

User Manual

PMA1101

Railway Inverter

Revision: 1.0

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Revision History

Date	Rev.	Change
22.06.2026	1.0	Initial version

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Changes

The information and specification contained in this document are believed to be correct at time of publication. However, Acal BFi Germany GmbH accepts no responsibility for consequences arising from printing errors or inaccuracies. The content of this document is subject to change without notice.

Exclusion and limitation of liability

Acal BFi assumes no liability for damage caused by failure to observe the warning instructions in this user manual or by improper use of the product.

All instructions must be read carefully before installation and commissioning. Installation and commissioning must be carried out by qualified personnel only.

Safe operation of the product requires correct transport, storage, assembly, installation, operation and maintenance. Technical modifications to the product are not permitted. The safety regulations and provisions of the country in which the product is used must be observed.

The product contains hazardous voltages and is not intended to be opened by the end user. The internal input fuse is not customer-replaceable. No liability is assumed for damages caused by unauthorized opening, modification, misuse, force majeure or disaster situations.

1 About This User Manual

1.1 Introduction

This user manual describes the safe installation, operation and handling of the PMA1101 Inverter. The product is a DC-AC inverter for railway rolling-stock applications and converts a 510 VDC nominal input supply into a stabilized 230 VAC sine-wave output.

To prevent personal injury and material damage, read this user manual and all other applicable project documentation before transporting, installing, commissioning, operating or servicing the product. Keep this user manual available with the device for the entire service life of the product and provide access to all future users.



WARNING

Any misuse of the product and failure to observe the warnings contained herein or improper interference with the safety equipment and the product may result in material damage, personal injury, electric shock, or even death.

1.2 Symbols

This document contains the following symbols to highlight the various levels of danger:

Symbol	Description
 DANGER	Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
 WARNING	Indicates a hazardous situation which, if not avoided, could result in death, serious injury or major property damage.
 CAUTION	Indicates a hazardous situation which, if not avoided, could result in minor injury or property damage.
	Indicates important information for correct installation, operation or handling of the product.

2 Safety Information

2.1 Designated Use

The PMA1101 Inverter, also referred to as the product in this user manual, is designed for use in railway rolling-stock applications. Typical loads include passenger USB charging points and passenger power sockets.

The product is intended for operation from a DC input supply in the specified range and provides a galvanically isolated 230 VAC output. It may only be used within the electrical, mechanical and environmental limits defined in this user manual.

The product must be installed in a protected environment suitable for an IP20 metal-enclosed device. Operation is only permitted with sufficient cooling and with the housing, grounding and connector arrangement specified for the final application.

2.2 Qualification of Personnel

Installation, commissioning, troubleshooting and service activities must only be carried out by qualified personnel. Qualified personnel are persons who, due to their professional training, knowledge and experience as well as knowledge of the relevant standards and regulations, are able to assess the assigned work and recognize possible hazards.

Electrical work must only be carried out by qualified electricians or railway maintenance personnel authorized for the respective vehicle and voltage system.

2.3 Risks Involved in Incorrect Use of the Product



DANGER

The product is operated with life-threatening DC input voltage and hazardous AC output voltage. Incorrect handling can lead to death or serious personal injury by electric shock.



DANGER

The product may contain hazardous residual voltage after the supply has been disconnected. The voltage over capacitors connected to the high-voltage installation must fall below 50 V within two minutes after finishing the earthing procedure of the high-voltage installation. Always verify the absence of voltage before touching conductors.



WARNING

The product can heat up during operation. Housing surfaces and cooling surfaces may become hot. Allow the device to cool down before touching or servicing it.

2.4 Protection against Touching Electrical Parts



DANGER

It is dangerous to touch parts that are under voltages greater than 50 V. During operation, parts of the product and the connected system carry hazardous voltages. The product must only be operated when properly installed and connected.

- Do not remove the cover or open the product unless explicitly authorized by the manufacturer and the vehicle maintenance procedure.
- Before installation, removal or service, disconnect the DC input supply and the output/control circuits according to the vehicle safety procedure.
- Complete the required earthing procedure and verify that hazardous voltages have discharged below 50 V before touching conductors.
- Use only suitable test equipment rated for the voltage level and environment.
- Do not replace the internal input fuse. The fuse is internally mounted and shall only open in case of a defect requiring repair.

2.5 Protection against Magnetic or Electromagnetic Fields



WARNING

Magnetic and electromagnetic fields exist in the immediate vicinity of power-carrying conductors. They may pose a risk to persons with cardiac pacemakers, metallic implants or hearing aids.

- Persons with cardiac pacemakers, metallic implants or hearing aids must consult a physician before accessing areas where power electronics equipment is installed, operated or serviced.
- Observe all local and railway-specific rules regarding access to electrical equipment areas.

2.6 Protection against Touching Hot Parts



WARNING

The housing and cooling surfaces may become hot during operation, particularly at high ambient temperature or high load. Touching hot surfaces may cause burns.

- Avoid touching the housing during operation.
- Allow sufficient cooling time before handling the product after operation.
- Ensure that the cooling concept, air paths and heat-dissipating surfaces are not blocked.

2.7 Protection when Handling and Assembling



WARNING

Improper handling during transport, mounting or removal may cause personal injury or product damage.

- Use suitable lifting and handling equipment for a device weighing up to 25 kg.
- Avoid impact, dropping, crushing or mechanical stress on the housing and connectors.
- Install the product vertically upwards as specified for the final housing concept.

- Consider vibration requirements according to EN 61373, Category 1, Class B.
- Use only approved mating connectors, cables and crimp contacts.
- Protect against injuries from sharp edges.

3 Product Description

3.1 System Description

The PMA1101 Inverter converts a 510 V railway DC supply into a stabilized 230 VAC, 50 Hz sine-wave output. Typical loads include passenger USB charging points and passenger power sockets.

The product is intended for use in railway rolling stock and is designed for applications where galvanic isolation, controlled start-up and compliance with railway environmental and EMC requirements are required. The product supports a DC input voltage range from 400 VDC to 600 VDC. The minimum start voltage is 450 VDC.

The output is a single-phase 230 VAC supply with pure sine waveform. The product supports capacitive loads by ramping up at start; multiple starts in current-limit mode may occur until the capacitive load is charged. In case of excessive current during startup a short circuit is detected (see 3.5.3 Overcurrent Protection).

3.2 Connectors

3.2.1 Input Connector

Pin	Function
1	510 VDC plus
2	510 VDC minus
3	Not connected
GND	Protective ground / GND

Harting part number	Quantity	Description
9120033052	1	Han Q3/0-m-crimp HV
9320006105	3	Han HsC Male Crimp Contact Level 2.5 mm ²
9200030301	1	Han A Base Panel 1 Lever

3.2.2 Output Connector

Pin	Function
1	230 VAC L
2	230 VAC N
3	GND / Protective earth

Harting part number	Quantity	Description
9140033101	1	Han MOD C-MODULE FEM. INSERT C
9320006205	3	Han HsC Female Crimp Contact Level 2.5 mm

3.2.3 Signal Connector

Pin	Function
1	“Output OK” relay COM
2	“Output OK” relay NO

Pin	Function
3	“Output OK” relay NC
4	“Power output control signal” 110 VDC +
5	“Power output control signal” 110 VDC –
6	Not connected
7	Not connected
8	Not connected
9	Power supply 110 VDC +
10	Power supply 110 VDC –

Harting part number	Quantity	Description
9320103001	1	Han EE CRIMP TERM. MALE INSERT
9330006104	4	Han E MALE CRIMP CONTACT 1.5
9300060301	1	Han E BULKHEAD HOUSING

3.3 Visualization

Indicator	Description
Inverter OK LED	Green LED indicating that the inverter is operating and the output voltage is within the specified range. The LED is installed on the lower side of the inverter. The LED will turn off in case of a shutdown by the On/Off signal or a shutdown by a protection (e.g. input voltage / overcurrent / overtemperature)

3.4 Output and Control Signals

Signal	Type	Function
On/Off Signal	Input, galvanically isolated according to safety standard	Controls the 230 VAC output. High signal (>50 VDC, signal range 55–165 VDC): output switched on and remains on while signal remains high. Low signal (<50 VDC): output switched off.
Inverter OK Signal	Potential-free relay contact, galvanically isolated according to safety standard	Indicates that the inverter is operating and output voltage is within specified range. Maximum switching voltage: 165 V. Maximum switching current: 0.5 A.

3.5 Protections

3.5.1 Input Overvoltage

The product shall not be damaged by input voltages up to 800 VDC for a maximum duration of 5 seconds.

Above 620 VDC [+5% / -0%], the inverter stops. It restarts automatically when the input voltage reaches 600 VDC [± 5 %].

3.5.2 Input Undervoltage

Below 400 VDC [+0% / -5%], the inverter stops. It restarts automatically when the input voltage reaches 430 VDC [± 5 %].

3.5.3 Overcurrent Protection

Overcurrent protection is activated for the following conditions:

- $P_{out, rms} > 3.7 \text{ kW}$ [± 5 %] for longer than 5 seconds [± 10 %]
- $P_{out, rms} > 4 \text{ kW}$ [± 5 %]

In case of overcurrent the inverter remains switched off until reset.

Reset procedure after overcurrent protection:

- Switch the 110 VDC power output control signal to low.
- Switch the 110 VDC power output control signal back to high.

To allow charging of high capacitive loads the following startup conditions apply:

- Inverter stops if the output current is $> 34 \text{ A}$ [± 10 %] for time longer than 4 seconds [± 10 %]
- Inverter stops if the output current is $> 75 \text{ A}$ [± 10 %]

Startup conditions apply when the inverter is turned on using the 110 VDC power output control signal or automatically after an overvoltage / undervoltage / overtemperature event.

3.5.4 Thermal Protection

The product is designed to operate continuously within the temperature/output-power range shown in Annex A. Operation above the continuous derating range and up to 3,600 VA may lead to temporary shutdown due to overtemperature protection. The inverter restarts automatically when the temperature has decreased.

4 Installation and Commissioning

4.1 General Installation Requirements

- Install the inverter in the vertical upwards orientation.
- Always provide earth between grounding point and train chassis.
- Ensure sufficient clearance for connector mating, cable bending radius and service access.
- Ensure sufficient space around the inverter for conductive cooling (min. 15cm above and below cooling holes and 5 cm behind heatsink).
- Do not block cooling holes.
- The product requires a protective ground connection according to the relevant railway standards. The grounding point shall be used to connect sufficient connection to the train chassis. The connection must be mechanically secure, electrically conductive and protected against loosening under vibration.

4.2 Electrical Connection Sequence

 DANGER	Before connecting or disconnecting the inverter, ensure that the DC input supply and all output/control circuits are safely isolated and earthed.
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1. Verify that the inverter type, connector pinout and installation location match the project documentation.
2. Inspect the housing, connectors and grounding point for transport damage or contamination.
3. Connect the protective ground / chassis grounding point.
4. Connect the 230 VAC output connector.
5. Connect the signal connector required for the On/Off signal and the Inverter OK signal.
6. Connect the DC input connector with correct polarity.
7. Verify insulation, grounding and connector locking.
8. Apply DC input voltage within the specified range.
9. Apply a high On/Off signal to start the output. The output shall be available within a maximum of 5 seconds after the input voltage is within range.

4.3 Pre-Commissioning Checklist

Item	Check
Installation	Inverter mounted vertically upwards; mechanical fixing secure; vibration requirements considered.
Grounding	Grounding point connected to train chassis.
Input	Input voltage range verified; polarity checked; no reverse polarity applied.
Output	230 VAC output wiring checked; PE/N concept in accordance with vehicle distribution network.
Signals	On/Off signal range 55–165 VDC available; Inverter OK relay connected within 165 V / 0.5 A limits.
Cooling	Cooling fins and airflow paths unobstructed. Sufficient space around the inverter for conductive cooling (min. 15cm above and below cooling holes and 5 cm behind heatsink).
Documentation	User manual available.

5 Operation

5.1 Normal Start-Up

The inverter starts when the DC input voltage is within the specified range and the On/Off control signal is high. The output shall start within a maximum of 5 seconds.

- Input voltage within range: 400–600 VDC.
- Minimum start voltage: 450 VDC.
- On/Off control signal high: >50 VDC, signal input range 55–165 VDC.
- Output: 230 VAC nominal, 50 Hz nominal.
- Green Inverter OK LED and Inverter OK relay indicate output voltage within the specified range.

5.2 Normal Shut-Down

The 230 VAC output is switched off when the On/Off control signal is low (<5 VDC) or when the input voltage leaves the permissible operating range.

5.3 Fault Behavior and Reset

Condition	Behavior	Required action
Input overvoltage	Inverter stops and restarts automatically when input voltage is in the allowed range.	Check input voltage
Input undervoltage	Inverter stops and restarts automatically when input voltage is in the allowed range.	Check input voltage
Overtemperature	Temporary shutdown may occur when operated above continuous derating range. The inverter recovers automatically after cooling.	Reduce load and/or ambient temperature; verify cooling path.
Overcurrent	Inverter stops and remains switched off until reset.	Remove short circuit or excessive capacitive load at output. Switch the 110 VDC power output control signal to low and back to high to restart inverter.
Inverter OK LED off / relay not indicating OK	Output voltage is not within specified range or inverter is not operating.	Check input voltage, On/Off signal, load, temperature and space for cooling.

6 Maintenance and Service

6.1 Maintenance Concept

No periodic preventive maintenance is specified for the inverter. The product is intended for operation as a closed, enclosed metal-housing device. Internal components are not customer-serviceable unless explicitly defined in an approved service procedure.

- Do not open the housing without authorization.
- Do not replace the internal input fuse. If the internal fuse has opened, the product must be inspected or repaired by authorized service personnel.
- Keep cooling fins and external surfaces free from excessive contamination.

6.2 Cleaning

Cleaning shall only be performed when the product has been safely isolated and discharged. Use dry or slightly damp lint-free clothes. Do not use aggressive solvents and do not allow liquids or dust to enter connectors or ventilation paths.

7 Technical Data

7.1 Input Data

Parameter	Comment	Min.	Nom.	Max.
Input voltage	Minimum start voltage: 450 VDC.	400 VDC	510 VDC	600 VDC
Inrush current		—	—	20 A
Reverse polarity protection		Yes		

7.2 Output Data

Parameter	Comment	Min.	Nom.	Max.
Output voltage	Pure sine wave. Ramp-up at start in case of capacitive load; multiple starts in current-limit mode may occur until capacitive load is charged.	218 VAC	230 VAC	242 VAC
Output frequency		49.5 Hz	50 Hz	50.5 Hz
Output power	Apparent power. See Annex A: Derating.	—	3,000 VA	3,600 VA
Startup time	Timing starts when input voltage is within range.	—	—	5 s

7.3 User Interface and Signal Data

Parameter	Value
Inverter OK LED	Green LED indicating that the inverter is operating and the output voltage is within the specified range. LED installed on lower side of inverter.
On/Off signal	Control input, 55–165 VDC. High signal >50 VDC switches 230 VAC output on. Low signal <50 VDC switches output off.
Inverter OK relay	Output signal by potential-free relay contact. Indicates inverter working and output voltage within specified range. Maximum switching voltage: 165 V. Maximum switching current: 0.5 A.

7.4 Mechanical Data

Parameter	Comment	Min.	Typ.	Max.
Height	Inverter is mounted vertically upwards. Placement of large components shall consider vibration and orientation.	—	—	520 mm
Width	Inverter is mounted vertically upwards. Placement of large components shall consider vibration and orientation.	—	—	460 mm
Depth	Inverter is mounted vertically upwards. Placement of large components shall consider vibration and orientation.	—	—	120 mm
Weight		—	—	21.2 kg

7.5 Environmental Data

Parameter	Comment	Min.	Typ.	Max.
IP class		IP20		
Pollution degree		2		
Ambient temperature	See Annex A: Derating.	-25 °C	—	70 °C
Height of usage		—	—	1,000 m
Vibration		EN 61373, Category 1, Class B		

7.6 Certification Standards

Safety Standard	Title / Conditions
EN 50155	Railway applications – Rolling stock – Electronic equipment.
EN 50124-1	Railway applications – Insulation coordination – Part 1: Basic requirements – Clearances and creepage distances for electrical and electronic equipment.
EN 50153	Railway applications – Rolling stock – Protective provisions relating to electrical hazards.

EMC Standard	Title
EN 50121-3-2	Railway applications – Electromagnetic compatibility – Part 3-2: Rolling stock – Apparatus.

8 Manufacturer

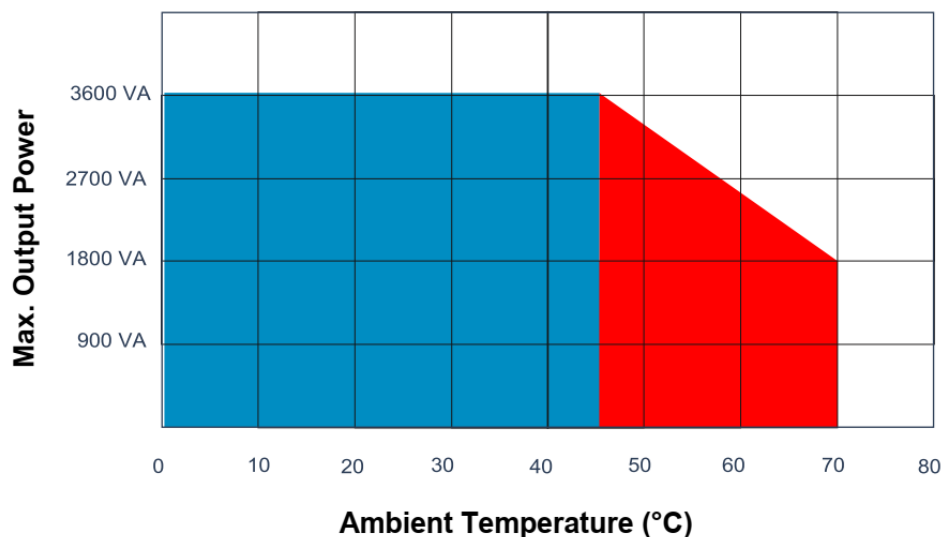
Manufacturer of the product is:

Acal BFi Germany GmbH
Assar Gabrielsson Straße 1
63128 Dietzenbach
Germany

Please contact Acal BFi in case of questions, failures or technical problems.

Annex A: Derating

The inverter shall operate without interruption within the temperature/output-power range specified. Operation with higher power than specified in the continuous derating range and up to 3,600 VA is possible but may lead to temporary shutdowns after some time because of overtemperature protection. The inverter recovers automatically after cooling.



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