Technical specification

EV PowerCharger 110/3000 HE IP67 G2

Part no.: 241121.110

Document Change Record

Rev.	Date (dd.mm.yyyy)	Pages affected	Change Description

Table of Contents

1 General description

The charger is designed for maximal utilization of a 16A wall socket. It provides an output power in excess of 3 kW with a very high efficiency up to 95%. Through the built in CAN bus connection the unit can be fully controlled from a master unit and all major values can be read back. The mechanical design with thermal coupling of all major heat generating components mounted against a solid aluminium outer wall. This is intended to be mounted against a cold-plate, water cooled or with a sufficient heat transfer capacity for the environmental specification applicable.

1.1 Performance criteria

1.1.1 Performance criterion A

The apparatus shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed.

1.1.2 Performance criterion B

The apparatus shall continue to operate as intended after the test without manual reset. The module shall not stop or reset during the test, and the output voltage must be with normal operating range.

1.1.3 Performance criterion C

Temporary loss of function is allowed, provided the function is self-recoverable.

1.1.4 Performance criterion R

Temporary loss of function is allowed, provided the function is self-recoverable. The protection devices are allowed to break down.

2 Electrical specifications

2.1 Input

2.1.1 Voltage

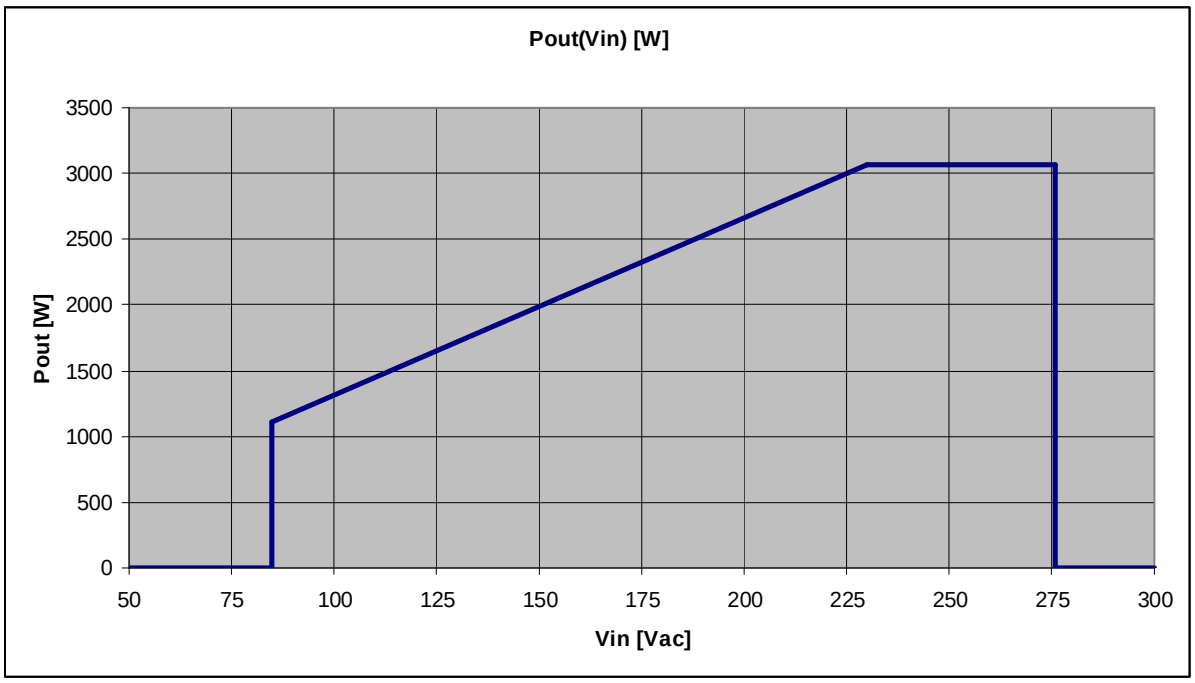


Figure 1: Output power vs. input voltage for AC input

- Nominal: 230 Vac
- Range: 230 - 275 Vac — Full output power
- Low voltage 1: 0 – 85 Vac — Shutdown
- Low voltage 2: 85 – 230 Vac — Max Iin 14A. Power 1100W and 3030W
- High voltage 1 230 – 275Vac — Full output power
- High voltage 2: 275 –300 Vac — Shut down.
- High voltage 3: 300 –> Vac — Not allowed, will damage the unit.

2.1.2 Current

- Nominal: 14.0 A_{rms} at 230 V_{rms} at full load
- Maximum: 14.0 A_{rms} at 85-230V_{rms} input and full load
- Inrush: < 22.4 A_{peak}, excluding X-capacitors, compliant to ETS 300 132-1
- THD: < 5 % at nominal input voltage and full load, provided voltage THD < 2%

2.1.3 Frequency

- Nominal Range: 45 – 66 Hz
- Extended range: DC-45 Hz with reduced spec

2.1.4 Power Factor

- > 0.99 at 50% to 100% load, nominal input voltage

2.1.5 Efficiency versus load

Peak efficiency: 95,6% at 45% load
Efficiency >95% at 20-70% load
Efficiency >94% at 15-100% load

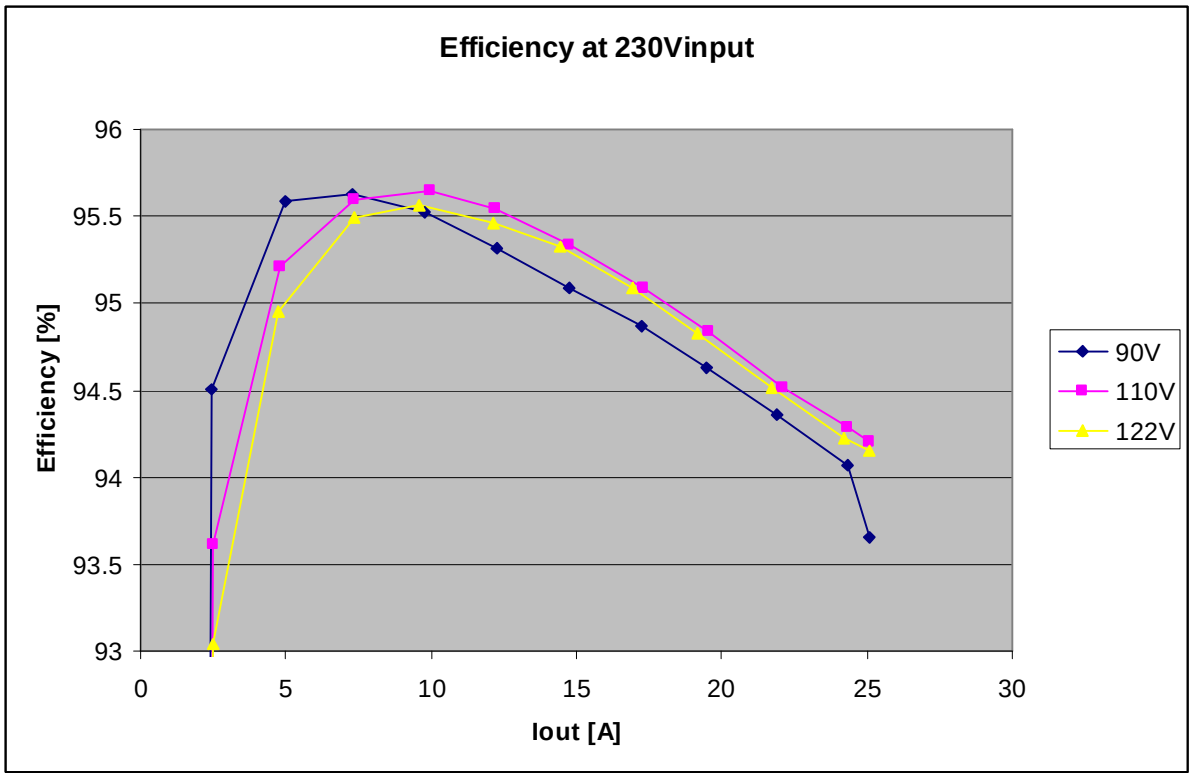


Figure 2: Typical efficiency at 230V_{ac}

2.1.6 Efficiency in current limit

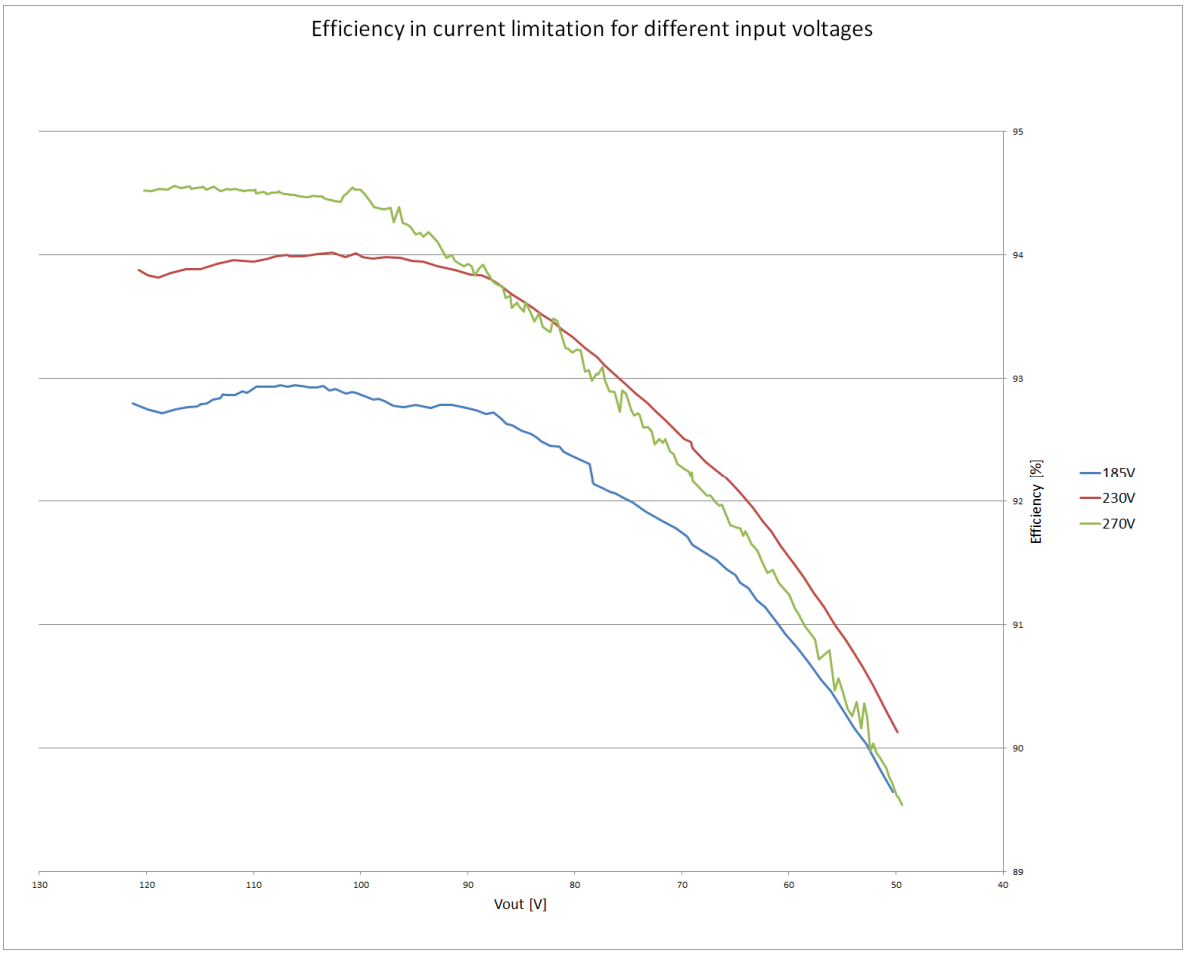


Figure 3: Efficiency at different input voltages at maximum power/ maximum current

2.1.7 Quiescent power

Power consumption with no load on output: <14W
Power consumption when output is disabled: <5W

2.1.8 DC input

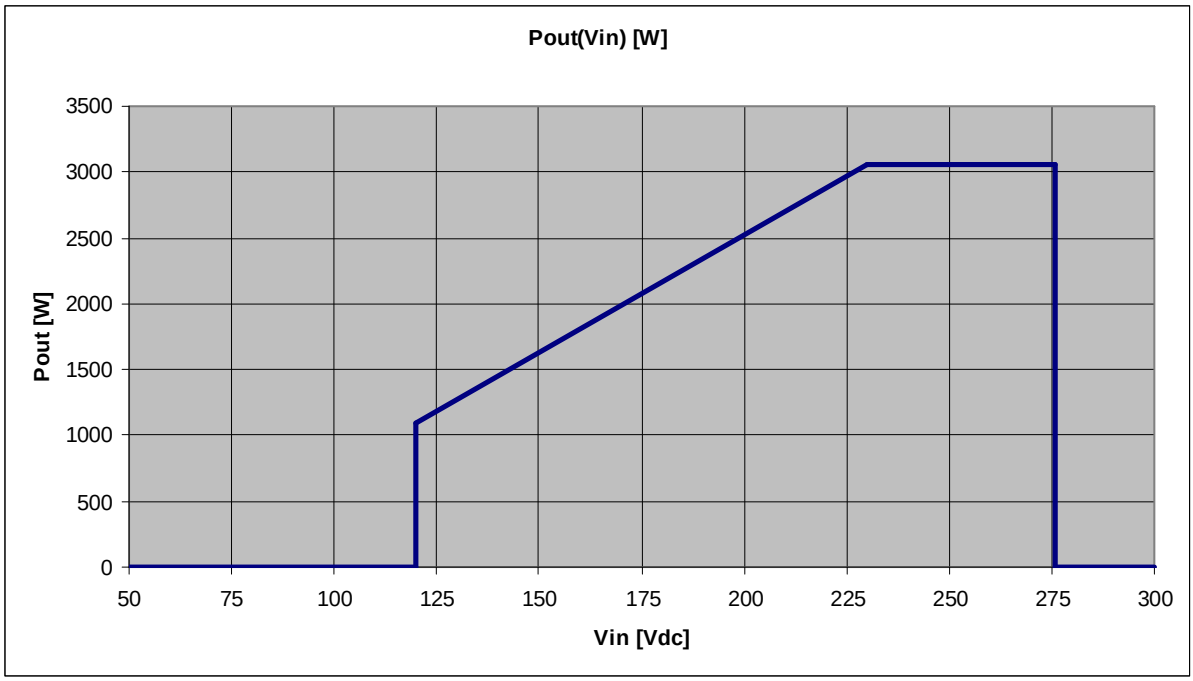


Figure 4: Output power vs. input voltage for DC input

• Nominal:	230 Vdc	
• Range:	120 - 275 Vdc	
• Startup:	120Vdc	
• Low voltage 1:	0 – 120 Vdc	Shutdown
• Low voltage 2:	120 – 230 Vdc	Linear between 1100W and 3030W
• High voltage 1:	230 – 275 Vdc	Full output power.
• High voltage 2:	275 – 300 Vdc	Shut down.
• High voltage 3:	300 -> Vdc	Not allowed, will damage the unit.

2.2 Output

2.2.1 Voltage

- Nominal: 92-122 V_{dc}
- Adjustable: 70-122 V_{dc}

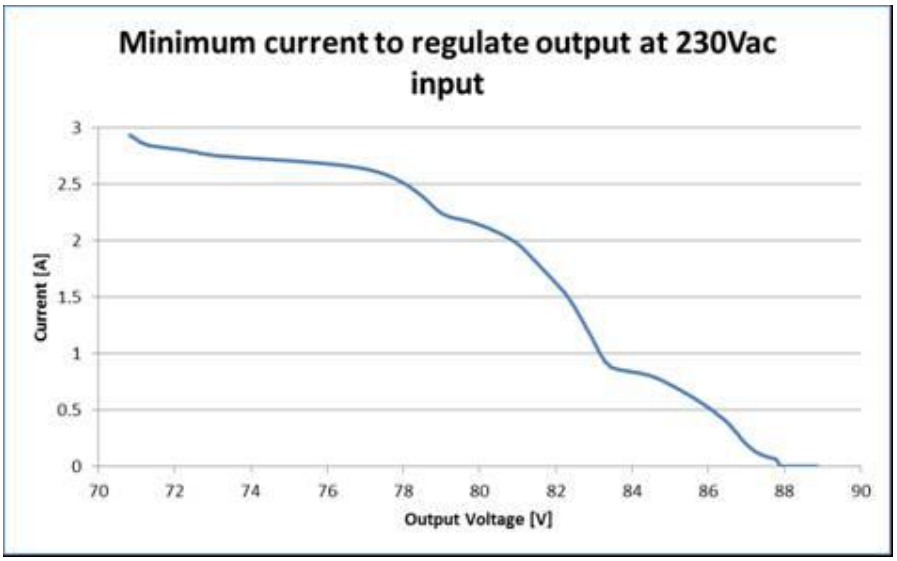
Minimum output voltages at no load may increase at light load and high input AC voltage.

Vac	Vout @ Vset = 90	Vout @ Vset = 110	Vout @ Vset = 122
230	91,3	110,5	122,5
270	103,6	110,5	122,5

Output voltage versus input voltage and set voltage at zero load.

Vac	Iout @ Vset = 90	Iout @ Vset = 110	Iout @ Vset = 122,5
230	1,92	1,06	1,94
275	2,37	1,15	1,93

Minimum output current to meet set voltage versus input voltage and set voltage



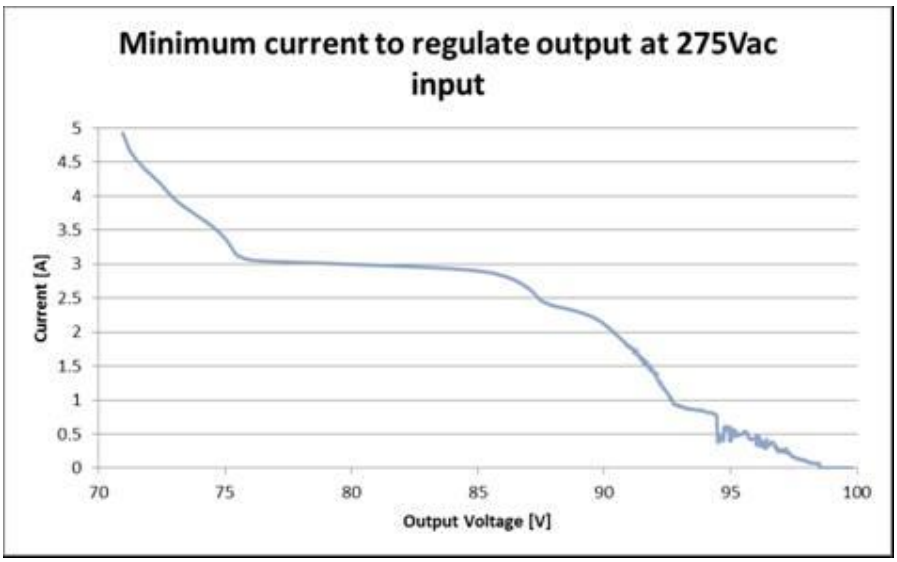


Figure 5 A and B: Minimum load to maintain voltage regulation at output for 230 and 275Vinput

2.2.2 Voltage Regulation

- Static regulation: ± 1.5 % for 0 – 100% load and nominal input voltage.

2.2.3 Dynamic response

- Dynamic regulation: -12.5/+5% < 30ms for load step 10% to 90% or opposite

2.2.4 Hold-up time

1370W Output:

- 20ms: Output drops from 110 to 87,8V

2.2.5 Ripple

- < 800 mV_{pp} (max) , 500 mV_{pp} (typ) differential, 30 MHz BW limited measurement

2.2.6 Current

- Maximum: 25 (+/-0.25) A_{dc} in current limitation

2.2.7 Power

- Nominal: Max 3030W output at nominal input voltage
- Power limit: adjustable 0 - 100 %, automatic reset
- Constant current: adjustable for output voltage 70-122V_{dc}, fixed 25A[1] for 50 to 70V_{dc}

[1]Less if the charger is derating (mains voltage or temperature)

2.3 Protection

2.3.1 Input

- 300V varistor L – N for transient protection
- Mains fuse: 2x25A (fast) 6.3x32mm in Live and Neutral, accessible to service personnel only.

2.3.2 Output

- Fuse 40A 150Vdc/250Vac in negative output, accessible to service personnel only.

2.3.3 Internal

The rectifier has several internal protection features:

- **Low input voltage:** If input voltage drops below $85V_{rms}$ or $120V_{dc}$, the module shuts down.
- **High input voltage:** If the input voltage is > 275Vac or 275Vdc the rectifier will go into self protective mode. The rectifier will survive up to 300Vac.
- **High output voltage:** The rectifier will selectively shut down if the output voltage exceeds $130V_{dc}$.
- **High temperature:** The unit will derate at heat sink temperatures above 60ºC, and finally shut down as the heat sink temperature increases. Derating and shut down point depends on actual load. The unit is self protective for any cooling and load combination, even without heat sink.
- **Short circuit:** The module is short circuit proof, and shuts down when the output goes below 50V.

3 Environment

The rectifier complies with the following standards:

- Storage: ETS 300 019-2-1 Class 1.2
- Transportation: ETS 300 019-2-2 Class 2.3

3.1 Temperature

3.1.1 Storage temperature

- -40°C - +85°C
- Recommended long-term storage temperature: 10 - 30 °C

3.1.2 Operating temperature

All temperatures are defined as the temperature in the heat sink the charger is mounted to.

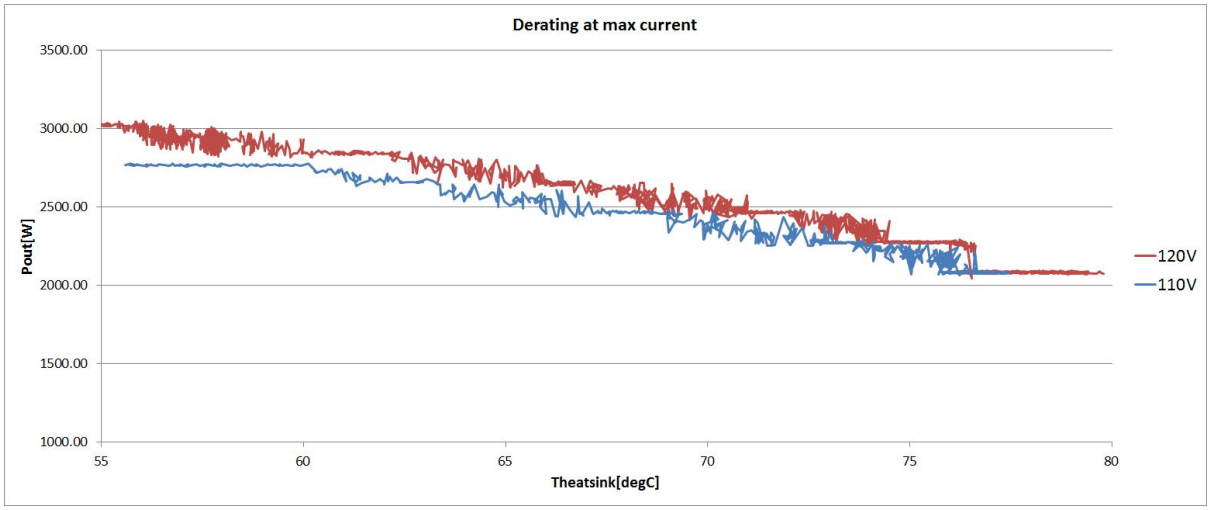


Figure 6: Derating curve for 110V (nominal) and 120V (max) output

- -40°C – -10°C full power, reduced performance
- -10°C - +60°C full power at nominal output voltage (-10°C - +55°C at max output voltage)
- +60°C – ca. +80°C reduced[1] output power
- Above +80degC Shutdown[1], automatic restart at lowered temperature

[1]Derating and shut down temperature depends on load.

3.2 Cooling

- Cold plate/ heat sink

3.3 Acoustic noise

< 30dBA at nominal input and full load

3.4 Shock and vibration

3.4.1 Vibration

The EV PC performs within the specified limits after exposure to the following vibration profile while unpowered (connectors and cables attached), and one sweep on each axis while powered: (Reference WDS 00.00EA-D11, 4.6.1)

The table should reflect a Moderate vibration level, vibration method B

Freq (Hz)	Accel (m/s^2)	Type	Time/sweep (min)	Sweeps/axis	Total
5-21.1	10mm p-p	Log	5	18	54 sweeps/18 hours
21.1-50	88.3 (9g's)	Log	5	18	54 sweeps/18 hours
50-100	68.6 (7g's)	Log	5	18	54 sweeps/18 hours
100-200	44.1 (4.5g's)	Log	5	18	54 sweeps/18 hours

Table 3.1. Vibration test

3.4.2 Shock

The PCU performs within the specified limits after exposure to the following while unpowered: (Reference WDS 00.00EA-D11, 4.6.3.3) – Medium Shock

Six 100g 10ms half-sine shock pulses, one in each opposite direction of each perpendicular axis.

4 Electromagnetic compatibility

The module complies with the European and International standards for EMC, details about levels and test conditions are listed in the following sections.

4.1 Emissions

Compliant to:

- **Radiated:** EN 61000-6-3, January 2007
  CISPR 22 Class B
  IEC 61000-6-4, 2nd edition, 2006
- **Conducted - Input:** EN 61000-6-3, January 2007
  CISPR 22 Class B
  IEC 61000-6-4, 2nd edition, 2006
- **Conducted - Output:** EN 61000-6-3, January 2007
  CISPR 22 Class A

Port	**Frequency Range (MHz)**	**Limits (dB(μV))**		**Note**
Enclosure	30 – 230 230 – 1000	30 37		1
		Quasi-peak	Average	
AC port	0,15 – 0,50 0,50 – 5 5 – 30	66 – 56 56 60	56 – 46 46 50	2
DC Port	0,15 – 0,5 0,5 –30	79 73	66 60	
Notes: 1) 10 m distance 2) Limit decrease linearly with logarithm of the frequency in the range 0,15 – 0,50				

Table 4.1. Limits for emissions

4.2 Immunity

Compliant to:

- EN 61000-6-1
- EN 61000-6-2
- EN 61000-6-3
- EN 61000-6-4

Immunity specification – Enclosure ports

Test	Environmental phenomena	Basic Standard IEC	Test value	Remarks
1.1	Power frequency magnetic field	IEC 61000-4-8	30A/m	
1.2	Radiated, radio-frequency electromagnetic field	IEC 61000-4-3	80MHz – 2000MHz: 10V / m 2.0GHz – 2.7GHz: 3V / m	This level normally allows the use of portable radiating equipment at 1m to 2m distance from installed equipment (see details in the basic standard)
1.3	Electrostatic discharge	IEC 61000-4-2	8 kV contact 15 kV air	-
1.4	Pulsed magnetic fields	IEC 61000-4-9	2000A/m	

Immunity specification – Signal ports

Test	Environmental phenomena	Basic Standard IEC	Test value	Remarks
2.5	Conducted disturbances Induced by radio frequency fields	IEC 61000-4-6	0.15-80MHz: 10 V_{RMS}	10V = 140 dB (µV)

Immunity specification – Low voltage AC input power ports

Test	Environmental phenomena	Basic Standard IEC	Test value	Remarks
3.1	Voltage dips	IEC 61000-4-11	Δ*U* 100% for 0,5 periods Δ*U* 100% for 1 periods Δ*U* 30% for 25 periods Δ*U* 60% for 10 periods	Δ*U* 100% for 0,5 periods Δ*U* 100% for 1 periods Δ*U* 30% for 25 periods Δ*U* 60% for 10 periods
3.2	Voltage interruptions	IEC 61000-4-11	Δ*U* 100% for 250 periods	Δ*U* 100% for 250 periods
3.3	Surge 1,2/50 µs Line to ground Line to line	IEC 61000-4-5	 2 kV 1 kV	 -
3.4	Fast transient / burst	IEC 61000-4-4	2 kV	-
3.5	Power Quality - Flicker	IEC 61000-3-3	Dmax 4% Dc 3.3% Dt 500msec Pst 1 Plt 0.65	
3.6	Conducted disturbances Induced by radio frequency fields	IEC 61000-4-6	0.15-80MHz: 10 V_{RMS}	10V = 140 dB (µV)

Immunity specification –DC output power ports

Test	Environmental phenomena	Basic Standard IEC	Test value	Remarks
4.6	Fast transient / burst	IEC 61000-4-4	2 kV	-
4.8	Conducted disturbances Induced by radio frequency fields	IEC 61000-4-6	0.15-80MHz: 10 V_{RMS}	10V = 140 dB (µV)

4.3 Input current harmonics

Table 4.2 defines the maximum permissible harmonic currents.

Harmonic number [n]	Maximum current [A]
Odd harmonics	
3	2,30
5	1,14
7	0,77
9	0,40
11	0,33
13	0,21
15 – 39	0,15 x 15/n
Even harmonics	
2	1,08
4	0,43
6	0,30
8 – 40	0,23 x 8/n

Table 4.2. Limits for harmonic currents

5 Safety

5.1 Design standard

UL60950/EN60950 - classification of equipment:

- Mobility: Fixed, for building in, direct plug-in
- Protection class: 1 (permanent connection to protective earth)
- Supply connection: Pluggable equipment type B
- Clearance and creepage class: Pollution degree 2, Material group III
- Intended site and usage: For use in restricted access locations - service access area
- Module IEC protection class: IP67. Total current from AC inputs to safety earth: < 3.5 mA at 50 Hz

5.2 Isolation voltages

- Input - earth: 1.5 kV_{ac} (basic insulation)
- Input - output: 1.5 kV_{ac} (basic insulation)
- Output - earth: 3.0 kV_{ac}(reinforced insulation)
- Can bus – primary 3.0 kV_{ac} (reinforced insulation)
- Can bus – secondary 3.0 kV_{ac} (reinforced insulation)
- Can bus – earth 0.5kV_{ac} (functional insulation)

Hi-pot test in production:

- Input – earth[1]: 2.12kVdc for 5s, max 50uA
- Input – output: 2.12kVdc for 5s, max 50uA
- Output – earth[1]: 2.12kVdc for 5s, max 50uA
- Can bus – earth: 500V dc for 5s, max 50uA

[1] Can bus connected to earth.

6 Software

The rectifier has two controller cards; a primary and secondary card.

The primary card hosts a Freescale MC56F8014 DSP that controls the PFC gates, monitors and controls the input stage and communicates with the secondary controller via a serial-line communications interface (SCI).

The secondary card hosts a Freescale MC56F8037 DSP that controls the DCDC stage, monitors and controls the output stage, communicates with the primary controller over SCI and with external devices on CAN.

6.1 Derating

The rectifier can derate due to:

1. Low mains voltage
2. High internal temperature
3. Low mains frequency

6.1.1 Temperature derating

The secondary controller derates the output power when one or more of the three internal temperature measurements exceed their derating thresholds. The rectifier shuts down when one of the temperature measurement exceed the shutdown threshold.

Temperature measurement	Derate start [°C (W)]	Shutdown [°C (W)]
Primary temperature	100 (3030W)	> 110 (2100W)
Secondary temperature	95 (3030W)	> 100 (2100W)
Transformer temperature	115 (3030W)	> 120 (2100W)

Table 3 Temperature derating and shutdown

6.1.2 Mains derating

The secondary controller derates the output power depending on the input voltage. See Section 2.1.1 for derating characteristics.

6.1.3 Mains frequency derating

The secondary controller derates the output power depending on the input voltage frequency.

Frequency [Hz]	Available power [W]
< 4 (DC)	3030W
5	970W
> 45	3030W

Table 4 Frequency derating

6.2 Output voltage control

An external control system can adjust the maximum voltage limit (float voltage) for a rectifier over CAN. Allowed limits are described in Section 2.2.1.

6.3 Maximum current control

The maximum current limit for the rectifier is 25A. If the rectifier derates due to low mains voltage, low mains frequency or high temperature the maximum current limit is decreased.

The maximum current limit is met by analog current limitation.

The hardware current control will always choose the **lowest** current demand from the following alternatives:

Current setting	Origin	Minimum	Maximum
Maximum current limit	Internal	$25A_{dc}$	$25A_{dc}$
Derated current limit	Internal	$5.8A_{dc}$	$25A_{dc}$

Table 5 Maximum current limits

6.4 Maximum power control

The maximum output power for the rectifier is 3030W and is available at max output voltage only. If the rectifier derates due to low mains voltage, low mains frequency or high temperature the maximum output power is decreased.

The maximum power limit is met by output voltage regulation.

The power limit regulator will always choose the **lowest** power demand from the following alternatives:

Power setting	Origin	Minimum	Maximum
Maximum power	Internal	3030W	3030W
Derated power	Internal	706W	3030W

Table 6 Maximum power limits

6.5 Software power/current demand

The output power and current can be controlled over CAN. The rectifier will use the user-defined current or power limits only if they are lower than the maximum current limit (Section 6.3) or the maximum power limit (Section 6.4).

The user-defined current and power limits are met by output voltage regulation.

The power and current demands are active in the range from 70 to $122V_{dc}$. Only the maximum current control is active below $70V_{dc}$.

Power setting	Origin	Minimum	Maximum
Power reference[2]	CAN	0W	3030W
DC current reference[2]	CAN	$0A_{dc}$	$25A_{dc}$
AC current reference[1]	CAN	$10A_{ac}$	$14A_{ac}$

Table 7 Software power/current demand

[1] The AC current reference is calculated to a DC current reference. Power losses are accounted for.
[2]For minimum load requirements refer to chapter 2.2.1.

7 Interface

7.1 Signals

Floating isolated CAN bus, reinforced insulation to primary and secondary circuits, functional insulation to chassis.

7.2 Connections

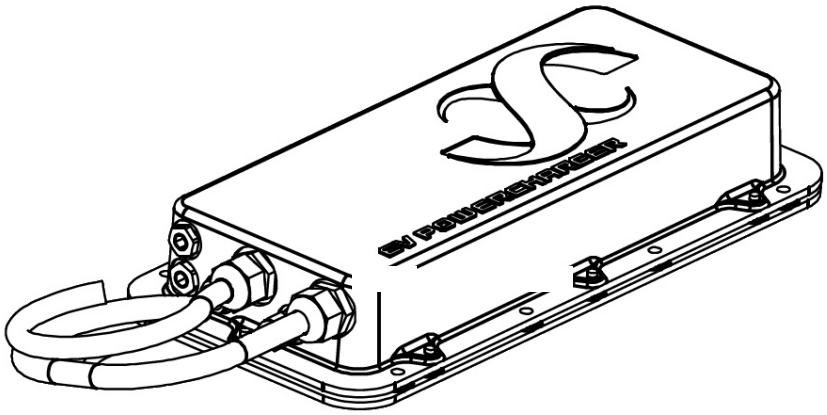


Figure 7: Charger with pigtails

The charger is delivered without connectors. Three cables come out of the charger:

1. Power output:
   - DC -
   - DC +

2. Power input:
   - Neutral
   - Live
   - PE

3. CAN communication:
   - CAN H
   - CAN L
   - CAN Ref

Colour map for the cables is found in the installation manual.

7.3 CAN

CAN protocol: CAN 2.0 A/B (11-bit identifier)
CAN baud rate: 500 Kbit (adjustable)

The rectifiers require an external control system to instruct them with control commands over CAN. Once receiving control commands from the control system the rectifiers will automatically transmit measurements and alarms at specific time intervals. The control system can turn the rectifiers on or off and adjust output power, output voltage and output current limits. When the rectifiers lose communication with the control system they turn off and await further instructions.

The rectifiers do not start until instructed to by an external control system.

7.3.1 Available measurements

The following rectifier measurements are automatically transmitted when communicating with an external control system.

Output voltage	0 – 135V_{dc} ± 1%
Output current	0 - 43A_{dc} ± 0.5A
Maximum output power	3030W
Available output power	0 – 3030W
Internal temperatures	-40 - +125 ± 3ºC
Mains voltage	0 - 300V_{ac} ± 3.5Vac (1%) at load > 5%
Mains frequency	0 – 63Hz
Mains current	0 – 14A
Rectifier status	All warnings and alarms

7.3.2 Rectifier settings

An external control system can adjust the following settings.

Output enable:	Output ON/OFF
Output voltage maximum limit:	70-122V_{DC}
Output current maximum limit	0 – 25A
Input current maximum limit	10 - 14A
Output power reference (0-100%)	0 – 3030W

The minimum load requirements given in chapter 2.1.1 are hardware limitations and limit the regulation range at low voltage and light loads.

7.3.3 Firmware update

Firmware updates are conducted over CAN. Mains voltage must be present.

7.3.4 Alarms and status

Table 8 lists all alarms, the corresponding status and action taken by the rectifier.

Alarm	Status	Description
DC overvoltage shutdown	Recoverable error	If the output voltage reaches 130V, the rectifier will selectively shut down. The rectifier attempts to restart three times within one minute before permanent shutdown.
Internal SCI communication failure	Non-recoverable error	The secondary controller (DC side) is unable to communicate with the primary controller (AC side) over the serial communication interface. The secondary controller turns off the DC/DC.
High mains	Recoverable error	If the input voltage reaches 275V the rectifier will shut down. The rectifier will turn back on when the input voltage sinks below 270V.
Low mains	Recoverable error	If the input voltage sinks below 79V the rectifier will shut down. The rectifier will turn back on when the input voltage reaches 84V.
High temperature	Recoverable error	The rectifier shuts down if one of the three internal temperature measurements exceeds the maximum threshold: Primary temperature: 110°C (AC side) Secondary temperature: 100°C (DC side) Transformer temperature: 120°C
Low temperature	Recoverable error	The rectifier shuts down if the primary temperature (AC side) falls below -45°C. The rectifier will turn back on when the temperature reaches -40°C.
Current limit	Recoverable error	The rectifier reports a current limit situation if it has derated the available output power due to high temperature, low mains or low AC frequency and is unable to deliver the desired power demand (over CAN). The rectifier does not shut down but continues to operate with limited power.
Module failure	Non-recoverable error	The rectifier reports module failure if the DC/DC has failed. The rectifier does not shut down.
DC undervoltage shutdown	Recoverable error	If the output voltage falls below 50V the rectifier will selectively shut down. The rectifier attempts to restart three times within one minute before permanent shutdown.
CAN communication timeout	Recoverable error	When communicating with an external control system the rectifier expects to receive a specific control message. If the control message interval exceeds one second the rectifier will shut down and signal a CAN communication timeout (in the last status message to the control system).

Table 8 Rectifier alarms

7.3.5 CAN identifiers

A rectifier reserves 16 CAN identifiers. 9 CAN identifiers are reserved for charger control, status messages, configuration and software updates. The remaining 7 CAN identifiers are reserved for future use.

CAN identifier offset	CAN message
1	Charger control[1]
2	Software update
3	Software update response
4	Configuration
5	Configuration response
6	Status #1
7	Status #2
8	Errors / Warnings
9	Serial number
10-16	RESERVED

Table 9 CAN identifiers

[1] The base CAN identifier is used as broadcast charger control

The CAN identifiers used by a rectifier are determined by a *base CAN identifier*, the rectifier's logical *address* and a CAN message offset. Both the base CAN identifier and a rectifier's logical address are configurable.

The CAN identifier for a specific CAN message, base CAN identifier and rectifier address configuration is:
Base CAN identifier: *0 – 0x6FF (0x2FF is default)*
Rectifier address: *1 – 16 (1 is default)*
Message CAN identifier: *CAN identifier offset + base CAN identifier + (rectifier address – 1) * 16*

8 Mechanical specification

The module is a stand-alone unit for permanent installation in electric vehicles.

8.1 Dimensions

- Width: 167mm
- Height: 60.8 mm
- Depth: 356 mm
- Weight: 4.3 Kg

8.2 Chassis

- Chassis material: Aluminium.

8.3 Enclosure

The enclosure is qualified according to following IP-ratings:

- IP67
- IP6K9K

9 Certifications

- CE
- UL recognised
- RoHS compliant

10 List of compliances

10.1 Safety

- IEC60950 3rd edition
- IEC60950-1
- UL60950 3rd edition
- UL60950-1

10.2 EMC

- IEC61000-6-1 (2005), immunity standard for residential, commercial and light-industrial environments:
  - IEC61000-4-2 : 2001
  - IEC61000-4-3 : 2007
  - IEC61000-4-4 : 2004
  - IEC61000-4-5 : 2005
  - IEC61000-4-6 : 2006
  - IEC61000-4-8 : 2001
  - IEC61000-4-9 : 2001
  - IEC61000-4-11 : 2004

- IEC61000-6-2 (2005), immunity standard for industrial environments:
  - IEC61000-4-2 : 2001
  - IEC61000-4-3 : 2007
  - IEC61000-4-4 : 2004
  - IEC61000-4-5 : 2005
  - IEC61000-4-6 : 2006
  - IEC61000-4-8 : 2001
  - IEC61000-4-9 : 2001
  - IEC61000-4-11 : 2004

- IEC61000-6-3 / A1 (2005), emissions standard for residential, commercial and light-industrial environments:
  - EN55022 : 2005
  - CISPR22 : 2005
  - IEC61000-3-2 : 2005
  - IEC61000-3-3 : 2005
  - IEC61000-3-11 : 2000

- IEC61000-6-4 (2001-10), emissions standard for industrial environments:
  - EN55011 : 2006
  - CISPR11 : 2006
  - IEC61000-3-2 : 2005
  - IEC61000-3-3 : 2005
  - IEC61000-3-11 : 2000

- FCC part 15 Subpart 109

10.3 Environment

- ETSI EN 300 019-2-1 V2.1.2 : 2000, Specification for environmental tests; Storage. Class 1.2, Weather protected, not temperature-controlled storage locations

  - IEC60068-2-1 : 2007
  - IEC60068-2-2 : 2007
  - IEC60068-2-6 : 2007
  - IEC60068-2-30 : 2005
  - IEC60068-2-56
  - IEC60068-2-64 : 2008

- ETSI EN 300 019-2-2 V2.1.2 : 1999, Specification for environmental tests; Transportation. Class 2.3, public transportation.
- Ford WDS 00.00EA-D11