

Short form Manual  
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# Lithium Ion Battery

With integrated Battery Management System

**CLAYTON**  
POWER™



## Safety Instructions

Lithium batteries are classified as Class 9 hazardous material UN3480, a power source with high energy density and dangerous materials in a closed metal case!

Installation must strictly follow the national safety regulations in compliance with the enclosure, installation, creep age, clearance, casualty, markings, and segregation requirements of the end-use application.

Installation must be performed by professional installers only. Switch off the system and check for hazardous voltages before altering any connection!

Lithium batteries must be handled only by qualified and trained personnel.

The lowest protection degree of specific parts of a lithium battery is IP20. Ensure that the installation of the lithium battery is in accordance with IP20 requirements.

Especially keep these rules:

- Do not open the Lithium Ion Battery.
- Do not discharge a new Lithium Ion Battery before it has been fully charged first.
- Charge only within the specified limits.
- Do not mount the Lithium Ion Battery upside down or on the sides for air-flow.
- Check if the Li-Ion battery has been damaged during transport.
- Do not put lithium systems in serial.

Dangers involved in case of fire:

- Danger of dust particle explosions
- Decomposition through fire or heat under development of toxic and cauterizing gases
- Combustion gasses which strongly irritate eyes and respiratory organs

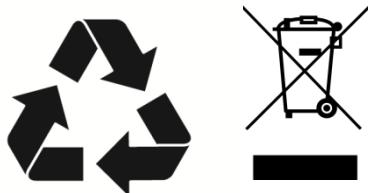
General actions to be taken by the driver if these dangers occur:

- Turn off the engine
- Put a warning signal on the road to warn others
- Inform others about the danger and direct them to stand away from the wind direction
- Call police and fire fighters immediately and notify them that lithium batteries (UN3480) is onboard

Instruction for fire extinguishing:

- Extinguish with water, if possible cover battery completely in water
- Extinguishing with water will produce fluoride, phosphate, fluoride-oxide and carbon-oxide.
- Alternatively extinguish with a CO<sub>2</sub> extinguisher.

Note: when put to storage the battery must be fully charged and must be charged again every 6 months.



ON-SPILLABLE  
LI-ION BATTERY

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## Handling and Maintenance

ATTENTION: Never connect Lithium Batteries in serial.

### Quick start:

Connect INPUT3 to GND or the black minus terminal.  
The battery starts up and LED's for fuel gauge and status become active.

### Start-up of an empty battery:

Restart the battery and begin charging in less than 30 seconds.  
If the battery is deeply discharged; restart and begin charging in less than 3 seconds.

### Periods between recharge in storage (off) and idle mode:

The time for a fully charged battery is:

#### 12V Lithium Ion Battery

Storage: 6 months

Idle: 9 days

#### 24V Lithium Ion Battery

Storage: 6 months

Idle: 15 days

### Overheating of the battery:

The red LED flash two times; wait until the battery has cooled down.

Other failures: See page 17

### EMC and standards:

#### 2006/95/EC (Safety directive);

The following harmonized standards have been applied:

EN 60950-1:2001+ A11:2004 (LVD)

#### 2004/108/EC (EMC directive);

The following harmonized standards have been applied:

EN 61000-6-3: 2007 Emission hold equipment

EN 61000-6-2: 2007 Immunity industrial

### Before Installation

ATTENTION: Read the safety instructions before starting to install the battery and install the needed functions as shown in the diagrams.

ATTENTION: When installing the battery, do not mount the Lithium Ion Battery upside down or on the sides for air-flow. Do not cover or block the fan or the air inlet to insure the battery does not overheat.  
Mounting holes are for prefixation, suitable fixation has to be added.

ATTENTION: Do not connect the batteries in series, only in parallel.

ATTENTION: Make sure the Lithium Ion Battery is powered down before starting the installation and do not connect any active wakeups before end of the installation.

ATTENTION: If DC consumers are part of the installation, please make sure to apply the DC consumers with a switch or fuse so they can be disconnected. The DC consumers may in some cases cause problems when starting up the system.

### In the box:

1x Lithium Ion Battery

1x Phönix connector 3 pol

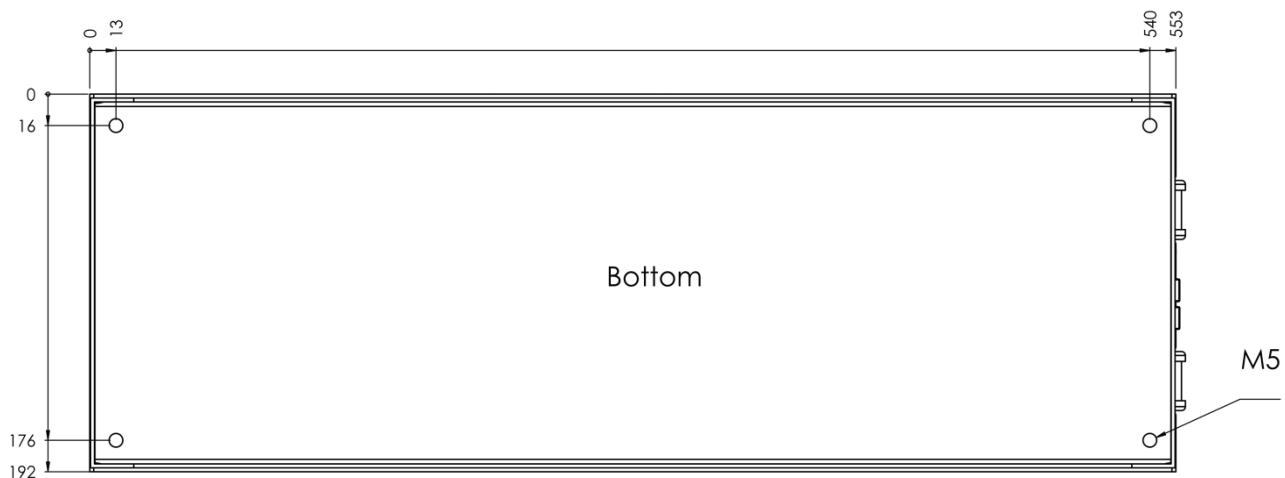
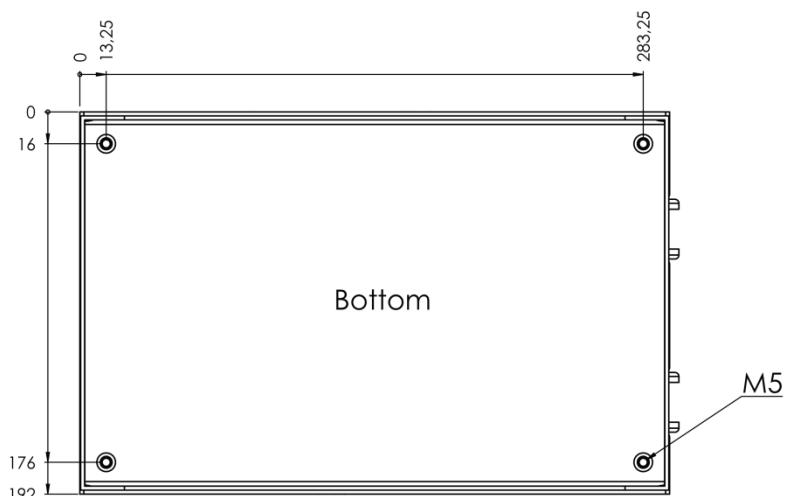
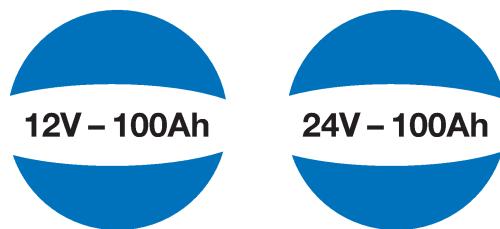
1x Phönix connector 5 pol  
1x CAN communication cable  
1x Shorform manual

## Mounting

ATTENTION: Mount the battery topside up, never upside down.

ATTENTION: Fans inside, be sure of that air must be able to flow through the ventilation.

Mounting holes for fixation: M5  
See more dimensions on page 15



## Installation Guide

ATTENTION: Before installing, make sure that all appliances are turned off.

### General Installation Instructions

A general system utilizing a CP Li-Ion battery, a CP G3 Inverter/Charger and a CP G3 Display all have the following in common.

It is highly recommended to add fuses to the 230 V<sub>ac</sub> output to protect the equipment.

The communications cable and power cables to the display unit must be 0.5 mm<sup>2</sup>.

The supplied 150 A fuse must be mounted on either the positive or negative terminal as illustrated here.



	Screw	Torque
Front	M8 X 12 mm	8 Nm
Top	M8 x 12 mm	12 Nm
Top w. CF8	M8 x 30	12 Nm
Mounting	M5 <sup>1</sup>	5 Nm

Note 1: The length of the M5 mounting screws depends on what the Li-Ion battery is mounted on.

## Standalone Setup

The diagram on Figure 1 shows how to wire a standalone system. This can be used as an Uninterruptable Power Supply (UPS) system.

**ATTENTION:** Make sure the AC mains is disconnected during assembly or service

### Connecting the G3 Inverter/Charger to the Li-Ion Battery

1. Connect the GND connections to all the components.
2. Connect all the data and small signal connections.
3. Connect the 230V<sub>ac</sub> mains connections.

NB: the 230V<sub>ac</sub> mains relay (not supplied) is essential for the system if it needs to charge from the mains supply.

4. Connect the positive DC supply.

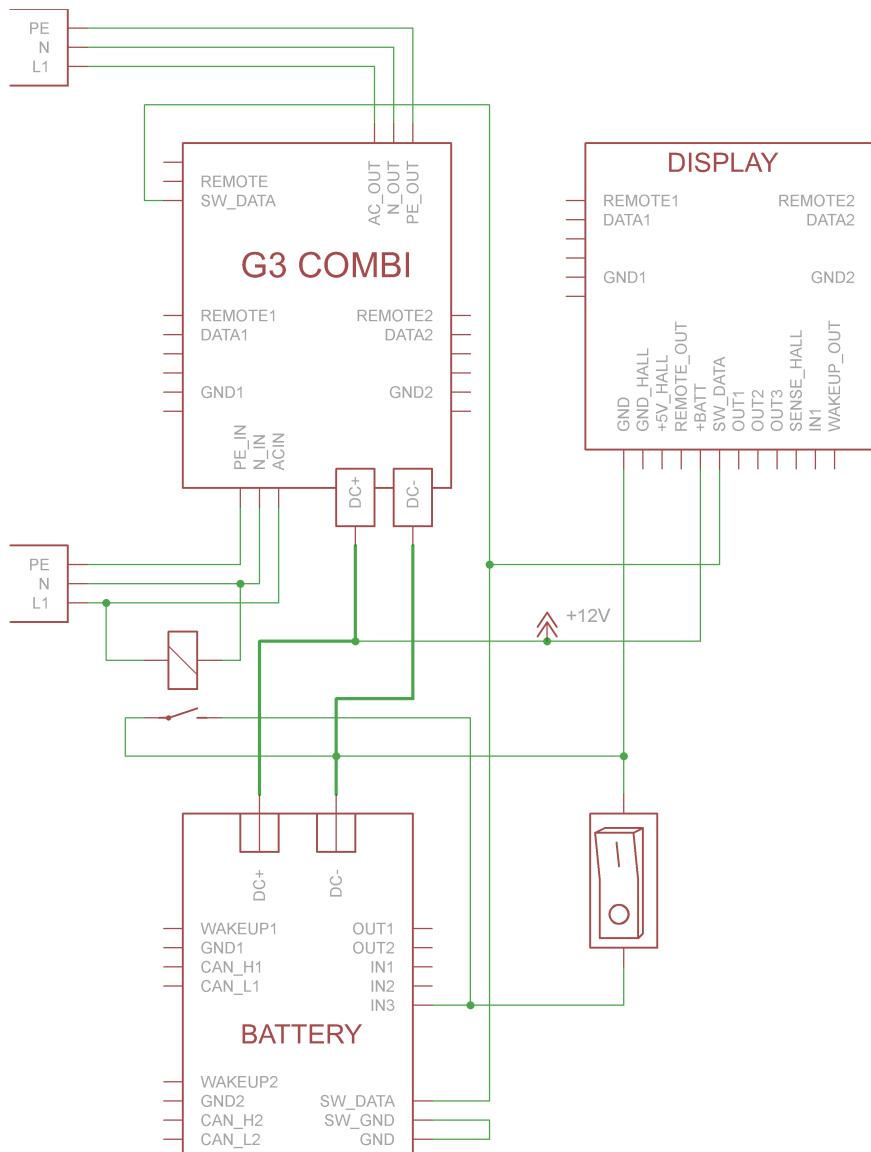


Figure 1

## Alternator Setup with Battery Separator

Starting with the standalone system, the display power (red wire) can be moved from the Li-Ion battery to the lead-acid battery as in Figure 2. This will enable the display to act as a wakeup for the battery.

- Using connection point, connect the positive terminal of the Li-Ion battery, the G3 Inverter/Charger and the G3 Display to the *DC OUTPUT* on the CDR Battery separator.
- Connect the *OUTPUT 2* to the *GND* terminal of the CDR battery separator.
- Connect the Lead-Acid battery *GND* to the negative terminal of the Li-Ion battery, the G3 Inverter/Charger and the G3 Display using a connection point.
- Connect the *INPUT 1* to the *D+* signal from the car.
- Connect the positive power from the lead acid battery in the car to the *DC INPUT* terminal on the CDR battery separator.

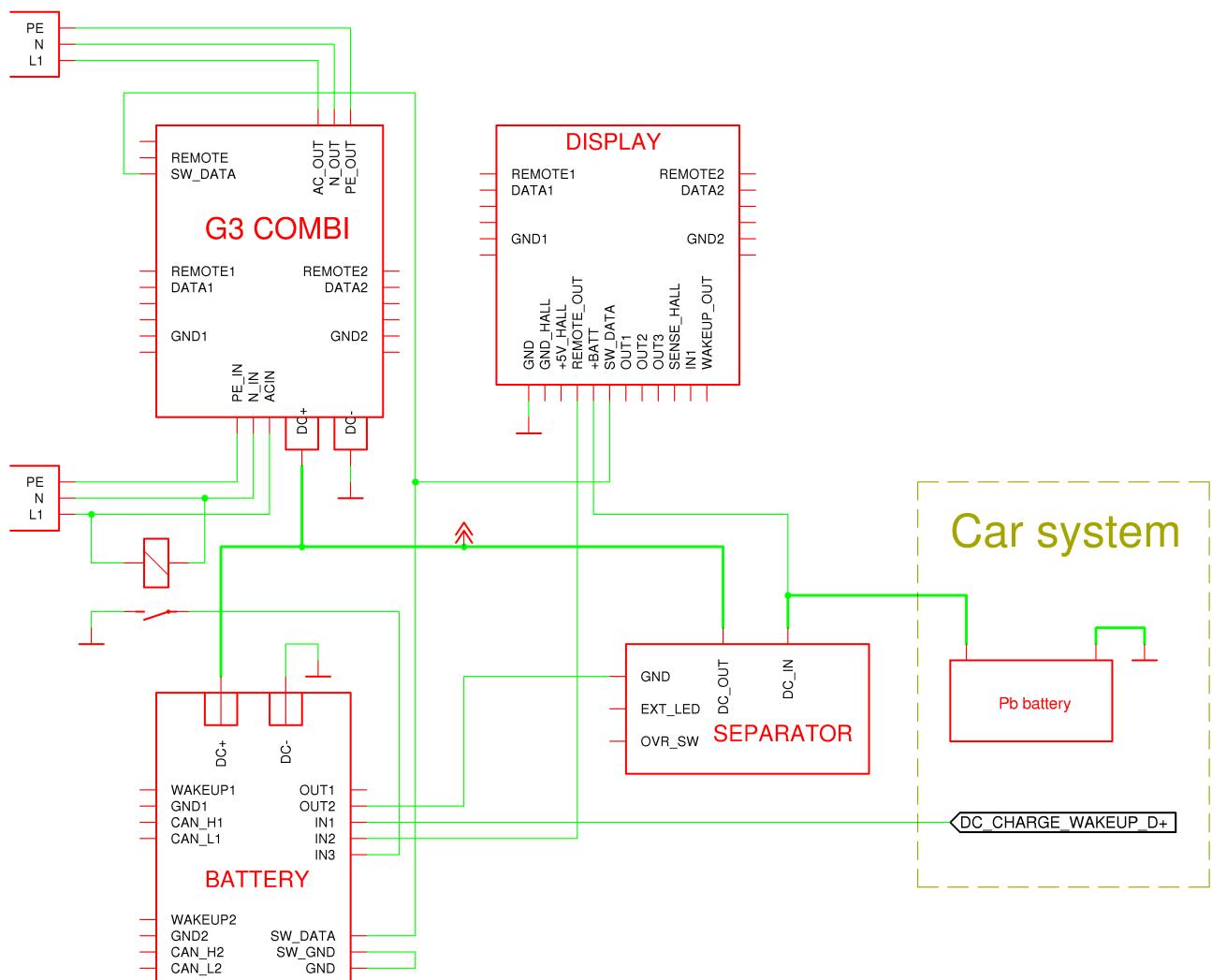


Figure 2

## Alternator Setup with 12V/24V DC-DC Converter

Using a 12V/24V DC-DC Converter insures that the voltage for charging the Li-Ion battery is sufficient. Figure 3 shows the diagram of how to connect this setup.

- Using a connection point, connect the positive terminal of the Li-Ion battery and the G3 Inverter/Charger to the 24V OUT on the Booster.
- Connect the G3 Display power to the Lead-Acid battery positive terminal.
- Connect the control coil of a 24Vdc relay from *OUTPUT 2* on the Li-Ion battery to the positive terminal on the Li-Ion battery.
- Connect the contact of the 24Vdc relay between the positive terminal of the Li-Ion battery and the *IGN* terminal of the booster.
- Connect the *INPUT 1* to the *D+* signal from the car.
- Using a connection point, connect the negative terminal of the Li-Ion battery, the G3 Inverter/Charger, the G3 Display and Lead-Acid battery to the *GND* on the Booster

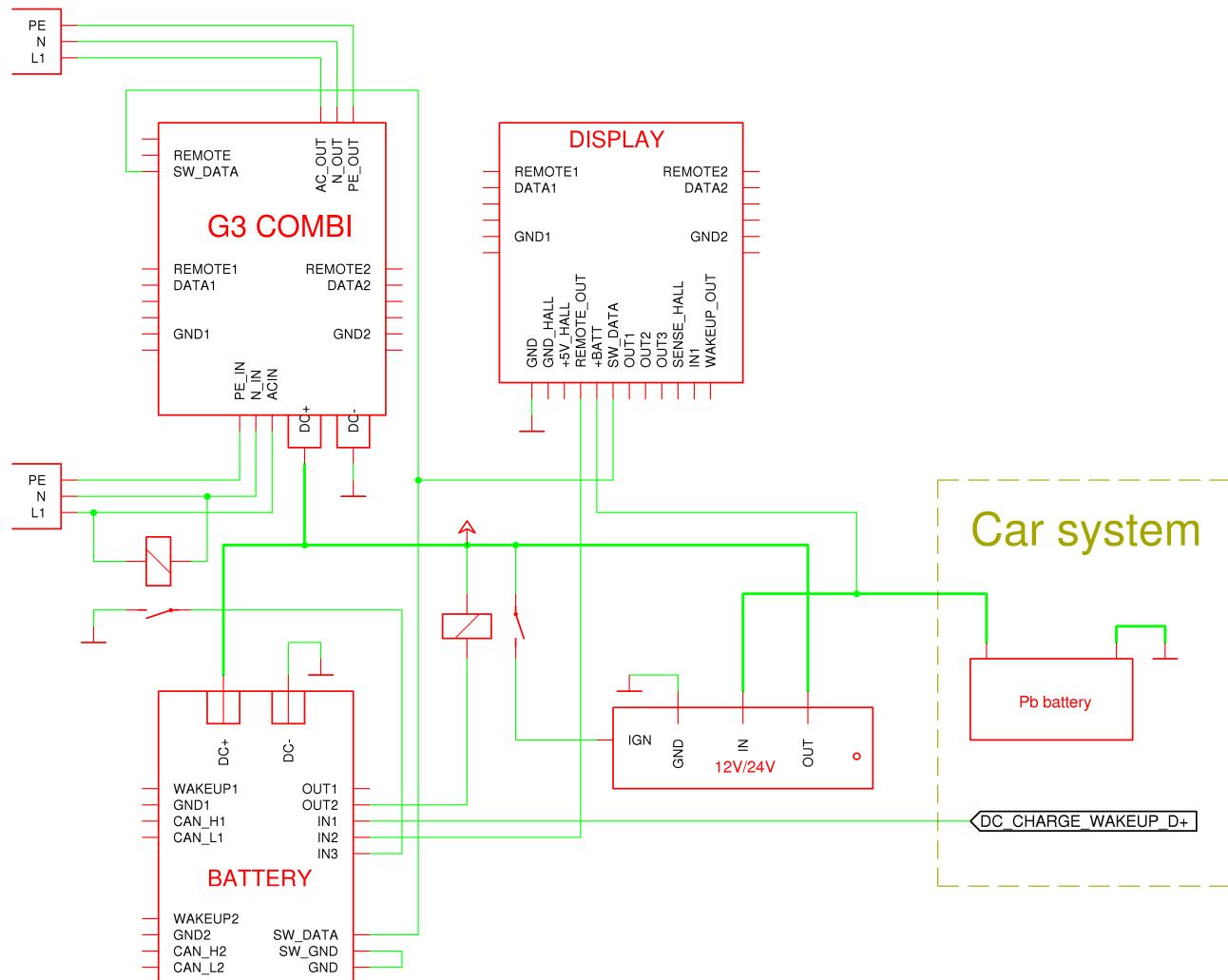


Figure 3

## Auxiliary Alternator

It is possible to charge from an extra alternator if it has a control function/input. This setup is shown in the diagram in Figure 4.

- Using a connection point, connect the negative terminal of the Li-Ion battery, the G3 Inverter/Charger and the G3 Display to the *GND* terminal on the alternator.
- Connect *OUTPUT 2* of the battery to whatever control function/input the alternator has.
- Using a connection point, connect the positive terminal of the Li-Ion battery, the G3 Inverter/Charger and the G3 Display to the *positive* terminal on the alternator.
- If possible, connect the G3 Display power to an alternate power source, including a *GND* connection to the rest of the system.

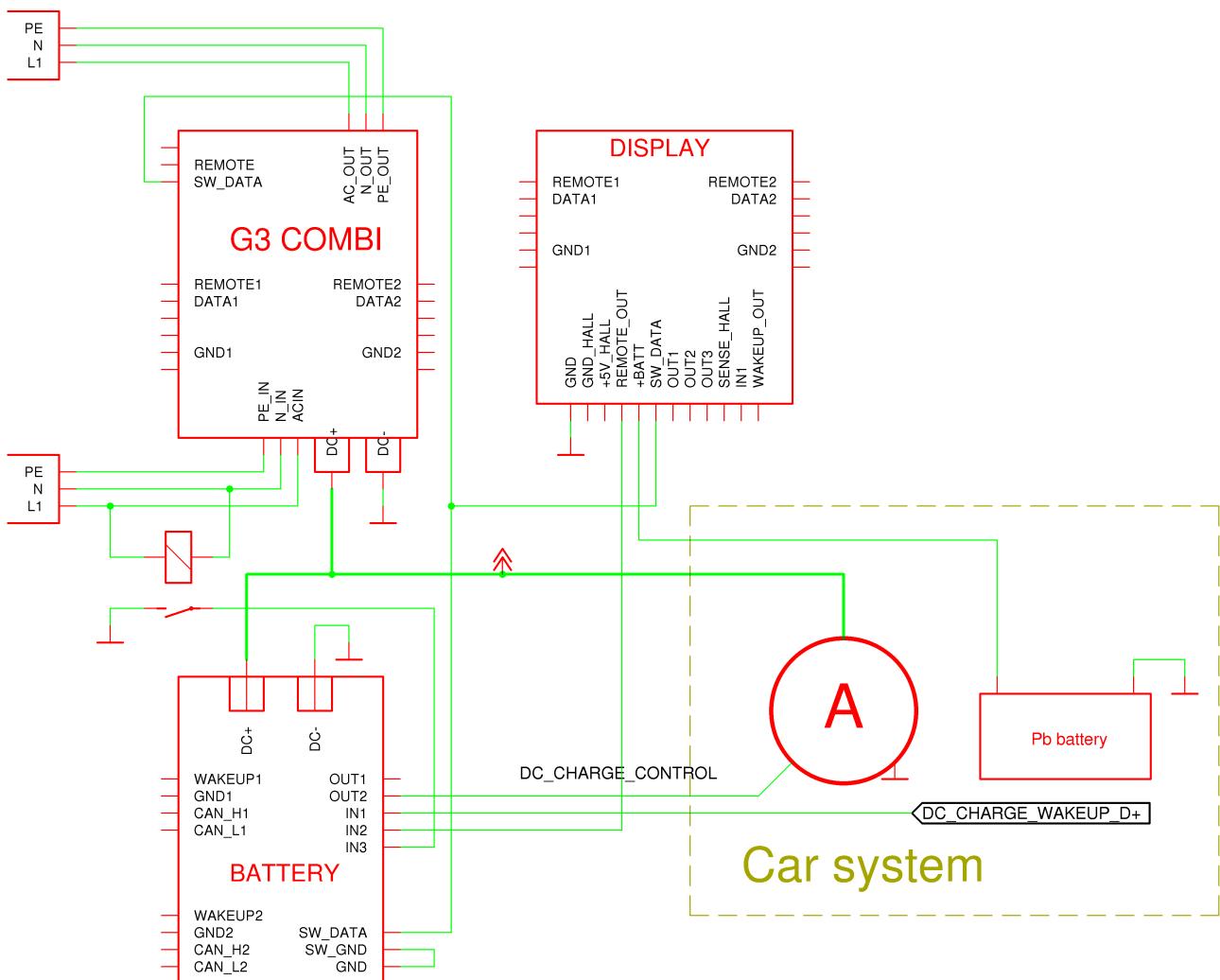


Figure 4

## Using an Alternate AC/DC or DC/DC charger

**ATTENTION:** Before installing, make sure all appliances are turned off.

**ATTENTION:** The CP Li-Ion battery must be able to stop the charging via a charge control relay.

Connect the DC Charging device to the battery through a DC charge control relay as shown in the diagram in Figure 5.

The charge control relay must get its control signal from *OUTPUT 2* on the battery.

A charge wakeup relay is connected between the power input pins of the charger to sense when the CP Li-Ion battery can start charging. This relay contact is connected between the *INPUT 1* on the Li-Ion battery and GND. The relay must be of a Normally Open type, in order to pull the input to GND when active.

Finally the DIP switch in the battery must have switch 2 in the on position.

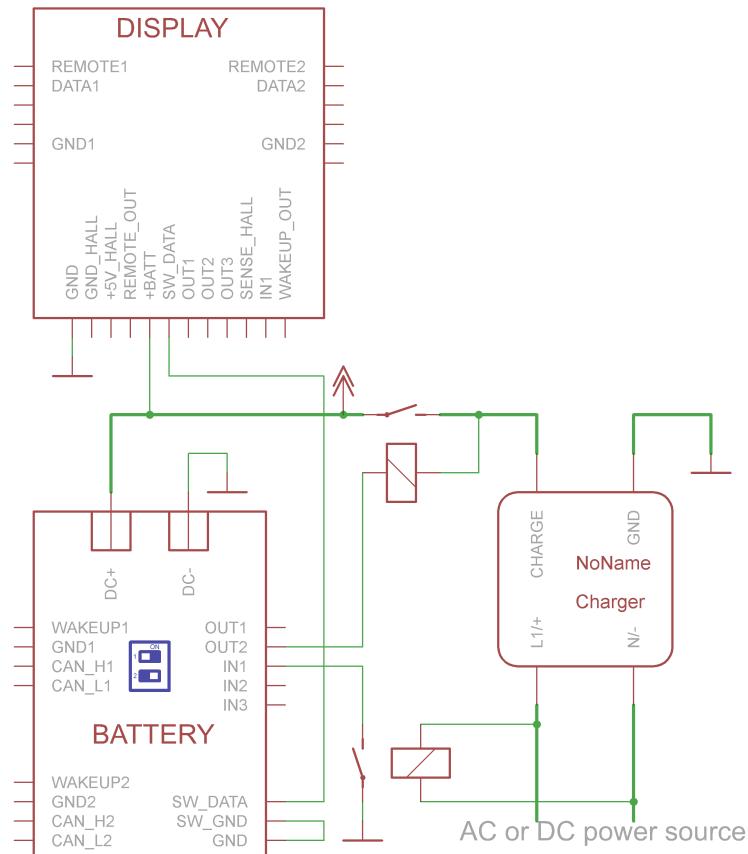


Figure 5

## Parallel Connection of Clayton Power Li-Ion Batteries

ATTENTION: Before installing, make sure that all appliances are turned off.

ATTENTION: Connect a maximum of 20 Clayton Power Li-Ion batteries in parallel.

ATTENTION: Do not mix Clayton Power Li-Ion batteries with batteries of different brands of batteries unless proper separation is used.

ATTENTION: Do not connect Clayton Power Li-Ion batteries in serial.

Make sure the DIP switch 1 is set as described on page 13.

### Cables

To ensure optimal performance all batteries in parallel must be connected to one pair of connection points. All cables from the batteries to these connection points must have the same length ( $\pm 20\%$ ).

All the cables must meet the following criteria

$35 \text{ mm}^2 < 2 \text{ m}$

$50 \text{ mm}^2 < 3 \text{ m}$

$75 \text{ mm}^2 < 5 \text{ m}$

## Serial Connection of Clayton Power Li-Ion Batteries

Do not connect the CP Li-Ion batteries in serial.

## DIP Switch functionality

Two DIP switches are placed in a cutout in the front of the battery. These are illustrated in Figure 5 and Figure 7.

### Switch 1

To connect batteries in parallel, each battery must be connected via the CAN bus with the supplied 4p4 cables. The two batteries with only one cable must have switch 1 in the on position. The rest of the batteries must have switch 1 in the off position.

A maximum of 20 CP Li-Ion batteries can be connected in parallel.

The SW communication must only be connected to one of the batteries. This should preferably be one of the end batteries as in Figure 7.

### Switch 2

Switch 2 is able to change the wakeup levels of input 1 and input 2.

Position	Input 1	Input 2
ON	Active Low and analog change	Active Low (TTL Levels)
OFF	Active high (TTL Levels)	Active High (TTL Levels)

The Analog Change Wakeup function is able to sense when the generator in a car is running.

Figure 6 Shows the basic connection needed to use the analog wakeup feature.

When the voltage on Input 1 is greater than 10V and raises with more than 0,5V within 5 seconds the battery will wake up. If the battery sees a current into the battery, it will stay on as long as there is charge current.

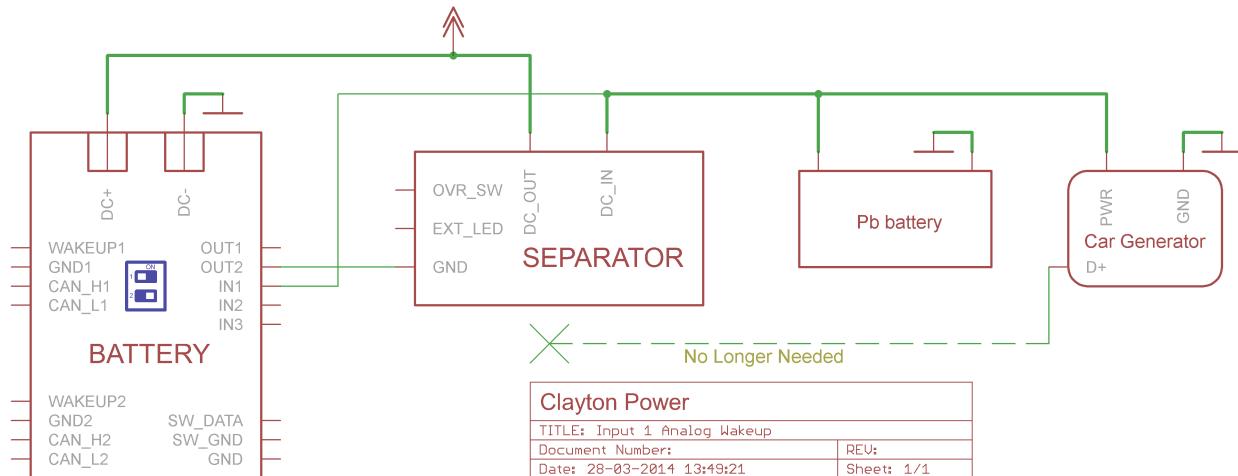


Figure 6

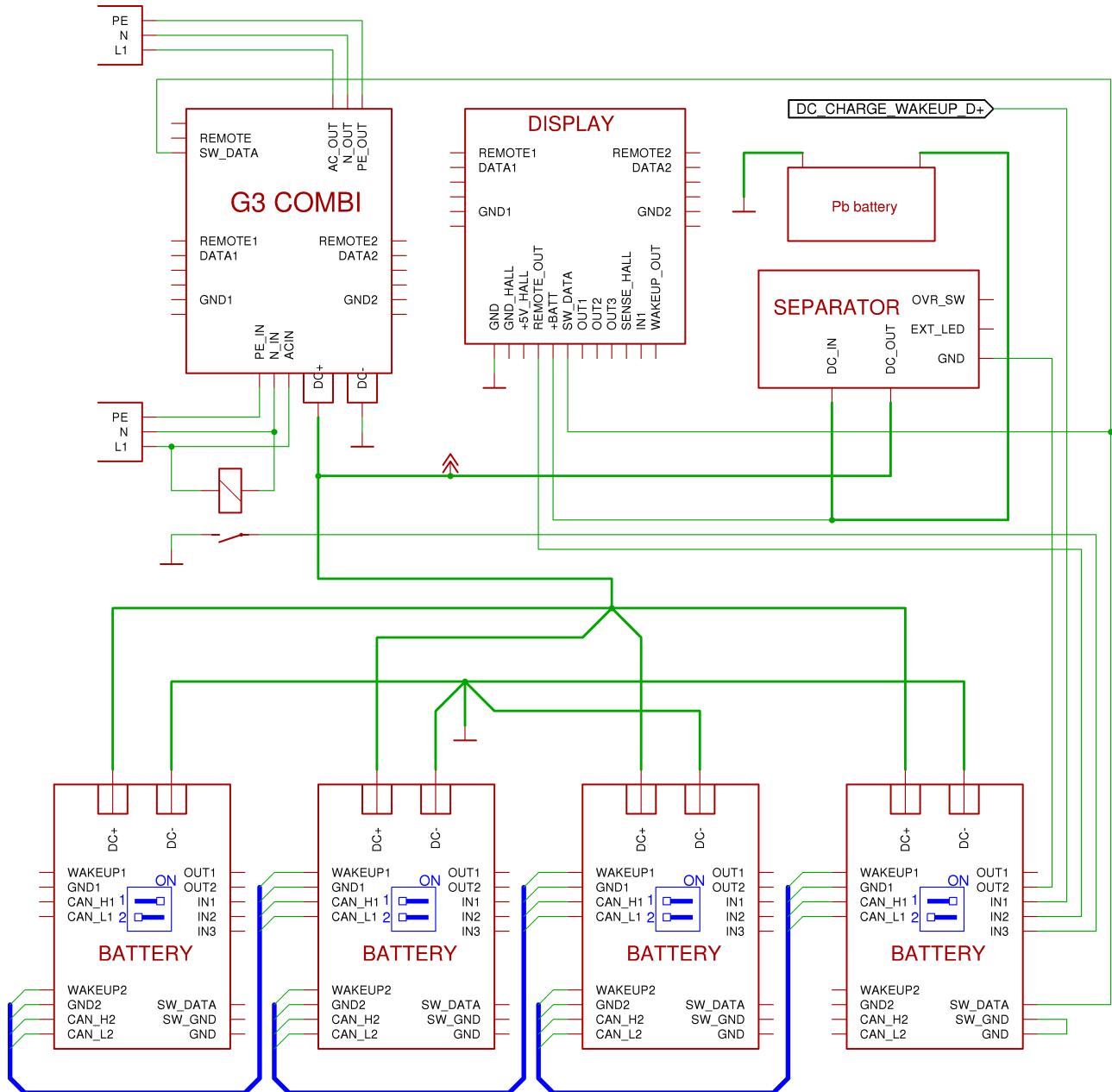
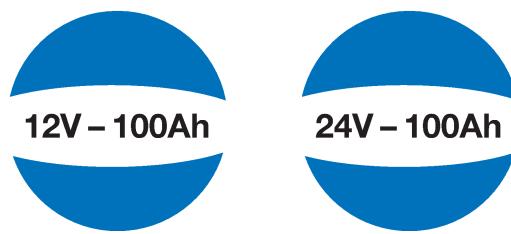
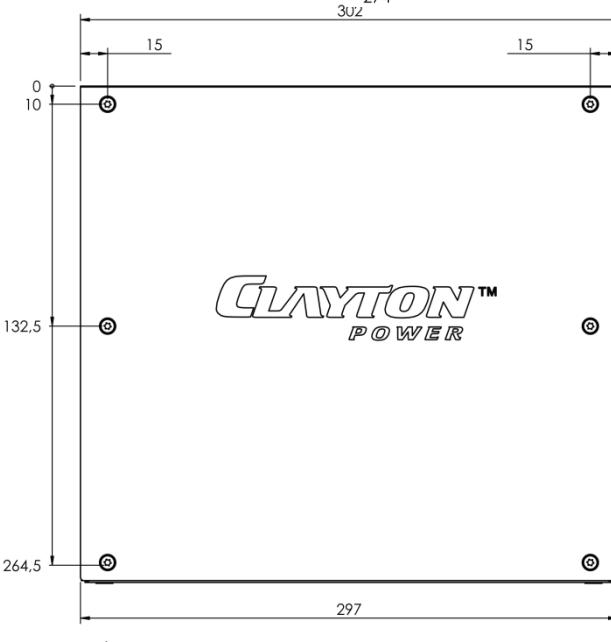
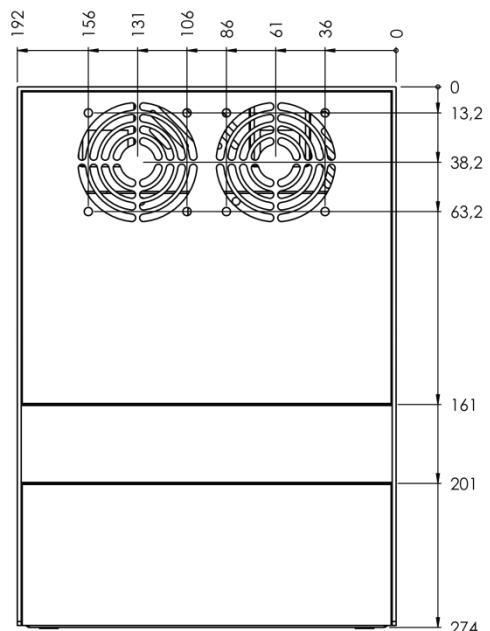
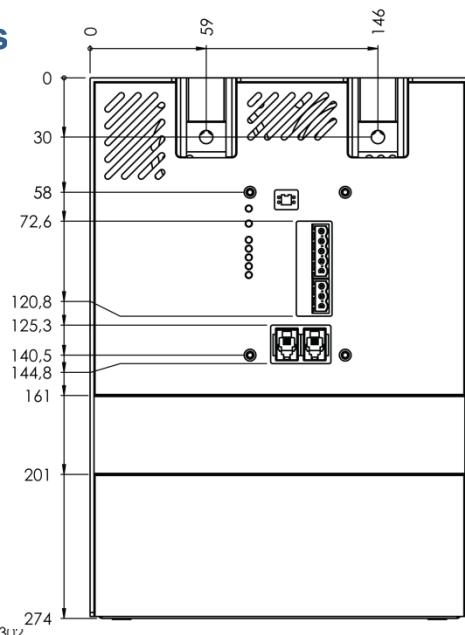


Figure 7

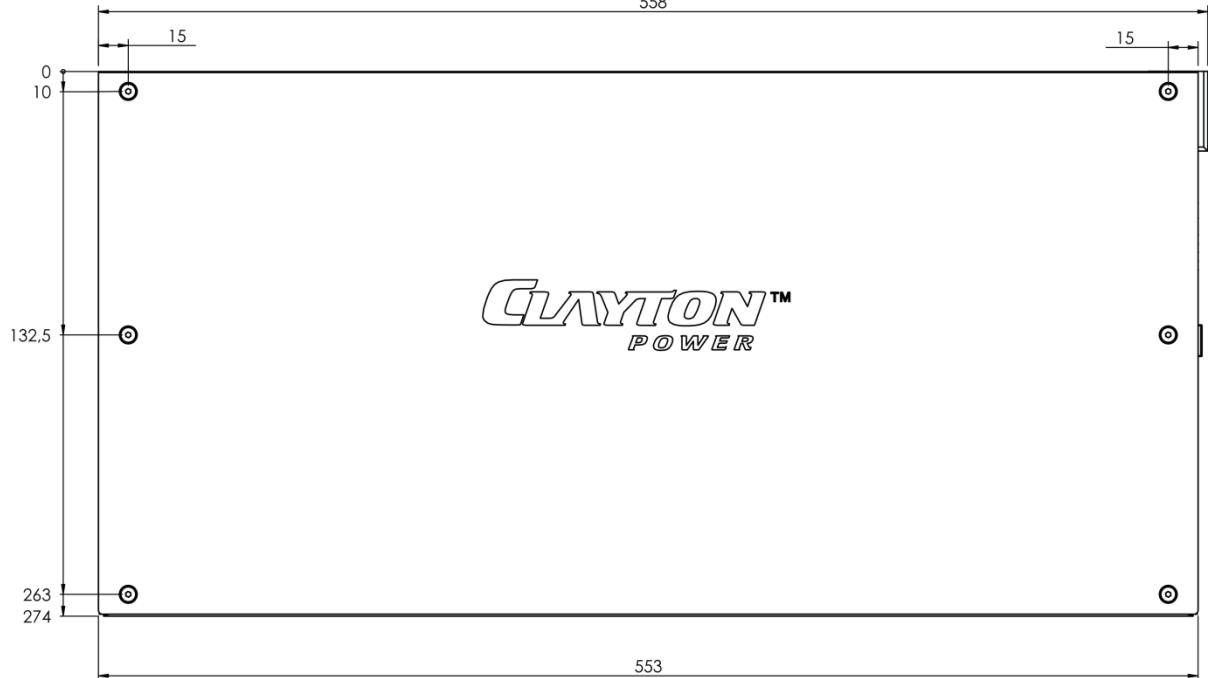
## Physical dimensions

Front and back of both  
24V and 12V  
Li-Ion battery



Left: Side of 12V Li-Ion battery

Below: Side of 24V battery



## Function Description

### Power On/Off

The Li-Ion battery will start when it detects wakeup active signal on one of the wakeup inputs. The Li-Ion battery will remain active until all active wakeup signals are deactivated.

Wakeup sources:

- |                            |  |
|----------------------------|--|
| • Input 1 (Active high)    | Car ignition signal                            |
| • Input 2 (Active high)    | Display remote out                             |
| • Input 3 (Active low)     | 230V <sub>ac</sub> Grid or manual switch input |
| • CAN wakeup (Active high) |  |

The default uses for the different inputs are as follows:

Input 1: Enables the system to charge the Li-Ion battery when the engine is running.

Input 2: If the G3 Display is powered on by the user, this will activate the Li-Ion battery.

Input 3: If the user plugs in a 230V<sub>ac</sub> source the Li-Ion battery will begin charging.

### Protections

To prevent hazardous use, the Li-Ion battery can disconnect the main switch by way of 4 measures

- Overcharge
- Deep discharge
- Temperature extremes
- Short circuit / over current.

The system ensures a high level of safety by 2 measures

- Communication to the control component
- Internal switch to cut off charge / discharge current

### Empty Li-Ion Battery

The Li-Ion battery will protect itself from deep discharge, by disconnecting the main switch and enter sleep mode when empty. The battery is able to startup and stay connected for 30 seconds, to allow charge current to rise above 1A, when empty.

If the Li-Ion battery is deeply discharged, the charge detection time is shortened to 3 seconds.

### Outputs

The battery has 2 outputs for controlling external equipment such as; Battery separator, Charger, Solar charger etc.

The outputs are of open collector type and can be configured from a PC.

The default output settings are

	Trigger condition	Reset condition	Purpose
Output 1	SOC < 10%	SOC > 11%	Driving an external Empty Li-Ion battery alarm
Output 2	Cell voltage > 4,1V	Cell voltage < 3,9V	Protect against overcharge from external charger

## Lithium battery general parameters

Battery type		100Ah-12V	100Ah-24V
Available capacity		80Ah	80Ah
Nominal battery voltage		12 VDC	24 VDC
Operation voltage discharge		9.2 VDC	18.4 VDC
Operation voltage charge		15 VDC	30 VDC
Cell voltage min cut-off		2.3 VDC	
Cell voltage max cut-off		4.2 VDC	
Continuous discharge current		100 A	
Max discharge Impulse current	10 min 5 Sec 10 µSec	200 A (temperature controlled) > 500 A > 1000 A	
Continuous charge current		100 A	
Lifecycle 80%DOD		> 3000	
Lifecycle 70%DOD		> 5000	
Operating temperature		-40°C~50°C	
Cooling		Forced fan	
Inputs (wakeup function)		3	
Outputs (Open Collector)		2	
Communication		CAN (SAE J1939) - CP Single Wire	
Parallel connection		1 to 20	
Self-discharge rate per month	(Sleep mode)	< 3%	
Operating mode consumption		350mA	180mA
Sleep mode consumption		< 2mA	< 2mA
Connection terminals		M8 screw	M8 screw
Weight		19 kg	36 kg
Dimensions in mm (H x W x L)		274 x 192 x 301	274 x 192 x 558

## Parallel connector parameters



Pin #	Signal name	Parameter	Value
1	CAN Wakeup	Output voltage (open drain)	Battery voltage * 2
		Output Impedance	10 KΩ
		Max Input Voltage	60 VDC
		Input Trigger Voltage (High/Low)	3.5 VDC
		Input Impedance (as pull down)	4,7 MΩ
2	CAN GND	Max Current	250 mA
		Fuse Rating	300 mA Thermal fuse
3	CAN High	Communication Speed	125 Kbps
		Communication Protocol	SAE J1939-11
		Output Impedance	> MΩ
4	CAN low	Communication Speed	125 Kbps
		Communication Protocol	SAE J1939-11
		Output Impedance	> MΩ

## Signal connector parameters



Pin name	Parameter	Value
Output 1 Output 2	Max Drain Voltage	45 VDC
	Max Sink Current	300 mA
Input 1 Input 2	Fuse Rating	300 mA Thermal fuse
	Topology	Open collector
	Max input Voltage	45 VDC
Input 3	Input voltage level (high/low)	TTL Levels
	Input Impedance (as pull up)	4.7 MΩ
	Max Input Voltage	45 VDC
SW Data (Single wire bus)	Input Trigger Voltage (High/Low)	3.8 VDC
	Input Impedance (as pull up to +5 V)	2 MΩ
	Communication Speed	9600 Baud
SW GND (Single wire bus)	Output Impedance (+12V)	1 KΩ
	Fuse Rating	300 mA Thermal fuse
	Max Current	300 mA
GND	Fuse Rating	300 mA Thermal fuse
	Max Current	300 mA
	Fuse Rating	300 mA Thermal fuse

## LED Codes

### Power LED (Blue)

Solid light	Connected
Flashing (3Hz)	Connected and charging

### Fuel gauge LED's

LED	SOC level	Status
100% (Green)	>90%	Solid light
	80% - 90%	Flashing (1Hz)
80% (Green)	>70%	Solid light
	60% - 70%	Flashing (1Hz)
60% (Green)	>50%	Solid light
	40% - 50%	Flashing (1Hz)
40% (Green)	>30%	Solid light
	20% - 30%	Flashing (1Hz)
20% (Red)	>10%	Solid light
	0% - 10%	Flashing (1Hz)

## LED Codes: Failure LED (Red)

Code	Failure	Failure description
1 Flash	Battery is empty	Battery is empty, restart the battery and ensure charge current (> 1 A) within 30 sec or the battery will enter sleep mode
2 Flash	Battery temperature too high	Battery temperature is too high, wait until the battery has cooled down.
3 Flash	Battery overloaded or short circuit	Battery overloaded, remove the load and restart the battery. The battery will enter sleep mode after 30 sec.
4 Flash	Pre-charge failure	Battery unable to pre-charge the load. Remove load and restart the battery. The battery will enter sleep mode after 30 sec.
5 Flash	Battery overcharged	Charger is overcharging the battery, check charger. Battery is protecting and doing maintenance balancing.
6 Flash	Internal failure: Cell voltage monitor	Battery cell voltage monitor is failing. The battery will enter sleep mode after 30 sec. Contact your supplier
7 Flash	Internal failure: Cell temperature monitor	Battery cell temperature monitor is failing. The battery will enter sleep mode after 30 sec. Contact your supplier
8 Flash	Internal failure: internal communication failure	Battery internal communication is failing. The battery will enter sleep mode after 30 sec. Contact your supplier
9 Flash	Internal failure: Other failures	Battery has other failures. The battery will enter sleep mode after 30 sec. Contact your supplier

## Features of the Li-Ion Battery



### **System Control**

The Li-Ion battery works as a controller in a complete power system. The Li-Ion battery manages power distribution and the priority of operation of different power consumers.

### **Charger Control**

It is necessary to control the charging of lithium batteries in order to avoid un-controlled disconnects and to protect the lithium cells from unstable conditions. The charging can be controlled via the interface using communication or output pins.

### **G3 Inverter/Charger control**

The lithium batteries can communicate with a CP G3 Inverter/Charger and control power distribution and charging.

### **Parallel connection**

Several lithium batteries can be parallel connected in order to increase battery capacity and current capability. The interconnected batteries have separate MOSFET safety breakers ensuring parallel connection without any safety risk while maintaining full control over the batteries.

### **Battery Management System**

Each lithium battery has a built-in Battery Management System ensuring full control and safety. The BMS monitors lithium cell activity and uses the information for safety, maintenance, SOC, and interface control.

### **Cell voltage measurement**

The BMS measures cell voltage with high accuracy. The accuracy is necessary to calculate the SOC as a few mV make a big difference.

### **Cell temperature measurement**

The BMS measures the temperature of all individual cells in a battery pack to ensure that none of the cells overheat or cause thermal runaway. The temperature information is also used for SOC calculations.

### **Shunt and current measurement**

The current goes through the BMS and the internal shunt. The BMS measures the current and uses it for protection and SOC calculation.

#### **Integrated MOSFET safety breaker**

The most important part of the BMS circuit protection is the integrated MOSFET safety breaker. It allows the BMS to cut off all charge and discharge currents in hazardous situations.

#### **Overload protection**

The advantage of the internal MOSFET safety breaker is its capability to disconnect high currents without damaging the main switch. The BMS can use the MOSFET safety breaker for overload protection without damaging the cells.

#### **Short-circuit protection**

The MOSFET safety breaker, in the BMS, protects the battery against output short-circuits. The MOSFET has a very short reaction time and can disconnect the output in short-circuit situations without damaging any components.

#### **Pre-charge function**

The BMS has a pre-charge function build into the MOSFET breaker. The pre-charge function reduces inrush currents when high-capacity consumers are connected.

#### **Advanced SOC calculation**

The highly advanced algorithm for SOC calculation involves a combination of voltage, temperature and impedance mapped in tables combined with detection of actual data. The data tables include information about SOC vs. OCV, immediate cell impedance, time-effected cell impedance, and temperature vs. cell impedance.

#### **Cell balancing**

The advanced SOC calculation ensures that all cells are kept in a balanced condition at all times. The BMS has a high cell-balance current that reduces the need for active cell balancing and restores the cells to a balanced condition faster. The BMS is cell balancing of each single cell in charge, discharge and idle mode.

#### **Interface**

Each lithium battery has an extended interface that allows it to control power distribution for different consumers. The interface can control alternative chargers, solar panels, gen-sets, and other charging devices. The control of external devices is ensured via several communications, wake-ups, and input and output pins.

- 2 CAN Communication connectors
- 1 CP Single Wire Communication
- 3 high/low inputs
- 2 open collection outputs

#### **Wake-up**

When the lithium battery is not in use enters the BMS a low power state. In this state the BMS keeps power consumption ultra-low to avoid further discharge of the lithium cells. The BMS can be reactivated through several wakeup high/low input pins and charge currents plugged into the battery.

#### **Configurable outputs**

The output pins can be configured via PC software to be triggered in occasion of different events caused by cell voltage, cell temperature, current and/or SOC levels.

#### **Statistics log**

The BMS statistics log is a diagnostics tool by which the BMS logs all events, ampere hours going in and out of the battery, and tracking failures. The information is stored in a non-volatile EEPROM.

#### **Firmware update via CAN**

The firmware can be updated via a simple USB connection to a CAN-adapter to ensure the newest firmware and functions.

## Warranty

### CAUTION & WARNING:

DO NOT USE OR ATTEMPT TO USE THIS PRODUCT UNTIL YOU HAVE READ THIS USER'S MANUAL IN ITS ENTIRETY. IMPROPER INSTALLATION OR USAGE OF THIS DEVICE MAY BE HAZARDOUS AND MAY CAUSE DAMAGE TO OTHER ELECTRICAL EQUIPMENT AND WILL VOID WARRANTY.

- Clayton Power warrants, to the original purchaser only, for a period of 24 months from the date of purchase, that the Clayton Power device will be in good working order when properly installed and operated as described in this manual.
- If the display fails within this time period under normal use, Clayton Power will, without charge, at the place of Clayton Power's choosing, repair or replace the display - with new or reconditioned parts or a new or reconditioned display as Clayton Power deems necessary.

This warranty is void and will not be applied if:

- The inverter has been used against the recommendations of this manual.
- The inverter has been used in an application outside of general automotive, solar, industrial or marine applications without the agreement of Clayton Power.
- The inverter has been modified or repaired without written authorization of Clayton Power.
- Reverse polarity, excessive overloading, general abuse, neglect, wear & tear, ingress of liquids (water, oil, acid, or otherwise), foreign objects, lightning strikes, over or under voltage, RFI/EMI, etc.

### Obtaining Warranty Service

To obtain warranty service, please contact the outlet at which you purchased your product. Do not contact Clayton Power directly. For warranty service you will require the following:

1. Proof of purchase
2. Model number
3. Serial number
4. Brief description of application and problem Telephone your Clayton Power dealer for an authorization number prior to dispatch - do not send without authorization. Once this number has been obtained, please carefully package your display and send (freight paid) to the Clayton Power dealer.

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