

# Charger for EDLC Capacitors (Ultra-Caps) PAS395

Revision: 3.1

Specification

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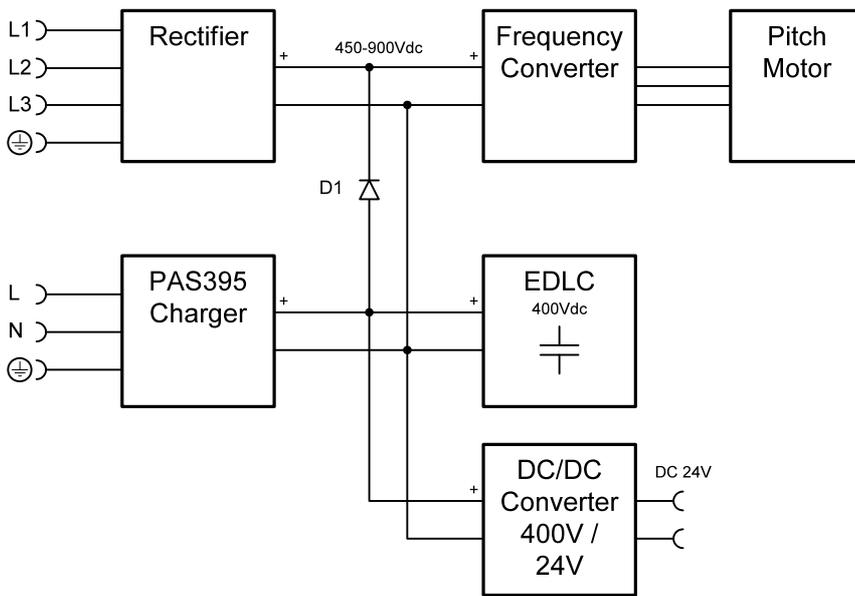
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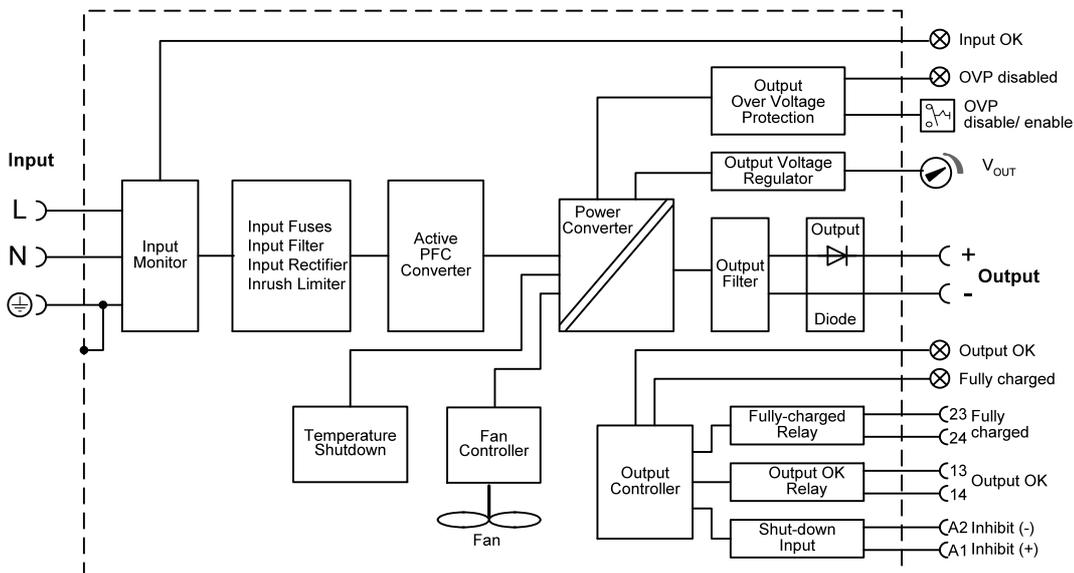
## **1 Functional Description**

- The charger is designed to charge EDLC (electrical double layer capacitors commonly known as Ultracaps, Supercaps or Greencaps) with a constant current – constant voltage characteristic (float charge mode).
- The charger is suitable to be used in a permanently spinning rotor-hub of a wind turbine.
- The charger is suitable for flange mounting. Any mounting orientation is allowed.
- Most of the heat will be conducted through the base-plate of the charger. A good thermal connection to the cabinet or an external heatsink can improve the MTBF and life time expectancy.
- The charger is equipped with an internal fan which turns on when necessary.
- The charger comprises an internal diode in series to the positive output voltage path in order to protect against back-feeding voltages.
- The input-, output and signal terminals are pluggable. Hot-swap ability is not supported.
- A voltage applied on the inhibit terminal stops the charging mode.
- The charger contains a “Fully-Charged” and an “Output-OK” relay contact.
- A redundant control circuit monitors the end-of-charge voltage and switches the charger off in case of a too high voltage. After such an event, automatic start attempts occur until the failure is cleared.

## 2 Typical Wiring Scheme



## 3 Functional Diagram



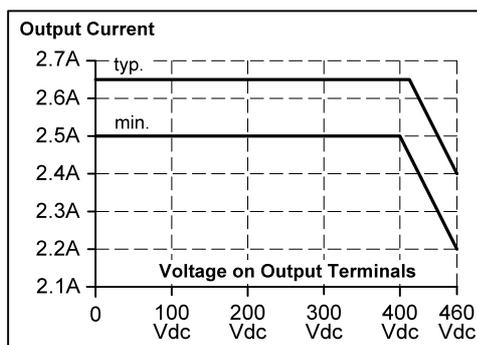
## 4 Performance Description

### 4.1 Input

Input Voltage:	AC 220-240V <sup>-20%/+10%</sup> (176 to 264Vac)
Turn-on Voltage	typ. 164Vac
Shut-down Voltage	typ. 151Vac
Input Current:	typ. 5.2A (at 230Vac and 1000W output power)
Input Frequency:	50-60Hz <sup>±6%</sup>
Power Factor:	> 0.9
Inrush Current:	< 10A peak (active limited, temperature independent)

### 4.2 Output

End-of-Charge Voltage:	Adjustable: 360-460Vdc (output voltage) Factory setting: 410Vdc
OVP voltage:	370-470Vdc; auto setting (OVP = Output over-voltage protection) The OVP voltage automatically adjusts to 10V higher than the end-of-charge voltage after following the procedure for setting the end-of-charge voltage. Testing the OVP level: Tune the end-of charge-voltage potentiometer clockwise until the “Fully Charged” LED starts flashing. This indicates the OVP level.
Output Current:	min. 2.5A at 400Vdc end-of-charge voltage



Output Ripple-Voltage:	Without connected capacitor bank: typ. 6V <sub>pp</sub> , max. 10V <sub>pp</sub> With connected capacitor bank: negligible
Output Current Ripple:	During charging: typ. 150mA <sub>pp</sub> , max. 300mA <sub>pp</sub>
Output Return Current:	Max. 1mA (discharge current when charger is not working)

**Procedure for Setting the End-of-Charge” Voltage:**

Setting the end-of-charge voltage shall be done in a laboratory. The output shall be open (not loaded, no capacitor needed). The output voltage (end-of-charge voltage) shall be measured with a digital voltmeter.

Factory setting of the end-of-charge voltage is 410Vdc and the OVP level is 10V higher. Changing of these values can be done according to the following examples:

Example 1:

Setting the end-of-charge voltage to 420V and OVP to 430V

**Step 1:** Push the “OVP disable / enable” button to disable the OVP. The red LED will start and keep flashing for two minutes. For this period of time the end-of-charge voltage can be set without triggering the OVP. Ensure that the unit is not in OVP mode before starting with step 1.

**Step 2:** Set the end-of-charge voltage to 420V

**Step 3:** Push the “OVP disable / enable” button again to set the OVP voltage 10V higher than the end-of-charge voltage(= 430Vdc). Red LED will go off. → done

Example 2:

Setting the end-of-charge voltage to 430V and OVP to 450V

**Step 1:** Push the “OVP disable / enable” button to disable the OVP. The red LED will start and keep flashing for two minutes. For this period of time the end-of-charge voltage can be set without triggering the OVP.

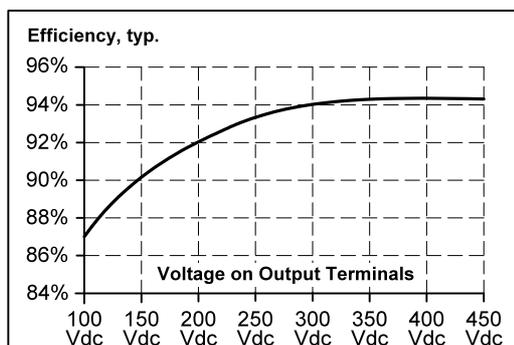
**Step 2:** Set the end-of-charge voltage to 440V

**Step 3:** Push the “OVP disable / enable” button again to set the OVP voltage 10V higher than the end-of-charge voltage(= 450Vdc). Red LED will go off.

**Step 4:** Set the end-of-charge voltage to 430V (without pushing the button) → done

## 5 General Data

Efficiency: typ. 94.4 %  
 at 400Vdc output voltage, 2.6A output current and 230Vac input voltage.

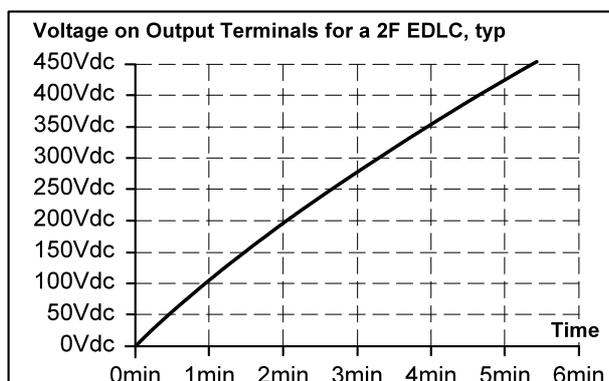


Full-load Power Losses: typ. 60.8W at 400Vdc output voltage and 2.6A output current

No-load Power Losses: typ. 12 W at 360Vdc output voltage  
 typ. 13 W at 400Vdc output voltage  
 typ. 15 W at 460Vdc output voltage

## 6 Charging Performance

The charger is suitable to charge capacitors up to 5F. The typical capacitance is considered to be 2F. Therefore, most of the following curves and investigations apply for this size of capacitor unless otherwise stated.



## 7 Signals, LEDs



**Inhibit Input:** A signal voltage of at least 18V on the inhibit input terminal stops the charging mode. Safety features are not included. The input is galvanically isolated by an optocoupler. Typ. signal current; 4.2mA at 18V and 5.4mA at 24V.

**Output-OK Relay Contact:** This relay contact closes (normally-open-contact) when the charger works properly and no internal faults or abnormal conditions are present. The contact is open when:

- the inhibit input is active or
- the over-temperature protection is activated or
- during overload or short-circuit conditions or
- when the over-voltage protection circuit has triggered.

Contact ratings: max. 30Vdc, 0.5A resistive load  
min. 1mA at 5Vdc (minimum permissible load)

**Fully-charged Relay Contact:** This relay contact closes (normally-open-contact) when the end-of-charge voltage is achieved.

Contact ratings: max. 30Vdc, 0.5A resistive load  
min. 1mA at 5Vdc (minimum permissible load)

**Input-OK LED:** This green LED is on, when input voltage is higher than 150Vac.

**Output-OK LED:** This green LED is synchronized with the Output-OK relay contact. The LED is on when the relay contact is closed.

**Fully-charged LED:** This green LED is off during charging and is on when the end-of-charge voltage is achieved. The LED is flashing when the unit enters the over-voltage protection level area (charger has switched off and makes start-up attempts).

## 8 LEDs and Relay Contacts Pattern

	Input-OK LED	Output-OK LED	Fully charged LED	Output OK Contact*)	Fully charged Contact
Capacitors in charging mode	ON	ON	OFF	closed	open
Capacitors fully charged	ON	ON	ON	closed	closed
Inhibit input activated	ON	OFF	OFF ***)	open	open***)
Capacitor does not permit charging (e.g. short circuit across output)	ON	typ. ON 130s OFF 110s...	OFF	typ. ON 130s OFF 110s...	open
No capacitor connected	ON	ON	ON	closed	closed
Over-temperature shut-down (OTP)	ON	OFF	according to the state-of-charge	open	according to the state of charge
Over-voltage protection activated (OVP)	ON	OFF **)	flashing	open **)	closed
Input voltage < 150V	OFF	OFF	OFF	open	open

\*) The Output-OK contact is synchronized with the Output-OK Led.

\*\*\*) Short single pulses will be suppressed in order to avoid a false triggering of the OVP.

\*\*\*) delayed by a couple of seconds

## 9 Environment

Operational Temp. Range: -40°C to +65°C

Storage Temp. Range: -55°C to +85°C

Humidity: 10 – 90% r.H.  
Do not energize while condensation is present

Altitude: 0 to 6000m above sea level

Overvoltage Category III up to 2000m altitude  
II up to 6000m altitude  
according to IEC 62103, EN 50178

Degree of pollution 2 (IEC 62103, EN 50178, not conductive)

Shock According to IEC 60068-2-27  
20g 11ms, 3 bumps / direction, 18 bumps in total  
30g 6ms, 3 bumps / direction, 18 bumps in total

Vibration sinusoidal According to IEC 60068-2-6  
2-17.8Hz: ±1.6mm; 17.8-500Hz: 2g, 2 hours / axis

Vibration random According to IEC 60068-2-64  
10-500Hz: 0.5 m<sup>2</sup>/s<sup>3</sup>  
Test duration: 120 minutes

## 10 Dielectric Strength, Isolation, Leakage Current

The output is floating and has no ohmic connection to the ground.

The following type and factory tests are conducted by the manufacturer. The test duration is 60s for type tests and 5s for the factory tests.

Type- & Factory Tests	Output	PE	Signal Pins
Input	2.5kVac	2.5kVac	3.0kVac
Output		2.5kVac	3.0kVac
PE			500Vac

Field tests may be conducted in the field using the appropriate test equipment which applies the voltage with a slow ramp (2s up and 2s down). Prior to the field test, special treatment of the unit may be necessary. Connect all input-terminals together as well as all output poles before conducting the test. When testing, set the cut-off current settings of the test equipment to a value larger or equal than 10mA. Optionally, a DC test voltage can be applied too. In such cases, multiply the AC test voltages with the factor 1.41.

The test duration for field tests should not exceed 10s, since every high-pot test adds extraordinary stress to the unit.

Field Tests	Output	PE	Signal Pins
Input	2kVac	2kVac	2.5kVac
Output		2kVac	2.5kVac
PE			500Vac

Isolation resistance            Input to output: 200MΩ (measured with 500Vdc)  
    Input to PE (earth): 200MΩ (measured with 500Vdc)  
    Output to PE (earth): 100MΩ (measured with 500Vdc)

Leakage Current:                max. 1.5mA (measured one minute after turning on the unit)

## 11 EMC

<b>EMC Immunity</b>	Generic standards: EN 61000-6-1 and EN 61000-6-2			
Electrostatic discharge	EN 61000-4-2	Contact discharge	8kV	Criterion A
		Air discharge	15kV	Criterion A
Electromagnetic RF field	EN 61000-4-3	80MHz-2.7GHz	20V/m	Criterion A
Fast transients (Burst)	EN 61000-4-4	Input lines	4kV	Criterion A
		Output lines	4kV	Criterion A
		Signal lines	2kV	Criterion A
Surge voltage on input	EN 61000-4-5	L → N	2kV	Criterion A
	EN 61400-24	L → N	LPZ 2	
	EN 61000-4-5	L → PE	4kV	Criterion A
EN 61400-24	L → PE	LPZ 2		
Surge voltage on output	EN 61000-4-5	+ → -	1kV	Criterion A
	EN 61400-24	+ → -	LPZ 2	
	EN 61000-4-5	+ / - → PE	4kV	Criterion A
EN 61400-24	+ / - → PE	LPZ 2		
Surge voltage on signals	EN 61000-4-5	signal → PE	1kV	Criterion A
	EN 61400-24	signal → PE	LPZ 2	
Conducted disturbance	EN 61000-4-6	0.15-80MHz	20V	Criterion A
Mains voltage dips	EN 61000-4-11	0% of 220Vac (=0V)	20ms	Criterion A
		40% of 220Vac (=88V)	200ms	Criterion C *)
		70% of 220Vac (=154V)	500ms	Criterion A
Voltage interruptions	EN 61000-4-11	0% of 220Vac (=0V)	5000ms	Criterion C
Powerful transients	VDE 0160	over entire load range	750V, 1.3ms	see note M

### Criteria:

**A:** Power supply shows normal operation behavior within the defined limits.

**C:** Temporary loss of function is possible. Power supply may shut-down and restarts by itself. No damage or hazards for the power supply will occur.

\*) signal status and LED will remain appropriate (= Criterion A)

**Note M:** The protection circuit switches off the converter for approx. 2 seconds, which is not considered to be a problem for the charging process.

<b>EMC Emission</b>	Generic standards: EN 61000-6-4	
Conducted emission	EN 55011, EN 55022, FCC Part 15, CISPR 11, CISPR 22	Input lines: Class A Signal lines: Class A
Radiated emission	EN 55011, EN 55022	Class A
Harmonic input current	EN 61000-3-2	Class A fulfilled (active PFC)
Voltage fluctuations, flicker	EN 61000-3-3	fulfilled *)

This device complies with FCC Part 15 rules.

Operation is subjected to following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

\*) Tested with constant current loads, non pulsing

## 12 Protection Features

The output is short-circuit, overload and no-load proof. After removing the fault, an auto-restart will be performed.

### **Over- temperature protection:**

A temperature sensor monitors the internal temperature of a semiconductor. If the temperature rises above a certain level, the fan will be turned on. If the temperature keeps rising, the output will switch off in order to protect the charger. The output will automatically turn on again as soon as the temperature decreases by 5°C. The “Output-OK” LED will be off and the “Output-OK” contact will be open when the over-temperature protection is active.

### **Output over- voltage protection (OVP) circuit:**

In case of an internal power supply defect, a redundant circuit limits the maximum voltage on the output terminals. If the fault has not removed within 2.5s, the “Output-OK” LED will be turned off and the “Output-OK” contact will open.

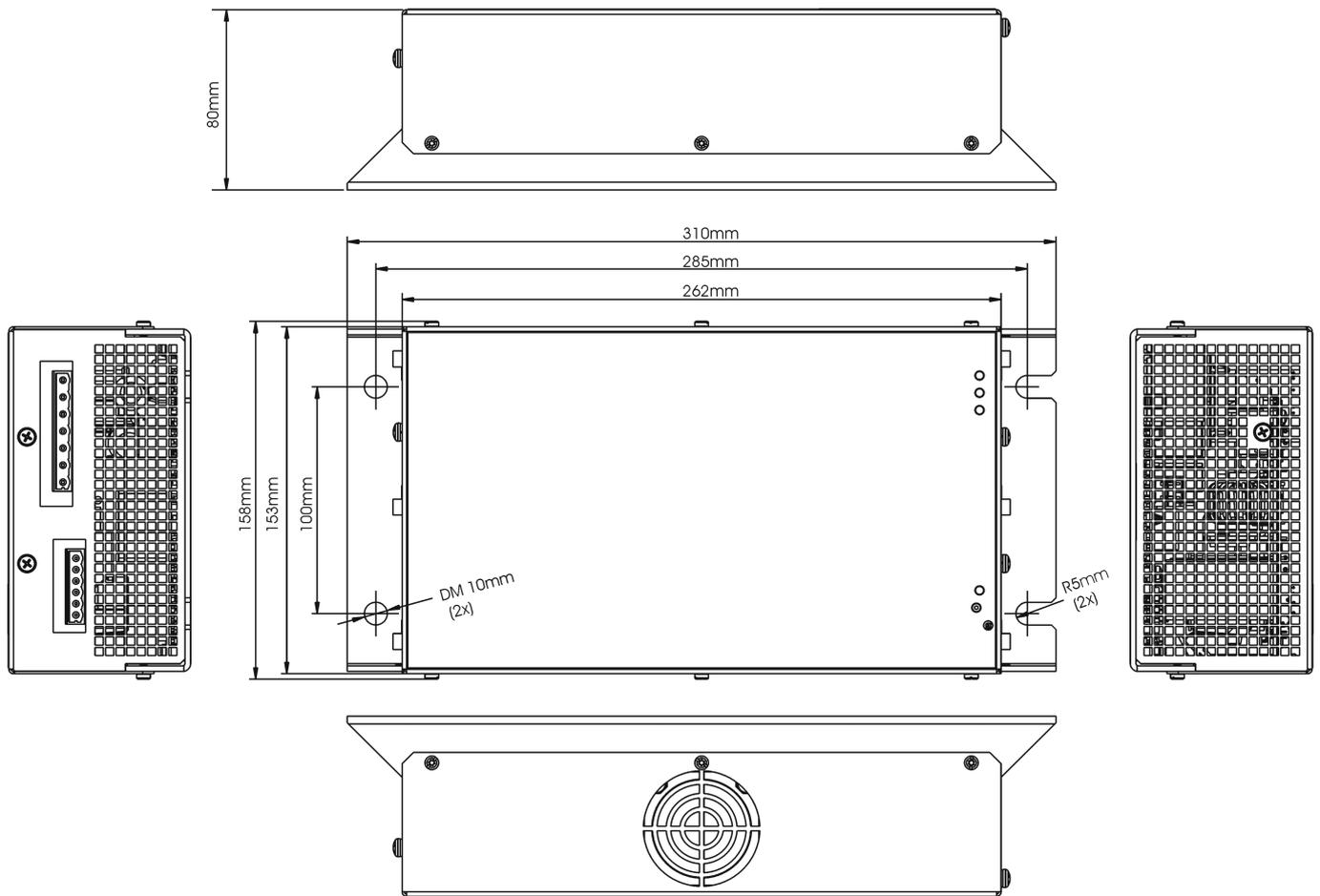
### **Overload and short-circuit protection:**

An overload or short circuit on the output will be recognized by the slew-rate of the voltage change on the output. If the output does not reach typ. 40Vdc within 130s after starting to charge, the charger will stop and will make a pause of 110s before a new charging cycle starts. These cycles continue until the fault has been removed.

### 13 Mechanical Dimensions

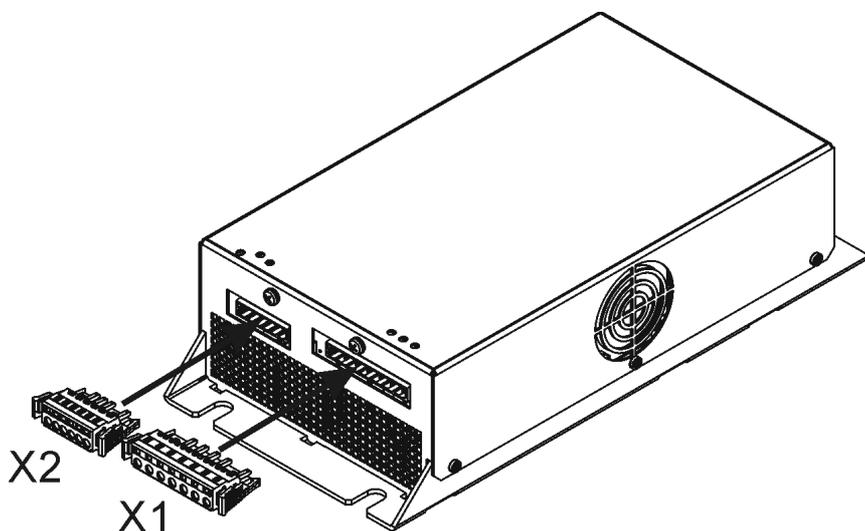
Dimensions: 310 x 158 x 80mm (L x W x H)

Weight: approx. 2.3kg



## 14 Terminals and Wiring

Two self-locking plug-connectors (X1, X2) with spring-clamp connection points



### Pin assignment:

#### X1: Power Connector

- 1 Vout (+)
- 2 not used
- 3 Vout (-)
- 4 not used
- 5 PE
- 6 N
- 7 L

#### X2: Signal Connector

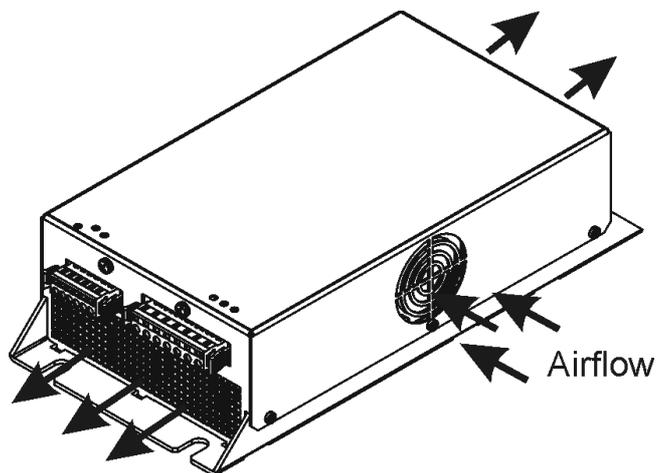
- 1 Inhibit (+)
- 2 Inhibit (-)
- 3 Fully charged contact
- 4 Fully charged contact
- 5 Output-OK contact
- 6 Output-OK contact

Cross section 0.08 - 2.5 mm<sup>2</sup> (solid)  
 0.08 - 2.5 mm<sup>2</sup> (fine-stranded)  
 0.25 - 1.5 mm<sup>2</sup> (fine-stranded with ferrule and plastic collar)  
 0.25 - 2.5 mm<sup>2</sup> (fine-stranded with ferrule, without plastic collar)  
 28 - 12 AWG

Recommended stripping length: 8 - 9mm (0.31 - 0.35in)

## 15 Cooling

The charger has a temperature controlled fan included, which makes the unit suitable for any mounting orientation and also suitable for applications where the heat cannot be transferred through the base plate of the unit.



The fan will only run if needed during high temperatures. The fan will also run for 8 seconds after applying sufficient input voltage. This allows to check the function of the fan. Furthermore, the fan will run approximately every three hours for a short time to avoid a stiffness of the fan after long breaks and to extend the life of the fan.

## 16 Approvals



GL (Germanischer Lloyd); planned



The CE mark indicates conformance with the:

- EMC directive 2004/108/EC,
- Low-voltage directive (LVD) 2006/95/EC and
- RoHS directive 2011/65/EU.