Power Electronic Solutions for Public Transport

TRAMS, TROLLEYBUSES, METRO, eBUSES

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TRAMS, TROLLEYBUSES, METRO, eBUSES

MEDCOM is a manufacturer of modern tra-ction inverters for asynchronous drives and auxiliary converters installed in vehicles powered by 600 VDC/750 VDC catenary system.

Drive inverters are based on the IGBT technology. Owing to the application of modern control systems, they ensure antislip control of the drive torque of the respective vehicle axles, effective electrodynamic braking within the whole speed range of the vehicle and a possibility of emergency braking in case of blackout in the traction network.

Currently produced inverters with output po-wer range from 100 kW to 350 kW ensure very good driving parameters of the vehicle. Their main advantages are a low level of noise emission and a high driving comfort.

Static converters with output power ranging from 5 to 132 kW ensure power supply for subassemblies of the drive system and all other loads (control, lighting, compressors, fans of the devices) of the vehicle. Apart from that, the static converters may also supply heating, ventilation and air conditioning systems.

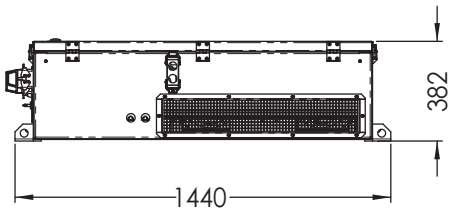
All inverters and converters are equipped with a diagnostic-control system based on a MVB, CAN 2.0 B or RS232 interface.

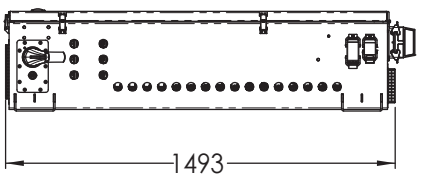
FT-80-600D integrated with PSM-42 for eBuses

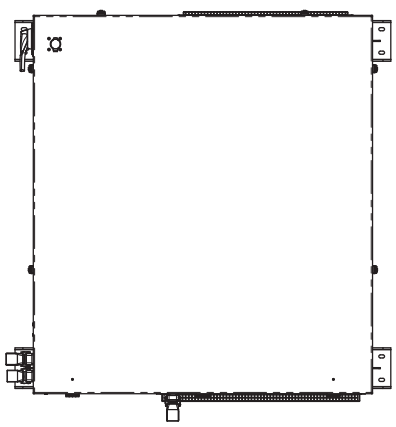
Traction Inverter integrated with Auxiliary Converter

Traction inverter is intended to supply MT motors which drive the bus wheels. The inverter container with the RWN switchgear and PSM static converter is intended for installation on the vehicle roof. The traction inverter is intended for power supply from a traction battery.
The power train of the system enables accelerating, driving with a set torque, coasting and recuperative braking. It also enables accelerating, driving and braking when travelling in a reverse direction.
The traction inverter enables conversion of the input voltage to regulated output variable voltage within a range of 0 to the rated traction motor voltage, while maintaining a constant relationship between the output voltage and voltage frequency (U/F).
The traction drive used in the electric bus is composed of the traction inverter, MT traction motor and RH braking resistor. The high voltage circuit is additionally composed of the PSM static converter. Traction inverter and static converter are cooled by forced air circulation. The braking resistor is cooled by natural air circulation. The use of air cooling enables reliable operation in a wide range of external temperatures. The supply of the fan in the drive box is provided by a 3x400 V, 50 Hz inverter in the static converter.
The power supply when driving is provided by a set of batteries grouped in battery packs. The Battery Management System (BMS) manages the operation of the packs, controlling the charge level of the cells and sending information to the drive control system on the current which may be drawn from the battery at a given moment.
The inverter is manufactured in the HV IGBT technology. The inverter control is provided by DSP (Digital Signal Processing), using FOC SVPWM (Field Oriented Control Space Vector Pulse Width Modulation). The control system ensures constant torque acceleration and low power losses.
The inverter meets the UIC and EN standards on safety and electromagnetic compatibility. The system has very low levels of low frequency interference generated in the traction wire network.
Inverter diagnostics and control is provided using the CAN-Bus interface. The system is adopted to operate with a recorder of traction parameters and inverter parameters, which enables the reconstruction of power supply conditions in case of interference in the operation or in case of failure of the drive system.

Housing







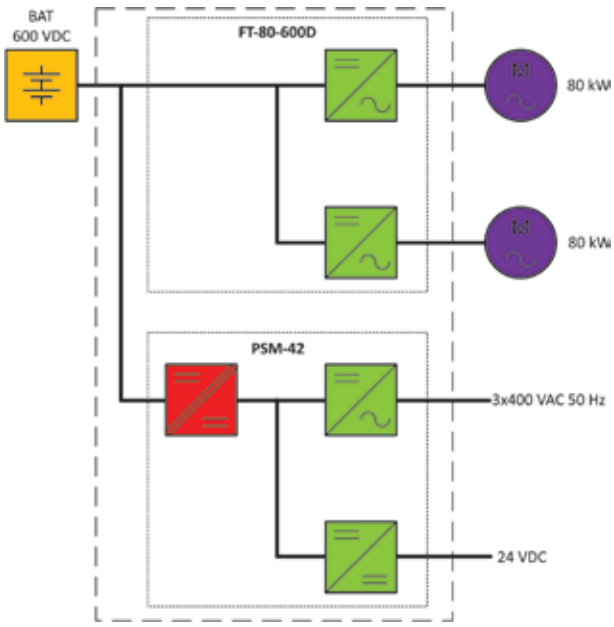
FT-120-600D integrated with PSM-42 for eBuses

Traction Inverter integrated with Auxiliary Converter

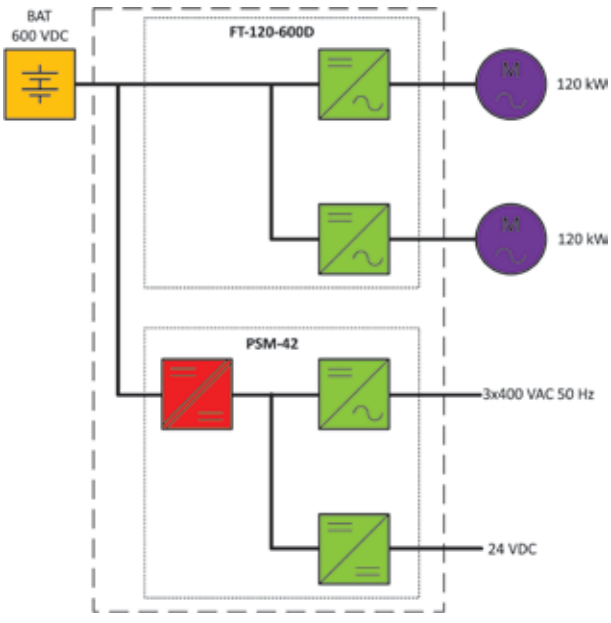
FT-80-600D		
Input voltage	**600 VDC**	
Rated power	**2×80 kW**	
Rated current	**185 Arms**	
Auxiliary voltage	**24 V DC +25% –30%**	
PSM-42		
Input voltage	**600 VDC**	
Output power	**42 kW**	
DC Output	**24 V DC / 12 kW**	
AC Output	**3×400 V 50 Hz / 30 kVA**	
Auxiliary voltage	**24 V DC +25% –30%**	
Housing		
Cooling method	**Forced-air**	
Weight	**310 kg ±10%**	
Dimensions	**1440×1450×382 mm**	
Protection ratio	**Clean section**	**IP55**
	Dirty section	**IP20**

FT-120-600D		
Input voltage	**600 VDC**	
Rated power	**2×120 kW**	
Rated current	**185 Arms**	
Auxiliary voltage	**24 V DC +25% –30%**	
PSM-42		
Input voltage	**600 VDC**	
Output power	**42 kW**	
DC Output	**24 V DC / 12 kW**	
AC Output	**3×400 V 50 Hz / 30 kVA**	
Auxiliary voltage	**24 V DC +25% –30%**	
Housing		
Cooling method	**Forced-air**	
Weight	**310 kg ±10%**	
Dimensions	**1440 x 1450 x 382 mm**	
Protection ratio	**Clean section**	**IP55**
	Dirty section	**IP20**

Block diagram



Block diagram



FT-160-600 SiC integrated with PSM-42 SiC for eBuses

Traction Inverter integrated with Auxiliary Converter

The FT-160-600 SiC traction inverter has been designed to drive eBus. The inverter is based on the IGBT full-SiC technology. It is controlled by means of the DSP (Digital Signal Processor) technology, applying the FOC SVPWM (Field Oriented Control Space Vector Pulse Width Modulation) algorithm. The controller guarantees optimum control of the asynchronous motor's performance, achieving very good traction parameters and a high level of driving comfort. The inverter has been equipped with a natural air-cooling system. The system meets all European standards and Regulation no. 100 with regard to safety and radio interferences. The system is installed on the roof. The system has been equipped with an integrated high voltage switchgear to connect traction battery, battery chargers and precharge system. The latest generation components and an extensive diagnostic system guarantee a high level of reliability and low operating costs. A static 30 kVA/3×400 Vac and 12 kW/24 Vdc converter are placed in the same case.

Electric vehicles are an important part of life all over the world. By incorporating the newest silicon carbide (SiC) technology in our traction converters, power losses can be reduced up to 30% of conventional devices along with significant noise reduction. Utilizing SiC enables reduction of size and weight even by 40%. The use of this technology is a true technical evolution in designing of innovative power electronics devices for public transport.

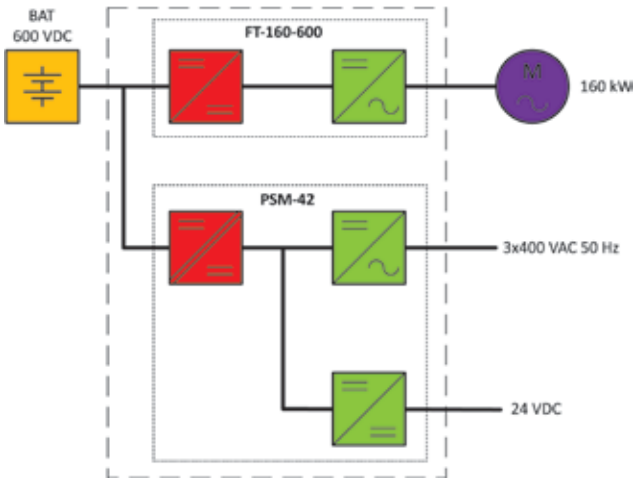
Specification of the FT-160-600 SiC inverter	
Input voltage	**520–750 VDC**
Auxiliary voltage	**24 VDC, +30 ÷ –40%**
Rated current	**300 Arms**
Maximum current	**500 Arms**
Rated power	**160 kW**
Frequency	**0–350 Hz**
PWM frequency	**2–6 kHz**
Insulation strength	**2,5 kV**
Cooling	**natural, air**
Dimensions	**1430×990×330 mm**

Specification of the PSM-42 SiC converter	
Input voltage	**520–750 VDC**
Auxiliary voltage	**24 VDC, +30 ÷ –40%**
AC output nominal power	**30 kVA**
AC output voltage	**3x400 VAC ±10% (sinus)**
AC output frequency	**50 Hz**
AC output current	**43 A**
Overcurrent	**1.5 In/30 s**
Electronic protection	**overcurrent/overvoltage/overheating**
DC output nominal power	**12 kW**
DC output voltage	**24 VDC**
DC output current	**500 A**
Insulation strength	**2,5 kV**
Cooling	**natural, air**
Weight of the set	**165 kg**

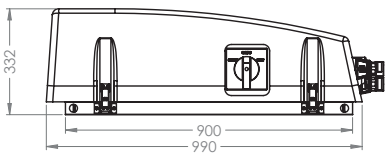
FT-160-600 SiC integrated with PSM-42 SiC for eBuses

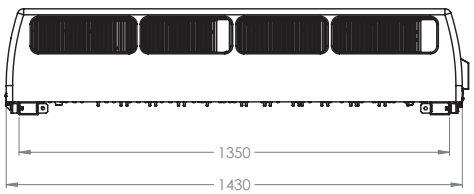
Traction Inverter integrated
with Auxiliary Converter

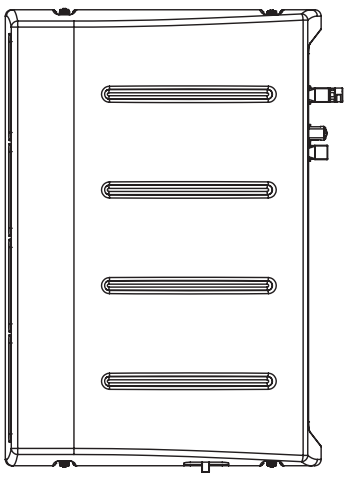
Block diagram



Housing

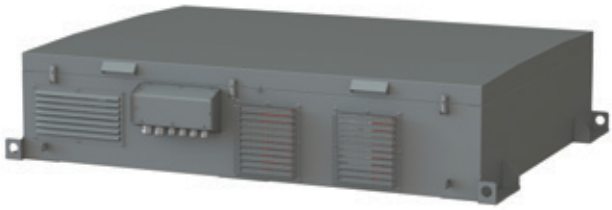






FT-50-600-Q-Combo integrated with PSM-50 SiC

Traction Inverter
for Asynchronous Drives



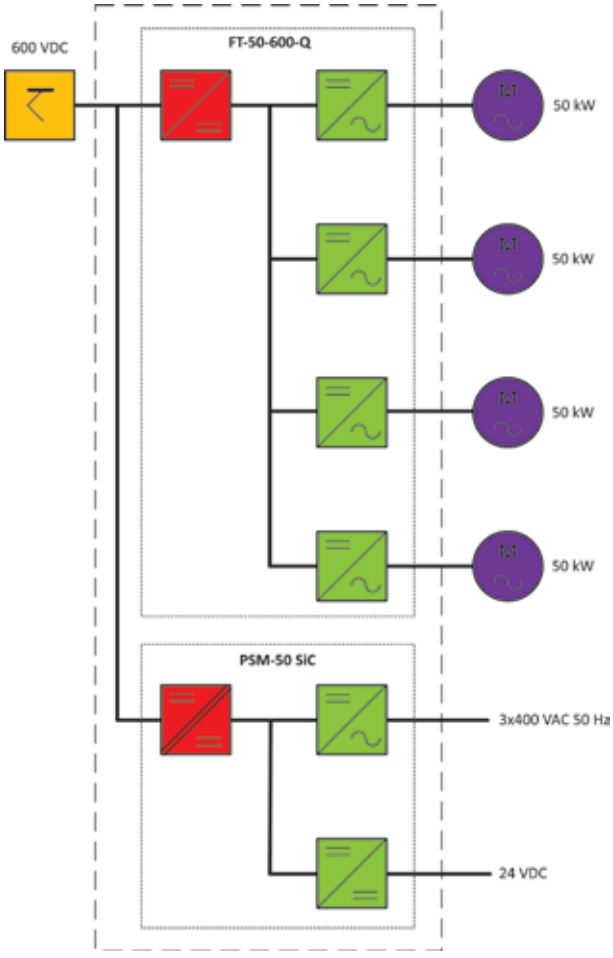
The power box and propulsion of the FT-50-600-Q-Combo tram consists of four FT-50-600 inverters and one PSM-50 SiC static inverter.
The FT-50-600 traction inverter is a device that transforms the input voltage from the pantograph
into a three-phase alternating voltage of variable amplitude and frequency while maintaining a constant U/f ratio.
Key benefits of the inverter include: a low distortion level of the AC output voltage, and very high efficiency and overload capability.
The inverter is equipped with its own system of forced cooling, which ensures correct operation in a wide range of outdoor temperatures. The speed control of the fan is provided as a function of the inverter temperature.

The capacitors used in the DC circuits are made using a "self-healing", segment technology that provides high reliability and durability.
One box contains four inverters; each inverter controls one motor (a one-to-one solution). Their control system is based on the DSP (Digital Signal Processor) and provides control and supervision over the operation of the inverters. The applied FOC SV PWM algorithm (Field Oriented Control Space Vector Pulse Width Modulation) ensures correct traction parameters of the drive.
The PWM (Pulse Width Modulation) technology with integrated LC filter and applied algorithms maintains a total harmonic distortion of less than 5% in the supply voltage of the asynchronous motors and other devices for alternating current. This increases the reliability of the device and limits voltage surges in the coil, as well as reduces damage to the wire insulation and lowers noise emissions.

Advanced control and diagnostic features provide trouble-free and efficient operation of the vehicle. The control system of the inverter ensures that the drive has a precisely controlled torque (on the shaft) and provides regenerative braking. The device is equipped with internal cooling by forced air fans (with increased durability) and is designed for installation on the tram roof. Communication with the tram control system is provided by the CAN 2.0B HMI.
The control algorithms of inverters are equipped with a software anti-slip system that ensures the immediate return of adhesion between wheel and rail (by reducing the torque on the shaft – if there is a slip).
DSP provides optimum control of the drive and protects the drive against damage of the whole chain of equipment: inverter-motor-brake resistor.
The modular design of the inverter allows easy access to every component, simplifying maintenance.
Each inverter control system is programmed to detect any lock and wheel slip.
The converter is made with SiC technology (silicon carbide) that provides improved performance parameters such as: switching speed, working temperature, current density, dielectric strength and lower activation resistance. This technology reduces the size and weight of the inverter, while increasing its efficiency.

The control system ensures high frequency stability, very good symmetry of the output voltage phases and a very low level of interference generated by the system.
Semiconductor components of the device are selected with some excess to ensure the correct level of system overload.
The device is completely maintenance-free – the control system controls the status of the output terminals and protects the inverter during prolonged overload or a short circuit.
The PSM-SiC 50 static converter is designed for transforming the overhead contact line voltage of 600 V to 24 VDC and 3×400 VAC (50 Hz) voltages and feeding the auxiliary circuits of the vehicle.

Block diagram

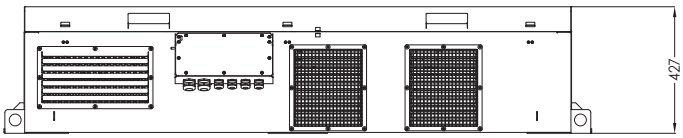


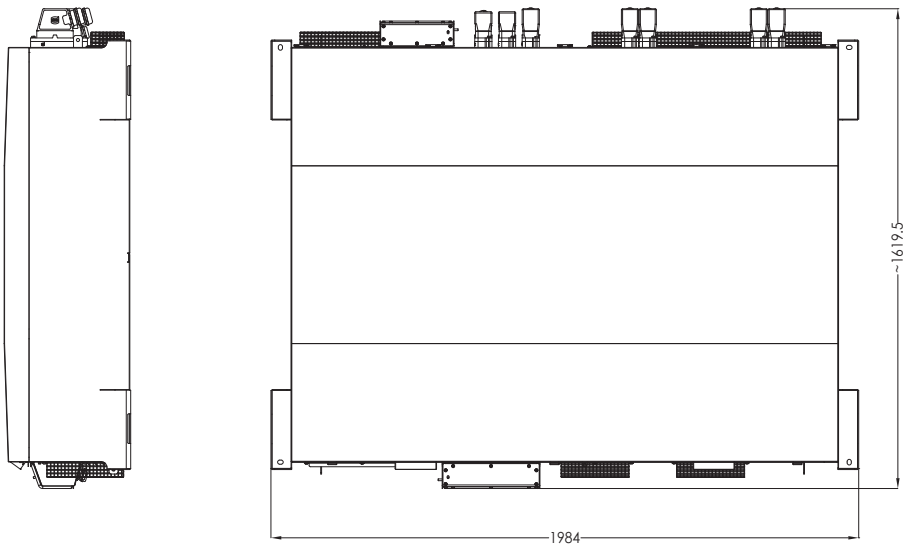
FT-50-600-Q-Combo integrated with PSM-50 SiC

Traction Inverter
for Asynchronous Drives

FT-50-600		
Input voltage	**600 VDC +25% ÷ –30%**	
Rated power	**50 kW**	
Rated current	**4×150 A**	
Auxiliary voltage	**24 VDC +25% ÷ –30%**	
PSM-50SiC		
Input voltage	**600 VDC +25% ÷ –30%**	
Output power	**50 kVA**	
DC Output	**24 V / 6 kW**	
AC Output	**3×400 V / 50 kVA, cosφ=0,9**	
Auxiliary voltage	**24 VDC +25% ÷ –30%**	
Housing		
Cooling method	**forced-air**	
Weight	**555 kg ±10%**	
Dimensions	**1984×1620×427 mm**	
Protection ratio	**Clean section**	**IP54**
	Dirty section	**IP20**

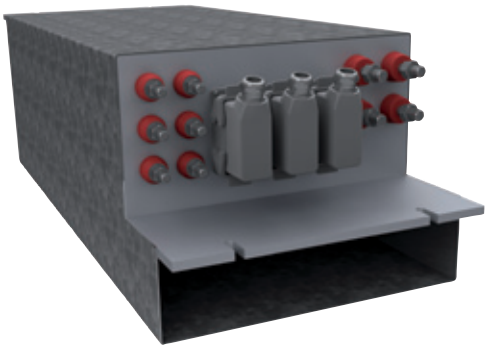
Housing





FT-100-600

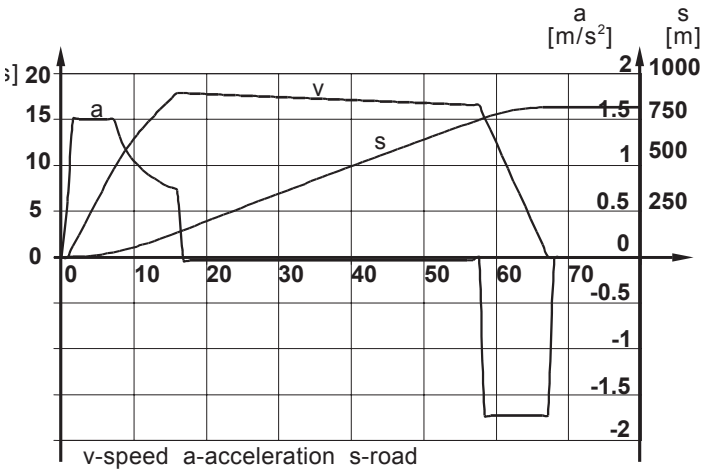
Traction Inverter
for Asynchronous Drives



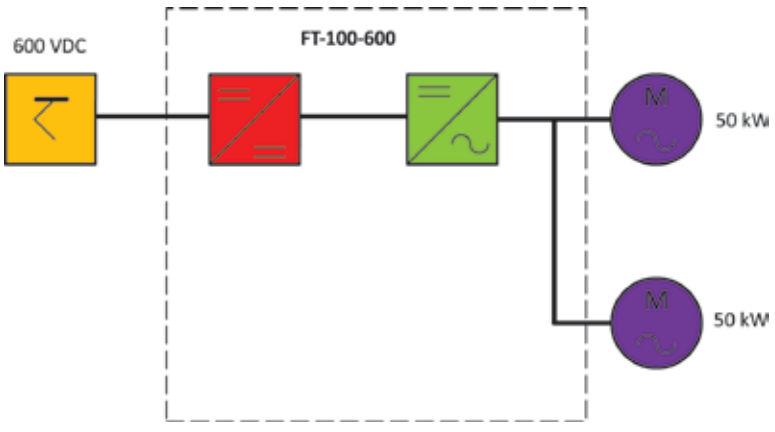
The FT-100-600 drive traction inverter is designed for driving the 105N trams, WrAs 205 trams or similar. A direct micropro-cessor-controlled (DSP) transistor converter (IGBT) has been applied in the system. The implemented control algorithm ensures optimum control of the motors speed (2 motors per an inverter) during the start and electrodynamic braking (with or without recuperation). The inverter is equipped with a MVB, CAN 2.0 B interface for con-trol and diagnostics; it is also possible to set the torque with an analogue input. The control system checks periodically the motor's insulation and temperature. The system is installed in the space previously occupied by the resistors (on-roof mounting version is also available). The converter and braking resistors are cooled with a forced (external) air stream from the fan of the traction motors.

Specification	
Input voltage	**600 VDC, +25 ÷ –30%**
Auxiliary voltage	**40 VDC, +10 ÷ –40%**
Rated current	**180 Arms**
Maximum current	**360 Arms**
Rated power	**100 kW**
Frequency	**0–130 Hz**
PWM frequency	**3 kHz**
Insulation strength	**4 kV**
Cooling	**forced-air**
Weight	**110 kg**
Dimensions	**1095×333×430 mm**

Traction characteristics of the 105N tram with a set of two FT-100-600 inverters



Schematic diagram of the FT-100-600 inverter

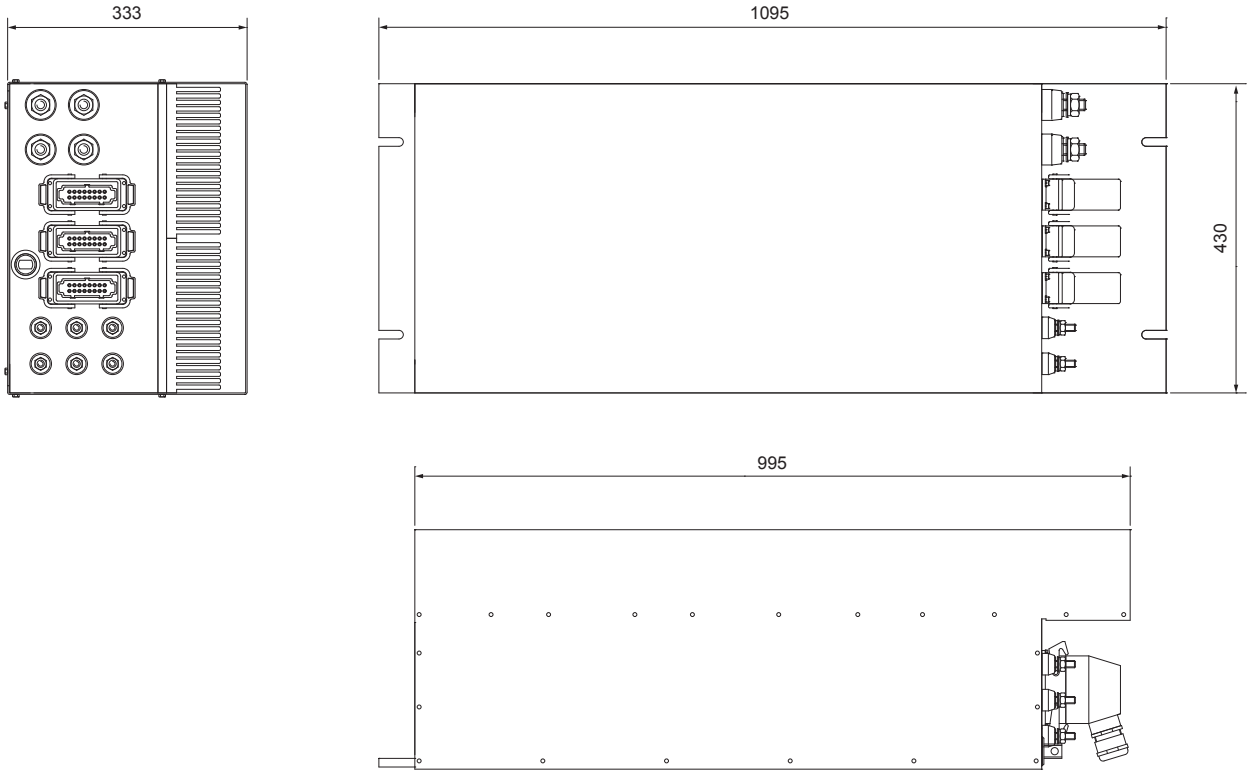


FT-100-600

Traction Inverter
for Asynchronous Drives

Specification of the tram (105N) with the set of two FT-100-600 inverters	
Supply voltage	**600 VDC, +25 ÷ –30%**
Rated power	**200 kW**
Peak power	**400 kW**
Number of motors per vehicle	**4 (4×50 kW)**
Maximum torque referred to the motor shaft	**450 Nm**
Acceleration at start to the speed of 35 km/h	**1.5 m/s²**
Tram car deceleration at braking	**1.7 m/s²**
Tram car deceleration at emergency braking	**2.7 m/s²**
Tram car maximum speed	**60 km/h (16.6 m/s)**

Housing



FT-105-600D

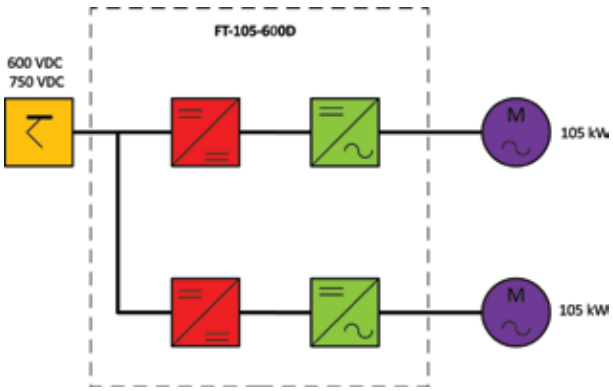
Traction Inverter
for Asynchronous Drives

The application of independent inverters for powering of single motors guarantees high traction parameters, perfect performance at the slip point and no influence of non-uniform wear of wheel's tyres on the drive's performance. The FT-105-600D drive inverter is a modern module inverter incorporating the IGBT technology.

The converter control operates in the DSP technology (Digital Signal Processor) with application of the Field Oriented Control Space Vector Pulse Width Modulation. The inverter system enables the drive to work with regulated torque, regenerative braking or rheostatic braking. The inverter has been equipped with a forced air-cooling system and can be built up on the vehicle's roof (two inverter modules in one container). It is controlled by a MVB, CAN 2.0 B connection. The inverter's controller has been equipped with a built-in anti-slip system. Additionally, the system is equipped with an emergency power supply system (from the vehicle's battery), which enables the vehicle to move out the intersectional isolator or crossing (in case of main power failure).

Specification of the FT-105-600D inverter	
Input rated voltage	**600 VDC (750 VDC), +30 ÷ –30%**
Auxiliary voltage	**24 VDC +30 ÷ –40%**
Rated current	**2×200 A**
Peak current	**2×400 A**
Rated power	**2×105 kW**
Frequency	**0–130 Hz**
PWM frequency	**3 kHz**
Insulation strength	**4 kV**
Cooling	**forced-air,**
Weight	**400 kg**
Dimensions	**450×1200×1320 mm**

Schematic diagram of the FT-105-600D inverter



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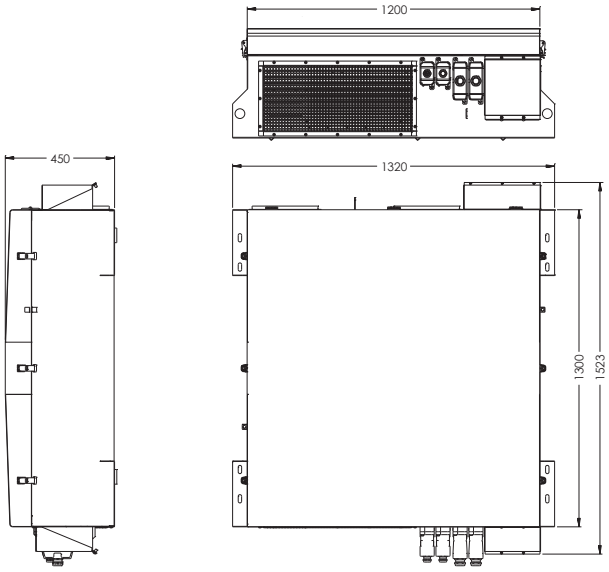


Parameters of the tram car with the FT-105-600D inverters	
Supply voltage	**600 VDC (750 VDC), +25 ÷ –30%**
Rated power	**4×105 kW**
Number of motors per vehicle	**4**
Acceleration of the tram car at the starting to the speed of 35 km/h	**1.5 m/s²**
Tram car deceleration at braking (electrical)	**1.7 m/s²**
Tram car deceleration at emergency braking	**3 m/s²**
Maximum tram car speed at constant power	**70 km/h (19.4 m/s)**

FT-120-750D integrated with PSM-60I

Traction Inverter integrated with Auxiliary Converter – Traction set for Trams

The application required inverters for powering motors on one bogie with the virtual axle algorithm for axleless vehicle. System guarantees high traction parameters and perfect dynamic performance. The FT-120-750D drive inverter is a modern module inverter incorporating the IGBT technology. The converter control operates in DSP technology with application of the Field Oriented Control Space Vector Width Modulation. The inverter system enables the drive to work with regulated torque, regenerative braking or rheostatic braking. The inverter has been equipped with a forced air-cooling system and can be built up on the vehicle's roof (two inverter modules in one container) It is controlled by a CAN 2.0B connection. The inverter's controller has been equipped with a built-in anti-slip system. Additionally, the system is equipped with a an emergency power supply system (from the vehicle's battery), which enables the vehicle to move out the intersectional isolator or crossing (in case of main power failure). Integrated with traction inverters FT-120-750D static converter PSM60I has been designed to convert DC voltage of the 750 VDC traction into 26 VDC voltage as well as into 3×400 VAC voltage, needed to supply the auxiliary circuitry in the tram system, driver's air conditioning and car ventilation. The very lightweight, extremely efficient converter based on IGBT technology.

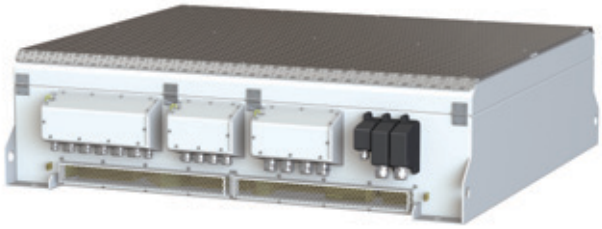
Specification of the FT-120-750D inverter	
Input voltage	**750 VDC, +25 ÷ –30%**
Auxiliary voltage	**24 VDC, +25 ÷ –30%**
Rated current	**2×300 A**
Maximum current	**2×600 A**
Rated power	**2×120 kW**
Frequency	**0–160 Hz**
PWM frequency	**1.5–2.5 kHz**
Insulation strength	**4 kV**
Cooling	**forced-air**
Dimensions	**470×1700×1700 mm** (integrated set)

Integrated PSM-60I static converter	
Output voltage DC	**26 VDC**
P = 10 kW; In = 390 A; Un = 28.1 V (20°C); Thermal voltage compensation: up to 5°C: 28.4 V, above 5°C: drop of 57 mV/°C; Temperature range up to +40°C; Reduction of battery charging current; Voltage stability ≤ 1%; Voltage ripples ≤ 0.5%; Electronic (overload, short circuit) protection	
Output voltage AC	**3×400 VAC (50 Hz)**
S = 50 kVA; Voltage stability ≤ ±5%; Frequency stability ≤ ±0.1%; THD(u) ≤ 5%; Electronic (overload, short circuit) protection	
Maximum power	**60 kW**
Total efficiency	**≥ 92%**
Protection: • against the change of power supply polarity • against overvoltages in the power supply network • against short-lasting (up to 10 s) blackouts • inverter interlock at the one-phase decay	
Monitoring	**CANopen**
Weight of the set	**550 kg ±10%**

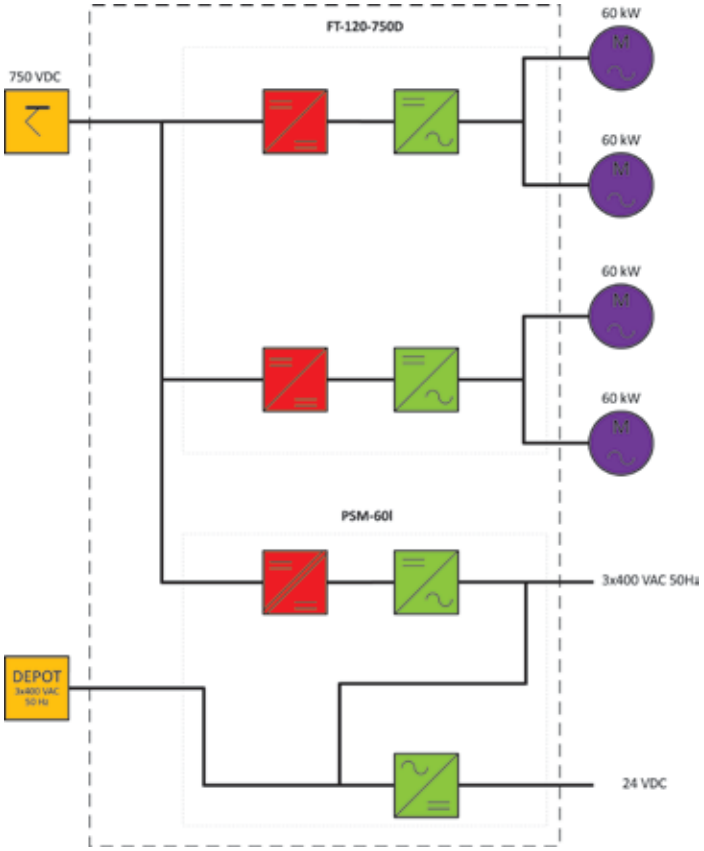
Parameters of the tram car with the FT-120-750D inverter	
Supply voltage	**750 VDC, +25 ÷ –30%**
Rated power	**2×4×60 kW**
Number of motors per vehicle	**8**
Acceleration of the tram car at the starting to the speed of 35 km/h	**1.5 m/s²**
Tram car deceleration at braking (electrical)	**1.7 m/s²**
Tram car deceleration at emergency braking	**3 m/s²**
Maximum tram car speed at constant power	**70 km/h (19.4 m/s)**

FT-120-750D
integrated with PSM-60I

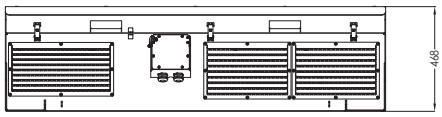
Traction Inverter integrated with Auxiliary Converter – Traction set for Trams

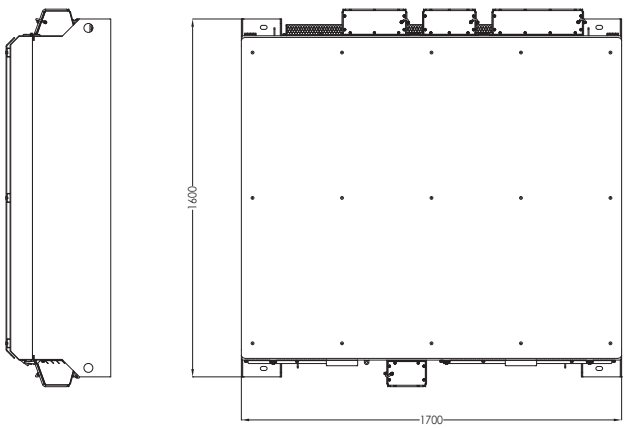


Block diagram



Housing





FT-130-600D-EO

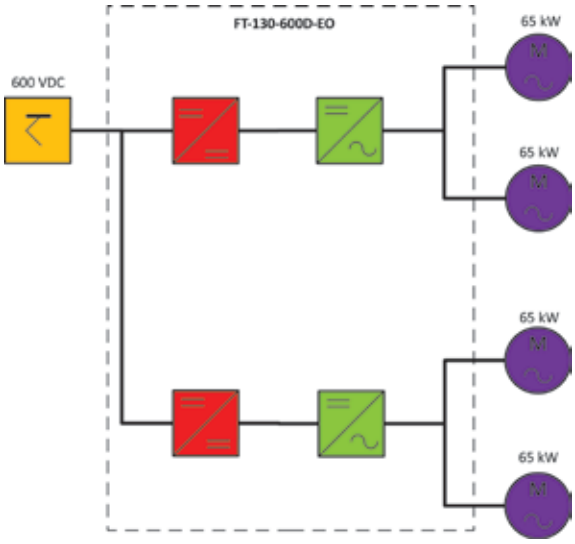
Traction Inverter
for Asynchronous Drives

The application required inverters for powering motors on one boogie with the virtual axle algorithm for axleless vehicle. System guarantees high traction parameters and perfect dynamic performance. The FT-130-600D-EO drive inverter is a modern module inverter incorporating the IGBT technology. The converter control operates in the DSP technology (Digital Signal Processor) with application of the Field Oriented Control Space Vector Pulse Width Modulation. The inverter system enables the drive to work with regulated torque, regenerative braking or rheostatic braking.

The inverter has been equipped with a forced air-cooling system and can be built up on the vehicle's roof (two inverter modules in one container). It is controlled by a CAN 2.0 B connection. The inverter's controller has been equipped with a built-in anti-slip system. Additionally, the system is equipped with an emergency power supply system (from the vehicle's battery), which enables the vehicle to move out the intersectional isolator or crossing (in case of main power failure).

Specification of the FT-130-600D-EO inverter	
Input rated voltage	**600 VDC, +30 ÷ –33%**
Auxiliary voltage	**24 VDC, +25 ÷ –30%**
Rated current	**300 A**
Peak current	**600 A**
Rated power	**2×130 kW**
Frequency	**0–160 Hz**
PWM frequency	**1000–2500 Hz**
Insulation strength	**4 kV, 50 Hz, 1 min**
Cooling	**forced-air**
Weight (with/without DCDC)	**352 kg/332 kg**
Dimensions	**450×1280×1300 mm**

Schematic diagram of the FT-130-600D-EO inverter

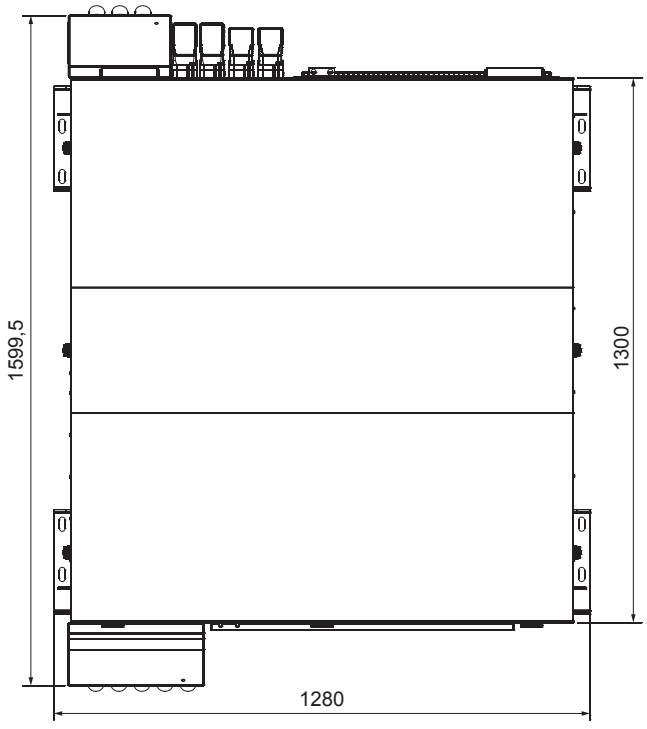


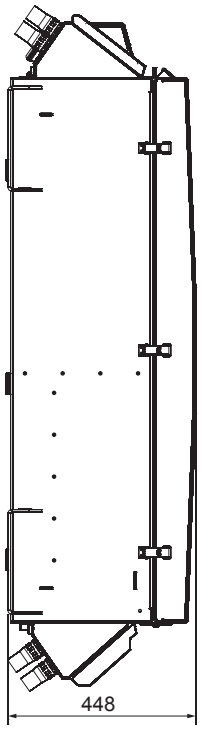
Parameters of the tram car with the FT-130-600D-EO inverter	
Supply voltage	**600 VDC (750 VDC), +25 ÷ –30%**
Rated power	**2×4×65 kW**
Number of motors per vehicle	**8**
Acceleration of the tram car at the starting to the speed of 35 km/h	**1.5 m/s²**
Tram car deceleration at braking (electrical)	**1.7 m/s²**
Tram car deceleration at emergency braking	**3 m/s²**
Maximum tram car speed at constant power	**70 km/h (19.4 m/s)**

FT-130-600D-EO

Traction Inverter
for Asynchronous Drives

Housing





FT-160-600

Traction Inverter
for Asynchronous Drives

The power set type FT-160-600 is dedicated to supply all equipment for powering electric bus. System contains two inver-ters for powering single or double asynchronous motors with algorithm virtual differential axle and auxiliary converter for supply DC and AC load.

The FT-160-600 drive inverter is a modern module inverter incorporating the IGBT technology. The converter control ope-rates in the DSP technology (Digital Signal Processor) with application of the Field Oriented Control Space Vector Pulse Width Modulation. The inverter system enables the drive to work with regulated torque, regenerative braking or rheostatic braking. The inverter has been equipped with a forced air-cooling system and can be built up on the vehicle's roof. It is controlled by a CAN 2.0 B connection. The inverter's controller has been equipped with a built-in anti-slip system.

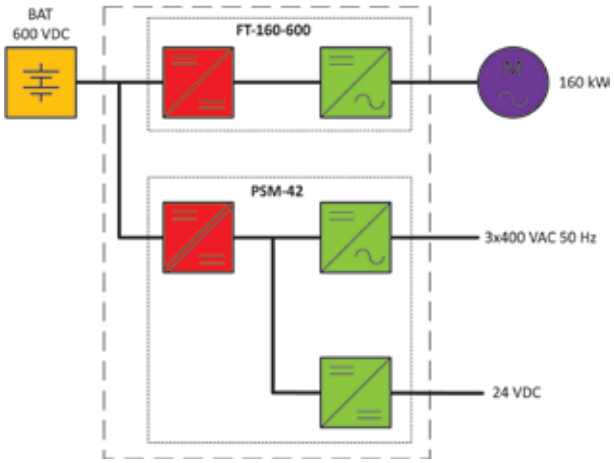
Parameters of the bus with the FT-160-600 inverter	
Supply voltage	**600 VDC (520–748 V)**
Rated power	**160 kW**
Number of motors per vehicle	**1 or 2**
Acceleration of the electric bus at the starting to the speed of 30 km/h	**1.5 m/s²**
Bus deceleration at braking (electrical)	**1.7 m/s²**
Bus deceleration at emergency braking	**3 m/s²**
Maximum bus speed at constant power	**70 km/h (19.4 m/s)**

Specification of the FT-160-600 inverter	
Input rated voltage	**686 VDC (520–748 V)**
Auxiliary voltage	**24 VDC, +25 ÷ –30%**
Rated current	**300 A**
Peak current	**500 A**
Rated power	**160 kW (2×80 kW)**
Frequency	**0–350 Hz**
PWM frequency	**2000–6000 Hz**
Insulation strength	**2.5 kV, 50 Hz, 1min**
Output voltage DC	**24 V**
P = 10 kW, In = 390 A, Un = 28 V, Thermal voltage compensation	
Output Voltage AC	**3×400 VAC, 50Hz**
S = 20 kVA, Voltage stability <5%, THD(U)<5%, Overload 200%	
Cooling	**forced-air**
Weight	**330 kg**
Dimensions	**400×1600×1340 mm**

FT-160-600

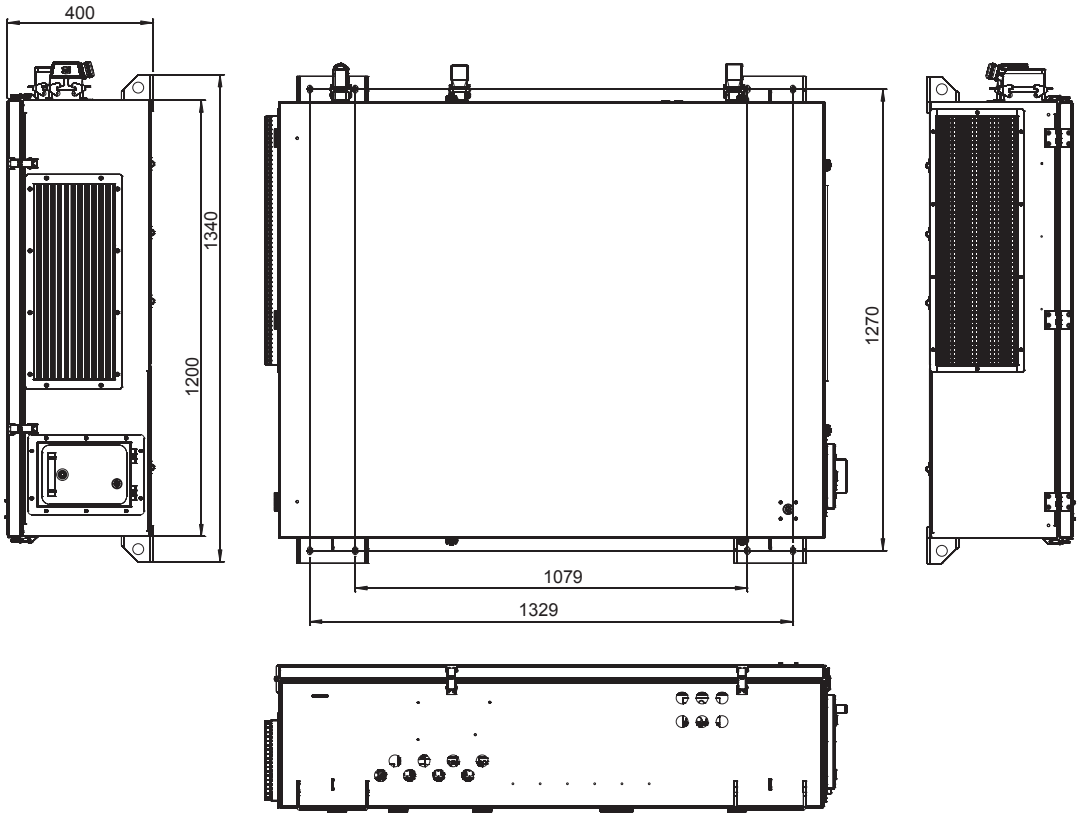
Traction Inverter
for Asynchronous Drives

Schematic diagram of the FT-160-600 inverter



Parameters of the bus with the FT-160-600 inverter	
Supply voltage	**600 VDC (520 V – 748 V)**
Rated power	**160 kW**
Number of motors per vehicle	**1 or 2**
Acceleration of the electric bus at the starting to the speed of 30 km/h	**1.5 m/s²**
Bus deceleration at braking (electrical)	**1.7 m/s²**
Bus deceleration at emergency braking	**3 m/s²**
Maximum bus speed at constant power	**70 km/h (19.4 m/s)**

Housing

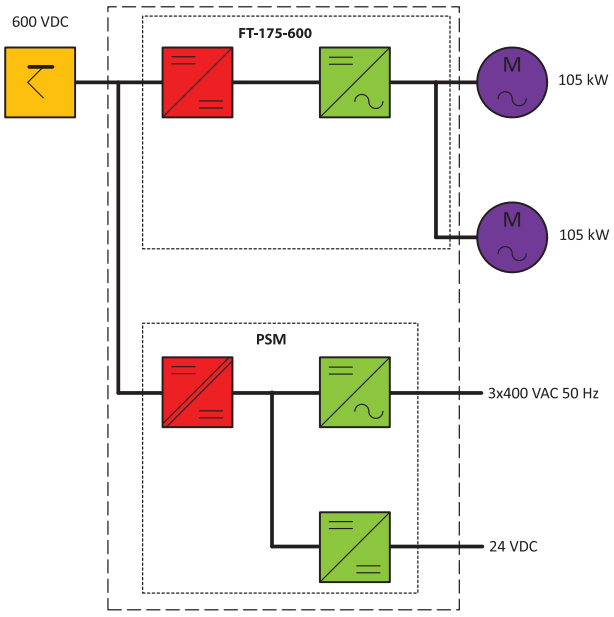


FT-175-600

Traction Inverter
for Asynchronous Drives

The FT-175-600 traction inverter has been designed to drive the Trollino T12 trolleybus. The inverter is based on the IGBT technology. It is controlled by means of the DSP (Digital Signal Processor) technology, applying the FOC SVPWM (Field Oriented Control Space Vector Pulse Width Modulation) algorithm. The controller guarantees optimum control of the asynchronous motor's performance, achieving very good traction parameters and a high level of driving comfort. The inverter has been equipped with a forced air-cooling system. The system meets all European standards with regard to safety and radio interferences. The system is installed in the space previously occupied by the resistors (on-roof mounting version is also available). The system has been equipped with an integrated reverser, which operates with regenerative or rheostatic braking. The latest generation components and an extensive diagnostic system guarantee a high level of reliability and low operating costs. A static 32 kW or 16 kW converter and appropriate switchgear are placed in the same case.

Block diagram



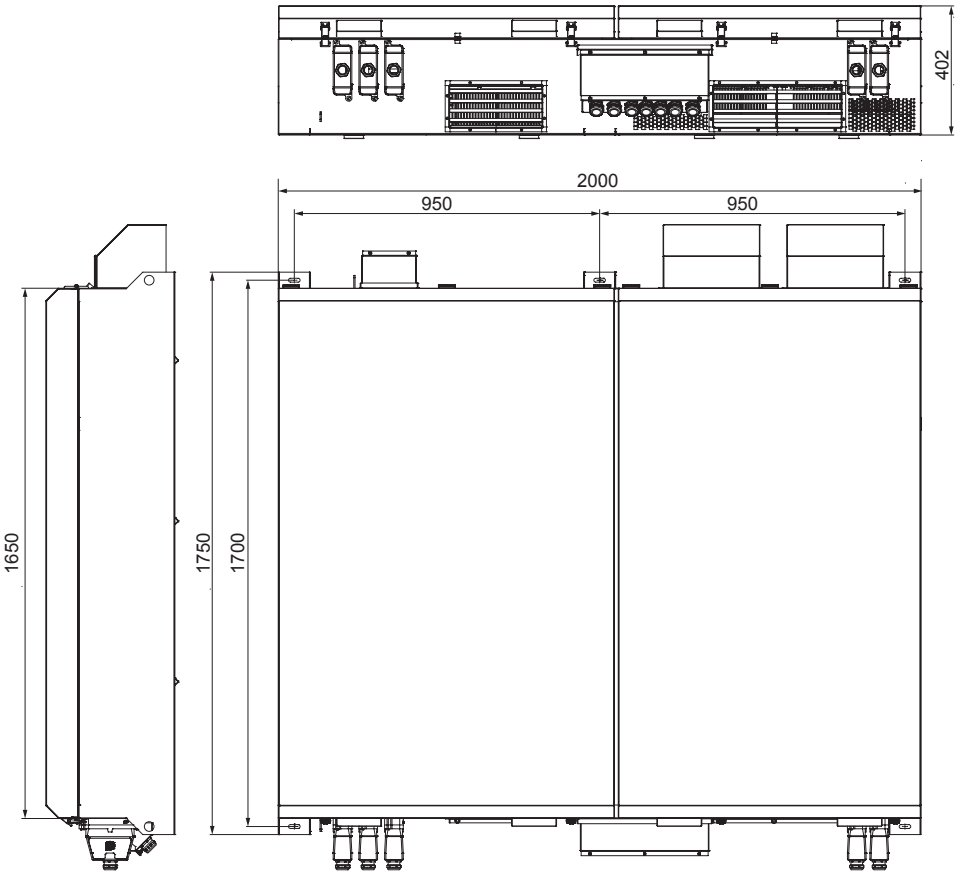
Specification of the FT-175-600 inverter	
Input voltage	**600 VDC (750 V), +30 ÷ –30%**
Auxiliary voltage	**24 VDC, +30 ÷ –40%**
Rated current	**400 Arms**
Maximum current	**600 Arms**
Rated power	**175 kW**
Frequency	**0–130 Hz**
PWM frequency	**1.5–2.5 kHz**
Insulation strength	**4 kV**
Cooling	**forced-air**
Weight	**670 kg**
Dimensions	**402×2000×1750 mm**

FT-175-600

Traction Inverter
for Asynchronous Drives

Traction parameters of the Trollino12M trolleybus with the FT-175-600	
Input voltage	**600 VDC, +30 ÷ –30%**
Rated power	**175 kW**
Maximum torque referred to the motor shaft	**450 Nm**
Acceleration at starting up to the speed 35 km/h	**1.5 m/s²**
Vehicle deceleration at braking (electrical)	**1.7 m/s²**
Vehicle deceleration at emergency braking	**3 m/s²**
Vehicle maximum speed at constant power	**65 km/h (18 m/s)**

Housing



FT-250-600T integrated with PSM-44T

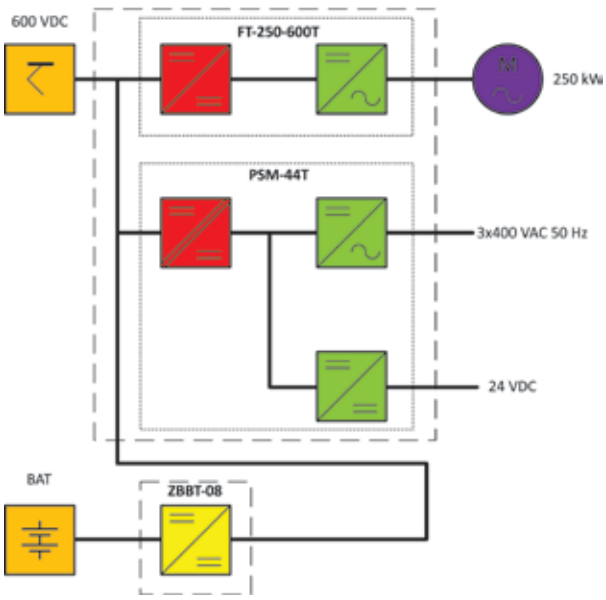
Traction Inverter integrated with Auxiliary Converter

The FT-250-600T traction inverter is designed to power the traction motor, which drives the wheel axle of the trolleybus. The container that houses the FT-250-600T traction inverter with a RWN 300-600 switchboard and PSM-44T static converter is to be mounted on the roof of the vehicle. The traction inverter is designed for the traction power supply of 600 V DC.
The drive assembly ensures the vehicle start-up, driving at a set torque, coasting and braking of the vehicle. It also enables start-up, driving and braking after setting driving in the reverse direction. The traction inverter transforms the input voltage of 600 VDC into an adjustable output voltage in the range from 0 to the rated voltage of the traction motor, maintaining a constant ratio between the output voltage and voltage frequency (U/f).

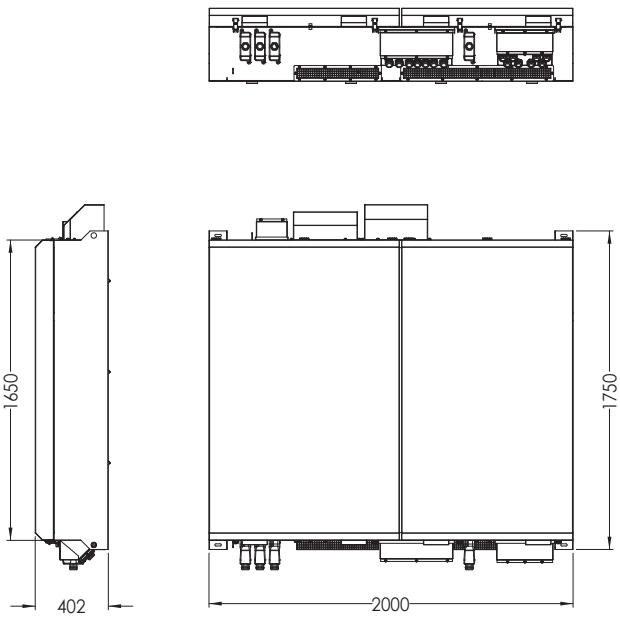
The FT-250-600T inverter is made with HV IGBT 1.7 kV technology. Control of the converter is provided by the DSP (Digital Signal Processor), which uses FOC SVPWM (Field Orientation Control Space Vector Pulse Width Modulation). In the range of high speeds, the system operates with synchronized Bus Clamping Pulse Width Modulation (BCPWM), which reduces the losses and noise emissions. The control system provides the start-up with a constant torque and low power loss. The system of bus bars combined with the IGBT driver guarantee a failure-free operation during short-circuits and eliminates the risk of secondary damage during transistor failure. The polypropylene capacitors ensure high durability and resistance of the system to voltage changes in the overhead line. The inverter meets UIC and EN standards for safety and electromagnetic compatibility. The system has very low levels of low-frequency interference generated in the overhead line. The diagnostics and inverter control is provided via the CANBus interface. The system is adapted to cooperate with a device that records traction and inverter parameters, which allows the user to review the conditions of power supply in case of malfunctions or failures in the drive system.

FT-250-600T		
Input voltage	**600 VDC +25% –30%**	
Rated power	**250 kW**	
Rated current	**430 Arms**	
Auxiliary voltage	**24 VDC +25% –30%**	
PSM-44T		
Input voltage	**600 VDC +25% –30%**	
Output power	**44 kW**	
DC Output	**28,8 V DC / 420 A (12 kW)**	
AC Output	**3×400 V / 50 Hz (32 kVA)**	
Auxiliary voltage	**24 VDC +25% –30%**	
Housing		
Cooling method	**forced-air**	
Weight	**700 kg ±10%**	
Dimensions	**2000×1750×405 mm**	
Protection ratio	**Clean section**	**IP55**
	Dirty section	**IP20**

Block diagram



Housing



FT-250-600/750
integrated with PSM-52T and FCEC-85

Traction Inverter integrated with Auxiliary Converter and Fuel Cell Converters

The FT-250-600/750 traction inverter is designed to power the traction motor, which drives the wheel axle of the trolleybus. The container that houses the FT-250-600/750 traction inverter together with the RWN-360-600/750 switchboard, PSM-52T static converter and FCEC-85 fuel cell converter, is to be mounted on the roof of the vehicle. The traction inverter is used for the traction power supply of 600/750 V DC.

The drive assembly ensures the vehicle start-up, driving at a set torque, coasting and braking of the vehicle. It also enables start-up, driving and braking after setting driving in the reverse direction. The traction inverter transforms the input voltage of 600/750 VDC into an adjustable output voltage in the range from 0 to the rated voltage of the traction motor, maintaining a constant ratio between the output voltage and voltage frequency (U/f).

The traction drive used in the trolleybus consists of the FT-250-600/750 traction inverter, MT drive motor, RH braking resistor, RWN-360-600/750 high voltage switchboard, PSM-52T static converter and FCEC-85 fuel cell converter. The high voltage circuit comprises also a current collector, surge limiter and fast circuit breaker. The transistor converters, line choke and inverters are cooled by forced air circulation. The brake resistor is cooled naturally. The use of air cooling ensures reliable operation over a wide range of outdoor temperatures. The fans installed in the housing of the drive assemble are controlled by FT-250-600/750 inverters. The inverter controls the operation of the inverter fan and the fan for the PSM-52T static converter.

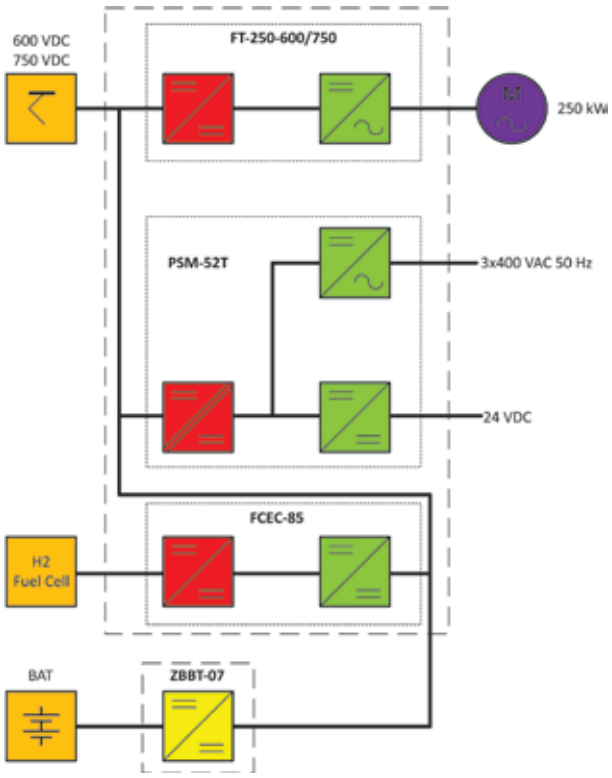
The FT-250-600/750 inverter is made with HV IGBT 1.7 kV technology. Control of the converter is provided by the DSP (Digital Signal Processor), which uses FOC SVPWM control (Field Orientation Control Space Vector Pulse Width Modulation). In the range of high speeds, the system operates with synchronized Bus Clamping Pulse Width Modulation (BCPWM), which reduces the losses and noise emissions. The control system provides the start-up with a constant torque and low power loss. The system of bus bars combined with the IGBT driver guarantee a failure-free operation during short-circuits and eliminates the risk of secondary damage during transistor failure. The polypropylene capacitors ensure high durability and resistance of the system to voltage changes in the overhead line. The inverter meets UIC and EN standards for safety and electromagnetic compatibility. The system has very low levels of low-frequency interference generated in the overhead line.

Diagnostics and inverter control is provided via the CANBus interface. The system is adapted to cooperate with a device that records the traction and inverter parameters, which allows the user to review the conditions of power supply in case of malfunctions or failures in the drive system.

The PSM-52T static converter is designed for transforming an overhead contact line voltage of 600/750 V, to 24 VDC and 3x400 VAC (50 Hz) voltages of the traction battery or fuel cell and for feeding the auxiliary circuits of the vehicle.

The fuel cell inverter is designed for transforming the fuel cell voltage to the voltage required to power the traction inverter over the sections without access to the overhead line.

Block diagram

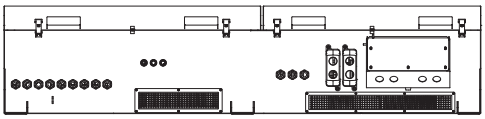


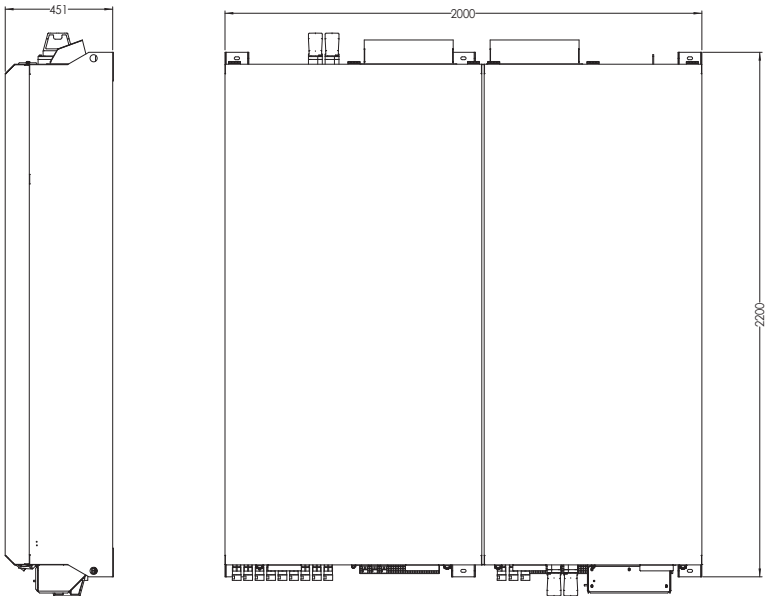
FT-250-600/750
integrated with PSM-52T and FCEC-85

Traction Inverter integrated with Auxiliary Converter and Fuel Cell Converters

FT-250-600/750		
Input voltage	**600/750 VDC**	
Rated power	**250 kW**	
Rated current	**430 Arms**	
Auxiliary voltage	**24 VDC +25% ÷ –30%**	
PSM-52T		
Input voltage	**600/750 VDC**	
Output power	**52 kW**	
DC Output	**24 V DC / (19 kW)**	
AC Output	**3×400 V / 50 Hz (30 kVA)**	
Auxiliary voltage	**24 VDC +25% ÷ –30%**	
FCEC-85		
Input voltage	**280..420 VDC**	
Input power	**85 kW**	
Rated current	**288 ADC**	
Housing		
Cooling method	**forced-air**	
Weight	**945 kg ±10%**	
Dimensions	**2200×2000×450 mm**	
Protection ratio	**Clean section**	**IP55**
	Dirty section	**IP20**

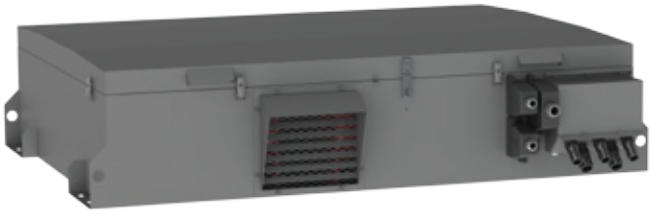
Housing





FT-350-600I
integrated with PSM-30I

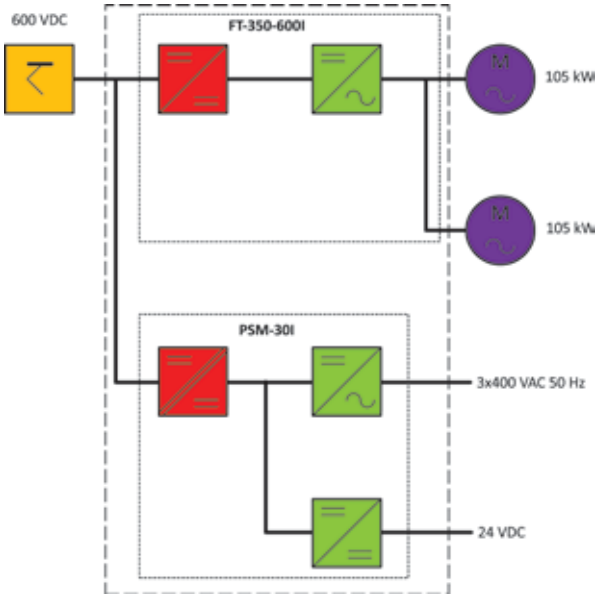
Traction Inverter for Asynchronous Drives



The application of independent inverters for powering of two motors guarantees high traction parameters, perfect performance at the slip point and no influence of non-uniform wear of wheel's tires on the drive's performance. The FT-350-600I drive inverter is a modern module inverter incorporating the IGBT technology. The converter control operates in the DSP technology (Digital Signal Processor) with application of the Field Oriented Control Space Vector Pulse Width Modulation. The inverter system enables the drive to work with regulated torque, regenerative braking or rheostatic braking. The inverter has been equipped with a forced air-cooling system and can be built up on the vehicle's roof (two inverter modules in one container). It is controlled by a CAN 2.0 B connection. The inverter's controller has been equipped with a built-in anti-slip system. Additionally, the system is equipped with an emergency power supply system (from the vehicle's battery), which enables the vehicle to move out the intersectional isolator or crossing (in case of main power failure).

Specification of the FT-350-600I inverter	
Input rated voltage	**600 VDC, +40 ÷ –33%**
Auxiliary voltage	**24 VDC, +25 ÷ –30%**
Rated current	**380 A**
Peak current	**600 A**
Rated power	**210 kW**
Frequency	**0–160 Hz**
PWM frequency	**1500–2500 Hz**
Insulation strength	**4 kV, 50 Hz, 1 min**
Cooling	**forced-air**
Weight	**580 kg**
Dimensions	**424×1546×1800 mm** (integrated set)

Schematic diagram of the FT-350-600I inverter



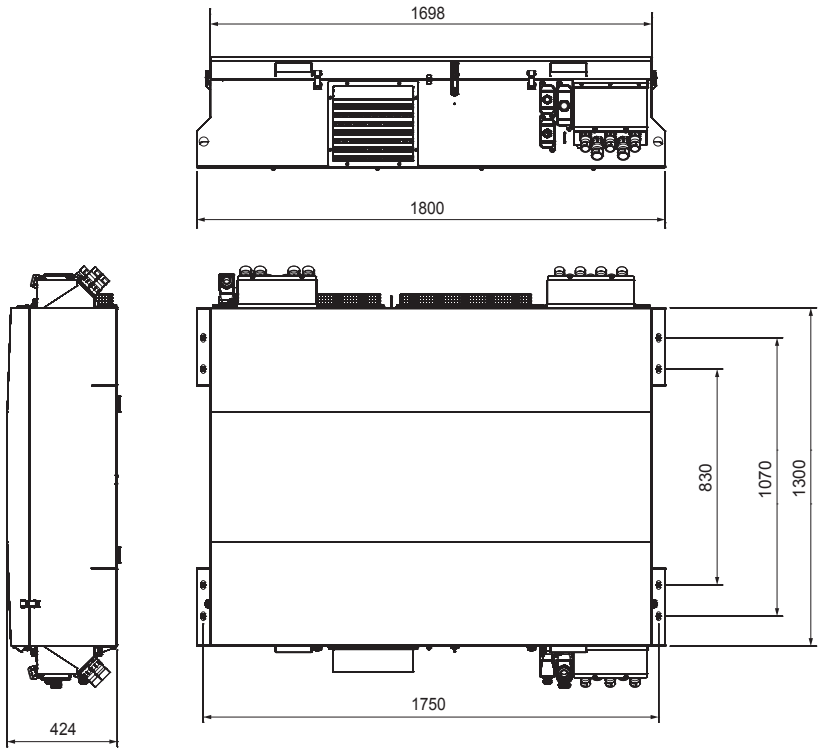
FT-350-600I
integrated with PSM-30I

Traction Inverter for Asynchronous Drives

Integrated PSM-30TI auxiliary converter	
Output voltage DC P = 10 kW; In = 390 A; Un = 28.1 V (20°C)	**26 VD**
AC output	**3×400 V, 50 Hz/25 kVA, cosϕ = 0,9**
AC voltage stability	**≤ ±5%**
Frequency stability	**≤ ±0,1%**
THD	**≤ 5%**

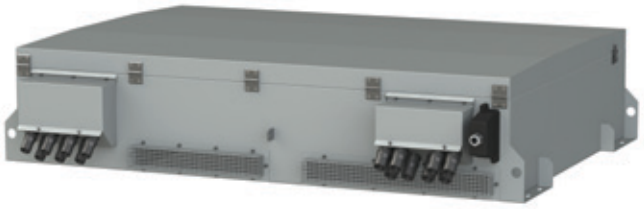
Parameters of the tram car with the FT-350-600I inverter	
Supply voltage	**600 VDC (750 VDC), +25 ÷ –30%**
Rated power	**350 kW**
Number of motors per vehicle	**4**
Acceleration of the tram car at the starting to the speed of 35 km/h	**1.5 m/s²**
Tram car deceleration at braking (electrical)	**1.7 m/s²**
Tram car deceleration at emergency braking	**3 m/s²**
Maximum tram car speed at constant power	**70 km/h (19.4 m/s)**

Housing



FT-350-600
integrated with PSM-38i

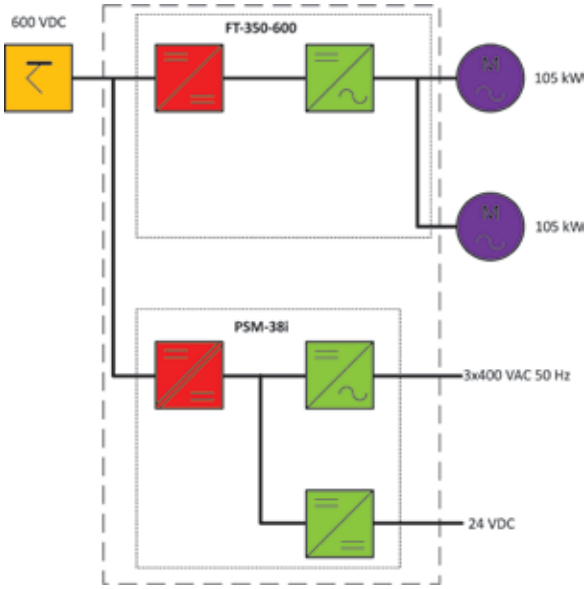
Traction Inverter integrated
with Auxiliary Converter



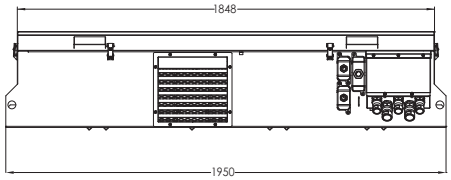
The application of independent inverters for powering of two motors guarantees high traction parameters, perfect performance at the slip point and no influence of non-uniform wear of wheel's tires on the drive's performance. The FT-350-600 drive inverter is a modern module inverter incorporating the IGBT technology. The converter control operates in the DSP technology (Digital Signal Processor) with application of the Field Oriented Control Space Vector Pulse Width Modulation. The inverter system enables the drive to work with regulated torque, regenerative braking or rheostatic braking. The inverter has been equipped with a forced air-cooling system and can be built up on the vehicle's roof (two inverter modules in one container). It is controlled by a CAN 2.0 B connection. The inverter's controller has been equipped with a built-in anti-slip system. Additionally, the system is equipped with an emergency power supply system (from the vehicle's battery), which enables the vehicle to move out the intersectional isolator or crossing (in case of main power failure).

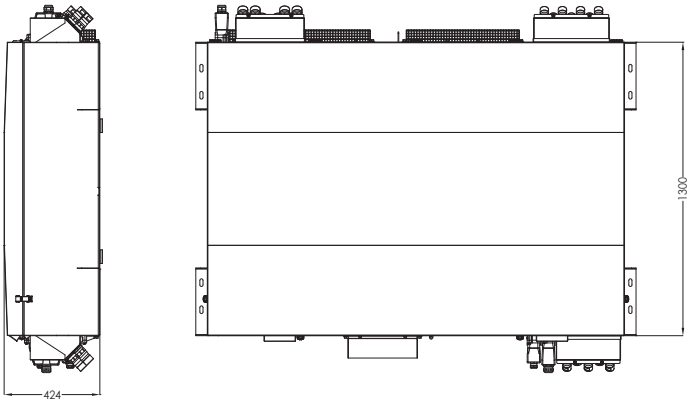
FT-350-600		
Input voltage	**600 VDC**	
Rated power	**210 kW**	
Rated current	**380 Arms**	
Auxiliary voltage	**24 VDC +25% ÷ –30%**	
PSM-38i		
Input voltage	**600 VDC**	
Output power	**38 kW**	
DC Output	**26 V / 10 kW**	
AC Output	**3×400 V 50 Hz / 35 kVA**	
Auxiliary voltage	**24 VDC +25% ÷ –30%**	
Housing		
Cooling method	**forced-air**	
Weight	**580 kg ±10%**	
Dimensions	**424 ×1800×1546 mm**	
Protection ratio	**Clean section**	**IP65**
	Dirty section	**IP20**

Block diagram



Housing



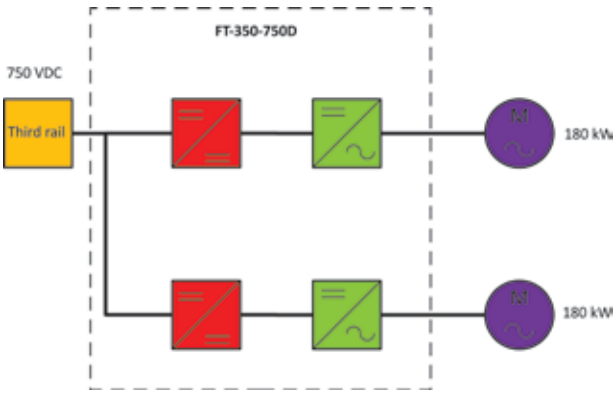


FT-350-750D

Traction Inverter for Asynchronous Drives

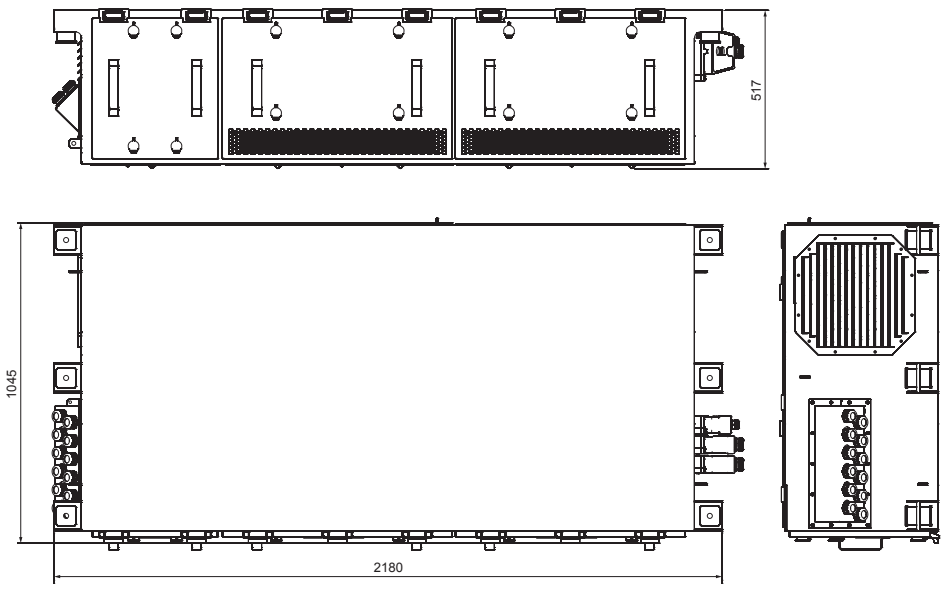
The FT-350-750D traction inverter has been designed to drive motors of metro vehicles and is powered from the 750 VDC traction. This inverter has been designed as two inverters, each of them to power one traction motor. Both inverters have been designed and built in the IGBT technology. Digital Signal Processor (DSP) system provides the control and monitoring of the operation. FOC SVM (Field Oriented Control Space Vector Modulation) algorithm ensures perfect traction parameters of the propulsion. Advanced control and diagnostics system ensures a failure-free and cost effective operation of the vehicle. The inverter system enables the performance of the drive with a regulated torque, regenerative or rheostatic braking. The inverter is equipped with an internal cooling system with durable fans; it is designed to be mounted under the frame of the car. The inverter is controlled by CAN 2.0 B or MVB connections and its controller is equipped with a very effective anti-slip system. The inverter has two independent outputs for motors with fully independent motor control capability. This allows for achieving much higher traction performance parameters of vehicles in acceleration and braking modes and provides special advantage in difficult rail conditions like soiled, wet or uneven rails as well as superior performance on curves and rail junctions. Due to its excellent anti-slip and full motor control the inverter provides perfect protection of motor and gearbox against overload and generates savings on wheels maintenance costs owing to a larger tolerance for wheels diameter difference.

Schematic diagram of the FT-350-750D inverter



Specification of the FT-350-750D inverter	
Input voltage	**750 VDC (550–925 VDC)**
Auxiliary voltage	**48 VDC, 24 VDC**
Rated current	**2×300 Arms**
Maximum current	**2×400 Arms**
Rated power	**360 kW**
Frequency	**0–180 Hz**
PWM frequency	**1.5–2.5 kHz**
Insulation strength	**4 kV**
Cooling	**forced-air**
Weight	**600 kg**
Dimensions	**2180×1045×517 mm**

Housing



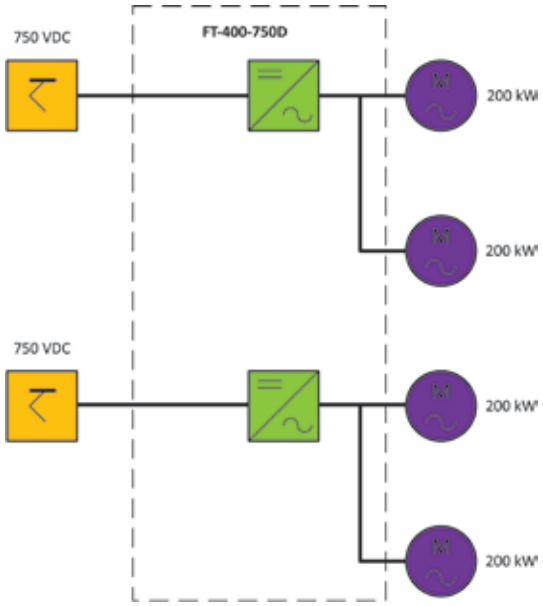
FT-400-750D

Traction Inverter for Asynchronous Drives

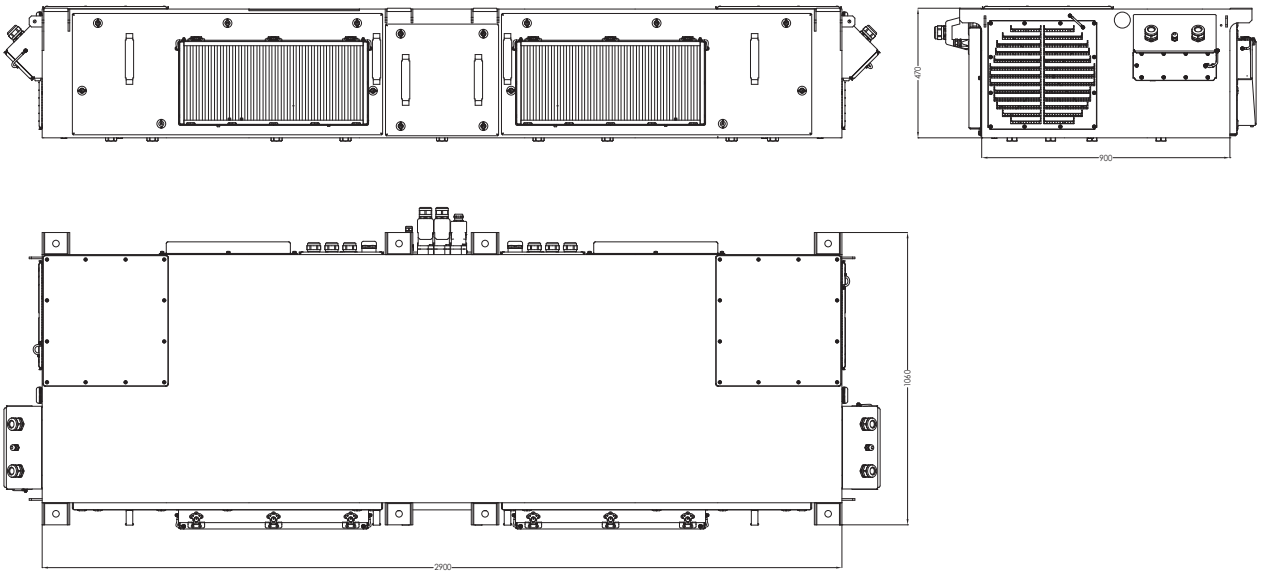
The FT-400-750D traction inverter has been designed to drive motors of metro vehicles and is powered from the 750 VDC traction. This inverter has been designed as two inverters, each of them to power one traction motor. Both inverters have been designed and built in the IGBT technology. Digital Signal Processor (DSP) system provides the control and monitoring of the operation. FOC SVM (Field Oriented Control Space Vector Modulation) algorithm ensures perfect traction parameters of the propulsion. Advanced control and diagnostics system ensures a failure-free and cost effective operation of the vehicle. The inverter system enables the performance of the drive with a regulated torque, regenerative or rheostatic braking. The inverter is equipped with an internal cooling system with durable fans; it is designed to be mounted under the frame of the car. The inverter is controlled by CAN 2.0 B or MVB connections and its controller is equipped with a very effective anti-slip system. The inverter has two independent outputs for motors with fully independent motor control capability. This allows for achieving much higher traction performance parameters of vehicles in acceleration and braking modes and provides special advantage in difficult rail conditions like soiled, wet or uneven rails as well as superior performance on curves and rail junctions. Due to its excellent anti-slip and full motor control the inverter provides perfect protection of motor and gearbox against overload and generates savings on wheels maintenance costs owing to a larger tolerance for wheels diameter difference.

FT-400-750D		
Input voltage	**750 VDC**	
Rated power	**2×400 kW**	
Rated current	**3×560 A**	
Auxiliary voltage	**24 VDC +25% ÷ –30%**	
Housing		
Cooling method	**forced-air**	
Weight	**870 kg**	
Dimensions	**2900×1060×900 mm**	
Protection ratio	**Clean section**	**IP56**
	Dirty section	**IP20**

Block diagram



Housing



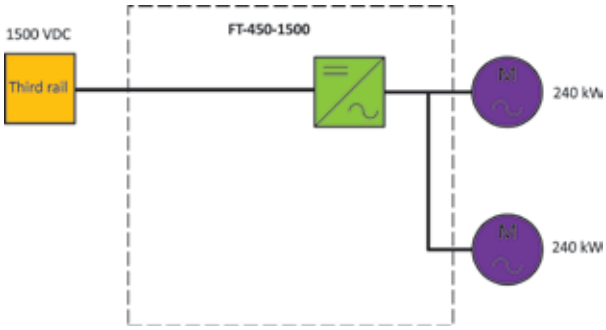
FT-450-1500

Traction Inverter for Asynchronous Drives

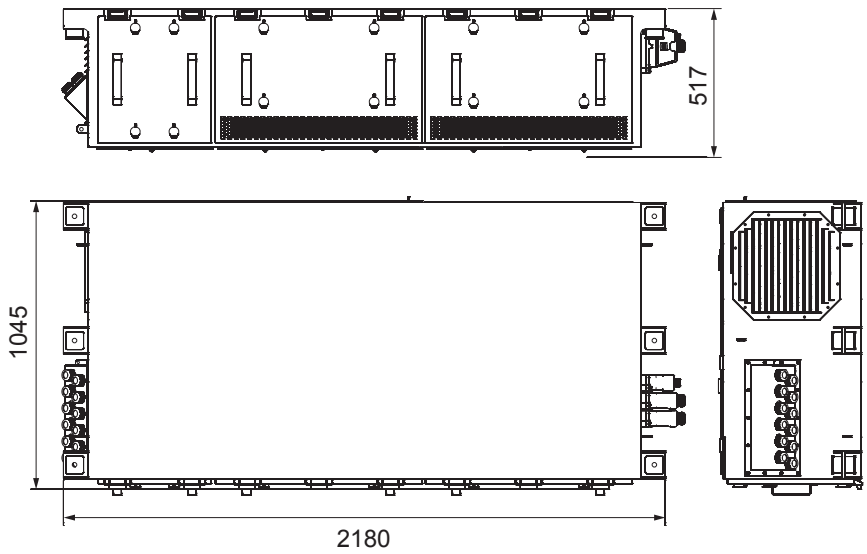
The FT-450-1500 traction inverter has been designed to drive motors of metro vehicles and is powered from the 1500 VDC traction. This inverter supplies two traction motors. The inverter has been designed and built in the IGBT technology. Digital Signal Processor (DSP) system provides the control and monitoring of the operation. FOC SVM (Field Oriented Control Space Vector Modulation) algorithm ensures perfect traction parameters of the propulsion. Advanced control and diagnostics system ensures a failure-free and cost effective operation of the vehicle. The inverter system enables the performance of the drive with a regulated torque, regenerative or rheostatic braking. The inverter is equipped with an internal cooling system with durable fans; it is designed to be mounted under the frame of the car. The inverter is controlled by CAN Open or MVB connections and its controller is equipped with a very effective anti-slip system. Additionally the inverter system is also protected with a thyristor crowbar. The inverter meets UIC and EN standards requirements in regard to safety and electromagnetic compatibility. The system has very low levels of low frequency interferences generated to the traction network.

Specification of the FT-350-750D inverter	
Input voltage	**1500 VDC (1000–1800 VDC)**
Auxiliary voltage	**110 VDC**
Rated current	**320 A**
Maximum current	**420 A**
Rated power	**480 kW**
Frequency	**0–180 Hz**
PWM frequency	**0.5–2 kHz**
Insulation strength	**6 kV**
Cooling	**forced-air**
Weight	**500 kg**
Dimensions	**2180×1045×517 mm**

Schematic diagram of the FT-450-1500 inverter

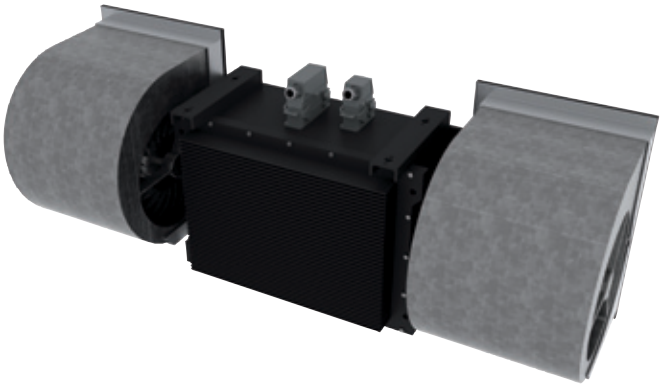


Housing



PSM-5-105N

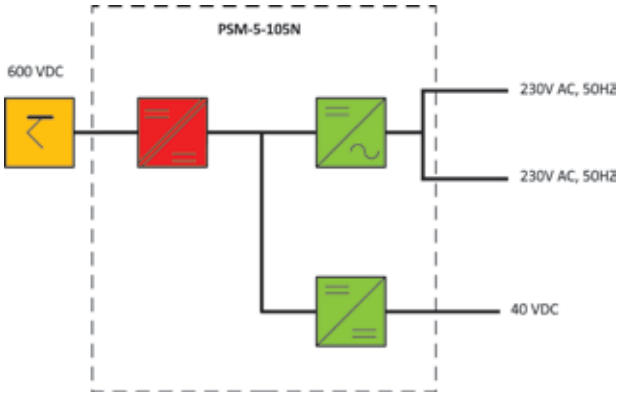
Static Converter



The PSM-5-105N static converter coupled with a ventilation unit is designed to supply auxiliary circuitry of the tram with direct voltage of 42 V, as well as to supply asynchronous motors of its own ventilation set with single-phase AC of 230 V, 50 Hz.

Specification	
Input voltage	**600 VDC, +30 ÷ –30% (750 VDC)**
Output voltage	**42 VDC** **230 V, 50 Hz, 1.1 kVA**
Rated power	**5 kW**
Ambient temperature	**–30 ÷ +40°C**
Protection ratio	**IP55**
Weight	**120 kg**
Dimensions	**1385×525×438.5 mm**

Block diagram



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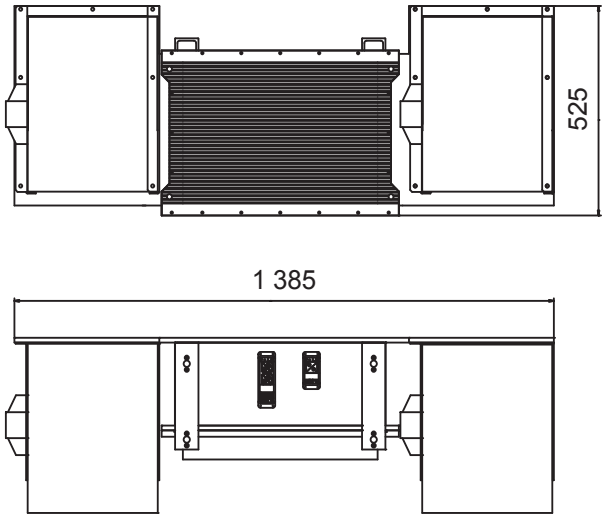
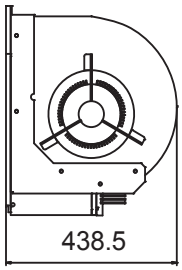


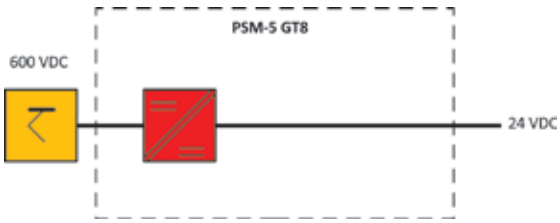


PSM-5 GT8

Static Converter

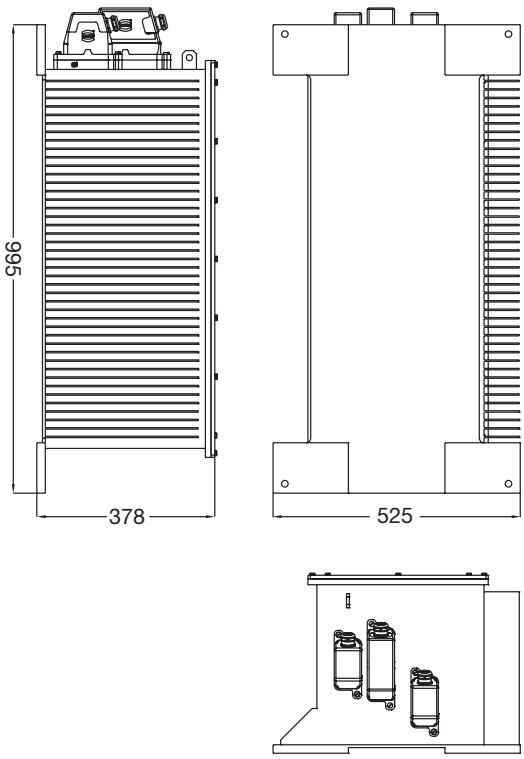
The PSM-5 GT8 static converter is a device designed to convert the traction supply voltage of 600 V into 24 V DC for tramway low voltage grid.

Block diagram



Specification	
Input voltage	**400–900 VDC**
Output power	**5 kW**
Output DC	**24 VDC / 210 A**
DC Voltage stability	**< 1%**
DC Voltage ripples	**< 1 Vpp (at nominal load)**
General efficiency	**≥ 90%**
Ambient temperature	**–30 ÷ +40°C**
Protection ratio	**IP64**
Weight	**100 kg**
Dimensions	**378×995×525 mm**

Housing



PSM-8E

Static Converter

Static auxiliary converter PSM-8E is a device designated for the conversion of the input of the catenary's voltage of 600 V DC into auxiliary voltages of 100 VDC and 2×200 V 60 Hz.

The PSM-8E converter is a completely automatic device which provides power supply to low voltage circuits using the energy from the catenary line. For starting, operation supply of an auxiliary voltage 100VDC from a battery is not required because the converter is equipped with a dead battery start unit (DBS).

Owing to the application of the latest generation single chip microprocessors and IGBT transistors, the converter delivers a sinusoidal voltage on its output with low harmonics contents. In the case of supplying the electric motors, this feature is advantageous (as compared to power supplies with square or trapezoidal output waveforms) because it significantly reduces power losses in the motors.

The control system ensures very good frequency stability, very good phase symmetry of the output voltage and a very low level of interference generated by the system.

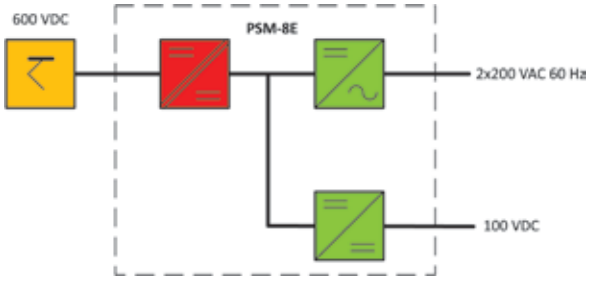
The semiconductors used in the device are selected with a margin allowing obtaining appropriate overloads of the system.

The device is a completely automatic device – the controller controls the states of the output terminals and prevents the inverter operating in case of prolonged overload or a short circuit.

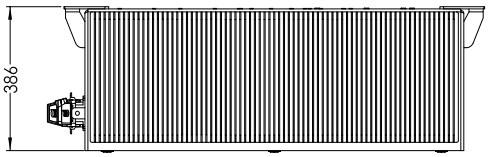
The PSM-8E converter is designed as a single unit placed inside aluminium housing and mounted on the underframe of the tram.

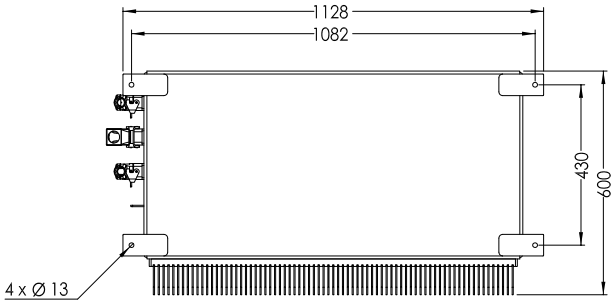
PSM-8E		
Input voltage	**600 VDC**	
Output power	**8 kVA**	
DC Output	**100 VDC ±1%**	
AC Output	**2×200 V 60 Hz**	
Housing		
Cooling method	**Natural air cooling**	
Weight	**150 kg**	
Dimensions	**1128× 600×386 mm**	
Protection ratio	**Clean section**	**IP 54**

Block diagram



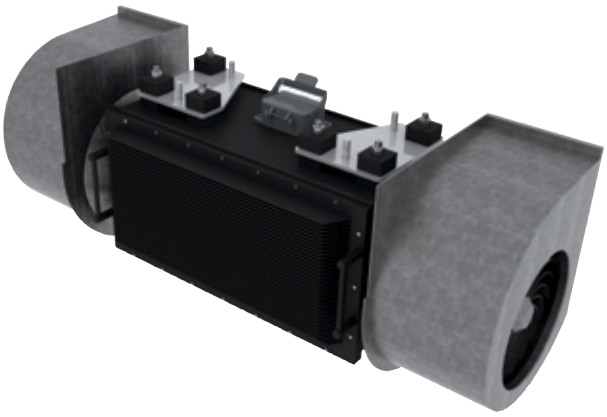
Housing





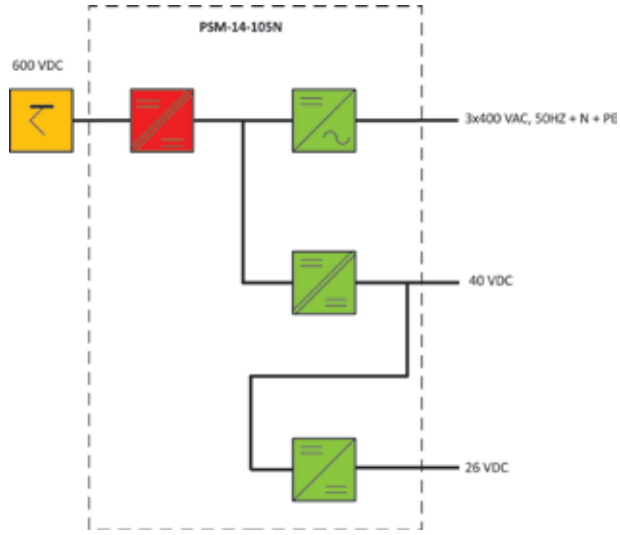
PSM-14-105N

Static Converter



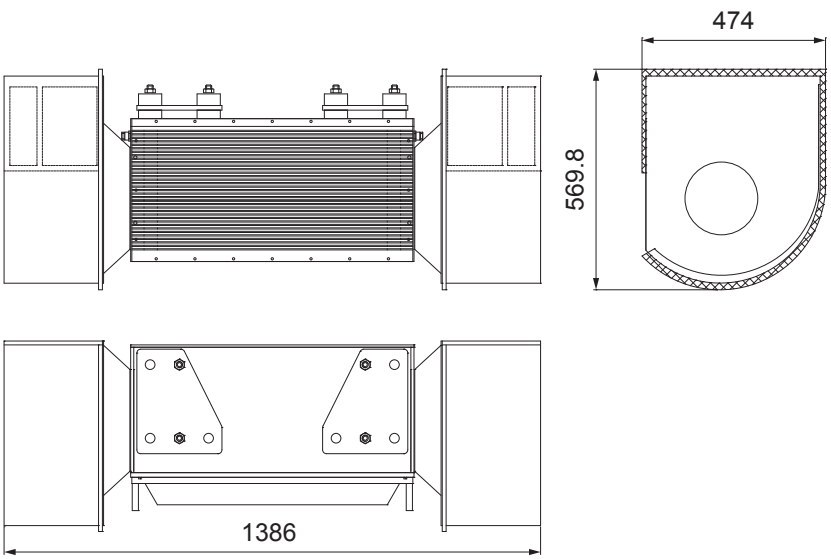
The PSM-14-105N static converter has been designed to convert the DC tram traction voltage (600 VDC/750 VDC) into 40 VDC, 24 VDC and 3×400 V/50 Hz voltage of auxiliary circuits (with a possibility of supplying single-phase loads). Integrated ventilation unit cools the traction motors, traction converter and braking resistor.

Block diagram



Specification	
Input voltage	**400–900 VDC**
Operating voltage	**360–1000 VDC**
Total power	**11 kVA**
DC1 output	**40 VDC/55 A**
Limitation of the battery charging current	**22 A**
DC2 output	**26 VDC/115 A**
DC voltage stability	**≤ 1%**
DC voltage ripples	**≤ 1 Vpp (rated load)**
AC1 output (50 Hz)	**3×400 VAC (230 VAC)/5 kVA**
AC2 output (50 Hz)	**230 V/0.4 kVA**
Total efficiency	**≥ 90%**
Ambient temperature	**–30 ÷ +40°C**
Protection ratio	**IP64**
Weight	**130 kg**
Dimensions	**570×1386×474 mm**

Housing



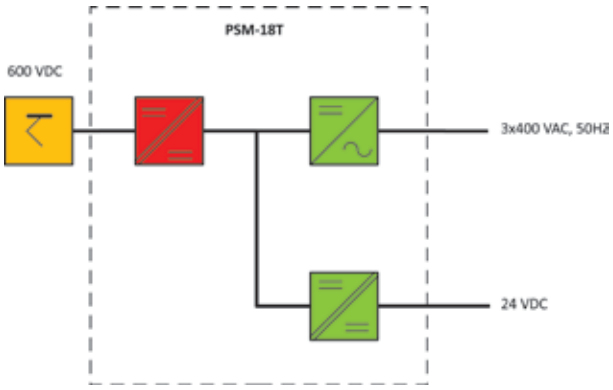
PSM-18T

Static Converter

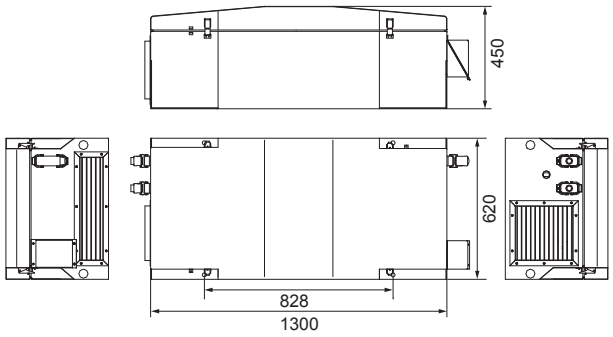
The PSM-18T static converter has been designed to convert DC voltage of the 600 VDC traction into 24 V DC voltage as well as 3×400 V and 230 V AC voltage, needed to supply the auxiliary circuitry in the tram system, driver's air conditioning and car ventilation.

Specification	
Input voltage	**420–750 VDC**
Output voltage DC	**24 VDC**
P = 2.4 kW; In = 100 A; Un = 28.1 V (20 °C); Thermal voltage compensation: up to 5°C: 28.4 V, above 5°C: drop of 57 mV/°C; Temperature range up to +40°C; Reduction of battery charging current; Voltage stability ≤ 1%; Voltage ripples ≤ 0.5%; Electronic (overload, short circuit) protection	
Output voltage AC	**3×400 VAC (50 Hz)**
S = 4.5 kVA; Voltage stability ≤ ±5%; Frequency stability ≤ ±0.2%; THD(u) ≤ 5 %; Acceptable unbalancing of phase load – 30%; Electronic (overload, short circuit) protection	
Maximum power	**9 kW/5 s**
Total efficiency	**≥ 85%**
Protection: • against the change of power supply polarity • against overvoltages in the power supply network • against short-lasting (up to 10 s) blackouts • inverter interlock at the one-phase decay	
Monitoring	**CANopen**
Ambient temperature	**–30 ÷ +40°C**
Protection ratio	**IP64**
Weight	**170 kg**
Dimensions	**620×450×1300 mm**

Block diagram

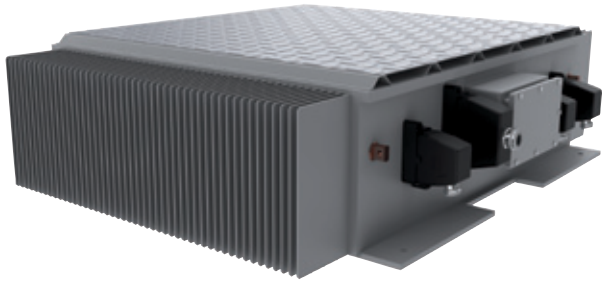


Housing



PSM-30T

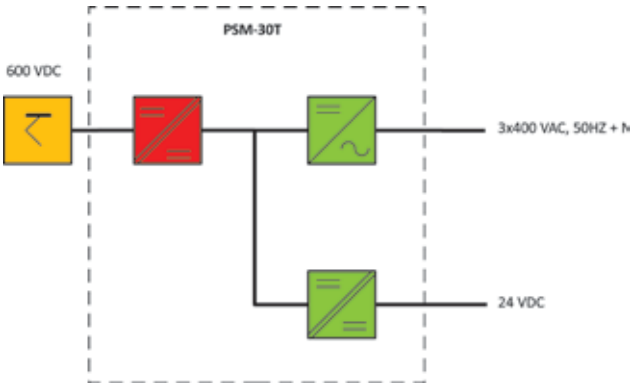
Static Converter



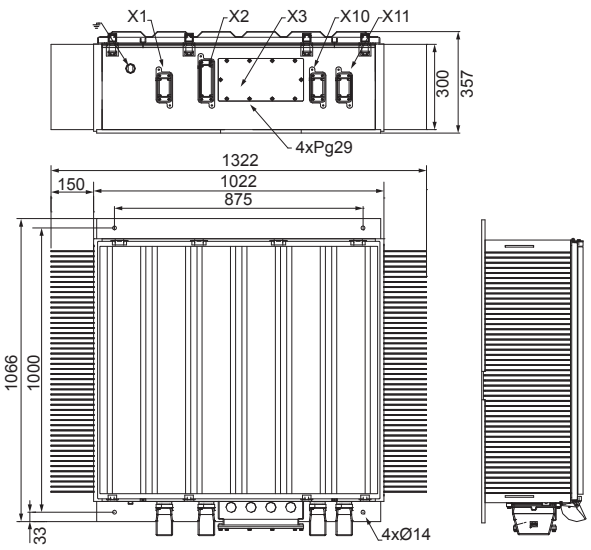
The PSM-30T static converter has been designed to convert DC voltage of the 600 VDC traction into 24 V DC voltage as well as into 3×400 V and 230 V AC voltage, needed to supply the auxiliary circuitry in the tram system, driver's air conditioning and car ventilation.

Specification	
Input voltage	**400–900 VDC**
Output voltage DC	**26 VDC**
P = 10 kW; In = 390 A; Un = 28.1 V (20°C); Thermal voltage compensation: up to 5°C: 28.4 V, above 5°C: drop of 57 mV/°C; Temperature range up to +40°C; Reduction of battery charging current; Voltage stability ≤ 1%; Voltage ripples ≤ 0.5%; Electronic (overload, short circuit) protection	
Output voltage AC	**3×400 VAC (50 Hz)**
S = 20 kVA; Voltage stability ≤ ±5%; Frequency stability ≤ ±0.1%; THD(u) ≤ 5%; Electronic (overload, short circuit) protection	
Maximum power	**35 kW**
Total efficiency	**≥ 92%**
Protection: • against the change of power supply polarity • against overvoltages in the power supply network • against short-lasting (up to 10 s) blackouts • inverter interlock at the one-phase decay	
Monitoring	**CANopen**
Ambient temperature	**–30 ÷ +40°C**
Protection ratio	**IP55**
Weight	**240 kg**
Dimensions	**357×1322×1066 mm**

Block diagram

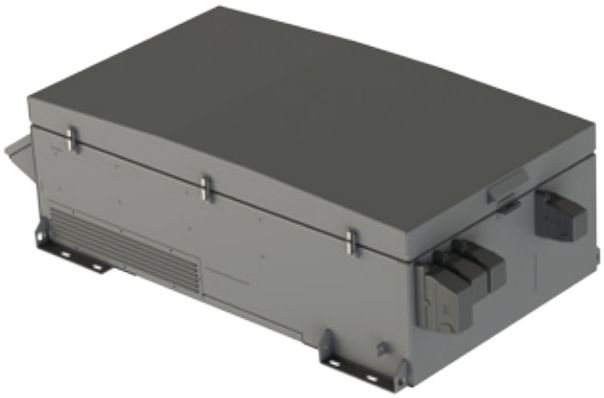


Housing



PSM-30TI

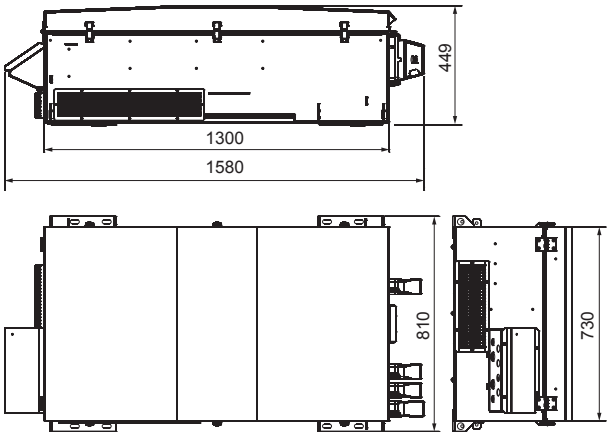
Static Converter



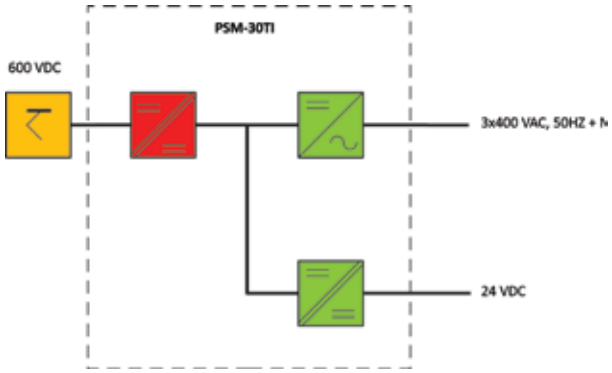
The PSM-30TI static converter has been designed to convert DC voltage of the 600 VDC traction into 26 VDC voltage as well as into 3×400 VAC voltage, needed to supply the auxiliary circuitry in the tram system, driver's air conditioning and car ventilation.

Specification	
Input voltage	**400–900 VDC**
Output voltage DC	**26 VDC**
P = 10 kW; In = 390 A; Un = 28.1 V (20°C); Thermal voltage compensation: up to 5°C: 28.4 V, above 5°C: drop of 57 mV/°C; Temperature range up to +40°C; Reduction of battery charging current; Voltage stability ≤ 1%; Voltage ripples ≤ 0.5%; Electronic (overload, short circuit) protection	
Output voltage AC	**3×400 VAC (50 Hz)**
S = 25 kVA; Voltage stability ≤ ±5%; Frequency stability ≤ ±0.1%; THD(u) ≤ 5%; Electronic (overload, short circuit) protection	
Maximum power	**35 kW**
Total efficiency	**≥ 92%**
Monitoring	**CANopen**
Ambient temperature	**–30 ÷ +40°C**
Protection ratio	**IP56/IP23**
Weight	**220 kg**
Dimensions	**450×1300×810 mm**

Housing



Block diagram



PSM-55

Static Converter

The converters are equipped with a natural air-cooling syste which operates within a wide range of external temperatures. The diagnostics and control of the converters are provided via a d fined interface.

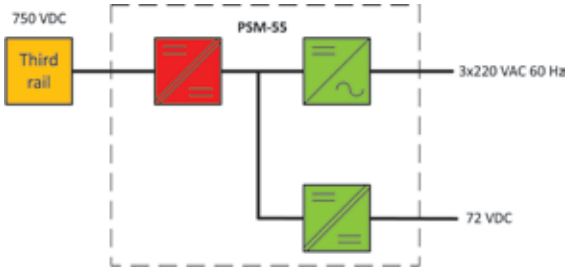
The converter is a high power device based on IGBT technology.

The static converter PSM-55 is a fully automated device designed for converting the traction power supply voltage 750 VDC to the 72 VDC voltage of auxiliary circuits, 3x220 V/60 Hz and batteries charging. The device uses the technique of a multiple conversion of energy. High voltage from the 3rd rail (750 VDC) is converted into the HF alternating voltage, and then transformed and rectified to obtain low-voltages (voltage inverter and the output voltage of 72 V). The 72 V output voltage is adjusted to the charge status of the battery cooperating with the converter so that the charging current of the connected battery is not exceeded. In the case of overload of the converter, an internal current limit circuit operates.

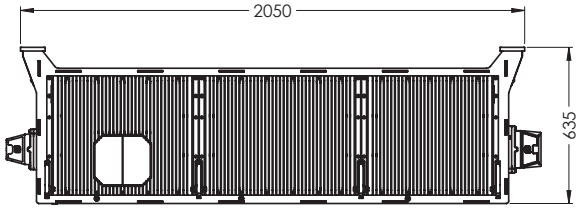
The PSM-55 converter is mounted under the frame of the metro coach.

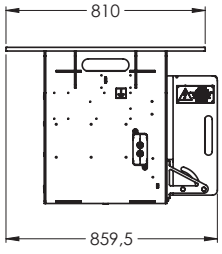
PSM-55		
Input voltage	**750 VDC**	
DC Output	**72 VDC +/-2% / 15 kW**	
AC Output	**3×220 VAC +/-5% / 60 Hz / 40 kVA**	
Housing		
Cooling method	**Natural air cooling**	
Weight	**560 kg**	
Dimensions	**2050×860×635 mm**	
Protection ratio	**Clean section**	**IP56**

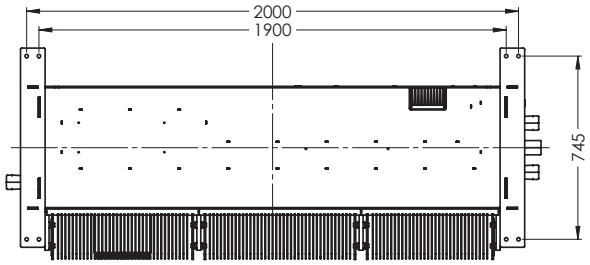
Block diagram



Housing







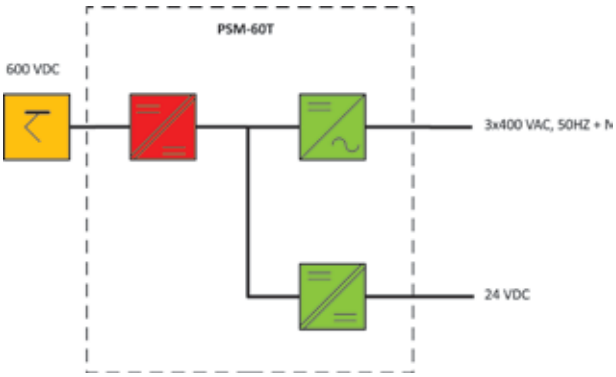
PSM-60T

Static Converter

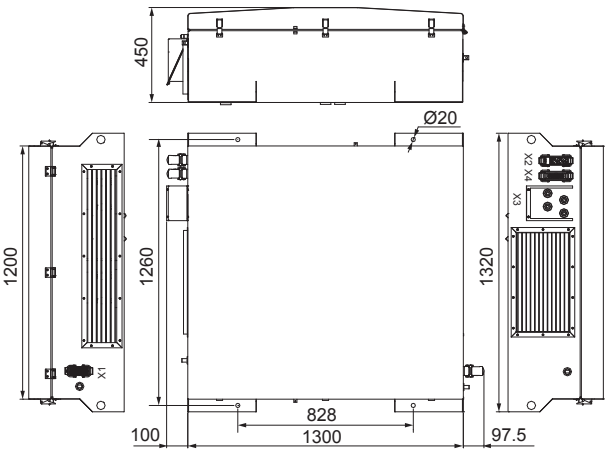
The PSM-60T static converter has been designed to convert DC voltage of the 600 VDC traction into 24 V DC voltage, as well as 3×400 V and 230 V AC voltage, needed to supply the auxiliary circuitry of the tram system, driver's air conditioning and car ventilation.

Specification	
Input voltage	**400–900 VDC**
Output voltage DC	**26 VDC**
P = 10 kW; In = 390 A; Un = 28.1 V (20°C); Thermal voltage compensation: up to 5°C: 28.4 V, above 5°C: drop of 57 mV/°C; Temperature range up to +40°C; Reduction of battery charging current; Voltage stability ≤ 1%; Voltage ripples ≤ 0.5%; Electronic (overload, short circuit) protection	
Output voltage AC	**3×400 VAC (50 Hz)**
S = 50 kVA; Voltage stability ≤ ±5%; Frequency stability ≤ ±0.1%; THD(u) ≤ 5%; Electronic (overload, short circuit) protection	
Maximum power	**60 kW**
Total efficiency	**≥ 92%**
Protection: • against the change of power supply polarity • against overvoltages in the power supply network • against short-lasting (up to 10 s) blackouts • inverter interlock at the one-phase decay	
Monitoring	**CANopen**
Ambient temperature	**–30 ÷ +40°C**
Protection ratio	**IP30**
Weight	**ca. 420 kg**
Dimensions	**450×1300×1200 mm**

Block diagram



Housing



PSM-68

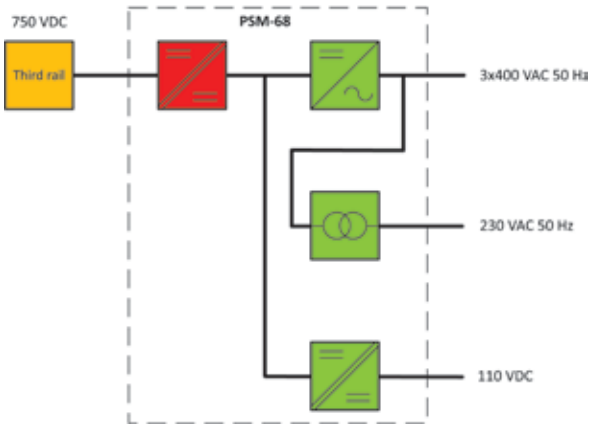
Static Converter

The static converter PSM-68 is a fully automated device designed for converting traction power supply 750 VDC voltage to 110 VDC voltage of auxiliary circuits, 3×400 V/50 Hz and batteries charging. The device uses the technique of multiple conversion of energy. Constant voltage from the overhead line (750 V) is converted into HF alternating voltage, and then transformed and rectified to obtain low-voltages (voltage inverter and output voltage of 24 V).

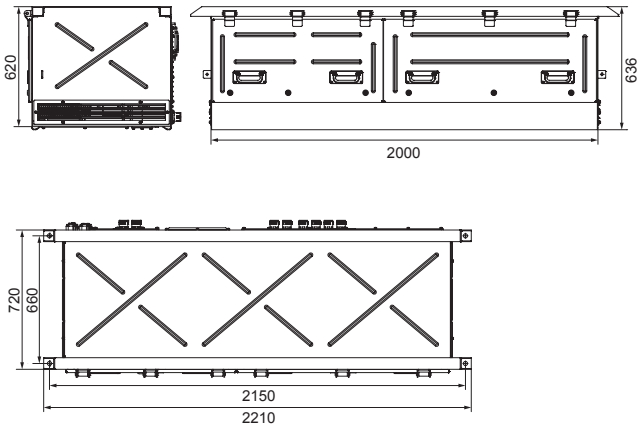
110 V output voltage is adjusted to the charge state of the battery cooperating with the converter so that the charging current of the connected battery is not exceeded. In case of converter overload an internal current limit circuit operates. The PSM-68 converter is mounted under the frame of a metro car. Access to its components is provided from the side of the vehicle, after removal of the side flaps.

Specification	
Input voltage	**750 VDC**
Output voltage DC	**3AC**
Rated Voltage 3 AC: 3×400 V 50 Hz; Output current 3 AC: 3×40 A; Voltage stability AC: ±5%; Frequency Tolerance: ±1%; Harmonics content (THD); ±5%	
Output voltage DC	**3×400 VAC (50 Hz)**
System Voltage: 110 V; DC output current: 333 A; Permissible voltage range (static): –30 ÷ +25%; AC Component: <1% Urms; Battery charging limit: 50 A; Standard accuracy current limiting battery charge: ±5%; Battery charging methods IU and IU0U	
Operating temperature	**–25 ÷ +45°C**
Output power	**3AC – 28 kVA, DC – 40 kW**
General efficiency	**≥ 92%**
Monitoring	**MVB**
Protection ratio	**IP55**
Weight	**380 kg ±10%**
Dimensions	**2000×620×720 mm**

Block diagram



Housing



PSM-69ST2

Static Converter

LRV contains two Auxiliary Power Supply (APS), which provides three-phase 208 VAC (60 Hz), one-phase 120 VAC (60 Hz) and 29.6 VDC powered from a 1500 VDC input. The PSM-69 is mounted on the roof of the vehicle.

The 1500 VDC power is supplied from the catenary to the APS via the pantograph, input fuse and high voltage distribution circuit, which are of the car-builder's scope. 1500 VDC is supplied to the DC/DC converter located in the APS via a pre-charge circuit and input filter. The DC/DC converter generates a constant stable DC voltage with isolation between the input and output. The stable DC voltage is supplied to the static inverter for generating the three-phase 208 VAC (60 Hz). The three-phase AC voltage is converted via the transformer to the one-phase 120 VAC (60 Hz). The AC voltage is also supplied to the battery charger for generating 29.6 VDC. The battery charger can be also supplied by the three-phase depo 208 VAC (60 Hz). Both the static inverter and the battery charger are located in the APS.

The APS for the application in the LRV project is designed with the application of state-of-the-art modern solutions provided by the world's technology: IGBT modules, Digital Signal Processors, modern magnetic materials, resin stabilization and others. The MEDCOM technological and circuitry solution provides excellent output parameters.

The APS for the LRV project is supplied from the 1500 VDC overhead power supply. The APS provides three-phase 208 VAC (60 Hz), one-phase 120 VAC (60 Hz) and 29.6 VDC.

The converter (PSM-69) will consist of a pre-charge circuit that limits the inrush current during the converter switching on. For 3AC output the input DC voltage will be converted by a DC/DC frontend converter into the intermediate DC voltage (approx. value 360 VDC) used by the 3AC output converter. The frontend converter provides stabilization of the DC voltage for the 3AC inverter and provides insulation between the HV and LV terminals. In case of INV failure, its output is separated by the S3 contactor. The converter will provide AC output (for the parameters: see option descriptions and schematics). The single phase 10 kVA output will be provided by a separate transformer.

A separate AC/DC converter will provide DC voltage for the DC circuits and battery charger (two separate outputs).

The APS will have DEPOT input that enables power supply to the battery charger or the battery charger and 3AC / 1AC output (current limited to 25 A).

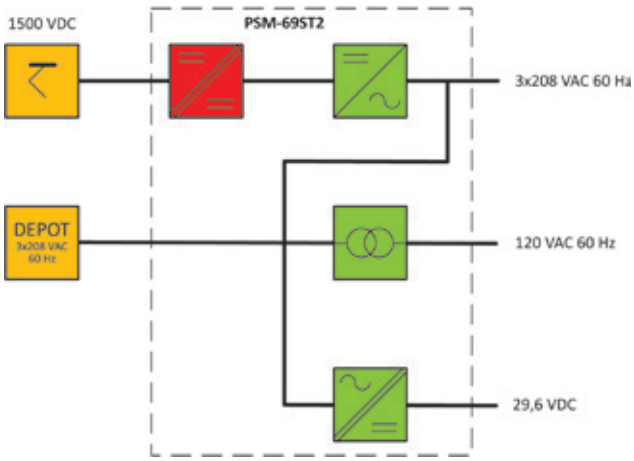
Control of the converter is made with the application of microprocessor circuits that provide perfect control over the output parameters of the converter as well as protection against overload and short-circuit conditions.

PSM-69ST2		
Input voltage 1	**1500 VDC**	
Input voltage 2	**3×208 VAC, 60 Hz**	
Output power	**69 kW**	
DC Output	**29,6 VDC 14 kW**	
AC Output 1	**3×208 VAC, 60 Hz / 45 kVA**	
AC Output 2	**120 VAC, 60 Hz / 10 kVA**	
Housing		
Cooling method	**forced-air**	
Weight	**475 kg**	
Dimensions	**1850×1260×491 mm**	
Protection ratio	**Clean section**	**IP 54**

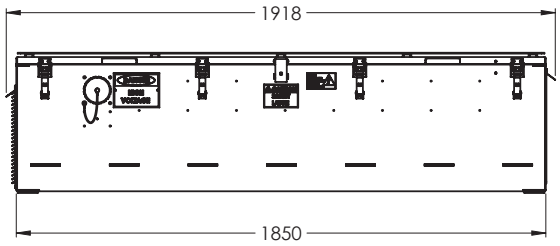
PSM-69ST2

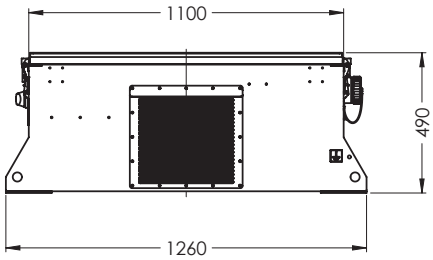
Static Converter

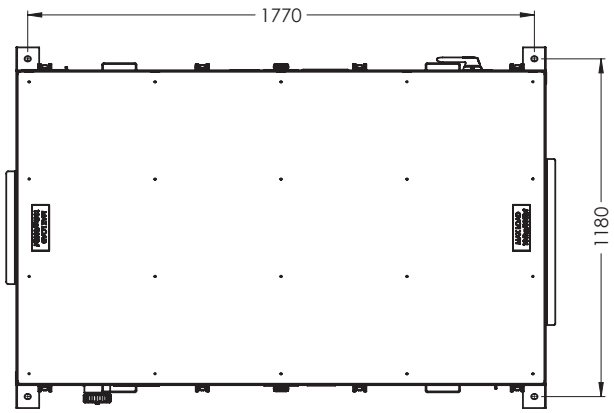
Block diagram



Housing







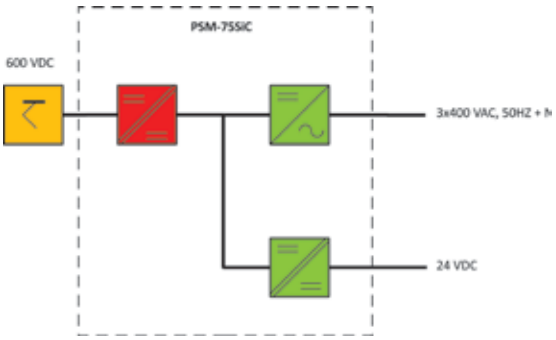
PSM-75SiC

Static Converter

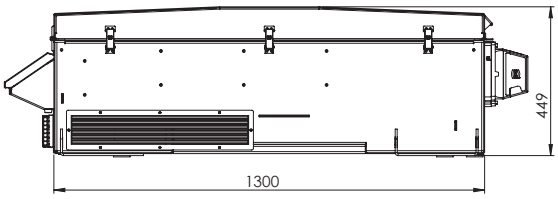
The PSM-75SiC static converter has been designed to convert DC voltage of the 600 VDC traction into 24 VDC voltage as well as into 3×400 VAC voltage, needed to supply the auxiliary circuitry in the tram system, driver's air conditioning and car ventilation. The very lightweight, extremely efficient converter is based on SiC technology.

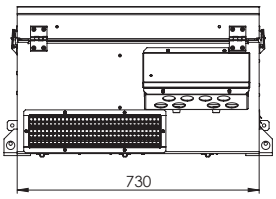
Specification	
Input voltage	**400–900 VDC**
Operating range of input voltage	**360÷1000 VDC**
Total power	**75 kVA**
Output DC	**27,5 V/10 kW**
Voltage stability DC	**< 1%**
Voltage ripple DC	**< 1 Vpp (at rated load)**
Output AC	**3×400 V/65 kVA, cos φ = 0,9**
Voltage stability AC	**≤ ±5%**
Frequency regulation	**≤ ±0,1%**
Harmonics content (THD)	**≤ 8%**
Max. current of neutral wire	**29 A**
Efficiency	**> 92%**
Ambient temperature	**−30 ÷ +40°C**
Protection ratio	**IP23 / IP56**
Weight	**260 kg**
Dimensions (H×W×D)	**450×1300×810 mm**

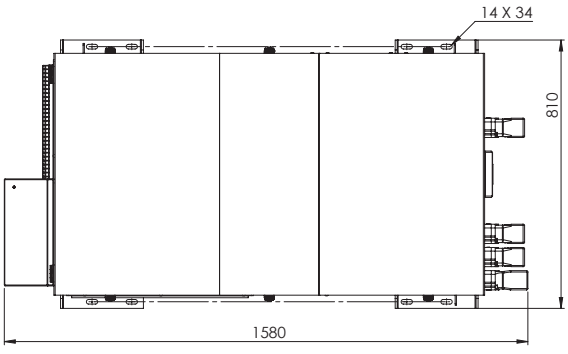
Block diagram



Housing

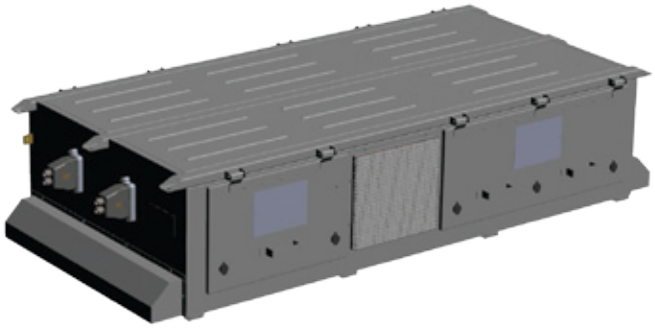






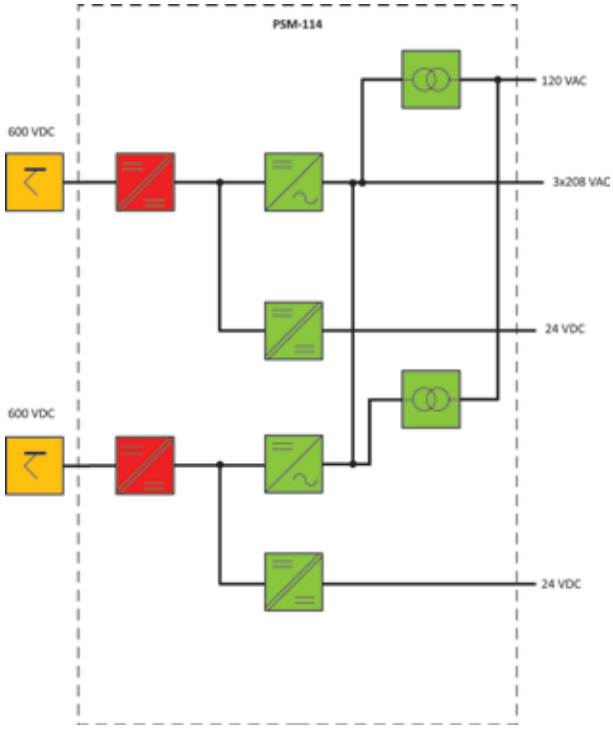
PSM-114

Static Converter



Static converter PSM-114 is a fully automated device designed for converting traction power supply voltage 750 VDC to 28 VDC voltage of auxiliary circuits, 3×208 V/60 Hz and batteries charging. The device uses technique of multiple conversion of energy. Constant voltage from the over-head line (750 V) is converted into HF alternating voltage, and then transformed and rectified to obtain low-voltages (voltage inverter and the output voltage of 28 V). 28 V output voltage is adjusted to the charge status of the battery cooperating with the converter so that the charging current of the connected battery is not exceeded. In the case of overload of the converter an internal current limit circuit operates.
PSM-114 converter is mounted under frame of LRV S200 car. Access to its components is provided on the side of the vehicle, after removing the side flaps and bottom covers (applies to main fans).

Block diagram

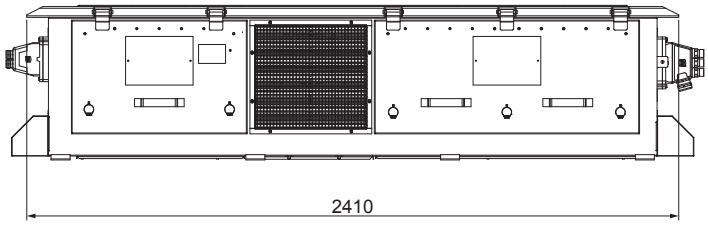


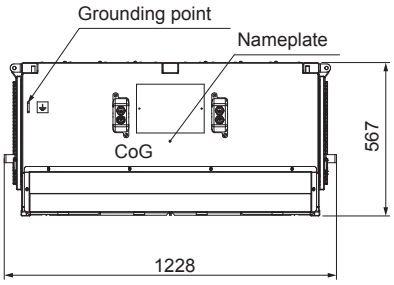
Specification		
Input voltage	**660 VDC**	
Operating range	**420÷1100 VDC**	
Total power	**114 kVA**	
Output DC1	**28,6 V/7 kW**	
Output DC2	**28,6 V/7 kW**	
Additional parameters of DC outputs	**In = 250 A; thermal voltage compensation; Electronic protection (overload shortcircuit)**	
DC output stability	**< 1%**	
DC voltage ripples	**< 1 Vpp (at rated load)**	
Output AC1	**3×208 V/90 kVA**	
Output AC2	**120 V/10 kVA**	
AC output stability	**≤ ±5%**	
Overall efficiency	**> 88%**	
Ambient temperature	**-40 ÷ +47°C**	
Protection degree	**Dirty zone** **Clean zone**	**IP20** **IP64**
Weight	**765 kg**	
Dimensions (H×W×D)	**567×1100×2410 mm**	

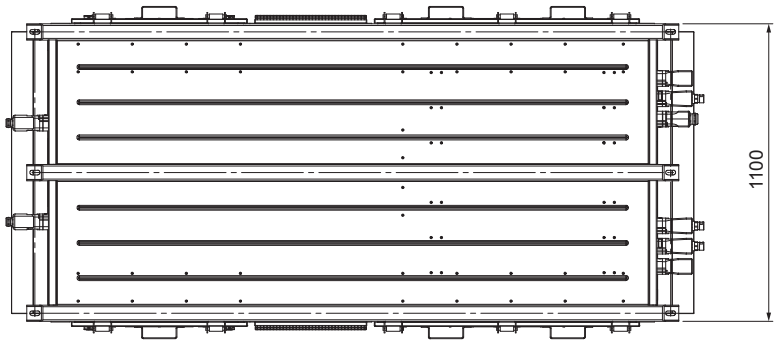
PSM-114

Static Converter

Housing







PSM-114SD9

Static Converter

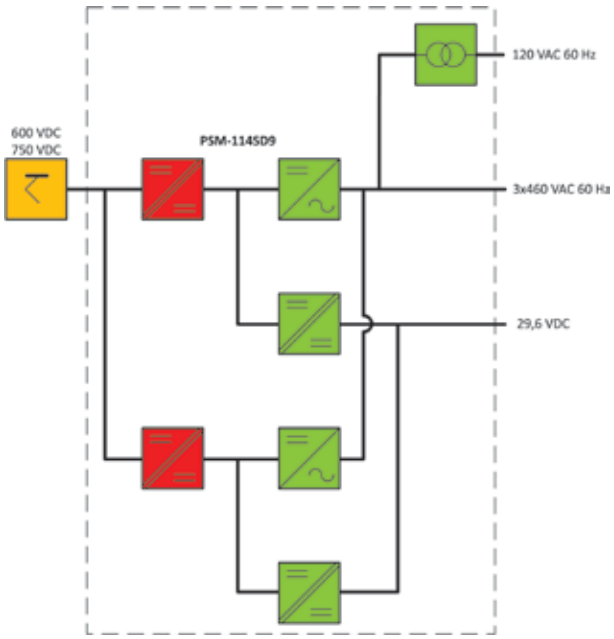
The static converter PSM-114SD9 is a fully automated device designed for converting the traction power supply voltage 750/600 Vdc to the 29.6 Vdc voltage of auxiliary circuits, 3×460 Vac / 60 Hz and batteries charging. The device uses the technique of the multiple conversion of energy. The constant voltage from the over-head line (600/750 V) is converted into an HF alternating voltage, and then transformed and rectified to obtain low-voltages (with a voltage inverter and the output voltage of 29.6 V). The 29.6 V output voltage is adjusted to the charge status of the battery cooperating with the converter so that the charging current of the connected battery is not exceeded. In the case of overload of the converter an internal current limit circuit operates.
The PSM-114SD9 converter is mounted on the roof of the LRV car. Access to its components is provided after removal of the cover or side grilles (for the line choke or fan).
The main function of the APS for this project is to convert from the 600/750 VDC catenary power supply to the three-phase 460 VAC, single phase 120 VAC 60Hz and 29.6 VDC and to provide the three-phase voltage to AC loads and to provide the 29.6 VDC to the DC load and to charge the battery.
In addition to this main function, the APS has various functions for protection, support of diagnosis, and support maintenance.

The functions of the APS are shown as follows:

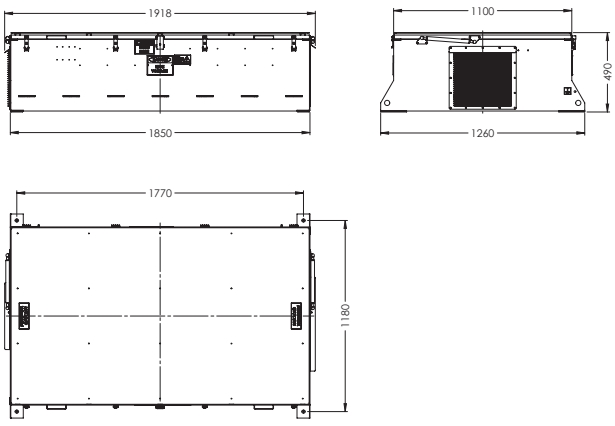
- AC output voltage control
- DC output voltage control
- Battery discharging current
- Start and stop logic
- Protections
- Fault data
- Portable Test Unit (PTU) functions
- Train Network Communication

PSM-114SD9		
Input voltage	**600/750 VDC**	
Output power	**114 kW**	
DC Output	**29,6 VDC 14 kW**	
AC Output 1	**3×460 VAC 60 Hz 90 kVA**	
AC Output 2	**120 VAC 60 Hz 10 kVA**	
Housing		
Cooling method	**forced-air**	
Weight	**488 kg**	
Dimensions	**1918×1260×490 mm**	
Protection ratio	**Clean section**	**IP55**
	Dirty section	**IP20**

Block diagram



Housing



PSM-130MS

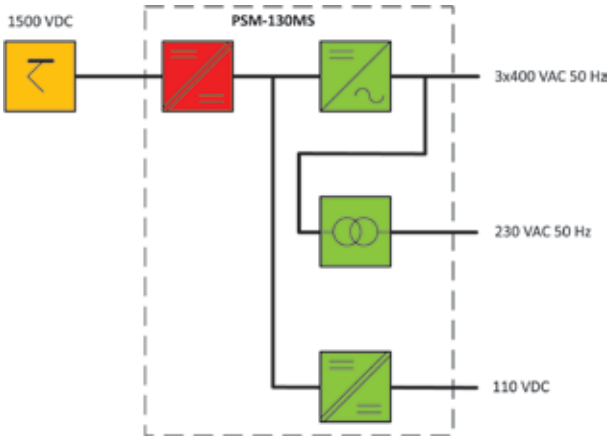
Static Converter

The on-board auxiliary power supply system is energized by two auxiliary inverters (AUX) in the Metro cars. The primary circuit of the auxiliary inverters is connected directly to the 1500 VDC main circuit. The auxiliary inverter in the Metro car is supplied by the neighbouring motor car.
Each auxiliary inverter includes a three-phase inverter and DC/DC converter (battery charger).
The auxiliary inverter has the following outputs (with galvanic insulation to the input):

- 3×400 V AC for auxiliary components (air compressor, traction container fans, cab and passenger HVAC)
- 230 V AC only for sockets
- 110 V DC for the battery charger, control supply, lighting, ventilation of passenger compartments and ventilation of HVAC cab.

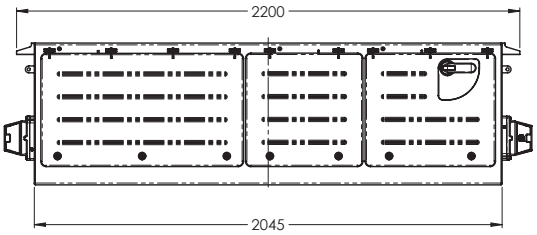
The auxiliary inverter is mounted on the underframe of the Metro car. Access to the components of the inverter is provided on the side of the vehicle, after removing the maintenance flaps.
The auxiliary inverter is designed to convert the incoming DC voltage to the DC voltage (110 V) and AC (3×400 V, 230 V) necessary in low-voltage train installations.
The inverter is designed to work with the MVB bus control. It is also fitted with the Ethernet bus, used for equipment diagnostics. The inverter is equipped with an auto-start system (in the presence of HV voltage) and a pre-charge circuit, limiting the inrush current.
The inverter is started by the MVB bus control signals.

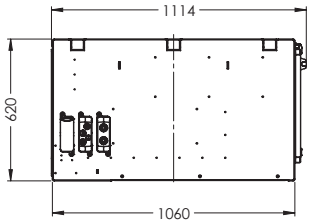
Block diagram

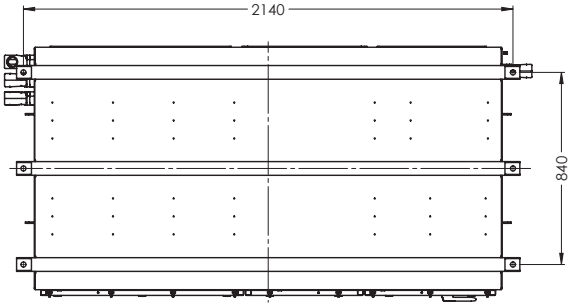


PSM-130MS		
Input voltage	**1500 VDC**	
Output power	**130 kW**	
DC Output	**110 VDC / 30 kW**	
AC Output 1	**3×400 V / 50 Hz / 97 kVA**	
AC Output 2	**230 V / 50 Hz / 3 kVA**	
Housing		
Cooling method	**forced-air**	
Weight	**655 kg**	
Dimensions	**2200×1114×620 mm**	
Protection ratio	**Clean section**	**IP 55**

Housing







PSM-132

Static Converter

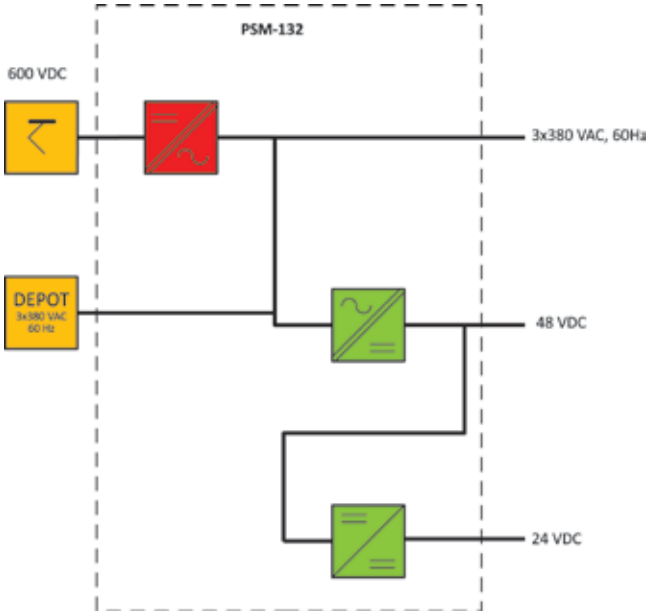
The PSM-132 static converter has been designed to convert DC voltage of the 750 VDC metro traction into 3×380 VAC 60 Hz AC voltage, applied in the low voltage systems of metro, used to supply the auxiliary circuitry in the metro system, air conditioning and DC loads.

Specification	
Input voltage	**750 VDC**
Operating input voltage	**500–1000 VDC**
Depot input voltage	**3×380 VAC/60 Hz***
Overvoltage protection	**MOV, SCR Crowbar**
Output voltage DC1	**48 V (45–52 V)***
P = 15 kW, In = 270 A; Voltage stability ±1%; Battery current regulator 0.1–1 In; Voltage ripples < 2%; Voltage thermal compensation	
Output voltage DC2	**24 VDC**
P = 1 kW; In = 42 A; Voltage stability ±3%; Voltage ripples < 2% ; Electronic short circuit protection	
Output voltage AC	**3×380 V/60 Hz**
S = 117 kVA; Overload capacity 2×In/3 s (200%/3 s); Voltage stability ±5%; Frequency stability ±1%; Output wave shape sinusoidal; THD(u) < 5%; Electronic short circuit protection	
Total output power	**132 kW**
Total efficiency	**≥ 92%**
* other voltages on request	
Protection • overload protection • overcurrent protection • overtemperature protection • protection against short circuit	
Monitoring	**CANopen, MVB**
Mounting	**under the frame**
Cooling	**forced-air**
Ambient temperature	**–25 ÷ +45°C**
Protection ratio	**IP55/IP20**
Weight	**1050 kg**
Dimensions	**2180×1000×600 mm**

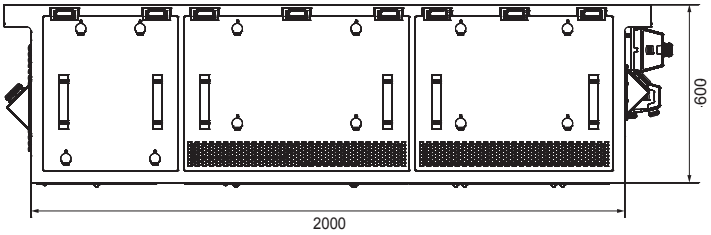
PSM-132

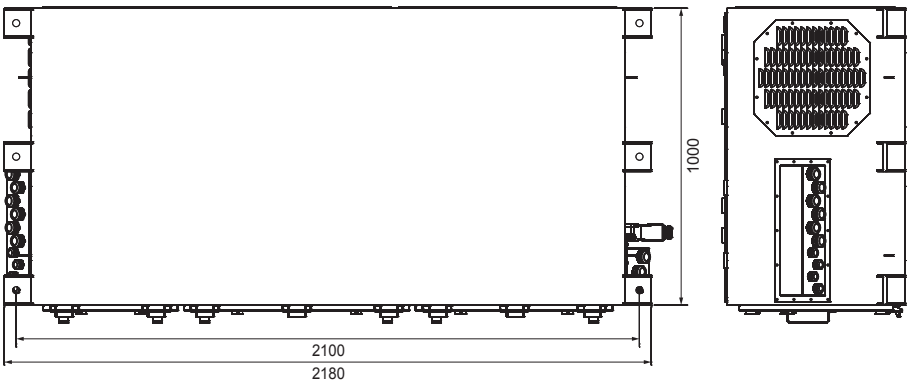
Static Converter

Block diagram



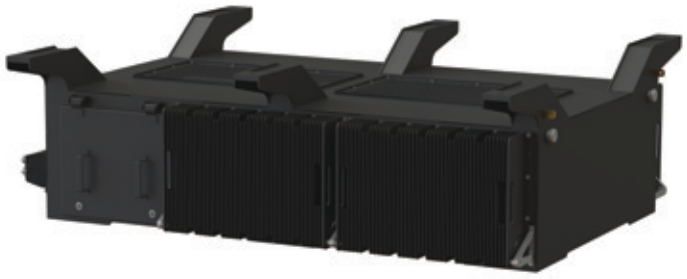
Housing





PSM-145 SiC

Static Converter



The MEDCOM Auxiliary Power Unit PSM-145 SiC is designed with the application of state-of-the-art modern solutions provided by the world's technology: IGBT and SiC modules, Digital Signal Processors, modern magnetic materials, resin stabilization and others. The modern technological and circuitry solution provides excellent output parameters.
The converter's maintenance is optimized, and automatic control systems monitor the states of the outputs and protect them against overloads or short circuits. Every fault state is detected and followed by an appropriate alarm signal.
The controls of the converter are performed in DSP (Digital Signal Processor) technology.
The system is characterized by a low level of harmonics distortion in the output voltage, very high efficiency and high overload capability.
The applied bus-bar system in combination with a perfect IGBT and SiC driver guarantees a failure free performance on short-circuits and eliminates the possibility of secondary damages in case of transistor failure.
The applied polypropylene capacitors ensure a long service lifetime and resistance of the system against voltage changes in the traction network. The capacitor operating current is over-dimensioned with reference to the max operating current and the capacitors are doubled to lower the real value of current across the element. An additional mechanical protection cover suppressing the explosion energy is added. The converters meet the international and EN standards in safety and electromagnetic compatibility.
The system provides a very low level of interferences emitted to the traction network and loads.
The converters are equipped with a natural air-cooling system to cool down power elements (IGBT and SiC).
The system operates within a wide range of external temperatures.
The diagnostics and control of the converters are provided via the defined interface.

HV circuit

The input is equipped with a pre-charge system (U1), which limits the inrush converter current resulting from charging of the internal capacitors. The input voltage through the bridge rectifier (to handle reverse polarity of input voltage) LC filter (U2) is fed to the DC/DC chopper converter (U3) built on IGBT technology. The output of the DC/DC chopper converter is connected to the DC/DC resonant converter (U4) built on SiC technology which creates the intermediate DC voltage used by the output converters. The output voltage DC/DC resonant converter is stabilized, which allows normal operation within a wide range of input line voltages. The output voltage is designed in an optimal range which allows using SiC transistors with very low commutation losses.

3AC circuit (based on SiC technology)

From the voltage supplied by the resonant DC/DC converter (U4) the output inverter (U5) creates 3×380 V 50 Hz voltage.
The 3AC inverter (U5) is a typical 4 branch DC/AC design using SiC modules. The DC input voltage of the inverter is constant, which provides a zero-switching current mode in all conditions. The 3-phase output LC filter eliminates HF components on the output. The 3AC circuit is fitted with an output contactor.
The AC output of the converter is:

- protected from short circuits and overloads by an electronic control system of the inverter
- connected to the train's AC network through a three-phase contactor
- protected against over-voltage and under-voltage (reconnection is automatic)

DC output (based on SiC technology)

The DC link voltage converter (U7) provides 110 V DC output. The charger block contains transformers ensuring galvanic insulation. The output of 110 V DC is provided by the DC/DC converter, made with SiC modules, the output transformer and rectifier. The filtered output voltage is in the 77-137.5 V range.
The DC output of the converter is:

- protected from short circuits and overloads by an electronic control system
- protected against over-voltage and under-voltage (reconnection is automatic)

The control system monitors the output current by adjusting the output voltage. Increase in the output current above the nominal value in the event of an overload or short circuit reduces the output voltage and causes stabilization of the maximum current.
The output voltage is limited by the converter to prevent the overload risk to the battery circuit.
The charger control system has electronic protection against short circuits and overloads. In the case of short circuit or overload, the power supply current regulator lowers the DC output voltage and the output current is stabilized so as not to exceed the maximum current power supply.

NOTE

Thanks to the applied parallel structure of the power converter, the DC output and AC outputs are powered independently and failure in one of them does not block the operation of the other.

Control system

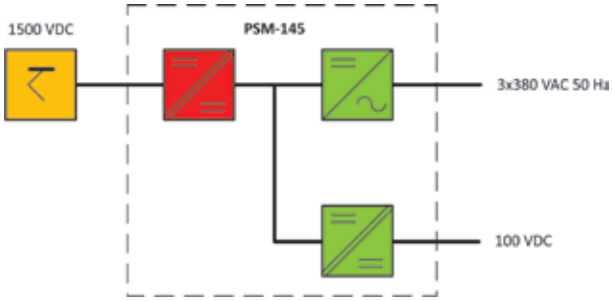
The microprocessor control block (U8) ensures proper operation of the converter in a wide range of supply voltage used in the traction grid. It also controls the alarm signals of the DC and 3AC outputs.
The control of the converter is performed in DSP (Digital Signal Processor) technology. The system is characterized by a low level of harmonics distortion in the output voltage, very high efficiency and high overload capability. The applied bus-bar system in combination with IGBT and SiC technology guarantees a failure-free performance upon short-circuits and eliminates the possibility of secondary damages in case of transistor failure. The applied polypropylene capacitors ensure a long service lifetime and resistance of the system against voltage changes in the traction network. The transistor soft crowbar protects the inverter system. The converter meets the international and EN standards in safety and electromagnetic compatibility. The system provides a very low level of interferences emitted to the traction network and loads.

PSM-145 SiC

Static Converter

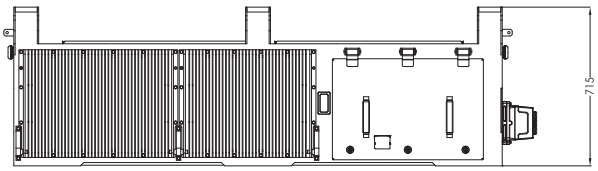
Inverter control is implemented through hardwire signals. In addition, the converter is equipped with an Ethernet interface (CAN-ETH module).
Owing to the application of the latest generation single-chip microprocessors, IGBTs and SiC technology, the converter delivers a sinusoidal voltage on its output with low harmonics contents. In case of supplying the electric motors, this feature is advantageous (as compared to power supplies with square or trapezoidal output waveforms) because it significantly reduces power losses in the motors.
The control system ensures high frequency stability, very good phase symmetry of the output voltage and very low level of interference generated by the system.
The semiconductor components are selected with a high margin that enables high overload of the system.
The device requires simple maintenance – the control system tests the states of the output terminals and protects the converter in case of prolonged overload or short-circuit.
The converter is equipped with a dead battery system (U6 – DBS) that enables a converter start when input high voltage is present but the coach battery is flat.

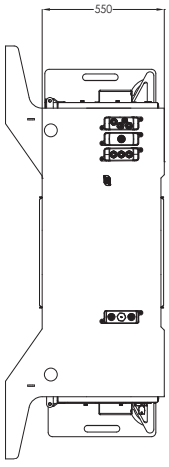
Block diagram

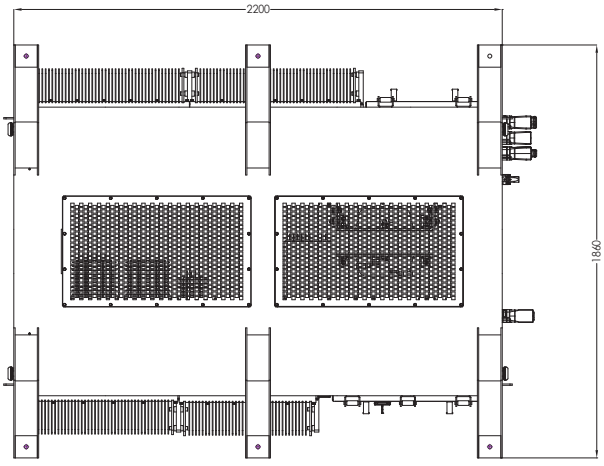


PSM-145		
Input voltage	**1500 VDC**	
DC Output	**110 VDC / 25 kW**	
AC Output	**3x380 V / 50 Hz / 120 kVA**	
Housing		
Cooling method	**Natural air cooling**	
Weight	**820 kg**	
Dimensions	**2200×1800×715 mm**	
Protection ratio	**Clean section**	**IP 54**

Housing







UOE-60S

Battery Power Supply for Propulsion Drives

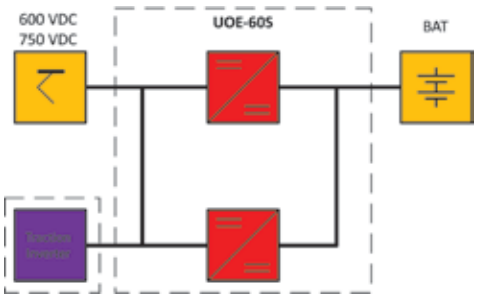
Energy Storage Battery Charger UOE-60S is a fully automated device designed for converting traction power supply voltage 600/750 VDC to the battery voltage for charging and back, to convert battery voltage to the traction voltage level. Battery is charged by constant value of current up to the full charge statement. Back conversion, from battery to traction voltage is done while battery voltage is higher than bottom limit, as determined by the battery manufacturer. In the case of overload of the converter an internal current limit circuit activates.

UOE-60S is prepared to be mounted on the roof of the vehicle. Access to its components is provided by upper cover or via dismounting of the side co-vers.

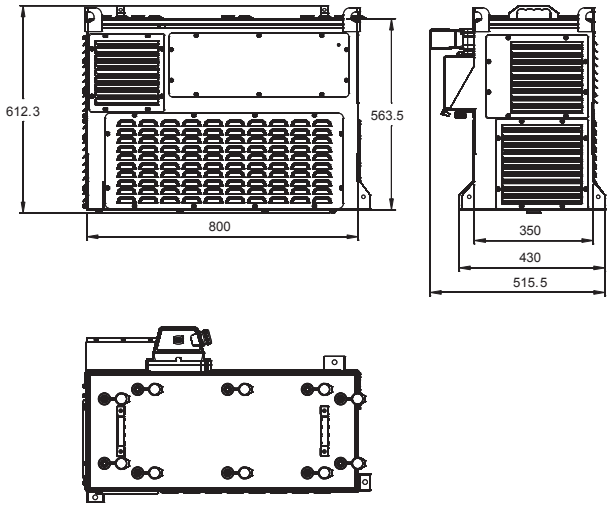
In 2014, Medcom, together with Siemens Rail Sys-tems USA and Corvus, broke the Guinness World Record for the longest distance travelled by a battery-powered tram. On 15 July 2014, on the San Diego Green Line, a controlled and supervised test was performed todrive the vehicle as far as possible on a single electrical charge. The result was stunning – 24.596 km (15.283 miles) with a maximum speed of 40 km/h – and was certified as a Guinness World Record, for the “longest distance travelled in 24 hours by a battery po-wered tram on a single charge”.

This result improved on the previous record by one-third.

Block diagram



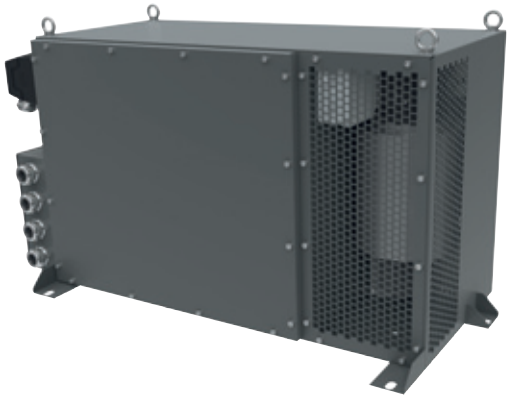
Housing



Specification	
Input parameters	
Input voltage	**600/750 VDC**
Input protection	**internal protection**
Overvoltage protection	**OV3 class**
Operating temperature	**–40 ÷ +45°C**
Start of operation	**–40 ÷ +85°C**
Storage/Transportation	**–40 ÷ +75°C**
Output power	**60 kW continuous** **160 kW/20 s**
General efficiency	**≥ 92%**
Protection class	**IP55**
Mass	**ca. 146 kg ±10%**
Dimensions	**800×515.5×612.3 mm**
Output parameters	
Rated voltage	**355 VDC**
Output current	**150 A**
Output power	**60 kW**
Voltage stability (static)	**±1.5%**
Current overload	**400 A 20 s**
Short circuit protection	**yes**
Current stability	**±5%**
Battery charging methods	**constant voltage,** **current limited**
Supply parameters	
Rated voltage	**24 VDC**
Operating voltage	**16.8–30 VDC**
Power supply	**max 120 W**

UOE-01

Ultracapacitor Energy Recovery Unit



Ultracapacitor Energy Recovery Unit UOE-01 is a sophisticated device that enables you to use your energy in the most efficient way. The idea behind the device assumes rapid energy storage through braking energy recovery of a light rail or metro train that is in motion. UOE-01 can be installed on a vehicle or in a substation and its main benefit is the reduction of grid power consumption (energy consumption up to 30 % and peak power demand up to 50 %). This is followed by energy reuse for acceleration and bridging of non-powered sections. Application of the UOE-01 allows for exploitation of larger or heavier trains with the possibility of more trains simultaneously running in the same network.

The UEO-01 is based on supercapacitors as the main energy storage unit. Heavy transportation vehicles have special demand for energy storage devices. These are first of all robustness and reliability, long lifetime and low maintenance requirements. Such energy recovery devices must be able to efficiently deliver high peak currents in difficult conditions. The operational duty cycle is high and the level of frequent discharges is deep. Additionally, the device should be easy to integrate with the construction of the vehicle.

Its main advantage in the case of trams and trains is that their primary energy demand can be reduced largely, which is reflected in longer or higher performance of the vehicles on an existing track. Moreover, energy recovery unit can be also used to cope with peak power demands.

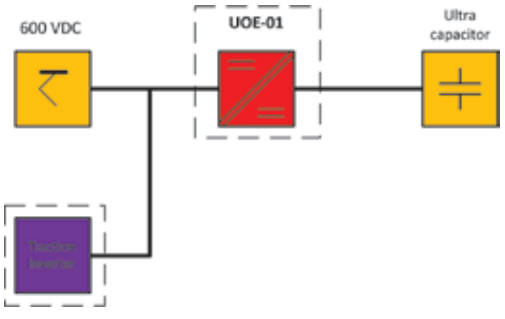
The technical solution is based on a DC-DC converter and a bank of ultracapacitors. To make the design as simple as possible, which is reflected in higher reliability, the DC-DC constant current regulator is the most straightforward form of active charging. Such a DC-DC converter may come in two forms, either as a boost or buck regulator, depending on application. Because the load on track varies quickly ultracapacitors, which can be charged and discharged fast and most importantly at the same rates as opposed to classic battery, are a perfect choice. This is very useful in energy recovery systems applied in electrodynamic braking.

Main advantages of ultracapacitors as energy storage devices are:

- high efficiency,
- high current capability,
- wide temperature range – unlike traditional batteries whose capacity varies with temperature,
- wide voltage range – possible operation in series,
- condition monitoring – state of charge and health,
- long life cycle – 10^7 cycles,
- long operational life – 10 years,
- ease of maintenance – practically maintenance free.

Specification	
Control method	**PWM controlled chopper converter**
Nominal traction supply voltage	**600 VDC**
Traction supply voltage tolerance	**+25 ÷ –25%**
UCM ultracapacitors nominal voltage	**3×125 = 375 VDC**
Ultracapacitors supply voltage tolerance	**+4 ÷ –50%**
Auxiliary supply voltage 1	**24 VDC**
Auxiliary supply voltage 1 tolerance	**+25 ÷ –30%**
Auxiliary supply voltage 2	**230 VAC 50 Hz**
Auxiliary supply voltage 2 tolerance	**+10 ÷ –10%**
Supply voltage at the UCM ultracapacitors battery	**U_{min} 187 VDC** **U_{max} 390 VDC**
Voltage at the Udc inverter	**Udc_{min} 650 VDC** **Udc_{max} 650 VDC**
Driving with the ultracapacitors battery	
Discharging the ultracapacitors battery	
Maximum instantaneous current	**300 A**
Recuperation to the ultracapacitors battery	
Charging the ultracapacitors battery – recuperation current	**Maximum instantaneous 300 A**
Nominal power	**100 kW**
PWM frequency	**2 kHz**
Cooling	**forced-air**
Protection ratio	**IP65**
Weight	**130 kg**
Dimensions	**800×350×480 mm**

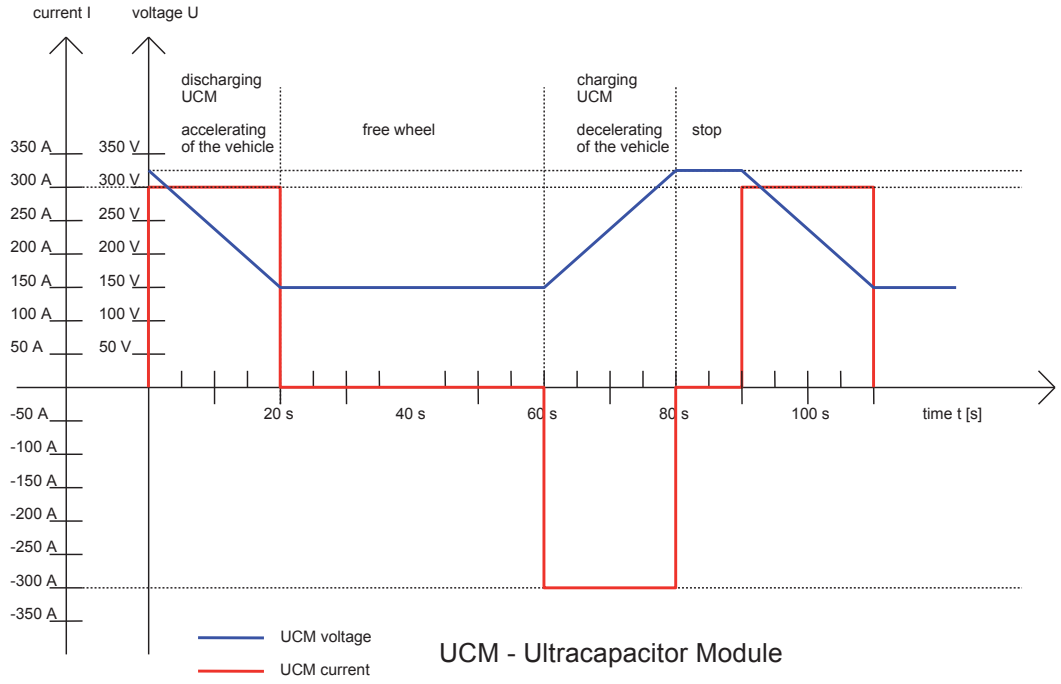
Block diagram



UOE-01

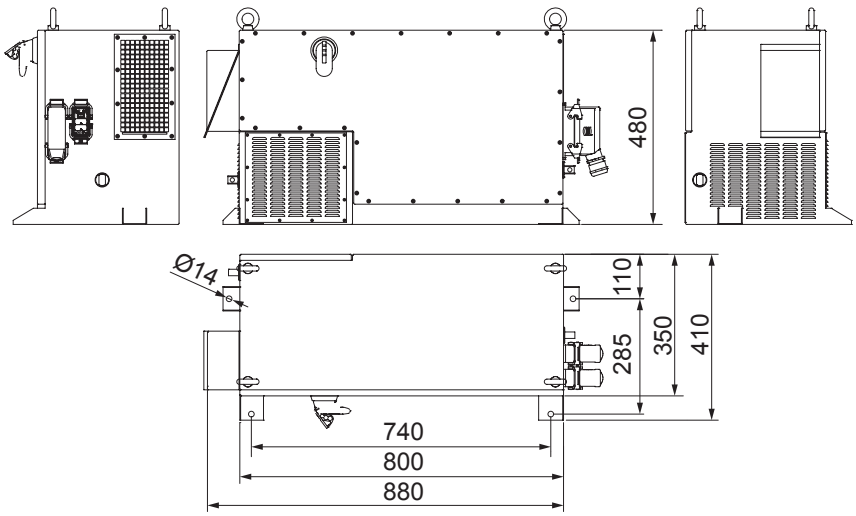
Ultracapacitor Energy Recovery Unit

Current and voltage courses at the ultracapacitor system



UCM - Ultracapacitor Module

Housing



UOE-02

Ultracapacitor Energy Recovery Unit

Electrical parameters	
Type	**UOE-02**
Nominal catenary voltage	**600 VDC (750 VDC)**
Maximum catenary voltage	**850 VDC (1000 VDC)**
Catenary voltage tolerance	**+25 ÷ –25%**
Average power	**100 kW**
Maximum power	**360 kW**
Auxiliary voltage 1	**24 VDC**
Tolerance of auxiliary voltage 1	**+25 ÷ –30%**
Auxiliary voltage 2	**3×400 VAC, 50 Hz**
Stored energy	**1 kWh**
Nominal capacity of super capacitor bank	**20–60 F**

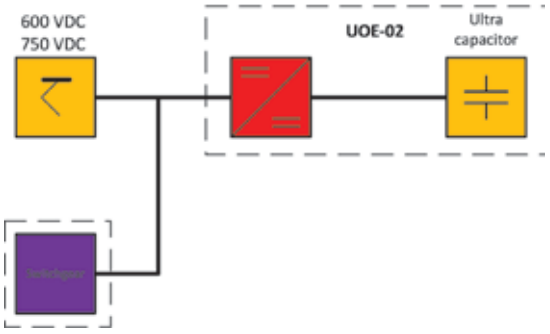
Insulation strength	
Power supply circuit of UOE-02 to housing	**4.0 kV 50 Hz 1 min**
Control circuit to housing	**0.5 kV 50 Hz 1 min**
Ultracapacitors bank to housing	**4.0 kV 50 Hz 1 min**
Cooling	**forced-air**
Degree of protection (clean/dirty zone)	**IP65/IP23**
Weight	**640 kg**
Dimensions (length×width×height)	**2054×1639×472 mm**

Energy recovery system UOE-02 with banks of supercapacitors are used to recovery LRV braking energy and storage them in supercapacitors. Storage energy is used to supply auxiliary circuit on LRV during stand or it is consumed by traction inverter during start-up of LRV. When emergency driving is required, energy stored in supercapacitors can be also consumed by propulsion system (eg. in case of no catenary voltage appearance).

UOE-02 is equipped with a CAN communication interface. Energy regeneration system communicates with the traction inverter and, on the base of the data received about torque and vehicle speed, starts charging or discharging supercapacitors. Information about the operating mode, alarms and measured parameters in energy recovery system are transmitted to the driver's control panel.

System is mounted on the roof of vehicle. System and super capacitors are forcing air-cooled. Energy recovery system is designed to operate in ambient temperatures of –40°C to +50°C.

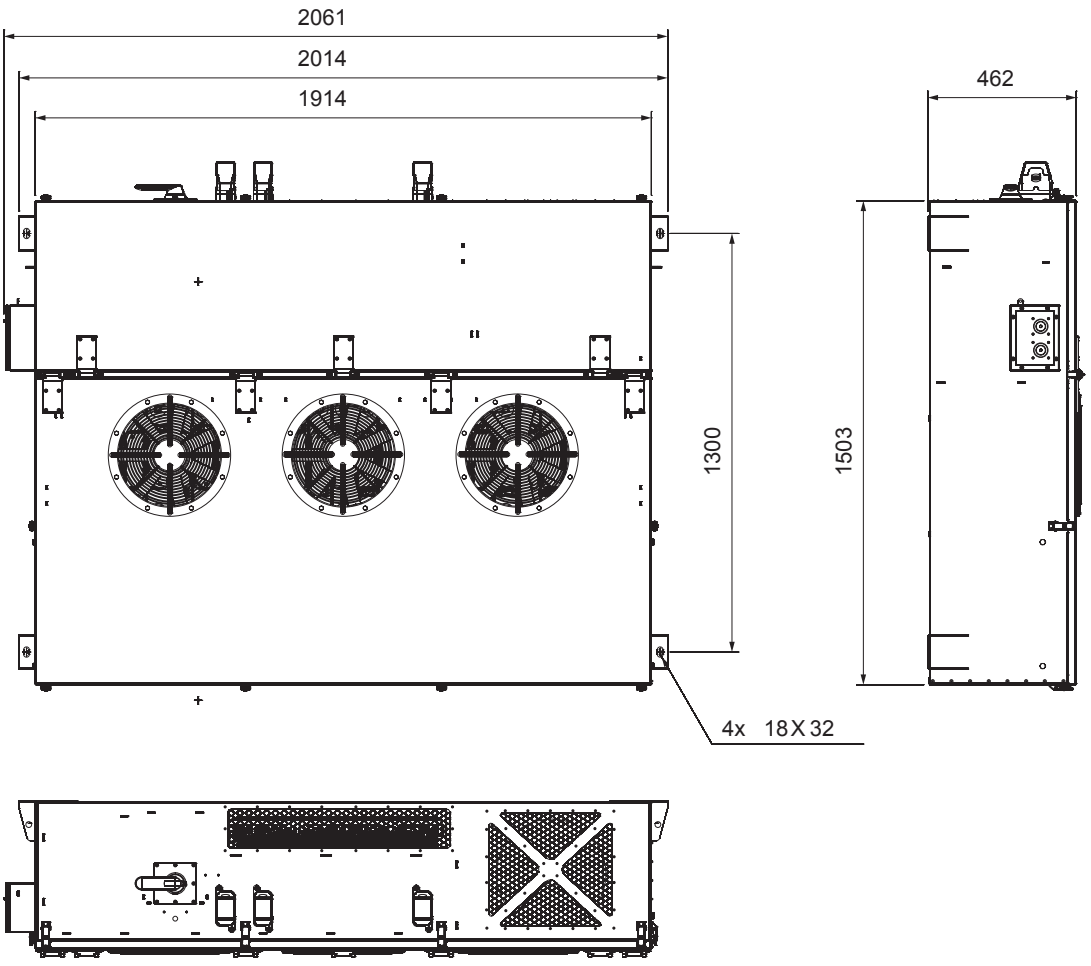
Block diagram



UOE-02

Ultracapacitor Energy Recovery Unit

Housing



OESS-100S

Onboard Energy Storage System

MEDCOM OESS-100S for the application in LRVs has been designed with the application of state-of-the-art modern solutions provided by the world's technology: IGBT modules, Digital Signal Processors, modern magnetic materials, resin stabilization and others. Its modern technological and circuitry solution provides excellent output parameters.

The MEDCOM OESS-100S is powered from the DC line (750 VDC). Using power conversion technology and modern PWM algorithms, the LTO battery is charging and discharging depending on the state of the operation.

MEDCOM OESS-100S for the application in LRVs has been designed with the application of state-of-the-art modern solutions provided by the world's technology: IGBT modules, Digital Signal Processors, modern magnetic materials, resin stabilization and others. The modern technological and circuitry solution provides excellent output parameters.

Basic features of the MEDCOM OESS-100S:

- The controls of the converter are performed in DSP (Digital Signal Processor) technology.
- The applied bus-bar system in combination with a perfect IGBT driver guarantees a failure free performance upon short-circuits and eliminates the possibility of secondary damages in case of transistor failure.
- The applied polypropylene capacitors ensure a long service lifetime and resistance of the system against voltage changes in the traction network.
- The converters meet the international and EN standards in safety and electromagnetic compatibility.
- The system provides a very low level of interferences emitted to the traction network and loads.
- The converters are equipped with a liquid cooling system which operates within a wide range of external temperatures.
- The diagnostics and control of the converters are provided via a defined interface.

The system input is equipped with a manual CD1 disconnector that disconnects the OESS-100S system from the power supply (insulation break). Behind the switch, the common input signal is divided into two redundant DC/DC systems. Each system is protected by fuses and is equipped with a pre-charging system to prevent any inrush current. The pre-charge system is monitored and controlled by the DSP (control unit). Behind the pre-charge system LC filters are provided, independent for each system.

The bidirectional DC/DC converter was built on IGBT technology. Two branches of choppers are charged and discharged according to the operating mode. At the battery output, LC filters and pre-charge to prevent an inrush current from the battery side are installed. Batteries are protected by fuses in both poles. The battery disconnectors BD1 and BD2 allow disconnecting the battery from the converter.

Each battery works with one DC/DC converter. The DSP communicates with the BMS, which protects the battery from damage in case of for example a high battery temperature.

Both converters communicate with each other and implement a digital algorithm for balancing the battery currents. This ensures even battery charging.

Two cooling units assigned to each converter are responsible for cooling of the system.

A microprocessor control block ensures proper operation of the converter in a wide range of supply voltage used in the traction grid. The control of the converter is performed in DSP (Digital Signal Processor) technology.

The converter meets the international and EN standards in safety and electromagnetic compatibility. The system provides a very low level of interferences emitted to the traction network and loads.
MEDCOM OESS-100S is supplied from the DC line (750 VDC). Using power conversion technology and modern PWM algorithms, the LTO battery is charging and discharging depending on the state of the operation.

The OESS system is designed to charge a chemical battery and to use the energy stored in a battery for autonomous driving (with a lowered pantograph).

Depending on the permissible load of the catenary, the system adjusts the charging parameters of the battery so that it does not exceed the permissible power input of the vehicle.

During drive from the catenary, the battery is charged with a nominal current. When vehicle braking is detected, the charging current is increased twice for a time of 10 s to allow the energy to be received from the electrodynamic braking. At the start-up time, the battery charging current is limited to 0.5 In.

Upon receipt of information on the necessity of driving with the lowered pantograph, the bidirectional converter goes into battery discharge mode and generates on the supply terminals a voltage of 750 V. In the lowered pantograph driving mode, the battery is charged when the recuperation braking is detected. During a stop of the vehicle, the battery charging current is limited to 0.5In to limit the pantograph current.

The converter works with BMS and adjusts the charging / discharging parameters for information sent from the BMS. This is to protect the battery from damage.

The converter is protected from the input side by a fuse and has electronic overload protection. The batteries too are protected by fuses. For maintenance work, the energy storage system can be disconnected using a service disconnect switch. This ensures the isolation of both battery poles from the remaining electrical circuits of the vehicle.

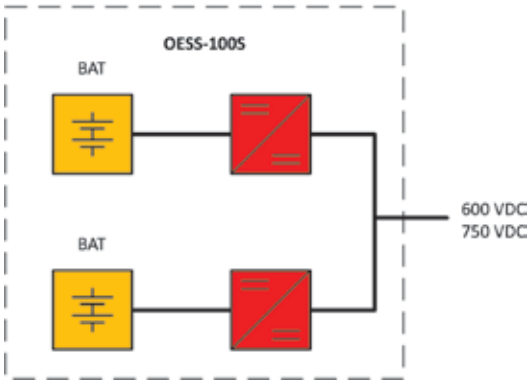
OESS-100S

Onboard Energy Storage System

The battery charger maintenance is optimized, and automatic control systems monitor the states of the outputs and protect them against overloads or short circuits. Every fault state is detected and followed by an appropriate alarm signal sent through the gateway to the MVB network.

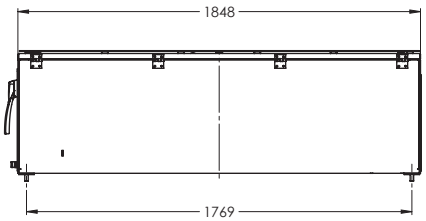
Redundancy concept
The OESS include two completely independent subsystems, each capable of supplying power / charging at half of the rate of the entire OESS. A single point failure never leads to a 100% failure but only to a 50% power / capacity reduction. This also includes single point failures of the control electronics, sensors, and cooling / chiller components. A single point failure in the cooling system does not lead to a failure of both the independent OESS subsystems.

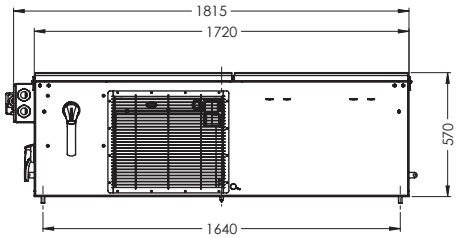
Block diagram

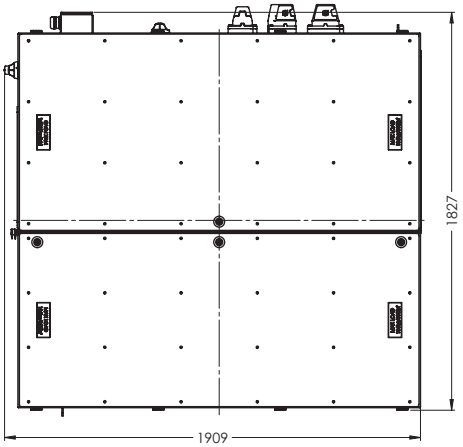


OESS-100S		
Input / Output voltage	**600/750 VDC**	
Rated power	**2×100 kW**	
Battery type	**LTO**	
Housing		
Cooling method	**Forced-liquid**	
Weight	**1560 kg**	
Dimensions	**1860×1844×563 mm**	
Protection ratio	**Clean section**	**IP 55**
	Dirty section	**IP 21**

Housing







EBC-40M

Battery Chargers for eBuses

MAINTENANCE / MOBILE CHARGERS

Mobile devices with power up to 100 kW. Easy operation and compact size. Mobile equipment, fitted with wheels. Charging performed vie CCS Type 2 or CHAdeMO interfaces. The device has a communication interface for remote supervision by the dispatcher.

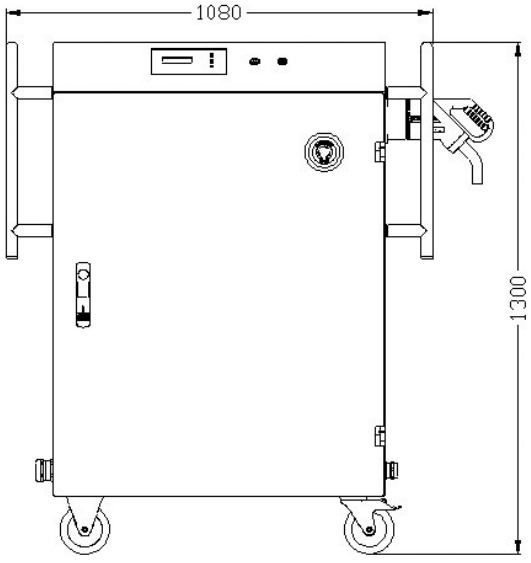
The devices are equipped with:

- LED indicators informing about the charger status
- OLED Operator panel
- Sound signals for completed operation
- Emergency button

Specification of the EBC mobile series chargers	
Catalogue designation	**EBC**
Charging type	**DC**
Rated power of the station [kW]	**30–100**
Maximum charging current [A]	**60-160**
Nominal charging voltage [V]	**50–800 VDC**
Efficiency [%]	**≥95**
THDi [%]	**≤5**
Active power factor cos Φ	**≥0.99**
Operational temperature [°C]	**–30°C ÷ +45°C**
Connector type	**CCS type 2, CHAdeMO**
Ingress protection (IP code)	**IP 54**

Block diagram

Housing



EBC-80S

Battery Chargers for eBuses

STATIONARY PLUG-IN CHARGERS

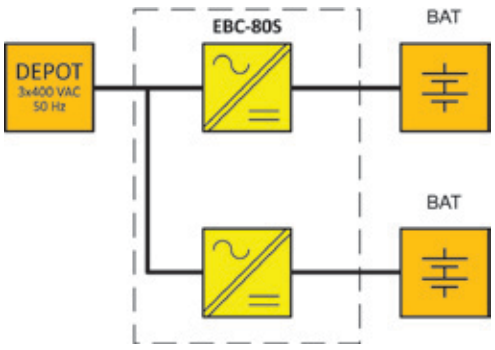
A stand-alone device for simultaneous charging of one or two electric vehicles. Designed for fast DC charging. Available with wireless communication via Wi-Fi, LTE. The monitoring function may be performed via mobile applications with data saving in the cloud, available reporting features and data archiving using OCPP 1.6 or MODBUS TCP.

Similarly to maintenance chargers, the devices are equipped with:

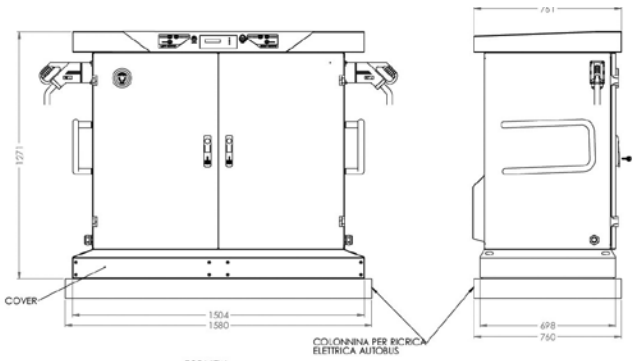
- LED indicators informing about the charger status
- OLED Operator panel
- Sound signals for completed operation
- Emergency button
- Key switch enabling the operation

Specification of the stationary EBC series chargers	
Catalogue designation	**EBC**
Charging type	**direct current (DC)**
Rated power of the station [kW]	**30–150**
Maximum charging current [A]	**60–200**
Nominal charging voltage [V]	**50-800 VDC**
Efficiency [%]	**≥95**
THDi [%]	**≤5**
Active power factor cos Φ	**≥ 0.99**
Operational temperature [°C]	**–30°C ÷ +45°C**
Connector type	**CCS type 2, CHAdeMO**
Ingress protection (IP code)	**IP 54**

Block diagram

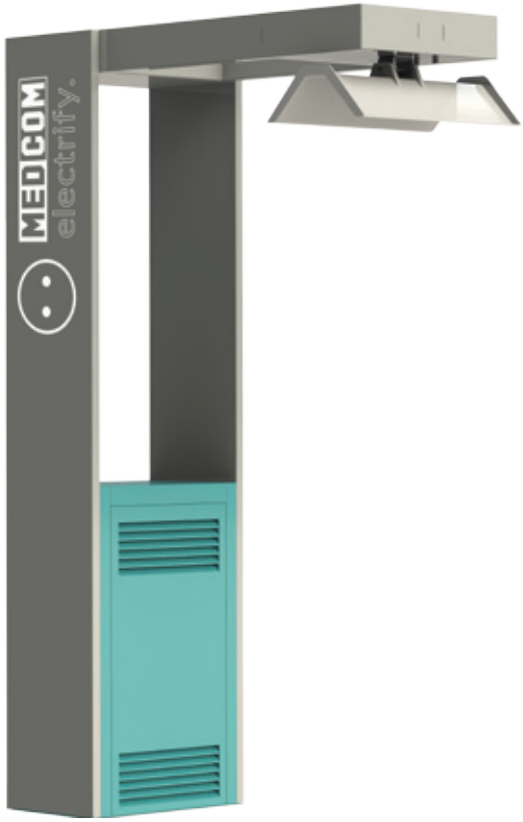


Housing



EBC-180P

Battery Chargers for eBuses



PANTOGRAPH CHARGERS

Fast, modular chargers with a pantograph connector. Completely customised design, the dimensions have not been standardized. The station is designed to charge electric vehicles via the pantograph connector with output power from 150 to 950 kW. It is also equipped with an emergency plug-in connector, up to 200 A. The wireless communication is available via Wi-Fi and LTE. Chargers of this type offer the monitoring function performed via mobile applications with data saving in the cloud, reporting features and data archiving using OCPP 1.6 and MODBUS TCP.

The devices are equipped with:

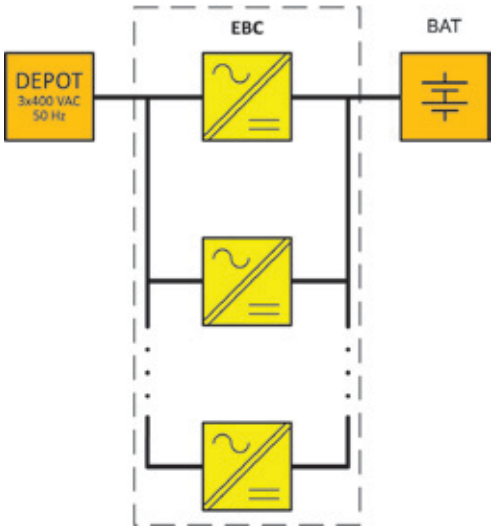
- Light signalling of the power supply
- Signalling the battery charge status
- Communication interface for remote supervision by the dispatcher
- Signalling the battery charge status is installed on the vehicle.

Specification of pantograph EBC series chargers	
Catalogue designation	**EBC**
Charging type	**DC**
Rated power of the station [kW]	**150-950 kW**
Maximum charging current [A]	**1200**
Nominal charging voltage [V]	**200-800 VDC**
Efficiency [%]	**≥95**
THDi [%]	**≤5**
Active power factor cos Φ	**≥ 0.99**
Operational temperature [°C]	**-30°C ÷ +45°C**
Connector type	**pantograph connector, optionally: emergency plug-in connector**
Ingress protection (IP code)	**IP 54**

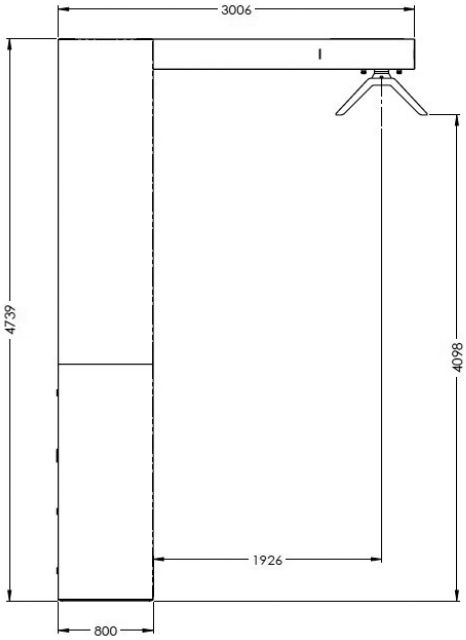
EBC-180P

Battery Chargers for eBuses

Block diagram



Housing



SERIES OF CHARGERS (eBus)

Type		Maximum battery charging current	Maximum charging power
MOBILE CHARGERS	EBC-30M	**60 A**	**30 kW**
	EBC-50M	**80 A**	**50 kW**
	EBC-100M	**160 A**	**100 kW**
STATIONARY CHARGERS	EBC-30S	**60 A**	**30 kW**
	EBC-50S	**80 A**	**50 kW**
	EBC-100S	**160 A**	**100 kW**
	EBC-150S	**200 A**	**150 kW**
PANTOGRAPH CHARGERS	EBC-150	**240 A**	**150 kW**
	EBC-200	**320 A**	**200 kW**
	EBC-250	**400 A**	**250 kW**
	EBC-350	**560 A**	**350 kW**
	EBC-500	**800 A**	**500 kW**
	EBC-650	**1040 A**	**650 kW**

Equipment

	Light signalling of the power supply	Signalling the battery charge status	OLED Operator panel	OCPP 1.6 communica-tion interface	Sound signalling	Key switch enabling the operation	Option of limiting the output power	Visual fault indication
EBC-30M	**yes**	**yes**	**yes**	**opcja**	**yes**	**optionally**	**yes**	**yes**
EBC-50M	**yes**	**yes**	**yes**	**opcja**	**yes**	**optionally**	**yes**	**yes**
EBC-100M	**yes**	**yes**	**yes**	**opcja**	**yes**	**optionally**	**yes**	**yes**
EBC-30S	**yes**	**yes**	**yes**	**opcja**	**yes**	**optionally**	**yes**	**yes**
EBC-50S	**yes**	**yes**	**yes**	**opcja**	**yes**	**optionally**	**yes**	**yes**
EBC-100S	**yes**	**yes**	**yes**	**opcja**	**yes**	**optionally**	**yes**	**yes**
EBC-150	**yes**	**yes**	**optionally – pantograph (yes – plug-in type)**	**optionally**	**optionally**	**optionally**	**yes**	**yes**
EBC-200	**yes**	**optionally**	**optionally**	**optionally**	**optionally**	**optionally**	**optionally**	**yes**
EBC-250	**yes**	**optionally**	**optionally**	**optionally**	**optionally**	**optionally**	**optionally**	**yes**
EBC-350	**yes**	**optionally**	**optionally**	**optionally**	**optionally**	**optionally**	**optionally**	**yes**
EBC-500	**yes**	**optionally**	**optionally**	**optionally**	**optionally**	**optionally**	**optionally**	**yes**
EBC-650	**yes**	**optionally**	**optionally**	**optionally**	**optionally**	**optionally**	**optionally**	**yes**

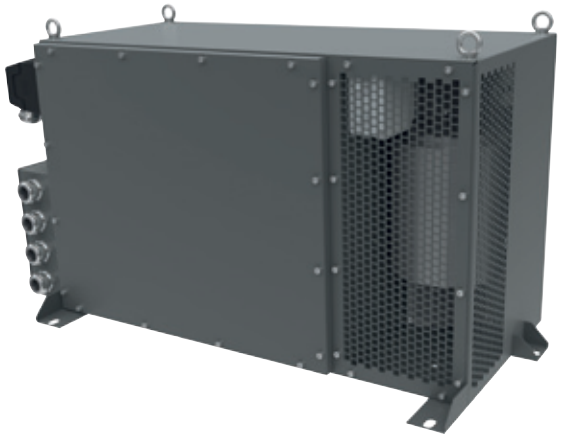
SERIES OF CHARGERS (eBus)

Electrical parameters

	Range of output voltages	Power supply voltage	Maximum battery charging current	Connection to the vehicle
EBC-30M	**200÷800 V**	**3×400 V ±10%, 50 Hz; (optionally: 600 VDC, 750 VDC)**	**60 A**	**CCS Type2, CHAdeMO**
EBC-50M	**200÷800 V**	**3×400 V ±10%, 50 Hz; (optionally: 600 VDC, 750 VDC)**	**80 A**	**CCS Type2, CHAdeMO**
EBC-100M	**200÷800 V**	**3×400 V ±10%, 50 Hz; (optionally: 600 VDC, 750 VDC)**	**160 A**	**CCS Type2, CHAdeMO**
EBC-30S	**200÷800 V**	**3×400 V ±10%, 50 Hz; (optionally: 600 VDC, 750 VDC)**	**60 A**	**CCS Type2, CHAdeMO**
EBC-50S	**200÷800 V**	**3×400 V ±10%, 50 Hz; (optionally: 600 VDC, 750 VDC)**	**80 A**	**CCS Type2, CHAdeMO**
EBC-100S	**200÷800 V**	**3×400 V ±10%, 50 Hz; (optionally: 600 VDC, 750 VDC)**	**160 A**	**CCS Type2, CHAdeMO**
EBC-150S	**200÷800 V**	**3×400 V ±10%, 50 Hz; (optionally: 600 VDC, 750 VDC)**	**200 A**	**CCS Type2, CHAdeMO**
EBC-150	**200÷800 V**	**3×400 V ±10%, 50 Hz; (optionally: 600 VDC, 750 VDC)**	**240 A – pantograph (200 A – plug-in)**	**CCS Type2 (Mode 4, Case C) or pantograph (Mode 4, Case C); optionally: CCS 2 and pantograph in one device**
EBC-200	**200÷800 V**	**3×400 V ±10%, 50 Hz; (optionally: 600 VDC, 750 VDC)**	**320 A**	**pantograph (Mode 4, Case C); optionally: additional plug-in connector CCS 2 to 200 A**
EBC-250	**200÷800 V**	**3×400 V ±10%, 50 Hz; (optionally: 600 VDC, 750V DC)**	**400 A**	**pantograph (Mode 4, Case C); optionally: additional plug-in connector CCS 2 up to 200 A**
EBC-350	**200÷800 V**	**3×400 V ±10%, 50 Hz; (opcja: 600 VDC, 750 VDC)**	**560 A**	**pantograph (Mode 4, Case C); optionally: additional plug-in connector CCS 2 to 200 A**
EBC-500	**200÷800 V**	**3×400 V ±10%, 50 Hz; (optionally: 600VDC, 750 VDC)**	**800 A**	**pantograph (Mode 4, Case C); optionally: additional plug-in connector CCS 2 to 200 A**
EBC-650	**200÷800 V**	**3×400V ±10%, 50 Hz; (optionally: 600 VDC, 750 VDC)**	**1040 A**	**pantograph (Mode 4, Case C); optionally: additional plug-in connector CCS 2 to 200 A**

ZBBT200-DC40-AU250

Battery Power Supply for Propulsion Drives



The battery power supply for propulsion drives ZBBT200-DC40-AU250 is used for:

- powering traction and auxiliary converters from the battery; if no grid power is available on current collectors,
- charging the traction battery from the catenary including the regenerated energy,
- charging the traction battery from the 3×400 V 50 Hz platform grid isolated from power supply by a separating transformer.

The advantage of the solution is that the trolleybus can drive even if no supply voltage is available or if it has to pass a section of the route with no grid, e.g. a historical district of a town.

During its normal operation the ZBBT200-DC40-AU250 power supply charges the trolleybus traction battery by converting the supply power in a suitable manner. The ZBBT200-DC40-AU250 power converter is controlled via a microprocessor controller, which monitors the supply voltage and the battery's charging current, protecting it against damage. During the stop time at the depot the traction battery may be charged with 3×400 VAC supply voltage from external grid. The pantograph must be lowered when the battery is being charged from a 3×400 VAC source. If there is no supply voltage in the traction grid, the traction inverter is powered by the ZBBT200-DC40-AU250 power supply with traction battery voltage. This allows the vehicle to return to the depot in emergency mode (with the battery discharged in various profiles).

Specification	
Control	**Resonant two quadrant converter**
Nominal traction supply voltage	**600 VDC (+30 ÷ –30%)**
Nominal battery supply voltage	**200 VDC (+40 ÷ –30%)**
Auxiliary supply voltage 1	**24 VDC (+25 ÷ –30%)**
Auxiliary supply voltage 2	**230 VAC 50 Hz (+10 ÷ –10%)**
Basic/forming battery charging	IUI charging with direct current, switching off after certain voltage is reached and time controlled switching off
Basic battery float charging	
Battery current Current from the traction	**16 A** **7 A**
Basic battery quick charging	
Battery current Current from the traction	**40 A** **18 A**
Nominal voltage of switching threshold of battery charging current	**255 VDC for T = 20°C**
Driving on battery	
Traction inverter current Battery current Traction inverter current Battery current	**72 A (U = 670 VDC)** **250 A** **85 A (U = 470 VDC)** **300 A at Umin**

ZBBT200-DC40-AU250

Battery Power Supply for Propulsion Drives

Battery charging recuperation quick method	
Battery current	**40 A**
Maximum instantaneous current	**300 A**
Nominal power	**50 kW**
Resonant frequency	**14 kHz**
PWM frequency	**28 kHz**
Cooling	**forced-air**
Weight	**130 kg**
Dimensions	**800×350×480 mm**

Housing