Battery Communication Interface

Version V1.3, January 2026



Technical User Manual

Battery Communication Interface (BCI)

Thank you for purchasing the Super B BCI. We are pleased that you have chosen Super B Lithium Power B.V.

Disclaimer of liability

This technical user manual provides detailed information necessary for the installation, use and maintenance of the BCI. This technical user manual is intended for use by both the installer and the end user of the Lithium Iron Phosphate (LFP) battery. Only qualified and certified personnel are authorized to install and perform maintenance on the LFP battery. During the use of the product, user safety should always be ensured, so installers, users, service personnel and third parties can safely use the LFP battery.

Copyright

Copyright© Super B All rights reserved. Licensed software products are owned by Super B or its subsidiaries or suppliers and are protected by national copyright laws and international treaty provisions. Super B products are covered by Dutch and foreign patents, issued and pending. Information in this publication supersedes that in all previously published material. Specifications and price change privileges reserved. Super B is a registered trademark.

Contact Information
Super B Lithium Power B.V.
Europalaan 202
7559 SC Hengelo (Ov.)
The Netherlands
Tel: +31(0)88 00 76 000
E-mail: info@super-b.com
Web: www.super-b.com

Table of content

1. General information 9

1.1 Safety guidelines 9

1.2 Stay Informed 9

1.3 Contacting Super B – Service & Support 10

1.4 Software Updates 11

1.5 Disposal 11

2. Introduction 13

2.1 Product description 13

2.2 Intended use 13

2.3 Limitations of use 14

2.4 Glossary of Terminology 14

2.5 Used symbols 15

3. Product specifications 16

3.1 Typical setup of the BCI 16

3.2 Product features 16

3.3 BCI functional behaviour 17

3.4 General 17

3.4.1 Power inputs and functionality 17

3.4.2 BCI States 19

3.4.3 Contactor behaviour 22

3.5 BCI control functions 23

3.5.1 Auto-on 23

3.5.2 SoC shutdown/Switch-OFF 23

3.5.3 Reset 24

4. General product specifications 25

4.1 Electrical specifications 25

4.2 Mechanical specifications 25

4.3 Compliance specifications 26

4.4 Environmental specifications 26

4.5 Scope of delivery 27

4.6 Connections, indicators, and controls 29

4.6.1 CAN connector pinout (Master/Slave) 30

4.6.2 J3 (I/O Connection 10) 30

4.6.3 J4 (I/O Connection 10) 31

4.6.4 Indicators 31

4.7 Peripheral equipment 32

5. Installation 34

5.1 General information 34

5.2 Unpacking 34

5.3 Required tools for installation 34

5.4 Placement of the BCI 34

5.5 Coin Cell 35

5.6 Wire sizes 35

5.7 Electrical installation 35

5.8 Electrical installation - BCI power from battery bank 36

5.8.1 Circuit description 37

5.9 Electrical installation - BCI externally powered 38

5.9.1 Circuit description 39

5.10 Manual control 40
5.11 Pre-charge selection 40
5.12 CANBus 43
5.12.1 General information 43
5.12.2 Connecting the CAN network cables 43
5.12.3 CAN Bus network topology 44
5.12.4 CAN Bus power 46
5.12.5 12 V systems with less than 16 batteries 47
5.12.6 Integrating CAN Protocol 47
5.13 Be in Charge Software and App 47
5.14 Monitoring and control with Be in Charge software 48
5.15 BCI in substring topology 49
5.15.1 Introduction and use 50
5.15.2 Communication wiring diagram using substring topology 50
5.15.3 Power and communication diagram in substring topology 51
5.15.4 Connecting the bank to the DC-BUS 52
5.15.5 Connecting the battery bank to the DC-BUS with use of Be in Charge 53
5.15.6 Connecting the battery bank to the DC-BUS by CANopen control 54
5.15.7 Configuring BCIs for substring topology 54
5.15.8 Set safe connection voltage difference 55
5.15.9 Redundancy 57
5.15.10 Connecting the bank to DC Bus with redundancy enabled 57
5.16 Resolve connection rejection 58
5.17 General purpose I/O 59
6. BCI use 60

6.1	General information	60
6.2	Configuring the BCI and the battery bank	60
6.3	Battery ID's	60
6.3.1	Battery ID renumbering procedure	61
6.3.2	Renumbering batteries for a new system using point-to-point connection	61
6.3.3	Replacing an LFP battery in an existing system	64
6.3.4	Renumbering batteries through the BCI	65
6.4	Battery layout	68
6.5	Input level configuration	69
6.6	BCI Modules	69
6.7	Monitoring and controlling the LFP battery bank	70
6.8	Pre-charge adjustment	70
6.9	General settings: Automatic control	71
6.10	General settings: State-of-charge switch-OFF level	72
6.11	Charge Current request compliance (I-request)	73
6.11.1	General settings: Minimum I-request	74
6.11.2	I-request Control Loop	75
6.11.3	Minimum I-request	76
6.11.4	I request soft-start ramp enabled	76
6.11.5	I-request soft-start ramp	76
6.11.6	I-request loop enabled	76
6.11.7	Proportional gain	77
6.11.8	Integral gain	77
6.11.9	Differential gain	77
6.11.10	Maximum integral step size	77

6.11.11 Critical overshoot detection threshold 77
6.11.12 Critical overshoot prevention offset 77
6.11.13 Maximum load compensation windup 77
6.11.14 Float voltage gain 77
6.11.15 Saving a configuration 77
6.12 Status and control 78
6.13 Status of the battery bank 79
6.14 Battery heating 82
6.14.1 Heater control buttons 83
6.14.2 Heating strategy: manual 84
6.14.3 Heating strategy: on-charger availability 84
6.14.4 Heating strategy: Min SoC (Thermostat function) 84
6.14.5 Heating strategy: without I-request compliant charger 85
6.14.6 Heating strategy: with I-request compliant charger 85
6.14.7 Heater module warning 85
6.15 Real Time clock (RTC) 86
7. Maintenance 88
7.1 General information 88
7.2 Inspection 88
7.3 Cleaning 88
7.4 Replacing the coin cell battery (BCI HW V1.7 and above) 88
8. Storage 91
9. Transportation 92
10. Disposal and recycling 93
10.1 WEEE 93

10.2 RoHS 93

11. Troubleshooting 94

12. Warranty and liability 96

13. References – Figures 97

14. References – Tables 99

1. General information

1.1 Safety guidelines

IMPORTANT!

- Read this technical user manual carefully before use.
- Retain the original product documentation for future reference.
- Treat the BCI as described in this technical user manual.
- Only use Super B LFP traction batteries with the BCI.
- The battery safety precautions as referred to in the Super B battery manual should always be observed.
- Understanding battery management systems, voltage, current limits, and safety protocols is essential to prevent damage or unsafe conditions.
- The BCI shall not be used outside the electrical and mechanical specifications specified in this manual.
- Use correct cables for the BCI and batteries. Consult your installer for more details.
- Use only insulated tools.
- In case of an undervoltage shutdown, charge immediately.

WARNING!

- Danger of electric shock.
- Only trained experts should handle or install a BCI and/or related battery systems as these systems can deliver very high currents and/or voltages.
- Do not remove the BCI from its original packaging until required for use.
- Do not mix LFP batteries of different capacity, size, or type.
- Do not disassemble, crush, puncture or shred the BCI.
- Never install or use a damaged BCI.
- Do not expose the BCI to heat or fire.
- Avoid short circuit the LFP battery. When working with batteries remove watches, rings, and other metal objects.

CAUTION!

- This BCI is only for Super B batteries. Refer to the applicable Super B battery manual that can be found on our website: www.super-b.com.

1.2 Stay Informed

To get the most out of your Super B product, we recommend staying up to date with the latest information.

Join the Super B community and receive exclusive updates and insights, including:

- Product updates and improvements
- Important safety notifications
- Firmware releases and technical information
- News and developments from Super B

You can subscribe to the Super B newsletter via the link or QR code provided below.

Figure 1. https://www.super-b.com/newsletter-signup

1.3 Contacting Super B – Service & Support

If you have questions, experience issues, or require assistance, Super B offers several support options. Choosing the right contact method helps us support you as quickly and effectively as possible.

Telephone Support

Phone: +31 (0)88 007 6000

Use telephone support for:

- Urgent technical issues
- Immediate assistance during installation or commissioning
- Situations where the product cannot be operated safely

Email Support

- support@super-b.com – for technical questions, troubleshooting, and service-related issues
- sales@super-b.com – for product information, quotations, and commercial questions

Please include relevant product details (type, serial number, installation details) to help us assist you efficiently.

Support Ticket System

For structured support and service requests, you can open a **support ticket** via the Super B support portal.



Figure 2 Super B Support | Lithium Battery Help & Resources

Use the support ticket system for:

- Technical issues that require investigation
- Warranty claims
- Repair or return requests
- Tracking the status of ongoing cases

Using the ticket system ensures clear communication and proper documentation throughout the support process.

Warranty and Returns
Please note that **all warranty and return cases must be handled through a registered RMA (Return Material Authorization)**. Products returned without a valid RMA may not be processed.

1.4 Software Updates

Information about available software updates is communicated via:

- The Super B newsletter
- The Super B website or support portal
- The Be In Charge App (Epsilon only)
- The Super B FTP server (registered users only) ftp://organization@downloads.super-b.com

If you are unsure whether your BCI is running the latest software version, contact Super B support.

1.5 Disposal

Dispose the BCI in accordance with local, state, and federal laws and regulations. Do not mix with other (industrial) waste.



Figure 3

2. Introduction

2.1 Product description

The Battery Communication Interface (BCI) is a device designed to enhance the protection of Super B LFP batteries, especially in multi-battery configurations, by controlling contactors or relays to ensure safe operation. The BCI collects data from one or multiple LFP batteries by a CANopen communication bus. This data contains information about the status and the current use of the LFP batteries. If one or more LFP batteries report an issue, the BCI will automatically turn off the contactors to protect the LFP batteries. The BCI can be used to manage a single LFP battery, it is intended to collect data from multiple LFP batteries in series and/or parallel for controlling contactors.

Other typical functions are:

- Control pre-charge functionality.
- Protocol conversions (depending on BCI software version).
- Control charger by CAN or charge enable signal (depending on BCI software version).
- Manage the heaters of Super B LFP batteries outfitted with heating elements.

2.2 Intended use

⚠ **WARNING! Only trained experts should handle or install a BCI and/or related battery systems as these systems can deliver very high currents and/or voltages.**

⚠ **WARNING! Understanding battery management systems, voltage, current limits, and safety protocols is essential to prevent damage or unsafe conditions.**

Note: Always refer to chapter 1, General information.

Note: The boundaries of the BCI, as described in this technical user manual, should always be upheld.

Potential applications to use the BCI in combination with LFP batteries from Super B are:

- Off grid applications.
- Marine applications.
- Medium for (renewable) energy storage (traction).
- Battery for vehicles.

Depending on the application it can be necessary that additional components are required to ensure that the installation is compliant with the applicable regulations.

See section 4.1, Electrical specifications.

The BCI is provided as a standalone device. It is the responsibility of the customer to source any additional components required for the protecting the LFP batteries. Super B cannot be held responsible for installations which were not made by Super B.

Super B also offers the option of supplying the complete installation. This can be a standard solution or a custom solution. The standard solution can be found on our website or by contacting our Sales Department. The custom solution needs to be aligned with our Sales- and Application Engineering contact. Contact Super B in case this technical user manual does not cover or address your application.

2.3 Limitations of use

The BCI may **NOT** be used in medical or in aviation applications. The BCI may not be used for any purposes other than described in this technical user manual. Any usage of the BCI outside the scope of the described applications, or for purposes not mentioned in this document, will be considered improper use, and will void the product warranty. Super B cannot be held responsible for any damage caused by improper, incorrect, or unwise use of the product. Read and understand this entire technical user manual before using the product.

2.4 Glossary of Terminology

Table 1. Glossary of Terminology

BMS	Battery Management System
BIB	Battery Interface Box
BCI	Battery Communication Interface
LFP	Lithium Iron Phosphate (LiFeP04)
DC-BUS	Load/Charger side of the main contactor(s)
SoC level	State of charge level
CANopen communication bus	CAN Bus protocol
Be in Charge Software	Software used for configuring and monitoring the battery system (desktop)
Be in Charge App	Mobile application available for both Android and iOS devices and can be downloaded via the Google Play Store.

PCB	Printed Circuit Board
PLC	Programmable Logic Controller

2.5 Used symbols

The following icons will be used throughout the manual:

IMPORTANT! An important sign is used to emphasize how important something is. States precautions and restrictions that must be followed.

WARNING! A warning sign indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION! A caution sign indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury.

Note: A Note sign is used to address practices not related to physical injury. It provides tips on correct use and supplementary information.

3. Product specifications

3.1 Typical setup of the BCI

Figure 4 depicts a typical setup of the BCI. The circuit shows the interconnections of the BCI in an installation to protect the LFP battery (bank).

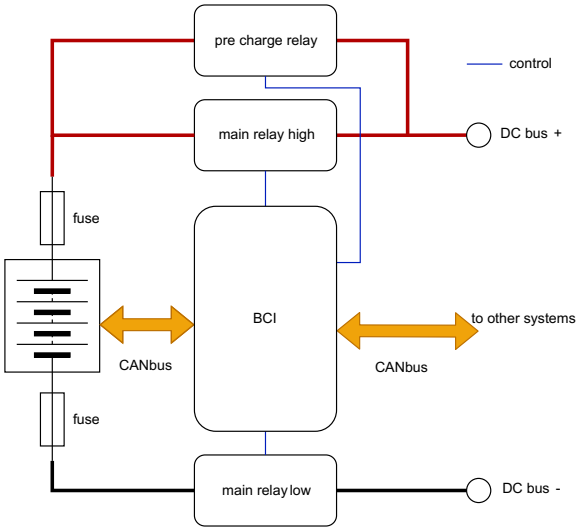


Figure 4. Typical BCI setup

3.2 Product features

- The BCI is a device to protect Super B LFP batteries.
- The BCI is a standalone device.
- The BCI can be configured using a CAN to USB converter (see section 4.7, Peripheral equipment, table 12) and the Be in Charge software.
- Two power supply inputs:
- External/DC-BUS Power Input: Allows the BCI to be powered either from an external source or directly from the DC-BUS.
- Battery Bank Power input: Enables the BCI to be powered from the battery bank. This input includes a self-disconnect feature for added safety.
- Two CAN communication ports:

- The master port indicated by J1. This port is dedicated for the LFP batteries. The communication protocol is CANopen.
- The slave port indicated by J2. This port is to communicate with an external network.
- Up to sixteen LFP batteries can be connected to the BCI Master side CAN Bus without the need of external CAN power (Super B LFP batteries need power on their CANopen Interface).
- Up to 100 LFP batteries can be connected to the BCI with the use of external CAN power.
- Large battery banks can be built by using BCI substring topology.
- Collecting information of all LFP batteries in the battery bank and presenting it as one LFP battery on the CAN Bus.
- Three dry outputs to control the minus, the plus, and the pre-charge contactor of the LFP battery bank.
- Drive a Pre-charge contactor to connect to a capacitive load to prevent inrush currents.
- A mechanism that allows temporary reconnection of the LFP battery bank to the DC-BUS in an undervoltage situation.
- Complete power down in case of an undervoltage of the LFP battery bank (I < 1 µA).
- Programmable power down on user adjustable LFP battery (bank) SoC level.
- Programmable Auto-On function. Four galvanic isolated inputs for manual operation.
- The BCI has an open collector output/input for various additional applications.
- Diagnostic Logging function.
- Three status LEDs to indicate the status of the BCI and the LFP battery bank.
- A Real Time Clock for accurate time stamped function, statistics, and error logging (Hardware version V1.7 and above).BCI functional behaviour

3.3 BCI functional behaviour

3.4 General

The BCI monitors all connected LFP batteries through the CAN Bus. Whenever one or more LFP batteries report an alarm, or are missing on the CAN Bus, the BCI will drive the contactors to disconnect the LFP battery (bank) from the DC-BUS to avoid misuse of the LFP battery or to prevent an unsafe situation. The alarms from the LFP battery can differ with each battery type. Because the alarm is indicated to the BCI as a general alarm, any Super B LFP battery with CANopen communication can be used in combination with the BCI. For alarms triggered by the LFP battery, please refer to the LFP battery manual. See our website: www.super-b.com.

3.4.1 Power inputs and functionality

The BCI can be powered by an external power supply or by the LFP battery bank. When powered from the LFP battery bank, the maximum number of LFP batteries in series is limited to four.

⚠ **CAUTION! The BCI can only be powered by an LFP battery bank if the bank consists of four or less LFP batteries in series.**

The BCI is equipped with two power supply inputs and one ground (GND) input, as described in section 4.6, Connections, indicators, and controls.

- Battery supply input (J4 pin 9): This input is used to connect the battery to the BCI.
- DC-BUS / external supply input (J4 pin 10): This input allows the BCI to be powered from either the DC-BUS or an external power input
- Ground/minus input (J4 pin 1): This input serves as the ground (GND) or negative connection for the system

The DC-BUS / external supply input J4 Pin 10 can be used if the LFP battery bank consists of more than 4 LFP batteries in series or when the self-shutdown functionality is not used. There is no need to connect to the LFP battery supply input. The LFP battery supply input J4 Pin 9 has internal disconnect functionality to minimize self-consumption in case of a shut down. If the LFP battery bank is drained and there is a risk of damaging the LFP batteries, the BCI disconnects the LFP battery bank from the DC-BUS and shuts down itself to no longer drain the LFP batteries. Figure 5 and 3 present simplified connection diagrams that provide a clear illustration of the procedure for supplying the BCI. Only when the BCI is powered from the LFP battery bank the self-shutdown functionality is used. See section 4.1, Electrical specifications, for more details.

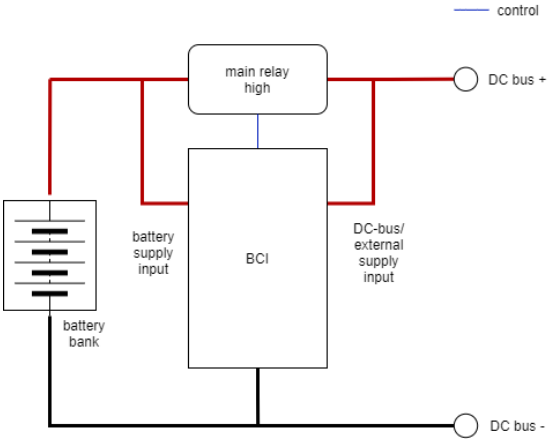


Figure 5. BCI supplied by the LFP battery bank

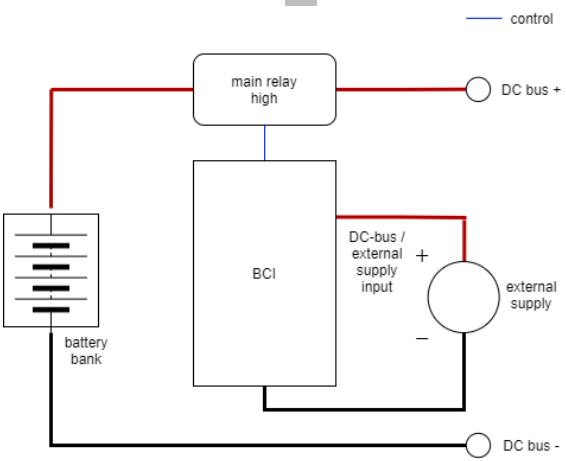


Figure 6. BCI supplied by external power supply

⚠ **CAUTION! When LFP battery banks with a setup depicted in Figure 6 are connected in parallel via the DC-BUS, the self-shutdown functionality will only be activated when the power to all BCIs is turned off. This ensures that the system remains safe and prevents any power flow when the BCIs are not operational.**

3.4.2 BCI States

The different BCI states, are listed in Table 2:

Table 2. BCI states

State	Main relay high	Main relay low	Pre-charge relay	Description
ON	On	On	Off	Bank is connected to the DC-BUS
OFF	Off	Off	Off	Bank is disconnected from the DC-BUS
Pre-charge	Off	On	On	Bank is pre-charging the DC-BUS
Alarm	Off	Off	Off	An error occurred
Undervoltage reboot	On	On	Off	BCI is turned on again after an undervoltage shutdown
Shutdown	Off	Off	Off	BCI is in power down mode

3.4.2.1 ON state

The BCI is IN or can be set to the ON state when there are no active errors. In the ON state the BCI enables the main contactor(s), the LFP battery bank is connected to the DC-BUS. The BCI can be set to ON state using the Be in Charge software, or automatically when the Auto- On feature is enabled. Note that the BCI can only reach the ON state via the Pre-charge state.

3.4.2.2 OFF state

The BCI can be set in OFF state manually by the Be in Charge software. The BCI disables all contactors in the OFF state and the LFP battery bank is disconnected from the DC-BUS. The BCI boots in the OFF state.

3.4.2.3 Pre-charge state

A contactor that must switch a large capacitive load can be exposed to high electric current during initial turn-on. This current, if not limited, can cause considerable stress or damage to the system components. Pre-charging is implemented to increase the lifespan of electronic components and increase reliability of the contactor. In the pre-charge state the main relay is disabled and the pre-charge relay is enabled. See section 3.4.3.2 and 3.4.3.3 for more details related to the behaviour of voltage dependent or time dependent pre-charge settings.

3.4.2.4 Alarm state

The BCI is in alarm state due to the following:

- The number of LFP batteries that respond to a present request does not match the number of LFP batteries configured in the BCI. If the error is not resolved within 20 seconds, the BCI goes to OFF state.
- One or more of the LFP batteries have reported an alarm. When the alarm of the LFP battery is cleared the BCI stays in OFF state. Depending on which type of alarm the LFP battery signalled, this alarm can be cleared automatically. Refer to the battery manual for alarm details and resolutions. If the alarm state is cleared and the Auto-On feature is enabled, the BCI can go back to the ON state.

3.4.2.5 Undervoltage OFF state - BCI externally powered

If the BCI is powered by an external power supply and an undervoltage event will occur, the BCI will go to OFF state.

The BCI can be turned ON again by forcing the relay ON by software or by hardware input. The BCI will go into the undervoltage recovery state.

3.4.2.6 Undervoltage recovery state - BCI externally powered

In the undervoltage recovery state the LFP battery (bank) will be connected to the DC-BUS, but discharging is limited regarding capacity to 0.1 Ah. This allows chargers that need to see a

battery voltage, to start charging. The BCI will now allow the LFP battery bank to be discharged with 0.1 Ah before it will go to OFF state again. When the LFP battery bank is charged with 1 Ah, the BCI will switch to the ON state. The BCI will also go to the OFF state after 10 minutes spent in the undervoltage recovery state, which implies that the LFP battery bank should be charged with at least 1 Ah to avoid unnecessary shutdown.

3.4.2.7 Shutdown state - BCI battery bank powered

In this state the main relays and the pre-charge relay are disabled. The BCI does not take any power from the LFP battery bank and will turn off. If there is power on the DC-BUS, the BCI will stay on and takes only power from the DC-BUS

3.4.2.8 Undervoltage Shutdown - BCI battery bank powered

When a LFP battery indicates an undervoltage, the BCI will go into the shutdown state to prevent draining the LFP batteries further. The BCI can be turned on again by a power cycle or by applying voltage on the load side (i.e., turning on a charger). The BCI will go into the undervoltage recovery state.

3.4.2.9 Undervoltage recovery state - BCI battery bank powered

⚠ **CAUTION! Charge the LFP batteries immediately in case of an undervoltage shutdown.**

In the undervoltage recovery state the LFP battery (bank) will be connected to the DC-BUS, but discharging is limited regarding capacity to 0.1 Ah. This allows chargers that need to see a battery voltage, to start charging. The BCI will now allow LFP the battery bank to be discharged with 0.1 Ah before it goes to shutdown state again. When the LFP battery bank is charged with 1 Ah the BCI will switch to the ON state. The BCI will also go to the shutdown state after 10 minutes spent in the undervoltage recovery state, which implies that the LFP battery bank should be charged with at least 1 Ah to avoid unnecessary shutdown.

The BCI behaviour during undervoltage shutdown is different from other error states. This was implemented specifically to prevent draining of the LFP battery bank and allow the automatic recovery as soon as a charger is connected. Refer to section 5.8 (systems ≤ 60Vdc) and section 3.4.3.3 (systems > 60Vdc) for details about undervoltage behaviour of the BCI.

When the batteries reach undervoltage or State of Charge shutdown level (see section 3.5.2, SoC shutdown/Switch-OFF), the BCI is designed to shut down. However, this shutdown cannot occur if the BCI is still being powered by the charger located on the load side, as the charger continues to supply power to the BCI. As a result, the undervoltage protection mechanism is prevented from activating until the charger is no longer supplying power.

In this situation, the BCI will go to OFF state but will not go to shut down. To resolve this, all loads and the charger should be turned off, which will force the BCI to go to shut down.

To charge the batteries, the charger should be turned back on again, which will power up the BCI. The user can set the BCI to ON state, which will start the charging process.

If there are parallel LFP battery banks, ensure that all other BCIs are off before proceeding.

3.4.3 Contactor behaviour

The BCI has drivers to control two external protection contactors and one external pre-charge relay:

- Main High Side (+)
- Main Low Side (-)
- Pre-charge

3.4.3.1 Turn on behaviour

When the BCI is set to ON state the contactors turn on in a certain sequence.

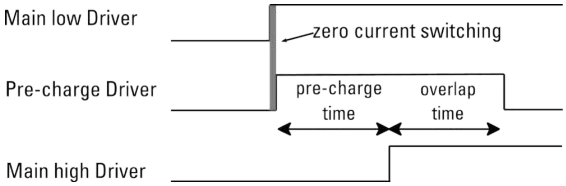


Figure 7. Turn-on Sequence of contactors

When the system switches ON, the main low side contactor and pre-charge relay are active immediately. The main high side contactor will be active only after the pre-charge sequence is completed. See following Sections for Pre-charge behaviour.

For systems ≤ 60Vdc, the main low side contactor may be omitted if allowed by applicable regulations.

3.4.3.2 Pre-charge relay behaviour - BCI battery bank powered

To minimize the inrush current, the main high side contactor will only be closed if the voltage difference measured over this contactor is less than 1.25V x [number of LFP batteries in series]. An external pre-charge contactor should be connected to Pin 3 and 4 of connector J4 Pin 3 and J4 Pin 4. See section 4.6, Connections, indicators and controls, Figure 10. For example, for a 48 V system (4 LFP batteries in series) the voltage across the relay should be less than 5 V. The BCI will remain in overlap state 1 seconds after the main contactor has been enabled.

3.4.3.3 Pre-charge relay behaviour - BCI externally powered

For limiting the inrush current for systems > 60Vdc an external pre-charge relay should be connected to connector J4, Pin 3 and 4. See section 4.6, Connections, indicators and controls,

Figure 10. However, the switching behaviour is different, and solely depends on time, because the voltage difference over the contactor cannot be measured by the BCI. With the Be in Charge software it is possible for the user to select a pre-charge duration > 3 seconds. By default, the switching behaviour is set to 3 seconds.

The value of the pre-charge resistance and power rating is best calculated based on the knowledge of the capacitive load of the system.

3.4.3.4 Turn off behaviour

When the BCI is set to OFF state, all contactors become inactive. First the Main high contactor is switched off, then the Main low contactor is switched off. This is to have zero current switching of the Main low contactor.

3.5 BCI control functions

3.5.1 Auto-on

The Auto-On function automatically sets the BCI into ON state when the BCI is powered up. Also, if a battery alarm has occurred and this alarm is cleared (see section 3.4.2.4, Alarm state), the BCI automatically goes to the ON state if the Auto-on function is enabled. The Be in Charge software can be used to control the Auto-on function. See section 6.9, General settings: Automatic control. This functionality only works with at most 4 LFP batteries in series.

3.5.2 SoC shutdown/Switch-OFF

The SoC switch-OFF is a function that makes it possible, at a certain level of state of charge, to put the BCI in:

- Shutdown state: if the BCI is powered by the LFP batteries,
- OFF state: if the BCI is powered by an external power supply.

The user can set the level for this function, which can be enabled or disabled according to preference. By default, this function is disabled. Control and configuration of this function are managed through the “Be in Charge” software. See section 6.9, General settings: Automatic control.

When the LFP battery bank reaches the SoC set level, the BCI will go into shutdown or OFF state. It is activated only with descending SoC level. If the BCI is in SoC shutdown/OFF state it can be turned ON again by power-cycling it. When the BCI is turned ON again, it is in the SoC recovery state, during which it will not shutdown on SoC again unless the SoC of the LFP battery (bank) is charged 1% above the set level. This re-enables the functionality. Once the SoC shut down/off state has occurred and the BCI is turned ON again, the LFP battery bank can be discharged further until an undervoltage occurs. The BCI will report a warning that the SoC is running low when the reported SoC is within 10% over the set shut down level.

Note: It is possible – with BCI software version 2.35 or higher and the latest Be in Charge software - to configure the BCI to display and use the average SoC of the bank versus the lowest. Super B recommends using the lowest.

3.5.3 Reset

Even with Auto-On enabled, some alarm types of the LFP battery can only be cleared by a reset. To perform a reset, the user can select either to add an external hardwired reset button on the BCI inputs (J3 pins 3-4, see chapter 5.10, Manual control) or reset by CANopen with use of the Be in Charge software.

4. General product specifications

Table 3. General product specifications

Product description:	SB BCI-C1
Product designation:	2CAN/115/80/29
Product type:	Battery Communication Interface
Product Lifespan:	Designed for a long service life

4.1 Electrical specifications

Table 4. Electrical specifications

Description	Value	Unit
Power supply	7.5...60	Vdc
Power supply required if BCI is powering the CAN Bus	15…60	Vdc
Power consumption excluding CAN power	<1	W
Power consumption “full shut down”	<1	µW
Internal Relay switch current (max, all 4)	4	A
Internal Relay switch voltage (max, all 4)	60	Vdc
Internal Relay isolation voltage	60	Vdc
Input voltage for manual control inputs	0...60	Vdc
Input high level	6.4...6.8	Vdc
Input isolation voltage	60	Vdc
Generic IO open drain, referring to BCI ground	60	Vdc
	100	mA

4.2 Mechanical specifications

Table 5. Mechanical specifications

Height (H)	28.5 / 29.5 mm
Width (W)	114.5 / 115.5 mm
Thickness (T)	79.5 / 80.5mm
Weight	136g ± 10 g
Case material	PC / ABS (FR3010)

4.3 Compliance specifications

Table 6. Compliance specifications

Certifications	CE

4.4 Environmental specifications

Table 7. Environmental specifications

Operating temperature range	-40°C to 85°C / -40°F to 185°F
Recommended storage temperature range	-40°C to 85°C / -40°F to 185°F
Relative humidity	5-85%, non-condensing
Ingress protection	IP20
Shock and vibration	Tested according to DNV requirements

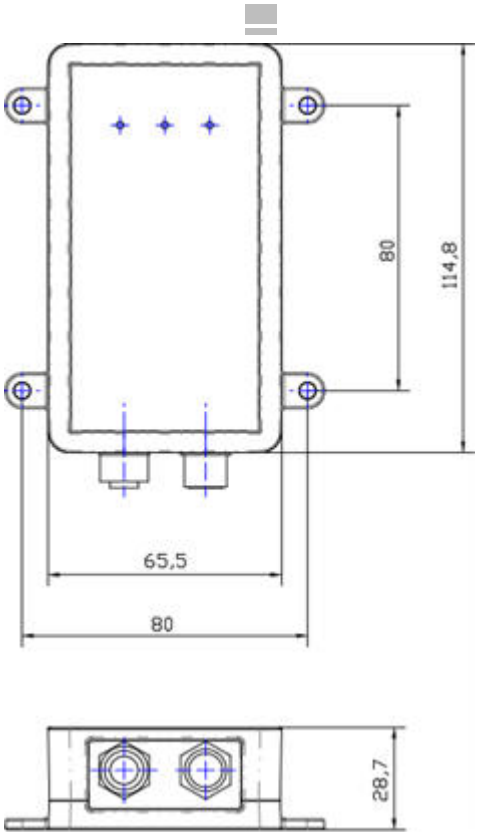


Figure 8. Dimensions in mm

⚠ **WARNING! The BCI may only be used in conditions as specified in this technical user manual. Exposing the BCI to conditions outside the specified boundaries may lead to serious damage to the product and/or serious injury to the user.**

4.5 Scope of delivery



Figure 9. Scope of delivery

1. (1x) Battery Communication Interface (BCI)
2. (2x) Phoenix plug 10 MC 1,5/10-STF-3,81 1827787
3. (3x) CAN Cable male to male 0.6m

4.6 Connections, indicators, and controls

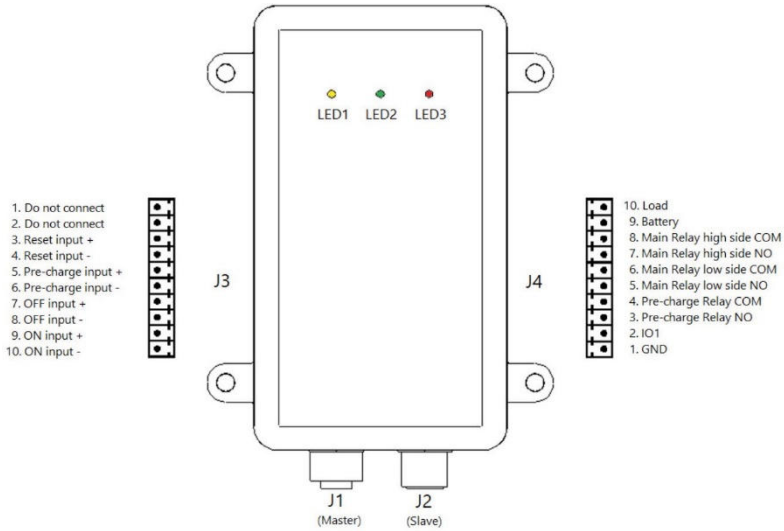


Figure 10. Connections, Indicators, and controls

- J1, CAN Master connector; 5-pin CANopen micro style connector female
- J2, CAN Slave connector; 5-pin CANopen micro style connector male
- J3, I/O Connector, 10 pole; Phoenix MPE030-38110
- J4, I/O Connector, 10 pole; Phoenix MPE030-38110
- LED 1 - Yellow
- LED 2 - Green
- LED 3 - Red

4.6.1 CAN connector pinout (Master/Slave)

Table 8. CAN connector pinout

PIN #	Signal	Master side	Slave side
1	CAN_SHLD	Optional CAN Shield	Optional CAN Shield
2	CAN_V+	CAN Bus supply voltage 12 V	Not connected
3	CAN_GND	Ground / 0V	Ground / 0V
4	CAN_H	CAN_H bus line (dominant high)	CAN_H bus line (dominant high)
5	CAN_L	CAN_L bus line (dominant low)	CAN_L bus line (dominant low)

Male Female

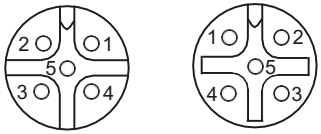


Figure 11. CAN Connections Male and Female

4.6.2 J3 (I/O Connection 10)

Table 9. J3 (I/O Connection 10)

PIN	Description
1	Not used
2	Not used
3	Reset input +
4	Reset input -
5	Pre-charge input +
6	Pre-charge input -

7	Main Relay/Contactor Off input +
8	Main Relay/Contactor Off input -
9	Main Relay/Contactor On input +
10	Main Relay/Contactor On input -

4.6.3 J4 (I/O Connection 10)

Table 10. J4 (I/O Connection 10

PIN	Description
1	GND
2	IO1
3	Pre-charge relay NO
4	Pre-charge relay common
5	Main relay, low side NO
6	Main relay, low side common
7	Main relay, high side NO
8	Main relay, high side common
9	Battery Supply input+
10	Load + DC-BUS / ext. supply input-

4.6.4 Indicators

Table 11. Indicators

LED 1 (Yellow)	LED 2 (Green)	LED 3 (Red)	Mode
Flashing	Off	Off	Pre-charge
Off	On	Off	Main relay On

On	On	Off	Main relay Off
On	On	On	Battery in error mode or communicatio n error
Off	Flashing	Off	CAN network scanning

4.7 Peripheral equipment

The BCI can be used in combination with the following Super B products:

Table 12. Optional peripheral equipment

Article name	EAN code
Nomia 12 V100Ah	8718531360662
Nomia 12 V160Ah	8718531360570
Nomia 12 V210Ah	8718531361645
Nomia 12 V340Ah	8718531362314
Nomada 12 V105Ah	8718531361799
Nomada LT 12 V105Ah	8718531362536
Relay GX14BA 12 V 350A	8718531361157
Relay GX14CA 24 V 350A	8718531361164
Relay GX14FA 48 V 350A	8718531361171
Relay GX16BE 12 V 600A	8718531361096
Relay GX16CE 24 V 600A	8718531361102
Relay GX16FE 48 V 600A	8718531361089
Relay TBS RBS 12 V500A	8718531362031

Relay TBS RBS 24 V500A	8718531362048
Relay LIR250 12 V/24 V 500A	8718531361126
CAN Terminator Female Low Profile	8718531362000
CAN Terminator Male Low Profile	8718531361997
CAN Cable 0.6m Male to Female	8718531360716
CAN Cable 1m Male to Female	8718531360723
CAN Cable 2m Male to Female	8718531360730
CAN Cable 5m Male to Female	8718531360747
CAN Cable 10m Male to Female	8718531360754
CAN Cable 0.6m Female right angled to Male straight	8718531361492
CAN Cable with inline terminators 0.5m	8718531362505
CAN Cable splitter	8718531361065
CAN Splitter Male to 9x Female	8718531361065
CAN T-Splitter Male to Male + Female	8718531360761
CAN power cable 2m	8718531360792
CAN to USB Converter	8718531361201
Be in Charge Monitoring Kit (incl. Be in Charge software)	8718531362086

5. Installation

5.1 General information

⚠ **WARNING! Never install or use a damaged BCI.**

⚠ **CAUTION! Do not reverse connect the BCI.**

⚠ **CAUTION! Use the BCI within the specifications.**

5.2 Unpacking

Inspect the BCI for any signs of damage upon unpacking. In case of damage, please reach out to your reseller for assistance.

5.3 Required tools for installation

- Screwdriver flat 5 mm.
- M3 Torx screwdriver (for replacement coin cell when needed).
- Cables. Align with the installer that cables meet isolation and colors standards.

5.4 Placement of the BCI

The BCI must be securely mounted in a fixed position to prevent any movement. The mounting holes should be used (See Figure 4Figure 12). The device can be mounted in any orientation.

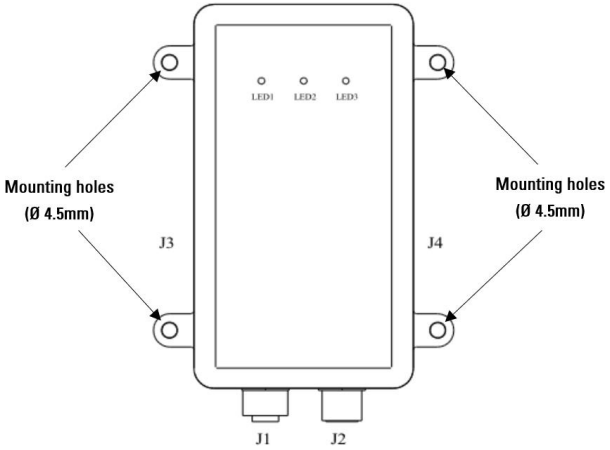


Figure 12. Mounting the BCI

5.5 Coin Cell

Compatible BCIs (Hardware version V1.7 and above) are delivered fitted with a CR1216 coin cell, which is used to power the internal Real Time clock (RTC). After installing it into an application, remove the coin cell insulator tab to power the Real Time clock.

Note: Remember to set the RTC time using the Be in Charge software. More details can be found in section 6.15, Real Time clock and section 7.4, Replacing the coin cell battery.

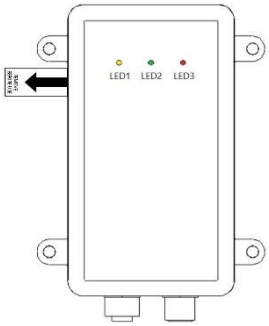


Figure 13. Coil cell for RTC

5.6 Wire sizes

⚠ **CAUTION! Use appropriate wire for the connection to ensure no overheating or unnecessary losses occur.**

⚠ **CAUTION! To ensure IP20, make sure to use the right wire size.**

Table 13. Connecting wires

Recommended wire size	1 mm^2, Stranded wire and ferrule(s)
Maximum wire size	1.5 mm^2, Stranded wire and ferrule(s)

Coordinate with the installer to ensure that cables conform to the appropriate standards, including correct isolation and colors, will be utilized.

5.7 Electrical installation

⚠ **CAUTION! High voltages may be present in the LFP battery system. Access to the battery system is only allowed by trained professionals.**

⚠ **WARNING! Always take safety precautions when working on battery systems.**

Safety components selection and design (fuses, cable thickness etc.) should be done following safety guidelines especially for systems > 120Vdc. Super B is not responsible for the overall system integration.

In certain applications, the components below might be necessary depending on applicable local regulations.

- Ground Fault Detection device.
- Emergency stop.
- EMC Filter.
- Manual disconnect switch.

If the BCI is used with a LFP battery bank that consists of four or less LFP batteries in series (48 V or less) the battery supply power input of the BCI and its functionality can be used.

If the BCI is used with a LFP battery bank with a higher voltage it needs to be powered by an external power supply. This supply can be between 15 and 60Vdc, typical 24 Vdc.

Note: Super B offers a complete solution for systems ≤ 60Vdc; the Battery Interface Box (BIB).

Next Chapter will describe the differences in detail and show examples of complete installations for each of those systems.

5.8 Electrical installation - BCI power from battery bank

A typical setup for a 48 V or lower Installation is depicted below.

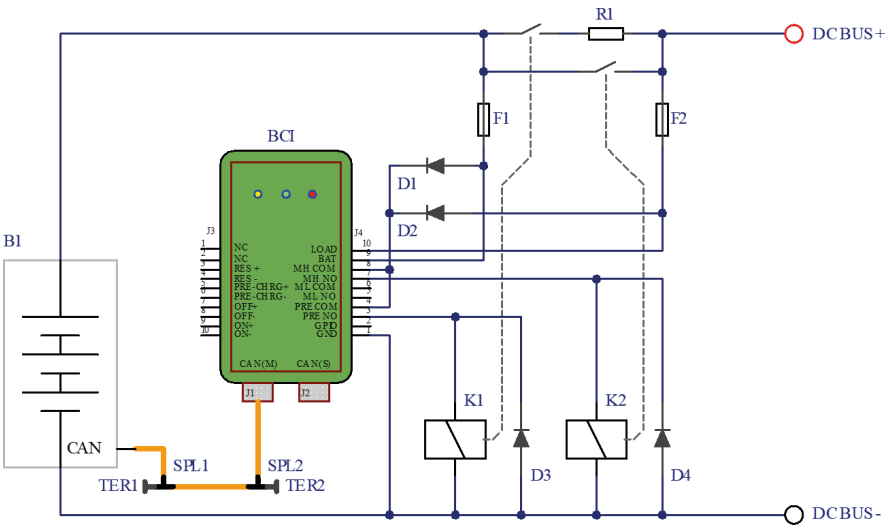


Figure 14. BCI powered from battery bank

5.8.1 Circuit description

The BCI (Battery Control Interface) is powered by the battery bank through specific pins. Pin one is for the negative connection, and pins 9 and 10 are for positive connections. The BCI decides which pin to draw power from based on the status of the main contactor: it uses power from pin 10 when the main contactor is closed and from pin 9 when the main contactor is open.

The contactor coils (K1 and K2) are connected to the BCI's pre-charge and main contactor drivers. Diodes D3 and D4 are used to handle the back-EMF (electromotive force) from the contactor coils, but if the contactors already have built-in back-EMF diodes, D3 and D4 should not be installed. Diodes D1 and D2 provide power to the contactor coils.

Fuses F1 and F2 should be placed close to the terminals of the main contactor to protect the circuit. The pre-charge resistor must be selected according to the specific requirements of the application. Instructions for its calculation can be found in section 5.11, Pre-charge of the manual.

Table 14. Circuit description

Component	Specification	Remark
D1	100 V 3 A	
D2	100 V 3 A	
D3	100 V 3 A	might not be needed depends on relay
D4	100 V 3 A,	might not be needed depends on relay
F1	5A 100 V	
F2	5 A 100 V	
K1	Na	Depends on application
K2		Depends on application
R1		Depending on application, see section 5.11

5.9 Electrical installation - BCI externally powered

Figure 15 depicts a typical setup drawn of an externally powered Installation usually higher than 48 V.

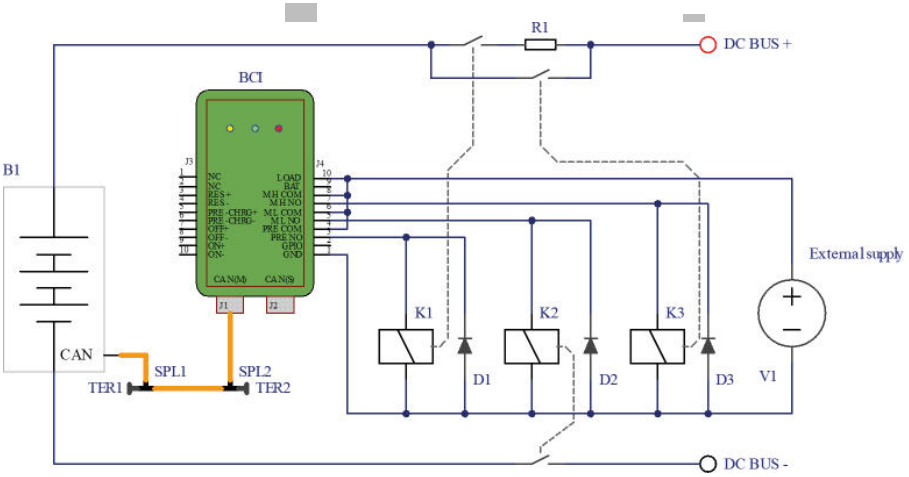


Figure 15. BCI externally powered

5.9.1 Circuit description

The BCI Is powered by the external power supply, through pin 1 (minus) and pin 10 (plus). The coils of contactors K1, K2 and K3 are connected to the pre-charge driver, the main contactor low and the main contactor high drivers of the BCI. D1, D2 and D3 are to absorb the back- EMF of the contactor coils. Some contactors have built-in back-EMF diodes or transient diodes. In that case it is advised not to install D1, D2 and D3. The pre-charge resistor should be tailored to the application. See section 5.11, Pre-charge selection, for calculating the pre-charge.

Table 15. Circuit description

Component	Remark
D1	Depends on contactor
D2	Depends on contactor
D3	Depends on contactor
K1	Depends on application
K2	Depends on application
K3	Depends on application
R1	Depending on application, see 5.11

	Depends on application
External supply	24 V 1 A, power for the contactors should be added

5.10 Manual control

The BCI can be controlled manually with external hardwired control buttons. The manual inputs can be normally open contacts or normally closed contacts. A typical setup is depicted in Figure 16.

The manual inputs are default configured for "active high," so normally open contacts can be used. This can be configured under Input level configuration, see section 6.5, Input level configuration.

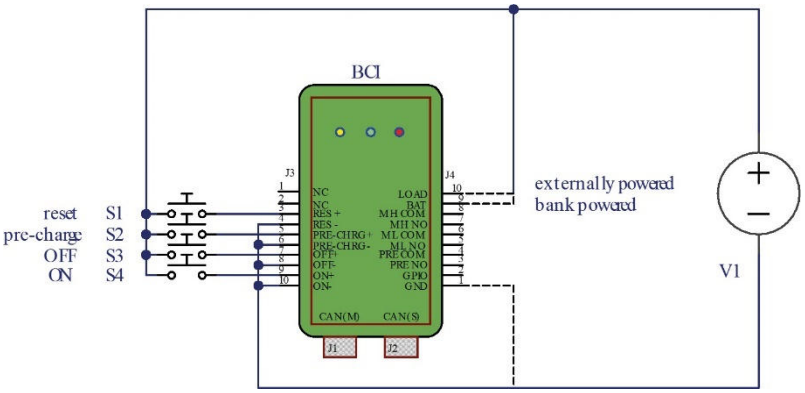


Figure 16. manual controls

The buttons act in the following priorities:

1. Reset
2. OFF
3. Pre-charge / ON

Note: The ON signal always goes through pre-charge phase.

5.11 Pre-charge selection

A contactor that must switch a large capacitive load can be exposed to high electric current during the initial turn-on. This current, if not limited, can cause considerable stress or damage to the system components. Pre-charging is implemented to increase the lifespan of electronic components and increase reliability of the contactor. In the pre-charge state the main relay is

disabled and the pre-charge relay is enabled. Refer to sections 3.4.3.2 and 3.4.3.3 for details about the behaviour.

When pre-charging a DC-BUS, usually not only the capacitive load needs to be considered. Often the DC-BUS has a more complex impedance and there is some resistive load that must be considered choosing the pre-charge resistor.

Figure 17 illustrates a potential load configuration. The purpose of the pre-charge circuit is to charge the DC-BUS so that the voltage across the main contactor is small enough to turn it on without damaging it.

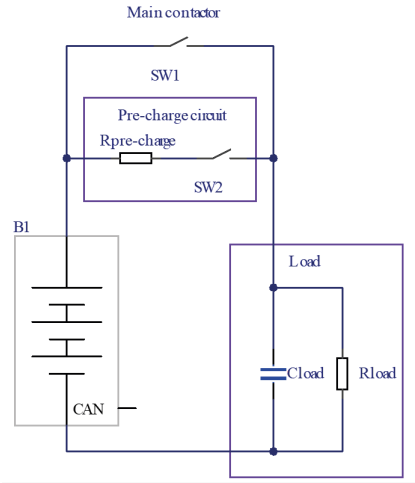


Figure 17. Simplified circuit

When the main contactor is about to close, the voltage across it must be less than:

Equation 1

$$U_{contactor} < I_{make} \cdot R_{battery\ bank}$$

This means that the value of the pre-charge resistor needs to be large enough to limit the maximum current (when the load is at 0 V):

Equation 2

$$R_{pre\text{-}charge} > \frac{U_{battery\ bank}}{I_{max\ pre\text{-}charge}} - R_{battery\ bank}$$

The maximum current is the limit in this equation, it is given for any of the components in the pre-charge path, such as the relay or the load itself.

If the load has a resistive impedance as well, the steady-state voltage will not become equal to the battery voltage. This means that the value of the pre-charge resistor needs to be low enough to make the voltage across the main contactor as low as stated in Equation 1. Which leads to the following:

Equation 3

$$R_{\text{pre-charge}} < R_{\text{load}} \frac{U_{\text{contactor}}}{U_{\text{battery bank}} - U_{\text{contactor}}}$$

Equation 2 and Equation 3 are the limits for selecting the resistance value of the pre-charge resistor.

Below is an example of how to select a pre-charge resistor and set the pre-charge duration for a system consisting of thirty-two batteries in series:

Considering:

- System voltage 460V (32 charged batteries in series, at end of charge voltage).
- A capacitive load of 10mF.
- A resistive load of 1 kOhm.
- The maximum switching current of the contactor is 600A.
- The battery bank total internal resistance is 160mΩ.
- The maximum acceptable voltage difference across the contactor is 96V (600A x 160mΩ).

The pre-charge resistor must be smaller than: 263 Ohm. The closest standard value is 220 Ohm. The inrush current is reduced significantly after approximately a time of 5 x τ.

$$\tau = R \cdot C = \frac{1000 \cdot 220}{1000 + 220} \cdot 10 \text{ mF} = 1.8 \text{ s}$$

5 x τ = 9 seconds.

It is advised to set the pre-charge time to 10 seconds or more. Refer to section 3.4.3.3, Pre-charge relay behaviour for more information.

The resistor needs to dissipate as much energy as the energy stored in the load's capacitors:

$$E = \frac{c \cdot v^2}{2} = \frac{10 \text{ mF} \cdot 460^2}{2} = 1058 \text{ J}$$

$$P = \frac{E}{5 \cdot \tau} = \frac{1058}{9} = 117\ W$$

This power is dissipated for a relative short time. The pre-charge resistor must be chosen to be able to handle this power/ energy.

Note: If needed, please contact Super B for selecting the ohmic value of the pre-charge circuit and the maximum current the pre-charge circuit can deliver.

Note: If the BCI is measuring the voltage across the contactor, it only activates the main contactor if the voltage difference is small enough. Refer to section 3.4.3.2 for details about the behaviour.

⚠ **CAUTION! If the load draws more current than the pre-charge current, the BCI will not be able to engage the main relay, since it cannot properly pre-charge the system.**

❗ Important **the load may not be engaged before the BCI is done pre-charging.**

5.12 CANBus

5.12.1 General information

To use the BCI as described in chapter 6, BCI use, the CAN Master bus needs to be connected to the Super B LFP batteries. More information on the CANopen bus can be found at the CiA website: www.can-cia.org. The required documentation can be found in the following CiA documents (or in future version of these documents):

- CiA 301
- CiA 303_1 V1.8.0; sections 5 (AC and DC parameters) and 7.2: (5-pin "micro" style connector).

5.12.2 Connecting the CAN network cables

To create the CAN Bus connection between the LFP batteries and the BCI, follow these steps:

1. Prepare the Components: Ensure you have the BCI unit, the male-to-male cable, and the splitters required to connect the LFP batteries.
2. Connect the BCI to the Male-to-Male Cable: Plug one end of the male-to-male cable into the CAN interface port on the BCI unit.
3. Connect the First Splitter: Connect the other end of the male-to-male cable to the first splitter.
4. Connect the Battery Bank: From the first splitter, connect the rest of the battery bank using additional splitters as needed. Each LFP battery should be connected to the CAN Bus through these splitters.

5. Consult Battery Manuals: Refer to the manuals of the LFP batteries that will be connected to the BCI for further information about the CAN network. This step ensures compatibility and provides any specific instructions for setting up the CAN connection with those batteries.
6. Verify Connections: Double-check all connections to ensure they are secure and properly seated.
7. Power On: Once all connections are verified, power on the BCI and the connected LFP batteries.
8. Test Communication: Test the communication between the BCI and the LFP batteries to ensure they are properly connected and functioning as expected.
9. Following these steps will establish the CAN Bus connection between the LFP batteries and the BCI unit as depicted in Figure 18, CAN connection J1 to BCI.

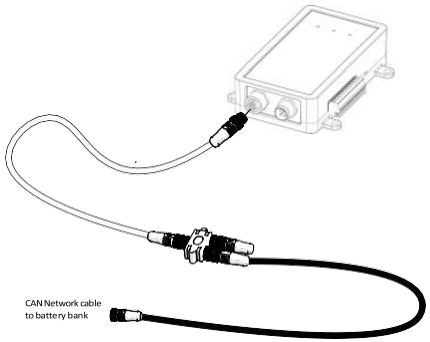


Figure 18. CAN connection J1 to BCI

5.12.3 CAN Bus network topology

Note: Do not use a ring- or a star topology.

Note: A high-speed bus requires termination at the two ends of the bus.

Note: The CAN cable between the Master port J1 and the splitter is male-male cable, all other cables are equipped with a male and female connector.

The CAN Bus network topology consists of a backbone where CAN devices connect to as shown in Figure 19. CAN Bus wiring diagram

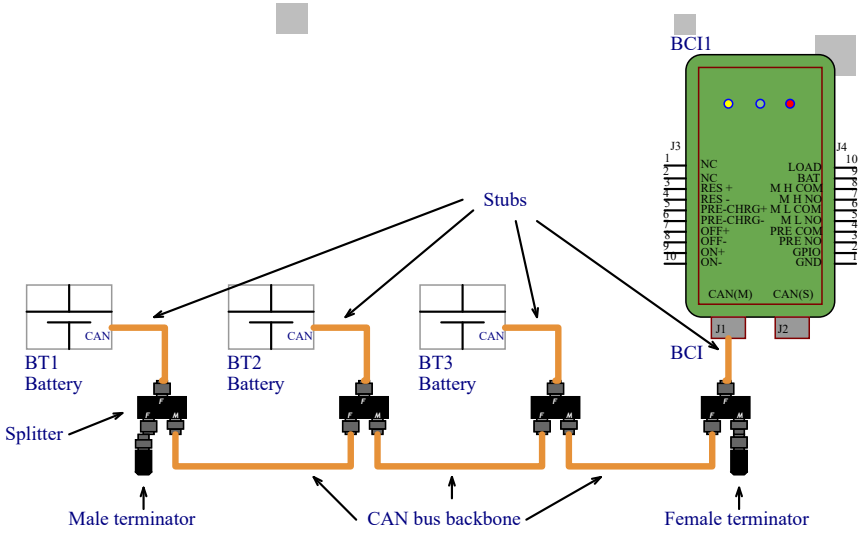


Figure 19. CAN Bus wiring diagram

To connect devices to the backbone, splitters are used. A splitter has three connections, two of them are to continue the backbone, the other one is to branch of the backbone. This is referred to as a stub. There are Super B battery models that are equipped with an internal splitter. They have two CAN connectors one male and one female. In that case a splitter is not needed with each battery.

The maximum CAN Bus backbone length is limited, and the maximum stub length is also limited. The maximum length depends on the bitrate that is used. Because all Super B LFP batteries have a bitrate of 250kbps, the only maximum lengths for this bitrate are mentioned in Table 16. CAN Bus speed.

Table 16. CAN Bus speed

Bit rate	Bus length (L)	Max. stub length (S)	Accumulated stub length
250 kbps	250 m	11 m	55 m

Note: The CAN Bus needs to be terminated on both ends.

The CAN Bus is a high-speed bus. Because of this the CAN Bus needs termination resistors at each the end of the backbone to operate properly. This is shown in Figure 19. CAN Bus wiring diagram

The value of these resistors must be 120Ω. More information on termination resistors can be found in CiA document 303_1 V1.8.0, section 5.12.

5.12.4 CAN Bus power

Note: The CAN Bus power must be at least 10 V and may not exceed 30 V.

Note: An external power source must be able to deliver sufficient power.

The LFP batteries of Super B that can be connected in series must be provided with power on their CAN interface. This is because the internal CAN circuit is galvanically isolated from the cells and the BMS. The BCI provides this power on the CAN Master interface, but it is limited to 16 LFP batteries. If more LFP batteries are connected to the CAN Bus, power must be provided by another source. To connect another source to the CAN Bus, a CAN power cable must be used. The CAN power cable must be connected to the backbone as shown in Figure 20.

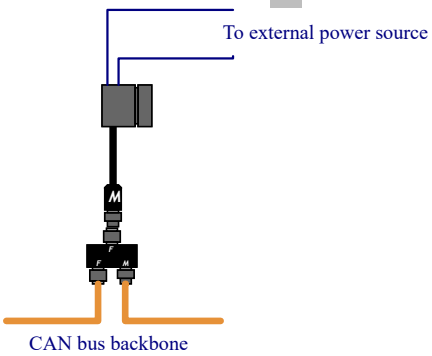


Figure 20. CAN Bus power

If a battery bank is configured as a 12 or 24 V system, the CAN Bus can be powered directly by the bank. In other cases, the external supply must be provided by other means. This could be a voltage converter with an output voltage between 12 and 24 V connected to the battery bank or any other external power source with this voltage specification.

The external power source needs to be tailored to the bank size regarding current because every battery's CAN interface takes some power. As a general guideline 25mA is consumed per battery connection when the CAN Bus is fully operational.

5.12.5 12 V systems with less than 16 batteries

In case of 12 V systems with less than 16 batteries, a power cable is necessary depending on the hardware version of the BCI.

5.12.6 Integrating CAN Protocol

For integrating the Super B CAN protocol please contact your Super B Sales representative or Super B Application Engineering department.

5.13 Be in Charge Software and App

Super B provides a Be in Charge Software tool which can be used to read out the internal BMS system of the LFP battery. The software uses a CAN to USB converter to connect to the communication interface. The software can read out the actual status like battery / cell voltages and temperature, but also statistical information. The Be in Charge software can also be used to update the installed firmware of the LFP battery. The Be in Charge software and hardware are not included in the scope of delivery for the LFP battery.

Super B also provides a Be in Charge App for mobile devices such as Android and Apple. The App can be found in the Google Play Store or Apple App Store.

SCAN ME

Figure 21. QR for APP

The Be in Charge App uses the Bluetooth connection of a mobile device to connect to the LFP battery. After the connection has been established all important information can be read out such as voltage / current levels, warnings / errors and state of charge.

⚠ **CAUTION! When updating the battery firmware, the battery might become unresponsive and can disable the output voltage on the terminals for a few seconds to minutes. Please be aware of this happening in your application and make sure this firmware update can be carried out safely.**

5.14 Monitoring and control with Be in Charge software

Note: Product images may differ from the actual unit due to continuous improvements. Design specifications are subject to change without notice.

Connect your CAN to USB device as depicted below.

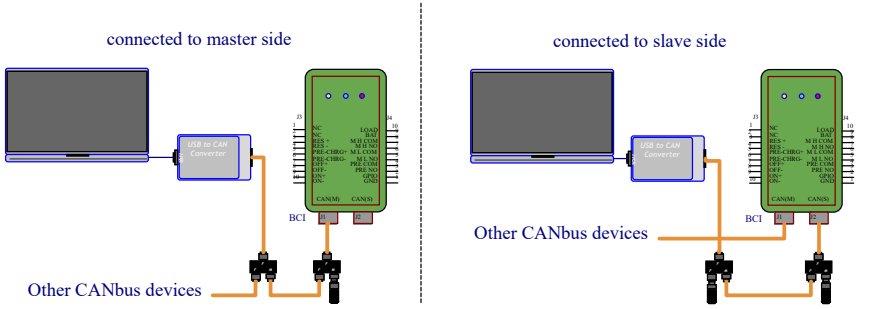


Figure 22. CAN to USB connection

To monitor and control your device, open the Be in Charge software.

To discover your BCI, press the SCAN button.

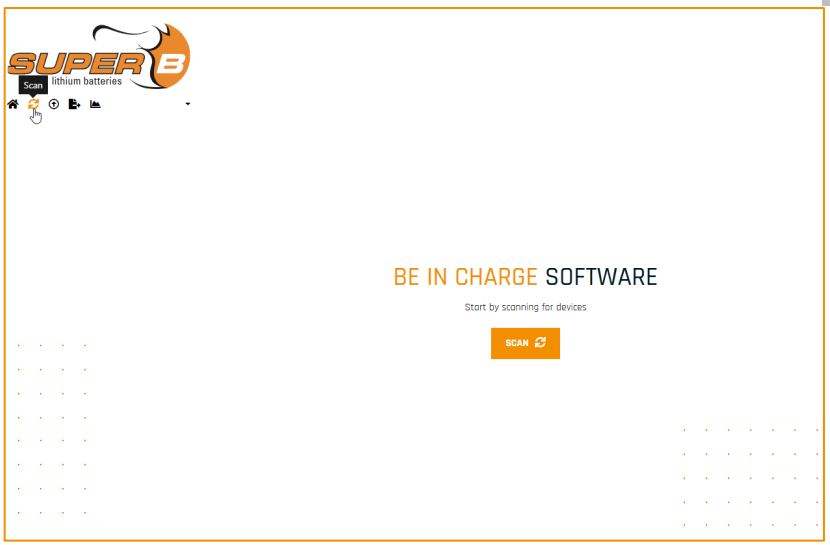


Figure 23. Press SCAN button in Be in Charge software.

You will see the BCI device, the LFP batteries and other devices attached.

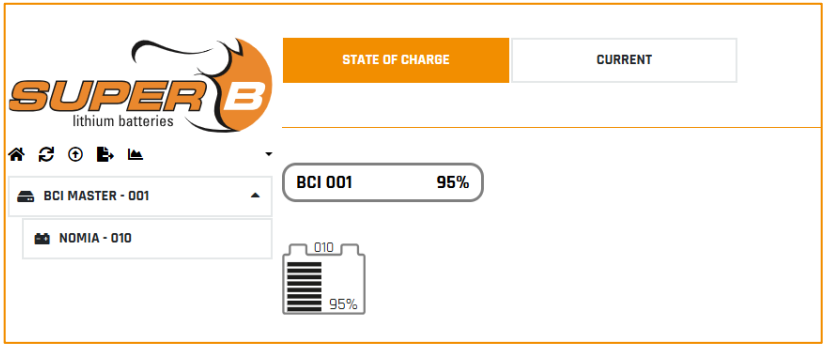


Figure 24. Display shows BCI device, batteries, and connections

Now you can see your BCI and batteries.

5.15 BCI in substring topology

The next pargraphs are about using the BCI in a layered configuration

5.15.1 Introduction and use

In previous chapters the system configurations contained one BCI and one or more batteries. The BCI can also be used in a cascaded configuration which is referred to as substring topology. This is convenient in some applications like:

- Large battery banks. There is a maximum of 100 LFP batteries that can be connected to the BCI (64 LFP batteries is the recommended limit due to bus- and protocol speed limitations).
- Provide redundancy to some level.
- Represent all LFP batteries as one battery bank or one string.

A battery bank can be constructed using a substring topology, supporting configurations of up to 500 LFP batteries. For larger systems, the substring topology remains applicable, though it is advisable to incorporate a higher level of control to ensure efficient operation. In such cases, the system should be designed with multiple parallel substring topologies, each monitored and controlled by a central device, such as a Programmable Logic Controller (PLC). The specifics of where to integrate this monitoring and control device will be detailed in chapter 5.14.2. 'Communication wiring diagram using substring topology.

5.15.2 Communication wiring diagram using substring topology

To establish a substring topology, Battery Communication Interfaces (BCIs) must be connected in a cascaded manner, as illustrated in Figure 25. Communication connection diagram

This setup involves connecting the slave port of one BCI, referred to as the string-BCI, to the master port of another BCI, known as the controller-BCI. The controller-BCI is higher in the hierarchy and manages the string-BCI. However, the string-BCI retains control over the individual batteries connected to it. In the event of an alarm condition triggered by a battery, the string-BCI will autonomously disconnect contactors. Importantly, the controller-BCI cannot override the string-BCI to force it into "ON" state if the associated battery string is not safe to operate. This functionality is implemented for safety reasons.

Note: LFP batteries should only be connected to a string-BCI for the purpose of CAN communication.

Note: Cascading may only occur to a depth of one layer

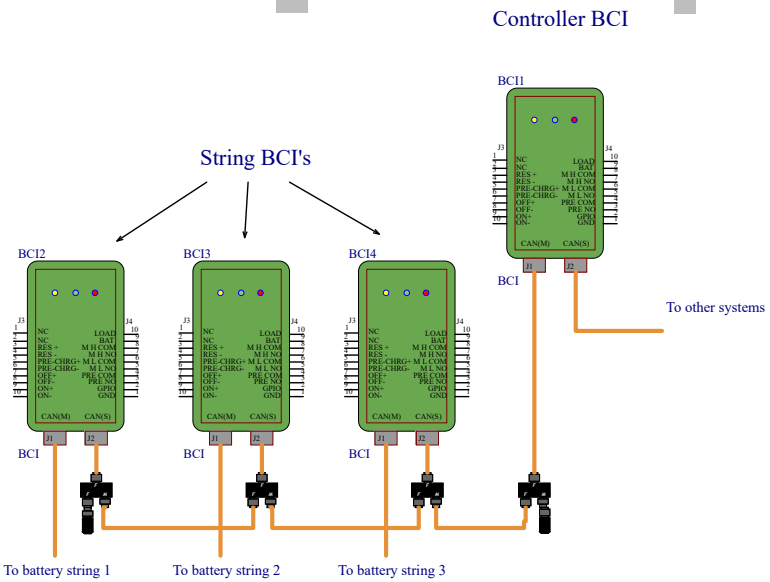


Figure 25. Communication connection diagram

Multiple string BCIs can be connected to a single controller BCI, as depicted in Figure 25. When BCIs are cascaded in this manner, their logical behaviour differs depending on their role in the hierarchy. As a result, they are distinguished as either a string BCI or a controller BCI. The string BCI operates at a lower level, managing individual batteries, while the controller BCI oversees and controls multiple string BCIs higher in the system hierarchy.

5.15.3 Power and communication diagram in substring topology

In Figure 25 a typical setup is shown for a sub-string topology with three string BCI's and a controller BCI. As described before, a BCI has a Master CAN port (J1) and a Slave CAN port (J2). Only the string BCI is connected to the LFP batteries by the CAN master port (J1). The controller BCI may only be connected to the string BCI or string BCI's by its Master port (J1) referred to as SC-CAN Bus (string-controller-CAN Bus). The batteries may not be connected to the SC-CAN-bus.

The string-controller CAN Bus does not require independent power supply. It operates through the communication lines established between the string BCI's and the controller BCI, relying on the system's existing power infrastructure for data transfer and control.

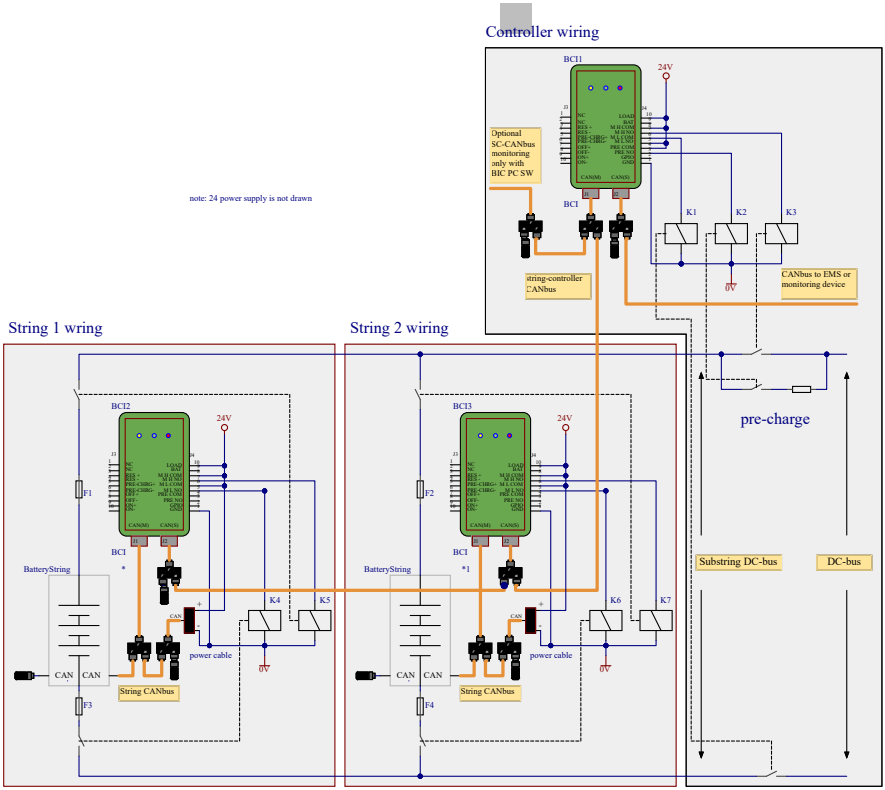


Figure 26. Typical setup

In Figure 26. Typical setup, BCI 1 is the controller BCI, BCI 2 and BCI 3 are string BCIs. The wiring diagram of the power lines is also drawn. As can be seen in Figure 26Figure 25, all BCIs control contactors. The controller BCI controls the contactors (K1, K3) and pre-charge contactor (K2). These contactors connect the local DC-BUS to the DC-BUS. The string BCIs control the contactors between the battery strings and the local DC-BUS (K4, K5 and K6, K7). Note that there is no pre-charge circuit present between the battery string and the local DC-BUS. This is because pre-charging is used for charging capacitive loads when turning on the system and does not have any function connecting the battery string(s) to the local DC-BUS. Therefore, the pre-charge circuit is only present between the substring DC-BUS and the DC-BUS.

5.15.4 Connecting the bank to the DC-BUS

Connecting the substring-DC-BUS to the DC-BUS and connecting a battery string to the substring-DC-BUS must be performed in specific order and under certain conditions. This ensures that inrush currents are limited and remain within the specification of the components in the circuit. The logic

within the BCI only permits closing of the contactors when the conditions for doing so are met. Below is a list outlining the conditions.

- The contactors that connect the local DC-BUS to the DC-BUS can only be closed when at least one battery string is connected to the local DC-BUS.
- Connecting a battery string to the local DC-BUS is only allowed when no battery string is connected yet.
- When the voltage difference between the battery string to be connected and the local DC-BUS is below a certain level. A battery string can only be connected if there are no errors in that battery string.

The BCI does not have an automatic procedure to close the contactors when substring topology is used. The reason for that is that there can be circumstances that a battery string needs to be charged (or discharged) to be allowed to connect to the local DC-BUS. Because the BCI is not in control of charging or discharging the battery bank, controlling the contactors must be done on system level by e.g., an Energy Management System or manually using the Be in Charge software. An example of how to connect a battery to the DC-BUS using the Be in Charge software is described in the following chapter.

5.15.5 Connecting the battery bank to the DC-BUS with use of Be in Charge

Figure 27 shows a screenshot of the Be in Charge software with the status of the contactors in a three-substring system.

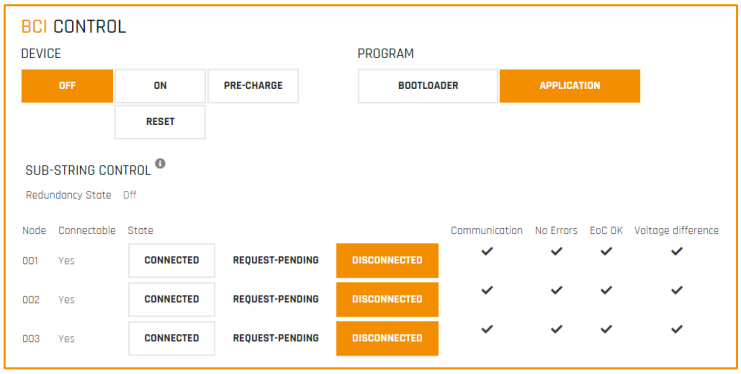


Figure 27. Three-substring system with one contactor ON and two OFF

The system is currently in the OFF state, which is typical during the first-time boot up process. The procedure to engage the entire battery bank to the DC-BUS is as follows:

1. Connect node 001 by clicking on CONNECTED in the row of node 001. REQUEST-PENDING will color orange and DISCONNECTED will color white

2. Wait until CONNECTED in the row of node 001 colors orange,
   string 001 is now connected to the local DC-BUS
3. Connect node 002 by clicking on CONNECTED in the row of node 002.
   REQUEST-PENDING will color orange and DISCONNECTED will color white
4. Wait until CONNECTED in the row of node 002 colors orange,
   string 002 is now connected to the local DC-BUS
5. Do this until all strings are connected.
6. If all strings are connected click ON (top left).
   The PRE-CHARGE button will color orange and when the pre-charge time has passed the ON button will color orange.
7. The battery bank is now connected to the DC-BUS.

This sequence ensures that the battery bank is engaged safely and within the required parameters, minimizing the risk of damaging components or overloading the system

5.15.6 Connecting the battery bank to the DC-BUS by CANopen control

When connecting the battery bank to the DC-BUS using Be in Charge, all CAN Bus commands, and the necessary logic are handled by the software application automatically. However, if the installation requires controlling the contactors via an external device such as a PLC or an industrial PC, the same logic must be implemented within that device. Below is a summary of steps that need to be implemented.

Controlling the BCI to close a battery string contactor is done in an interrogative manner. It involves:

- Fetching information if it is allowed to close the battery string contactor.
- If so, request to close the battery string contactor.
- Fetch information to see if the battery string contactor was closed by the BCI.
- Do this for each string until all are connected.
- Please refer to the CANopen documentation (see section 6.2) for the BCI for the implementation of this interface.
  The local DC-BUS is now fully connected.
- Close the contactor of the controller BCI to connect the local DC-BUS to the DC-BUS.
  The battery bank is now connected to the DC-BUS.

Requesting the BCI to close a contactor will be granted if the conditions stated in the above list are met. If not, the request will not be executed. See chapter 5.15.9, Redundancy, for more details.

5.15.7 Configuring BCIs for substring topology

When BCIs are used in a substring topology they need to be configured so they can execute the logic, corresponding to either the substring contactors (BCI 2 and BCI 3) or the main contactors (BCI 1) see Figure 26. Typical setup.

A BCI is configured as a standalone device by default for systems described earlier in this manual. This can be changed by using the Be in Charge software.

The BCI can be configured in three functional modes:

1. Standalone BCI functionality (BCI), default. This is a BCI which is standalone and will automatically switch off the contactors in case of an error. The terminology only offers a distinction with the Controller BCI functionality
2. Controller BCI functionality (cBCI). This BCI will control the string-BCIs through the local CAN-bus. It allows for redundant sub-strings, so its own relay/contactor can remain closed even if one (or more) substrings are disconnected, for example if one string is in error and may not be charged or discharged.
3. String BCI functionality (sBCI). Similar functionality to the Standalone BCI. However, incoming relay commands need to come from a Controller BCI. Manual commands from the Be in Charge software are not accepted to ensure the expected system behaviour.

In Figure 28, Select functional mode, a screenshot is shown of the dropdown menu to set the BCI in the mode that corresponds to the correct functionality.

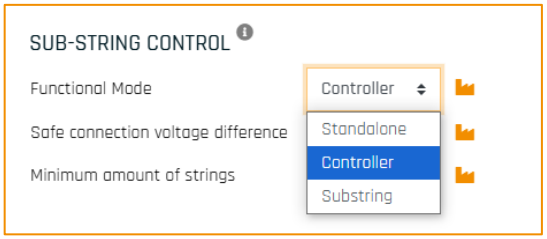


Figure 28. Select functional mode

5.15.8 Set safe connection voltage difference

In Section 5.15.4, it is stated that when connecting one substring to another, the voltage difference between the two substrings must fall within a specified range. If the voltage difference exceeds or falls short of this range, the request to connect the substrings will not be granted. The value of this range can be set only in the controller BCI. This is because the controller BCI has the information of all the battery string voltages and therefore it could compare them to see if it is allowed to connect substrings to the local DC-BUS.

This value can be adjusted by using the Be in Charge software. Figure 29. substring control depicts a screenshot of this parameter.

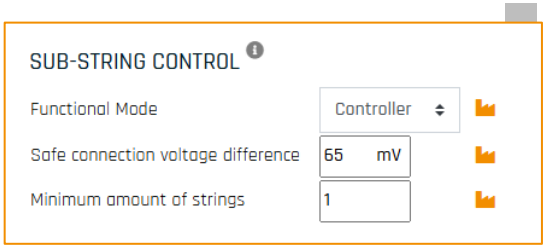


Figure 29. substring control

Safe connection voltage difference must be set in such a way that when the contactor closes the current running through all components involved in the circuit will be within their specification. Consider the contactor, wiring, fuses, the batteries, etc.

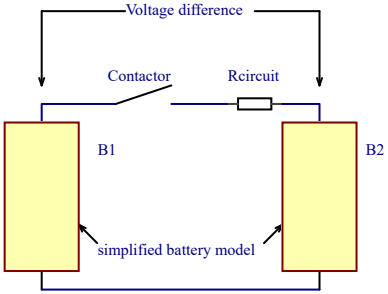


Figure 30. Simplified circuit

Figure 30 shows a simplified circuit for clarification how to acquire the value for this setting. In this figure B1 and B2 represent two battery strings. The contactor will connect the strings together. When that happens, a current will flow through the circuit depending on the voltage difference of the battery strings and the circuit resistance. $R_{circuit}$ represents all the resistance in the circuit apart from the battery strings themselves. So, when the contactor closes the current that will flow becomes: $I = \frac{V_{difference}}{2R_{battery}+R_{circuit}}$

The value of the *Safe-connection Voltage difference* must be adjusted in such a way that all the components in the circuit can handle this current.

For convenience, the value is referred to one battery. This means that the cBCI will consider the number of batteries in series in the string.

When more strings are connected in parallel the impedance of those in parallel becomes lower and therefore the current will become higher when the contactor closes. With properly designed

contactors, fuses and cabling, the impedance of the battery should be dominant in the circuit. Therefore, as rule of thumb it can be stated that:

$$V_{safe\ connetion\ difference} \leq I_{max} * R_{battery}$$

With I_{max} being the maximum peak that is allowed and $R_{battery}$ the impedance of the battery type being used. Contact Super B for the "R battery" information

5.15.9 Redundancy

A substring topology battery bank allows redundancy regarding battery strings. For a full redundant system two (or more) complete battery bank are needed. The redundancy referred to in this chapter is redundancy of battery strings.

It is possible for a battery bank with substring topology to remain operational even if one or more battery strings are not participating. There may be instances where a battery string cannot be used due to various reasons. For example, if a string becomes too warm or communication is lost due to a broken CAN cable, the corresponding string-BCI (sBCI) will open its contactor, effectively disconnecting that battery string from the system. As a result, the string will no longer participate in the battery bank, but the remaining strings can continue to operate normally, ensuring the overall functionality of the battery bank is maintained.

The logic of the cBCI opens the main contactor of the battery bank if the number of participating battery strings is zero (at least one battery string should participate). This means that in the above scenario, one cBCI opens its contactor, the cBCI will keep the main contactor closed if at least one string is connected. It is possible for the user to change this value with the Be in Charge software by editing minimum number of strings (see section 5.15.8, Figure 29. It can be set between one and the number of battery strings in the battery bank. In case it is set to the number of battery strings in the battery bank, the cBCI will open the main contactor if one battery string does not participate anymore.

5.15.10 Connecting the bank to DC Bus with redundancy enabled

In Section 5.15.4 is described how to connect the battery bank to the DC-BUS without redundancy enabled by setting minimum number of strings to 1. When redundancy is used, it might occur that a string needs to be charged first before it can be connected to the other strings when the voltage difference is too big. This contradicts with the redundancy logic which does not allow single string operation. To solve this, the redundancy logic has a startup sequence state which allows a single string connection to the DC-BUS. This way a single string can be charged to meet conditions to connect it together with other strings to the local DC-BUS. Figure 31, sequence active, illustrates this scenario, where Node 2 is connected, while Nodes 001 and 003 remain unconnected. Additionally, the main contactor is in the "ON" position. The redundancy state indicates that the

redundancy sequence is active, signaling the system's startup state.

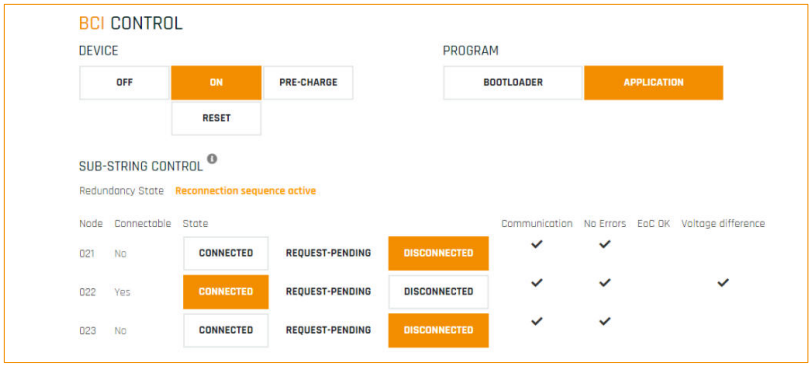


Figure 31. Redundancy state startup sequence active

Once the number of strings connected match the minimum number of strings, the redundancy state will change to operational. See Figure 32, Redundancy state operational.

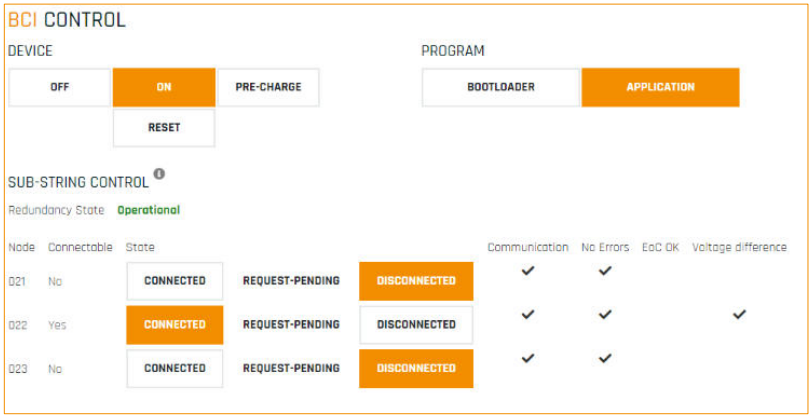


Figure 32. Redundancy state operational

5.16 Resolve connection rejection

When a battery string cannot be connected to the local DC-BUS, there can be multiple reasons. To obtain the reason it is most convenient to use the Be in Charge software and, because this might involve more detailed information of the system, the local CAN-Bus must be used to interface with (see section 5.15.3, in substring topology, Figure 26. Typical setup).

The following reasons might occur:

1. One or more of the batteries is in alarm. This will be indicated on the sBCI. Refer to section 6.6, Status of the battery bank, to resolve this.
2. The voltage difference is too big. This occurs when one or more strings are connected to the local DC-BUS and one or more string are too high or too low in voltage to be connected. To solve this is to decrease the voltage difference by charging or discharging the string(s) that is (are) connected. The most obvious method is usually to first connect the string that is the lowest in voltage and charge until the voltage difference is small enough to connect the other strings.
3. There is no communication with the string. Check if the sBCI is powered and connected properly to the cBCI.The sBCI or cBCI may be in error due to not properly configured. Verify if the settings are correct and check the alarms from the sBCI and cBCI.



5.17 General purpose I/O

The BCI has an output function that - as of software version 2.36 - provides a signal for chargers. It can only be used in combination with LFP batteries that support this feature also. Contact Super B to obtain the software.

This mechanism controls chargers by using the pin IO1 to allow to charge if it is pulled

low by the BCI. The BCI will inquire from the LFP batteries if charging is allowed. This

function does not control the state of the BCI (like ON state or OFF state) should charging not be allowed, it only signals towards the charger. See section 4.1, Electrical specifications.

Table 17. General purpose I/O

Pin 1 (J4)	GND
Pin 2 (J4)	IO1

6. BCI use

6.1 General information

⚠ **CAUTION! In case of an undervoltage shutdown, charge immediately.**

IMPORTANT! Follow the Safety guidelines and measures of Chapter 1.

If a preconfigured BCI has been ordered at Super B, the steps in section 6.2 are not necessary. If this is not the case, configuring can be done as described in section 6.2, Configuring the BCI and the battery bank.

All the battery (bank) values can be monitored on both BCI ports. The battery bank can also be controlled via both ports. If the slave port (J2) is used for another protocol than CANopen, monitoring and control of the battery bank using the Be in Charge software can only be done on the master port (J1).

6.2 Configuring the BCI and the battery bank

Before the BCI and battery bank can be used, the BCI needs to be configured, and the batteries need to have a unique battery Node ID. Configuring the BCI and the LFP batteries can be done by using the Super B Be in Charge software.

For connecting the BCI to a computer, a CAN to USB converter is required, see section 4.7, Peripheral equipment, Table 12. Refer to section 5.12.2, Figure 18 for connecting the CAN to USB converter to the BCI.

6.3 Battery ID's

In multi-battery systems, each LFP battery shall have a unique Node ID number. The default Node ID for a Super B LFP battery is ten. This number shall be changed depending on the configuration. If a complete system has been ordered at Super B, the LFP batteries will have been preconfigured, and renumbering is not necessary. If this is not the case, renumbering can be done manually.

Any Node ID number between 2 and 100 can be assigned to an LFP battery. Node ID 1 should not be used for LFP batteries as it is reserved for the BCI. We recommend not to use Node ID 10 for multi battery configurations as it may be confusing in case an LFP battery is added to the system.

Multiple LFP batteries with the same number will result in unpredictable behaviour of the system.

It is recommended to label the LFP batteries with their assigned Node ID. Try to number the LFP batteries in such a way that the battery bank configuration (number in parallel, number in series) can be easily recognized. For example, in a four series two parallel system use Node ID 11, 12,

13, 14 for the four LFP batteries in series and Node ID 21, 22, 23, 24 for the other four LFP batteries in series.

6.3.1 Battery ID renumbering procedure

The following paragraphs explain how to renumber batteries ID's in different setups.

6.3.2 Renumbering batteries for a new system using point-to-point connection

Use the following procedure to renumber the Node ID for each LFP battery in the system:

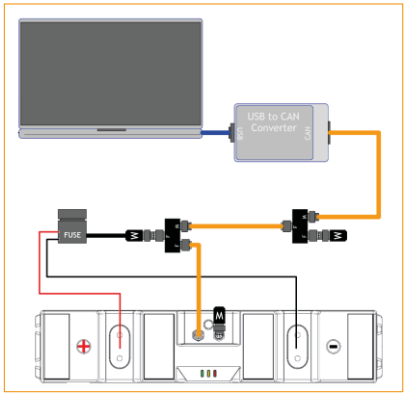


Figure 33. Example point-to-point connection to a Nomada battery

1. Connect one LFP battery to the CAN Master bus (see section 5.12)
2. Select the 'Scan' button to start scanning for devices. You can also select the scan/refresh icon in the top-left corner.
3. To make changes to battery Node ID it is necessary to set the user level to 'Expert User' (Figure 34, Figure 35)

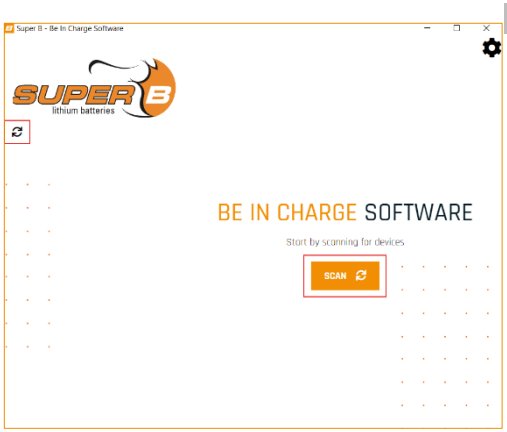


Figure 34. 'Scan' for devices

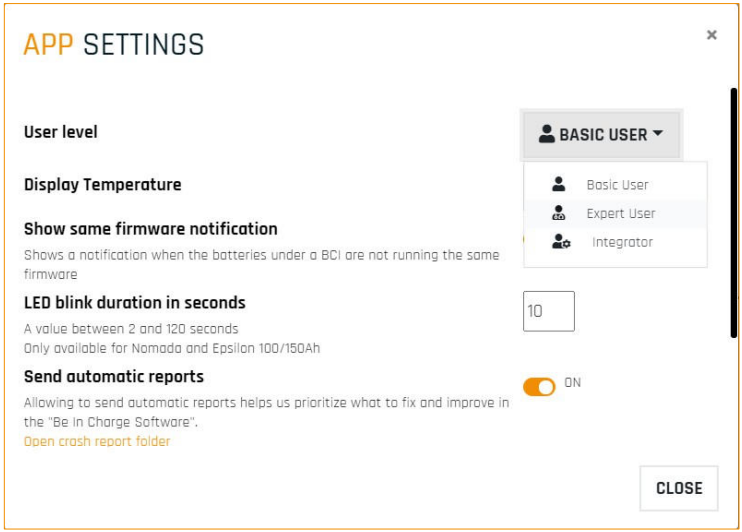


Figure 35. Set to expert user

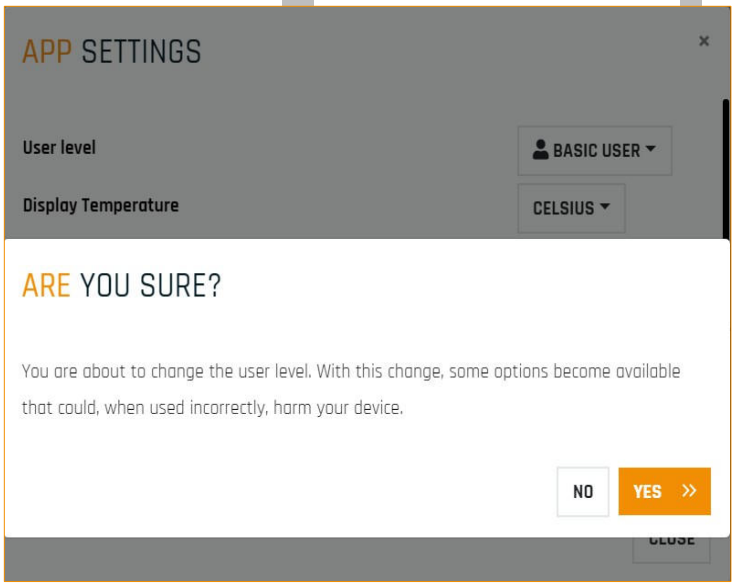


Figure 36. Confirm

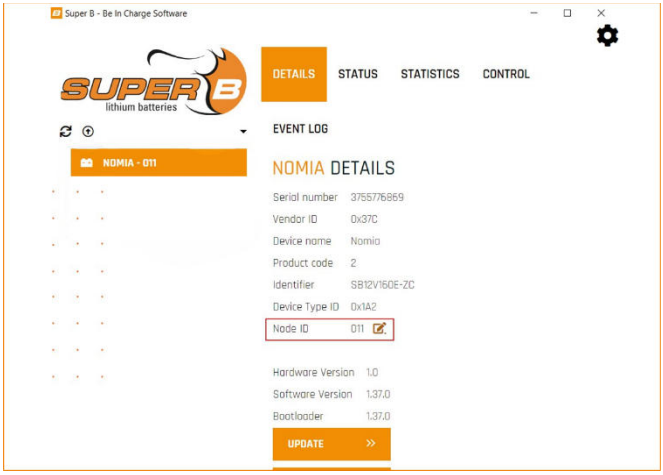


Figure 37. Change the battery 'Node ID' of the first LFP battery

Navigate to the 'Details' page and make sure to change the battery Node ID of the battery to 11 (Figure 37, Figure 38).

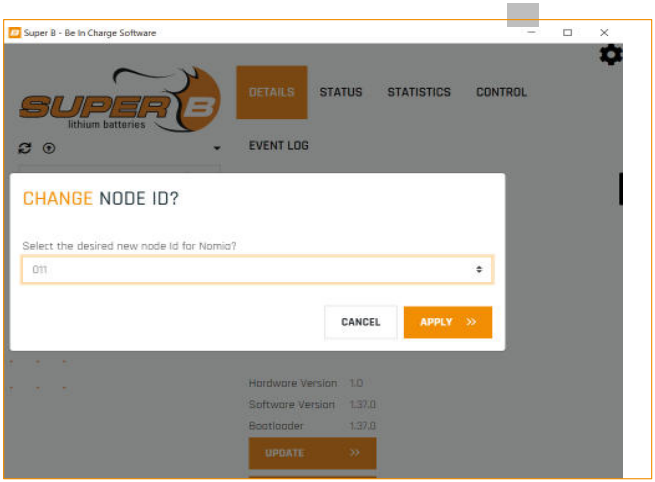


Figure 38. Select the desired new Node ID from the dropdown menu

1. Verify if the correct number is assigned to the LFP battery by selecting the scan/refresh icon on the top-left corner.
2. Connect the next LFP battery and repeat step 4 and 5 until all LFP batteries have been assigned a unique Node ID.

Once all the batteries are renumbered, connect the BCI and press the Full scan button, as shown in Figure 39.

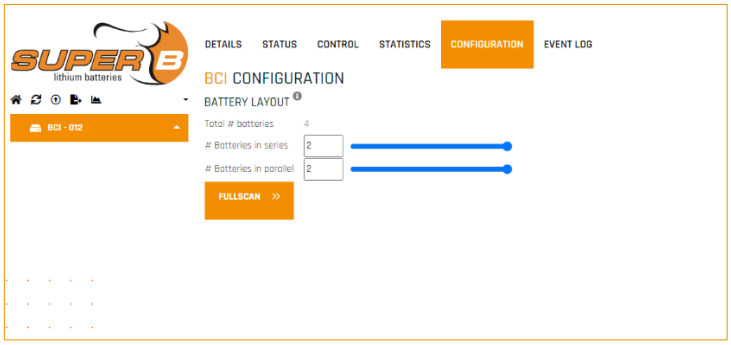


Figure 39. Configure the BCI by pressing the Full scan button

Continue with the LFP battery layout as described in section 6.4, Battery layout.

6.3.3 Replacing an LFP battery in an existing system

- Use the procedure in section 6.3 to renumber the new LFP battery with the Node ID of the LFP battery that will be replaced in the existing battery system.
- Safely remove the LFP battery from the existing system, including all the power cables and CAN cables.
- Install the new LFP battery in the system.
- Press the Full scan button as explained in section 6.3.2, step 7. This will re-configure the BCI with the new LFP battery.

6.3.4 Renumbering batteries through the BCI

Note: Super B always advises to use a point-to-point connection (See section 6.3.2) to renumber Node IDs of LFP batteries in an existing installation

Use the following procedure to renumber the Node ID for each LFP battery in the system.

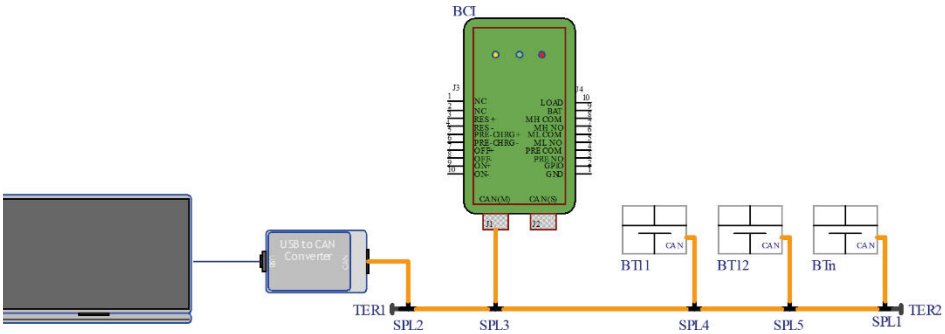


Figure 40. Renumber battery one

Connect one LFP battery to the CAN Master bus (see section 5.12.2, figure 15).

Select the 'Scan' button to start scanning for devices. You can also select the scan/refresh icon in the top-left corner. See Figure 41.

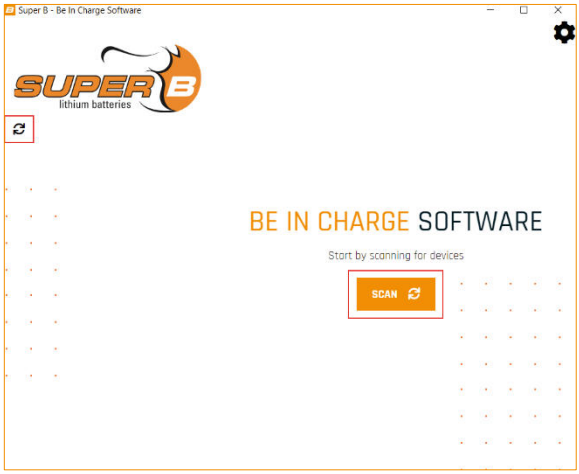


Figure 41. Scan for devices

1. To make changes to battery Node ID it is necessary to set the user level to 'Expert User' (Figure 42, Figure 43).

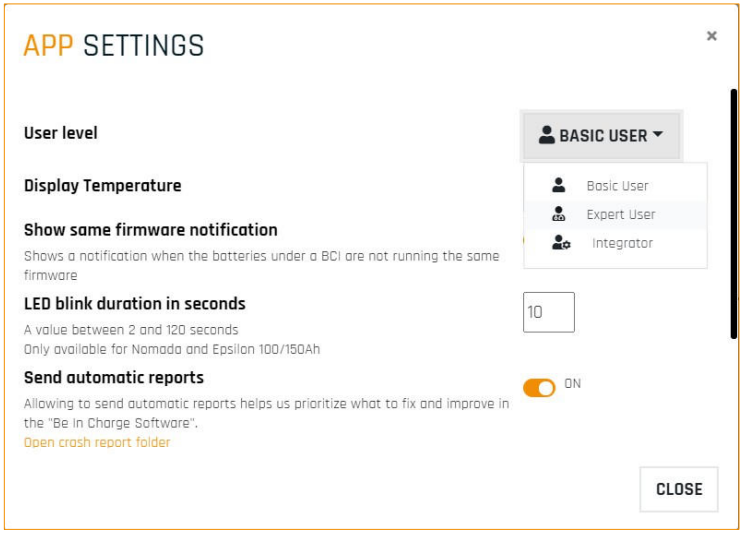


Figure 42. Set user level to 'Expert User'

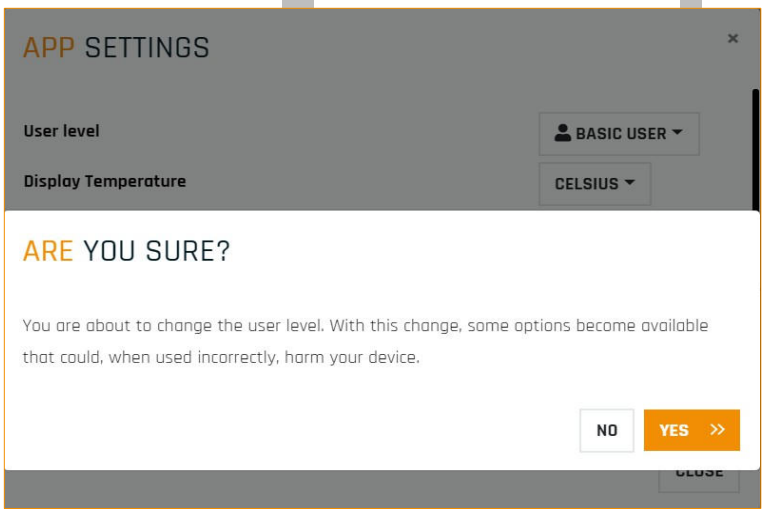


Figure 43. Confirm expert user

2. Navigate to the 'Details' page and make sure to change the battery Node ID of the first battery to 11 (Figure 44, Figure 45).

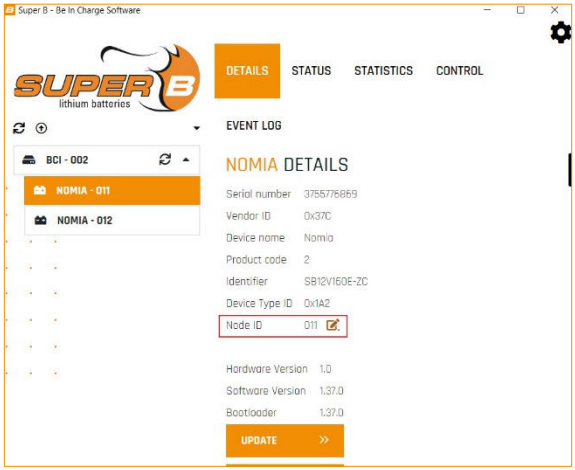


Figure 44. Change the battery "Node ID" of the first LFP battery

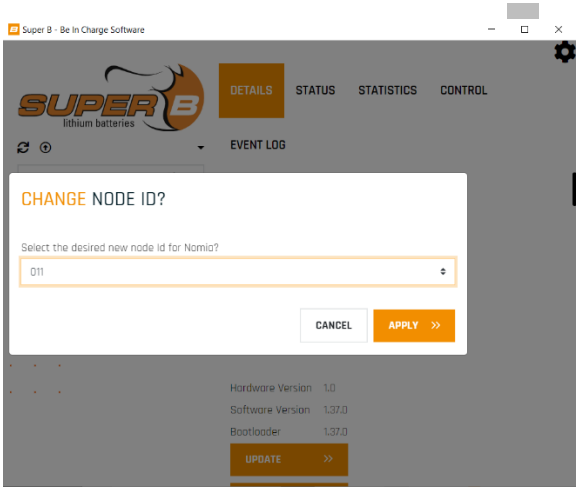


Figure 45. Select the desired new Node ID from the dropdown menu

3. Verify if the correct number is assigned to the LFP battery by selecting the scan/refresh icon on the top-left corner.
4. Connect the next LFP battery and repeat step 4 and 5 until all LFP batteries have been assigned a unique Node ID
5. Press the Full scan button as explained in Step 7 of section 6.3.2. This will re-configure the BCI with the new LFP battery

Continue with the battery layout as described in section 6.3.2.

6.4 Battery layout

The BCI represents a battery bank as one LFP battery. To be able to do so, the BCI must be informed about the layout of the batteries. This means configuration must be done to "tell" the BCI how the LFP batteries are connected (parallel and/or series). The number of LFP batteries that are connected is detected by the BCI itself by doing a full scan. If the BCI is not configured by Super B the end user must follow the procedure below to set the LFP battery layout.

1. Connect all LFP batteries to the BCI via the CAN connection as described in section 5.12.2, Connecting the CAN network cables.
2. Perform a scan by selecting the scan button or refresh icon on the top-left corner. The Be in Charge software requests the BCI to scan for connected LFP batteries. When the scan is completed, the number of LFP batteries connected will be shown in the "configuration tab" in the "Total # batteries" field (see section 6.5, Figure 46).
3. Configure the battery bank with the slide bar in the "# Batteries in series" and "# Batteries parallel" fields. The number of LFP batteries in series multiplied by the number of LFP

batteries in parallel should be equal to the total amount of LFP batteries. The Be in Charge software will not allow an invalid configuration

6.5 Input level configuration

The BCI contains four hardware inputs: OFF, Reset, ON and Pre-charge (see Figure 46). The inputs can be used to control the BCI. With the "Input level configuration" box you can select whether the inputs should be active high or active low.

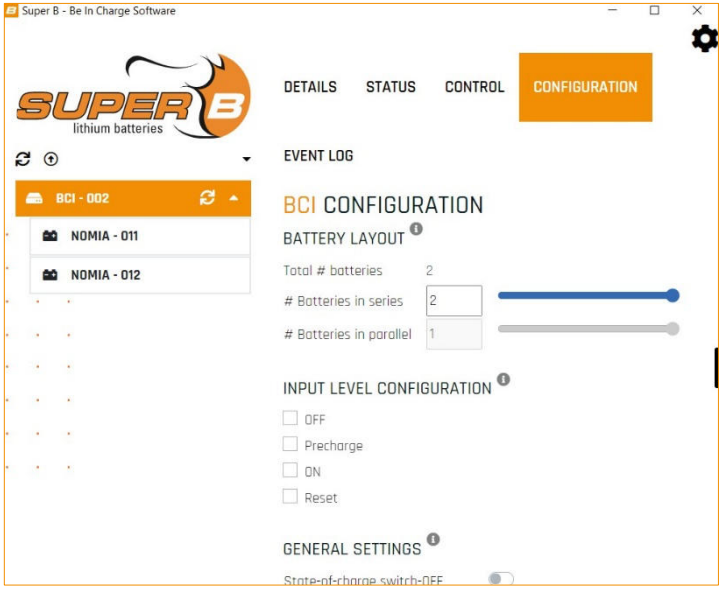


Figure 46. Be in Charge Software - Input level configuration

6.6 BCI Modules

The BCI Modules (see Figure 47) can be used to select the communication protocol. The default setting is CANopen (CiA418 and Super B features). There is also an option to use proprietary protocols. This list is subject to change. The list may look different depending on the software version.

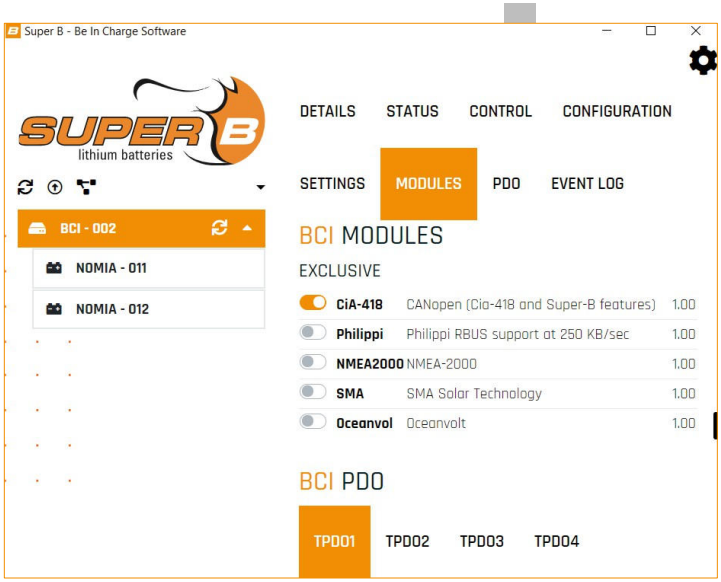


Figure 47. BCI Modules and communication protocol

6.7 Monitoring and controlling the LFP battery bank

All the LFP battery (bank) values can be monitored and controlled on both ports if the slave port (J2) uses the CANopen protocol. See section 4.6, In case a different CAN protocol is selected on the slave port (J2), then monitoring and control can only be done using the master port (J1) using the Be in Charge software.

6.8 Pre-charge adjustment

When the BCI is powered externally (see section 5.9), it is possible to adjust the pre-charge duration in the below section (see Figure 48). This can only be adjusted when "External power" is enabled.

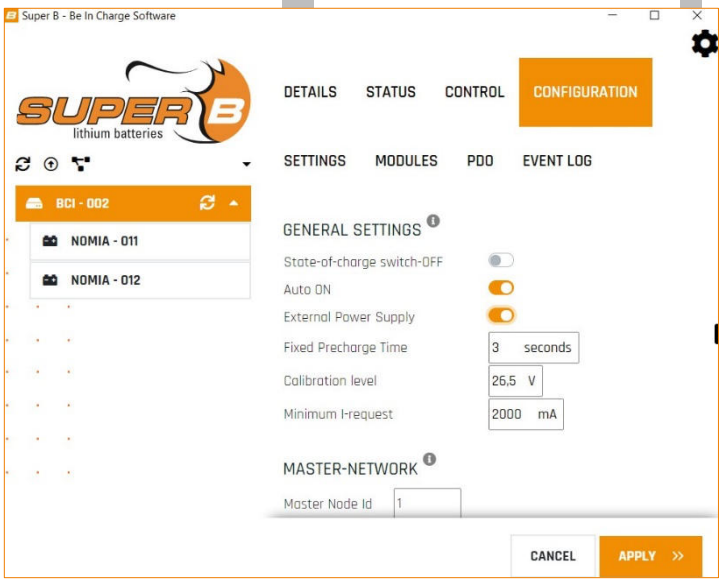


Figure 48. BCI Pre-charge time

6.9 General settings: Automatic control

The Auto On enables the automatic start up option (see section 3.5.1, Auto-on). The main relay(s) will be engaged automatically when the BCI starts up when all the alarms are cleared (see Figure 49). When Auto On is disabled the Control buttons in the control tab or the external control inputs can be used.

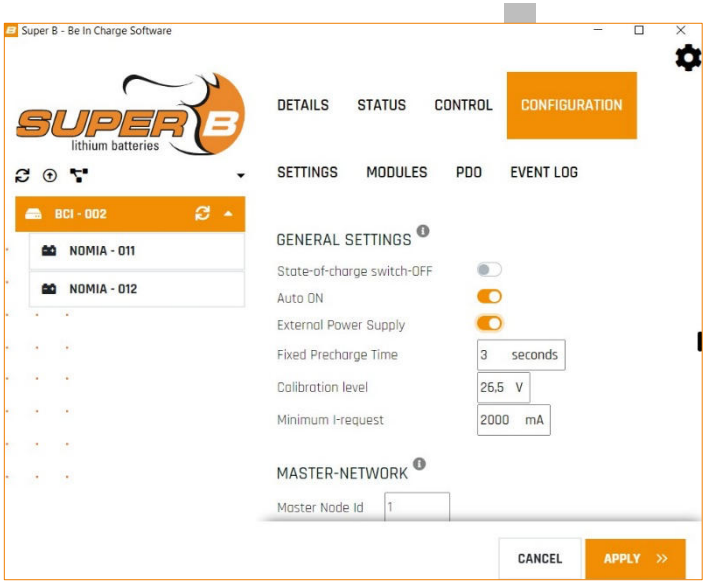


Figure 49. BCI Pre-charge time

6.10 General settings: State-of-charge switch-OFF level

The State-of-Charge switch-OFF level is a function that makes it possible to put the BCI in shutdown state (see section 3.5.2) at a certain level of state of charge. This level can be set by the user (see Figure 50). By default, this function is disabled.

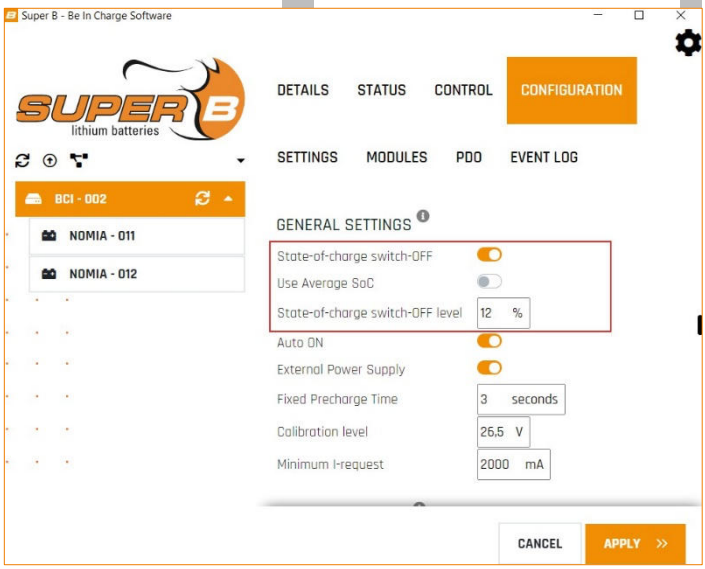


Figure 50. SoC switch OFF level

6.11 Charge Current request compliance (I-request)

Charge current request is a CiA 418 CANopen object for batteries meant to control chargers to deliver the charge current that is requested by the battery. All Super B LFP-batteries with a CAN interface and the BCI are compliant with the Charge Current request, but it is referred to as I-request which will be used through the rest of the document. I-request is a dynamic value and can be anything between zero and the maximum charge current the battery can accept. If a charger complies with the charge current requested object, the battery or battery bank will charge and balance out in the fastest and the safest way. This CANopen object is described in CiA 418 CANopen documentation (Obj. 0x6070).

As stated before, the BCI collects information from the connected batteries and presents the connected batteries as one battery. It also uses the I-request information from all the batteries to calculate the charge current that is needed to charge the battery bank in the most efficient way and, the BCI makes sure that all the batteries get no more current than the charge current they request.

In addition, chargers which are used with a BCI Module (See Section 6.6. BCI Modules), such as the Elcon Bus module or the Studer module, are I-request compliant by design.

Please refer to the Usage & maintenance manual for more details related to the charging by I-request.

6.11.1 General settings: Minimum I-request

⚠ **WARNING! Do not set this value higher than the specification of the battery used.**

The minimum I-request value is needed to properly balance out a battery bank when a charger is used that complies with I-request. The minimum I-request value must match the maximum continues balance current of the batteries that is used in the battery bank. The BCI needs to know this value to charge and balance out the battery bank in the least amount of time.



Figure 51. Minimum I-request.

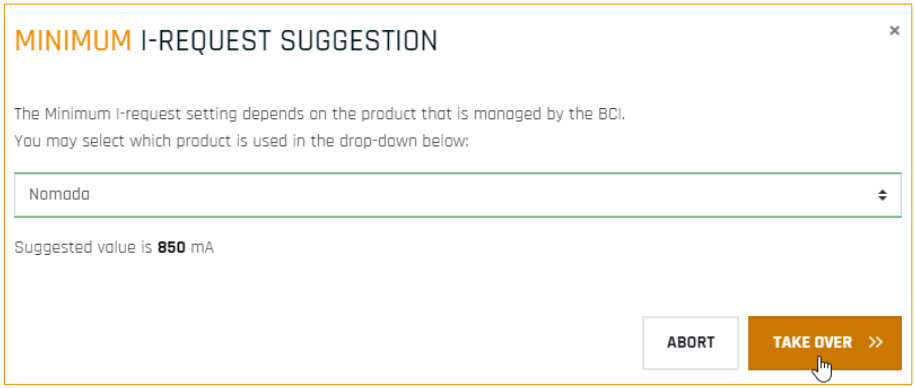


Figure 52. Select an appropriate product



Figure 53. Charge setting screen

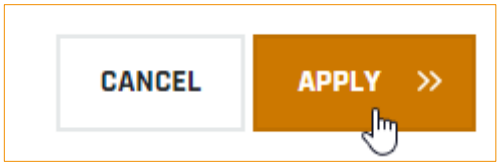


Figure 54. Select an appropriate dialog box

The value depends on the battery type used. Refer to the battery manual or consult Super B for properly setting this value.

6.11.2 I-request Control Loop

⚠ **WARNING! These setting should only be done by users familiar with PID control loop systems.**

⚠ **WARNING! System behaviour and wrong settings can lead to unstable behaviour of the PID loop.**

Note: The default settings usually work well for most cases.

There are applications where a battery bank is being charged while there are also consumers present on the DC-BUS. When the BCI would only request the charger for current that is indicated by the batteries, the other consumers would consume current from their current from the batteries. Therefore, the battery will get less current than it requests for.

It could even be that the battery needs to provide current together with the charger to provide enough current for the consumers. Which means the batteries will be discharged. In these cases, the BCI should not just request current just for the batteries but also current for the consumers. This is done by the Charge Current Request control loop, which can be used in these situations.

What the BCI does when the Current control loop is used, is compare the current it requests with the current the battery bank gets. If this differs the BCI will change the request current thereby controlling the charger to deliver the current needed for the battery bank and for the consumers. The control loop does this continuously to compensate the requested current for variance in consumer currents. For example, when a light is turned on or off or to compensate for consumers that vary in power consumption by themself like refrigerators.

The charge current control loop consists of a PID control loop. In general, a PID control loop has several parameters to tune the control loop to the specific environment it is used in. In Figure 55 a screen shot of all parameters for tuning the PID loop is shown.

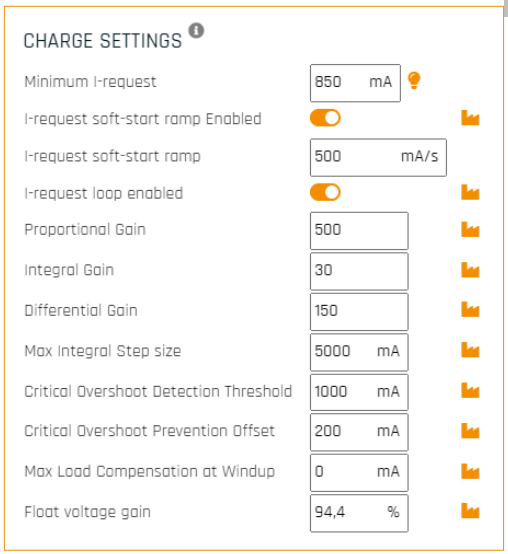


Figure 55. PID parameters

The following will describe the need and effect of the parameters shown in Figure 55.

6.11.3 Minimum I-request

The minimum I-request is to make sure all LFP batteries will be fully charged without overcharging any battery. See section 6.11.1, General settings: Minimum I-request, for more details. It does not have effect on the dynamic behaviour of the PID control loop.

6.11.4 I request soft-start ramp enabled

This enables or disables the limiter for maximum current increase per second. This is a current ramp limiting function that can slow down the charging request on sudden high current request from the battery bank. It can prevent unstable behaviour.

6.11.5 I-request soft-start ramp

This value sets the maximum current increase per second if I-request soft-start ramp is enabled. The recommended current increase per second is 100 – 1000 mA/s.

6.11.6 I-request loop enabled

This enables or disables the current controlled loop.

6.11.7 Proportional gain

This is the K_p of a classic PID loop.

6.11.8 Integral gain

This is the K_i of a classic PID loop.

6.11.9 Differential gain

This is the K_d of a classic PID loop.

6.11.10 Maximum integral step size

This is the maximum step in current that the integrator of the PID loop can increment every second. This helps with preventing a quick rise in the requested current for large systems.

6.11.11 Critical overshoot detection threshold

In case a battery does not request any charge (e.g. due to low temperature on the cells), but it receives more than this configurable value, the BCI will quickly detect this as an overshoot. Then the PID loop quickly resets the requested system current to zero.

6.11.12 Critical overshoot prevention offset

In case a battery does not request any charge (e.g. due to low temperature on the cells), the BCI will regulate the current with a small offset to prevent overshooting and charging the battery by accident due to system dynamics.

6.11.13 Maximum load compensation windup

When the BCI is requesting the maximum amount of current for the battery bank, it cannot compensate for any consumers or loads. This value extends the windup limit to allow for load-compensation by consumers in such situations.

6.11.14 Float voltage gain

If the default settings result in unstable behaviour of charge current, contact Super B to properly configure the control loop as this is a system-dependent configuration.

6.11.15 Saving a configuration

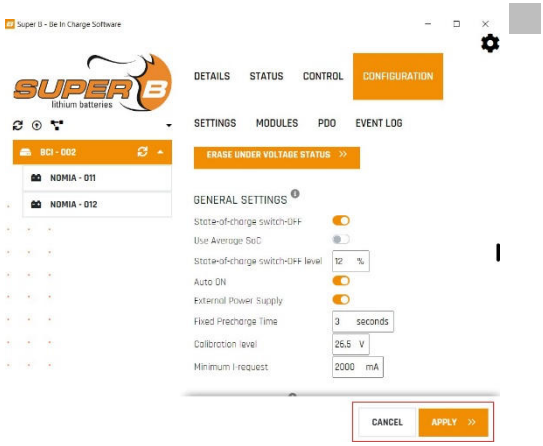


Figure 56. Saving a configuration

To save a configuration select the "Apply" button on the bottom-right corner (see Figure 56).

6.12 Status and control

The state of the BCI can be controlled by the Be in Charge software. The Be in Charge software can read and set the state of the BCI. The current state of the BCI is displayed on the indication bar, as shown in Figure 57, under the BCI Control tab.

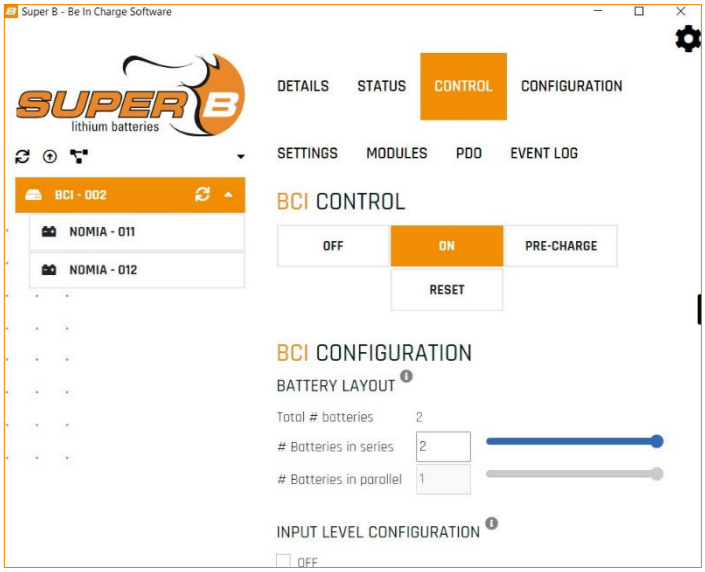


Figure 57. BCI Control tab

The state of the BCI can be manually controlled by using the buttons underneath the BCI Control tab. The reset button can be used to reset the BCI when the LFP battery is in alarm state.



Figure 58. Reset control button

More information about the different state and the corresponding behaviour can be found in section 3.4.2

6.13 Status of the battery bank

The status of the battery bank can be seen in the Status tab of the Be in Charge software (see Figure 59 to Figure 65). The information shown in the image is subject to change depending on the Be in Charge software version. They show respectively the BCI in ON state, OFF state (due to battery error), warning state (only available as of BCI SW version 2.35 or later) and 1Ah undervoltage recovery state.

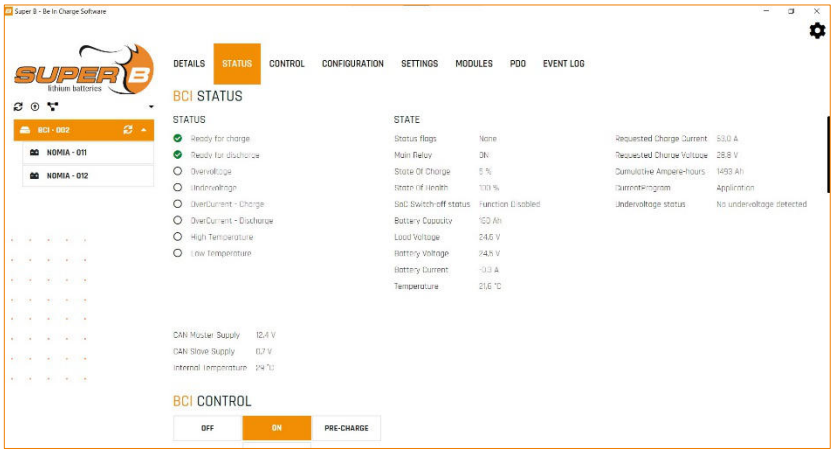


Figure 59. BCI Status tab: ON

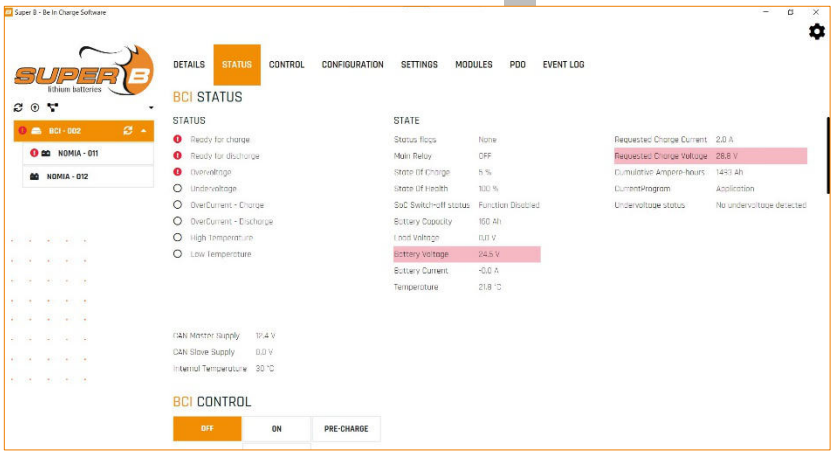


Figure 60. BCI Status tab: OFF – battery in overvoltage

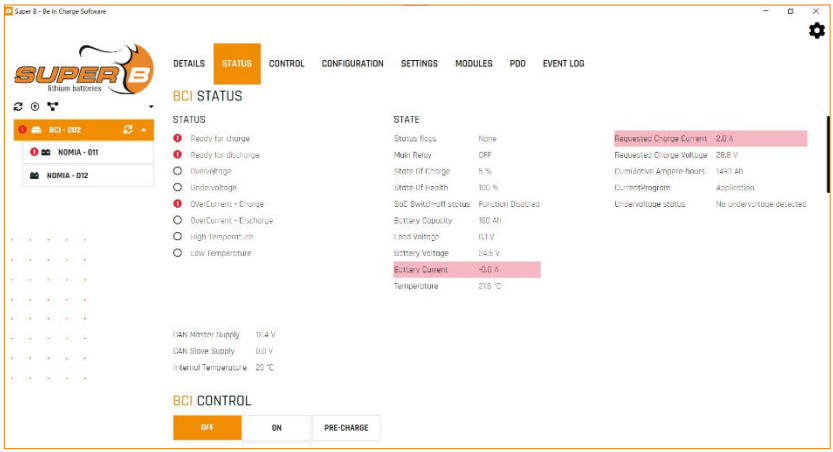


Figure 61. Status tab: OFF – battery in overcurrent while charge

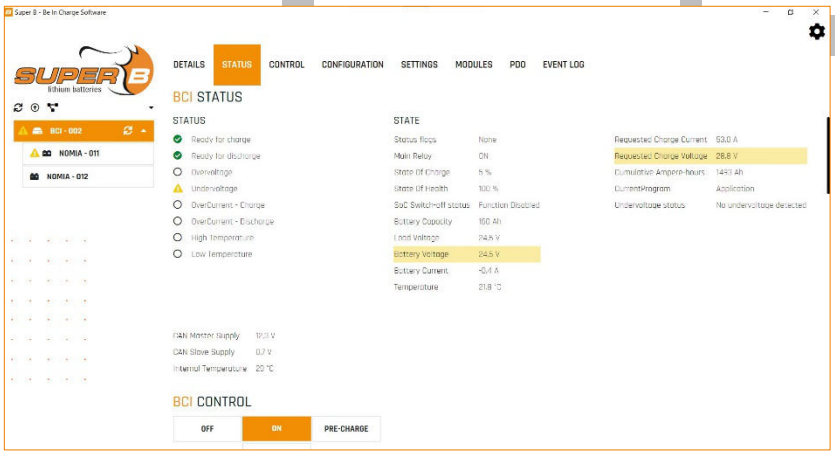


Figure 62. BCI Status tab: undervoltage warning

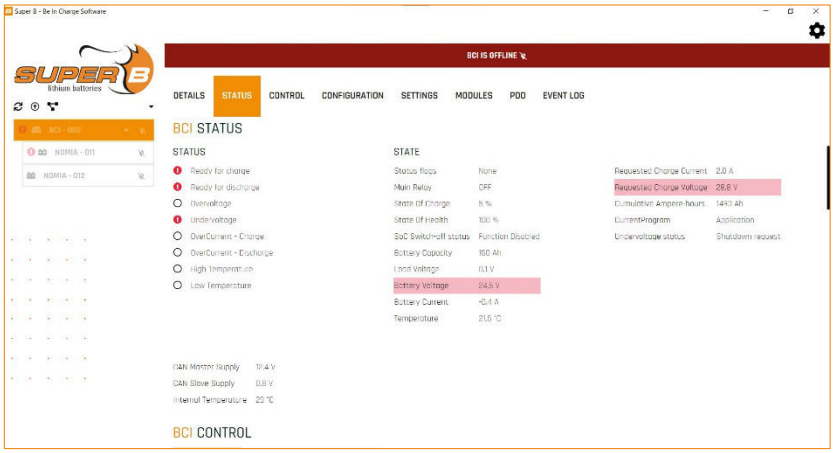


Figure 63. BCI Status tab: undervoltage complete shutdown

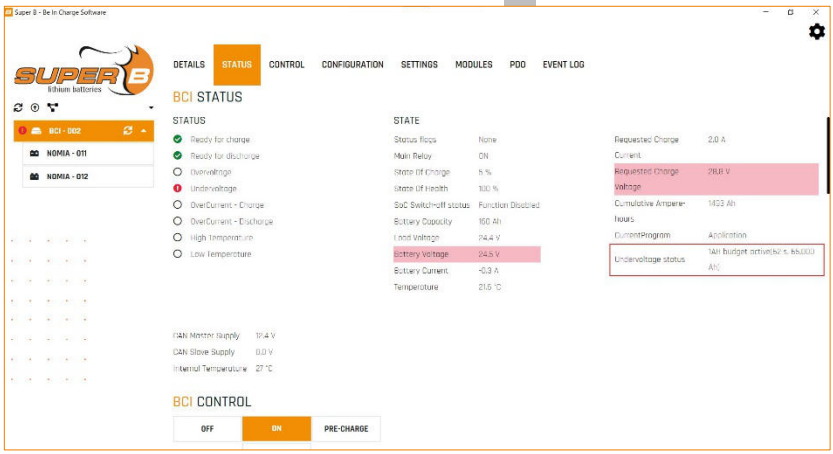


Figure 64. BCI Status tab: 1Ah undervoltage recovery state

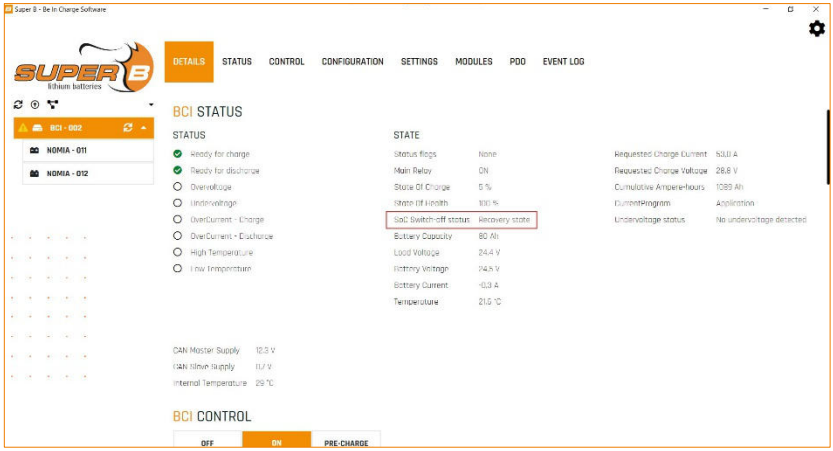


Figure 65. Be in Charge status tab: SoC recovery state (see section 3.4.2)

6.14 Battery heating

Note: This functionality is available with system batteries with integrated heater elements.

Note: This functionality is available in software version V2.40 and higher and in the Be in Charge Software version 1.5.0 and higher.

Typically, LFP batteries cannot be charged at temperatures below 0° C (32° F). However, Super B offers a range of LFP battery types equipped with integrated heaters, enabling charging even when the ambient temperature is below freezing. The operation of these heaters is managed by the Battery Control Interface (BCI), which ensures:

- That all cells in the battery bank are heated up to a configurable heating endpoint. This point is always above the allowed charge limit of the battery in use.
- That all cells in the battery bank are kept above a certain configurable heating endpoint. This point is always above the allowed discharge limit of the battery in use.

Every installation has different requirements regarding heating. Therefore, different types of heating strategies are implemented. The user can configure the strategy that applies best for the installation in the modules section explained in the following sections.

There are three heating strategies, which are explained in the sections below.

4. Manual.
5. On-Charger Availability.
6. Min. SoC



Figure 66. Heater strategy

Battery Heater Control Module

6.14.1 Heater control buttons

In the Be in Charge software there are 3 fields to control the heater module and display the status.

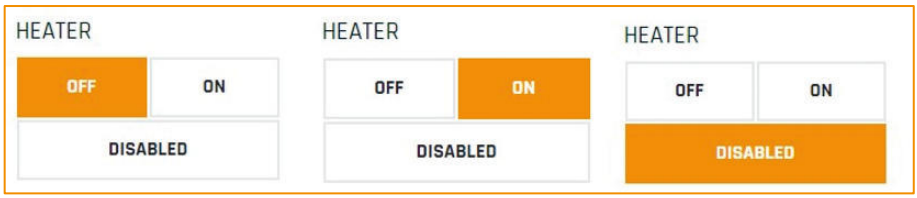


Figure 67. Be in Charge Software: Heater control buttons

The buttons are explained below.

Table 18. Heater control buttons

Button state	Meaning
Off	The heaters are currently off. The BCI can re-enable the heaters based on the heating strategy (See previous sub-sections).
On	The heaters are currently on. The user can press this button to issue a manual heating request. The heating will stop when the Heater Temperature Endpoint is reached for all battery cells.
Disabled	In case of an automated Heating strategy (i.e., On Charger-availability and Min. SoC), the user can explicitly request not heat the batteries to save energy.

6.14.2 Heating strategy: manual

The user can use the Be in Charge software to control the heaters manually.

When the button 'manual' is clicked, the batteries will be heated up to the heating endpoint temperature. Once the heating endpoint is reached, the heaters will turn off and stay off. If the batteries cool down, the user needs to press the button 'manual' again to heat the batteries up again.

The heating endpoint is configurable because it provides a tradeoff between energy consumption and battery performance. LFP (Lithium Iron Phosphate) cells typically perform better above 10° C.

6.14.3 Heating strategy: on-charger availability

Note This functionality requires the I-request control loop to be enabled. See section 6.11, I-request control loop.

Note See section 6.11, I-request charger compliance, for I-request compliant chargers.

In case any battery cell is below the allowable charge temperature, the BCI will regulate the charge current in such a way that only the heaters are receiving power. Once the heating endpoint is reached, the BCI will keep the batteries above the allowable charge temperature and the battery bank can be charged. The charge current will increase so that both heaters are supplied with power if necessary, and the battery cells are charged.

6.14.4 Heating strategy: Min SoC (Thermostat function)

The BCI will keep the batteries at a certain temperature by using energy from the battery bank. Heating will stop if the SoC of any of the batteries decreases below the configured Min. SoC level.

In this mode, the target temperature is configurable by the Thermostat Setpoint in the Be in Charge Software.

6.14.5 Heating strategy: without I-request compliant charger

Note The system can "lock out" in such an installation.

If the charger is not compliant with I-request (see section 6.11), the system can "lock out" if a battery drops below the configured Min. SoC and the temperature is below the charge temperature. In such a case, the user needs to use the manual control to heat up the battery bank to warm up the cells above 0° C (32° F)

6.14.6 Heating strategy: with I-request compliant charger

Note: This functionality requires the I-request control loop to be enabled. Refer to section 6.11 (I-request control loop).

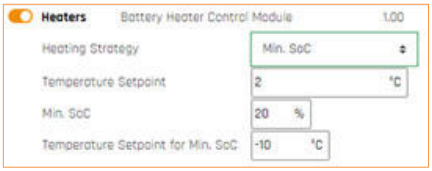


Figure 68. Be in Charge Software: Heater module configuration

The BCI will heat up the batteries to the heating endpoint if a charger is attached (see previous section). Then, the batteries are allowed to charge.

6.14.7 Heater module warning

In case of warnings related to battery heating, the BCI status will show an orange mark.

More detailed information on the specific warning can be found next to the heater control buttons. See Figure 69.

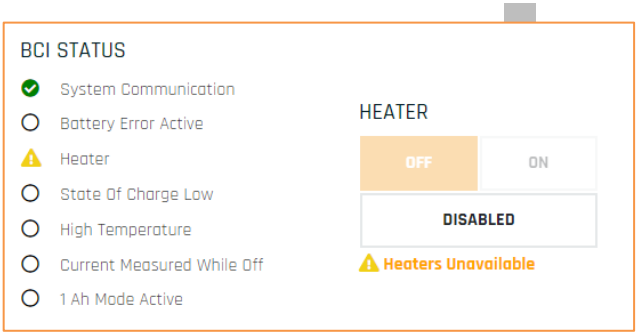


Figure 69. Be in Charge software: Heater module status locations

All error messages from the heater module are explained below.

Table 19. Heater module error messages

Error message	Meaning
Low SoC	In the case of the Min. SoC strategy: The SoC is too low. The user can manually request heating by pressing the ON button. Heating will stop as soon as the heating endpoint is reached.
Low temperature discharge	The battery temperature is too low, and discharging (and therefore using the integrated heaters) is not allowed.
Battery status	One or more batteries have an active warning or error, which prevent heating.
High temperature	The battery temperature is too high. Heater usage is disabled.
Heaters unavailable	One or more batteries do not have integrated heater elements.
Invalid data	The BCI needs to collect data from the batteries. Common during startup and should resolve as soon as the system is operational.

6.15 Real Time clock (RTC)

Note: Accurate time-stamped error logs (available in software version ≥ V2.39, with BCI Hardware version ≥ 1.7).

Compatible BCIs (Hardware version V1.7 and above) are delivered fitted with an CR1216 coin cell, which is used to power the internal Real Time clock (RTC). This provides additional functions in case an external/battery bank power is lost or not present.

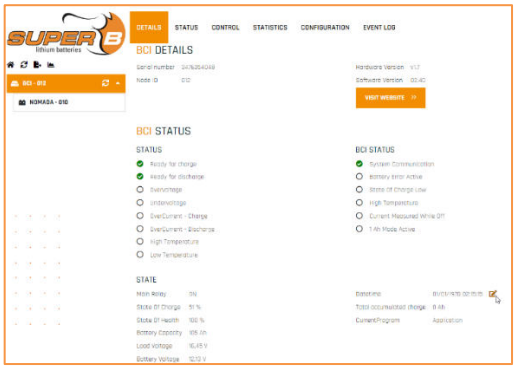


Figure 70. Set Real Time clock

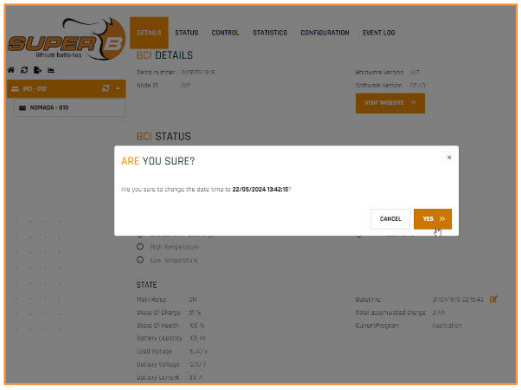


Figure 71. Confirm the Real Time clock

7. Maintenance

7.1 General information

Disconnect the BCI from all loads and LFP batteries before performing cleaning and maintenance activities.

7.2 Inspection

Inspect for loose and/or damaged wiring and contacts, cracks, deformations, or damage of any other kind. If damage to the BCI is found, it must be replaced. Do not attempt to use a damaged BCI.

7.3 Cleaning

If necessary, clean the BCI with a soft, dry cloth. Never use liquids, solvents, or abrasives to clean the BCI.

7.4 Replacing the coin cell battery (BCI HW V1.7 and above)

⚠ **WARNING! Only trained experts shall handle or install a BCI and/or the related battery systems. These systems can deliver very large currents and/or high voltages.**

The CR1216 coin cell will last approximately 3 years when no power is applied to the BCI across that entire period. With external power applied to the BCI, the coin cell capacity should last > 5 years.

In applications where there are frequent power interruptions to the BCI, it is recommended to change the coin cell every 3 years.

In applications where power loss to the BCI is negligible, it is recommended to change the coin cell every 5 years.

To replace the cell in the enclosure:

- Safely power down the application setup.
- Remove the BCI from the application installation.
- Remove the four screws on the bottom side of the enclosure using an M3 Torx screwdriver (see Figure 72).

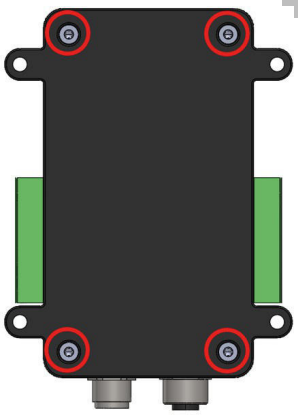


Figure 72. Remove these screws to access the PCB

- Open the enclosure and remove the PCB.

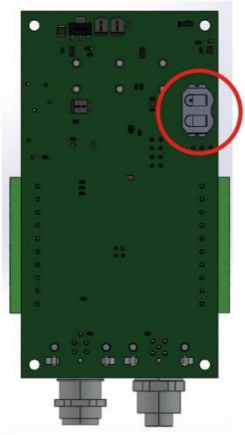


Figure 73. Coin cell location

- On the top left side of the PCB the old cell can be located and removed as shown in Figure 73.
- Ensure there are no signs of leakage from the old cell. If there is, carefully use contact cleaner to remove the corrosion in the area.
- Replace the cell with a new 30mAh CR1216 cell.
- Reinstall the PCB back in the enclosure and screw back in the 4 M3 screws.
- Reinstall into the application setup.

To synchronize the time, connect the BCI with a CAN USB interface and open the Be in Charge software. The date and time will be initially set to 01/01/1970 when the coin cell is replaced. Click the icon next to the datetime entry to resynchronize the time on the BCI.

8. Storage

To optimize the lifespan of the BCI the user needs to take temperature and humidity requirements into account during storage (see section 4.4, Environmental specifications). If these instructions are not followed, the BCI might be damaged and misbehave. Do not attempt to use it. Replace it with a new BCI.

9. Transportation

No special measures or restrictions apply to transport and shipment of the BCI. If it is shipped together with Super B LFP batteries, lithium battery legislation applies. Refer to the manual of the Super B LFP battery for detailed instructions. In case of doubt contact your distributor or Super B directly.

10. Disposal and recycling

The BCI is classified as "Small IT waste." The BCI is compliant with WEEE and RoHS.

10.1 WEEE

The Waste from European Electrical and Electronic Equipment Directive (WEEE) applies to a wide range of electronic and electrical products. WEEE encourages the collection, treatment, recycling, and recovery of waste electrical and electronic equipment. WEEE makes producers and importers responsible for financing the collection, treatment, and recovery of WEEE. Reference: The Waste Electrical and Electronic Equipment (WEEE) Directive 2012/19/EU.

10.2 RoHS

The RoHS Directive will ban placement into the EU market of new electrical and electronic equipment containing more than designated maximum allowable levels of lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyl (PBB) and polybrominated diphenyl ether (PBDE) flame retardants, effective June 8th, 2011.

RoHS works in conjunction with the EU WEEE Directive. RoHS supports WEEE by reducing the amount of hazardous chemicals used in production. In turn it reduces the risk of exposure to recycling staff as well as a reduction in recycling costs. Manufacturers will need to ensure that their products, parts, and components comply with RoHS to be distributed and sold in the EU. Reference RoHS Directive 2011/95/EU.

11. Troubleshooting

In the event of abnormal BCI operation, the LEDs provide diagnostic feedback indicating the nature of the fault. Table 20. LED behaviour overview can be used to interpret the LED patterns and determine the corresponding BCI status.

Table 20. LED behaviour overview

Indicator	Meaning	Solution
Green LED blinking	BCI in bootloader.	Check the BCI settings. Connect a PC with monitor software. Perform a software flash.
Green LED blinking with short off intervals	BCI scans for LFP batteries.	Wait 10 minutes after booting until the blinking stops.
Yellow LED blinking	BCI is in pre-charge mode.	Configure BCI to ON-state.
	BCI has just booted and has not yet switched the relays.	Typically, the relay should be enabled within 2 minutes.
	The difference in voltage between battery bank and charger is too high to safely switch on the main relay.	Wrong configuration of pre-charge system. Turn off all loads before switching on the BCI. After the BCI is turned on, the loads can be enabled.
Yellow LED ON	Main contactor(s) open.	Check if BCI is configured for Automatic startup option (Section 3.5.1).
Red LED is on	One or more LFP batteries are reporting an error or the BCI is not configured (first bootup).	Determine which LFP battery is reporting the error. Check for excessive heat, any damage, short circuits etc. Take appropriate safety precautions. If the problem has been resolved, reset the system (pushbutton or through the Be in Charge software).
	The BCI cannot find one or multiple LFP batteries.	Check the CAN cables.
		Check the CAN terminators.

		In case more than 16 LFP batteries are connected, check if external power supply is functional.
		Ensure bitrates are set at 250kbps for each LFP battery.
Red LED blinking one flash in one second	Battery layout configuration incorrect.	Doublecheck the battery layout. Does it match completely with the configuration as stored in the BCI?
	The BCI is not configured (first bootup).	See section 6.2.
Entries in the BCI Event log time are incorrect	The coin cell is either missing or empty.	Fit a new CR1216 coin cell. See section 7.4.

Troubleshooting. If the problem(s) persist, please contact your Super B representative for further assistance.

12. Warranty and liability

No rights can be derived from this document. Any installation or use contrary to these instructions may void the warranty granted to you. Please refer to the sales agreement for warranty and other provisions applicable to your purchase. In case the product is defective, contact your dealer, reseller, or retailer. Super B's liability for any of its products is limited to the corresponding provisions under mandatory applicable law.

13. References – Figures

Figure 1. https://www.super-b.com/newsletter-signup 10
Figure 2 Super B Support | Lithium Battery Help & Resources 11
Figure 2 12
Figure 3. Typical BCI setup 16
Figure 4. BCI supplied by the LFP battery bank 18
Figure 5. BCI supplied by external power supply 19
Figure 6. Turn-on Sequence of contactors 22
Figure 7. Dimensions in mm 27
Figure 8. Scope of delivery 28
Figure 9. Connections, Indicators, and controls 29
Figure 10. CAN Connections Male and Female 30
Figure 11. Mounting the BCI 34
Figure 12. Coil cell for RTC 35
Figure 13. BCI powered from battery bank 37
Figure 14. BCI externally powered 39
Figure 15. manual controls 40
Figure 16. Simplified circuit 41
Figure 17. CAN connection J1 to BCI 44
Figure 18. CAN Bus wiring diagram 45
Figure 19. CAN Bus power 47
Figure 20. QR for APP 48
Figure 21. CAN to USB connection 48
Figure 22. Press SCAN button in Be in Charge software. 49
Figure 23. Display shows BCI device, batteries, and connections 49
Figure 24. Communication connection diagram 51
Figure 25. Typical setup 52
Figure 26. Three-substring system with one contactor ON and two OFF 53
Figure 27. Select functional mode 55
Figure 28. substring control 56
Figure 29. Simplified circuit 56
Figure 30. Redundancy state startup sequence active 58
Figure 31. Redundancy state operational 58
Figure 32. Example point-to-point connection to a Nomada battery 61
Figure 33. 'Scan' for devices 62
Figure 34. Set to expert user 62
Figure 35. Confirm 63
Figure 36. Change the battery 'Node ID' of the first LFP battery 63
Figure 37. Select the desired new Node ID from the dropdown menu 64
Figure 38. Configure the BCI by pressing the Full scan button 64
Figure 39. Renumber battery one 65

Figure 40. Scan for devices 66
Figure 41. Set user level to 'Expert User' 66
Figure 42. Confirm expert user 67
Figure 43. Change the battery "Node ID" of the first LFP battery 67
Figure 44. Select the desired new Node ID from the dropdown menu 68
Figure 45. Be in Charge Software - Input level configuration 69
Figure 46. BCI Modules and communication protocol 70
Figure 47. BCI Pre-charge time 71
Figure 48. BCI Pre-charge time 72
Figure 49. SoC switch OFF level 73
Figure 50. Minimum I-request. 74
Figure 51. Select an appropriate product 74
Figure 52. Charge setting screen 74
Figure 53. Select an appropriate dialog box 75
Figure 54. PID parameters 76
Figure 55. Saving a configuration 78
Figure 56. BCI Control tab 79
Figure 57. Reset control button 79
Figure 58. BCI Status tab: ON 79
Figure 59. BCI Status tab: OFF – battery in overvoltage 80
Figure 60. Status tab: OFF – battery in overcurrent while charge 80
Figure 61. BCI Status tab: undervoltage warning 81
Figure 62. BCI Status tab: undervoltage complete shutdown 81
Figure 63. BCI Status tab: 1Ah undervoltage recovery state 82
Figure 64. Be in Charge status tab: SoC recovery state (see section 3.4.2) 82
Figure 65. Heater strategy 83
Figure 66. Be in Charge Software: Heater control buttons 83
Figure 67. Be in Charge Software: Heater module configuration 85
Figure 68. Be in Charge software: Heater module status locations 86
Figure 69. Set Real Time clock 87
Figure 70. Confirm the Real Time clock 87
Figure 71. Remove these screws to access the PCB 89
Figure 72. Coin cell location 89

14. References – Tables

Table 1. Glossary of Terminology 14
Table 2. BCI states 19
Table 3. General product specifications 25
Table 4. Electrical specifications 25
Table 5. Mechanical specifications 26
Table 6. Compliance specifications 26
Table 7. Environmental specifications 26
Table 8. CAN connector pinout 30
Table 9. J3 (I/O Connection 10) 30
Table 10. J4 (I/O Connection 10 31
Table 11. Indicators 31
Table 12. Optional peripheral equipment 32
Table 13. Connecting wires 35
Table 14. Circuit description 38
Table 15. Circuit description 39
Table 16. CAN Bus speed 45
Table 17. General purpose I/O 59
Table 18. Heater control buttons 84
Table 19. Heater module error messages 86
Table 20. LED behaviour overview 94



For more information please contact:
Super B Lithium Power B.V.
Europalaan 202
7559 SC Hengelo (Ov.)
The Netherlands
Tel: +31 (0)88 0076 000

E-mail: info@super-b.com
Web: www.super-b.com