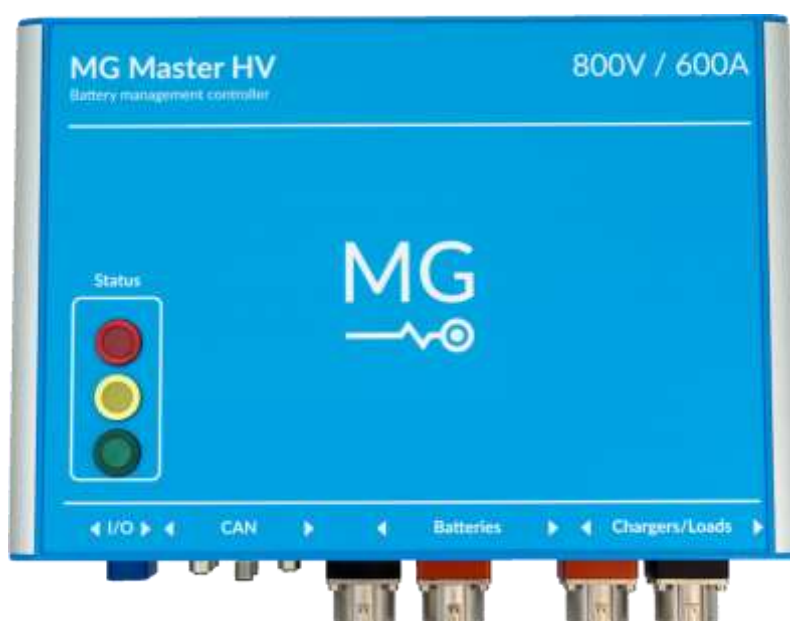


MG Master HV

- Manual -

MGMHV800300 and MGMHV800500

MG Energy Systems B.V.



Version:	2.1
Date:	07-05-2020

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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.	A.T. Rienstra
15-04-2019	Changed main contactor state to “Closed” only in chapter 7.8.	M. Scholten
07-05-2020	Changes made to this revision: <ul style="list-style-type: none"> ▪ Section 7.3.5 clarified on the definition of “safe situation”; ▪ Updated Terms, Definitions and abbreviations; ▪ Updated scope of delivery. Now with cable assembly I/O cable; ▪ Changed text of chapter 4; ▪ Changed text and structure of chapter 7; 	A.T. Rienstra M. Scholten F. Schothorst

1.2 Terms, definitions, and abbreviations

Table 2 - List of terms, definitions, and abbreviations

Battery cell	The smallest building block in a battery, a chemical unit with a positive and negative terminal.
Battery cell cassette	An assembly of a cassette with a battery cell.
Battery cell block	An assembly of multiple battery cassettes.
Battery module	An assembly of battery cell cassettes including BMS.
Battery pack	Consists of one or more battery modules in combination with a battery management controller (BMS).
Battery system	Consists of one or multiple battery packs connected to a common DC-bus.
Battery management controller	Controls, manages and protects one or multiple battery modules.
BMS	Battery Management System that is integrated in the battery pack.
Master BMS	Shorthand for a <i>battery management controller</i> in a MG energy systems battery system.
Slave BMS	The part of the BMS that is integrated in the battery module.
Redundancy BMS	The redundancy BMS that is integrated in the battery module.
Boundary limit	A boundary limit consists of two level values, a set and a clear value, combined with a time condition.
EMS	<i>Energy Management System</i> ; The EMS controls all power sources and consumers in a system in which a battery system may be a component.
DC-bus	Is the main DC-bus of the application where all user equipment is connected too, like generators, propulsion systems and other chargers and loads.
CAN-bus	<i>Controller Area Network bus</i> ; CAN-bus is a standard serial data bus that provides data communication between two or more devices.

HVIL	<i>High Voltage Interlock Loop</i> ; is a wire loop which is created for protection of disconnecting cables from the battery system while in operation. It isolates the electrical connections of the batteries from the system when loop is not closed.
ATC	Allow-to-charge - A digital output used to control chargers.
ATD	Allow to discharge – A digital output used to control loads.
Warning	A warning is a condition of such level causing the BMS to report a warning not critical to system operation, however counter action is needed to avert triggering fail-safe state. According the rules of DNV-GL the definition of a condition of this level is a pre-warning.
Failsafe	A condition of adequate level that causes an Alarm causing the battery pack to go into failsafe state.
SOC	State-of-Charge – reflects the level of charge of a battery pack or battery module relative to its capacity. The units of SOC are percentage points where 0% indicates fully discharged and 100% indicates fully charged.
SOH	State-of-Health – reflects the level of health of a battery pack or battery module relative to its initial capacity.

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.



ELECTRICAL HAZARD:

The possibility of electrical risks if instructions are not followed in a proper manner.



NOTICE:

- A potential situation which, if not avoided, could result in an undesirable result or state.
- A practice not related to personal injury.

2.2 User health and safety

2.2.1 General precautions

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



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 local 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 manufacturer's 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.
- Master HV I/O cable assembly 2m (MGCAA0010014).



NOTICE:

Not within the scope of delivery:

- Power cables and connectors (details can be found in chapter 0).
 - Communication cables and connectors (details can be found in chapter 6.2.2).
 - Fuses.
-

4 GENERAL DESCRIPTION

4.1 The battery system

The battery system is one or more battery packs that can be connected to an energy management system (EMS). A battery pack consists of one battery management controller that is monitoring and protecting a single or up to 48 battery modules. These battery modules can be connected in series or in parallel to meet the required system voltage and capacity

4.2 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.

4.3 Battery management controller

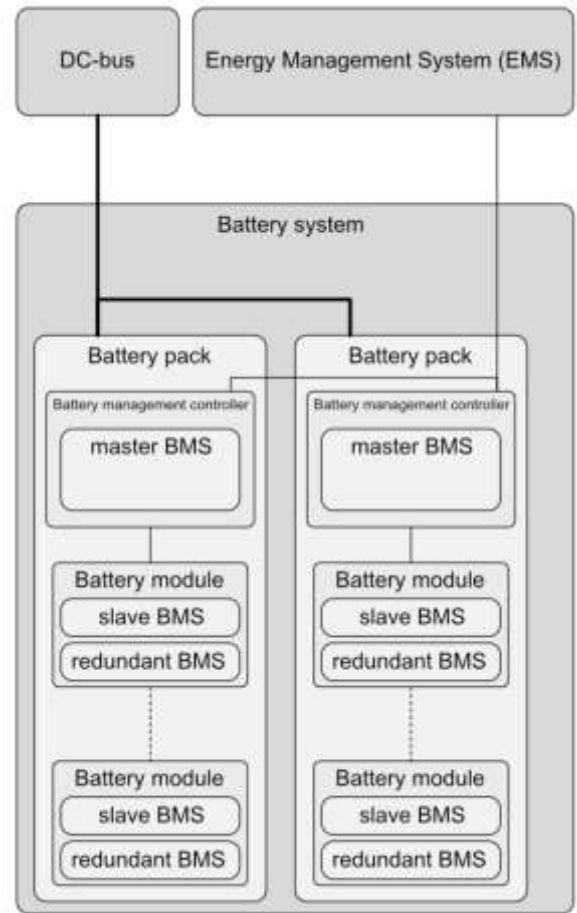
The battery management controller, the MG Master HV, is the safety and control unit of the battery pack. It communicates with the battery modules and provides information to the EMS. The master BMS functionality is added to provide all the safety and control measures. All the hardware to connect the battery pack to, or disconnect the battery pack from the DC-bus is integrated. This includes main contactors and pre-charging. Each battery management controller protects the connected battery modules against overcharging, over-discharging, over- and under-temperature, and controls the balancing of the battery cells.

Also safety features like, E-Stop and HVIL functionality are present. There is support to provide easy diagnostics and system configuration.

4.4 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 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 measuring the battery cell parameters i.e cell voltage, cell temperature, and humidity inside the enclosure. Besides measuring, 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 be communicated to the EMS by CAN-bus. If the exceeded threshold stays, the master BMS has the possibility to electrically isolate the battery pack from the DC-Bus by opening its 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 4 shows an overview of the connector types in relation with the models and the maximum current.

Table 4 - 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 0.

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.

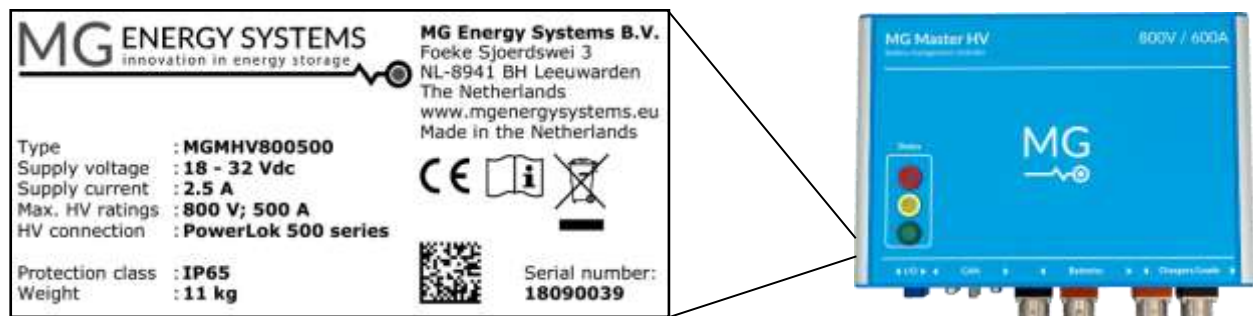






Figure 1 - Example identification label

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 5.

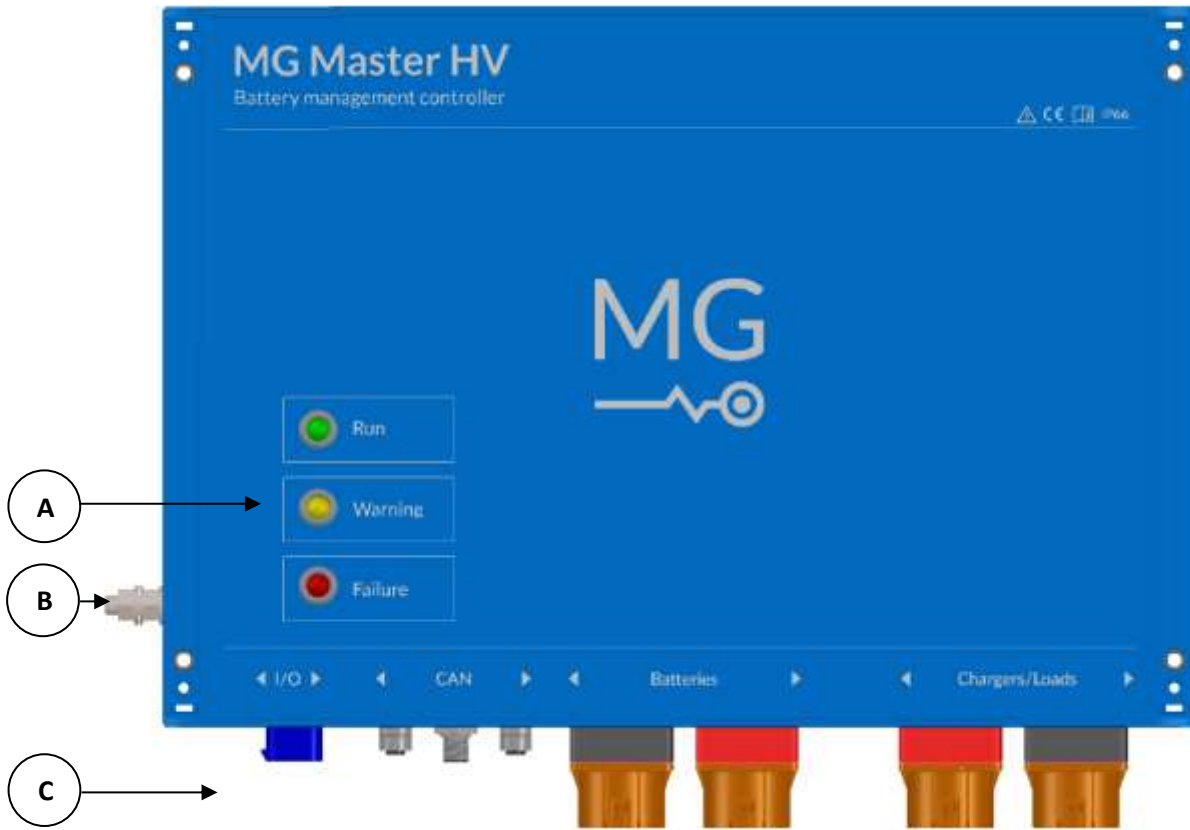
Table 5 - Identification lable logo explanation

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

6 CONNECTIONS

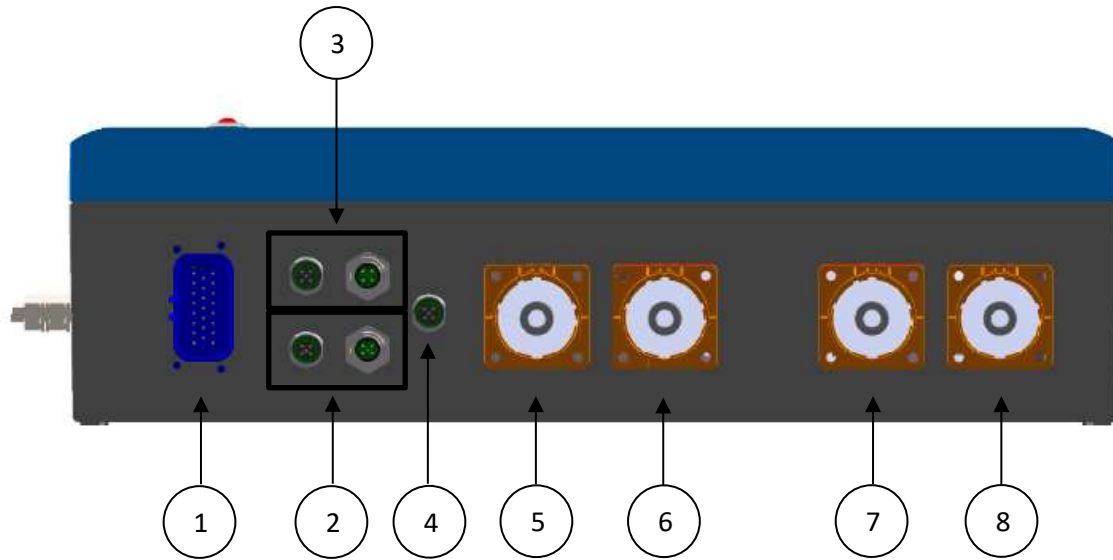
This chapter shows an overview of the connections and parts of the MG Master HV.

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	BMS CAN-bus connections.
3	EMS 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

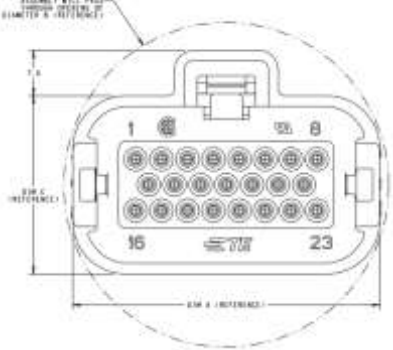

The following tables give the types and pinning of the I/O connector of the Master HV.

	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: GND	
2	24VGND	Power supply: GND	
3	24VGND	Power supply: GND	
4	Output_2+	Common alarm output	Relay contact: Max. 30 VDC fused 1,5 A
5	Output_2-	Common alarm output	Relay contact: Max. 30 VDC fused 1,5 A
6	-	N.C.	
7	E-Stop_OUT	E-Stop input	Output voltage = Supply voltage; Fuse: 140 mA
8	E_Stop_IN	E-Stop input	24 VDC, 5 mA (opto isolated)
9	24V_IN	Power supply: +	18 VDC to 32 VDC
10	ATC+	Allow to Charge	Relay contact: Max. 30 VDC fused 1,5 A
11	ATD+	Allow to Discharge	Relay contact: Max. 30 VDC fused 1,5 A
12	Output_1+	Programmable output	Relay contact: Max. 30 VDC fused 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+	Programmable input	24 VDC, 5 mA (opto isolated)
16	24V_IN	Power supply: +	18 VDC to 32 VDC
17	24V_IN	Power supply: +	18 VDC to 32 VDC
18	ATC-	Allow to Charge	Relay contact: Max. 30 VDC fused 1,5 A
19	ATD-	Allow to Discharge	Relay contact: Max. 30 VDC fused 1,5 A
20	Output_1-	Programmable output	Relay contact: Max. 30 VDC fused 1,5 A
21	Digital_Input_3-	Programmable input	GND of Digital_Input_3+
22	Digital_Input_2-	Programmable input	GND of Digital_Input_2+
23	Digital_Input_1-	Programmable input	GND of Digital_Input_1+

1.1.1.1 Connector view

TE Connectivity: AMPSEAL 770680-5	
Back view of connector	
	

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:

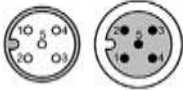
- Data communication between battery module(s) and master BMS;
- The battery module uses the V+ to enable the power of the internal BMS;
- The V+ is also used as HVIL;

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



NOTICE:

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

6.2.3 Power connectors

Table 7 and table 8 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 7 - 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	Over-moulded cable assembly:	Over-moulded cable assembly:
- HVIL type required.	PL10X-501-120: 350A	PL10Y-501-120: 350A
- Use only straight versions.	PL10X-501-135: 400A	PL10Y-501-135: 400A
- Over-moulded cable assembly only.	PL10X-501-150: 500A	PL10Y-501-150: 500A

Table 8 - 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	Over-moulded cable assembly:	Over-moulded cable assembly:
- HVIL type required.	PL10X-301-35: 150A	PL10Y-301-35: 150A
- Use only straight versions.	PL10X-301-50: 200A	PL10Y-301-50: 200A
	PL10X-301-70: 250A	PL10Y-301-70: 250A
	PL10X-301-95: 300A	PL10Y-301-95: 300A
	Plug connector:	Plug connector:
	PL18X-301-35: 150A	PL18Y-301-35: 150A
	PL18X-301-50: 200A	PL18Y-301-50: 200A
	PL18X-301-70: 250A	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 MG Master HV block schematic

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

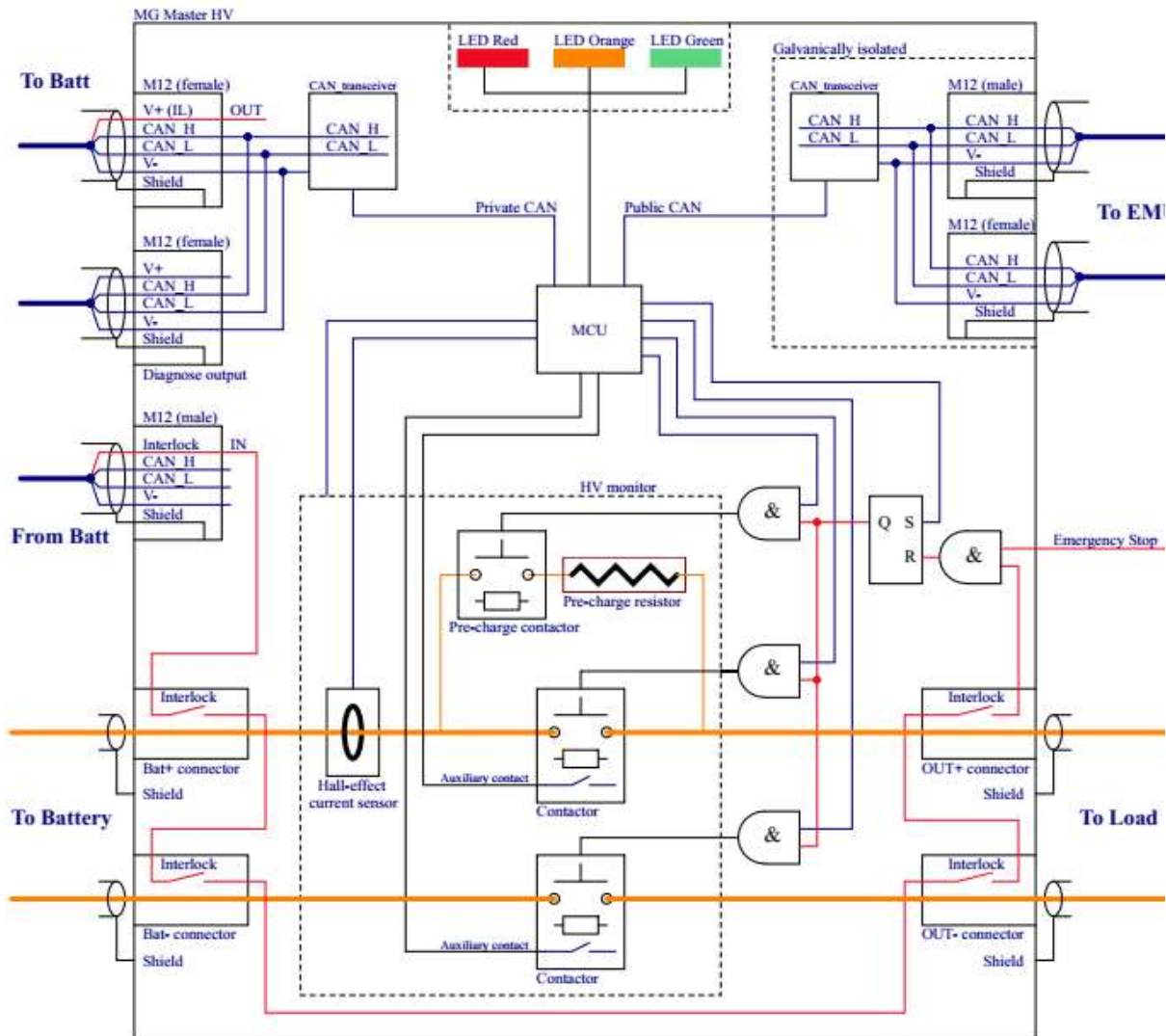


Figure 3 - Master HV schematic overview

7.2 Theory of operation

The system will start initializing the battery pack when an external auxiliary power is applied. In this state, the communication is setup to detect the connected battery modules and parameter monitoring is started. After a successful initializing, the battery pack will wait for a command from the EMS. In this state the battery pack is isolated from the DC-bus. The battery pack will start to connect the DC-bus when a connect-command is received from the EMS. Pre-charging will be performed first to slowly rise the output voltage on capacitive loads, preventing damage on the connected equipment and internal contactors of the battery pack due to high inrush currents. The main contactors will close when pre-charging is successful. If pre-charging fails, and the DC bus voltage did not rise to the correct level, the battery pack will go to the failsafe state. During operation, when the battery pack is connected to the DC-bus, the master BMS is monitoring the state and health of the battery modules.



NOTICE:

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

7.3 Battery pack states

The battery pack can be in different states:

- Initialization;
- DC bus isolated;
- DC bus connecting;
- DC bus connected;
- Failsafe;

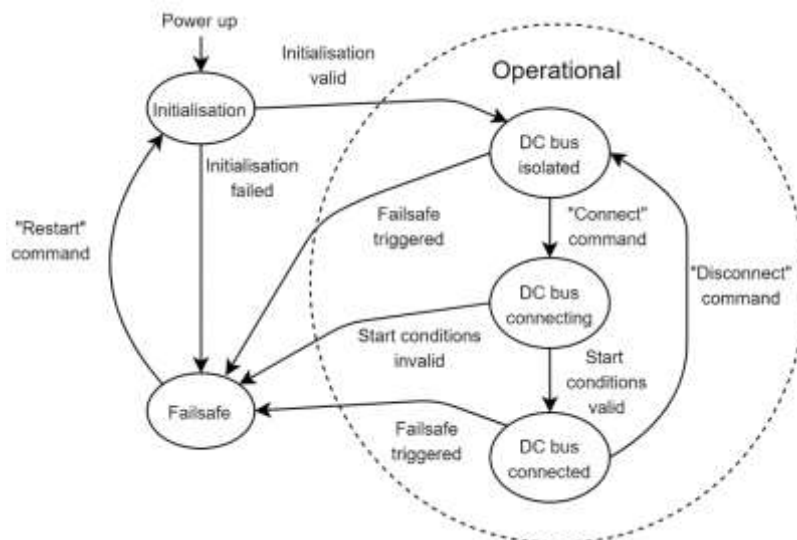


Figure 4 - State machine overview

7.3.1 Initialization state

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

7.3.2 Operational

The battery pack is in “DC bus isolated” state by default when entering operational mode. The battery pack is isolated from the DC-bus and waits for a connect-command from the EMS in this state. When a connect-command is received, the battery pack will start pre-charging the DC-bus. This is the “DC bus connecting” state. Once the “DC bus connecting” is finished it will go to the “DC bus connected” state, in this state the battery pack is connected to the DC-bus and can be charged and discharged.

The following functions will be executed during operational mode:

- Monitoring slave BMS parameters;
- Monitoring master BMS parameters and I/Os;
- Cell balancing control;
- Monitoring battery module communication;
- Monitoring EMS communication;
- Control and verify contactors;
- Charge and discharge parameter control;

7.3.3 DC-bus connecting 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.

7.3.3.1 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.

7.3.3.2 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.

7.3.3.3 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.

7.3.4 DC-bus connected state

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

During operation the HVIL and E-Stop are continuously monitored.

7.3.5 Failsafe 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, i.e. DC-bus disconnected, monitoring of the system keeps running and the EMS is informed about the battery system status.

In sections 7.3.4 the possible trigger conditions to go into failsafe state are described. Besides the software triggers, there are also two hardware triggers to enter failsafe state, by means of:

- Opening of the HVIL loop;
- Activation of the E-Stop;

These hard-wired connections are based on a loop which must be broken to trigger a failsafe condition. If the system is reset from failsafe state by receiving the "reset" command, it will enter the DC-bus isolated state. This is done to prevent the system from automatically continue if the failsafe situation is resolved, i.e. the battery system's main contactors remain open until the "start" command is received.

7.4 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 failsafe state and informs the EMS.

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. This gives the redundancy BMS the ability to open the main contactors independently from any software.

7.5 Emergency stop

The E-Stop is a dedicated hardwired input for the emergency stop feature. The battery pack is immediately disconnected from the DC-bus when the E-Stop is activated. This triggers a failsafe condition.

Optionally there is an input available for an externally added E-Stop functionality feedback circuit. This input will be monitored and the state will be send to the EMS.

Requirements for the emergency stop implementation depend on the application.



NOTICE:

If the battery pack does not make use of an emergency stop, make sure the contact is bridged.

7.6 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	Run: system is in initialising	Open
Green	On	Run: system is operational	Closed
Yellow	On	Warning: system is operational, but needs attention	
Red	On	Failure: system is in fail-safe state	Open

7.7 Master HV boundary limits

The boundary limits that are used for internal measurements and timeouts are listed in this chapter. A level will be triggered when a boundary condition is true for a defined period of time.

The tables with the boundary limits consist of:

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

7.7.1 External auxiliary power supply (24 VDC)

Name	Level	Boundary condition	Time
Hardware failure warning	Set	= invalid	30 sec.
	Clear	= valid	30 sec.
Over voltage warning	Set	≥ 32000 mV	10 sec.
	Clear	< 32000 mV	10 sec.
Over voltage critical	Fail-safe	≥ 35000 mV	+20 sec.
Under voltage warning	Set	≤ 18000 mV	10 sec.
	Clear	> 18000 mV	10 sec.
Under voltage critical	Fail-safe	≤ 15000 mV	+20 sec.

7.7.2 Internal power supply (12 VDC)

Name	Level	Boundary condition	Time
Hardware failure warning	Set	= invalid	30 sec.
	Clear	= valid	30 sec.
Under voltage warning	Set	≤ 11500 mV	10 sec.
	Clear	> 11500 mV	10 sec.
Under voltage critical	Fail-safe	≤ 11000 mV and power supply feedback is bad.	+20 sec.

7.7.3 Battery pack voltage

Name	Level	Boundary condition	Time
Hardware failure warning	Set	= invalid	30 sec.
	Clear	= valid	30 sec.
Hardware failure warning	Set	\geq Over voltage critical or \leq under voltage critical ¹	10 sec.
	Clear	$<$ Over voltage critical or $>$ under voltage critical ¹	10 sec.

¹ Critical battery cell over or under voltage times number of cells per battery module in series times number of battery modules in battery pack in series.

7.7.4 Positive DC-bus voltage

Name	Level	Boundary condition	Time
hardware failure warning	Set	= invalid	30 sec.
	Clear	= valid	30 sec.

Name	Level	Boundary condition	Time
Hardware failure warning	Set	\geq Over voltage critical or \leq under voltage critical ¹	10 sec.
	Clear	< Over voltage critical or > under voltage critical ¹	10 sec.
Service request	Set	Contactors closed and $\geq 104\%$ ² of the battery pack voltage or $\leq 96\%$ ² of the battery pack voltage	2 sec.
	Clear	System restart	

¹ Critical battery cell over or under voltage times number of cells per battery module in series times number of battery modules in battery pack in series.

² The 4% has a minimum of 2000mV and a maximum of 10000mV

7.7.5 Negative DC-bus voltage

Name	Level	Boundary condition	Time
hardware failure warning	Set	= invalid	30 sec.
	Clear	= valid	30 sec.
Service request	Set	Contactors closed and $\geq 4\%$ ¹ of the battery pack voltage	2 sec.
	Clear	System restart	

¹ The 4% has a minimum of 2000mV and a maximum of 10000mV

7.7.6 Battery pack current

Name	Level	Boundary condition	Time
Hardware failure warning	Set	= invalid	30 sec.
	Clear	= valid	30 sec.
Hardware failure warning	Set	Contactors opened and hardware sensor wires failure detected	1 hours
	Clear	System restart	
Hardware failure warning	Set	Contactors closed and hardware sensor wires failure detected	24 hours
	Clear	System restart	
Hardware failure critical	Fail-safe	Hardware sensor wires failure detected	on start-up

7.7.7 PCBA master temperature

Name	Level	Boundary condition	Time
Hardware failure warning	Set	= invalid	30 sec.
	Clear	= valid	30 sec.
Over temperature master warning	Set	$\geq 90,0$ °C	30 sec.
	Clear	< 90,0 °C	30 sec.

7.7.8 Bottom plate master temperature

Name	Level	Boundary condition	Time
Hardware failure warning	Set	= invalid	30 sec.
	Clear	= valid	30 sec.
Over temperature master warning	Set	$\geq 90,0$ °C	30 sec.

Name	Level	Boundary condition	Time
	Clear	< 90,0 °C	30 sec.

7.7.9 Pre-charge resistor temperature

Name	Level	Boundary condition	Time
Hardware failure warning	Set	= invalid	30 sec.
	Clear	= valid	30 sec.
Over temperature master warning	Set	>= 90,0 °C	30 sec.
	Clear	< 90,0 °C	30 sec.

7.7.10 Private CAN-bus communication timeout

Name	Level	Boundary condition	Time
Private CAN-bus communication timeout warning	Set	= not received all required data	10 sec.
	Clear	= received all required data	0 sec.
Private CAN-bus communication timeout critical	Fail-safe	= not received all required data	30 sec.

7.7.11 Public CAN-bus communication timeout

Name	Level	Boundary condition	Time
Public CAN-bus communication timeout warning	Set	= no command received from EMS	600 ms.
	Clear	= command received from EMS.	0 sec.
Public CAN-bus communication timeout critical	Fail-safe	= no command received from EMS	2 sec.

7.7.12 Pre-charge DC-bus

Name	Level	Boundary condition	Time
Short-circuit	Fail-safe	DC-bus voltage does not rises to a boundary of 10% of the battery pack voltage	500 ms.
Overloaded	Fail-safe	DC-bus voltage does not reach $\pm 5\%$ ¹ of the battery pack voltage	10 sec.

¹ with a boundary of ± 10 V

7.7.13 Internal CAN-bus power supply

Name	Level	Boundary condition	Time
Service request	Set	= Power switch over load detected	0 ms.
	Clear	= Power switch good	1200 ms.

7.7.14 Diagnostic CAN-bus power supply

Name	Level	Boundary condition	Time
Service request	Set	= Power switch over load detected	0 ms.
	Clear	= Power switch good	1200 ms.

8 INTEGRATION REQUIREMENTS AND INSTRUCTIONS

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.



NOTICE:

The MG Master HV does not contain main fuses. The fuses must be place externally.



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 BMS CAN-bus connection

The BMS CAN-bus is used for communication between the connected battery modules and the MG Master HV. All relevant data is send from the battery modules to the MG Master HV.

Figure 5 shows an example of how the BMS CAN-bus must be connected.

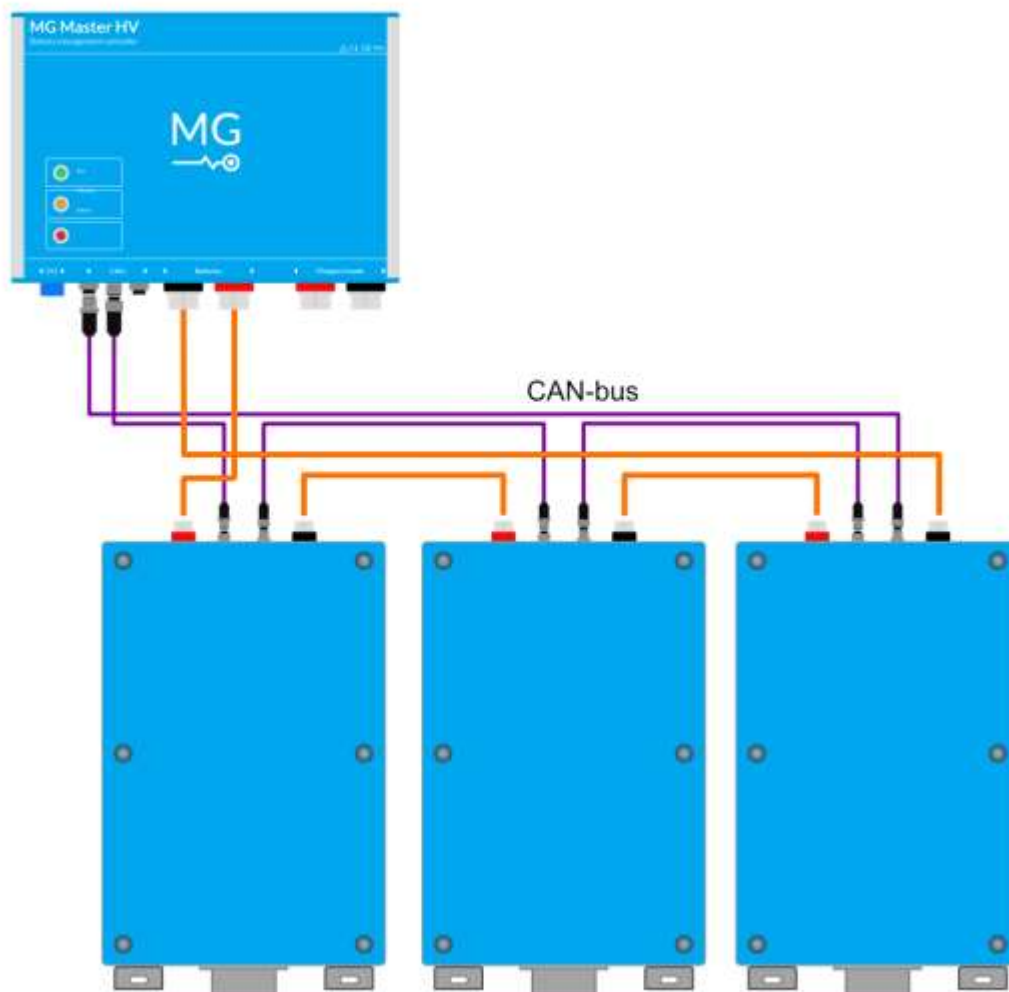


Figure 5 - CAN-bus connection example

The CAN-bus connection starts at the MG Master HV and will be daisy chained through all the batteries back to the MG Master HV. By creating a loop back to the MG Master HV the HVIL is closed and can be monitored. Refer to chapter 7.47.4 for details about the HVIL.



NOTICE:

Only MG equipment may be connected to the BMS CAN-bus.

8.3.3 EMS CAN-bus connection

For correct operation it is important that the MG Master HV is controlled via the EMS 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.

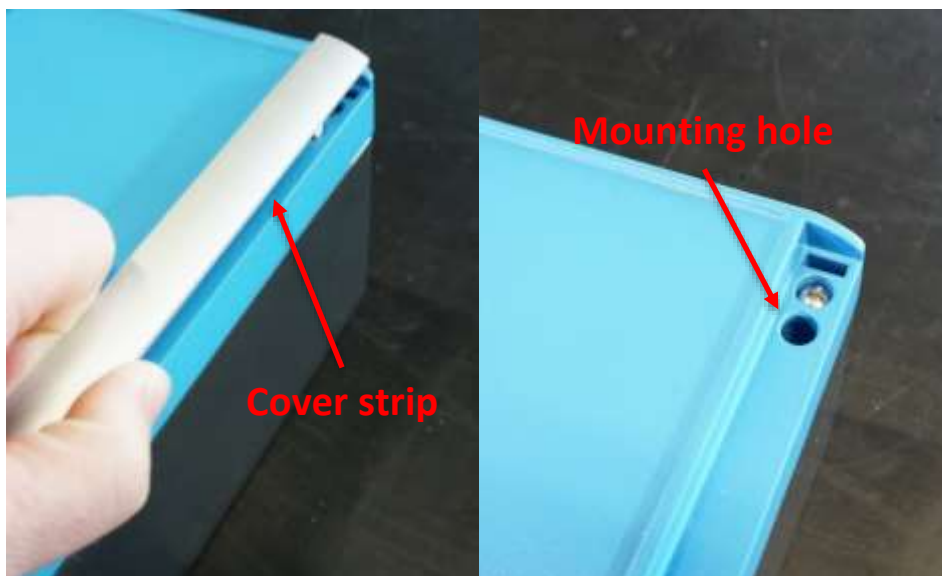
9.2 Mounting procedure

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 to 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 mm².



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.



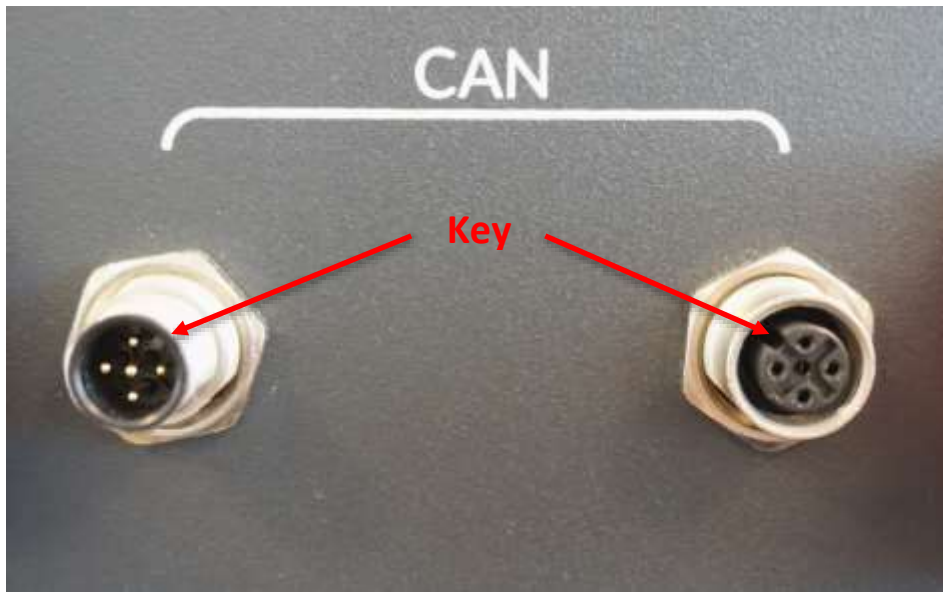
WARNING:

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 0 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™.



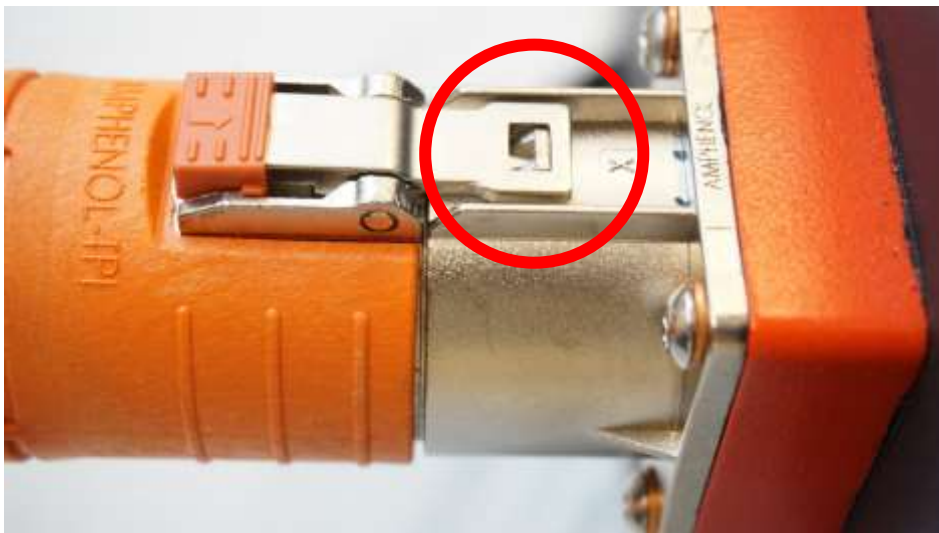
NOTICE:

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 pour or spray water directly onto the device. When cleaning the device be aware that the connected battery string is a permanent energy source. Even when the device is turned off, the battery power connections might carry dangerous voltage levels.

10.1.1 Connections

It will suffice to check all connections once a year. Check if all connectors are mated correctly according 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 6.

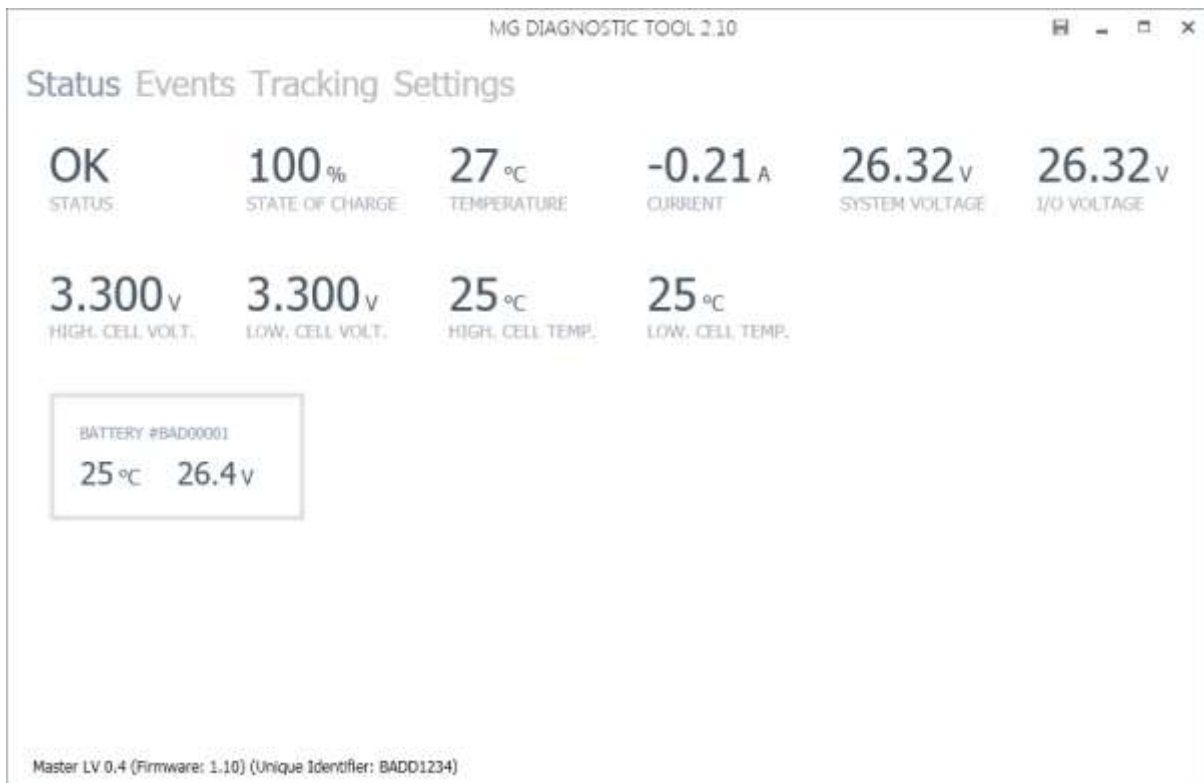


Figure 6 - Status overview of the MG Diagnostics Tool software

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 7.

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 7 - 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 1 (relay output)	Max. 30 VDC fused 1,5 A	
Common alarm output 2 (relay output)	Max. 30 VDC fused 1,5 A	
Digital input 1 ¹	24 VDC, 5 mA	
E-Stop status (input 2)	24 VDC, 5 mA	
Leakage detection (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 8. Unless otherwise stated all dimensions are stated in millimetres [mm].

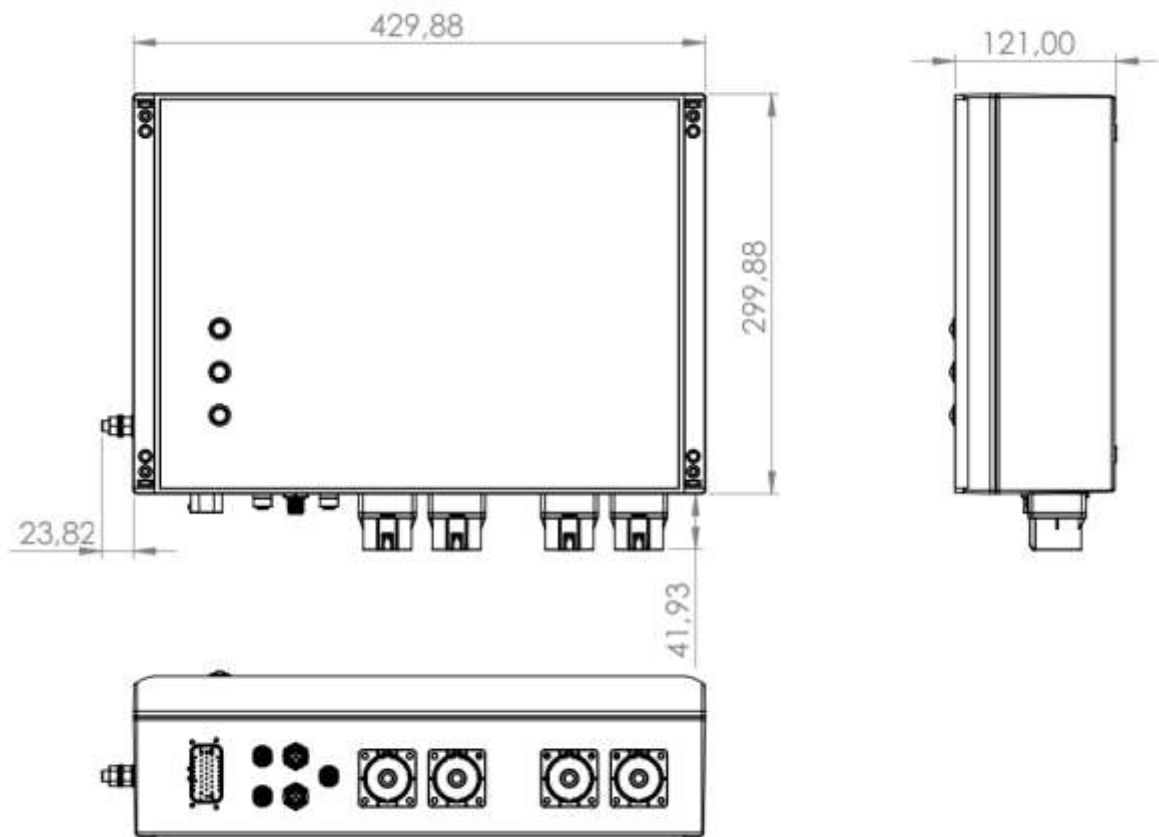


Figure 8 – Dimensions, lay-out, and mounting holes

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	Master HV I/O cable assembly 2m.	MG Energy Systems B.V.		MGCAA0010014
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.



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