selectronic
POWER ON

SelectCell

Ultimate 280 Series

Instruction Manual

Instruction - Operation - Service

Revision Control

03	22/07/2021	Revision Warnings
04	08/04/2022	Manager - Worker
05	14/11/2022	Review of new PCC/PCM codes

Limitation of Warranty and Liability

The limitation of warranties and liabilities as per SelectCell full warranty terms and conditions described in the product warranty document.

The information included in this manual has been written for the purpose of providing the user with more detail and clarity in terms of content. Nonetheless, Selectronic Australia reserves the right to modify the contents of this manual through future revisions at any time and without prior notice.

Confidentiality

All information provided by Selectronic Australia by virtue of this User Manual and any data or features that may be disclosed by such shall be completely confidential and may not be shared with third parties or used for purposes other than that for which is was intended without prior and express written authorization from Selectronic Australia.

Limitations on the use of this equipment

This equipment may not be used in applications for recharging electric vehicles. Selectronic Australia shall not be held liable for use with these types of application. The buyer shall be wholly responsible.

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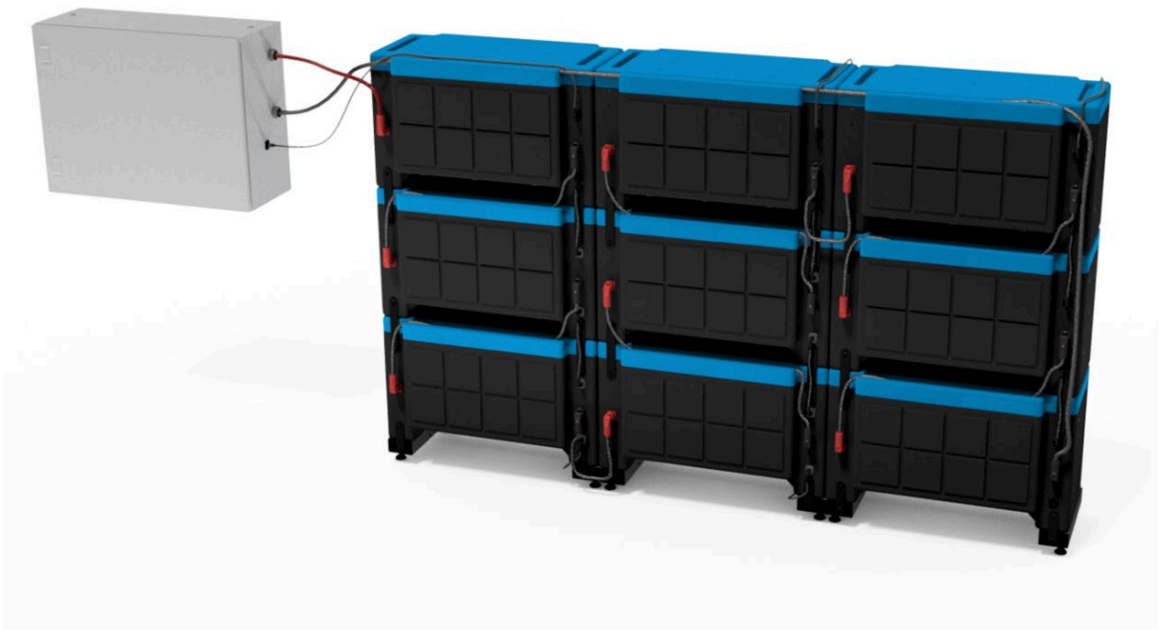
1. Introduction

1.1 Purpose

The following document represents the complete manual for the installation, use and maintenance of the SelectCell energy storage system, comprising SelectCell Ultimate 280 Series modules and PCC protection and control cabinet.

1.2 Acronyms

FAT	Factory Acceptance Tests
BMS	Battery management system
SelectCell Ultimate Series	Battery pack 48V 280Ah
EMS	Energy management system
PCC	Power Control Cabinet
SoC	State of charge. Amount of energy in battery
SoF	State of function. Maximum admissible amount of charge or discharge current at any moment
STRING	Cabinet containing various modules and a PCC



2. Safety

WARNING: RISK OF FIRE OR EXPLOSION

Failure to comply with safety messages may cause serious injury, death or damage to property

DANGER!

Always use the SelectCell Ultimate 280 module with a PCC protection and control system. Never connect the module without the PCC.

To prevent high inrush currents, a bus pre-charge is required. A direct connection may result in damage to the system. This pre-charge is managed from the PCC.

DANGER!

Check that the voltage is within range before connecting the equipment to the inverter. NEVER connect the string if the voltage is out of range or NULL.

DANGER!

NEVER remove or bypass PCC switching and protection systems.

DANGER!

Do not short-circuit the current circuit terminals of the SelectCell Ultimate 280 module or the PCC. The short-circuit current may be several thousand amperes. Prolonged short-circuiting will destroy the battery module and electrolyte may leak out of the cells, causing a fire and/or explosion.

DANGER!

SelectCell installation and maintenance personnel shall wear protective apparel, special gloves and safety glasses. All personal metal objects such as wristwatches, rings, jewelry, etc., shall NOT be worn while working with the SelectCell Ultimate 280 modules.

DANGER!

To avoid short-circuits and electric shock, use safety tools (EN 60900) and protection devices when installing and servicing the equipment.

DANGER!

Do not connect or disconnect the load when the main contactor is closed. This may cause an electric arc and expose personnel to high DC voltage. The electric arc might also destroy connectors, due to a welding effect.

DANGER!

In case of fire, disconnect the circuit from the battery and use a CO2 extinguisher to extinguish the fire. The batteries contain flammable materials. Always inform fire-fighters about the lithium batteries.

DANGER!

Do not open the covers on the SelectCell Ultimate 280 modules. Do not place or drop conductive objects inside the battery module or between the module's terminals.

DANGER!

Do not expose to temperatures above 65ºC. The equipment will not be operational beyond these temperatures, however, even with non-operational equipment exposing the cells to high temperatures may cause fire and/or explosion.

DANGER!

Do not immerse the SelectCell Ultimate 280 module in water or any other liquid.

DANGER!

Never drop or knock the SelectCell Ultimate 280 modules.

DANGER!

If chargers/converters are used, use only those authorised by Selectronic. Misuse of the battery module during charging or discharging may cause the equipment to age prematurely leading to fire and/or explosion. Both units have complex communications and these need to be carried out by authorised specialists.

DANGER!

In the event of an emergency, read the MSDS (Material Safety Data Sheet) for the cells before proceeding.

DANGER!

Battery terminals are live – DO NOT TOUCH. DO NOT BREAK UNDER LOAD.

2.1 General information

The SelectCell Ultimate is a smart energy storage system with Li-ion cells.

The whole system contains a high energy capacity. To minimize the risk of electric shock, short-circuit, explosion and/or fire, follow the relevant procedures and local guidelines, as well as the instructions that are included with the system.

Only qualified personnel should perform the installation, in accordance with the applicable regulations. Systems with visible electrical connections have to be isolated from public access. For safety purposes, cover all direct connections and terminals.

Carefully read, understand and apply all requirements presented in this section.

2.2 Safety Instructions– Potential hazards

- **The area around the SelectCell Ultimate shall be kept**
- **clear and free** of combustible materials, gasoline and/or other flammable fumes, vapours and liquids.
- The area defined by safety margins for the necessary supply and venting of air shall be respected.

  In the event of an emergency, the SelectCell has electrical safety cut-off elements (fuses and contactors). It is advisable to install an element that protects against over-current and possible short-circuiting. It is also advisable that the cut-off element can be manually operated if necessary. Remember, because this is a battery, the STRING's internal DC bus will always be live.
- **Do not use the module if any of its parts have been immersed in water**. A water damaged cell is potentially dangerous. Any attempts to use the system could cause a fire or an explosion. In such cases, contact Selectronic to have the battery pack inspected.
- The following instructions shall always be followed:
  - **Any air inlet or outlet within the room shall be kept clear and free of obstacles.**
  - **The floor shall be capable of bearing the weight of all equipment, keeping in mind the weight of each battery is 105kg.**
  - **There shall be no obvious signs of wear on any STRING element.**
  - **As this is a battery, there is voltage on the cabinet's +/- output terminals whenever the PCC contactor is closed.**

2.3 Electrical safety

- Never remove safety guards or devices that protect against live parts.
- Do not reach inside the STRING or the modules, nor touch any internal component.
- Do not use or handle any SelectCell component when accidentally wet, or with wet hands or feet.
- In the event of a failure or incident, as a first step cut off the current. To rescue a person being electrocuted, do not touch them but immediately stop the current.

- If it is not possible or takes too long to cut the current, try to disengage them by means of an insulating element (wooden strip or board, rope, wooden chair ...).
- Whenever a battery is not installed on the STRING, make sure that the power terminals at the front are protected against accidental contact given that the terminals are energised.
- Make sure that the output and input connection cables are not short-circuited.
- Make sure there is no short circuit between positive and negative terminals at any point.
- Make sure there is always protective insulation on the output and input cables and a reliable connection.
- Never use cables that are visibly damaged or that may be suspected of being damaged.
- Minimise conductivity, avoiding surfaces in contact with water. Hands and clothes have to be dry.
- Do not use, install or store the system under wet or damp conditions.

2.4 Mechanical safety

- Due to the weight of the battery modules (>100 kg), mechanical means have to be employed to install them.
- Do not stack **SelectCell Ultimate modules more than 4 high.**

2.5 User requirements

In addition to personnel who work with the module, workplace users should also implement safety measure by applying the minimum provisions on the protection of the health and safety of workers exposed to electrical risk in the workplace, refer to your local jurisdiction.

Hazards related to electrical risk are specifically identified during the work process with this equipment. This does not exclude the possible existence of other risks present during handling and use, such as overexertion, posture, or other measures against health risks. Operators shall receive the necessary training, sufficient to be able to prevent and avoid any risks arising from use of the equipment.

By design the equipment protects against these risks under normal operating conditions, however, it is with operations that differ from normal ones (installation, maintenance, ...) where special precautions have to be taken.

Particular care should be taken when handling modules, due to their weight. Respect guidelines according to current regulations regarding ergonomics in the. Use appropriate handling equipment.

2.6 Lockout-tagout of machines and installations (L.O.T.O.)

To perform operations, absent of voltage (L.O.T.O.), the device shall be locked and tagged to non-hazardous voltage values. The following section is based on the lockout-tagout at several points according to:

1. Restrict access to the work area to prevent entry of unauthorised personnel.
2. It shall be disconnected and isolated from the supply network or connection to the converter.
3. Once disconnected, the STRING shall be sectioned into parts with voltages below 75 VDC.
4. The terminals of these parts shall be protected by insulating caps designed for this purpose.
5. Given that the batteries are an energy storage system, it is impossible to make certain points of the system free of voltage. If there is any exposed point where the voltage cannot be eliminated, the terminals will have to be tagged, indicating the voltage value at that point.
6. Prior to conducting any work, the voltage shall be measured at the point where the work is to be done. Some points may be energised directly from the batteries.
    - Use only 600V insulated tools
    - If terminals are exposed during the sectioning process, use 600V rated insulating gloves.
    - Use a face shield during the work.
    - Should it be necessary to perform an operation on a battery pack, place the modules on insulating matting.
    - Use insulating footwear.
    - To avoid possible short-circuiting, do not carry any conductive device (e.g. pens, tape measures, etc.) during the work.
    - Do not wear any metal, conductive or sharp edged accessories.

2.7 Switching, measurements and checks

The regulation permits operations and interventions without lockout-tagout, provided that an equivalent level of safety is guaranteed.

These interventions are called switching, trials and checks. They have to be carried out by authorised personnel with protection devices and personal protective equipment appropriate for the voltages in question.

Special protection against short-circuits should be ensured. Instructions to follow:

- The operations shall only be carried by authorised, duly trained, personnel.
- Safety apparel that covers the whole body (long sleeves) shall be used. Fireproof or flame retardant, with protection against chemicals and arc flash.
- The work shall be done from a solid, stable support
- If a work table is used, it shall be insulated or covered with Insulating matting.
- No terminal with an electrical charge should be left uncovered. If, after removing the connections, the terminals are exposed, then they have to be protected with the terminal covers supplied.
- All tools shall be insulated and rated up to 600V
- Operators shall not wear or carry any metal elements or devices.
- The work area shall be free of obstacles.
- If necessary, when there are exposed terminals nylon slings shall be used instead of chains.
- The operator shall wear a face shield or safety glasses to protect against short-circuits

Occasionally, depending on the operation, there should be a preventive resource worker present.

General description

The Selectronic SelectCell Ultimate 280 Series is a lithium-ion battery, 48VDC nominal and 280Ah capacity.

Each one of the modules or batteries comprises 15 x 3.2V cells in series welded using laser technology. The voltage of each of these cells and the temperature of the module is continuously monitored by its own local card (BMS), developed by Selectronic.

Each module is fitted with a 300A single-pole fuse, accessible via a cover on the side of the module, enabling a quick change in the event of electrical failure on the installation. See corrective maintenance instruction in section 13.4.

The SelectCell Ultimate 280 Series modules can be connected in Series in towers up to 3 high. In turn, each group of batteries can be connected in parallel by using the Manager-Worker configuration, making it possible to increase the system's energy and total power.

The system requires a PCC protection and control body in order to operate. These control bodies contain the system's protection elements, as well as a card responsible for managing them (EMS).

This EMS card acts as the Manager for the system, receiving all the information from the BMS found in the system's battery modules via ISO SPI communications. To complete the information needed, a reading of the current passing through the circuit is made, as well as several voltage readings at string level.

Via an independent communications channel, the EMS also manages the exchange of information with a higher order system; be it an inverter, PC or SCADA. The EMS uses all of this information to operate the protection systems, collect statistical data and send critical information to external systems (measurements, states, alarms, ...).

In turn, there is a system Manager in the Manager/Worker systems, in charge of centralising the information from all of the Workers and managing the opening of their respective contactors. This equipment is the one that communicates with the inverter in order to transmit both the necessary information and the system's alarms. This communication is done via the CAN or Modbus TCP/IP protocol.

4. Specifications

4.1 Summary

Name	SelectCell Ultimate 280 Series	PCC WORKER/SINGLE 150V / 500A	PCM SINGLE	PCC MANAGER
Code	005376	005384 / 5392	005391	005385
Image				
Description	LiFePO4 Battery	Power protection cabinet, up to 150v 300A / 500A Suitable for both simple and master/ slave systems	Power protection and control module up to 150V / 200A. Only suitable for single string (three batteries)	Manager for 2 or more workers. Only suitable for master/ worker systems
Mech. Charac.	762x405x448 105kg	800x300x1000 90kg	762x250x165 15kg	800x300x1200 125kg
Elec. Charac.	Voltage: 48V Capacity: 280Ah Energy: 13.4 kWh	Max. voltage: 150v Max. current: 300A / 500A	Max. voltage: 150V Max. current: 200A	0v - 1000V 0A - 1000A

4.2 SelectCell Ultimate 280 Series

4.2.1 Physical characteristics

The following table gives the specifications of the **SelectCell Ultimate 280 SERIES module:**

Physical characteristics	
Height	448 mm
Width	762 mm
Depth	405 mm
Weight	≈105kg

The following table lists the SelectCell Ultimate 280 Series module **interfaces**, with a short description of each.

SelectCell Ultimate Series module Interfaces	
Power	**Positive (1):** Left side of module HARTING 1000VDCc 200A Fast Connector **Negative (2):** Right side of module
Communications	2 Fast Connectors RJ45 Right side **(3)**

4.2.1 Electrical characteristics

Electrical specifications	
Nominal voltage (VDC)	48
Minimum static voltage, SOC 0% (VDC)	42
Maximum static voltage, SOC 100% (VDC)	52,2
Nominal current during charge/discharge: (A)*	<140
Maximum current during charge/discharge: (A)*	200
Rated energy (Kwh)	13,4 kWh
Rated capacity (Ah)	280Ah

4.3 PCC WORKER / SINGLE / 150V

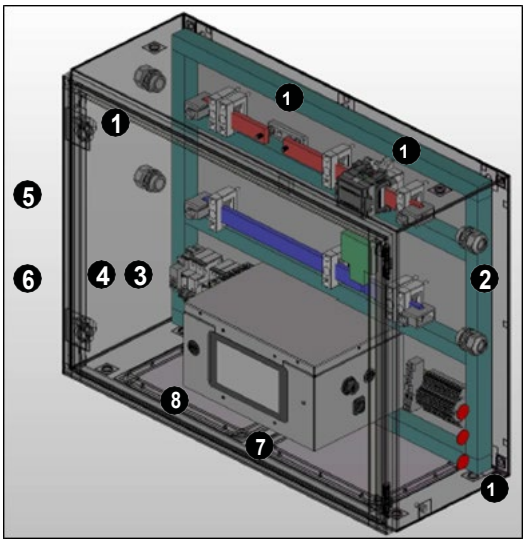
4.3.1 Physical characteristics

The physical dimensions of **PCC WORKER 150V / 500A** are as following:

Physical characteristics	
Height	1000mm
Width	800mm
Depth	300mm
Weight	~90Kg

The following table lists the interfaces with a short description of each.

PCC 150V / 500A Interfaces	
Power	**OUTPUT (1) - Left side of cabinet:** Depending on the number of outputs needed; Max cable 185mm^2 1 Output as standard **INPUT (2) - Right side of cabinet:** Depending on the number of inputs needed; Minimum cable 50mm^2 4 inputs as standard
ULTRA-LOW MODE breaker (4)	Front panel for switching on after entering ULTRA LOW MODE
CAN communications (5)	RJ45 connector on left side of PCC; non-crossover Cat5e SERIES cable
Modbus/TCP Communications (6)	RJ45 connector on left side of PCC; non-crossover Cat5e SERIES cable
HMI (7)	Touch screen on the PCC
User access (8)	USB connector on the PCC
On and Error LED (9)	RED to show a system error on the PCC's front panel; GREEN system ON
ISO SPI Communications (10)	Female RJ45 connector for SelectCell Ultimate modules on the right side; Own COM cable incl.
Fuse	On positive terminal 150VDC / 500A continuous
Contactor	On positive terminal



4.3.2 Electrical characteristics

Electrical characteristics	
Maximum voltage (Vdc)	150VDC
Maximum current during CHARGE/DISCHARGE	500A
Maximum peak current DISCHARGE	600A (1-2 min)

Notes:

4.5 PCM SINGLE 200A

4.5.1 Physical characteristics

The physical dimensions of the **PCM Single** are as follow:

Physical characteristics	
Height	165mm
Width	762mm
Depth	250mm
Weight	≈15 Kg

The following table lists the **interfaces** with a short description of each.

PCM 150V / 800V 200A Interfaces	
Power	**OUTPUT (1) – Back of equipment:** M12 cable gland; Minimum cable 50mm^2 **INPUT (2) – Front of equipment:** Harting Han S connectors; Minimum cable 50mm^2
ON/OFF switch (3)	Back panel for switching on/off
Modbus/TCP Communications (4)	RJ45 connector at the rear of PCM; non-crossover Cat5e SERIES cable
HMI (5)	Touch screen on the PCM
User access (6)	USB connector on the PCM
Error LED (7)	RED to show a system error on the PCM's front panel;
ISO SPI Communications (8)	Female RJ45 connector for SelectCell Ultimate modules on the front; Own COM cable included
24Vdc Bus (9)	24Vdc Bus to power the Manager's electronics
Contactor	On positive terminal

Notes:

4.5.2 Electrical characteristics

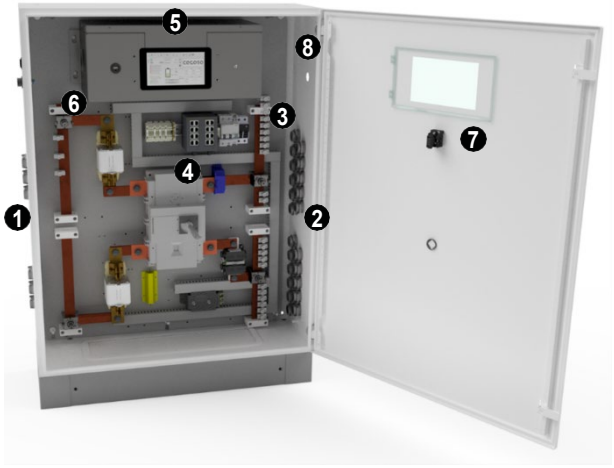
Electrical characteristics	
Maximum voltage (Vdc)	150VDC
Maximum current during CHARGE/DISCHARGE	175A
Maximum peak current DISCHARGE	200A (1-2 min)

4.9 PCC MANAGER 1000A

4.9.1 Physical characteristics

The physical dimensions of the **PCC Manager Busbar Cabinet son Worker** are as follow:

Physical characteristics	
Height	1,300mm
Width	800mm
Depth	300mm
Weight	≈120 Kg



PCC Manager 1000A Interfaces	
Power	**OUTPUT (1) – Left of equipment:** Bare wire terminal block; Max cable 120mm² 6 outputs standard **INPUT (2) – Right of equipment:** Bare wire terminal block; Max. cable 185mm² 4 inputs standard
Door Isolator Switch (3)	Door Isolator switch
Modbus/TCP Communications (4)	Internal switch used to connect communication with workers. Detachable cable gland used to pass cables inside the cabinet
HMI (5)	Touch screen on the PCC
User access (6)	USB connector on the PCC
Error Led (7)	RED to show a system error on the PCC's front panel
Bus 24Vdc (8)	24Vdc Bus to power the manager's

4.9.2 Electrical characteristics

Electrical characteristics	
Maximum voltage (Vdc)	1000V
Maximum current during continuous Charge/Discharge	1000A

4.10 Hardware

4.10.1 Battery module

Each battery module consists of:

- **Cells 3.2V – 280 Ah;** forming a final array of 48V – 280 Ah
- **BMS:** Card that takes the direct voltage reading for each one of the cells and temperature reading for the module
- **Fuse:** Each module has a fuse interposed between the cell links. The acts in the event of an internal short-circuit or short-

circuit on one of the modules' terminals, opening the string and preventing adjacent modules (depending on the position of the shorted module) from feeding the fault

4.10.2 PCC

The protection module comprises the following elements:

- **EMS:** This collects the data from all the BMS, manages these data, acts on protection elements and communicates with equipment at a higher level.
- **HMI:** Touch screen, connected directly to the EMS. This shows data on the state of the system, allowing manual intervention if required.
- **Error LED:** This LED flashes when the EMS detects a fault on the system, whether it be an electrical or hardware fault.
- **On LED:** This LED stays lit green when connected.
- **Contactor:** Safety element that cuts the current in the event of a system alarm. Located just before the protection module's output terminals, it is used to isolate the cabinet before conditions that guarantee correct connection to the bus are established, as well as protecting the string against external faults.
- **Current transformer:** Transformer that reads the system's total input and output currents to calculate the charge remaining in the battery, as well as protection functions.
- **Power supply:** One a stationary battery's applications is to be used as an uninterruptible power supply. To achieve this, the electronics that manage the batteries cannot stop receiving energy, so the only way to ensure this is to feed it off the batteries themselves.
- **On/Off switch:** Used to start the PCC once the power connections have been made. Should the PCC have to be put out of operation, this switch is also used to switch it off and isolate the electronics from the power supply.
- **Breaker:** In the event of entering ultralow mode this device switches off the entire system to ensure there is no consumption.
- **Power terminals:** Access for the customer's power cables is located on the right side of the electric cabinet.
- **Communications connector:** Both Communications connectors are located on the right side of the PCC, identified as "CANbus" and "Modbus"

The Modbus/TCP connector uses a standard TCP cable.

The pinout for the CAN Communications cable can be checked in chapter 9.2 CAN protocol. If a different pinout is required, please contact Selectronic for assistance.

4.10.3 PCM

The protection module comprises the following elements:

- **EMS:** This collects the data from all the BMS, manages these data, acts on protection elements and communicates with equipment at a higher level.
- **HMI:** Touch screen, connected directly to the EMS. This shows data on the state of the system, allowing manual intervention if required.
- **Error LED:** This LED flashes when the EMS detects a fault on the system, whether it be an electrical or hardware fault.
- **Contactor:** Safety element that cuts the current in the event of a system alarm. Located just before the protection module's output terminals, it is used to isolate the cabinet before conditions that guarantee correct connection to the bus are established, as well as protecting the string against external faults.
- **Current transformer:** Transformer that reads the system's total input and output currents to calculate the charge remaining in the battery, as well as protection functions.
- **Power supply:** One a stationary battery's applications is to be used as an uninterruptible power supply. To achieve this, the electronics that manage the batteries cannot stop receiving energy, so the only way to ensure this is to feed it off the batteries themselves.
- **On/Off switch:** Circuit breaker inside PCC used to start the PCM once the power connections have been made. Should the PCM have to be put out of operation, this switch is also used to switch it off and isolate the electronics from the power supply.
- **Power terminals:** Access for the customer's power cables is located on the front of the module
- **Communications connector:** Both Communications connectors are located on the back side of the PCM, identified as "CANbus" and "Modbus"

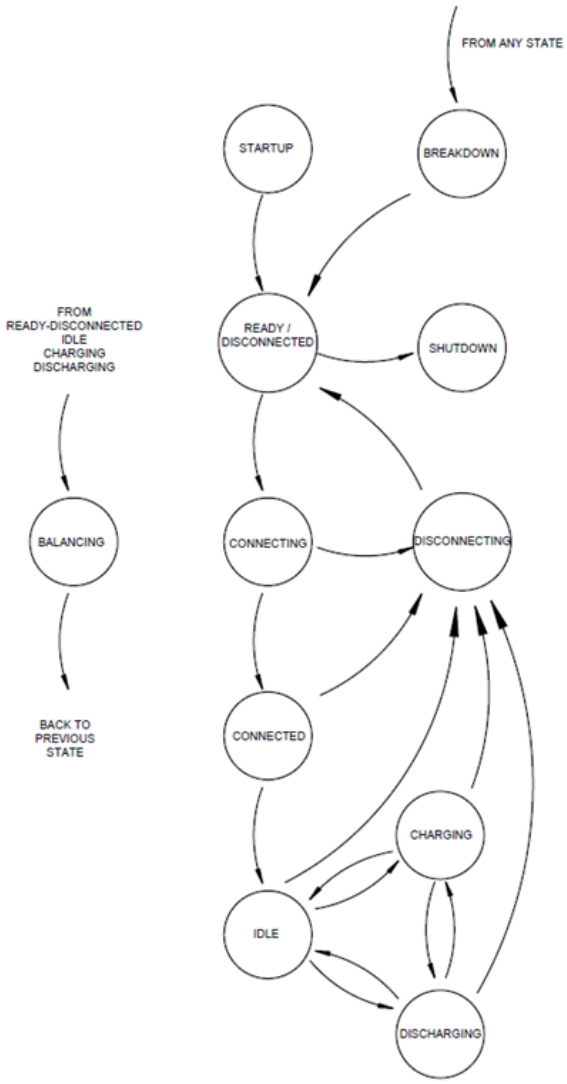
5. Operating modes and processes

5.1 State machine

The string is controlled by a sequential state machine. This state machine is managed by the EMS located inside the PCC. The user can check the state of the string both from the HMI and by communications at address 0x3000 - 1 via CAN or at address 3001 via Modbus.

The EMS state machine has the following states:

- **Start-up:**
  This starts the card, communications, and each of the BMS located inside the battery packs. System settings anderror-free check.
- **Ready / Disconnected:**
  Value at memory location = 2
  Once the start-up sequence has finished, the system remains in this state until the connection sequence starts, whether due to a command, if the battery works together with a manager or after a standby period, if the battery works independently.
- **Eq Balancing:** Value at memory location = 3
  If the EMS detects that the charge difference between cells is too high, and that system conditions are suitable for the string to enter equalization, the EMS automatically orders the equipment to this state. In this state any excess energy in cells with the most charge will be dissipated until all the cells have approximately the same stored energy.
- **Connecting:** Value at memory location = 4
  Transition state. the state machine changes to this state once the connection command has been received and the pre-charge has been performed (pre-charge is optional, described in its own chapter). If the bus voltage reading is correct, it orders the contactor to close and then changes to the connected state.
  If the voltage reading is not correct, the sequence is aborted and it changes to the disconnecting state.
- **Connected:** Value at memory location = 5
  Transition state. After receiving the close command and running the connection sequence, the string will have the contactor closed. If no errors occur within a specific time, it changes to the idle state.
- **Idle**:
  Value at memory location = 15
  Once the string is connected, it remains in this state until a through-current is detected. If the current value read has a positive sign, it changes to the charging state, but if it is a negative sign, then it changes to the discharging state.
- **Charging:**
  Value at memory location = 25
  In this state the current is being fed to the string, so the SoC value will grow proportionally to the current read and the protection functions with the “charge” suffix will be enabled.
- **Discharging:** Value at memory location = 35
  In this state the current is being drawn from the string. The SoC value will decrease proportionally to the current read and the protection functions with the “discharge” suffix will be enabled.
- **Disconnecting:** Value at memory location = 6
  Transition state. As soon as a disconnection command is received or an error occurs during the connection sequence, the system will change to this state as a step prior to opening the contactor.
- **Breakdown:** Value at memory location = 1
  If the system experiences a critical fault (any error that prevents safe use of the batteries), the EMS will change to the Breakdown state, in which the contactor opens. It will remain in this state until the errors are cleared, either via the local HMI or by receiving a communications command to reset errors.
- **Shutdown:**
  This state appears when a software reset is performed on the EMS, either due to a settings change or a firmware update. During this state, the EMS saves the system’s state to memory, to continue under the same conditions once the restart has finished.



5.2 Start-up and shut-down processes

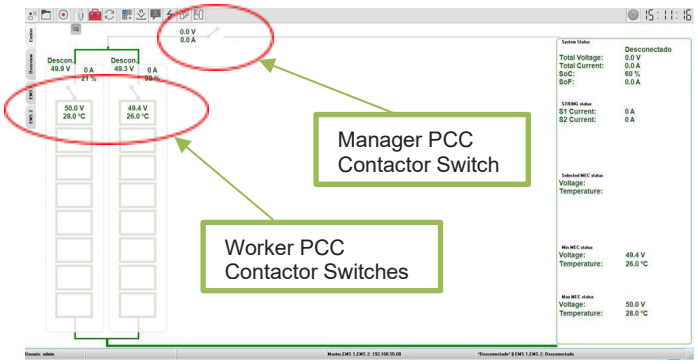
Please refer to the Installation Section page 28 prior to starting the system.

Once the PCC is energized, the control electronics in the PCC powers up. The EMS then checks hardware integrity (own hardware and that of the BMS distributed by communications) and that the cabinet distribution set-up corresponds with that read. If no error is detected, the EMS allows work with batteries to commence. The time required for start-up is less than 1 minute.

Prior to starting normal battery operation, it is advisable to charge the modules up to 100% SoC.

To stop the system, via the touch screen, press the switch icon. The string should never be switched off while current is flowing through the system.

The contactor has to be opened from the screen (connect button) prior to switching off the PCC.



DANGER:
ELECTRONICS SELF-CONSUMPTION
The electronics inside the cabinet are powered by the batteries. If the batteries are not going to be used for a prolonged period, the PCC has to be switched off.

5.3 Connection process

SelectCell Ultimate 280 systems can operate in 2 different ways: Worker mode and Stand-alone mode

In **Worker mode** control depends on a higher level system, be it SCADA, an inverter or operation personnel. In this mode, after the system is started it remains in the ready/disconnected state until it receives an external close command.

In **stand-alone mode** the system automates various operations, including direct connection. Once the SelectCell is started in this mode, if no critical errors occur, the contactor will close independently. This mode is used together with inverters that do not have communications, or whose communications system is not suitable for controlling lithium battery pack switches.

The latter (stand-alone) is the default connection mode.

5.4 Ultra-low consumption mode

Should the batteries be left unattended for a prolonged period, the cabinet has an ultra-low consumption system to protect them. If the equipment were to be left on without supervision or use, the electronics in the batteries would consume their energy, so if the EMS detects a battery voltage value lower than a desirable level, it follows a series of steps as the voltage decreases, until it switches the string off completely.

In the case of the PCC, there is a circuit breaker to switch off consumption definitively. To switch the equipment back on, it is necessary to use the switch again. Contact Selectronic for information on how to do this safely, because when the system restarts there should be an energy source available to charge the batteries (grid, generator, renewable...)

Input conditions for this ULTRA-LOW CONSUMPTION mode:

Current less than 2A AND minimum cell value <2975mV for 2h

The actions that occur are as follows:

1. Contactor opens due to undervoltage
2. BMS switched off on each of the batteries
3. Screen and EMS switched off.

If the battery does reach any of these points it may still be re- covered, however, it requires a specific charging method.

DANGER:

ULTRA-LOW CONSUMPTION MODE

If the user detects that the string has disconnected itself and that the screen is off, charging battery should be avoided.

If the battery tries to charge normally in this state; in the best of cases, it would lead to a severe loss of capacity for the equipment; in the worst case it would cause a short circuit.

Under these conditions the battery has to be recharged in a specific way.

Please contact Selectronic's technical support department so that it can analyse the situation and provide additional instructions.

5.5 Pre-charge process

The pre-charge process is designed to be used with commercial inverters. It requires specific custom-built hardware for this application.

Power inverters, MPPT controllers and most of the power electronics equipment work with a set of capacitors, coils and transistors to modify the input signal to achieve the desired output signal for the application.

To solve this problem, a DC bus soft-start is used.

In this instance, instead of initially closing the circuit with the main contactor; an auxiliary contactor is used, which is connected in series with a resistor that limits the current. This resistor decreases the capacitors' energization current and once the DC bus is energized, the main contactor closes while this auxiliary contactor is disconnected, as long as the bus pre-charge has been done safely by reaching the desired bus voltage level.

5.6 Passive equalisation

As the string charges and discharges, slight differences in the chemistry of the cells produce different resistive values, leading to differing losses during use of the battery and different amounts of energy stored in each cell.

The end of the charging process is determined by the cell that has the highest amount of stored energy in the whole string (when a cell reaches 100% charge, the process stops regardless of the charge stored in the rest of the string's cells), while the end of the discharge process is determined by the cell with the least amount of charge.

The differences in stored energy increase as the number of cycles in the string increases; making the system increasingly less efficient. To solve this problem, the EMS monitors the difference between cells, initiating the equalisation process whenever necessary.

Cell imbalance is due to different factors, the most common being:

- **Depth of Discharge (DoD):** Higher DoD, greater imbalance.
- **Charge and discharge cycles:** More cycles, greater imbalance.
- **Operating temperature:** Working at temperatures other than the optimum one produces greater imbalance for the same charge/discharge cycle.
- **Charge/discharge current:** Higher currents, greater imbalance.

The charge in a cell is partially related to the voltage in that cell. SelectCell constantly controls the voltage in each of its cells. If a high imbalance between cells is detected at any point, then the EMS enters passive equalisation mode, assuming the string is not being used.

During this process, any excess energy in cells with the largest amount of charge is dissipated. By doing this, the charge value of each cell begins to decrease slowly until each cell reaches the charge value of the least charged cell.

There are two passive equalisation modes: Normal mode and extreme mode.

A typical equalisation process, where a set of lithium-ion cells with initially spread voltages is reduced over time as the process is executed.

6. System monitoring

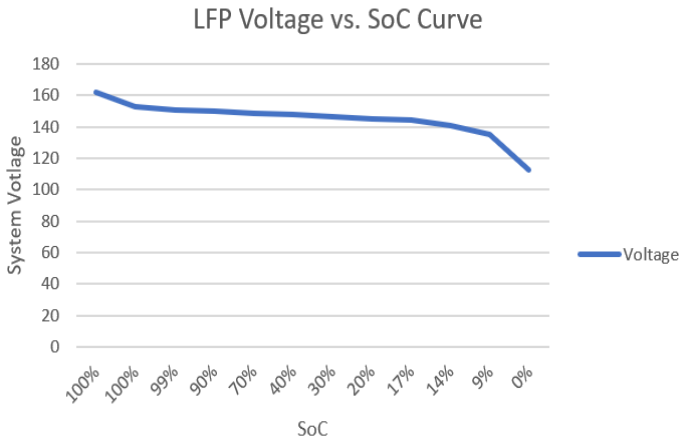
6.1 State of Charge (SoC) calculation

One of the most important aspects in a battery is to know how much stored energy remains in it, in order to determine how the battery can be used.

This is quite simple with lead acid batteries, given that the system voltage is practically proportional to the charge remaining in the batteries.

However, LFP-type batteries have a characteristic discharge curve in which the voltage is flat for most of its utilization range, and where a variation of 1-2 mV could represent a 10-20% error when estimating the charge. Only the voltage extremes vary enough to be able to relate directly to the charge remaining in the battery.

This, coupled with the fact that the shape of the characteristic varies with different factors (discharge current, temperature ...), makes direct measurement of the voltage to represent the charge remaining in the battery infeasible.



To solve this problem and attain a faithful representation of the system's state of charge, a mixed solution has been applied.

During most of the utilisation range the EMS continuously calculates the batteries' SoC using a coulometric based algorithm. A reading is taken of the output current during discharge and input current during charge, and the SoC is then updated by adding or subtracting this energy.

An update of the estimated charge is performed at the ends of the curve (0-20% and 95-100% charge), where the voltage can be more precisely related to the remaining charge; updating the SoC to this voltage under certain physical conditions.

- **100% update;** given the SW defined voltage and current conditions to interpret that the battery is fully charged. Similarly, if one of the series reaches a value of 3575mV for 10 seconds.
- **Idle update;** The EMS electronics use their own algorithms to update the SOC when idle (ZERO current after a period of inactivity) depending on the voltage of cells only within the range from 0 to 20%.
- **0-20% update based on discharge current;** The EMS electronics use their own algorithms to update the SOC based on the discharge current of each module connected in parallel and minimum cell voltage; this SOC value is only updated with current within the range from 0 to 20%

6.2 Ideal charging conditions

The EMS system constantly controls the SOC conditions, temperature, voltages of the entire system and uses communications to send the inverters/chargers the optimum charge voltage and charge current values in order to ensure correct control of the charging process.

- **Charge voltage** based on cell temperature:
  - Between 0 and 5ºC 51.5V
  - Between 6 and 10ºC 52V

- Between 11 and 40ºC 52.2V
- Between 41 and 45ºC 51.8V
- Above 46ºC 51.5V

- **Charge current** based on cell temperature:

Charge current		Temperature					
		0 - 5ºC	6 - 10ºC	11 - 25ºC	26 - 40ºC	41 - 45ºC	>46ºC
SOC	0 - 20%	0,2C	1C			0,5C	0,2C
	21 - 50%	0,3C	1C			0,5C	0,3C
	51 - 60%	0,3C	1C			0,5C	0,3C
	61 -70%	0,3C	0,5C	1C		0,5C	0,3C
	71 - 80%	0,3C	0,5C	1C		0,5C	0,2C
	81 - 95%	0,3C	0,3C	0,5C			0,2C
	96 – 100%	0,1C					

Table 8. Charge currents based on SOC & Temperature

6.3 State of Function (SoF) and final battery use

State of function (SoF) is an algorithm that shows the largest amount of current that a battery can absorb or supply depending on the charge stored in the string, and adjusted with reference to various physical, chemical and electrical characteristics.

6.4 Calculation of battery integrity (SoH)

The battery ages over time due to several reasons: Number of charge and discharge cycles performed, over-currents, humidity, chemical changes due to time or extreme temperatures, ...

All of these factors mean that the battery is not able to store as much energy as it did when new. As a way to indicate how much the battery has aged, and consequently how much energy it is able to supply, an SoH algorithm has been developed.

This algorithm uses various equations to compare the present discharge cycle with a standard discharge cycle, and then internally update how much stored energy represents 100% SoC, showing the user the quotient of maximum storable capacity with respect to the theoretical maximum capacity as a % (SoH).

To do this, several charge-discharge cycles are stored under different physical conditions. These cycles are used for comparison. In day-to-day operations, the EMS controls several key variables and if these coincide with those stored in a standard cycle, it then compares the energy exchanged during that cycle with the energy of the standard cycle.

Included among these control variables are:

- SoC start and end value
- Average temperature during the cycle
- Average current during the cycle
- Percentage of imbalance between cells

6.5 Extending the life and end use of the batteries

Due to various factors, the battery loses some of the useful capacity it can supply.

The factors that affect the life of a lithium battery are the following:

- Using the battery outside the recommended temperature range.
- Subjecting the battery to deep discharges, below 5% of SoC
- Heavy charging and discharging (high currents)

Depending on the application, there will be conditions that can be met and others that cannot. E.g., in an application for an uninterrupted power supply, the priority is to guarantee that the demanded current is supplied with respect to the number of cycles that the battery can provide. Lost capacity generated by possible current peaks is offset by the number of cycles demanded from the battery, since in this type of application the battery is not working continuously.

In those cases where battery use is continuous, as in renewable energy installations, the priority is to maximize battery life. In these cases where moderate charges and discharges are performed with reduced values of current, other values such as DoD will be controlled in order to maximize battery life.

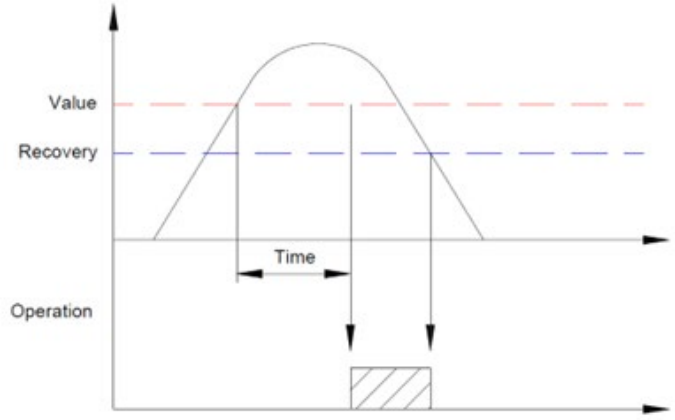
7. Electrical safeguards

The EMS system continuously monitors the current, voltage and temperature values at different points on each of the mod- ules. Likewise, it continuously checks the state of the contactor and the state of the string within the state machine. If the EMS detects that there is a problem with the process, it operates the contactor to isolate the battery and clear the fault.

7.1 Parameters involved in the protection functions

Each protection function is factory set, based on the composition of the battery pack and the chemistry that it uses. Functions that have been operated are displayed on the HMI and communicated through any of the communication options.

The nomenclature and meaning are as follow:



XXX_XXX_value: Value from which, if we stay at, we will end up operating.

XXX_XXX_time: Time required for the protection to operate, once the battery is in an unsafe situation.

XXX_XXX_recovery: After having operated, dropping below this value will reset the operation variable.

Depending on the severity of the fault, there are 2 operation levels:

XXX_XXX_warning: This variable indicates that the system is heading towards a dangerous situation. If this variable is detected, the system control should act to correct the situation.

XXX_XXX_alarm: This variable indicates that the system is in a dangerous state. The EMS will operate the cut-off elements to isolate the string.

7.2 Reclose

The EMS monitors the electrical and temperature values before, during and after a fault. If it detects that the system has recovered after a fault, and that it is safe to continue with the operation, it will close the contactor again. Should an SOTF (switch on to fault) situation occur, this reclose is limited to a maximum of 3 times over a period of 5 minutes.

There are, however, several safeguards where the reclose does not operate as it would be harmful to the string, meaning that the battery can only be brought back into service once an authorised person verifies that the cause of the fault has been corrected, that the equipment is not damaged, and that the battery can be reconnected to the bus.

7.3 Undertemperature

The EMS controls the temperature at which each module is both a charging and discharging. If there is a temperature below an admissible range, the string will trigger an alarm. If this temperature drops even further, it opens the safeguard to protect the batteries.

There is a group of safeguards for undertemperature during charge and another group for undertemperature during discharge.

Name of variable	Operating value	Operating time
Undertemperature in charge warning	0ºC	30 seconds
Undertemperature in charge alarm	-20ºC	30 seconds
Undertemperature in charge recovery	2ºC	30 seconds
Undertemperature in charge warning	-15ºC	30 seconds
Undertemperature in charge alarm	-20ºC	30 seconds
Undertemperature in charge recovery	-13ºC	30 seconds

7.4 Over-temperature

The EMS controls the temperature at which each module is both a charging and discharging. If there is a temperature below an admissible range, the string will trigger an alarm. If this temperature drops even further, it opens the safeguard to protect the batteries.

Name of variable	Operating value	Operating time
Overtemperature in charge warning	48ºC	30 seconds
Overtemperature in charge alarm	51ºC	30 seconds
Overtemperature in charge recovery	46ºC	30 seconds
Overtemperature in charge warning	48ºC	30 seconds
Overtemperature in charge alarm	51ºC	30 seconds
Overtemperature in charge recovery	46ºC	30 seconds

7.5 Undervoltage

Causes the voltage drop in a battery for long periods to progressively deteriorate the electrode materials. The first problem that occurs is that the anode's copper current collector dissolves in the electrolyte. This not only increases the cell's self-discharge rate, but if an attempt were made to recover the cell by recharging it, those copper metal ions dispersed by the electrolyte would not necessarily reintegrate on the current collector but would remain as copper metal wherever they were. This situation could

eventually cause a short-circuit between the electrodes. Keeping the cells at low voltage for prolonged periods also has an effect on the cathodes. A low voltage causes the gradual breakdown of the cathode, due to the gradual release of oxygen from the lithium iron phosphate cathode, and with it a permanent loss of capacity.

Name of variable	Operating value	Operating time
Undervoltage warning	2900 mV	5 seconds
Undervoltage warning recovery	3200 mV	5 seconds
Undervoltage alarm	2700 mV	5 seconds
Undervoltage alarm recovery	2950 mV	30 seconds

**Note: This protection function is calculated at the cell level*

7.6 Overvoltage

If the charge voltage increases above the level recommended for the cells, this produces an increase in the amount of current flowing through it. Excessive current means that lithium ions cannot settle fast enough in the carbon anode's lattice and end up depositing themselves on the surface of the anode as lithium metal.
As is the case during operations at low temperatures, at best this effect will produce a loss of capacity, and in the worst case a short-circuit, due to this lithium being deposited as dendrites that can perforate the insulation.

Name of variable	Operating value	Operating time
Overvoltage warning	3650 mV	5 seconds
Overvoltage warning recovery	3400 mV	5 seconds
Overvoltage alarm	3800 mV	5 seconds
Overvoltage alarm recovery	3600 mV	30 seconds

**Note: This protection function is calculated at the cell level*

7.7 Temperature difference

The EMS monitors the temperature at several points on each battery module. If a temperature difference occurs between the maximum measured temperature and the minimum measured temperature, this would indicate that the system that reads these data has failed (NTC, connection cable, BMS, ...).

Under such conditions, the operation of all modules within a correct temperature range cannot be guaranteed, so the string will be isolated.

This function is not included in the reclose process.

Name of variable	Operating value	Operating time
Temperature difference alarm	10ºC	10 seconds

7.8 Voltage difference

The EMS monitors the voltages of each and every one of its cells. If a voltage difference occurs above a certain value between the maximum measured voltage and the minimum measured voltage, this would indicate that the system that reads these data has failed (connection cable, BMS, ...) or that there is a cell with a problem.

Given that the integrity of the whole system cannot be guaranteed, the EMS will activate the protections to isolate it.

This function is not included in the reclose process

Name of variable	Operating value	Operating time
Voltage difference alarm	1000 mV	10 seconds

7.9 PCM 48 300 charge and discharge currents

A large increase in the current supplied by the battery might indicate that a short-circuit has occurred at the cabinet output. To prevent feeding the fault and/or damaging internal or external components with the circulating current, should an abrupt, sustained increase in current be detected, the EMS will activate the protection elements to isolate the system.

This function is not included in the reclose process. The defined values to be controlled in order to avoid triggering the current alarms are those indicated in this table:

Name of variable	Operating value	Operating time
Continuous overcurrent in charge (A)	SOF_CH + tolerance (*)	120 seconds
Continuous overcurrent in discharge (A)	SOF_DCH + tolerance (**)	120 seconds
Peak overcurrent in discharge (A)	120	60 seconds
Shortcircuit in charge (A)	2x Inom	100 ms
Shortcircuit in discharge (A)	2x Inom	100 ms

(*) The SOF_ CH is detailed in point 6.2 Ideal charging conditions, based on the system's temperature and SOC.

(**) The SOF_ DCH is always at 275A, except when an alarm or warning is triggered.

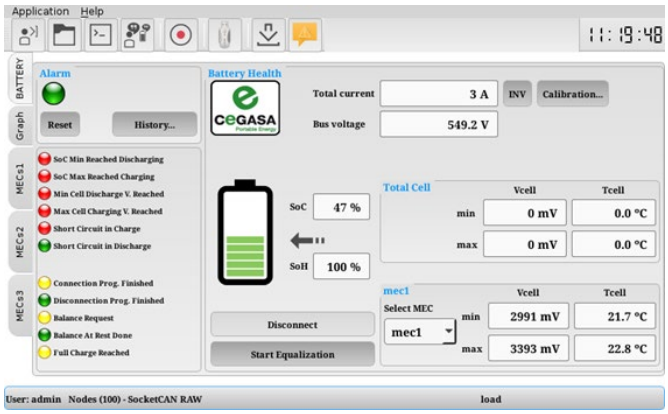
8. Data display

8.1 HMI display

The protection module has a built-in touch screen. This is used to display existing EMS data.

The HMI includes the following screens:

Main screen:



This is the screen displayed when the system is started. It provides a summary of the most significant battery data:

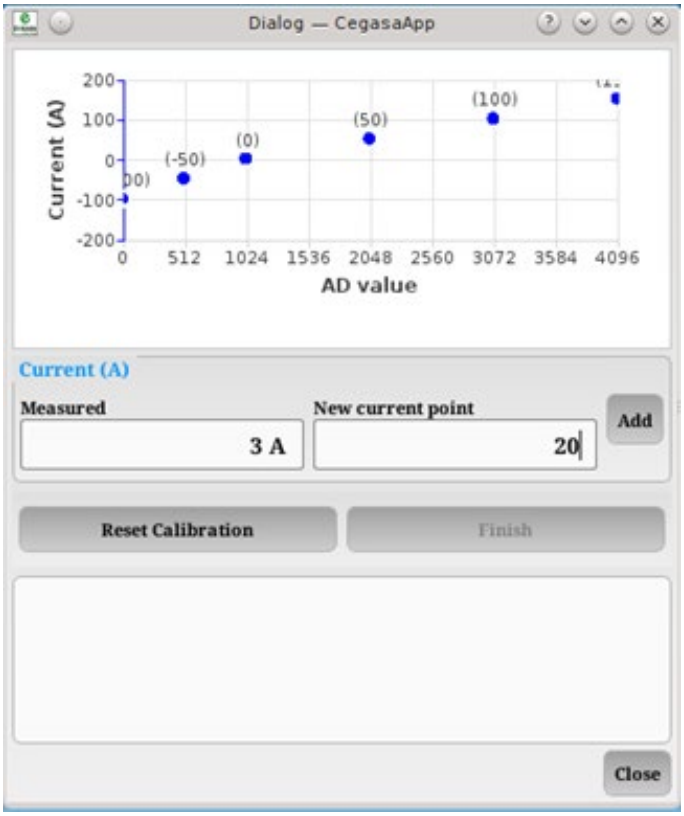
- State of Charge
- State of Health
- Current value in the system
- Cabinet's Voltage
- Minimum and maximum voltages and temperatures in the cabinet and per module
- Battery status (charging, discharging, balancing, on idle...)
- Alarms and flags

Likewise, this screen can be used to issue commands to connect and disconnect the contactor, equalise the battery or reverse the direction of the current if the current transformer has been connected the wrong way.

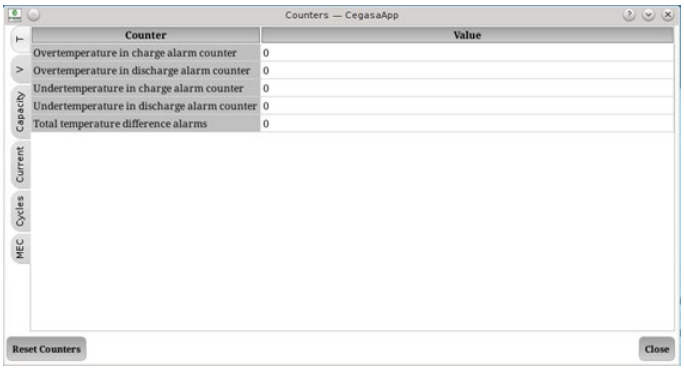
It is also possible to access log and calibration sub-screens from this screen.

Calibration sub-menu:

Due to the fact that the current transformer has a tolerance, the software-controlled option to correct its measurement errors has been implemented. The calibration screen shows the sys- tem's latest calibration, as well as options to delete or change it. Consult Selectronic if necessary.



Log screen



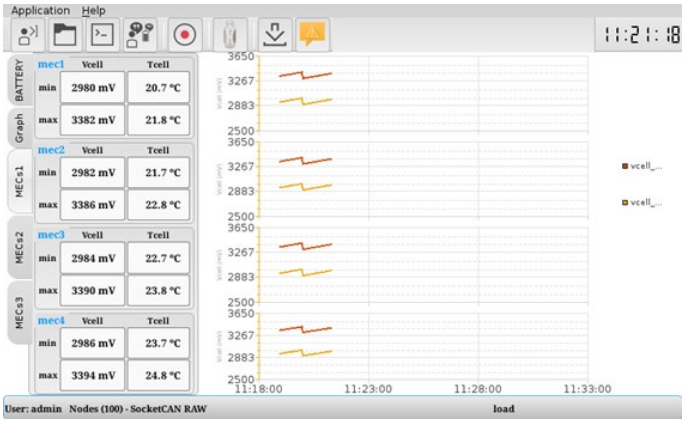
The counters included in the string can be consulted on these screens.

Among these are counters for alarms, trips, energy and cycles.

Graph screen

This screen displays the battery's most significant data in graph form, with values for the last 15 minutes.

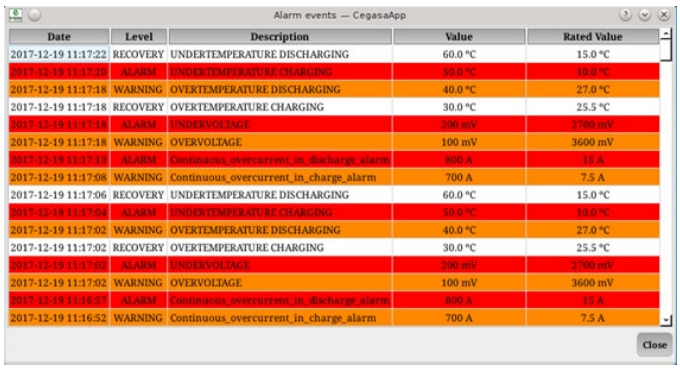
MEC screen



These screens make it possible to view maximum/minimum serial voltage and maximum/minimum temperature data separated by battery module.

Each screen stores the data for 4 battery modules and MEC tabs appear on the left side of the screen, based on the mod- ules in the string.

Alarms and events screen



This screen is accessible from any of the previous screens.

To open it, click the alarm icon on the top ribbon menu.

This screen makes it is possible to view all the events generated within the string chronologically, for subsequent use or failure analysis.

It shows the type of event that has occurred (alarm, trip, command ...), if it has been activated/deactivated, the time it occurred, and the value at which this change occurred, whether a relevant value associated with the event exists.

8.2 Remote display

There is an option for remote reading of the EMS data.

To access these data, a PC can be connected through the CAN communications connector, found on the PCC protection module. An is CAN adapter is used on the connector's output to provide a USB input for the PC.

This software shows the same screens that are available on the raspberry display. If required, Selectronic provides this software

Direct access to the CAN adapter drivers

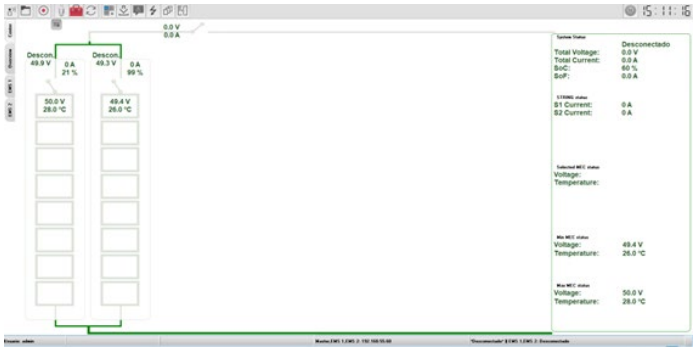
Note: In CAN communication there can only be one manager, consequently, if the external output is used to display data on a PC, then the EMS will not be able to communicate with the converter via CAN.

8.3 Manager Screen

The manager PCM/PCC has the following functions:

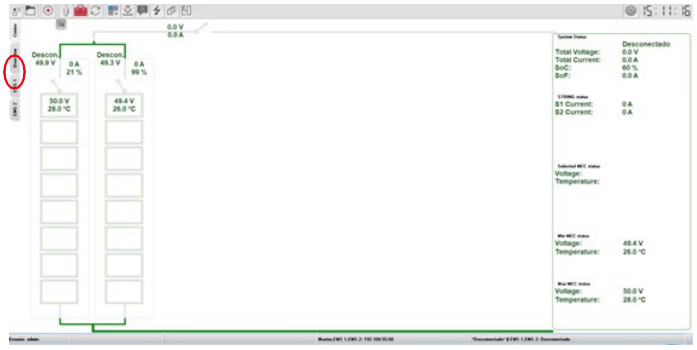
- Communication with the strings' PCM and the inverter's EMS
- Information about all the Workers
- Control the whole battery system
- Update firmware of all PCMs
- Control the main contactor and the contactor for each PCM chain.

The following image shows the main window displayed when starting up a 2- Worker system:

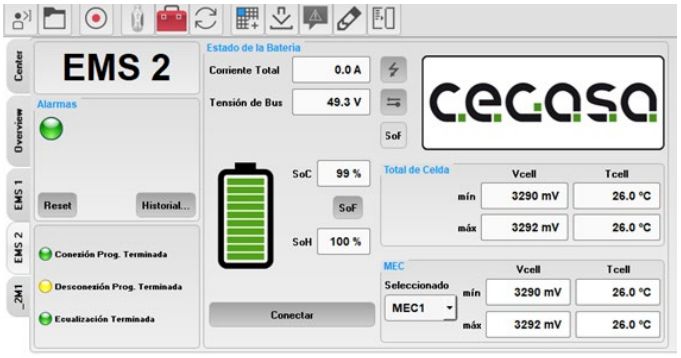


This shows that all contactors are in the open state. Here we can see system information such as the voltage of each Worker; the voltage of each battery module; the capacity of each module; the status and voltage of each battery Worker.

From here, we can access the window for each PCM string, which provides extra information. To do this, click on the tabs on the left side:



And now we have access to the EMS's first PCM:

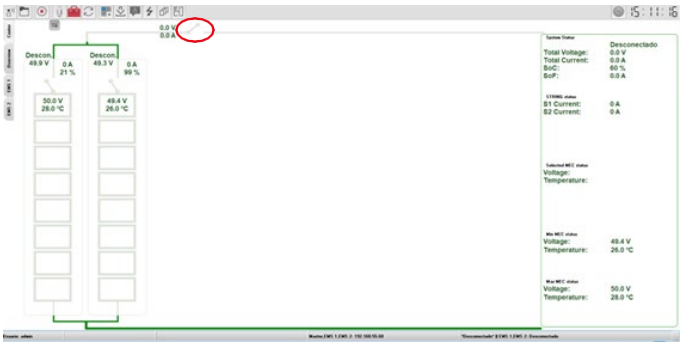


We can access the rest of the Worker s in a similar

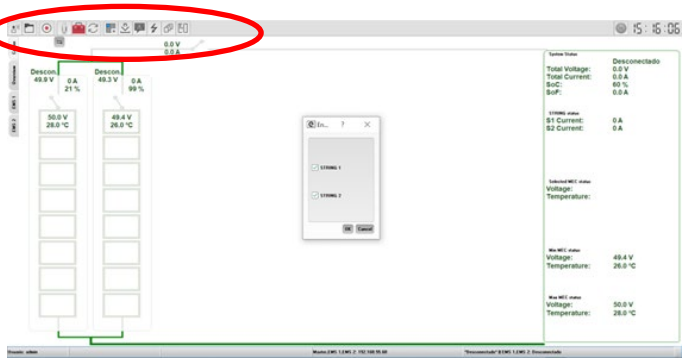
8.3.1 Contactor switching

The manager SCADA can be used to control the operation of the contactors, both the main contactor and the contactors for each Worker. We can activate the main contactor using the manager SCADA.

We select the Workers that we wish to connect, all are selected by default.

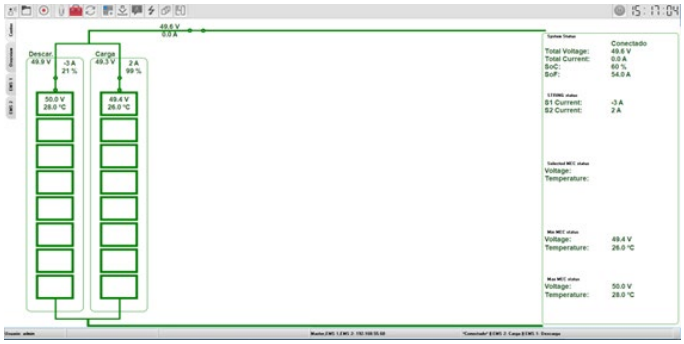


The SCADA will ask which of the Workers should close the contactor. Via the Menu icons. select the PCC Worker's and connect each Worker individually.



The contactors for each group will close, assuming closing conditions are met and Worker shutdown is safe. If a string does meet conditions and cannot be closed, then the manager will try to close the next one. When the Worker contactor closing operation has finished, the main contactor will close.

When a string contactor is closed, the Worker will appear green. The following image shows all contactors in the closed



To open all the contactors, click on the icon for the main contactor. It is also possible to open only selected Workers. To do this, click on the icon of the three squares. Now select the string that you want to disconnect and press OK.

8.3.2 Reset strings

If a string goes into error status, the contactor for this string will open while the rest of the system continues to operate. If the cause of the error disappears, then the affected Worker will try to reset itself, assuming the voltage conditions are met. If, after being reconnected, the error is repeated 3 times in less than 15 minutes, then the string will stop attempting to reset itself and remain in stand-by until manually reset.

The way to reset the Worker manually is explained

- Charge the connected strings up to 100% of their capacity.
- Then disconnect all strings, and connect the Worker that has to be reset.
- Charge this string up to 100% of its capacity.
- Connect all the Workers

Once all of Workers are reconnected, the system can be fully operational again.

N.B. refer to section 11.8 Commissioning

9 Communications

9.1 Introduction

The PCC is capable of external communications for data exchange and system control.

This is available for both CAN and Modbus TCP protocols

9.2 CAN protocol

This protocol, designed for the automotive industry, has as a characteristic immunity to noise and the capacity to detect errors and faults in the communications channel.

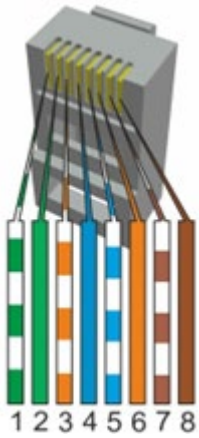
This network is physically connected to the EMS, consequently making all the data generated in the EMS available, as well as the data received by the EMS from each of the BMS. This EMS network acts as a Worker, so it never sends data through the communications channel unless they are externally demanded by a manager on this network.

In order for a SCADA or converter to communicate with the string, both the data transmission speed and the unique identifier of the equipment are required. The ID for the SMB is fixed, namely node 2. The established communication speed is 500 kBd. The EMS has certain IDs reserved for communication and other restricted ones. The manager that wants to communicate with the cabinet has to have its ID set to one of the values between 101 and 106, inclusive.

Between these two extremes, communication is made by means of SDOs (service data objects), i.e., each time the SCADA or converter requests information, it will ask the EMS for the specific data, pointing to the address of its object dictionary, according to a SYNC request.

An RJ45 connector is available for external communication.

The standard pinout for the connection cable is shown below. If needed, this pinout can be altered. Please consult Selectronic.



Inverter	PIN	Signal
SMA	4	CAN_H
	5	CAN_L
	2	CAN_GND
Victron	7	CAN_H
	8	CAN_L
	3	CAN_GND
Selectronic	1	CAN_H
	2	CAN_L
	3	CAN_GND

If necessary, ask Selectronic for the CAN bus output communications protocol

9.3 Modbus protocol

The Modbus protocol is an open protocol developed for industrial use. The SelectCell uses its TCP version. This type of communication is client server, with the EMS being the data

To start communication in this mode, the IP address, netmask and gateway parameters have to be configured, which will have to be done by the network administrator to adapt them to the system where it is going to be integrated. To facilitate integration, all data will be sent as a Holding Register, regardless of its format. The Modbus map (ask Selectronic if needed) indicates how each of the addresses should be interpreted, as well as the information they contain.

There is an RJ45 connector at the back of the PCM or the side of the PCC for communication via Modbus. Use of a CAT5e cable, or superior, is recommended for the connection, with a maximum theoretical length of 100m.

9.4 Type of data

The data to be shared between the string and the external control are divided into four categories:

- **Commands:** Inverter commands that make changes to the state of the string
- **Configuration values:** Variables that describe the installed system.
- **Present values:** Analogue or digital variables that describe the present state of the system. These include the SoC, current readings or alarm notifications.
- **Counters and logs:** Variables that record what happened in the string during its operation.

10. Installation requirements and recommendations

Applicable regulations

Where batteries are installed in parallel, the recommendation is for all DC cable lengths to be equi-distant between all batteries and PCC's.

Further, where multiple PCC Workers are installed, DC cable lengths between Manager and Worker PCCs are recommended to be equi-distant.

Do not connect a single battery or series 144V battery string to any sized PCC. The minimum battery quantity is:

- 48V system, 3x 48V batteries in parallel MINIMUM.
- 144V system, 3x 144V battery strings in parallel MINIMUM.
- 40kWh system, NOTE: a PCM is required for a single 144V battery string.

50mm2 DC cabling installed between batteries and PCC/M must be specified X90 or better, where the cable is supplied by the installer.

Given below are the standards applied to this type of system.

Requirements for Electrical installation

Battery terminals are live – DO NOT TOUCH.
DO NOT BREAK UNDER LOAD.

If the equipment is going to be connected to a converter, then the set consisting of the string and converter will be connected to the electrical installation as receiver and generator. This set shall comply with the requirements related to both these functions.

If used in a network, it shall be considered as a network generator, with no voltage limits.

The electrical installation set shall comply with the requirements refer to AS5139 and local jurisdiction.

The installer / designer is responsible to establish the technical conditions and safeguards that have to be met by electrical installations connected to a supply source within low voltage limits, in order to:

- Protect the safety of people and property.
- Ensure the normal operation of said installations and r prevent disturbance occurring in other installations and/ or services.
- Contribute to the technical reliability and economic efficiency of the installations.

10.1.2 Requirements for Battery Installations

Standard Safety requirements for secondary batteries and battery installations. Stationary batteries, containing requirements for safety aspects associated with assembly, use, inspection, maintenance and disposal.

The standard AS/NZS 5139 deals with Lithium-ion batteries.

Below is a summary of the most important considerations of the said standard.

It describes key measures to protect against hazards arising from:

- Electricity
- Gas emissions
- Electrolyte, in cells used in this String
- Protection against electric shock
- Protection against direct contact

Batteries with a rated voltage greater than 60V in direct current shall be located in closed places with restricted access. Doors on battery rooms are considered obstacles and shall therefore be marked with signs according to section 12.1 ("Dangerous voltage", "Fire, naked flames, smoking prohibited" and "Accumulator battery room").

If protection is applied by means of barriers or enclosure, the degree of protection shall be at least EN 60529 IP2X (Protection against solid objects > 12 mm, water untested). This shall ensure protection against indirect contact.

Protection shall also be available through automatic disconnection of the supply, disconnection and isolation. Likewise, the battery installation shall have devices for disconnecting all lines for input and output circuits and earth connection potential.

Short-circuit prevention and protection against other effects of electric current

Apart from electric shock, current in battery systems may cause other hazards. This is due to the possible existence of a high current flow due to a fault, but it is not possible to remove the voltage from the battery terminals. Points to consider in this section: short-circuits, protection measures during maintenance, leakage currents.

Provisions against electrolyte hazards

This type of cell does not contain electrolyte that can be spilled, it is absorbed by the separator paper. Should it be suspected that it may be possible to come into contact with it, then the following safeguards should be used:

- Protective glasses or masks for the eyes and face.
- Protective gloves

In case of contact with eyes, rinse immediately with plenty of water for at least 15 minutes and seek immediate medical attention.

In case of contact with skin, the affected area should be washed with plenty of water or neutralising aqueous solutions such as soapy water. If skin irritation persists, medical attention should be sought.

The cells shall only be handled by Selectronic personnel.

Housing – Cover

The batteries should be covered and in protected places. If necessary, electrical protection and even restricted access should be implemented.

The following types of housing may be used:

- Special rooms for batteries.
- Specifically separated areas with electrical protection.
- Strings or enclosures inside or outside the buildings.
- Battery compartments inside the devices.

The following factors should be taken into account when selecting the housing:

- Protection against external hazards (fire, water, shock, vibration ...)
- Protection against battery-related hazards (high voltage, explosion hazards, electrolyte hazards ...)
- Protection against unauthorized access.
- Protection against extreme environmental influences (temperature, humidity, air pollution ...)

Working on or near batteries

To accommodate inspection, maintenance and loading of elements, an adequate workspace is required. A free passage at least 600mm wide shall be maintained at all times to allow emergency evacuation.

Any work on the batteries or within the safety distance for welding, drilling or similar tools shall only be performed by personnel who have been advised about the possible hazards. Before beginning work, disconnect the battery and any flammable fumes or gases from the batteries should be removed

FIRE REGULATIONS

These shall comply with local Jurisdiction Regulation of fire safety in industrial establishments.

The purpose of this regulation is to establish and define the requirements and conditions that establishments and installations for industrial use shall meet in order to ensure safety in the event of a fire, prevent this from occurring, respond appropriately should it occur, limit its spread and enable its suppression in order to cancel or reduce the damage or loss that the fire may cause to people or property.

Fire prevention activities shall seek to limit the presence of fire hazards and the circumstances that may cause a fire. Fire response activities shall seek to control or fight the fire in order to extinguish it and minimise any damage or loss that may occur.

This regulation shall be applied as a complementary measure to the fire protection measures established in current regulations that regulate industrial, sectoral and/or specific activities, for aspects not foreseen in the latter, which shall be fully implemented.

REGULATIONS FOR USE AND MAINTENANCE

Only authorised representatives shall perform maintenance on SelectCell batteries.

10.2 Environmental requirements

Parameters	Technical specification	Comments
Operating Temperature Range during CHARGE (ºC)	0ºC ~ + 45ºC	
Operating Temperature Range during DISCHARGE (ºC)	-20ºC ~ + 45ºC	
Humidity (RH%)	5%≤RH≤85%	

10.3 Maintenance and storage procedure

The customer is responsible for complying with this procedure:

- Each month, check the voltage (within the range of the battery) and the visual state of the casing (no bumps, swelling or discolouration) and the positive and negative terminals of the power connector (free of oxidation).
- If the battery is to be left off, then it has to be charged every 3 months up to 40 - 60% SoC.
- A full charge is recommended every 10-15 days to update SoC and maintain measurement performance.
- Storage recommendations
- Do not expose to direct sunlight or rainfall

Parameters	Technical specification	Comments
RECOMMENDED STORAGE SOC (%))	40-60%	
STORAGE TEMPERATURE RANGE (ºC)	-20ºC ~ + 45ºC	
RECOMMENDED STORAGE TEMPERATURE RANGE (ºC)	15ºC ~ + 25ºC	
Humidity (RH%)	5% ≤RH≤85%	

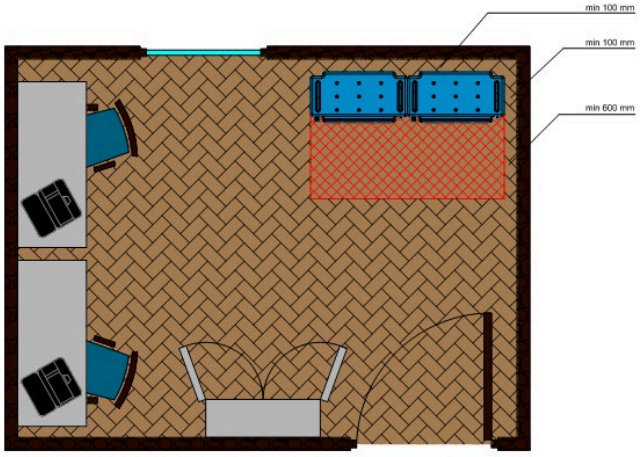
10.4 Layout

Place the equipment in a flat area that can support the specified weight.

With regard to accessing the equipment:

- **Front access** 600 mm
- **Side and rear access** At least 100mm for air circulation
- Each battery module weighs approximately 105 kg. It should not be moved without tools or machinery that guarantee safe transportation.

  When installing, the pallet containing the battery modules shall be positioned as close as possible to the final installation point. From this point up to the installation area, the path shall be level, without steep slopes, steps or any other situation that makes it impossible to transport the equipment safely.



11. Installation

Caution: ***Given that the modules are supplied with electrical charge levels necessary to maintain the chemical properties of the batteries, the entire installation process shall performed with the recommended protection equipment.***

After completion of installation, battery system is recommended to reach 100% SoC before commencing normal operation and cycling.

11.1 Electrical and component verification

Follow these steps prior to installing the system:

a. Measure DC voltage between the positive and negative terminals on each battery module (points 1 & 2). Check that polarity is correct and that the voltage is within range (≈ 48VDC)

b. Check that the modules have not been damaged during shipment and that the cover is not open or dented.

11.2 Steps to follow

Each battery module and PCM/PCC are pre-wired, pre-set and factory tested.

After receiving and unpacking the system, the installer should find that each string contains:

- 1 PCM / PCC
- Various SelectCell Ultimate 280
- Battery modules, One or several base frames
- A set of fastening plates
- A set of communication cables (*)
- A set of connector kits and power cables

(*) Should the project have more than 4 modules, these have to be distributed in several columns. The wiring between columns will be done using these cables.

11.3 Different possible configurations

Thanks to the modular design of the SelectCell, the system can be installed according to spatial needs. Accordingly, the batteries can be installed in the following ways:

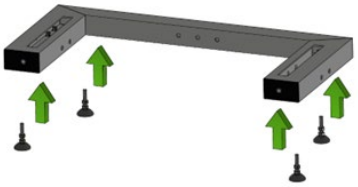
1. Stack up to 4 high

2. Place several batteries in a row

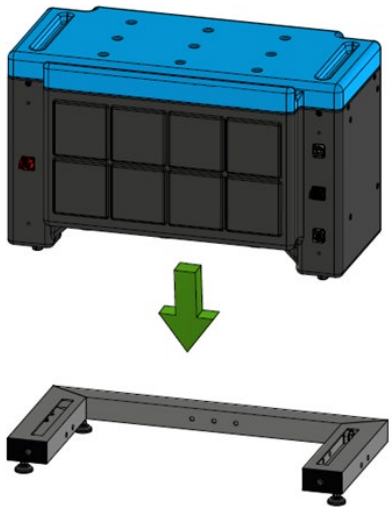
3. Place back to back

11.4 SelectCell Installation

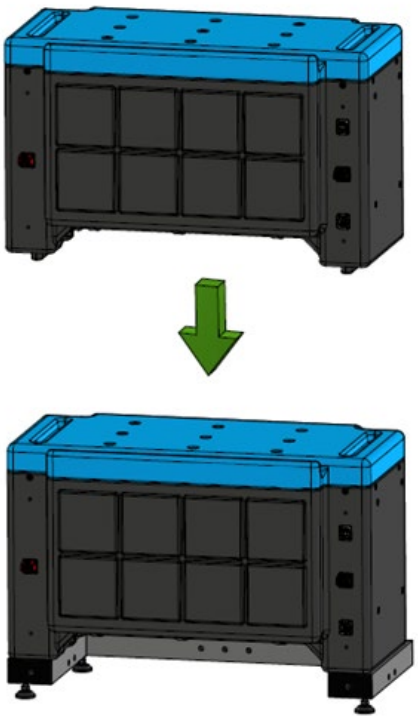
1. First place the base frame on the floor and use the feet to level it. If required, secure the string to the floor, the base frame has a space where brackets can be fitted. The SelectCell system is designed to be stationary, with no possibility of movement and with its weight distributed evenly.



2. Stand the first SelectCell module on the base frame that is al- ready level and fixed to the floor. Any module can be inserted in any order in the string, without affecting power or communications.

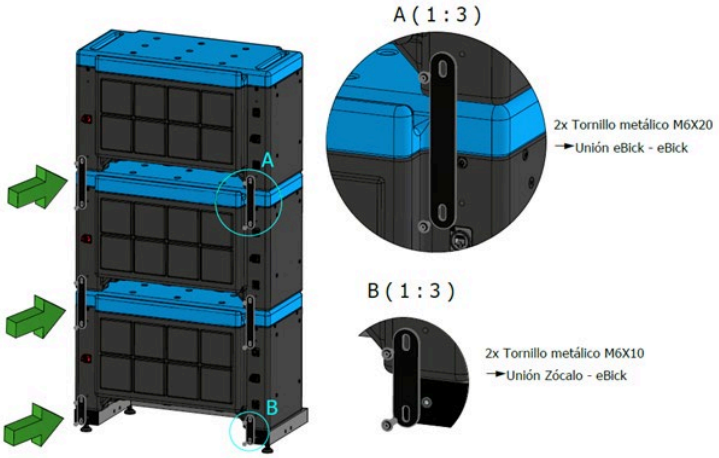


3. Stack the rest of SelectCell modules up to a maximum of 4 high. Without connecting the power or communications.



4. Use the fastening plates to fasten all the SelectCell modules to each other, to the base frame.

Note: Screw length is different when fastening the PCM (see picture below)

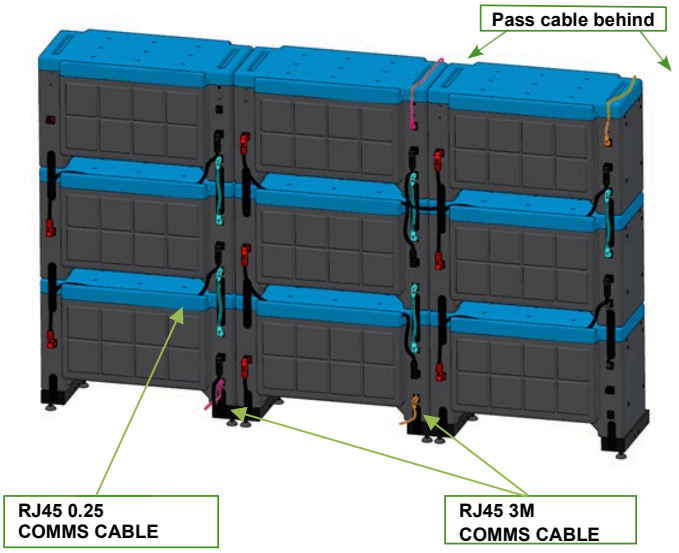


11.5 Communication connections

11.5.1 Connections between batteries

Starting with the battery closest to the PCC or PCM, use the RJ45 MALE communications connectors on the right side to connect communications between modules.

Back-wall system



The RJ45 communication cables are ALWAYS connected between towers from the bottom connector (bottom module in the tower) to the top connector (top module in the tower) using the 3 METRE long Comms cable RJ45

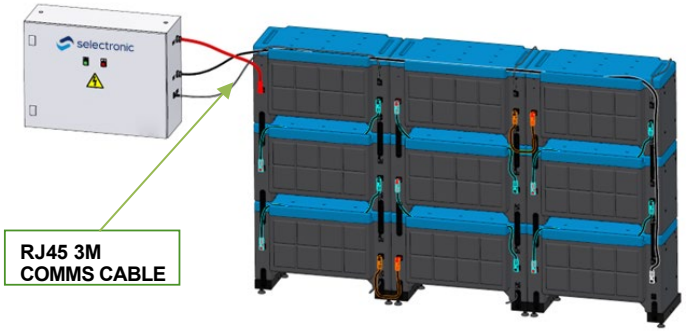
NEVER BETWEEN BOTTOM MODULES.

Back - back system

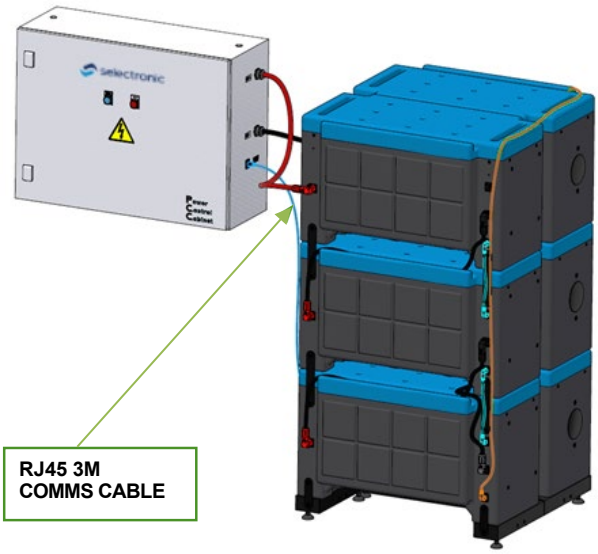
11.5.2 Battery connections with PCC or PCM

Having interconnected all the batteries by following point 11.5.1, the communications connection can be made between the module whose upper RJ45 is free and the PCC or PCM (depending on the project).

PCC connection on wall-back system



PCC connection on back-back system



PCM connection on back-wall system

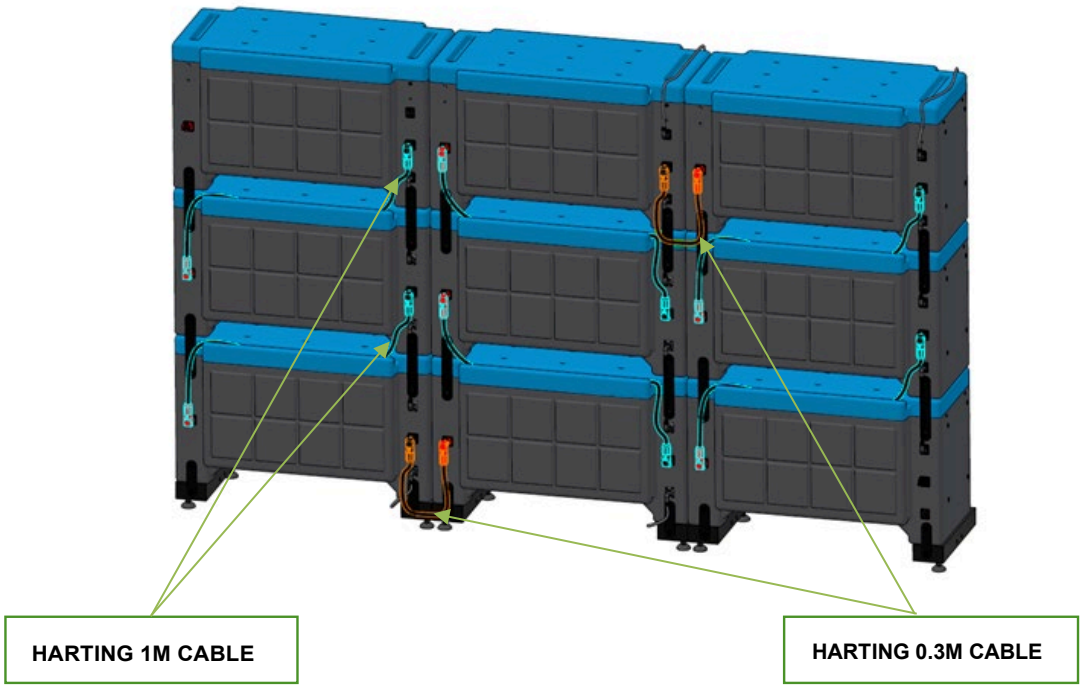
PCM connection on back-back system

11.6 Power connection

Power connections between batteries

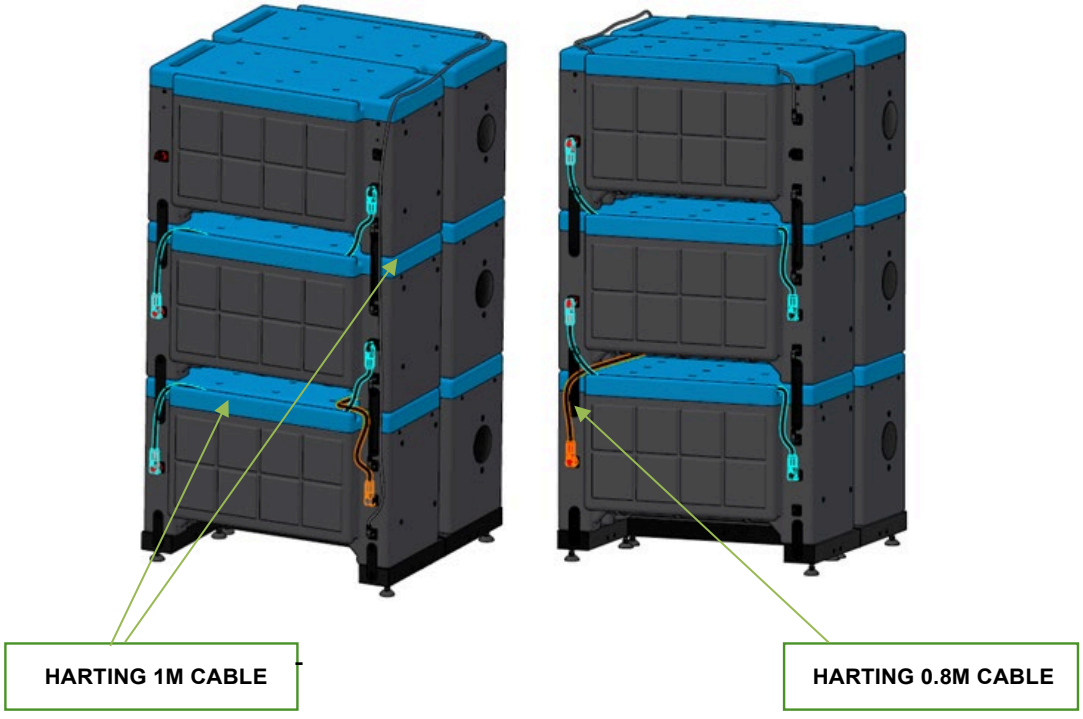
- Be sure to use PPE (protective gloves and safety glasses)
- Without connecting to the PCC (leave that till last), connect all the power connectors between the columns;
- **IMPORTANT respect cable polarity with the modules**
- **IMPORTANT: NEVER connect a module's two poles (POSITIVE-NEGATIVE) with cable. Short-circuit hazard.**

Connection between modules in back-wall installation



*N.B. modules can be connector vertically or horizontally.

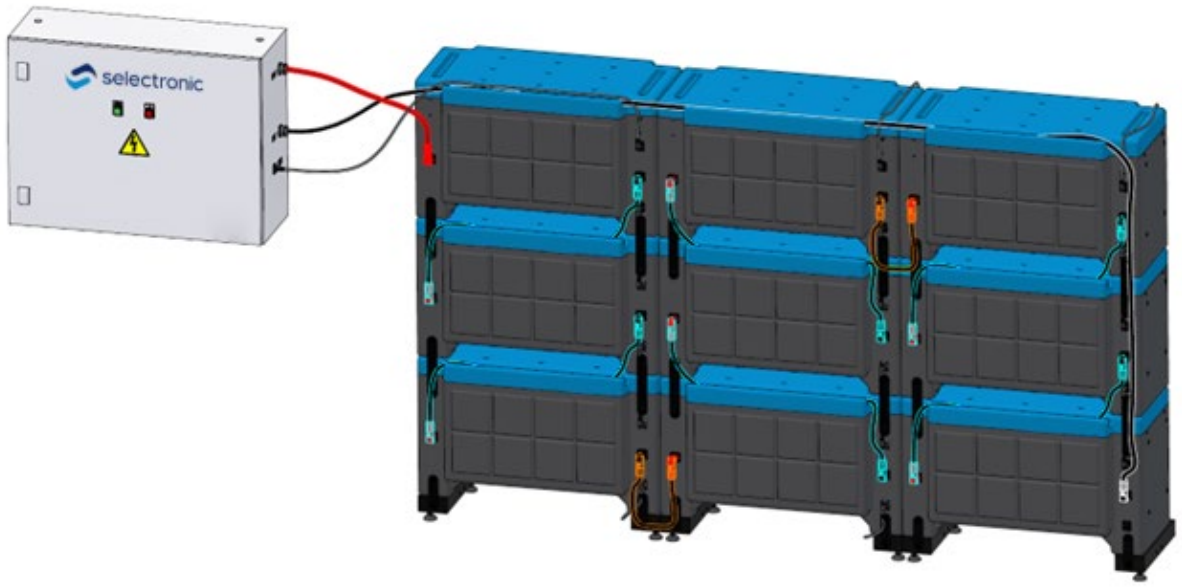
PCM connection on back-back system



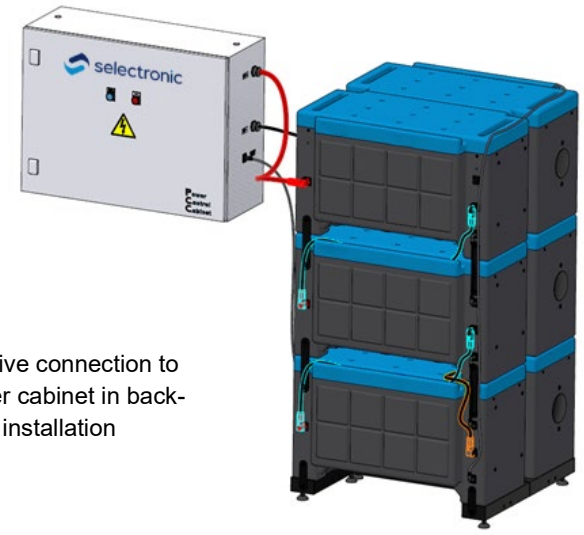
11.6.2 Battery connections with PCC or PCM

- Be sure to use PPE (protective gloves and safety glasses)
- First use the SelectCell Ultimate 280 Series CONNECTOR INSTALLATION KIT to prepare the necessary length of cable between the cabinet and the battery's negative and positive poles. Cable characteristics for nominal current of 200A.
- It is important to respect the polarity when connecting to the PCC cabinet's power busbar.
- Before connecting, check there is NO continuity on the PCC cabinet's positive and negative busbar poles.
- First connect the connection to the PCC cabinet's busbar at a torque of 15Nm and then use the HARTING connectors to connect to the system's positive and negative poles.

Connection between modules in back-wall installation



PCC connection on back-back system



Positive connection to power cabinet in back-back installation

Negative connection to power cabinet in back-back installation

PCC connection on back-back system

PCM connection on back-back system

Once the cables have been fitted and their routes defined, tighten the four screws on each cable gland to secure the said cable in the desired position.

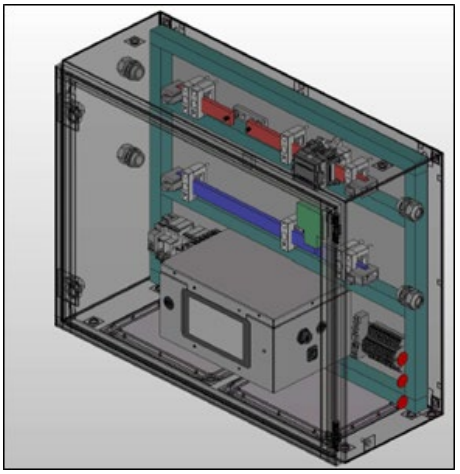
Tighten the 4 screws of each of the bushings to prevent them from turning.

Grounding

There is a ground screw on the PCC. This screw is used to eliminate any electrical noise that may affect the electronics. A cable with a cross-section of between 1 mm2 and 2.5 mm2 has to be connected this M5 screw.

External wiring

On the left side of the PCC cabinet there is an output busbar to make the mechanical connection with cable (nominal current 200A) at a tightening torque of 15Nm.



11.7 Manager / Worker Systems

In Manager/Worker systems, the different strings are connected in parallel in the Manager cabinet or module. In the case of the PCM Manager, only the Modbus communications of each system are centralised. However, with the PCC Manager, in addition to communications, the power for each string is also in parallel.

It is possible to set up different configurations using the different references available. These systems are sized by Selectronic's project department.

Notes:

Notes:

11.8 Commissioning

External communications

There are 2 RJ45 connectors at the back of the PCM.

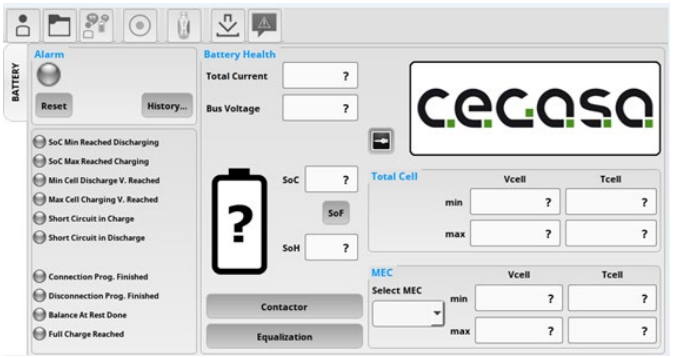
The Modbus/TCP connection is made using a standard CAT5e cable (maximum length < 100m).

The CAN connection is made using a SERIAL Ethernet cable. The pinout for this is described in section 9.2. To ensure correct communication, the cable should be less than 10m long.

ID configuration

Once the batteries have been installed and the power and communication cables have been connected, the PCM/C can be turned on using the ON/OFF switch. During the initial start-up, the layout of the modules' serial numbers has to be configured.

Once the DCM/C has started, it displays all read values as "?" until distribution of battery modules is configured.



The first step in this process is to log in to the system as an administrator.

The default user is ***admin*** and the default password is ***cegasa***.

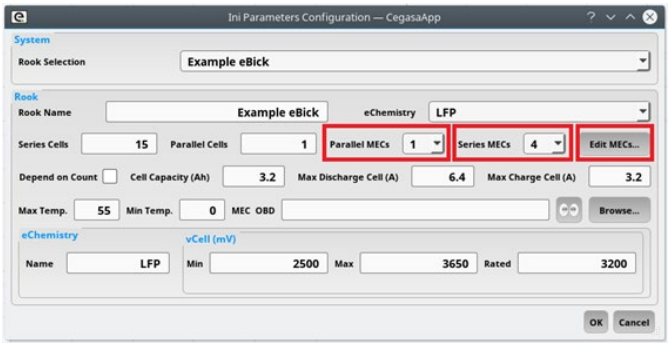
Please contact your administrator if the access data have been changed.

Having accessed the system, the ini file has to be changed.

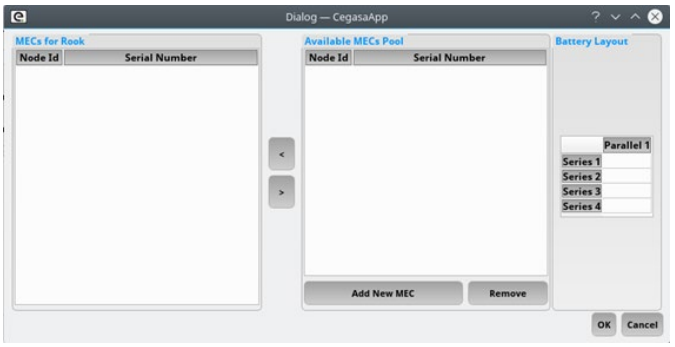
In the dialogue box enter the number of modules in series and parallel

In this example there are 4 modules to connect in series (final bus voltage of 200Vdc) and only one string to connect on the system (1 parallel)

Once the number of modules has been configured, the IDs have to be configured on the "Edit MECs" screen.



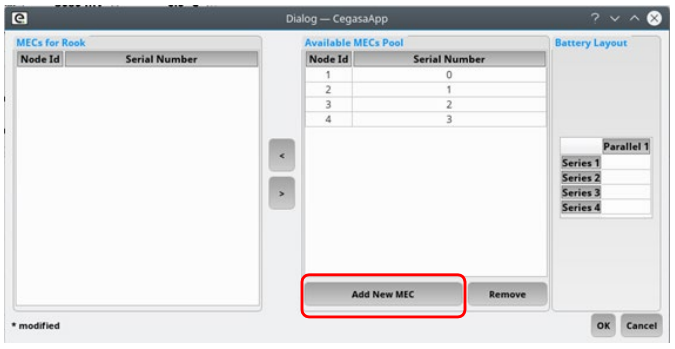
The following screen displays what is seen during the initial start-up.



The battery layout table on the right shows the series and parallel configuration that has been defined in the previous screen.

The software does not show any of the modules during the initial start-up. They have to be configured manually.

To do this, click on the "Add New MEC" button as many times as there are battery modules. In this particular example, 4 times.

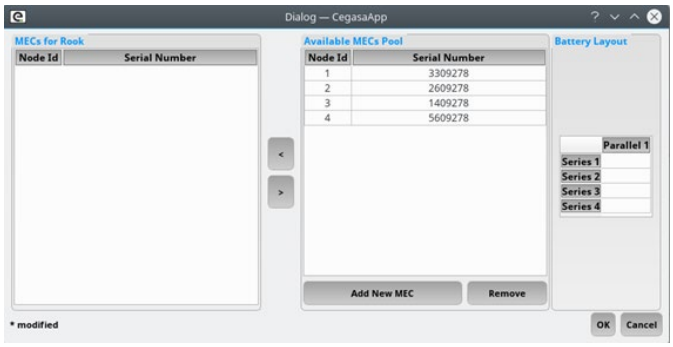


After clicking the button, the software generates battery modules that can then be configured, and these appear inside the "Available MECs Pool" table. As they have not yet been configured, they appear with the default values.

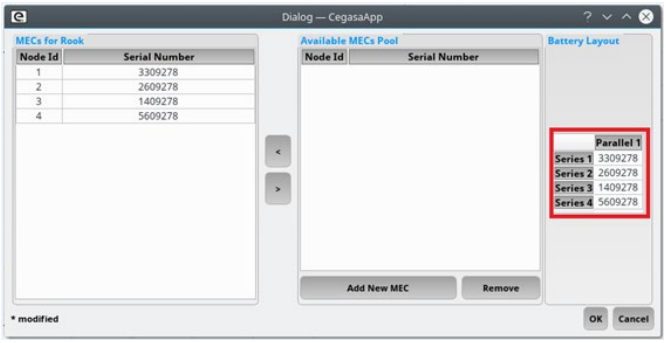
To change the serial and/or ID number, just click on the one that needs changing and an on-screen keyboard will appear so that the new number can be entered. It is a matter of calling the modules the same as their ID, serial number = Node ID

Upon initial connection, the PCC Workers will display a default SoC value (e.g. 25% or 100%). The system must be charged to 100% SoC upon initial operation, for each PCC Worker.

Once the serial numbers have been changed to reflect the ones that had been written down, select the first one and click on the “<” arrow to pass it over to the “MECs for Rook” table. Do the same with the rest of the modules, following the ID numbers.

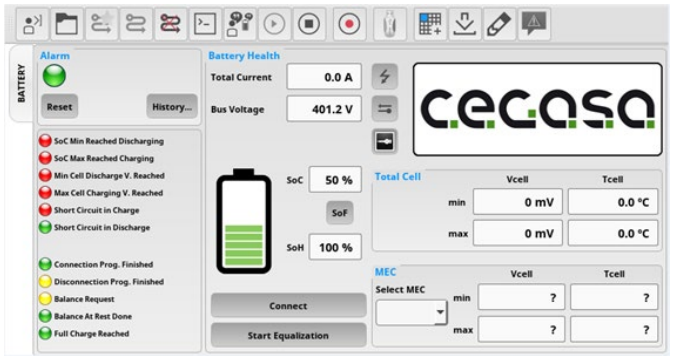


The screen now shows a layout that matches its physical counterpart.



After accepting the changes on both pop-up screens, a warning appears, stating that changes have occurred and requesting permission to restart.

After restarting, the display shows the battery values. The installation is now completed.



Notes:

12. Transportation requirements and recommendations

- The battery modules contain hazardous substances classified as class 9 in the ADR 2013 document, identified by the number UN3480.

-Their shipment requires:

- Modules to be sent in packing group 1, with approved boxes. It is advisable to keep the original shipping boxes.
- Transportation with ADR authorisation to move this type of substances.

13. Maintenance plan

There are three types of maintenance within the maintenance plan, depending on the personnel and the type of incident that may occur.

The tasks mentioned in this plan are the minimum considered essential for maintaining the equipment during the proposed warranty period. All of these have to be included in the final maintenance programme.

Listed below is the maintenance schedule necessary for installing the storage system.

13.1 Predictive maintenance

Proposed Level I maintenance to be performed by the customer's own personnel. The training required to carry out all the actions mentioned below shall be provided.

The proposed incidents that can be addressed at Level I all focus on analysis and simple resolution, they do not include scheduled maintenance, analysis, or complex fault-finding tasks. These last two types of intervention shall be detailed further below.

The proposed Level I maintenance includes the following types of work:

13.1.1 Verifying voltages, warnings and alarms

IMPORTANT: It is necessary to perform this section on installations where the string is not operational for prolonged periods.

Objective: Every three months, use a PC, external CAN or HMI to monitor the voltage values (Vcellmin - Vcellmax) of each module, if the value of Vcell min is equal to or less than 3200 mV charge the string up to the desired energy value.

Check the rest of values, events and alarms to make sure that the equipment is operating correctly.

13.2 Preventive maintenance

To guarantee the useful life of the storage system, it is necessary to carry out preventive maintenance tasks on a regu- lar basis. Preventive maintenance makes it possible to detect repeated faults, reduce dead spots due to stops, increase the equipment's useful life, reduce repair costs and detect weak points in the installation, among a long list of other advantages.

This work may be carried out by the customer's personnel or Selectronic, depending on the maintenance schedule and the corresponding training plan. If performed by the customer's personnel, these shall have to be trained and authorized by Selectronic To maximise the life of the system, **annual intervention** including the tasks listed below is proposed, however, the preventive maintenance plan may be coordinated based on the customer's needs.

To guarantee the operation of the storage system, it is necessary to comply with the proposed preventive maintenance, frequency and interventions.

13.2.1 Preventative maintenance schedule

This section lists the main maintenance tasks that should be carried out on each of the main components, however, they are merely indicative. The maintenance ranges (personnel necessary, personnel profile, tools needed and description of the maintenance to be done) are detailed further below.

DESCRIPTION OF THE TASK (monthly)	
01.	Charge the battery at least once a month (SoC> 80%) This point is necessary to comply with warranty requirements.

DESCRIPTION OF THE TASK (yearly)	
01.	Check the general state of the modules (appearance, leaks, etc.)
02.	Check the electrical resistance of each of the battery modules
03.	Check for rust and/or blackening due to arc flash on the PCC's output terminals. If present, clean with a wire brush.
04.	Check the tightening torque of the PCC's output terminals
05.	Visually inspect the condition of the communication cables
06.	Use HMI to check that all modules are communicating with the EMS
07.	Test mechanical elements (contactors, repeating relays)
08.	Check EMS and BMS inputs and outputs
09.	Check the calibration and reading of voltage and current sensors. Collect data for events and alarms and analyse them.
10.	Register of internal counters to detect one-off and recurrent faults. Correction of these faults.
11.	Controlled and recorded charge and discharge. Charge and discharge the battery to points defined for correcting the SoC, according to point 13.2.2, measure string ageing (SoH) and assess the battery's remaining useful life.
12.	Check the string for hot spots using a thermographic camera.

13.3 Corrective maintenance

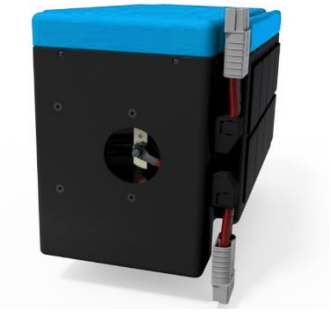
Should planned replacement of any component be required, a joint action plan can be agreed between Selectronic and the customer. Planning sufficiently in advance to organise the availability of the installation as well as the necessary Selectronic personnel and equipment would be required.

Should the module's single-pole fuse need to be changed, then proceed as follows:

Prior to conducting any preventive and/or corrective maintenance, Lockout-tagout of machines and installations (L.O.T.O) shall be observed. – SECTION 2.7

1. Reference of fuse to be changed:
   576-155.0892.6301

   https://www.littelfuse.com/products/fuses/automotive-passenger-car/high-current-fuses/cf8/155_0892_6171.aspx
2. Use a Phillips head driver to unscrew the module's left-hand fuse cover.
3. Check that there is NO continuity between positive and negative on the fuse to verify that it has blown.
4. Use an insulated spanner to remove the fuse, putting the fasteners to one side.
5. Insert the new fuse, refit the fasteners and tighten to a torque of 12Nm



13.4 Maintenance requirements

The following table shows a summary of the needs for the different maintenance work, such as the tools, operator profile and time required:

PREDICTIVE MAINTENANCE (Customer personnel)			
TOOLS NEEDED		OPERATOR PROFILE	FREQUENCY
01.	Multimeter	2 operators from the Selectronic commissioning department with knowledge of the installation and CAN communications. Assistance from a customer operator with knowledge of SCADA	Annual (8 hour workday)
02.	Current clamp		
03.	Torque wrench		
04.	Thermographic camera		
05.	Equipment's HMI or PC with CAN adapter to display and modify the battery status		

CORRECTIVE MAINTENANCE (Selectronic personnel)		
TOOLS NEEDED	OPERATOR PROFILE	FREQUENCY
Depending on the procedure	Depending on the procedure	Depending on the procedure

SelectCell Battery Data	
Electrical Characteristics	**Ultimate 120/144V - (3 batteries in series)**
Electrochemical	Lithium Iron Phosphate LFP
Cell type	Prismatic
Rated voltage per battery	144V DC
Maximum battery voltage	156.6V DC
Minimum battery voltage	126V DC
Battery capacity per string	40.3kWh
Maximum system capacity	3MWh
Rated continuous charge	20kW / 140A
Max continuous charge or discharge	25.3kW / 175A
Peak discharge 1-2mins	40.3kW / 200A
Communications	**Ultimate 120/144V - (3 batteries in series)**
Operation without comms to inverter	No
Communications type to inverter	CANbus
Individual string by string, and battery data	Yes
Data Communication to SP PRO	**Ultimate 120/144V - (3 batteries in series)**
Basic data set	No
Advanced data set and monitoring	Yes
Installation	**Ultimate 120/144V - (3 batteries in series)**
Operating temperature without derating	15°C to 30°C
Maximum operating temperature	-20°C to +55°C
Charging temperature range	0°C to 45°C
Max battery modules stacked vertically	4
Inter battery power connection	Harting plug
Inter battery communications connection	RJ45
Physical	**Ultimate 120/144V - (3 batteries in series)**
Dimensions w x d x h (mm)	762 x 405 x 448 +/- 2mm
Weight per battery	105kg
Protection	IP30
Product warranty	8 years
Performance warranty	60% of retained capacity after 10yrs or 35.6MWh per battery,

Power Control Cabinets (PCC) 120 - 144V DC systems						
	PCC144-300F	**PCC144-500F**	**PCC144S-500F**	**PCC144M-1000**	**PCC144M-1500**	**PCC144M-2000**
Configuration Type	Single	Single	Worker	Manager	Manager	Manager
Maximum DC Current Rating	300A	500A	500A	1000A	1500A	2000A
System redundancy	No	No	Yes with 2 or more Worker cabinets.			
BMS	Individual battery management system			Central battery management system		
DC Voltage range	100-162V					
No of battery string inputs	5	5	4	N/A	N/A	N//A
Max cable size for battery inputs	50mm2	50mm2	50mm2	N/A	N/A	N/A
Cable entry method	Cable Gland					
Battery Input fusing	200A			N/A	N/A	N/A
No of Worker cabinet Inputs	N/A			4	6	9
Max cable size of Worker inputs	N/A			185mm		
No. of Inverter outputs	3			6	9	12
Max cable size for Inverter outputs	120mm			120mm		
Inverter over current protection	500A			1000A	1500A	2000A
Inverter DC Isolator	No			No		
Battery Isolation device	No			Yes	No	No
Pre-charge Protection	Yes			N/A		
kWh Capacity	80kWh	120-200kWh	120-160kWh	120-640kWh	120-960kWh	120-1280kWh
Max Inverter kW Capacity	43kW	72kW	72kW	144kW	216kW	288kW
Dimensions HxWxD	1000 x 800 x 300			1200 x 800 x 300	1400 x 800 x 300	TBC
Weight	90kg			120kg	170kg	TBC
IP Rating	IP 21					
Mounting Options	Wall / Floor			Floor		
Warranty	2 years					

YEARS OF ENERGY STORAGE EXPERIENCE

Selectronic Australia, a leading brand in energy storage and management systems.

- Specialising in the design and development of energy solutions for residential and industrial sectors.
- Experts in the latest generation Lithium-Ion based energy accumulation technologies.
- Innovating battery solutions.
- A highly motivated and qualified team.
- A culture of quality and customer service.
- Research and Development characterisation laboratories.
- Australian owned, committed to innovation and sustainable development.
- Country of Origin, Vitoria-Spain. A European group of companies committed to innovation and sustainable development.

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