Innovation in energy storage

Version 1.2 – 08-11-2024

Lithium-Ion RS LFP Battery Series

- Manual -

MGRS480230M
MGRS480230

MG Energy Systems B.V.

TABLE OF CONTENTS

1 GENERAL

Before continuing read the instructions in this chapter carefully and be sure the instructions are fully understood. If there are questions after reading the instructions please consult MG Energy Systems.

1.1 Document history

Table 1 - Document history

Rev.	Date	Changes	Revision author
1.2	08-11-2024	Update images, graphs and minor changes.	MS
1.1	11-09-2024	Updated boundary limits to release 1.x8.	WP
1.0	07-03-2024	Initial document.	MS

1.2 Terms, abbreviations, and definition

Table 2 - Terms, abbreviations, and definitions

Battery cell	*Battery cell;* the smallest building block in a battery, a chemical unit.
Battery module	*Battery module;* is an assembly of submodules, BMS, fluid cooling and outer enclosure.
BMS	*Battery Management System;* The BMS is the electronics that monitors the battery cell parameters to keep it within the operation specifications.
CAN-bus	*Controller Area Network bus;* CAN-bus is a standard serial databus that provides data communication between two or more devices.
C-rate	*C-Rate;* the current (A) used to charge/discharge the battery system divided by the rated ampèr-hours (Ah).
BOL	*Beginning-of-life;* Typically used to indicate a value like the internal resistance at the beginning of life of the battery module.
EOL	*End-of-life;* Typically used to indicate a value like the internal resistance at the end of life of the battery module.
DeviceNet	*DeviceNet*; is a network protocol used in the automation industry to interconnect control devices for data exchange, standardised in the IEC 62026-3.
EMS	*Energy Management System;* The EMS controls all power sources and consumers in a system.
HVIL	*High Voltage Interlock Loop;* is a wire loop which is created for protection of pulling cables from the battery system while in operation. It shuts down the system when loop is not closed.
MSDS	*Material Safety Data Sheet;* is a document that lists information relating to occupational safety and health for the use of various substances and products.
NMEA 2000	*National Marine Electronics Association's* NMEA 2000 is a plug-and-play communications standard used for connecting marine sensors and display units within ships and boats, standardised in the IEC 61162-1.
PPS	*Propagation Prevention System*; a fluid based protection system to prevent cell-to-cell and module-to-module propagation in case of a thermal runaway of one cell.
SoC	*State-of-Charge;* is the remaining capacity in a battery cell or module in percent (%).
SoH	*State-of-Health;* is a figure of merit of the condition of a battery (or a cell, or a battery pack), compared to its ideal conditions.

1.3 This revision

This revision replaces all previous revisions of this document. MG Energy Systems B.V. has made every effort to ensure that this document is complete and accurate at the time of writing. In accordance with our policy of continuous product improvement, all data in this document is subject to change or correction without prior notice.

1.4 Scope

This product manual contains technical description, installation, safety and commissioning instructions and other relevant information for the MG RS battery series.

1.4.1 Document structure

This document is structured into three categories:

- System design: Guidelines and general recommendations for system integrators and designers.
- Installation, commissioning and maintenance: Procedures and instructions for installers and maintenance personnel.
- Operation: Instructions and procedures for general users.

1.5 Related documents

More related documents for the MG RS battery module can found on our Download Center.

2 SAFETY INSTRUCTIONS

2.1 Safety message level definition

Table 3 - Safety message levels overview

⚠	**WARNING:** A hazardous situation which, if not avoided, could result in death or serious injury.
⚠	**CAUTION:** A hazardous situation which, if not avoided, could result in minor or moderate injury.
⚠	**LIMITATION:** A limitation to use which must be considered for safe use of the equipment.
⚡	**ELECTRICAL HAZARD:** The possibility of electrical risks if instructions are not followed in a proper manner.
ⓘ	**NOTICE:** ▪ A potential situation which, if not avoided, could result in an undesirable result or state. ▪ A practice not related to personal injury.

2.2 User health and safety

General precautions
This product is designed and tested in accordance with international standards. The equipment should be used according the intended use only.

⚠	**WARNING:** A battery is a permanent energy source which cannot be turned off.
⚡	**ELECTRICAL HAZARD:** ▪ Wear applicable personal protective equipment when working on a battery system. ▪ Use insulated tools when working on a battery system. ▪ Make sure the locale health and safety regulations for working on battery systems are followed.

2.2.1 Qualifications and training

The personnel responsible for the assembly, operation, inspection, and maintenance of the battery system must be appropriately qualified. The purchasing company is responsible for:

- Defining the responsibilities and competency of all personnel working with this product and all relevant systems.
- Providing instruction and training.
- Ensuring that the contents of the operating and safety instructions have been fully understood by the personnel.
- Ensuring that the system is installed in compliance to all local, federal codes or any other organism with jurisdiction over the system.

MG Energy system can, at the purchaser request provide all necessary training or instructions required for proper installation and usage of the system.

2.2.2 Non-compliance risks

Failure to comply with all safety precautions can result in the following conditions:

- Death or serious injury due to electrical, mechanical, and chemical influences.
- Environmental damage due to the leakage of dangerous materials.
- Product damage.
- Property damage.
- Loss of all claims for damages.

2.2.3 Risk assessment

For every integration of the battery system it might be applicable, depending on the application, to perform a risk assessment.

Goal of the risk assessment is to identify the hazards and determine the corresponding risks for the particular application.

The following topics need to be addressed:

- Fire hazards (fire from the batteries, fire from external source etc.)
- Environmental hazards (moisture, water ingress, vibration, heat etc.)
- Electrical hazards (short-circuit, cable dimensioning, cable routing etc.)
- Installation and operational hazards (lifting, communication, power loss etc.)

2.2.4 Unacceptable modes of operation

The operational reliability of this product is only guaranteed when it is used as intended. The operating limits on the identification tag and in the data sheet may not be exceeded under any circumstances. If the identification tag is missing or worn, contact MG Energy Systems B.V. for specific instructions.

WARNING:
The battery modules must be used in combination with a MG Master HV or MG Master LV.

3 TRANSPORT, STORAGE, UNPACKING AND HANDLING

3.1 Transport

The package and transport instructions provided by the manufacturer must be followed under all circumstances.

Notes on transport:

- Use original packaging materials.
- Lithium-Ion batteries are dangerous goods and must be transported according to the applicable rules.
- Transportation company and shipper must be qualified to transport and package dangerous goods.
- The SoC during transport must be ≤ 30%.

For details on transport of this battery module see the MSDS and general transport instructions.

CAUTION:
It is not allowed to transport, connect or operate a damaged battery.

NOTICE:
No liability can be accepted for damage during transport if the equipment is not transported in its original packaging or if the original packaging is opened before the destination is reached.

NOTICE:
The SoC of the battery as delivered from factory is ≤ 21%.

3.2 Storage

The storage instructions provided by the manufacturer must be followed in all circumstances.

Notes on storage:

- Battery module must be stored in its original packaging.
- Store in a dry, clean, and conditioned location.
- Local regulations for storage of dangerous goods may be applicable.
- Recommended storage temperature of the battery module is between +10°C to +25°C.
- It is recommended to limit the battery charge between 50% and 70% SoC. This will limit calendric aging.

The battery module self-discharge is 6% per year @25 °C and 12% per year @40 °C when not connected to any equipment. Recharging is required when the voltage is in the range of the cut-off voltage.

NOTICE:
Check the voltage of the stored battery module every year.
When the battery module voltage is below the cut-off voltage, recharging is required. Contact MG Energy Systems for specific instructions and tools.

3.3 Unpacking

Follow these handling guidelines when handling the product to prevent damage during unpacking:

- Use care when handling the product.
- Leave protective caps and covers on the product until installation.

NOTICE:
Do NOT remove the exhaust pressure relief!

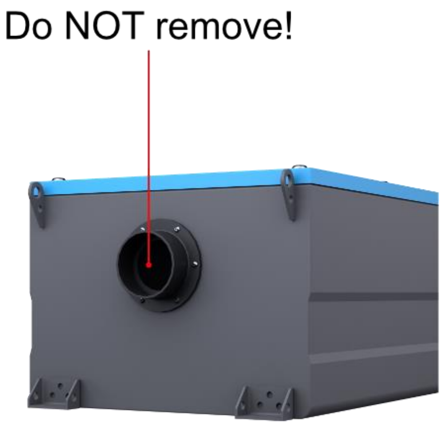


Figure 1 - Do NOT remove the pressure relief

3.3.1 Lifting the battery module

Use the lifting points on the sides of the battery module for lifting:

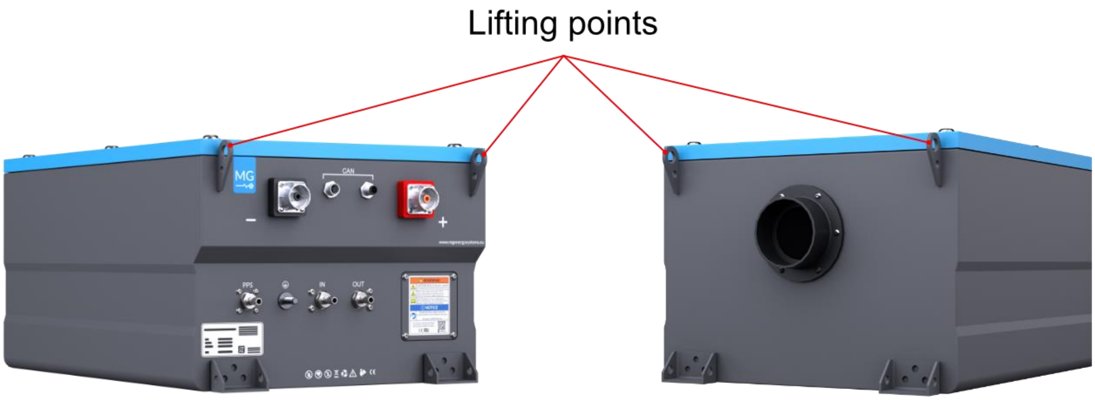


Figure 2 - RS battery module lifting points

CAUTION:
Always take the local applicable standards and regulations regarding the prevention of accidents into account when handling the product.

CAUTION:
Be aware of the total mass of the product and do not lift heavy objects unassisted.

3.3.1.1 Lifting positions

Lifting the battery module in the following positions is allowed:

Figure 3 - Lifting positions

WARNING:
Always use at least four lifting points!

3.3.2 Scope of delivery

The scope of delivery is as following:

- MG RS230 battery module of type as described in chapter 5.
- 1x Quick installation guide – RS230 Battery module.

NOTICE:
Not within the scope of delivery:

- Power cables and connectors (details can be found in chapter 6.3.1.1).
- Communication cables and connectors (details can be found in chapter 6.3.1).
- Exhaust parts.
- Liquid cooling connection couplings. The battery module is delivered with blind plugs.
- Fuses.
- RS Rack system.
- Master BMS, either MG Master HV or MG Master LV.

4 GENERAL DESCRIPTION

The RS 230 lithium-ion battery offers high performance together with the highest safety standards. This LiFePO4 based battery module contains a professional liquid thermal management system and a unique patented cell level propagation protection system. The combination of these safety and performance features make the RS battery suitable for large energy storage applications as well as smaller peak power packs. This makes the RS Series a high performance battery module for hybrid or electric vehicles, vessels, industrial machinery and solar off-grid applications. Thanks to the modular design, easily create 48 up to 900 Vdc systems.

All relevant information of this product can be found on the MG Download Center.

4.1 Battery system components

MG Energy Systems Lithium-Ion battery system consists of the following components:

- One or more MG RS LFP battery module;
- One or more MG Master HV or MG Master LV battery management systems; Details of these battery management controllers can be found in their separate manuals;
- MG Energy Monitor (optional);
- MG SmartLink MX or MG SmartLink PLC for parallel redundant control (optional);

4.2 Functional description

MG Energy Systems battery system philosophy is to have one master BMS, e.g. a MG Master HV or MG Master LV, per string of battery modules which communicates with one or more slave BMSs integrated in the Lithium-Ion battery module(s). The slave BMSs are monitoring the battery cell parameters like cell voltage, cell temperature, and humidity inside the enclosure. Besides monitoring, the slave BMS also controls balancing of cells based on the input of the master BMS.

All these parameters are send to the master BMS via a dedicated CAN-bus which collects all the data and monitors these parameters with different thresholds. When a parameter exceeds the threshold this will first be communicated to the user/EMS/PMS via the, separated, auxiliary CAN-bus. If the exceeded threshold stays, the master BMS has the possibility to disconnect the batteries from the system by opening the main safety contactors.

Functional and safety features of the MG RS battery module are:

- Modular design in combination with flexible rack design makes integration in small spaces possible.
- Robust steel enclosure with high IP rating.
- Exhaust system with over-pressure mechanism, used to output toxic gasses to a safe area during a thermal runaway of a battery cell. This avoids containment of gases within the battery space and therefor lowers the systems complexity to limit the risks involved.
- Fluid thermal management (cooling/heating) to increase performance, safety, and cycle life.
- Cell-to-cell propagation protection.
- Each string of batteries has its own MG Master BMS for protection, control, and logging.
- Marine type approvals for Lloyds (in progress).

4.2.1 Battery module schematic overview

Figure 4 shows a detailed schematic of the electrical components in the RS230 battery module.

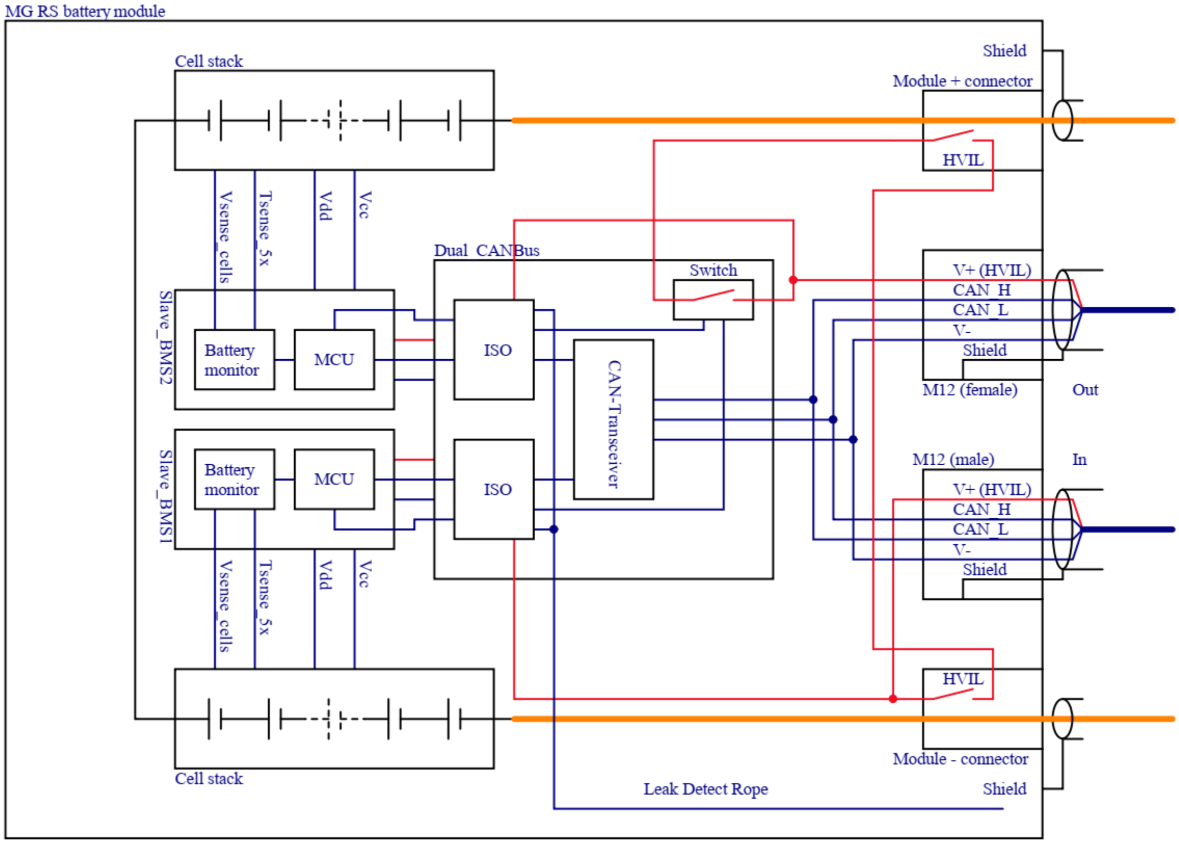


Figure 4 - Electrical block schematic of the RS230 battery module

4.3 Example systems

Different kind of battery systems can be created because of the modular design. Battery modules can be placed in series and parallel to create higher voltages and larger capacities.

Contact MG Energy Systems B.V. for more information about possible configurations.

4.3.1 Low voltage systems

Low voltages systems up to 96 VDC are setup with the MG Master LV. For more information about the MG Master LV, please refer to the data sheet and manual.

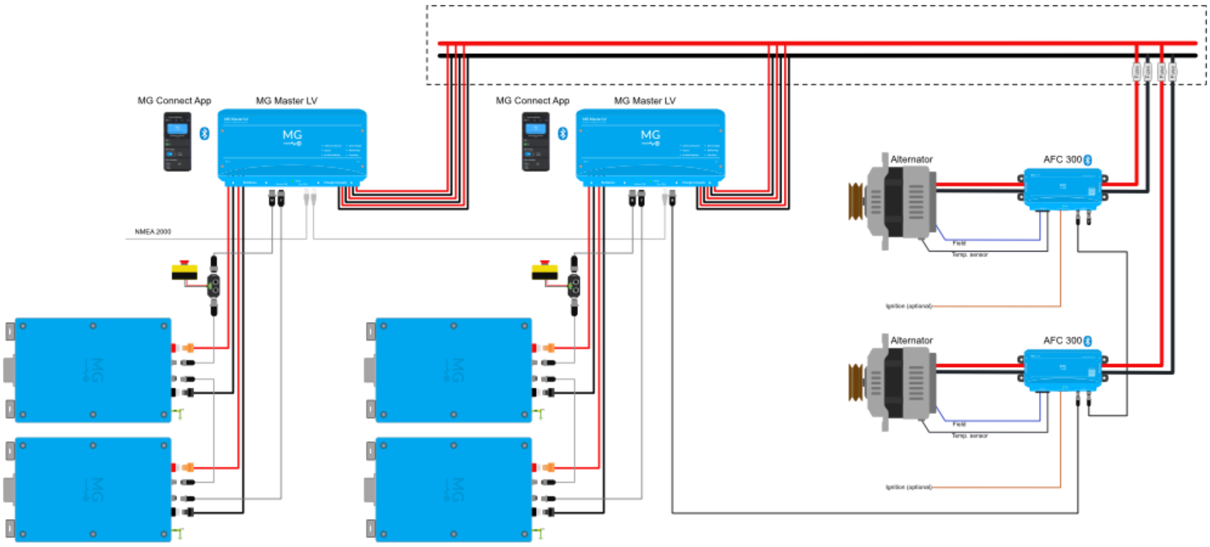


Figure 5 – Example schematic of 48 V RS230 battery system with MG Master LV and AFC300

Low voltage systems can also be setup with the MG Master HV. In this case the system can be used in marine class register approved systems.

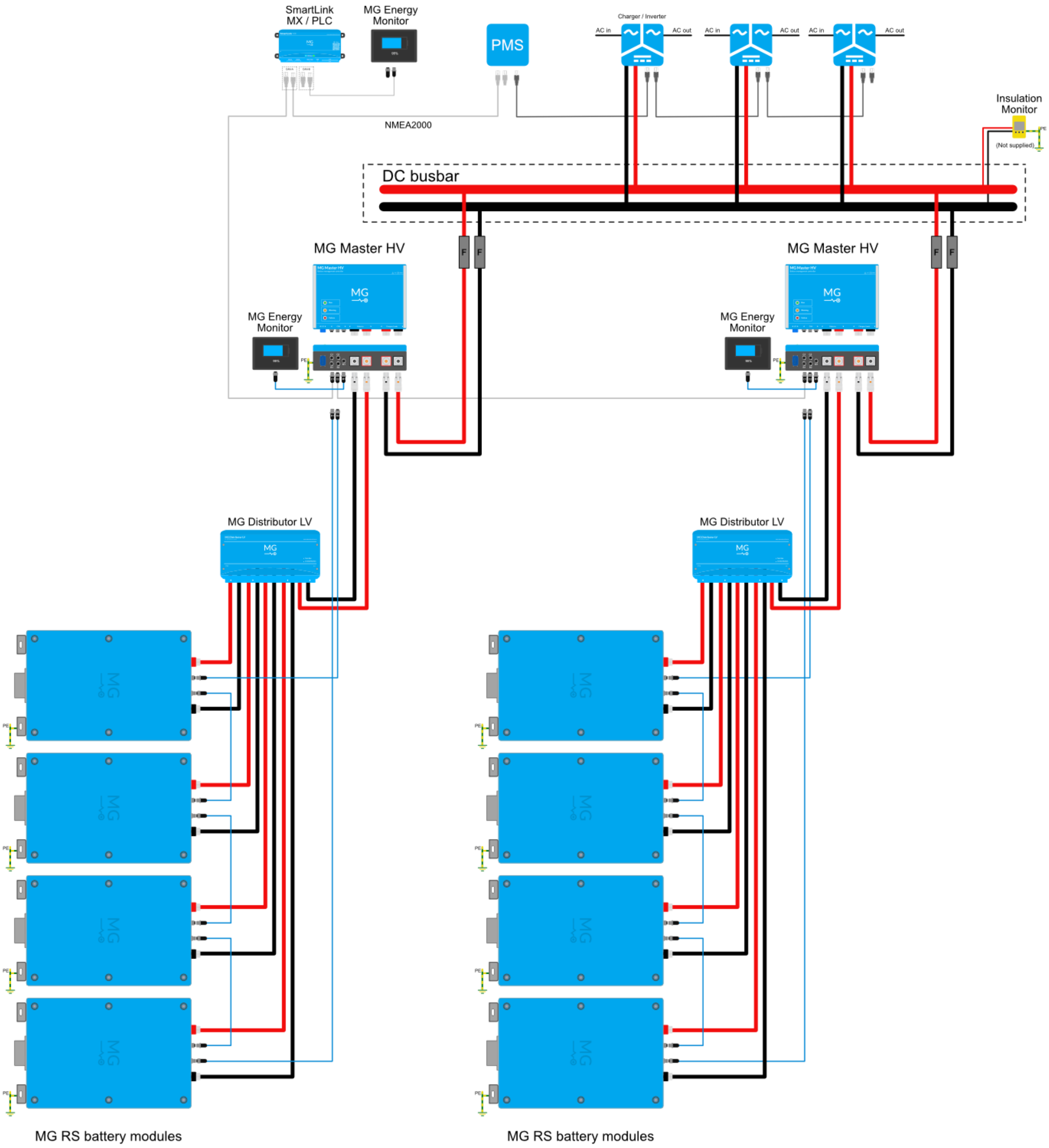


Figure 6 - Low voltage RS battery system in combination with a MG Master HV

NOTICE:
When using the MG Master HV at lower voltages, i.e. 48VDC up to 144VDC, the pre-charge circuit may not be sufficient. This is depending on the capacity of the connected equipment. Refer to the manual of the MG Master HV for detailed information.

4.3.2 High voltage systems

High voltage systems from 144 VDC up to 900 VDC are setup with the MG Master HV. For more information about the MG Master HV, please refer to the data sheet and manual.

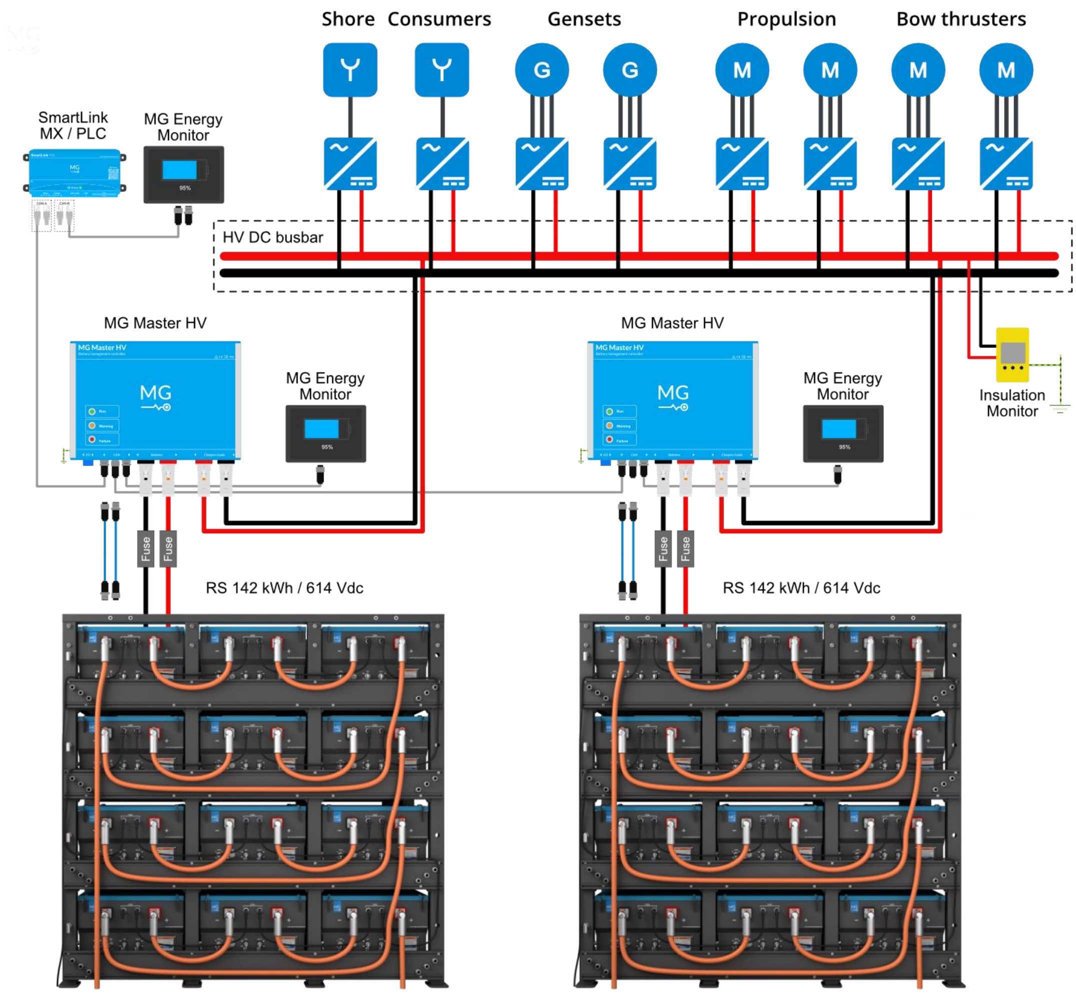


Figure 7 – Simplified system schematic of a two RS230 - 614 V batterybanks with Master HVs

5 MODELS

5.1 Models and configurations

The RS LFP series lithium-ion battery features several configurations. All configurations have the same enclosure dimensions.

5.1.1 Battery designation

As per IEC 62620 it is required to state a standard designation per battery module configuration. For the RS series lithium-ion battery these are given in table 4.

Table 4 - Battery module designation as per IEC 62620

Article number	Designation
MGRS480230M	IFpP/55/174/205/[1P16S]E/-10NA/90

5.1.2 Ordering information

The power connector configuration can be ordered as following:

Article number	Name	Connector type
MGRS480230M	MG RS230 Battery 51.2V/230 Ah/11.8 kWh Marine	Amphenol PowerLok™ 300 Series

5.2 Identification label

The identification label of the MG RS battery module is located at the front of the enclosure.

Example identification label:

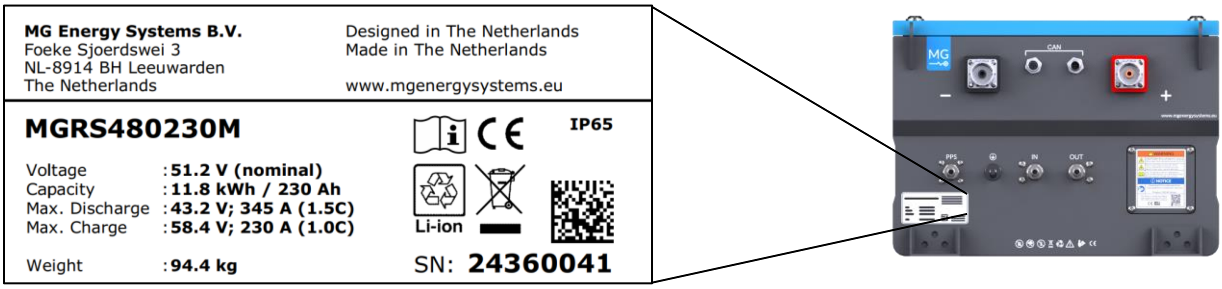


Figure 9 - Example identifications label

The identifications label shown in figure 9 contains written information about the product. The explanation of the symbols used on the identification label is stated in table 5.

Table 5 - Identification lable logo explaination

CE	Declaration of conformity with health, safety, and environmental protection standards for products sold within the European Economic Area as per directive 2014/35/EU.
(manual symbol)	Symbol indication the manual must be red before installation and use of the device.
(WEEE symbol)	Device is treated according the Waste Electrical and Electronic Equipment (WEEE) Directive 2012/19/EU.
(data matrix)	GS1 data matrix type barcode containing detailed product information.

5.2.1 Other labels

Figure 10 shows the additional labels on the battery module.

Figure 10 - Additional warning and informational labels

5.3 Approvals and standards

The RS battery conforms to an extensive list of standards and tests.

- Lloyds Type Approval (in progress)
- ES-TRIN (in progress) – IEC-EN62619 and IEC_EN62620
- Declaration of Conformity
- Material safety datasheet
- UN38.3 certificate

6 OVERVIEW

This chapter shows an overview of the RS battery module.

6.1 Front overview

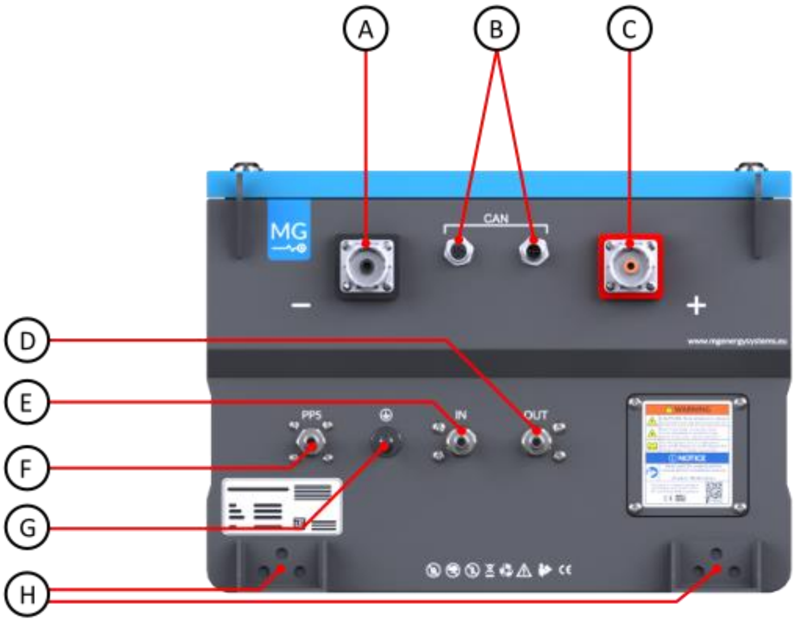


Figure 11 - Front overview

Table 6 - Module connection overview legend

Part	Description
A	Negative power connection
B	CAN-Bus connectors M12
C	Positive power connection
D	Fluid cooling outlet
E	Fluid cooling inlet
F	PPS inlet connection
G	Equipotential bonding connection (M8 bolt)
H	Mounting brackets

6.2 Rear overview

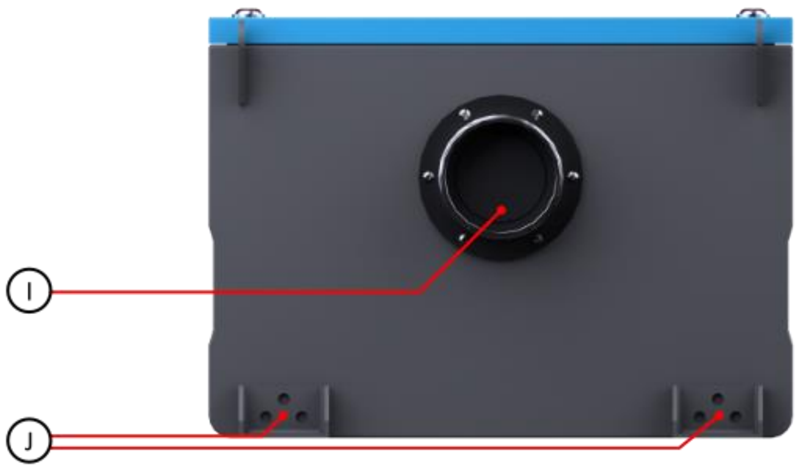


Figure 12 - Rear overview

Table 7 - Battery module rear view legend

Part	Description
I	Gas exhaust
J	Mounting brackets

6.3 Connection details

6.3.1 CAN-bus communication

A MG Master BMS communicates with the connected battery modules via CAN-bus. This is a dedicated CAN-bus where only MG battery modules of the same type or other MG devices may be connected.

The CAN-Bus connection is used for several functions:

- Data communication between battery module(s) and master BMS;
- The battery module uses the CAN-Bus V+ voltage to enable the power of the internal BMS;
- The CAN-Bus V+ voltage is also used as HVIL voltage source;

6.3.1.1 M12 CAN-Bus connector

The connectors used for connecting the CAN-bus are all of the same type, namely a circular M12 connector with 5 positions and A-coded keying.

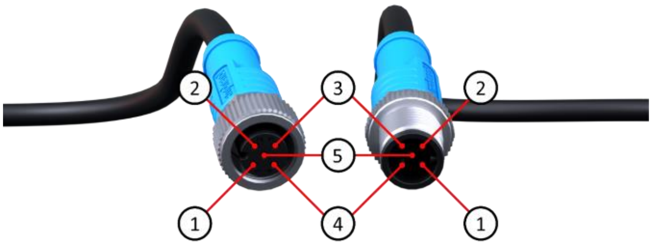


Figure 13 - M12 CAN-Bus connector pinout

Table 8 - M12 CAN-Bus connector pinout

Connector pins and specifications			
Name/Purpose	**Pin**	**Voltage**	**Current**
Shield	1		
CAN VCC	2	≤ 18 VDC	≤ 1 A
CAN GND	3		≤ 1 A
CAN-H	4		
CAN-L	5		

Cables to be used for the system are typically referred to as NMEA 2000 or DeviceNet compatible cables. The minimum requirements for cables are:

- Twisted pair connected to pins 4 and 5 for communication with a minimum wire cross sectional area of 0.2 mm² (24 AWG).
- Pair of conductors connected to pin 2 and 3 for power and HVIL with a minimum wire cross sectional area of 0.34 mm² (22 AWG).
- Cable with braided shielding connected to pin 1.

NOTICE:
Do NOT use sensor/actor cables. They often don’t have any twisted pairs and are therefore not suitable for this application.

6.3.2 Power connections

For the RS230 battery module’s power connections, Amphenol PowerLok™ 300 Series connectors are used. These power connectors can handle a voltage of 1000 VDC and have an integrated HVIL for safety.

The continuous current of the system is depending on the cable cross section, ambient temperature and type of cable.

6.3.2.1 Connector details

Table 9 show an overview of the standard connector types in relation with the models and the maximum currents. Contact MG Energy Systems B.V. for cable options and possibilities.

Amphenol PowerLok™ 300 Series


Table 9 - Amphenol PowerLok™ 300 Series

Brand	Amphenol PowerLok™	
Series	300 series	
	Positive terminal (orange)	***Negative terminal (black)***
Receptacle types (mounted on MG RS module)	PL00X-301-10-M10	PL00Y-301-10-M10
Plug must be of HVIL type. The `-5` postfix is indicating for use with the Huber & Suhner Radox cable.	**Plug connector:** PL28X-301-50-5: 200 A PL28X-301-70-5: 250 A PL28X-301-95-5: 300 A PL18X-301-50-5: 200 A PL18X-301-70-5: 250 A PL18X-301-95-5: 300 A	**Plug connector:** PL28Y-301-50-5: 200 A PL28Y-301-70-5: 250 A PL28Y-301-95-5: 300 A PL18Y-301-50-5: 200 A PL18Y-301-70-5: 250 A PL18Y-301-95-5: 300 A

6.3.3 Equipotential bonding connection

The equipotential connection is mounted on the front of the RS battery module. It consists out of an M8 bolt.

Figure 14 – M8 equipotential bonding connection

6.3.4 Fluid thermal management connections

The fluid thermal connections are by default delivered with a blind plug. These can be replaced with the desired connection type for the application. The basic connection is a G 1/4" inner thread.

Figure 15 - G 1/4" inner threaded connections close-up

6.3.4.1 Example connections

Table 10 shows different example connection for the liquid cooling and PPS that can be used.

Table 10 - Example connections

Connection type: Hose pillar Article: GT1410 MSV ED Material: Nickel-plated brass **Hose connection:** This liquid cooling connection accepts a hose with an inner-diameter (ID) of 10 mm.	
Connection type: Push-in Article: IQSL 1410 G MSV Material: Nickel-plated brass **Hose connection:** This liquid cooling connection accepts a calibrated hose with an outer-diameter (OD) of 10mm. For example 10 mm Parker / Legris hose.	

6.3.5 Exhaust connection

The function of the exhaust connection with pressure relief is to release gasses in case of a thermal runaway event. The flammable and toxic gasses can be evicted from the module and released in a safe area (outside).

The diameter of the exhaust is dimensioned to connect piping with an inner diameter of 80 mm. Refer to the RS230 drawing for details.

Figure 16 - Exhaust on the rear of the RS battery module

6.3.6 PPS connection

The PPS connection is an optional system used to fill the battery with a PPS fluid to prevent thermal runaway propagation in case of a single cell thermal runaway event. The connection type is the same as for the fluid thermal management connections in chapter 6.3.4.

See the MG RS PPS Tank manual for detailed information about the pressurized tank.

NOTICE:
The PPS system is an *optional* system. Due to the LFP chemistry of the cells, the RS230 has no thermal runaway propagation between cells as tested according to the IEC-EN62619 test 7.3.3 – Propagation test.

NOTICE:
It is recommended to monitor the pressure on the PPS tank with a sensor that is connected to an alarm system.

7 BATTERY MODULE PROPERTIES

This chapter describes detailed information about the properties and behaviour of the RS battery modules.

7.1 Open-circuit voltage versus State-Of-Charge

The graphs below give information about the open-circuit voltage versus the State-Of-Charge for the RS battery module.

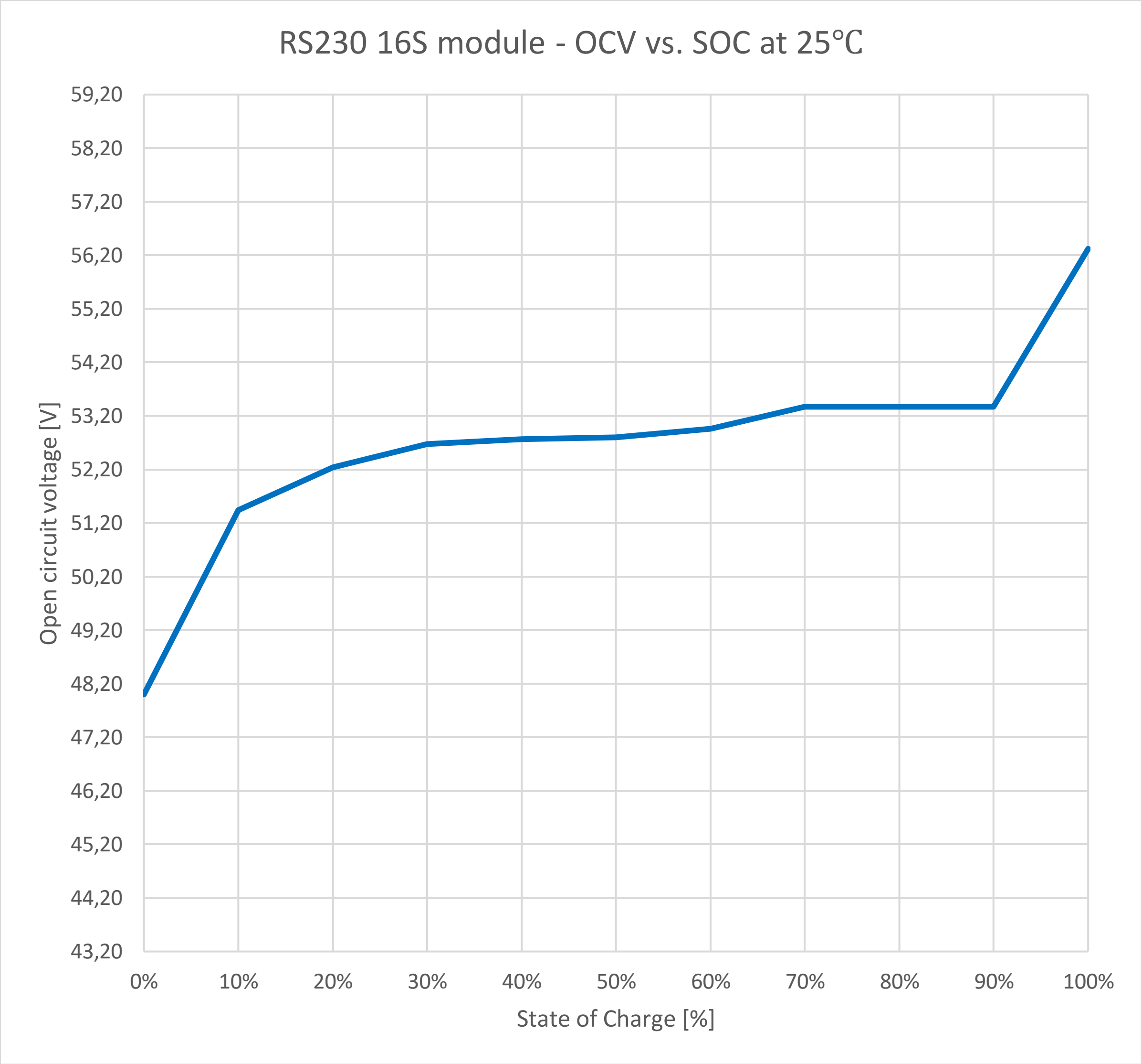


Figure 17 - Open-circuit voltage vs SOC RS230

7.2 Internal resistance and heat dissipation

The internal resistance of RS modules depends on different factors. Each module type has a different resistance due to the internal electrical configuration.

The main factors influencing the resistance is temperature, and SOC and SOH. Table 11 shows the internal resistance for BOL and EOL together with the heat dissipation at different C-rates.

Table 11 - Average module internal resistances

Module current (A)		Heat dissipation (W) / Battery module @ 25 °C	
C-Rate	Current	BOL (12mΩ)	EOL (18mΩ)
0.5	115	159	238
0.7	161	311	467
1.0	230	635	952

7.2.1 Internal resistance change towards EOL

All Lithium-Ion cell will age and lose some performance during use. This aging will affect different factors but mainly the internal resistance and capacity. Temperature and DOD (depth-of-discharge) are leading factors in the aging process. In general, the higher the temperature of the module during use, the faster the aging. Same is true for DOD, cell aging is worse if full cycles (100% DOD) occur on a regular base.

As a guideline for the change of internal resistance of the module, it can be expected to increase by 1.5 times during its life (EOL is defined here at 70% SOH). This practically means that the heat generated by each module is increasing over its lifetime. Refer to Table 11 for the EOL heat dissipation values at different charge and discharge currents.

7.2.2 Important note on the capacity of the cooling system

The values given in Table 11 can be used to make an approximation on the heat rejection of a system, but it has to be used with caution. Due to the specific heat of the system (battery mass and coolant system volume) most energy that is generated is “stored” in the mass of the system. This means that high load peaks don’t directly lead to a significant increase in temperature. This will take some time to build-up. Due to this buffering effect of this process, the cooling capacity of the system can be dimensioned significantly smaller than the highest peaks that are expected to occur.

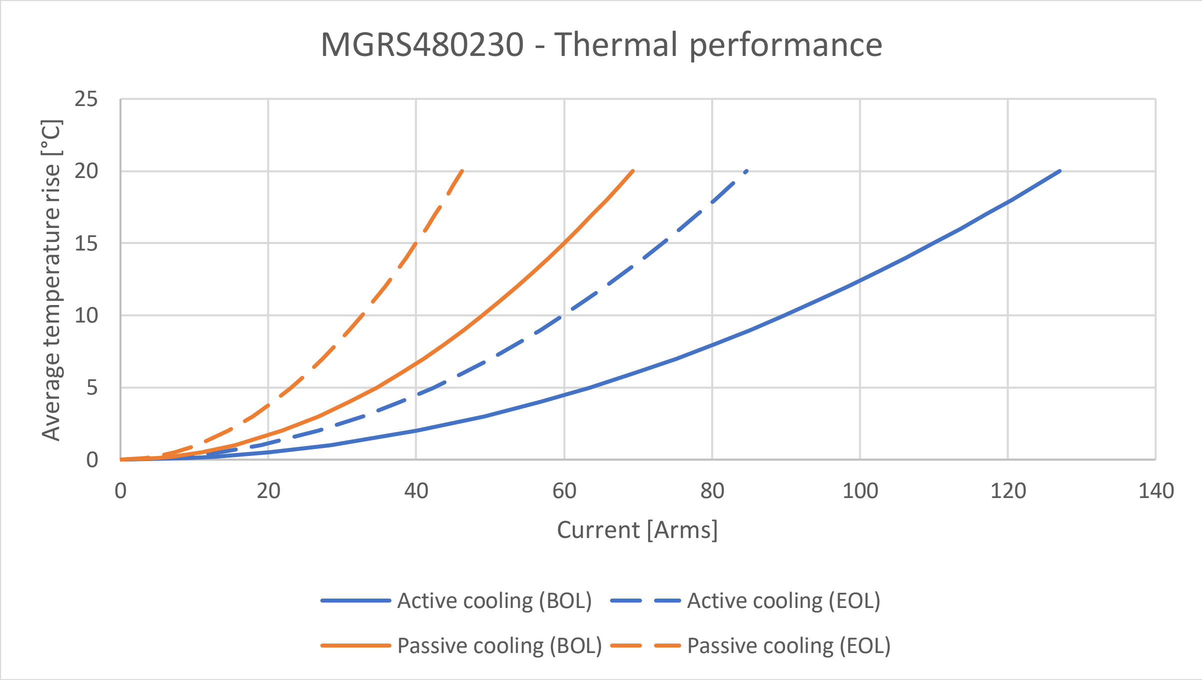
7.3 Battery strategy

The battery system can operate according two different battery strategies, namely *default* and *performance*. Selecting between these will make changes to some of the boundary limits. In *performance* the master BMS allows a higher temperature and current limit. Recommended is to use the *Default* battery strategy when possible. A detailed description of the boundaries related to the battery strategy can be found in chapter 13. Selection of the battery strategy is done in the master BMS, please refer to the manual of the specific master BMS for details.

7.4 Performance

The RS battery module can be used with and without liquid thermal management system. The key limiting factor of the battery module’s performance is the module’s temperature. This temperature must be within its operating temperature window during operation. The temperature and temperature rise is mainly depending on the combination of charge/discharge currents and the duration. Paragraph 7.4.1 and 7.4.2 show graphs to describe the different thermal behaviour of the battery module.

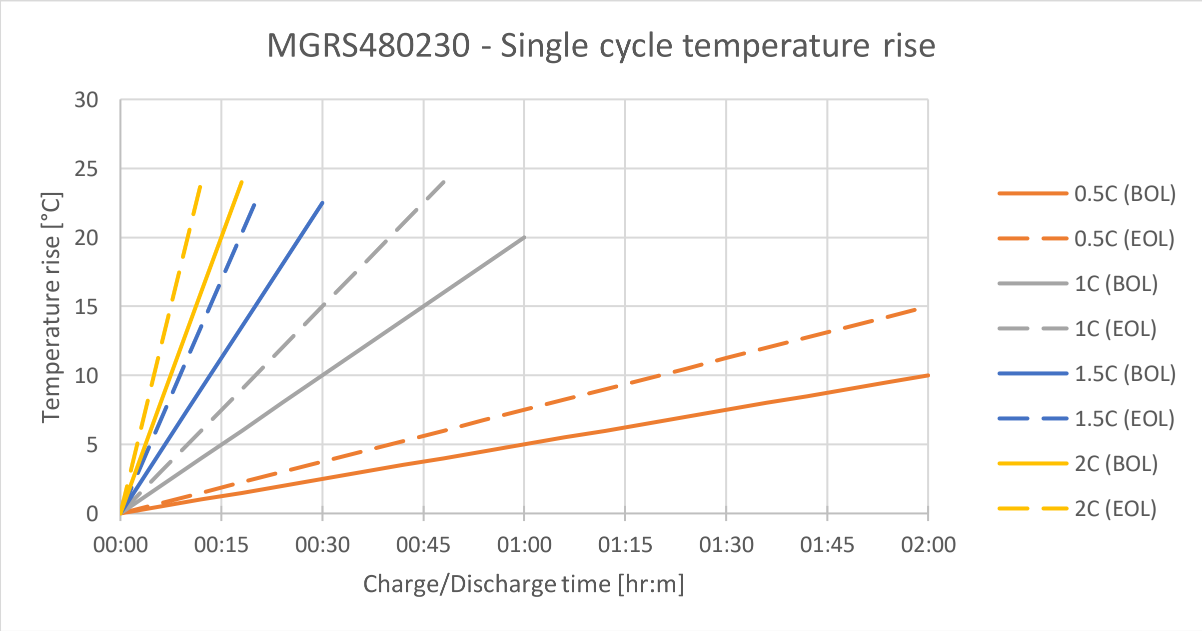
7.4.1 Thermal performance



Notes thermal performance:

- BOL values are tested values
- EOL values are calculated based on manufacturer recommendation (1.5xBOL)
- Based on 20 °C ambient/coolant temperature
- Arms values should be calculated on a time period of at least 3 hours
- Battery peak temperature can be calculated on the single cycle graph

7.4.2 Single cycle temperature rise



Notes on Single cycle temperature rise:

- BOL values are tested values
- EOL values are calculated based on manufacturer recommendation (1.5xBOL)
- Based on 20 °C ambient/coolant/starting temperature

7.5 Short-circuit currents

The short-circuit currents are highly depended on the temperature of the module. Second (less significant) factor is SOC, but due to the flat voltage charge/discharge curve. Worst-case scenario should be around the nominal voltage range of the LFP module (3.1Vdc - 3.3Vdc).

High and low values of SOC will lead to an increase of internal resistance, herby limiting the short-circuit currents.

Calculations in Table 12 are based on a 52.8V module voltage and a 0 mΩ short-circuit load.

Table 12 - Detailed specifications of RS230 modules (internal resistance & short circuit current)

Module temperature	Configuration	Module internal resistance [mΩ]	Module peak short-circuit current [kA]
10 °C	MGLFP24x230 (230Ah)	17	3.1
25 °C	MGLFP24x230 (230Ah)	12	4.4
45 °C	MGLFP24x230 (230Ah)	8	6.6

7.6 Fluid cooling volume

The RS battery module fluid cooling has a volume of approximately 135 ml.

7.7 Balancing

The slave BMS uses a passive balancing method to equalize the cell voltages. The balancing resistors have an equivalent resistance of 20.5 Ω to balance per cell. The balancing current is approximately 170 mA. The actual cell balancing algorithm is controlled by the master BMS, since balancing is performed over the complete battery pack.

8 INTEGRATION REQUIREMENTS AND INSTRUCTIONS

This chapter describes the integration requirements and instruction. Read this chapter carefully.

8.1 Risk assessment

Integration of a battery system requires in any case an assessment of the risks. Depending on the application, specific rules might apply.

A basic risk assessment is available in the RS - Basic risk assessment.
A description of the risks and control measures can be found in the RS - Safety description.

NOTICE:
Before integration design check the applicable rules for the application where the battery system will be integrated in.

8.2 Project process

The review of integration consists of the following steps:

1. Design of electrical installation by electrical system integrator.
2. Review of schematic of the actual electrical installation by MG.
3. Installation of the battery system by electrical system integrator.
4. Review of the installation by MG. Send pictures of the installation and connections.
5. Commissioning of the battery system (MG, electrical system integrator). Remote commissioning is possible. A skilled technician must be on site to configure and test the system.
6. System ready for use.

8.3 Location

The location of the battery system needs special attention, since some regulatory categorize Lithium-Ion battery systems as hazardous. Check for the local rules for the requirements of the battery system location in the used application.

General recommendations and requirements for the battery space with respect to the battery module are as following:

- Make sure the battery space is in accordance with the applicable rules.
- Keep the battery string connection cables as short as possible.
- Make sure that the DC cabling of each parallel battery or string have the same cable lengths.
- Ensure that the equipment is used under the correct operating conditions.

8.3.1 Environment

The battery modules must be placed in a space that is moisture free, non-condensing and protected against fluid (water, oil etc.) ingress.

WARNING:
Moisture or water can damage the battery and its electronics. This might lead to dangerous situations.

8.4 Thermal management

8.4.1 Design rules

Below a list of design rules for the liquid cooling system.

- Connect the liquid cooling of each battery module in parallel.
- Inlet temperature must be Non-condensing.
- When using chilled liquid with a heat exchanger, make sure an active temperature control is installed to bypass the heat exchanger.
- Install a flow sensor or indicator.
- Recommended is to install a particle filter.

Find an example schematic of the liquid cooling system in Appendix B.

8.4.2 Requirements table

Cooling system	Fluid cooling system may be closed-loop or open-loop
Coolant type	Any water or glycol type based, in any mixture depending on the application use. - Use demineralized water. - Use a corrosion inhibitor.
Coolant inlet temperature	Recommended range of 20 °C to 30 °C. Non-condensing. Higher temperatures are possible at request. This could reduce cycle life and performance.
Maximum inlet pressure	2 bar (versus ambient)
Maximum outlet pressure	2 bar (versus ambient)
Operational flow	1 l/min with a pressure drop of 0.3 to 0.5 bar.

When the battery system is not used it is allowed to use the storage temperature range.

⚠

CAUTION:
The following aspects must be taken into account:

- Non-condensing temperature control.
- Always use hoses, tubes and other components for compatibility with the required regulations and class register.

8.4.2.1 Pressure versus flow

Figure 18 shows the pressure loss versus flow.

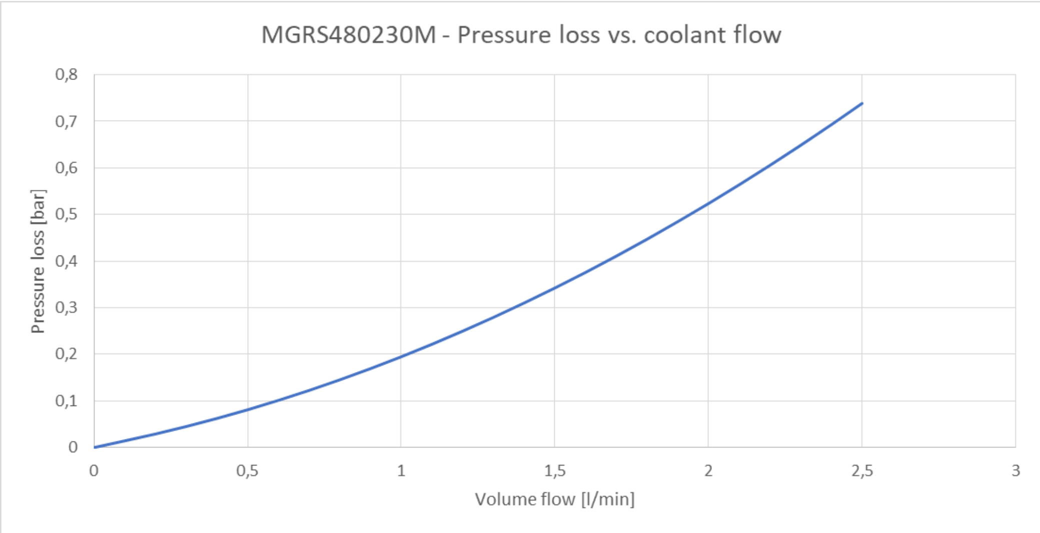


Figure 18 - Pressure loss versus cooling flow

8.5 Propagation protection system (PPS)

The battery module is equipped with a thermal Propagation protection Systems (PPS). The PPS connection is an optional system used to fill the battery with a PPS fluid to prevent thermal runaway propagation in case of a single cell thermal runaway event. If a thermal runaway event occurs, the PPS fluid will be automatically released into the battery module. The propagation protection fluid is normally contained in a pressurised tank, a PPS tank.

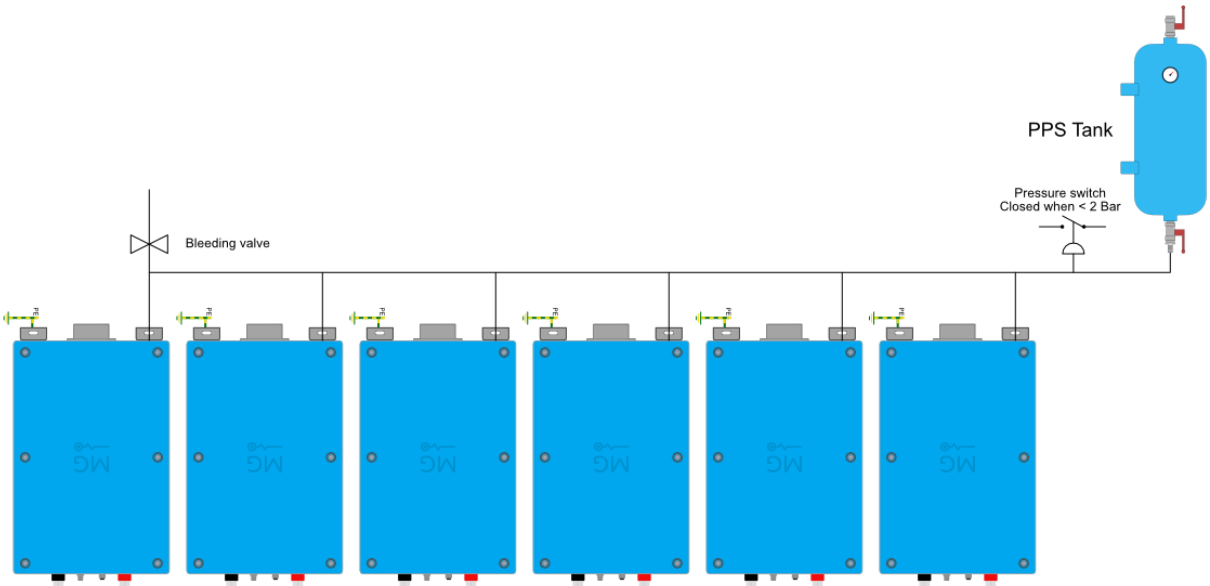


Figure 19 - Propagation prevention system connection schematic

NOTICE:
Multiple battery modules can be connected in parallel to one PPS tank. It is recommended to install at least one PPS tank per battery string.

WARNING:
Make sure the Propagation Protection System is used as described under all circumstances.

LIMITATION:
A single PPS pressure container can, for integration reasons, serve more than one battery module by parallel connection. In such a situation it must be considered than when the PPS system is triggered in one battery module, the remaining parallel connected battery modules are unprotected from that point on.

CAUTION:
When the PPS is activated, fluid will flow into the battery module. When there is flowing more than 12 litres into the battery module it will reach the exhaust output and fluid will flow into the exhaust ducting.

8.5.1 PPS tank

There is a standard PPS tank part available.

More detailed information about the PPS tank, such as installation instructions and commissioning can be found in the MG RS PPS Tank Manual.

8.6 Exhaust

The exhaust system has the function to channel the released gasses during a thermal runaway event to a safe area. To be able to do this, an exhaust output with pressure relief is designed at the rear of the battery module. A ducting system can be connected to extract the toxic and flammable gasses from the module and prevent it from releasing in the battery area (closed area).

The battery module is provided with an exhaust connection as described in chapter 6.3.5.

To provide a connection to a ducting system a flange part is available.

Article number	Description
MG3000473	Racking exhaust flange kit

Refer to the Racking exhaust flange kit drawing on the MG Download Center for details.

The kit consists out of the following parts

- Racking exhaust flange;
- Silicon gasket;
- Viton seal;

8.6.1 Example ducting arrangement

Figure 20 shows an example of a ducting arrangement of the battery modules.

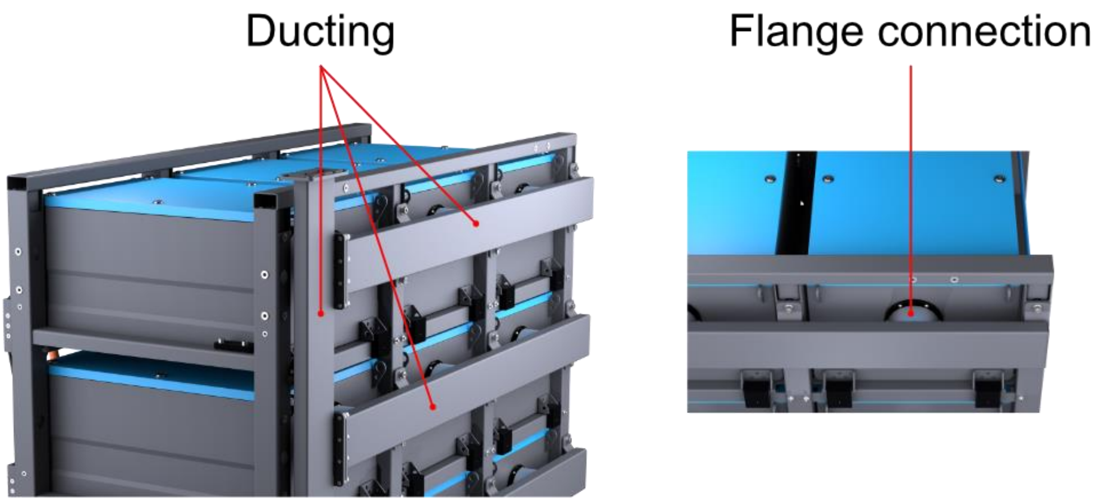


Figure 20 - Example ducting and flange connection

Recommended options for the exhaust ducting design are:

- Add a drain to the lowest points in the ducting system. This will help to remove any liquids for example the liquid of the PPS after a thermal runaway event;
- Add a nozzle to apply air pressure to the ducting system. This will help to clean the exhaust system from remaining gasses after a thermal runaway event and makes it safe to remove the broken battery module.

8.7 Inclination

There is no operational effect on the battery system when an inclination is applied. There is a minor effect regarding the PPS system in certain situations. Therefore it is recommended to mount the battery modules in such a way that the longest length of the battery modules will experience the smallest angle of inclination. The maximum dynamic angle is 22.5 ° on any axis.

These requirements are depending on the type of application. The risk of the effects need to be assessed on a case by case basis. Contact MG Energy Systems B.V. for specific application information.

8.8 Battery rack

It is recommended to mount the battery modules in a rack secured with all four mounting brackets. Different parameters need to be taken into account when designing the battery rack:

- Weight of the battery modules;
- Shock and impact requirements;
- Battery module spacing;
- Fluid cooling and exhaust pipes.

There are two options for a battery rack:

- The customer/shipyard/OEM manufacturer designs and produce their own battery rack;
- MG provides their standard RS battery Rack. Including exhaust and liquid cooling manifolds. For more information about the standard rack contact MG Energy Systems B.V.;

8.8.1 MG RS battery rack

The standard MG RS battery rack provides all the necessary requirements to install, connect and mount the battery modules. Different physical layouts can be configured to fulfil the requirements of the application. Figure 21 shows an example rack configuration.

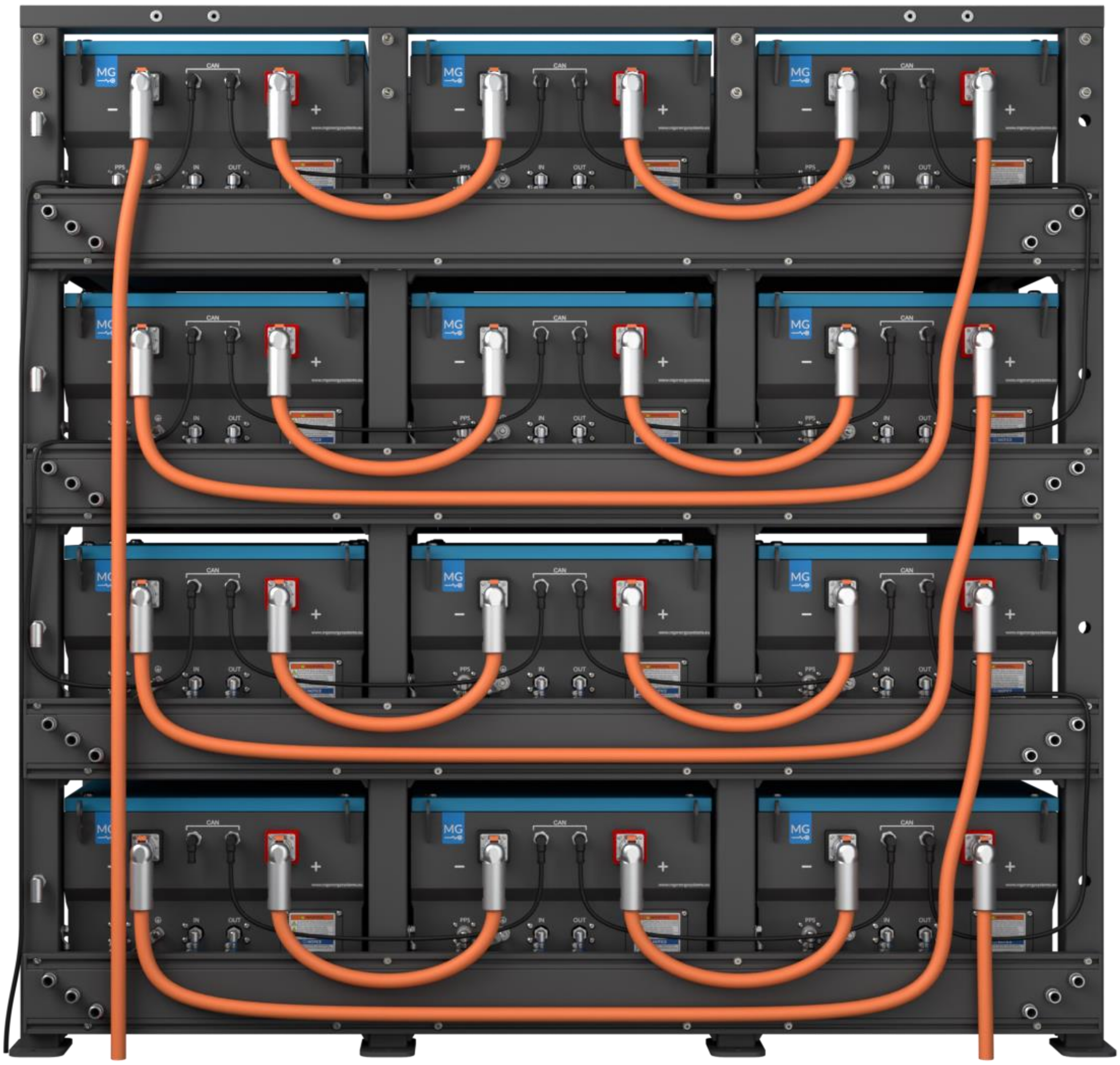


Figure 21 - RS Rack example

Refer to the MG RS battery rack description document for detailed information about the standard RS Rack.

9 INSTALLATION

Read the installation instructions in this chapter before commencing installation activities.

⚠

WARNING:
Before continuing make sure the following instructions are met:

- Ensure that the connection cables are provided with fuses and circuit breakers.
- Never replace a protective device by a component of a different type. Refer to the ordering information sections of this manual or contact manufacturer for a correct replacement.
- Before switching the device on, check whether the available DC bus voltage range conforms to the configuration of the product as described in the manual.
- Ensure that the equipment is used under the correct operating conditions.
- Ensure that there is always sufficient free space around the product.
- Install the product in an environment that can sustain some heat. Ensure therefore that there are no chemicals, plastic parts, curtains or other textiles, etc. in the immediate vicinity of the equipment.

9.1 Installation procedures

Below the basic installation procedures at battery module level.

1. Mount the battery module: mounting procedure;
2. Equipotential bonding of the battery modules: equipotential bonding procedure;
3. Connect the battery module electrically: electrical connection procedure;
4. PPS connection procedure;
5. Exhaust connection procedure;

NOTICE:
During installation a check form needs to be used to log the installation procedure. This log will be checked during commissioning.

9.2 Mounting procedure

This procedure describes how to mount the battery module with respect to the integration requirements stated in chapter 8.

1. Lift the battery module to its location using the mounting points specified in Figure 22.
2. Use M8 bolts with body washers and spring washers or a lock nut for mounting.
3. Tighten the M8 bolts at the four mounting points with **20 Nm**.

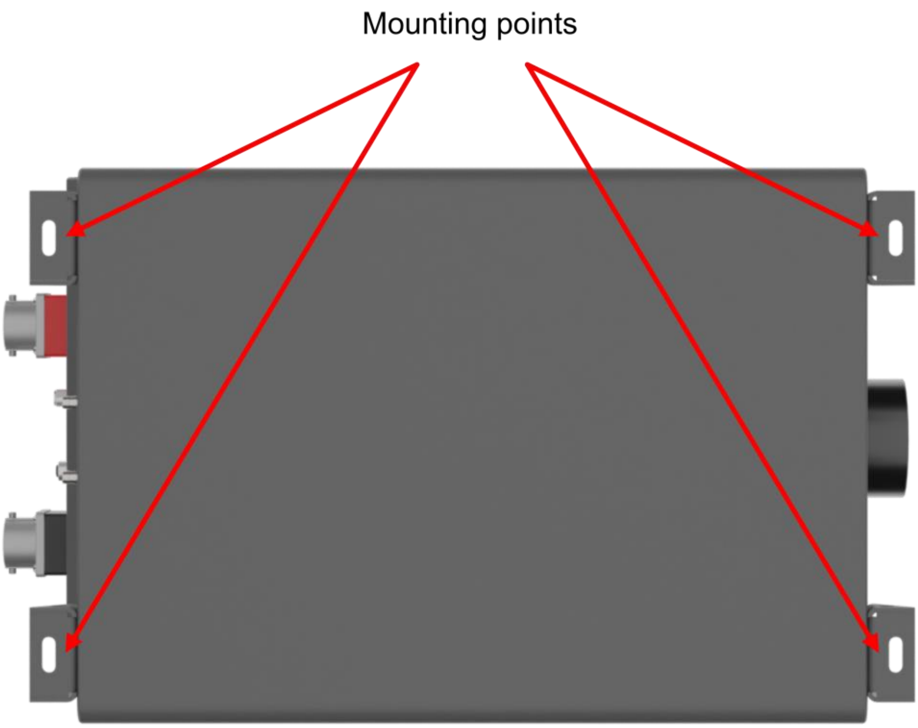


Figure 22 – Mounting points (bottom view)

Figure 23 - Front view mounting

9.3 Electrical connection procedure

The battery module can be used in combination with other battery modules of the same type and always in combination with a MG Master BMS.

ELECTRICAL HAZARD:
The battery modules can be placed in series up to 900 VDC. Make sure to wear proper insulation gloves and safety goggles. Take the local safety regulation and procedures into account before starting the connection procedure.

ELECTRICAL HAZARD:
Before connecting the DC power cables, make sure the other ends are protected or connected.

9.3.1 Equipotential bonding procedure

The equipotential bonding connection location of the battery module is the same as the mounting bracket. One of the four mounting points can be used to connect a bonding wire or a contact washer as shown in Figure 24. Equipotential bonding connection scheme and the required wire cross-section depend on local standards and regulation. The typical used wire cross-section is 16 mm^2 with a minimum of 10 mm^2.

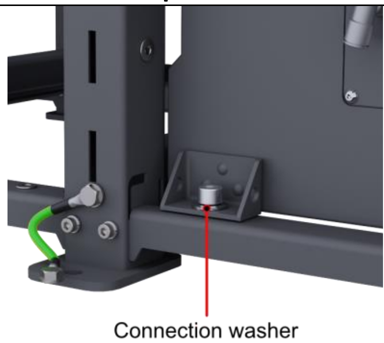
Option 1	Option 2
	

Figure 24 - Equipotential bonding options

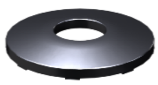


Figure 25 - Contact washer

NOTICE:
Local standards and regulation might be applied for sizing and connection type of the equipotential bonding.

NOTICE:
Make sure a contact washer is used to make a good connection through the powder coating.

9.3.2 CAN-Bus connection procedure

This section describes the connection of the RS battery communication cables.

9.3.2.1 Basic connection layout

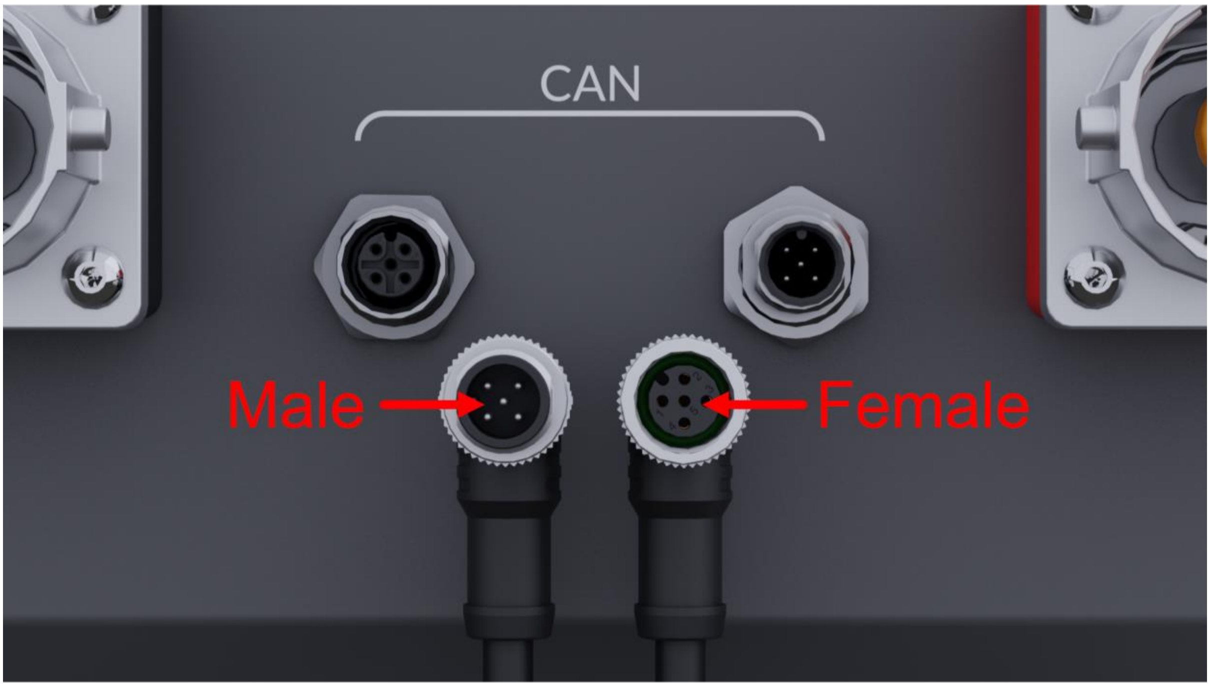
The layout of the CAN-Bus connection is as following:

1. Start with a CAN-bus cable at the MG Master BMS, the Battery CAN-Bus, and go to the first battery.
2. Connect from the first to the second battery. Repeat this until the last battery module.
3. Connect the last battery back at the MG Master BMS's Battery CAN-Bus.

9.3.2.2 Connecting procedure

The following procedure describes the connecting of a M12 connector to the RS battery module.

1. Check for the keying of the CAN-Bus connectors.



NOTICE:
To avoid EMC issues it is recommended not to route CAN-bus cables alongside power cables.

2. Bring the connections face of the cable connector up the device connector in such a way that the position of the key matches to that of the opposing connector.

3. Connector in place.

4. RS battery module with fully connected CAN-Bus M12 connectors.

Figure 26 - Fully connected CAN-Bus

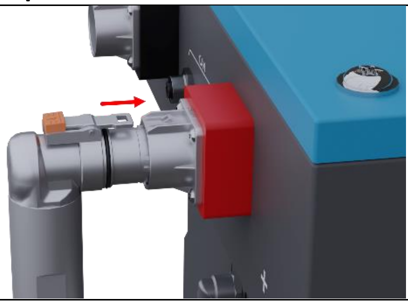
9.3.3 Power connection procedure

The power connections make use of the Amphenol PowerLok™ connectors. See section 6.3.1.1 for detailed information about types and cable sizes available.

ELECTRICAL HAZARD:
The battery modules can be placed in series up to 900 VDC. Make sure to wear proper insulation gloves and other applicable safety gear.

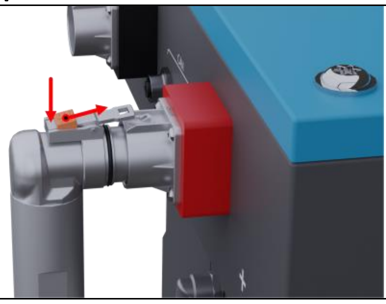
Follow this procedure to connect the Amphenol PowerLok™ connectors to the battery module:

1. Plug in the Amphenol PowerLok™.

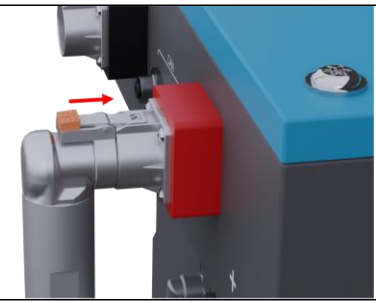
Amphenol PowerLok™ 300

Push the connector.

NOTICE:
Orange is the positive terminal of the battery and black is the negative terminal of the battery. This cannot be switched because connectors are keyed.

2. Push in and lock the connector.

Amphenol PowerLok™ 300

Push the orange/black lip forwards and down before pushing the connector in.

3. Lock and check if the connector is locked.

Amphenol PowerLok™ 300

Check if the connector is locked.

9.4 Fluid cooling connection procedure

The fluid thermal management of the battery system is a two-line system, consisting of a cold supply line and hot return line. Each battery module is connected in parallel to the supply and return line.

The type of connection can be changed with any type of coupling with an outer thread of a G 1/4".

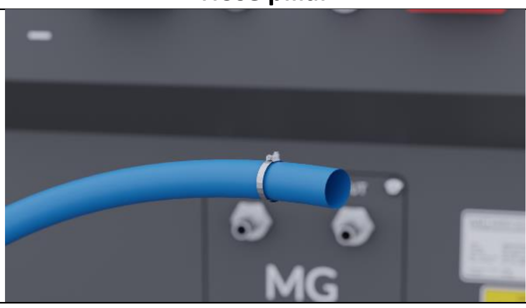
NOTICE:
The maximum torque for the coupling in the enclosure is 16 Nm.

9.4.1 Example hose connection procedure

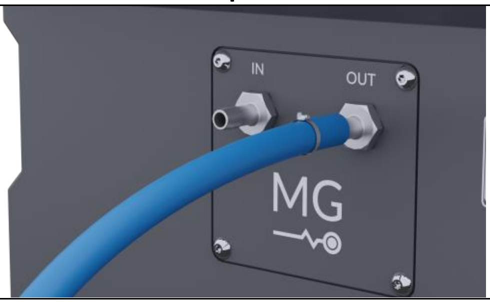
Fluid cooling hose connection is explained in the following steps for the example connections in chapter 6.3.4.1.

1. Take the correct hose to connect to the fluid cooling connection.

WARNING:
Use the appropriate hose type for the different type of fluid connections. See chapter 6.3.4.

Push-in connector	Hose pillar
	
	Place a hose clamp on the hose.

2. Connect the hose to the fluid cooling connection.

Push-in connector	**Hose pillar**
	
Push the hose into the push in connection.	Push the hose over the pillar.

3. Check the locking of the hose connection.

Push-in connector	**Hose pillar**
	
Push the hose al the way into the connection and check if the hose is locked.	Push the hose al the way into the connection and lock the hose with the hos clamp.

4. Repeat the steps for all fluid cooling connections.

⚠ **WARNING:**
Do NOT connect the fluid cooling system before the cooling system is tested without the connection of the battery modules.

9.5 PPS connection

The PPS connection can be connected in the same way as the liquid thermal management connections. Refer to chapter 9.4 for details.

WARNING:
Always test on leakages with an air pressurized PPS system first before filling the PPS tank with fluid. See the RS PPS Tank manual for details about this procedure.

9.6 Exhaust connection

The RS battery module will be connected to a flange part which is mounted on a bigger exhaust ducting system. To have a leak free connection Molykote 55 O-ring grease needs to be added to the O-ring of the flange part before sliding in the battery module.

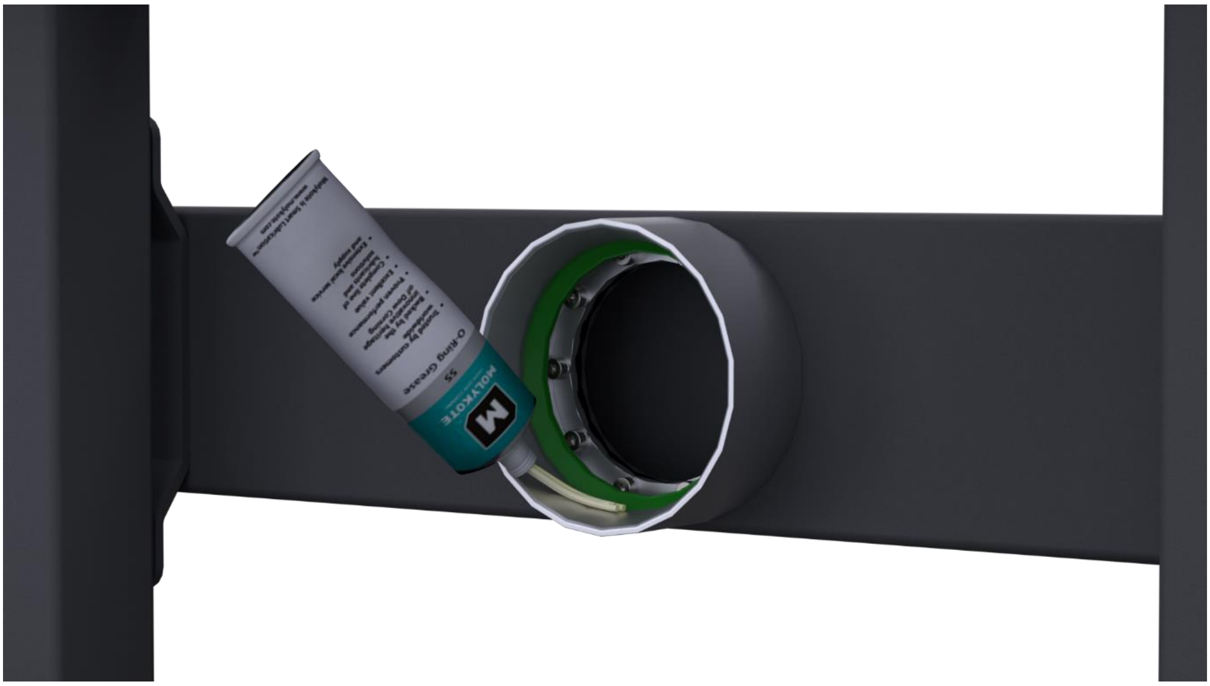


Figure 27 - Adding grease to the O-ring in the flange part

10 COMMISSIONING

The commissioning of an RS battery system must always be performed by an employee of MG Energy Systems B.V. or a technician trained by MG Energy Systems B.V.

10.1.1 Commissioning checklist

The commissioning consist at least of the following parts:

- Check the mechanical installation of the battery modules;
- Check exhaust installation;
- Check the equipotential bonding connections;
- Check fluid cooling installation;
- Filling and testing of fluid cooling installation;
- Check the PPS installation: Installation of the PPS tank and connections;
- Filling and testing of the PPS tank;
- Check electrical connections;
- Check insulation resistance;
- Configure the Master BMS;
- Start-up the system;
- Check charge and discharge limitation functionality;

Some of the points from the list can be covered in the early stages of the project to limit the onsite presence of the commissioning and detect design flaws early. See chapter 8.2 for details on the project process.

11 DECOMMISSIONING PROCEDURES

This chapter describes procedures to decommission the battery system or module for several situations.

11.1 Procedure: removing a malfunctioning battery module

This chapter describes the procedure to follow if a malfunction in a battery module has occurred.

⚠ **WARNING:**

- Use the correct personal safety gear.
- The released gasses during a thermal runaway are explosive and toxic.
- Always consult the local safety protocols before performing any procedures.

ⓘ **NOTICE:**
The procedures in this chapter are indicative and can differ depending on the situation, (local) regulations and standards. Therefore MG Energy Systems B.V. cannot accept responsibility for damage, injury, or expenses resulting thereof.

11.1.1 Detecting malfunctioning

A malfunctioning battery module can lead to a number of different situations that takes the complete battery system out of operation. The list below shows the most plausible alarms that can occur on the MG Master BMS.

- High temperature alarm;
- Damaged temperature sensors alarm (at least 2);
- Damaged BMS: no communication, no temperatures, voltages etc;

Other signs of a malfunctioning battery module:

- Low insulation resistance;
- Leakage detection alarm;
- Low cooling fluid level switch alarm;
- Smoke/gas in the gas exhaust and coming out at the end of the ducting;
- PPS Tank released the containing fluid. Pressure drops towards 0 Bar;
- Enclosure of battery module has a higher temperature comparing to the other battery modules;
- A battery module emits an unusual smell.
- A battery module such a high temperature that it cannot be touched.
- A battery module changes colour and/or shape.

These alarms and signs, but not limited to, are an indication for a malfunctioning battery module.

ⓘ **NOTICE:**
In case of the suspicion of a malfunctioning battery module or any anomalies pointing towards this. It is mandatory to stop the battery system from operating and contact MG Energy Systems B.V. for specific instructions.

11.1.2 Monitoring the battery module

Depending on the situation and damage, several actions may be taken.

11.1.2.1 Example situation 1

One of the battery modules in a system is malfunctioning and it still communicating with the MG Master BMS. In that case the temperature of the particular battery module can be monitored by the MG Diagnostic Tool or any other monitoring system which is digitally connected to the MG Master BMS.

11.1.2.2 Example situation 2

One of the battery modules in a system is malfunctioning and is not communicating anymore with the MG Master BMS. In that case it is advised to monitor the temperature of the battery module in another way, for example a thermal imaging camera or external temperature sensor.

11.1.3 Remove and secure the battery module

The following procedure is only applicable when the battery module has cooled down, and thermally stable to ensure a safe removal of the battery module.

1. Take the system out of operation. Contactors of the MG Master BMS open.
2. Disconnect the main power connectors from the MG Master BMS.
3. Find and inspect the particular battery module.
4. Before removing the battery module, verify whether the temperature has cooled down within safety levels. This can be checked with either a thermal imaging camera or using the MG Diagnostic Tool if possible.

WARNING:
Wear protective clothing and gloves to avoid injuries through heat.

5. Disconnect the power and communication connectors from the particular battery module.

ELECTRICAL HAZARD:
When there is a low insulation resistance in the battery system or battery module, make sure using proper insulation gloves before touching any parts of the battery system.

6. Clean the exhaust ducting system from any gas by blowing clean air through.
7. Remove the battery module.
8. Place the exhaust overpressure protection back into the module to contain the PPS media from spilling.

WARNING:
Keep the module horizontal during removal to maintain sufficient cooling of the PPS media around the internal battery cells.

9. Place the battery module in a water filled container at a safe location, for example outside. The temperature of the battery module will be kept low and the module is secured from a new event.

NOTICE:
In some cases it is not possible to remove and secure the battery module immediately. In those situations it is mandatory to constantly monitor the temperature of the battery module to be prepared for any emergency situation.

11.2 Procedure: removing a battery module from a functioning system

In some cases batteries need to be removed from a correct functioning system to be stored for a longer period of time and reinstalled later. This chapter describes the procedures for removing the batteries and prepare them for storage. Before starting the removal procedure make sure the battery bank is charged between 50% and 70% SoC.

11.2.1 Removing battery modules

The following procedure is only applicable when the battery module has cooled down, and thermally stable to ensure a safe removal of the battery modules.

1. Take the system out of operation. Contactors of the MG Master BMS open.
2. Disconnect the main power connectors from the MG Master BMS.

ELECTRICAL HAZARD:
Use proper insulation gloves before removing any parts of the battery system.

3. Disconnect all power cables from the batteries.
4. Disconnect all communication cables from all batteries.
5. Remove each battery module one by one.
6. Prepare the modules for a long storage period.

11.2.2 Prepare the battery module for a longer storage period

Additional preparations are required when the battery modules are stored for a longer period of time and are removed from a correct operating system.

- Flush every battery module, to extract the liquid cooling fluid, with low pressure air.
- Make sure the battery modules are charged between 50% and 70% SoC.
- Make sure the storage requirements from chapter 3.2 are met.

12 SERVICE

12.1 Maintenance

For maintenance it will be sufficient to inspect the following points once a year:

- Check power connectors for correct mating and locking.
- Check if all communication connections are mated.
- Check for traces of water, oil, moisture, any other fluids or dust.
- Check for signs of corrosion.
- Clean the device.
- Check status with the MG Diagnostic Tool, MG Connect App or MG Energy Portal.

ELECTRICAL HAZARD:
Do not poor or spray water directly onto the device. When cleaning the device be aware that the connected battery string is a permanent energy source. Even when the device is turned off, the battery power connections might carry dangerous voltage levels.

12.1.1 Cleaning

Cleaning of the device is best done using a dry or slightly damp cloth. Limit the use of cleaning agents. If a cleaning agent is to be used, use of an electrically non-conductive cleaning agent is advised.

It is important to keep the battery spaces clean and tidy in order to minimise the need for cleaning. Prevent the use of moisture, vaporizing agents, oil, grease, etc. in the vicinity of the device.

12.1.2 PPS system pressure

It is recommended to check the PPS pressure and liquid level on a regular bases. The pressure must be in range of 2 - 3 bar gauge pressure and the level of fluid must be 12 litres. Frequency of this check depends on the applicable rules, but must be done at least annually or the system can be applied with a pressure switch connected to an alarm system.

12.2 End-of-life

The battery module is considered end-of-life if the SoH is decreased to 70 %. After this period it is strongly advised to replace the battery module to ensure maximum safety.

If the application does not feature an EMS or the EMS does not support live monitoring of the SoH, it is good practice to check the SoH manually on a regular basis. Manually checking of the SoH can be done using the MG Diagnostic Tool software. The frequency on which the SoH check is carried out depends on the applicable rules, but must be done at least annually.

12.3 Disposal

Batteries marked with the recycling symbol must be processed locally via a recognized recycling agency. By agreement, they may be returned to the manufacturer. Batteries must not be mixed with domestic or industrial waste. Before disposal it is recommended to discharge the battery module to 0 VDC.

13 BOUNDARY LIMITS

The boundary limits that are used by the master for the battery modules are listed in this chapter. A level will be triggered when a boundary condition is true for a defined period of time.

Battery thresholds are compatible with the following master BMS firmware versions or higher:

- Master HV 1.28 or higher
- Master LV 1.38 or higher

13.1 Slave BMS

Boundary limits for the slave BMS are defined to keep the battery within the manufacturer specifications.

The tables with the boundary limits consist of:

- Name, description of the situation;
- Action, action on respond of the boundary, set/clear or failsafe;
- Boundary condition, contains a value that is needed for an action in combination with the time. This depends on the master strategy setting, default or performance;
- Time that the boundary condition has to be present before it will be triggered. Times indicated with "+" start counting if the previous boundary condition above is set.

13.1.1 Cell voltage

Table 13 Cell voltage boundary limits slave BMS

Name	Action	Boundary condition	Time
Almost charged	Set	>= 3440 mV	10 sec.
	Clear	< 3390 mV	10 sec.
Charged	Set	>= 3520 mV	+10 sec.
	Clear	< 3440 mV	10 sec.
Over voltage warning	Set	>= 3600 mV	+20 sec.
	Clear	< 3520 mV	20 sec.
Over voltage critical	Failsafe	>= 3650 mV	+5 sec.
Over voltage safety lock	Set safety lock	>= 3850 mV	+5 sec.
Almost discharged	Set	<= 3100 mV	10 sec.
	Clear	> 3150 mV	10 sec.
Discharged	Set	<= 3000 mV	+10 sec.
	Clear	> 3100 mV	10 sec.
Under voltage warning	Set	<= 2900 mV	+20 sec.
	Clear	> 3000 mV	20 sec.
Under voltage critical	Failsafe	<= 2850 mV	+5 sec.
Under voltage safety lock	Set safety lock	<= 1850 mV	+5 sec.

13.1.2 Cell temperature charging

Table 14 Cell temperature charging boundary limits slave BMS

Name	Action	Boundary condition		Time
		Default	Performance	
Over temperature alert	Set	>= 43 °C	>= 53 °C	5 sec.
	Clear	< 42 °C	< 52 °C	5 sec.
Over temperature	Set	>= 45 °C	>= 55 °C	+20 sec.
	Clear	< 43 °C	< 53 °C	20 sec.
Over temperature critical	Failsafe	>= 50 °C and charge current > 5% battery capacity	>= 60 °C and charge current > 5% battery capacity	+60 sec.
Over temperature safety lock	Set safety lock	>= 65 °C		+5 sec.
Under temperature alert	Set	<= 1 °C		5 sec.
	Clear	> 2 °C		5 sec.
Under temperature	Set	<= 0 °C		+20 sec.
	Clear	> 1 °C		20 sec.
Under temperature critical	Failsafe	<= -5 °C and charge current > 5% battery capacity		+60 sec.
Under temperature safety lock	Set safety lock	<= -35 °C		+5 sec.

13.1.3 Cell temperature discharging

Table 15 Cell temperature discharging boundary limits slave BMS

Name	Action	Boundary condition	Time
Over temperature alert	Set	>= 53 °C	5 sec.
	Clear	< 52 °C	5 sec.
Over temperature	Set	>= 55 °C	+20 sec.
	Clear	< 53 °C	20 sec.
Over temperature critical	Failsafe	>= 60 °C	+60 sec.
Under temperature alert	Set	<= -19 °C	5 sec.
	Clear	> -18 °C	5 sec.
Under temperature	Set	<= -20 °C	+20 sec.
	Clear	> -19 °C	20 sec.
Under temperature critical	Failsafe	<= -25 °C and discharge current > 10% battery capacity	+60 sec.

13.1.4 Power terminal temperature

Table 16 Power terminal temperature boundary limits slave BMS

Name	Action	Boundary condition	Time
Over temperature alert	Set	>= 60 °C	5 sec.
	Clear	< 59 °C	5 sec.
Over temperature	Set	>= 70 °C	+20 sec.
	Clear	< 60 °C	20 sec.
Over temperature critical	Failsafe	>= 80 °C	+60 sec.

13.1.5 Current

Table 17 Current boundary limits slave BMS

		Boundary condition		
Name	**Action**	**Default**	**Performance**	**Time**
Charging over current warning	Set	> 1.0C		10 sec.
	Clear	<= 1.0C		10 sec.
Charging over current critical	Failsafe	> 1.2C		+20 sec.
Discharging over current warning	Set	> 1.0C	> 1.5C	10 sec.
	Clear	<= 1.0C	<= 1.5C	10 sec.

13.1.6 Balancing

Table 18 Balancing boundary limits slave BMS

Name		**Boundary condition**	**Time**
Offset cell voltage		> 50 mV	1 min.
Balancing cell voltage		>= 3375 mV	1 min.
Battery pack current		current within ±5% battery capacity	1 min.

13.1.7 Deviation voltages and temperatures

Table 19 Deviation voltage and temperature boundary limits slave BMS

		Boundary condition		
Name	**Level**	**Default**	**Performance**	**Time**
Deviation cell temperature	Set	Difference highest and lowest cell temperature >= 15 °C		4-6 min.
	Clear	Difference highest and lowest cell temperature < 12 °C		4-6 min.

13.1.8 Leakage detection

Table 20 - Leakage detection warning boundary limits slave BMS

		Boundary condition		
Name	**Level**	**Default**	**Performance**	**Time**
Leakage detection warning	Set	When detected.		60 sec.
	Clear	When not detected.		60 sec.

13.1.9 Internal humidity

Table 21 - Leakage detection warning boundary limits slave BMS

		Boundary condition		
Name	**Level**	**Default**	**Performance**	**Time**
Internal humidity warning	Set	>= 93 %		2 min.
	Clear	< 90 %		2 min.

13.2 Monitoring BMS

The monitoring BMS has thresholds that are beyond the regular slave BMS thresholds stated in section 13.1. When a critical monitoring BMS level is triggered, the master is informed that the hard-wired interlock will be interrupted after 15 seconds. The Master BMS will go to fail-safe once the hard-wired interlock loop is interrupted.

13.2.1 Cell voltage

Table 22 Cell voltage boundary limits redundancy unit BMS

		Boundary condition		
Name	**Level**	**Default**	**Performance**	**Time**
Hardware failure warning	Set	= invalid		1 sec.
	Clear	= valid		1 sec.
Sensor failure critical	Interrupt HVIL	= invalid		90 sec.
Over voltage warning	Set	>= 3850 mV		1 sec.
	Clear	< 3850 mV		1 sec.
Over voltage critical	Interrupt HVIL	>= 3850 mV		60 sec.
Under voltage warning	Set	<= 1850 mV		1 sec.
	Clear	> 1850 mV		1 sec.
Under voltage critical	Interrupt HVIL	<= 1850 mV		60 sec.

13.2.2 Cell temperature

Table 23 Cell temperature boundary limits redundancy unit BMS

		Boundary condition		
Name	**Level**	**Default**	**Performance**	**Time**
Sensor failure warning	Set	= invalid		1 sec.
	Clear	= valid		1 sec.
Sensor failure critical	Interrupt HVIL	2 or more temperature sensor invalid		90 sec.
Over temperature warning	Set	>= 65 °C		1 sec.
	Clear	< 65 °C		1 sec.
Over temperature critical	Interrupt HVIL	>= 65 °C		90 sec.
Under temperature warning	Set	<= -35 °C		1 sec.
	Clear	> -35 °C		1 sec.
Under temperature critical	Interrupt HVIL	<= -35 °C		90 sec.

13.2.3 Power terminal temperature

Table 24 Power terminal temperature redundancy unit BMS

		Boundary condition		
Name	**Level**	**Default**	**Performance**	**Time**
Sensor failure warning	Set	= invalid		1 sec.
	Clear	= valid		1 sec.
Over temperature warning	Interrupt HVIL	>= 95 °C		1 sec.
Over temperature critical	Interrupt HVIL	>= 95 °C		75 sec.

14 TECHNICAL SPECIFICATIONS

The technical specifications of this product can be downloaded from the MG Download Center.

https://downloads.mgenergysystems.eu/rslfp/data-sheets/mgrs480230m

15 DIMENSIONS

The dimensions of this product can be downloaded from the MG Download Center.

https://downloads.mgenergysystems.eu/rslfp/drawings/total-assembly-230

16 CONTACT DETAILS

For specific questions please feel free to contact us.

16.1 Sales

For sales related questions, please contact a local dealer.

For specific sales questions, please contact our sales team:

MG Sales team
sales@mgenergysystems.eu

16.2 Technical support

For technical support, please follow the steps below:

1. Consult the Manual.
   Manual can be found on the MG Download Center.
2. Watch the Installation Videos.
   Videos can be found on MG's You Tube channel.
3. Check Your Software Version.
   Check and update the products software version to latest using the MG Connect App (Apple or Android) or MG Diagnostic Tool.
4. Contact MG Service Point.
5. Contact MG technical support.
   Send an email with your technical questions to support@mgenergysystems.eu.