HIGH POWER SERIES

11 kW Bidirectional Power Unit, DC/DC

HIGH POWER | E-MOBILITY | EV CHARGERS

OVERVIEW

BMPU-R2 is a grid-tied power supply capable of bidirectional conversion between AC (grid) and DC.

BMPU-R2-DC is a specific configuration, compatible with DC grids.

It features a modular design capable of parallel operation and can be used as a part of a very high-power system.

Typical application: electric vehicle supply equipment (EVSE) connected to ESS or DC grid

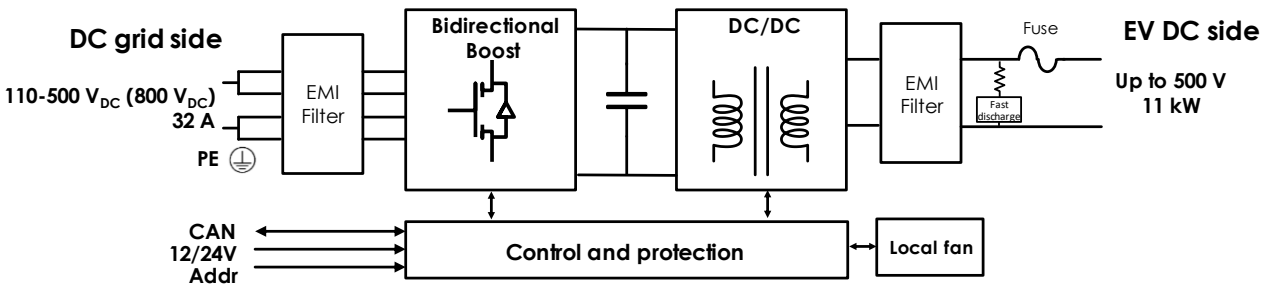
VERSIONS

	GRID INPUT	EV SIDE
BMPU-R2-500-32-DC	500V – 32A	500 V – 32 A
BMPU-R2-500-32-DC-HV	800V – 32A	500 V – 32 A

FEATURES

- 32A, 500V / 800V on DC grid side
- Reinforced galvanic isolation between input and output
- Integrated forced air cooling with fan speed control
- Form factor: 448.4×360.6×88mm, fits a 19” rack, 2U
- CANopen compatible digital bus with advanced control, monitoring and logging capabilities
- Integrated protections: OCP, OTP and UVLO
- This version inherits the hardware of BMPU-R2-500-32, with some adaptations. A dedicated cost effective DCDC is in the W&W roadmap.

BLOCK DIAGRAM



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Revision date: 08/2023

WARNING
This equipment operates at voltages and currents that can result in electrical shock, fire hazard and/or personal injury if not properly handled or applied. Equipment must be used with necessary caution and appropriate safeguards employed to avoid personal injury or property damage.
This board must be used only by qualified engineers and technicians familiar with risks associated with handling high voltage electrical and mechanical components, systems, and subsystems.

Table of Contents

1. Absolute maximum ratings

Table 1-1: Absolute maximum ratings

Parameter		Condition	Min	Max	Units
LV Input Voltage			0	29	V
EV DC side voltage			0	500	V
EV DC output to PE				±500	V
DC grid voltage	BMPU-R2-500-32-DC			500	V
	BMPU-R2-500-32-DC-HV			850	V
Operating Temperature			-10	70	°C
Long term storage Temperature			-30	70	°C
Temperature change rate				5	°C/min

Recommended maximum ambient temperature is 45°C, beyond 45°C, linear derating on power output is applied.

2. Electrical Characteristics

All specifications are given for ambient temperatures up to 45°C unless otherwise noted.

Table 2-1: Electrical characteristics

Parameter	Condition	Value			Units
		Min	Typ	Max	
DC grid side					
Voltage (DC version)		110	350	500	V_{DC}
Voltage (DC-HV version)		110	700	800	V_{DC}
Current		-32		32	A
Inrush current	During 1 ms			8	A
Input capacitor to be pre-charged			1.5		mF
Current measurement accuracy	32Arms			5	%
Voltage measurement accuracy	500V_{DC}			2.3	%
EV side					
Voltage		150		500	V_{DC}
Power	Charge Discharge			10.5 -11	kW
Maximum power variation (SW programmable)	Active power			30	kW/s
Current	Charge Discharge			30 -32	A
Voltage measurement accuracy	@500V			0.5	%
Current measurement accuracy	@ 32Adc			1	%
CAN communication					
CAN baud rate			500		kbps
CAN common mode range[1]		-7		7	V
Digital Inputs					
Positive going input current (Charge permission, Address, EMS)		2		10	mA
Negative going input current (Charge permission, Address, EMS)				0.1	mA
Maximum reverse voltage				5.5	V
LV input					
Supply voltage		9	24	29	V
Power consumption	@9V input @12V input @24V input	5[2] 5 5		27.5[3] 25 24	W
Input current start-up (inrush)	@24V input during 1ms			30	A
Under Voltage Shutdown				9	V
Insulation					
Input (DC grid) to output (EV)	50/60 Hz, 1 min	3200			V_{RMS}
Input (DC grid) to case (PE)	50/60 Hz, 1 min	3200			V_{RMS}
Output (EV) to case (PE)	50/60 Hz, 1 min	1600			V_{RMS}
Y-capacitor DC grid to PE				27	nF
Y-capacitor BAT+ to PE or BAT- to PE				35.3	nF

[1] CAN common mode; CAN_H and CAN_L versus CAN_GND
[2] Standby mode operation
[3] Three-phase with neutral operation with fans at full speed

2.1. Safe Operating Area (SOA) and typical efficiency

BMPU-R2-DC is based on highly efficient full SiC (Silicon Carbide) technology. Peak efficiency reaches 97% and efficiency is consistently above 94% for a wide range of battery voltage and current.

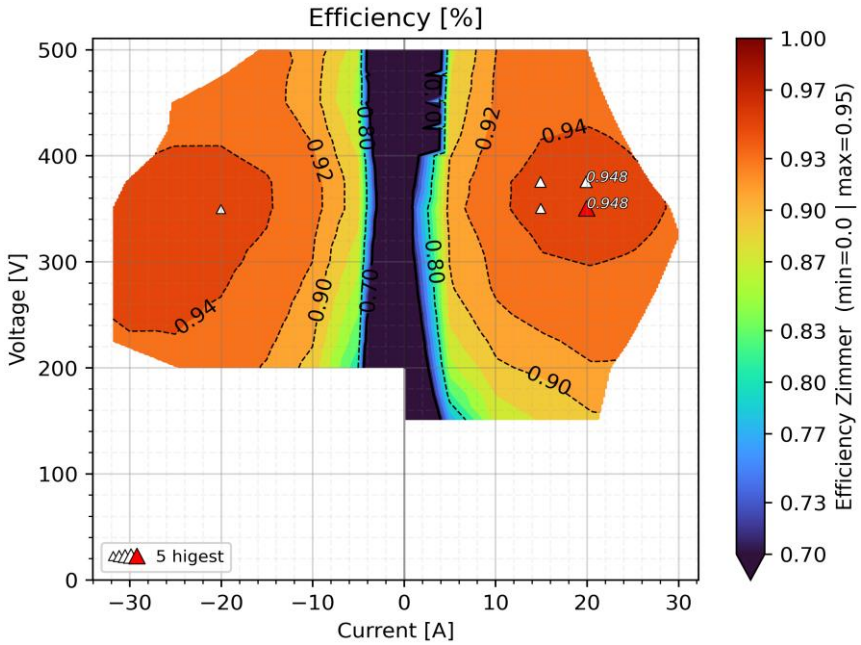


Figure 2-1: SOA of the BMPU-R2-500-32-DC with SW 2.5.4r (build 19020) at 350V input voltage (SN231)

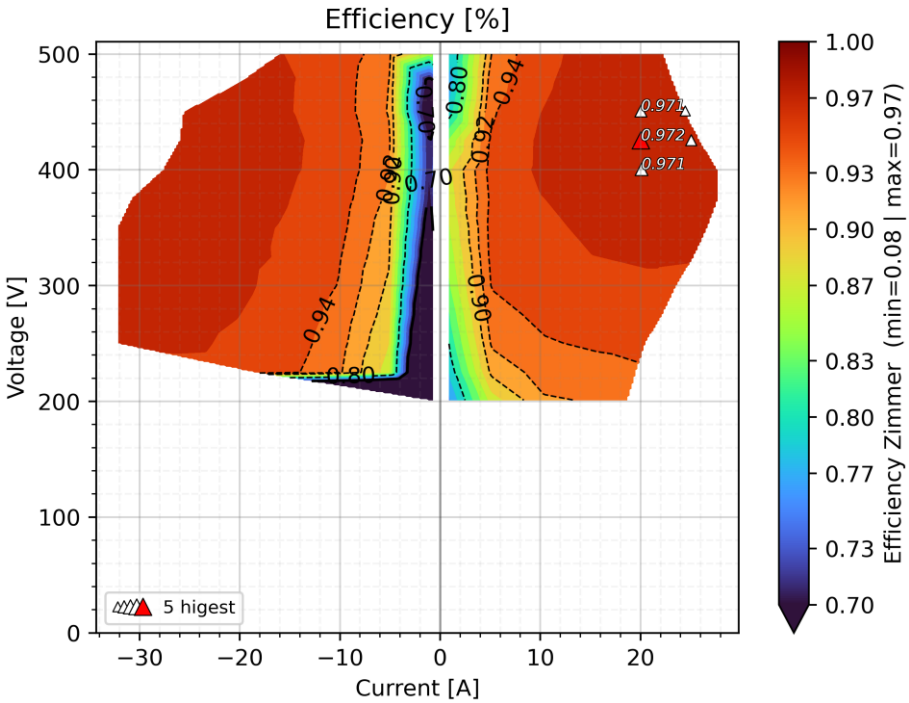


Figure 2-2: SOA of the BMPU-R2-500-32-DC-HV with SW 2.5.4r (build 19024) at 700V input voltage (SN233)

2.2. Output power derating

The output power vs DC grid voltage is limited by the 32Amp capability of the DC grid.

3. Safety instructions

3.1. Caution

The following safety instruction must be observed during all phases of operation, service and repair of this equipment. Failure to comply with the safety precautions or warnings in this documentation violates safety standards of design, manufacture and intended use of this equipment and may impair the built-in protections within. WATT & WELL shall not be liable for users to comply with these requirements.

3.2. Installation

BMPU-R2-DC device must be installed following installation chapter.
This product is a safety Class 1 instrument. To minimize shock hazard, the instrument chassis must be connected to installation protective earth (safety ground) with the dedicated ground terminal.

The protective earth terminal must be connected to the safety electrical ground before another connection is made. Any interruption of the protective ground conductor, or disconnection of the protective earth terminal will cause a potential shock hazard that might cause personal injury.

BMPU-R2-DC device is designed to be accessible only for trained staff operators in **restricted access locations.**

3.3. Input rating

Do not use power supplies which exceed the input voltage rating of this instrument. The electrical rating of this instrument is given into the chapter 2 of this document.

3.4. Live circuits

Operating personnel are not allowed to open the case of this equipment. Internal adjustment or component replacement is not allowed by non-WATT & WELL qualified personnel. Never replace components with cable connected to this instrument. To avoid injuries, always disconnect power and remove external voltage sources before touching components.

3.5. Hot surface

Surface of the product could be hot during and after operation. Use protection before touching the device.

3.6. Parts substitution and modifications

Parts substitutions and modifications are allowed by authorized WATT & WELL service personnel only.
For repairs or modification, the unit must be returned to WATT & WELL's After Sale Service. Contact After Sale Service (aftersales@wattandwell.com) to obtain a return merchandise authorization (RMA) number.

WATT & WELL
After Sale Service
121 Rue Louis Lumière
84120 PERTUIS
France

3.7. Environmental condition

BMPU-R2-DC device safety approval applies to the following operating conditions:

- Integrated into EVSE system (in a 19" cabinet or a custom build enclosure)
- Maximum relative humidity : 95% at 40°C non-condensing
- Altitude : up to 2000m
- Pollution degree : 2 [Note 4] (Pollution degree 3 possible as an option)
- Overvoltage category : III (4kV) on AC side
  : 2.5kV on DC side
  : 500V on LV side
- IP degree of enclosure : IP2X


Protective ground conductor terminal

The charging station where BMPU-R2-DC will be installed should meet the requirements of environmental protection as defined in IEC 61851-1:2019.
The IP degree needs to reach IP44 or above for outdoor use or IP21 for indoor use.
Avoid using the charger in the offshore environment near the sea or near a pollution source or in a corrosive and damaging environment. If you need to use it in the above environment, the protection level of the station needs to reach IP65, otherwise it may lead to the failure of BMPU-R2-DC. This damage caused will not be covered by the warranty.

[4] Attention should be paid to avoid ingress of water, metallic or conductive particles, dust or corrosive atmospheric that may cause early failures of equipment.

3.8. Normative compliance

BMPU-R2-500-32 meets the intent of directives:

- Low Voltage: 2014/35/UE
- CEM 2014/30/UE
- RoHS: 2011/65/UE
- WEEE: 2012/19/EU

The compliance was demonstrated to the normative reference:

Normative	Name	Note
NF EN IEC 61000-6-1	Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity standard for residential, commercial and light-industrial environments	
NF EN IEC 61000-6-2	Electromagnetic compatibility (EMC) Part 6-2: Generic standards Immunity for industrial environments	
NF EN IEC 61000-6-3	Electromagnetic compatibility (EMC) Part 6-4: Generic standards Emission standard for residential, commercial and light-industrial environments	
NF EN IEC 61000-6-4	Electromagnetic compatibility (EMC) Part 6-4: Generic standards Emission standard for industrial environments	
IEC 61000-3-2	Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)	
IEC 61000-3-3	Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection	
IEC 61000-4-11	Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests for equipment with input current up to 16 A per phase	Criterion B
IEC 61000-4-28	Electromagnetic compatibility (EMC) – Part 4-28: Testing and measurement techniques – Variation of power frequency, immunity test	Criterion A
IEC 61000-4-6:2013	Conducted RF Fields	10Vrms AC line, DC power out, LV power in
IEC 61000-4-4:2012	Electrical fast transient/burst immunity test AC power line	±2KV
IEC 61000-4-5:2014	Surge immunity test AC power line	±2KV common mode ±1KV differential mode
IEC 61000-4-8:2009	Power frequency magnetic field immunity test	30A/m criterion A
IEC 61000-4-3:2006 /AMD1:2007/AMD2:2010	Radiated, radiofrequency, electromagnetic field immunity test	Industrial Level
IEC 61000-4-2:2008	Electrostatic discharge immunity test	±4KV contact ±8KV air discharges
CISPR 16-2-1:2014/AMD1:2017	Conducted emission AC line	Class B
CISPR 16-2-3:2016	Radiated emission	Class B[5]

[5] with 1 turn ferrite FAIR-RITE 0431177081 on AC input port and 1 turn ferrite Wurth Elektronik 74271222 on CAN communication port and an external filter on LV port. External LV filter proposal: B84112G0000B030 from EPCOS/TDK

The foregoing information relates to product versions V2.4.1 and higher.
The previous versions are non-CE compliant and are considered as evaluation kits destined for professionals to be used solely at research and development facilities for such purposes.

Please also note that **BMPU-R2-500-32** is designed to be compatible with the following norms:

Normative	Name	Note
IEC 61851-1:2019 (ed 3.0)	Electric vehicle conductive charging system Part 1: General requirements	
IEC 61851-23 (ed 1.0)	Electric vehicle conductive charging system Part 23: DC electric vehicle charging station	
IEC 61851-23/AC1 2016	Corrections of IEC 61861-23 ed1.0 (2014)	

However, it is the user's responsibility to ensure that BMPU-R2-DC is installed and used in compliance with all local country laws and regulations.

4. Installation

Do not use or install BMPU-R2-DC product in case of visible physical damage.

4.1. Mechanical installation

4.1.1. Handling

BMPU-R2-DC product has a weight about 14.4 Kg. For correct handling, follow instruction below:

- The product must be handled flat.
- For operator safety use personal protective equipment.
- Do not stack units (each unit should be self-supported and secured with the front and rear brackets)

4.1.2. Mounting

BMPU-R2-DC can be mounted on standard 19” cabinets.
Note that the BMPU-R2-DC is a heavy instrument and requires the cabinet to be equipped with slides or rails that support the chassis along the depth.
Minimum air flow required for air cooling is 3.4 m^3/min (120 CFM)
Recirculating of hot air should be minimized by ensuring fresh (cold) on the input (see Figure 4-1).
In addition, minimum distances for air cooling are:

- 15 cm for front side
- 9 cm for rear side

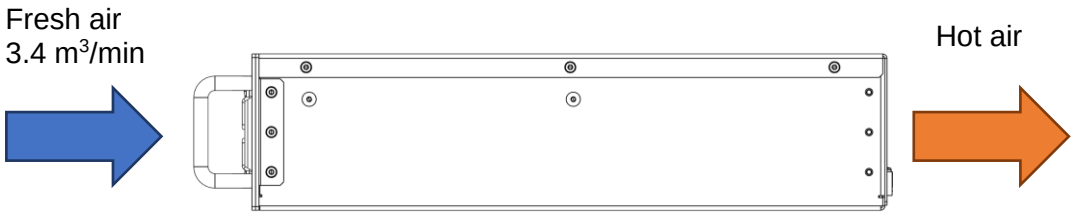


Figure 4-1: Air flow direction

4.2. Electrical installation

4.2.1. Legal installation

Electrical installation shall comply with international standards such as IEC or the requirements in national standards of each country.

4.2.2. Safety Notice

Never invert the polarity of the connector. Never force to place a connector. Use only approved manufacturer parts for electrical or mechanical connection.
It is strongly recommended to fix the cables to avoid any stress on the connection. All high-power connectors must be screwed up to avoid any disconnection.
Be careful if other devices are connected, there is a risk of electrical charge transfer.
It is forbidden to open the cover. Only W&W approved personnel are allowed to do maintenance operation. waiting time after complete suppression of input voltage before opening the device should be respected.

4.2.3. Protective earth

The protective earth (PE) terminal must be connected to the safety electrical ground before another connection is made. Any interruption of the protective ground conductor, or disconnection of the protective earth terminal will cause a potential shock hazard that might cause personal injury or death. Protective earth connection is made through AC input connector.

Use the protective earth terminal with minimal characteristics:

- Wire section (minimal): 4 mm²

In addition, all parts of the chassis where BMPU-R2-DC is to be installed (i.e., the 19" cabinet) need to be grounded. An electrical connection to PE through mechanical parts must be made.

4.2.4. DC grid

DC grid is defined as input DC+ and DC-.
BMPU-R2-DC products must be protected against short circuits and overload protection with external devices such as DC fuses or circuit breakers.

4.2.5. LV DC input

LV input must be connected to 12Vdc or 24Vdc bus. This input must be protected with a rapid fuse 20A rating
This cable must be shorter than 3m.

4.2.6. DC Output

DC output is galvanically isolated from protective earth.
This cable must be shorter than 30 m.

4.2.7. EMI requirements

BMPU-R2-DC converters are considered as evaluation kits destined for professionals to be used solely at research and development facilities for such purposes.
Integrator is responsible to use best practice for final system to avoid high EMI emissions.

4.2.8. Series operation

Series operations of BMPU-R2-DC is not allowed. Consult factory if series connection is required.

4.3. Disposal

(Mandatory application within the European Union)
Do not dispose of electronic tools tighter with household waste material. In accordance with WEEE European Directive (2012/19/UE), Electric material that has reached the end of their life must be collected separately and return to an environmentally compatible recycling facility. Please contact WATT & WELL for any questions about WEEE

5. Hardware specification

5.1. Theory of operation

BMPU-R2-DC consist of 2 power converting stages:

- Bidirectional boost that interfaces the DC input bus grid. This stage uses a **two-phase boost** topology.
- DC/DC converter that performs galvanic isolation and DC side regulation. It is based on a full SiC resonant topology

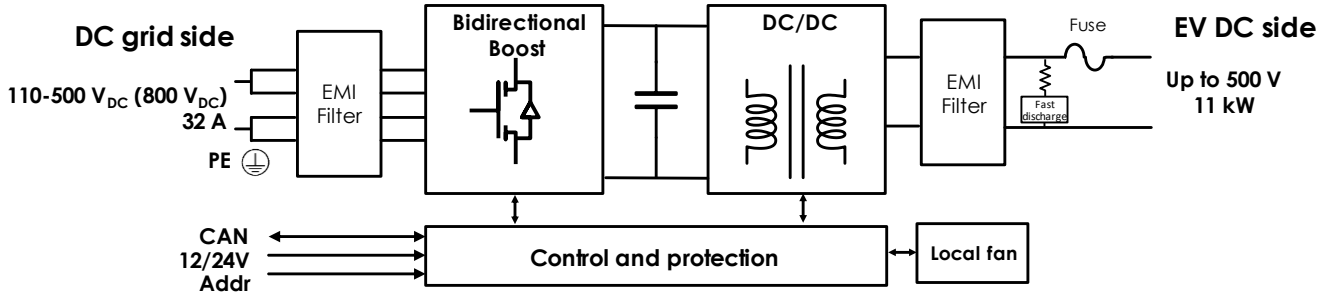


Figure 5-1 BMPU-R2-DC 11 kW high level synoptic

5.2. Interfaces

a) Low voltage connector

Located on the front panel. Cable connected to these ports must be less than 3m long.
LV connector is used to supply power to fans and control independently of the DC or AC supplies.
Connector Reference (converter side): Phoenix Contact MSTB 2,5/ 2-GF-5,08 1776508

Recommended matting connectors (wire harness side):

Side	Connector	Manufacturer	Wire	Ferrule	Crimping tool
LV	MSTB 2,5/ 2-STF-5,08 – 1777989 (Screw terminal)	Phoenix contact	0.8mm2 (18AWG)	x	x

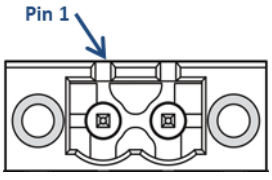


Figure 5-2: Low voltage connector

PIN	FUNCTION	DESCRIPTION	Preferred wiring color
1	LV_IN-	Low Voltage supply return (0V typ)	**Black**
2	LV_IN+	Low Voltage supply (24V typ)	**Red**

b) DC grid side connector

Located on the back panel.
Connector Reference (converter side): Phoenix Contact DFK-PC 5/ 6-GF-7,62 – 1727731

Recommended matting connectors (wire harness side):

Side	Connector	Manufacturer	Wire	Ferrule	Crimping tool
AC	SPC 5/ 6-STF-7,62 Ref: 1996168	Phoenix contact	4mm2	3200959	Crimpfox DUO16S Ref 1202877

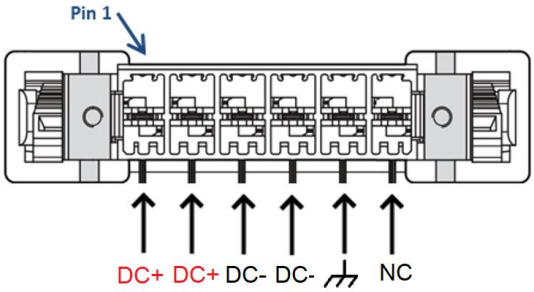


Figure 5-3: DC grid connector for BMPU-R2-500-32-DC

PIN	FUNCTION	DESCRIPTION	Preferred wiring color
1	DC+	DC input positive line	**Red**
2	DC+	DC input positive line	**Red**
3	DC-	DC input negative line	**Black**
4	DC-	DC input negative line	**Black**
5	PE	Protective Earth	**Green/yellow** striped
6	NC	Not connected	

Pins DC+ (1 and 2) shall be connected together to reach the full current (32A).
Pins DC- (3 and 4) shall be connected together to reach the full current (32A).

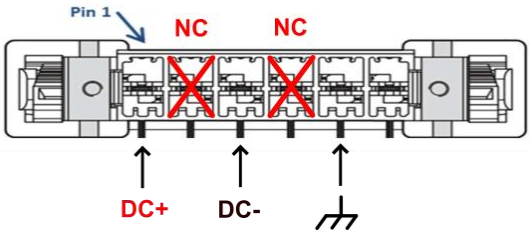


Figure 5-4: DC grid connector for BMPU-R2-500-32-DC-HV

PIN	FUNCTION	DESCRIPTION	Preferred wiring color
1	DC+	DC input positive line	**Red**
2	NC	Not connected (mandatory)	
3	DC-	DC input negative line	**Black**
4	NC	Not connected (mandatory)	
5	PE	Protective Earth	**Green/yellow** striped
6	NC	Not connected	

c) DC EV side connectors

Located on the back panel. Cable connected to these ports must be less than 30m long.
Connector Reference (converter side): Phoenix Contact: DFK-PC 6-16/ 2-GF-SH-10,16 1701935

Recommended matting connectors (wire harness side):

Side	Connector	Manufacturer	Wire	Ferrule	Crimping tool
DC	SPC 16/ 2-STF-10,16 Ref: 1711378	Phoenix contact	10mm2	3200551	Crimpfox DUO16S Ref 1202877

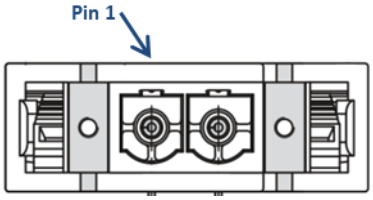


Figure 5-5 - DC_OUT connector

PIN	FUNCTION	DESCRIPTION	Preferred wiring color
1	DC_OUT-	DC Output return (0)	**Black**
2	DC_OUT+	DC Output (positive)	**Red**

d) COM connector

BMPU-R2-DC features a galvanically isolated CAN bus for digital communications with other boards.
The COM connector is an RJ45 connector. Cable connected to these ports must be less than 3m long.

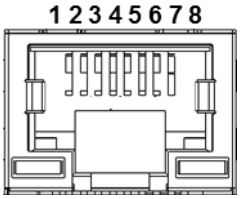


Figure 5-6 : COM connector front view

Table 5-1 – COM connector pinout

PIN	FUNCTION	DESCRIPTION
1	CAN H	CAN differential +
2	CAN L	CAN differential -
3	GND_ISO	Ground reference for CAN
4	EM_SHUT_RTN	Emergency Shutdown return line (negative)
5	EM_SHUT	Emergency Shutdown (positive)
6	NC	Not Connected
7	GND_ISO	Ground reference for CAN
8	ES_R/W	Read/write pin in case of daisy chained power units (Mandatory to keep floating)

Note on CAN bus termination: CAN bus is expected to be terminated at each bus end with a 120 Ω resistance. Wiring should be selected to have an intrinsic impedance of the twisted that match this 120 Ω.

By default, BMPU-R2-DC does not include any 120 Ω resistor to avoid overloading the bus when multiple nodes are present.

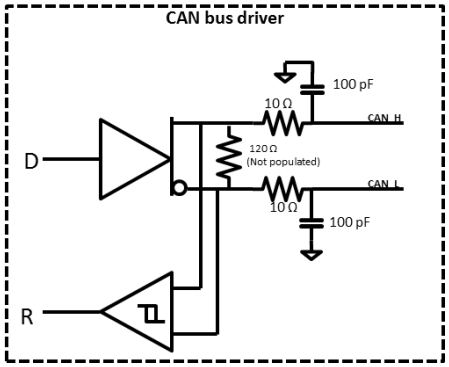


Figure 5-7: CAN transceiver simplified diagram

Note on CAN bus shield: Although ISO 11898-2 does not specify the wires type or the need for a shield, a shielded cable is recommended for electronically harsh environments. It is recommended to ground the shield at a single point on the dedicated shield pin of the COM connector to avoid ground loops.
Also, remember that the CAN bus being isolated, the CAN_GND should be wired between nodes.

e) Emergency Shutdown

The COM connector also transmits an **Emergency Shutdown** (EM_SHUT) signal. This signal can be used to trigger an unconditional shutdown of the BMPU-R2-DC operation. See Table 5-1 for the pinout of EM_SHUT within the COM connector.
In addition, a fast discharge circuit is enabled to discharge the internal output capacitors to a safe level (<<60V) in less than 1 second.
EM_SHUT logic is as follows:

- "floating": Emergency Shutdown triggered (EM_SHUT=1)
- 12V or 24V: normal operation (EM_SHUT=0)

The simplified circuit of the EM_SHUT is given in Figure 5-8.

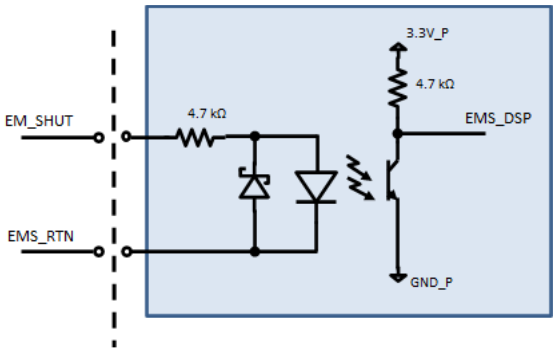


Figure 5-8 DSI input circuit

f) Address selector and Charge Permission.

Each BMPU-R2-DC takes its CAN **address** at boot based on the Addressing connector on the front panel.

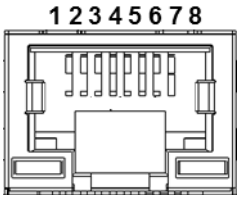


Figure 5-9: Addressing connector (RJ45) front view

Table 5-2: Addressing connector pinout

PIN	FUNCTION	DESCRIPTION
1	ADDR0	Address bit 0 (positive)
2	ADDR3	Address bit 3 (positive)
3	ADDR1	Address bit 1 (positive)
4	ADDR4	Address bit 4 (positive)
5	ADDR2	Address bit 2 (positive)
6	GND_ISO	Return (negative)
7	CHARGE_P2	Charge Permission 2 (positive)
8	UNUSED	Not used

Up to 32 units can be addressed with 5 DSI (digital signal inputs). The default value of each unconnected line is logic ‘0’. An addressing line tied to GND_ISO is logic ‘1’.

Address	CAN ID
00000	80
00001	81
00010	82
00011	83
00100	84
00101	85
00110	86
00111	87
01000	88
01001	89
01010	90
01011	91
01100	92
01101	93
01110	94
01111	95
10000	96
10001	97
10010	98
10011	99
10100	100
10101	101
10110	102
10111	103
11000	104
11001	105
11010	106
11011	107

11100	108
11101	109
11110	110
11111	111

Both CAN and addressing connectors transmits optional DSI (digital signal input)

"**Charge Permission"** signal: CHARGE_P2. This signal can be used as a redundant stop signal in such way BMPU-R2-DC stops operation when it receives a stop instruction by either "Charge Permission signal" or "CAN communication message". This functionality helps achieve compliance with safety features of some EV charging protocols like CHAdeMO. It is disabled by default.
When Charge Permission is enabled, logic levels are defined as

- '0' or floating: no output (forbidden operation). If a start message is received by CAN, a fault will be generated.
- '1' or shorted to GND_ISO: charge permission OK (system can start if a CAN message is received)

"ES_R/W" signal: should be kept floating by user on CAN connector side. It is used to disable the charging process of all units chained together in case of a fault on one unit.

LEDs
4 LEDs on front panel indicate the status of the system

Table 5-3 – LED overview

LED	NAME	COLOR	FUNCTION	Description
1	FLT	Red	Fault	Indicates a fault in the system. Systems is stopped as a result
2	DC	Blue	DC output	• **Continuous:** System in CHARGING mode • **Blinking at 5Hz:** (only in DISCHARGING/CHARGING) DC voltage is out of range. Output power is set off and charger remains waiting for DC input voltage to return within acceptable range.
3	AC	Blue	DC output	• **Continuous:** System in DISCHARGING mode
4	RDY	Yellow	Voltage presence	• **Slow blink:** Auxiliary voltage only (12V) • **Continuous**: DC voltage and Aux voltage

g) Protective Earth

Protective Earth is connected through the DC input connector in the rear panel to the rack chassis.

6. Control specifications

6.1. Theory of operation

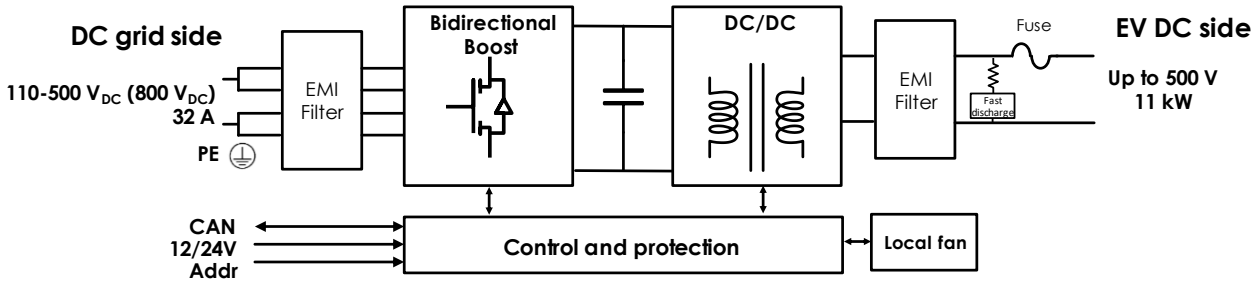


Figure 6-1 Converter synoptic

The control system of BMPU-R2-DC consists of the following aspects:

- The overall behavior of BMPU-R2-DC is determined by a state machine that defines the possible actions of the converter depending on user state request and selected power mode.
- Boost control system that regulates phase currents and DC bus voltage in CHARGING/DISCHARGING operations.
- DC/DC control system that regulates Input power, Battery side current and voltage.
- Software protections against over/under-voltage, over/under current, over-temperature, communication loss…etc.
- DC out fast discharge control
- CAN communication based on CANopen protocol
- Relays management, fan speed control and LEDs lighting.

6.2. User inputs

BMPU-R2-DC uses a fully digital, microcontroller-based regulator. This approach allows very flexible control of the system. Figure 6-2 shows the regulation parameters that must be set through CAN messages to achieve the desired operating point. These parameters are defined as follows.

1. **State request:** The State Request word is used to request a state change. Four actions can be requested by the user as described in the following table

State	Definition
Standby	System stopped and power off
Power On	System pre-charged and ready to start
Charging	Charge is ongoing
Fault Ack	Fault acknowledgement

2. **Power mode:** selection of operating power mode:
   - **CHARGING/DISCHARGING – DC grid power control mode:** charger is current-controlled source where DC grid power is controlled. Battery DC side voltage is not controlled.

- **CHARGING/DISCHARGING – DC voltage control mode:** charger is voltage-controlled source where EV DC side voltage is controlled. DC grid side (Input) power is not controlled.

3. **Grid configuration:** It must be set to DCDC configuration (refer to Table 6-8: System configuration definition)

4. **Charging current limitation:** limitation of charging current (effective in CHARGING mode)

5. **Discharging current limitation:** limitation of discharging current (effective in DISCHARGING mode)

6. **Grid side power setpoint:** Input power target (Active only in CHARGING/DISCHARGING -Grid side power control mode). It is effective when power droop control is deactivated.
   - Positive value requests charger to operate in CHARGING mode
   - Negative value requests charge to operate in DISCHARGING mode

7. **DC voltage setpoint:** Battery side voltage target (Active in CHARGING/DISCHARGING - DC voltage control mode or in DC power control mode for CHARGING (charging) only).

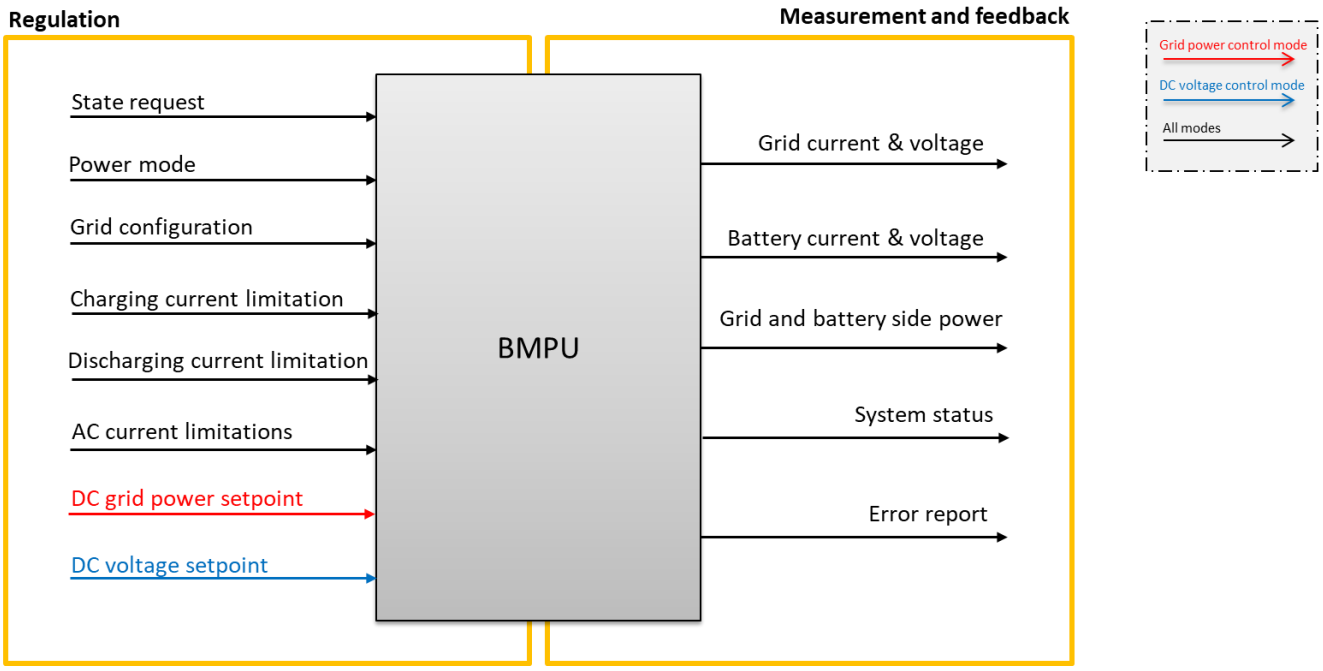


Figure 6-2: High level charger regulations and measurements

WARNING
Setpoint inputs dedicated to one mode are not effective in another. For example, Grid side power setpoint has no impact on Grid side power in DC voltage control mode. However, DC voltage setpoint is considered in Grid side power control to limit battery voltage when charging and it is not effective when discharging.

Charging and discharging current limitations can be overridden by system limitations as thermal derating, battery maximum power…etc.

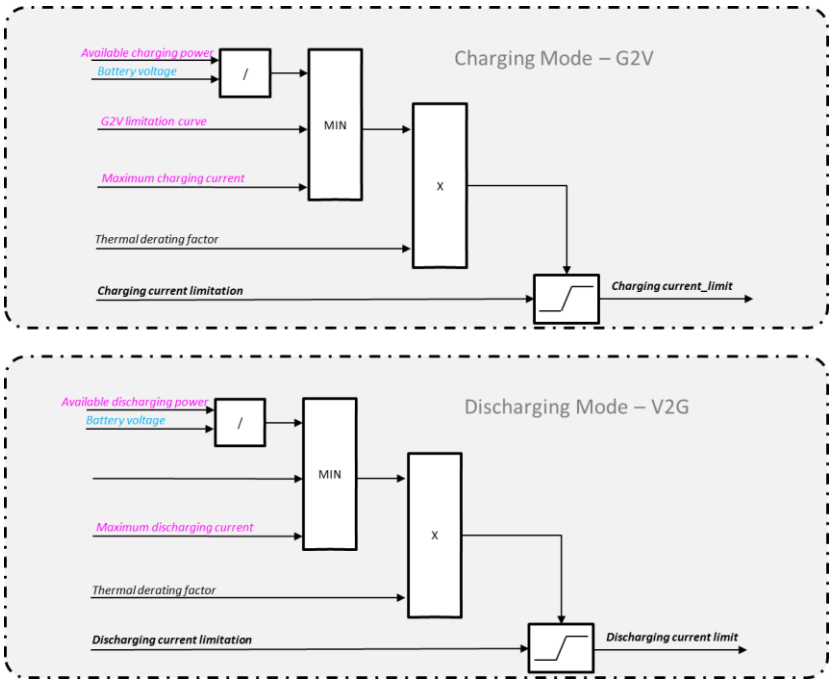


Figure 6-3 Charging and discharging current limitations

With

- **Charging current limitation:** limitation setpoint requested by user
- **Discharging current limitation:** limitation setpoint requested by user
- **Maximum charging current:** set to 30A by default
- **Maximum discharging current:** set to 32A by default
- **CHARGING limitation curve:** lookup table based on Grid side voltage derating (for grid voltage > 500 V) and DC voltage derating (for battery voltage < 350V)
- **DISCHARGING limitation curve** lookup table based DC voltage derating (for battery voltage > 450V)
- **Available charging/discharging power:** it is calculated as follows.

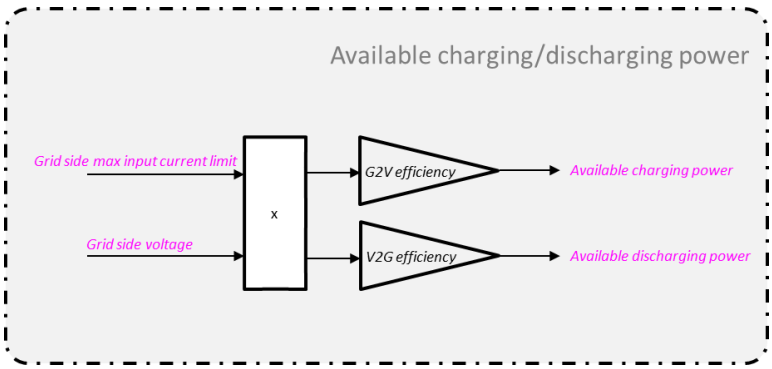


Figure 6-4 Available charging/discharging power

- **thermal_derating_factor:** Thermal derating consists of derating delivered power linearly between derating start temperature threshold and shutdown temperature. The derating is applied by reducing the charging or discharging current by a thermal derating factor. This factor is the product of three factors driven from each type of temperature as shown in figure below. Thermal protection thresholds are defined based on component (mosfets, magnetics…etc) temperature specifications, experimental mapping, and sensors accuracy.

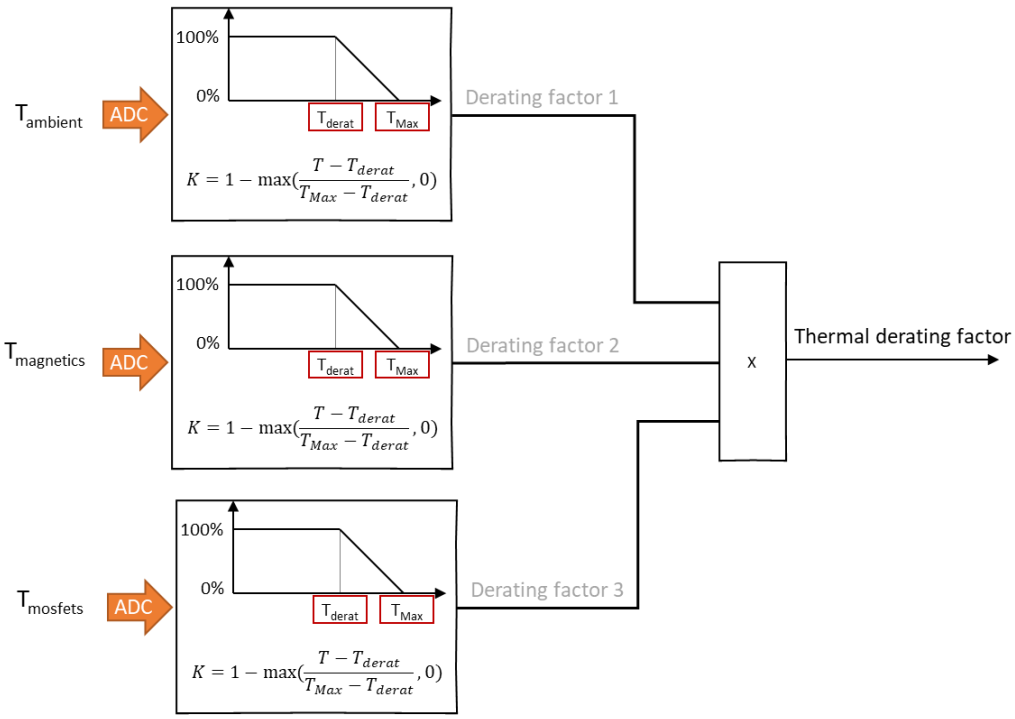


Figure 6-5 Thermal derating

Please note that changing the protection thresholds by the user is very risky and may result to the destruction of the product.

6.3. User outputs

The system returns measured current, voltage, and power for grid side input. It also returns battery current, voltage, and power. Feedback is given on the system status and errors are reported in the fault word. Refer to section 6.4 for details on fault word in Table 6-10.

The status of the state machine is indicated in the System State bits within Status Word (see Status word definition). Possible values are detailed in Table 6-4.

Available values of power and current are returned by the converter. They are calculated based on DC grid side voltage, battery voltage, thermal derating and user-defined maximum values. Refer to TPDOs list in section 6.4 for available quantities.

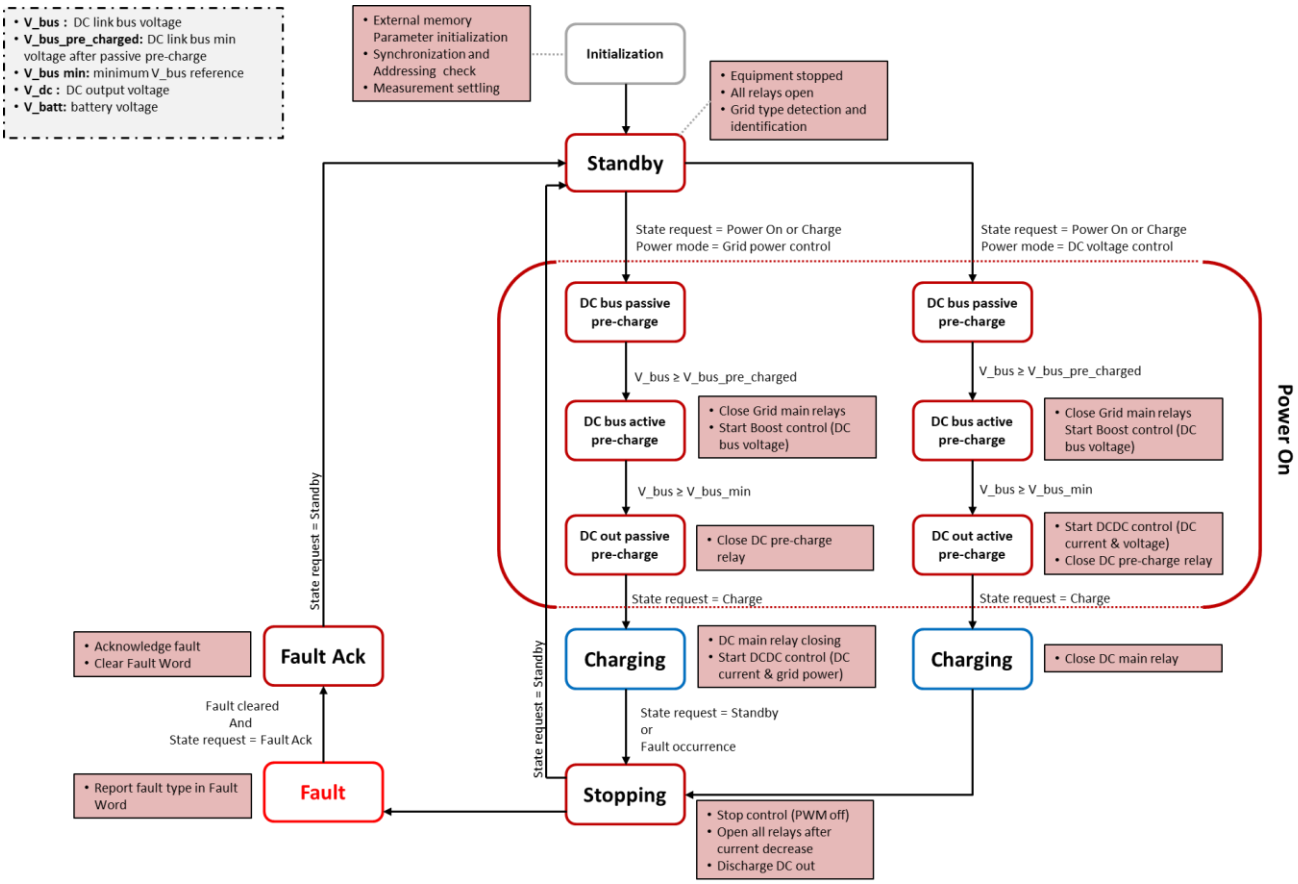


Figure 6-6: Charger State Machine

6.4. CAN communication

CAN Network

The CAN network is composed of at least 2 nodes; Control master node and the BMPU-R2-DC charger node

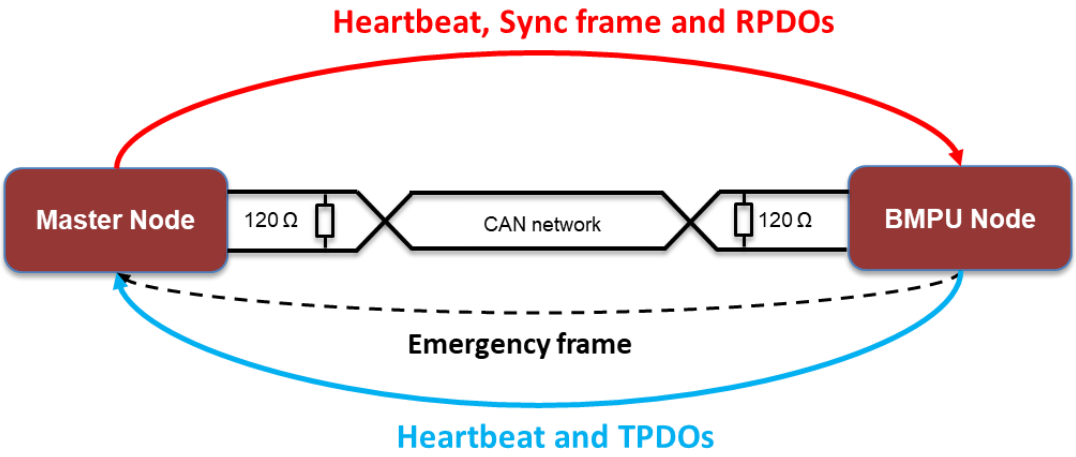


Figure 6-7: CAN network illustration

BMPU-R2-DC charger is controlled by RPDO messages where regulation inputs (as illustrated in Figure 6-7) are transmitted from the Master node to the charger control unit.

Master node receives measurement and feedbacks from the charger via TPDOs messages. Synchronization message (sync frame) must be sent from the Master to charger to enable TPDOs transmission.

BMPU-R2-DC charger transmits periodically to the master a heartbeat frame to notify its presence on the network. Similarly, it must receive the master heartbeat frame periodically, otherwise charger goes to fault mode due to CAN communication timeout.

In case or error, charger send an emergency frame to notify its fault mode.

Node IDs and messages data are detailed in the following paragraphs.

CAN baud rate

CAN 2.0A cadenced at 500kbit/s with little endian byte order.

Node ID

See section **Address selector** in section Address selector and Charge Permission. Default address is x50 (80).

Frame ID

Frame IDs are defined by the relation: Frame ID = Node ID + ID offset

In what follows default node ID x50 is considered and ID offset is given for every frame.

Heartbeat frame

Charger automatically transmits its communication state at regular intervals as evidence of its communication ability. This frame is sent by charger every 1 sec.

Charger also consumes the heartbeat of its master (expected to have the nodeID 0x1). So, the master shall emit every 1 second a heartbeat frame with an *operational* status. If this frame is not received by the charger, the charge will be stopped, and the charger will go into fault state.

Node	Frame ID	ID offset	DLC	Byte 0
Charger	x750	x700	1	ChargerStatus
Master	x701	X700	1	MasterStatus

- Status = 0 at bootup (1 frame with 0 to be sent at boot)
- Status = 5 when node communication stack is operational (to be sent periodically)
- Status = 4 when node communication stack is stopped (to be sent periodically)
- Status = 127 when node communication stack is pre-operational (to be sent periodically)

Sync frame

To trig synchronous sending of TPDO frames, charger must receive SYNC message.

Frame ID	DLC
x80	0

It is recommended to send it every 50 ms.

Transmit Process Data Object (TPDO)

Frame ID	ID offset	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
x1D0	x180	8	itfc_current_state				itfc_critical_fault_word			
x2D0	x280	8	itfc_v_batt_max		itfc_i_batt_max		itfc_i_grid_max		itfc_P_grid_max	
x3D0	x380	8	itfc_pos_active_ available_power		itfc_neg_active_ available_power		Reserved		Reserved	
x4D0	x480	8	itfc_v_L1mL4_rms		itfc_i_L1_rms		itfc_P_L1		Reserved	
x1B0	X160	8	itfc_v_L2mL4_rms		itfc_i_L2_rms		itfc_P_L2		Reserved	
x2B0	X260	8	itfc_v_L3mL4_rms		itfc_i_L3_rms		itfc_P_L3		Reserved	
x3B0	X360	8	itfc_v_grid		itfc_i_grid		itfc_P_grid		Reserved	
x4B0	X460	8	itfc_v_batt		itfc_i_batt		itfc_P_batt		itfc_available_i_batt	

- TPDOs data description is given in Table 6-2.

- Each TPDO is transmitted after reception of N number of Sync message. This number is defined by the transmission type parameter of the TPDO. For BMPU R2, transmission type for TPDOs is defined in the following table.

Table 6-1 TPDOs transmission type

TPDO ID	Transmission type
x1D0	1
x2D0	1
x3D0	1
x4D0	1
x1B0	1
x2B0	1
x3B0	1
x4B0	1

For example, when using transmission type 34, the TPDO is transmitted after every 34th Sync message.

Emergency frame

Emergency frame sent by charger in case of default.

Frame ID	ID offset	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
X0D0	x80	8	Error code		Error register	Unused	Data			

- *Error Code*: 0xFF01 if the charger went to safeD. Other Error codes due to communication stack are defined by CANopen.
- *Error Register*: In case of SafeD error, to be ignored.
- *Data*: In case of SafeD error, data = CriticalFaultWord, else, to be ignored.

Receive Process Data Object (RPDO)

The RPDO frames are the charger control frames. Charger state, mode, grid configuration and setpoints (control targets and limitations) are communicated to the charger via the control frames.

Frame ID	ID offset	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
x250	x200	8	itfc_pfc_state _request	itfc_pfc_ mode_request	itfc_grid_conf _request	Reserved	Reserved		Itfc_battery_ voltage_setpoint	
x350	x300	8	itfc_i_charge_limit		itfc_i_discharge_limit		itfc_active_power _setpoint_W		Reserved	
X450	x400	6	Reserved		Reserved		Reserved			

- RPDOs data description is given in Table 6-2.

Data units and type definition

Messages data types and units are defined in the table below:

Table 6-2: Frame data definition

Signal	Definition	LSB value	Unit	Data type	r/w (from master point of view)	Frame
itfc_pfc_state _request	Power state request: StandBy, PowerOn, Charge	See Request word def	NA	Uint8	w	RPDO0
itfc_pfc_mode_request	Mode request: CHARGING/DISCHARGING (power or voltage control)	See Request word def	NA	Uint8	w	RPDO0
itfc_grid_conf_request	Grid configuration request	See Request word def	NA	Uint8	w	RPDO0
itfc_battery_voltage_setpoint	DC side voltage target in CHARGING/DISCHARGING voltage control mode	0,1	V	Uint16	w	RPDO0
itfc_i_charge_limit	DC charging current limit	0,1	A	Uint16	w	RPDO1
itfc_i_discharge_limit	DC discharging current limit	0,1	A	Uint16	w	RPDO1
itfc_active_power_setpoint	Active power target in CHARGING/DISCHARGING grid side power control mode (power droop control must be deactivated)	10	W	int16	w	RPDO1
itfc_current_state	Power state feedback (see Status Word)	See StatusWord def	NA	Uint32	r	TPDO0
itfc_critical_fault_word	Critical fault word	See CriticalFaultWord def	NA	Uint32	r	TPDO0
itfc_v_batt_max	Maximum battery voltage	0,1	V	Uint16	r	TPDO1
itfc_i_batt_max	Maximum battery current	0,1	A	Uint16	r	TPDO1
itfc_i_grid_max	Maximum grid side current	0,1	A	Uint16	r	TPDO1
itfc_P_max	Maximum grid side ppower	10	W	Uint16	r	TPDO1
itfc_pos_active _available_power	Available CHARGING grid power	10	W	int16	r	TPDO2
itfc_neg_active _available_power	Available DISCHARGING grid power	10	W	int16	r	TPDO2
itfc_v_L1mL4_rms	L1 phase voltage	0,1	V	int16	r	TPDO3
itfc_i_L1_rms	L1 phase average current	0,1	A	int16	r	TPDO3
itfc_P_L1	L1 phase power	10	W	int16	r	TPDO3
itfc_v_L2mL4_rms	L2 phase voltage	0,1	V	int16	r	TPDO4
itfc_i_L2_rms	L2 phase average current	0,1	A	int16	r	TPDO4
itfc_P_L2	L2 phase power	10	W	int16	r	TPDO4
itfc_v_L3mL4_rms	L3 phase voltage	0,1	V	int16	r	TPDO5
itfc_i_L3_rms	L3 phase average current	0,1	A	int16	r	TPDO5
itfc_P_L3	L3 phase power	10	W	int16	r	TPDO5
itfc_v_grid	Grid voltage	0,1	V	int16	r	TPDO6
itfc_i_grid	Overall grid current	0,1	A	int16	r	TPDO6
itfc_P_grid	Overall grid power	10	W	int16	r	TPDO6
itfc_v_batt	Overall battery voltage	0,1	V	int16	r	TPDO7
itfc_i_batt	Overall battery current	0,1	A	int16	r	TPDO7
itfc_P_batt	Overall battery side power	10	W	int16	r	TPDO7
itfc_available_i_batt	Available battery current	0.1	A	int16	r	TPDO7

Status word definition

Table 6-3: Status Word

Bit	Flag name	Flag definition
0:3	SystemState	State, see SystemState_e enum explanation
4:7	SystemSubState	SubState, see SystemSubState_e enum explanation
8:10	SystemDcdcState	DCDC state, see SystemDcdcState enum explanation
11:12	SystemMode	Mode, see SystemMode enum explanation
13:15	SystemConfiguration	Configuration, see SystemConfiguration enum explanation
16	CurrentRegulationFlag	Set to 1 if PU is limited by max Current
17	VoltageRegulationFlag	Set to 1 if PU is limited by max Voltage
18	GridPowerRegulationFlag	Set to 1 if PU is limited by max active Power
19	Reserved	
20	MaxBatteryChargingCurrentFlag	Set to 1 if PU is limited by max charging current
21	MaxBatteryDischargingCurrentFlag	Set to 1 if PU is limited by max discharging current
22	Reserved	
23	PfcOnFlag	Set to 1 if Boost is ON
24	DcdcOnFlag	Set to 1 if DCDC is ON
25	InputCurrentLimitationFlag	Set to 1 if PU is limited by input current
26	Reserved	
27	ThermalLimitationFlag	Set to 1 if PU is limited by thermal heating
28	GridDetectionFlag	Set to 1 if Grid is detected
29	Unused0	Unused
30	Unused1	Unused
31	AggregatedPusFlag	Set to 1 if it is a master Pu in charge of 1 or several distant (slave Pus)

Table 6-4: System states definition

Value	Name	Definition
0	STATE_INIT	System is starting
1	STATE_STANDBY	Power is off, system waits a request
2	STATE_POWER_ON	System ready to start
3	STATE_CHARGE	Charge is ongoing
4	STATE_SAFE_D	Critical fault occurred; system halted in this mode until user action.
5	RESERVED	For future use
6	STATE_STOPPING	Converter is stopping and power is being killed off
7	STATE_LOCK_DSP	The state machine waits for DCDC to be in Standby mode
8	STATE_FAULT_ACK	Fault acknowledgement

Some intermediate sub-states exist in the state machine that are also accessible through the status word. Although these sub-states are transparent to the user, they are documented on Table 6-5 for completeness.

Table 6-5: System Sub State definition

Value	Name	Definition
0	SUBSTATE_INIT	System initialization
1	SUBSTATE_STANDBY	Power is off
2	SUBSTATE_STANDBY_PASSIVE_PRECHARGE	Precharge relays are set ON to allow passive pre-charge and grid nominal voltage is identified
3	SUBSTATE_STANDBY_PASSIVE_PRECHARGE_ DRIVER_ON	Passive pre-charged is completed, power legs pwm drivers are on.
4	SUBSTATE_STANDBY_ACTIVE_PRECHARGE	DC link voltage and soft start conditions are checked, system starts Boost closed loop control to complete active pre-charge
5	SUBSTATE_PFC_CHARGING	DCDC is ready and charging starts in DISCHARGING and CHARGING modes
6	SUBSTATE_SAFE_C	Reserved
7	SUBSTATE_VSI_ACTIVE_PRECHARGE	Reserved
8	SUBSTATE_VSI_CHARGING	Reserved
9	SUBSTATE_STOPPING	System is requested to stop; power is still on
10	SUBSTATE_SAFE_D	Critical fault occurred, system halted in this mode until fault clearance or STANDBY request.
11	SUBSTATE_LOCK_DSP	The Boost waits for DCDC Standby mode status
12	SUBSTATE_FAULT_ACK	Fault acknowledgement

The DCDC converter is supervised by an inner state machine that is controlled by the charger state machine. The DCDC states are presented in Table 6-6: DCDC states definition

Table 6-6: DCDC states definition

Value	Name	Definition
0	STATE_DCDC_INIT	System is starting
1	STATE_ DCDC_STANDBY	Power is off, system waits a request
2	STATE_ DCDC_POWER_ON	System ready to start
3	STATE_ DCDC_CHARGE	Charge on going
4	STATE_ DCDC_SAFE_D	Critical fault occurred; system halted in this mode until user action.
5	STATE_ DCDC_STOPPING	Converter is stopping and power is being killed off
6	STATE_ DCDC_LOCK_DSP	The DCDC waits a request for Standby mode
7	STATE_ DCDC_FAULT_ACK	DCDC fault acknowledgement

The operating mode (Grid side power control or Battery side DC voltage control) must be requested by SystemMode whose values are described in Table 6-7: System mode definition.

Table 6-7: System mode definition

Value	Name	Definition
0	MODE_UNKNOWN	Operation mode is not specified, system remains in stand by state
1	MODE_VSI	Reserved
2	MODE_PFC_POWER	Grid side power control mode for CHARGING/DISCHARGING operations with constant current control on battery side
3	MODE_PFC_VOLTAGE	Battery side DC voltage control mode for CHARGING/DISCHARGING operations with constant voltage control on battery side

Grid configuration must be determined prior to any charger utilization. Grid configuration is requested by SystemConfiguration with the values defined in Table 6-8: System configuration definition. It must be set to the value **5** for BMPU-R2-DC.

WARNING
Any value of SystemConfiguration different of 5 or 0 could damage the converter in power operation.

Table 6-8: System configuration definition

Value	Name	Definition
0	CONF_UNKNOWN	Grid configuration is not specified, system remains in stand by state.
1	CONF_SINGLE_PHASE_TWO_WIRE	Reserved
2	CONF_SINGLE_PHASE_FOUR_WIRE	Reserved
3	CONF_THREE_PHASE_THREE_WIRE	Reserved
4	CONF_THREE_PHASE_FOUR_WIRE	Reserved
5	CONF_DCDC	BMPU connected to DC grid

SystemMode and SystemConfiguration can be changed only during STATE_STANDBY. This is to prevent any modification during power operations.

During the passive pre-charge step, the converter determines the grid nominal voltage value. The latter is used to determine over/under voltage protection thresholds and power droop control

parameters. Note that grid nominal voltage can forced to user-input value via CAN communication. However, droop control and Over/Under voltage protections are only valid for DC grid nominal voltage of 350V or 700V. If different value is used or detected, over-voltage protection considers protection thresholds of 700V grid and under-voltage protection takes thresholds of 350V grid.

Table 6-9 DC grid nominal voltage identification

Input voltage range	Considered grid Nominal voltage	Note
250 V – 480 V	350 V	LV version input voltage
490 V – 800 V	700 V	HV version input voltage
0 V – 250 V	Measured input voltage	

Critical Fault Word Code

In order to prevent system from failure event which could damage product, BMPU-R2-DC has several security faults. These faults statuses are indicated in bit-wise word “CriticalFaultWord” defined as follows:

Table 6-10: CriticalFaultWord definition

Bit	Fault name	Fault definition
0	Over_current_L1	Over-current protection on phase L1
1	Over_current_L2	Over-current protection on phase L2
2	Over_current_L3	Over-current protection on phase L3
3	Over_current_L4	Over-current protection on phase L4
4	Over_voltage_L1	Over-voltage protection on phase L1
5	Over_voltage_L2	Over-voltage protection on phase L2
6	Over_voltage_L3	Over-voltage protection on phase L3
7	Over_voltage_L4	Over-voltage protection on phase L4
8	Over_frequency	Unused
9	Under_frequency	Unused
10	Anti_Islanding	Unused
11	Ov_v_bus	Over-voltage protection on DC-link Bus
12	Ov_v_batt	Over-voltage protection on battery
13	UV_v_batt	Under-voltage protection on battery
14	OC_i_batt	Over-current protection on battery
15	Over_Temp_dcdc_prim	Thermal shutdown on DCDC grid side mosfets
16	Over_Temp_dcdc_sec	Thermal shutdown on DCDC battery side mosfets
17	Over_Temp_pfc	Thermal shutdown on Boost mosfets
18	Over_Temp_transformer	Thermal shutdown on DCDC transformer
19	Over_Temp_ambient	Thermal shutdown on ambient temperature
20	OVRT_disconnection	Grid disconnection after over-voltage ride through
21	UVRT_disconnection	Grid disconnection after under-voltage ride through
22	OVP_Aux_LV	Over-voltage protection on LV auxiliary power supply
23	UVP_Aux_LV	Under-voltage protection on LV auxiliary power supply
24	emergency_shutdown	Emergency shutdown input triggered
25	device_timeout	No reception of master heartbeat frame for more than timeout period
26	dcdc_pfc_com_loss	Communication loss between Boost and DCDC
27	dcdc_pfc_com_erros	Communication errors between Boost and DCDC
28	chargeP	No charge permission input (only in DC voltage control mode)
29	address_selection	No valid address selected
30	precharge_failure	DC-link bus pre-charge not completed during allowed time or voltage drops below the passive pre-charge maximum voltage.
31	OV_Regul_v_batt	Regulation loss of battery voltage (only in DC voltage control mode)

6.5. Droop control and Over/Under voltage protections

Grid side power droop control is available only with Grid side power control mode and it is active by default. The droop control can be deactivated via CAN communication.

The droop control expected behavior and Over/Under voltage protection thresholds are described by the following illustration:

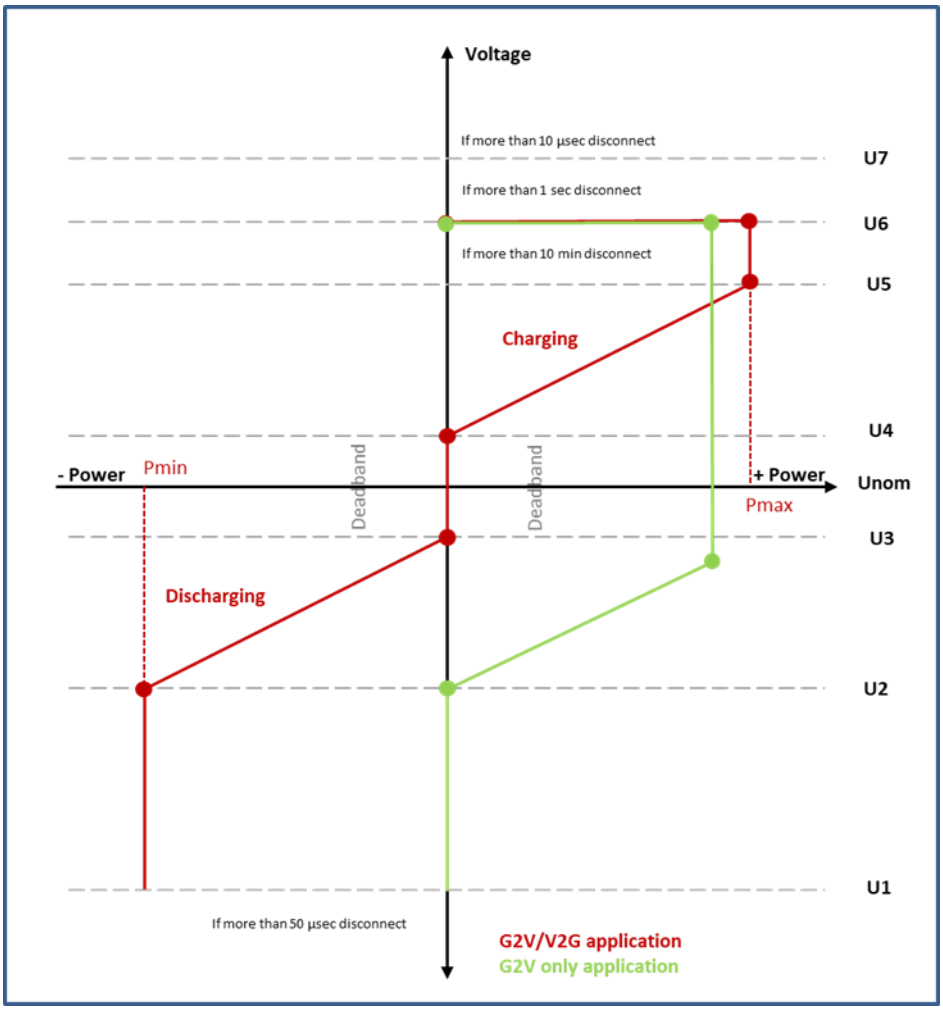


Figure 6-8 Default power droop control

The default droop control is bidirectional for G2V/V2G applications. It can be configured for unidirectional application (G2V only) by setting the control parameters via CAN communication.

The default values of the parameters for the droop control configuration are listed below with their ESD (Electronic Datasheet) names.

Table 6-11 Power droop control parameters

Parameter	350V grid	700V grid	ESD parameter name
Unom	350	700	
U1	250	500	dcdc_**XXX**_emergency_limit_V
U2	320	640	dcdc_**XXX**_undersupplied_limit_V
U3	345	690	dcdc_**XXX**_start_discharge_V
U4	355	710	dcdc_**XXX**_start_charge_V
U5	380	760	dcdc_**XXX**_oversupplied_limit_V
U6	400	800	dcdc_**XXX**_overshoot_limit_V
U7	420	844	dcdc_**XXX**_overvoltage_limit_V
Pmax	+11040	+11040	active_power_ref_max
Pmin	-11040	-11040	active_power_ref_min

XXX = 350 or 700

7. Mechanical specifications

BMPU-R2-DC measures 448.4 × 88 × 360.6 mm (excluding connectors and handles).
By default, side brackets with handles are added on front face to be mounted as a standard 19" rack 2U tall.
Brackets on rear panel (see WA018 on Product accessories) can be added for additional support.
On request, handles can be removed for a more compact integration, and customized front face is available to reduce its width from 480 mm to 448.4 mm.

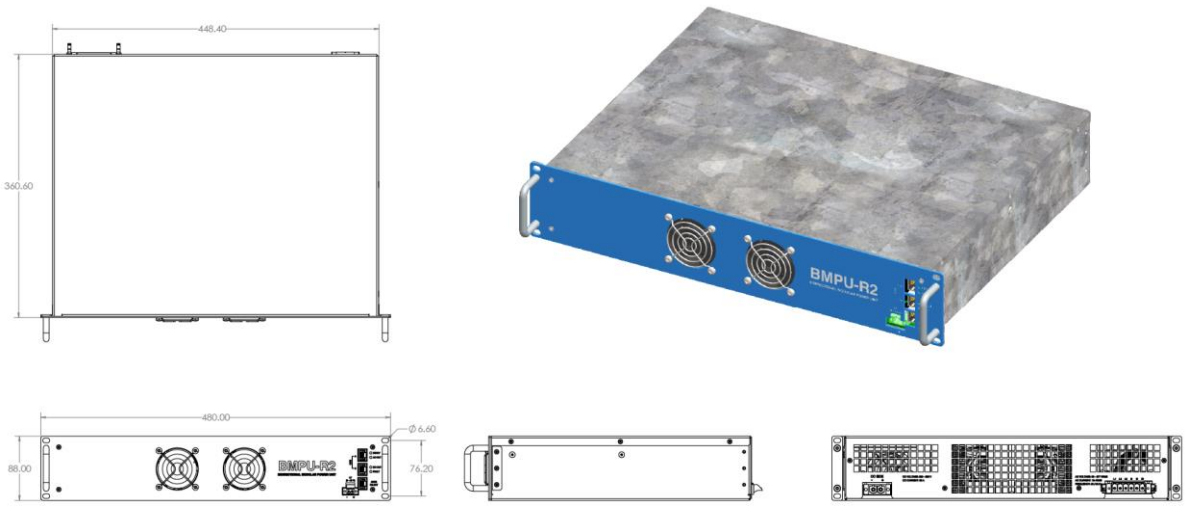


Figure 7-1: BMPU-R2-DC assembly drawing (with default real panel support)

8. Maintenance

It is forbidden to open the product.

8.1. Cleaning

Use a soft cloth for cleaning the device. Do not use cleaning agent.
Internal dust could be removed with vacuum cleaner or dry air cleaning.

8.2. Cooling fan

Cooling fans are internally controlled. Do not obstruct apertures on the case side.

8.3. Fuse replacement

DC side is protected by an adequate fuse.
Fuse replacement is only allowed by WATT & WELL qualified personnel. Return product to factory for replacement.

9. Ordering information

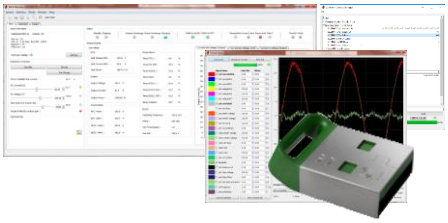
9.1. Product Reference

	Status	P	Grid side	EV DC side	Other
BMPU-R2-500-32	Active	11 kW	AC 3Φ+N	500V, 32A	
BMPU-R2-500-32-DC	Active	11 kW	DC – 500V	500V, 32A	
BMPU-R2-500-32-DC-HV	Active	11 kW	DC – 800V	500V, 32A	

The product will be shipped in a cardboard box H 210, W 470, L 550 (15 Kg)

9.2. Product accessories

WA012 – Set of matting connectors BMPU-R2 AC side (1996168), DC side (1711378) and LV side (1873207). Unwired	
WA013 – Pre-wired AC harness 32A BMPU-R2 with 6mm² color-coded wire and IEC 60309 32A plug (3P+N+PE) Cable length: 2.5m (other lengths under request)	
WA005 – Pre-wired DC harness with 10mm² color-coded wire and M6 lug termination Cable length: 2.5m (other lengths under request)	
WA016 – Pre-wired LV harness With color-coded 4mm insulated banana plug Cable length: 2.5m (other lengths under request)	
WA018 – Bracket without handle (set of 2) Can be mounted on rear side to provide additional support	

WA007 – CAN bus adaptor from RJ45 to DB9 including 120 Ω termination resistance	
WA009 – USB to CAN transceiver (Kvaser) Compatible with BMPU Monitor	
WA021 – BMPU monitor license (USB license dongle) A Windows based GUI (Graphical User Interface) for easy access to measurements, monitoring and configuration parameters. It can be used to control BMPU-R2-DC as a PC based master or to speed-up integration of a dedicated system master. See BMPU-R2-DC GUI user guide for more details.	

9.3. Related products

EVI – Electrical Vehicle Interface

EVI is a dual standard Supply Equipment Communication Controller (SECC) with all required signals for CCS2 /Combo and CHAdeMO communications.

Main features:

- CCS protocol compatible
  - ISO15118-2 and ISO15118-20
- CHAdeMO compatible (via Extension board)
  - Version 0.9 & 1.2
- Insulation Measurement Device according to IEC61557-8
- High voltage 920V charging.
- OCPP 1.6 and soon OCPP 2.0.1
- Smart Charging & V2G charging modes
- Cable temperature measurement
- Crypto ready with Secure Element embedded

EVIX – EVI Extension board:

An optional extension board (EVIX) can add additional functions such as:

- EVIX-AD6: Addressing of 6 power units
- EVIX-AD14: Addressing of 14 power units
- EVIX-AD6-CHA: CHAdeMO HW interface & Addressing 6 power units
- EVIX-IO: Peripheral extension board

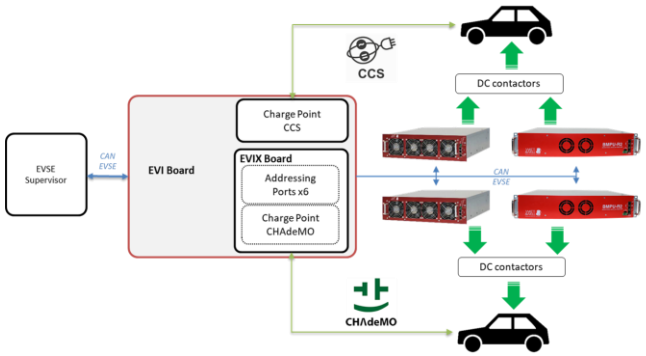


Figure 9-1: EVI & EVIX integration on EVSE environment

Other customization options available under request

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