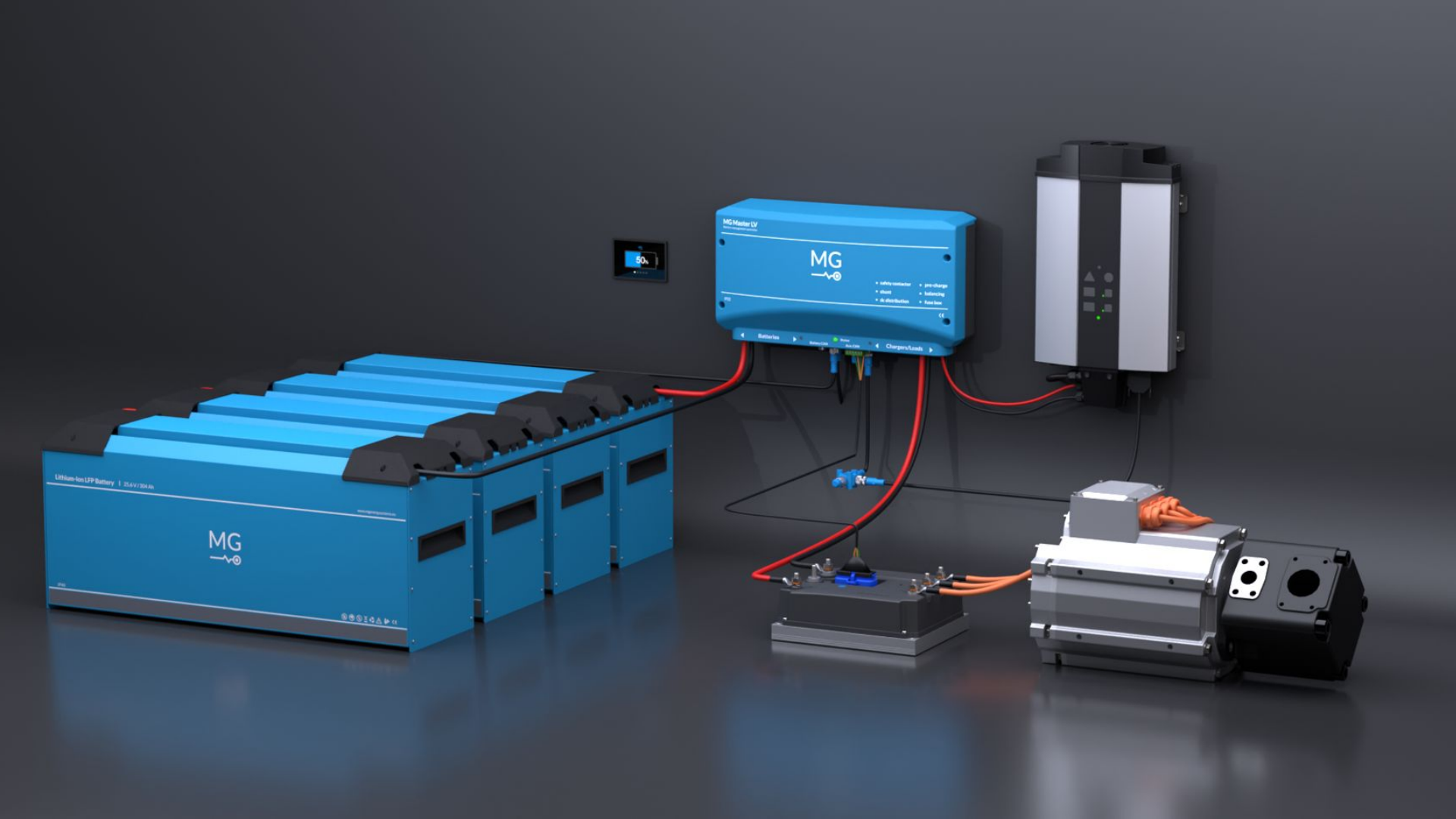
High Voltage Systems
Part I

MG


MG Master LV
MG
Batteries
Chargers/Loads
Lithium-Ion LFP Battery
MG

Part I

72 Vdc and 96 Vdc

Part II

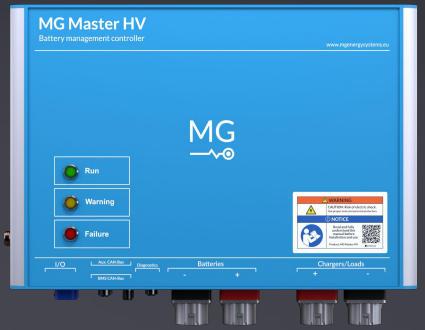
48 Vdc up to 900 Vdc

Part I

72 Vdc and 96 Vdc

Part II

48 Vdc up to 900 Vdc



Part I - 72 Vdc and 96 Vdc systems

Why >48 Vdc ?

Lower currents and
smaller electric engines

High power output:

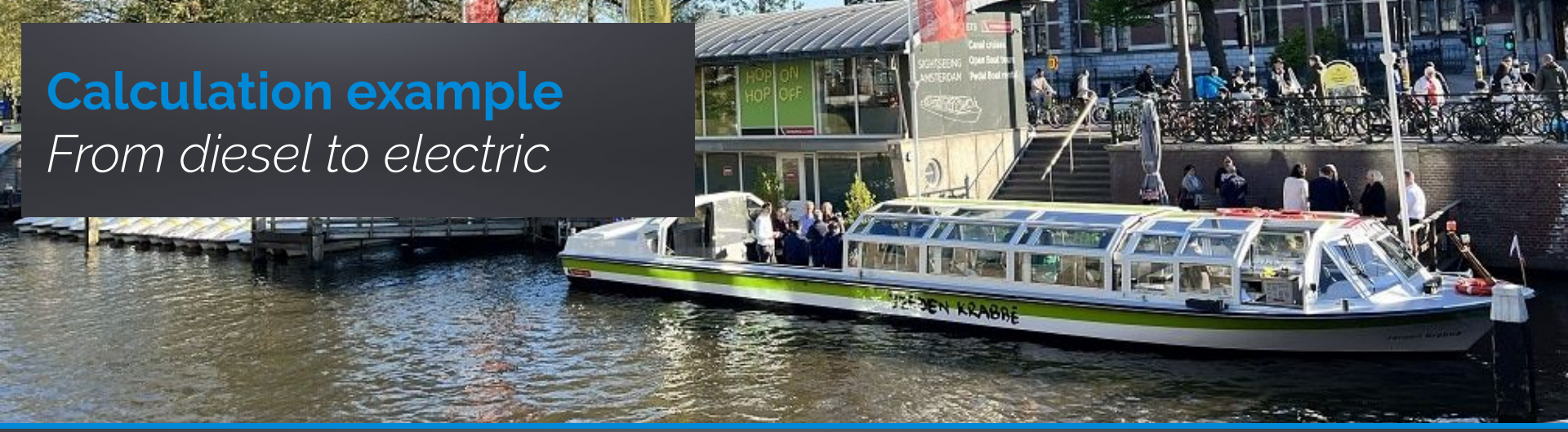
- Electric and hybrid propulsion
- Hydraulic powerpacks
- Electric engines

> 400 Vdc:
Hybrid and full-electric systems on
large vessels / mobility
(mostly between 400 and 900V)

Calculation example

From diesel to electric

Diesel Engine (ICE)	Nominal Diesel Power	Electric Power
120 pk	**90 kW**	**60-70 kW**



Calculation example

From diesel to electric

Electric Power

60-70 kW

D.O.D. 80%
E.O.L. 70%

Nominal power

20 kW

Duration

8 h

Battery bank

160 kWh

C-Rating Example: 6kW electric motor

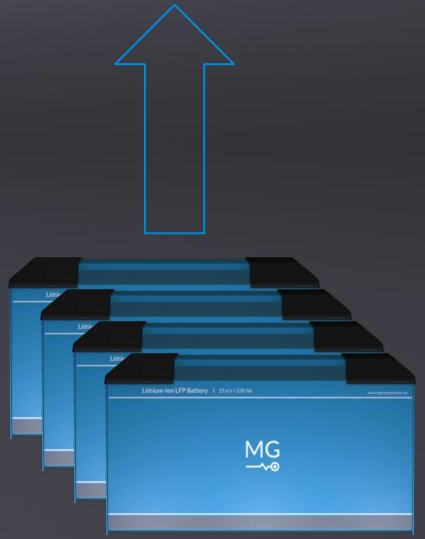
1C

5.8 kWh

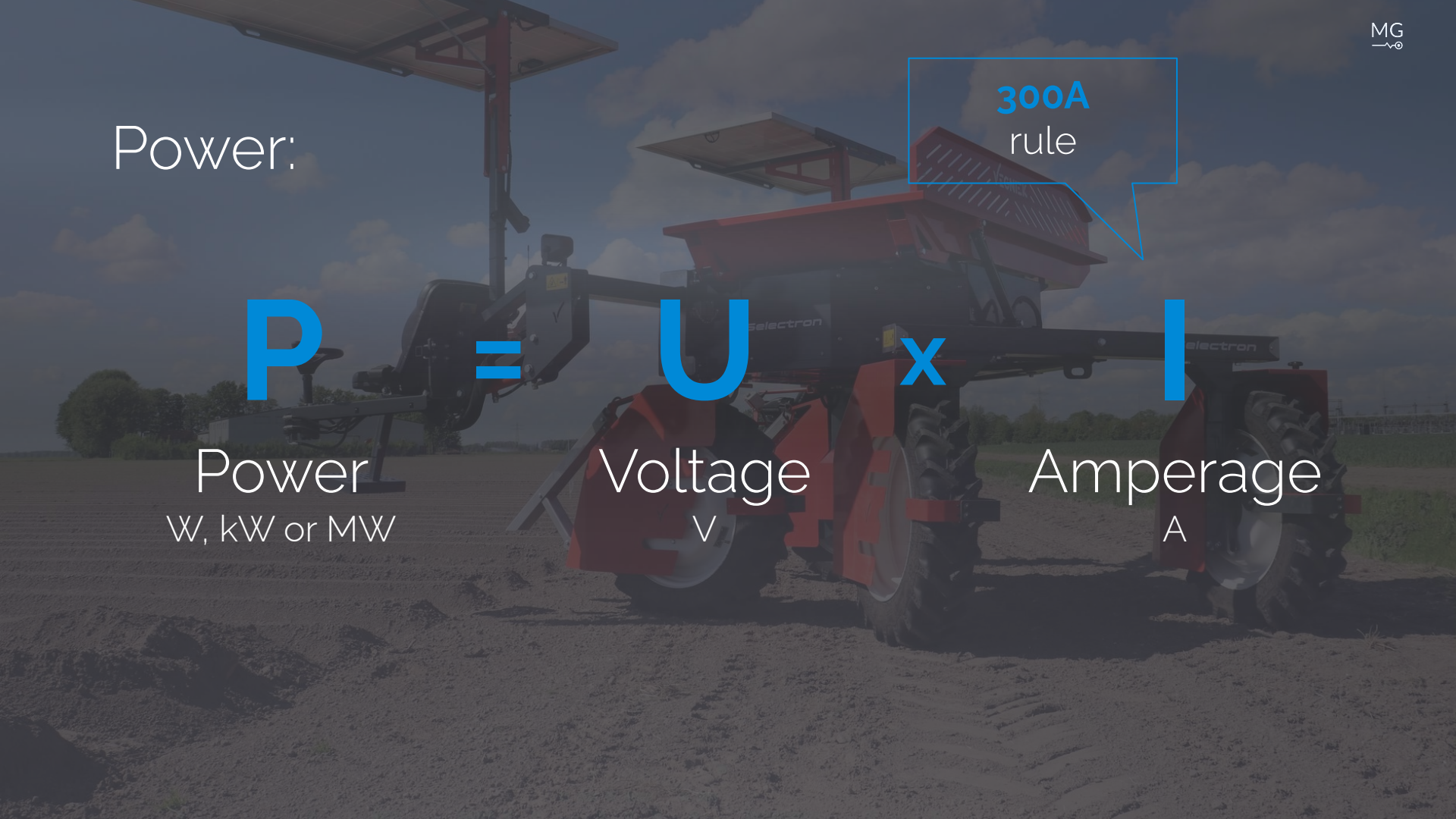
0.5C

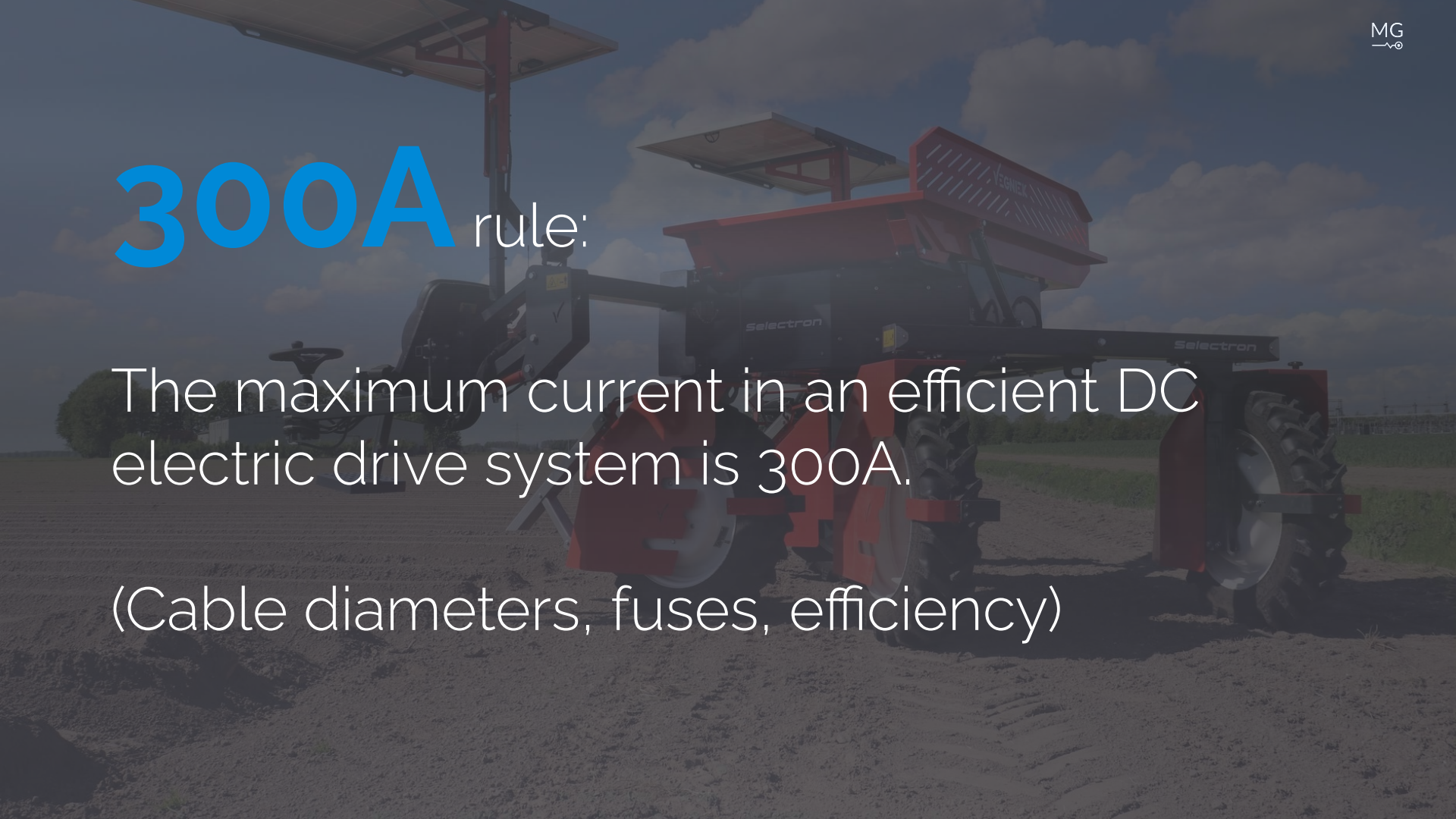
11.6 kWh

0.25C



23.2 kWh


300A
rule
Power:
P = U x I
Power
W, kW or MW
Voltage
V
Amperage
A



300A rule:

The maximum current in an efficient DC electric drive system is 300A.

(Cable diameters, fuses, efficiency)

P	U	I_{max}
15 kW	48 V	300 A
30 kW	96 V	300 A
45 kW	144 V	300 A
60 kW	200 V	300 A

Master LV and Master HV

BMS for systems from 12V up to 900V

+	(Touch)safe up to 48V systems Available components Easy to install Master LV Price	+	More efficient Higher power outputs Engines are more compact Inverters are more compact
−	Limited in power Less efficient Thick cables	−	Complexity of the system Less availability of standard components CAN-bus and EMC

Master LV

72V and 96V

500A

Master LV

- Cell balancing (BMS)
- Safety contactor
- Pre-charge
- Shunt
- DC distribution
- Fuse box
- Bluetooth

Safety and Control Unit

Protection against:

- Over-charging
- Over-discharging
- Over-temperature
- Under-temperature
- Balancing

Balancing (BMS)

Main function: battery bank protection

Gathering cell voltage and temperatures from the battery modules

Monitors cell voltage, temperatures and current

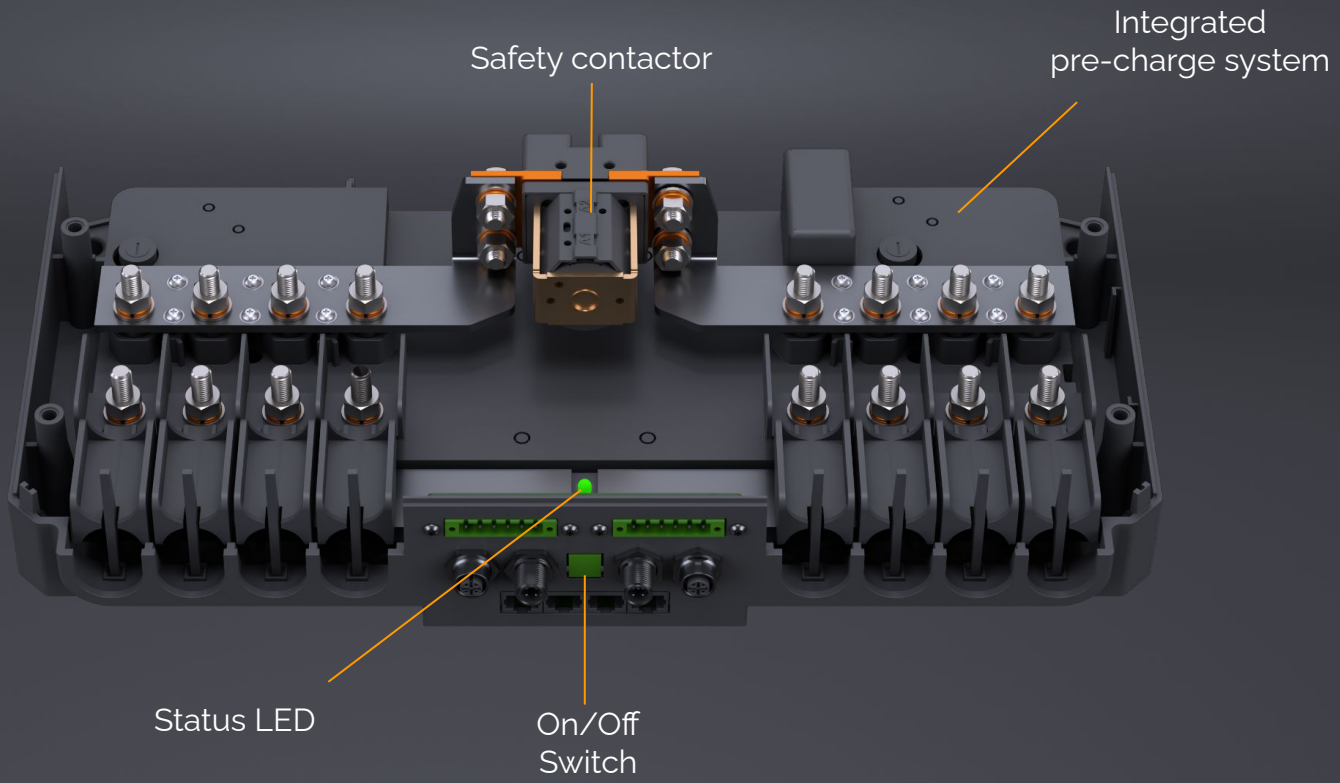
Monitors communication time-out on the batteries

Controls balancing

Event logging to internal flash memory

Charger/loads control

Safety Contactor



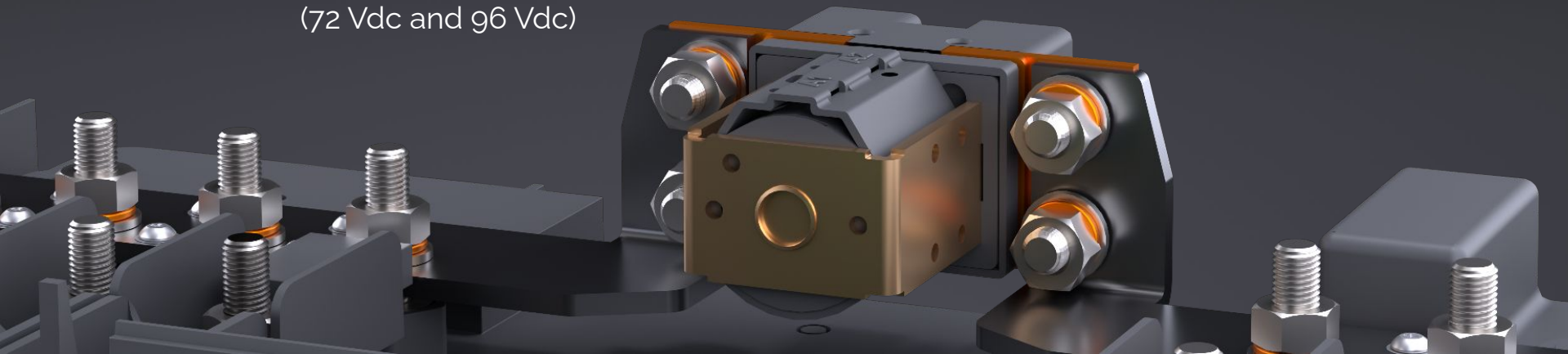
Safety Contactor

Integrated safety contactor as second level protection

Models:

- 150A / 400A / 600A / 1000A
  (12 and 24 / 48 Vdc)

- 500A
  (72 Vdc and 96 Vdc)



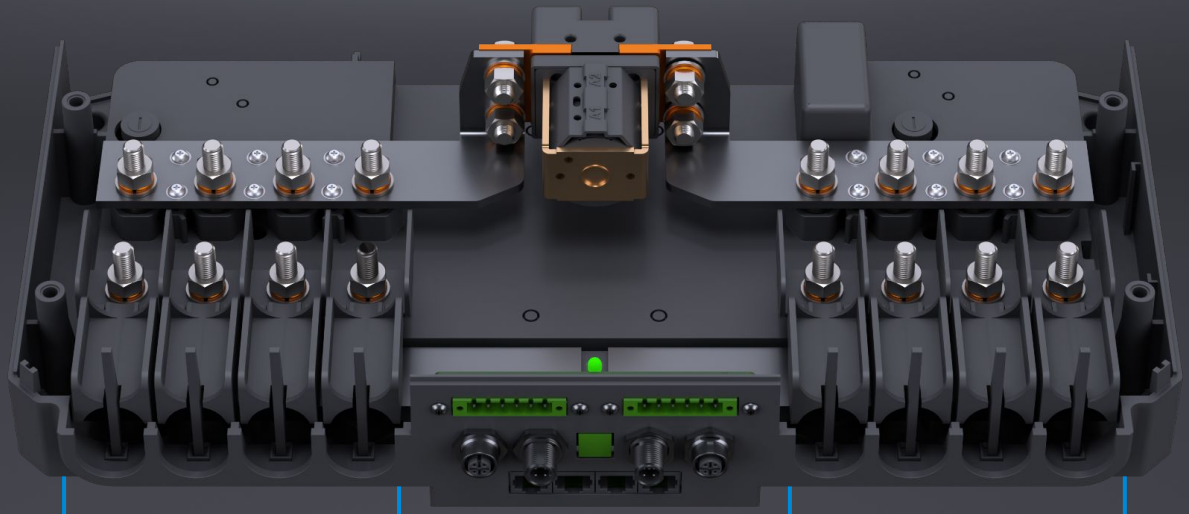
Pre-Charge

Automatic at startup

Safety contactor closes when 80% of the battery voltage is reached

- No welding of the safety contactor
- No sparks

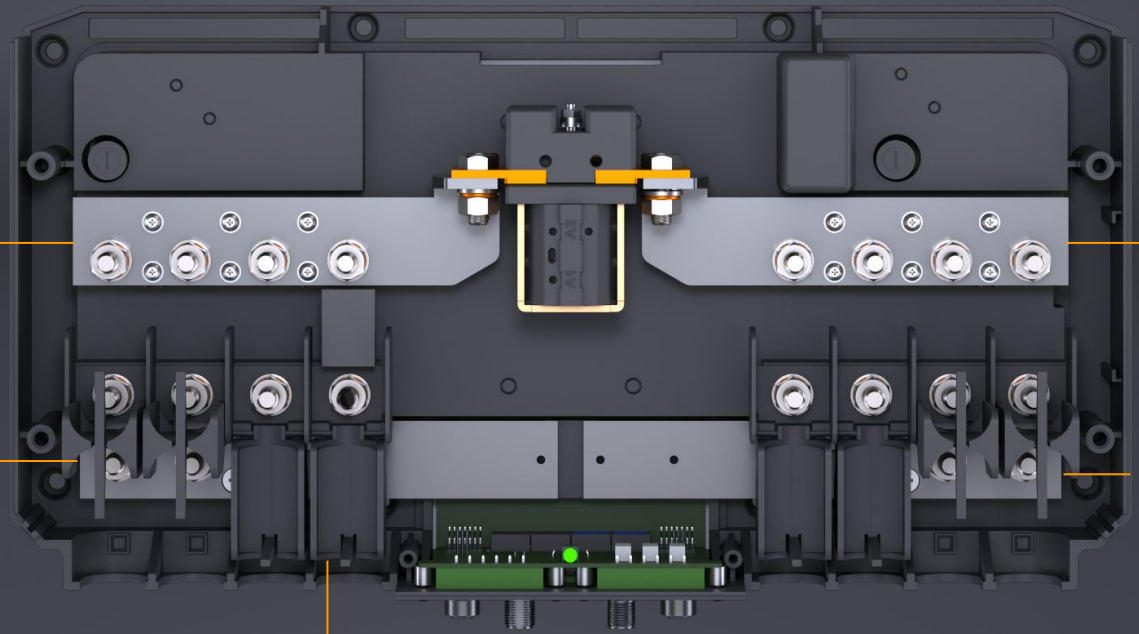
DC Distribution



Battery connections

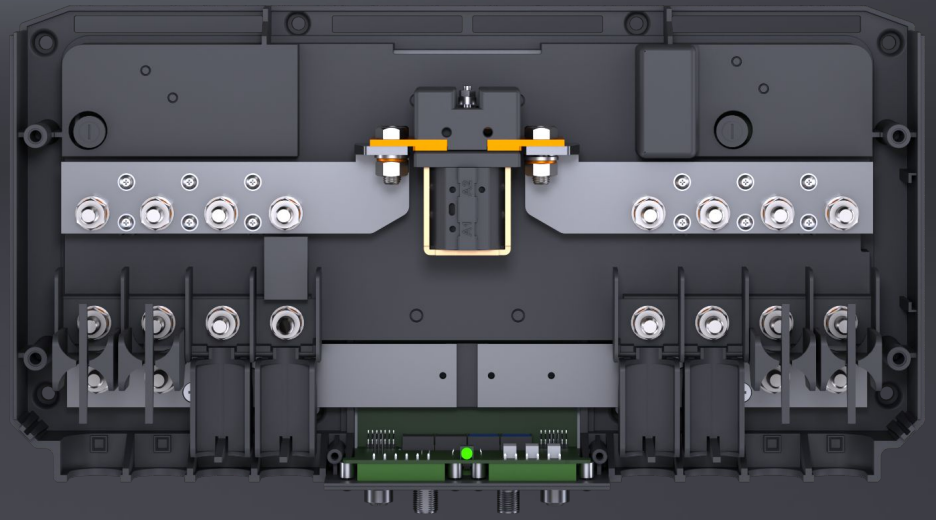
Chargers & load connections

DC Distribution



DC Distribution

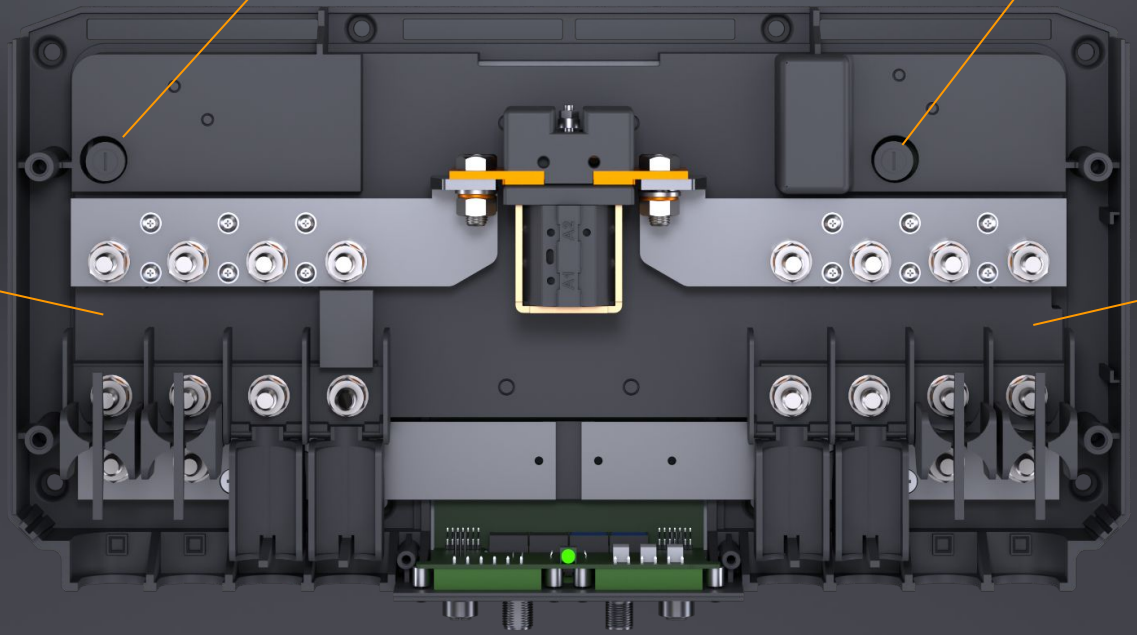
- Bolt down M8
- 4 inputs and
  4 outputs available
- Fuse holder (+) MEGA Fuse
- Max. cable diameter: 120 mm2
  (depending on cable lug)



Fuses

Fuse main
control unit (PCB)

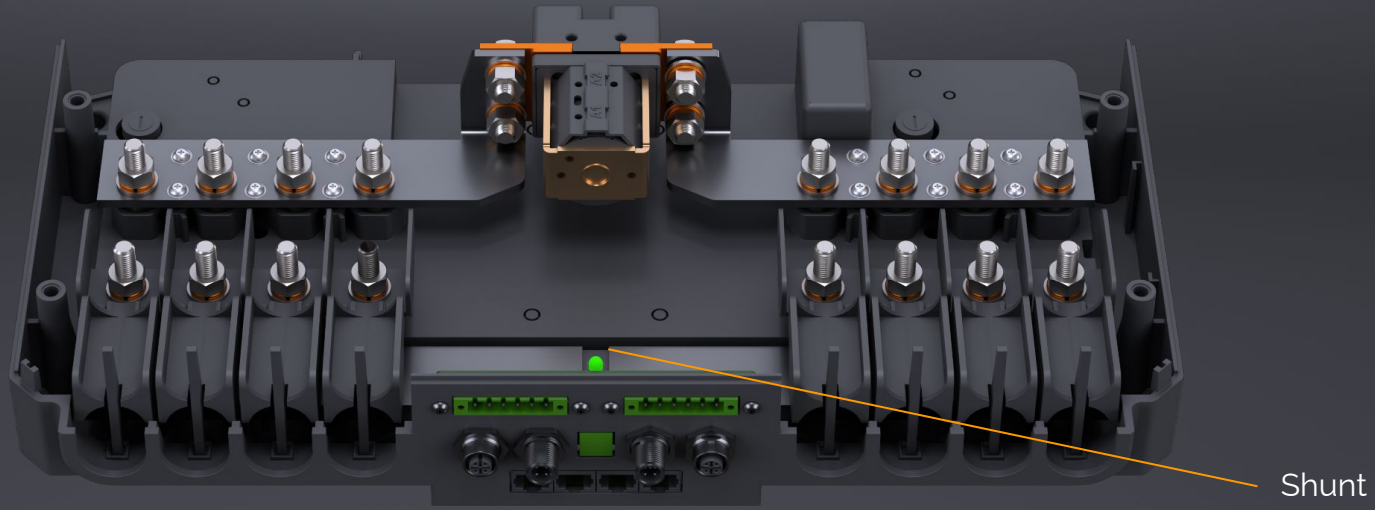
Pre-charge
fuse (10A)



Fuse holders
to protect
parallel battery banks
(4x)

Fuse holders
to protect
chargers and loads
(4x)

Shunt



CAN-Bus

Battery CAN-Bus
M12
RJ45

Auxiliar CAN-Bus
M12
RJ45

CAN-Bus communication

- NMEA2000
- SMA
- Custom

I/O Connections

I/O connector **A**

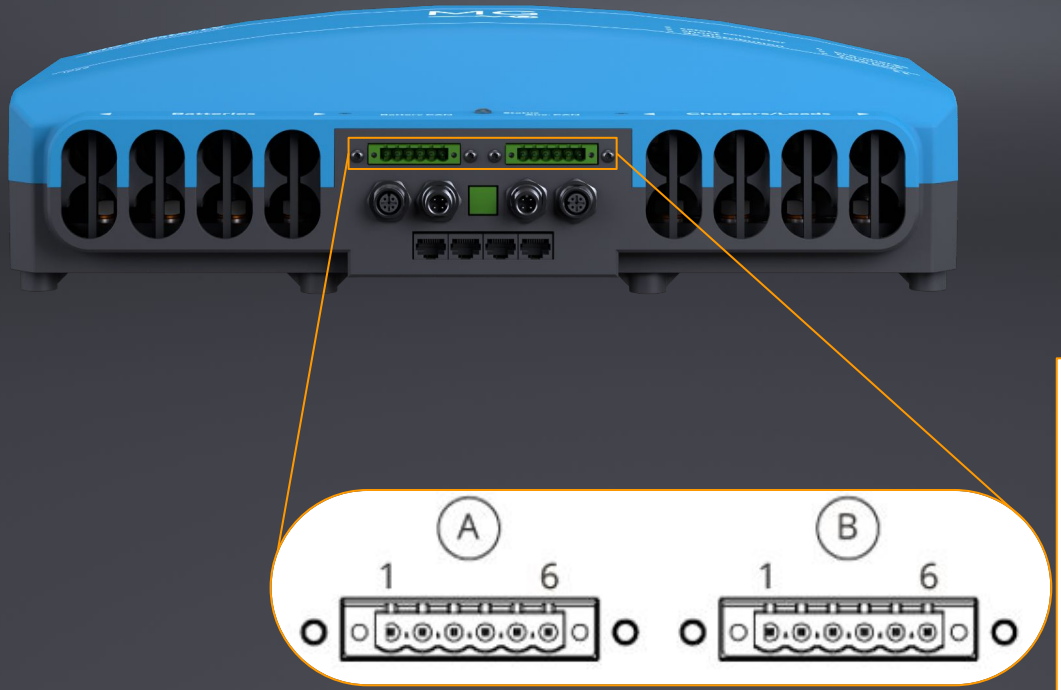
I/O connector **B**

To control chargers and loads
(allow to charge / allow to discharge)

Programmable contact

Remote on/off switch and status LED

I/O Connections



Connector pins and specifications					
Conn.	Pin	I/O	Voltage	Current	Purpose
A	1	Out	13,5 V	1 A	Aux. power output
	2	Out	13,5 V	1 A	Allow-to-Charge
	3	Out	13,5 V	1 A	Allow-to-Discharge
	4	In			External start button
	5	Out	13,5 V	140 mA	External status output
	6	-			GND
B	1	Out	Max. 60 VDC	0,8 A @ 60 VDC	Allow-to-charge
	2				
	3	Out	Max. 60 VDC	0,8 A @ 60 VDC	Allow-to-discharge
	4				
	5	Out	Max. 60 VDC	0,8 A @ 60 VDC	Programmable output
	6				

External Start Button & Status Indication

Connector A
Pin 4: External Start button
Pin 5: External Status output
Pin 6: GND

External Start Button & Status Indication

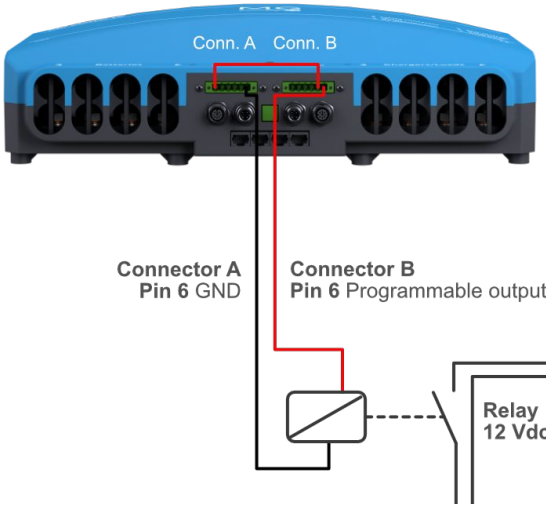
Pin 4,5,6
Start button must be momentary
Status LED must be 12V type

Programmable Relay

Switching possible on the following parameters:

- State-Of-Charge
- Current
- Temperature
- Cell voltage
- Failsafe
- Warning
- System Active
- Discharge almost not allowed

Programmable Relay



Connector pins and specifications					
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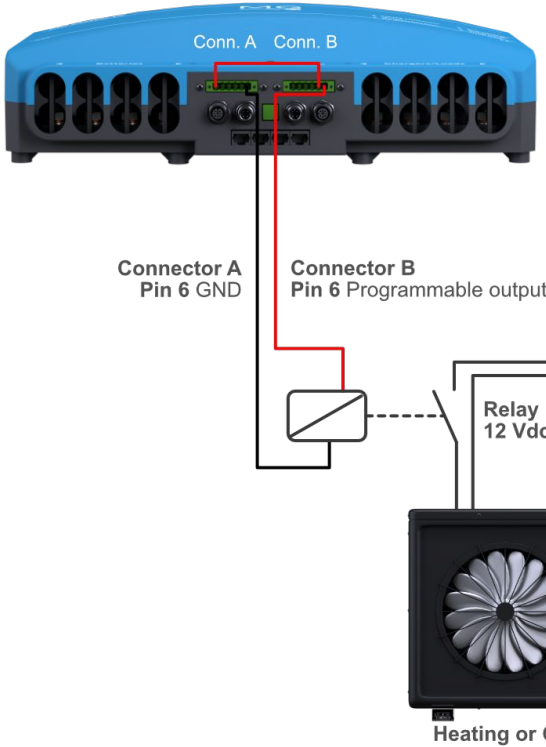
A	1	Out	13,5 V	1 A	Aux. power output
	2	Out	13,5 V	1 A	Allow-to-Charge
	3	Out	13,5 V	1 A	Allow-to-Discharge
	4	In			External start button
	5	Out	13,5 V	140 mA	External status output
	6	-			GND
B	1	Out	Max. 60 VDC	0,8 A @ 60 VDC	Allow-to-charge
	2				
	3	Out	Max. 60 VDC	0,8 A @ 60 VDC	Allow-to-discharge
	4				
	5	Out	Max. 60 VDC	0,8 A @ 60 VDC	Programmable output
	6				

Programmable Relay



Connector A
Pin 1 Aux. power output (13.5 V - 1 A)

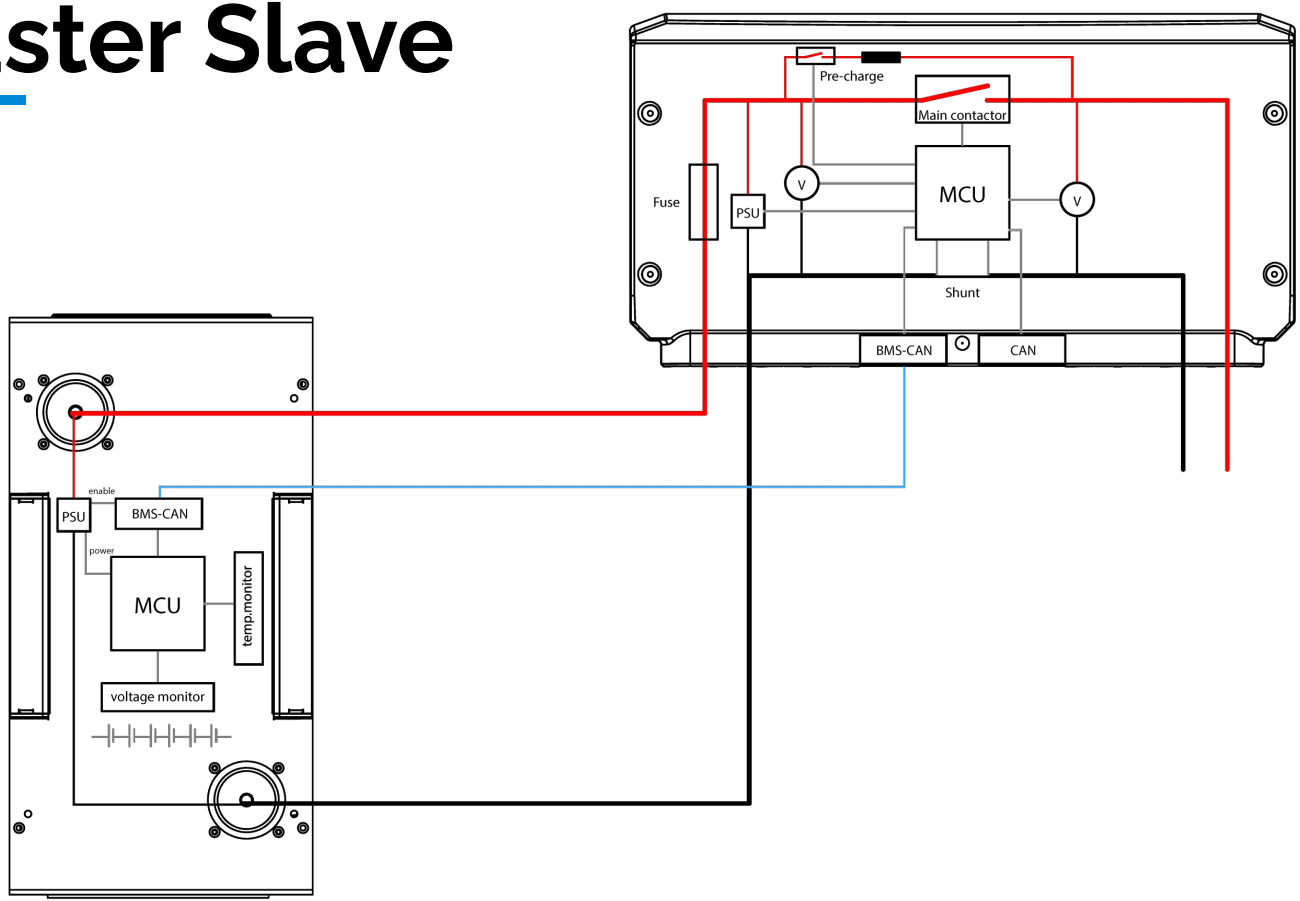
Connector B
Pin 5 GND

Connector pins and specifications					
Conn.	Pin	I/O	Voltage	Current	Purpose
A	1	Out	13,5 V	1 A	Aux. power output
	2	Out	13,5 V	1 A	Allow-to-Charge
	3	Out	13,5 V	1 A	Allow-to-Discharge
	4	In			External start button
	5	Out	13,5 V	140 mA	External status output
	6	-			GND
B	1	Out	Max. 60 VDC	0,8 A @ 60 VDC	Allow-to-charge
	2				
	3	Out	Max. 60 VDC	0,8 A @ 60 VDC	Allow-to-discharge
	4				
	5	Out	Max. 60 VDC	0,8 A @ 60 VDC	Programmable output
	6				

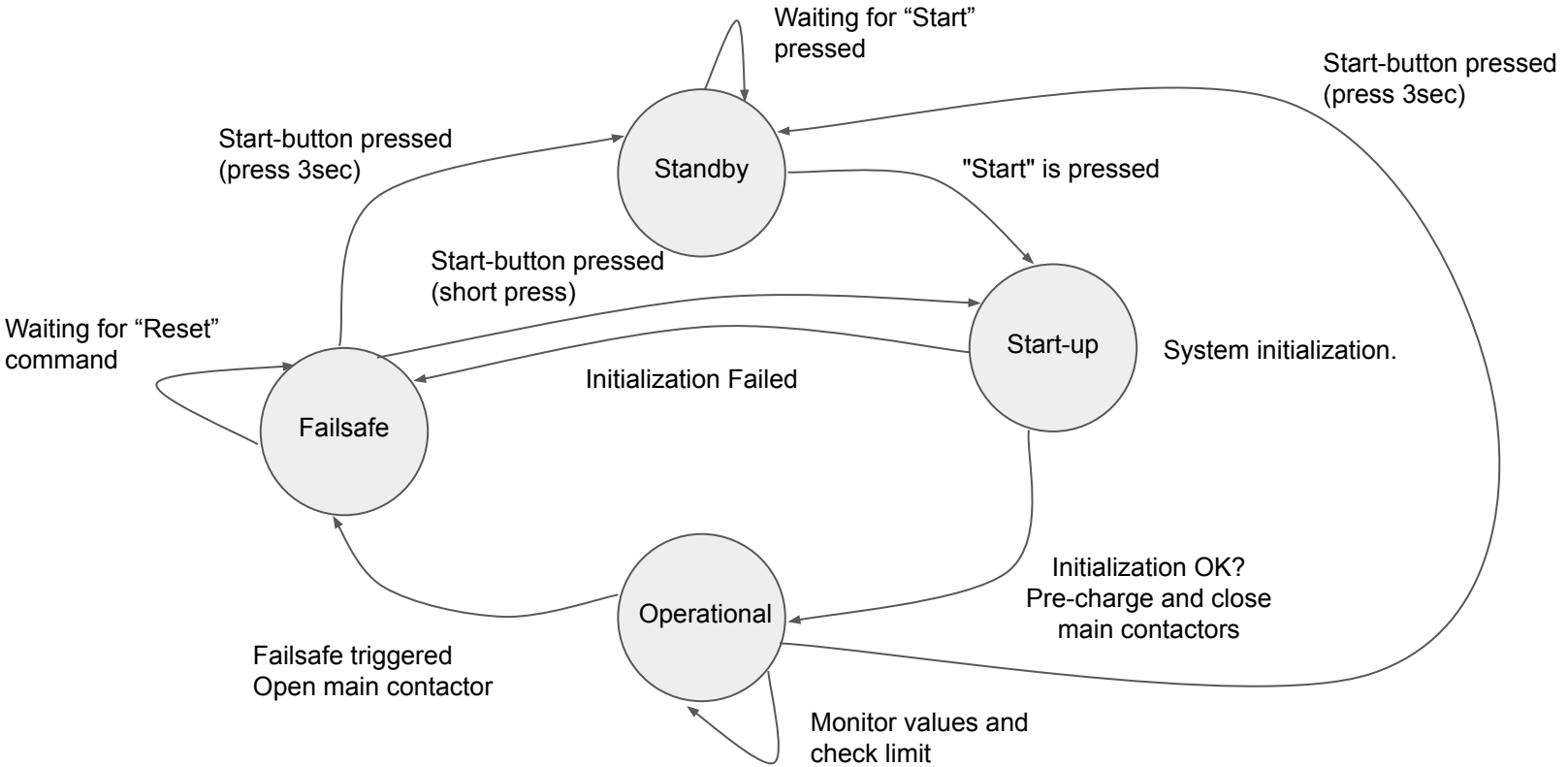
M12 CAN-Bus


MG Master LV
MG
safety contactor
pre-charge
shunt
balancing
dc distribution
fuse box
IP22
Batteries
Battery-CAN
Status
Aux.-CAN
Chargers/Loads
M12
Terminator
(male)
M12 - RJ45
M12
Terminator
(male)

Master Slave



Master LV: BMS State Machine



Power-up Sequence

1. Make sure that all energy consumers are switched off before starting up the system, because the MG Master LV will pre-charge the system before closing the safety contactor.
2. Press the START-button (green button) on the front of the MG Master LV to start the system.
3. The system is pre-charging now. The safety contactor is closed as soon as the voltage rises above 80% of the battery voltage.
4. If the status LED is continuously on, the system is running and ready for use.

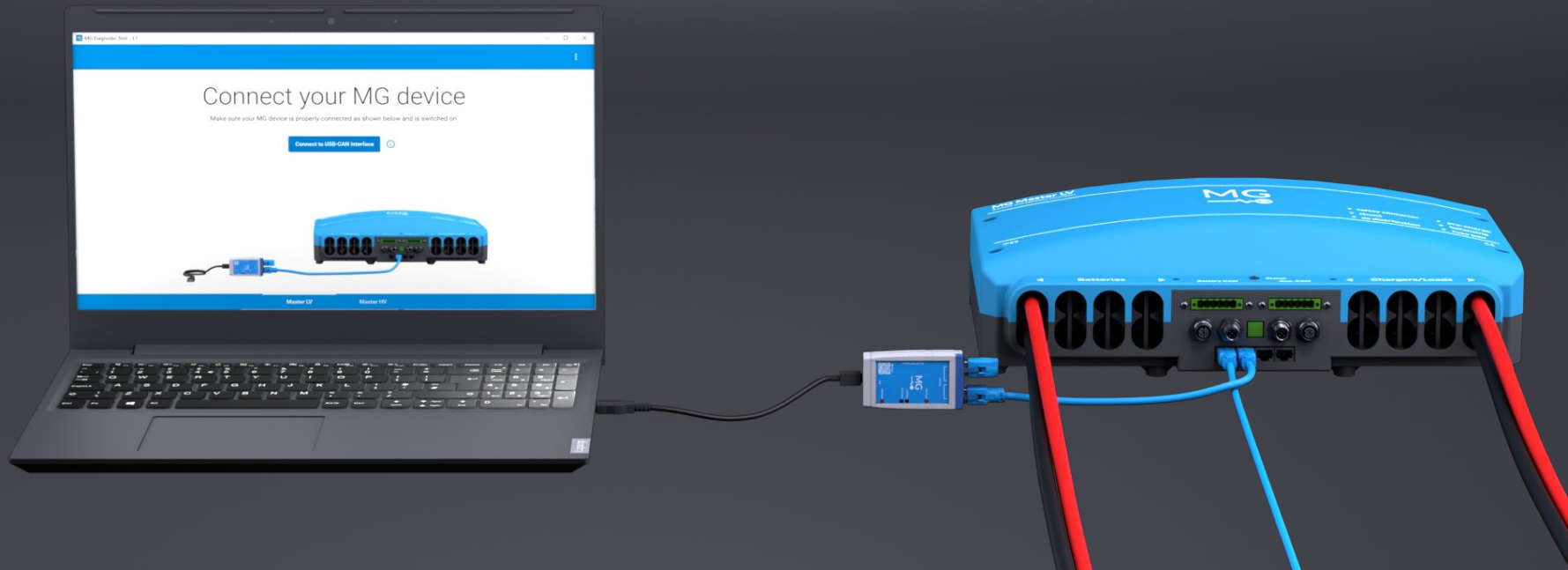
NOTE: Pre-charge can handle a max. of 10A.
Make sure DC-users are off during pre-charging.

Pre-Charging

- Before closing the main safety contactor, the output of the MG Master LV will be pre-charged by a relay and resistor.
- Pre-charge circuit can handle up to 10A of constant DC-consumers.
- The main contactor closes if the output voltage is more than 80% of the system battery voltage within 10 seconds (in future firmware it will be 30 seconds). If this condition is not reached within the specified time the MG Master LV will go to failsafe (error 5).
- Error 6 will occur when pre-charge fuse is broken.

Accessories

USB CAN-Interface



Diagnostic Tool

Tool to read status on pack and battery level, shows event list, history values and used to do settings.

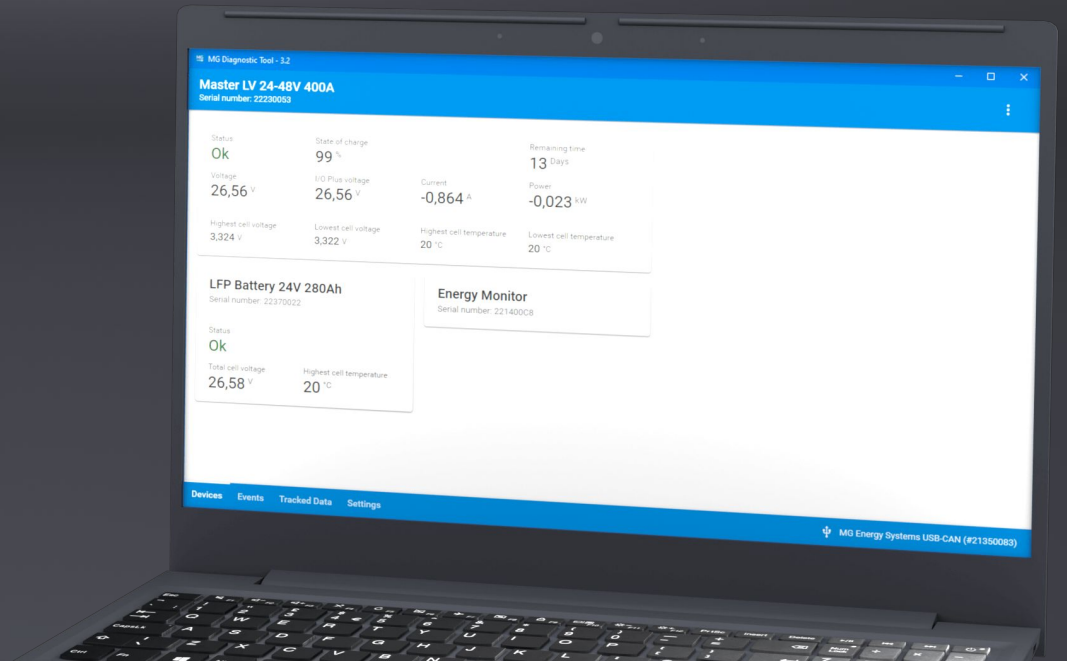
Connect a laptop or PC with windows with an USB-CAN interface to the BMS CAN-Bus of the Master LV.

Supported USB-CAN interfaces: **MG USB-CAN**, **Kvaser**, **PCAN (Victron)**

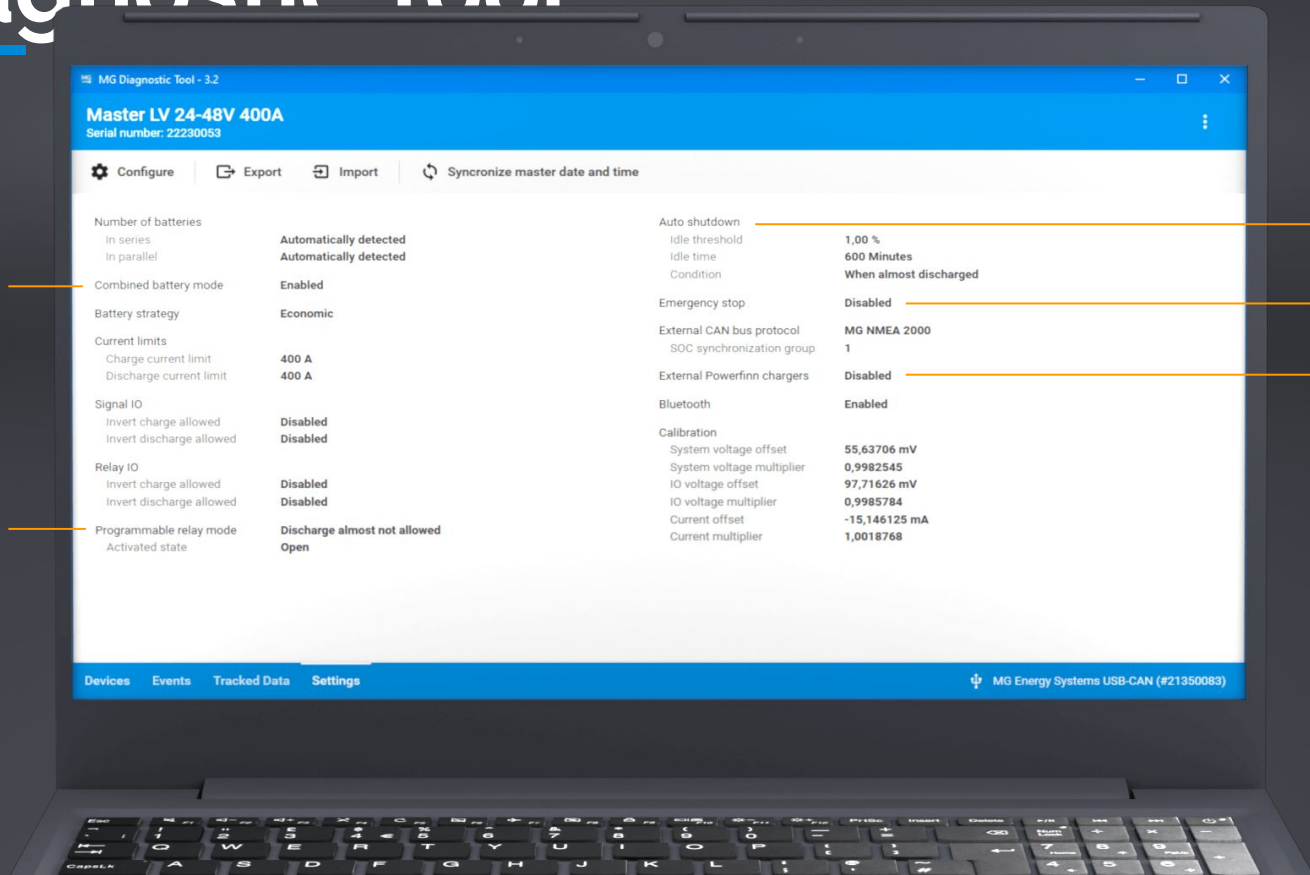
Old tool versions don't work with new firmware versions. For example Diagnostic tool 2.08 works only with firmware 1.8. If firmware is update to 1.10, Diagnostic tool 2.10 needs to be used.

Diagnostic Tool

- Overview status
- Event logging
- Tracking values (history)
- Settings
- Programmable relay
- Emergency button
- Updating firmware



Diagnostic Tool



Combined battery mode

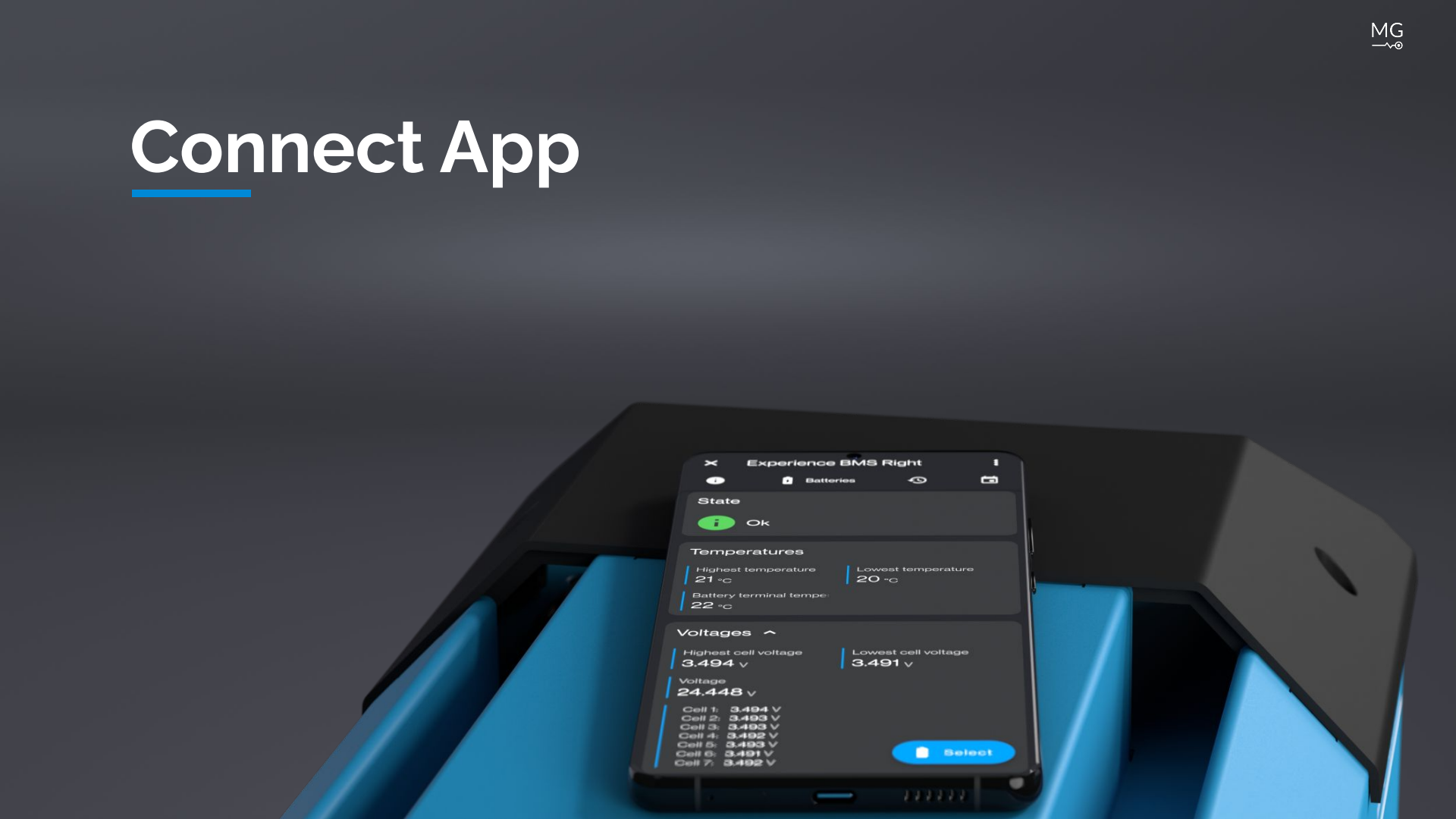
Programmable relay

Auto-shutdown

Emergency Switch

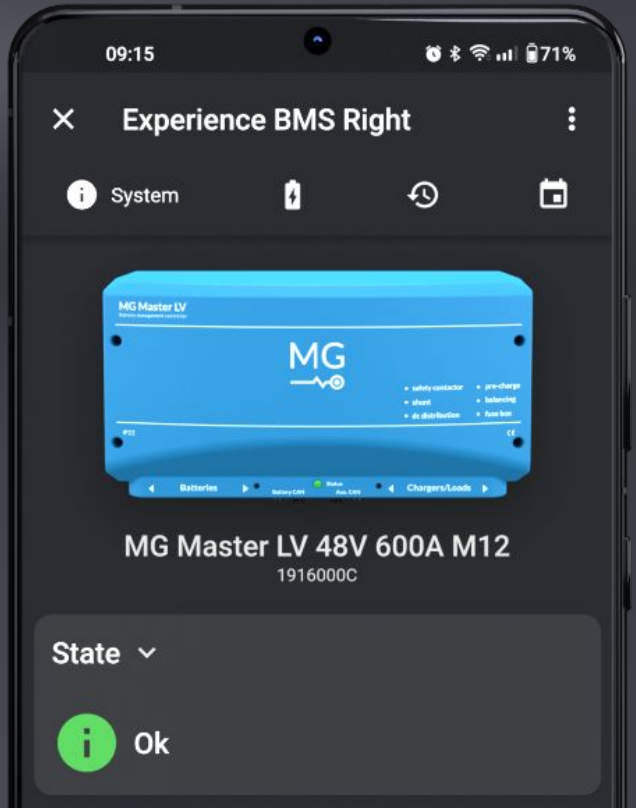
Charger support

Connect App

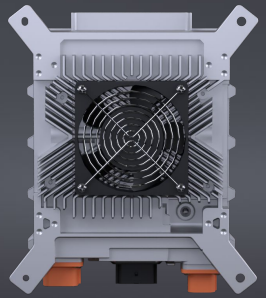

Experience BMS Right
Batteries
State
Ok
Temperatures
Highest temperature
21 °C
Lowest temperature
20 °C
Battery terminal tempe
22 °C
Voltages
Highest cell voltage
3.494 V
Lowest cell voltage
3.491 V
Voltage
24.448 V
Cell 1: 3.494 V
Cell 2: 3.493 V
Cell 3: 3.493 V
Cell 4: 3.492 V
Cell 5: 3.493 V
Cell 6: 3.491 V
Cell 7: 3.492 V
Select

Connect App

- Overview status
- Event logging
- Tracking values (history)
- Settings
- Programmable relay
- Emergency button
- Updating firmware (Coming)



Chargers



	TC Charger	Robust
Power	3.3 kW and 6.6 kW	3 kW
Voltage	Up to 450 V	Up to 520 V
CAN-Bus	Yes *	Yes
Value / Price	++	+/-

* SmartLink MX required

Charging on 24, 48, 72 and 96V

Robust Series

24 Vdc, **48** Vdc,
72 Vdc and **96** Vdc

CAN-Bus controlled
by MG Master LV

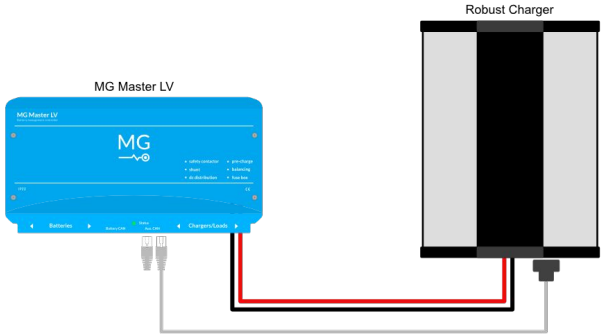
IP66 rating

Passive cooling

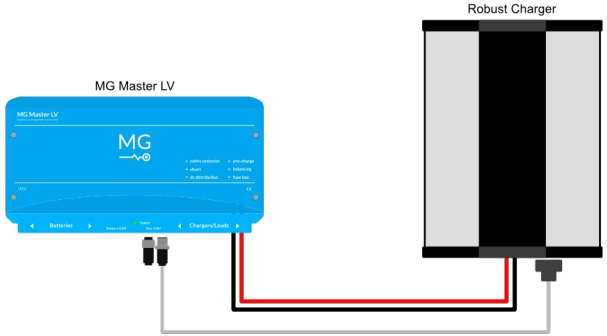
Designed for harsh
environment

CAN-Bus Controlled

Master LV sends charge voltages and current continuously
Master LV sets the charger with a default start-up voltage and current. This makes automatic start-up of the Master LV possible when the 230 Vac connection is powered.



RJ45 to HDP26
Cable 2mtr.

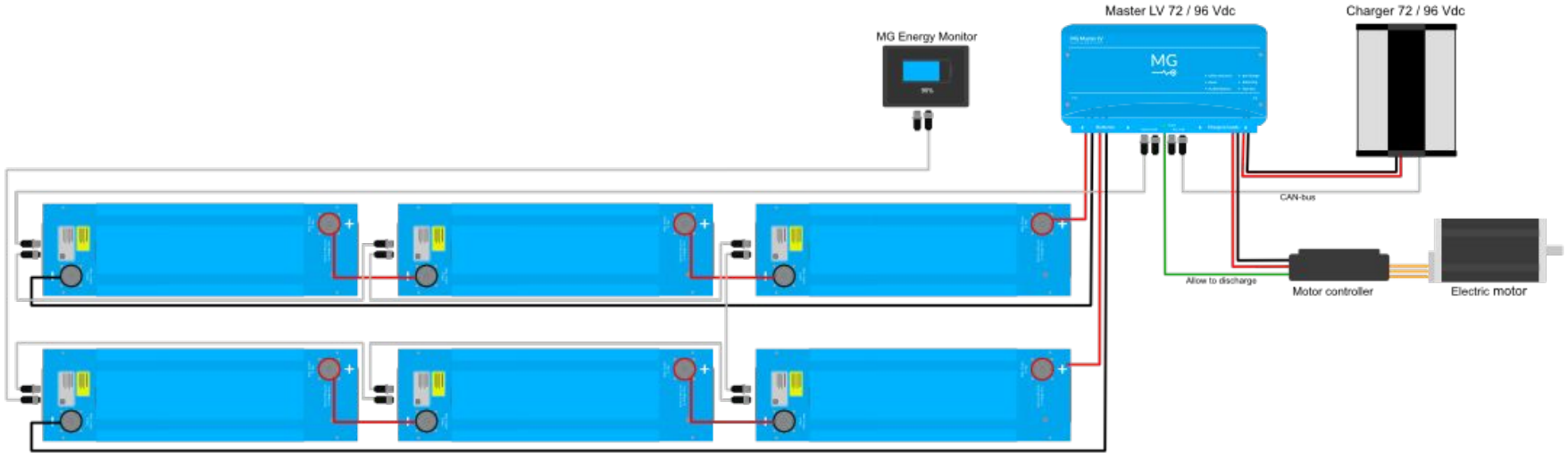


M12 to HDP26
Cable 2mtr.

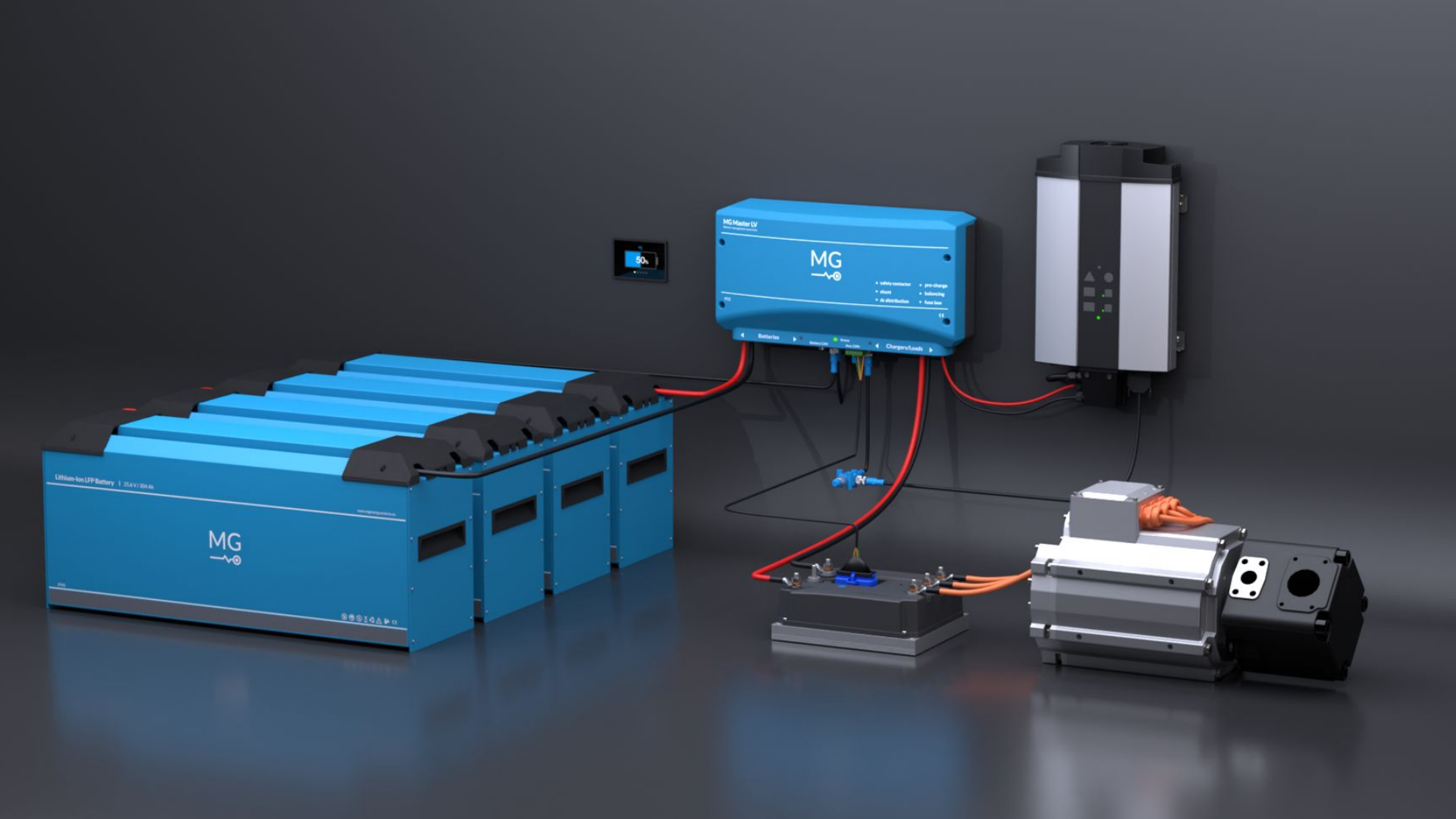
Robust Chargers Models

MGROB3000024	Robust charger 3000W, **24V**, IP66, CAN
MGROB2300024	Robust charger 2300W, **24V**, IP66, CAN
MGROB3000048	Robust charger 3000W, **48V**, IP66, CAN
MGROB3000096	Robust charger **72V/96V**, 30A, IP66, CAN, Up to 144 Vdc
MGROB3000280	Robust charger **280V**, 10A, IP66, CAN, Up to 520 Vdc

72 Vdc System M12 CAN-Bus 3S2p



72 Vdc configuration, 3x MG batteries in series, 2 paralallel strings (3S2P)

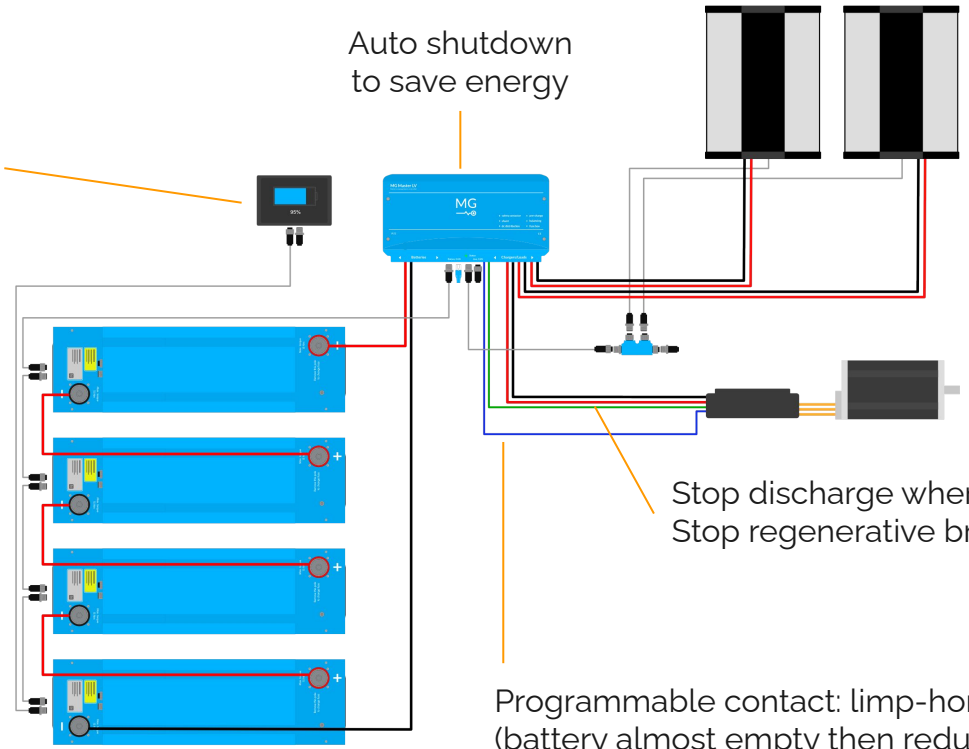

MG Master LV
MG
Batteries
Chargers/Loads
Lithium-Ion LFP Battery
MG

96 Vdc system

MG Energy Monitor for showing battery status
Fast start-up for electric driven applications

Auto shutdown to save energy

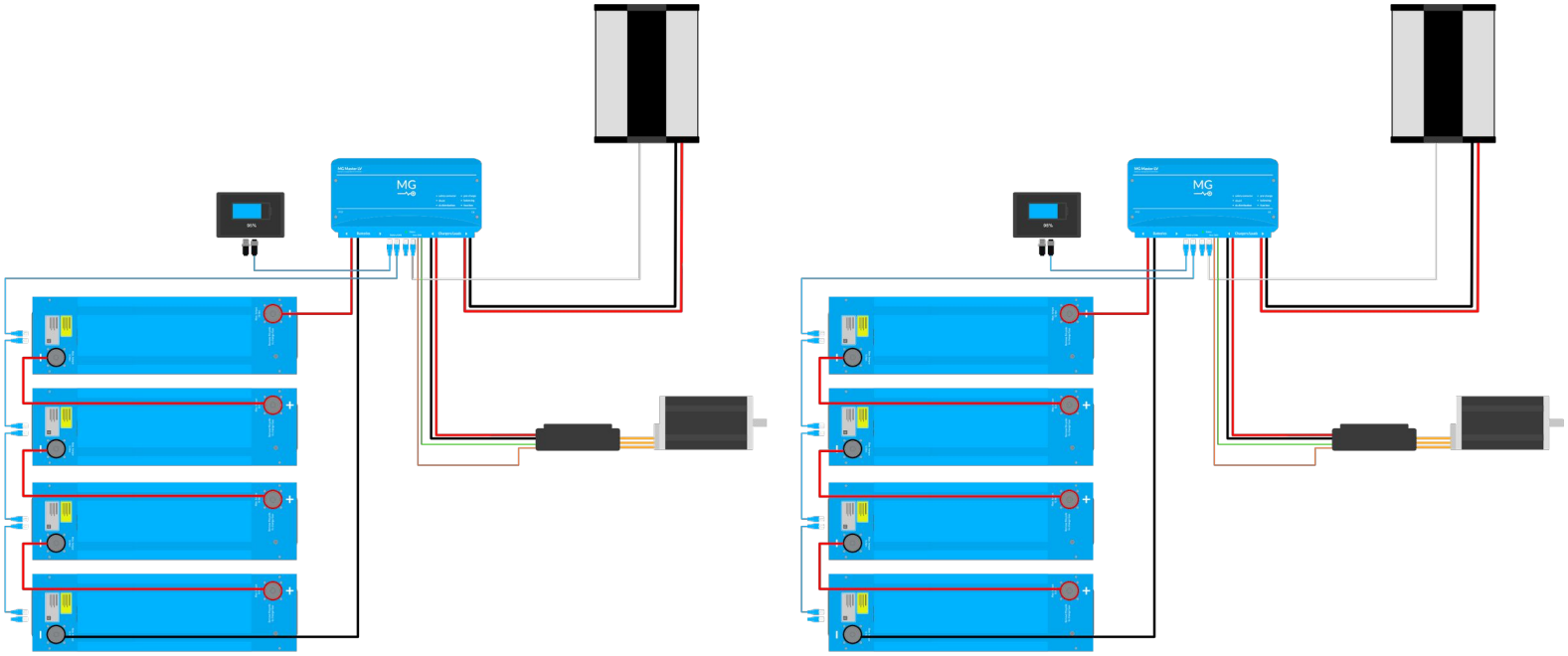
Chargers CAN-Bus controlled



Stop discharge when battery empty
Stop regenerative braking (charging) when battery is full

Programmable contact: limp-home mode
(battery almost empty then reduce motor power)

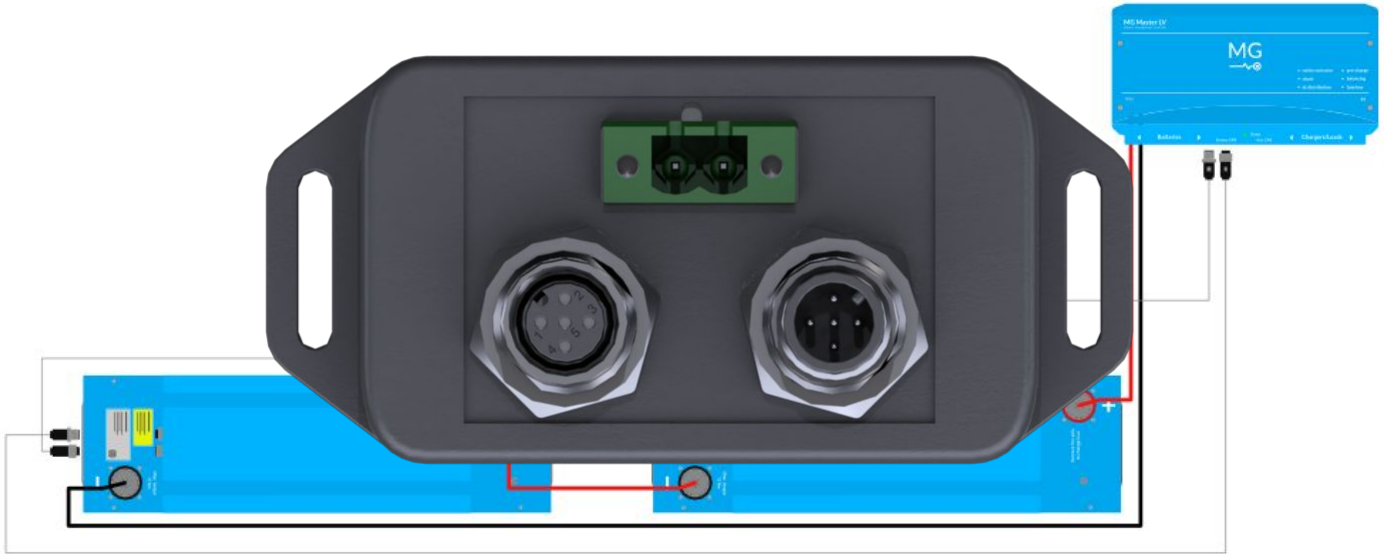
96 Vdc system starboard - port



Starboard

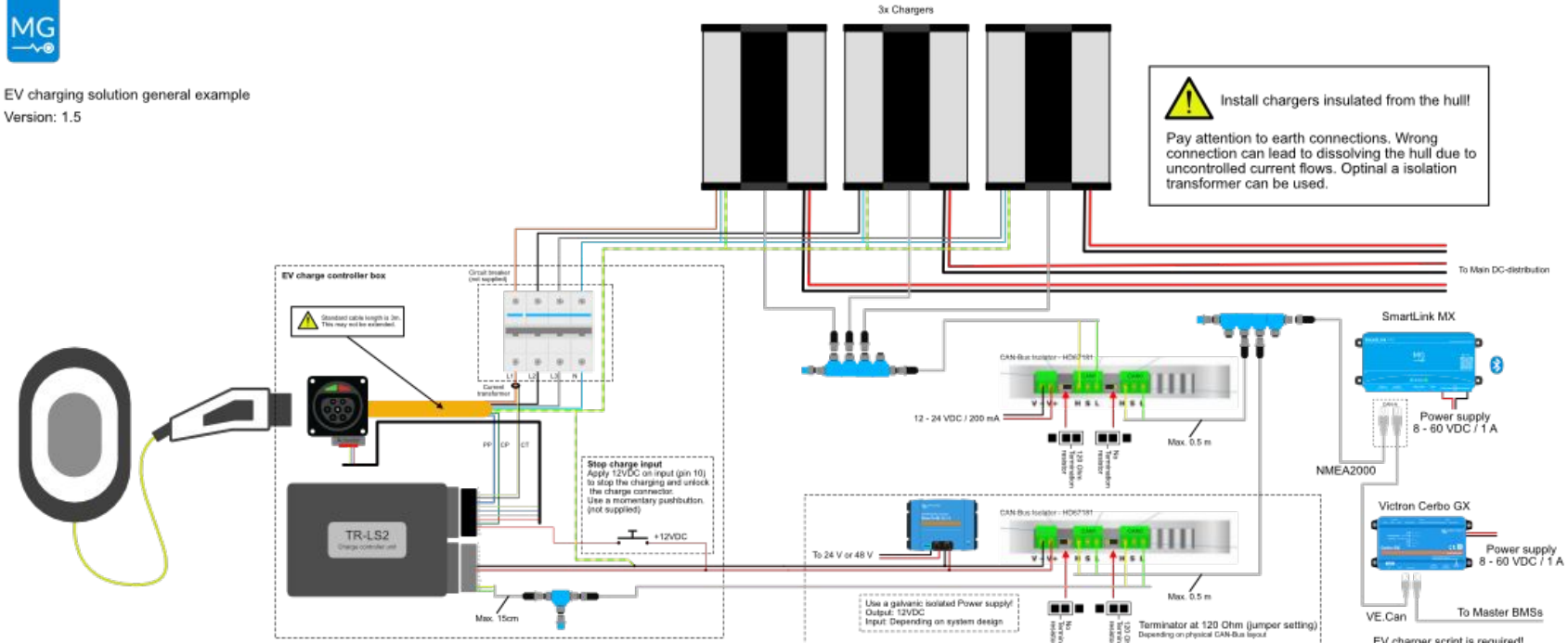
Port

M12 Interlock Adapter



EV charging solution general example

Version: 1.5



TR-LS2 pinning

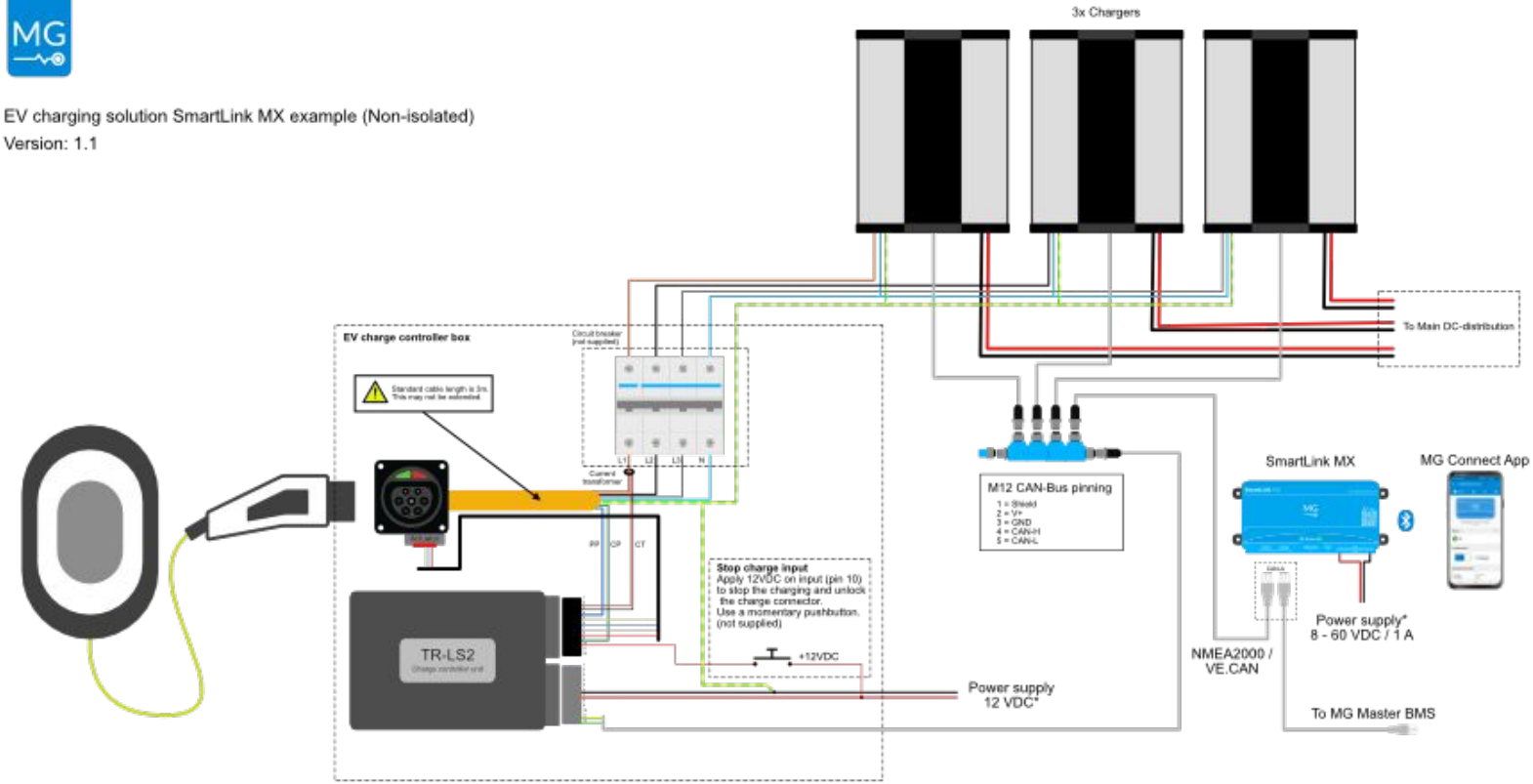
BLACK CONNECTOR 1		
PIN	SIGNAL	COMMENTS
1	LED_1 cable locked	Internal resistor 270Ω on 5V (15 mA max.)
2	Current sensor (yellow)	AC current sensor
3	Current sensor (black)	AC current sensor
4	PP	PP charging inlet (cable current lim.)
5	Actuator-1 (yellow)	Lock position switch supply (protected)
6	Actuator-2 (blue)	Lock position switch input
7	Actuator-4 (white)	Lock servo actuator B
8	Actuator-3 (red)	Lock servo actuator A
9	CP	CP charging inlet (EVSE current lim.)
10	Stop charging	9V...30V pulse input
11	Rotary switch (white)	Rotary switch for charging speed
12	Rotary switch (brown)	Rotary switch for charging speed ground

GREY CONNECTOR 2		
PIN	SIGNAL	COMMENTS
1	Display_TX	Display (RS232)
2	LED_2 charger enable	Internal resistor 270Ω on 5V (15 mA max.)
3	Interlock signal	High side driver (1 A max. protected)
4	Controller interlock (NO)	Relays contact (2 A max.)
5	Controller interlock (COM)	Relays contact (2 A max.)
6	GND	Chassis and charging cable PE
7	9V...30V input	Constant supply (internally fused 4 A)
8	Charger enable (COM)	Relays contact (2 A max.)
9	Charger enable (NO)	Relays contact (2 A max.)
10	Charger enable signal	High side driver (1 A max. protected)
11	CAN_H	Connection with BMS
12	CAN_L	Connection with BMS

M12 CAN-Bus pinning

1 = Shield
2 = V+
3 = GND
4 = CAN-H
5 = CAN-L

EV charging solution SmartLink MX example (Non-isolated)
Version: 1.1



TR-LS2 pinning

BLACK CONNECTOR 1		
PIN	SIGNAL	COMMENTS
1	LED_1 cable locked	Internal resistor 270Ω on 5V (15 mA max.)
2	Current sensor (yellow)	AC current sensor
3	Current sensor (black)	AC current sensor
4	PP	PP charging inlet (cable current lim.)
5	Actuator-1 (yellow)	Lock position switch supply (protected)
6	Actuator-2 (blue)	Lock position switch input
7	Actuator-4 (white)	Lock servo actuator B
8	Actuator-3 (red)	Lock servo actuator A
9	CP	CP charging inlet (EVSE current lim.)
10	Stop charging	9V…30V pulse input
11	Rotary switch (white)	Rotary switch for charging speed
12	Rotary switch (brown)	Rotary switch for charging speed ground

GREY CONNECTOR 2		
PIN	SIGNAL	COMMENTS
1	Display_TX	Display (RS232)
2	LED_2 charger enable	Internal resistor 270Ω on 5V (15 mA max.)
3	Interlock signal	High side driver (1 A max. protected)
4	Controller interlock (NO)	Relays contact (2 A max.)
5	Controller interlock (COM)	Relays contact (2 A max.)
6	GND	Chassis and charging cable PE
7	9V…30V input	Constant supply (internally fused 4 A)
8	Charger enable (COM)	Relays contact (2 A max.)
9	Charger enable (NO)	Relays contact (2 A max.)
10	Charger enable signal	High side driver (1 A max. protected)
11	CAN_H	Connection with BMS
12	CAN_L	Connection with BMS

*Power supply from Aux. power of MG Master LV

MG