MG Master HV

- Installation manual -

MGMHV800300 and MGMHV800500

MG Energy Systems B.V.

Version:	**2.0**
Date:	**08-03-2019**

MG Energy Systems B.V. | Foeke Sjoerdswei 3 | 8914 BH Leeuwarden | The Netherlands
+31 (0)58 750 89 47 | info@mgenergysystems.eu | www.mgenergysystems.eu

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

Revision	Changes	Revision author
11-03-2019	Initial document.	Ane Tjitze Rienstra

1.2 Terms, definitions, and abbreviations

Battery system	A battery system consists of one or more battery modules in combination with one or more battery management controllers.
BMS	*Battery Management System;* The BMS is the electronics that monitors the battery cell parameters to keep it within the operation specifications.
EMS	*Energy Management System;* The EMS controls all power sources and consumers in a system.
CAN-bus	*Controller Area Network bus;* CAN-bus is a standard serial data bus that provides data communication between two or more devices.
DeviceNet	A network protocol used in the automation industry to interconnect control devices for data exchange, standardised in the IEC 62026-3.
EMS	*Energy Management System;* The EMS controls all power sources and consumers in a system.
HAZID	*Hazard Identification;*
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.
NMEA 2000	A plug-and-play communications standard used for connecting marine sensors and display units within ships and boats, standardised in the IEC 61162-1.
SoC	*State-Of-Charge;* is the remaining capacity in a battery cell or module in percent (%).

2 SAFETY INSTRUCTIONS

2.1 Safety message level definition

Table 2 - Safety message levels overview

WARNING:
A hazardous situation which, if not avoided, could result in death or serious injury.

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.

ELECTRICAL HAZARD:
The product is used in combination with a permanent energy source (battery). Even if the equipment is switched off.

- Wear applicable personal protective equipment when working on a battery system.
- Use insulated tools during when working on a battery system.
- Make sure the locale regulations for working on battery systems are followed.

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 priority over the manufacturers specification in this manual in case of regulatory conflicts.

Instruction 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 emission of hazardous substances.
- 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.

3 TRANSPORT, STORAGE, AND UNPACKING

3.1 Transport

The Package and transport instructions provided by the manufacturer must be followed in all circumstances.

Notes on transport:

- Transport in original packaging.

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.

3.2 Storage

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

Notes on storage:

- Store in a dry and clean location.

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 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 Master HV 144-800V/300A or MG Master HV 144-800V/500A.
- Mating I/O connector part as stated in 6.2.1.

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 6.2.2).
- Fuses.

4 GENERAL DESCRIPTION

The MG Master HV is the safety and control unit of the battery system. It protects the connected battery modules against overcharging, over-discharging, over- and under-temperature, and controls the balancing of the battery cells.

The system operates stand-alone and requires no user interactions during normal operation. If, however, user input is required, e.g. during an error, a warning is raised. Actions required depending on the type of warning.

4.1 Battery system components

MG's Lithium-Ion battery system consists of the following components:

- One or more MG Master HV battery management systems (see 5.1 for available models).
- One or more Lithium-Ion battery modules, e.g. RS series or HE series.

Consult MG Energy Systems B.V. for compatibility of Master HV models with the different battery types and numbers.

4.2 Functional description

The main function of the BMS is to avoid electrical abuse of the battery cells and therefore limit the risk of thermal abuse coming from electrical origin. In order to avoid electrical abuse the BMS monitors different parameters to detect battery failures.

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

All these parameters are send to the 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. If the exceeded threshold stays, the master BMS has the possibility to disconnect the batteries from the system by opening the main contactors.

5 DEVICE MODELS

5.1 Models

There are two models of the MG Master HV. The **MGMHV800500** and **MGMHV800300.**

The differences between the two models are the power connectors. Table 3 shows an overview of the connector types in relation with the models and the maximum current.

Table 3 - List of available models

	MGMHV800300	MGMHV800500
Connector series	Amphenol PowerLok™ 300-Series	Amphenol PowerLok™ 500-Series
Maximum current	300 A[1]	500 A[1]

[1] Maximum current is depending on the cross section of the connected battery cables. For details and options see chapter 6.2.3.

5.2 Identification label

The identification label of the MG Master HV is located at two positions; one user accessible label at the left side of the enclosure as shown in figure 1, and one inside the enclosure where it is protected from the wear from the environment.

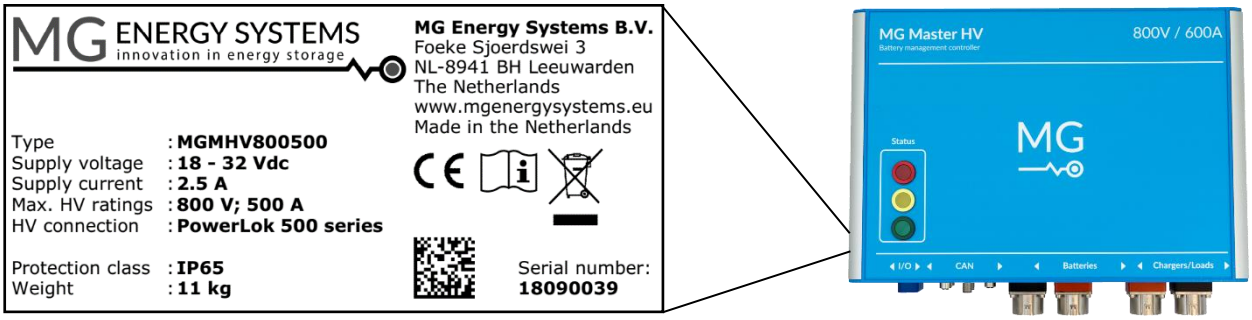


Figure 1 - Example identification label

The identifications label shown in figure 1 contains written information about the product. The explanation of the symbols used on the identification label is stated in table 4.

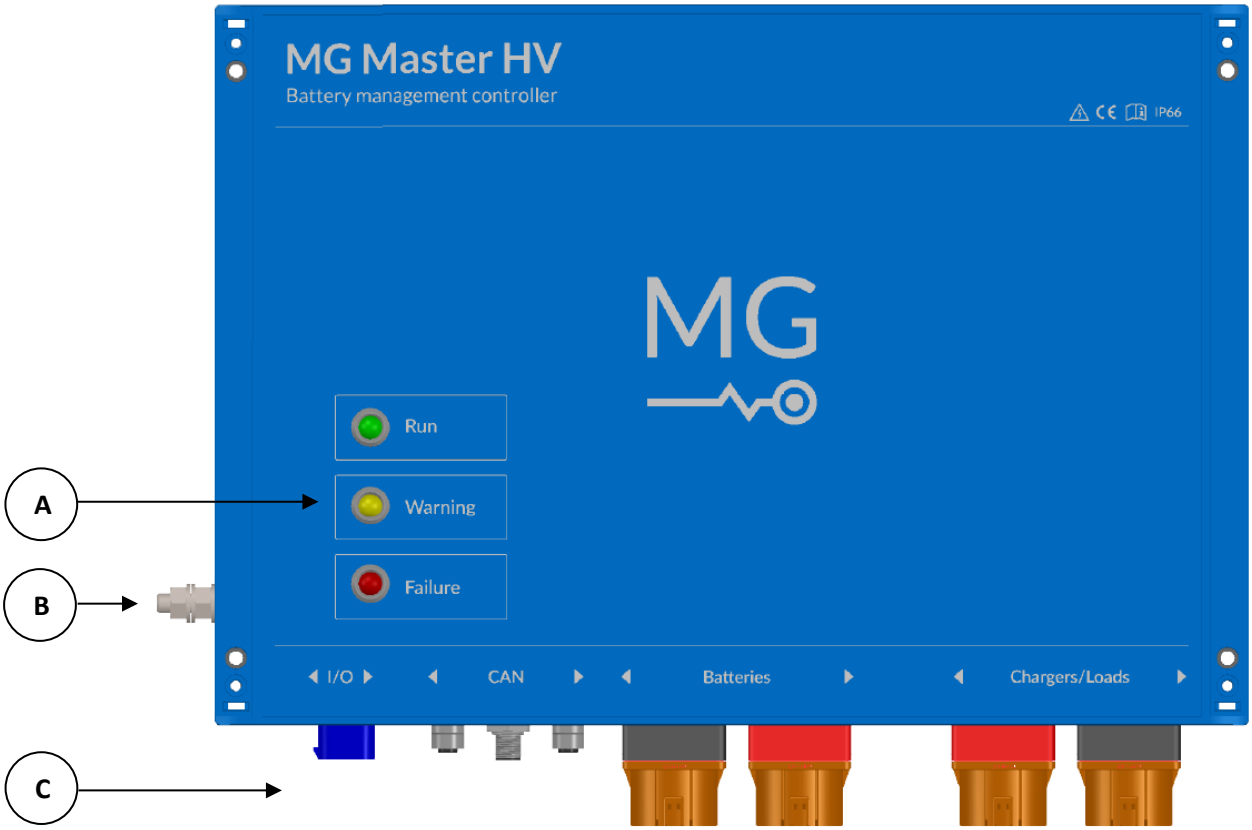
Table 4 - Identification lable logo explaination

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 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 CONNECTIONS

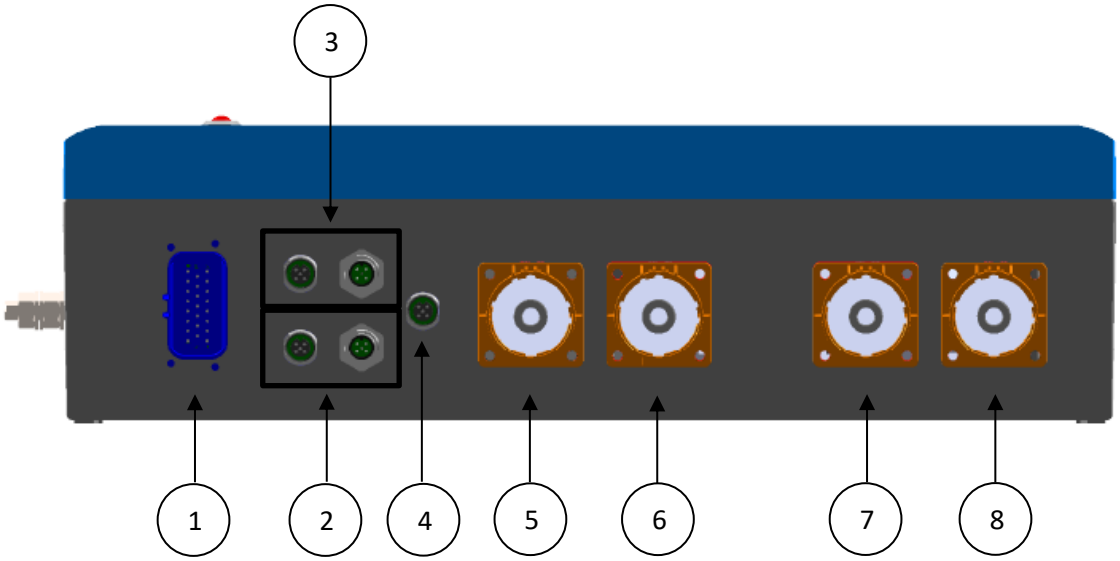
This chapter shows an overview of the connections and parts of the MG Master HV.

6.1 General overview



Part	Description
A	Status LEDs; indicating the system status.
B	Equipotential bonding point.
C	Bottom side of the device containing all electrical connections.

6.2 Detailed connection overview



Item	Description
1	Logic I/O and power supply connections.
2	Battery system CAN-bus connections.
3	User (auxiliary) CAN-bus connections.
4	CAN-bus diagnostic port. Used to connect with the “Diagnostic Tool” software.
5	Negative (-) terminal for power connection of battery string.
6	Positive (+) terminal for power connection of battery string.
7	Negative (-) terminal for power connection of charger/loads.
8	Positive (+) terminal for power connection of charger/loads.

6.2.1 Logic I/O and power supply connector details

The following tables give the types and pinning of the I/O connector of the Master HV.

	Article	Website
Connector brand	TE Connectivity	
Connector type	AMPSEAL 1-776228-5	http://www.te.com/usa-en/product-1-776228-5.html
Mating type	AMPSEAL 770680-5	http://www.te.com/usa-en/product-770680-5.html
Pin type	770520-1	http://www.te.com/usa-en/product-770520-1.html
Wire diameter	0,5 - 1,5 mm2	

6.2.1.1 I/O connector pinning

Pin	Name	Description	Specifications
1	24VGND	Power supply return connection	
2	24VGND	Power supply return connection	
3	24VGND	Power supply return connection	
4	-	No connection	
5	-	No connection	
6	-	No connection	
7	EM_OUT	Emergency stop output	Output voltage = Supply voltage; Fuse: 140 mA

8	EM_IN	Emergency stop input	24 VDC, 5 mA (opto-isolated)
9	24V_IN	Power supply positive connection	18 VDC to 32 VDC
10	Output_1+	Allow to Charge	Relay contact: Max. 30 VDC resettable fuse 1,5 A
11	Output_2+	Allow to Discharge	Relay contact: Max. 30 VDC resettable fuse 1,5 A
12	Output_3+	Programmable output	Relay contact: Max. 30 VDC resettable fuse 1,5 A
13	Digital_Input_3+	Programmable input	24 VDC, 5 mA (opto-isolated)
14	Digital_Input_2+	Programmable input	24 VDC, 5 mA (opto-isolated)
15	Digital_Input_1+	Do not connect! (connected to pin 7)	24 VDC, 5 mA (opto-isolated)
16	24V_IN	Power supply positive connection	18 VDC to 32 VDC
17	24V_IN	Power supply positive connection	18 VDC to 32 VDC
18	Output_1-	Allow to Charge	Relay contact: Max. 30 VDC resettable fuse 1,5 A
19	Output_2-	Allow to Discharge	Relay contact: Max. 30 VDC resettable fuse 1,5 A
20	Output_3-	Programmable output	Relay contact: Max. 30 VDC resettable fuse 1,5 A
21	Digital_Input_3-	Programmable input	Return of Digital_Input_3+
22	Digital_Input_2-	Programmable input	Return of Digital_Input_2+
23	Digital_Input_1-	Do not connect! (connected to pin 8)	Return of Digital_Input_1+

6.2.2 CAN-bus connector details

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

The CAN-Bus connection is used for several functions:

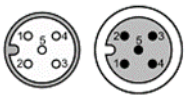
- Data communication between battery module(s) and master BMS;
- The battery module uses the V+ to enable the power of the internal BMS;
- The V+ is also used as HVIL;

Contact MG Energy Systems B.V. for cable options and possibilities.

6.2.2.1 Connector details

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

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

Pin	Description	Connector view (mating side)
1	Shield	M12 plug/socket, 5-pin, A-coded  Male Female
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 mm^2 (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 mm^2 (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 connectors

Table 6 and table 7 show an overview of the standard connector types in relation with the models and the maximum current. Contact MG Energy Systems B.V. for cable options and possibilities.

Table 6 - MGMHV800500 power connectors

Power connectors on the **MGMHV800500**		
Brand/type	Amphenol PowerLok™	
Series	500-series	
	Positive terminal (orange)	***Negative terminal (black)***
Receptacle types (mounted on MG Master HV)	PL00X-501-10-M10	PL00Y-501-10-M10
Plug types - HVIL type required. - Use only straight versions. - Over-moulded cable assembly only.	**Over-moulded cable assembly:** PL10X-501-120: 350A PL10X-501-135: 400A PL10X-501-150: 500A	**Over-moulded cable assembly:** PL10Y-501-120: 350A PL10Y-501-135: 400A PL10Y-501-150: 500A

Table 7 - MGMHV800300 power connectors

Power connectors on the **MGMHV800300**		
Brand/type	Amphenol PowerLok™	
Series	300-series	
	Positive terminal (orange)	***Negative terminal (black)***
Receptacle types (mounted on MG Master HV)	PL00X-301-10-M10	PL00Y-301-10-M10
Plug types - HVIL type required. - Use only straight versions.	**Over-moulded cable assembly:** PL10X-301-35: 150A PL10X-301-50: 200A PL10X-301-70: 250A PL10X-301-95: 300A **Plug connector:** PL18X-301-35: 150A PL18X-301-50: 200A PL18X-301-70: 250A	**Over-moulded cable assembly:** PL10Y-301-35: 150A PL10Y-301-50: 200A PL10Y-301-70: 250A PL10Y-301-95: 300A **Plug connector:** PL18Y-301-35: 150A PL18Y-301-50: 200A PL18Y-301-70: 250A

6.2.4 Equipotential bonding point

The equipotential bonding point location of the Master HV is on the lower left side of the enclosure as shown in figure 2.

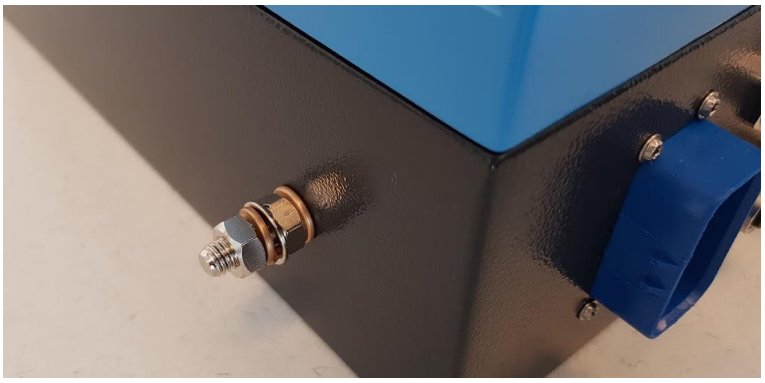


Figure 2 - Equipotential bonding point location

NOTICE:
Depending on the situation additional insulation resistance monitoring might be required.

7 OPERATION

This chapter describes the operation of the Master HV in a battery system.

7.1 Master HV schematic overview

Figure 3 shows the internal schematic overview of the MG Master HV.

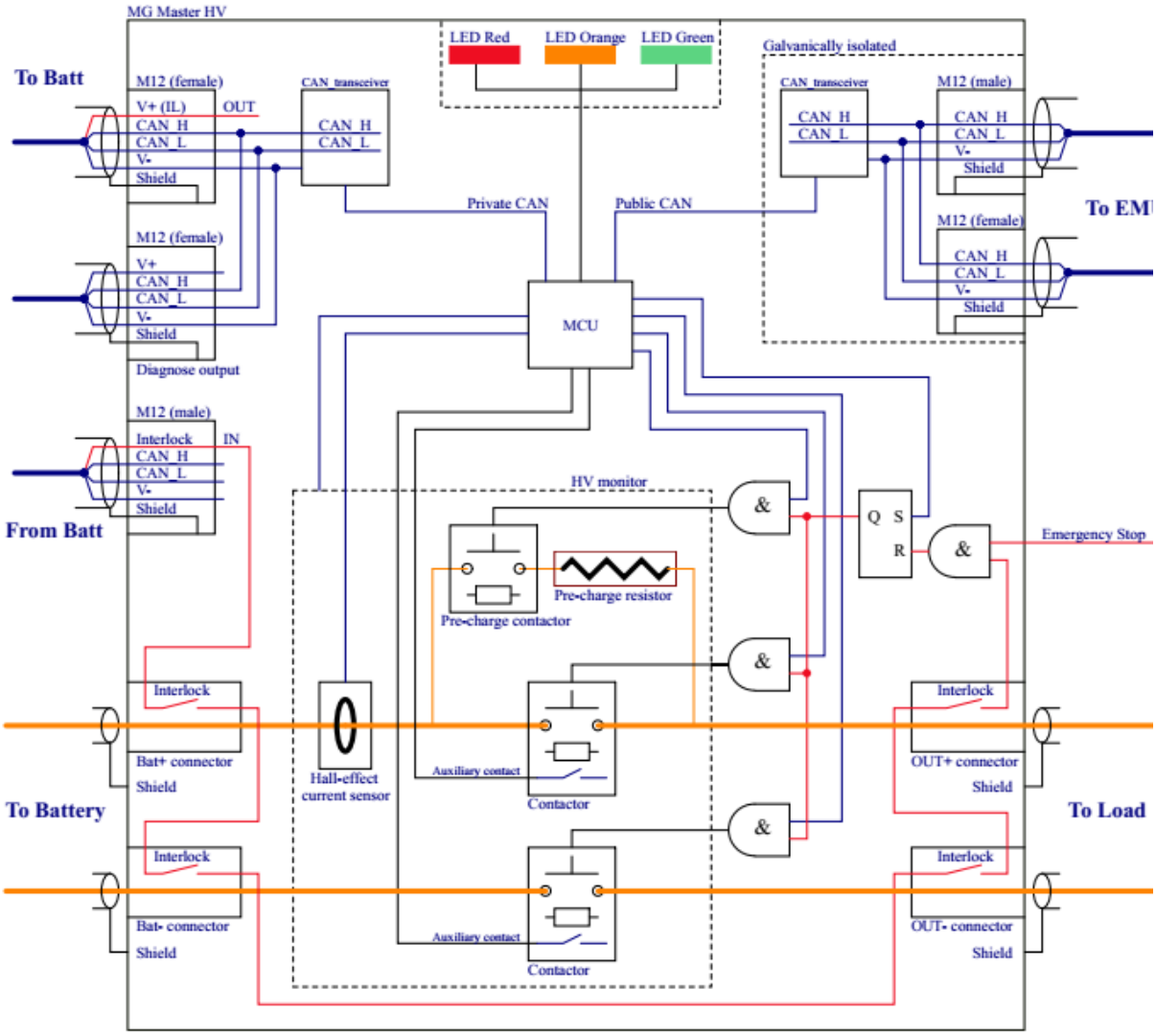


Figure 3 - Master HV schematic overview

7.2 Theory of operation

The MG Master HV enters first an idle state when the 24 VDC power is applied. Communication with the battery modules is setup and initial battery module configuration and values are checked if the values exceed the threshold the system directly goes to fail-safe situation.

In idle state the systems waits for a start command from the charger/inverter or EMS. After receiving the start command the system will go to operational mode.

The high voltage load is pre-charged and the contactors are closed. If starting up the system fail, e.g. due to pre-charge time-out or contactor welding detection, the system will go to fail-safe state. When pre-charging succeeds the main contactors are closed and the system will go into operational state.

During operational state, batteries can be charged and discharged. While in operational state, cell voltages, temperatures and balancing control information is communicated from the battery modules to the Master HV. These values combined with string voltage and string current are monitored. If one of the parameters exceeds the threshold the systems sends a warning to the user via de auxiliary CAN-bus. Depending on the exceeded threshold the system will go into fail-safe state if the situation remains for a predefined period.

NOTICE:
All commands and statuses are described in the communication guide. Contact MG Energy Systems B.V. for a copy.

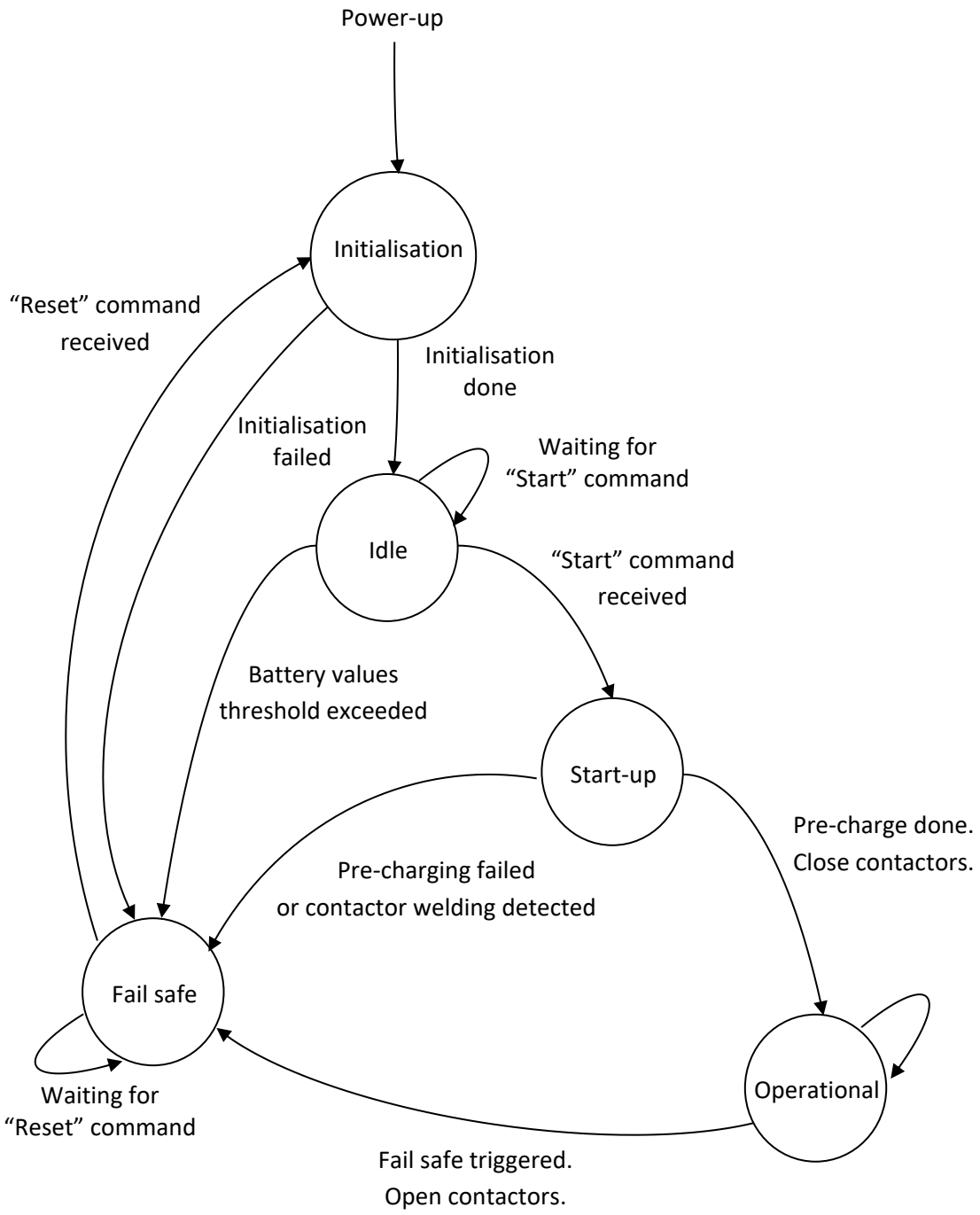


Figure 4 - State machine overview

7.3 Initialisation state

Initialization state is defined as the transition state between when 24 VDC power is supplied to the moment the system goes into idle state.

7.3.1 Fail-safe triggers

The situations resulting in fail-safe state from initialisation state are listed in table 8.

Table 8 - List of initialisation state fail-safe triggers

Name	Trigger condition
Battery configuration mismatch	Number of detected batteries connected are not equal to the number stored in the settings.
No batteries detected at start-up	No communication with any of the connected batteries.
Interlock failure	Interlock circuit open
Emergency stop	Emergency stop circuit open

7.4 Idle state

In the idle state the Master HV is communication with the battery modules collecting data and checking against the thresholds. In this state the Master HV waits for a CAN-bus message command from external equipment to start pre-charging and switch the main contactors to have the battery string voltage on the output.

7.4.1 Fail-safe triggers

The situations resulting in fail-safe state from initialisation state are listed in table 9.

Table 9 - List of idle state fail-safe triggers

Name	Trigger condition
Battery configuration mismatch	Number of detected batteries connected are not equal to the number stored in the settings.
Interlock failure	Interlock circuit open
Emergency stop	Emergency stop circuit open

7.5 Start-up state

When the system is in start-up state, before the main contactors are closed, the voltage difference between the load and the battery string can be several hundreds of volts. Closing the main contactors at this point in time might cause excessive current flowing from the battery string to the load. This excessive current can lead to contactor welding and/or damage load connected equipment. Therefore pre-charging is required, in this phase it will pre-charging the load towards the battery string voltage level.

CAUTION:
The system integrator must ensure the following conditions are met during system design:

- The pre-charge system is calculated to handle capacitive loads up to 30mF.
- The pre-charge system cannot handle resistive loads.

The degree of current flowing from the battery string to the load upon closing of the main contactors depends on the battery string voltage and the type of load connected. The largest currents are to be expected with large capacitive loads connected.

In order to limit the current a pre-charge contactor is used to apply the battery string voltage to the load through a resistor. In this way the load voltage ramps-up controlled with limited current. The next sections describe the checks done during pre-charging.

7.5.1 Short-circuit

During pre-charging the load voltage is monitored. If the voltage not ramps-up to a minimum of 10% of the battery string voltage within 500 ms, there is the probability of a short-circuit in the load's DC connections. The system will go into fail-safe state.

7.5.2 Ramp-up time-out

If the voltage not reaches 95% of the battery string voltage within 10 seconds, the DC-Bus has a too high load to pre-charge and the system will go into fail-safe state. If pre-charging is successful and the voltage has reached 95% of the battery string voltage, it will close the main contactors.

7.5.3 Pre-charge resistor temperature

The temperature of the pre-charge resistor is measured to prevent overheating during multiple pre-charge attempts in a short time**.**

7.5.4 Fail-safe triggers during start-up state

During the start-up state the fail-safe triggers are stat in table 10.

Table 10 – List of start-up state fail-safe triggers

Name	Trigger condition
Emergency stop	Emergency stop circuit open
Pre-charge short-circuit	< 100 V within 500 ms.
Pre-charge high load	< 95% of the battery string voltage within 10 seconds.
Contactor welding	One of the aux. contacts is closed before pre-charging is initiated.

7.6 Operational state

During operational state the system continuously monitors all batteries in the string together with the system level parameters.

During operation the HVIL and emergency stop loop are continuously monitored.

7.6.1 Battery module level controlled and monitored points

The Master HV monitors the battery modules through the integrated slave BMS inside the battery modules. The slave BMS measure the following:

- Cell voltage of each in series connected cell.
- Temperatures of the cells.
- Air temperature inside the enclosure (battery module dependent).
- Humidity inside the enclosure (battery module dependent).

Based on the previous mentioned points the Master HV determines the following:

- Monitoring maximum cell voltage deviation.
- Monitoring maximum cell temperature deviation.

7.6.2 System level controlled and monitored points

Monitoring, measuring and control by the Master HV.

- Measure current of the connected string of batteries.
- Measure voltage of the connected string of batteries.
- Measure voltage of the charger/load.
- Monitoring of battery CAN-bus communication (keep alive watchdog)
- Monitoring 24 V power supply.
- Monitoring HVIL.
- Monitoring emergency stop.
- Monitoring maximum charge and discharge currents.
- Monitoring contactor welding.
- Monitoring contactor switching.
- Keep track of the system SoC.
- Keep track of the system SoH.
- Control of balancing of the cells voltage.
- Communication with energy management system, DC/DC or DC/AC converter.
- Internal event logging.

7.6.3 Fail-safe triggers during normal operational state

The situations resulting in fail-safe state are listed in table 11.

Table 11 – List of operational state fail-safe triggers

Name	Trigger condition	Description
One or more batteries did not respond	Data time out is detected on one or more connected batteries.	More than 30 seconds no response from one are more batteries.
Interlock failure	Interlock circuit open	May also be opened by redundancy BMS of battery module.
User communication timeout	User CAN-bus data time out is detected.	More than 2 seconds there is no user command message received. Note: only active when specific CAN-bus protocol is selected.
Emergency stop	Emergency stop circuit open	
Contactor mechanically check	When contactor has to be opened and is mechanically closed or when contactor has to be closed and is mechanically opened.	Mechanically opened and closed is check by measuring auxiliary contact of contactor.
Contactor voltage check	When contactor is closed and voltage measured over contactor is more than 4% of the systems voltage.	
Overvoltage critical	(Refer to the applicable battery module manual for the exact values.)	
Under-voltage critical		
Over temperature critical		
Under temperature critical charging		
Under temperature critical discharging		

7.7 Fail-safe state

The fail-safe state can be entered from any other state at any time. In this state the system goes to a safe situation. In sections 7.3 to 7.6 the possible trigger conditions to go into fail-safe mode are described for each state. Besides the previous mentioned software triggers, there are also two hardware triggers to enter fail-safe state, by means of:

- A HVIL for the battery system.
- An emergency stop connection for auxiliary use.

These hard-wired connections are based on a loop which must be broken to go into fail-safe state. If the system is reset from fail-safe state by receiving the “reset” command , it will enter idle state first. This is done to prevent the system from automatically continue if the fail-safe situation is resolved, i.e. the battery system’s main contactors remain open until the “start” command is received.

7.7.1 High-voltage interlock loop

The HVIL hard-wired loop to the positive and negative main contactors intended for the battery system. The battery system is operable when the loop is closed. If for some reason the loop is broken, the main contactors will open without intervention of the software. The software however will detect the HVIL trigger and enters fail-safe state and informs the user.

All the power, I/O and connectors of the MG Master HV has a built-in HVIL for safety. If one of the connectors is disconnected from the battery module or MG Master HV the main contactors are opened. In case of the power connectors this will happen before the connector breaks the power circuit. This will prevent arcing if the power connector is disconnected from the battery module and lowers the risk of injuries.

Depending on the battery module model and type the HVIL also runs through the battery module. Refer to the applicable battery module for more details on the HVIL scheme.

7.7.2 Emergency stop

The emergency stop is hard-wired the positive and negative main contactors intended for auxiliary use. The battery system is operable when the loop is closed. If for some reason the loop is broken, the main contactors will open without intervention of the software. The software however will detect the emergency stop trigger and enters fail-safe state and informs the user.

Requirements for the emergency stop implementation depend on the application.

NOTICE:
If the auxiliary system does not make use of an emergency stop make sure the contact is bridged.

7.8 Status indication

The MG Master HV is equipped with three status indication LEDs on the front.

Status LED	Function	Description	Main contactor state
Green	Flashing	System is in initialising.	Open
Green	On	System is running	Open or closed
Yellow	On	System warning, service request	
Red	On	System in fail-safe	Open

8 INTEGRATION REQUIREMENTS

8.1 Risk assessment

Integration of a battery system requires, in any case, an assessment of the risks. Depending on the application, rules need to be applied.

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

8.1.1 Marine application

Integrating a battery system in a marine application, e.g. a vessel, yacht or work boat, specific rules are required. For example a large vessel can be build according to a class register like Lloyds, DNV-GL or Bureau Veritas. In this case the class register need to be informed about the battery installation. Each class register has its own requirements and rules for integrating a battery system.

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 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 MG Master HV are as following:

- Place the MG Master HV close to the battery modules in order to keep the battery string connection cables as short as possible.
- Ensure that the equipment is used under the correct operating conditions.

8.3 Connections and communication

When the battery system is integrated special attention must be given to the connections from and to the MG Master HV.

8.3.1 Power connection

Requirements for the power connections are:

- Place fuses in-line with the positive and the negative battery string connection cables.
- Place fuses in-line with the positive and the negative load connection cables.
- Make sure all components used in the power lines can handle the load profile as designed.

CAUTION:
The correct fuse values must be applied according to the regulations and guidelines. The fuse value must fit the cable cross section and battery system short circuit currents.

8.3.2 CAN-bus connection

For correct operation it is important that the MG Master HV is controlled correctly via the auxiliary CAN-bus. Therefore the communication between an EMS, inverters, converter, or chargers and the MG Master HV must be considered.

Since integration differ from case-to-case the MG Master HV has no internal termination resistors. For correct operations external termination resistors must be applied.

NOTICE:
A communication guide to control the MG Master HV through the auxiliary CAN-bus connection is available which describes the communication protocol and possibilities.

9 INSTALLATION

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

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

- Ensure that the connection cables are provided with fuses and circuit breakers.
- Never replace a protective device by a component of a different type. Refer to the ordering information sections of this manual or contact manufacturer for a correct replacement.
- Before switching the device on check whether the available voltage source conforms to the configuration settings 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 a heatproof environment. Ensure therefore that there are no chemicals, plastic parts, curtains or other textiles, etc. in the immediate vicinity of the equipment.

9.1 Installation procedures

Below the basic installation procedures at battery module level.

1. Mounting procedure of the device.
2. Equipotential bonding procedure of the device.
3. Electrical connection procedure of the device.

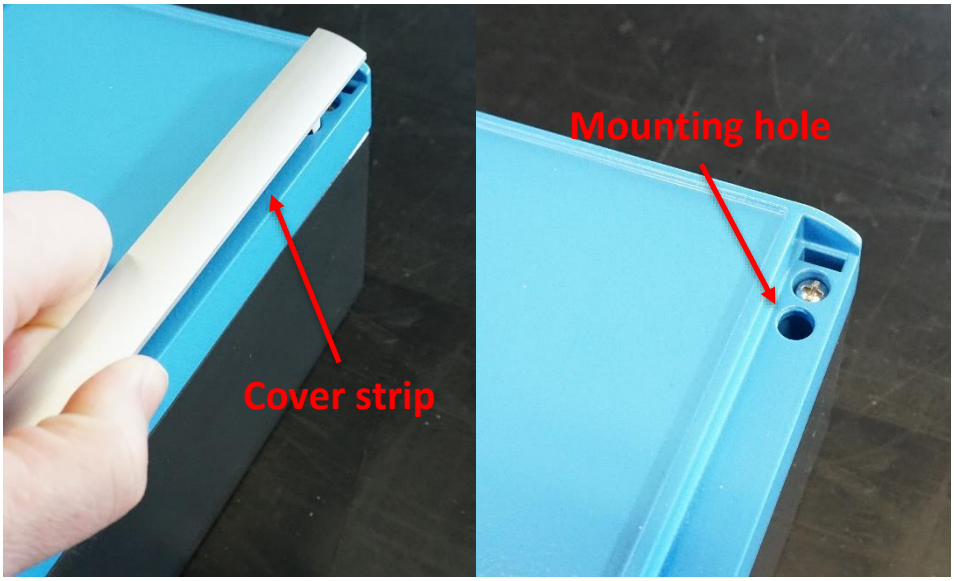
During installation a check form needs to be used to log the installation procedure. This log will be checked during commissioning.

9.2 Mounting procedure

This procedure describes how to mount the battery module with respect to the integration requirements stated in chapter 8. Mounting is done in the following steps:

1. Prepare the mounting holes according the measurements [mm] given in the picture below. Since the way of mounting strongly depends on the mounting surface it is left up to the personnel mounting the device to use the proper materials, i.e. the correct bolts, screws, plugs, etc. for the situation. Make sure the construction is rigid and is able to support the weight of the device.

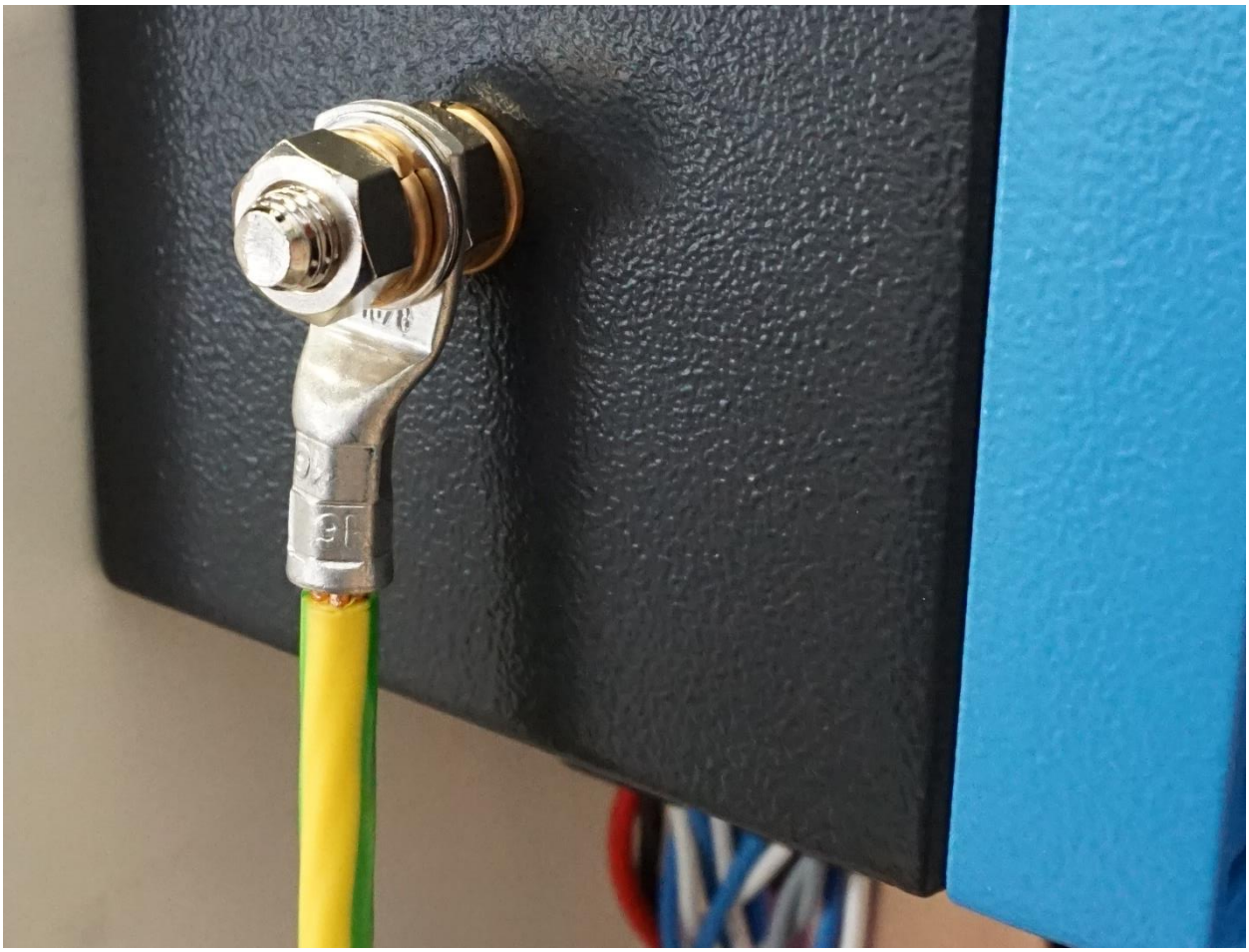
2. Remove the cover strips from each side of the device.



3. Mount the device onto the mounting holes using the appropriate materials and tighten them accordingly.

9.3 Equipotential bonding connection

The equipotential bonding point thread size is M8 with a maximum fastening torque of 11 Nm. Equipotential bonding connection scheme and the required wire cross-section depend on local standards and regulation. The typical used wire cross-section is 10 mm^2.



9.4 Electrical connection procedure

The MG Master HV has several connection each for a dedicated purpose. Refer to chapter 6 for information about the available connections. Refer to the system installation manual for instructions on wiring, routing, and used cable lengths.

9.4.1 Logic I/O and power supply connection

For the power supply, emergency stop connection, logic inputs, and logic outputs the MG Master HV is equipped with a 23 pin AMPSEAL header from Amphenol. The mating connector is composed from a connector housing and terminals which must be crimped onto the wire-ends.

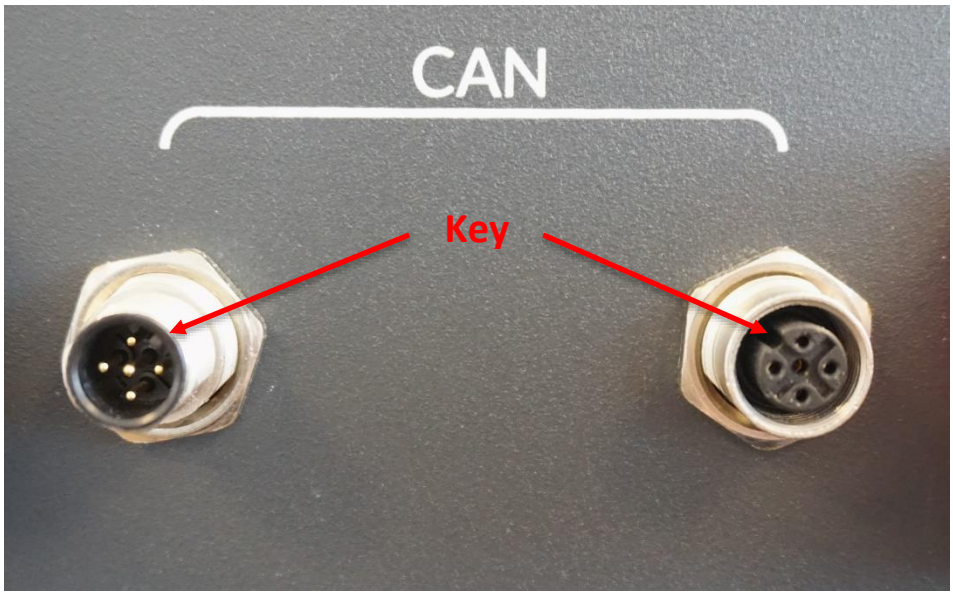
NOTICE:
Refer to Amphenol Instruction Sheet 408-3229 (link) for a details description on how to mount the mating part onto the wire or cable. To mount the terminals dedicated crimp tooling is required.

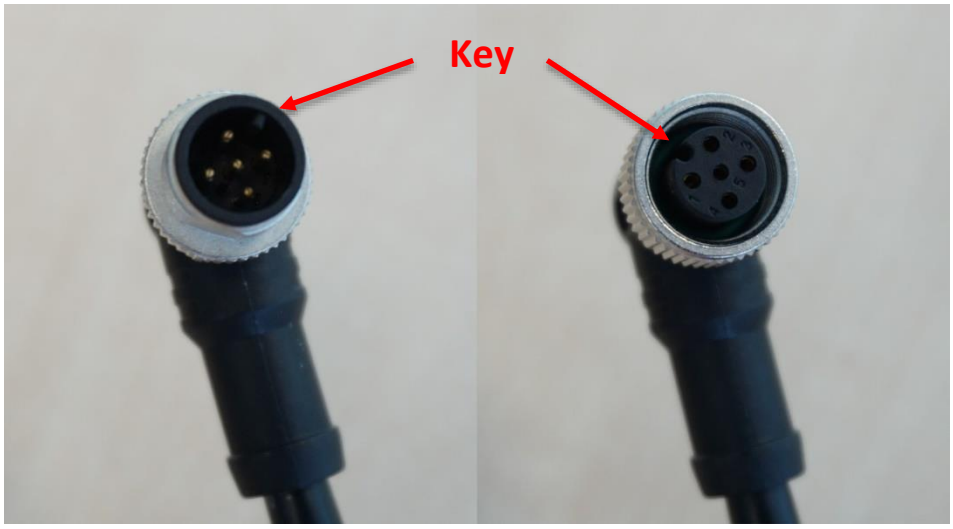
WARNING:
Before mating the connector to the MG Master HV make sure that the 24 VDC power supply is turned off or disconnected.

9.4.2 CAN-bus connection procedure

Connection of the CAN-bus cable connectors is done in the following way:

1. Locate the key in both connectors.





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

3. Lock the connector by rotating the locking nut clockwise. Hand-tightened will be sufficient, do not use tooling to tighten.

4. Connectors in place.

Un-mating of the connector CAN-bus connectors is done by the above steps in opposite order.

9.4.3 Power connection procedure

The power connections make use of the Amphenol PowerLok™ connectors. See chapter 6.2.3 for detailed information about types and cable sizes available.

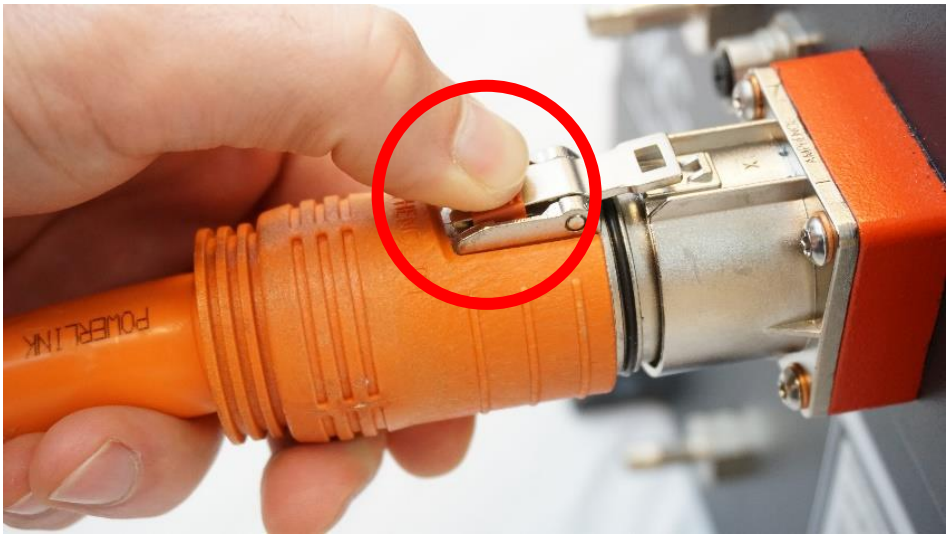
ELECTRICAL HAZARD:
The battery modules can be placed in series up to 800 VDC. Make sure to wear proper insulation gloves.

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

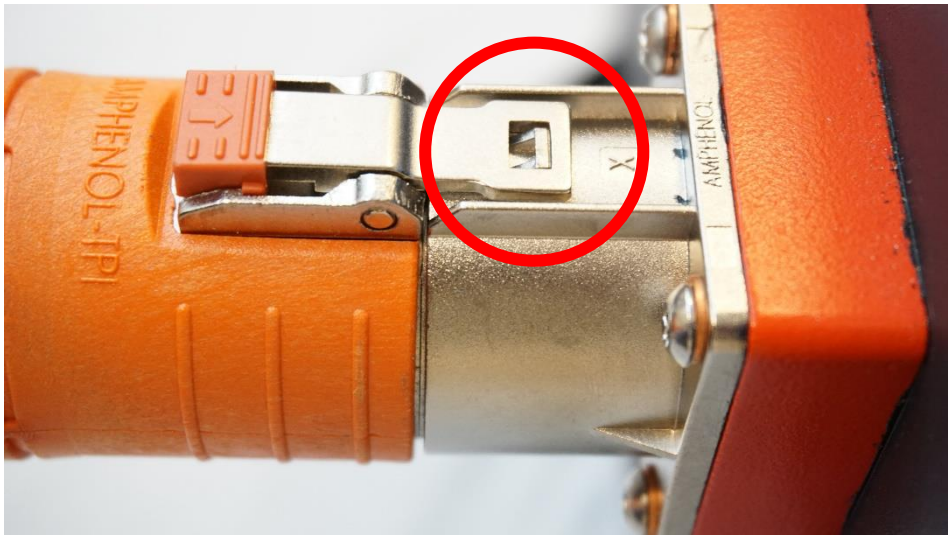
1. Plug in the Amphenol PowerLok™.

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

2. Push the orange/black lip forward to lift the locking mechanism.



3. Push the connector to the end. Make sure it clicked and is locked.



Un-mating of the connector Amphenol PowerLok™ connectors is done by the above steps in opposite order.

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 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.

10.1.1 Connections

It will suffice to check all connections once a year. Check if all connectors are mated correctly according the instructions given in section 6.2 of this manual.

10.1.2 Cleaning

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

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

10.2 Diagnostics

With the MG Diagnostic Tool it is possible to read all the information from the battery systems. This information contains all the individual cell voltages, temperatures, current etc.

Refer to the MG Diagnostic Tool software manual for a detailed description on features and operation. This chapter highlights only some of the most important features.

10.2.1 Status

After start-up the MG Diagnostics Tool shows an overview of the status of the system. In the status screen the most relevant parameters are shown as can be seen in figure 5.

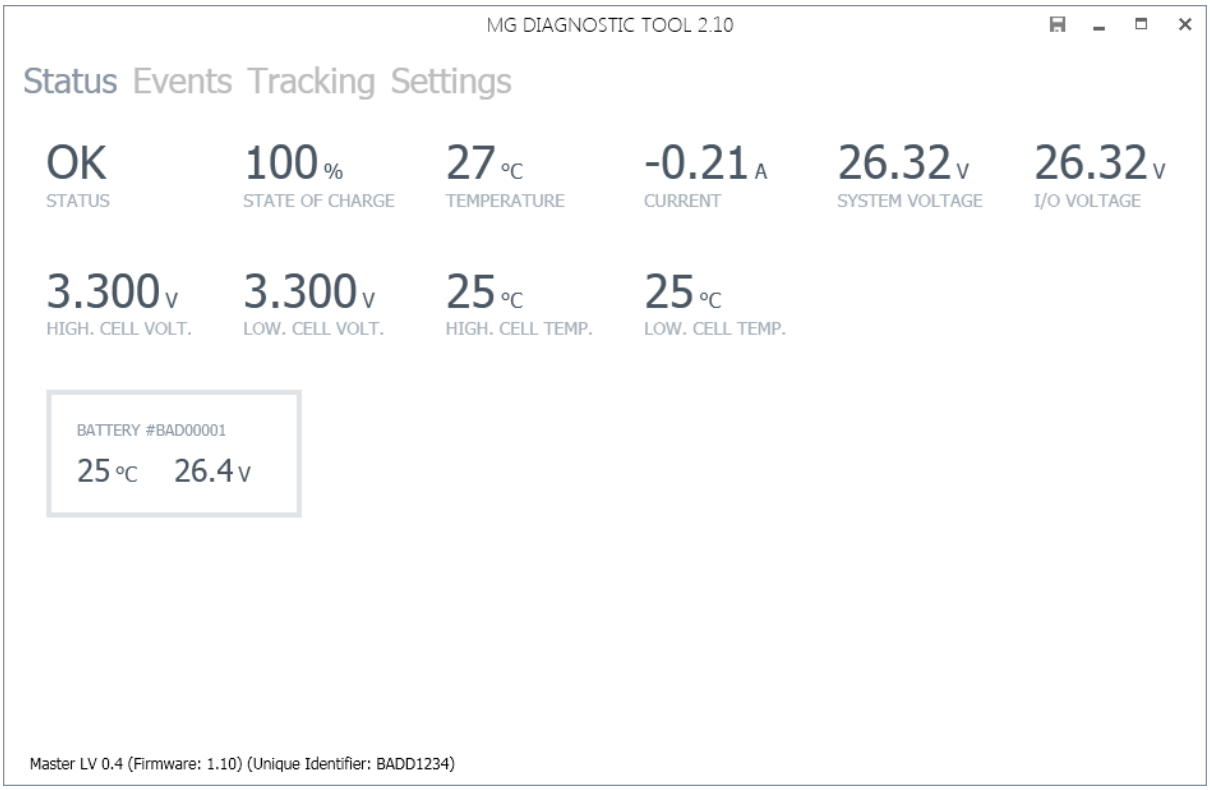


Figure 5 - Status overview of the MG Diagnostics Tool software

10.2.2 Event logging

The MG Master HV stores information on an internal memory with daily reports and special events, such as fail-safe triggers that have occurred. The recorded information can be extracted from the MG Master HV and saved to a file by the MG Diagnostics Tool.

Daily reports will be stored with the following information; uptime, energy charged, energy discharged, average cell temperature, highest cell voltage, lowest cell voltage, highest cell temperature, and lowest cell temperature.

Fail-safe events are stored with a time-stamp and the origination fail-safe trigger.

A complete log could look like the screenshot shown in figure 6.

Status Events Tracking Settings

TIME OF OCCURRENCE	MESSAGE
8/4/2017 2:44:54 PM	Shutting down
8/4/2017 2:45:01 PM	Slave update started
8/4/2017 2:45:03 PM	Slave update completed
8/4/2017 2:45:08 PM	Battery configuration successfully detected
8/4/2017 2:50:07 PM	Shutting down
8/4/2017 2:51:36 PM	Slave update started
8/4/2017 2:51:38 PM	Slave update completed
8/4/2017 2:51:38 PM	Slave update started
8/4/2017 2:51:41 PM	Slave update completed
8/4/2017 2:51:46 PM	Battery configuration successfully detected
8/4/2017 7:44:10 PM	Shutdown requested because the button is pressed
8/4/2017 7:44:13 PM	Shutting down
8/8/2017 4:01:19 PM	Starting up because the button is pressed
8/8/2017 4:01:20 PM	Daily summary created
8/8/2017 4:01:24 PM	Battery configuration successfully detected
8/8/2017 7:18:07 PM	Shutdown requested because the button is pressed
8/8/2017 7:18:10 PM	Shutting down
8/9/2017 5:09:01 PM	Starting up because the button is pressed
8/9/2017 5:09:02 PM	Daily summary created
	Day: 2017-08-08 UTC Uptime: 196 minutes Energy charged: 0.00 kWh Energy discharged: 0.04 kWh Average cell temperature: 26 °C Highest cell voltage: 3709 mV (battery: BAD00002, cell 6) Lowest cell voltage: 3686 mV (battery: BAD00001, cell 1) Highest cell temperature: 22 °C (battery: BAD00001, cell 0) Lowest cell temperature: 20 °C (battery: BAD00001, cell: 2)
8/9/2017 5:09:06 PM	Battery configuration successfully detected
8/9/2017 5:12:46 PM	Shutdown requested because the button is pressed
8/9/2017 5:12:49 PM	Shutting down
8/14/2017 10:26:06 AM	Starting up because the button is pressed
8/14/2017 10:26:07 AM	Daily summary created
8/14/2017 10:26:11 AM	Battery configuration successfully detected

Figure 6 - Screenshot of event list in the diagnostic tool

10.3 Updating

The firmware of the MG Master HV can be updated using the MG Diagnostic Tool. Contact your supplier for more information.

WARNING:
Updating firmware may only be done when the system is in maintenance. Firmware updates while charging/discharging may cause damage to the battery system and/or other connected equipment.

NOTICE:
The instructions in this section assumes the MG Diagnostics Tool software is already installed and configured on a computer. If in this section a reference is made to “computer”, the computer running the MG Diagnostics Tool software is meant with it.

For a full instruction of the MG Diagnostic Tool refer to the manual of the software.

Updating procedure

1. Connect the M12-connector of the Kvaser Leaf Light HS v2 M12 to the diagnostic port of the MG Master HV (see section 6.2).
2. Connect the USB-connector of the Kvaser Leaf Light HS v2 M12 to the computer.
3. Start the MG Diagnostic Tool software on the computer.
4. Power-on the 24V power supply to start the MG Master HV (see section 6.2).
5. The MG Diagnostic Tool will ask for confirmation to update to the new firmware version.
6. System will shut-down and perform the firmware update.
7. When the update was successful, the system will start-up automatically. During start-up the firmware of the battery modules are checked and will be updated automatically if necessary. This means start-up of the system takes more time than a normal start-up.

11 TECHNICAL SPECIFICATIONS

11.1 Specifications

Technical specifications	MG Master HV 800V – 300A MGMHV800300	MG Master HV 800V – 500A MGMHV800500
Supply voltage	24 VDC (18 VDC to 32 VDC)	
Supply current	2,5 A	
Maximum load voltage	800 VDC	
Maximum load current continuous	300 A	500 A
Weight	11 kg	
Dimensions (l x w x h)	430x329x121 mm	
Features		
Fuse	No, external fuse need to be added	
Integrated main contactors	In positive and negative HV lines	
Integrated pre-charge circuit	Yes	
Event logging	Internal event logging memory	
Logic input / output		
Emergency switch connection	Yes	
Allow-to-charge (relay output)	Max. 30 VDC fused 1,5 A	
Allow-to-discharge (relay output)	Max. 30 VDC fused 1,5 A	
Programmable output (relay output)	Max. 30 VDC fused 1,5 A	
Digital input 1	24 VDC, 5 mA	
Digital input 2	24 VDC, 5 mA	
Digital input 3	24 VDC, 5 mA	
Environmental		
Operating temp. charge	-20 to +50 °C	
Humidity	≤ 95% (non-condensing)	
IP-Protection class	IP65	
Connections		
Power connections	Amphenol PowerLok™ 300-series	Amphenol PowerLok™ 500-series
CAN-Bus connection (batteries)	2x M12 5 pin A-coded	
CAN-Bus connection (auxiliary)	2x M12 5 pin A-coded	
Diagnostic port (CAN-Bus)	1x M12 5 pin A-coded	
Standards		
EMC: Emission	CISPR 16-2-1:2014, CISPR 16-2-3+A1+A2:2010	
EMC: Immunity	IEC 60533:2015, IEC 61000-4-2:2008, IEC 61000-4-3+A1+A2, IEC 61000-4-4:2012, IEC 61000-4-5:2014, IEC 61000-4-6:2013	

11.2 Dimensions

Dimensions, lay-out, and mounting hole positions can be found in figure 7. Unless otherwise stated all dimensions are stated in millimetres [mm].

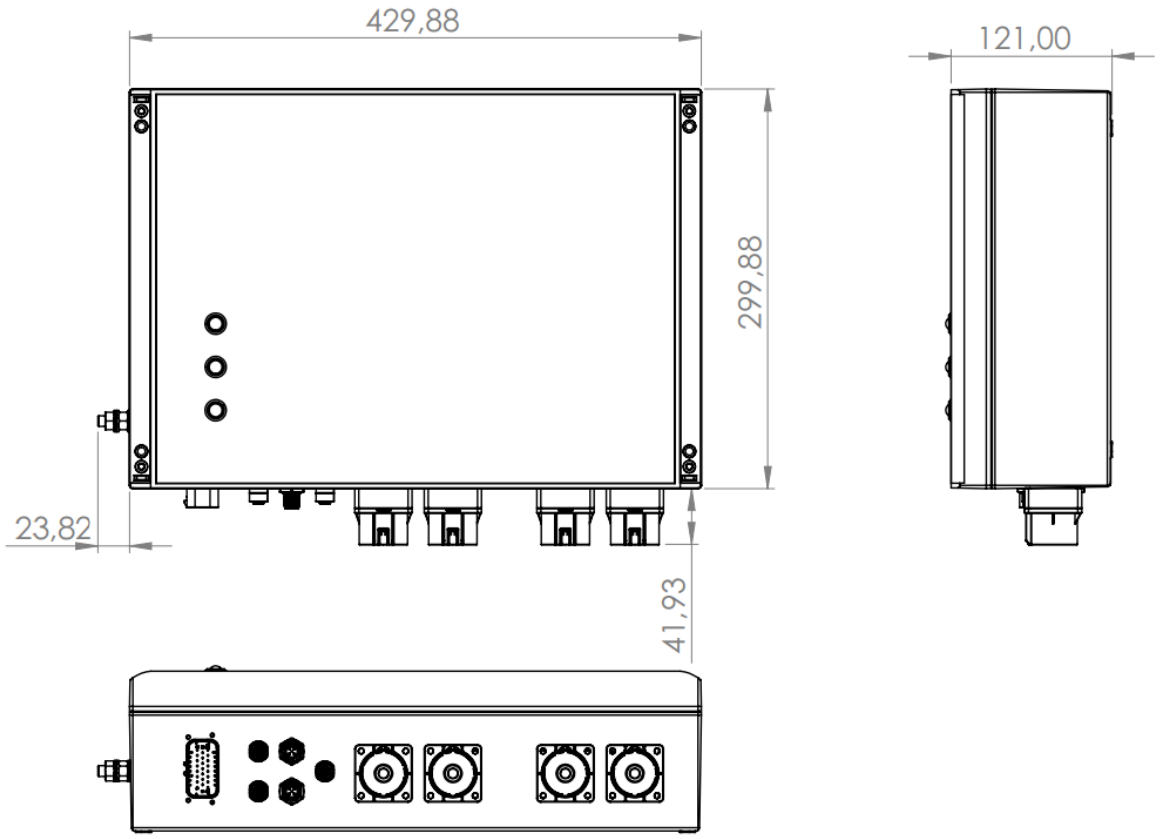


Figure 7 – Dimensions, lay-out, and mounting holes

12 ORDERING INFORMATION

This chapter describes the MG order numbers for spare-, service-, and replacement-parts for the MG Master HV.

Item	Description	Manufacturer	Type	MG order number
1.1	Logic I/O and power supply connector housing	TE Connectivity	770680-5	MGCON0010001
1.2	Logic I/O and power supply connector crimp terminal	TE Connectivity	770520-1	MGCON0010002
2	Power connector 300-series 200A orange positive terminal	Amphenol	PL18X-301-50	MGPL18X-301-50
3	Power connector 300-series 250A orange positive terminal	Amphenol	PL18X-301-70	MGPL18X-301-70
4	Power connector 300-series 200A black positive terminal	Amphenol	PL18Y-301-50	MGPL18Y-301-50
5	Power connector 300-series 250A black positive terminal	Amphenol	PL18Y-301-70	MGPL18Y-301-70
6	USB-CAN Transceiver	MG Energy Systems B.V.		MGUSBCAN001
7	USB-CAN Transceiver	Kvaser Inc.	Leaf Light HS v2 M12	MGUSBCAN002

13 CONTACT DETAILS

For specific questions please feel free to contact us.

MG ENERGY SYSTEMS innovation in energy storage

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