

## Power Electronic Solutions for Public Transport

### LOCOMOTIVES

MEDCOM 2018 TR.01.01-09/18EN



# LOCOMOTIVES

**MEDCOM is a manufacturer of single- and multisystem propulsion systems as well as high power static converters, which are used to supply on-board loads in electric locomotives.**

MEDCOM developed modern traction inverters for new and modernized locomotives operated around Europe. Propulsion systems for locomotives provide output power of up to 2.8 MW. The converters are manufactured with the power ranging from 80 kW to 500 kW and can operate separately or in redundancy systems. These devices have high overload capabilities, which allow large motors (compressors, engine fans and resistor fans) start up easily.

In the case of train systems, where coaches are powered only with low voltage, MEDCOM may also deliver converters with the output power of up to 500 kW with three-phase output.

The devices for charging on-board batteries provide a high quality charging process for all types of batteries. The standard operation temperature range is  $-40^{\circ}\text{C} \div +70^{\circ}\text{C}$ .

The converters are equipped with a diagnostic-control system based on MVB, CAN 2.0 B, RS232, RS485 interfaces or the Ethernet.

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# FT-1600-3000

## Traction Inverters

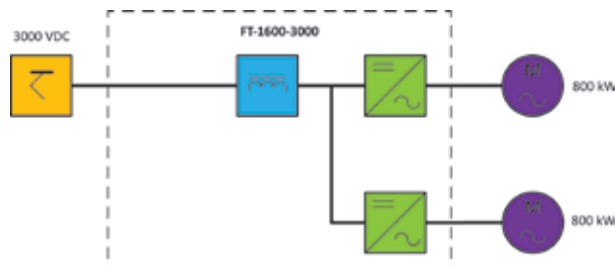
The FT-1600-3000 traction inverter is a modern chopperless system of the direct three-phase inverter based on the HV IGBT 6.5 kV technology. The control of the converter is performed in the DSP (Digital Signal Processor) technology with the application of the FOC SVPWM (Field Oriented Space Vector Pulse Width Modulation). Within the range of high speeds, the system co-operates with a synchronized Bus Clamping Pulse Width Modulation, which causes reduction of losses and noise. The control system ensures acceleration with a constant torque and low power losses. The drive can operate with rheostatic or regenerative braking. The inverter system guarantees very good traction parameters and perfect stabilization of the driving torque. The applied braking resistors made of stainless steel guarantee a long service lifetime and low noise level. The applied system of busbars combined with a perfect IGBT driver guarantee a failure-free performance at short circuits. It also eliminates the possibility of secondary damages in case of the transistor's failure. The applied polypropylene capacitors ensure long service lifetime and resistance of the system to changes of voltage in the traction network. The inverter system is also protected with a thyristor crowbar. The inverter meets UIC and EN standards requirements with regard to safety and electromagnetic compatibility. The system has very low levels of low frequency interferences conducted to the traction network. The inverter is equipped with a forced air-cooling system and operates within the temperature range of  $-25^{\circ}\text{C} \div +40^{\circ}\text{C}$ . Lack of the cooling liquid increases the reliability and lowers operating costs of the vehicle. The diagnostics and control of the inverter is possible through the CANbus interface.



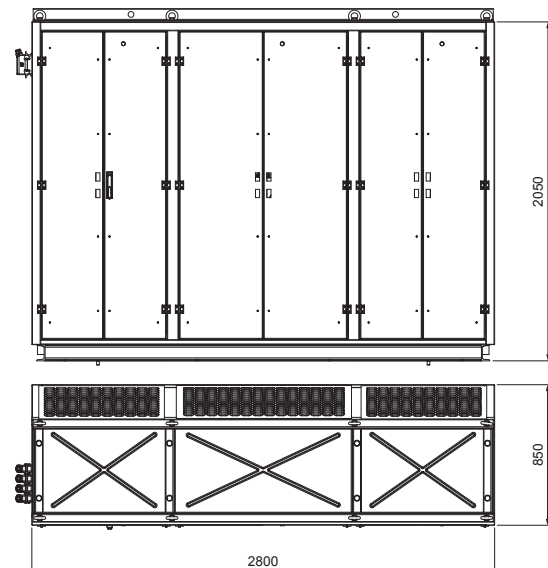
### Specification

Input voltage	3000 VDC, $+30 \div -30\%$
Auxiliary voltage	24 VDC, $+25 \div -30\%$
Output rated current	2×260 A
Maximum output current	2×300 A
Rated power	2×800 kW
Frequency	0–180 Hz
PWM frequency	300–900 Hz
Insulation strength	10.2 kV
Cooling	forced-air
Weight (without output chokes)	2530 kg
Dimensions	850×2800×2050 mm

### Schematic diagram



### Housing



# FT-2400-3000

## Traction Inverters

SFT-traction inverters 2400-3000 are used to drive the axles of the wheels in the electric locomotives of the E6ACT series. The use of two sets of inverters provides the drive of six driving axles of the locomotive. SFT-2400-3000 traction inverters are designed for installation inside the locomotive.

SFT-2400-3000 traction inverters are used to support start-up, driving with the specified torque, braking and coasting of the locomotive. They also enable start-up, driving and braking after setting driving in the reverse direction.

SFT-2400-3000 inverters transform the input voltage of the 3 kV DC present in the input circuit to the adjustable output voltage varying in the range from 0 to the rated supply voltage of the traction motors. SFT-2400-3000 are produced using the latest technologies. FOCSVM control eliminates oscillation hazardous for gears and ensures high efficiency of the drive.

Traction inverters implement electrodynamic resistive braking and the recuperation of electricity. Switching from the recuperative braking to resistive braking is made automatically and smoothly. Traction converters operate reliably at a supply voltage compatible with the requirements of PN-EN 50163:2006. Traction converters are resistant to short-circuits in the motors' circuits. The main circuit devices may be easily accessed and disassembled for service purposes in case of faults and they are protected against moisture and dust.

During braking, the vehicle's kinetic energy is converted in the motors into electricity (by regenerative motor operation) and it is transmitted to a network. If the voltage on the power supply bus exceeds 3830 V, the transistor keys are turned on to activate the brake resistor.

The set of SFT-2400-3000 is made using HV IGBT 6.5 kV technology. Control of the converter is provided by 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 an excellent IGBT driver guarantee a failure-free operation during short-circuits and eliminates the risk of secondary damage during the 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.

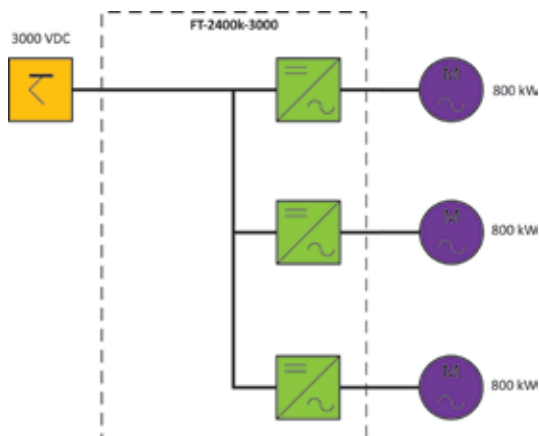
### FT-2400-3000

Input voltage	<b>3000 VDC</b>
Rated power	<b>3×850 kW</b>
Rated current	<b>3×3×320 A</b>
Auxiliary voltage	<b>110 VDC +25% ÷ -30%</b>

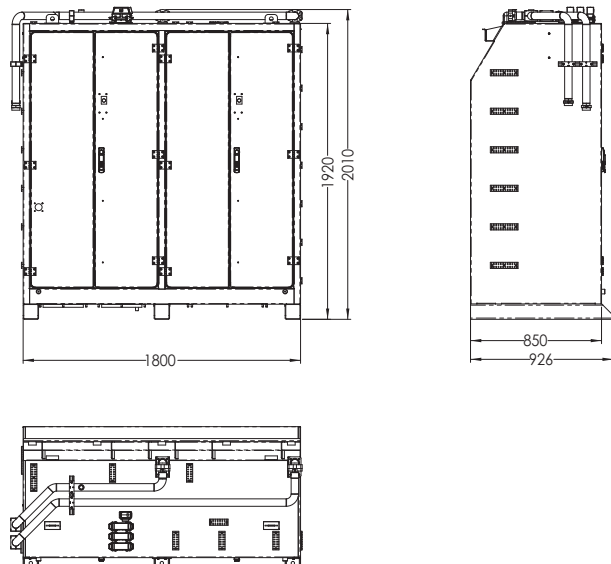
### Housing

Cooling method	<b>Liquid cooling</b>
Weight	<b>1425 ± 10% kg</b>
Dimensions	<b>926×1800×2025 mm</b>
Protection ratio	<b>Clean section      IP 56</b>

### Schematic diagram



### Housing



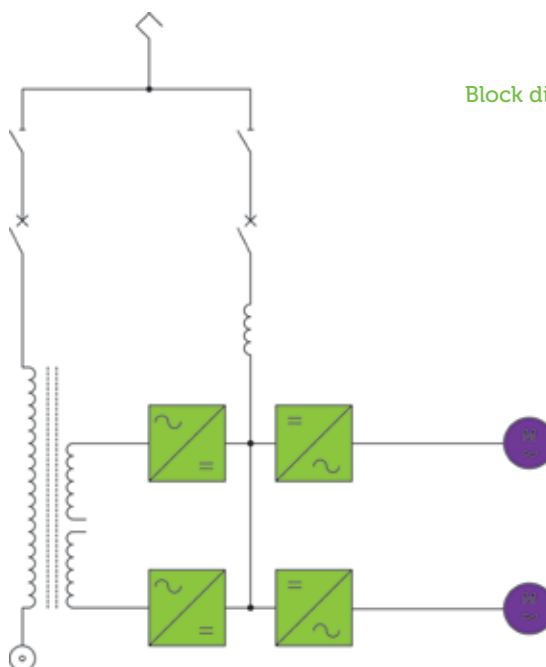
# FT-2800-MS

## Traction Inverter for Asynchronous Drives

The FT-2800-MS traction inverter is a modern chopperless system, designed to drive wheel axles in E4MSU series multi-system electric locomotives. The inverter is based on the HV IGBT 6.5 kV technology. The control of the converter is performed in the DSP (Digital Signal Processor) technology with the application of the FOC SVPWM (Field Oriented Space Vector Pulse Width Modulation). With the range of high speeds, the system co-operates with a synchronized Bus Clamping Pulse Width Modulation, which causes reduction of losses and noise. The control system ensures acceleration with a constant torque and low power losses.

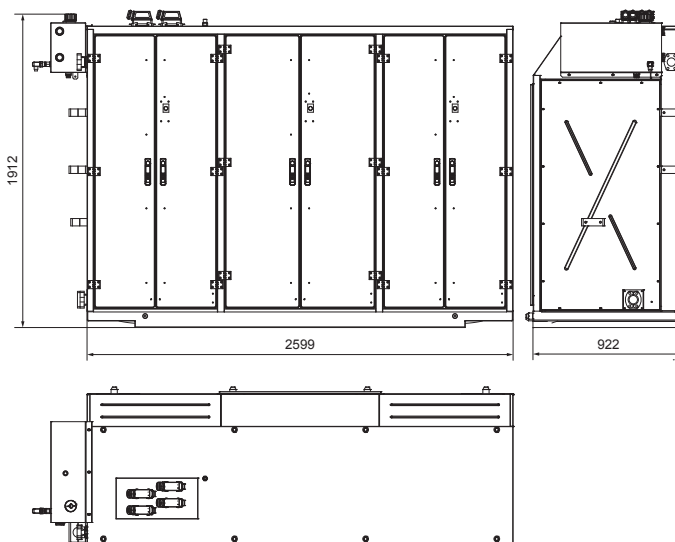
### Specification

Input rated voltage DC1	<b>3000 VDC</b>
Input voltage AC1	<b>15000 V, 16 <math>\frac{2}{3}</math> Hz</b> (-20 ÷ +15%)
Input voltage AC2	<b>25000 V, 50 Hz</b> (-25 ÷ +10%)
Output rated current	<b>2×400 A</b>
Maximum output current	<b>2×500 A</b>
Rated power	<b>2×1400 kW</b>
Output voltage	<b>2×2340 VAC</b>
Auxiliary voltage	<b>24 VDC (-30 ÷ +25%)</b>
Frequency	<b>0–50 Hz</b>
PWM frequency	<b>300–900 Hz</b>
Insulation strength	<b>10.2 kV</b>
Protection ratio	<b>IP56</b>
Total efficiency	<b>98%</b>
Ambient temperature	<b>-30 ÷ +40 °C</b>
Cooling	<b>liquid</b>
Weight	<b>2100 kg</b>
Dimensions	<b>2599×922×1912 mm</b>



Block diagram

### Housing





# PSM-19U

## Static Converter

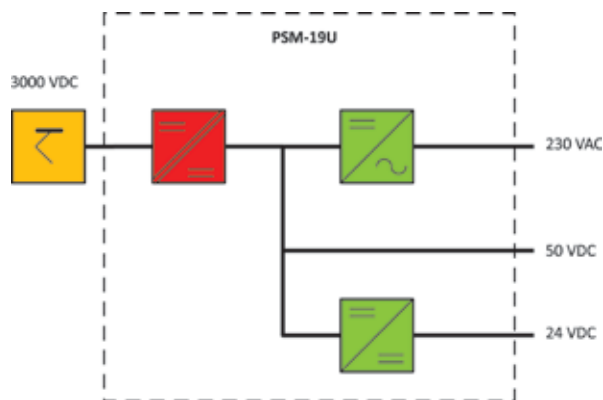
The PSM-19U static converter is a device designed to convert 3000 VDC traction voltage into 50 VDC and 24 VDC as well as 230 VAC used in low voltage system of an electric locomotive.

### Specification

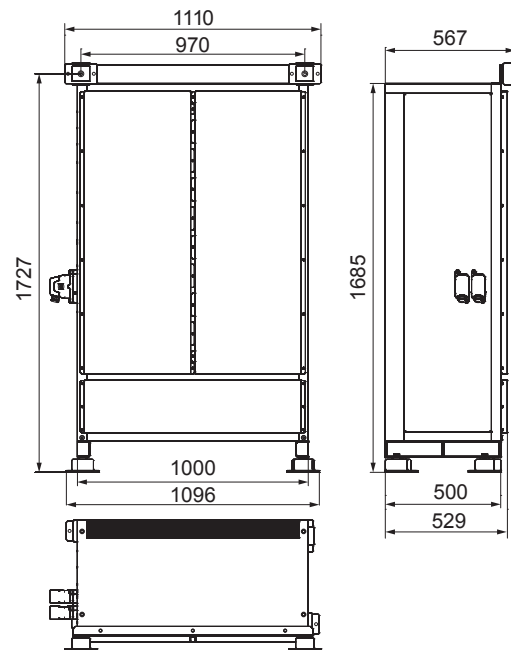
<b>Input voltage</b>	<b>3000 VDC</b> (operating range 2200÷4000 V)
<b>Output voltage</b>	
230 V 50 Hz	<b>P = 16.1 kW; voltage stability <math>\leq \pm 10\%</math>; frequency stability <math>\leq \pm 1.0\%</math>; THD(u) <math>\leq 5\%</math>; In = 70 A</b>
50 VDC	<b>P = 3 kW; voltage stability <math>\pm 2\%</math>; In = 60 A</b>
24 VDC	<b>P = 0.6 kW; voltage stability <math>\pm 5\%</math>; In = 25 A</b>
Total power	<b>19.7 kW</b>
Efficiency	<b>&gt; 83%</b>
Ambient temperature	<b>-40 ÷ +40°C</b>
Protection degree	<b>IP56</b>
Weight	<b>300 <math>\pm 10\%</math></b>
Dimensions	<b>1000×529×1602 mm</b>



### Block diagram

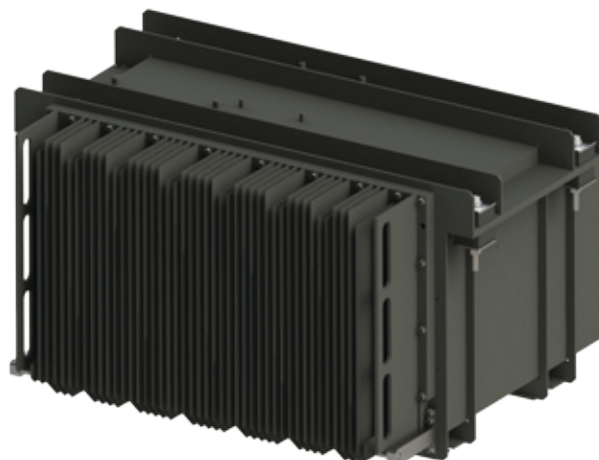


### Housing



# PSM-35

## Static Converter



The PSM-35 static converter has been designed to convert 3000 VDC voltage used in the railway traction networks into 3×400 VAC, used in the low voltage installation of the EP09 electric locomotive. The control system of the converter is powered from an external voltage of 110VDC. Converter PSM-35 is a fully automated and allows continuous supply of low-voltage circuits, independently of the actual input voltage (in compliance with the Technical Specifications).

### Block diagram



### Specification

<b>Input voltage</b>	<b>3000 VDC</b> (operating range 2000÷4000 V)
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<b>Output voltage</b>	<b>3×400 VAC (50 Hz)</b>
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S = 35 kVA In = 36 A;  
 Overload capability 80 kVA/5 s;  
 Voltage stability  $\leq \pm 5\%$ ;  
 Frequency stability  $\leq \pm 0.5$  Hz;  
 THD(u)  $\leq 5\%$ ;  
 Permissible load asymmetry 30%;  
 Electronic short circuit and overload protection

<b>Rated power</b>	<b>35 kW</b>
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<b>Total efficiency</b>	<b><math>\geq 90\%</math></b>
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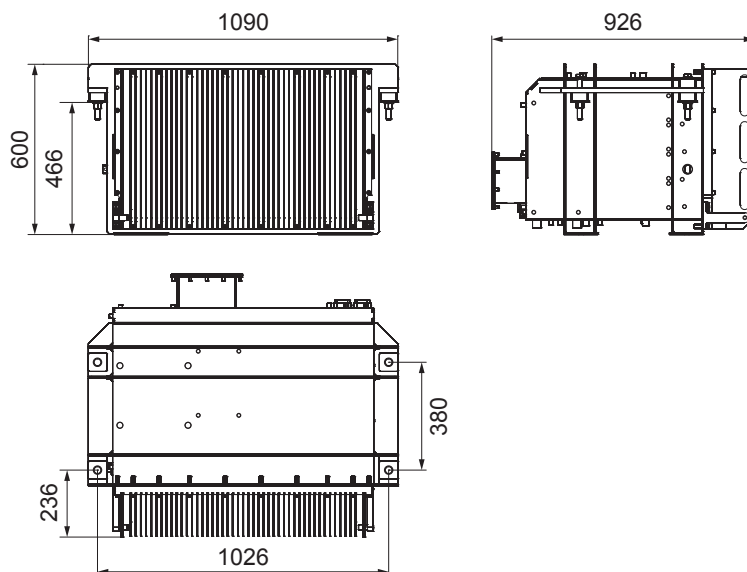
<b>Ambient temperature</b>	<b><math>-30 \div +50^\circ\text{C}</math></b>
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<b>Protection ratio</b>	<b>IP56</b>
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<b>Weight</b>	<b>300 kg</b>
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<b>Dimensions</b>	<b>600×906×1090 mm</b>
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### Housing



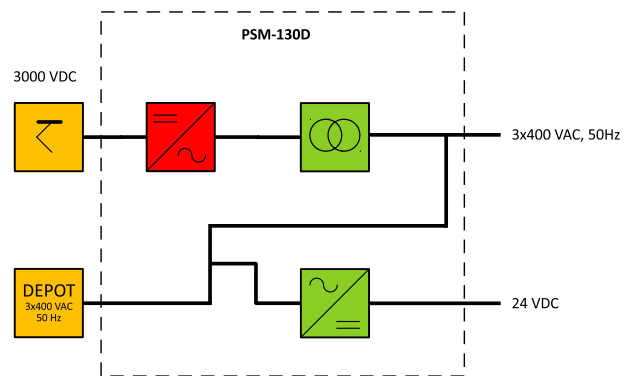
# PSM-130D

## Static Converter

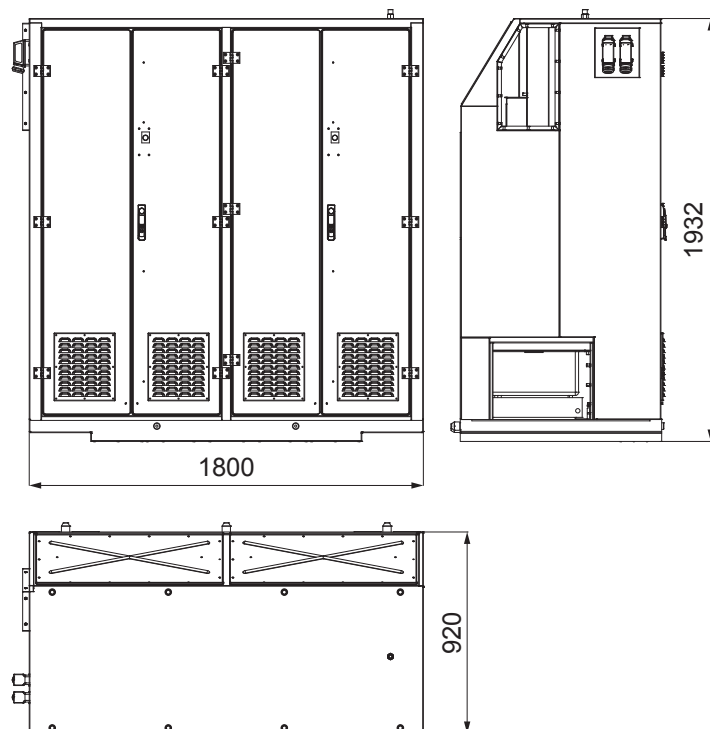


The static converter PSM-130D type consists of two 130 kVA converters in one cabinet with the operation redundancy. Both converters have been designed to supply the circuits of electric locomotive with  $3 \times 440$  V/60 Hz and 24 VDC voltages. Input power supply for this converter is 3000 VDC or 25 kVAC, depending on operation mode of the locomotive. In both modes of locomotive operation the converters are supplied from DC link circuits, each auxiliary converter from its corresponding FT-2800-MS propulsion inverter system. It is possible to use  $3 \times 400$  V 50 Hz depot power supply. The control units of the PSM-130D are supplied from a 24 VDC source.

### Block diagram



### Housing





# PSM-130D

## Static Converter

Specification	
<b>Input voltage HVDC</b>	<b>3000 VDC</b> direct from FT-2800-MS (operating range 2000÷4000 VDC)
Overvoltage protection	<b>MOV</b>
Input -output galvanic isolation	<b>yes</b>
<b>Input voltage AC DEPOT</b>	<b>3×400 VAC/50 Hz</b> (the same voltage on the output)
Input power	<b>44 kVA</b>
3-wire input	<b>L1, L2, L3</b>
Necessary short circuit protection before depot input	
<b>Output voltage AC</b>	<b>3×440 VAC/60 Hz</b>
Output power	<b>130 kVA</b>
3-wire output	<b>L1, L2, L3 grounded neutral</b>
Power factor	<b>≥ 0.85</b>
Voltage stability	<b>≤ 5%</b>
Frequency stability	<b>≤ 1%</b>
Overload /short circuit capacity	<b>3×In/3 s (300%/3 s)</b>
THD(u)	<b>≤ 5%, typical 3%</b>
Electronic overload and short circuit protection	<b>yes</b>
<b>Output voltage DC</b>	<b>24 VDC (range 16.8÷30 V)</b>
Output power	<b>8 kW</b>
Output current	<b>300 A</b>
Voltage stability	<b>≤ 1%</b>
Voltage ripples	<b>≤ 2%</b>
Battery current limit	<b>0.1–1 In</b>
Electronic overload and short circuit protection	<b>yes</b>
Output voltage thermal compensation	<b>option</b>
<b>General</b>	
Total output power	<b>130 kVA/122 kW</b>
Efficiency	<b>≥ 90%</b>
Dielectric Strength Test HV/LV	<b>9.5 kV, 50 Hz, 1 min</b>
Dielectric Strength Test LVAC/LVDC	<b>2.5 kV, 50 Hz, 1 min</b>
Monitoring	<b>CANopen</b>
Ambient temperature	<b>–30 ÷ +40°C</b>
Cooling	<b>forced-air</b>
Assembling	<b>inside locomotive</b>
Protection level	<b>IP22</b>
Weight of set	<b>1950±50 kg</b>
Dimensions of set	<b>1800×920×1932 mm</b>

# PSM-175 SiC

## Static Converter

The PSM-175 SiC static converter is designed to generate the operating voltage of 3×400 V, 50 Hz required to power auxiliary circuits in the locomotive. PSM-175 SiC is used to convert the DC input voltage of 3 kV to an AC sinusoidal voltage of 3×400 V. The converter is equipped with efficient transformers providing galvanic isolation of the overhead line circuit from the circuits of the receivers. The locomotive is equipped with two fully redundant converters, each with a capacity of 175 kVA. At any given time, only one static converter is operating. In case of damage to the inverter or inverter container (which supplies the inverter), the master control system activates the second operational converter, ensuring the continuity of supply to the receivers.

The traction converters operate reliably at a supply voltage compatible with the requirements of the PN-EN 50163:2006. The static converter withstands short circuits in the output circuit.

The set of 2×PSM-175 SiC is made using the SiC technology. Control of the converter is implemented using a DSP (Digital Signal Processor). The power modules made of silicon carbide increase the switching frequency and significantly reduce the power loss in SiC modules, transformers and chokes.

The converter meets UIC and EN standards for safety and electromagnetic compatibility. Diagnostics and converter control is provided via the CANBus interface.

The converter has a single-phase voltage output of 230 V. For optimal use of the cooling liquid system and the space available in containers, the DC/DC blocks of two converters are mounted in two driving system containers. Two inverter blocks of two inverters are mounted in a separate container, which uses forced air cooling provided by a fan.



### PSM-175 SiC

Input voltage **3000 VDC (from catenary)**

Rated power **2×175 kVA**

AC Output 1 **3×400 V / 50 Hz / 175 kVA**

AC Output 2 **230 V / 50 Hz / 3.5 kVA**

### Housing

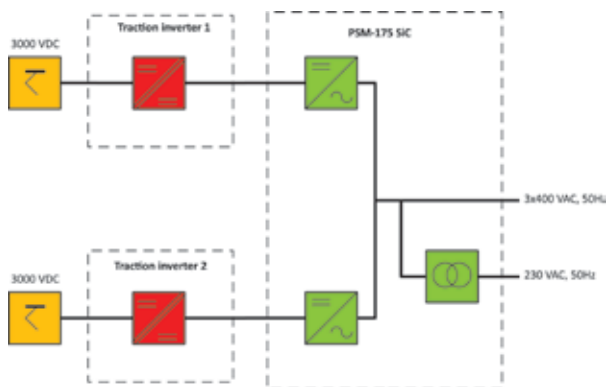
Cooling method **Air and liquid cooling**

Weight **470 ± 10%**

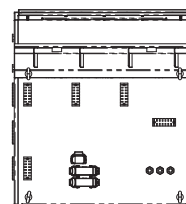
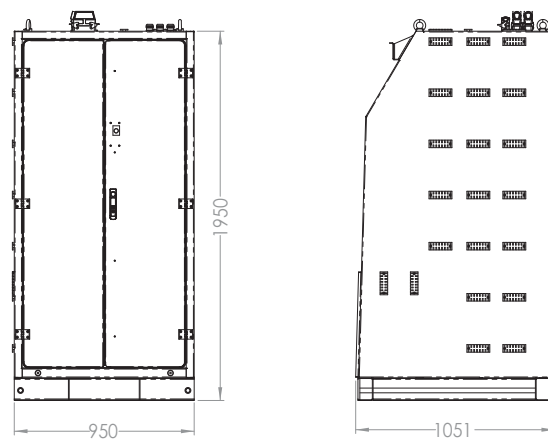
Dimensions **950×1017×1950 mm**

Protection ratio **Clean section IP 56**

### Block diagram



### Housing



# ZB110DC150

## Battery charger



The ZB110DC150R power supply adapter is designed for converting the 3×400 VAC-50 Hz voltage to a DC voltage of 101-140 V, intended for using in low-voltage systems of rail coaches.

This device draws electricity from the 3×400 V (50 Hz) network and generates a 101–140 V DC voltage, intended for supplying the circuits of the rail coach system.

Key advantages of the power supply adapter include: good stability of the output voltage and very low output voltage ripple.

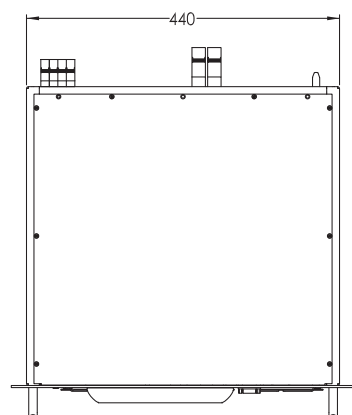
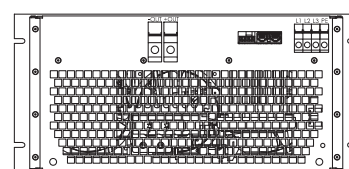
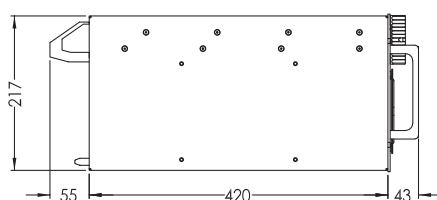
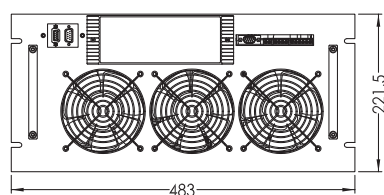
The device is completely maintenance-free – it is equipped with a microprocessor control system, which limits the output current in case of an overload or short circuit.

The power supply adapter has a galvanic isolation between the input and output circuit.

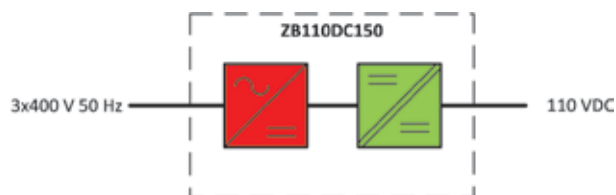
### PSM-230

Input voltage	<b>3×400 V AC</b>
Rated output power	<b>15 kW</b>
Rated output voltage	<b>101 – 140 V DC</b>
Output voltage stability	<b>2%</b>
Output voltage ripples	<b>0.5%</b>
Efficiency	<b>&gt;88%</b>
Ambient temperature	<b>–25°C ÷ +45°C</b>
Cooling	<b>forced-air</b>
Protection ratio	<b>IP 21</b>
Weight	<b>38 kg</b>
Dimensions	<b>483×221, 5×518 mm</b> <b>Rack Mount 5U</b>

### Housing



### Block diagram



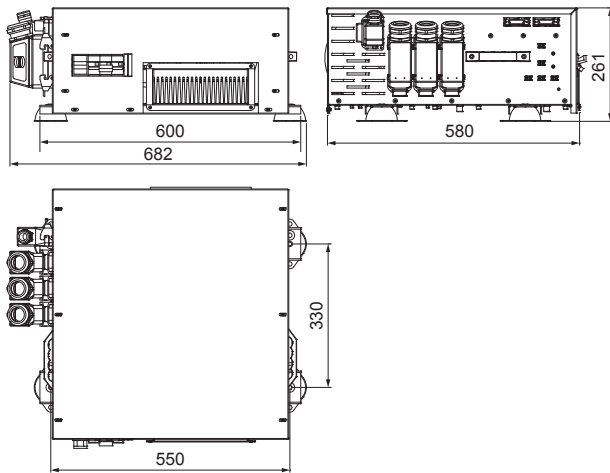
# SWG-01

## Excitation System for Diesel-Electric Locomotive



The SWG-01 system is designed to control synchronous generators by controlling the excitation current. It is also used to power supply voltage inverters for compressors and fans for cooling DC motors. The system consists of an input rectifier and an excitation supply for the auxiliary generator.

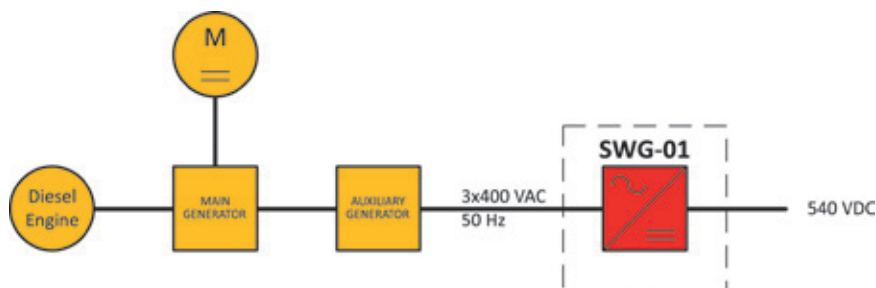
### Housing



### Specification

Input voltage	3×400 VAC (±20%)
Auxiliary input voltage	24 V DC (+25 ÷ -30%)
Main excitation current range	0÷60 A
Main excitation voltage range	0÷100 V
Auxiliary excitation current range	0÷10 A
Auxiliary excitation voltage range	0÷24 V
Output voltage	540 VDC (±25%)
Maximum output current	100 A
Interface	CANbus (CAN 2.0 B)
Cooling	forced-air (500 m³/h)
Ambient temperature	-25 ÷ +50°C
Weight	70 kg
Dimensions	600×586×261 mm

### Blok diagram of the SWG-01 Excitation System for diesel locomotive



# FN25+5/540

## Auxiliary Circuit Inverter



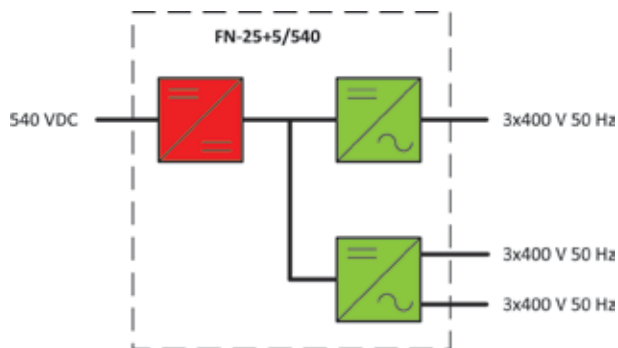
FN25+5/540 auxiliary circuit inverters are designed to supply power for compressor in 6Dg/B locomotives (25 kVA inverter) and traction motors fans (5 kVA inverter). Inverters allow to start the motor of the locomotive with the characteristics  $V/f = \text{const}$ . Application ramp reduces the inrush current of the motor.

The DSP microcontroller controls inverters and delivers information via CANopen and to digital isolated outputs. FN25+5/540 inverters are equipped with several electronic protection system like overload, short circuit, overheating, loss of communication and overvoltage protection.

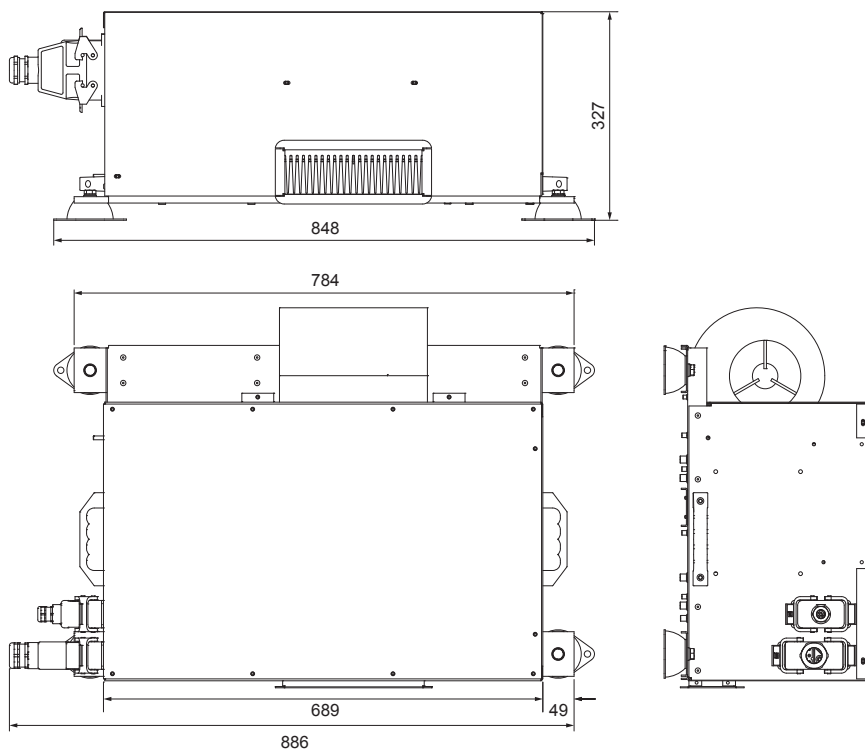
Output sine wave filter eliminates problems of motor/cable insulation failures, heating, and audible noise. Sine Wave Filters also reduce electromagnetic interferences (EMI) by eliminating the high  $dV/dt$  associated with inverters' output waveforms.

Inverters are connected to the system by Han-Modular® industrial connectors system. Han® connectors allow for connecting the devices fast and with quality assurance.

### Block diagram



### Housing



# FN25+5/540

## Auxiliary Circuit Inverter

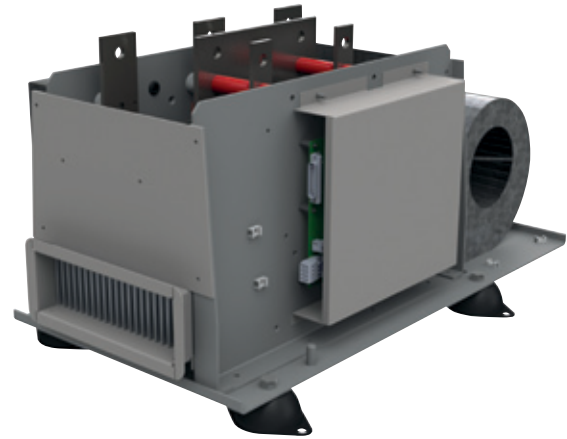
Specification	
Input rated voltage	540 VDC
Input voltage range	400÷750 VDC
<b>Inverter I</b>	
Output rated voltage	3×400 VAC
Rated power	5 kVA
Rated frequency	50 Hz
Frequency output range	5÷67 Hz
Output voltage shape	sinusoidal
Voltage drop on the output sinusoidal filter	≤ 8% (with nominal load)
Current overload	2 In/10 s
Short circuit protection	32 A
<b>Inverter II</b>	
Output rated voltage	3×400 VAC
Rated power	25 kVA
Rated frequency	50 Hz
Frequency output range	5÷67 Hz
Output voltage shape	sinusoidal
Voltage drop on the output sinusoidal filter	≤ 8% (with nominal load)
Current overload	2 In/10 s
Short circuit protection	155 A
<b>Power supply for electronic circuits</b>	
Input rated voltage	24 VDC
Input voltage range	16÷28 VDC
Current consumption	≤ 7 A (7 A – fan at maximum speed)
<b>Digital input</b>	
Input rated voltage	24 VDC
Current consumption	10 mA
Electric insulation of Input	2.5 kV (optoelectronic)
<b>Digital output</b>	
Output contacts	1NO, 1NC
Electric insulation of output	2.5 kV
<b>Communication</b>	
Transmission interface	CANopen
Electric insulation of transmission interface	2.5 kV (optoelectronic)
Dimensions	330×596×942 mm
Weight	80 kg



# ZT-900

## Traction Rectifier

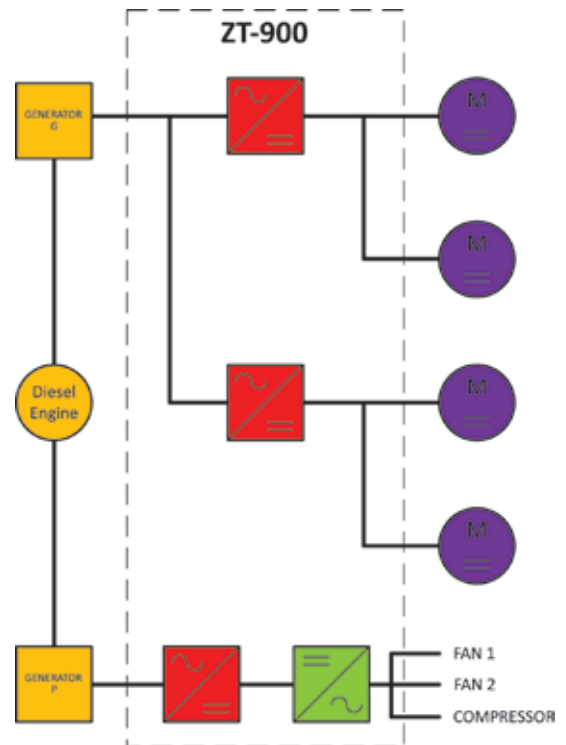
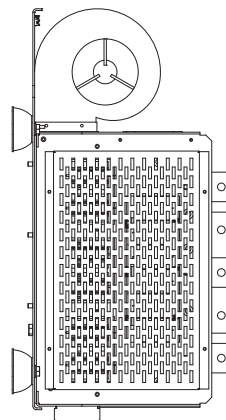
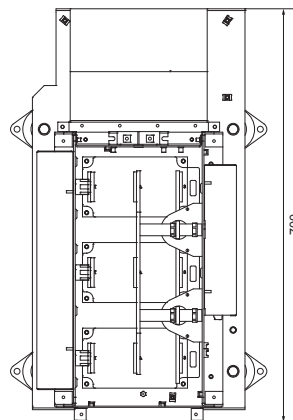
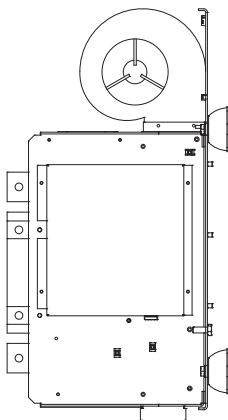
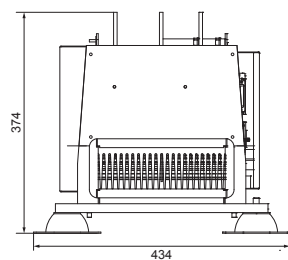
The ZT-900 is a diode rectifier which supplies two DC traction motors in the 6Dg/B (SM42) diesel locomotive. The ZT-900 allows for measurement of the DC current and DC voltage of each motor and is equipped with overvoltage protection and fan speed control.



Block diagram of power supply

Specification	
Input voltage	3×0–600 VAC, 20–60 Hz
Output voltage	0–900 VDC
Auxiliary voltage	24 VDC, +25 ÷ –30%
Output current	0–1000 ADC
Maximum power	350 kW
Efficiency	99.4%
Insulation strength	3.6 kV, 50 Hz, 1 min
Ambient temperature	+25 ÷ +50°C
Cooling	forced-air 600 m³/h
Weight	59 kg
Dimensions	700×374×434 mm

### Housing



# FTM-3-24 Rack

## 3-Phase Emergency Inverter



The converter FTM-3-24 (DC/AC converter) is designed to convert input voltage 24 VDC into  $3 \times 280 \div 460$  VAC ( $35 \div 60$  Hz), to supply fans and pumps in railway vehicles. Power dissipated in the inverter is blown out by fans which force cooling air flow. The input voltage 24 VDC (in the range of  $16,8 \text{ V} \div 31,5 \text{ V}$ ) is fed by the filter (1) to the DC / DC converter (2), which produces a

stabilized voltage 35 VDC. The next element is the converter 35 V / 650V (3) with galvanic isolation. Inverter (4) converts the voltage of 650 VDC to three-phase AC voltage, which through inductive output filter (5) is applied to the output terminals X2. The control signal Ethernet bus driven phase allows you to adjust the output voltage of the range  $280 \div 460 \text{ V}$  ( $35 \div 60$  Hz).

### Specification

#### DC input

Nominal Input Voltage	<b>24 V</b>
Tolerance of input voltage	<b>(16.8 V) – 18–31,5 V</b>
Switch-on voltage	<b>18 V</b>
Switch-off voltage	<b>16,8 V</b>
Nominal input current at 24 V	<b>130 A</b>

#### AC output

Output voltage range	<b>3 AC 280÷460 V; <math>\pm 5\%</math></b>
Frequency range (adjustable)	<b>35–60 Hz</b>
Oscillation mode	<b>sinusoidal (sinus filter)</b>
Output phase current	<b>4,33 A</b>
Output power (continuous)	<b>3.0 kVA, <math>\cos\phi = 0.85</math></b>

#### Temperature-dependent absorption of power

**$-25^{\circ}\text{C} < T < 40^{\circ}\text{C}$**

#### Environments

Relative humidity	<b>0–95%</b>
Ambient temperature	<b><math>-25 \div 40^{\circ}\text{C}</math></b>
Storage temperature	<b><math>-40 \div 80^{\circ}\text{C}</math></b>
Operating altitude	<b><math>\leq 1400 \text{ m}</math></b>
Noise level	<b><math>&lt; 60 \text{ dB(A)}</math></b>

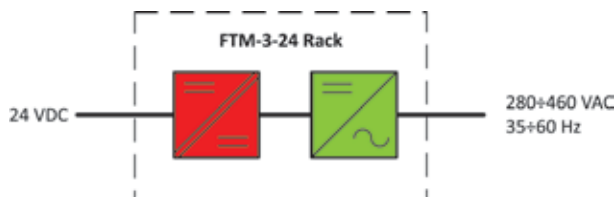
#### Mechanical data

Weight	<b><math>20 \pm 1 \text{ kg}</math></b>
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#### General

Starting time	<b><math>&lt; 10 \text{ s}</math></b>
Discharging time	<b><math>&lt; 5 \text{ min}</math></b>

### Block diagram



### Housing

