

Lithium-Ion LFP series battery module

- Manual -

MGLFP240280, MGLFP241280 (LFP 280Ah)

MG Energy Systems B.V.



| | |
|------------------|-------------------|
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TABLE OF CONTENTS

| | | |
|-------|--|----|
| 1 | GENERAL | 6 |
| 1.1 | Document history | 6 |
| 1.2 | Terms, abbreviations, and definition | 6 |
| 2 | SAFETY INSTRUCTIONS..... | 7 |
| 2.1 | Safety message level definition | 7 |
| 2.2 | User health and safety | 7 |
| 2.2.1 | General precautions..... | 7 |
| 2.2.2 | Qualifications and training..... | 8 |
| 2.2.3 | Non-compliance risks | 8 |
| 2.2.4 | Unacceptable modes of operation | 8 |
| 3 | TRANSPORT, STORAGE AND UNPACKING..... | 9 |
| 3.1 | Transport..... | 9 |
| 3.2 | Storage | 9 |
| 3.3 | Unpacking | 10 |
| 3.3.1 | Scope of delivery..... | 10 |
| 4 | GENERAL DESCRIPTION..... | 11 |
| 4.1 | Battery system components | 11 |
| 4.2 | Functional description | 11 |
| 4.3 | Example systems | 12 |
| 4.3.1 | Low voltage systems | 12 |
| 4.3.2 | High voltage systems | 13 |
| 5 | MODELS | 14 |
| 5.1 | Models and configurations | 14 |
| 5.1.1 | Battery designation..... | 14 |
| 5.2 | Identification label | 15 |
| 6 | OVERVIEW..... | 16 |
| 6.1 | Connection overview | 16 |
| 6.2 | Connections details..... | 17 |
| 6.2.1 | RJ45 CAN-bus connector details | 17 |
| 6.2.2 | M12 CAN-bus connector details | 18 |
| 6.2.3 | Power connections..... | 19 |
| 6.3 | Status indication | 21 |
| 6.3.1 | Indication | 21 |

| | | |
|--------|--|----|
| 7 | INTEGRATION REQUIREMENTS AND INSTRUCTIONS | 22 |
| 7.1 | Risk assessment | 22 |
| 7.2 | Location..... | 22 |
| 7.2.1 | Environment..... | 22 |
| 7.2.2 | Thermal management..... | 22 |
| 7.3 | Placement | 23 |
| 7.3.1 | Positioning the battery | 23 |
| 7.3.2 | Mounting considerations | 24 |
| 7.3.3 | Battery module spacing requirements | 25 |
| 7.3.4 | Placement in sealed spaces or compartments | 25 |
| 7.4 | Electrical..... | 26 |
| 7.4.1 | Power cables | 26 |
| 7.4.2 | Parallel configuration | 27 |
| 7.4.3 | Paralleling using the Distributor LV..... | 30 |
| 7.4.4 | Series configuration | 31 |
| 7.4.5 | Charger..... | 32 |
| 8 | INSTALLATION | 33 |
| 8.1 | Installation procedures | 33 |
| 8.2 | Mounting procedure | 34 |
| 8.3 | Equipotential bonding connection procedure | 34 |
| 8.4 | Electrical connection procedure | 35 |
| 8.4.1 | Power connection procedure | 35 |
| 8.4.2 | CAN-bus connection procedure | 37 |
| 8.5 | Fuse replacing procedure..... | 38 |
| 8.5.1 | Dummy fuse | 38 |
| 8.5.2 | Replacement instructions | 38 |
| 9 | COMMISSIONING | 40 |
| 10 | SERVICE | 41 |
| 10.1 | Maintenance | 41 |
| 10.1.1 | Connections | 41 |
| 10.1.2 | Cleaning..... | 41 |
| 10.2 | End-of-life..... | 41 |
| 10.3 | Disposal | 41 |
| 11 | BOUNDARY LIMITS | 42 |

| | | |
|--------|-----------------------------------|----|
| 11.1 | Limits..... | 42 |
| 11.1.1 | Cell voltage..... | 42 |
| 11.1.2 | Cell temperature charging..... | 43 |
| 11.1.3 | Cell temperature discharging..... | 43 |
| 11.1.4 | Power terminal temperature..... | 43 |
| 11.1.5 | Current..... | 44 |
| 11.1.6 | Balancing..... | 44 |
| 12 | TECHNICAL SPECIFICATIONS..... | 45 |
| 12.1 | Dimensions..... | 46 |
| 13 | ORDERING INFORMATION..... | 47 |
| 14 | CONTACT DETAILS..... | 48 |

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 |
|------|------------|---|---------------------|
| 0.1 | 18-08-2020 | Initial document | Ane Tjitze Rienstra |
| 1.0 | 20-09-2020 | Added schematics, detailed connector information etc. | Mark Scholten |
| 1.1 | 20-10-2020 | Minor changes and typo fixes. | Mark Scholten |
| 1.2 | 11-11-2020 | Fixed typos. | Mark Scholten |

1.2 Terms, abbreviations, and definition

Table 2 - Terms, abbreviations, and definitions

| | |
|----------------|---|
| Battery cell | <i>Battery cell</i> ; the smallest building block in a battery, a chemical unit. Cell is the bare Lithium-Ion battery cell. |
| Battery module | <i>Battery module</i> ; is an assembly of submodules, BMS, fluid cooling and outer enclosure. |
| Battery stack | <i>Battery stack</i> ; is a set of multiple cells in cell cassettes constructed as one. |
| BMS | <i>Battery Management System</i> ; The BMS is the electronics that monitors the battery cell parameters to keep it within the operation specifications. |
| CAN-bus | <i>Controller Area Network bus</i> ; CAN-bus is a standard serial data-bus that provides data communication between two or more devices. |
| C-rate | <i>C-Rate</i> ; the current (A) used to charge/discharge the battery system divided by the rated ampere-hours (Ah). |
| EMS | <i>Energy Management System</i> ; The EMS controls all power sources and consumers in a system. |
| HVIL | <i>High Voltage Interlock Loop</i> ; 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. |
| IC | <i>Integrated Circuit</i> ; is a chip containing an electronics circuit; |
| MSDS | <i>Material Safety Data Sheet</i> ; is a document that lists information relating to occupational safety and health for the use of various substances and products. |
| NMEA 2000 | <i>National Marine Electronics Association's NMEA 2000</i> 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. |
| PCB | <i>Printed Circuit Board</i> ; is a board containing an electronic circuit; |
| PCBA | <i>Printed Circuit Board Assembly</i> ; is a board containing an electronic circuit including passive and active components; |
| SoC | <i>State-of-Charge</i> ; is the remaining capacity in a battery cell or module in percent (%). |
| SoH | <i>State-of-Health</i> ; is a figure of merit of the condition of a battery (or a cell, or a battery pack), compared to its ideal conditions. |

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

2.2.1 General precautions

This product is designed and tested in accordance with international standards. The equipment should be used according to 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 local health and safety regulations for working on battery systems are followed.
- There is a risk of electrocution and burns when working on higher voltage systems without proper protective gear and special training.

2.2.2 Qualifications and training

The personnel responsible for the assembly, operation, inspection, and maintenance of the battery system must be appropriately qualified. The user company must do the following tasks:

- Define the responsibilities and competency of all personnel working on the battery system.
- Provide instruction and training.
- Ensure that the contents of the operating and safety instructions have been fully understood by the personnel.
- Check the local safety rules and guidelines they have higher preference over the manufacturers specification in case of regulatory conflicts.
- Working on higher voltages requires specific training and certification.

Instructions and training can be carried out by MG Energy Systems B.V. by order of the user company.

2.2.3 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.

2.2.4 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 may only be used in combination with a master BMS.
(MG Master LV or MG Master HV)

3 TRANSPORT, STORAGE AND UNPACKING

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 $\leq 30\%$.



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



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 $\leq 30\%$.

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 $+10^{\circ}\text{C}$ to $+25^{\circ}\text{C}$.
- It is recommended to limit the battery charge between 50% and 70% SoC. This will limit calendric aging.

The battery module's SoC is decreasing 1% per year. Recharging is required when the voltage is in the range of the cut-off voltage.



NOTICE:

Check the MG Master LV or MG Master HV manual for storage of a connected system.



NOTICE:

Check the voltage of the stored battery module every year.
When the battery module voltage is < 24 VDC, 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.



CAUTION:

Always take the local applicable standards and regulations regarding the prevention of accidents into account when handling the product. Be aware of the total mass of the product and do not lift heavy objects unassisted.

3.3.1 Scope of delivery

The scope of delivery is as following:

- MG LFP battery module of type as described in chapter 5.
- Quick instruction guide.



NOTICE:

Not within the scope of delivery:

- Power cables and connectors (details can be found in chapter 6.2.3).
 - Communication cables and connectors (details can be found in chapter 6.2).
-

4 GENERAL DESCRIPTION

The LFP battery series is based on LiFePO₄ chemistry. The next generation battery cells of this chemistry gives this battery module a high energy density and long cycle life. A modular and compact design makes system integration more flexible, especially in refit applications. The passive cooling concept keeps integration simple and straight forward.

These features make this battery suitable for large energy storage applications as well as small peak power packs in hybrid solutions.

4.1 Battery system components

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

- One or more **MG LFP battery modules** of the same type;
- 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 description documents;

4.2 Functional description

MG's system philosophy is to have one master BMS, e.g. a MG Master LV or MG Master HV, per bank 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 and cell temperature. 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 MG Master LV or MG Master HV 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 via the, separated, auxiliary CAN-bus or the I/O connections. If the exceeded threshold stays, the master BMS has the possibility to disconnect the batteries from the system by opening the main contactors.

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

- Robust chemistry;
- Modular design;
- High energy density;
- Plug and Play installation: Automatic configuration;
- Low voltage solutions: 24 V up to 96 V;
- High voltage solutions: Up to 460 V;
- RJ45 or M12 CAN-Bus connector options;

4.3 Example systems

Different kind of battery system configurations 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 voltage systems up to 96 VDC are setup with the MG Master LV series. For more information about the MG Master LV, please refer to the data sheet and manual.

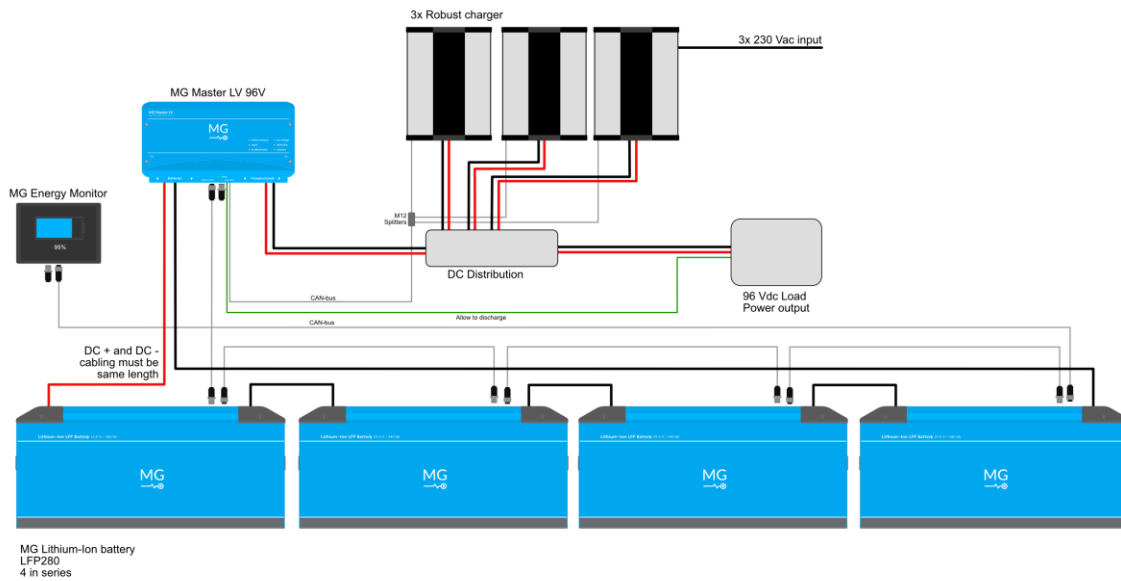


Figure 1 - 96 VDC propulsion system

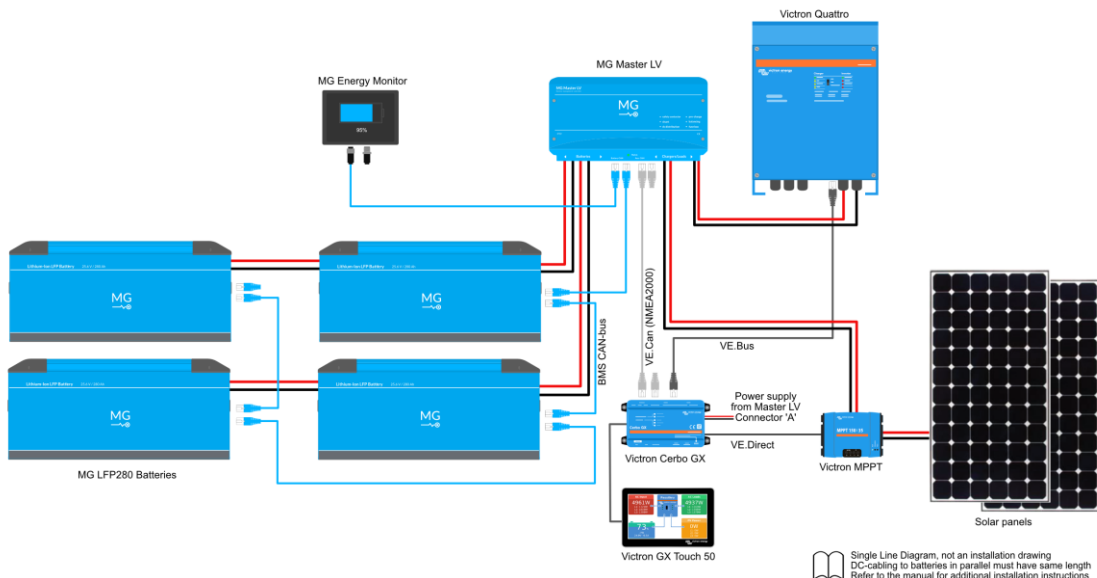


Figure 2 - 48 V small ESS

4.3.2 High voltage systems

High voltage systems up to 460 VDC are setup with the MG Master HV series. For more information about the MG Master HV, please refer to the data sheet and manual.

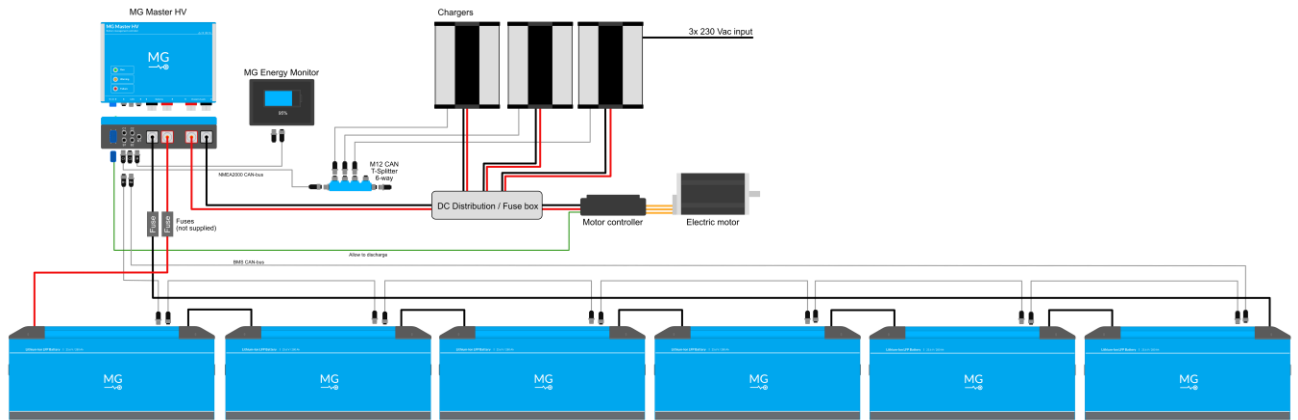


Figure 3 - 144 VDC propulsion system

5 MODELS

5.1 Models and configurations

The LFP series lithium-ion battery features 2 models. One model suitable for systems voltages up to 96 VDC and one for systems voltage up to 460 VDC please refer to chapter 12.

| Article number | Description | Remarks |
|----------------|--|-------------------------------------|
| MGLFP240280 | MG LFP Battery 25.6V/280Ah/7200Wh | 24 V up to 96 V, RJ45 connectors |
| MGLFP241280 | MG LFP Battery 25.6V/280Ah/7200Wh (M12, HV) | 24 V up to 460 V, M12 connectors |

5.1.1 Battery designation

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

Table 4 - Battery module designation as per IEC 62620

| Article number | Designation |
|----------------|------------------------------------|
| MGLFP24x280 | IFpP/652/294/193/[1P8S]M/-10+40/90 |

5.2 Identification label

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

Example identification label:

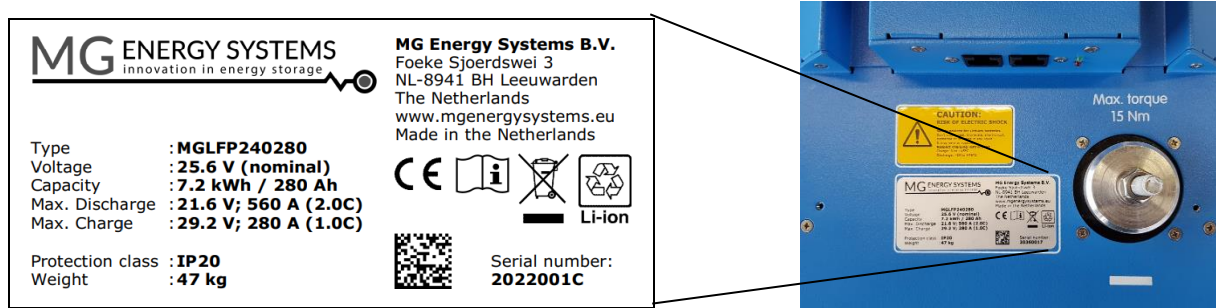






Figure 4 - Example identifications label

The identifications label shown in figure 4 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 explanation

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

6 OVERVIEW

This chapter shows an overview of the LFP battery.

Each battery module contains the following common parts:

- Negative battery pole connection;
- Positive battery pole connection;
- BMS CAN-bus connection, either RJ45 or M12;
- Status LEDs;

6.1 Connection overview

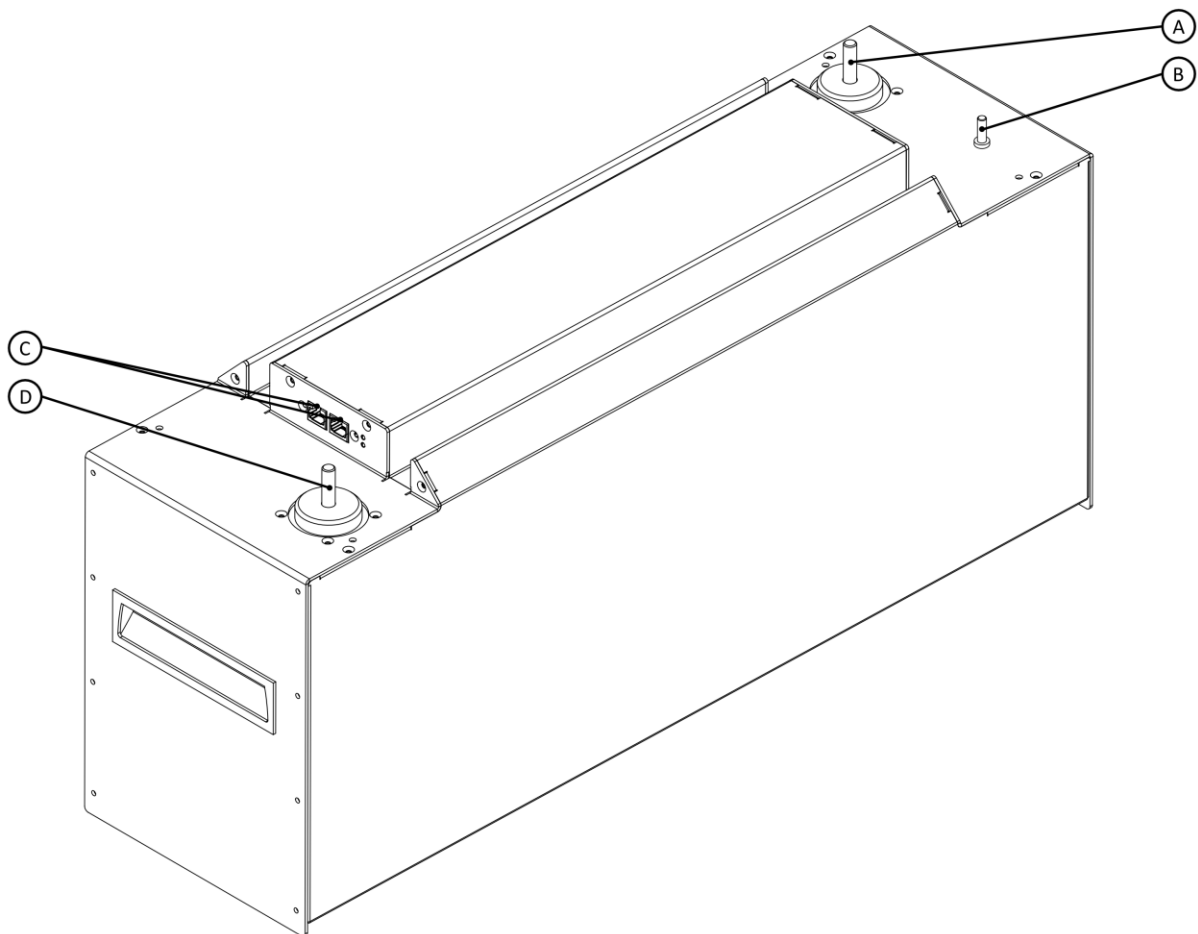


Figure 5 – LFP 280 Ah module overview

Table 6 - Module connection overview

| Part | Description |
|------|--|
| A | Positive power connection (including fuse). M8 bolt connection. |
| B | Equipotential bonding connection (only available on the (M12, HV) option). |
| C | CAN-Bus communication, either RJ45 or M12. |
| D | Negative power connection. M8 bolt connection. |

6.2 Connections details

Each battery module contains two CAN-Bus connectors to connect to one of the master BMSs.

This CAN-Bus connection is used for several functions:

- Data communication between battery module(s) and master BMS;
- The battery module uses the V+ to enable the power of the internal BMS;

The HE Series have the option to have RJ45 or M12 CAN-Bus connectors.

6.2.1 RJ45 CAN-bus connector details

The standard connectors in the LFP Series are the RJ45 CAN-Bus connectors.

6.2.1.1 Connector details

Typical cables that are used for the RJ45 CAN-Bus connections are standard CAT 5 Ethernet network patch cables.

Table 7 – RJ45 connector details

| Pin | Description | Connector view |
|-----|-------------|----------------------------------|
| 1 | | <p>RJ45 Pinout T-568B</p> |
| 2 | | |
| 3 | GND | |
| 4 | | |
| 5 | | |
| 6 | V+ | |
| 7 | CAN-H | |
| 8 | CAN-L | |



NOTICE:

Always use standard prefabricated Ethernet network patch cables (straight).



6.2.2 M12 CAN-bus connector details

The LFP Series have the option to contain M12 CAN-Bus connectors.

6.2.2.1 Connector details

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.

Table 8 - Circular M12 connector with 5 positions A-coded details

| Pin | Description | Connector view |
|-----|-------------|---|
| 1 | Shield | <p style="text-align: center;">M12, 5-pin, A-coded</p>   <p style="text-align: center;">Male Female</p> |
| 2 | V+ | |
| 3 | GND | |
| 4 | CAN-H | |
| 5 | CAN-L | |

Cables to be used for the battery 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.

6.2.3 Power connections

The power connections on the battery module consists of two M8 bolt connections. One is the positive battery pole and one is the negative battery pole.

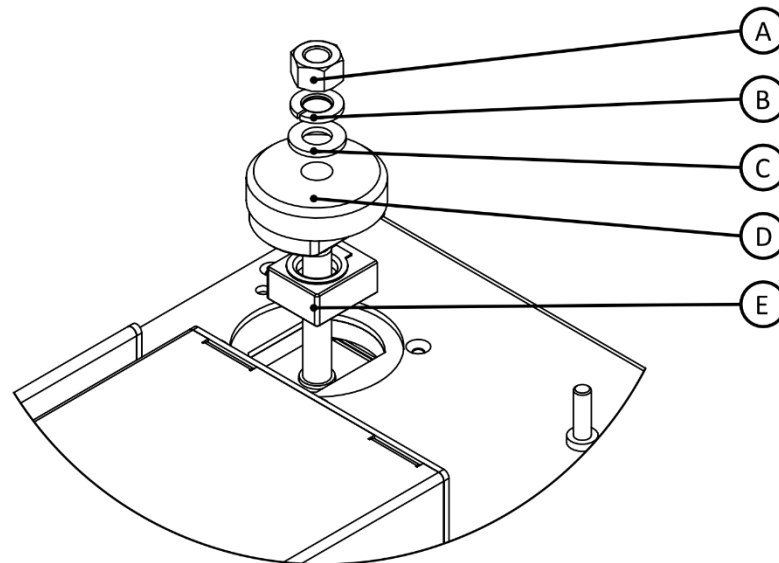
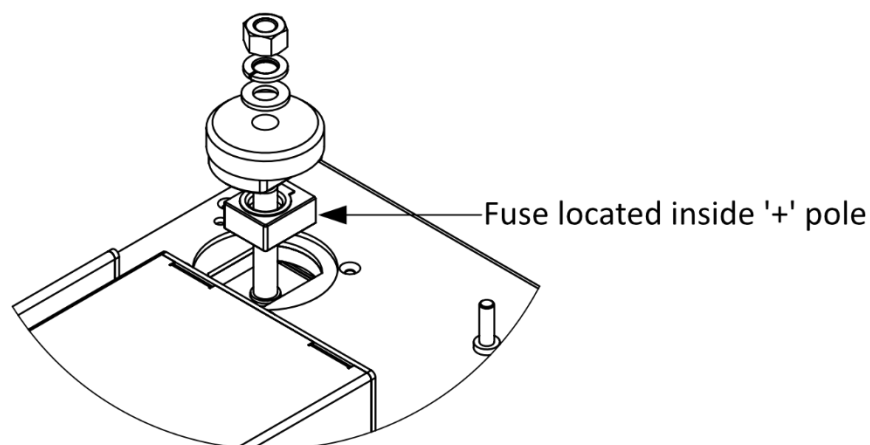


Figure 6 - Battery pole connection overview

| Part | Description |
|------|---------------|
| A | Nut |
| B | Spring washer |
| C | Washer |
| D | Battery pole |
| E | Fuse |

6.2.3.1 Fuse

The positive battery pole contains a protection fuse. This fuse is a CF8 fuse. The default value is 300 A. See chapter 8.5 for the replacement procedure.



Fuse types to use:

| MG Fuse article number | Fuse current | Fuse manufacturer article number |
|------------------------|--------------|----------------------------------|
| MGFUSE1580150 | 150 A | Little fuse CF8 - 155.0892.6151 |
| MGFUSE1580200 | 200 A | Little fuse CF8 - 155.0892.6201 |
| MGFUSE1580225 | 225 A | Little fuse CF8 - 155.2892.6221 |
| MGFUSE1580250 | 250 A | Little fuse CF8 - 155.0892.6251 |
| MGFUSE1580300 | 300 A | Little fuse CF8 - 155.0892.6301 |
| MG000034A | - | MG dummy fuse CF8 |



NOTICE:

A broken fuse is indicated by measuring no voltage on the battery terminals.



WARNING:

For systems with a voltage above 58 VDC, a dummy fuse is required. See chapter 6.2.3.2 and 8.5.1 for more information.



WARNING:

In some cases it is required to replace the fuse for a smaller one according to the cable size.

6.2.3.2 Dummy fuse

Replacing the fuse by a dummy fuse is needed in case the battery module is used in series above 58 V. This dummy fuse is actually a complete battery pole that replaces the battery pole with fuse holder. See chapter 8.5 for the replacement procedure.

6.3 Status indication

Figure 7 shows the location of the status indication LEDs. They are located next to the CAN-bus connections.

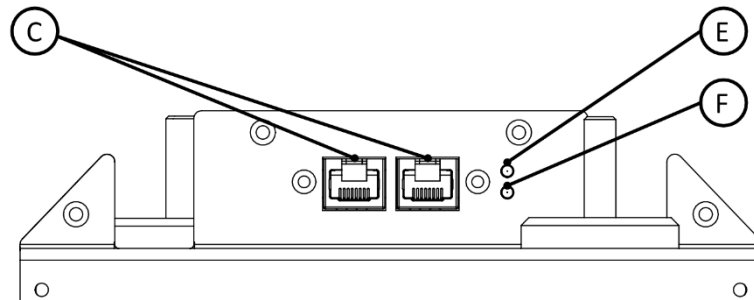


Figure 7 - Status LEDs overview

| Part | Description |
|------|-------------|
| E | Green LED |
| F | Red LED |

6.3.1 Indication

Table 6 shows the LED states and its meaning.

Table 9 - Status indication

| Green LED | Red LED | Description |
|-----------|---------|--|
| On | Off | Battery module is powered and internal BMS is operational. |
| On | On | Identification mode. The Red LED is turned on for a minute by the Diagnostic Tool to identify the battery. |
| Off | On | Battery module is in bootloader mode. Updating firmware is in progress. |
| Off | Off | Battery modules is Off. |

7 INTEGRATION REQUIREMENTS AND INSTRUCTIONS

7.1 Risk assessment

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

MG Energy Systems can supply the necessary basic documentation for risk assessment.



NOTICE:

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

7.2 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.

7.2.1 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.

7.2.2 Thermal management

The LFP Series battery modules are air cooled (convection). Therefore ambient temperature in the battery room directly affects the battery modules temperature.

- Make sure there is sufficient air flow in the battery space to dispose the heat rejected by the batteries and/or other equipment.
- The most optimized ambient temperature for the batteries is around 25 °C.



NOTICE:

Take into account the heat rejection of other equipment in the same space of the batteries.



NOTICE:

A significant decrease of cycle life will occur when the battery modules are used at high ambient temperatures.

If forced air ventilation is used for the battery room please make sure the environmental specifications, given in chapter 11, are met. Temperature difference should in no way cause condensation on the battery module nor on other parts of the battery room.

7.2.2.1 Heat rejection

Table 10 shows the heat rejection versus charge and discharge rates. These values are based on a nominal internal resistance of 6 mOhm.

Table 10 – Heat rejection versus charge/discharge rate.

| Cooling system | Passive air cooling (convection) |
|----------------|--|
| Heat rejection | 0.5 C = 118 W 1 C = 470 W 2 C = 1881 W |

7.3 Placement

This chapter will explain the design requirements for placement of the battery modules.

7.3.1 Positioning the battery

The battery module may only be placed with the topside facing upwards. Figure 8 shows the only possible position that is allowed.

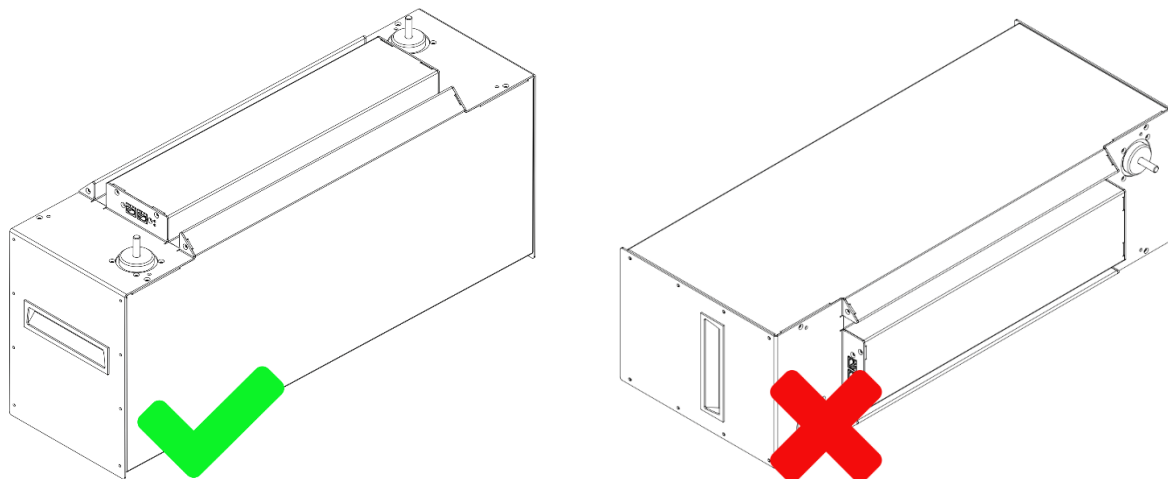


Figure 8 - Mounting position

7.3.2 Mounting considerations

Mounting of the battery modules can be either done by straps or brackets.

Some example are shown below.



NOTICE:

Mounting brackets or straps are not within the scope of delivery.

7.3.3 Battery module spacing requirements

Figure 9 shows the minimum spacing of the battery modules. It is required to maintain a clearance of 10 mm from all sides of the battery module.

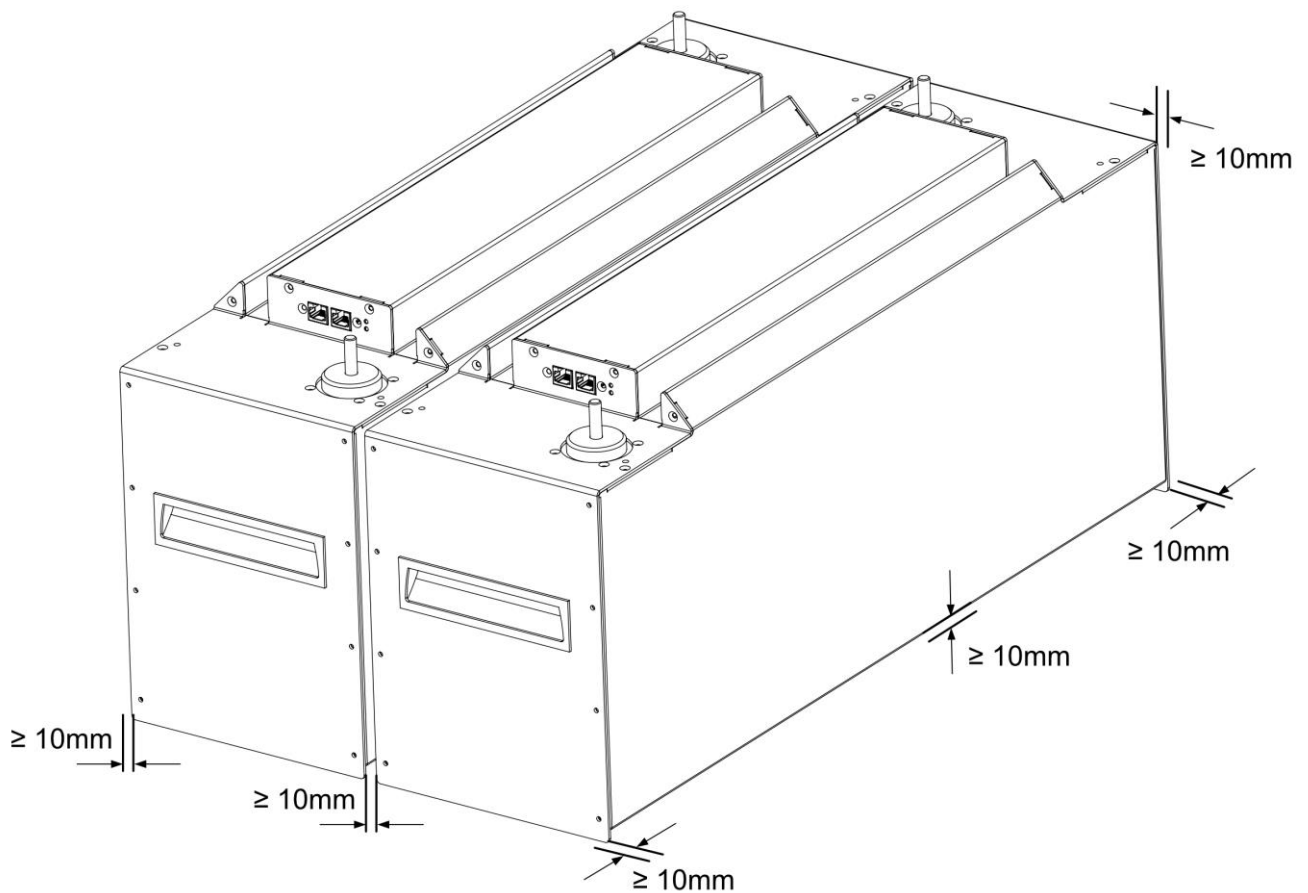


Figure 9 - Battery spacing requirements

7.3.4 Placement in sealed spaces or compartments

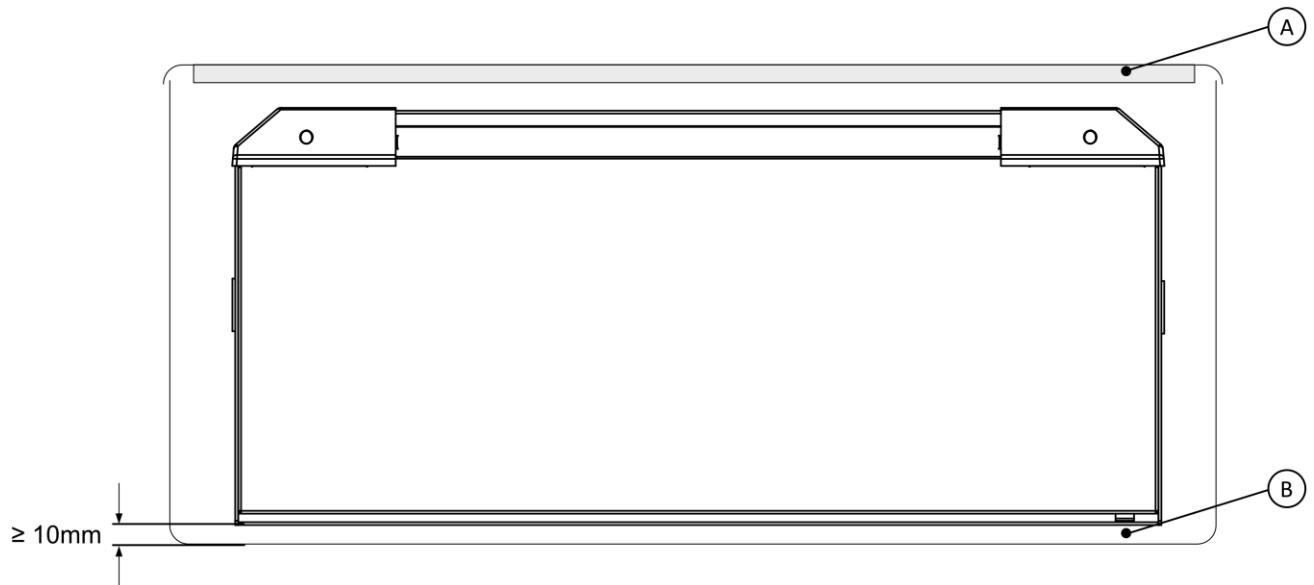
It is recommended to place the battery modules in some kind of box or sealed compartment. This protects the battery modules against water ingress and moisture. A lid or hatch above the battery modules can collect water from condensation that could drip onto the battery. This can damage the battery and therefore must be prevented at all times. A solution to this is to isolate the lid or hatch with a foam.

It is also recommended to place the battery module 10 mm from the bottom of the box or any floor. This creates some margin with water ingress from the bottom up or condensation.



NOTICE:

Respect the thermal management notes of the battery module in chapter 7.2.2 when used in sealed spaces or compartments.



| Part | Description |
|------|------------------------------------|
| A | Isolation foam. |
| B | Margin space from bottom or floor. |

7.4 Electrical

7.4.1 Power cables

Cable lengths need to be taken into account when designing a battery system. Batteries can be placed in parallel, for example in 24 VDC systems, or in series up to 460 VDC.



NOTICE:

- Use the correct cable type for the applicable system voltage.
 - Use the correct fuses for the applicable cable cross-section.
 - We recommend to size the cables to limit voltage drop to 1% or less.
-



NOTICE:

Check the power connections for excessive temperatures during a load test.

7.4.2 Parallel configuration

The battery module can set in parallel to create a larger system capacity. There is no limit of the number of batteries to connect in parallel, whatever is physically possible.

There are a number of possibilities with specific requirements to do this.



CAUTION:

Make sure the voltage of each battery module is equal when connecting them in parallel. Excessive high uncontrolled currents can flow between battery modules when the voltage is not equal. This can damage the batteries and might lead to other damage or injury.



NOTICE:

When connecting battery modules in parallel to a junction box:

- The power cables of each battery module need to have matching lengths as good as possible.

Battery modules can be connected separately in parallel to a Master LV. It has four power connection positions where four batteries could be connected. Refer to the Master LV manual for more information.

Figure 10 shows the most basic parallel connection that is possible. The power connection of each battery is directly connected to a Master LV.

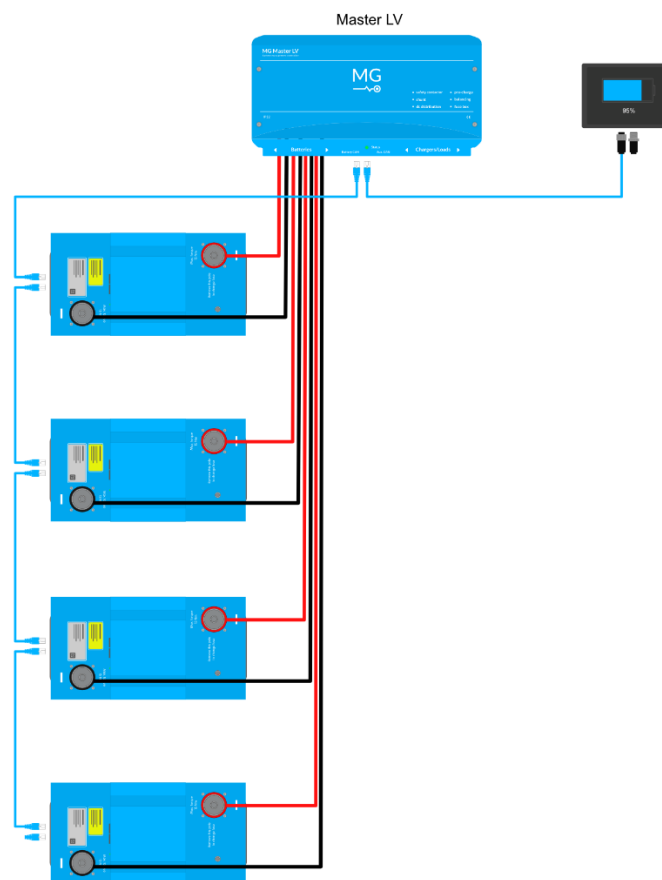


Figure 10 - Four battery module connected in parallel on a single Master LV

There are multiple options when connecting more than four batteries in parallel.

1. Paralleling at the battery modules.
2. Paralleling using the Distributor LV.
3. Paralleling using a custom bus bar connection system.

7.4.2.1 *Paralleling at the battery modules*

Paralleling at the battery modules makes it possible to connect more than four battery modules to a Master LV or other DC distribution. Important is that the cable lengths of the battery modules must be as equal as possible to prevent too much differences during charging and discharging.

Figure 11 shows the connection of two paralleled groups of two battery modules. The two batteries in a group are connected crosswise. This is done to make sure the two batteries have the same total length of power cables and thus the same cable resistance.

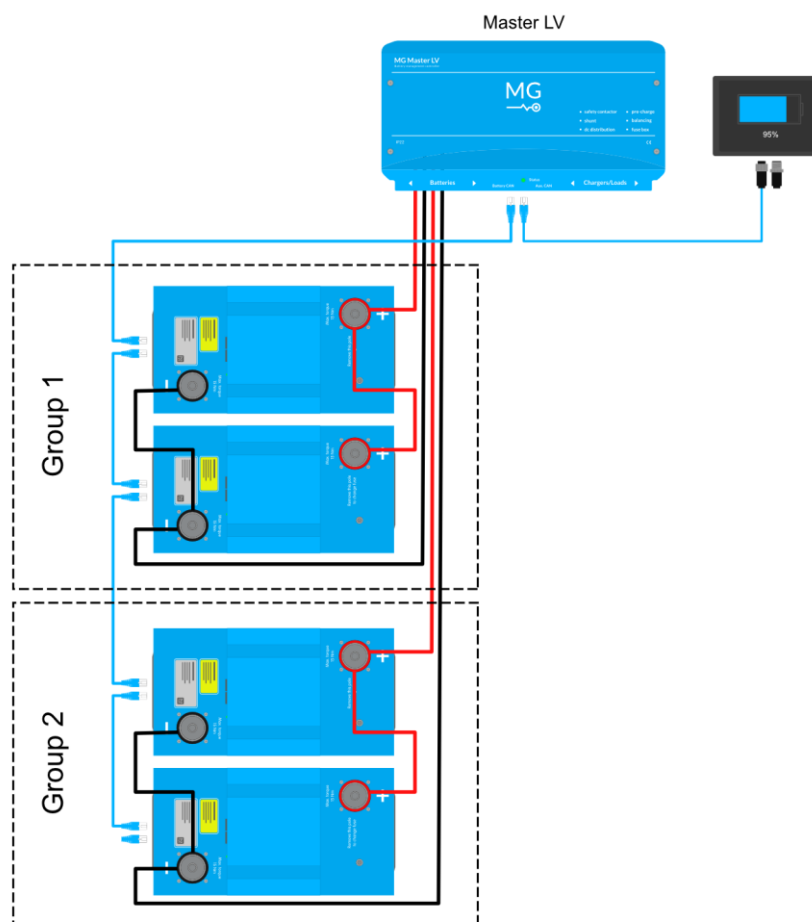


Figure 11 - Example of battery modules paralleled in groups



NOTICE:

- Do not create groups larger than five batteries;
- Only use this method in 24 V or 48 V systems;

Figure 12 shows the same paralleling method, but used for a 48 V system where battery modules are connected in series.

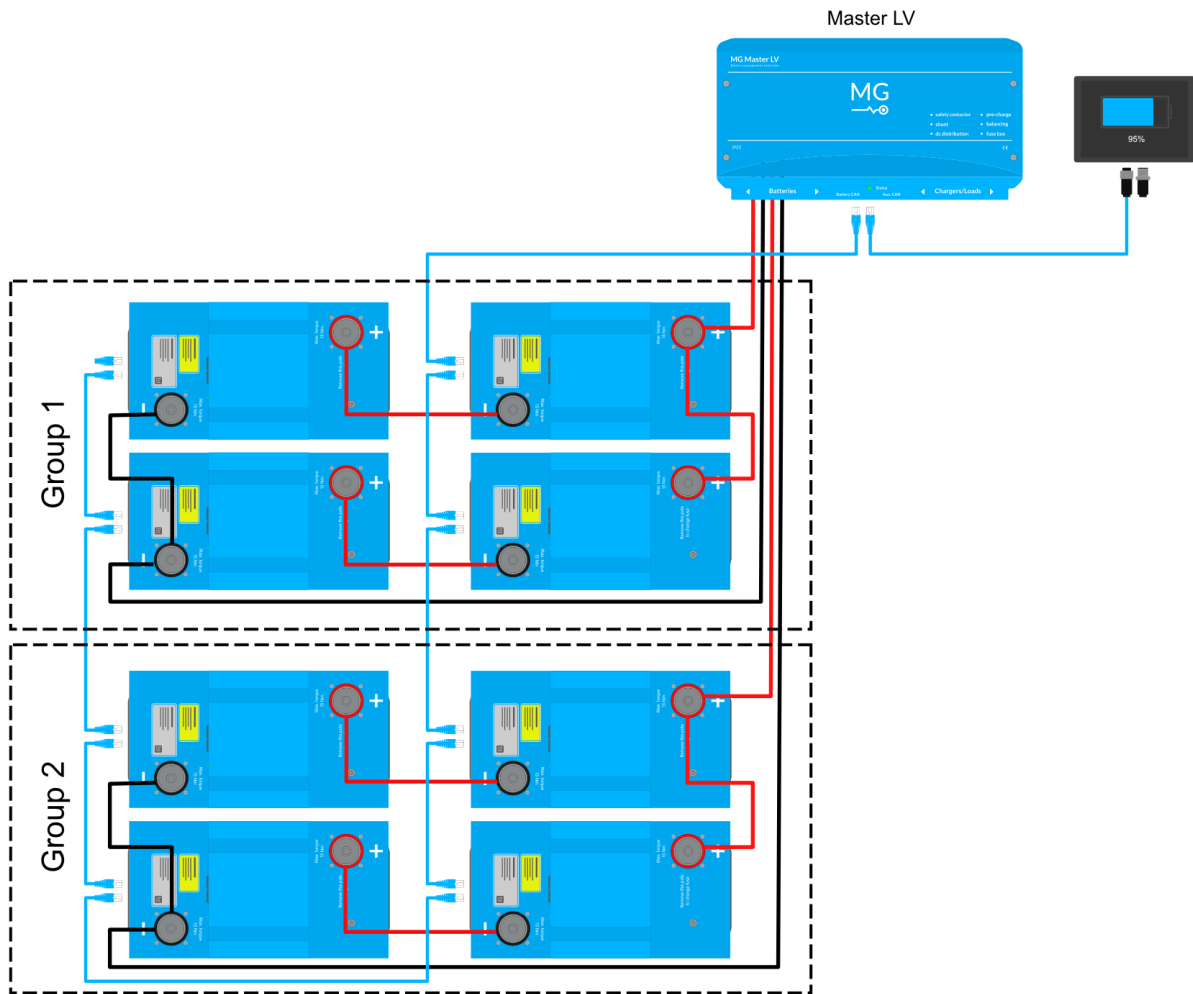


Figure 12 - Example of 48 V system with paralleled groups

7.4.3 Paralleling using the Distributor LV

Another option to parallel battery modules is to use the MG Distributor LV (MGLVDIST01001). Basically this DC distribution box has a positive and negative bus bar with the possibility to place fuses. Refer to the manual of the MG Distributor LV for more details.

Figure 13 shows an example of paralleling battery modules using the MG Distributor LV's.

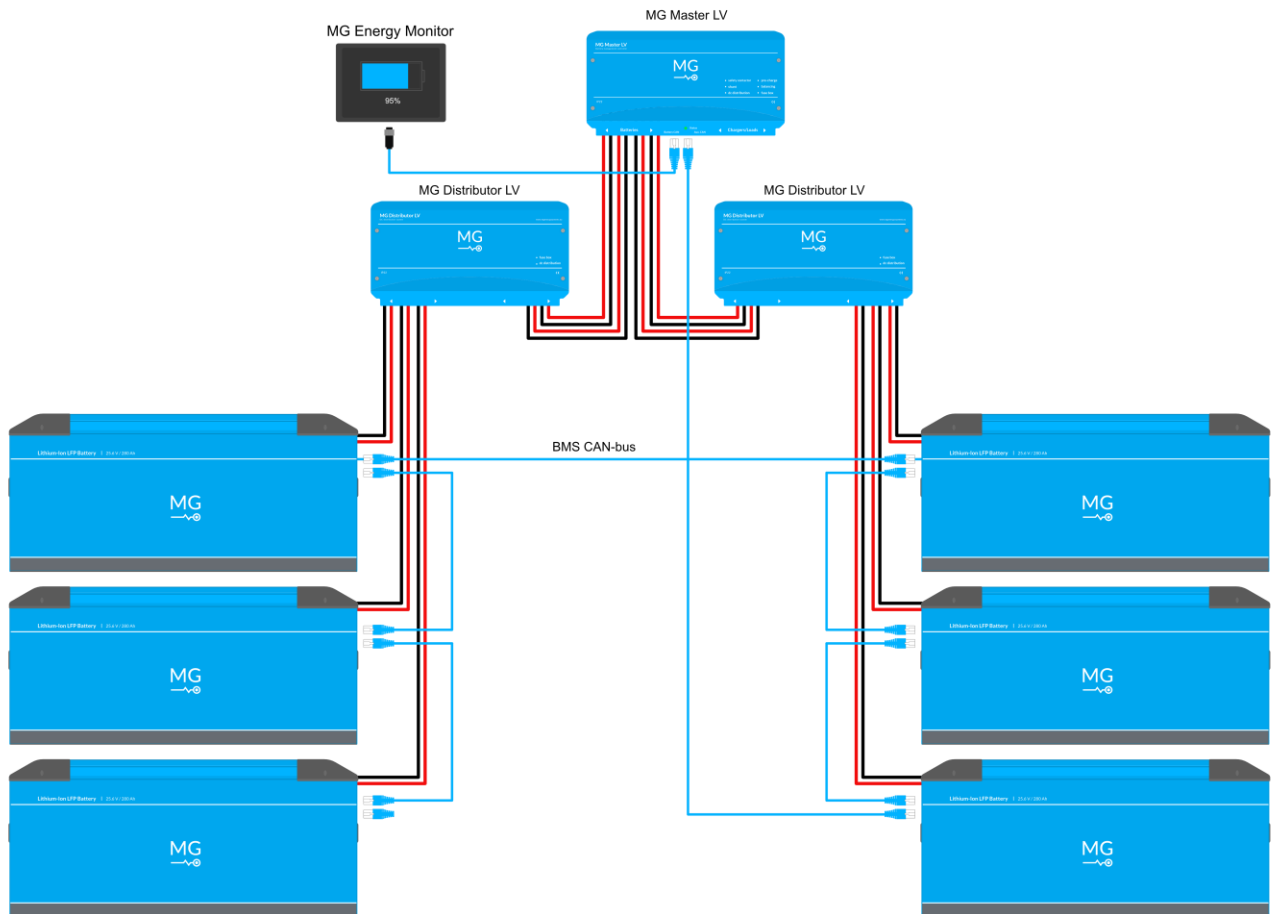


Figure 13 - Example of parallel connection with MG Distributor LV's

7.4.4 Series configuration

The battery modules can be connected in series up to 460 VDC which requires the use of the MG Master HV.

Table 11 shows the maximum number of battery modules in series per battery type. For the MGLFP240280, this is 4 which corresponds to a maximum voltage of 120 VDC. The MGLFP242280 can be connected in series up to 16 modules which corresponds to a maximum voltage of 460 VDC.

Table 11 - Maximum number of modules in series per battery type.

| Article number | Description | Voltage range | Maximum number of modules in series |
|----------------|--|-------------------------|-------------------------------------|
| MGLFP240280 | MG LFP Battery 25.6V/280Ah/7200Wh | 24 VDC up to 120 VDC | 4 |
| MGLFP241280 | MG LFP Battery 25.6V/280Ah/7200Wh (M12, HV) | 24 VDC up to up 460 VDC | 16 |



WARNING:

The fuse in each battery pole must be replaced by a dummy fuse when connecting more than 2 batteries in series. See chapter 6.2.3.1 for details and article number.



WARNING:

- Make sure high voltage battery systems are not accessible by non-authorized people or personnel.
- Mark the space of the high voltage battery installation with warning signs of **ELECTRICAL SHOCK** and the applicable signs according to the local rules and regulation.



NOTICE:

Some regulations require a manual battery or safety disconnect.

Figure 14 shows an example system of six MGLFP242280 battery modules in series connected to a MG Master HV.

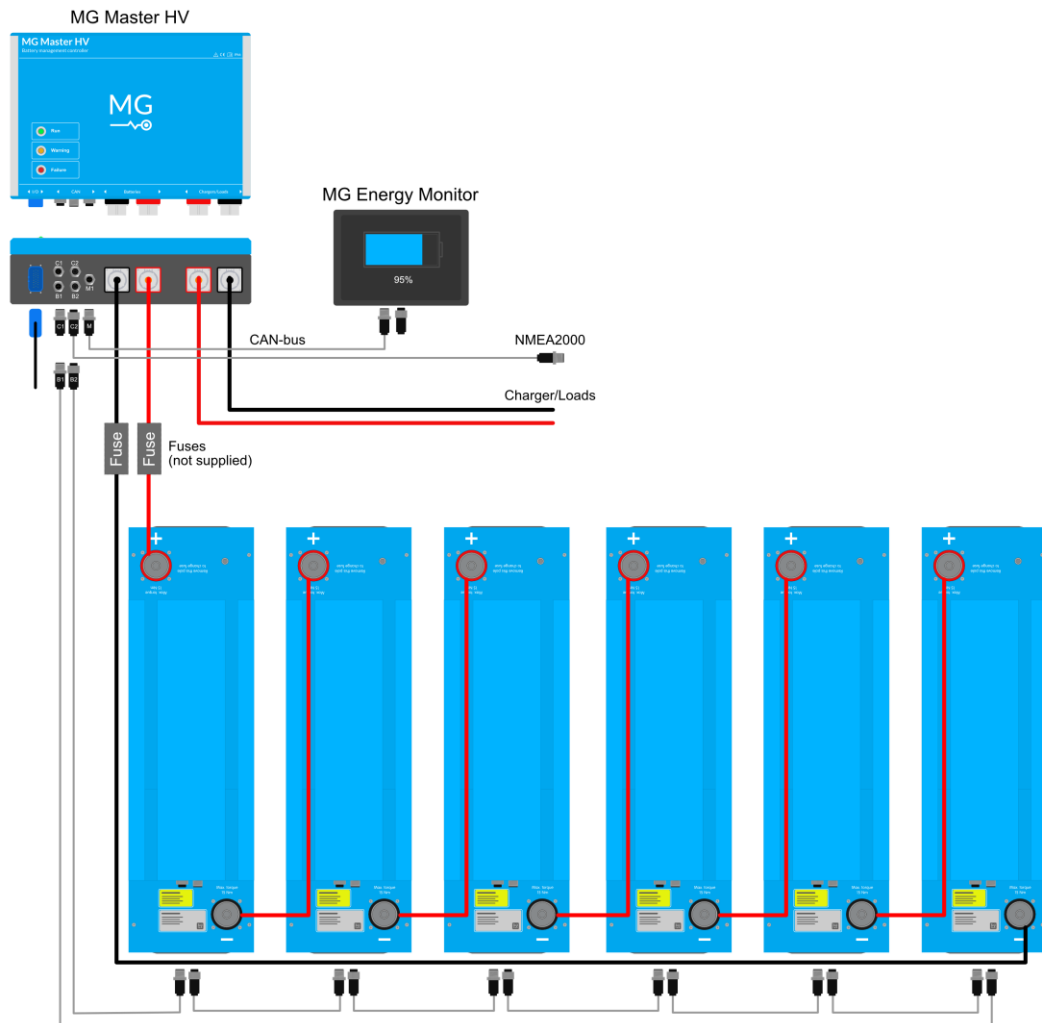


Figure 14 – Series configuration example

7.4.5 Charger

Any charger with constant voltage (CV) constant current (CC) charging can be connected to the MG battery system. The most important is that the charger can be stopped by the MG Master BMS when the batteries are fully charged. Therefore the charger needs to have the ability to stop and start it remotely with a contact. There are also a number of chargers available that are digitally controlled by the MG Master BMS. Refer to the MG Master LV or MG Master HV manual for more details.

7.4.5.1 Charger settings

Chargers that are controlled with on/off need to use the following voltage settings.

| | |
|---------------------------|----------|
| Absorption voltage | 28,2 VDC |
| Float voltage | 28,2 VDC |

This is the voltage setting for one battery. Multiply this by the number of batteries in series for system voltages > 24 VDC.

8 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. Never operate it in a wet or dusty environment.
 - 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.
-



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.
-

8.1 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. Replacing the internal fuse: Fuse replacing procedure;



NOTICE:

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

8.2 Mounting procedure

The battery module has no specific mounting points. Instead it can be mounted with brackets or straps as stated in chapter 7.3.2.

8.3 Equipotential bonding connection procedure

The equipotential bonding connection is located on top of the battery module next to the positive power connection as shown in chapter 6.1. Equipotential bonding connection scheme and the required wire cross-section depend on local standards and regulation. The typical used wire cross-section is 6 mm².

Connect a 6 mm² wire from the equipotential bonding point of each battery module in the system to a Protective Earth (PE).

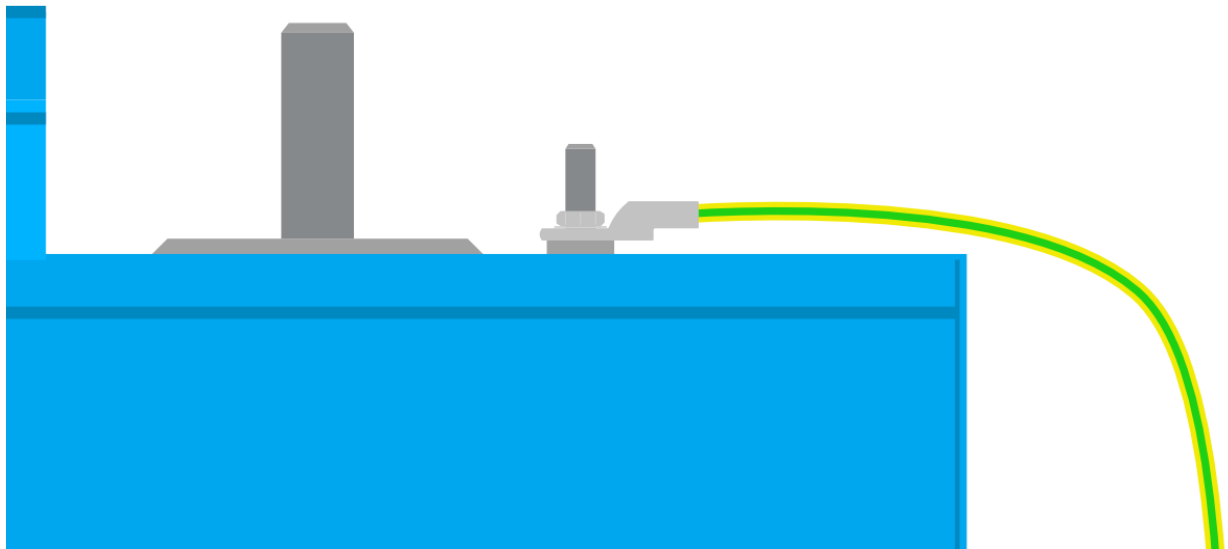


Figure 15 - Connection example of Equipotential bonding

8.4 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.



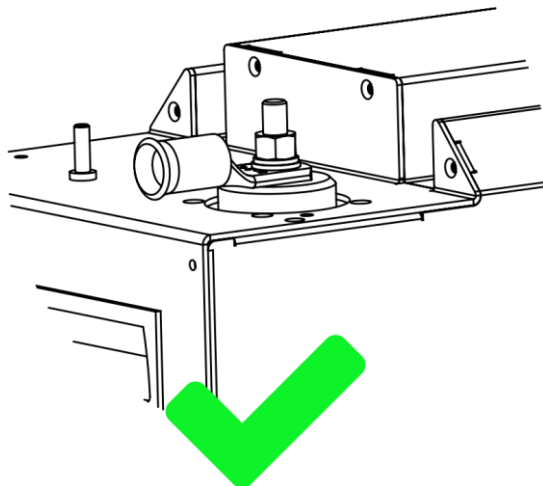
ELECTRICAL HAZARD:

The battery modules can be placed in series up to 460 VDC. Make sure to wear proper insulation gloves.

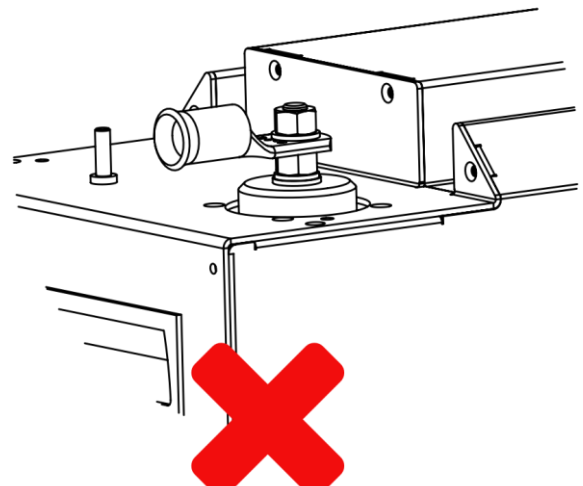
8.4.1 Power connection procedure

Below the procedure for connecting a power cable to the battery.

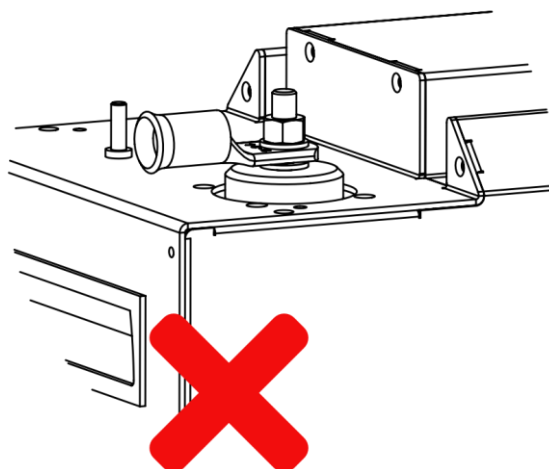
1. Remove the nut, spring washer and washer from the battery pole.
2. Clean the battery pole and the cable lug's contact surfaces for a low resistance connection.
3. Connect a power cable with M8 cable lug to the M8 bolt as shown in Figure 16.



Cable lug directly on top of battery terminal.



Cable lug connected with nut and washer in between.



Cable lug with washer in between

Figure 16 - Battery pole connection

4. Place back the washer, spring washer and the nut on top of the cable lug.
5. Tighten the nut with a torque of 20 Nm.



WARNING:

Make sure the cable lug is directly mounted to the battery pole without any washers or nuts in between.



NOTICE:

When removing the nut and washers from the battery pole, it will become loose. This is normal. When the cable is connected and the nut and washers back in place it will be tightened.



NOTICE:

Maximum torque of the battery poles is 20 Nm.



WARNING:

Stacking of multiple cable lugs is possible however we strongly advise against it. Connection resistance increases which, in time, might lead to excessive heat generation.

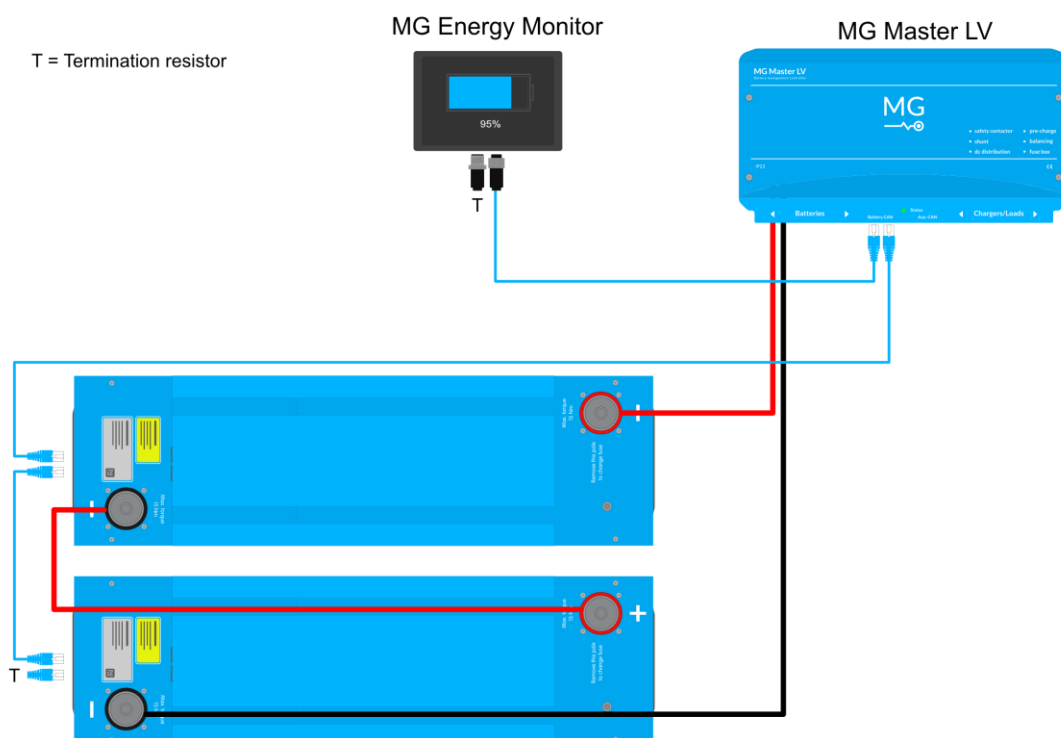
8.4.2 CAN-bus connection procedure

The battery modules communicated with a CAN-bus system to the MG Master BMS. This connection can either be with RJ45 or M12 connectors depending on the battery type. The same topology is used for both connector types. However, the MG Master LV and MG Master HV can have different connection configurations. For more information about the CAN-bus communication connection possibilities, refer to the MG Master LV or MG Master HV manual.

8.4.2.1 Basic connection

The most basic connection is as following:

1. Start with a CAN-bus cable at the MG Master BMS and go to the first battery.
2. Connect from the first to the second battery. Repeat this until the last battery module.
3. Place a termination resistor at the end and begin of the CAN-bus network.



WARNING:

Use the termination resistors delivered with the MG Master BMS. 3rd party termination resistors could damage the devices, because pinning could be different.

8.5 Fuse replacing procedure

Replacement of the fuse requires the battery system to shut down. The fuse can be replaced with a new fuse or with a dummy fuse.



WARNING:

- When replacing the fuse with a dummy fuse then fuse for the string of batteries needs to be installed separately in the system.
- Do not use the battery unfused.

8.5.1 Dummy fuse

The dummy fuse is actually a regular negative battery pole. Figure 17 shows the difference between the two.

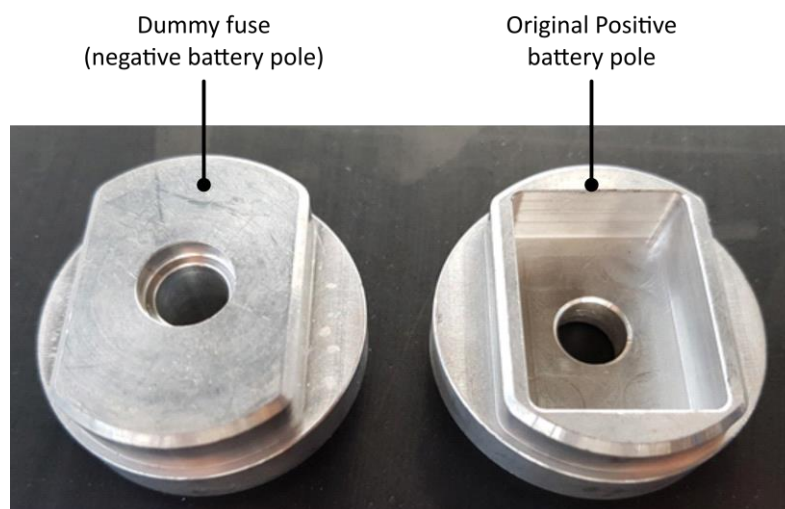
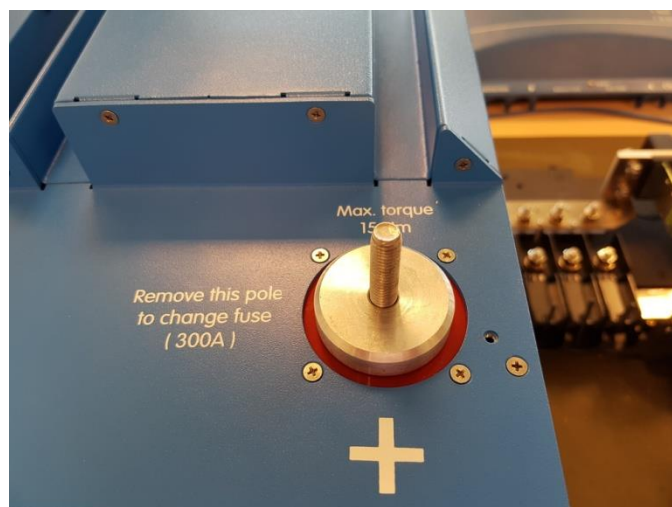


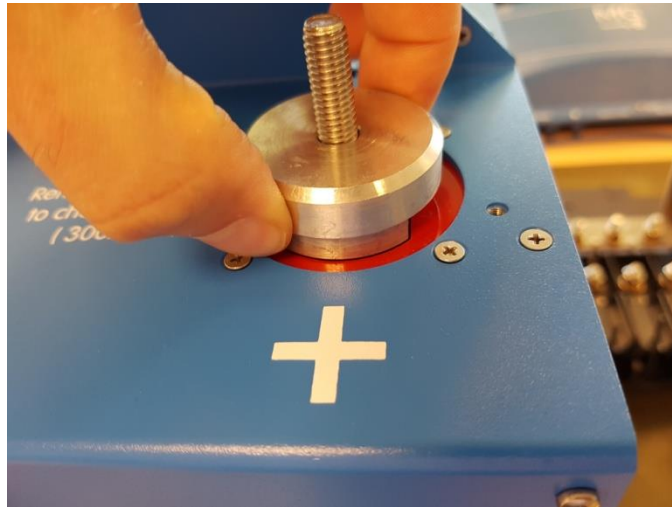
Figure 17 - Overview of negative and positive battery pole.

8.5.2 Replacement instructions

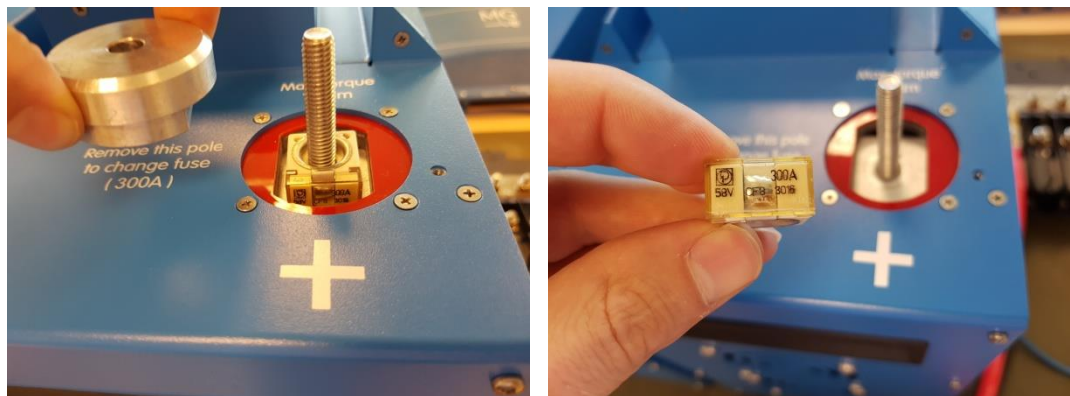
1. Remove the power cable from the + pole of the battery module.



- Lift the aluminium battery pole.



- Now the fuse can be checked and replaced with a new one or it can be replaced with a dummy fuse. If the fuse is replaced with a dummy fuse then clean the dummy fuse's battery pole with a fine sanding block. Recommended is to add an electrical joint compound for better conduction.



- Before connecting the power cable, the voltage of the battery module needs to be measured to check if it is the same as the parallel connected batteries. If not then charge/discharge the batteries separately to the same level.
- Connect the power cables with the instructions of chapter 8.4.1.

9 COMMISSIONING

Table 12 shows a list of points that need to be checked after installation.

Table 12 - Commissioning steps procedure

| | Description |
|--------------------------|--|
| <input type="checkbox"/> | Check all power connection are tightened with 20 Nm. |
| <input type="checkbox"/> | Check all CAN-bus cables are connected of the battery modules. |
| <input type="checkbox"/> | Check CAN-bus termination resistors are installed if applicable. |
| <input type="checkbox"/> | Perform a charge/discharge test run and measure the temperature of the battery terminals during the test. Check for excessive heat generation in the system. |



NOTICE:

For system commissioning procedure, refer to the manual of the MG Master LV or MG Master HV. If no commissioning procedure is available in the manual, contact MG Energy Systems.

10 SERVICE

10.1 Maintenance

The device does not require specific maintenance. When any maintenance or user intervention is required, the user will be notified via status information received by the auxiliary CAN-bus.



ELECTRICAL HAZARD:

Do not pour 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.

10.1.1 Connections

It will suffice to check all connections once a year. Check if all connectors are mated correctly according to the instructions given in sections 0 and 8.4 of this manual.

10.1.2 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 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.

10.2 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 safety.

10.3 Disposal

Batteries marked with the recycling symbol must be processed via a recognized recycling agency. By agreement, they may be returned to the manufacturer. Batteries must not be mixed with domestic or industrial waste.

11 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 1.14 or higher
- Master LV 1.24 or higher

11.1 Limits

Boundary limits are defined to keep the battery within manufacturer's 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;
- 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.

11.1.1 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. |
| Almost discharged | Set | ≤ 3075 mV | 10 sec. |
| | Clear | > 3125 mV | 10 sec. |
| Discharged | Set | ≤ 2800 mV | +10 sec. |
| | Clear | > 3075 mV | 10 sec. |
| Under voltage warning | Set | ≤ 2600 mV | +20 sec. |
| | Clear | > 2800 mV | 20 sec. |
| Under voltage critical | Failsafe | ≤ 2400 mV | +5 sec. |

11.1.2 Cell temperature charging

Table 14 Cell temperature charging boundary limits slave BMS

| Name | Action | Boundary condition | Time |
|----------------------------|----------|---|----------|
| Over temperature alert | Set | $\geq 43\text{ }^{\circ}\text{C}$ | 5 sec. |
| | Clear | $< 42\text{ }^{\circ}\text{C}$ | 5 sec. |
| Over temperature | Set | $\geq 45\text{ }^{\circ}\text{C}$ | +20 sec. |
| | Clear | $< 43\text{ }^{\circ}\text{C}$ | 20 sec. |
| Over temperature critical | Failsafe | $\geq 50\text{ }^{\circ}\text{C}$ and charge current > 5% battery capacity | +60 sec. |
| | | | |
| Under temperature alert | Set | $\leq 1\text{ }^{\circ}\text{C}$ | 5 sec. |
| | Clear | $> 2\text{ }^{\circ}\text{C}$ | 5 sec. |
| Under temperature | Set | $\leq 0\text{ }^{\circ}\text{C}$ | +20 sec. |
| | Clear | $> 1\text{ }^{\circ}\text{C}$ | 20 sec. |
| Under temperature critical | Failsafe | $\leq -5\text{ }^{\circ}\text{C}$ and charge current > 5% battery capacity | +60 sec. |

11.1.3 Cell temperature discharging

Table 15 Cell temperature discharging boundary limits slave BMS

| Name | Action | Boundary condition | Time |
|----------------------------|----------|--|----------|
| Over temperature alert | Set | $\geq 53\text{ }^{\circ}\text{C}$ | 5 sec. |
| | Clear | $< 52\text{ }^{\circ}\text{C}$ | 5 sec. |
| Over temperature | Set | $\geq 55\text{ }^{\circ}\text{C}$ | +20 sec. |
| | Clear | $< 53\text{ }^{\circ}\text{C}$ | 20 sec. |
| Over temperature critical | Failsafe | $\geq 60\text{ }^{\circ}\text{C}$ | +60 sec. |
| | | | |
| Under temperature alert | Set | $\leq -19\text{ }^{\circ}\text{C}$ | 5 sec. |
| | Clear | $> -18\text{ }^{\circ}\text{C}$ | 5 sec. |
| Under temperature | Set | $\leq -20\text{ }^{\circ}\text{C}$ | +20 sec. |
| | Clear | $> -19\text{ }^{\circ}\text{C}$ | 20 sec. |
| Under temperature critical | Failsafe | $\leq -25\text{ }^{\circ}\text{C}$ and discharge current > 10% battery capacity | +60 sec. |

11.1.4 Power terminal temperature

Table 16 Power terminal temperature boundary limits slave BMS

| Name | Action | Boundary condition | Time |
|---------------------------|----------|-----------------------------------|----------|
| Over temperature alert | Set | $\geq 60\text{ }^{\circ}\text{C}$ | 5 sec. |
| | Clear | $< 59\text{ }^{\circ}\text{C}$ | 5 sec. |
| Over temperature | Set | $\geq 70\text{ }^{\circ}\text{C}$ | +20 sec. |
| | Clear | $< 60\text{ }^{\circ}\text{C}$ | 20 sec. |
| Over temperature critical | Failsafe | $\geq 80\text{ }^{\circ}\text{C}$ | +60 sec. |

11.1.5 Current

Table 17 Current boundary limits slave BMS

| Name | Action | Boundary condition | | Time |
|----------------------------------|--------|--------------------|-------|---------|
| Charging over current warning | Set | > 1.0C | | 10 sec. |
| | Clear | <= 1.0C | | 10 sec. |
| Discharging over current warning | Set | > 2.0C | > 1C | 10 sec. |
| | Clear | <= 2.0C | <= 1C | 10 sec. |

11.1.6 Balancing

Table 18 Balancing boundary limits slave BMS

| Name | | Boundary condition | Time |
|------------------------|--|-------------------------------------|--------|
| Offset cell voltage | | > 50 mV | 5 min. |
| Balancing cell voltage | | >= 3350 mV | 5 min. |
| Battery pack current | | current within ±5% battery capacity | 5 min. |

12 TECHNICAL SPECIFICATIONS

Table 19 - Technical specifications

| Technical specifications | MGLFP240280 25.6 V / 280 Ah | MGLFP241280 25.6 V / 280 Ah (M12, HV) |
|--|---|--|
| Technology | Lithium-Ion next generation LiFePo4 | |
| Cell configuration | 8S1P | |
| Nominal voltage | 25.6 V | |
| Nominal capacity | 280 Ah | |
| Nominal energy | 7.2 kWh | |
| Cycle Life DOD 80% ¹ | > 3500 | |
| Specific energy ² | 136 Wh/kg | |
| Weight | 53 kg | |
| Discharge | | |
| Discharge cut-off voltage | 21.6 V | |
| Recommended discharge current | 140 A (0.5C) | |
| Continuous discharge current | 280 A (1.0 C) | |
| Maximum discharge current ³ | 560 A (2.0 C) | |
| Fuses ⁴ | 300A, fuse inside | |
| Charge | | |
| Maximum charge voltage | 29.2 V | |
| Recommended charge voltage | 28.2 V | |
| Recommended charge current | 140 A (0.5C) | |
| Continuous charge current | 280 A (1.0 C) | |
| Maximum charge current (10 s) ³ | 560 A (2.0 C) | |
| Configuration | | |
| Series configuration | Yes, up to 4 pcs. | Yes up to 16 pcs. |
| Parallel configuration | Yes, unlimited | |
| Redundant mode | Yes Using multiple Master BMSs | |
| Environmental | | |
| Operating temperature charge | 0 to +45°C | |
| Operating temperature discharge | -20 to +55°C | |
| Storage temperature | -20 to +45°C | |
| Humidity (non-condensing) | ≤ 95 % | |
| Mechanical | | |
| Power connections | M8 stud, Max. 20 Nm | |
| IP-Protection class | IP40 | |
| Cooling | Air, convection | |
| Dimensions (l x h x w) | 652 x 294 x 193 mm | |
| Safety | | |
| Battery Management System (BMS) | Integrated slave BMS | |
| Balancing | Passive | |
| Compatible BMS master controller | MG Master LV, MG Master HV ⁵ | |
| Communication | CAN-Bus (RJ45 connection) | CAN-Bus (M12 connection) |
| Standards | | |
| EMC: Emission | EN-IEC 61000-6-3:2007/A1:2011/C11:2012 | |
| EMC: Immunity | EN-IEC 61000-6-1:2007 | |
| Low voltage directive | EN 60335-1:2012/AC:2014 | |

¹ End-of-Life is 70% of initial capacity at 25 °C.

² Including BMS and enclosure.

³ Duration is depending on battery temperature.

⁴ Fuses can be replaced with dummy fuses for high power and high voltage applications. In this case the batteries need to be fuse elsewhere in the circuit.

⁵ For systems >96 V, order the M12, HV version.

12.1 Dimensions

Unless otherwise mentioned all dimensions are in mm.

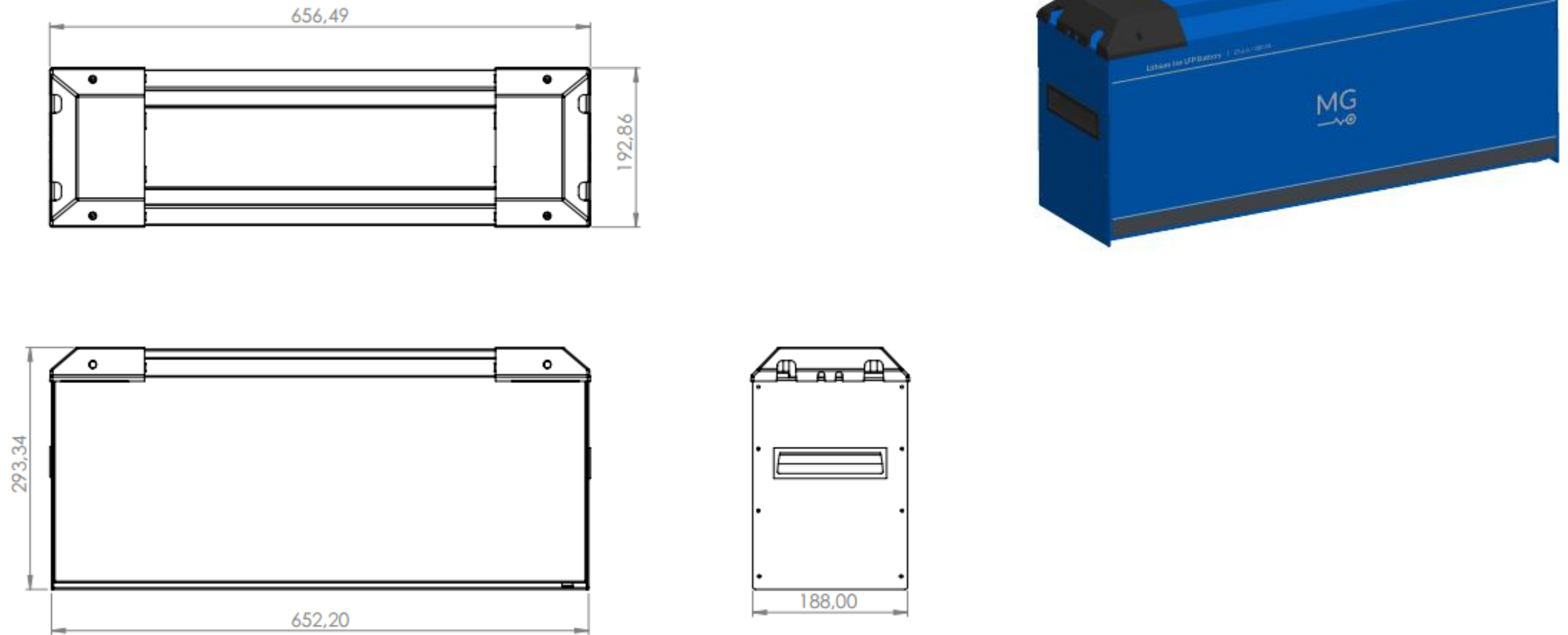


Figure 18 – Dimensions [mm]

13 ORDERING INFORMATION

This chapter describes the MG order numbers for spare-, service-, and replacement-parts for the MG LFP Series battery module.

| Item | Description | Manufacturer | Type | MG order number |
|------|-------------|--------------|------|-----------------|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |

14 CONTACT DETAILS

For specific questions please feel free to contact us.



MG Energy Systems B.V.

Foeke Sjoerdswei 3
NL-8914 BH Leeuwarden
The Netherlands

i : www.mgenergysystems.eu
e : info@mgenergysystems.eu
t : +31 (0) 58 750 89 47