Innovation in energy storage

Version 1.8 – 12-02-2026

Lithium-Ion 24V LFP battery module

- Manual -

MGLFP240280, MGLFP241280, MGLFP242280 (LFP 280Ah)
MGLFP240304, MGLFP242304 (LFP 304Ah)
MGLFP240230, MGLFP241230, MGLFP242230 (LFP 230Ah)
MGLFP244304 (LFP304 SLP)

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
0.1	18-08-2020	Initial document	A-T. Rienstra
1.0	20-09-2020	Added schematics, detailed connector information etc.	M. Scholten
1.1	20-10-2020	Minor changes and typo fixes.	M. Scholten
1.2	11-11-2020	Corrected typos.	M. Scholten
1.3	31-05-2022	Adjusted discharged voltage limits.	W. Portinga
1.4	7-11-2022	- Updated images - Extended storage notes text in chapter 3.2. - Changed voltage levels and number of battery modules in series to 144V and 6 modules in series. - Added chapter risk assessment to chapter 2.2.4. - Added "Other labels" to chapter 5.2.1. - Updated dummy fuse article number in chapter 6.2.2.1.1. - Removed 2C heat rejection from chapter Heat rejection. - Added placement in a battery box. - Changed float voltage in chapter 8.4.6.2. - Added chapter 9.1 Tooling. - Updated connection of positive and negative power cables and CAN Bus connections. - Extended the commissioning in chapter 10. - Extended the maintenance in chapter 12.1. - Changed "Dummy fuse" to non-fused battery terminal in the complete document.	M. Scholten
1.5	12-06-2023	- Removed additional boundary limit. - Added the 304 Ah battery type	M. Scholten
1.6	17-08-2023	- Added the battery box link - Minor changes and typo fixes	W. Jansma
1.7	29-01-2024	- Added the LFP230 M12, HV battery type - Changed risk assessment text in chapter 2.2.4 and 8.1. - Added regular charging in chapter 8.4.6.1. - Added decommissioning procedures in chapter 11.	M. Scholten
1.8	12-02-2026	- Added chapter with battery module properties. - Renamed chapter `Integration requirements …` to `Integration …`. - Changed `battery box` paragraph and moved from chapter `Placement` to chapter `Integration`. - Corrected designation of 230 and 304 battery type. - Added the LFP304 SLP battery model.	M. Scholten

		- Updated the boundary limits chapter.	

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. Cell is the bare Lithium-Ion battery cell.
Battery module	*Battery module;* is an assembly of submodules, BMS and outer enclosure.
Battery stack	*Battery stack;* is a set of multiple cells in cell cassettes constructed as one.
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 data-bus 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 ampere-hours (Ah).
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.
IC	*Integrated Circuit;* is a chip containing an electronics circuit;
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.
PCB	*Printed Circuit Board;* is a board containing an electronic circuit;
PCBA	*Printed Circuit Board Assembly;* is a board containing an electronic circuit including passive and active components;
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.

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

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 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 specifications, cable routing etc.)
- Installation and operational hazards (lifting, communication, power loss etc.)

2.2.5 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 MG Master BMS. (MG Master LV or MG Master HV)

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/Lithium-Ion batteries 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's SoC is decreasing 6 % per year when not connected to any equipment, including MG Master LV or MG Master HV. Recharging is required when the voltage is in the range of the under voltage voltage level.

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.

NOTICE:
Local regulations for storage of dangerous goods/Lithium-Ion batteries may be applicable.

3.3 Unpacking and handling

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.

3.3.1 Lifting the battery module

Use the handles on the side of the battery module for lifting:

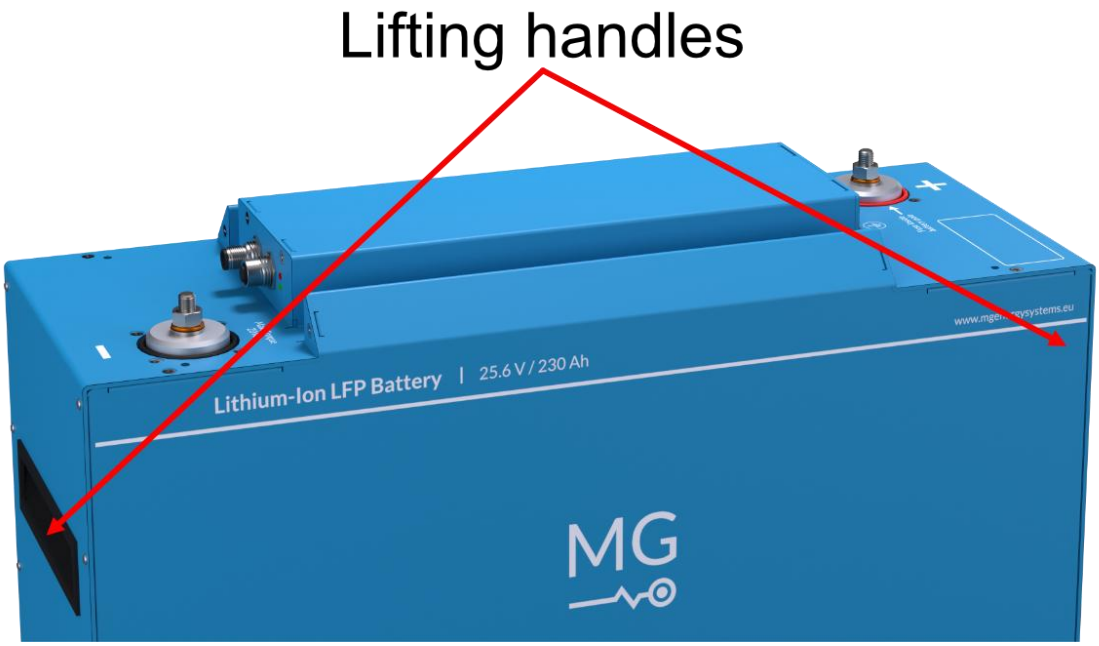


Figure 1 - LFP Lifting handles

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.

3.3.2 Scope of delivery

The scope of delivery is as follows:

- MG LFP 24V battery module of type as described in chapter 5.
- Quick installation guide: LFP 24V
- Top Ingress Protection Cover LFP 24V Series article numbers:
  LFP 280 / LFP 304 (SLP) = MG4000444,
  LFP 230 = MG4000502
- Non-fused battery terminal (article number: MG4000034).
  Only supplied with the following battery models:
  MGLFP241230
  MGLFP242230
  MGLFP241280
  MGLFP242280
  MGLFP241304
  MGLFP242304

NOTICE:
Not within the scope of delivery:
- Power cables and connectors (details can be found in chapter 6.2.2).
- 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

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

- One or more MG LFP battery modules of the same type;
- One MG Master LV or MG Master HV battery management system; Details of these battery management controllers can be found in their separate description documents;
- MG Energy Monitor (optional);
- MG SmartLink MX for parallel redundant control (optional);

4.2 Functional description

MG's system philosophy is to have one MG 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 MG Master BMS.

All these parameters are sent 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 MG 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;
- High voltage solutions;
- Fast and safe installation;
- 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.

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. The example in Figure 2 and Figure 3 are simplified schematics which are not showing all the details.

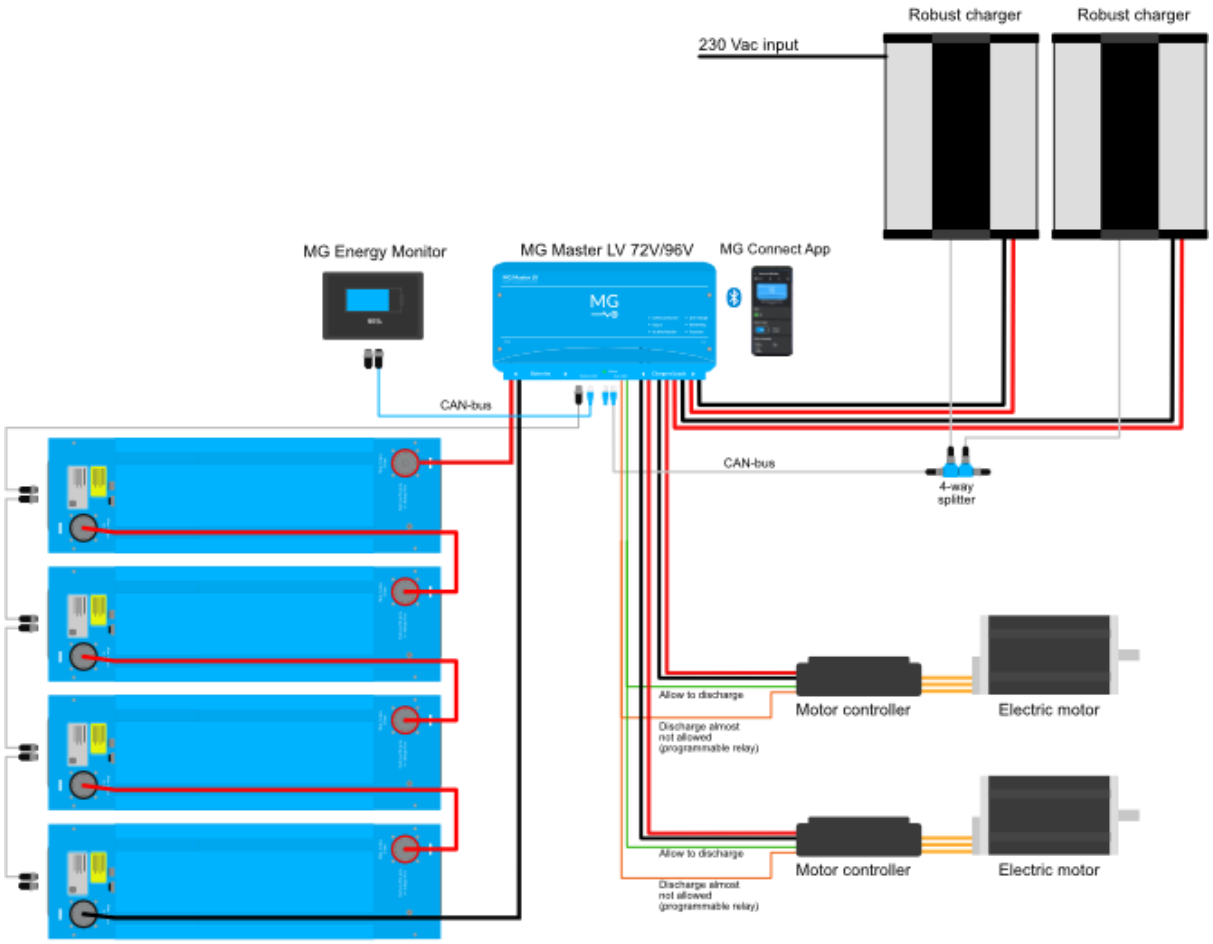


Figure 2 - 96 VDC propulsion system for industrial and marine applications

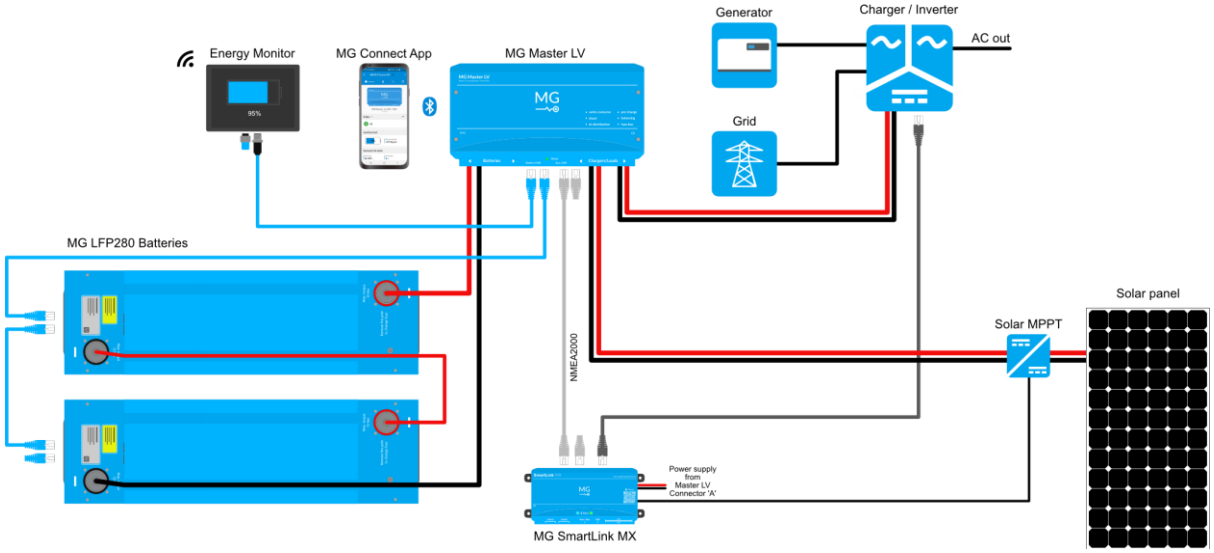


Figure 3 - 48 V small ESS/Solar/Off-grid system

4.3.2 High voltage systems

High voltage systems up to 144 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. The example in Figure 4 is a simplified schematic which is not showing all the details.

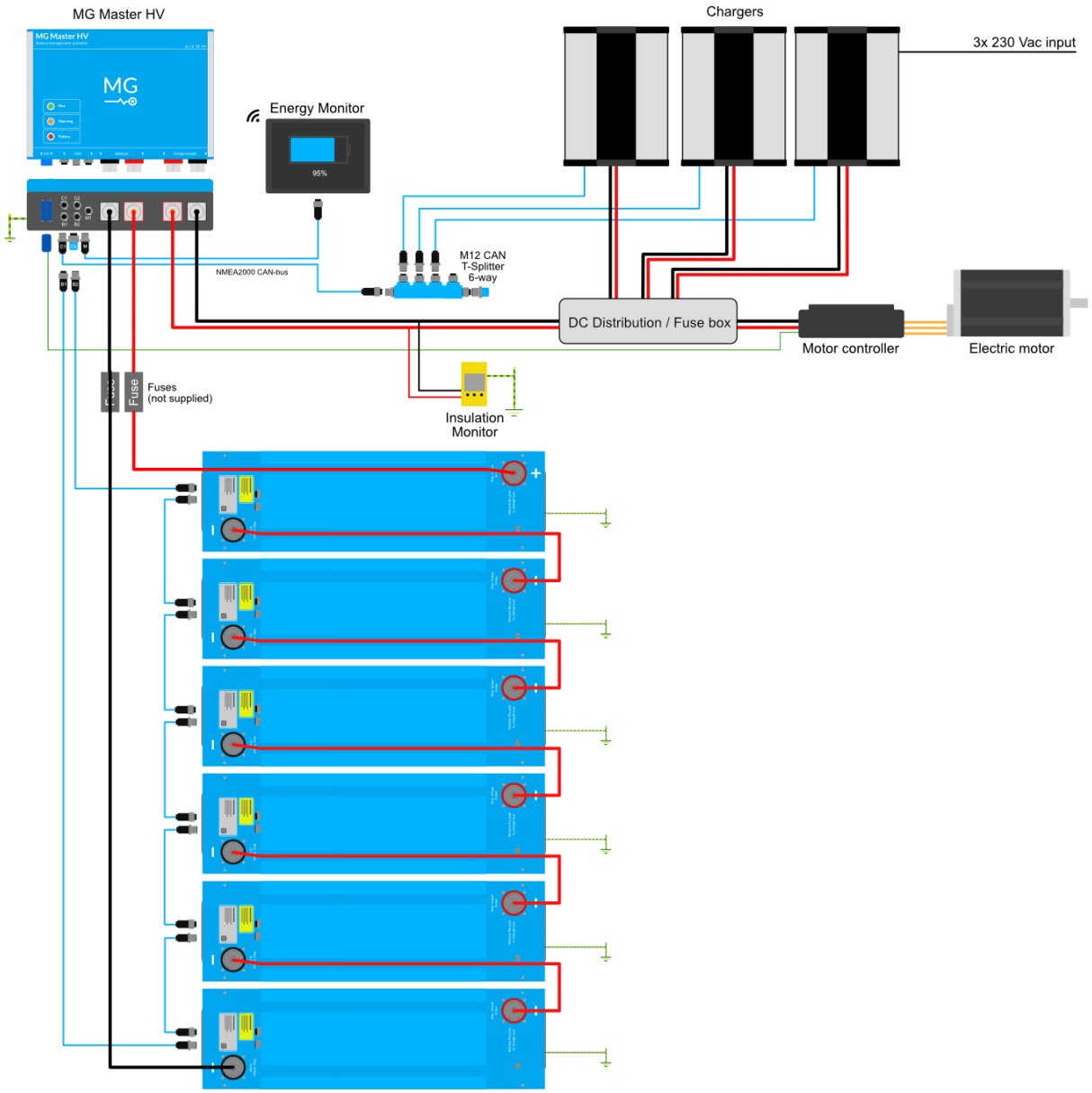


Figure 4 - 144 VDC propulsion system for industrial or marine applications

5 MODELS

The LFP Series has different models and configurations available. The main differences are battery module capacity, maximum system voltage and CAN Bus connector types.

5.1 Models and configurations

Table 4 lists the available battery module configurations.

Table 4 - Battery module configurations

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)	24 V up to 144 V, M12 connectors
MGLFP242280	MG LFP Battery 25.6V/280Ah/7200Wh (M12, HV)	24 V up to 470 V, M12 connectors
MGLFP240230	MG LFP Battery 25.6V/230Ah/5800Wh	24 V up to 96 V, RJ45 connectors
MGLFP241230	MG LFP Battery 25.6V/230Ah/5800Wh (M12)	24 V up to 144 V, M12 connectors
MGLFP242230	MG LFP Battery 25.6V/230Ah/5800Wh (M12, HV)	24 V up to 470 V, M12 connectors
MGLFP240304	MG LFP Battery 25.6V/304Ah/7800Wh	24 V up to 96 V, RJ45 connectors
MGLFP242304	MG LFP Battery 25.6V/304Ah/7800Wh (M12, HV)	24 V up to 470 V, M12 connectors
MGLFP244304	MG LFP Battery 25.6V/304Ah/7800Wh SLP (M12, HV)	24 V up to 563 V, M12 connectors

NOTICE: Using different LFP battery models in one system

Using the LFP280 and LFP304 in the same system is possible.
Many systems are using the MG LFP280 battery module. The firmware in both the MG Master LV and HV is accepting these different modules in one battery bank. This is implemented to add backwards compatibility for service and support requests, because the MG LFP304 replaces the MG LFP280 since Mid. 2023. The LFP304 is an upgrade of the LFP280 and therefore can be integrated in systems with existing LFP280 batteries.

Using the LFP230 in combination with the MG LFP280 or MG LFP304 in one battery bank is NOT possible
In general when designing new battery banks, it is not recommended and supported to use different battery models in one battery bank. For example the MG LFP230 battery module cannot be combined with a MG LFP304.

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 5.

Table 5 - Battery module designation as per IEC 62620

Article number	Designation
MGLFP240280, MGLFP241280, MGLFP242280	IFpP/72/174/200/[1P8S]E/-10NA/95
MGLFP240230, MGLFP241230, MGLFP242230	IFpP/55/174/205/[1P8S]E/-10NA/90
MGLFP240304, MGLFP242304	IFpP/73/175/205/[1P8S]E/-10NA/90
MGLFP244304	IFpP/73/175/205/[1P8S]E/-10NA/90

5.2 Identification label

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

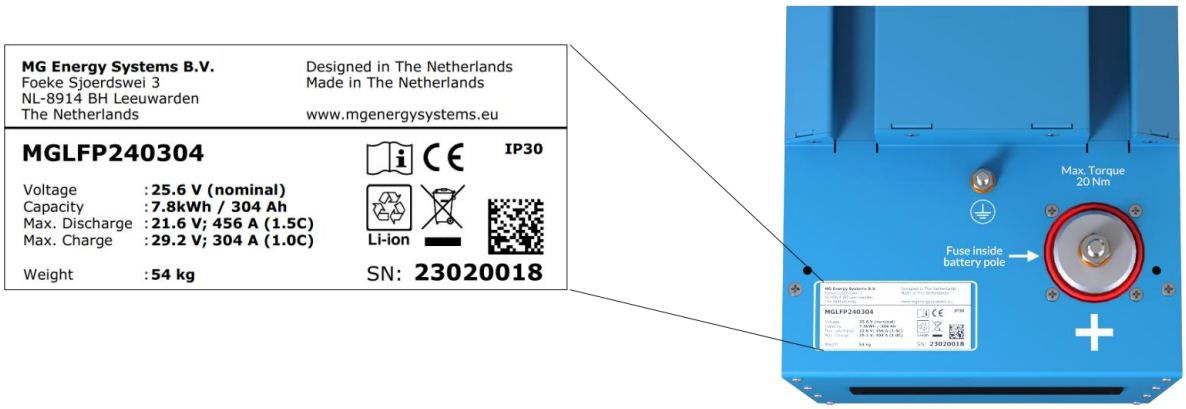


Figure 5 - Example identifications label LFP230/280/304

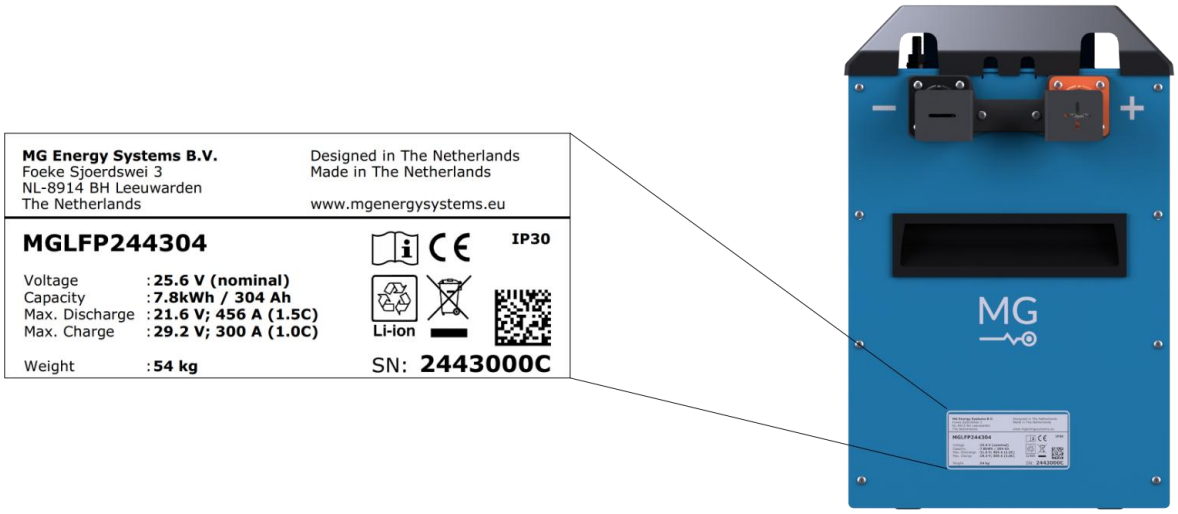


Figure 6 - Example identifications label LFP304 SLP

The identifications label shown in figure 5 and Figure 6 contains written information about the product. The explanation of the symbols used on the identification label is stated in table 6.

Table 6 - 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.
	Symbol indicating the manual must be read 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.

5.2.1 Other labels

Figure 7 shows the additional labels on the battery module.

Figure 7 - Additional warning and informational labels

5.3 Approvals and standards

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

IEC 62619
EN 62620

- Declaration of Conformity LFP 280 Ah series
- Declaration of Conformity LFP 230 and LFP 304 Series
- LFP cell propagation test
- Material safety datasheet

A complete list of all performed tests can be found at the following link:
LFP 24V List of Standards and Tests

NOTICE:
The IEC-EN62619 standard is applying to a battery in combination with the BMS such as the MG Master LV or MG Master HV. Always check for compliance with this combination.

6 OVERVIEW

This chapter shows an overview of the parts of the LFP battery.

Each battery module contains the following common parts:

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

6.1 Connection overview

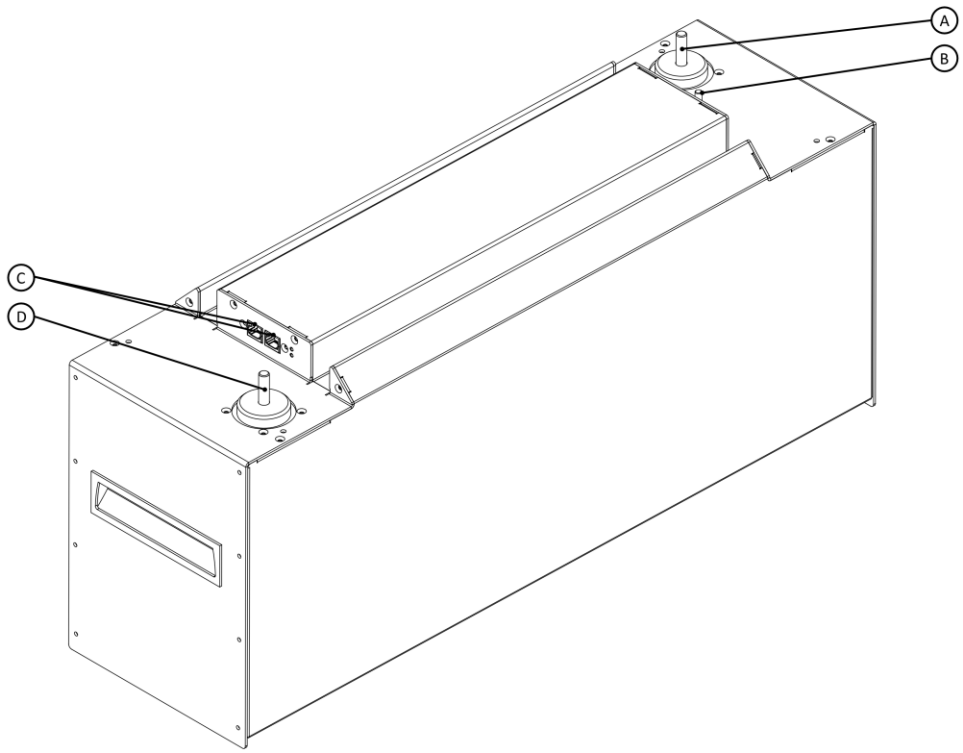


Figure 8 – LFP 230/280/304 Ah module overview

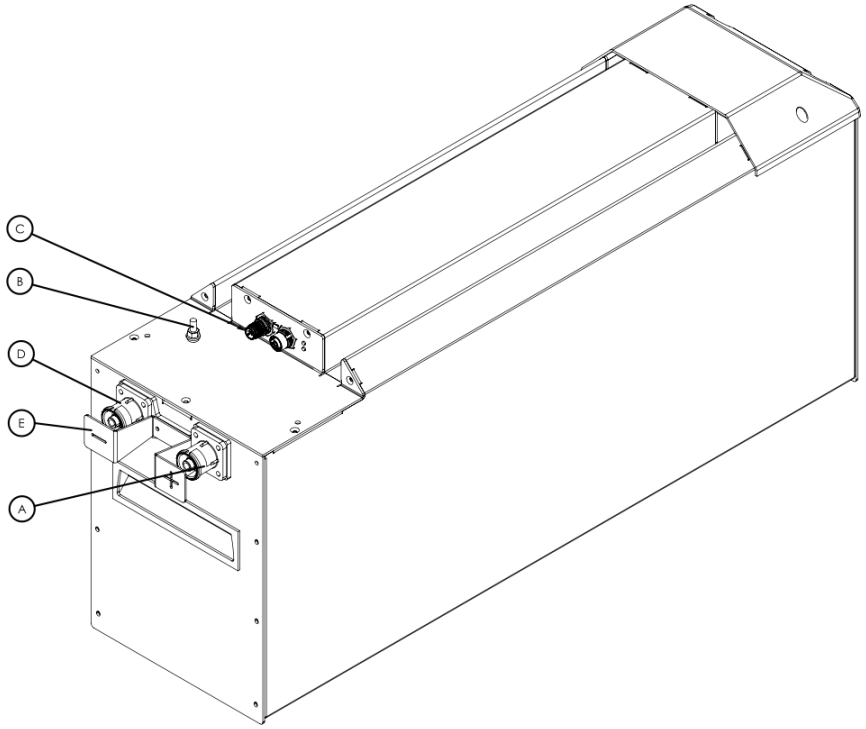


Figure 9 - LFP304 SLP module overview

Table 7 - Module connection overview

Part	Description
A	Positive power terminal.
B	Equipotential bonding connection.
C	CAN-Bus communication, either RJ45 or M12.
D	Negative power terminal.
E	Terminal front clamp bracket

6.2 Connections details

Each battery module contains two CAN-Bus connectors to connect to the MG Master BMS and to the next battery, if any.

This CAN-Bus connection is used for several functions:

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

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

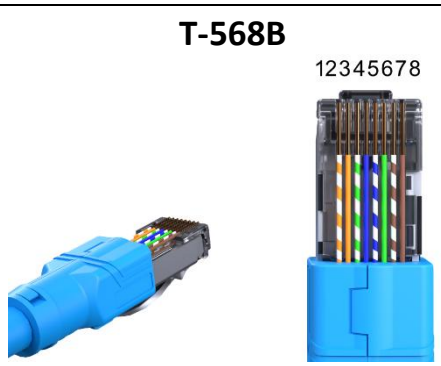
6.2.1 RJ45 CAN-bus connector details

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.

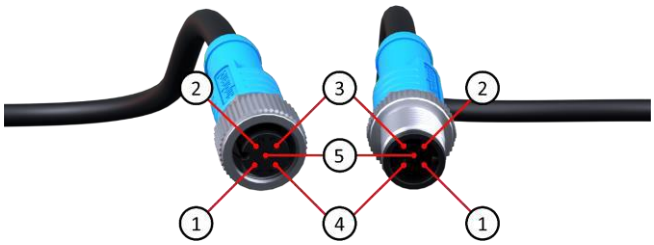
Table 8 – RJ45 connector details

Pin	Description	Connector view
1		
2		
3	GND	
4		
5		
6	V+	
7	CAN-H	
8	CAN-L	

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

6.2.1.2 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.



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.

6.2.2 Power connections

There are two types of battery terminals available.

- M8 bolt down battery terminal;
- SLP battery connector terminal;

6.2.2.1 M8 bolt down terminal

The power connections on the LFP230/280/304 battery module consists of two M8 bolt connections. One is the positive battery terminal and one is the negative battery terminal.

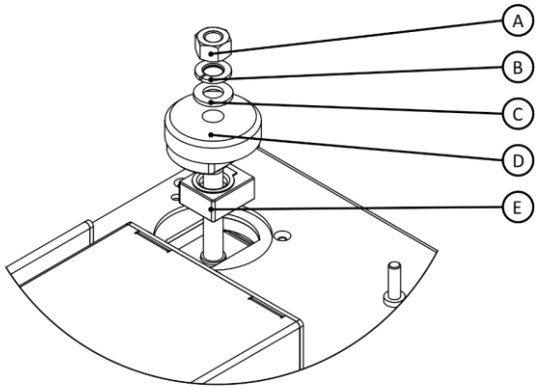


Figure 10 - Battery pole connection overview

Part	Description
A	Nut
B	Spring washer
C	Washer
D	Battery pole
E	Fuse (only positive battery pole)

6.2.2.1.1 Fuse

The positive battery terminal contains a protection fuse. This fuse is a CF8 fuse. See chapter 9.6 for the replacement procedure.

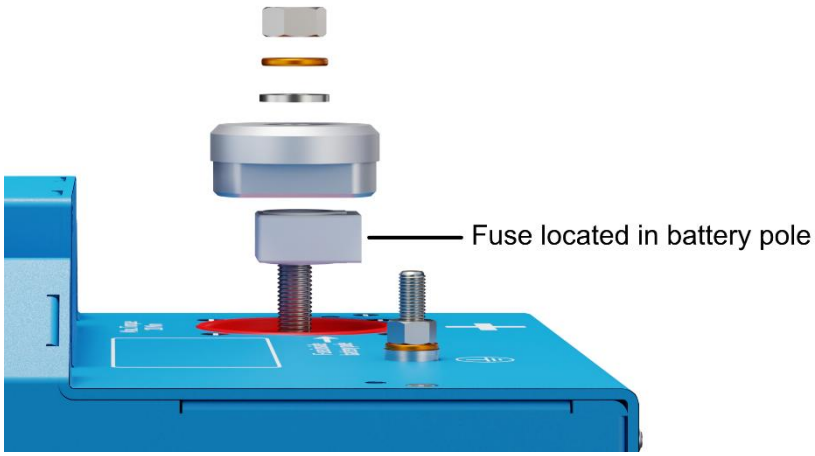


Figure 11 - Fuse location

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
MG4000034	-	Non-fused battery terminal (negative battery terminal)

Default fuse types:

Battery type	Default fuse installed
MGLFP240280, MGLFP241280, MGLFP242280	300 A
MGLFP240230, MGLFP241230, MGLFP241230	300 A
MGLFP240304, MGLFP242304	300 A
MGLFP244304	No fuse installed

NOTICE:
A broken fuse is indicated by measuring no voltage on the battery terminals. Before measuring the nut must be tightened first.

WARNING:
For systems with a voltage above 58 VDC, a non-fused battery terminal is mandatory. See chapter 6.2.2.2 and 9.6.1 for more information.

WARNING:
In some cases it is required to replace the fuse for a smaller one according to the cable size or can be fused elsewhere in the circuit.

6.2.2.2 Non-fused battery terminal

Replacing the fuse by a non-fused battery terminal is needed in case the battery module is used in series above 58 V. This non-fused battery terminal is actually a complete battery terminal that replaces the battery terminal with fuse holder. See chapter 9.6 for the replacement procedure.

6.2.2.3 SLP battery connector terminal

The MGLFP244304 battery model is equipped with Amphenol SurLok Plus power connectors. This provides a safe, easy and fast installation. Especially in systems at higher voltages.

Table … show the available connector plugs that fit the battery terminals.

Terminal Plug	Color	Cable size	Brand	MPN	MG part
Positive	Orange	50 mm2	Amphenol	SLPPC50BSO0	MG5001172
Negative	Black	50 mm2	Amphenol	SLPPC50BSB2	MG5001171
Positive	Orange	70 mm2	Amphenol	SLPPC70BSO0	MG5001170
Negative	Black	70 mm2	Amphenol	SLPPC70BSB2	MG5001169
Positive	Orange	95 mm2	Amphenol	SLPPC85BSO0	MG5001061
Negative	Black	95 mm2	Amphenol	SLPPC85BSB2	MG5001060

The keying that is used on the connector are as follows:

Connector	Key
Negative 	60°
Positive 	90°

6.3 Status indication

Figure 12 shows the location of the status indication LEDs. They are located next to the CAN-bus connections.

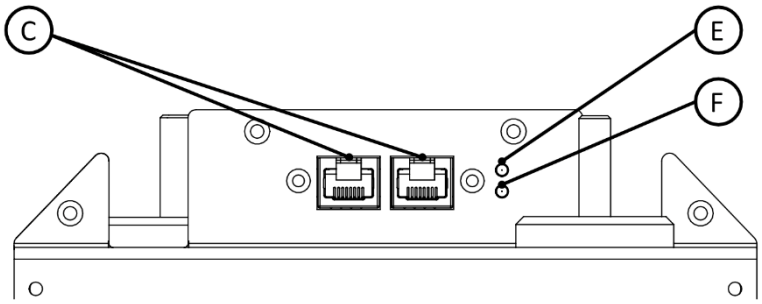


Figure 12 - Status LEDs overview

Part	Description
E	Green LED
F	Red LED

6.3.1 Indication

Table 9 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 module is Off.

7 BATTERY MODULE PROPERTIES

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

7.1 Internal resistance

The internal resistance of LFP modules depends on different factors. The main factor(s) influencing the resistance is temperature, and SoC (state of charge) and SoH (state of health). More extensive values can be found in Table 4.

Table 10 - Average module internal resistance LFP modules (new condition)

Model	Total pack resistance [mΩ] @ 25 °C	Heat rejection at 0.5C [W]	Heat rejection at 1C [W]
MGLFP24x230 (230Ah)	6	80	318
MGLFP24x280 (280Ah)	4.5	88	353
MGLFP24x304 (304Ah)		104	415

7.2 Internal resistance change towards EOL

All Lithium-Ion cells 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 50% during its life (EOL is defined here at 70% SoH). This practically means that the heat generated by each module could increase over its lifetime.

Table 11 - Expected module internal resistance RS modules (EOL condition)

Model	Total pack resistance [mΩ] @ 25 °C	Heat rejection at 0.5C [W]	Heat rejection at 1C [W]
MGLFP24x230 (230Ah)	9	119	476
MGLFP24x280 (280Ah)	6.8	133	533
MGLFP24x304 (304Ah)		157	628

7.2.1 Important note on heat rejection (air-cooling)

The values given in table 1 and 2 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 (due to the module mass) 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 and dissipated to the environment.

7.3 Short-circuit currents

The short-circuit currents are highly dependent 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 1 are based on a 26.4V module voltage and a 0 mΩ short-circuit load.

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

Module temperature	Configuration	Module internal resistance [mΩ]	Module peak short-circuit current [kA]
10 °C	MGLFP24x230 (230Ah)	8.5	3.1
	MGLFP24x280 (280Ah)	6.4	4.1
	MGLFP24x304 (304Ah)		
25 °C	MGLFP24x230 (230Ah)	6	4.4
	MGLFP24x280 (280Ah)	4.5	5.9
	MGLFP24x304 (304Ah)		
45 °C	MGLFP24x230 (230Ah)	4	6.6
	MGLFP24x280 (280Ah)	3	8.8
	MGLFP24x304 (304Ah)		

8 INTEGRATION

This chapter describes the necessary requirements, instructions and advice for integration of the battery module into the application.

8.1 Risk assessment

Performing a risk assessment for the integration of the battery system is depending on the application for which specific rules might apply. For example in a Marine application, class register rules might apply or on other cases standard CE-marking 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.

8.2 Location

The location of the battery system needs special attention, since some regulatory body 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.
- Ensure the battery space complies with the operating conditions of the batteries.
- Do not place the batteries next to a heat source.
- Accessibility for commissioning and service of battery modules must be maintained.
- Take into account the placement requirements in chapter 8.3.

8.2.1 Environment

The battery modules have an IP rating of IP30 (IP40 when the Ingress Protection Cover is installed). Placement of the battery modules must be in a dry space that is moisture and dust free, non-condensing and protected against fluid ingress (water, oil etc.) from top and bottom.

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

To protect the battery modules from both mechanical abuse and external environmental elements (such as water, moisture or fire), a solution could be to place the battery modules in a steel box or sealed compartment. The design and the requirement of applying a battery box may depend on the type of application, the outcome of a risk assessment, local regulations or additional safety measures prescribed by insurance companies.

For the implementation of a battery compartment the following additional measures could be included in the design:

- Isolated for 60 minutes fire retardant (A60).
- Fluid and gas tight.
- Gas exhaust connection to outside (safe area).
- Manual or automatic flooding option of the battery compartment.
- Temperature and/or smoke sensor.
- No electrical switching equipment or junction boxes inside.
- Place the battery modules with at least 10 mm clearance from the floor/bottom.
- Accessibility for commissioning and service of battery modules must be maintained.

NOTICE:
Respect the thermal management notes of the battery module in chapter 8.2.2 when used in sealed spaces or compartments.

NOTICE:
Always install the ingress cover protection on top of each battery module.
LFP 280 / LFP 304 / LFP 304 SLP = Article number: MG4000444,
LFP 230 = Article number: MG4000502

NOTICE:
Also find the guidelines for placement of batteries in a battery compartment on the MG Download Center

8.2.2 Thermal management

The LFP Series battery modules are air cooled. Therefore ambient temperature needs to be taken into account when selecting a space for the installation of the batteries.

- 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 are met. Temperature difference should in no way cause condensation on the battery module nor on other parts of the battery room.

8.2.3 Heat rejection

The heat rejection can be calculated from the internal resistance of the battery module. For detailed information refer to chapter 7.1 and 7.2.

8.3 Placement

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

8.3.1 Positioning the battery

The battery module may be placed upwards only.
Figure 13 shows the possible positions that are allowed.

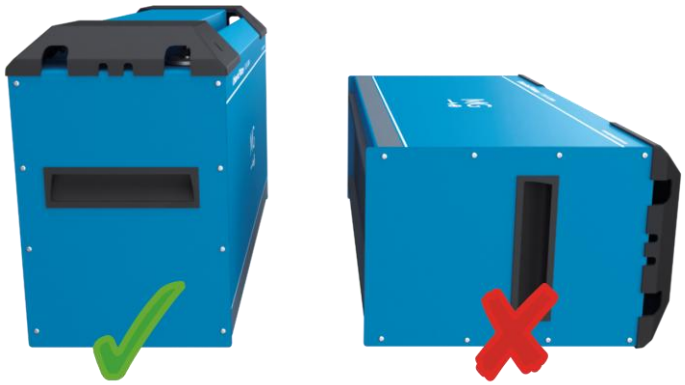


Figure 13 - Mounting positions of the LFP models

8.3.2 Mounting considerations

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

NOTICE:
- Mounting brackets or straps are not within the scope of delivery.
- Mounting accessories for 19 inch racks are available.

8.3.3 Battery module spacing requirements

Figure 14 shows the minimum spacing of the battery modules. It is mandatory to maintain a clearance of 10 mm from all sides of the battery module.

Figure 14 - Battery spacing requirements

8.4 Electrical

This chapter describes the installation and connections of the electrical wiring.

8.4.1 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 144 VDC.

NOTICE:

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

NOTICE:

Cable lug and battery must be cleaned before connection to ensure a low resistance connections. Check these power connections for excessive temperatures during a load test.

8.4.2 Parallel configuration

The battery module can be set in parallel to create a larger system capacity. The MG Master BMS can handle up to 96 LFP battery modules. Meaning that a 24 VDC system can have 96 LFP battery modules in parallel. For a 48 VDC system is would be 48 LFP battery modules in parallel.

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:

The power cables of each battery module need to have matching lengths as good as possible when connecting battery modules in parallel.

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

Figure 15 shows the most basic parallel connection that is possible. The power connection of each battery is directly connected to a Master LV.

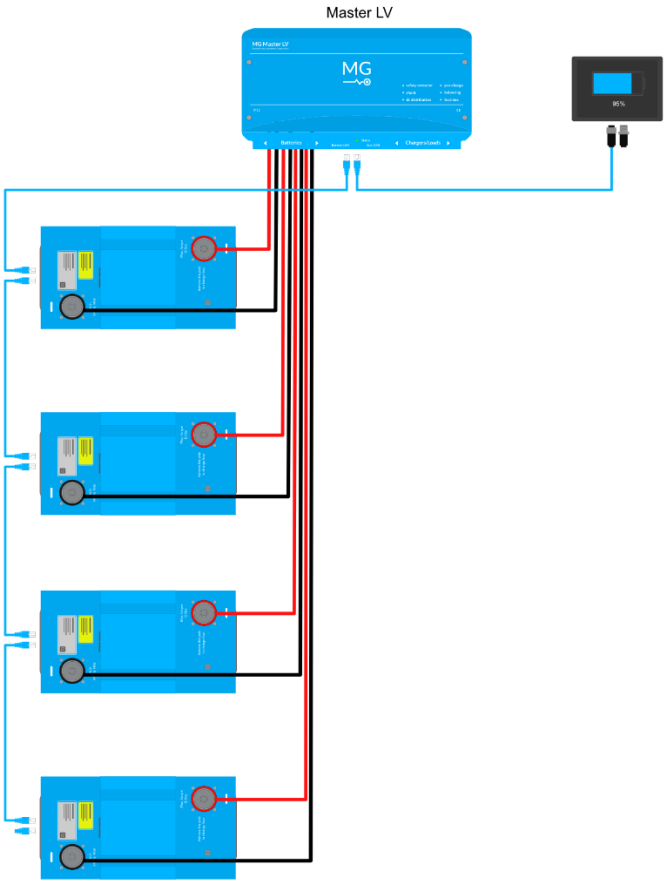


Figure 15 - Four battery module connected in parallel on a single Master LV. Cables must have matching lengths.

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.

8.4.2.1 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 16 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.

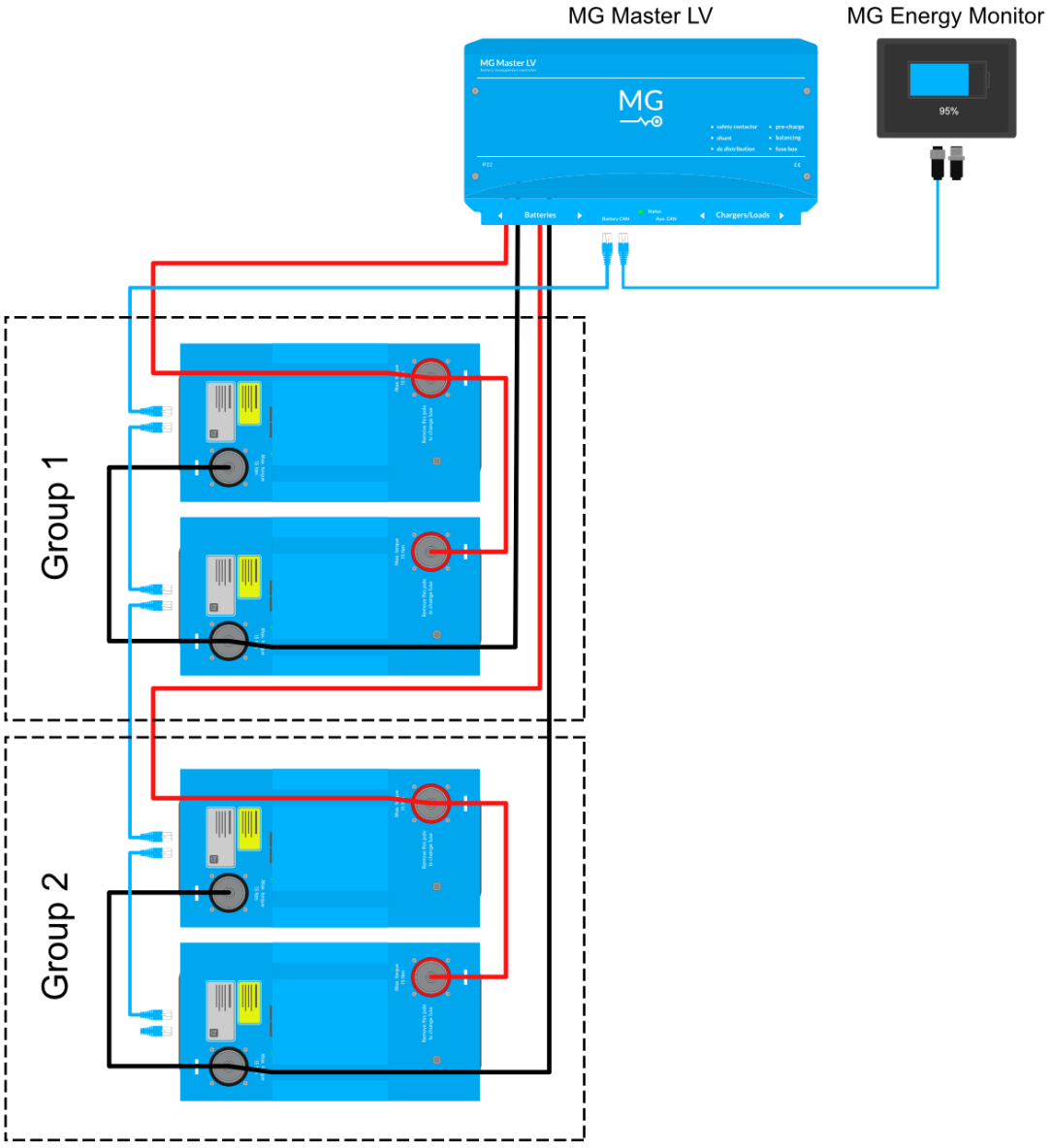


Figure 16 - Example of battery modules paralleled in groups

NOTICE:

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

Figure 17 shows the same paralleling method, but used for a 48 V system where battery modules are connected in series.

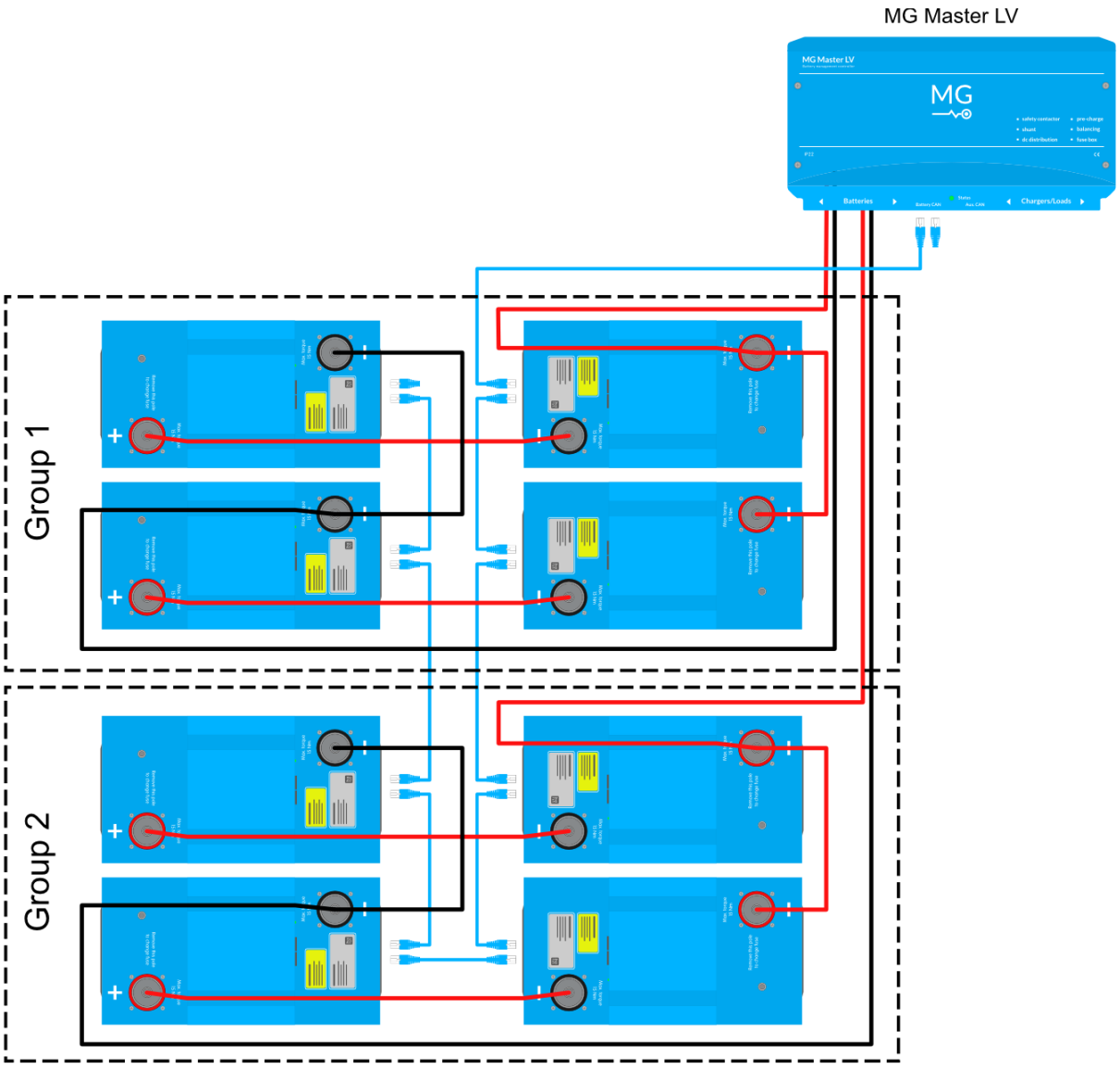


Figure 17 - Example of 48 V system with paralleled groups

8.4.3 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 18 shows an example of paralleling battery modules using the MG Distributor LV's.

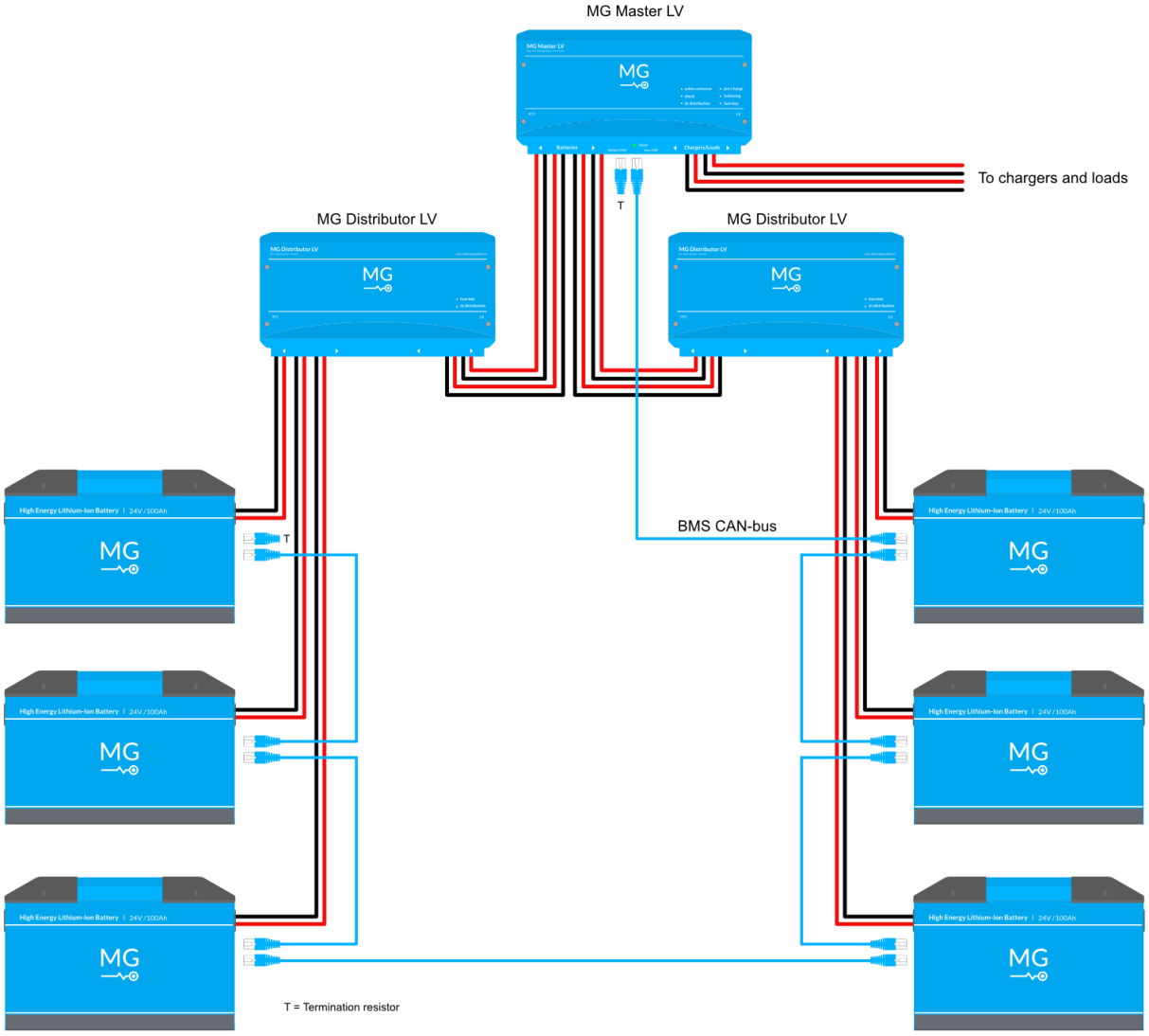


Figure 18 - Example of parallel connection with MG Distributor LV's

8.4.4 Paralleling using a custom bus bar connection system

Designing a custom DC-busbar system is beyond the scope of this manual.

8.4.5 Series configuration

The battery modules can be connected in series. Table 13 shows the maximum number of battery modules in series per battery type.

Table 13 - Maximum number of modules in series per battery type.

Article number	Voltage range	Maximum number of modules in series
MGLFP240280	24 V up to 96 V	4
MGLFP241280	24 V up to up 144 VC	6
MGLFP242280	24 V up to up 470 V	16
MGLFP240230	24 V up to 96 V	4
MGLFP241230	24 V up to up 144 V	6
MGLFP242230	24 V up to up 470 V	16
MGLFP240304	24 V up to 96 V	4
MGLFP242304	24 V up to up 470 V	16
MGLFP244304	24 V up to 563 V	22

WARNING:
The fuse in each battery pole must be replaced by a non-fused battery pole when connecting more than 2 batteries in series. See chapter 6.2.2.1.1 for details and article number.

WARNING:

- Make sure high voltage battery systems cannot be accessed 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 service disconnect.

Figure 19 shows an example system of 6 battery modules in series connected to a MG Master HV.

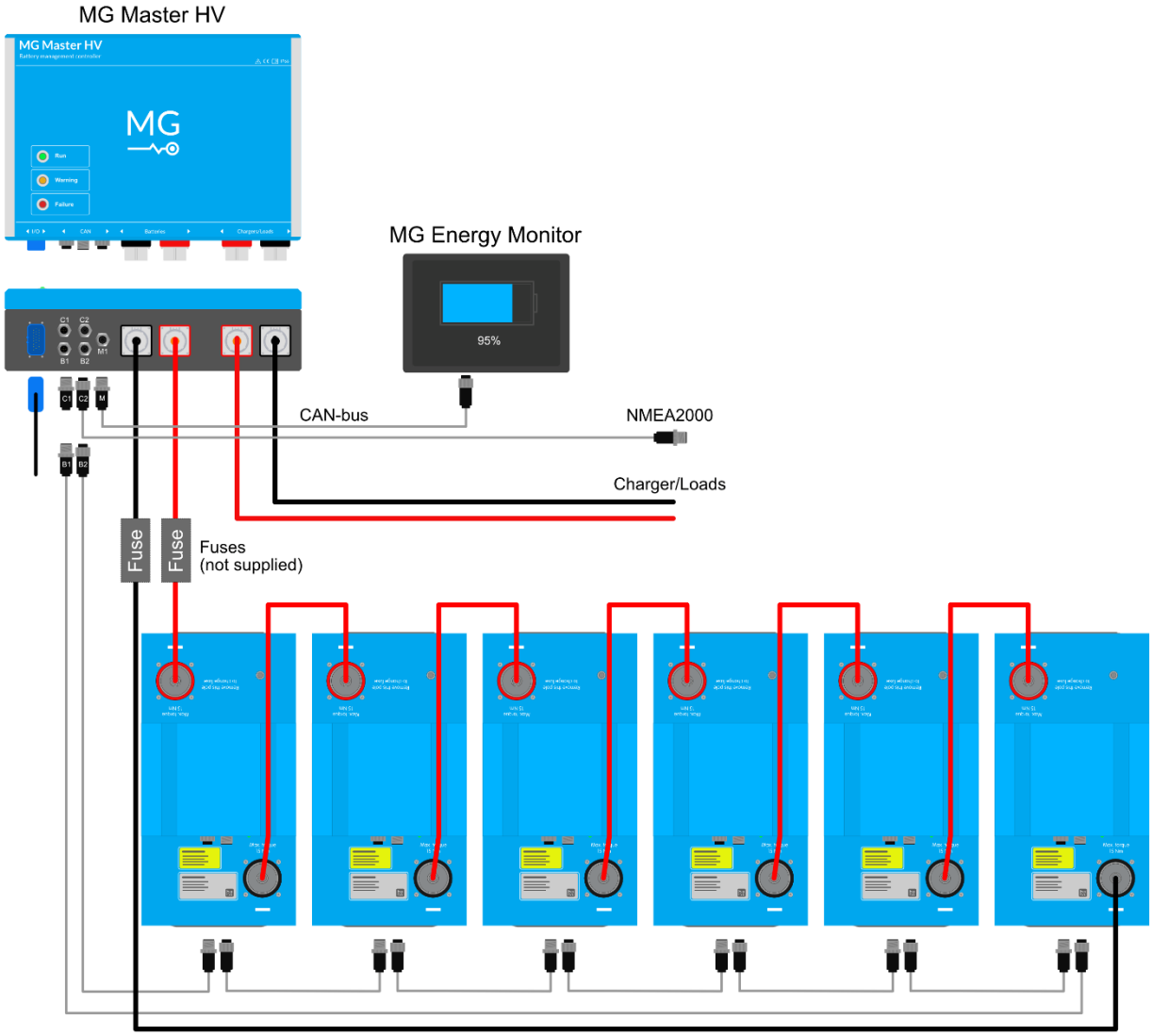


Figure 19 – Series configuration example

WARNING:
In systems with voltages > 58 V an insulation monitor is required.

NOTICE:

- Use the correct cable type for the applicable system voltage.
- Use the correct fuses for the applicable cable cross-section and voltage.

8.4.6 Charging

Any charger with constant voltage (CV) constant current (CC) charging can be connected to the MG battery system. 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 dry 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.

8.4.6.1 Periodic charging

It is important to charge the batteries regularly to 100%. This is necessary to recalibrate the State-of-Charge. The time of this period depends on the application and usage. Typically once a week should be sufficient.

NOTICE:
Recalibration of the SOC is performed at the end of the charge cycle. This means that sometimes the SOC is already at 100%, but the charger is still charging. It is important to let is charge until the Master BMS stops the charging.

8.4.6.2 Charger settings

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

Absorption voltage	28,2 VDC
Float voltage	26,4 VDC

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

9 INSTALLATION

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

Additional information for installation:

- Installation video: LFP 24V
- Quick installation guide: LFP 24V 230/280/304
- Quick installation guide: LFP 24V 304 SLP
- Technical drawings
- Application Notes

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.

9.1 Tooling

The required tools during installation are the following:

- Phillips screwdriver PH1 (insulated);
- Torque wrench M5 (8 mm) + M8 (13 mm) (insulated);

9.2 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. Installing the top ingress protection cover;
5. 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.

9.3 Mounting procedure

The battery module has no specific mounting points. Instead it can be mounted with brackets or straps as stated in chapter 8.3.2.

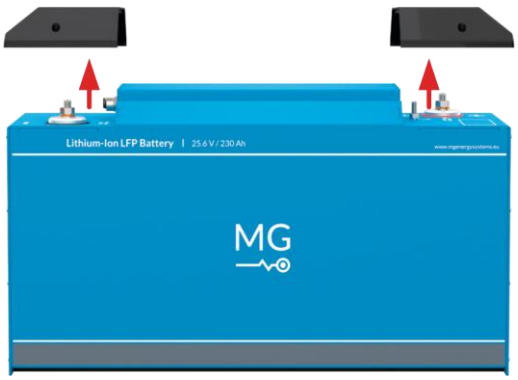
9.4 Electrical connection procedure

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. There is a connections procedure for the M8 Bolt terminal connection of the standard LFP battery and a SLP battery terminal connection procedure for the LFP-SLP battery module.

9.4.1 M8 Bolt battery terminal connection procedure

Before any electrical connection can be performed, the top covers from the battery module must be removed.

PH1



ELECTRICAL HAZARD:
The battery modules can be placed in series up to 144 VDC. Make sure to wear proper insulation gloves and safety goggles.

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

9.4.1.1 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 mm^2.

When the system voltage is > 58 Vdc then connect a 6 mm^2 wire from the equipotential bonding point of each battery module in the system to a Protective Earth (PE). Tighten it with 4Nm.

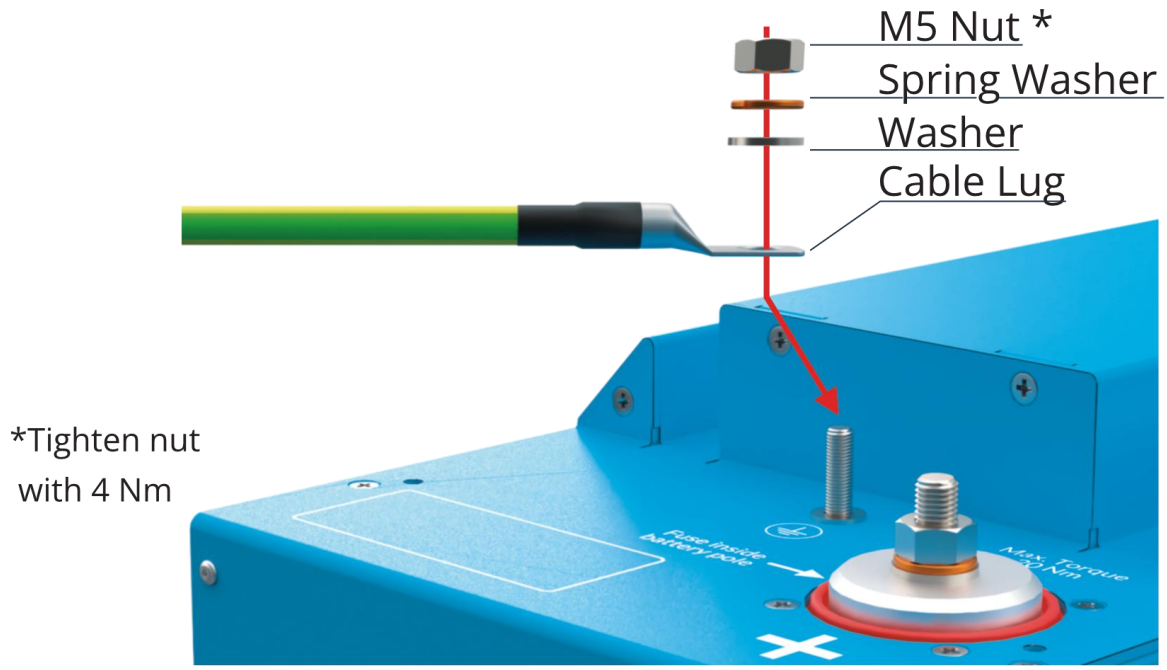


Figure 20 - Connection example of Equipotential bonding

ELECTRICAL HAZARD:
Make sure the equipotential bonding cable is routed with free clearance of the battery pole.

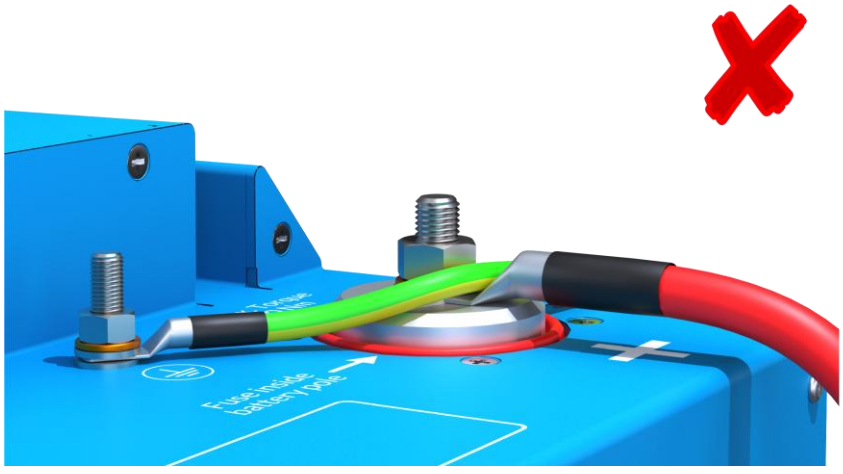


Figure 21 - Wrong routing of equipotential bonding wire

9.4.1.2 Positive and negative power connection procedure

Before connecting any power cable make sure the routing of the power cables is made properly. Figure 22 shows a wrong connection of the power cable which will interfere with the CAN-Bus connectors and protection cover. Figure 23 shows a good connection of the power cable. Refer to chapter 8.4 for details about the power connections.

Figure 22 - Wrong connection of power cable

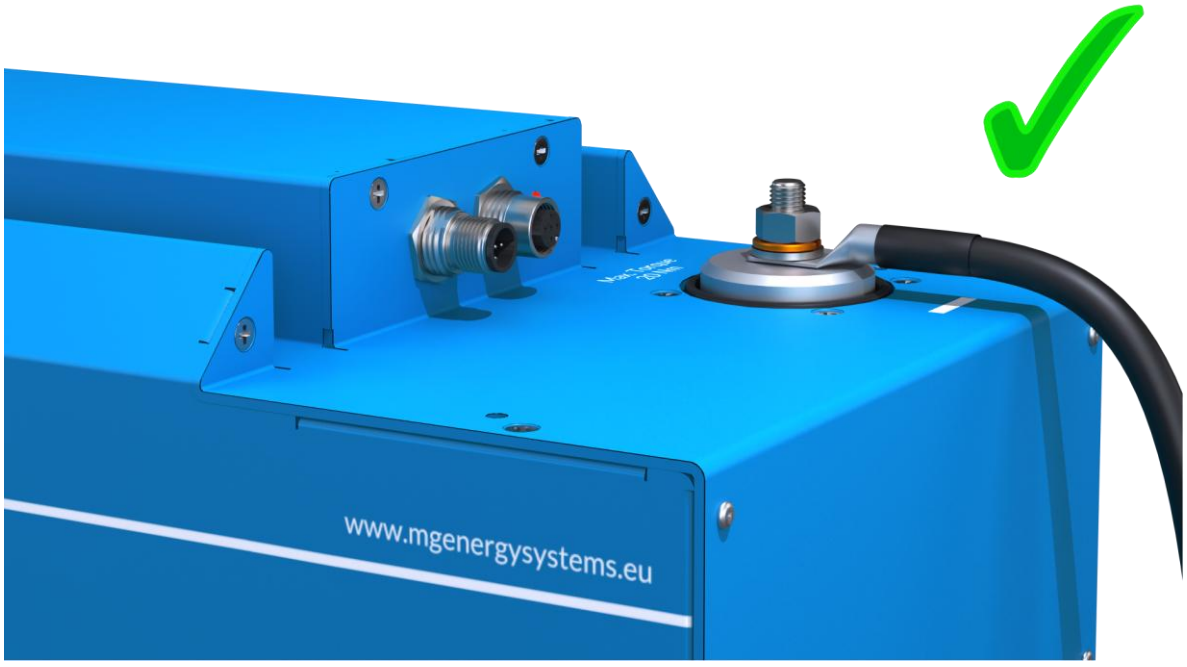
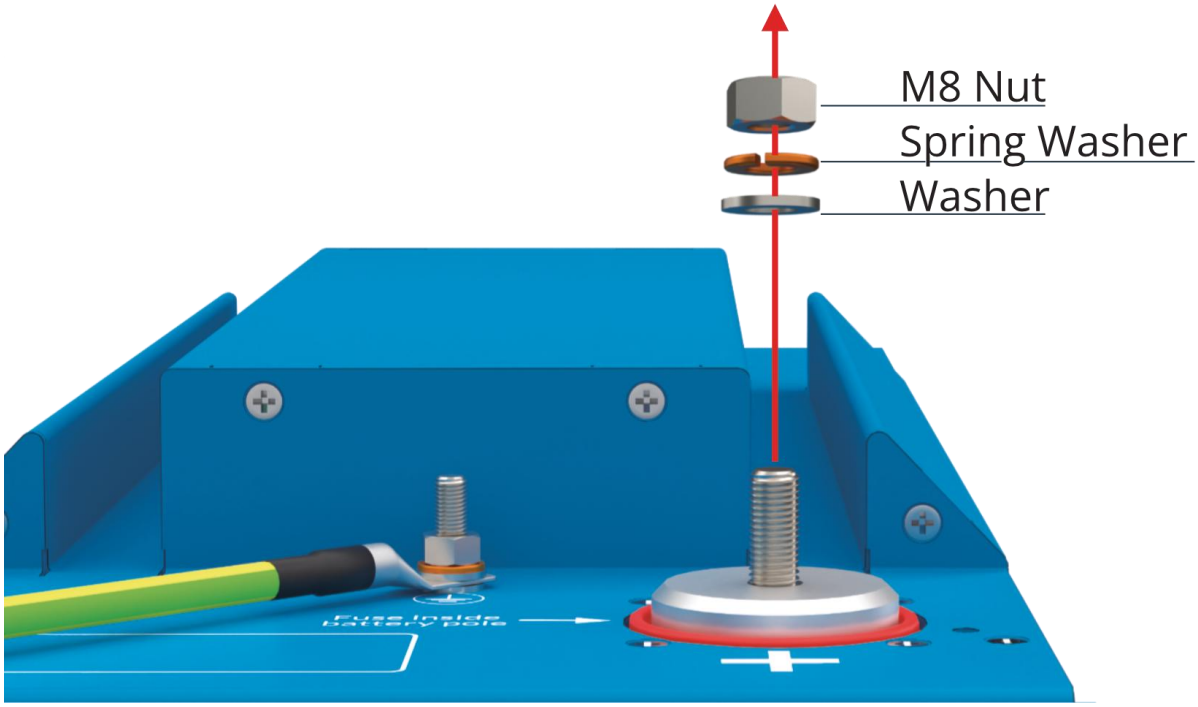


Figure 23 - Good connection of power cable

Below the procedure for connecting the power cables to the battery.

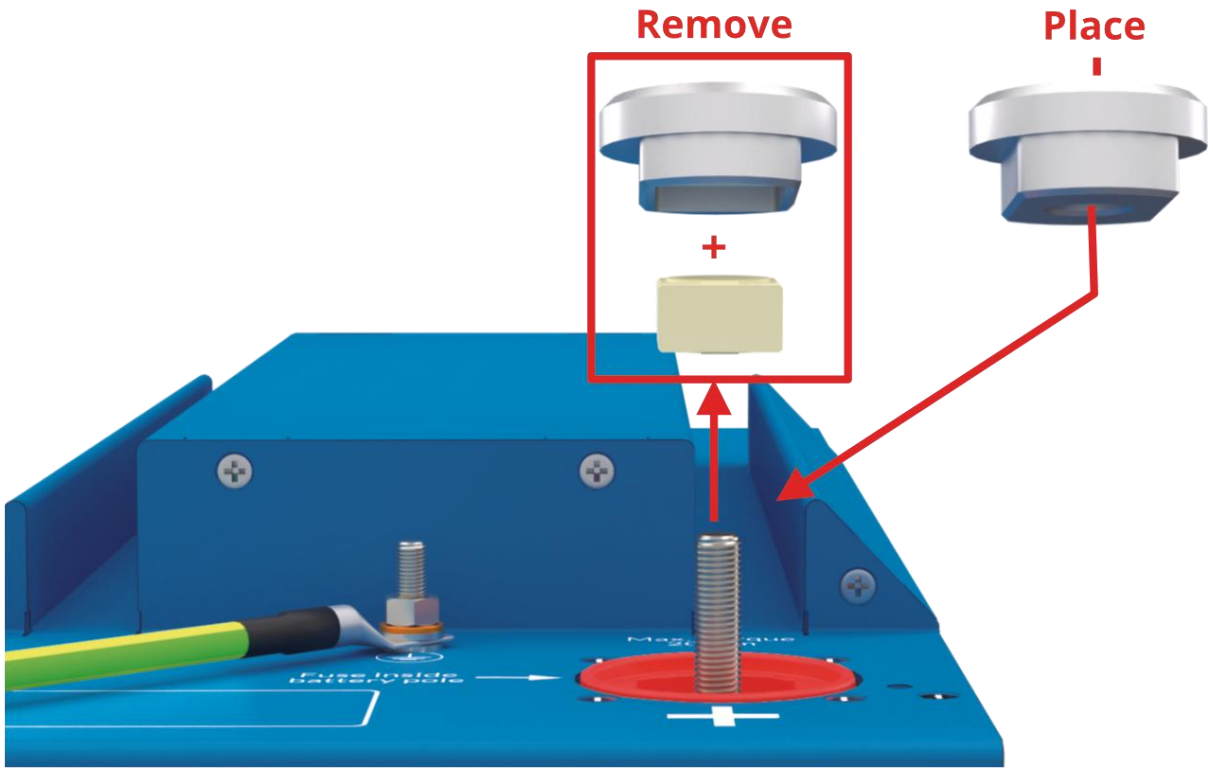
1. Remove the nut, spring washer and washer from the positive battery pole.



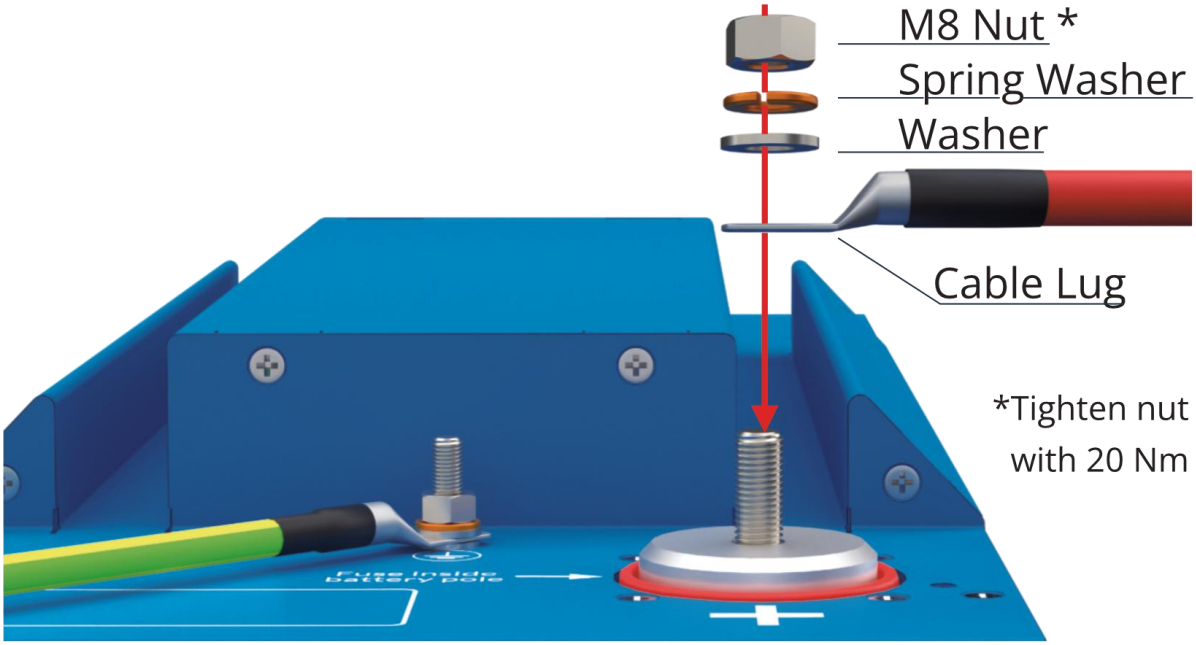
NOTICE:
When removing the nut and washers from the battery pole, it will become loose. This is normal. When the cable is connected and the nut and washers are back in place it will be tightened again.

2. Clean the battery pole and the cable lug's contact surfaces for a low resistance connection.

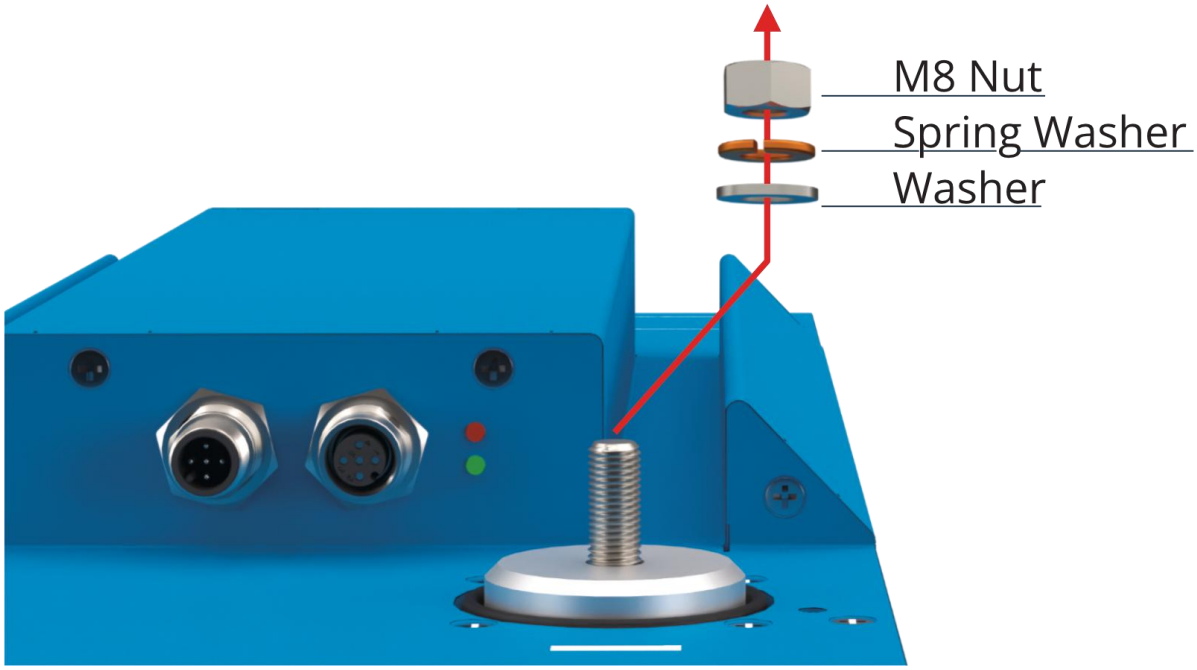
3. Depending on the system voltage or specific system design the battery fuse must be removed. In case of **system voltage > 58 Vdc**: replace battery pole + fuse with non-fused battery pole.



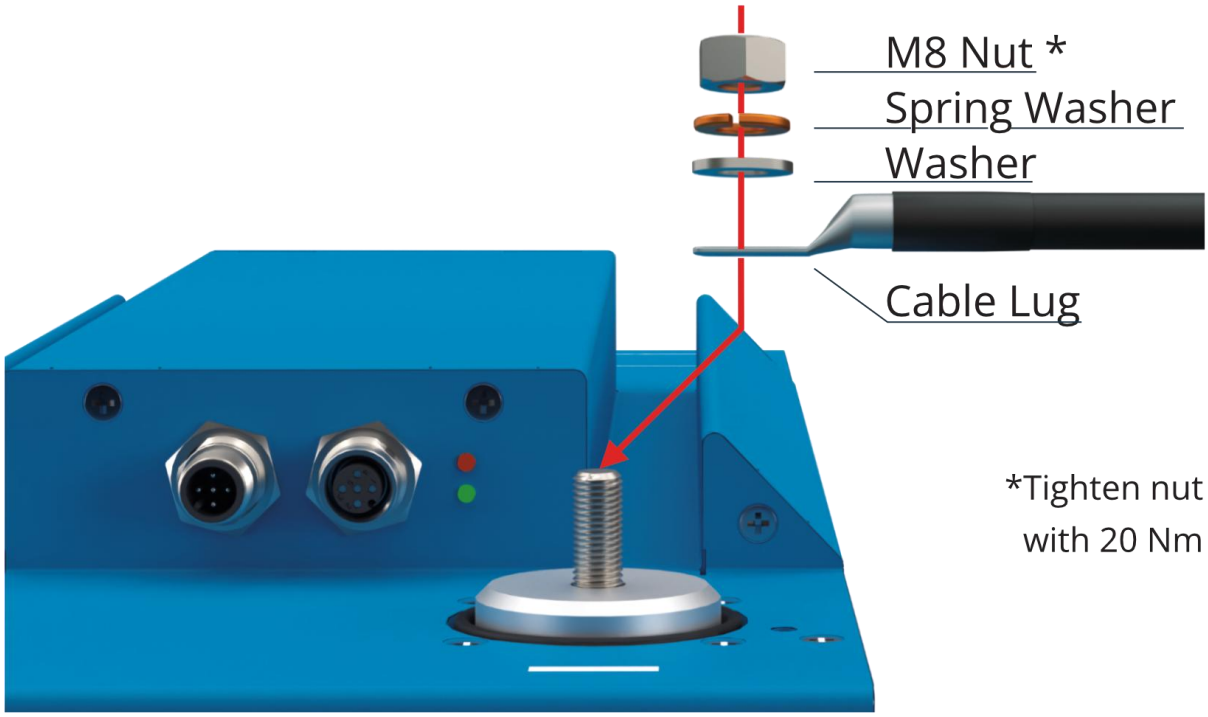
4. Connect the positive power cable with M8 cable lug to the M8 bolt as shown and place back the washer, spring washer and nut. Tighten the nut with a torque of 20 Nm.



5. Remove the nut, spring washer and washer from the negative battery pole.



6. Clean the battery pole and the cable lug's contact surfaces for a low resistance connection.
7. Connect the negative power cable with M8 cable lug to the M8 bolt as shown and place back the washer, spring washer and nut. 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.

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.

ELECTRICAL HAZARD:
Make sure power cables are routed properly to avoid sharp edges and other possible causes of a short-circuit. It is recommended to protect the cables with a conduit system.

9.4.2 SLP battery terminal connection procedure

Before any electrical connection can be performed, the front top cover from the battery module must be removed.

ELECTRICAL HAZARD:
The battery modules can be placed in series up to 563 V. Make sure to wear proper insulation gloves and safety goggles/mask.

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

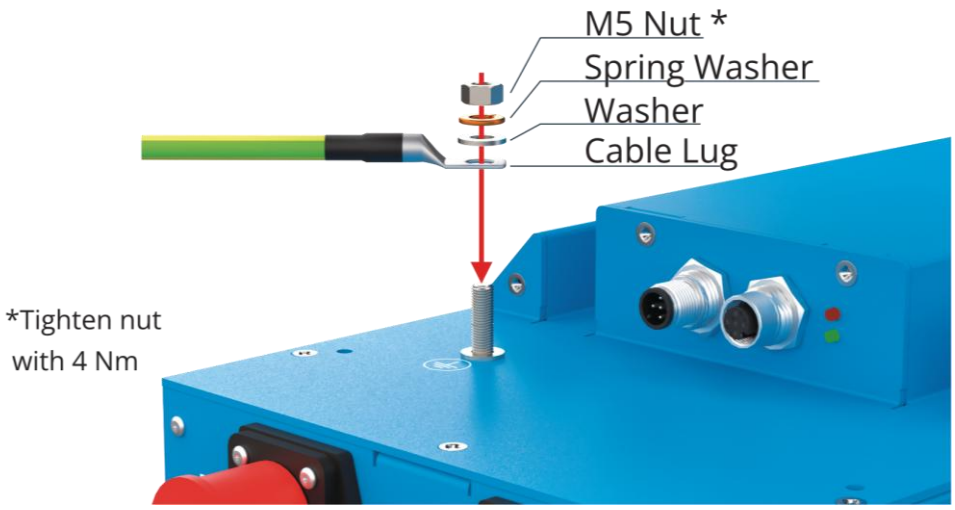
NOTICE:
The red protection caps protect the battery connectors from dust, moisture and particles during installation. Remove these caps only right before connecting the power cables.

Before connecting any power cable make sure the other end of the cable is connected to the MG Master BMS or a DC-distribution system.

9.4.2.1 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 mm^2.

When the system voltage is > 58 Vdc then connect a 6 mm^2 wire from the equipotential bonding point of each battery module in the system to a Protective Earth (PE). Tighten it with 4Nm.



9.4.2.2 Positive and negative power connection procedure

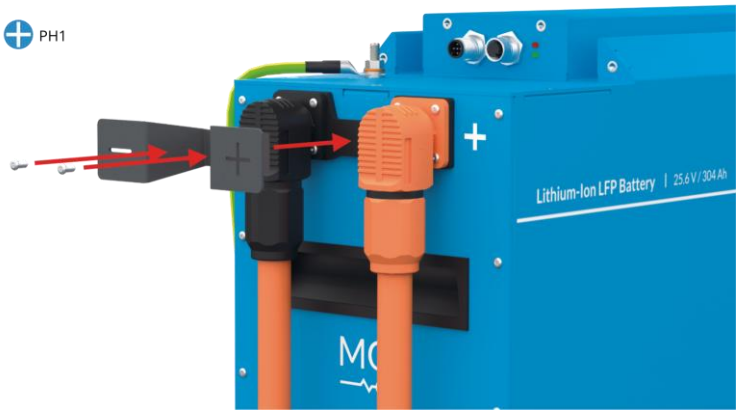
Before connecting any power cable make sure the other end of the cable is connected to the MG Master BMS or a DC-distribution system.

Below the procedure for connecting the power cables to the battery.

1. Remove the protection caps from the battery terminals.

2. Connect the SurLok connectors until it clicks. Pull each connector to make sure it is locked.

3. Mount the front clamp.



9.4.3 CAN-bus connection procedure

The battery modules communicate 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, MG Master HV manual.

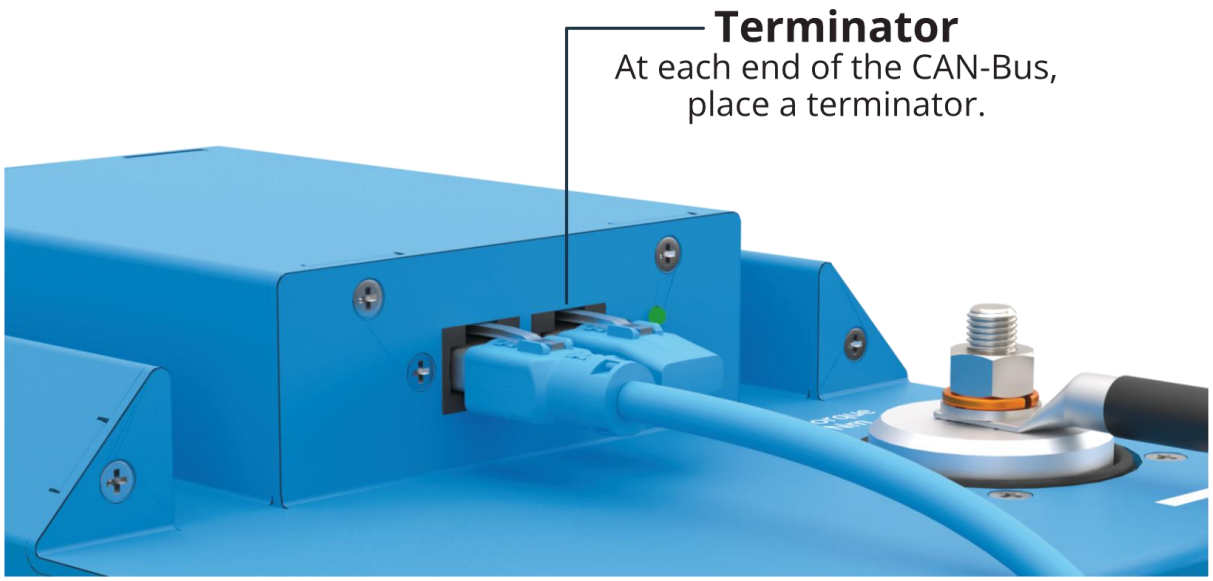


Figure 24 - RJ45 battery connection

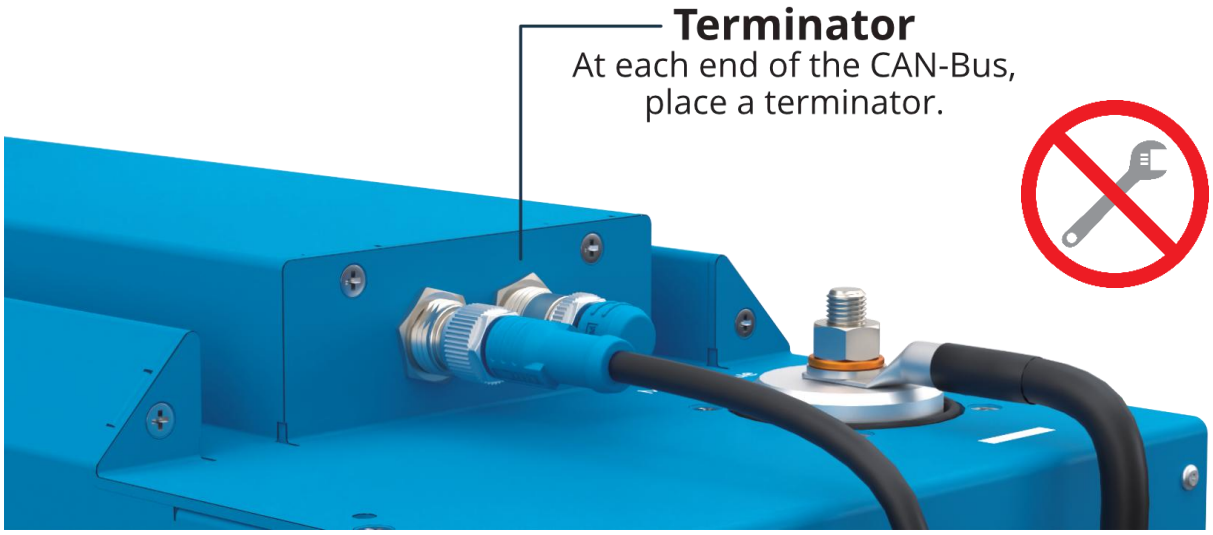


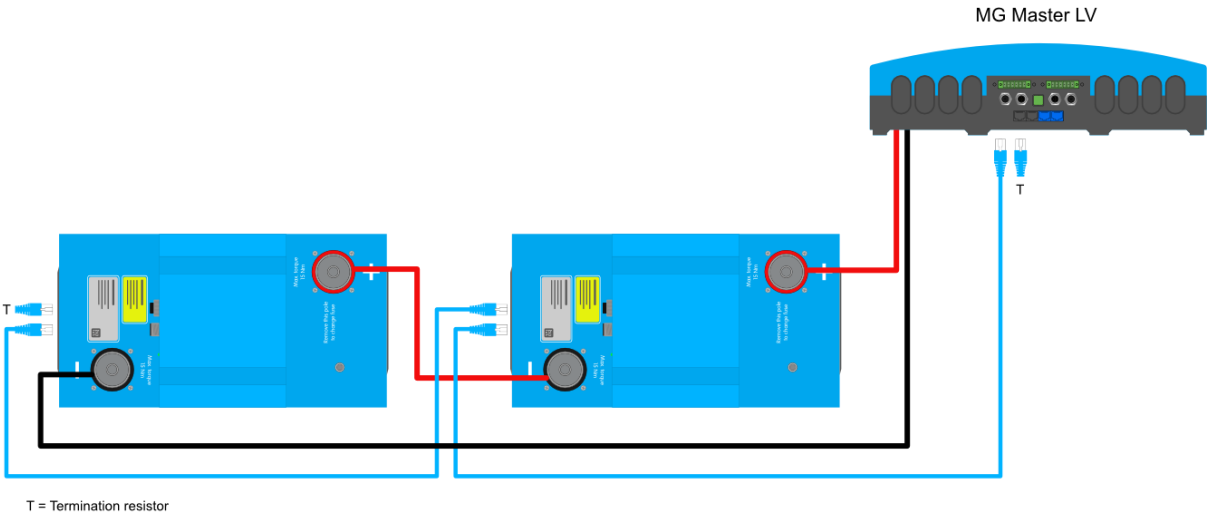
Figure 25 - M12 battery connection

9.4.3.1 Basic connection

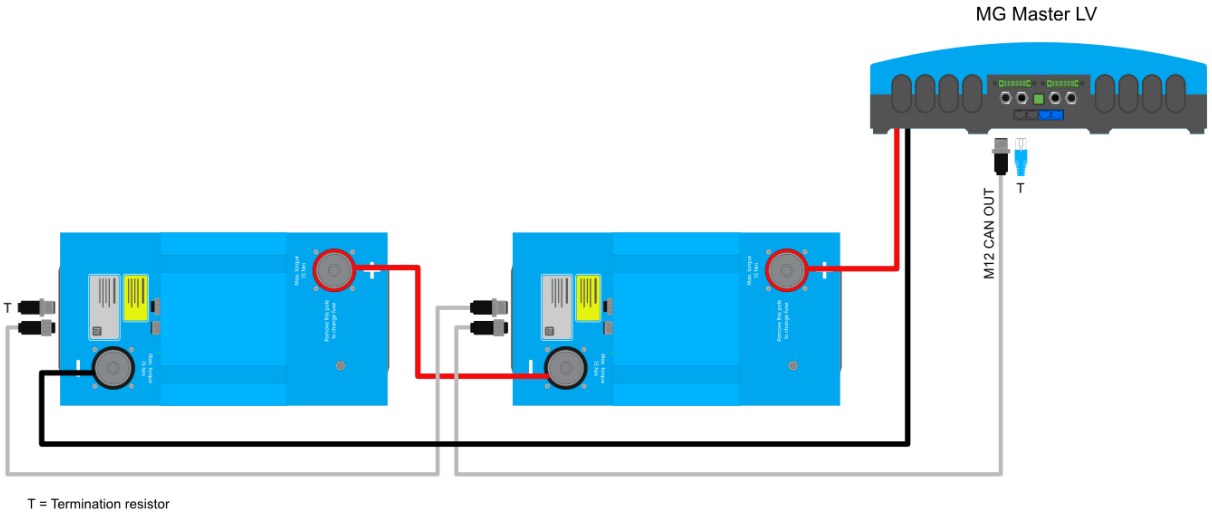
The most basic connection is as follows:

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. Place a termination resistor at the end and begin of the CAN-bus network.

RJ45 connection:



M12 connection:



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

9.5 Installing the top ingress protection cover

The top ingress protection cover is used to protect the battery module against the ingress of liquids from the top. This chapter describes the installation of the cover.

Figure 26 - Top ingress protection cover for LFP 230 and LFP 280

9.5.1 Batteries with M8 bolt terminals

The two black covers needs to be mounted before the top ingress protection cover can be mounted.

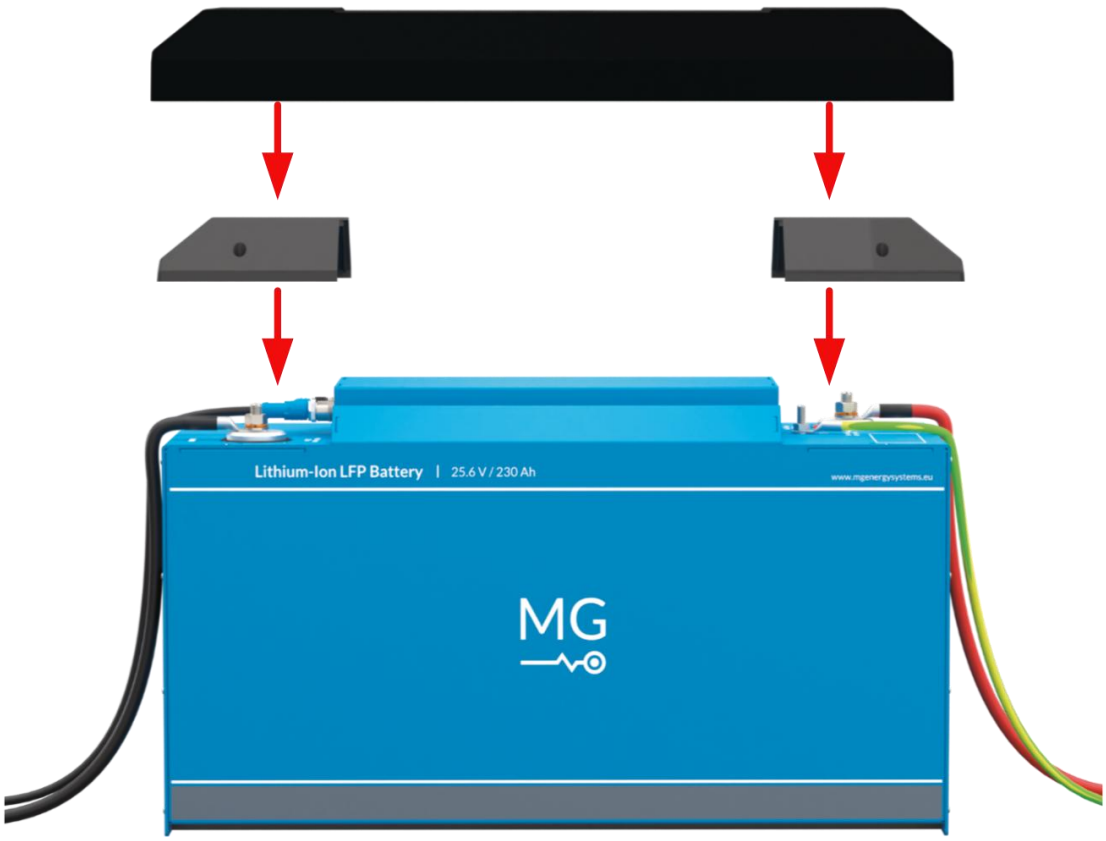
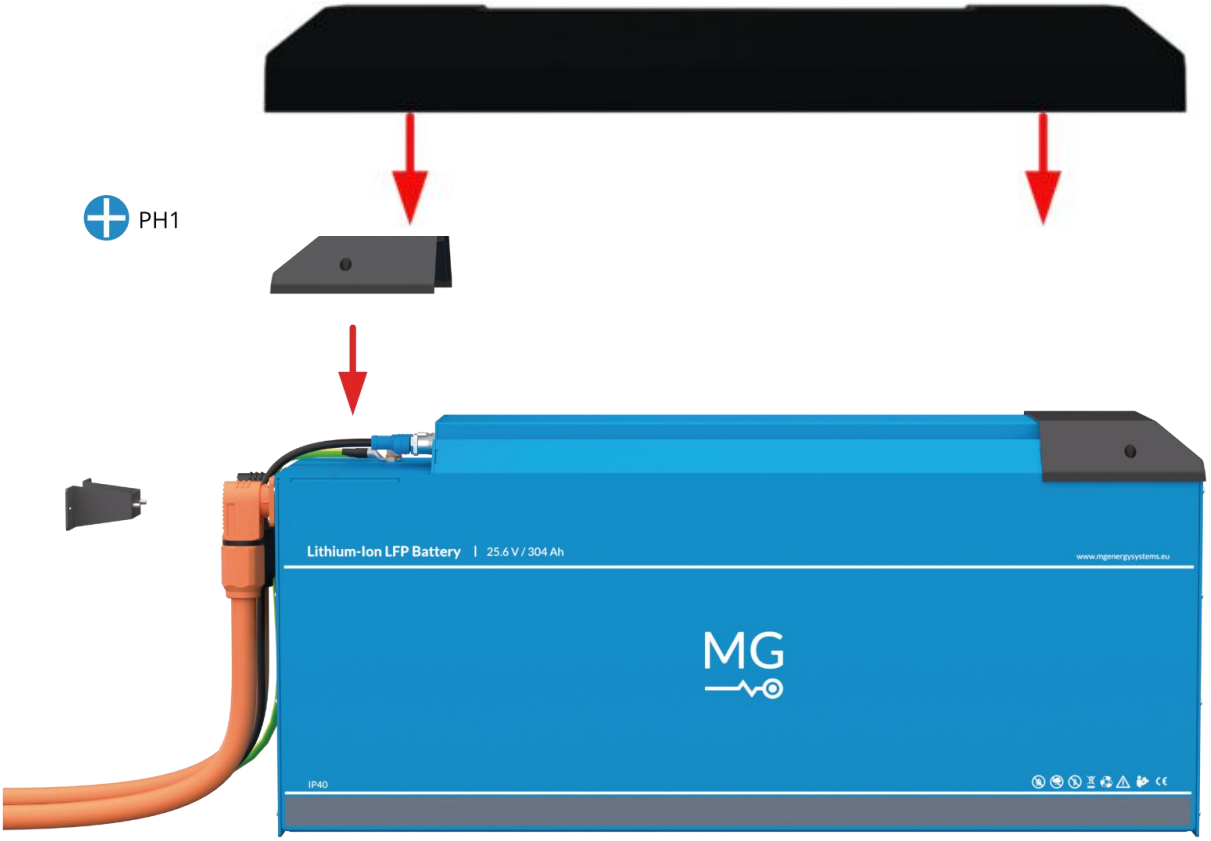


Figure 27 - Mounting ingress cover on top of battery module

9.5.2 Batteries with SLP connectors

The two black covers needs to be mounted before the top ingress protection cover can be mounted.



9.5.3 Placing the cover

The cover can be placed over the modules even when the cables are connected. The flexibility of the cover makes it to fit to almost every existing installation. In some cases the cover must be cut to make it fit. See chapter 9.5.5 for details on cutting the cover.

1. Place the ingress protection cover at three corners first as shown in Figure 28.

Figure 28 - First place three corners

2. Press the last corner in place until it snaps.

Figure 29 - Press the last corner

Figure 30 shows an example of a cover installed on a battery module.

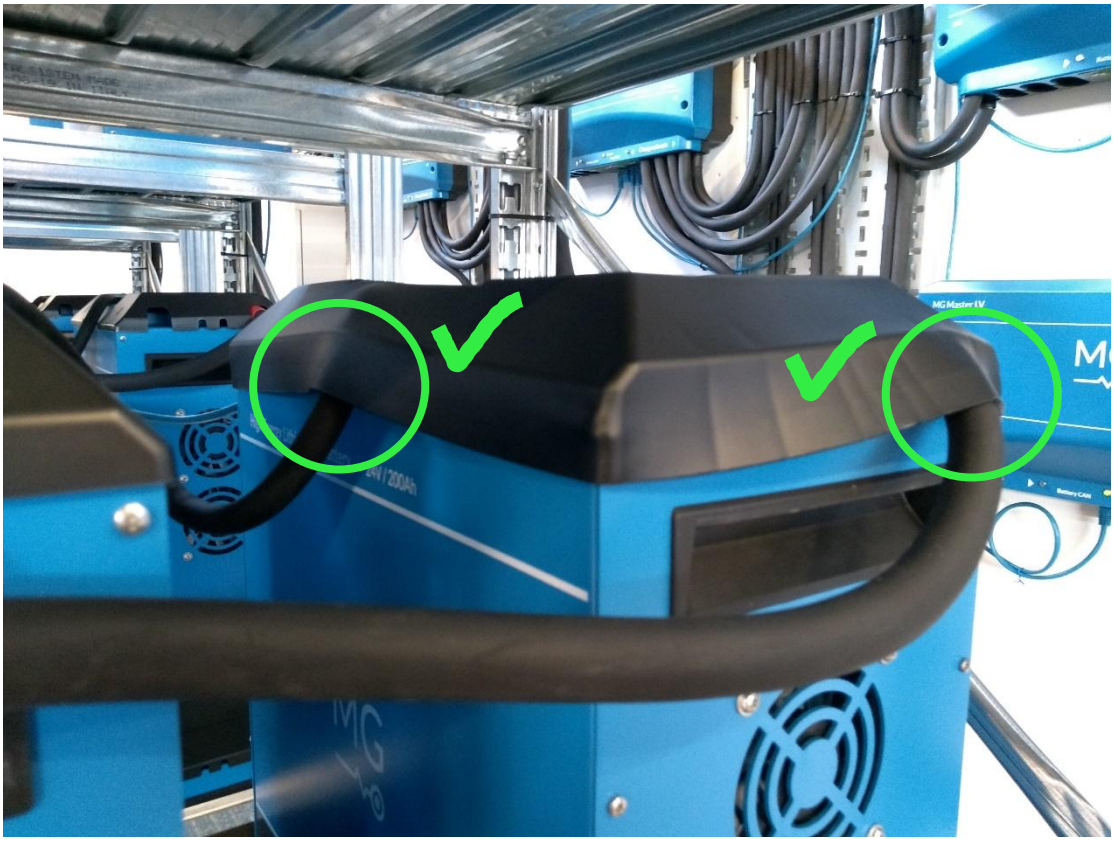
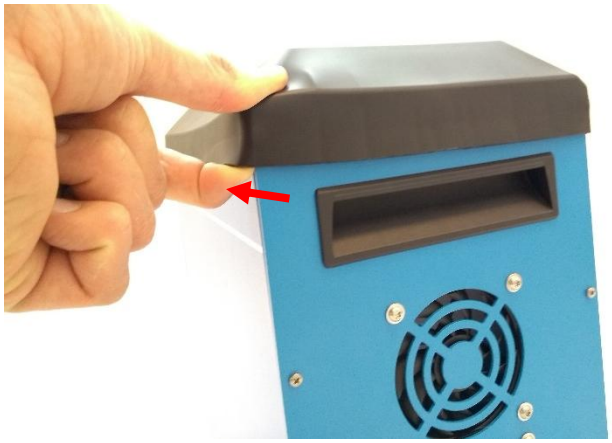


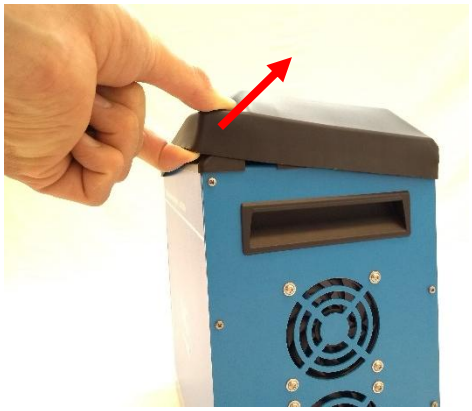
Figure 30 - Example of cover in installation

9.5.4 Removing the cover

1. Pull **one** corner away from the battery

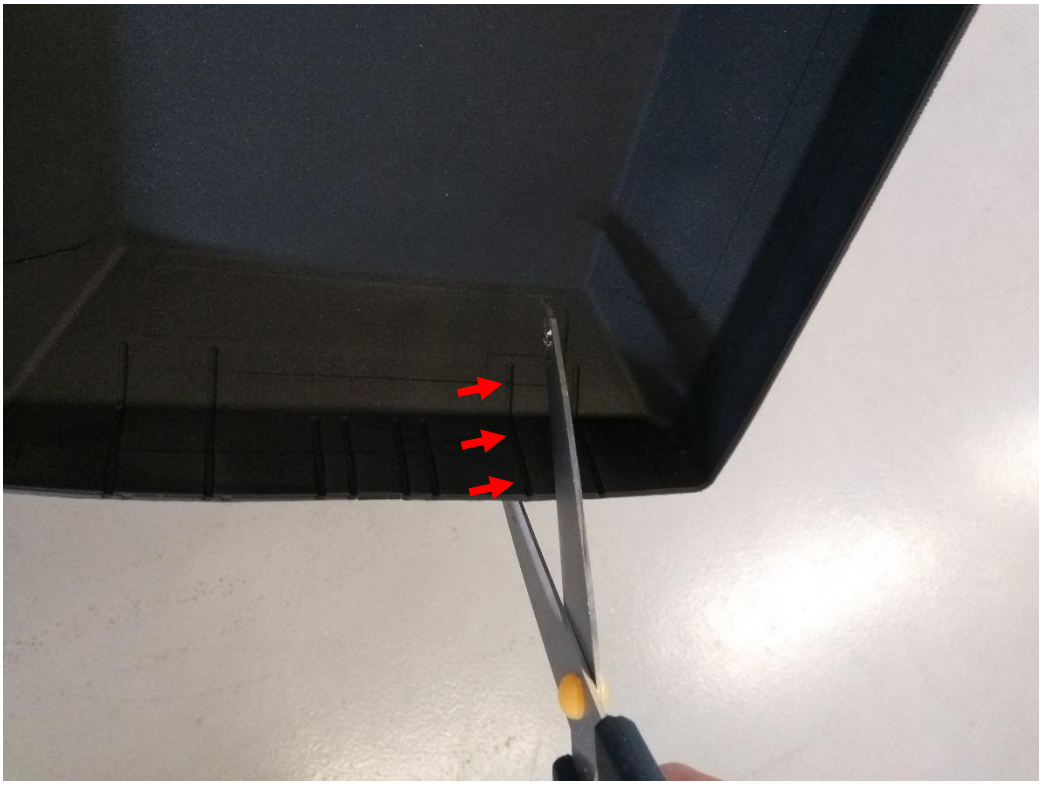


2. Lift the cover to release it.



9.5.5 Cutting the cover

If cutting is required use the cut lines at the inside of the cover as guide.



Do not remove the flap because it prevents water drips of entering the battery module or cable.

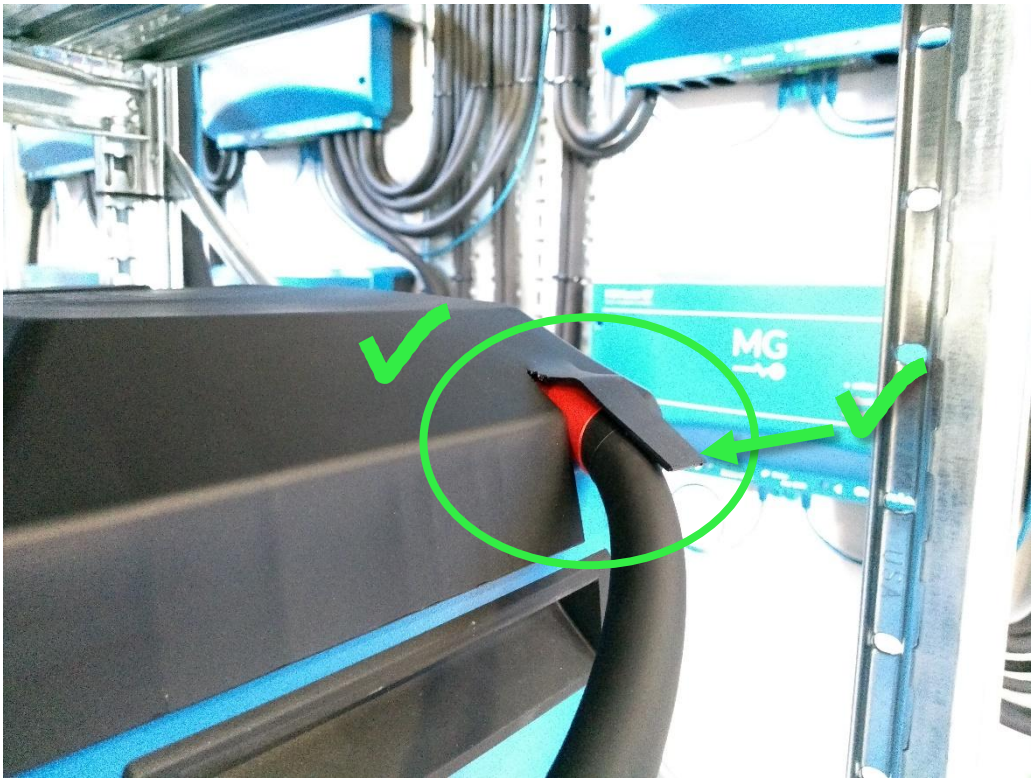


Figure 31 - Example to cutting out cable release.

9.6 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 non-fused battery pole.

WARNING:

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

9.6.1 Non-fused battery pole

The non-fused battery pole is actually a regular negative battery pole. Figure 32 shows the difference between the two.

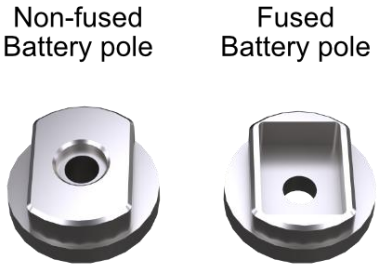
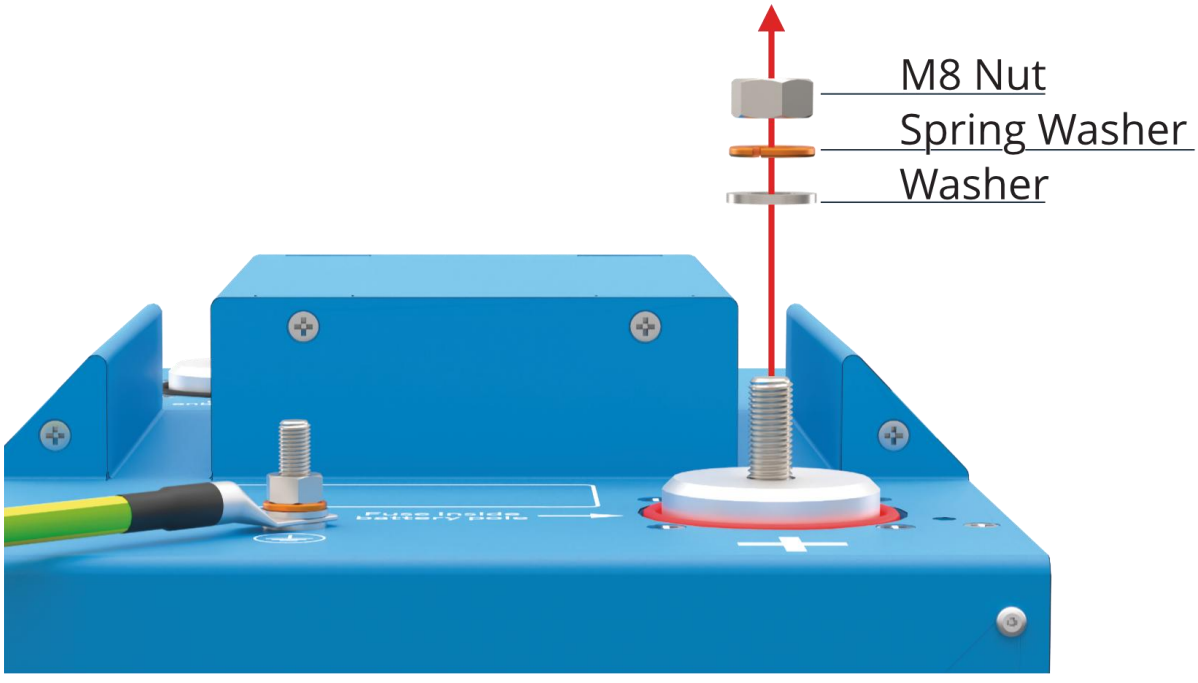


Figure 32 - Overview of negative and positive battery pole.

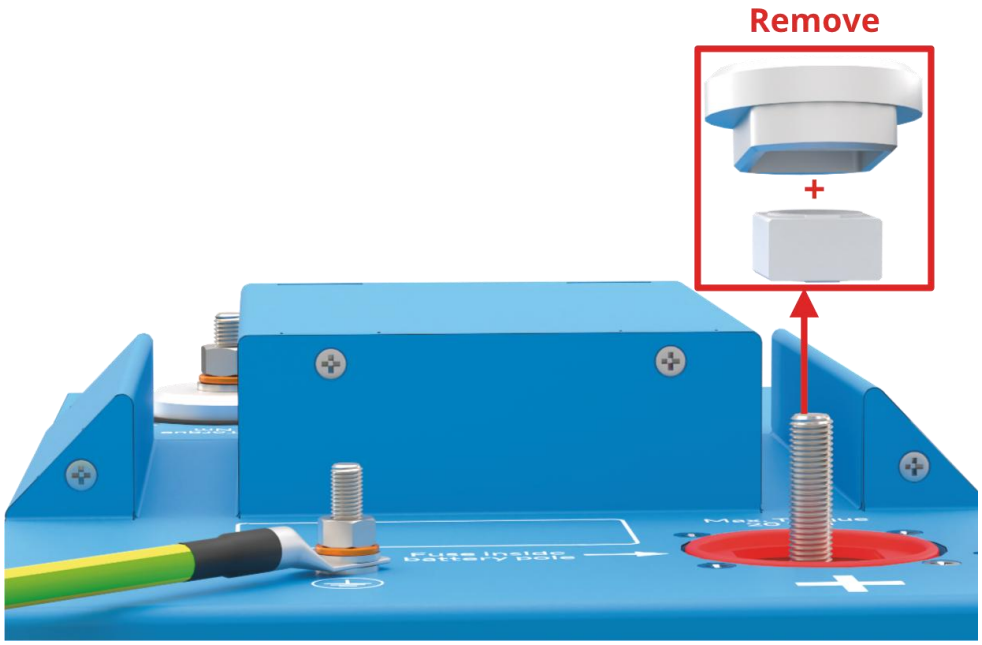
9.6.2 Replacement instructions

1. Remove the nut, spring washer and washer from the positive battery pole.



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 are back in place it will be tightened again.

2. Remove positive battery pole and fuse.



3. Now the fuse can be checked and replaced with a new one or it can be replaced with a non-fused battery pole. If the fuse is replaced with a non-fused battery pole then clean the battery pole with a fine sanding block (scotch-brite). Recommended is to add an electrical joint compound for better conduction.

4. 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.

5. Connect the power cables with the instructions of chapter 9.4.1.2.

10 COMMISSIONING

Table 14 shows a list of points that need to be checked after installation.

Table 14 - Commissioning steps procedure

	Description
❑	Is a risk assessment performed?
❑	Are the location and placement requirements in chapter 8.2 and 8.3 met?
❑	Are the batteries installed in a location where there is no possibility fluids can enter the battery module from the top or bottom? For example installation under the seams of hatches.
❑	Are the battery modules clean from any dust, metal pieces and loose wires?
❑	Are the batteries secured?
❑	Are the equipotential bonding cables connected, if applicable?
❑	Are the battery fuses replaced in case of system voltage of > 58 Vdc?
❑	For M8 bolt connection terminals: Are all battery terminal power connection tightened with 20 Nm? For SLP connector terminals: Are all battery terminal connectors plugged in until clicked?
❑	Are all CAN-bus cables connected?
❑	Are CAN-bus termination resistors installed in the correct way?
❑	Make sure there is not any equipment connected directly to the batteries.
❑	Is the top ingress protection cover installed?
❑	Perform a charge/discharge test run and measure the temperature of the battery terminals during the test. Is there excessive heat generation in the system or system components?
❑	Make a “Support Request”. This can either be done with the MG Diagnostic Tool or MG Connect App. See following links for details: - MG Diagostic Tool - MG Connect App
❑	Make pictures of the installation.
❑	Send the pictures and this form together with the system commissioning form to support@mgenergysystem.eu with the subject: <project name> - Commissioning.

NOTICE:
For the 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.

11 DECOMMISSIONING PROCEDURES

This chapter describes procedures to decommission the battery system or module in 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;
- Smoke/gas released from the battery module enclosure;
- 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 is 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(s).

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 or remove the fuses from the MG Master BMS and in other location of the battery system.
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 cables 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. Remove the battery module.
7. Place the battery module in a water filled container at a safe location, for example outside or in a special container. 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 cables and/or fuses 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.

- 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 if the batteries are secured.
- Check the electrical connections on torque.
- 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.

12.2 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.

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 1.31 or higher
- Master LV 1.40 or higher

13.1 Limits

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

The tables with the boundary limits consist of:

- *Description;* Description of the boundary limit;
- *Trigger action;* Action response of the boundary limit;
- *Condition;* Contains a required condition of a value triggering the action in combination with the time delay;
- *Delay*; The amount time a condition must be met before an indication will be activated or deactivated. A delay time with "+" starts counting when the previous condition is reached.

13.1.1 Trigger actions

Different actions are triggered for the parameters and conditions in the boundary limit tables followed by this paragraph. The list below gives all the possible trigger actions and their description. When the tables shows a trigger action that sets a particular flag, it will set the flag of the description in the corresponding flag register. For example. If an "Over voltage warning" condition is true, it will set the "Over voltage" flag in the warning register.

- *Status flag;* This flag is in a general purpose status register. Depending on the configuration of the connected Master BMS it might also trigger digital outputs. For example the Allow-to-Charge relay or the Allow-to-discharge relay.
- *Warning flag;* This flag is in the warning register. Depending on the configuration of the connected Master BMS it might also trigger digital outputs. For example the Programmable relay.
- *Fail-safe flag;* This flag is in the fail-safe register. When a corresponding parameter flag is set then this will trigger the Master BMS to open its main safety contactor.
- *Safely lock flag;* This is a single flag. When this is set, it will open the main safety contactor of the Master BMS and lock it to prevent start-up. It can be unlocked after a check-up by a certified dealer. Contact MG Energy Systems B.V..

13.1.2 Cell voltage

Table 15 Cell voltage boundary limits slave BMS

Charging				
Description	**Trigger action**		**Condition**	**Delay**
Almost charged	Set	Status flag	>= 3440 mV	10 sec.
	Clear		< 3390 mV	10 sec.
Charged	Set	Status flag	>= 3520 mV	+10 sec.
	Clear		< 3440 mV	10 sec.
Over voltage warning	Set	Warning flag	>= 3600 mV	+20 sec.
	Clear		< 3520 mV	20 sec.
Over voltage critical	Set	Fail-safe flag	>= 3650 mV	+5 sec.
Over voltage safety lock	Set	Lock flag	>= 3850 mV	-

Discharging				
Description	**Trigger action**		**Condition**	**Delay**
Almost discharged	Set	Status flag	<= 3100 mV	10 sec.
	Clear		> 3150 mV	10 sec.
Discharged	Set	Status flag	<= 3000 mV	+10 sec.
	Clear		> 3100 mV	10 sec.
Under voltage warning	Set	Warning flag	<= 2900 mV	+20 sec.
	Clear		> 3000 mV	20 sec.
Under voltage critical	Set	Fail-safe flag	<= 2850 mV	+5 sec.
Under voltage safety lock	Set	Lock flag	<= 1850 mV	-

13.1.3 Cell temperature charging

Table 16 Cell temperature charging boundary limits slave BMS

Over temperature				
Description	**Trigger action**		**Condition**	**Delay**
Over temperature alert	Set	Status flag	>= 43 °C	5 sec.
	Clear		< 42 °C	5 sec.
Over temperature	Set	Warning flag	>= 45 °C	+20 sec.
	Clear		< 43 °C	20 sec.
Over temperature critical	Set	Fail-safe flag	>= 50 °C and charge current > 5% battery capacity	+60 sec.
Over temperature safety lock	Set	Lock flag	>= 65 °C	-

Under temperature				
Description	**Trigger action**		**Condition**	**Delay**
Under temperature alert	Set	Status flag	<= 1 °C	5 sec.
	Clear		> 2 °C	5 sec.
Under temperature	Set	Warning flag	<= 0 °C	+20 sec.
	Clear		> 1 °C	20 sec.

Under temperature critical	Set	Fail-safe flag	<= -5 °C and charge current > 5% battery capacity	+60 sec.
Under temperature safety lock	Set	Lock flag	< -35 °C	-

13.1.4 Cell temperature discharging

Table 17 Cell temperature discharging boundary limits slave BMS

Over temperature				
Description	**Trigger action**		**Condition**	**Delay**
Over temperature alert	Set	Status flag	>= 53 °C	5 sec.
	Clear		< 52 °C	5 sec.
Over temperature	Set	Warning flag	>= 55 °C	+20 sec.
	Clear		< 53 °C	20 sec.
Over temperature critical	Set	Fail-safe flag	>= 60 °C	+60 sec.
Over temperature safety lock	Set	Lock flag	>= 65 °C	-

Under temperature				
Description	**Trigger action**		**Condition**	**Delay**
Under temperature alert	Set	Status flag	<= -19 °C	5 sec.
	Clear		> -18 °C	5 sec.
Under temperature	Set	Warning flag	<= -20 °C	+20 sec.
	Clear		> -19 °C	20 sec.
Under temperature critical	Set	Fail-safe flag	<= -25 °C and discharge current > 10% battery capacity	+60 sec.
Under temperature safety lock	Set	Lock flag	< -35 °C	-

13.1.5 Power terminal temperature

Table 18 Power terminal temperature boundary limits slave BMS

Description	**Trigger action**		**Condition**	**Delay**
Over temperature alert	Set	Status flag	>= 60 °C	5 sec.
	Clear		< 59 °C	5 sec.
Over temperature	Set	Warning flag	>= 70 °C	+20 sec.
	Clear		< 60 °C	20 sec.
Over temperature critical	Set	Fail-safe flag	>= 80 °C	+60 sec.

13.1.6 Current

Table 19 Current boundary limits slave BMS

Charging				
Description	**Trigger action**		**Condition**	**Delay**
Charging over current warning	Set	Warning flag	> 1.0C	10 sec.
	Clear		<= 1.0C	10 sec.
Charging over current critical	Set	Fail-safe flag	> 1.2C	+20 sec.

Discharging				
Description	**Trigger action**		**Condition**	**Delay**
Discharging over current warning	Set	Warning flag	> 1.0C	10 sec.
	Clear		<= 1.0C	10 sec.
Discharging over current critical	Set	Fail-safe flag	> 1.65C	+20 sec.

13.1.7 Balancing

Table 20 Balancing boundary limits slave BMS

Description		**Condition**	**Delay**
Offset cell voltage		> 25 mV	1 min.
Balancing cell voltage		>= 3350 mV	1 min.
Battery pack current		current within ±5% battery capacity	1 min.

14 TECHNICAL SPECIFICATIONS

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

https://downloads.mgenergysystems.eu/lfp24v/documents/technical-specification-en

15 DIMENSIONS

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

https://downloads.mgenergysystems.eu/lfp24v/drawings

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. Consult the MG Support Center.
3. Watch the Installation Videos.
   Videos can be found on MG's You Tube channel.
4. 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.
5. Contact MG Service Point.
6. Contact MG technical support.
   Send an email with your technical questions to support@mgenergysystems.eu.