the durability of the equipment in difficult and unique operating conditions typical, for example, of the traction sector is verified. Our products meet stringent quality requirements, which allows their reliable and safe use in transport infrastructure, rail vehicles, and electric buses, both in Poland and in European and global markets.

WE SPECIALIZE IN COMPREHENSIVE SERVICE

We advise, design customized solutions, manufacture, install, and configure equipment at the place of its use. We provide support from qualified engineers and specialists at every stage of the project. Our advantage is our technical knowledge and many years of market experience.

WE INVEST IN A COMPETENCE CENTER

We employ the best engineers and specialists in R&D, design, and mechanical departments. We focus on the development, training, and expansion of the competence of our employees. Since we value scientific experience, for many years we have been cooperating with the Warsaw University of Technology and other scientific centers in Poland and abroad.

Main office of
APS Energia SA

APS Energia SA
branch in Bydgoszcz

Economic Award of the President
of the Republic of Poland

APS ENERGIA'S MISSION

Our mission is to provide innovative power electronics solutions for the traction and transport sector. We focus on reliability, safety, and operational efficiency. Thanks to our experienced team, knowledge and creativity, we respond to the changing needs of the market by designing equipment and systems that improve the quality and efficiency of transport. We care about the professional development of our employees, and strive to create a work culture based on cooperation and sharing of knowledge and experience.

APS ENERGIA'S VISION

We believe in continuous development. By observing the needs of the market, leveraging more than 30 years of our experience in power electronics, and investing in competence centers, we want to integrate innovative solutions from various industries to support customers in achieving their goals. We strive to introduce customized, efficient solutions to reduce the cost of the operation of rolling stock in Poland and around the world. We want to become a global leader in power electronics for rail transport.

CALENDAR

1995 — Founding of Advanced Power Systems, a company specializing in plasma power supplies.

1998 — First award for the FAT system at the ENERGETAB trade fair.
The following years brought prestigious awards and certificates.

2009/ 2010 — Transformation of APS Energia sp. z o.o. (a limited liability company) into a joint stock company.

2013 — A debut on the NewConnect stock exchange market.
An order for the delivery of the first battery chargers from PESA Pojazdy Szynowe Bydgoszcz SA.
The start of APS Energia SA's operations in the traction market.

2015 — A debut on the Main Market of the Warsaw Stock Exchange.
IRIS Certification.

2016 — APS Energia SA's new main office in Stanisławów Pierwszy.

2017 — Beginning of supervised runs of an under-frame multi-system auxiliary converter for passenger coaches manufactured by APS Energia SA.
Winning the first major contract for the production of under-frame auxiliary converters for passenger coaches to be delivered to H. Cegielski - Fabryka Pojazdów Szynowych sp. z o.o.

2021 — Economic Award of the President of the Republic of Poland.

2022 — A new strategy for the APS Energia SA Group to become actively involved in the energy transition.

2024 — Winning the largest-ever contract for the supply of multi-system converters for H. Cegielski - Fabryka Pojazdów Szynowych sp. z o.o. - 300 units with an option for an additional 150 units.

2025 — Opening of APS Energia SA's design office in Bydgoszcz.
Tram drive inverters and the TCMS system.

WE DRIVE THE FUTURE OF RAIL TRANSPORT

APS Energia SA, as a Polish brand, has been designing and manufacturing advanced power electronics solutions for more than 30 years. We have gained our experience during various periods of the country's economic transition, and we have supplied equipment to more than 30 countries, often with differently required technical standards, climates, or certification requirements.

Since 2013, we have been intensively developing **a dedicated line of equipment for electric traction**– for both domestic and foreign markets. Our products are in operation today in rail vehicles manufactured by, among others: **PESA Pojazdy Szynowe Bydgoszcz SA, NEWAG SA, H. Cegielski – Fabryka Pojazdów Szynowych sp. z o.o., PKP Intercity Remtrak sp. z o.o.** (passenger coaches), and **Alstom SA**, and in stationary power supply systems in **PKP Polskie Linie Kolejowe SA** ad **PGE Energetyka Kolejowa**.

We constantly strive to maintain a high quality of cooperation with our current partners, but we also actively seek to establish relationships with all rolling stock manufacturers - both large market players and smaller companies specializing in upgrades and the repair of rolling stock. Our goal is to build long-term partnerships based on trust and joint technological development.

Thanks to such relationships, our solutions are already successfully working in various countries, including **in Germany, Czech Republic, Malaysia, Taiwan, Lithuania, Ukraine, Scandinavian countries, and, of course, Poland.**

Over the past decade, we have delivered more than **3,000 units of traction equipment**, each time adapting them to the country's specific standards, weather, and operating conditions.

The end users of our traction systems are rolling stock operators: state-owned railroad companies, local governments, and private carriers alike. In our direct cooperation with them we gain the most valuable experience concerning the operating conditions, functional expectations, and normative requirements, which inspires us to continuously improve and develop our product line for the traction sector.

We offer a comprehensive approach to traction. At APS Energia SA, traction is not just about vehicles - it is also about **stationary power supply systems.** We have been designing and supplying equipment for tram, trolleybus, and subway traction substations for years. Thanks to our flexibility and team of specialists, we are ready to participate in even the most demanding projects, from power supply systems to drive and control systems.

Our solutions are distinguished by:

- **Reliability** - a core value of the APS Energia SA brand;
- **Safety and quality** - proven in operation under extreme conditions;
- **Adaptation to the client's needs** - quick response, flexible approach, and in-house design facilities'
- **Polish technical thought** - developed by engineers with many years of experience;
- **Collaboration and partnership** - we design solutions together with our clients, not beside them.

Our product portfolio includes:

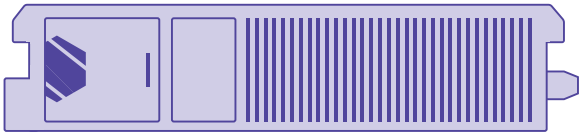
- Static converters for rail and electric transport;
- Battery chargers and DC/DC converters;
- Traction and auxiliary inverters;
- Train control and monitoring systems (TCMS);
- Systems and devices supporting traction vehicles;
- Railway signals using LED technology;
- Stationary power supply systems for traction;
- Service and technical support.

We are ready for more. We are not stopping - we design and test new power supply and propulsion solutions for **trams, subways, railroads,** and **stationary systems**. Our goal is to offer a full portfolio of products for traction - tailored to each type of rail vehicle and each type of power supply infrastructure.

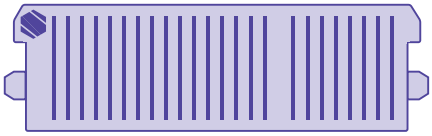
CONTENTS

1. STATIC CONVERTERS FOR RAIL AND ELECTRIC TRANSPORT

SINGLE-SYSTEM STATIC CONVERTER **BFI 50T TR**

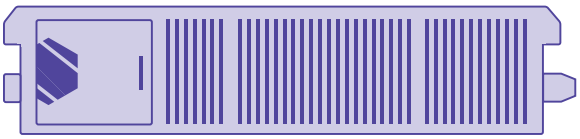


APS-50 WN TR



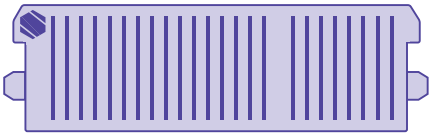
APS-50 NN

MULTI-SYSTEM STATIC CONVERTER **BFI 50T TRW**



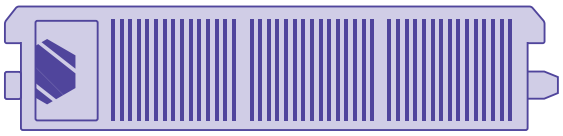
APS-50 WN TRW

APS-50 MAG TRW



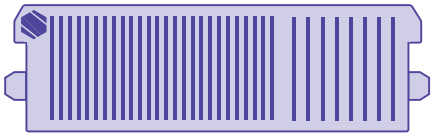
APS-50 NN

MULTI-SYSTEM STATIC CONVERTER **BFI 100T TRW**



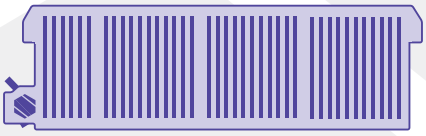
APS-100 WN TRW

APS-100 MAG TRW

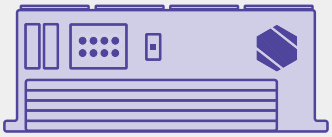


APS-100 NN

STATIC CONVERTER **STC 3×8**



TRAM STATIC CONVERTER **BFI 60T TR**



Static converters are critical devices in power supply systems for rail vehicles such as passenger coaches, electric multiple units, trams, subways, and locomotives. These power electronic devices convert the voltage coming from the catenary to a voltage that matches the requirements of the equipment being powered.

Thanks to our flexible approach, we are able to design and manufacture a device that meets individual client's needs.

The converters manufactured by APS Energia SA are tailored to our clients' needs and can be powered from various DC and AC traction power supply systems, as well as from a platform connection. **Their task is to power low-voltage on-board equipment, such as:**

- **air conditioning and heating equipment;**
- **lighting equipment;**
- **vacuum toilets and hand dryers;**
- **passenger information systems;**
- **monitoring systems;**
- **electric sockets;**
- **cell phone USB chargers;**
- **restaurant car equipment.**

Moreover, static converters charge on-board and auxiliary batteries, which are used for such purposes as starting vehicles or on-board equipment, as well as maintaining the operation of the vehicle's diagnostic and control system.

Modern static converters offered by APS Energia SA use advanced semiconductor technologies, such as:

- **IGBT;**
- **SiC MOSFET.**

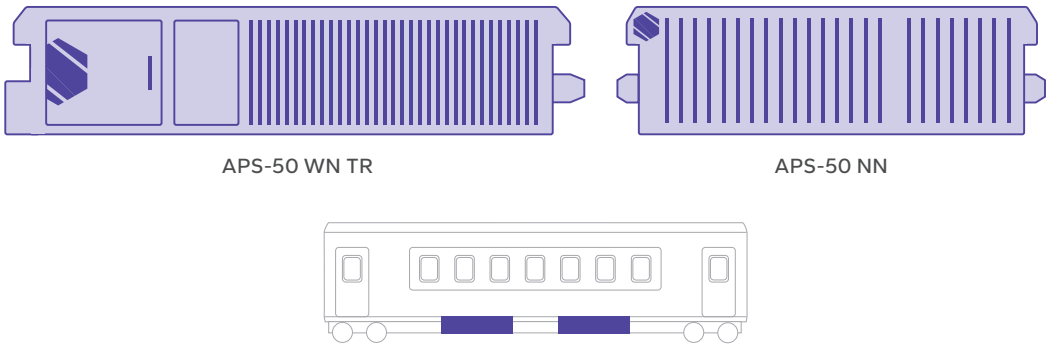
APS Energia SA designed its first converter for rail rolling stock in 2016. Several hundred units made by us have been placed on the market to date, and they work reliably in passenger coaches both in Poland and abroad.

Thanks to their modern design, resistance to harsh operating conditions, and the ability to adapt to individual clients' requirements, static converters from APS Energia SA are a reliable source of power in modern rolling stock.

Static converters manufactured by APS Energia SA are equipped with an autostart module, which allows the device to start even when the on-board battery is discharged or disconnected.

We carry out each production stage in compliance with the highest quality standards, in accordance with railroad standards and EU directives:		
CLC/TS 50701:2023	IEEE Std 802.3-2022	ISO 21106:2019
PN-EN 10204:2006	PN-EN 17023:2019-02	PN-EN 45545-1:2013-07
PN-EN 45545-2+A1:2024-04	PN-EN 45545-5+A1:2016-01	PN-EN 50121-3-2:2017
PN-EN 50124-1:2017-09	PN-EN 50125-1:2014-06	PN-EN 50126-1:2018-02
PN-EN 50126-2:2018	PN-EN 50155:2022-05	PN-EN 50160:2023-10
PN-EN 50163:2006	PN-EN 50325-1 :2020-10	PN-EN 50325-4:2004
PN-EN 50343:2025-07	PN-EN 50716:2024-05	PN-EN 61373:2011
PN-EN IEC 62847:2024-01	PN-EN IEC/IEEE 82079-1:2020-09	PN-EN ISO/IEC 17050-1:2010
UIC 550	UIC 550-2	UIC 550-3
UIC 552	2014/30/EU	2014/35/EU

1.1. SINGLE-SYSTEM STATIC CONVERTER BFI 50T TR



APS-50 WN TR

APS-50 NN

General layout of the modules of the BFI 50T TR single-system static converter in a passenger coach

The **BFI 50T TR single-system static converters** are designed for installation in railroad vehicles under their chassis. Their main task is to supply AC loads with the rated voltage of 3×400 V 50 Hz and 230 V 50 Hz, as well as to charge batteries and supply DC loads with the rated voltage of 24 V. The converters are powered with 3,000 V DC, 3×400 V 50 Hz, and 230 V 50 Hz (platform connectors). The BFI 50 TR converter consists of the APS-50 WN TR and APS-50 NN modules. The APS-50 WN TR module converts the supply voltage into an intermediate voltage. The APS-50 NN module consists of an inverter and two battery chargers.

A COMBO type passenger coach powered by the BFI 50T TR single-system static converter

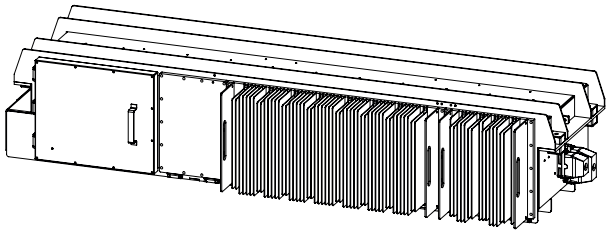
CHARACTERISTICS:

- high efficiency of the conversion system;
- overload and short-circuit protection for the inverter and chargers;
- possible operation with loads with a wide range of power factor;
- over-voltage and under-voltage protection from the DC supply voltage;
- temperature protection of power systems;
- convenient access to connections;
- galvanic separation of the input and output circuits;
- low level of the AC output voltage, higher harmonics;
- high stability of the output voltage frequency;
- high stability of the DC output voltage;
- remote signaling of an alarm state;
- CANopen communication protocol;
- device weight dependent on the configuration.

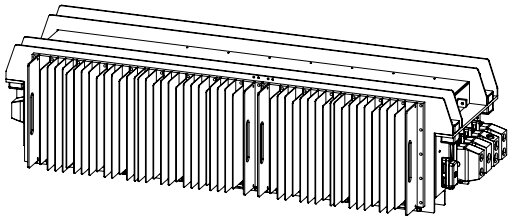
SINGLE-SYSTEM STATIC CONVERTER BFI 50T TR - BASIC CHARACTERISTICS	
CHARACTERISTIC	VALUE
ELECTRICAL CHARACTERISTICS	
Rated DC supply voltage	3,000 V
Range of DC supply voltage	Acc. to UIC 550
Rated power*	50 kW
Rated output voltages*	AC1: 3×400 V 50 Hz AC2: 230 V 50 Hz DC1, DC2: 24 V
Rated output current*	AC1: 55 A AC2: 59 A DC1: 250 A DC2: 75 A
TECHNICAL CHARACTERISTICS	
Enclosure protection rating	IP56
External dimensions (L × W × H)*	APS-50 WN TR: 2591 × 776 × 500 mm APS-50 NN: 1950 × 660 × 500 mm
Operating temperature*	-25 to +40 °C
Cooling type	passive

* - a product with other characteristics can be manufactured.

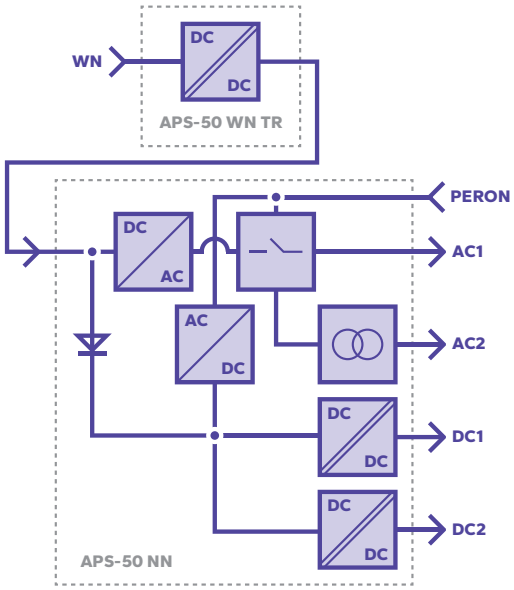
A 174A type passenger coach powered by the BFI 50T TR single-system static converter



General view of the APS-50 WN TR module
of the BFI 50T TR single-system static converter

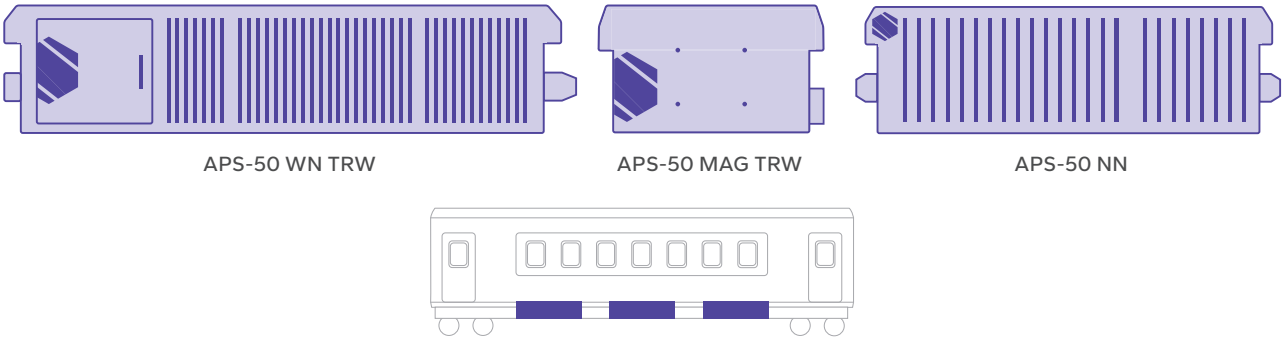


General view of the APS-50 NN module
of the BFI 50T TR single-system static converter



Block diagram of the single-system
static converter BFI 50T TR

1.2. MULTI-SYSTEM STATIC CONVERTER BFI 50T TRW



General layout of the modules of the BFI 50T TRW multi-system static converter in a passenger coach

The **BFI 50T TRW multi-system static converters** are designed for installation in railroad vehicles under their chassis. Their main task is to supply AC loads with the rated voltage of 3×400 V 50 Hz and 230 V 50 Hz, as well as to charge batteries and supply DC loads with the rated voltage of 24 V. The BFI 50T TRW converters can be powered from the catenary line with DC voltage of 3,000 V or 1500 V, and AC voltage of 1,500 V 50 Hz, 1,000 V 50 Hz, or 1,000 V 16 $^{2}/_{3}$ Hz, and from a platform connection with voltage of 3×400 V 50 Hz or 230 V 50 Hz.

The BFI 50T TRW converter consists of the APS-50 WN TRW, APS-50 MAG TRW, and APS-50 NN modules. The APS-50 MAG TRW module is a part of a high-voltage circuit that contains a traction choke that is part of the input filter. The APS-50 WN TRW module converts the catenary line a voltage into a 700 V DC intermediate voltage. The APS-50 NN module consists of an inverter and two battery chargers.

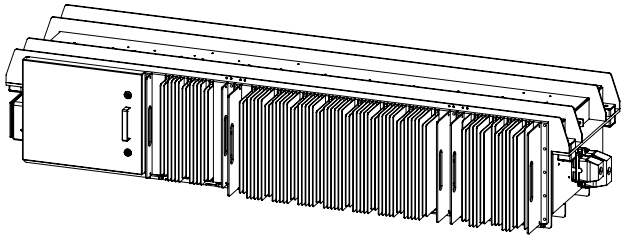
A 178A-1 type passenger coach powered by the BFI 50T TRW multi-system static converter

CHARACTERISTICS:

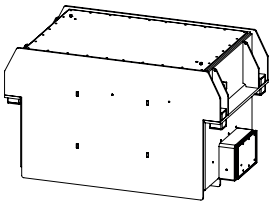
- high efficiency of the conversion system;
- overload and short-circuit protection for the inverter and chargers;
- possible operation with loads with a wide range of power factor;
- over-voltage and under-voltage protection from the DC supply voltage;
- temperature protection of power systems;
- convenient access to connections;
- galvanic separation of the input and output circuits;
- low level of the AC output voltage, higher harmonics;
- high stability of the output voltage frequency;
- high stability of the DC output voltage;
- remote signaling of an alarm state;
- TRDP communication protocol;
- device weight dependent on the configuration.

MULTI-SYSTEM STATIC CONVERTER BFI 50T TRW - BASIC CHARACTERISTICS	
CHARACTERISTIC	VALUE
ELECTRICAL CHARACTERISTICS	
Rated supply voltage	DC: 3,000 V, 1,500 V AC: 1,500 V 50 Hz, 1,000 V 50 Hz, 1,000 V 16 ²/₃ Hz
Supply voltage range	acc. to UIC 550
Rated power*	50 kW
Rated output voltages*	AC1: 3×400 V 50 Hz AC2: 230 V 50 Hz DC1, DC2: 24 V
Rated output current*	AC1: 61 A AC2: 44 A DC1: 250 A DC2: 80 A
TECHNICAL CHARACTERISTICS	
Enclosure protection rating	IP56
External dimensions (L × W × H)*	APS-50 WN TRW: 2560 × 776 × 500 mm APS-50-MAG TRW: 1065 × 616 × 620 mm APS-50 NN: 1950 × 660 × 500 mm
Operating temperature*	-25 to +40 °C , -40 to +40 °C
Cooling type	passive

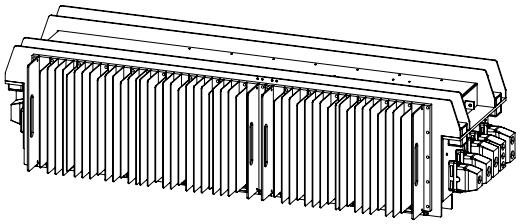
* - a product with other characteristics can be manufactured.



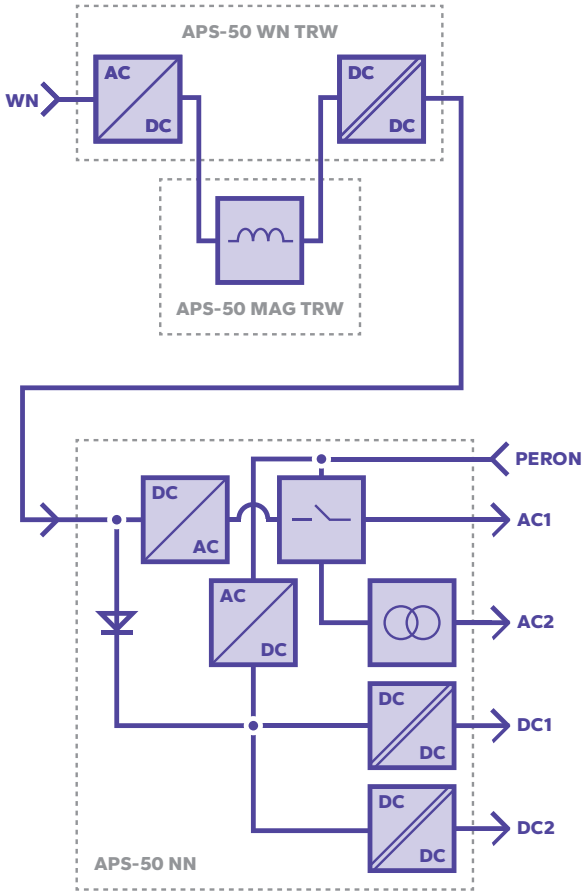
General view of the APS-50 WN TRW module of the BFI 50T TRW static multi-system converter



General view of the APS-50 MAG TRW module of the BFI 50T TRW static multi-system converter

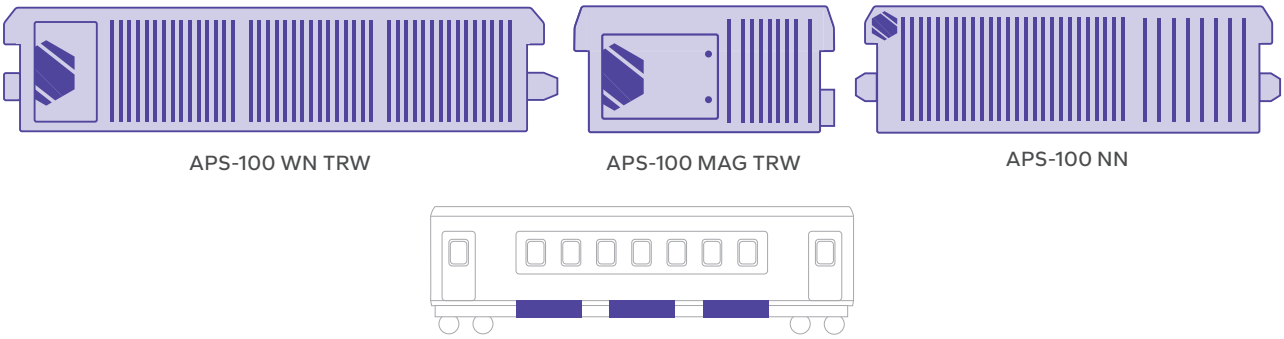


General view of the APS-50 NN module of the BFI 50T TRW static multi-system converter



Block diagram of the BFI 50T TRW multi-system static converter

1.3. MULTI-SYSTEM STATIC CONVERTER BFI 100T TRW



General layout of the modules of the BFI 100T TRW multi-system static converter in a passenger coach

The **BFI 100 TRW multi-system static converters** are designed for installation in railroad vehicles under their chassis. Their main task is to supply AC loads with the rated voltage of 3×400 V 50 Hz and 230 V 50 Hz, as well as to charge batteries and supply DC loads with the rated voltage of 24 V. The BFI 100 TRW converters can be powered from the catenary line with DC voltage of 3,000 V or 1500 V, and AC voltage of 1,500 V 50 Hz, 1,000 V 50 Hz or 1,000 V 16 $^{2}/_{3}$ Hz and from a platform connection with voltages of 3×400 V 50 Hz or 230 V 50 Hz or the power supply from an on-board generator 3×400 V 50 Hz.

The BFI 100T TRW converter consists of the APS-100 WN TRW, APS-100 MAG TRW, and APS-100 NN modules. The APS-100 WN TRW module is supplied with the basic supply voltage from the catenary line. The APS-100 MAG TRW module is a part of a high-voltage circuit that consists of an input diode rectifier and a traction choke. The APS-100 WN TRW module converts the catenary line voltage into an intermediate DC voltage. The APS-100 NN module consists of an inverter and two battery chargers.

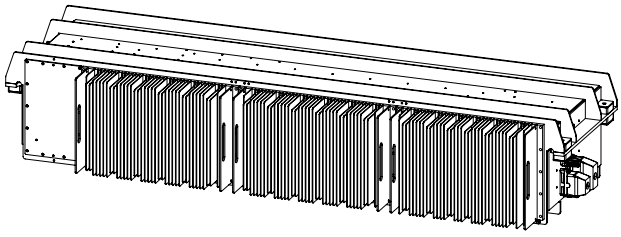
A 406A-40 WARS type restaurant car powered by the BFI 100T TRW multi-system static converter

CHARACTERISTICS:

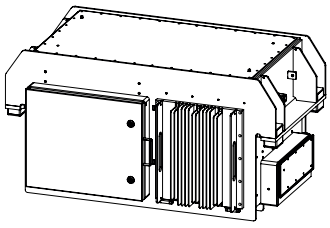
- high efficiency of the conversion system;
- overload and short-circuit protection for the inverter and chargers;
- possible operation with loads with a wide range of power factor;
- over-voltage and under-voltage protection from the DC supply voltage;
- temperature protection of power systems;
- convenient access to connections;
- galvanic separation of the input and output circuits;
- low level of the AC output voltage, higher harmonics;
- high stability of the output voltage frequency;
- high stability of the DC output voltage;
- remote signaling of an alarm state;
- TRDP communication protocol;
- device weight dependent on the configuration.

MULTI-SYSTEM STATIC CONVERTER BFI 100T TRW - BASIC CHARACTERISTICS	
CHARACTERISTIC	VALUE
ELECTRICAL CHARACTERISTICS	
Rated supply voltage	DC: 3,000 V, 1,500 V AC: 1,500 V 50 Hz, 1,000 V 50 Hz, 1,000 V 16 $^{2}/_{3}$ Hz
Supply voltage range	Acc. to UIC 550
Rated power*	100 kW
Rated output voltages*	AC1: 3×400 V 50 Hz AC2: 230 V 50 Hz DC1, DC2: 24 V
Rated output current*	AC1: 90 A AC2: 44 A DC1: 250 A DC2: 80 A
TECHNICAL CHARACTERISTICS	
Enclosure protection rating	IP56
External dimensions (L × W × H)*	APS-100 WN TRW: 2,686 × 844 × 500 mm APS-100 MAG TRW: 1,250 × 698 × 650 mm APS-100 NN: 1,950 × 660 × 500 mm
Operating temperature*	-25 to +40 °C , -40 to +40 °C
Cooling type	passive

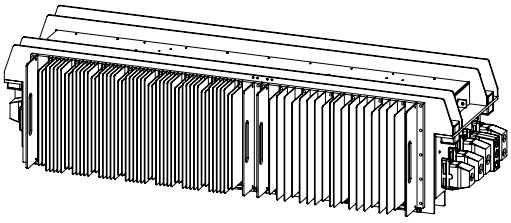
* - a product with other characteristics can be manufactured.



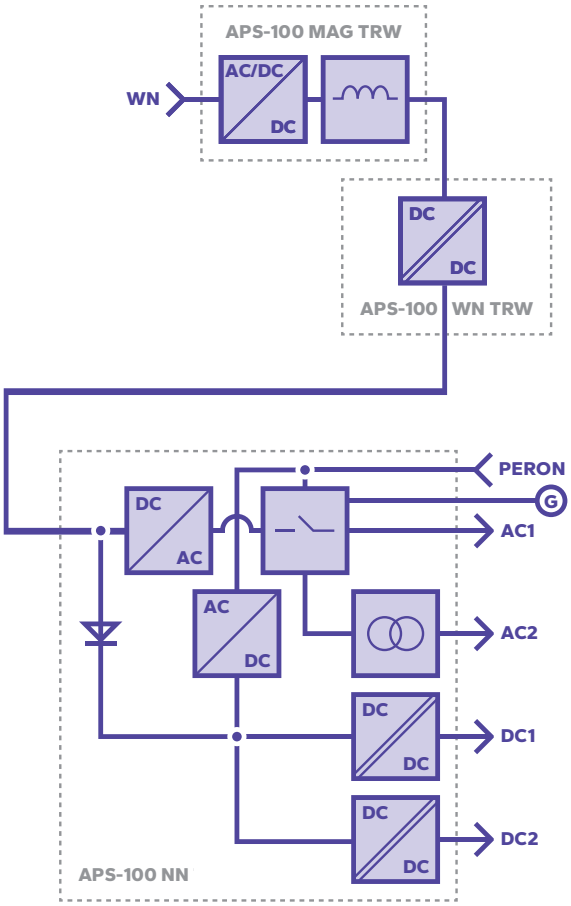
General view of the APS-100 WN TRW module
of the BFI 100T TRW static multi-system converter



General view of the APS-100 MAG TRW module
of the BFI 100T TRW static multi-system converter

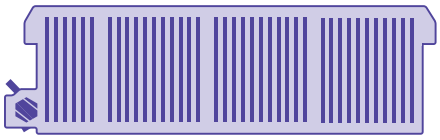


General view of the APS-100 NN module
of the BFI 100T TRW static multi-system converter

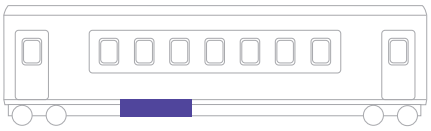


Block diagram of the BFI 100T TRW
multi-system static converter

1.4. STATIC CONVERTER STC 3×8



STC 3×8



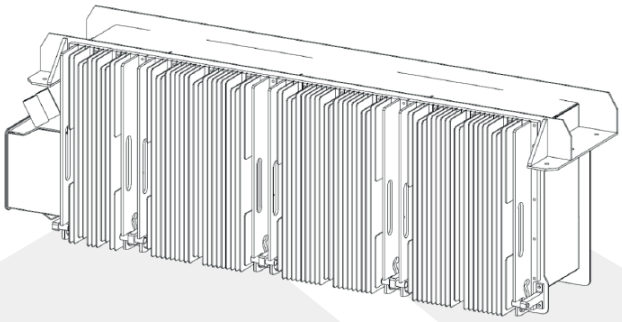
General layout of the STC 3×8 static converter in a passenger coach

The **STC 3×8 static converters** are designed for installation in railroad vehicles under their chassis. Their main task is to supply AC loads with the rated voltage of 3×380 V 50 Hz and 3×380 V with the regulated frequency, as well as DC loads with the rated voltage of 24 V. The converters are powered with 110 V DC

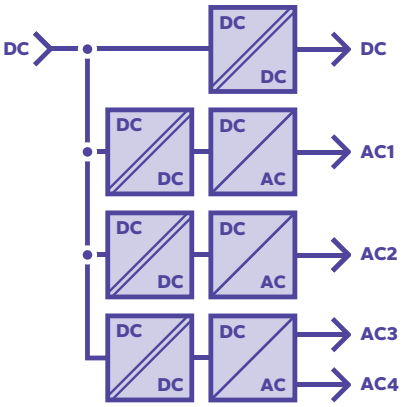
The converter consists of a 110/24 DC/DC module three 110/600 V DC/DC modules, and three 3×380 V inverters. Galvanic separation between the input and output circuits is provided in the converter. In addition, the device is equipped with a "soft-start" system.

CHARACTERISTICS:

- high efficiency of the conversion system;
- overload and short-circuit protection for the inverter;
- possible operation with loads with a wide range of power factor;
- over-voltage and under-voltage protection from the DC supply voltage;
- temperature protection of power systems;
- convenient access to connections;
- galvanic separation of the input and output circuits;
- low level of the AC output voltage higher harmonics;
- high stability of the output voltage frequency;
- high stability of the DC output voltage;
- remote signaling of an alarm state;
- CANopen communication protocol.



General view of the STC 3×8 static converter



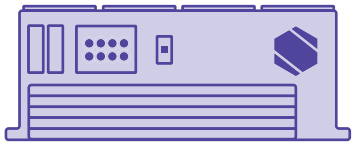
Block diagram of the STC 3×8 static converter

STATIC CONVERTER STC 3×8 - BASIC CHARACTERISTICS	
CHARACTERISTIC	VALUE
ELECTRICAL CHARACTERISTICS	
Rated dc input voltage	110 V
Range of DC input voltage	85 to 150 V
Rated DC input current*	190 A
Rated output voltage*, **	AC1, AC2: 3×380 V ±10 %, 50 Hz AC3, AC4: 3×190 to 3×380 V ±10 %, 38 to 50 Hz
Rated output power of a single inverter	8 kVA
Rated AC output current*	15 A
Rated DC output voltage*	24 V
Rated output power of a DC/DC converter*	300 W
Rated DC output current*	12.5 A
TECHNICAL CHARACTERISTICS	
Enclosure protection rating	IP56
Enclosure dimensions (L × W × H)*	2,002 × 651 × 450 mm
Operating temperature*	-45 to +50 °C
Cooling type	passive

* - a product with other characteristics can be manufactured.
** - adjustable from 38 to 50 Hz and 190 to 380 V.

A 61-779A type passenger coach supplied by the STC 3×8 static converter

1.5. TRAM STATIC CONVERTER BFI 60T TR



BFI 60T TR

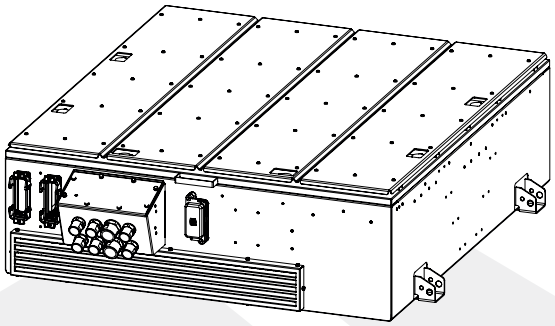
General layout of the BFI 60T TR
tram static converter in a tram

The **BFI 60T TR tram static converter** is designed to supply AC loads with a rated voltage of 3×400 V and 230 V 50 Hz, and to charge batteries and supply DC loads with a rated voltage of 24 V. The converter is powered by a 600 V constant voltage. The converter is equipped with a microprocessor system for the control and monitoring of the operating characteristics.

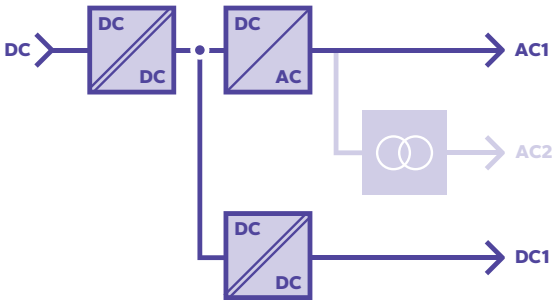
The device consists of an input filter section, a high frequency intermediate module, an inverter, and a battery charger. Some of the power is installed on a common heat sink with forced air cooling.

CHARACTERISTICS:

- SiC MOSFET technology;
- high efficiency of the conversion system;
- overload and short-circuit protection for the inverter and chargers;
- over-voltage and under-voltage protection from the DC supply voltage;
- temperature protection of power systems;
- convenient access to connections;
- galvanic separation of the input and output circuits;
- low level of the AC output voltage higher harmonics;
- high stability of the output voltage frequency;
- high stability of the DC output voltage;
- remote signaling of an alarm state;
- CANopen communication protocol;
- battery charging taking into account the temperature compensation factor.



General view of the BFI 60T TR tram static converter



Block diagram of the BFI 60T TR
tram static converter

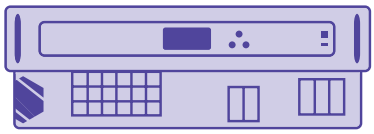
STATIC CONVERTER BFI 60T TR - BASIC CHARACTERISTICS	
CHARACTERISTIC	VALUE
ELECTRICAL CHARACTERISTICS	
Rated DC supply voltage	600 V
Range of DC supply voltage	400 V to 900 V
Rated power*	60 kW
Rated output voltages*	AC1: 3x400 V 50 Hz AC2**: 230 V 50 Hz DC1: 24 V
Rated output current*	AC1: 72 A AC2**: 9 A DC1: 390 A
TECHNICAL CHARACTERISTICS	
Enclosure protection rating (dirty zone / clean zone)	IP30 / IP56
Enclosure external dimensions (L × W × H)*	1,300 × 1,200 × 400 mm
Operating temperature*	-30 to +40 °C
Cooling type	forced, air

* - a product with other characteristics can be manufactured. ** - optional.

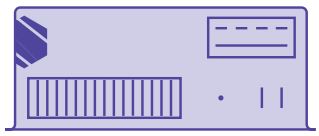
NOTES

2. BATTERY CHARGERS AND DC/DC CONVERTERS

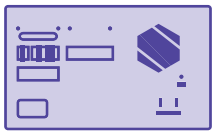
BATTERY CHARGERS **PBI MC**



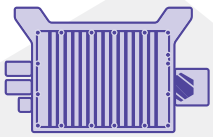
BATTERY CHARGERS **PBI LC**



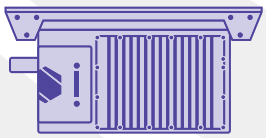
BATTERY CHARGERS **PBI TR**



BATTERY CHARGERS **PBI SP**

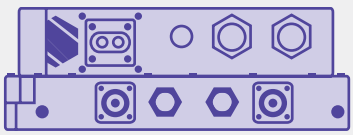


PBI SP1 and SP2



PBI SP3

DC/DC CONVERTERS **EPI SD**



The **battery chargers** offered by APS Energia SA are a key component of the power supply systems of traction vehicles. Their primary task is to simultaneously power DC loads and charge on-board batteries. Thanks to their functionality, reliability, and flexible configuration options, the battery chargers are broadly used in a variety of traction applications.

The battery chargers of the PBI range are compatible with various input voltage levels (230 V 50 Hz, 220 V 16 $^{2}/_{3}$ Hz, 3×400 V 50 Hz) and output voltages (24 to 110 V DC). As a result, they can be easily and simply integrated into many traction vehicle power supply systems.

These devices are designed to work reliably in various operating conditions, while the vehicle is either moving or stationary.

Depending on the type of design, they can be installed inside the vehicle, in 19" racks as MC series modules, in electrical cabinets as LC series modules, on the vehicle chassis as TR and SP series modules, or on the roof of the traction vehicle as TR MD series modules.

Dedicated power supply enclosures are designed to meet specific environmental requirements, including passive cooling, resistance to vibration and mechanical impact, and changing temperatures.

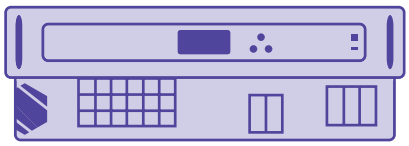
Battery chargers are provided with features such as temperature compensation of the battery charging voltage, communication interfaces (e.g. CAN), and external measurement modules. This ensures precise management of the battery charging process, full diagnostics, and integration with the vehicle's on-board control systems.

To date, APS Energia SA has already supplied **several hundred such devices for traction vehicles,** which are **in operation in 12 countries around the world.**

We carry out each production stage in compliance with the highest quality standards, in accordance with railroad standards and EU directives:		
CLC/TS 50701:2023	IEEE Std 802.3-2022	ISO 21106:2019
PN-EN 10204:2006	PN-EN 17023:2019-02	PN-EN 45545-1:2013-07
PN-EN 45545-2+A1:2024-04	PN-EN 45545-5+A1:2016-01	PN-EN 50121-3-2:2017
PN-EN 50124-1:2017-09	PN-EN 50125-1:2014-06	PN-EN 50126-1:2018-02
PN-EN 50126-2:2018	PN-EN 50155:2022-05	PN-EN 50325-1 :2020-10
PN-EN 50325-4:2004	PN-EN 50716:2024-05	PN-EN 61373:2011
PN-EN IEC/IEEE 82079-1:2020-09	PN-EN ISO/IEC 17050-1:2010	2014/30/EU
2014/35/EU		

Vehicle of the 111Ed GAMA type equipped with the PBI 24/300(100) MC battery charger

2.1. BATTERY CHARGERS PBI MC



PBI MC

General layout of the PBI MC
battery chargers in an electric vehicle

The **PBI MC battery chargers** are designed to be installed with 19" racks. They are manufactured in 4U to 6U enclosures. They are designed to supply power to on-board loads and to charge batteries with a rated voltage of 24 V DC. They are manufactured in versions from 50 to 350 A with external battery current measurement. They are powered with 3×400 V 50 Hz and 230 V 50 Hz voltages.

The PBI MC battery charger has a controller and a console with an LCD display, mounted in the power supply enclosure.

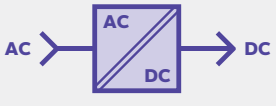
The modules are cooled with air flow forced by fans. The fans have three operating gears. The second and third gear are switched on when the power part radiator temperature increases. The fans are equipped with defect sensors. In addition, the PBI MC battery charger can be equipped with a battery grounding control system.

CHARACTERISTICS:

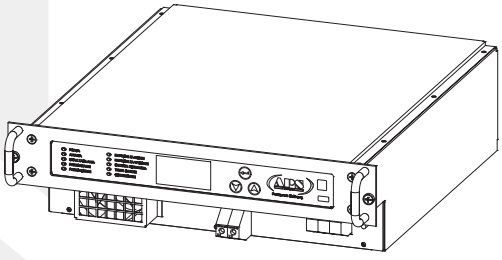
- galvanic isolation from the mains;
- very low current ripple and output voltage;
- temperature compensation of battery voltage;
- limiting the battery charging current;
- small and light;
- high stability of output voltages and currents;
- high efficiency;
- quiet operation;
- minimized interference (by using multi-stage interference filters).

BATTERY CHARGERS PBI MC - BASIC CHARACTERISTICS						
EQUIPMENT TYPE	**PBI 24/50 MC**	**PBI 24/125 MC**	**PBI 24/250 MC**	**PBI 24/300(100) MC**	**PBI 24/350 MC**	**PBI 110/100 MC**
CHARACTERISTIC	VALUE					
ELECTRICAL CHARACTERISTICS						
Rated AC supply voltage	3×400 V 50 Hz	230 V 50 Hz	3×400 V 50 Hz	3×400 V 50 Hz (230 V 50 Hz)	3×400 V 50 Hz	
Supply voltage range	±10 %			+10 to -15%		
Rated power*	1.2 kW	3.0 kW	6.0 kW	7.2 kW (2.4 kW)	8.4 kW	11.0 kW
Rated DC output voltage*	24 V					110 V
Rated output current*	50 A	125 A	250 A	300 A (100 A)	350 A	100 A
TECHNICAL CHARACTERISTICS						
Enclosure protection rating	IP20					
External dimensions (L × W × H)	482 × 496 × 142 mm		482 × 496 × 267 mm	482 × 496 × 142 mm	482 × 496 × 267 mm	
Height in a 19'' rack	4U		6U	4U	6U	
Operating temperature	-25 to +40 °C					
Cooling type	forced, air					

* - a product with other characteristics can be manufactured.

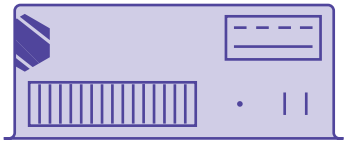


Block diagram of the PBI MC battery charger



General view of the PBI MC battery charger

2.2. BATTERY CHARGERS PBI LC



PBI LC

General layout of the PBI LC battery chargers in an electric vehicle

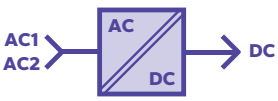
The **PBI LC battery chargers** are designed to be installed inside traction vehicles in the space of the electrical cabinet or places specially designated for this purpose. They are characterized by reduced noise emission during operation, compared to traditional PBI MC modules. They are designed to supply power to on-board loads and to charge batteries with a rated voltage of 24 V DC. The PBI LC battery charger operates in two charging modes: direct current mode and constant voltage mode. It is manufactured in a 350 A version with external battery current measurement. It can be powered from 2 voltage sources: 3×400 V 50 Hz and 230 V 50 Hz.

CHARACTERISTICS:

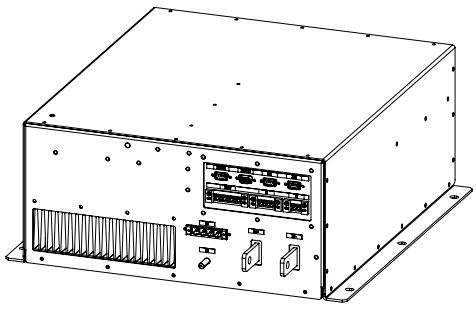
- possibility to install in a specially designated space in the traction vehicle;
- automatic temperature compensation for battery charging;
- galvanic isolation from the mains;
- limiting the battery charging current;
- high stability of output voltages and currents;
- high efficiency;
- quiet operation;
- minimized interference (by using multi-stage interference filters);
- CANopen communication protocol.

BATTERY CHARGERS PBI LC - BASIC CHARACTERISTICS	
EQUIPMENT TYPE	**PBI 24/350(100) LC**
CHARACTERISTIC	VALUE
ELECTRICAL CHARACTERISTICS	
Rated supply voltage	3×400 V 50 Hz
Optional supply voltage	230 V 50 Hz
Supply voltage range	±10 %
Rated power*	8.4 kW (2.4 kW for 230 V 50 Hz power supply)
Rated DC output voltages*	24 V
Rated output current*	350 A (100 A for 230 V 50 Hz power supply)
TECHNICAL CHARACTERISTICS	
Enclosure protection rating	IP20
External dimensions (L × W × H)*	548.5 × 492 × 202.5 mm
Operating temperature*	-25 to +55 °C
Cooling type	forced, air

* - a product with other characteristics can be manufactured.

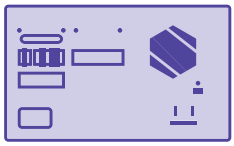


Block diagram of the PBI LC battery charger

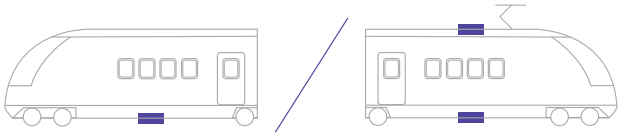


General view of the PBI LC battery charger

2.3. BATTERY CHARGERS PBI TR



PBI TR



General layout of the PBI TR battery chargers in a diesel/electric vehicle

The **PBI TR battery chargers** are designed to be installed in a dedicated enclosure for mounting under the traction vehicle and on the roof of the vehicle (MD version). The design of the device implies a completely passive cooling system using a massive heat sink.

The PBI TR battery chargers are designed to charge batteries from the 3×400 V 50 Hz and 230 V 50 Hz platform network, both while the vehicle is stationary and when it is moving, by controlling the diesel generator on the traction vehicle.

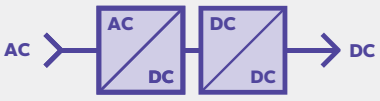
The switched on and unlocked power supply, after receiving information about the start of the 24 V DC diesel generator and in the absence of power supply from the platform network, automatically enters an operating state in which it controls the output voltage of the 24 V DC diesel generator by means of a 4-20 mA current output, thus charging the batteries in the vehicle. Control of the operation of the power supply and indication of the operating status is carried out by means of dedicated inputs and outputs, routed to the front panel of the device. In addition, operation status signaling is transmitted to the vehicle control system via the CANopen protocol.

CHARACTERISTICS:

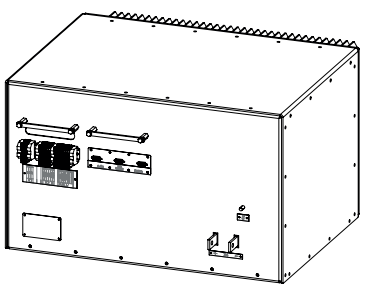
- installation under the vehicle or on the roof of the vehicle in a dedicated enclosure;
- possibility to control a diesel generator;
- power circuits protection (limits the output current without interrupting the work);
- built-in event buffer;
- galvanic isolation from the mains;
- very low current ripple and output voltage;
- temperature compensation of battery voltage;
- limiting the battery charging current;
- small size;
- high stability of output voltages and currents;
- high efficiency;
- quiet operation;
- minimized interference (by using multi-stage interference filters).

BATTERY CHARGERS PBI TR - BASIC CHARACTERISTICS					
EQUIPMENT TYPE	**PBI 24/350 TR**	**PBI 24/250 TR (DB)**	**PBI 24/250 TR**	**PBI 24/220(150) TR**	**PBI 24/350 TR MD1**
CHARACTERISTIC	VALUE				
ELECTRICAL CHARACTERISTICS					
Rated supply voltage	3×400 V 50 Hz				
Optional supply voltage	-			230 V 50 Hz	-
Supply voltage range	±10 %				
Rated power	8.4 kW	6.0 kW		5.3 kW (3.6 kW for 230 V 50 Hz power supply)	8.4 kW
Rated DC output voltages*	24 V				
Rated output current*	350 A	220 A		220 A (100 A for 230 V 50 Hz power supply)	350 A
TECHNICAL CHARACTERISTICS					
Enclosure protection rating	IP10	IP20			IP10
External dimensions (L × W × H)*	741 × 453 × 754 mm	432 × 453 × 754 mm			813 × 699 × 456 mm
Operating temperature*	-25 to +40 °C				
Cooling type	passive				

* - a product with other characteristics can be manufactured.

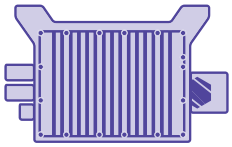


Block diagram of the PBI TR battery charger

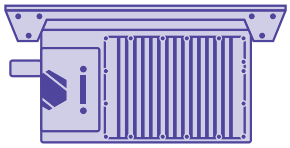


General view of the PBI TR battery charger

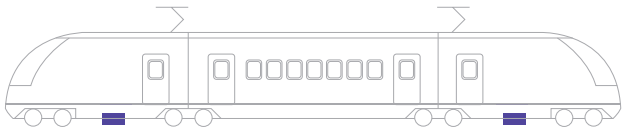
2.4. BATTERY CHARGERS PBI SP



PBI SP1 and SP2



PBI SP3



General layout of the PBI SP battery chargers in an electric vehicle

The **PBI SP battery chargers** are manufactured in a special enclosure suitable for mounting under a traction vehicle. They are designed to supply power to on-board loads and to charge batteries with a rated voltage of 24 V DC. The PBI SP power supply operates in two charging modes: direct current mode and constant voltage mode.

Controlling the operation of the power supply and signaling the operating status is done in two ways: through the pins of the dedicated connectors located on the chassis and additionally remotely using the TRDP protocol via an Ethernet communication bus to the vehicle control system.

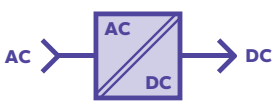
The SP series battery chargers can be supplied from voltages such as 3×400 V 50 Hz, 230 V 50 Hz and 220 V 16 ²/₃ Hz. The PBI SP power supply has an automatic temperature compensation function that adapts the battery voltage to the conditions in which the battery operates.

CHARACTERISTICS:

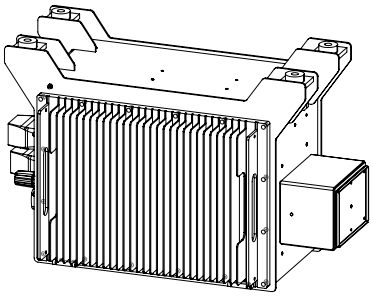
- installation under the vehicle in a special enclosure;
- overload and short-circuit protection;
- over-voltage and under-voltage protection from the supply voltage;
- contact and remote signaling of an alarm state;
- TRDP communication protocol;
- design of the PBI SP2 power supply based on SiC MOSFET technology;
- galvanic isolation from the mains;
- very low current ripple and output voltage;
- temperature compensation of battery voltage;
- limiting the battery charging current;
- small size;
- high stability of output voltages and currents;
- high efficiency;
- quiet operation;
- limiting the battery charging current;
- minimized interference (by using multi-stage interference filters).

BATTERY CHARGERS PBI SP - BASIC CHARACTERISTICS			
EQUIPMENT TYPE	**PBI 24/250 SP1**	**PBI 24/250(60) SP2**	**PBI 24/150 SP3**
CHARACTERISTIC	VALUE		
ELECTRICAL CHARACTERISTICS			
Rated supply voltage	3×400 V 50 Hz	3×400 V 50 Hz	220 V 16 ²/₃ Hz
Optional supply voltage	-	230 V 50 Hz	-
Supply voltage range	±10 %		+25 to -30%
Rated power	6.0 kW	6.0 kW (1.4 kW for 230 V 50 Hz power supply)	3.6 kW
Rated DC output voltages	24 V		
Rated output current*	250 A	250 A (60 A for 230 V 50 Hz power supply)	150 A
TECHNICAL CHARACTERISTICS			
Enclosure protection rating	IP56		IP65
External dimensions (L × W × H)*	888.5 × 567 × 413 mm		1,200 × 536 × 582 mm
Operating temperature*	-25 to +40 °C		-45 to +55 °C
Cooling type	passive		

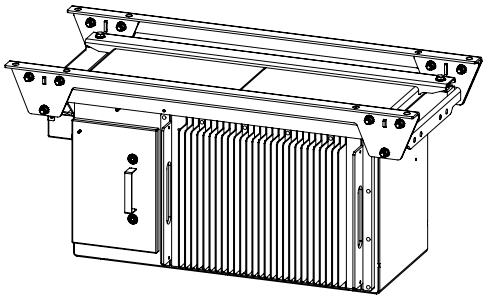
* - a product with other characteristics can be manufactured.



Block diagram of the PBI SP battery charger

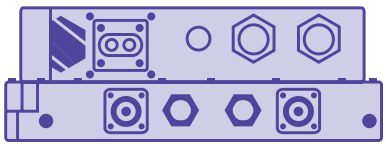


General view of the PBI SP1, PBI SP2 battery chargers

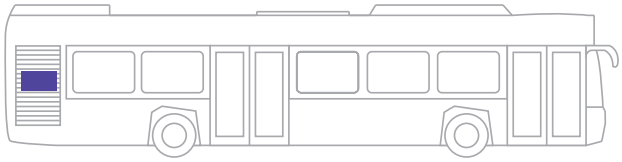


General view of the PBI SP3 battery charger

2.5. DC/DC CONVERTERS EPI SD



EPI SD



General layout of the EPI SD constant voltage converter in an electric bus

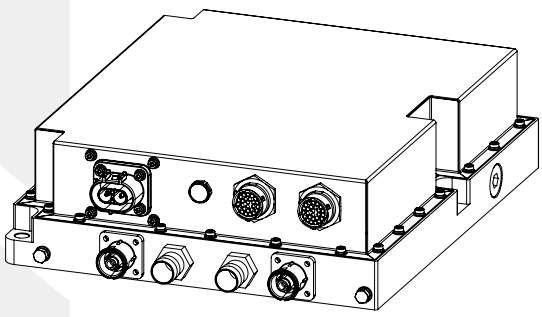
The **EPI SD DC/DC converter** is designed to supply a vehicle's on-board loads with a voltage of 28 V. The device's design includes SiC semiconductor modules mounted on a liquid-cooled heat sink. The device has an IP67-rated enclosure. Communication with the vehicle's systems is done via the CAN bus.

CHARACTERISTICS:

- microprocessor-based control and operating characteristics monitoring system;
- temperature protection of power systems;
- short-circuit protection;
- grounding control system;
- CAN J1939 communication protocol;
- small and light.

DC/DC CONVERTER EPI SD - BASIC CHARACTERISTICS	
EQUIPMENT TYPE	**EPI 800/28/250 SD2**
CHARACTERISTIC	VALUE
ELECTRICAL CHARACTERISTICS	
Rated DC supply voltage	800 V
Range of DC supply voltage	200 to 800 V
Rated DC output voltage	28 V
Rated output current	250 A
Auxiliary DC circuits rated supply voltage	24 V
Input capacity	120 µF
TECHNICAL CHARACTERISTICS	
Enclosure protection rating	IP67
External dimensions (L × W × H)*	355 × 310 × 100 mm
Operating temperature	-25 to +40 °C
Cooling type	forced, liquid

Block diagram of the EPI SD DC/DC converter



General view of the EPI SD DC/DC converter

Vehicle of the 48WE type equipped with the PBI 24/350 MC and the PBI 24/350 TR MD1 battery charger

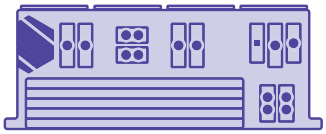
Vehicle of the PESA DART type equipped with the PBI 24/350 TR battery charger

Vehicle of the 847-10/CD type equipped with the PBI 24/350(100) LC TR1 battery charger

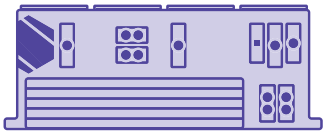
Vehicle of the DB LINK BR632 type equipped with the PBI 24/250 TR (DB) battery charger

3. TRACTION AND AUXILIARY INVERTERS

TRAM DRIVE INVERTERS **NT 4×75 600** AND **NT 2×105 600**

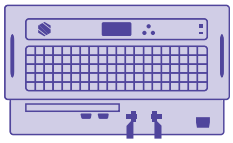


NT 4×75 600

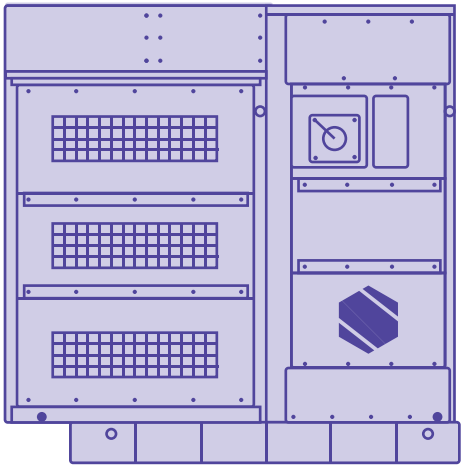


NT 2×105 600

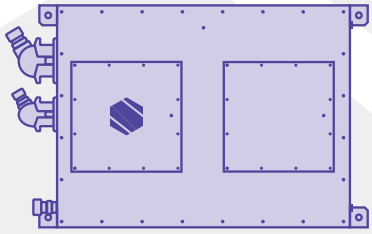
AUXILIARY INVERTERS **BFI MC**

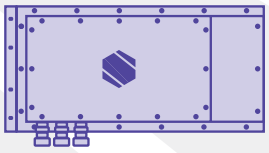


LOCOMOTIVE POWER SUPPLY SYSTEM

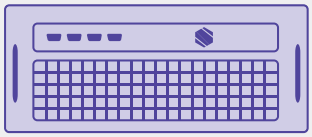


AUXILIARY DRIVE POWER SUPPLY SYSTEM OF AN INTERNAL COMBUSTION (HYBRID) VEHICLE





AUXILIARY POWER SUPPLY SYSTEM



Traction inverters are critical equipment in traction systems of rail vehicles such as trams, electric multiple units, subways, and locomotives, and of electric vehicles such as electric buses and trolleybuses. Their main task is to convert electricity from one form to another, most often from a direct current (DC) to the alternating current (AC) of adjustable frequency and amplitude, which powers the traction motors of rail vehicles.

In modern rail vehicles, the inverter is responsible for:

- control of the speed and torque of traction motors, by adjusting the frequency and supply voltage, for driving and braking;
- energy recovery - allows energy to be recovered during braking and returned to the catenary or batteries;
- protection of motors against overloads, overvoltages, and short circuits.

Modern inverters offered by APS Energia SA use advanced semiconductor technologies, such as:

- **IGBT;**
- **SiC MOFSET.**

Auxiliary inverters are smart power supplies for auxiliary on-board systems. Our inverters with adjustable frequency and output voltage are state-of-the-art solutions designed to reliably power auxiliary equipment in rail vehicles, electric buses, and trolleybuses. They are ideal for, among other tasks, controlling and powering traction motor fans and cooling systems of internal combustion engines, ensuring optimal operation and efficient energy management.

We also offer fixed-frequency inverter versions dedicated to powering on-board loads such as air conditioning, passenger sockets, and special room equipment, refrigerators, vending machines, and electric stoves, guaranteeing their stable and safe operation regardless of the operating conditions.

Thanks to their compact design, high efficiency, and flexible configurations, our auxiliary inverters integrate perfectly with modern on-board systems, thus supporting energy efficiency and both passenger and crew comfort.

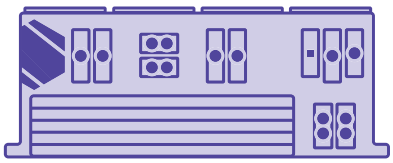
At APS Energia SA, inverter design is a complex, multi-stage process carried out in close cooperation with our clients. Each product is developed in accordance with individual technical requirements and an analysis of the operating conditions.

Our activities include:

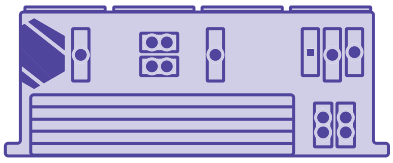
- **Conceptual phase** -identification of the application needs, selection of the circuit architecture, selection of the technology (IGBT / SiC), determination of the power range and environmental conditions.
- **Mechanical and electrical design** -development of system topologies, schematics, cooling systems (air, liquid), and installation methods (rooftop, underfloor, cabinet).
- **Developing control and communication software** - developed internally according to the client's requirements (e.g. CAN, Ethernet).
- **Prototyping and testing** - in our own laboratory using specialized test stands (e.g., climate chambers, dynamometers).
- **Production launch and integration with the vehicle** - support with the installation, startup, testing on the vehicle, and testing and certification.

We carry out each production stage in compliance with the highest quality standards, in accordance with railroad standards and EU directives:		
CLC/TS 50701:2023	IEEE Std 802.3-2022	ISO 21106:2019
PN-EN 10204:2006	PN-EN 17023:2019-02	PN-EN 45545-1:2013-07
PN-EN 45545-2+A1:2024-04	PN-EN 45545-5+A1:2016-01	PN-EN 50121-3-2:2017
PN-EN 50124-1:2017-09	PN-EN 50125-1:2014-06	PN-EN 50126-1:2018-02
PN-EN 50126-2:2018	PN-EN 50155:2022-05	PN-EN 50163:2006
PN-EN 50325-1 :2020-10	PN-EN 50325-4:2004	PN-EN 50716:2024-05
PN-EN 61373:2011	PN-EN IEC/IEEE 82079-1:2020-09	PN-EN ISO/IEC 17050-1:2010
2014/30/EU	2014/35/EU	

3.1. TRAM DRIVE INVERTERS NT 4×75 600 AND NT 2×105 600



NT 4×75 600



NT 2×105 600

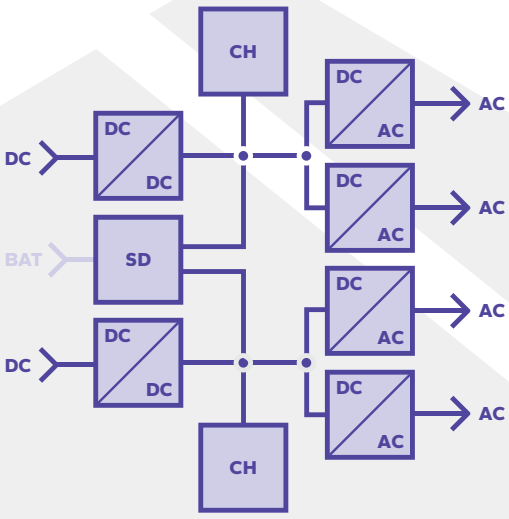
General layout of the NT 4×75 600 and NT 2×105 600 tram drive inverters in a tram

The **NT 4×75 600** and **NT 2×105 600 tram drive inverters** are designed to power asynchronous traction motors in tram propulsion systems. The task of inverters is to convert direct voltage (DC) into alternating voltage (AC) with adjustable frequency and amplitude. For proper operation, the converter uses external speed and temperature measurements.

The design of the device includes 2 or 4 inverters, which allow each motor to be powered independently. The inverter box is placed in a housing designed for installation on the roof of a vehicle. The device consists of two sections. Each section is equipped with its own controller, auxiliary power block, input filter, fan, and inverters. Some of the power is installed on a common heat sink with forced air cooling. On the chassis, there are power connections, communication connectors, service connectors, and an air inlet and outlet.

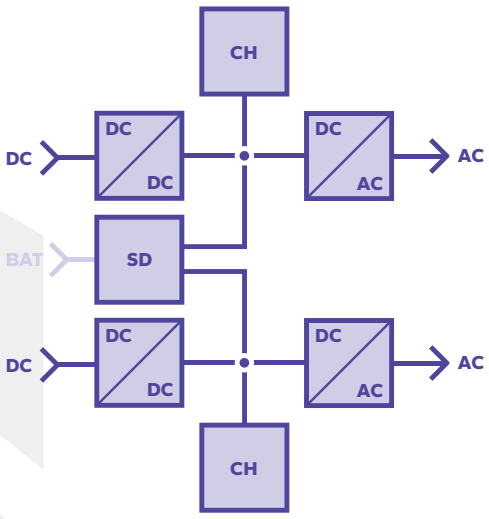
CHARACTERISTICS:

- precise torque setting through Direct Field Oriented Control (DFOC) with Space Vector Modulation (SVM);
- independent power supply and motor operation control;
- braking energy recovery and return to the catenary;
- integrated anti-skid system - no external controller required;
- short-circuit, overload, and temperature protection of power systems;
- integrated vehicle return system;
- self-test of the motor and internal characteristics of the converter to monitor aging and operational processes;
- communication with a master controller via CANopen.



SD - vehicle return system, CH - braking chopper

Block diagram
of the NT 4×75 600 tram drive inverter

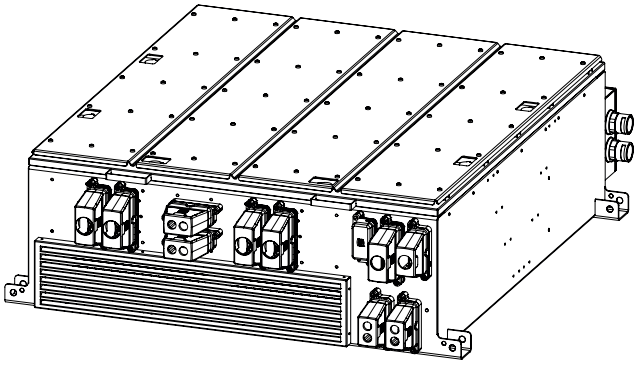


SD - vehicle return system, CH - braking chopper

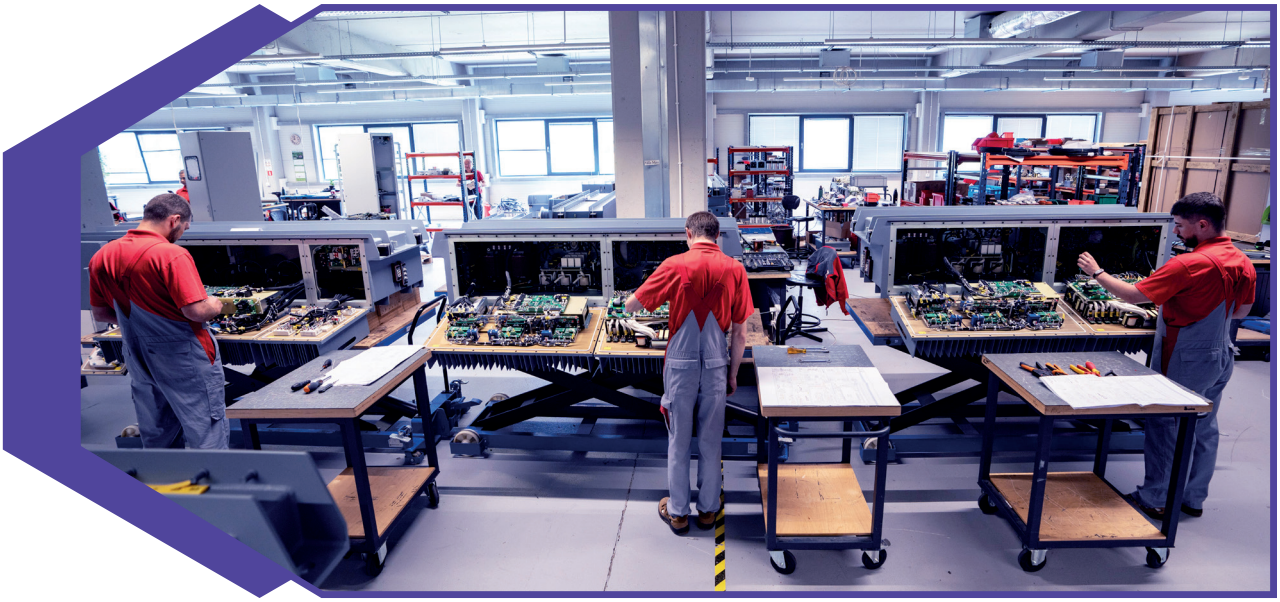
Block diagram
of the NT 2×105 600 tram drive inverter

TRAM DRIVE INVERTERS NT - BASIC CHARACTERISTICS		
EQUIPMENT TYPE	**NT 4×75 600**	**NT 2×105 600**
CHARACTERISTIC	VALUE	
ELECTRICAL CHARACTERISTICS		
Rated DC supply voltage	600 V	
Range of DC supply voltage	420 to 900 V	
Rated power (Pn)*	4×75 kW	2×105 kW
Number of inverters per box	4 pcs	2 pcs
Number of motors per inverter	1 pc	
Rated output current	160 A	190 A
Output frequency (1h)	0 to 165 Hz	
PWM frequency	2 to 4 kHz	
Overload capacity	2×Pn for 20 s	
Auxiliary DC circuits rated supply voltage	24 V	
TECHNICAL CHARACTERISTICS		
Enclosure protection rating	IP54	
Place of installation	outside, on the roof of the vehicle	
Enclosure external dimensions (L × W × H)	1,300 × 1,200 × 450 mm	
Cooling type	forced, air	
Material of the enclosure	Stainless steel	

* - A product with other characteristics can be manufactured.

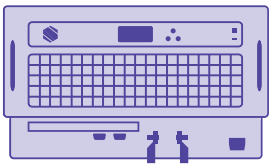


General view of the NT 4×75 600 tram drive inverter



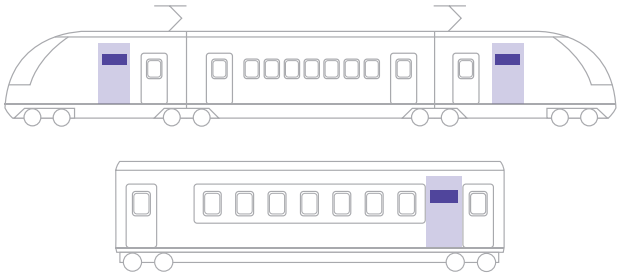
Final assembly of traction equipment

3.2. AUXILIARY INVERTERS BFI MC

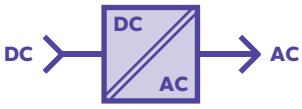


BFI MC

The **BFI MC inverter module** is designed to power AC loads with a rated voltage of 230 V AC. The inverter module is powered by 24 V DC.



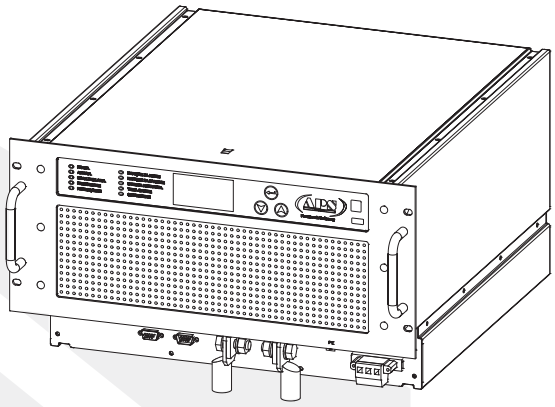
General layout of the BFI MC auxiliary inverters in an electric vehicle and passenger coach



Block diagram of the BFI MC auxiliary inverter

CHARACTERISTICS:

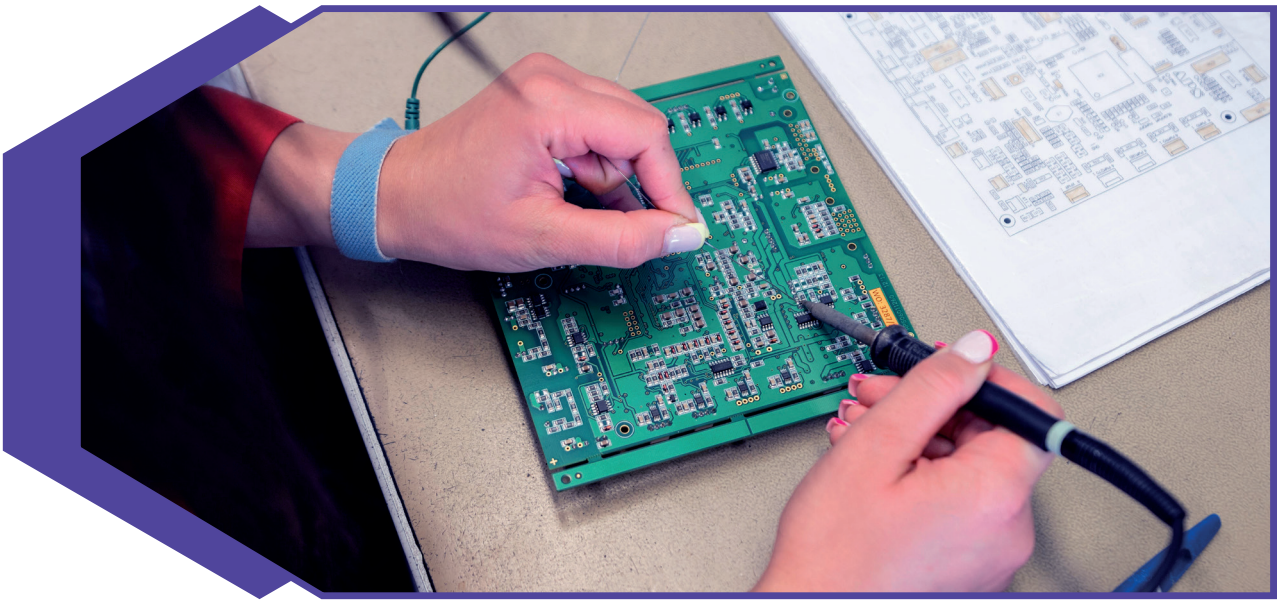
- possible operation with loads with a wide range of power factor;
- high efficiency of the conversion system;
- short-circuit protection for the inverter;
- over-voltage protection from the DC supply voltage;
- temperature protection of power systems;
- enclosure for installation in a 19" rack;
- convenient access to connections (from the front);
- galvanic separation of the input and output circuits;
- low level of the output voltage higher harmonics;
- remote alarm state signaling - potential-free relay contacts;
- integrated controller, with possibility to select the RS-485 communication protocol (Modbus RTU, IEC 60870-5-103);
- built-in event buffer.



General view of the BFI MC auxiliary inverter

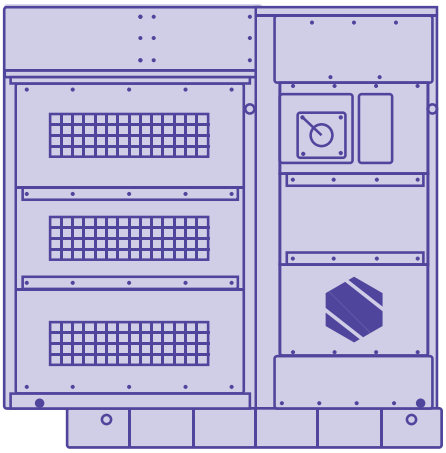
AUXILIARY INVERTERS BFI MC - STANDARD CHARACTERISTICS				
EQUIPMENT TYPE	**BFI 1,5S 24/230 MC**	**BFI 2S 24/230 MC**	**BFI 3,5S 24/230 MC**	**BFI 5S 24/230 MC**
CHARACTERISTIC	VALUE			
ELECTRICAL CHARACTERISTICS				
Rated DC input voltage	24 V			
Range of DC input voltage changes	18 to 36 V		16,8 to 36 V	22 to 31 V
Rated DC current consumption*	68 A		168 A	220 A
Rated AC output voltage*	230 V			
Output voltage frequency	50 Hz			
Output power*	1.5 kVA	2 kVA / 1.5 kW	3.5 kVA	5 kVA / 4 kW
Rated output current (In)	6.5 A	8.7 A	15.2 A	21.7 A
Overload capacity	<1.1×In long-term ≤1.25×In for 10 min ≤1.5×In for 3 min ≤2×In for 10 s	<1.1×In long-term ≤1.25×In for 10 min ≤1.5×In for 3 min	<1.1×In long-term ≤1.25×In for 10 min	
Voltage shape	sinusoidal			
Harmonic content (linear load)	<2 %			
Range of cos Φ characterizing the load	0.7 to 1.0			
Overcurrent protection	3×In for 100 ms			
TECHNICAL CHARACTERISTICS				
Enclosure protection rating	IP20			
Place of installation	vehicle interior			
Enclosure external dimensions (L × W × H)	482 × 492 × 267 mm / 19" × 6U			
Cooling type	forced, air			
Operating temperature*	-30 to +40 °C			

* - a product with other characteristics can be manufactured.

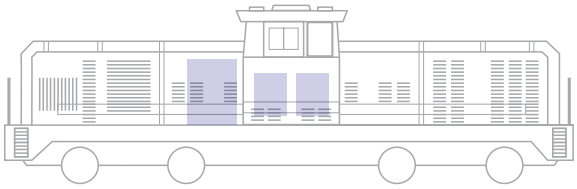


Production of traction equipment components

3.3. LOCOMOTIVE POWER SUPPLY SYSTEM



ZUT 6D-FPS



General layout of the ZUT 6D-FPS in a locomotive

CHARACTERISTICS:

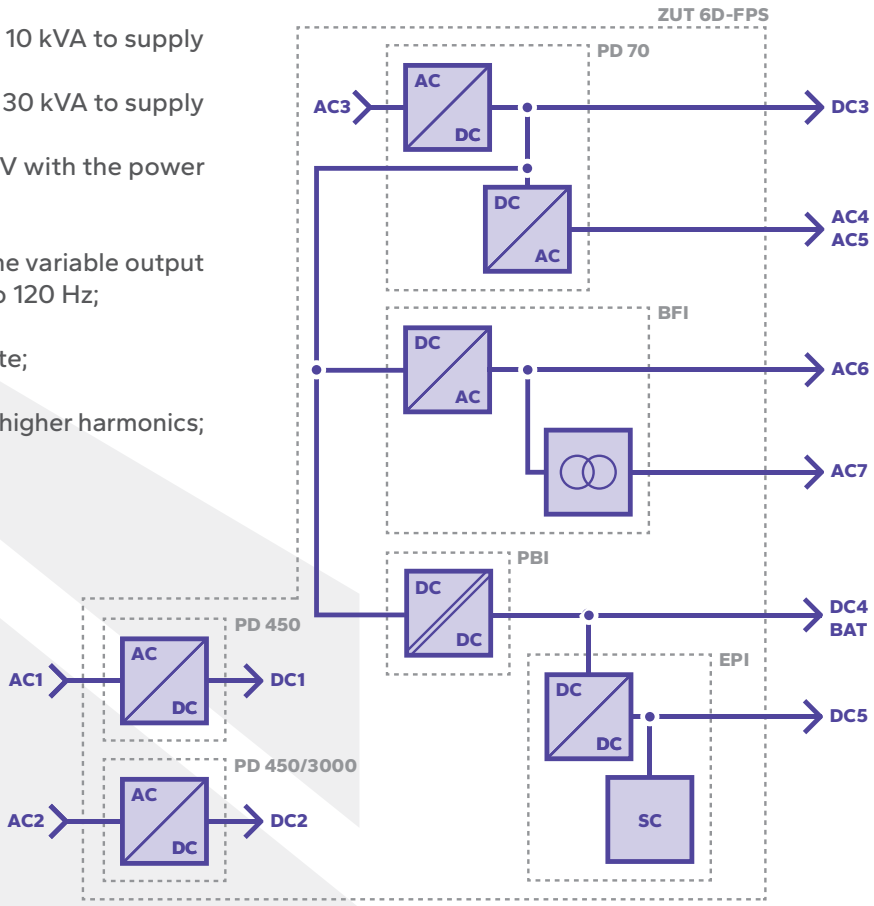
- 24 V on-board battery charger with output current up to 500 A;
- 24 V supercapacitor tray charger with current up to 240 A;
- inverter 3×400 V with a power of 10 kVA to supply the fans;
- inverter 3×400 V with a power of 30 kVA to supply auxiliary circuits;
- coupler power supply system 3 kV with the power of 450 kW;
- traction rectifiers 450 kW;
- possible operation with loads in the variable output voltage frequency range of 20 to 120 Hz;
- supercapacitor tray;
- remote signaling of an alarm state;
- CANopen communication
- low level of the AC output voltage higher harmonics;
- modular installation;
- dedicated integrated design;
- contact signaling.

The **ZUT 6D-FPS Traction Equipment Assembly** is a power electronic supply system for a shunting locomotive. The system includes power supply systems for traction motors, fan motors, 3×400 V and 24 V auxiliary circuits, a 3 kV coupler circuit, synchronous generator excitation control systems, on-board battery charging, and a super-capacitor starting assistance system for internal combustion engines.

DESIGN OF THE TRACTION EQUIPMENT ASSEMBLY:

ZUT 6D-FPS is a series of power electronic devices installed in an enclosure designed in accordance with the client's requirements. The traction equipment assembly includes, among others:

- battery charger - PBI 24/500 ZUT;
- supercapacitor charger - EPI 24/240/SC ZUT;
- starter tray with a supercapacitor bank;
- 3 kV rectifier - PD 450/3000/12T ZUT;
- inverter 3×400 V - BFI 30T 600/400 ZUT;
- traction rectifier - PD 450 T 600 TR;
- auxiliary inverter - BFI 10T 600/400 ZZP;
- auxiliary rectifier - PD 70/600/6T;
- generator excitation system - SAN-AVR-3G, SAN-AVR-3P;
- fire extinguishing system.

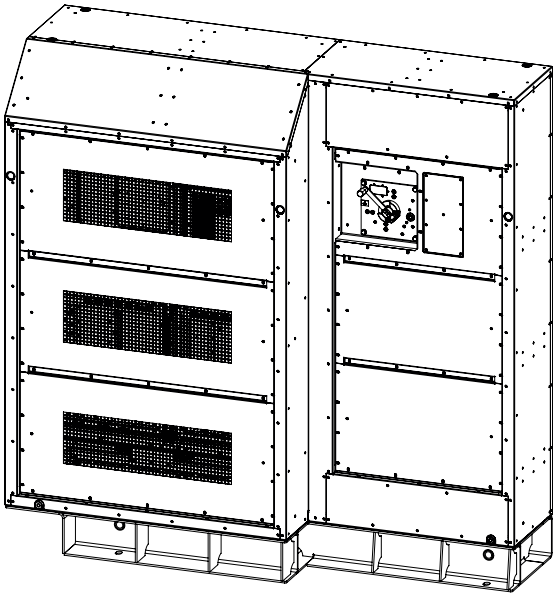


SC - supercapacitor

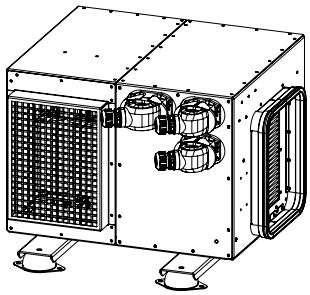
Block diagram of the ZUT 6D-FPS

TRACTION EQUIPMENT ASSEMBLY - BASIC CHARACTERISTICS			
EQUIPMENT TYPE		ZUT 6D-FPS	ZZP 70 T
CHARACTERISTIC		VALUE	
ELECTRICAL CHARACTERISTICS			
Rated input voltage	AC1: Traction rectifiers	3×550 V up to 90 Hz	
	AC3: Auxiliary rectifiers	3×400 V up to 60 Hz	
	Platform power supply	3×400 V 50 Hz	
	AC2: Coupler rectifier 3 kV	2 × (3×1,200 V) up to 90 Hz	
	Inverters	600 V	
	Chargers	600 V	
Rated output voltage	DC1: Traction rectifiers	800 V	
	DC2: Rectifier 3 kV	3,000 V	
	DC3: Auxiliary rectifiers	600 V	
	DC4: Battery charger	24 V	
	DC5: Supercapacitor charger	30 V	
	AC4, AC5: Internal combustion engine fans	3×400 V 50 Hz	
	AC6: Auxiliary electricity consumption	3×400 V 50 Hz	
	AC7: Single-phase output	230 V 50 Hz	
Rated power	DC1: Traction rectifiers	450 kW	
	DC2: Rectifier 3 kV	350 kW	
	DC3: Auxiliary rectifiers	70 kW	
	DC4: Battery charger	12 kW	
	DC5: Supercapacitor charger	7 kW	
	AC4, AC5: Internal combustion engine fans	10 kVA	
	AC6: Auxiliary electricity consumption	30 kVA	
	AC7: Single-phase output	5 kVA	
TECHNICAL CHARACTERISTICS			
Enclosure protection rating		IP20	
External dimensions (L × D × H)*		1,703 × 553 × 1,696.5 mm	540 × 626 × 403 mm
Operating temperature		-30 to +40 °C	
Cooling type		forced, air	
Resistance to vibration and mechanical impact		category 1 class B according to PN-EN 61373:2011	

* - installation customized according to the client's needs.



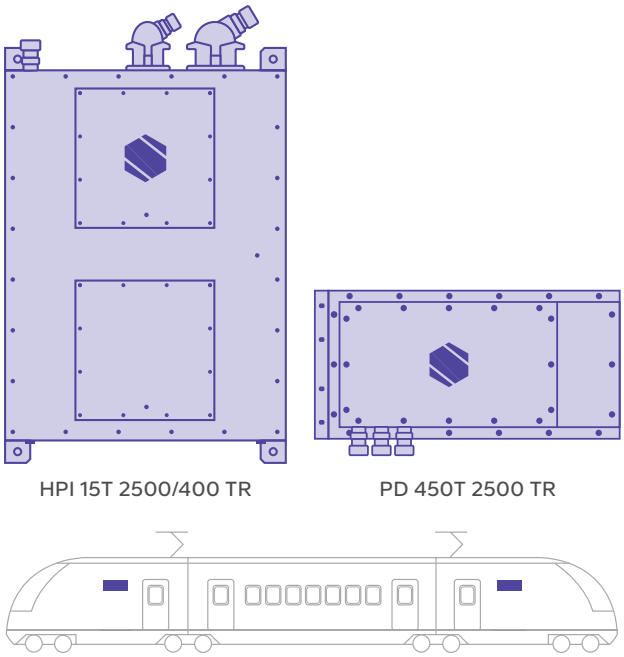
General view of the ZUT 6D-FPS



General view of the ZZP 70 T

Locomotive of the 6D-FPS type powered by the ZUT 6D-FPS Traction Equipment Assembly

3.4. AUXILIARY DRIVE POWER SUPPLY SYSTEM OF AN INTERNAL COMBUSTION (HYBRID) VEHICLE



HPI 15T 2500/400 TR PD 450T 2500 TR

General layout of the HPI 15T 2500/400 TR frequency converter and the PD 450T 2500 TR traction rectifier in an electric vehicle

Hybrid vehicle of the 228M type powered by the HPI 15T 2500/400 TR frequency converter, the PD 450T 2500 TR traction rectifier and the SAN-AVR3 controller

The internal combustion propulsion support system on traction vehicles supplies power to the cooling system of the internal combustion engine as well as powers and regulates the operation of the alternator.

DESIGN OF THE TRACTION EQUIPMENT ASSEMBLY:

- the **HPI 15T 2500/400 TR frequency converter** is designed to power the induction motor driving the radiator fan of an internal combustion engine. The converter makes it possible to adjust the speed of the powered induction motor;
- the **PD 450T 2500 TR traction rectifier** is designed to supply DC circuits and work with a three-phase synchronous brushless self-excited generator, controlled using the SAN-AVR3 controller;
- **SAN-AVR3** is a supervision and control system for a synchronous generator with an exciter. This system adjusts the three-phase output voltage of the generator by changing the excitation current of the exciter accordingly (see section 5.2).

CHARACTERISTICS:

Frequency converter HPI 15T 2500/400 TR:

- high efficiency of the conversion system;
- adjustable output voltage frequency;
- overload and short-circuit protection;
- possible operation with loads with a wide range of power factor;
- over-voltage and under-voltage protection from the DC supply voltage;
- temperature protection of power systems;
- low level of the AC output voltage higher harmonics;
- CANopen communication protocol.

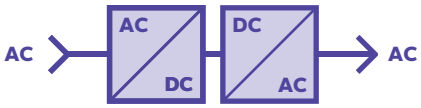
Traction rectifier PD 450T 2500 TR:

- high efficiency;
- temperature protection of power systems, reports too high temperature to the SAN-AVR3 controller;
- microprocessor-based control system for the operating characteristics of the rectifier.

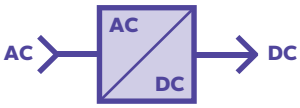
Hybrid vehicle of the 227M type powered by the HPI 15T 2500/400 TR frequency converter, the PD 450T 2500 TR traction rectifier and the SAN-AVR3 controller

AUXILIARY DRIVE POWER SUPPLY SYSTEM OF AN INTERNAL COMBUSTION (HYBRID) VEHICLE - BASIC CHARACTERISTICS		
EQUIPMENT TYPE	**HPI 15T 2500/400 TR**	**PD 450T 2500 TR**
CHARACTERISTIC	VALUE	
ELECTRICAL CHARACTERISTICS		
Rated AC supply voltage	3×2,500 V 60 Hz	
AC supply voltage range	3×1,570 V to 3×2,500 V 3×433 V to 3×690 V	3×1,450 V to 3×2,500 V
Rated power*	10 kW	450 kW
Rated output voltages*	AC: 3×400 V 50 Hz	DC: 3,600 V
Rated output current*	14 A	125 A
TECHNICAL CHARACTERISTICS		
Enclosure protection rating	IP20	IP23
Enclosure external dimensions (L × W × H)*	608 × 304 × 900 mm	735 × 387 × 360 mm
Operating temperature*	-30 to +40 ºC	
Cooling type	forced, air	air, in the inlet duct of the generator

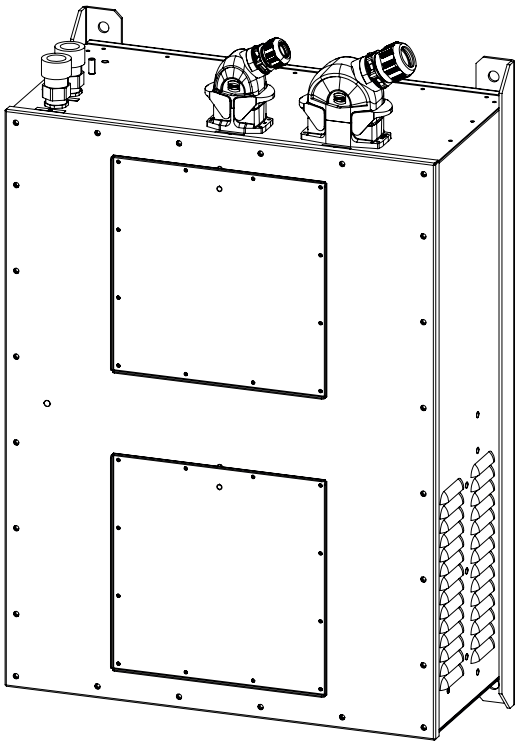
* - a product with other characteristics can be manufactured.



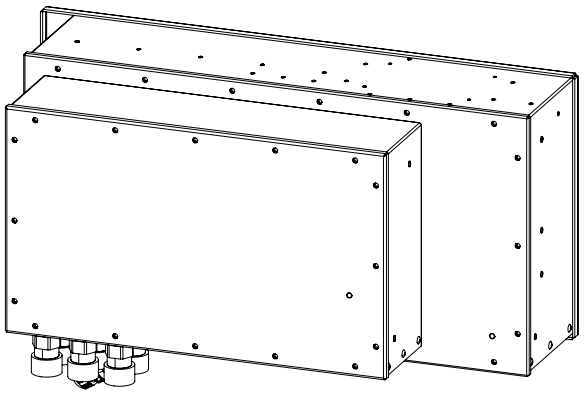
Block diagram of the HPI 15T 2500/400 TR frequency converter



Block diagram of the PD 450 T 2500 TR traction rectifier

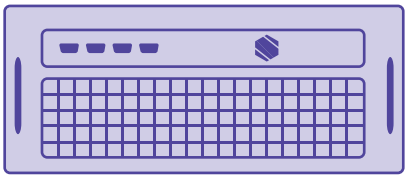


General view of HPI 15T 2500/400 TR frequency converter

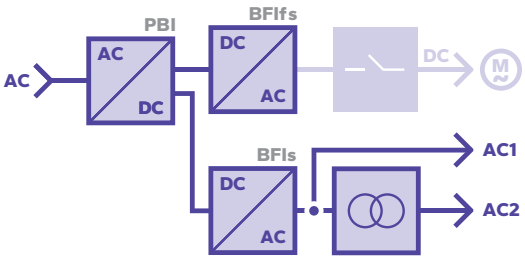


General view of PD 450 T 2500 TR traction rectifier

3.5. AUXILIARY POWER SUPPLY SYSTEM



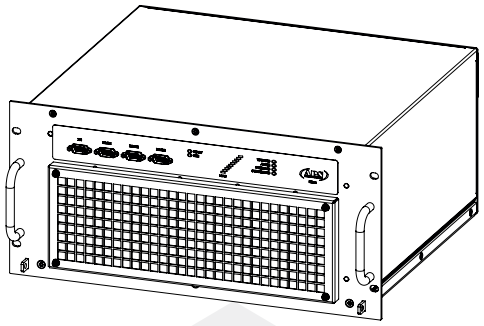
Auxiliary Power Supply System



Block diagram of the Auxiliary Power Supply System

The **Auxiliary Power Supply System**, which includes rectifier and inverter modules, plays a key role in ensuring reliable power supply for on-board equipment in the WL4 sleeper coaches operated by Swedish Railways. It converts the voltage from the catenary to characteristics suitable for powering various internal loads, such as lighting, heating systems, ventilation, air conditioning, and electrical sockets in passenger compartments. The rectifier is responsible for converting AC to DC, which is then adjusted by inverters to AC with the required characteristics, allowing proper power supply to standard on-board equipment. With such a system in place, WL4 sleeper coaches can operate comfortably and safely regardless of the external conditions, meeting high service quality standards.

Each inverter operates independently for dedicated loads. One inverter module is dedicated only to the HVAC compressor, while the other is dedicated to other three-phase loads with a fixed voltage frequency of 50 Hz, as well as single-phase loads supplied through a 400/230 V transformer.



General view of the Auxiliary Power Supply System

The Auxiliary Power Supply System includes:

- power supply module with active mains filter, without galvanic isolation PBIzas 600/35 M TR;
- drive inverter without galvanic isolation BFIfs 10T 600/400 M TR;
- 5 Hz inverter without galvanic isolation BFIs 10T 600/400 M TR;
- 1-phase 400/230 V AC transformer;
- external terminal strips for the modules.

AUXILIARY POWER SUPPLY SYSTEM - STANDARD CHARACTERISTICS	
CHARACTERISTIC	VALUE
ELECTRICAL CHARACTERISTICS	
RECTIFIER	
Rated AC supply voltage	340 V (+25%, -30%)
Supply voltage frequency	16 $^{2}/_{3}$ Hz
Rated input current	62 A
Rated DC output voltage	670 V
Rated output current	30 A
Rated output power	20 kW
Overload capacity	1.25×In for 5 s
AUXILIARY INVERTERS	
Rated DC supply voltage	670 V
Range of DC input voltage changes	560 to 840 V
Rated DC input current	13.5 A
Rated AC output voltage	3×400 V
Output voltage frequency	50 Hz
Rated AC output current (In)	14.5 A
Rated output power	10 kVA / 8 kW
Output voltage stability (static)	±1%
Output voltage stability (dynamic)	±5% over 10 ms
THDU (linear load)	< 2%
THDU (non-linear load)	< 5%
Frequency stability	±0.1%
Overload capacity	1.0×In to 1.1×In for 60 min
	1.1×In to 1.25×In for 60 s
	>1.25×In up to 5 s
Short-circuit current	3×In for 100 ms
Soft-start ramp*	5 s
TECHNICAL CHARACTERISTICS	
Enclosure protection rating	IP20
Dimensions (W × D × H)	482 × 442 × 222 mm
Operating temperature	-25 to +55 °C
Cooling type	forced, air

* - this characteristic applies only to the BFIfs inverter.

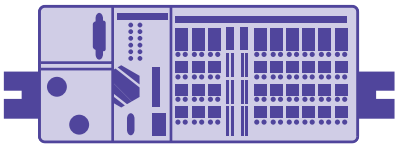
4. TRACTION VEHICLE CONTROL AND MANAGEMENT SYSTEMS

APS Energia SA as an experienced manufacturer of traction components such as converters, inverters, and drive systems, perfectly understands the requirements placed on modern rail vehicles. Our approach goes beyond providing individual components - we focus on full system integration, ensuring reliability, safety, and compatibility of solutions across the vehicle.

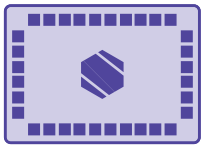
We know that the reliability of a rail vehicle depends not only on efficient propulsion, but also on the efficient management of its entire on-board infrastructure. That is why at APS Energia SA we develop and offer turnkey solutions for **Train Control and Monitoring Systems (TCMS)**.

These systems are ideal for modern rail vehicles, as they enable integration with propulsion, door, air conditioning, passenger information, and safety systems.

4.1. TCMS - TRAIN CONTROL AND MONITORING SYSTEMS



Central VCU



HMI Interface

General layout of the TCMS, including the central VCU and the HMI, in a tram

We would like to introduce our advanced **TCMS (Train Control and Monitoring System)** - an innovative solution dedicated to rail vehicle control. The TCMS combines a number of key functions, providing full control of vehicle operation, real-time diagnostics, and passenger safety. Our solution is based on proven PLC components and architecture open to other systems, and is characterized by its reliability, scalability, and easy integration with external systems.

The software is developed by a team of people with many years of experience in railroad and urban vehicle design.

DESIGN OF THE TCMS SYSTEM:

1. VEHICLE CONTROL UNIT (VCU)

This is the “brain” of the TCMS, responsible for collecting and processing data from various subsystems. It sends control commands to other devices (e.g. the drive, brake, air conditioning, doors, and event recorder). It can be located at a single place or, as is most often the case, have a distributed architecture. It serves as the superior management center responsible for data collection.

2. DISTRIBUTED I/O NODE ARCHITECTURE AND COMMUNICATION BUSES - CAN, ETH

Multi-channel communication nodes are located in different parts of the vehicle and are connected by a CAN and/or Ethernet network. They enable local control and data collection from peripheral devices, as well as data exchange between the vehicle control unit and various subsystems. They can be single- or multi-level (e.g., main bus + local buses in individual segments of the tram).

3. HUMAN-MACHINE INTERFACE (HMI)

An intuitive user interface provides access to real-time operating data, presents system statuses, and enables diagnostics. Screens and control panels in the driver's cab allow monitoring of the status of the vehicle, displaying messages and errors, and controlling functions (e.g. lighting, ventilation, and power supply). The HMI works in an isolated environment, which ensures easy deployment, upgrades, and application security and consistency.

4. DATABASE

The system collects information in the form of the following data:

- real-time operating logs - time series database;
- event and failure history - relational database.

The two-pronged approach to collecting diagnostic logs guarantees easy service and assistance in identifying problems, greater remote support capabilities, and the recording of a large amount of data for use in vehicle operation statistics.

5. TELEMETRIC SYSTEM

This system provides the ability to connect the TCMS to a remote diagnostics system, allowing real-time visualization of operating characteristics and viewing system operation logs for as many as 30 days in the past, all on a friendly and modern visual platform. This allows monitoring the status of the entire fleet of vehicles and immediately responding to defined events.

6. RESISTANCE TO INTERFERENCES AND CYBERSECURITY

The built-in features ensure a high level of security and reliability of the system's operation in light of the current requirements.

CHARACTERISTICS:

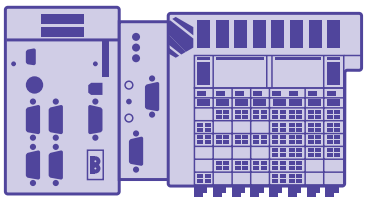
The TCMS from APS Energia SA fully meets the requirements of modern tram systems. Its use guarantees:

- **optimization of energy management** - smart algorithms that monitor energy consumption can significantly reduce the operating costs;
- **high level of security** - advanced diagnostic mechanisms allow a quick response whenever anomalies are detected;
- **real-time monitoring and diagnostics** - full control over the technical condition of all subsystems, allowing for immediate detection and rectification of any faults;
- **telemetry linked to a dedicated app** - provides access to real-time information;
- **integration with city infrastructure** - the ability to communicate with traffic management systems and infrastructure, contributing to seamless traffic and minimized delays;
- **support for passenger safety systems** - the TCMS supports anti-collision functions, CCTV monitoring, the event logger, and emergency event management;
- **resistance to interferences and cybersecurity** - the system's features provide a high level of security and reliability in the system;s operation.

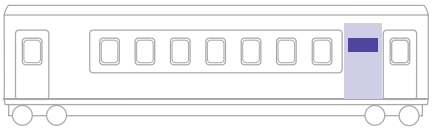
General view of the driver's HMI

General view of the telematics and diagnostics system

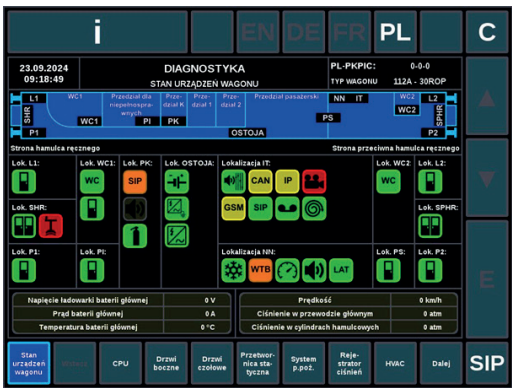
4.2. ON-BOARD PASSENGER COACH MANAGEMENT AND DIAGNOSTICS SYSTEM



On-board Passenger Coach Management and Diagnostics



General layout of the On-board Passenger Coach Management and Diagnostics System in a passenger coach



Interface of the On-board Passenger Coach Management and Diagnostics System

The **On-board Passenger Coach Management and Diagnostic System** is designed to monitor the technical condition of the equipment in the passenger coach and to control its operation. Local communication inside the coach is provided via a CAN bus using the CANopen protocol and via Ethernet using the TRDP protocol, which provides faster data transfer and more advanced device integration capabilities. Communication between coaches is enabled by the WTB gateway, allowing the system to communicate with equipment in other coaches in the same train.

CHARACTERISTICS:

On-board diagnostic systems collect and record diagnostic data via a CAN bus, Ethernet, and digital and analog inputs from such passenger coach equipment as:

- static converter;
- ventilation and air conditioning controller with temperature recording;
- exterior, front, and interior door controllers;
- toilet controller;
- fire-protection control unit;
- pressure logger;
- brake system;
- slip-protection controller;
- axle box temperature sensors;
- PIS and public address system;
- CCTV recorder;
- end connectors of gangway footplates;
- grounding system.

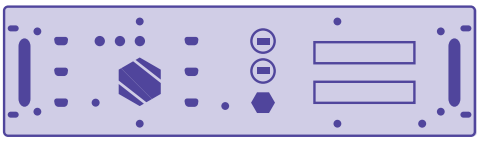
The extensive system of the diagnostic system can perform the following functions, among others:

- monitoring and diagnostics of CAN and Ethernet connections to other passenger coach equipment;
- recording selected characteristics in the logger with the ability to quickly access the archived data;
- uploading information to the on-board FTP server;
- simulating driving at speeds above 5 km/h and above 50 km/h;
- communication with other vehicles on the train via the WTB gateway;
- synchronization of the PIS between coaches via the WTB gateway;
- ability to view images from CCTV cameras;
- reporting service needs for the subsystems of the passenger coach.

NOTES

5. SYSTEMS AND DEVICES SUPPORTING TRACTION VEHICLES

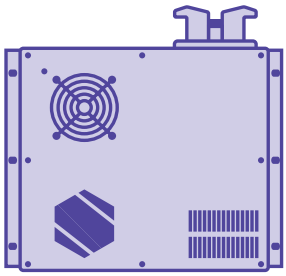
PRESSURE LOGGER **SAN-RC**



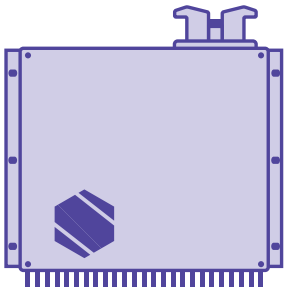
SAN-RC1

SAN-RC2

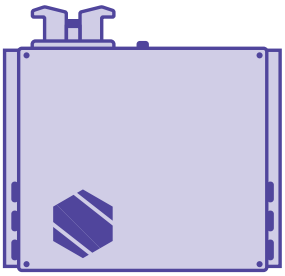
GENERATOR EXCITATION VOLTAGE CONTROLLER **SAN-AVR**



SAN-AVR3

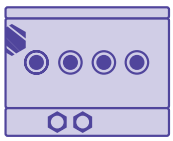


SAN-AVR4

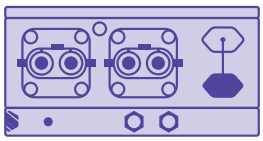


SAN-AVRS

BRAKING RESISTOR CHOPPER **RCH**

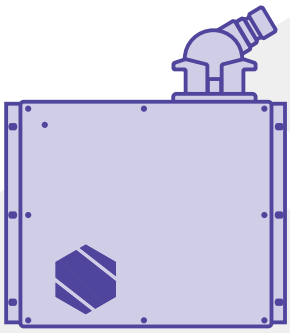


RCH 60/1k0-W

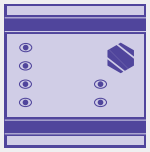


RCH 120/1000-W

SYNCHRONOUS GENERATOR MONITORING SYSTEM **SAN-BTK**



CHARACTERISTICS LOGGER **SAN-RP1**



Modern traction vehicles, both electric and diesel-electric, are increasingly equipped with advanced support systems and equipment designed to **improve reliability, energy efficiency,** and **operating safety.**

These devices are an integral part of the infrastructure of rail vehicles and perform a variety of functions - from braking energy management to precise monitoring and recording of operating characteristics.

In an era of increasing requirements for interoperability and digital communication in rail transport, devices that ensure compliance with international standards for communication protocols are also becoming crucial.

The devices and systems that support vehicle operation include:

- pressure loggers SAN-RC;
- excitation voltage controllers SAN-AVR;
- braking resistor choppers RCH;
- generator monitoring system SAN-BTK;
- characteristics logger SAN-RP1.

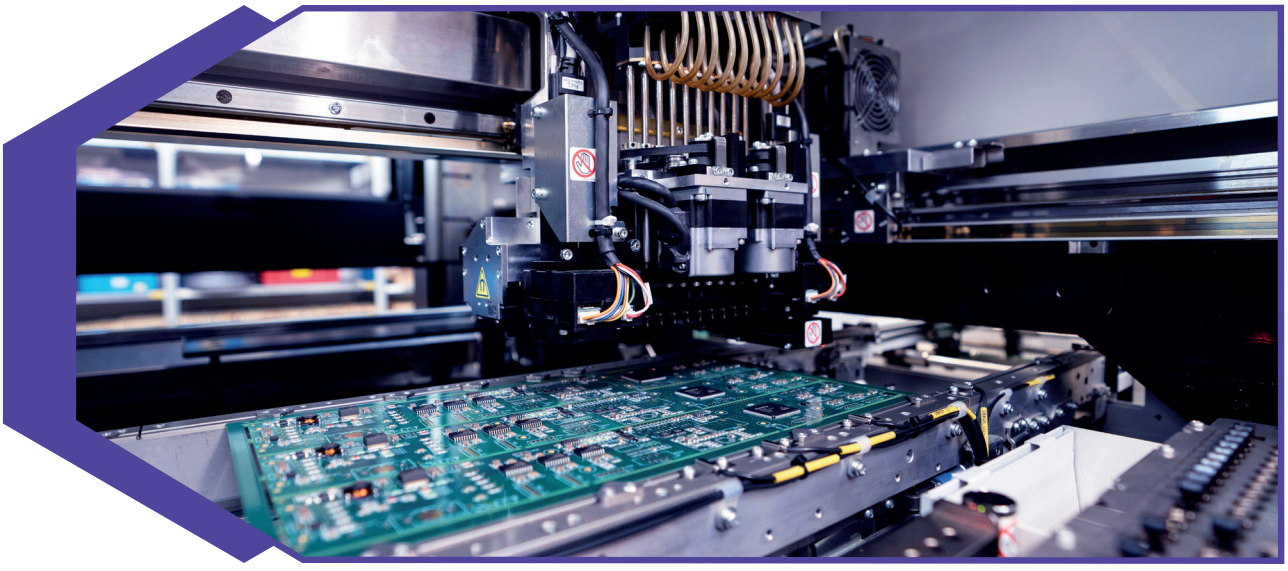
Systems and devices that support the operation of traction and electric vehicles are of great interest to our client. In recent years, we have delivered more than a thousand units that work reliably, achieving very high operating characteristics.

The use of such devices and systems not only optimizes the operation of propulsion and power supply systems, but also enables the implementation of modern diagnostics and automation systems.

The use of support systems and devices makes it possible to:

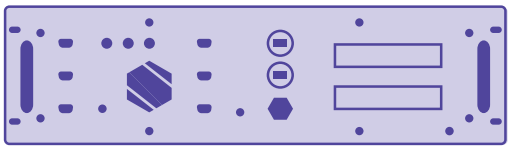
- detect faults faster;
- conduct predictive diagnostics;
- efficiently manage energy consumption;
- improve passenger comfort and safety.

We carry out each production stage in compliance with the highest quality standards, in accordance with railroad standards and EU directives:		
PN-EN 45545-2+A1:2024-04	PN-EN 45545-5+A1:2016-01	PN-EN 50121-1:2017-06
PN-EN 50121-3-1:2017-05	PN-EN 50121-3-2:2017	PN-EN 50121-4:2017-04
PN-EN 50121-4:2017-04	PN-EN 50124-1:2017-09	PN-EN 50124-2:2017-09
PN-EN 50125-1:2014-06	PN-EN 50126-1:2018-02	PN-EN 50129:2019-01
PN-EN 50153:2014-11	PN-EN 50155:2022-05	PN-EN 50716:2024-05
PN-EN 61373:2011	PN-K-23011:1998	2014/30/EU
2014/35/EU		

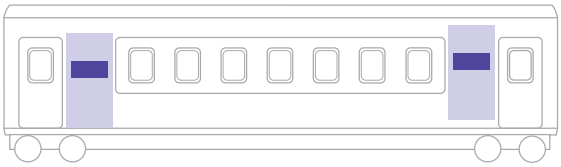


Automatic assembly line for SMD components

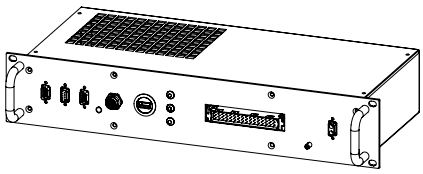
5.1. PRESSURE LOGGER SAN-RC



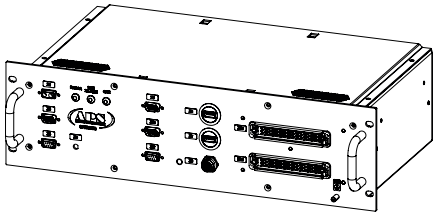
SAN-RC2



General layout of the SAN-RC pressure logger in a passenger coach



General view of the SAN-RC1 pressure logger



General view of the SAN-RC2 pressure logger

All measurements and device states are stored in the internal memory of the logger in files that can be accessed via an external USB memory stick or the Ethernet (FTP server).

The **SAN-RC pressure logger** used in the railway sector is a specialized measuring and recording device used for continuous monitoring and recording of air pressure values from sensors located in the vehicle's pneumatic system. In addition, the device records the vehicle's mileage by counting pulses from sensors installed on the vehicle's axles.

The pressure logger can be equipped with an internal GPS signal receiver. When the GPS antenna is connected, the vehicle's position and time will be recorded in the internal memory of the device. Information on the status of the monitored signals is made available to the on-board diagnostics system via the CAN network via the CANopen protocol.

Applications: electric and diesel locomotives, electric multiple units, passenger coaches and freight wagons with braking systems, urban rail vehicles (trams and subways).

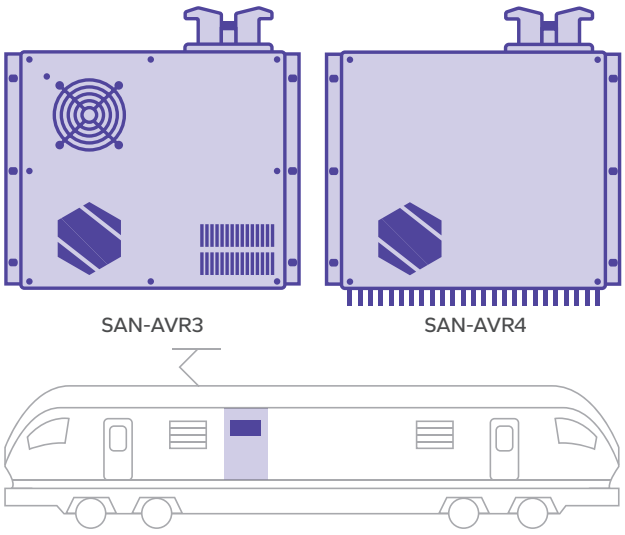
CHARACTERISTICS:

- pressure recording - work with analog sensors;
- speed and distance measurement - work with pulse sensors;
- adjustable wheel diameter value;
- saving measurement data in the internal memory;
- communication over a CAN network (CANopen);
- communication over a LAN (Ethernet);
- works with an external flash memory via a USB port;
- signaling of emergency conditions by means of potential-free outputs;
- recording vehicle position and time using the built - in GPS receiver.

PRESSURE LOGGER SAN-RC - STANDARD CHARACTERISTICS		
EQUIPMENT TYPE	**SAN-RC1**	**SAN-RC2**
CHARACTERISTIC	VALUE	
ELECTRICAL CHARACTERISTICS		
Rated DC supply voltage	24 V	
Range of DC supply voltage	16 to 30 V	
Rated power	16 W	20 W
Battery capacity*	1.2 to 17.2 Ah	
Battery type	maintenance-free lead-acid battery with AGM technology	
TECHNICAL CHARACTERISTICS		
Enclosure protection rating	IP20	
External dimensions (L × W × H)*	242 × 482 × 88 mm	293 × 482 × 133 mm
Operating temperature (EN 50178 class 3k3)*	+5 to +40 °C	
Cooling type	passive	
LINK CHARACTERISTICS		
GPS	No	Yes
Number of pressure measurements	4 pcs	8 pcs**
Number of digital inputs**	1 pc	8 pcs
Number of speed sensor inputs**	2 pcs	
Number of digital outputs**	2 pcs	4 pcs
Number of transistor outputs**	-	8 pcs

* - depending on the selected type and version of the device; ** - a device with different characteristics can be manufactured.

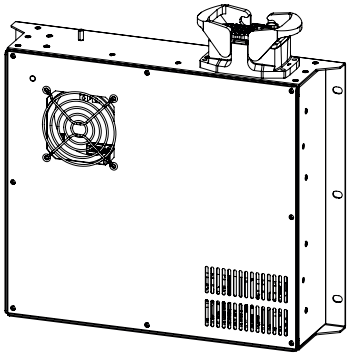
5.2. GENERATOR EXCITATION VOLTAGE CONTROLLER SAN-AVR



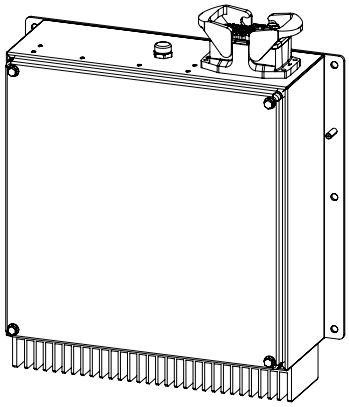
General layout of the SAN-AVR generator excitation voltage controller in a locomotive

The excitation current in an alternating current (AC) generator is controlled by a **SAN-AVR generator excitation voltage controller.** The SAN-AVR controller is used to maintain a stable generator output voltage regardless of the load or speed changes. The SAN-AVR controller from APS Energia SA is a state-of-the-art microprocessor-based device that has the ability to supervise the status of generator characteristics and control the excitation current via the CANopen communication protocol.

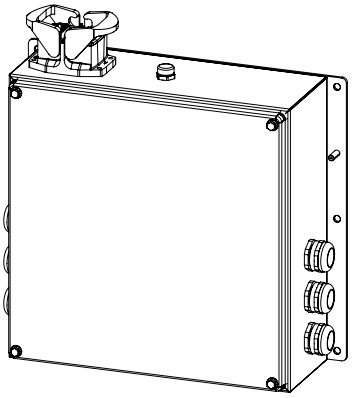
Generator excitation voltage controllers are used in locomotives and traction vehicles. SAN-AVR systems can be supplied with voltage and current measurement sensors (e.g., SAN-AVRS).



General view of the SAN-AVR3 generator excitation voltage controller



General view of SAN-AVR4 generator excitation voltage controller

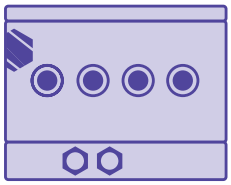


General view of the measurement system of the SAN-AVRS generator excitation voltage controller

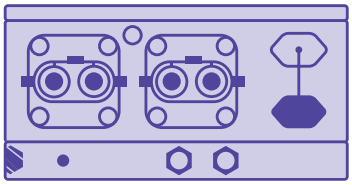
GENERATOR EXCITATION VOLTAGE CONTROLLER SAN-AVR - STANDARD CHARACTERISTICS					
EQUIPMENT TYPE	**SAN-AVR1**	**SAN-AVR2**	**SAN-AVR3**	**SAN-AVR4**	**SAN-AVRS**
CHARACTERISTIC	VALUE				
ELECTRICAL CHARACTERISTICS					
Range of DC supply voltage	16 to 30 V				-
Range of DC supply current	10 to 17 A			12 to 17 A	-
Range of DC output voltage	24 to 30 V	0 to 30 V	0 to 24 V		-
Range of DC output current	10 A		0 to 10 A	0 to 12 A	-
Alternator voltage control	±5%				
Response time to load increase	approx. 5 s				
Response time to load decrease	approx. 5 s				
TECHNICAL CHARACTERISTICS					
Enclosure protection rating	IP20			IP55	
External dimensions (L × W × H)*	284 × 350 × 80 mm			340×339×124mm	301×340×124mm
Operating temperature*	-30 to +40 °C			-40 to +70 °C	
Cooling type	forced, air			passive	-

* - a product with other characteristics can be manufactured.

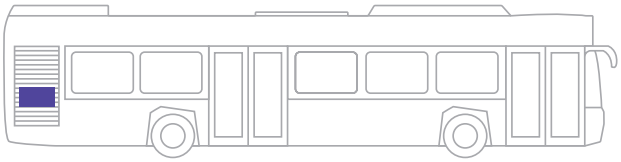
5.3. BRAKING RESISTOR CHOPPER RCH



RCH 60/1k0-W



RCH 120/1000-W



General layout of the RCH braking resistor chopper in an electric bus

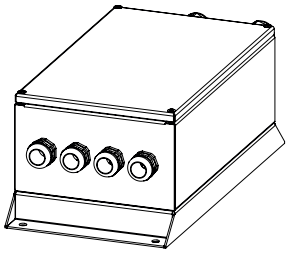
The **RCH braking resistor chopper** is designed to work with the propulsion system of an electric bus.

This device is used to control the flow of energy to the braking resistor. The main task of the braking resistor chopper is to turn the resistor on and off at the right time to safely dissipate excess electricity. The braking resistor chopper is an electronic circuit system that contains a solid-state IGBT module installed on a liquid-cooled heat sink.

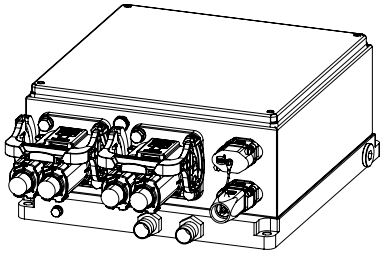
The braking resistor chopper has been on offer for 7 years, and its reliability is confirmed by installations made in public transport vehicles in Poland.

The RCH braking resistor chopper can operate in two modes:

- with an adjustable set voltage threshold;
- with an adjustable power value on the resistor.



General view of the RCH 60/1k0-W braking resistor chopper



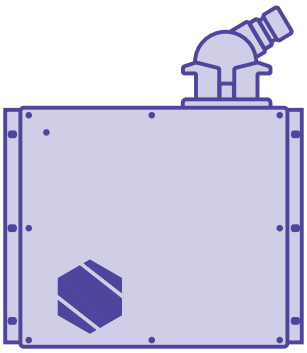
General view of the RCH 120/1000-W braking resistor chopper

The braking resistor chopper is needed when it is necessary to:

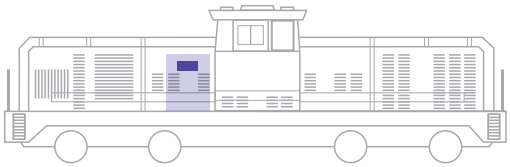
- protect the propulsion system during electrodynamic braking;
- enable controlled braking;
- optimize the resistor's switch-on time;
- minimize energy losses.

BRAKING RESISTOR CHOPPER RCH - STANDARD CHARACTERISTICS			
EQUIPMENT TYPE	**RCH 60/1K0-W**	**RCH 60/1000-W**	**RCH 120/1000-W**
CHARACTERISTIC	VALUE		
ELECTRICAL CHARACTERISTICS			
Rated DC supply voltage	750 V		
Maximum DC supply voltage	1,000 V		
Rated output current	80 A		300 A
Rated auxiliary DC supply voltage	24 V		
Rated power	60 kW		120 kW
TECHNICAL CHARACTERISTICS			
Enclosure protection rating	IP65		
Dimensions (L × W × H)	426 × 200 × 155 mm		376 × 310,5 × 150 mm
Operating temperature	-10 to +40 °C		
Cooling type	forced, liquid		
Coolant type	1:1 water/glycol mixture		
Minimum coolant flow rate	12 dm^3/min		
Maximum inlet coolant temperature	85 °C		
Internal output current measurement converter	no	yes	

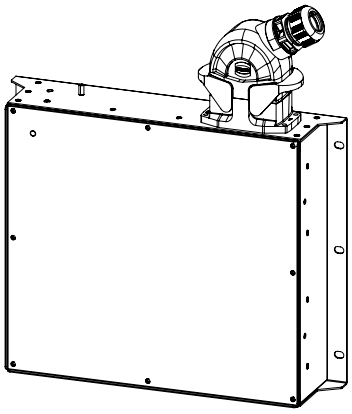
5.4. SYNCHRONOUS GENERATOR MONITORING SYSTEM SAN-BTK



SAN-BTK



General layout of the SAN-BTK synchronous generator monitoring system in a locomotive



General view of the SAN-BTK synchronous generator monitoring system

The **SAN-BTK synchronous generator monitoring** system is a part of the generator automation and protection system. It is a set of devices and sensors designed to continuously monitor the operating characteristics of a synchronous AC generator, including its voltage and frequency stability, to ensure:

- rapid detection of faults or overload conditions;
- the safety of people and equipment.

This monitoring system is used in diesel-electric locomotives or hybrid multiple units where:

- the generator's status is monitored - it detects overloads, overheating, and failures thanks to its advanced safety features;
- it enables integration into the vehicle control system thanks to the CANopen protocol - it supports diagnostics and remote management.

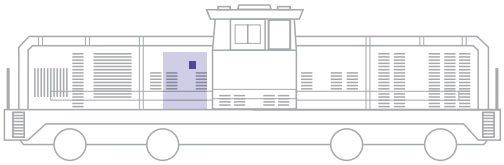
The synchronous generator monitoring system is an indispensable component of electric power automation that:

- increases reliability;
- enables predictive diagnostics;
- facilitates power quality management and grid integration.

SYNCHRONOUS GENERATOR MONITORING SYSTEM SAN-BTK - STANDARD CHARACTERISTICS	
CHARACTERISTIC	VALUE
ELECTRICAL CHARACTERISTICS	
Range of DC supply voltage	16 to 30 V
Range of DC supply current	10 to 17 A
TECHNICAL CHARACTERISTICS	
Enclosure protection rating	IP20
External dimensions (L × W × H)*	284 × 350 × 80 mm
Operating temperature	-30 to +40 °C

5.5. CHARACTERISTICS LOGGER SAN-RP1

SAN-RP1



General layout of the SAN-RP1 characteristics logger in a passenger coach and a locomotive

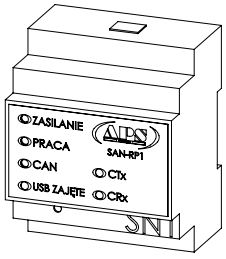
CHARACTERISTICS:

- high operating stability;
- logging of system operating characteristics;
- CAN - 300 V isolated link;
- work with an external flash memory via a USB port (A type port);
- handling and saving system logs to internal memory;
- signals of the following operating states:
  - power supply;
  - correct operation;
  - CAN;
  - USB busy;
  - communication over APSCAN - transmission;
  - communication over APSCAN - reception.

The **SAN-RP1 characteristics logger** is designed for continuous monitoring and recording of device characteristics for the diagnostic system via a CAN network from APS Energia SA. All measurements and device states are stored in the internal memory of the logger in files that can be accessed via an external USB memory stick. The logger is designed for installation inside the vehicle.

The benefits obtained when the vehicle is equipped with a characteristics logger:

- improved security level - enabling rapid restoration of the course of events in the case of an accident or collision;
- better control over the driver's work - verification of compliance of his or her actions with the applicable procedures;
- more efficient vehicle operation management - energy consumption assessment and technical component diagnostics;
- streamlined maintenance - using the data collected to schedule inspections and detect faults before they occur.



General view of the SAN-RP1 characteristics logger

CHARACTERISTICS LOGGER SAN-RP1 - STANDARD CHARACTERISTICS				
CHARACTERISTIC	VALUE			
ELECTRICAL CHARACTERISTICS				
Rated DC supply voltage	24 V			
Tolerance of DC supply voltage	9 to 36 V			
INTERFACE TYPE	**RS485**	**ETHERNET**	**CAN**	**USB**
Insulation on the link	300 V	100 V	300 V	-
Transmission speed	19,200 bp	10/100 Mbps	250 Mbps	-
Transmission characteristics	8N1	-	-	2.0
Transmission protocol	-	HTTP, SNTP,	APSCAN	-
TECHNICAL CHARACTERISTICS				
Enclosure fixing	DIN rail 35 mm			
External dimensions (L × W × H)*	79 × 92 × 60 mm			
Operating temperature*	+5 to +40 °C			

* - a product with other characteristics can be manufactured.

NOTES

6. RAILWAY SIGNALS USING LED TECHNOLOGY

Modern railroads require solutions that are reliable, energy-efficient, and resistant to environmental conditions. Traditional incandescent bulbs, used for decades in signaling, are being replaced by modern LED-based systems. **LED solutions are characterized by a several times longer service life, much lower power consumption, and immediate signal readiness.** Thanks to their high color stability and light intensity, even in extreme temperatures, they provide better visibility and greater safety. **LED technologies are becoming the global standard in railroad control systems**, supporting the global trends of infrastructure automation and digitization. The use of LED technologies also enables the integration of diagnostic and redundancy functions, contributing to the increased level of railroad safety required of SIL4-class systems. **Reduced service costs, elimination of service downtime, and high reliability are added advantages in the operation of railroad networks.** The dynamic growth of the market and increasing normative requirements strengthen the position of LED technologies as the basic signaling standard.

LED devices provide more than light - they are an intelligent component of the traffic control system.

ALDRI LED RAILWAY INDICATORS

Railroad indicators of the ALDRI type are electronic devices designed for installation within the trackside infrastructure. The indicators are made with LED technology. The design of these devices provides a constant light flux of the displayed indicator content, which is adjusted according to the intensity of the ambient light. In addition, the devices have a light flux correction system depending on the indicator's background environment. The indicators are developed in accordance with the "Technical Requirements for Signal Indicators and Boards Ie-102" and the "Conditions for the Approval for Use on Railway Lines Managed by PKP Polskie Linie Kolejowe SA of Railway Signaling Components Made with the LED Technology".

ALDRI LED railway indicators

ALDRI LED INDICATORS - BASIC CHARACTERISTICS	
CHARACTERISTIC	VALUE
ELECTRICAL CHARACTERISTICS	
AC supply voltage	88 to 264 V 50 Hz
Power consumption	12 to 24 W
Insulation withstand voltage	2,500 V 50 Hz for 60 s
MECHANICAL CHARACTERISTICS	
MTBF	>2,553,087 h
Operating temperature	-40 to +80 °C
Operating mode	day / night
LED color	white
Ingress protection rating	IP65
Dimensions of the indicator without the canopy	320 × 420 × 147 mm 450 × 420 × 147 mm

CHARACTERISTICS:

- compact aluminum enclosure;
- moisture condensation protection;
- correction of luminosity according to the intensity of ambient light in the range of 10 to 80,000 lx;
- wide range of AC or DC input voltages;
- very high optical efficiency - more than 86%;
- flicker protection;
- high visibility;
- compliance with the SIL4 safety level;
- LED interruption and short circuit monitoring based on a proprietary solution;
- mechanical strength: compliance with PN-EN 61373:2011 (category 1B);
- mechanical durability of more than 25 years;
- IP65 protection rating as a standard;
- low power consumption;
- emulation of the operation of a standard incandescent bulb with resistive characteristics;
- the ability to change the contents of the W21 indicator in a single housing.

ALRICS LED LIGHT SOURCE OF THE RAILROAD SIGNALING DEVICE

The ALRICS-type LED light source is an electronic light source designed for installation in the heads of railroad traffic control equipment. The use of non-incandescent LED technology ensures a constant luminous flux of emitted color. The device has a system of luminous flux adjustment depending on the temperature and intensity of ambient light, which contributes to the high perception of the state of the signaling device from a greater distance than in classic solutions with incandescent light sources. Full monitoring of interruptions and short circuits and all electrical characteristics of each diode individually, as well as protection against yellowing of the lens, ensures a very high level of safety that meets the SIL4 safety requirements. The proprietary patented lens ensures very high optical performance of the light source. The integrated lens is a matrix of 22 lenses made with the stepped technology. The use of LED sources in the SMT technology and in the measurement paths of low temperature drift components ensures very high values of the THR and MTBF characteristics.

CHARACTERISTICS:

- compliance with the SIL4 safety level;
- wide range of AC or DC input voltages;
- very high optical efficiency - more than 86%;
- integrated monolithic polycarbonate lens;
- protection against yellowing of light fixtures;
- use of 22 low-power LEDs from the automotive group;
- thermal correction of LEDs;
- maintenance-free;
- monitoring of short circuits and interruptions in the LED circuit;
- flicker with adjustable cycles;
- predicting major failures of each LED;
- safe shutdown in case of failure;
- works with relay interlock systems;
- compact dimensions;
- high availability;
- high reliability characteristics;
- compact extruded aluminum enclosure;
- optimal thermal management that extends the service life;
- a membrane that protects against moisture;
- IP65 protection rating as a standard;
- use as a retrofit device in heads with incandescent light sources.

ALRICS LED signaling device

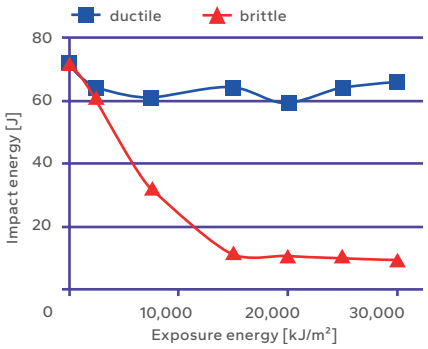
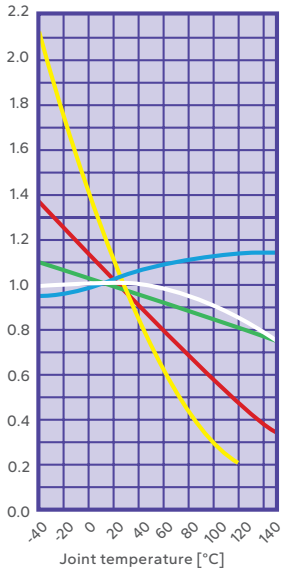


Diagram showing protection against yellowing of the lens - resistance of the lens to xenon radiation



Graph showing **relative luminous flux** in red, green, yellow, white, and blue.

LED ALRICS INDICATORS - BASIC CHARACTERISTICS	
CHARACTERISTIC	VALUE
ELECTRICAL CHARACTERISTICS	
AC supply voltage	88 to 264 V 50 Hz
DC supply voltage	130 to 389 V
Power consumption	14 W
Insulation withstand voltage	2,500 V 50 Hz for 60 s
MECHANICAL CHARACTERISTICS	
MTBF	>2,987,112 h
Operating temperature	-40 to +70 °C
Operating mode	day / night
Lens material	polycarbonate
Luminous flux distribution	3°/4° or 4°/16°
Polycarbonate lens	Ø 100 / 200 mm
LED color	red, green, yellow, blue, white
Ingress protection rating	IP65

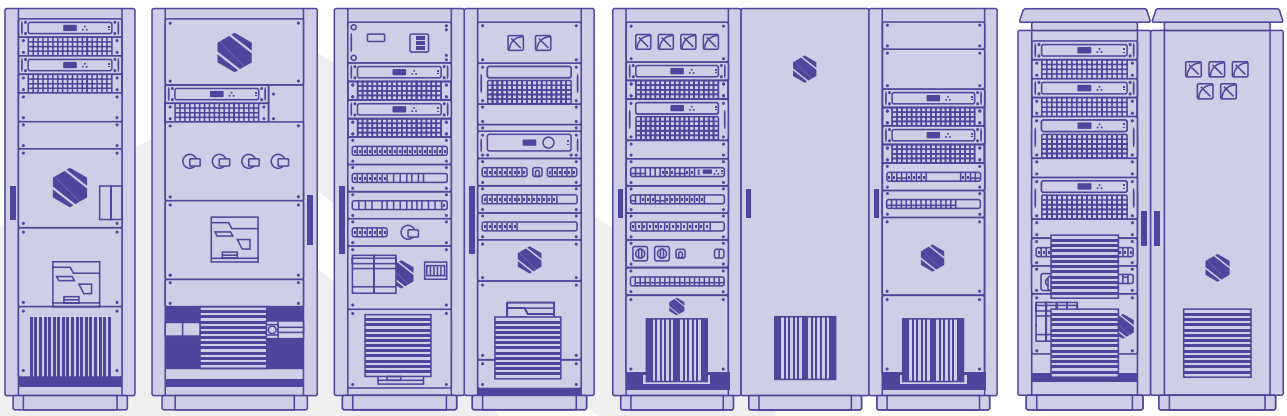
7. STATIONARY POWER SUPPLY SYSTEMS FOR TRACTION

DC POWER SUPPLY SYSTEMS

- TRANSFORMER SUBSTATION POWER SUPPLY SYSTEM **PT**
- AUXILIARY SWITCHGEAR POWER SUPPLY SYSTEM **RPW**

DC AND AC POWER SUPPLY SYSTEMS

- MULTI-VOLTAGE POWER SUPPLY SYSTEM FOR RAILROAD TRAFFIC CONTROL SYSTEMS **SRK**
- UNINTERRUPTIBLE POWER SUPPLY CABINET **SNG**
- POWER SUPPLY SYSTEM WITH A SWITCHGEAR **SZZR**



PT RPW SRK SNG SZZR

Stationary uninterruptible power supply systems are designed for supplying power for auxiliary consumption in traction substations, subways, and other rail transport systems. They are complex power electric systems designed to provide reliable power to auxiliary equipment and control systems.

They consist of multiple components that work together to convert, store, and distribute electricity. The key components of such systems are batteries charged by rectifiers that convert the alternating voltage (AC) from the electric grid to the direct voltage (DC) needed to properly charge batteries. Another extremely important component of the system is inverters, which convert DC voltage to AC voltage with the appropriate characteristics, making it possible to provide uninterruptible power to AC powered devices. These systems also often use DC/DC converters to generate different DC voltages suitable for different types of loads with galvanic isolation from the battery. Another integral part of a system containing an inverter is a bypass system, which allows the system to continue operating in the event of failure of one of the converter modules (inverter). The whole is complemented by control and monitoring systems that supervise the operating characteristics of individual components and ensure appropriate responses to changing operating conditions.

Modern auxiliary power supply systems are designed with a strong focus on reliability, energy efficiency, and the ability to integrate with the energy management systems of modern transport and logistics facilities.

Importantly, many of these devices and technical solutions are also used in the growing electromobility (e-mobility) sector. For example, rectifiers and DC/DC converters are an indispensable part of the electric vehicle charging infrastructure, where they are responsible for converting and stabilizing the voltage at charging stations. Energy storage equipment, previously used mainly as backup solutions in traction systems, is now being used to power fast chargers and even entire charging hubs in situations of limited access to the electric grid. Inverters and control systems also support bidirectional energy flow technologies, allowing energy to be returned from electric vehicles to the grid. Today, the experience gained in operating power supply systems in rail transport is successfully applied to modern electromobility solutions, fostering the integration of the two areas as part of a sustainable transformation in the energy and transport sectors.

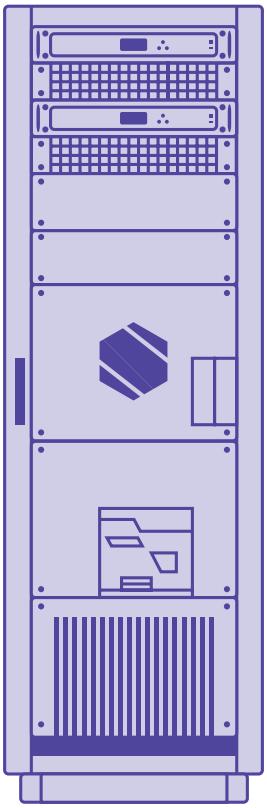
APS Energia SA has manufactured power supply systems for the stations of the second line of the Warsaw metro. The stations of the first and second lines of the Warsaw Metro built earlier also used power supply systems manufactured by APS Energia SA. These systems were responsible for uninterruptible power supply to the sensitive loads of the subway stations. In addition, systems from APS Energia SA play a key role in supplying power to essential systems and equipment of the subway stations in Kyiv (Ukraine).

The power supply systems designed and manufactured by the company are customized solutions that meet the specific needs a particular facility. They take into account both the technical requirements and the operating conditions, which allows for optimal adjustment of installation characteristics. Our customized approach to design and manufacturing makes it possible to ensure high reliability and energy efficiency, and to develop dedicated mechanical designs to meet our clients' needs.

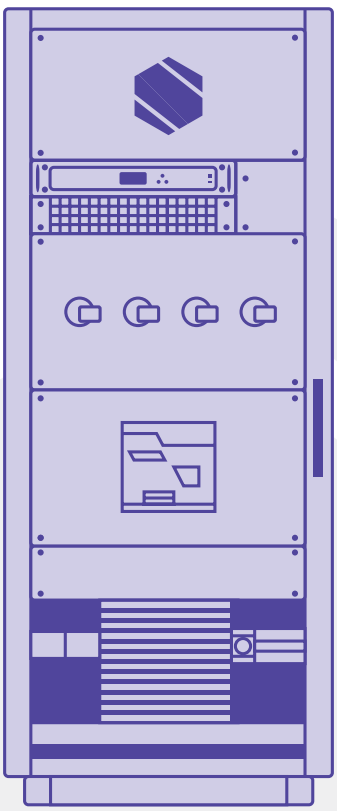
We carry out each stage in compliance with the highest quality standards, in accordance with railroad standards and EU directives:		
PN-EN 50178:2003	PN-EN 61000-2-2:2003	PN-EN 60529:2003
PN-EN 61204:2001/A1:2002	PN-EN 61204-3:2019-02	PN-EN 61204-6:2002
PN-EN IEC 60146–1–1:2024-12	PN-EN IEC 61000-2-4:2025-04	PN-EN IEC 61000–6–2:2019-04
PN-EN IEC 61000-6-4:2019-12	PN-EN IEC 62040-1:2019-11	PN-EN IEC 62040-2:2019-02
PN-EN IEC 62368-1:2024-06	2014/30/EU	2014/35/EU

7.1. DC POWER SUPPLY SYSTEMS

TRANSFORMER SUBSTATION POWER SUPPLY SYSTEM **PT**



AUXILIARY SWITCHGEAR POWER SUPPLY SYSTEM **RPW**



DC power supply systems are commonly used in rail vehicle transformer substations to provide stable and reliable power for key infrastructure equipment such as control and automation systems, safety and surveillance systems, communication and passenger information systems, emergency lighting, backup power systems, and detection and measurement systems.

SYSTEM COMPONENTS

DC power supply systems are characterized by their modularity and ability to integrate with modern monitoring and energy management systems. DC power supply systems may include the following components:

A **pulse buffer** rectifier in a modular enclosure, which is an alternating voltage (AC) to direct voltage (DC) converter. These DC power supply systems meet stringent requirements in terms of functionality, technical characteristics, and reliability. The rectifiers are designed to power DC loads and charge batteries. They can operate in the following modes: buffer operation, self-charging, and supervised charging. The devices can operate autonomously and/or in parallel.

An **automatic transfer switching (ATS) system** decides on the choice of the power supply source for the device. When voltage is present in source 1, the device is powered from it. In the event of an outage (total or one phase) of source 1, the ATS automatically switches the power supply of the device to source 2. An ATS can have different configurations, and its most common versions are based on either contactors or a modular automatic switching device. ATS systems are used primarily in low-voltage circuits, where a short interruption of power supply to loads during the switching operation of the power source is allowed.

A power supply system can be equipped with a **panel for DC voltage distribution** to loads compliant with specifications, with the required number of circuits including protection devices.

Independent of the measurement systems associated with the DSP controller, **analog and digital meters** are used to visualize measurements of various input and output characteristics (1st accuracy class).

EMI filters: single- or multi-stage filters on the input and output of rectifier modules reduce the level of conducted interference, limit the emission of interference in the device, and increase the immunity of the device to interferences.

Systems are cooled by circulated air forced by roof fans, which enters through an air intake located at the bottom of the enclosure. Air filters are located directly behind it. The two-stage rotational speed is adjustable as a function of the internal temperature of the device. In addition to cabinet ventilation, each module is independently cooled with its own fans.

The backup (emergency) energy source of the power supply system is a **battery bank**. The most common are maintenance-free VRLA-type batteries in 12 V blocks. However, it is also possible to use different types of batteries, in terms of both the electrolyte type (AGM, GEL, liquid electrolyte) and the technology (lead-acid, Ni-Cd, others). Battery capacity can be selected in a wide range of 10 to 3,000 Ah. The most common rated battery bank voltage is 220 V DC, but it can be 24, 48, 60, 110, 400 V DC, or other non-standard voltage, depending on the user's requirements and the design.

An **automatic surveillance system** provides monitoring, recording, and visualization of all system operating states and generates alarms when alarm states occur. Alarm states are signaled by potential-free contacts and by data transmission via the RS or LAN communication ports using transmission protocols. The display of the communication console shows the current characteristics of output voltages and currents, the synoptics of system operation, the primary grid voltages, the battery voltage and current, the ambient temperature, and other data that is important for the system's reliability. In addition, it is possible to equip the system with a serial CAN communication bus.

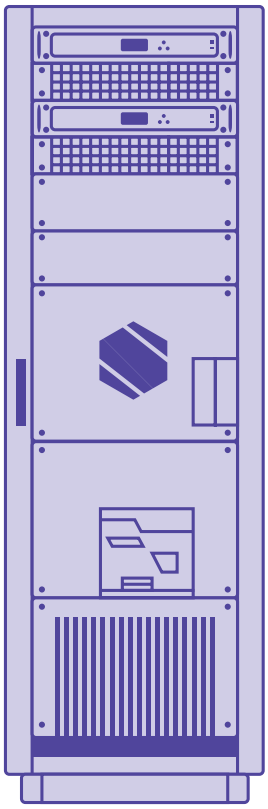
Industrial cabinet (one or more). The structure of the cabinets is welded and protected against corrosion with metallic coatings and powder coating.

Protections:

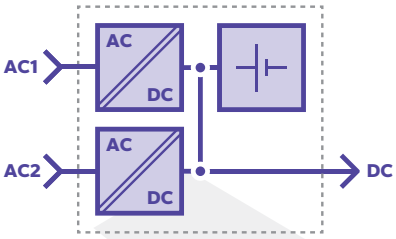
- overvoltage, overcurrent, short-circuit protections, etc.
- power supply battery over-charge protection;
- protection of internal systems from:
  - overheating of the power systems;
  - voltage increase on the transistors;
  - overvoltage caused by dynamic load changes;
  - internal short-circuits.

The details and type series of equipment manufactured by APS Energia SA can be found in the "Uninterruptible power supply systems" products catalog.

7.1.1. TRANSFORMER SUBSTATION POWER SUPPLY SYSTEM PT



Transformer Substation Power Supply System PT



Block diagram of the Transformer Substation Power Supply System PT

An example of a DC Power Supply System is a system consisting of two rectifier modules working with a single battery, installed in a common 19" rack. Such systems are used in transformer substation facilities (tram substations and trolleybus substations). Over the years, we have delivered and installed such systems in Łódź, Szczecin, Katowice, Poznań, and Lublin, among other cities.

Such systems are characterized by their high reliability and flexibility of operation due to the use of two independent rectifiers supplied from separate AC lines, which allows operation to continue even in the event of a failure of one power supply source.

The presence of a battery bank ensures power supply to loads in the event of a mains power outage.

The system is equipped with comprehensive overvoltage protection and protection devices on both the AC and DC sides, which protects the equipment and the installation from damage.

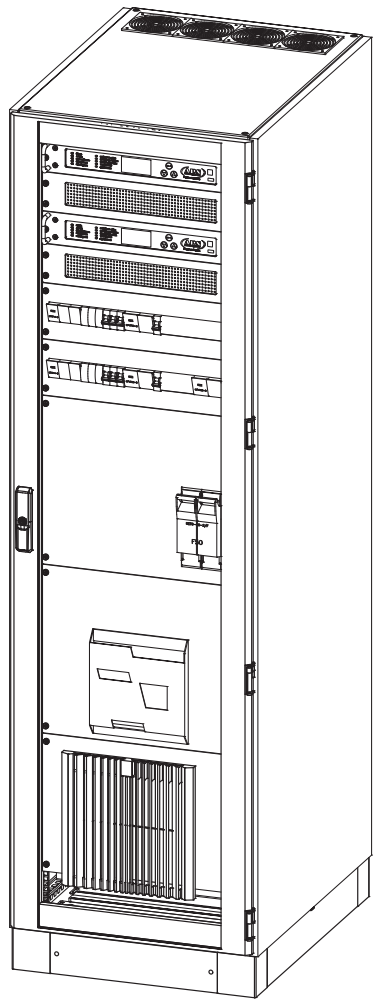
The ability to disconnect each rectifier independently facilitates servicing without interrupting the operation of the entire system, and the modular design provides great flexibility in expanding or modifying the system.

All these features make these systems a safe state of-the-art solution for the stable power supply of systems requiring constant DC voltage.

An uninterruptible voltage inverter module (usually with a power of 1 to 5 kVA) can also be installed in the rack to provide power to AC loads. Such versions are manufactured on special request of the client.

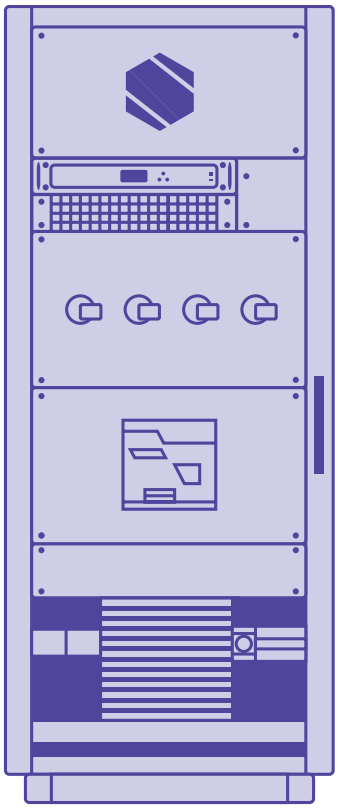
TRANSFORMER SUBSTATION POWER SUPPLY SYSTEM - STANDARD CHARACTERISTICS	
CHARACTERISTIC	VALUE
ELECTRICAL CHARACTERISTICS	
Rated AC1, AC2 supply voltage*	3×400 V 50 Hz
Rated DC output voltage*	220 V
Rated DC output current (In)*	2×20 A
Output voltage stability**	±0.6 %
Output voltage ripple***	±0.6 %
Range of thermal correction of buffer charging voltage	-10 to +50 °C
Temperature compensation of buffer charging voltage**	0 to 10 mV/°C/cell
Overload capacity	1.1×In for 3 s
Output current stability****	±1%
Output current ripple****	±1%
Battery charging characteristics	IU acc. to DIN 41773
MECHANICAL CHARACTERISTICS	
Enclosure protection rating*	IP20
Dimensions (W × D × H)*	R19": 600 × 800 × 2,000 mm (+100 mm base)
Operating temperature*	+5 to +40 °C
Cooling type	forced, air

* - a product with other characteristics can be manufactured; ** - buffer operation, voltage controller; *** - with resistive load;
**** - battery charging, current controller.



General view of the Transformer Substation Power Supply System PT

7.1.2. AUXILIARY SWITCHGEAR POWER SUPPLY SYSTEM RPW



Auxiliary Switchgear Power Supply System RPW

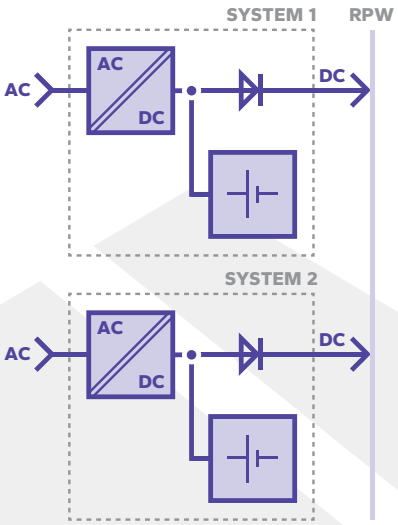
For many years, APS Energia SA has been a manufacturer and supplier of DC Power Supply Systems that work with the auxiliary switchgears of Warsaw subway stations.

The equipment is responsible for supplying power to the stations' internal circuits, such as the lighting, ventilation, control, and security systems.

By using 19" racks that include a rectifier module that works with a battery bank, these systems ensure the continued operation of key infrastructure even in the event of a mains power outage, which is critical to the reliability and safety of subway train operations. More than 20 complete power supply systems have been delivered as the construction of new subway stations continued.

The Auxiliary Switchgear Power Supply System is designed with two power supply paths, each of which includes a 220 V DC rectifier and an internal battery. The two paths are connected to a 220 V DC bus, to which the subway stations' internal loads are connected. Each path contains overcurrent protection devices, contactors, and isolation switches that enable independent operation and servicing.

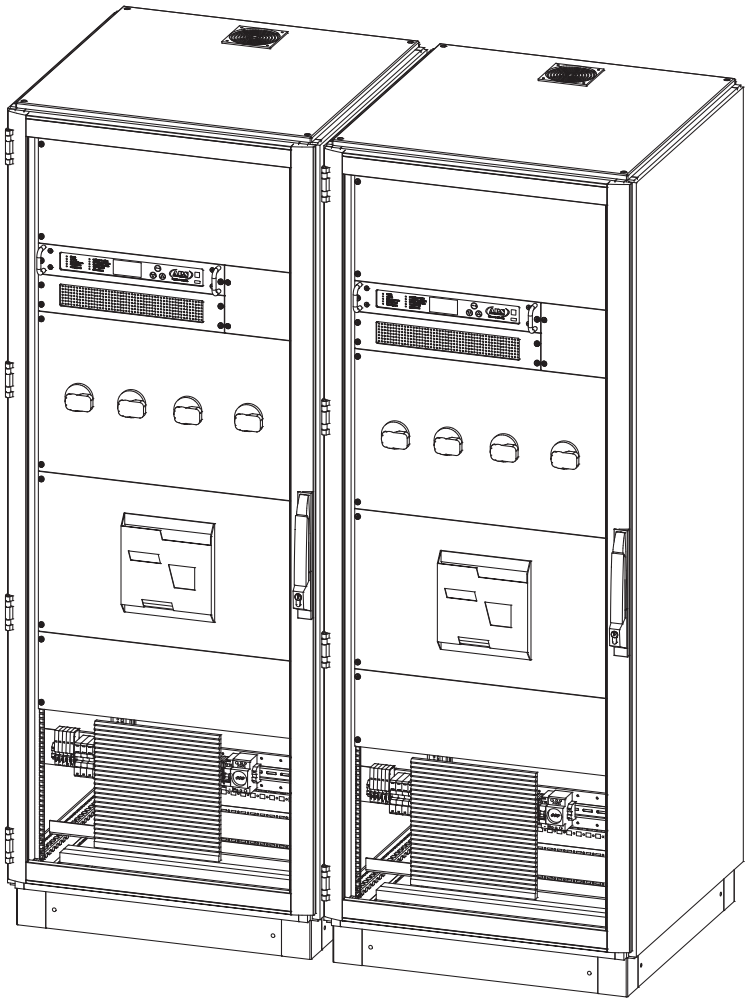
By using rectifiers and batteries, the system ensures continuity of the power supply even in the event of the failure of one of the power supply paths or a mains power outage.



Block diagram of the Auxiliary Switchgear Power Supply System RPW

AUXILIARY SWITCHGEAR POWER SUPPLY SYSTEM RPW - STANDARD CHARACTERISTICS	
CHARACTERISTIC	VALUE
ELECTRICAL CHARACTERISTICS	
Rated AC supply voltage*	3×400 V 50 Hz
Rated DC output voltage*	220 V
Rated DC output current*	20 A
Output voltage stability**	±0.6 %
Output voltage ripple***	±0.6 %
Range of thermal correction of buffer charging voltage	-10 to +50 °C
Temperature compensation of buffer charging voltage**	0 to 10 mV/ºC/cell
Overload capacity	1.1×In for 3 s
Output current stability****	±1%
Output current ripple****	±1%
Battery charging characteristics	IU acc. to DIN 41773
MECHANICAL CHARACTERISTICS	
Enclosure protection rating*	IP20
Dimensions (W × D × H)*	R19": 2×800 × 800 × 2,000 mm (+100 mm base)
Operating temperature*	+5 to +40 °C
Cooling type	forced, air

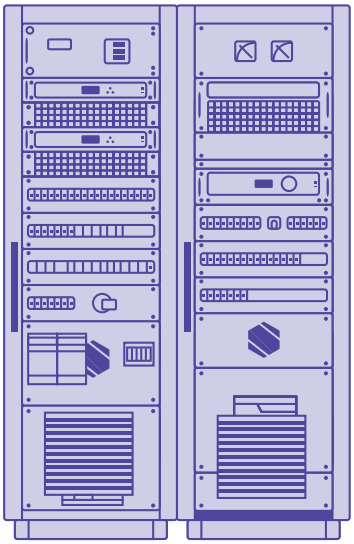
* - a product with other characteristics can be manufactured; ** - buffer operation, voltage controller; *** - with resistive load; **** - battery charging, current controller.



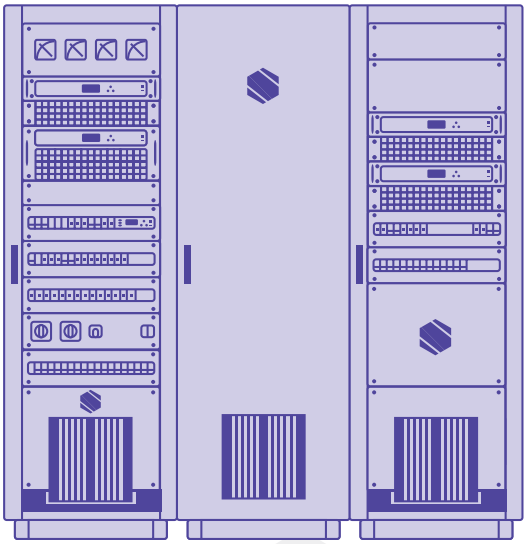
General view of the complete Auxiliary Switchgear Power Supply System RPW

7.2. DC AND AC POWER SUPPLY SYSTEMS

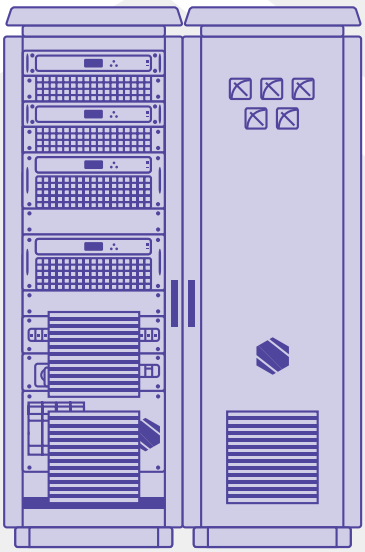
MULTI-VOLTAGE POWER SUPPLY SYSTEM FOR RAILROAD TRAFFIC CONTROL SYSTEMS **SRK**



UNINTERRUPTIBLE POWER SUPPLY CABINET **SNG**



POWER SUPPLY SYSTEM WITH A SWITCHGEAR **SZZR**



Multi-Voltage DC and AC Power Supply Systems used at rail vehicle stations complement the low-voltage infrastructure described earlier in the context of DC systems (see section 7.1. DC Power Supply Systems). By integrating both types of power supply, it is possible to comprehensively and reliably supply power to the entire station infrastructure while ensuring flexibility and continuity of operation in various scenarios.

Such systems can be used to supply power to the HVAC system, the general station lighting system, escalators and elevators, service and auxiliary sockets, and other critical loads depending on the user's needs.

SYSTEM COMPONENTS

DC and AC power supply systems are characterized by their modularity and the ability to integrate with modern monitoring and energy management systems. AC and DC power supply systems (in addition to the components described in section 7.1.) may include:

An **inverter module**, which is a DC to AC converter. The purpose of such a module is to supply power to critical loads that require uninterruptible power supply due to the need to maintain continuous operation of the loads or to ensure ideal supply voltage characteristics for the proper and reliable operation of other devices of the system. Inverters in modular enclosures are designed for installation in industrial cabinets. The devices can operate autonomously and/or in parallel (alone or in connection with an automatic bypass module).

Static switches, also known as **automatic bypasses** are essential components of modern power supply systems, providing smooth and safe switching between AC voltage sources. Static switches use an advanced semiconductor technology for fast and reliable switching, eliminating the risk of failure and minimizing downtime. An automatic bypass, which can be a component of an inverter module or can be installed in a separate module, guarantees continuity of the power supply and high efficiency of the operation of the entire power supply system. The system can operate in both on-line or off-line modes.

The **SAN8 automatic surveillance system** for AC systems provides monitoring, recording, and visualization of all system operating states and generates alarms when alarm states occur. Alarm states are signaled by potential-free contacts and by data transmission via the RS or LAN communication ports using transmission protocols. The display of the communication console shows the current characteristics of output voltages and currents, the synoptics of the system operation, the primary grid voltages, the battery voltage and current, the ambient temperature, and other data that is important for system reliability.

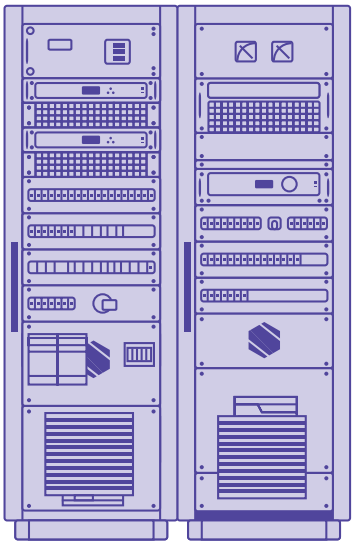
DC/DC voltage converters are designed to convert DC voltage to the stabilized DC voltage required by loads with galvanic isolation in the range of 24 to 220 V DC or other ranges. They are used to supply power to electronic devices and telecommunications systems. The devices can operate autonomously and/or in parallel.

A power supply system can be equipped with a **panel for AC or DC uninterruptible power distribution** compliant with the specifications of the loads, with the required number of circuits including protection devices.

A **safety switch** (often referred to as emergency switch) is a control system component whose main task is to immediately disconnect the power supply in situations where danger to people, equipment, or the environment occurs. It acts as a mechanical safety element that allows to quickly and easily break an electrical circuit - usually by pressing a large red "mushroom" button. When it is activated, the power supply is immediately cut off and the system remains in a stopped state until the switch is reset manually.

A **repair bypass**, based on a mechanical switch, is a solution that allows temporarily bypassing protection or power supply devices (such as an inverter or a static switch) and supplying loads directly from the power grid. A mechanical switch makes it possible to manually switch the circuit, ensuring the continuity of operation of the system during repairs.

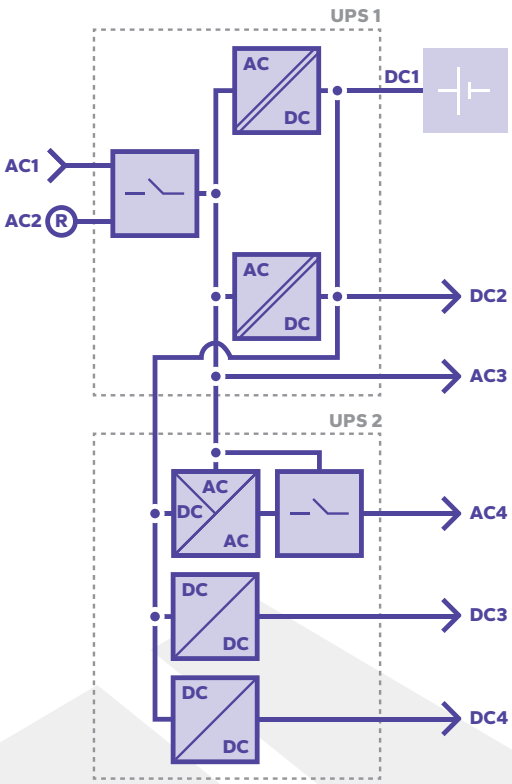
7.2.1. MULTI-VOLTAGE POWER SUPPLY SYSTEM FOR RAILROAD TRAFFIC CONTROL SYSTEMS SRK



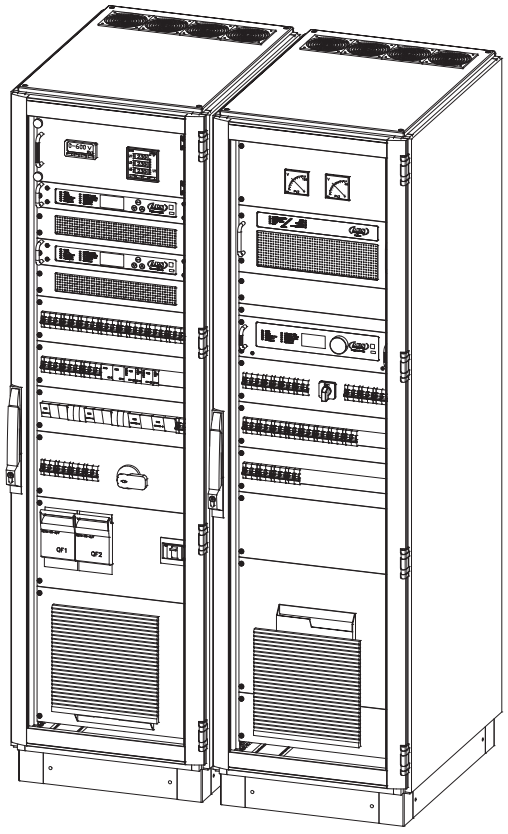
Multi-Voltage Power Supply System SRK

In modern trackside systems, one of the key elements that ensures reliability and continuity of operation is multi-voltage power supply cabinets. In such systems, uninterruptible power supply (UPS) system inverters manufactured by APS Energia SA play an important role. Their primary task is to the maintain power supply to railroad traffic control (RTC) devices such as semaphores, turnout drives, axle counting sensors, or logic relays, in the event of a power outage in the power grid.

UPS inverters are also used to supply power to railroad stations and equipment that controls train traffic, switch setting, route signaling, etc. The systems are used to supply power to systems and devices that are located at block posts for controlling and supervising train traffic, while ensuring safe distances between vehicles.



Block diagram of the Multi-Voltage Power Supply System



General view of the Multi-Voltage Power Supply System

In the railroad environment, UPS inverters based on on-line devices are used most commonly, as they provide the highest level of protection by continuously supplying power to loads and eliminating even short voltage interruptions. Power supply systems based on buffer rectifiers that act as both a power supply and a battery charger are also common. Systems of this type provide a stable output voltage to supply power to RTC equipment, while keeping the batteries fully charged. These systems work with batteries characterized by their high resistance to temperature fluctuations, vibration, and operation in industrial conditions. In addition to the primary power supply from the grid, dual-powered configurations that include backup power sources and automatic voltage source switches are often used. Modern UPS systems (AC and DC) are equipped with communication modules (e.g. SNMP, RS485) that allow remote monitoring of their technical status, battery charge level, and events history. Such systems guarantee uninterrupted operation of railroad infrastructure even in difficult power supply conditions that directly affect the safety and smoothness of train traffic.

MULTI-VOLTAGE POWER SUPPLY SYSTEM - STANDARD CHARACTERISTICS	
CHARACTERISTIC	VALUE
ELECTRICAL CHARACTERISTICS	
RECTIFIER SECTION	
Rated AC1, AC2 supply voltage*	3×400 V 50 Hz
Rated DC1 output voltage*	60 V
Rated DC1 output current (In_{DC1})*	100 A
Output voltage stability**	±0.6 %
Output voltage ripple***	±0.6 %
Range of thermal correction of buffer charging voltage	-10 to +50 °C
Temperature compensation of buffer charging voltage**	0 to 10 mV/ºC/cell
Overload capacity	1.1×In_{DC1} for 3 s
Output current stability****	±1%
Output current ripple****	±1%
Battery charging characteristics	IU acc. to DIN 41773
Additional AC3 output voltage	3×400 V 50 Hz
INVERTER SECTION	
Rated AC1, AC2 primary supply voltage*	3×400 V 50 Hz
Rated AC back-up supply voltage*	230 V 50 Hz
Rated DC1 supply voltage*	60 V
Permissible range of DC voltage changes*	51 to 82 V
Rated AC4 output voltage*	230 V 50 Hz
Output power*	2 kVA
Rated AC4 output current (In_{AC4})*	8.7 A
Overload capacity*	<1.1×In_{AC4} long-term
	1.1×In_{AC4} to 1.25×In_{AC4} for 10 min
	1.25×In_{AC4} to 1.5×In_{AC4} for 60 s
Range of cos φ characterizing the load	0.7 to 1.0
Harmonic content (linear load)	<2 %
Overcurrent protection*	6×In_{AC4} for 100 ms
Voltage shape	sinusoidal
DC/DC CONVERTER SECTION	
Rated DC3 output voltage (section 1)*	120 V
Rated DC3 output current (section 1)*	1.8 A
Rated DC4 output voltage (section 2)*	24 V
Rated DC4 output current (section 2)*	6.0 A
MECHANICAL CHARACTERISTICS	
Enclosure protection rating*	IP20
Dimensions (W × D × H)*	R19": 2×600 × 800 × 2,000 mm (+100 mm base)
Operating temperature*	0 to +50 °C
Cooling type	forced, air

* - a product with other characteristics can be manufactured;
** - buffer operation, voltage controller; *** - with resistive load; **** - battery charging, current controller.

The Multi-Voltage Power Supply System, which is described as an example, consists of UPS1 and UPS2 cabinets and is used to supply power to railroad control systems and equipment with the necessary AC voltages: 230 V (uninterruptible) and 230 V (mains), and DC voltages: 60 V and 24 V.

The basic operating state of the system is the state in which the RTC equipment is supplied from the 230 V AC uninterruptible source (output of the inverter module). In the event of a mains voltage failure, the inverter switches uninterruptedly to power supply from a 60 V DC battery, the charging and backup of which is done through the rectifier module. In addition, the inverter module is equipped with a Static Switch circuit, which improves the reliability of the system and switches the power supply of the loads to the mains in the event of an abnormal operation of the inverter or the occurrence of a strong interference of the inverter voltage. The Multi-Voltage Power Supply System has a repair bypass system to facilitate inspection and maintenance of the equipment that is part of the power supply system, as well as to repair individual modules and/or parts of the system.

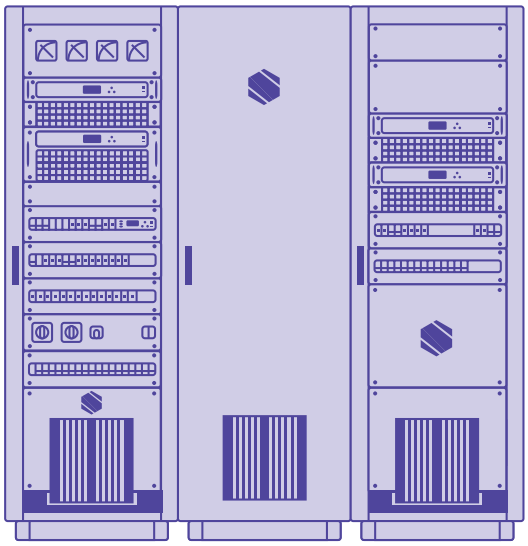
Over the past few years, 51 complete systems have been manufactured, including 115 cabinets. In different system configurations (depending on the facility), the equipment included:

- inverters in modular enclosures;
- rectifiers in modular enclosures;
- DC/DC converters in modular enclosures;
- an internal battery;
- an ATS system;
- an automatic bypass system;
- a repair bypass system.

Components of the Multi-Voltage Power Supply System:

- an inverter module with a static switch circuit (230 V AC uninterruptible power supply section);
- rectifier modules (60 V DC section);
- DC/DC converter modules (24 V DC section);
- 230 V AC section;
- a repair bypass system;
- system characteristics measuring devices;
- 60 V DC battery;
- an automatic surveillance system.

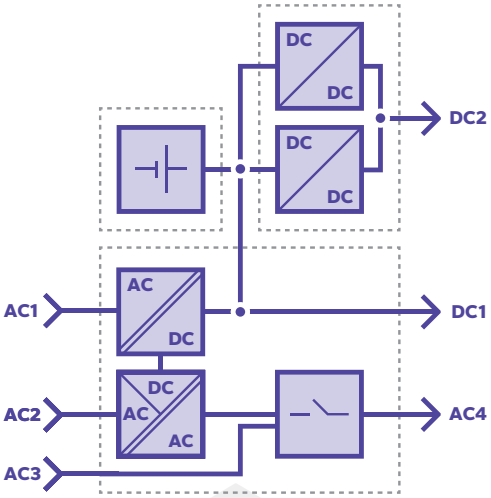
7.2.2. UNINTERRUPTIBLE POWER SUPPLY CABINET SNG



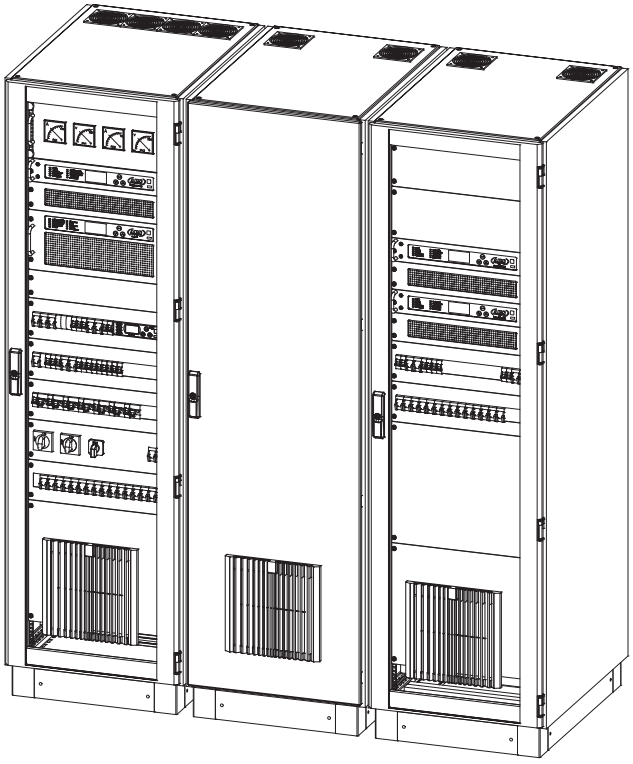
Uninterruptible Power Supply Cabinet SNG

The **Uninterruptible Power Supply Cabinet SNG** is an essential component of the power supply infrastructure of the automation, protection, and control systems in stationary arrangements, providing uninterruptible DC and AC power supply in the event of the mains power supply failure.

The system is based on an AC/DC converter (rectifier), a DC/AC converter (inverter), a DC/DC converter, as well as a battery bank and an automatic bypass system to ensure high reliability of the whole system. The system allows for the distribution of uninterruptible power supply to selected loads.



Block diagram of the Uninterruptible Power Supply Cabinet SNG



General view of the Uninterruptible Power Supply Cabinet SNG

Similar uninterruptible power supply cabinets are also successfully used in traction solutions, especially where continuity of operation of control, protection, and communication systems is required and efficiency of power transmission is of critical importance. Examples of its applications include:

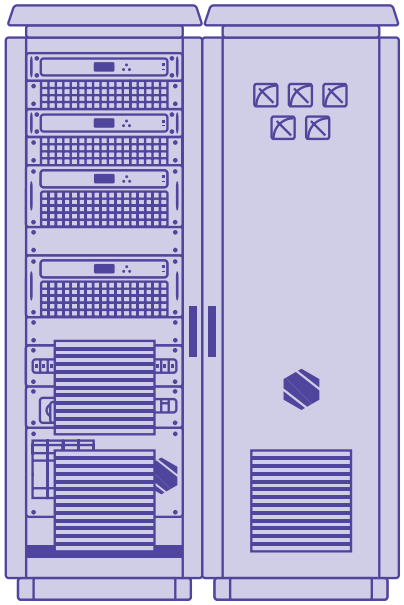
- traction substations - as emergency power supply for automation systems, catenary protection devices, and communications and telemechanical equipment;
- railroad traffic control points and signal towers - to sustain the operation of railroad traffic control systems, switches, semaphores, and signaling systems;
- station and stop infrastructure - e.g., emergency lighting, passenger information systems, and video surveillance (CCTV) systems;
- power supply systems in rail vehicles - as a local source of uninterruptible power supply for critical vehicle systems, such as braking, control, and onboard communication systems.

The use of systems based on 220 V DC and/or 230 V AC uninterruptible power supply in these areas significantly improves the reliability of the traction infrastructure operation, especially in the event of a primary power failure or anomalies in the grid.

UNINTERRUPTIBLE POWER SUPPLY CABINET SNG - STANDARD CHARACTERISTICS	
CHARACTERISTIC	VALUE
ELECTRICAL CHARACTERISTICS	
RECTIFIER SECTION	
Rated AC1 supply voltage*	3×400 V 50 Hz
Rated DC1 output voltage*	220 V
Rated DC1 output current (In_{DC1})*	25 A
Output voltage stability**	±0.6 %
Output voltage ripple***	±0.6 %
Range of thermal correction of buffer charging voltage	-10 to +50 °C
Temperature compensation of buffer charging voltage**	0 to 10 mV/°C/cell
Overload capacity	1.1×In_{DC1} for 3 s
Output current stability****	±1%
Output current ripple****	±1%
Battery charging characteristics	IU acc. to DIN 41773
INVERTER SECTION	
Rated AC2 primary supply voltage*	3×400 V 50Hz
Rated AC3 back-up supply voltage*	230 V 50 Hz
Rated DC supply voltage*	220 V
Permissible range of DC voltage changes*	176 to 270 V
Rated AC4 output voltage*	230 V
Output power*	2 kVA
Rated AC4 output current (In_{AC4})*	8.7 A
Overload capacity*	<1.1×In_{AC4} long-term
	1.1×In_{AC4} to 1.25×In_{AC4} for 10 min
	1.25×In_{AC4} to 1.5×In_{AC4} for 60 s
Range of cos φ characterizing the load	0.7 to 1.0
Harmonic content (linear load)	<2 %
Overcurrent protection*	5×In_{AC4} for 100 ms
Voltage shape	sinusoidal
DC/DC CONVERTER SECTION	
Rated DC supply voltage*	220 V
Rated DC output voltage*	24 V
Rated DC2 output current (In_{DC2})*	100 A
Output voltage stability	±0.6 %
Output voltage ripple***	±0.6 %
Overload capacity	1.5×In_{DC2} for 2 s
Output current stability	±1%
Output current ripple	±1%
MECHANICAL CHARACTERISTICS	
Enclosure protection rating*	IP20
Dimensions (W × D × H)*	R19": 3×600 × 800 × 2000 mm (+100 mm base)
Operating temperature*	0 to +50 °C
Cooling type	forced, air

* - a product with other characteristics can be manufactured; ** - buffer operation, voltage controller; *** - with resistive load;
**** - battery charging, current controller.

7.2.3. POWER SUPPLY SYSTEM WITH A SWITCHGEAR SZZR

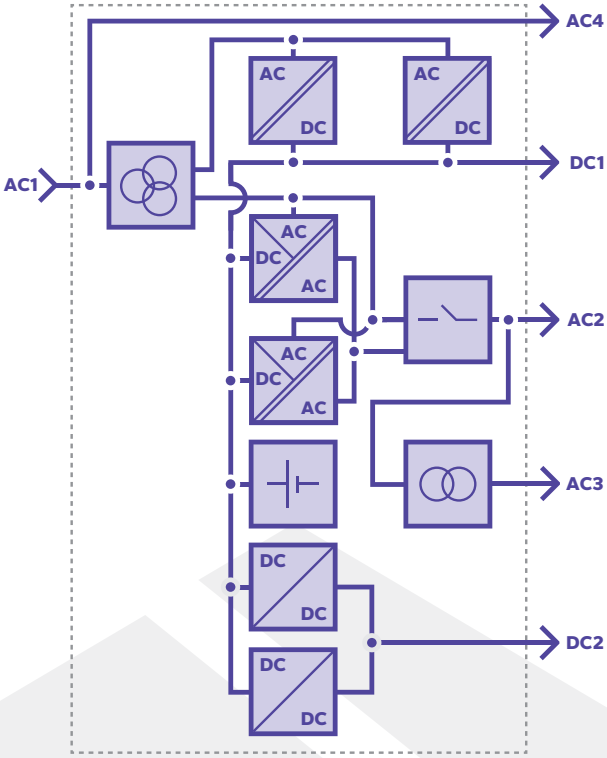


Power Supply System with a Switchgear SZZR

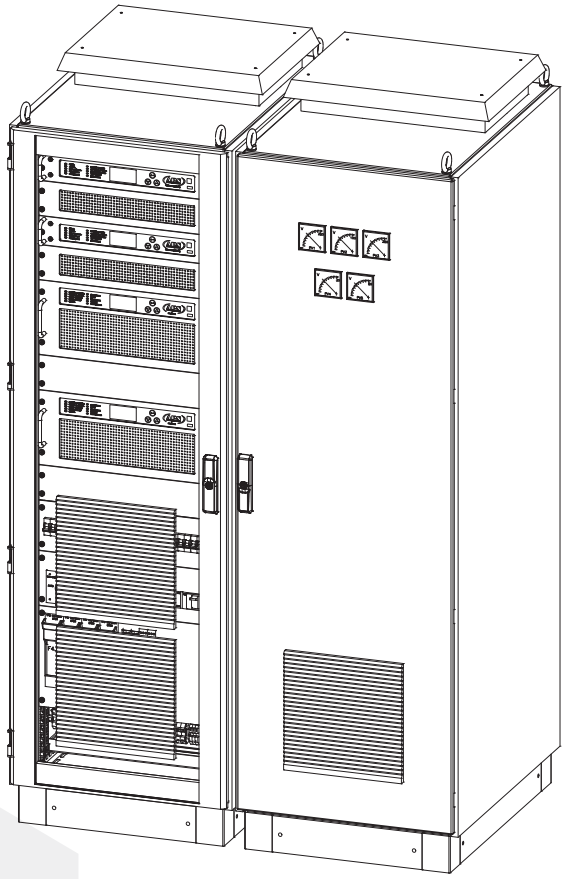
APS Energia SA is one of the leading European manufacturers of advanced uninterruptible power supply systems, whose products play a key role in transport infrastructure. The company has successfully delivered 80 dedicated UPS systems for the subway stations in Kyiv (Ukraine), which ensure the continuous operation of equipment of strategic importance to the safety and reliability of underground transport.

The designed systems have been specifically tailored to supply power to:

- communication systems (dispatching, technical services);
- radio surveillance and data transmission systems;
- advanced video surveillance (CCTV) systems;
- public address and warning systems (PAS, evacuation systems);
- telemechanical and station automation components.



Block diagram of the Power Supply System with a Switchgear SZZR



General view of the Power Supply System with a Switchgear SZZR

The UPS systems supplied are reliable sources of uninterruptible and non-uninterruptible power supply, both AC and DC, including:

- 220 V AC (uninterruptible) - the basic voltage for general and industrial loads;
- 80 V AC and 220 V AC - voltages used for specific communication and signaling solutions used by this particular client;
- 48 V DC and 24 V DC - voltages used to supply logic devices, relays, and data transmission systems.

POWER SUPPLY SYSTEM WITH A SWITCHGEAR - STANDARD CHARACTERISTICS	
CHARACTERISTIC	VALUE
ELECTRICAL CHARACTERISTICS	
RECTIFIER SECTION	
Rated AC supply voltage*	3×400 V 50 Hz
Rated DC1 output voltage*	48 V
Rated output current $2\times In_{DC1}$*	2×150 A
Output voltage stability**	±0.6 %
Output voltage ripple***	±0.6 %
Range of thermal correction of buffer charging voltage	-10 to +50 °C
Temperature compensation of buffer charging voltage**	0 to 10 mV/°C/cell
Overload capacity	$1.1\times In_{DC1}$ for 3 s
Output current stability****	±1%
Output current ripple****	±1%
Battery charging characteristics	IU acc. to DIN 41773
INVERTER SECTION	
Rated AC primary supply voltage*	3×220 V 50 Hz
Rated AC back-up supply voltage*	220 V 50 Hz
Rated DC supply voltage*	48 V
Permissible range of DC voltage changes*	41 to 58 V
Rated AC2 output voltage*	220 V 50 Hz
Output power*	8 kVA
Rated output current In_{AC2}*	36.4 A
Overload capacity*	$<1.1\times In_{AC2}$ long-term
	$1.1\times In_{AC2}$ to $1.25\times In_{AC2}$ for 10 min
	$1.25\times In_{AC2}$ to $1.5\times In_{AC2}$ for 1 min
Range of cos φ characterizing the load	0.7 to 1.0
Harmonic content (linear load)	<2 %
Overcurrent protection*	$9\times In_{AC2}$ for 100 ms
	$5\times In_{AC2}$ for 5 s
Voltage shape	sinusoidal
Additional output voltages*	AC3: 80 V 50 Hz
	AC4: 220 V 50 Hz
DC/DC CONVERTER SECTION	
Rated DC supply voltage*	48 V
Rated DC2 output voltage*	24 V
Rated DC2 output current*	2×8.4 A
TECHNICAL CHARACTERISTICS	
Enclosure protection rating*	IP20
Dimensions (W × D × H)*	R19": 2×600 × 800 × 1,800 mm (+100 mm base, +100 mm roof)
Operating temperature*	+5 to +40 °C
Cooling type	forced, air

* - a product with other characteristics can be manufactured; ** - buffer operation, voltage controller; *** - with resistive load;

**** - battery charging, current controller.

These systems operate in the buffer mode, integrated with high-end battery banks, which allows them to immediately take over the power supply in the event of a grid power outage, without any interruption in the operation of critical infrastructure.

Through the implementation of this project, APS Energia SA has confirmed its position as a trusted partner for the rail and transport sector in Central and Eastern Europe, providing solutions that ensure uninterrupted operation of the most important infrastructure systems, even in emergency situations.

8. SERVICE AND TECHNICAL SUPPORT

MAINTENANCE AND PERIODIC INSPECTIONS

Regular maintenance helps maintain the safety and efficiency of equipment, and reduces operating costs by lowering the risk of failure and extending the service life of the equipment.

SERVICE CONTRACTS AND PARTNERSHIP AGREEMENTS

Regular maintenance extends the life cycle of equipment, minimizes the number of defects, and allows equipment to be kept in optimal technical condition, which leads to better performance. We offer long-term and short-term contracts and adapt to the needs of our clients.

30 YEARS OF EXPERIENCE

OVER 20 THOUSAND COMMISSIONING, INSPECTION, SERVICING, AND MAINTENANCE OPERATIONS

TRAINING IN OPERATION AND USE OF EQUIPMENT

A TEAM OF QUALIFIED SPECIALISTS

MAINTENANCE SERVICE IN POLAND AND ABROAD

BATTERY TESTING, MAINTENANCE, AND CONTROL BATTERY DISCHARGE

The battery bank is the last back-up power source in the event of a failure. Regularly checking the condition of the battery ensures security in the event of a power outage in a critical situation.

TRAINING AND TECHNICAL ADVICE

APS Energia SA's experts have many years of experience in servicing uninterruptible power supply equipment. Training with our experts provides essential knowledge of operation and use of the equipment. We also provide specialized technical training.

COMMISSIONING AND ASSISTANCE

The stability and safety of an entire system's operation and performance depend on the correct connection of the device.

You can count on our specialists. We will come to your site and show you how to do it professionally.

CURRENT AND EMERGENCY REPAIRS, TROUBLESHOOTING, UPGRADES

As an equipment manufacturer, we have the knowledge, experience, measuring devices, and spare parts.

SPARE PARTS

Thanks to a broad selection of spare parts, our specialists repair equipment in the shortest time possible.

9. CERTIFICATES AND QUALITY MANAGEMENT

APS Energia SA treats the quality management system not as a formal obligation, but as a strategic tool to build trust in sectors with the most stringent requirements. The main objectives of the company's quality management system are:

- striving for continuous compliance of the developed technical solutions with the provisions of EU and national laws and clients' requirements;
- supervision of design compliant with IRIS requirements with particular focus on RAMS requirements;
- full traceability of components and materials;
- supervision of the supply chain;
- supervision and approval of special processes;
- full control over the change process.

CERTIFIED
ISO 9001
ISO 14001
ISO 45001
BUREAU VERITAS

IMQ CERTIFIED
INFORMATION SECURITY MANAGEMENT SYSTEM
ISO/IEC 27001:2022

IRIS Certification

CE

Each device manufactured by APS Energia SA undergoes a routine control process in accordance with relevant standards and testing that includes long-term soaking under various load conditions.

As part of type testing, we conduct mechanical strength tests, environmental tests, and electromagnetic compatibility (EMC) tests in laboratories accredited by the Polish Accreditation Center (PCA):

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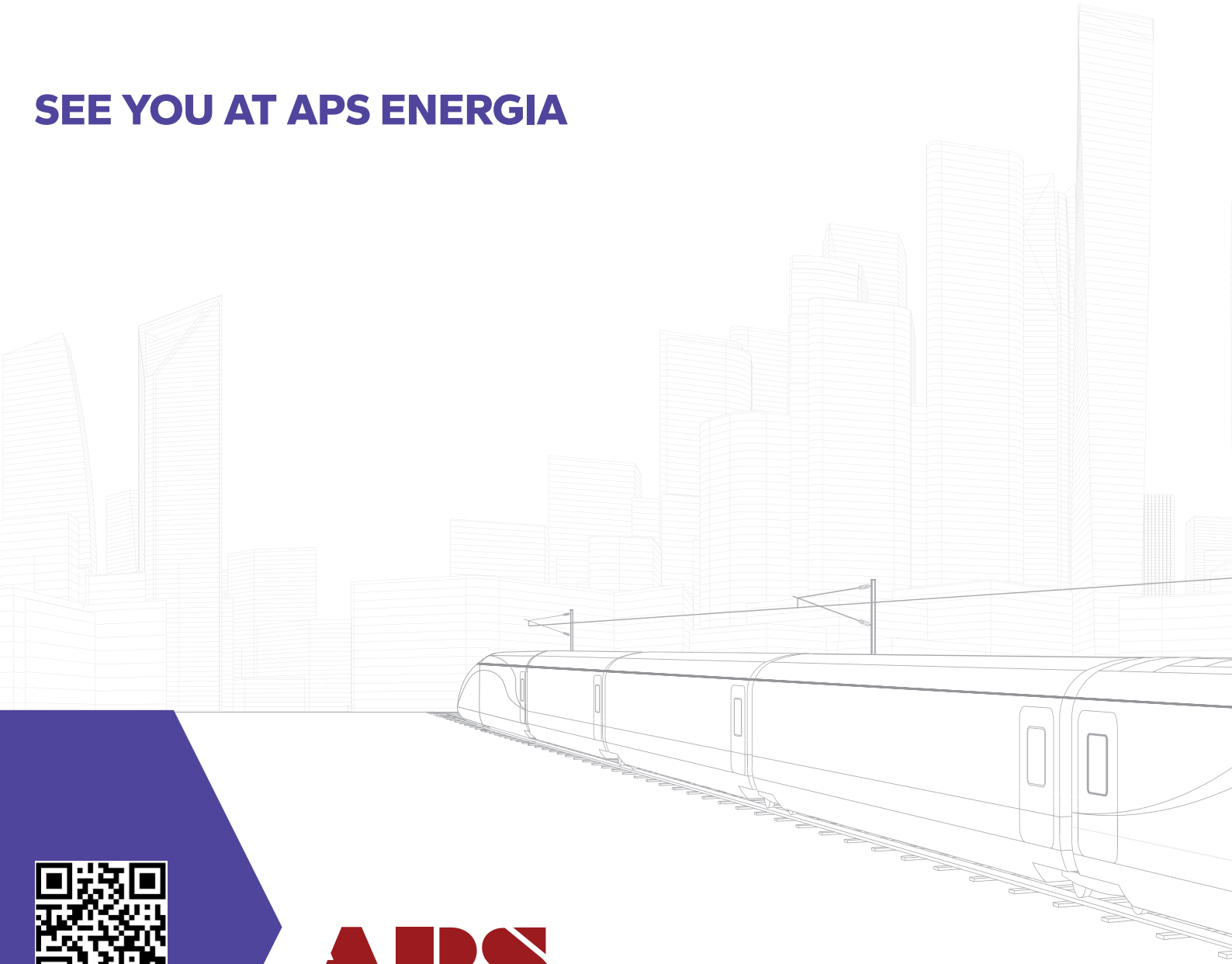
NORMATIVE REFERENCES	
2014/30/EU	Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility
2014/35/EU	Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits
CLC/TS 50701:2023	Railroad applications - Cybersecurity
IEEE 802.3-2022	Standard for Ethernet
ISO 21106:2019	Railway applications - Recyclability and recoverability calculation method for rolling stock
PN-EN 10204:2006	Metallic products - Types of inspection documents
PN-EN 17023:2019-02	Railway applications - Railway vehicle maintenance - Creation and modification of maintenance plan
PN-EN 45545-1:2013-07	Railway applications - Fire protection on railway vehicles - Part 1: General
PN-EN 45545-2+A1:2024-04	Railway applications - Fire protection on railway vehicles - Part 2: Requirements for fire behaviour of materials and components
PN-EN 45545-5+A1:2016-01	Railway applications - Fire protection on railway vehicles - Part 5: Fire safety requirements for electrical equipment including that of trolley buses, track guided buses and magnetic levitation vehicles
PN-EN 50121-1:2017-06	Railway applications - Electromagnetic compatibility - Part 1: General
PN-EN 50121-3-1:2017-05	Railway applications - Electromagnetic compatibility - Part 3-1: Rolling stock - Train and complete vehicle
PN-EN 50121-3-2:2017	Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock - Apparatus
PN-EN 50121-4:2017-04	Railway applications - Electromagnetic compatibility - Part 4: Emission and immunity of the signalling and telecommunications apparatus
PN-EN 50124-1:2017-09	Railway applications - Insulation coordination - Part 1: Basic requirements - Clearances and creepage distances for all electrical and electronic equipment

NORMATIVE REFERENCES - CONT.	
PN-EN 50124-2:2017-09	Railway applications - Insulation coordination - Part 2: Overvoltages and related protection
PN-EN 50125-1:2014-06	Railway applications. Environmental conditions for equipment - Part 1: Rolling stock and on-board equipment
PN-EN 50125-3:2003	Railway applications. Environmental conditions for equipment - Part 3: Equipment for signalling and tele-communications
PN-EN 50126-1:2018-02	Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part 1: Generic RAMS Process
PN-EN 50126-2:2018	Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part 2: Systems Approach to Safety
PN-EN 50129:2019-01	Railway applications - Communication, signalling and processing systems - Safety related electronic systems for signalling
PN-EN 50153:2014-11	Railway applications - Rolling stock - Protective provisions relating to electrical hazards
PN-EN 50155:2022-05	Railway applications. Rolling stock. Electronic equipment
PN-EN 50160:2023-10	Voltage characteristics of electricity supplied by public electricity networks
PN-EN 50163:2006	Railway applications - Supply voltages of traction systems
PN-EN 50178:2003	Electronic equipment for use in power installations
PN-EN 50325-1:2020-10	Industrial communications subsystem based on ISO 11898 (CAN) for controller-device interfaces - Part 1: General requirements
PN-EN 50325-4:2004	Industrial communications subsystem based on ISO 11898 (CAN) for controller-device interfaces - Part 4: CANopen
PN-EN 50716:2024-05	Railway Applications. Requirements for software development
PN-EN 60077-2:2018-01	Railway applications. Electric equipment for rolling stock - Part 2: Electrotechnical components. General rules
PN-EN 60310:2016	Railway applications - Traction transformers and inductors on board rolling stock
PN-EN 60529:2003	Degrees of protection provided by enclosures (IP Code)
PN-EN 60721-3-5:2010	Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities. Section 5: Ground vehicle installations
PN-EN 61000-2-2:2003	Electromagnetic compatibility (EMC) - Part 2-2: Environment - Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems (orig.)
PN-EN 61204:2001/A1:2002	Low-voltage power supply devices, d.c. output - Performance characteristics
PN-EN 61287-1:2014-12	Railway applications - Power converters installed on board rolling stock - Part 1: Characteristics and test
PN-EN 61373:2011	Railway applications. Rolling stock equipment. Shock and vibration tests
PN-EN IEC 60146-1-1:2024-12	Semiconductor converters. General requirements and line commutated converters - Part 1-1: Specification of basic requirements
PN-EN 50343:2025-07	Railway applications. Rolling stock. Rules for installation of cabling
PN-EN IEC 61000-2-4:2025-04	Electromagnetic compatibility (EMC) - Part 2-4: Environment. Compatibility levels in power distribution systems in industrial locations for low-frequency conducted disturbances
PN-EN IEC 61000-6-2:2019-04	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards. Immunity standard for industrial environments
PN-EN IEC 61000-6-4:2019-12	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards. Emission standard for industrial environments
PN-EN IEC 61204-3:2019-02	Low-voltage switch mode power supplies - Part 3: Electromagnetic compatibility (EMC)
PN-EN IEC 62040-1:2019-11	Uninterruptible power systems (UPS) - Part 1: Safety requirements
PN-EN IEC 62040-2:2019-02	Uninterruptible power systems (UPS) - Part 2: Electromagnetic compatibility (EMC) requirements
PN-EN IEC 62368-1:2024-06	Audio/video, information and communication technology equipment - Part 1: Safety requirements
PN-EN IEC 62847:2024-01	Railway applications. Rolling stock. Electrical connectors. Requirements and test methods
PN-EN IEC/IEEE 82079-1:2020-09	Preparation of information for use (instructions for use) of products - Part 1: Principles and general requirements
PN-EN ISO/IEC 17050-1:2010	Conformity assessment - Supplier's declaration of conformity - Part 1: General requirements
PN-K-23011:1998	Rolling stock - Electric power supply system for coach/wagon equipment - General requirements
UIC 550	Power supply installations for passenger stock
UIC 550-2	Power supply installations for passenger stock - Type testing
UIC 550-3	Power supply installations for passenger stock - Effect on electrical installations outside passenger coaches
UIC 552	Electrical power supply for trains. Standard technical characteristics of the train line

10. YOUR PLACE IN THE CATALOG

SEE YOU AT APS ENERGIA



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