BACANCY®
SYSTEMS PVT LTD

User Guide

BMS 16s 100A

Please completely read this document and the contained safety instructions and note all given information before usage.

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The product shown herein is not designed for use in lifesaving or life-sustaining applications unless otherwise expressly indicated. Customers who utilise or sell Bacancy Systems PVT LTD products that are not explicitly intended for such applications do so solely at their own risk.

This user guide is intended to improve the operator's efficiency throughout the procedure and does not entirely absolve them of responsibility.

Change Record

Rev. No.	Date	Details	Revised By	Approved By
1	02/05/2025	Initial Release	Rajkumar Patel	Riken Suthar
2	04/05/2026	Revised Email Address	Rajkumar Patel	Riken Suthar

Table of Contents

List of Figures

List of Tables

1. About this Document

1.1 Information on the User Guide

This user guide contains basic information to be considered in the utilisation of the product. A precondition for safe working is the observance of all stated safety instructions and directions. Therefore, this user guide should be read and applied without fail by any person assigned to the installation and operating procedures of the product or system.

This user guide is part of the product, and the case may have to be passed to third parties or the following owners. It must be permanently kept at the usage site and be available for the operating personnel who are responsible for the installation of this product or system.

We are eager to ensure the comprehensiveness, relevance, and up-to-dateness of this user guide. It may become essential to make spontaneous changes to the product and its operation, which may not align with this manual, to maintain our technical advancement. In that case, Bacancy Systems PVT LTD will provide you with a new manual. We exclude liability for disturbances, failures, and resulting damages.

The illustrations in this user guide will provide a better understanding. It can occur that illustrations are not drawn to scale or deviate somewhat from the original.

1.2 Limitations of Liability

All statements and remarks in this user guide have been aggregated with consideration of current standards, laws, and regulations, the state of technology, as well as our extensive knowledge, long-time expertise, and experience. In special models, due to demands for additional order options or the latest technical alterations, the actual scope of delivery can differ from the explanations and elaborations described here.

The manufacturer excludes any liability for damages caused by:

- Inappropriate assembling and installation.
- Non-observance of the user manual.
- Non-intended and improper use.
- Use beyond operation limits.
- Deployment of insufficiently qualified and trained personnel.
- Use of unauthorised spare parts and accessories.

2. Safety

The safety directions, cautions, warnings, and notices are stated here. Moreover, in this user guide's section, the following sections have to be followed to reduce potential health risks and prevent hazardous situations as per the ISO 45001:2018 standard for occupational health and safety.

2.1 Safety Graphical Pictogram or Symbol

These prescribe safety signs for the purposes of accident prevention, fire protection, health hazard information, and emergency evacuation as per the ISO 7010:2019 standard for graphical symbols, safety colours, and registered safety signs.

The safety instructions are structured as follows:

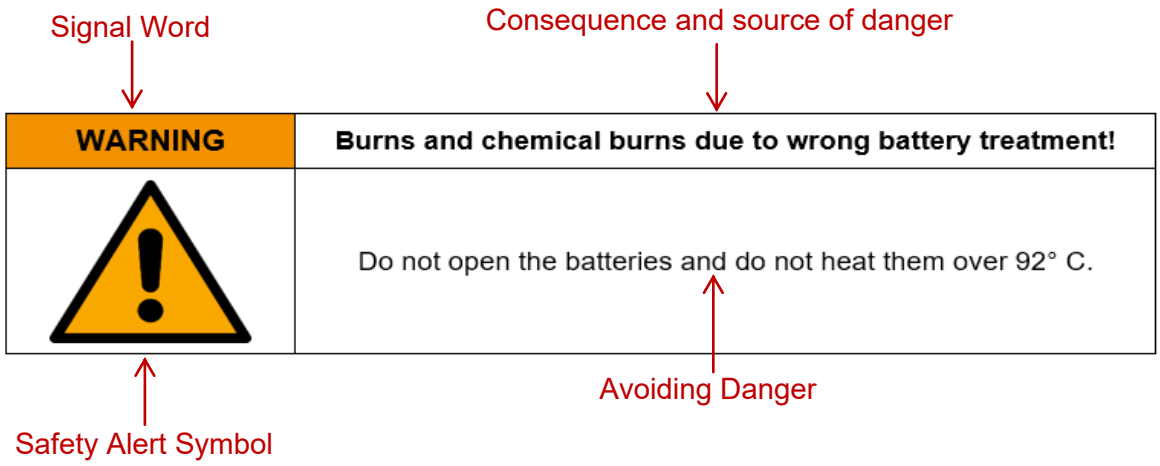


Figure 1 Safety Instruction

Table 1 Safety Graphical Pictogram or Symbol

Pictogram / Symbol	Signal Word	Meaning
	DANGER!	In case of non-compliance with this safety instruction, death or serious injury will occur.
	WARNING!	In case of non-compliance with this safety instruction, death or serious injury can occur.
	CAUTION!	In case of non-compliance with this safety instruction, a minor or moderate injury can occur.
	NOTICE!	In case of non-compliance with this safety instruction, material damage can occur.
	NOTE!	Useful notice or tip on the products or system's easy operation.

2.2 Safety Instruction and Warnings

MANDATORY REQUIREMENT	
	**General Safety and Documentation** The user shall read and fully understand the user guide before operating or maintaining the product. All installation, operation, and maintenance procedures must be performed in accordance with the provided documentation and under the supervision or advice of a qualified professional.
	**Electrical Connection and Handling** Before connecting measurement cables, the user shall verify the polarity between the battery and Bacancy's BMS Module. The BMS module shall not be replaced with a damaged battery or one exhibiting high internal resistance. Only the prescribed connecting cable shall be used; no additional object or device shall be connected between the battery and the BMS module.
	**Installation and Maintenance** Installation and maintenance should be carried out under the supervision or advice of a qualified professional.
	**Tools and Personal Protective Equipment (PPE)** Only special insulated tools shall be used during installation, operation, and maintenance. The user should wear appropriate PPE, including: – Eye protection – Protective rubber aprons, gloves, and boots
	**Disconnect Power Supply** The power source or plug should be disconnected in the event of an unanticipated event or when conducting maintenance and repair.

PROHIBITED ACTIONS	
	**Hazardous Work and Environment** Hot work shall be strictly prohibited in close proximity to fully charged batteries to prevent explosions. The assembly or disassembly of any component (including open, repaired, default parameter, or modified production units) shall be strictly prohibited. Unauthorised modifications shall void the warranty and may result in service discontinuation. The use of a high-pressure washer to clean the product is prohibited.
	**Improper Equipment and Environmental Conditions** The BMS module shall not be installed in environments characterised by: – High concentrations of oxidising or salted gases – Wet, dusty, or unstable surfaces – Proximity to extreme heat, open flames, or sparks – High-temperature variations or physical vibrations – Presence of highly flammable materials or gas accumulations – Areas unprotected from water or high humidity Metallic articles (e.g., watches, bracelets, rings, necklaces) shall not be worn during installation, operation, or maintenance.
	**Fire Extinguisher** In the event of a fire, the use of a dry powder fire extinguisher should be advised for fire control, and the use of water should be prohibited.

DANGER - HIGH-RISK HAZARDS	
	**Electrical and Explosive Risk** To mitigate risks of arc flash, explosion, or electric shock, the user shall: – Handle batteries and the BMS module with extreme care
	**Fire and Chemical Exposure** Open flames, smoking, or any activity that might create sparks near the batteries shall be strictly avoided. Battery electrolyte solutions, being highly corrosive, must be handled only with appropriate protective equipment to prevent serious injury.

WARNING - SERIOUS POTENTIAL HAZARDS	
	**Operation Near Batteries and Machine Tools** When operating machine tools in the vicinity of the battery, the user shall take all necessary precautions to prevent sparks, short circuits, or explosions. Any indication of excessive heat from the BMS module should be investigated immediately, as it may signal a damaged battery or improperly mounted cables.
	**Environmental and Installation Conditions** The installation site should be free from: – Constant exposure to oxidising or salted gases – High humidity, wetness, dust, or sources of extreme heat – Open flames, sparks, or significant temperature fluctuations The user should ensure that the environment is safe and secure before commencing installation work.

2.3 The Responsibility of the Operator

The product is associated with industrial safety standards. However, the operator who is installing or operating the product is liable for the legal responsibilities for operational safety. In addition to the operational safety instructions in this manual, the safety, accident prevention, and environmental protection regulations valid for the operational area of the product shall be followed.

2.4 Person in Charge of Operations

WARNING!	**Risk of injury caused by lack of adequate qualification!**
	Inappropriate handling of the product can lead to severe personal injuries and material damage.

In this manual, the following qualifications are specified:

Instructed Person	An instructed person is someone who has been instructed by the operator or manufacturer on the given tasks and potential hazards in the event of incorrect behaviour, as well as being semi-skilled and knowledgeable about the necessary safety procedures and safeguards.
Qualified Specialised Professional	Qualified specialised professionals are individuals who are knowledgeable with the assembly, commissioning, and operation of the product and process qualifications related to their work. The specialised individual is able to recognise hazards and prevent potential hazards because of their professional training, knowledge, and experience, as well as their understanding of the appropriate regulations.

2.5 In an Occurrence of Danger or an Accident

Preventive Measures:

- Always be prepared for accidents or fires!
- Keep first-aid equipment (ambulance boxes, blankets, etc.) within easy reach.
- Inform personnel with accident alerting, first-aid, and emergency services.
- Keep clear access routes for emergency vehicles.

If the occurrence happens, follow these steps:

- Turn off the product immediately.
- Implement first-aid procedures.
- Get people out of hazardous areas.
- Inform the appropriate person at the usage spot.
- Contact a doctor and/or the fire department.

3. Packaging, Transport and Storage

3.1 Inspection, Packaging and Transport

The products have been properly secured to ensure sufficient safeguarding during shipment. Please scrutinise the delivered products for overall quality and transportation problems as soon as possible.

In the instance of external shipment damage, proceed as follows:

- Do not accept delivery or accept it only on reserve.
- Issue a complaint.
- Do not use items that are obviously defective.

3.2 Transport

Always ensure that your equipment is transported in safe and appropriate containers while transporting it to the usage location or in the field.

Never transfer everything in an unplanned way in the vehicle. Hits and thrusts might seriously impair the product's functionality.

Always use the original packaging, transport containers, transport boxes, or equivalent packaging, whether transporting by train, aircraft, or ship. The container shields the goods from impacts and vibrations.

3.3 Storage

Strictly store the product in well-ventilated, dry spaces. During storage, keep it dry and leverage the original packaging if possible.

Avoid extreme heat fluctuations during storage. The initiation of water condensation can impair the product's operation.

When storing, keep in mind the temperature restrictions of the product. Please refer to the product's technical data for valid storage temperatures.

4. Intended Use

This user guide provides essential information about the Battery Management System (BMS), with a primary focus on the technical aspects of the BMS-16s 100A. It presents details in graphical and tabular formats across various sections for better understanding.

- **Sections 1 to 3** cover important preliminary information, including document and product liability, safety guidelines, as well as packaging, transportation, and storage requirements. These sections outline essential pre-use practices to follow before, during, and after using the product.
- **Section 5** delves into the technical aspects of the BMS, detailing its functions, features, applications, technical specifications, and interfaces. It also provides guidance on setup, integration with other components, and mechanical dimensions to facilitate installation.
- **Section 6** focuses on BMS installation, covering the connection diagram and procedures, configuration for lower-cell battery packs, and BMS self-current consumption.
- **Section 7** explains the mobile application, including installation, usage, and configuration.
- **Section 8** provides fault codes along with their explanations.
- **Section 9** introduces the IONDash web analytics tool, detailing the login process and explaining each tab.
- **Section 10** outlines the protection mechanisms of the BMS.
- **Section 11** offers support for firmware upgrades.
- **Sections 12 and 13** address troubleshooting and frequently asked questions (FAQs) related to BMS.

Finally, the appendix section included disposal of the product, abbreviation, and glossary, as well as the company's help desk and contact information.

WARNING!	**Risk caused by inappropriate use!**
	Any unconventional use and/or different operation of the product can lead to hazardous situations. • Only use the product in a conventional manner.

4.1 Limitation

The product is intended for use in an operational environment. It should not be used in hostile or explosive conditions.

The operator should consult local safety authorities and safety representatives before performing tasks in hazardous areas or in similar circumstances.

4.2 Alteration and Restoration of the Product/System

To prevent risks and make sure optimal performance, no alterations, attachments, or restoration of the product are permitted without explicit authorisation of Bacancy Systems PVT LTD

5. Structure and Function

Figure 2 BMS 16S-100A.

The Bacancy 16s BMS is a state-of-the-art battery management system (BMS) designed for lithium-ion and lithium-iron phosphate ($LiFePO_4$) battery packs with a series configuration of 8s to 16s. Available in 40A, 60A, and 100A variants, it is suitable for a wide range of power applications such as electric vehicles, energy storage systems and industrial applications. This advanced Battery Management System (BMS) offers real-time monitoring, comprehensive protection, and multiple communication options, ensuring efficient and safe battery operations.

Engineered to comply with AIS-156 Amendment 3, a key standard for automotive battery systems, the Bacancy 16s BMS is particularly well-suited for electric vehicles (EVs). Its cloud-based analytics and customisable configurations make it a reliable solution for energy storage systems and industrial applications. Additionally, its versatile communication interfaces-including Bluetooth, Wi-Fi, CAN, and GSM/GPS - enhance its connectivity, making it a future-ready and robust battery management system.

5.1.1 Feature

List of Feature
Advanced Battery Monitoring: Tracks cell voltage, pack voltage, temperature, charge/discharge current, and SoC in real time.
Cell Balancing: Supports passive balancing, ensuring all battery cells maintain equal voltage levels.
Over-the-Air (OTA) Updates: support firmware updates via Wi-Fi or cloud connectivity.
Comprehensive Protection Mechanisms: Includes over voltage, under voltage, over current, short circuit, and temperature protection.

Customisable Configuration: The user can set charge/discharge limits, alert thresholds, and safety parameters via the mobile application or Ion Dash.
Multiple Communication Interface: Provided with Bluetooth, CAN communication, Wi-Fi, and GSM/GPS connectivity for enhanced data access.
State or Charge (SoC) and **State of Health (SoH) Estimation:** Uses a hybrid algorithm (OCV & Coulomb) for precise calculations.
Long-Term Storage Mode: A feature to completely cut off the BMS power when storing batteries for extended periods.

5.1.2 Application

List of Applications
Electric Vehicles (EVs) & Hybrid Electric Vehicles (HEVs): Manage battery packs in e-bikes, e-rickshaws and electric scooters.
Renewable Energy Storage Systems: Used in solar and wind power storage solutions.
Industrial and Home Battery Storage: Manages backup power systems and UPS.
Swappable Battery Systems: Helps optimise battery life and performance in battery swapping applications.
Marine & Aerospace Applications: Used in electric boats and drones.

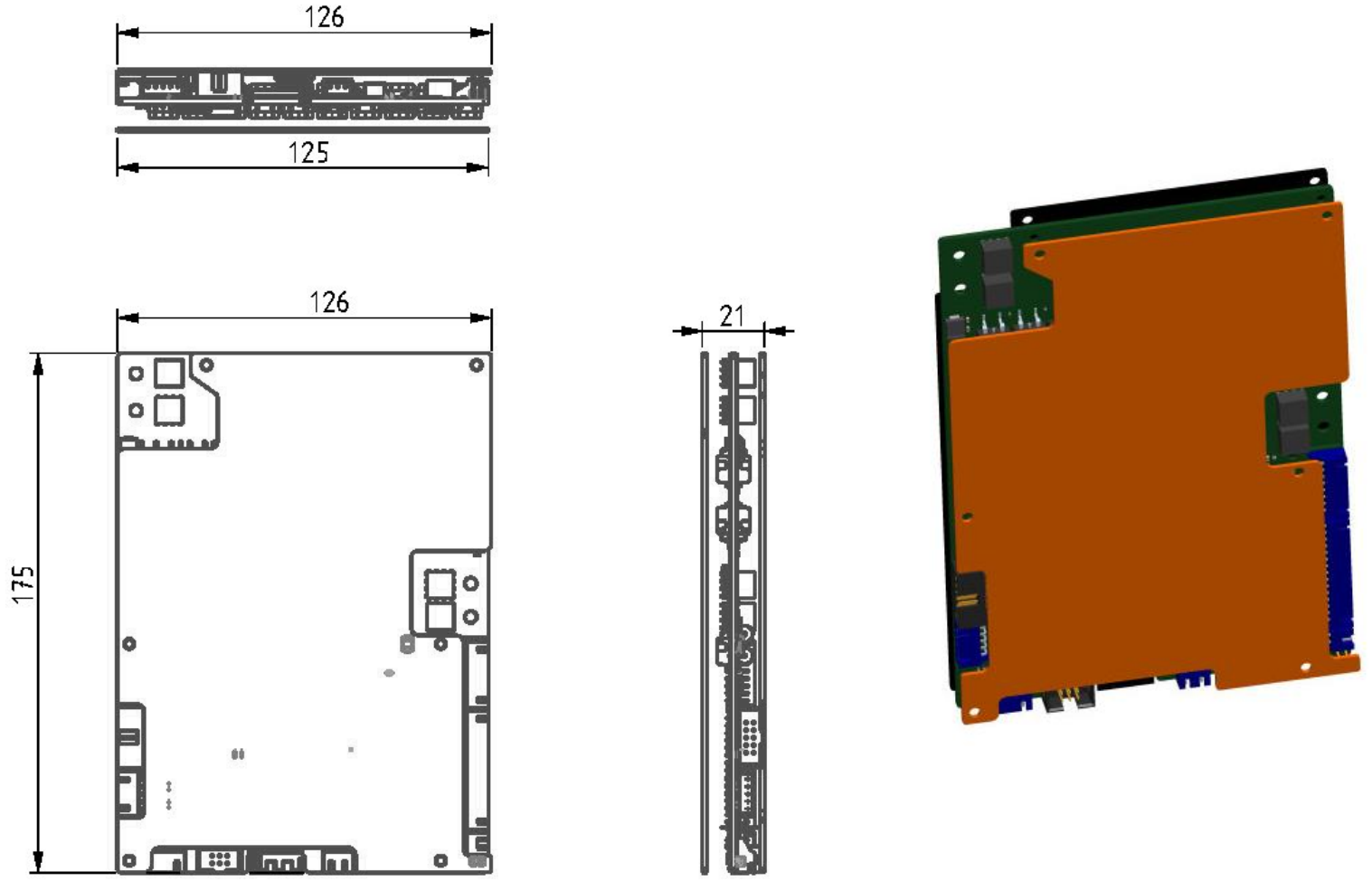
5.2 Function

5.2.1 Technical Specification

Product Properties	
Product Type	BMS 16s-100A
Product Family	Battery Management Systems (BMS)
Electrical Properties	
Operating Voltage Range	15 V to 78 V
Cell Voltage and Measurement Range	Up to 5 V
Charging and Discharging Current	Constant 100 A
Peak Discharge Current	~150 A (30 Second)
Consumption	
Standby Power Consumption	~0.224 W (Without Ignition) ~0.083 W (With Ignition)
Operating Power Consumption	~1.1 W (With Active 4G Module, BLE & Wi-Fi)
Full Discharge Sleep Consumption	~0.084 W (With / Without Ignition Type BMS)
Cell Supported	
Chemistry	NMC / NCM, LFP, Lithium Iron, Lithium Polymer
Configuration	Series
Monitored Cell	8s to 16s
Balancing Method	
Cell Balancing Topology	Dissipative

	(Passive; Default up to 150 mA & Scalable on Request)
Communication	
Wireless	BLE 4.2 | Wi-Fi | GSM / GPRS / LTE Interface
Wired	Non-Isolated CAN
Machine-to-Machine	MQTT Protocol
Digital Input / Output Pins	
Fan and Buzzer	2 Output Pin
Smoke Sensor	1 Input Pin ADC-Based
Temperature Sensor	
External Support	4 NTC for Battery Pack
Internal Support	2 On-Board PCB Sensor
Measurement Accuracy	
SOC	± 4% (SoC Algorithm with OCV Compensation)
Temperature	± 2°C
Cell Voltage	± 10 mV
Current	Up to 2% at Calibration Point
Safety Protection	
Over/under cell voltage, over/under temperature during charge and discharge, over current during charge and discharge, pack over/under voltage and MOSFET failure notification	
Calculation	
SoC and SoH	Coulomb Counting and OCV Models
Standard	
Compliance	AIS-156 Amendment-3
Support	
Integration Option	Small OLED, Buzzer, Fan, Smoke Detection Sensor and Ignition Signal
Software	Firmware Over-The-Air (FOTA)
Event Log Data	Alert, Fault and Diagnosis
Ambient Condition	
Operating Temperature	-20°C to 85°C
Storage Temperature	-30°C to 85°C
Relative Humidity	5 % to 95 % No Condensation
Mechanical Properties	
Dimension (L X B X H)	175 X 125 X 20 mm
Weight	580 g & 235 g (Without Enclosure)

5.2.2 Mechanical Diagram



*All dimensions are in **mm**.*

5.2.3 Interface

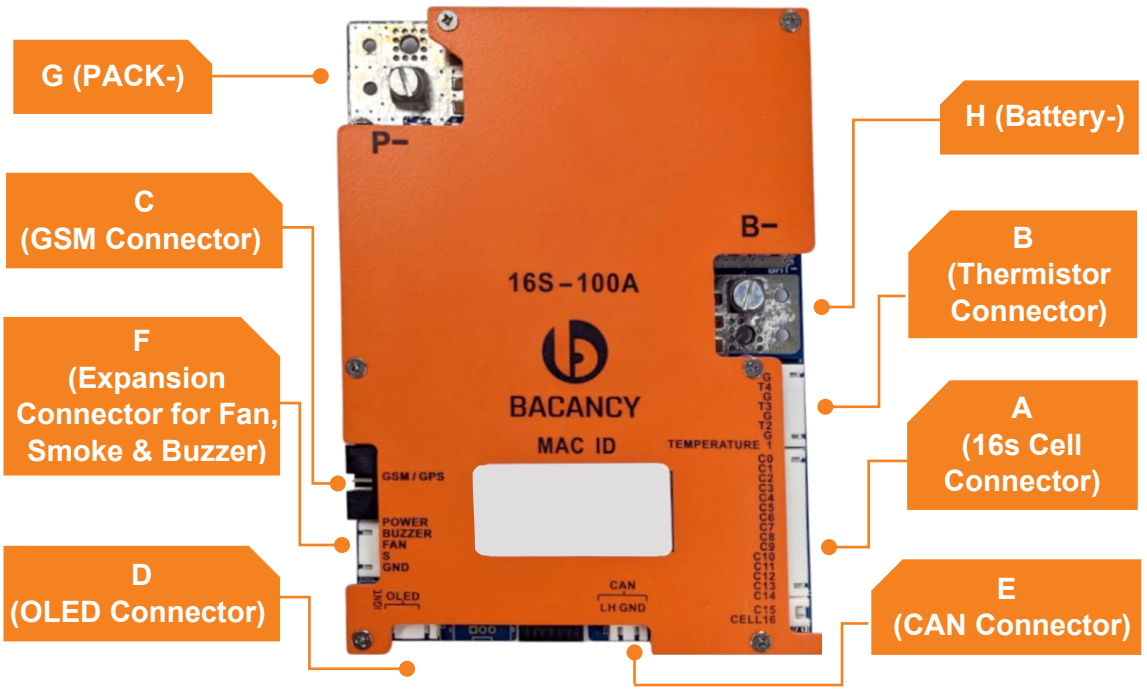


Figure 3 Interface.

Table 2 Cell Connector.

No.	Connector	Pin	Name	Description	Max. Rating	I/O Status
1.	A (Cell Connector)	1	C-	Battery Pack Negative	-	-
2.		2	C1	1st Cell +	5V	Input
3.		3	C2	2nd Cell +	5V	Input
4.		4	C3	3rd Cell +	5V	Input
5.		5	C4	4th Cell +	5V	Input
6.		6	C5	5th Cell +	5V	Input
7.		7	C6	6th Cell +	5V	Input
8.		8	C7	7th Cell +	5V	Input
9.		9	C8	8th Cell +	5V	Input
10.		10	C9	9th Cell +	5V	Input
11.		11	C10	10th Cell +	5V	Input
12.		12	C11	11th Cell +	5V	Input
13.		13	C12	12th Cell +	5V	Input
14.		14	C13	13th Cell +	5V	Input
15.		15	C14	14th Cell +	5V	Input
16.		16	C15	15th Cell +	5V	Input
17.		17	C16	16th Cell +	5V	Input

Table 3 External Thermistor Connector.

No.	Connector	Pin	Name	Description	Max. Rating	I/O Status
1.	B (External Thermistor Connector)	1	T1	Thermistor 1 Signal	3.3V	Input
2.		2	G	Thermistor 1 Ground	GND	Input
3.		3	T2	Thermistor 2 Signal	3.3V	Input
4.		4	G	Thermistor 2 Ground	GND	Input
5.		5	T3	Thermistor 3 Signal	3.3V	Input
6.		6	G	Thermistor 3 Ground	GND	Input
7.		7	T4	Thermistor 4 Signal	3.3V	Input
8.		8	G	Thermistor 4 Ground	GND	Input

Table 4 4G Module.

No.	Connector	Pin	Name	Description	Max. Rating	I/O Status
1.	C (4G Module)	1	VCC 12V	12V Power	12V	Output
2.		2	VCC 3V3	3.3V Power	3.3V	Output
3.		3	TX	GPRS/GSM Transmitter Signal	Signal	Output
4.		4	GPRS PWRST	GPRS Rest Signal	3.3V	Output
5.		5	GPRS RX	GPRS/GSM receive Signal	Singal	Input
6.		6	GPRS CTR	GPRS / GSM Receive Signal	3.3V	Output
7.		7	GPRS nRST	Not use (Future Stick)	Not Use	Not Use
8.		8	GND	Ground	GND	Input
9.		9	GSM PWR CTR	GPRS / GSM Power Rest	3.3V	Output
10.		10	GND	Ground	GND	Input

Table 5 OLED Connector.

No.	Connector	Pin	Name	Description	Max. Rating	I/O Status
1.	D (OLED Connector)	1	IGN	Ignition of the BMS (Active Low Signal)	Give Input Active Low (GND)	Input
2.		2	IO1/SCL	OLED Module Clock signal for I2C Communication	Signal	Output
3.		3	IO2/SDA	OLED Module Data Signal for I2C Communication	Signal	Input / Output
4.		4	VCC 3V3	OLED Module 3.3V Power	3.3V	Output
5.		5	GND	Ground	GND	Input

Table 6 CAN Connector.

No.	Connector	Pin	Name	Description	Max. Rating	I/O Status
1.	E (CAN Connector)	1	CAN_N	CAN Low Signal	+58 V	Input
2.		2	CAN_P	CAN High Signal	+58 V	Input
3.		3	GND	Ground	GND	Input

Table 7 Expansion Peripheral Connector.

No.	Connector	Pin	Name	Description	Max. Rating	I/O Status
1.	F (Expansion Peripheral Connector)	1	VCC	Power of Smoke Module	5V and 12V	Output
2.		2	BUZ_VCC	Power Control of Buzzer	5V and 12V	Output
3.		3	FAN_VCC	Power Control of Fan	5V and 12V	Output
4.		4	SMOKE_VCC	Smoke Analog Signal Input	3.3V	Input
5.		5	GND	Ground	GND	Input

Table 8 Pack (-) Connector.

No.	Connector	Pin	Name	Description	Max. Rating	I/O Status
1.	G (Pack -)	1	Pack (-)	Battery Pack Negative Terminal	Negative	Output

Table 9 Battery (-) Connector.

No.	Connector	Pin	Name	Description	Max. Rating	I/O Status
1.	H (Battery -)	1	Battery (-)	BMS Negative Terminal	Negative	Input

6. Connection and Installation

6.1 Requirement Before Connection

A. The kit includes the following components for a single BMS unit:

Table 10 Single BMS Unit with Components.

No.	Description
1.	BMS Pro Board
2.	Cell Tapping Cable: a. 15 Pins + 2 Pins Connector.
3.	One Set of Cables for the Buzzer, Fan and Sensor Connection
4.	Four Thermistors with Cable for Temperature Sensing
5.	One Buzzer
6.	Two Screws for Main Terminal (Pack - and Battery -) connection
7.	If required/Optional: **a.** OLED with Cable **b.** CAN interface Cable **c.** GSM/GPS Board with Cable **d.** Fan

B. The kit does not include the following components for a single BMS unit, even though they are required for BMS connection:

Table 11 Single BMS Unit without Components.

No.	Description
1.	Recommended wire rating for B - and P - Connection: **a.** 16s-40A: 2 Nos. 6 sq.mm Wire with Lug **b.** 16s-60A: 2 Nos. 8 sq.mm Wire with Lug **c.** 16s-100A: 2 Nos. 14sq.mm Wire with Lug

6.2 Connection Diagram

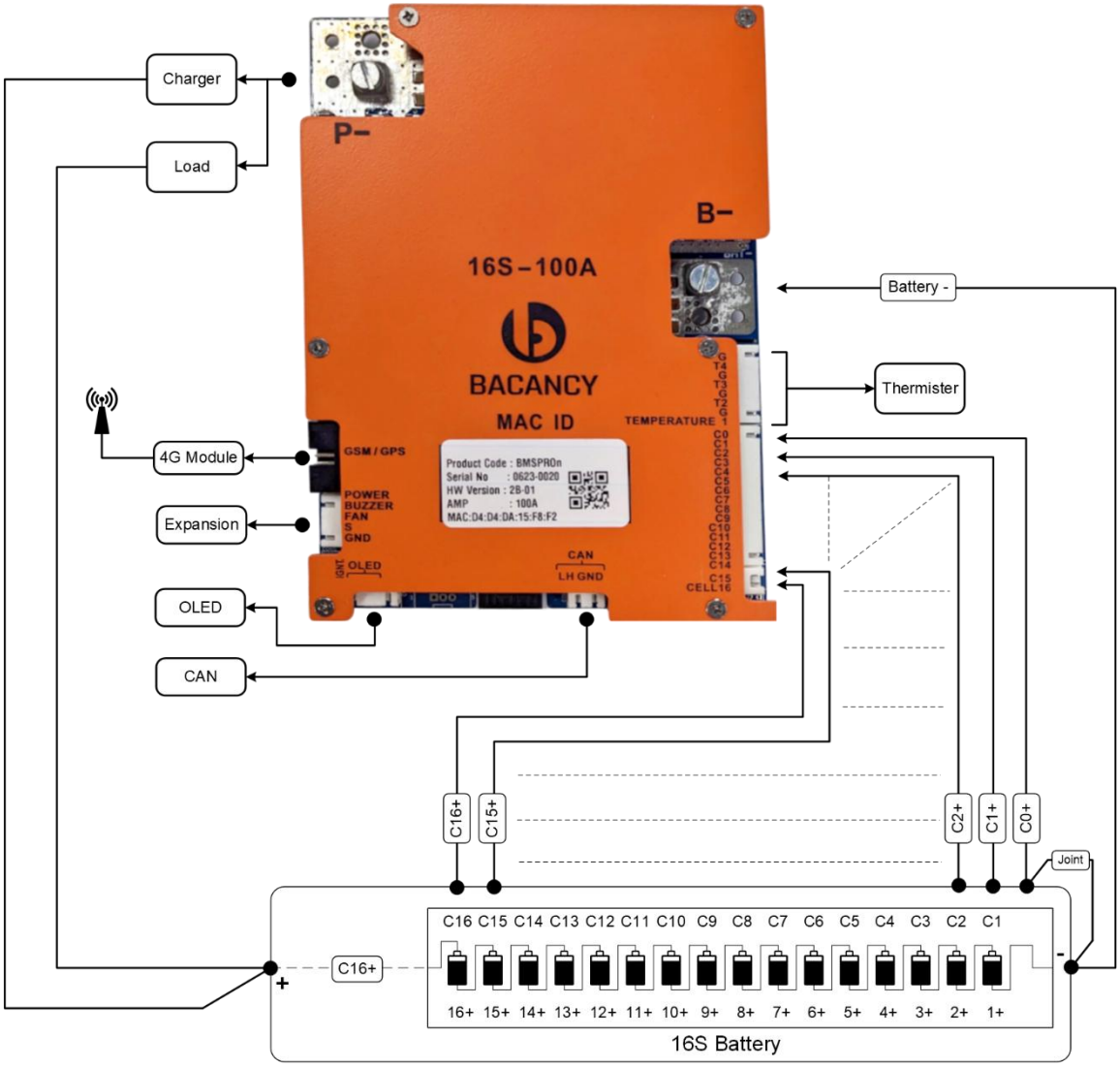


Figure 4 Connection Diagram for BMS with 16s Battery.

6.2.1 Connection and Verification Procedure

MANDATORY	Anti-Static Gloves
	Anti-static hand gloves should be used when handling the BMS and connecting it to the battery, as well as during the battery pack assembly.

MANDATORY	Connection Sequence
	To avoid damage, users should comply the connection procedure described below.

- **Connection Procedures**

Step 1 Before commencing BMS and Battery Integration, make sure the battery has been in relax mode for one hour or at least half an hour. This step aims to decrease small/floating voltage spikes.

Step 2 Connect the buzzer to the BMS's corresponding port.

Step 3 Connect the GSM module and OLED to the appropriate ports if necessary.

Step 4 Connect the external thermistor to the BMS's corresponding port.

Step 5 If necessary, connect the CAN connector to a CAN communication port.

Step 6 Connect the negative connection of the battery pack to the battery (-) port.

Step 7 Connect the negative terminal of the load/charger to the PACK (-) of the BMS.

Step 8 Connect the battery-side cell taping connection to the cell tapping port of the BMS (it will power on). Connect the most negative terminal of the cell (0th tapping or common GND of the 15-pin connection) first, followed by the 2-pin connector.

NOTE!	For Disconnection of BMS with Battery Pack
	When disconnecting the BMS from the battery pack, make sure the user does so in reverse order.

- **Calibration Procedures**

Step 1 After successfully integrating the Battery Management System (BMS) with the battery for the first time, use the mobile application to perform the RESET calibration procedure.

Step 2 The BMS will then compute the final State of Charge (SoC) using the preset SoC versus OCV (open-circuit voltage) graph.

Step 3 Ensure that the mobile application displays the correct pack voltage, cell voltage, and temperature.

Step 4 To verify these readings, use a digital multimeter to measure:

A. Individual cell voltages

B. Pack voltage

Step 5 If there is any discrepancy between the mobile application readings and the multimeter measurements, follow the calibration process outlined in Section 7.5.

NOTE!	Observation for calibration
	If the battery has been relaxed (no charge/discharge) for at least two hours, the calibration procedure is not required.

6.2.2 Adjusting a 16s BMS for Lower Cell Counts

Scenario: Assume the customer has a 16s BMS and wants to set up a battery with 14 cells in series.

- **Configuration Procedure**

Step 1 Connect battery cell 14 to the 16th tap of the BMS and cell 13 to the 15th tap of the BMS.

Step 2 Connect battery cell 12 to the 14th, 13th, and 12th taps of the BMS. In short, take three wires from the 12th cell and connect them to the 14th, 13th, and 12th taps of the BMS.

Step 3 Continue connecting the remaining cells in sequence (e.g., cell 11 to the 11th tap, cell 10 to the 10th tap, and so on).

Step 4 Complete the setup by connecting the main negative terminal of the battery to the 0s tap of the BMS.

The figure depicts the construction of a 16-cell BMS for a battery with 14 cells connected in series.

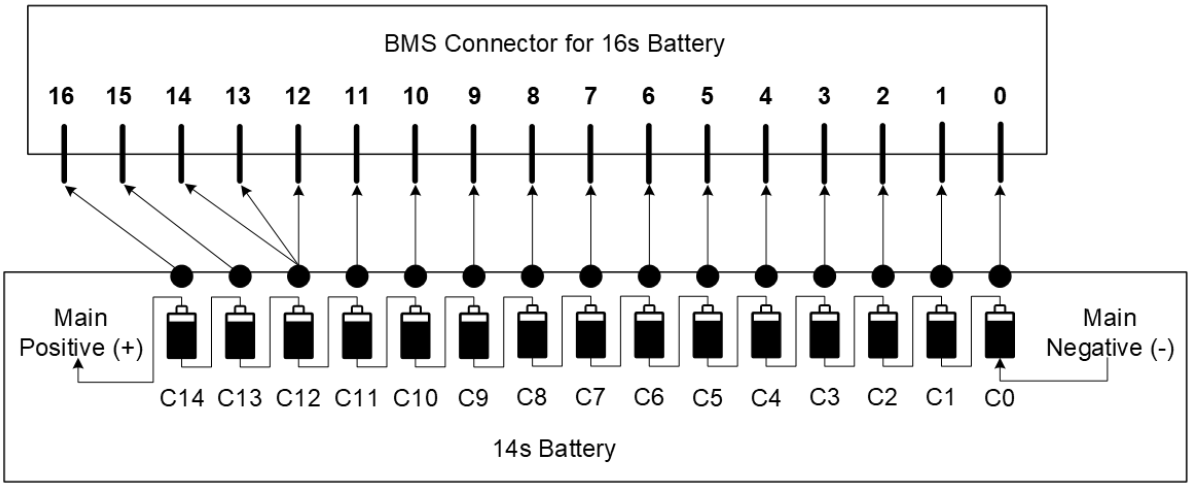


Figure 5 BMS 16s Connect to A 14-Cell Battery.

Additional Information:

- If your battery has fewer than 14 cells, start by connecting the 16s and 15s taps to the highest cell numbers available in your battery pack (e.g., cells 12 and 11). Then, continue connecting the remaining series in descending order, ensuring each tap corresponds to a cell (e.g., connect cell 10 to taps 14s, 13s, 12s, 11s, and 10s). Finally, complete the setup by connecting the lower cells (e.g., cell 9 to 9s, cell 8 to 8s, and so on).
- After completing the hardware setup, if your BMS is not preconfigured for your lower cell count battery, you'll need to adjust some BMS parameters as follows:
    1. Set the maximum/minimum pack voltage or COC/COD threshold based on the new cell count.
    2. Update the cell tapping configuration through the mobile app using the following navigation: Configuration (bottom left corner) > BMS Configuration > Threshold Configuration > Cell Tapping Configuration.
       Here, disable the unused cells. For example, if you're using a 14-cell battery, turn off cells taps 12 and 14.

6.3 BMS Self-Current Consumption

In sleep mode, the BMS will automatically turn off all external interfaces (GSM, Wi-Fi, CAN, and Bluetooth) to conserve battery life.

The table below outlines the power consumption ratings in various operating modes:

Table 12 BMS Self-Current Consumption.

Consumption State	Consumption with Ignition	Consumption without Ignition
	100A BMS at 52.2 Volt	100A BMS at 52.2 Volt
Idle Sleep	1.2 mA (~0.063 W)	4.3 mA (~0.224 W)
Critical Over Discharge (COD) Sleep	1.6 mA (~0.084 W)	1.6 mA (~0.084 W)
Active BMS, No GSM, Live Wi-Fi with Active Internet	12.0 mA (~0.63 W)	11.7 mA (0.61 W)
Active BMS, No GSM, Wi-Fi Interface OFF	11.8 mA (~0.62 W)	11.5 mA (~0.60 W)
Active BMS, GSM with Active Internet, Live Wi-Fi with Active Internet	19.6~23.7 mA (~1.1 W)	19.6~23.6 mA (~1.1 W)
Active BMS, GSM with Active Internet, Wi-Fi Interface OFF	19.4 - 24.5 mA (~1.2 W)	19.6-23.4 mA (~1.1 W)

7. Mobile Application Overview

7.1 Android Application Installation

After successfully connecting the battery pack to the BMS, install the ION bSense Android application to communicate with the BMS hardware. *(The Bacancy team will provide the source/link for installation.)*

For a first-time installation, the installer must request download access from Bacancy. Once Bacancy approves the request, the installer can proceed with the installation.

Follow these steps to complete the setup:

Step 1 **Install & Grant Permissions:**

After installing the app, allow Bluetooth, Location, and Storage permissions.

Step 2 **Login:**

Enter your login credentials in the designated fields.

Step 3 **Connect to the Device:**

Once logged in, tap on the device MAC address or device name to establish a connection.

7.2 Home Screen

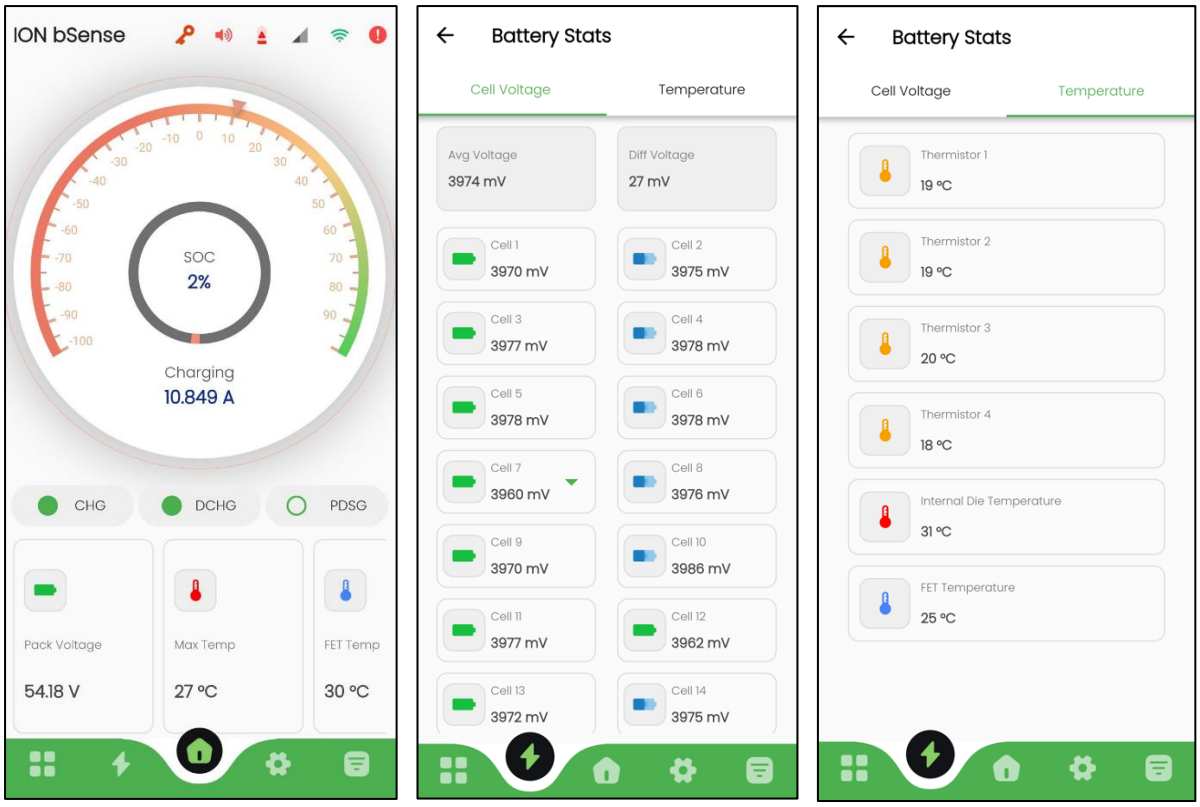


Figure 6 Battery Summary Pages.

The Battery Management System (BMS) continuously monitors both the pack voltage and individual cell voltages, displaying real-time measurements in the ION bSense application.

As shown in the figure above, users can view the following parameters directly from the home screen.

The table below provides a detailed breakdown of the monitored values.

Table 13 ION bSense Application: Monitored Values.

No.	Monitored Values
1.	Current Battery State
2.	Charge Discharge MOSFET Status
3.	Short Notation of Live Fault
4.	Remaining Battery Capacity
5.	Pack Voltage
6.	Maximum External Thermistor Temperature
7.	Current 4G Module Connection
8.	Wi-Fi Connection Status

7.3 Cell/Pack Voltage and Temperature Monitoring

Table 14 Voltage and Temperature Monitoring.

No.	Voltage and Temperature Monitoring
1.	Pack Voltage is displayed on the Battery Summary page in the application.
2.	To view cell voltages, tap on the Pack Voltage tile on the home screen. This will display live voltage readings for each cell by its number.
3.	A blue icon indicates that a cell is currently balancing.
4.	Temperature monitoring is crucial for hardware safety. The BMS Pro measures: • FET temperature • Internal DIE temperature • Four external thermistor temperatures (connected during battery assembly) These values are available in the Battery Temperature tab on the Battery Summary page (see *Figure 5*).
5.	To view individual temperature readings, tap on the Max Temperature tile in the FET Temperature section. The user can monitor: • Thermistors 1 to 4 • Internal DIE temperature • FET temperature (see *Figure 5*).
6.	The Temperature Indication icon changes colour based on different temperature ranges (as shown in *Figure 5*).

7.4 Battery Configuration and Protection

The primary goal of the Battery Management System (BMS) is to protect the battery from internal faults and ensure optimal performance. Proper battery configuration is essential for seamless integration with the BMS.

Follow these steps to configure the battery with the BMS:

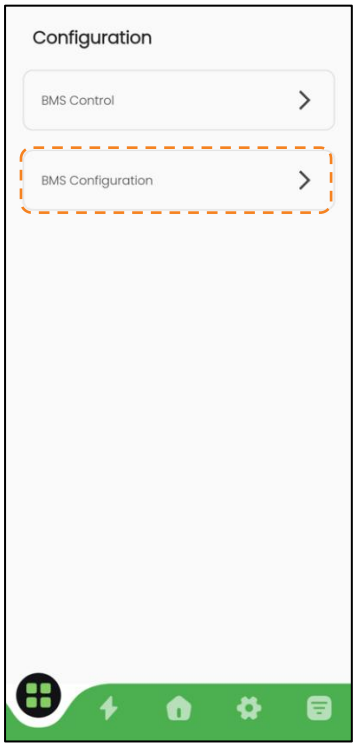


Figure 7 Configuration.

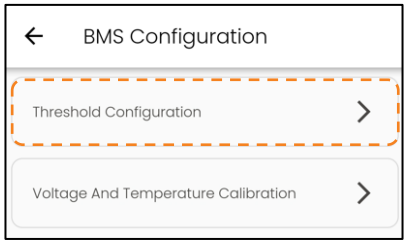


Figure 8 BMS Configuration.

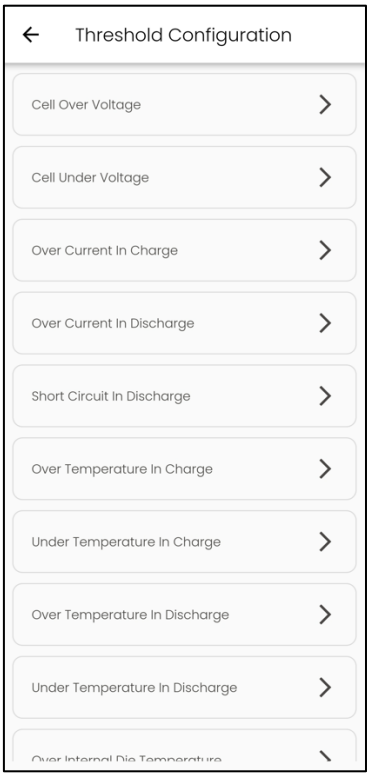


Figure 9 Threshold Configuration.

- Click on the Change Configuration menu at the bottom left corner.
- Navigate to BMS Configuration and select Threshold Configuration.
- This will open all threshold-related settings (refer to *Figure 8*).

Step 1

- The battery manufacturer can modify the configuration based on the battery's requirements.

NOTE!	Understanding the Parameter
	Changing these settings may affect BMS functionality. It is highly recommended to fully understand the parameters before making any modifications.

Step 2 Enable/Disable Faults Using Alert Masking

- It is strongly recommended to keep all fault protection enabled in the final battery pack assembly.
- If alert masking is enabled and a fault occurs, the BMS will take action on FETs.
- If alert masking is disabled, the BMS will not take action on FETs; it will only send a notification.

7.5 Voltage and Temperature Calibration

- After successfully integrating the BMS with the battery, it is mandatory to verify the measurement accuracy during the final battery assembly at the production stage. This is a one-time process.
- Additionally, it is recommended to recheck all measurements periodically, especially after a few months of battery operation, to ensure continued accuracy and performance.

Follow these steps to ensure accurate calibration of the BMS

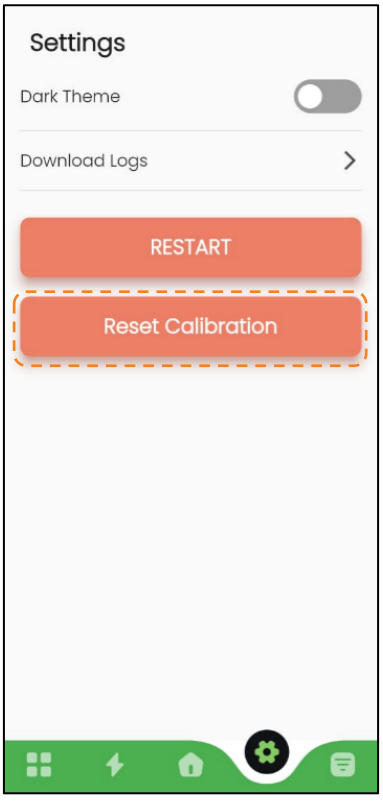


Figure 10 Setting Menu.

NOTE!	Battery in Relex Mode
	To minimize small or floating voltage variations, ensure the battery remains in relax mode for at least 30 minutes to 1 hour before starting the calibration process.

7.5.1 Calibration Process:

Step 1

- Use a high-accuracy digital multimeter (DMM) to measure all 16 cell voltages and the pack voltage directly at the BMS input (including bus bar and cell tapping cable resistance).
- Record all measurements for comparison.

Step 2

- Compare the recorded DMM measurements with the BMS readings displayed in the mobile application on the home screen (pack voltage) and cell voltage screen.

Step 3

- If you notice a significant difference (greater than 5 mV in cell voltage or 100 mV in pack voltage), proceed with calibration.

Step 4

- Reset Calibration (Mandatory Step)
  - In the mobile application, go to Settings and select RESET CALIBRATION (refer to *Figure 9*).
  - The BMS will restart after this step.
  - Reconnect the mobile application once the device is visible again on the discovery page.

Step 5

- Re-measure cell and pack voltages using the DMM and compare them with the mobile application readings.
- Observation: In 99% of cases, the BMS provides accurate readings after completing this step.

7.6 Alert and Fault Summary

The alert and fault lists are accessible via the warning icon on the Battery Summary screen. Additionally, the application provides notifications when it is connected to the BMS.

- Alerts are displayed as shown in *Figure 11*.
- Faults are detailed in *Section 8*.

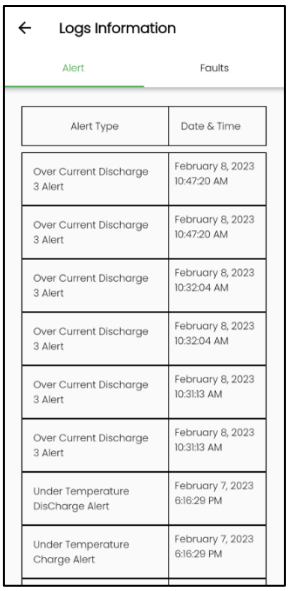


Figure 11 Alert & Fault Summary

7.7 SoC and SoH Estimation

7.7.1 State of Charge (SoC)

The State of Charge (SoC) represents the available charge in the battery. It is determined by measuring the inflow and outflow of current during charging and discharging, using a technique called the Coulomb Counting Method.

Bacancy has developed a hybrid algorithm for SoC estimation, which requires an accurate SoC vs. Open Circuit Voltage (OCV) graph.

NOTE!	SoC vs OCV Graph
	Battery manufacturers must provide the SoC vs. OCV graph for the specific battery model. This data is crucial for ensuring accurate SoC estimation.

7.7.2 State of Health (SoH)

The State of Health (SoH) indicates the overall condition and lifespan of the battery. It is determined by tracking the number of charge-discharge cycles completed during battery operation.

NOTE!	Maximum Cycle Count
	Battery manufacturers must provide the maximum cycle count for their battery. This value will be pre-configured by the Bacancy team before shipping the BMS.

7.8 BMS Control

Figure 12 Configuration.

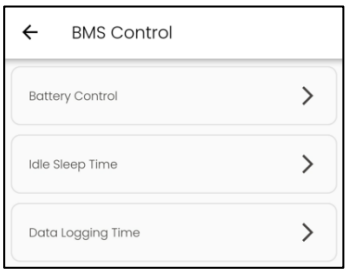


Figure 13 BMS Control.

As shown in *Figure 12*, the BMS control includes three different options:

1. **Battery Control:**

- Allows manual control of charge and discharge MOSFETs.

NOTE!	MOSFET is not recommended.
	Manual operation of MOSFETs is not recommended, as it may affect BMS functionality.

2. Idle Sleep Time:

- Used to configure the idle sleep duration for the BMS.
- Example: If set to 10 minutes, the BMS will enter sleep mode if no current inflow or outflow is detected (*battery in relax mode*) for 10 minutes.
- The BMS will automatically wake up when:
  - A charger is connected.
  - An Ignition signal is given via Ignition IO (active low).
- Bacancy offers two types of BMS configurations:

  Ignition BMS:

  - Equipped with an Ignition IO (active low).
  - The BMS wakes up automatically when the user provides an Ignition signal.
  - Suitable for applications where the battery is integrated with a vehicle or system that requires ignition-based activation.

  Non-Ignition BMS:

  - Does not have an Ignition IO.
  - The BMS wakes up only when a charger is connected or when a significant load is applied.
  - Ideal for standalone battery packs or applications without an ignition system.

IMPORTANT	Ignition or Non-Ignition Configuration
	The battery manufacturer must specify the required BMS type before shipment so Bacancy can configure the BMS software accordingly.

3. Data Logging Time:

Bacancy BMS complies with the latest AIS-156 Amendment-3 and supports offline data storage in its onboard memory.

Configuring Offline Data Logging Frequency

Battery manufacturers can configure data logging frequency for different operating modes:

- Idle Mode
- Charging Mode
- Discharging Mode

Recommendation	Preserve Storage Space
	In Idle Mode, set a lower logging frequency to preserve storage space for long-term data retention.

Downloading Stored Data via Mobile Application

The user can download the stored data from the Settings menu:

Step 1 Tap on Download Logs.

Step 2 Click the Download button on the next screen.

Step 3 To view downloaded files, tap on Available Files.

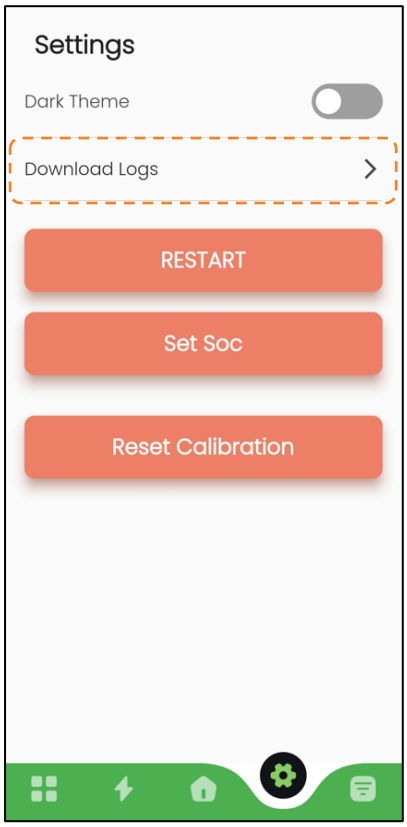


Figure 14 Download Logs.

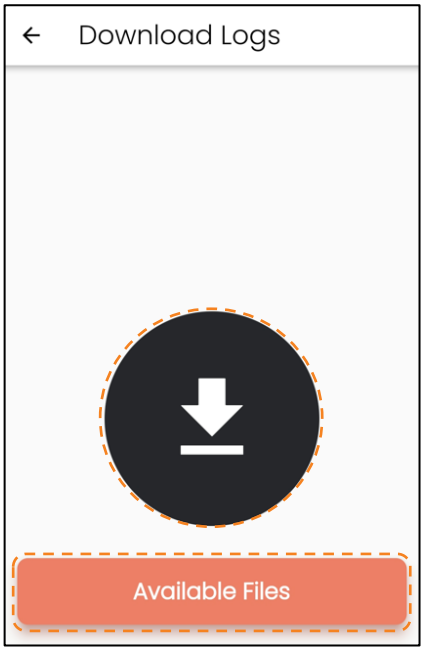


Figure 15 Download Button.

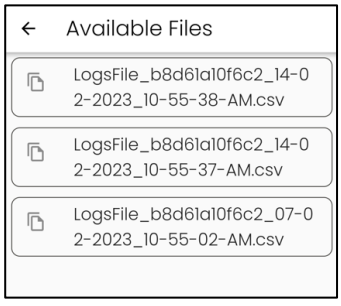


Figure 16 Available Files.

7.9 Wi-Fi Control

Figure 17 Notification Bar.

Once the BMS successfully connects to Wi-Fi with an active internet connection, all battery parameters will be published on the cloud. Follow these steps to establish a Wi-Fi connection:

Wi-Fi Connection Status Indicators

1. **Grey Icon (Wi-Fi Off)**
   - The Wi-Fi interface of the BMS is not active.
   - Tap the Wi-Fi icon once to activate the interface.
   - The icon will turn red after successful activation.
2. **Red Icon (Wi-Fi On, No Internet)**
   - BMS Wi-Fi is active, but no internet connection is available.
   - To connect:
     - Ensure a Wi-Fi router or mobile hotspot with an active internet connection is nearby.
     - Tap and hold the red Wi-Fi icon.
     - Enter the SSID (Wi-Fi name) and password, then press Submit.
     - If successful, the icon will turn green (see point 4).
     - If the network has no internet, the icon will turn blue (see point 3).
3. **Blue Icon (Connected to Router, No Internet)**
   - The BMS is connected to a Wi-Fi network, but the network does not have internet access.
   - Check the router or hotspot to ensure it has a working internet connection.
4. **Green Icon (Connected to Internet)**
   - The BMS is successfully connected to Wi-Fi and the internet.
   - Battery parameters will now be uploaded to the cloud.

7.10 4G Module Control

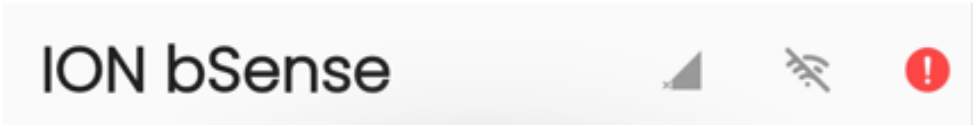


Figure 18 4G Module Network.

Follow these steps to establish an internet connection using the 4G module with BMS:

Step 1 Check Hardware & SIM

- Ensure the 4G module is properly connected to the BMS.
- Insert a SIM card with an active internet connection.

Step 2 Connect Mobile Application

- Open the mobile application and connect it to the BMS.
- Look for the signal indicator at the top next to the Wi-Fi icon.

Step 3 Set APN (Access Point Name)

- Tap and hold the signal indicator icon to open APN settings.
- Select SIM card provider (e.g., JIO, Airtel).
- Press the Submit button.

Step 4 Restart & Reconnect

- The BMS will restart after submitting the APN settings.
- The mobile application will disconnect temporarily.

Step 5 Re-establish Connection

- Reconnect to the BMS and wait for a few seconds/minutes.

Step 6 Check Connection Status

- If the internet is successfully connected, the application will display the correct icon.
- If the 4G module is still not connected, a different icon will be displayed, indicating that the internet connection is not established.

8. OLED Display

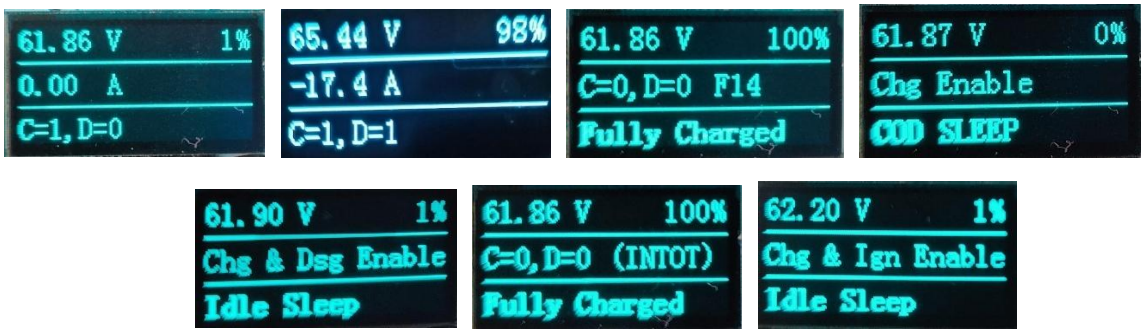


Figure 19 OLED Display with Data.

The OLED display provides essential live battery parameters, allowing for a quick assessment of the battery status. The displayed information includes:

1. **Pack Voltage:** Displays the current voltage of the battery pack.
2. **State of Charge (SoC):** Indicates the remaining charge in the battery.
3. **Live Current:** Shows the real-time current flow in and out of the battery.
4. **Charge & Discharge MOSFET Status:** Displays the state of MOSFETs:

   C = 1, D = 0 → Charge MOSFET is ON, Discharge MOSFET is OFF.
5. **Fault Code (F0 to F20):** Displays fault codes. (Refer to the fault code mapping table below for details.)
6. **Battery State:** Indicates the current battery mode, such as:
   - Fully Charged
   - Critical Over Discharge (COD) Sleep
   - Idle Sleep
7. **Signal Notation for Waking from Sleep:** Displays signals required to wake the battery from sleep mode, such as:
   - Chg Enable
   - Chg & Dsg Enable
   - Chg & Ign Enable

This information helps users monitor and troubleshoot the battery system efficiently.

8.1 List of Fault Codes

Table 15 Fault Code with Meaning.

Fault Code	Meaning
F0	Cell Over Voltage
F1	Cell Over Voltage
F2	Over Temperature Charge
F3	Over Temperature Discharge
F4	Under Temperature Charge
F5	Under Temperature Discharge
F6	Internal Over Temperature
F7	Internal Under Temperature
F8	Over Temperature in FET
F9	RESERVED
F10	Over Current in Discharge1
F11	Over Current in Discharge2
F12	Over Current in Discharge3
F13	Over Current in Charge
F14	Critical Over Charge
F15	Critical Over Discharge
F16	Short Circuit Discharge
F17	Charge FET Failure
F18	Discharge FET Failure
F19	Low SoC Detected
F20	Buzzer Enabled

9. IONDash Web Analytics Tool

9.1 IONDash Log-in

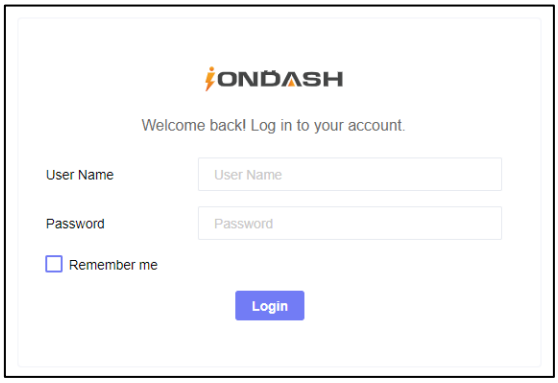


Figure 20 Login Credentials.

Follow these steps to access your **IONDASH** account and monitor battery parameters:

Step 1 Visit the IONDASH Portal

- Go to iondash.io in your web browser.

Step 2 Enter Login Credentials

- Use the username and password provided by Bacancy Systems.
- Click on the “Login” button to access your account.

Once logged in, the user can monitor battery parameters, alerts, and performance metrics in real time.

9.2 Home Page

This home page provides a quick overview of your battery management system, ensuring efficient monitoring and control.

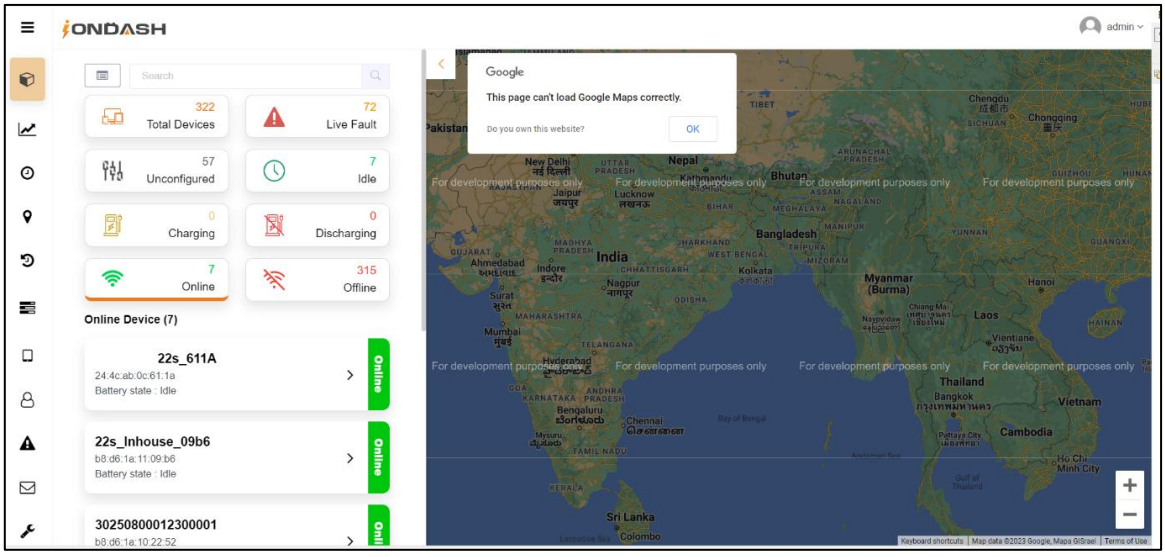


Figure 21 Home Page.

Features:

1. **Real-Time Device Summary:** View a real-time summary of all connected devices.
2. **Device Count & Configuration Status:** Check how many devices have been added and whether they are configured.
3. **Live Device Status:** Monitor which devices are online and their current state (charging, discharging, or idle).
4. **Alert & Fault Notifications:** Get updates on recent alerts and faults for all devices.
5. **Device Location & List:** Track the location of all devices and access the complete device list.

- **Device List**

The navigation bar on the left allows quick access to live data, alerts, reports, and settings. By clicking on “More Details”, the user can view in-depth information about a specific battery pack.

Figure 22 Device List.

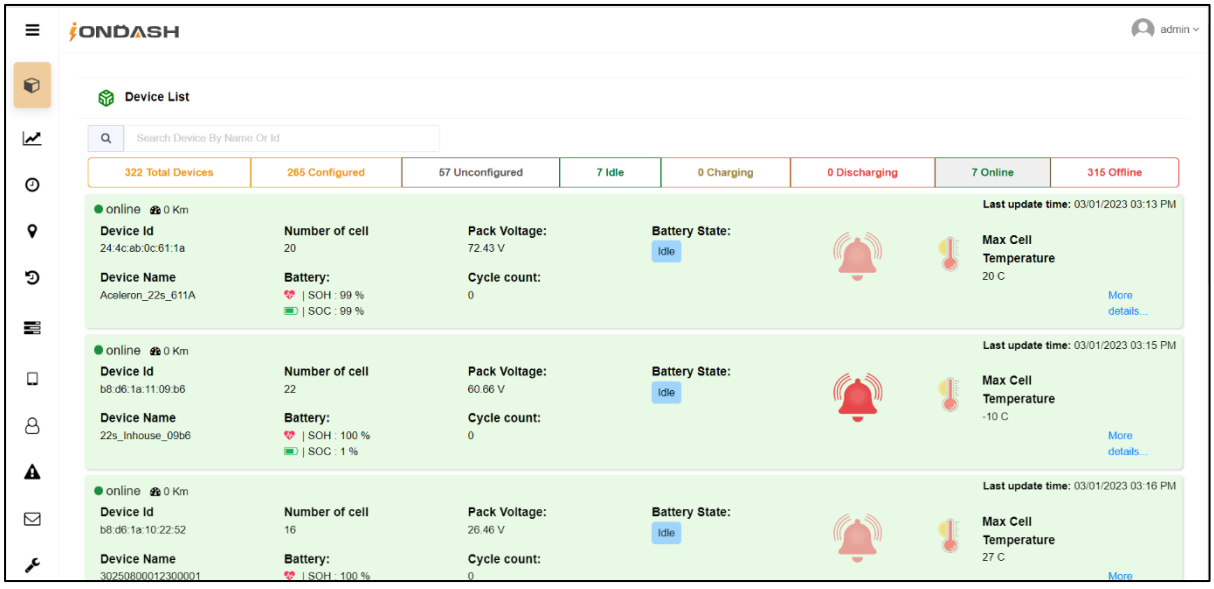


Figure 23 Device List Page.

The Device List page provides a detailed view of all battery packs, displaying key information such as:

- **Device ID & Name:** Unique identifier and name of the battery pack.
- **Number of Cells:** Total cells in the battery pack.
- **Pack Voltage:** The current voltage of the battery pack.
- **Battery State:** Indicates if the battery is Idle, Charging, or Discharging.
- **State of Health (SOH) & State of Charge (SOC):** Show battery health and remaining charge.
- **Cycle Count:** The number of charge/discharge cycles completed.
- **Max Cell Temperature:** The highest temperature detected in the battery pack.

9.2.1 Individual Device Dashboard

The Individual Device Dashboard allows users to access detailed information about a specific battery pack. Here's how it works:

- **Navigate to the Device Dashboard**
  - Click on the right arrow (>) highlighted in the image to access the selected device's detailed data.

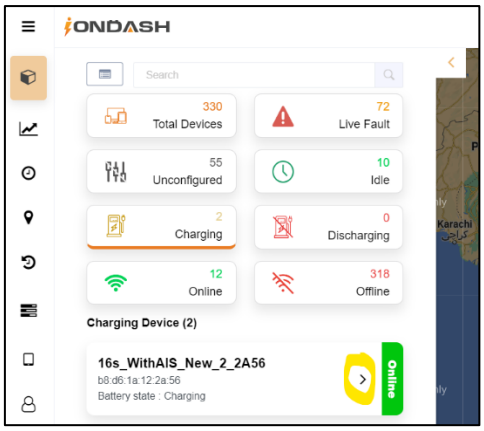


Figure 24 Individual Device Dashboard.

- **Key Information Displayed**

1. **Basic Details:** Customer name, battery pack capacity, IMEI number of the 4G module, BMS software version, etc.

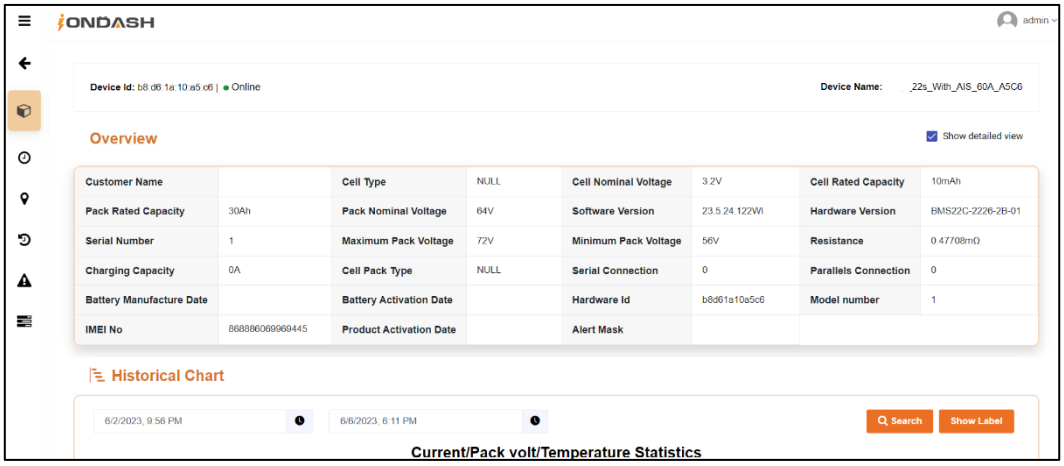


Figure 25 Basic Overview of Individual Device.

- **Historical Data View:**
  - Apply a specific time filter to review stored data on the IonDash server.
  - Analyse long-term battery performance trends
  - Identify fluctuations and critical events in the dataset

2. Current/Pack Volt/Temperature Statics:

This static provides a detailed view of battery performance over a selected time range. This tool helps users diagnose battery efficiency and detect anomalies for proactive maintenance.

Key Features:

- **Time-Based Data Analysis:**
  - The User can apply a specific time filter for historical performance review.
- **Graphical Representation of Key Metrics:**
  - Max & Min Temperature (°C): Tracks thermal variations.
  - Pack Voltage (V): Monitors voltage fluctuations.
  - Battery Current (A): Shows charging/discharging patterns.
  - State of Charge (SoC %): Displays battery charge level.
- **Interactive Data Points:**
  - Hovering over points provides precise real-time values.

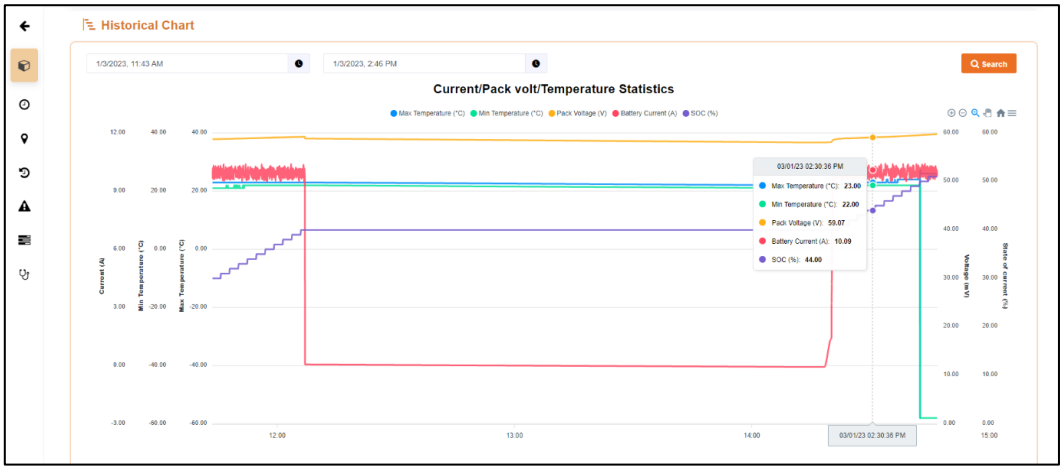


Figure 26 Current/Pack Volt/Temperature Statistics.

3. Individual Cell Voltage/Pack Volt/Temperature/Current Statistics

This dashboard presents multiple graphical representations of key battery performance metrics. These visualisations assist users in analysing historical data and diagnosing battery performance efficiently.

Key Features:

- **Individual Cell Voltage:**
  - Displays maximum and minimum cell voltage (mV)
  - Voltage difference tracking to monitor variations
  - Interactive tooltip for precise data insights
- **Pack Voltage Statistics:**
  - Shows overall pack voltage trend over time
  - Identifies voltage fluctuations and stability
- **Temperature Statistics:**
  - Monitors maximum and minimum cell temperature (°C)
  - Helps in detecting potential thermal issues
- **Current Statistics:**
  - Tracks battery charge/discharge current (A)
  - Identifies charging/discharging cycles and irregularities

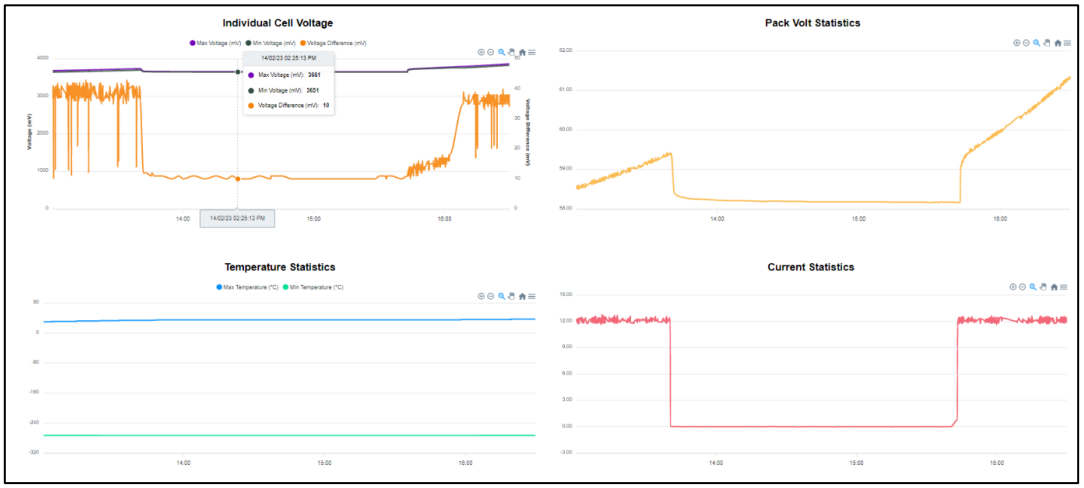


Figure 27 Individual Cell Voltage/Pack Volt/Temperature/Current Statistics.

4. Operational and Alram Statistics

This page provides a comprehensive statistical summary of battery pack operations and alarms over a selected time period. It helps in monitoring battery pack efficiency and identifying critical alarm trends.

Key Features:

- **Operational Statistics**

  Displays a pie chart representing different battery states:

  - Charging Time
  - Discharging Time
  - Idle Time (Highlighted in the image: 48hr 00min 00sec)

- **Alarm Statistics**

  Displays a pie chart representing alarm states:

  Categorized into:

  - Advisory
  - Normal
  - Critical

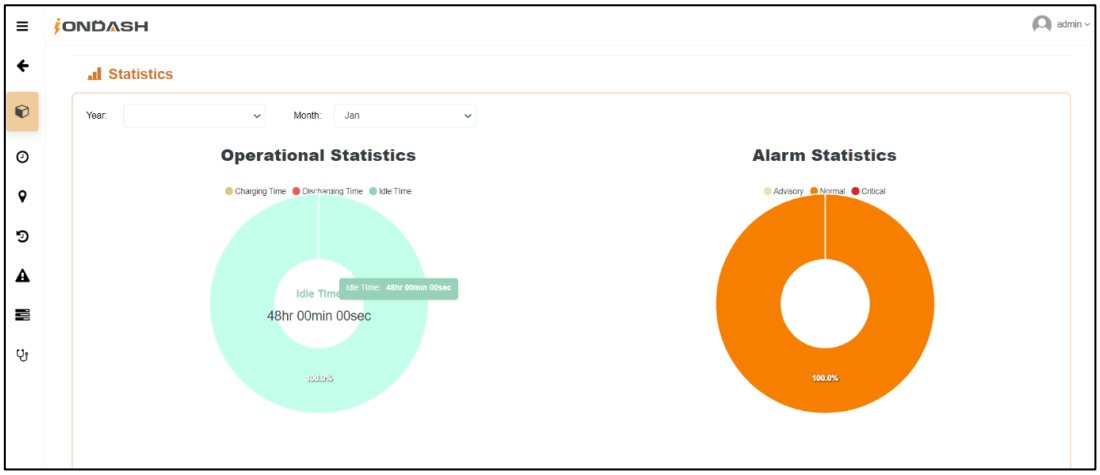


Figure 28 Operational and Alarm Statistics.

9.3 Real-Time Monitoring Tab

The Real-Time tab provides a detailed and live overview of battery pack performance, offering insights into various electrical and thermal parameters.

Key Features:

- **Battery Status Updates:** Live data on Pack Voltage, Current, SOC, SOH, Temperature, and Faults.
- **Alert & Fault Notifications:** Displays recent alerts and categorized fault statuses (Solved/Unsolved).
- **Internet Dependency:** If the BMS is connected to the internet, real-time data is displayed. If offline, the last recorded data is shown.

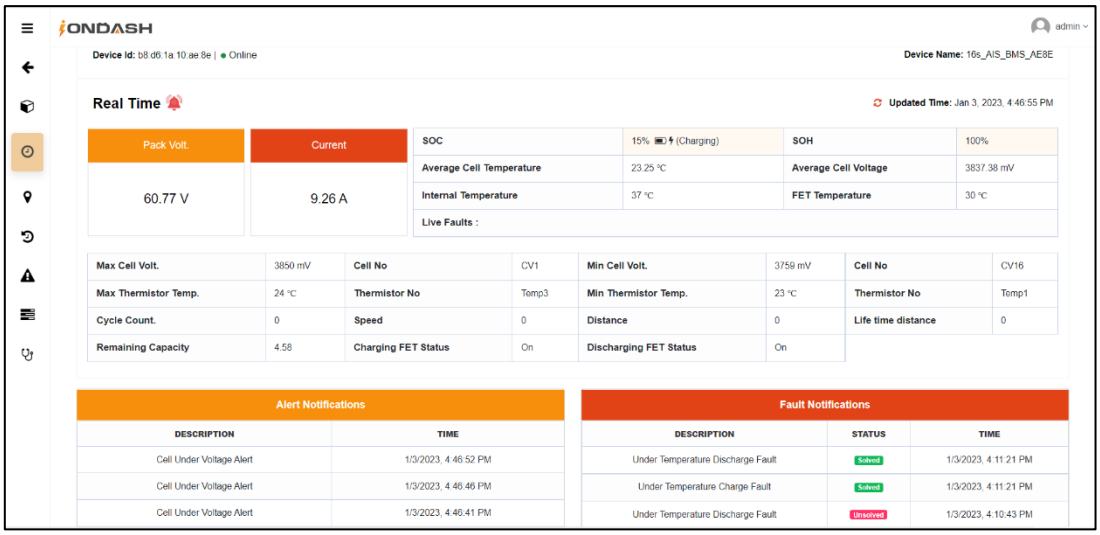


Figure 29 Real-Time Monitoring Tab.

9.3.1 Real-time Cell Voltage Monitoring

The Cell Voltage Monitoring dashboard provides real-time insights into individual cell voltages within the battery pack.

Figure 30 Real-time Cell Voltage Monitoring.

Key Features:

- **Real-Time Cell Voltage Tracking**
  - Displays maximum, minimum, and voltage differences across all battery cells.
  - Ensures uniform voltage distribution to maintain battery health.
- **Cell Balancing Status**
  - The highlighted cells (red-coloured bars) indicate that those cells are in the cell-balancing process.
  - Balancing is crucial to maintain voltage uniformity and prevent overcharging or undercharging.
- **Fault & Alert Statistics**
  - Bar charts provide an overview of faults and alerts categorised by type and frequency.
  - Helps users identify potential risks and take preventive actions.

9.4 Tracking Tab

The Tracking Dashboard in IonDash provides real-time location tracking and historical trip monitoring for battery-powered devices.

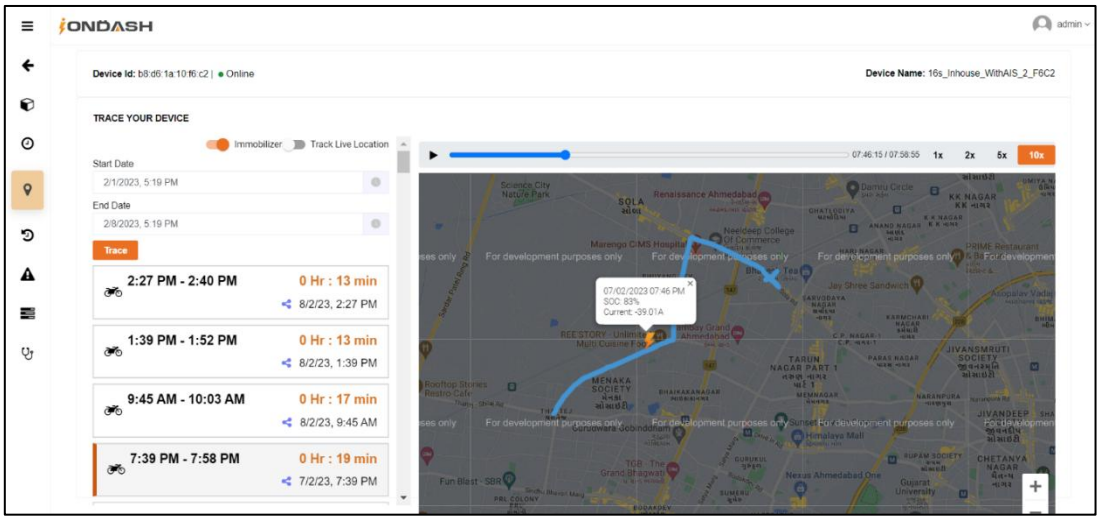


Figure 31 Tracking Tab.

Key Features:

- **Live Location Tracking**
  - The user can track their battery's live location on an interactive map.
  - Displays real-time State of Charge (SoC) and current flow by hovering over the IonDash icon.
- **Historical Trip Replay**
  - The user can select a date range to view past trips.
  - Trips can be played back at multiple speeds (1x, 2x, 6x, 10x) to analyse movement patterns.
- **Immobiliser Functionality**
  - Remotely turn ON/OFF the battery for security and theft prevention.
  - Ensures that only authorised users can activate the battery.

9.5 Device History Tab

The Device History tab provides a detailed log of all battery parameters over time, allowing users to analyse past performance and trends.

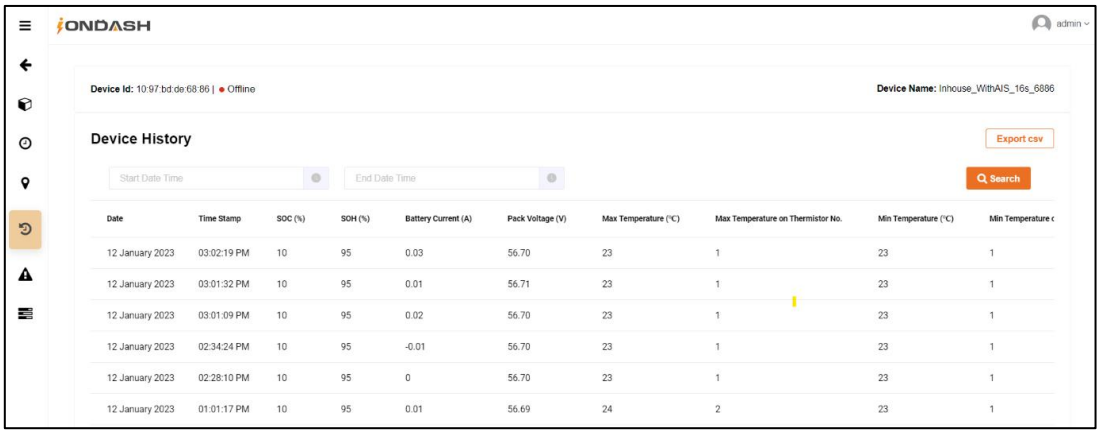


Figure 32 Device History Tab.

Key Features:

- **Timestamped Battery Data**
  - The user can view historical data of the battery with exact timestamps.
  - Helps in tracking changes in battery health over time.
- **Monitored Parameters**
  - **State of Charge (SoC) (%):** Tracks battery charge level.
  - **State of Health (SoH) (%):** Measures overall battery health.
  - **Battery Current (A):** Displays current flow.
  - **Pack Voltage (V):** Shows total battery voltage.
  - **Maximum & Minimum Temperature (°C):** Monitors thermal performance.
  - **Individual Cell Voltage:** Checks voltage variations between cells.
- **Export & Data Filtering**
  - The user can filter data by selecting a start & end date for precise analysis.
  - Data can be downloaded or exported in ".CSV" format, allowing for further verification and analysis in Excel.

9.6 Alert and Fault Tab

The Alerts & Fault Notifications tab provides users with a detailed view of all reported alerts and faults related to battery performance.

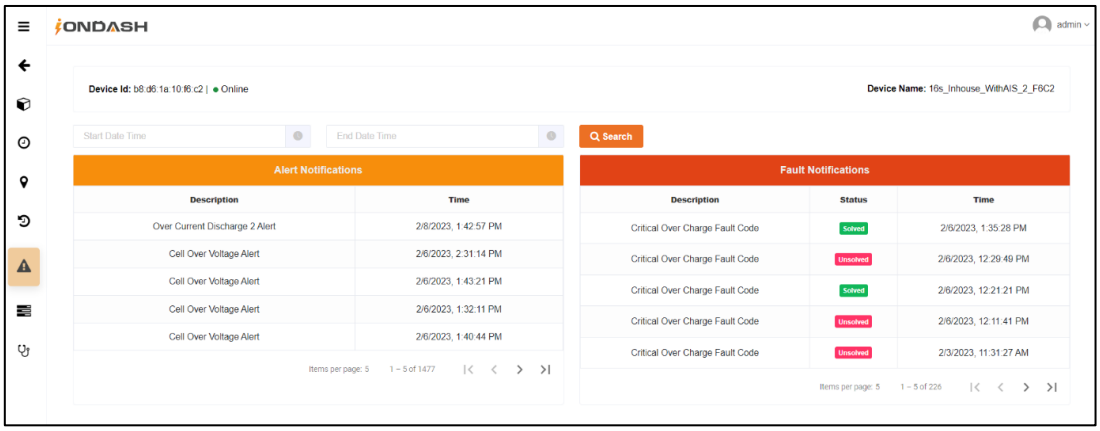


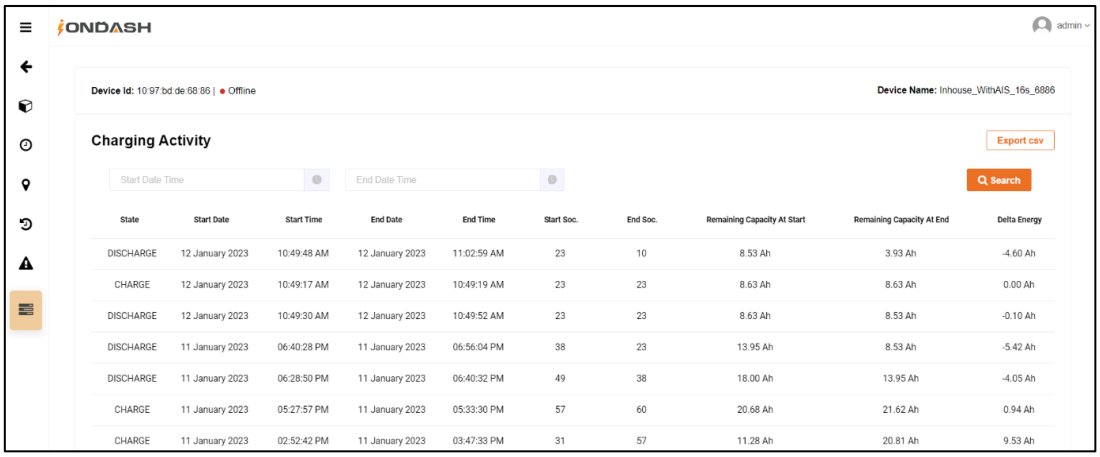
Figure 33 Alert and Fault Tab.

Key Features:

- **Alerts & Fault Categorisation**
  - Alerts - Includes warnings such as over-voltage, under-voltage, and discharge alerts.
  - Faults - Displays critical errors like over-charge faults, which may require immediate attention.
- **Time-Based Filtering**
  - The user can apply specific time filters to analyse alerts and faults within a given time frame.
  - Helps in diagnosing historical battery issues effectively.
- **Real-Time Fault Status**
  - Faults are categorised as Solved or Unsolved for quick identification of unresolved issues.
  - Helps technicians and users prioritise necessary actions.

9.7 Charging Activity Tab

The Charging Activity tab provides users with a complete record of battery charging and discharging events for better energy tracking and management.



State	Start Date	Start Time	End Date	End Time	Start Soc.	End Soc.	Remaining Capacity At Start	Remaining Capacity At End	Delta Energy
DISCHARGE	12 January 2023	10:49:48 AM	12 January 2023	11:02:59 AM	23	10	8.53 Ah	3.93 Ah	-4.60 Ah
CHARGE	12 January 2023	10:49:17 AM	12 January 2023	10:49:19 AM	23	23	8.63 Ah	8.63 Ah	0.00 Ah
DISCHARGE	12 January 2023	10:49:30 AM	12 January 2023	10:49:52 AM	23	23	8.63 Ah	8.53 Ah	-0.10 Ah
DISCHARGE	11 January 2023	06:40:28 PM	11 January 2023	06:56:04 PM	38	23	13.95 Ah	8.53 Ah	-5.42 Ah
DISCHARGE	11 January 2023	06:28:50 PM	11 January 2023	06:40:32 PM	49	38	18.00 Ah	13.95 Ah	-4.05 Ah
CHARGE	11 January 2023	05:27:57 PM	11 January 2023	05:33:30 PM	57	60	20.68 Ah	21.62 Ah	0.94 Ah
CHARGE	11 January 2023	02:52:42 PM	11 January 2023	03:47:33 PM	31	57	11.28 Ah	20.81 Ah	9.53 Ah

Figure 34 Charging Activity Tab.

Key Features:

- **Charge & Discharge Logs**
  - The system records every **charge** and **discharge** cycle.
  - Helps track how energy is being used and replenished over time.
- **Detailed Event Tracking**
  - **Start & End Time**: Know exactly when a charging or discharging session began and ended.
  - **Start & End SoC (%)**: Monitors charge in battery **State of Charge (SoC)** for each session.
  - **Energy Added / Dissipated (Ah)**: Show how much energy was stored or consumed in **Ampere-hours (Ah)**.
  - **Activity Duration**: Helps in analysing battery usage patterns.
- **Time-Based Filtering & Export Options**
  - The user can apply time filters to track specific charge/discharge sessions.
  - Export data in CSV format for further analysis and verification.

9.8 Device and User Management

Bacancy Systems is working on an advanced Device/User Management feature to enhance user control and accessibility.

10. BMS's Protection Mechanisms

Battery Management System (BMS) Pro is designed to protect the battery in terms of voltage, current, and temperature. It supports various protection mechanisms and allows for protection masking to enable or disable FET control with faults and alerts. If any fault occurs, BMS will turn off the respective FET to prevent damage.

Table 16 Protection Type and Description.

No.	Protection Type	Description
1	Cell Over Voltage Protection (COV)	Prevents cells from overcharging.
2	Cell Under Voltage Protection (CUV)	Prevents excessive discharge.
3	Over Current in Charge (OCC)	Protects against excessive charging current.
4	Over Current in Discharge 1 (OCD1)	Protects against mild discharge overload.
5	Over Current in Discharge 2 (OCD2)	Protects against moderate discharge overload.
6	Over Current in Discharge 3 (OCD3)	Protects against severe discharge overload.
7	Short Circuit in Discharge (SCD)	Disconnects in case of a short circuit.
8	Over Temperature in Discharge (OTD)	Prevents battery overheating during discharge.
9	Under Temperature in Discharge (UTD)	Prevents operation in extreme cold conditions.
10	Over Temperature in Charge (OTC)	Prevents overheating during charging.
11	Under Temperature in Charge (UTC)	Prevents charging in extreme cold.
12	Critical Over Charge Fault (COC)	Shuts off charging if pack voltage is too high.
13	Critical Over Discharge Fault (COD)	Shuts off discharge if pack voltage is too low.
14	FET Over Temperature Fault (FETOT/OTF)	Prevents FET overheating.
15	Charge FET Failure (CFF)	Detects and alerts about charge FET failure.
16	Discharge FET Failure (DFF)	Detects and alerts about discharge FET failure.
17	Low SoC	Alerts when the battery reaches a low state-of-charge.
18	Buzzer ON	Activates the buzzer in case of faults.
19	Smoke Detected	Alerts when smoke is detected.

10.1 Protection Mechanism in Detail

1. **Cell Over/Under Voltage Protection (COV/CUV)**
   - **COV Trigger Scenario:** If any cell voltage exceeds the over-voltage threshold, an alert is triggered. If it remains high for a configurable time, a COV fault occurs, turning off the charge FET.
   - **CUV Trigger Scenario:** If any cell voltage drops below the under-voltage threshold, an alert is triggered. If it remains low for a configurable time, a CUV fault occurs, turning off the discharge FET.
   - **Recovery:** The fault resolves when the voltage returns to the recovery threshold range.
2. **Over Current in Charge/Discharge (OCC/OCD)**
   - **OCC Trigger Scenario:** Charging current exceeds OCC threshold → alert is triggered → if sustained, OCC fault occurs.
   - **OCC Recovery:** Disconnect the charger; it recovers after a limited discharge current is present.
   - **OCD Trigger Scenario:** Discharging current exceeds OCD threshold → alert is triggered → if sustained, OCD fault occurs.
   - **OCD Recovery:** Connect the charger; it recovers after a limited charging current is present.
3. **Short Circuit in Discharge (SCD)**
   - **Trigger:** If the voltage difference exceeds the short circuit threshold, both FETs are turned off.
   - **Recovery:** Fault resolves after the configured recovery time.
4. **Over/Under Temperature in Charge/Discharge**
   - BMS Pro supports six temperature sensors:
     - Four external thermistors
     - One internal die thermistor
     - One FET temperature thermistor

   If any temperature exceeds the threshold limits, alerts and faults are triggered.

5. **Critical Over Charge Fault (COC)**
    - **Trigger:** If the pack voltage exceeds the critical over-charge threshold, an alert occurs. If sustained, a COC fault occurs, turning off the charge FET.
    - **Recovery:** The fault resolves when the pack voltage drops to the recovery threshold. The user can connect a load to allow discharge.
6. **Critical Over Discharge Fault (COD)**
    - **Trigger:** If the pack voltage drops below the critical over-discharge threshold, an alert occurs. If sustained, a COD fault occurs, turning off the discharge FET.
    - **Recovery:** The fault resolves when the pack voltage rises to the recovery threshold. The user can connect a charger to allow charging.
7. **Charge FET Failure (CFF)**
    - **Trigger:** Charge FET failure is detected.
    - **Action:** The buzzer turns ON.
    - **Recommendation:** Replace the BMS immediately.
8. **Discharge FET Failure (DFF)**
    - **Trigger:** Discharge FET failure is detected.
    - **Action:** The buzzer turns ON.
    - **Recommendation:** Replace the BMS immediately.
9. **Low SoC**
    - **Trigger:** SoC drops below the configured threshold.
    - **Recovery:** Resolves when SoC rises above the threshold.
10. **Buzzer Activation (Various Scenarios)**
    - **Scenario 1:** The Buzzer turns ON if the external thermistor temperature is too high until it cools down.
    - **Scenario 2:** The Buzzer turns ON when CFF or DFF failure occurs (only during charging/discharging).
    - **Scenario 3:** The Buzzer turns ON when smoke is detected.
11. **Smoke Detection**
    - **Trigger:** The BMS detects smoke.
    - **Action:** The buzzer turns ON.

11. Firmware Upgrade Support

BMS Pro supports Over-the-Air (OTA) updates, allowing seamless software upgrades whenever new features or improvements are introduced by Bacancy Systems.

- Any new feature or update is automatically delivered to the BMS via OTA.
- The software update cycle and support duration will be defined by Bacancy Systems.

This ensures that the BMS remains up to date with the latest enhancements without requiring manual intervention.

12. Troubleshooting

A. Parameters Not Displayed in the Application

This issue occurs if the BMS and BMS Pro applications are not correctly paired via Bluetooth.

- Ensure Bluetooth permission is allowed for the BMS Pro Application.
- Verify that Bluetooth is not connected to any other device.
- Restart the application. The parameters should now be displayed properly.

B. State of Charge (SoC) Not Accurate

If the SoC reading is incorrect, follow the steps outlined in Section 7.7 of the user guide.

C. OLED Display Not Working

If using BMS hardware for the first time:

- Ensure proper connection following the sequence in Section 6.2.1.
- If the connections are correct, remove the OLED from the board and reconnect.
- Navigate to the 'About' section and restart the BMS, as illustrated in *Figure 13*.

D. Location Option Not Visible Properly

- Verify that the GSM module is properly connected to the hardware.
- If not connected, reconnect and restart the BMS from the application.
- If the GSM module is connected after all cell and pack connections, restart the BMS to configure it with the GSM module.
- If the issue persists:
  - Check if the SIM card is inserted correctly in the GSM module.
  - Ensure the SIM card has an active internet pack.

13. FAQs of BMS

Q.1 What types of batteries does Bacancy's BMS support?

Answer: Bacancy's BMS supports both NMC (Lithium Nickel Manganese Cobalt Oxide) and LFP (Lithium Iron Phosphate) battery chemistries.

Q.2 What is the major difference between LFP and NMC batteries?

Answer: The primary difference between LFP and NMC batteries lies in their chemical composition, which affects their performance, safety, and lifespan.

Q.3 What is the maximum cell voltage supported by Bacancy's BMS?

Answer: BMS supports a maximum cell voltage of 4.5V.

Q.4 What is a C-rating?

Answer: The C-rating measures how quickly a battery can be fully charged or discharged.
For example, a 1C charge rate means the battery charges from 0-100% in one hour.

Q.5 What is the charging current?

Answer: Charging current refers to the amount of current supplied to charge the battery.

Q.6 What is discharging current?

Answer: Discharging current is the amount of current the battery can safely supply to a connected load.

Q.7 What is pre-charge and pre-discharge? Does Bacancy's BMS support these features?

Answer:

- Pre-charge is used to limit the inrush current during power-up. This function is typically handled by the charger, so Bacancy's BMS does not include pre-charge functionality.
- Pre-discharge allows for controlled current flow before full discharge. Bacancy's BMS supports pre-discharge.

Q.8 How many temperature input interfaces does Bacancy's BMS have?

Answer: Bacancy's BMS includes temperature input interfaces as follows:

- **16-cell BMS:** 4 external sensors + 2 onboard sensors.

Q.9 Does Bacancy's BMS include general-purpose GPIOs?

Answer: Yes, Bacancy's BMS provides GPIOs for various applications, such as ignition lock, buzzer/fan control, and smoke detection sensors.

Q.10 What is a short circuit, and does Bacancy's BMS offer protection against it?

Answer: A short circuit occurs when the battery's positive and negative terminals connect without a load, potentially damaging the battery. Bacancy's BMS provides Short Circuit Protection (SCD), which is configurable based on battery chemistry and can be adjusted through the mobile application.

Q.11 What is the overvoltage and undervoltage limits in Bacancy's BMS?

Answer:

- Overvoltage limit: 4500mV (4.5V)
- Undervoltage limit: 2000mV (2.0V), the user can configure these limits using the mobile application.

Q.12 How does Bacancy calculate SoC (State of Charge) and SoH (State of Health)?

Answer: Bacancy calculates SoC and SoH using the coulomb counting method, which tracks charge flow over time.

Q.13 What is OCV (Open Circuit Voltage)?

Answer: OCV (Open Circuit Voltage) refers to the voltage of a battery when no load is connected to it.

14. Appendix

14.1 Abbreviations and Glossary

°C	*The degree Celsius (symbol: °C) can refer to a specific point on the Celsius temperature scale or to a difference or range between two temperatures.*
4G (LTE)	*LTE stands for Long Term Evolution. It's a term used for the particular type of 4G that delivers a fast mobile Internet experience.*
A	*An ampere is a unit of measure of the rate of electron flow or current in an electrical conductor.*
ADC	*An Analog-to-Digital Converter (ADC) is an electronic device or circuit that converts continuous analog signals into discrete digital values. It plays a crucial role in digital signal processing by enabling computers and digital systems to process real-world signals such as sound, temperature, and pressure.*
AIS-156 Amendment-3	*AIS-156 Amendment 3 refers to the latest update in the Automotive Industry Standard (AIS)-156, which outlines safety and performance requirements for electric vehicles (EVs) with battery swap technology in India. This standard is regulated by the Ministry of Road Transport and Highways (MoRTH) and the Automotive Research Association of India (ARAI).*
APN	*An Access Point Name (APN) is the gateway between a mobile network (such as 4G/5G) and the internet. It defines the settings that a device (smartphone, tablet, or IoT device) uses to connect to the internet or a private network through a carrier's mobile data service.*
BLE	*Bluetooth Low Energy (BLE) is a wireless communication technology designed for low power consumption while maintaining reliable short-range connectivity. It is a subset of Bluetooth but optimized for applications that require minimal energy usage, such as IoT devices, wearables, and smart home gadgets.*
CAN	*A controller area network (CAN) bus is a high-integrity serial bus system for networking intelligent devices. CAN buses and devices are common components in automotive and industrial systems.*
Coulomb	*The Coulomb (C) is the SI unit of electric charge, named after Charles-Augustin de Coulomb, a French physicist. It represents the amount of charge transported by a one-ampere current in one second.*
DIE	*Internal DIE Temperature refers to the temperature of the semiconductor die (chip) inside an integrated circuit (IC), microprocessor, or microcontroller. This temperature is critical for ensuring the proper operation and longevity of electronic components.*

DMM	*A Digital Multimeter (DMM) is an electronic measuring instrument used to measure voltage, current, resistance, and sometimes additional parameters like capacitance, frequency, temperature, and continuity. It is an essential tool for electricians, engineers, and hobbyists working with electrical and electronic circuits.*
EVs	*An EV is defined as a vehicle that can be powered by an electric motor that draws electricity from a battery and is capable of being charged from an external source.*
FET	*A Field-Effect Transistor (FET) is a type of transistor that controls the flow of electrical current using an electric field. It is widely used in amplifiers, digital circuits, and switching applications due to its high input impedance and low power consumption.*
FOTA	*Firmware over-the-air is an update that is downloaded by the device over the internet.*
g	*A gram (g) is a unit of mass in the metric system. It is commonly used to measure small amounts of weight in everyday life, science, and industry.*
GND	*GND stands for Ground. A common or shared return route of electrical current to the power source that enables the completion of the circuit refers to the ground in both electrical and electronic circuits.*
GPIO	*General Purpose Input/Output*
GPRS	*GPRS (General Packet Radio Service) is a mobile data service that allows devices to transmit and receive data over 2G and 3G cellular networks. It enables services like internet browsing, MMS, and basic online applications on mobile devices.*
GPS	*GPS (Global Positioning System) is a satellite-based navigation system that provides location, velocity, and time data to GPS receivers anywhere on Earth, as long as there is an unobstructed line of sight to at least four GPS satellites.*
GSM	*GSM (Global System for Mobile Communication) is a digital mobile network that is widely used by mobile phone users in Europe and other parts of the world.*
HEVs	*HEVs (Hybrid Electric Vehicles) are vehicles that combine an internal combustion engine (ICE) with an electric motor and battery to improve fuel efficiency and reduce emissions. HEVs do not need to be plugged in; instead, they recharge their batteries through regenerative braking and the engine.*

I/O	*I/O (Input/Output) refers to the communication between a system (such as a computer, microcontroller, or device) and the external world. It includes both input (data received) and output (data sent).*
IGN	*In the context of a Battery Management System (BMS), IGN (Ignition) refers to the ignition signal input that tells the BMS when the vehicle or system is powered ON. This signal is crucial for activating, monitoring, and managing the battery pack efficiently.*
LFP (LiFePO4)	*LFP (Lithium Iron Phosphate, $LiFePO_4$) is a type of lithium-ion battery chemistry known for its high safety, long cycle life, and thermal stability. It is widely used in electric vehicles (EVs), energy storage systems, and industrial applications.*
mA	*A milliampere is one-thousandth of an ampere, which is the base unit for measuring electrical current.*
MAC	*A MAC (Media Access Control) address is a unique identifier assigned to a device's network interface card (NIC) for communication on a network. It is used in Ethernet and Wi-Fi networks to ensure proper data transmission between devices.*
mm	*The millimetre is a unit of length in the International System of Units (SI), equal to one-thousandth of a metre.*
MOSFET	*A MOSFET (Metal-Oxide-Semiconductor Field-Effect Transistor) is a semiconductor device used for switching and amplifying electronic signals. It is a type of field-effect transistor (FET) and is widely used in power electronics, digital circuits, and microprocessors.*
MQTT	*MQTT (Message Queuing Telemetry Transport) is a lightweight, publish-subscribe messaging protocol designed for low-bandwidth, high-latency, or unreliable networks. It is widely used in IoT (Internet of Things), home automation, and industrial applications.*
mV	*mV (millivolt) is a unit of electric potential (voltage) equal to one-thousandth (1/1000) of a volt (V). It is commonly used in low-voltage applications, such as sensors, biomedical devices, and precision electronics.*
NCM/NMC	*NCM (Nickel Cobalt Manganese) is a lithium-ion battery chemistry that uses Nickel (Ni), Cobalt (Co), and Manganese (Mn) as key cathode materials. It is widely used in electric vehicles (EVs), energy storage systems (ESS), and portable electronics due to its high energy density and balanced performance.* ***Note:** NMC and NCM are the same; the terms are used interchangeably, depending on the manufacturer.*

nRST	*nRST (Active-Low Reset) is a signal used in microcontrollers, processors, and other digital circuits to reset the system. The "n" or "¯" (overline) notation indicates that the reset is active when the signal is LOW (0V).*
OLED	*OLED (Organic Light-Emitting Diode) is a display technology that uses organic compounds to emit light when an electric current is applied. Unlike LCDs, OLEDs do not require a backlight, allowing for thinner, more flexible, and energy-efficient displays with better contrast and colour accuracy.*
OTA	*An over-the-air update is a firmware or operating system update that is downloaded by the device over the internet.*
PCB	*A PCB (Printed Circuit Board) is a thin board made of insulating material (like fiberglass) with copper traces that electrically connect components.*
SCL	*SCL (Serial Clock Line) is the clock signal used in the I²C (Inter-Integrated Circuit) communication protocol. It synchronizes data transfer between a master and slave device.*
SDA	*SDA (Serial Data Line) is the data transmission line used in the I²C (Inter-Integrated Circuit) communication protocol. It works together with SCL (Serial Clock Line) to enable communication between a master (e.g., microcontroller) and one or more slave devices (e.g., sensors, displays, EEPROMs, etc.).*
SoC	*SoC (State of Charge) refers to the remaining battery capacity expressed as a percentage of its full charge. It indicates how much energy is left in a battery relative to its total capacity, similar to a fuel gauge in a car.*
SoH	*SoH (State of Health) is a measure of a battery's overall condition and aging, typically expressed as a percentage (%) of its original capacity and performance. It indicates how much a battery has degraded over time compared to when it was new.*
Sq.mm	*Sq.mm (Square Millimeter or mm²) is a unit of area measurement in the metric system, representing the area of a square with each side measuring 1 millimeter.*
UPS	*A UPS (Uninterruptible Power Supply) is a device that provides emergency power to electrical systems when the main power supply fails or experiences fluctuations. It ensures continuous operation of computers, servers, medical devices, and other critical equipment.*
V	*Voltage, also known as (electrical) potential difference, electric pressure, or electric tension is the difference in electric potential between two points.*

VCC	*VCC (Voltage Common Collector) refers to the positive supply voltage in an electronic circuit, typically powering transistors, ICs (Integrated Circuits), and microcontrollers.*
W	*The symbol W is the International System of Units (SI) symbol for the watt, which is the standard unit of power. One watt is equal to one joule per second.*
Wi-Fi	*Wi-Fi is a family of wireless network protocols based on the IEEE 802.11 family of standards, which are commonly used for local area networking of devices and internet access, allowing nearby digital devices to exchange data by radio waves.*

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